PROFITABILITY IMPROVEMENT OF CONSTRUCTION FIRMS THROUGH CONTINUOUS IMPROVEMENT USING RAPID IMPROVEMENT PRINCIPLES AND BEST PRACTICES

by

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Dedication

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I dedicate this in love and respect in appreciation of their selfless support.

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LIST OF ABBREVIATIONS

Abbreviations	Stands for
BSC	Balanced Score Card
CI	Continuous Improvement
CPM	Critical Path Method
BPM	Business Process Management
BPMM	Business Process Maturity Model
BPR	Business Process Reengineering
CSFs	Critical Success Factors
EFQM	European Foundation for Quality Management Excellence Model
5S	Sort-Straighten-Shine-Standardize and Sustain
FMEA	Failure Mode and Effect Analysis
IGLC	International Group for Lean Construction
ISPI	International Society for Performance Improvement
KPI	Key Performance Indicator
KPM	Key Performance Measure
OE	Organizational Effectiveness
OEC	Organizational Effectiveness Checklist
PDCA	Plan-Do-Check-Act
RIPs & BPs	Rapid Improvement Principles and Best Practices
RPN	Risk Priority Number
SCM	Supply Chain Management
TA	Tasks Anticipated
TMR	Tasks Made Ready
TQM	Total Quality Management

GLOSSARY

Best Practices (BPs): Construction Industry Institute defines best practices as “process[es] or method[s] that, when executed effectively, [lead] to enhanced project performance.” Processes, practices, and systems identified among industry leaders are described as “best practices” and may provide models for other organizations with similar functions, contingencies, and missions. Besides, professional associations may generate normative standards and principles characteristic of effectiveness and efficiency, asking panels of experts in a given field. Best practices, then, usually take the form of a comprehensive set of standards, guidelines, norms, reference points, or benchmarks that inform practice and help to improve performance.

Continuous Improvement: All coordinated efforts designed to accelerate the achievement of specified organizational objectives through change, learning and innovation (Lahy and Found, 2015).

Lean Construction: It is a philosophy of business management applied to construction industry projects. It is expressed as an ideal to pursue, principles to follow in pursuit of the philosophy ideals, and methods to employ in the application of the principles (Ballard and Hamzeh, 2007).

Logistics: By moving materials, services, funds, and information up and down the supply chain, ‘logistics’ ensures delivery of the right products and services in the right quantities to the right customers at the right time while minimizing costs. Some of the leading logistics functions are managing customer service, orders, inventory, transportation, storage, handling, packaging, information, forecasting, production planning, purchasing, cross-docking, repackaging, preassembly, facility location and distribution (Simchi-Levi et al. 2003; Gourdin 2006; Bowersox et al. 2007; Hamzeh et al., 2007).

Look ahead planning is the first step in production planning. It starts by taking a lookahead filter from the phase schedule and then breaking processes into operations, identifying and removing constraints, and designing operations (Ballard, 1997: Hamzeh et al., 2008).

Master Scheduling: is the first step in front-end planning and involves developing logistics plans and work strategies before setting project milestones.

Performance: performance is the ability (of people, teams, organizational units, and projects) to meet organizational objectives (Lahy and Found, 2015).

Phase / Pull Scheduling builds on the milestones set in master scheduling to define milestone deliverables, breakdown milestones into constituent activities, perform collaborative reverse phase scheduling and adjust the schedule to meet the available time frame.

Rapid Improvement Principles (RIPs) are principles that have shown improved results when used appropriately in construction and extracted from manufacturing, aerospace, service, and other industries.

Supply Chain is a network of companies exchanging materials, services, information, and funds one with another to satisfy end-user needs.

Supply Chain Management (SCM) is: (a) a collaborative relationship between supply chain firms pursuing global optimization goals by joint planning, management, implementation and control of operations; (b) an interdependence among firms requiring holistic analysis of tradeoffs shaping the performance of the whole chain; and (c) a quest towards customer satisfaction that translates into benefits for the whole network (Bowersox et al., 2007; Ayers, 2006; Tommelein et al., 2003, and Simchi-Levi et al., 2003).

Weekly Work Planning drives the production process by developing reliable weekly work plans and initiates preparations to perform work as planned. General foremen and superintendents promote plan reliability at the weekly work planning level by making only quality assignments and reliable promises to shield production units from variability in upstream tasks. Percent Plan Complete (PPC), a metric used to track the performance of reliable promises, measures the percentage of tasks completed relative to those planned. Analyzing reasons for plan failures and acting on those reasons is the basis of learning (Ballard, 2000).

ABSTRACT

The internal and external challenges construction companies face such as variability, low productivity, inefficient processes, waste, uncertainties, risks, fragmentation, adversarial contractual relationships, competition, and those resulting from internal and external challenges such as cost overruns and delays negatively affect company performance and profitability. Though research publications abound, these challenges persist, which indicates that the following gaps exist. Lean construction, process improvement, and performance improvement research have been conducted wherein improvement principles, and best practices are used to ameliorate performance issues, but several knowledge gaps exist. Few companies use these improvement principles and best practices. For those companies applying improvements, there is no established link between these improvements and performance/profitability to guide companies. Further, even when companies use improvement principles and best practices, they apply only one or two, whereas an integrated application of these improvement principles and best practices would be more effective. The other gap the author identified is the lack of strategic tools that construction companies can use to improve and manage their profitability. This thesis tried to fill the knowledge gap, at least partially, by developing a two-part excellence model for profitability improvement of construction companies. The excellence model lays out strategies that would enable companies to overcome the challenges and improve their profitability. The excellence model also gives an iterative and recursive continuous improvement model and flowchart to improve the profitability of construction companies. The researcher used high impact principles, guidelines, and concepts from the literature on organizational effectiveness, critical success factors, strategic company profitability growth enablers, process improvement, and process maturity models, performance improvement, and organizational excellence guidelines to develop the two-part excellence model.

The author also translated the two-part excellence model into the diagnostic tool and Decision Support System (DSS) by use of process diagrams, fishbone diagrams, root cause analysis, and use of improvement principles, countermeasures and best practices at the most granular (lowest intervention) levels to do away with root causes of poor performance. The author developed the diagnostic tool and Decision Support System (DSS) in Access 2016 to serve as a strategic tool to improve and manage the profitability of construction companies. The researcher used improvement principles, and best practices from scientific and practitioner literature to

develop company and project process flow diagrams, and fishbone (cause and effect) diagrams for company, department, employee, interactions and project performance for the profitability improvement, which are the engines of the diagnostic tool and DSS. The diagnostic tool and DSS use continuous improvement cycles iteratively and recursively to improve the profitability of construction companies from the current net profit of 2-3 percent to a higher value.

1. INTRODUCTION

1.1 Background and Needs

Profitability and financial success are some of the main drivers in any business, including construction companies. Achieving success requires deliberate effort by planning for, working towards success, and using a feedback loop to improve performance continuously. In planning for and working towards success, companies can take two alternative approaches. Companies can either exploit all potential improvements or target high impact improvements, processes, and activities. The first approach can involve a combinatorially explosive number of options, which entails solution filtering and pruning, a problem that is yet not satisfactorily addressed (Eaton, 1994). In the second approach, the organization identifies and applies a range of critical success factors (CSFs), organizational effectiveness and excellence guidelines that are vital to success.

Critical success factors are the operationally focused high impact few issues (typically four or five to achieve a strategic objective) that require the company to prioritize the core value-adding activities and processes fundamental to the achievement of strategic objectives (Alarcon and Serpell, 1996). Rockart and Delong (1988) defined CSFs as the limited number of areas in which results, if satisfactory, will ensure the organization's successful competitive performance. CSFs are the few crucial areas where things must go right for the business to flourish. Van Tiem et al. (2012) define CSFs as problems or opportunities that determine an organization's success or failure. Construction companies need to have an explicit formula for success (Clemen and Reilly, 2014), i.e., it is essential to know the critical success factors (CSFs), organizational effectiveness guidelines, and excellence in core processes in their business. Such of a focus of organizations to create value for their clients and profit for their company, and the use a small number of KPMs or KPIs to monitor their performance ensures success and gives an organization a competitive edge (Chartered Institute of Management Accountants (CIMA), 2009; Mbugua et al., 1999; Holohan, 1992; Rockart and Delong 1988; Kaplan and Norton, 1996; Barkley, 2001). The simpler and easier it is for employees and partnering organizations in projects to understand drivers of profit, the easier it is for them to align their efforts to support the strategy. Identifying and crystallizing the essential CSFs, organizational effectiveness, and excellence guidelines and KPMs or KPIs to monitor performance for a business is one of the simplest and most effective ways of communicating a company's strategy (CIMA, 2009). These are also critical elements for best implementing the strategy of a company (Holohan, 1992).

Designing and perfecting the core company and project processes are vital for dynamic capability and excellence in the fiercely competitive environment (Sivusuo et al., 2018; van Looy et al., 2011). Tripathi and Jha (2018) highlight the importance of identifying CSFs and instilling them in company employees' work ethics for the success of construction companies. Further, monitoring plan implementation is necessary to get feedback to improve activities and core processes continuously.

Profitability is the ability of a construction company to generate profit in the future, i.e., the capability to exploit the potential for profit generation and to sustainably generate profit over a long period for long term survival of the company (Cui, 2005; Tamer, 2009). Profit refers to the company's total net income during a specified period, while profitability refers to the company's operating efficiency to get sufficient return on the capital and other resources deployed in the business operation over an extended period. Financial difficulties are the most prevalent symptoms of construction company distress (Jagafa and Wood, 2012). Improving the financial performance of the construction industry is crucial for all stakeholders within the construction industry in general and construction companies in particular (Bates, 1989; Bruderl et al., 1992; Holtz-Eakin, 1994; Everett and Watson, 1998). Profit is a crucial component in calculating a company's profitability (Mahdavi, 2016). A company's profitability determines its future payoffs, which is a crucial factor that determines the value of a company (Ro, 2013).

Construction companies' performance and the industry's has a direct impact on citizens' quality of life as it provides the society with the facilities needed for life (the National Academies of Sciences, 2009). The construction industry also underpins all other sectors of the economy by providing the infrastructure and facilities essential for the production and distribution of goods and services (Jones and Saad, 2003). The other meaningful way the construction industry affects the economy of a country is by creating jobs for millions. The construction industry's performance also directly influences regional, state, national, and international economic development (Woods, 2000). However, construction contracting is a high risk, dynamic and complex business, which is subject to a high level of uncertainty due to fragmented nature of the industry and its high susceptibility to environmental influences (Khosrowshahi and Howes, 2005) that cause low profits or loss, endangering the health of construction companies (Han et al., 2007). Result of industry-wide studies indicate that most construction projects yield net profits of 2–3% of the total project cost (Forbes and Ahmed, 2011). Loss of profit is a very disruptive force for construction companies (Han et al., 2007). Arditi et al. (2000) say that insufficient profit caused about 27% of construction company failures in the U.S. Construction company failure is the second largest next to the restaurant business and about 50% of construction companies in the U. S. fail before they reach ten years in business (Schaufelberger, 2009). Company failure is very disruptive to the industry and may also cause significant rippling effects in an economy (Wong and N.G., 2010). It is beneficial to recognize performance issues that can potentially lead to company failure at the earliest opportunity (Wong and N.G., 2010) so that organizations can take remedial measures. Performance tracking and performance measurement help to recognize performance issues as soon as they occur.

Despite past research efforts to solve construction company problems and to improve performance, construction companies are still suffering from challenges of low profitability, shrinking profit margins, stagnant productivity, and poor performance (Egan, 1998) that puts them in a precarious position. Many construction companies often operate at a razor-thin profit or a loss (Cui, 2005; Kangari and Boyer, 1981), making profitability unreliable and difficult to manage (Cui, 2005). Too many clients are also dissatisfied with the overall performance of construction (Egan, 1998). About 80% of projects worldwide are not delivering on projects in one or more substantive ways, which suggests that several aspects are missing from our understanding and practice of construction project management (Jones and Saad, 2003). Improvement makes processes and products simpler to operate or use, better, faster, and cheaper (Shingo, 1988). Performance improvement has been an active area of research for many years that resulted in different models of improvement (Wilmoth et al., 2002), which all use best practices to alleviate performance problems (van Tiem et al., 2012). Many researchers have also identified rapid improvement principles that have been successful in improving processes in other industries. These improvements include identifying and removing bottlenecks, establishing work processes in a continuous flow, using a planning system that causes work to flow across the value stream, minimizing inventory through just-in-time delivery, and pull flow control. However, many construction companies have not effectively deployed these rapid improvement principles (RIPs) in construction. Rapid improvement principles (RIPs) developed in or adopted into the construction industry are also not effectively deployed. Further, best practices like using integrated, aligned teams (business, operations, maintenance, and engineering), benchmarking (best in class), and metrics (safety, cost, schedule, operability, value creation), constructability reviews and the like are also not effectively used in construction.

There are several reasons for the lack of use of rapid improvement principles and best practices. Bashir et al. (2010) did an extensive literature review and classified barriers to implementation of lean construction principles into six categories as management, financial, educational, government, technical, and human attitudinal issues. Sarhan and Fox (2013) conducted an extensive literature review and identified ten barriers to implementation of lean construction principles, and determined by a survey that the significant barriers in the U.K. are lack of awareness, lack of top management commitment, and culture and social, attitudinal issues. Four of the types of reasons identified by the two preceding publications overlap. Construction Industry Institute (CII) identified barriers to implementation of its best practices (BPs) as lack of familiarity with Best Practices (BPs), lack of commitment to BPs, failure to integrate new ideas into company procedures, limited benchmarking of costs and benefits and lack of innovation within the industry due to risk aversion (CII, RT-166). Even in cases where companies implement these rapid improvement principles and best practices, only one or two are adopted (CII, RT-166). The demand side of construction is increasing fast. As an example, the world urban population is increasing by 200,000 people per day, all of whom need affordable housing, power, water supply, sanitation, offices, and transportation (World Economic Forum, 2016). Construction companies need to improve their profitability significantly, and the industry is under a moral obligation to transform in order to meet this demand (World Economic Forum, 2016). A solution to try, which might sustainably solve the problem of razor-thin profit and low profitability of construction companies and transform profitability improvement, is extraction, integration, and application of rapid improvement principles and best practices (RIPs and BPs). Systematically adopting the rapid improvement principles and best practices (RIPs and BPs), establishing a link in a measurable way between the implementation of these RIPs and BPs with profitability, and systematic management and improvement of profitability (Cui, 2005; Bititci and Nudurupati, 2002) using RIPs and BPs as levers may result in transformative profitability improvement.

Other than the work done by the Solutions for Profitability and Assessment of Risk in Construction (SPARC) laboratory at Purdue University by Cui (2005), Tamer (2009) and Mahdavi (2016), there is not much literature, tools, and models on profitability improvement of construction companies. Cui (2005) developed a model for analyzing the profitability of construction firms using system dynamics. His model comprised of three essential elements: the quality characteristics (magnitude) of profit, the potential for profit, and sustainability of profit. He used system equations to investigate the effect of bid-winning ratio on profitability to improve the bidding strategy to increase the bid-winning ratio. He also investigated the impact of overdraft and cash policies on profitability considering the effect of interest rate, material discount, material and labor cost overruns, overbilling, and under billing strategies. However, he did not investigate the improvement of profitability of construction firms through the implementation of RIPs and BPs.

Tamer (2009) developed a protocol to analyze profitability to understand the gap between actual and estimated profit and the origins of loss or gain on work break down structure of completed construction projects. The protocol assigns numerical values for the relationships/interactions between cost centers and profit centers (projects) depending on whether expected supports are met or not to show the influence the relationships have on profit margins. Then one investigates all positive and negative relationships to find the right strategy for profitability improvement. Tamer established the framework for data collection and analysis of the interactions, yet he did not investigate profitability improvement that can result from the implementation of RIPs and BPs.

There have been some profit modeling studies made using regression analysis. The following two studies used data analysis to predict profit.

Han et al. (2007) worked on a quantitative profit scale-based prediction model for international projects using factor analysis and multiple regression analysis. The model serves as a systematic risk screening tool used to select international candidate projects to complete profitably. Han et al. (2007) randomly selected one hundred twenty-six overseas projects constructed by Korean contractors from 1085 projects and collected data by questionnaire survey. They collected the data on 64 risk variables that affect profit margin. This model has limitation in that it can be used only for the types of projects surveyed and for the duration of the data; hence, companies cannot use the model for future decisions. Further, it serves for project analysis only, and companies cannot use it for company analysis.

Deng and Smyth (2013) performed an analysis of the performance of 265 of the U.K.'s largest construction firms using 10-year financial data (2002 – 2011). They used factor analysis and data envelopment analysis (DEA) on the 10-year financial data of the companies. DEA model is a nonparametric linear programming technique that involves integrating and modeling multiple inputs and multiple outputs relationships without an a priori underlying functional form assumption. They concluded that firm performance is multi-dimensional, dynamic (longitudinally changing with time for each company), and cross-sectionally comparable to competitors' performance. They aggregated all key performance indicators into one synthetic measure using data envelopment analysis. They also concluded that profitability is the most reliable firm performance measure. This model also has limitation in that it can be used only for the types of companies surveyed and for the duration of the data; hence, companies cannot use the model for future decisions. Lack of company performance data also makes use of this method difficult. Furthermore, this method does not help measure, track, and get feedback to improve current performance.

The prediction model (decision support system) that gives immediate feedback to aid and guide strategic company decisions regarding profitability improvement and management will be instrumental.

Therefore, the author identified the following research gaps:

- Lack of systematic way of adopting RIPs and BPs. Even the few companies using RIPs and BPs apply only one or two RIPs and BPs.
- Lack of established link between RIPs and BPs, with profitability
- Lack of systematic profitability improvement and management tools and methods.

Therefore, there is a knowledge gap and lack of strategic tools that construction companies can use to manage and improve their profitability. Further, a systematic method for the application of improvement principles and tools to effect improvement in profitability is not yet available. This research aims at filling these gaps.

1.2 Thesis of Dissertation

Planning for success and excellence does not assure success by itself. Often, the actual implementation deviates from the plan due to bottlenecks, problems, risks, competitions, resulting in a razor-thin and unreliable profit, and low profitability. To address the problem of razor-thin profit and low profitability of construction companies, and effect rapid and transformative profitability improvement, it is crucial to apply continuous improvement. The goal is to continuously improve the company, departments, employees, interactions, sustainability issues, and projects by applying rapid improvement principles and best practices to problems/bottlenecks and identified improvement opportunities, which is likely to result in significant improvement in the profitability of construction firms. The purposes of this research are to develop a two-part profitability improvement excellence model and translate it into a transformative diagnostic framework and decision support system for construction companies that help to systematically manage and improve their profitability as RIPs and BPs are applied as levers to implement the CSFs, improve the core processes and profit influencing factors thereby alleviating the bottlenecks and exploiting the improvement opportunities.

The database of RIPs and BPs extracted from literature in the construction industry, and other industries are used in the decision support system to effect rapid and transformative profitability improvement of construction companies. RIPs and BPs are extracted from lean construction, the theory of constraints, performance improvement, business model innovation, value innovation, change management and organization development, process performance measurement system and advanced work packaging, lean six sigma, improvement science, value improving practices and best practices, and breakthrough thinking.

The Thesis of the Dissertation:

Continuous improvement of the performance of company, departments, employees, interactions, sustainability issues and projects by applying rapid improvement principles and best practices to company problems/bottlenecks and identified improvement opportunities is likely to result in significant improvement in the profitability of construction firms.

1.3 Specific Objectives

The target users of the two-part excellence model for profitability improvement of construction companies and systematic diagnostic tool and decision support system are highway and civil construction companies. The two-part excellence model lays out profitability improvement strategies and the corresponding operating decisions and gives iterative and recursive continuous improvement cycles. The diagnostic tool helps to identify problems, and the decision support system aids in root cause analysis and in selecting rapid improvement principles and best practices that will potentially help improve the profitability of construction firms.

The specific objectives are to:

- Develop a model that would help profitability improvement of construction companies and Fill the identified knowledge gap regarding the lack of model and literature on profitability improvement of construction companies, at least partially.
- Develop a systematic diagnostic tool that construction companies can use to analyze their core company and project processes, organizational units, internal and external interactions. The diagnostic tool will help to identify bottlenecks, issues, challenges, and risks, and to identify improvement opportunities.
- Develop a decision support system that aids construction company managers and improvement teams to conduct gap analysis, root cause analysis, and improvement by applying RIPs, countermeasures and BPs to generate strategic short-term and long-term solutions to improve profitability.

1.4 Research Questions

This research tries to answer the following research questions to fill the identified research gaps and attain the listed specific research objectives:

1. How can the identified knowledge gap be filled, at least partially?
2. How can bottlenecks that limit the profitability of construction companies, and improvement opportunities be identified?
3. What steps could the researcher take to systematically rectify the root causes of the bottlenecks and exploit the identified improvement opportunities?
4. Can a strategic decision support system be developed and implemented to help improve construction companies' profitability in the short-term and long-term?

1.5 Scope

The research objective is to develop an approach that construction companies can use to diagnose problems and carry out improvement at the company level, project, department, process, for sustainability initiative, and at employee levels. The target users of this research output are highway and civil engineering construction companies.

1.6 Expected Outcomes

The author expects the following outcomes at the end of this research:

1. He develops a model that partially fills the identified knowledge gap regarding lack of models and literature on profitability improvement of construction companies
2. He develops a tool that helps to identify bottlenecks/problem areas.
3. He develops a tool that helps to carry out root cause analysis to determine the causes of the bottlenecks and help select improvement principles and best practices to eliminate the root causes, thereby improving profitability.

1.7 Structure and Organization of the Dissertation

The underlying structure for review of the problems and analysis to forward the two-part excellence model and development of the diagnostic tool and decision support system as solutions to the problems is continuous improvement framework. The structure is shown in Fig. 1.1.

Organization of the Dissertation

The dissertation is organized as follows. It begins with problems and gap identification regarding razor-thin and unreliable profit and low profitability of construction companies in Chapter 1. This chapter also discusses the model and diagnostic tool and DSS required for the transformation of construction companies to overcome the challenges and fill the gaps. Chapter 2 reviews and synthesizes relevant literature to use the information to develop a model for profitability improvement of construction companies. Chapter 3 uses the constructive research methodology to develop a two-part profitability improvement excellence model for construction companies. Chapter 4 deals mainly with the development of process flow and fishbone diagrams using rapid improvement principles and best practices, and with the use of rapid improvement principles and best practices in interventions. Chapter 5 deals with the development of the diagnostic tool and the DSS based on the two-part excellence model and demonstrates the use of the tool with a sample company example. Chapter 6 points out some impediments to the implementation of improvements and change, and suggests some ways to overcome the barriers. Finally, Chapter 7 gives a summary, conclusions, and suggestions for future research.

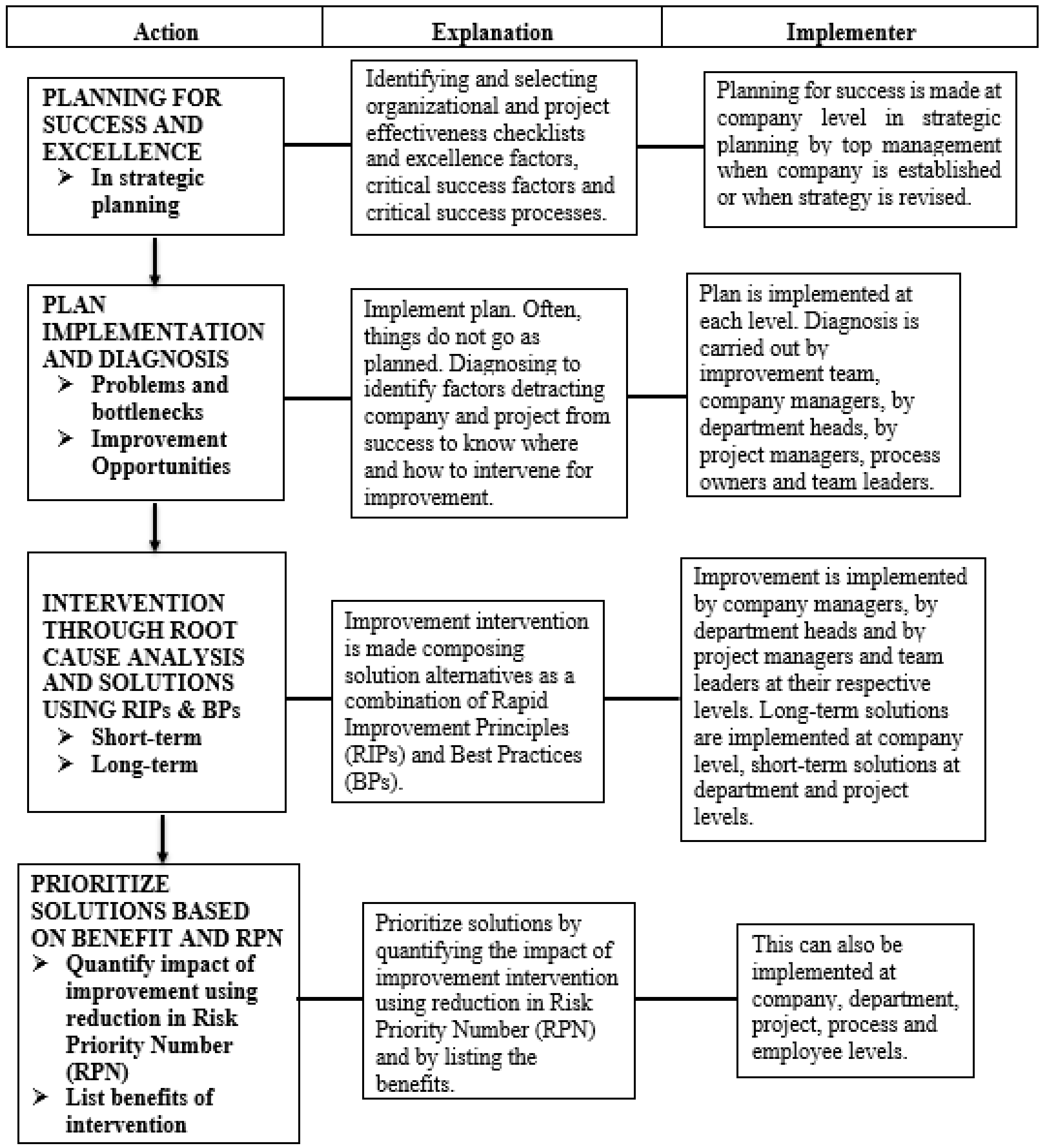


Figure 1.1 Structure of the dissertation

1.8 Summary of Chapter 1

This chapter has identified the research gaps that the researcher set out to fill. Construction companies face different challenges that forced them to suffer from razor-thin and unreliable profit, low profitability, and high mortality rate, which makes meeting the high construction demand difficult. It went on to say that improving the financial performance of construction companies is crucial to building their capacity. Construction companies need transformation through improvement to enable the construction industry to support all other sectors of the economy, to meet the high construction demand and to help avoid the high mortality rate of construction companies. The chapter pointed out deficiencies in improvement as few companies using RIPs and BPs. Even the few companies using RIPs and BPs apply only one or two RIPs, and BPs, whereas RIPs and BPs would be more effective if used together in an integrated way. The chapter identified research gaps as 1) lack of a systematic way of adopting RIPs and BPs 2) lack of an established link between RIPs and BPs with profitability 3) lack of systematic profitability management and improvement tools and methods. The chapter gave research objectives as the development of a model for profitability improvement of construction companies and development of a diagnostic tool and DSS. The chapter posed research questions, if answered, that would help achieve the research objectives. The chapter also gave the thesis and scope of the dissertation, and finally lays out the structure and organization of the dissertation.

Chapter 2 will review and synthesize relevant previous research and professional work to extract principles, guidelines, and concepts that would help to develop a model for profitability improvement of construction companies and for the development of a diagnostic tool and DSS.

2. LITERATURE REVIEW

This chapter will review relevant previous research and professional work that has influenced this study. First, the literature on planning for success and excellence will be reviewed, followed by a review of literature on plan implementation and comparison of plan with actual implementation. Finally, the review will be on the literature on improvement interventions required to close the gaps between plan and implementation. The chapter has five sections. Section 2.1 deals with planning for success and excellence. Section 2.2 deals with implementation of plan, evaluation of plan implementation (whether implementation conforms to plan), diagnosis of problems/bottlenecks and recurrent undesirable events that detract construction companies from success (in cases of a gap between plan and implementation), in which case selection and implementation of improvement interventions become necessary. Section 2.3 discusses the origin, application and effectiveness of RIPs and BPs. Section 2.4 reviews profitability research at the SPARC laboratory at Purdue University. Section 2.5 posed an essential question about whether a theory of continuous improvement exists. Finally, Section 2.6 gives points of departure of this work from the existing body of knowledge.

2.1 Planning for Construction Company Success

2.1.1 Introduction

It is crucial to understand and synthesize the challenges construction companies face to help focus effort on resolving them. Different methods and approaches used in practice and those published in the scientific literature will be instrumental in designing improvement interventions. Towards that end, review on the state of the art organizational and process improvement methods help to inform the development of an effective solution to the problem of razor-thin profit and low profitability of construction firms.

With the global population predicted to reach around 9.8 billion by 2050 – and more than two out of every three people living in cities by 2050 (Ritchie and Roser, 2020) – the construction demand has never been higher. However, focusing on this strong demand obscures a more precarious reality. Underlying challenges in profitability, productivity, and project performance could derail the industry's growth. This vital industry is facing the following internal and external challenges that resulted in relatively poor performance of the sector and low profitability of construction firms (Jones and Saad, 2003).

Challenges due to internal causes:

a. One of the challenges construction companies face is variability. Variability is ubiquitous in construction. It undermines project performance, disrupts the workflow, and results in detrimental consequences on cost, duration, and quality (Hamzeh, 2009). With each construction project being unique, factors behind this variability are plentiful (Ballesteros-Pérez et al., 2017). These factors, including project location, clients, regulations, labor, equipment, technology, subcontractors, experience, stakeholders, and even the project team, are likely to change, at least partially, among projects (Chudley and Greeno, 2016) plus many others. Continuous long and short-term planning and scheduling is the most effective antidote of variability, which Appendix B treats.
b. The other challenge due to internal causes is low productivity that directly affects profitability. Construction labor productivity directly affects profitability (Forbes and Ahmed, 2011). Any improvement intervention needs to focus on project productivity, which is the case in this research. Studies showed that construction productivity has declined by 0.5% a year in the U.S. for the 40 years leading to 2010 (Forbes and Ahmed, 2011).
c. The other challenge due to internal causes is inefficient (wasteful) processes that directly affect profitability. The next most effective way recommended in the literature to improve profitability is to use end to end processes with continuous workflow (Hammer, 2007), which this research does by developing company and project process flow diagrams (given in Appendix A). Waste increases project durations and costs, and often results in quality issues. About 25% - 50% of construction costs are lost to work process waste, resource waste, and inefficiencies in labor and material controls (Forbes and Ahmed, 2011). Construction Industry Institute study shows that 47% of the time spent in construction is non-productive (Dikemann et al., 2004). The percentage of weekly work plans completed in construction projects is as low as 50% (Ballard, 2000; Forbes and Ahmed, 2011).

Challenges due to external causes:

a. The construction industry faces several challenges due to external causes. One of these challenges is high uncertainty and risk involved in construction work that erodes estimated profit mark up (Yoon et al., 2014; Wong and NG, 2010). Adverse weather, fluctuating interest rates, inflation, change orders, and government regulations are sources of risks that a contractor must deal with (Cui, 2005).
b. The other pressing challenge is fragmented structure and project processes (Jones and Saad, 2003; Dave, 2013), which can result in inefficiencies affecting profit. Many companies and activities are involved in projects creating several interfaces and handoffs of tasks (Antoniadis et al., 2008). Loss in productivity can occur at the interfaces between trades or between companies unless the prime contractor manages the interfaces well.
c. The other main challenge is low-profit margins due to the fierce price competition (Jones and Saad, 2003; Egan, 1998), which is one of the main topics of this research. Currently, the barriers to entry into small and medium-size construction businesses are low, creating a saturated marketplace with heavy competition. This competition resulted in shrinking profit margins constraining essential reinvestment in new technology, and better business practices (Jones and Saad, 2003; Pekuri et al., 2014). Low-profit margin has significantly limited the industry because most contractors, clients, and consultants forgo the opportunity for continuous improvement through innovation and research in the delivery of projects to achieve cost and time reduction and enhance quality and safety (Jones and Saad, 2003). As a result, clients purchase construction as a commodity, based on low cost rather than value to clients, which affects profit.
d. The other major challenge is the adversarial relationship between parties to contracts caused by price-competitive procurement of construction and unfair and opportunistic unloading of risk on the party, which is not in the best position to handle the risk. Experienced industry practitioners pointed out that the most important causes of adversarial relationships are poorly defined scope of the project, excessive change orders, changes not adequately managed, lack of communication of objectives, unrealistic project schedule, and unrealistic project budget (CII SP 166-4). The adversarial relationship adds to the risk and erosion of profit markups. Disagreements and claims can escalate to litigation, and the

National Academy of Sciences report (2009) shows that a transactional cost of $4 billion to $12 billion is lost each year in the U. S. to resolve construction disputes and claims, which weakens construction companies and reduces their profit.

e. There is considerable fluctuation in construction work volume depending on how the economy is doing (Wong and NG, 2010), which means that there is a lack of continuity of revenue and profit generation. There is a saying that construction is the barometer of the health of the economy of a country.

Results of internal and external challenges:

a. Cost and time overruns are recurrent problems in the construction industry. Seldom are construction projects completed within time and budget (Jones and Saad, 2003), resulting in wastage of limited resources of clients, and erosion of profit margin of construction companies. Cost overruns and schedule delays can occur due to different reasons listed above and others. For instance, Rosenfeld (2014) determined fifteen root causes of cost overruns internationally with the top three being premature or incomplete tender documents, too many changes in client requirements and suicide tendering. Kermanshachi (2016) says inaccurate estimates or poor execution can also cause overruns..
b. Too many clients are dissatisfied with the overall performance of construction (Egan, 1998). About 80% of projects worldwide do not deliver the required results in one or more substantive ways (Jones and Saad, 2003). It is difficult for construction companies to get jobs and generate profit sustainably without meeting client requirements.
c. The most adverse effect of the challenges listed here is to result in distress, decline, and failure of construction companies. There is ample literature on construction company distress, decline, and failure. Jagafa and Wood (2012) summarized the factors causing construction company distress and failure. There are 52 failure causes classified into seven categories (Jagafa and Wood, 2012): budgetary issues (5 factors), human factors or organizational capital issues (33 factors), issues of adaptation to market conditions (2), business issues (2), macroeconomic issues (5), natural factors (3), and social factors (2), some of which coincide with the above list. Researchers also ranked these failure factors, but as in most cases, they did not reach consensus among themselves on the ranking of

these failure factors. Jagafa and Wood (2012) also summarized and ranked symptoms/indicators of construction company failure in order of importance in Table 2-1.

Table 2-1 Symptoms/Indicators of business failure in order of importance

Performance symptoms of distress potentially leading to failure	
Budgetary issues	**Business and market adaptability issues**
1. Insufficient profit 2. Heavy operating expenses 3. Receivable difficulties from the client 4. Burdensome institutional debt	1. Inadequate sales 2. Poor company image 3. Business conflicts 4. Not competitive

(Source: Jagafa and Wood, 2012)

Construction companies can overcome these challenges using models of excellence for profitability improvement and diagnostic tool and a DSS that uses Rapid Improvement Principles (RIPs) and Best Practices (BPs) as levers to resolve these issues thereby improving construction company profitability.

It is important for companies to address these challenges head-on and re-imagine their business processes to achieve significant profitability improvement and growth. Such an improvement and growth is possible through planning for success, excellence, and effectiveness, and plan implementations at the company, department, project, process, and employee levels.

2.1.2 Planning for Success at Company Level

The quality of decisions at the strategic level directly affects the profitability and business success of construction companies. When owners establish a new company or restructure an existing company due to distress internally or due to changes in the business environment, owners use a structured design framework called business strategy. Business strategy is a pattern of decisions needed to determine organizational goals and objectives (Ansof, 1968; Andrews, 1987; Davenport and Short, 1990; Porter, 1985). The quality of planning to develop business strategy and translating it into a business model and value innovation is one of the factors that determine the success of a company, as will be discussed in Section 2.3.

In guiding the development of business strategy, researchers conceptualized organizations different ways such as coalitions satisfying the demands of the main strategic constituencies

(Pfeffer & Salancik, 1978) rational entities pursuing goals and objectives (Perrow, 1970; Latham & Locke, 1991); cooperatives meeting the specific objectives of its members (Cummings, 1977); open systems strongly influenced by their environment (Katz and Kahn, 1978); organized teams guided by social contracts (Keeley, 1980); political arenas in pursuit of self-interest and power (Gaertner & Ramnarayan, 1983); complex adaptive systems (Bushe and Marshak, 2015), and other conceptualizations. The conceptualization of organizations determines how one models organizational effectiveness or success or excellence.

There are three high impact approaches to planning for success at the company level in the literature: organizational effectiveness, critical success factors, and organizational excellence approaches.

2.1.2.1 Organizational Effectiveness (OE) Approach

As the definitions and conceptualizations of the organization have changed, with that has changed the definition of an effective organization and ways to evaluate organizational effectiveness. This fragmentation of conceptualizations of organization prevented development of a coherent framework or model for the OE construct and evaluating organizational effectiveness (Martz, 2008).

The literature on organizational effectiveness is replete with models, but researchers failed to reach consensus on how to model OE, measure OE, and which factors drive OE (Dikmen et al., 2005). Models of OE discussed in the literature, current ways OE is evaluated, suggested way to evaluate OE, and strategic enablers of OE will be discussed next.

a) Models of Organizational Effectiveness in the Literature

All of the models discussed below explain ways of achieving effectiveness by focusing on different means, highlighting different stakeholder perspectives, and internal and external variables. No one model captures all factors in one. Improvement of companies needs to address all areas by integrating interventions. It is also useful to know and use the information in planning for the success of construction companies.

The Goal Model

The goal model defines effectiveness as the attainment of, or progress towards, organization's predetermined goals (Dikmen et al., 2005; Martz, 2008). This model is outcome-focused. Under this category, the most well-known model, management by objectives, measures effectiveness by the percentage of objectives the organization has achieved (Martz, 2008). The goal-achievement model assumes organizations to be deliberate, rational, and goal-seeking. It also assumes that organizational goals exist, organizational goals are specific and measurable, relevant to the organization's purpose, realistic, meaningful, reflective of outcomes, operative (not merely statement of official goals), and can be defined differently than constraints (Martz, 2008). Goals become external constraints (instead of internal artifacts) when the company is held accountable to deliver by influential groups such as owners, managers, and others. A second difference between goals and constraints is that attaining goals fully or partially indicates the degree of effectiveness, whereas constraints must be satisfied always for effectiveness (Martz, 2008).

Systems Model

Broadly, a system is a group of interacting or interrelated elements, forming a unified whole (Martz, 2008). An open system has a porous boundary through which it exchanges matter and energy with its environment (von Bertalanffy, 1968). Katz and Kahn (1978) modeled organizations as open input-output systems where organizations receive input from the environment and transform input to output through internal processes and exchange its outputs for money with the external environment for the next cycle of input-output-exchange. Effectiveness is measured quantitatively in terms of the relationship between output and input. The systems method to evaluate organizational effectiveness emphasizes not only the outputs or impacts but also the processes used to achieve organizational purposes (Handa and Adas, 1996; Dikmen et al., 2005; Martz, 2008).

The systems model incorporates many presuppositions, such as (Martz, 2008):

i. system boundaries are clear,
ii. the connection between the organization's inputs and outputs is clear,
iii. the organization can acquire and utilize the most desirable resources, and
iv. management of the organization can control the environment.

Some of these presuppositions may not hold, especially management's control of the external business environment.

The Process Model

This model builds on the goal and system models and emphasizes the effectiveness of the significant processes in measuring organizational effectiveness (Martz, 2008). Steers (1976) suggested goal optimization, emphasis on human behavior in an organizational setting, and system perspective for an effective organization. Goal optimization deals with attaining goals within the constraints facing the organization. Goal optimization uses an open system perspective wherein both internal and external factors affect organizational effectiveness. The human behavioral aspect relates to aligning organizational and individual goals for the employees to help the organization effectively accomplish its goals. This model does not specify criteria for effectiveness or give an end state, but instead, it focuses on a continuous process of becoming effective (Steers, 1976). The increasing interest in process optimization led to the of the Capability Maturity Model (CMM) development, which contends that the outcome of a process is a function of the organization's maturity and associated processes (Software Engineering Institute, 2007). Hammer (2007) refined and extended the CMM as a process and enterprise maturity model (PEMM) to organizations operating in any industry. Seesing (2003) also independently extended the maturity model for projects as per the Project Management Institute (PMI) body of knowledge to organizations. Kaplan and Norton (1992, 1996) developed the balanced scorecard in the early 1990s, which is another extension of the process model. They forwarded it as a performance measurement and management tool that addresses financial, processes, customer, and growth and learning perspectives. The balanced scorecard also attempts to focus on process improvement in an organization’s improvement effort (Martz, 2008, van Looy et al., 2011).

The process model has the same assumptions as to the system and goal models, but one difference is that the process model assumes management has no control over external forces that can affect the organization's performance. A limitation of this model is that the undue emphasis on internal efficiencies of processes may prevent the organization from observing environmental changes that make the organization noncompetitive or irrelevant (Martz, 2008). Pekuri et al. (2014) raise another point saying that business model innovation is more critical to success than internal process efficiency (see subsection 2.3.1.3).

Strategic Constituencies Model

According to this model, an effective organization satisfies the demands of its strategic constituencies in as much as these strategic groups (such as investors, customers, employees, and suppliers) are essential to the survival of a company (Pennings and Goodman 1977). This model considers an organization as a political arena where participants work towards self-interest and power vie for control over resources. Each of the constituencies has a unique set of perspectives and values in the assessment of organizational effectiveness. Effectiveness is then, in the minds of the beholder (Martz, 2008).

Competing Values Model

Quinn and Rohrbaugh (1981, 1983) carried out extensive data collection on major indicators of organizational effectiveness, statistical data analysis, and validation to narrow effectiveness factors from 30 to seventeen and then grouped these into a three-values competing spatial model: internal-external, flexibility-control, and means-ends. Quinn and Rohrbaugh (1983) discovered that two major dimensions underlying the effectiveness conceptions were enough to model organizational effectiveness: organizational focus (internal-external) and organizational preference for structure (flexibility-control). The first dimension deals with a shift in focus from the development and well-being of employees to an external focus on the development and well-being of the organization itself. The second dimension deals with the contrast between stability and control versus flexibility and change. Figure 2.1 shows the competing values model.

As a mapping device, the competing values model helps organizations understand what organizational effectiveness looks like, or see improvement opportunities. One of the limitations of the model is that it does little to offer the degree of organizational effectiveness. Other limitations include ignoring the processes, lack of attention to output quality, and the omission of cost-effectiveness (fiscal viability) and lack of organizational environmental and social impacts among organizational effectiveness criteria (Martz, 2008).

Organizational conceptualizations also affect the way organizations and researchers evaluate organizational effectiveness. In this respect, the way or level of sophistication of evaluation is essential. Martz (2008) discusses three basic levels of evaluation of organizational effectiveness as Levels 1, 2, and 3.

	Internal	External
Flexibility	**Human Relations Model** ♦ Training ♦ Participation ♦ Empowerment ♦ Morale ♦ Cohesion	**Open System Model** ♦ Adaptability ♦ Flexibility ♦ Growth ♦ Resource acquisition ♦ Innovation
Control	**Internal Process Model** ♦ Stability, continuity ♦ Planning ♦ Control ♦ Information management ♦ Routinization, formalization	**Rational Goal Model** ♦ Productivity ♦ Efficiency ♦ Goal attainment ♦ Task focus ♦ Performance

Figure 2.1 The competing values framework
(Source: Martz, 2008)

b) Levels of Evaluation of Organizational Effectiveness

Level 1 Evaluation

Organizations carry out Level 1 evaluation in the form of performance measurement systems or quality assurance methods. The evaluation and performance measurement share many common elements (e.g., identification of measures and metrics, data collection and analysis, and interpretation). Evaluation includes performance measurement as a data collection and monitoring component of the evaluation process. Organizational effectiveness and evaluation focus on the organizational conceptualization, whereas performance measurement focuses on quantifying internal processes using a set of metrics (Henri, 2004). Performance measurement models and frameworks have been developed such as the Balanced Score Card (BSC) (Norton and Kaplan, 1992 and 1996), Strategic Measurement Analysis and Reporting Technique (SMART) (Cross and Lynch, 1989), Integrated Performance Measurement System Reference Model (Bititci et al., 1998), Performance Prism (Neely and Adams, 2001), Supportive Performance Measurement Matrix (Keegan et al., 1989), the Results/Determinants Matrix (Fitzgerald et al., 1991), the European Foundation for Quality Management (EFQM) excellence model, ISO TQM standards (ISO 9001) and International Project Management Association's excellence baseline. Researchers developed frameworks and models to serve as a basis for performance improvement, but the frameworks and models do not tell a company what to measure (Neely et al., 1996) and some frameworks like the BSC are so involved as to require a consultant for implementation. Researchers developed performance measurement design processes to follow (Neely et al., 1996; Bititci et al., 1998) and some suggested consultancy processes for the development of performance measures from CSFs (Parmenter, 2015). Fitzgerald et al. (1991) suggest that there are two basic types of performance measures in organizations: results-based (financial performance, competitiveness) and those that determine the results (capability and maturity of processes, resource utilization, and innovation). Measuring profitability in terms of leading performance indicators would give evaluative feedback for performance improvement. These leading indicators may relate to inputs to the process strings connected to profitability, or the activities within the processes, or outputs of the processes. The Chartered Institute of Management Accountants (CIMA, 2009) advises that performance measures be simple, easy to measure and understand, outward-looking, long-term oriented, both financial and non-financial, with the two correlated, viable, capable of generating fast feedback, flexible, continuous and be able to show trends. Table 2-2 gives the example of Key Performance Indicators (KPIs) suggested by CIMA. These KPIs are suggested mainly for manufacturing companies. Some of these KPIs can be adopted to construction directly. Researchers can develop similar KPIs for construction companies corresponding to those KPIs that apply to the manufacturing industry only.

According to Neely et al. (1995), performance measurement is the process of continuously quantifying effectiveness and efficiency of actions; in other words, performance measurement is a continuous improvement tool (Bititci and Nudurupati, 2002). The performance measurement system assists in the evaluation, i.e., in identifying key areas that need improvement, diagnosing and analyzing the reasons behind the low performance, planning and implementing changes necessary to improve performance measurably, monitoring the results to find whether they achieved the expected results and developing a closed-loop control system to promote continuous improvement (Bititci and Nudurupati, 2002).

Table 2-2 Examples of some key performance indicators

Frequency

Key Performance Indicators	Weekly	Monthly	Quarterly	Yearly
Strategic	• Plant uptime • Production target compliance	• Total revenue • Revenue growth • Organic growth • Operating expenses • Volume • Capital expenditure to revenue percentage	• Customer satisfaction	• Employee satisfaction • Workforce knowledge/ skills gap
Financial	• Overdraft • Cash flow	• Sales per sales force member • Order book • Days credit given • Days credit taken • Gross and net margin • Profit • Profit and loss account • Balance sheet	• (as for monthly) • Projects	• Profit • Profit per staff member • Gearing • Liquidity • Interest cover
Operational	• Keeping to schedule	• Units produced per production force member • Level of projects per production force member • Supplier product quality	• Manufacturing lead time • Stock • Production utilization • Rejects	• Employee turn over • Indirect/direct labor productivity • Percentage wastage
Marketing/ Quality	• Customer complaints • On-time delivery	• Market share • Sales achieved and orders in hand • Repeat orders	• New product frequency • New product time to market	• Price

(source: Chartered Institute of Management Accountants, CIMA, 2009)

Level 2 Evaluation

Level 2 evaluation consists of an organization getting external evaluator audit adherence to policies and procedures to supplement internal evaluation. An example is an external financial auditor who checks compliance with regulations. Internal auditors do the same types of audits, but the purpose is that of control. Another example is an evaluation by the Malcolm Baldridge and EFQM experts to evaluate companies for excellence awards.

Level 3 Evaluation

In the third level of organizational evaluation, the organization internalizes evaluation as part of the itrs culture. The realization of this level involves the full integration and acceptance of the evaluation of everything organization does as the essence of the organization in addition to the use of levels one and two evaluations (i.e., internal evaluations and use of external evaluators). Such an organization is an evaluative organization (Martz, 2008). The evaluative organization is an enhanced learning organization in which learning informs actions. An evaluative organization also collects data and evaluates the effect learning has on performance. A learning organization has the processes and capacity to capture/acquire knowledge and implement behavioral changes to adapt to its changing environment (Martz, 2008). However, a learning organization does not collect information to determine the effect learning has on organizational effectiveness. An evaluative organization fully integrates the evaluative attitude and culture into its business processes.

What is the latest development in the evaluation of organizational effectiveness? What is the suggested method to evaluate organizational effectiveness? Martz (2008) developed and forwarded the organizational effectiveness checklist as a comprehensive way of evaluating OE.

c) Organizational Effectiveness Checklist

Martz (2008) developed an easy to use Organizational Effectiveness Checklist (OEC). His checklist uses the open system organizational model and based mainly on the Competing Values approach, but he refined and simplified it. He developed it based on similarities of organizations so that researchers and organizations can use it for all organizations. Organizational evaluation using the Organizational Effectiveness Checklist (OEC) involves comparing an organization to the twelve universal criteria of merit listed in Table 2-3 along with suggested measures for each criterion. The criteria are grouped into four dimensions [(1) Purposeful, (2) Adaptable, (3) Sustainable, and (4) Harm Minimization] to illustrate the connection with the definition of organizational effectiveness.

Dikmen et al. (2005) say that it is difficult to measure and model OE in construction companies due to (1) the fact that OE depends on a very complicated value chain, one that operates at both corporate and project levels, as well as from (2) the high number of parties involved in different parts of the value chain. The checklist may be adapted to specific construction companies' conditions to help see improvement opportunities or provide criteria that effective organizations fulfill.

Table 2-3 Merit criteria for evaluation and suggested measures

Dimension	Criteria	Suggested measures of effectiveness
Purposeful	Efficiency	Profit per employee-hour
		Revenue per employee-hour
		Profit per square meter
		Cost per unit of output
		Cost per client served
		Revenue multiplier
		Fixed asset utilization rate
	Productivity	Unit volume per machine-hour
		Unit volume per employee-hour
		Gross output per machine-hour
		Gross output per employee-hour
		No. of billable hours per employee-hour
		No. of clients served per employee-hour
		Gross payroll power
	Stability	Extent of routinization
		Planning and goal setting
		Extent of job rotations
		No. of layoffs during the period
		Compliance with established procedures
		Alignment of strategy, mission, vision
		Safeguarding assets
Adaptable	Innovation	Training as a percentage of net revenue
		R&D expenses as a percentage of net revenue
		No. of new markets entered during the period
		New product development rate
		Administrative process change frequency
		Operational process change frequency
		Willingness to innovate
	Growth	Relative market share change
		Profit or fund growth during the period
		Compounded annual growth rate (revenue)
		Change in manpower
		New market revenue growth
		New customer revenue growth
		Net change in assets
	Evaluative	Task force utilization
		Performance management system utilization
		Feedback system utilization
		Percent of internally generated business ideas
		No. of new initiatives launched
		Change initiatives launched during the period
		Percent of externally generated business ideas

Table 2-3 continued

Sustainable	Fiscal health	Return on net assets/equity /invested capital
		Free cash flow
		Net debt position
		Expense ratios
		Profitability ratios
		Liquidity ratios
		Fund equity balance
	Output quality	External review / accreditation
		Customer retention rate
		Client satisfaction / loyalty
		Internal quality measures
		Response time
		Service errors
		Warranty claims
	Information Management	Role ambiguity
		No. of company-wide meetings per year
		Timeliness of information
		No. of staff meetings per month
		Integrity of information
		Access to procedures, rules, and regulations
		Perceived adequacy of information available
	Conflict-cohesion	Work group cohesion
		Commitment
		Workplace incivility
		Absenteeism
		Employee turnover
		Violence of conflict
		Bases of power
Harm minimization	Intra-Organizational	Instances of ethical breach
		Components of organizational justice
		Evidence of monitoring systems
		Evidence of workforce training
		Results of ethics audits
		External / internal audits
		No. of employee accidents
	Extra-Organizational	Regulatory compliance
		External audits
		Emissions levels (pollutants, noise)
		Environmental controls and monitoring
		Ecological footprint change
		Philanthropic activities
		Contribution to the larger system

(Source: Martz, 2008)

d) Strategic Enablers of Organizational Effectiveness

Strategic company growth management is another area of research with some useful information for profitability improvement. There are two types of company growth, including profitability growth and revenue growth (Lindholm, 2008; Bhattacharya and Momaya, 2009). The focus of this research is on profit and profitability growth. Bhattacharya and Momaya (2009) summarized high impact areas and enablers of organizational effectiveness and growth for the construction industry. They identified thirteen general growth enablers of construction companies through literature review, which are: value innovation, client-centric approach, operational efficiencies, human skill management (flexibility and scalability), inspiring leadership, technical capabilities, financial strength, collaborations in new markets, mergers and acquisitions in segments of low growth, global operations, cost leadership, diversification and operations in sectors of high margins. They carried out Interpretive Structural Modeling (ISM) to hierarchically rank high impact enablers for the Indian construction industry context. Bhattacharya and Momaya (2009) concluded that inspiring leadership is the highest-ranking enabler (with high profitability driving power) of construction company growth followed by human resources skills management. The next enablers are drivers of process performance which drive company processes and systems toward the execution or achievement of goals and the objectives of the companies such as value innovation, process operational efficiencies, building technical capabilities and competencies, supply chain collaboration, and availability of financing for executing construction operations. The next drivers of profitability growth are customer-centric approach and cost leadership, which help achieve the ultimate business goal of customer satisfaction. Cost leadership is especially crucial for construction companies because most commonly, construction companies secure jobs through competitive bidding. These same thirteen factors drive the profitability growth of construction companies internationally, but their order may differ from country to country.

It would be useful to combine organizational effectiveness principles and guidelines with critical success factors for a higher impact on success.

2.1.2.2 Critical Success Factors (CSFs) Approach

In trying to develop an executive information system to support managers' work, researchers in the area of information systems were trying to answer the question, "What do managers do?" Daniel (1961) saw that companies' information systems produced vast amounts of information, but little of the information met the managers' information needs. Daniel conceived the idea of success factors and used Critical Success Factors (CSFs) to determine the critical few areas managers need to focus their attention in running the business. A decade later, Anthony et al. (1972) expanded Daniel's work by concentrating on the design of management control systems and recognized that CSFs differ from manager to manager as well as from company to company. They emphasized the need for three criteria in such systems.

> "The control must be tailored to the specific industry in which the company operates and to the specific strategies that it has adopted;
> It must identify the critical success factors that should receive continuous management attention if the company is to be successful; and
> It must highlight performance concerning these key variables in reports to all levels of management" (Holohan, 1992).

Rockart (1979) made the use of CSFs popular. As described in Section 1.1, Rockart and Delong (1988) defined CSFs as the limited number of key areas in which results, if satisfactory, will ensure the organization's successful competitive performance.

The CSF process is a flexible top-down method designed to help managers and systems designers identify the information necessary to support the critical business areas (Holohan, 1992). The CSF approach provides simplicity and clarity, whereby a manager can concentrate on those few variables which capture the strategic essence of the business. The exercise of determining CSFs for a company starts with a definition of the mission of the company, which gives the raison d'être of the company. The mission of a company rarely changes, but strategic objectives and other elements emanating from objectives can change when restructuring a company or reengineering a business process. Then the strategic objectives (goals) that help the company to accomplish its mission at a particular point in time are derived, which is followed by the formulation of strategies that help the company hit the goals. Only then can one determine the limited number of critical areas where the manager needs to focus. These are the CSFs. Rockart (1979) points out that regular CSFs review is required to make adjustments due to the continually changing nature of the business environment. Rockart (1979) identified four prime sources of CSFs for any organization working in any industry:

a. ***Structure of the industry***: Structure of the industry is a characteristic that determines a set of CSFs that a company uses.

b. ***Competitive strategy, industry position, and geographic location***: Each organization has its strategies and strategic plan that works for the nature of the industry in which it operates.
c. ***Environmental factors*** - The effects of the environment upon the organization behavior are essential to understanding the CSFs to be used
d. ***Temporal factors*** - CSFs change with the shift in organizational priorities, where the areas of activity for success change, and some activities become more critical, whereas other activities may become less critical.

Parmenter (2015) gives a similar procedure to develop CSFs and lays out a way to derive KPIs and other performance measures from the CSFs. Once the company or researcher identifies the CSFs and quantifiable measures to monitor them, one devises the KPIs (Holohan, 1992; Mbugua, 1999). There are hundreds of papers on the topic, but the two most developed and easy to use methodologies are those laid out by Martz (2008) and Parmenter (2015).

Another practical approach for companies to succeed is through the adoption of organizational excellence principles and guidelines.

2.1.2.3 Organizational Excellence Approach

Organizations are increasingly striving to excel by improving their way of working. Two primary approaches in the literature on ways to achieve excellence are through business process improvement by using Business Process Maturity Models (BPMMs) and through the use of organizational excellence models.

a) Business Process Maturity Models (BPMMs)

Processes are at the very heart of each organization. Processes describe how an organization operates and therefore impacts how the organization performs (van Looy et al., 2011). A process is made of a series of interconnected activities that take input, adds value to it, and produce output valued by the customer. Farrar (2006) defines a process as a set of sequential or concurrent activities performed by a process team led by a process owner that transforms inputs into useful outputs for customers that meet requirements and utilize resources to produce the outputs. His illustration of this definition for the Boeing company is shown in Figure 2.2.

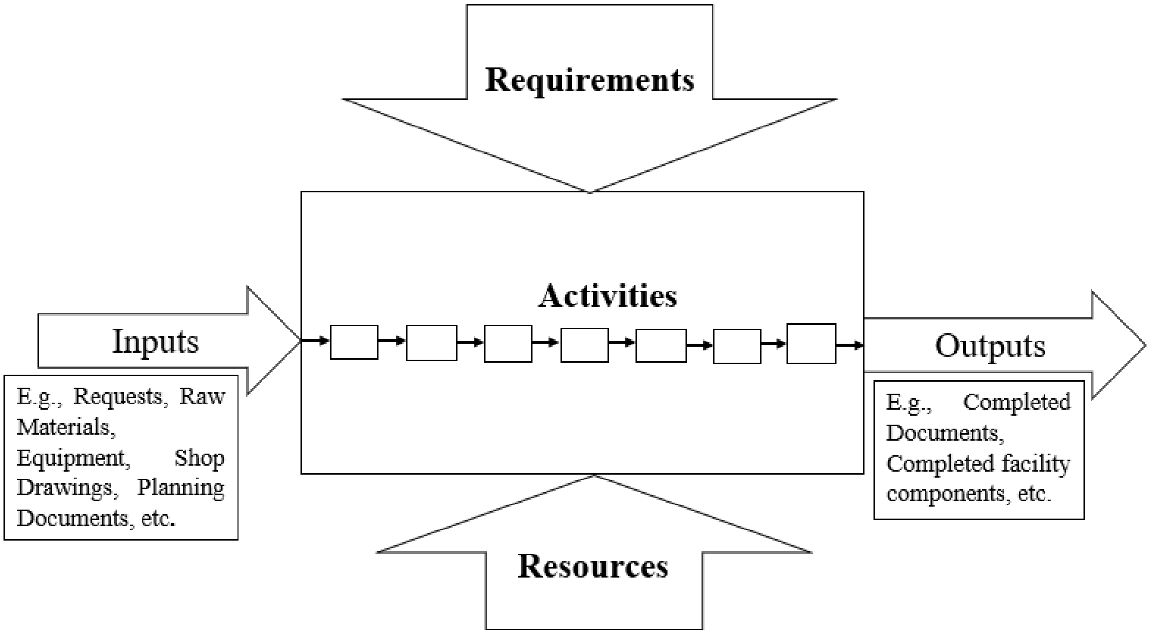


Figure 2.2 Process as a set of sequential or concurrent activities
(Source: Farrar, 2006)

Different literature reports on the contribution of the use of processes to higher company performance (Hammer, 2007; Maier et al., 2012; Vanhaverbeke and Torremans, 1998; Cottrell, 2006; van Looy et al., 2011). Hammer (2007) says business processes that run from end to end across an enterprise can lead to dramatic enhancements in performance, enabling organizations to deliver higher value to customers in ways that also generate higher profits for shareholders. Key company and project process flow diagrams are given in Appendix A to help companies use them as a guide as they map their processes.

A limitation of the process model pointed out in subsection 2.1.2.1 is that the emphasis on efficiencies of internal processes may distract the organization from observing long-term environmental changes that make the organization noncompetitive or irrelevant (Martz, 2008). Continuous environmental scanning and ensuring sustainable competitive advantage help overcome this drawback. Sivusuo et al. (2018) stress the importance of building dynamic capabilities and organizational process maturity for sustainable competitive advantage in a dynamic and fiercely competitive environment. Maturity models find their origin in the work of Nolan (1973) and Crosby (1979). Currently, there is a proliferation of Business Process Maturity Models (BPMMs) in the scientific literature (van Looy et al., 2011). Van Looy et al. (2011), for example, used a sample of 69 business process maturity models (BPMMs) to validate the comprehensive framework that they developed, which the author will discuss later. However, researchers did not reach a consensus on the capability areas needed for excellence (van Looy et al., 2011). Rumelt et al. (1991) say that a firm develops certain resources over a long period, and these capabilities become the sources of competitive advantage. Tvorik and McGivern (1997) expanded the term "resources" to capabilities that reside within the firm. They described it in terms of five organizational variables that contribute to its capabilities: i) organizational alignment ii) organizational skills and learning iii) industry structure and strategic group iv) organizational resources and v) leadership and vision. Van Looy et al. (2011) carried out an extensive literature review to develop a single comprehensive framework to resolve the lack of consensus on what constitutes organizational capabilities. Their framework consists of the following **six capability** areas (van Looy et al., 2011):

1. **Business process modeling capability** consists of business process design and analysis. The design includes putting process designs in textual/graphical form and setting performance indicators and targets. Business process analysis refers to the validation, simulation, and verification of a (re)designed business process model (van Looy et al., 2011). Netjes et al. (2006) explain that business process modeling specifies: (1) the process structure, i.e., the relationship between inputs, activities, outputs, business rules, and data, (2) the resource structure, i.e., who (e.g., role) or what (e.g., departments, IT) executes the activities, (3) the allocation logic, i.e., how operators assign resources to activities, and (4) the interfaces between business processes and between business processes and external entities.
2. **Business plan deployment capability** consists of business process implementation and enactment and business process measurement and control. Business process implementation and enactment includes both the preparation and actual running of business processes. During implementation, operators translate the high-level business process models into deployable models by adding operational details (van Looy et al., 2011). Business process measurement and control involves recording and gathering log files, real-time monitoring and using the log files to check and maintain conformance with the

business process models (by correcting deviations), and provide information on the current status of active instances (Weske, 2007; Netjes et al., 2006).

3. **Business process optimization capability** involves process evaluation and improvement based on real metrics. Two frequently used evaluation techniques are business activity monitoring and process mining (Weske, 2007; zur Muehlen, 2005). Business process improvement involves optimizing the models through redesign using evaluation results as feedback. Depending on the evaluation results, business process optimization varies from smaller, incremental changes to larger, radical improvements, such as Business Process Reengineering (BPR) (Harrington, 1991; Hammer and Champy, 1993). Many optimization techniques originated from quality movements and Total Quality Management. Specific techniques, such as the theory of constraints, Lean, and Six Sigma, are also frequently combined in a larger improvement methodology (Nave, 2002).
4. **Management capability** includes the management of business processes, each with a process owner and a cross-functional team. Management capability has five parts: strategy and KPIs, roles and responsibilities, skills and training, daily management, and external relationships and service level agreements.
5. **Culture capability** area has to do with organizational characteristics, instead of specific business processes and involves a process-oriented culture with rewards linked to the performance of business processes instead of departments. Culture capability has four parts: values, attitudes and behavior, appraisal and rewards, and top management commitment.
6. Finally, the **structure capability area** is also an organizational characteristic. It is about having a process-oriented organization chart and process-oriented management/ governance bodies. Currently, most construction companies are functionally structured. Van Looy et al. (2011) suggested using a matrix organization for functionally structured companies to implement end-to-end processes. Cheng et al. (2006) suggest that end-to-end organizational process execution in construction companies is smoother using multi-functional teams with weak functional departments supporting processes.

In addition to the capabilities described thus far, Sivusuo et al. (2018) say that mobilizing employee creativity and passion is a crucial element in building dynamic capability and sustainable competitive advantage in a fiercely competitive business environment, which is the case for construction companies. They based their analysis on Hamel's (2007) pyramid of human capabilities shown in Figure 2.3.

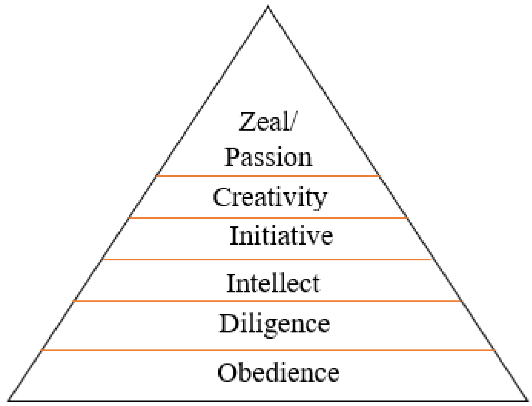


Figure 2.3 Pyramid of Human Capabilities
(Source: Hamel, 2007)

Hamel (2007) showed that companies could buy the bottom three (obedience, diligence, and intellect) through the hiring process. Organizations will not achieve excellence if they develop only these three human capability elements in their processes. They will not achieve a sustainable competitive advantage (Sivusuo et al., 2018). Developing the top three (initiative, creativity, and zeal/passion) is what helps an organization to attain excellence and sustainable competitive advantage (Sivusuo et al., 2018). These are employee qualities money cannot buy. Management cannot tell employees to be passionate about their work; passion comes only from inside, from the employees themselves. The top three human capability elements are also the most difficult to manage. What organizations can do is create a conducive environment that helps employees bring out their best creativity and passion, to support and train employees, and to motivate them using different incentives (Sivusuo et al., 2018). Company executives must consider these three elements while building work teams.

How well can an organization improve its processes? Experts designed Business Process Maturity Models (BPMMs) from which organizations gradually benefit in their journey towards excellence (van Looy et al., 2011). Maturity aims at systematically assessing and improving the capabilities, i.e., skills or competencies of employees, predictability of business processes, and their organization to deliver higher performance. BPMMs present a sequence of maturity levels and a step-by-step improvement roadmap with goals and best practices to reach each following maturity level. Experts labeled the maturity levels in different ways in different BPMMs, which requires some discussion and evaluation. Some labeled them based on business process optimization e.g., as 'initial,' 'managed,' 'standardized, 'predictable,' and 'innovating.' Others express maturity levels as advancements in Business Process Management (BPM), e.g., 'BPM initiation,' 'BPM evolution,' and 'BPM mastery.' Still, others labeled them based on business process integration, e.g., as 'ad hoc,' 'defined,' 'linked,' and 'integrated.' In engineering and construction areas, Kwak and Ibbs (2000) adapted the Berkeley Project Management Process Maturity Model from the work of Crosby (Crosby, 1979), Paulk et al. (1993), and McCauley (1993). They used 'Adhoc', 'planned,' 'managed,' 'integrated,' and 'sustained' as the maturity levels. Kwak and Ibbs (2000) used a questionnaire survey to measure maturity levels of project management for the Project Management Institute (PMI) eight Knowledge Areas and six Project Phases for engineering construction, telecommunications, information system, and hi-tech manufacturing projects. Their work is exhaustive and insightful, but they considered mainly functional project execution and did not consider end-to-end project processes. Sarshar et al. (2000) adapted the Capability Maturity Model (the CMM) of Paulk et al. (1993) from software projects to civil engineering construction and developed Standardized Process Improvement for Construction Enterprises (SPICE) framework, which applies to both project and company. They used such maturity level descriptors as 'initial/chaotic,' 'planned and tracked,' 'good practice sharing,' 'quantitatively controlled,' and 'continuously improving'. SPICE is a staged evolutionary process improvement model shown in Figure 2.4, where the five levels of maturity serve as measures of capability and as goals to attain in improvement efforts.

The description of the five maturity levels is given in Table 2-4.

Sarshar et al. (2000) further identified the following eight construction project processes to improve through the five maturity levels: 1) brief and scope of work management 2) project planning 3) project tracking and monitoring 4) subcontract management 5) project change management 6) health and safety management 7) risk management, and 8) project team coordination. Seesing (2003) developed a maturity model as per PMI, but he also extended the maturity model to the company. Hauser and Chapman (2014) identified the following core construction company processes: estimating, pricing, project management, communication, scheduling, subcontractor management, job costing, project closeout, and lessons learned. One can

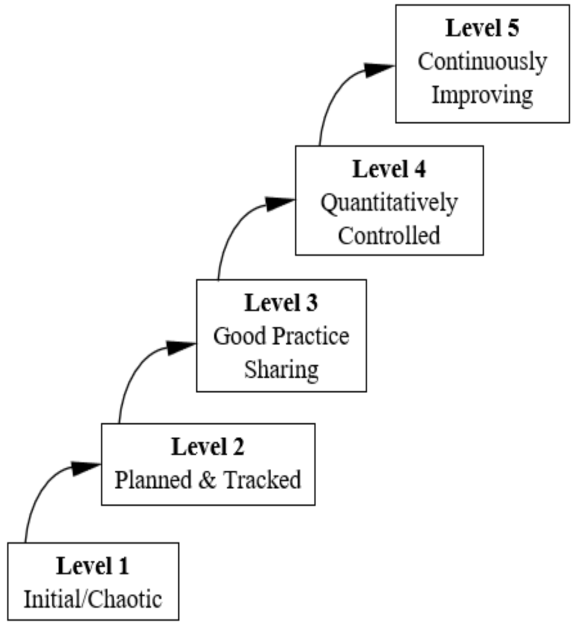


Figure 2.4 The SPICE construction company status and improvement model
(Source: Sarshar et al., 2000; Finnemore et al., 2007)

add procurement, equipment, training, and marketing processes to this list. Table 2-5 summarizes major company and project processes versus the five maturity levels.

Table 2-4 Description of the five maturity levels of the SPICE framework

Maturity Levels	Description
Level 1	No key processes and little process focus. The process capability of a Level 1 organization is unpredictable as the processes are constantly changed in an ad hoc manner. Performance depends on the capability of individuals rather than that of organization
Level 2	There is a level of project predictability and the organization has established policies and procedures for managing the major project-based processes. Organizations make realistic commitments based on previous experience. At this stage, processes for good project management are planned, tracked and enforced on every project. Each project within the organization is thus predictable.
Level 3	Both management and engineering activities are documented, standardized and integrated throughout the organization. Organizational standard processes are available and can be assessed by all employees. All projects use approved, tailored versions of the organization's standard processes, which take account of each project's unique characteristics. Teams and units share good practices and ideas to verify that the work has been done correctly and identify areas for further improvement. At this level, there is a significant visibility of projects.
Level 4	Organization has the capability to set quality goals for products, processes and supply chain relationships. Productivity and quality are measured for important construction process activities across all projects. Organization gains control of projects by narrowing variations in process performance so that they fall within acceptable limits.
Level 5	The entire supply chain network focusing on continuous process improvement. Organizations take proactive (rather than reactive) and collaborative approach to identify and strengthen areas for improvement before any problems emerge. Innovations are identified and disseminated throughout the organization.

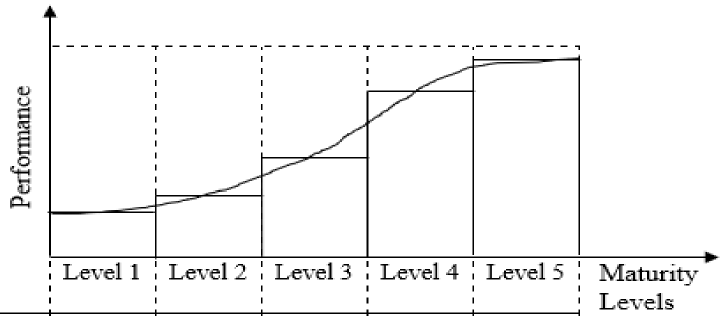
Many scholars have (mostly empirically) examined the capability areas as critical success factors to realize business process excellence, which van Looy et al. (2011) consolidated into their capability maturity framework discussed earlier. Maier et al. (2011) dealt with maturity grids as an assessment and improvement tool, but that requires to fully define processes and the attributes by defining each cell in the maturity grid. The selected approach in this research is a staged evolutionary approach where the decision-maker engages in the improvement of company and project processes by selecting RIPs and BPs that would resolve the root causes holding company back from attaining higher performance. It is essential to allow for the fact that processes under assessment are, in many cases, social processes that require the judgment of the decision-maker (Pfleeger et al., 1994).

Table 2-5 Matrix of the core construction company and project processes with maturity levels

	Process Maturity Levels				
Core construction company processes	Level 1	Level 2	Level 3	Level 4	Level 5
1. Communication					
2. Equipment management					
3. Estimating					
4. Finance process					
5. Job costing					
6. Lessons learned					
7. Marketing process					
8. Pricing					
9. Procurement management					
10. Project closeout					
11. Scheduling					
12. Subcontractor management process					
13. Training program					
Core construction project processes	Level 1	Level 2	Level 3	Level 4	Level 5
1. Change control					
2. Monitoring and control					
3. Planning					
4. Quality assurance					
5. Risk management					
6. Safety and health management					
7. Scope and brief management					
8. Team coordination					

(Source: Table constructed based on information from Sarshar et al., 2000; Hauser and Chapman, 2014)

An important question is: "What is the value-added by improving core company and project processes?" Studies showing the relationship between improvement/process maturity and organizational performance are scarce. Kalinowski (2016) surveyed 84 Polish companies and concluded that process maturity and organizational performance have a significant positive relationship. After so much search, the only useful data the author could find is benchmarking data based on results of over 2000 professional service organizations shown in Figure 2.5 from the website of Service Performance Insight (SPI) (https://spiresearch.com/ps-maturity/). It shows the relationship between improvement achieved (maturity level attained) and performance level achieved. The author fitted the smooth curve to the histogram plot given by SPI.



Performance Items	Level 1	Level 2	Level 3	Level 4	Level 5
Confidence in Professional Service (PS) leadership (5 points scale)	3.28	3.98	4.31	4.83	5.00
Year-over-year change in PS revenue	3.0%	5.7%	9.7%	13.8%	22.2%
Bid-to-win ratio (per 10 bids)	3.40	4.11	5.21	6.39	7.58
Deal in pipeline relative to quarterly forecast	125%	147%	182%	243%	275%
Employee billable utilization	60.3%	69.2%	74.8%	81.4%	84.6%
Project delivered on time	72.7%	78.1%	83.3%	82.7%	90.8%
Annual revenue per billable consultant (k)	$104	$169	$215	$247	$291
Annual revenue per employee (k)	$77	$130	$175	$208	$253
Profit (EBITDA)	4.7%	7.8%	15.2%	22.6%	35.2%

Figure 2.5 Effect of continuous process improvement on performance
(Source: Website of SPI - https://spiresearch.com/ps-maturity/)

Process improvement and quality management initiatives and their influence on performance excellence have led to an explosion of standards, regulations, bodies of knowledge, statutes, and models that one finds in the literature such as the Malcolm Baldridge and EFQM (Table 2-6). These assessment and improvement frameworks often seek to enable the assessment of individual professionals and organizational capabilities. The next topic of discussion concerns such models of excellence, which have a significant contribution to organizational and project performance.

b) Company Excellence Models

The development and proliferation of excellence models followed the Japanese quality movement and the introduction of the Deming award by the Japanese Union of Scientists and Engineers. The principles of TQM forms the basis of these excellence models, i.e., the whole organization needs to be improved to ensure excellence. The most common excellence models are ISO TQM standards (ISO 9001), the Malcolm Baldrige Quality Award, the European Foundation for Quality Management Excellence Model (EFQM), and the Australian Business Excellence Framework. In the area of projects, including engineering, the International Project Management Association (IPMA) developed three excellence models: the Individual Competence Baseline

(ICB), the Project Excellence Baseline (PEB), and the Organization Competence Baseline(OCB). Table 2-6 summarizes the capability areas/attributes of the above-mentioned organizational excellence models.

Table 2-6 Summary of capability attributes of different excellence models

No.	**ISO TQM (ISO 9001)**	**Malcolm Baldridge**	**EFQM**	**Japanese Deming Award**	**Australian Business Excellence**	**IPMA: OCB**
1	Customer focus	Leadership	Leadership	Organization and its management	Leadership	Governance & management systems
2	Leadership	Strategic planning	People	Education	Customer & stakeholders	Organizational structure
3	Engagement of people	Customer and market focus	Strategy	Quality information	Strategy and planning	Processes
4	Process approach	Measurement, analysis and knowledge management	Partnerships and resources	Planning	People	Culture
5	Improvement	HR/workforce focus	People results	Analysis	Information & knowledge	People and teams
6	Evidence based decision making	Process management	Customer results	Standardization	Process management, improvement & innovation	Other resources
7	Relationship management	Business results	Society results	Control	Results and sustainable performance	PEB
8			Business results	Quality assurance		People and purpose
9				Results		Process and resources
10						Project results

Two observations can be made comparing Table 2-6 with van Looy et al. (2011) comprehensive BPMMs capability framework. The first is that there is a lot of overlap regarding processes, management, culture, and structure capability attributes. This means that BPMMs and excellence models are converging. The second observation is that 4 of the six excellence models explicitly list process as an excellence attribute, which shows that process management and improvement is a high impact improvement area (hence given in Appendix A). Therefore, information synthesized from the excellence models and BPMMs will be used in the next subsection, and in the next chapter to forward models of excellence for profitability improvement of construction companies.

These models of excellence have helped companies conduct self-assessment, some obtain awards and improve their performance. Suarez et al. (2016) conducted a systematic literature review on the impact of the implementation of the European Foundation for Quality Management Excellence Model (EFQM) on company performance and concluded the following:

- There is empirical evidence of the validity, reliability, and predictive power of the EFQM model when applied to different spheres of sectors and activities.
- There is a strong correlation between scores in the EFQM criteria and organizational performance results. Businesses with higher scores in the criteria obtained better results.
- Businesses that have received the EFQM model awards of quality have obtained better results than those that received no awards or got no recognition of excellence.
- Among the most significant impacts of the implementation of the EFQM model are the improvement of company image, greater client satisfaction, increased employee commitment and satisfaction, the greater profit derived from higher exports, greater predisposition to innovation, strengthening the effectiveness of knowledge management and optimization of the use of information systems. These benefits helped companies get a greater competitive advantage.
- The most important motivations for implementing the EFQM model are productivity, optimization of resources, improvement of quality of products and services, and reduction of costs.

Organizational excellence guidelines will be extracted and will be used in developing an excellence model for profitability improvement of construction companies in the next chapter. Alomairy (2016) conducted a study on the effect of the Malcolm Baldridge performance excellence program on organizational performance for his Ph.D. dissertation through data collection and analysis from twenty-four companies that implemented the Baldridge excellence model over five years. His result shows that organizations can systematically improve their performance when implementing the Baldrige performance excellence program.

Construction company effectiveness, success, and excellence considerations would be incomplete without these considerations for projects in project-based companies such as construction firms.

2.1.3 Planning for Success at Project Level

2.1.3.1 Project Effectiveness Approach

Project effectiveness in meeting profitability and project goals is of central importance to project-based companies. Researches on project success show that it is impossible to generate a universal checklist of project success criteria suitable for all projects (Abiodun, 2017). Silva et al. (2016) carried out a systematic literature review on the topic and came up with a definition for construction project success in terms of ten criteria: time, cost, quality, safety, client satisfaction, employees' satisfaction, cashflow management, profitability, environmental performance and learning, and development.

Theoretical treatment of the subject has produced many publications but there are very few practical tools that help project improvement. One of the practical tools is Best Productivity Practices Improvement Implementation (BPPII) for infrastructure projects developed on the premises that productivity is the top factor affecting project effectiveness and performance (Forbes, 2011, Lindholm, 2008), and that implementation of best practices increases the chance of project success (Nasir, 2013; Nasir et al., 2016). This tool is developed as a Best Productivity Practices Improvement Implementation (BPPII) index with the categories, sections, and elements shown in Table 2-7. The information from BPPII is used in the database of the decision support system for improvement of project productivity in chapter 3.

Best practices were previously usable only at the company level but the BPPII makes the application of best practices possible at the project level. Further, RIPs and BPs can be applied to ameliorate problems faced in individual activities and processes within projects.

Table 2-7 BPPII Infrastructure Categories, Sections, and Elements

I-MATERIALS MANAGEMENT	II- CONSTRUCTION MACHINERY & EQUIPMENT LOGISTICS
A. Procurement Strategy A1. Procurement procedures & plans for materials A2. Long-lead/critical equipment & materials identification A3. Procurement team **B.** Materials Management System B1. Project team materials status database B2. On-site material tracking technology B3. Materials delivery schedule **C.** Receipt & inspection of materials C1. Materials inspection process C2. Materials inspection team C3. Post receipt preservation & maintenance	**A.** Construction machinery & equipment availability A1. Procurement procedures & plans for construction machinery A2. Construction Machinery Productivity Analyses A3. Construction Machinery and Equipment Maintenance **B.** Tools and Equipment Management BPs B1. Site Tools and Equipment Management Strategy B2. Tools & Equipment Tracking B3. On-site Tools Maintenance B4. Construction Machinery & Equipment Utility Requirements
III – EXECUTION APPROACH	**IV – HUMAN RESOURCES MANAGEMENT**
A. Planning A1. Short Interval Planning A2. Well defined scope of work A3. Use of Software A4. Dedicated Planner A5. Construction Work Packages (CWP) **B.** Constructability Reviews B1. Design readiness for construction B2. Utility Alignment & Adjustments B3. Contract Types/Strategies B4. Model Requirements/3D Visualization **C.** Acquisition Strategy C1. Right of Way, Land, and Utilities Acquisition Strategy C2. Contracts & Agreements with Agencies C3. Utility Agreements **D.** Regulatory Requirements/Reviews D1. Environmental Requirements D2. Regulatory Requirements/Permitting Requirements	**A.** Planning A1. Crews Composition/Crew Formation A2. Skills Assessment and Evaluation **B.** Training and Development B1. Employees / Trades Technical Training B2. Career development **C.** Behavior C1. Nonfinancial Incentive Programs C2. Financial Incentive Programs C3. Social Activities **D.** Organizational Structure D1. Maintain Stability of Organization Structure D2. Clear Delegation of Responsibility **E.** Employment E1. Retention Plan for Experienced Personnel E2. Exit Interview

Table 2-7 continued

V - CONSTRUCTION METHODS	VI – SAFETY AND HEALTH
A. Project Schedule Control A1. Integrated Schedule A2. Work Schedule Strategies A3. Schedule Execution and Management	**A.** Job Site Safety A1. Formal Health and Safety Policy A2. Health and Safety Plans/Zero Accident Techniques A3. Task Safety Analysis A4. Hazards Analysis A5. Hazards Planning
B. Site Layout Plan B1. Dynamic site layout plan B2. Traffic Control Plan B3. Site security plan B4. Machinery & Equipment positioning strategy	**B.** Substance Abuse Program B1. Drugs and Alcohol Testing Program
C. Design/Construction Plan & Approach C1. Communications, Coordination, & Agreements C2. Project start-up plan C3. Project Completion Plan C4. Innovations & New Technologies C5. House Keeping	**C.** Health and Safety Training & Orientation C1. Health and Safety Training Programs C2. Toolbox Safety Meetings

(Source: Nasir et al., 2016)

2.1.3.2 Project Critical Success Factors (CSFs) Approach

Identifying critical success factors (CSFs) in projects is very useful due to strategic and tactical benefits to project execution. Identification of project CSFs helps allocate limited resources to the critical high impact factors to ensure project success (Hwang and Lim, 2013).

Hwang and Lim (2013) identified 32 CSFs for projects from literature and used a survey of expert opinion in Singapore with an analytic hierarchy process to rank the top 10 CSFs for contractors, owners, and consultants. Accordingly, the top 10 CSFs for contractors in Singapore in the order of importance are: 1) realistic obligations/clear objectives and scope 2) adequacy of plans and specification 3) constructability 4) adequate planning and control techniques 5) construction control meetings 6) schedule updates 7) risk identification and allocation 8) site inspections 9) contractual motivation/incentives 10) adequacy of funding. Researchers recommend that each company identifies and uses project CSFs that work for its situation to increase the likely hood of success in the projects it constructs (Hwang and Lim, 2013).

Zwikael and Globerson (2006) carried out a study on the CSFs for projects and found out that planning processes are high-ranking success factors. They called these CSFs Critical Success Processes. In CPM schedules, the use of the mean activity durations means that the probability of completion of each activity is 0.5. Dependence between the chains of activities in paths of schedule network adds to this uncertainty in activity durations. The resulting total project duration for a CPM critical chain of activities will have a very low probability of being attained (treated in Appendix B). From Hwang and Lim's (2013) list of top 10 CSFs, the fourth and sixth items are planning tasks.

2.1.3.3 Critical Success Processes

Zwikael and Globerson (2006) measured the impact of sixteen planning processes on project success in terms of four outcomes: schedule overrun, cost overrun, project performance, and client satisfaction. They conducted a questionnaire survey of 282 managers and wrote a multivariate linear regression equation for each of the four success measures as a function of the sixteen planning processes. Their results indicate that the following six have significantly higher impact:

1. Definition of activities to execute in the project
2. Schedule development
3. Organizational planning
4. Staff acquisition
5. Communications planning
6. Developing the project plan

They called these CSFs Critical Success Processes. Hamzeh (2009) focused on short-term planning (look ahead and weekly planning) to improve the predictive power of Percent Plan Complete (PPC) as an indicator for higher project productivity. Since variability is endemic to construction activities, strategically placing buffers in specific locations is required to cater for variability (Hamzeh, 2009). For an ongoing project, Hamzeh (2009) recommended using and tracking Tasks Anticipated (TA), Tasks Made Ready (TMR), and constraint removal in lookahead plans to improve Percent Plan Complete (PPC) of tasks on critical and near-critical paths to enhance project productivity. TA measures the percentage of tasks anticipated on the lookahead plan two weeks ahead of execution. TMR measures the performance of lookahead planning in identifying and removing constraints to make tasks ready for execution (Ballard, 1997; Hamzeh et al., 2008). TMR (i, j) measures the percentage of tasks anticipated on the lookahead plan i weeks ahead of week j, with week j being the week of execution (the week covered by the weekly work plan) (Hamzeh et al., 2011). Appendix B gives a detailed treatment of planning and scheduling as a solution to variability in projects.

Things do not go as planned often for effectiveness, success, and excellence. In such cases, performance analysis of factors detracting company and projects from success becomes necessary as a prerequisite for performance improvement interventions.

2.2 Construction Company Performance Improvement Intervention and Change Management

Figure 2.6 gives a synthesis of the challenges, problems, and bottlenecks from the literature reviewed so far, and the suggested ways to overcome the challenges. These challenges will be the starting points for the model constructs to solve the problem of razor-thin and unreliable profit and low profitability of construction companies. The interventions need to reduce or eliminate the adverse effects of the challenges to improve company profitability.

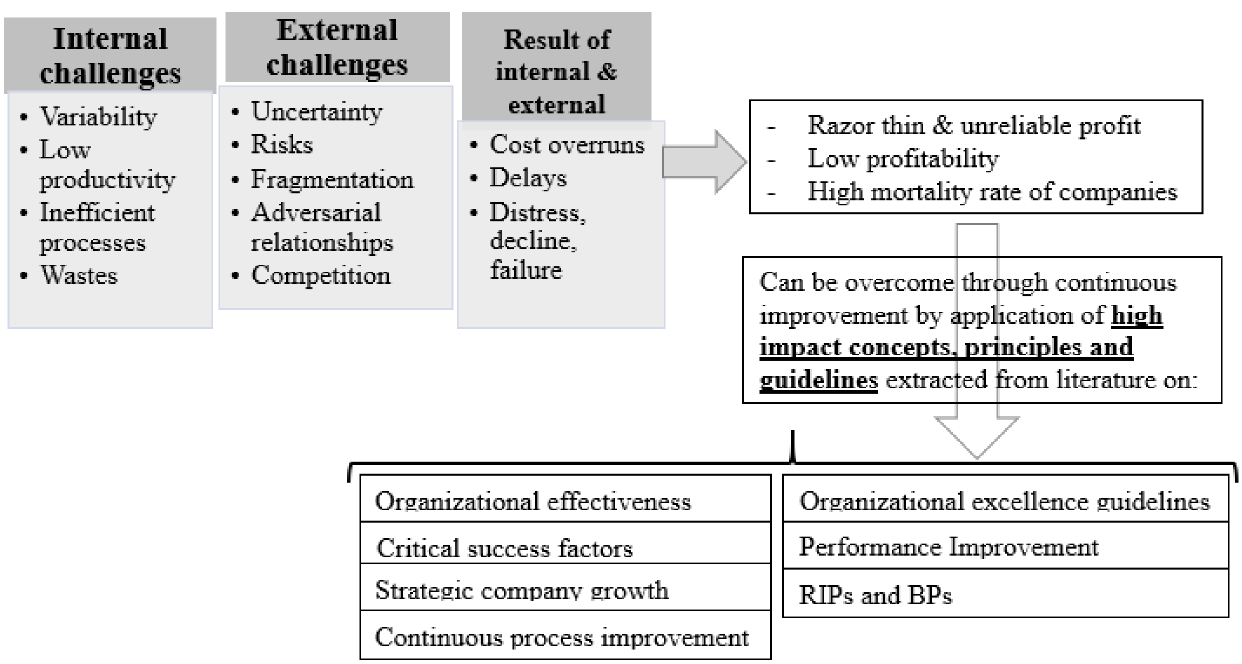


Figure 2.6 Challenges, problems and bottlenecks to be resolved by improvement interventions

Targeting high impact improvements helps achieve faster results. Bititci and Nudurupathi (2002) recommended that a systematic closed-loop approach that promotes continuous improvement be adopted. According to Deming, business processes should be analyzed and measured to identify the sources of variations that cause the processes to deviate from customer requirements. Besides wisdom from the literature reviewed thus far and synthesized in Figure 2.6, this subsection continues with review and will review the very ripe field of performance improvement intervention to use the wisdom for effective and faster interventions.

An organization is a living social system in a continual change and motion (Barrett in Bushe and Marshak, 2015). Performance is affected by a myriad of organizational, environmental, work, and individual employee factors (van Tiem et al., 2012). Performance Improvement (PI) has long been an established scientific field for improving human performance in the workplace. Performance Improvement (PI) is the science and art of improving the people, process, performance, organizations, and ultimately society (van Tiem et al., 2012). International Society for Performance Improvement (ISPI) was established in 1962 (formerly known as National Society for Programmed Instruction (NSPI)); its scholars and practitioners anchor their research and knowledge in theories such as general systems theory, psychology, industrial engineering, communication, information-processing, cybernetics, cognitive engineering, psychometrics, instructional design, behavioral analysis, and many more (Geis, 1986; Rosenberg, Coscarelli, and Hutchison,1992; Stolovitch and Keeps, 1992; Binder,1995; Pershing, 2006; Dean and Ripley,1997; Chow, 2010). Through ISPI, van Tiem, Moseley, and Dessinger (2012) provided an overarching performance improvement model shown in Figure 2.7 as the foundation for Performance Improvement (PI) research and practice. This model underpins change management and sustainable change through analysis, design, development, implementation, and evaluation, focusing on the performance improvement of worker, work, workplace, and world (societal) perspectives. It is impossible to give the list of all the foundational models, methods, and techniques that have influenced the vast field, but this discussion will highlight the essential pieces that different researchers contributed towards the development of the PI model in Figure 2.7.

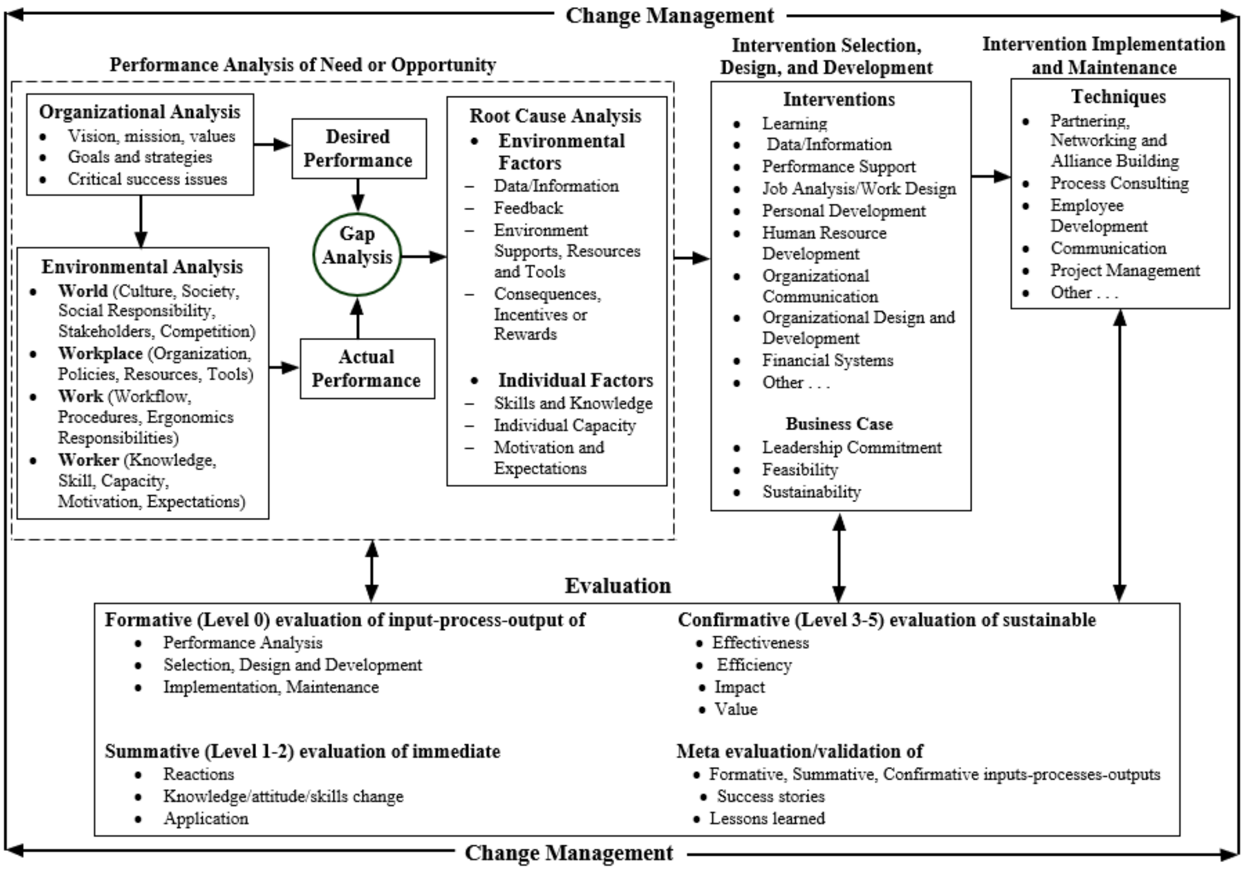


Figure 2.7 The Performance Improvement (PI) model
(Source: van Tiem et al., 2012)

2.2.1 Brief Review of Concepts Different Researchers Contributed to Model in Figure 2.7

Gilbert, Harless, Mager, and Rummler are considered pioneers (Wilmoth, 2002). Gilbert (1978) is known as the father of performance improvement (PI), and he said that improving workers' performance must begin with identifying and resolving the environmental barriers, thus enabling the performers to achieve maximum performance. He is also known for developing his behavior engineering model, believing that the most significant barrier to effective (which he called worthy) performance comes from a lack of information and management support rather than an individual's lack of desire to perform well. Gilbert defined worthy performance as behavior valued for its accomplishment. Worth is determined by dividing the value by cost (W = V/C). Worth was the first conceptualization of return on investment (van Tiem et al., 2012). Harless (1973) believed that understanding the cause of the problem should drive the solution and suggested conducting front-end analysis before improvement interventions. Tessmer and Richey (1997) stressed contextual analysis in designing improvement interventions. They defined context as a multilevel body of factors encompassing the environment in which performance takes place and the simultaneous interaction of several mutually influential factors. They say that the multilevel nature of context means that different spatial and temporal levels of context need to be considered, for instance, the immediate and surrounding contexts.

Mager's work (1961) on preparing instructional objectives revolutionized the instructional design and performance improvement. He championed the next important concept, that of measurability (Wilmoth, 2002). He provided the concept of objectives as a consistent framework for describing desired outcomes. Analysts must be able to measure performance gaps, and eventually, performance gains to judge the effectiveness of given interventions. He believed that performance outcomes or results describe the change that occurs due to performance improvement. Rummler (2007) says that analysis should account for the fact that organizational and individual performance are unique and require different solutions. Rummler and Brache (1995) defined three levels of performance: organizational, process, and performer levels. They said individual employee's performance is linked to process and organizational performance. Rummler (2007) stressed the importance of improving organizational processes. Brethower (1999) considered organizations as adaptive systems in conducting improvement interventions and forwarded the total management system theory. He described his total system management in six theory points and three system principles, summarized as follows. A system is made of a collection of elements and relationships held together by a common purpose (Brethower, 1999). An adaptive system is one that can adapt to changing circumstances to fulfill its purpose and one that can change its purpose to adapt to a changing world. Internal relationships are essential in providing the value to be added. External relations define and realize the value added by the system. Maintaining and aligning the two interconnected sets of relationships, internal and external, is necessary for survival. Systemic variables are interconnected, and performance is multiply caused; there is no such thing as an independent variable in a living system (Brethower, 1999). It is difficult to predict the actions required to maintain each sets of relationships in advance, but feedback must guide subsequent actions. Feedback is information about performance that guides performance. There is a small set of interconnected variables (called value set variables) that must remain within a narrow range of values for the living system to survive and remain healthy (Brethower, 1999). Value set variables must be maintained even as the company adapts; otherwise, the company will die. It is impossible to maximize the functioning of a subsystem and the total system at the same time. Kaufman and English (1979) dealt with performance gap analysis, which they called needs analysis. They say that most organizational interventions target inputs and processes with some interest in products. Rarely does an intervention consider linkages between all the organizational elements: inputs, processes, products, outputs, and outcomes or consequences. They contend that any intervention should include “what is” and “what should be” in these five areas (inputs, processes, products, outputs, and outcomes or consequences) for the gap (needs) analysis.

Langdon (1995) dealt with another important concept, culture and believes that an essential element of culture (including organizational culture) is language, and making a significant change in culture is difficult without a common language. He advanced a common language for work with defined words, syntax, message, and medium as crucial elements. For example, he defined inputs as the resources available or needed to produce outputs. Conditions are existing factors that influence inputs and processes used to produce an output, a process as the actions necessary to use the inputs to produce products under certain conditions, and consequences are the effects an output has on a person, product, service or situation (such as customer satisfaction, needs met, opportunity exploited).

The other element is motivation. Keller (2000) forwarded the motivational model of attention, relevance, confidence, and satisfaction in performance improvement. Attention has to do with capturing the interest of people and stimulating their curiosity. Relevance is about the need to show the usefulness of the task for career development and professional growth. Confidence is about helping people believe they can succeed in accomplishing the task. Satisfaction is about reinforcing accomplishment with rewards.

The next element needed is evaluation. Kirkpatrick’s four evaluation levels consist of reaction, learning, behavior, and results (Praslova, 2010). Historically, formative and summative evaluations formed the foundations for judging a program in improving performance before, during, and immediately after implementation of improvement interventions. Dessinger and Moseley (2003) expanded traditional evaluation to long-term evaluation by confirming the institutionalization of changes. They called it a confirmative evaluation.

Wilmoth (2002) reviewed and classified PI models in different ways. One way is to classify by the scope as organizational versus individual. The other way is on the process as linear versus non-linear. The third way is diagnostic versus process or holistic. The PI model given in Figure 2.7 is a diagnostic one.

2.2.2 Discussion on Performance Improvement (PI) Model Given by ISPI

The Performance Improvement (PI) Model given by the International Society for Performance Improvement (ISPI) shown in Figure 2.7 is a diagnostic and strategic tool for improving workplace performance because it is a thoughtful and evidence-based approach (van Tiem et al., 2012). The following systems-based phases form the components of the PI model in Figure 2.7 :

a. Performance Analysis
b. Intervention selection, design, and development
c. Intervention implementation and maintenance, and
d. Evaluation.

The design of the model implies both a linear and an iterative progression of events. There are advantages to following the phases sequentially without omitting any phase. An intervention should not be prescribed without first observing and analyzing the situation to determine the root causes.

Performance improvement means change. The PI model illustrates a systemic process for planning and accomplishing the desired changes (van Tiem et al., 2012). Change management is the overarching accomplishment in the model and surrounds each stage in performance improvement to signify that change occurs, and one must account for the change from the first analysis question.

Discussion of each of the phases follows:

2.2.2.1 Performance Analysis

The organizational analysis in Figure 2.7 investigates the organization’s vision, mission, values, goals, strategies, and critical success issues to determine the desired performance level, driving the need for change (desired performance or ‘what should be’). The purpose of the organizational analysis is not only to seek directions set by these strategic planning elements in defining success but also to identify whether there are deficiencies in these strategic elements, their communication, their alignment, or implementation. The analysis may involve extant data analysis, interviews, surveys, and group processes.

Environmental Analysis

Environmental analysis is a diagnostic phase that examines the following to determine actual performance (the existing situation) or ‘what is’:

- ***World***— Analysis of the world environment focuses on global societal realities that impact organizational and human performance and cultural issues that affect the workplace, work, and workers such as society, culture, social responsibility, stakeholders, and competition.
- ***Workplace***— This analysis focuses on what is happening inside the organization to support performance with such considerations as resource allocation, tools, policies, feedback, consequences of performance or nonperformance, retention efforts, and succession planning. The Great Place to Work Institute identified five dimensions of great workplaces: credibility, respect, fairness, pride, camaraderie, and intimacy (van Tiem et al., 2012).
- ***Work***—focuses on the analysis of job design or process level considerations such as workflow, ergonomic issues, procedures, and work responsibilities.
- ***Worker***—deals with personal considerations of employees such as skill level, knowledge, motivation, capacity, and expectations.

Gap Analysis

Gap analysis involves identifying and analyzing the difference between ‘what is’ or achieved outcome (current reality) and ‘what should be,’ the desired future successful end state after the change, and improvements have occurred using the organizational and environmental analysis results. The gap descriptions may be both quantitative and qualitative. Prioritizing the gaps is necessary to focus on top priority gaps to address within available resource constraints. Van Tiem et al. (2012) recommend using the criticality ranking matrix of performance gaps from 1 (least critical) to 10 (most critical) and reaching of consensus among the improvement team before proceeding to root cause analysis.

Root Cause Analysis

Root cause analysis involves determining the causes of performance gaps. While organizational, environmental, and gap analyses yield valuable information, a root cause analysis determines why the performance gap exists.

Various experts have viewed causes from different perspectives. Historically, experts like Robert Mager, Peter Pipe, Thomas Gilbert, Geary Rummler, Alan Brache, and Joe Harless suggest that performance problems are mostly deficiencies of knowledge, skills, training, or a host of management deficiencies. Rossett identified four kinds of drivers, causes, barriers, or obstacles that impact success or failure: lack of skill, knowledge, and information; flawed incentives; flawed environment, tools, and processes; and lack of motivation. Drivers are everything that it takes to enable performance to grow. Gilbert forwarded three theorems to provide structure to both root cause analysis and human performance:

- Value is in the accomplishment (in overt performance, not in covert behavior).
- Measure against a standard - comparing the very best instance of performance with typical or actual performance. This comparison helps to see opportunities for bettering the situation.
- Assess environmental versus individual causes - this helps to identify where one has to look to find the causes of competence and incompetence.

A variety of techniques and tools are available for conducting root cause analysis: interview, observation, survey, focus groups, fishbone diagram, and portfolio analysis (van Tiem et al., 2012). Root cause analysis helps to identify causal factors for undesirable outcomes or negative consequences using a structured approach with techniques designed to provide a focus for identifying and resolving problems. Many undesirable outcomes occur daily in construction companies and their many projects. Often, equipment or process-related issues are corrected, and the process started back again without identifying and addressing the various root causes, in which case the problem is likely to recur.

Latino et al. (2011) say that virtually all undesirable outcomes are the results of human decision error (human errors of omission or commission). All undesirable outcomes will have either physical, human, or latent roots. Physical roots are occurrences like equipment failure for which mechanical failure is the cause for which verification consists of eyewitness accounts, statistics, certified tests, inspections, measurement data, and the like. Human root causes are decision errors,

errors of omission, or commission, which means that either people decided not to do something they should have done or done something they were not supposed to do. Latent root causes are the organizational systems put in place to help people make better decisions such as policies, operating procedures, maintenance procedures, purchasing practices, store and inventory practices, training systems, and quality control mechanisms. (Latino et al., 2011). When such systems are flawed, they result in decision errors. They are latent because they stay hidden for a long time until they finally combine with other factors to cause undesirable outcomes. Deming says that failure in these express organizational decision systems causes 80% of company problems for which management blames employees.

Two types of events can occur in a construction company:

1. **Sporadic (acute) events** – are rarely occurring, dramatic events that cost a business much money in lost revenue (profit) and to fix.
2. **Recurrent events** - are events that repeatedly occur that their cost becomes the cost of doing business. The cost of each event is low, but the aggregate cost is high due to the high frequency of the occurrences. Examples of recurrent construction events are low productivity, inefficient utilization of labor, material, and equipment, interruptions, early mobilization, inferior working conditions, poor quality, poor safety, neglect of flow in CPM schedules and scheduling activities only, lack of skilled labor.

   Being **proactive** about these events improves profit significantly (Latino et al., 2011).

The company can carry out Root Cause Analysis (RCA) for both types of events, but the focus in profit improvement is on recurrent events. Their cost is part of the cost of conducting business and so cutting their cost results in a significant improvement in profit (Latino et al., 2011).

- Root Cause Analysis (RCA) helps to determine factors causing recurrent events to help proactive prevention of their occurrence.
- RCA is also a way to keep corporate memory as lessons learned that benefit a company for years to come despite workforce turnover (Latino et al., 2011).

Where are the company's most significant issues? How do companies know? It is by carrying out Opportunity Analysis. Opportunity Analysis is a technique to identify the essential failures (Significant Few) by analyzing objectively all the historical events contributing to their performance or lack thereof. FMEA was developed in the aerospace industry to determine what failure events could occur within a given system, which is very staff-hour intensive (Latino et al., 2011). The literature recommends using modified and simplified FMEA, which is called Opportunity Analysis. Two primary reasons to perform an Opportunity Analysis are:

- to make a persuasive business case to analyze one event versus another
- to focus the organizational improvement effort on the most significant events to achieve quantum leaps in productivity with fewer of the organization's resources (80/20 rule: 20% or less of the undesirable events that we uncover by conducting an in-depth Opportunity Analysis will help save approximately 80% of the losses that organization incurs).

Tools that assist groups or individuals in identifying the root causes of problems are known as root cause analysis tools. The four tools commonly used in the manufacturing industry are the five whys, the fishbone diagram, the regulatory forms, and the logic tree (Latino et al., 2011). There is not much-published literature on root cause analysis tools in civil engineering construction. Rosenfeld (2014) used an expand–focus approach for root cause analysis of project cost overruns. Maemura et al. (2018) determined factors by conducting an interview with experts and drawing the root causes of recurring contractual conflicts in international construction projects into a fishbone diagram.

Latino et al. (2011) say that the five whys technique is the most commonly used, but its primary deficiency is that it assumes failure occurs in a linear pattern. Multiple factors combine laterally, and there is seldom a single root cause for an undesirable outcome. The second most commonly used analytical tool is the fishbone diagram. The spine of the fish represents the sequence of events leading to the undesirable outcome (Figure 2.8). The fishbone themselves represent cause categories that have potential contributions to the sequence of events (Latino et al., 2011). A minor shortcoming of this tool is that people tend to limit the cause categories to either of the following (Latino et al., 2011):

The 6M's: Management, Man, Method, Machine, Material, Measurement.

The 4P's: Place, Procedure, People, Policies.

The 4S's: Surroundings, Suppliers, Systems, Skills

This deficiency can be overcome by exhaustively listing all possible causes and factors, and prioritizing the more significant factors by Risk Priority Number (RPN). This tool is powerful if an exhaustive list of causes is analyzed as it enables the evaluation of all risks (fishbone diagrams are developed for processes, departments, and other performance areas and given in Appendix A). The second shortcoming is that team brainstorming is usually used in conjunction with the fishbone diagram to determine the causal factors by consensus. In such a case, the causal factors are determined based on hearsay (not on facts), and the improvement team may miss one or more root causes. This shortcoming can be overcome by expert analysis and by thorough fact-finding and data collection.

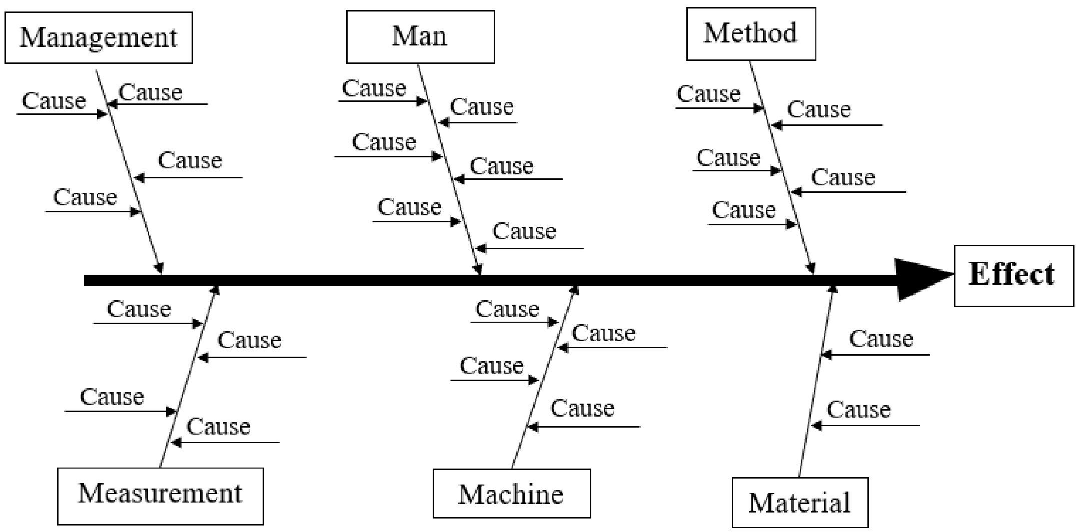


Figure 2.8 Sample Fishbone Diagram
(Source: Latino et al., 2011)

Latino et al. (2011) developed a logic tree specifically for root cause analysis. The logic tree is an expression of cause-and-effect relationships that queued up in a particular sequence to cause an undesirable outcome. Hard evidence serves to validate these cause-and-effect relationships as opposed to hearsay. Figure 2.9 gives a logic tree diagram. It helps organize all the data collected and putting the data into an understandable and logical format for comprehension (Latino et al., 2011).

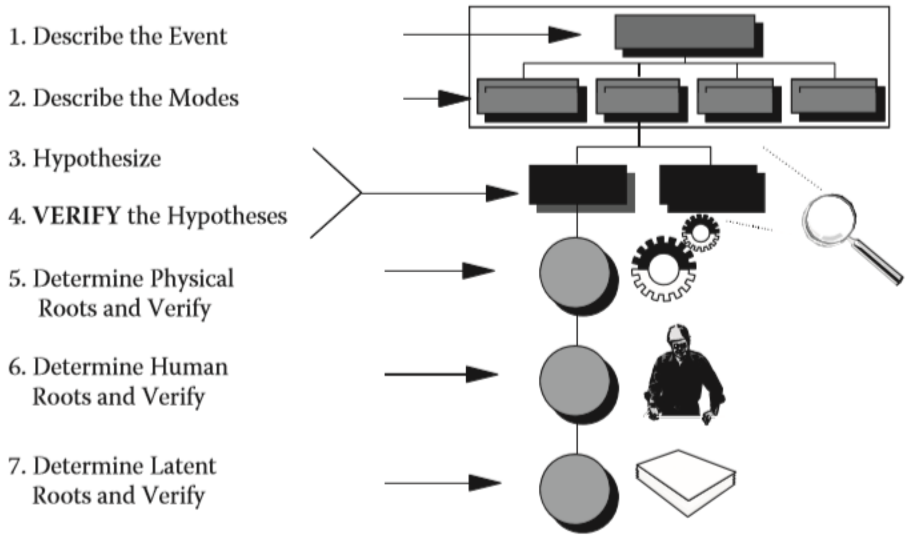


Figure 2.9 Logic tree

(Source: Latino et al., 2011)

It is essential to rank the causes or factors to identify the most important ones. The Pareto principle also called the 80/20 rule, is one way to identify the vital few, which says 20% of the causes (the significant few) cause 80% of the problems. One can achieve significant improvement by focusing on the significant few. Figure 2.10 shows a sample Pareto diagram.

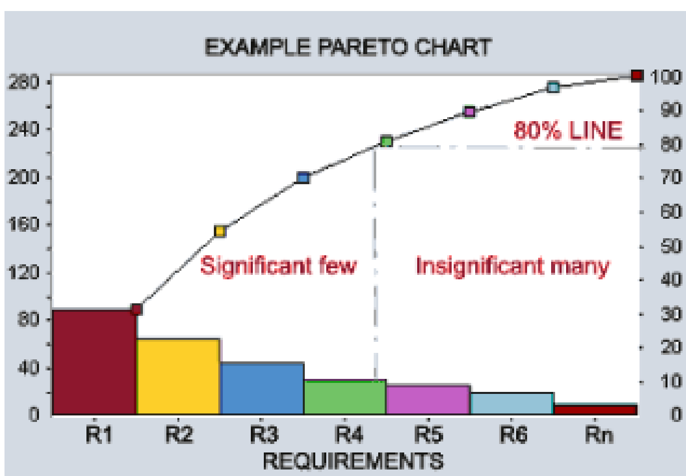


Figure 2.10 Sample Pareto Chart

(Source: http://mylearningcafe.blogspot.com/2014/09/seven-basic-tools-of-quality.html)

Another powerful prioritization method is Failure Mode and Effect Analysis (FMEA) using Risk Priority Number (RPN), which this research applies. The improvement team or the operational team can use FMEA to select the significant few to improve by reducing RPN.

Bititci and Nudurupathi (2002) contend that one of the key activities with a significant impact on continuous improvement is defining the performance indicators and modeling their relationship. They used fishbone diagrams to identify leading performance indicators that influence lagging performance indicators. These leading indicators relate to the activities in the process, inputs to the process, or even outputs of the process. Kaufman and English (1979) contend that any intervention should include "what is" and "what should be" in the inputs, processes, products, the outputs, and outcomes or consequences and the linkages among these five elements. The essence of Latino et al. (2011) logic tree is taken in this research regarding data collection to verify physical, human, and latent root causes of failure in developing fishbone diagrams. This idea is ingenious as it helps to carry out root cause analysis while improving the lagging performance measures through manipulation of the leading performance indicators improving the factors on the fishbone diagrams using RIPs, countermeasures and BPs. The author collected extensive data on the root causes of failure of factors on the fishbone diagrams, best practices, and rapid improvement principles that would eliminate the failure root causes to drive improvement of the leading indicators from an extensive literature review. Accordingly, process flow diagrams and the corresponding fishbone diagrams are developed for construction company and project processes listed in Table 2-5 and other performance areas, and given in Appendix A. Figure 2.11 gives an example company estimating process flow diagram and Figure 2.12 gives the corresponding fishbone diagram.

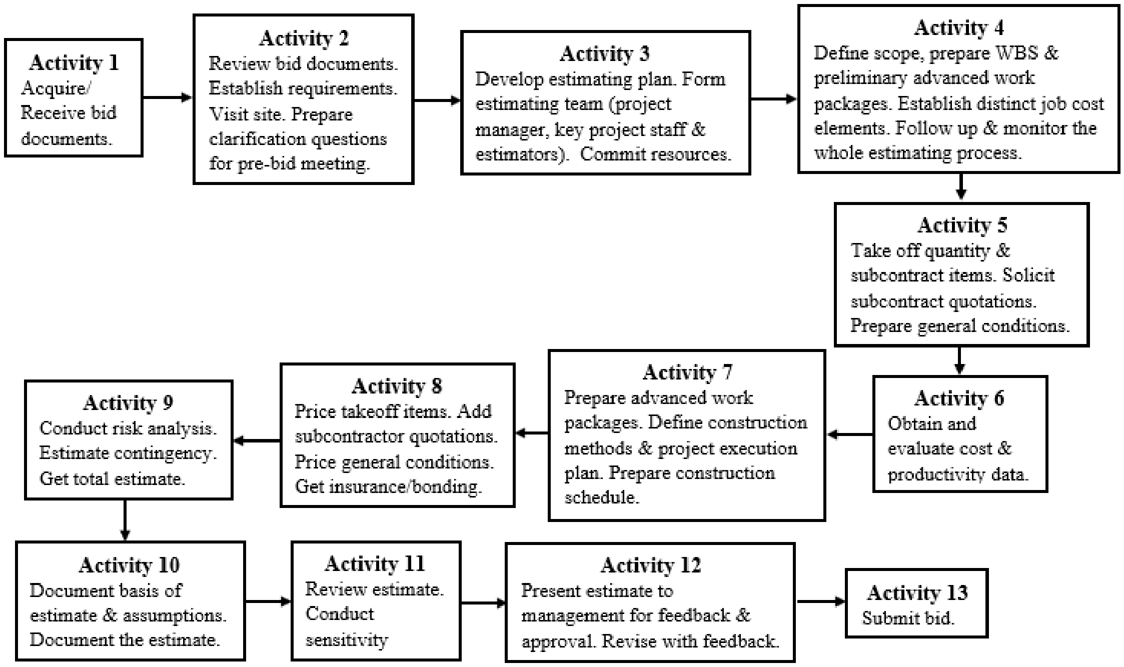


Figure 2.11 Construction company estimating process flow diagram

(Source: Estimating process diagram is developed based on Rios et. al, 2006 and Oberlender, 2003.)

The process flow diagrams help focus on the activities and handoffs/interfaces between activities and operators, inputs, processes, products, outputs, and outcomes or consequences and linkages among these five elements. After process mapping, it is vital to investigate all bottlenecks, risks, problems, and factors that negatively and positively influence the process flows. The author exhaustively listed all the factors and causes that influence the performance of processes using fishbone diagrams. This research focuses on the leading performance indicators and the RIPs, countermeasures, and BPs to manipulate the factors to effect improvement in the lagging process performance indicators.

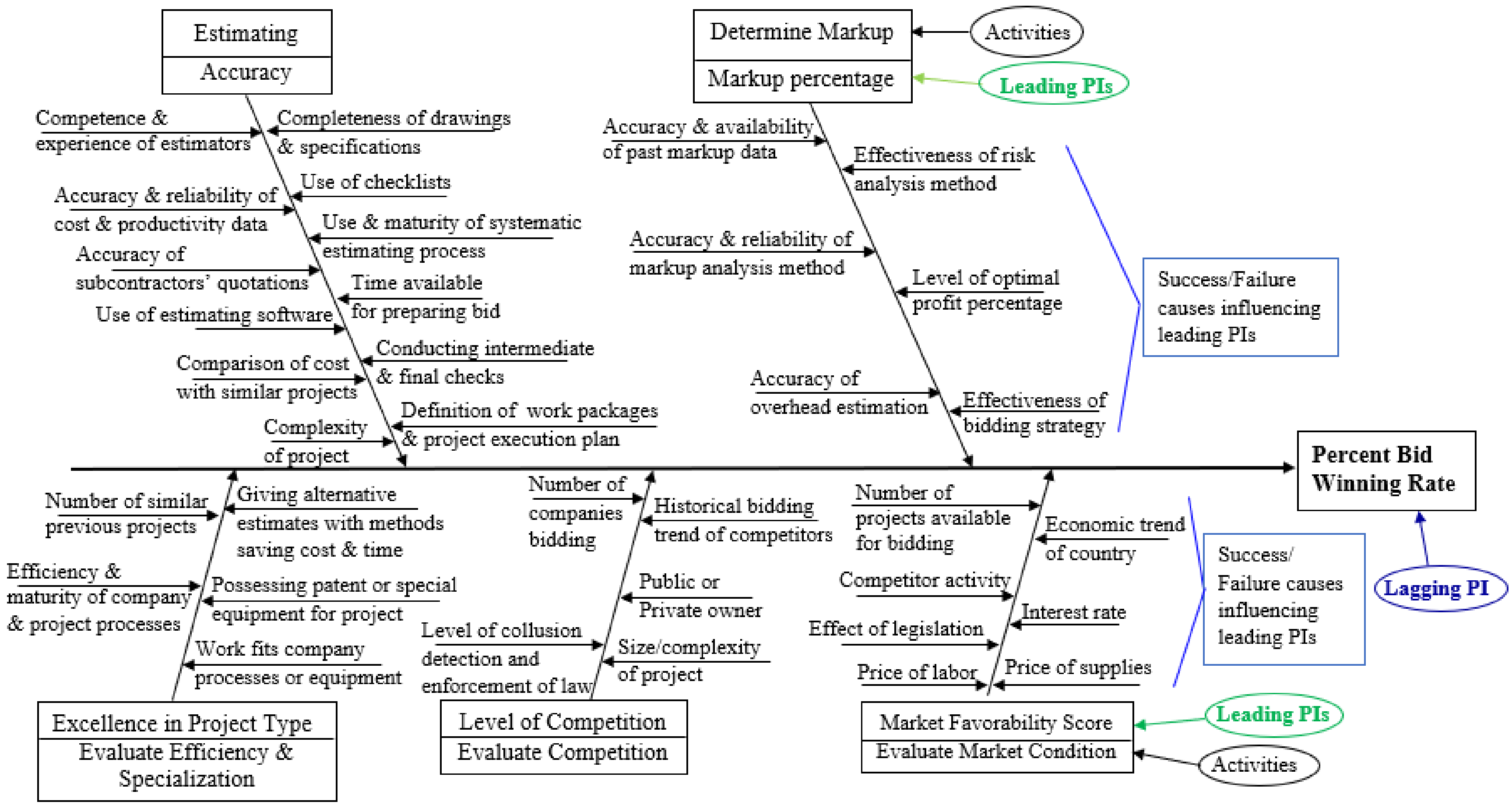


Figure 2.12 Construction company estimating process bid win rate cause and effect diagram

(Source: Bid winning rate cause and effect diagram is developed based on Rios et. al, 2006, Oberlender, 2003 and McGuire, 2006).

The inward-pointing arrows that represent the performance of the five leading indicators in Figure 2.12 derive the bidding department performance for project profitability using Failure Mode and Effect Analysis (FMEA) to derive the improvement, as shown in Table 2-8(Bititci and Nudurupati, 2002).

The improvement involves root cause analysis and matching the root causes with rapid improvement principles, countermeasures, and best practices that eliminate the root causes from the database of rapid improvement principles, countermeasures, and best practices (given in Appendix F). Improvement makes processes simpler, better, faster, and cheaper (Shingo, 1988). Once the factors influencing performance indicators are determined, improvement or operational teams use Failure Mode and Effect Analysis (FMEA) through computations of RPN values to derive improvement (Bititci and Nudurupati, 2002). The improvement team computes RPN values in Table 2-8 before and after the intervention. The reduction in the total RPN value due to the improvement gives the level of improvement attained.

FMEA allows the teams to prioritize each influencer's potential impact or cause (failure mode) according to its:

- ***Frequency of occurrence***: How often can a failure mode occur? The rating scale ranges from Very Rare = 1 to Very Often = 10.
- ***Severity***: Once a failure occurs, how severe would its impact be on the problem one is trying to control? The rating scale ranges from Very Low = 1 to Very High = 10.
- ***Detectability***: How difficult or easy is it to detect the occurrence (or possible occurrence) of a failure mode before it affects the process performance? The rating scale ranges from Very Easy = 1 to Very Difficult = 10.

Table 2-8 gives an example for the estimating team to monitor and improve the leading performance indicator, accuracy of bid estimates, and factors influencing the accuracy of bid estimates from left top inward pointing arrow in Figure 2.12. The improvement team fills this table before the intervention, and the factors ranked based on RPN to identify the significant few. The table will also be prepared after improvement, to show the impact of the intervention.

Table 2-8 FMEA for accuracy of bid estimates in Figure 2.12

Failure Mode - Accuracy of Bid Estimates	Frequency of Occurrence	Severity	Detectability	RPN (Risk Priority Number)
Competence of engineers				
Use of software				
Markup strategy & scenario				
Time available for estimating				
Quality of drawings & specifications				
Total				

Figure 2.13 shows a branch on an arbitrary example cause and effect diagram. Figure 2.14 gives a filled and prioritized FMEA example table. The rating scale ranges from 1-10 for the frequency of occurrence, severity, and detectability, as discussed previously. The improvement team subjectively assesses these numbers from their experience with the operation of the system under improvement.

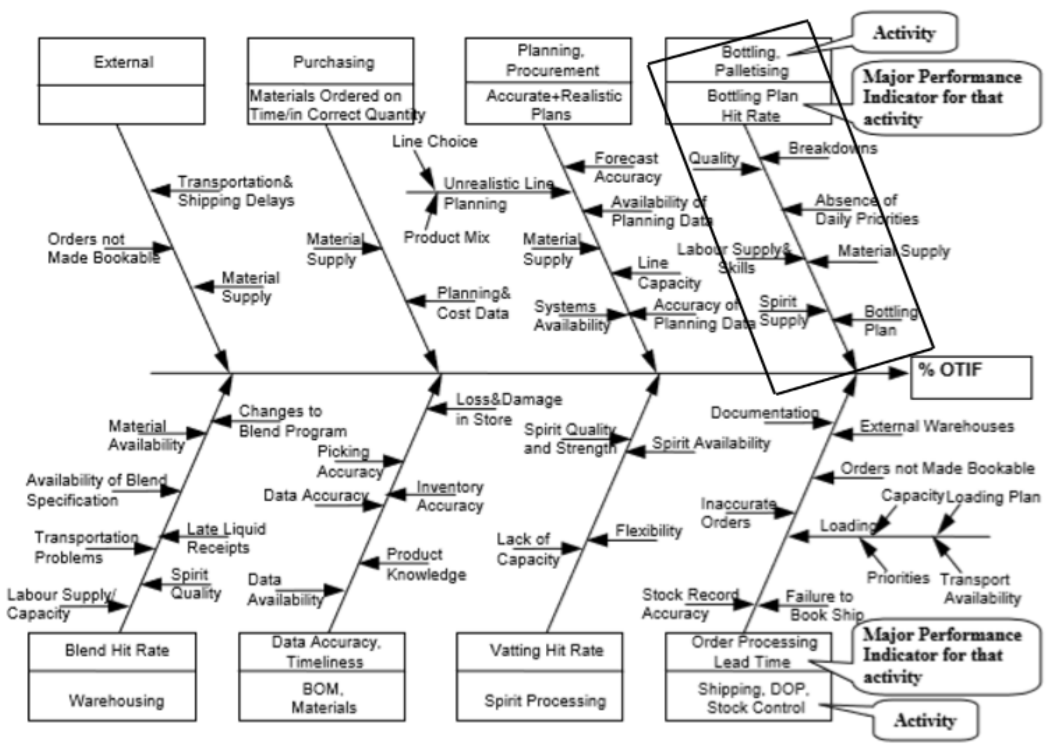


Figure 2.13 Example fishbone diagram with a branch for investigation selected by box

(Source: Bititci and Nudurupati, 2002)

Before intervention

Failure Mode Hit Rate → OTIF	Occurrence	Severity	Detectability	RPN (Risk Priority Number)
Breakdowns	6	9	7	378
Absence of Daily Priorities	5	6	6	180
Quality	3	4	5	60
Material Supply	2	7	4	56
Bottling Plan	3	7	4	84
Spirit Supply	2	7	4	56
Labour Supply and Skills	1	3	3	9
Total				823

Figure 2.14 Example FMEA table filled and prioritized based on RPN values
(Source: Bititci and Nudurupati, 2002).

The FMEA table can be filled after the intervention to see the impact of the improvement. Figure 2.15 gives the filled FMEA example table after the top two priority factors are improved in Figure 2.14 (i.e., their RPNs reduced).

After intervention

Failure Mode Hit Rate → OTIF	Occurrence	Severity	Detectability	RPN (Risk Priority Number)
Breakdowns	6	9	3	162
Absence of Daily Priorities	0	6	6	0
Quality	3	4	5	60
Material Supply	2	7	4	56
Bottling Plan	3	7	4	84
Spirit Supply	2	7	4	56
Labour Supply and Skills	1	3	3	9
Total				427

Figure 2.15 FMEA table showing a reduction in RPN value of the top two factors after improvement
(Source: Bititci and Nudurupati, 2002)

The PI model in Figure 2.7 lists the following as needing investigation in root cause analysis:

- **Environmental Factors**
  - ***Data/Information*** - Data and information needed to successfully perform includes job or task procedures, organizational policies, customer requirements, supplier concerns or tolerance levels for machinery.
  - ***Feedback*** – people need to be given timely feedback on the results of their work activities.

- *Environment Supports, Resources, and Tools* - Environmental support may include ergonomic, health, wellness, and safety considerations that impact performance such as air quality, workspace, rest areas, lighting, workload, and workflow design. Resources refer to the time, money, materials, and personnel allocated to the tasks. Resources must be adequate and of sufficient quality to allow for the successful accomplishment of the tasks. Tools refer to instruments required to complete the job.
- *Consequences, Incentives, or Rewards* – Consequences are events or effects produced by a preceding act. For example, inappropriate lighting may cause eye strain and prevent an employee from doing a stellar job. Incentives are the stimuli that influence or encourage people to do their jobs. Incentives may be monetary, nonmonetary, and career development opportunities.

- **Individual Factors**

Equipment and financial reserves are essential, but people are the heart and soul of an organization (van Tiem et al., 2012). The individual factors consist of the following:

- *Skills and Knowledge* - People will not be able to perform to standards if they do not know how to perform.
- *Individual Capacity*- represents a match or mismatch between the employee and the job requirement. The lack of ability means that recruiters made a mistake while selecting an employee. An employee was hired, transferred, or promoted into a job that the person could not perform or learn.
- *Motivation and Expectations* - Motivation comes from within. Expectation also comes from within the person by expecting or believing that certain resources or conditions are required to perform a task. If employees are not motivated to perform or feel that the company did not meet their expectations, there is a good chance that there will be a gap between desired and actual performance.

It would be good to consider these causes and other causes to be comprehensive in root cause analysis.

The next step in the PI model in Figure 2.7 after uncovering the root causes is intervention selection, design, and development.

2.2.2.2 Intervention Selection, Design, and Development

Intervention selection is the process of identifying and recommending the most appropriate activities, RIPs, countermeasures, and BPs to successfully resolve a performance improvement problem, opportunity, or challenge. Appropriate, cost-effective, and sustainable interventions need to be selected or designed. The improvement team makes the selection from possible interventions listed in the model in Figure 2.7 and other lists that would resolve the root causes of the identified gaps. The improvement team uses its judgment to determine which intervention to use, but the team selects RIPs and BPs based on the problems and contexts for which RIPs and BPs were efficacious in the past. Each intervention type has sub-classifications.

- ***Learning Interventions*** – knowledge management, organizational learning, learning management system, content management system, education/training, self-directed learning.
- ***Performance Support Interventions*** – performance support tools or job aids, electronic performance support systems, documentation and standards, expert systems.
- ***Job Analysis/Work Design Interventions*** – consist of job analysis (job descriptions, job specifications), work design (job design, job enlargement, job rotation, job enrichment, reengineering, realignment, restructuring), human factors (ergonomics, safety engineering, security management, green workplace), quality improvement (Total Quality Management (TQM), continuous improvement, preventive maintenance, Six Sigma, lean organizations).
- ***Personal Development Interventions*** – include feedback, coaching, mentoring, emotional intelligence, social intelligence, cultural intelligence, communities of professional practice.
- ***Human Resource Development Interventions*** – include talent management, individual growth, and organizational growth.
- ***Organizational Communication Interventions*** – consist of either one or combinations of communication networks, information systems, suggestion systems, grievance systems, dispute resolution, social media.
- ***Organizational Design and Development Interventions*** – includes empowerment (team strategies, virtual teams, problem-solving), organizational pro-action (strategic planning, appreciative inquiry, environmental scanning, , outsourcing, benchmarking, balanced scorecard, dashboards), organizational values (culture, diversity, inclusion strategies, globalization, localization, social responsibility, ethics, decision making).

- ***Financial Systems Interventions*** – consist of open-book management, profit versus cost center, cash flow analysis and cash flow forecast, financial forecasting, capital investment and spending, mergers, acquisitions, and joint ventures.

These suggested interventions are also used as part of the database of RIPs, countermeasures, and BPs to resolve root causes of failures of factors on fishbone diagrams in this research.

Using sound selection methods is more important than merely getting the right "answer". The recommended way to select a performance improvement intervention is to use the team approach (van Tiem et al., 2012). Creating a team to select potential interventions helps to ensure that there is a broad base of support. It is equally essential that the teams be cross-functional to ensure a diversity of experiences and ideas needed to harness the organization's creative forces. Team involvement and team commitment to the ultimate decision will minimize conflict and resistance later during implementation. There is no easy method to select possible interventions or solutions to performance problems or opportunities. If there are multiple problems, it is necessary to rank the problems according to pre-selected criteria; for example: which problem has the most impact on the bottom line? Which problem can be fixed in the shortest time and for the least expenditure of resources? Usually, the improvement team can develop the criteria from the performance analysis results, especially the organizational and environmental analyses. Van Tiem et al. (2012) recommend the steps in Figure 2.16 for the selection process.

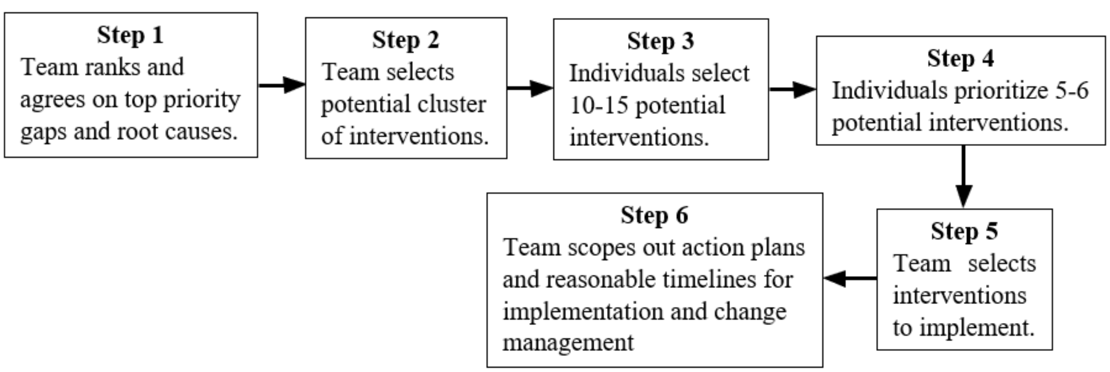


Figure 2.16 Selection process of improvement interventions

(Source: Modified from van Tiem et al., 2012)

Van Tiem et al. (2012) give these general suggestions for selecting successful interventions:

a. Base decisions on a comprehensive understanding of the situation. A comprehensive understanding of the situation is where past performance and root cause analysis efforts come together.
b. Target the right people to engage in improvement effort, in the right setting, and at the right time.
c. Have a sponsor who will champion the intervention.
d. Use a team approach; draw upon expertise from all areas in the company.
e. Include cost and be value sensitive.
f. Meet comprehensive, prioritized requirements, based on what is most important.
g. Investigate a variety of intervention options because a new intervention can be costly to develop.
h. Consider long-term versus short-term effectiveness. Use multiple strategies to effect change. Interventions should be sufficiently powerful.
i. Company must plan to institutionalize the intervention over time and engraining it in the organization's culture. Interventions should be sustainable.
j. Keep viability of development and implementation in mind. An intervention needs human resources and organizational support, and it must be cost and value-effective.

2.2.2.3 Intervention Implementation and Maintenance

Implementation is the process of communicating, piloting, launching, monitoring and modifying interventions (van Tiem et al., 2012). Its intended outcome is institutionalizing the planned intervention, resulting in long-term change within the organization (Moseley and Hastings, 2005). The maintenance of interventions over time is not an easy process because it is filled with risk and reward, success and failure, and readiness and resistance to change. However, the performance improvement team can realize sustainability if it assumes leadership for planning, orchestrating, nurturing, guiding, maintaining and evaluating the interventions within the organization culture as well as its internal and external clients (van Tiem et al., 2012).

Implementation and maintenance involve the use of the following techniques:

- ***Partnering, Networking, and Alliance Building***: – Performance improvement team needs to network, partner, and build alliances with various involved departments, stakeholders, and champions to ensure an accurate understanding of expectations and concerns.
- ***Process Consulting***: – process consulting may be necessary if the improvement involves an extensive redesign of processes.
- ***Employee Development***: – employee development such as training, learning organizations, job aids, documentation, mentoring, or coaching is likely so that all involved people and teams are ready to participate to enable employees to retain competitiveness and to prepare for the organization's future.
- ***Communication***: – communication is critical to achieving this phase. There is a need to communicate expectations throughout the organization. Performance improvement implementation requires the communication of plans and progress.
- ***Project Management***: the improvement team carefully structures the improvement effort and manages the improvement project to ensure timely execution of tasks within budget and as expected.

2.2.2.4 Evaluation

Evaluation is rendering a judgment of merit or worth about an object of evaluation, which in this case, is the effectiveness of improvement interventions. Measuring and reporting results are critical for maintaining the confidence of the organization and stakeholders. The improvement team should measure inputs, processes, and outputs throughout the performance improvement process. The different levels of evaluations are (van Tiem et al., 2012):

- ***Formative (Level 0) Evaluation*** – Pre-formative evaluation establishes the baseline or "what is." Usually, this is considered part of formative evaluation. Formative or Level 0 evaluation occurs during performance analysis and intervention selection, design, development, and the intervention implementation and maintenance stages, as needed. Formative evaluation is a diagnostic tool that serves as feedback and continuous improvement or quality control tool to improve the intervention development process. It is like the "cook tasting the soup – who uses the feedback to improve the cooking."

- ***Summative (Levels 1 and 2) Evaluation*** – Summative evaluation (like the customer tasting the soup) takes place afterward to render a judgment of worth or merit and determines the immediate reaction; knowledge, skill, and change in attitude; plus, initial application or adoption of the intervention or interventions.
- ***Confirmative (Levels 3 to 5) Evaluation*** – Confirmative evaluation focuses on sustainable effectiveness, efficiency, impact, and value, including return on investment. Is the value worth the effort? Confirmative evaluation keeps the team focused on what is essential to the customers and what to measure to meet their expectations continuously. Rather than a formative or summative event, confirmative evaluation is an ongoing process designed to "take a pulse" before, during, and after an intervention is implemented (Seels and Richey, 1994).
- ***Meta-Evaluation*** – Finally, it is critical to evaluate the evaluation process itself, known as meta-evaluation, to ensure that optimal information is garnered and considered. By documenting success stories and lessons learned, it is possible to predict future change initiatives and plan effectively for positive outcomes.

In summary, information from performance improvement discussions in this section will be used in developing the two-part model of excellence for profitability improvement in Chapter 3 and enrich the database of RIPs, countermeasures, and BPs used in the DSS developed in this research.

2.3 Origin, Application, and Effectiveness of Rapid Improvement Principles and Best Practices

This research requires extracting RIPs from lean construction, the theory of constraints, business model innovation, value innovation, change management and organization development, improvement science, value improving practices, breakthrough thinking, and performance improvement and using them in company improvement as will be discussed in Chapter 4. The improvement also requires the use of BPs developed by the Construction Industry Institute and other sources, as will be discussed in Chapter 4. This subsection discusses the origin, application, and effectiveness of RIPs and BPs. These methods consist of four classifications for ease of discussion of their origin, application, and effectiveness: methods based on value creation, methods based on the theory of constraints, best practices and value improving practices, and capability maturity models.

2.3.1 Organizational and Process Improvement Approaches Based on Value Creation

Companies exist to solve clients' problems and meet one or more needs, i.e., to create value for clients. Value creation and meeting client needs must dictate most business decisions.

Value-based improvement principles began when top Toyota people visited Ford in 1949 and concluded that Toyota could eliminate the many wastes incurred by Ford, and gradually developed just in time production at Toyota (Forbes and Ahmed, 2011). Later Toyota adopted total quality management, which is driven by an organizational strategy of focus on all areas of company and unity of purpose, an internal and external customer focus, obsession with quality, scientifically based decision making and problem-solving, continuous process improvement, long-term commitment, teamwork, employee engagement and empowerment, and education and training (Forbes and Ahmed, 2011). These developments led to a focus on customer-defined value and striving for customer satisfaction, breakthrough thinking, and lean manufacturing at Toyota that gave it a competitive edge internationally.

Principles and frameworks based on value are breakthrough thinking, lean construction, business model innovation, value innovation, and total quality management and quality management systems. The treatment in this subsection consists of a brief discussion of each and pointing out things for takeaways.

2.3.1.1 Breakthrough Thinking

Breakthrough Thinking is an innovative and revolutionary new approach of creative problem solving aimed at meeting customer needs in the future, and a method for arriving at truly original, lasting answers that not only addresses an immediate problem but provides a solid foundation for ongoing development and constructive change (Bozeman, 2004). The focus is on coming up with a situation-specific solution that serves the purpose of utilizing an absolute benchmark to get a solution for the future (Hibino, 2006). It involves systems thinking, a thorough analysis of alternative solutions to meet desired ends, engagement of as many people as possible in the solution process, and continuing change and improvement in the long term (Hibino, 2006).

Situation-specific solutions led Toyota not to pursue mass production but to come up with production techniques of cars in small quantities that work for the Toyota situation (low capital) and the Japanese market (demand for customized cars). Purpose-driven solution led Toyota to extract the purpose of belt conveyor, which is to move parts and meet the same purpose with just in time delivery of assembly parts to produce cars just in time to meet customer demand. This development led to the Toyota Production System and the Toyota Way (lean manufacturing), which are business philosophies that strive to create the most value for customers and exceed customer expectations at the least cost possible. Currently, breakthrough thinking is the secret of Toyota's automotive industry leadership. Toyota uses two managements: improvement or kaizen management and breakthrough management (Hibino, 2006). The kaizen management is onsite, small incremental change where onsite people are involved. Breakthrough Toyota uses absolute benchmark and drastic change.

These principles are especially useful and effective for construction because each project is unique, requiring a situation-specific solution that meets the project's purpose. Systems thinking helps coordinate subcontractors, suppliers, and the many trades involved in any project. These features are the foundations for organizing projects to advance performance beyond typically achieved results. The goal is to tabulate these extracted principles in the database for use in the development of the diagnostic tool and the Decision Support System (DSS) in this research.

2.3.1.2 Lean Construction

Lean thinking starts with customer-defined value and advocates designing organization structures and processes to meet customer requirements best. Lean efforts aim to eliminate all the steps in producing goods or services that do not add value to the final customer. The team needs to keep only the steps and activities for which the customer is willing to pay. In lean thinking, first, a company must meet customer requirements, and at the same time, maximize its profit. The improvement team achieves the objective of increasing profit by focusing on reducing costs using Equation 2.1.

$$\textbf{Profit} = \textbf{Selling Price} - \textbf{Cost} \quad . \quad . \quad . \quad . \quad (2.1)$$

Toyota realized that the market dictates the selling price, and the company cannot increase price. Therefore, the only way available to Toyota to increase profit is to decrease costs. In lean thinking the objective of cost reduction is attained by focusing on a system-view of an organization. Toyota crystalized lean thinking into the following five guidelines.

a. Specify value from the customer's perspective
b. Map the value streams, and remove wasteful and non-value adding activities
c. Flow – make the processes flow without stoppage or disruption
d. Pull – let customer order pull every task and material when a customer order is received
e. Perfection – continuously improve processes to perfection

Value, flow, pull, and continuous improvement are threshold concepts that, if implemented well, result in the effectiveness of the implementation of lean.

Koskela pioneered the adoption of lean principles from manufacturing to construction and forwarded the Transformation - Flow - Value (TFV) theory of construction (Koskela, 2000). He contends that construction is a combination of the transformation of inputs (materials and information), the flow of tasks and information, and value creation for the client and delivery by having the output conform to the customer's requirements.

Different researchers contributed to the adoption of different elements of the five lean guidelines to construction. Greg Howell and Glen Ballard identified the key "item" flowing on a project as the work that is completed by one operator and handed off to his/her successor downstream (Lichtig, 2006). Like just-in-time deliveries of materials, one trade delivers work it completes to downstream performers. Finding that the theories of dependence and variation largely explain what happens on a project when reliable workflow between trades is not maintained, Howell and Ballard developed a planning system that enables a project team to focus its attention on causing work to flow across the value stream (Lichtig, 2006). Patty contends that this is the theory, but the application has mostly focused on construction, the prime contractor operations, and a few major suppliers. The deficiency in efficacy is that the trust in the mutual benefit is insufficient to support flow across the value stream. Clients are seldom involved, and less often do they see the benefits (Patty & Denton, 2010). Foremen and the superintendents do advanced task planning as the last planners. The goal of task-level planning is to create a reliable workflow by collaboratively developing look ahead, weekly and daily work plan for a segment of the work.

Goldratt separately illustrated the importance of workflow reliability on throughput in his book entitled "The Goal" (Goldratt and Cox, 2004). Creating flow, whether of materials, workforce, equipment, or information, exposes the inefficiencies that demand immediate actions. Foremen and superintendents should network only tasks ready for execution on the moving window of execution planning (the 4 to 6 weeks look ahead plan). The work of a business is then in making and keeping commitments (Macomber, 2008).

Koskela and Sharpe (1994) carried out research specifically on improvement and suggested carrying out construction process flow analysis to see options for improvement. They contended this results in improvement by elimination or reduction of activities that do not add value in flow processes and increased output value from the customer point of view through measurement of value loss. They stressed that the reduction of variability and cycle time as very important to effect improvement. The identification of non-value adding activities may be time-consuming, and measurement of value loss may be problematic, and it may be more productive to focus on all available top priority improvement opportunities.

Serpell et al. (1996) applied lean principles to develop a framework for construction improvement and waste reduction shown in Figure 2.17 and applied it in a three-year consultancy and research project on housing construction projects. The construction projects consist of a 324-unit low-income housing project and a 2030-unit mid-income housing project in Chile. Table 2-9 shows the benefits accrued from applying the improvement effort, which shows the effectiveness of lean principles.

Table 2-9 Summary of benefits

Construction Project	Selected Direct and Expected Benefits
Low-income housing project with a total of 324 units. (3 months of research time)	• 10% increase of productive labour time • 40% increase in productivity of concreting crews • Improved construction methods • Reduction of rework
Mid-income housing project with a total of 30 units (2 months of research time)	• Reduction of wasted time • Increase of productivity through a better balance between construction operations • Reduction of construction major cycle time
Mid-income housing project with a total of 2000 units (1 year of research time)	• 25% increase of productive labour time • Reduction of housing units construction costs • 70% reduction of clients' complaints due to low quality of product

(Source: Serpell et al., 1996)

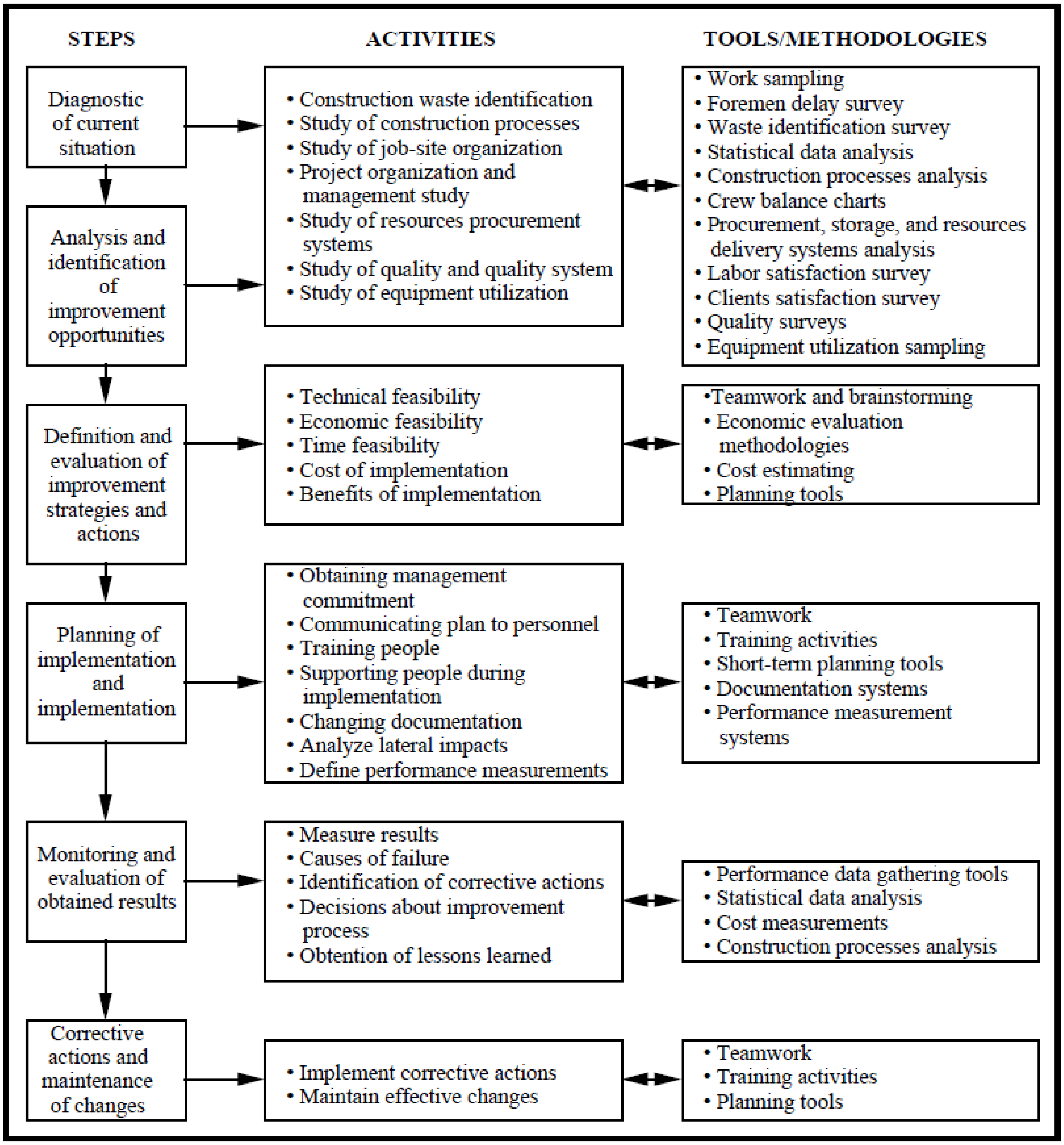


Figure 2.17 Improvement methodology

(Source: Serpell et al., 1996)

Serpell et al. (1996) developed the framework for construction projects, but it can apply to the company level with minor modifications.

Process orientation is effective in improving performance but two of the lean thinking guidelines, flow and pull, only suggest organizational design and process orientation for realization, but these lean principles do not explicitly emphasize process orientation. Subsection 2.1.2 discussed process orientation and its benefits.

A model that emphasizes company structuring for customer value creation that can result in transformational change is business model innovation. Business model innovation can significantly improve profitability, but the construction industry did not make use of this concept (Pekuri et al., 2013). Business models are an essential part of successful businesses as they define the way companies create value for their customers and subsequently generate profit from their operations (Pekuri et al., 2013).

2.3.1.3 Business Model Innovation

Conventional construction company business models neglect the customer value creation and revolve around internal efficiency (Pekuri, 2015). Business model innovation is more useful to success than product or service innovation (Pekuri et al., 2014a). A business model reflects management's vision about what customers need and how to organize the company to meet those needs best (Pekuri et al., 2014b). The most commonly used definition for business model is that by Osterwalder and Pigneur (2009), which defines a business model as the description of the rationale of how an organization captures, creates, and delivers value. Osterwalder and Pigneur forwarded the following nine building blocks to aid the preparation of business models: value propositions, key activities, key resources, key partners, customer segments, channels, customer relationships, cost structures, and revenue streams.

Pekuri et al. (2013) interviewed managers in construction companies in Finland to explore how business model concepts are understood. The interview results indicate that the managers in construction companies do neither understand the concept properly nor exploit any similar value creation analysis in their business. Pekuri et al. (2014a) argued that lean must be adopted as a new business model to make transformational change successful. Some people consider lean as an operational level transformation, Pekuri et al. (2013) consider it as a business model, that links operations with strategies.

