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The Application of Systems Engineering to Project Management

A Review of Their Relationship

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ABSTRACT

This study investigated the application of systems engineering to project management. There is an increasing complexity to modern projects, and lifecycle-focused project management displays the inability to manage the risks associated with increased project complexity. A more adequate approach to these issues is presented in the systems engineering processes. It was proposed that the application of systems engineering concepts will allow improve the management of complex projects and the mitigation of risks. Additionally, qualitative research conducted via the collection and analysis of credible information yielded data that supported this proposition. Since systems engineering processes are adaptable, they are suited to manage complex problems. It was concluded that applying systems engineering to project management was beneficial, and the integration of methodologies was valuable to the successful completion of large scale, complex projects.

KEYWORDS

Project Management, Projects, Systems Engineering, Systems Thinking

INTRODUCTION

Background

The use of projects and project management as a means to add value to an organization was proven essential to the growth and development of modern industry. To improve operations, to react to opportunity, and to manage the challenges that arise within a business environment, projects are required. Contrary to processes or operations, projects are unique and must be treated individually. While no two projects are the same, they share a set of properties that qualify them as such. There are specified objectives, durations, budgets, and general constraints that all projects have. Projects are multifunctional, spanning across numerous industries, sectors, or departments and the use of both human and nonhuman resources are required. One of the most defining properties of a project is that it has defined start and end dates, so it is always finite. Projects can be considered as temporary endeavors that offer unique solutions. Also, it should be noted that there are many differences between projects and processes. Repetitive or ongoing activities that utilize well-established systems and practices would be the definition of processes. Furthermore, there is a high certainty of success and a low risk of failure when performing processes. While processes serve to support the status quo, projects tend to violate established practices and upset the status quo. Although higher risk is

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associated with projects than processes, projects tend to yield greater rewards (Pinto, 2019; Ahern, Leavy, & Byrne, 2014; Badi & Pryke, 2016; Azar, 2012).

A necessary tool to mitigate risk and to ensure that a project is completed to specification within its constraints is project management. By dividing a project into smaller, more manageable tasks and subtasks, project managers can maintain a higher level of control over their projects. By recognizing that all projects have finite life cycles, this can be achieved. Furthermore, there are four main points to a project lifecycle. The initial phase of the project lifecycle is the conceptualization phase. During this phase, the initial goals and specifications of a project are developed. Project scope begins to take shape, and key stakeholders are recognized at this stage. The conceptualization phase is then followed by a planning phase. During planning, specifications become more detailed, and project scope becomes better defined. To develop planning documents, such as schedule, budget, and schematics, these elements can be used. After the completion of planning, project execution can begin. The execution phase sees project-related work being performed and completed. Once work is completed, the project termination phase is initialized. During the termination phase, final products are transferred to the customer or stakeholders, and resources can be reassigned. Essentially, the termination phase is completed with the closing of a project. The aspects of a project life cycle provide abilities that are vital for project control. Also, the waypoints by which project completion can be measured are lifecycle stages. There is also a means for visualizing the activities required for project completions provided by life cycle aspects, as well as some of the challenges that a given project may face (Pinto, 2019; Al-Kadeem, et al., 2017a; Eskerod & Blichfeldt, 2005; Zelinka & Amadei, 2019).

Primarily, there are many shortcomings attributed to traditional project management. The ability to track and maintain a pre-specified duration and budget is one of the most important aspects of project management. In projects today, increased rates of project failure are commonly derived from cost overruns and delays. Also, consistency between tasks and/or whole projects is lacking in projects. It is being shown that the current practices of project management are becoming less able to manage project risks. At the core of these notable deficiencies is the inability to manage increased complexity. To deal with the risks associated with increased complexity, a new approach to project management should be taken, as modern projects are growing larger and more complex. The field of project management has the potential to make improvements to its practices: enter the field of systems engineering.

An interdisciplinary approach to the realization of successful systems is referred to by the term "systems engineering". To clearly define customer requirements early in development and to proceed with the design and validation of systems is the focus of systems engineering. Meanwhile, the overarching problem that is to be solved is always considered. It is stated by The International Council on Systems Engineering (INCOSE) that:

Systems Engineering integrates all the disciplines and specialty groups into a team effort, forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. (INCOSE, 2018)

In attempting to understand the field of systems engineering, it is crucial to first understand systems. A system has been defined by a consensus of INCOSE Fellows as a construct or collection of different elements that produce unobtainable results by the elements alone. From numerous different disciplines and resources from people to facilities, software, and documents, systems utilize certain elements. To add value that is greater than the value of its individual parts to business and technical fields alike, a system provides its service. The benefit of utilizing systems to achieve goals is that systems level results can be expected, such as control functions, performance, behavior, and quality. Moreover, there is adaptability and comprehensibility to systems.

The field of project management is currently struggling to manage the risks associated with the increasing complexity of modern projects. Through the application of systems engineering processes and concepts, project management methodologies can be improved to better mitigate risks and to manage increased complexity. This paper presents and analyzes some of the shortcomings of traditional project management. It also highlights a number of advantages of systems engineering concepts, as well as how they can be applied to project management. The research was conducted via a qualitative approach, but quantitative data was also taken into account. The application of systems engineering to project management may remedy some the issues currently faced by modern projects. If systems engineering processes can be applied to project management, then the field of project management serves to benefit from these applications.

Though literature usually addresses the crucial role of these variables, their concepts, and models in project management and performance, more information is required. For example, literature should address how the variables cause a smooth progression in project management and performance. Thus, this study was derived from this research gap, as it aimed to assess the most recent elements and applications of the variables, their concepts, and models. Additionally, this study aimed to assess any overlaps and disparities between these variables, concepts, and models. As a result, an objective was to propose a framework that features the best elements of the current model, which will outline a "collective" framework for any project, operation, or performance. Furthermore, the research aimed to supply evidence-based answers to prominent questions from experts on these variables, their concepts, and models, such as the best methods in applying them. Future research about these variables, their concepts, and models can build upon the research findings and act as a platform.

Furthermore, it will become more important for the future of project management and engineering managers to make good decisions in engineering. Because this study addresses the future of these topics, it is important for engineering management practitioners. This study also outlines its relevance and contribution to the engineering management field. The critical implications from the findings are also explained from different organizational levels (i.e., corporate, managerial, and project team). Lastly, the conclusions of this study can be used by engineering management practitioners to improve capitalizing on these factors and relationships at different levels of project environments and operations.

This research was meant to address the efficiency of these variables, their concepts, and models, as well as their likenesses and differences. Data has been added from various studies with the same hypotheses as this paper. This study adapted various research perspectives and ideas to suggest new solutions for current problems. First, this study takes a design-science-investigate approach. Second, it approves a valuable growth reveal for reasonable and hypothetical application. Finally, it generates a suitable assessment model for these variables, their concepts, and models. This study focuses on evaluation instruments to respond to the examination question, as well. In the analysis, the consequences of the meetings are outlined, and the conclusion addresses initial discoveries to recommend ideas for future studies.

This study not only contributes to the limited research on applying these variables, their concepts, and models to project management and operations management, but it also contributes to the profession. In the findings, the real-world examples show the need to apply these theories to true-to-life situations. Essentially, these different variables, their concepts, and models are focused on to contribute to current literature and to propose a unified framework. Ignoring this topic has created a research gap that can be confusing for future researchers. Thus, by studying and understanding the relationship between these variables, the research void will be filled, which will enhance the methods for applying them.

Additionally, this study contributes to Industrial Engineering (IE) research because it accelerates the work process for an engineer. Though the latest technology can help engineers in maintaining the system, it can also help to save on productivity-hindering resources, such as time, money, materials, energy, and machine time. Thus, because this model offers new ideas for products and for practitioners, productivity will improve.

