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An SSM-TRIZ Methodology for Business Problem Structuring

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Abstract. 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 paper 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. This paper 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 paper applies the joint methodology to examine the business problem of developing a Professional Development platform for INCOSE. 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.

Keywords: Soft Systems Methodology, TRIZ, Contradictions, Professional Development

Introduction

The daunting challenge posed by unstructured, complex and vague problem situations has led to action research activities to resolve these situations (Hindle, 2011). These unstructured problems were observed to involve multiple stakeholders, multiple perspectives, a variety of uncertainties, conflicting interests, and significant intangibles (Mingers & Rosenhead, 2004). Hence, problem structuring methods (PSM) concepts were subsequently developed to drive organizations to apply systemic methodologies for resolving their problems. These PSMs offer "a way of representing the situation that will enable participants to clarify their predicaments, converge on a potentially actionable mutual problem or issue within it, and agree on the commitments that will at least partially resolve it" (Mingers & Rosenhead, 2004). This paper provides robust approach towards structuring and resolving problem situations with conflicting elements by combining the relative strengths of SSM (Soft Systems Methodology) and TRIZ (*Teoriya Resheniya Izobretatelskikh Zadatch* or the 'Theory of Inventive Problem Solving) in a complementary manner. We also describe the application of the SSM-TRIZ methodology to a professional development initiative.

Soft Systems Methodology. Checkland's initial formulation of SSM (Checkland, 1976) stemmed from acute problems that existed within various organizations and were not stated in precise terms (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 problems 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' and are later compared with the real world (Jackson M. C., 2003).

Checkland (1981) presents the commonly used seven-stage cyclic, learning process for SSM that was further adapted to address cultural and political interests (Checkland 1990). In a bid to present SSM as an all-purpose approach to tackling complex situations, Checkland & Scholes (1990) and Checkland & Poulter (2006) adopted an experiential learning approach for disseminating its principles and methods.

SSM has inadequacies in handling problems with conflicting interests. Jackson & Keys (1984) classified problem contexts into four classes and provided suitable methodologies for resolving each problem class. For this paper, the type of problem that will be focused on is that of a systemic-pluralist nature. 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 (Ackoff, 1974; Jackson & Keys, 1984) classify a problem context as pluralist 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 the conflict.

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.

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 solutions.

TRIZ methodology. The TRIZ methodology, invented by Genrikh Altshuller, 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. Figure 1 depicts the main stages in utilizing TRIZ and the toolboxes employed as described by Chai, Zhang, & Tan (2005).

