AN SSM-TRIZ METHODOLOGY FOR BUSINESS PROBLEM STRUCTURING

by

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To God be the glory! He led me this far and will lead me further.

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ABSTRACT

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Checkland developed Soft Systems Methodology (SSM) to address problem situations from a systems perspective; however, SSM needs to be extended with other methods to find superior solutions that overcome the need for a compromise or trade-off between conflicting or contradictory elements. This thesis extends Checkland's SSM approach to resolve problems with conflicting or contradictory elements. This work integrates the powerful benefits of TRIZ-based analysis into SSM and provides a means for systemic resolution of business problems with conflicting sub-system elements. Furthermore, this study acknowledges that soft problems can have conflicting relationships among their elements, compares the strengths and weaknesses of SSM and TRIZ in problem structuring, and presents a collaborative SSM-TRIZ approach for problem structuring. Finally, this thesis applies the joint methodology to examine the business problem of customer needs assessment for a certain market segment of INCOSE's planned Professional Development initiative. Although SSM-TRIZ helps structure problems with opposing requirements, it does not always provide definitive, prescriptive solution implementations for technical and business issues. Hence, hard thinking approaches cannot be discarded in practice after implementing SSM-TRIZ. Text mining was selected for providing a final and definite solution to the problem situation of interest.

CHAPTER 1. INTRODUCTION

1.1 Research Motivations

The rise of Problem Structuring Methods (PSMs) – an aspect of soft 'OR (Operations Research),' during the late 1970s and early 1980s was not without purpose. Business managers and even researchers were facing imminent limitations and constraints in their application of existing OR methods (F. Ackerman 2011). Ackoff best summed up these limitations by describing OR as 'mathematically sophisticated but contextually naïve' (R. Ackoff 1979). Ackerman rightly posited that the need to appreciate the power, politics and social demands of the organizational life is critical. An understanding of these key contextual aspects is key to producing implementable agreements especially in situations where there are no common grounds on what the exact problems or solutions are (F. Ackerman 2011). Wooley and Pidd divided problems into three broad constituents namely mathematical, messy (wordy complexity) and Churchman's 'wicked-problems.' Problem structuring becomes more important as we traverse from mathematical to wicked problems and is the right thing to do when sponsors ask for help with problems (Wooley and Pidd 1981). Wooley and Pidd further defined problem structuring as: 'process by which the initially presented set of conditions is translated into a set of problems, issues, and questions sufficiently well-defined to allow specific research action.'

The value of applying PSMs in real life situations in business, policy development and analysis, production and manufacturing, community development, and development planning, is sometimes underestimated. However, PSMs have been deployed to shape implementation, to reasonable success, for various sponsor problems all around the world. Checkland and Scholes (1990) detailed an application of Soft Systems Methodology (SSM), in specifying role boundaries and improving operational effectiveness and efficiency for Shell's Manufacturing Function department. Bombardier (a Canadian-based company) had in the past recruited a team from University of Strathclyde to help develop models capable of quantifying resulting delays and disruptions which would carry conviction (against a tunnel building company) in a court of law (Ackerman, Eden and Williams 1997; Williams et al. 1995). Strategic Options Development and Analysis (SODA) map was used as a knowledge acquisition process for building a foundation for developing influence diagram and System Dynamics (SD) models which eventually secured an

out-of-court settlement for Bombardier. Also, SODA and SSM approaches as detailed by Ormerod (1995) were employed in understanding Sainsbury's business strategy and environment for helping the company develop new IT strategies. Another interesting application was narrated in Mingers and Rosenhead (2004) where the Strategic Choice Analysis (SCA) and robustness analysis were used in preparing a policy analysis and planning decisions unit for Venezuela's Ministry of Planning. It can be observed from all the studies outlined above that the sponsors recognized the need to recast the original set of problems and questions into well-defined ones for actionable implementation. When sponsors avoid the fundamental process of structuring issues, they stand to lose sight of the problem context, solve the wrong problem and traverse unnecessary project boundaries (or fail to cross relevant ones). Subsequently, these wrong steps will not only lead to project failure but also incur a waste of time, energy and resources especially financial.

Falling into the trap of solving the 'wrong' problems is not uncommon and Leggett's classic example of a manufacturing plant simulation project (Leggett 1978), lends a useful case study. Watson's paper (C. Watson 1976) provided a good pathway on how to properly structure problems to avoid common problem-solving pitfalls. It is the challenges to problem-solving as detailed by Watson that provided solid reality-checks that this thesis will strive to avoid as his guidelines are still invaluable in today's complex world. The successes of most of the application examples earlier explained were due to the prior appreciation and 'soft' modeling of the problem situations. These success declarations are not a statement from the researchers alone but also from the sponsors since their satisfaction with consultancy projects define success. No amount of drastic, initial quantitative approach to the problems would have provided implementable solutions.

A sponsor organization whose initiative provided a testing ground for this thesis appears to have already fallen into the problem-solving trap discussed above. The sponsor is the International Council on Systems Engineering (INCOSE) which is the largest professional organization committed to the development and advancement of Systems Engineers. The pertinent evolution of the professional development industry is way beyond formal methods such as courses and conferences. However, we cannot deny the informal possibilities in areas such as peer learning, mentoring, and leadership development which differs from the more common certification courses (Mizell 2010). Most educational providers especially MOOCs and e-learning businesses are still heavily focused on formal modes of delivering continuous learning and marketplace skills. It is no

longer a secret of the huge potential of leveraging on the informal but more motivating aspects of Professional Development (PD) nowadays.

Despite the organization's conscious efforts to achieving her objectives, organizations relying on complex systems still experience requirements, design, implementation and integration issues that call for a rounded approach to talent management through professional development. INCOSE has been saddled with requests from these companies who are part of her corporate advisory board, to rise to these challenges. For a while, this organization has always provided in 'silos' some form of professional development through her certification program, technical publications, webinars, symposiums, conferences, chapter meetings, and workshop. Now it has become clear that an integrated online platform is needed to keep in touch with current digital realities and sustain a continuous professional development outlook. However, it was interesting to see that the key drivers of the project of interest recognized the need for customer needs assessment but were already developing solutions that had not been fed with outcomes from a thorough customer needs assessment. This work will try to structure an aspect of the customer needs situation intending to come up with outcomes that can help the sponsor develop better solutions and ensure initiative success.

1.2 Thesis Topic and Research Questions

The purpose of this research effort is to develop a systems framework that holistically captures the wider context of customer needs assessment for INCOSE's PD initiative towards providing actionable solutions for implementation. However, the framework needs to be able to accurately identify the type of problem been dealt with by INCOSE. Jackson and Keys (1984) classified problem contexts into six and provided suitable methodologies for resolving each problem class. Oliga (1988) provided a detailed summary of Jackson and Keys' classification (in Figure 1.1) backed up with the four dimensions of inquiry detailed by Banathy (1987). A critical look at our problem of interest after attending strategy sessions and numerous meetings towards its development led to the observation that it is an unstructured problem situation involving multiple stakeholders, multiple perspectives, variety of uncertainties, conflicting interests, and significant intangibles as noted in the literature (Rosenhead and Mingers 2001).

Participants' relationship	System type: Mechanical	System type: Systemic
Coercive	Mechanical–coercive Methodologies Yet to emerge	Systemic–coercive Methodologies Yet to emerge
Pluralist	Mechanical–pluralist (heuristic) Methodologies 1. Dialectical inquiring systems, e.g., SAST 2. (Double-loop organizational learning)	Systemic–pluralist (purpose seeking) Methodologies 1. Interactive planning 2. Checkland's soft systems methodology
Unitary	Mechanical–unitary (rigidly controlled) (deterministic) Methodologies 1. Classical OR 2. Systems engineering 3. Systems analysis 4. (Living systems process analysis) 5. (Management cybernetics)	Systemic–Unitary (purposive) Methodologies 1. Organizational cybernetics 2. Sociotechnical systems thinking 3. General systems theory 4. Modern contingency theory 5. (Living system process analysis) 6. (System design)

Figure 1.1 Problem Contexts and Methodologies (Oliga 1988)

This class of the problem context being dealt with in this thesis is systemic-pluralist. This problem situation is systemic in the sense that it is open, has purposeful parts, is only partially observable and cannot be understood using reductionist methods (R. Ackoff 1974). Jackson and Keys (1984) classified a pluralist problem context based on objectives to be attained. When the set of decision-makers cannot find common ground on set goals and consequently make their respective decisions with differing objectives, then we have a pluralist problem context. Pluralism brings about conflict.

Challenges of the INCOSE PD initiative that are addressed by this research include addressing the professional development needs of prospective professionals, students, and individuals who are involved in endeavors that straddle systems engineering (SE). The additional challenge is that these prospective individuals are not members of INCOSE, belong to a wide range of disciplines but have PD needs that INCOSE is best primed to meet. Also, customer demographics data on this customer segment is not available, and this reality might have shaped the PD initiative's drivers within INCOSE to commence developing solutions without consulting on what this special group of prospective users could need. A key stakeholder of the PD steering

group within INCOSE stressed the need for knowledge gleaned from aspects of customer needs assessment to be fed into the requirements definition for the PD online platform about to be developed. This is the main objective that drives this thesis. Due to the practical nature of this research, it is pertinent to understand that it is a form of action research and care needs to be taken in the way it is structured. This research aims to employ what Checkland and Holwell (1998) call the 'organized use of rational thought' paradigm. This approach is the heart of Action Research (AR).

The following research questions were investigated within an action research framework for addressing INCOSE's PD challenges:

- Can a suitable form of PSM framework be developed within an AR lens to holistically and systematically convert the unstructured systemic-pluralist challenges of INCOSE's prospective customer segment's PD needs, into a refined set of 'soft' problems and solutions?
- How does the resulting framework allow for further implementation of 'hard' OR methods towards developing definitive solutions from the refined 'soft' problems?

1.3 Thesis Roadmap

Chapter 1 of this thesis provides an overview of the motivation for this research, along with detailing the research questions and roadmap. Chapter 2 presents a literature review that provides an overview of how action research works and background information on the wider issue of customer needs assessment, data and its place within the Business Model Canvas (BMC). This chapter sets the background for the research methodology used in this research effort by selecting appropriate PSM methods that can capture the problem situation by harnessing the strengths and weaknesses of each method. Also, the chapter portrays an understanding of the wider SE market and known customer segment that INCOSE hopes to conquer. Chapter 3 conveys the research approach of resolving the systemic-pluralist nature which is a novel, joint methodology that combines two methodologies that were reviewed in Chapter 2. Chapter 4 showcases a stage-by-stage application of the research methodology using the case study for this thesis. The unstructured problem is viewed through a holistic understanding of INCOSE's current PD situation to identify cogent issues and proffer actionable solutions that will better meet the key stakeholders' needs. Chapter *5* seeks to respond to the second research question by converting one of the proffered

solutions from Chapter 4 to a text mining problem for obtaining definitive answers that INCOSE PD steering group can leverage upon during their development of an online platform capability for PD. Chapter 6 summarizes the findings from the application of the research methodology and provides next steps recommendations for INCOSE. Also, it states the opportunities for further research in the application, and evaluation of the novel methodology developed in this thesis.

CHAPTER 2. LITERATURE REVIEW

2.1 Action Research

In influencing diverse aspects of human affairs, it is pertinent to understand the complexity of things; a distinction from the immutable laws of nature, which natural scientists regularly deal with (Checkland and Holwell 1998). In the pursuit of employing an organized, rational thinking approach (commonly used by natural scientists) in intervening in human situations, there is a need to understand that underlying theories and practice are in a state of constant interactions propounded to explain the Framework-Methodology-Application (FMA) model in Figure 2.1 below.

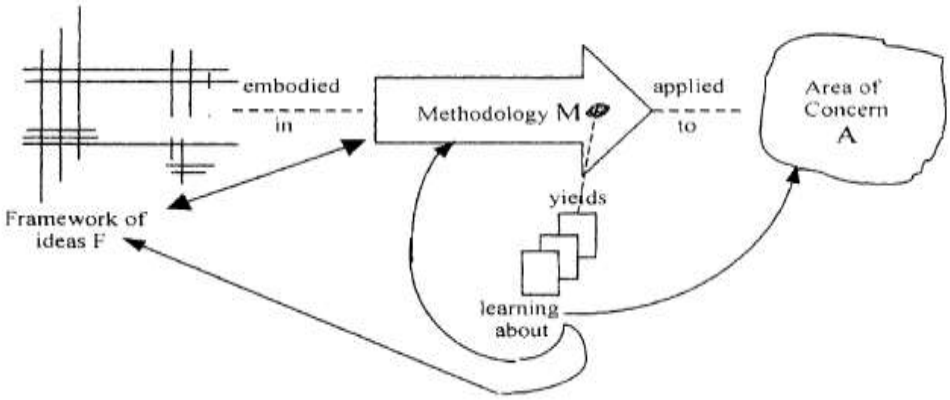


Figure 2.1 Elements relevant to any piece of research (Checkland and Holwell 1998, 13)

As indicated in Figure 2.1, all forms of research inquiry can be implied to include all these research elements. This thesis will investigate a rational intervention which will leverage on the theoretical framework of PSMs to determine or develop a methodology for application towards the objective of this work centered around INCOSE. In applying this research framework, it is critical to understand the rational intervention to be conducted in this study falls within the context of the INCOSE business model. Since the application problem is a business one, it will be more insightful to problem-solving to review a preliminary investigation into the market identification and value proposition of the ideal solution INCOSE aims to develop. These two customer requirement activities are limited to the existing INCOSE members' point of view although such

a background understanding can help the problem-solver better appreciate the business situation and environment.

2.2 Business Model Canvas

When thinking about how businesses make profits, it is not out of order to think of what their business models entail. The earliest mention of business models was made as a solution to capturing the decision processes needed to solve business problems using mathematical and simulation models (Bellman et al. 1957). There are various definitions of what a business model means with (Zott, Amit and Massa 2011) presenting an array of some in literature as follows: 'At a general level, the business model has been referred to as a statement (Stewart and Zhao 2000), a description (Weil and Vitale 2001), a representation (Morris, Schindehutte and Allen 2005) (Shaler, Smith and Linder 2005), an architecture (Durbosson-Torbay, Ostenwalder and Pigneur 2001) (Timmers 1998), a conceptual tool or model (George and Bock 2011, A. Ostenwalder 2004, Osterwalder, Pigneur and Tucci 2005), a structural template (Amit and Zott 2001), a method (Afuah and Tucci 2003), a framework (Afuah 2004), a pattern (Brousseau and Penard 2006), and a set (Seelos and Mair 2007)'.

