THESIS

IDENTIFICATION AND RANKING OF CRITICAL SUCCESS PRACTICES FOR PROJECTS AND PRODUCTS.

Submitted by

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In partial fulfilment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Fall 2020

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ABSTRACT

IDENTIFICATION AND RANKING OF CRITICAL SUCCESS PRACTICES FOR PROJECTS AND PRODUCTS.

Project results continue to fail despite the large number of efforts invested by researchers towards project success (Terry Cooke Davies, 2002). Identification of Critical Success Factors for a product/project has been a challenge (Uluocak, 2013). Thus, it is essential to conduct study in determining these primary factors contributing towards product/project success. Although several studies have been conducted in identifying the success factors for product/project in diverse range of areas but none have explored actual industrial scenarios from a wide range of fields to derive the critical success practices followed by validation through working professionals. Thus, this study aimed at identifying the critical success practices for projects/products. The research design constituted of in-depth case studies allowing an outlook into actual industrial scenarios providing a list of critical practices contributing towards success as well as failure of a product/project in various fields as the first part. Second part of the research involved validation of the determined critical practices through focus-group survey with working professionals and graduate students. This study data exhibited variation in the views of survey subjects towards the critical success practices based on their work experience, possession of INCOSE/PMI certification and in terms of their roles in the firm such as Managers, Engineers, Marketing/Sales, and Engineering managers. RII tool and Henry Garrett Ranking Method were used to analyze data from Likert-scale based and ranking questions respectively/ In conclusion,

this study was also able to identify, evaluate and rank the critical success practices for a wide range of projects/products providing a foundation for execution of successful projects in future.

ACKNOWLEDGMENTS

I would like to thank my advisor Prof. Ann Batchelor for her mentorship and support which made this research possible. Her immense knowledge, continuous motivation, unmeasured support and thorough guidance was the driving force for completion of this research. I would also like to thank my thesis committee members; Dr. James Adams and Dr. Lumina Albert for their thoughtful guidance throughout this project.

Also, sincerely thankful to the PMI Mile-Hi chapter and Systems Engineering department for helping me in distributing the survey. With a special mention to Prof. Greg (Bo) Marzolf, Dr. Steve Simske, and Dr. Erika Miller; and all the faculty and staff members of Systems Engineering department for their support and guidance throughout the master's program. I am thankful to Ingrid Bridge for her support throughout my graduate school journey by patiently answering all my countless doubts and concerns. I would also like to thank Saloni Purandare for her support.

Finally, I would like to thank all my friends and family for their support and guidance.

DEDICATION

To

Padmaja Ketkale, Digvijay Ketkale, and Jyoti Patil.

And in Loving memories of

Chandrakant (Raju) Adinath Ketkale and Manisha Ajit Patil

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1 INTRODUCTION

There have been numerous studies dated back to the late 1980s wherein researchers have been trying to identify and thoroughly understand the reasons that can lead to project success such as but not limited to; Baker BN, Murphy DC & Fisher D in 1988 and Pinto JK, Slevin DP in 1988. Critical Success Factors (CSFs) are defined as those factors that can decide the success or failure of a project/product. Despite the efforts made by researchers in the past towards ensuring project success, project results continue to fail (Terry Cooke Davies, 2002). It has been a challenging task for academic researchers as well as practitioners to discern what the primary *practices* within the identified CFS actually comprise as the CSFs have changed with time. (Uluocak, 2013)

In order to reduce the number of project failures and to increase project success, it is crucial to study a wide range of projects/products resulting in the determination of critical success practices that can contribute towards project/product success. Success criteria can be defined as the measures by which the success or failure of a project or business will be judged (Terry Cooke Davies, 2002). According to Creasy and Anantatmula (2013), the definition of project success is still inconsistent even after a wide range of studies have been conducted on it. Project success, however, has received significant attention in the project management field in the last three decades (Olawale et al., 2020; Ika, 2009; Cicmil and Hodgson, 2006; Pinto and Slevin, 1988). “Whilst this attention has relatively improved the understanding of project success, a degree of complexity and conceptual ambiguity still surrounds the concept, and this presents significant problems for researchers” (Olawale et al., 2020, p. 2). Similar findings have been reported by Ika et al. (2012), Thomas and Fernandez (2008), Hyväri (2006), as well as by Belassi and Tukel (1996).