Since this study features helpful information for readers, the IE research field can benefit. Also, this study uses simple vocabulary to illustrate the effectiveness of these variables, their concepts, and models. There is a clear theoretical framework that adds helpful information in this study to serve as a reference for future readers, as well.

Overall, the study follows this format: section two contains a high-level literature review for currently available literature in these research fields. For section three, the research methodology is explained to execute the research study. Section four shows the findings and analysis. Lastly, section five outlines any implications for the practitioner, suggestions for future research avenues, illustrates research limitations, and provides general conclusions.

LITERATURE REVIEW

Project Management

Project management was defined by the Project Management Body of Knowledge (PMBoK) as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. The field of project management and the techniques utilized by project managers have proven crucial to the growth and development of modern industry. The study of project management, as per the Project Management Institute, focused on obtaining specified goals through expert level management of budgets, schedules, and constraints. Furthermore, the PMBoK definition of project success was stated as accomplishing "project objectives within schedule and within budget to satisfy the stakeholder and learn from experience" (PMBoK, 2018; Hartono, FN Wijaya, & M. Arini, 2014; Marcelino-Sádaba et al., 2014; Parast, 2011). Thus, the project management field is essential to the success of projects.

At the core of project management is the concept of project life cycles. There are four critical phases of projects in the project life cycle that must occur for a project to be considered complete: Conceptualization, Planning, Execution, and Termination. In *Project Management: Achieving a Competitive Advantage*, Jeffrey K. Pinto states that these "stages are the waypoints at which the project team can evaluate both its performance and the project's overall status" (Pinto, 2019; Xiong et al., 2017; Von Thiele Schwarz, 2017; Usman Tariq, 2013). He highlighted that the project lifecycle is only applicable after the commencement of a project. The ability for project managers to measure progress is an essential element of a project's success. Project management professionals also can generate a useful visualization of potential challenges to be faced through the project lifecycle. Additionally, Pinto drew attention to some of the common sources of challenges due to change that occurred during a project. He stated that client interests often shifted during the project lifecycle. A customer's level of enthusiasm or concern about the project was often the source of client-based change. Project stake was also a common factor because "the longer the life of a project, the greater the investment" (Pinto, 2019; Xue, Baron, & Esteban, 2016; Zwikael, & Smyrk, 2012; Nikabadi & Hakaki, 2018). The commitment of resources, the degree of innovation, and the level of uncertainty were all other relevant sources of change. Overall, these sources of change can occur in varying degrees throughout the project lifecycle.

Aspects of project management have been used for centuries throughout the world. The construction of the great pyramids in Egypt, the Colosseum in Rome, and Westminster Abbey in England can be associated with project management aspects. However, project management has only entered the mainstream as a field of study within the last fifty years. According to Doctor Tom Seymour of Minot State University, there are four periods of project management that span the last century. The first period was referred to as "prior to 1958," which accounted for the invention of the Gantt Chart, job specifications, and other aspects that set the basis for modern project management. The Hoover Dam and Interstate Highways were some examples of large-scale projects completed in this period. The second period of modern project management was an interval between 1958 and 1979, which saw the introduction of management science. During this time, the PERT system and Critical Path Method were also introduced, and the Project Management Institute is founded. Additionally, the third period of modern project management came with the introduction of personal computers. This period lasted between 1980 and 1994, which increased use of technology in project management operations and provided a greater ability to multitask. With the increased usage of technology also came a number of software models and theories to improve the abilities of project managers. Finally, the current period of project management began in 1995 and has seen improvements to previous technologies and methods, such as the introduction of Microsoft Project and the Critical Chain Path Method.

The current applications of traditional project management are far from limited. Numerous sectors and industries utilize project management techniques for various reasons. The common connection between these diverse fields is the need to achieve a goal, whatever it may be. One area where project management has proven beneficial is to the construction/renovation industries. A piece written by Naomi Kachoka and Ruth Hoskins highlighted the use of project management in managing renovation operations during a project at Chancellor College Library. The writing stated that the number of renovation projects being conducted is increasing and that project management techniques are beneficial to the success of these projects. Furthermore, Kachoka and Hoskins pointed out that the lack of project management directly affects the abilities of renovation projects to be completed on time and within budget. Kachoka and Hoskins were members of a team tasked with the renovation of a school library. They studied the project success based on PMBoK standards and concluded that the major weaknesses of their project were as follows:

Some of the observable weaknesses in the management of the floor covering renovation project were: failure to identify a project manager, poor communication channels, lack of proper documentation, such as a project plan, a communication plan, a staffing management plan, a budget plan, a procurement plan and a project report, lack of proper monitoring and quality control mechanisms to ensure that planned targets were being met, poor risk management, poor cost estimations and cost control, and poor procurement planning. (Kachoka & Hoskins, 2017; Zwikael, & Smyrk, 2012; Yun et al., 2016; Nabavi & Balochian, 2018)

Furthermore, the team concluded that the project could have benefited substantially from the utilization of PMBoK concepts and processes. They recommended that the University of Mawali should adopt standardized PMBoK methodologies to obtain the advantage of project management in the future.

Also, the ability of project management to mitigate the high level of risk associated with most projects is essential to the success of projects. Dr. Dan Vescu of the University of Brasov in Transylvania provided an outline of numerous project risks and mitigation practices. This overview came at a time when Romania was lacking in the completion of credible and efficient projects. Dr. Vescu stated that within project lifecycles, two categories of risk exist. The first category is internal risk and includes risks related to ambiguity, imprecise definitions of scope and responsibility, and technology. The external risk factors are the second category. Political and regulatory circumstances, environmental and natural disasters, and social and economic risks are all included with external risk factors. Furthermore, Dr. Vescu displayed a few of the techniques available to mitigate project risks. The assumption, monitoring, avoidance, and outsourcing of risk are all allowed with traditional project management practices. The overview also provided a proposed set of guidelines for mitigating risks. First, the source of the risk should be located, followed by an evaluation and analysis of the causes. The fourth step requires the decision of a level of tolerance of risk. Then, corrective or preventive measures could be put in place to mitigate risks. Finally, project control could be assumed and balanced.

A study conducted by S.C. Hlophe and J.K. Visser of the University of Pretoria Department of Engineering and Technology Management attempted to determine whether project risk management plays a factor in project success. The focus of this study was the projects carried out during outage periods of continuously operated plants. The study was conducted via 61 questionnaires surveying 13 South African coal fired power stations. The research concluded that the majority of outage projects fail due to a non-adherence to project risk management practices. The study also revealed that while project risk management practices were widely recognized as a factor in the success of projects, the level of compliance to these practices was subpar. Hlophe and Visser (2018) stated that "Understanding the probability of risks occurring, and being able to evaluate their probability, severity, and criticality requires a great degree of experience and knowledge" (Winter et al., 2006a; Papke-Shields & Boyer-Wright, 2017; Omamo et al., 2018). Hlophe & Visser also concluded that more adequate training would ensure the effectiveness of project risk management and the success of projects. Not only did this study present an application of project management, but it also portrayed one of the many benefits of project management methodologies.

Furthermore, a separate study has been conducted by the United States Air Force concerned with the issues of cost and schedule overruns affecting large scale projects. The study was conducted and the findings recorded by Capt Ryan Trudelle, USAF, Edward D. White, Lt Col Clay Koschnick, USAF, Lt Col Jonathan D. Ritschel, USAF, and Lt Col Brandon Lucas, USAF. The study focused on the ability of project managers to utilize statistical techniques to mitigate the risk of cost and schedule overruns. The study showed that when a contingency has an interval between 15% and 25%, the risk of critical overruns becomes minimized. The data also showed that a set of five variables place projects at risk of overrun. Included in this list of variables were project duration and size. Projects that had durations greater than 58 months from the completion of a "B" milestone were at risk of overrun, as were extremely large project, generally with budgets exceeding $17.5 billion, illustrating that statistical techniques are important in quality control and project management.