Al-Debei and Avison (2010) describes these definitions as incomplete and proceeded to list inference criteria for defining what a business model is. Criteria were stated based on definition comprehensiveness/generality, beyond components definition, and synthesis of previous definitions in the literature. These criteria were then used in providing a combined definition of a business model by Al-Debei and Avison (2010, 372) as: "*an abstract representation of an organization, be it conceptual, textual, and/or graphical, of all core interrelated architectural, co-operational, and financial arrangements designed and developed by an organization presently and in the future, as well all core products and/or services the organization offers, or will offer, based on these arrangements that are needed to achieve its goals and objectives*". From all these definitions, there is a need for companies to understand the inner workings of the business model to take advantage of the leverage it can provide. (Ostenwalder and Pigneur 2010), describes the business model as a 'must have' for new startups to gain more insight into business and better position their products/services as market leaders.

Saxena, Deodhar and Ruohonen (2017) explain business model ontologies as models that avidly describe and elucidate some of the research efforts that attempt to project business models

as a ‘construct, and their range of conceptualizations.’ Their study further states that business model ontologies provide a detailed explication of what the business model is while citing three business model ontologies from literature. The three ontologies are namely Zott and Amit (2010), Johnson, Christensen, and Kagermann (2008), and Ostenwalder and Pigneur (2010).

The ontology of Zott and Amit provides an ‘abstract approach’ to the theoretical framework of the business model by hinging on the ‘structure, content and governance of activities’ (Saxena, Deodhar and Ruohonen 2017). For the second ontology, Johnson, Christensen, and Kagermann (2008) defined a business model to comprise of four ‘interlocking elements’ that collectively ‘create and deliver values’ (Saxena, Deodhar and Ruohonen 2017). The interlocking elements identified above are the CVP, the profit formula, the key resources, and the key processes. An advantage of this ontology is its structurally-oriented attribute. The third business model ontology cited by Saxena, Deodhar and Ruohonen (2017) is that of Osterwalder and Pigneur (2010) which defined a business model as ‘the rationale of how an organization creates, delivers and captures value.’ Its visual framework is known as a diagram referred to as a Business Model Canvas (BMC). The BMC in Ostenwalder and Pigneur (2010) is a business model that describes each element of the business implementation strategy and links them with one another to explain functionality. BMC has nine components, and they are the building blocks (in Figure 2.2) that the BMC utilizes to visually demonstrate the interconnecting nature of its components.

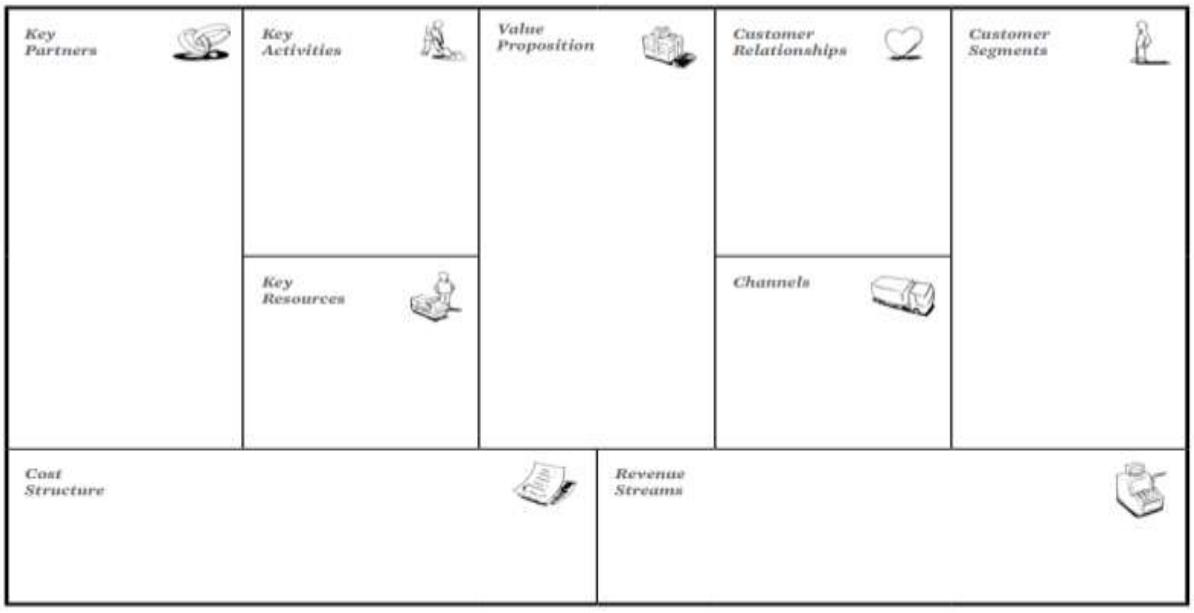


Figure 2.2 The Business Model Canvas (Ostenwalder and Pigneur 2010, 44)

2.3 Business Analytics

In keeping up with the digital realities of the nowadays, INCOSE's business model will not be thorough without appreciating and making allowances for the latest craze in the business world – data. There has been a huge commercial excitement around business analytics and data. Companies that seek to stay ahead of the business competition seek to create financial and economic value through exploration of internal and external data resources (Vidgen, Shaw and Grant 2007). A popular definition of analytics is covered in Davenport and Harris (2007) as "the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions." Furthermore, Hindle and Vidgen (2018) characterized business analytics as "descriptive (e.g., customer segmentation), predictive (e.g., customer churn modelling), and prescriptive (e.g., offer this loyal customer a discount) model building using data sources that may be heterogeneous (e.g., text, video) and 'big'". Hindle and Vidgen further attributed these business analytics models to help organizations make quicker, better, and more intelligent decisions to create business value in the broadest sense –potentially the difference between survival and extinction in an increasingly competitive world.

The BMC framework of Figure 2.2 was used by Hindle and Vidgen (2018) to identify leverage points for business analytics, i.e., to identify the data, tools, and analyzes that are most likely to address the goals of the business and make the best use of scarce resources. Also, Hindle and Vidgen provided a generic road map for analytics applications shown in Figure 2.3 below.

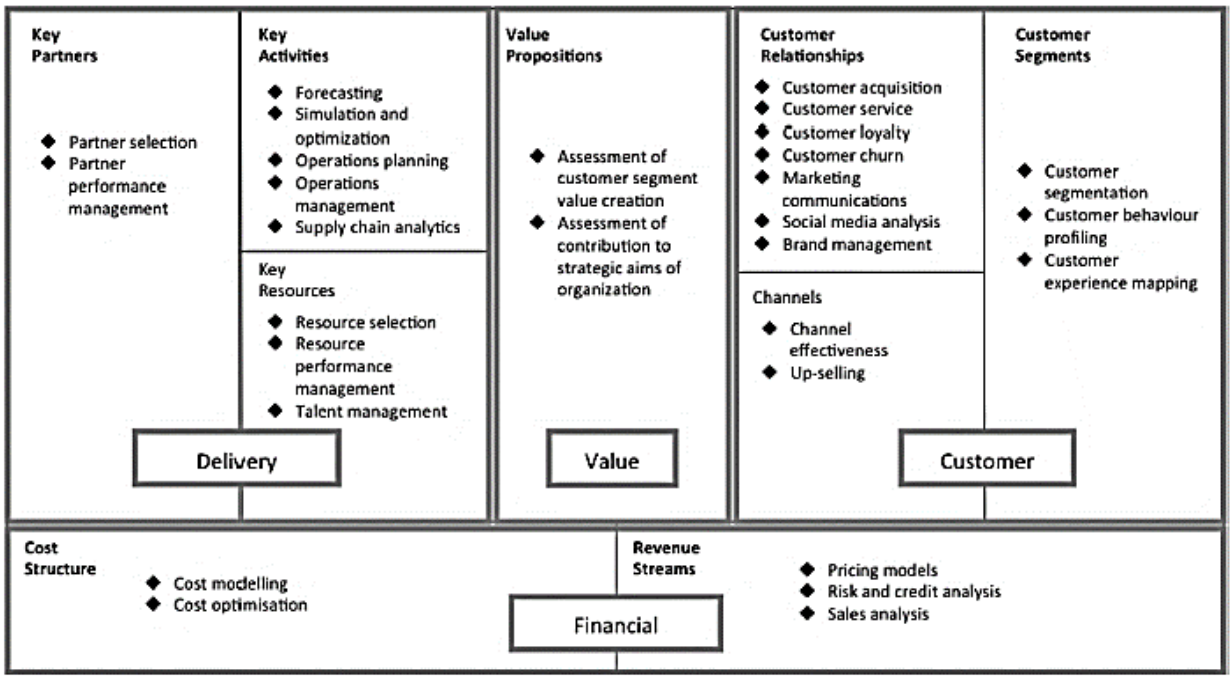


Figure 2.3 The BMC with generic analytics overlay (Hindle and Vidgen 2018, 843)

More precisely, the rational intervention that this work will bring must always be cognizant of the predictive/explanatory opportunities data can provide due to the current business realities within the sphere of PD. However, the predictive, explanatory, and prescriptive data models are hard OR methods which require certain assumptions before they can be used. These assumptions stated by Daellenbach (2001) require a problem situation to be clearly defined, objectives, alternative courses of actions and constraints of the decision choices must be well-known. Also, the problem is relatively well-structured, and of a technical nature devoid of human aspects.

The fallout of this discussion on data models and business analytics only confirms the train of thought that motivated this research. That is, the problematic issue at hand must be well-structured first before any definitive solution that can aid implementation can be made. Based on this conviction, an investigation into the problem to be solved will commence with an attempt to scour through existing literature to uncover what has been previously done. Subsequently, efforts will be made towards selecting the most appropriate methods for structuring INCOSE's PD problem situation concerning customer needs assessment.

2.4 Overview of relevant PSMs

It is worthy to note that the problem situation of a lack of knowledge of prospective customer needs for INCOSE PD initiative is an unstructured one. The only understanding of this problem situation which involves context to be uncovered is that it is a systemic-pluralist problem situation according to Jackson and Keys' classification. With this understanding, the next step to take is to uncover relevant PSMs from literature to determine fit for the problem situation of interest. A methodical description of PSMs was described by Daellenbach (1994) as below:

- *Focusing on structuring a problem situation, rather than on solving a problem*
- *Aiming to facilitate a dialogue between stakeholders to achieve the greater shared perception of the problem situation, rather than to provide a decision aid to the decision maker*
- *Initially considering 'What' questions, such as: "what is the nature of the issue?"; "what are appropriate objectives given the differing worldviews of stakeholders?"; "which changes are systemically desirable and culturally feasible?" and only then "how could these changes be best achieved?"*
- *Seeking to elicit resolution of the problem through debate and negotiation between the stakeholders, rather than from the analyst*
- *Seeing the role of the "analyst" as a facilitator and resource person who relies on the technical subject expertise of the stakeholders.*

Also, an iterative capability for PSMs was specified by Rosenhead and Mingers (2001) with an ability to move between "analysis of judgmental inputs and the application of judgment to analytic outputs" (Rosenberg 2006). Both authors further presented five primary PSMs namely Soft Systems Methodology (SSM) (P. Checkland 2001), Strategic Options Development and Analysis (SODA) (Eden and Ackerman 2001), Strategic Choice Approach (SCA) (J. Friend 2001), Robustness Analysis (Rosenberg and Mingers 2001) and Drama Theory (Bennett, Bryant and Howard 2001). SSM, SODA and SCA are the most generally applicable (Belton and Stewart 2010) due to their ability to 'surface ideas and structure thinking' about any broadly defined issue. In keeping up with the action research paradigm guiding this work, the theoretical framework for the most common PSMs from literature is pointed out in Table 2.1 below.

Table 2.1 Relevant PSMs and their theoretical foundations (Belton and Stewart 2010, 218 and J. Mingers 2011, 733)

Method	Description	Theoretical Foundation
Soft Systems Methodology (SSM)	Uses rich pictures, CATWOE, root definitions and conceptual models to explore the issue from several different perspectives.	• Churchman's dialectical inquiry • Vickers' social processes • Interpretive sociology.
Strategic Options Development and Analysis (SODA)	Beginning with a process of idea generation seeks to capture and structure the complexity of an issue reflected by multiple perspectives.	• Kelly's psychological theory of 'personal constructs.'
Strategic Choice Approach (SCA)	Four modes – Shaping, Designing, Comparing, Choosing. Focuses on key uncertainties (about related areas, environment, and values) and analysis of interconnected decision options.	• Planning philosophy and methodologies
Strategic Assumption and Testing (SAST)	Used to challenge deeply held assumptions by surfacing then and challenging them with their opposites.	• Churchman's dialectical approach
Critical Systems Heuristics (CSH)	Used to challenge the boundaries drawn up to circumscribe the focus of planning or design.	• Churchman's dialectical approach • Habermas's critical theory
Hypergames, Metagames and Drama Theory	Appropriate in multi-party contexts, where the outcome is dependent on the inter-dependent actions of the parties – seeks to identify stable options.	• Games Theory
Robustness Analysis	Focuses on identifying options which perform well in all possible futures.	• Decision analysis and planning methodologies
Interactive Planning	Used to assist participants in designing a desirable future for their organization and bringing it about.	• Pragmatism and systems theory

There have been some attempts within the literature that tried applying some relevant PSMs in resolving problem situations of a systemic-pluralist nature. The SSM approach was innovatively used by Winter (2006) at the front-end of a Branch Specific Range (BSR) project for Tesco in the UK by distinguishing the content of the problem situation and activity planning. This distinction was the driver of the Tesco intervention where SSM was used to help plan the process of the educational workshop (SSMp), in addition to tackling the actual content of BSR (SSMc). Furthermore, an SSM and Multi-Criteria Decision Analysis (MCDA)-based methodological

approach for structuring multi-objective problems involving multi-stakeholder environmental decision-making for a public transport company (Teles and Freire de Souza 2014). An Interests-coordination SSM (ISSM) framework was developed in Jianmei (2010) and was applied to a knowledge management project in China. The framework was theoretically built on the Interest Man assumption and is a conglomerate of soft and hard systems methods. PSMs such as SSM, SAST and Conflict Analysis alongside quantitative methods such as Multi-Criteria Decision Analysis (MCDM), game phase, ELECTRE, and Analytical Hierarchical Process (AHP).