The most appropriate and innovative business model is derived from company strategies to best serve the target clients. The business model is subordinate to strategy and helps implement company strategy; hence the business model is an enabler of strategy implementation (Stampfl, 2016). The business model helps an organization get organized efficiently around value creation and customer satisfaction. Companies can develop business methods based on a business model and can patent the business methods to gain a competitive edge if they pass the tests of patentability (USPTO, 2016). A company can synergistically use a business model with value innovation to gain even more edge. Value innovation provides a systematic and efficient way to maximize customer value, minimize competition from rivals, and maximize profit at the same time.

2.3.1.4 Value Innovation

Value innovation provides a systematic and efficient strategic change initiative to maximize customer value and reduce the cost of their operations, thereby minimizing competition from rivals and maximizing profit simultaneously, which construction companies badly need.

In order to reconstruct customer value elements, Kim and Mauborgne (2015) suggested the use of a four actions framework, which consists of:

- **Eliminate**: Which factors can a company eliminate that the industry has long competed on to add value by reducing cost?
- **Reduce**: Which factors should a company reduce well below the industry standard to add value by reducing cost?
- **Raise**: Which factors should the company raise well above industry standard to add value?
- **Create**: Which factors should the company create that the industry has never offered to add value to the customers?

Realized reality of service relative to the expectations determines the client's evaluation of value. The Theory of Service Relativity states that a client's perception of value is equal to the delivered reality (R) less expectations (E), or $V = R - E$ (Albrecht, 1998). Aggressively managing client expectations through communications is a construction company's best opportunity to influence the client's perception of value (Millhollan, 2008).

Value curves are useful for focusing efforts on the crucial factors with the most impact, and the purpose of the curves is to highlight the parameters most valued by clients in a future product and to compare them with those of existing products. From the discrepancy between the two curves emerge opportunities for improvement and innovation (Perez et al., 2010). The goal of value innovation is not only to stay ahead of the competition but also to make competition irrelevant by creating uncontested market space (Kim and Mauborgne, 2015). No research is done so far on the application and adoption of these powerful principles to construction.

Once the company has identified parameters most valued by clients, it would be advantageous to translate those into a business model and organizational design to create the most value for clients and meet their needs.

2.3.1.5 Total Quality Management (TQM) and Quality Management System

TQM is an organization-wide philosophy of continuously improving the quality of company's products and services and the quality of its processes, to meet customer needs and exceed customer expectations. Construction companies need this strategic focus because the attainment of acceptable levels of quality in the construction industry has long been a challenge (Stewart and Spencer, 2006). The Construction Industry Institute (CII) estimates that in the United States, one rework accounted for 10% of the project cost (Forbes and Ahmed, 2011). About 80% of projects worldwide do not meet client requirements in one or more substantive ways (Jones and Saad, 2003). It is difficult for a construction company to survive in the long-term without meeting client requirements. Meeting client requirements entails that everyone in the organization plays a role in providing quality products and services. Even the customers themselves and suppliers are part of the TQM. TQM is attained and becomes part of the organization's culture to satisfy and even exceed customer expectations when all employees practice the following five principles:

- Produce quality work the first time
- Focus on the customer
- Have a strategic approach to improvement
- Improve continuously
- Encourage mutual respect and teamwork

One of the most commonly used quality management systems is the ISO quality management systems. ISO quality management principles in order of priority are (ISO 9001: 2015):

- Customer focus
- Leadership
- Engagement of people
- Process approach

- Improvement
- Evidence-based decision making
- Relationship management

These principles have the primary goal of meeting customer requirements. They overlap with lean thinking, business model innovation, and value innovation and require a strategic approach to improvement. These principles will also be tabulated in the database of the decision support system.

2.3.2 Organizational and Process Improvement Approaches based on Theory of Constraints and Change Management

Improvement using the theory of constraints advocates beginning with the constraint that most limits throughput. Removing or elevating the constraint creates substantial improvement to the value stream in a short time, which is beneficial for igniting the required employee momentum and support. Methods under this category are the theory of constraints, change management, and improvement science.

2.3.2.1 The Theory of Constraints

Goldratt forwarded the theory of constraints, which is a very effective method with significant performance improvement in manufacturing and service companies. The theory of constraints is a method that focuses on profit improvement by systematizing and taking a scientific approach to work process improvement. The theory of constraints bases its analysis on the fact that inherent simplicity underlies every complex system, and the best way to manage, control and improve the system is by capitalizing on its inherent simplicity (Goldratt and Cox, 2004). It hypothesizes that every complex system consists of multiple linked activities, one of which constrains the entire system. This method conceptualizes most businesses as a linked set of processes that transform inputs into saleable outputs. Since the focus only needs to be on the constraints, implementing the theory of constraints can result in substantial improvement without tying up many resources, showing results in about three months of effort.

Any business' goal is to make profit in the short term and the long term and achieve performance improvement to maintain competitiveness. The theory of constraints provides a robust set of tools for helping to achieve this goal such as:

The Five Focusing Steps

The Thinking Processes

Throughput accounting

The Five Focusing Steps

Goldratt gives a five-step process that a change agent can follow to strengthen the weakest link or links. In his book entitled "*The Goal,"* Goldratt proves that most organizations have very few actual constraints (Goldratt and Cox, 2004). The five focusing steps are:

Step 1. Identify the system's bottlenecks

Step 2. Decide how to remove the bottlenecks if possible

Step 3. Elevate the system's constraints (increase the capacity of the bottlenecks)

Step 4. Subordinate everything else so that they march or flow to the tune of the constraints

Step 5. If bottleneck has moved to another location after elevating the current one, go back to step 1

The five focusing steps are cyclical processes and provide a systematic and focused approach to performance improvement.

The Thinking Processes

The Theory of Constraints includes a sophisticated problem-solving methodology called the Thinking Processes. The Thinking Processes are scientific "cause and effect" tools that analyze many interdependencies in complex systems. The problem solving involves first identifying the root causes of undesirable effects, and then removing the undesirable effects without creating new ones.

Thinking processes answer the following three questions:

- What needs to be changed? i.e., what is
- What should it change to? i.e., what should be
- What actions will cause change? i.e., how to close the gap

Throughput Accounting

Throughput accounting is an alternative accounting methodology that attempts to eliminate harmful distortions introduced by traditional accounting practices – that consider inventory as assets. Treating inventory as assets often drive undesirable behavior at companies – producing items that are not truly needed. Accumulating inventory inflates assets and generates a "paper profit" based on the inventory that may or may not ever is sold (e.g., due to obsolescence), and that incurs cost as it sits in storage. On the other hand, the theory of constraints considers inventory as a liability, because inventory ties up cash that could be used elsewhere more productively.

The theory of constraints does not explicitly account for external environmental influences. It also assumes that all problems lend to cause-effect analysis, including adaptive problems such as human resource problems and limiting human behavior.

A comparison of lean principles and the theory of constraints may be insightful. Where the theory of constraints starts by identifying constraints, lean thinking instructs the change agent to rethink the notion of value first. By walking the value stream, from finished goods to raw materials, and repeatedly asking: "Are my customers willing to pay for this?" the change agent identifies opportunities for eliminating waste from the system. Further, value stream mapping is a handy and powerful tool for determining which areas of the system to improve. As well, the future state map keeps the organization focused on moving towards a common goal.

Diagnostic framework and decision support system in this research uses cause-effect analysis in identifying bottlenecks and determine their root causes. The application of rapid improvement principles and best practices eliminate the root causes of the bottlenecks to solve the problem experienced by a company.

Most of the wicked problems are mainly related to human resources performance, which does not follow cause-effect relations. Principles of change management in a social system are appropriate for such problems, which Subsection 2.3.2.2 discusses.

2.3.2.2 Change Management and Organization Development

Human resources are the most critical but the most complex to manage (van Tiem et al., 2012; Sivusuo et al., 2018).

Lean construction does not explicitly emphasize human resources management except some lean rapid improvement principles touching upon human resources like trust, mutual benefit, engagement of people, respect for people, and never blaming the employees for defect or fault because 80% of the problems are due to poor management decisions (Deming,). The theory of constraints, business model innovation, and value innovation do not consider human resources and deal with only technical aspects. TQM and quality management system touch upon human resources tangentially by such statements as encourage mutual respect and teamwork, and engagement of people.

Researchers have done work in two main areas on change management and organization development (OD): diagnostic organization development and dialogic organization development.

Kurt Lewin's and Ron Lippitt's change theories developed in the 1940s and 1950s form the basis for diagnostic organization development (Jones and Brazzel, 2014). Organizations are considered open systems, which depend on the environment for inputs. In this model, people used analogies of organizations such as machines and the human body where the expert and doctor collect data, diagnose, and give feedback on "as is" and intervenes to ameliorate the problems using cause and effect analysis (Bushe and Marshak, 2015). Change is conceptualized as a planned process in which the change agent "unfreezes" a current social equilibrium, "moving" the company or unit to a new and more desirable future equilibrium that will then be "refrozen" to help sustain the change. A crucial aspect of planned change is action research that includes "diagnosis" of the existing situation to know where and how to intervene to induce movement in the direction of the desired state (Jones and Brazzel, 2014). The failure rate of social change and improvement initiatives in organizations is high (McFillen et al., 2013) because most problems that involved people are complex adaptive types (Schein, 2015; Kegan, 2015; Lahey, 2017). Schein also reports that the commonly used solution method of problems using ideal types and benchmarking are useless in most situations because the organizational and occupational cultures could only solve their problems in terms of their cultural affordances and constraints (Schein, 2015). Diagnostic OD works well for technical problems where there is some understanding of cause-effect relationships for which use of expertise to solve the problem at hand works (Bushe and Marshak, 2015).

Dialogic organization development was developed from diagnostic OD gradually influenced by such developments as social constructionism, complexity sciences, linguistic turn in social sciences, appreciative inquiry, open systems, and others. Organizations are modeled as self-organizing entities and socially constructed realities that are created, sustained, and changed by the prevailing dialogues (conversations), narratives, and stories through which people make meaning about their experiences (Bushe and Marshak, 2015).

The change theory in dialogic OD holds that change emerges from disturbances that change the conversations (the dialogues), shaping meaning-making, and everyday thinking and behavior.

Emphasis is given to changing conversations to change mindsets and ways of thinking that lead to new behaviors. The change practices in the industry using dialogic OD involve co-inquiry, collective discovery, and generativity to foster or accelerate change by involving more and different voices, altering how and which people talk with each other, and by stimulating alternative or generative images to shape how people think about things (Bushe and Marshak, 2015). Dialogic OD focuses on solving adaptive challenges or wicked problems to which nobody knows the solution. The change agent or the sponsor forwards the problem, shows the complexity, and engages as many people and stakeholders up and down the supply chain as possible for co-inquiry and collective discovery. The solution emerges from the engagement. According to Bushe and Marshak (2015), dialogic OD assumes that changes are emergent and brings about changes by creating new conversations that:

- disrupt habits and embed meanings so that something new can emerge
- bring increased diversity into conversations so that the conversations may yield creative and innovative solutions
- motivate networks of people to suggest and try small changes that, if successful, can be leveraged into transformational change.

Transformational change results from these conversations, which help disrupt the current status quo by introducing new and generative images that allow people to see old situations from new perspectives, and change the core organizational narratives - the prevailing beliefs, stories and images that shape how people in the organization make meaning of any situation (Bushe and Marshak, 2015)

2.3.2.3 Improvement Science

Construction suffers from cost overruns, delays in projects, and quality problems. Improvement helps to make processes simpler, better, faster, and cheaper (Shingo, 1988) to help solve these problems and exploit improvement opportunities. Intervention improves quality, reduces cost, and increases reliability.

The core framework of improvement science is the Deming or PDCA cycle, a process for rapid cycles of feedback and learning from implementation of improvement, coupled with three basic questions that help drive improvement intervention:

i. What are the improvement team trying to improve or attain?

ii. How will the team know that a change results in improvement of performance?
iii. What change can improvement team make that will result in improvement?

The PDCA cycle provides a way to learn how an improvement works on a small scale before scaling it up. Other improvement science tools and processes include measurement data display and analysis strategies (such as control charts and run charts and) that reveal the extent and causes of variation within a system with "practical measurement" strategies that allow evaluation of potential improvement ideas during cycles of rapid prototyping and testing (Yeager et al., 2013). Improvement science applies at various grain sizes of a company, such as in a department, a whole organization, or a group of organizations.

Experimental science, which uses the randomized controlled trial (RCT) method, provides a gold standard for drawing causal inferences and thereby builds basic knowledge (how one causes another). However, experimental science draws causal conclusions by minimizing variation in both treatment and setting (Lipsey, 1993). Unfortunately, variation is the primary issue that the improvement team needs to understand (Bryk et al., 2011). RCT assumes the needed knowledge is "in" the implementation of the intervention and ignores the contribution of system of profound knowledge in producing success or failure. Deming advocates that all managers need to have what he called a System of Profound Knowledge, that consists of the following

- Appreciation of a system (suppliers, producers, and customers of goods and services) and understanding of the overall processes
- Knowledge of variation, its range and causes of variation in quality, and statistical sampling to measure variations
- Theory of knowledge, which he describes as the concepts explaining knowledge and the limits of what can be known.
- Knowledge of psychology: (concepts of human nature).

In contrast, improvement science treats variation in implementation and setting as essential sources of information. Improvement science provides tools to grasp and learn from variation (in both positive and negative directions) in the redesign of both the interventions and the system. As Bryk et al. (2010) note, " improvement research directs efforts toward understanding how to integrate artifacts with efficacy into varied contexts adaptively". Improvement science and experimental science thus hold different assumptions about scale-up. Experimental science assumption is that scale-up occurs through faithful implementation of a proven program in new settings. Improvement science assumes scale-up occurs through the integrating basic knowledge with system of profound knowledge pointed out earlier. Such an integration helps to build knowledge about shared ownership of improvement interventions, to build and share knowledge among practitioners, to learn from variations in practice, and to motivate frontline innovators. The organization's routines may contain some of this knowledge: Many researchers have noted that organizational and system factors crucially shape program implementation and have strongly suggested to conduct research on the factors that allow research-based knowledge to impact practice (Coburn & Stein, 2010). However, there is relatively little research in the improvement science area, which emphasizes building organization members' understanding of the problem and its causes to help buy-in to improvement interventions, identification of improvement ideas within and outside organizations, and rapid testing of promising ideas through PDCA cycles.

Like improvement science, action research also focuses on identifying, analyzing, and resolving problems in specified contexts, often using a process like the PDCA cycle to enact and study change.

2.3.3 Best Practices and Value Improving Practices

Different communities of research and practice have been promoting practices that improve the profitability and performance of construction companies by applying best practices and value improving practices. Best practices (BPs) were developed by the Construction Industry Institute (CII), which began operation in 1983 as a construction industry organization with membership consisting of owners, construction contractors, engineering firms, and research institutions across North America. Independent Project Analysis Inc. (IPA) is a private organization specializing in project evaluation and benchmarking since its inception in 1987. It developed value improving practices (VIPs).

CII promotes Best Practices (BPs) as practices that can lead to enhanced project performance. BPs address management and technical areas, including pre-project planning, alignment, change, dispute resolution, constructability, and design effectiveness (Lozon and Jergeas, 2008). The BPs consist of 17 practices listed in Table 2-10. Chapter 4 deals with the application of these BPs to different cost centers and profit centers.

Table 2-10 Construction Industry Institute's (CII's) list of Best Practices (BPs)

1. Advanced work packaging	10 Materials management
2. Alignment	11 Partnering
3. Benchmarking and metrics	12 Planning for modularization
4. Change management	13 Planning for startup
5. Constructability reviews	14 Project risk assessment
6. Dispute prevention and resolution	15 Quality management
7. Front end planning	16 Team building
8. Implementation of CII research	17 Zero accident techniques
9. Lessons learned	

(Source: CII)

IPA recommends VIPs be applied through the early phases of a project life cycle to improve the design process. VIPs focus on many technical areas, including optimization, quality, constructability, technology, and capacity (Lozon and Jergeas, 2008). The VIPs consist of 12 practices listed in Table 2-11.

Table 2-11 Independent Project Analysis Inc. (IPA's) list of Value Improving Practices (VIPs)

1. Classes of facility quality	7. Process reliability modeling
2. Constructability reviews	8. Process simplification
3. Customized standards and specifications	9. Technology selection
4. Design to capacity	10. Traditional value engineering
5. Energy optimization	11. Waste minimization
6. Predictive maintenance	12. 3D computer-aided design (CAD)

(Source: Lozon and Jergeas, 2008)

These BPs and VIPs will be used in the database as part of rapid improvement solutions to construction company problems.

2.3.4 Capability Maturity Model (CMM) Based Approach

One of the solutions approaches to low profitability, and poor performance of organizations has been the capability maturity based approach. The CMM contends that the outcome of a process is a function of the maturity of the organization and its associated processes. Sarshar et al. (2000) developed the Standardized Process Improvement for Construction Enterprises (SPICE) framework based on CMM, as discussed in Subsection 2.1.2. Sarshar et al. (2000) were inspired by Herbleb's (1994) analysis, which showed that software companies implementing the Capability Maturity Model (CMM) attained an average of 35% productivity improvement and an average of

39% post-delivery defect reduction. Sarshar et al. wanted to look into adaptation of the CMM to construction and if construction companies can attain similar results. The SPICE framework has Five levels of maturity to serve as measures of capability and as goals to be attained in improvement efforts, as discussed in Subsection 2.1.2.

Other improvement models based on CMM are the European Foundation for Quality Management (EFQM) excellence model, ISO TQM standards (ISO 9001), and International Project Management Association's excellence baseline (individual, project and organization, 2015, 2016, 2013).

2.4 Profitability Research Done at SPARC Laboratory

Before construction company-specific profitability research began at Solutions for Profitability and Assessment of Risk in Construction (SPARC) laboratory at Purdue University, profitability analysis of construction companies was conducted the same way as other general businesses without accounting for the peculiarities of construction. However, Cui (2005) says that the models used for profitability analysis were not flexible and powerful enough to lead construction companies to higher performance in the rapidly changing construction market. Further, he says that those models used historical cost data whereas, in construction, costs can change fast. Therefore, he proposed a dynamic model for profitability analysis that uses current costs and feedback to simulate changes in profit flows, considering interactions among profit centers, cost centers, and external entities such as clients, subcontractors, and suppliers. Cui's theory of dynamic profitability management consists of three interactive and integrated elements the quality characteristics (magnitude) of profit, the potential for profit, and the sustainability of profit. Tamer (2009) developed a protocol for the profitability analysis of construction companies based on Cui's system dynamics model. Tamer's work identifies the interactions between cost centers and profit centers that are not working effectively as well as the work packages that were affected and to what extent. He used a system where he assigns values of 1, 0, or -1 to interactions based on performance metrics of organizational units and skill levels of interacting entities whether each provides the expected level of support in the interaction or not. The limitation Tamer et al. (2012) identified in Cui's model is that construction companies cannot identify the sources of gain or loss of profit in an organizational unit. For example, if there is a 3% decrease in the profit margin of a project, the model can show the decrease but cannot indicate which organizational unit performance is the reason for the decrease. The protocol enables identifying the unit and interactions responsible for profit gain or loss in past projects so that corrective actions to the cost centers that were not effective could lead to improve future profitability. Tamer added a useful piece of showing profit gain or loss on WBS, which enables companies to predict their profitability for a prospective project by analyzing the profit gains or losses at a construction project level on past projects. Tamer's work does not dive deeper within a cost center or profit center for a detailed diagnosis of the flaws and does not determines the RIPs and BPs that might be most effective in addressing the situation.

The current work aims mainly at the development of a two-part excellence model for profitability improvement of construction companies, which is the topic of discussion in Chapter 3. The current research also aims at refining Tamer's work and advancing construction company profitability research further by digging deeper within a cost center or profit center for a detailed diagnosis of the problems and to apply the RIPs and BPs that might be most effective to address the situation. One of the areas that need improvement in Tamer's protocol is the discrete values of 1, 0, and -1 analyst assigns, based on skill levels of interacting entities. A detailed questionnaire serves to measure/assess company performance concerning profitability and to identify problem areas, with a diagnostic score ranging from 0-5, 0 means the improvement items are not relevant to company, 1 being poor performance and 5 being the best performance (see Table 3-2). Diagnosis areas are divided mainly into cost centers and profit centers, which further subdivides into the company, department, employee, interactions, project, and strategic initiatives in this research. The improvement team assigns scores and weights to the issues of the cost centers (company, departments, sustainability initiatives and employees) and profit centers (projects) and calculates the diagnostic score. The diagnostic score can take any rational number between 1 and 5. The diagnostic score is more accurate than the discrete 1, 0, -1 assignment. Further, the diagnostic score gives better information and can be used to rank/prioritize problem areas for further detailed analysis and improvement.

The other refinement made is that subdivisions into company, departments, projects, employees, strategic initiatives and interactions, following international society for performance improvement recommendation (van Tiem et al., 2012), provide better accuracy in the analysis (as detailed in Chapter 3). In contrast, Tamer's protocol lumps all improvement items under interactions. The other refinement made is regarding root cause analysis. Root cause analysis in this research mainly uses fishbone diagrams, and then, the root cause of each factor's failure on the fishbone diagram selected from the database. Thus, the root cause analysis in this research using fishbone diagrams and database of the root causes further refines and extends analysis forwarded by Tamer. Tamer dealt with analysis, and the analysis culminates by showing analysis results and hence does not give RIPs and BPs to ameliorate problems and bottlenecks limiting profitability. The other significant development in this research is that a two-part profitability improvement model, and strategic diagnostic tool and DSS developed in this research are instrumental in profitability improvement and management of construction companies.

Construction companies need to control risks to enhance their profitability as part of their long-term business planning (Yoon et al., 2014). Yoon et al. (2014) developed Tamer's protocol for profitability analysis and extended it further into a risk management protocol. The protocol provides a systematic way of overcoming the difficulty to analyze the probability and impact of risks associated with the inherent uncertainties in construction projects. Construction companies can utilize the risk management protocol to establish risk management strategies by evaluating the effectiveness of the relationships among cost centers, profit centers, and externals. As a result, construction companies can reap the benefits of promoting efficient organizational management, making profitable business partnerships with external entities and getting straightforward risk management guidelines for future projects.

Mahdavi (2016) developed an innovative platform and decision support system that uses a system of systems concept in an agent-based model to simulate a contractor's project portfolio's financial outcome based on predefined scenarios. The simulation uses computer software to investigate the result of parameters when the decision variables of importance are varied. It provides an economical and fast way of determining effects as compared to actual implementation. Mahdavi's analysis is scenario-based; hence, the effect of variable values outside the values in the simulation scenarios is not known. Further, he did not look into how to predictably manage and improve profitability by applying RIPs, countermeasures, and BPs. Finally, he looked into the effect of external entities on the profitability of construction firms; however, his work did not explore internal company improvement.

The last piece needed to develop the two-part excellence model for profitability improvement is a continuous improvement theoretical framework, but the question is, "Is there one?"

2.5 Does Theory of Continuous Improvement Exist?

The author planned to use a continuous improvement framework as a theoretical underpinning for this research, but he stumbled against a wall: does a theory of continuous improvement exist? Many researchers wrestled with this question (Lahy and Found, 2015; Zangwill and Kantor, 1998; Schmidt et al., 2014; Singh and Singh, 2015). One cannot answer this question as 'yes' because there is not a theory of continuous improvement forwarded in the research literature. It is also difficult to answer 'no' because there is sufficient published evidence that some tools and methods produce better results consistently, such as just in time, quality improvement initiatives, lean, six-sigma, agile, and other methods. These emanated from total quality management, just-in-time, and kaizen. Two historical origins of this continuous improvement go back to Toyota and statistical reasoning. Taiichi Ohno and Shigeo Shingo implemented just-in-time at Toyota that catalyzed a revolution in the production of a magnitude similar to Henry Ford's assembly line. The second trend is the statistical reasoning and quality movement Shewhart conceived in the 1920s as the Shewhart Cycle (Plan-Do-Study-Act (PDSA)), which monitors and forecasts improvement by a quantitative approach. Its contemporary renaissance occurred with Deming's lecture of 1950 to Japanese company executives in which the importance of business process measurement and analysis is highlighted to identify the sources of variations that cause the processes to deviate from customer requirements. He also highlighted the usefulness of Shewhart's cycle, which he popularized as Plan-Do-Check-Act cycle, then after called Deming's cycle. These methodologies often do not explain how or why their mechanisms work and lack underpinnings by laws. Koskela (2000) says that they are developed heuristically by trial and error. Lahy and Found (2015) and Zangwill and Kantor (1998) say that there is a theory of continuous improvement, but not yet discovered. They went further and proposed initial theory as a starting point for further development into a comprehensive theory that explains phenomena, and helps predict performance as a function of continuous improvement interventions. By far, Lahy and Found's work is exhaustive and more developed as a starting theory of continuous improvement.

Lahy and Found (2015) conducted an extensive systematic literature review on the topic in search of an underlying theory of continuous improvement. They started with the lack of consensus on the definition of the term 'continuous improvement' and pointed out six ambiguities around the term in the published literature. They proposed a comprehensive definition of the term 'continuous improvement' to overcome the six ambiguities they identified. They defined the term as "***All***

coordinated efforts designed to accelerate the achievement of specified organizational objectives through change, learning and innovation" (Lahy and Found, 2015). Then, they used Schmenner and Swink's (1998) five criteria for a good theory to forward an initial theory of continuous improvement. The five criteria (listed below a-e in italics) and their application by Lahy and Found (2015) follows:

a. *The phenomenon to explain is clearly defined. Unambiguous measures enhance this clarity*.

   The researchers are seeking to explain the existence of an underlying theory of continuous improvement. They say that continuous improvement is more of a framework and mindset than a set of tools or techniques. Innovation and learning are part of continuous improvement. Continuous improvement can be at a team level, small group level, or organization-wide (with or without top management support) and 'coordinated,' which means it can be a battery of improvement philosophies opposed to an individual philosophy. They believe continuous improvement is a means to an end, and they suggested the unambiguous measure to use is "how well is our continuous improvement approach delivering the organizational objectives it set out to achieve" and not "how well is the organization doing continuous improvement."

b. *The purpose is to describe some inference about underlying regularities from empirical observations or logical analysis.*

   Despite the lack of an agreement on definition of continuous improvement, several articles have reported observed regularities and common themes in the published literature in the area of continuous improvement. There has been considerable research into identifying standard practices and regularities of continuous improvement (Lahy and Found, 2015). In some cases, observations from the practices show some patterns in specific organizations; for example, the collection and practices used by Toyota form the foundations for a grouping of continuous improvement ideas, which can be broadly classified under the term "lean." Similarly, the improvement practices observed at Motorola can be broadly classified as "Six-sigma." Other observed regularities regarding continuous improvement have been grouped under different titles, such as "TQM," "Agile," or "Systems Thinking."

c. *There should be precise statements describing these regularities or laws. Mathematical statements of the laws will help the precision*.

Schmenner and Swink (1997) state that "as researchers find more and more evidence that supports the hypotheses, especially evidence of different kinds, then they can often organize the hypotheses into laws". Lahy and Found (2015) contend that this holds in the case of continuous improvement, and they proposed five initial laws of continuous improvement.

i. ***Law of organizational focus*** - organizations conduct continuous improvement to achieve specified organizational objectives

ii. ***Law of quality*** - Performance (defined by the ability to meet organizational objectives) will be improved as the quality is improved and waste declines. This Law is from Schmenner and Swink's (1998) theory of operations.

iii. ***Law of the experience curve*** - This Law states that performance of people improves over time with experience at carrying out the processes. This law applies unless there is lack of incentive to improve or worse yet, disincentive. For example, lack of employment after completion of project may come into play reducing the effect of productivity gain from experience, especially towards end of project for temporary employees provided lack of employment after completion of project does not come into play reducing the effect of productivity gain from experience, especially towards end of projects for temporary employees. Zangwill and Kantor (1998) have researched this Law in more detail who proposed a mathematical statement to define this Law, the Continuous Improvement Differential Equation. They used the Lotka-Volterra approach of predators and prey. Here the prey is the inefficiencies, wastes, errors that impair the operations of the process. The predators are improvement teams and management because they are attempting to eradicate the inefficiencies and wastes to improve the system.

iv. ***Law of contiguity and cumulative capabilities*** - This Law indicates that the more skills and ideas organizations bring together from different sources, the higher potential for new ideas for continuous improvement. Mobilization of cumulative capabilities links the theory to learning, in that the more learning and knowledge the organization coordinates, the more likely the improvements will be to achieve the specified objectives.

v. ***The Law of diminishing returns*** - indicates that performance gain versus continuous improvement follows shape of a typical S-curve. This is to say that initially, improvement may have a significant impact on performance, but as one contiues with improvement, it will become increasingly difficult to maintain the same rate of improvement over time. Figure 2.18 shows such an S-curve.

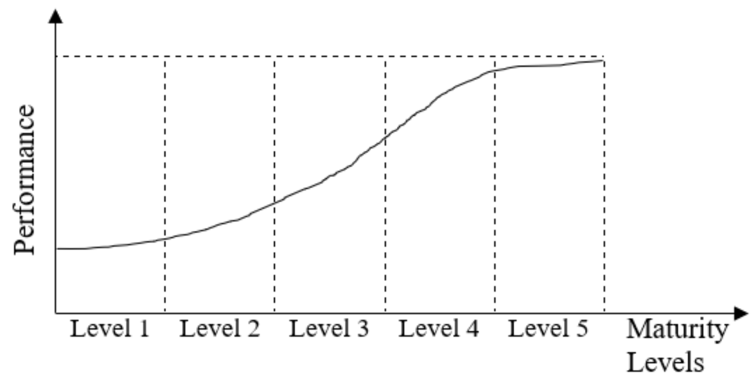


Figure 2.18 Performance as a function of continuous improvement from one maturity level to higher maturity levels.

(Source: Modified from that in the website of SPI - https://spiresearch.com/ps-maturity/)

Figure 2.18 shows only kaizen type of improvement, but Lahy and Found used the term continuous improvement for both kaizen and breakthrough (radical) improvement. In the case of a breakthrough, there will be a quantum jump in the S-curve, as shown in Figure 2.19.

d. The theory should indicate a mechanism - that explains why the laws work as they do and how, and in which ways, the laws may be subject to limitations.

Lahy and Found (2015) say that the closest mechanism they could find for continuous improvement is in the more established methodologies such as lean and six-sigma. However, these methodologies often do not explain how nor why the mechanisms work, nor are they underpinned with laws. They proposed the mechanism in Figure 2.20 as an initial basis for the development of a continuous improvement mechanism.

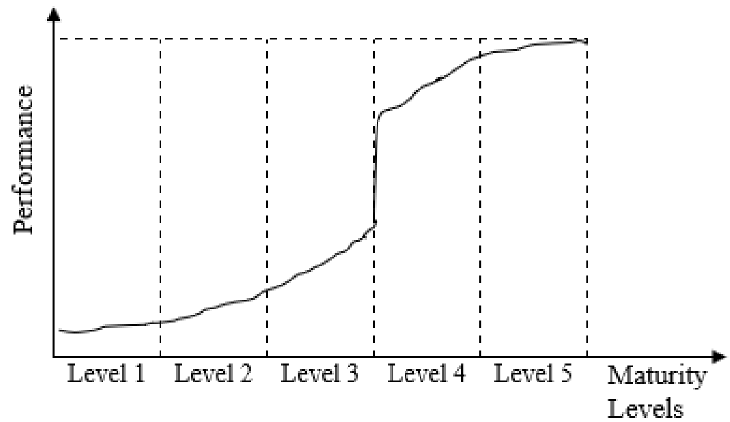


Figure 2.19 A jump in S-curve in the case of radical improvement

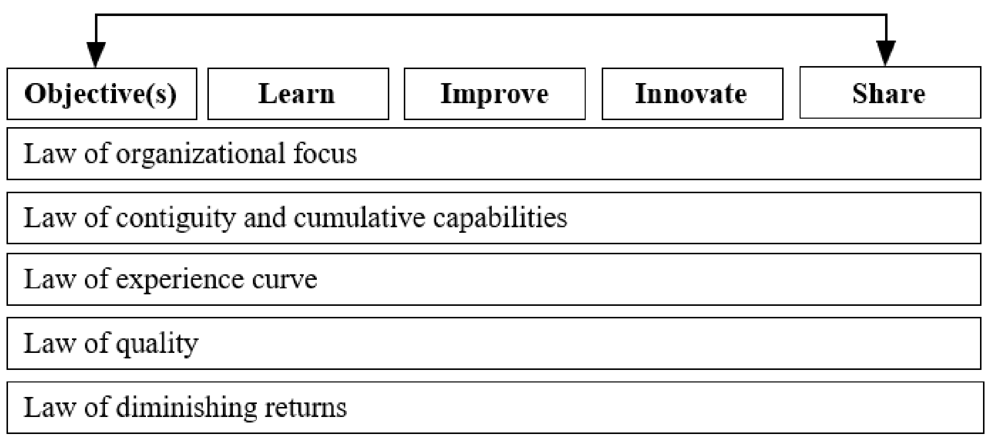


Figure 2.20 Lahy's and Found's proposed mechanism for the theory of continuous improvement (source: Lahy and Found, 2015)

e. *The more powerful the theory, the more likely it will unify various laws and generate predictions or implications that researchers can test with data.*
   It will be possible to mathematically test the laws and use them to generate predictions only after the theory and laws are established and understood. They recommended further research be done and input from practitioners be incorporated to develop a robust theory of continuous improvement.

Singh and Singh (2015) pointed out some important aspects of continuous improvement (CI) in their systematic literature review on the topic. They said CI is an integrative management philosophy aimed at continuously improving the quality of products, services, and processes to achieve customer satisfaction. To continuously improve performance, Schmidt et al. (2014) recommended carrying out PDCA iteratively and recursively at different levels of the company (company, department, and team levels). Such a multilevel application of CI requires the application of PDCA cycles within PDCA cycles. Figure 2.21 shows the recursive and iterative application of PDCA.

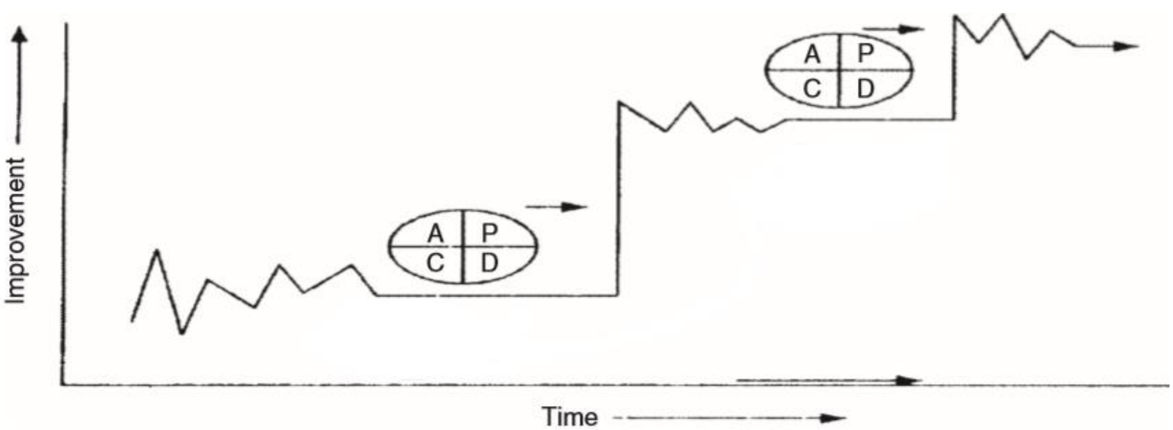


Figure 2.21 Recursive and iterative application of Plan-Do-Check-Act (PDCA) cycles

(Source: Singh and Singh, 2015)

Singh and Singh (2015) summarized the principles underpinning the CI philosophy as:

a. Customer-driven organization
b. Leadership – the need of leaders to establish unity of purpose and direction, and to involve people in achieving organizational goals
c. People participation
d. Process approach
e. Evidence-based decision making
f. Partnership development.

Further, the knowledge base and problem-solving activities drive CI (Schroeder, 1993). FMEA will also be used in this research because it is one of the enablers of CI (Davadasan et al., 2003).

These points by Singh and Singh (2015) may be used with those proposed by Lahy and Found (2015) as an initial theory of CI to develop a two-part excellence model of profitability improvement in Chapter 3.

2.6 Summary of Chapter 2

The literature reviewed in this chapter can be summarized and synthesized by a fulcrum-lever analogy, as shown in Figure 2.22. The negative effect of internal and external challenges construction companies face on profitability that resulted in specific challenges regarding profitability is shown on the negative arm of the fulcrum. Applying the high impact principles, concepts, and guidelines extracted from the literature listed on the positive arm helps overcome the adverse effects of the challenges that help improve the profitability from the current net profit of 2-3 percent to a higher value.

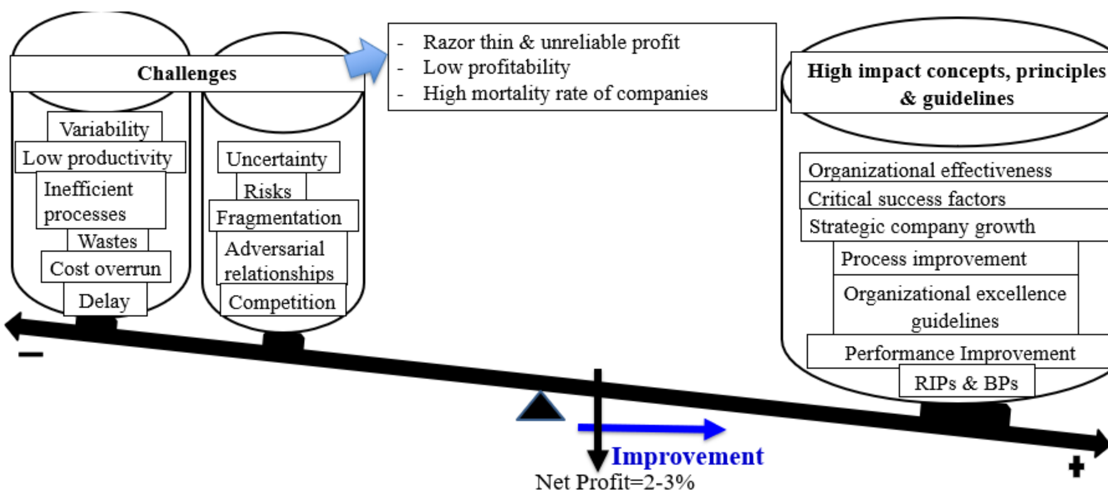


Figure 2.22 Negative and positive effects on profitability and improvement of profitability of construction companies

Chapter 3 will give the research methodology and detail the research process to use to develop a two-part excellence model of profitability improvement for construction companies. Further, Chapter 3 will also deal with the development of the diagnostic tool and DSS based on the two-part excellence model.

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter introduces the methodology used to conduct the research and gives the blueprint of the research process from inception to completion. The author conducted the research in five main phases shown in Figure 3.1. In the first phase, an extensive literature review is conducted on challenges and problems limiting construction company profitability and high impact literature synthesized to forward solutions. The author had to modify the original data collection plan in the second phase, and he synthesized the data collected from literature into different usable forms for the forwarded solutions. Phase three gives the methodology used to develop the two-part model of excellence for the profitability improvement of construction companies, which he translated into the diagnostic tool and Decision Support System in Phase four. Finally, in phase five, the researcher dealt with the validation of the two-part profitability excellence model, and diagnostic tool and DSS.

A section is devoted to the treatment of each phase. Section 3.2 discusses Phase II, Section 3.3 deals with Phase III, Section 3.4 is devoted to Phase IV, and finally, Section 3.5 treats Phase V.

3.2 Data Collection

The original research plan included data collection from companies, data analysis, and its use to refine the database of RIPs and BPs. The original research plan uses the difference between KPIs' target values and the actual values of KPIs to identify performance gaps. Then Delphi's study would be used to rank RIPs and BPs based on their influence on KPIs and the database of RIPs and BPs refined with weights assigned to RIPs and BPS based on rank. Accordingly, a questionnaire survey was designed to determine KPIs companies use and the target values. The researcher contacted 588 highway and civil construction companies in the U. S. to fill the questionnaire through email and telephone calls. Only three responses were received. The second country the author tried was Ethiopia. The author asked 40 highway and civil construction companies in Ethiopia to fill the

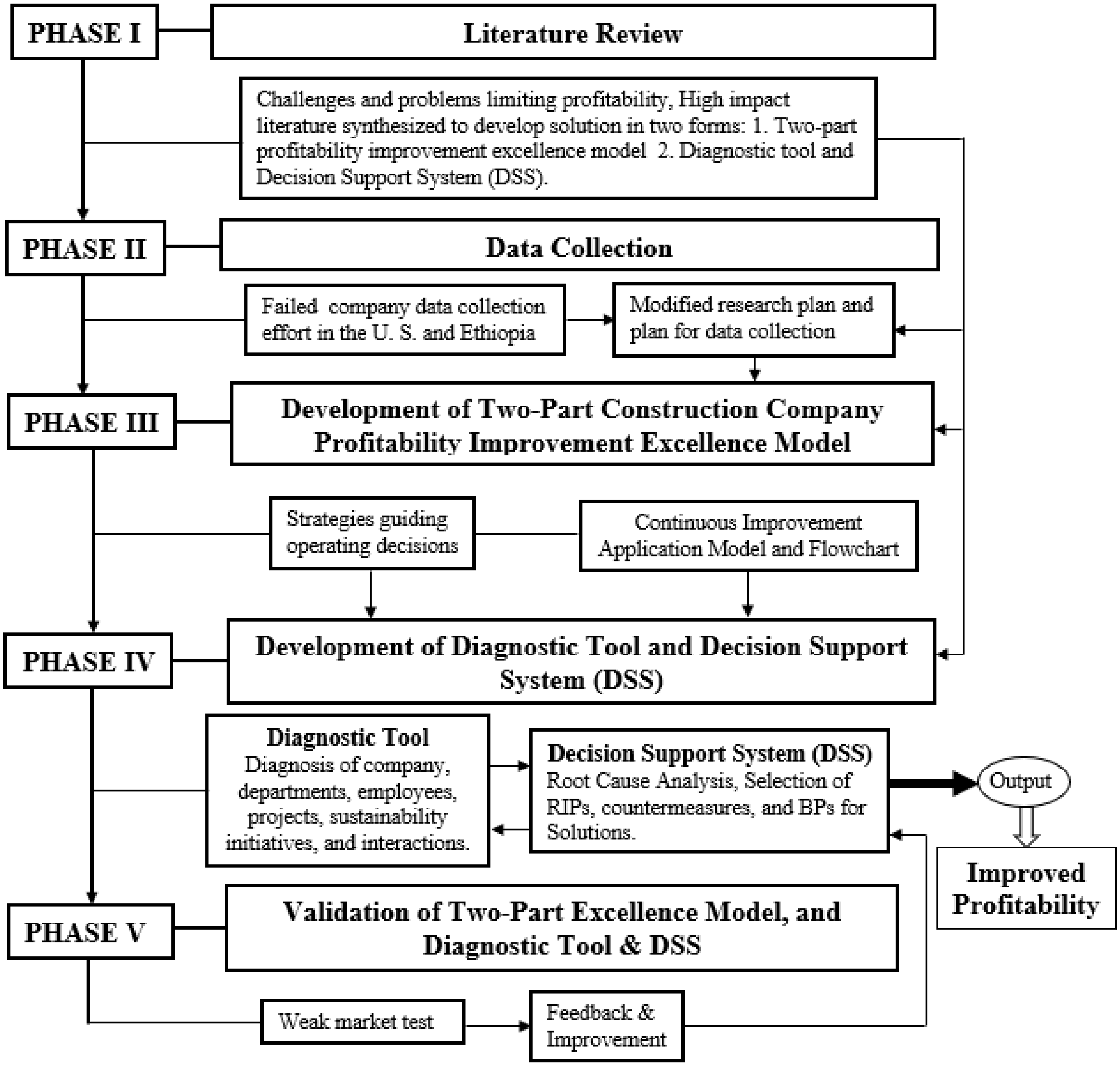


Figure 3.1 Research procedure

Questionnaire. Nineteen responses were received. Summary statistics show that there is not as such the practice of performance measurement using KPIs. There is no knowledge about critical success factors either. Delphi study could not be carried out because there are not as such established KPIs in use. The absence of established KPIs and the practice of performance measurement using KPIs necessitated a change in the research plan.

The modified research plan was to use a diagnostic questionnaire to identify performance gaps and problem areas. High impact concepts, principles, RIPs and BPs from the literature were used as data to create the diagnostic questionnaire. The other change is that high impact concepts, principles, RIPs, and BPs extracted from the extensive literature review are used as the input data to prepare improvement artifacts such as process flow diagrams and fishbone diagrams, and to prepare a database of root causes, RIPs, countermeasures, and BPs (summarized in Table 5-5). Further, the research uses high impact principles and concepts synthesized from the literature to develop a two-part excellence model for construction company profitability improvement.

3.3 Methodology for Development of a Two-Part Construction Company Profitability Improvement Model

Continuous improvement is the theoretical framework that guides the development of a profitability improvement model to solve the problem of razor-thin profit and the low profitability of construction firms. Currently, there is no underlying theory of continuous improvement that meets the criteria for a good theory, as defined by Schmenner and Swink (1998). It is wiser to use the initial theory proposed by Lahy and Found (2015) and use suggestions by Singh and Singh (2015) discussed in Section 2.5. Therefore, the author assumes that the five laws of continuous improvement apply, and profitability improvement that will be attained follows the S-curve shown in Figure 2.18.

The challenges, problems, and bottlenecks from the literature are the starting points for the development of the model constructs (Figures 3.4 and 3.5) to address the research questions presented in Section 1.4. The internal and external challenges construction companies face, which forced companies to suffer from razor-thin and unreliable profit, low profitability, and high mortality rates, can be overcome by applying high impact concepts, principles, and guidelines to develop a model using the methodology outlined below. The model applies the high impact principles to company, department, interactions, employee, sustainability issues, and projects using continuous improvement tool iteratively and recursively to improve profitability from the current net value of 2-3 percent to a higher value. The idealized conceptual framework shown in Figure 3.2 captures this mechanism.

The following procedure is used to construct the idealized conceptual framework in Figure 3.2

- Continuous Improvement (CI) framework
- The adverse effects of challenges on profitability is captured by the weights of the challenges moving the lever down

- The impact of high-impact principles and guidelines on improving profitability is captured by the weight of principles moving the positive profitability arm of the lever down
- A lever and fulcrum analogy to show the negative and positive effects on profitability
- The positive effect should be greater than the negative effect for profitability improvement
- The high impact principles and guidelines will be applied iteratively to improve the company, departments, interactions, employee, sustainability and project performance to improve profitability

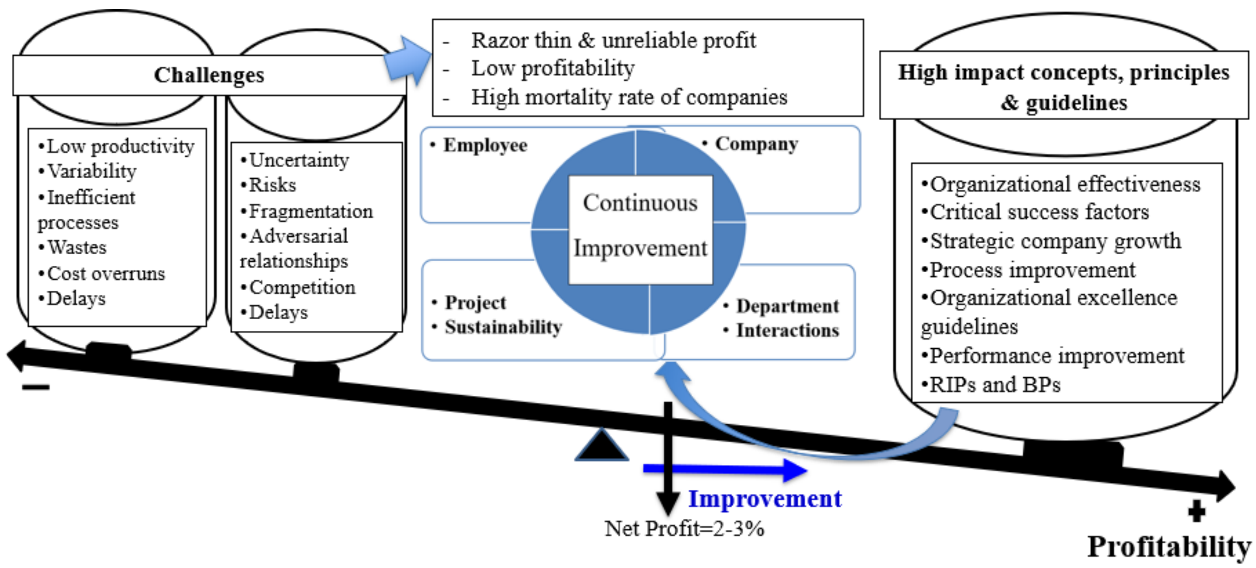


Figure 3.2 Idealized conceptual framework used in developing the two-part profitability improvement excellence model and DSS

Research questions and the nature of the research dictates the choice of research methods. The literature classifies research methods in different ways. One general approach is classification into pure and applied research. Kasanen et al. (1993) Kasanen et al. (1993) say that a constructive applied research approach is a research procedure that solves practical problems managers face by producing novel constructs such as models, diagrams, and plans. The characteristic of applied studies is the production of new knowledge in the form of normative applications. Technical norms are forms of practical reasoning. Kasanen et al. (1993) say that there are several examples of applied constructive studies in technical sciences, clinical medicine, and operations research. The creation of Braille alphabets, the development of computer languages, the development of new pharmaceuticals, and new treatment for a disease are good examples of constructs. Examples of management constructs are return on investment and activity-based costing. The purposes of constructive research are to solve practical problems and add new knowledge simultaneously. The practical problem the author is trying to solve in this research is the razor-thin profit and low profitability of construction firms. The author found the constructive research approach to be the most suitable one to conduct this kind of research. In the constructive method used in this research, a suite of methods and techniques are pulled together and integrated in a new way to construct a two-part model of excellence for profitability improvement of construction companies that forms the basis for the diagnostic tool and decision support system. The author applied continuous improvement iteratively and recursively to guide the development of the excellence model. The model construct is developed after many iterations, and Figures 3.4 and 3.5 show the latest version.

Every problem solving is not constructive research. Kasanen et al. (1993) say that four elements of constructive research distinguish it from scientific problem solving and consulting shown in Figure 3.3:

- The practical relevance of the problem to be solved
- Use of available theoretical knowledge to build a construct that solves the problem at hand
- Novelty and contribution of the construct to theoretical knowledge, and
- The practical usefulness of the solution in the industry.

According to Kasanen et al. (1993), Labro and Tuomela (2003), Lukka (2000), there are six crucial steps in the constructive research approach:

1. to find a practically relevant problem, which also has research potential
2. to obtain a profound understanding of the topic
3. to innovate, iterate and construct a theoretically grounded solution idea
4. to implement the solution in practice and test whether it works as expected
5. to examine the scope of applicability of the solution in the industry and
6. to show the research contribution to the body of knowledge and the theoretical connections.

Figure 3.3 illustrates the six steps of the constructive research approach grouped into four distinguishing elements. The arrows show the time that elapses in carrying out each step. Most steps in Figure 3.3 are partly overlapping with the previous and following steps. The second step – obtaining a profound understanding of the topic and the third step - showing the theoretical contribution - continue throughout the whole research process.

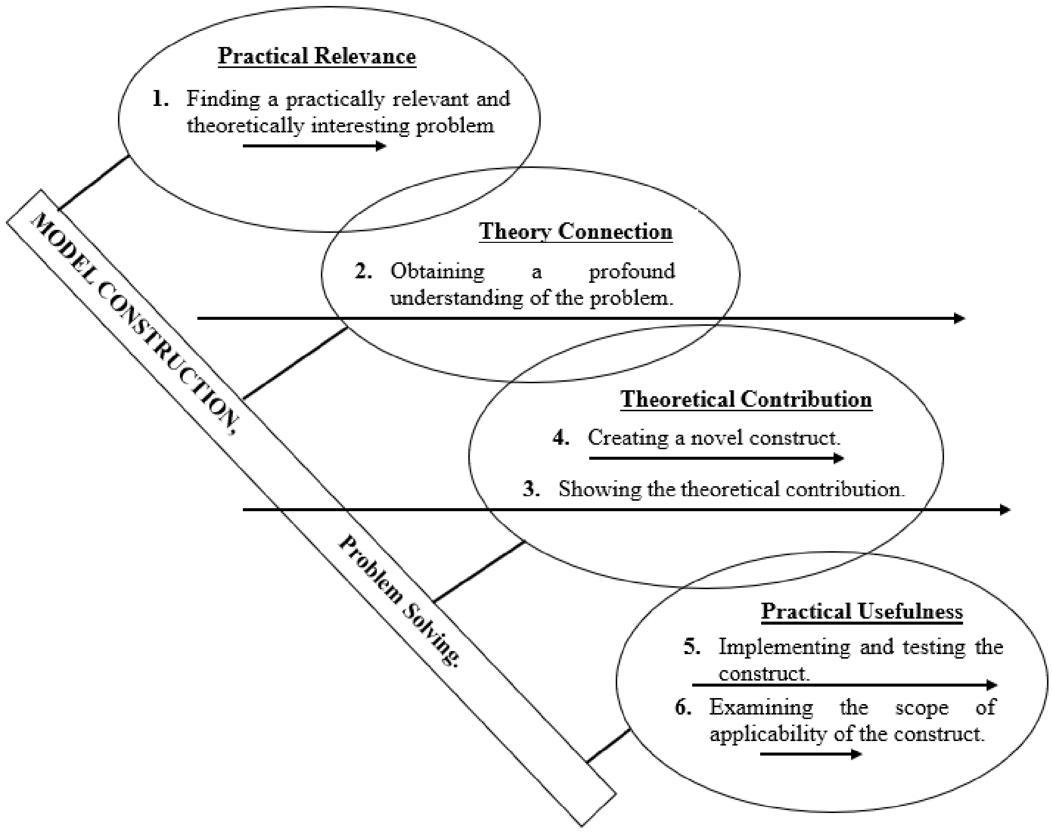


Figure 3.3 The four elements and six steps of the constructive research approach
(Source: Summarized from Kasanen et al., 1993; Lindholm 2008; Labro and Tuomela 2003)

The development of the model of excellence for profitability improvement is done in two major parts: strategies guiding operating decisions (Figure 3.4), and recursive and iterative continuous improvement application model and flowchart to guide performance improvement (Figure 3.5) that would lead to profitability improvement.

3.3.1 High Impact Strategic, Tactical and Operational Profitability Improvement Actions

Every action in a construction company has an effect on the profitability of a company but to varying degrees. The literature reviewed thus far is synthesized and distilled down into high impact profitability improvement strategies and operational decisions shown in Figure 3.4 for faster and effective profitability improvement of construction companies.

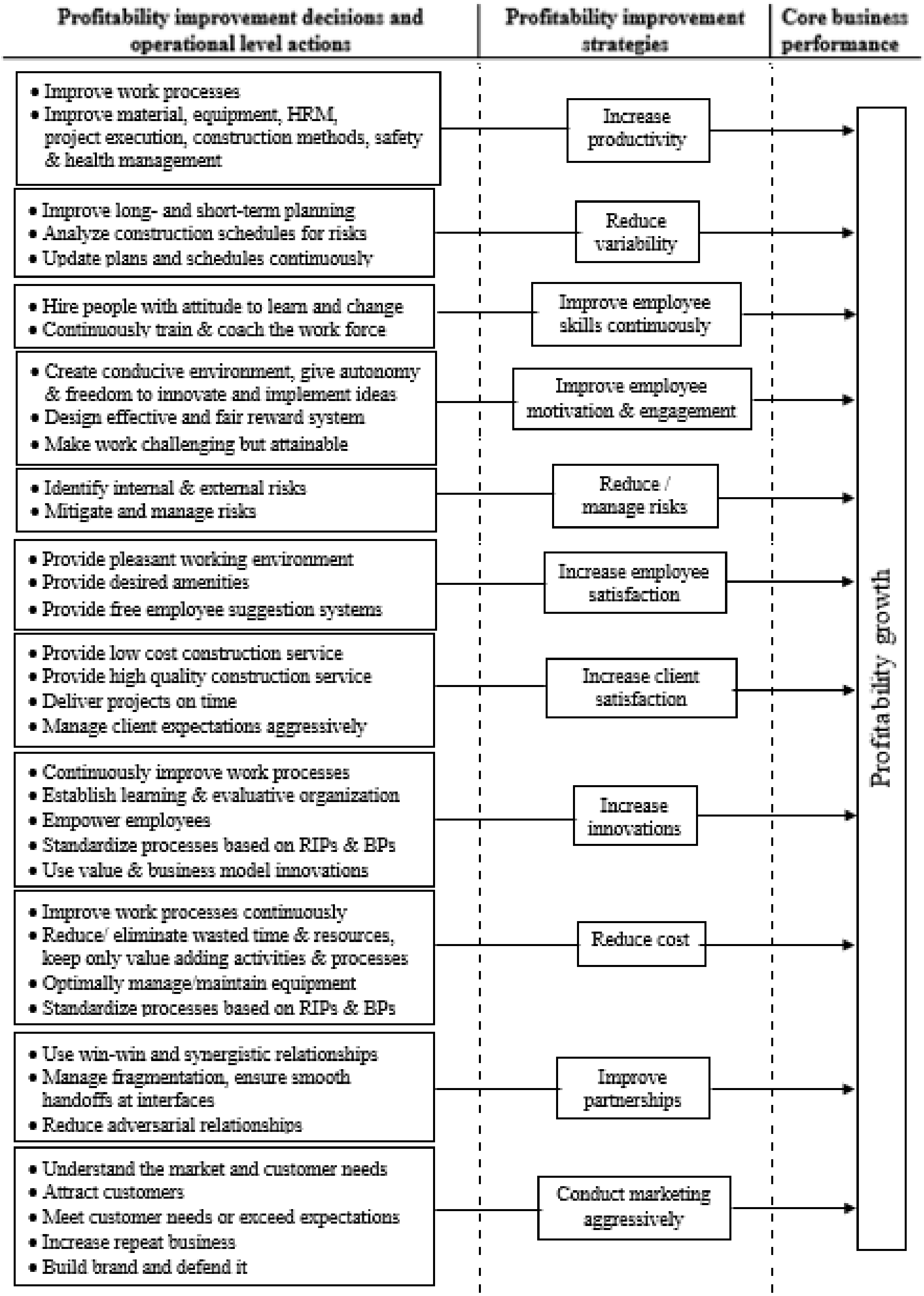


Figure 3.4 Part 1 - Model that gives profitability improvement strategies guiding operating decisions

3.3.2 Development of Two-Part Model of Excellence for Profitability Improvement of Construction Companies

The author used six steps to construct the two-part excellence model shown in Figures 3.4 and 3.5.

Step 1: Finding a practically relevant research problem with research potential

Razor-thin profit and low profitability of construction companies are practical problems identified in background and needs (Section 1.1). Literature review on causes of razor-thin and unreliable profit and low profitability of construction firms helped to identify lack of strategic tools for profitability improvement and management, and the apparent gap in knowledge to solve the problem. Various challenges, risks, and problems construction companies face are identified that limit achieving higher profitability or even forces them to operate at a loss. Finally comes formulation of the research questions and objectives to address the problems and fill the knowledge gap.

Step 2: Obtaining a profound understanding of the topic

Becoming familiar with both the practical and theoretical bases of the topic forms the second step in the constructive research approach (Labro and Tuomela, 2003). The author obtained a profound understanding of the topic through the extensive literature review conducted in Chapter 2. In Chapter 2, relevant previous research and professional work on the study topic are reviewed and synthesized to understand the challenges construction companies face, different methods and approaches used in practice and those published in the scientific literature on the state of the art organizational and process improvement methods to inform the development of an effective solution to the razor-thin and unreliable profit, and low profitability of construction firms. High impact concepts, principles, and guidelines extracted from the literature on strategic management, organizational and process excellence guidelines, company and project organizational and process improvement methods, are used in developing the model of excellence in Figures 3.4 and 3.5.

Step 3: Creating a novel construct

An intensive search both practically and theoretically for an innovative solution is the primary feature distinguishing constructive research from other types of applied research and most consulting work (Labro and Tuomela, 2003). According to Lukka (2000), the innovation phase is a creative, and possibly even heuristic sequence of events, which was the case in developing model in Figures 3.4 and 3.5.

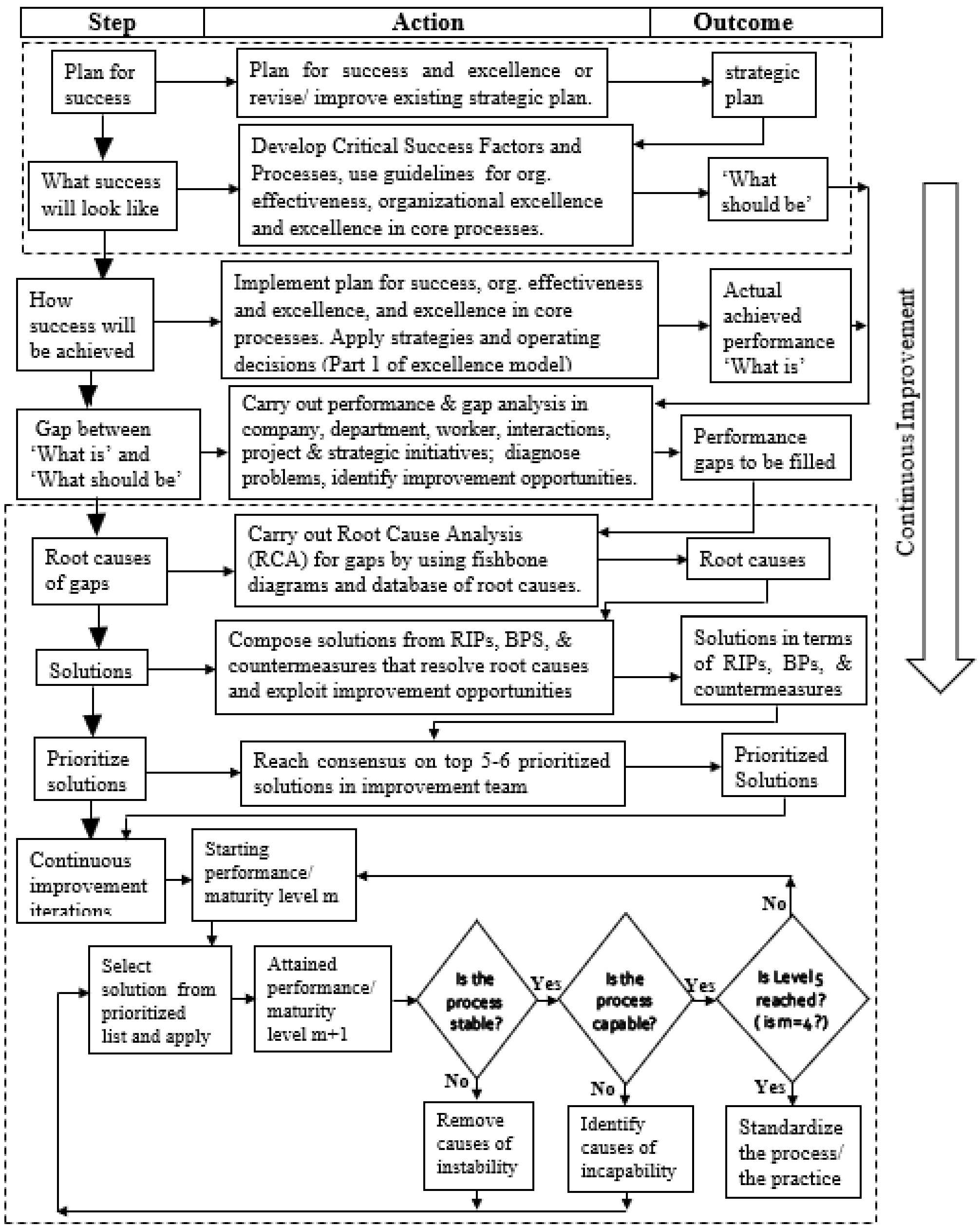


Figure 3.5 Part 2 - Proposed continuous improvement model and flowchart

The researcher put ideas from strategic management, process improvement, organizational excellence models, performance improvement, and continuous improvement together and iteratively refined these principles to develop these models. Next is a description of the summary of the development of the constructs.

Strategic planning can contribute to the financial success of a firm and to the critical drivers of success, excellence, and effectiveness that are iteratively refined and listed as functional strategies that incorporate these drivers in the second column in Figure 3.4. The single critical question that guided the intensive search practically and theoretically that culminated in the development of Figure 3.4 What innovative and easy-to-use strategies, will help construction companies overcome the challenges they face and help them add value by improving profitability? This question is broken down into three guidelines. The first guideline is that the strategies should enable construction companies to reduce or eliminate the effects of the challenges they face and create added value to the core business. Table 3-1 lists the challenges and the strategy devised to reduce or eliminate the effects of the challenges.

Table 3-1 Challenges and the strategy devised to reduce or overcome them

Challenge	**Strategy to reduce or overcome the challenge**
Variability	Reduce variability
Low productivity	Increase productivity
Inefficient processes and wastes	Improve employee skills continuously, increase innovations, improve employee motivation and engagement
Client dissatisfaction	Increase client satisfaction
Fragmentation and adversarial relationships	Improve partnerships
Cost overruns	Reduce/manage risks, improve employee skills continuously, increase innovations, improve employee motivation and engagement

The second guideline used is to develop strategies that would enable construction companies to meet client needs and succeed in the construction business. Such strategies are those emphasizing employee skills development, employee motivation and engagement, increasing innovation, and increasing client satisfaction.

The third guideline is to help construction companies reach their intended market, and help them to build and improve their brand image through aggressive marketing. Aggressive marketing helps overcome a problem reported in the literature, which is the target market's lack of brand recognition.

Explanation of the development of the strategies and corresponding operating decisions follows:

a. ***Increasing productivity*** – Productivity is the most significant factor affecting profitability. Productivity is stagnant in construction (Egan, 1998). Increasing productivity will have a significant effect on profitability improvement. The strategy is translated into the following operating decisions applied mainly to projects

- Improving work processes (Cottrell, 2006; Hammer, 2007; Sarshar et al., 2000)
- Improving material, equipment, HRM, project execution, construction methods, safety & health management of construction projects (Nasir, 2013; Ellis and Lee, 2006; Arditi et al., 1985)

b. ***Reducing Variability*** - Variability is ubiquitous in construction. It undermines project performance, disrupts the workflow, and results in detrimental consequences on cost, duration, and quality (Hamzeh, 2009). With each construction project being unique, factors behind this variability are plentiful (Ballesteros-Pérez et al., 2017). These factors, including project location, clients, regulations, labor, equipment, technology, subcontractors, experience, stakeholders, and even the project team, are likely to change, at least partially, among projects (Chudley and Greeno, 2016) plus many others. Reducing variability helps overcome these problems and reduce risks. The following are operating decisions based on this strategy

- Improving long- and short-term planning (Appendix B; PMI (PMBOK), 2017; GAO, 2015; Millhollan, 2009; Hendrickson, 2003)
- Analyzing construction schedules for risks (Appendix B; Nasir, 2009; Hendrickson, 2003)
- Updating plans and schedules continuously (Appendix B; Nasir, 2009; GAO, 2015; Hendrickson, 2003)

c. ***Improve employee skills continuously*** – employees are the heart and soul of organizations (van Tiem et al., 2012) who supply their skills to help achieve organizational goals. Continuously improving employee skills helps an organization stay competitive in the fiercely competitive construction market. The following operating decisions help achieve this strategy.

- Hire the top talent always (van Tiem et al., 2012)
- Continuously train and coach the work force (van Tiem et al., 2012, Sivusuo et. al, 2018)

d. ***Improve employee motivation and engagement*** – motivated employees can give their best creativity and effort to task accomplishment. Sivusuo et al. (2018) and Hamel (2007) say that mobilizing employee creativity and passion is crucial in building dynamic capability and sustainable competitive advantage in a fiercely competitive business environment. Organizations need to create a conducive environment to help employees bring out their best creativity and passion, support, train and coach them, and motivate them to attain excellence (Sivusuo et al., 2018). The operating decisions that help achieve this strategy are:

- Create a conducive environment, give autonomy & freedom to innovate and implement ideas (Sivusuo et al., 2018)
- Design effective and fair reward and recognition/appreciation system (van Tiem et al., 2012)
- Make work challenging but attainable (Bushe and Marshak, 2015)

e. ***Increase employee satisfaction*** – employees with job satisfaction are happy, loyal, and productive. Employee attitudes reflect the moral of the company. Employee satisfaction drives productivity and customer satisfaction (Matzler et al., 2004). The following are the operating decisions

- Provide pleasant working environment (van Tiem et al., 2012)
- Provide desired amenities (van Tiem et al., 2012)
- Provide free employee suggestion systems (van Tiem et al., 2012)

f. ***Reduce/manage risks*** - One of the challenges construction companies face is high uncertainty and risk involved in construction work that erodes estimated profit mark up (Yoon et al., 2014; Wong and NG, 2010). Adverse weather, fluctuating interest rates, inflation, change orders, and government regulations are sources of risks that a contractor must deal with (Cui, 2005). The following are the operating decisions

- Identify internal and external risks (PMBOK, 2017)
- Mitigate and manage risks (PMBOK, 2017)

g. ***Increase client satisfaction*** - Too many clients are dissatisfied with the overall performance of construction (Egan, 1998). About 80% of projects worldwide do not deliver results to expectations in one or more substantive ways (Jones and Saad, 2003). Ahmed and Kangari (1995) say that factors that drive client satisfaction in construction are time, cost, quality, client service orientation of contractor, communication skills, and response to complaints. The following are the operating decisions

- Provide low-cost construction service (Egan, 1998; Bhattacharya and Momaya, 2009)
- Provide high-quality construction service (Jones and Saad, 2003)
- Deliver projects on time
- Manage client expectations aggressively through communications (Millhollan, 2008)

h. ***Increase innovations*** – increasing innovations in terms of using new technologies (machines or ICT), using improved business processes and business practices, improves profitability and competitive advantage (Seaden et al., 2003; Jones and Saad, 2003). Innovation in the delivery of projects helps to achieve cost and time reductions and enhance quality and safety (Jones and Saad, 2003). The operating decisions that help increase innovation are

- Continuously improve work processes (van Looy et al., 2011, Sarshar et al., 2000)
- Establish learning and evaluative organization (Martz, 2008)
- Empower employees (van Tiem et al., 2012)
- Standardize processes based on RIPs and BPs (Sarshar et al., 2000, Patty and Denton, 2010)
- Use value & business model innovations (Kim and Mauborgne, 2015; Pekuri et al., 2014b)

i. ***Reduce cost*** – reducing cost has a significant effect on getting more jobs due to the competitive bidding practice in construction. Reducing cost using innovations helps increase the profit and profitability of a company. The list below gives the operating decisions

- Improve work processes continuously (van Looy et al., 2011, Sarshar et al., 2000)
- Reduce/ eliminate wasted time and resources, keep only value adding activities and processes
- Optimally manage/maintain equipment (Nasir, 2013)
- Standardize processes based on RIPs and BPs (Sarshar et al., 2000, Patty and Denton, 2010)

j. ***Improve partnerships*** – Subcontracting is a common practice in the construction industry, and it can account for as much as 90% of the total value of a construction project (Nobbs, 1993). Many companies and activities are involved in any project creating several interfaces and handoffs of tasks (Antoniadis et al., 2008). This fragmented structure and project processes present a serious challenge (Jones and Saad, 2003; Dave, 2013) that can result in inefficiencies affecting profit. Further, a positive relationship is vital for all parties' success because the adversarial relationship is damaging. In order to improve the partnership of contractor-subcontractor relationships, mutual trust has a positive effect on contractor competitiveness (Tan et al., 2017). A long-term partnering relationship based on win-win principles is more likely to benefit both parties (Tan et al., 2017). Thomas and Flynn, (2011) give the best practices of subcontract management. The operating decisions follow

- Use win-win and synergistic relationships (Tan et al., 2017)
- Manage fragmentation and ensure smooth handoffs at interfaces (Antoniadis et al, 2008)
- Reduce adversarial relationships (Tan et al., 2017)

k. ***Conduct marketing aggressively*** – Marketing is an activity with the potential for increasing sales (Arditi et al., 2008), and hence with the potential to increase profits. Marketing aids a construction company to reach its intended market. An appropriate mix of product, price, promotion, place, and people should be used in marketing (Arditi et al., 2008) to secure jobs in the cluttered and fiercely competitive construction market and to build a brand (Balmer and Greyser, 2009). Given the intense competition, effective marketing of their services is imperative for contractors in achieving competitive advantage. The operating decisions are listed below

- Understand the market and customer needs (Polat and Donmez, 2010)
- Attract customers (Kottler and Armstrong, 2009)
- Meet customer needs or exceed expectations (Arditi et al., 2008)
- Increase repeat business (Arditi et al., 2008)
- Build brand and defend it (Balmer and Greyser, 2009)

The author incorporated the critical drivers of success, excellence, and effectiveness synthesized from the literature into the continuous improvement implementation model and flowchart in Figure 3.5. The question that guided the search to develop the second component of the excellence model (Figure 3.5) is: What step-by-step and easy-to-use procedure can construction companies follow to improve their profitability and add value to the core business? Planning for success includes these profit drivers (the first two steps in Figure 3.5).

The first column in Figure 3.4 deals with the tactical and operational implementation of the plan, and the third step in Figure 3.5 is about plan implementation.

Actual performance during implementation often deviates from the plan due to problems, bottlenecks, risks, challenges, and issues in which case improvement team needs to make an organizational and environmental analysis of the employee, project, department, interactions, and company. This feedback serves to improve performance. Gap analysis information (fourth step in Figure 3.5) signals improvement team areas in which to carry out root cause analysis (fifth step in Figure 3.5) through fishbone diagrams such as those shown in Figures 2.12, which Appendix A gives for all processes, departments and improvement areas (van Tiem et al., 2012; Bititci and Nudurupathi, 2002). RPN in FMEA tables, such as Table 2-8, will be used to prioritize the factors to be improved to address the top root causes by improvement interventions.

Solutions that resolve the root causes of the specific factors on fishbone diagrams and help to exploit improvement opportunities are composed of RIPs and BPs (sixth step in Figure 3.5). The team conducts solution prioritization using criteria established during diagnosis and gap analysis. If there are multiple problems, it is necessary to rank the problems according to pre-selected criteria; for example: Which problem has the most impact on the bottom line? Which problem can be fixed in the shortest time and for the least expenditure of resources? Usually, the performance analysis results guide the development of the criteria for the selection of problems for improvement. The solutions will advance the performance level to the next maturity level. Continuous improvement cycle is applied here within the larger continuous improvement cycle of the whole flowchart. Mainly, tasks are process-based, and Hammer (2007) says business processes that run from end to end of a company can result in dramatic enhancements in performance, enabling organizations to deliver higher value to customers (company and project process flow diagrams given in Appendix A). Solutions are expected to advance the process maturity to the next level, and the solution will be iterated through continuous improvement until maturity level 5 is reached, and until the processes are both stable and capable.

Step 4: Implementing and testing the construct

Since constructive research relies on the pragmatic notion of truth, the implementation phase is an elementary part of the research (Lukka, 2000). The implementation test has a two-fold purpose: a successful implementation means both the research process has been successful, at least with regards to the most critical factors, and that the construct is technically feasible (Lukka, 2000). The two-part excellence model is implemented to develop a diagnostic tool and DSS in Access

2016 environment to help profitability improvement of construction companies. At least one company should be found to use the construct and decision support system for both testing usefulness and validity of the construct, as will be discussed in the next step.

Step 5: Examine the scope of applicability of the construct

The researcher should consider broader implications of the constructs, i.e., external validity. The fifth step involves discussing those aspects of the constructs that could be transferable to other organizations (Labro and Tuomela, 2003). In his dissertation, in which he used the constructive approach, Kasanen (1986) makes a case for market-based validation of managerial constructs, arguing that the testing of the pragmatic adequacy of a construct takes time and requires several attempts of application. The concept of innovation diffusion underlies the following market tests, i.e., managerial constructs are viewed as products competing in the market of solution ideas.

- **Weak market test**: Has any manager responsible for the financial results of his or her business unit been willing to apply the construct in question in his or her actual decision making?
- **Semi-strong market test**: Has the construct become widely adopted by companies?
- **Strong- market test**: Have the business units applying the construct systematically produced better financial results than those which are not using it?
- systematically produced better financial results than those which are not using it?

A point to note is that even the weak market test is relatively strict — it is probably not often that a tentative construct can pass it.

The author asked a highways and bridge construction company to use the constructs (the two-part excellence model), and diagnostic tool and DSS (computer tool) developed based on the construct, and feedback received. First of all, the constructs and the computer tool pass the weak market test because the company was willing to use both the construct and the computer tool for its decisions. Second, the feedback received was positive about their usefulness. Hence the construct and the computer tool pass the weak market test (Appendix F).

Step 6: Showing the theoretical contributions

According to Lukka (2000), there are two primary ways of contributing to theory in constructive studies. First, the construct itself may be such a novel that it introduces an awareness of a completely new means to achieve certain ends. Second, a constructive case study can help develop, illustrate, refine, or test a theory (Keating, 1995).

In this study, the emphasis is on the first type of contribution because the two-part excellence model and the computer tool are novelties that provide a new means to profitability improvement end of construction companies. The two-part excellence model for profitability improvement of construction companies consists of Part 1- strategies and the corresponding profitability improvement operating decisions, and Part 2 – the proposed model of continuous improvement application flowchart. The model construct and the computer tool are a novelty that 1) develops the relationship between corporate strategic management systems and profitability improvement operating decisions (Figure 3.4) – in Part 1, and 2) provides a step by step process to continuously improve profitability (Figure 3.5) – in Part 2. The computer tool makes the application of the two-part excellence model easy and complements the two-part excellence model. The model construct and the computer tool lead to better means to identify and prove the contribution of profitability improvement interventions to the firm and the possibilities for adding value. The field has been lacking this type of model.

Further study can be done in the future as a case study, and the research product may be implemented in case companies. Data may be collected after one, two, or three years of implementation to see its impact on profitability. Feedback can also be collected to improve the constructs and the computer tool.

3.4 Development of Diagnostic Tool and Decision Support System (DSS)

A construction company knows it has problems if it observes a gap between goals/plans and the achieved outcomes, organizational anomalies, and if employees and stakeholders report dysfunctions. No one method or symptom magically guides the way to improvement. The problem may also span across multiple departments/units and levels/hierarchies. The best way to go about improvement is to use a structured approach: first to identify where the problem is and then to do in-depth analysis in the problem areas to identify the root causes and the needed interventions.

The diagnostic tool directly implements step 4, and the DSS implements steps 5-8 iterative and recursive flowchart parts of the excellence model in Figure 3.5 reproduced in Figure 3.6. The following subsections first deal with the development of the diagnostic tool, which will be followed by the development of the Decision Support System (DSS) based on the flowchart in Figure 3.7.

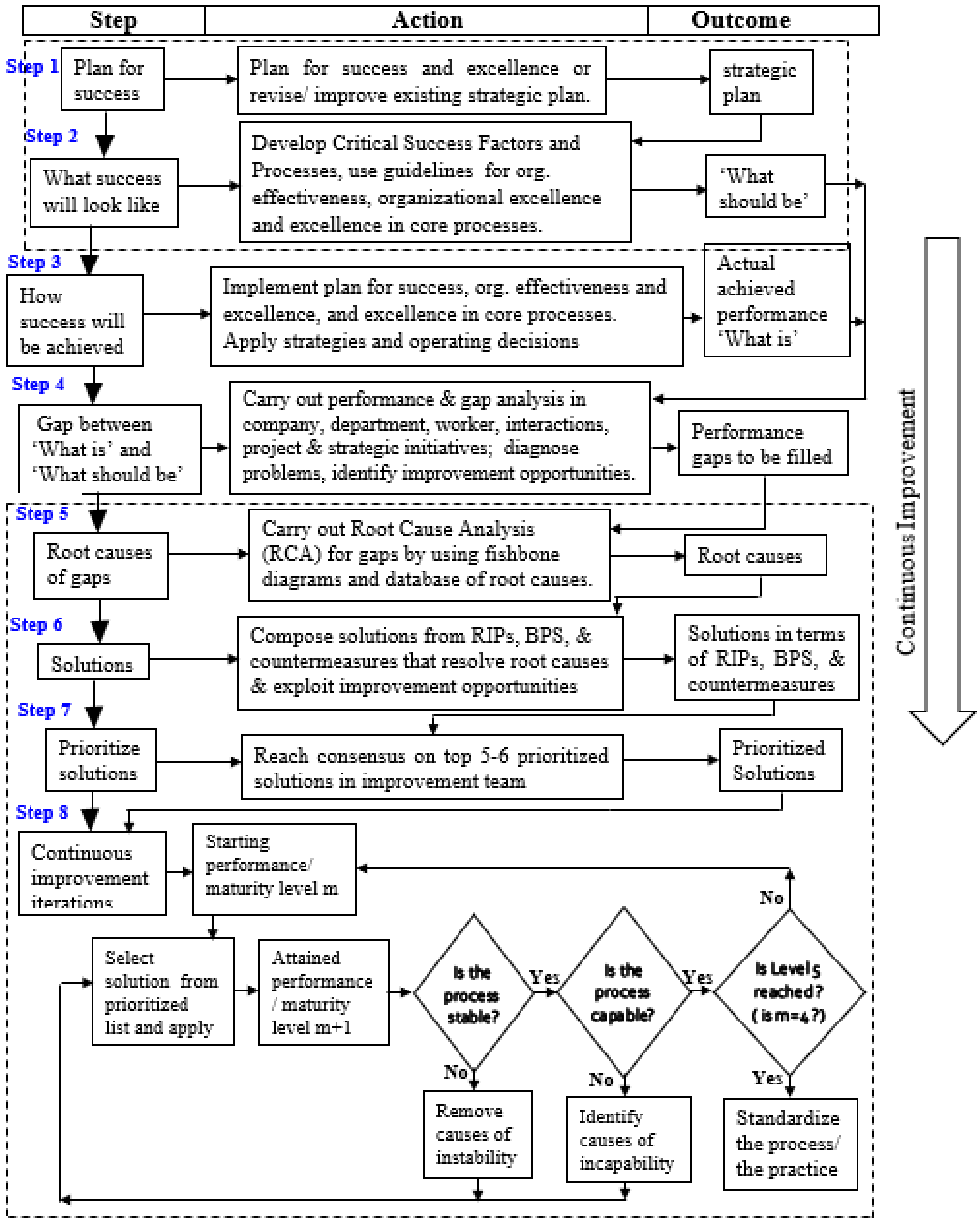


Figure 3.6 Steps in the proposed continuous improvement model and flowchart

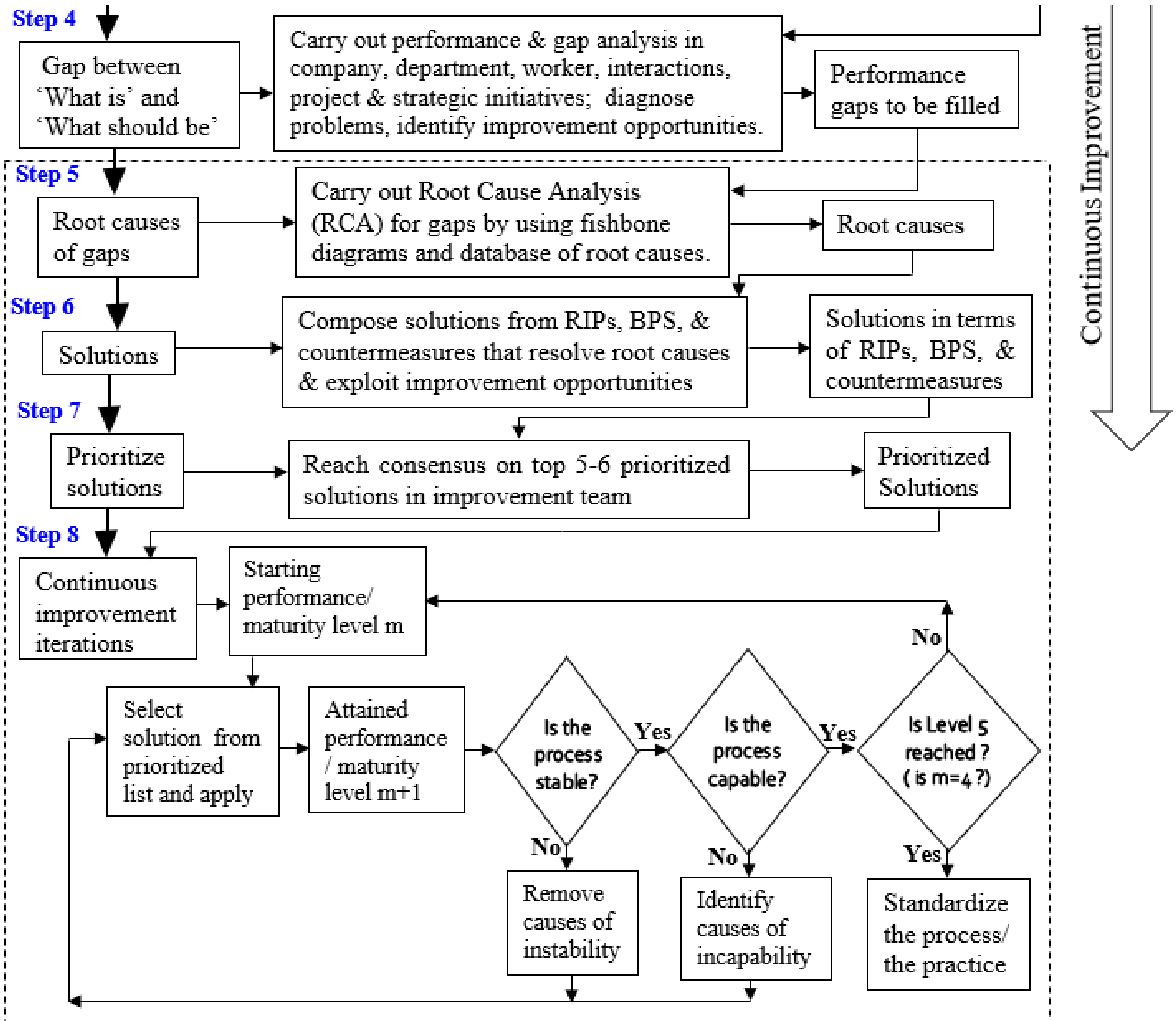


Figure 3.7 Flowchart used in development of diagnostic tool and DSS

3.4.1 Development of Diagnostic Tool

The practice in performance improvement is that a team composed of people from different departments and units carries out improvement (van Tiem et al., 2012). The first step after recognition of the existence of problems is for the team to carry out analysis of the company, departments, interactions, projects, employees, and strategic initiatives to identify the problem areas and bottlenecks. Each team member does his/her analysis, lists the problems and bottlenecks, ranks them, and then the team should reach consensus on the top priority problems to be resolved.

The author developed the diagnostic tool and DSS so companies can use either of two alternative approaches in carrying out improvement. One approach is to use a diagnostic questionnaire to detect problem areas and carry out a full diagnosis of the organization. The second approach is a partial diagnosis that follows the identification of problem areas by using Tamer's work but only takes a deep dive for the identified cost centers or profit centers.

Conducting a full diagnosis using a diagnostic questionnaire for company assessment is common practice in organization improvement and consulting practice. However, such diagnosis and improvement have not permeated the facilities construction companies, where the impact would be most profound. Such diagnosis and improvement is also resisted the most by construction companies. This research used the diagnostic questionnaires given in Appendix D for the development of the diagnostic part of the computer tool. Organizational assessment literature, construction company challenges and problems identified through literature review and diagnostic questionnaires used in organization development in other industries and the construction industry are used to develop the diagnostic questionnaire.

In the second approach of partial diagnostics, Tamer's work will be used to identify the problematic interaction areas between cost centers and profit centers that are not working effectively as well as the work packages that were affected. Then a deep dive is taken only for the identified cost centers or profit centers.

The International Institute for Performance Improvement classifies intervention areas into four as **worker, work, work environment,** and **the world** (van Tiem et al., 2012). The world refers to the societal perspective of interventions such as environmental effects and sustainability of solutions. In this research, a similar breakdown is used but with a little modification and addition of interactions and projects. This research divides the diagnosis and improvement areas into **company, department, employee, interactions, project,** and **sustainability issues**. The issues of the cost centers (company, departments, employees, and site teams) and profit centers (projects) are subdivided for ease of diagnosis and improvement, as shown in Figure 3.8.

The diagnostic questionnaire is developed to capture the main performance issues in Figure 3.8. Process flow diagrams and fishbone diagrams are developed, and then the main essences of the process flow and fishbone diagrams are summarized and captured in the diagnostic questionnaire.

More often, there are multiple problems, in which case it is necessary to rank the problems. Multiple options are available for the ranking. One method is to use the diagnostic score to rank the problems, from least score (top priority problem) to highest score (least priority problem).

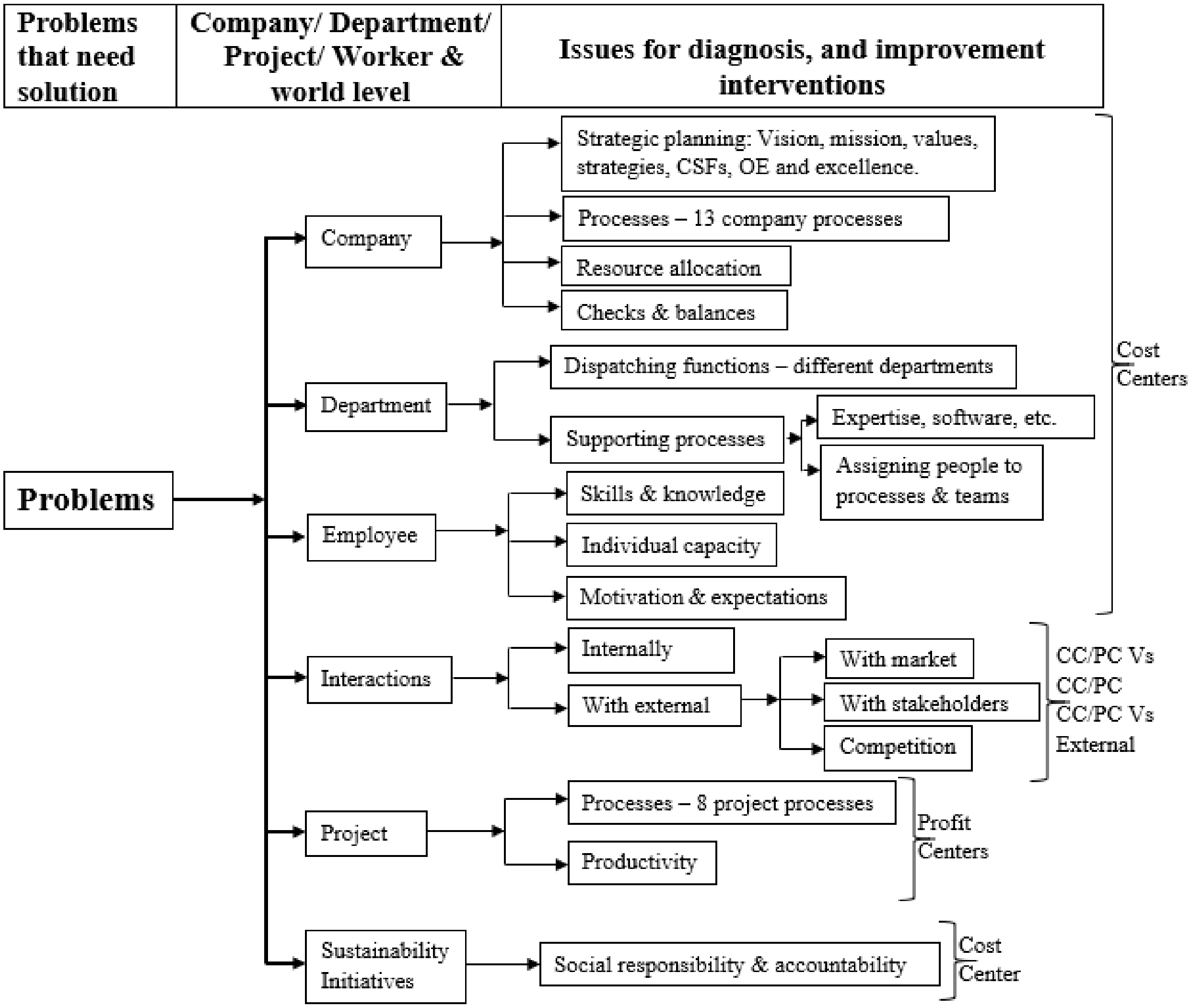


Figure 3.8 Issues for diagnosis, and improvement interventions

Another method is to develop criteria from the performance analysis results and do the ranking according to the pre-selected criteria; for example, which problem has the most impact on the bottom line? Which problem can be fixed in the shortest time and for the least expenditure of resources? Still, another method, in case of gap analysis is, to use the criticality ranking matrix. Van Tiem et al. (2012) recommend using the criticality ranking matrix of performance gaps from 1 (least critical) to 10 (most critical). Gap analysis involves identifying and analyzing the difference between '*what is*' or current reality and '*what should be*,' the desired future successful end state after the change, and improvements have occurred using the analysis results. The gap descriptions may be both quantitative and qualitative. A diagnostic score is used to rank the problems in this research.

Average Weighted Score

The diagnostic score, also called the average weighted score, is calculated from the score and weight users assign to each diagnostic question item using Equation 3.1.

$$\boldsymbol{Avg.Weighted\ Score} = \frac{\sum \boldsymbol{Score * Weight}}{\sum \boldsymbol{Weight}} \qquad . \qquad . \qquad (3.1)$$

The score ranges from 0 to 5. Each of the scores has the meaning given in Table 3-2:

Table 3-2 Scoring scale

Score	Definition	Score	Definition
0	This is not relevant to us	3	We do this sometimes
1	We do not do this	4	We frequently do this
2	We rarely do this	5	We usually do this

The weight values are taken from those in the Analytic Hierarchy Process, which are 1, 3, 5, 7, or 9 (Saaty, 1987). Table 3-3 gives the definition of the relative scale.

If all items are equally weighted, then all questionnaire items are assigned a weight of 1. If the items have different relative importance in contributing towards the objectives, the least important may be assigned a weight of 1, and all the rest weighted relative to it.

Table 3-4 gives an example of a diagnostic questionnaire for company communication process with scores and weights selected by users, and computation of weighted score for each item made. The sum of the weights and weighted scores are calculated and shown at the bottom of the respective columns. The average weighted score is then calculated using Equation 3.1

Table 3-3 The fundamental scale of weights

Intensity of importance	Definition	Explanation
1	Baseline importance	This activity contributes the least to objective
3	Moderate importance	Experience and judgment strongly favor that this activity moderately contributes to objective compared to the activity of baseline importance
5	Essential or strong importance	Experience and judgment strongly favor that this activity is essential or strongly contributes to objective compared to the activity of baseline importance
7	Very strong importance	This activity is strongly favored, and its dominance demonstrated in practice as compared to the activity of baseline importance
9	Extreme importance	The evidence favoring this activity over the activity of baseline importance is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

Table 3-4 Computation of diagnostic score for company communication process

Item ID	Company Communication Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company employs a strategic and structured approach to internal and external communications.	3	3	9
2	Our company strives to meet stakeholder information needs through its communication plans and implementations.	2	1	2
3	Our company carries out stakeholder engagement assessments to identify communication requirements.	2	1	2
4	Our company carries out communication styles assessment to tailor styles to stakeholders.	3	1	3
5	Our company documents and sends out all communications contemporaneously.	3	1	3
6	We are effective at communicating with customers, subcontractors, suppliers, the public, and the market.	4	3	12
7	Our company uses the best communication practices.	3	5	15
		Sum	**15**	**46**

Average Weighted Score = 3.07

The diagnostic score for company communication process is

$$Avg.Weighted\ Score = \frac{\sum Score * Weight}{\sum Weight} = \frac{46}{15} = 3.07$$

The performance of Cost Centers (company processes, departments, checks, and balances), project productivity and processes, influence a company performance, which Figure 3.9 shows as the influential company profitability factors in the form of cause and effect diagram. The diagnostic score calculated for each of the issues in Figure 3.8 will be used to rank the problems. An issue with the smallest score is the top priority problem. Figure 3.9 will also be used to summarize the diagnostic scores for ease of presentation.

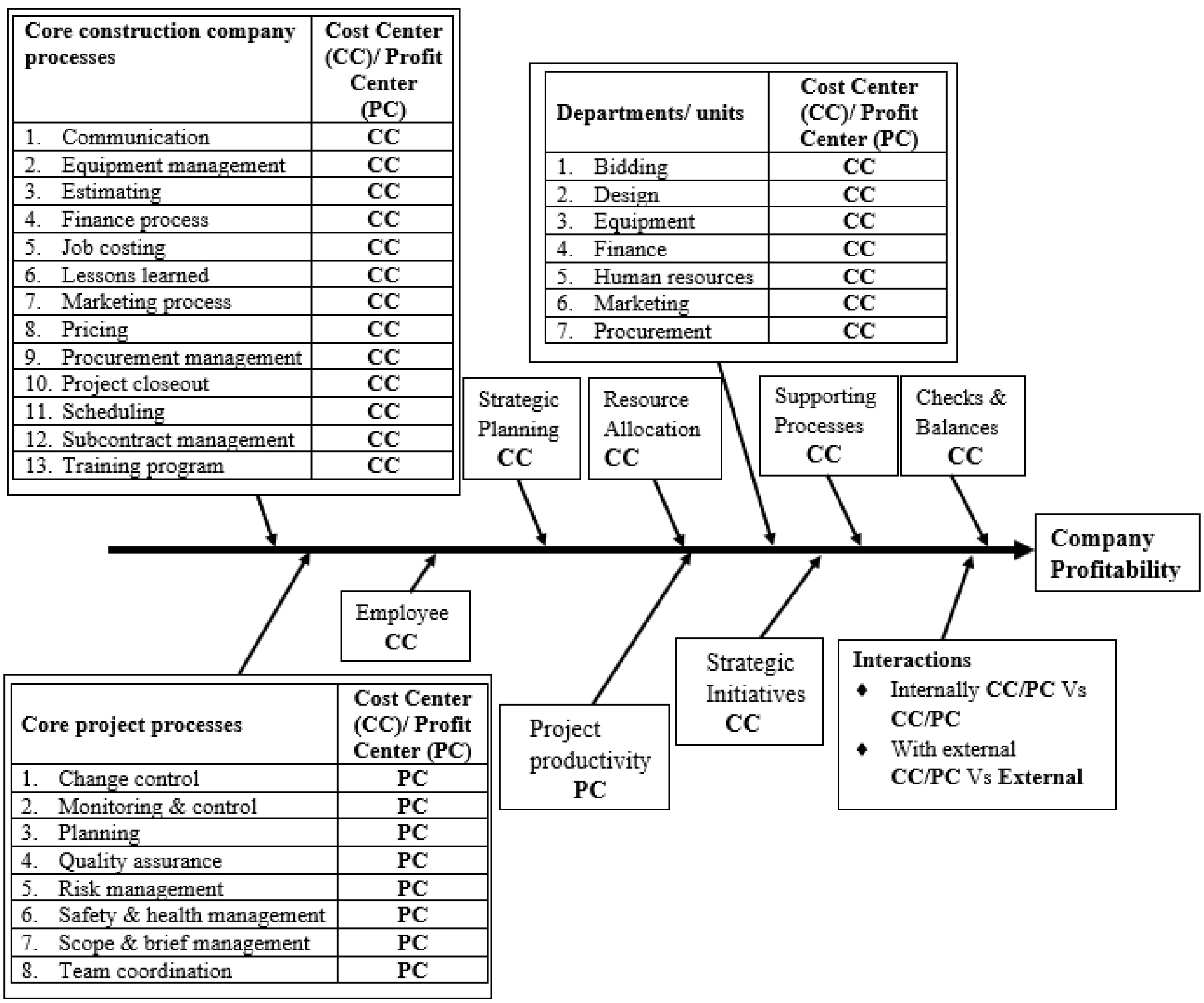


Figure 3.9 Performance of core company and project processes, organizational units, project productivity and other factors affecting company profitability

In the case of interactions, the diagnostic score may give the status of a department regarding its interaction with all cost centers and profit centers, but it does not give much useful information about the interaction of the unit with a specific cost center or profit center. The same thing holds for interactions with external stakeholders. As one can see in Table 3-5, there are four cost centers served by bidding. Two of the questionnaire items deal with bidding service to design; one item gives bidding interaction with HR, two items evaluate bidding service to marketing, and two items deal with the interaction of bidding with procurement. In the case of interactions, Tamer's protocol or the diagnostic questionnaire may be used.

Table 3-5 Bidding cost center internal interaction with four cost centers

Item ID	Bidding Interactions - service provided by bidding	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	BIDDING Eval. By Design 1. Bidding corrects bid drawings it receives from the client during the bidding process.	Design	3	3	9
2	BIDDING Eval. By Design 2. Bidding incorporates missing information into drawings during bidding.	Design	3	3	9
3	BIDDING Eval. By HR. Bidding submits list & qualification of new hires in time to HR.	HR	4	3	12
4	BIDDING Eval. By Marketing 1. Bidding wins jobs it bids through low prices to attract customers in line with marketing strategy.	Marketing	2	5	10
5	BIDDING Eval. By Marketing 2. The winning bid price enables the company to complete the job with profit.	Marketing	3	7	21
6	BIDDING Eval. By Procurement 1. Bidding produces accurate estimates during bidding that provide reliable information for equipment procurement during project implementation.	Procurement	3	5	15
7	BIDDING Eval. By Procurement 2. Bidding produces accurate estimates during bidding that provide reliable information for material procurement during project execution.	Procurement	3	5	15
			Sum	31	91
	Average Weighted Score =	**2.94**			

$$\boldsymbol{Avg.Weighted\ \ Score} = \frac{\sum \boldsymbol{Score*Weight}}{\sum \boldsymbol{Weight}} = \frac{\mathbf{91}}{\mathbf{31}} = \mathbf{2.94}$$

The diagnostic score of 2.94 glosses over any one of the interactions that bidding has with any of the four cost centers. Treating each interaction separately is more productive, for which four diagnostic scores need to be calculated, one for each cost center or Tamer's protocol may be used. This same discussion applies to interactions with external stakeholders. Figure 3.10 shows the internal and external interactions on the macro view of the organization.

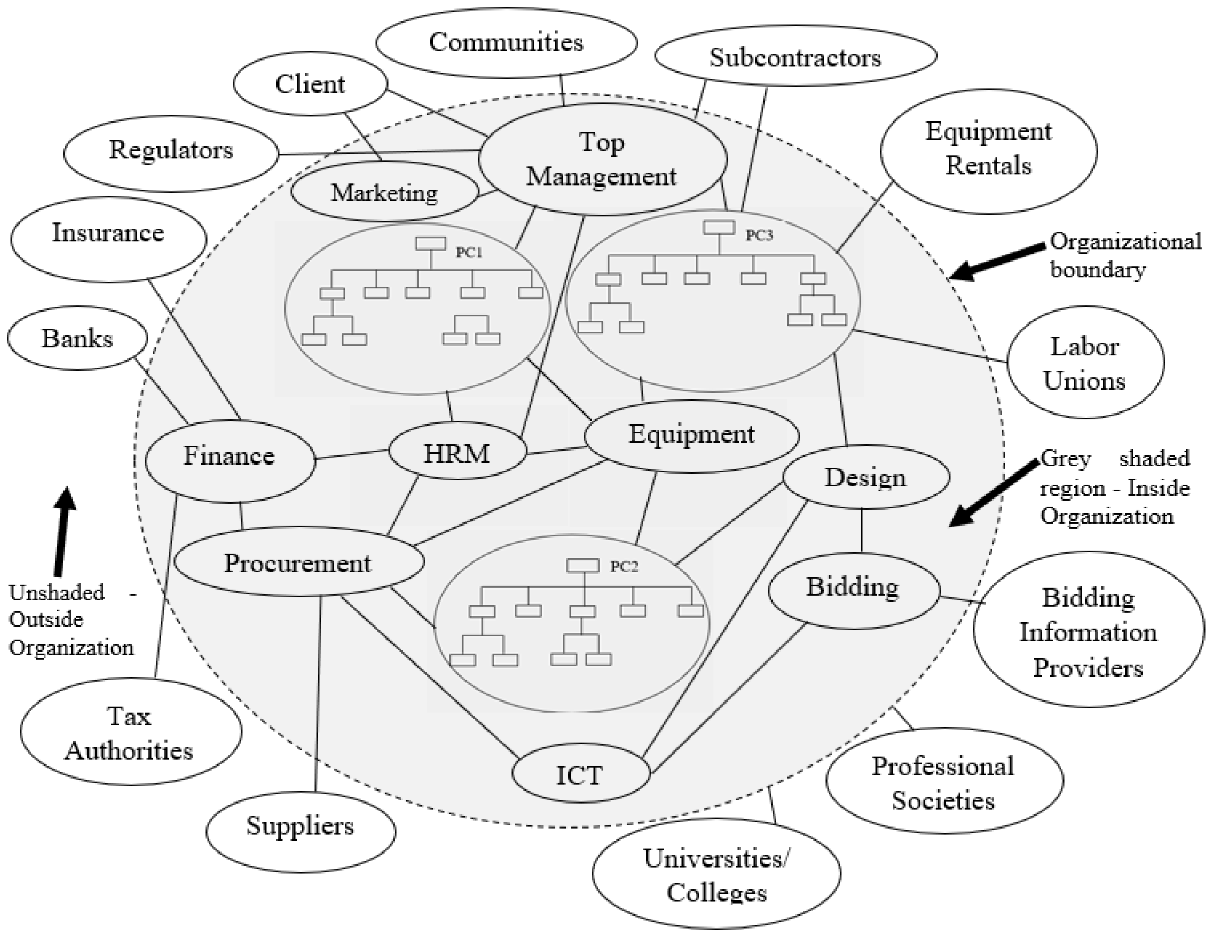


Figure 3.10 Internal and external interactions and macro view of an organization

To use Tamer's protocol, the interactions between entities are shown on an interaction diagram such as Figure 3.11. The rating scale and its definition are as follows

-1 The entity performed below expectations. Relationships negatively affected.

0 The entity performed as expected. No change in the nature of the relationship.

1 The entity performed above expectations. Relationships positively affected.

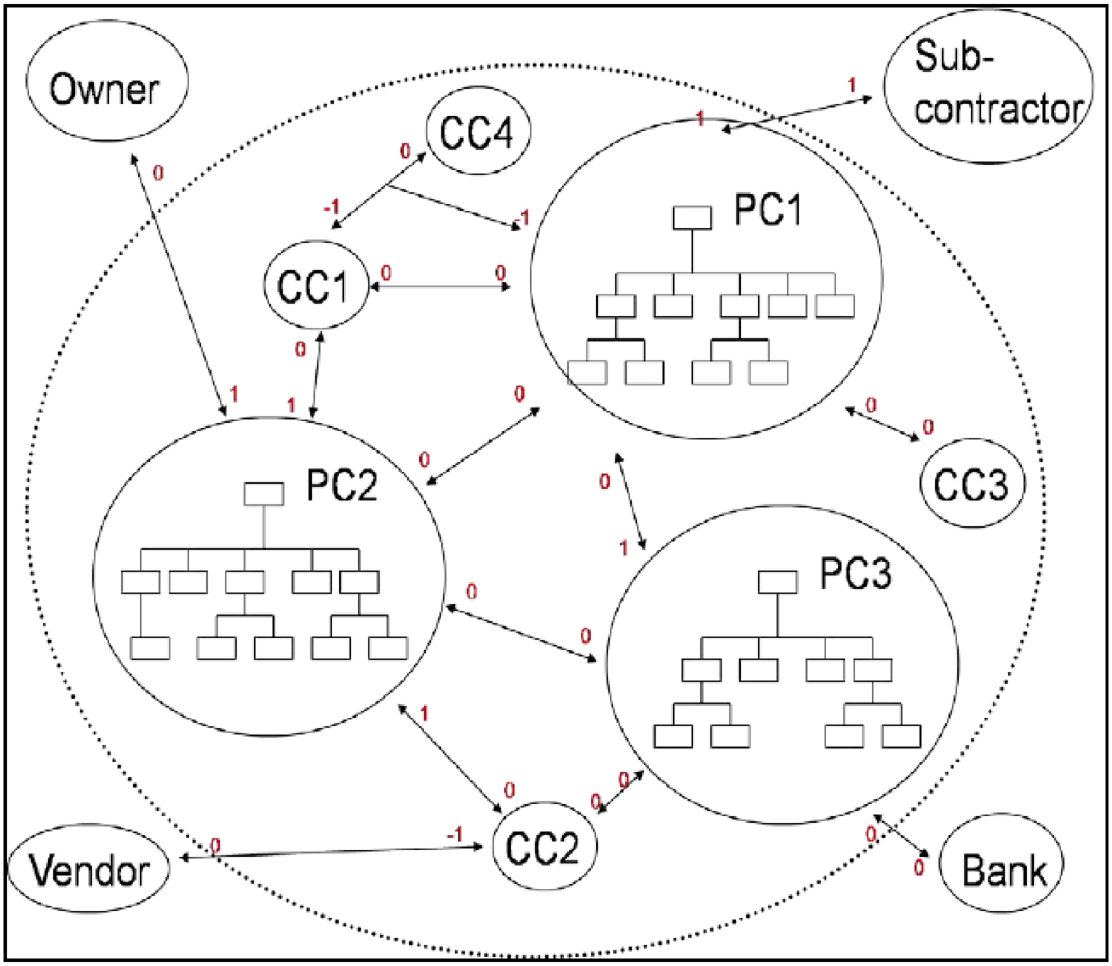


Figure 3.11 Interaction score of 1, 0, -1 shown on the macro view of an organization
(Source: Tamer, 2009)

Owner-PC2 relationship is (0,1). The owner exceeded what is expected of it by PC2, hence there will be more profit to PC2 than estimated during bidding. PC2 performed up to the expectations of the owner. Subcontractor-PC1 relationship is (1, -1). The subcontractor performed less than PC1 expected of it, hence there will be a reduction in the profit margin of PC1 due to this negative relationship.

3.4.2 Development of Decision Support System

Development of the Decision Support System involves root cause analysis (Step 5 in Figure 3.6 and 3.7), selecting RIPs, BPs, and countermeasures to compose solutions (Step 6), prioritize solutions by ranking (Step 7), and continuous improvement iterations (Step 8) to advance performance to level 5. The solution will be picked from prioritized solutions and applied in the continuous improvement interventions. Improvement is a time-consuming project, and so it is good practice to have a reserve of prioritized solutions so that one will be able to use them again for some time to come without the need to go through the whole improvement process (van Tiem et al., 2012).

3.4.2.1 Root Cause Analysis

The next step after identifying problems is to carry out root cause analysis. Root cause analysis corresponds to Step 5 in the flowchart given in Figure 3.7.

While performance and gap analyses yield valuable information, a root cause analysis determines why the performance gap exists. Latino et al. (2011) says that there is never one root cause for an undesirable effect, a chain of causes combine in series and parallel to cause a failure. The causes consist of causal factors that relate to an event in the sequence, and root causes that the improvement team needs to remove to have interrupted that step of the sequence chain that resulted in the undesired effect. The causal factors are anything that drives or hinders the performance of processes, activities, inputs, outputs, or even outcomes. An effective way to exhaustively list success/failure factors and carry out root cause analysis is by using fishbone diagrams (refer to literature review).

Fishbone Diagrams

The development of the fishbone diagrams for root cause analysis of the issues in Figure 3.8 follow either of the following two ways depending on whether the issues are process related or not :

a. Processes (company and project processes, resource allocation process, checks and balances process) and
b. Non-process (organizational unit issues)

a. Drawing fishbone diagrams for processes

In the case of root cause analysis for process issues, one first draws process diagrams. As was treated in the literature review, processes are at the very heart of every organization because they are the means through which companies create value for their customers (Vanhaverbeke and

Torremans, 1998). Ample literature stresses the contribution of the process focus on higher productivity and efficiency (Bititci and Nudurupati, 2002; Vanhaverbeke and Torremans, 1998; Kueng, 2000). Process analysts draw processes as a series of activities that take inputs, use resources, and produce outputs that must meet requirements and satisfy customer needs (Farrar, 2006). Therefore, one maps processes first and then draws the corresponding fishbone diagrams for each process diagram.

Process mapping begins with the identification of the critical processes from the competitive strategy of the company. Process mapping helps to understand a process by building graphically the relationships between cost centers, profit centers, interactions, activities, personnel, information, and objects involved (Biazzo, 2000; Netjes et al., 2006). Analysts do process mapping as follows:

- definition of the boundaries and the customers of the process, of the main inputs and outputs and the actors involved in the workflow;
- interviews with those responsible for the various activities within the process and study of available documentation (manuals, procedures, and other relevant documents);
- creation of the process map based on the information acquired and step by step revision of the process map

In this research, the author drew process maps using information from practitioners and scientific literature. Professional material, books, journals, google searches, from blogs, google scholar, and library search are used to gather every information on a given process. The author placed a particular emphasis on best practices, improvement, and success factors in drawing the fishbone diagram for the process under investigation. After an exhaustive gathering of information to make sure important information is not left out, the author organized and refined the information. Figure 3.12 shows an example construction company estimating process flow diagram. The purpose of drawing process diagrams is not only to use it in the analysis in the DSS but also to make information from the literature available to companies to help them map their processes as they use the DSS (process flow diagrams are prepared for core company and project processes and given in Appendix A).

After drawing the process flow diagrams, one draws the fishbone diagram for the process flow diagram in one of two alternative ways: In the first way of drawing fishbone diagrams for processes, the analyst exhaustively lists, and refines the list of causal factors that drive or hinder the performance of processes (inputs, activities, resources, process flows, outputs and linkages between these elements). Particular emphasis is placed on best practices and improvement principles in listing down the main factors and the subfactors. The final factors are then grouped on a branch of a fishbone diagram, and leading indicator assigned to each grouping. The second alternative is by first listing the main factors affecting a process performance (with leading indicator assigned to the main factors) and then breaking down the main factors into subfactors. Exhaustively listing all the causal success and failure factors that, if not taken care of, can negatively affect the performance of the process, i.e., success and failure factors are the root causes of failure. This listing of influencing factors is a risk identification process, and the risk management is done using Failure Mode and Effect Analysis (FMEA), as will be discussed later. In the example fishbone diagram in Figure 3.13, the main factors affecting bid win rate are the accuracy of the estimate, markup percentage, excellence in project type to bid for, level of competition, and market condition in the type of work company does. In Figure 3.13, twelve subfactors are influencing the accuracy of bid estimate, six subfactors influencing markup percentage and so on. In exhaustively listing all possible subfactors influencing a given main factor, some of these subfactors are BPs and RIPs from literature listed as influencing factors to improve the main factor. As an example, the following are Best Practices (BPs) in estimating (Rios et al., 2006):

1. Definition of the scope of work
2. Definition of the project execution plan
3. Determination of the estimating data and cost estimating method to be used
4. Allocation of qualified human resources
5. Calculation of cost of significant elements
6. Determination of cost of design, project management, startup, and owners cost
7. Normalization of data, determination of exchange rates and escalation of future costs
8. Determination of contingency to be applied
9. Conducting intermediate and final checks of estimates
10. Comparison of cost with similar projects

One can see that some these BPs are used as subfactors on the fishbone diagram in Figure 3.13.

The logic is that by making sure failure in the subfactors does not occur, we eliminate the root causes of failures and undesirable performance outcomes in the lagging indicator one cares about.

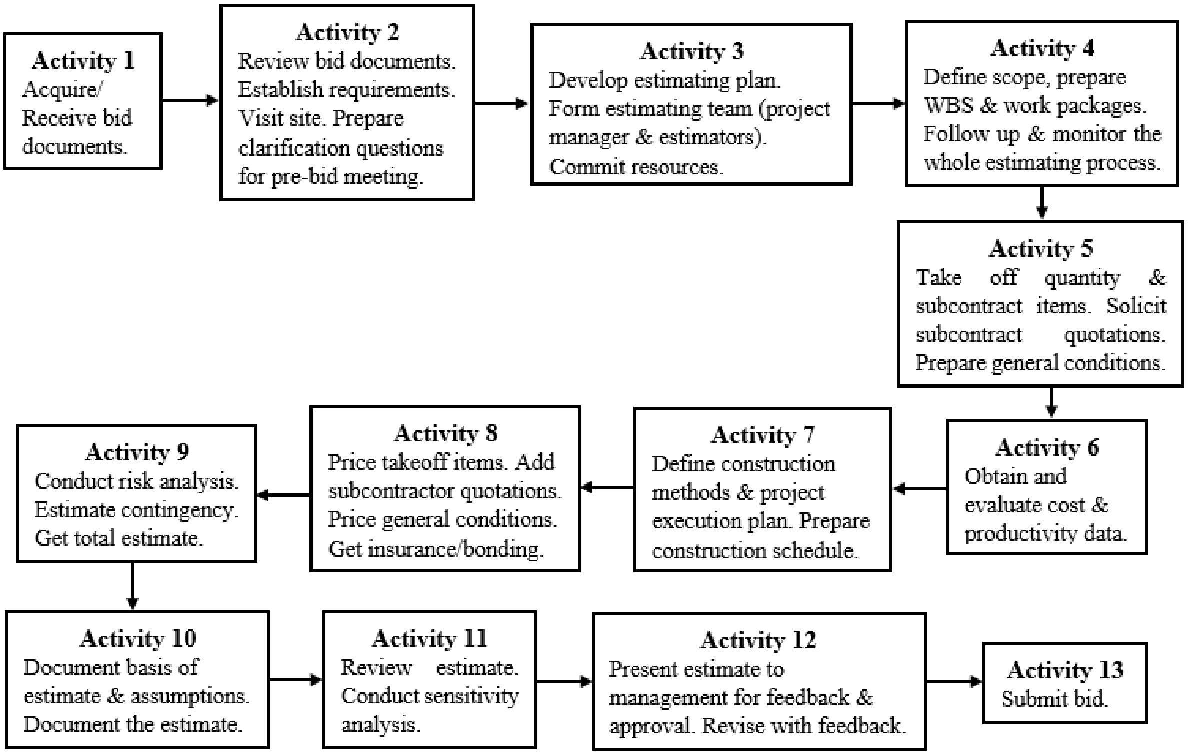


Figure 3.12 Estimating process flow diagram
(Source: Developed based on Rios et al., 2006; Hendrickson, 2003; Oberlender, 2003; McGuire, 2006)

The process performance indicator will usually be a lagging indicator. The percentage bid winning rate in Figure 3.13 is a lagging performance indicator. The problem with lagging indicators is that by the time they indicate poor performance, the situation is out of control and it is too late to do anything about them. So, what is required is to use a set of leading indicators that can be manipulated and monitored using timely feedback to ensure the processes do not go out of control, i.e., lagging indicators can be proactively improved and managed using leading performance indicators. Usually, these leading indicators relate to the inputs to the process or the activities within the process or even outputs of the process or linkages between these elements. Researchers used different methods. Bititci and Nudurupati (2002) used the performance indicator of each activity on process flow diagram as a leading indicator. In this research, performance indicators of the main factors are used as the leading indicators.

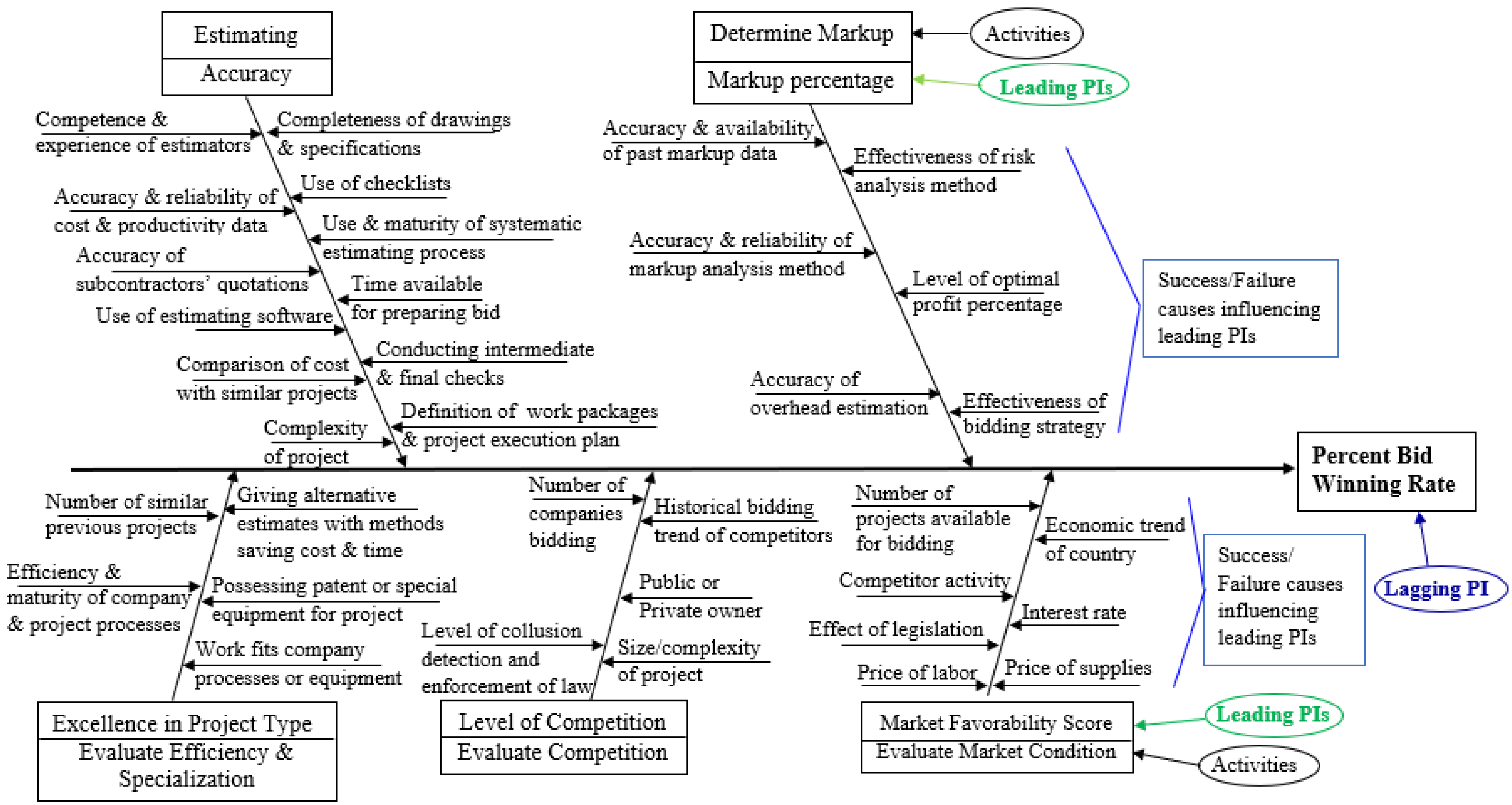


Figure 3.13 Fishbone diagram for estimating process bid win rate

(Source: Developed based on Rios et al., 2006; Hendrickson, 2003; Oberlender, 2003; McGuire, 2006)

Fishbone diagrams are drawn for each of the issues in Figure 3.8 except strategic planning, interactions, and sustainability initiatives, and given in Appendix A. The leading indicators are improved and monitored by manipulating the subfactors by applying RIPs, countermeasures, and BPs from the database of the DSS (given in Appendix F) as will be discussed in subsection 3.4.2.2.

Using the fishbone diagrams to establish this link between leading performance indicators and lagging performance indicators is effective in driving continuous improvement. Continuous improvement using the fishbone diagrams is carried out using FMEA through the computation of Risk Priority Numbers (RPN).

FMEA is a systematic method of identifying and preventing process and product problems before they occur (Jevgeni et al., 2015) and hence improves the reliability and predictability of processes. Continuous improvement using FMEA allows the improvement teams to prioritize the potential impact of each cause (failure mode) according to its: frequency of occurrence, severity, and detectability.

Frequency of occurrence: How often can a failure mode occur? The rating scale ranges from Very Often = 10 to Very Rare = 1.

Severity: Once a failure occurs, how severe would its impact be on the problem one is trying to control? The rating scale ranges from Very High = 10 to Very Low = 1.

Detectability: How difficult or easy is it to detect the occurrence (or possible occurrence) of a failure mode before it affects the process performance? The rating scale ranges from Very Difficult = 10 to Very Easy = 1.

Table 3-6 gives a more precise definition of the rating scale.

FMEA involves assigning values ranging from 1-10 to frequency of occurrence, severity, and detectability of failure of each subfactor on a branch, calculating Risk Priority Number (RPN) from Equation 3.2 and ranking subfactors from the highest RPN to the lowest, subfactor with the highest RPN factor being the most prone to failure (most unreliable one).

$$\boldsymbol{RPN = Occurrence * Detectability * Severity} \qquad . \qquad . \qquad (3.2)$$

Table 3-7 gives example RPN calculation for accuracy of bid estimates, which is one of the main factors and a leading indicator in Figure 3.13.

RPN will be calculated after improvement. The reduction in RPN is directly related to the level of improvement made (Bititci and Nudurupati, 2002). The assignment of 1-10 to the frequency of occurrence, severity, and detectability are subjective, based on the experience of members of the improvement team. However, that is the best information available with which to work. KPIs would have been better used, but as described in Section 3.2, construction companies do not use KPIs for performance measurement. An improvement team decision-making process adds value by reducing the bias that might creep in if only one individual were to do the assessment.

Table 3-6 Rating scale for frequency of occurrence, severity, and detectability

Rating Level	**Definition of the rating level**
10	91 -100% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
9	81 -90% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
8	71 -80% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
7	61 -70% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
6	51 -60% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
5	41 -50% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
4	31 - 40% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
3	21 - 30% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
2	11 - 20% of the maximum (maximum frequency, severity, or difficulty to detect from past data).
1	0 -10% of the maximum (maximum frequency, severity, or difficulty to detect, from past data).

The reduction in RPN may be given in percentage as in Equation 3.3 to gauge the level of improvement attained.

$$\%\ \textbf{age reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100} \qquad (3.3)$$

Table 3-7 FMEA for accuracy of bid estimates

Item ID	Factors affecting accuracy of bid Estimates	Frequency of Occurrence	Severity	Detectability	Risk Priority Number (RPN)	Rank
1	Competence & experience of estimators	4	5	2	40	9
2	Completeness of drawings & specifications	7	6	8	336	1
3	Accuracy & reliability of cost and productivity data	3	7	6	126	5
4	Use of checklist for estimate completeness and basis	2	6	2	24	10
5	Accuracy of subcontractors' quotations	5	7	7	245	2
6	Use and maturity of systematic estimating process	2	3	2	12	11
7	Time available for preparing estimates	8	7	4	224	3
8	Comparison of cost with similar projects	6	4	2	48	8
9	Use of estimating software	2	3	1	6	12
10	Conducting intermediate and final checks	6	6	3	108	6
11	Definition of project execution plan	6	7	2	84	7
12	Complexity of project	5	6	6	180	4

The improvement team may decide to make all improvements at once or may decide to improve in phases or make improvements to a few top-ranked factors. The top 6 or 8 priority factors may be improved within the available budget, time, and other resources, and the rest improved in the next budget cycle or phase.

b. Drawing fishbone diagrams for departments

The difference between drawing fishbone diagrams for processes and departments is that in the case of processes, we begin by drawing process flow diagrams and then draw the fishbone diagram. In the case of departments, there are no process flow diagrams. Drawing fishbone diagrams for departments follow either of the two ways used to draw fishbone diagrams for processes.

c. Database of Root Causes

After carrying out root cause analysis using the fishbone diagrams, the next step is to determine the root causes of each subfactor's failure on the branch of the fishbone diagram selected by RPN prioritization. Root causes of failure of all the subfactors for fishbone diagrams given in Appendix A are documented in the database of the DSS and reproduced in Appendix E. For example, the top three subfactors affecting the accuracy of bid estimates from Table 3-7 are Completeness of drawings & specifications (RPN = 336), Accuracy of subcontractors' quotations (RPN = 245) and Time available for preparing estimates (RPN = 224). Table 3-8 gives root causes of failure of these three subfactors obtained from the database of root causes of the DSS.

Table 3-8 Root causes of failure of top three subfactors

Top priority subfactors	**Root cause/s**	**Solution in terms of RIPs and/or BPs**
Completeness of drawings & specifications (RPN = 336)	Oversight by consultants due to time pressure or lack of experience or capacity.	
Accuracy of subcontractors' quotations (RPN = 245)	Time pressure to estimate or lack of capacity.	
Time available for preparing estimates (RPN = 224)	Poor project planning by client.	

The improvement team needs to refill Tables 3-7 and recalculate RPN after interventions through the selection of RIPs, countermeasures, and BPs from the database of the DSS.

Interactions between departments are challenging to analyze the way we did for company and project processes because departments are related to one another in different ways. Lack of pattern in department interactions made the development of fishbone diagrams for the interactions very difficult. The processes also capture most parts of the interactions. Therefore, the author suggests a solution that involves the following two elements:

1. Assigning responsible owners for each of the processes to make sure someone attends the processes. Assigning owners to each process helps ensure activities and responsibilities outside the scope of departments do not fall between the cracks (Vanhaverbeke and Torremans, 1998), which improves the efficiency of the processes and ensures smooth interactions. Table 3-9 gives the suggested owner for each company and project process.

2. Each department or unit head may be required to plan for and request any support and service of other departments or units ahead.

Table 3-9 Process owners of company and project processes

Key construction company processes	Suggested process owners
1. Estimating	Bidding department head
2. Pricing	Bidding department head
3. Communication	Deputy manager
4. Scheduling	Scheduling expert
5. Subcontractor management	Deputy manager
6. Job costing	Design head and project managers
7. Project closeout	Project managers
8. Lessons learned	Design head, bidding head and project managers
9. Procurement management	Procurement head
10. Equipment management	Equipment head
11. Training program process	Deputy manager
12. Finance process	Finance head
13. Marketing process	Deputy manager or marketing head
All project processes	Project managers

3.4.2.2 Intervention Selection in terms of RIPs and BPs

Intervention selection is the process of identifying and recommending the most appropriate RIPs and BPs to successfully resolve a performance improvement problem, bottleneck, or challenge or exploit an opportunity. This step involves selecting RIPs and BPs from the DSS database to compose them into solution alternatives, which is Step 6 in Figure 3.7.

Selection of RIPs, BPs, and countermeasures to Causes of Failures from Database

RIPs, BPs, and countermeasures that eliminate the root causes of failure of all the subfactors in all fishbone diagrams in Appendix A are documented in the database of the DSS and can be selected as will be described in Section 5.2. The RIPs, BPs and countermeasures are documented in the database (and Appendix E) from the extensive literature review, as discussed in Section 2.3, that would eliminate or reduce the identified root causes.

Step 7 in Figure 3.7 involves the prioritization of solutions by ranking. It is good practice to select several solutions, with some being for later use because a new intervention can be costly to develop (van Tiem et al., 2012). Each team member selects 10-15 potential solutions and ranks the top 5-6 (van Tiem et al., 2012). Then the team gets together and selects top solutions on which it establishes a consensus. Continuous improvement iterations will be made in Step 8 using the prioritized solutions to advance performance until level 5 is reached. RIPs, countermeasures, and BPs that eliminate the root causes of top priority subfactors in Table 3-7 are selected from the DSS database and given in the last column of Table 3-8, which is reproduced in Table 3-10.

Table 3-10 Solution to root causes of failure of top three factors influencing accuracy of estimates

Top priority subfactors	**Root cause/s**	**Solution in terms of RIPs and/or BPs**
Completeness of drawings & specifications (RPN = 336)	Oversight by consultants due to time pressure or lack of experience or capacity.	List items missing from drawings and specifications exhaustively and ask client for clarification.
Accuracy of subcontractors' quotations (RPN = 245)	Time pressure to estimate or lack of capacity.	Exercise due care in subcontractor selection. Give training support to long-term partners.
Time available for preparing estimates (RPN = 224)	Poor project planning by client.	Assign more resources, make data and other inputs ready and easy to use, use software, develop estimating expertise.

Regarding process maturity levels, Sarshar et al. (2000) classification ranging from Level 1 to Level 5 given in Figure 2.4 is used. For levels of best project productivity practices implementation, the elements listed in Table 2-7 are rated as per rating levels in Table 3-11 in the DSS.

Table 3-11 Definition of the different levels of rating

Rating Level	**Definition of rating level**
Level 0	The planning and implementation of the element is not applicable.
Level 1	The planning and implementation of the element is not addressed in any capacity on the project.
Level 2	The planning and implementation of the element is addressed up to a certain extent, but in a below average manner.
Level 3	The element has average level of planning and implementation.
Level 4	The planning and implementation of the element is thorough, above average, but not perfect.
Level 5	The element has the highest possible planning and implementation level, i.e. at most state of the art and technologically advanced level.

3.5 Validation of Two-Part Excellence Model, and Diagnostic Tool and DSS

The weak market test is conducted to carry out external validation of the two-part excellence model and diagnostic tool and DSS, which requires giving the model and computer tool to the manager of a construction company. The model and computer tool pass the weak market test if the manager is willing to use them for his/her management decisions. The author asked a highways and bridge construction contracting company in Ethiopia to use both the two-part excellence model and computer tool. The company is a midsize company that constructs federal roads and bridges in Ethiopia and has 68 permanent employees. The company owner and manager was willing to use both the two-part excellence model and diagnostic tool and DSS, and gave feedback to the author. The feedback is that the manager wants to use both for his decisions, and found both useful. The company manager's response is documented in Appendix F. The company manager went above and beyond what the author asked him, to give a thorough review (given in Appendix F) but was not willing to give his company data to be used as case example in this thesis. The company case example was not a requirement of the weak market test, but the author asked the manager if he would give his detailed company information.

3.6 Point of Departure from Current Body of Knowledge

This research contributes to body of knowledge in several ways. First, it forwards a two-part profitability improvement excellence model for construction companies that gives strategies to overcome challenges, problems, bottlenecks, and issues construction companies face. The excellence model also helps to improve profitability applying continuous improvement through iterative and recursive application of continuous improvement at the company, department, interactions, projects, sustainability issues and employee levels. The two-part excellence model is a novel strategic construct that can reasonably be expected to result in profitability improvement if companies use it. The excellence model is translated into the diagnostic tool and Decision Support System (DSS) in Access 2016 that construction companies can use to diagnose their current status to identify bottlenecks. The development of the two-part excellence model and the computer tool is significant and useful because it makes the removal of bottlenecks and solutions of problems more manageable.

Second, the DSS helps to do root cause analysis to pinpoint what causes the undesirable effects and gives guidance on the selection of rapid improvement principles, countermeasures, and best practices that help improve profitability. The DSS gives immediate feedback about profitability improvement in terms of reduction in Risk Priority Number (RPN) that help drive management and continuous improvement of profitability, which is a significant contribution.

Currently, the profitability of construction companies is low. Such a system that helps to manage and improve profitability will be beneficial to solve the existing problem of razor-thin profit and low profitability, and is a point of departure from available methods in the industry. Such continuous feedback also helps develop an achievement culture that benefits employees, companies, industry, and country.

Other researchers tried to solve construction industry problems by productivity improvement, using technology, improving contractual relations, and applying lean construction, which all resulted in improvement, but construction industry problems persisted, and results were not as effective as expected. Extraction of all rapid improvement principles and best practices in the construction industry and other industries, their integration, and their application to effect rapid and transformative profitability improvement is the other point of departure from previous work.

Developing a DSS that aids getting fast and immediate feedback for decision making may help/contribute towards IT-driven construction industry practice to exploit the potential of IT capability.

3.7 Summary of Chapter 3

In this chapter, the research methodology used in the development of the two-part excellence model and the diagnostic tool and DSS are discussed. Constructive applied research is used for the development of the two-part construction company profitability improvement model.

The diagnostic tool and DSS is developed based on and using the recursive and iterative continuous improvement model as a flow chart. Access 2016 is used for the development.

Weak market test is used to externally validate the two-part profitability improvement model, and the diagnostic tool and DSS. Internal validation of the diagnostic tool and DSS will be conducted in Chapter 5 by way of sample company example.

Chapter 4 discusses use of rapid improvement principles and best practices for improvement. Chapter 5 will deal with the way to use the diagnostic tool and decision support system and demonstrate the use of the diagnostic tool and DSS by applying it to a mid- size highway sample company.

4. BEST PRACTICES AND RAPID IMPROVEMENT PRINCIPLES

Section 4.1 deals with the use of Best Practices (BPs) developed by the Construction Industry Institute and others for improvement interventions. Section 4.2 deals with the use of Rapid Improvement Principles (RIPs) extracted from lean construction, the theory of constraints, business model innovation, value innovation, change management and organization development, improvement science, value improving practices, breakthrough thinking, and performance improvement. Section 4.3 discusses the application of BPs and RIPs in the development of process flow and fishbone diagrams for company and project processes. Section 4.4 addresses some problems, with the RIPs and BPs for their resolution not addressed in the classifications in Sections 4.1 and 4.2. Finally, Section 4.5 gives a conclusion on chapter 4.

4.1 The Use of Best Practices in Improvement

Construction Industry Institute (CII) advocates that the construction industry can create predictable value for stakeholders and society through the use of its validated 17 industry best practices (Construction Industry Institute, 2011). CII also demonstrated through quantitative analyses on the relationships between best practices and project performance in its 2010 CII Value of Best Practices Report. This section discusses the application of these BPs to the improvement of the different cost centers and profit centers. This section also addresses Best Practices developed by the International Society for Performance Improvement (ISPI) and other best practices recommended in the scientific literature. The discussion follows the following format to structure the discussion: name of BP, source of BP (agency or author), definition or description of the BP, circumstances/situations and contexts in which the BP applies, and cost center or profit center where the BP applies.

4.1.1 Construction Industry Institute Best Practices

The Construction Industry Institute best practices in alphabetical order are:

a. **Advanced Work Packaging (AWP)**

Definition or description of the BP

Advanced Work Packaging (AWP) is an overall planned, executable process flow of all the detailed work packages (construction (CWP), engineering (EWP), and installation (IWP)) to support efficient execution at the workface (Construction Industry Institute, 2011). AWP provides conducive foundation for productive and progressive construction and presumes the existence of a construction execution plan. IWP consists of construction scope of work, safety procedures, quality requirements, direct field equipment, specialty tools and consumables, materials, and interdependencies (Ed Bryan seminar). CWP consists of craft/workforce, special permits / regulatory requirements, subcontractors, vendor support data, rigging studies, scaffolding, risk register, project controls, turn over documents, and contact list (Nasir, 2013). EWP consists of drawings and engineering information.

Circumstances/situations and contexts in which the BP applies

AWP applies to all construction workface planning. It is used in interactive, collaborative, structured and focused workface execution planning of implementation of construction tasks. AWP removes some of the routine execution planning from field supervision by explicitly considering work packages during project definition, engineering, and construction planning (Construction Industry Institute, 2011). The work packaging and constraint management process removes the guesswork from execution at the workface by closely defining the scope of all work involved and ensuring that all things necessary for execution are in place.

Cost center or profit center where the BP applies

The BP applies to look ahead planning on projects, to design department supporting site teams preparing shop drawings, coordinating site tasks and reconciling conflicts, to procurement department and process using the information to procure materials and equipment required by work packages, and to facilitate the logistics.

b. Alignment

Definition or description of the BP

It is the condition that project participants are working together to meet a uniformly defined and understood set of project objectives (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Its implementation is suggested when various vendors and subcontractors are involved in a project. Three dimensions: vertical (top-down within an organization), horizontal (cross-organizational between CCs and PCs), and longitudinal (through the project life cycle) (Construction Industry Institute, 2011). It is implemented by a project manager on construction projects to overcome ineffective communication and interactions among stakeholders, who develop and communicate clear goals to each stakeholder. Alignment helps avoid wasted effort, which would occur due to a lack of alignment.

Cost center(CC) or profit center(PC) where the BP applies

Alignment is applied in project execution/implementation on site - each CC or PC and external stakeholder doing its part on time and as per quality standards. The project manager can ensure alignment through effective communications. Alignment also applies to interactions between CCs and PCs, CCs and CCs, PCs, and PCs in working towards project objectives.

c. Benchmarking and Metrics (BMM)

Definition or description of the BP

Benchmarking is a systematic way of measuring an organization's performance against recognized leaders to determine best practices that, when adopted and utilized, leads to superior performance (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Companies can conduct performance assessment and use of CII BPs using an online CII tool after project phases or at project closeout. Results compare project performance to industry performance. Another way to apply BMM is by performance measurement. Indirect performance measurement is adopted in this research using a reduction in Risk Priority Number (RPN) due to the absence of satisfactory performance measurement practice indicated by the questionnaire survey in Section 3.2.

Cost center(CC) or profit center(PC) where the BP applies

BMM applies to all CCs and PCs. Performance measurement is a prerequisite for any improvement effort. There is a need to develop an easy-to-use performance measurement system for construction companies using Parmenter's (2015) or Martz's (2008) recommendations.

d. Change Management

Definition or description of the BP

Change management is an organization's process of incorporating a balanced change culture of recognizing, planning, and evaluating project changes (scope, error, design development, estimate adjustments, and changed conditions) to manage them effectively (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Change management BP will be required when several engineering firms are involved in project development due to an increased number of errors caused by miscommunication. This BP is also effective in high-craft labor turnover due to difficult job site conditions and competitive adjustment plans.

Cost center(CC) or profit center(PC) where the BP applies

Change management applies to PCs (projects). Design, procurement, and finance CCs will be affected by changes.

e. Constructability

Definition or description of the BP

Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

By design firms during the design development phase for a facility (peer review and feedback system). Peer reviews uncover and correct design inconsistencies and specify alternative construction methods. The feedback process includes the capture and transfer of lessons learned. By contractors during the preparation of work packages and shop drawings (included as project productivity factors in the DSS in this research).

Cost center(CC) or profit center(PC) where the BP applies

Constructability is applied in Design and Procurement departments. It is accomplished by the inclusion of experienced construction personnel during design and procurement.

f. Disputes Prevention and Resolution

Definition or description of the BP

Dispute prevention and resolution techniques include dispute review boards as an alternate dispute resolution method for addressing disputes in early stages before affecting the progress of the work, and before creating adversarial positions leading to litigation (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

A low responsible bidder system of contractor selection results in adversarial relationships between contractor and owner and between contractor and subcontractors. If project teams could not prevent claims and cannot settle amicably, the use of low cost and shorter time resolution alternatives becomes necessary.

Cost center(CC) or profit center(PC) where the BP applies

It is applicable where signed contract agreements exist between parties such as owner and contractor, and contractor and subcontractors/vendors. The contract is signed by top management for the contractor. The project manager may sign a contract with subcontractors and vendors.

g. Front End Planning (FEP)

Definition or description of the BP

FEP is the process through which owners develop sufficient strategic information to address risk and commit resources to maximize project success (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Applied to infrastructure projects during feasibility, concept, and detailed scope (before detailed design and construction) to assist teams in developing well-defined projects (Bingham and Gibson, 2017). Companies can use the Project Definition Rating Index (PDRI) to measure the level to which the project is defined.

Cost center(CC) or profit center(PC) where the BP applies

Owners usually apply FEP, but a contracting company can do something similar in project planning before beginning construction. The project manager is best to lead the planning effort.

h. Implementation of CII Research

Definition or description of the BP

Implementation of CII research is an effective and comprehensive use of proven CII products by organizations, as outlined in the CII Implementation Model (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

The company, at any level of BP implementation, can apply the CII BPs.

Cost center(CC) or profit center(PC) where the BP applies

Applicable by all CCs and PCs.

i. Lessons Learned

Definition or description of the BP

Effective lessons learned program (LLP) would facilitate the continuous improvement of processes and procedures and provides a direct advantage in an increasingly competitive market (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

All organizations need lessons learned (LL) program, but LL helps keep and pass on company memory as turnover increases and employees age. Globalization also increases the need for LL programs to ensure that an organization can address critical issues such as culture, language, distance, and diversity (Construction Industry Institute, 2011).

Cost center(CC) or profit center(PC) where the BP applies

Few companies have successfully identified and transferred knowledge from current projects to future projects (Construction Industry Institute, 2011). Project managers may collect, and transfer lessons learned to the database, company experts in the design department may validate lessons learned.

j. Materials Management

Definition or description of the BP

Materials management is an integrated process for planning and controlling all necessary efforts to ensure that the company appropriately specifies the quality and quantity of materials and equipment on time, obtains at a reasonable cost, and makes available when needed (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Materials and related services account for a large percentage of total installed cost in infrastructure projects; hence this BP is applicable under all situations and circumstances. Further, infrastructure projects use equipment/machinery heavily, and effective equipment management determines the success of a project.

Cost center(CC) or profit center(PC) where the BP applies

Equipment department, and process managing equipment. The procurement department and procurement process apply materials management, but the majority of organizations reported regularly outsourcing transportation and logistics, supplier quality management, purchasing, and expediting.

k. Partnering

Definition or description of the BP

Partnering is a long-term agreement between two or more organizations as in an alliance, or it may apply to a shorter period, such as for a single project. Partnering serves specific business objectives by maximizing the effectiveness of each participant's resources in constructing a project (Construction Industry Institute, 2011). Patty and Denton (2010) deals with application of lean principles to long-term partnering, which they called and claim will result in relational competitive partnering but fails to give the crucial ingredients for it to work. Chan et al. (2004) list these elements as critical success factors of partnering as adequate resources, support from top management, mutual trust, long-term commitment, effective communication, efficient coordination, and productive conflict resolution. Choquette (1994) adds a partnering charter as a useful ingredient that help practical implementation of partnering in a project. Partnering charter should be developed jointly by all parties to the project and identifies specific mutual goals and objectives of the partnering participants for continuous evaluation and review against the agreed upon mutual goals. In the case of a single project, Rahman and Kumaraswamy (2008) say that relational contracting is more effective (than partnering) because it enables integration of stakeholders goals.

Circumstances/situations and contexts in which the BP applies

Its implementation is suggested when a company (owner or contractor) needs the expertise and resources of various vendors and subcontractors to carry out a project successfully.

Cost center(CC) or profit center(PC) where the BP applies

Top management of contracting company gets into partnering agreements with subcontractors and vendors. The interaction occurs between CCs and PCs with the external stakeholders (subcontractor, vendor).

l. Planning for Modularization

Definition or description of the BP

In Planning for modularization, client and contractors evaluate and determine the possibility of offsite production of modular components for cost and time saving. Planning for modularization is conducted during front end planning phase to achieve specific strategic objectives and improved project outcomes. The process includes developing a business case and execution strategy for the large-scale transfer of stick-built construction effort from the job site to fabrication shops or yards (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

It is advantageous for companies to use modularization, prefabrication, and preassembly in situations when site production is difficult or when site productivity is low or when quality standards on site are difficult to attain and when prefabrication and preassembly are significantly cheaper and faster.

Cost center(CC) or profit center(PC) where the BP applies

The design department can apply this BP in producing shop drawings, procurement departments in purchasing materials, equipment and components, projects in planning, production, and installation of modular units.

m. Planning for Startup

This BP applies to only industrial projects (CII BMM 2010-4). The projects considered in this research are highway and civil (infrastructure) projects.

n. Project Risk Assessment

Definition or description of the BP

Project risk assessment is the process of identifying, assessing, and managing risks. The project team evaluates risk exposure for potential project impact to provide the focus for mitigation strategies (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Having a process in place that identifies and monitors project risks can be essential to both preventing the failure of a project and improving the project's outcomes (Construction Industry Institute, 2011).

Cost center(CC) or profit center(PC) where the BP applies

Bidding department can apply this BP in conducting estimating, project manager in project risk management and schedule management, top management in pricing bids.

o. Quality Management

Definition or description of the BP

Quality management incorporates all activities conducted to improve the efficiency, contract compliance, and cost-effectiveness of design, engineering, procurement, QA/QC, construction, and startup elements of construction projects so that owners' business and project objectives are achieved (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

Quality management should be applied to all phases of project including construction phase (Included as project QA process and fishbone diagram in the DSS in this research).

Cost center(CC) or profit center(PC) where the BP applies

Quality management applies to all phases of the project, including the construction phase (Included as project QA process and fishbone diagram in the DSS in this research).

p. Team Building

Definition or description of the BP

Team building is a project-focused process that builds and develops shared goals, interdependence, trust, commitment, and accountability among team members, seeking to improve team members' problem-solving skills (Construction Industry Institute, 2011). Team building resolves differences, removes roadblocks, and proactively builds and develops the group into an aligned, focused, and motivated work team that strives for a joint mission and shared goals, objectives, and priorities (Construction Industry Institute, 2011). Patty and Denton (2010) argue that team building exercise is often a waste of time if the teams go back to work as usual. They suggest that it is more effective use of time and resources if implemented for team derivation of work process standards to yield performance excellence and training their teams on trust. Work process standards are standard best procedures for carrying out processes, which is developed from repeated experiences and best practices. Trust and standards may be part of the solution and team effectiveness is a well- researched topic on which literature abounds (Willemon and Thamhain, 1983, Solis et. al, 2013, and Jackson and Madsen, 2004; Katzenbach and Smith, 1993; Dyer et al., 2007; Albanese, 1994, Chinowsky et al., 2008). Some of this literature give characteristics of high performance teams (HPT) in general (Jackson and Madsen, 2004; Katzenbach and Smith, 1993; Dyer et al., 2007) and high performance multi-stakeholder teams in construction (Albanese, 1994, Chinowsky et al., 2008; Solis et. al, 2013). Katzenbach and Smith, (1993) give characteristics of HPT as individual and mutual accountability, specific team purpose that the team itself delivers, collective work products, encourages open-ended discussions and active problem solving meetings, measures performance directly by assessing collective work products, discusses, decides, and does real work together. Dyer et al. (2007) gives characteristics of HPT as a teams that clearly articulate goals and metrics that indicate goal achievement, clearly articulate means to achieve goals, make effective decisions, communicate effectively, give and receive feedback, build trust and commitment to team and goals, resolve disputes and disagreements, and the like. Jackson and Madsen (2004) and others add one important ingredient not pointed out by others. It is team leadership characteristics for HPT. There is ample but as a sample, essential leadership qualities include the following: 1) having a vision— meaning one should see the crisis before it happens and act upon it; 2) convincing the opinion leaders of the importance of the goals at hand; 3) organizing quantitative goals; 4) being persistent in asking for the goals to be met; 5) endurance testing—whereby leaders must remain steadfast amongst team members trying to test the leaders commitment; 6) the ability to induce creativity once goals are set; and 7) staying out of the team's way (Regan in Jackson and Madsen (2004)). Some of these characteristics are included in process flow and fishbone diagrams for effectiveness of project team coordination in Appendix A on pages 357-358, and Appendix E on pages 686-695.

Circumstances/situations and contexts in which the BP applies

Team building is essential to get a project undertaken. The team consists of owners, consultants, contractors, subcontractors, and suppliers. These team members share the common goal of constructing a project, but because of conflicting and competing interest a project may suffer from a lack of teamwork (Bender and Septelka, 2002). Team-building techniques help to minimize adversarial relationships that may occur due to differences in interests. Partnering and relational contracting helps improve multi-stakeholder project team performance. There is concern by some experts that there is resistance to change as discussed in Chapter 6 and implementation needs to improve.

Cost center(CC) or profit center(PC) where the BP applies

Project manager, all CCs, and external stakeholders are involved in building project teams, but the project manager has a significant responsibility. The project manager selects team members from different CCs, and the CCs should allow their people to join project teams. External stakeholders, such as owners and subcontractors, form part of the project team.

q. Zero Accidents Techniques

Definition or description of the BP

Zero accident techniques include the site-specific safety programs and the implementation, auditing, and incentive efforts undertaken to create a conducive project environment and training that enables achievement of zero accidents goal (Construction Industry Institute, 2011).

Circumstances/situations and contexts in which the BP applies

This technique applies to all projects. Safety measures are taken in planning, design, and construction, but the implementation of the technique takes place on project sites.

Cost center(CC) or profit center(PC) where the BP applies

Projects implement zero accident techniques.

4.1.2 Best Practices by International Society for Performance Improvement

Member scholars and practitioners of International Society for Performance Improvement (ISPI) have actively engaged in performance improvement research since 1962 that resulted in different models of improvement (Wilmoth et al., 2002) which all use best practices to alleviate performance problems (van Tiem et al., 2012). Below, discussion of these BPs follows:

a. Learning/Training Interventions

Definition or description of the BP

These BPs apply to knowledge and training management. These consist of the following from which improvement teams can select: knowledge management, organizational learning, learning management system, content management system, education/training, self-directed learning, on-the-job learning, just-in-time learning, action learning, blended learning, technical and non-technical learning, social learning, interactive learning technologies, enterprise learning, classroom learning, distance/distributed learning, online/e-learning, wikis, avatars, and more, games/simulations (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

Continuous training is needed to develop the knowledge, skills, and abilities (KSA) of employees to help the company achieve a competitive advantage, profitability, and growth. Training is also a prerequisite for innovation and continuous improvement.

Cost center(CC) or profit center(PC) where the BP applies

Employees in all CCs and PCs need training. Top management is in charge of training through the HR department.

b. Performance Support Interventions

Definition or description of the BP

Applied in supporting workers' performance on the job. Job aids consist of the following: performance support tools or job aids, electronic performance support systems, documentation and standards, and expert systems (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These tools aid employees to overcome their limitations (e.g., cognitive overload, attention span, fatigue, and the like) and magnify/maximize employee strengths.