While project management practices have proven their importance in achieving goals, there are many prevalent shortcomings associated with the discipline. An article published in the South African Journal of Industrial Engineering's November 2017 issue shed some light on a few of these issues. The article was based on the findings of a study on large infrastructure projects (LIPs) in South Africa. The study focused mainly on the issue of large infrastructure projects overrunning budgets and missing critical dates. Findings showed that the amount of infrastructure spending in the South African region is increasing, but so was the number of failed LIPs. "Infrastructure expenditure in Sub-Saharan Africa (SSA) is expected to increase by 10 per cent on a year-to-year basis, from US$ 70 billion in 2013 to US$ 180 billion by 2025, with South Africa and Nigeria accounting for the bulk of this expenditure" (Mabelo & Sunjka, 2017; Milner, 2016; Galli et al., 2017; Galli, 2018c). The pair argued that the project lifecycle is inadequate for the mitigation of large scale project risks because of the increasing levels of complexity associated with LIPs.

Another article was also published by the South African Journal of Industrial Engineering, and it highlighted a few of the problems commonly faced during the execution phase of the project lifecycle. The study showed that a stakeholder's level of trust in their project managers changes with relation to project schedule performance. Essentially, when projects fail to meet critical dates, then clients lose faith in their project management team. This becomes an issue when paired with the findings of Mabelo and Sunjka; projects are missing critical dates in alarming numbers. This study, conducted by A.M. Chitango and L. Pretorius, has made it clear that when stakeholders lose trust in the project management team, then they often implement varying levels of project controls. These controls have been shown to affect a project manager's ability to ensure the success of a project:

demanding more project progress reports; conducting more progress meetings; conducting more progress inspections; delaying approval and payment of the engineering consultant's invoices; and applying delay-damages penalties. These controls were found to be aimed at putting pressure on the engineering consultant to work faster and increase project work completion. (Chitango & Pretorius, 2018; Galli & Kaviani, 2018; Brown & Eisenhardt, 1995)

Furthermore, increased project controls that were implemented by stakeholders could be detrimental to project management operations. The increased use of project controls required more work to be performed by project management professionals. Progress reporting, approvals, etc., required the time and attention of project managers. As a result, there can be decreases in work completion rates and general workforce productivity. The team concluded by recommending a more dynamic systems approach to project management.

The University of Pretoria in South Africa argued that a definitive factor in the success and failure of projects was the communication of information between project management teams and elements. Thus, the role that project management offices play in transferring project knowledge is essential to project completion. The research team implied that the short-term, finite views of project lifecycles encouraged deficiencies in traditional project management processes. The study presented a conceptual model that could be used by project management organizations to assist in managing project knowledge transfer. The conceptual model emphasized the ability to manage knowledge transfer not only during short term endeavors, but also during long term processes. The shortcomings and deficiencies of traditional project management are becoming more prevalent with the increased size and complexity of modern projects. This general increase in project complexity creates the potential for improvement to traditional project management practices.

An introduction to project complexity and the role that it plays in project management has been published on a website from the Project Management Institute (PMI). According to the piece, the complexity of projects spanning all industries is increasing and will continue to in the future. The PMI also recognizes the inabilities of traditional project management to deal with increased complexity. Some of the cited issues with project management are linear approaches to project life cycles, illusions of control, and the unpredictability of human nature (Cooke-Davies, 2018; David, David, & David, 2017; Galli & Hernandez-Lopez, 2018). The article also stressed the need for project managers and teams to understand systems and systems engineering concepts, as they provide viable solutions to the problems associated with increased complexity.

Systems Engineering

The International Council of Systems Engineering, or INCOSE, referred to the field of systems engineering as "an interdisciplinary approach and means to enable the realization of successful systems" (INCOSE, 2018; Galli, 2018a; Hoon Kwak, & Dixon, 2008; Schwedes, Riedel, & Dziekan, 2017; Aslani, Akbari, & Tabasi, 2018). A simplified view of systems engineering is as a systems-thinking based approach to problem-solving. The view of a whole as the sum of its parts, as opposed to a singular event, is the core concept of systems thinking. INCOSE notes that the value added by a system is greater than the value contributed by its individual parts because of the relationship created between them. A methodological view of problem or project elements is required by the systems engineering approach to problem solving.

Essentially, similar processes to the field of project management are utilized by systems engineering. Unlike project management, systems engineering processes do not take a finite approach to problem-solving. The basis of a finite project lifecycle and the view of projects as temporary are seen within traditional project management processes. The SIMILAR Process (State, Investigate, Model, Integrate, Launch, Assess and Re-evaluate) is utilized by systems engineering. As outlined by the SIMILAR Process, the first phase of problem-solving is to state the problem. The development phase of a project lifecycle is comparable to this phase, as problems and goals are defined and outlined. There is a statement of mandatory requirements, as well as the development of a problem statement. Once a problem statement has been created, systems engineering team members can then investigate alternative solutions. In the investigation phase, research and experiments are performed to ensure that the system provides the best solution to the specified problem. At the conclusion of investigations, the proposed system can be modeled. Analogs, analytic equations, block and flow diagrams, and computer simulations should be what models consist of, according to INCOSE.

The ability to create dynamic PERT charts and to study scheduling changes before they occur is provided by system models. After modeling, integration can begin. During the integration phase, to work towards a larger goal, subsystems are utilized comprehensively. The integration of subsystems allow for a system to be created and operated using efficient means. Once a system is launched, outputs are produced. Allowing a system to operate in the manner it was designed is essentially launching a system. System outputs can then be collected and analyzed, and to assess system performance, output data is used. For mitigating risk and measuring productivity and efficiency, performance measures are valuable. One of most important aspects of the SIMILAR Process is the re-evaluation phase, as feedback from assessment data is utilized to modify or adjust the system. Re-evaluation should be a continual process and should also work parallel with the system. Although it is usually presented in a linear manner, SIMILAR Process phases are free to be arranged in any order that the systems engineering team sees fit, so they are non-linear. On the contrary, the linear and finite project lifecycle are adhered to by project managers.

Aside from the adaptability of core processes, systems engineering holds a number of other advantages over traditional project management practices. According to research conducted by Hanumanthrao Kannan, Christina Bloebaum, and Bryan Mesmer of Iowa State University and the University of Alabama, the incorporation of value-based systems engineering can produce increased consistency in Large Scale Complex Engineered Systems (LSCES). Furthermore, the team explored the ability of systems engineering practices to mitigate the risk of cost overruns and delays. Kannan et al. (2017) referred to LSCES in the context of large-scale systems design, but the characteristics of an LSCES do not bound to a single discipline or industry (Nagel, 2015; Xue, Baron, & Esteban, 2017; Todorović et al., 2015). To describe large scale transportation, infrastructure, and construction projects, the term large scale complex engineered system can also be used. The requirement of multidisciplinary resources and diverse subsystems are common features of LSCES, and it will also generally span multiple geographic locations (Kannan et al., 2017; Medina & Medina, 2015; Lee et al., 2013). Many innovations for increasing system consistency have come from research, and increased consistency is associated with a number of implications that will be further discussed in subsequent sections. The study concluded that adaptability and control were key factors to increasing consistency. It also demonstrated that there is a value gap between traditional project management and systems engineering.