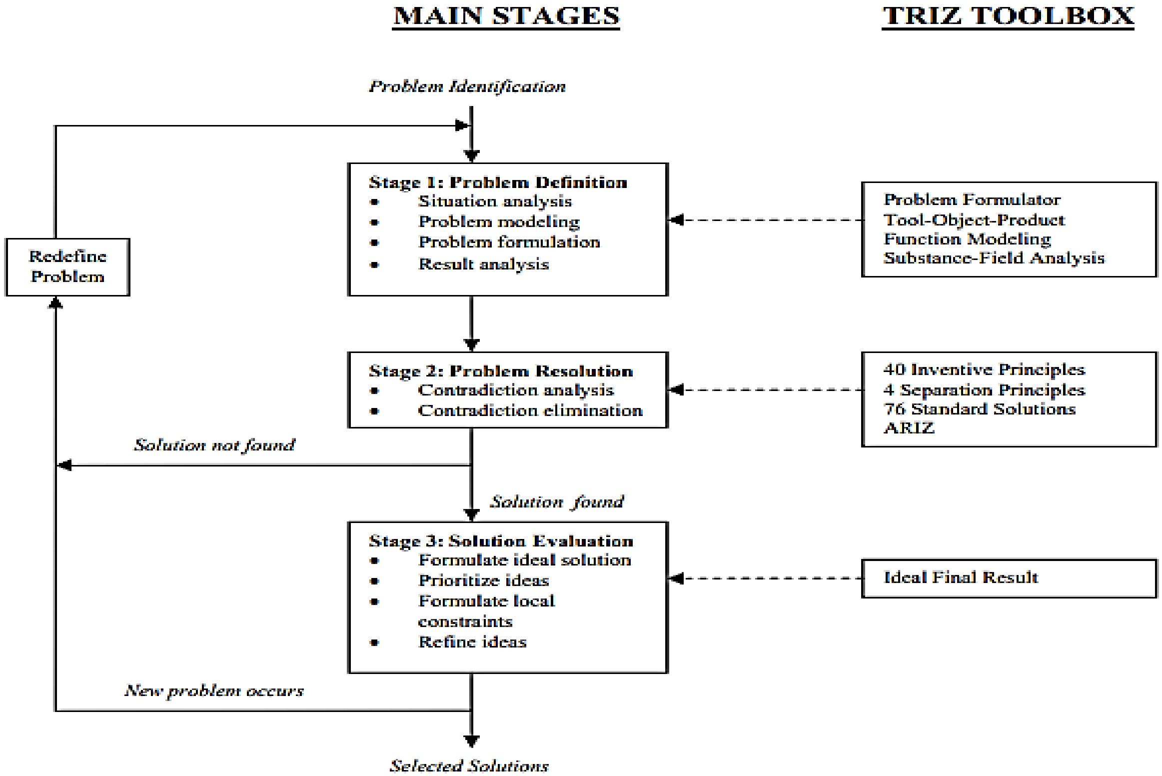

Figure 1. TRIZ Problem-solving model
Source: (Chai, Zhang, & Tan, 2005)

Ilevbare, Probert, & Phaal (2013) indicate contradictions, ideality, and evolution patterns are the main foundations of the TRIZ problem-solving process and further list the main tools and techniques of TRIZ. These tools are listed in Figure 1 and include 40 inventive principles, 76 standard solutions, separation principles, contradiction matrix, Ideal Final Result, function analysis, substance-field, nine windows, creativity tools, and ARIZ. The range of TRIZ applications is quite broad. Bonnema (2011) applied TRIZ alongside Funkey Architecture in creating a design tool for simplifying and improving system architectures. Funkey Architecture was already an established integrated approach to system architecting, which concurrently used functions, key drivers, and system budgets for overall system partitioning. 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 a technology. The resulting tool also compares options and aims to optimize how systems work at different stages of decomposition. Although TRIZ has been applied extensively in technical venues (mostly engineering), it has been applied in non-technical domains such as business model innovation, new service design, and education. Khomenko and Ashtiani (2007) extend the application of TRIZ towards a general audience irrespective of domain. The business application of TRIZ is well explicated by Souchkov (1998), and Ishida (2003) further explores business model innovation using TRIZ.

Strengths and weaknesses of SSM and TRIZ: Opportunity for Synergy

In solving problems with conflicting integral elements, this paper 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 our interested type of problems 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 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.

The SSM-TRIZ Methodology

We developed the SSM-TRIZ methodology using a framework that consists of the seven steps shown in Figure 2 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.

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.

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.

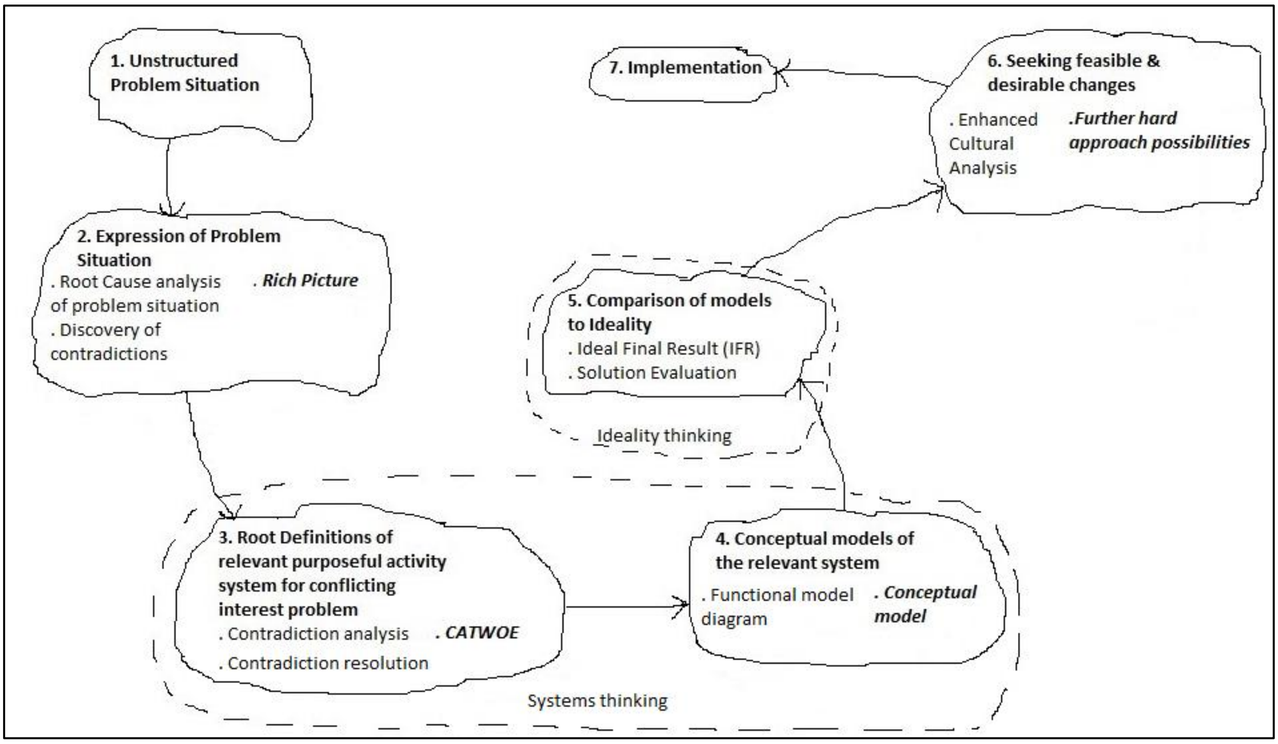

Figure 2. Phases of SSM-TRIZ Methodology

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.