Project success depends on the perspective. Although the fixed parameters of project success such as Project Management Institute's (PMI) cost, performance, schedule, and customer satisfaction are standard, project success largely depends on the completion of projects on stakeholder requirements (Rehman, 2020; Müller &Turner, 2010). Measuring success only in terms of cost, schedule, performance is insufficient without the inclusion of customer satisfaction (Irimia-Diéguez et al., 2015)

Definitions of project success used in this study are: the achievement of the predetermined project goals on time, within budget, performance, and respective stakeholder's satisfaction, which closely aligns with the definition provided by PMI "Success is measured by product and project quality, timeliness, budget compliance, and degree of customer satisfaction" (Project Management Body of Knowledge (PMBOK), 6th edition 2017,p.13). This study focuses on the identification, evaluation, and ranking of the practices within the success factors that can enable timely, within budget completion of a wide range of projects resulting into the stakeholder's satisfaction based on a targeted survey of professionals and case studies of unsuccessful and successful projects. The professional organizations PMI and International Council of Systems Engineering (INCOSE) played a significant role in this study through providing conceptual understanding.

2 AIMS AND OBJECTIVES

The objectives of this study are to identify, evaluate, and rank the critical practices which contribute to the success of a wide range of complex projects/products. To achieve this goal, the study endeavors to answer research questions as follows:

1. What are the real practices that contribute to project/product success or failure?
2. Among the identified practices, what is the level of importance that these practices hold in terms of benefits to an organization for its project's/product's success when compared to each other?
3. What are the technical practices that contribute to the project/product success?
4. What are the managerial practices that contribute to the project/product success?
5. What are the top five Technical practices surveyed that contribute to success as evaluated separately based on 1) years of experience of the participants, 2) role of the participant in the organization, and 3) if the participant possesses a certificate in PMI or INCOSE?
6. What are the top five Managerial practices surveyed that contribute to success as evaluated separately based on 1) years of experience of the participants, 2) role of the participant in the organization, and 3) if the participant possesses a certificate in PMI or INCOSE?

3 METHODS

Multiple studies previously have determined the success factors in various fields utilizing different methods. The research design opted in previous studies concerned with the determination of project/process success factors varies as summarized:

- Critical success factors for software projects were examined by Sudhakar (2012). The author followed two steps to identify and rank the CSFs. First, an extensive literature review was conducted in which the author found 80 factors which were then categorized in seven (7) different categories. The second step ranked those factors depending on the number of occurrences of that specific factor in the literature. The top five (5) factors of each category were then identified which as CSFs for software projects. Some of the significant CSFs for software projects are " top management support, communication in the project, clear project goal, user involvement, team work, reliability of output and project planning" (Sudhakar, 2012, p. 552).
- Critical success factors for general projects were examined by Baccarini and Collins (2003). The authors followed two steps to identify and rank the CSFs. The first step was completed by conducting a survey with members of the Australian Institute Project Management (AIPM). A total of 150 members completed the survey. The questionnaire included demographic information on the respondents, definition and criteria of project success, and critical success factors for project success. The question related to CSF, however, was an open-ended qualitative question. CSFs were ranked based on the responses. In the second step, the authors conducted a literature review which validated the top six (6) factors determined by the survey: Project understanding; competent project

team; communication; realistic time and cost estimates; adequate project control; and client involvement. The next three (3) were not found in the literature review: risk management; resources; and team work.

- Critical success factors for Sustainable Construction projects were examined by Gunduz and Almuajebh (2020). The authors employed three steps to identify and rank the CSFs. First, an extensive literature review was conducted. The authors found 40 factors that were then categorized into seven (7) categories. The second step was to conduct a targeted survey in which 148 construction professionals completed the survey. The first portion of the questionnaire covered the questions regarding the respondent's background. The second questionnaire portion included the 40 factors from the literature review rated on a scale of one to nine. The third step analyzed the survey data using the Relative Importance Index (RII) and the Analytical Hierarchy Process (AHP) tool. The RII tool is generally used to prioritize indicators based on a Likert-type scale. AHP is a structured technique used for organizing and analyzing complex decisions. "The results indicate that the majority of the significant factors were about financial problems (Mechanism of financial payments, project's adequate funds/resources), administrative aspects (Influence of client/client's representative, availability of experienced managers and skillful workforce), and the authorities' approval mechanisms (statutory approvals environment)" (Gunduz and Almuajebh, 2020, p. 13).

From the conducted literature review, a consolidated list of factors contributing towards product/project success is: top management support; communication; team work; project planning; project's adequate funds/resources; availability of experienced managers and skillful workforce; clear project goal; realistic time and cost estimates; risk management; client involvement.