In addressing systemic-pluralist issues, some of the above interventions, though greatly helpful in advancing problem resolution, were limited it would be limited in other applications. The Tesco intervention was able to resolve the conflict by getting the decision-making stakeholders into workshops and 'ironing' things out. Conflict resolution is not always that simple considering the unpredictable interest nature of man and when the main actors are physically distant from each other. Also, the ISSM framework though ground-breaking in recognizing the Interest Man assumption failed to fully synchronize the foundational requirements for soft and hard problem resolution methods within its framework. Its application of soft and hard approaches interchangeably directly contravenes Daellenbach's requirements for hard systems methods can be used.

However, of the three most generally applicable PSMs identified by Rosenhead and Mingers, SSM is the most notable among these PSMs, especially when considering Jackson's argument for its application in systemic-pluralist problem situations (Jackson and Keys 1984). Both authors recommended SSM due to its ability to holistically 'gain an understanding' of a purposeful system's numerous parts and various actors having diverse perspectives. Also, SSM's capacity to accommodate conflicting responsibility of a system/organization's purposeful parts (plurality) sealed its acceptance.

2.5 Soft Systems Methodology

Checkland (1976) described the initial attempt towards formulating SSM. The formulation of SSM stemmed from acute problems that existed within the organizations of interest and are not stated in precise terms (M. C. Jackson 2003). The methodology is a softer, more flexible answer to the unsuccessful research application of systems engineering approach towards a broad spectrum of management problems (Hindle 2011). SSM approaches soft issues by initially setting

up the most vivid possible picture describing the scope of the problem situation. Next, this methodology explores conceptual models which are human activity systems, each with a world view (or *Weltanschauung*). These notional systems which can be named in 'root definitions,' are later compared with the real world (M. C. Jackson 2003).

Furthermore, it is significant to express the strong cultural and political accommodations made in Checkland's four-activity SSM. Here, he pointed out the need for problem situation debates to provide direction on changes that will improve the situation through accommodation of conflicting interests Checkland (1990). In a bid to present SSM as an all-purpose approach to tackling complex situations, Checkland and Scholes (1990) and Checkland and Poulter (2006) adopted an experiential learning approach of disseminating its principles and methods. This learning procedure is shown in Figure 2.4.

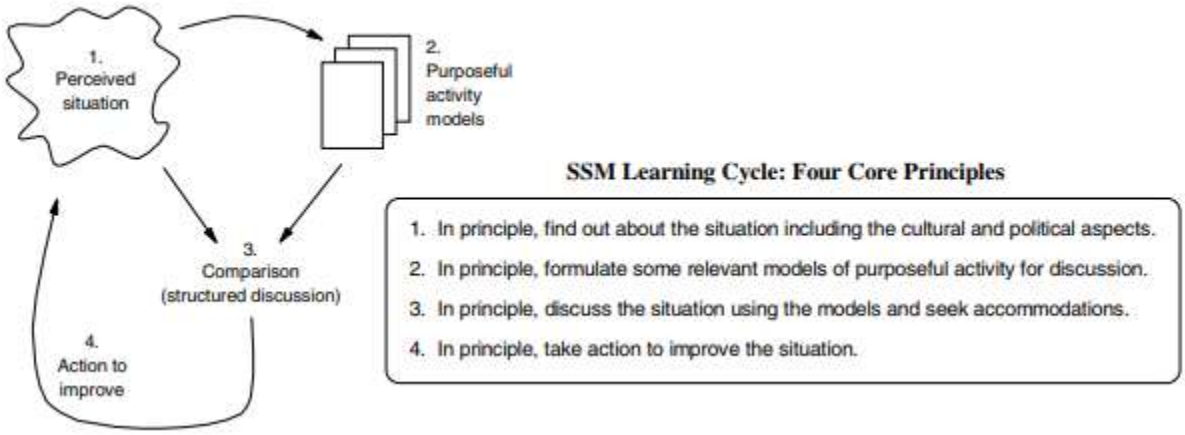


Figure 2.4 The four activity learning model of SSM (Checkland and Scholes 1990)

Checkland (1981) presented the first seven-stage cyclic, learning system of SSM which starts with the identification of a problem situation before it becomes expressed as a rich picture which aids a creative understanding and dissemination of the problem as is. Subsequently is the eminence of the system thinking phase where root definitions of relevant purposeful activity systems. This is where Jackson (2003) explains the need to pay attention to the 'essence of the relevant system' which is made possible by CATWOE (Customers, Actors, Transformation Process, World view, Owners and Environmental Constraints). The world view reflects a different way each root definition visualizes the problem situation.

Afterward, conceptual models of the relevant systems are named in the root definitions before they are compared to the real-world situation. Ultimately, systematically desirable and culturally feasible changes are considered in acting to improve the problem situation. However, due to the limiting representation of the pioneer seven-stage approach and a lack of systemic understanding of the process, a better representation of the methodology was developed by Checkland and Scholes (1990) as a 'two-strand model.' This new model provided a more enhanced form of cultural analysis namely: Analysis 1, 2 and 3. Analysis 1 considers the roles of client, problem-solver, and problem-owners concerning the intervention. Analysis 2 appraises roles, norms, and values in a social system analysis manner. The third form of analysis explores the politics of the problem situation and how power is secured and used.

An intriguing aspect of problem situations is the likely presence of conflicting interests. Among the major criticisms of SSM (M. C. Jackson 1982, M. C. Jackson 1983, and M. C. Jackson 2000), this methodology is seen as having a limited domain of application. Furthermore, Jianmei (2010) alluded to SSM's inability as a methodology to tackle some special soft problems such as those of interest conflicts due to its generic positioning. The dominant view among critics of SSM is that it leads to a consensus worldview that does not take the possibility of fundamental conflicts of interests seriously.

This research will seek to provide a more robust approach towards structuring problem situations with conflicting elements through a soft systems approach. The concept of conflict needs to be well scrutinized. It depicts the presence of opposing elements or sub-elements of a system. Within a soft version of another method – TRIZ, this is called a 'contradiction.' Chai, Zhang, and Tan (2005) define contradiction analysis as the process of structuring a problem into the form of a contradiction by identifying two conflicting components or two opposite requirements to the same problem element. Hence, it is important to understand how TRIZ resolves contradictions, so this method can be explored in this work's quest of structuring the pluralist aspect (which brings conflict) of INCOSE PD problem situation in a systemic and holistic soft approach.

2.6 TRIZ

TRIZ (*Teoriya Resheniya Izobretatelskikh Zadatch* or the 'Theory of Inventive Problem Solving") was invented by Genrikh Altshuller and, is a well-structured innovative problem-solving approach. It is a process utilizing systematic thinking tools that are intended to replace

unsystematic trial-and-error method approaches that some managers and engineers employ in searching for solutions. Although this method does not directly provide answers, it proposes various resolution principles to solve a problem of interest. Altshuller came up with this methodology after analyzing thousands of patents and successfully categorizing these patents in a novel way that identifies problem-solving processes rather than classifying patents according to industries.

Domb (1998) details the approach employed by TRIZ for problem-solving and explains how TRIZ overcomes the psychological inertia barrier of problem-solving by generalizing a specific problem into a similar TRIZ generic problem. It then employs a comparison of this generic TRIZ problem and a similar generic TRIZ solution to generate solutions for the specific problem. The main stages in utilizing TRIZ and the toolboxes employed are further described by Chai, Zhang, and Tan (2005) and summarized in Figure 2.5.

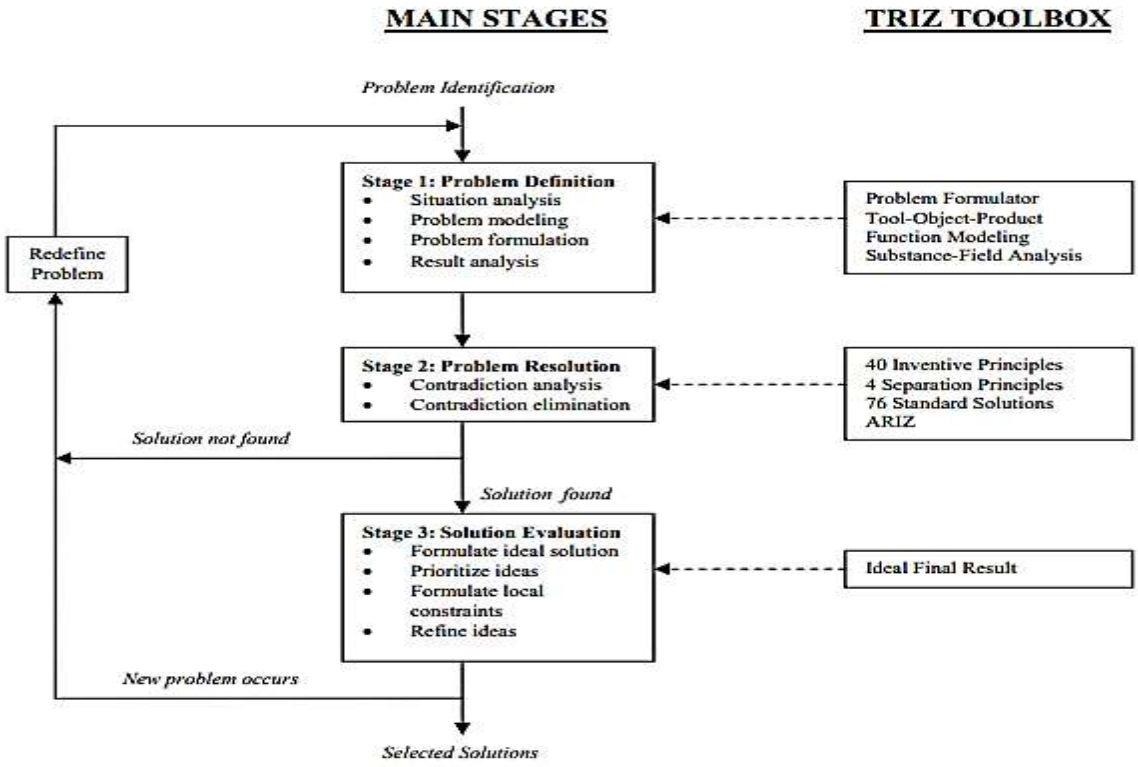


Figure 2.5 TRIZ Problem-solving model (Chai, Zhang and Tan 2005)

Ilevbare, Probert and Phaal (2013), indicated contradictions, ideality and evolution patterns to be the main foundations of the TRIZ problem-solving process and further listed the main tools

and techniques of TRIZ. Some of them are listed in Figure 2.5 and are 40 inventive principles, 76 standard solutions, separation principles, contradiction matrix, Ideal Final Result, function analysis, substance-field, nine windows, creativity tools, and ARIZ among others. The range of TRIZ applications is notably wide with a lot of forays into the technical domain. Within Systems Engineering, it has been significantly applied for systems architecting. Bonnema (2011) applied TRIZ alongside Funkey Architecture in creating a design tool for simplifying and improving system architectures while Bryan and Dagli (2005) focused on applying TRIZ for knowledge capture. Also, the TRIZ Trade study tool was developed by Blackburn, Mazzuchi, and Sarkani (2015) to identify system conflicts, both across alternatives and within technology, and at different stages of requirements decomposition, to compare options and optimize how systems work. Although TRIZ has been applied mostly in technical (mostly engineering) domains, it has been applied in non-technical domains such as business model innovation, new service design, education, among others. The work of Khomenko and Ashtiani (2007) was on extending the application of TRIZ towards a general audience irrespective of the domain to be studied. The business application of TRIZ was well explicated by Souchkov (1998) and Ishida (2003) going further in exploring business model innovation.

Jackson (2003) argues that SSM:

- is ‘much less obviously’ the most suitable approach in dealing with problems requiring the organizational design of complex systems with significant conflict or coercion.
- provides a little perspective on why problems occur according to hard system thinkers and
- don’t take the idea of obeying cybernetic laws when organizing complex systems seriously in SSM.

Although SSM appears relatively weak in handling these special problem situations, it can be made more robust by deploying its areas of strength alongside TRIZ; which focuses on resolving contradictions arising from conflicting interests. In resolving these deficiencies, a methodology should be able to provide a resolution mechanism for problems of conflicting-interests nature, answer the question of why problems do occur (which can reveal contradictions of the problem) and proffer an idealized standard against which we can measure our progressive solution.

CHAPTER 3. RESEARCH METHODOLOGY: SSM-TRIZ

3.1 Strengths and Weaknesses of SSM and TRIZ: Opportunities for Synergy

In solving problems with conflicting integral elements, this thesis seeks to explore a holistic and systemic approach which considers different perspectives of important actors. Also, this study needs to employ a systematic procedure in resolving conflicting elements of the problems situation of interest without compromising. Table 1 showcases the strengths and weaknesses of both methodologies during application. Where SSM fails, TRIZ supports and vice-versa. It is due to the complementary nature of both methods that this work subsequently makes a case for a dual methodology towards solving our problem-type of interest. While SSM is most appropriate in providing and embracing a holistic, systemic and multi-perspective approach to problem resolution, TRIZ offers a resolution mechanism for systemic-pluralist problems by identifying contradictions.

Table 3.1 Comparison of SSM and TRIZ methods for resolving problems with conflicting interests

Method	Strengths	Weaknesses
SSM	• Provides a holistic understanding of the problem from a systemic perspective • Integrates various perspectives of different actors involved in resolving the problem.	• Does not provide firm guidelines toward uncovering why problems occur • Does not proffer a mechanism/tool for resolving contradictions which are at the heart of conflicting interests' problems • Ideality thinking is not part toolbox as the aim of resolution is towards rejecting compromise(s). • Discourages hard system thinking approaches in most cases unless worldviews have been collapsed into one.
TRIZ	• Breaks problems down into discovering inherent contradictions that provide clues for the solutions • Embraces the concept of ideality • Possesses contradiction resolution techniques (40 inventive principles, ARIZ, separation techniques, etc.) • Encourages the further pursuit of hard thinking approaches for definitive solution implementations.	• Tools for problem definition do not encompass a holistic appreciation of the issue at hand • The resolution process is based on the perspective of the problem-solver instead of embracing the perspectives of other principal actors.