Seeking feasible and desirable changes. SSM allows for the adoption of the logic-based stream of cultural analysis at this stage (Checkland & 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.

Application: A Professional Development Initiative for INCOSE

The pertinent evolution of the professional development industry is way beyond formal methods like courses, conferences, etc., and we cannot deny the informal possibilities in areas such as peer learning, mentoring, and leadership development, which differ 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. Consequently, there is a considerable potential to leverage the informal but more motivating aspects of Professional Development.

The International Council on Systems Engineering (INCOSE) is the largest professional organization committed to the development and advancement of systems engineers. 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 asked by companies who are part of her Corporate Advisory Board (CAB), to rise to these challenges. INCOSE has always provided in 'silos' some form of professional development through her certification program, technical publications, webinars, symposiums, conferences, chapter meetings, and workshops. 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 approach.

This realization led to the establishment of a Professional Development Steering Group, which was tasked with coming up with a scalable, integrative professional development platform and business model implementation framework. The integrated online platform should provide education and training, mentoring, knowledge products, internship/job experience, certification and technical leadership opportunities in one platform. These requirements were elicited from one-on-one interviews and surveys detailed in Takacs et al. (2017). These interviews were conducted with existing INCOSE-affiliated educational providers, INCOSE members and technical working group members who were willing to be interviewed or surveyed. Also, the platform should allow for feedback and data analysis to foster continuous improvement of the platform. The possibility for customer feedback will lead to INCOSE having a more rounded platform for Professional Development.

However, as stated by Kindstrom & Kowalkowski (2015), established organizations like INCOSE will often find the provision of additional services to be time-consuming and complicated. The difficulty is because of the existing business model will need to be considered, and the model might be complicated to change radically due to path dependencies and organizational inertia (Kowalkowski et al. 2012). Also, a widespread understanding of the constituent elements of a business model is that it can in some cases, involve inherent contradictory factors (Doleski, 2015).

The problem to be solved. As stated earlier, INCOSE has had issues articulating how profitable the proposed online platform for professional development can be. The primary question has been about figuring how best to satisfy the needs of various market segments concerning education and training, certification, knowledge products and other aspects of the value stream in an inexpensive manner. 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 (Figure 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.