Thorough literature analysis and surveys have been used in past to determine and validate the CSFs. The identified CSFs are very broad categories and it is important to identify the critical success practices within them. However, a research design that explores actual industrial scenarios from a wide range of fields to derive the critical success practices followed by validation through working professionals was not found. Thus, in this study to achieve the goal of determining the critical success practices for a project/product, literature analysis will be executed in terms of in-depth case studies allowing an outlook into actual industrial scenarios followed by validation through focus-group survey.

The selection of ten (10) projects from different industrial sectors was chosen to ensure coverage of a wide range of disciplines and success practices. The case studies conducted are from aerospace industries, construction industries, automobile industries, and software industries. The projects selected are chosen from projects executed within the last two decades. The ten case studies are equally divided between successful and failed industrial projects to understand practices that led to either project/product success or failure. The consolidated list of success factors determined earlier will help examine the case studies to obtain critical success practices. Through the case studies, the list of critical practices were used to build the survey questionnaire for validation and ranking.

A targeted survey of working professionals/ graduate students working within projects was conducted. The questionnaire included questions regarding the professional background of the participants and questions focusing on the weighted value relating to each practice's relative importance. The survey focused on recruitment of individuals with first-hand knowledge about current problems and trends in industry related to project and product success. Finally, the data analysis resulted into ranking of the critical project/product success practices determined through case studies and survey.

4 DATA

A two-step process was used to collect and analyze data: 1) data collected and analyzed from the case studies and 2) the data collected and analyzed from survey. Case study data involved qualitative analysis based on the consolidated list of success factors derived from the literature review to determine crucial practices contributing towards product/project success, whereas survey data involved quantitative analysis of the conducted focus group survey.

4.1 SUCCESSFUL PROJECT'S CASE STUDIES RESEARCH

4.1.1 APPLE'S IPHONE

Apple, a technology-manufacturing organization, launched their first iPhone on June 29, 2007 (Apple Inc., 2007). Over 500,000 units were sold during the first weekend of the launch. Since the launch date, millions of iPhones have been sold which makes it one of the most successful mobile phone products ever launched (Laugesen and Yuan, 2010). In 2012 Apple became the wealthiest company in the world in terms of the most cash on hand, as shown in their balance sheet (Johnson et al.,2012) and has been on Fortune's list of the top five of Fortune 500 companies from 2014 till the date.

Continuous Requirements and Feasibility Analysis Practices

Apple had been conducting surveys and studies to target the right customers for entry into the mobile phone market. The results of their early studies indicated that mobile phone users are mainly college graduates, with high income, mostly male, aged 25-30 years. The demographics studies also demonstrated that over half of the customers belonged to information, art or scientific profession. In order to target other segments, Apple reduced the price and undertook actions regarding product's applications that would attract a wide range of customer (Capatina & Draghescu, 2015).

Apple undertook a survey before the launch of iPhone 3G to understand customer requirements in terms of new features. The top five (5) results of this survey in terms of expected customer needs were 1) 3G capability (19%), 2) 3rd party software (18%), 3) GPS (15%), 4) e-mail integration (10%) and 5) voice recognition (8%). Apple's subsequent product that is iPhone 3G had all these features in it (Laugesen, Yuan, 2010).

Focused Systems Thinking

Apple developed a subset of its Mac OS X adapted its computer operating system for iPhone. This added more value to the iPhone since the integration allowed different apple products (MacBook, iPad, iPod) to operate on a similar operating system (De Stefani, 2015). Common operating procedures simplified operation for the customer adhering to Apple's "easy to use" mantra while encouraging multiple-Apple product's purchase. This can be verified by the fact that three quarters of iPhone customers had previously purchased Apple products at least once (Capatina & Draghescu, 2015).

Apple, already successful with iPod music and video platform, presented iPhone as an advanced version of iPod. The full integration of iPhone with Apple's iTunes store allowed the iPod consumers to be familiar with the ecosystem that was created by Apple for its devices (De Stefani, 2015). This helped Apple to maintain their current users and attract new users allowing its products to be competitive and achieve high level of cross-functionality. (De Stefani, 2015)

Focused Human Machine Integration

As emphasized in Isaacson (2011), Steve jobs in one of his meetings stated "they (referring to the phones manufactured by other brands in 2005) were way too complicated. They had features nobody could figure out, including the address book. It was just Byzantine" and thus derived his inspiration for development of iPhone based on the concept of other phones being overly complicated and lagging ease of user adaptability. "US consumers were not convinced that they need mobile services that they think are too complicated" (Venkatesh et al., 2003, p. 54) demonstrating a need for simple uncomplicated mobile internet experience if more consumer adoption was desired. In 2004, US consumers rated the cell phone as the most hated invention that they cannot live without in a survey conducted by MIT. Whereas according to Laugesen and Yuan (2010) iPhone is uncomplicated and in terms of application, it has ability to replicate most of the applications fulfilled by a computer with internet experience, majorly contributing to its high user demand. This demonstrates attention to advantageous intelligent human machine integration.