In relation to the previous work by Kannan et al. (2017), a study that focused on the applications of systems engineering to current nuclear energy production processes also explored the advantage of integrating value-based systems into design and development phases (Gimenez-Espin, 2013; Detert, 2000). Many characteristics of large-scale complex engineered systems are often featured in nuclear energy projects, so they can benefit from the advantages of systems engineering applications. The study was conducted by Dan Wolff, Richard Brown, Paul Curson, Rob Ellis, Tanya Galliara, and Matt Harris, and was published in the May 2018 edition of IEEE Transactions on Plasma Science. Wolff and company investigated the applications of systems engineering to the design, integration, and maintenance of nuclear fusion plants. Due to the associated complexity and size of most nuclear energy projects, traditional project management practices are failing to keep projects in control. It was proposed that SIMILAR processes could aid in mitigating risks associated with nuclear energy projects. An emphasis on the modeling, integration, and re-evaluation elements of systems engineering is also made (Wolff et al., 2018; Andersen, 2014; Cova & Salle, 2005; Galli, 2018b). The authors concluded that the potential benefits of systems focused processes, both short and long term, justified a wider adoption of systems engineering in the nuclear energy industry.

Another advantage of systems engineering over project management is in risk management. The ability of traditional project management to mitigate risk is subject to uncertainty and limited by an array of factors. Abdel Badri of the University of Quebec’s School of Industrial Engineering cites these factors as project complexity, project variety/diversity, interdependence within projects, and organizational context. Badri’s article attempts to shed light on the complexity of risk management in traditional project management. The article also showed the advantages of utilizing a systems-engineering-based approach to project risk management. The research concluded that the linear project lifecycle is not adept at managing risks as projects grow more complex. Badri recommended the implementation of a risk management cycle that continuously evaluates risk and highlights mitigation strategies. Thus, a greater ability to mitigate risk could be provided by systems engineering with the emphasis on re-evaluation in the SIMILAR.

A study performed by Islamic Azad University School of Engineering found that potential changes in current project management practices could decrease both cost and an almost variance. Furthermore, applying systems engineering and dynamics concepts to traditional project management practices increased project control, decreasing both cost and variance. These results were based on simulations and models created during the study (Kiani et al, 2018; Easton, & Rosenzweig, 2012; Labedz & Gray, 2013; Gafi & Javadian, 2018). The team pointed out the importance of their findings to the construction management industry, but the application of systems engineering and its processes to the field of project management could be of equal importance to numerous other industries.

The use of systems engineering processes and concepts is advantageous to the current business landscape, as firms continue to undertake projects at increasing rates. An adaptable field that can be used for an almost infinite number of applications is systems engineering. For the implementation of systems engineering processes, projects that involve complex organizations and organizational structures are prime candidates. A case study conducted by Dawn Gilbert and Mike Yearworth of the University of Bristol in the United Kingdom set out to investigate the effects of organizational complexity on the ability of project managers to meet delivery expectations. The study compared traditional project management methodologies to a more systems-focused approach. Also, the team presented the idea that organizations can be viewed as complex adaptive systems. The traditional "reductionist" approach to projects that involve complex organizations was based on a simplistic "cause and effect" views of problem-solving. This encouraged a positivist research approach that "draws superficially (if at all) from any recognizable theoretical position" (Gilbert & Yearworth, 2016; Arumugam, 2016; Besner & Hobbs, 2012; Burnes, 2014). The study concluded with the position that traditional project management methodologies could benefit from the addition of systems engineering processes when dealing with complex organizations.

Overall, it has been shown that systems engineering processes can also benefit the design phase of project life cycles. In systems engineering, the SIMILAR process highlighted the importance of the modeling and integration of systems. In their article "Design Verification through virtual prototyping techniques based on Systems Engineering," Ricardo Mejia Gutierrez and Ricardo Carvajal Arango presented an analysis of traditional design verification activities. The subject of study was the integration of software tools into existing product development processes. The pair made the argument that the design stage of complex product development projects could benefit from the implementation of modeling and integration processes. Also, they drew attention to the importance of modeling in the development of new products and innovations. The data collected from system modeling could be analyzed and could aid in the verification of designs. Gutierrez and Arango also presented an argument for the integration of development software into existing design processes. The integration of systems was an integral part of the systems engineering SIMILAR process. By integrating design, modeling, and costing subsystems, designs can be verified and feasibility can be decided with a higher degree of certainty.

Systems engineering approaches to problem-solving are becoming more prevalent across the modern business landscape. One sector where systems engineering is increasing in popularity is the medical industry. An article by Doctor Amye J. Tevaarwerk, Doctor Jennifer R. Klemp, and other American Cancer Society associated personnel presented a systems-engineering approach to health management of cancer survivors. The team stated:

Maintaining their health requires communication and coordination among and between specialists, primary care, and survivors to deliver necessary preventive and supportive care. Ongoing survivorship care can be fragmented by inadequate communication and care coordination processes. This fragmentation contributes to inferior health outcomes stemming from a failure to provide necessary care and the provision of unnecessary or duplicative services. (Tevaarwerk et al, 2018; Loyd, 2016; Gholizad et al., 2017)

They maintained that the communication and coordination of medical care elements was becoming more intensive due to increasing complexity. To mitigate the risks associated with increased complexity, it was suggested that medical care elements be viewed as subsystems, as opposed to resources, and that the integration of these subsystems provided abilities to better manage the health of cancer survivors.

As mentioned previously, an approach to problem-solving is systems engineering, so industrial problems can be managed by systems engineering processes. Commonly, to problem-solve, industrial firms undertake projects. Ideally, to control these solutions, the field of project management should be suitable. However, the overwhelming majority of cited works expressed problems that project management faced, including risk management inabilities, inconsistency, and project failures. A research paper by Dennis A. Perry III, Bill Olson, Paul Blessner, and Timothy D. Blackburn of The George Washington University also drew attention to the troubles of risk and opportunity management in industrial projects. The research paper stated that "The management of problems can be inconsistent, from one project to another, from one organization to another, and even from one project manager to another within the same organization" (Perry et al, 2016; Parker, Parsons, & Isharyanto, 2015; Sharon, Weck, & Dori, 2013). The team recommended that systems engineering concepts be applied to current industrial problem management landscape. Also, the high stakes for failure associated with subpar problem management created opportunities to improve current project management practices. Perry et al. (2016) concluded by stating that "The role of problem management in the system life cycle must be explored, and refinements to the model may consider feedback loops and knowledge management for continuous improvement of the system or program" (Shenhar & Levy, 2007; Sutherland, 2004). The findings presented in this research paper reflected a common desire for improvement to traditional project management through the incorporation and application of systems engineering concepts.

RESEARCH METHODOLOGY

Literature Review Research Approach

The literature review was a two-step process. First, there was a search for relevant information, such as inputting keywords. This step was less structured than the second step, which was the review process. In it, databases and search strong were used, and tables of contents from two journals were searched through.

Part 1: Explorative and Unstructured Literature Review

This study aimed to reconsider certain keywords, so publications that addressed the keywords had to be explored. Thus, 31 journal articles and 7 related books were collected. Then, the keywords were assessed within the 38 publications to use them as search terms in the structured review.

Part 2: Structured Literature Review

A structured and systematic approach was used to find methods for conducting reviews. This section contains four phases. First, there was preparation and scoping. Second, there was planning the review.

Third, there was a search, assessment, and selection of literature. Finally, there was an evaluation of selected literature.

For phase (1), the review scope concentrated on project-relevant research about marketing and strategic planning as key concepts in the studies. As a result, it was anticipated for the search to generate sufficient evidence and journals for the study.

Phase (2) involved connecting other concepts (the keywords, how they relate, how they interact) to the keywords for more information. However, the concepts of success, evaluation, and impact were too vague, as they did not result in practical and focused results.

In phase (3), relevant results were compiled by searching through many databases: ProQuest, Business Source Complete, Elsevier, EBSCO, ABI/Inform Global, ScienceDirect, etc. As a result, 15 conference papers and 25 results were collected that were relevant to the journals. Overall, 40 results of conference and journal papers were found.