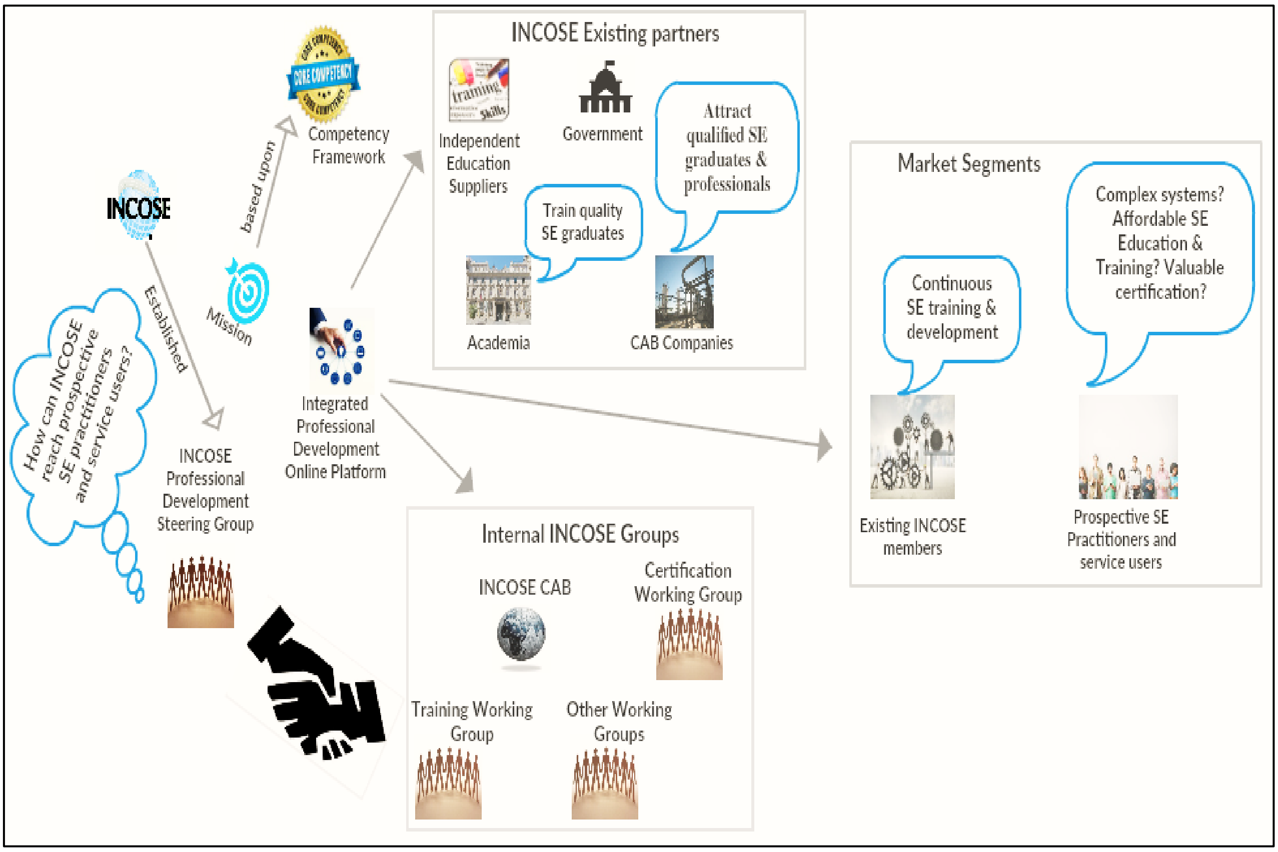

Figure 3: Rich Picture of INCOSE's Current Professional Development Circle.

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

In the rich picture shown as Figure 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 'Profit for Professional Development Initiative' as shown in Figure 4. The RCA diagram helps us uncover and visualize contradictions which constitute the starting point problem.

Root definition and conceptual model of the relevant system. In this stage, contradiction analysis is the first procedure to carry out. In Figure 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 & 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.