4.1.2 TOYOTA'S CAMRY

Toyota has received many awards and honors for its cars and its manufacturing techniques. According to TOYOTA's newsroom, in 2012 Toyota was the winner in three different automotive categories in the "Top Scoring Car awards". In 2014 and 2015, Toyota received the title of the most valuable automotive brand in the world according to Interbrand's 2015 annual report. In 2019 Toyota was ranked No. 1 motor vehicle company for the fifth consecutive year by Fortune Magazine under the "World's Most Admired companies" annual ranking. Being the best-selling car in America for 14 consecutive years, in 2016 Toyota Camry claimed top position in Cars.com's American-Made Index category (America's Best-Selling Car Still Most 'American-Made, 2016).

Continuous Requirements Practices

Toyota's concept of 'local customization' incorporated continuous requirement analysis in its philosophy while encouraging operations and products to incorporate the diversity and sophistication of local markets around the world (Osono et al., 2008). Toyota's policy of 'customer first' was important to meet needs of every customer globally (Osono et al., 2008). To achieve this goal of satisfying its customers, the company invested continuous efforts in identifying the customer needs and determine perfect solutions for these needs. To understand the customer requirements, Toyota officials engaged in observation and interaction with target customers (depending on the car segment) (Osono et al., 2008). By studying the customer needs in this way, Toyota took significantly less time to introduce a new car compared to its global competitors. Toyota' s policy of giving the customer needs highest priority dictated this behavior (Osono et al., 2008). This philosophy has ensured Toyota Camry's position of the best-selling car in US, exhibiting its potential to satisfy its user needs over the period of 14 years.

Training employees - Human Resource Management

Many companies use "Up or out" philosophy which means promoting the good performing employee and ask those who are underperforming to leave the company. On the other hand, Toyota has used "Up and in" philosophy for its workers which is to promote the good performing employee and train those who are underperforming; this philosophy has been implemented in Toyota Camry's production like for all of its other products. This philosophy emphasizes on continuous development of individual creative potential through learning and improvement. Toyota believes in training its employees and the company rarely forces employees out even if the employee is an under performer. In fact, when the employees are under performers it focuses on upgrading their capabilities through various OJT (on-the-job) training and evaluation schemes. Toyota's OJT consists of five categories of training companywide – supervisor-oriented, management training, qualification-based training, improvement-based training, and knowledge or skill-based training. All these programs vary in length and content depending on the level of job and its function (Osono et al., 2008).

Focus on Quality Management and Risk Management

Toyota Production System uses many tools for all of its models for various causes but the common goal achieved from all the tools listed below is to minimize waste, improve efficiency, improved quality and risk management. Some of the tools and techniques used in Toyota Production System (TPS) are Lean manufacturing system, Just-in-Time (JIT), Kaizen (continuous improvement), Jikoda, andom monitoring boards, Kanban, Six Sigma, Plan-Do-Check-Act cycle, Fault Tree Analysis (FTA), Design Review Based on Failure Mode (DRBFM), Quality Functional Deployment (QFD), 5S: Seiri (sort); Seiton (set in order); Seiso (shine); Seiketsu (standardize); Shitsuke (sustain), Design For Manufacturing (DFM), Design For Assembly (DFA), POKA-YOKE (mistake-proofing), and many more. (Chiarini, 2013) (Toyota Motor Corporation., *Toyota Production System: Vision & Philosophy* n.d; Osono et al., 2008).

4.1.3 REFURBISHING HEATHROW AIRPORT TERMINAL 1

Refurbishment of Heathrow's forty-year-old Terminal 1 airport was undertaken by British Airport Authority (BAA) Airports Ltd. in 2004. Heathrow, the busiest airport in the world, used the 40 year-old Terminal 1 only for short-haul European destinations. After the refurbishment, however, Terminal 1 would also be used for international passengers as well. In September 2008, Heathrow Airport Terminal 1 was completed. This project involved more than

500,000 working hours and did not exceed the limit of $106.56 million (approx. £57.6 million in 2008) budget (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008).