Cost center(CC) or profit center(PC) where the BP applies

These tools are usable by employees in all CCs and PCs. Appropriate aids need to be developed for each CC and PC, and for the job type employees perform.

c. Job Analysis

Definition or description of the BP

Applies in determining what the job entails. Job analysis consists of job descriptions and job specifications (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

The company needs to give each employee his/her job descriptions and specifications so that he/she knows what the company expects of him/her and the best way to accomplish the job.

Cost center(CC) or profit center(PC) where the BP applies

This BP applies to employees in all CCs and PCs.

d. Work Design

Definition or description of the BP

Applies to the design of the work to enable high worker performance. The list of these BP comprises job design, job enlargement, job rotation, job enrichment, reengineering, realignment, and restructuring (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

This BP is an enabler of high worker performance by maximizing employee strengths.

Cost center(CC) or profit center(PC) where the BP applies

This BP applies to employees in all CCs and PCs.

e. Human Factors

Definition or description of the BP

Human factors BPs consist of ergonomics, safety engineering, security management, and green workplace (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs are enablers of high worker performance by maximizing employee strengths and ensuring safe work accomplishment.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to employees in all CCs and PCs.

f. Quality Improvement

Definition or description of the BP

Quality improvement BPs consist of Total Quality Management (TQM), continuous improvement, preventive maintenance, six-sigma, and lean organizations (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs aim at improving the quality of products and services to ensure customer satisfaction.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to employees in all CCs and PCs.

g. Personal Development Interventions

Definition or description of the BP

These BPs apply to develop individual employees. Personal development interventions consist of feedback, coaching, mentoring, emotional intelligence, social intelligence, cultural intelligence, and communities of professional practice (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs help develop soft employee skills to maximize employees' efficiency and effectiveness (productivity).

Cost center(CC) or profit center(PC) where the BP applies

This BP applies to employees in all CCs and PCs.

h. HR Development Interventions: Talent Management

Definition or description of the BP

These BPs Apply in developing HR of the company. Talent management consists of staffing, employee development, retention, compensation/benefits, health and wellness, retirement planning, and labor relations (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

This BP helps the company to manage the talent of its employees.

Cost center(CC) or profit center(PC) where the BP applies

This BP applies to employees in all CCs and PCs.

i. HR Development Interventions: Individual Growth

Definition or description of the BP

Individual growth BPs consist of motivation, performance management, key performance indicators (KPIs), performance appraisals, 360-degree appraisals, competencies, and competency testing (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs aim at giving feedback to employees so that they improve their performance.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to employees in all CCs and PCs.

j. HR Development Interventions: Organizational Growth

Definition or description of the BP

Organizational growth BPs consists of succession planning, career pathing, leadership development, executive development, management development, and supervisory development (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs help develop the leadership of the company.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to leaders at different levels of a company, including unit heads (of CCs and PCs), team leaders, and supervisors.

k. Organizational Communication Interventions

Definition or description of the BP

Organizational communication interventions BPs consist of communication networks, information systems, suggestion systems, grievance systems, dispute resolution, and social media (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs aims at improving organizational and project communication.

Cost center(CC) or profit center(PC) where the BP applies

These BPs applies to all CCs and PCs.

l. Organizational Design and Development Interventions: Empowerment

Definition or description of the BP

Empowerment BPs consist of team strategies, virtual teams, and problem-solving (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs aim at empowering employees to improve their decision-making capacity and productivity.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to all company and project teams.

m. Organizational Design and Development Interventions: Organizational Pro-Action

Definition or description of the BP

Organizational Pro-Action BPs consists of strategic planning, environmental scanning, appreciative inquiry, outsourcing, benchmarking, balanced scorecard, and dashboards (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs aim at SWOT analysis, maximizing strengths and minimizing threats.

Cost center(CC) or profit center(PC) where the BP applies

Top management conducts such an analysis.

n. Organizational Design and Development Interventions: Organizational Values

Definition or description of the BP

Organizational Values BPs consists of culture, diversity, inclusion strategies, globalization, localization, social responsibility, ethics, and decision making (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs help build values and culture that would ensure the long-term survival and success of the company.

Cost center(CC) or profit center(PC) where the BP applies

Top management applies these BPs is applied.

o. Financial Systems Interventions

Definition or description of the BP

Financial system intervention BPs consist of open-book management, profit versus cost center, financial forecasting, capital investment and spending, cash flow analysis, cash flow forecasting, mergers, acquisitions, and joint ventures (van Tiem et al., 2012).

Circumstances/situations and contexts in which the BP applies

These BPs aim to make detailed financial information and data available to help determine financial status and aid evidence-based decision making.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to top management, finance department, and finance process.

4.1.3 Best Practices from other Sources

Best practices forwarded by organizations and authors are included under this sub section.

a. Best Practices in Strategic Human Resource Management from literature review by Beh and Loo (2013)

Definition or description of the BP

These consist of seven best practices associated with strategic human resource management: 1) internal career opportunities 2) training systems 3) appraisals 4) profit-sharing plans 5) employment security 6) voice mechanisms (grievance systems and participation in decision making) and 7) degree to which jobs are narrowly designed.

Circumstances/situations and contexts in which the BP applies

Literature shows that organizations engaging or adopting HRM best practices will outperform organizations that do not (Beh and Loo, 2013). A synergistic HRM system is a enables the firm to use its human capital as an essential competitive advantage and enhance firm performance (Boxall and Purcell, 2003). These BPs need to apply in circumstances of lack of skilled and competent workforce. Implementation of these BPs will help the company be more efficient, productive, and innovative on its HRM practices implementation that aligns with the firm’s objective, business needs, and culture to sustain competitive advantage in the market.

Cost center(CC) or profit center(PC) where the BP applies

These BPs apply to the human resource department.

b. Scheduling Best Practices by U. S. Government Accountability Office

Definition or description of the BP

These BPs consist of ten best practices associated with developing and maintaining a reliable, high-quality schedule are: 1) capturing all activities 2) sequencing all activities 3) establishing the duration of all activities 4) assigning resources to all activities 5) verifying that the schedule can be traced both horizontally and vertically 6) confirming that the critical path is valid 7) ensuring reasonable total float 8) conducting a schedule risk analysis 9) updating the schedule using actual progress and logic 10) maintaining a baseline schedule.

Circumstances/situations and contexts in which the BP applies

The construction document (the agreement, drawings, technical specifications) gives the project's end product and the general timeframe for completing the project. The construction document does not give the details of the project from start to end. The schedule gives this detail, i.e., the schedule is the timetable of activities of a project. A well-planned schedule is a fundamental project management tool. A well-formulated schedule also facilitates the analysis of how a change affects the project program.

Cost center(CC) or profit center(PC) where the BP applies

A schedule is developed for each project under the management of the project manager.

c. **Best Practices of Subcontract Management by Thomas and Flynn (2011)**

Definition or description of the BP

This has two parts: managing people and managing the work.

BPs of subcontract management has two parts: managing people and managing the work.

Managing people consists of involving all subcontractors in developing the project plans and schedule, building a trusting relationship by treating subcontractors fairly, not engaging in the practice of bid shopping, seeking commitments from all parties at a pre-bid meeting, helping the subcontractors do timely work by providing assistance and resources as appropriate, walking the job frequently, getting to know the subcontractors' workers and offer assistance as appropriate, explaining expectations to subcontractors before bid submission, meeting regularly with subcontractor supervisors individually.

Managing the work involves identifying the controlling subcontractor, writing a fair and balanced subcontract, developing a submittal schedule and change order log, paying subcontractors on time, prequalifying subcontractors based on their previous work, safety, and financial situation, requiring the subcontractors to hold weekly toolbox meetings, evaluating the subcontractor's performance at regular intervals, requiring subcontractors to maintain good housekeeping, requiring subcontractors to maintain safe working practices, considering the development of coordination drawings, enforcing the contract, Letting all subcontractors review every proposed change order, and meeting regularly with subcontractors collectively.

Circumstances/situations and contexts in which the BP applies

Subcontractors can contribute as much as 90% of the total value of a construction project (Nobbs, 1993). It would be logical for a contractor to focus its effort on this area where major work takes place to improve performance and productivity.

Cost center(CC) or profit center(PC) where the BP applies

Project managers do subcontractor management on their projects. Top management may select subcontractors and sign partnering and alliance relationships, but project managers conduct subcontractor management.

d. Estimating Best Practices by Rios et al. (2006)

Definition or description of the BP

Best Practices to use in estimating are the following: 1) Definition of the scope of work 2) Definition of the project execution plan 3) Determination of the estimating data and cost estimating method to be used 4) Allocation of qualified human resources 5) Calculation of cost of major elements 6) Determination of cost of design, project management, startup, and owners cost 7) Normalization of data, determination of exchange rates and escalation of future costs 8) Determination of contingency to be applied 9) Conducting intermediate and final checks of estimates 10) Comparison of cost with similar projects.

Circumstances/situations and contexts in which the BP applies

To be used in estimating for bidding.

Cost center(CC) or profit center(PC) where the BP applies

Applied by Bidding Department.

e. Best Practices in Strategic Communications from www.causecommunications.org

Definition or description of the BP

The top ten best practices in strategic communications are: 1) 1) commit to focusing time and resources on communications. Allocate a healthy budget to communication because good communications is essential to profitability and sustainability

2) take the time to assess and evaluate current communications before moving forward. Identify the right metrics and establish a baseline for measuring the success of efforts. How will one know how far he or she has come if he/she does not know where he/she started? 3) know one's audiences and continuously seek their feedback. Frame and tailor messages to ensure they are memorable and relevant to the audiences. Test materials and messages before publicly unveiling them. 4) know peer institutions as well as know own organization. Build a company brand by distinguishing the organization from others. Then, reinforce the unique brand identity by linking materials visually and using consistent messages. 5) Develop a strategic communications plan with specific, realistic, and measurable goals. Plan for potential crises so that negative impact is minimized 6) organizational identity is a key component of the company brand. Develop it

strategically and protect it vigorously 7) Practice authentic storytelling and use it as a technique to inspire the audiences and personalize the organization's message. Branding is especially important when attracting and retaining clients: 8) Partner with like-minded organizations to maximize communications effectiveness and expand the reach 9) Show board members the return they will receive from investing in communications, whether increasing revenues and advancement of mission or building reputation. Then go one step further and engage board members as ambassadors for the cause 10) Set milestones and build in checkpoints to evaluate the effectiveness of communications on an ongoing basis. Adjust the strategy based on results and feedback.

Circumstances/situations and contexts in which the BP applies

These BPs are used in planning for communications and in communications management, both corporate and project.

Cost center(CC) or profit center(PC) where the BP applies

Applied by top management, all CCs, and PCs.

f. Construction Safety Best Practices by Hinze et al. (2013)

Definition or description of the BP

Hinze et al. (2013) forwarded seven practices as best practices from the analysis of empirical data that differentiate safety performance. These are 1) worker-to-worker observation programs 2) worker-safety perception surveys 3) tracking of first-aid injuries 4) supervisor involvement in policymaking 5) active owner involvement in safety 6) site-specific safety training for managers 7) adequate safety staffing and other practices.

Circumstances/situations and contexts in which the BP applies

These BPs apply to project site safety that is implemented by all project staff from project manager down to the laborers.

Cost center(CC) or profit center(PC) where the BP applies

Projects apply these BPs.

4.2 The Use of Rapid Improvement Principles for Improvement Interventions

There is sufficient published evidence that the application of some rapid improvement principles, tools, and methods such as just in time, quality improvement initiatives, lean, six- sigma produce better results consistently. Some RIPs extracted from different areas will be applied for improvement in this section following the same format as in Section 4.1.

Three groups of RIPs to be discussed are lean principles from the Toyota Way, lean principles and tools from lean construction and RIPs from other sources.

4.2.1 Toyota Way Lean Principles

The Toyota Way lean principles are:

a. Identify customer value and create value for the customer

Definition or description of the RIP

Companies exist to create value for customers, i.e., to enable the customer to accomplish their business well by creating a facility that serves its purpose well at least cost possible within quality standards.

Circumstances/situations and contexts in which the RIP applies

Value creation applies during both design and construction of a facility.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

b. Map the value stream

Definition or description of the RIP

Mapping value stream begins by defining value from the customers perspective and then analysis of the value stream consisting of all value-adding and non-value adding activities needed to bring raw material through to end customer. Drawing the value stream from the end product back through to the raw materials for the product family to be improved helps see values that the company can create for the client and the waste that can be eliminated. This map is drawn using standard symbols and makes up the ‘Current State Map’ (CSM) for the selected product value stream. Once wasteful steps are eliminated, flow can be introduced to the remaining ‘value-adding’ processes (Womack and Jones, 1996). This forms a ‘Future State Map’ (FSM) designed to represent the ideal production process without the wastes also drawn using standard symbols (Tapping et al., 2002). Value stream mapping (VSM) is a mapping tool that is used to map not only material flows but also the information flows that signal and control production processes in a productive process or an entire supply-chain networks (Braglia et al., 2011). Improvement is measured using metrics such as improvement in lead times, through put rates and value-added ratios.

Braglia et al. (2011) pointed out that VSM works for linear value streams and fails in cases of complex value streams where two or more value streams merge. They proposed Improved VSM where VSM are developed iteratively for the critical and near critical paths (responsible for determining the lead time) and optimized (minimum work in process).

Circumstances/situations and contexts in which the RIP applies

This RIP applies to all tasks. Value stream mapping is the fundamental Toyota Way or Lean system through which work process opportunity to improve is specifically identified and quantified within the context necessary for interfacing with other work processes, but some experts say that this is not applied at all in construction.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

c. Pursue perfection through continuous improvement

Definition or description of the RIP

Continuously improving performance by applying continuous improvement helps attain the excellence of the company.

Circumstances/situations and contexts in which the RIP applies

This RIP applies to all tasks, units, and teams.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

d. Be guided by sense of purpose

Definition or description of the RIP

The company should be driven by a sense of purpose to contribute to society by taking care of its work force, communities, and society at large (who are company customers also) beyond profit. Toyota's strong sense of mission and commitment to its employees, customers, and society are the foundation for all the other principles it applies (Liker, 2004). It is vital to establish the constancy of purpose also.

Circumstances/situations and contexts in which the RIP applies

It is crucial to be purpose-driven and get buy-in from employees, communities, and customers for the long-term survival of a company. Place great emphasis on values and purpose. Govern through shared values and sound judgment.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP is strategic and all-encompassing and applies to all CCs and PCs.

e. Strive for long-term success over short-term financial gains

Definition or description of the RIP

It is good to be cost-conscious, but short-term financial gains should be secondary to decisions that benefit the company long-term.

Circumstances/situations and contexts in which the RIP applies

Companies need to evaluate decisions and actions using the criterion of effect on long-term company goals and objectives.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP is strategic, and all-encompassing, and applies to all CCs and PCs.

f. Be self- reliant and take charge of your destiny

Definition or description of the RIP

Develop core knowledge and responsibility internally and outsource only peripheral items to subcontractors and suppliers.

Circumstances/situations and contexts in which the RIP applies

It is recommended to use the resources and capabilities of long-term partnering subcontractors and suppliers but to keep the capabilities in core business internally to ensure the long-term competitiveness of the company.

Cost center(CC) or profit center(PC) where the RIP applies

Top management applies this RIP because it is strategic.

g. Focus on the customer

Definition or description of the RIP

The goal of the Toyota Way is adding value to employees, customers, and society to enhance customer satisfaction (all are customers, and customer-first philosophy needs to be applied). by Providing valuable products and services and meeting customer needs help company to generate lasting profit. Downstream process, work station, or department is treated as a customer of the previous operation and as a supplier to the next operation downstream.

Circumstances/situations and contexts in which the RIP applies

It is essential to always ask the following questions in making any decisions and taking any actions "What value are we adding from the customer's perspective? Is the customer willing to pay for this action?" Understand what the customer needs and wants, and let customer-first philosophy guide decisions and actions, and extend customer focus philosophy to internal company management (employees, teams, departments) and interactions with external stakeholders (subcontractors, suppliers).

Cost center(CC) or profit center(PC) where the RIP applies

This RIP is strategic and all-encompassing and applies to all CCs and PCs.

h. Ensure one piece continuous flow

Definition or description of the RIP

To ensure continuous flow, products should be made to move continuously through the processing steps with minimal waiting time and unnecessary handling in between (ideally linking operations together to get intermediate waiting time to zero). When operations are linked together, different teams are forced to cooperate, teams receive rapid feedback on earlier quality problems, there will be control over the process, and workers are directly pressured to solve the problems that surface. Ohno (1988) said that one piece flow reduces inventory and makes any problems to surface, which people are forced to solve, or the system stops producing. Creating flow forces teams to correct problems, resulting in reduced waste.

Circumstances/situations and contexts in which the RIP applies

This RIP applies to all processes. The purpose is to optimize process flow by reducing waste and by reducing non-value adding times and activities.

Continuous flow and takt time easily applies in repetitive tasks such as those in manufacturing and service operations (Liker 2004). Creating a continuous process flow in construction is a considerable challenge due to one-of-a-kind features of construction products, fragmented nature, and low standardization of activities (Koskela 2000). Greg Howell and Glen Ballard identified the key “item” flowing on a project is the work that is completed by one operator and handed off to his/her successor. Weekly plans, material flow, and workforce flow help realize workflow.

Cost center(CC) or profit center(PC) where the RIP applies

Flow occurs in company and project processes operated/ managed by process owners. Project teams manage project processes.

i. Use Takt time (cycle time) for flow rate

Definition or description of the RIP

Takt is a German word that means rhythm. It is the rate of customer demand for products produced by a process. Patty and Denton (2010) recommend a Takt time of two hours in construction operations. Their recommendation is based on the fact that the status should be updated on regular intervals (called “takt time”) determined by the team. This could be chosen as often as every two or four hours, or every day as required to maintain a realistic overall picture of where the team is headed. When foremen are asked, they preferred the takt time to be two hours to avoid their teams standing around idle.

Circumstances/situations and contexts in which the RIP applies

Takt time is a metric used to control flow. If the flow is faster than takt time, there will be overproduction. If the flow is slower than takt time, there is a bottleneck. Takt time sets the pace and is used to advise workers when they are faster or slower. Takt time and continuous flow applies in repetitive tasks such as those in manufacturing and service operations (Liker 2004).

Cost center(CC) or profit center(PC) where the RIP applies

All company and project processes.

j. Use pull system to trigger production

Definition or description of the RIP

The pull system in manufacturing is just-in-time manufacturing when a customer order is received: the customer order pulling the production..

Circumstances/situations and contexts in which the RIP applies

Target completion dates drive pull system in construction, for which lookahead planning can be used to control the pull flow. Pull flow control applies to the customer of each process internally (Ballard 2000).

Cost center(CC) or profit center(PC) where the RIP applies

All processes, departments and teams.

k. Use visual control of flow

Definition or description of the RIP

Ohno (1988) invented simple signals, called Kanban consisting of empty bins, cards, or carts as a means for signaling the assembly line to produce the required number of parts. Kanban, as an effective and advanced visual control system, includes a rich information (container capacity, the part number, and certain other information). Kanban helps increase flexibility to respond to customer demand, eliminate overproduction, and reduces costs by eliminating waste.

Circumstances/situations and contexts in which the RIP applies

Visual control simplifies management because all the required information is available at a glance.

Cost center(CC) or profit center(PC) where the RIP applies

All processes can use the RIPs, but it is especially useful at workface on projects.

l. Level out the work load

Definition or description of the RIP

Leveling is the effort to balance the workload to the capacity of the process (machine and operators) and to maintain a constant flow (Shingo 1988).

Circumstances/situations and contexts in which the RIP applies

Use leveling workload in situations where there is variability in the workflow of any trade by using flexible and cross-trained employees with flexible machines and an effective quality assurance system. Prepare weekly work plans and implement them to level out the workload. Construction activities require a different amount of time, and leveling out may be difficult compared to manufacturing. The last planner system helps to achieve a stable and reliable workflow.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all processes but primarily to site tasks.

m. Eliminate different forms of waste

Definition or description of the RIP

Leveling out eliminates unevenness, which is one form of waste, which helps eliminate non-value adding activities and overloading people and machines, the other two forms of waste.

Circumstances/situations and contexts in which the RIP applies

Avoid these wastes under all circumstances and situations.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all processes and departments, including projects.

n. Stop production process when defect is detected

Definition or description of the RIP

This RIP emphasizes control where the people doing the work are allowed to stop production and fix problems to get right quality during first time of production. Companies can use either automatic defect detection and stoppage of production (autonomation) or Andon lights. Andon helps to control the flow visually.

Circumstances/situations and contexts in which the RIP applies

This RIP is a quality assurance function that companies need to follow in all processes, CCs, and PCs. Build at the right quality the first time. Involve people and give responsibility to employees for quality. The other way to implement this RIP is through quality circles. The practice of using inspection to fix construction problems needs to be changed by doing things right first and preventing defects.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP needs to be applied by all CCs and PCs.

o. Standardize tasks/components

Definition or description of the RIP

Gibb and Isack (2001) said in tasks where there are some regularities and repetitions, standardization can be employed. Standardization involves the extensive use of procedures, processes, components or products, in which there are regularities, repetitions, and a record of successful practice recorded in reference materials for performing a particular process or operation.

Circumstances/situations and contexts in which the RIP applies

Standardization helps reduce the effect of a one-of-a-kind project. It also helps to eliminate waste due to inconsistent methods and random activities, reduction, or elimination of process variation needed to establish standardized procedures and work methods (Liker and Meier 2006). Variation means inability to standardize by definition. Standardize tasks as much as possible. Components can be standardized through prefabrication and preassembly when site production is difficult or costly, or meeting quality standards at the site are challenging. Companies can implement standardization in construction by prefabrication of components and standardizing repeatable elements of tasks in processes.

Cost center(CC) or profit center(PC) where the RIP applies

Standardizing task applies to all CCs and PCs.

p. Use visual process management including 5S

Definition or description of the RIP

Visual management is a technique that communicates important information in the physical workplace using a system of information displays using labels, signs, color coding, and other markings instead of written instructions. Visual management helps assess the status of a situation at a glance to detect abnormalities while ensuring safety and stability in task accomplishments.

Circumstances/situations and contexts in which the RIP applies

Visual management is enabler for implementation of visual techniques such as standard work, good site practice such as 5S, total productive maintenance (TPM), Kanban, mistake proofing, prototyping and sampling, quick changeover, and pull production (Tezel et al., 2010) especially during the early phase of improvement interventions. Research shows that people tend to learn and process information more visually, and attracted by what they see (Ho 1999).

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs but mainly in site task operations.

q. Use reliable and thoroughly tested technology only

Definition or description of the RIP

Technology /pieces of equipment need to be thoroughly tested and evaluated before purchase to ensure value-add by supporting people and supporting the process in question. It should be right-sized and solution-specific (not silver bullet). Further, the company should integrate the different technologies it uses together seamlessly. Technology must also support company values.

Circumstances/situations and contexts in which the RIP applies

This RIP applies to all equipment and machinery procurement.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs that need some form of technology to support their work.

r. Apply principle of servant leadership, in which leaders support, serve and coach their people

Definition or description of the RIP

It is based on an ethical and caring concern for others (employees and teams adding value at the workface), and it is about enhancing the growth of others while caring about the quality of our institutions and organizations.

Circumstances/situations and contexts in which the RIP applies

Leaders at all levels need to support company culture, support people doing the work, and live the company's core values.

Cost center(CC) or profit center(PC) where the RIP applies

Leaders at all levels in all CCs and PCs need to apply this RIP.

s. Form high performance multi-functional teams

Definition or description of the RIP

A high-performance work team is a group of goal-focused individuals with complementary skills and specialized expertise that innovate, collaborate, and produce consistently superior results.

The group relentlessly pursues performance excellence through shared goals, shared leadership, collaboration, open communication, clear role expectations and team operating rules, early conflict resolution, and a strong sense of accountability and trust among its members. High-performance teams are formed through carefully screening prospective employees and developing them through training, mentoring, and coaching.

Circumstances/situations and contexts in which the RIP applies

This RIP is required while forming project teams and different work teams to run different company and project processes. These teams are the ones who do the actual work of the company and add value. The construction industry is characterized by extensive labor-only craft-based subcontracting prohibiting investment in training. Labor unions may train their members.

Cost center(CC) or profit center(PC) where the RIP applies

Leaders at all levels in all CCs and PCs need to apply this RIP.

t. Form strategic, long-term partnership (alliance) with selected few partners

Definition or description of the RIP

This is to form long-term partnerships with companies having complementary capabilities to gain access to new markets and channels, share infrastructure or intellectual property, or reduce risk. This consists of network of subcontractors, suppliers and joint venture companies which one engages by challenging and helping them grow and improve.

Circumstances/situations and contexts in which the RIP applies

Subcontracting can account up to 90% of a contractors work. Material and equipment suppliers are used in construction. Contractor can improve efficiency and profitability forming strategic partnership with selected subcontractors and suppliers in each major area of work.

Cost center(CC) or profit center(PC) where the RIP applies

PCs heavily use subcontractors and suppliers. Top management enters into partnering agreements with subcontracting and supplier companies to use them on projects.

u. Go to see to thoroughly understand the situation and solve problems

Definition or description of the RIP

This RIP requires the improvement team to have first-hand information through visits and data collection. Go and see; do not rely on reports.

Circumstances/situations and contexts in which the RIP applies

Data collection should be avoided as much as possible to reduce cost. Complex problems may need data collection and analysis for effective solution. To go and see oneself is effective way to understand situations (Imai 1997).

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

v. Use a sound decision making process to establish consensus

Definition or description of the RIP

Using a sound decision-making process involves considering all solution alternatives broadly and developing a persuasive evidence-based rationale for selection and establishing consensus within the team.

Circumstances/situations and contexts in which the RIP applies

In solving any problem, the company needs to use a participative and consultative approach to get broad ideas and to reach a consensus. This principle is applicable in the construction industry, where various stakeholders (designers, contractors, sub-contractors, and other participants) put in efforts.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

w. **Sustain organizational learning through continuous improvement and relentless reflection**

Definition or description of the RIP

Reflection and lessons learned need to be done at key milestones and project completion.

Circumstances/situations and contexts in which the RIP applies

Lessons learned help avoid problems that previously occurred. It also helps to solve problems that have already occurred using the root causes and methods that worked previously.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

x. **Just in time (JIT)**

Definition or description of the RIP

JIT is a lean tool; the goal is to create precisely the right products (equipment, information, or service), in exactly their needed quantities, at precisely the required time.

Circumstances/situations and contexts in which the RIP applies

JIT applies to deliveries from suppliers, giving training to employees. The JIT ideal is the elimination of physical buffers (material and time) between production processes and the achievement of one-piece flow. Ohno could virtually eliminate such in-process inventories because production scheduling provided sufficiently stable coordination of flows. Construction scheduling does not provide such stabilization. Consequently, it is not appropriate to eliminate physical buffers without first attacking the causes of variation and uncertainty.

Cost center(CC) or profit center(PC) where the RIP applies

JIT applies to all CCs and PC. Its application requires accuracy and detail in planning and scheduling.

4.2.2 Lean Principles and Tools from Lean Construction

a. The Last Planner System (LPS)

Definition or description of the tool

The Last Planner System is a lean planning and control tool that helps to translate lean manufacturing to lean construction (Gao and Low, 2014). The last planners are the lowest level in the hierarchy of planners, i.e., they are the general foremen and superintendents that plan executable weekly and daily tasks on site. Last planners ensure that all prerequisite tasks and resources are ready to before releasing a task for execution (Ballard, 2000; Ala-Risku and Karkkainen, 2006).

Circumstances/situations and contexts in which the tool applies

The LPS uses the overall project plan as the general framework but uses 4-6 weeks lookahead planning, weekly planning, and daily planning if necessary to get a more flexible executable tasks that is cognizant of the project's actual progress (Ballard, 2000; Kenley and Seppanen, 2010).

Cost center(CC) or profit center(PC) where the tool applies

The last planners are the general foremen, who prepare weekly implementation work packages to their foremen for execution at the workface.

b. Percent Plan Complete (PPC)

Definition or description of the tool

PPC is a metric used in the Last Planner System to measure the effectiveness of the planning done by the last planners. It is the ratio of the number of tasks that "did" get done to the total number that site team planned to get done, and reasons for plan failure are identified and rectified.

Circumstances/situations and contexts in which the RIP applies

PPC is a metric used to measure plan reliability while implementing the LPS.

Cost center(CC) or profit center(PC) where the RIP applies

PPC is used on projects at the workface by foremen to measure reliability of their weekly plans.

c. **Tasks Made Ready(TMR) and Tasks Accomplished (TA) (Hamzeh, 2009)**

Definition or description of the tools

Project people can game PPC like any performance measurement system, and high PPC does not necessarily mean high productivity or completion of the project as per the CPM schedule. People can plan easy tasks that they can complete quickly or tasks that are not on the critical path, achieving high PPC, but productivity is not high, nor is the schedule met. TA measures the percentage of tasks anticipated on the lookahead plan two weeks ahead of execution. TMR measures the performance of lookahead planning in identifying and removing constraints to make tasks ready for execution (Ballard, 1997; Hamzeh et al., 2008). TMR (i, j) measures the percentage of tasks anticipated on the lookahead plan i weeks ahead of week j, with week j being the week of execution (the week covered by the weekly work plan) (Hamzeh et al., 2011).

Circumstances/situations and contexts in which the tools apply

TA and TMR need to be used to improve PPC as an indicator of project productivity and project completion as per the CPM schedule.

Cost center(CC) or profit center(PC) where the tools apply

General foremen and their foremen can use TA and TMR to improve PPC's predictive power as a productivity indicator of performance at the workface.

d. **Enthrone mutual benefits as the way business is done**

Definition or description of the RIP

Suppliers and service providers must be worked with like partners to improve quality and reduce the variation of what is delivered, in a win-win relationship (Patty and Denton, 2010).

Circumstances/situations and contexts in which the RIP applies

Base relationships with external partners and internal partners (employees) on sharing benefits fairly for a win-win relationship.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

e. Use pull process flow to align efforts and control interactions between processes

Definition or description of the RIP

All processes should be aligned end to end to create value for the client (Patty and Denton, 2010).

Circumstances/situations and contexts in which the RIP applies

Its implementation is suggested when various vendors and subcontractors are involved in a project.

Cost center(CC) or profit center(PC) where the RIP applies

Alignment is applied in project execution/implementation on site - each CC or PC and external stakeholder doing its part on time and as per quality standards. The project manager can ensure alignment through effective communications.

f. Remove root causes of variability

Definition or description of the RIP

Variability needs to be removed or controlled because it havocs damage on project cost, schedule, and quality (Patty and Denton, 2010).

Circumstances/situations and contexts in which the RIP applies

Variability and uncertainty result from adverse weather, inflation in material cost, fluctuating interest rates, change orders, fragmented structure and project processes, price competition, adversarial relationships, and fluctuation in work volume.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

g. **Create a sense of urgency using stretch goals (e.g., using target criteria and target costs)**

Definition or description of the RIP

Setting challenging but attainable goals to spur creativity and innovation (Patty and Denton, 2010).

Circumstances/situations and contexts in which the RIP applies

Getting satisfied with current performance and complacency makes a company prone to decline and failure due to competitive threats.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

h. **Create predictability by keeping promises**

Definition or description of the RIP

Every employee and team need to make promises that they are sure to deliver, and decline that they are not able to and enabling others to plan with a high degree of confidence in future actions and performance (Patty and Denton, 2010).

Circumstances/situations and contexts in which the RIP applies

This RIP must apply to all process teams interacting with other teams.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all interactions between CCs and PCs and interactions with external.

i. **Use mistake proofing (poka-yoke) to prevent mistakes/defects from occurring**

Definition or description of the RIP

Mistake proofing is a system for defect and error prevention by the design of work processes or devices that make mistakes impossible to happen.

Circumstances/situations and contexts in which the RIP applies

This RIP helps overcome rework from substandard work. Create a structured environment to check the accuracy and dimensional compliance with tolerances at different points in the process to ensure that defects do not pass downstream.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to PCs.

j. Use time compression (Time Based Management (TBM))

Definition or description of the RIP

Time compression is reducing overall construction time by either eliminating redundant operations or by performing operations in parallel.

Circumstances/situations and contexts in which the RIP applies

This RIP applies in cases where project teams need to reduce the project duration by improving the schedule.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to PCs.

k. Use process simplification

Definition or description of the RIP

Complicated and convoluted processes may be simplified, cutting out unnecessary elements.

Circumstances/situations and contexts in which the RIP applies

Complicated and lengthy processes may present cost, safety, or quality issues, in which case simplification is the solution.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all processes in CCs and PCs.

l. Use relational form of contract to overcome adversarial relations

Definition or description of the RIP

A relational contract is a type of contract where benefits and risks are shared between parties equitably.

Circumstances/situations and contexts in which the RIP applies

The currently used form of contract in the design-bid-build project delivery system is adversarial. Relational contracts help overcome such adversarial relationships.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies between company and client, and between company and subcontractors/vendors.

m. Use daily huddle meetings

Definition or description of the tool

It is a daily floor shop meeting of construction teams to discuss the day's task, safety issues to take care of and responsibilities of team members, and about letting other teams know their responsibility related to the work.

Circumstances/situations and contexts in which the tool applies

Daily huddle meetings help every site employee knows what his/her assignment and responsibility for the day is.

Cost center(CC) or profit center(PC) where the tool applies

This RIP applies to project teams at the workface.

n. Use early warning system of any problem happening

Definition or description of the RIP

Some problems may have some precursor symptoms that can be used as a warning to avoid the problem.

Circumstances/situations and contexts in which the RIP applies

Workers' negligence of observance of safety best practices may signal safety issue, or unusual machine sounds may signal machine/equipment issues, and the like. It would be advantageous to use such early warnings to revert the problems.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

o. Use 3D visualizations/diagrams to aid easy understanding for craft workers

Definition or description of the RIP

3D drawings and diagrams help visualizations and simplify the work of craft people.

Circumstances/situations and contexts in which the RIP applies

This RIP is especially useful in detailing complicated facility parts/components.

Cost center(CC) or profit center(PC) where the RIP applies

3D visualization applies to the design department preparing shop drawings, engineer/designer printing 3D model of the structure and the like.

p. Set-based design

Definition or description of the RIP

It is best to develop an exhaustive set of design alternatives to select the best option.

Circumstances/situations and contexts in which the RIP applies

This RIP is useful in developing alternative designs for a facility.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to design firms. A contractor can apply it in design-build projects. This RIP has limited application in preparing shop drawings by the design department.

q. Target costing

Definition or description of the RIP

Target costing involves designing a facility to client prescribed total cost budget.

Circumstances/situations and contexts in which the RIP applies

This RIP applies when the client has put a cap on the maximum budget earmarked for the procurement of the facility.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to design firms developing the design of a facility. A contractor applies this RIP in design-build contracts.

4.2.3 Rapid Improvement Principles from other Sources

a. Cost-time or (A+B) bidding system

Definition or description of the RIP

This RIP involves contractor selection based on two criteria: cost and time. Cost-time or A+B system of contractor selection is suggested as a solution to low bid contractor selection to overcome the resulting adversarial relationships.

Source of RIP

The source of this RIP is construction contract law.

Circumstances/situations and contexts in which the RIP applies

The client applies this RIP in the selection of contractors during bidding. Contractors association can try to influence clients to change to A+B type of bidding. Top management of contractor firms can act in relationships with professional societies in the advocacy.

Cost center(CC) or profit center(PC) where the RIP applies

Cost-plus time selection criteria apply to the client company.

b. Use space planning techniques for site layout

Definition or description of the RIP

This means dividing site space into material storage, work space, space for equipment and traffic (circulation) to avoid congestion and interference between trades.

Source of RIP

The source of this RIP is resource management, space being one of the resources. This was a PhD thesis title of Dr. Tommelein.

Circumstances/situations and contexts in which the RIP applies

This RIP applies to project site layout.

Cost center(CC) or profit center(PC) where the RIP applies

This applies to projects.

c. Use cost reduction techniques

Definition or description of the RIP

Next to functionality and safety, cost reduction is what the client would appreciate (which adds value for the client).

Source of RIP

The source of this RIP is value innovation.

Circumstances/situations and contexts in which the RIP applies

Use cost reduction techniques to reduce facility cost for the client and to maximize contractor profit.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

d. Empower people to decide on the best way to do their jobs

Definition or description of the RIP

Decentralizing management and decision making mobilize the capability and creativity of all human resources.

Source of RIP

Human resources management

Circumstances/situations and contexts in which the RIP applies

Giving employees autonomy is one of the best human resources motivators.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all teams in all CCs and PCs.

e. Develop situation specific solution in problem solving

Definition or description of the RIP

Situation specific solutions led Toyota not to pursue mass production but to come up with production techniques of cars in small quantities that work for the Toyota situation (low capital) and the Japanese market (demand for customized cars).

Source of RIP

Breakthrough thinking (Hibino, 2003; Nadler and Hibino, 2010; Bozeman, 2004)

Circumstances/situations and contexts in which the RIP applies

This RIP applies to any problem-solving situation.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

f. **Provide purpose driven solution (jobs to be done approach)**

Definition or description of the RIP

Purpose-driven solution led Toyota to extract the purpose of belt conveyor, which is to move parts and meet the same purpose with just in time delivery of assembly parts to produce cars just in time to meet customer demand.

Source of RIP

Breakthrough thinking (Hibino, 2003; Nadler and Hibino, 2010; Bozeman, 2004)

Circumstances/situations and contexts in which the RIP applies

The focus in developing a solution to a problem should be on the purpose to be served or the job to be done.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

g. **Use systems thinking in managing projects and company**

Definition or description of the RIP

Systems thinking helps coordinate subcontractors, suppliers, and the many trades involved in any project.

Source of RIP

Breakthrough thinking (Hibino, 2003; Nadler and Hibino, 2010; Bozeman, 2004)

Circumstances/situations and contexts in which the RIP applies

These features are the foundations for organizing projects to advance performance beyond what can be reasonably expected.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

h. **Develop business model for the segment of construction market you are in**

Definition or description of the RIP

This RIP helps organize a company to create value for the target client best.

Source of RIP

Business model innovation.

Circumstances/situations and contexts in which the RIP applies

This RIP needs to be applied to enable strategy implementation of the company.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP is applied by top management.

i. **Apply value innovation to the segment of construction market you are in**

Definition or description of the RIP

This involves identifying value elements most valued by target customers so as to be able to provide best value to them.

Source of RIP

Value innovation.

Circumstances/situations and contexts in which the RIP applies

This needs to be applied to enable profit maximization and beating the competition.

Cost center(CC) or profit center(PC) where the RIP applies

Top management level applies this RIP.

j. **Encourage mutual respect and teamwork**

Definition or description of the RIP

This RIP means that mutual respect between team members needs to be encouraged and that it needs to be communicated that disrespectful and selfish behavior is unacceptable. Incentives should be targeted towards high team performance rather than individual employee performance.

Source of RIP

Total Quality Management.

Circumstances/situations and contexts in which the RIP applies

This RIP needs to be applied to promote professionalism and workplace harmony.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all teams in all CCs and PCs.

k. Make decisions based on evidence

Definition or description of the RIP

The solution to any problem needs to be based on data and evidence. This RIP is in line with the lean principle that says, 'Go and see for yourself.'.

Source of RIP

ISO 9001: 2015.

Circumstances/situations and contexts in which the RIP applies

This RIP helps make decisions based on full information and data about the problem at hand.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP needs to be applied to all teams in all CCs and PCs, and management at all levels.

l. Identify the constraints/bottlenecks and eliminate/elevate them

Definition or description of the RIP

Theory of constraints hypothesizes that every complex system consists of a series of linked activities, one of which constrains upon the entire system.

Source of RIP

Theory of Constraints.

Circumstances/situations and contexts in which the RIP applies

Focus on removing if possible or on elevating the constraints to attain improvement in performance and profit. Goldratt showed that most organizations have very few actual constraints.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

m. Minimize inventory

Definition or description of the RIP

In traditional accounting, inventory is an asset. Treating inventory as an asset often drives undesirable behavior at companies – producing items that are not actually needed. Accumulating inventory inflates assets and generates a "paper profit" based on the inventory that may or may not ever be sold, which incurs cost as it sits in store. The theory of constraints, on the other hand, considers inventory to be a liability because inventory ties up cash that useable elsewhere more productively.

Source of RIP

Theory of Constraints.

Circumstances/situations and contexts in which the RIP applies

One-piece flow attains this goal well because it helps minimize inventory. Buffers (small inventories at intermediate points) are used to take care of uncertainties and variability in construction, challenging to eliminate.

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

n. Use effective workforce motivational means

Definition or description of the RIP

Motivate employees to unlock their potential for the company, and employee benefit using such means as good wages, a full appreciation of work done, job security, promotion, and growth, making work challenging and exciting.

Source of RIP

Human resources management.

Circumstances/situations and contexts in which the RIP applies

Use or maximize motivational capital for the benefit of all stakeholders (internal (employees, company), external stakeholders and society at large).

Cost center(CC) or profit center(PC) where the RIP applies

This RIP applies to all CCs and PCs.

4.3 Application of Best Practices and Rapid Improvement Principles in the Development of Process Flow and Fishbone Diagrams

The BPs and RIPs discussed in Section 4.2 are quite limited in number, whereas the problems that need solutions are innumerably many. This disparity between problems and solutions necessitated the development of a systematic and scalable approach. This scalable approach consists of first classifying problem areas as pertaining to the company, department, interactions, projects, employee, and strategic initiatives to capture all problems companies face. Second, it involves drawing process and fishbone diagrams and anchoring the improvement on fishbone diagrams. As previously discussed, fishbone diagrams help carry our risk analysis, help link leading indicators, and subfactors to lagging indicators facilitate the use of Failure Mode and Effect Analysis to drive continuous improvement.

Subsection 3.4.2 discussed how BPs and RIPs are used to develop process flow and fishbone diagrams. In exhaustively listing all possible causes of failure in developing a fishbone diagram, some of the subfactors are BPs and RIPs, whereas other factors are common factors. BPs and RIPs are used whenever they are applicable to process flow and fishbone diagram. Table 4.1 gives an example of using BPs in estimating for development of activities for estimating process flow in Figure 3.12 and the development of the subfactors for the fishbone diagram in Figure 3.13.

The other subfactors on the fishbone diagram in Figure 3.13 are common factors determined while exhaustively listing factors influencing each of the five leading indicators (main factors).

This way of using BPs and RIPs applies to all 15 company processes, eight project processes and the corresponding fishbone diagrams, seven departments and units, and project productivity fishbone diagrams listed in Appendix A. Table 4-2 gives BPs and RIPs used for the development of each process flow and fishbone diagram.

Table 4-1 Use of estimating BPs in development of subfactors on fishbone diagram for estimating

No.	Best Estimating Practice	Activity number on process flow diagram	Main factor on fishbone diagram (the leading indicator)	Subfactor on fishbone diagram developed based on the BP
1	Definition of scope of work	4	Accuracy of estimate	Use of checklists
2	Definition of project execution plan	7	Accuracy of estimate	Definition of work packages & project execution plan
3	Determination of the estimating data and cost estimating method to be used	6	Accuracy of estimate	Accuracy & reliability of cost & productivity data
4	Allocation of qualified human resources		Accuracy of estimate	Competence & experience of estimators
5	Calculation of cost of major elements		Accuracy of estimates	Use of checklists
6	Determination of cost of design, project management, startup and owners cost			
7	Normalization of data, determination of exchange rates and escalation of future costs			
8	Determination of contingency to be applied	9, 11	Markup percentage	Accuracy & availability of past markup data, Effectiveness of risk analysis method, Accuracy & reliability of markup analysis method, Optimal profit percentage.
9	Conducting intermediate and final checks of estimates		Accuracy of estimates	Conducting intermediate & final checks
10	Comparison of cost with similar projects		Accuracy of estimates	Comparison of cost with similar projects

Table 4-2 BPs and RIPs used in the development of company processes and development of the corresponding fishbone diagrams

Core construction company processes	**BPs**	**RIPs**
1. Communication	Alignment, Communication BPs, partnering, organizational communication interventions	Form strategic partnership, pursue perfection through continuous improvement (communication), enthrone mutual benefit as the way business is done.
2. Equipment management	Materials (equipment) management, Quality improvement.	Use only reliable and thoroughly tested technology
3. Estimating	Estimating BPs, Constructability, Risk assessment	Make decision based on evidence.
4. Finance process	Change management, Financial systems interventions, Organizational communication interventions.	
5. Job costing	Change management, Organizational communication interventions.	Make decision based on evidence.
6. Lessons learned	Lessons learned, Constructability.	Sustain organizational learning through continuous improvement and relentless reflection
7. Marketing process	Communication BPs, Organizational Communication Interventions	Focus on the customer, Identify customer value, Organizational Design and Development Interventions: Organizational Pro-Action.
8. Pricing	Project risk assessment, Estimating BPs,	Make evidence based decisions
9. Procurement management	Constructability, Materials management, Dispute resolution, Organizational communication interventions.	Make evidence-based decisions
10. Project closeout	Lessons learned, Constructability.	Sustain organizational learning through continuous improvement and relentless reflection.
11. Scheduling	Scheduling BPs, Constructability, Change management, Project risk assessment	Focus on the customer, Standardize tasks/components, Make decisions based on evidence.

Table 4-2 Continued

Core construction company processes	**BPs**	**RIPs**
12. Subcontract management process	BPs of subcontract management, Partnering, Project risk assessment, Dispute prevention and resolution, Materials management, Change management, Team building.	Enthrone mutual benefits as the way business is done, Use systems thinking in managing projects, Encourage mutual respect and teamwork.
13. Training program	Learning/Training intervention BPs, Lessons learned	Sustain organizational learning through continuous improvement and relentless reflection.
14. Resource allocation	Alignment, Organizational development: Empowerment, Organizational development: Organizational Values	Be guided by sense of purpose, Encourage mutual respect and teamwork, JIT.
15. Checks and balances	Materials management, Quality management, Financial Systems Interventions	Use mistake proofing to prevent mistakes from occurring, Use early warning system of any problem happening

Table 4-3 BPs and RIPs used in the development of project processes and development of the corresponding fishbone diagrams

Construction project processes	**BPs**	**RIPs**
1. Change control	Change management, Mistake proofing, Constructability, Communication BPs.	Make decisions based on evidence
2. Monitoring and control	Communication BPs, Change management, Subcontract management BPs.	Make decisions based on evidence
3. Planning	FEP, Constructability, Materials management, Planning for modularization	Use systems thinking in managing project, Identify bottlenecks and eliminate/elevate them,
4. Quality assurance	Quality management, Materials management, Quality improvement,	Map the value stream, Stop production to correct defects, Remove root causes of variability, Use mistake proofing to prevent defects from occurring.
5. Risk management	Project risk assessment, Change management, FEP,	Make decisions based on evidence. Remove root causes of variability,
6. Safety and health management	Zero accident techniques, BPs of safety management, Constructability.	Use visual process management including 5S, Use process simplification.
7. Scope and brief management	Change management, FEP.	Use systems thinking in managing projects and company.
8. Team coordination	Team building, Change management.	Use a sound decision making process to establish consensus, Encourage mutual respect and teamwork.

Table 4-4 BPs and RIPs used in the development of fishbone diagrams for departments and organizational units

Departments/Organizational units	**BPs**	**RIPs**
1. Bidding department	Estimating BPs, Constructability, Planning for modularization	Make evidence-based decisions.
2. Design department	Constructability, change management, Quality management,	Use sound decision making process to establish consensus, Make evidence-based decisions.
3. Equipment department/unit	Materials (equipment) management, Quality improvement.	Use only reliable and thoroughly tested technology
4. Finance department	Change management, Financial systems interventions, Organizational communication interventions.	Make evidence-based decisions.
5. Human resources department	BPs in strategic HRM, Talent management, Individual growth, Organizational communication interventions, Organizational development: Empowerment.	Enthrone mutual benefit as the way business is done, Be guided by sense of purpose.
6. Marketing unit	Communication BPs, Organizational Communication Interventions	Focus on the customer, Identify customer value, Organizational Design and Development Interventions: Organizational Pro- Action.
7. Procurement department	Materials management, Constructability, Change management, , Planning for modularization, Quality management, Organizational communication interventions.	Enthrone mutual benefit as the way business is done, Make evidence-based decisions.

Project productivity improvement factors given in Table 4-5 with the sub divisions listed in Table 2-7 are developed from CII Best Project Productivity Improvement Implementation for industrial projects, which Nasir (2013) adopted to infrastructure projects. This means the sub divisions are themselves BPs.

Table 4-5 BPs and RIPs used in the development of fishbone diagram for project productivity factors

Project productivity improvement factors	**BPs**	**RIPs**
1. Materials management	Materials management, Constructability, Change management, , Planning for modularization, Quality management, Organizational communication interventions.	Enthrone mutual benefit as the way business is done, Make evidence-based decisions.
2. Construction machinery & equipment	Materials (equipment) management, Quality improvement.	Use only reliable and thoroughly tested technology
3. Execution approach	Constructability, Change management, Quality management, Quality improvement.	Use mistake proofing, Eliminate different forms of waste, Stop production to correct defects.
4. Human resources management	Team building, BPs in strategic HRM, Talent management, Individual growth, Organizational communication interventions, Organizational development: Empowerment.	Empower people to decide on the best way to do their job
5. Construction methods	Quality management, BPs in schedule management, Use visual process management including 5S, BPs in communication.	Use space planning techniques for site layout
6. Health and safety management	Zero accident techniques, BPs of safety management, Constructability.	Use visual process management including 5S, Use process simplification.

4.4 Some Problems with the Corresponding RIPs and BPs to Resolve Them

Each of the BPs and RIPs in Sections 4.1 and 4.2 resolve some problems and apply under some circumstances and contexts. Some problems do not fit into the list in Sections 4.1 and 4.2 because the BPs and RIPs are limited in number and context, whereas problems are innumerably many, and the contexts varied. Table 4-6 gives such problems with BPs and RIPs to resolve them

Table 4-6 Some Problems with the Corresponding RIPs and BPs to Resolve Them

Problems/bottlenecks	**Causes/Root causes**	**RIPs and BPs that resolve**
One-of-a-kind project	Each facility is different.	The negative effect can be reduced through standardization, modular coordination and widened role of subcontractors
Difficulties of site production	Site condition is difficult to control because operations are carried out outside.	Increased prefabrication, temporal decoupling and through specialized multi-functional teams.
Temporary multi-organization	Each facility owner is different, and each facility requires many specialties.	Encouragement of longer-term strategic alliances.
Congestion problem on site among multiple trades	Lack of or poor planning of site space	Use space planning techniques, determine rate of work flow in terms of rate and direction to minimize interference among trades.
Substandard work that needs rework	Poor quality control, poor supervision, deficient information or delayed information.	Quality assurance in place, mistake proofing in place.
Temporary work stoppages due to inclement weather.	Uncertainty about weather.	Identify activities/operations prone to inclement weather and use forecast data available as much as possible.
Time off for union activities	Employee grievances	Eliminate employee grievances through mutual benefits (through good HRM and through profit sharing).
Absentee time including late start and early quits	Poor culture and poor management	Establish social norms, manage by winning workers willingness than by incentives and contracts, use motivational capital.
Low productivity	There are many causes of low productivity	Train employees, increase use of prefabrication and preassembly, move towards cooperative team work rather than contracts where everybody seeks to get as much legal insulation as possible, improve safety training, improve communications, solicit suggestions from employees on productivity improvement.
Lack of skilled labor	Lack of body that works on it	Keep pay and benefits competitive, encourage labor unions to train their members.

Table 4-6 continued

Problems/bottlenecks	Causes/Root causes	RIPs and BPs that resolve
Failure of weekly work plans	Insufficient and inadequate material, poor design quality, uncertainty in arrival time of materials, deficient information, poor planning and supervision.	Prepare weekly work packages, carry out detailed look ahead and weekly planning and constraint removal, (Ballard, 1995)
Time wasted transporting/handling materials on site(15% of labor time on some sites)	Poor planning	Use mobile warehouses. Use JIT delivery to avoid multiple handling.
Grievances and concerns of laborers and foremen	Lack of communication	Install suggestion boxes at work places where problems and suggested solutions are collected from laborers and foremen. Invite laborers and foremen to breakfast or lunch at certain intervals.
Hierarchical organization	Functionally organized company	Transform organization to process-oriented and team-based flat organization that makes decision making faster (Koskela and Leikas, 1994).
Long and complicated information and material flows	Poor planning, wasteful processes and activities.	Simplification (Koskela and Leikas, 1994).
Confusion and disorder	Poor communication	Use visual management (Koskela and Leikas, 1994).
Poor coordination	Poor planning	Electronic data interchange (Eaton, 1994), coordination drawings
Flow activities (which add cost but no value)		Eliminate flow activities entirely (Eaton, 1994).
Inefficiency and ineffectiveness of conversion activities	Lack of awareness and knowledge, lack of tools.	Move responsibility from supervisors to workers for self-management in which workers review entire process. With training on ways to identify and eliminate these inefficiencies, workers will be able to eliminate the problems and improve conversion activities (Eaton, 1994).
Variation and uncertainty	Lack of thorough analysis of variation, uncertainties and risks	Shielding tasks from upstream uncertainty through planning and providing buffers (Ballard and Howell, 1995).

Table 4-6 continued

Poor accuracy	Site condition difficult to control, lack of knowledge, lack of mistake proofing implements	Increase prefabrication, raise precision level to avoid adjustment work Tanskamen et al., 1993, use mistake proofing.
Delays	Poor planning, late or unclear or defective information.	Use foremen delay survey (Alarcon, 1994).
Waiting times	Poor planning, congested site, overmanning, poor crew balance, waiting for materials, instructions, tools or equipment.	Use multi-functional teams to balance production rhythm (Alarcon, 1994).
Failure to complete weekly work plans	Poor planning	Identify root causes of plan failure to take preventive and improvement measures (Hamzeh, 2009).
Deficiency in financial reporting is one of the causes of company failure	Poor financial process, procedures and systems.	Use throughput accounting and lean accounting, use improved
Failure to evaluate profitability as one of the causes of failure of company	Poor financial systems and controls, lack of timely financial performance feedback to take corrective measures	Institute efficient job costing and reporting procedure, prepare weekly and monthly financial performance reports using software
Poor invoicing procedures one of the causes of company failure	Lack of detailed estimates to enable detailed job costing and follow up.	
Delay in collecting payments from clients	Lack of efficient collection process and procedure,	Collect payment the earliest time it is due because cash is the life blood of construction companies.
Fluctuation in construction material cost as one of the causes of company failures	Market condition, which is uncontrollable.	Keep record of percent material increases to be used in future contingency calculations.
Material problem	Lack of material at work place, material not well distributed, inadequate transportation means for materials (Serpell, 1997)	Use planning, constraint removal

Table 4-6 continued

Labor inefficiencies	Ineffective utilization of resources (labor, material, tools, equipment and information), management caused unfavorable working condition (out of sequence work and congestion), workforce management deficiencies (insufficient work to perform, overstaffing, cleanup and incidental work at inappropriate times, ineffective use of work teams) (Thomas and Ellis	Use modules and preassemblies, multi skilling (if union does not limit it), use space planning techniques and successful practices,
Delay claims (Yates and Epsein, 2006)	Improperly drafted contract document, erroneously prepared bids, owner failing in their responsibilities, owners' inadequate contract administration	Joint effort and mutual assent, solving problems rather than prevailing in dispute resolution (Yates and Epsein, 2006), drafting contract well, checking scope well in detail and improve accuracy of bids, use relational contracts (Lichtig, 2010).
Claims in general	Changed conditions, design changes, defective specifications, quantity variations, delays, disruptions, accelerations root cause complexity of project, price structure of industry, super legalistic approach	Eliminate or reduce these causes.

4.5 Summary of Chapter 4

Chapter 4 discussed RIPs and BPs and their use in improvement. Mainly, the discussion dealt with the use of RIPs and BPs for the development of process flow diagrams and fishbone diagrams because the improvement using diagnostic tool and DSS is anchored on the fishbone diagrams as a systematic and scalable improvement approach to solving any problem in any context.

Chapter 5 will deal with the way to use the diagnostic tool and decision support system and demonstrate the use of the diagnostic tool and DSS by applying it to a mid-size highway sample company.

5. DEVELOPMENT OF DIAGNOSTIC TOOL AND DECISION SUPPORT SYSTEM FOR PROFITABILITY IMPROVEMENT OF CONSTRUCTION COMPANIES

This chapter first gives an introduction in Section 5.1 about when improvement and Decision Support System (DSS) is needed, defines DSS, gives types and categories of DSS, describes the importance of user interface, the development environment for DSS and criteria for evaluation of the effectiveness of DSS. Section 5.2 gives the flowchart used and describes the input-process-output model of the diagnostic tool and DSS developed in this research. It also walks the reader through the use of the diagnostic tool and DSS. Section 5.3 gives a complete sample company example on the use of the diagnostic tool and DSS

5.1 Introduction

Construction companies operate in an increasingly complex environment and the magnitude of the decisions' consequences at the strategic level demand high-quality decisions. Decision support systems need to integrate all the decisions at different levels, such as strategic, tactical, and operational

5.1.1 Definition of Decision Support System

Researchers could not reach a consensus on the definition of Decision Support System (DSS), but a DSS in simple terms is a computer-based tool that assists decision-makers in their decision-making process (Mahdavi, 2016). Decision Support System (DSS) is the area of information systems that focuses on supporting and improving managerial decision making. A DSS provides the decision-makers with processed information to assist in evidence-based decision making. Hastak (1994) says that a DSS is a computer tool that helps improve the effectiveness of decision-making in a semi-structured situation where the decision-maker applies his/her judgment to input data and information, the computer tool helps carry out information processing, and then the decision-maker uses processed information to decide the best course to take.

A combination of one or more decision support tools may compose a decision support system. Figure 5.1 shows three classifications of decision support tools developed by operations research, artificial intelligence, and statistical analysis.

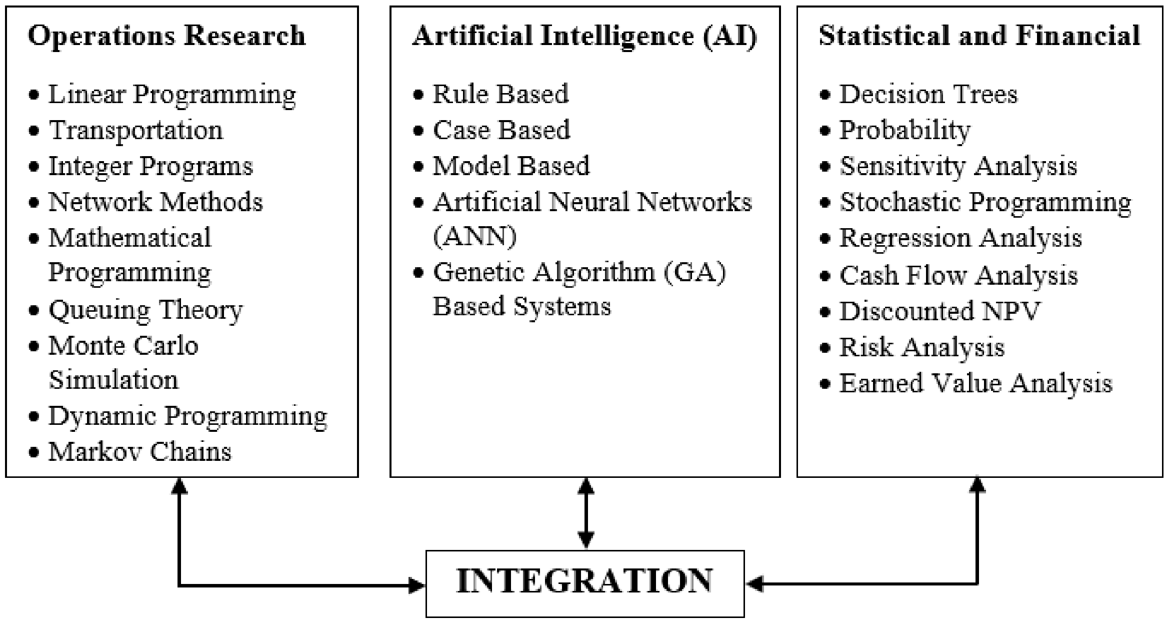


Figure 5.1 Decision support tools ranging from deterministic to dynamic and uncertain problems
(Source: Khosrowshahi and Howes, 2005)

This research uses risk analysis through Failure Mode and Effect Analysis (FMEA) on fishbone diagrams combined with root cause analysis, textual and numerical database, and computations using formulas in developing the diagnostic tool and DSS.

5.1.2 Categories of Decision Support System

The literature identifies five categories of DSS: model-driven DSS, communications driven DSS, data-driven DSS, document-driven DSS, knowledge-driven DSS(Power, 2002). A hybrid of data-driven DSS and model-driven DSS is used in this research because profitability improvement excellence models form the basis for the DSS wherein textual and numerical data input are processed to provide textual and numerical information (outputs) to assist decision-making.

One or more quantitative models perform the primary functions of a model-driven decision support system where the user manipulates model parameters to investigate options.

Different quantitative models in a model-driven DSS help decision-makers develop and manipulate a simplified representation of a situation (Power and Sharda, 2005). The quantitative models can be classified as algebraic and differential equation models, decision tree and decision matrix, decision analysis tools such as forecasting models, Monte Carlo and discrete event simulation models, analytical hierarchy process, multi-attribute and multi-criteria models, network and optimization models, and quantitative behavioral models for multi-agent simulations, network and optimization models, and quantitative behavioral models for multi-agent simulations.

5.1.3 User Interfaces of DSS

The design, features, and capabilities of the user interface of a DSS are essential to the success of the system. The user interface helps input values, manipulate values, and view results. The user interface features influence how the user understands results and hence influences choices. DSS developers should anticipate the way users enter values, the order of input fields, and stimuli given to them about what values the user needs to input. The user interface design can also bias users if the interface uses inappropriate input data elicitation approaches.

In developing a model-driven or data-driven DSS, a developer needs to elicit values of certain and uncertain quantities and qualities, objective and subjective probabilities, weights, and utilities that will be used in the decision. A question or other type of stimulus may be used to elicit values. The elicitation approach may reduce or increase errors in the values that the user inputs. The three main elicitation methods are numerical, graphical, or verbal elicitation. The diagnostic tool and DSS in this research uses numerical elicitation.

5.1.4 Development of DSS and mechanisms of delivery

DSS generators provide the environment in which to build most model-driven and data-driven DSS. Spreadsheets have become the most ubiquitous DSS generators. This research used Access 2016 for the development of the diagnostic tool and DSS.

5.1.5 Effectiveness of DSS

DSS serves the purpose of improving managerial decision making. One gauges the effectiveness of a DSS by the quality of judgment and the theoretical foundation in decision-making principles.

This research developed a transformative diagnostic tool and DSS that would help construction companies to manage and improve their profitability as rapid improvement principles, and best practices are applied to alleviate bottlenecks and recurrent undesirable outcomes.

5.2 Diagnostic Tool and Decision Support System Developed in this Research

5.2.1 Way to Use the Diagnostic Tool and DSS

The diagnostic tool directly implements step 4, and the DSS implements steps 5-8, iterative and recursive flowchart parts of the excellence model in Figures 3.6 and 3.7 reproduced in Figures 5.2 and 5.3.

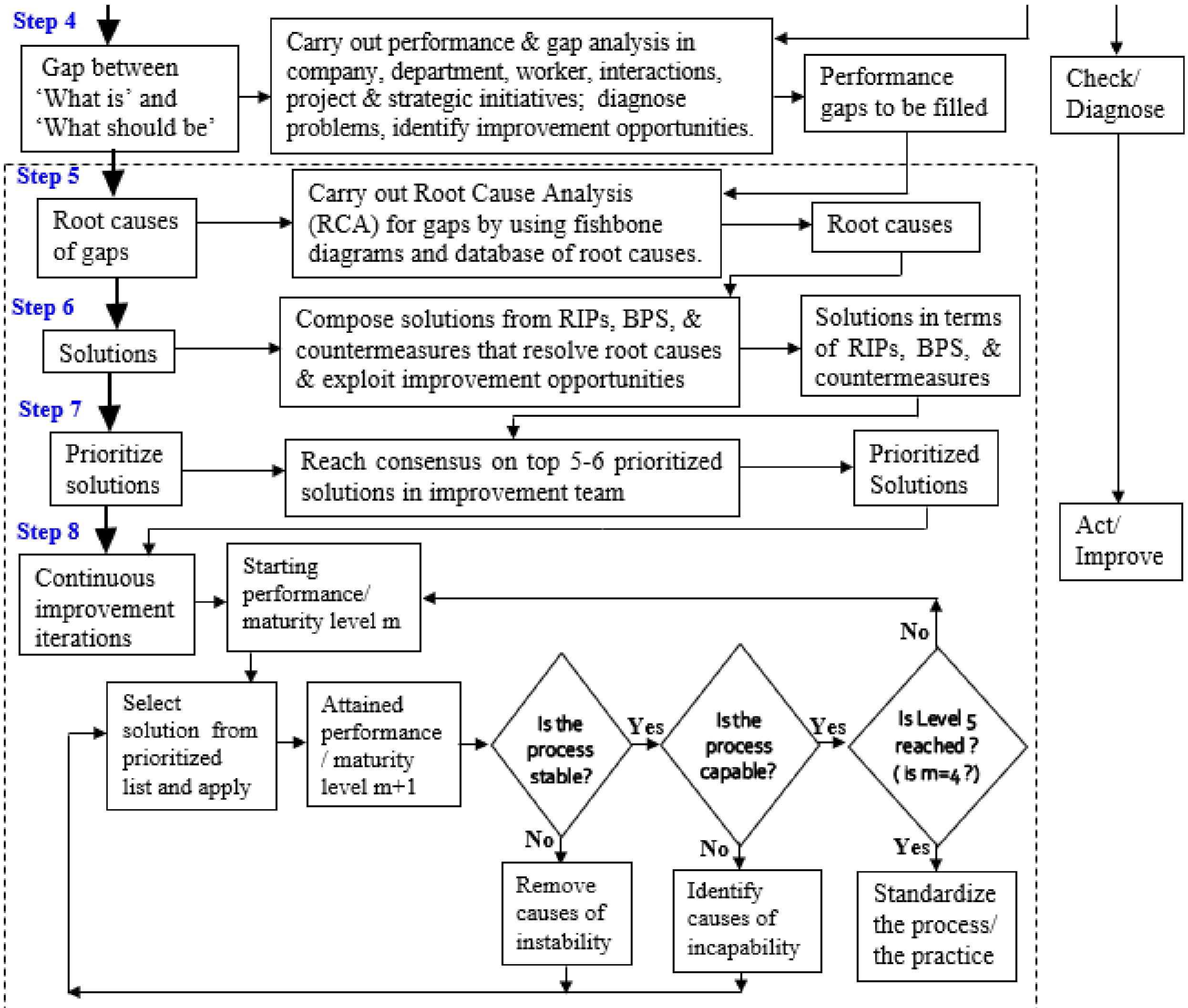


Figure 5.2 Flow chart of the diagnostic tool and DSS

Improvement areas are divided into **company, department, employee, interactions, project,** and **sustainability initiatives** in this research. Each of the six areas is further subdivided, as shown in Figure 5.3 to make conducting the diagnosis and improvement easy and systematic. The diagnostic tool and DSS is organized following this problem breakdown structure, and the procedure to go deeper from higher-level strictly follows the breakdown structure given by Figure 5.3. Now, a detailed explanation of the use of the diagnostic tool and DSS follows.

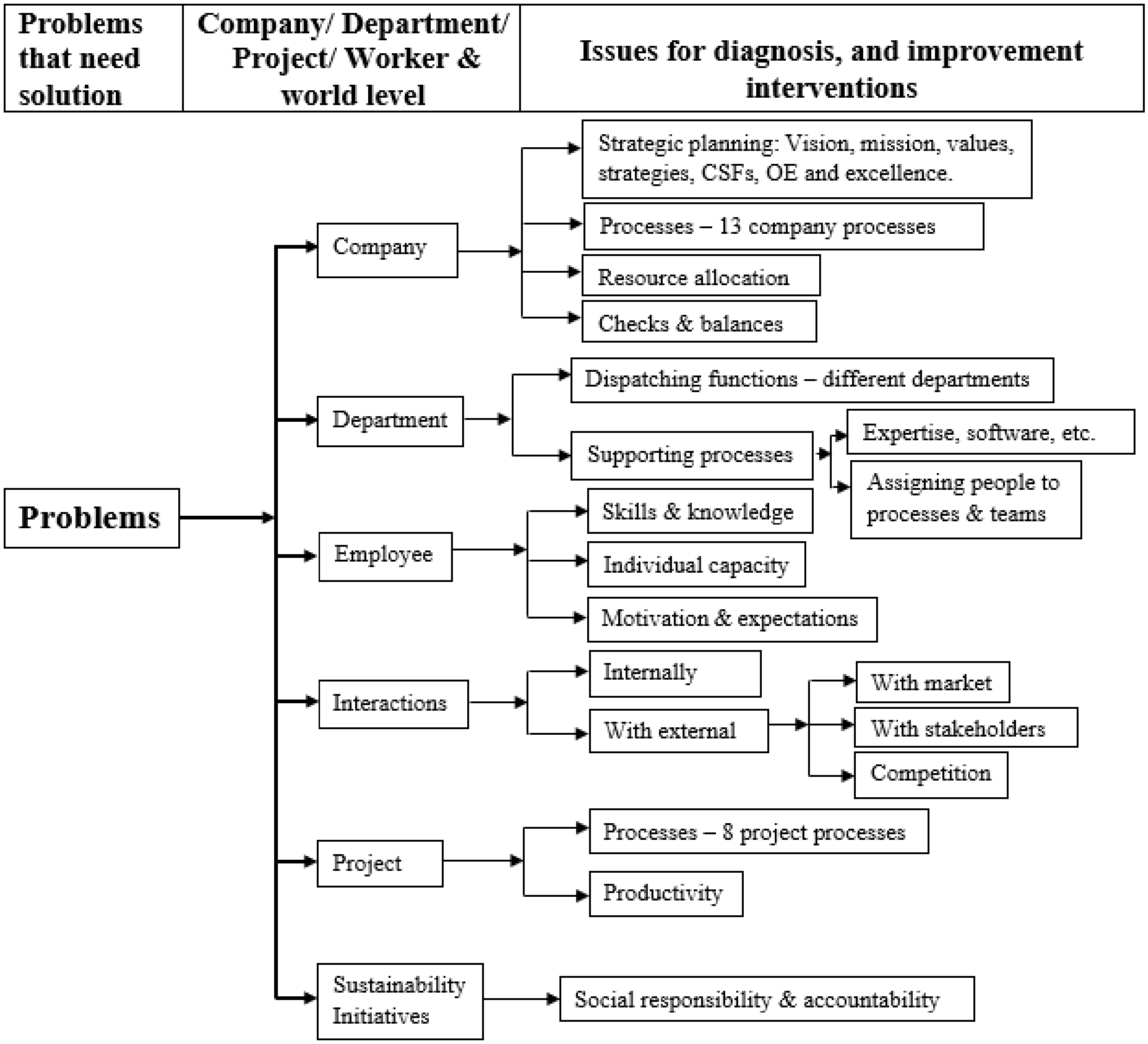


Figure 5.3 Problem breakdown structure for diagnosis and improvement

Figure 5.4 shows the tool and DSS's main user interface that a user sees when he/she first opens it. The computer tool has two parts: Diagnostic tool and DSS with a button for each on the user interface. The diagnostic questionnaire given in Appendix C is used in this computer tool for the diagnostic part. The user needs to click the button which reads “Carryout Diagnosis”, to carry out diagnosis, which opens the screen shown in Figure 5.5.

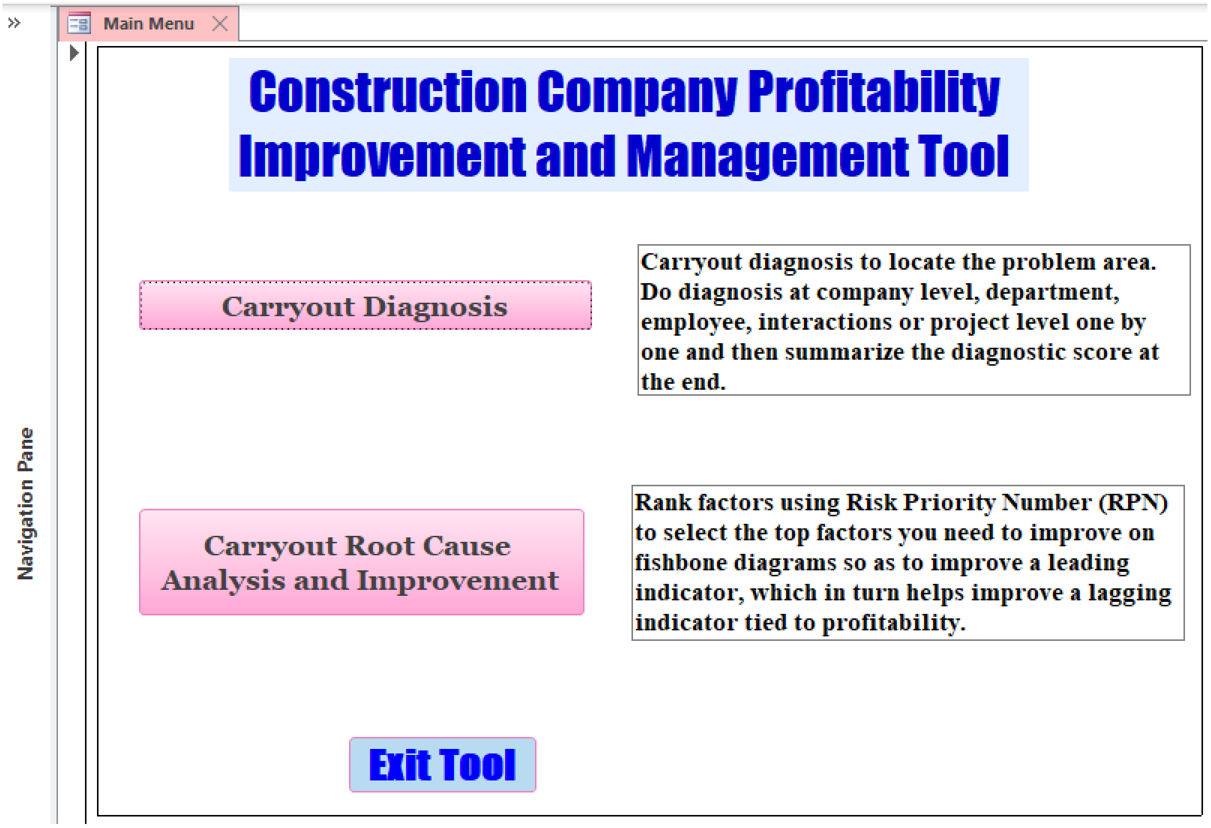


Figure 5.4 Main menu of user interface of diagnostic tool and DSS

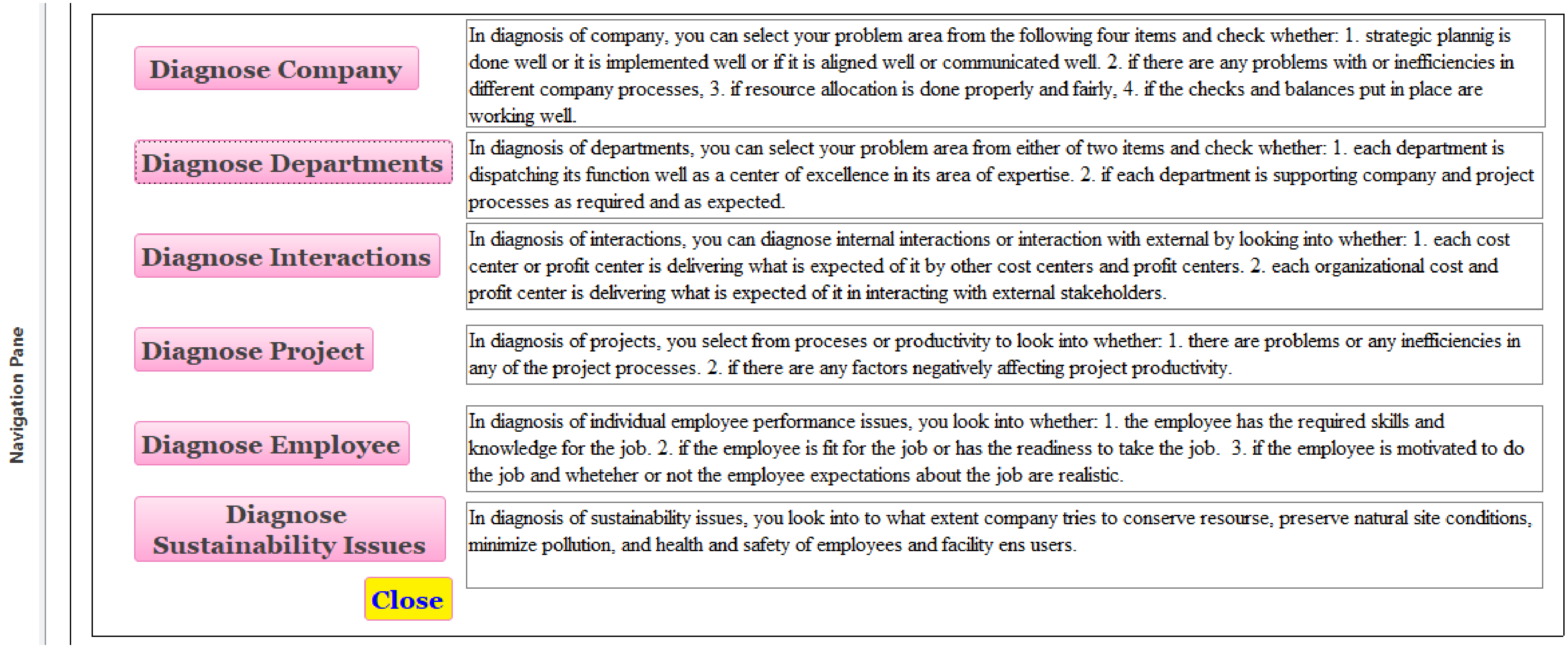


Figure 5.5 Diagnosis areas

Clicking on “Diagnose Company” in Figure 5.5 brings up the screen in Figure 5.6.

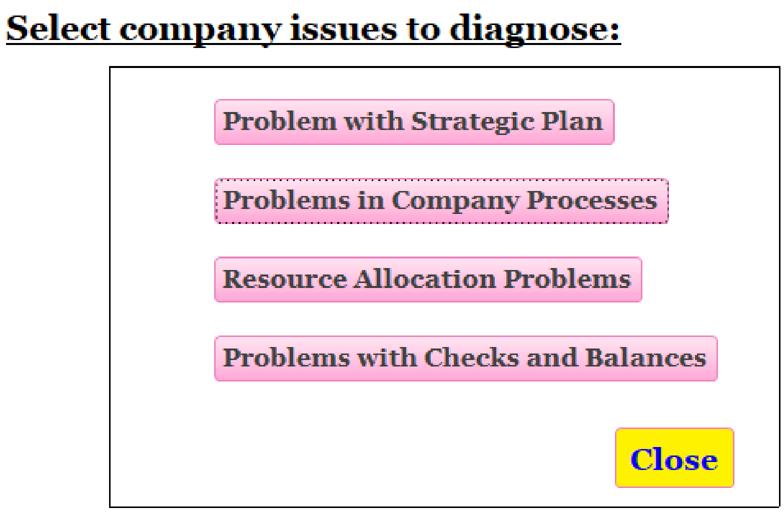


Figure 5.6 Company issues for diagnosis

Clicking “Problem in Company Processes” brings up the screen shown in Figure 5.7.

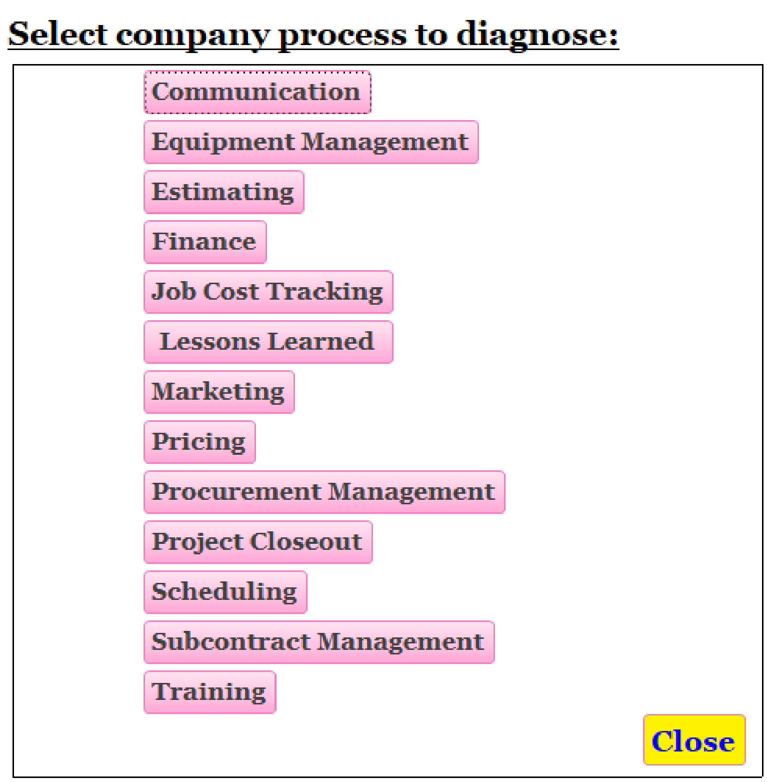


Figure 5.7 Company process issues for diagnosis

Clicking the “Communication” button brings up the screen in Figure 5.8. User inputs score and weight values for each questionnaire item by clicking the down arrows and selecting values. Score is selected as either 0,1,2,3,4, or 5. Weight is selected from 1, 3, 5, and 9 as discussed in Chapter 3. The scale descriptions of the score and weight are also given in the tool (top of Figure 5.8).

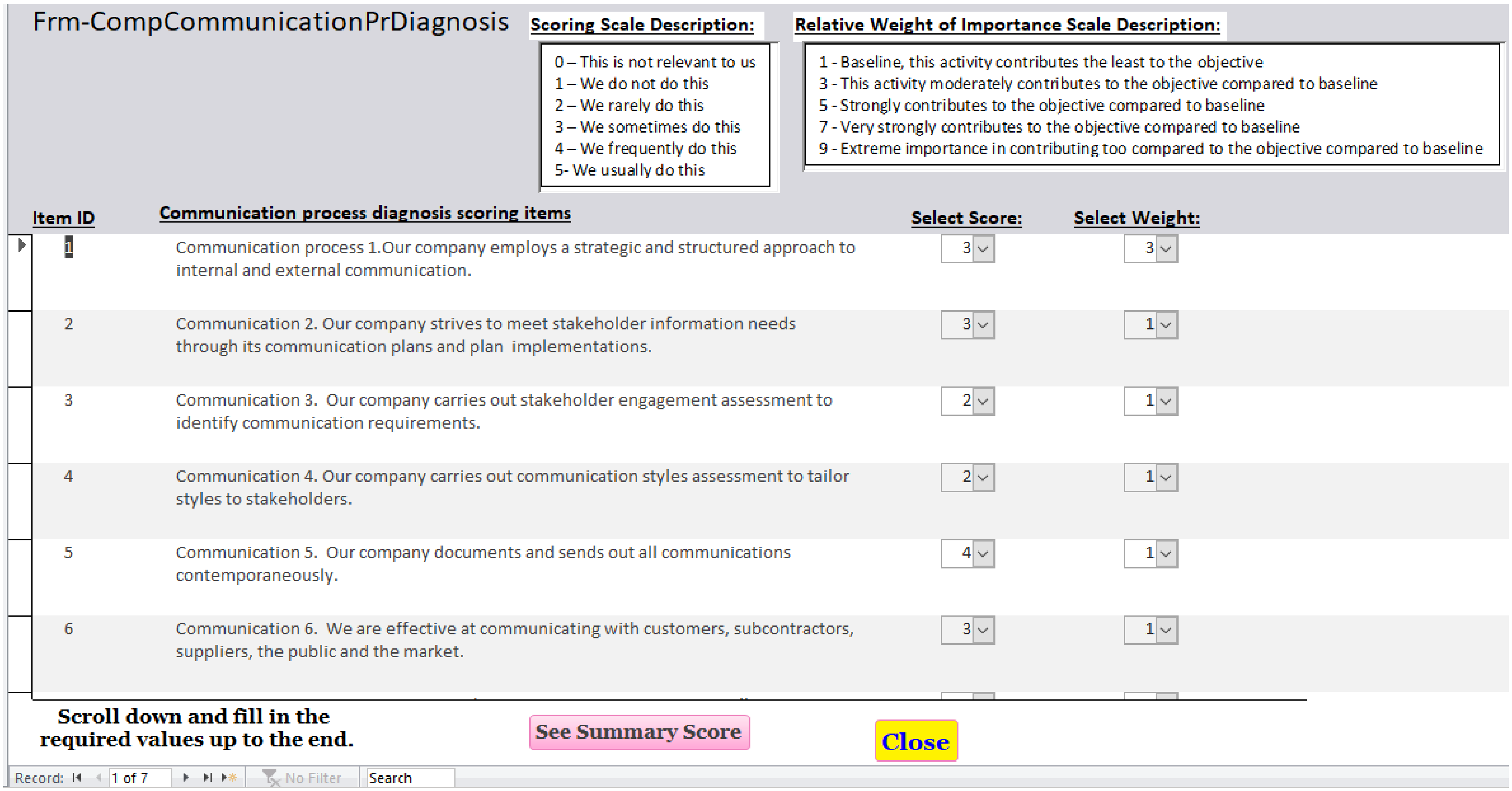
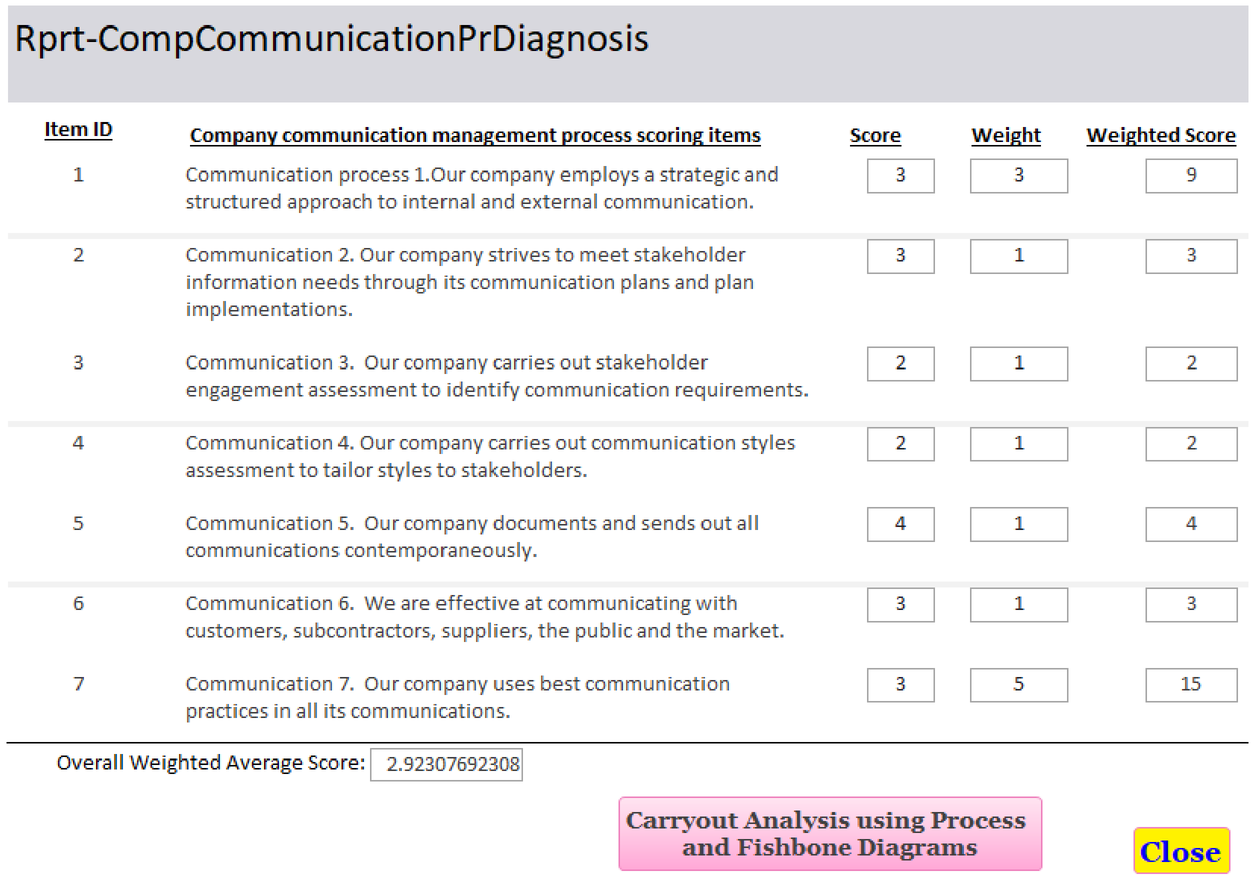


Figure 5.8 Diagnostic questionnaire items

Clicking the “See Summary Score” button at the bottom of Figure 5.8, brings up a screen in Figure 5.9 that shows at the bottom, a diagnostic score (Overall Average Score) result of 2.923.


Rprt-CompCommunicationPrDiagnosis

Item ID	Company communication management process scoring items	Score	Weight	Weighted Score
1	Communication process 1.Our company employs a strategic and structured approach to internal and external communication.	3	3	9
2	Communication 2. Our company strives to meet stakeholder information needs through its communication plans and plan implementations.	3	1	3
3	Communication 3. Our company carries out stakeholder engagement assessment to identify communication requirements.	2	1	2
4	Communication 4. Our company carries out communication styles assessment to tailor styles to stakeholders.	2	1	2
5	Communication 5. Our company documents and sends out all communications contemporaneously.	4	1	4
6	Communication 6. We are effective at communicating with customers, subcontractors, suppliers, the public and the market.	3	1	3
7	Communication 7. Our company uses best communication practices in all its communications.	3	5	15

Overall Weighted Average Score: 2.92307692308

Carryout Analysis using Process and Fishbone Diagrams

Close

Figure 5.9 Diagnostic score computation result

The diagnostic score ranges from 0 (poor performance) to 5 (best performance). A diagnostic score of 2.923 means that there is room for improvement to bring it to a score of 5.

The author computed diagnostic scores for all areas of Figure 5.3 for a sample example company, which Figure 5.10 shows the summary. One can use the diagnostic score to rank the problem areas and select the areas for further detailed analysis (root cause analysis and improvement).

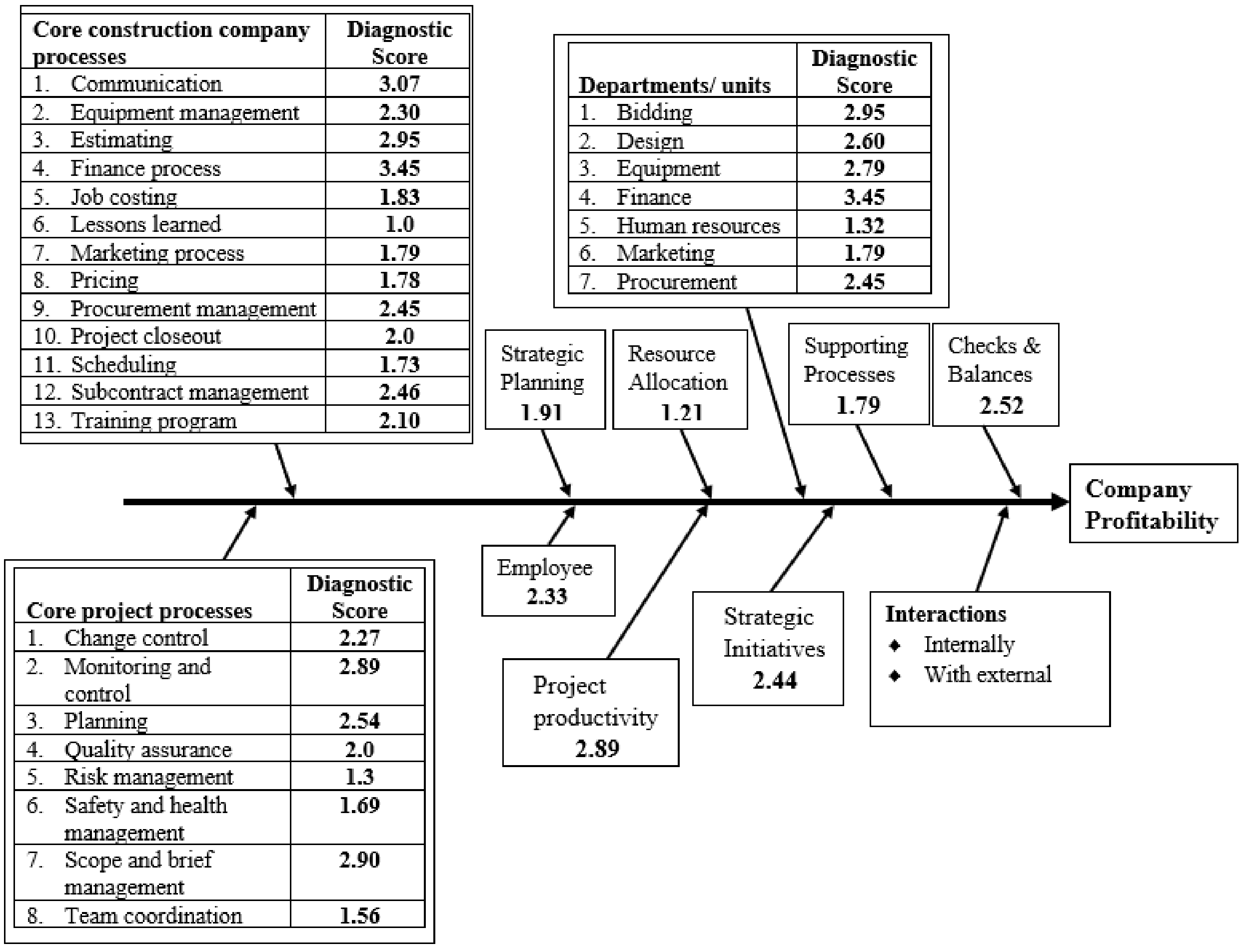


Figure 5.10 Summary of diagnostic scores

The problem areas are ranked using diagnostic scores from the smallest to the largest, the problem with the smallest diagnostic score being the top priority problem. In Figure 5.10, the problem with 'Lessons Learned' is a top priority problem.

The steps to follow in root cause analysis and improvement is that the user either clicks the button at the bottom of Figure 5.9 that reads “Carry out Analysis using Process and Fishbone Diagrams”, which brings up the screen in Figure 5.13 or clicks the second button on the main user interface (Figure 5.4), which brings up the screen in Figure 5.11. The user follows the first route if he/she wants to diagnose and improve the specific area. The user follows the second route for total diagnosis and improvement of multiple areas. Figure 5.11 forms the menu, which gives all areas to be improved.

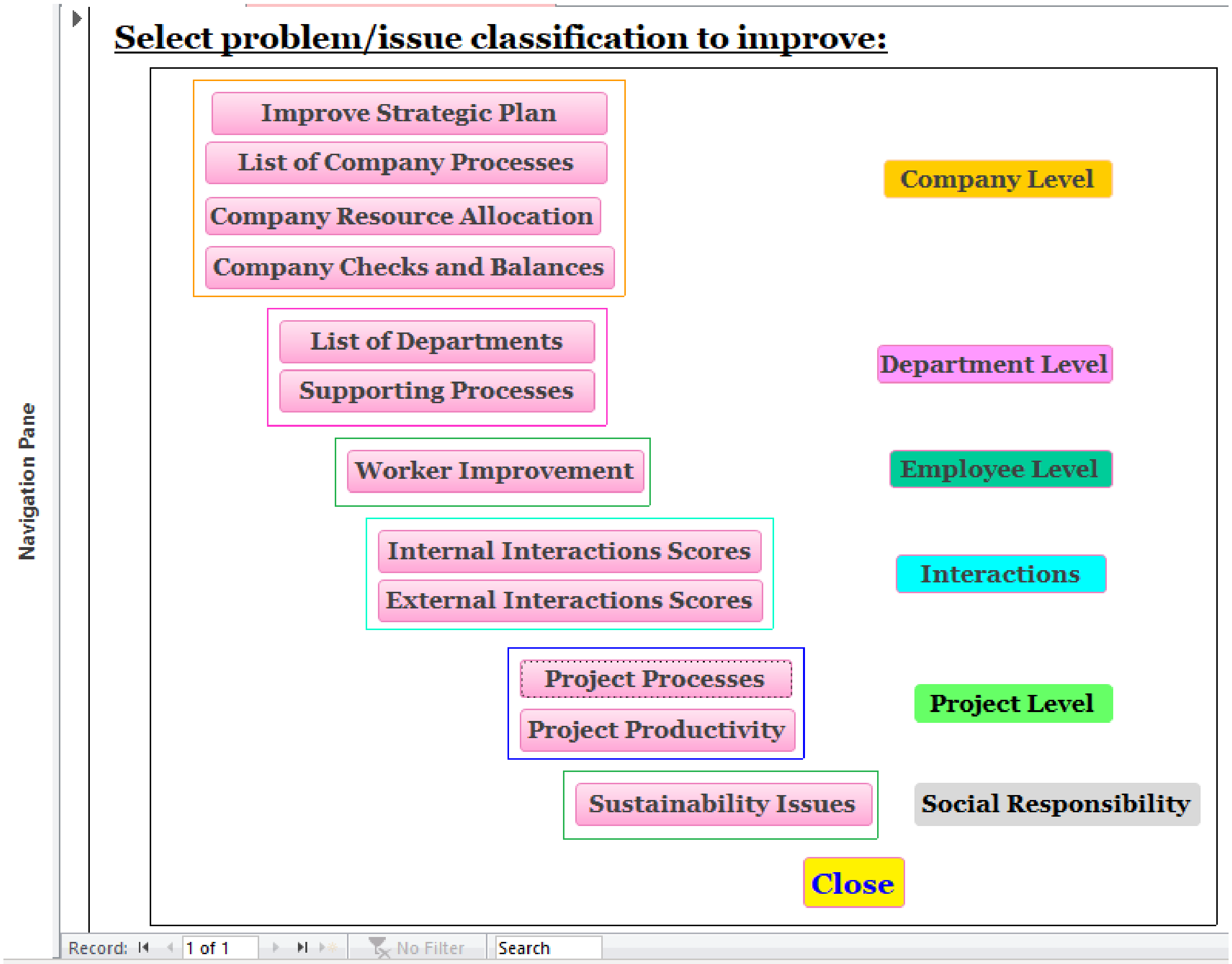


Figure 5.11 Issue classification for root cause analysis

"Lessons Learned" is under "List of Company Processes". Clicking the "List of Company Processes" button in Figure 5.11 brings up the screen shown in Figure 5.12.

Figure 5.12 List of company processes to select from and improve

Clicking the "Lessons Learned" button (Figure 5.12), process flow diagram for lessons learned, the corresponding fishbone diagram, and buttons to let the user select a branch on the fishbone diagram (each corresponding to a leading indicator) appear together on a screen as shown in Figure 5.13. After Figure 5.13, the two routes merge. For total improvement (route two), user goes back and selects item to improve from the list.

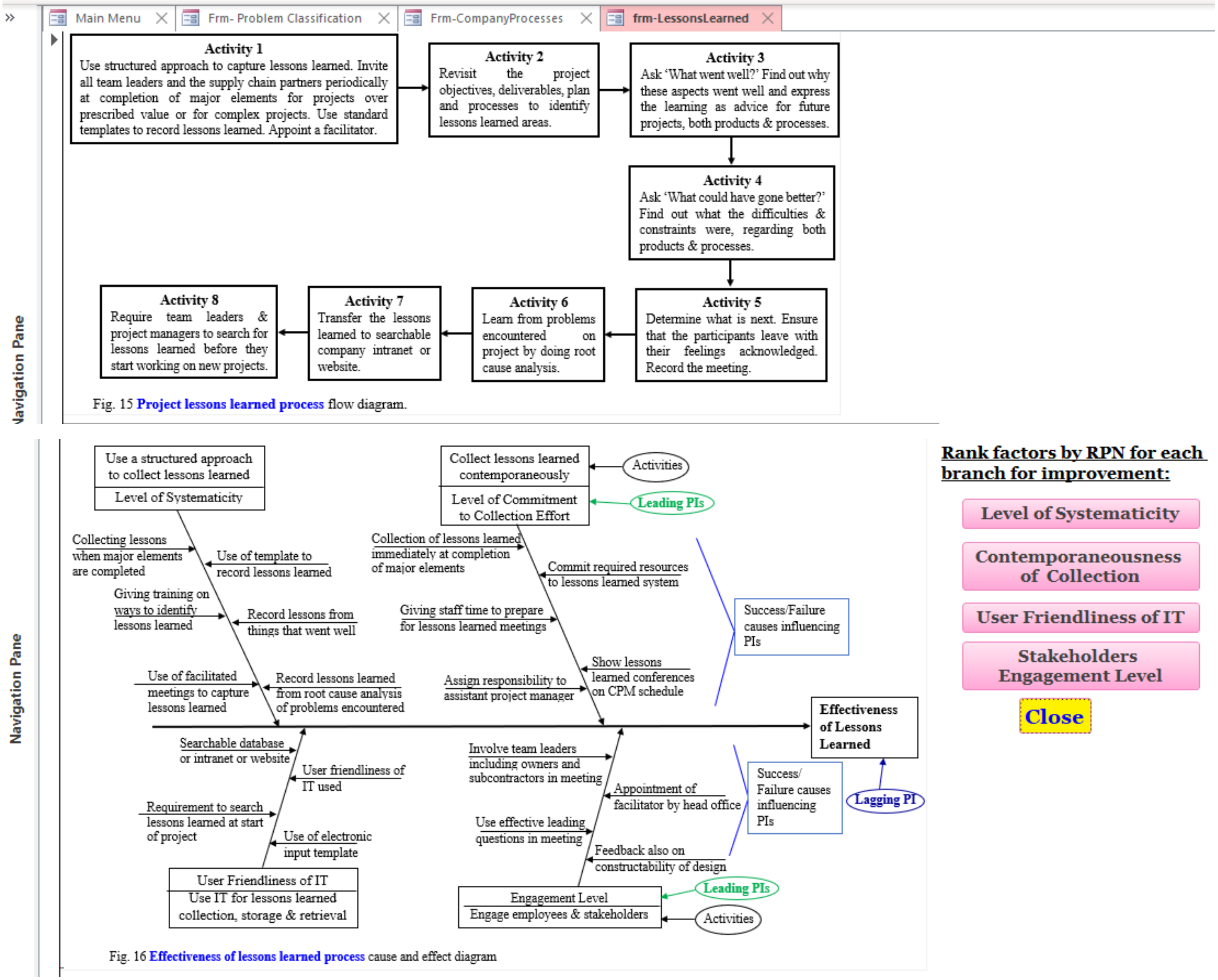


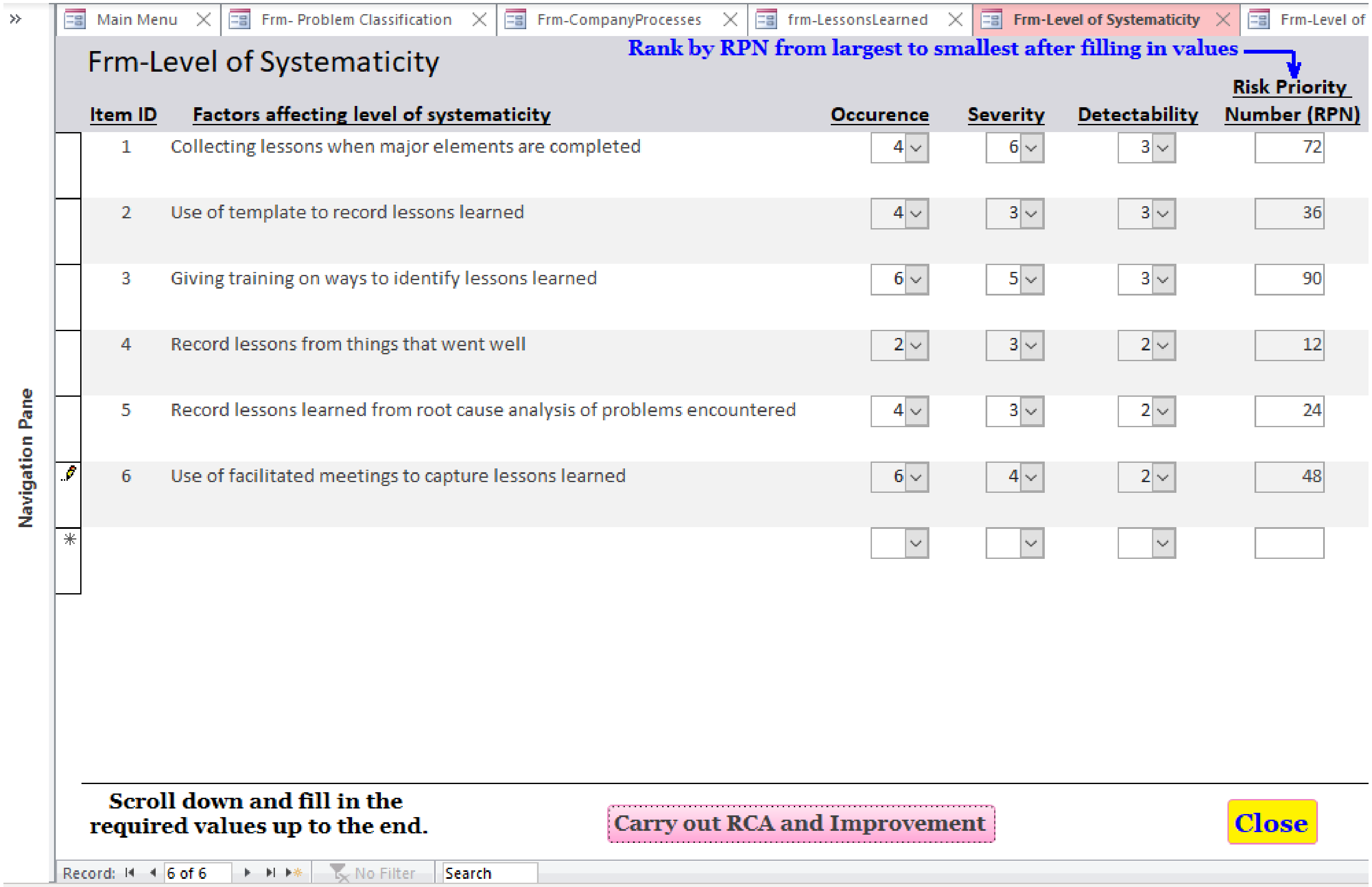
Figure 5.13 Process flow and fishbone diagrams for lessons learned, and buttons for leading indicators

The user will first click the button corresponding to the leading indicator he/she wants to improve, which brings up input form where Failure Mode and Effect Analysis data is input. Figure 5.14 shows an example when the user clicks the “Level of Systematicity” button in Figure 5.13. The form has down arrows that the user clicks to select input values for the **frequency of occurrence, severity,** and **detectability** of failure for each of the factors on the branch of the fishbone diagram the user tries to improve. 1-10 are the values that appear when the down arrow is pressed. The DSS will automatically calculate the Risk Priority Number (RPN) and display it to the user in the last column in Figure 5.14 once the user has selected values.

The form asks the user to rank and select top priority factors that the user wants to improve. The form has a button at the bottom that helps users carry out root cause analysis and improvement after the user has selected top factors that need intervention (See Figure 5.14). Improvement is usually a team effort. Each member of the team selects his/her input values. The team members will discuss their rankings, and they need to arrive at a consensus on top priority factors they decide to improve.

Table 5-1 Failure Mode and Effect Analysis (FMEA) for “Level of Systematicity” leading indicator

Item ID	**Factors affecting Level of Systematicity**	**Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**	**Ranking**
1	Collecting lessons when major elements are completed	4	6	3	72	2
2	Use of template to record lessons learned	4	3	3	36	4
3	Giving training on ways to identify lessons learned	6	5	3	90	1
4	Record lessons from things that went well	2	3	2	12	6
5	Record lessons learned from root cause analysis of problems encountered	4	3	2	24	5
6	Use of facilitated meetings to capture lessons learned	6	4	2	48	3
				Total RPN =	**282**	



Item ID	Factors affecting level of systematicity	Occurence	Severity	Detectability	Risk Priority Number (RPN)
1	Collecting lessons when major elements are completed	4	6	3	72
2	Use of template to record lessons learned	4	3	3	36
3	Giving training on ways to identify lessons learned	6	5	3	90
4	Record lessons from things that went well	2	3	2	12
5	Record lessons learned from root cause analysis of problems encountered	4	3	2	24
6	Use of facilitated meetings to capture lessons learned	6	4	2	48

Figure 5.14 FMEA analysis for Level of Systematicity

Table 5-2 gives information in Table 5-1 ordered by ranking.

Table 5-2 Factors affecting level of systematicity ordered by RPN ranking

Ranking	**Item ID**	**Factors affecting Level of Systematicity**	**Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**
1	3	Giving training on ways to identify lessons learned	6	5	3	90
2	1	Collecting lessons when major elements are completed	4	6	3	72
3	6	Use of facilitated meetings to capture lessons learned	6	4	2	48
4	2	Use of template to record lessons learned	4	3	3	36
5	5	Record lessons learned from root cause analysis of problems encountered	4	3	2	24
6	4	Record lessons from things that went well	2	3	2	12
					Total RPN =	**282**

Effectiveness of lessons learned has inherent unreliability of 282 concerning Level of Systematicity in conducting lessons learned performance, where the total RPN can be used to drive improvements in this process. Bititci and Nudurupati (2002) say that a significant reduction in RPN results in a significant improvement in the output measure (i.e., level of systematicity in this case). The user can do such RPN computation and ranking for the remaining three branches of the fishbone diagram.

The user can choose to improve all the six factors in Table 5-2 or only some of them depending on the availability of resources and other factors. Selecting the top four factors by their RPN value in Figure 5.14 (and Table 5-2) and clicking the button at the bottom, saying “Carryout RCA and Improvement” brings up the screen in Figure 5.15. The form that appears displays the factor, root cause of its failure, and RIPs, countermeasures, and BPs that would eliminate the root causes. One can navigate the factors, root causes, RIPs, countermeasures, and BPs using small arrows at the bottom of the screen.

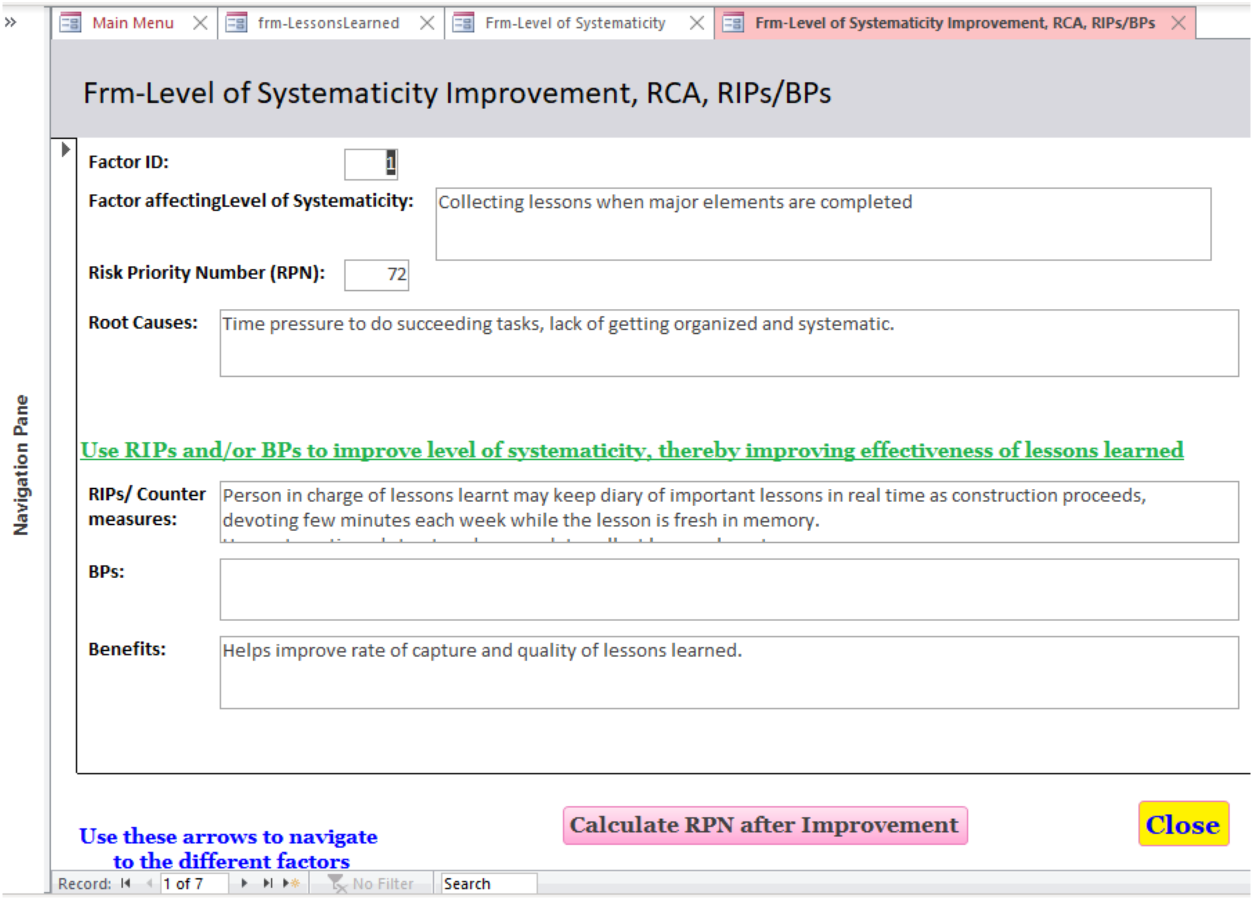


Figure 5.15 Root cause analysis of selected top priority factors and selection of RIPs and BPs from database of DSS

Table 5-3 gives the root causes of failure of factors on the branch of the fishbone diagram from the database and selected RIPs, countermeasures, and BPs from the database that would eliminate the root causes.

Table 5-3 Root causes of failure of each factor and selected RIPs, countermeasures and BPs to eliminate each root cause influencing level of sytematicity

Factor	**RPN (Rank)**	**Root cause of failure in factor from database (Figure 5.15)**	**RIPs, countermeasures, and BPs for improvement (that eliminate the root causes) from database (Figure 5.15)**
Giving training on ways to identify lessons learned	90 (1)	Lack of experts that give training. Allocation of insufficient budget for such trainings. Lack of understanding of importance and impact of lessons learned on future projects.	Assign top engineers of company to prepare training material and give training. Allocate sufficient budget and include training as part of project cost. Top management need to be convinced about lessons learned and they need to buy into the importance.
Collecting lessons when major elements are completed	72 (2)	Time pressure to do succeeding tasks. Lack of getting organized and systematic.	Person in charge of lessons learnt may keep diary of important lessons in real time as construction proceeds, devoting few minutes each week while the lesson is fresh in memory. Use systematic and structured approach to collect lessons learnt. Lessons learned is an after action review that requires detailed and clear recording of pertinent information.
Use of facilitated meetings to capture lessons learned	48 (3)	Lack of commitment and action to this level of detail as to plan for facilitated meeting, allocating budget and showing on CPM schedule. Lack of systematicity and structure.	Head office may pay for facilitated lessons learned meeting or a budget may be allocated as part of the project cost.
Use of template to record lessons learned	36 (4)	Not developing template (excel is used mostly) or if developed, template not user friendly.	Develop, user friendly (easy to use) electronic input form that can be used at job sites on laptops, desktops, ipads and smart phones. Put things that are proven to work in a template to be followed subsequently.

The user needs to recalculate RPN for the four factors assuming these improvements are applied, i.e., the user estimates the frequency of occurrence, severity, and detectability of failure after improvement. The user does the RPN recalculation by clicking the "Calculate RPN after Improvement" button and filling the information in the form that appears (Figure 5.15).

The fourth column in Table 5-3 gives RIPs, countermeasures, and BPs that would eliminate the failure root causes of the top-ranked factors. The frequency of occurrence of a failure in the top-ranked factor dropped to zero.

Improvement made to the second top factor, assigning responsibility to a person to record lessons learned in real-time as the construction of components is underway, reduces the frequency of failure of the factor to zero.

Regarding facilitated lessons learned meeting, head office paying for facilitated lessons-learned meetings or budget allocation as part of the project cost may reduce the failure. Usually, project managers complain about getting requested support from the top management because top management attention spreads wide and thin to head office, and all projects company undertakes. The frequency of occurrence may be difficult to eliminate, but it may reduce from 6 to 3.

Using electronic templates is the best way to record lessons learned, but the company under consideration has limited expertise in ICT. The company can use hard copy templates, but there is the risk of losing or misplacing the hard copy. Using hard copies may reduce the frequency of occurrence from 4 to 2. Applying these RIPs, countermeasures, and BPs for the improvement, the RPN was reduced from 282 to 78 (See Tables 5-2 and 5-4).

Improvement team can use FMEA as a live improvement tool, which is updated every time the team takes an improvement action or every time one of the input conditions (i.e., failure mode, frequency of occurrence, severity, detectability) changes.

Table 5-4 RPN values after application of RIPs and BPS given in Table 5-3

Rank	**Item ID**	**Factors affecting Level of Systematicity**	**Frequency of Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**
1	3	Giving training on ways to identify lessons learned	0	5	3	0
2	1	Collecting lessons when major elements are completed	0	6	3	0
3	6	Use of facilitated meetings to capture lessons learned	3	4	2	24
4	2	Use of template to record lessons learned	2	3	3	18
5	5	Record lessons learned from root cause analysis of problems encountered	4	3	2	24
6	4	Record lessons from things that went well	2	3	2	12
					Total RPN =	**78**

The percentage reduction in RPN gives the extent of improvement made from the available opportunity. The RPN is reduced from 282 to 78 (Table 5-2 to Table 5-4) through improvement intervention. Therefore, the percentage reduction in RPN is

$$\%\ \textbf{reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100}$$

$$\%\ \textbf{reduction in RPN} = \frac{\mathbf{282-78}}{\mathbf{282}} * \mathbf{100} \quad = \mathbf{72}\%$$

The improvement team can conduct such improvements for selected top priority factors on the remaining three branches of the fishbone diagram.

As can be seen in Table 5-3, to eliminate each root cause or group of root causes, two or more RIPs, countermeasures and BPs are listed. The improvement team needs to prioritize RIPs, countermeasures, and BPs for improvement of each factor and consensus established in the improvement team. The team can come up with prioritized solutions that they use to iterate through improvement until the team attains Level 5 of performance.

It is important to point out that some subjectivity is involved in estimating scores and weights in the computation of diagnostic scores and assigning values to the frequency of occurrence, severity, detectability in FMEA computations of Risk Priority Numbers (RPN).

5.2.2 Input-Processing-Output of Diagnostic Tool and DSS

Figure 5.16 gives inputs, internal processing and outputs of the diagnostic tool and DSS.

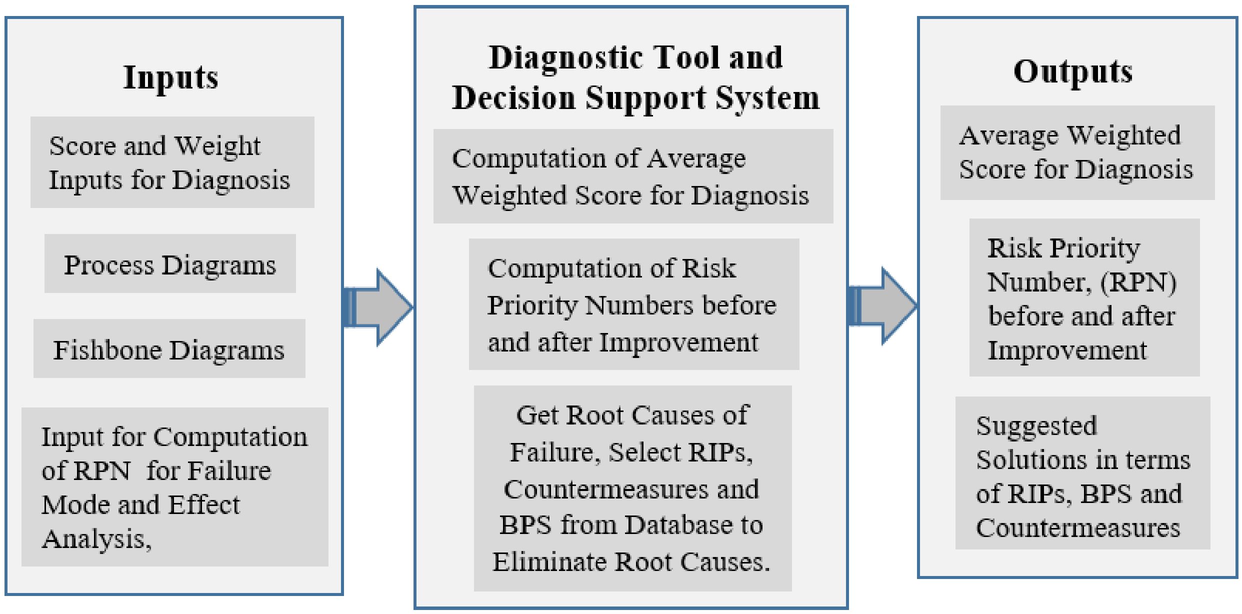


Figure 5.16 Inputs, internal processing and outputs of the diagnostic tool and DSS

5.2.2.1 Inputs

The four inputs to the diagnostic tool and DSS in Figure 5.16 are described as follows:

a) Score and Weight Input for Diagnosis

The improvement team can use the diagnostic questionnaire to conduct diagnosis in each of the subdivisions in Figure 5.3. The purpose of diagnosis is to identify problem areas that need further detailed analysis and improvement and get a diagnostic score indicating the company's current status in its different issue classifications. The team can prioritize the areas that need the most attention using the diagnostic score. A form asks users to input score by selecting values from a dropdown box of the level or status of practice in each of the statements in the questionnaires, and the corresponding weight the user assigns to each questionnaire item. The score ranges from 0 to 5. The weight values are taken from the Analytic Hierarchy Process (1, 3, 5, 7, or 9) but redefined as a relative scale in Table 3-3. Figure 5.17 shows a screenshot of the input form.

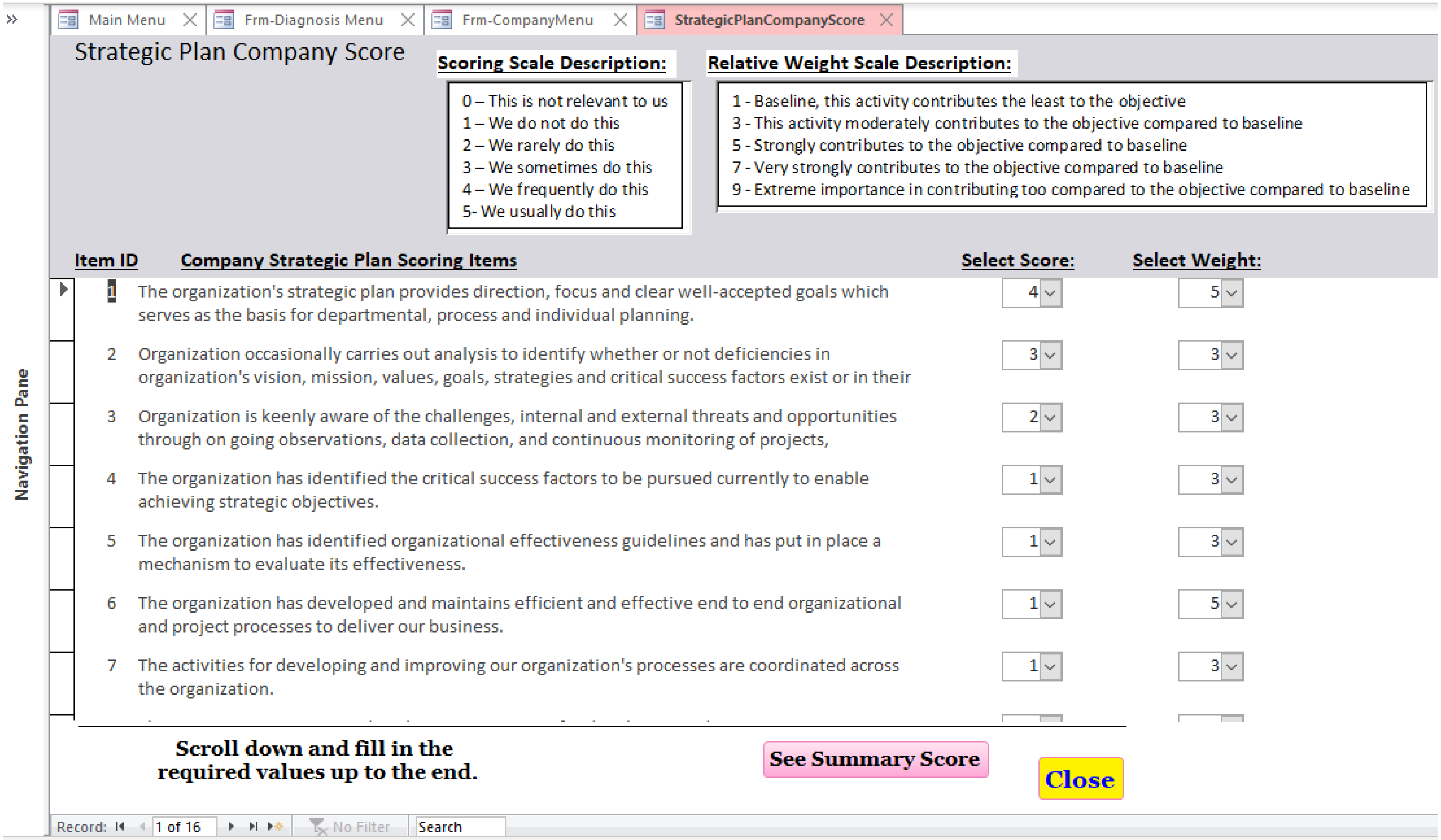


Figure 5.17 Input form for diagnostic questionnaire

b) Process Diagrams

Process flow and fishbone diagrams are embedded in the DSS for company and project processes(Figure 5.18) to facilitate the analysis. The user sees them when he/she clicks a button at the bottom of the screen that says, "Carryout RCA (root cause analysis) and Improvement" in Figure 5.14, which gives a summary score of diagnosis.

c) Fishbone Diagrams

Fishbone diagram corresponds to each process flow for departments, resource allocation, checks and balances, employees, and project productivity. The fishbone diagrams are embedded in the DSS to serve multiple purposes. The first purpose is to help carry out root cause analysis by giving a list of all the possible factors and failure modes that can influence a lagging performance indicator. The second purpose is to carry out risk analysis of failure in any of the factors on each branch of the fishbone diagrams by failure mode and effect analysis through the computation of Risk Priority Number (RPN). The RPN will be used to prioritize factors to be improved. The third purpose is to retrieve the root causes of failure of each factor from the DSS database, and RIPs, countermeasures, and BPs selected from the database for improvement that eliminates the root cause of the failures.

The fourth purpose of fishbone diagrams is to establish the link between leading indicators and lagging indicators, thus helping proactive management of the lagging indicators. Fishbone diagrams drive continuous improvement through RPN. The RPN is also an indirect means of performance measurement to drive continuous improvement. When there is a significant reduction in RPN, there will be a significant improvement in performance (Bititci and Nudurupati, 2002)..

d) Inputs for Computation of Failure Mode and Effect Analysis

The process flow diagram, the fishbone diagram, and buttons to select a branch on the fishbone diagram appear together on a screen (See Figure 5.18 as an example for the equipment management process). The user will first click the button corresponding to the leading indicator he/she wants to improve, which brings up input form where Failure Mode and Effect Analysis data is input.

Figure 5.19 shows an example when the user clicks the "Accuracy of Procurement/Rental Plan" button. The form has down arrows that the user clicks to select input values for the **frequency**

of occurrence, severity, and **detectability** of failure for each of the factors on the branch of the fishbone diagram the user tries to improve. The DSS will automatically calculate the Risk Priority Number (RPN) and display it to the user in the last column in Figure 5.19 once the user has selected values. The form asks the user to rank and select top priority factors that the user wants to improve. The form has a button at the bottom that helps users carry out root cause analysis and improvement after the user has selected top factors that need intervention (See Figure 5.19). Improvement is usually a team effort. Each member of the team selects his/her input values. The team members will discuss their rankings, and they need to arrive at a consensus on top priority factors to improve.

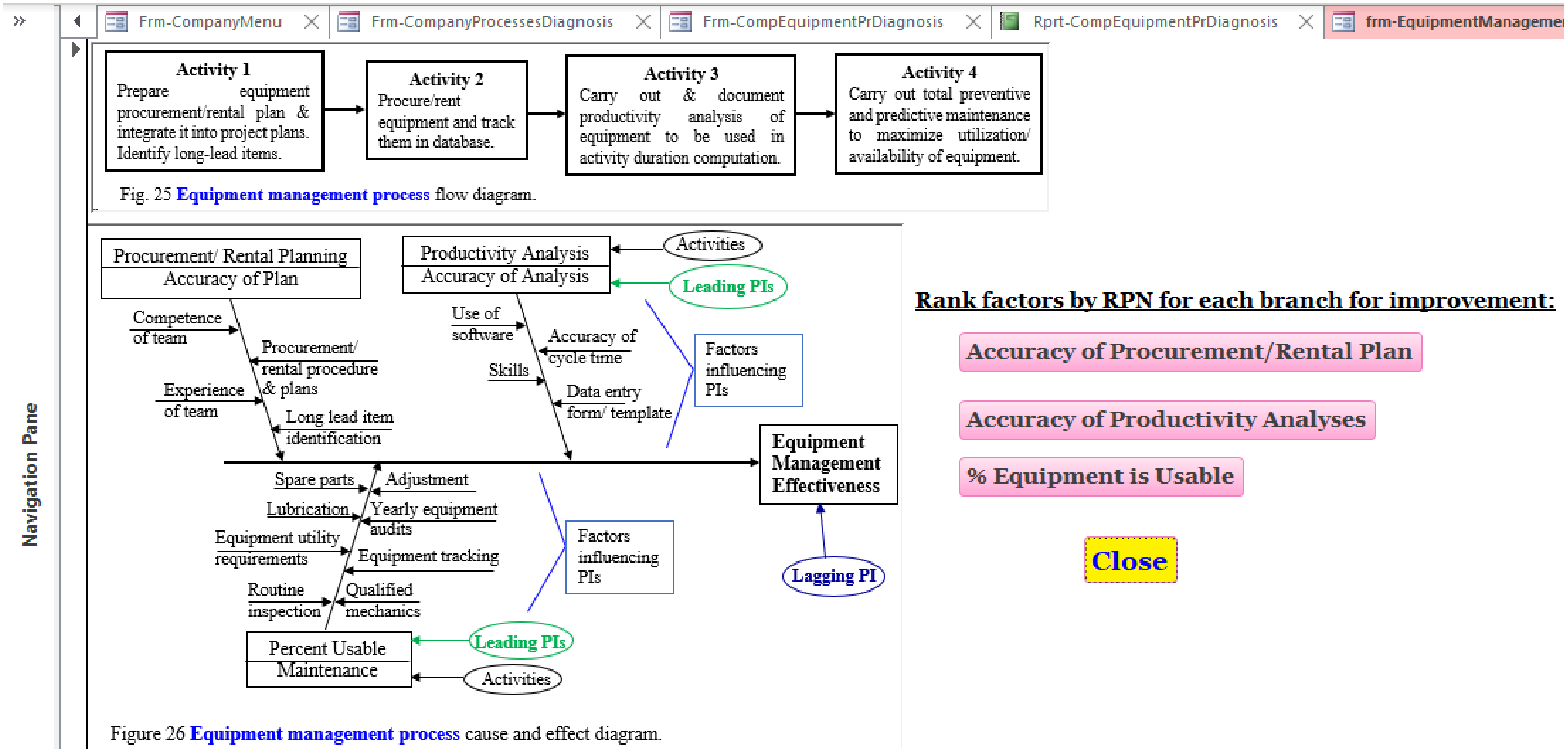


Figure 5.18 Process flow diagram for equipment management and the corresponding fishbone diagram with buttons for leading performance indicator of each branch

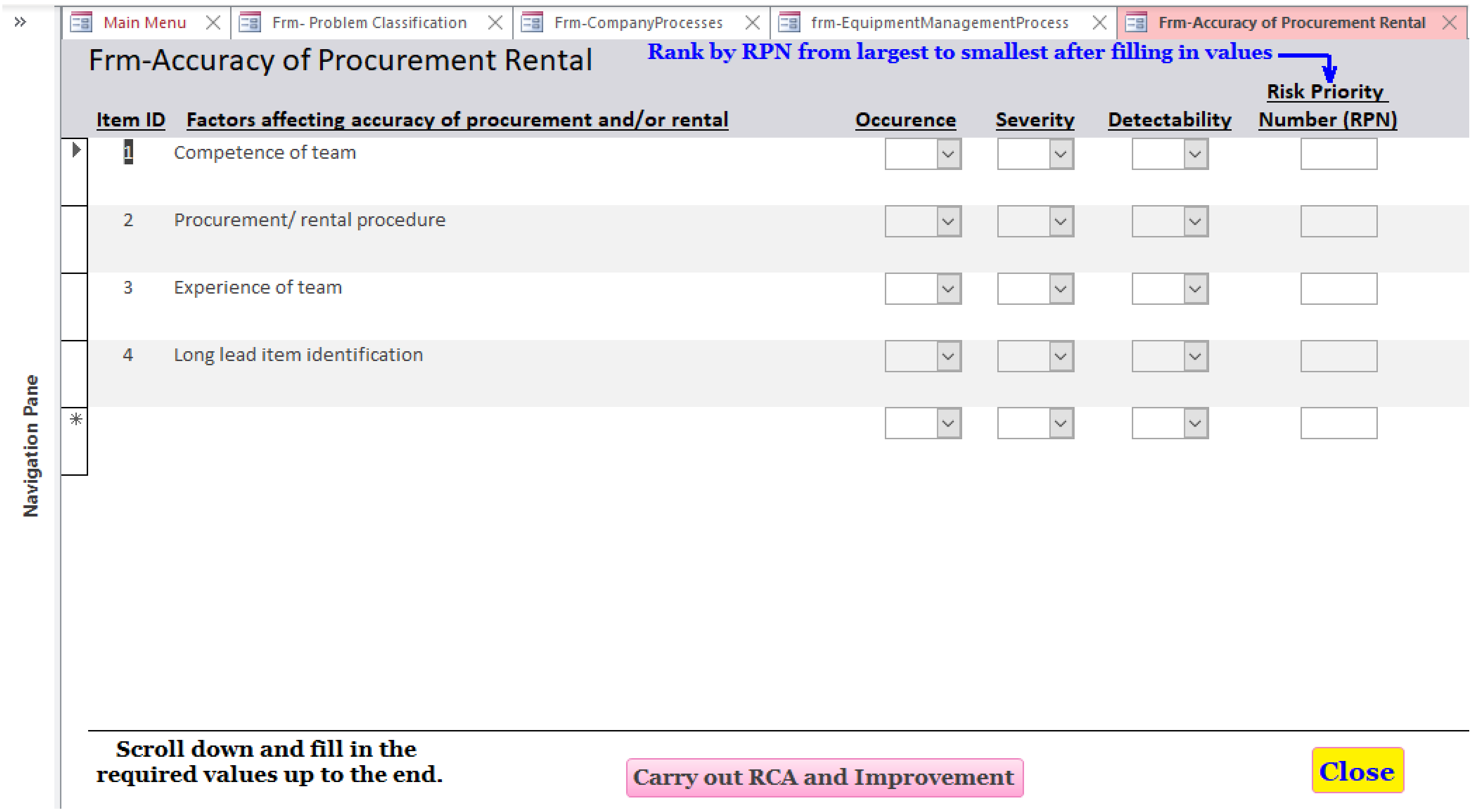


Figure 5.19 Failure Mode and Effect Analysis data input form to calculate RPN and prioritize influencing factors for improvement

5.2.2.2 Processing

The processing done by the diagnostic tool and DSS in Figure 5.16 are described as follows:

a) Average Weighted Score

An average weighted score is calculated using Equation 5.1

$$\boldsymbol{Avg.Weighted\ Score} = \frac{\sum \boldsymbol{Score*Weight}}{\sum \boldsymbol{Weight}} \quad . \quad . \quad (5.1)$$

b) Computation of Risk Priority Number

Equation 5.2 is used to calculate Risk Priority Number (RPN).

$$\boldsymbol{RPN = Occurrence * Detectability * Severity} \quad . \quad . \quad (5.2)$$

c) Getting Root Causes of Failures in Factors, Selection of RIPs and BPs from Database

Root cause analysis is done mainly through the fishbone diagrams. All possible factors that could affect the lagging performance indicator of interest through the leading indicators on each branch are listed, which means the analyst identifies and addresses all the root causes of poor performance. Failure mode and effect analysis help make sure those root causes do not cause failure in performance. Reducing RPN reduces or does away with the effects of the root causes on the performance of interest. That way, the risk of the root causes realizing and causing failure is minimized.

The final bit of root cause analysis at the factor level (most granular level) is done in the DSS when the user presses the button at the bottom saying, “Carry out RCA and Improvement” (in Figure 5.19), a form appears (such as Figure 5.20) that lists root causes of the specific factor on fishbone diagram under investigation. Applying RIPs, countermeasures, and BPs from the database that eliminate the root causes helps carry out improvement at the most granular, factor level. The last line in Figure 5.20 gives the benefits of using RIPs, countermeasures, and BPS.

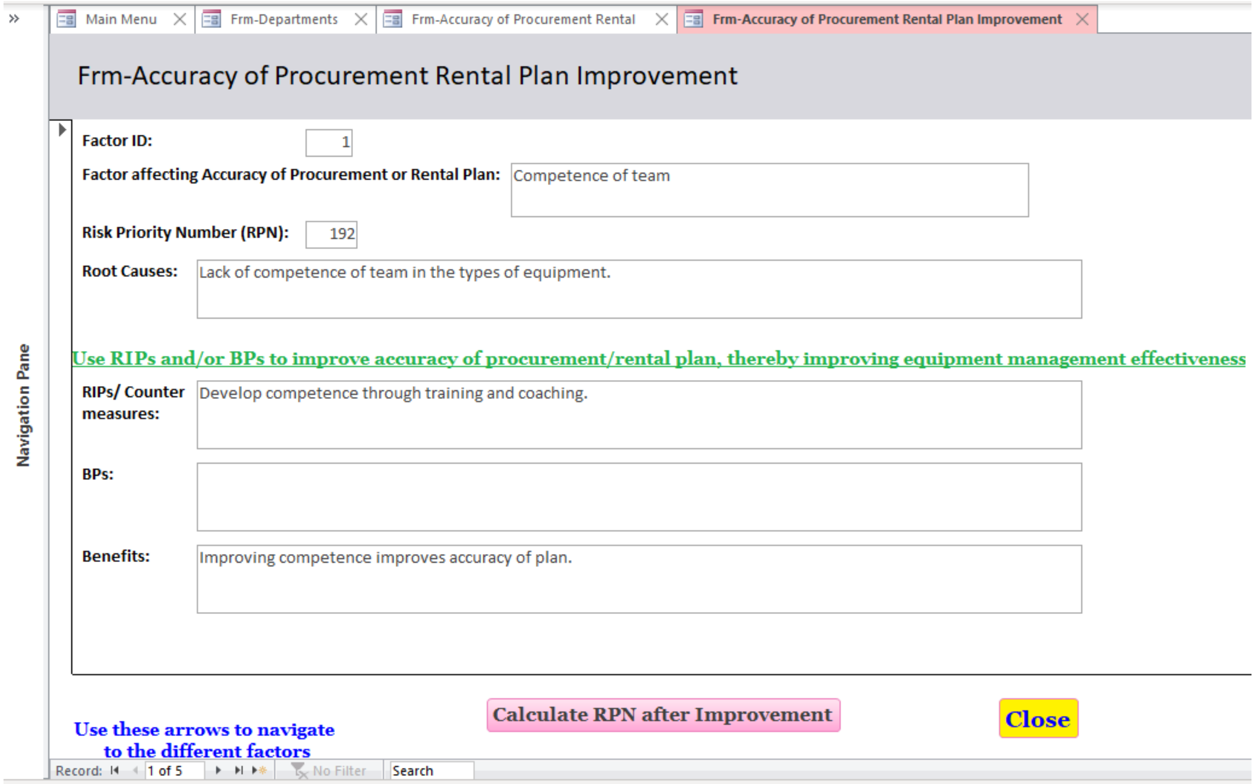


Figure 5.20 Root Cause Analysis and selection of RIPs, counter measures and BPs for improvement.

The processing that occurs in the diagnostic tool and DSS is interactive i.e., the user inputs data, the tool processes information, and shows outputs to user, the user uses the output to decide the course of action to take, and so on. Inputting, processing, and outputs occur in series or parallel interactively.

5.2.2.3 Output

The three outputs in the diagnostic tool and DSS in Figure 5.16 are described as follows:

a) Average Weighted Score for Diagnosis

The average weighted score for each issue classification is output when the user finished filling score and weight in the diagnostic questionnaire and presses the button at the bottom that reads “See Summary Score,” as shown in Figure 5.17. The summary score gives diagnostic metrics as an average weighted score ranging from 0 to 5. 0 means the improvement is not relevant to company, 1 is poor performance, and 5 is the best performance. The improvement team can use the average weighted score to prioritize the areas of the company that need attention and further detailed analysis.

b) Risk Priority Number before and after Improvement

Risk Priority Number (RPN) results appear when the user does root cause analysis and improvement to factors on a branch of fishbone diagram by pressing the buttons corresponding to the leading performance indicator of the branch under consideration. These RPN values (as in Figure 5.19) are ranked by the user from the highest to the lowest to determine top priority factors that need improvement. These RPN values are the ones before improvement.

The user then presses the button at the bottom of the screen (as in Figure 5.19) that reads “Carry out RCA and Improvement” that brings up the form in Figure 5.20. After root causes are determined, and RIPs, countermeasures, and BPs selected for each top priority factor on the branch of the fishbone diagram under consideration, RPN after improvement is calculated by pressing the button at the bottom of Figure 5.20 saying “Calculate RPN after Improvement.” The difference between total RPN before and after improvement indicates the extent of improvement attained (Bititci and Nudurupati, 2002). User can calculate percentage reduction in RPN using Equation 5.3.

c) Suggested Solutions in terms of RIPs, Countermeasures and BPs

RIPs and BPs selected to improve each factor on the fishbone diagram (see Figure 5.20) are used to compose the suggested solutions. The user then assesses the solution and makes final adjustments.

This dissertation uses data collected from an extensive literature review in different forms. Table 5-5 lists the different forms of data used in the diagnostic tool and DSS and its location in the computer tool and the dissertation document.

Table 5-5 Data collected from literature review used in diagnostic tool and DSS

Data collected	**Purpose**	**Artifact**	**Location of Artifact**	
			In tool and DSS	In Appendix
Diagnostic/ assessment statements	Assessing situations and detecting problems.	Questionnaire	In database of tool as diagnostic questionnaire	Appendix C
Process flows data collected from scientific and practitioner literature	To help see and map company and project processes.	Process flow diagrams	Process flow diagrams shown to users in forms of DSS (like in Figure 5.18)	Appendix A
Fishbone diagrams for company & project processes, departments, for most areas that need improvement from scientific and practitioner literature	To do root cause analysis, to establish links, to help quantify improvements in terms of reduction in RPN.	Fishbone diagrams	Fishbone diagrams shown to users in forms of DSS (like in Figure 5.18)	Appendix A
Root causes of failures of factors shown on fishbone diagram collected from scientific and practitioner literature	To do root cause analysis	Root causes	In database of DSS as textual data (like in Figure 5.20)	
RIPs and BPs collected from scientific and practitioner literature	To improve by doing away with root causes of failure of factors on fishbone diagrams	RIPs and BPs	In the database of DSS as textual data (like in Figure 5.20)	

5.3 Company Example

This section illustrates the use of diagnostic tool and DSS through an example of a sample midsize highway construction company The company has problems such as cost and time overruns in its projects, high employee turnover, and low bid winning rat. It is not easy to describe all the information about the company, but the information is input into the computer tool, output included in this section, and Appendix D, and discussions made.

The second purpose the example serves is to show the internal validity of the diagnostic tool and DSS. Validation involves the following:

a. Show that the algorithm works
b. What goes in and comes out are logical
c. The computations make sense, and
d. The improvement using the tool is useful to companies implementing the tool

The weak market test conducted in Chapter 3 addresses the fourth point well. The feedback received from the company about the two-part excellence model and the computer tool is that they are useful, and the company wants to use them for actual decisions (Appendix F).

The tables in this example are reproduced in MS Excel to check whether the algorithm of the computer tool works. The results of excel computation show that the tool gives correct results.

The first task is to do a diagnosis using the questionnaire in Appendix C. The example follows the same order as in Appendix C.

COMPANY

<u>Strategic Planning:</u>

The information for the questionnaire items are filled in as shown in Figure 5.21

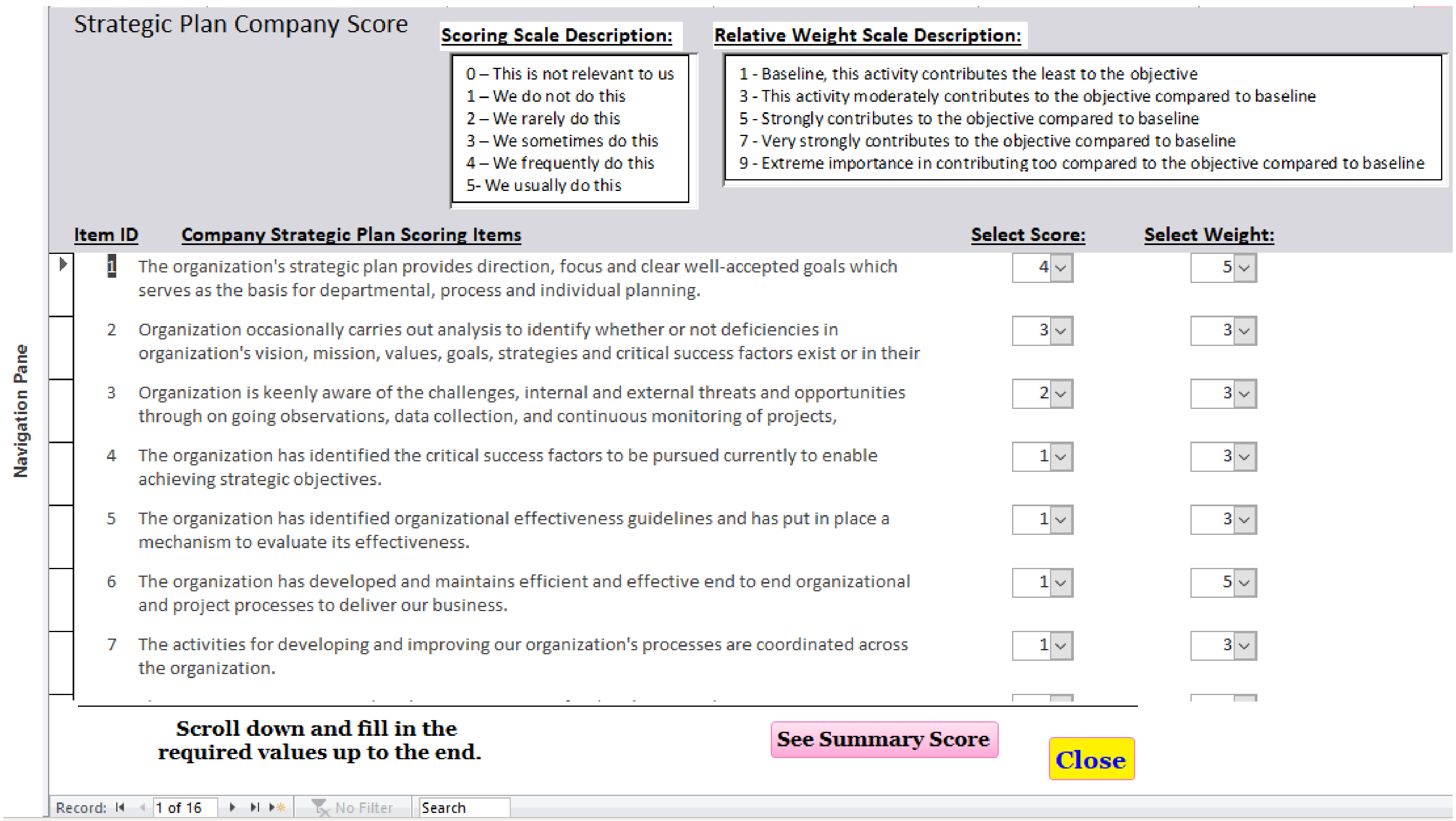
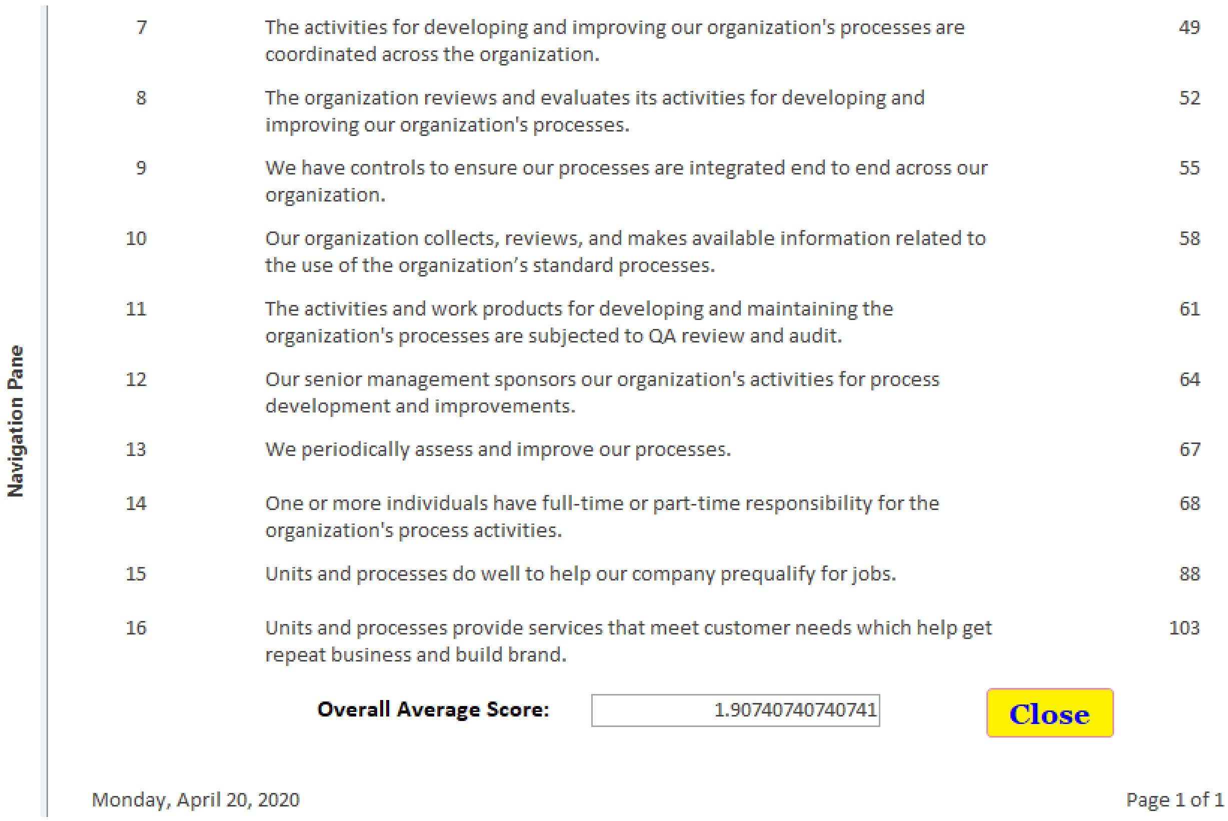


Figure 5.21 Input scores and weights for computation of diagnostic score

Clicking the button that reads "See Summary Score" at the bottom of Figure 5.21, a screen appears. Scrolling down to the bottom, one sees a diagnostic score result of 1.907, which Figure 5.22 shows the screenshot.



7	The activities for developing and improving our organization's processes are coordinated across the organization.	49
8	The organization reviews and evaluates its activities for developing and improving our organization's processes.	52
9	We have controls to ensure our processes are integrated end to end across our organization.	55
10	Our organization collects, reviews, and makes available information related to the use of the organization's standard processes.	58
11	The activities and work products for developing and maintaining the organization's processes are subjected to QA review and audit.	61
12	Our senior management sponsors our organization's activities for process development and improvements.	64
13	We periodically assess and improve our processes.	67
14	One or more individuals have full-time or part-time responsibility for the organization's process activities.	68
15	Units and processes do well to help our company prequalify for jobs.	88
16	Units and processes provide services that meet customer needs which help get repeat business and build brand.	103

Overall Average Score: 1.90740740740741 **Close**

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Figure 5.22 Diagnostic score result of computation

The same computation is done in MS Excel and shown in Table 5-6 to show that the diagnostic tool and DSS works as expected. The inputs and outputs are also logical and make sense.