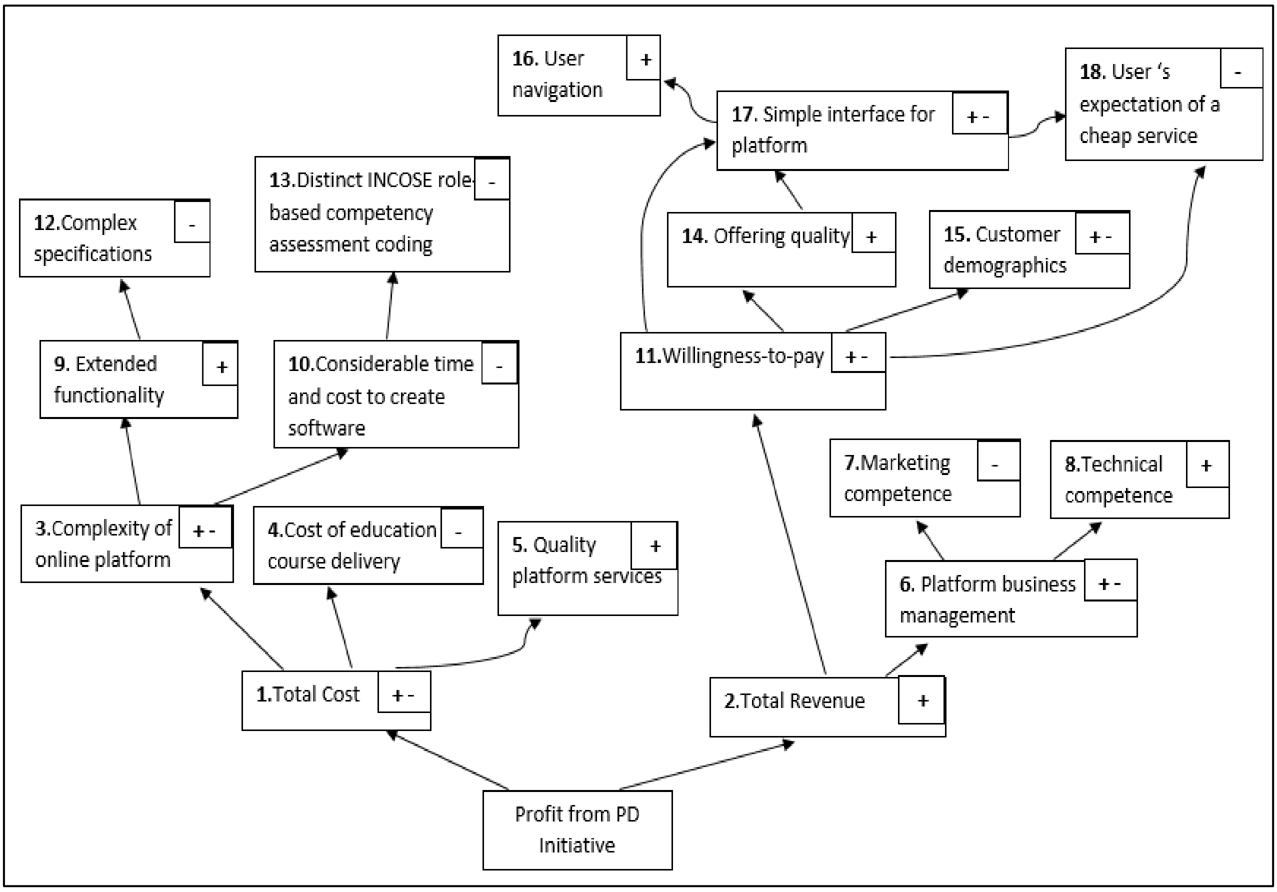

Figure 4: Root Cause-effect chain for profit generation.

Also, a contradiction can also result in another contradiction as seen with boxes 11 and 15 in Figure 4. The odds of the project attaining sustainability, effectiveness, and objectives will significantly increase by resolving some of the following contradictions identified in Figure 4:

- Total Cost: INCOSE needs to incur costs of delivery to offer an array of quality platform courses for users but does not want to incur costs of course delivery (Box number 1).
- The complexity of online platform: The platform's complex specifications allow for extended functionality to suit users' needs, but also drives the cost of software development higher (Box number 3).
- Platform business management: INCOSE members (mostly engineers) possess technical competence to ensure platform delivers on technical excellence but do not necessarily have the business and marketing competence needed for successful marketing and sales (Box number 6).
- Willingness-to-pay: INCOSE wants to offer a quality learning experience for users, but users generally expect lower subscription fees for service. (Box number 11).
- Customer demographics: Prior information on customer archetype and other user needs will ensure effective targeting and higher conversion rate for marketing campaigns, but the process of information elicitation could be expensive and time-consuming especially for prospective SE practitioners not associated with INCOSE (Box number 15).
- Simple interface for the platform: The platform's simple interface helps user navigation and functionality but can also create an expectation for cheap subscription fees (Box number 17).

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 one element which states that 'INCOSE needs to incur costs of delivery to offer an array of quality platform courses for users but does not want to incur costs of course delivery.'

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 (offer an array of quality platform courses) with Setting and Condition A ('incur costs of delivery' and 'online platform') and Setting and Condition B ('not incurring costs of delivery' and 'online platform').

The flow logic employed for contradiction resolution is shown in Figure 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 will not work, and the next technique for trial will be Separate Gradually. The complete resolution of contradiction will not permit starting with setting A and ending with setting B, so 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. Finally, settings A needs to be minimized, so this separation technique resolves 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. Figure 5 shows the logical flow used to identify the separation technique to resolve a contradiction.