Subcontractor Management

One of the main challenges that the project team had to face was management of different people and teams because of project's complexity and size. A large number of workers were involved as 11 top-tier suppliers reporting directly to the project manager and dozens more were subsequently reporting to them. It was important for the project manager to ensure that all parties delivered the quality of work and level of standards that BAA normally expects as large number of stakeholders were involved. For the sake of quality and design requirements of the project, a very clear mandate was issued to the third-party suppliers and contractors to ensure that they follow a specific framework (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008).

Timely Resolution of Cost and Schedule Issues

The project manager had an effective and coordinated delivery team that could respond instantly to the demands of this project by co-locating main contractor located in the same office as that of project team (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008). The project manager personally ensured that any issue was resolved quickly whenever a problem arose. Many changes to the original plan were incorporated due to changes in a decorative cladding system, problems with the pre-existing floor, delays from airline partners in terms of their move date, etc.

As noted, budgetary reviews resulted in major late changes on the project's original plans. For example, the original design called for the installation of a decorative cladding system above the ticket desks for British Midland International airlines for aesthetics and lighting. This was deleted from the project scope just four weeks before the opening of check-in desks. The project team faced a difficult task of finding an acceptable alternative solution which had to be procured and installed in less than four weeks. The project team and main contractor held a brainstorming session to explore ways to address these late changes. A brainstorming session introduced a way to resolve this issue by using paneling which had been used over past 12 months from various other construction activities This proposal was approved by the relevant stakeholder and the new cost-efficient paneling system was installed prior to the deadline (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008).

Focused Planning and Systems Thinking

The project team also focused from a system perspective during cost estimating and budgeting in the early planning stages of the project. In exploring the balance in terms of work that could be undertaken at night versus daytime hours, the team discovered that night work was more costly with less productivity (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008). This allowed them to plan for efficiency and had a significant impact on the project budget.

Focus on Customer/User Objectives

As the airport was still in-use daily, the requirement to maintain ongoing operations without disturbing the travelling public was a challenging priority. As an example, the existing floor in East Linear face of the terminal was found to be constructed from a different material when compared to the rest of the floor and was damaged. It was challenging to repair the damaged 40 year-old floor while other construction work was taking place simultaneously in the area. The project team comprised of all the relevant stakeholders including the main contractor, terminal maintenance and other contractors again met to discuss the re-flooring issue. A joint phasing plan to sequence work and provide storage for tools and materials was created. The unexpected re-flooring work was finished in the line of original time schedule and did not become a barrier for other works. Although this added a 21-weeks of extra work for reflooring, the team still managed to deliver it on time without disturbing operations (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008).

Communication Management Practices

One of the tasks within the scope was to replace the existing information technology (IT) system within the terminal building. This task included standard office network, specialist flight system such as flight information display screens, regulatory systems for passengers processing, and closed-circuit television To deal with issues associated with this task on a timely basis and to speed communication, the IT team at British Airport Authority (BAA) decided to rely on its customized software; an 'Online Change Control' system. This system allowed any member of the team to capture changes and send them to senior project manager for instant approval or rejection. This software was used by both on-site and off-site members to report the changes. This solution made sure that everyone had a good communication between the contractor and team. This software saved the time on the project as it reduced the delay in communication for communicating various issues one of the examples mentioned was the budgeting issue that was directly communicated by the offsite members to the project manager through the software resulting into “ instantaneous approve/reject the requests”. Thus, this system proved to be very crucial for the sake of the project success (BAA Airports Ltd. changes the face of the world’s the busiest airport through project management, 2008, p.7).

Focus on Risk Management

There were many risks involved in executing the project plan on an existing 40 year-old terminal. Two primary risk management schedules were developed and maintained, one at strategic level and other to deal with day-to-day risks. Risk management plans and procedures were guided by PMBOK with formal review meetings held every month. Risk schedules were reviewed, updated and published (BAA Airports Ltd. changes the face of the world’s the busiest airport through project management, 2008). Two examples of serious risks mitigation efforts are discussed below.

Example 1. A number of the ceiling tiles in Terminal 1 were damaged requiring replacement which also resulted in finding asbestos was also found in the ceiling. Simply erecting scaffolding in the damaged areas, removing and replacing the damaged tile would create health and safety risks to the 20 million passengers that pass through the Terminal 1. To deal with this problem the team again involved relevant stakeholders such as health and safety officers, terminal operations teams, and the main contractors to review all the possible options with the risks and associated mitigation solutions. The best mitigation solution found resulted in the creation of an airtight area within the contaminated roof-void that prevented any leakage into the airport. Further mitigated reduced risk by hiring a qualified asbestos removal contractor to remove the asbestos. After the asbestos removal was complete, the tiles were replaced and air sample testing confirmed that the area was safe. (BAA Airports Ltd. changes the face of the world’s the busiest airport through project management, 2008).