Table 5-6 Diagnostic score computation for Strategic planning scoring items done in MS Excel

Item ID	Strategic Planning Scoring Items	Selected Score	Selected Weight	Weighted Score
1	The organization's strategic plan provides direction, focus and clear well-accepted goals which serves as the basis for departmental, process and individual planning.	4	5	20
2	Organization occasionally carries out analysis to identify whether or not deficiencies in organization's vision, mission, values, goals, strategies and critical success factors exist or in their communication or in their alignment or in their implementation.	3	3	9
3	Organization is keenly aware of the challenges, internal and external threats and opportunities through on going observations, data collection, and continuous monitoring of projects, employees, clients, processes, competition, stakeholders and markets for possibilities.	2	3	6
4	The organization has identified the critical success factors to be pursued currently to enable achieving strategic objectives.	1	3	3
5	The organization has identified organizational effectiveness guidelines and has put in place a mechanism to evaluate its effectiveness.	1	3	3
6	The organization has developed and maintains efficient and effective end to end organizational and project processes to deliver our business.	1	5	5
7	The activities for developing and improving our organization's processes are coordinated across the organization.	1	3	3
8	The organization reviews and evaluates its activities for developing and improving our organization's processes.	1	3	3
9	We have controls to ensure our processes are integrated end to end across our organization.	1	3	3
10	Our organization collects, reviews, and makes available information related to the use of the organization’s standard processes.	1	3	3
11	The activities and work products for developing and maintaining the organization's processes are subjected to QA review and audit.	1	3	3
12	Our senior management sponsors our organization's activities for process development and improvements.	1	3	3
13	We periodically assess and improve our processes.	1	3	3
14	One or more individuals have full-time or part-time responsibility for the organization's process activities.	1	1	1
15	Units and processes do well to help our company prequalify for jobs.	4	5	20
16	Units and processes provide services that meet customer needs which help get repeat business and build brand.	3	5	15
	Sum		54	103
	Average Weighted Score	**1.907**		

The same computation is done for all areas and given in Appendix D. The summary of the diagnostic scores excluding interactions is given in Figure 5.23

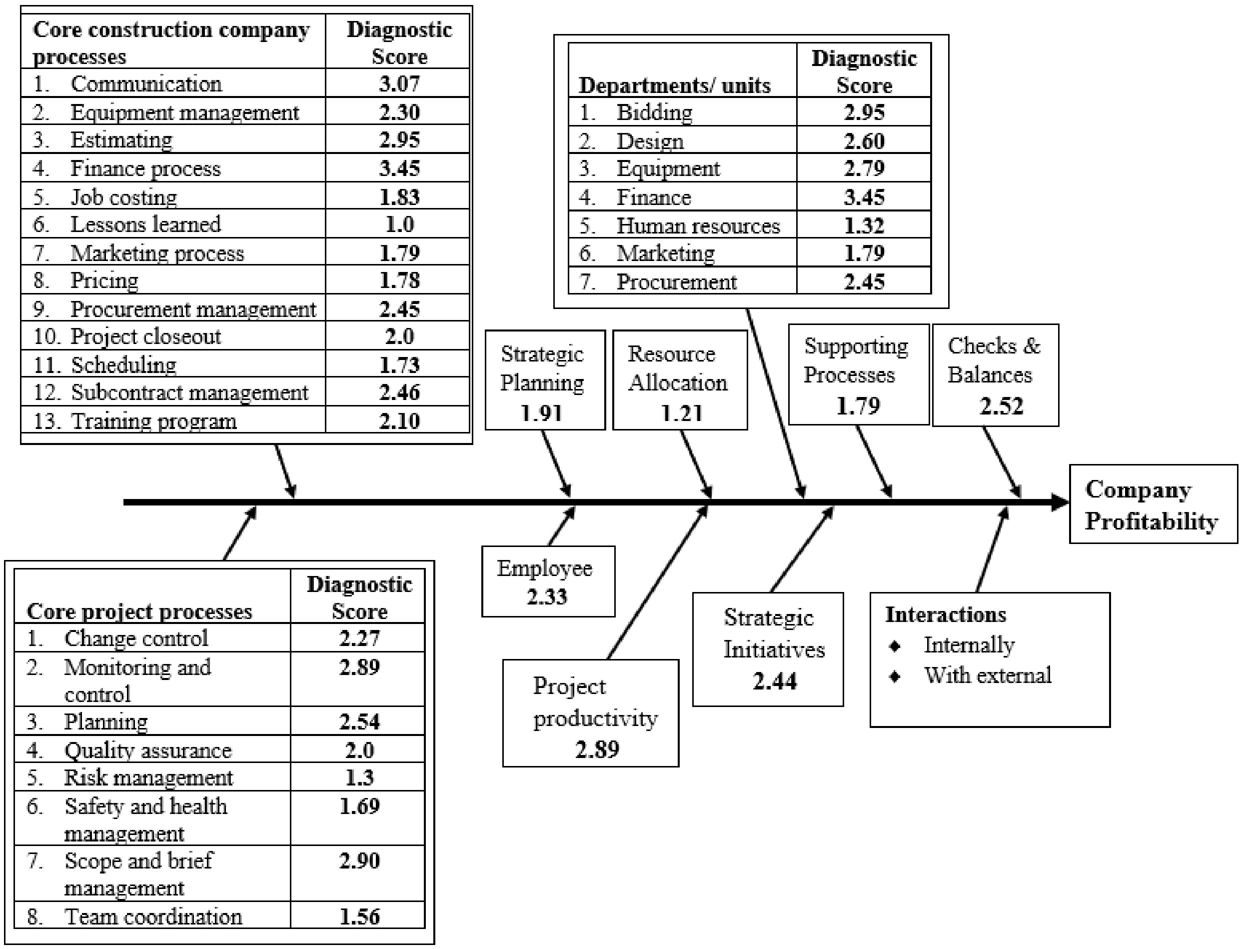

Figure 5.23 Summary of diagnostic score computations

The diagnostic score values are out of 5. 0 means the improvement is not relevant to the company, 1 is poor performance, and 5 is the best performance. Figure 5.23 shows that many problem areas need improvement.

Excel calculations verified each of the results in Figure 5.23 from the diagnostic tool and DSS. The inputs and outputs are also logical and make sense. Verification and sense-making validate the diagnostic tool part.

The top priority problem areas in decreasing order of importance with their diagnostic score are:

In **company processes**: Lessons learned (1.0), scheduling (1.73), pricing (1.78), marketing (1.79), job costing (1.83), project closeout (2.0), training program (2.10), equipment management (2.30) have low diagnostic scores.

Under **company classification**, resource allocation (1.21) and strategic planning (1.91) have low scores.

In **departments**: HR (1.32), marketing (1.79), supporting processes (1.79).

In **project processes**: Risk management (1.3), team coordination (1.56), safety and health management (1.69), QA (2.0), change control (2.27).

Overall, the ranking of the problems with their RPN in bracket is:

1) company lessons learned process (1.0)

2) company resource allocation (1.21) 3) project risk management process (1.3) 4) HR department (1.32) 5) project team coordination (1.56) 6) project safety and health management (1.69) 7) company scheduling process (1.73) 8) company pricing process (1.78) 9) marketing department (1.79) and 10) departments supporting processes (1.79)

11) company job costing process (1.83)

12) company strategic planning (1.91)

13) company project closeout (2.0) and project QA (2.0) 15) company training program (2.10) 16) project change control process (2.27)

17) company equipment management process (2.30).

Further detailed analysis and the cutoff diagnostic score to use depends on the resources available to do root cause analysis and improvement. In this example, the top two problems identified, lessons learned, and resource allocation need improving. Lessons learned example began in Section 5.2 will be completed, and then resource allocation will be treated.

The fishbone diagram for lessons learned in Figure 5.13 shows that the four leading indicators to improve through root cause analysis and application of RIPs, countermeasures, and BPs are Level of Systematicity, Contemporaneousness of Collection, User Friendliness of IT and Stakeholder Engagement Level. Failure Mode and Effect Analysis and improvement were made for the first leading indicator (level of systematicity). Now, the FMEA analysis and prioritization of factors for the remaining three branches of the fishbone diagram (remaining three leading indicators) — Contemporaneousness of Collection, User Friendliness of IT and Stakeholder Engagement Level are carried out clicking their respective buttons (Figure 5.13) and given in Tables 5-7 to 5-9.

Table 5-7 Failure Mode and Effect Analysis (FMEA) for "contemporaneousness of collection of lessons learned" leading indicator

Item ID	**Factors affecting Contemporaneousness of Collection of Lessons Learned**	**Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**	**Rank**
1	Giving staff time to prepare for lessons learned meetings	6	5	3	90	1
2	Collection of lessons learned immediately at completion of major elements	4	6	3	72	2
3	Commit required resources to lessons learned system	4	5	3	60	4
4	Assign responsibility of managing lessons learned collection and documentation to assistant project manager	8	4	2	64	3
5	Show lessons learned conferences on CPM schedule	7	4	2	56	5
				Total RPN =	**342**	

Table 5-8 FMEA calculation for "user friendliness of IT" leading indicator

Item ID	**Factors affecting User Friendliness of IT**	**Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**	**Rank**
1	Requirement to search lessons learned at start of project	5	6	5	150	1
2	User friendliness of IT used	6	4	2	48	2
3	Use of electronic input template	7	3	2	42	3
4	Searchable database or intranet or website	2	4	2	16	4
				Total RPN =	**256**	

Table 5-9 FMEA for “level of stakeholders’ engagement in collection of lessons learned” leading indicator

Item ID	Factors affecting Level of Engagement of Stakeholders	Occurrence	Severity	Detectability	Risk Priority Number (RPN)	Rank
1	Involve team leaders including owners and subcontractors in lessons learned meetings	5	5	8	200	1
2	Appointing facilitator by head office	4	4	3	48	2
3	Use effective leading questions in meeting	2	2	2	8	3
4	Feedback also on constructability of design	2	2	2	8	4
				Total RPN =	264	

The cutoff RPN can be decided branch by branch or overall for the three branches. Tables 5-10 to 5-12 give RPN values assuming that factors with RPN above 40 are decided to be improved. The tables also give the root causes with the corresponding RIPs, countermeasures, and BPs from the database.

Table 5-10 Failure root causes and selected RIPs, countermeasures and BPs for “contemporaneous of collection” leading indicator

Factor	**Root cause of failure in factor**	**RIPs, countermeasures and BPs for improvement (that eliminate the root causes)**
Giving staff time to prepare for lessons learned meetings	Time pressure on staff to do their assigned work. Lack of understanding of the strategic importance of lessons learned on company bottom line. Putting in partial resources or effort.	Assign required resources, including staff time, and put in the required effort.
Collection of lessons learned immediately at the completion of major elements	Time pressure to do succeeding tasks. Lack of getting organized and systematic.	A person in charge of lessons learned may keep a diary of important lessons in real-time as construction proceeds, devoting few minutes each week while the lesson is fresh in memory, and compiling the document when a major element is completed. Keep a detailed and precise recording of pertinent information for ease in compiling and documentation.
Commit required resources to lessons learned system	Budget constraint limiting amount of resources allocated for lessons learned. Putting in partial resources or effort.	Assign required resources and put in the required effort to reap benefits. Put in concerted and full effort.
Assign responsibility of managing lessons learned collection and documentation to assistant project manager	Lack of responsible person who coordinates and follows up lessons learned effort.	Assign responsibility to one person (to assistant project manager) and check how he/she is doing occasionally.
Show lessons learned conferences on CPM schedule	Not considering lessons learned conferences during project planning and scheduling.	Include conference for lessons learned in project planning and scheduling. Assign specific tasks to team leaders at start of project on lessons learned they need to record real time.

Table 5-11 Failure root causes and selected RIPs, countermeasures and BPs for "user friendliness of IT" leading indicator

Factor	Root cause of failure in factor	RIPs, countermeasures and BPs for improvement (that eliminate the root causes)
Requirement to search lessons learned at the start of projects	Lack of use of IT or database difficult to search for information. A hard copy is even more difficult to search for information.	Use IT capability and potential to support and facilitate lessons learned system.
User-friendliness of IT	Lack of use of IT for collection and retrieval of lessons learned. Excel used in most cases for computations and data. IT cumbersome to use.	Make IT user friendly to both input data, search and retrieve information so busy people would not be discouraged to document or use lessons learned.
Use of electronic input template	Lack of use of well thought out and formulated template where in best practices in lessons learned are incorporated. Lack of being parsimonious in selecting the most important and yet complete information to collect.	Use electronic easy to use template to facilitate lessons learned documentation by busy people. Use IT capability and potential to support lessons learned system.

Table 5-12 Failure root causes and selected RIPs, countermeasures and BPs for "level of stakeholders' engagement" leading indicator

Factor	Root cause of failure in factor	RIPs, countermeasures and BPs for improvement (that eliminate the root causes)
Involve team leaders, including owners and subcontractors in lessons learned meetings	Leaving out important stakeholders from meetings. Not reminding stakeholders about lessons learned meeting ahead of time.	Involve team leaders including owners and subcontractors in lessons learned meetings to get richer information. Inform external stakeholders at the beginning of the project that you hold lessons learned at completion of major elements.
Appointing facilitator by head office	Budget constraint to hire a facilitator.	The head office may allocate budget, or even better if the cost of hiring facilitator may be made part of the project cost.

Next is to recalculate RPN for the factors on the three branches to which these RIPs are applied.

Table 5-13 RPN values after application of RIPs and BPS given in Table 5-10

Item ID	Factors affecting Contemporaneousness of Collection of Lessons Learned	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Giving staff time to prepare for lessons learned meetings	1	5	3	15
2	Collection of lessons learned immediately at completion of major elements	0	6	3	0
3	Commit required resources to lessons learned system	2	5	3	30
4	Assign responsibility of managing lessons learned collection and documentation to assistant project manager	2	4	2	16
5	Show lessons learned conferences on CPM schedule	3	4	2	24
				Total RPN =	**85**

Applying these RIPs for the improvement, the RPN was reduced from 342 to 85.

$$\%\ \textbf{reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100}$$

$$\%\ \textbf{reduction in RPN} = \frac{\mathbf{342 - 85}}{\mathbf{342}} * \mathbf{100} \quad = \mathbf{75}\%$$

Table 5-14 RPN values after application of RIPs and BPS given in Table 5-11

Item ID	Factors affecting User Friendliness of IT	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Requirement to search lessons learned at start of project	2	6	5	60
2	User friendliness of IT used	2	4	2	16
3	Use of electronic input template	0	3	2	0
4	Searchable database or intranet or website	2	4	2	16
				Total RPN =	**92**

Applying these RIPs for the improvement, the RPN was reduced from 256 to 92.

$$\%\ \textbf{age reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100}$$

$$\%\ \textbf{age reduction in RPN} = \frac{\mathbf{256-92}}{\mathbf{256}} * \mathbf{100} \quad = \mathbf{64}\%$$

Table 5-15 RPN values after application of RIPs given in Table 5-12

Item ID	Factors affecting Level of Engagement of Stakeholders	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Involve team leaders including owners and subcontractors in lessons learned meetings	2	5	8	80
2	Appointing facilitator by head office	2	4	3	24
3	Use effective leading questions in meeting	2	2	2	8
4	Feedback also on constructability of design	2	2	2	8
				Total RPN =	120

Applying these RIPs for the improvement, the RPN was reduced from 264 to 120.

$$\%\ \textbf{reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \textbf{100}$$

$$\%\ \textbf{reduction in RPN} = \frac{\textbf{264}-\textbf{120}}{\textbf{264}} * \textbf{100} \quad = \textbf{55}\%$$

The number of RIPs and countermeasures listed in Tables 5-10 to 5-12 are few due to difficulty encountered finding them. Therefore, the author could not make iterations. Overall solution alternatives can be varied, considering the different number of problems to address. This example addresses only two of the identified problems, lessons learned, and resource allocation, whereas there are 14 problem areas with a diagnostic score of 2 or less, and 15 problem areas with a diagnostic score between 2 and 3.

Next is an improvement in resource allocation. FMEA analysis will be conducted clicking the "Company Resource Allocation" button on Figure 5.11, which brings up the screen in Figure 5.24.

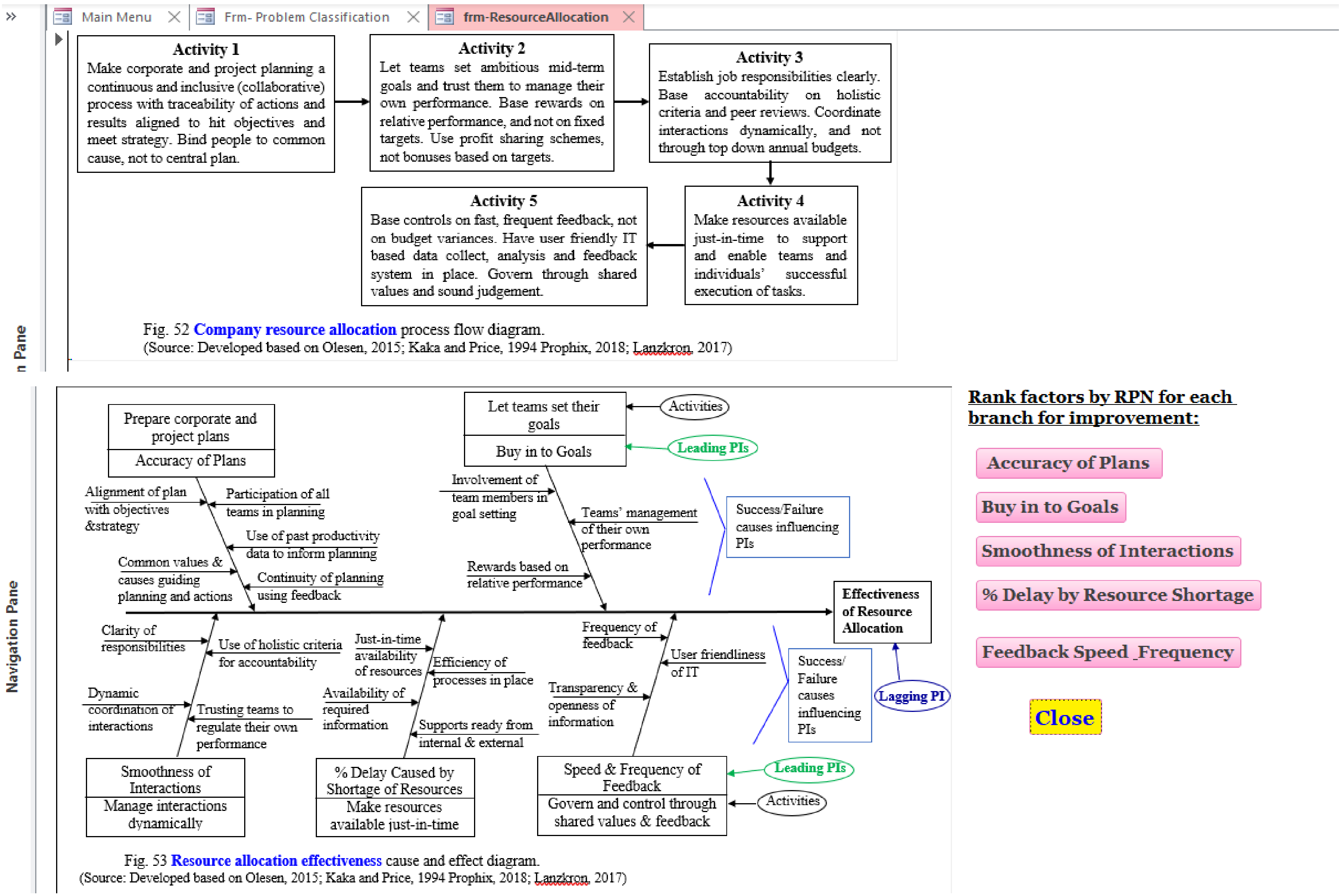

Figure 5.24 Process flow diagram for company resource allocation and the corresponding fishbone diagram

FMEA tables for the five branches are given in Tables 5-16 to 5-20.

Table 5-16 FMEA computation for "accuracy of corporate plan" leading indicator

Item ID	**Factors affecting accuracy of corporate plans**	**Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**
1	Alignment of plan with objectives and strategy	4	6	3	72
2	Participation of all teams in planning	8	7	1	56
3	Use of past productivity data to inform planning	3	6	2	36
4	Common values & causes guiding planning and actions	8	4	2	64
5	Continuous improvement of planning using feedback	7	5	3	105
				Total RPN =	**333**

Table 5-17 FMEA computation for "buy into goals" leading indicator

Item ID	**Factors affecting setting and buy into goals**	**Occurrence**	**Severity**	**Detectability**	**Risk Priority Number (RPN)**
1	Involvement of team members in goal setting	8	7	1	56
2	Teams' management of their own performance	7	3	2	42
3	Rewards based on relative performance	6	3	2	36
				Total RPN =	**134**

Table 5-18 FMEA calculation for "smoothness of interactions" leading indicator

Item ID	Factors affecting smoothness of interactions	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Clarity of responsibilities	4	6	3	72
2	Use of holistic criteria for accountability	4	4	3	48
3	Dynamic coordination of interactions	6	3	5	90
4	Trusting teams to regulate their own performance	6	5	2	60
				Total RPN =	**270**

Table 5-19 FMEA calculation for "resource shortage caused delays" leading indicator

Item ID	Factors affecting resource shortage caused delays	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Just in time availability of resources	7	7	4	196
2	Efficiency of processes in place	4	5	3	60
3	Availability of required information	3	6	3	54
4	Supports ready from internal and external	7	6	5	210
				Total RPN =	**520**

Table 5-20 FMEA calculation for "speed and frequency of feedback" leading indicator

Item ID	Factors affecting speed and frequency of feedback	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Frequency of feedback	6	6	3	108
2	User friendliness of IT	6	4	2	48
3	Transparency & openness of information	6	4	2	48
				Total RPN =	**204**

All the RPN values are relatively high. All factors may be improved by first getting root causes of failure of the factors from the database and then getting RIPs that would eliminate the root causes of failure from the database.

Table 5-21 Failure root causes and selected RIPs, counter measures and BPs for "accuracy of corporate plans" leading indicator

Factor	**Root cause of failure in factor**	**RIPs and BPs for improvement (that eliminate the root causes)**
Alignment of plan with objectives and strategy	Weak link of plan to objectives and strategy	As you continuously and collaboratively plan and schedule, make sure to anchor all plans on strategic objectives and critical success factors of the company.
Participation of all teams in planning	Top down plans or annual budgets	Let each team develop its own ambitious mid-term goals and manage their own performance. Use common cause and values to help people incorporate work as part of their purpose in life.
Use of past productivity data to inform planning	Unrealistic numbers or outdated information used in planning and resource allocation.	Use past productivity data adjusted for current contextual factors in planning and resource allocation.
Common values & causes guiding planning and actions	Contracts and targets used to guide plans and actions.	Govern through shared values and common causes.
Continuous improvement of planning using feedback	Static top down plans or annual budgets	Use continuous and dynamic planning based on feedback.

Table 5-22 Failure root causes and selected RIPs, counter measures and BPs for "buy into goals" leading indicator

Factor	**Root cause of failure in factor**	**RIPs and BPs for improvement (that eliminate the root causes)**
Involvement of team members in goal setting	Top down plans or annual budgets prepared by top management. Lack of expertise in team engagement in goal setting.	Involve each team member in preparing plans and goal setting of his/her job.
Teams' management of their own performance	Focus and practice of supervisors' management of teams' performance.	Profit sharing schemes motivate teams and employees to put in all effort and creativity for higher productivity. Teams are best if they manage their own performance and peer review.
Rewards based on relative performance	Rewards based on targets, which are based on inaccurate data.	Use relative performance based on actual current data that can be adjusted from time to time as to stretch teams.

Table 5-23 Failure root causes and selected RIPs, counter measures and BPs for smoothness of interactions leading indicator

Factor	**Root cause of failure in factor**	**RIPs and BPs for improvement (that eliminate the root causes)**
Clarity of responsibilities	Vaguely communicated responsibilities.	Make responsibilities and expectations crystal clear to every employee and every team.
Use of holistic criteria for accountability	Using partial and unstructured criteria that confuses people.	Use holistic criteria if you want employees to perform holistically.
Dynamic coordination of interactions	Expecting static type interactions.	Use just in time coordination of interactions in real time.
Trusting teams to regulate their own performance	Supervisors' management of teams' performance.	Trusting people is the best way to give them autonomy, and often people are trust worthy unless you have reasons not to.

Table 5-24 Failure root causes and selected RIPs, counter measures and BPs for "resource caused delays" leading indicator

Factor	**Root cause of failure in factor**	**RIPs and BPs for improvement (that eliminate the root causes)**
Just in time availability of resources	Uncertainty in planning and holding inventory of resources to cater for the uncertainty.	Use detailed plan to help make reources available at the time they are needed with minimal inventory.
Efficiency of processes in place	Poor processes.	Resources include processes used to execute tasks, and improve processes for efficiency continuously.
Availability of required information	Incomplete or deficient information.	Make all the required information supporting tasks available.
Supports ready from internal and external	Some supports missing from plan.	Check things repeatedly to make sure everything needed is ready to accomplish tasks without any problem.

Table 5-25 Failure root causes and selected RIPs, counter measures and BPs for "speed and frequency of feedback" leading indicator

Factor	**Root cause of failure in factor**	**RIPs and BPs for improvement (that eliminate the root causes)**
Frequency of feedback	Less frequent feedback.	Provide frequent feedback that helps adjustment of performance.
User friendliness of IT	Not so easy to use IT	Use user friendly IT for data collection, analysis and feedback.
Transparency & openness of information	Secrecy of information.	Make information transparent and open as employees are the owners of the company and processes so they make better decisions.

The RPN calculations after application of these RIPs are given in Tables 5-26 to 5-30.

Table 5-26 RPN values after application of RIPs given in Table 5-21

Item ID	Factors affecting accuracy of corporate plans	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Alignment of plan with objectives and strategy	0	6	3	0
2	Participation of all teams in planning	4	7	1	28
3	Use of past productivity data to inform planning	0	6	2	0
4	Common values & causes guiding planning and actions	3	4	2	24
5	Continuous improvement of planning using feedback	2	5	3	30
				Total RPN =	**82**

RPN is reduced from 333 to 82 through the improvement.

$$\%\ \textbf{reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100}$$

$$\%\ \textbf{reduction in RPN} = \frac{\mathbf{333-82}}{\mathbf{333}} * \mathbf{100} \quad = \mathbf{75}\%$$

Table 5-27 RPN values after application of RIPs and counter measures given in Table 5-22

Item ID	Factors affecting setting and buy into goals	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Involvement of team members in goal setting	0	7	1	0
2	Teams' management of their own performance	0	3	2	0
3	Rewards based on relative performance	0	3	2	0
				Total RPN =	**0**

RPN is reduced from 134 to 0 through the improvement, a 100% reduction in RPN.

Table 5-28 RPN values after application of RIPs given in Table 5-23

Item ID	Factors affecting smoothness of interactions	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Clarity of responsibilities	0	6	3	0
2	Use of holistic criteria for accountability	2	4	3	24
3	Dynamic coordination of interactions	2	3	5	30
4	Trusting teams to regulate their own performance	2	5	2	20
				Total RPN =	**74**

RPN is reduced from 270 to 74 through the improvement.

$$\% \textbf{ age reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100}$$

$$\% \textbf{ age reduction in RPN} = \frac{\mathbf{270-74}}{\mathbf{270}} * \mathbf{100} \quad = \mathbf{72}\%$$

Table 5-29 RPN values after application of RIPs given in Table 5-24

Item ID	Factors affecting resource shortage caused delays	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Just in time availability of resources	3	7	4	84
2	Efficiency of processes in place	2	5	3	30
3	Availability of required information	0	6	3	0
4	Supports ready from internal and external	3	6	5	90
				Total RPN=	**204**

RPN is reduced from 520 to 204 through the improvement.

$$\% \textbf{ reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \mathbf{100}$$

$$\% \textbf{ reduction in RPN} = \frac{\mathbf{520-204}}{\mathbf{520}} * \mathbf{100} \quad = \mathbf{61}\%$$

Table 5-30 RPN values after application of RIPs given in Table 5-25

Item ID	Factors affecting speed and frequency of feedback	Occurrence	Severity	Detectability	Risk Priority Number (RPN)
1	Frequency of feedback	0	6	3	0
2	User friendliness of IT	2	4	2	16
3	Transparency & openness of information	0	4	2	0
				Total RPN =	**16**

RPN is reduced from 204 to 16 through the improvement.

$$\% \ \textbf{reduction in RPN} = \frac{\textbf{RPN before improvement} - \textbf{RPN after Improvement}}{\textbf{RPN before improvement}} * \textbf{100}$$

$$\% \ \textbf{reduction in RPN} = \frac{\textbf{204} - \textbf{16}}{\textbf{204}} * \textbf{100} \quad = \textbf{92}\%$$

The input data for FMEA computations are logical, and the outputs checked by excel calculations in the tables given in this chapter. The root causes of failure of factors on fishbone diagrams and the corresponding RIPs and BPs from the database are also logical and make sense. Checking computations and sense-making validates the DSS part of the computer tool developed in this research.

5.4 Summary of Chapter 5

Chapter 5 discussed ways to use the diagnostic tool and DSS developed in this research and demonstrated its use through a sample highway company example. The chapter also demonstrated the internal validation of the diagnostic tool and DSS by showing three of the following four requirements: a) show that the algorithm works, b) what goes in and comes out are logical, c) the computations make sense, and d) that the tool is useful to companies implementing it. The item in d) is external validation, which was conducted in Chapter 3 by conducting the weak market test.

Chapter 6 discusses issues related to resistance to change and lack of reception by construction companies of improvement tools and strategies such as the one developed in this research. The chapter also suggests ways to overcome resistance from the extant literature.

6. OVERCOMING BARRIERS TO IMPLEMENTATION OF IMPROVEMENT INTERVENTIONS

6.1 Introduction

RIPs consist of principles extracted from lean construction, the theory of constraints, performance improvement, business model innovation, value innovation, change management and organization development, process performance measurement system and advanced work packaging, lean six sigma, improvement science, value improving practices and best practices, and breakthrough thinking.

Many authors have published barriers to the implementation of lean construction principles. Sarhan and Fox (2013) summarized the barriers to lean implementation into ten types as:

1. Fragmentation and involvement of many subcontractors
2. Procurement and contract strategy which is adversarial
3. Lack of adequate awareness and understanding of lean
4. Culture and human attitudinal issues
5. Time and commercial pressure
6. Financial issues – not allocating sufficient budget for improvement
7. Lack of top management commitment
8. Separation of design and construction
9. Educational issues
10. Lack of process-based performance measurement systems

Sarhan (2011) recommended to take the following actions to overcome barriers to implementation of lean construction principles:

Public Organizations (Governmental)

- Implementing a lean culture across the whole business and value chain
- Procurement to be based on an organization's lean initiatives along with their career profile, rather than the lowest price
- Establishing a lean construction certification scheme
- Supply-chain management

- Allocating champions of practice to provide learning opportunities to all of its members and prepare project teams for challenges they may face

Private Organizations

- Providing a formal lean training/induction matrix
- Hiring external lean consultants
- Devising internal metrics of leading parameters for evaluating performance and organizational learning
- Increasing the lean awareness/knowledge of clients through the publishing of successful lean case studies
- Creating a gain and share benefit scheme, where bonuses and incentives are based on the profitability of the production rather than the productivity rates

Graduates

- Lean principles to be added to the curriculum at universities and colleges
- Companies and organizations to provide lean induction sessions to all recent graduates

Senior Managers

- Professional institutions should only award chartered/ incorporated status to professionals and managers who could demonstrate at least a basic level of awareness and understanding of lean

The Construction Industry Institute (CII) summarized the barriers to implementation of its best practices as:

- Low familiarity of companies with best practices
- Lack of commitment of company managers to best practices
- Top management limited emphasis on training and education of best practices
- Failure to integrate new ideas and recommendations into an organization's procedures
- A limited benchmarking of costs and benefits
- Lack of innovation within the industry due to risk aversion

CII developed best practices implementation model shown in Figure 6.1 to overcome these barriers.

Figure 6.1 CII Best Practices implementation model.
(Source:https://www.construction-institute.org/resources/knowledgebase/best-practices/implementation-of-cii-research/topics/rt-166)

The other way CII tries to show the effectiveness of its best practices is by publishing success stories of companies that used its best practices.

First, an assessment will be made of impediments to implementation of improvements, which will be followed by recommendations of activities necessary for successful implementation.

6.2 Assessment of Impediments to Successful Implementation

The product of this dissertation or similar improvement interventions can be considered as being "implemented" if the target audience adopts it for use as a decision-support tool. Even though the construction companies may recognize immense potential benefits that may accrue by using the product of this dissertation, some of these companies might be reluctant to implement it for several reasons.

One of the leading causes of resistance to change is the lack of clear communication (and explanation) to people whom the change impacts, and resist change due to uncertainty and fear. So, most change agents have stressed the need for

- Lots of communication about what, why, how, when
- Having everyone understand what happens if no change occurs
- Remove barriers
- Support with training, coaching, role models, incentives

These actions work sometimes, but mostly they are not enough and do not work. The reason is that this does not address the underlying problem that all have with change, including senior management, who, as leaders, are a significant part of the problem. The following are highlighted as underlying problems of change in individuals and organizations by some authors

1. Changing beliefs and mindsets is challenging
2. People are overwhelmed by psychological demand on them from complexities of work and life in the fiercely competitive global marketplace, which requires a lot of information processing
3. Lack of genuine dialogues in organizations around the undiscussable due to organizational politics and organizational norms

The next subsections discuss each of these.

6.2.1 Changing Beliefs and Mindsets Is Very Difficult

A study on at-risk heart patients showed when doctors tell them that they will die unless they change their habits, only one in seven will be able to follow through. Desire, motivation, and urgency are not enough, even in life or death, which is very urgent. Kegan and Lahey believed there must be some valid reason. Kegan (2015) and Lahey (2017) developed a tool they called the X-ray matrix to uncover the beliefs and significant, hidden assumptions driving people's actual behavior in personal and organizational life as opposed to expected behaviors. X-ray matrix is a tool with four columns that provide a view of why the conflict exists and why it is not a simple technical fix to resolve the issue (that it is an adaptive challenge or wicked problem). In the first column of the X-ray matrix is recorded the visible commitment - improvement goal/commitment, column 2 is things that the individual or group is Doing/Not doing with regards to commitment as per the improvement goal, i.e., what are the behaviors currently in operation instead of the desired behaviors? Hidden competing commitments that work against improvement goal/official commitment, such as the person's perceived identity, go into the third column. The fourth column will record the significant assumptions underlying the hidden commitments that guide behavior and actions. One of the many examples to which an x-ray matrix was applied that they presented in conferences is a 58-year-old heart patient. The man did not follow the advice of his doctor to take his prescriptions daily. They discovered that the man worries that himself will feel like a sick older man with one foot in the grave if he takes his medications daily, whereas the man believes to be in his prime years when he needs to enjoy life. He also said that he would be reminded of his mortality daily if he takes his medications, which takes the fun out of life. In a way, he is self-protecting from threats of the image he dreads. These significant assumptions are the lens with which he sees the world, and he is sure about them. He equates certainty with correctness, which he perceives as reality. The change comes if others shed light on his significant assumptions and help him see the distortions of what he perceives as reality and correct. He will not change unless people help him take off his lens. There can be millions of significant assumptions people hold that guide their actions, but people have commonalities, and things that activate responses to threats fall into a few categories. David Rock's SCARF model classifies them into five as:

Status – where one feels his/her position is in the pecking order

Certainty – one's perception of how well he/she can predict the future

Autonomy – how much one feels he/she has choices and feels he/she can make choices

Relatedness – how safe does one feel with other people (trust or mistrust)

Fairness – one's perception of how fairly other people are treating him/her

Our individual beliefs, along with the collective mindsets in organizations, combine to create a potent immunity to change.

6.2.2 People are Overwhelmed by Psychological Demand on Them from Complexities of Work and Life in The Information Work of Companies of The Fiercely Competitive Global Marketplace

Kegan and Lahey (2009) say that people are overwhelmed by psychological demand on them from complexities of work and life in the information age in the fiercely competitive global marketplace. They introduced the idea of 3 levels of mental complexity

Level 3 – socialized mind – team player, follower, reliant

Level 4 – self-authoring mind – agenda driving, leader, problem-solving, independent

Level 5 is a self-transforming mind – meta-leader, multi-frame, and can hold contradictions, problem finding, and interdependent.

Kegan and Lahey (2009) showed the following statistics hold

Level 5 < 1%

Between levels 4 and 5 <10%

Between Levels 3 and 4: 30 – 40%

Level 3 or less: 40 – 50%

This statistic confirms the dysfunctional behavior seen in many organizations. People at level 3 can do most things, but making difficult decisions is harder for them. Most people rarely get past level 3 as the statistic shows or only just begun to travel to the next level of mind order. The low level of mental complexity of the majority of people explains why they have problems coping with the complex world in which they live.

6.2.3 Lack of genuine dialogues in organizations around the undiscussables due to organizational politics and organizational norms

Argyris (2000) pointed out that in most organizations, the espoused theory of action and implemented theory are different. We fail to recognize the two are different, or if we do recognize it, then we blame other people or circumstances for our failure to use the espoused theory. Actual practice is geared towards coverups and camouflages, which naturally will be full of inconsistencies that create confusion. Companies are content to leave these issues as non-discussable and be unwilling to discuss the fact that they are non-discussable. They get accepted as the way things are.

The organization system revolves around what Argyris calls Model I (Argyris, 1977), which means that little learning occurs, and that people do not change their behavior but continue to believe that they are correct and there is no need to change or question their assumptions or reasons (Argyris, 1977). There is no inquiry; the status quo is okay. Model I is a theory of action that is mostly used in organizations by most people. It is based on some inherent beliefs, such as maximizing winning and minimizing losing, minimizing negative feelings, and being rational rather than emotional. It allows for minimal testing of theories or assumptions. It is self-referential (I am right, and if you see it my way, you will understand) and self-sealing (do not believe the problem can be solved, and so people seek to cover it up), resulting in a single loop learning. Model II seeks to be minimally defensive and action learning-oriented, trying to understand our emotions and how they influence our actions. Argyris (1977) developed a tool he called the left column and right column analysis. It involves testing out theories publicly, providing evidence, and double-loop learning. Model II asks why we act the way we do, try to understand why we cover up the non-discussable, and bring this out into the open to see if we can operate differently, be more open about our feelings, and learn and change. He notes that in the culture of many organizations, there are non-discussable issues, which we skirt around and do not rock the boat, which means the organization does not learn.

The change from the dominant Model I system to Model II requires both effort and time on the part of management, as people will tend to drift back to what they are comfortable doing. Being aware of the problem is not sufficient to cause a change of behavior as this is an adaptive problem that requires an understanding of people's significant assumptions that drive their actions, and helping people take off their lenses (that gives them a distorted image of reality).

In addition to the resistance to change in general in companies, the following specific barriers may hold construction companies back from using the tool developed in this research and similar improvement tools.

- Inadequate knowledge base.
- Unwillingness to spend time and money to adopt a new tool in a time of fiscal austerity, even though it can produce a long-term gain.
- Conflict between implementation requirements and other policies. There is a risk in adopting a new decision-support tool that the short-term results or other non-financial outcomes coming from that tool might suggest the need for changes in policy or work practices that the company may be unwilling or unable to pursue.

6.3 Activities Necessary for Successful Implementation

For companies seeking to adopt the dissertation's two-part profitability excellence model and DSS, the activities they need to carry out to ensure successful implementation include:

(a)Activities by the Different Stakeholders:

- To use Kegan and Lahey's X-ray matrix (2009) to uncover contradictions and significant, hidden assumptions driving people's behavior that works against improvement interventions. To use Argyris (1977), Model II double-loop learning, where people use openness and feedback in improvement interventions. It is essential to treat improvement interventions as adaptive problems where people's behavioral change and change in mindset are the goals.

- To work on the client. Improvements benefit the client most, and the client can require specific methods and practices by inserting some contract clauses. For this, universities better focus on big clients like Departments of Transportation, Energy, Waterworks to educate them about the need for implementation of these improvement principles and best practices. Then clients' capacity needs to be built because the clients' engineers should be well versed in these principles to write and administer such contracts.
- The government can and should play a role as it did in safety implementation. Heavy industry, (driven largely by plant insurance costs, physical disruption and loss of life associated with industrial construction accidents in operating plants undergoing maintenance or shut down turnaround projects), performed root cause analysis, asking the difficult multi-layered "why" questions, innovated, and demonstrated highly improved construction safety was not only feasible, but economical when all the costs were considered. Once feasibility was proven, and with the balance of industry failing to police itself effectively, the heavy hand of government broadened the demonstrated feasibility into enhanced minimum expectations required by law. There is some concern that government is not implementing the rules well, largely because they are notoriously underfunded, but the net result is that there has been significant positive impact on safety in most sectors.
- government may play a role as it did in safety implementation. Different Governments issued safety rules, and clients and contractors who do not comply levied with a hefty penalty. There is some concern that government is not implementing the rules well, but the net is that there is some positive impact on safety. Researchers can forward something similar, which governments can implement through policy instruments. Another result that helped is that contractors with poor safety records are asked high prices for coverage by insurance companies.
- The other best way is to support those very few companies that are willing to implement it to win most of the available jobs. It is advantageous to have few big companies with significant market share for the technologies to diffuse into the industry (currently, too many companies with small market share, all fragile). The rest will wake up when their survival is in question. Nothing else can wake up construction companies out of complacency.

- Construction agencies such as the Ministry of Construction in the UK and equivalent organizations in other countries have a significant role to play by charting the way and setting goals or targets for the construction industry. A good example is the Latham Report (Constructing Excellence -1993), the Egan Report (Rethinking Construction-1998) in the UK construction industry. The government can incentivize to encourage companies to meet the targets.
- A well-designed modular implementation plan using appropriate technology transfer tools and techniques to ensure a clear understanding of the use and benefits of the study product for companies willing to implement. This may consist of phases of implementation and evaluation, and supporting the implementation with trainings, revision of manuals and procedures for the new way of doing things resulting from the implementation.
- Learning from the experiences of others who have tried to do the same or similar thing that this dissertation has forwarded.

(b) Suggested Ownership of Improvements by Research Institutions

It is sustainable if an institution champions the improvement than by an individual. Pilot applications of the two-part excellence model and DSS in companies willing to use the model and the DSS serves as a demonstration of its efficacy. Companies that adopt the two-part excellence model and DSS can know where to go if they need to train workers or to customize the tool later.

(c) Continuous Feedback

A plan needs to be in place with a person assigned responsibility to follow up and collect continuous feedback from early adopters of the two-part excellence model and DSS in order to judge the progress and consequences of implementation.

6.4 Identification of Possible Leaders in Application of the Product of the Dissertation.

The successful implementation of any research product depends on the proper identification of specific companies that have recognized the problem and actively search for a solution, who can serve as champions of the improvement. Publishing these companies' success stories and their progress will demonstrate the efficacy of the models/tools and the improvements that can be attained using the models/tools

7. SUMMARY AND CONCLUSIONS

7.1 Summary of Dissertation

The main objectives the author set out to attain in this dissertation were to partially fill the identified knowledge gap regarding the profitability improvement of construction companies, and to develop a strategic tool that construction companies can use to improve and manage their profitability. Accordingly, this dissertation has the following two significant outcomes:

1. Development of a two-part profitability improvement excellence model for construction companies that would partially fill the identified knowledge gap. The internal and external challenges construction companies face that resulted in a razor-thin and unreliable profit, shrinking profit margins and low profitability can be overcome by
    a. Applying the strategies laid out in the strategies-actions model in their business decisions to guide their operating and tactical decisions
    b. Using continuous improvement through iterative and recursive application of continuous improvement to predictably advance the company from lower maturity and performance levels to level 5.
2. Development of a diagnostic tool and Decision Support System (DSS). The diagnostic tool helps diagnose and detect/identify problem areas that need in-depth analysis to identify the problems/gaps. Once the problems are identified by in-depth analysis, the DSS helps carry out root cause analysis mainly using fishbone diagrams for which all influencing factors of success and failure are shown on the branches, which are root causes at the same time. Root cause analysis continues by getting root causes for failures of the influencing factors on the branches of fishbone diagrams from the DSS database. Retrieval of the root causes from the database is followed by retrieval of RIPs, countermeasures, and BPs from the database of the DSS that eliminate failure root causes of the specific factors. The solutions are composed of the RIPs, countermeasures, and BPs to help apply them to resolve performance issues in an integrated way. Such an improvement overcomes the limitations with the current practice of companies using only one or two RIPs and BPs in their improvement efforts. Conducting improvement using a team is recommended where each team member uses the diagnostic tool and DSS at each stage, and a consensus is reached

between members of a team at each stage i.e., at diagnosis, root cause analysis, and improvement. Using team increases chance of success of improvement interventions by enabling to harness a broad set of expertise and experience to get creative solutions, and by reducing resistance to implementation as the different parts of the company represented by their team members will own the change.

In summary, the two-part excellence model, diagnostic tool, and DSS can be used to manage and continuously improve construction companies' profitability. The DSS helps carry out more effective root cause analysis and extraction, integration, and application of RIPs, countermeasures, and BPs ensuring predictability of profitability improvement and management.

7.2 Contributions of Dissertation

The main contribution of the dissertation is that it argues continuous improvement need to be applied to overcome the internal and external challenges construction companies face by diagnosing to identify problem areas and applying RIPs and BPs to resolve problems and bottlenecks. Towards this end, this thesis forwards a two-part excellence model for profitability improvement of construction companies (Part 1- strategies and corresponding profitability improvement operating decisions and Part 2 - the proposed model and flowchart for application of continuous improvement) and implements it in a strategic diagnostic tool and DSS as a proof of concept. The research uses data and information gathered from an extensive literature review in the development of both the excellence model and diagnostic tool and DSS.

In the development of the two-part profitability improvement excellence model, the high impact principles, concepts, and guidelines from the literature are used to iteratively develop strategies that would help overcome the challenges construction companies face. The literature consists of organizational effectiveness, critical success factors, business process improvement, and process maturity models, strategic company profitability growth enablers, organizational excellence guidelines, and performance improvement guidelines. The excellence model also provides a useful tool for the recursive and iterative application of continuous improvement to continuously improve profitability. The two-part excellence model is a strategic novel construct, i.e., by providing specific strategies that can guide construction company operating decisions to help overcome the challenges and helping continuously improve profitability through continuous improvement and FMEA tools.

The strategic diagnostic tool and DSS developed based on the two-part excellence model is unique in the following three attributes:

1. It uses process flow diagrams that guide companies and provides information that helps companies map their processes. The purpose is to help companies design their processes in a continuous flow that can drastically improve their productivity and profitability.
2. It uses fishbone diagrams for most areas of improvement intervention. Using fishbone diagrams has several benefits for profitability improvement of companies:
    a. It establishes a link between influential factors, leading performance indicators, and lagging performance indicators influencing company profitability, thus enabling proactive improvement and management of profitability.
    b. It helps root cause analysis by giving all possible influencing factors of success and failure, so managers and improvement teams can proactively avoid failures (minimizing risks) and ensure success.
    c. Using fishbone diagram with RPN, leading and lagging performance indicators provides a quantitative way (but the indirect way) to measure performance that helps drive improvement. The use of such quantitative performance measurement to drive continuous improvement brings company and teams into achievement mindset and culture.
3. It helps integration and use of RIPs, countermeasures, and BPs to provide a solution to performance problems detracting companies from achieving higher profitability and hence helps significantly improve the profitability of construction companies.

7.3 Conclusions

The following conclusions can be drawn about the two-part excellence model, and the diagnostic tool and DSS developed in this research:

1. The two-part excellence model is a strategic novel construct that specifies strategies that can guide construction company operating decisions to focus on high impact factors and profit drivers. The excellence model also gives a step by step flowchart that companies can follow to help overcome the challenges and helping continuously improve profitability

through continuous improvement tool. The two-part excellence model, if used, increases the likely hood of significant profitability improvement.

2. The diagnostic tool and DSS helps conduct profitability improvement by supporting effective decision- making
3. The diagnostic tool and DSS help to integrate and apply RIPs, countermeasures, and BPs, hence helping to overcome the current problem of applying one or two RIPs and BPs or no application at all.
4. The diagnostic tool and DSS helps to manage profitability predictably, overcoming the problem of unreliability of profit of construction companies.

7.4 Broader Impact

Profitability improvement requires improvement of each department, unit, and team in a construction company and its projects; hence, the two-part excellence model and the DSS developed in this research can serve as a company and project management tool. The process flow and fishbone diagrams developed for the DSS are so comprehensive and exhaustive as to serve as a strategic company and project management tools.

The focus of the study in this dissertation is on the highway and civil construction companies. The two-part excellence model is generic and can be used to manage any project-based company: commercial, institutional, IT projects-based, manufacturing projects. The diagnostic tool and DSS can also be used to manage any project-based company except the project productivity part of the DSS, which specifically applies only to highway and infrastructure projects.

The DSS uses leading indicators to get feedback that proactively helps manage and control projects and company performance. Further, the DSS requires granular activity level management, work package level management, bottom-up approach, and continuous planning/scheduling, which is more accurate and useful.

The two-part excellence model and the DSS are excellent supplements in undergraduate and graduate-level lean construction, company and project process improvement, and construction innovation courses in that the DSS is interactive and helps explore different possibilities.

7.5 Limits and Future Research

Lindholm (2008) modified a previously developed model that helps evaluate value-added by corporate facilities management to a company and collected data on the measures in the model. He reported some tangible benefits gained by using the modified model in the case company, and he recommended that data be collected on benefits some years after implementation. Testing of the pragmatic adequacy of a construct takes time and requires several attempts of application. Weak market test is only indicative of the usefulness of model or tool. Data may be collected from case applications of model and tool one, two, three years after application to fully validate the products. The author suggests the two-part excellence model be applied to a case company or companies after baseline data is collected on the current state of affairs, and then data collected on the same parameters 1-3 years after the implementation of the excellence model and DSS. Such a comparison of performance parameters before and after implementation helps measure the impact of the model and helps collect feedback that would help improve the two-part excellence model.

The other limitation pertains to assignment of values to score, weight, frequency of occurrence, detectability and severity in conducting diagnosis and improvement using the diagnostic tool and DSS. The assignment has got some subjectivity.

The original plan for this thesis was to carry out survey of performance measurement systems and KPIs used by construction companies in the U. S. and Ethiopia. The gap in performance was expected to be measured in terms of the difference between target values of KPIs and actual values of KPIs. Sampled companies in the U. S. contacted were not willing to fill the questionnaire, probably because the information is sensitive and proprietary. Companies in Ethiopia filled the questionnaire, and 19 responses were received. The data summary shows that there is not such a performance measurement system used by the construction companies, and there is no understanding of Critical Success Factors. The absence of KPIs in companies forced the author to modify the research plan to use a reduction in Risk Priority Number to measure the improvement achieved through interventions instead of using KPIs. A performance measurement system is necessary to drive improvement efforts. Future research may look into the development of a performance measurement system based on Critical Success Factors.

This research touched upon value innovation and its benefits for construction companies in the literature review. The significance of value innovation in driving performance improvement and its effectiveness in achieving sustainable, dynamic competitive advantage warrants the development of value curves for different sectors of the construction business through future research.

Figure 2.18 shows that performance gain as a function of continuous improvement follows a lazy s-curve reaching a plateau after level 4. In the literature, it is recommended to begin the next cycle of continuous improvement once the plateau is reached (Lahy and Found, 2015). Further research may be conducted to look into the first continuous improvement cycle being applied to short-term interventions, and the next cycle of continuous improvement cycle after the plateau be applied to long-term interventions, thus enabling strategic planning for the company undergoing the improvement.

The diagnostic tool and DSS developed in this research can be improved in future research by incorporating an expert system using a knowledge base with artificial intelligence to improve its performance and effectiveness.

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APPENDIX A CONSTRUCTION COMPANY AND PROJECT PROCESS FLOW AND FISHBONE (CAUSE AND EFFECT) DIAGRAMS

The process flow diagrams and fishbone (cause and effect) diagrams used in the Decision Support System (DSS) are given in this appendix. Figure A.1 gives the list of items on the right most end of the branches (circled by oval) for which process diagrams and fishbone diagrams are drawn. Process and/or fishbone diagrams are drawn for all except for strategic planning under company branch, and interactions.

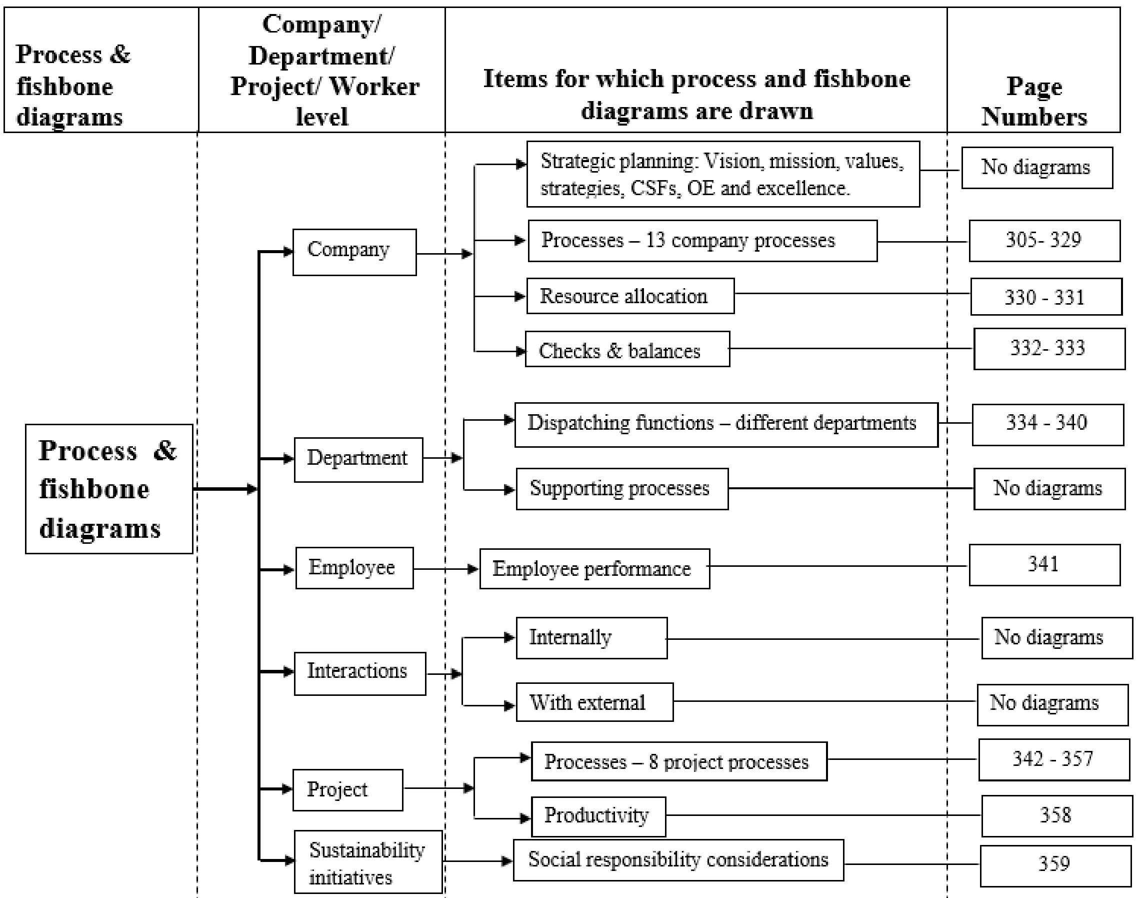


Figure A.1 **List of items** for which process diagrams and fishbone diagrams are drawn

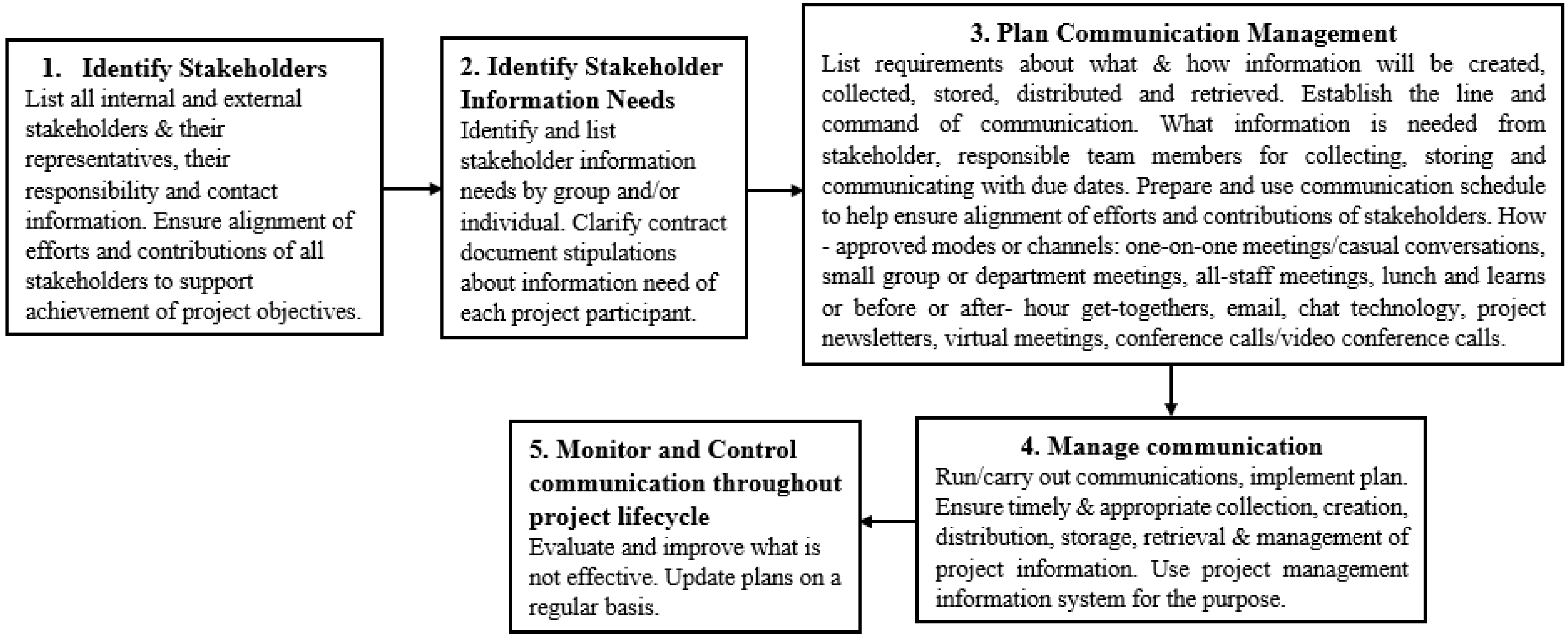


Figure A.1 **Communication management process** flow diagram (Source: Developed based on PMI (PMBOK), 2017)

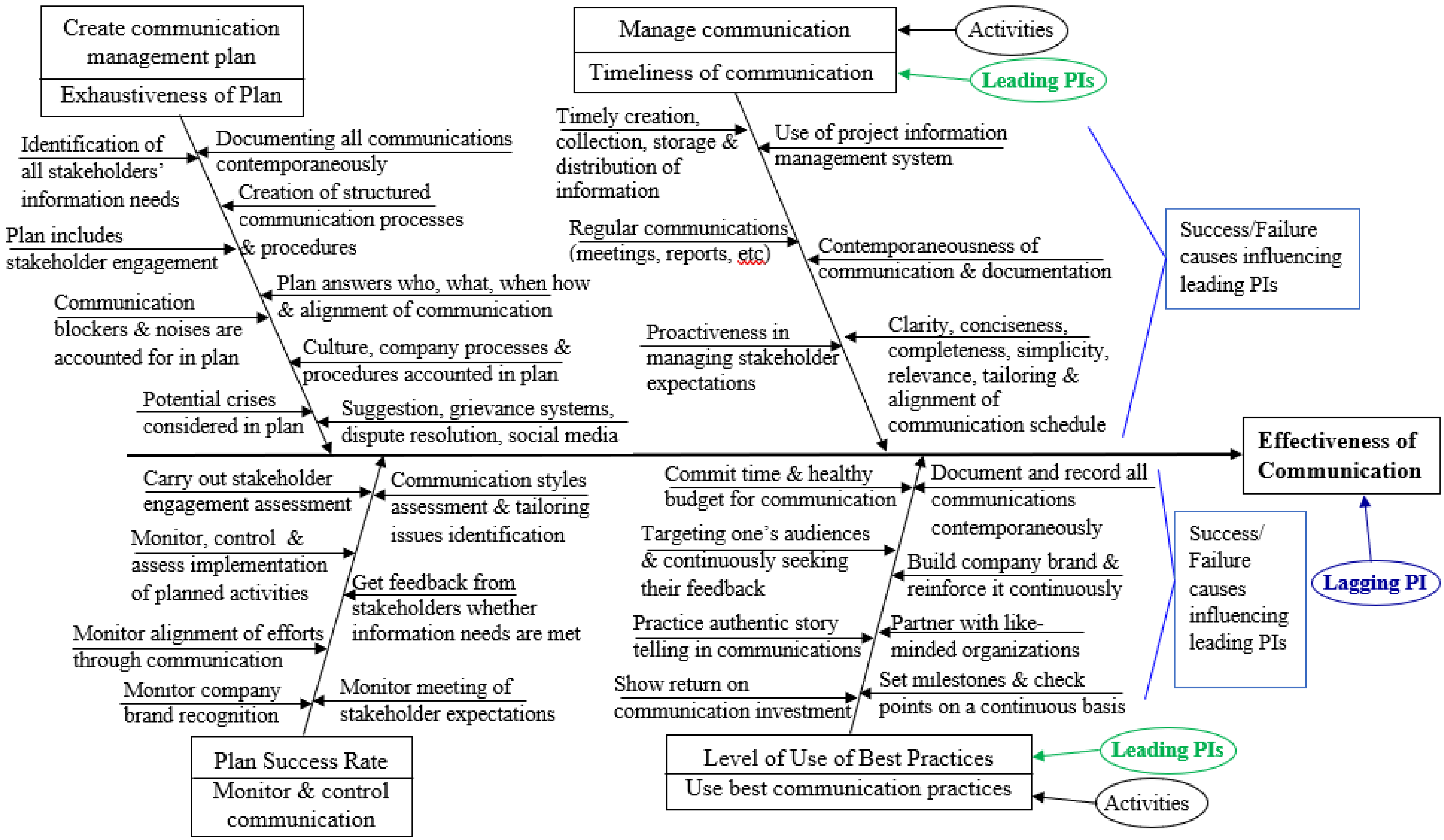


Figure A.2 **Effectiveness of communication management process** cause and effect diagram (Source: Developed based on PMI (PMBOK), 2017)

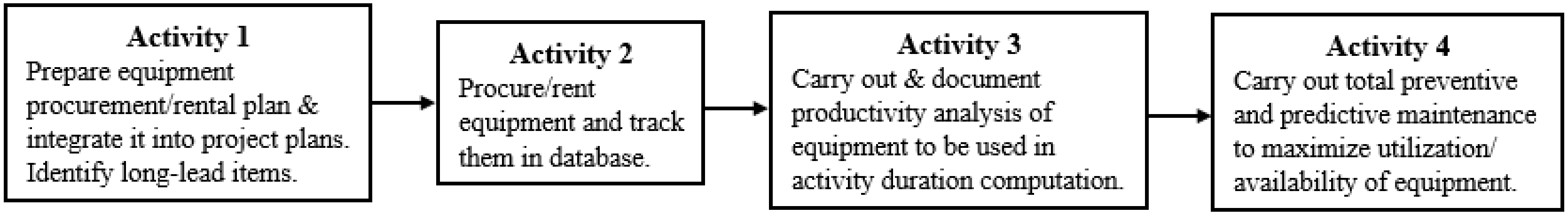


Figure A.3 **Equipment management process** flow diagram.(Source: Developed based on Nasir, 2013)

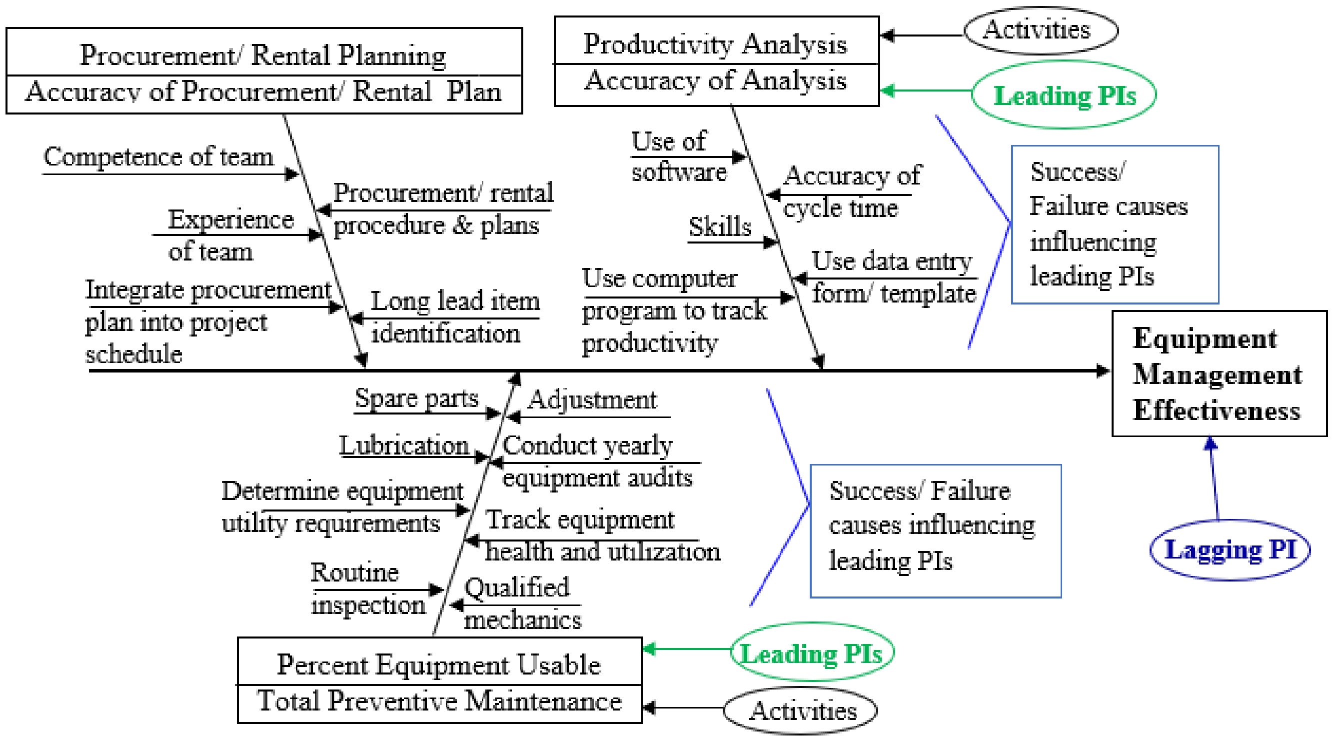


Figure A.4 **Equipment management process** cause and effect diagram. (Source: Developed based on Nasir, 2013)

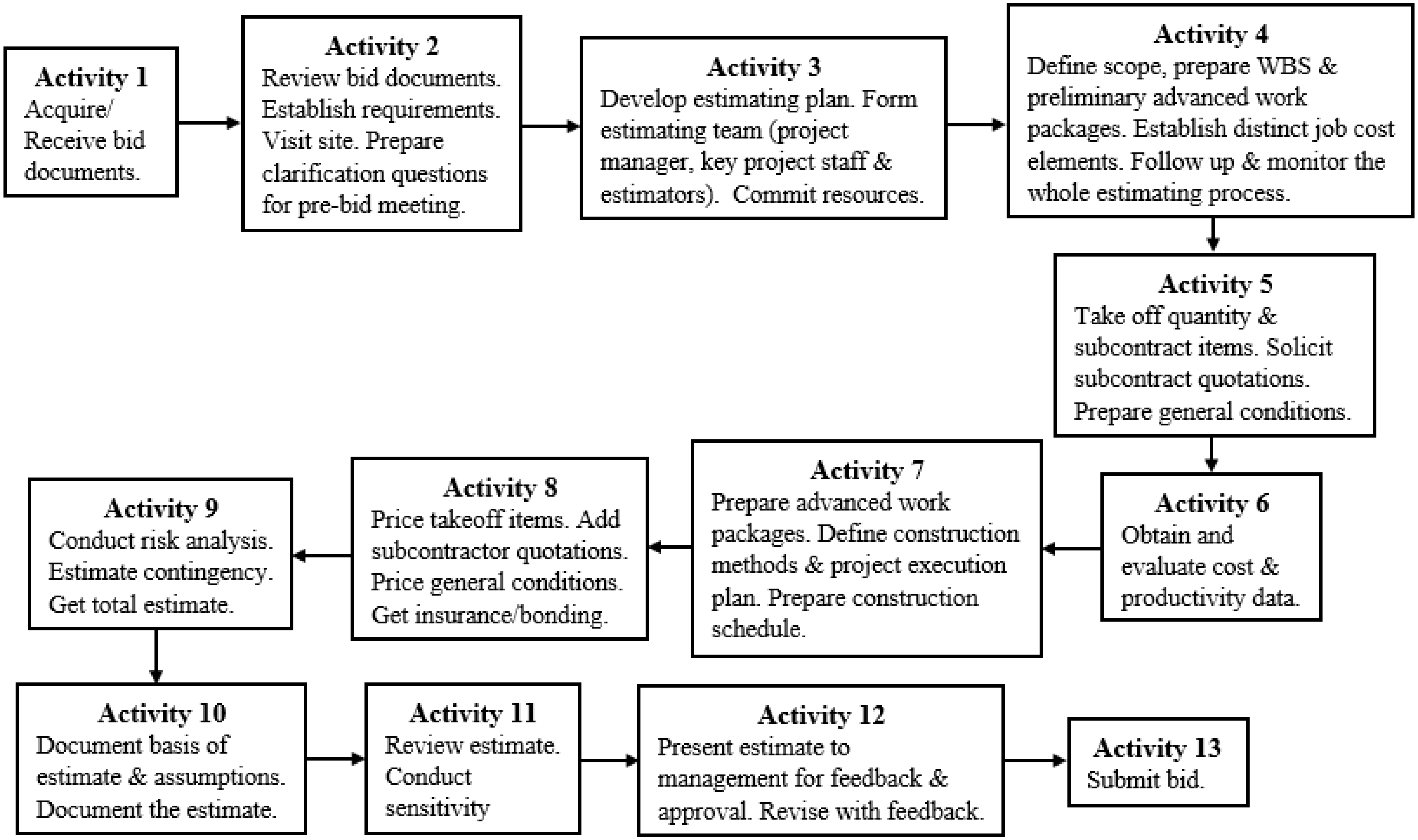


Figure A.5 **Construction estimating process** flow diagram (Source: Developed based on Rios et al., 2006; Hendrickson, 2003; McGuire, 2006)

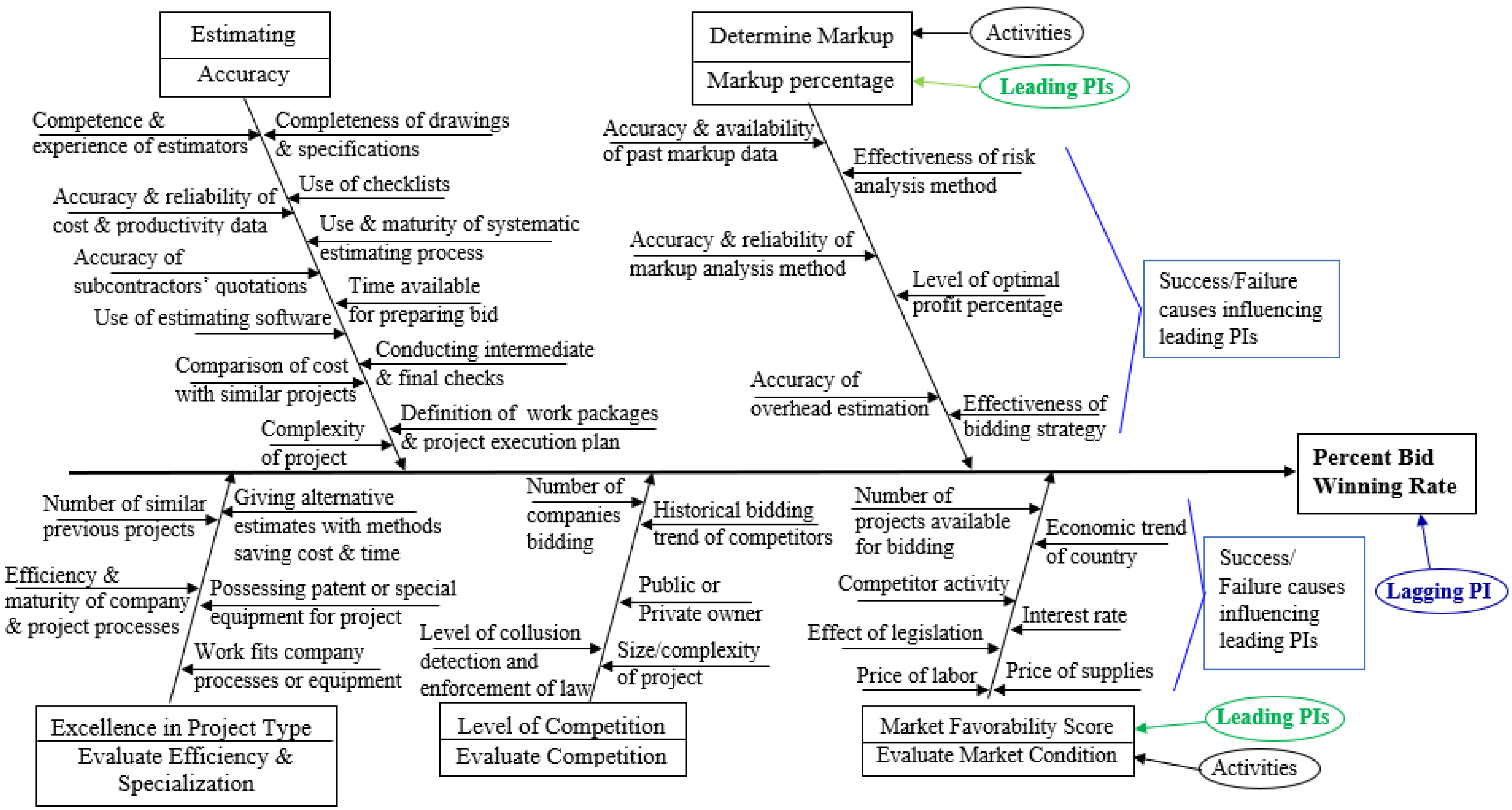


Figure A.6 **Estimating process** bid win rate cause and effect diagram (Source: Developed based on Rios et al., 2006; Hendrickson, 2003; McGuire, 2006)

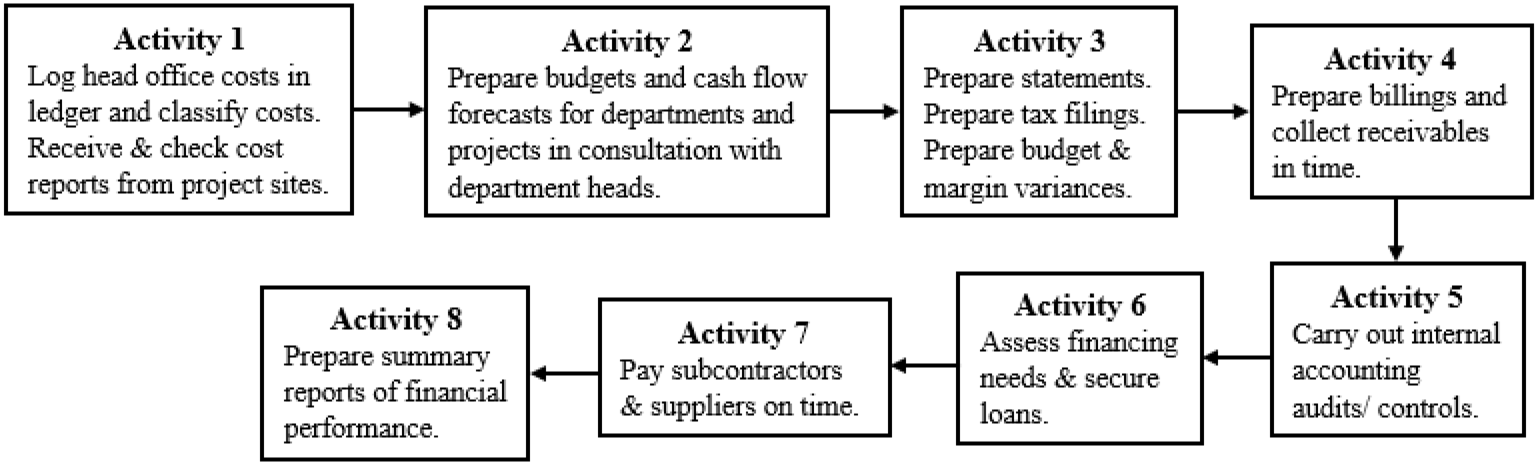
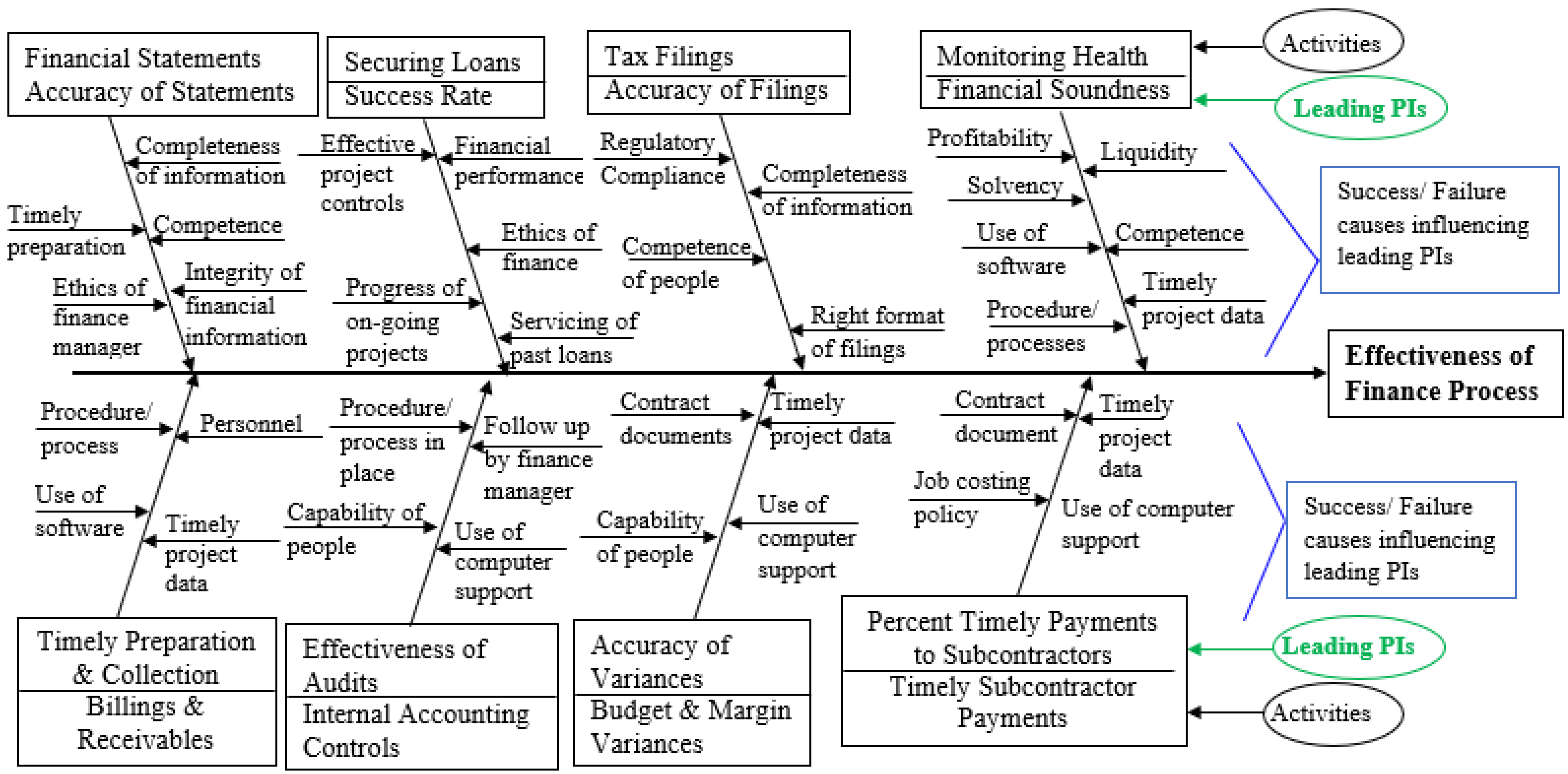


Figure A.7 **Finance management process** flow diagram.(Source: Developed based on Brignall, 2007)



A.8 **Finance management process** cause and effect diagram.(Source: Developed based on Brignall, 2007)

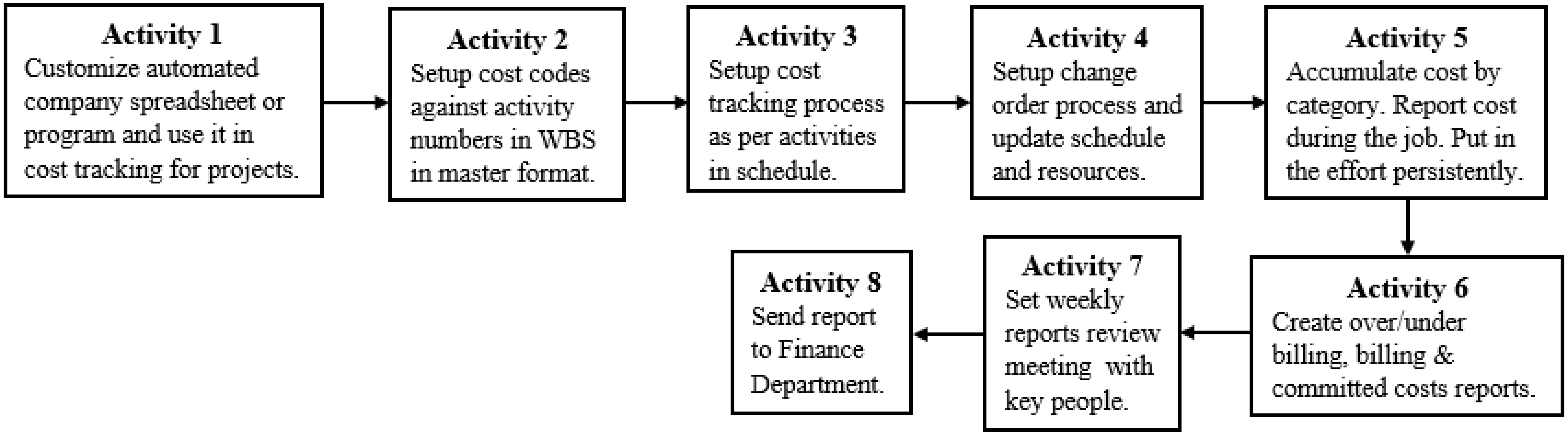


Figure A.9 **Job cost tracking and reporting process** flow diagram (Source: Developed based on Fayek, 2001 and https://ryvit.com/blog/job-costing-best-practices).

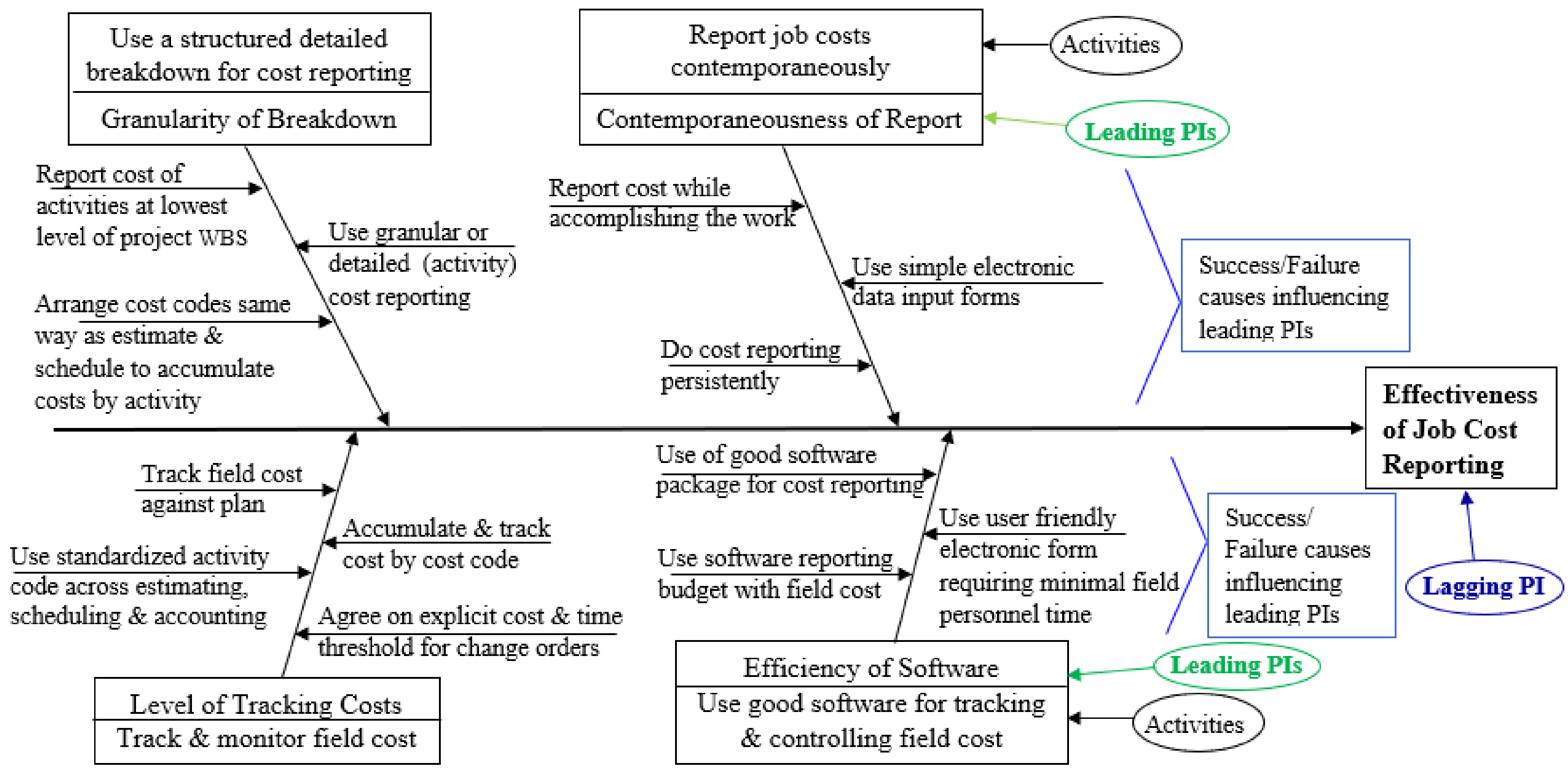


Figure A.10 **Effectiveness of job costing process** cause and effect diagram (Source: Developed based on Fayek, 2001 and https://ryvit.com/blog/job-costing-best-practices).

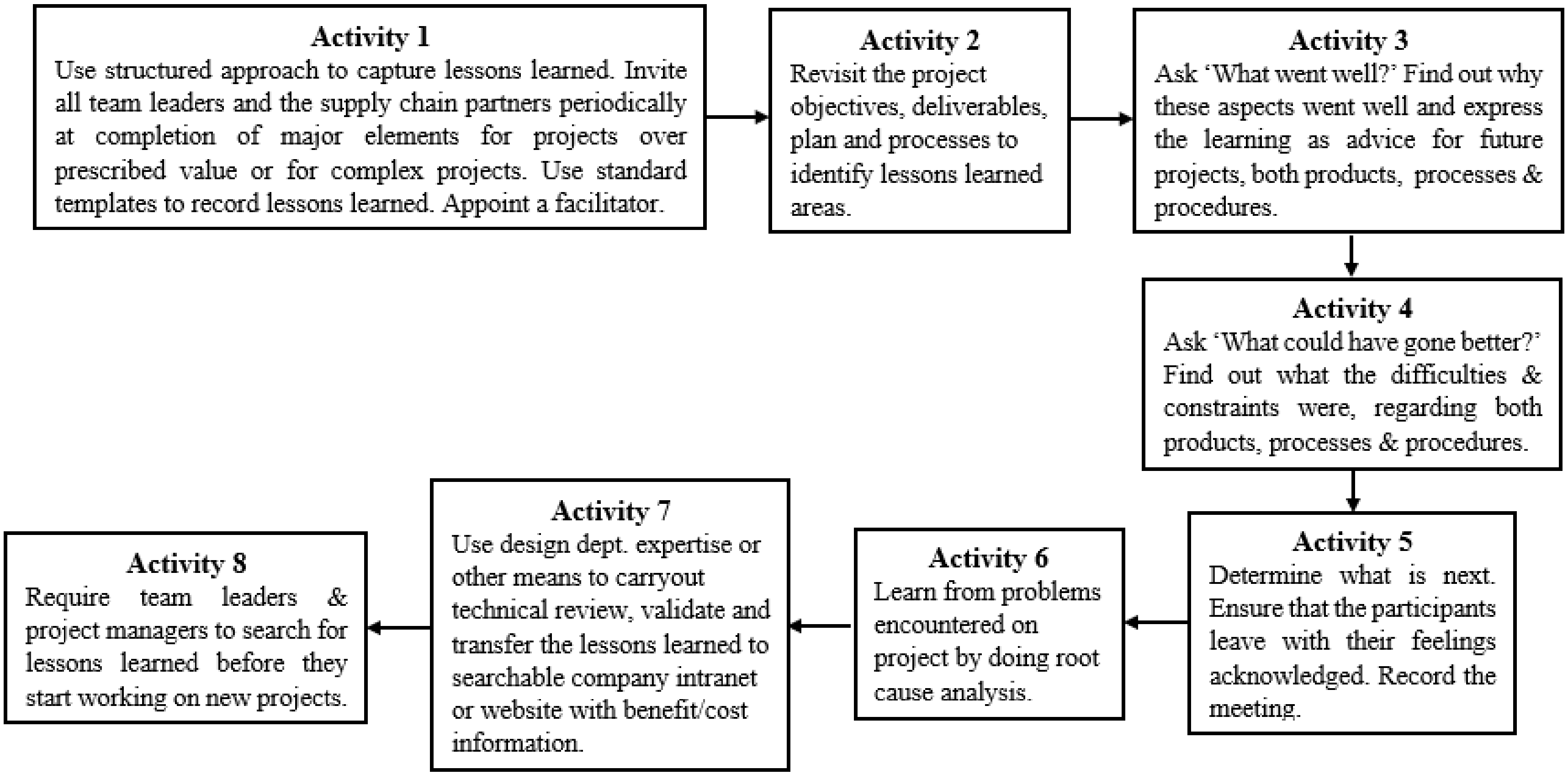


Figure A.11 **Project lessons learned process** flow diagram (Source: Developed based on Collinson and Parcell, 2001; Carrillo, 2005; Ferrada et al., 2016; Construction Industry Institute, 2011).

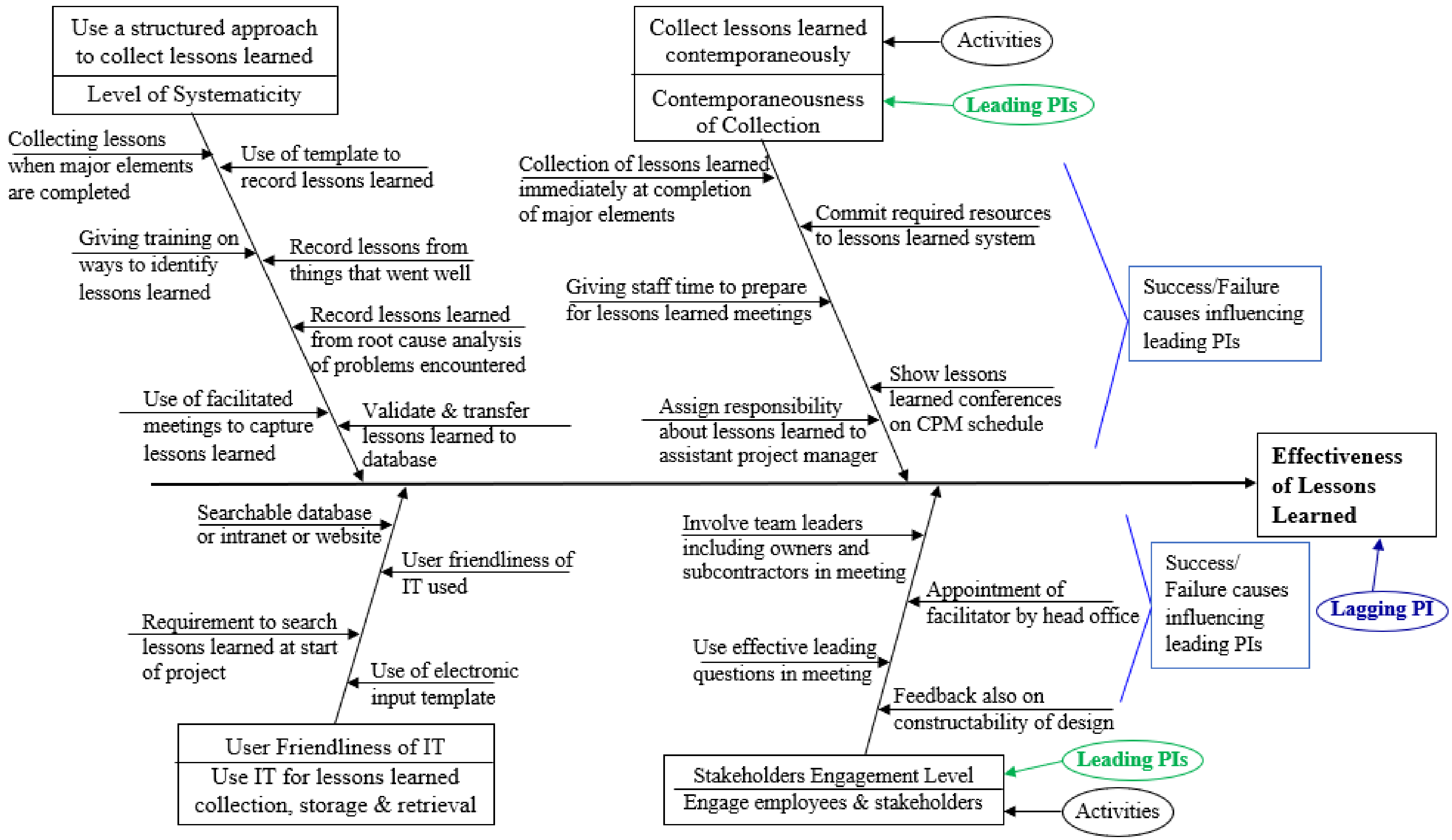


Figure A.12 **Effectiveness of lessons learned process** cause and effect diagram (Source: Developed based on Collinson and Parcell, 2001; Carrillo, 2005; Ferrada et al., 2016; Construction Industry Institute, 2011).

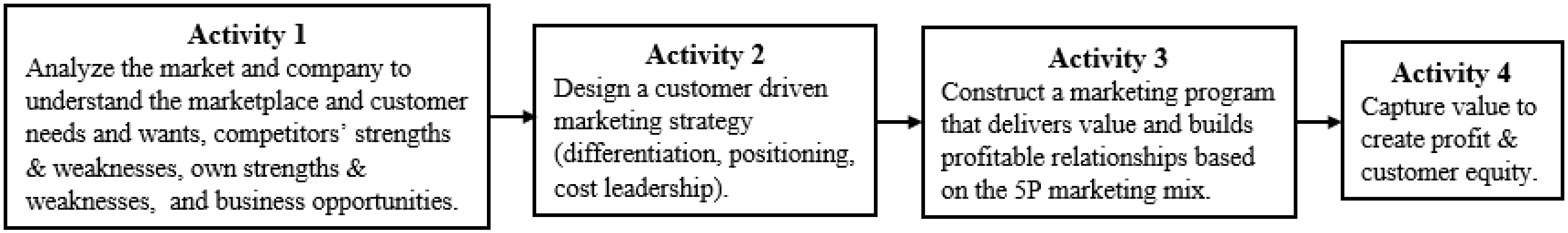


Figure A.13 **Marketing management process** flow diagram.(Source: Developed based on Polat and Donmez, 2010; Kotler and Armstrong, 2009; Arditi et al., 2008).

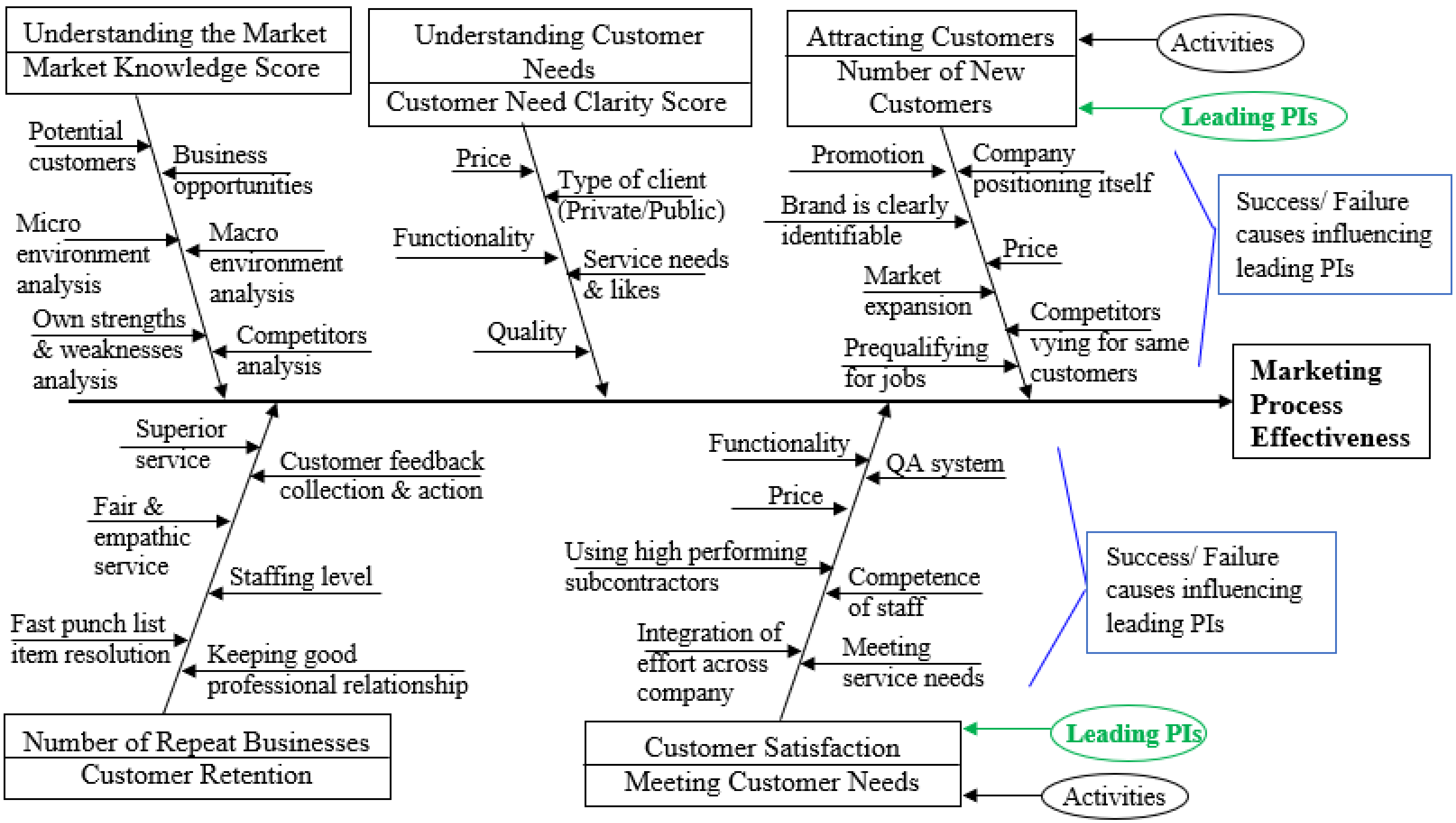


Figure A.14 **Marketing management process** cause and effect diagram.(Source: Developed based on Polat and Donmez, 2010; Kottler and Armstrong, 2009; Arditi et al., 2008)

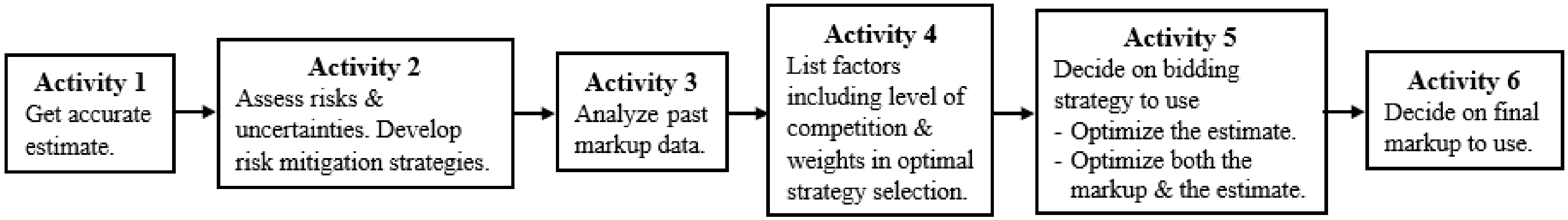


Figure A.15 Construction **pricing process** flow diagram (Developed based on McGuire, 2006)

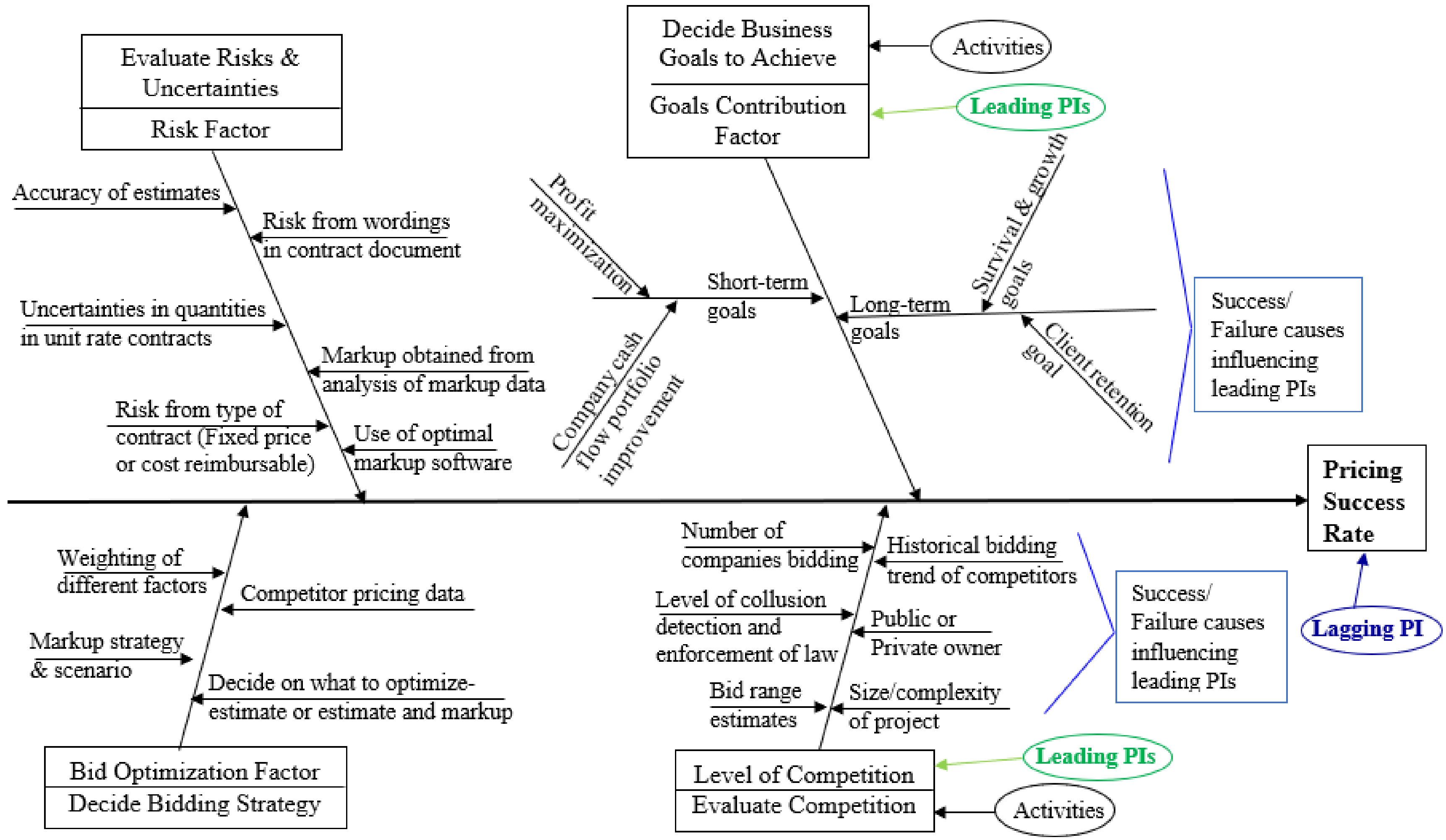


Figure A.16 **Pricing success rate** cause and effect diagram (Source: Developed based on McGuire, 2006)

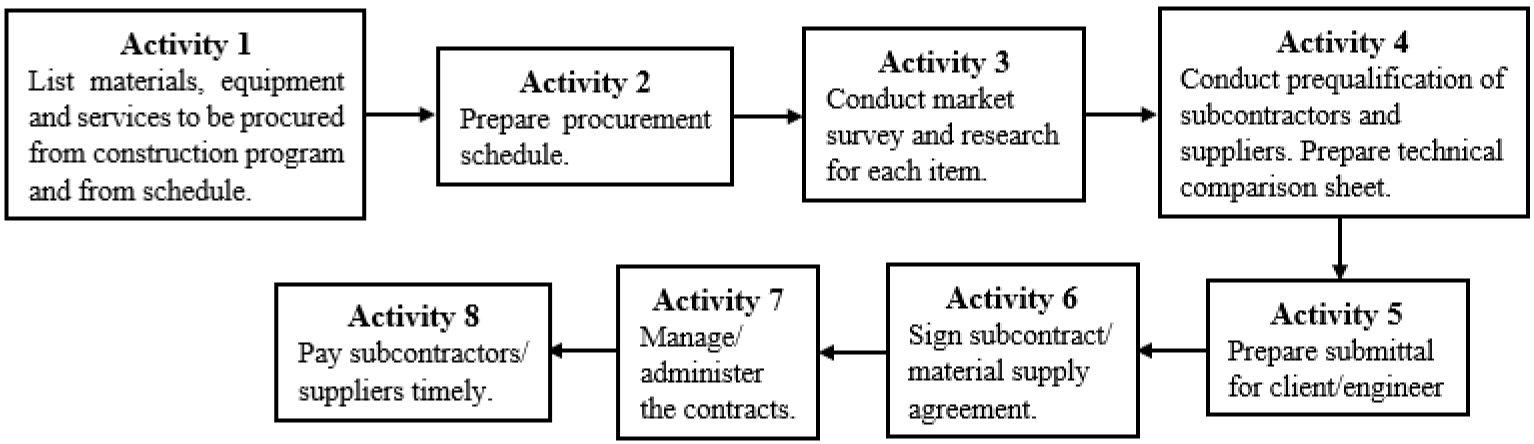


Figure A.17 **Procurement process** flow diagram.

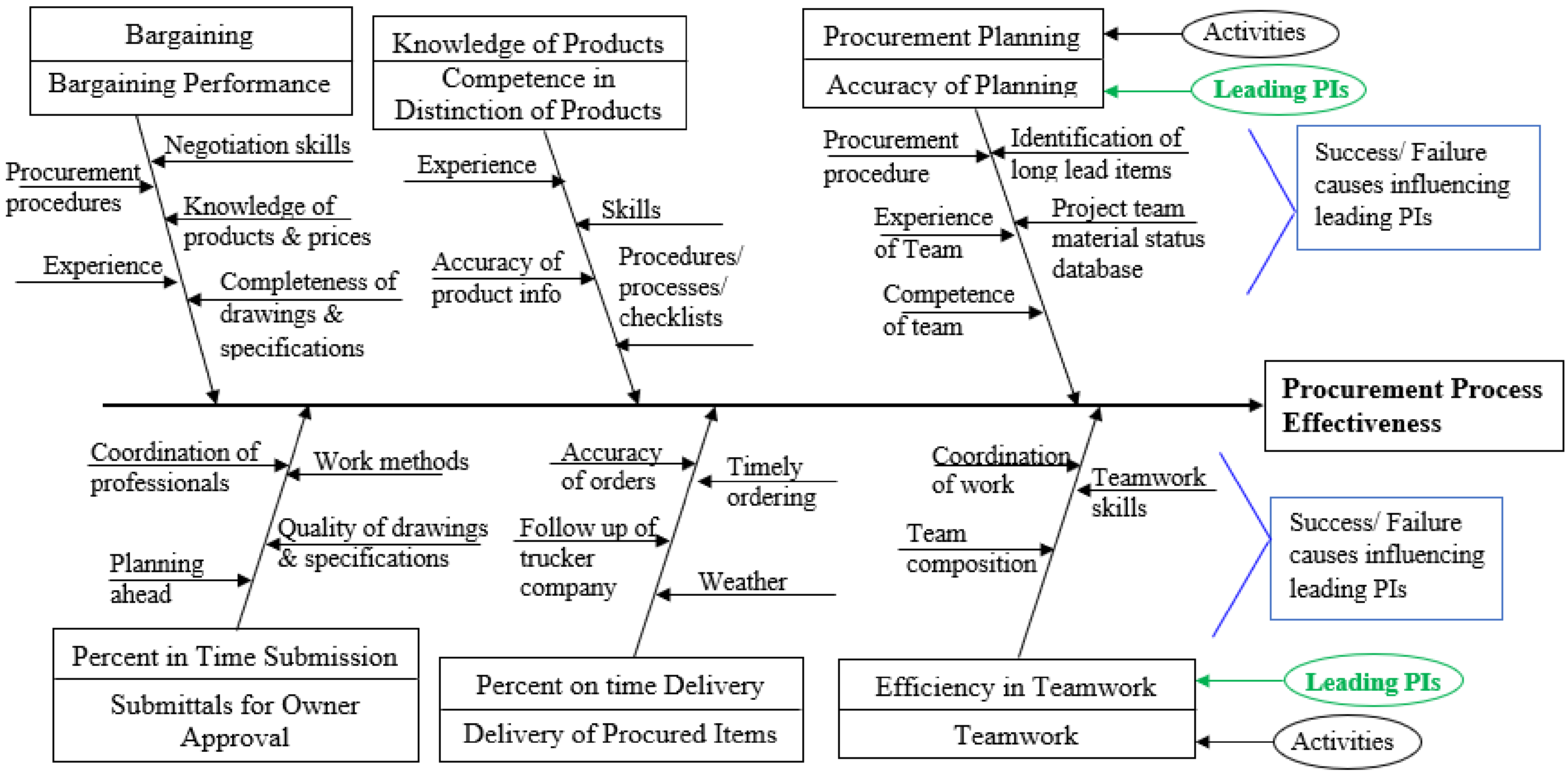


Figure A.18 **Effectiveness of procurement process** cause and effect diagram.

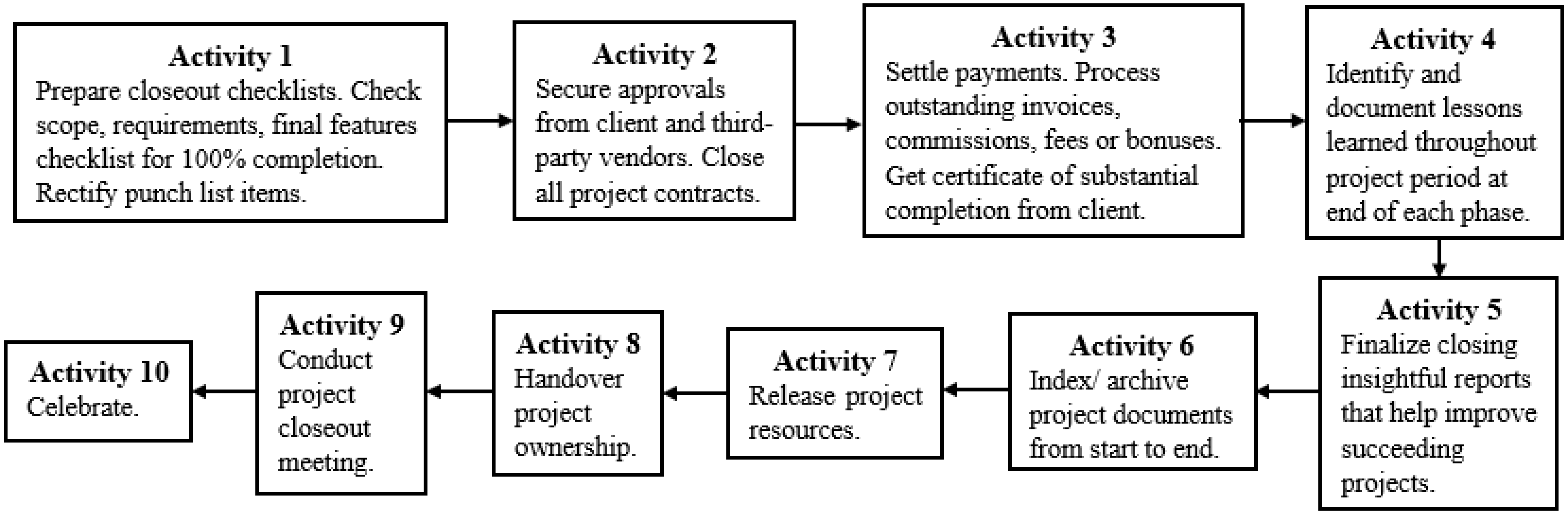


Figure A.19 **Project closeout process** flow diagram (Developed based on Rogers, 2012;)

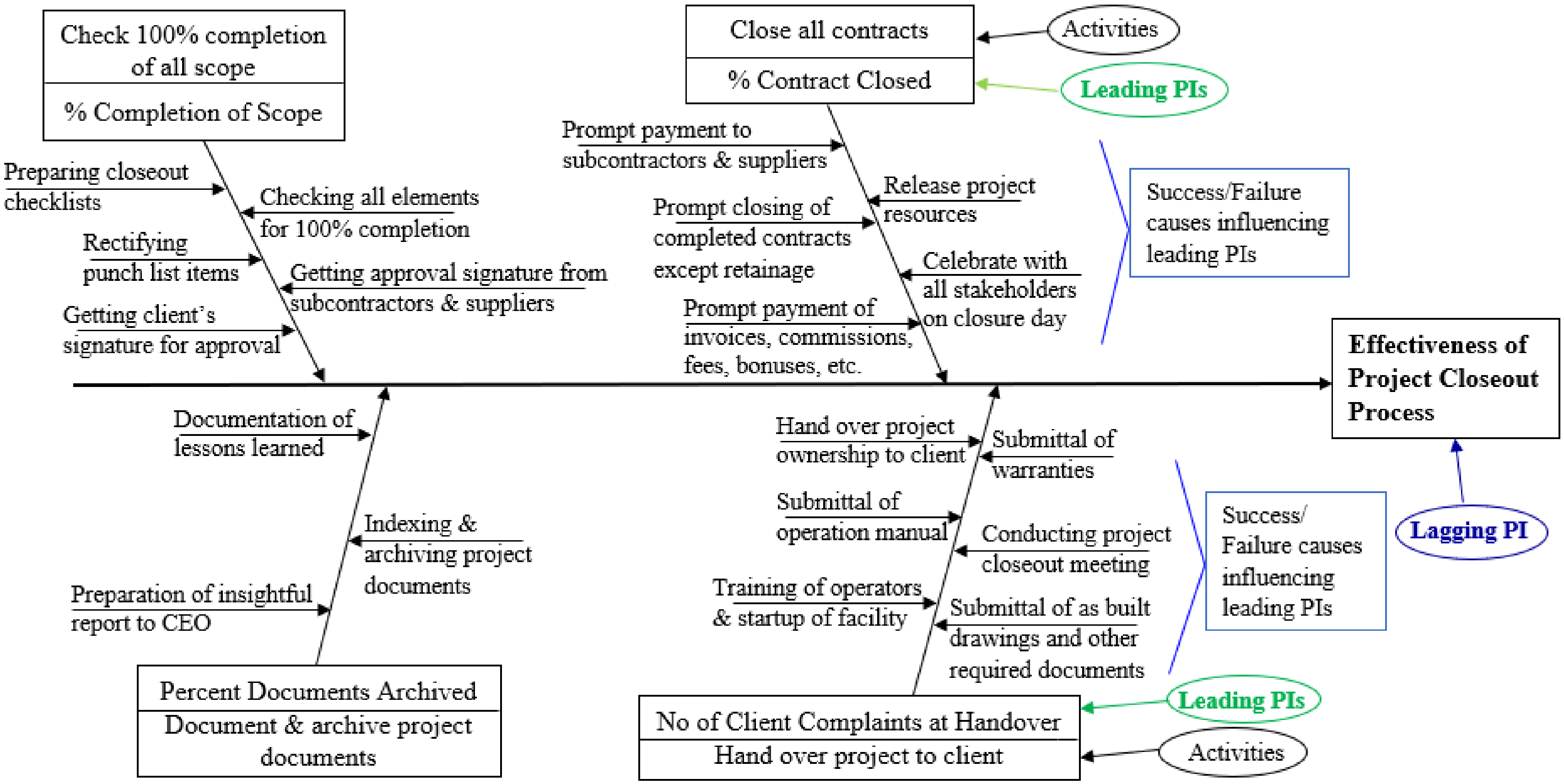


Figure A.20 **Effectiveness of project closeout process** cause and effect diagram (Developed based on Rogers, 2012;)

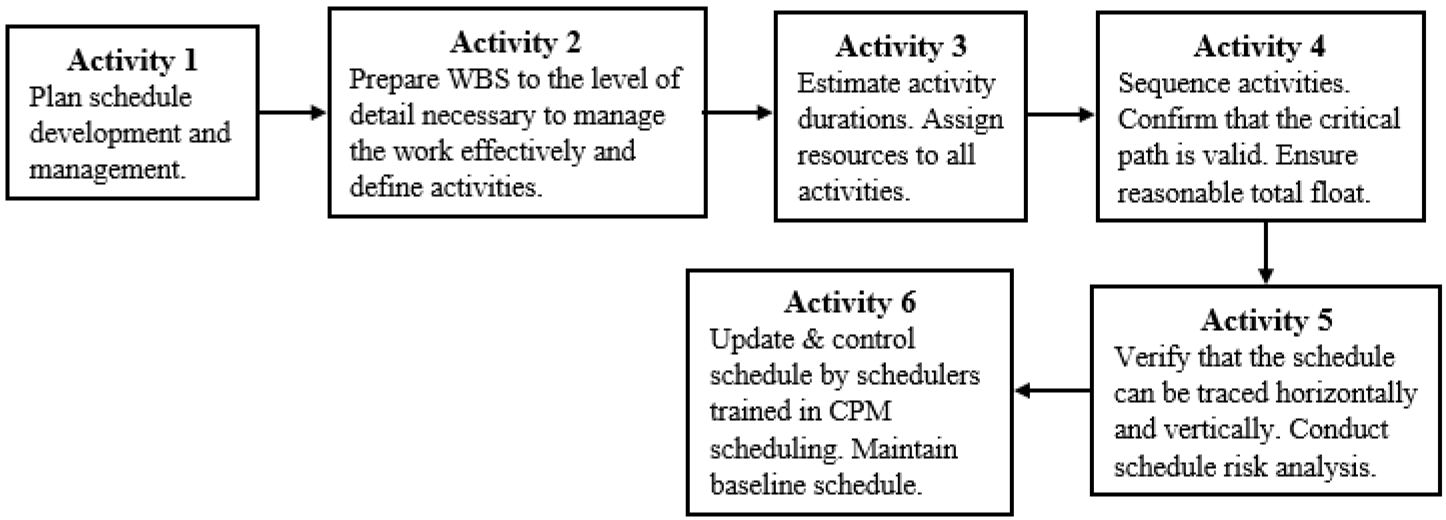


Figure A.21 **Construction schedule development & management process** flow diagram (Developed based on PMI (PMBOK), 2017; GAO, 2015; Millhollan, 2009)

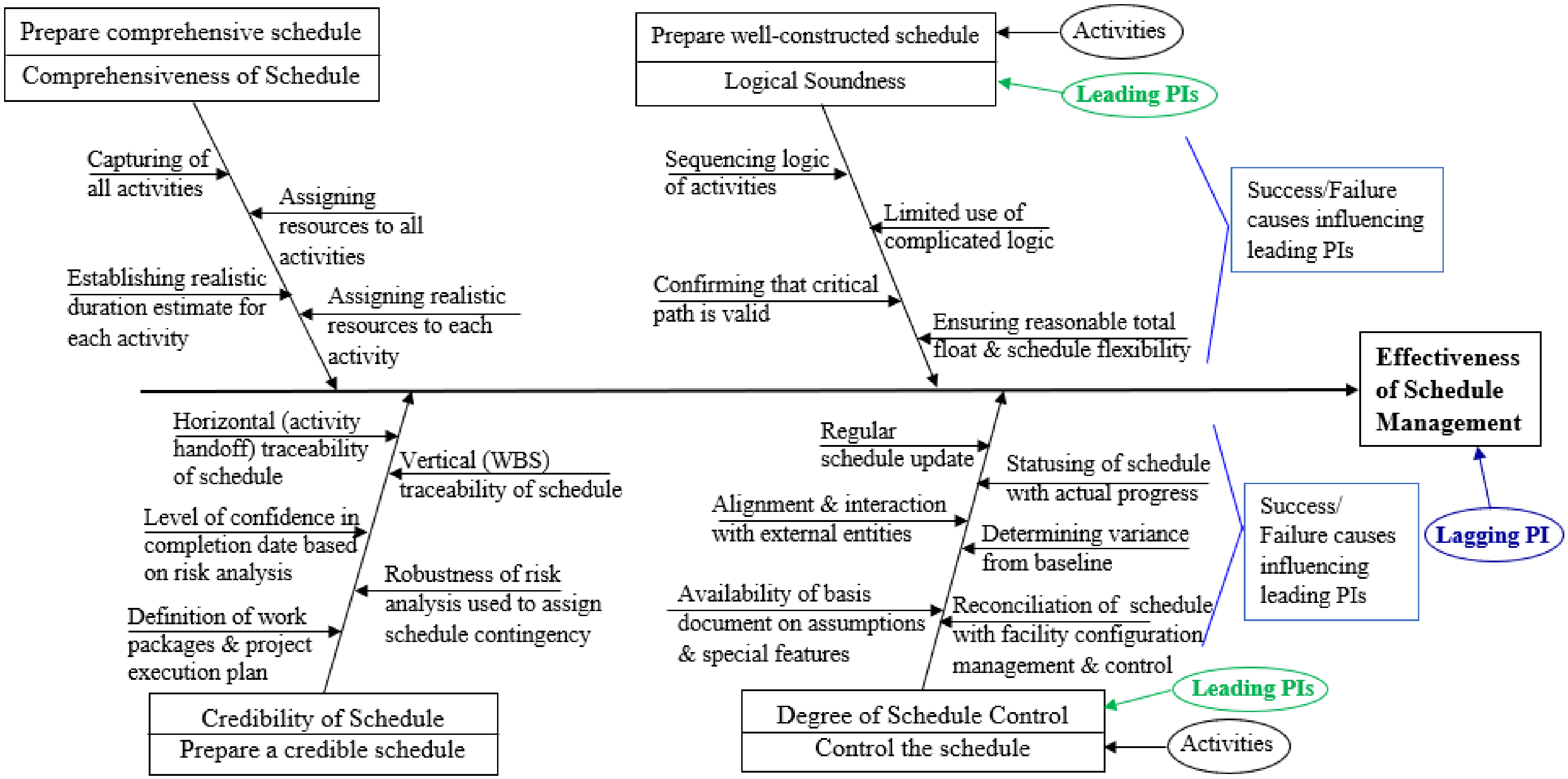


Figure A.22 **Construction schedule management process effectiveness** cause and effect diagram (Source: Developed based on PMI (PMBOK), 2017; GAO, 2015; Millhollan, 2009)

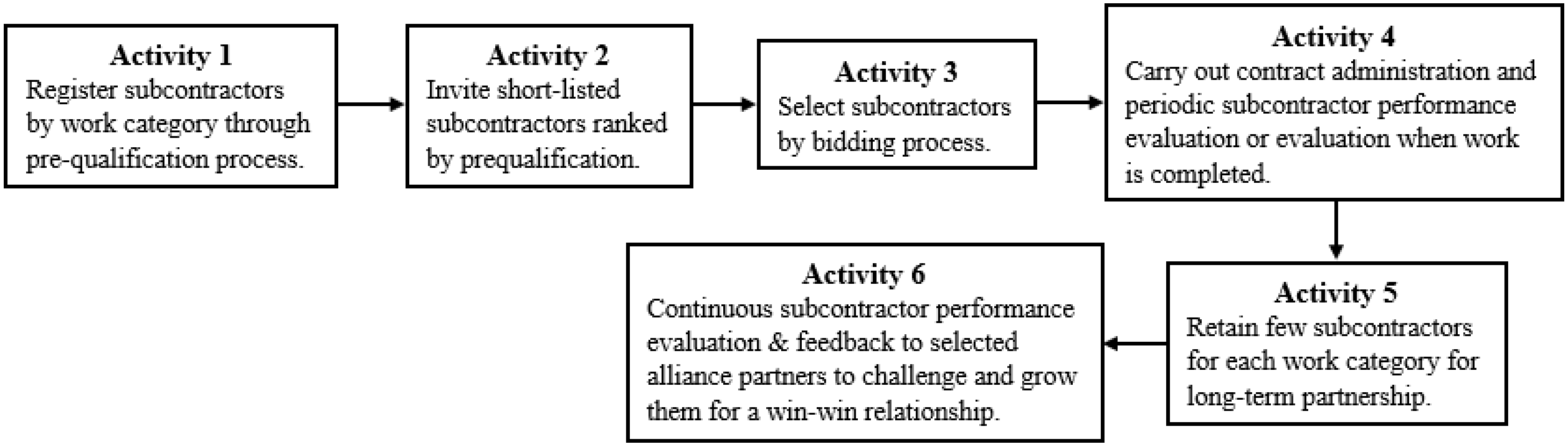


Figure A.23 **Subcontract management process** flow diagram (Source: Developed based on Thomas and Flynn, 2011; Nobbs, 1993)

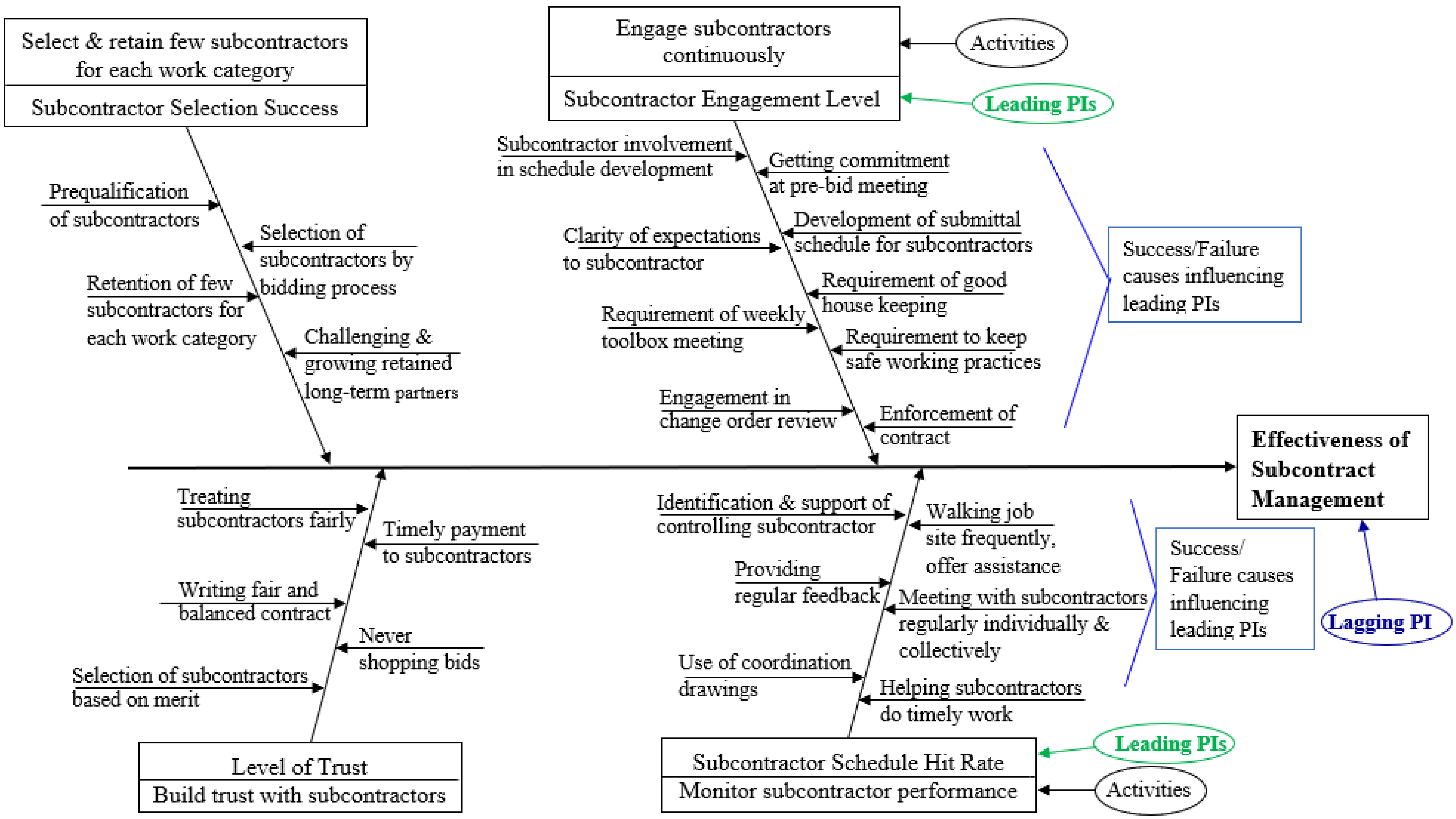


Figure A.24 **Effectiveness of subcontract management process** cause and effect diagram (Source: Developed based on Thomas and Flynn, 2011; Nobbs, 1993)

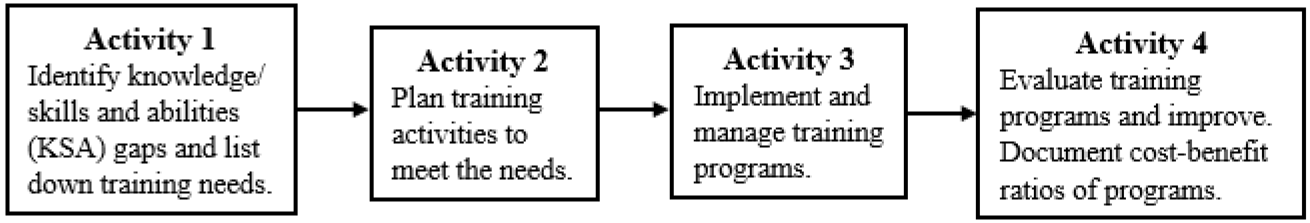


Figure A.25 **Training program management process** flow diagram (Source: Developed based on Muench, 2006; van Adelsberg, 1999; Fenner et al., 2018)

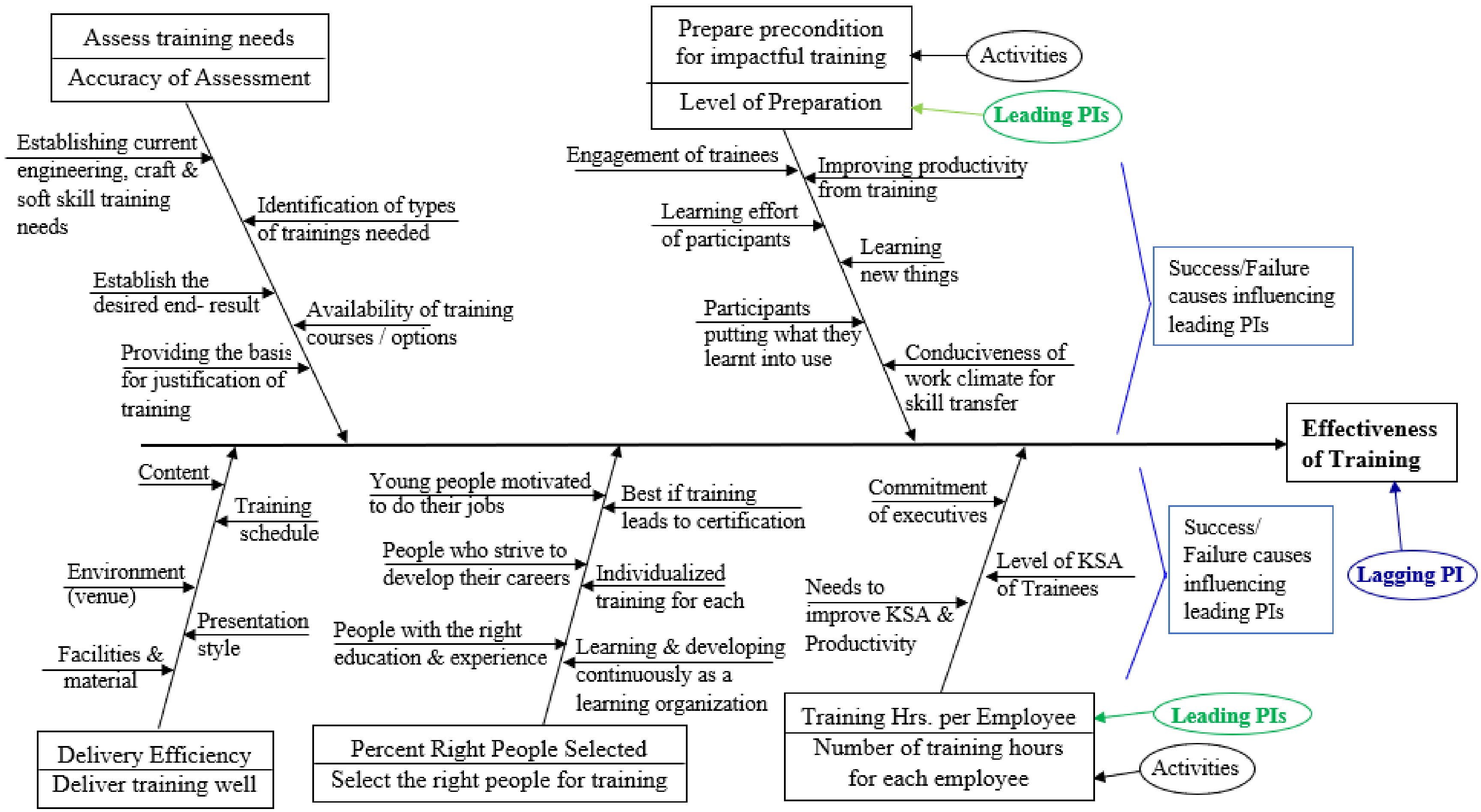


Figure A.26 **Effectiveness of training process** cause and effect diagram (Source: Developed based on Muench, 2006; van Adelsberg, 1999; Fenner et al., 2018)

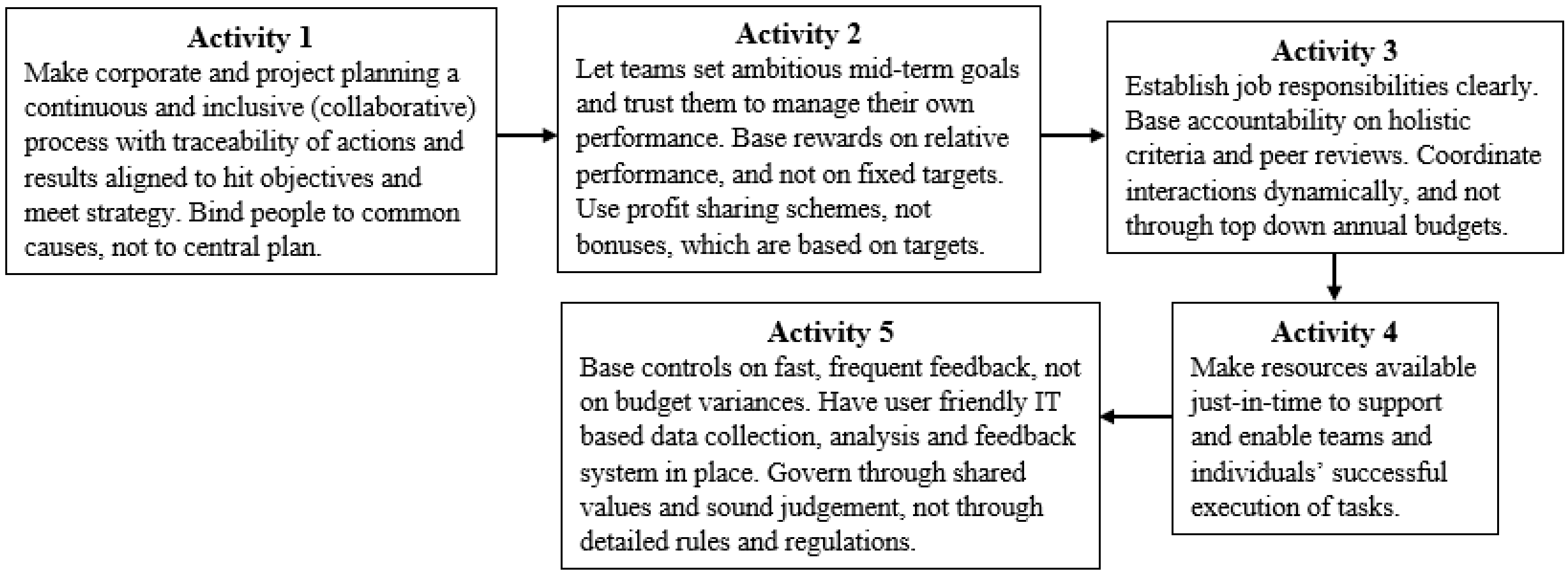


Figure A. 27 **Company resource allocation** process flow diagram. (Source: Developed based on Olesen, 2015; Kaka and Price, 1994; Prophix, 2018; Lanzkron, 2017)

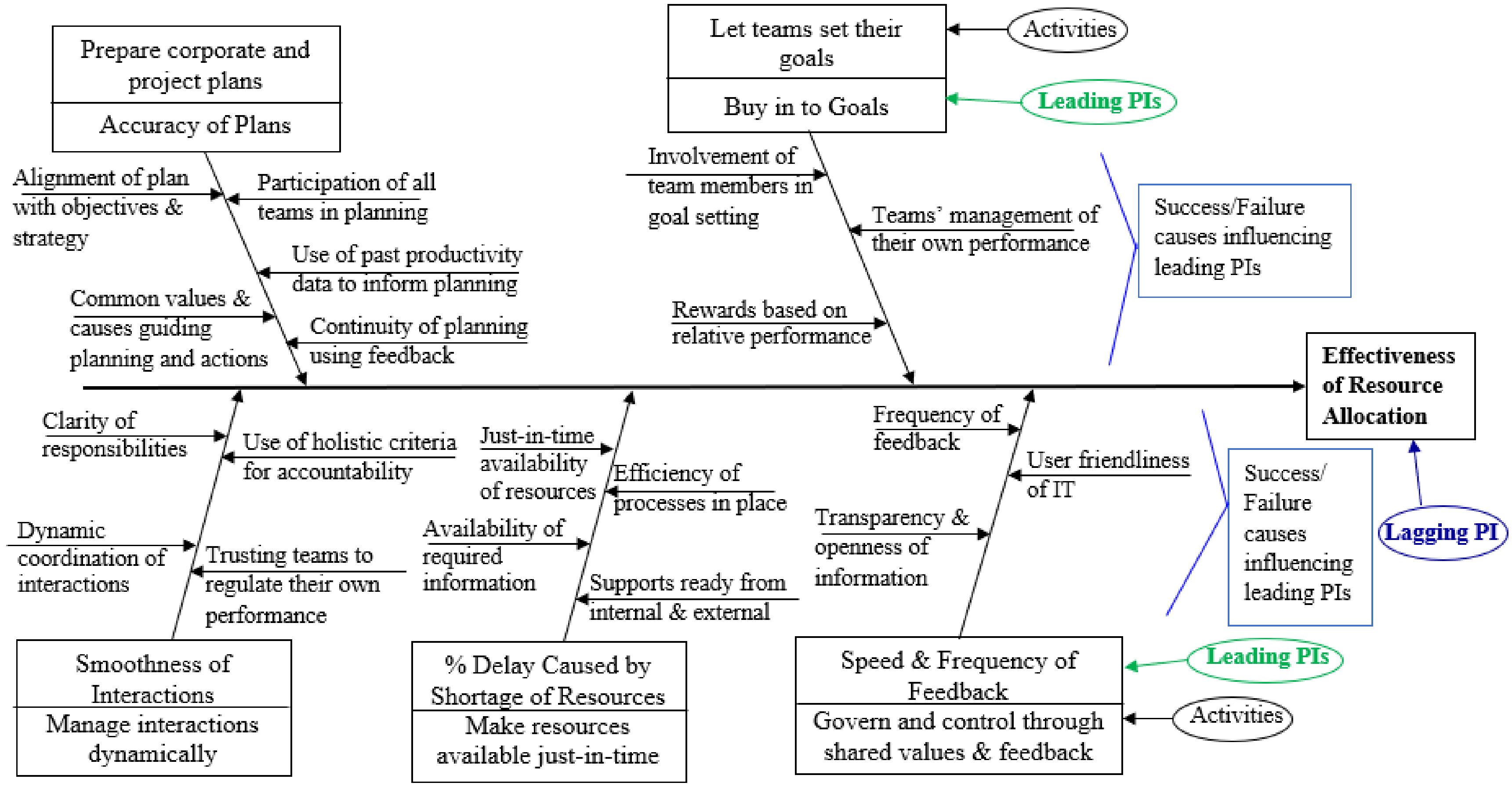


Figure A.28 **Resource allocation effectiveness** cause and effect diagram. (Source: Developed based on Olesen, 2015; Kaka and Price, 1994; Prophix, 2018; Lanzkron, 2017)

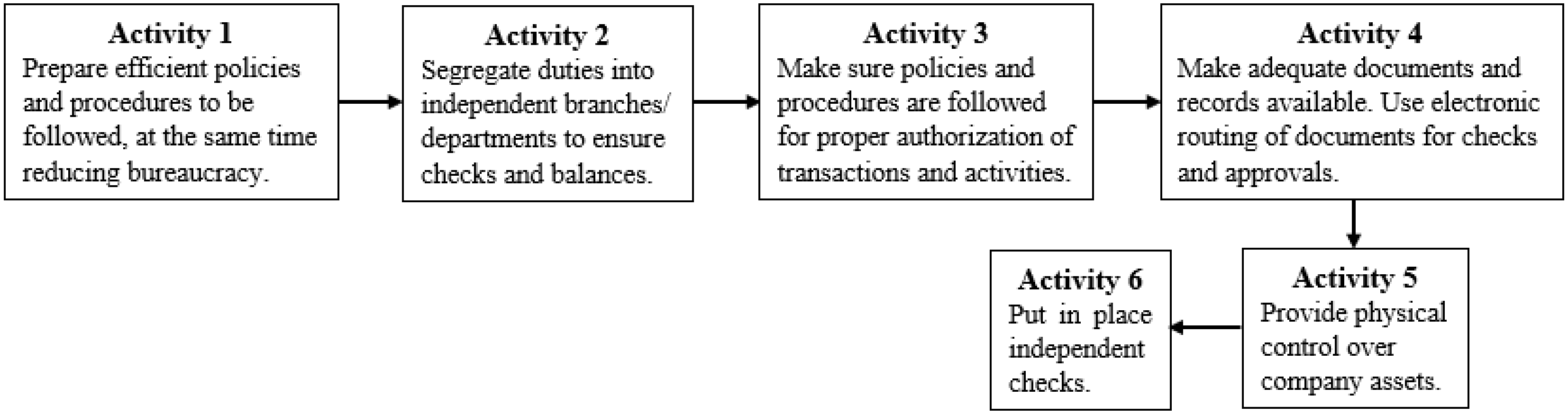


Figure A.29 **Company checks and balances** process flow diagram.(Source: Developed based on Brignall, 2007)

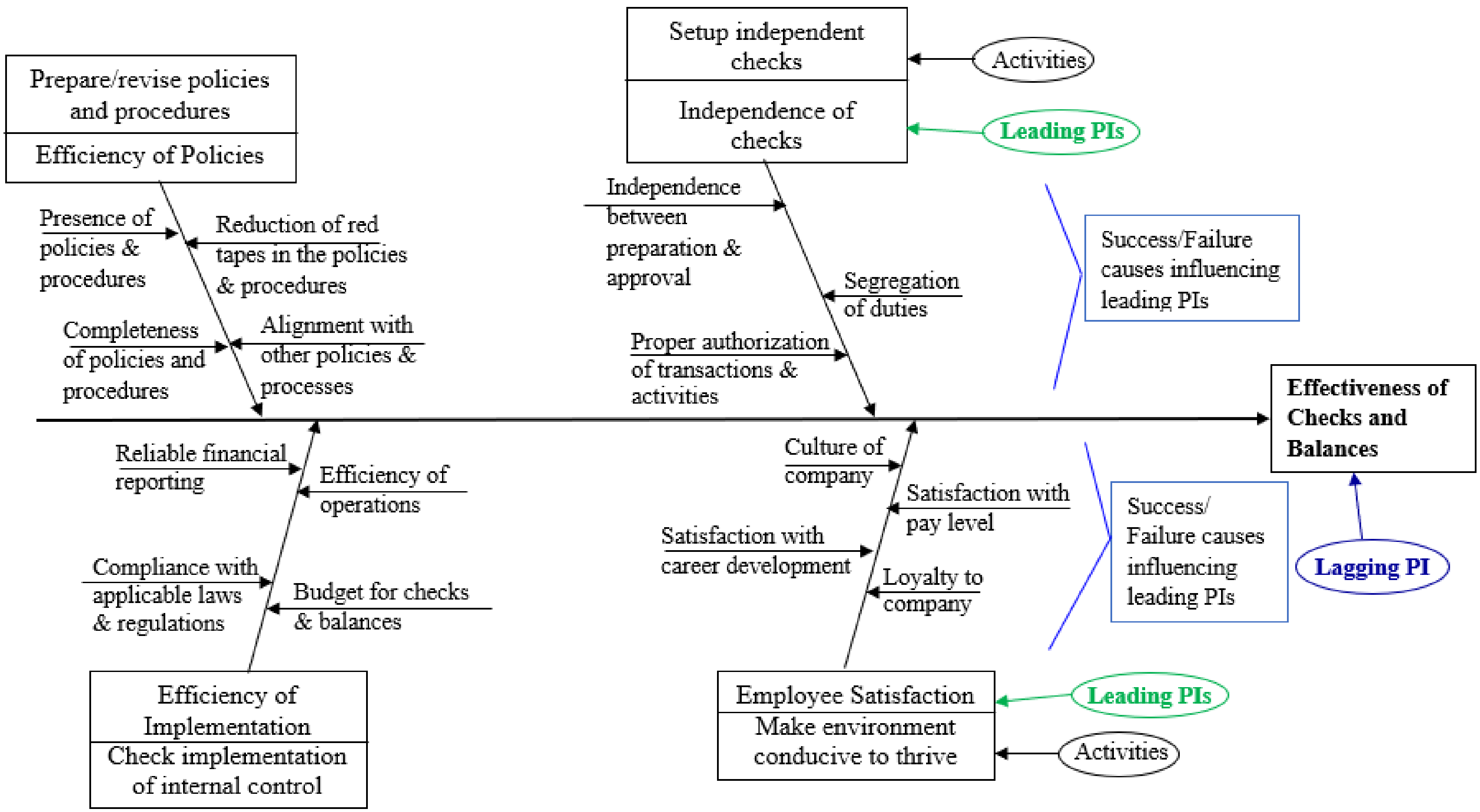


Figure A.30 **Checks and balances effectiveness** cause and effect diagram.(Source: Developed based on Brignall, 2007)

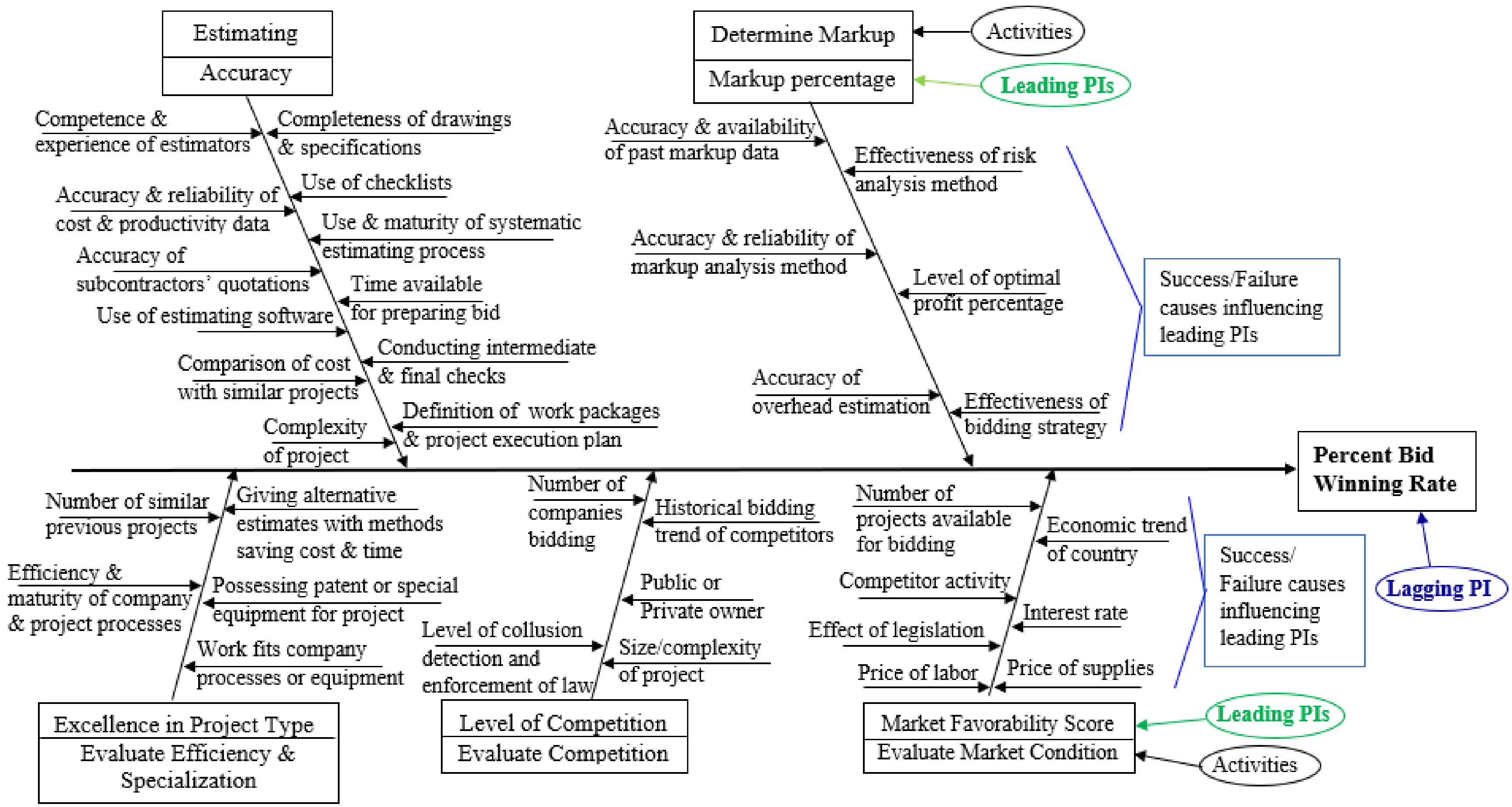


Figure A.31 **Bidding department effectiveness** cause and effect diagram.