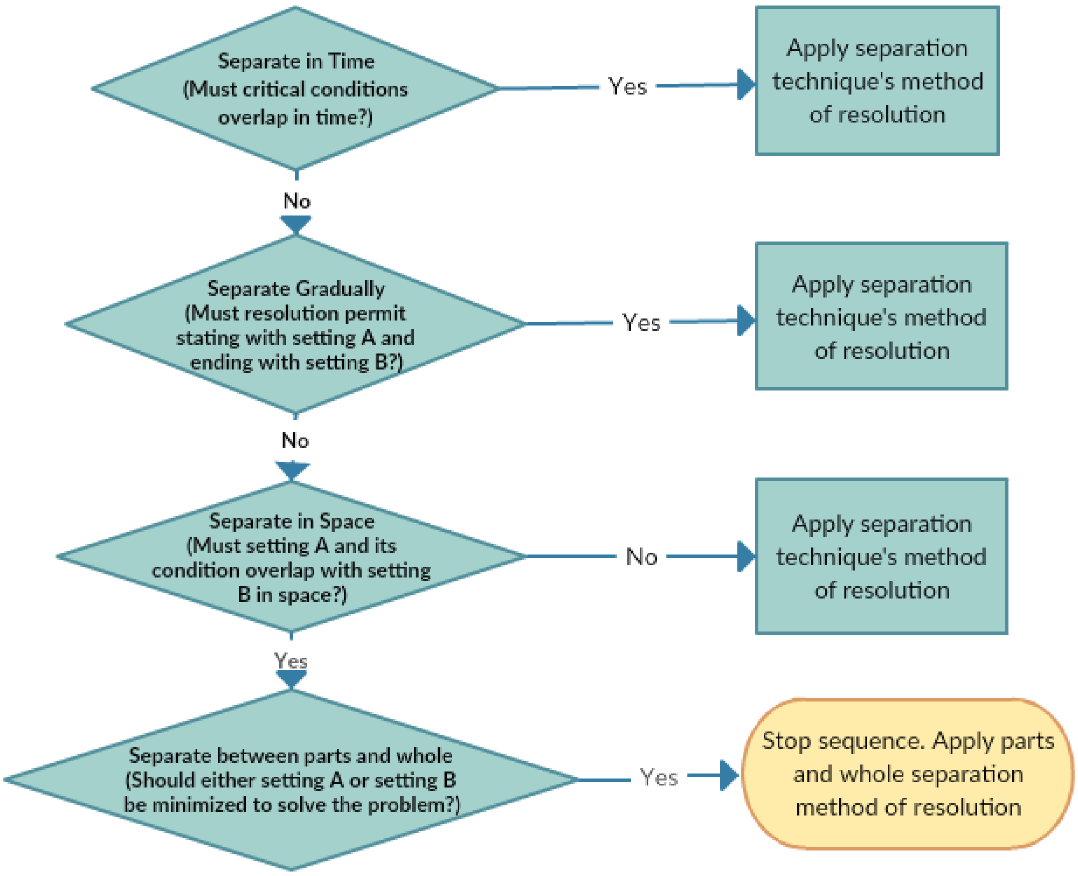

Figure 5. Contradiction resolution flowchart

After applying the logical flow in Figure 5, we deduced that our contradiction of interest was to be resolved by the separation between parts and whole technique. 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 parts and whole separation technique is the Merging method. This method stresses that: 'segmented or individual elements have the property of being setting A. When made to interact with each other by (field, mediator, method or arrangement), the overall effect is setting B. The idea for our previously stated contradiction is that the cost of course delivery can be divided into sub-elements. If INCOSE can come up with a way of not being responsible for all sub-elements of cost delivery, then the overall effect can approximate closer to not incurring huge costs of course delivery (setting B). A solution statement summarizing this idea from the merging method is as follows:

Solution statement 1: *INCOSE offering an array of quality courses accessible via an online platform while not incurring costs of course delivery by transferring aspects of delivery costs to independent educational suppliers and academia (associated with INCOSE) to incur in a mutually beneficial arrangement by developing and running their course and training lectures on INCOSE's web platform.*

Another method from parts and whole separation technique that can spin a solution idea is the elimination and transformation approach. An explanation of this approach is that 'inexpensive particles or segmented sub-elements which are (setting A) can be made to lose their (setting A) by eliminating them and transforming their implementation to be (setting B).' A resulting idea from this for our problem situation is that there can be inexpensive aspects of the online platform development cost that should be removed from the software development. Implementing this form of cost savings this way will be beneficial to INCOSE's objective and will no longer add to the cost of software development. A solution statement summarizing this idea from the mixture method is as follows:

Solution statement 2: *The online functionality of matching INCOSE SE mentors to customers can be eliminated thus reducing the cost of software development. However, the mentoring needs of users will be met by encouraging INCOSE membership for mentorship connections to be established and secured. Solution strategy leads to membership growth and an increase in annual membership dues.*

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 paper uncovers two solutions from the parts and whole separation technique; 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: Current INCOSE professional members, prospective SE practitioners, 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, competition from renowned academic systems engineering certification programs, industry trends in general, market size.

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 6.