Example 2. The renovation required the installation of a new electrical distribution panel to meet the greater electricity demand. To accomplish this, power to the entire terminal required shutting down and restarting on the new panel. A power shutdown and restart had never occurred previously. As the building was 40 years old, there was a significant risk that when power was turned off, that some of the equipment would fail to restart when the power was switched back on. This distribution panel also provided power to the Central Search Area where BAA security processed passengers and to the main route for the passengers to take to their departing flights. To deal with this risk, consider the objective of maintaining continuing operations, and formalize a plan the project team convened a high-level risk management and analysis meeting which included all the relevant stakeholders including the main contractor. After subsequent meetings, all the interest parties reviewed the analyses, plans, risks, roles, responsibilities and mitigation activities for the task. Formal monthly risk reviews contributed to the successful replacement of the electrical distribution panel and the successful equipment restart without any incidents or inconvenience to operations (BAA Airports Ltd. changes the face of the world's the busiest airport through project management, 2008).

4.1.4 PROJECT: INDRA'S AUTOMATED VOTE-COUNTING SYSTEM IN NORWAY

Indra is a global-level technology offering proprietary solutions covering a wide range of applications, from "air-traffic management in Germany to implementing a judicial management system in Ecuador" (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012, p. 1). In 2011 Indra was awarded a project in Oslo Norway for developing a complex voting information system for the local elections. The project was started 10 months before the next election. The top-level needs were to create a more efficient voting system in comparison with previous systems used, deliver accurate election results in the short time available and to keep stakeholder satisfied. The project was successfully completed on time and within the $ 2.7 million (approx. €2.1 million in 2012) budget. As reported, roughly 500,000 ballot papers were counted from 111 polling stations in only five and a half hours whereas the expected time was ten hours, exhibiting the fast-tracked completion of such tasks. (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012). Thus, the team was successful in proving an efficient process which saved cost, time and human resource.

Integrated Information Practices

Indra relies on its own project management methodology which is based on the standardized project management practices in PMI's PMBOK Guides. Indra used this methodology which has been proven successful for them over last two decades. Indra's integrated custom-built information system enabled the team to store and monitor the real-time data on individual projects, including work breakdown structure, milestones, budgeting, goals, issues, progress and risks. Indra credits their integrated approach as one of the main reasons behind the success. Mr. Sevilla states "Our integrated approach helps by providing a precise and complete view of the status of the project itself – not only with the regard to the planned performance, but also with regard to its impact in the strategic allocated goals in accordance with the portfolio budget." (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012, p. 2).

Focus on Risk Management and User Training

Numerous important risks were identified and managed in this project. During project execution, an observed spike in total pre-poll voter turnout of 27% versus 13% during the previous election was identified. Indra correctly interpreted that these number showed a much higher turnout could be expected on election day. To mitigate this newly identified risk of having a high probability of experiencing shortages of equipment used in the voting process or overuse of existing equipment resulting into its breakdown during voting, the company acquired additional equipment and spare parts to avoid the likely risks. Configuration and testing of acquired equipment was also conducted in advance. Duplication of ballots, another identified risk, was mitigated by printing a unique serial number on every ballot (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012).

Stakeholder understanding and acceptance was identified as the greatest risk by Indra as they were introducing a new electronic system for counting votes. Ms. Furtos said “As in every change process, we were concerned that the users might not be convinced to buy in to our system and therefore show resistance to it” (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012 , p.3) To mitigate this risk, Indra concentrated on training the stakeholders, discussing and guiding the requirements from them. A risk register and issue log were maintained in a distributed system, which allowed Indra to keep monitoring revisions and status updates for project meetings. Stakeholders, specifically system users were provided with training by Indra as they were launching a new electronic system for conducting the election. According to Ms. Frutos “In every session, there were open discussions and guidance provided in relation to the election rules and regulation” (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012, p. 3). This helped Indra in understanding and subsequently addressing the requirements and concerns of stakeholder. Ms. Frutos also said “This was highly appreciated by stakeholders as it contributed to clarifying doubts and provided a common understanding on how to proceed in certain situations" (Standardized project management helps Indra successfully deploy a high-profile automated vote-counting system in Norway, 2012, p.3). Regulatory stakeholders like council officials and political party representative by providing them user training reports and testing results of the system during the committee meetings.