The end of the search involved looking through Tables of Contents for tier 1 and tier 2 journals, which would also be academic and practitioner-based. Furthermore, it was ensured that all relevant articles were found with or without matching the keywords. Any selected journals were used as premier specialty journals for the keywords, and the search and selection process involved three streams (as seen in Figure 1, below): the explorative and unstructured search, the structured search with search strings, and scanning the Table of Contents.

Performing the three streams condensed the results to 42 publications for the analysis. Between 24 and 18 results were collected in the selection process by focusing on the results from academic journal articles, literature reviews, conference papers and proceedings, and books. Additionally, triangulation methods were applied. The first selection was done to see if the resulting publications were linked to both the keywords and to the project research. This evaluation was done with a set of inclusion and exclusion criteria highlighting the abstract, but some publications included the entire paper or only the introduction.

In phase (4), the information was organized into an inductive and deductive analysis. Then, this was documented with a software package. The university and country of each author was documented in the deductive analysis. Research genres were documented as empirical research, theory development, research essays and literature reviews, or “other”. Also, the deductive coding was added by proving that the publications applied theoretical frameworks, such as through a research-based view and contingency theory. It was also documented if the publication featured a model.

A grounded theory approach was applied for the inductive analysis to code certain publications with open and selective codes. Most of the selected publications were based on the average number of citations annually. Thus, the older publications were balanced with the newer ones. Also, relevant literature reviews were included that represented even more pertinent studies. Then, certain current publications were also included that contributed to the keywords research.

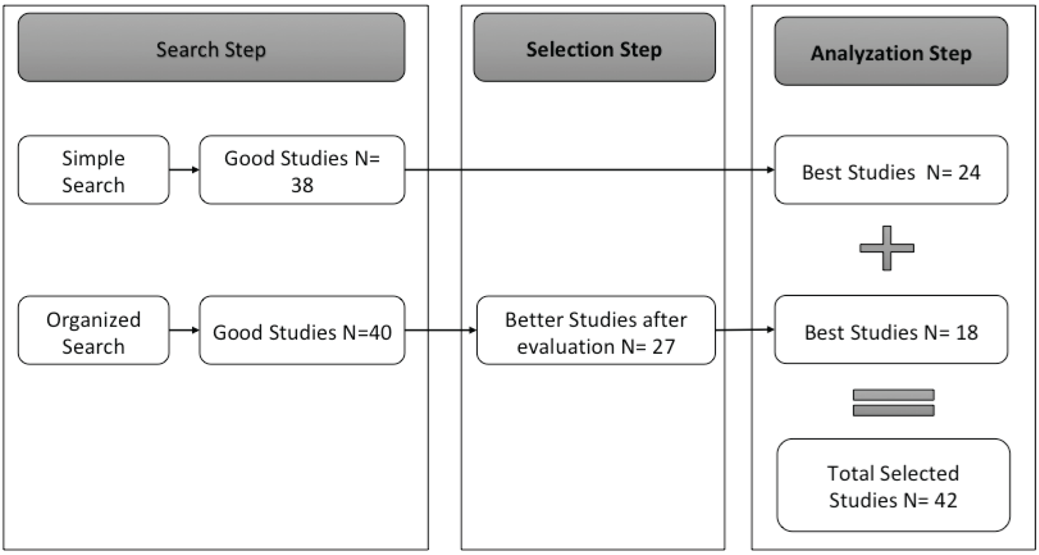
Within phase (4), key themes were generated by studying the list of open codes to assemble them into axial and selective codes. The first two parts of the literature review occurred between December 2018 and March 2019, as this correlated with related research activities. During this time, the final evaluation of relevant materials and their overlap was assessed, as well.

Evidently, there were key themes that the variables and concepts shared from descriptive and trait perspectives. Statistical analysis and investigating other variables/factors made our research conclusions more significant, as well. Table 1 includes the 42 identified studies, and key themes were addressed.

By evaluating the 42 studies, the literature evaluated the keywords through using various statistical methods from relational and causal viewpoints. Thus, the research conclusions were given more weight and value. Table 2 summarizes the statistical methods utilized for the 42 studies. Also, Table 3 summarizes the number of factors or variables studied within the journals.

The findings for these research methods that were based on the themes/topics were from subsequent sections.

Figure 1. Research approach for literature review



FINDINGS

Project Failure

The obtained data revealed that the most prevalent issue to project management was the risk of project failure. The causes of project failures vary widely, but two factors were vital to the declaration of success or failure. These factors were cost and duration, and attention to cost and schedule management was essential to the success of projects. Data provided by Mabelo and Sunjka's research study showed that traditional project management techniques could not maintain control of project costs and durations. In the research paper published by the South African Journal of Industrial engineering, they state the following:

The megaproject market is worth about $9-trillion each year and globally, big builds are in a mess. It is rare to have one completed on time and on budget. . .Data from more than 300 global megaprojects shows that 65 percent of industrial projects with budget larger than 1 billion in 2010 U.S. dollars failed to meet business objectives. In some industrial sectors the failure rate was as high as 75 percent. (Mabelo & Sunjka, 2017; Svejvig & Andersen, 2015)

It is also made evident that the failings of project management to maintain control and complete projects successfully is detrimental to the project management industry. The high rate of failure among high cost projects served as a deterrent to potential stakeholders or investors. Failures of that magnitude can bankrupt firms and can destabilize entire economies.

An analysis of a study by Capt Ryan Trudelle, USAF, Edward D. White, Lt Col Clay Koschnick, USAF, Lt Col Jonathan D. Ritschel, USAF, and Lt Col Brandon Lucas, USA also yielded noteworthy data about the failures of projects and project management. The study presented estimations of the likelihood of US Department of Defense (DoD) acquisitions projects remaining both within budget and duration. The research team utilized a number of statistical analysis techniques, including regression analysis, to formulate a conclusion. The results of their analysis of 49 DoD acquisitions projects supported the position that large scale projects were at high risk of failure. The data showed that 51% of DoD acquisitions projects overrun both cost and duration. It was also shown that DoD acquisitions

Table 1. Identified studies from research approach by theme

Theme #1	Theme #2
Ahern, Leavy, & Byrne, (2014) Arumugam, (2016) Azar, (2012) Badri, (2015) Cova & Salle (2005) David, David, & David, (2017) Eskerod & Blichfeldt, (2005) Galli & Kaviani, (2018) Galli et al., (2017) Hartono, FN Wijaya, & Arini, (2014) Kachoka & Hoskins, (2017) Mejía-Gutiérrez & Carvajal-Arango, (2017) Nikabadi & Hakaki, (2018) Tshuma, Steyn, & Waveren, (2018) Xue, Baron, & Esteban, (2016) Xue, Baron, & Esteban, (2017) Andersen, (2014). Schwedes, Riedel, & Dziekan, (2017) Wolff et al., (2018)	Al-Kadeem et al., (2017a) Badi & Pryke, (2016) Chitango & Pretorius, (2018) Hlophe & Visser, (2018) Kiani, Hosseini, & Abdi, (2018) Medina & Medina, (2015) Milner, (2016) Parast, (2011) Parker, Parsons, & Isharyanto, (2015) PMBOK® Guide and Standards (n.d.) Sharon, Weck, & Dori, (2013) Seymour & Hussein, (2014) Shenhar & Levy, (2007) Yun et al., (2016) Gimenez-Espin, (2013) Kwak, & Dixon, (2008) Nabavi & Balochian, (2018) Sutherland, (2004) Zelinka & Amadei, (2019)
Theme #3	**Theme #4**
About Systems Engineering, (2018) Cooke-Davies, (2018) Detert, (2000) Easton & Rosenzweig, (2012) Gafi & Javadian, (2018) Galli, (2018c) Galli & Hernandez-Lopez, (2018) Omamo et al. (2018) Svejvig & Andersen, (2015) Todorović et al., (2015) Labedz & Gray, (2013) Lee et al., (2013) Mabelo & Sunjka, (2017) Pinto, (2019) Trudelle et al., (2017) Usman Tariq, (2013) Von Thiele Schwarz, (2017) Zwikael & Smyrk, (2012)	Aslani, Akbari, & Tabasi, (2018) Besner & Hobbs, (2012) Brown & Eisenhardt, (1995) Burnes, (2014) Galli, (2018a) Galli, (2018b) Gholizad et al., (2017) Gilbert & Yearworth, (2016) Kannan, Mesmer, & Bloebaum, (2017) Perry et al., (2016) Xiong et al., (2017) Winter et al., (2006a) Loyd, (2016) Marcelino-Sádaba et al., (2014) Nagel, (2015) Papke-Shields & Boyer-Wright, (2017) Tevaarwerk et al., (2018) Vescu, (2015) Zhang et al., (2016)

projects costing more than $17.5 billion have a 77% chance of experiencing cost overruns/schedule slippage even when a 15% contingency was in place. When contingency level was increased to 25%, the risk of overruns/slippage only decreased to approximately 21%. Further research and analysis led to the discovery of a commonly cited cause for project failure: increased complexity.