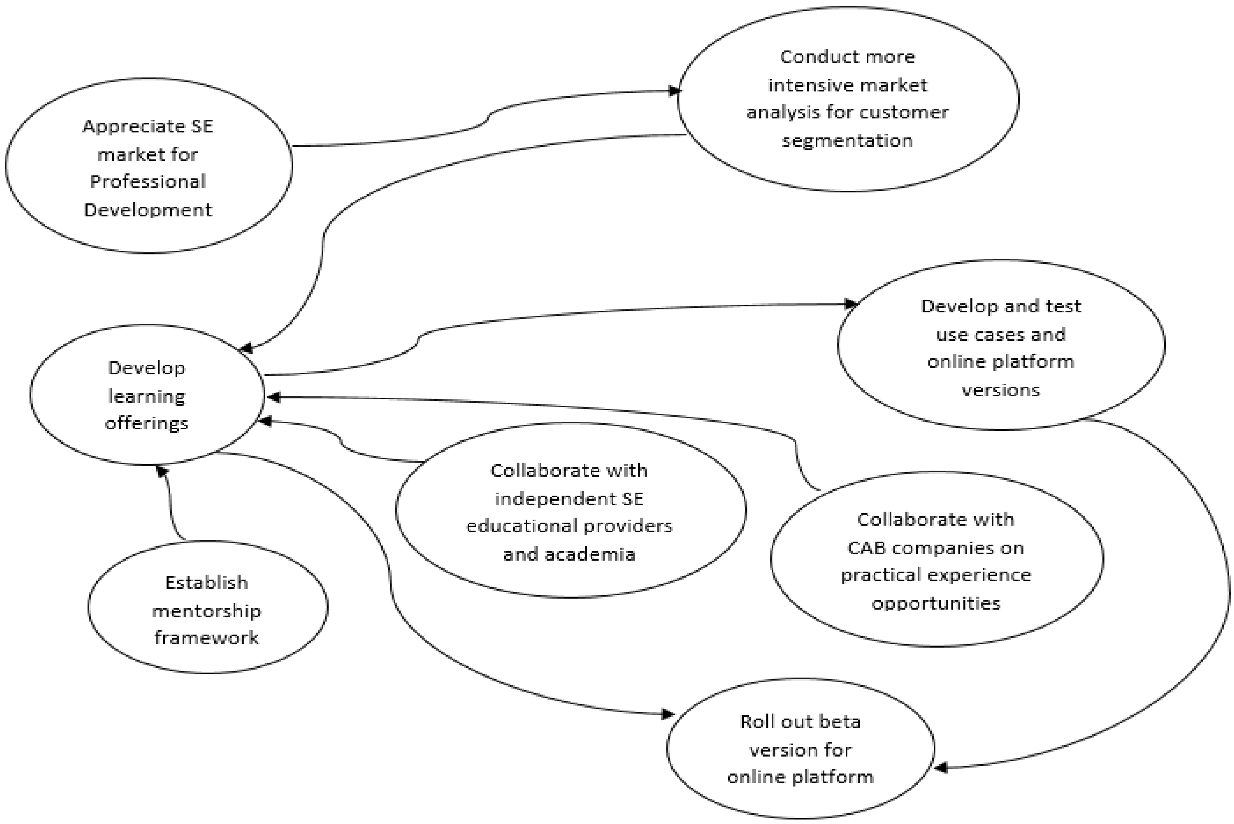

Figure 6: Conceptual model for purposeful activity system.

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. Having conducted a brief CATWOE analysis, our SSM-TRIZ method encourages the further construction of a functional analysis diagram as depicted in Figure 7, which maps components of this professional development service and other resources and their functional interrelationships.

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 offering an array of quality courses accessible via an online platform while not incurring costs of course delivery. The IFR for our problem situation is the need to incur minimal costs while providing an online platform solution capability for INCOSE.

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 course quality must not be compromised. Therefore, course quality is a criterion against which our selected solution statement is measured. A solution statement that accounts for consideration of quality is as follows.