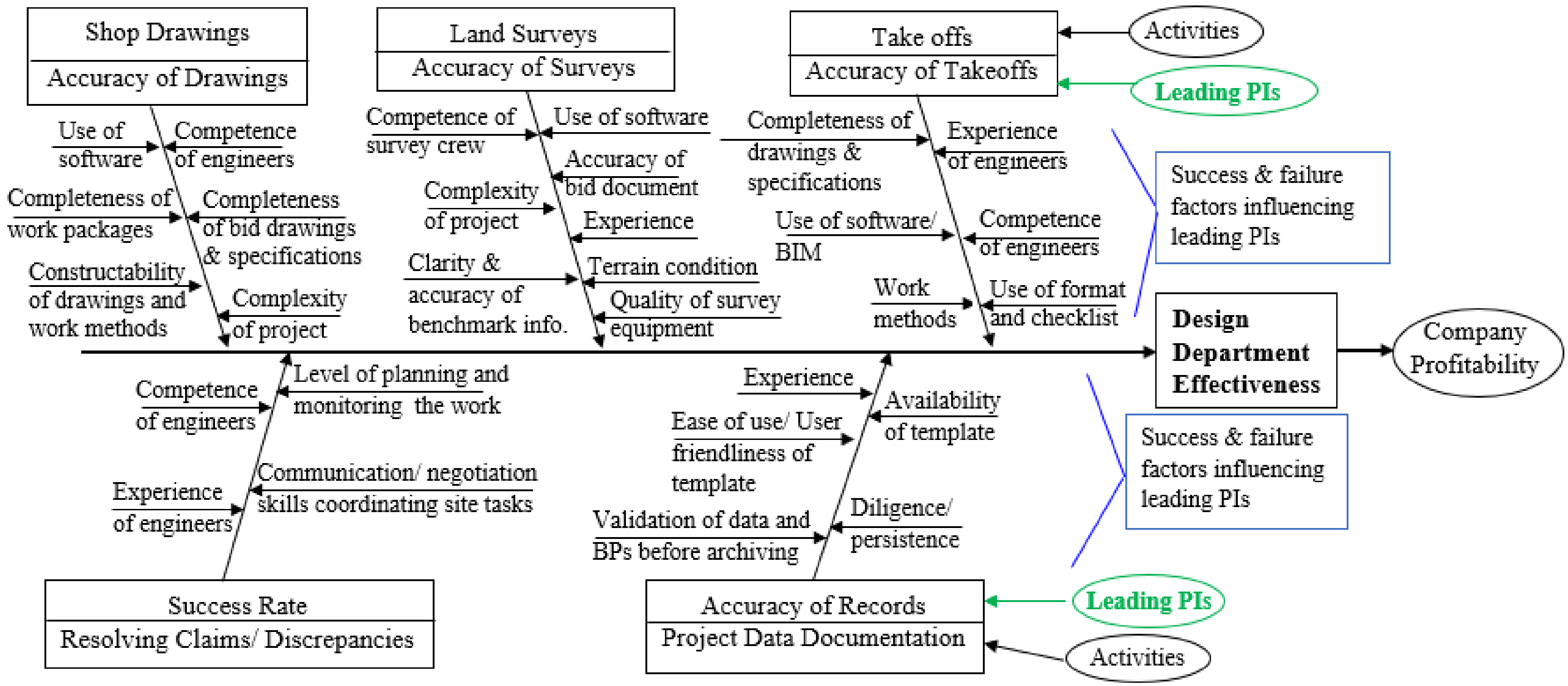


Figure A.32 **Design department effectiveness** cause and effect diagram.

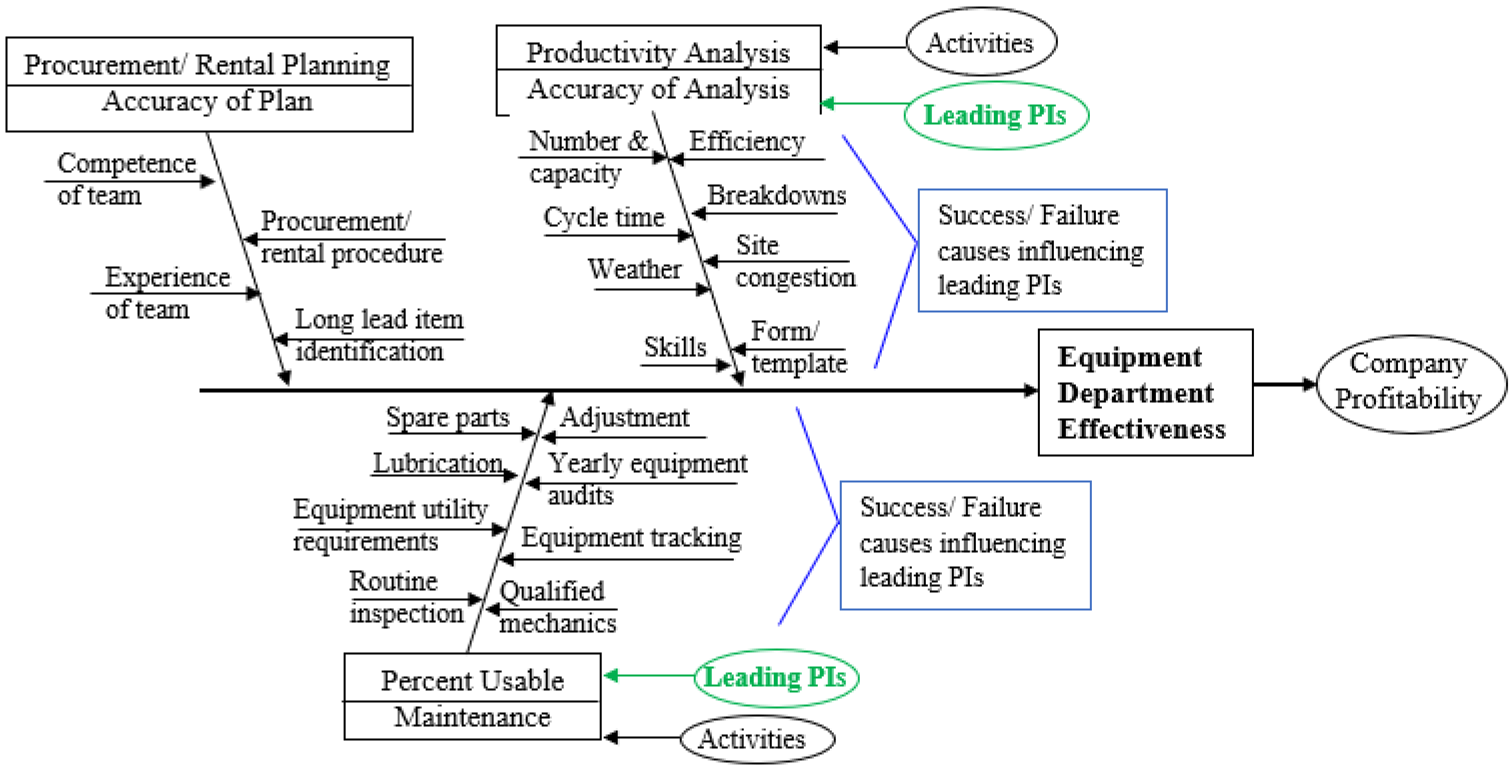


Figure A.33 **Equipment department effectiveness** cause and effect diagram.

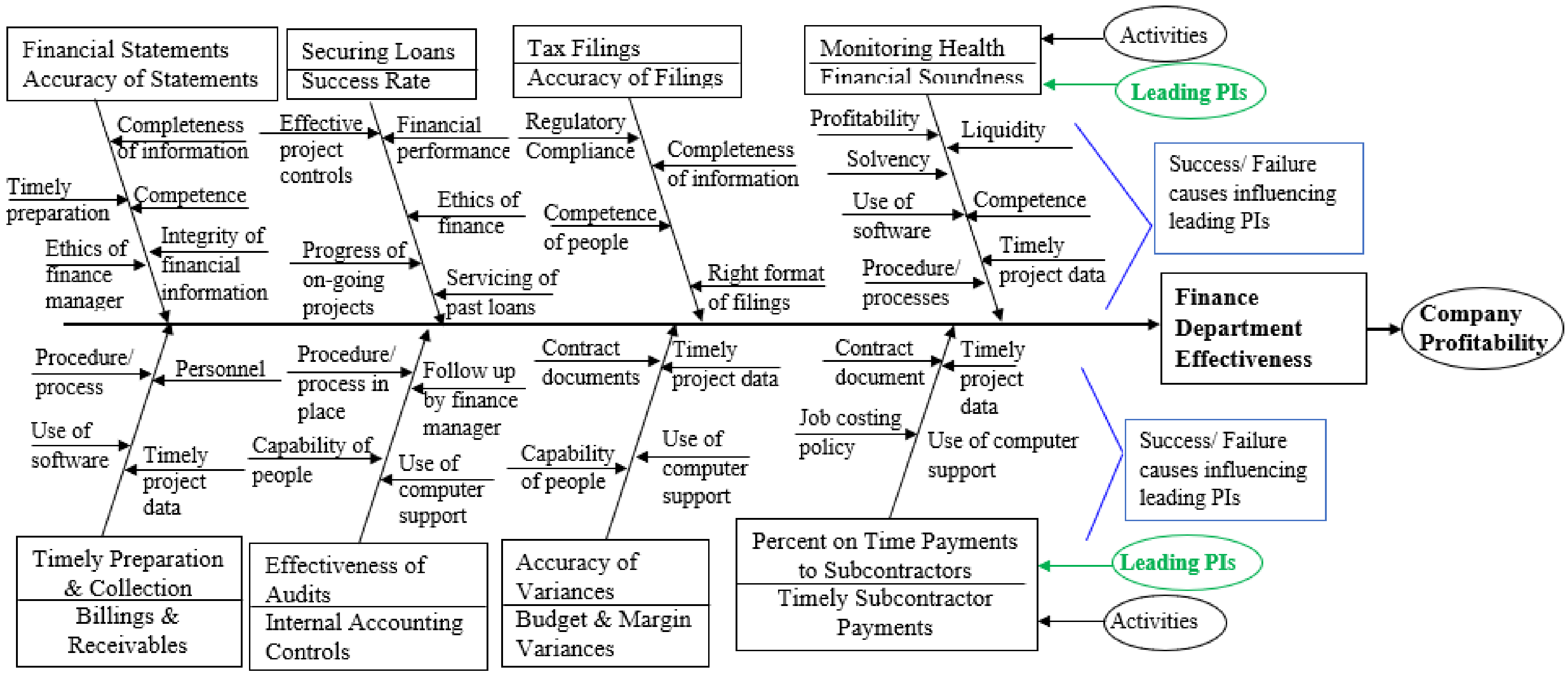


Figure A.34 **Finance department effectiveness** cause and effect diagram.

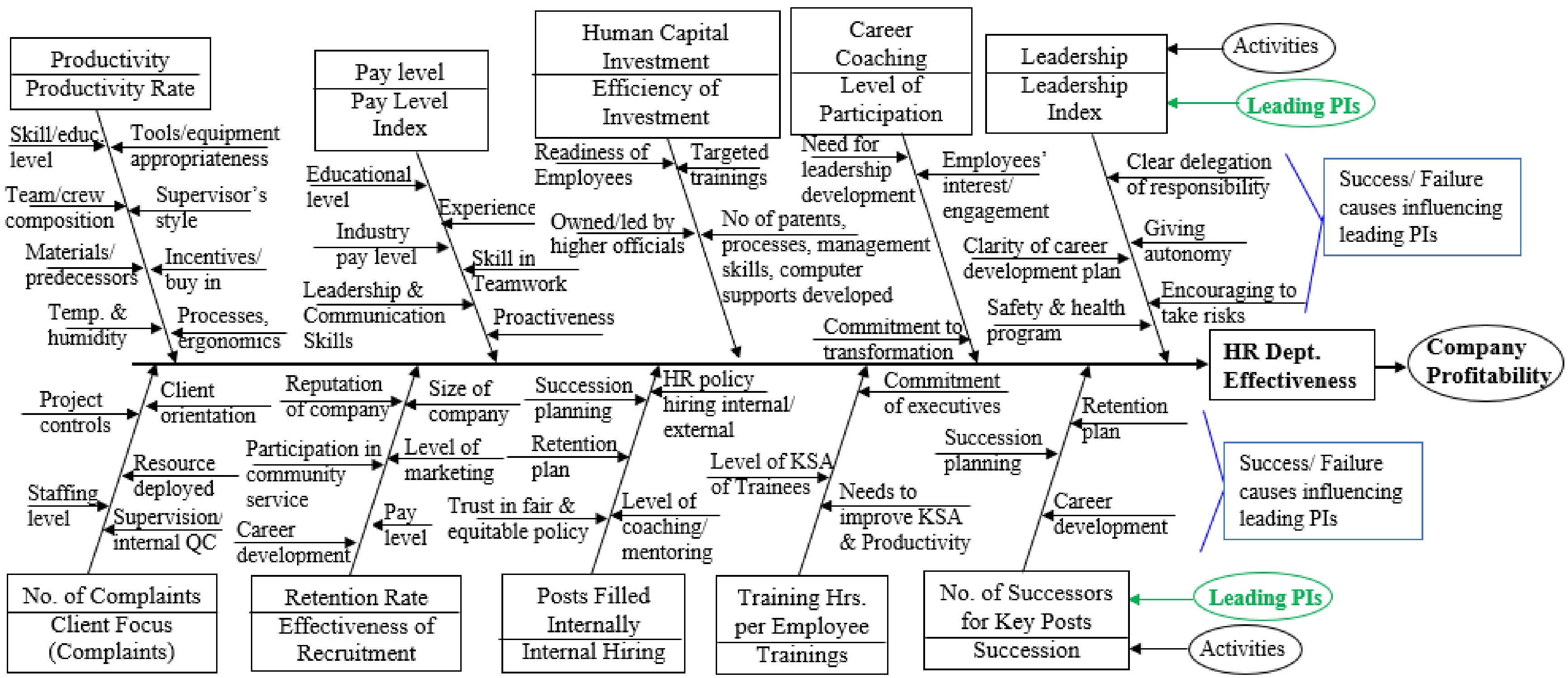


Figure A.35 **Human resources department effectiveness** cause and effect diagram.(Source: Developed based on Iveta, 2012; Beh and Loo, (2013)

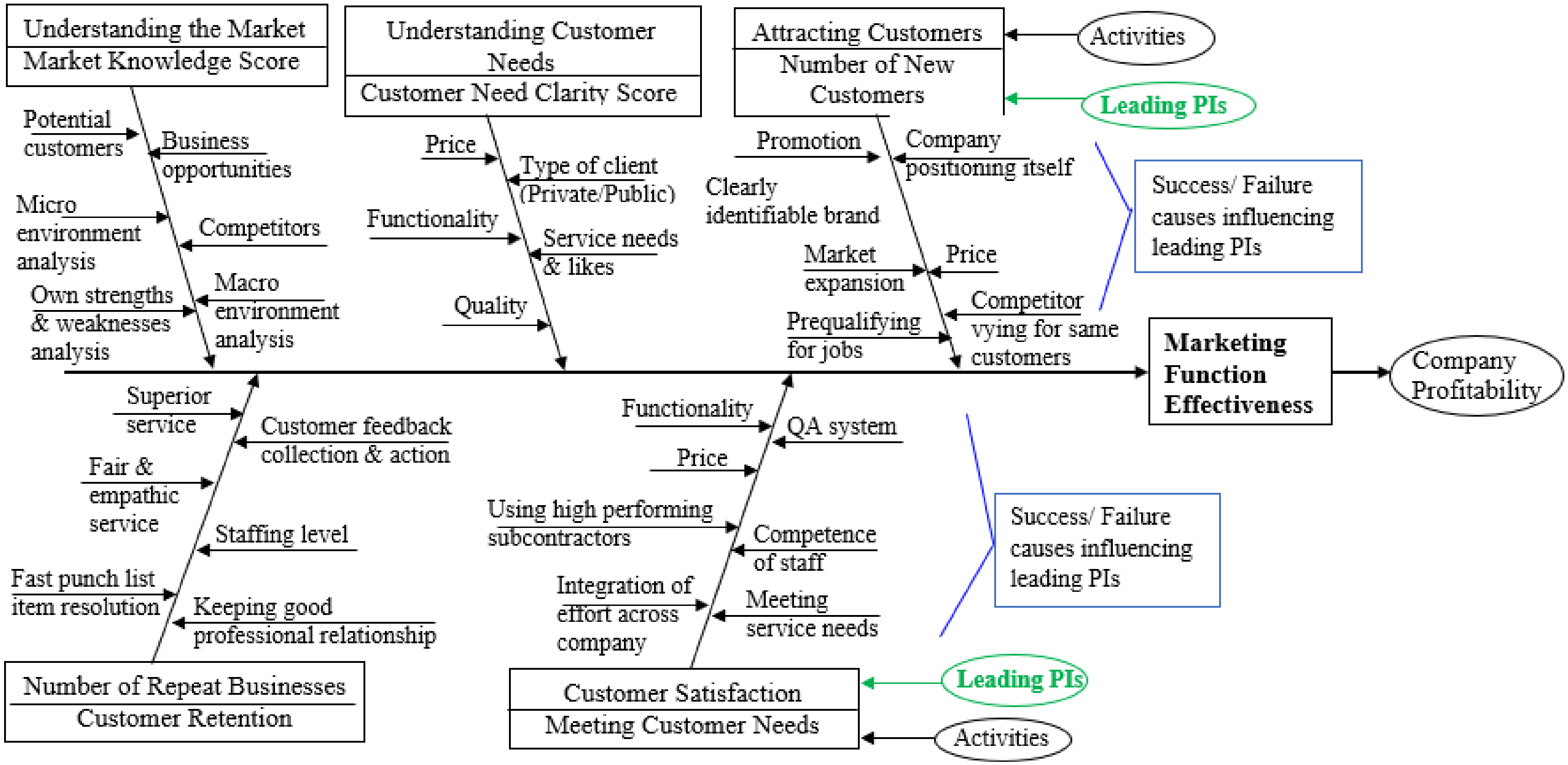


Figure A.36 **Marketing function/department effectiveness** cause and effect diagram.

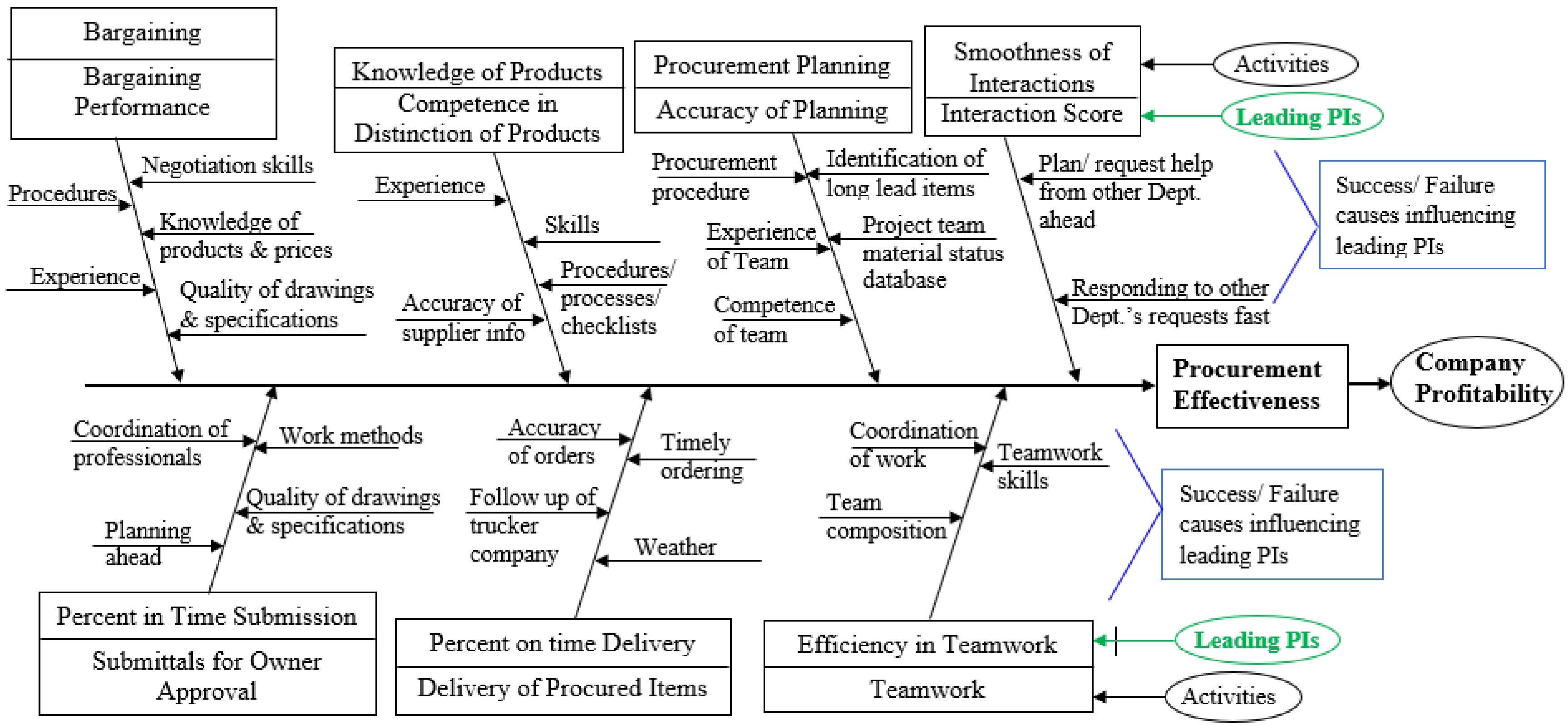


Figure A.37 **Procurement department effectiveness** cause and effect diagram.

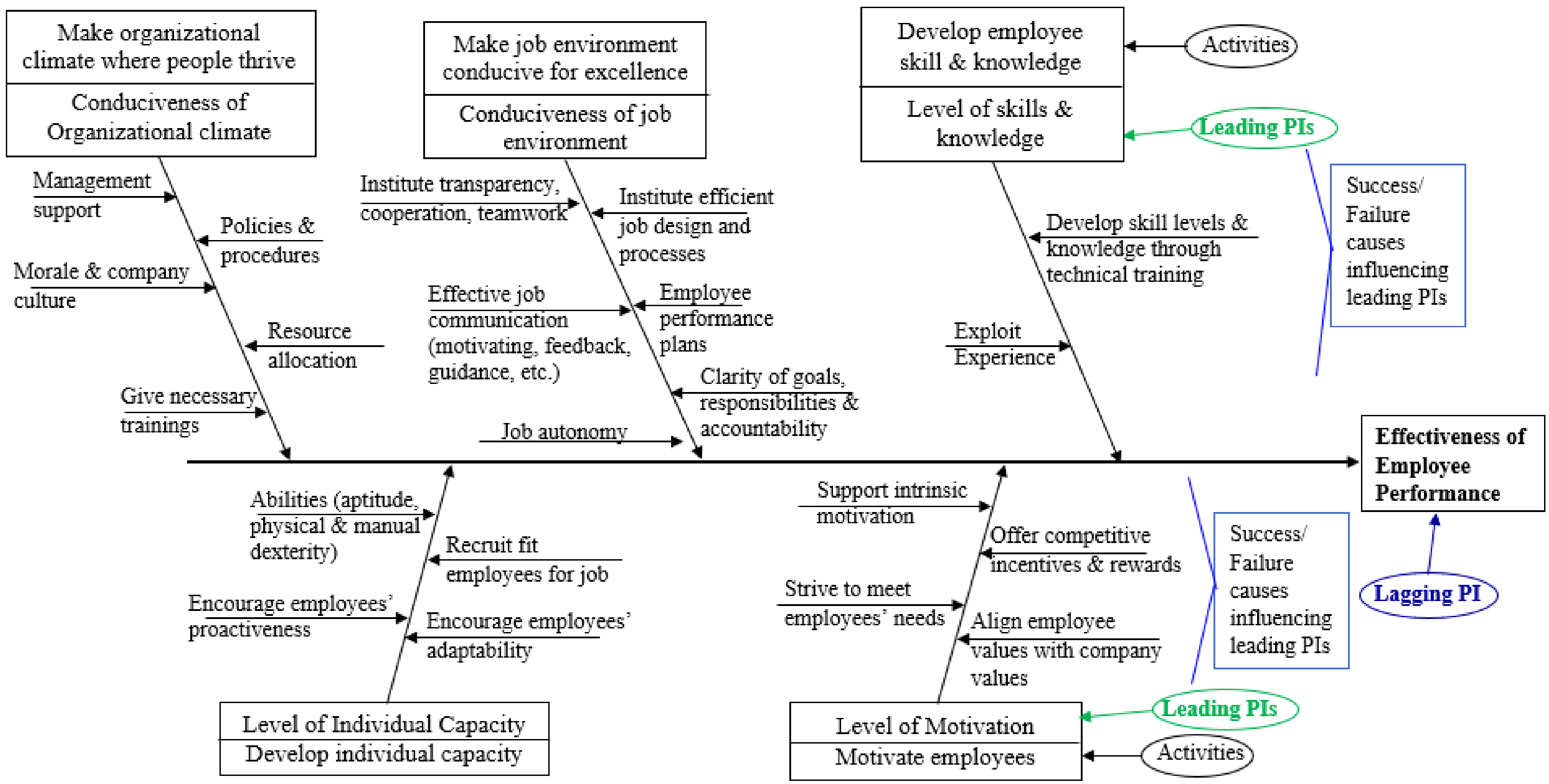


Figure A.38 **Employee performance effectiveness** cause and effect diagram (Source: Developed based on van Tiem et. al, 2012; Diamantidis and Chatzoglou, 2019; US Government Office of Personnel Management, 2017)

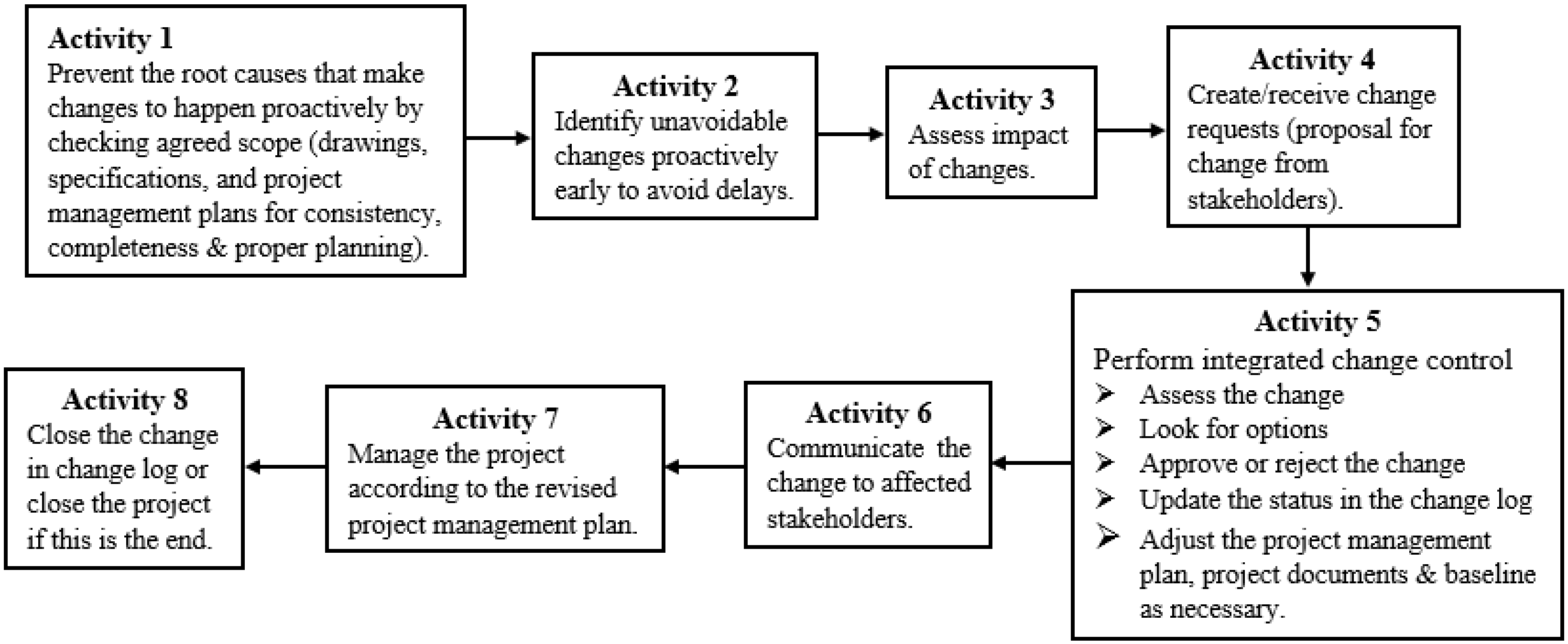


Figure A.39 **Project scope change control and management process** flow diagram (Source: Developed based on PMBOK, 2017; Millohan, 2008)

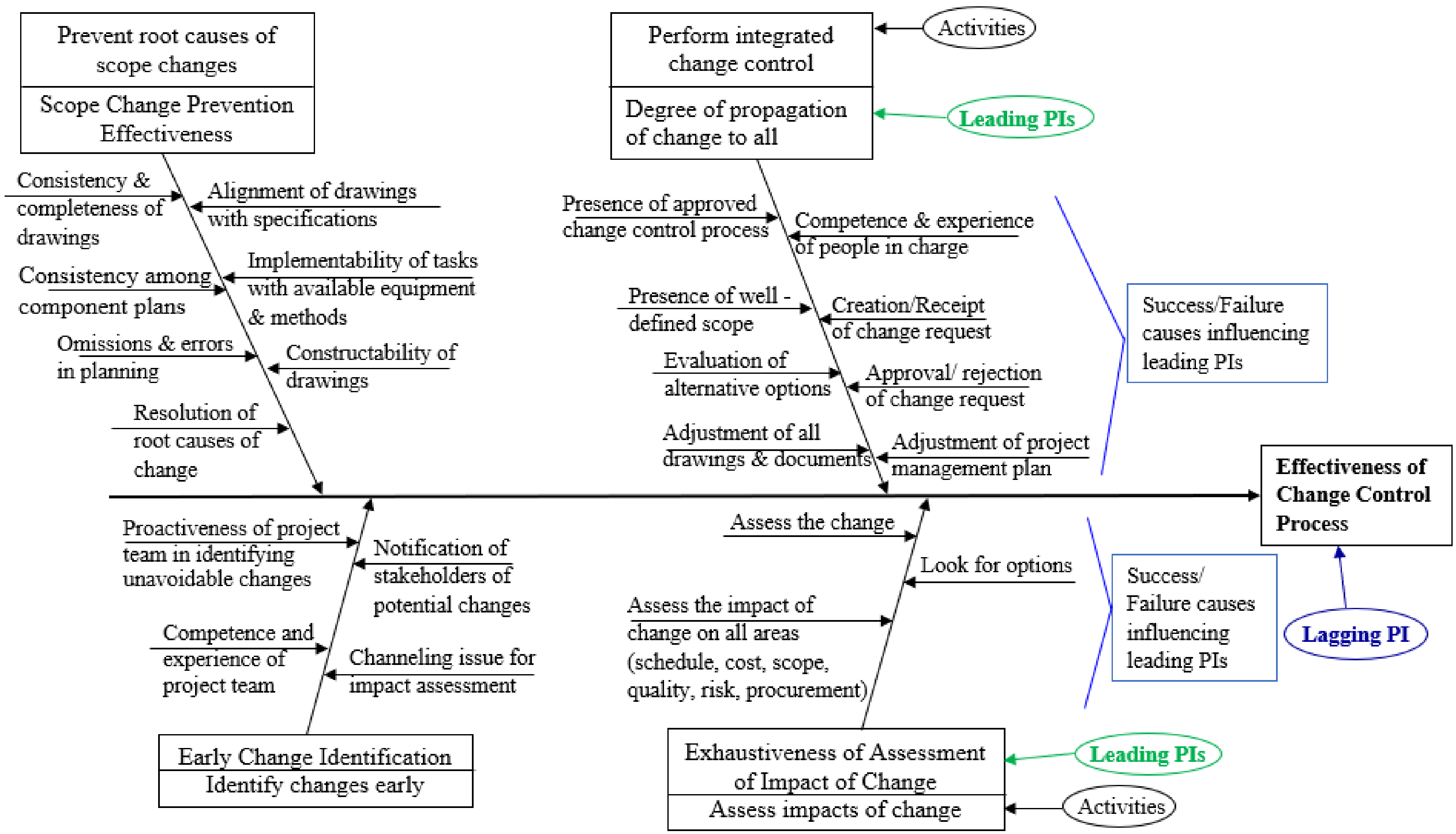


Figure A.40 **Effectiveness of change control** cause and effect diagram (Source: Developed based on PMI (PMBOK), 2017; Millhollan, 2008).

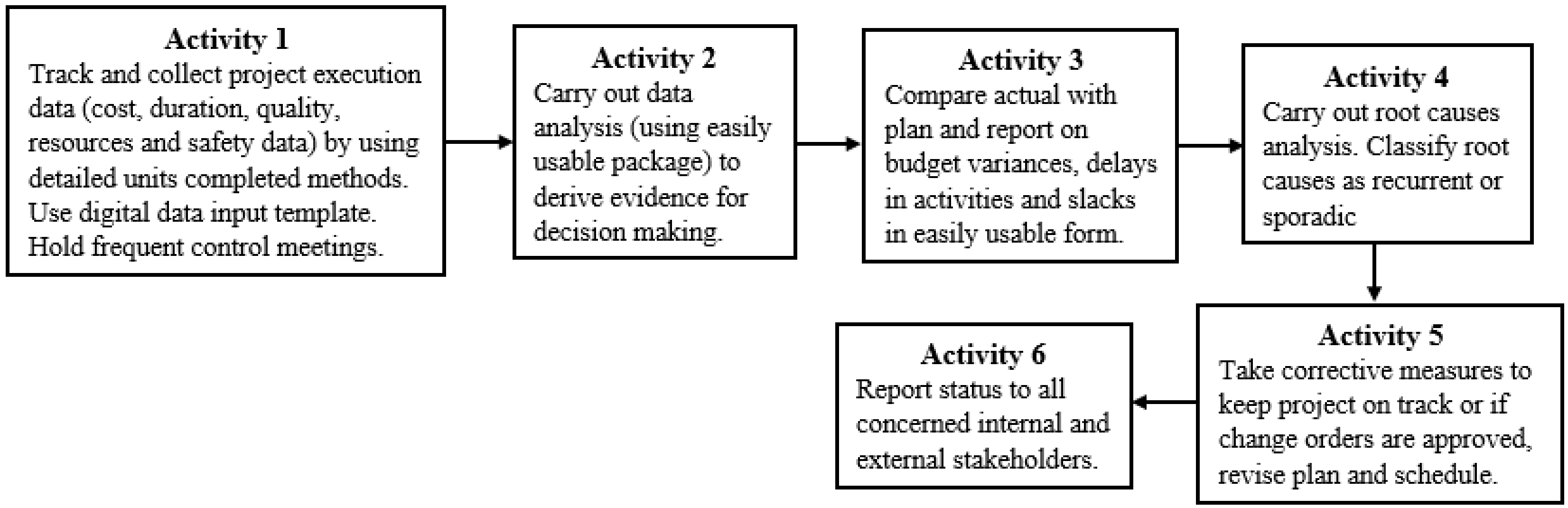


Figure A.41 **Project monitoring and control process** flow diagram (Source: Developed based on Orgut et. al, 2018, Millhollan, 2008; PMI(PMBOK), 2017).

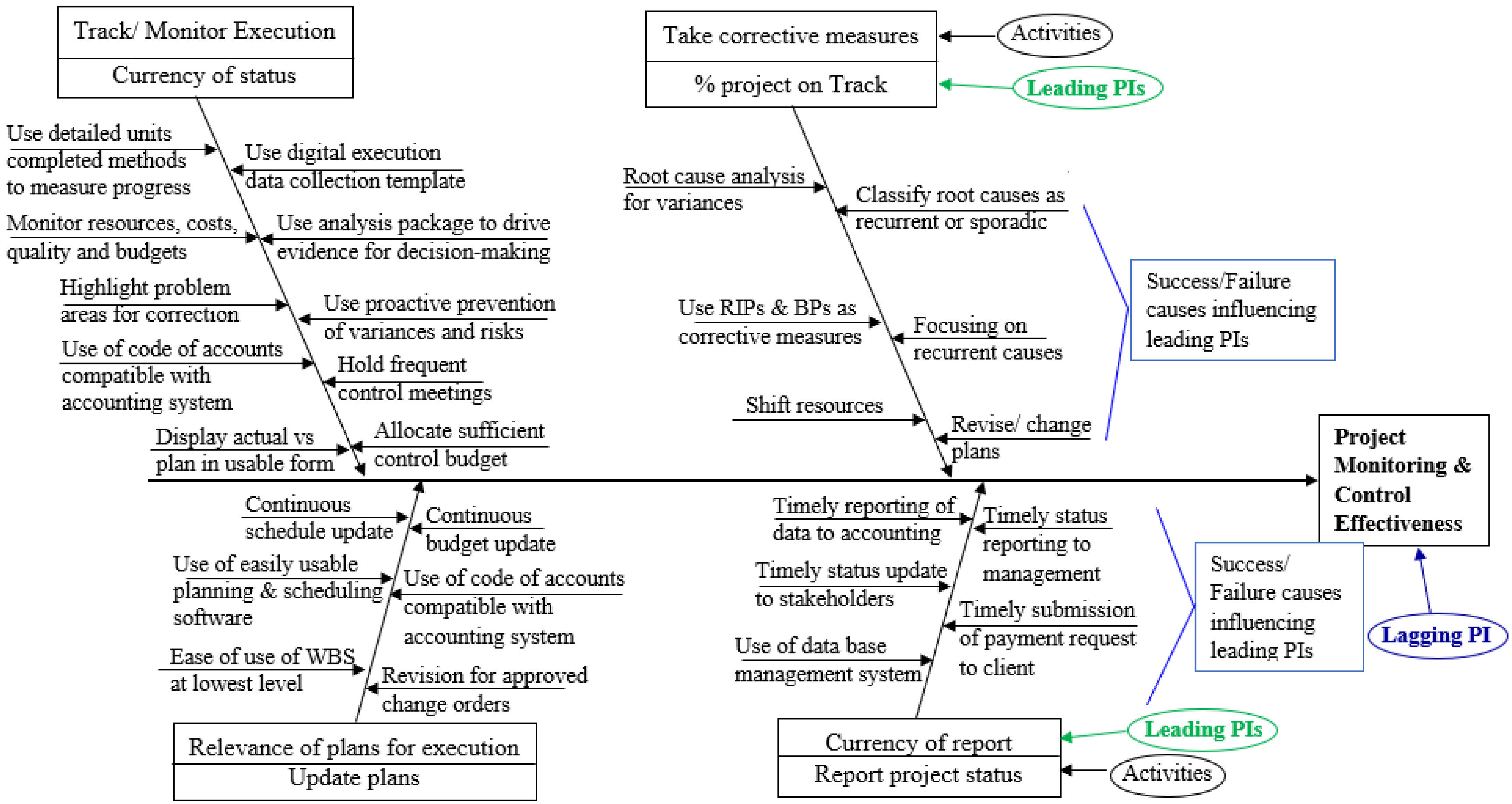


Figure A.42 **Project monitoring and control effectiveness** cause and effect diagram (Source: Developed based on Orgut et. al, 2018, Millhollan, 2008; PMI(PMBOK), 2017).

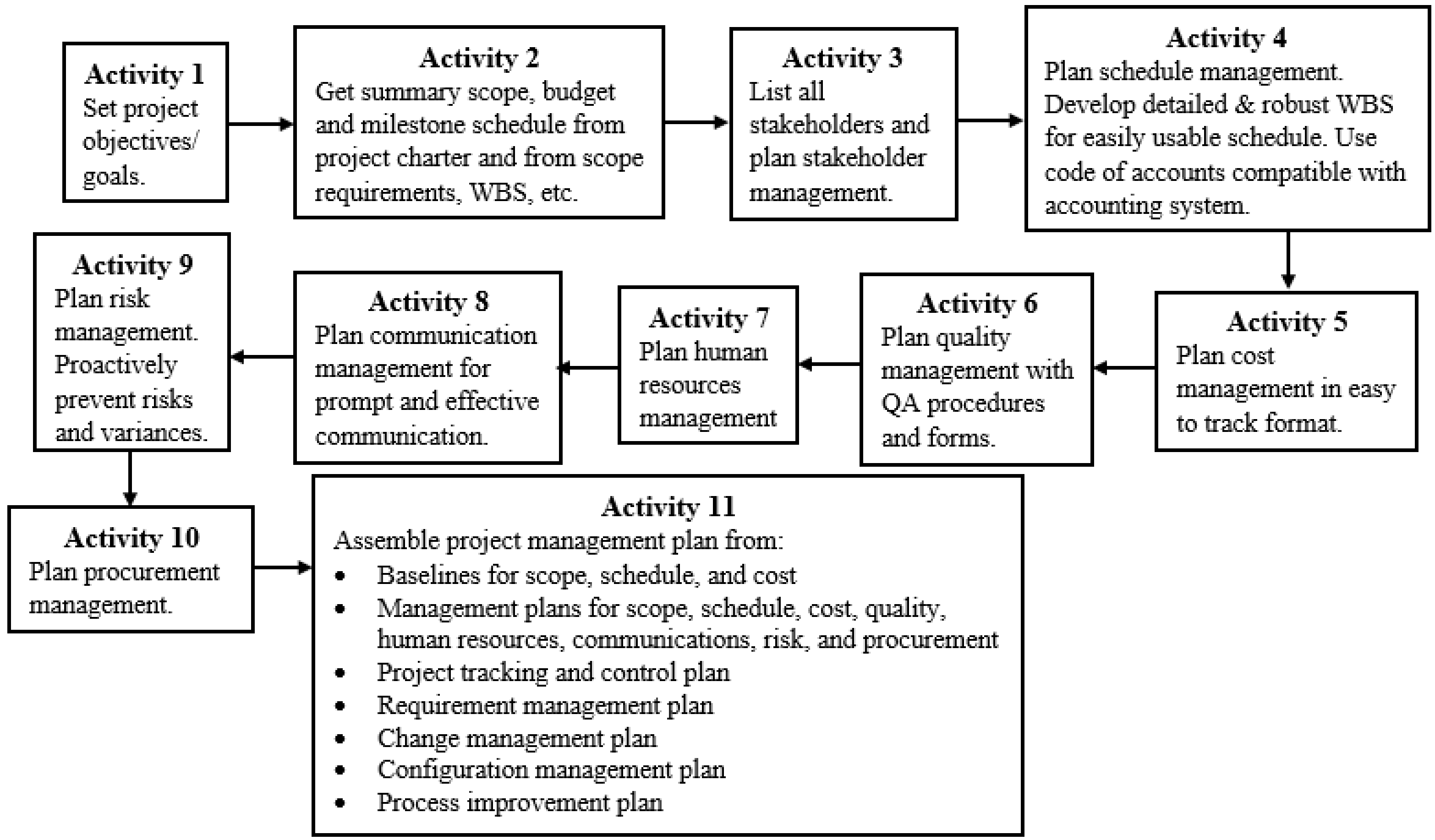


Figure A.43 **Project planning process** flow diagram (Source: Developed based on PMI(PMBOK), 2017; Nasir, 2013; Hendrickson, 2003).

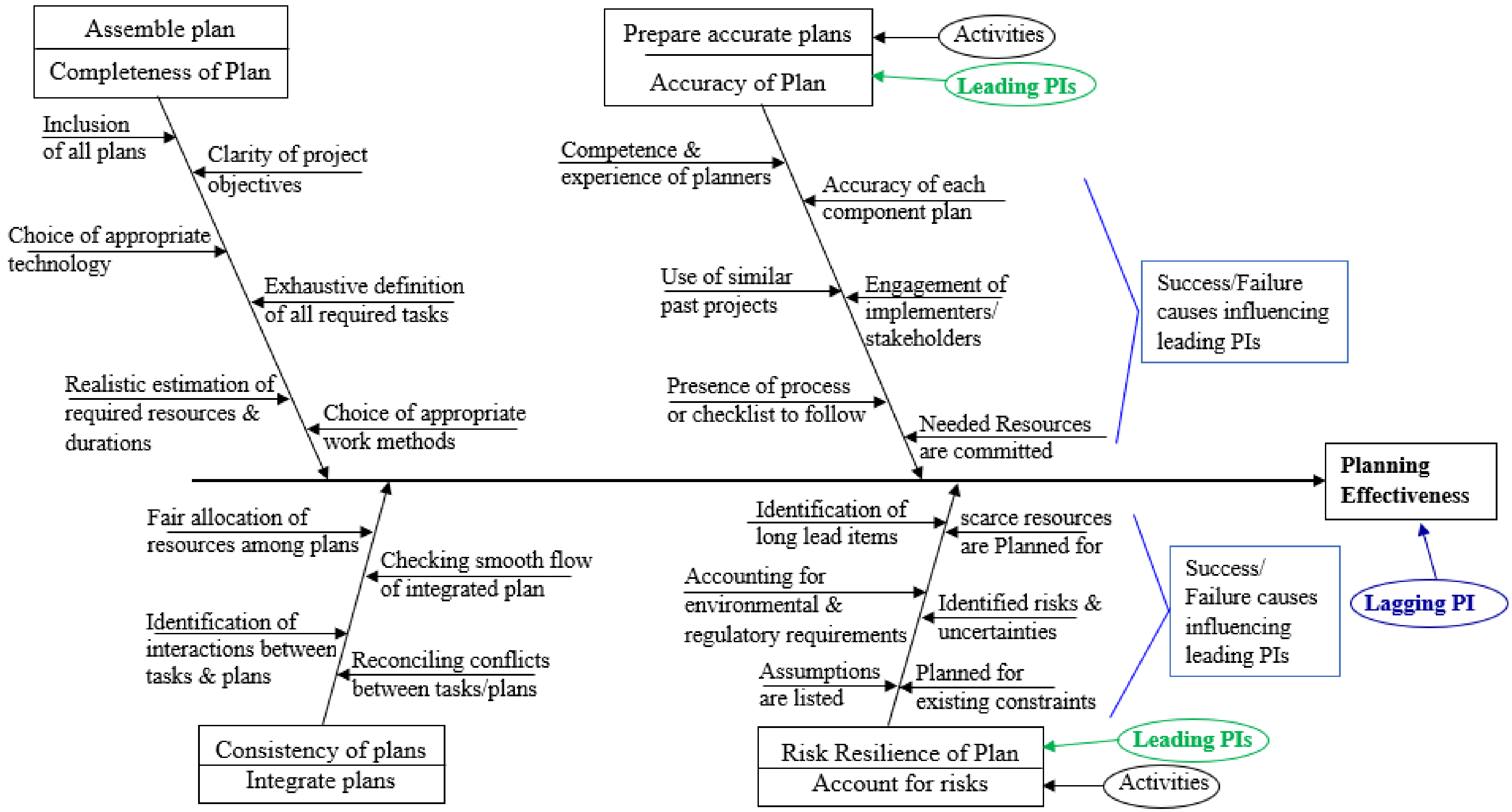


Figure A.44 **Planning effectiveness** cause and effect diagram (Source: Developed based on PMI(PMBOK), 2017; Nasir, 2013; Hendrickson, 2003).

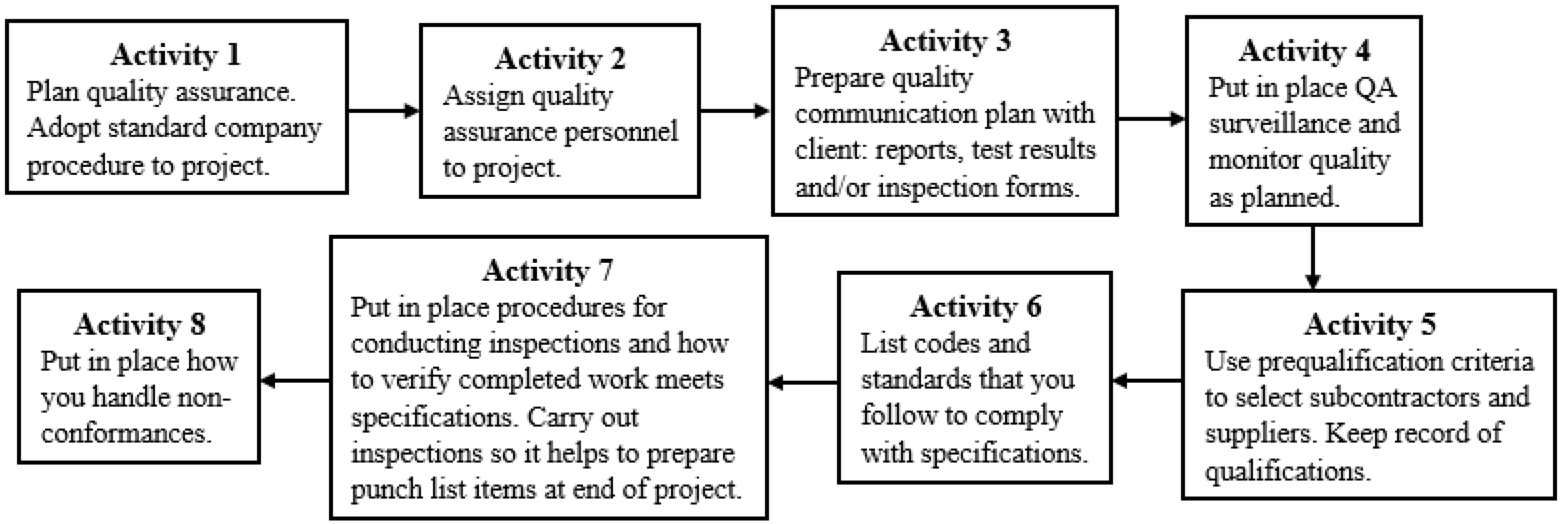


Figure A.45 **Project QA** process flow diagram (Source: Developed based on PMBOK, 2017; Hendrickson, 2003; www.firsttimequality.com/Blog/bid/75546/How-to-Write-a-Construction-Quality-Control-Plan)

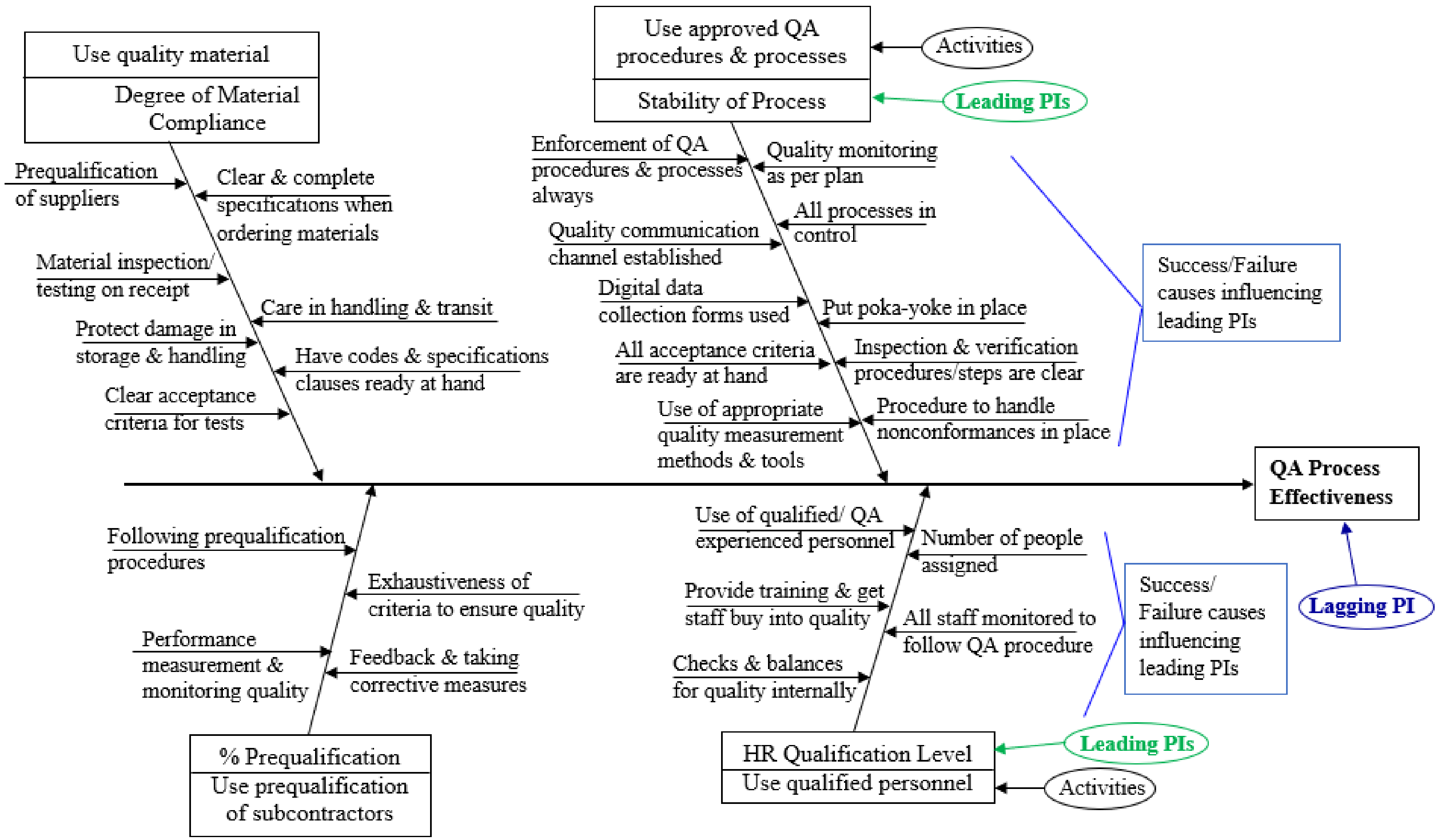


Figure A.46 Project QA effectiveness cause and effect diagram (PMI (PMBOK), 2017; Hendrickson, 2003; www.firsttimequality.com/Blog/bid/75546/How-to-Write-a-Construction-Quality-Control-Plan)

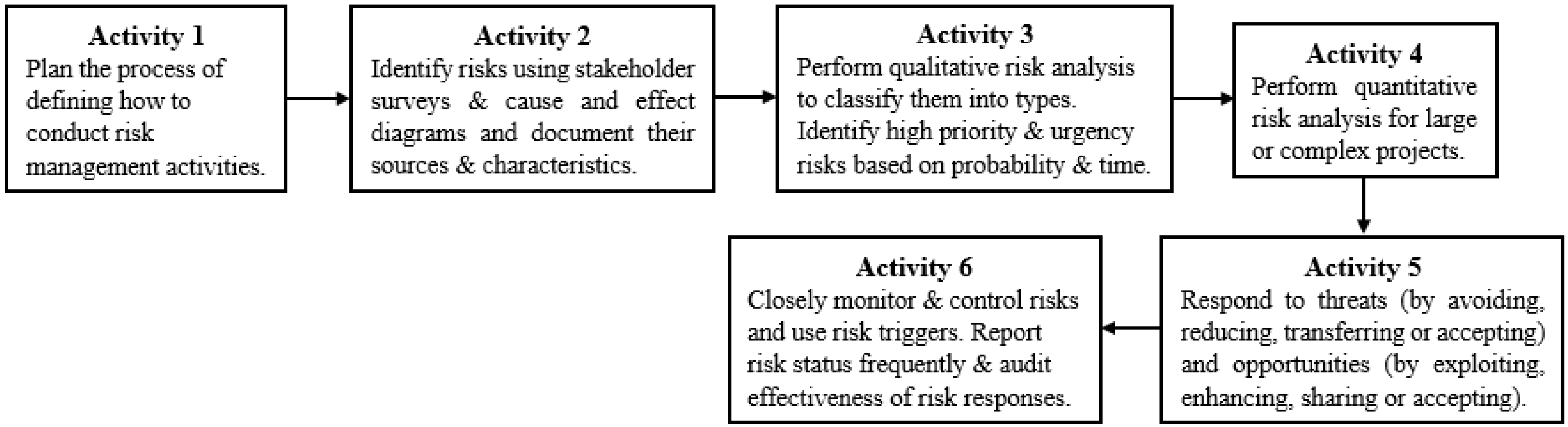


Figure A.47 **Project risk management process** flow diagram (Source: Developed based on PMBOK, 2017).

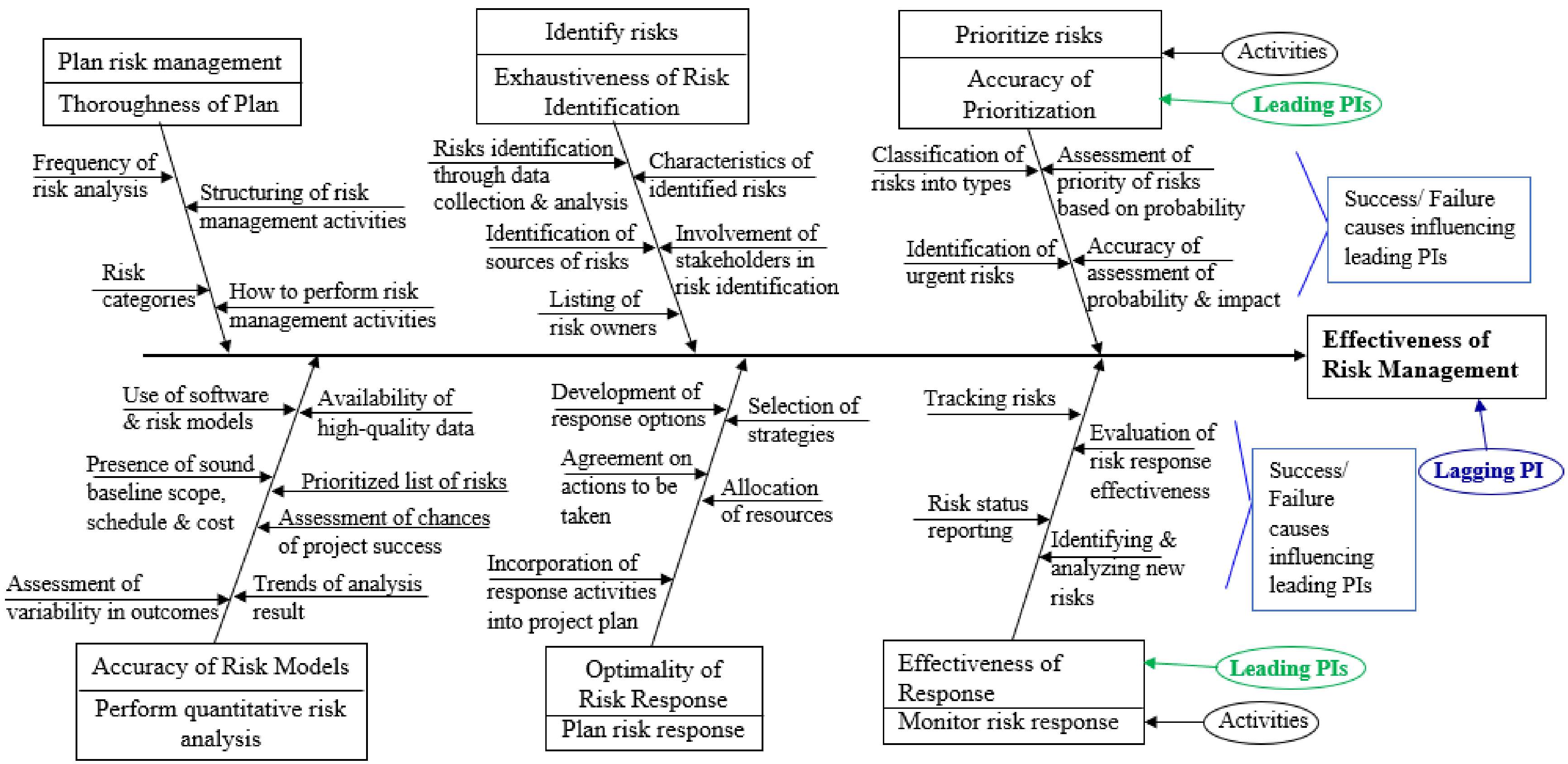


Figure A.48 **Project risk management effectiveness** cause and effect diagram (Source: Developed based on PMI (PMBOK), 2017).

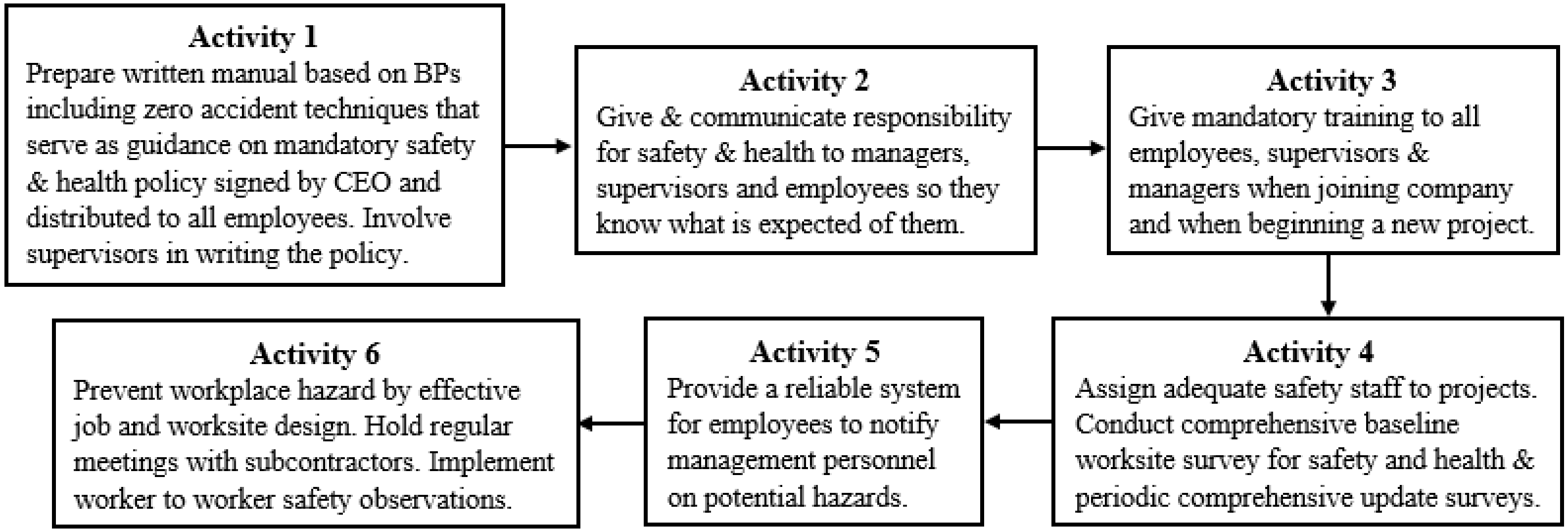


Figure A.49 **Project safety and health management process** flow diagram (Source: Developed based on Hinze et. al, 2013; www.osha.gov 1926 Subpart C; Alruqi et. al, 2019; Construction Industry Institute, 2011).

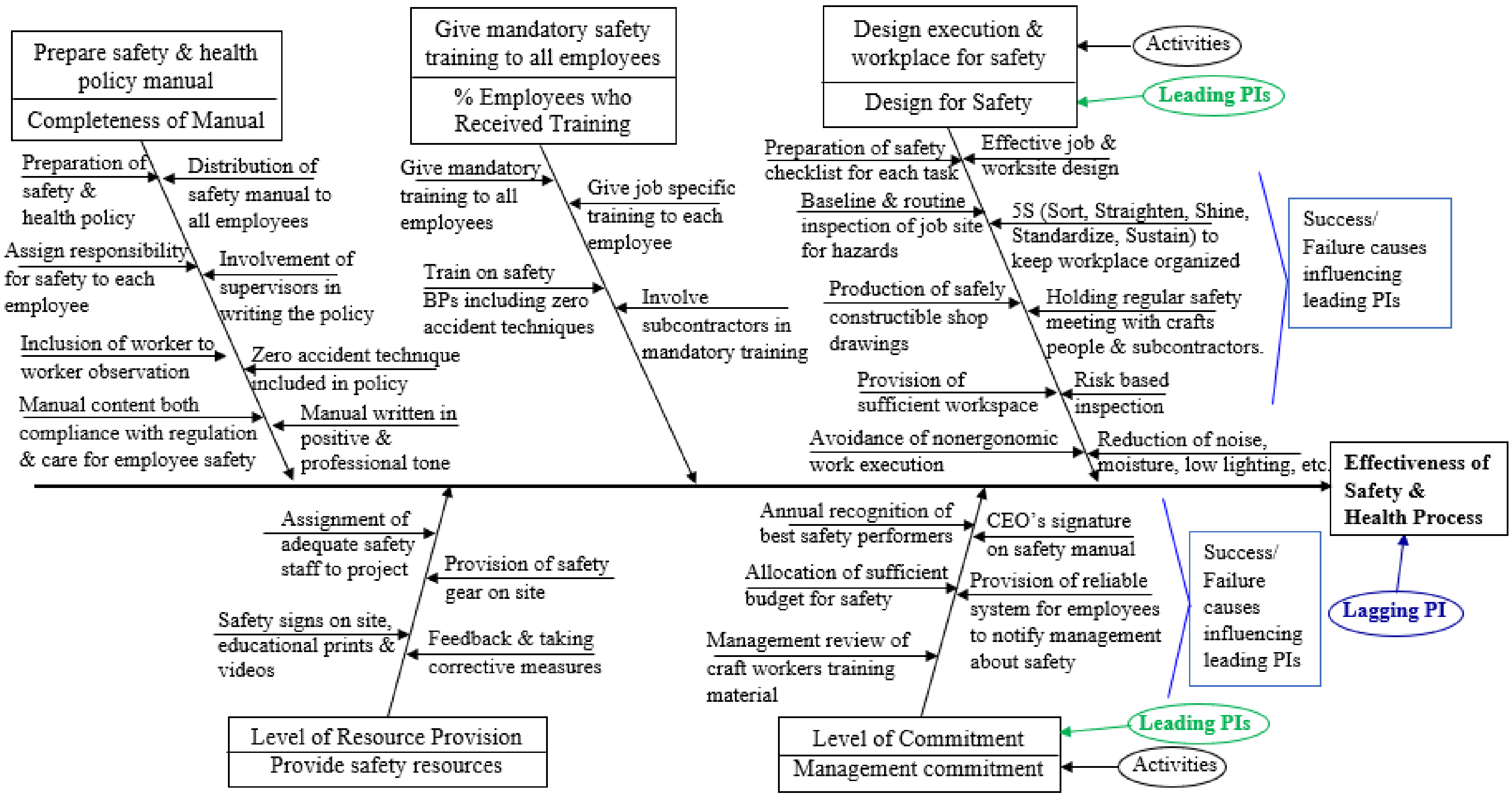


Figure A.50 **Project safety and health management effectiveness** cause and effect diagram (Source: Developed based on Hinze et. al, 2013; www.osha.gov 1926 Subpart C; Alruqi et. al, 2019; Construction Industry Institute, 2011)

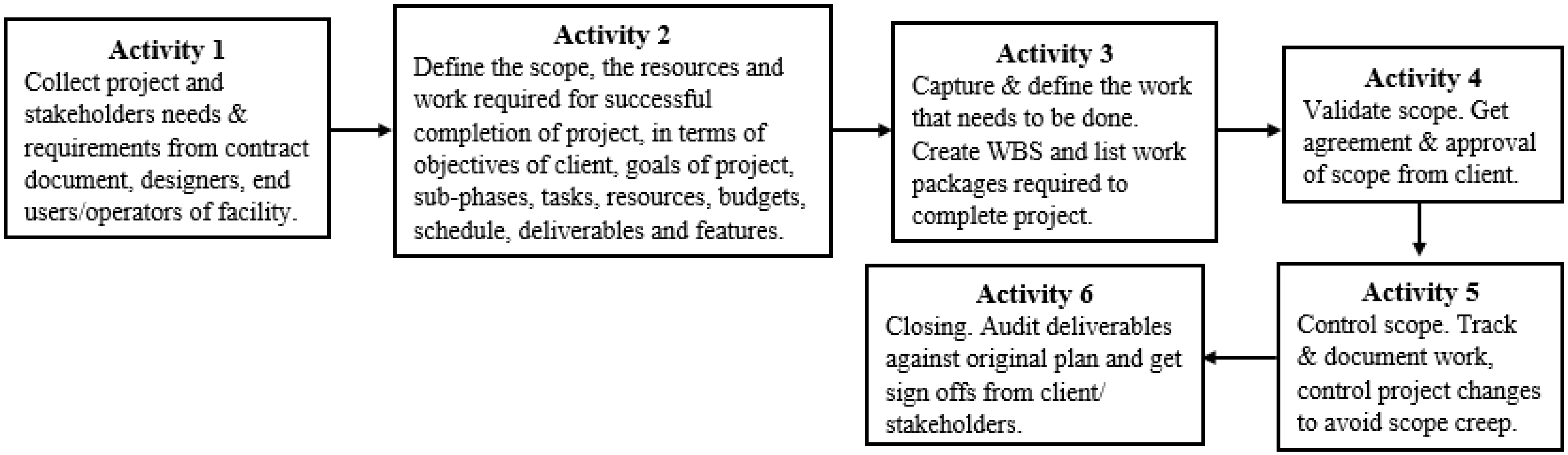


Figure A.51 **Project brief and scope management process** flow diagram (Developed based on Burek, 2006; PMI (PMBOK), 2017).

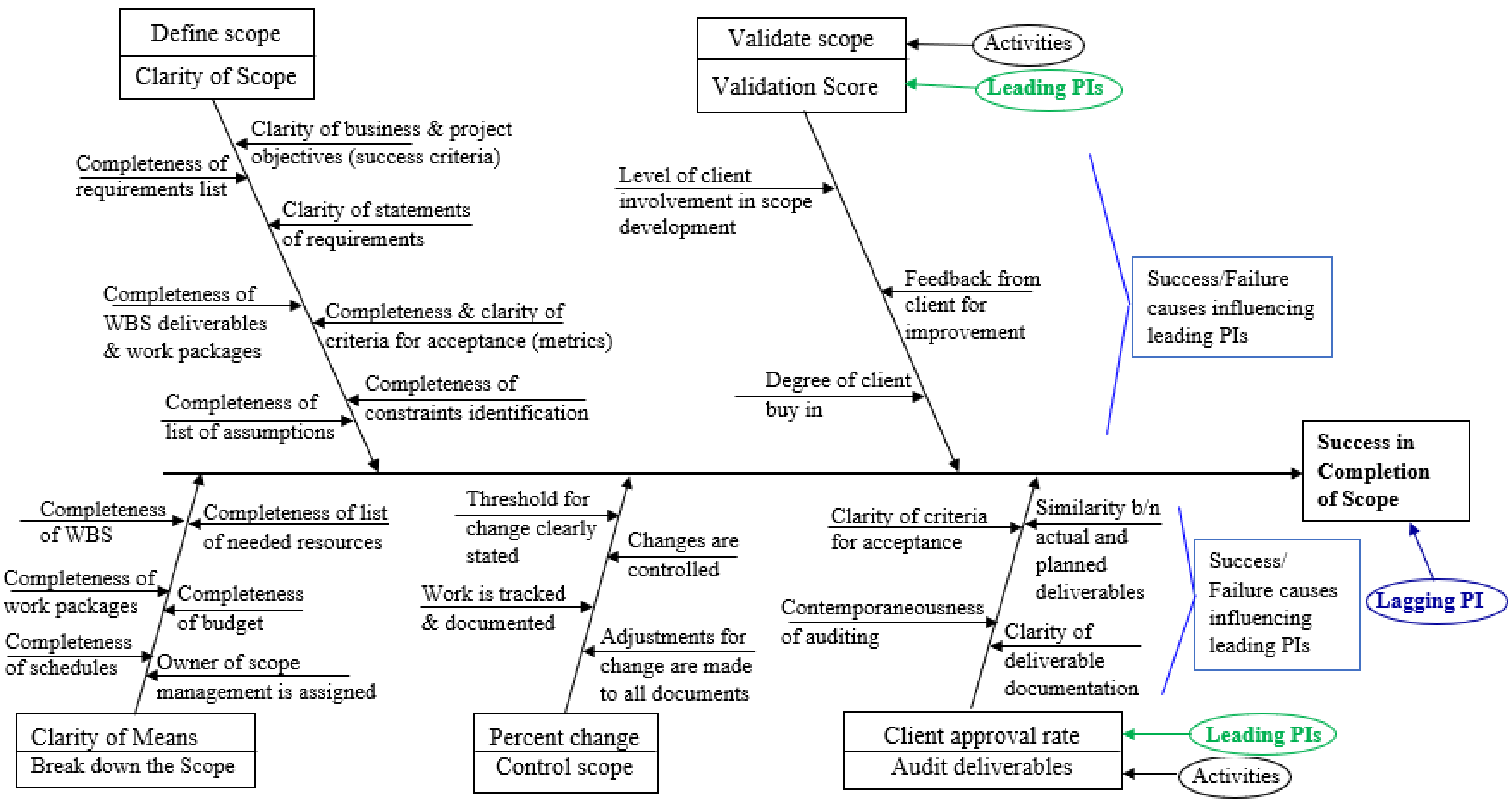


Figure A.52 **Success in scope completion** cause and effect diagram (Source: Developed based on Burek, 2006; PMI (PMBOK), 2017)

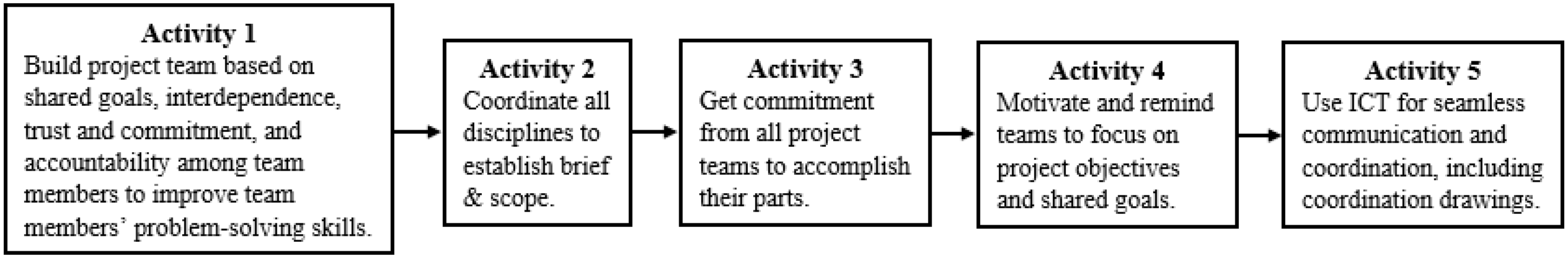


Figure A.53 **Project team coordination & management process** flow diagram (Source: Developed based on (developed based on Wilemon and Thamhain, 1983, Solis et. al, 2013, and Jackson and Madsen, 2004; Construction Industry Institute, 2011).

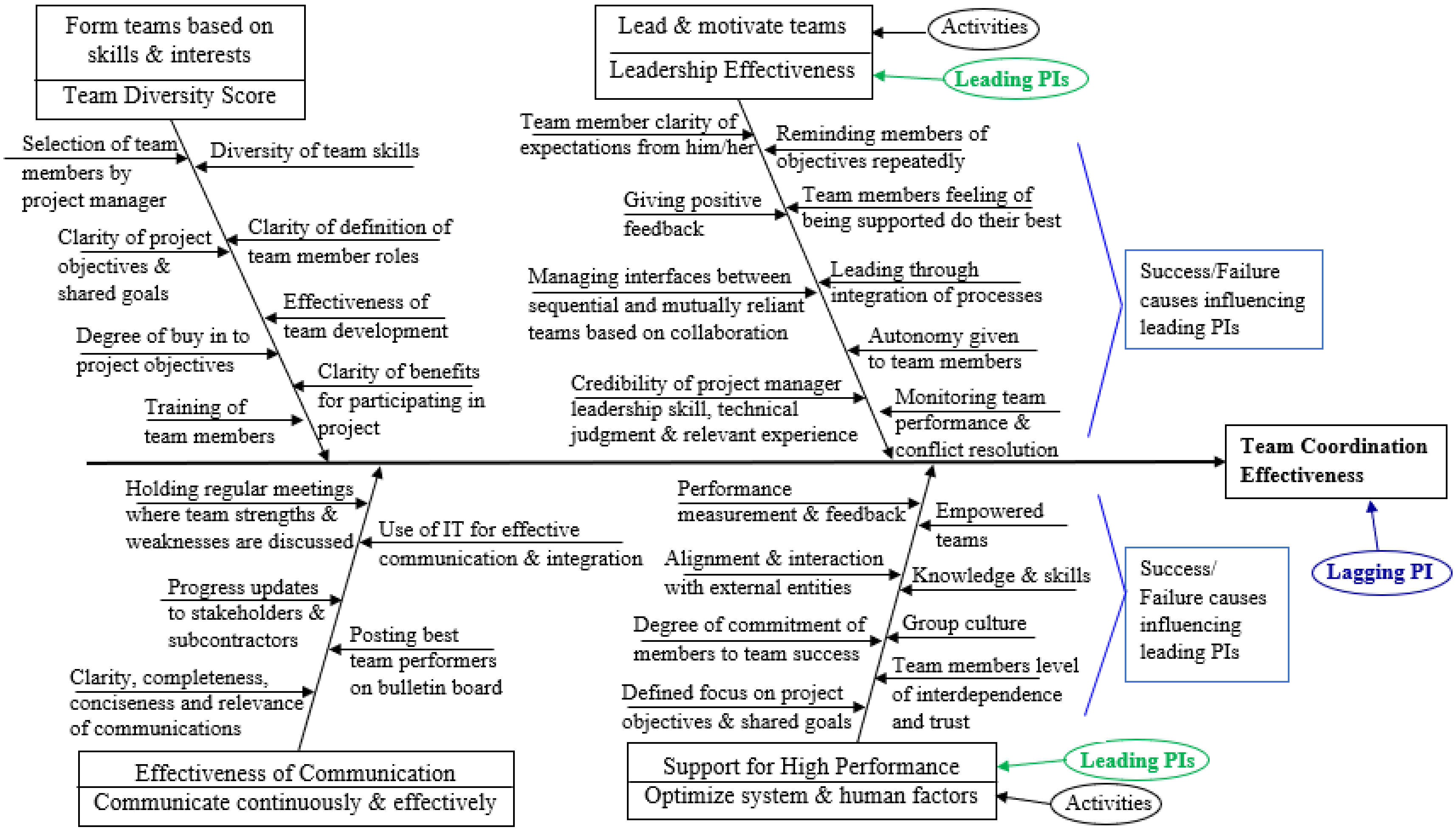


Figure A.54 **Project team coordination and management effectiveness** cause and effect diagram (Source: Developed based on Willemon and Thamhain, 1983, Solis et. al, 2013, and Jackson and Madsen, 2004; Construction Industry Institute, 2011).

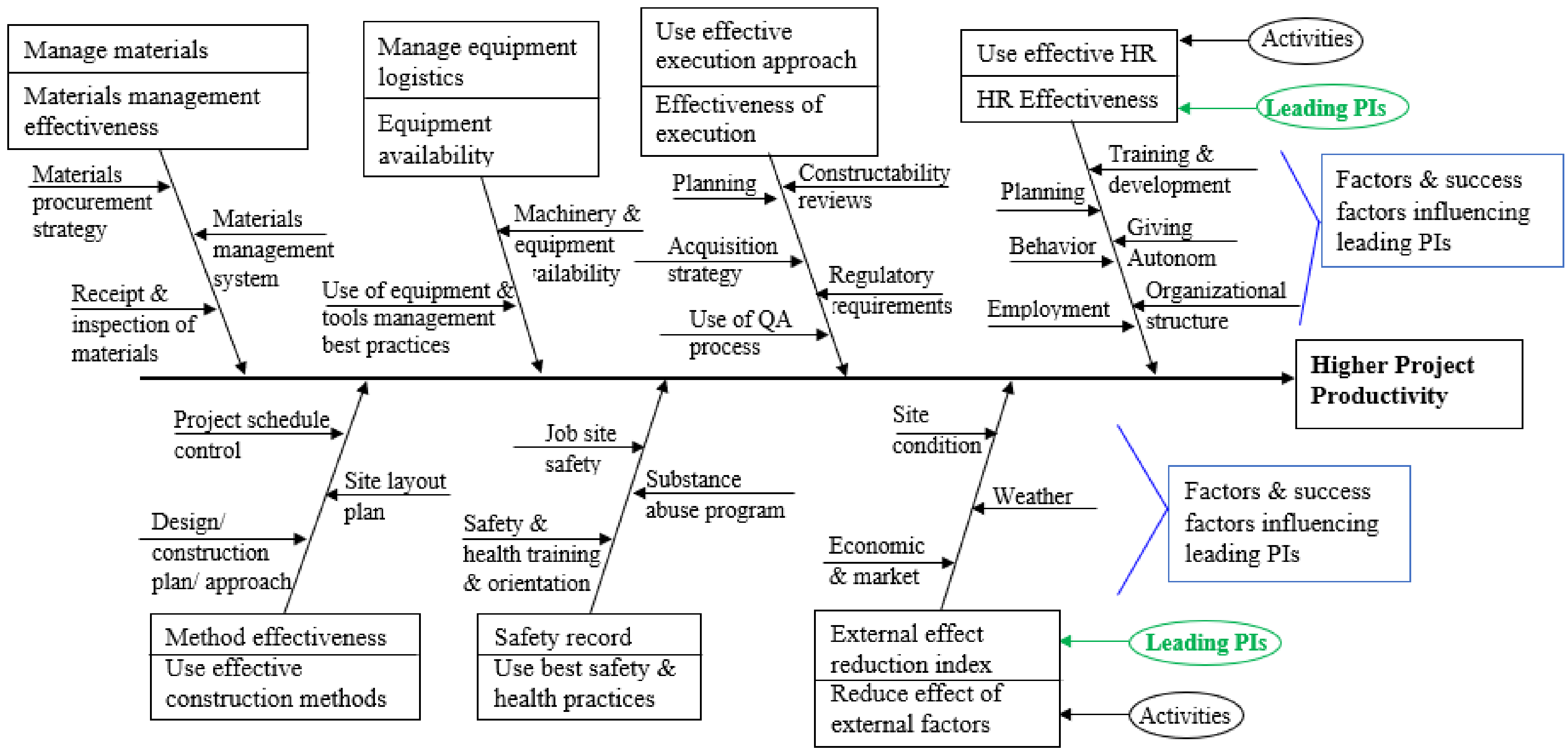


Figure A.55 **Project productivity** cause and effect diagram (Source: Developed based on Nasir et al., 2013).

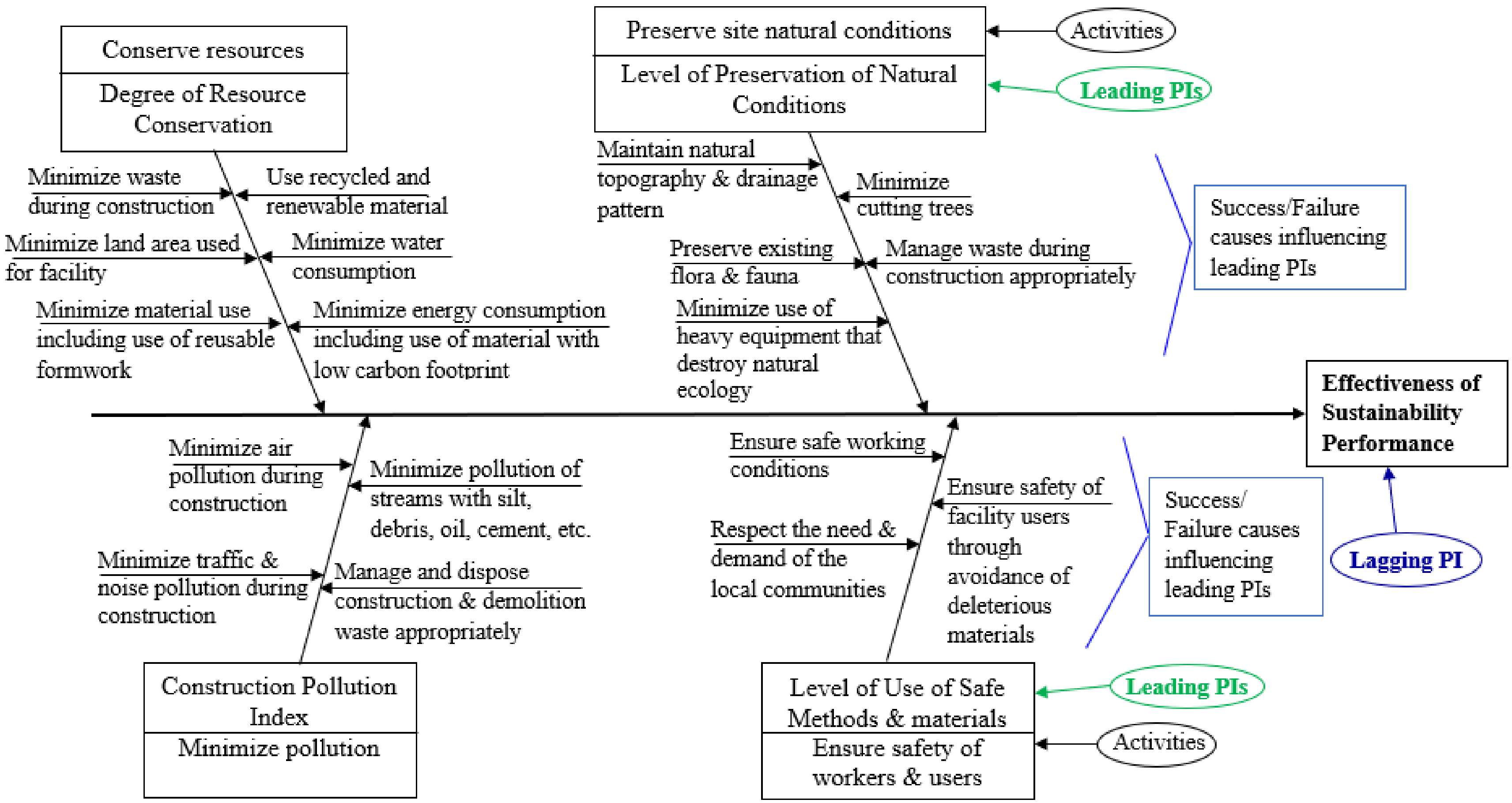


Figure A.56 **Sustainability initiatives** cause and effect diagram (Source: Developed based on Nasir et al., 2013) (Source: Developed based on Sev, 2009; Zutshi et al., 2015; Ochieng et al., 2014)

APPENDIX B CONTINUOUS PLANNING AND SCHEDULING TO OVERCOME VARIABILITY

B.1 Variability in Activity Duration and Chain of Activities on a Path

Constructing projects is the main business of construction companies and therefore, the focus needs to be on projects. In construction projects, planning and scheduling are the high impact interventions to overcome variability and uncertainty (Zwikael and Globerson 2006).

Given the uncertain and sometimes unpredictable nature of construction project environment, planning should be dynamic, continuous and iterative for both long-term and short-term planning. In quantifying impact of interventions, Mahdavi (2016) began with cost loaded CPM baseline schedule and used it with earned value management. The estimated mean duration for each activity in CPM schedule is known, which serves as a starting point for improvement. Through continuous planning and constraint removal, improvement in activity duration can be achieved from productivity rates under different conditions. The author believes planning and scheduling needs to be done continuously to overcome variability and uncertainty, and hence will begin with baseline schedule in his effort to analyze schedule and cost through simulation.

While simplicity to use CPM made it popular, PERT has been seldom used and in very special cases (Lee, 2005). CPM uses a single estimate for activity duration, which is the mean activity duration. However, this causes problems due to randomness and stochastic nature of activity durations in construction. PERT is better in this regard because it accounts for this randomness by using three-time estimates: optimistic, most likely and pessimistic estimates. In CPM, use of the mean activity durations means that the probability of completion of each activity is 0.5 (Lee, 2005). Dependence between chain of activities in a schedule network path adds to this uncertainty in activity durations and the resulting total project duration for a CPM critical chain of activities will have a very low probability of being attained. Some scheduling software allow carrying out Monte Carlo simulation to determine total project duration and probability of project completion (Lee, 2005; Mahdavi, 2016). AbouRizk and Halpin determined that construction activity durations have beta distribution (AbouRizk and Halpin, 1992). Simulation software make one crude assumption about probability distribution of total project duration, which is the assumption of normal distribution Lee (2010). Lee (2005, 2010) developed simulation program and showed that it is in rare cases that the total project duration is normally distributed.

One very useful information that Lee et. al (2012) used in their investigation is that the coefficient of variation of activity duration is about 20%. They took this value based on Ang and Tang's work (1975). This assumption explicates the problem with lack of three activity time estimates for a beta distribution the author was struggling with when used with Shankar and Siresha's (2009) modification to classical PERT given below with optimistic time estimate (a), most likely time (b) and pessimistic time estimate (c). Therefore, the author will use CPM activity durations with a 20% coefficient of variation to get activity duration parameters for beta distribution of each activity.

$$Mean\ duration, \mu = \frac{5a+17b+5c}{27} \quad . \quad . \quad . \quad . \qquad (5.1)$$

$$Variance, \sigma^2 = \frac{(17b-27a+10)(27c-10a-17b)}{2300} \quad . \quad . \quad . \qquad (5.2)$$

Result from analysis of many projects showed that

$$b = \frac{2a+c}{3} \quad . \quad . \quad . \quad . \quad . \qquad (5.3)$$

Substitution of Equation 5.3 into Equations 5.1 and 5.2 gives

$$\mu = \frac{59a+42c}{135} \quad . \quad . \quad . \quad . \quad . \qquad (5.4)$$

$$Standard\ deviation,\ \sigma = \frac{c-a}{\sqrt{35}} \quad . \quad . \quad . \quad . \qquad (5.5)$$

PERT beta shape parameters α and β are

$$\alpha = \frac{4b+c-5a}{c-a} \quad . \quad . \quad . \quad . \quad . \qquad (5.6)$$

$$\beta = \frac{5c-a-4b}{c-a} \quad . \quad . \quad . \quad . \quad . \qquad (5.7)$$

$$COV = \frac{\sigma}{\mu} = 0.2 \quad . \quad . \quad . \quad . \quad . \qquad (5.8)$$

Using Equation 5.8 with Equations 5.4 to 5.8 gives

$$a = 0.8446\mu, \quad c = 2.0278\mu, \quad \alpha = 2.33\ and\ \beta = 3.67$$

These will be used in CPM schedule simulation in Section 5.3. Next, will be discussed CPM algorithm that help write CPM schedule needed for schedule simulation.

B.2 Critical Path Scheduling Computation Algorithms

The deterministic formulas that will be used for simulation are critical path scheduling formulas and cost computed based on the schedule. Assuming an activity on arrow network and finish to start precedence, for a project with n+1 nodes (events) the initial event numbered 0 and the last event n. Assuming the time at which node events occur to be t_1, t_2, . . ., t_n respectively. t_0=0. For an activity starting at event (node) i and ending at event j having a duration of D_{ij}, the following inequality constraint holds (Hendrickson, 2003)

$$t_j \geq t_i + D_{ij} \qquad . \quad . \quad . \quad . \quad . \quad . \qquad (5.9)$$

This relationship can be written for each activity, and must hold true for any schedule that is feasible.

Mathematically, the critical path scheduling problem is then to minimize the time of project completion, tn subject to the constraints that each completion event of each node cannot occur until each of the predecessor activities have been completed:

$$\textbf{Minimize} \quad z = t_n \qquad . \quad . \quad . \quad . \qquad (5.10)$$

$$\textbf{Subject to} \quad t_0 = 0 \qquad . \quad . \quad . \quad . \qquad (5.11)$$

$$t_i - t_j - D_{ij} \geq 0 \quad \text{for each activity (i, j)} \qquad . \quad . \qquad (5.12)$$

Equations 5.10 to 5.12 (the objective function and each of the constraints) are linear equations and therefore the problem is a linear programming problem.

More efficient techniques than a linear programming algorithm (such as the simplex method) can be used for the solution of the problem taking advantage of the network structure of the problem. The efficient solution process uses the following algorithms based on the node labeling given above.

Table B-1 Critical Path Scheduling Algorithms (Activity-on-Arrow Representation)

Event Numbering Algorithm
Step 1: Give the starting event number 0. *Step 2*: Give the next number to any unnumbered event whose predecessor events are each already numbered. Repeat Step 2 until all events are numbered.
Earliest Event Time Algorithm
Step 1: Let E(0) = 0. *Step 2*: For j = 1,2,3,...,n (where n is the last event), let $E(j) = \text{maximum}\ \{E(i) + D_{ij}\}$ where the maximum is computed over all activities (i,j) that have j as the ending event.
Latest Event Time Algorithm
Step 1: Let L(n) equal the required completion time of the project. Note: L(n) must equal or exceed E(n). *Step 2*: For i = n-1, n-2, ..., 0, let $L(i) = \text{minimum}\ \{L(j) - D_{ij}\}$ where the minimum is computed over all activities (i,j) that have i as the starting event.

The earliest start (ES) time for each activity (i, j) is equal to the earliest possible time for the preceding event E(i).

$$ES(i, j) = E(i) \quad . \quad . \quad . \qquad (5.13)$$

The earliest finish(EF) time for each activity (i, j) can be calculated by.

$$EF(i, j) = E(i) + D_{ij} \quad . \quad . \qquad (5.14)$$

The latest finish time consistent with the completion of the project in the desired time frame L(n) is equal to the latest possible time L(j) for the succeeding event:

$$LF(i, j) = L(j) \quad . \quad . \quad . \quad . \qquad (5.15)$$

The earliest finish time for each activity (i, j) can be calculated by.

$$LS(i, j) = L(j) - D_{ij} \quad . \quad . \quad . \qquad (5.16)$$

Activities are identified in this algorithm by the predecessor node (event) i and the successor node j. The algorithm simply requires that each event in the network should be examined in turn beginning with the project start (node 0).

An activity (i, j) is critical if it satisfies all of the following conditions:

$$E(i) = L(i) \quad . \quad . \quad . \quad . \qquad (5.17)$$

$$E(j) = L(j) \quad . \quad . \quad . \quad . \qquad (5.18)$$

$$E(i) + D_{ij} = L(j) \quad . \quad . \quad . \quad . \quad (5.19)$$

$$ES(i, j) = LS(i, j) \quad . \quad . \quad . \quad . \quad (5.20)$$

$$EF(i, j) = LF(i, j) \quad . \quad . \quad . \quad . \quad (5.21)$$

Float is very valuable since it represents schedule flexibility or available maneuvering room. Activities on critical path are rigid. Free float (FF) is the time delay which can be assigned to any activity without delaying subsequent activities, which is obtained for activity (i, j) from Equation 5.22

$$FF(i, j) = E(j) - E(i) - D(i, j) \quad . \quad . \quad (5.22)$$

Independent float (IF) is the amount of delay which can be assigned to any one activity without delaying subsequent activities or restricting the scheduling of preceding activities. IF(i, j) for activity (i, j) can be obtained from

$$IF(i, j) = \{ 0 \quad \text{or} \quad E(j) - L(j) - D_{ij} \quad . \quad . \quad (5.23)$$

Total float (TF) is the maximum amount of delay which can be assigned to any activity without delaying the entire project.

$$TF(i, j) = L(j) - E(i) - D(i, j) \quad . \quad . \quad . \quad (5.24)$$

Any activity on the critical path has all three values of float equal to zero. The converse is also true, any activity with zero total float is on a critical path.

Time and activity graphs are extremely useful in portraying the current status of a project as well as the existence of activity float while monitoring projects (Figure 5.1). Adeli and Karim give such a progress plot for linear facilities projects with repetitive tasks like highway projects as shown in Figure 5.2.

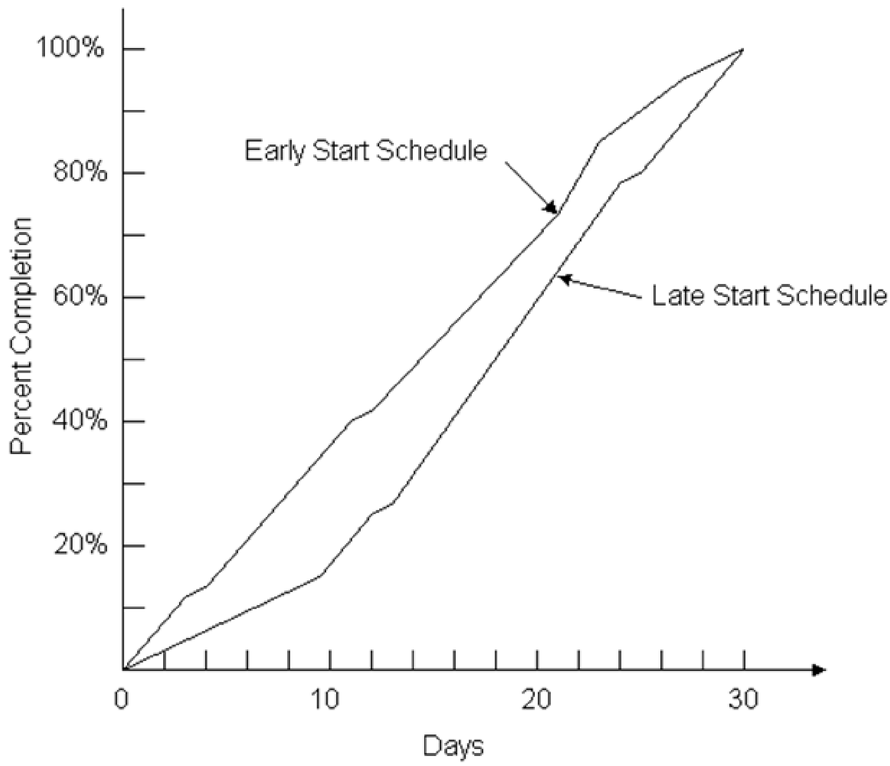


Figure B.1 Percentage Completion versus Time for Alternative Schedules

(Source: Hendrickson, 2003)

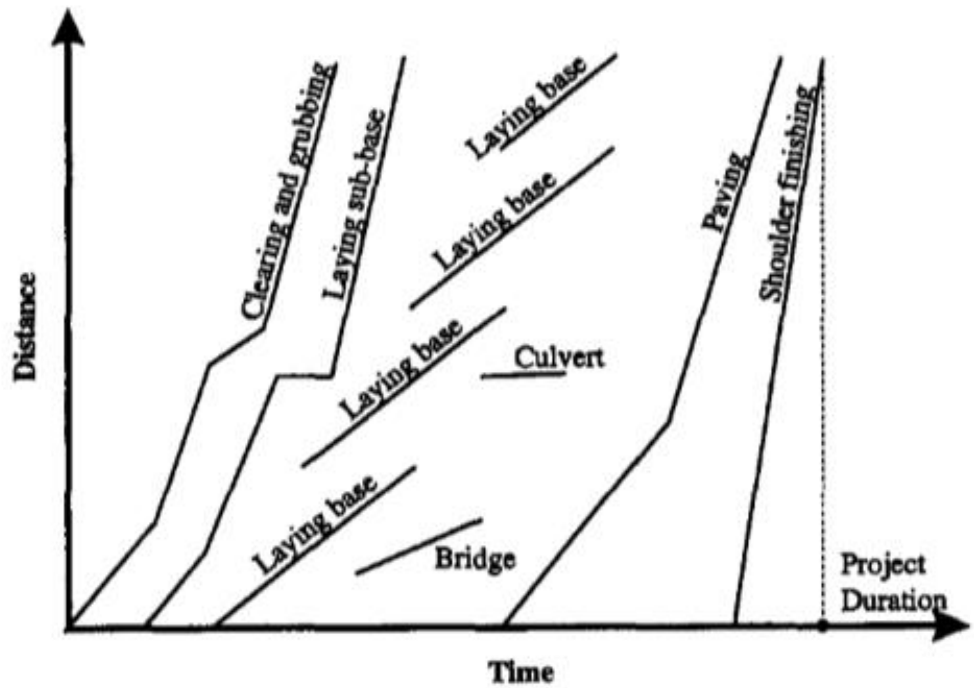


Figure B.2 Linear Planning Chart
(Source: Adeli and Karim, 1997)

B.3 Scheduling with Uncertain Durations

Unfortunately, durations of activities are estimates of the actual time required to complete activities and they are liable to a significant amount of uncertainty (Hendrickson, 2003). Two simple approaches have been in use to deal with activity duration uncertainties. The first one is ignoring the uncertainty and treating activity durations as deterministic. The second is application of heuristic contingency factor in the vicinity of 10% to each activity duration (Hendrickson, 2003). This may result in more accurate schedules but formal scheduling methods that incorporate uncertainty more formally are useful as a means of obtaining greater accuracy or in understanding the effects of delays.

The most common formal approach to incorporate uncertainty in the scheduling process is to prepare CPM schedule with one activity duration (the expected time) for each activity and then analyze the results from probabilistic perspective. This process is referred to as the PERT evaluation method. While the PERT method is widely available, it suffers from three major shortcomings. The first is that it focuses on a single critical path whereas many paths may become critical due to randomness of activity durations. Hence, the PERT method underestimates the actual project durations. The second is that independence of activity durations is assumed whereas, in many cases the activity durations have correlations (Hendrickson, 2003). Therefore, PERT underestimates variance of the critical path and gives over-optimistic estimate of meeting a project deadline. The third is that PERT requires three-time estimates which makes the labor to estimate activity durations three-fold.

An alternative to PERT is to use a straightforward Monte Carlo simulation, which uses sets of artificial but realistic activity durations and then apply deterministic scheduling procedure to each set of durations. This is the procedure that is used in this research. Beta distribution of activity durations is assigned to each activity duration from which artificial activity durations are generated by random number generator.

B.4 Simulation of Schedule and Cost for Baseline Schedule

The discussions thus far in this chapter will be put together to begin with a baseline schedule and to simulate schedule and cost. Monte carlo simulation will be used and random numbers following beta distribution are generated.

Information for a simple sports facility project with twelve activities is given in Table 5.1. The indirect cost is assumed 10% of the direct cost (indirect cost=$394/day).

Table B-2 Sports facility project baseline information

Activity	**Activity Description**	**Duration (days)**	**Predecessor**	**Activity Cost ($)**
A	Mobilize	2	-	7,880
B	Stock materials	4	A	29,200
C	Clearing and grubbing	6	A	12,320
D	Grading for road	7	A	12,580
E	Finish grade	5	B, C	17,400
F	Prefab bleachers	16	B	35,280
G	Landscape	12	B, C	55,280
H	Pave roadway	8	D	44,400
I	Place tennis court	10	E	48,800
J	Erect/paint bleachers	7	C, F	36,160
K	Curbing	5	G, H	15,000
L	Final inspection/cleanup	3	I, J, K	8,320

(Source: Hinze, 2012)

Table B-3 CPM schedule and cost computation

Activity	Mean Duration (days)	Minimum duration, a	Maximum duration, c	Random, beta curve	Predec. Activity	Activity Cost ($)	Direct Cost/day ($/day)	Early Start (ES)	Early Finish (EF)	Successor Activity (SA)	Late Start (LS)	Late Finish (LF)	Direct Activity Cost ($)
A	2.00	1.6892	4.0556	2.6192	--	7880	3940	0.00	2.62	B	0.00	2.62	10319.60
B	4.00	3.3784	8.1113	4.3365	A	29,200	3940	2.62	6.96	E, F, G	2.62	6.96	17085.86
C	6.00	5.0676	12.1669	7.0733	A	12320	3940	2.62	9.69	E, G, J	4.34	11.41	27868.90
D	7.00	5.9122	14.1947	7.4296	A	12580	3940	2.62	10.05	H	11.33	18.76	29272.43
E	5.00	4.2230	10.1391	6.4649	B, C	17400	3940	9.69	16.16	I	15.19	21.65	25471.53
F	16.00	13.5136	32.4451	16.9851	B	35280	3940	6.96	23.94	J	6.96	23.94	66921.39
G	12.00	10.1352	24.3338	15.1671	B, C	55280	3940	9.69	24.86	K	11.41	26.58	59758.20
H	8.00	6.7568	16.2226	7.8243	D	44400	3940	10.05	17.87	K	18.76	26.58	30827.92
I	10.00	8.4460	20.2782	10.5778	E	48800	3940	16.16	26.74	L	21.65	32.23	41676.57
J	7.00	5.9122	14.1947	8.2909	C, F	36160	3940	23.94	32.23	L	23.94	32.23	32666.00
K	5.00	4.2230	10.1391	5.6496	G, H	15000	3940	24.86	30.51	L	26.58	32.23	22259.58
L	3.00	2.5338	6.0835	4.3700	I, J, K	8320	3940	32.23	36.60	--	32.23	36.60	17217.79
	28	23.6488	56.77896	35.02177	Total	**322620**		**Project Duration=**	**36.60**			**Total Direct Cost =**	**381345.77**
												Grand Total Cost =	**395766.83**

The project duration and total cost for the CPM schedule are 28 days and $333, 652 respectively assuming fixed durations (mean activity times).

Monte Carlo simulation is run for project duration and total project cost for stochastic time randomly generated for beta distributions. The results are given in Figures 5.3 through Figure 5.6 for different number of iterations.

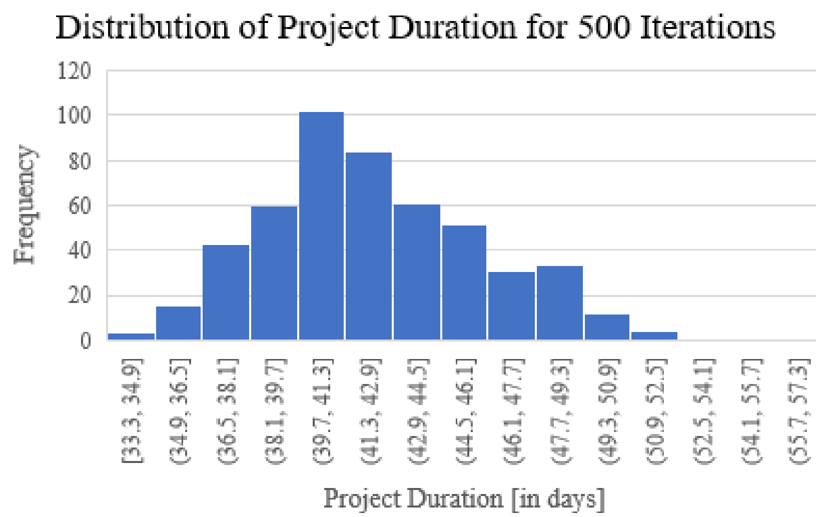


Figure B.3 Histogram showing distribution of project duration for 500 iterations

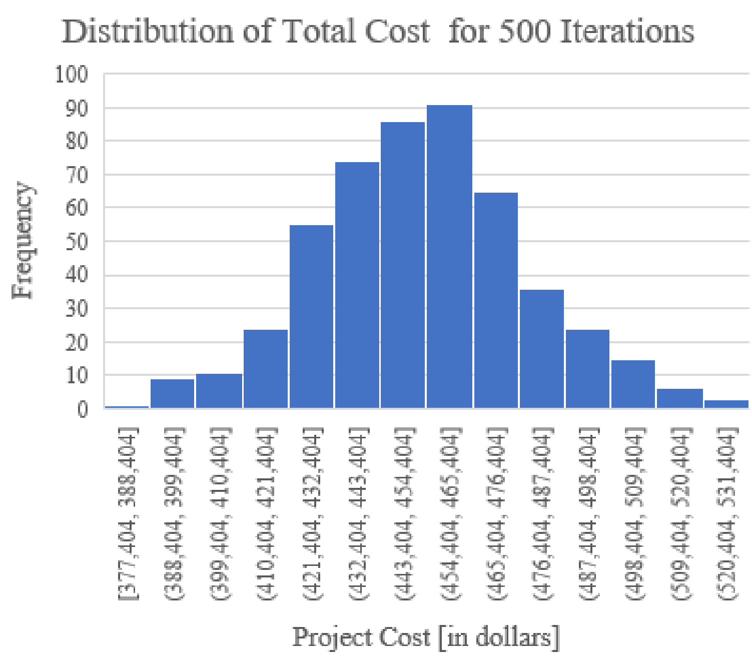


Figure B.4 Histogram showing distribution of project cost for 500 iterations

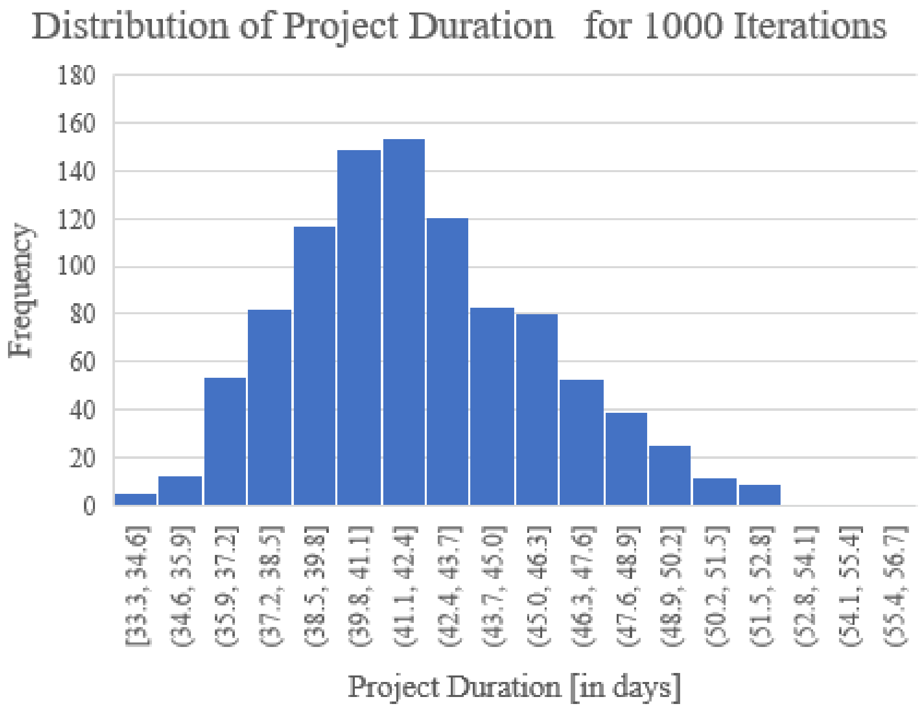


Figure B.5 Histogram showing distribution of project duration for 1000 iterations

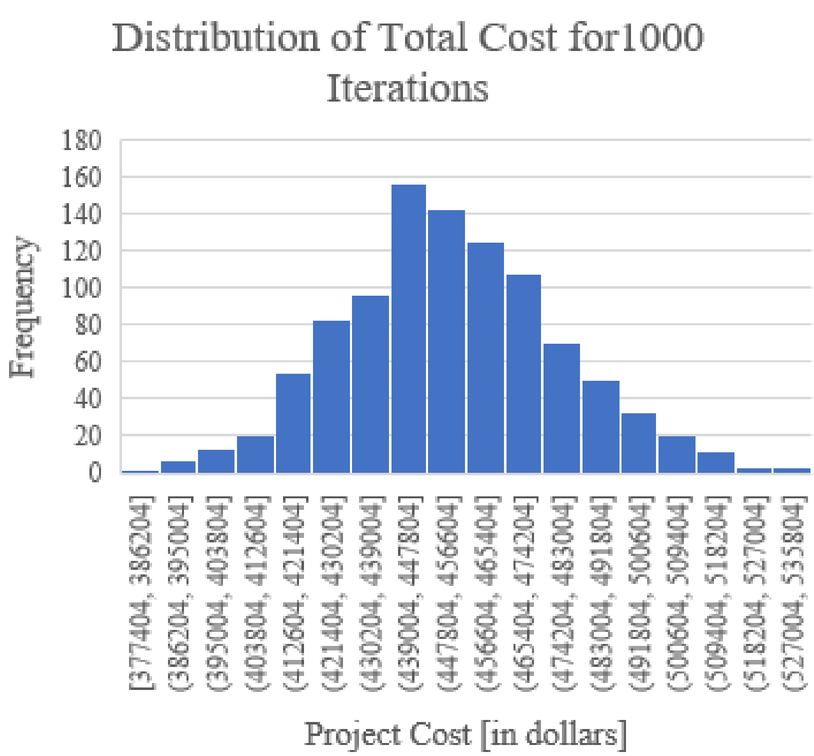


Figure B.6 Histogram showing distribution of project cost for 1000 iterations

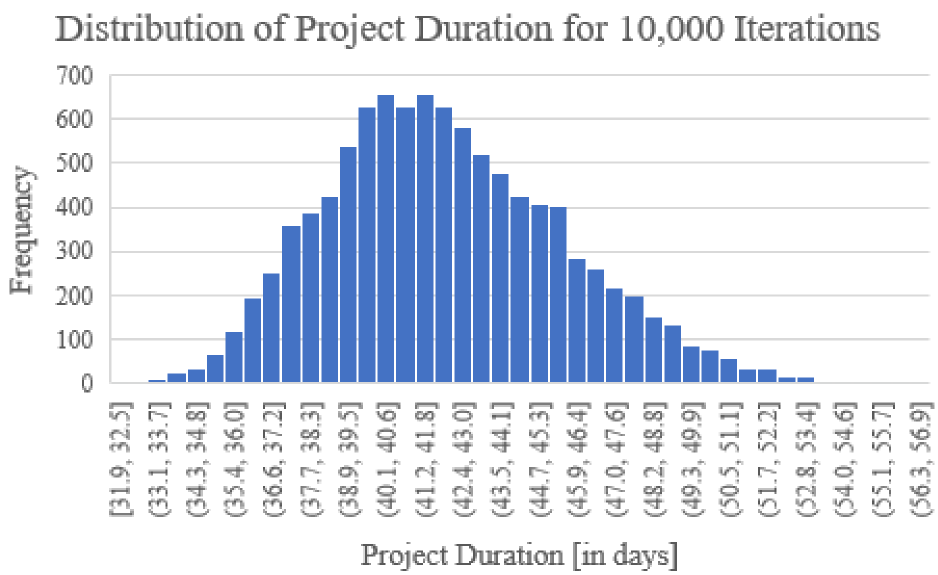


Figure B.7 Histogram showing distribution of project duration for 10000 iterations

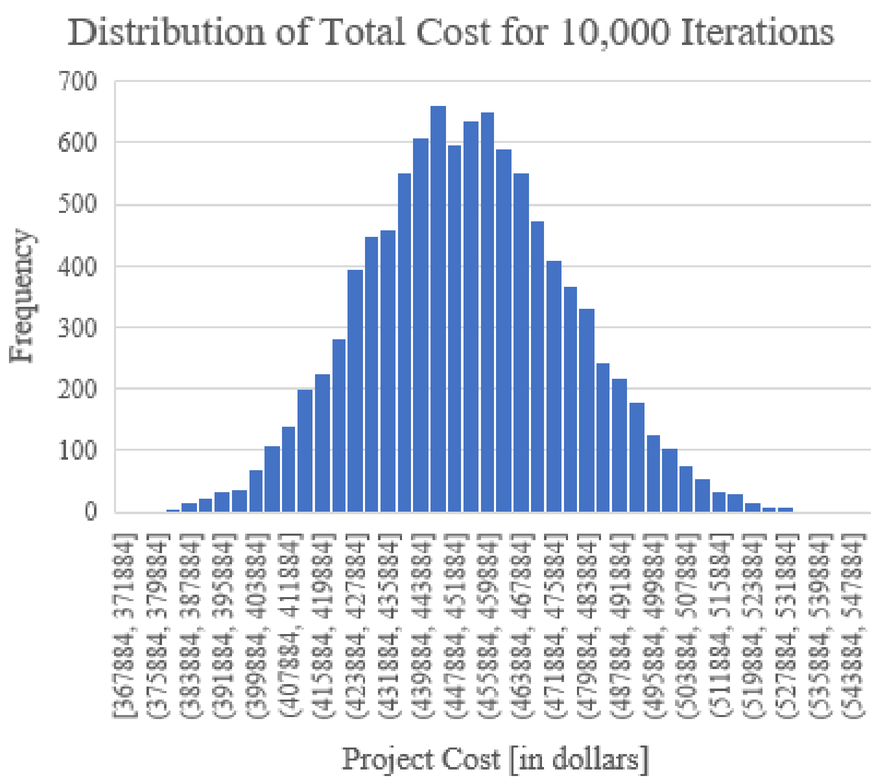


Figure B.8 Histogram showing distribution of project total cost for 10000 iterations

The area at the left of a given time value under the project duration histogram gives the probability of completing the project by that duration. We see that the project cannot be completed within 32 days because it does not appear on the time axis of the histogram for 500 and 1000 iterations. It appears on the 10,000 iterations but the area is approximately zero, which means the probability of completing the project within 32 days is zero. This is in line with the literature. The probability of each activity getting completed is 0.5, and for a series of activities in series, their probability of getting completed is the product of activity probabilities, and so to get the project completed by the deterministic CPM project duration is very small, zero in this example.

Likewise, the probability of getting the project completed using $333, 652 is zero. This shows the importance of carrying out schedule and cost simulation to clearly understand the schedule and cost risks in a project. This also shows the importance of more detailed planning/scheduling and analysis. The importance of continuous and iterative planning and scheduling for project success cannot be over emphasized.

Alternatively, the baseline schedule may be improved through critical chain scheduling for on-going projects. Group of related activities on CPM network can be improved and buffer magnitude and location determined. First, each work package will be improved. Since variability is endemic to construction activities, strategically placing buffers in certain locations is required to cater for variability (Hamzeh, 2009). It cannot be done here because the author does not have detailed information about the equipment and human resources available for the project, and about the contextual situations of the project.

B.5 Lookahead and Weekly Work Planning

CPM schedule or master schedule has severe limitations as it does not give details that enable actual task execution (Hinze, 2012). Short interval schedules address this limitation. 4-6 week lookahead plan and weekly work plans (sometimes daily work plans) are used on many projects. PPC is a metric used to measure percentage of weekly work plans that got completed. PPC was forwarded as a measure of project progress but many cases were reported where people game it, plan and complete easy tasks or tasks that are not on the critical path driving PPC up while the project is not progressing well. Hamzeh et. al (2011) said PPC does not directly measure project progress, but measures the extent to which operators keep promises, and hence the extent to which future workload may be predictable. They also gave a condition under which PPC gives project progress. Hamzeh (2009) recommended using and tracking Tasks Anticipated (TA), Tasks Made Ready (TMR) and constraint removal in lookahead plans to improve Percent Plan Complete (PPC) of tasks on critical and near critical paths and to enhance project productivity. TA expresses foresight in anticipating tasks and identifying constraints and specifically measures the percentage of tasks anticipated on the lookahead plan two weeks ahead of execution. Establishing foresight is only one part of lookahead planning; it should be combined with screening, proactive removal of constraints, and prioritizing tasks for execution, which are captured by measuring TMR. TMR (i, j) measures the percentage of tasks anticipated on the lookahead plan i weeks ahead of week j, with week j being the week of execution (the week covered by the weekly work plan) (Hamzeh et. al, 2011). TMR thus measures the success in identifying and removing constraints ahead of time contributing to an increase in task completion and project productivity.

Improving short-term planning, we can successfully complete the last and crucial mile of the journey to ensure successful execution of projects.

APPENDIX C DIAGNOSTIC QUESTIONNAIRE USED IN DIAGNOSTIC TOOL OF THE DSS

Figure C.1 gives outline of items to be diagnosed by means of diagnosis questionnaire in the third column of the branches.

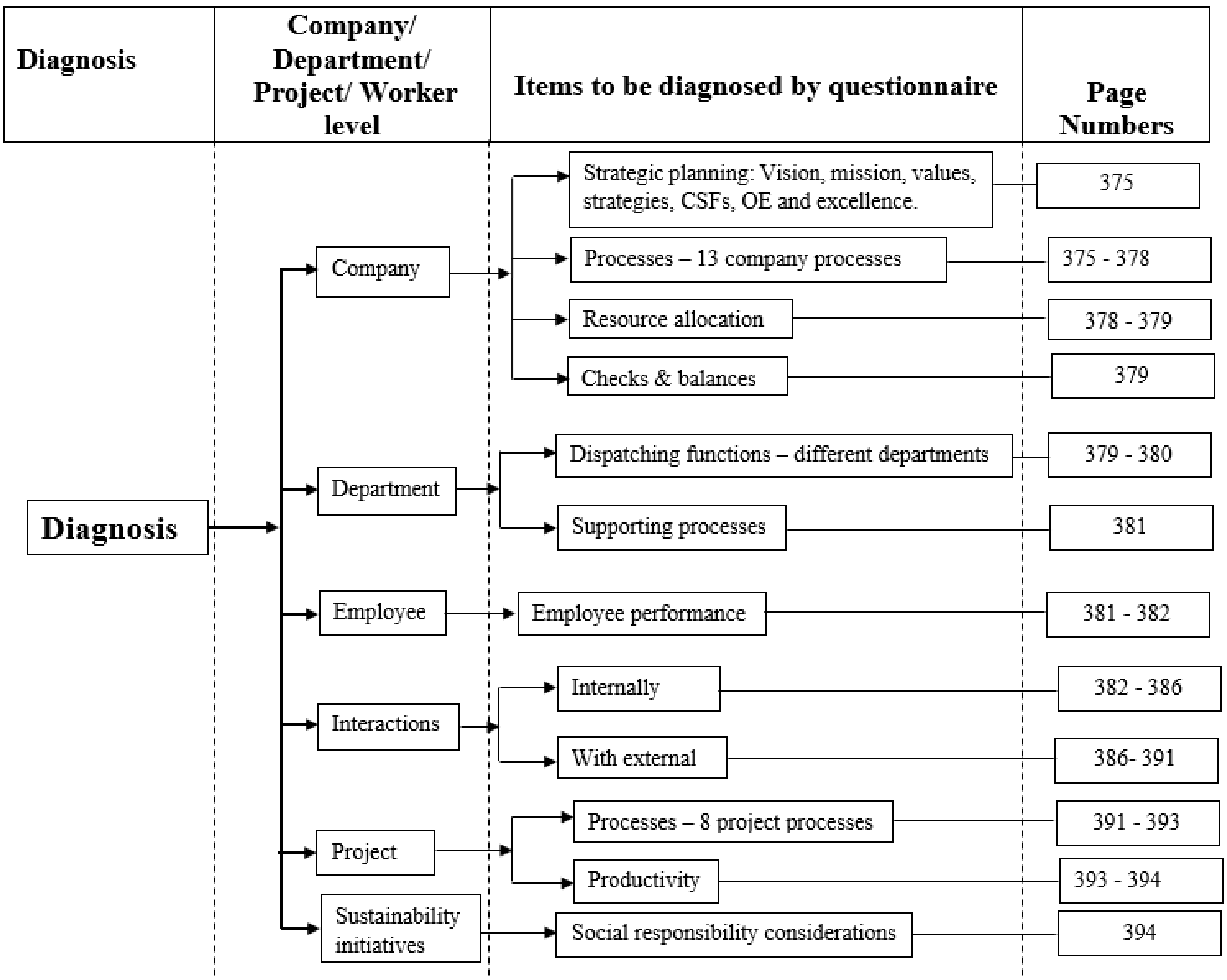


Figure C.1 Outline of items to be diagnosed with page numbers

COMPANY

Strategic Planning:

1. The organization's strategic plan provides direction, focus and clear well-accepted goals which serves as the basis for departmental, process and individual planning.
2. Organization occasionally carries out analysis to identify whether or not deficiencies in organization's vision, mission, values, goals, strategies and critical success factors exist or in their communication or in their alignment or in their implementation.
3. Organization is keenly aware of the challenges, internal and external threats and opportunities through on going observations, data collection, and continuous monitoring of projects, employees, clients, processes, competition, stakeholders and markets for possibilities.
4. The organization has identified the critical success factors to be pursued currently to enable achieving strategic objectives.
5. The organization has identified organizational effectiveness guidelines and has put in place a mechanism to evaluate its effectiveness.
6. The organization has developed and maintains efficient and effective end to end organizational and project processes to deliver our business.
7. The activities for developing and improving our organization's processes are coordinated across the organization.
8. The organization reviews and evaluates its activities for developing and improving our organization's processes.
9. We have controls to ensure our processes are integrated end to end across the organization.
10. Our organization collects, reviews, and makes available information related to the use of the organization's standard processes.
11. The activities and work products for developing and maintaining the organization's processes are subjected to QA review and audit.
12. Our senior management sponsors our organization's activities for process development and improvements.
13. We periodically assess and improve our processes.
14. One or more individuals have full-time or part-time responsibility for the organization's process activities.
15. Units and processes do well to help our company prequalify for jobs.
16. Units and processes provide services that meet customer needs which help get repeat business and build brand.

Company Processes:

A. Communication Process

1. Our company employs a strategic and structured approach to internal and external communication.
2. Our company strives to meet stakeholder information needs through its communication plans and plan implementations.
3. Our company carries out stakeholder engagement assessment to identify communication requirements.
4. Our company carries out communication styles assessment to tailor styles to stakeholders.
5. Our company documents and sends out all communications contemporaneously.

6. We are effective at communicating with customers, subcontractors, suppliers, the public and the market.
7. Our company uses best communication practices in all its communications.

B. Equipment management process

1. We plan well for equipment procurement and rental
2. Construction equipment procurement (purchase, renting or leasing) is integrated into project schedules.
3. We carry out productivity analysis of all our equipment.
4. Our company uses computer program to track health and maintenance of our equipment fleet.
5. Our company uses computer programs to track productivity and utilization of our equipment fleet.
6. Our company uses total preventive maintenance in equipment management.

C. Estimating process

1. We continuously collect information on new bids through our networks and subscriptions.
2. We have a systematic estimating process formally defined and followed in our organization.
3. Best estimating practices are always followed in our organization.
4. Accuracy of our estimates are improving with time.
5. Our bid markup percentage is continuously improving.
6. We bid only on projects in which we have excellence and experience.
7. We evaluate market favorability whenever we bid.

D. Finance management process

1. Finance process results in accurate financial statements.
2. Our finance process provides timely data to monitor financial health of our business.
3. Our finance process enables preparation of bills and collection of receivables in a timely manner.
4. Finance process produces accurate budget and margin variances.
5. We pay our subcontractors as soon as we receive payment for the work from client.
6. We have effective internal accounting controls.
7. Our tax filings are accurate.

E. Job costing process

1. Our company tracks and reports field job costs weekly.
2. Our company reports job cost by activity and cost code.
3. Our company establishes job cost elements to be reported when estimating the job.
4. Explicit cost and time thresholds are agreed with client for change orders.

F. Lessons learned process

1. Our company has a structured way to document lessons learned throughout the project execution period.
2. Lessons learned database is accessible to employees.
3. Lessons learned database is easy and fast to use.
4. Lessons learned database is easy to use also on construction sites.
5. Our company management supports lessons learned program.
6. Our company uses expertise of design department to validate lessons learned and transfer to database and to review content of database regularly to take out obsolete ones.

G. Marketing process

1. We conduct and review regular market analyses.
2. We review and monitor external economic influences on our organization.
3. We review and monitor external political influences on our organization.
4. We are effective at attracting new customers.
5. We routinely collect, evaluate and monitor customer feedback.
6. We are effective at retaining existing customers.
7. We have an excellent understanding of our customers' needs and likes.
8. We monitor how long it takes to resolve punch list items.

H. Pricing process

1. Our company evaluates risk from the type of contract the client selected when pricing projects.
2. Our company evaluates risk from wording used in the contract document.
3. Our company evaluates uncertainties in quantities while bidding in unit price contracts.
4. Our company bidding strategy is either to optimize estimates or to optimize both estimates and markup.
5. We have clear understanding of competitors' pricing.

I. Procurement process

1. Our company has a strategic approach to procurement.
2. Our company follows standard procedures and approvals in conducting procurement.
3. Our company established long-term strategic partnerships with few suppliers for frequently purchased items.
4. Our company has experienced procurement professionals with deep knowledge about materials and suppliers.
5. Our company has experienced negotiators in conducting purchases.
6. Our procurement department gets submittals in time for owner approval.
7. Our procurement department has track record of on time delivery.

J. Project closeout process

1. Our company uses standard checklist in closing out projects.
2. Our company plans ahead and works towards a smooth and phased project closeout by making key documents ready.

3. Our company involves all concerned stakeholders in closeout.
4. Our company solicits feedbacks from stakeholders while closing out projects.
5. Our company documents lessons learned while closing out projects.

K. Scheduling management process

1. Our company produces comprehensive and accurate resource loaded project schedules.
2. Our company produces well - constructed schedules with clear logic and total floats.
3. Our company produces credible schedules with contingency and prioritized risks.
4. Our company schedules are updated regularly with actual progress and logic.
5. Our company uses scheduling best practices.

L. Subcontract management process

1. Our company uses documented procedure for selecting subcontractors based on their ability to perform the work (based on previous work, safety and financial soundness).
2. Our company writes a fair and balanced subcontract.
3. Our company involves subcontractors in developing project plans and schedules.
4. Our projects follow a written organizational policy for managing subcontracts.
5. The company holds regular meetings with subcontractor supervisor individually and collectively.
6. The company monitors and supports subcontractors' work (results and performance of subcontractors tracked against their commitments).
7. Changes to subcontracts are made with the agreement of both the prime contractor and the subcontractor.
8. Our people responsible for managing subcontracts are trained to manage subcontracts.
9. Our organization reviews and evaluates its activities for subcontract management.

M. Training management process

1. Our organization follows a written policy to meet its training needs.
2. We plan our training activities.
3. We determine the training needs of individuals, departments and/or projects prior to selecting trainings to offer.
4. Our company gives training to all project teams on topics they need to perform their roles.
5. Adequate resources are provided to implement our organization's training program.
6. Our organization reviews and evaluates the activities of its training program.

<u>Company Resource Allocation:</u>

1. Corporate planning is a continuous and collaborative process aligned with objectives and strategy.
2. Corporate planning and teams' implementation of plans is guided by common causes and shared values.
3. Resource allocation serves company objectives and strategy to help success.
4. Teams set ambitious mid-term goals and resource allocation supports teams to achieve their goals.

5. Resources (tools, equipment and finance) are made available to each team and employee just in time based on detailed plans to enable successful execution of tasks.
6. Efficient and improved processes are put in place as part of resource allocation to enable higher productivity.
7. IT based fast and frequent feedback are made available to operators as part of resource allocation.
8. We keep both the big picture and detailed information in perspective in both planning, execution and resource allocation.

Company checks and balances:

1. We have checks and balances to ensure unethical behavior is in check.
2. We have checks and balances to make sure mistakes (technical, legal, regulatory) that endanger survival of the company are not made.
3. Duties of preparers and approvers of important transactions and business activities are segregated into independent branches of the company.
4. Checks and balances procedures are checked for red tapes and unnecessary bureaucracy.
5. Checks and balances processes are reconciled and aligned with other company and project processes.
6. Electronic routing of documents is used in creation and approval of documents.
7. We make sure policies and procedures are followed for proper authorization of transactions and important business activities.

DEPARTMENT

Department functions (different departments):

A. Bidding department

1. We continuously collect information on new bids through our networks and subscriptions.
2. We have a systematic estimating and bidding process formally defined and followed in our organization.
3. Best estimating practices are always followed in our organization.
4. Accuracy of our estimates are improving with time.
5. Our bid markup percentage is continuously improving.
6. We bid only on projects in which we have excellence and experience.
7. We evaluate market favorability whenever we bid.

B. Design department

1. Accuracy of our shop drawings is improving from time to time.
2. Accuracy of our land surveys is good.
3. Accuracy of our quantity takeoffs is reliable.
4. Our design department is good at resolving discrepancies and claims.
5. Accuracy of documentation of project data is good.

C. Equipment department/unit

1. We plan well for equipment procurement and rental
2. Construction equipment procurement (purchase, renting or leasing) is integrated into project schedules.

3. We carry out productivity analysis of all our equipment.
4. Our company uses computer program to track health and maintenance of our equipment fleet.
5. Our company uses computer programs to track productivity and utilization of our equipment fleet.
6. Our company uses total preventive maintenance in equipment management.

D. Finance

1. Finance Dept. prepares accurate financial statements.
2. Our finance department provides timely data to monitor financial health of our business.
3. Our finance prepares bills and collects receivables in a timely manner.
4. Finance Dept. prepares accurate budget and margin variances.
5. We pay our subcontractors as soon as we receive payment for the work from client.
6. We have effective internal accounting controls.
7. Our tax filings are accurate.

E. Human resources

1. We have effective recruitment system in place to attract and acquire top talent.
2. We develop the competence of our people continually in terms of skills, knowledge and attitude.
3. In our HR performance management, managers give personalized goals to employees.
4. We have a robust set of HR policies and procedure in place.
5. We effectively communicate with our staff.

F. Marketing department/unit

1. We conduct and review regular market analyses.
2. We monitor and review external economic influences on our organization.
3. We monitor and review external political influences on our organization.
4. We are effective at attracting new customers.
5. We routinely collect, monitor and evaluate customer feedback.
6. We are effective at retaining existing customers.
7. We have an excellent understanding of our customers' needs and likes.
8. We monitor how long it takes to resolve punch list items.

G. Procurement department

1. Our company has a strategic approach to procurement.
2. Our company follows standard procedures and approvals in conducting procurement.
3. Our company established long-term strategic partnerships with few suppliers for frequently purchased items.
4. Our company has experienced procurement professionals with deep knowledge about materials and suppliers.
5. Our company has experienced negotiators in conducting purchases.
6. Our procurement department gets submittals in time for owner approval.
7. Our procurement department has track record of on time delivery of procured items.

<u>Supporting processes:</u>

1. The organization has assigned deputy manager to manage program of all company and project processes to whom process owners report.
2. The organization has developed and maintains efficient and effective end to end organizational and project processes to deliver our business.
3. The activities for developing and improving our organization's processes are coordinated across the organization.
4. The organization reviews and evaluates its activities for developing and improving our organization's processes.
5. We have controls to ensure our processes are integrated end to end across our organization.
6. Our organization collects, reviews, and makes available information related to the use of the organization's standard processes.
7. The activities and work products for developing and maintaining the organization's processes are subjected to QA review and audit.
8. Our senior management sponsors our organization's activities for process development and improvements.
9. We periodically assess and improve our processes.
10. One or more individuals have full-time or part-time responsibility for the organization's process activities.
11. Units and processes do well to help our company prequalify for jobs.
12. Departments assign employees with the needed expertise to processes as excellence centers in the areas of their functional expertise.
13. Departments resolve technical problems encountered while running processes that need expertise of departments, which could not be resolved by department employees assigned to processes.
14. Departments support and coordinate with team leaders and process owners in performance appraisal, rewarding employees and giving feedback to employees they assigned to processes. These employees are under team leaders and process owners as 80-90% of their time is devoted to processes and departments are in a supporting position to give professional functional appraisal and feedback.
15. Departments support employees assigned to processes in capacity building with training, coaching, mentoring and career development in consultation with team leaders and process owners.
16. Departments regularly assess new developments and technologies in the industry in their functional areas of expertise and keep company in the fore front for competitiveness.
17. Departments support process control efforts and efforts to setup new processes or to change old ones to remain competitive in the continually changing business environment.

EMPLOYEE PERFORMANCE

1. We always make sure employees' knowledge and skills match task performance requirements.
2. We offer training to employees on the body of knowledge which, if mastered, would contribute to or enhance work behavior to enhance and enable employee learning and development.
3. Each new hire or employee assigned to new position works under a mentor.

4. We use clear guidelines and criteria to objectively assess employee performance.
5. Each employee is provided constructive feedback by coworkers and managers based on performance assessment.
6. A spectrum of employee development techniques such as training, career development and organization development is used from the start of employment of a candidate.
7. We carry out competencies testing to identify best candidates for jobs.
8. We help each employee plan his/her career path and provide horizontal and vertical lines of opportunity for them to advance their career to their full potential.
9. We use structured rewards and incentives for outstanding performance.
10. We manage employee expectations to match job reality through communication.

INTERACTIONS

<u>Internally: A department serving other departments</u>.

A. Bidding

1. BIDDING Eval. By Design 1. Bidding corrects bid drawings it receives from client during bidding process.
2. BIDDING Eval. By Design 2. Bidding incorporates missing information into drawings during bidding.
3. BIDDING Eval. By HR. Bidding submits list & qualification of new hires in time to HR.
4. BIDDING Eval. By Marketing 1. Bidding wins jobs it bids through low price to attract customers in line with marketing strategy.
5. BIDDING Eval. By Marketing 2. The winning bid price enables company complete the job with profit.
6. BIDDING Eval. By Procurement 1. Bidding produces accurate estimates during bidding that provide reliable information for equipment procurement during project implementation.
7. BIDDING Eval. By Procurement 2. Bidding produces accurate estimates during bidding that provide reliable information for material procurement during project execution.

B. Design

1. DESIGN Eval. By Bidding 1. Design Dept. provides accurate cost & productivity data to Bidding Dept. to be used in bidding estimates.
2. DESIGN Eval. By Bidding 2. Design Dept. provides cost and productivity data promptly when requested by Bidding Dept.
3. DESIGN Eval. By HR. Design Dept submits list & qualification of new hires in time to HR.
4. DESIGN Eval. By Procurement 1. Design Dept. produces accurate and realistic shop drawings for construction.
5. DESIGN Eval. By Procurement 2. Design Dept. takeoffs are accurate and reliable to use them for procurement during construction.
6. DESIGN Eval. By Projects 1. Design Dept. does a good job of reconciling discrepancies between drawings, and between drawings & specifications
7. DESIGN Eval. By Projects 2. Design Dept. does a good job of resolving claims with owners and subcontractors in projects.
8. DESIGN Eval. By Projects 3. Design Dept. does a good job in correcting bid drawings during construction.

9. DESIGN Eval. By Projects 4. Design Dept. produces clear coordination drawings of own teams and subcontractors' teams.
10. DESIGN Eval. By Projects 5. Design Dept. does a good job of proactively coordinating all activities on site and letting all know ahead of time.
11. DESIGN Eval. By Projects 6. Design Dept. does a good job of letting all actors know the sequence of their site activities ahead of time.

C. Equipment

1. EQUIPMENT Eval. By Design 1. Equipment Dept. collects and archives accurate and reliable equipment productivity data.
2. EQUIPMENT Eval. By Design 2. Equipment Dept. equipment productivity data is presented in a clear and easy to use way.
3. EQUIPMENT Eval. By HR. Equipment submits list & qualification of new hires in time to HR.
4. EQUIPMENT Eval. By Projects 1. Equipment Dept. fairly allocates new and equipment in good condition to projects.
5. EQUIPMENT Eval. By Projects 2. Equipment Dept. allocates the right type/ most appropriate equipment type for the job.
6. EQUIPMENT Eval. By Projects 3. Equipment Dept. allocates experienced operators and mechanics fairly.
7. EQUIPMENT Eval. By Projects 4. Equipment Dept. does very good job in equipment repair & maintenance.
8. EQUIPMENT Eval. By Procurement. Equipment Dept. submits list and specification of equipment to be purchased in time for procurement planning.

D. Finance

1. FINANCE Eval. By Bidding 1. Finance Dept. obtains bond document of sufficient coverage from insurance companies and provides it to Bidding Dept. in time.
2. FINANCE Eval. By Bidding 2. Finance shops for bonding price to get low cost coverage.
3. FINANCE Eval. By HR 1. Finance Dept. effects payments to employees on time.
4. FINANCE Eval. By HR 2. Finance Dept. processing of travel & field work payments are easy and efficient.
5. FINANCE Eval. By HR 3. Finance submits list & qualification of new hires in time.
6. FINANCE Eval. By Procurement 1. Finance Dept. effects payments to vendors for purchased equipment promptly.
7. FINANCE Eval. By Procurement 2. Finance Dept. effects payments to vendors for purchased materials promptly.
8. FINANCE Eval. By Projects 1. Finance Dept. effects payments to vendors for purchased materials.
9. FINANCE Eval. By Projects 2. Finance pays project employees on time.
10. FINANCE Eval. By Projects 3. Finance's processing of travel expenses is fast and short.
11. FINANCE Eval. By Top Management 1. Finance Dept. produces statements on time.
12. FINANCE Eval. By Top Managemnt 2. Finance Dept. prepares financial analysis and reports on time.

E. Human resources

1. HR Eval. By Bidding 1. HR hires experienced estimators requested by bidding in a timely manner.
2. HR Eval. By Bidding 2. HR provides competitive welfare and incentives to Bidding Dept. employees.
3. HR Eval. By Bidding 3. HR cares for the comfort of bidding employees.
4. HR Eval. By Bidding 4. HR design of ergonomics of bidding employees is adequate.
5. HR Eval. By Bidding 5. HR processes and passes pays of employees of Bidding Dept. to finance on time.
6. HR Eval. By Bidding 6. HR plans career development of each Bidding Dept. employee.
7. HR Eval. By Bidding 7. HR gives necessary training to estimators of Bidding Dept.
8. HR Eval. By Design 1. HR hires & trains design engineers for Design Dept. in a timely manner.
9. HR Eval. By Design 2. HR hires & trains surveyors for Design Dept. in a timely manner.
10. HR Eval. By Design 3. HR provides competitive welfare and incentives to Design Dept. employees.
11. HR Eval. By Design 4. HR cares for the comfort of design employees.
12. HR Eval. By Design 5. HR cares for the ergonomics of design employees.
13. HR Eval. By Design 6. HR processes and passes pays of employees to finance on time.
14. HR Eval. By Design 7. HR plans career development of each employee.
15. HR Eval. By Equipment 1. HR hires & trains equipment operators & mechanics in a timely manner.
16. HR Eval. By Equipment 2. HR provides competitive welfare and incentives to Equipment Dept. employees.
17. HR Eval. By Equipment 3. HR cares for the comfort of equipment employees.
18. HR Eval. By Equipment 4. HR cares for the ergonomics of equipment employees.
19. HR Eval. By Equipment 5. HR processes and passes pays of our employees to finance on time.
20. HR Eval. By Equipment 6. HR plans career development of each employee.
21. HR Eval. By Finance 1. HR hires & trains accountants & clerks for Finance Dept. in a timely manner.
22. HR Eval. By Finance 2. HR provides competitive welfare and incentives to Finance Dept. employees.
23. HR Eval. By Finance 3. HR cares for the comfort of finance employees.
24. HR Eval. By Finance 4. HR cares for the ergonomics of finance employees.
25. HR Eval. By Finance 5. HR processes and passes pays of our employees to finance on time.
26. HR Eval. By Finance 6. HR plans career development of each employee.
27. HR Eval. By Finance 7. HR submits labor hours in time.
28. HR Eval. By Marketing 1. HR hires & trains marketing professionals in a timely manner.
29. HR Eval. By Marketing 2. HR provides competitive welfare and incentives to Marketing employees.
30. HR Eval. By Marketing 3. HR cares for the comfort of marketing employees.
31. HR Eval. By Marketing 4. HR ensures ergonomics design is adequate for marketing employees.
32. HR Eval. By Marketing 5. HR processes and passes pays of our employees to finance on time.

33. HR Eval. By Procurement 1. HR hires & trains procurement professionals in a timely manner.
34. HR Eval. By Procurement 2. HR provides competitive welfare and incentives to Procurement Dept. employees.
35. HR Eval. By Procurement 3. HR cares for the comfort of procurement employees.
36. HR Eval. By Procurement 4. HR cares for the ergonomics of procurement employees.
37. HR Eval. By Procurement 5. HR processes and passes pays of employees to finance on time.
38. HR Eval. By Procurement 6. HR plans career development of each employee.
39. HR Eval. By Projects. HR hires required people for projects in a timely manner.

F. ICT

1. ICT Eval. By Bidding 1. ICT follows up timely purchase and installation of estimating software.
2. ICT Eval. By Bidding 2. ICT provides timely maintenance of estimating software.
3. ICT Eval. By Design 1. ICT follows up timely purchase and installation of design software.
4. ICT Eval. By Design 2. ICT provides timely maintenance of design software.
5. ICT Eval. By Equipment 1. ICT developed and updates equipment productivity data collection & analysis package.
6. ICT Eval. By Equipment 2. The package is user friendly and intuitive.
7. ICT Eval. By Finance 1. ICT follows up timely purchase and installation of accounting software.
8. ICT Eval. By Finance 2. ICT provides timely maintenance of accounting software.
9. ICT Eval. By HR. ICT submits list & qualification of new hires in time.

G. Marketing

1. MARKETING Eval. By Bidding 1. Marketing dept gets good information on new bids in a timely manner.
2. MARKETING Eval. By Bidding 2. Marketing Dept. acquires new bid documents in time.
3. MARKETIN Eval. By Top Management 1. Marketing dept makes realistic promises that company can deliver.
4. MARKETIN Eval. By Top Management 2. Marketing Dept. professionals know company processes and capability as to realistically talk about company services and advertise.

H. Procurement

1. PROCUREMENT Eval. By Bidding. Procurement purchased estimating software in time
2. PROCUREMENT Eval. By Equipment 1. Procurement Dept. purchases the right type/ most appropriate equipment.
3. PROCUREMENT Eval. By Equipment 2. Procurement Dept. purchases the lowest cost equipment without compromising quality.
4. PROCUREMENT Eval. By Equipment 3. Procurement Dept. is free of corruption and strives to maximize company profit.
5. PROCUREMENT Eval. By HR. Procurement submits list & qualification of new hires in time.
6. PROCUREMENT Eval. By Projects 1. Procurement Dept. purchases the right type/ most appropriate materials for the job.

7. PROCUREMENT Eval. By Projects 2. Procurement Dept. purchases the lowest cost material satisfying quality requirements.
8. PROCUREMENT Eval. By Projects 3. Procurement Dept. is free of corruption and strives to maximize company profit.

I. Projects

1. PROJECTS Eval. By Finance 1. Projects submit project labor hours in time to finance.
2. PROJECTS Eval. By Finance 2. Projects submit subcontractor payment approvals in time.
3. PROJECTS Eval. By HR 1. Our project teams have a very good safety & health record.
4. PROJECTS Eval. By HR 2. Our projects are good at implementing drugs and alcohol testing program.
5. PROJECTS Eval. By HR 3. Our projects are implementing health &safety trainings & orientation well.
6. PROJECTS Eval. By HR 4. Projects submits list & qualification of new hires in time.
7. PROJECTS Eval. By Marketing 1. Projects resolve punch list items fast that help company with customer retention.
8. PROJECTS Eval. By Marketing 2. Projects submit subcontractor payment approvals in time.
9. PROJECTS Eval. By Top Management 1. Our project teams do a good job of delivering projects that meet customer needs that help us get job continuously.
10. PROJECTS Eval. By Top Management 2. The quality of construction and service our project teams provide help us get repeat business.
11. PROJECTS Eval. By Top Management 3. We are proud of our project teams because they are front line people who deliver the quality service to clients on our behalf.

Departments/units/internal entities interacting with EXTERNAL stakeholders:

A. Bidding department

1. Bidding interaction with bidding information providers. Bidding subscribes to bidding information providers for a fee.
2. Bidding interaction with networks. Bidding takes advantage of trade association memberships, local chamber of commerce and online network like LinkedIn.
3. Bidding interaction with owners. Bidding takes advantage of subscription to different owners' magazines.

B. Finance department

1. Finance interaction with banks1. Finance establishes good relationship with banks to secure the needed construction loans quickly.
2. Finance interaction with banks2. Finance services construction loans in time.
3. Finance interaction with insurance1. Finance shops for list price bid and performance bonds.
4. Finance interaction with insurance2. Finance shops for list price construction insurance (property damage and third party injuries or damage claims).
5. Finance interaction with tax authorities1. Finance files taxes in the right format (in compliance with regulatory requirements).
6. Finance interaction with tax authorities2. Finance files taxes in time.

C. Marketing

1. Marketing interaction with prospective clients1. Marketing develops effective promotion and builds clearly identifiable brand.
2. Marketing interaction with prospective clients2. Marketing built professional company website and has a good social media presence.
3. Marketing interaction with prospective clients3. Marketing is good at identifying client needs and at demonstrating company has a clear differentiating capacity to meet those needs.
4. Marketing interaction with prospective clients4. Marketing is good at market research and at identifying new opportunities.
5. Marketing interaction with prospective clients5. Company is good at prequalifying for jobs.
6. Marketing interaction with current clients1. Marketing follows up that project teams and head office gives superior, fair and emphatic service to clients.
7. Marketing interaction with current clients2. Marketing follows up that appropriate level of competencies and staffing levels are used in serving clients.
8. Marketing interaction with current clients3. Marketing follows up that high performing subcontractors are used on projects.
9. Marketing interaction with current clients4. Marketing follows up that quality standards are kept.
10. Marketing interaction with current clients5. Marketing follows up that client expectations are managed through effective communications.
11. Marketing interaction with current clients6. Marketing ensures that punchlist items are resolved fast.
12. Marketing interaction with current clients7. Marketing collects client feedback and acts on them fast.
13. Marketing interaction with current clients8. Marketing follows up that good professional relations are maintained with the clients.
14. Marketing interaction with past clients1. Marketing follows up to get recommendation from past clients.
15. Marketing interaction with past clients2. Marketing follows up to get repeat business from past clients.
16. Marketing interaction with past clients3. Marketing follows up with past clients to get feedback on performance of constructed facility after 5, 10, 15 years as appropriate.
17. Marketing interaction with the public1. Marketing promotes the services of the company to let the public know the company exists and to let the public know what the company does.
18. Marketing interaction with the public2. Marketing arranges for engagement of company in community services and offer help in a way that show cases company expertise.
19. Marketing interaction with the public3. Marketing takes advantage of trade association membership, local chamber of commerce, online network like LinkedIn and subscription to different construction magazines including big owners' magazines.

D. Procurement

1. Procurement interaction with suppliers1. Procurement established long-term strategic partnerships with few suppliers for frequently purchased items.
2. Procurement interaction with suppliers2. Procurement has good relationship with equipment dealers and gets detailed up to date specification informations.

3. Procurement interaction with equipment rentals. Procurement has good relationship with equipment rental companies as to get good equipment on short notice.
4. Procurement interaction with logistics providers. Procurement has good relationship with logistics companies that deliver purchased materials and equipment.

E. Project manager

1. Project manager interaction with client1. Project manager prepares detailed plans of action and communicates the plan to client effectively to enable project completion within time and budget.
2. Project manager interaction with client2. Project manager manages the project strictly to the requirements of the contract.
3. Project manager interaction with client3. Project manager manages client expectations through effective communication.
4. Project manager interaction with client4. Project manager continuously engages the client for the project initiative.
5. Project manager interaction with client5. Project manager interacts with client through formal reporting systems (schedule and cost progress reports).
6. Project manager interaction with client6. Project manager interacts with client through informal reporting systems (including contractor marketing activities, informal negotiations of disputes and shared decision-making on contract implementation procedure.
7. Project manager interaction with client7. Project manager interacts with client in problem solving.
8. Project manager interaction with subcontractor1. Project manager interacts with subcontractor through informal reporting systems (including contractor marketing activities, informal negotiations of disputes and shared decision-making on contract implementation.
9. Project manager interaction with subcontractor2. Project manager involves subcontractors in schedule development.
10. Project manager interaction with subcontractor3. Project manager communicates expectations clearly to subcontractors.
11. Project manager interaction with subcontractor4. Project manager develops submittal schedule for subcontractors.
12. Project manager interaction with subcontractor5. Project manager communicates requirement of safe working practices to subcontractors.
13. Project manager interaction with subcontractor6. Project manager engages subcontractors in change order reviews.
14. Project manager interaction with subcontractor7. Project manager issues coordination drawings to subcontractors.
15. Project manager interaction with subcontractor8. Project manager meets with subcontractors regularly individually and collectively.
16. Project manager interaction with subcontractor9. Project manager provides regular feedback to subcontractors.
17. Project manager interaction with subcontractor10. Project manager communicates requirement of toolbox meeting to subcontractors.
18. Project manager interaction with subcontractor11. Project manager communicates requirement of good house-keeping to subcontractors.

19. Project manager interaction with subcontractor12. Project manager walks the jobsite frequently and help the subcontractors do timely work.
20. Project manager interaction with subcontractor13. Project manager identifies and supports the controlling subcontractor.
21. Project manager interaction with subcontractor14. Project manager pays subcontractors timely.
22. Project manager interaction with subcontractor15. Project manager manages relationship with subcontractors and makes sure the contract is enforced.
23. Project manager interaction with suppliers1. Project manager communicates clearly the dimensions and specifications of supply items ordered.
24. Project manager interaction with suppliers2. Project manager identifies long lead items and orders them in time.
25. Project manager interaction with suppliers3. Project manager lists material and equipment to be procured from schedule and plan and prepares submittal schedule for owner approval.
26. Project manager interaction with suppliers4. Project manager gives detailed and complete drawings to suppliers.
27. Project manager interaction with suppliers5. Project manager pays suppliers timely.
28. Project manager interaction with trade unions. Project manager complies with collective union agreements.
29. Project manager interaction with regulators1. Project manager knows the regulators and their expectations.
30. Project manager interaction with regulators2. Project manager ensures projects meet code and other regulatory requirements.
31. Project manager interaction with regulators3. Project manager ensures compliance is shown on construction schedules.
32. Project manager with communities1. Project manager builds positive and sustainable relationships in communities with key individuals, groups and organizations
33. Project manager with communities2. Project manager demonstrates sensitivity to community concerns and issues.
34. Project manager with communities3. Project manager goes to community services physically few times a year where they create good impressions and avoid sales pitches.
35. Project manager with communities4. Project manager offers help to communities in the area of expertise that showcases the companies’ capacity.
36. Project manager with communities5. Project manager designs and implements community programs few times a year where all employees are involved in philanthropy, volunteerism, partnerships or in kind donations.

F. Top management

1. Top Management with client1. Top management makes itself available to clients for open and honest communication, and makes feel the client their ideas and concerns are taken seriously.
2. Top Management with client2. Top management makes the client feel the enthusiam, zeal, positive energy and confidence so that the client enjoys working with the company.
3. Top Management with client3. Top management establishes personal connection with client representatives and acknowledges them as individuals to show genuine concern about their family, kids, and personal life.