Increasing Complexity

Projects are inherently complex endeavors and, until somewhat recently, traditional project management practices can account for complexity. Data extracted from multiple sources showed a general increase in project complexity is occurring in projects across the project management industry. An introduction to complexity published on the Project Management Institute stated that of 1,500 surveyed Project Management CEO's, 79% expected to see project complexities continue to increase in the future. The survey data also showed that nearly 50% of CEO's doubted their firm's ability to manage increases in complexity. Similarly, the study performed by Mabelo and Sunjka presented data comparable to

Table 2. Systematic analysis results by statistical analysis method

Statistical Method	Number of Articles (Frequency)	Author(s)
Regression	17 (23.29% of total articles)	Azar, (2012) Cova & Salle, (2005). David, David, & David, (2017) Detert, (2000) Easton & Rosenzweig, (2012) Galli et al., (2017) Gimenez-Espin, (2013) Hlophe & Visser, (2018) Kachoka & Hoskins, (2017) Loyd, (2016) Nabavi & Balochian, (2018) Nikabadi & Hakaki, (2018) Seymour & Hussein, (2014) Sutherland, (2004) Wolff et al., (2018) Xue, Baron, & Esteban, (2017) Zwikael & Smyrk, (2012)
ANOVA	15 (20.55% of total articles)	About Systems Engineering (2018) Ahern, Leavy, & Byrne, (2014) Badri, (2015) Brown, & Eisenhardt, (1995) Cooke-Davies, (2018) Gafi & Javadian, (2018) Galli, (2018b) Galli, (2018c) Kannan, Mesmer, & Bloebaum, (2017) Kiani, Hosseini, & Abdi, (2018) Mejía-Gutiérrez & Carvajal-Arango, (2017) Nagel, (2015) Papke-Shields & Boyer-Wright, (2017) Xiong et al., (2017) Yun et al., (2016)
Q-Test	14 (19.18% of total articles)	Arumugam, (2016) Aslani, Akbari, & Tabasi, (2018) Badi & Pryke, (2016) Gilbert & Yearworth, (2016) Kwak, & Dixon, (2008) Labedz & Gray, (2013) Mabelo & Sunjka, (2017) Parker, Parsons, & Isharyanto, (2015) PMBOK® Guide and Standards (n.d.) Schwedes, Riedel, & Dziekan, (2017) Tevaarwerk et al., (2018) Usman Tariq, (2013) Von Thiele Schwarz, (2017) Zelinka & Amadei, (2019)
t-Test	13 (17.81% of total articles)	Andersen, (2014) Besner & Hobbs, (2012) Burnes, (2014) Eskerod & Blichfeldt, (2005) Galli, (2018a) Winter et al., (2006a) Hartono, FN Wijaya, & Arini, (2014) Lee et al., (2013) Perry et al., (2016) Sharon, Weck, & Dori, (2013) Shenhar & Levy, (2007) Trudelle et al., (2017) Zhang et al. (2016)
Chi-Square Test	16 (21.92% of total articles)	Al-Kadeem et al., (2017a) Chitango & Pretorius, (2018) Galli & Kaviani, (2018) Galli, & Hernandez-Lopez, (2018) Gholizad et al., (2017) Omamo et al. (2018) Marcelino-Sádaba et al., (2014) Medina & Medina, (2015) Milner, (2016) Parast, (2011) Pinto, (2019) Svejvig & Andersen, (2015) Todorović et al., (2015) Tshuma, Steyn, & Waveren, (2018) Vescu, (2015) Xue, Baron, & Esteban, (2016)

Table 3. Systematic analysis results by number of variables studied

No. Factors Studied	Number of Articles (Frequency)	Author(s)
1	14 (19.18% of total articles)	Andersen, (2014) Besner & Hobbs, (2012) Chitango & Pretorius, (2018) David, David, & David, (2017) Galli, (2018b) Gholizad et al., (2017) Kiani, Hosseini, & Abdi, (2018) Lee et al., (2013) Medina & Medina, (2015) Nagel, (2015) Papke-Shields, & Boyer-Wright, (2017) Sutherland, (2004) Von Thiele Schwarz, (2017) Yun et al., (2016)
2	13 (17.81% of total articles)	Al-Kadeem et al., (2017a) Azar, (2012) Badri, (2015) Brown, & Eisenhardt, (1995) Galli & Hernandez-Lopez, (2018) Omamo et al. (2018) Mabelo & Sunjka, (2017) Mejía-Gutiérrez & Carvajal-Arango, (2017) Pinto, (2019) Shenhar & Levy, (2007) Seymour & Hussein, (2014) Wolff et al., (2018) Xue, Baron, & Esteban, (2016)
3	14 (19.18% of total articles)	Arumugam, (2016) Badi & Pryke, (2016) Cooke-Davies, (2018) Eskerod & Blichfeldt, (2005) Galli et al., (2017) Gimenez-Espin, (2013) Loyd, (2016) Marcelino-Sádaba et al., (2014) Nikabadi & Hakaki, (2018) PMBOK® Guide and Standards (n.d.) Svejvig & Andersen, (2015) Usman Tariq, (2013) Winter et al., (2006a) Zhang et al., (2016)
4	11 (15.07% of total articles)	Ahern, Leavy, & Byrne, (2014) Detert, (2000) Easton & Rosenzweig, (2012) Galli, (2018a) Kwak, & Dixon, (2008) Labedz & Gray, (2013) Nabavi & Balochian, (2018) Parast, (2011) Todorović et al., (2015) Zelinka & Amadei, (2019) Zwikael & Smyrk, (2012)
5	11 (15.07% of total articles)	Aslani, Akbari, & Tabasi, (2018) Burnes, (2014) Cova & Salle, (2005) Gafi & Javadian, (2018) Galli, (2018c) Hlophe & Visser, (2018) Kachoka & Hoskins, (2017) Kannan, Mesmer, & Bloebaum, (2017) Perry et al., (2016) Sharon, Weck & Dori, (2013) Xue, Baron, & Esteban, (2017)
6	12 (16.44% of total articles)	About Systems Engineering (2018) Galli & Kaviani, (2018) Gilbert & Yearworth, (2016) Hartono, FN Wijaya, & Arini, (2014) Milner, (2016) Parker, Parsons, & Isharyanto, (2015) Schwedes, Riedel, & Dziekan, (2017) Tevaarwerk et al., (2018) Trudelle et al., (2017) Tshuma, Steyn, & Waveren, (2018) Vescu, (2015) Xiong et al., (2017).

the data provided by the PMI's introduction to complexity. First, a survey distributed by Mabelo and Sunjka yielded that 60% of project management personnel agreed that project complexity was not gauged at the onset of a project. Also, approximately 50% of respondents agreed that the risk of project failure increases with the complexity.