3.2 The SSM-TRIZ Methodology

The SSM-TRIZ methodology was developed for this thesis using a framework that consists of the seven steps shown in Figure 3.1 with the bold header words in each step indicating the central idea. Steps 2,3, 4 and 6 consists of two separate columns of step activities. The ones on the left show the TRIZ approaches while the ones on the right (in bold and italics) show the SSM approaches. These method steps are further condensed into four stages of SSM-TRIZ application for better understanding and practice.

Stage 1. Expression of problem situation: Conversion of the unstructured problem to problem with inherent contradictions. In the first two stages, the problem-solver will attempt to gain a deeper understanding of what the problem is. The merit of adopting a TRIZ approach in processing these stages is that it helps us discover the underlying contradictions that make the problem appear as one with conflicting interests. The rich picture diagram from SSM is still in use as we still need to envision the social stream around the problem and its possible interrelationships. This picture will guide us into selecting the issue of interest and subsequently employ the root cause analysis method in breaking the problem down into its inherent contradictions. It is when these contradictions are discovered that we can then proceed about resolution. If hidden contradictions within a problem with conflicting interests cannot be discovered, then efforts towards problem resolution will likely be futile.

Stage 2. Root definition and conceptual model of the relevant system. This stage encompasses method steps 3 and 4 which is where systems thinking is implemented. Here, the relevant system is the Human Activity System that is critical to the problem. The CATWOE model for determining customers, actors, transformation, world-view, owners and environmental constraints is constructed. This SSM method guides us as we analyze the contradictions discovered. There are different techniques for contradiction analysis such as separation techniques and 40 principles, and the problem solver has a choice of which to use depending on domain application and experience. Furthermore, the conceptual model from the contradiction analysis is then derived from a

functional model diagram which organizes CATWOE elements into subsystems and provides insight regarding useful interrelationships.

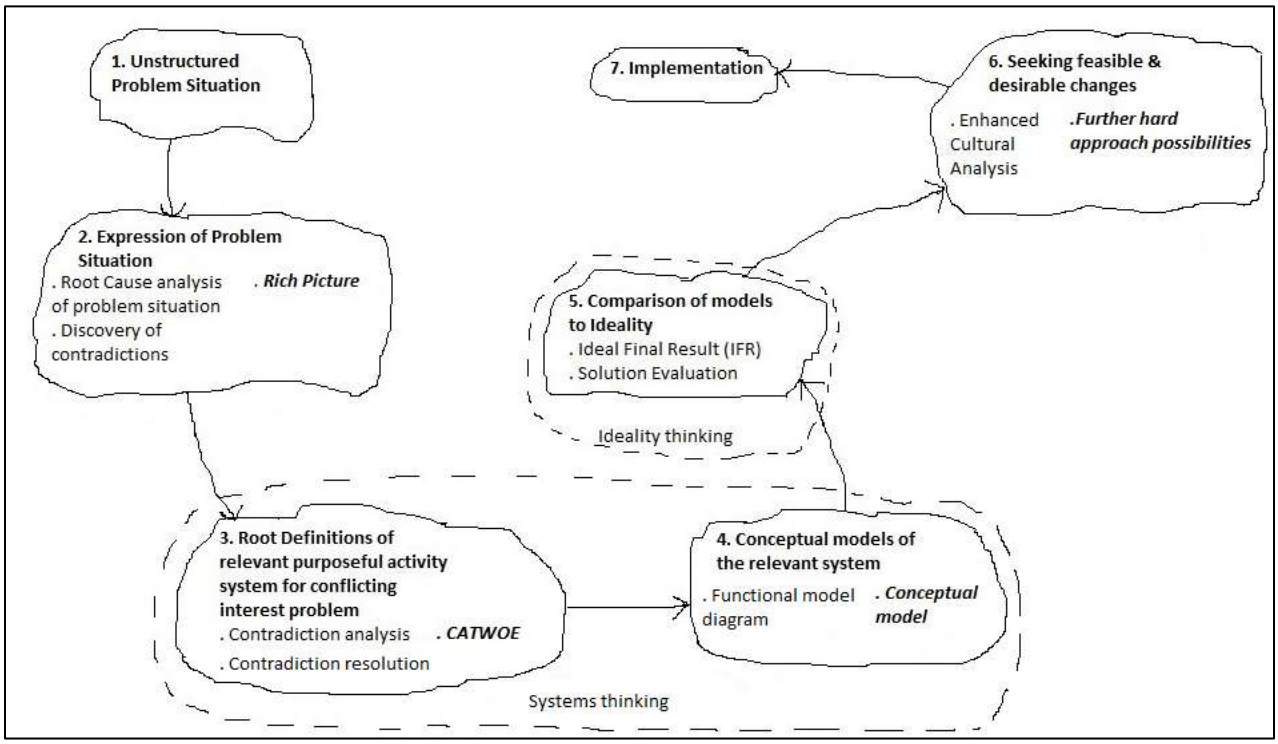


Figure 3.1 Phases of SSM-TRIZ Methodology

Stage 3. Comparison of models to ideality. Step 5 of the methodology involves a comparison of the conceptual models developed to the ideal solution the problem-solver envisioned initially. The thinking here is that of ideality, which is not included in the standalone SSM. The reasoning is that any model existing in the real world is far from ideal and needs to be improved. The perfect world encompasses a solution model to the problem at hand with conflicting interests; hence, the need to compare these two worlds to check the progress of problem resolution. No compromise is permitted, and the concept of Ideal Final Result (IFR) is a pre-implementation description of the problem situation after the problem has been solved. An ideal solution delivers a useful solution that accommodates the inherent contradictions. The selected solution idea from the contradiction resolution phase is compared against the IFR to ensure it satisfies the ideal expectation. Otherwise, another alternative solution will have to be tried.

Stage 4. Seeking feasible and desirable changes. SSM allows for the adoption of the logic-based stream of cultural analysis at this stage (Checkland and Scholes 1990). The SSM-TRIZ methodology does not seek to abandon this SSM approach. However, it encourages the possibility of ending the 'soft' phase of problem-solving and switching into adopting System Identification techniques in resolving some conceptual models. Not all business problems or non-technical problems have 'soft' solutions. If there is a possibility of measuring input and output data from these models, then system identification techniques (a form of hard-systems thinking) could suffice in narrowing down towards feasible solutions. System identification methods, such as heuristics, statistics, machine learning, and optimization, can then be used depending on suitability.

CHAPTER 4. APPLICATION

4.1 Market Identification and Value Proposition

The overarching function of the INCOSE's proposed integrated online platform will be in providing Systems Engineering education to all applicable industries in a rounded approach based on INCOSE's competency framework (INCOSE 2018). Customers requiring one or more of its component functions such as education and training, mentoring, knowledge products, internship/job experience, certification, and technical leadership opportunities, will only need to refer to one online platform to obtain what they need. The target industries for this solution are those applying System Engineering and those that develop integrated systems - not industries that apply Systems Engineering per se. There is a need to design, deploy, and manage complex systems over their lifecycles due to increased prevalence of technology, service delivery, and job integration. According to Global Market Insights (2016), the integrated systems industry is divided into Product, Service, and End-Use industries.

INCOSE has two broad markets namely her CAB (Corporate Advisory Board) companies and non-CAB companies. The CAB companies are 106 in number and span companies in aerospace and defense, manufacturing, automobile, government, and higher education sphere. The bulk of INCOSE members work for or once worked for these CAB member companies featuring General Electric, Airbus, MIT, Honeywell, Lockheed Martin, Idaho National Laboratories among others. However, the non-CAB companies are companies in the Systems Engineering and Integrated Systems space but are not associated with INCOSE in any way. It is companies in this second classification who need their workforce to be better-trained in Systems Engineering principles and applications in other to combat requirement traceability and tracking, implementation, verification, and design issues, especially with nonconformance reports. This market is projected to constitute a massive percentage of the projected $9.5 billion market volume of the global integrated systems. This report by Global Market Insights also predicted the market volume to increase to $30 billion by 2022 with a Compound Annual Growth Rate of 15% from 2015 – 2022 (Davis 2016).

The Integrated Systems Product industry is further segmented into an integrated platform and integrated infrastructure sections. Integrated Systems Service is subdivided into

installation/integration, consulting services, and maintenance/support. Finally, the Integrated Systems End-Use industry is further divided into Banking, Financial Services and Insurance (BFSI), Aerospace and defense, Automobile, IT and Telecom, Retail, Manufacturing, Healthcare, Higher Education and others (Global Market Insights 2016). Information Technology/Telecommunication and BFSI are predicted to evolve as the dominant forces in the market share due to the huge acceptance rates of Systems Engineering across these areas of application (Davis 2016). A look at the current crop of CAB members in INCOSE depicts a North American dominance which appears likely to continue due to the quick pace of technological breakthrough and heavy industry penetration of integrated systems according to Global Market Insights. An interesting perspective to the market for this professional development platform is that big players such as Oracle, and HP, who in addition to IBM account for over 50% of overall systems engineering/integrated systems market share in 2014 is not even associated with INCOSE or part of registered CAB members.

This presents a huge opportunity for the professional organization if the right value proposition and business operations are established. The good thing is that a direct competition to this proposed professional development platform is non-existent as there are no other dominant Systems Engineering organizations other than INCOSE. However, employees and even big companies patronize the larger and more famous brand in the Project Management Institute (PMI) in seeking professional development opportunities. Also, higher education institutions such as MIT and John Hopkins could even be a more formidable competitor due to their bigger brand and a wealth of capable alumni practicing Systems Engineering.

4.2 Value Proposition

In this section, a value canvas is constructed to map all competitive value factors in the eye of the customer against the relevant market segments. In INCOSE's case, the distinguishable market groups are Current Systems Engineering (SE) professional members, Prospective SE professional members, and Education Providers. Current SE professional members include CAB member company employees in industries such as aerospace and defense, military, and manufacturing, who form the bulk of INCOSE members now. Prospective SE professionals are professionals in Integrated Systems Service and Products industry who are engaged in SE activities but are not utilizing cutting-edge SE methods in prosecuting their business activities. The Education Providers market group encompasses independent SE training providers and interested

universities who form a different group with a varying preference for competitive factors compared to professionals. These three market groups were evaluated against eight competitive factors as below:

- Education and Training: Just-In-Time training and SE education opportunities through short courses or online degree programs.
- Experience Opportunities: Application area demonstration of taught methods.
- Contact and Mentoring: Guidance and direction from a top professional in the same/similar field of expertise.
- Knowledge/Products: Publication manuals, and magazines.
- Internship/Job Experience: Summer internship and Coop opportunities for students to gain a practical appreciation of theory learned in school or through online courses.
- Certification
- Technical-Leadership: INCOSE's framework for developing qualified and sound professionals both technically and managerially. It fosters interactions and participation in working groups and other programs alongside experienced technical professionals who have risen to top management levels in their respective companies.
- Feedback and Analytics: A key satisfaction factor among professionals seeking professional development. This fulfills the need to track performance, technical development, choice of offerings needed to plug competency gap and customer reviews of professional development offerings.

The value curves for INCOSE's professional development offerings are shown in Figure 4.1 below. In providing a more rigorous assessment of the weights market segments place on different offerings for the final strategy canvas, an indirect weight elicitation technique will be used. This method is the Balance beam method developed by Watson and Buede (1987) for indirect weight elicitation. In applying this method to INCOSE offerings, an attempt for the traditional SE user market segment will be explained. Here, we rank from greatest to lowest of the offering objectives is: Certification (C), Education and Training (ET), Contact and Mentoring (CM), Technical Leadership (TL), Feedback and Analytics (FA), Knowledge/Products (KP), Experience Opportunities (EO), and Internship/Job Opportunities (IJ). The inequality equations are:

1) $C > ET + CM$ 2) $ET > CM + TL$ 3) $ET > CM + FA$

4) $CM > TL + FA$
5) $CM > TL + KP$
6) $TL > FA + KP$
7) $FA > KP + EO$
8) $KP > EO + IJ$

In the next step of the balance beam method, assume that stakeholders provide the following quantitative assessments:

1) $IJ = 1; EO = 1.5$
2) $KP > 2.5$
3) $KP = 3$
4) $FA > 4.5$
5) $FA = 5$
6) $TL > 8$
7) $11.5 < CM < 3.5$
8) $CM = 13$
9) $18 < ET < 21.5$
10) $ET = 20$
11) $CM > 33$
12) $CM > 33.5$

Hence, normalized weights for the objectives are:

[C, ET, CM, TL, FA, KP, EO, IJ] = [0.3918, 0.2339, 0.1520, 0.0994, 0.0584, 0.0350, 0.0175, 0.0116].

After scoring and calculating normalized weights for the other two market segments above, the following table mapping market segments to offering weights peculiar to their decision choice is shown in Table 4.1 below.

Table 4.1 Strategy Canvas Weight elicitation table for INCOSE PD tool

Offering/Market Segment	**Traditional SE Professional Members**	**Prospective SE Professional members**	**Higher Education**
1. Education and Training	0.2339	0.3975	0.3484
2. Experience Opportunities	0.0175	0.0361	0.1936
3. Contact and Mentoring	0.1520	0.1506	0.0726
4. Knowledge/Products	0.0350	0.2409	0.0145
5.Internship/Job Experience	0.0116	0.0120	0.2904
6. Certification	0.3918	0.0180	0.0416
7. Technical Leadership	0.0994	0.2409	0.0096
8. Feedback and Analytics	0.0584	0.0843	0.0290

It can be observed that Education and Training, was the most competitive factor for all market groups. However, INCOSE's dilemma is how to integrate these offerings into an online platform to appeal to all market groups to drive not only profit in the short-run but also membership in the long-run.

Figure 4.1 INCOSE Professional Development Platform Value Canvas

4.3 INCOSE and the Business Model

It is critical to revisit the reason the sponsor organization (INCOSE) finds herself in the problem situation which this research aims to resolve. INCOSE's objective is to create value for individuals and corporate bodies by increasing the proficiency of the global systems engineering workforce. The organization aims to be the prime professional body facilitating engagement between suppliers and consumers of SE professional development. INCOSE recognizes an integrated online platform is needed to keep in touch with current digital realities and sustain a continuous professional development outlook. The projected potential benefits increased revenue for INCOSE increased competency among SE practitioners, quantitative competency tracking, service analytics, and reviews, and promotion of general interest in Systems Engineering. INCOSE's business model canvas for this PD initiative has nine components as shown in Figure 4.2 below.