4. Top Management with client4. Share scientific knowledge about the clients project area in simple language about why you do things the way you do, the process it takes to help client feel knowledgeable and in the loop for the project initiative.
5. Top Management with client5. Give expert opinion in the best interset of the project and the client on any issues that may come up and help/guide them decide what they want.
6. Top Management with client6. Top management manages client expectations through communication to be realistic and exceeds those expectations as leading experts and professional.
7. Top Management with subcontractors1. Top management gets subcontractor commitment at pre bid meetings.
8. Top Management with subcontractors2. Top management challenges and helps partnering subcontractors grow.
9. Top Management with regulators1. Top management follows a strategy of constructive engagement with regulators in the construction industry.
10. Top Management with regulators2. Top management gives input to regulators during rule-making to affect it in the best interest of the company and industry.
11. Top Management with regulators3. Top management presents the firm in the best light to regulators during examination and lets them find out what management has overlooked.
12. Top Management with regulators4. Top management explains the facts that got the company there genuinely during investigation which may result in the charge being dropped (courts too would drop it if the facts are convincing and the intention of the company is genuine).
13. Top Management with regulators5. Top management knows the regulators and their expectations.
14. Top Management with regulators6. Top management ensures projects meet code and other regulatory requirements.
15. Top Management with regulators7. Top management ensures compliance is shown on construction schedules.
16. Top Management with regulators8. Top management instills in all employees that compliance with regulatory requirements instills public trust in the organization and promotes confidence in company services and products.
17. Top Management with professional associations1. Top management registered the company in trade associations.
18. Top Management with professional associations2. Top management sends company representatives to trade shows.
19. Top Management with professional associations3. Top management encourages employees to professional conferences.
20. Top Management with professional associations4. Top management encourages employees to get trainings and professional certifications.
21. Top Management with professional associations5. Top management requires all employees to comply with code of ethics of professional associations.
22. Top Management with professional associations6. Top management subscribes to journal of academic societies and uses the information in training and development of employees.
23. Top Management with communities1. Top management builds positive and sustainable relationships in communities with key individuals, groups and organizations
24. Top Management with communities2. Top management demonstrates sensitivity to community concerns and issues.

25. Top Management with communities3. Top management goes to community services physically few times a year where they create good impressions and avoid sales pitches.
26. Top Management with communities4. Top management offers help to communities in the area of expertise that showcases the companies' capacity.
27. Top Management with communities5. Top management designs and implements community programs few times a year where all employees are involved in philanthropy, volunteerism, partnerships or in kind donations.
28. Top Management with communities7. Top management strives to be the investment of choice, the supplier of choice, the employer of choice and a neighbor of choice.

PROJECT

Project processes: (The project processes dealt with in here are from the list suggested by Sarshar et al., (2000). They did a good job developing the SPICE framework, which the author hoped they continued with the research. Information used to develop this part of the diagnostic questionnaire is mainly obtained from the SPICE questionnaire the author received from Professor Sarshar. The author would like to thank her for providing the information and would like to acknowledge her here.)

A. Change control

1. We plan for our project change control and management procedures in our projects.
2. We distribute standard reports on project changes to all affected groups and individuals.
3. Our projects follow a written organizational policy for implementing project change control activities.
4. We incorporate the changes we make into design drawings to produce as built drawings.
5. Our project personnel are trained to perform project change control & management activities for which they are responsible.
6. Project change control & management activities for controlling variations to projects are subjected to QA review and audit.
7. Our organization reviews and evaluates its activities for project change control & management.

B. Monitoring and control

1. Our projects' actual results (e.g. milestones and budget) are compared with estimates in the project plans.
2. Corrective actions are taken when actual results differ significantly from a project's plans.
3. Changes in a projects' commitments are communicated to and agreed by all affected groups and individuals within those groups.
4. Our projects follow a written organizational policy for tracking their performance.
5. Someone on a project is assigned specific responsibilities for tracking project performance relative to the project plan.
6. The activities for project tracking and oversight are reviewed with the project manager on a periodic basis.
7. Our organization reviews and evaluates its activities for Project Tracking and Oversight.

C. Planning

1. Estimates and schedules (e.g. program and cost) are documented for use in tracking projects.
2. The plans document the activities to be performed and the commitments made in relation to a project.
3. All affected groups agree to their commitments relating to a project.
4. Our projects follow a written organizational policy for the planning of projects.
5. Adequate resources are provided for planning projects (e.g., funding and experienced individuals).
6. Our project managers on projects review the activities for planning on both periodic and event-driven basis.
7. Our organization reviews and evaluates its activities for Project Planning.

D. Quality assurance

1. Our company plans QA activities.
2. QA activities provide objective verification that products and activities adhere to applicable standards, procedures, and requirements.
3. The results of QA reviews and audits are provided to affected groups and individuals (e.g., those who performed the work and those who are responsible for the work).
4. Issues of noncompliance are addressed by senior management (e.g. deviations from applicable standards).
5. Our projects follow a written organization policy for implementing QA activities.
6. Adequate resources are provided for performing QA activities (e.g. funding and a designated manager who will receive and act on non-compliance items).
7. Our Project Managers review activities for QA on a periodic basis.
8. Our organization reviews and evaluates its activities for QA.

E. Risk management

1. We plan and conduct risk management on all our projects.
2. Our projects follow a written organizational policy for carrying out risk management.
3. Member(s) of the project team who are responsible for risk management activities receive training to carry out their roles.
4. We monitor risk mitigation activities to ensure that the desired results are being obtained.
5. Activities for risk management are reviewed with the project manager on both periodic and event-driven basis.
6. Our organization reviews and evaluates its risk management activities.

F. Safety and health management

1. Our organization follows written policy about health and safety on our project sites.
2. Our organization involves supervisors in making health and safety policy.
3. Our organization conducts frequent and regular safety inspections to proactively identify and control hazards.
4. We give site specific safety training to managers, employees and subcontractors on hazard identification and control.
5. We assign adequate safety staff to projects.
6. Our project safety staff holds regular safety meetings with all subcontractors.
7. We implement worker-to-worker safety observation action initiative on all our projects.

8. We frequently conduct workers' safety perception surveys.
9. Our organization periodically reviews and evaluates our safety and health policy.

G. Scope and brief management

1. Documented project brief and scope is established at the commencement of our projects.
2. When a project brief changes, the necessary adjustments to programs, drawings and activities are made.
3. Our projects follow a written organizational policy for managing the brief and scope through the project life cycle.
4. Our people in projects who are charged with management responsibilities for the brief and scope are trained in the procedures for managing project brief and scope.
5. The activities for managing and updating project brief and scope are subject to Quality Assurance review.
6. Our organization reviews and evaluates its activities for brief and scope Management.

H. Team coordination and management

1. The various disciplines collaborate with each other and the client to establish the brief and scope requirements
2. The disciplines agree to their commitments as represented in an overall project plan.
3. The disciplines identify, track, and resolve interdisciplinary issues (e.g., incompatible programs, technical risks etc).
4. Our organization follows a written policy for interdisciplinary coordination.
5. The support tools used by different disciplines enable effective communication and coordination (e.g., compatible planning software, CAD standards etc).
6. The activities for interdisciplinary coordination are reviewed with the project manager on both a periodic and event-driven basis.
7. Our organization reviews and evaluates its activities for interdisciplinary communication.

<u>Project productivity:</u>

1. PRODTVTY Materials 1. Our projects follow procurement plans and procedures for acquisition of materials and equipment.
2. PRODTVTY Materials 2. We use systematic materials tracking and management system on project sites.
3. PRODTVTY Materials 3. We inspect and classify all materials on delivery on sites before storage.
4. PRODTVTY Equipment 1. We follow a structured approach to machinery procurement and maintenance to ensure their availability when needed on site.
5. PRODTVTY Equipment 2. We follow tools and equipment management best practices for tracking and maintenance.
6. PRODTVTY Execution 1. We carry out detailed short-term planning to produce advanced work packages.
7. PRODTVTY Execution 2. We conduct constructability review before execution.
8. PRODTVTY Execution 3. We follow a structured approach to acquisition of right of way, land and utilities.

9. PRODTVTY Execution 4. We conduct reviews to meet environmental, regulatory and permitting requirements.
10. PRODTVTY HR 1. We make skills assessment and evaluation in determining project crews' composition and formation.
11. PRODTVTY HR 2. We train our project employees technically in their trades to advance their career development.
12. PRODTVTY HR 3. We incentivize to reinforce desired behaviors.
13. PRODTVTY HR 4. We keep clear line of command and delegation of responsibility.
14. PRODTVTY HR 5. We have retention plan for our experienced personnel.
15. PRODTVTY Construction Methods 1. We control our schedule execution and management on projects.
16. PRODTVTY Construction Methods 2. We follow best site planning practices.
17. PRODTVTY Construction Methods 3. We follow best practices in communication, coordination and project completion and startup plans.
18. PRODTVTY Safety 1. We follow job site safety guidelines and best practices.
19. PRODTVTY Safety 2. We implement drugs and alcohol testing program.
20. PRODTVTY Safety 3. We implement health & safety training programs.

<u>Sustainability and Social Accountability Initiative:</u>

1. Our company tries to conserve resources in constructing projects.
2. Our company tries to preserve natural site conditions of project sites as it carries out constructions.
3. Our company tries to minimize pollution to the environment in its construction operations.
4. Our company ensures safety and health of its employees working on projects.
5. Our company tries to ensure health of end facility users by avoiding use of deleterious construction materials.
6. Our company implements environmental management systems voluntarily to dispatch its social accountability.

APPENDIX D COMPUTATION OF DIAGNOSTIC SCORE FOR EXAMPLE COMPANY

Figure D.1 gives outline of items to be diagnosed by means of diagnosis questionnaire in the third column of the branches.

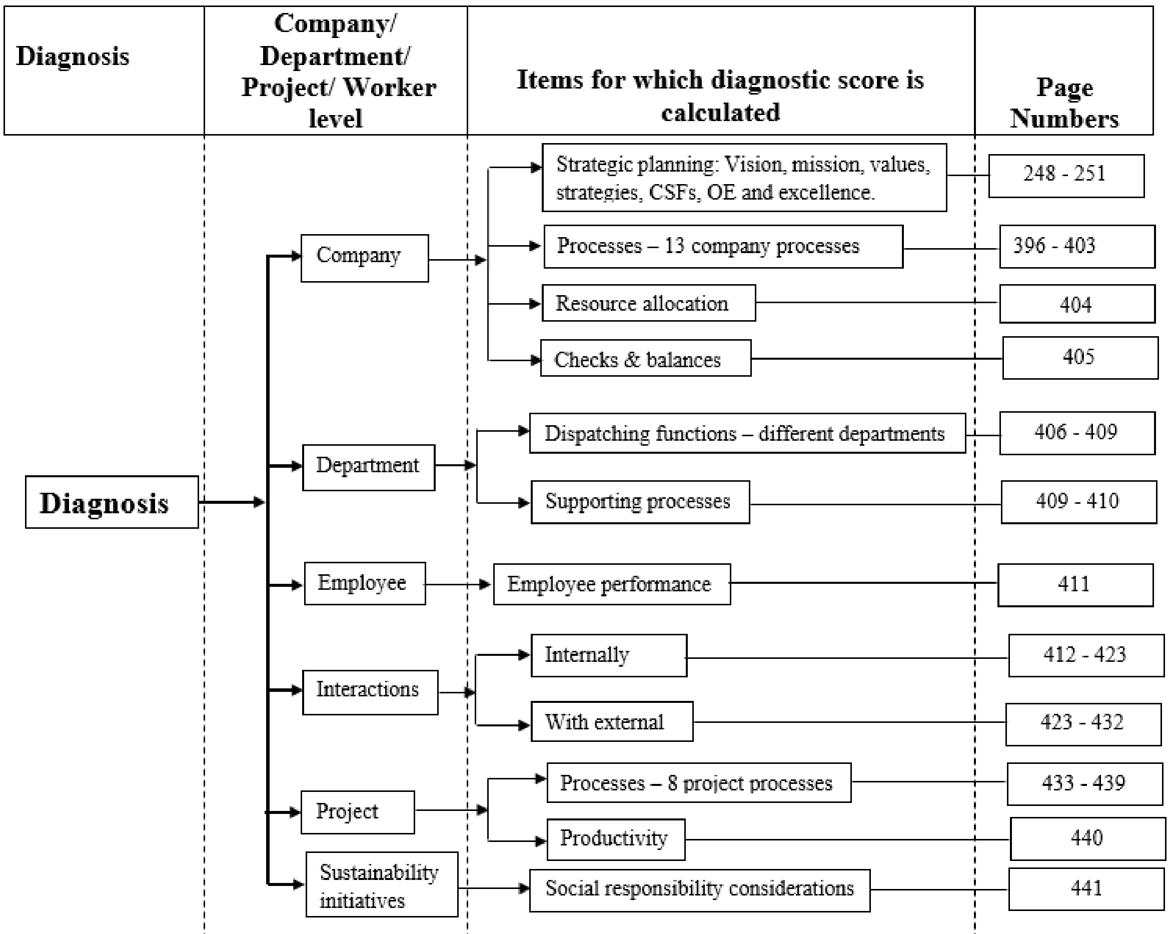


Figure D.1 Outline of items for which diagnostic scores are calculated with page numbers

<u>Company Processes:</u>

A. Communication Process

Table D-1 Computation of diagnostic score for communication process

Item ID	Company Communication Processes Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company employs a strategic and structured approach to internal and external communication.	3	3	9
2	Our company strives to meet stakeholder information needs through its communication plans and implementations.	2	1	2
3	Our company carries out stakeholder engagement assessment to identify communication requirements.	2	1	2
4	Our company carries out communication styles assessment to tailor styles to stakeholders.	3	1	3
5	Our company documents and sends out all communications contemporaneously.	3	1	3
6	We are effective at communicating with customers, subcontractors, suppliers, the public and the market.	4	3	12
7	Our company uses best communication practices.	3	5	15
	Sum		**15**	**46**
	Average Weighted Score	**3.07**		

B. Equipment Management Process

Table D-2 Computation of diagnostic score for equipment management process

Item ID	Company Equipment Management Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We plan well for equipment procurement/rental	3	3	9
2	Construction equipment procurement (purchase, renting or leasing) is integrated into other project schedules.	2	3	6
3	We carry out productivity analysis of all our equipment.	4	1	4
4	Our company uses computer program to track health and maintenance of our equipment fleet.	1	1	1
5	Our company uses computer programs to track productivity and utilization of our equipment fleet.	1	1	1
6	Our company uses total preventive maintenance in equipment management.	2	1	2
	Sum		**10**	**23**
	Average Weighted Score	**2.3**		

C. Estimating Process

Table D-3 Computation of diagnostic score for estimating process

Item ID	Company Estimating Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We continuously collect information on new bids through our networks and subscriptions.	4	5	20
2	We have a systematic estimating process formally defined and followed in our organization.	3	3	9
3	Best estimating practices are always followed in our organization.	2	5	10
4	Accuracy of our estimates are improving with time.	2	1	2
5	Our bid markup percentage is continuously improving.	2	1	2
6	We bid only on projects in which we have excellence and experience.	4	3	12
7	We evaluate market favorability whenever we bid.	1	1	1
	Sum		**19**	**56**
	Average Weighted Score	**2.95**		

D. Finance Management Process

Table D-4 Computation of diagnostic score for finance process

Item ID	Company Finance Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Finance process results in accurate financial statements	4	3	12
2	Our finance process provides timely data to monitor financial health of our business.	2	1	2
3	Our finance process enables preparation of bills and collection of receivables in a timely manner.	3	1	3
4	Finance process produces accurate budget and margin variances.	2	1	2
5	We pay our subcontractors as soon as we receive payment for the work from client	3	1	3
6	We have effective internal accounting controls	4	3	12
7	Our tax filings are accurate	4	1	4
	Sum		**11**	**38**
	Average Weighted Score	**3.45**		

E. Job Cost Tracking Process

Table D-5 Computation of diagnostic score for job costing process

Item ID	Company Job Costing Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company tracks and reports field job costs weekly.	2	1	2
2	Our company reports job cost by activity and cost code.	2	1	2
3	Our company establishes job cost elements to be reported when estimating the job.	1	1	1
4	Explicit cost and time thresholds are agreed with client for change orders.	2	3	6
	Sum		**6**	**11**
	Average Weighted Score	**1.83**		

F. Lessons Learned Process

Table D-6 Computation of diagnostic score for lessons learned process

Item ID	Company Lessons Learned Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company has a structured way to document lessons learned throughout the project execution period.	1	3	3
2	Lessons learned database is accessible to employees.	1	1	1
3	Lessons learned database is easy and fast to use.	1	1	1
4	Lessons learned database is easy to use also on construction sites.	1	1	1
5	Our company management supports lessons learned program.	1	1	1
	Sum		**7**	**7**
	Average Weighted Score	**1.00**		

G. Marketing Process

Table D-7 Computation of diagnostic score for marketing process

Item ID	Company Marketing Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We conduct and review regular market analyses.	1	1	1
2	We monitor and review external economic influences on our organization.	2	1	2
3	We monitor and review external political influences on our organization.	2	1	2
4	We are effective at attracting new customers.	2	3	6
5	We routinely collect, monitor and evaluate customer feedback.	1	3	3
6	We are effective at retaining existing customers.	3	1	3
7	We have an excellent understanding of our customers' needs and likes.	2	3	6
8	We monitor how long it takes to resolve punch list items.	2	1	2
	Sum		**14**	**25**
	Average Weighted Score	**1.79**		

H. Pricing Process

Table D-8 Computation of diagnostic score for pricing process

Item ID	Company Pricing Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company evaluates risk from the type of contract the client selected when pricing projects.	2	1	2
2	Our company evaluates risk from wording used in the contract document.	2	1	2
3	Our company evaluates uncertainties in quantities while bidding in unit price contracts.	3	1	3
4	Our company bidding strategy is either to optimize estimates or to optimize both estimates and markup.	2	3	6
5	We have clear understanding of competitors' pricing.	1	3	3
	Sum		**9**	**16**
	Average Weighted Score	**1.78**		

I. Procurement Process

Table D-9 Computation of diagnostic score for procurement process

Item ID	Company Procurement Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company has a strategic approach to procurement.	2	3	6
2	Our company follows standard procedures and approvals in conducting procurement.	3	1	3
3	Our company established long-term strategic partnerships with few suppliers for frequently purchased items.	2	3	6
4	Our company has experienced procurement professionals with deep knowledge about materials and suppliers.	3	1	3
5	Our company has experienced negotiators in conducting purchases.	3	1	3
6	Our procurement department gets submittals in time for owner approval.	3	1	3
7	Our procurement department has track record of on time delivery.	3	1	3
	Sum		**11**	**27**
	Average Weighted Score	**2.45**		

J. Project Closeout Process

Table D-10 Computation of diagnostic score for project closeout process

Item ID	Company Project Closeout Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company uses standard checklist in closing out projects.	2	3	6
2	Our company plans ahead and works towards a smooth and phased project closeout by making key documents ready.	2	3	6
3	Our company involves all concerned stakeholders in closeout.	3	1	3
4	Our company solicits feedbacks from stakeholders while closing out projects.	2	1	2
5	Our company documents lessons learned while closing out projects.	1	1	1
	Sum		**9**	**18**
	Average Weighted Score	**2**		

K. Scheduling Management Process

Table D-11 Computation of diagnostic score for scheduling management process

Item ID	Company Scheduling Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company produces comprehensive and accurate resource loaded project schedules.	3	3	9
2	Our company produces well - constructed schedules with clear logic and total floats.	2	1	2
3	Our company produces credible schedules with contingency and prioritized risks.	1	1	1
4	Our company schedules are updated regularly with actual progress and logic.	2	1	2
5	Our company uses scheduling best practices.	1	5	5
	Sum		**11**	**19**
	Average Weighted Score	**1.73**		

L. Subcontract Management Process

Table D-12 Computation of diagnostic score for subcontract management process

Item ID	Company Subcontract Management Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company uses documented procedure for selecting subcontractors based on their ability to perform the work (based on previous work, safety and financial soundness).	2	3	6
2	Our company writes a fair and balanced subcontract.	3	1	3
3	Our company involves subcontractors in developing project plans and schedules.	3	3	9
4	Our projects follow a written organizational policy for managing subcontracts.	2	1	2
5	The company holds regular meetings with subcontractor supervisor individually and collectively.	2	1	2
6	The company monitors and supports subcontractors' work (results and performance of subcontractors tracked against their commitments).	3	1	3
7	Changes to subcontracts are made with the agreement of both the prime contractor and the subcontractor.	4	1	4
8	Our people responsible for managing subcontracts are trained to manage subcontracts.	2	1	2
9	Our organization reviews and evaluates its activities for subcontract management.	1	1	1
	Sum		13	32
	Average Weighted Score	**2.46**		

M. Training Management Process

Table D-13 Computation of diagnostic score for training management process

Item ID	**Company Training Process Scoring Items**	**Selected Score**	**Selected Weight**	**Weighted Score**
1	Our organization follows a written policy to meet its training needs.	2	3	6
2	We plan our training activities.	1	1	1
3	We determine the training needs of individuals, departments and/or projects prior to selecting trainings to offer.	3	3	9
4	Our company gives training to all project teams they need to perform their roles.	1	1	1
5	Adequate resources are provided to to implement our organization's training program.	2	1	2
6	Our organization reviews and evaluates the activities of its training program.	2	1	2
	Sum		10	21
	Average Weighted Score	**2.10**		

Company Resource Allocation:

Table D-14 Computation of diagnostic score for company resource allocation

Item ID	Company Resource Allocation Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Corporate planning is a continuous and collaborative process aligned with objectives and strategy.	2	3	6
2	Corporate planning and teams' implementation of plans is guided by common causes and shared values	1	5	5
3	Resource allocation serves company objectives and strategy to help success.	1	5	5
4	Teams set ambitious mid-term goals and resource allocation supports teams to achieve their goals.	1	3	3
5	Resources (tools, equipment and finance) are made available to each team and employee just in time based on detailed plans to enable successful execution of tasks.	2	1	2
6	Efficient and improved Processes are put in place as part of resource allocation to enable higher productivity	2	1	2
7	IT based fast and frequent feedback are made available to operators as part of resource allocation	1	1	1
8	We keep both the big picture and detailed information in perspective in both planning, execution and resource allocation	1	5	5
	Sum		**24**	**29**
	Average Weighted Score	**1.21**		

Company Checks and Balances:

Table D-15 Computation of diagnostic score for company checks and balances

Item ID	Company Checks and Balances Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We have checks and balances to ensure unethical behavior is in check	3	5	15
2	We have checks and balances to make sure mistakes (technical, legal, regulatory) that endanger survival of the company are not made	2	7	14
3	Duties of preparers and approvers of important transactions and business activities are segregated into independent branches of the company	3	3	9
4	Checks and balances procedures are checked for red tapes and unnecessary bureaucracy	2	1	2
5	Checks and balances processes are reconciled and aligned with other company and project processes	2	1	2
6	Electronic routing of documents is used in creation and approval of documents	1	1	1
7	We make sure policies and procedures are followed for proper authorization of transactions and important business activities	3	5	15
	Sum		**23**	**58**
	Average Weighted Score	**2.52**		

DEPARTMENT

A. Bidding Department

Table D-16 Computation of diagnostic score for bidding department

Item ID	Bidding Department Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We continuously collect information on new bids through our networks and subscriptions.	4	5	20
2	We have a systematic estimating process formally defined and followed in our organization.	3	3	9
3	Best estimating practices are always followed in our organization.	2	5	10
4	Accuracy of our estimates are improving with time.	2	1	2
5	Our bid markup percentage is continuously improving.	2	1	2
6	We bid only on projects in which we have excellence and experience.	4	3	12
7	We evaluate market favorability whenever we bid.	1	1	1
	Sum		**19**	**56**
	Average Weighted Score	**2.95**		

B. Design Department

Table D-17 Computation of diagnostic score for design department

Item ID	Design Department Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Accuracy of our shop drawings is improving with time.	3	1	3
2	Accuracy of our land surveys is good.	3	1	3
3	Accuracy of our quantity takeoffs is reliable.	3	1	3
4	Our design department is good at resolving discrepancies/claims.	2	1	2
5	Accuracy of documentation of project data is good.	2	1	2
	Sum		**5**	**13**
	Average Weighted Score	**2.60**		

C. Equipment Department/Unit

Table D-18 Computation of diagnostic score for equipment department/unit

Item ID	Equipment Department Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We plan well for equipment procurement/rental	3	3	9
2	Construction equipment procurement (purchase, renting or leasing) is integrated into other project schedules.	2	1	2
3	We carry out productivity analysis of all our equipment.	3	3	9
4	Our company uses computer program to track health and maintenance of our equipment fleet.	1	1	1
5	Our company uses computer programs to track productivity and utilization of our equipment fleet.	3	1	3
6	Our company uses total preventive maintenance in equipment management.	3	5	15
	Sum		**14**	**39**
	Average Weighted Score	**2.79**		

D. Finance Department

Table D-19 Computation of diagnostic score for bidding department

Item ID	Finance Department Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We prepare accurate financial statements.	4	3	12
2	Our finance department provides timely data to monitor financial health of our business.	2	1	2
3	Our finance prepares bills and collects receivables in a timely manner.	3	1	3
4	We prepare accurate budget and margin variances.	2	1	2
5	We pay our subcontractors as soon as we receive payment for the work.	3	1	3
6	We have effective internal accounting controls.	4	3	12
7	Our tax filings are accurate.	4	1	4
	Sum		**11**	**38**
	Average Weighted Score	**3.45**		

E. Human Resources Department

Table D-20 Computation of diagnostic score for bidding department

Item ID	Human Resources Department Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We have effective recruitment system in place to attract and acquire top talent.	3	3	9
2	We continually develop the competence of our people in terms of skills, knowledge and attitude.	3	1	3
3	In our HR performance management, managers give personalized goals to employees.	1	7	7
4	We have a robust set of HR policies and procedure in place.	3	5	3
5	We effectively communicate with our staff.	3	3	3
	Sum		**19**	**25**
	Average Weighted Score	**1.32**		

F. Marketing Department/Unit

Table D-21 Computation of diagnostic score for marketing department/unit

Item ID	Marketing Department/Unit Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We conduct and review regular market analyses.	1	1	1
2	We monitor and review external economic influences on our organization.	2	1	2
3	We monitor and review external political influences on our organization.	2	1	2
4	We are effective at attracting new customers.	2	3	6
5	We routinely collect, monitor and evaluate customer feedback.	1	3	3
6	We are effective at retaining existing customers.	3	1	3
7	We have an excellent understanding of our customers' needs and likes.	2	3	6
8	We monitor how long it takes to resolve punch list items.	2	1	2
	Sum		14	25
	Average Weighted Score	**1.79**		

G. Procurement Department

Table D-22 Computation of diagnostic score for procurement department

Item ID	Procurement Department Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company has a strategic approach to procurement.	2	3	6
2	Our company follows standard procedures and approvals in conducting procurement.	3	1	3
3	Our company established long-term strategic partnerships with few suppliers for frequently purchased items.	2	3	6
4	Our company has experienced procurement professionals with deep knowledge about materials and suppliers.	3	1	3
5	Our company has experienced negotiators in conducting purchases.	3	1	3
6	Our procurement department gets submittals in time for owner approval.	3	1	3
7	Our procurement department has track record of on time delivery.	3	1	3
	Sum		**11**	**27**
	Average Weighted Score	**2.45**		

Supporting Processes:

Table D-23 Computation of diagnostic score for departments supporting processes

Item ID	Department Process Support Scoring Items	Selected Score	Selected Weight	Weighted Score
1	The organization has assigned deputy manager to manage program of all company and project processes to whom process owners report.	1	5	5
2	The organization has developed and maintains efficient and effective end to end organizational and project processes to deliver our business.	1	5	5
3	The activities for developing and improving our organization's processes are coordinated across the organization.	1	3	3
4	The organization reviews and evaluates its activities for developing and improving our organization's processes.	1	3	3

5	We have controls to ensure our processes are integrated end to end across our organization.	1	3	3
6	Our organization collects, reviews, and makes available information related to the use of the organization's standard processes.	1	1	1
7	The activities and work products for developing and maintaining the organization's processes are subjected to QA review and audit.	1	3	3
8	Our senior management sponsors our organization's activities for process development and improvements.	1	3	3
9	We periodically assess and improve our processes.	1	3	3
10	One or more individuals have full-time or part-time responsibility for the organization's process activities.	1	1	1
11	Units and processes do well to help our company prequalify for jobs.	4	5	20
12	Departments assign employees with the needed expertise to processes as excellence centers in the areas of their functional expertise.	3	5	15
13	Departments resolve technical problems encountered while running processes that need expertise of departments, which could not be resolved by department employees assigned to processes.	3	1	3
14	Departments support and coordinate with team leaders and process owners in performance appraisal, rewarding employees and giving feedback to employees they assigned to processes. These employees are under team leaders and process owners as 80-90% of their time is devoted to processes and departments are in a supporting position to give professional functional appraisal and feedback.	3	3	9
15	Departments support employees assigned to processes in capacity building with training, coaching, mentoring and career development in consultation with team leaders and process owners.	2	3	6
16	Departments support regularly assess new developments and technologies in the industry in their functional areas of expertise and keep company in the fore front for competitiveness.	2	3	6
17	Departments support process control efforts and efforts to setup new processes or to change old ones to remain competitive in the ever changing business environment.	2	3	6
	Sum		53	95

Average Weighted Score 1.79

EMPLOYEE

Table D-24 Computation of diagnostic score for employee

Item ID	Employee Diagnostic Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We always make sure employees' knowledge and skills match task performance requirements	3	1	3
2	We offer training to employees on the body of knowledge which, if mastered, would contribute to or enhance work behavior to enhance and enable employee learning and development	2	3	6
3	Each new hire or employee assigned to new position works under a mentor.	2	3	6
4	We use clear guidelines and criteria to objectively assess employee performance.	3	3	9
5	Each employee is provided constructive feedback by coworkers and managers based on performance assessment.	2	3	6
6	A spectrum of employee development techniques such as training, career development and organization development is used from the time the candidate accepts the offer.	2	1	2
7	We carry out competencies testing to identify best candidates for jobs.	3	1	3
8	We help each employee plan his/her career path and provide horizontal and vertical lines of opportunity for them to advance their career to their full potential.	2	1	2
9	We use structured rewards and incentives for outstanding performance.	3	1	3
10	We manage employee expectations to match job reality through communication.	2	1	2
	Sum		**18**	**42**

Average Weighted Score 2.33

INTERACTIONS

<u>Internal Interactions: a department serving other cost centers, and profit centers</u>

A. Bidding Department

Table D-25 Computation of diagnostic score for bidding internal interactions

Item ID	Bidding Interactions - service provided by bidding	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	BIDDING Eval. By Design 1. Bidding corrects bid drawings it receives from client during bidding process.	Design	3	1	3
2	BIDDING Eval. By Design 2. Bidding incorporates missing information into drawings during bidding.	Design	2	1	2
3	BIDDING Eval. By HR. Bidding submits list & qualification of new hires in time to HR.	HR	4	1	4
4	BIDDING Eval. By Marketing 1. Bidding wins jobs it bids through low price to attract customers in line with marketing strategy.	Marketing	3	1	3
5	BIDDING Eval. By Marketing 2. The winning bid price enables company to complete the job with profit.	Marketing	3	3	9
6	BIDDING Eval. By Procurement 1. Bidding produces accurate estimates during bidding that provide reliable information for equipment procurement during project implementation.	Procurement	3	3	9
7	BIDDING Eval. By Procurement 2. Bidding produces accurate estimates during bidding that provide reliable information for material procurement during project execution.	Procurement	2	1	2
	Sum			11	32
	Average Weighted Score	**2.91**			

B. Design Department

Table D-26 Computation of diagnostic score for design department internal interactions

Item ID	Design Interactions - service provided by design	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	DESIGN Eval. By Bidding 1. Design Dept. provides accurate cost & productivity data to Bid ding Dept. to be used in bidding estimates.	Bidding	2	1	2
2	DESIGN Eval. By Bidding 2. Design Dept. provides cost and productivity data promptly when requested by Bidding Dept.	Bidding	3	1	3
3	DESIGN Eval. By HR. Design Dept submits list & qualification of new hires in time to HR.	HR	4	1	4
4	DESIGN Eval. By Procurement 1. Design Dept. produces accurate and realistic shop drawings for construction.	Procurement	4	1	4
5	DESIGN Eval. By Procurement 2. Design Dept. takeoffs are accurate and reliable to use them for procurement during construction.	Procurement	3	1	3
6	DESIGN Eval. By Projects 1. Design Dept. does a good job of reconciling discrepancies between drawings, and between drawings & specifications during construction.	Project	3	1	3
7	DESIGN Eval. By Projects 2. Design Dept. does a good job of resolving claims with owners and subcontractors in projects.	Project	2	1	2
8	DESIGN Eval. By Projects 3. Design Dept. does a good job in correcting bid drawings during construction.	Project	4	1	4
9	DESIGN Eval. By Projects 4. Design Dept. produces clear coordination drawings of own teams and subcontractors' teams.	Project	1	1	1

10	DESIGN Eval. By Projects 5. Design Dept. does a good job of proactively coordinating all activities on site and letting all know ahead of time.	Project	1	1	1
11	DESIGN Eval. By Projects 6. Design Dept. does a good job of letting all actors know the sequence of their site activities ahead of time.	Project	1	1	1
	Sum			11	28
	Average Weighted Score	**2.55**			

C. Equipment Department

Table D-27 Computation of diagnostic score for equipment department internal interactions

Item ID	Equipment Dept. Interactions - service provided by Equipment Dept.	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	EQUIPMENT Eval. By Design 1. Equipment Dept. collects and archives accurate and reliable equipment productivity data.	Design	3	3	9
2	EQUIPMENT Eval. By Design 2. Equipment Dept. equipment productivity data is presented in a clear and easy to use way.	Design	3	1	3
3	EQUIPMENT Eval. By HR. Equipment submits list & qualification of new hires in time to HR.	HR	4	1	4
4	EQUIPMENT Eval. By Projects 1. Equipment Dept. fairly allocates new and equipment in good condition to projects.	Project	4	1	4
5	EQUIPMENT Eval. By Projects 2. Equipment Dept. allocates the right type/ most appropriate equipment type for the job.	Project	4	1	4
6	EQUIPMENT Eval. By Projects 3. Equipment Dept. allocates experienced operators and mechanics fairly.	Project	4	1	4

7	EQUIPMENT Eval. By Projects 4. Equipment Dept. does very good job in equipment repair & maintenance.	Project	3	5	15
8	EQUIPMENT Eval. By Procurement. Equipment Dept. submits list and specification of equipment to be purchased in time for procurement planning.	Procurement	3	3	9
	Sum			16	52
	Average Weighted Score	**3.25**			

D. Finance Department

Table D-28 Computation of diagnostic score for finance department internal interactions

Item ID	Finance Interactions - service provided by finance	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	FINANCE Eval. By Bidding 1. Finance Dept. obtains bond document of sufficient coverage from insurance companies and provides it to Bidding Dept. in time.	Bidding	4	1	4
2	FINANCE Eval. By Bidding 2. Finance shops for bonding price to get low cost coverage.	Bidding	4	1	4
3	FINANCE Eval. By HR 1. Finance Dept. effects payments to employees on time.	HR	4	1	4
4	FINANCE Eval. By HR 2. Finance Dept. processing of travel & field work payments are easy and efficient.	HR	4	1	4
5	FINANCE Eval. By HR 3. Finance submits list & qualification of new hires in time.	HR	4	1	4
6	FINANCE Eval. By Procurement 1. Finance Dept. effects payments to vendors for purchased equipment promptly.	Procurement	4	1	4
7	FINANCE Eval. By Procurement 2. Finance Dept. effects payments to vendors for purchased materials promptly.	Procurement	4	1	4

8	FINANCE Eval. By Projects 1. Finance Dept. effects payments to vendors for purchased materials.	Project	4	1	4
9	FINANCE Eval. By Projects 2. Finance pays project employees on time.	Project	4	3	12
10	FINANCE Eval. By Projects 3. Finance's processing of travel expense are fast and short.	Project	4	1	4
11	FINANCE Eval. By Top Management 1. Finance Dept. produces statements on time.	Top Management	3	1	3
12	FINANCE Eval. By Top Management 2. Finance Dept. prepares financial analysis and reports on time	Top Management	3	1	3
	Sum			14	54
	Average Weighted Score	**3.86**			

E. Human Resources Department

Table D-28 Computation of diagnostic score for HR internal interactions

Item ID	HR Interactions - service provided by HR	Depart/ Unit served	Selected Score	Selected Weight	Weighted Score
1	HR Eval. By Bidding 1. HR hires experienced estimators requested by bidding in a timely manner.	Bidding	3	1	3
2	HR Eval. By Bidding 2. HR provides competitive welfare and incentives to Bidding Dept. employees.	Bidding	3	1	3
3	HR Eval. By Bidding 3. HR cares for the comfort of bidding employees.	Bidding	3	1	3
4	HR Eval. By Bidding 4. HR design of ergonomics of bidding employees is adequate.	Bidding	2	1	2
5	HR Eval. By Bidding 5. HR processes and passes pays of employees of Bidding Dept. to finance on time.	Bidding	3	1	3

6	HR Eval. By Bidding 6. HR plans career development of each Bidding Dept. employee.	Bidding	3	1	3
7	HR Eval. By Bidding 7. HR gives necessary training to estimators of Bidding Dept.	Bidding	2	1	2
8	HR Eval. By Design 1. HR hires & trains design engineers for Design Dept. in a timely manner.	Design	3	1	3
9	HR Eval. By Design 2. HR hires & trains surveyors for Design Dept. in a timely manner.	Design	3	1	3
10	HR Eval. By Design 3. HR provides competitive welfare and incentives to Design Dept. employees.	Design	3	1	3
11	HR Eval. By Design 4. HR cares for the comfort of design employees.	Design	3	1	3
12	HR Eval. By Design 5. HR cares for the ergonomics of design employees.	Design	2	1	2
13	HR Eval. By Design 6. HR processes and passes pays of employees to finance on time.	Design	4	1	4
14	HR Eval. By Design 7. HR plans career development of each employee.	Design	3	1	3
15	HR Eval. By Equipment 1. HR hires & trains equipment operators & mechanics in a timely manner.	Equipment	2	1	2
16	HR Eval. By Equipment 2. HR provides competitive welfare and incentives to Equipment Dept. employees.	Equipment	3	1	3
17	HR Eval. By Equipment 3. HR cares for the comfort of equipment employees.	Equipment	3	1	3
18	HR Eval. By Equipment 4. HR cares for the ergonomics of equipment employees.	Equipment	2	1	2
19	HR Eval. By Equipment 5. HR processes and passes pays of our employees to finance on time.	Equipment	4	1	4

20	HR Eval. By Equipment 6. HR plans career development of each employee.	Equipment	3	1	3
21	HR Eval. By Finance 1. HR hires & trains accountants & clerks for Finance Dept. in a timely manner.	Finance	3	1	3
22	HR Eval. By Finance 2. HR provides competitive welfare and incentives to Finance Dept. employees.	Finance	3	1	3
23	HR Eval. By Finance 3. HR cares for the comfort of finance employees.	Finance	3	1	3
24	HR Eval. By Finance 4. HR cares for the ergonomics of finance employees.	Finance	2	1	2
25	HR Eval. By Finance 5. HR processes and passes pays of our employees to finance on time.	Finance	4	1	4
26	HR Eval. By Finance 6. HR plans career development of each employee.	Finance	3	1	3
27	HR Eval. By Finance 7. HR submits labor hours in time.	Finance	4	1	4
28	HR Eval. By Marketing 1. HR hires & trains marketing professionals in a timely manner.	Marketing	2	1	2
29	HR Eval. By Marketing 2. HR provides competitive welfare and incentives to Marketing employees.	Marketing	3	1	3
30	HR Eval. By Markting 3. HR cares for the comfort of marketing employees.	Marketing	3	1	3
31	HR Eval. By Marketing 4. HR ensures ergonomics design is adequate for marketing employees.	Marketing	2	1	2
32	HR Eval. By Marketing 5. HR processes and passes pays of our employees to finance on time.	Marketing	3	1	3
33	HR Eval. By Procurement 1. HR hires & trains procurement professionals in a timely manner.	Procurement	2	1	2

34	HR Eval. By Procurement 2. HR provides competitive welfare and incentives to Procurement Dept. employees.	Procurement	3	1	3
35	HR Eval. By Procurement 3. HR cares for the comfort of procurement employees.	Procurement	3	1	3
36	HR Eval. By Procurement 4. HR cares for the ergonomics of procurement employees.	Procurement	2	1	2
37	HR Eval. By Procurement 5. HR processes and passes pays of employees to finance on time.	Procurement	4	1	4
38	HR Eval. By Procurement 6. HR plans career development of each employee.	Procurement	3	1	3
39	HR Eval. By Projects. HR hires required people for projects in a timely manner.	Project	3	1	3
	Sum			39	112
	Average Weighted Score	**2.87**			

F. ICT Unit

Table D-29 Computation of diagnostic score for ICT unit internal interactions

Item ID	ICT Interactions - service provided by ICT	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	ICT Eval. By Bidding 1. ICT follows up timely purchase and installation of estimating software.	Bidding	4	1	4
2	ICT Eval. By Bidding 2. ICT provides timely maintenance of estimating software.	Bidding	3	1	3
3	ICT Eval. By Design 1. ICT follows up timely purchase and installation of design software.	Design	4	1	4
4	ICT Eval. By Design 2. ICT provides timely maintenance of design software.	Design	3	1	3
5	ICT Eval. By Equipment 1. ICT developed and updates equipment productivity data collection & analysis package.	Equipment	1	1	1

6	ICT Eval. By Equipment 2. The package is user friendly and intuitive.	Equipment	1	1	1
7	ICT Eval. By Finance 1. ICT follows up timely purchase and installation of accounting software.	Finance	4	1	4
8	ICT Eval. By Finance 2. ICT provides timely maintenance of accounting software.	Finance	3	1	3
9	ICT Eval. By HR. ICT submits list & qualification of new hires in time.	HR	3	1	3
	Sum			9	26
	Average Weighted Score	**2.89**			

G. Marketing Department/Unit

Table D-30 Computation of diagnostic score for marketing department/unit internal interactions

Item ID	Marketing Interactions - service provided by marketing	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	MARKETING Eval. By Bidding 1. Marketing dept gets good information on new bids in a timely manner.	Bidding	3	1	3
2	MARKETING Eval. By Bidding 2. Marketing Dept. acquires new bid documents in time.	Bidding	3	1	3
3	MARKETIN Eval. By Top Management 1. Marketing dept makes realistic promises that company can deliver.	Top Management	3	1	3
4	MARKETIN Eval. By Top Management 2. Marketing Dept. professionals know company processes and capability as to realistically talk about company services and advertise.	Top Management	2	1	2
	Sum			4	11
	Average Weighted Score	**2.75**			

H. Procurement Department

Table D-31 Computation of diagnostic score for procurement internal interactions

Item ID	Procurement Interactions - service provided by procurement	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	PROCUREMENT Eval. By Bidding. Procurement purchased estimating software in time	Bidding	4	1	4
2	PROCUREMENT Eval. By Equipment 1. Procurement Dept. purchases the right type/ most appropriate equipment.	Equipment	3	1	3
3	PROCUREMENT Eval. By Equipment 2. Procurement Dept. purchases the lowest cost equipment without compromising quality.	Equipment	3	1	3
4	PROCUREMENT Eval. By Equipment 3. Procurement Dept. is free of corruption and strives to maximize company profit.	Equipment	3	1	3
5	PROCUREMENT Eval. By HR. Procurement submits list & qualification of new hires in time.	HR	3	1	3
6	PROCUREMENT Eval. By Projects 1. Procurement Dept. purchases the right type/ most appropriate materials for the job.	Project	3	1	3
7	PROCUREMENT Eval. By Projects 2. Procurement Dept. purchases the lowest cost material satisfying quality requirements.	Project	3	1	3
8	PROCUREMENT Eval. By Projects 3. Procurement Dept. is free of corruption and strives to maximize company profit.	Project	3	1	3
	Sum			8	25
	Average Weighted Score	**3.13**			

I. Project

Table D-32 Computation of diagnostic score for project internal interactions

Item ID	Project Interactions - service provided by project	Depart./ Unit served	Selected Score	Selected Weight	Weighted Score
1	PROJECTS Eval. By Finance 1. Projects submit project labor hours in time to finance.	Finance	3	1	3
2	PROJECTS Eval. By Finance 2. Projects submit subcontractor payment approvals in time.	Finance	3	1	3
3	PROJECTS Eval. By HR 1. Our project teams have a very good safety & health record.	HR	4	1	4
4	PROJECTS Eval. By HR 2. Our projects are good at implementing drugs and alcohol testing program.	HR	3	1	3
5	PROJECTS Eval. By HR 3. Our projects are implementing health &safety trainings & orientation well.	HR	3	1	3
6	PROJECTS Eval. By HR 4. Projects submits list & qualification of new hires in time.	HR	4	1	4
7	PROJECTS Eval. By Marketing 1. Projects resolve punch list items fast that help company with customer retention.	Marketing	2	1	2
8	PROJECTS Eval. By Marketing 2. Projects submit subcontractor payment approvals in time.	Marketing	3	1	3
9	PROJECTS Eval. By Top Management. Our project teams do a good job of delivering projects that meet customer needs that help us get job continuously.	Top Management	3	1	3
10	PROJECTS Eval. By Top Management 2. The quality of construction and service our project teams provide help us get repeat business.	Top Management	3	1	3

11	PROJECTS Eval. By Top Management 3. We are proud of our project teams because they are front line people who deliver the quality service to clients on our behalf.	Top Management	3	1	3
	Sum			11	34
	Average Weighted Score	**3.09**			

Internal Entities Interacting with External Stakeholders:

A. Bidding Department

Table D-33 Computation of diagnostic score for bidding external interactions

Item ID	Project Interactions - service provided by project	External Stakeholder	Selected Score	Selected Weight	Weighted Score
1	**Bidding interaction with bidding information providers.** Bidding subscribes to bidding information providers for a fee.	Bidding information providers	3	1	3
2	**Bidding interaction with networks.** Bidding takes advantage of trade association memberships, local chamber of commerce and online network like LinkedIn.	Network	2	1	2
3	**Bidding interaction with owners.** Bidding takes advantage of subscription to different owners' magazines.	Owner magazines	3	1	3
	Sum			3	8
	Average Weighted Score	**2.67**			

B. Finance Department

Table D-34 Computation of diagnostic score for finance department external interactions

Item ID	Project Interactions - service provided by finance	External Stakeholder	Selected Score	Selected Weight	Weighted Score
1	**Finance interaction with banks1.** Finance establishes good relationship with banks to secure the needed construction loans quickly.	Bank	3	1	3
2	**Finance interaction with banks2.** Finance services construction loans in time.	Bank	2	1	2

3	**Finance interaction with insurance1.** Finance shops for list price bid and performance bonds.	Insurance	4	1	4
4	**Finance interaction with insurance2.** Finance shops for list price construction insurance (property damage and third party injuries or damage claims).	Insurance	4	1	4
5	**Finance interaction with tax authorities1.** Finance files taxes in the right format (in compliance with regulatory requirements).	Tax authorities	3	1	3
6	**Finance interaction with tax authorities2.** Finance files taxes in time.	Tax authorities	3	1	3
	Sum			6	19
	Average Weighted Score	**3.17**			

C. Marketing

Table D-35 Computation of diagnostic score for marketing external interactions

Item ID	Project Interactions - service provided by marketing	External Stakeholder	Selected Score	Selected Weight	Weighted Score
1	**Marketing interaction with prospective clients1.** Marketing develops effective promotion and builds clearly identifiable brand.	Prospective clients	2	1	2
2	**Marketing interaction with prospective clients2.** Marketing built professional company website and has a good social media presence.	Prospective clients	2	1	2
3	**Marketing interaction with prospective clients3.** Marketing is good at identifying client needs and at demonstrating company has a clear differentiating capacity to meet those needs.	Prospective clients	2	1	2
4	**Marketing interaction with prospective clients4.** Marketing is good at market research and at identifying new opportunities.	Prospective clients	2	1	2
5	**Marketing interaction with prospective clients5.** Company is good at prequalifying for jobs.	Prospective clients	3	1	3
6	**Marketing interaction with current clients1.** Marketing follows up that project teams and head office gives superior, fair and emphatic service to clients.	Current clients	2	1	2
7	**Marketing interaction with current clients2.** Marketing follows up that appropriate level of competencies and staffing levels are used in serving clients.	Current clients	2	1	2

8	**Marketing interaction with current clients3.** Marketing follows up that high performing subcontractors are used on projects.	Current clients	2	1	2
9	**Marketing interaction with current clients4.** Procurement Marketing follows up that quality standards are kept.	Current clients	2	1	2
10	**Marketing interaction with current clients5.** Marketing follows up that client expectations are managed through effective communications.	Current clients	1	1	1
11	**Marketing interaction with current clients6.** Marketing ensures that punch list items are resolved fast.	Current clients	1	1	1
12	**Marketing interaction with current clients7.** Marketing collects client feedback and acts on them fast.	Current clients	3	1	3
13	**Marketing interaction with current clients8.** Procurement Marketing follows up that good professional relations are maintained with the clients.	Current clients	2	1	2
14	**Marketing interaction with past clients1.** Marketing follows up to get recommendation from past clients.	Past clients	1	1	1
15	**Marketing interaction with pas clients2.** Marketing follows up to get repeat business from past clients.	Past clients	2	1	2
16	**Marketing interaction with past clients3.** Marketing follows up with past clients to get feedback on performance of constructed facility after 5, 10, 15 years as appropriate.	Past clients	1	1	1
17	**Marketing interaction with the public1.** Equipment Promotes the services of the company to let the public know the company exists and to let the public know what the company does.	General public	3	1	3
18	**Marketing interaction with the public2.** Equipment Marketing arranges for engagement of company in community services and offer help in a way that show cases company expertise.	General public	1	1	1
19	**Marketing interaction with the public3.** Marketing takes advantage of trade association membership, local chamber of commerce, online network like LinkedIn and subscription to different construction magazines including big owners' magazines.	General public	1	1	1

	Sum			19	35
	Average Weighted Score	**1.84**			

D. Procurement

Table D-36 Computation of diagnostic score for procurement external interactions

Item ID	Project Interactions - service provided by procurement	External Stakeholder	Selected Score	Selected Weight	Weighted Score
1	**Procurement interaction with suppliers1.** Procurement established long-term strategic partnerships with few suppliers for frequently purchased items.	Suppliers	3	1	3
2	**Procurement interaction with suppliers2.** Procurement has good relationship with equipment dealers and gets detailed up to date specification information.	Suppliers	3	1	3
3	**Procurement interaction with equipment rentals.** Procurement has good relationship with equipment rental companies as to get good equipment on short notice.	Equipment rentals	2	1	2
4	**Procurement interaction with logistics providers.** Procurement has good relationship with logistics companies that deliver purchased materials and equipment.	Logistics providers	3	1	3
	Sum			4	11
	Average Weighted Score	**2.75**			

E. Project Manager

Table D-37 Computation of diagnostic score for project manager external interactions

Item ID	Project Interactions - service provided by project manager	External Stakeholder	Selected Score	Selected Weight	Weighted Score
1	**Project manager interaction with client1.** Project manager prepares detailed plans of action and communicates the plan to client effectively to enable completion of the project within time and budget.	Client	3	3	9
2	**Project manager interaction with client2.** Project manager manages the project strictly to the requirements of the contract.	Client	3	1	3

3	**Project manager interaction with client3.** Project manager manages client expectations through effective communication.	Client	2	1	2
4	**Project manager interaction with client4.** Project manager manages continuously engages the client for the project initiative.	Client	2	1	2
5	**Project manager interaction with client5.** Project manager interacts with client through formal reporting systems (schedule and cost progress reports).	Client	4	1	4
6	**Project manager interaction with client6.** Project manager interacts with client through informal reporting systems (including contractor marketing activities, informal negotiations of disputes and shared decision-making on contract implementation procedures).	Client	3	1	3
7	**Project manager interaction with client7.** Project manager interacts with client in problem solving.	Client	4	1	4
8	**Project manager interaction with subcontractor1.** Project manager interacts with client through informal reporting systems (including contractor marketing activities, informal negotiations of disputes and shared decision-making on contract implementation procedures).	Subcontractors	4	1	4
9	**Project manager interaction with subcontractor2.** Project manager involves subcontractors in schedule development.	Subcontractors	3	1	3
10	**Project manager interaction with subcontractor3.** Project manager communicates expectations clearly to subcontractors.	Subcontractors	3	1	3
11	**Project manager interaction with subcontractor4.** Project manager develops submittal schedule for subcontractors.	Subcontractors	1	1	1
12	**Project manager interaction with subcontractor5.** Project manager communicates requirement of safe working practices to subcontractors.	Subcontractors	2	1	2
13	**Project manager interaction with subcontractor6.** Project manager engages subcontractors in change order reviews.	Subcontractors	3	1	3

14	**Project manager interaction with subcontractor7.** Project manager issues coordination drawings to subcontractors.	Subcontractors	1	1	1
15	**Project manager interaction with subcontractor8.** Project manager meets with subcontractors regularly individually and collectively.	Subcontractors	2	1	2
16	**Project manager interaction with subcontractor9.** Project manager provides regular feedback to subcontractors.	Subcontractors	2	1	2
17	**Project manager interaction with subcontractor10.** Project manager communicates requirement of toolbox meeting to subcontractors.	Subcontractors	1	1	1
18	**Project manager interaction with subcontractor11.** Project manager communicates requirement of good house-keeping to subcontractors.	Subcontractors	1	1	1
19	**Project manager interaction with subcontractor12.** Project manager walks the jobsite frequently and help the subcontractors do timely work.	Subcontractors	2	1	2
20	**Project manager interaction with subcontractor13.** Project manager identifies and supports the controlling subcontractor.	Subcontractors	2	1	2
21	**Project manager interaction with subcontractor14.** Project manager pays subcontractors timely.	Subcontractors	3	1	3
22	**Project manager interaction with subcontractor15.** Project manager manages relationship with subcontractors and makes sure the contract is enforced.	Subcontractors	3	1	3
23	**Project manager interaction with suppliers1.** Project manager communicates clearly the dimensions and specifications of supply items ordered.	Suppliers	3	1	3
24	**Project manager interaction with suppliers2.** Project manager identifies long lead items and orders them in time.	Suppliers	4	1	4
25	**Project manager interaction with suppliers3.** Project manager lists material and equipment to be procured from schedule and plan and prepares submittal schedule for owner approval.	Suppliers	3	1	3

26	**Project manager interaction with suppliers4.** Project manager gives detailed and complete drawings to suppliers.	Suppliers	3	1	3
27	**Project manager interaction with suppliers5.** Project manager pays suppliers timely.	Suppliers	3	1	3
28	**Project manager interaction with trade unions.** Project manager complies with collective union agreements.	Trade unions	3	1	3
29	**Project manager interaction with regulators1.** Project manager knows the regulators and their expectations.	Regulators	1	1	1
30	**Project manager interaction with regulators2.** Project manager ensures projects meet code and other regulatory requirements.	Regulators	4	1	4
31	**Project manager interaction with regulators3.** Project manager ensures compliance is shown on construction schedules.	Regulators	1	1	1
32	**Project manager with communities1.** Project manager builds positive and sustainable relationships in communities with key individuals, groups and organizations	Communities	2	1	2
33	**Project manager with communities2.** Project manager demonstrates sensitivity to community concerns and issues.	Communities	3	1	3
34	**Project manager with communities3.** Project manager goes to community services physically few times a year where they create good impressions and avoid sales pitches.	Communities	2	1	2
35	**Project manager with communities4.** Project manager offers help to communities in the area of expertise that showcases the companies' capacity.	Communities	1	1	1
36	**Project manager with communities5.** Project manager designs and implements community programs few times a year where all employees are involved in philanthropy, volunteerism, partnerships or in kind donations.	Communities	1	1	1
	Sum			38	94
	Average Weighted Score	**2.47**			

F. Top Management

Table D-38 Computation of diagnostic score for top management external interactions

Item ID	Project Interactions - service provided by project	External Stakeholder	Selected Score	Selected Weight	Weighted Score
1	**Top Management with client1.** Top management makes itself available to clients for open and honest communication, and makes feel the client their ideas and concerns are taken seriously.	Client	3	1	3
2	**Top Management with client2.** Top management makes the client feel the enthusiasm, zeal, positive energy and confidence so that the client enjoys working with the company.	Client	2	1	2
3	**Top Management with client3.** Top management establishes personal connection with client representatives and acknowledges them as individuals to show genuine concern about their family, kids, and personal life.	Client	2	1	2
4	**Top Management with client4.** Share scientific knowledge about the clients' project area in simple language about why you do things the way you do, the process it takes to help client feel knowledgeable and in the loop for the project initiative.	Client	1	1	1
5	**Top Management with client5.** Give expert opinion in the best interest of the project and the client on any issues that may come up and help/guide them decide what they want.	Client	1	1	1
6	**Top Management with client6.** Top management manages client expectations through communication to be realistic and exceeds those expectations as leading experts and professional.	Client	1	1	1
7	**Top Management with subcontractors1.** Top management gets subcontractor commitment at pre-bid meetings.	Subcontractors	4	1	4
8	**Top Management with subcontractors2.** Top management challenges and helps partnering subcontractors grow.	Subcontractors	1	1	1
9	**Top Management with regulators1.** Top management follows a strategy of constructive engagement with regulators in the construction industry.	Regulators	1	1	1

10	**Top Management with regulators2.** Top management gives input to regulators during rule- making to to affect it in the best interest of the company and industry.	Regulators	1	1	1
11	**Top Management with regulators3.** Top management presents the firm in the best light to regulators during examination and lets them find out what management has overlooked.	Regulators	1	1	1
12	**Top Management with regulators4.** Top management explains the facts that got the company there genuinely during investigation which may result in the charge being dropped (courts too would drop it if the facts are convincing and the intention of the company is pure).	Regulators	1	1	1
13	**Top Management with regulators5.** Top management knows the regulators and their expectations.	Regulators	1	1	1
14	**Top Management with regulators6.** Top management ensures projects meet code and other regulatory requirements.	Regulators	4	1	4
15	**Top Management with regulators7.** Top management ensures compliance is shown on construction schedules.	Regulators	1	1	1
16	**Top Management with regulators8.** Top management instills in all employees that compliance with regulatory requirements instills public trust in the organization and promotes confidence in company services and products.	Regulators	1	1	1
17	**Top Management with professional associations1.** Top management registered the company in trade associations.	Professional associations	3	1	3
18	**Top Management with professional associations2.** Top management sends company representatives to trade shows.	Professional associations	2	1	2
19	**Top Management with professional associations3.** Top management encourages employees to professional conferences.	Professional associations	2	1	2
20	**Top Management with professional associations4.** Top management encourages employees to get trainings and professional certifications.	Professional associations	1	1	1

21	**Top Management with professional associations5.** Top management requires all employees to comply with code of ethics of professional associations.	Professional associations	3	1	3
22	**Top Management with professional associations6.** Top management subscribes to journal of academic societies and uses the information in training and development of employees.	Professional associations	1	1	1
23	**Top Management with communities1.** Top management builds positive and sustainable relationships in communities with key individuals, groups and organizations	Communities	2	1	2
24	**Top Management with communities2.** Top management demonstrates sensitivity to community concerns and issues.	Communities	2	1	2
25	**Top Management with communities3.** Top management goes to community services physically few times a year where they create good impressions and avoid sales pitches.	Communities	2	1	2
26	**Top Management with communities4.** Top management offers help to communities in the area of expertise that showcases the companies' capacity.	Communities	1	1	1
27	**Top Management with communities5.** Top management designs and implements community programs few times a year where all employees are involved in philanthropy, volunteerism, partnerships or in kind donations.	Communities	1	1	1
28	**Top Management with communities7.** Top management strives to be the investment of choice, the supplier of choice, the employer of choice and a neighbor of choice.	Communities	1	1	1
	Sum			**28**	**47**
	Average Weighted Score	**1.68**			

PROJECT

Project Processes:

A. Change Control Process

Table D-39 Computation of diagnostic score for change control process

Item ID	Project Change Control Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We plan for our project change control and management procedures in our projects.	3	3	9
2	We distribute standard reports on project changes to all affected groups and individuals.	3	3	9
3	Our projects follow a written organizational policy for implementing project change control activities.	1	1	1
4	We incorporate the changes we make into design drawings to produce as built drawings.	3	1	3
5	Our project personnel are trained to perform project change control & management activities for which they are responsible.	1	1	1
6	Project change control & management activities for controlling variations to projects are subjected to QA review and audit.	1	1	1
7	Our organization reviews and evaluates its activities for project change control & management.	1	1	1
	Sum		**11**	**25**
	Average Weighted Score	**2.27**		

B. Monitoring and Control Process

Table D-40 Computation of diagnostic score for monitoring and control process

Item ID	Project Monitoring and Control Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our projects' actual results (e.g. milestones and budget) are compared with estimates in the project plans.	4	3	12
2	Corrective actions are taken when actual results differ significantly from a project's plans.	4	1	4
3	Changes in a projects' commitments are communicated to and agreed by all affected groups and individuals within those groups.	3	1	3
4	Our projects follow a written organizational policy for tracking their performance.	2	1	2
5	Someone on a project is assigned specific responsibilities for tracking project performance relative to the project plan.	2	1	2
6	The activities for project tracking and oversight are reviewed with the project manager on a periodic basis.	2	1	2
7	Our organization reviews and evaluates its activities for Project Tracking and Oversight.	1	1	1
	Sum		9	26
	Average Weighted Score	**2.89**		

C. Planning Process

Table D-41 Computation of diagnostic score for planning process

Item ID	Project planning scoring items	Selected Score	Selected Weight	Weighted Score
1	Estimates and schedules (e.g. program and cost) are documented for use in tracking projects.	3	3	9
2	The plans document the activities to be performed and the commitments made in relation to a project.	3	5	15
3	All affected groups agree to their commitments relating to a project.	3	1	3
4	Our projects follow a written organizational policy for the planning of projects.	1	1	1
5	Adequate resources are provided for planning projects (e.g., funding and experienced individuals).	2	1	2

6	Our project managers on projects review the activities for planning on both periodic and event-driven basis.	2	1	2
7	our organization reviews and evaluates its activities for Project Planning.	1	1	1
	Sum		13	33
	Average Weighted Score	**2.54**		

D. Quality Assurance Process

Table D-42 Computation of diagnostic score for QA process

Item ID	**Project QA Process Scoring Items**	**Selected Score**	**Selected Weight**	**Weighted Score**
1	Our company plans QA activities.	2	1	2
2	QA activities provide objective verification that products and activities adhere to applicable standards, procedures, and requirements.	3	3	9
3	The results of QA reviews and audits are provided to affected groups and individuals (e.g., those who performed the work and those who are responsible for the work).	1	1	1
4	Issues of noncompliance are addressed by senior management (e.g. deviations from applicable standards).	2	3	6
5	Our projects follow a written organization policy for implementing QA activities.	1	1	1
6	Adequate resources are provided for performing QA activities (e.g. funding and a designated manager who will receive and act on non-compliance items).	1	1	1
7	Our Project Managers review activities for QA on a periodic basis.	2	1	2
8	Our organization reviews and evaluates its activities for QA.	2	1	2
	Sum		12	24
	Average Weighted Score	**2.00**		

E. Risk Management Process

Table D-43 Computation of diagnostic score for risk management process

Item ID	Project Risk Management Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	We plan and conduct risk management on all our projects.	2	3	6
2	Our projects follow a written organizational policy for carrying out risk management.	1	1	1
3	Member(s) of the project team who are responsible for risk management activities receive training to carry out their roles.	1	1	1
4	We monitor risk mitigation activities to ensure that the desired results are being obtained.	1	3	3
5	Activities for risk management are reviewed with the project manager on both periodic and event-driven basis	1	1	1
6	Our organization reviews and evaluates its risk management activities.	1	1	1
	Sum		10	13
	Average Weighted Score	**1.30**		

F. Safety and Health Management Process

Table D-44 Computation of diagnostic score for safety and health management process

Item ID	Project Safety Management Process Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our organization follows written policy about health and safety on our project sites.	3	3	9
2	Our organization involves supervisors in making health and safety policy.	1	3	3
3	Our organization conducts frequent and regular safety inspections to proactively identify and control hazards.	2	1	2
4	We give site specific safety training to managers, employees and subcontractors on hazard identification and control.	1	1	1
5	We assign adequate safety staff to projects.	1	1	1
6	Our project safety staff holds regular safety meetings with all subcontractors.	1	1	1
7	We implement worker-to-worker safety observation action initiative on all our projects	1	1	1
8	We frequently conduct workers' safety perception surveys.	1	1	1
9	Our organization periodically reviews and evaluates our safety and health policy.	3	1	3
	Sum		13	22
	Average Weighted Score	**1.69**		

G. Scope and Brief Management Process

Table D-45 Computation of diagnostic score for scope and brief management process

Item ID	Project scope management process scoring items	Selected Score	Selected Weight	Weighted Score
1	Documented project brief and scope is established at the commencement of our projects.	4	5	20
2	When a project brief changes, the necessary adjustments to programs, drawings and activities are made.	4	1	4
3	Our projects follow a written organizational policy for managing the brief and scope through the project life cycle.	2	1	2
4	Our people in projects who are charged with management responsibilities for the brief and scope are trained in the procedures for managing project brief and scope.	1	1	1
5	The activities for managing and updating project brief and scope are subject to Quality Assurance review.	1	1	1
6	Our organization reviews and evaluates its activities for brief and scope Management.	1	1	1
	Sum		10	29
	Average Weighted Score	**2.90**		

H. Team Coordination and Management Process

Table D-46 Computation of diagnostic score for team coordination and management process

Item ID	Project team coordination process scoring items	Selected Score	Selected Weight	Weighted Score
1	The various disciplines collaborate with each other and the client to establish the brief and scope requirements.	3	1	3
2	The disciplines agree to their commitments as represented in an overall project plan.	3	1	3
3	The disciplines identify, track, and resolve interdisciplinary issues (e.g., incompatible programs, technical risks, etc.).	2	1	2
4	Our organization follows a written policy for interdisciplinary coordination.	1	1	1
5	The support tools used by different disciplines enable effective communication and coordination (e.g., compatible planning software, CAD standards etc).	1	3	3
6	The activities for interdisciplinary coordination are reviewed with the project manager on both a periodic and event-driven basis.	1	1	1
7	Our organization reviews and evaluates its activities for interdisciplinary communication.	1	1	1
	Sum		9	14
	Average Weighted Score	**1.56**		

Project Productivity:

Table D-47 Computation of diagnostic score for project productivity

Item ID	Project Productivity Scoring Items	Selected Score	Selected Weight	Weighted Score
1	**Materials 1.** Our projects follow procurement plans and procedures for acquisition of materials and equipment.	3	3	9
2	**Materials 2.** We use systematic materials tracking and management system on project sites.	2	1	2
3	**Materials 3.** We inspect and classify all materials on delivery on sites before storage.	3	1	3
4	**Equipment 1.** We follow a structured approach to machinery procurement and maintenance to ensure their availability when needed on site.	3	3	9
5	**Equipment 2.** We follow tools and equipment management best practices for tracking and maintenance.	3	3	9
6	**Execution 1.** We carry out detailed short-term planning to produce advanced work packages.	3	5	15
7	**Execution 2.** We conduct constructability review before execution.	3	3	9
8	**Execution 3.** We follow a structured approach to acquisition of right of way, land and utilities.	3	1	3
9	**Execution 4.** We conduct reviews to meet environmental, regulatory and permitting requirements.	3	1	3
10	**HR 1.** We make skills assessment and evaluation in determining project crews' composition and formation.	3	5	15
11	**HR 2.** We train our project employees technically in their trades to advance their career development.	3	1	3
12	**HR 3.** We incentivize to reinforce desired behaviors.	2	1	2
13	**HR 4.** We keep clear line of command and delegation of responsibility.	3	1	3
14	**HR 5.** We have retention plan for our experienced personnel.	2	1	2
15	**Constr. Methods 1.** We control our schedule execution and management on projects.	3	3	9
16	**Constr. Methods 2.** We follow best site planning practices.	3	3	9
17	**Constr. Methods 3.** We follow best practices in communication, coordination and project completion and startup plans.	3	3	9
18	**Safety 1.** We follow job site safety guidelines and best practices.	3	5	15
19	**Safety 2.** We implement drugs and alcohol testing program.	1	1	1
20	**Safety 3.** We implement health & safety training programs.	3	1	3
	Sum		**46**	**133**
	Average Weighted Score	**2.89**		

Table D-48 Computation of diagnostic score for sustainability initiatives

Item ID	Company Sustainability Initiative Scoring Items	Selected Score	Selected Weight	Weighted Score
1	Our company tries to conserve resources in constructing projects.	4	3	12
2	Our company tries to preserve natural site conditions of project sites as it carries out constructions.	2	1	2
3	Our company tries to minimize pollution to the environment in its construction operations.	2	5	10
4	Our company ensures safety and health of its employees working on projects.	4	3	12
5	Our company tries to ensure health of end facility users by avoiding use of deleterious construction materials.	3	1	3
6	Our company implements environmental management systems voluntarily to dispatch its social accountability.	1	5	5
	Sum		18	44
	Average Weighted Score =	**2.44**		

APPENDIX E ROOT CAUSES OF FAILURE OF FACTORS ON FISHBONE DIAGRAMS WITH THE CORRESPONDING RAPID IMPROVEMENT PRINCIPLES, COUNTERMEASURES AND BEST PRACTICES TO RESOLVE THEM IN DATABASE OF DECISION SUPPORT SYSTEM

Figure E.1 gives outline of items for which root cause analysis and improvement by means of RIPs, counter measures and BPs are documented in the database of the DSS.

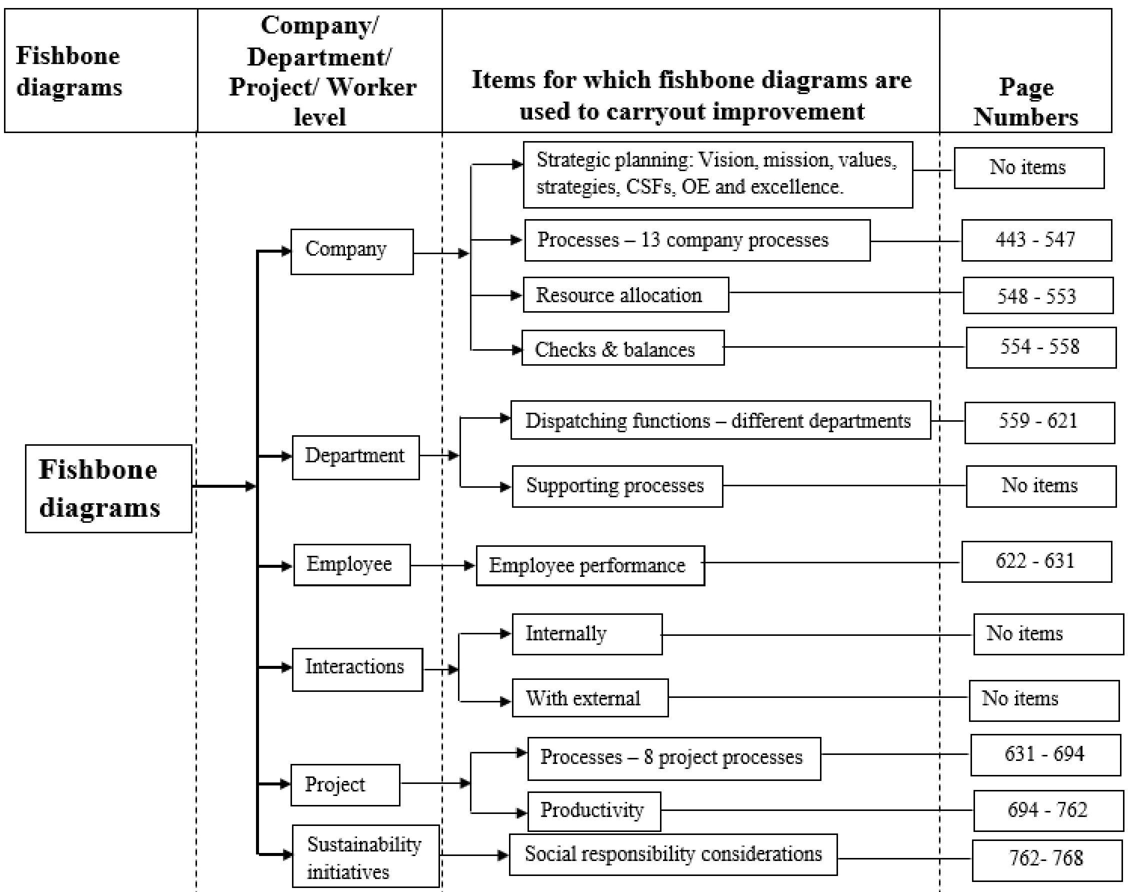


Figure E.1 Outline of items for which root cause analysis and improvement by means of RIPs, counter measures and BPs are documented in the database of the DSS

COMPANY

Company Processes:

A. Communication Process

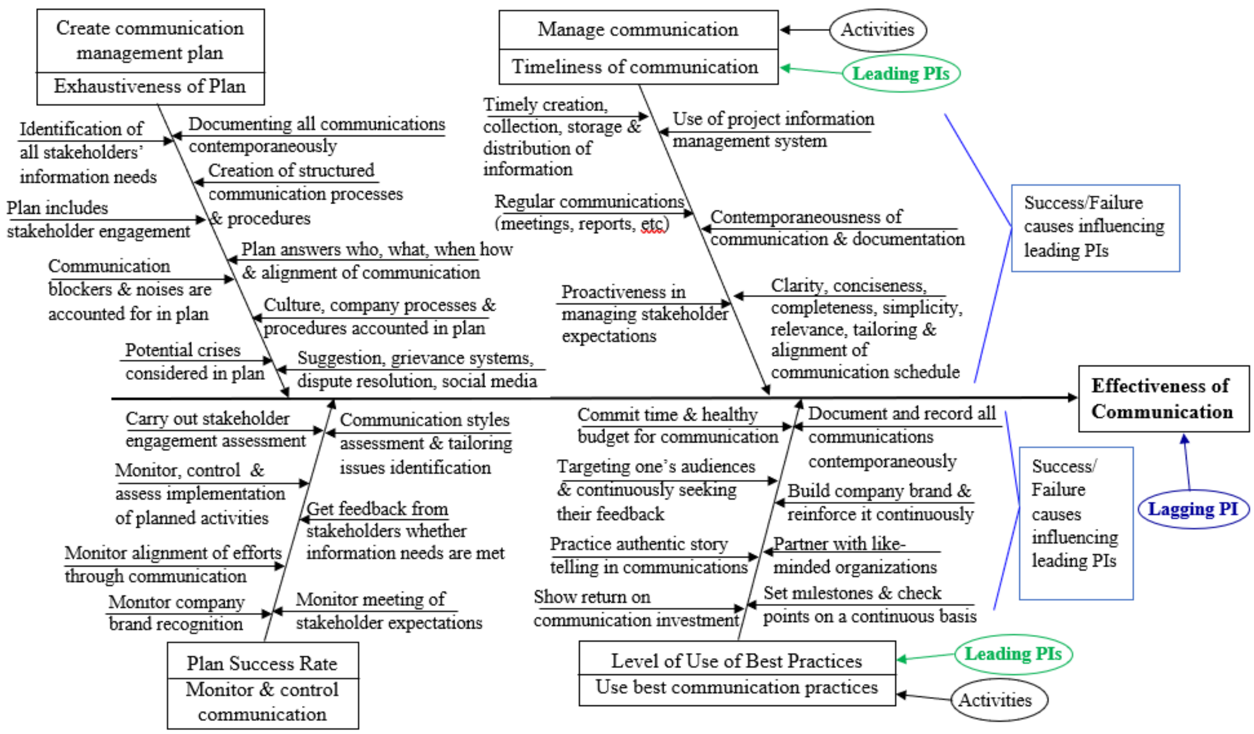


Figure E.2 Fishbone diagram for effectiveness of communication management process

1. **Leading Indicator:** Exhaustiveness of Plan

a. **Factor on fishbone diagram**: Identification of all stakeholders' information needs.

Root causes of failure

Lack of identification of stakeholders roles and responsibilities, and what is expected of them for a smooth project flow, and to engage all stakeholders for the project initiative, which is the basis for identification of stakeholder communication needs, or partial identification of stakeholder information needs.

RIPs, counter measures and/or BPs that eliminate the root causes

Clarify contract stipulations of information needs of each project stakeholder so that through communications you make it clear to everybody on his/her roles and responsibilities and on what is expected of him/her for a smooth project flow, and you engage all stakeholders for the project initiative.

b. **Factor:** Documenting all communications contemporaneously.

Root causes of failure

Lack of contemporaneous documentation of communications because people are busy and/or lack the commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Best communication practice is to document and record all communication you have on a project, including oral discussions contemporaneously because these are invaluable evidence in case of claims or to clarify if any question arises in the future. Nobody knows what the future holds.

c. **Factor on fishbone diagram:** Plan includes stakeholder engagement for project initiatives.

Root causes of failure

Insufficient thought and planning given to engagement of stakeholders for the project initiative. Lack of grasp and understanding/going through drawings, specifications, change order forms and RFI in detail because these documents establish the basis for all construction communications.

RIPs, counter measures and/or BPs that eliminate the root causes

Project manager is the champion of project initiatives, who need to engage all project participants.

Roughly 90% of project managers' job is communication. Project manager may carry out assessment of level of stakeholder engagement to identify communication gaps. Top company management, department heads and team leaders need to communicate well and continuously.

d. **Factor**: Creation of structured communication processes & procedures.

Root causes of failure

Lack of enough emphasis on communication. Lack of well-structured communication system.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow written procedure about when, who, what of information creation and dissemination.

Organization supports and encourages a communication system that allows messages to move from sender to receiver, informally and formally, enhancing job performance and job satisfaction (van Tiem et al., 2012).

Use IT (Project Management Information System) to facilitate structured approach.

e. **Factor**: Communication blockers & noises are accounted for in plan.

Root causes of failure

Often communication barriers (receiver's education, language, culture, noisy surroundings, hostility, distance) are not accounted for.

RIPs, counter measures and/or BPs that eliminate the root causes

Reduce effect of noise and lower communication blockers that reduce accuracy of information transmission. Increase accuracy of information and smoothness of its flow.

f. **Factor**: Plan answers who, what, when, how and alignment question of communications.

Root causes of failure

Some of these important elements may be missing in the plan.

RIPs, counter measures and/or BPs that eliminate the root causes

Burden of communication (its effectiveness) is on the sender.

Plan must answer all these questions and all stakeholders' needs must be addressed. Information should be concise, clear, complete, simple, relevant and tailored to stakeholder and channel. Use communication to ensure alignment of effort of all project participants as per CII Best Practice.

g. **Factor**: Culture, company processes, procedures, historical records, lessons learnt accounted for in communication plan.

Root causes of failure

Lack of considerations of these factors or some factors not considered well.

RIPs, counter measures and/or BPs that eliminate the root causes

Communication plan should account for organization's culture, processes, procedures, historical records and lessons learnt.

h. **Factor**: Potential crises considered in plan.

Root causes of failure

Potential crises considered in plan

RIPs, counter measures and/or BPs that eliminate the root causes

Considering failures in planning is good project management practice.

2. **Leading Indicator:** Exhaustiveness of Plan

a. **Factor on fishbone diagram**: Identification of all stakeholders' information needs.

Root causes of failure

Lack of identification of stakeholders roles and responsibilities, and what is expected of them for a smooth project flow, and to engage all stakeholders for the project initiative, which is the basis for identification of stakeholder communication needs, or partial identification of stakeholder information needs.

RIPs, counter measures and/or BPs that eliminate the root causes

Clarify contract stipulations of information needs of each project stakeholder so that through communications you make it clear to everybody on his/her roles and responsibilities and on what is expected of him/her for a smooth project flow, and you engage all stakeholders for the project initiative.

b. **Factor:** Documenting all communications contemporaneously.

Root causes of failure

Lack of contemporaneous documentation of communications because people are busy and/or lack the commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Best communication practice is to document and record all communication you have on a project, including oral discussions contemporaneously because these are invaluable evidence in case of claims or to clarify if any question arises in the future. Nobody knows what the future holds.

c. **Factor on fishbone diagram:** Plan includes stakeholder engagement for project initiatives.

Root causes of failure

Insufficient thought and planning given to engagement of stakeholders for the project initiative. Lack of grasp and understanding/going through drawings, specifications, change order forms and RFI in detail because these documents establish the basis for all construction communications.

RIPs, counter measures and/or BPs that eliminate the root causes

Project manager is the champion of project initiatives, who need to engage all project participants.

Roughly 90% of project managers' job is communication. Project manager may carry out assessment of level of stakeholder engagement to identify communication gaps. Top company management, department heads and team leaders need to communicate well and continuously.

d. **Factor**: Creation of structured communication processes & procedures.

Root causes of failure

Lack of enough emphasis on communication. Lack of well-structured communication system.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow written procedure about when, who, what of information creation and dissemination.

Organization supports and encourages a communication system that allows messages to move from sender to receiver, informally and formally, enhancing job performance and job satisfaction (van Tiem et al., 2012).

Use IT (Project Management Information System) to facilitate structured approach.

e. **Factor**: Communication blockers & noises are accounted for in plan.

Root causes of failure

Often communication barriers (receiver's education, language, culture, noisy surroundings, hostility, distance) are not accounted for.

RIPs, counter measures and/or BPs that eliminate the root causes

Reduce effect of noise and lower communication blockers that reduce accuracy of information transmission. Increase accuracy of information and smoothness of its flow.

f. **Factor**: Plan answers who, what, when, how and alignment question of communications.

Root causes of failure

Some of these important elements may be missing in the plan.

RIPs, counter measures and/or BPs that eliminate the root causes

Burden of communication (its effectiveness) is on the sender.

Plan must answer all these questions and all stakeholders' needs must be addressed. Information should be concise, clear, complete, simple, relevant and tailored to stakeholder and channel. Use communication to ensure alignment of effort of all project participants as per CII Best Practice.

g. **Factor**: Culture, company processes, procedures, historical records, lessons learnt accounted for in communication plan.

Root causes of failure

Lack of considerations of these factors or some factors not considered well.

RIPs, counter measures and/or BPs that eliminate the root causes

Communication plan should account for organization's culture, processes, procedures, historical records and lessons learnt.

h. **Factor**: Potential crises considered in plan.

Root causes of failure

Potential crises considered in plan

RIPs, counter measures and/or BPs that eliminate the root causes

Considering failures in planning is good project management practice. Stakeholders are important influential resources and should be treated as potential sources of risk and opportunity within the project (https://www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/key-principles/).

i. **Factor**: Suggestion systems, grievance systems, dispute resolution, social media used in communications.

Root causes of failure

Lack of such established systems, and even if they exist, not being used properly.

RIPs, counter measures and/or BPs that eliminate the root causes

Encourage and supports formal and informal suggestion systems to improve performance because proactive organizations rely on suggestions of employees to improve products, processes, and services. Put formal processes in place for submitting, evaluating, and processing suggestions, responding to grievances and complaints. Organizations set grievance systems in place to investigate complaints about wages, hours, and conditions of employment and/or work practices. Organizational culture allows individuals or groups to resolve differences of opinion amicably or through negotiation, mediation, or collaboration. Social media as an organizational communication technology is represented in discussion forums, blogs, wikis, podcasts, videos, pictures, and so forth. (van Tiem et al., 2012)

3. **Leading Indicator:** Timeliness of communication

a. **Factor:** Timely creation, collection, storage & distribution of information.

Root causes of failure

Lack of contemporaneous documentation of communications because people are busy and/or lack the commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Do all creation and dissemination of information contemporaneously in a structured way.

b. **Factor:** Use of project and company information management systems.

Root causes of failure

Lack of use of project and company information management system.

RIPs, counter measures and/or BPs that eliminate the root causes

People, data, and technology work together to retrieve, process, store, and disseminate information, supporting informed decision making and sound organizational and project management (van Tiem et al., 2012).

Use IT to facilitate a structured approach to communication activities.

c. **Factor:** Contemporaneousness of communication & documentation.

Root causes of failure

Lack of contemporaneous documentation of communications because people are busy and/or lack the commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Do all creation and dissemination of information contemporaneously in a structured way. Keep a careful and systematically organized record of all aspects of communications with stakeholders that occur over time. This includes meetings, phone calls, emails, and even conversations, and commitments made. Project manager can prevent misunderstandings and delays if he/she can easily demonstrate the history of all aspects of stakeholder communications, which is especially challenging with multi-year projects where representatives change over time.

d. **Factor:** Regular communications (meetings, reports, etc).

Root causes of failure

Lack of regularity of communications.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep the routine of regular communications.

e. **Factor:** Proactiveness in managing stakeholder expectations.

Root causes of failure

Lack of proactiveness in managing stakeholder expectations. Lack of or partial use of employee suggestion systems and grievance reporting systems.

RIPs, counter measures and/or BPs that eliminate the root causes

Aggressively manage stakeholder expectations through timely and continuous communication.

Proactive organizations rely on suggestions of employees to improve products, processes, and services (van Tiem et al., 2012). Organizations set grievance systems in place to investigate complaints about wages, hours, and conditions of employment and/or work practices (van Tiem et al., 2012).

f. **Factor:** Clarity, conciseness, completeness, simplicity, relevance, tailoring & alignment of communication schedule.

Root causes of failure

Lack of these communication elegance attributes in communication and its schedule.

RIPs, counter measures and/or BPs that eliminate the root causes

Use these communication elegance attributes in communication and its schedule.

Use alignment CII BP principles.

4. **Leading Indicator:** Communication Plan Success Rate

a. **Factor**: Carrying out stakeholder engagement assessment.

Root causes of failure

Lack of assessment of stakeholder engagement or not doing it well to get feedback for improvement.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor engagement plan implementation and get feedback for improvement. Project success means different things to different stakeholders and project manager need to establish what all stakeholders perceive success to be for them in the context of project delivery. A project may be unclear to its stakeholders, particularly in the early stages, in terms of purpose, scope, risks and approach, which requires consulting early and often.

Regular consultation early on is essential to ensure that requirements are agreed among stakeholders and an acceptable delivery solution to the majority of the stakeholders is negotiated (www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/key-principles/). Remember, stakeholders are only humans: It is useful to understand that humans do not always behave in a reasonable, rational, predictable or consistent. Human feelings and potential personal agendas may come into play. The project manager can assess if there is a better way to work together and maintain a productive relationship by understanding the root cause of stakeholder behavior . Develop trusting relationship, which makes working together easy and effective, speeds up problem solving and decision-making (www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/key-principles/). Compromise to establish the most acceptable baseline across a set of stakeholders' diverging priorities and expectations. Assess the relative importance of stakeholders to establish a weighted hierarchy against the project requirements and agreed by the client.

b. **Factor**: Communication styles assessment & tailoring issues identification

Root causes of failure

Lack of or not doing well styles assessment and issues identification regarding styles assessment.

RIPs, counter measures and/or BPs that eliminate the root causes

Use a style that helps you effectively communicate with the stakeholder in question. Monitor whether the style is best for the stakeholder in question and get feedback for improvement.

c. **Factor**: Monitor, control & assess implementation of planned activities.

Root causes of failure

Lack of monitoring and control or not monitoring or collecting feedback well.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor and control plan implementation and get feedback on implementation of plan for improvement.

d. **Factor**: Get feedback from stakeholders whether information needs are met.

Root causes of failure

Not getting feedback from stakeholders whether you are meeting stakeholder information needs.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor plan implementation whether you are meeting information needs.

e. **Factor**: Monitor company brand recognition.

Root causes of failure

Lack of monitoring brand recognition or not doing it well to get feedback for improvement.

RIPs, counter measures and/or BPs that eliminate the root causes

Use communication to build and reinforce company brand, and ensures communication aligns with vision, mission, values and strategies of company. Monitor plan implementation and get feedback for improvement.

f. **Factor**: Monitor meeting of stakeholder expectations.

Root causes of failure

Lack of monitoring and feedback whether expectations are met.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor whether stakeholder expectations are met and get feedback for improvement.

g. **Factor**: Monitor alignment of efforts of all stakeholders through effective communication.

Root causes of failure

Lack of use of communication to ensure alignment of efforts.

RIPs, counter measures and/or BPs that eliminate the root causes

Use CII alignment BP principles. Project manager, makes sure all participants contribute their part on time and as per quality standards.

5. **Leading Indicator:** Level of Use of Best Practices

a. **Factor**: Commit time and healthy budget for communication.

Root causes of failure

Lack of allocation of sufficient resources, which constrains the work.

RIPs, counter measures and/or BPs that eliminate the root causes

Avoid time and resource constraint on communications.

b. **Factor**: Document and record all communications contemporaneously.

Root causes of failure

Being lax on doing communication documentation contemporaneously due to time pressure of work.

RIPs, counter measures and/or BPs that eliminate the root causes

Contemporaneous documentation is a time proven wisdom to be implemented.

c. **Factor**: Targeting one's audiences & continuously seeking their feedback.

Root causes of failure

Not tailoring communication to the target audience (engagement, style, channel). Not getting feedback or not well taken into consideration.

RIPs, counter measures and/or BPs that eliminate the root causes

Tailor communication to the target audience and continuously get their feedback to adjust communications.

d. **Factor**: Build company brand & reinforce it continuously.

Root causes of failure

Little attention given to branding or lack of knowhow about its importance.

RIPs, counter measures and/or BPs that eliminate the root causes

Communication is the top way to build and reinforce company brand. Maximize use to achieve branding.

e. **Factor**: Practice authentic story telling in communications.

Root causes of failure

Lack of knowledge of importance of authentic story telling in producing desired outcome/impact.

RIPs, counter measures and/or BPs that eliminate the root causes

Authenticity helps target audience to relate on a personal basis.

f. **Factor**: Partner with like- minded organizations.

Root causes of failure

Lack of thought given to selection of long-term partners.

RIPs, counter measures and/or BPs that eliminate the root causes

Partnering with like-minded organizations reduces the risk of discord.

g. **Factor**: Show return on communication investment.

Root causes of failure

Not giving thought to show return on communication investment.

RIPs, counter measures and/or BPs that eliminate the root causes

Show the benefit exceeds investment on communications to present a strong business case.

h. **Factor**: Set milestones and check points on a continuous basis.

Root causes of failure

Lack of such systematicity.

RIPs, counter measures and/or BPs that eliminate the root causes

Manage communication systematically using feedback to improve performance. (https://www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/key-principles/).

h. **Factor**: Suggestion systems, grievance systems, dispute resolution, social media used in communications.

Root causes of failure

Lack of such established systems, and even if they exist, not being used properly.

RIPs, counter measures and/or BPs that eliminate the root causes

Encourage and supports formal and informal suggestion systems to improve performance because proactive organizations rely on suggestions of employees to improve products, processes, and services. Put formal processes in place for submitting, evaluating, and processing suggestions, responding to grievances and complaints. Organizations set grievance systems in place to investigate complaints about wages, hours, and conditions of employment and/or work practices. Organizational culture allows individuals or groups to resolve differences of opinion amicably or through negotiation, mediation, or collaboration. Social media as an organizational communication technology is represented in discussion forums, blogs, wikis, podcasts, videos, pictures, and so forth. (van Tiem et al., 2012)

6. **Leading Indicator:** <u>Timeliness of communication</u>

i. Factor: Timely creation, collection, storage & distribution of information.

Root causes of failure

Lack of contemporaneous documentation of communications because people are busy and/or lack the commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Do all creation and dissemination of information contemporaneously in a structured way.

j. **Factor:** Use of project and company information management systems.

Root causes of failure

Lack of use of project and company information management system.

RIPs, counter measures and/or BPs that eliminate the root causes

People, data, and technology work together to retrieve, process, store, and disseminate information, supporting informed decision making and sound organizational and project management (van Tiem et al., 2012).

Use IT to facilitate a structured approach to communication activities.

k. **Factor:** Contemporaneousness of communication & documentation.

Root causes of failure

Lack of contemporaneous documentation of communications because people are busy and/or lack the commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Do all creation and dissemination of information contemporaneously in a structured way. Keep a careful record of all aspects of stakeholder communications that occur over time. This includes meetings, phone calls, emails, and commitments made. Misunderstandings and delays can be prevented if you can easily demonstrate the history of all aspects of communication with your stakeholders – which is especially challenging with multi-year projects where representatives change over time.

l. **Factor:** Regular communications (meetings, reports, etc).

Root causes of failure

Lack of regularity of communications.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep the routine of regular communications.

m. **Factor:** Proactiveness in managing stakeholder expectations.

Root causes of failure

Lack of proactiveness in managing stakeholder expectations. Lack of or partial use of employee suggestion systems and grievance reporting systems.

RIPs, counter measures and/or BPs that eliminate the root causes

Aggressively manage stakeholder expectations through timely and continuous communication.

Proactive organizations rely on suggestions of employees to improve products, processes, and services (van Tiem et al., 2012). Organizations set grievance systems in place to investigate complaints about wages, hours, and conditions of employment and/or work practices (van Tiem et al., 2012).

n. **Factor:** Clarity, conciseness, completeness, simplicity, relevance, tailoring & alignment of communication schedule.

Root causes of failure

Lack of these communication elegance attributes in communication and its schedule.

RIPs, counter measures and/or BPs that eliminate the root causes

Use these communication elegance attributes in communication and its schedule.

Use alignment CII BP principles.

7. **Leading Indicator:** Communication Plan Success Rate

a. Factor: Carrying out stakeholder engagement assessment.

Root causes of failure

Lack of assessment of stakeholder engagement or not doing it well to get feedback for improvement.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor engagement plan implementation and get feedback for improvement. Project success means different things to different people and you need to establish what your stakeholder community perceives success to be for them in the context of project delivery. Consult, early and often: A project, particularly in the early stages, may be unclear to its stakeholders, for example, in terms of purpose, scope, risks and approach. Early, then regular consultation is essential to ensure that requirements are agreed and a delivery solution is negotiated that is acceptable to the majority of stakeholders (www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/key-principles/).

Remember, stakeholders are only humans: Accept that humans do not always behave in a rational, reasonable, consistent or predictable way and operate with an awareness of human feelings and potential personal agendas. By understanding the root cause of stakeholder behavior, you can assess if there is a better way to work together to maintain a productive relationship. Develop trusting relationship, which makes working together easy and effective, speeds problem solving and decision-making (www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/key-principles/). Compromise to establish the most acceptable baseline across a set of stakeholders' diverging expectations and priorities. Assess the relative importance of all stakeholders to establish a weighted hierarchy against the project requirements and agreed by the client.

b. **Factor:** Communication styles assessment & tailoring issues identification

Root causes of failure

Lack of or not doing well styles assessment and issues identification regarding styles assessment.

RIPs, counter measures and/or BPs that eliminate the root causes

Use a style that helps you effectively communicate with the stakeholder in question. Monitor whether the style is best for the stakeholder in question and get feedback for improvement.

c. **Factor:** Monitor, control & assess implementation of planned activities.

Root causes of failure

Lack of monitoring and control or not monitoring or collecting feedback well.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor and control plan implementation and get feedback on implementation of plan for improvement.

o. **Factor**: Get feedback from stakeholders whether information needs are met.

Root causes of failure

Not getting feedback from stakeholders whether you are meeting stakeholder information needs.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor plan implementation whether you are meeting information needs.

p. **Factor**: Monitor company brand recognition.

Root causes of failure

Lack of monitoring brand recognition or not doing it well to get feedback for improvement.

RIPs, counter measures and/or BPs that eliminate the root causes

Use communication to build and reinforce company brand, and ensures communication aligns with vision, mission, values and strategies of company. Monitor plan implementation and get feedback for improvement.

q. **Factor**: Monitor meeting of stakeholder expectations.

Root causes of failure

Lack of monitoring and feedback whether expectations are met.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor whether stakeholder expectations are met and get feedback for improvement.

r. **Factor**: Monitor alignment of efforts of all stakeholders through effective communication.

Root causes of failure

Lack of use of communication to ensure alignment of efforts.

RIPs, counter measures and/or BPs that eliminate the root causes

Use CII alignment BP principles. Project manager makes sure all participants contribute their part on time and as per quality standards.

8. **Leading Indicator:** <u>Level of Use of Best Practices</u>

i. **Factor**: Commit time and healthy budget for communication.

Root causes of failure

Lack of allocation of sufficient resources, which constrains the work.

RIPs, counter measures and/or BPs that eliminate the root causes

Avoid time and resource constraint on communications.

j. **Factor**: Document and record all communications contemporaneously.

Root causes of failure

Being lax on doing communication documentation contemporaneously due to time pressure of work.

RIPs, counter measures and/or BPs that eliminate the root causes

Contemporaneous documentation is a time proven wisdom to be implemented.

k. **Factor**: Targeting one's audiences & continuously seeking their feedback.

Root causes of failure

Not tailoring communication to the target audience (engagement, style, channel). Not getting feedback or not well taken into consideration.

RIPs, counter measures and/or BPs that eliminate the root causes

Tailor communication to the target audience and continuously get their feedback to adjust communications.

l. **Factor**: Build company brand & reinforce it continuously.

Root causes of failure

Little attention given to branding or lack of knowhow about its importance.

RIPs, counter measures and/or BPs that eliminate the root causes

Communication is the top way to build and reinforce company brand. Maximize use to achieve branding.

m. **Factor**: Practice authentic story telling in communications.

Root causes of failure

Lack of knowledge of importance of authentic story telling in producing desired outcome/impact.

RIPs, counter measures and/or BPs that eliminate the root causes

Authenticity helps target audience to relate on a personal basis.

n. **Factor**: Partner with like- minded organizations.

Root causes of failure

Lack of thought given to selection of long-term partners.

RIPs, counter measures and/or BPs that eliminate the root causes

Partnering with like-minded organizations reduces the risk of discord.

o. **Factor**: Show return on communication investment.

Root causes of failure

Not giving thought to show return on communication investment.

RIPs, counter measures and/or BPs that eliminate the root causes

Show the benefit exceeds investment on communications to present a strong business case.

p. **Factor**: Set milestones and check points on a continuous basis.

Root causes of failure

Lack of such systematicity.

RIPs, counter measures and/or BPs that eliminate the root causes

Manage communication systematically using feedback to improve performance.

B. Equipment Management Process

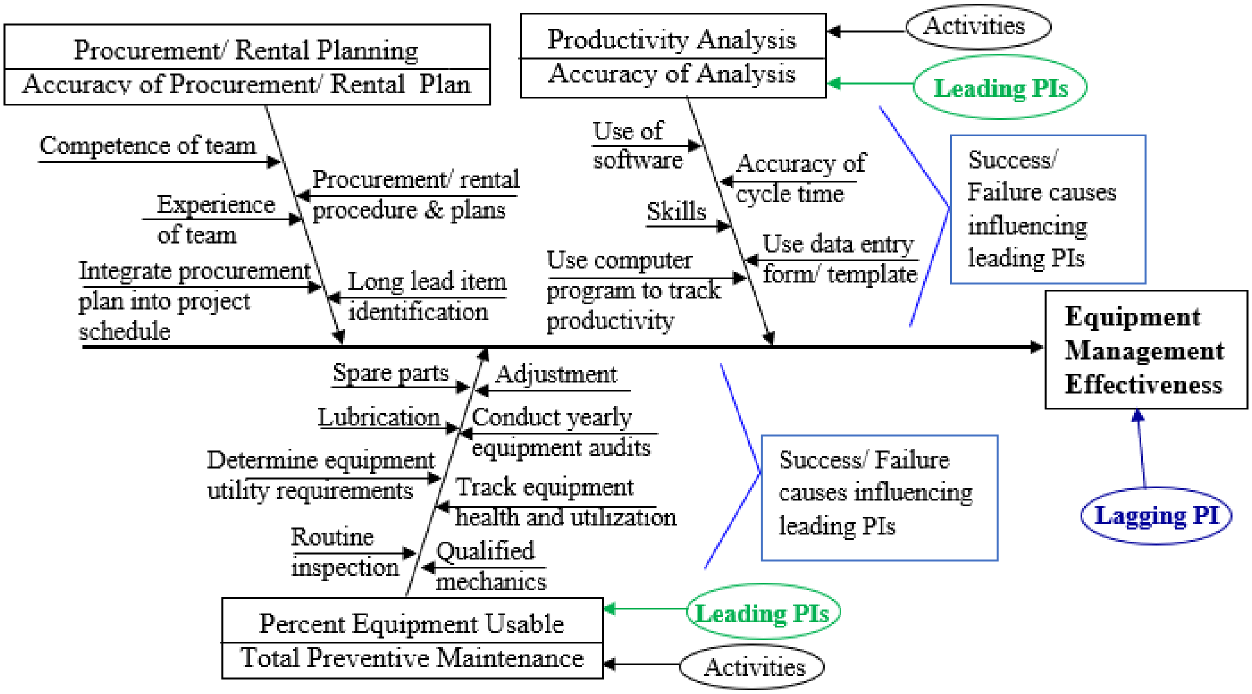


Figure E.3 Fishbone diagram for Equipment management process

1. **Leading Indicator:** Accuracy of Procurement/ Rental Plan

a. Factor on fishbone diagram: Competence of team.

Root causes of failure

Lack of competence of team in the types of equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence through training and coaching.

b. **Factor:** Procurement/ rental procedure.

Root causes of failure

Absence of established procedure.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop procedure to ensure efficiency, and for checks and balances.

c. **Factor on fishbone diagram:** Experience of team.

Root causes of failure

Lack of experience due to high turnover.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop team experience through retention, training and coaching.

d. **Factor**: Long lead item identification.

Root causes of failure

Sometimes lack of identification of long lead items.

RIPs, counter measures and/or BPs that eliminate the root causes

List equipment to be procured or rented ahead of time, especially long lead items.

2. **Leading Indicator:** <u>Accuracy of Equipment Productivity Analysis</u>

a. **Factor:** Accuracy of cycle time determination.

Root causes of failure

Lack of accurate cycle time computation.

RIPs, counter measures and/or BPs that eliminate the root causes

Determine cycle time accurately as it forms the basis for productivity computation.

b. **Factor:** Use of software

Root causes of failure

Using inefficient or not user friendly software.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software to simplify computations and produce results/reports.

c. **Factor:** Skills.

Root causes of failure

Lack of skill.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop skill of people in charge through training and coaching.

d. **Factor:** Data entry form/ template.

Root causes of failure

Not user friendly data entry form.

RIPs, counter measures and/or BPs that eliminate the root causes

User friendly data entry makes entry fast and accurate.

e. **Factor:** Use computer program to track productivity.

Root causes of failure

Unavailability of productivity tracking computer program or program not user friendly.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop easy to use computer program or spreadsheet to track equipment productivity.

3. **Leading Indicator:** Percent Equipment Usable

a. **Factor**: Spare Parts.

Root causes of failure

Unavailability of some parts on market.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep data on availability of spare parts for each type of equipment in their data file.

b. Factor: Adjustment

Root causes of failure

Not checking/making adjustments regularly.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure each equipment adjustment is checked at regular intervals.

c. **Factor**: Lubrication.

Root causes of failure

Not lubricating sufficiently.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure all equipment are lubricated well and do not be sparing on lubrication supplies.

d. **Factor**: Conduct yearly equipment audits.

Root causes of failure

Lack of yearly audits or not done well.

RIPs, counter measures and/or BPs that eliminate the root causes

Do yearly audits of equipment and determine which ones need maintenance, which replacement.

e. **Factor**: Determine equipment electric and other utility requirements.

Root causes of failure

Not observing/meeting utility requirements well.

RIPs, counter measures and/or BPs that eliminate the root causes

Have equipment specifications handy and follow the specifications while using the equipment.

f. **Factor**: Track equipment health and utilization.

Root causes of failure

Not having equipment tracking system.

RIPs, counter measures and/or BPs that eliminate the root causes

It would be best to have some form of computer tracking system for equipment health and utilization.

g. **Factor**: Routine inspection.

Root causes of failure

Not keeping routine inspection times for equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep routine inspections to keep equipment in optimal operating condition.

h. **Factor**: Qualified mechanics.

Root causes of failure

Incompetence of mechanics..

RIPs, counter measures and/or BPs that eliminate the root causes

Hire one top mechanic in the market and develop junior mechanics through training and coaching.

C. Estimating Process

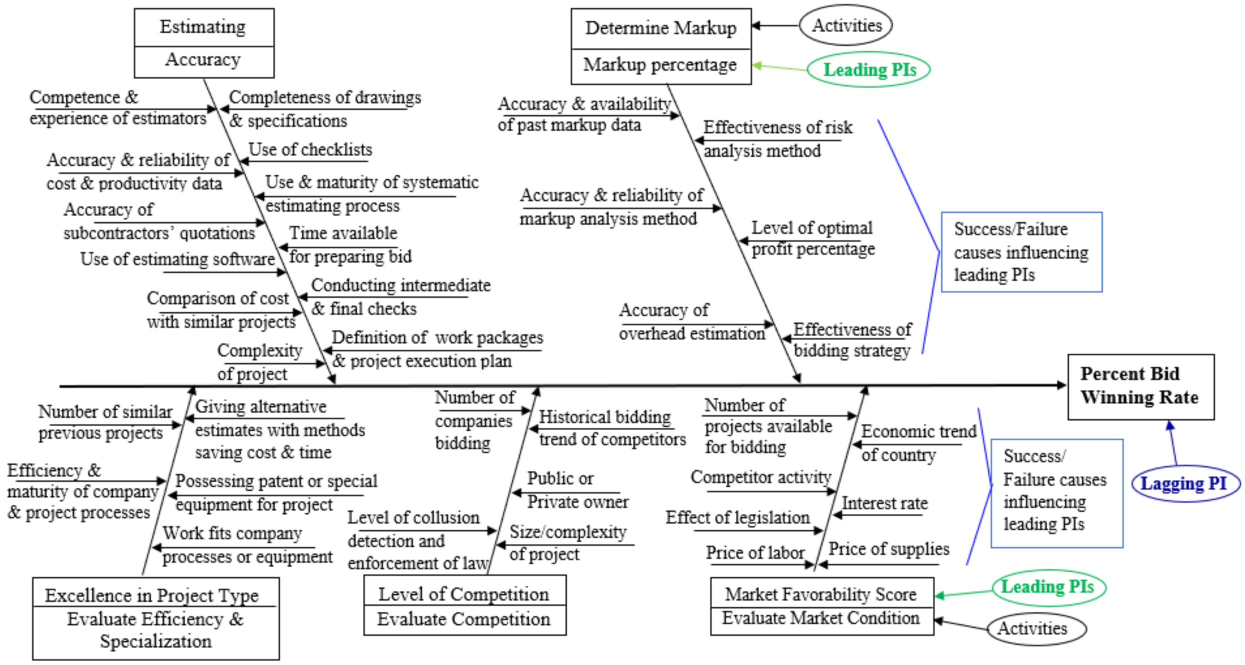


Figure E.4 Fishbone diagram for estimating process

1. Leading Indicator: Estimating Accuracy

a. Factor on fishbone diagram: Competence and experience of estimators.

Root causes of failure

Inexperienced estimator hired due to budget constraint.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire senior estimator in 3-5 years or get junior estimators trained.

b. Factor: Completeness of drawings & specifications**.**

Root causes of failure

Oversight by consultants due to time pressure.

RIPs, counter measures and/or BPs that eliminate the root causes

List items missing from drawings and specifications exhaustively and ask for clarifications from client. Review bid documents, Assign qualified estimators, Define scope of work.

c. Factor on fishbone diagram: Accuracy and reliability of cost and productivity data.

Root causes of failure

Not keeping data of past projects well, not accurately recording data while it was current because people are busy.

RIPs, counter measures and/or BPs that eliminate the root causes

Simplifying data recording procedure using IT so it can be done in short time. Normalize estimating data of data, determination of escalation of future costs.

d. Factor: Use of checklist for estimate completeness and basis.

Root causes of failure

Lack of checklist (not developed).

RIPs, counter measures and/or BPs that eliminate the root causes

Develop and use checklist.

e. Factor: Accuracy of subcontractors' quotations.

Root causes of failure

Time pressure to estimate or lack of capacity.

RIPs, counter measures and/or BPs that eliminate the root causes

Exercise due care in subcontractor selection. Give training support to long-term partners.

f. Factor: Use and maturity of systematic estimating process.

Root causes of failure

Lack of developed estimating process or immaturity of estimating process.

RIPs, counter measures and/or BPs that eliminate the root causes

Use flowchart from literature and other information to develop your own process with procedures, policies and metrics.

g. Factor: Time available for preparing estimates.

Root causes of failure

Outside control of contractor, poor project planning by client.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign more resources, make data and other inputs ready and easy to use, use software, develop estimating expertise.

h. Factor: Comparison of cost with similar projects.

Root causes of failure

Lack of comparison of cost of project being estimated with similar projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep important summary of past projects handy to use.

i. Factor: Use of estimating software.

Root causes of failure

Lack of financial resources or lack of training in using software.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy best software fit for your type of job, train your people.

j. Factor: Conducting intermediate and final checks.

Root causes of failure

Time pressure forces people to overlook conducting intermediate & final checks.

RIPs, counter measures and/or BPs that eliminate the root causes

Including checks in standard procedures and policies as a QA task. Conducting thorough review and feedback at the end.

k. Factor: Definition of work packages and project execution plan.

Root causes of failure

Not putting in sufficient effort to go to this detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Use past data on project execution in developing project execution plan and developing realistic estimates.

Use Advanced Work Packaging (AWP). Use constructability and lessons learned in preparing advanced work packages.

l. Factor: Complexity of project.

Root causes of failure

Lack of consideration or understanding of complexity.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise, train your people, buy software.

2. Leading Indicator: <u>Markup percentage</u>

a. Factor: Accuracy & availability of past markup data.

Root causes of failure

Inaccuracy or unavailability of past markup data.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep record and develop the data.

b. **Factor:** Effectiveness of risk analysis method.

Root causes of failure

Lack of formal risk analysis method or some risks omitted in analysis may transpire or lack of capacity to do risk analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise by training. Determine contingency to be applied to different projects.

c. **Factor:** Accuracy & reliability of markup analysis method.

Root causes of failure

Lack of formal analysis of markup(use of intuition and experience).

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise and procedure/method for it.

d. **Factor:** Level of optimal profit percentage.

Root causes of failure

Lack of formal analysis to determine optimal profit and use of only intuition and experience.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise and procedure/method for computation of optimal percentage of profit.

e. **Factor:** Accuracy of overhead estimation.

Root causes of failure

Head office overhead may be accurately estimated but some items may be missed from project overheads.

RIPs, counter measures and/or BPs that eliminate the root causes

Document data for future use.

f. **Factor:** Effectiveness of bidding strategy.

Root causes of failure

Extensive knowledge of historical bids, knowledge of competitors historical markup, and practice is required but any one of these may be missing.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop extensive knowledge of historical bids, knowledge of competitors, and practice with time/experience.

3. Leading Indicator: Excellence in Project Type

a. Factor: Number of previous similar projects constructed by company.

Root causes of failure

Losing in bid competitions may not allow having many similar project experiences.

RIPs, counter measures and/or BPs that eliminate the root causes

Excel in any project you construct.

b. Factor: Giving alternative estimates with methods saving cost and time

Root causes of failure

Time pressure to submit bid may not allow alternative bids.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop module packages and expertise with detailed cost that can be assembled and used on many projects.

c. Factor: Efficiency & maturity of company and project processes.

Root causes of failure

Lack of maturity of processes, it takes time and resources to develop maturity and efficiency.

RIPs, counter measures and/or BPs that eliminate the root causes

Continuously and relentlessly improve processes. Instill culture of continuous improvement in employees.

d. Factor: Possessing patent or trade secrets or special equipment for project.

Root causes of failure

Lack of inimitable resources that would help sustainable competitive advantage.

RIPs, counter measures and/or BPs that eliminate the root causes

Empower employees to innovate continuously.

e. Factor: Work fits company processes or equipment.

Root causes of failure

Lack of capitalizing on strengths.

RIPs, counter measures and/or BPs that eliminate the root causes

Take only projects in which you are sure to delight the customer.

f. Factor: Use of best estimating practices.

Root causes of failure

Lack of use of best estimating practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Best practices are developed over many years by trial and error, and are tested to produce better results. Using them is wise.

4. Leading Indicator: Level of Competition

a. Factor: Number of companies bidding.

Root causes of failure

Not bidding in specialized or complex projects. Not differentiating the company from many, doing type of job everybody does. Not getting that number.

RIPs, counter measures and/or BPs that eliminate the root causes

Build competitive edge continuously by improving processes and competence of employees.

b. Factor: Historical bidding trend of competitors.

Root causes of failure

Not having data on historical bidding trend of competitors or not doing this trend analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out competitor trend analysis, and other evidences that helps you to make better decisions.

c. Factor: Level of collusion detection and severity of penalty for collusion.

Root causes of failure

Not speaking out to policy makers about it.

RIPs, counter measures and/or BPs that eliminate the root causes

Advocate for a level field for competition and commensurate penalty for corruptions through professional associations.

d. Factor: Public/Private owner.

Root causes of failure

Not strategizing the bidding differently for public and private work.

RIPs, counter measures and/or BPs that eliminate the root causes

Make this distinction to adjust your bidding strategy. Competitive bidding and social responsibility for public projects and profit maximization in the case of private projects.

e. Factor: Size/complexity of project.

Root causes of failure

Lack of consideration or understanding of size or complexity on bidding.

RIPs, counter measures and/or BPs that eliminate the root causes

Use modularization and dynamic capability building to handle large and complex projects.

5. Leading Indicator: Market Favorability Score

a. Factor: Number of projects available for bidding.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider risks, threats and opportunities in your analysis.

b. Factor: Economic trend of country.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider the effect of economic trend of the country and its effect on the type of construction you do. Consider risks, threats and opportunities in your analysis.

c. Factor: Competitor activity.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out analysis of competitor activities to better position yourself in the competition.

d. **Factor:** Interest rate.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Get information about trends in interest rate.

e. **Factor:** Effect of legislation.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Get information if there are any changes in regulatory frameworks that may affect your business.

f. **Factor:** Price of supplies.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Estimate price fluctuation of materials on the market.

g. **Factor:** Price of labor.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Price of labor always trends up. Availability of skilled labor in the area of project needs study and data collection.

D. Finance Management Process

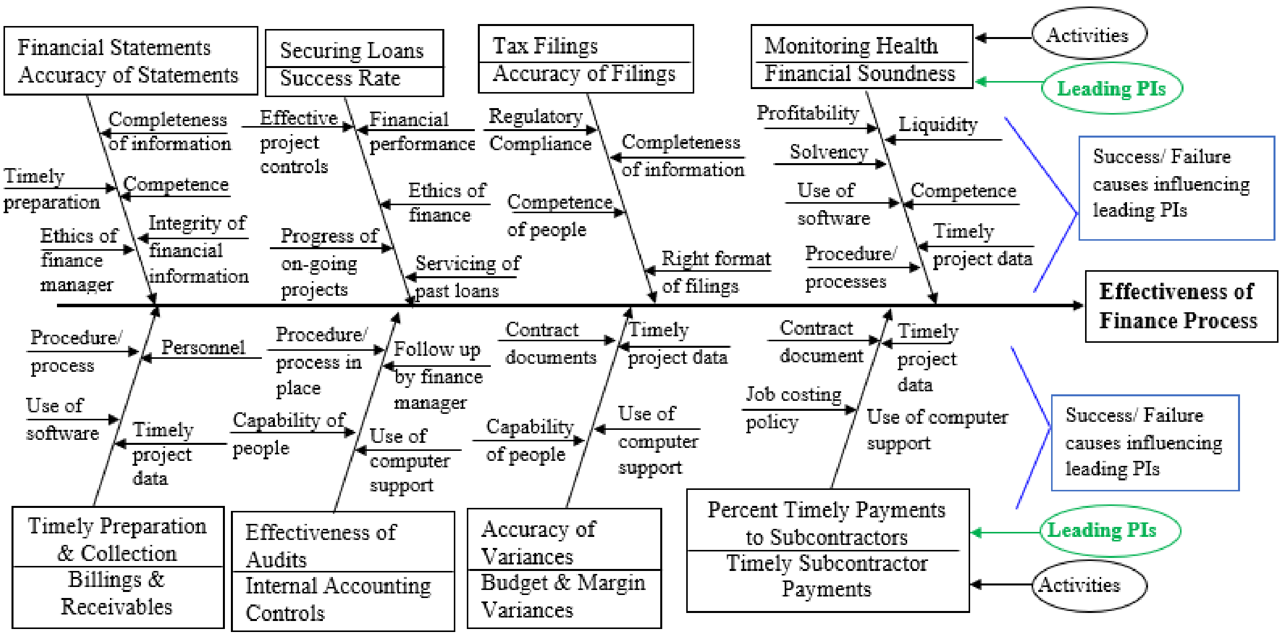


Figure E.5 Fishbone diagram for finance process

1. **Leading Indicator**: Accuracy of Statements

a. **Factor**: Timely preparation of statements.

Root causes of failure

Not including all costs and incomes fully at their correct periods.

RIPs, counter measures and/or BPs that eliminate the root causes

Track and record financial information in a timely manner.

b. **Factor:** Completeness of information.

Root causes of failure

Lack of completeness of information.

RIPs, counter measures and/or BPs that eliminate the root causes

Use checklist of tasks on schedules to check missing financial information reported from projects.

c. Factor: Competence of finance people.

Root causes of failure

Incompetence of finance staff.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence through training and coaching.

d. Factor: Ethics of finance manager.

Root causes of failure

Ethics infractions are often observed in construction companies.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop procedures to follow and code of ethics that will be enforced. Use checks and balances to make sure corruption does not creep in.

e. Factor: Use of software.

Root causes of failure

Staff may not be that conversant with software.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy an accounting software that fits the company.

f. Factor: Integrity of financial information.

Root causes of failure

Internal auditing not that thorough.

RIPs, counter measures and/or BPs that eliminate the root causes

Ensure integrity of financial information through internal auditing.

2. Leading Indicator: Success Rate in Securing Loans

a. Factor: Effective project controls in place.

Root causes of failure

Not doing well in project controls shows lenders poor management.

RIPs, counter measures and/or BPs that eliminate the root causes

Do well in these determinants of success in securing loans.

b. Factor: Financial performance.

Root causes of failure

Challenges and problems company and projects face.

RIPs, counter measures and/or BPs that eliminate the root causes

Do well in the tasks of finance department making current financial information available for better decision making.

c. Factor: Ethics of finance manager.

Root causes of failure

Not doing checks and balances well.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in place effective checks and balances procedure in place.

d. Factor: Progress of on-going projects.

Root causes of failure

Not doing well in these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Do well in the tasks of finance department making current financial information available for better decision making.

e. Factor: Servicing of past loans.

Root causes of failure

Not doing well in servicing past loans.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare different scenarios of loan servicing with the effect it will have company liquidity and solvency for better top management decision making.

3. Leading Indicator: Accuracy of Tax Filings

a. Factor: Regulatory Compliance.

Root causes of failure

Inefficiency that causes unnecessarily lengthy work to comply with regulations.

RIPs, counter measures and/or BPs that eliminate the root causes

Accurate tax filing is a constraint under which company should operate to avoid being sued by government.

b. Factor: Completeness of information.

Root causes of failure

Incompleteness or inconsistency of information can invite legal problem.

RIPs, counter measures and/or BPs that eliminate the root causes

Complete and consistent information in tax filing is important to avoid troubles.

c. **Factor:** Competence of people.

Root causes of failure

Lack of competent accounting staff due to high turnover.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire senior accountants in each area and use them to coach junior accountants.

d. **Factor:** Right format of filings.

Root causes of failure

Not following format well or not understanding the format.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow the format exactly as required.

4. **Leading Indicator**: Monitoring of Financial Health

a. **Factor**: Profitability.

Root causes of failure

Lack of profit information to be used as feedback to improve performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare data on this financial information contemporaneously to know financial soundness of company.

b. **Factor:** Liquidity.

Root causes of failure

Lack of liquidity information constraining cash flow planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Make current liquidity data available for better decision making.

c. **Factor:** Solvency.

Root causes of failure

Lack of solvency information constraining cash flow and purchases planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Make current solvency data for better decision making.

d. **Factor:** Timely project data.

Root causes of failure

Delays in reporting of project cost data.

RIPs, counter measures and/or BPs that eliminate the root causes

Agree and establish with projects time window through which they send project cost data.

e. **Factor:** Procedure/ processes.

Root causes of failure

Not establishing finance processes/procedures or not following processes and procedures well.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow processes/procedures strictly because they are the best ways to do tasks determined from many years of experience through trial and error to distinguish what works from those which do not work.

f. **Factor:** Use of software.

Root causes of failure

Lack of software or staff not conversant at using software.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software to process information and to produce reports because this makes the work easier, faster and more accurate.

g. Factor: Competence.

Root causes of failure

Lack of competence of finance people or juniors hired due to budget constraint.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire one senior accountant and use him/her to coach junior employees.

5. Leading Indicator: <u>Timely Preparation and Collection of Billings</u>

a. Factor: Procedure/ process.

Root causes of failure

Inefficient procedures may delay readiness of information in a timely manner.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure to prepare and collect receivables in a timely manner.

b. Factor: Personnel.

Root causes of failure

Incompetence of personnel may affect timely preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Use training and coaching to improve competence of finance employees. Make sure to prepare and collect receivables in a timely manner.

c. Factor: Use of software.

Root causes of failure

Incompetence in the use of software can delay preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy cheap software that serves company finance purpose or develop it in house.

d. **Factor:** Timely project data.

Root causes of failure

Delay in receipt of project data may delay timely preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish time windows with projects during which they send their cost data for inclusion in monthly statements.

6. **Leading Indicator**: Effectiveness of Internal Audits

a. **Factor**: Procedure/ process in place.

Root causes of failure

Inefficiency of process/ procedure.

RIPs, counter measures and/or BPs that eliminate the root causes

Put process/ procedure in place for internal audit/control for checks and balances.

b. **Factor:**. Follow ups by finance manager

Root causes of failure

Not paying attention to follow ups.

RIPs, counter measures and/or BPs that eliminate the root causes

Use of checklists and good management practices by finance manager.

c. **Factor:** Capability of people.

Root causes of failure

Not developing capability of people.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence of people through training and coaching.

d. Factor: Use of computer support.

Root causes of failure

Not making use of IT potential.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software for efficiency of effort.

7. Leading Indicator: Accuracy of Variances

a. Factor: Contract documents.

Root causes of failure

Not following requirements of contract documents.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow contract documents strictly.

b. Factor:. Capability of people

Root causes of failure

Incompetence of finance people.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve competence through training and coaching.

c. Factor: Use of computer support.

Root causes of failure

Not using software well.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software for accuracy of calculations.

d. Factor: Timely project data.

Root causes of failure

Delay in receipt of project data may delay timely preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish time windows with projects during which they send their cost data for inclusion in monthly statements.

8. Leading Indicator: Percent Timely Payment to Subcontractors

a. Factor: Contract documents.

Root causes of failure

Not following requirements of contract documents.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow contract documents strictly.

b. Factor:. Timely project data

Root causes of failure

Delaying subcontractor payment due to delay of executed subcontract work from project site..

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure to pay subcontractors in a timely manner.

c. Factor: Job costing policy.

Root causes of failure

Putting in place not so intuitive and easy to use costing procedure in place.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop efficient and easy to execute job cost tracking procedures supported by software.

d. Factor: Computer support.

Root causes of failure

Not using software well or absence of software.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software for fast and efficient effort.

E. Job Costing Process

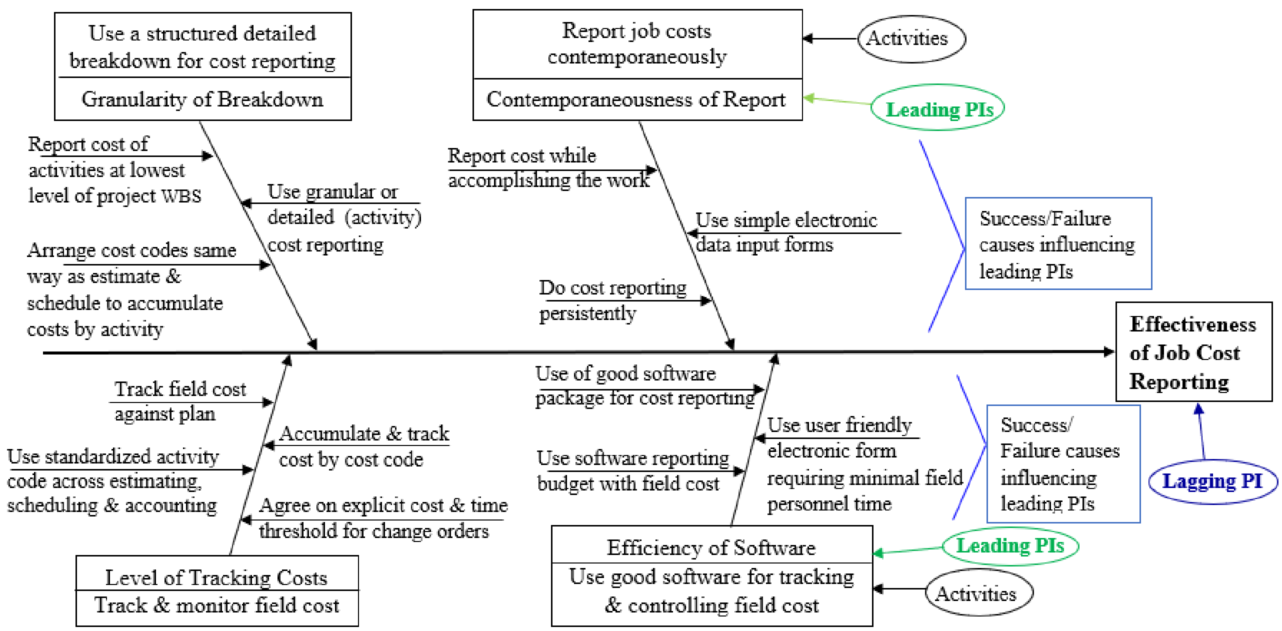


Figure E.6 Fishbone diagram for job cost tracking process

1. **Leading Indicator**: Granularity of Breakdown

a. Factor: Report cost of activities at lowest level of project WBS.

Root causes of failure

Reporting aggregates or lack of systematic detailed reporting.

RIPs, counter measures and/or BPs that eliminate the root causes

Arranging the estimate summary in the same format in which the job cost information will be accumulated will enable a controller, president or project manager to effectively manage contract activities.

b. **Factor:** Use granular or detailed (activity) cost reporting.

Root causes of failure

Reporting aggregates or lack of systematic reporting.

RIPs, counter measures and/or BPs that eliminate the root causes

Use activity based costing as per schedule activities.

c. **Factor:** Arrangement of estimates same way as schedule to accumulate costs by activity.

Root causes of failure

Using different breakdown and reporting on site and in accounting.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence through training and coaching.

2. **Leading Indicator**: Contemporaneousness of Report

a. **Factor**: Cost reporting while accomplishing the task.

Root causes of failure

Procrastination or time pressure.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate few minutes every day to input cost data into electronic form. Do the documentation persistently.

b. **Factor:** Use of simple electronic data input forms.

Root causes of failure

Lack of such forms or not using it well.

RIPs, counter measures and/or BPs that eliminate the root causes

As a project manager, require your general foremen, superintendents and cost engineers to use the form. As a person in charge, check the documentation regularly.

c. Factor: Persistently doing the reporting.

Root causes of failure

Lack of persistence.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate few minutes every day to input cost data into electronic form. Do the documentation persistently.

3. Leading Indicator: Level of Tracking Costs

a. Factor: Tracking field cost against plan (budget).

Root causes of failure

Lack of detailed cost tracking.

RIPs, counter measures and/or BPs that eliminate the root causes

Track cost by schedule activity. Allocate few minutes everyday to input cost data into electronic form. Do the documentation persistently.

b. Factor: Tracking by cost code to be used by accounting.

Root causes of failure

Lack of detailed cost tracking.

RIPs, counter measures and/or BPs that eliminate the root causes

Coding activity cost using standard format like master format serves both accounting and schedule activities cost tracking.

c. Factor: Using standardized activity code across estimating, scheduling & accounting.

Root causes of failure

Using different activity cost code across estimating, scheduling & accounting causing confusion.

RIPs, counter measures and/or BPs that eliminate the root causes

Use standardized activity code across estimating, scheduling & accounting. This is an idea that works best.

d. Factor: Agree on explicit cost & time threshold for change orders.

Root causes of failure

Lack of agreed threshold on cost and time threshold for change orders that leads to claims and litigation..

RIPs, counter measures and/or BPs that eliminate the root causes

It is good practice for the project manager to be firm on fixing thresholds on change orders.

4. Leading Indicator: Efficiency of Software

a. Factor: Use of good software package for cost reporting.

Root causes of failure

Lack of good software due to budget constrain.

RIPs, counter measures and/or BPs that eliminate the root causes

Using good software may cost to buy it and train people but the return is much bigger than the investment.

b. Factor: Using friendly electronic form requiring minimal field personnel time.

Root causes of failure

Lack of good software due to budget constrain.

RIPs, counter measures and/or BPs that eliminate the root causes

Using user friendly electronic form requiring minimal field personnel time encourages people to input data and eliminates procrastination due to time pressure.

c. Factor: Software reporting budget with field cost.

Root causes of failure

Lack of good software due to budget constraint.

RIPs, counter measures and/or BPs that eliminate the root causes

Having field cost and budget side by side helps compare and easily see the variance.

F. Lessons Learned Process

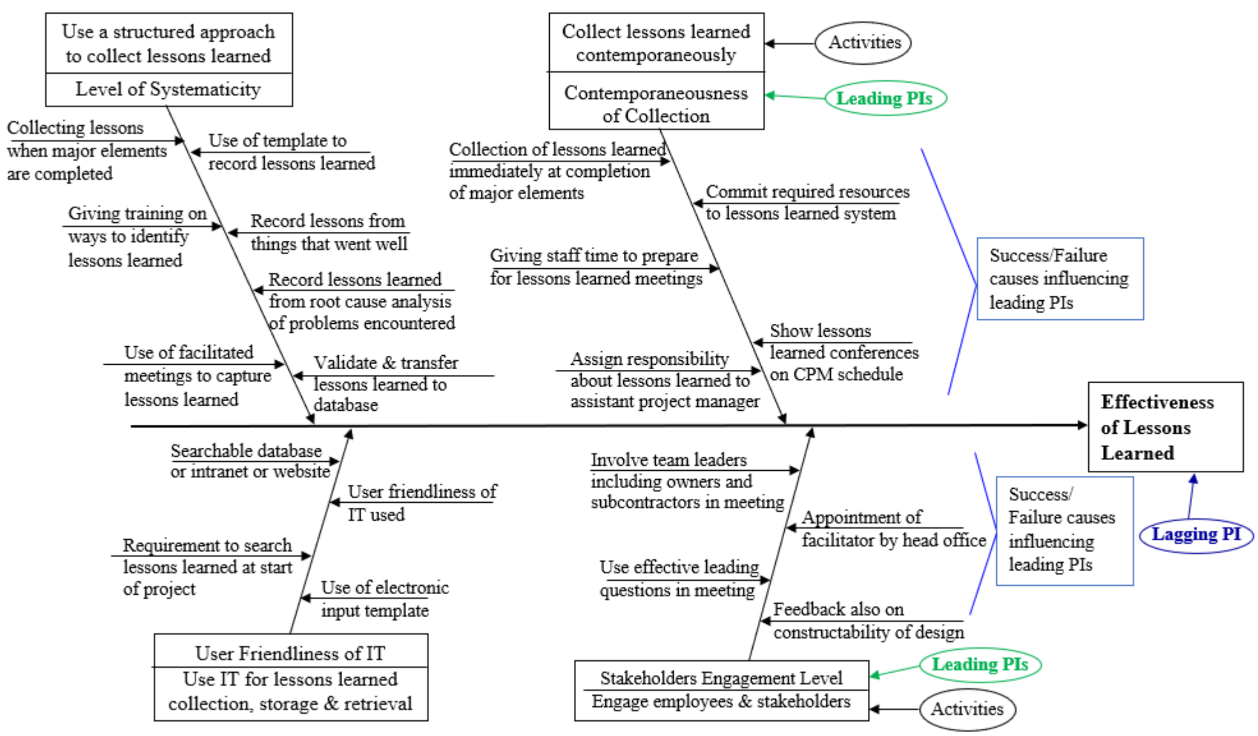


Figure E.7 Fishbone diagram for lessons learned process

1. **Leading Indicator**: Level of Systematicity

a. **Factor**: Collecting lessons when major elements are completed.

Root causes of failure

Time pressure to do succeeding tasks, lack of getting organized and systematic.

RIPs, counter measures and/or BPs that eliminate the root causes

Person in charge of lessons learnt may keep diary of important lessons in real time as construction proceeds, devoting few minutes each week while the lesson is fresh in memory.

Use systematic and structured approach to collect lessons learnt.

Lessons learned is an after action review that requires detailed and clear recording of pertinent information.

b. **Factor:** Use of template to record lessons learned.

Root causes of failure

Not developing template or if developed, template not user friendly.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop, user friendly (easy to use) electronic input form that can be used at job sites not only on laptops and desktops but also on ipads and smart phones.

Put things that are proven to work in a template to be followed subsequently..

c. **Factor:** Giving training on ways to identify lessons learned.

Root causes of failure

Lack of experts that give training. Allocation of insufficient budget for such trainings. Lack of understanding of importance and impact of lessons learned on future projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign top engineers of company to prepare training material and give training. Allocate sufficient budget and include training as part of project cost. Top management need to be convinced about lessons learned and they need to buy into the importance.

Lessons learned is a best practice that is part of learning in organization and knowledge management that help also keep project and corporate memories.

d. **Factor**: Record lessons from things that went well.

Root causes of failure

Lack of comprehensiveness (products and processes) of lessons learnt.

RIPs, counter measures and/or BPs that eliminate the root causes

Record lessons learned for both products and processes. Lack of details when recording that impairs understanding when read by others (blind spot by recorders not recognizing the importance of somethings they know, which they feel everybody knows)..

e. **Factor:** Record lessons learned from root cause analysis of problems encountered.

Root causes of failure

People do not want to record failures because they think they will be held responsible or they may feel they will be considered by others as incompetent. Lack of comprehensiveness of lessons learnt..

RIPs, counter measures and/or BPs that eliminate the root causes

Management should assure people of no bad consequences if they are open and honest about failures because that helps avoid recurrence of failures. Record lessons learned for failure of both products and processes.

f. **Factor:** Validate & transfer lessons learned to database.

Root causes of failure

Lack of validation of lessons learned.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department is in good position as one that translates bid drawings and specifications into shop drawings. Use expertise of design department to validate lessons learned. Regularly check those in database because some may have to be taken out..

g. Factor: Use of facilitated meetings to capture lessons learned.

Root causes of failure

Trying to capture lessons learned through individual efforts in a disorganized and non-systematic way.

RIPs, counter measures and/or BPs that eliminate the root causes

Use scheduled lessons learned meetings at completion of major elements to capture lessons learned. Show meeting on project schedule, and make sure all stakeholders prepare for the meeting and participate in the meeting. Conduct the meeting with the help of a professional facilitator..

2. Leading Indicator: Contemporaneousness of Collection

a. Factor: Collection of lessons learned immediately at completion of major elements.

Root causes of failure

Time pressure to do succeeding tasks. Lack of getting organized and systematic.

RIPs, counter measures and/or BPs that eliminate the root causes

Person in charge of lessons learnt may keep diary of important lessons in real time as construction proceeds, devoting few minutes each week while the lesson is fresh in memory, and compiling the document when a major element is completed.

Keep detailed and clear recording of pertinent information for ease in compiling and documentation.

b. **Factor: C**ommit required resources to lessons learned system.

Root causes of failure

Budget constraint limiting amount of resources allocated for lessons learned. Putting in partial resources or effort.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign required resources and put in the required effort to reap benefits.

c. **Factor:** Giving staff time to prepare for lessons learned meetings.

Root causes of failure

Time pressure on staff to do their assigned work. Lack of understanding of the strategic importance of lessons learned on company bottom line. Putting in partial resources or effort.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign required resources, including staff time and put in the required effort.

d. **Factor:** Show lessons learned conferences on CPM schedule when major elements are completed.

Root causes of failure

Not considering lessons learned conferences during project planning and scheduling.

RIPs, counter measures and/or BPs that eliminate the root causes

Include conference for lessons learned in project planning and scheduling.

Assign specific tasks to team leaders at start of project on lessons learned they need to record real time.

e. **Factor:** Assign responsibility to assistant project manager.

Root causes of failure

Lack of responsible person who coordinates and follows up lessons learned effort.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign responsibility to one person (to assistant project manager) and check how he/she is doing occasionally.

3. Leading Indicator: User Friendliness of IT

a. Factor: Searchable database or intranet or website

Root causes of failure

Lack of use of IT for collection and retrieval of lessons learned.

RIPs, counter measures and/or BPs that eliminate the root causes

Use IT capability and potential to support lessons learned system.

b. Factor: User friendliness of IT used.

Root causes of failure

Lack of use of IT for collection and retrieval of lessons learned. Excel used in most cases for computations and data. Cumbersome IT to use.

RIPs, counter measures and/or BPs that eliminate the root causes

Make IT user friendly to both input data, search and retrieve information so busy people wouldn't be discouraged to document or use lessons learned.

c. Factor: Requirement to search lessons learned at start of project.

Root causes of failure

Lack of use of IT or database difficult to search for information. Hard copy is even more difficult to search for information.

RIPs, counter measures and/or BPs that eliminate the root causes

Use IT capability and potential to support and facilitate lessons learned system.

d. Factor: Use of electronic input template.

Root causes of failure

Lack of use of well thought out and formulated template where in best practices in lessons learned are incorporated. Lack of being parsimonious in selecting the most important and yet complete information to collect..

RIPs, counter measures and/or BPs that eliminate the root causes

Use electronic easy to use template to facilitate lessons learned documentation by busy people. IT strength and potential to support lessons learned systems.

4. Leading Indicator: Engagement Level

a. Factor: Involve team leaders of owners and subcontractors in lessons learned meetings.

Root causes of failure

Leaving out important stakeholders from meetings. Not reminding stakeholders about lessons learned meeting ahead of time.

RIPs, counter measures and/or BPs that eliminate the root causes

Involve team leaders including owners and subcontractors in lessons learned meetings to get richer information. Inform external stakeholders at the beginning of project that you hold lessons learned at completion of major elements.

b. Factor: Appointing facilitator by head office.

Root causes of failure

Budget constraint to hire facilitator.

RIPs, counter measures and/or BPs that eliminate the root causes

Head office may allocate budget, or it may be made part of project cost.

c. Factor: Use effective leading questions in meeting.

Root causes of failure

Leading meeting by inexperienced people in getting the best out of people.

RIPs, counter measures and/or BPs that eliminate the root causes

It is best to use facilitator to make the most out of the meeting.

d. Factor: Feedback also on constructability of design.

Root causes of failure

Leading meeting by inexperienced people in getting the best out of people.

RIPs, counter measures and/or BPs that eliminate the root causes

It is best to use facilitator to make the most out of the meeting.

G. Marketing Process

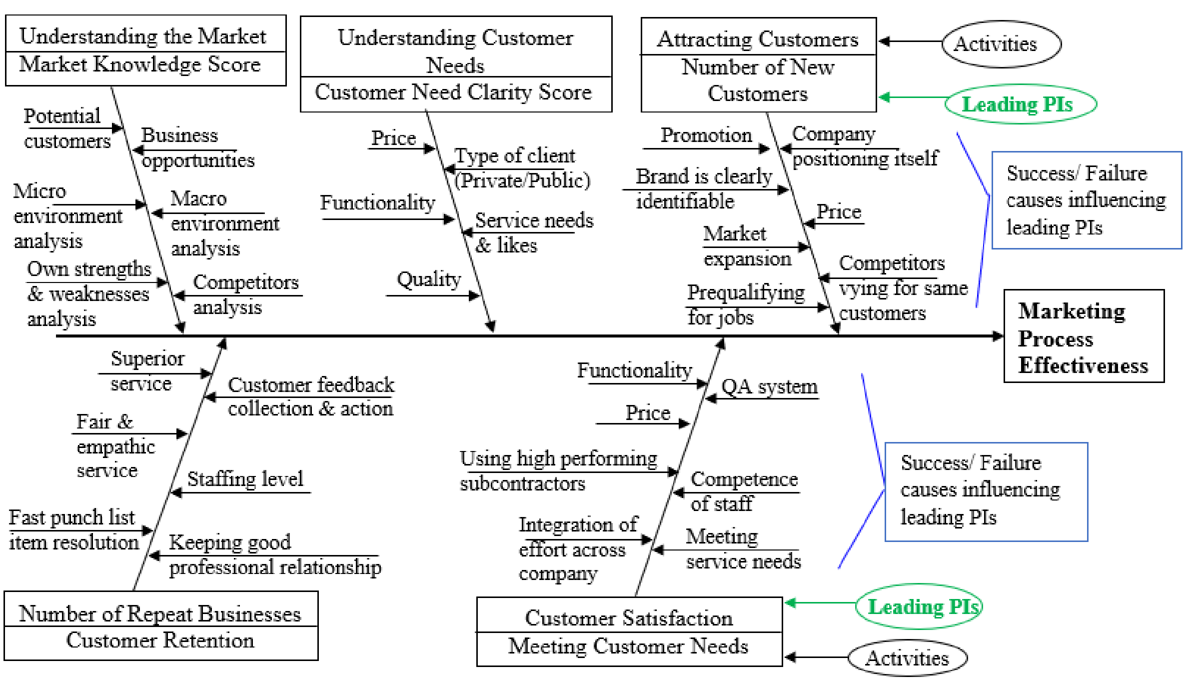


Figure E.8 Fishbone diagram for marketing process

1. **Leading Indicator**: Market Knowledge Score

a. **Factor**: Potential customers.

Root causes of failure

Not identifying all potential customers or not addressing them well.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify and carry out analysis and prioritization of profitable customers to target for marketing.

b. **Factor:** Business opportunities.

Root causes of failure

Lack of proper analysis to identify and rank profitable opportunities.

RIPs, counter measures and/or BPs that eliminate the root causes

Actively look for exploitable opportunities continuously.

c. **Factor:** Micro environment analysis.

Root causes of failure

Not carrying out meaningfully useful and detailed micro analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out effect of company micro environment factors (customers, suppliers, competitors, employees, shareholders and media) on your business.

d. **Factor**: Macro environment analysis.

Root causes of failure

Not carrying out meaningfully useful and detailed macro analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out effect of company macro environment factors (political, economic, social, technological, and legal/regulatory factors) on your business.

e. Factor: Own strengths & weaknesses analysis.

Root causes of failure

Having blind spots about own strengths & weaknesses or not carrying out analysis well.

RIPs, counter measures and/or BPs that eliminate the root causes

Know your strengths and weaknesses so you maximize your strengths and minimize your weaknesses.

f. Factor: Competitors analysis.

Root causes of failure

Not conducting competitor analysis well.

RIPs, counter measures and/or BPs that eliminate the root causes

To win, analyze competitor strengths, weaknesses, bidding strategies and bidding trends and make informed decisions.

2. Leading Indicator: <u>Customer Need Clarity Score</u>

a. Factor: Price.

Root causes of failure

Not being the lowest bidder.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve processes and skills to improve productivity that enables being the lowest bidder.

b. Factor: Type of client (Private/Public).

Root causes of failure

Lack of tailoring bidding to the type of client.

RIPs, counter measures and/or BPs that eliminate the root causes

Adjust bidding strategy to the type of contract (competitive or negotiated) in order to win.

c. Factor: Functionality.

Root causes of failure

Lack of expertise in functionally efficient design.

RIPs, counter measures and/or BPs that eliminate the root causes

The contribution of contractor to functionality is limited in design-bid-construct type contracts but in design-build functionally efficient facility can be designed for the business of the client.

d. Factor: Service needs and likes.

Root causes of failure

Lack of focus on service needs and likes.

RIPs, counter measures and/or BPs that eliminate the root causes

You need to know the service needs and likes of your client to meet those needs.

e. Factor: Quality.

Root causes of failure

Lack of sufficient focus on quality.

RIPs, counter measures and/or BPs that eliminate the root causes

Ensure quality work through improvement of processes, skills and client expectation management.

3. Leading Indicator: Number of New Customers

a. Factor: Promotion

Root causes of failure

Not doing promotion well. Construction companies are weak on this.

RIPs, counter measures and/or BPs that eliminate the root causes

Promote your services so clients know you exist and know what you do. Try to get recommendations from your previous customers because new customers believe these testimonies than promotions.

b. Factor: Company positioning itself.

Root causes of failure

Lack of this strategy.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify client needs and demonstrate that you meet those needs to position yourself at the top in clients' minds.

c. Factor: Brand is clearly identifiable.

Root causes of failure

Lack of awareness about importance and use of brand.

RIPs, counter measures and/or BPs that eliminate the root causes

Your brand is your identity and work towards establishing it in the mind of your potential market and defending it vigorously.

d. Factor: Market expansion.

Root causes of failure

Lack of such growth strategies.

RIPs, counter measures and/or BPs that eliminate the root causes

Market expansion is one way to grow your company and your revenue.

e. Factor: Price.

Root causes of failure

Lack of focus on this important strategy that helps win more job.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve processes and skills to improve productivity that enables being the lowest bidder.

f. Factor: Prequalifying for jobs.

Root causes of failure

Not giving this much focus.

RIPs, counter measures and/or BPs that eliminate the root causes

Prequalifying for jobs is a good way to demonstrate to clients that you have the necessary capacity to do jobs.

g. Factor: Competitor vying for same customers.

Root causes of failure

Not putting effort into exceling amongst competitors.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider that you are competing with many companies who could win and snatch your job. Know strengths and weaknesses of your competitors.

4. Leading Indicator: <u>Number of Repeat Business</u>

a. Factor: Superior service.

Root causes of failure

Lack of practicing of these good practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Applying these good practices helps to have repeat business.

b. Factor: Customer feedback collection & acting on feedback.

Root causes of failure

Lack of practice of these good practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Applying these good practices helps to have repeat business.

c. Factor: Fair & empathic service.

Root causes of failure

Lack of practicing of such good business practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Applying these good business practices helps to have repeat business.

d. Factor: Staffing level.

Root causes of failure

Understaffing to serve customers to reduce costs.

RIPs, counter measures and/or BPs that eliminate the root causes

Staff to appropriate levels for best customer services.

e. Factor: Fast punch list item resolution.

Root causes of failure

Dragging and delaying punch list items correction.

RIPs, counter measures and/or BPs that eliminate the root causes

Good practice is to check quality and resolve items when the tasks are accomplished because you have all the resources to do it.

f. Factor: Keeping good professional relationship.

Root causes of failure

All company staff interacting with external stakeholders need professional public relations training.

RIPs, counter measures and/or BPs that eliminate the root causes

Always be an expert helping and guiding clients and subcontractors with your expertise. Always stay positive and helpful to stakeholders.

5. Leading Indicator: Customer Satisfaction

a. Factor: Functionality.

Root causes of failure

Lack of focus on producing facility that improves functions of the business of the client.

RIPs, counter measures and/or BPs that eliminate the root causes

Always keep the interest of the client and add value to facility that would enable client do its businesses well.

b. Factor: QA system.

Root causes of failure

Not strictly following QA system.

RIPs, counter measures and/or BPs that eliminate the root causes

Implement the QA processes and procedures put in place to ensure customer satisfaction.

c. Factor: Price.

Root causes of failure

Providing least price facility of high quality is what the client wants.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve your processes to increase productivity. This helps company to be the lowest bidder.

d. Factor: Using high performing subcontractors.

Root causes of failure

Not following subcontractor prequalification guidelines well.

RIPs, counter measures and/or BPs that eliminate the root causes

Subcontractors perform a significant portion of the work. Pay special attention in selection and supervision of subcontractors.

e. Factor: Competence of staff.

Root causes of failure

Not investing time and money on sharpening competence of staff.

RIPs, counter measures and/or BPs that eliminate the root causes

Workers are the heart and soul of organizations whose competence need to be developed to help company succeed.

f. Factor: Integration of effort across company.

Root causes of failure

Not coordinating efforts across company and projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Putting in concerted effort is synergistic in getting customers satisfied.

g. Factor: Meeting service needs.

Root causes of failure

Lack of focus on what the customer asks for.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide exactly what the customer needs and asks for, not what you think is best for the client. Anything extra is not appreciated by the client.

H. Pricing Process

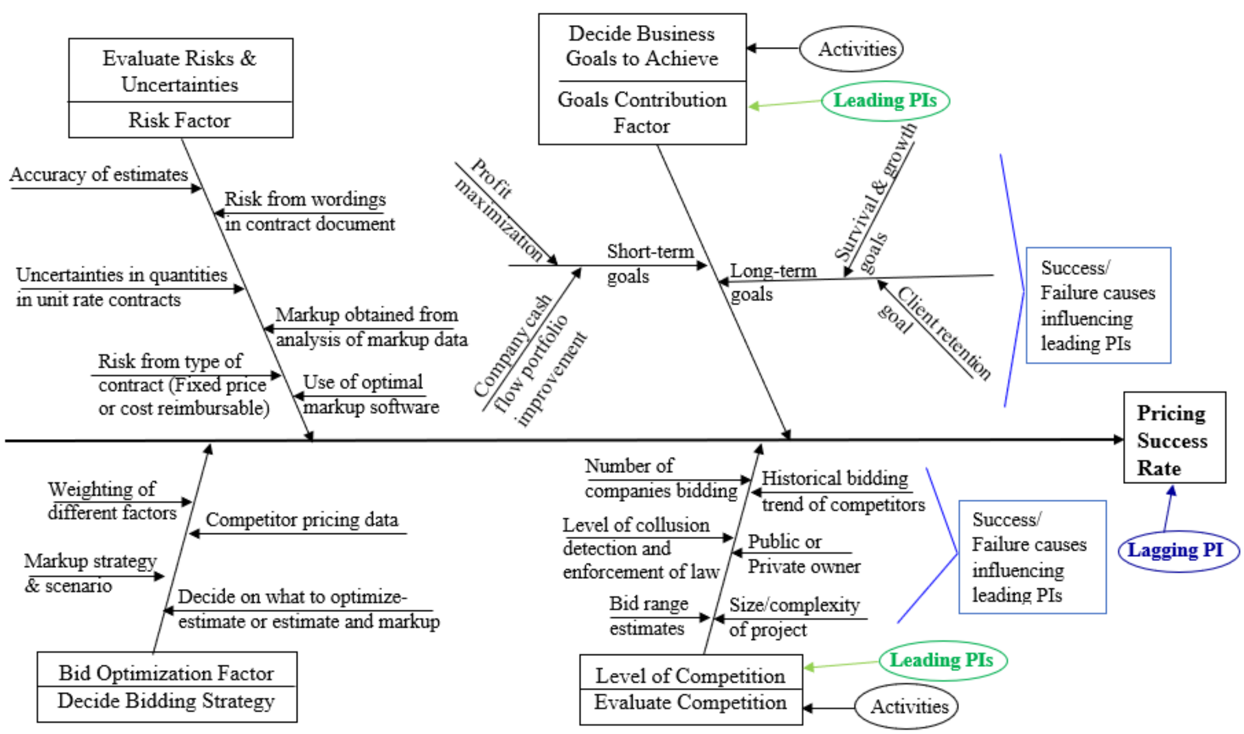


Figure E.9 Fishbone diagram for pricing process

1. **Leading Indicator**: Risk Factor

a. Factor: Accuracy of estimates.

Root causes of failure

Lack of consideration or lack of knowhow how to estimate accuracy of estimates to help assess risk from it.

RIPs, counter measures and/or BPs that eliminate the root causes

Collect data on accuracy of estimates because it serves as an invaluable information in future bids.

b. Factor: Risk from wordings in contract document.

Root causes of failure

Lack of assessment of risk from wording or lack of knowhow to assess the risk from wording of contract.

RIPs, counter measures and/or BPs that eliminate the root causes

Use risk analysis from wording to either give feedback to clients or classify clients for future business. This is a constraint under which a company must operate because the company does not have part in drafting the contract.

c. Factor: Uncertainties in quantities in unit rate contracts.

Root causes of failure

Lack of assessment of uncertainties in quantities.

RIPs, counter measures and/or BPs that eliminate the root causes

Experience is the best educator about variations in quantity.

d. Factor: Markup obtained from analysis of markup data.

Root causes of failure

Lack of markup data or not taking advantage of it or not knowing how to analyze the data.

RIPs, counter measures and/or BPs that eliminate the root causes

Collect markup data and get some analysis method.

e. Factor: Risk from type of contract (Fixed price or cost reimbursable).

Root causes of failure

Lack of treatment of the risks differently.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out detailed risk analysis and apply risk management methods.

f. Factor: Use of optimal markup software.

Root causes of failure

Lack of use of such software.

RIPs, counter measures and/or BPs that eliminate the root causes

It may be expensive to buy such a software but if bought gives a competitive advantage.

2. Leading Indicator: Goals Contribution Factor

a. Factor: Profit maximization.

Root causes of failure

Lack of consideration of business goals in pricing decisions.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider different goals and factors to decide the best way to price bids.

b. Factor: Company cash flow portfolio improvement.

Root causes of failure

Lack of consideration of business goals in pricing decisions.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider different goals and factors to decide the best way to price bids.

c. Factor: Survival & growth goals.

Root causes of failure

Lack of consideration of business goals in pricing decisions.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider different goals and factors to decide the best way to price bids.

d. Factor: Client retention goal.

Root causes of failure

Lack of consideration of business goals in pricing decisions.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider different goals and factors to decide the best way to price bids.

3. Leading Indicator: <u>Bid Optimization Factor</u>

a. Factor: Weighting of different factors

Root causes of failure

Often treating all factors equally or ignoring some factors totally.

RIPs, counter measures and/or BPs that eliminate the root causes

Collect data on relative importance of factors for pricing.

b. Factor: Competitor pricing data.

Root causes of failure

Lack of this data or not using it well.