4.1.5 HONG KONG NATURAL GAS PIPELINE

This project was created in response to Hong Kong, one of the world's most populous cities, needing a consistent supply of clean energy resource to its 7.1 million residents. Previously Hong Kong relied on its Black Point power station to draw natural gas from the Yacheng 13-1 gas field in Hainan China. These reserves, however, were beginning to diminish in the late 2000s. Three new gas sources were identified by HKSAR government and Central government of the people's Republic of China as possible starting points, the Second West-East Gas Pipeline (WEPII), the world's longest natural gas pipeline was selected to deliver gas to Hong Kong. In 2008, both the governments signed a memorandum and building of an additional pipeline began to bring WEPII's gas to Hong Kong by the end of 2012. CLP/CAPCO, a joint venture of ExxonMobile Energy and CLP Power HongKong, managed the project (Project Management Helps Create World's Longest Natural Gas Pipeline, 2014).

Focus on Planning and Risk Management

This was a highly complex project which included numerous complex challenges. Regulations were one of the main challenges as the proposed pipeline crossed the border between mainland China to Hong Kong. With differing regulation on both sides, permits, rules and regulations of each government must be satisfied. Also, statutory approval practices and differing practices between the jurisdictions had to be fulfilled. Communication challenges existed as different working groups used different languages and all the parties involved had different requirements for reporting and documentation. The multitude of stakeholders to be managed included over 30 authorities in both jurisdictions. It was additionally challenging to meet the strict but different Environmental requirements for each jurisdiction. The groundwork of laying the pipeline was another main difficulty. The twenty kilometres of undersea pipeline was required to go through three channels: Tonggu Channel, Dachan Fairway and Urmston Road. Urmston Road channel is one of the world's busiest marine channel. The groundwork also involved laying pipeline in the shallow water with dredged marine channel and an existing subsea pipeline (Project Management Helps Create World's Longest Natural Gas Pipeline, 2014). With such an immense and complex project, the project team engineered, scheduled and painstakingly planned the project prior the project commencing, increasing the probability that the project could be accomplished safely and would work properly. As part of the planning, the project also conducted an extensive marine traffic impact assessment before laying the pipeline. Working together with local marine and port control authorities involved enabled the laying of the pipeline to avoid channel traffic. The entire 20km pipeline was laid in just six to seven months. The scope was tightly controlled by the project team to manage the timelines. Any changes to the scope would pass through a change management system which use to keep everything on track (Project Management Helps Create World's Longest Natural Gas Pipeline, 2014).

Focus on Communication

To build effective teams and to enhance the communication, program and project managers realized communication was an important factor for the project's success. Focus on communication also meant creating processes to use the right resources for the right task and materials and discussion were created in multiple languages.

Focus on Quality Management

There were many scheduled and non-scheduled management walkthroughs along with project manager's daily site visit to ensure the highest quality work. Third party inspections were also undertaken on the critical tasks to ensure the quality of the task like pipe welding, which earned 100 percent acceptance rate (Project Management Helps Create World's Longest Natural Gas Pipeline, 2014).

4.1.6 RESULTS OF FIVE SUCCESSFUL PROJECT'S CASE STUDIES

Below are the tabulated results from the above case studies of five successful projects. The table below helps to connect the practices with respect to the case studies. Since the table below is for case studies of successful project, the practices have affected the project positively, which is the reason behind the project's success.

Table 1 - Results of five successful project's case studies.

Practices	**Successful projects**				
	Apple's iPhone	**Toyota's Camry**	**Refurbishing Heathrow Airport Terminal 1**	**Project: Indra's Automated Vote-Counting system in Norway**	**Hong Kong Natural Gas Pipeline**
Continuous Requirements Analysis	✓	✓			
Continuous Feasibility analysis	✓				
Focused Systems Thinking	✓		✓		
Focused Human Machine Integration	✓				
Training Employees - Human Resource Management		✓			
Focus on Quality Management		✓			✓
Focus on Risk Management		✓	✓	✓	✓
Sub-Contractor Management			✓		
Timely Resolution of Cost and Schedule Issues			✓		
Focused Planning			✓		✓
Focus on Customer/User Objectives			✓		
Communication Management			✓		✓
Integrated Information Practices				✓	
Focus on User Training				✓	

4.2 FAILED/UNSUCCESSFUL PROJECT'S CASE STUDIES RESEARCH

4.2.1 DENVER VA HOSPITAL

According to Office of Audits and Evaluations (2016), the population of veterans increased over the years in late 90s and early 2000s near the Denver area, thus there was a need of a new facility to replace its old and inadequate facility which was built in 1951. It was proposed that the new Denver facility would be larger than previous facility, would have additional functional capabilities, and would have 30 beds designated for Spinal Cord Injury patients. There were many delays to initiate the project and the concept, scope, and design underwent major changes from 2000 through 2009. Veteran Affairs (VA)'s 2009 plan estimated approximately $536.6 million in construction cost and planned to finish construction in 2013. According to Gutierrez et al. (2018) the Denver VA hospital was supposed to open in 2013 but eventually opened in August 2018 with the total cost of $ 1.73 B. Thus, the project had five years of schedule overrun and approx. $1B of cost overrun.