Risk Mitigation

Increases in project sizes and complexity, as well as increased risk of project failure, substantiates the potential for improvement to traditional project management practices. The necessity for updates to the field of project management will only increase as time moves forward. Data representing the relationships between risks, costs, and time, as well as the possibility of mitigating risks and project completion, has been obtained from an article by Adel Badri of the University of Quebec. Figure 2 and Figure 3 respectively display this data.

Essentially, increased costs from resolving the unmitigated risks are a result of failure. For identifying and managing risks associated with complex projects, the linear functionality of project lifecycles is not sufficient.

Furthermore, a study conducted by S.C. Hlophe and J.K. Visser of the University of Pretoria, South Africa, presented data relating to project management professional's ability to manage risk. The study was conducted via the distribution and analysis of a survey to collect information about project lifecycle risk management. A sample of 61 completed surveys were collected, as approximately 90% of respondents agreed that risk management was essential to managing a project and that risk management increased the probability of success. More than 70% of these respondents agreed that cost overruns, delays, and schedule extensions were results of poor risk management. The data also showed that approximately 48% of the firms surveyed did not apply risk management throughout the duration of a project lifecycle. Finally, over 40% of respondents expressed uncertainty to the effectiveness of their risk management processes. Hlophe and Visser concluded the following:

Figure 2. Relationship between risk and cost (Badri, 2015)

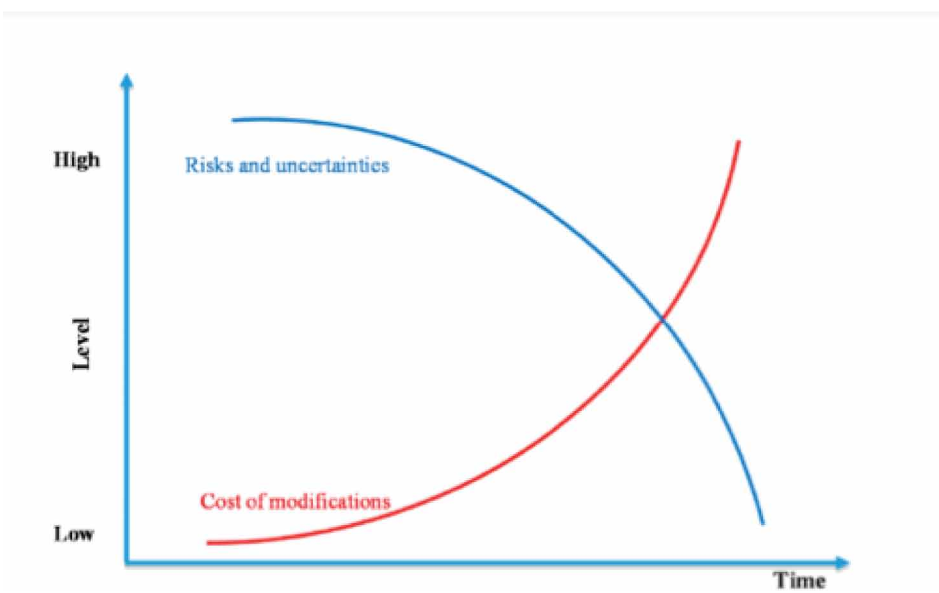
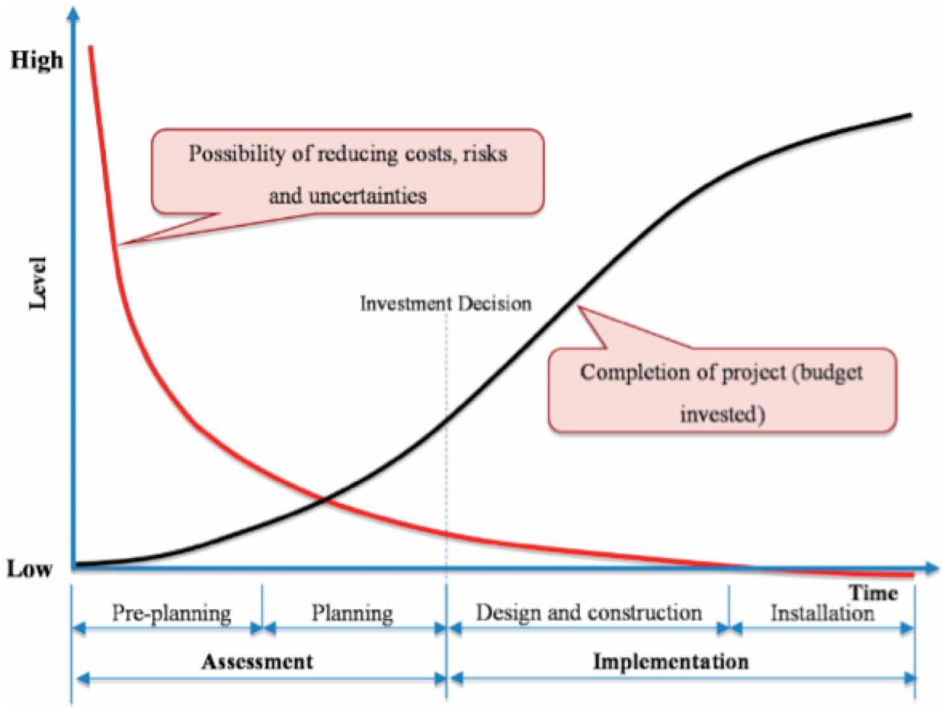


Figure 3. Relationship of cost, risk and project life cycle (Badri, 2015)



Most shutdowns fail due to non-adherence to project risk management practices. Understanding the probability of risks occurring, and being able to evaluate their probability, severity, and criticality requires a great degree of experience and knowledge. Thus, training and experience play major roles in ensuring the effectiveness of the risk management process. Organisations should be prepared to commit time and money to building capacity in and knowledge of project risk management. (Hlophe & Visser, 2018)

Recommendations made by the research team suggested that project management firms consider making modifications and improvements to the way that project risks are managed. They stated that there are currently inconsistencies in how project management firms manage risks. They continued that increased consistency in applying risk management will create more certainty and improve the probability of success.

Systems Engineering Applications

To manage modern large-scale projects, systems engineering concepts are already being applied. A guide to the application of systems engineering in large infrastructure projects published by INCOSE in 2012 has already been developed and applied to telecommunications, military, manufacturing, and aerospace industries. Furthermore, the INCOSE working group has compiled a library of case studies relating to the application of systems engineering in large infrastructure projects. These studies confirmed that it is beneficial to apply systems engineering concepts to the management of complex projects. They also confirmed evidence that systems engineering concepts are advantageous when applied to risk mitigation (Mabelo & Sunjka, 2017).

Population Parameters

A compilation of data obtained for this research paper expressed a number of concerns about the current state of project management. Of the 20 sources obtained and analyzed, 35% highlighted shortcomings and inabilities of traditional project management. Reasonings were varied from source to source, but the general consensus among the 35% was the same: there were problems with project management. 65% of the total sources analyzed express advantages of systems engineering concepts and processes. Also, 25% of the population explicitly proposed the use of SIMILAR process concepts when managing systems or projects. The research performed for this paper has shown that traditional project management practices can benefit from the application of systems engineering concepts.

DISCUSSION

Implications to the Field of Project Management

From the research performed and data obtained, it can be implied that the current state of project management is in need of improvement. It has been previously shown that project management is becoming less able to achieve stakeholder goals. Most notably, projects are being deemed failures from not maintaining cost and duration budgets. Findings have also implied that there is potential for project management to be improved by the application of systems engineering. Data extracted from a source by Hossein Kiani, Seyed Hossein Hosseini and Farshid Abdi yielded that the application of systems methodologies to project management led to a near 10% decrease in costs and a 26% decrease in variations. The Project Management Institute added that understanding systems was necessary for project managers to deal with increasing project complexity.