RIPs, counter measures and/or BPs that eliminate the root causes

Collect and use competitor pricing data.

c. Factor: Markup strategy and scenario.

Root causes of failure

Lack of systematic markup strategy and scenario.

RIPs, counter measures and/or BPs that eliminate the root causes

Use a systematic strategy.

d. Factor: Decide on what to optimize- estimate or estimate and markup.

Root causes of failure

Lack of strategy often or not basing decisions on evidence.

RIPs, counter measures and/or BPs that eliminate the root causes

Use a systematic strategy.

4. Leading Indicator: Level of Competition

a. Factor: Number of companies bidding.

Root causes of failure

Not bidding in specialized or complex projects. Not differentiating the company from many, doing type of job everybody does. Not getting that number.

RIPs, counter measures and/or BPs that eliminate the root causes

Build competitive edge continuously by improving processes and competence of employees.

b. Factor: Historical bidding trend of competitors.

Root causes of failure

Not having data on historical bidding trend of competitors or not doing this trend analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out competitor trend analysis, and other evidences that helps you to make better decisions.

c. Factor: Level of collusion detection and enforcement of law.

Root causes of failure

Not speaking out to policy makers about it.

RIPs, counter measures and/or BPs that eliminate the root causes

Advocate for a level field for competition and commensurate penalty for corruptions through professional associations.

d. Factor: Public or Private owner.

Root causes of failure

Not strategizing the bidding differently for public and private work.

RIPs, counter measures and/or BPs that eliminate the root causes

Make this distinction to adjust your bidding strategy. Competitive bidding and social responsibility for public projects and profit maximization in the case of private projects.

e. Factor: Bid range estimates.

Root causes of failure

Lack of bid range estimates or lack of such a consideration.

RIPs, counter measures and/or BPs that eliminate the root causes

Estimate bid ranges from competitor pricing data.

f. Factor: Size/complexity of project.

Root causes of failure

Lack of consideration or understanding of size or complexity on bidding.

RIPs, counter measures and/or BPs that eliminate the root causes

Use modularization and dynamic capability building to handle large and complex projects.

I. Procurement Process

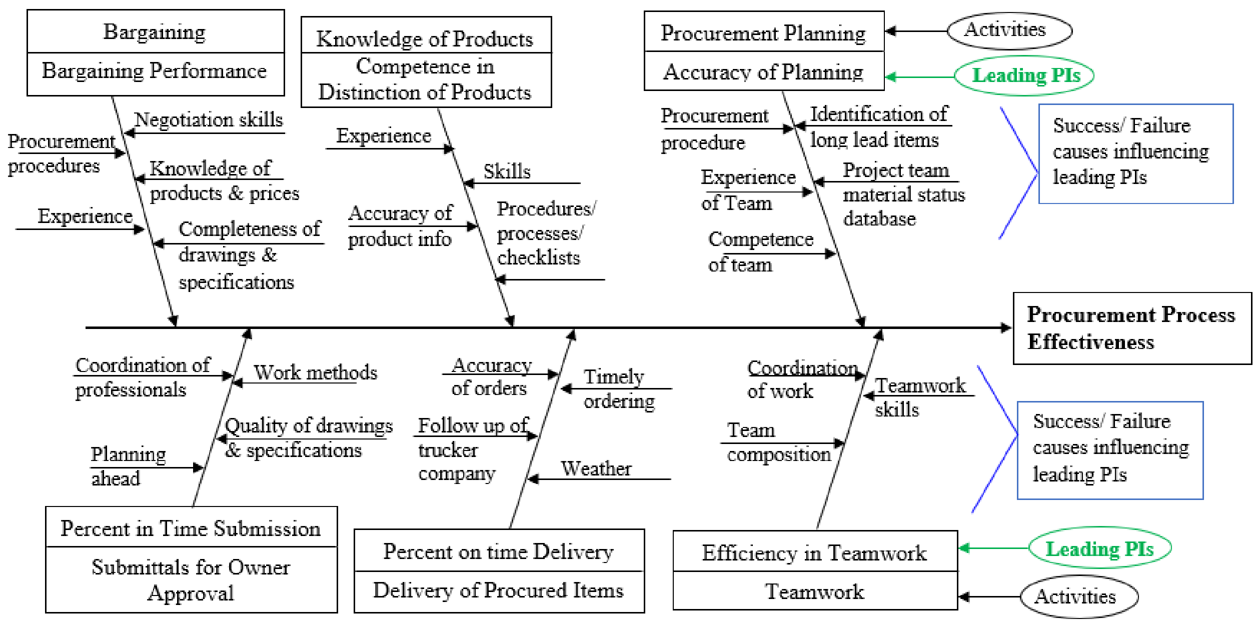


Figure E.10 Fishbone diagram for procurement process

1. **Leading Indicator**: Bargaining Performance

a. **Factor**: Procurement procedures.

Root causes of failure

Lack of development of procedure or not following it well.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in places procedures with checks and balances.

b. Factor: Negotiation skills.

Root causes of failure

Lack of negotiation skills or not preparing well before negotiations.

RIPs, counter measures and/or BPs that eliminate the root causes

Train procurement people in developing their negotiation skills.

c. Factor: Knowledge of products & prices.

Root causes of failure

Not much experience with products & prices.

RIPs, counter measures and/or BPs that eliminate the root causes

Procurement procedure should include exhaustive research on products and prices before selection. Coach and develop young people.

d. Factor: Procurement experience.

Root causes of failure

Procurement inexperience.

RIPs, counter measures and/or BPs that eliminate the root causes

Use coaching and mentoring of young people to help them gain experience.

e. Factor: Completeness of drawings & specifications

Root causes of failure

Missing information.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department should first check it before forwarding the shop drawings for procurement.

2. Leading Indicator: Competence in Distinction of Products

a. Factor: Experience.

Root causes of failure

Lack of experience in distinction of products.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

b. Factor: Skills.

Root causes of failure

Lack of skill in distinction of products.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

c. Factor: Accuracy of product and supplier info.

Root causes of failure

Lack of effort on researching product information.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

d. Factor: Procedures/ Processes/ Checklists.

Root causes of failure

Lack of inclusion of product distinction in procurement procedures and processes.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

3. Leading Indicator: Accuracy of Planning

a. Factor: Procurement procedure

Root causes of failure

Not accounting for procedure in planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Put the procedure as integral part of the planning.

b. Factor: Identification of long lead items.

Root causes of failure

Sometimes these items may be overlooked.

RIPs, counter measures and/or BPs that eliminate the root causes

List items to be purchased exhaustively from construction plan and schedule.

c. Factor: Experience of team.

Root causes of failure

Lack of experience or not having sufficient experience.

RIPs, counter measures and/or BPs that eliminate the root causes

Build experience of team through coaching.

d. Factor: Project team material status database.

Root causes of failure

Not communicating timely about status.

RIPs, counter measures and/or BPs that eliminate the root causes

Get status updates regularly.

e. Factor: Competence of team.

Root causes of failure

Lack of competence of team.

RIPs, counter measures and/or BPs that eliminate the root causes

Build competence of team through training and coaching.

4. Leading Indicator: Percent in Time Submission for Owner Approval

a. Factor: Coordination of professionals.

Root causes of failure

Couldn't coordinate well or some not meeting deadlines.

RIPs, counter measures and/or BPs that eliminate the root causes

Coordinate and remind professionals working on shop drawings, bill of quantities, procurement, contracts, etc.

b. Factor: Work methods.

Root causes of failure

Not choosing the work methods most suited to equipment and skills company has.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department need to consider work methods in preparing shop drawings.

c. Factor: Planning ahead.

Root causes of failure

Not planning well or in detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Plan ahead for timely submission and list down items for procurement from construction schedule, drawings and specifications.

d. Factor: Completeness of drawings and specifications.

Root causes of failure

Document with some missing information.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department needs to check completeness before going on to other tasks.

5. Leading Indicator: <u>Percent in Time Delivery</u>

a. Factor: Accuracy of orders

Root causes of failure

Orders with some items missing.

RIPs, counter measures and/or BPs that eliminate the root causes

Have items to be procured listed and double checked.

b. Factor: Timely ordering.

Root causes of failure

Not ordering in time or some items missing while ordering.

RIPs, counter measures and/or BPs that eliminate the root causes

List items to be purchased exhaustively from construction plan and schedule with required ordering and receipt dates.

c. Factor: Follow up of trucker company.

Root causes of failure

Not reminding and following up regularly.

RIPs, counter measures and/or BPs that eliminate the root causes

Have some procedure of follow up with logistics companies.

d. **Factor:** Weather.

Root causes of failure

Not accounting for weather while planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider effect of weather on logistics and delivery of items.

6. **Leading Indicator**: Efficiency in Teamwork

a. **Factor**: Coordination of work.

Root causes of failure

Lack of clarity of team member roles and coordination problems among procurement team.

RIPs, counter measures and/or BPs that eliminate the root causes

Make role of each team member clear. Team leader needs to coordinate all work.

b. **Factor:** Effectiveness of team development.

Root causes of failure

Not managing team development through all phases of its development affecting its effectiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Team leader needs to manage and lead the team through all its development phases so that the team develops effectively.

c. **Factor:** Diversity of team member skills.

Root causes of failure

Lack of consideration of diversity in team member skills in forming teams.

RIPs, counter measures and/or BPs that eliminate the root causes

Compose teams diversely in terms of expertise and experience.

J. Project Closeout Process

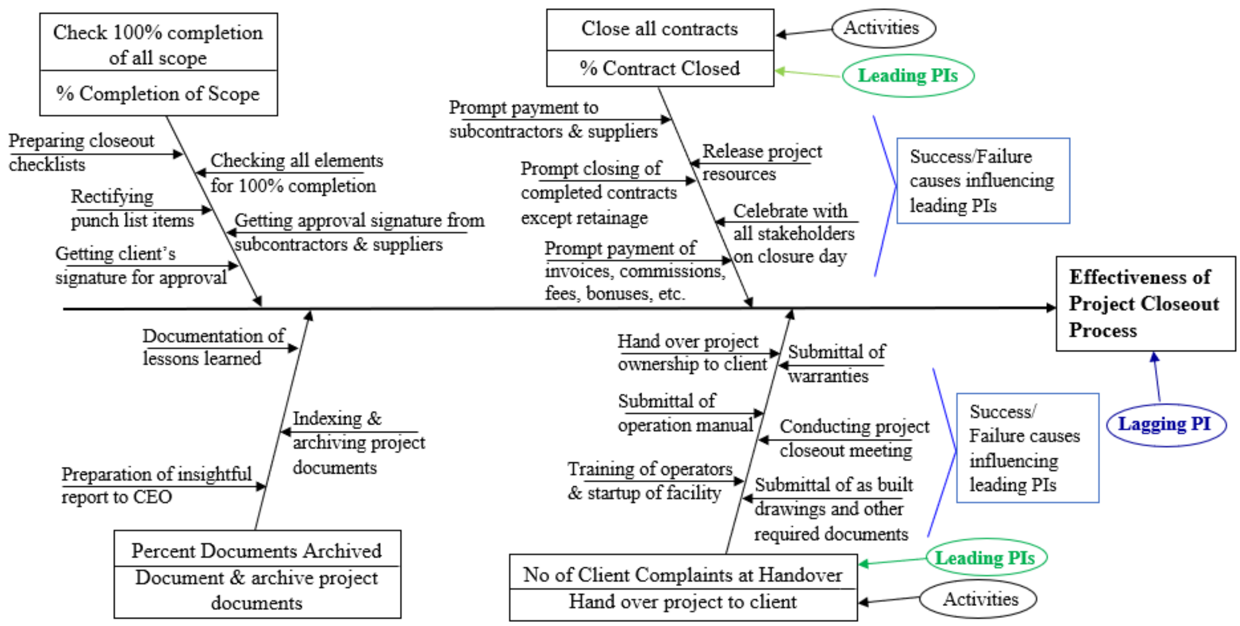


Figure E.11 Fishbone diagram for project closeout process

1. Leading Indicator: Percent Completion of Scope

a. Factor: Checking all elements for 100% completion.

Root causes of failure

Procrastination.

RIPs, counter measures and/or BPs that eliminate the root causes

Use a closeout checklist to check 100% completion.

b. Factor: Rectifying punch list items.

Root causes of failure

Keeping punch list items for after contractor closeout of project.

RIPs, counter measures and/or BPs that eliminate the root causes

It is best to rectify items including punch list items before closeout.

c. **Factor:** Getting client's signatures for approval.

Root causes of failure

Lack of getting approval signatures due to client complaints.

RIPs, counter measures and/or BPs that eliminate the root causes

Manage client expectations aggressively and communicate throughout project duration well.

d. **Factor**: Getting approval signature from subcontractors & suppliers.

Root causes of failure

Lack of getting approval signatures due to unfair treatment.

RIPs, counter measures and/or BPs that eliminate the root causes

Manage subcontractors and their expectations and communicate throughout project duration well.

e. **Factor:** Preparing closeout checklists

Root causes of failure

Lack of being systematic.

RIPs, counter measures and/or BPs that eliminate the root causes

Check all deliverables and prepare closeout checklist that ensures nothing is left out.

2. **Leading Indicator**: <u>Percent Contract Closed</u>

a. **Factor**: Prompt payment to subcontractors & suppliers.

Root causes of failure

Delaying payments after client has paid for the work completed.

RIPs, counter measures and/or BPs that eliminate the root causes

Treat subcontractors fairly and pay them as soon as you receive payment from client for subcontract work done.

b. **Factor:** Release project resources.

Root causes of failure

Keeping resources when needed no more.

RIPs, counter measures and/or BPs that eliminate the root causes

Release any resources you are sure not to be needed.

c. **Factor:** Prompt closing of completed contracts except retainage.

Root causes of failure

Lack of prompt closing when contract is completed.

RIPs, counter measures and/or BPs that eliminate the root causes

Closing contracts bit by bit as soon as they are completed is good practice while the work is fresh in memory, and easens work load at the end.

d. **Factor:** Celebrate with all stakeholders on closure day.

Root causes of failure

Overlooking this social aspect.

RIPs, counter measures and/or BPs that eliminate the root causes

It is good to recognize and appreciate hard work of people.

e. **Factor:** Prompt payment of invoices, commissions, fees, bonuses, etc.

Root causes of failure

Delaying payments after work is completed.

RIPs, counter measures and/or BPs that eliminate the root causes

Pay out all cleared cases of payments.

3. Leading Indicator: <u>Percent Document Archived</u>

a. Factor: Documentation of lessons learned

Root causes of failure

Lack of documenting and archiving systematically for later reference.

RIPs, counter measures and/or BPs that eliminate the root causes

Validate and document lessons learned for use on future projects.

b. Factor: Indexing and archiving project documents.

Root causes of failure

Lack of documenting and archiving systematically for later reference.

RIPs, counter measures and/or BPs that eliminate the root causes

Index and archive documents when they are fresh in memory as these will be invaluable reference in future similar projects.

c. Factor: Preparation of insightful report to CEO.

Root causes of failure

Lack of documenting and archiving systematically for later reference.

RIPs, counter measures and/or BPs that eliminate the root causes

Insightful report to CEO will help the CEO to use lessons learned and archived document, and recommend it to people working on future similar projects.

4. Leading Indicator: No of Client Complaints at Handover

a. Factor: Hand over project ownership to client.

Root causes of failure

Not doing these things well or as appropriate depending on facility and contract type.

RIPs, counter measures and/or BPs that eliminate the root causes

The earliest you handover ownership, the more you save on overhead.

b. Factor: Submittal of warranties.

Root causes of failure

Not doing these things well or as appropriate depending on facility and contract type.

RIPs, counter measures and/or BPs that eliminate the root causes

Submit warranties and other required document to minimize client complaints and improve chance of getting repeat business.

c. Factor: Submittal of operation manual.

Root causes of failure

Not doing these things well or as appropriate depending on facility and contract type.

RIPs, counter measures and/or BPs that eliminate the root causes

Submit operational manual if the contract requires it.

d. Factor: Conducting project closeout meeting.

Root causes of failure

Not doing these things well or as appropriate depending on facility and contract type.

RIPs, counter measures and/or BPs that eliminate the root causes

Conducting project closeout meeting is important to formally transfer ownership of project to client.

e. **Factor:** Training of operators & startup of facility.

Root causes of failure

Not doing these things well or as appropriate depending on facility and contract type.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide training and start up facility if the contract requires so.

f. **Factor:** Submittal of as built drawings and other required documents.

Root causes of failure

Not doing these things well or as appropriate depending on facility and contract type.

RIPs, counter measures and/or BPs that eliminate the root causes

Submit as built drawings and other required documents because client needs them for operation and maintenance.

K. Scheduling Management Process

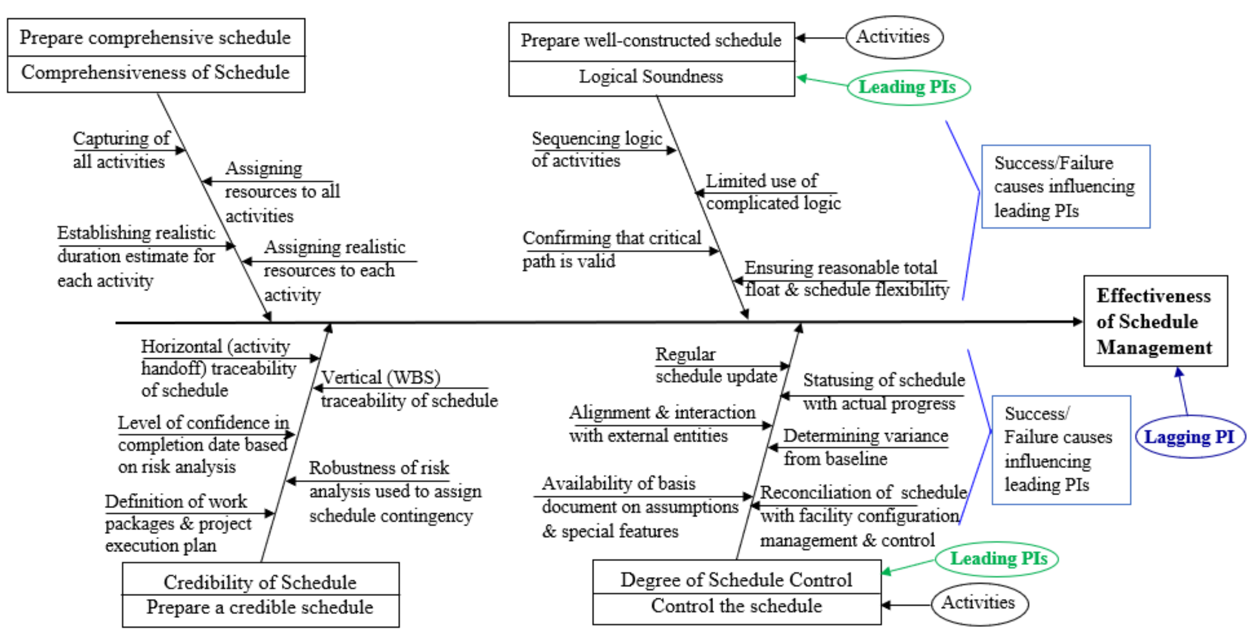


Figure E.12 Fishbone diagram for schedule management process

1. Leading Indicator: Comprehensiveness of Schedule

a. Factor: Capturing of all activities.

Root causes of failure

Missing out activities.

RIPs, counter measures and/or BPs that eliminate the root causes

Breakdown project systematically hierarchically to make sure you are exhaustive enough to capture all activities. Capture all activities as defined in the WBS.

b. Factor: Assigning resources to all activities.

Root causes of failure

Lack of preparation of execution plan.

RIPs, counter measures and/or BPs that eliminate the root causes

Use realistic estimates in assigning resources. Make sure labor, materials, travel, facilities, and equipment are available when needed for the work.

c. Factor: Establishing realistic duration estimate for each activity.

Root causes of failure

Lack of preparation of execution plan or preparation of deficient execution plan.

RIPs, counter measures and/or BPs that eliminate the root causes

Use realistic resources and accurate historical data in estimating activity durations.

d. Factor: Assigning realistic resources to each activity.

Root causes of failure

Junior or inexperienced staff doing the resource assignment to activities.

RIPs, counter measures and/or BPs that eliminate the root causes

Use experienced staff to do resource assignment to activities so realistic and practicable assignment can be made.

2. Leading Indicator: Logical Soundness of Schedule

a. Factor: Sequencing logic of activities.

Root causes of failure

Often engineers are good at sequencing logic of activities, but mistake may be made sometimes.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out detailed analysis and sequence all activities with predecessor and successor logic. Use only limited and justified complicated logic.

b. Factor: Limited use of complicated logic.

Root causes of failure

Use of complicated logic due to lack of due diligence in analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out detailed analysis. Due diligence and effort in planning pays off later during implementation.

c. Factor: Confirming that critical path is valid.

Root causes of failure

Unwillingness to put effort into the iterative work.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out detailed analysis. Determine the critical path, the activities that determine the earliest finish date of project.

d. Factor: Ensuring reasonable total float and schedule flexibility.

Root causes of failure

Unwillingness to put effort into the iterative work.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out detailed analysis to determine floats that give schedule flexibility information.

3. Leading Indicator: Credibility of Schedule

a. Factor: Horizontal (activity handoff) traceability of schedule

Root causes of failure

Lack of checking horizontal traceability.

RIPs, counter measures and/or BPs that eliminate the root causes

Determine the order of events necessary to get the required aggregated project outcomes.

b. Factor: Vertical (WBS) traceability of schedule.

Root causes of failure

Lack of checking vertical traceability.

RIPs, counter measures and/or BPs that eliminate the root causes

Determine hierarchical traceability of schedule in the WBS.

c. Factor: Level of confidence in completion date based on risk analysis.

Root causes of failure

Lack of proper risk analysis on projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Conduct proper schedule risk analysis to determine the probability of project completion by the stipulated date and cost.

d. Factor: Robustness of risk analysis used to assign schedule contingency.

Root causes of failure

Lack of proper risk analysis on projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Conduct proper schedule risk sensitivity analysis to determine contingency with the required level of confidence.

e. Factor: Definition of work packages and project execution plan.

Root causes of failure

Lack of definition of work packages and/or preparation of project execution plan or lack of clarity of definition of work packages and project execution plan.

RIPs, counter measures and/or BPs that eliminate the root causes

Use Advanced Work Packaging (AWP).

4. Leading Indicator: No of Client Complaints at Handover

a. Factor: Regular schedule update.

Root causes of failure

Lack of monitoring and control of schedule that renders it useless.

RIPs, counter measures and/or BPs that eliminate the root causes

Update schedule regularly (by a scheduler trained in CPM). Write narrative that describes the update to the schedule.

b. Factor: Statusing of schedule with actual progress.

Root causes of failure

Lack of monitoring and control of schedule that renders it useless.

RIPs, counter measures and/or BPs that eliminate the root causes

Status progress with actual progress and logic to realistically forecast program dates for activities.

c. Factor: Alignment & interaction with external entities.

Root causes of failure

Lack of showing client and subcontractor work on schedule.

RIPs, counter measures and/or BPs that eliminate the root causes

Show client and other stakeholder responsibilities on schedule that you share with them.

d. Factor: Determining variance from baseline.

Root causes of failure

Lack of monitoring and control of schedule that renders it useless.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor and control schedule to continuously determine and correct its deviation from baseline.

e. Factor: Availability of basis document on assumptions and special features.

Root causes of failure

Basis document missing or incomplete.

RIPs, counter measures and/or BPs that eliminate the root causes

There should be basis document accompanying the schedule explaining the overall approach to the program, defines assumptions and describes unique features of the schedule.

f. Factor: Configuration management control.

Root causes of failure

Lack of reconciliation of schedule with configuration of facility parts being constructed.

RIPs, counter measures and/or BPs that eliminate the root causes

The schedule should be subject to configuration management control process.

L. Subcontract Management Process

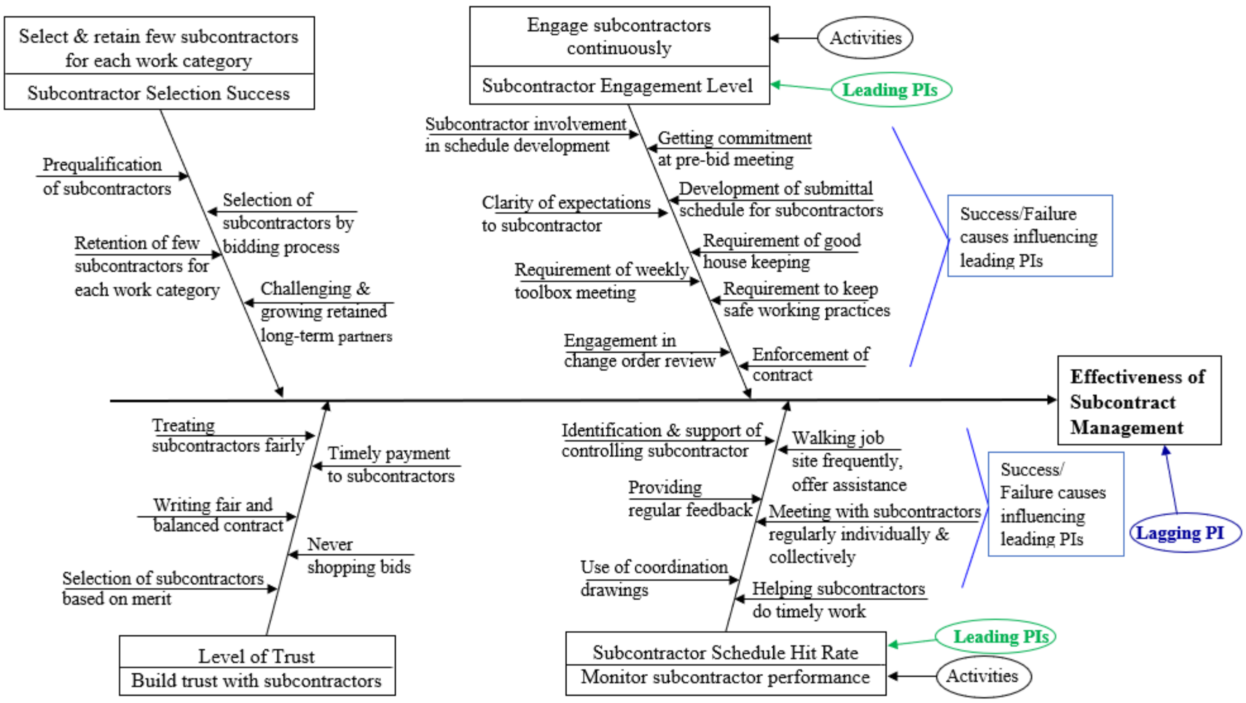


Figure E.13 Fishbone diagram for subcontract management process

1. **Leading Indicator**: Subcontractor Selection Success

a. **Factor**: Prequalification of subcontractors.

Root causes of failure

Lack of use of prequalification in selecting contractors.

RIPs, counter measures and/or BPs that eliminate the root causes

Prequalify subcontractors based on their previous work, safety, and financial situation.

b. Factor: Selection of subcontractors by bidding process.

Root causes of failure

Not enforcing this requirement all the time.

RIPs, counter measures and/or BPs that eliminate the root causes

Never engage in the practice of bid shopping and select subcontractors based on merit only by the bidding process.

c. Factor: Retention of few subcontractors for each work category.

Root causes of failure

Not keeping sufficient number of subcontractors for each work category.

RIPs, counter measures and/or BPs that eliminate the root causes

Build partnership with few subcontractors and help them build their capacity. Check cultural similarities between the parties or matched expectations in the arrangement. Important attributes are trust, dialogue, values, degree of reciprocity, and level of respect.

d. Factor: Challenging & growing retained ones long-term.

Root causes of failure

Lack of such a consideration.

RIPs, counter measures and/or BPs that eliminate the root causes

Build partnership with few subcontractors and help them build their capacity. Most subcontractors are small family businesses who have limited financial and personnel resources. A little help is a lot of help for them.

2. Leading Indicator: Subcontractor Engagement Level

a. Factor: Subcontractor involvement in schedule development.

Root causes of failure

Lack of subcontractor involvement in schedule development.

RIPs, counter measures and/or BPs that eliminate the root causes

Involve subcontractors in schedule development for buy in and for the schedule to be useful.

b. Factor: Getting commitment at pre-bid meeting.

Root causes of failure

Getting commitment at pre-bid meeting not done well.

RIPs, counter measures and/or BPs that eliminate the root causes

Get commitment from subcontractors at pre-bid meeting helps them to know what is expected of them and you reduce a lot of headache.

c. Factor: Clarity to subcontractor of your expectations from them.

Root causes of failure

Lack of clarity of what is expected of them on the subcontractor side.

RIPs, counter measures and/or BPs that eliminate the root causes

Be clear about expectations and responsibilities of subcontractors so that they deliver it.

d. Factor: Development of submittal schedule for subcontractors.

Root causes of failure

Lack of submittal schedule for subcontractors of drawings and material.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop and give submittal schedule for subcontractors of drawings and materials.

e. Factor: Requirement of weekly toolbox meeting.

Root causes of failure

Lack of this requirement in subcontract clauses.

RIPs, counter measures and/or BPs that eliminate the root causes

Put weekly toolbox meeting requirement in subcontract clauses you sign with subcontractors.

f. Factor: Requirement of good house-keeping.

Root causes of failure

Lack of this requirement in subcontract clauses.

RIPs, counter measures and/or BPs that eliminate the root causes

Put good house-keeping requirement (5S) in subcontract clauses.

g. Factor: Engagement in change order review.

Root causes of failure

Lack of subcontractor involvement in change order review.

RIPs, counter measures and/or BPs that eliminate the root causes

Engage all subcontractors in change order review because they can be affected.

h. Factor: Requirement to keep safe working practices.

Root causes of failure

Lack of this requirement in subcontract clauses.

RIPs, counter measures and/or BPs that eliminate the root causes

Put safe working practices requirement in subcontract clauses and include subcontractors in safety trainings.

i. Factor: Enforcement of contract.

Root causes of failure

Being lax on enforcing contracts.

RIPs, counter measures and/or BPs that eliminate the root causes

Enforce contract always and remind continuously but don't be harsh on subcontractors.

3. Leading Indicator: Level of Trust

a. Factor: Treating subcontractors fairly.

Root causes of failure

Acting bossy on subcontractors because they are under you and not treating them fairly.

RIPs, counter measures and/or BPs that eliminate the root causes

Treat subcontractors with respect and curtousy.

b. Factor: Timely payment to subcontractors.

Root causes of failure

Delaying subcontractor payment unfairly after receiving payment from owner.

RIPs, counter measures and/or BPs that eliminate the root causes

Pay subcontractors what they completed and deserve to receive according to contract because they can be struggling financially. There is no legal or ethical basis to delay the payment.

c. Factor: Writing fair and balanced contracts.

Root causes of failure

Acting bossy on subcontractors because they are under you and not treating them fairly.

RIPs, counter measures and/or BPs that eliminate the root causes

Write fair and balanced subcontract for a win-win relationship.

d. Factor: Never shopping bids.

Root causes of failure

Acting foolishly for short-term and small financial gain.

RIPs, counter measures and/or BPs that eliminate the root causes

Never shop bids because it destroys trust.

e. Factor: Selection of subcontractors based on merit.

Root causes of failure

Not implementing selection of subcontractors based on merit wel.

RIPs, counter measures and/or BPs that eliminate the root causes

Selection based on merit helps both company and subcontractor. Never operate on favoritism or other ways because they destroy trust and company reputation

4. Leading Indicator: Subcontractor Schedule Hit Rate

a. Factor: Identification & support of controlling subcontractor.

Root causes of failure

Not supporting, not giving feedback to subcontractors and lack of proper management of them.

RIPs, counter measures and/or BPs that eliminate the root causes

Support all subcontractors but the controlling subcontractor needs support because otherwise the schedule can be delayed.

b. Factor: Walking job site frequently, offering assistance as needed.

Root causes of failure

Not supporting, not giving feedback to subcontractors and lack of proper management of them.

RIPs, counter measures and/or BPs that eliminate the root causes

It is good practice to follow up and show that you care about subcontractors performance. A little support helps them accomplish a lot.

c. **Factor:** Providing regular feedback.

Root causes of failure

Not supporting, not giving feedback to subcontractors and lack of proper management of them.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide regular and honest feedback so that they improve, and also they grow.

d. **Factor:** Meeting with subcontractors regularly individually & collectively.

Root causes of failure

Not supporting, not giving feedback to subcontractors and lack of proper management of the.

RIPs, counter measures and/or BPs that eliminate the root causes

Meet with subcontractors regularly individually to know their individual concerns. Meet with subcontractors collectively to know their concerns working together as work of one may affect the other.

e. **Factor:** Use of coordination drawings.

Root causes of failure

Not supporting, not giving feedback to subcontractors and lack of proper management of them.

RIPs, counter measures and/or BPs that eliminate the root causes

Using coordination drawings helps subcontractors know their allotted time and space, and the effect delay of any subcontractor will have on others.

f. Factor: Supporting subcontractors do timely work.

Root causes of failure

Not supporting, not giving feedback to subcontractors and lack of proper management of them.

RIPs, counter measures and/or BPs that eliminate the root causes

Support subcontractors to do not only quality work but also timely work.

M. Training Management Process

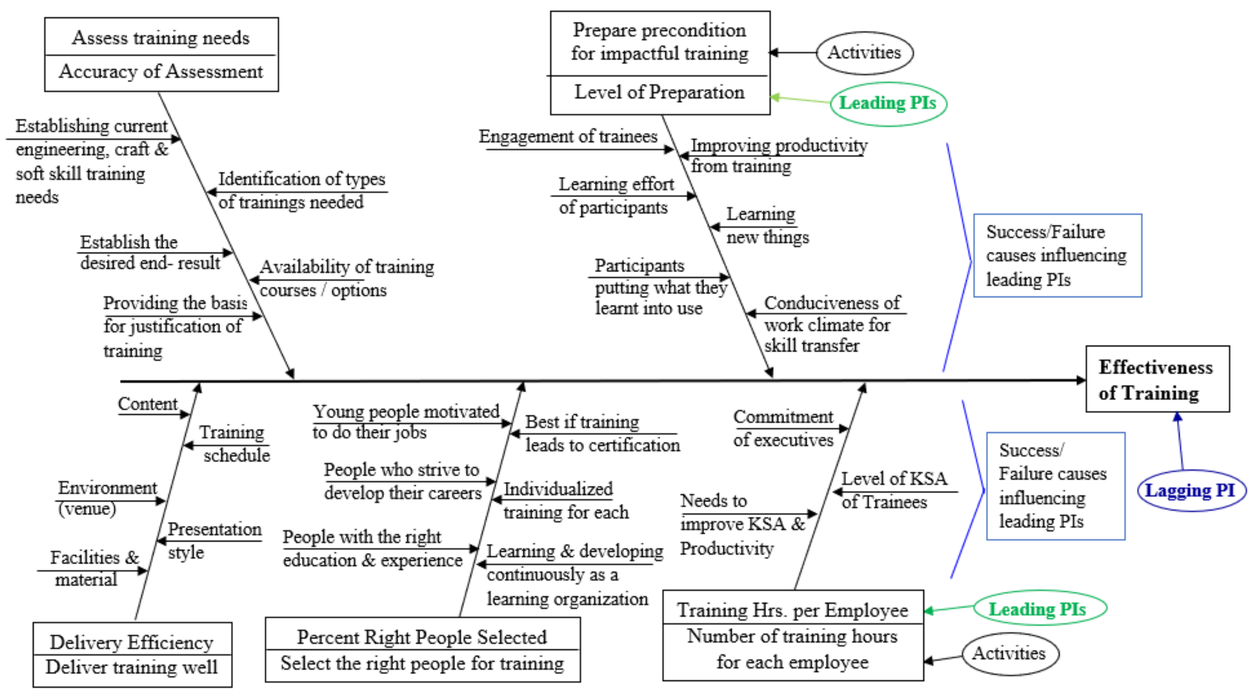


Figure E.14 Fishbone diagram for training program management process

1. **Leading Indicator**: Accuracy of Training Needs Assessment

a. **Factor**: Establishing current engineering, craft and soft skill training needs.

Root causes of failure

Lack of structured and systematic approach regarding training.

RIPs, counter measures and/or BPs that eliminate the root causes

The organization identifies the hard (technical) and soft (non-technical) skills needed to meet business goals.

b. **Factor:** Identification of types of trainings needed.

Root causes of failure

Lack of identification of trainings needed and not phasing/staggering them.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify training types needed and stagger while giving them (technology, quality, skills, soft skills, professional (engineering), legal, team, managerial, safety trainings, etc.).

c. **Factor:** Establish the desired end- result.

Root causes of failure

Lack of clear definition of the specific objectives of trainings.

RIPs, counter measures and/or BPs that eliminate the root causes

List down learning objectives and work backwards to content and skills that enable hit the objectives.

d. **Factor**: Availability of training courses/options.

Root causes of failure

Lack of strategy and methods to do training.

RIPs, counter measures and/or BPs that eliminate the root causes

Training/learning can be selected from a wide range of options: Organizational Learning, Education/ Training, Self-Directed Learning, On-the-Job Learning, Just-in-Time Learning, Action Learning, Blended Learning, Technical and Non-Technical Learning, Social Learning, Interactive Learning Technologies, Enterprise Learning, Classroom Learning, Distance/Distributed Learning, Online/e-Learning, Wikis, Avatars, and More, Games/Simulations van Tiem et al., 2012)..

e. **Factor**: Providing the basis for justification of training.

Root causes of failure

Lack of such strategizations.

RIPs, counter measures and/or BPs that eliminate the root causes

Show benefit to cost ratio or return on training investment to provide the evidence/justification needed for decision making.

2. **Leading Indicator**: Level of Preparation of Pre-condition for Training

a. **Factor**: Engagement of trainees.

Root causes of failure

Lack of the desired levels of preparation or lack of employees buy in into the training.

RIPs, counter measures and/or BPs that eliminate the root causes

Collect data from middle and supervisory management and employees on training needs to improve performance and come up with a consensus so that employees own your vision.

b. **Factor:** Improving productivity from training.

Root causes of failure

Lack of the desired levels of preparation or lack of employees buy in into the training.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide training on skills exactly needed to help improve performance and avoid extraneous effort and resources.

c. Factor: Learning effort of participants.

Root causes of failure

Lack of the desired levels of preparation or lack of employees buy in into the training.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees to be on the same page with management so they buy in and put in effort into the training.

d. Factor: Learning new things.

Root causes of failure

Lack of the desired levels of preparation to deliver new, relevant and useful things.

RIPs, counter measures and/or BPs that eliminate the root causes

Delivering to employees what they know is boring and damaging to the training. Deliver what advances their career.

e. Factor: Participants putting what they learnt into use.

Root causes of failure

Lack of the desired levels of employees buy in into the training.

RIPs, counter measures and/or BPs that eliminate the root causes

Using training skills can fail due to lack of buy in. Improve all factors that affect buy in.

f. Factor: Conduciveness of work climate for skill transfer.

Root causes of failure

Lack of the desired levels of preparation or lack of employees buy in into the training.

RIPs, counter measures and/or BPs that eliminate the root causes

Using training skills can fail due to lack of conducive environment to apply skills learnt. Improve all environmental factors that affect skill transfer to work.

3. Leading Indicator: Delivery Efficiency

a. Factor: Content.

Root causes of failure

Lack of sufficient preparation on content and delivery due to insufficient budget or poor planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on all factors and details to make sure desired training goals are hit.

b. Factor: Training schedule.

Root causes of failure

Lack of sufficient preparation on content and delivery due to insufficient budget or poor planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Stagger training schedule to distribute training expenditures over longer time, and to distribute staff off work for training out.

c. Factor: Environment (venue).

Root causes of failure

Selecting inferior environment not conducive for learning to save expenses.

RIPs, counter measures and/or BPs that eliminate the root causes

Select conducive physical environment for learning.

d. Factor: Presentation style.

Root causes of failure

Lack of sufficient preparation on content and delivery due to insufficient budget or poor planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Presentation style should be one that works for the learners best.

e. Factor: Facilities & material.

Root causes of failure

Lack of sufficient preparation on content and delivery due to insufficient budget or poor planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Use most effective material that help retention. Facility for training may be close to office but employees shouldn't be distracted by work.

4. Leading Indicator: Percent Right People Selected

a. Factor: Young people motivated to do their jobs selected.

Root causes of failure

Lack of attention to this detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Include these details as part of training processes and procedures.

b. Factor: Best if training leads to certification.

Root causes of failure

Absence of certification in the area or in the country.

RIPs, counter measures and/or BPs that eliminate the root causes

Include these details as part of training processes and procedures.

c. **Factor:** People who strive to develop their careers.

Root causes of failure

Lack of attention to this detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Include these details as part of training processes and procedures.

d. **Factor:** Individualized training for each.

Root causes of failure

Lack of prepared career path for each employee.

RIPs, counter measures and/or BPs that eliminate the root causes

Include these details as part of training processes and procedures.

e. **Factor:** People with the right education and experience.

Root causes of failure

Lack of attention to this detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Include these details as part of training processes and procedures.

f. **Factor:** Learning & developing continuously as a learning organization.

Root causes of failure

Lack of such strategic vision of great benefit.

RIPs, counter measures and/or BPs that eliminate the root causes

Include these details as part of training processes and procedures.

5. Leading Indicator: Training Hours per Employee

a. Factor: Commitment of executives.

Root causes of failure

Lack of such considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve these factors to improve impact of training on company performance.

b. Factor: Level of knowledge, skills and abilities (KSA) of Trainees.

Root causes of failure

Lack of such considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve these factors to improve impact of training on company performance.

c. Factor: Needs to improve KSA and Productivity.

Root causes of failure

Lack of such considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve these factors to improve impact of training on company performance.

<u>Company Resource Allocation:</u>

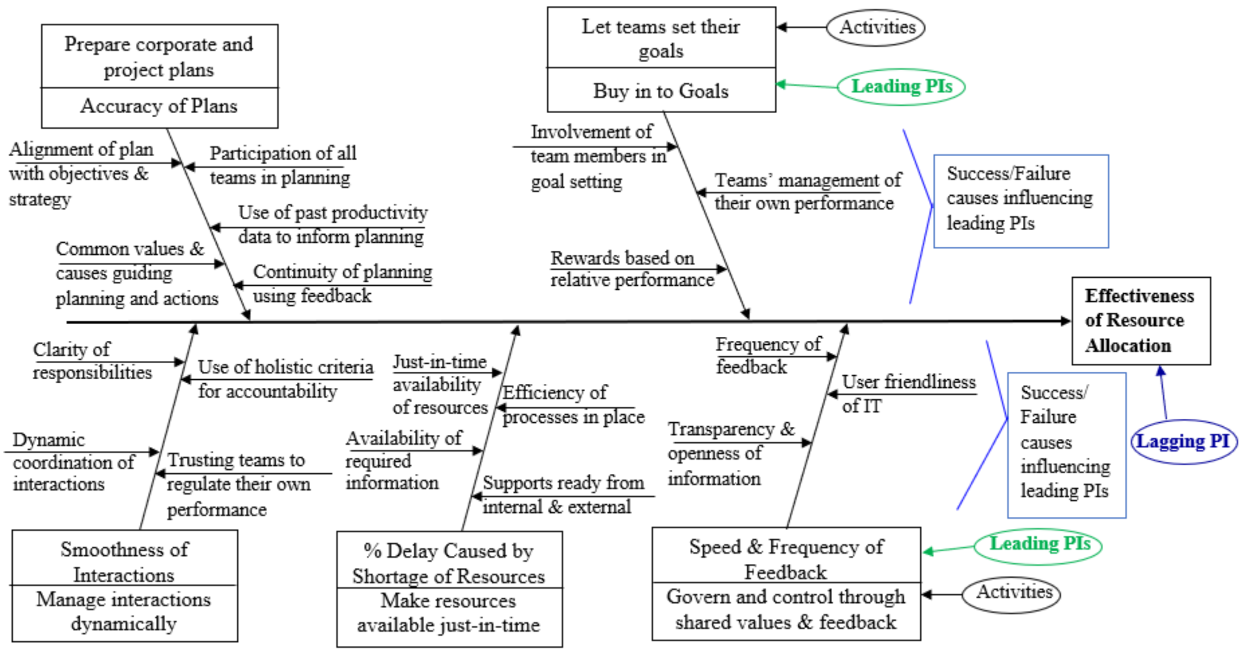


Figure E.15 Fishbone diagram for company resource allocation process

1. **Leading Indicator**: <u>Accuracy of Corporate Plans</u>

a. **Factor**: Alignment of plan with objectives and strategy.

Root causes of failure

Weak link of plan to objectives and strategy.

RIPs, counter measures and/or BPs that eliminate the root causes

As you continuously and collaboratively plan and schedule, make sure to anchor all plans on strategic objectives and critical success factors of the company.

b. **Factor:** Participation of all teams in planning.

Root causes of failure

Top down plans or annual budgets.

RIPs, counter measures and/or BPs that eliminate the root causes

Let each team develop its own ambitious mid-term goals and manage their own performance. Use common cause and values to help people incorporate work as part of their purpose in life.

c. Factor: Use of past productivity data to inform planning.

Root causes of failure

Unrealistic numbers or outdated information used in planning and resource allocation.

RIPs, counter measures and/or BPs that eliminate the root causes

Use past productivity data adjusted for current contextual factors in planning and resource allocation.

d. Factor: Common values and causes guiding planning and actions.

Root causes of failure

Contracts and targets used to guide plans and actions.

RIPs, counter measures and/or BPs that eliminate the root causes

Govern through shared values and common causes.

e. Factor: Continuity of planning using feedback.

Root causes of failure

Static top down plans or annual budgets.

RIPs, counter measures and/or BPs that eliminate the root causes

Use continuous and dynamic planning based on feedback.

2. Leading Indicator: Buy into Goals

a. Factor: Involvement of team members in goal setting.

Root causes of failure

Top down plans or annual budgets.

RIPs, counter measures and/or BPs that eliminate the root causes

Involve each team member in preparing plans and setting goals.

b. Factor: Teams' management of their own performance.

Root causes of failure

Supervisors' management of teams performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Profit sharing schemes motivate teams and employees to put in all effort and creativity for higher productivity. Teams are best if they manage their own performance and peer review.

c. Factor: Rewards based on relative performance.

Root causes of failure

Rewards based on targets, which are based on inaccurate data.

RIPs, counter measures and/or BPs that eliminate the root causes

Use relative performance based on actual current data that can be adjusted from time to time as to stretch teams.

3. Leading Indicator: Smoothness of Interactions

a. Factor: Clarity of responsibilities.

Root causes of failure

Vaguely communicated responsibilities.

RIPs, counter measures and/or BPs that eliminate the root causes

Make responsibilities and expectations crystal clear to every employee and every team.

b. **Factor:** Use of holistic criteria for accountability.

Root causes of failure

Using partial and unstructured criteria that confuses people.

RIPs, counter measures and/or BPs that eliminate the root causes

Use holistic criteria if you want employees to perform holistically.

c. **Factor:** Dynamic coordination of interactions.

Root causes of failure

Expecting static type interactions.

RIPs, counter measures and/or BPs that eliminate the root causes

Use just in time coordination of interactions in real time.

d. **Factor:** Trusting teams to regulate their own performance.

Root causes of failure

Supervisors' management of teams performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Trusting people is the best way to give them autonomy, and often people are trust worthy unless you have reasons not to.

4. **Leading Indicator**: Percent Delay Caused by Resource Shortage

a. **Factor**: Just in time availability of resources.

Root causes of failure

Holding inventory of resources.

RIPs, counter measures and/or BPs that eliminate the root causes

Detailed plan helps make resources available at the time they are needed with minimal inventory.

b. Factor: Efficiency of processes in place.

Root causes of failure

Poor processes.

RIPs, counter measures and/or BPs that eliminate the root causes

Resources include processes used to execute tasks, and improve processes for efficiency continuously.

c. Factor: Availability of required information.

Root causes of failure

Incomplete or deficient information.

RIPs, counter measures and/or BPs that eliminate the root causes

Make all the required information supporting tasks available.

d. Factor: Supports ready from internal and external.

Root causes of failure

Some supports missing from plan.

RIPs, counter measures and/or BPs that eliminate the root causes

Check things repeatedly to make sure everything needed is ready to accomplish tasks without any problem.

5. Leading Indicator: Speed and Frequency of Feedback

a. Factor: Frequency of feedback.

Root causes of failure

Less frequent feedback.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide frequent feedback that helps adjustment of performance.

b. Factor: User friendliness of IT.

Root causes of failure

Not so easy to use IT.

RIPs, counter measures and/or BPs that eliminate the root causes

Use user friendly IT for data collection, analysis and feedback.

c. Factor: Transparency & openness of information.

Root causes of failure

Secrecy of information.

RIPs, counter measures and/or BPs that eliminate the root causes

Make information transparent and open as employees are the owners of the company and processes so they make better decision.

Company checks and balances:

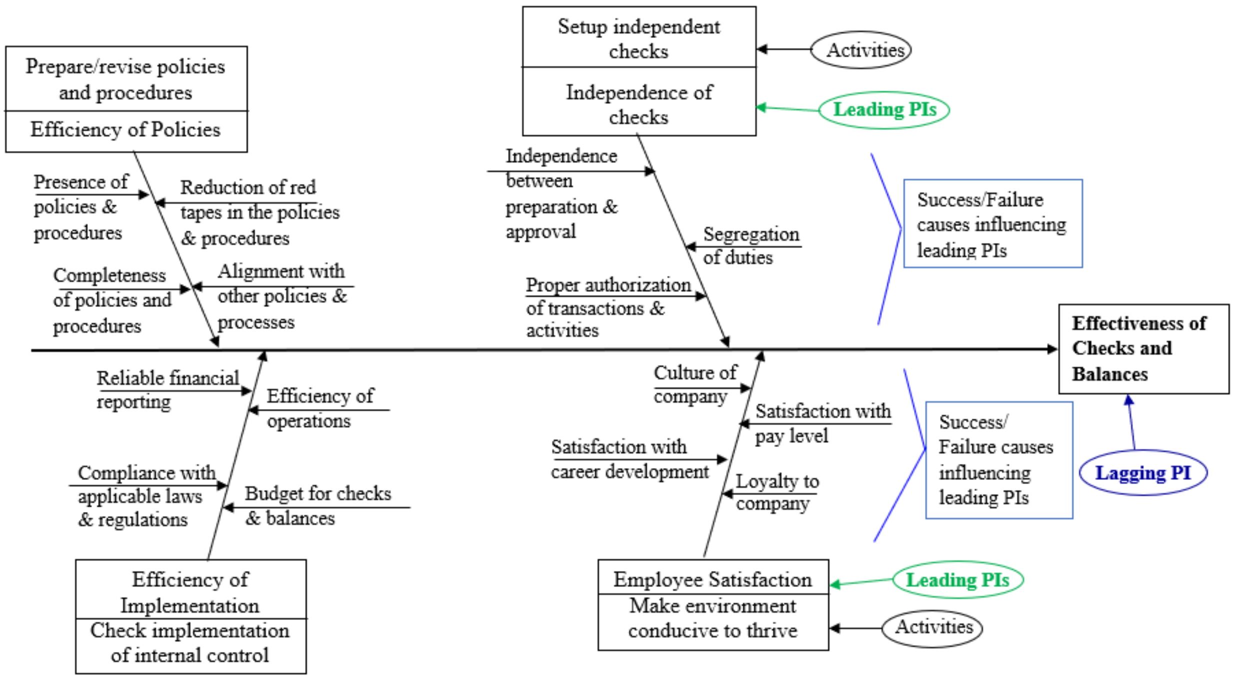


Figure E.16 Fishbone diagram for company checks and balances

1. **Leading Indicator**: Efficiency of Policies

a. Factor: Presence of policies and procedures.

Root causes of failure

Lack of due consideration to avoid inefficiencies.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in place policies and procedures for checks and balances to reduce mistakes professionally, legally and prevent improper behavior in organization.

b. Factor: Reduction of red tapes in the policies and procedures.

Root causes of failure

Lack of due consideration to avoid inefficiencies.

RIPs, counter measures and/or BPs that eliminate the root causes

Checks and balances can cost more money and decrease efficiency but can be critical in helping to identify internal and external theft. Reduce red tapes to reduce the effect on efficiency.

c. **Factor:** Completeness of policies and procedures.

Root causes of failure

Lack of due consideration to avoid holes in policies and procedures.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure there are no holes in the policies and procedures.

d. **Factor**: Alignment with other policies and processes.

Root causes of failure

Lack of alignment between different policies and procedures.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure policies and procedures are reconciled and aligned with all other processes and procedures.

2. **Leading Indicator**: Independence of Checks

a. **Factor**: Independence between preparation and approval.

Root causes of failure

Lack of separation of powers of preparer, checker and approver.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure preparer, checker and approver are under entirely different departments or units.

b. Factor: Segregation of duties.

Root causes of failure

Lack of segregation of duties of preparer, checker and approver.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure duties of preparer, checker and approver are segregated into separate branches.

c. Factor: Proper authorization of transactions and activities.

Root causes of failure

Not following the procedures put in place.

RIPs, counter measures and/or BPs that eliminate the root causes

Not following the procedures put in place.

3. Leading Indicator: Efficiency of Implementation

a. Factor: Reliable financial reporting.

Root causes of failure

Lack of sufficient consideration of factors affecting efficiency of implementation of checks and balances.

RIPs, counter measures and/or BPs that eliminate the root causes

Apply checks and balances to ensure integrity of financial statements.

b. Factor: Efficiency of operations.

Root causes of failure

Lack of sufficient consideration of factors affecting efficiency of implementation of checks and balances.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure implementation of checks and balances does not negatively affect efficiency of company and project processes.

c. **Factor:** Compliance with applicable laws and regulations.

Root causes of failure

Lack of sufficient consideration of factors affecting efficiency of implementation of checks and balances.

RIPs, counter measures and/or BPs that eliminate the root causes

Apply checks and balances to ensure integrity of financial statements and compliance with government regulations.

d. **Factor:** Budget for checks and balances.

Root causes of failure

Lack of sufficient consideration of factors affecting efficiency of implementation of checks and balances.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate healthy budget for checks and balances so it is run optimally.

4. **Leading Indicator**: Employee Satisfaction

a. **Factor**: Culture of company.

Root causes of failure

Not working hard towards establishing a high bar culture.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish a culture where theft and improper behavior is unacceptable.

b. Factor: Satisfaction with pay level.

Root causes of failure

Lack of awareness that unfairly low pays force people to consider illegal way to get what they deserve.

RIPs, counter measures and/or BPs that eliminate the root causes

Pay employees fairly (commensurate with knowledge, skill, experience and effort).

c. Factor: Satisfaction with career development.

Root causes of failure

Lack of awareness that unclear career path makes people not to care about company.

RIPs, counter measures and/or BPs that eliminate the root causes

Have HR and each employee develop a clear career path jointly in which the employee agrees to.

d. Factor: Loyalty to company.

Root causes of failure

Not working hard to winning hearts and minds of employees.

RIPs, counter measures and/or BPs that eliminate the root causes

Work hard to get buy ins, to win hearts and minds.

DEPARTMENTS

<u>Department functions (different departments):</u>

A. Bidding Department

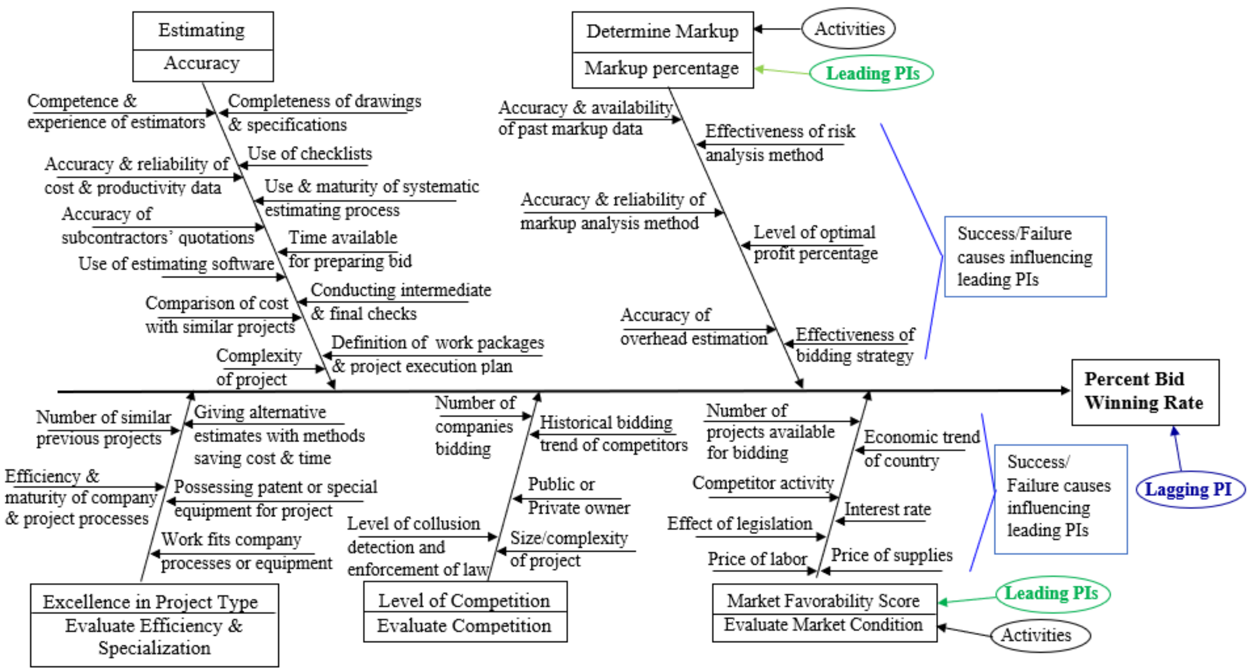


Figure E.17 Fishbone diagram for bidding department

1. **Leading Indicator:** <u>Estimating Accuracy</u>

a. **Factor on fishbone diagram**: Competence and experience of estimators.

Root causes of failure

Inexperienced estimator hired due to budget constraint.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire senior estimator in 3-5 years or get junior estimators trained.

b. **Factor:** Completeness of drawings & specifications**.**

Root causes of failure

Oversight by consultants due to time pressure.

RIPs, counter measures and/or BPs that eliminate the root causes

List items missing from drawings and specifications exhaustively and ask for clarifications from client. Review bid documents, Assign qualified estimators, Define scope of work.

c. Factor on fishbone diagram: Accuracy and reliability of cost and productivity data.

Root causes of failure

Not keeping data of past projects well, not accurately recording data while it was current because people are busy.

RIPs, counter measures and/or BPs that eliminate the root causes

Simplifying data recording procedure using IT so it can be done in short time. Normalize estimating data of data, determination of escalation of future costs.

d. Factor: Use of checklist for estimate completeness and basis.

Root causes of failure

Lack of checklist (not developed).

RIPs, counter measures and/or BPs that eliminate the root causes

Develop and use checklist.

e. Factor: Accuracy of subcontractors' quotations.

Root causes of failure

Time pressure to estimate or lack of capacity.

RIPs, counter measures and/or BPs that eliminate the root causes

Exercise due care in subcontractor selection. Give training support to long-term partners.

f. Factor: Use and maturity of systematic estimating process.

Root causes of failure

Lack of developed estimating process or immaturity of estimating process.

RIPs, counter measures and/or BPs that eliminate the root causes

Use flowchart from literature and other information to develop your own process with procedures, policies and metrics.

g. **Factor:** Time available for preparing estimates.

Root causes of failure

Outside control of contractor, poor project planning by client..

RIPs, counter measures and/or BPs that eliminate the root causes

Assign more resources, make data and other inputs ready and easy to use, use software, develop estimating expertise.

h. **Factor:** Comparison of cost with similar projects.

Root causes of failure

Lack of comparison of cost of project being estimated with similar projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep important summary of past projects handy to use.

i. **Factor:** Use of estimating software.

Root causes of failure

Lack of financial resources or lack of training in using software.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy best software fit for your type of job, train your people.

j. **Factor:** Conducting intermediate and final checks.

Root causes of failure

Time pressure forces people to overlook conducting intermediate & final checks.

RIPs, counter measures and/or BPs that eliminate the root causes

Including checks in standard procedures and policies as a QA task. Conducting thorough review and feedback at the end.

k. Factor: Definition of work packages and project execution plan.

Root causes of failure

Not putting in sufficient effort to go to this detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Use past data on project execution in developing project execution plan and developing realistic estimates.

Use Advanced Work Packaging (AWP). Use constructability and lessons learned in preparing advanced work packages.

l. Factor: Complexity of project.

Root causes of failure

Lack of consideration or understanding of complexity.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise, train your people, buy software.

2. Leading Indicator: <u>Markup percentage</u>

a. Factor: Accuracy & availability of past markup data.

Root causes of failure

Inaccuracy or unavailability of past markup data.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep record and develop the data.

b. **Factor:** Effectiveness of risk analysis method.

Root causes of failure

Lack of formal risk analysis method or some risks omitted in analysis may transpire or lack of capacity to do risk analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise by training. Determine contingency to be applied to different projects.

c. **Factor:** Accuracy & reliability of markup analysis method.

Root causes of failure

Lack of formal analysis of markup(use of intuition and experience).

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise and procedure/method for it.

d. **Factor:** Level of optimal profit percentage.

Root causes of failure

Lack of formal analysis to determine optimal profit and use of only intuition and experience.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop expertise and procedure/method for computation of optimal percentage of profit.

e. **Factor:** Accuracy of overhead estimation.

Root causes of failure

Head office overhead may be accurately estimated but some items may be missed from project overheads.

RIPs, counter measures and/or BPs that eliminate the root causes

Document data for future use.

f. **Factor:** Effectiveness of bidding strategy.

Root causes of failure

Extensive knowledge of historical bids, knowledge of competitors historical markup, and practice is required but any one of these may be missing.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop extensive knowledge of historical bids, knowledge of competitors, and practice with time/experience.

3. Leading Indicator: Excellence in Project Type

a. Factor: Number of previous similar projects constructed by company.

Root causes of failure

Losing in bid competitions may not allow having many similar project experiences.

RIPs, counter measures and/or BPs that eliminate the root causes

Excel in any project you construct.

b. Factor: Giving alternative estimates with methods saving cost and time

Root causes of failure

Time pressure to submit bid may not allow alternative bids.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop module packages and expertise with detailed cost that can be assembeled and used on many projects.

c. Factor: Efficiency & maturity of company and project processes.

Root causes of failure

Lack of maturity of processes, it takes time and resources to develop maturity and efficiency.

RIPs, counter measures and/or BPs that eliminate the root causes

Continuously and relentlessly improve processes. Instill culture of continuous improvement in employees.

d. Factor: Possessing patent or trade secrets or special equipment for project.

Root causes of failure

Lack of inimitable resources that would help sustainable competitive advantage.

RIPs, counter measures and/or BPs that eliminate the root causes

Empower employees to innovate continuously.

e. Factor: Work fits company processes or equipment.

Root causes of failure

Lack of capitalizing on strengths.

RIPs, counter measures and/or BPs that eliminate the root causes

Take only projects in which you are sure to delight the customer.

f. Factor: Use of best estimating practices.

Root causes of failure

Lack of use of best estimating practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Best practices are developed over many years by trial and error, and are tested to produce better results. Using them is wise.

4. **Leading Indicator**: Level of Competition

a. **Factor**: Number of companies bidding.

Root causes of failure

Not bidding in specialized or complex projects. Not differentiating the company from many, doing type of job everybody does. Not getting that number.

RIPs, counter measures and/or BPs that eliminate the root causes

Build competitive edge continuously by improving processes and competence of employees.

b. **Factor:** Historical bidding trend of competitors.

Root causes of failure

Not having data on historical bidding trend of competitors or not doing this trend analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out competitor trend analysis, and other evidences that helps you to make better decisions.

c. **Factor:** Level of collusion detection and severity of penalty for collusion.

Root causes of failure

Not speaking out to policy makers about it.

RIPs, counter measures and/or BPs that eliminate the root causes

Advocate for a level field for competition and commensurate penalty for corruptions through professional associations.

d. **Factor:** Public/Private owner.

Root causes of failure

Not strategizing the bidding differently for public and private work.

RIPs, counter measures and/or BPs that eliminate the root causes

Make this distinction to adjust your bidding strategy. Competitive bidding and social responsibility for public projects and profit maximization in the case of private projects.

e. Factor: Size/complexity of project.

Root causes of failure

Lack of consideration or understanding of size or complexity on bidding.

RIPs, counter measures and/or BPs that eliminate the root causes

Use modularization and dynamic capability building to handle large and complex projects.

5. Leading Indicator: Market Favorability Score

a. Factor: Number of projects available for bidding.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider risks, threats and opportunities in your analysis.

b. Factor: Economic trend of country.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factor.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider the effect of economic trend of the country and its effect on the type of construction you do. Consider risks, threats and opportunities in your analysis.

c. Factor: Competitor activity.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out analysis of competitor activities to better position yourself in the competition.

d. **Factor:** Interest rate.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Get information about trends in interest rate.

e. **Factor:** Effect of legislation.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Get information if there are any changes in regulatory frameworks that may affect your business.

f. **Factor:** Price of supplies.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Estimate price fluctuation of materials on the market.

g. **Factor:** Price of labor.

Root causes of failure

Lack of analysis of opportunities and threats in the market due to these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Price of labor always trends up. Availability of skilled labor in the area of project needs study and data collection.

B. Design department

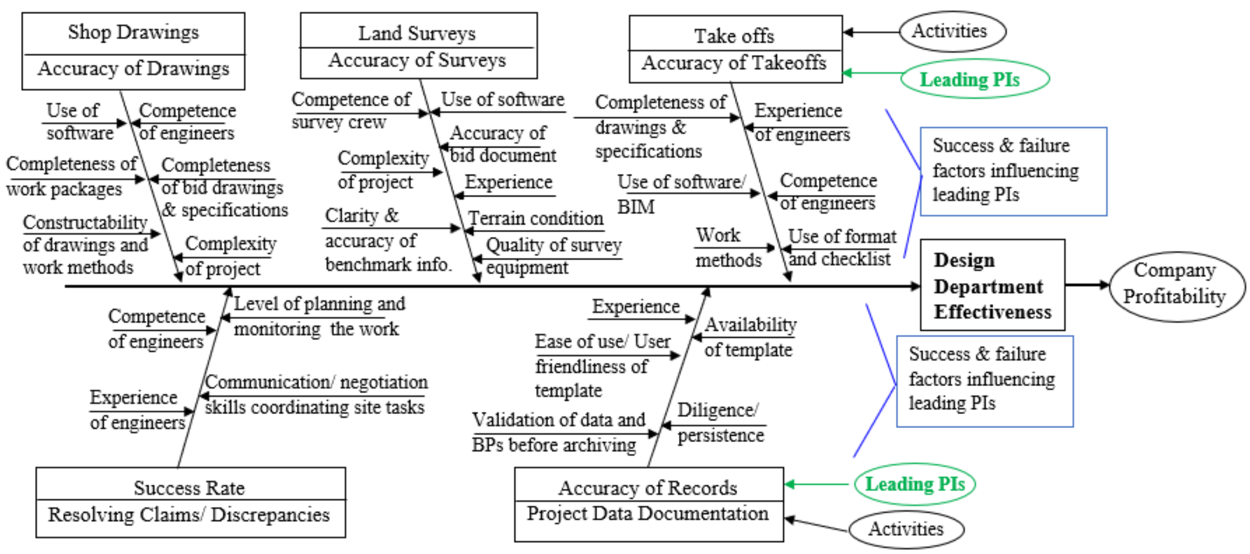


Figure E.18 Fishbone diagram for design department

1. Leading Indicator: Accuracy of Drawings

a. Factor on fishbone diagram: Use of software.

Root causes of failure

Not exploiting the power of available software in company like AutoCAD and BIM. Lack of experienced CAD operators.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software and competent CAD/BIM operators for faster and more accurate drawing production.

b. Factor: Competence of engineers**.**

Root causes of failure

Lack of competence and construction experience of engineers in charge of producing shop drawings.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence of engineers through training, mentoring and coaching.

c. Factor on fishbone diagram: Constructability of shop drawings and selection of most efficient work methods.

Root causes of failure

Lack of focus on these determinants.

RIPs, counter measures and/or BPs that eliminate the root causes

Shop drawings should suit the work method that will be used with the equipment and tools.

d. Factor: Completeness of bid drawings and specifications.

Root causes of failure

Mistakes and missing information carrying over from bid document into the construction phase.

RIPs, counter measures and/or BPs that eliminate the root causes

Check completeness and ask for clarification from client before proceeding to producing working drawings. Make sure scope of work is covered.

e. Factor: Completeness of work packages.

Root causes of failure

Work packages missing some elements.

RIPs, counter measures and/or BPs that eliminate the root causes

Check work packages for completeness and notify design head.

f. Factor: Complexity of project.

Root causes of failure

Not putting in as much effort the complexity requires or lack of competence of engineers or lack of understanding the complexity

RIPs, counter measures and/or BPs that eliminate the root causes

Assign experienced engineers who are detail oriented. Provide sufficient detail with constructability considerations.

2. Leading Indicator: Accuracy of Surveys

a. Factor: Accuracy & availability of past markup data.

Root causes of failure

Lack of focus on competence and experience as drivers of accuracy of surveys.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire one senior and competent surveyor and use him/her to coach junior surveyors.

b. **Factor:** Use of software.

Root causes of failure

Lack of software or lack of staff that knows how to use software.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy cheap software that serve your purpose. Train your staff to use software.

c. **Factor:** Complexity of project.

Root causes of failure

Lack of detailed planning to gather information required for the complexity of the project.

RIPs, counter measures and/or BPs that eliminate the root causes

Plan in detail and list down all the information to collect that are required for the project.

d. **Factor:** Accuracy of bid document.

Root causes of failure

Inaccuracy of bid document overlooked during bidding carrying over to construction.

RIPs, counter measures and/or BPs that eliminate the root causes

Clarify any missing information or inaccuracies with the client and check information needed before conducting surveys.

e. **Factor:** Clarity and accuracy of benchmark info.

Root causes of failure

Lack of clarity and/or accuracy of benchmark info.

RIPs, counter measures and/or BPs that eliminate the root causes

Clarify benchmark info before proceeding to conduct surveys.

f. **Factor:** Experience of surveyors.

Root causes of failure

Lack of focus on experience as driver of accuracy of surveys.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire one senior and experienced surveyor and use him/her to coach junior surveyors.

g. **Factor:** Terrain condition and forest cover.

Root causes of failure

Planning for survey of rough terrain and forested area the same way as other areas or lack of appreciation of a difficult terrain or presence of forest on accuracy of land surveys.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out detailed plan for surveying accounting for the difficult terrain or forest cover.

h. **Factor:** Quality of survey equipment.

Root causes of failure

Using one type of equipment for all types of survey work or lack of equipment of the required accuracy and precision that fits the type of work.

RIPs, counter measures and/or BPs that eliminate the root causes

Select and use the most appropriate type of equipment (in terms of accuaracy, precision and capability) for the type of data required for the work. Use software that the processing of data collected by the equipment requires.

3. Leading Indicator: Accuracy of Takeoffs

a. Factor: Completeness of drawings & specifications.

Root causes of failure

Not checking completeness before conducting takeoffs. Not focusing on these drivers of takeoff accuracy.

RIPs, counter measures and/or BPs that eliminate the root causes

Check completeness and get clarification from client before proceeding to do takeoff.

b. Factor: Experience of engineers.

Root causes of failure

Lack of experience of engineers. Not focusing on this as driver of takeoff accuracy.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire experienced engineer and use him/her to coach junior engineers.

c. Factor: Use of software/ BIM.

Root causes of failure

Lack of using the potential of available IT capability.

RIPs, counter measures and/or BPs that eliminate the root causes

Use capability of software you have to improve accuracy of takeoffs.

d. Factor: Competence of engineers.

Root causes of failure

Lack of competence of engineers.

RIPs, counter measures and/or BPs that eliminate the root causes

Always hire the top engineers because that is more cost effective.

e. Factor: Work methods.

Root causes of failure

Not considering work method during takeoffs.

RIPs, counter measures and/or BPs that eliminate the root causes

Work method should be ready by the time takeoff is done and consider work method that may require adjustment of takeoffs to suit the work method that will be used for the tasks.

f. Factor: Use of takeoff formats, and checklists.

Root causes of failure

Not using takeoff formats. Not using checklists. Or not following the format and checklist well.

RIPs, counter measures and/or BPs that eliminate the root causes

Formats and checklists are prepared from many years of accumulated best practice and should always be followed. Develop formats and checklists using your best minds.

4. Leading Indicator: Success Rate in Resolving Claims

a. Factor: Competence.

Root causes of failure

Insufficient attention paid to these drivers.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence in contract administration and project management through training and certification.

b. Factor: Level of understanding the work.

Root causes of failure

Insufficient attention paid to these drivers.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department need to understand the details of the work and what it entails to do it to be able to resolve discrepancies and claims.

c. Factor: Experience.

Root causes of failure

Insufficient attention paid to these drivers.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department engineers need negotiation skills to resolve claims with clients and subcontractors.

d. Factor: Communication Skills.

Root causes of failure

Insufficient attention paid to these drivers.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department engineers need communication skills to resolve claims with clients and subcontractors.

5. Leading Indicator: Accuracy of Records

a. Factor: Experience.

Root causes of failure

Lack of focus on these drivers of project record accuracy.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop experience of people through coaching.

b. Factor: Availability of template.

Root causes of failure

Lack of focus on these drivers of project record accuracy.

RIPs, counter measures and/or BPs that eliminate the root causes

Use database management software form template to simplify data entry.

c. Factor: Ease of use/user friendliness of template.

Root causes of failure

Lack of focus on these drivers of project record accuracy.

RIPs, counter measures and/or BPs that eliminate the root causes

Make the electronic form as user friendly as possible.

d. Factor: Diligence/ persistence.

Root causes of failure

Lack of focus on these drivers of project record accuracy.

RIPs, counter measures and/or BPs that eliminate the root causes

It requires persistence to get good quality documentation.

e. Factor: Validation of data and BPs before archiving.

Root causes of failure

Lack of such a practice.

RIPs, counter measures and/or BPs that eliminate the root causes

Use design department expertise to validate data, lessons learned and best practices before archiving to improve the quality and accuracy.

C. Equipment department/unit

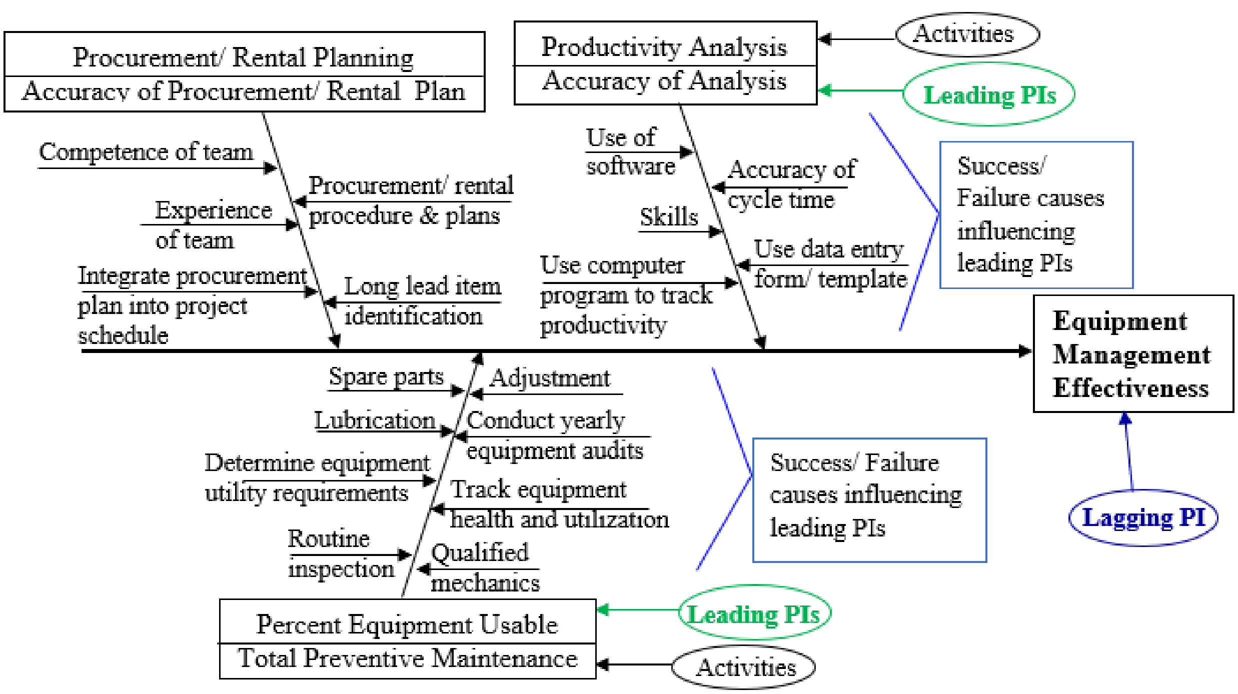


Figure E.19 Fishbone diagram for equipment department

1. **Leading Indicator:** Accuracy of Procurement/ Rental Plan

a. Factor on fishbone diagram: Competence of team.

Root causes of failure

Lack of competence of team in the types of equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence through training and coaching.

b. **Factor:** Procurement/ rental procedure.

Root causes of failure

Absence of established procedure.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop procedure to ensure efficiency, and for checks and balances.

c. **Factor on fishbone diagram:** Experience of team.

Root causes of failure

Lack of experience due to high turnover.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop team experience through retention, training and coaching.

d. **Factor**: Long lead item identification.

Root causes of failure

Sometimes lack of identification of long lead items.

RIPs, counter measures and/or BPs that eliminate the root causes

List equipment to be procured or rented ahead of time, especially long lead items.

2. **Leading Indicator:** Accuracy of Equipment Productivity Analysis

a. **Factor:** Accuracy of cycle time determination.

Root causes of failure

Lack of accurate cycle time computation.

RIPs, counter measures and/or BPs that eliminate the root causes

Determine cycle time accurately as it forms the basis for productivity computation.

b. **Factor:** Use of software

Root causes of failure

Using inefficient or not user friendly software.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software to simplify computations and produce results/reports.

c. **Factor:** Skills.

Root causes of failure

Lack of skill.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop skill of people in charge through training and coaching.

d. **Factor:** Data entry form/ template.

Root causes of failure

Not user friendly data entry form.

RIPs, counter measures and/or BPs that eliminate the root causes

User friendly data entry makes entry fast and accurate.

e. **Factor:** Use computer program to track productivity.

Root causes of failure

Unavailability of productivity tracking computer program or program not user friendly.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop easy to use computer program or spreadsheet to track equipment productivity.

3. **Leading Indicator:** Percent Equipment Usable

a. **Factor**: Spare Parts.

Root causes of failure

Unavailability of some parts on market.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep data on availability of spare parts for each type of equipment in their data file.

b. Factor: Adjustment

Root causes of failure

Not checking/making adjustments regularly.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure each equipment adjustment is checked at regular intervals.

c. **Factor**: Lubrication.

Root causes of failure

Not lubricating sufficiently.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure all equipment are lubricated well and do not be sparing on lubrication supplies.

d. **Factor**: Conduct yearly equipment audits.

Root causes of failure

Lack of yearly audits or not done well.

RIPs, counter measures and/or BPs that eliminate the root causes

Do yearly audits of equipment and determine which ones need maintenance, which replacement.

e. **Factor**: Determine equipment electric and other utility requirements.

Root causes of failure

Not observing/meeting utility requirements well.

RIPs, counter measures and/or BPs that eliminate the root causes

Have equipment specifications handy and follow the specifications while using the equipment.

f. **Factor**: Track equipment health and utilization.

Root causes of failure

Not having equipment tracking system.

RIPs, counter measures and/or BPs that eliminate the root causes

It would be best to have some form of computer tracking system for equipment health and utilization.

g. **Factor**: Routine inspection.

Root causes of failure

Not keeping routine inspection times for equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep routine inspections to keep equipment in optimal operating condition.

h. **Factor**: Qualified mechanics.

Root causes of failure

Incompetence of mechanics..

RIPs, counter measures and/or BPs that eliminate the root causes

Hire one top mechanic in the market and develop junior mechanics through training and coaching.

D. Finance Department

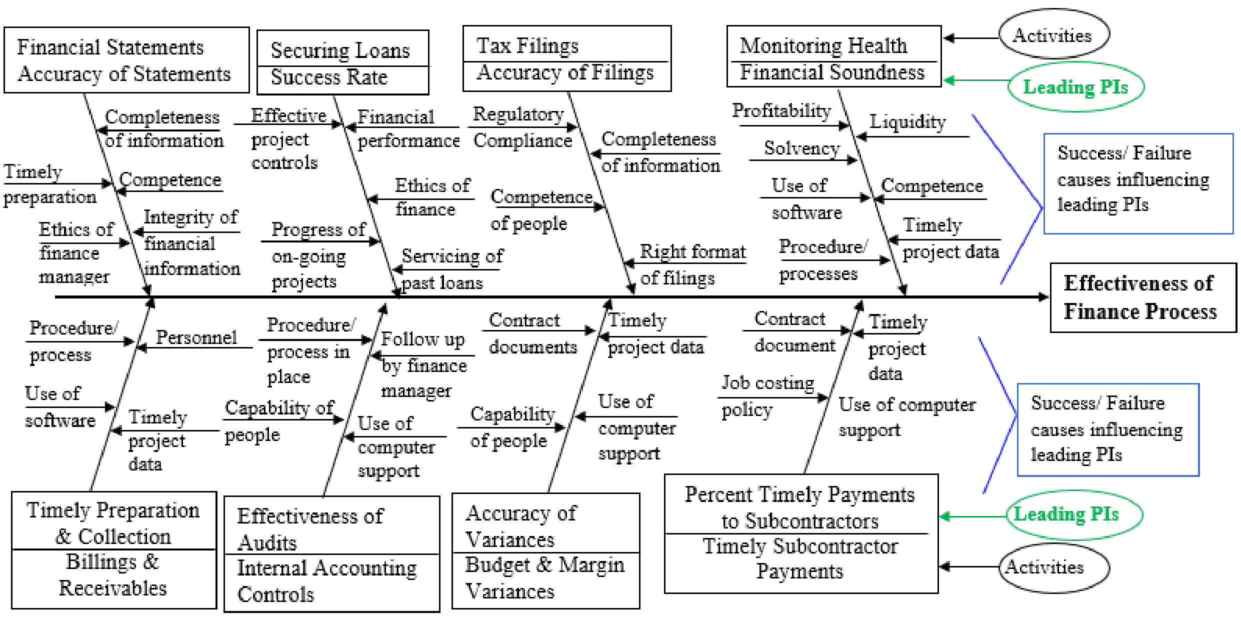


Figure E.20 Fishbone diagram for finance department

1. Leading Indicator: Accuracy of Statements

a. Factor: Timely preparation of statements.

Root causes of failure

Not including all costs and incomes fully at their correct periods.

RIPs, counter measures and/or BPs that eliminate the root causes

Track and record financial information in a timely manner.

b. **Factor:** Completeness of information.

Root causes of failure

Lack of completeness of information.

RIPs, counter measures and/or BPs that eliminate the root causes

Use checklist of tasks on schedules to check missing financial information reported from projects.

c. **Factor:** Competence of finance people.

Root causes of failure

Incompetence of finance staff.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence through training and coaching.

d. **Factor:** Ethics of finance manager.

Root causes of failure

Ethics infractions are often observed in construction companies.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop procedures to follow and code of ethics that will be enforced. Use checks and balances to make sure corruption does not creep in.

e. **Factor:** Use of software.

Root causes of failure

Staff may not be that conversant with software.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy an accounting software that fits the company.

f. **Factor:** Integrity of financial information.

Root causes of failure

Internal auditing not that thorough.

RIPs, counter measures and/or BPs that eliminate the root causes

Ensure integrity of financial information through internal auditing.

2. **Leading Indicator**: Success Rate in Securing Loans

a. **Factor**: Effective project controls in place.

Root causes of failure

Not doing well in project controls shows lenders poor management.

RIPs, counter measures and/or BPs that eliminate the root causes

Do well in these determinants of success in securing loans.

b. **Factor:** Financial performance.

Root causes of failure

Challenges and problems company and projects face.

RIPs, counter measures and/or BPs that eliminate the root causes

Do well in the tasks of finance department making current financial information available for better decision making.

c. **Factor:** Ethics of finance manager.

Root causes of failure

Not doing checks and balances well.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in place effective checks and balances procedure in place.

d. Factor: Progress of on-going projects.

Root causes of failure

Not doing well in these factors.

RIPs, counter measures and/or BPs that eliminate the root causes

Do well in the tasks of finance department making current financial information available for better decision making.

e. Factor: Servicing of past loans.

Root causes of failure

Not doing well in servicing past loans.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare different scenarios of loan servicing with the effect it will have company liquidity and solvency for better top management decision making.

3. Leading Indicator: Accuracy of Tax Filings

a. Factor: Regulatory Compliance.

Root causes of failure

Inefficiency that causes unnecessarily lengthy work to comply with regulations.

RIPs, counter measures and/or BPs that eliminate the root causes

Accurate tax filing is a constraint under which company should operate to avoid being sued by government.

b. Factor: Completeness of information.

Root causes of failure

Incompleteness or inconsistency of information can invite legal problem.

RIPs, counter measures and/or BPs that eliminate the root causes

Complete and consistent information in tax filing is important to avoid troubles.

c. Factor: Competence of people.

Root causes of failure

Lack of competent accounting staff due to high turnover.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire senior accountants in each area and use them to coach junior accountants.

d. Factor: Right format of filings.

Root causes of failure

Not following format well or not understanding the format.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow the format exactly as required.

4. Leading Indicator: Monitoring of Financial Health

a. Factor: Profitability.

Root causes of failure

Lack of profit information to be used as feedback to improve performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare data on this financial information contemporaneously to know financial soundness of company.

b. **Factor:** Liquidity.

Root causes of failure

Lack of liquidity information constraining cash flow planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Make current liquidity data available for better decision making.

c. **Factor:** Solvency.

Root causes of failure

Lack of solvency information constraining cash flow and purchases planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Make current solvency data for better decision making.

d. **Factor:** Timely project data.

Root causes of failure

Delays in reporting of project cost data.

RIPs, counter measures and/or BPs that eliminate the root causes

Agree and establish with projects time window through which they send project cost data.

e. **Factor:** Procedure/ processes.

Root causes of failure

Not establishing finance processes/procedures or not following processes and procedures well.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow processes/procedures strictly because they are the best ways to do tasks determined from many years of experience by trial and error to distinguish what works from those which do not work.

f. Factor: Use of software.

Root causes of failure

Lack of software or staff not conversant at using software.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software to process information and to produce reports because this makes the work easier, faster and more accurate.

g. Factor: Competence.

Root causes of failure

Lack of competence of finance people or juniors hired due to budget constraint.

RIPs, counter measures and/or BPs that eliminate the root causes

Hire one senior accountant and use him/her to coach junior employees.

5. Leading Indicator: Timely Preparation and Collection of Billings

a. Factor: Procedure/ process.

Root causes of failure

Inefficient procedures may delay readiness of information in a timely manner.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure to prepare and collect receivables in a timely manner.

b. Factor: Personnel.

Root causes of failure

Incompetence of personnel may affect timely preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Use training and coaching to improve competence of finance employees. Make sure to prepare and collect receivables in a timely manner.

c. Factor: Use of software.

Root causes of failure

Incompetence in the use of software can delay preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Buy cheap software that serves company finance purpose or develop it in house.

d. Factor: Timely project data.

Root causes of failure

Delay in receipt of project data may delay timely preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish time windows with projects during which they send their cost data for inclusion in monthly statements.

6. Leading Indicator: Effectiveness of Internal Audits

a. Factor: Procedure/ process in place.

Root causes of failure

Inefficiency of process/ procedure.

RIPs, counter measures and/or BPs that eliminate the root causes

Put process/ procedure in place for internal audit/control for checks and balances.

b. Factor:. Follow ups by finance manager

Root causes of failure

Not paying attention to follow ups.

RIPs, counter measures and/or BPs that eliminate the root causes

Use of checklists and good management practices by finance manager.

c. Factor: Capability of people.

Root causes of failure

Not developing capability of people.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop competence of people through training and coaching.

d. Factor: Use of computer support.

Root causes of failure

Not making use of IT potential.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software for efficiency of effort.

7. Leading Indicator: Accuracy of Variances

a. Factor: Contract documents.

Root causes of failure

Not following requirements of contract documents.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow contract documents strictly.

b. Factor:. Capability of people

Root causes of failure

Incompetence of finance people.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve competence through training and coaching.

c. Factor: Use of computer support.

Root causes of failure

Not using software well.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software for accuracy of calculations.

d. Factor: Timely project data.

Root causes of failure

Delay in receipt of project data may delay timely preparation and collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish time windows with projects during which they send their cost data for inclusion in monthly statements.

8. Leading Indicator: Percent Timely Payment to Subcontractors

a. Factor: Contract documents.

Root causes of failure

Not following requirements of contract documents.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow contract documents strictly.

b. Factor:. Timely project data

Root causes of failure

Delaying subcontractor payment due to delay of executed subcontract work from project site..

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure to pay subcontractors in a timely manner.

c. **Factor:** Job costing policy.

Root causes of failure

Putting in place not so intuitive and easy to use costing procedure in place.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop efficient and easy to execute job cost tracking procedures supported by software.

d. **Factor:** Computer support.

Root causes of failure

Not using software well or absence of software.

RIPs, counter measures and/or BPs that eliminate the root causes

Use software for fast and efficient effort.

E. Human Resources

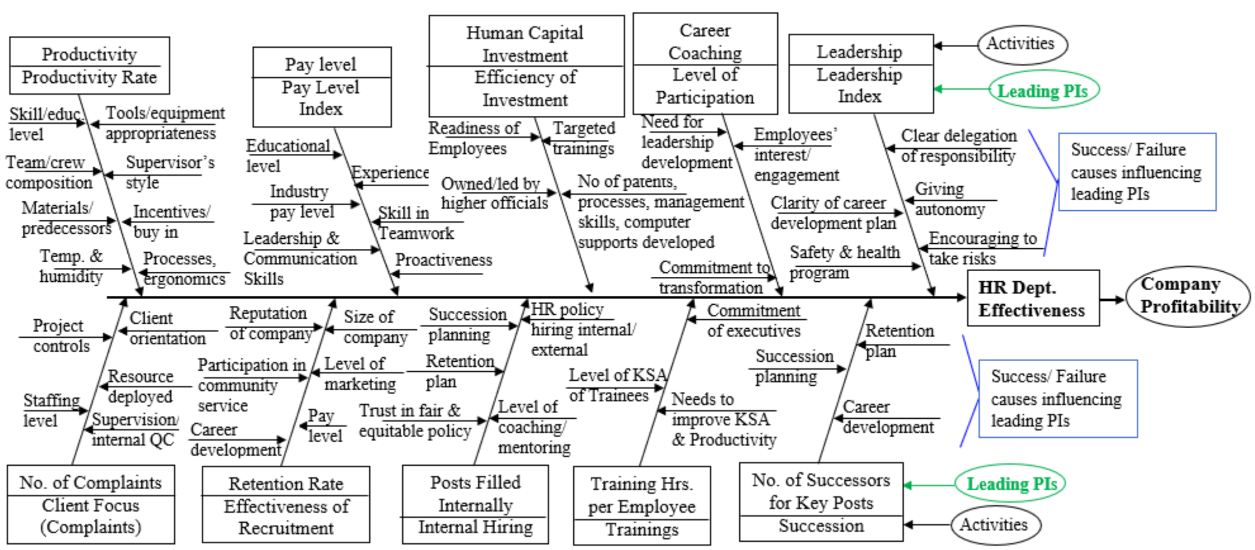


Figure E.21 Fishbone diagram for human resources department

1. Leading Indicator: Productivity Rate

a. Factor: Skill/educational Level.

Root causes of failure

Lack of skilled workers on the market. Lack of training materials, capable trainers and strategies.

RIPs, counter measures and/or BPs that eliminate the root causes

Give training and coach, after hour trainings, etc. Continuously hire and continuously train, mentor and coach.

b. Factor: Tools/equipment appropriateness.

Root causes of failure

Using inappropriate or defective equipment/tools.

RIPs, counter measures and/or BPs that eliminate the root causes

Use most suited equipment/tools for job and keep items in optimal working conditions, apply 5S.

c. Factor: Team/crew composition.

Root causes of failure

Not paying attention to importance of this while forming teams.

RIPs, counter measures and/or BPs that eliminate the root causes

Put members with complementary skills and strengths together. Ask and record employee strengths and weaknesses at job interview and keep the information in their file.

d. Factor: Supervisor's style.

Root causes of failure

Not paying attention to importance of this factor.

RIPs, counter measures and/or BPs that eliminate the root causes

Coach all supervisors to be fair, accommodating and supportive of workers. Put a requirement that being bossy or harsh is not acceptable.

e. **Factor:** Materials/ predecessor activities.

Root causes of failure

Lack of detailed planning and consideration of materials and predecessor activities.

RIPs, counter measures and/or BPs that eliminate the root causes

Plan well to make sure all necessary materials and predecessor activities are completed before a task begin.

f. **Factor:** Incentives/ employee buy in.

Root causes of failure

Lack of optimal incentives and employee buy in.

RIPs, counter measures and/or BPs that eliminate the root causes

Tailor incentives and buy in strategies to cultural and educational level/conciousness level of society. Speak the language people understand. Ask "Where do you want to be in 5 years, 10 years?" Help them achieve these goals and help them help you achieve your organizational goals.

g. **Factor:** Temperature and humidity (environment).

Root causes of failure

Lack of consideration of environmental effect on productivity or not being thorough in the consideration.

RIPs, counter measures and/or BPs that eliminate the root causes

Include environmental factors in estimating productivity as realistically as possible.

h. Factor: Processes, ergonomics.

Root causes of failure

Lack of awareness about effect of process efficiency on productivity. Ergonomics also is not considered well in estimating profitability.

RIPs, counter measures and/or BPs that eliminate the root causes

Use end to end processes and prepare and display process flow diagrams to drastically improve productivity. Work on ergonomics also.

2. Leading Indicator: Pay Level Index

a. Factor: Educational level.

Root causes of failure

Not considering these determinants of pay level.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees develop themselves through training, mentoring and coaching.

b. Factor: Experience.

Root causes of failure

Not considering these determinants of pay level.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees develop themselves through training, mentoring and coaching.

c. Factor: Industry pay level.

Root causes of failure

Not considering these determinants of pay level.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure to pay more than the industry pays to attract top talent.

d. Factor: Skill in Teamwork.

Root causes of failure

Not considering these determinants of pay level.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees develop themselves through training, mentoring and coaching.

e. Factor: Leadership and Communication Skills.

Root causes of failure

Not considering these determinants of pay level.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees develop themselves through training, mentoring and coaching.

f. Factor: Proactiveness.

Root causes of failure

Not considering these determinants of pay level.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees develop themselves through training, mentoring and coaching.

3. Leading Indicator: Efficiency of Investment in HR

a. Factor: Readiness of Employees.

Root causes of failure

Lack of consideration of determinants of efficiency of investment in human capital.

RIPs, counter measures and/or BPs that eliminate the root causes

Continuously assess these factors and get feedback for improvement of outcomes of investment in people.

b. **Factor:** Targeted trainings.

Root causes of failure

Lack of consideration of determinants of efficiency of investment in human capital.

RIPs, counter measures and/or BPs that eliminate the root causes

Continuously assess these factors and get feedback for improvement of outcomes of investment in people.

c. **Factor:** Owned/led by higher officials.

Root causes of failure

Lack of consideration of determinants of efficiency of investment in human capital.

RIPs, counter measures and/or BPs that eliminate the root causes

Continuously assess these factors and get feedback for improvement of outcomes of investment in people.

d. **Factor:** No of patents, processes, management skills, computer supports developed.

Root causes of failure

Lack of consideration of determinants of efficiency of investment in human capital.

RIPs, counter measures and/or BPs that eliminate the root causes

Continuously assess these factors and get feedback for improvement of outcomes of investment in people.

4. **Leading Indicator**: Participation in Coaching

a. Factor: Need for Leadership Development.

Root causes of failure

Coaching not exploited well.

RIPs, counter measures and/or BPs that eliminate the root causes

Use coaching in employee development, and especially in leadership development.

b. Factor: Employees' interest/ engagement.

Root causes of failure

Coaching not exploited well.

RIPs, counter measures and/or BPs that eliminate the root causes

Inspire employees to engage in and participate in coaching.

c. Factor: Commitment to Transformation.

Root causes of failure

Coaching not exploited well.

RIPs, counter measures and/or BPs that eliminate the root causes

Inspire employees to commit to transformation.

5. **Leading Indicator**: Leadership Index

a. Factor: Clear delegation of responsibility.

Root causes of failure

Lack of awareness about these factors as determinants of leadership effectiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Leadership is the art of getting things done through people efficiently and effectively through the implementation of these best practices.

b. Factor: Giving autonomy.

Root causes of failure

Lack of awareness about these factors as determinants of leadership effectiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Leadership is art of getting things done through people efficiently and effectively through the implementation of these best practices.

c. Factor: Clarity of career development plan.

Root causes of failure

Lack of awareness about these factors as determinants of leadership effectiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Leadership is the art of getting things done through people efficiently and effectively through the implementation of these best practices.

d. Factor: Encouraging to take risks.

Root causes of failure

Lack of awareness about these factors as determinants of leadership effectiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Leadership is all about getting things done through people efficiently and effectively through the implementation of these best practices.

e. Factor: Safety & health program.

Root causes of failure

Not working out safety and health program out well.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare safety policy and implementation procedure with input from all supervisors to be distributed to all employees.

6. Leading Indicator: No of Client Complaints

a. Factor: Project controls.

Root causes of failure

Lack of focus on these factors helping to attain client satisfaction.

RIPs, counter measures and/or BPs that eliminate the root causes

Control all projects against plans to ensure plan is achieved.

b. Factor:. Client orientation

Root causes of failure

Lack of focus on these factors helping to attain client satisfaction.

RIPs, counter measures and/or BPs that eliminate the root causes

Client satisfaction should be the goal of HRM and every employee.

c. Factor: Resource deployed.

Root causes of failure

Lack of focus on these factors helping to attain client satisfaction.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate the appropriate type and amount of resources to serve to client satisfaction.

d. Factor: Staffing level.

Root causes of failure

Lack of focus on these factors helping to attain client satisfaction.

RIPs, counter measures and/or BPs that eliminate the root causes

Staff to appropriate level to ensure client satisfaction.

e. Factor: Supervision/ internal QC.

Root causes of failure

Lack of focus on these factors helping to attain client satisfaction.

RIPs, counter measures and/or BPs that eliminate the root causes

Client satisfaction should be the goal of HRM and every employee.

7. Leading Indicator: Employee Retention Rate

a. Factor: Reputation of company.

Root causes of failure

Lack of consideration of these factors affecting retention in recruitment and management.

RIPs, counter measures and/or BPs that eliminate the root causes

Always try to build a positive image with all stakeholders.

b. Factor: Size of company

Root causes of failure

Lack of consideration of these factors affecting retention in recruitment and management.

RIPs, counter measures and/or BPs that eliminate the root causes

Size is not something you can change overnight but plan for growth systematically and scientifically.

c. Factor: Company's participation in community service.

Root causes of failure

Lack of consideration of these factors affecting retention in recruitment and management.

RIPs, counter measures and/or BPs that eliminate the root causes

Use every opportunity to participate in community service.

d. Factor: Level of marketing.

Root causes of failure

Lack of consideration of these factors affecting retention in recruitment and management.

RIPs, counter measures and/or BPs that eliminate the root causes

Aggressively market the company products and services within available budget.

e. Factor: Career development.

Root causes of failure

Lack of consideration of these factors affecting retention in recruitment and management.

RIPs, counter measures and/or BPs that eliminate the root causes

Help employees develop their career to help company achieve its goals (win-win symbiotic relation).

f. Factor: Pay level.

Root causes of failure

Lack of consideration of these factors affecting retention in recruitment and management.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure to pay more than the industry pays to retain top talent.

8. Leading Indicator: Internally Filling Posts

a. Factor: Succession planning.

Root causes of failure

Lack of exploiting these factors to hire internally.

RIPs, counter measures and/or BPs that eliminate the root causes

Apply experiential assignments, mentoring, training, and personnel development to prepare people for high level assignments. Use systematic processes to identify employees for senior management positions.

b. Factor: HR policy internal/external hiring

Root causes of failure

Lack of exploiting these factors to hire internally

RIPs, counter measures and/or BPs that eliminate the root causes

Hire internally by developing your employees as much as possible and hire externally if only necessary.

c. Factor: Retention plan.

Root causes of failure

Lack of exploiting these factors to hire internally.

RIPs, counter measures and/or BPs that eliminate the root causes

Retention plan should be part of HRM.

d. Factor: Level of coaching/ mentoring.

Root causes of failure

Lack of exploiting these factors to hire internally.

RIPs, counter measures and/or BPs that eliminate the root causes

Focus on mentoring and coaching to improve internal hiring and employee development.

e. Factor: Trust in fair & equitable policy.

Root causes of failure

Lack of exploiting these factors to hire internally.

RIPs, counter measures and/or BPs that eliminate the root causes

Build trust of employees in fair treatment and policy.

9. Leading Indicator: Training Hours per Employee

a. Factor: Commitment of executives.

Root causes of failure

Lack of such considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve these factors to improve impact of training on company performance.

b. Factor: Level of knowledge, skills and abilities (KSA) of Trainees

Root causes of failure

Lack of such considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve these factors to improve impact of training on company performance.

c. Factor: Needs to improve KSA and Productivity.

Root causes of failure

Lack of such considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve these factors to improve impact of training on company performance.

10. Leading Indicator: No of Successors for Key Posts

a. Factor: Succession planning.

Root causes of failure

Lack of awareness about preparing successors or factors affecting it.

RIPs, counter measures and/or BPs that eliminate the root causes

These factors affecting number of successors for key positions determines success of leadership.

b. Factor: Retention plan

Root causes of failure

Lack of awareness about preparing successors or factors affecting it.

RIPs, counter measures and/or BPs that eliminate the root causes

These factors affecting number of successors for key positions determines success of leadership.

c. Factor: Career development.

Root causes of failure

Lack of awareness about preparing successors or factors affecting it.

RIPs, counter measures and/or BPs that eliminate the root causes

These factors affecting number of successors for key positions determines success of leadership.

F. Marketing Department/Unit

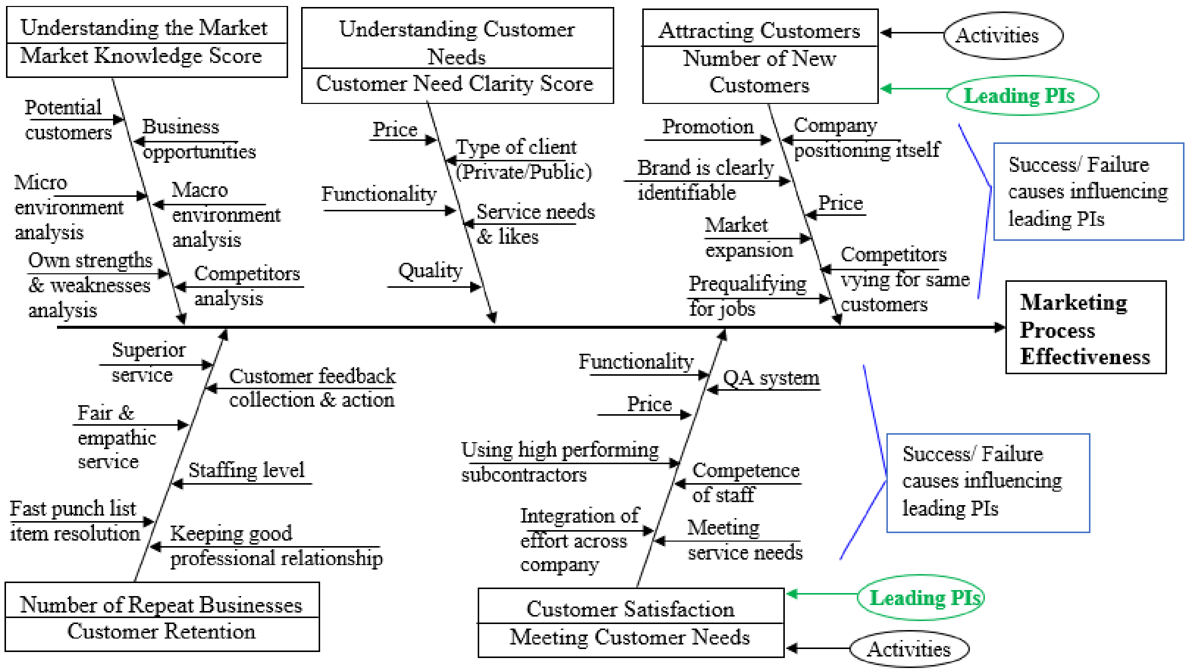


Figure E.22 Fishbone diagram for marketing department/unit

1. Leading Indicator: Market Knowledge Score

a. Factor: Potential customers.

Root causes of failure

Not identifying all potential customers or not addressing them well.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify and carry out analysis and prioritization of profitable customers to target for marketing.

b. Factor: Business opportunities.

Root causes of failure

Lack of proper analysis to identify and rank profitable opportunities.

RIPs, counter measures and/or BPs that eliminate the root causes

Actively look for exploitable opportunities continuously.

c. **Factor:** Micro environment analysis.

Root causes of failure

Not carrying out meaningfully useful and detailed micro analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out effect of company micro environment factors (customers, suppliers, competitors, employees, shareholders and media) on your business.

d. **Factor**: Macro environment analysis.

Root causes of failure

Not carrying out meaningfully useful and detailed macro analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out effect of company macro environment factors (political, economic, social, technological, and legal/regulatory factors) on your business.

e. **Factor:** Own strengths & weaknesses analysis.

Root causes of failure

Having blind spots about own strengths & weaknesses or not carrying out analysis well.

RIPs, counter measures and/or BPs that eliminate the root causes

Know your strengths and weaknesses so you maximize your strengths and minimize your weaknesses.

f. **Factor:** Competitors analysis.

Root causes of failure

Not conducting competitor analysis well.

RIPs, counter measures and/or BPs that eliminate the root causes

To win, analyze competitor strengths, weaknesses, bidding strategies and bidding trends and make informed decisions.

2. Leading Indicator: Customer Need Clarity Score

a. Factor: Price.

Root causes of failure

Not being the lowest bidder.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve processes and skills to improve productivity that enables being the lowest bidder.

b. Factor: Type of client (Private/Public).

Root causes of failure

Lack of tailoring bidding to the type of client.

RIPs, counter measures and/or BPs that eliminate the root causes

Adjust bidding strategy to the type of contract (competitive or negotiated) in order to win.

c. Factor: Functionality.

Root causes of failure

Lack of expertise in functionally efficient design.

RIPs, counter measures and/or BPs that eliminate the root causes

The contribution of contractor to functionality is limited in design-bid-construct type contracts but in design-build functionally efficient facility can be designed for the business of the client.

d. Factor: Service needs and likes.

Root causes of failure

Lack of focus on service needs and likes.

RIPs, counter measures and/or BPs that eliminate the root causes

You need to know the service needs and likes of your client to meet those needs.

e. Factor: Quality.

Root causes of failure

Lack of sufficient focus on quality.

RIPs, counter measures and/or BPs that eliminate the root causes

Ensure quality work through improvement of processes, skills and client expectation management.

3. Leading Indicator: Number of New Customers

a. Factor: Promotion

Root causes of failure

Not doing promotion well. Construction companies are weak on this.

RIPs, counter measures and/or BPs that eliminate the root causes

Promote your services so clients know you exist and know what you do. Try to get recommendations from your previous customers because new customers believe these testimonies than promotions.

b. Factor: Company positioning itself.

Root causes of failure

Lack of this strategy.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify client needs and demonstrate that you meet those needs to position yourself at the top in clients' minds.

c. Factor: Brand is clearly identifiable.

Root causes of failure

Lack of awareness about importance and use of brand.

RIPs, counter measures and/or BPs that eliminate the root causes

Your brand is your identity and work towards establishing it in the mind of your potential market and defending it vigorously.

d. Factor: Market expansion.

Root causes of failure

Lack of such growth strategies.

RIPs, counter measures and/or BPs that eliminate the root causes

Market expansion is one way to grow your company and your revenue.

e. Factor: Price.

Root causes of failure

Lack of focus on this important strategy that helps win more job.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve processes and skills to improve productivity that enables being the lowest bidder.

f. Factor: Prequalifying for jobs.

Root causes of failure

Not giving this much focus.

RIPs, counter measures and/or BPs that eliminate the root causes

Prequalifying for jobs is a good way to demonstrate to clients that you have the necessary capacity to do jobs.

g. Factor: Competitor vying for same customers.

Root causes of failure

Not putting effort into exceling amongst competitors.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider that you are competing with many companies who could win and snatch your job. Know strengths and weaknesses of your competitors.

4. Leading Indicator: Number of Repeat Business

a. Factor: Superior service.

Root causes of failure

Lack of practicing of these good practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Applying these good practices helps to have repeat business.

b. Factor: Customer feedback collection & acting on feedback.

Root causes of failure

Lack of practice of these good practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Applying these good practices helps to have repeat business.

c. Factor: Fair & empathic service.

Root causes of failure

Lack of practicing of such good business practices.

RIPs, counter measures and/or BPs that eliminate the root causes

Applying these good business practices helps to have repeat business.

d. **Factor:** Staffing level.

Root causes of failure

Understaffing to serve customers to reduce costs.

RIPs, counter measures and/or BPs that eliminate the root causes

Staff to appropriate levels for best customer services.

e. **Factor:** Fast punch list item resolution.

Root causes of failure

Dragging and delaying punch list items correction.

RIPs, counter measures and/or BPs that eliminate the root causes

Good practice is to check quality and resolve items when the tasks are accomplished because you have all the resources to do it.

f. **Factor:** Keeping good professional relationship.

Root causes of failure

All company staff interacting with external stakeholders need professional public relations training.

RIPs, counter measures and/or BPs that eliminate the root causes

Always be an expert helping and guiding clients and subcontractors with your expertise. Always stay positive and helpful to stakeholders.

5. **Leading Indicator**: Customer Satisfaction

a. **Factor**: Functionality.

Root causes of failure

Lack of focus on producing facility that improves functions of the business of the client.

RIPs, counter measures and/or BPs that eliminate the root causes

Always keep the interest of the client and add value to facility that would enable client do its businesses well.

b. **Factor:** QA system.

Root causes of failure

Not strictly following QA system.

RIPs, counter measures and/or BPs that eliminate the root causes

Implement the QA processes and procedures put in place to ensure customer satisfaction.

c. **Factor:** Price.

Root causes of failure

Providing least price facility of high quality is what the client wants.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve your processes to increase productivity. This helps company to be the lowest bidder.

d. **Factor:** Using high performing subcontractors.

Root causes of failure

Not following subcontractor prequalification guidelines well.

RIPs, counter measures and/or BPs that eliminate the root causes

Subcontractors perform a significant portion of the work. Pay special attention in selection and supervision of subcontractors.

e. **Factor:** Competence of staff.

Root causes of failure

Not investing time and money on sharpening competence of staff.

RIPs, counter measures and/or BPs that eliminate the root causes

Employees are the heart and soul of organizations whose competence need to be developed to help company succeed.

f. **Factor:** Integration of effort across company.

Root causes of failure

Not coordinating efforts across company and projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Putting in concerted effort is synergistic in getting customers satisfied.

g. **Factor:** Meeting service needs.

Root causes of failure

Lack of focus on what the customer asks for.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide exactly what the customer needs and asks for, not what you think is best for the client. Anything extra is not appreciated by the client.

g. Procurement department

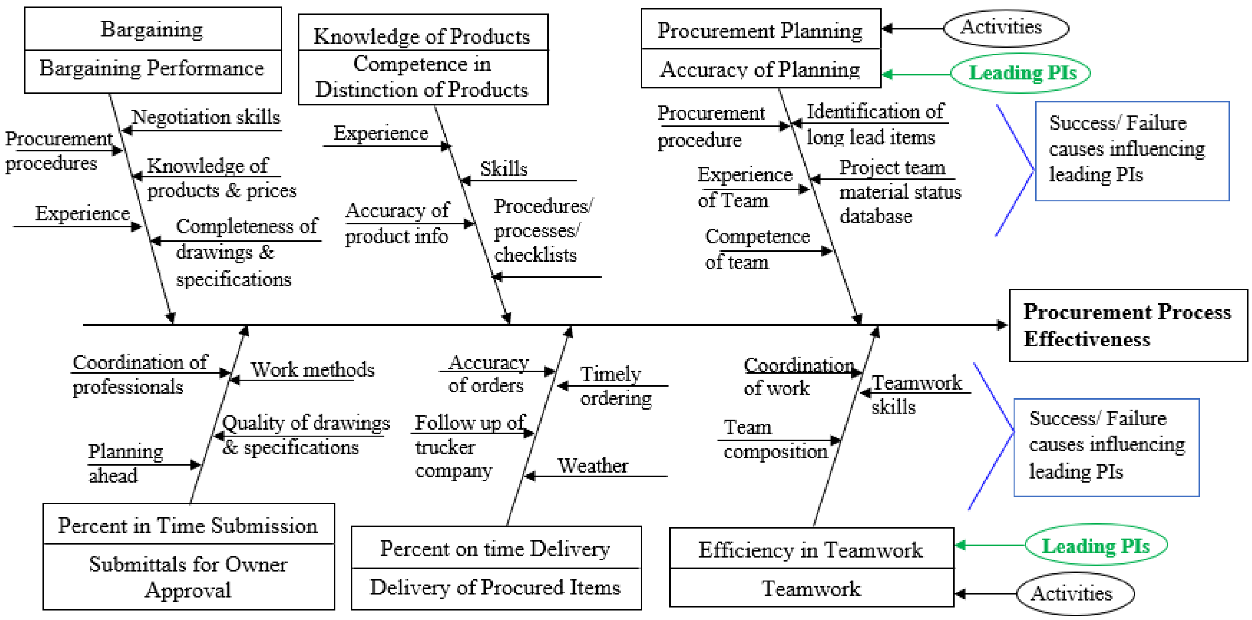


Figure E.23 Fishbone diagram for procurement department

1. **Leading Indicator**: Bargaining Performance

a. **Factor**: Procurement procedures.

Root causes of failure

Lack of development of procedure or not following it well.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in places procedures with checks and balances.

b. **Factor:** Negotiation skills.

Root causes of failure

Lack of negotiation skills or not preparing well before negotiations.

RIPs, counter measures and/or BPs that eliminate the root causes

Train procurement people in developing their negotiation skills.

c. **Factor:** Knowledge of products & prices.

Root causes of failure

Not much experience with products & prices.

RIPs, counter measures and/or BPs that eliminate the root causes

Procurement procedure should include exhaustive research on products and prices before selection. Coach and develop young people.

d. **Factor**: Procurement experience.

Root causes of failure

Procurement inexperience.

RIPs, counter measures and/or BPs that eliminate the root causes

Use coaching and mentoring of young people to help them gain experience.

e. **Factor:** Completeness of drawings & specifications

Root causes of failure

Missing information.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department should first check it before forwarding the shop drawings for procurement.

2. **Leading Indicator**: Competence in Distinction of Products

a. **Factor**: Experience.

Root causes of failure

Lack of experience in distinction of products.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

b. Factor: Skills.

Root causes of failure

Lack of skill in distinction of products.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

c. Factor: Accuracy of product and supplier info.

Root causes of failure

Lack of effort on researching product information.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

d. Factor: Procedures/ Processes/ Checklists.

Root causes of failure

Lack of inclusion of product distinction in procurement procedures and processes.

RIPs, counter measures and/or BPs that eliminate the root causes

Work on improving competence of procurement staff in distinction of products through training and coaching.

3. **Leading Indicator**: Accuracy of Planning

a. **Factor**: Procurement procedure

Root causes of failure

Not accounting for procedure in planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Put the procedure as integral part of the planning.

b. **Factor:** Identification of long lead items.

Root causes of failure

Sometimes these items may be overlooked.

RIPs, counter measures and/or BPs that eliminate the root causes

List items to be purchased exhaustively from construction plan and schedule.

c. **Factor:** Experience of team.

Root causes of failure

Lack of experience or not having sufficient experience.

RIPs, counter measures and/or BPs that eliminate the root causes

Build experience of team through coaching.

d. **Factor:** Project team material status database.

Root causes of failure

Not communicating timely about status.

RIPs, counter measures and/or BPs that eliminate the root causes

Get status updates regularly.

e. Factor: Competence of team.

Root causes of failure

Lack of competence of team.

RIPs, counter measures and/or BPs that eliminate the root causes

Build competence of team through training and coaching.

4. Leading Indicator: Percent in Time Submission for Owner Approval

a. Factor: Coordination of professionals.

Root causes of failure

Couldn't coordinate well or some not meeting deadlines.

RIPs, counter measures and/or BPs that eliminate the root causes

Coordinate and remind professionals working on shop drawings, bill of quantities, procurement, contracts, etc.

b. Factor: Work methods.

Root causes of failure

Not choosing the work methods most suited to equipment and skills company has.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department need to consider work methods in preparing shop drawings.

c. Factor: Planning ahead.

Root causes of failure

Not planning well or in detail.

RIPs, counter measures and/or BPs that eliminate the root causes

Plan ahead for timely submission and list down items for procurement from construction schedule, drawings and specifications.

d. Factor: Completeness of drawings and specifications.

Root causes of failure

Document with some missing information.

RIPs, counter measures and/or BPs that eliminate the root causes

Design department needs to check completeness before going on to other tasks.

5. Leading Indicator: Percent in Time Delivery

a. Factor: Accuracy of orders

Root causes of failure

Orders with some items missing.

RIPs, counter measures and/or BPs that eliminate the root causes

Have items to be procured listed and double checked.

b. Factor: Timely ordering.

Root causes of failure

Not ordering in time or some items missing while ordering.

RIPs, counter measures and/or BPs that eliminate the root causes

List items to be purchased exhaustively from construction plan and schedule with required ordering and receipt dates.

c. Factor: Follow up of trucker company.

Root causes of failure

Not reminding and following up regularly.

RIPs, counter measures and/or BPs that eliminate the root causes

Have some procedure of follow up with logistics companies.

d. Factor: Weather.

Root causes of failure

Not accounting for weather while planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Consider effect of weather on logistics and delivery of items.

6. Leading Indicator: Efficiency in Teamwork

a. Factor: Coordination of work.

Root causes of failure

Lack of clarity of team member roles and coordination problems among procurement team.

RIPs, counter measures and/or BPs that eliminate the root causes

Make role of each team member clear. Team leader needs to coordinate all work.

b. Factor: Effectiveness of team development.

Root causes of failure

Not managing team development through all phases of its development affecting its effectiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Team leader needs to manage and lead the team through all its development phases so that the team develops effectively.

c. Factor: Diversity of team member skills.

Root causes of failure

Lack of consideration of diversity in team member skills in forming teams.

RIPs, counter measures and/or BPs that eliminate the root causes

Compose teams diversely in terms of expertise and experience.

EMPLOYEE PERFORMANCE

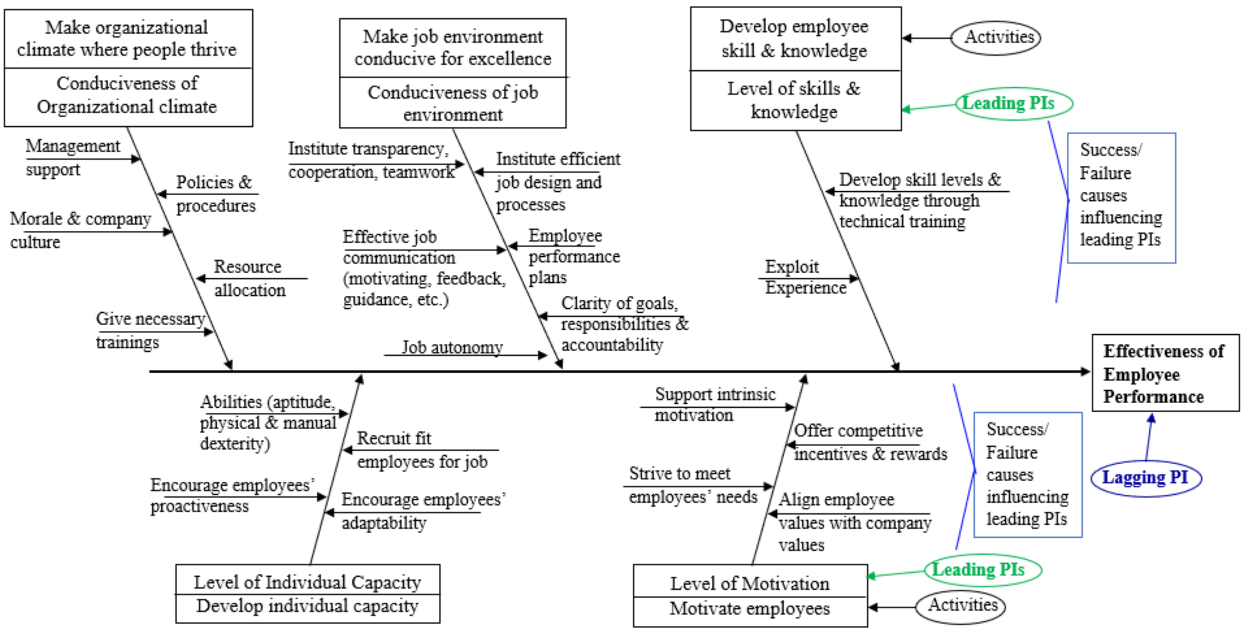


Figure E.24 Fishbone diagram for employee performance

1. **Leading Indicator**: Conduciveness of Organizational Climate

a. **Factor**: Management support.

Root causes of failure

Flawed environment support, tools and other resources. Inadequate working conditions, unavailability of tools or not optimally arranged, insufficient time to get job done.

RIPs, counter measures and/or BPs that eliminate the root causes

Management needs to help employees that management supports their job related efforts for improved performance. Management support also improves commitment and proactivity.

b. Factor: Policies & procedures.

Root causes of failure

Deficiency or incompleteness in key policies. Work unrelated to organization's mission and needs. Policies not supporting optimal performance well.

RIPs, counter measures and/or BPs that eliminate the root causes

Put policies and procedures in place that support optimal performance. Check policies for alignment among themselves. Put in place procedures as document containing "cookbook-style, step-by-step procedures (preferably graphically) of the best way to carry out tasks.

c. Factor: Morale & company culture.

Root causes of failure

Complaints and whining in company due to employees dissatisfaction with management or dissatisfaction with incentives. Poorly developed culture (poor transparency, cooperation, teamwork and accomplishment culture). Deficiency or incompleteness in corporate culture.

RIPs, counter measures and/or BPs that eliminate the root causes

Management should work hard towards establishing a positive job environment and culture where transparency, cooperation, teamwork and accomplishment are promoted by deeds and words. Positive and supportive interrelationships between coworkers and teams should be promoted so everybody fills respected and loved, so everybody feels he/she belongs to the company.

d. Factor: Resource allocation.

Root causes of failure

Flawed support with tools and other resources. Inadequate working conditions, tools unavailable or not optimally arranged, insufficient time to get job done. Lack of information to perform when they are needed; Information not given on a timely basis, little documentation, performance standards are non-existent, data are not tied to performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure resources are available just in time when they are needed (staff, tools, equipment, supplies/materials, time, money, space). Support people with resources to achieve optimal performance.

e. Factor: Give necessary trainings

Root causes of failure

Training to help employees acquire new knowledge and skills or to keep up to date with technology is not conducted well or company is discouraged by temporary nature of employees (especially the trades and manual labor.

RIPs, counter measures and/or BPs that eliminate the root causes

Acquisition of new knowledge and skills through training leads to improved employee performance. Dynamism in the market makes it difficult to know what skills workforce should have but adaptability helps adjust. Training culture has a strong impact on employees' skill flexibility, proactivity and adaptability, factors which improve employee performance.

2. Leading Indicator: <u>Conduciveness of Job Environment</u>

a. Factor: Institute transparency, cooperation, teamwork.

Root causes of failure

Values required to create a healthy work environment such as transparency, cooperation, teamwork & accomplishment are not advocated very well as part of the corporate culture.

RIPs, counter measures and/or BPs that eliminate the root causes

Advocate values such as transparency, cooperation, teamwork & accomplishment required to create a healthy work environment well as part of the corporate culture.

b. Factor: Institute efficient job design and processes.

Root causes of failure

Processes are not well developed due to lack of detailed job analysis and/or lack of trial and error in refining processes. Job not well designed using analysis method.

RIPs, counter measures and/or BPs that eliminate the root causes

Design job for optimal performance. Use work design interventions such as job design, job enrichment, job enlargement, job rotation, reengineering, realignment and restructuring. Use job analysis interventions such as job description and job specifications. Continuously refine processes through trial and error to put in place the most efficient processes (the fastest, leanest, and most reliable methods to accomplishing tasks) in place. Design the physical work space ergonomically to minimize barriers to optimal performance.

c. Factor: Effective job communication (motivating, feedback, guidance, etc.).

Root causes of failure

Lack of frequent and appropriate communications in motivating employees, giving frequent job performance feedback, giving guidance, etc.

RIPs, counter measures and/or BPs that eliminate the root causes

Use structured and genuine appreciation. Demonstrate appreciation through rewards and incentives to enthusiastic and energized employees who work effectively. Managers and co-workers freely provide suggestions and advice. Structured feedback, such as 360-degree feedback, is viewed as non-threatening and helpful. Make sure that feedback is welcomed, valued, and sought. 360-degree feedback (Use a multi-source feedback approach that allows multiple individuals to rate skills and behaviors of an employee. Emphasize assessing and improving employee performance while enhancing and maximizing organizational and individual development.).

d. Factor: Employee performance plans.

Root causes of failure

Not letting each employee set medium term goals and help them develop performance plans with their supervisors.

RIPs, counter measures and/or BPs that eliminate the root causes

Let each employee set medium term goals and help each develop performance plan with his/her supervisor.

e. Factor: Job autonomy.

Root causes of failure

Not asking employees set medium term goals. Lack of establishing responsibilities clearly. Lacking accountability system.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish and allocate job responsibilities clearly to support achievement of desired results. Put in place accountability system.

f. Factor: Clarity of goals, responsibilities & accountability.

Root causes of failure

Not giving employees freedom to decide on ways to perform their jobs.

RIPs, counter measures and/or BPs that eliminate the root causes

Give job autonomy to each employee to unleash their creativity and intrinsic motivation. Let the employees work out various aspects of work taking into account the functions and performance objectives of the work.

3. Leading Indicator: Level of Skills and Knowledge

a. Factor: Develop skill levels & knowledge through technical training

Root causes of failure

Lack of continuously developing skills of employees through different means. Lack of skills, training, education, knowledge, learner unable to learn, problem due to boss of the learner, problem with the organization in planning learning. Unable to maneuver the system.

RIPs, counter measures and/or BPs that eliminate the root causes

Necessary attention need to be given to continuously develop skill levels and knowledge through education and training, on the job learning, learning organization, mentoring, coaching, employee development, succession planning and career pathing. Use education and training to enhance and enable employee learning and development. The use of interactive learning technologies involve the learner and supports just-in-time and just-for-me learning. Organization values, supports, rewards education and training for all members. Use on the job learning process for increasing learners' competencies while working; can be formal or informal; can occur consciously or unconsciously. These instantly increase competencies while working with new knowledge and/or skills applied and integrated immediately on the job. Organizations as entities can learn. They function effectively, efficiently, and provide value to customers through the goods and services they offer. Organizational learning focuses on Senge's core disciplines which permit an organization to function as a learning organization. Viewed as a continuous process within an organization; learning results when it is tied to the strategic objectives of the organization and is targeted at performance improvement. Assign experienced employees to help new hires or people with new job assignments to quickly adapt to new job requirements. Following the wise counsel of mentors leads to job advancement or better projects and assignments. Make it highly visible and structured program with senior executives participating. Put in place a coaching system where managers assist employees to improve performance by analyzing problems, offering suggestions, discussing errors and mistakes, and recommending organizational resources (such as training) to overcome problems. Make sure suggestions are viewed as useful and positive. Managers and co-workers freely provide suggestions and advice. Structured feedback, such as 360-degree feedback, is viewed as non-threatening and helpful. Make sure that feedback is welcomed, valued, and sought. Apply a full spectrum of development: employee training, employee development, career development, and organization development from the start of employment of the candidate through the employee's entire tenure. Use systematic processes to identify employees for senior management positions. Use experiential assignments, mentoring, training, and personnel development to prepare people for high level assignment. Develop employees effectively through a series of jobs and related assignments. Make horizontal and vertical lines of opportunity available for employees.

b. Factor: Exploit Experience.

Root causes of failure

Lack of systematic transfer of lessons learned from past experience to current work.

RIPs, counter measures and/or BPs that eliminate the root causes

Exploit skills employees bring from past experience to transfer lessons learned to improve job performance.

4. Leading Indicator: Level of Individual Capacity

a. Factor: Abilities (aptitude, physical & manual dexterity).

Root causes of failure

Lack of assessment of employee aptitude, ability, physical or manual dexterity; inadequate job analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Use competencies testing to identify best candidates for jobs to determine appropriate skill levels and job readiness. Competency testings are also organizational capabilities that align employee behavior and action with the organization's strategic plan. Conduct regular constructive performance appraisals, containing honest representation of employee efforts and helpful recommendations for improvement. Have healthy dialogue with each employee establishing workable objectives and planning for consistent application.

b. Factor: Recruit fit employees for job.

Root causes of failure

Lack of or deficiencies in competencies testing to identify best candidates for jobs to determine appropriate skill levels and job readiness.

RIPs, counter measures and/or BPs that eliminate the root causes

Use competencies testing to identify best candidates for jobs to determine appropriate skill levels and job readiness. Competency testing is also organizational capabilities that align employee behavior and action with the organization’s strategic plan. Hire people with a variety of skills because it forms the basis for creating multiple alternatives to current or future job requirements.

c. Factor: Encourage employees’ proactiveness.

Root causes of failure

Lack of setting the example by management and team leaders in proactiveness about problems before they occur.

RIPs, counter measures and/or BPs that eliminate the root causes

Encourage, collect and implement employees' voluntary and constructive efforts to improve firm's procedures in the workplace. Encourage and collect innovative suggestions for change and recommendations of modifications to standard procedure. Fuel employee innovations through profit sharing.

d. Factor: Encourage employees’ adaptability.

Root causes of failure

Lack of employees capacity of performing well under dynamic internal and external environments. Lack of flexibility under changes.

RIPs, counter measures and/or BPs that eliminate the root causes

Recognize employees reacting with proper urgency in life threatening, dangerous or emergency or crisis situations. Show appreciation to employees who remain composed when faced with difficult circumstances and demanding work load. Recognize people who develop creative solutions for unusual, complex and indeterminate job related problems through profit sharing and the like. Appreciate employees that easily deals with unpredictable or unexpected job related events and circumstances and applies the appropriate solution.

5. **Leading Indicator**: Level of Motivation

a. **Factor**: Support intrinsic motivation

Root causes of failure

Lack of promoting professionalism and self- satisfaction from being the best engineer.

RIPs, counter measures and/or BPs that eliminate the root causes

Use structured and genuine appreciation. Demonstrate appreciation through rewards and incentives to enthusiastic and energized employees who work effectively.

b. **Factor:** Offer competitive incentives and rewards.

Root causes of failure

Flawed incentives, lack of motivation.

RIPs, counter measures and/or BPs that eliminate the root causes

Use structured and genuine appreciation. Demonstrate appreciation through rewards and incentives to enthusiastic and energized employees who work effectively.

c. **Factor:** Strive to meet employees' needs.

Root causes of failure

Lack of scientific considerations of social, belongingness and relatedness need of employees as social beings.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish a positive, supportive and cooperative work environment where everyone supports everybody succeed. Make sure the company is where everybody thrives.

d. **Factor:** Align employee values with company values.

Root causes of failure

Lack of governance on shared values. Management actions not showing company values. Employees confused about company values.

RIPs, counter measures and/or BPs that eliminate the root causes

Use the good values each employee has, align it with company values so that employee goals and company goals are achieved at the same time.

PROJECT

Project Processes:

A. Change Control

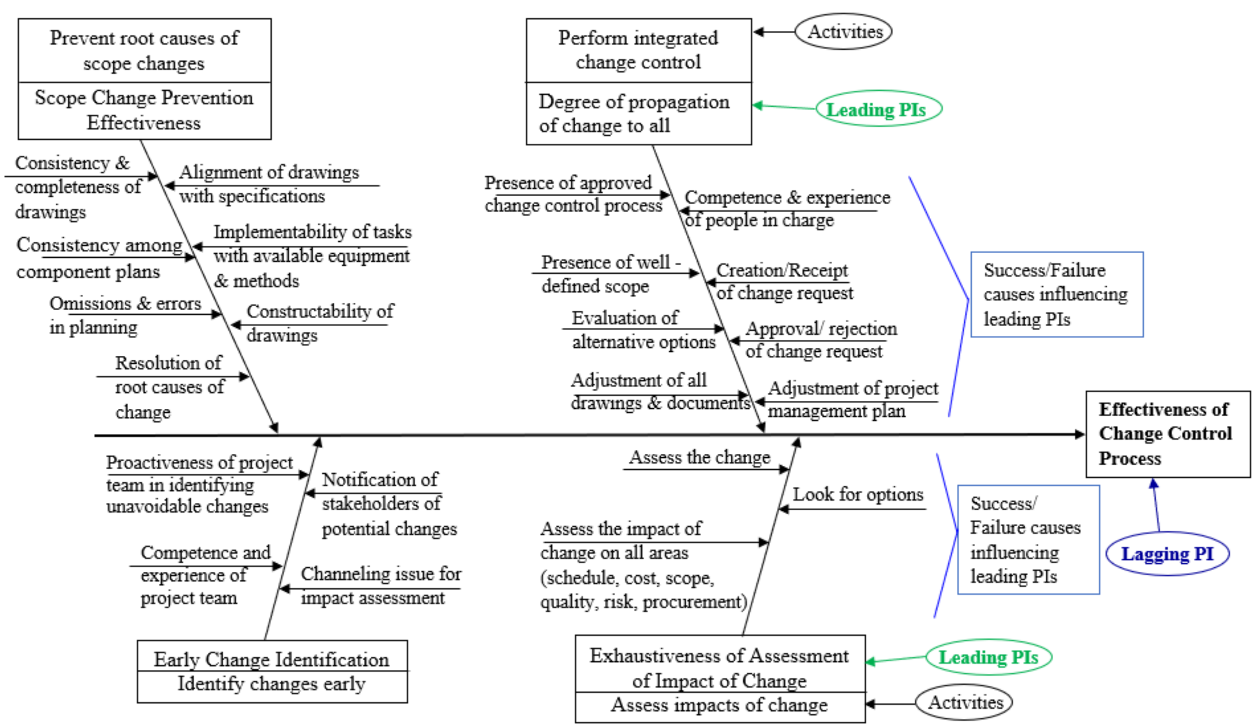


Figure E.25 Fishbone diagram for project change control process

1. Leading Indicator: Scope Change Prevention Effectiveness

a. Factor: Consistency and completeness of drawings.

Root causes of failure

Lack of detailed reconciliation and alignment of drawings.

RIPs, counter measures and/or BPs that eliminate the root causes

Engineers responsible for their part must study drawings and specifications to decide the best way to build, which helps identify inconsistencies and misalignments.

b. Factor: Alignment of drawings with specifications.

Root causes of failure

Inattention to alignment of drawings with specifications in tender document preparation possibly due to time pressure.

RIPs, counter measures and/or BPs that eliminate the root causes

Engineers responsible for their part must study drawings and specifications to decide the best way to build, which helps identify inconsistencies and misalignments. Specifications have precedence over drawings, and so drawings should be corrected.

c. Factor: Consistency among component plans.

Root causes of failure

Lack of detailed reconciliation and alignment of drawings.

RIPs, counter measures and/or BPs that eliminate the root causes

Engineers responsible for their part must study drawings and specifications to decide the best way to build, which helps identify inconsistencies and misalignments.

d. Factor: Implementability of tasks with available equipment & methods.

Root causes of failure

Lack of in depth thought about implementation issues.

RIPs, counter measures and/or BPs that eliminate the root causes

Engineers responsible for their part must study drawings and specifications to decide the best way to build, compare with available methods and choose based on equipments that the company have or can rent.

e. Factor: Omissions & errors in planning

Root causes of failure

Oversight and negligence.

RIPs, counter measures and/or BPs that eliminate the root causes

Make sure you avoid omissions & errors because they add to your risk. Omissions and errors in planning are not scope changes. They are in the scope but mistake made.

f. Factor: Constructability of drawings.

Root causes of failure

Time pressure or lack of experience results in poor constructability drawings.

RIPs, counter measures and/or BPs that eliminate the root causes

Use feedback from estimating to produce drawings of better constructability.

g. Factor: Resolution of root causes of change

Root causes of failure

Lack of focus on the root causes and trying to solve targeting the symptom.

RIPs, counter measures and/or BPs that eliminate the root causes

Prevent the root causes of change from past experiences proactively such as the items listed thus far.

2. Leading Indicator: Degree of Propagation of Change to All

a. Factor: Presence of approved change control process.

Root causes of failure

Lack of change control process or lack of implementation.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop and use a structured process for change control like the one developed here.

b. Factor: Competence and experience of people in charge.

Root causes of failure

Treating change control as low priority and assigning inexperienced people.

RIPs, counter measures and/or BPs that eliminate the root causes

It is always cheaper to hire the best people.

c. Factor: Presence of well-defined scope.

Root causes of failure

Absence of well-defined scope makes change difficult to identify.

RIPs, counter measures and/or BPs that eliminate the root causes

Use the well- defined scope to identify change.

d. Factor: Creation/Receipt of change request.

Root causes of failure

Delay in distinguishing whether change is unavoidable or not.

RIPs, counter measures and/or BPs that eliminate the root causes

The contractor forwards a change request if unavoidable change is identified. Receive unavoidable changes from other stakeholders also for deliberation.

e. Factor: Evaluation of alternative options.

Root causes of failure

Lack of depth of evaluation of alternative options.

RIPs, counter measures and/or BPs that eliminate the root causes

Look into alternative options and forward with recommended choice of integrated change with the merits and demerits and impacts for client to decide.

f. Factor: Approval/ rejection of change request.

Root causes of failure

Delay in decision for approval or rejection.

RIPs, counter measures and/or BPs that eliminate the root causes

Implement what is agreed up on with the client.

g. Factor: Adjustment of all drawings and documents.

Root causes of failure

Adjustment not carried through due to oversight or cursory corrections.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry through the correction required by the approved change to all documents affected by it.

h. Factor: Adjustment of project management plan.

Root causes of failure

Adjustment not carried through due to oversight or cursory corrections.

RIPs, counter measures and/or BPs that eliminate the root causes

Adjust the project management plan accordingly. The time and cost may be affected.

3. Leading Indicator: Early Change Identification

a. Factor: Proactiveness of project team in identifying unavoidable changes

Root causes of failure

Time pressure or lack of experience causes lack of proactiveness.

RIPs, counter measures and/or BPs that eliminate the root causes

Engineers responsible for their part must study drawings and specifications to decide the best way to build, which helps identify inconsistencies and misalignments.

b. Factor: Notification of stakeholders of potential changes.

Root causes of failure

Delay in communication.

RIPs, counter measures and/or BPs that eliminate the root causes

It is good to communicate to all stakeholders that will potentially be affected by the change as soon as possible.

c. Factor: Competence and experience of project team.

Root causes of failure

Treating change control as low priority and assigning inexperienced people.

RIPs, counter measures and/or BPs that eliminate the root causes

It is always cheaper to hire the best people.

d. Factor: Channeling issue for impact assessment.

Root causes of failure

Procrastination or complacence.

RIPs, counter measures and/or BPs that eliminate the root causes

Look into alternative options and forward with recommended choice of integrated change with the impacts for client to decide.

4. Leading Indicator: Exhaustiveness of Assessment of Impact of Change

a. Factor: Assess the change.

Root causes of failure

Skipping over this step, which could generate useful information.

RIPs, counter measures and/or BPs that eliminate the root causes

Assess which workgroup or process will be impacted by the change and magnitude of change in terms of cost, time and number of people affected.

b. Factor: Look for options.

Root causes of failure

Exploring limited options.

RIPs, counter measures and/or BPs that eliminate the root causes

Evaluate options to deal with change.

c. Factor: Assess the impact of change on all areas (schedule, cost, scope, quality, risk, procurement).

Root causes of failure

Not assessing impact exhaustively.

RIPs, counter measures and/or BPs that eliminate the root causes

Look into alternative options and forward with recommended choice of integrated change with the impacts for client to decide.

B. Monitoring and Control

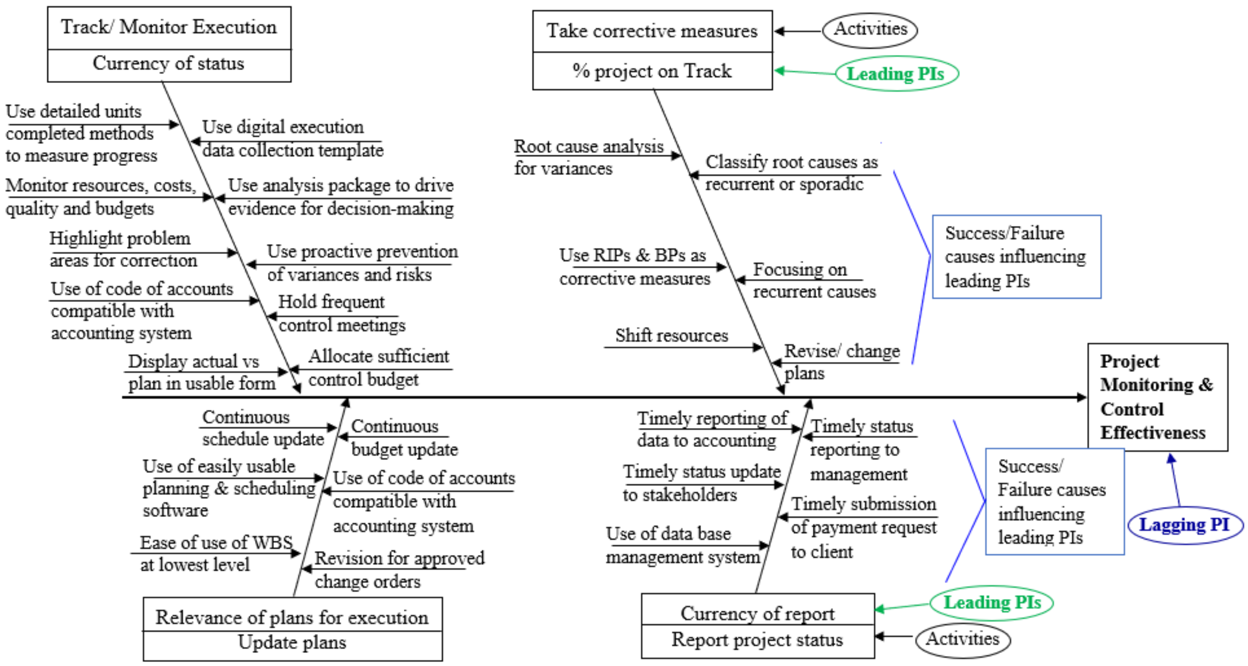


Figure E.26 Fishbone diagram for project monitoring and control process

1. **Leading Indicator**: <u>Currency of Status</u>

a. **Factor**: Use detailed units completed methods to measure progress.

Root causes of failure

Use of other progress measurement methods such as judgment(supervisor opinion), incremental milestones, weighted or equivalent units completed and resource expenditure (Orgut et. al, 2020).

RIPs, counter measures and/or BPs that eliminate the root causes

Use digital collection forms to collect detailed units completed (by discrete activities), which is objective and accurate. Use computer package to do calculations to derive information for decision making. Compare schedule against baseline to determine variances.

b. **Factor:** Use digital execution data collection template.

Root causes of failure

Lack of package that forces spreadsheet data collection or manual paper and pen data collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Use digital collection forms to collect detailed units completed (by discrete activities), which is objective and accurate. Use computer package to do calculations to derive information for decision making.

c. **Factor:** Monitor resources, costs, quality and budgets.

Root causes of failure

Lack of attention to track performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Accumulate cost by category (material, labor, equipment, facilities, utilities, travel, overhead, etc) and then add up for each activity.

d. **Factor**: Use analysis package to drive evidence for decision-making.

Root causes of failure

Lack of such a package.

RIPs, counter measures and/or BPs that eliminate the root causes

Get and use package that gives information/evidence in easily usable form for decision making.

e. **Factor:** Highlight problem areas for corrective action

Root causes of failure

Lack of focus due to lack of information.

RIPs, counter measures and/or BPs that eliminate the root causes

Use variances to highlight deviations from plan.

f. **Factor**: Use proactive prevention of variances and risks.

Root causes of failure

Complacence and following usual practice of being reactive.

RIPs, counter measures and/or BPs that eliminate the root causes

Use lessons learned to prevent variances and risks proactively.

g. **Factor:** Use of code of accounts compatible with accounting system

Root causes of failure

Using usual practice of using different codes for scheduling activities and cost accounting for activities.

RIPs, counter measures and/or BPs that eliminate the root causes

Use the same accounts in estimating, scheduling and accounting.

h. **Factor:** Hold frequent control meetings

Root causes of failure

Lack of paying sufficient attention to control meetings. Busy with work.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in place a structured process to contemporaneously discuss and fix variances.

i. **Factor**: Display actual vs plan in usable form.

Root causes of failure

Complacency. Following usual practice.

RIPs, counter measures and/or BPs that eliminate the root causes

Use package that outputs information juxtaposing actual with planned.

j. Factor: Allocate sufficient control budget

Root causes of failure

Often low budget is allocated due to poor prioritization.

RIPs, counter measures and/or BPs that eliminate the root causes

2.1% control budget showed better performance as compared to 0.9% which showed worst performance (Jaselskis, 2018).

2. Leading Indicator: <u>Percent Project on Track</u>

a. Factor: Root cause analysis for variances.

Root causes of failure

Short sightedness, correcting variances and proceeding with work without determining root causes. Variances are likely to recur.

RIPs, counter measures and/or BPs that eliminate the root causes

Use data and information from past occurrences to know how the variances have occurred in the past. Identify the physical, human and latent root causes.

b. Factor: Classify root causes as recurrent or sporadic.

Root causes of failure

Not classifying as recurrent or sporadic.

RIPs, counter measures and/or BPs that eliminate the root causes

Use past data for recurrent. Use analysis on the variance for sporadic because you do not have past data to rely on.

c. Factor: Use RIPs & BPs as corrective measures.

Root causes of failure

Not using RIPs and BPs known to be effective. Complacency.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify the most effective RIPs and BPs to use to resolve the root causes of the variances so they do not recur.

d. Factor: Focusing on recurrent causes.

Root causes of failure

Lack of systematic approach in resolving variances.

RIPs, counter measures and/or BPs that eliminate the root causes

Focus on recurrent ones.

e. Factor: Shifting resources.

Root causes of failure

Other solutions may be tried while shifting resources may be the cost effective solution.

RIPs, counter measures and/or BPs that eliminate the root causes

Shifting resources is one solution if the root cause of the identified variance is shortage of resources.

f. Factor: Revise/ change plans.

Root causes of failure

Lack of frequent plan updates.

RIPs, counter measures and/or BPs that eliminate the root causes

Revise plans and schedules to incorporate the suggested solutions.

3. Leading Indicator: Relevance of Plans for Execution

a. Factor: Continuous schedule update

Root causes of failure

Lack of regular schedule update.

RIPs, counter measures and/or BPs that eliminate the root causes

Update schedule regularly using actual progress(scheduler trained and experienced in CPM scheduling). Give schedule narrative describing updates.

b. Factor: Continuous budget update.

Root causes of failure

Lack of budget update.

RIPs, counter measures and/or BPs that eliminate the root causes

Update budget regularly as schedule is updated with actual progress.

c. Factor: Use of easily usable planning & scheduling software.

Root causes of failure

Use of intricate software requiring detailed knowledge.

RIPs, counter measures and/or BPs that eliminate the root causes

Construction engineer should be able to read schedule information from software.

d. Factor: Use of code of accounts compatible with accounting system.

Root causes of failure

Use different coding for activity scheduling, job costing and cost control, causing confusion.

RIPs, counter measures and/or BPs that eliminate the root causes

Activity based costing with master format coding used for activity scheduling, job cost reporting and cost control.

e. **Factor:** Ease of use of WBS to effectively manage task at lowest level.

Root causes of failure

Not robust WBS used.

RIPs, counter measures and/or BPs that eliminate the root causes

Plan to the level of detail necessary to manage the work effectively. Use discrete activities for progress measurement.

f. **Factor:** Revision for approved change orders.

Root causes of failure

Not carrying changes through to all document.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry the approved change through to all documents affected by the change.

4. **Leading Indicator**: Currency of Status report

a. **Factor**: Timely reporting of data to accounting.

Root causes of failure

Procrastination.

RIPs, counter measures and/or BPs that eliminate the root causes

Establish a routine and habit of data entry as soon as a task is completed. Setup your package so that it produces the required reports as soon as data entry is completed.

b. Factor: Timely status reporting to management.

Root causes of failure

Procrastination.

RIPs, counter measures and/or BPs that eliminate the root causes

Setup your package so that it produces the required reports as soon as data entry is completed. Use template/format.

c. Factor: Timely status update to stakeholders.

Root causes of failure

Procrastination.

RIPs, counter measures and/or BPs that eliminate the root causes

Setup your package so that it produces the required reports as soon as datya entry is completed.

d. Factor: Use of data base management system.

Root causes of failure

Lack of knowledge of database and its benefits.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop simple database in access, where you can use data entry form, generate reports. Tie database to analysis software you use .Setup your package so that it produces the required reports as soon as data entry is completed.

e. Factor: Timely submission of payment request to client

Root causes of failure

Procrastination.

RIPs, counter measures and/or BPs that eliminate the root causes

Setup your package so that it produces the required reports as soon as data entry is completed.

C. Planning

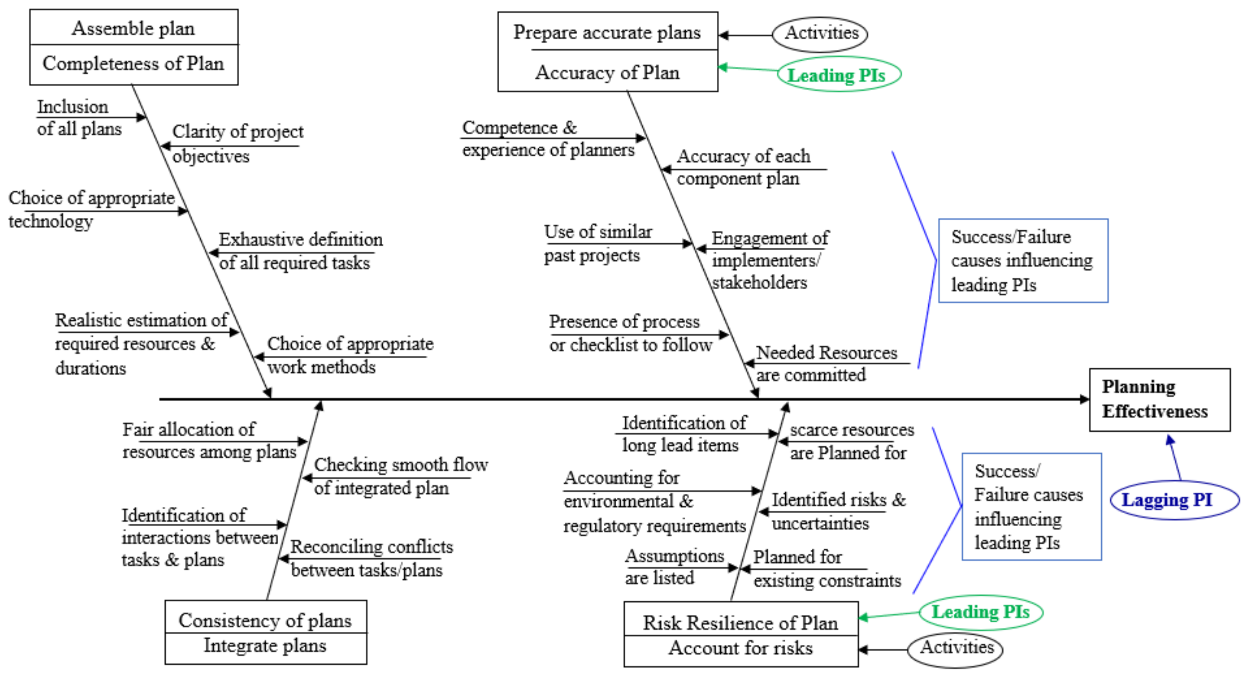


Figure E.27 Fishbone diagram for project planning process

1. **Leading Indicator**: Completeness of Plan

a. **Factor**: Inclusion of all plans.

Root causes of failure

Some plans missing or not well developed.

RIPs, counter measures and/or BPs that eliminate the root causes

Define, prepare, and coordinate all plan components and consolidate them into an integrated project management plan.

b. Factor: Clarity of project objectives.

Root causes of failure

Objectives not clearly defined or not measurable (not SMART). Lack of clarity and depth to the original specification document.