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr><td rowspan="2">Universities (Educational suppliers)

Wiley Deltak

Career Expos

Education Marketing experts</td><td>-Competency/Skills Assessment

-Online course and learning

-Mentoring

-Certification program

-Competency Development Tracking</td><td rowspan="2">CAREER PROFESSIONALS
-Stage by stage competency tracking, guidance and direction for further competency development
-Practical and real-world interaction with SE experts via mentoring.

UNIVERSITIES
-Strong brand partner for wider program access to professionals
-Job recruitment opportunities for graduates</td><td>GET: Virtual Open House, Email blast, Website Advertising

KEEP: Mentoring services, Specialized competency tracking

GROW: Referral/Reward program, Early Completion discounts, Access to Companies' Talent Development programs</td><td rowspan="2">CAREER PROFESSIONALS
-Systems Engineers in US
-Professionals with MSSE, MS, BS in Engineering, Science and Management

UNIVERSITIES
-Target Universities with MSSE degrees and large representation in INCOSE
-Universities with strong brand recognition for Engineering, Science & Management</td></tr>
<tr><td>Key Resources
-INCOSE Database Management personnel
-Mentors
-Intellectual property (Business information, branding, trade secret)
-Computers Hardware
-Certification/Training team
-Competency Decision support program</td><td>Channels
Website</td></tr>
<tr><td colspan="2">Cost Structure
Storage costs, Advertising/Marketing costs, Educational outreach costs, Potential labor costs</td><td colspan="3">Revenue Streams
CAREER PROFESSIONALS
-Freemium model
$1000/Certificate upon Successful completion

UNIVERSITIES
Mentorship: $1000- $15000
Virtual Open House: $10000-$15000
Email blast: $5000- $8000
Website advertising: $1000- $5000</td></tr>
</table>

Figure 4.2 INCOSE Professional Development Business Model Canvas

4.4 Application of SSM-TRIZ to the problem situation

As stated earlier, INCOSE has had issues pinpointing the needs of prospective professionals who are involved in the SE space, need more SE education. The major question has been about figuring how to elicit the 'pains' of this market segment concerning education and training, certification, knowledge products and other aspects of the value stream without in an inexpensive manner. Unlike existing/current INCOSE members, there is no information on prospective members in the SE space. An attempt to deploy surveys may yield low responses not representative of the population of interest. Asides, the survey approach will also be time-consuming and expensive for INCOSE. The organization had no option of addressing this dilemma. Hence, the SSM-TRIZ methodology will be used in uncovering possible contradictions inherent in this problem in a holistic manner towards generating a solution. An expression of the problem situation is the foundational stage of problem-solving. A rich picture (see Figure 4.3) provides a social

stream around the problem that reflects the worldview of a problem-solver and guides how they select the unstructured conflict-interests problem.

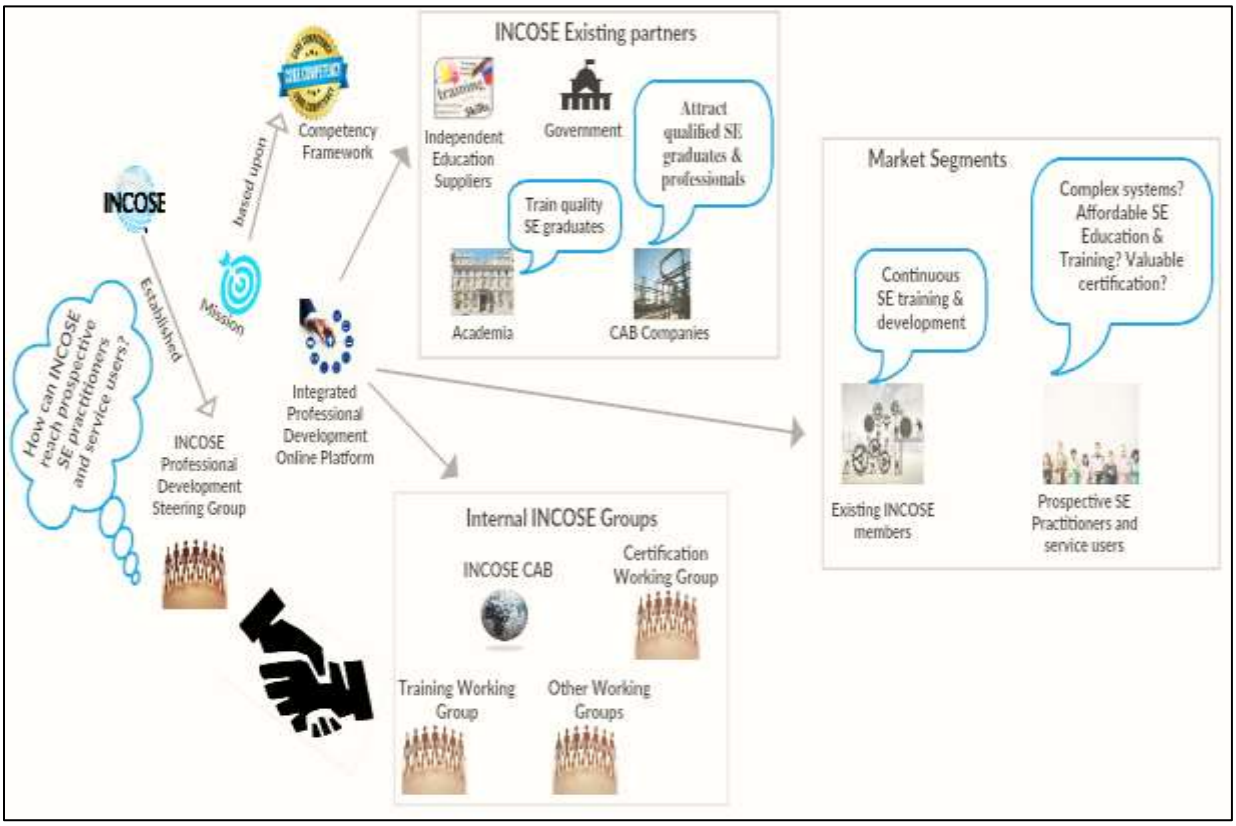


Figure 4.3 Rich Picture of INCOSE's current professional development circle

4.4.1 Expression of problem situation: Conversion of unstructured problem to problem with inherent contradictions

In the rich picture shown as Figure 4.3, it can be observed that INCOSE created a steering group to actualize the vision that has been projected for professional development in systems engineering education and practice. The main elements of this situation (such as structure, processes, people, issues raised and conflicts) were also represented in the picture. The primary stakeholders for this professional development initiative such as INCOSE Corporate Advisory Board, Professional Development Steering Group, CAB companies, independent educational providers, current INCOSE professional members, prospective SE practitioners, academia, and other INCOSE working groups, were captured in this picture. The processes of establishing the steering group within INCOSE, collaborative relationships (handshake in bold) between the

steering group and critical stakeholders such as the relevant working groups within INCOSE, were also captured. The chat pop-up in the diagram expressed the underlining issues and concerns each stakeholder had on their own or about this initiative.

The next step in this stage is developing a root cause analysis (RCA) diagram, which is constructed with the starting point as 'Who are the prospective SE service users and what are their needs' as shown in Figure 4. The RCA diagram helps us uncover and visualize contradictions which constitute the starting point problem.

4.4.2 Root definition and conceptual model of the relevant system

In this stage, contradiction analysis is the first procedure to carry out. In Figure 4.4, there are root cause elements with positive and negative signs (+-). These are the contradictions discovered after decomposing the unstructured starting problem into its root cause elements. Chai, Zhang and Tan (2005) define contradiction analysis as the process of structuring a problem into the form of a contradiction by identifying two conflicting components or two opposite requirements to the same problem element.

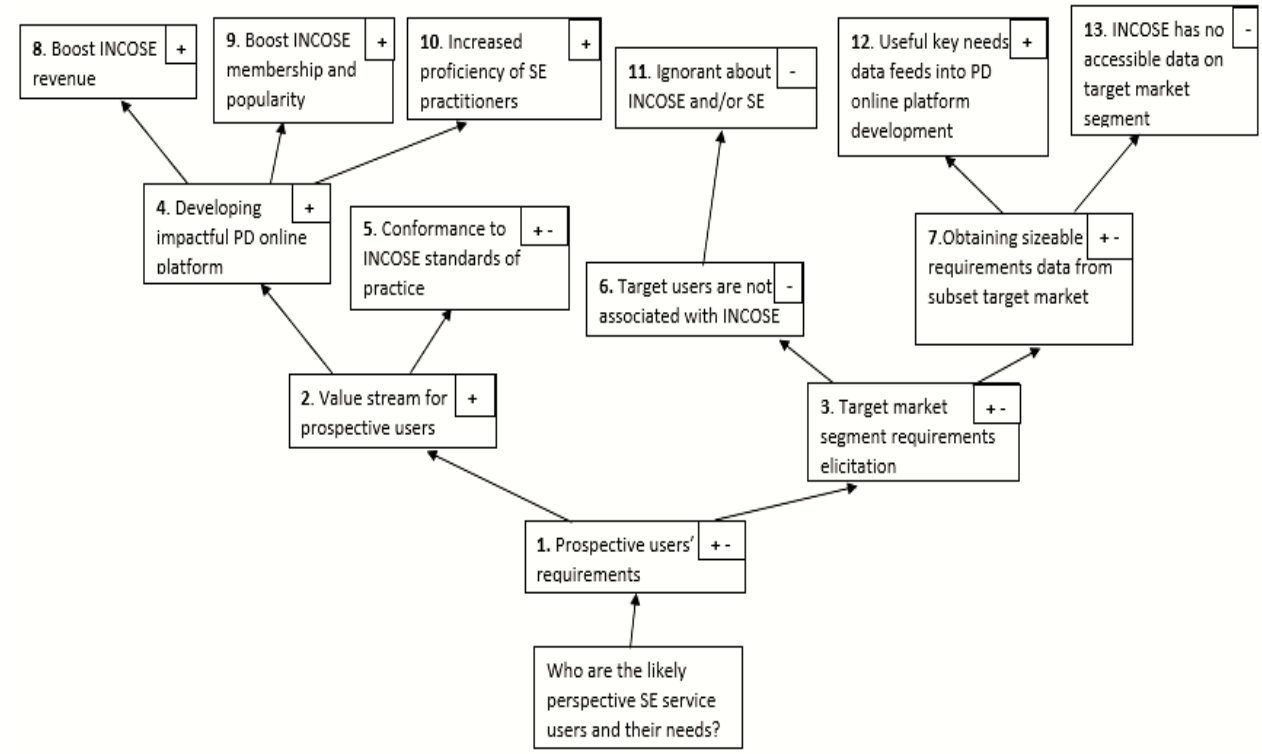


Figure 4.4 Root cause-effect chain for the problem situation

Also, a contradiction can also result in another contradiction as seen in boxes 1 and 3 and boxes 3 and 7 in Figure 4.4. The odds of the project attaining its objectives, sustainability, and effectiveness will significantly increase by resolving some of the following contradictions identified from the figure:

- Prospective users' requirements: INCOSE needs to determine the value stream of prospective users but does not have a clear-cut way of eliciting target market segment's requirements (Box number 1).
- Target market segment requirements: There is a need to obtain sizeable and representative data from target users, but these users have no association with INCOSE (Box number 3).
- Conformance to INCOSE standards of practice: There is a need to accommodate needs suited to professionals from other disciplines interfacing with SE, but the online PD platform and its inherent resources must conform to INCOSE's standards of SE practice. (Box number 5).
- Obtaining sizeable requirements data: Prior information on customer archetype and other user needs will enrich PD offerings development during platform development, but there is no accessible data on the target market segment (Box number 7).

Next, we apply contradiction resolution techniques from opensourcetriz.com (Ball et al., n.d.) in resolving one of the essential contradictions due to its significant impact on the cost of development. This contradiction is the box number seven element which states that 'Useful key needs data will enrich PD service development during platform development, but there is no accessible data on the target market segment.'

In resolving this contradiction, the variety of separation techniques and logical steps detailed on opensourcetriz.com website were applied. Firstly, it is crucial breaking this contradiction down into a statement with one element, two knob settings each with a corresponding condition. The decomposition details that the selected contradiction has an element (PD service development) with Setting and Condition A ('Useful key needs data feeds into platform development' and 'online platform development') and Setting and Condition B ('No accessible data on target market segment' and 'requirements gathering').

The flow logic employed for contradiction resolution is shown in Figure 4.5. It starts with trying out Separation in Time since it has the largest number of opportunities for a solution (Ball et al., n.d.). Following the flow of this figure, we note that the critical conditions of the

contradiction must overlap in time, so the Separation in Time technique can be applied as a separation technique. The next technique for trial will be Separate Gradually. The complete resolution of contradiction will permit starting with setting B and ending with setting A, so this technique can also provide solution ideas for resolving the contradiction of interest. Next, the Separate in Space technique will be tried. Settings and conditions A and B do not overlap in space; hence the next technique of Separate between the Parts and Whole is considered. Neither settings A nor settings B needs to be minimized, so this separation technique does not resolve the contradiction, and we stop the sequential flow here. An important caveat here is that this contradiction resolution process is limited to the subject matter knowledge of the author. Another person might be able to resolve this contradiction in box one via either separation in time, gradually, or space depending on the subject knowledge of the problem-solver. Figure 4.5 shows the logical flow used to identify the separation technique to resolve a contradiction.