The analysis and presentation of data compiled for this research paper has led to the conclusion that systems engineering concepts are applicable to project management practices. Also, the addition of modeling, integration, and re-evaluation measures to project lifecycles allows for the better management of risks associated with complex projects. Sources indicate that the modeling, integration, and re-evaluation concepts of systems engineering were better prepared to manage complex undertakings than the traditional project lifecycle. It was made clear that the adaptable and cyclical nature of the SIMILAR process makes systems engineering concepts better suited to manage complex endeavors because it highlights the importance of modeling, integrating, and re-evaluating project aspects to the mitigation of risk. Data obtained from the study by Kannan et al. implied that statistical design practices utilized in conjunction with modeling and integration processes created increased consistency among systems or projects. It has also been shown by Wolff et al. that the integration of modeling and re-evaluation processes to design phases were advantageous to the mitigation of risks, such as unclear requirements, cost overruns, and schedule slippage.

Applications to the Field of Project Management

Overall, research findings expressed that the application of systems engineering processes and concepts to current project management operations can mitigate some of the risk associated with complex projects. In the article by Adel Badri, information that supports a systems-engineering approach to risk management and mitigation can be found. Badri provided a model for improved project risk managements that incorporates elements of the systems engineering SIMILAR process. The author stated that the non-linear, continuous approach to management taken by systems engineers was superior to the use of project lifecycles because the SIMILAR process was perpetually re-evaluating and updating processes when identifying sources of risk. Thus, this approach to project management is preferable because it reduces the need for risks to be identified during development, which can be near impossible for complex projects.

Research and analysis habe also found that risk associated with complex projects can be mitigated by increasing consistency. Data obtained from Hanumanthrao Kannan, Christina Bloebaum, and

Bryan Mesmer of Iowa State University and the University of Alabama respectively showed that systems engineering concepts can be used to increase the level of consistency in complex systems. Kannan et al. demonstrated that using statistical design and quality control elements in conjunction with system models leads to more consistent results among systems. The increase in consistency between systems provided useful inferences about similar systems. Increased consistency from system to system reduces the impacts of unmitigated risks because data can be drawn and modeled from consistent systems, which leads to faster and more efficient risk mitigation.

Relating to the subject of project consistency, attention should be paid to the findings of Dennis A. Perry and his colleagues. Their research findings highlighted the potential applications of systems engineering when managing industrial problems. The management of industrial problems was generally inconsistent, lacking in standardized practices, and recording methods. Most importantly, to undertake industrial problems, the project lifecycle is not suited because projects are finite, and industrial problems are often related to industrial processes and operations. Standardized methodologies, adaptability, and focus on continuous evaluation and modification associated with systems engineering can improve the project lifecycle.

Finally, as previously shown by Mabelo and Sunjka, the application of systems engineering concepts already demonstrate its value. To manage complex projects, soft systems methodology is a systems engineering concept that is currently being used. To define stakeholder requirements and to create a common understanding of the project, soft systems methodologies are used through the integration of design and management elements. Other systems engineering concepts that are currently being applied to large scale project management include "requirement management, verification and validation, stakeholder management, and asset lifecycle considerations" (Mabelo & Sunjka, 2017). The current applications of systems engineering in the management of projects has been acknowledged as beneficial to the management of risks and requirements throughout the project lifecycle by the INCOSE Working Group.

CONCLUSION

Organizational Implications

It was found within the research on the acquired skill and management strategies that these variables, their concepts, and models are required to conduct business projects and project management. Furthermore, the variables, their concepts, and models encourage teams to utilize specific skills to help reach their goals, so this approach is more valuable than technology. The results emphasize that strategic planning is needed, along with a top-down and bottom-up approach to leadership, especially with project management, operations management, and process improvement. Also, the results show the need to apply these variables, their concepts, and models to leadership styles and tools.

This study revealed that current issues in project management and operational performance were from poor leadership skills. Emphasizing a bottom line approach (profits and costs) will only give temporary solutions. With the proper tools, supervising project management and operational performance can be successful, which will also improve the performance, profits, and costs in an organization. Financial elements are usually focused on by business leaders, but a good long-term leadership strategy is to manage many different elements of a business (operations, project management, financials, performance, strategy, and human resources).

Managerial and Team Implications

The implications from this study include that the results examine both variables in a new way to fill a void in research. Also, this study focused on how the variables, concepts, and models are affected by each other and other factors. Performance and effectiveness can be affected by these concepts.

For projects and performances of organizations, this study can serve as an outline, so knowing the relationship between these variables can improve management with better mentoring or managerial constructs. Thus, flaws with project and organizational performance and effectiveness can be improved by teams and organizations.

The many advantages of improving training programs for project and organizations performance and effectiveness are revealed by the implications. Most of all, project teams, project leadership, and organizational leadership can gain training on assessing the performance of a team, project, or organization to measure it against standard and industry accepted models and concepts. Information on how to manage teams and projects can also be given by such training, which can improve leadership methods. Essentially, teams and leaders can learn about how teams and projects affect performance and reliability for project and team performance and effectiveness.

Implications and Applications to Fields of Project Management and Engineering Management

With these variables, their concepts, and models, projects can clearly benefit, but engineers and technical professions could use more attention. An engineer was once considered as someone who solved problems with technology and mathematical tools. Recently, this term changed to someone who offers economically viable solutions by using technology and mathematical tools. Thus, for engineering decisions, these variables, their concepts, and models can be useful. To guarantee that the engineer's knowledge will benefit the investors, engineers should know business management and maturity models.

The scientific idea of the cause and effect relationship is a part of engineering, so there are different management schools of thinking. Thus, it would be beneficial for these concepts to be united. Since management has been ignored for its role in performance and operational-related decisions in project success, engineering improves its projects with management. According to research, a project's elements can be identified by the models. Since this is usually described in reference to business, this study showed the need to know these methods from an engineering perspective and pure engineering filed techniques: budgeting, equipment, purchasing material, etc.

The objective for this analysis was to reveal the best practices for these variables, their concepts, and models to provide future researchers with a reference. Additionally, this study featured helpful information on project management and operational performance, as well as how to best manage these elements with these variables, their concepts, and models. The IE/EM profession and research field relies on project management and operational performance, but lean thinking is not always the solution. Thus, these variables, their concepts, and models were created and managed with the best concepts for projects.

Furthermore, this study supplied relevant information to stakeholders, such as system engineers, project managers, and other experts in industrial engineering and engineering management. Thus, maturity can be applied to project management. Stakeholders will also be persuaded to capitalize on the roles of system engineering and project management.

In general, this study addressed new ideas about how these variables, their concepts, and models influence project management and operational performance development. If used with the objectives of new product development, then the logic of systems thinking can be beneficial. This research addressed new territory by studying how small companies can generate new products, even without established processes by only containing one other product.

Limitations

There were some limitations within this study. Most of all, there was a limited sample size that only studied key factors, which could cause some bias and validity from the findings and conclusions. A larger sample size could have alleviated this limitation. Additionally, the key factors and their relationship were only studied from a project environment perspective. This made the conclusions and analysis exclusive to project environments. As a result, it would be difficult to argue that the findings are applicable to other arenas (i.e., supply chain management, operations management, or strategic management).

Future Research

Finally, there were some other areas for future research to study, such as how these factors relate in the context of other industries and managerial settings. The strengths and weaknesses of these variables, concepts, models, their relationship, and what outside sources affect them could be studied. Additionally, these factors and their relationship from different perspectives could be studied. By assessing these factors under organizational, strategic, or cultural viewpoints, insight can be found about how this relationship is perceived from different views. Thus, the impact that culture, strategy, human resources, and operations can have on the key variables and their relationship can be better understood.

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