RIPs, counter measures and/or BPs that eliminate the root causes

Use project plans to help you achieve project objectives.

c. Factor: Choice of appropriate technology.

Root causes of failure

Much thought not put into technology selection.

RIPs, counter measures and/or BPs that eliminate the root causes

Compare existing with improved and choose based on cost and time. Prefabrication and preassembly may also be considered.

d. Factor: Exhaustive definition of all required tasks.

Root causes of failure

Lack of a robust WBS that decomposes deliverables into work packages.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop a logical, clear and exhaustive breakdown of project hierarchically into work packages.

e. Factor: Realistic estimation of required resources and durations

Root causes of failure

Lack of realistic estimate due to inexperience of estimators.

RIPs, counter measures and/or BPs that eliminate the root causes

Record standard resource requirements for each activity and adjust for the special conditions of particular project.

f. Factor: Choice of appropriate work methods.

Root causes of failure

Choice of methods less appropriate, costly or methods that can be executed with available equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Select most appropriate method in terms of cost efficiency, availability of equipment or other criteria.

2. Leading Indicator: <u>Accuracy of Plan</u>

a. Factor: Competence and experience of planners.

Root causes of failure

Inexperienced planners assigned.

RIPs, counter measures and/or BPs that eliminate the root causes

Use experienced and top notch engineers.

b. Factor: Active engagement of implementers/ stakeholders.

Root causes of failure

Lack of engagement of all stakeholders.

RIPs, counter measures and/or BPs that eliminate the root causes

Get active stakeholder engagement in the development and composition of plans.

c. Factor: Accuracy of each component plan.

Root causes of failure

Poor quality content or missing items from plans.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow process flow in developing each plan.

d. Factor: Needed resources are committed.

Root causes of failure

Lack of exhaustive resource allocation.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify potential resource bottlenecks so that schedule, resource allocation or technology changes can be made to avoid problems.

e. Factor: Presence of process or template or checklist to follow in planning.

Root causes of failure

Lack of or deficient process or template or checklist to follow in planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow process flow in developing each plan. Integrate schedule and budget information over time.

f. Factor: Use of plan of similar past projects (lessons learned).

Root causes of failure

Not utilizing lessons learned.

RIPs, counter measures and/or BPs that eliminate the root causes

Use the rich information from similar successful pas projects. Review lessons learned register.

3. Leading Indicator: Consistency of Plans

a. Factor: Fair allocation of resources among plans

Root causes of failure

Lack of equitable resource allocation for optimum overall project performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate resources as you coordinate and integrate all plans based on overall optimal outcome.

b. Factor: Checking smooth flow of integrated plan.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Put tasks into process flows. Show tasks of all plans on an integrated schedule to help resolve issues.

c. Factor: Identification of interactions between tasks and plans.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Check task times and space requirements to avoid conflicts or congestion. Show tasks of all plans on an integrated schedule to help resolve interaction issues.

d. Factor: Reconciling conflicts between tasks/plans.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Check task times and space requirements to avoid conflicts or congestion. Show tasks of all plans on an integrated schedule to help resolve conflicts.

4. Leading Indicator: <u>Risk Resilience of Plans</u>

a. Factor: Identification of long lead items

Root causes of failure

Lack of identification of long lead items.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify long-lead items to make sure these do no constrain construction operations.

b. Factor: Planned for scarce resources.

Root causes of failure

Lack of identification of and/or planning for scarce resources.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify scarce resources to make sure these do no constrain construction operations.

c. Factor: Accounted for environmental and regulatory requirements.

Root causes of failure

Missing some environmental and regulatory requirements in planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Show environmental and regulatory requirements on schedule and tie them to milestones.

d. Factor: Identified risks & uncertainties.

Root causes of failure

Missing some risks and uncertainties.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify risks using stakeholder survey & cause and effect diagrams and document their characteristics. Carry out analysis to the appropriate level of detail.

e. Factor: Listed assumptions.

Root causes of failure

Missing some assumptions.

RIPs, counter measures and/or BPs that eliminate the root causes

List your assumptions or premises used in planning about things over which you have no control.

f. Factor: Planned for existing constraints.

Root causes of failure

Lack of identification of and/or planning for some constraints.

RIPs, counter measures and/or BPs that eliminate the root causes

List down constraints so that one accounts for them in planning.

D. Quality Assurance

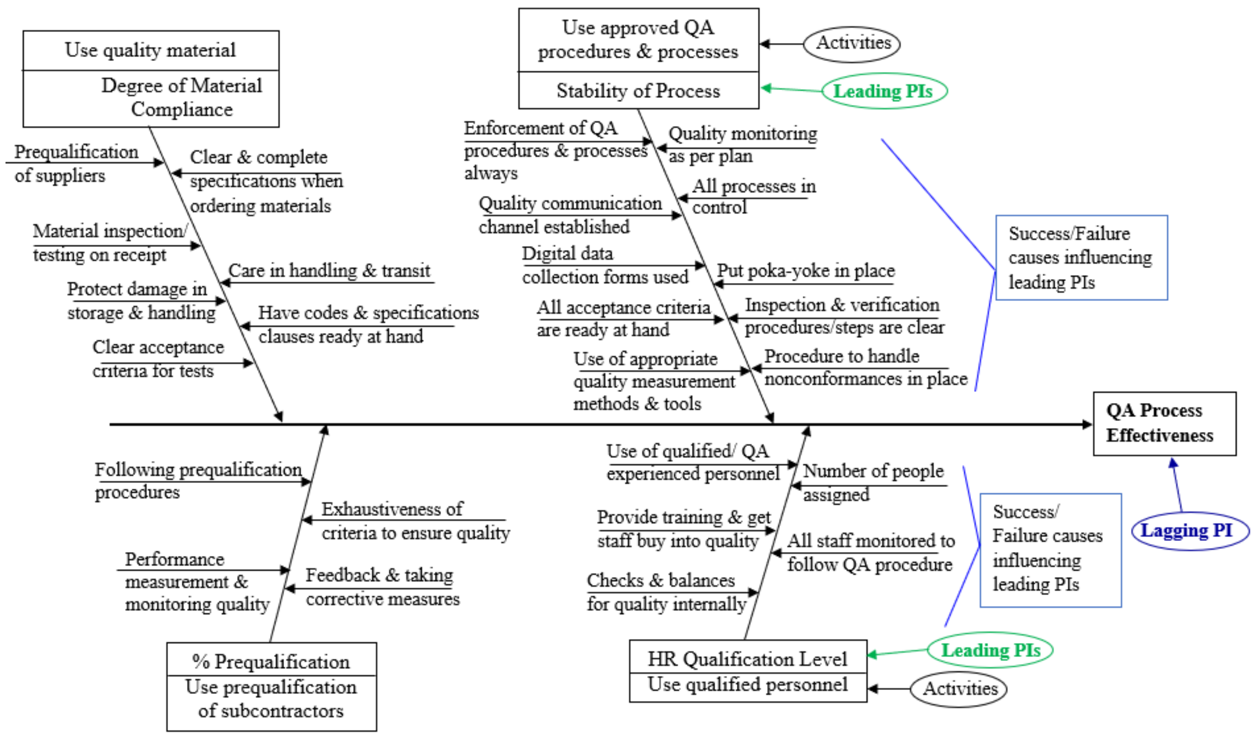


Figure E.28 Fishbone diagram for project quality assurance process

1. **Leading Indicator**: Degree of Material Compliance

a. **Factor**: Prequalification of suppliers.

Root causes of failure

Using low cost suppliers without pre qualifications.

RIPs, counter measures and/or BPs that eliminate the root causes

Prequalify your suppliers and monitor their material quality.

b. **Factor:** Clear & complete specifications when ordering materials.

Root causes of failure

Lack of clarity or some information missing while ordering materials.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide sufficient specification and requirements to ensure suppliers understand what is required.

c. **Factor:** Material inspection/ testing on receipt.

Root causes of failure

Trusting suppliers and not inspecting/testing.

RIPs, counter measures and/or BPs that eliminate the root causes

Trust your inspections and test results only.

d. **Factor**: Care in handling and transit.

Root causes of failure

Care in handling not clearly communicated to truckers.

RIPs, counter measures and/or BPs that eliminate the root causes

List down handling procedures and requirements to truckers.

e. **Factor:** Protect damage in storage and handling

Root causes of failure

Lack of clarity on cares required in storage and handling.

RIPs, counter measures and/or BPs that eliminate the root causes

List down storage procedures and requirements and communicate to people in charge of storage.

f. **Factor**: Have codes and specification clauses at hand.

Root causes of failure

Searching through discourages and may be missed.

RIPs, counter measures and/or BPs that eliminate the root causes

Have code and specification clauses handy for easy reference.

g. **Factor**: Clear acceptance criteria for tests.

Root causes of failure

Lack of clear acceptance criteria.

RIPs, counter measures and/or BPs that eliminate the root causes

Clear acceptance criteria helps quality assurance and communicates requirements clearly. Makes inspection and testing easy.

2. **Leading Indicator**: Stability of QA Process

a. **Factor**: Enforcement of QA procedures & processes always.

Root causes of failure

Lack of implementation of QA procedures.

RIPs, counter measures and/or BPs that eliminate the root causes

Convince employees and especially the superintendent who runs the day to day operations about importance of implementing the procedures always to get buy in. Get their feedback if they think it is unnecessary.

b. **Factor:** Quality monitoring as per plan.

Root causes of failure

Complacency and procrastination.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor quality weekly or monthly as per your plan.

c. **Factor:** Quality communication channel established.

Root causes of failure

Lack of or oversight in establishing channel to communicate quality, hence client losing confidence in contractor.

RIPs, counter measures and/or BPs that eliminate the root causes

Do you hold routine production meetings where you will discuss quality issues? Will you be submitting reports, test results, and/or inspection forms to your client? Establish these in the communication plan.

d. Factor: All processes in control.

Root causes of failure

Not paying attention to process control.

RIPs, counter measures and/or BPs that eliminate the root causes

Improve the processes to improve quality. Follow processes that are developed from best practices and keep all outcomes within acceptable limits.

e. Factor: Digital data collection forms used.

Root causes of failure

Procrastination or use of paper forms.

RIPs, counter measures and/or BPs that eliminate the root causes

Make digital forms ready before work begins and enter data as soon as work is completed. Get results immediately.

f. Factor: Put poka-yoke in place.

Root causes of failure

Complacency and carelessness to identify past quality issues.

RIPs, counter measures and/or BPs that eliminate the root causes

Prevention is much cheaper than rework. Identify where quality issues occurred in the past and prevent those from recurring.

g. Factor: All acceptance criteria are ready at hand.

Root causes of failure

Lack of clear acceptance criteria.

RIPs, counter measures and/or BPs that eliminate the root causes

Clear acceptance criteria helps quality assurance and communicates requirements clearly. Makes inspection and testing easy.

h. Factor: Inspection and verification procedures/steps are clear.

Root causes of failure

Unclear inspection and verification procedures/steps. Procedures not specified.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide discrete steps to follow and procedure to inspect, test and verify whether quality requirements are met or not.

i. Factor: Use of appropriate quality measurement methods and tools.

Root causes of failure

Measurement methods and tools not laid out.

RIPs, counter measures and/or BPs that eliminate the root causes

List the best measurement and most cost effective methods and tools available in the industry for each explicitly so people are clear about expectations.

j. Factor: Procedure to handle nonconformances in place.

Root causes of failure

Lack of or vaguely described procedure to follow in cases of nonconformances.

RIPs, counter measures and/or BPs that eliminate the root causes

Implement procedure laid out in case of nonconformances.

3. Leading Indicator: <u>Percent Prequalification of Subcontractors</u>

a. Factor: Following prequalification procedures

Root causes of failure

Not following prequalification procedure or picking subcontractor on low cost only.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow prequalification procedures to ensure capability of subcontractors to perform work. Include record of subcontractor qualifications. Monitor their performance.

b. Factor: Exhaustiveness of criteria to ensure quality.

Root causes of failure

Lack of exhaustiveness of prequalification criteria.

RIPs, counter measures and/or BPs that eliminate the root causes

Prequalification criteria should cover all the important quality performance factors.

c. Factor: Performance measurement and monitoring quality.

Root causes of failure

Lack of performance monitoring. Procrastination or being complacent.

RIPs, counter measures and/or BPs that eliminate the root causes

Measure and monitor performance of subcontractors.

d. Factor: Feedback and taking corrective measures.

Root causes of failure

Lack of sufficient feedback to subcontractors on material quality and workmanship.

RIPs, counter measures and/or BPs that eliminate the root causes

Give subcontractors feedback and support them build capacity because they usually lack the fund or the training or the personnel.

4. Leading Indicator: HR Qualification Level

a. Factor: Use of qualified/ experienced personnel

Root causes of failure

Use of people not well qualified to reduce cost.

RIPs, counter measures and/or BPs that eliminate the root causes

Use quality personnel with the required qualification, training & experience.

b. Factor: Number of people assigned.

Root causes of failure

Few people than needed assigned to reduce cost.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign sufficient quality staff.

c. Factor: Provide training and get staff buy in for quality.

Root causes of failure

Lack of sufficient quality training.

RIPs, counter measures and/or BPs that eliminate the root causes

Assess knowledge gaps continuously and give training continuously to keep your human resources productive.

d. Factor: All staff monitored to follow QA procedure.

Root causes of failure

No mechanism to put in place to check whether staff follows the procedure or not.

RIPs, counter measures and/or BPs that eliminate the root causes

It is important all staff implement the QA procedures.

e. Factor: Checks and balances for quality internally.

Root causes of failure

Lack of understanding of the benefits of checks and balances by employees.

RIPs, counter measures and/or BPs that eliminate the root causes

Quality personnel should belong to a different department than the superintendents who do the job.

E. Risk Management

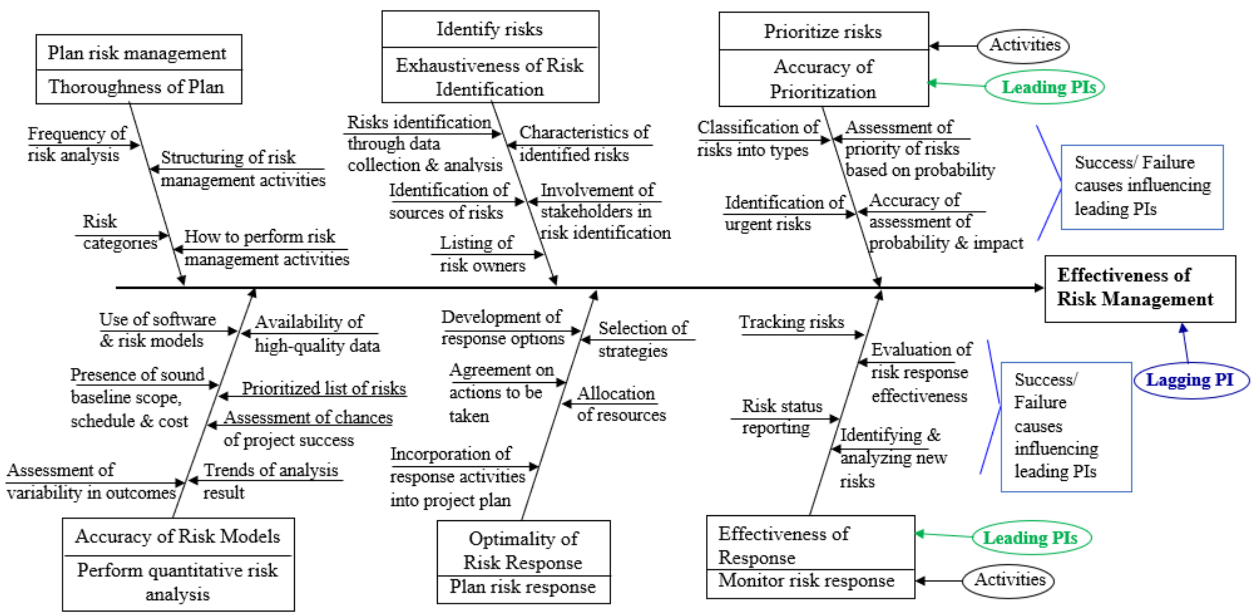


Figure E.29 Fishbone diagram for project risk management process

1. **Leading Indicator**: Thoroughness of Risk Plan

a. **Factor**: Frequency of risk analysis.

Root causes of failure

Not knowing when to carry out analysis and to what depth to do analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Planning for risk management process should begin when a project is conceived and should be completed early in the project. It may be necessary to revisit this process later in the project life cycle, for example at a major phase change, or if the project scope changes significantly, or if a subsequent review of risk management effectiveness determines that the Project Risk Management process requires modification.

b. **Factor:** Structuring of risk management activities.

Root causes of failure

Lack of structured approach to risk analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Use a structured risk management approach (eg. As per PMBOK, Chp 11) to make sure you reap the benefits.

c. **Factor:** Risk categories.

Root causes of failure

Not distinguishing the types of risks.

RIPs, counter measures and/or BPs that eliminate the root causes

Break down risk using risk breakdown structure into technical, management, commercial and external. Break these down further according to PMBOK, Chp 11, 2017.

d. Factor: How to perform risk management activities.

Root causes of failure

Not following a process.

RIPs, counter measures and/or BPs that eliminate the root causes

Risk management plan is a part of the project management plan that describes how risk management activities will be structured and performed. Project risk management includes the processes of risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project. Plan for these activities and put in place a process to follow like the one prepared in this work.

2. Leading Indicator: <u>Exhaustiveness of Risk Identification</u>

a. Factor: Risks identification through data.

Root causes of failure

Lack of awareness on ways to identify project risks.

RIPs, counter measures and/or BPs that eliminate the root causes

Though it is impossible to predict every single risk that may happen on a project, in most cases, running through the individual threats and opportunities for each phase of a project can help analysts spot risks early on. Use brainstorming, checklists and interviews as data collection tools to identify risks in a project.

b. Factor: Characteristics of identified risks.

Root causes of failure

Lack of awareness about effect of risk characteristics on risk response.

RIPs, counter measures and/or BPs that eliminate the root causes

Use risk characteristics in deciding how to respond like probability, strategic impact, urgency, detectability, severity, manageability, controllability, connectivity, proximity, dormancy and propinquity.

c. Factor: Identification of sources of risks.

Root causes of failure

Not identifying sources of risks.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify risk sources for example PESTLE (political, economic, social, technological, legal, environmental), VUCA (volatility, uncertainty, complexity, ambiguity), or TECOP (technical, environmental, commercial, operational, political), etc.

d. Factor: Involvement of stakeholders in risk identification.

Root causes of failure

Overlooking the importance of engagement.

RIPs, counter measures and/or BPs that eliminate the root causes

Involve stakeholders in risk identification through engaging them in brainstorming and interviews.

e. Factor: Listing of risk owners.

Root causes of failure

Not assigning risk owners.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign risk ownership based on whoever is in the best position to handle the risk.

3. Leading Indicator: Accuracy of Risk Prioritization

a. Factor: Classification of risks into types

Root causes of failure

Lack of systematic analysis of risks by classification based on impact or source.

RIPs, counter measures and/or BPs that eliminate the root causes

Classify risks into types based on the RBS you devised or based on the custom risk classification you devised.

b. Factor: Assessment of priority of risks based on probability.

Root causes of failure

Lack of prioritization strategy (probability or RPN or urgency or impact or some other prioritization criteria).

RIPs, counter measures and/or BPs that eliminate the root causes

You can prioritize based on frequency of occurrence (probability) or based on impact if a risk occurred. One simple method is to use frequency of occurrence, severity and detectability to calculate Risk Priority Number (RPN) and prioritize using RPN.

c. Factor: Identification of urgent risks.

Root causes of failure

Lack of identifying urgent risks.

RIPs, counter measures and/or BPs that eliminate the root causes

The project team and risk analyst may consider other risk characteristics while prioritizing individual project risks for further analysis and action in addition to probability and impact, one of which is urgency. Urgency is the period of time within which a response to the risk is to be implemented in order to be effective. A short period indicates high urgency.

d. Factor: Accuracy of assessment of probability and impact.

Root causes of failure

Not paying attention to accuracy of our data used in analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Assess accuracy of assessment of probability & impact based on accuracy of data used to make assessments and based on the accuracy of the model or software used for analysis.

4. Leading Indicator: Accuracy of Risk Models

a. Factor: Use of software & risk models

Root causes of failure

Lack of fund to buy software or lack of people with expertise to carry out quantitative risk analysis. CPM schedules quite overestimate completion time and cost.

RIPs, counter measures and/or BPs that eliminate the root causes

Quantitative risk analysis usually requires specialized risk analysis software and expertise in the development and interpretation of risk models. It also consumes additional time and cost.

b. Factor: Availability of high-quality data.

Root causes of failure

Lack of expertise in collecting high quality probability and impact data

RIPs, counter measures and/or BPs that eliminate the root causes

Undertaking a robust quantitative risk analysis depends on the availability of high-quality data about individual project risks and other sources of uncertainty.

c. Factor: Presence of sound baseline scope, schedule and cost.

Root causes of failure

Lack of well-developed baseline scope, schedule and cost.

RIPs, counter measures and/or BPs that eliminate the root causes

Undertaking a robust quantitative risk analysis depends on the availability of a sound underlying project baseline for scope, schedule, and cost.

d. Factor: Prioritized list of risks.

Root causes of failure

Lack of prioritized list of risks. Lack of systematic approach to risk analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Prioritized list of risk is obtained from qualitative risk analysis. Quantitative risk analysis may not be required for all projects.

e. **Factor:** Assessment of chances of project success.

Root causes of failure

Lack of this assessment.

RIPs, counter measures and/or BPs that eliminate the root causes

Quantitative risk analysis is most likely appropriate for strategically important projects, large or complex projects, contractually required risk analysis, or projects in which a key stakeholder requires it. Quantitative risk analysis is the only reliable method to assess overall project risk through evaluating the aggregated effect on project outcomes of all individual project risks and other sources of uncertainty. Use Monte Carlo simulation to accurately assess chances of project success.

f. **Factor:** Assessment of variability in outcomes.

Root causes of failure

Lack of thorough and/or systematic analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out assessment of variability in outcome using simulation and/or sensitivity analysis.

g. **Factor:** Trends of analysis result.

Root causes of failure

Lack of thorough and/or systematic analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Use trend of analysis result to guide your decision on risk response you select.

5. Leading Indicator: Optimality of Risk Response

a. Factor: Development of response options

Root causes of failure

Lack of exhaustiveness of options.

RIPs, counter measures and/or BPs that eliminate the root causes

Planning risk responses is the process of developing options, selecting strategies, and agreeing on actions to address overall project risk exposure, as well as to treat individual project risks.

b. Factor: Selection of strategies.

Root causes of failure

Lack of engagement of stakeholders in selection of strategies.

RIPs, counter measures and/or BPs that eliminate the root causes

Select the most effective and least costly option.

c. Factor: Agreement on actions to be taken.

Root causes of failure

Lack of engagement of stakeholders in selection of strategies or actions to be taken.

RIPs, counter measures and/or BPs that eliminate the root causes

Stakeholders need to agree on the actions to be taken and who takes the actions.

d. Factor: Allocation of resources.

Root causes of failure

Not allocating sufficient resources.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate the required resources to respond to the risks.

e. Factor: Incorporation of response activities into plan.

Root causes of failure

Not putting response activities on project schedule.

RIPs, counter measures and/or BPs that eliminate the root causes

Put the response activities on project schedule.

6. Leading Indicator: Optimality of Risk Response

a. Factor: Tracking/monitoring risks

Root causes of failure

Lack of persistence in tracking/monitoring risks.

RIPs, counter measures and/or BPs that eliminate the root causes

Monitor/track risks through technical performance data collection and analysis, reserve analysis, auditing effectiveness of the risk management process at appropriate frequency, through meetings (general or specifically risk review meeting.

b. Factor: Evaluation of risk response effectiveness.

Root causes of failure

Lack of exhaustive response analysis.

RIPs, counter measures and/or BPs that eliminate the root causes

Evaluate risk response activities for effectiveness so that you adjust the approach. One way is by auditing effectiveness of the risk management process at appropriate frequency, through meetings (general or specifically risk review meeting.

c. Factor: Risk status reporting.

Root causes of failure

Lack of frequent risk status reporting.

RIPs, counter measures and/or BPs that eliminate the root causes

The risk report describes sources of overall project risk and the current overall project risk status.

d. **Factor:** Identifying & analyzing new risks.

Root causes of failure

Assuming the risk register is static.

RIPs, counter measures and/or BPs that eliminate the root causes

Add any newly identified risks to the risk register and carry out analysis and response as appropriate.

F. Safety and Health Management

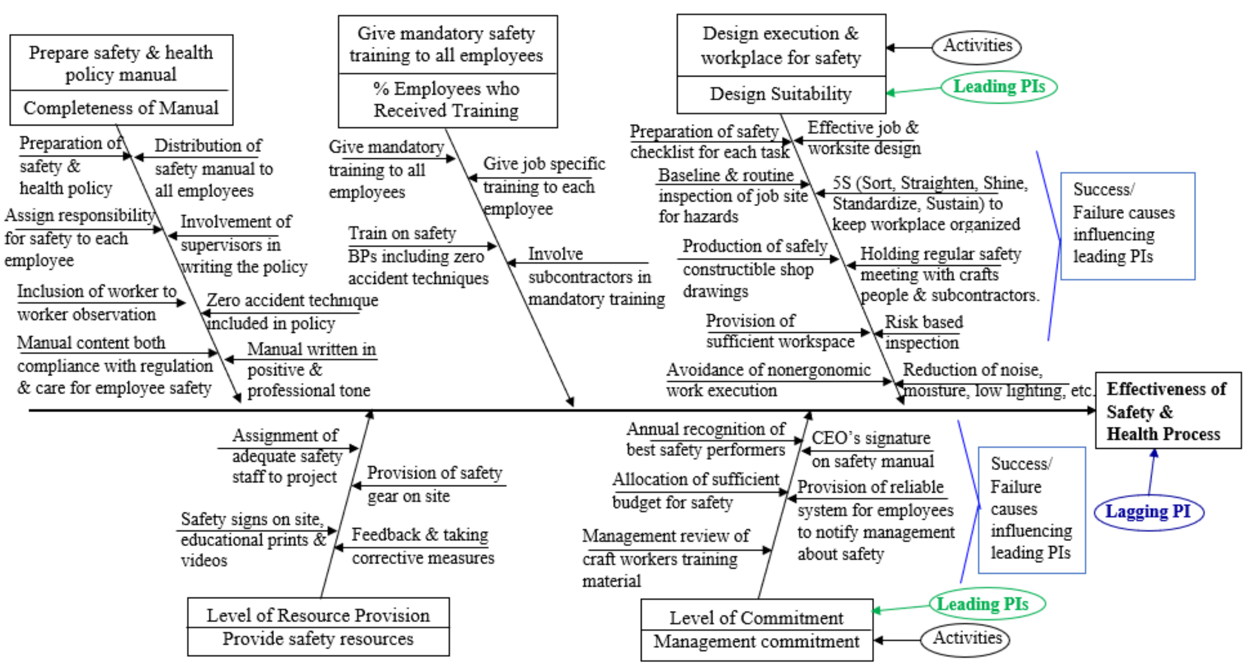


Figure E.30 Fishbone diagram for project safety and health management process

1. **Leading Indicator**: <u>Completeness of Safety Manual</u>

a. Factor: Preparation of safety & health policy.

Root causes of failure

Lack of policy. Lack of comprehensiveness to ensure safety and health.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare exhaustive policy using best practices from literature.

b. Factor: Distribution of safety manual to all employees.

Root causes of failure

Lack of distribution or manual not distributed to all.

RIPs, counter measures and/or BPs that eliminate the root causes

Distribute manual electronically to each employee. Prepare the top 10 or 20 in pictorial form to distribute to illiterate manual laborers.

c. Factor: Assigning responsibility for safety to each employee.

Root causes of failure

Vagueness on assignment of responsibility.

RIPs, counter measures and/or BPs that eliminate the root causes

Clearly write what is expected of each employee. Employees should be clear that their safety and safety of their fellow workers is in their hands. Tie safety performance to recognition and violation to serious penalty to the extent of losing their jobs.

d. Factor: Involvement of supervisors in writing the policy.

Root causes of failure

Lack of involvement of supervisors in policy writing, which causes them not to own the policy.

RIPs, counter measures and/or BPs that eliminate the root causes

Supervisors know the details and intricacies of tasks and so they know the hazards and best ways to prevent them. Use this wealth of information and experience. Involving supervisors in writing policy makes them own the policy and implementation will be eas.

e. **Factor:** Inclusion of worker to worker observation

Root causes of failure

Lack of awareness about the benefit of inclusion of worker to worker observation.

RIPs, counter measures and/or BPs that eliminate the root causes

Worker to worker safety observation is effective because 4 eyes are better than 2 eyes. When one is busy, others may see potential hazards and alert the operator of potential hazard.

f. **Factor**: Clarity of manual writing.

Root causes of failure

Lack of clarity and comprehensibility. Written to the level of people who write it, not to the level of the average audience.

RIPs, counter measures and/or BPs that eliminate the root causes

Write in Clear and simple words and sentence structures so that it is easily comprehensible to all employees. The majority of construction workers have a low educational level.

g. **Factor:** Manual content both compliance with regulation & care for employee safety

Root causes of failure

Often, manuals are written just to comply with government regulations.

RIPs, counter measures and/or BPs that eliminate the root causes

Success of most safety programs is not due to compliance. It is from safety programs exceeding compliance requirements. Employees feel respected and cared for if company dispatches its moral obligation to avoid harm and accidents to its employees.

h. Factor: Manual written in positive and professional tone.

Root causes of failure

Often manual writers do not pay attention to this aspect.

RIPs, counter measures and/or BPs that eliminate the root causes

Write in a tone that empowers and enables employees with the tone of "We can do it" stressing the benefits to the employee, the company and the society.

2. Leading Indicator: Percent Employees who Received Training

a. Factor: Give mandatory training to all.

Root causes of failure

Not implementing this requirement persistently.

RIPs, counter measures and/or BPs that eliminate the root causes

Give training on safety on root causes of accidents, how to prevent them, inspections before starting task and so on.

b. Factor: Give job specific training to each employee.

Root causes of failure

Giving general training, which many may not be able to transfer to their jobs well.

RIPs, counter measures and/or BPs that eliminate the root causes

Give job specific safety trainings (contextual), which is usable as it is without need to transfer or translate to their context.

c. Factor: Involve subcontractors in mandatory training.

Root causes of failure

Lack of inclusion of subcontractors in mandatory training.

RIPs, counter measures and/or BPs that eliminate the root causes

A large proportion of work is accomplished by subcontractors. Give job specific safety training to subcontractors because they may not have such training in house due to limited finance or expertise. Most subcontractors are small family owned businesses.

d. Factor: Train on safety BPs including zero accident techniques.

Root causes of failure

Lack of use of best safety practices, which are proven to be effective.

RIPs, counter measures and/or BPs that eliminate the root causes

Use best safety practices for fast and effective outcomes.

3. Leading Indicator: Design for Safety

a. Factor: Preparation of safety checklist for each task

Root causes of failure

No checklist prepared for each task.

RIPs, counter measures and/or BPs that eliminate the root causes

Prepare exhaustive list of items to check for safety from best experiences.

b. Factor: Effective job and worksite design.

Root causes of failure

Lack of effective job and worksite design or lack of awareness about its importance.

RIPs, counter measures and/or BPs that eliminate the root causes

Design the job content so as to enable decision, problem solving, empowerment and productive reflection. Design the worksite to eliminate travel and moving materials in a continuous work flow. Ensure safe accomplishments of tasks.

c. **Factor:** Baseline & routine inspection of job site for hazards.

Root causes of failure

Lack of job site inspection or incompleteness of inspection to identify all job hazards.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out baseline (minimum required to ensure safety) and routine inspection to check the most common source/cause of hazards for the job from past incidents.

d. **Factor:** 5S (Sort, Straighten, Shine, Standardize, Sustain) to keep workplace organized.

Root causes of failure

Lack of work place organization.

RIPs, counter measures and/or BPs that eliminate the root causes

Apply 5S to keep work place organized.

e. **Factor**: Production of safely constructible shop drawings

Root causes of failure

Lack of such considerations or not applied well.

RIPs, counter measures and/or BPs that eliminate the root causes

Make components easily constructible to reduce safety hazards. Components that are intricate or need exertion can contribute to occurrence of accidents.

f. **Factor:** Holding regular safety meeting with crafts people and subcontractors.

Root causes of failure

Not holding regular safety meeting with crafts people & subcontractors or lack of awareness about its benefits.

RIPs, counter measures and/or BPs that eliminate the root causes

Hold regular safety meetings with craftspeople and subcontractors. Require pretask safety meeting of crews.

g. **Factor:** Provision of sufficient workspace.

Root causes of failure

Lack of awareness.

RIPs, counter measures and/or BPs that eliminate the root causes

A worker needs a workspace of 200-300m2 depending on the task type. Operating in a limited work space can cause accidents.

h. **Factor:** Risk based inspection.

Root causes of failure

Lack of risk based inspection.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out inspection on risks known to exist from past occurrences. Carry out risk analysis based on probability of occurrence, severity and detectability.

i. **Factor:** Avoidance of nonergonomic work execution.

Root causes of failure

Not distinguishing nonergonomic positions.

RIPs, counter measures and/or BPs that eliminate the root causes

Use accumulated knowledge from ergonomic research to avoid nonergonomic positions and job execution.

j. **Factor:** Reduction of noise, moisture, low lighting, etc.

Root causes of failure

Not reducing environmental distractions.

RIPs, counter measures and/or BPs that eliminate the root causes

Reduce distractions in the work environment that increase job hazard.

4. Leading Indicator: Level of Resource Provision for Safety

a. Factor: Assignment of adequate safety staff to project

Root causes of failure

Lack of adequate safety staff on site.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign sufficient safety staff that inspect work site regularly and recommend safety corrections.

b. Factor: Provision of safety gear on site.

Root causes of failure

Not enforcing this requirement always.

RIPs, counter measures and/or BPs that eliminate the root causes

Require a 100% PPE on site.

c. Factor: Safety signs on site, educational prints and videos.

Root causes of failure

Not providing signs and/or information.

RIPs, counter measures and/or BPs that eliminate the root causes

Provide as much signs, educational/informational prints and videos. Make all information available to all.

d. Factor: Feedback and taking corrective measures.

Root causes of failure

Lack of feedback collection.

RIPs, counter measures and/or BPs that eliminate the root causes

Collect feedback from employees and use it to improve safety measures.

5. Leading Indicator: Level of Management Commitment to Safety

a. Factor: Annual recognition of best safety performers

Root causes of failure

Lack of formal recognition of best safety performers.

RIPs, counter measures and/or BPs that eliminate the root causes

Give recognition of best performance of required safety behavior to serve as an example for the rest to follow.

b. Factor: CEO's signature on safety manual.

Root causes of failure

Lack of such an emphasis on importance of safety.

RIPs, counter measures and/or BPs that eliminate the root causes

Get the CEO sign the manual that is distributed to all employees.

c. Factor: Allocation of sufficient budget for safety.

Root causes of failure

Budget constraint.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate sufficient budget if you want to get it done well.

d. Factor: Provision of reliable system for employees to notify management about safety.

Root causes of failure

Not setting up such infrastructure to collect any concerns or safety violations.

RIPs, counter measures and/or BPs that eliminate the root causes

Put in place a reliable reporting way that is easily accessible at place of work of all employee.

e. Factor: Management review of craft workers training material.

Root causes of failure

Not putting in this last important effort by management, which can improve the material or catch many errors.

RIPs, counter measures and/or BPs that eliminate the root causes

Review training materials to ensure the required content is covered and the information is communicated effectively to the craft level of understanding.

G. Scope and brief management

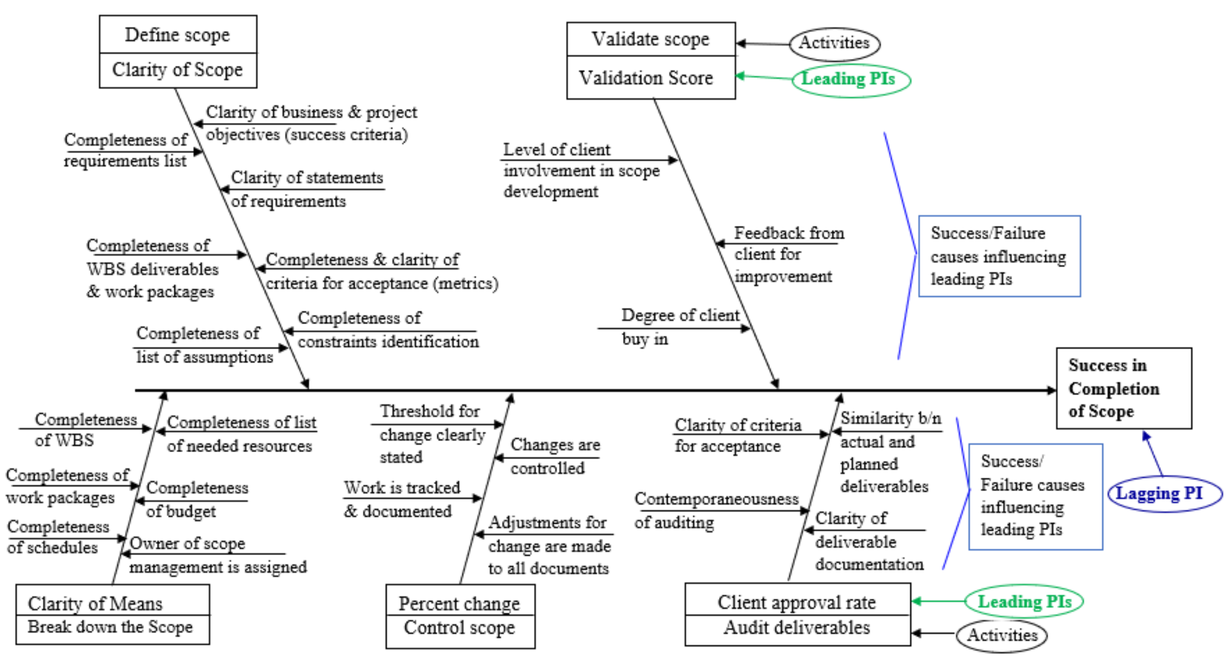


Figure E.31 Fishbone diagram for project scope and brief management process

1. Leading Indicator: Clarity of Scope

a. Factor: Inclusion of all plans.

Root causes of failure

Some plans missing or not well developed.

RIPs, counter measures and/or BPs that eliminate the root causes

Define, prepare, and coordinate all plan components and consolidate them into an integrated project management plan.

b. Factor: Clarity of project objectives.

Root causes of failure

Objectives not clearly defined or not measurable (not SMART). Lack of clarity and depth to the original specification document.

RIPs, counter measures and/or BPs that eliminate the root causes

Use project plans to help you achieve project objectives.

c. Factor: Choice of appropriate technology.

Root causes of failure

Much thought not put into technology selection.

RIPs, counter measures and/or BPs that eliminate the root causes

Compare existing with improved and choose based on cost and time. Prefabrication and preassembly may also be considered.

d. Factor: Exhaustive definition of all required tasks.

Root causes of failure

Lack of a robust WBS that decomposes deliverables into work packages.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop a logical, clear and exhaustive breakdown of project hierarchically into work packages.

e. Factor: Realistic estimation of required resources and durations

Root causes of failure

Lack of realistic estimate due to inexperience of estimators.

RIPs, counter measures and/or BPs that eliminate the root causes

Record standard resource requirements for each activity and adjust for the special conditions of particular project.

f. **Factor**: Choice of appropriate work methods.

Root causes of failure

Coice of methods less appropriate, costly or methods that can be executed with available equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Select most appropriate method in terms of cost efficiency, availability of equipment or other criteria.

g. **Factor**: Choice of appropriate work methods.

Root causes of failure

Choice of methods less appropriate, costly or methods that can be executed with available equipment.

RIPs, counter measures and/or BPs that eliminate the root causes

Select most appropriate method in terms of cost efficiency, availability of equipment or other criteria.

2. **Leading Indicator**: Validation of Scope

a. **Factor**: Competence and experience of planners.

Root causes of failure

Inexperienced planners assigned.

RIPs, counter measures and/or BPs that eliminate the root causes

Use experienced and top notch engineers.

b. **Factor:** Active engagement of implementers/ stakeholders.

Root causes of failure

Lack of engagement of all stakeholders.

RIPs, counter measures and/or BPs that eliminate the root causes

Get active stakeholder engagement in the development and composition of plans.

c. **Factor:** Accuracy of each component plan.

Root causes of failure

Poor quality content or missing items from plans.

RIPs, counter measures and/or BPs that eliminate the root causes

Follow process flow in developing each plan.

3. **Leading Indicator**: Consistency of Plans

a. **Factor**: Fair allocation of resources among plans

Root causes of failure

Lack of equitable resource allocation for optimum overall project performance.

RIPs, counter measures and/or BPs that eliminate the root causes

Allocate resources as you coordinate and integrate all plans based on overall optimal outcome.

b. **Factor:** Checking smooth flow of integrated plan.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Put tasks into process flows. Show tasks of all plans on an integrated schedule to help resolve issues.

c. Factor: Identification of interactions between tasks and plans.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Check task times and space requirements to avoid conflicts or congestion. Show tasks of all plans on an integrated schedule to help resolve interaction issues.

d. Factor: Reconciling conflicts between tasks/plans.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Check task times and space requirements to avoid conflicts or congestion. Show tasks of all plans on an integrated schedule to help resolve conflicts.

e. Factor: Identification of interactions between tasks and plans.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Check task times and space requirements to avoid conflicts or congestion. Show tasks of all plans on an integrated schedule to help resolve interaction issues.

f. Factor: Reconciling conflicts between tasks/plans.

Root causes of failure

Lack of time, space and resource requirements for tasks.

RIPs, counter measures and/or BPs that eliminate the root causes

Check task times and space requirements to avoid conflicts or congestion. Show tasks of all plans on an integrated schedule to help resolve conflicts.

4. **Leading Indicator**: Risk Resilience of Plans

a. Factor: Identification of long lead items

Root causes of failure

Lack of identification of long lead items.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify long-lead items to make sure these do no constrain construction operations.

b. Factor: Planned for scarce resources.

Root causes of failure

Lack of identification of and/or planning for scarce resources.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify scarce resources to make sure these do no constrain construction operations.

c. Factor: Accounted for environmental and regulatory requirements.

Root causes of failure

Missing some environmental and regulatory requirements in planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Show environmental and regulatory requirements on schedule and tie them to milestones.

d. Factor: Identified risks & uncertainties.

Root causes of failure

Missing some risks and uncertainties.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify risks using stakeholder survey & cause and effect diagrams and document their characteristics. Carry out analysis to the appropriate level of detail.

5. Leading Indicator: Risk Resilience of Plans

a. Factor: Identification of long lead items

Root causes of failure

Lack of identification of long lead items.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify long-lead items to make sure these do no constrain construction operations.

b. Factor: Planned for scarce resources.

Root causes of failure

Lack of identification of and/or planning for scarce resources.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify scarce resources to make sure these do no constrain construction operations.

c. Factor: Accounted for environmental and regulatory requirements.

Root causes of failure

Missing some environmental and regulatory requirements in planning.

RIPs, counter measures and/or BPs that eliminate the root causes

Show environmental and regulatory requirements on schedule and tie them to milestones.

d. Factor: Identified risks & uncertainties.

Root causes of failure

Missing some risks and uncertainties.

RIPs, counter measures and/or BPs that eliminate the root causes

Identify risks using stakeholder survey & cause and effect diagrams and document their characteristics. Carry out analysis to the appropriate level of detail.

H. Team Coordination and Management

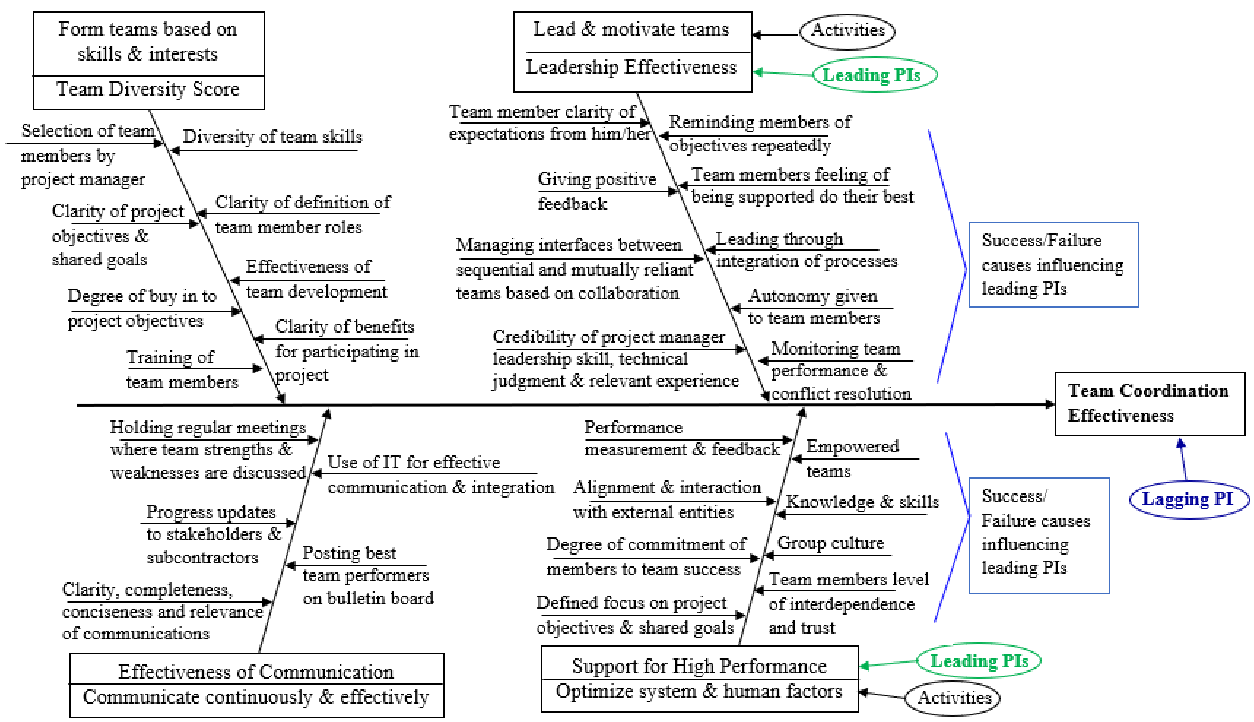


Figure E.32 Fishbone diagram for project team coordination and management process

1. **Leading Indicator**: Team Diversity Score

a. **Factor**: Selection of team members by project manager.

Root causes of failure

Project personnel are assigned to the project teams by functional managers, and the project manager has little or no input in the selection process.

RIPs, counter measures and/or BPs that eliminate the root causes

Let the project manager select his team members rather than functional managers assigning what is available vs the best.

b. Factor: Diversity of team skills.

Root causes of failure

Not paying attention to diversity in composing teams.

RIPs, counter measures and/or BPs that eliminate the root causes

Building project team is the process of transforming a collection of individuals with different needs, backgrounds and expertise into an integrated, effective work unit using various methods. In this transformation, the goals and energies of individual contributors merge and support the objectives of the team.

c. Factor: Clarity of project objectives.

Root causes of failure

Unclear project objectives.

RIPs, counter measures and/or BPs that eliminate the root causes

Project objectives should be crystal clear because if you do not know the destination, you cannot have a journey. This is the starting point for team formation and for leadership throughout the project life cycle.

d. Factor: Clarity of definition of team member roles.

Root causes of failure

Lack of clarity of team roles.

RIPs, counter measures and/or BPs that eliminate the root causes

Assign/ negotiate roles when people join your project team. It would be best to give them job descriptions. Ambiguous and overlapping and ambiguous role responsibilities are also major contributors to role conflicts.

e. Factor: Degree of buy in to project objectives

Root causes of failure

Lack of team member commitment.

RIPs, counter measures and/or BPs that eliminate the root causes

Try to resolve the root causes of lack of buy in such as insecurity, conflict, lack of interest, lack of alignment of project with career development goals.

f. Factor: Effectiveness of team development.

Root causes of failure

Lack of knowledge about the dynamics of team development.

RIPs, counter measures and/or BPs that eliminate the root causes

Team development passes through forming, storming, norming and performing. During the storming phase, constructive critique and conflict is the goal. The project manager may invite open sharing of ideas and even competing visions. Support everyone, especially those who tend to be insecure. Calm difficult people by reminding them to be civil. Stay positive.

g. Factor: Training of team members

Root causes of failure

Lack of skill enhancement on projects.

RIPs, counter measures and/or BPs that eliminate the root causes

Train team members that lack some skills needed for the job.

h. Factor: Clarity of benefits for participating in project.

Root causes of failure

Lack of clarity of benefits for participating in project.

RIPs, counter measures and/or BPs that eliminate the root causes

Let every project team know what rewards might result upon completion.

2. Leading Indicator: Leadership effectiveness

a. Factor: Team member clarity of expectations from him/her.

Root causes of failure

Lack of clarity on roles and responsibilities by team members.

RIPs, counter measures and/or BPs that eliminate the root causes

Make each team member roles and responsibilities clear once you have negotiated and agreed with them. Best to give job description to each.

b. Factor: Reminding members of objectives repeatedly.

Root causes of failure

Lack of helping team members focus.

RIPs, counter measures and/or BPs that eliminate the root causes

As a project manager, as part of motivating your team, remind them of project objectives and objective of each team member repeatedly.

c. Factor: Giving positive feedback.

Root causes of failure

Often focus on what is not accomplished as compared to those that are done well.

RIPs, counter measures and/or BPs that eliminate the root causes

Give positive feedback to each team member.

d. Factor: Team members feeling of being supported to do their job best.

Root causes of failure

Lack of support of each team member from the project manager.

RIPs, counter measures and/or BPs that eliminate the root causes

As a project manager, your job is to bring out the best from every team member by creating conducive environment for them.

e. Factor: Managing interfaces between sequential and mutually reliant teams based on collaboration.

Root causes of failure

Not managing interfaces and handoffs well for sequential and mutually reliant team.

RIPs, counter measures and/or BPs that eliminate the root causes

Manage especially interfaces and handoffs between teams because that is outside the responsibility of the teams. That is the responsibility of the project manager. Be proactive about it.

f. Factor: Leading through integration of processes

Root causes of failure

Lack of integration of processes.

RIPs, counter measures and/or BPs that eliminate the root causes

Empress on teams to focus on the whole process rather than efficiency of their individual tasks.

g. Factor: Credibility of project manager leadership skill, technical judgment & relevant experience.

Root causes of failure

Lack of appreciation of credibility to team success.

RIPs, counter measures and/or BPs that eliminate the root causes

Credibility of the project manager among team members is crucial. It grows with the image the project manager develops in the project team of a sound decision maker in both relevant technical expertise and general management. Credibility can be enhanced by the project manager's relationship to other key managers who support the team's efforts.

h. Factor: Autonomy given to team members.

Root causes of failure

Not giving autonomy.

RIPs, counter measures and/or BPs that eliminate the root causes

Give team members to decide about their jobs.

i. Factor: Monitoring team performance and conflict resolution

Root causes of failure

Lack of continuous monitoring.

RIPs, counter measures and/or BPs that eliminate the root causes

Project manager needs to conduct regular project status review meetings to keep project team informed about progress and watch for any unanticipated role conflicts over the project's life.

3. Leading Indicator: Effectiveness of Communication

a. Factor: Holding regular meetings where team strengths and weaknesses are discussed

Root causes of failure

Not holding regular meetings.

RIPs, counter measures and/or BPs that eliminate the root causes

Hold regular meetings as an effective communication method to discuss progress, weaknesses and strengths. Open communication in such teams means a focus on coaching instead of on directing and a focus on the ability to immediately address issues openly and candidly. The key to team performance is open lines of communication at all times to provide motivation, maintain interest and promote cooperation.

b. **Factor:** Use of IT for effective communication and integration.

Root causes of failure

Not using the potential of IT for communication and integration.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop project information system template and using it on project to facilitate and integrate communication.

c. **Factor:** Progress updates to stakeholders and subcontractors.

Root causes of failure

Lack of progress update.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out regular update to client, subcontractors and other stakeholders regularly.

d. **Factor:** Posting best team performers on bulletin board.

Root causes of failure

Not recognizing best performers.

RIPs, counter measures and/or BPs that eliminate the root causes

Recognize best team performers different ways. One way is posting best performers on project bulletin board.

e. **Factor:** Clarity, completeness, conciseness and relevance of communications.

Root causes of failure

Lack of clarity, completeness, conciseness or relevance of communication.

RIPs, counter measures and/or BPs that eliminate the root causes

Give clear complete, relevant and to the point information in communications.

4. Leading Indicator: Support for High Performance

a. Factor: Performance measurement & feedback

Root causes of failure

Lack of performance measurement.

RIPs, counter measures and/or BPs that eliminate the root causes

Carry out performance measurement as a feedback and management tool for continuous improvement.

b. Factor: Empowered work teams.

Root causes of failure

Lack of empowerment.

RIPs, counter measures and/or BPs that eliminate the root causes

Empowered work teams increase ownership, provide an opportunity to develop new skills, boost interest in the project and facilitate decision-making.

c. Factor: Alignment & interaction with external entities.

Root causes of failure

Lack of consideration with external entities whereas up to 90% of work may be subcontracted.

RIPs, counter measures and/or BPs that eliminate the root causes

Synchronous team performance in teams from different organizations.

d. Factor: Knowledge and skills.

Root causes of failure

Lack of awareness or appreciation of need for knowledge, skills and expertise in for project success.

RIPs, counter measures and/or BPs that eliminate the root causes

Project teams are typically time-limited and produce one-time outputs . Project team tasks are not repetitive and involve considerable application of knowledge, judgment and expertise. As a result, membership is usually diverse, drawing from different disciplines and functional units, so specialized expertise can be applied to the project.

e. **Factor:** Needs of individuals.

Root causes of failure

Not paying attention to the individual's needs as we work towards team objectives.

RIPs, counter measures and/or BPs that eliminate the root causes

Meet individual career, social and emotional needs while aligning it with team objectives. Career needs can be met by training and enhancing skills of individuals. As a team leaders insure that your members are always enhancing their skills—skills that include technical, problem solving, decision-making, interpersonal, and teamwork skills.

f. **Factor:** Group culture.

Root causes of failure

Not paying attention to or not working on building a good culture.

RIPs, counter measures and/or BPs that eliminate the root causes

Develop a good team culture where team members collaborate, share knowledge, communicate and most importantly support one another.

g. **Factor:** Defined focus.

Root causes of failure

Lack of defining focus of the team.

RIPs, counter measures and/or BPs that eliminate the root causes

Define the objectives clearly and let each team member grasp the objectives and let them select the role they want to play.

h. Factor: Team members level of interdependence and trust.

Root causes of failure

Lack of trust that eats away interdependence.

RIPs, counter measures and/or BPs that eliminate the root causes

Create a trusting relationship which is the basis for healthy interdependence for support, feedback and critique in a high performance team.

Project productivity:

Project productivity information detailed here is expounded treatment of the list in Table 2-7 and is mainly based on Nasir, 2013.

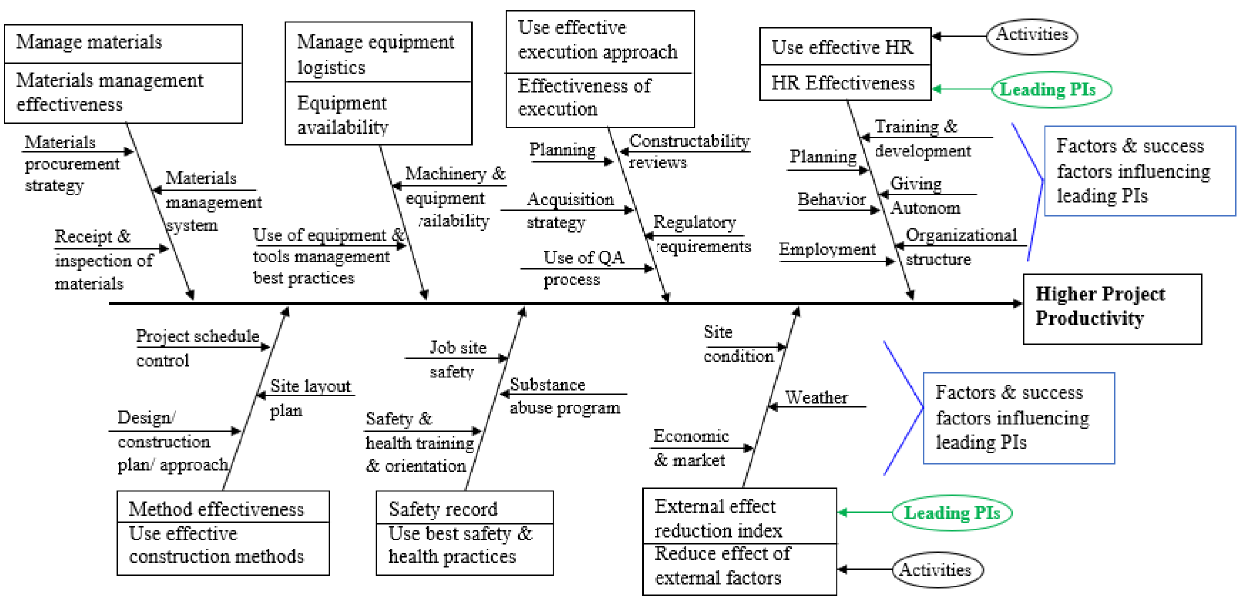


Figure E.33 Fishbone diagram for project productivity

1. Leading Indicator: Materials Management

a. Factor: A1.1. Procurement Procedures and Plans for Materials and Equipment [Right material unavailable at the time needed].

Root causes of failure

Lack of documented procurement plan for materials. Some items deficient in quantity or quality. Deficient procurement procedures, incomplete list of material prepared from construction program and schedule, poor communication between site and procurement dept , deficiency in logistics.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Borrow material from similar nearby project of own company (eg cement, steel bars, and the like).

Use expedited procurement and delivery to get material holding up work, possibly using own truck. Fill demand from head office store or from other projects of company.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Follow company guidelines, requirements, or systems for purchasing, expediting, and delivery of materials.

Use strategic approach to procurement. Follow standard company procedures and approvals. Prepare and follow list from program & schedule. Remind transport companies regularly and track shipments. Facilitate a purchasing system that has the capability of allowing field purchase of consumables. Develop a list of authorized suppliers. Integrate procurement schedule with a project information system that automatically updates the procurement schedule as the construction schedule changes.

Table E-1 Levels of use of best project productivity practices regarding procurement of materials and equipment:

Level 0	A procurement plan for materials and equipment is not applicable
Level 1	There is no documented procurement plan for materials and equipment
Level 2	A procurement plan and schedule exists only for large materials and equipment and costly items
Level 3	Continuation of Level 2, plus plan includes all materials, equipment, and consumables. Also, there is an established protocol for identifying reputation of potential vendors
Level 4	Continuation of Level 3, plus plan identifies necessary equipment and onsite resources to support delivery
Level 5	Continuation of Level 4, plus the procurement schedule is integrated with a project information system that automatically updates the procurement schedule as the construction schedule changes

b. Factor: A1.2. Long-Lead/Critical Materials Identification.

Root causes of failure

Lack of or deficient documented procurement plan for long-lead and critical materials. Lack of information and/or communication about long lead/critical items.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Borrow material from similar nearby company project or expedite purchase and bring by own truck.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Identify items requiring a long lead time for procurement ahead, adhere to the materials management plan, coordinate the procurement schedule of long-lead and critical materials with the construction schedule. Follow established protocol for identifying reputation of potential vendors.

Table E-2 Levels of use of best project productivity practices regarding long-lead/critical materials identification:

Level 0	A separate procurement plan for long-lead & critical materials and equipment is not applicable
Level 1	There is no documented procurement plan for long-lead and critical materials and equipment
Level 2	A procurement plan and schedule exists for long-lead & critical materials and equipment
Level 3	Continuation of Level 2, plus there is an established protocol for identifying reputation of potential vendors
Level 4	Continuation of Level 3, plus plan identifies necessary equipment and onsite resources to support delivery.
Level 5	Continuation of Level 4, plus the procurement schedule is integrated with a project information system that automatically updates the procurement schedule as the construction schedule changes.

c. Factor: A1.3. Procurement Team.

Root causes of failure

Lack of experience, dysfunctional team, incomplete information from design or poor communication, unethical team. Unclear expression and understanding of authority and responsibility for procurement of materials. Lack of integration with engineering, design, and construction schedules.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Assist team to do its job or use some time of lightly loaded experienced engineers in team leadership.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Assign a small team from the project team and give it responsibility for procurement and timely delivery of materials & equipment that work with procurement department. Hold meeting with team to discuss any issues and difficulties they face.

Table E-3 Levels of use of best project productivity practices regarding procurement team:

Level 0	A procurement team for materials and equipment is not applicable
Level 1	There is no procurement team for materials and equipment
Level 2	There is a designated procurement team at the main office but none at the project site
Level 3	There is a designated procurement team at the project level, but they can procure daily consumable materials and are not qualified and authorized to procure costly, long-lead critical materials and equipment
Level 4	Continuation of Level 3, plus the procurement team is qualified and authorized to procure all materials and equipment for the project.
Level 5	Continuation of Level 4, plus the procurement team has been integrated with other project teams such as engineering, design, construction, etc., and it is integrated with a project information system that automatically updates the procurement schedule as the construction schedule changes.

d. **Factor**: A1.4. Supplier prequalification & selection, early notification triggers for material supply.

Root causes of failure

Lack of timely supplier prequalification and selection, late notification of suppliers.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Support suppliers to expedite in case of late notification or pick supplier with good performance from list.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Support suppliers to expedite. Have a checklist of supplies and trigger dates for notification.

e. Factor: B1.1. Project Team Materials Status Database

Root causes of failure

Procedure for daily inputting data not established, procrastination of putting in data due to busy work schedule, absence of database, not user friendly package.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Get report on inventory level from project store clerk weekly or bi weekly.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Get report on inventory level from project store clerk weekly or bi weekly.

Table E-4 Levels of use of best project productivity practices regarding project team materials status database:

Level 0	Project team material status database is not applicable.
Level 1	There is no formal paper based system used to track materials status.
Level 2	There is a formal paper based system to track materials status.
Level 3	A proprietary internal materials status software tool is used, but it is not integrated with your company's project control systems or used by other contractors.
Level 4	An available software tool is used but it is only integrated internally with your company's project control systems.
Level 5	An available software tool is used by all stakeholders that are integrated with your supply chain and other project control systems.

f. Factor: B1.2. On-Site Material Tracking Technology [especially at projects with large laydown yards and costly materials and equipment].

Root causes of failure

Absence of material tracking package. People do not know how to use technology.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Get report on receipt, transfer & usage level from project store clerk weekly or bi weekly.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Avoid/minimize re handling of materials on site by delivery and storage close to area of use. Project team should decide whether an on-site material tracking system (such as Barcodes, Radio Frequency Identification (RFID) tags, Ultra-Wide Band (UWB) tags, Global Positioning Systems (GPS)) is required or not and cost efficiency also. Ask ICT unit to develop time sheet material tracking program to record receipt and transfer of materials to final installation. Automate & integrate the tracking system completely with other project processes.

g. **Factor**: B1.3. Materials Delivery Schedule

Root causes of failure

Schedule not prepared or incomplete, schedule not monitored/not acted on, resource loaded and leveled schedule not prepared or incomplete. Lack of experience of responsible person for tracking and reminding suppliers and truckers..

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Identify items urgently needed to expedite their delivery. Get updates at weekly meetings.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Consider a just-in-time delivery schedule if possible. Assign responsibility to track and remind to a person (possibly to store clerk).

Prepare material delivery schedule based on the materials procurement plan and follow it to trigger early notification of suppliers and truckers. Date and time of materials arrival at job site, date when the materials are required at site, storage of materials onsite.

Table E-5 Levels of use of best project productivity practices regarding material delivery schedule:

Level 0	Materials delivery schedule is not applicable.
Level 1	There is no documented materials delivery schedule.
Level 2	Materials delivery is planned early in the project and is integrated with a project schedule.
Level 3	Continuation of Level 2 plus the schedule is automatically updated on receipt of new information as procurement proceeds.
Level 4	Continuation of Level 3 plus the schedule is automatically linked with procurement, materials management, and overall project scheduling systems.
Level 5	Continuation of Level 4 plus materials delivery planning and management is completely integrated with other automated project processes including automated materials tracking throughout the supply chain.

h. Factor: C1.1. Materials Inspection Process

Root causes of failure

Lack of formal inspection process or deficiency in process, QA Process not followed well, Lack of knowledge of materials, inspector do not have full information about requirements in specifications. Wrong material or size or quantity delivered to site accepted by site people.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Use onsite experienced site and materials engineers to check materials against specifications before receipt. Return any material that doesn't meet specifications and drawings. Make relevant specification clauses & requirements ready and at hand when receiving materials on site and check as per normal practice, to be confirmed later.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Clearly state requirements to suppliers, which will later be used to check on receipt of material.

Make relevant specification clauses & requirements ready and at hand when receiving materials on site or when testing material pre dispatch from supplier facility. Define formal steps and activities of the inspection process, with approval signature by inspector after receipt of material. Organize materials receipt inspections immediately upon delivery of materials. Verify that the materials received conform to specifications, standards, drawings, etc. Separate materials into categorical stages of the receipt process (e.g. materials awaiting inspection, storage area restocking, scrap, and/or awaiting shipment). Record the locations of the materials and mark for tracking.

Table E-6 Levels of use of best project productivity practices regarding materials inspection process:

Level 0	A materials inspection process is not applicable.
Level 1	There is no materials inspection process.
Level 2	A materials inspection process is only utilized for large items or costly items on a project.
Level 3	A materials inspection process is utilized that includes all items delivered to the site. There is a lack of organization of the process, and materials are not separated into stages of the receipt process nor does it record the location of the materials and mark the materials for tracking
Level 4	A materials inspection process is used at the supplier and onsite, and organizes materials receipt inspections immediately upon delivery of materials, verifies that materials conform to standards, and organizes materials for tracking.
Level 5	Continuation of Level 4, plus the process includes separation of material into categorical stages of the receipt process (e.g. awaiting inspection, storage area restocking, scrap, and/or awaiting for shipment, verification if the materials conform to specifications, standards, drawings, etc., record of the location of materials and marked materials for tracking, and prioritization quality).

i. Factor: C1.1. Materials Inspection Process

Root causes of failure

Lack of experience or expertise in materials, incomplete information from design dept. and from specifications, dysfunctional team, lack of coordination of team effort, lack of coordination with client inspectors.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Identify items urgently needed to expedite their delivery. Site engineer may help team resolve problems.

Use onsite experienced site and materials engineers to check types, sizes and quantities against requirements before receipt.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Establish close relationships, and establish open and regular communication with teams. Appoint a team leader and give him/her responsibility. Train people in their areas of weaknesses.

Table E-7 Levels of use of best project productivity practices regarding materials inspection process:

Level 0	Materials inspection team is not applicable.
Level 1	There is no materials inspection team.
Level 2	There is a designated materials inspection team but no training and qualifications of the individual's skill level is specified.
Level 3	Continuations of Level 2, plus inspections are performed by project managers or craft workers rather than the team.
Level 4	Continuation of Level 3, plus the inspection team can adequately inspect materials and understand the material specifications.
Level 5	Continuation of Level 4, plus the members of the inspection team are experts at inspection processes and procedures, and knows how to inspect materials and understands the material specifications.

j. Factor: C1.3. Post Receipt Preservation and Maintenance

Root causes of failure

Lack of systematic/structured storage and record keeping, security problem (theft). There may not be post receipt preservation and maintenance plan.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Check store organization and implement 5S in store to keep place organized and clean. Get materials in store inspected to check condition and rectify any problems (eg. rust in steel, moisture damage to cement, security issues, etc.).

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Store items close to work area to avoid/minimize re handling of materials on site. Use site planning. Have specifications handy.

An inventory of materials should be made by recording the following information of the stored materials: location, description, quality, marking, preservation of the materials after delivery to the jobsite. Ask ICT unit to develop time sheet material tracking computer program to record receipt and transfer of materials to final installation and inventory status. Check condition of storage to avoid spoilage of material.

Table E-8 Levels of use of best project productivity practices regarding post receipt preservation and maintenance:

Level 0	Post receipt preservation and maintenance is not applicable.
Level 1	There is no post receipt preservation and maintenance plan.
Level 2	There is a plan for post receipt preservation and maintenance for large and/or costly items only.
Level 3	Continuation of Level 2, plus plan is used for all materials delivered to site. A plan for a complete inventory of the material after it has been delivered to the site and passed inspection is in place for the purpose of knowing the status and location of the material.
Level 4	Continuation of Level 3, plus plan includes materials to be stored in manner so it will be best preserved and maintained.
Level 5	Continuation of Level 4, plus there is a process in place to notify the inspection team of what must be done to preserve and maintain material while in storage. The inventory of materials is documented by recording the following characteristics of the stored materials: location, description, quality, and marking.

2. **Leading Indicator**: Machinery and Equipment Availability/Logistics

a. **Factor**: A2.1. Procurement procedures & plans for construction machinery

Root causes of failure

Deficiency in selection of most appropriate type and size of equipment, deficiency in selecting versatile equipment, deficient procurement procedures or deficient implementation, deficient or incomplete information on items to be procured, poor communication, lack of planning, deficient logistics management.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Borrow equipment from other project.

Use expedited procurement (renting) and delivery to get equipment holding up work or move equipment here from other project.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Select most appropriate versatile type and size of equipment. Follow up and remind logistics companies.

Prepare construction equipment procurement strategies such as hiring or leasing. Establish a procedure for identifying reputation of potential machine and equipment suppliers. Integrate construction equipment schedule with other project schedules. Coordinate the construction machinery procurement schedule with the construction schedule. Develop a list of authorized suppliers. Coordinate with equipment logistics to determine the required at site dates for required rental machinery.

Table E-9 Levels of use of best project productivity practices regarding procurement of materials and equipment:

Level 0	A procurement plan for construction machinery and equipment is not applicable.
Level 1	There is no documented procurement plan for construction machinery.
Level 2	A procurement plan and schedule exists for purchasing, leasing or renting construction machinery.
Level 3	Continuation of Level 2, plus there is an established protocol for identifying reputation of potential vendors.
Level 4	Continuation of Level 3, plus plan identifies necessary equipment and onsite resources to support delivery.
Level 5	Continuation of Level 4, plus the procurement schedule is integrated with a project information system that automatically updates the procurement schedule as the construction schedule changes.

b. Factor: A2.2. Long-Lead/Critical Machines Identification.

Root causes of failure

Lack of or deficient documented procurement plan for long-lead and critical machinery. Lack of information and/or communication about long lead/critical machines.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Borrow equipment from nearby company project or rent equipment from nearby.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Identify items requiring a long lead time with trigger points for notification in time for procurement ahead, adhere to the materials management plan, coordinate the procurement schedule of long-lead and critical materials with the construction schedule. Follow established protocol for identifying reputation of potential vendors.

c. Factor: A2.3. Procurement Team.

Root causes of failure

Lack of experience, dysfunctional team, incomplete information from design or poor communication, unethical team. Unclear expression and understanding of authority and responsibility for procurement of materials. Lack of integration with engineering, design, and construction schedules.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Assist team to do its job or use some time of lightly loaded experienced engineers in team leadership.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Assign a small team from the project team and give it responsibility for procurement and timely delivery of materials & equipment that work with procurement department. Hold meeting with team to discuss any issues and difficulties they face.

The project manager or site engineer may follow up team functioning. Ask team for weekly or monthly updates as appropriate. Project manager discusses procurement issues in site team meetings.

Table E-10 Levels of use of best project productivity practices regarding procurement team:

Level 0	A procurement team for materials and equipment is not applicable
Level 1	There is no procurement team for materials and equipment
Level 2	There is a designated procurement team at the main office but none at the project site
Level 3	There is a designated procurement team at the project level, but they can procure daily consumable materials and are not qualified and authorized to procure costly, long-lead critical materials and equipment
Level 4	Continuation of Level 3, plus the procurement team is qualified and authorized to procure all materials and equipment for the project.
Level 5	Continuation of Level 4, plus the procurement team has been integrated with other project teams such as engineering, design, construction, etc., and it is integrated with a project information system that automatically updates the procurement schedule as the construction schedule changes.

d. Factor: A2.4. Construction Machinery Productivity Analyses.

Root causes of failure

Machinery requirements and usage are not planned and tracked. Lack of computer program to record and analyze productivity & utilization, lack of persistence in productivity data collection, deficiency in communicating information with equipment dept.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Repeatedly remind equipment operators and supervisors of work that use machines to minimize downtime, to avoid loss and to make sure to make profit. Remind foremen to make sure their daily work assignments are sequenced and planned well, and not constrained by machine unavailability or low productivity.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Plan machinery requirements and usage and tie that to project schedule. Resource level schedule. Audit usage, report & track downtime, adjust equipment schedule/plan based on audit.

Table E-11 Levels of use of best project productivity practices regarding construction machinery productivity analyses:

Level 0	Use of Construction Machinery is not applicable.
Level 1	Construction Machinery is utilized but requirements and usage are not planned and tracked.
Level 2	Machinery requirements are planned and scheduled on a spreadsheet or tracking device but are not tied to a schedule. Usage is tracked against a budget activity.
Level 3	Continuations of Level 2, plus needs are reviewed regularly in planning meetings. A mechanism for resolving conflicts and allocation of machinery is established.
Level 4	Continuation of Level 3, plus schedule resource curves are driver in mobilization and demobilization of equipment on site. Schedule is resource levelled with consideration of minimizing in/out cycle of equipment and maximizing use.
Level 5	Continuation of Level 4, plus usage is audited and downtime reported and tracked, equipment schedule/plan adjusted as required based on audits.

e. Factor: A2.5. Construction Machinery and Equipment Maintenance

Root causes of failure

Lack of total preventive maintenance or deficient implementation, difficulty hiring experienced mechanics, not ready for breakage of the unexpected, not replacing equipment due to budgetary constraint.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Do routine checks and maintenance to keep machines usable. Fix any problems machines have and use them for the scheduled work. Move here equipment from other project if the problem is not fixable for the present task.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Keep each machine at its optimum benefit to cost ratio of operating it, otherwise dispose/sell it. Carry out preventive maintenance. Update maintenance schedule electronically and computer program is used to automatically issue maintenance due notices to concerned parties for each machine.

Table E-12 Levels of use of best project productivity practices regarding construction machinery and equipment maintenance:

Level 0	Equipment maintenance is not applicable.
Level 1	Equipment maintenance is not planned for on the project.
Level 2	On site equipment is logged in a manual or simplified spreadsheet database. Schedule of required maintenance per type of equipment is identified but not linked to individual construction equipment items with status. Maintenance is done routinely by operator request.
Level 3	Continuation of Level 2, plus equipment is linked to individual construction equipment items with status, and maintenance is centrally scheduled and accomplished.
Level 4	Continuation of Level 3, plus a computer based program is utilized for all equipment on site including scheduled and actual on / off site dates, required and accomplished maintenance logs and usage logs.
Level 5	Continuation of Level 4, plus on site or outsourced maintenance is identified with electronic links to required purchase order information. Routine maintenance schedule is electronically updated and maintenance due notices are automatically issued via an email system to required parties. Automated machine health monitoring and notification systems are also used to some extent.

f. Factor: B2.1. Site Tools and Equipment Management Strategy.

Root causes of failure

Poor tool management program. Not sorting tools in good condition from those needing maintenance/broken ones. Poor layout of gang boxes & tools room. Having only one big tools room instead of several small close to work areas.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Sort out and maintain or get rid of broken ones as appropriate. Design layout for tool room. Buy tools urgently needed from petty cash/consumables budget.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Select the most appropriate type and size of tool for each task. Use 5S. Construct small tools room at several places close to work. Set up a tool and equipment distribution strategy (e.g. tool box or toll & equipment storage area). Tool acquisition strategy that addresses both off-the-shelf (readily available) and custom (difficult to acquire) tools. Decide whether tool management is performed in house or by a third party vendor. All necessary tools and equipment must be properly accounted for before the beginning of the construction phase.

Table E-13 Levels of use of best project productivity practices regarding site tools and equipment management strategy:

Level 0	A site tool and equipment management strategy is not applicable.
Level 1	There is no site tool and equipment management strategy.
Level 2	The use of tool and equipment storage areas has been established.
Level 3	Continuation of Level 2, plus a decision of whether tool management will be performed in-house or by a third party vendor.
Level 4	Continuation of Level 3, plus temporary power requirements for tools have also been established and maintained during construction. Procedures are established to properly account for tools on a weekly or other regularly scheduled basis.
Level 5	Continuation of Level 4 plus includes the commitment of foremen and craft workers to be accountable for the proper care and use of the tools and equipment.

g. Factor: B2.2. Tools & Equipment Tracking

Root causes of failure

Lack of tools tracking system or deficiency in implementation. Not holding people in charge of tools accountable for lost items.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Prepare paper tracking and routing form and give it to tool room personnel. Establish procedures to properly account for tools on a weekly or other regularly scheduled basis.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Set up a tool and equipment distribution strategy (e.g. tool box or toll & equipment storage area) . Tool acquisition strategy that addresses both off-the-shelf (readily available) and custom (difficult to acquire) tools . Decide whether tool management is performed in house or by a third party vendor. Developing tools and equipment lists considering project requirements. Use a bar coding system on all small tools and equipment. Link a tool to a craftsmen’s ID when a tool is checked out.

Table E-14 Levels of use of best project productivity practices regarding tools and equipment tracking:

Level 0	Project tool and equipment tracking status database is not applicable.
Level 1	There is no database and no formal paper based system to track tools.
Level 2	There is no database, but there is a formal paper based system to track tool tracking status.
Level 3	A software application is used but not integrated with your company's other information technology systems.
Level 4	A software application is used and is integrated with your company's other information technology systems. The system includes bar coding of tools.
Level 5	Continuation of Level 4, plus the system also includes RFID tracking of tools and equipment.

h. Factor: B2.2. Tools and Equipment Tracking

Root causes of failure

Absence of mechanism for identifying tools that need routine maintenance or replacement. Absence of documented on-site tool maintenance plan.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Hire outside maintenance technician to fix tools and equipment that are out of order. Get critical tools needed for current job from head office or purchase them.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Keep record for tools and equipment status always. Develop a mechanism for identifying tools that require routine maintenance or replacement of wearable parts. Maintain tools to warranty specs throughout the lifecycle of the project. Establish points (e.g. operating hours or duration of tool ownership) when a worn part should be replaced. Assign train and qualified tool room personnel dedicated to repair and maintain tools or contract it to outside company to do maintenance.

Table E-15 Levels of use of best project productivity practices regarding tools and equipment tracking:

Level 0	On-site tool maintenance is not applicable.
Level 1	There is no documented on-site tool maintenance plan.
Level 2	A mechanism for identifying tools that require routine maintenance or replacement of wearable parts is established.
Level 3	Established points of tool use (e.g. operating hours or duration of tool ownership) are set when tools are inspected for required maintenance.
Level 4	Continuation of Level 3, plus a contract has been established with outside vendor or other personnel offsite to provide required maintenance.
Level 5	Continuation of Level 4, plus qualified and dedicated personnel in the tool room exist to provide tool maintenance and repairs.

i. **Factor**: B2.4. Construction Machinery & Equipment Utility (consumables and inputs) Requirements

Root causes of failure

Not meticulously identifying inputs/consumptions of machines for optimum performance. Absence of documentation of machinery & equipment utility requirement..

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

check machines and equipment operating manuals for optimum performance and to avoid damaging machines.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Power and water requirements of all machines must be established during planning phase and for applying to utility companies for connections. Establish temporary utility requirements also. Avoid wastage of utilities/power. Power (hard line, solar, auxiliary), water, air and specialty gases, fuel, communications (cables, fiber-optics), other user defined inputs to operate machines and equipment efficiently. Use commitment of foremen and craft workers to be accountable for the proper care and use of the machinery and equipment.

Table E-16 Levels of use of best project productivity practices regarding construction machinery & equipment utility (consumables and inputs) requirements:

Level 0	A machinery and equipment utility requirement is not applicable.
Level 1	There is no machinery and equipment utility requirement documented.
Level 2	The machinery and equipment utility requirements have been established.
Level 3	Continuation of Level 2, plus a decision of whether utility requirements will be performed in-house or by a third party vendor.
Level 4	Continuation of Level 3, plus temporary utility/power requirements for machinery and equipment have also been established and maintained during construction. Procedures are established to properly account for requirements on a weekly or other regularly.
Level 5	Continuation of Level 4 plus the commitment of foremen and craft workers to be accountable for the proper care and use of the machinery and equipment.

3. Leading Indicator: Effectiveness of Execution

a. Factor: A3.1. Short Term Planning (Look ahead (2-5 weeks) and weekly work planning must be done each week)

Root causes of failure

Failure of short term plans is due to deficiency in one or more of the following: scattered and evolving information (e.g. physical environment, underground conditions, weather, etc), availability and supply of resources, unexpected coordination problem with other crews, unknown technical conflicts.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Collect as much information as possible to correct deficiencies and fire fight the urgent critical path tasks. Put team of foremen and supervisors/superintendents together to produce temporary solution.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use foremen planning, supervisors quality circles and operations/systems analysis consultant to do planning of different breadth on site. Shield work from upstream variability. Have workable backlog for which constraints are removed. Design work in continuous flow process to force visibility. Use visual control. Plan well and use planning system that causes work to flow across the value stream (to reduce the effects of dependence and variation).

Utilize short interval planning (look ahead and weekly planning) by detailing the required materials, tools and equipment, labor, and project information required to complete each task and to identify & remove constraints. Resource load activities in the project schedule. Avoid congestion. Plans should show: the tasks to be performed, the numbers of craft workers needed for each task, the estimated duration for each task, the required materials, tools and equipment, labor, and project information required to complete each task. Focus on creating predictability by helping everyone keep his/her commitments..

Table E-17 Levels of use of best project productivity practices regarding short term planning (Look ahead (2-5 weeks) and weekly work planning must be done each week):

Level 0	The use of short interval plans are not applicable.
Level 1	The use of short interval plans has not been addressed.
Level 2	Short interval planning is utilized by taking action based on reported status of on-going activities. Activities in the project schedule are not resource loaded and short interval plans do not detail the required materials, tools and equipment, labor, and required project information.
Level 3	Short interval planning is utilized by detailing the required materials, tools and equipment, labor, and project information required to complete each task. Activities in the project schedule are not resource loaded.
Level 4	Continuations of Level 3, plus activities in the project schedule are resource loaded to help with short interval planning. The short interval plan considers the effects of craft density due to other area activities and potentially related impacts of congestion and coordination issues.
Level 5	Continuation of Level 4, plus constraints from required deliverables, materials, equipment, labor and information are visible by area. Alternate plans are prepared such as modified equipment/machinery schedules, shortened shifts, lengthened shifts, or added shifts in case the original plans did not work.

b. Factor: A3.2. Well defined scope of work

Root causes of failure

Vaguely defined scope for some or all members of the project team due to one or more: the project's goals are not clearly described, the owner's vision for the facility are not clearly described, lack of clarity on basic requirements of the project, clear delineation of the timeframe of all the work involved to produce the project's deliverables. Work is released to the field on drawings with incomplete design, and execution is controlled with a milestone schedule. Constructability not reviewed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Use previous experience to come up with way of meeting scheduled critical path items to avoid delaying the project.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use previous experience to come up with way of meeting scheduled critical path items to avoid delaying the project.

Table E-18 Levels of use of best project productivity practices regarding defining work well:

Level 0	A well-defined scope of work is not applicable.
Level 1	Work is released to the field on drawings with incomplete design, and execution is controlled with a milestone schedule.
Level 2	Continuation of Level 1, plus design is complete. Work is released to the field via drawings without constructability review; execution is controlled with a master schedule.
Level 3	Continuation of Level 2, but with scope and design being complete. Also, Constructability review has been performed and execution is controlled with and integrated schedule.
Level 4	Continuation of Level 3, plus duration for scope of the work package is defined, material availability, testing and inspection requirements are defined, man-hours are charged against the work package, but budget and quantities are not reflected in scope of work.
Level 5	Continuation of Level 4, plus budget, quantities, and man-hours for the scope of work are reflected in the overall schedule. Completion percentage of the work package will be reflected in the integrated schedule.

c. Factor: A3.3.Use of Software

Root causes of failure

Lack of use of the potential of planning and CAD software for planning and scheduling to improve efficiency and productivity. Lack of knowledge to use full capability of software a company owns like MS Project or Primavera.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

The cheapest to use and find is excel for immediate solution. Use paper and pencil for emergency situation. Use print outs from MS Project if software is available.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Give training on use of software on projects. Use software for construction efficiency in scheduling (weekly, monthly, etc.), materials identification, materials delivery, managing life cycle data including asset information, models, and electronic documents, different project information, Civil Information System (CIS), Geographical Information System (GIS), Building Information Modeling (BIM) and Work packages. Use a software system to track the generation and closure of work packages, sign off work steps electronically and update work package status electronically.

Table E-19 Levels of use of best project productivity practices regarding use of software:

Level 0	Utilization of software in planning is not applicable.
Level 1	The project uses a software system to track the generation and closure of work packages. However, it is not integrated, material status and drawing status must be entered manually. Work steps are signed off in the package when completed.
Level 2	Continuation of Level 1, plus percent complete is entered by reviewing the package. Work package status is updated to the master schedule manually.
Level 3	Continuation of Level 2, plus the project uses a software system to generate the work package and automatically includes the drawings and material delivery status. Schedule, percent complete, test and inspection status, and closure must be entered manually by review of the work package.
Level 4	Continuation of Level 3, plus which is updated regularly and automatically includes and provides current design drawing information, updated status of materials, implementation schedule with durations and quantities, test and inspection status, percent complete and closure. Work steps are signed off electronically, however work package status is updated to the master schedule manually.
Level 5	Continuation of Level 4, plus work steps are signed off electronically and work package status is updated electronically.

d. **Factor**: A3.4.Dedicated Planner

Root causes of failure

Lack of specifically dedicated planner for the planning, monitoring, reporting of the construction schedule, coordinating the schedule planning with procurement, engineering, design, and others. Most companies using one scheduler at head office with poor information on progress and status on site. Relying on electronic status communication, which is not as effective as being on site.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Construction manager or assistant to the project manager may serve as a planner temporarily or work with head office scheduler. Best practice is to get weekly update on planning as it is critical to project success.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Update schedule, material status, delivery dates of material and equipment continuously, preferably using synchronized and integrated project software. Assign dedicated planner who: plan all necessary work related to project construction schedule, organize the timelines for all construction activities, initiate and communicate regarding the confirmation and inspection of all items delivered, outstanding/past due items, update schedule as needed, obtain feedback/approval of field supervisors for construction schedule, update scheduling and management as appropriate. Handling of outstanding, past due items at lowest level, escalate as necessary based upon severity, impact on schedule, and past due status timeline , integrate communication of release, tracking, and consumption of materials into schedule. synchronize and coordinate through utilization of project software.

Table E-20 Levels of use of best project productivity practices regarding use of dedicated planner:

Level 0	Dedicated planner is not applicable.
Level 1	Hiring of dedicated planner has not been addressed.
Level 2	Dedication of single planner or multiple personnel with specific sectional responsibilities based upon project scope, size, and need. Initial planning needs to be coordinated with procurement, planning, and others. High level synchronization driven through utilization of project software.
Level 3	Initiate & maintain communication regarding the confirmation & inspection of all items delivered, outstanding/past due items. Update scheduling and management as appropriate. Handling of outstanding, past due items at lowest level, escalate as necessary based upon severity, impact on schedule, and past due status timeline.
Level 4	Continuation of Level 3, plus continued update of scheduling & management. Onsite inspection as necessary regarding the release, tracking, and consumption of materials. Escalated precedence on outstanding and past due items. Report progressing & audit of progressing, validate to schedule.
Level 5	Continuation of Level 4, plus continued communication of release, tracking, and consumption of materials. Initiate completion milestone, return to stores unused/not needed materials. Final validation and auditing.

e. Factor: A3.5.Advanced Construction Work Packages (AWP)

Root causes of failure

Incomplete work packages missing one or more information, which renders them inexecutable.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Use foremen, supervisors and superintendents expertise to develop executable work package for current tasks.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Take time to plan the AWP to the level of easily executable construction tasks based on the scope of work and information provided in the AWP. Keep all work faces productive, especially with critical path tasks. All work should have a responsible owner. Use standardization, prefabrication and preassembly as much as possible. Develop advanced work package that is clear, complete and executable consisting of: construction scope of work, engineering information, craft / manpower, direct field equipment and materials, safety, quality, special permits / regulatory requirements, subcontractors, vendor support data, rigging studies; scaffolding, special construction equipment, tools and consumables, risk register, project controls, turnover documents and contact list.

Table E-21 Levels of use of best project productivity practices regarding Advanced Construction Work Packages (AWP):

Level 0	Completion of construction work packages is not applicable.
Level 1	Required construction work packages have not been addressed.
Level 2	Construction work packages are partially complete, though there are several sections that remain incomplete. A basic budget and schedule has been completed.
Level 3	All sections of the construction work packages have been addressed. The sections display no in-depth consideration.
Level 4	Continuation of Level 3, plus in-depth consideration for most of the sections. A comprehensive schedule and budget has been provided.
Level 5	Continuation of Level 4, plus all sections have received in-depth consideration. The construction task can be performed easily based on the scope of work and information provided in the construction work packages.

f. **Factor**: A3.6.Coordination drawing with subcontractors

Root causes of failure

Separately developed drawings and plans miss the real time putting together of elements, which causes clashes, congestion and problem with work sequence.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Project manager may discuss it in weekly meeting with subcontractors, get their information and construction manager may draw coordination drawing for current and near-term tasks.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use ICT for seamless communication and coordination. Manage sequential and mutually reliant teams based on collaboration. Develop a drawing that shows own tasks and all subcontractors with time using color codes. 3D drawings and color coded BIM are very effective. Use these to detect clashes, congestion, unrealistic tasks to execute, etc.

g. **Factor**: B3.1. Design readiness for construction and completeness of design

Root causes of failure

Design readiness for construction is not addressed. Incomplete designs, inadequate designs and lack of inclusion of client/owner activities in schedule causes schedule changes and schedule disasters. Schedule is not ready for design before actual construction begins or before relevant phase is mobilized.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Focus in getting design completed and ready if it is not. Prepare shop drawings.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use top company expertise at this critical phase of project to proactively avoid many problems. Confirm that design for all phases of construction is complete and adequate, and complete schedule before mobilizing any phase of construction.

Involve the owner in the schedule preparation and integrate owner activities in the schedule.

Use critical path scheduling, reverse phase scheduling, or coordination drawings or some other means of coordination of the project's activities.

Table E-22 Levels of use of best project productivity practices regarding design readiness for construction and completeness of design:

Level 0	Design readiness for construction is not applicable.
Level 1	Design readiness for construction is not addressed.
Level 2	Some scheduling and coordination of the phases of construction has been performed by the General Contractor, Construction Manager, or another agent of the Owner.
Level 3	Continuation of Level 2, plus the General Contractor, Construction Manager, or another agent of the Owner has created a detailed schedule for all phases of construction.
Level 4	Continuation of Level 3, plus the owner is more involved and all phases of the project have been determined and the schedule is complete before construction. The schedule or sequence of activities may change after construction starts.
Level 5	Continuation of Level 4, plus scheduled to be completed before construction and any relevant phases are mobilized. This scheduling utilizes critical path scheduling, reverse phase scheduling, or some other means of coordination of the project's activities.

h. Factor: B3.2. Utility Alignment and Adjustments

Root causes of failure

Construction plan not accounting for constraint paused by utilities in planning and scheduling can cause delays.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Expedite things if there are any delays in the process of marking utilities or rerouting utilities.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Properly review arrangements for working around or rerouting the utilities should be included. Get city approvals for detours around utilities. Communicate with businesses and local community/residencies and make arrangements for temporary shut offs and interruptions. Have a review process when constructing a facility that crosses or runs parallel to utilities. List utilities, locations, and put warning signs. Put physical markings to delineate and protect the horizontal route of underground facilities from being damaged, construct detours, and integrate all activities related to utilities alignments with other project schedules.

Table E-23 Levels of use of best project productivity practices regarding utility alignment and adjustments:

Level 0	Utility alignment/adjustment is not applicable.
Level 1	Utility alignment/adjustment is not addressed.
Level 2	The project has a review process for working in areas surrounding utilities. The process includes list of utilities, locations, and warning signs.
Level 3	Continuation of Level 2, plus necessary detours have been planned when necessary. City approvals have been obtained.
Level 4	Continuation of Level 3, plus communication with businesses and local community/residencies have been made. Arrangements for temporary shut offs and interruptions have been made.
Level 5	Continuation of Level 4, plus the physical markings described to mark the horizontal route of underground facilities have been protected, detours have been constructed, and the all activities related to utilities alignments have been integrated with other project schedules.

i. Factor: B3.3. Contract Types/Strategies (contract risk minimization)

Root causes of failure

Deficiency in selection of appropriate type of contract for a sub task of project and in risk allocation associated with types of contracts.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Write fair contracts to avoid adversarial relationships. Establish protocols for selecting designers, contractors, suppliers, and manufacturers and use benefit-cost analysis to select from different contract types and project delivery methods. Identify the corresponding fee/payments structure and risk allocation. Study and monitor the local conditions in the project area including labor market regularly.

Table E-24 Levels of use of best project productivity practices regarding contract types/strategies (contract risk minimization):

Level 0	Contract types/strategies is not applicable.
Level 1	Contract types/strategies is not addressed.
Level 2	The project has a review process for project design and construction delivery. It considers fee structure and financing options, but risks associated with different contract types are not considered.
Level 3	Continuation of Level 2, plus risks associated with different contract types are also considered. Cost benefit analysis for different types of contracts and project delivery methods are performed.
Level 4	Continuation of Level 3, plus the labor market information and reports are also studied and considered before awarding contracts.
Level 5	Continuation of Level 4, plus the local conditions in the project area are studied and monitored regularly. The company has established protocols for selecting designers, contractors, suppliers, and manufacturers.

j. **Factor**: B3.4. Design improvement

Root causes of failure

Lack of expertise to improve design on part of the contractor. Approval by client's engineer may take long time because the engineers may not have the incentive and the obligation to do the review.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Look for improved design or construction methods that saves time and cost.

k. **Factor**: B3.5. Model Requirements/3D Visualization

Root causes of failure

Many contractors may not have the expertise to do 3D and 4D modeling.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Hire one senior engineer with CAD and BIM experience and hire young graduates out of college to work under the senior engineer to build capacity in this area.

Table E-25 Levels of use of best project productivity practices regarding model requirements/3D visualization:

Level 0	Project model requirements are not applicable.
Level 1	Level 1 Integration of the projects 3D and schedule information has not been addressed
Level 2	Level 2 A 4D Model has been established for the project.
Level 3	Continuation of Level 2 plus includes basic updates manually made based on scheduled changes.
Level 4	Continuation of Level 3, plus the model is dynamic and includes material specifications, change order documentation, and other pertinent design and construction information related to the 4D model.
Level 5	Continuation of Level 4, plus automatically updated based work progress as measured ubiquitously by RFID, laser imaging or other technologies is also automatically updated based on scheduled changes.

l. **Factor**: 3.6. Simplification to overcome project complexity and relative level of work difficulty

Root causes of failure

Lack of accounting for project complexity in preparing shop drawings and work methods.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Prepare simplified designs and shop drawings with more details, use simpler work methods to reduce work hours and safety risks to workers. Use simulation to show how construction progresses..

m. **Factor**: C3.1. Right of Way, Land, and Utilities Acquisition Strategy

Root causes of failure

Lack of due attention to securing right of way, land and utilities..

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Hire an expeditor to follow right of way and land acquisition matters and compensation payments.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Implement a public consultation process. Pay special attention to identification of long-lead and problematic parcels of land. Relocation of existing land owners. Identifying responsible parties for land acquisition and utility adjustments. Appraisal issues. Dealing with existing structures. Establish a review process for identifying and acquiring right-of-way and utility adjustments for long-lead parcels of lands, which have historically been found problematic. Log all property descriptions into project information systems and integrate them with project schedules.

Table E-26 Levels of use of best project productivity practices regarding right of way, land, and utilities acquisition strategy:

Level 0	Right-of-way and land acquisition are not applicable.
Level 1	There is no documented right-of-way and land acquisition plan.
Level 2	The project has a review process for identifying and acquiring right-of-way and utility adjustments for long-lead parcels of lands, which have historically been found problematic.
Level 3	Continuation of Level 2, plus plan identifies and acquires all right-of-way, utilities, and parcels of land in the project's scope. It has identified responsible parties for dealing with these matters.
Level 4	Continuation of Level 3, plus all information related to property descriptions from survey information have been transformed into a form of documentation that can be logged into project information systems.
Level 5	Continuation of Level 4, plus all property descriptions have been logged into project information systems and integrated with project schedules.

n. Factor: C3.2. Contracts and Agreements with Public Agencies

Root causes of failure

Utility agreements and joint use contracts is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Get utilities sign joint use agreement with client, which effectively allow the utility to share space on public or private right-of-way. Ensure that the review and approval processes are coordinated in a timely and efficient manner. Have in place contractual agreements with local public agencies regarding compliance with local regulations and procedures, administration and acquisition of right of way (who will be responsible for acquisition and payments, owner or public agencies) and long term operations and maintenance of utilities and cost sharing.

Table E-27 Levels of use of best project productivity practices regarding contracts and agreements with public agencies:

Level 0	Contracts and agreements with local public agencies are not applicable.
Level 1	Contracts and agreements with local public agencies is not addressed.
Level 2	The project has a review process for working with local agencies, but no formal contracts and agreements have been signed.
Level 3	Continuation of Level 2, plus formal contracts and agreements have been signed. Approvals from concerned agencies have been obtained.
Level 4	Continuation of Level 3, plus all activities related to contracts and agreements have been integrated with other project schedules.
Level 5	Continuation of Level 4, plus automatic reminders for renewal are generated in advance before a contract or agreement expires.

o. Factor: C3.3. Utility Agreements

Root causes of failure

Utility agreements and joint use contracts is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Address utility agreements as soon as possible.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Show utility agreements on schedule. Identify Public or private utilities. Prepare and sign utility agreements, plans, documentation, estimate, etc. Get crossing permits for highways, railroads, canals, etc. Determine compliance requirements with concerned jurisdictional requirements and approvals.

Table E-28 Levels of use of best project productivity practices regarding utility agreements:

Level 0	Utility contracts and agreements are not applicable.
Level 1	Utility agreements and joint use contracts is not addressed.
Level 2	The project has a review process for utility agreements and the use of utilities, but no formal contracts and agreements have been signed.
Level 3	Continuation of Level 2, plus formal contracts and agreements have been signed for utilities use and adjustments. Approvals from concerned agencies have been obtained.
Level 4	Continuation of Level 3, plus all activities related to contracts and agreements have been integrated with other project schedules.
Level 5	Continuation of Level 4, plus automatic reminders for renewal are generated in advance before a contract or agreement expires.

p. **Factor**: D3.1. Environmental Requirements

Root causes of failure

Lack of attention to environmental requirements.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Tie environmental requirements to schedule & milestones. Identify environmental documentations (environmental assessments (EA), environmental impact statements (EIS), environmental impact report (EIR), jurisdictional environmental policies, Federal and Provincial environmental policies to comply with and mitigation techniques for habitat, water quality, wetland, storm water, cultural resources, noise and how to comply with these.

Table E-29 Levels of use of best project productivity practices regarding environmental requirements:

Level 0	Environmental requirements are not applicable.
Level 1	Environmental requirements and related issues have not been addressed.
Level 2	Initial investigations based upon environmental assessments and reports, jurisdictional and federal policies, mitigation techniques, timeline to attain, assignment of environmental responsibilities, pre-construction requirements has been completed.
Level 3	Continuation of level 2, plus environmental requirements tied to scheduling and milestones.
Level 4	Continuation of Level 3, plus system established for tracking & monitoring of environmental requirements, release, and closeout driven by requirements.
Level 5	Continuation of Level 4, plus system is automatically updated based on continued updates to schedule, permit closeouts, escalation of delays due to permit as deemed necessary dependent on severity of issue & assistance required.

q. **Factor**: D3.2. Regulatory Requirements/Permitting Requirements

Root causes of failure

Required permitting has not been addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

List down all permits required on project and show them on schedule. Identify and plan for getting the different permits required to complete the project such as access to jobsite, city permits, provincial permits federal permits, etc.

Table E-30 Levels of use of best project productivity practices regarding regulatory requirements/permitting requirements:

Level 0	Regulatory/Permitting requirements are not applicable.
Level 1	Required permitting has not been addressed.
Level 2	Initial investigations based upon projected needs of permits, timeline to attain, how long permit is good for, are multiple permits needed, assignment of permit responsibility, signoff authority, pre-inspection requirements, fees have been completed.
Level 3	Continuation of level 2, plus permit requirements tied to scheduling & milestones.
Level 4	Continuation of Level 3, plus system established for tracking of permit acquisition, release, and closeout driven by requirements and as designated by permit type.
Level 5	Continuation of Level 4, plus system is automatically updated based on continued updates to schedule, permit closeouts; escalation of delays due to permit as deemed necessary dependent on severity of issue & assistance required.

r. **Factor**: E3.1 Supervision of all work for completion without stopping

Root causes of failure

Oversight or inattention by supervisors and project management team..

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Management/supervisors should increase their presence during key times of the day. Prepare AWP and plan construction tasks in a continuous flow from start to finish without stopping which helps force visibility.

s. **Factor**: E3.2 QA verification before any work starts

Root causes of failure

Not following QA process and procedure. Oversight or inattention by QA personnel.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Put poka-yoke in place. Make sure QA and other aspects of AWP is complete and the package is ready to complete without stopping..

t. **Factor**: E3.3 QA supervision and monitoring

Root causes of failure

Not following QA process and procedure for QA surveillance. Oversight or inattention by QA personnel.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Put poka-yoke in place. Supervise the material and workmanship through out to completion.

u. **Factor**: E3.4 Continuous cost control and monitoring

Root causes of failure

Procrastination to input/keep records contemporaneously. Lack of software for input and analysis.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use proactive prevention of variances and risks. Display actual cost vs budget in usable form. Look out for cost saving work methods always.

v. **Factor**: E3.5 Good Labor Relations

Root causes of failure

Use of poor labor management approaches.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Work for the employees if you want them work for you and give you their very best. Eliminate employee grievances through good HRM.

4. **Leading Indicator**: HR Effectiveness

a. **Factor**: A4.1.Crews Composition/Crew Formation

Root causes of failure

Proper planning for crew composition for different tasks, activities, phases, locations, etc. is not made. Lack of commitment from crew members advancing their interest instead of the project's. Conflict between crew members.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Form crews before project begins. Assess performance of crew after completion of each task and make adjustments accordingly to improve performance and productivity. Follow up crew esp. if the members are put together from different organizations.

Compose the crew with diverse skill and experience from as much as you can find on the market, assign a good team leader, train them and monitor team functioning. Assess crew formation and their performance regularly on a daily, weekly, and monthly basis. Make and monitor necessary changes and update the schedules.

Table E-31 Levels of use of best project productivity practices regarding crews composition/crew formation:

Level 0	Crew composition is not applicable.
Level 1	Level 1 Crew composition is not addressed.
Level 2	Level 2 Crew formation is addressed on the jobsite after the beginning of the project.
Level 3	Crew formation is addressed before the beginning of construction work, based on the experience and knowledge of workers, job requirements, and location.
Level 4	Continuation of Level 3, plus the performance of crew is assessed after completion of each task and adjustments made accordingly to improve performance and productivity.
Level 5	Continuation of Level 4, plus the crew formation and their performance is assessed regularly on daily, weekly, and monthly basis. Necessary changes are made and monitored and the schedules are updated automatically.

b. Factor: A4.2. Skills Assessment and Evaluation

Root causes of failure

Skills assessment and evaluation is not addressed, or it is addressed after project commenced.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Offer training that enable employees to be proactive. Offer after hour trainings to enhance skill of craft workers. Tie pay to productivity and plan career development for each. Assess the skills level of all craft workers before hiring them for the project or organization. This helps in planning for crew composition and management, training, and tasks assignments..

Table E-32 Levels of use of best project productivity practices regarding skills assessment and evaluation:

Level 0	Skills assessment and evaluation is not applicable.
Level 1	Skills assessment and evaluation is not addressed.
Level 2	Skills assessment and evaluation is addressed on the jobsite after the beginning of the project.
Level 3	Skills assessment and evaluation is addressed before the beginning of construction work, at the time of hiring, and based on the experience and knowledge of workers, job requirements, and location.
Level 4	Continuation of Level 3, plus the assessment and evaluation is made again after completion of each task and adjustments made accordingly to improve performance and productivity.
Level 5	Continuation of Level 4, plus the assessment and evaluation is performed regularly on daily, weekly, and monthly basis. Necessary changes are made and monitored and the schedules are updated automatically.

c. **Factor**: A4.3.Project Manager, superintendents & foremen Experience & Dedication

Root causes of failure

Lack of experience and/or dedication of project manager, superintendent and foremen.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Hire project manager, superintendents and foremen with the required experience and dedication. These leaders may use formal, reward/penality, expert, attractive power to lead their people.

d. **Factor**: A4.4. Head Office Support Services

Root causes of failure

Lack of dedication and support of top management.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Project manager needs to use attractive power in dealing with head office. Plan about support you need ahead, have a regular and clear communication with head office and report problems proactively to get their support. Remind them repeatedly because they are busy people.

e. **Factor**: B4.1. Employees / Trades Technical Training

Root causes of failure

Trades technical training is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Experienced craft people may give training to people working under them for immediate needs.

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Assess your employees skills and provide technical training to your employees and trades in various disciplines such as tools usage, installation procedures, reading drawings, scheduling, etc. Give training on usage of new technologies especially. Prepare and give first mandatory training using work hours. Give after hour skills development training to prepare them for certification exams and to develop craft workers career. Encourage employees to get certified. Pay more to certified than noncertified.

Table E-33 Levels of use of best project productivity practices regarding employees / trades technical training:

Level 0	Trades technical training is not applicable.
Level 1	Trades technical training is not addressed
Level 2	Trades technical training is addressed on the jobsite after the beginning of the project.
Level 3	Trades technical training is provided to a worker when he begins working for the company, and if needed extra training will occur on the job site.
Level 4	Continuation of Level 3, plus craft worker is certified to work in that trade. Before each project, new training in the trade will take place if necessary.
Level 5	Continuation of Level 4, plus craft worker takes part in training for new technologies that are introduced in that trade annually and bi-annually.

f. **Factor**: B4.2. Career development

Root causes of failure

Career development is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Have career development plan for each employee and tie their performance and promotion to their career development. Formal career development plan for craft workers and long-term options.

Table E-33 Levels of use of best project productivity practices regarding career development:

Level 0	Career development is not applicable.
Level 1	Career development is not addressed.
Level 2	The organization does not have a formal career development plan for craft workers, but management will discuss future plans with the craft workers.
Level 3	The organization has a formal career development plan for craft workers, but it only addresses short term career developments.
Level 4	Continuation of Level 3, plus it addresses long term career developments and options.
Level 5	Continuation of Level 4, plus addresses the expected performance of the worker and how the performance will affect his/her career development.

g. **Factor**: B4.3. Multiskilling

Root causes of failure

Most people are trained and have experience in narrow areas.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Train your craft people in multiple skills because it increases labor flexibility & efficiency and has potential labor saving of 5-20% and potential 35% reduction in work force size.

h. **Factor**: C4.1. Nonfinancial Incentive Programs (Recognitions)

Root causes of failure

Recognition program is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Recognize employees with best productivity, quality and safety formally in company newsletter, bill boards and yearly certificate awards by top management, and through paid vacations. Issue annual performance reports, and along with it report names of best performers. Motivate employees through full appreciation of work, job security and making work challenging and interesting.

Table E-34 Levels of use of best project productivity practices regarding nonfinancial incentive programs (recognitions):

Level 0	Recognition or non-financial incentive program is not applicable.
Level 1	Recognition program is not addressed.
Level 2	The organization has an informal recognition program that will recognize craft workers occasionally, but not in a formal manner.
Level 3	The organization has a formal recognition program that provides recognition on long term basis.
Level 4	Continuation of Level 3, plus it recognizes craft workers on a regular basis for both positive safety results and good safety behavior.
Level 5	Continuation of Level 4, plus with attending safety meetings and classes. The rewards are given on both short and long term basis, and they are recognized by the upper management of the organization. Each year the recognition program provides a report of the safety performance of the company, discusses how the organization can improve in regard to safety, and constantly looks into tweaking the program to improve it.

i. **Factor**: C4.2. Financial Incentive Programs

Root causes of failure

Financial incentive program is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Give financial rewards and promotions also to best performers. Keep pay and benefits competitive. Motivate employees through good wages, job security and promotion and growth. Align improvement and benefit sharing. Give bonuses based on achievements in terms of productivity, quality, and safety.

Table E-35 Levels of use of best project productivity practices regarding financial incentive programs:

Level 0	Financial incentive program is not applicable.
Level 1	Financial incentive program is not addressed.
Level 2	The organization has an informal incentive program that will recognize craft workers occasionally, but not in a formal manner.
Level 3	The organization has a formal incentive program that provides incentives on long term basis.
Level 4	Continuation of Level 3, plus it provides a monetary bonus for craft workers on a regular basis for both positive safety results and good safety behavior.
Level 5	Continuation of Level 4, plus with attending safety meetings and classes. The rewards are given on both a short and long term basis, and they are recognized by the upper management of the organization. Each year the incentive program provides a report of the safety performance of the company, discusses how the organization can improve in regard to safety, and constantly looks into tweaking the program to improve it.

j. **Factor**: C4.3. Social Activities

Root causes of failure

Social activities for the craft workers are not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Plan formal social activity for the craft workers once or twice a year in which the project managers will attend, along with a yearly organization wide social activity. Invite workers for breakfast or lunch at certain intervals.

Table E-36 Levels of use of best project productivity practices regarding financial incentive programs:

Level 0	Social activities for the craft workers are not applicable.
Level 1	Social activities for the craft workers are not addressed.
Level 2	The organization does not formally plan social activities for the craft workers, and there is only a yearly organization wide social activity.
Level 3	The organization formally plans a social activity for the craft workers once or twice a year in which the project managers will attend, along with a yearly organization wide social activity.
Level 4	Continuation of Level 3, plus several times throughout the year which the project managers will attend, along with a yearly organization wide social activity.
Level 5	Continuation of Level 4, plus monthly which the project managers will attend and upper management including the president will attend on a quarterly basis, along with a yearly organization wide social activity.

k. **Factor**: D4.1. Maintain Stability of Organization Structure

Root causes of failure

No plans to manage change of key people in contract.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use mechanisms to keep stability such as avoiding changes in key personnel by contract clause that specifies all key personnel on both Owner & Contractor teams, along with possible successors and right of approval by the other party. Avoid changes in key personnel. Plans for incorporating any unusual or unplanned staff changes. There is an individual on site who has the authority to act for the contractor.

Table E-37 Levels of use of best project productivity practices with regard to maintaining stability of organization structure:

Level 0	Maintaining the Stability of the Organizational Structure is Not Applicable.
Level 1	No plans to manage change of key people in contract.
Level 2	Owner & Contractor name/define key individuals in contract.
Level 3	Continuation of Level 2, plus state that they cannot be changed without notice and prior approval.
Level 4	Continuation of Level 3, plus designated successors (which are pre-approved).
Level 5	Continuation of Level 4, plus contract specifies all key personnel on both Owner & Contractor teams, along with possible successors and right of approval by the other party.

l. **Factor**: D4.2. Clear Delegation of Responsibility

Root causes of failure

There is not a clear delegation of responsibility and authority.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

The internal workings of each party must be known and understood to each other. Get names of responsible people formally delegated and authorized to make decisions by client with whom you work.

Table E-38 Levels of use of best project productivity practices with regard to maintaining stability of organization structure:

Level 0	Clear Delegation of Responsibility is Not Applicable.
Level 1	Simple & centralized.
Level 2	Simple & very formal.
Level 3	Stable project environment & more formal.
Level 4	Formal, but differing between technical, admin., etc.
Level 5	There is a formal delegation of authority that is clearly defined for all involved parties. The plan is reviewed periodically and evolves when necessary

m. **Factor**: E4.1. Retention Plan For Experienced Personnel

Root causes of failure

A retention plan is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use practices like aggressive craft training program that includes programmed pay increases when craft workers become certified, working with craft workers to find employment opportunities on other company projects after their respective work on their current project ends, and offering retention bonuses and preferred hiring status on the next project for the same employer Ensure client satisfaction to continuously secure jobs to retain your experienced craft people.

Table E-39 Levels of use of best project productivity practices with regard to retention plan for experienced personnel:

Level 0	Retention Plan for Experienced Personnel is Not Applicable.
Level 1	A retention plan is not addressed.
Level 2	Each craft foreman is responsible for retention of his craft workers.
Level 3	Craft training is available but not required. Journeymen have higher pay & preferred hiring status on the next project for the same employer.
Level 4	Continuation of Level 3, plus craft training is required for sub-journeymen: testing & certification is available on site. The employer makes available a list of opportunities for the next project.
Level 5	Continuation of Level 4, plus Craft training for sub-journeymen is required. Testing & certification on the site lead to pay increases. Employer meets with individual craft workers and offers job(s) at new project site(s) as per requirements.

n. **Factor**: E4.2. Exit Interview

Root causes of failure

A retention plan is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use practices like aggressive craft training program that includes programmed pay increases when craft workers become certified, working with craft workers to find employment opportunities on other company projects after their respective work on their current project ends, and offering retention bonuses and preferred hiring status on the next project for the same employer Ensure client satisfaction to continuously secure jobs to retain your experienced craft people.

Table E-40 Levels of use of best project productivity practices with regard to exit interview:

Level 0	Exit Interview is Not Applicable.
Level 1	No exit interview.
Level 2	Exit interview for key craft only.
Level 3	Random exit interviews when there is time.
Level 4	Formal exit interview for all craft.
Level 5	Formal exit interview for all craft and feedback to management about lessons learned and how to improve retention when applicable.

5. **Leading Indicator**: <u>Method Effectiveness</u>

a. **Factor**: A5.1. Integrated Schedule

Root causes of failure

The use of an integrated schedule using CPM has not been addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Show the entire project scope and activities of all trades, permits, environmental, etc and also show link to functions. Avoid schedule acceleration by schedule control. Update the CPM schedule regularly and compare with base schedule to know differences to correct. Earned progress for the activity is based on measured/assessed work complete per deliverable/s per activity.

Table E-41 Levels of use of best project productivity practices regarding integrated schedule:

Level 0	The use of an integrated schedule using CPM is not applicable.
Level 1	The use of an integrated schedule using CPM has not been addressed
Level 2	Developing a schedule with no resources present and managing schedule status via duration / remaining duration but no link to earned percent complete progress from associated deliverables per activity.
Level 3	Developing a schedule with resources present but no link to earned percent complete progress from associated deliverables per activity.
Level 4	Developing a schedule with resources present but no link to earned percent complete progress from associated deliverables per activity. Resources are updated to reflect current work content (quantity adjustments).
Level 5	Continuation of Level 4 and updated to include quantity adjustments. Earned progress for the activity is based on measured/assessed work complete per deliverable/s per activity. Progress measurement performed in application adapted specifically for deliverable/quantity completed status and earned value calculations, which are appropriately linked to schedule activities.

b. Factor: A5.2. Proper Work Sequencing

Root causes of failure

Poor logic or some sequencing links missing.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Develop a horizontally traceable (handoff) schedule. Simplify sequencing logic. Show all links between predecessor and successor activities.

c. Factor: A5.3. Work Schedule Strategies

Root causes of failure

The development of a work schedule strategy has not been addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use 40 hour week strategy efficiently to avoid any possibility of acceleration to stay on schedule. If acceleration can't be avoided, strategy considers multiple work schedules considering critical and near critical activity sequences. Strategies consider potential impact on worker fatigue, supervision, safety, and absenteeism. Each potential strategy's impact analyzed for manpower density and congestion at an area / sub-area level.

Table E-42 Levels of use of best project productivity practices regarding work schedule strategies:

Level 0	The development of a work schedule strategy is not applicable.
Level 1	The development of a work schedule strategy has not been addressed
Level 2	Strategy is based on a single work schedule be it either a straight time 40 hour per week schedule, overtime, or other work schedule
Level 3	Strategy considers multiple work schedules considering critical and near critical activity sequences.
Level 4	Continuation of Level 3, plus strategies considers potential impact on worker fatigue, supervision, safety, and absenteeism.
Level 5	Continuation of Level 4, plus each potential strategy's impact analyzed for manpower density and congestion at an area / sub-area level.

d. Factor: A5.4. Schedule Execution, Monitoring and Management

Root causes of failure

The development of a schedule compliance plan has not been addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Carry out comparison of actual performance with baseline based on quantity reports rigorously done by individual(s) trained on formally defined rules of completion, critical & near critical path analysis, change management analysis, risks assessment scenarios/analysis, date variance analysis to approved baseline or previous update period, start / finish percent achieved ratio analysis.

Table E-43 Levels of use of best project productivity practices regarding schedule execution, monitoring and management:

Level 0	The development of a schedule compliance plan is not applicable.
Level 1	The development of a schedule compliance plan has not been addressed.
Level 2	Consistent follow up to monitor the following; schedule updated periodically, critical path analysis, progress narrative prepared as required and effective team participation in schedule updates.
Level 3	Continuation of Level 2, plus Quantity reports are regularly performed but rules of completion are not formally defined. Upon request, or as project requires, may include any of the following: change management analysis, risks assessment scenarios/analysis, date variance analysis to approved baseline or previous update period, start / finish percent achieved ratio analysis, communication with material suppliers to ensure material will arrive on site when planned.
Level 4	Continuation of Level 3 plus monitor the following; schedule rigorously updated based on manual input of quantity reports, critical and near critical path analysis, progress narrative prepared and effective team participation in schedule updates. Quantity reports rigorously done by individual(s) trained on formally defined rules of completion. Material suppliers routinely contacted to track status of material delivery dates.
Level 5	Continuation of Level 4, plus will consistently include all of the following, based on project requirements and observed schedule status conditions: change management analysis, risks assessment scenarios/analysis, date variance analysis to approved baseline or previous update period, start / finish percent achieved ratio analysis; also included is automated progress tracking using 3D imaging, and UWB or RFID tags.

e. Factor: B5.1. Dynamic site layout plan

Root causes of failure

A site layout plan has not been addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Examine the schedule and decide/list down when temporary facilities (TF) will be installed on site at different times, removal or turn over time of TFs, dynamically plan the site optimally for work areas of own and different parties to ensure safety, minimize worker travel to and from TF, optimally locate office trailers, lunch facilities, sanitation and hygiene facilities, field job shacks, welding shields, weather protection, temporary lighting, air handling units temporary underground utilities (e.g. telecommunications and sanitary), blast zones, heavy haul roads and turning radii requirements.

Table E-43 Levels of use of best project productivity practices regarding dynamic site layout plan:

Level 0	Site layout plan is not applicable for the project.
Level 1	A site layout plan has not been addressed.
Level 2	The project team examines the project schedule and assesses when Temporary Facilities (TF) will be brought in.
Level 3	Continuation of Level 2, plus what sizes will be needed prior to the start of the project. No consideration is given to the addition, removal and/or turnover of TFs at different stages of the project. No analysis is done with regards to the layout of the project to optimize locations of the TFs to limit travel time to and from.
Level 4	Continuation of Level 3, plus consideration is given to the addition, removal and/or turnover of TFs at different stages of the project.
Level 5	Continuation of Level 4, plus the team analyzes the layout of the project including where the different parties will be working and place their TFs in the optimum location in order to limit travel time to and from TFs.

f. Factor: B5.2. Traffic Control Plan

Root causes of failure

Traffic control plans have not been addressed for the project.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Prepare project a traffic control plan and equipment for all times of the day including trained persons for traffic control. Make sure of compliance with jurisdictional requirements, detours or by-pass plans, appropriate signs, markings, and barricades, safety equipment, such as: barrels, signage, flagmen, vertical panels, clear zone protection devices, such as: concrete traffic barriers, metal beam guard fencing, appropriate end treatments, pedestrian safety.

Table E-44 Levels of use of best project productivity practices regarding traffic control plan:

Level 0	Traffic control plans are not applicable for the project.
Level 1	Traffic control plans have not been addressed for the project.
Level 2	Project has some traffic control plans and is used on a reactive basis.
Level 3	Project has a traffic control plan, equipment, and an arrangement for day light traffic control only and has no trained traffic control persons.
Level 4	Project has a traffic control plan and equipment for all times of the day including trained persons for traffic control.
Level 5	Continuation of level 4, plus a trained traffic control supervisor. It has an approved contingency plan in place to accommodate unexpected situations, and has designed and constructed alternate arrangements for traffic such as detours, flyovers, etc.

g. Factor: B5.3. Site security plan

Root causes of failure

A loose security system used on site.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Develop a plan to keep the site safe for the workers, the pedestrians or citizens that will operate close to the site, the people that will be making deliveries to the site, and will keep tools and equipment away from situations that will make vandalism and theft easy.

Table E-45 Levels of use of best project productivity practices regarding site security plan:

Level 0	Site security plan is not applicable for the project.
Level 1	Site does not institute security with regards to entry to site, securing commodities, or tools and equipment.
Level 2	The site controls entry and exit from the site, but does not have any other formal security throughout the site.
Level 3	Site has established security procedures including visitor sign in and sign procedure and security guards at every gate. The site has implemented security measures to ensure the preservation of company assets. Protocols have been identified for searches of individuals and their personal property. Searches are conducted randomly.
Level 4	Continuation of Level 3, plus site has ensured that material is not leaving the jobsite by instituting "lock-ups" for items that are prone to theft.
Level 5	Continuation of Level 4, plus the use of electronic security has been implemented such as security cameras.

h. Factor: B5.4. Machinery & Equipment positioning strategy

Root causes of failure

There is no strategy for positioning of equipment at the project site.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Evaluate haul routes for all heavy transport for clearance and load capability. Carry out heavy rigging and lifting studies for critical lifts including evaluation of equipment and rigging selection and crane location. Use the following equipment positioning strategies: use software for crane animation that examine location and availability, crane interference. 3D modeling and visualization of construction sequence promotes better understanding of where to locate construction equipment to aid in constructability for locating and utilizing equipment for better utilization and for heavy lifts. Develop lift plan based on the following considerations: 1) a construction execution plan that includes sequential erection of a facility and is coordinated with machinery availability; 2) a rigging and heavy haul engineering study; 3) an evaluation of the need of lifting equipment; 4) an evaluation of the need of elevated platforms.

Table E-46 Levels of use of best project productivity practices regarding machinery & Equipment positioning strategy:

Level 0	Equipment positioning strategy is not applicable.
Level 1	There is no strategy for positioning of equipment at the project site.
Level 2	Heavy Rigging and Lifting Studies are accomplished on all critical lifts including evaluation of equipment and rigging selection and crane location. Haul Routes for all heavy transport are evaluated for clearance and load capability.
Level 3	Continuation of Level 2, plus planning includes use of 2D layout and studies to aid in constructability for locating and utilizing equipment.
Level 4	Continuation of Level 3, plus some 3D modeling studies to aid in constructability for locating and utilizing equipment.
Level 5	Continuation of Level 4, plus planning includes use of 3D layout studies and 3D modeling/visualization to aid in constructability for locating and utilizing equipment.

i. Factor: C5.1. Communications, Coordination, and Agreements

Root causes of failure

Lack of documented plan for communication, coordination, and agreements between different stakeholders.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Have a review process for communication, coordination, and agreements between different stakeholders: contractors and suppliers, owner/funding agencies, environmental protection agencies, law enforcement agencies, parks and wildlife agencies, local, provincial, and federal departments, department of transportations, utilities companies and air quality boards.

Table E-47 Levels of use of best project productivity practices regarding communications, coordination, and agreements:

Level 0	Communication, coordination, and agreements between different stakeholders are not applicable.
Level 1	There is no documented plan for communication, coordination, and agreements between different stakeholders.
Level 2	The project has a review process for communication, coordination, and agreements between different stakeholders; however, no formal written plan exists.
Level 3	The project has formal written plans and procedures for communication, coordination, and agreements between different stakeholders. It has identified responsible parties for dealing these matters.
Level 4	Continuation of Level 3, plus there are designated personnel for ensuring proper communications and coordination between different stakeholders.
Level 5	Continuation of Level 4, plus all information related to communications and coordination have been logged into project information systems and integrated with project schedules.

j. Factor: C5.2. Project start-up plan

Root causes of failure

A partial start-up plan has been assembled but does not provide for buy-in by the operations group, no hazard analysis has been performed, no component/system test protocols have been developed and the plan has not been communicated to affected stakeholder.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Prepare a facility commissioning plan before you hand over the facility that identifies the objectives and goals of the start-up team with the buy-in of the affected stakeholders. Train operators. Submit operation manual.

Table E-48 Levels of use of best project productivity practices regarding project start-up plan:

Level 0	No start-up and commissioning plan exists.
Level 1	A partial start-up plan has been assembled but does not provide for buy-in by the operations group, no hazard analysis has been performed, no component/system test protocols have been developed and the plan has not been communicated to affected stakeholder.
Level 2	A basic start-up and commissioning plan has been developed and with input and buy-in of management, operations, engineering, safety and other affected employees but the plan has not been implemented.
Level 3	Continuation of Level 2, plus with considerations for interfaces with construction and operations. A commissioning plan has been developed that identifies the objectives and goals of the start-up team with the buy-in of the affected stakeholders.
Level 4	Continuation of Level 3, plus with consideration for cost analysis and detailed scheduling components. The plan is well communicated to all affected employees.
Level 5	Continuation of Level 4, plus with the plan being implemented on the project with proper review by the affected stakeholders for applicability at regular intervals as deemed necessary by the start-up and management teams.

k. Factor: C5.3. Project Completion Plan

Root causes of failure

The project completion requirements/turn over procedures has not been identified.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Document all the project completion requirements and plan in advance to ensure a smooth transition to operations. Issues to consider include quality assurance/quality control, final code inspection, landscape requirements, substantial completion certificate and community acceptance. Check all elements for 100% completion. Rectify punch list items. Close all contracts. Get approval signatures from subcontractors and suppliers. Submit all warranties and manuals. Handover project ownership to client..

Table E-49 Levels of use of best project productivity practices regarding project completion plan:

Level 0	The project completion requirements/turn over procedures is not applicable.
Level 1	The project completion requirements/turn over procedures has not been identified.
Level 2	The project has a turnover procedure that defines the parameters of system completion and delineates the requirements for the turnover of systems from construction to startup.
Level 3	The project has a formal turnover process that defines the necessary documentation, system boundary identification, parameters of system completion and other parameters of system completion to assure proper turnover of project systems from construction to start-up and from start-up to operations.
Level 4	Continuation of Level 3, plus the procedure has been reviewed and approved by all stakeholders and all affected employees have been properly trained in the process.
Level 5	Continuation of Level 4 plus has the approval of project management and is reviewed for applicability during all phases of the turnover process.

l. **Factor**: C5.4. Innovations and New Technologies

Root causes of failure

Innovations and new technologies investigation is not addressed.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Make use of innovations in new materials, equipment, information systems, technologies, work methods, management techniques, etc. to increase the performance and productivity of project.

Table E-50 Levels of use of best project productivity practices regarding innovations and new technologies:

Level 0	Innovation in new materials, equipment, information systems is not applicable.
Level 1	Innovations and new technologies investigation is not addressed.
Level 2	The project does not have a formal program for the investigation of innovations and new technologies. Implementation of innovations and new systems will only occur after the industry-wide implementation.
Level 3	The organization has an informal program for the investigation of innovations, and they will investigate the feasibility of the new technologies on a regular basis.
Level 4	Continuation of Level 3, plus the program is formal to investigate new systems and they will investigate the feasibility of the new technologies on a regular basis.
Level 5	Continuation of Level 4, plus they investigate all new technologies using a formal system of rating the new technology.

m. Factor: C5.5. House Keeping

Root causes of failure

Regular housekeeping has not been addressed on the project.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Do house-keeping to ensure that the work face is organized, and all materials, tools, and equipment are properly stored to ensure that they are not misplaced and can be easily retrieved for use. These times should be documented on the schedule, and a convenient time to schedule housekeeping sessions is on Friday afternoons or the afternoon on the final day of the work week or final 30 minutes of each workday. Use 5S.

Table E-51 Levels of use of best project productivity practices regarding house-keeping:

Level 0	Housekeeping is not applicable to the project.
Level 1	Regular housekeeping has not been addressed on the project.
Level 2	Housekeeping occurs only after incidents occur.
Level 3	Housekeeping occurs on a bi-weekly scheduled basis.
Level 4	Major travel paths are organized and clean. "Roll backs" are held weekly.
Level 5	All work areas are well organized and designated crews are regularly cleaning.

n. Factor: C5.6 Construction technology

Root causes of failure

Efficient and effective technologies are not fully utilized due to budget constraint.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use construction technologies like precast, preassembly to increase productivity.

6. Leading Indicator: <u>Safety Record</u>

a. Factor: A6.1. Formal Health and Safety Policy

Root causes of failure

Organization does not have a formal health and safety policy.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Implement health and safety policy of company on site. Prevent hazard by job and worksite design, constructability reviews of shop drawings and equipment operations.

Table E-52 Levels of use of best project productivity practices regarding formal health and safety policy:

Level 0	Formal health and safety policy for the organization is not applicable.
Level 1	Organization does not have a formal health and safety policy.
Level 2	Organization has a formal health and safety policy. The policy is documented and publicized. Policy includes dealing with the health and safety issues of its workers.
Level 3	Continuation of Level 2, plus it is periodically updated based on the organizational and industry feedback.
Level 4	Continuations of Level 3, plus the organization screens sub-contractors for their health and safety programs and chooses those with records of good performance.
Level 5	Continuation of Level 4, plus health and safety policy is integrated with procurement processes. Money is budgeted on the construction projects to address various health and safety issues.

b. Factor: A6.2. Health and Safety Plans/Zero Accident Techniques

Root causes of failure

Zero Accident Techniques are not applicable to the project.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Implement zero accident techniques on the project and a very proactive approach towards safety through: management commitment, staffing for safety, planning(pre-project and pre-task), safety education (orientation and specialized training), worker involvement, evaluation and recognition award, subcontract management, accident/incident investigations.

Table E-53 Levels of use of best project productivity practices regarding health and safety plans/zero accident techniques:

Level 0	Zero Accident Techniques are not applicable to the project.
Level 1	No Zero Accident Techniques have been examined and considered for the project.
Level 2	Some Zero Accident Techniques utilized on the project. The project has a reactive approach towards safety.
Level 3	Most but not all Zero Accident Techniques are utilized on the project.
Level 4	All Zero Accident Techniques are utilized on the project.
Level 5	Zero Accident Techniques fully utilized on the project. The project has a very proactive approach towards safety.

c. Factor: A6.3. Task Safety Analysis

Root causes of failure

No task safety analysis is utilized or incomplete analysis.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Perform Job Safety Analysis (JSA) on each task on a daily basis, determine safety hazards for the specific task, take protective measures, participation in safety task analysis (e.g. toolbox talks, job safety analyses).

Table E-54 Levels of use of best project productivity practices regarding task safety analysis:

Level 0	Task Safety Analysis is not applicable to the project.
Level 1	No Task Safety Analysis is utilized.
Level 2	Limited Task Safety Analysis is utilized only on high risk areas of the project. The project has a reactive approach towards safety.
Level 3	Most but not all Zero Accident Techniques are utilized on the project.
Level 4	Job safety analyses are utilized daily on the project.
Level 5	Job safety analyses are utilized daily on the projects on all tasks and some crews perform additional job safety analyses as task changes.

d. Factor: A6.4. Hazards Analysis

Root causes of failure

No hazard identification process is in place on the project.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Perform hazard analysis to identify all on-site situations that could potentially lead to a hazardous or dangerous environment for the workers such as working at heights, soil stability, stability of falsework, toxic chemical exposure, hazardous waste disposal, environmental hazards. Identify hazards for the proposed scope of work and incorporate it into the project's task specific safety planning process.

Table E-55 Levels of use of best project productivity practices regarding hazards analysis:

Level 0	The process for hazard identification process is not applicable on the project.
Level 1	No hazard identification process is in place on the project.
Level 2	Hazards are identified for high risk work only.
Level 3	Hazards are identified for most work.
Level 4	Hazards are identified for the proposed scope of work.
Level 5	Hazards are identified for the proposed scope of work and incorporated into the project's task specific safety planning process.

e. Factor: A6.5 Hazards planning

Root causes of failure

Lack of planning or lack of information for planning.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Identify job hazards and plan for their mitigation or avoidance.

Table E-56 Levels of use of best project productivity practices regarding hazards planning:

Level 0	No hazard evaluation has been performed
Level 1	A system hazard analysis has been performed but no plan is in place to address the hazards.
Level 2	A system hazard analysis has been performed; a plan has been developed but not communicated to affected staff.
Level 3	Continuation of Level 2, plus it is communicated to affected staff and training of affected employees has been performed and the plan is usually implemented.
Level 4	Continuation of Level 3, plus a plan has been developed with input of the safety department and training of all affected employees has been performed and the procedure is properly implemented.
Level 5	Continuation of Level 4, plus a detailed system hazard analysis has been performed, a plan has been developed with input of the safety department, Start-up group and the operations staff and management that establishes appropriate physical and administrative controls integrating the operations procedures and all start-up and operations employees have been trained and the procedure is properly implemented.

f. Factor: A6.6. Hazardous Material Handling Plan

Root causes of failure

No plan is put in place to address the hazards.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Be prepared to handle hazardous material and let knowledgeable people handle it, and have measures set up to control the substance in case of an accident.

g. Factor: B6.1. Drugs and Alcohol Testing Program

Root causes of failure

Organization/Project Drug and Alcohol Testing Policy is not written or publicized.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Implement drug and alcohol testing policy for all employees. The policy should consider the following: pre-employment testing for illegal drugs, testing for reasonable cause, post-accident testing for illegal drugs, random drug tests for all employees.

Table E-57 Levels of use of best project productivity practices regarding drugs and alcohol testing program:

Level 0	Organization/Project drug testing is not applicable.
Level 1	Organization/Project Drug and Alcohol Testing Policy is not written or publicized.
Level 2	Organization/Project Drug and Alcohol Testing Policy are written and publicized. Policy includes pre-employment testing and post -accident testing.
Level 3	Continuation of Level 2, plus with reasonable cause, project access requirements, and post -accident testing.
Level 4	Continuation of Level 3, plus random selection testing.
Level 5	Continuation of Level 4 plus allows for probable cause searches for drugs and alcohol. Policy also addresses management of prescription drugs used at work. Policy includes provision for confidential treatment or rehabilitation through Employee Assistance Programs either voluntary enrolment before a positive test result or mandatory as a condition of future/continued employment.

h. Factor: C6.1. Health and Safety Training Programs

Root causes of failure

The project does not have a project specific new hire safety orientation.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Conduct project specific new hire safety orientation. Orientation addresses management commitment, general project safety rules, emergency procedures, personal protective equipment, use of ladders and safe access to elevated work areas, hazard communication, housekeeping, fire prevention and protections, barricades, injury/illness reporting, lock-out and tag-out processes, confined spaces, compressed gas cylinders, back injury prevention, excavation and trenching, and hand power tool safety, zero accidents philosophy, general project safety rules and behavioral based training.

Table E-58 Levels of use of best project productivity practices regarding health and safety training programs:

Level 0	Occupational Health and Safety compliance training is not applicable.
Level 1	The project does not have a project specific new hire safety orientation.
Level 2	Project specific new hire orientation addresses personal protective equipment, housekeeping and access to site, ladders and safe access to elevated platforms, fall protection, excavations and trenching, tools and equipment, electrical hazards and fire prevention. Supervisors receive additional orientation on behavior or people based safety, conduct of safety meetings, first aid and medical treatment processes, job hazard analysis, consequences for violation of job site work rules and violence, alcohol and drugs in the workplace.
Level 3	Continuation of Level 2, plus all personnel must pass fitness for duty testing prior to attending the project specific new hire safety orientation. Orientation addresses management commitment, general project safety rules, emergency procedures, personal protective equipment, use of ladders and safe access to elevated work areas, hazard communication, housekeeping, fire prevention and protections, barricades, injury/illness reporting, lock-out and tag-out processes, confined spaces, compressed gas cylinders, back injury prevention, excavation and trenching, and hand power tool safety.
Level 4	Continuation of Level 3, plus orientation addresses zero accidents philosophy and general project safety rules.
Level 5	Continuation of Level 4, plus craft workers trained on behavioral based training.

i. **Factor**: C6.2. Toolbox Safety Meetings

Root causes of failure

Project issues toolbox topics via handouts to employees on a periodic basis.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Conduct toolbox meeting frequently (daily or weekly) to maintain awareness, updated training, and convey important safety and health information. Meetings address current job status and hazards presented by upcoming project activities, corrective actions, review recorded injuries and near misses, or reiterate job site safety rules and expectations. It is important to set time aside during the meeting for interactive discussion and allows worker questions and feedback

Table E-59 Levels of use of best project productivity practices regarding toolbox safety meetings:

Level 0	Project does not conduct safety meetings (not applicable).
Level 1	Project issues toolbox topics via handouts to employees on a periodic basis.
Level 2	The project conducts a monthly meeting at or near breaks. Meetings reiterate job site safety rules.
Level 3	The project conducts a weekly meeting at or near breaks. Meetings reiterate job site safety rules.
Level 4	The project conducts weekly meetings at a prearranged time, generally the start of the day. Meetings address current job status and hazards presented by upcoming project activities, corrective actions, review recorded injuries and near misses, or reiterate.
Level 5	Continuation of Level 4, plus the day of the meeting vary on which they occur, or conduct them daily. Meetings address current job status and hazards presented by upcoming project activities, corrective actions, review recorded injuries and near misses, or reiterate job site safety rules and expectations.

7. Leading Indicator: External Factors Reduction Index

a. **Factor**: A7.1. Subsurface condition (as compared to expectation)

Root causes of failure

Poor/inadequate site investigation and soil testing makes the risk worse.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Subsurface condition is one of the risk factors due to wide heterogeneity of subsurface soil strata, which often is different from soil profile descriptions in bid documents. Have a plan to use scattered and evolving information about underground conditions to come up with solutions without delaying the project.

b. **Factor**: A7.2. Topography (plane or rugged)

Root causes of failure

Determined by natural topography of the land over which facility will be built.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Conduct survey data collection of the segments you absolutely need because topographic data is one of the scattered and evolving information that the project team need to be prepared to act on and find workable solution that meet project requirements.

c. **Factor**: B7.1. Availability of weather data (to predict in order to avoid effect of weather)

Root causes of failure

Presence of recorded data on weather for the site or nearby areas.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Use as much past data you can find to predict inclement weather and minimize risk factor to construction projects. Use internet weather channel information/forecasts if nothing else could be found.

d. **Factor**: C7.1. Skilled Labor Availability

Root causes of failure

City/town or remote area and size of city.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Highly-skilled and highly-valued construction workers may be a challenge to find and even not available in the labor market. The workers may be required to be hired from other cities or provinces. Proper planning for crew composition for different tasks, activities, phases, locations, etc. can affect the project performance and productivity. Work with what you can find as much as possible, and train for any skill deficiencies.

e. **Factor**: C7.2. Inflation and Material Cost Escalation

Root causes of failure

Market conditions.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Include an inflation and material cost escalation factor in estimates. Have clauses in contract agreements so that client pays for it.

f. **Factor**: C7.3. Union Activities

Root causes of failure

Presence or absence of unionization of labor.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Resolve all employee grievances to avoid risk of union activities on your projects and company.

g. **Factor**: D 7.1 Timely progress payment

Root causes of failure

Diligence of clients engineers and staff. Contractor's project manager communication and management of client..

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Establish a good relationship with client, and act as a trust worthy professional advisor that works for the client's interest. Win the owner and owner's engineer so they pay you progress payments timely.

h. **Factor**: D 7.2 Timely inspection of completed work

Root causes of failure

Diligence and number of client's staff assigned. Their cooperativeness.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Establish good and professional relation with clients engineers, and communicate regularly and proactively about his/her inspections and approvals.

i. **Factor**: D 7.3 Timely Approval/Responses to RFI

Root causes of failure

Lack of diligence of client project staff, early request from project manager or reminders.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Establish good and professional relation with clients engineers, and communicate regularly and proactively about his/her inspections and approvals.

j. **Factor**: D 7.4 Fairness of Owner's Representative

Root causes of failure

Experience of owner's representative. Power given to representative. Work load. Contractor's project manager relationship management.

Emergency RIPs, counter measures and/or BPs that eliminate the root causes

Short-term RIPs, counter measures and/or BPs that eliminate the root causes

Evaluate fairness of clients representative and win him/her over for your cause.

Sustainability and Social Accountability Initiative:

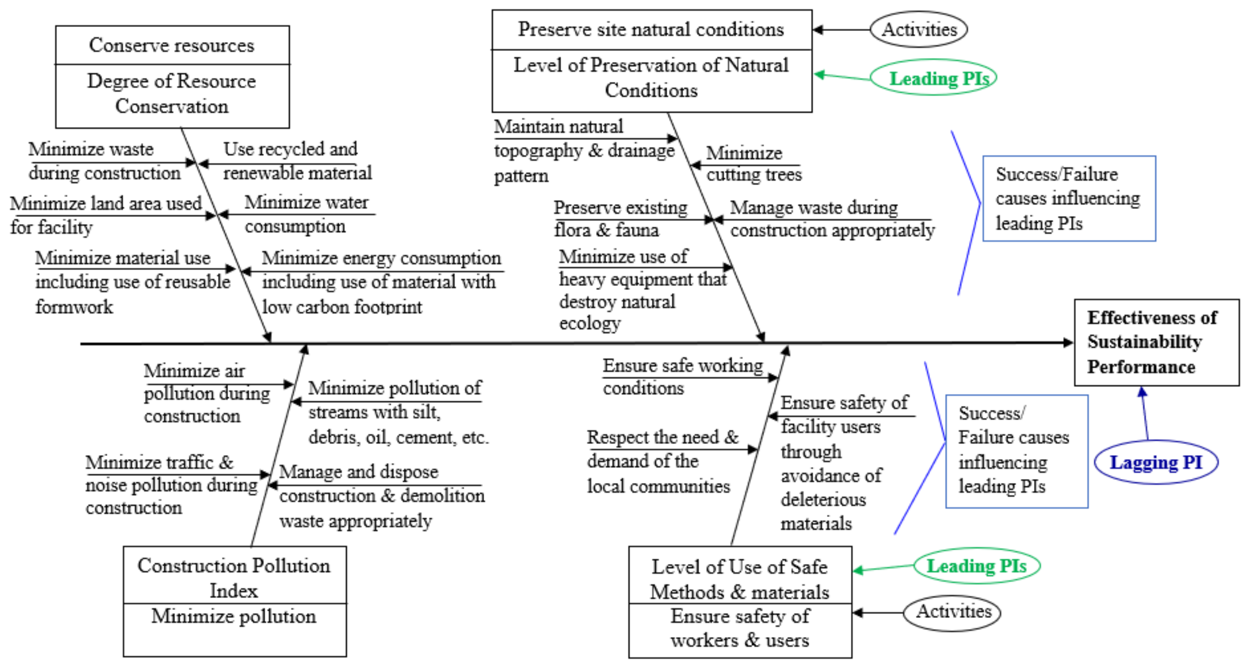


Figure E.34 Fishbone diagram for sustainability and social accountability initiative

1. **Leading Indicator**: Degree of Resource Conservation

a. **Factor**: Minimize waste during construction.

Root causes of failure

Not putting in place measures that enable waste reduction. Not taking active and tangible measures to minimize construction waste.

RIPs, counter measures and/or BPs that eliminate the root causes

Use mistake proofing to reduce rework. Use precise quantity calculations to avoid excess material orders. Reduce concrete mortar trims and cutoffs using precise formwork, etc.

Waste generated by construction and demolition accounts for a significant proportion of landfills (about 40% in many countries). Minimizing waste helps reduce this volume.

b. **Factor:** Use recycled and renewable material.

Root causes of failure

Lack of awareness about the environmental and resource impact of material selection for both temporary and permanent work.

RIPs, counter measures and/or BPs that eliminate the root causes

The contractor has little latitude for selection of material for permanent work but has the full discretion to select material for false work and formwork. Use renewable material like timber that can easily be grown, use reusable formwork and falsework(like steel) that has also economic benefit.

c. **Factor:** Minimize water consumption.

Root causes of failure

Lack of awareness about scarcity of potable water.

RIPs, counter measures and/or BPs that eliminate the root causes

Use pipe water only when absolutely necessary. Use untreated, river water whenever possible and use minimal amounts possible.

d. **Factor**: Minimize land area used for facility.

Root causes of failure

Lack of awareness that land area is one of the scarce resources.

RIPs, counter measures and/or BPs that eliminate the root causes

Contractor has limited say on the area the facility sits on but can minimize area affected by facility like highway side ditches and erosion protection work.

e. Factor: Minimize material use including use of reusable formwork

Root causes of failure

Lack of appreciation of the saving from thoughtful planning in cutting (wall or flooring blocks or tiles) items by trying to optimize use of materials for construction.

RIPs, counter measures and/or BPs that eliminate the root causes

Always have a mindset of optimizing use of resources. Use easily grown timber or steel for false and formwork.

f. Factor: Minimize energy consumption including use of material with low carbon footprint.

Root causes of failure

Lack of awareness or lack of these considerations.

RIPs, counter measures and/or BPs that eliminate the root causes

Producing energy is one of the activities that produce a lot of carbon. Minimizing use of commercially available energy (electric or fuel) helps minimize carbon emission. Use renewable energy such as hydropower electricity, solar energy and wind power. Minimize use of material with high carbon footprint like cement.

2. Leading Indicator: <u>Level of Preservation of Natural Conditions at Site</u>

a. Factor: Maintain natural topography & drainage pattern.

Root causes of failure

Lack of awareness about the importance or not giving due consideration.

RIPs, counter measures and/or BPs that eliminate the root causes

Natural topography and drainage pattern at site is established through equilibrium of erosion and deposition through thousands of years if not millions. Disrupting this equilibrium sets off another natural process to re-establish equilibrium which is disruptive. Maintain natural topography.

b. Factor: Minimize cutting trees.

Root causes of failure

Lack of due attention.

RIPs, counter measures and/or BPs that eliminate the root causes

A tree takes decades to reach the maturity it is at now. Cut trees only those on the alignment of the highway or civil structure. It would be good if client plants a tree or more for each tree that is cut. A mature tree has better capacity to regulate the climate than newly planted ones.

c. Factor: Preserve existing flora and fauna.

Root causes of failure

Existing flora and fauna resulted from thousands or millions of years of natural selection and development. Lack of awareness or due attention.

RIPs, counter measures and/or BPs that eliminate the root causes

Preserve the flora and fauna to keep the forest cover and natural equilibrium.

d. Factor: Manage waste during construction appropriately.

Root causes of failure

Lack of awareness.

RIPs, counter measures and/or BPs that eliminate the root causes

Waste from construction and demolition accounts for a significant proportion of landfills (about 40% in many countries). This is a large volume that needs planning for. Manage and dispose them appropriately to make sure the environment is not affected. Recycle or repurpose demolition waste as much as possible.

e. Factor: Minimize use of heavy equipment that destroys natural ecology.

Root causes of failure

Lack of awareness about the effect of heavy equipment on the ecology.

RIPs, counter measures and/or BPs that eliminate the root causes

The site top soil is full of life and life support through which water, air and food flows. Heavy equipment destroys all the life support of worms and microorganisms due to the heavy weight. Minimize its use and limit it to parts beneath the permanent structure.

3. Leading Indicator: <u>Construction Pollution Index</u>

a. Factor: Minimize air pollution during construction

Root causes of failure

Not paying much attention to effect of site operations on environmental pollution.

RIPs, counter measures and/or BPs that eliminate the root causes

Air pollutants include dust and exhaust from equipment that run on carbon fuel. Spray site with water. Put off engines when you are not operating your vehicles and machines.

b. Factor: Minimize pollution of streams with silt, debris, oil, cement, etc.

Root causes of failure

Lack of due attention or lack of government regulation about the matter.

RIPs, counter measures and/or BPs that eliminate the root causes

Try as much as possible to release into the natural stream only pure, uncontaminated water by silt, clay, debris, oil from equipment, etc.

c. Factor: Minimize traffic & noise pollution during construction.

Root causes of failure

Lack of due attention.

RIPs, counter measures and/or BPs that eliminate the root causes

Let minimum traffic to the site. Tell all operators to switch their engines off when they are not operating their vehicles and machines.

d. Factor: Manage and dispose construction and demolition waste appropriately.

Root causes of failure

Lack of due consideration or attention.

RIPs, counter measures and/or BPs that eliminate the root causes

Manage and dispose construction and demolition waste appropriately so they do not contaminate the environment.

4. Leading Indicator: Level of Use of Safe methods and Materials

a. Factor: Ensure safe working conditions for your employees

Root causes of failure

Usually health and safety are stressed but there may be gaps in implementation of safety and health guidelines.

RIPs, counter measures and/or BPs that eliminate the root causes

The ultimate purpose of building facilities and caring for the environment is to create an environment in which human beings enjoy life and thrive. It would be self-defeating if people are hurt or their health compromised in the construction process.

b. Factor: Ensure safety of facility users through avoidance of deleterious materials.

Root causes of failure

Lack of awareness or due attention.

RIPs, counter measures and/or BPs that eliminate the root causes

Some construction materials are deleterious to health because themselves negatively affect health or release gases and/or fluid through chemical reaction during the design period of the facility. Such materials should be avoided.

c. Factor: Respect the need & demand of the local communities.

Root causes of failure

Lack of due attention to the fact that local communities are the owners and beneficiaries of the facilities we construct.

RIPs, counter measures and/or BPs that eliminate the root causes

Keep the demands of communities because they have preferences about what is best for them and for the environment because they live with the facility and the effects of the facility. It is good practice to involve and get feedback from the communities in which the facility is being constructed and respect their needs and demands.

APPENDIX F INFORMATION OF COMPANY USED FOR THE WEAK MARKET TEST

The company that used the two-part excellence model and diagnostic tool & DSS is a roads and bridges construction company that does federal roads construction in Ethiopia. The company size in terms of number of employees is 68. The company representative that used the excellence model and diagnostic tool and DSS is owner and general manager of the company. In the weak market test, the purpose is to see whether any manager responsible for the financial results of his or her business unit is willing to apply the construct in question in his or her actual decision making.

The questions the author asked the company representative and his responses are given below.

Two-part profitability improvement excellence model:

Use these three questions to guide your review of the two-part profitability improvement excellence model

1. Do you think the models in Figure 1 and 2 are useful?
2. Are you willing to use them in your company?
3. What improvements do you suggest to the models in Figure 1 and 2?

Response of the representative is:

Q1. Do you think the two parts of the model are useful?

A1.My answer is yes. They are useful.

Q.2. Are you willing to use them in your company?

A2.I am willing to use it in my company.

Q3. What improvements do you suggest to parts of the model?

I have two comments.

(a)In Part 1 which is entitled “Model that gives profitability improvement strategies that guide operating decisions” there is a box labeled “Conduct marketing aggressively” which is placed at the bottom of the figure. To the right of this box, there is another box and the last statement in this box reads “Increase repeat business”. I suggest this statement (i.e. Increase repeat business) should be rephrased. I cannot recommend how it should be phrased because I did not understand the meaning Sir.

(b) In Part 2 which is entitled “Recursive and iterative continuous improvement model and flowchart”, there is one step stated as “Is the process stable? capable?”. I suggest this statement should be rephrased like “Is the process stable and capable?” to signify the need of both to be met at the same time.

Question given to the company representative as a guide in his evaluation of diagnostic tool and DSS and his response

1. Strengths and weaknesses of the diagnostic tool and DSS
2. Summary about the tool after you have used it.

Response of the representative is:

I have been trying hard to find weaknesses all this time to no avail. It is really comprehensive and near to perfect. I politely comment that I could not find three areas in the model. These are contract administration, value engineering and knowledge management. Perhaps you have already included them somewhere and maybe I could not find them. For instance, I have seen that the model has a lesson learned part but as you may know lessons learned fall under the umbrella of a broader concept of knowledge management which is increasingly getting attention in the project management community. In the Project Management Institute’s book “A Guide to the Project Management Body of Knowledge (PMI, 2013), the terms “Knowledge Management” and “Lessons Learned” appeared one and seventy seven times respectively. However, in their sixth edition of the same book (PMI, 2017), “Knowledge Management” appeared 32 times whereas “Lessons Learned” featured more than 400 times indicating the increased emphasis PMI placed on the subject. The significant increment of lessons learned appearance from 77 to 400 is mainly because under the knowledge area section of the 2017 edition of PMBOK, a new process called “Manage Project Knowledge” has been added under the “Project Integration Management”. I really do not dare to tutor you about the other two topics (value engineering and contract administration issues) for obvious reasons. Reviewing the model was not only a privilege but also a lesson for myself.

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EDUCATION

PhD in Civil Engineering – Construction Engineering and Management (August 2020)

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Certificate in Engineering Education – (December 2019)

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Certificate in Logistics and Supply Chain Management - (2012)

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MBA – (July 2003)

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Post Graduate Diploma – Earthquake Engineering (1997)

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