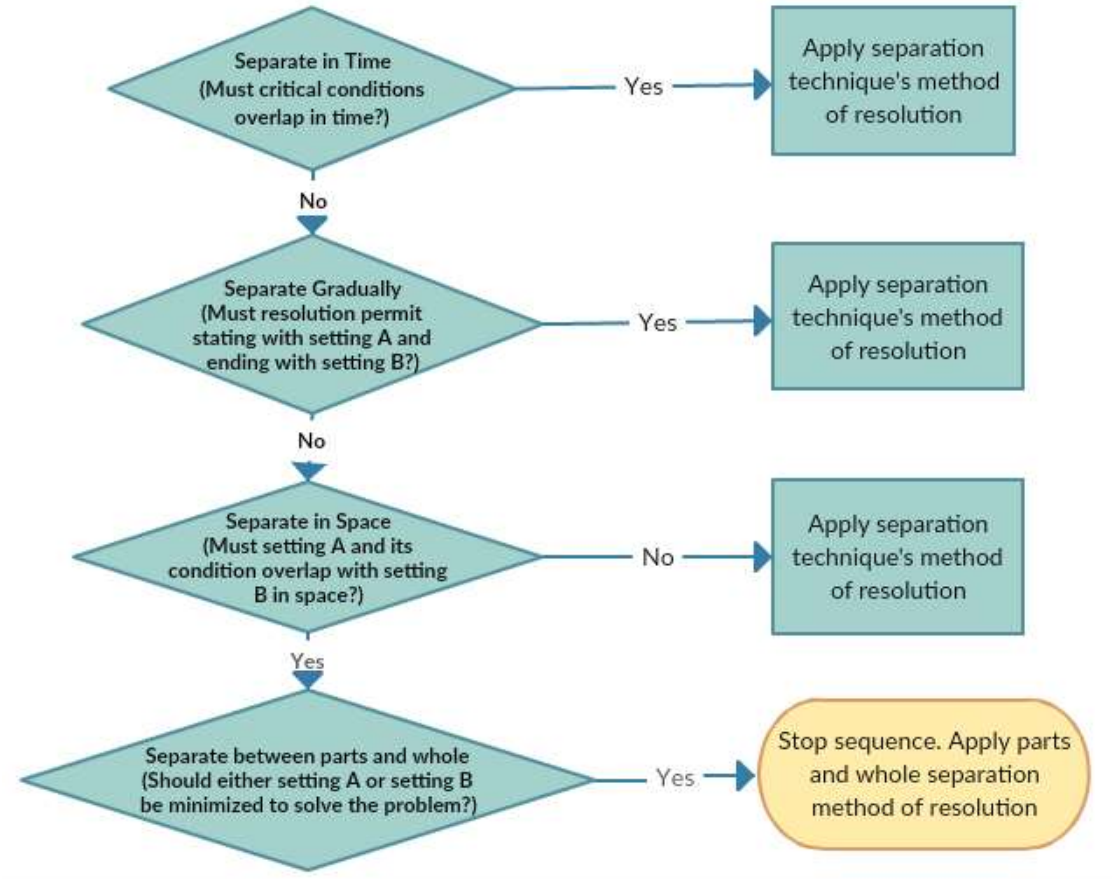


Figure 4.5 Contradiction resolution flowchart

After applying the logical flow in the figure above, we deduced that our contradiction of interest could be resolved by the separation in time and by gradually techniques. In coming up with a solution, it is pertinent to apply the effective separation technique's method of resolution to uncover possible solutions for the contradiction of interest. From opensourcetriz.com (Ball et al., n.d.), the practical solution strategy from the separation by gradually technique is the method of repeated use. This method stresses that: 'Individual (elements) which are (setting A/B) come into play gradually during (condition A/B). In the end, the sum effect is setting B/A.' The idea for our previously stated contradiction is that several professional disciplines are involved in activities requiring SE domain knowledge. If these disciplines can be determined with already available data about the professional needs of the practitioners obtained, INCOSE will end up having requirements data about its target market segment for this problem situation. The data can then be useful for developing learning/service offerings for the online PD platform which results in setting A. The solution statement summarizing this idea from the method of repeated use is as follows:
Solution statement 1: *INCOSE can obtain useful key needs data that enrich PD service development during platform development when there are no accessible data on the target market segment by identifying professional disciplines from the target market segment (not associated with INCOSE) and obtaining available public data concerning professional needs of the practitioners that can be resolved using SE domain knowledge.*

Another solution method from the separation in time technique that can spin a solution idea is the separation on condition method. There are four steps to this approach. Firstly, we identify the changing conditions of our contradiction. Subsequently, we identify the most important field that changes between the two changing conditions identified during the first step. Thirdly, we identify the required function that changes the field. Finally, we identify a physical phenomenon that can deliver the required function. For the contradiction we are attempting to resolve, the changing conditions are between requirements gathering and online platform development. The most important field that changes as the conditions change here is 'information.' With requirements gathering condition, there is no information while during platform development, there is information. The required function to deliver information is the requirement/needs gathering process. One possible phenomenon of delivering the required function here could be collaborating with more established PD organizations such as the Project Management Institute

(PMI) that has access to customer archetype and professional needs data of professionals from diverse disciplines. A solution statement summarizing this idea from this method is as follows:
Solution statement 2: *INCOSE can collaborate with established PD organizations such as PMI in gathering PD needs of professionals from disciplines that apply activities closely related, intertwined or can be improved with SE. Since organizations such as PMI has these data not available to INCOSE, this contradiction is resolved.*

Thus, TRIZ's separation techniques point us towards finding a practical method that will minimize the cost of delivery. There are numerous other separation techniques such as 'direction,' 'perspective,' 'frame of reference,' and 'between substance and field.' These other techniques can be consulted further when the first four do not help produce solutions. It is critical to note that many solutions can be generated from the different techniques of contradiction resolution under a separation technique. Subsequently, an ample set of solutions will be created if solutions can be obtained from multiple separation techniques. For the sake of brevity, this thesis uncovers two solutions from the separation in time and by gradually techniques; however, there are possibilities for more answers to be generated in practice.

Since one of the most critical contradictions has been resolved, it can be safely argued that there is a better understanding of the likely CATWOE elements that will feed into a conceptual model of the solution later on. Hence, we derive the following CATWOE components:

- Customers: Prospective SE practitioners and companies (Users).
- Actors: INCOSE Professional Development Steering Group, educational/life-long learning providers, CAB companies, Academia, INCOSE working groups, software developers.
- Transformation Process: Users with little or no systems engineering knowledge and experience are transformed into proficient systems engineering practitioners.
- Weltanschauung (Worldview): that revenue generation and membership drive for INCOSE depend upon the provision of an online educational platform that is based on a systems engineering role-based competency framework (INCOSE 2018) that integrates classroom learning with practical experience and technical leadership opportunities by leveraging on users' competency assessment results.
- Owner: INCOSE.

- Environmental Constraints: Limited Funds, collaboration agreement issues, competition from renowned academic systems engineering certification programs, and online PD industry trends in general.

This CATWOE analysis yields a root definition states that this professional development initiative is an INCOSE owned systems engineering educational service system which provides classroom learning with practical experience and technical leadership opportunities contingent on systems engineering role-based competency framework through an integrated online platform to develop increasingly skilled global systems engineering workforce. Furthermore, the systems thinking the ideology of SSM is used for our application situation. The conceptual model of the purposeful activity systems is shown in Figure 4.6 below.

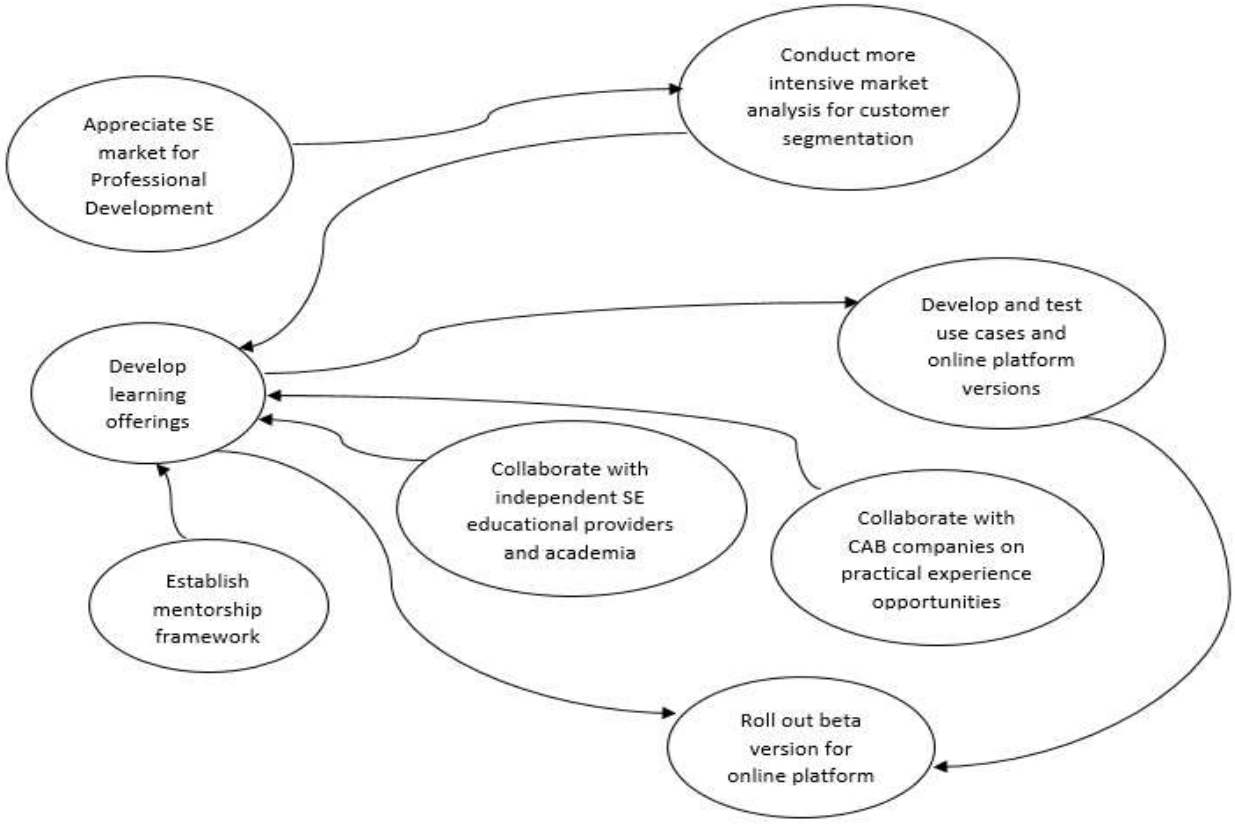


Figure 4.6 Conceptual model for purposeful activity system

It is worth noting that a problem-solver with a different worldview could have constructed a separate root cause analysis and conceptual model diagrams for this same problem situation. After conducting a brief CATWOE analysis, our SSM-TRIZ method encourages the further

construction of a functional analysis diagram as depicted in Figure 4.7, which maps components of this professional development service and other resources and their functional interrelationships.

4.4.3 Comparison of the model to ideality

Here, the as-is resolution of the contradiction is evaluated against the ideal settings and conditions that will be a part of the resolution. For our application problem, our as-is resolution involves INCOSE possessing useful key needs data will enrich PD service development during platform development even when there are no directly accessible data on the target market segment. The IFR for our problem situation is the need to access data on prospective users' PD needs and glean useful and actionable information from the data. Solution statement 1 is arbitrarily selected for the sake of illustration to be compared against the IFR. Thus, we can safely conclude that solution statement 1 supports the IFR since its setting and condition are the expected knobs for the ideal situation.

The ideal resolution for our studied contradiction is for INCOSE to offer an array of quality platform courses online without incurring costs of course delivery. In providing solutions that satisfy these constraints, it is pertinent to note that the data/requirement gathering process (useful function) must not be expensive, time-consuming or present more complicated implementation problems. It is based on these three solution evaluation criteria that solution statement 1 is selected ahead of solution 2. Solution statement 2 will require working through collaboration 'kinks' with PMI which some stakeholders within INCOSE may not favor especially those who want the organization to own and profit from the initiative fully. Also, solution one is preferred as it is likely cheaper and less time-consuming strategy to implement. A solution statement that accounts for the three evaluation criteria is as follows.

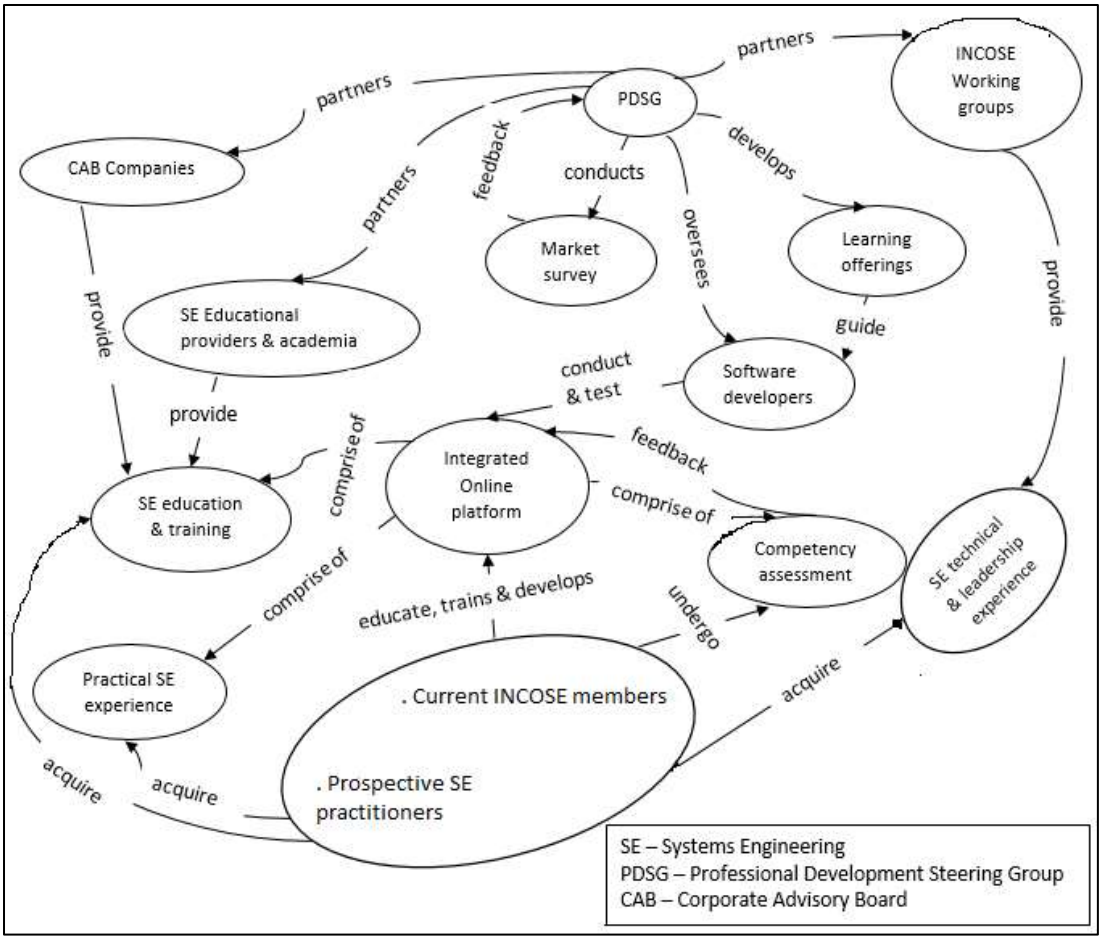


Figure 4.7 Function Analysis Diagram

Selected Solution Statement: *INCOSE can obtain useful key needs data that enrich PD service development during platform development when there are no accessible data on the target market segment by identifying professional disciplines from the target market segment (not associated with INCOSE) and obtaining available public data concerning professional needs of the practitioners that can be resolved using SE domain knowledge.*

4.4.4 Seeking feasible and desirable changes

Finally, a soft solution trail of the problem situation has been created but further hard systems thinking approaches are needed for a definitive implementation of the final solution. How do we achieve the selected solution statement? Firstly, there is a need to identify disciplines that overlap with SE. A popular one is business analysis (BA) which is a discipline that intersects a lot with SE in its activities, and whose practitioners can apply some SE knowledge and practice in

resolving their various PD needs. The solution statement below provides a final solution statement from the SSM-TRIZ methodology for this case study.