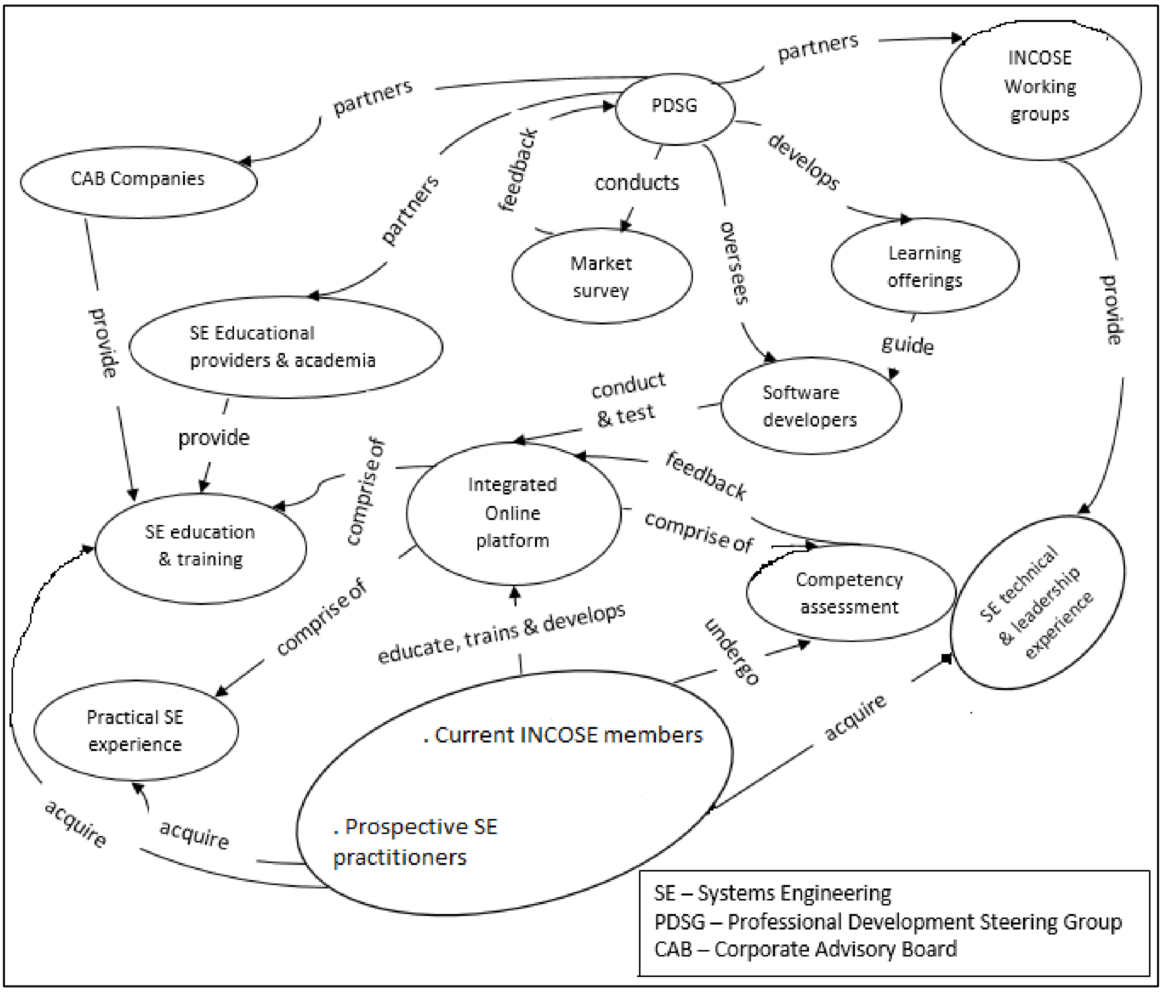

Figure 7: Function analysis diagram.

<u>Refined Solution Statement 1</u>: *INCOSE offering an array of quality courses accessible via an online platform while not incurring costs of course delivery by transferring aspects of delivery costs to independent educational suppliers and academia (associated with INCOSE) in a mutually beneficial arrangement by developing and running their course and training lectures on INCOSE's web platform. INCOSE can decide to establish a vetting framework for these educational suppliers to ensure that lecture videos and materials found on the web platform are up to the organization's rigorous systems engineering standards.*

<u>Refined Solution Statement 1*</u>: *INCOSE offering an array of quality courses accessible via an online platform while not incurring costs of course delivery by transferring aspects of delivery costs to independent educational suppliers and academia (associated with INCOSE) in a mutually beneficial arrangement by developing and running their course and training lectures on INCOSE's web platform. INCOSE can decide to establish a vetting framework for these educational suppliers to ensure*

that lecture videos and materials found on the web platform are up to the organization's rigorous systems engineering standards. Also, she can take advantage of the different legal rules in various countries in defining and instituting vetting processes with educational suppliers and academia especially in nations adopting the English rule.

Table 2: Summary of SSM-TRIZ stages for application problem in this paper

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 5 contradictions namely: *Total Costs, Complexity of online platform, Platform business management, Willingness-to-pay, Customer demographics, Simple interface for platform*
Root Definition and Conceptual Model of relevant System	Contradiction analysis	Subject matter knowledge and expertise	Contradiction: *INCOSE needs to incur costs of delivery to offer an array of quality platform courses for users but does not want to incur costs of course delivery (Total Costs)* Element: *Offer an array of quality platform courses* Setting A: *incur costs of delivery* Setting B: *does not incur the costs of delivery* Conditions A & B: *online platform*
	Contradiction resolution	Separation Techniques	Effective separation technique: *Parts & Whole* Solutions: *Solution Statement 1(Merging method of resolution) and Solution Statement 2* (*Mixture method of resolution*)
	Mapping solution statement 1 to 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: Platform *Quality* Refined solution statement 1
Seeking feasible and desirable changes	Accommodate refined solution statement 1 for political and socio-economic factors	Enhanced cultural Analysis	Refined solution statement 1*

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. The optimal subscription fee to charge users based on quantitative customer demographics data and other marketing indices, is one to be solved through optimization, data analytics, text mining (semantic analysis of users' requirements), etc. Table 2 provides a summary of the SSM-TRIZ stages and their sequential steps applied towards resolving the box number one contradiction (Total Costs) in Figure 4.

Conclusion, Limitations and Further Work

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 (strengths and weaknesses detailed in Table 1), 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 Optimization, System Identification techniques in heuristics, optimization, statistics, decision theory, etc., 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.

This paper 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, we strongly encourage empirical, deductive studies that quantitatively assess the effectiveness of SSM-TRIZ via questionnaires and cross-sectional surveys.

Disclaimer: The conclusions and recommendations expressed in this paper are those of the authors and do not necessarily reflect the positions of the International Council on Systems Engineering (INCOSE).

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