Refined Solution Statement: *INCOSE can obtain useful key needs data that enrich PD service development during platform development when there are no accessible data on the target market segment by identifying professional disciplines from the target market segment (not associated with INCOSE) and obtaining available public data concerning professional needs of the practitioners that can be resolved using SE domain knowledge. INCOSE can obtain user-generated data and glean key professional requirements and needs from available BA online forums.*

Obtaining definite key SSM-TRIZ encourages exploring 'hard' system approaches such as optimization, data analytics, and text mining (semantic analysis of users' requirements). These off-core approaches provide quantitative or definite solutions to the structured problem situation and solution from SSM-TRIZ. For our case study, a quantitative method of eliciting information from online user-generated data will be needed in providing a definite solution to INCOSE's customer needs assessment problem situation. Table 4.2 provides a summary of the SSM-TRIZ stages and their sequential steps applied towards resolving the box number seven contradiction (Obtaining sizeable requirements data) in Figure 4.4.

Table 4.2 Summary of SSM-TRIZ stages for application problem

SSM-TRIZ Stage	Activity	Methods Used	Results
Expression of Problem Situation	Envision social stream around the problem of interest.	Rich Picturing	Rich Picture of Professional Development Initiative
	Conduct root-cause analysis/discovery of contradictions.	Root Cause Analysis Diagram	Discovery of 4 contradictions namely: *Prospective users' requirements, target market segment requirements, conformance to INCOSE standards of practice, obtaining sizeable requirements data*
Root Definition and Conceptual Model of relevant System	Contradiction analysis	Subject matter knowledge and expertise	Contradiction: *Useful key needs data will enrich PD service development during platform development, but there is no accessible data on the target market segment. (Prospective users' requirements)* Element: O*ffer an array of quality platform courses* Setting A: *Useful key needs data feeds into platform development* Setting B: *No accessible data on target market segment* Conditions A: *online platform development* Conditions B: *requirements gathering*
	Contradiction resolution	Separation Techniques	Effective separation techniques: *Gradually and Time* Solutions: *Solution Statement 1(Repeated use method of resolution) and Solution Statement 2* (*Separation on condition method of resolution*)
	Mapping solution statements 1and 2 to the root definition	CATWOE	Root definition statement
	Mapping solution statement 1 to the conceptual model	Conceptual modeling	Conceptual model Function analysis diagram
Comparison of the model to Ideality	Mapping solution statement 1 to the IFR	Ideality thinking	The decision on whether solution statement 1 matches IFR: *YES.*
	Solution Evaluation	Subject matter knowledge and expertise	Evaluation criterion: *Process cost, time and implementation complexity* Selected solution statement
Seeking feasible and desirable changes	Accommodate refined solution statement 1 for political and socio-economic factors	Enhanced cultural Analysis	Refined solution statement

CHAPTER 5. FURTHER HARD APPROACH METHODS

5.1 Need for Text Mining

Solution statements are the result of the SSM-TRIZ approach. However, there are applicable situations that require definite solutions for implementation. Having resolved the unstructured problem situation of the case study, a solution statement towards implementation is as follows:

'INCOSE can obtain useful key needs data that enrich PD service development during platform development when there are no directly accessible data on the target market segment by identifying professional disciplines from the target market segment (not associated with INCOSE) and obtaining available public data concerning professional needs of the practitioners that can be resolved using SE domain knowledge. User-generated data can be obtained towards gleaning key professional requirements and needs from available BA online fora.'

In deriving insights from the user-generated data online, quantitative methods of inquiry are required to extract key phrases and topics that can provide insights into developing the online platform tool. One of such methods is text mining which is a process of extract interesting and significant patterns to explore knowledge from textual data sources (Fan et al. 2006). Text mining handles natural language texts that are stored in a semi-structured and unstructured format (Weiss et al. 2010). The steps involved in text mining (Talib et al. 2016 and Chidambaram and Sumathy 2013) that will be applied in this case study are: collecting unstructured data, text preprocessing, text transformation, feature selection, text mining methods, and interpretation.

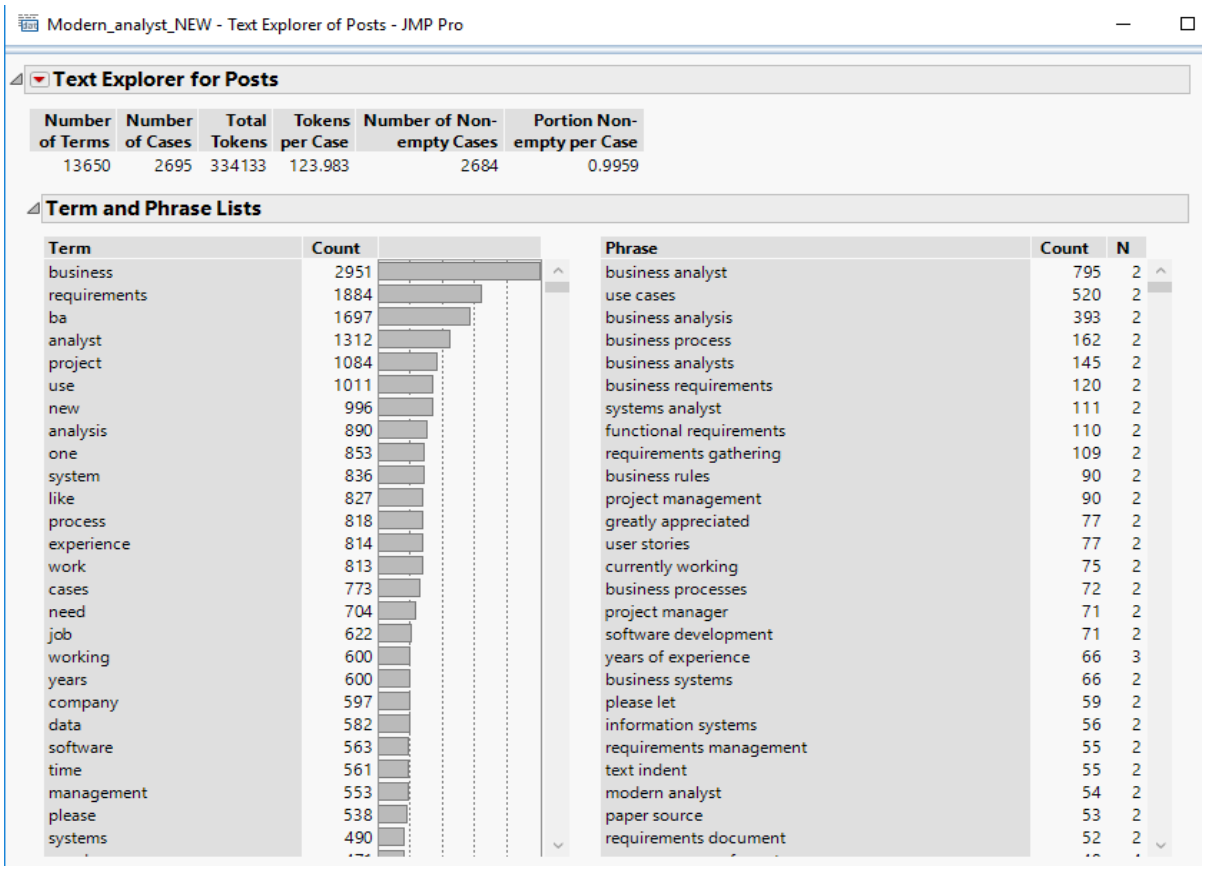
5.2 Collection of unstructured data

The discipline that was identified to overlap with SE from chapter 4 is business analysis (BA) which is one that intersects a lot with SE in its activities, and whose practitioners can apply some SE knowledge and practice in resolving their various PD needs. A popular online forum for business analysts is 'modernanalyst.com.' Here, a diverse collection of aspiring and practicing BAs express and provide needs, useful information and other concerns that matter to the group. Python scripting language alongside the Beautiful Soup package was used to extract author name, posting date, number of posts, post title and thread details for all threads (almost 3000) visible on

the website from November 26, 2006, to February 22, 2019. The python code for extracting the web data from the website is in the Appendix.

5.3 Text Preprocessing and Transformation

During this stage, text preprocessing activities such as tokenization, stop-word removal and stemming are carried out. JMP Pro software was used to clean further the CSV file obtained from data collection during this stage. The software's 'Text Explorer' function was deployed in removing blank spaces, commas, stop-words such as 'a,' 'is,' and 'an,' and identifying the root of certain words. The Text Explorer platform in JMP uses a bag of words approach (Klimberg and McCullough 2016). Furthermore, it ignores the order of words except for phrases, and the analysis is based on the count of words and phrases and the words are processed in three stages to develop the document term matrix (DTM). The frequency of keywords and phrases and associated word cloud are displayed in figures 5.1 and 5.2 below.



Number of Terms	Number of Cases	Total Tokens	Tokens per Case	Number of Non-empty Cases	Portion Non-empty per Case
13650	2695	334133	123.983	2684	0.9959

Term	Count
business	2951
requirements	1884
ba	1697
analyst	1312
project	1084
use	1011
new	996
analysis	890
one	853
system	836
like	827
process	818
experience	814
work	813
cases	773
need	704
job	622
working	600
years	600
company	597
data	582
software	563
time	561
management	553
please	538
systems	490

Phrase	Count	N
business analyst	795	2
use cases	520	2
business analysis	393	2
business process	162	2
business analysts	145	2
business requirements	120	2
systems analyst	111	2
functional requirements	110	2
requirements gathering	109	2
business rules	90	2
project management	90	2
greatly appreciated	77	2
user stories	77	2
currently working	75	2
business processes	72	2
project manager	71	2
software development	71	2
years of experience	66	3
business systems	66	2
please let	59	2
information systems	56	2
requirements management	55	2
text indent	55	2
modern analyst	54	2
paper source	53	2
requirements document	52	2

Figure 5.1 Frequency of keywords and phrases

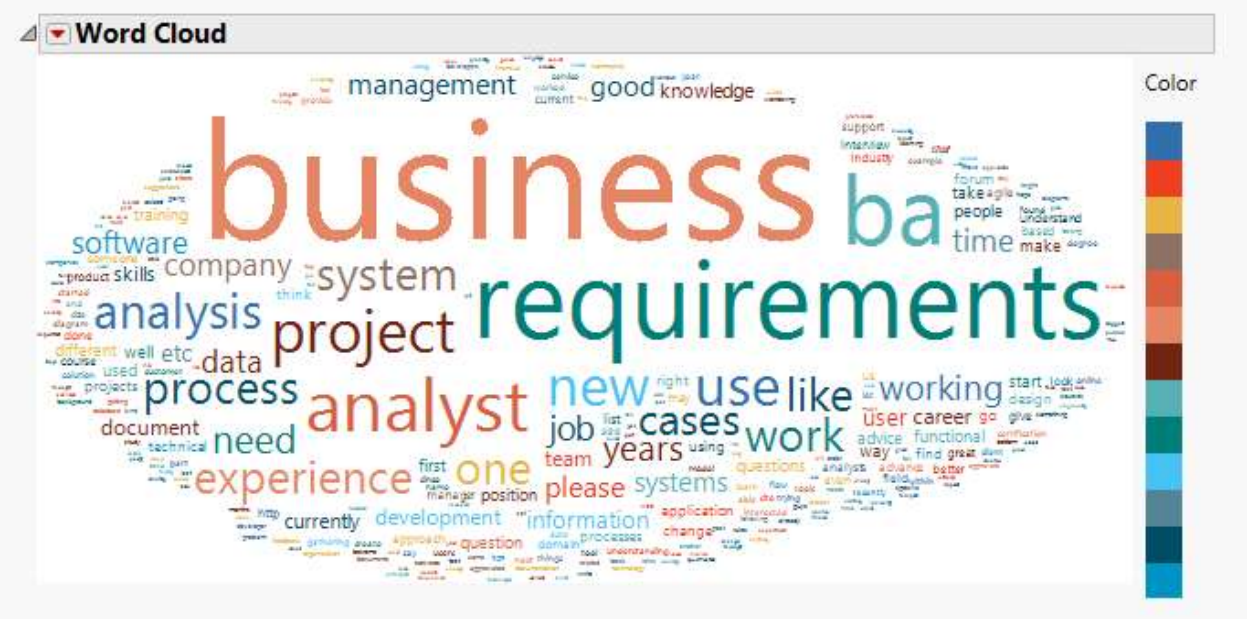


Figure 5.2 Word cloud output

5.4 Feature selection and Latent semantic analysis

In this stage, features which are redundant or irrelevant are removed (Chidambaram and Sumathy 2013) such as the deletion of an irrelevant topic which was about font sizes and margins (Topic 1). Afterward, latent semantic analysis (LSA) which is a family of mathematical and statistical techniques for extracting and representing the terms and phrases from a corpus (Klimberg and McCullough 2016) was performed on the DTM. The DTM is reduced dimensionally to a manageable size for quicker analysis by applying singular value decomposition (SVD). The ‘Latent Semantic Analysis, SVD’ and ‘Topic Analysis, Rotated SVD’ functions on JMP Pro were used to achieve this. The JMP output is shown in Figure 5.3 below.

Top Loadings by Topic

Topic 2		Topic 3		Topic 4		Topic 5	
Term	Loading	Term	Loading	Term	Loading	Term	Loading
people	0.43100	system	0.67997	years	0.55003	plan	0.69122
even	0.42718	cases	0.64039	experience	0.51711	management	0.65363
like	0.41497	use	0.61604	career	0.43069	documents	0.62241
time	0.37874	users	0.60416	analyst	0.40498	project	0.53276
one	0.35783	requirements	0.56928	working	0.39946	change	0.50348
well	0.34766	stakeholders	0.53795	worked	0.39556	document	0.45146
make	0.34451	user	0.51918	ba	0.38549	documentation	0.45051
ask	0.33756	design	0.44960	degree	0.34091	model	0.44207
far	0.32469	functional	0.44657	skills	0.32854	environment	0.44021
say	0.32273	needs	0.34802	job	0.31201	report	0.35182
things	0.32057	scope	0.32304	work	0.30966	may	0.34791
questions	0.31702	software	0.30703	background	0.30168	risk	0.32940
look	0.31513			advice	0.29887	testing	0.32348
go	0.30236			currently	0.29532		
someone	0.30037			move	0.28657		
good	0.29771						
done	0.29702						

Topic 6		Topic 7		Topic 8		Topic 9		Topic 10	
Term	Loading	Term	Loading	Term	Loading	Term	Loading	Term	Loading
data	0.52033	agile	0.67748	university	0.78429	knowledge	0.52917	community	0.3942
models	0.48397	development	0.57760	specific	0.62162	industry	0.51683	site	0.3909
customer	0.47159	software	0.44930	related	0.59545	please	0.43311	risk	0.3413
modeling	0.40685	changes	0.44303	engineering	0.58014	answer	0.42573	resources	0.3164
sales	0.39364	quality	0.43121	techniques	0.56889	study	0.38325	tool	-0.3024
order	0.35013	technology	0.33723	full	0.53983	one	0.33260	needs	0.2924
develop	0.34917	various	0.31880	skills	0.46828	ba	0.33223	available	0.2816
organization	0.34149	developers	0.31274	training	0.46235	important	0.33215	may	0.2688
business	0.31732	place	0.30078	include	0.33280	question	0.30719	certification	0.2666
processes	0.31727	world	0.30074	courses	0.32683	give	0.30663	excel	-0.2588
tools	0.29167	see	0.29188	ideas	0.27953	mba	0.30612	used	-0.2462
understand	0.28440	great	0.28009			another	0.30201	another	-0.2461

Figure 5.3 Topic Analysis output

5.5 Interpretation

Key phrases from the posts of forum contributors on modernanalyst.com shows (from Figures 5.1 and 5.2) that there are terms and topic areas best covered in knowledge and practice within SE and by INCOSE that generate popular interest within the BA space. Terms such as ‘requirements,’ ‘system(s),’ ‘use,’ ‘cases,’ and ‘process’ are congruent with SE. A look at the phrases section generates better insight. Key SE phrases such as ‘use cases,’ ‘business requirements,’ ‘functional requirements,’ ‘requirements gathering,’’ requirements document,’ ‘user stories,’ and ‘systems analyst’ generate close to 40% of the total phrase count.

By observing figure 5.3, we can see that there are different topic clusters each containing words that resonate within a central theme. Topic 3, for example, is about issues around requirements gathering, use-case scenario, and stakeholder collaboration. Topic 4 covers the practical and technical experience ‘buzz’ prevalent within the BA professional space as expected. Topic 5 is about project planning and management while topic 6 involves the process appreciation and modeling space. Topic 7 is more concerned about the integration of technological resources while topic 8 covers training. All the topical interpretations outlined above are at the heart of the INCOSE PD initiative, and the application of text mining presents conclusive solutions to the unstructured problem situation initially resolved with the SSM-TRIZ methodology.

CHAPTER 6. CONCLUSION AND FUTURE RESEARCH

6.1 Summary

This thesis provided answers to the research questions by directing the flow of rational inquiry into the development and application of the SSM-TRIZ methodology within the action research framework as shown in figure 6.1. The response to the research questions is provided in Table 6.1. Also, this thesis has shown that hard 'OR' approaches such as text mining can be used for providing definite solutions that clients might want as a resolution to a problem situation.

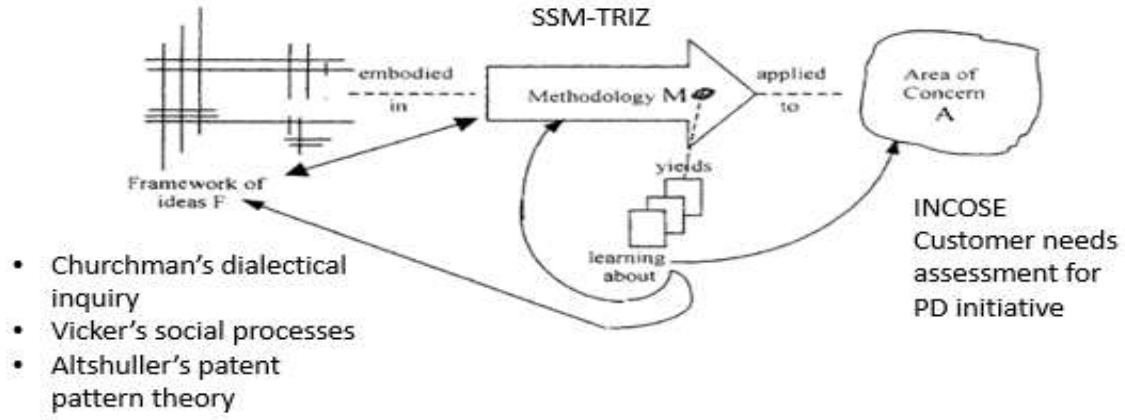


Figure 6.1 Thesis' action research form of rational inquiry

Table 6.1 Answers to thesis research questions

Research Questions	Answers
Can a suitable form of PSM framework be developed within an AR lens to holistically and systematically convert the unstructured systemic-pluralist challenges of INCOSE's prospective customer segment's PD needs, into a refined set of 'soft' problems and solutions?	Absolutely. The SSM-TRIZ methodology was developed from the action research pathway shown in figure 6.1 to convert INCOSE's unstructured customer needs problem situation into a Refined Solution Statement.
How does the resulting framework allow for further implementation of 'hard' OR methods towards developing definitive solutions from the refined 'soft' problems?	The refined solution statement from the SSM-TRIZ framework permitted the implementation of text mining towards providing definitive solutions from key phrases, terms, word cloud, and topic clusters.

The adoption of a methodology like SSM-TRIZ can be very beneficial within the business and technical applications. Many problems have some inherent contradictions that must be resolved. Since SSM and TRIZ cannot independently resolve these kinds of issues in a holistic, systemic and perspectives-embracing manner, the SSM-TRIZ methodology provides a resolution approach that sustains the benefits of the soft systems method by helping to narrow down unstructured business problems into structured soft solutions that expose questions that can be solved quantitatively. A significant problem that many companies face is their tendency to waste funds on solution approaches for issues that have not been defined. This prevalence was well explored by Spradlin (2012) when making a case for the problem-definition process.

This approach does not definitively solve all problems with contradictions; however, SSM-TRIZ encourages breaking out of 'soft solution' paradigm and adopting other techniques such as optimization, system identification, statistics, and decision theory for seeking desirable changes to the system in addition to soft methods. Ariyur (2017) states that contradiction resolution approaches like TRIZ do not provide definitive, prescriptive solution implementations for technical and business problems. SSM-TRIZ can solve those requiring soft solutions, but many business solutions need further adoption of hard-thinking approaches in providing final solutions to business problems—customer segmentation is a case in point. SSM-TRIZ helps with the problem definition phase and can help companies save money that could have gone down the drain when solving problems that were not structured for solutions. This methodology goes further in providing a path to integrating quantitative approaches if the need arises.

6.2 Opportunities for INCOSE

This thesis provides an avenue for INCOSE to gain insights into the professional development needs of a target market (not associated with INCOSE) for her PD initiative. The process of understanding the problem situation systemically and holistically and resolving apparent contradictions bedeviling the customer needs assessment process for the prospective users' group was achieved with the SSM-TRIZ methodology. This approach not only resolved the problem situation but also led the process of problem-solving in a pathway that is less expensive, less time-consuming and easy to implement. INCOSE can be confident in conducting market survey schemes in collaboration with the hosts of modernanalyst.com to elicit customer archetype data and more comprehensive PD requirements further that INCOSE can provide from

forum contributors. Data obtained from this process can feed into the online PD platform INCOSE is developing in ensuring that the platform is well designed and suited to the intended market segment.

6.3 Future Research

This thesis applied the SSM-TRIZ methodology with a single case study. Further case studies are needed to develop this methodology further and evaluate its performance against its objective. Examples of application are in the areas of structuring business model innovation and the business analytics process. Also, there is a need for empirical, deductive studies that quantitatively assess the effectiveness of SSM-TRIZ via questionnaires and cross-sectional surveys.

In addressing the pluralist nature of this thesis' problem situation, other management methods such as Theory of Constraints (TOC) can be attempted in future studies. The solutions generated can then be compared with TRIZ for further comparative studies. Also, the further hard approach implemented in this thesis can be improved. Within the text analytics method, sentiment analysis of the key terms and phrases can provide more detailed insight into the general feeling of the business analysts within the forum.

APPENDIX

```
#Webscraping of user-generated data from modernanalyst.com

#importing necessary libraries
import pandas as pd
import urllib
import datetime
import bs4 as bs
from bs4 import SoupStrainer
from bs4 import BeautifulSoup
import urllib.request, urllib.error, urllib.parse
import re

#get page
link = "https://www.modernanalyst.com/Community/Forums/tabid/76/forumid/-
1/scope/threads/Default.aspx"
print(link)

import time
from urllib.request import FancyURLopener  # This is library that helps us create the headless
browser
from random import choice #This library helps pick a random item from a list

user_agents = [
   'Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
Chrome/41.0.2228.0 Safari/537.36',
   'Opera/9.80 (X11; Linux i686; Ubuntu/14.10) Presto/2.12.388 Version/12.16',
   'Mozilla/5.0 (Windows; U; Windows NT 6.1; rv:2.2) Gecko/20110201',
   'Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_3) AppleWebKit/537.75.14 (KHTML, like
Gecko) Version/7.0.3 Safari/7046A194A',
   'Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko)
Chrome/42.0.2311.135 Safari/537.36 Edge/12.246'
]

# Code if you do not want deprecation message
import urllib.request as req

urlreq = req.Request(url=link,
        headers = {'User-Agent':choice(user_agents)})

f = req.urlopen(urlreq)

html = f.read().decode('utf-8')
html
```

```
#BeautifulSoup takes a string object and parse out the document structure
# and turn it into a BeautifulSoup object.
soup = BeautifulSoup(html, "html5lib")
#Create a new list to store all thread links on modenanalysts.com
New_Links=[]
links = soup.body.find_all("a",attrs={"class": "Forum_NormalBold"})
print ([link['href'] for link in links])
for link in links:
   New_Links.append(link['href'])
New_Links
len(New_Links)

from selenium import webdriver
from selenium.webdriver.chrome.options import Options
from selenium.webdriver.support.ui import WebDriverWait
chrome_options = Options()  #importing the necessary modules
chrome_options.add_argument('--headless')
chrome_options.add_argument('--no-sandbox')
chrome_options.add_argument('--disable-dev-shm-usage')
driver = webdriver.Chrome( options = chrome_options)
driver = webdriver.Chrome(r"C:/Users/CORAL/chromedriver.exe") #declaring the executable
path
driver.wait = WebDriverWait(driver, 2)
browser = webdriver.Chrome('chromedriver.exe')

from bs4 import BeautifulSoup
from time import sleep
import requests
import urllib.request as req

number_of_pages = int(soup.find("td", class_ = "Forum_FooterText").text[9:])
print(number_of_pages)

type(number_of_pages)

#creating an empty list to store all page links with each page storing aggregated threads
MA_Links = []
for page_number in range(1, number_of_pages+1):
   url_of_page_i = 'https://modernanalyst.com/Community/Forums/tabid/76/forumid/-
1/scope/threads/currentpage/' +  "{}".format(page_number) + '/Default.aspx'
   MA_Links.append(url_of_page_i)
print(MA_Links)
print(len(MA_Links))

from bs4 import BeautifulSoup
```

```
from time import sleep
import requests
from random import randint
import urllib.request as req
Threads_Links = []

for link in MA_Links:
print(link)

urlreq = req.Request(url=link)
f = req.urlopen(urlreq)

    html1 = f.read().decode('utf-8')
    soup1 = BeautifulSoup(html1, "html5lib")

    # parse your html to get all thread links
    for h in soup1.find_all('a', attrs={'class': 'Forum_NormalBold'}):
        Threads_Links.append((h['href']))
print(len(Threads_Links))
print(Threads_Links)

import pandas as pd
from bs4 import BeautifulSoup
from time import sleep
import requests
from random import randint
import urllib.request as req


Posting_date = []
Author_name = []
No_of_author_posts = []
Post_title = []
Posts = []

#preventing code breakdown due to multiple requests
counter=0

for thread_link in Threads_Links:
    try:
        print(thread_link)
        # download the html
        urlreq_i = req.Request(url=thread_link)
        fi = req.urlopen(urlreq_i)
        htmli = fi.read().decode('utf-8')
        # build a new soup from the link
```

```
        soupi = BeautifulSoup(htmli, "html5lib")
        # parse your html to get posts, posting date, authors and number of posts
        posts = soupi.find_all("table", width="100%")[0]

    except:
        print('print has failed')
        continue

       post_date = posts.find("span", class_= "Forum_HeaderText").text.replace("\xa0", "")
       Posting_date.append(post_date)

    author_name = posts.find("a", class_="Forum_Profile").text
    Author_name.append(author_name)

    no_of_posts = posts.find("span", class_="Forum_Normal").text
    No_of_author_posts.append(no_of_posts)

    post_title = posts.find("span", class_="Forum_NormalBold").text
    Post_title.append(post_title)

    post_detail = posts.find("span", id="spBody").text
    Posts.append(post_detail.replace("\n", " ").replace("\xa0", " "))


    sleep(randint(1,10))

    # Writing it to csv file
    MA_posts = pd.DataFrame({
            'Author_name': Author_name,
            'Posting_date': Posting_date,
            'Number_of_posts': No_of_author_posts,
            'Post_title': Post_title,
            'Posts': Posts,
        })

    #writing dataframe into csv file
    MA_posts.to_csv("Files_Directory/Modern Analyst/Modern_analyst_NEW.csv", sep=',',
encoding='utf-8', index=False)

print(Posting_date)
print(Author_name)
print(No_of_author_posts)
print(Post_title)
print(Posts)
```

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