Lack of Requirements Analysis

According to Office of Audits and Evaluations (2016), there were many elements in the design that exceeded the healthcare facility standards like custom walls, custom glass, custom wood and custom floors which added more to the cost. The Joint Venture Team (JVT) was responsible for the design services for this project, they designed the project being overly focused on the aesthetic features and was way beyond the needs of the serving veterans. Thus, the design added additional cost and construction complexities.

No Focus on Feasibility Analysis

According to Office of Audits and Evaluations (2016), VA was not able to ensure that its design would meet the Estimated Construction Cost at Award (ECCA). The design was not feasible with respect to the budget. Instead of selecting a conventional and simpler-to-construct designs, VA selected a complex design. This complex design had implications on constructability, cost, and potential future expansion. Thus, there was poor feasibility analysis on the VA's part.

Insufficient Risk Management

As mentioned in Office of Audits and Evaluations (2016), there were many warnings given to VA from internal and external sources regarding the rising costs on the project but Senior VA officials disregarded and ignored those warnings. According to Office of Audits and Evaluations" VA did not enforce the reconciliation of widely divergent cost estimates between its designer (the JVT) and construction contractor (KT), as contractually required" (2016, p. iii). Reconciliation process was a tool for VA which they could use to assure themselves that the project could be completed in the given budget. As VA failed to add the reconciliation provisions in the contract, they limited their own abilities to ensure that the design provided by the JVT could be constructed within the budget.

Lack of Scope Management

As explained in Office of Audits and Evaluations (2016), there were multiple extensive changes to the design, scope and concept of the project by the VA senior officials. Because of these frequent changes there were delays in settling on a basic design plan and site. In order to process 633 out of the 1080 change requests, VA took a timeframe of less than a day to 1086 days. On an average VA took around 264 days to process change request. Some of the reasons that contributed to the delays were the complex review and approval process, insufficient staffing, significant increase in the change requests, and lack of agreement on requested changes.

Inadequate Staffing Policy

According to Office of Audits and Evaluations (2016), the project was inadequately staffed in the key areas by VA. VA senior staff had many warnings about the need of more staff but they did not response to those warnings. The need for more staffing such as engineering and contracting staff for the project was identified by two United States Army Corps of Engineers reports (2011 and 2015).

Slow Decision-Making Process

As per the Office of Audits and Evaluations (2016), there was a summit in 2013 with VA and contractor personnel to avoid project cost overruns. The outcomes of this summit had significant cost reduction suggestions regarding the project, but most of these suggestions were rejected by VA and the remaining few changes that VA accepted were not incorporated in the project design. In total the meeting identified $402 million in cost savings proposal, but VA's slow decision-making progress combined with slow construction progress resulted in most of these proposals not being feasible to include in designs.

Lack of Systems Thinking

One of the significant factors mentioned in the Office of Audits and Evaluations (2016), was the project's mismanagement, delays, and cost overruns was the VA's decision of to change its acquisition strategy from Design-Bid-Build (DBB) contract to an Integrated-Design and Construct (IDc) contract. This decision to switch from DBB to IDc acquisition strategy by VA was made in 2010 which was very late in the project's lifecycle that is 4 years into the project. The decision was based on the reasoning that when the goal of a project is cost containment and to expedite the schedule, IDc contracts are used. Although these benefits were expected by the VA but the late change resulted in more schedule and cost overrun. According to Office of Audits and Evaluations (2016), the reasons this change was not beneficial to this project were "VA was inadequately experienced with IDc contracts, staff assigned to the project were inadequately trained on the IDc contract type, VA brought KT onto the project too late for KT to be able to provide effective input to the design, VA inhibited effective teamwork and communication among the parties involved in the IDc process, which hindered the IDc implementation." (2016, p. iv).

4.2.2 CALIFORNIA HIGH-SPEED RAIL

California High-Speed Rail project started in 2008 with the goal of connecting major cities in California like San Francisco and Los Angeles by a high-speed train. CHSRA (California High Speed Rail Authority) assured in 2008 that the high-speed rail would be able to travel from Los Angeles to San Francisco in less than two hours forty minutes with a high speed of 220 miles per hour. CHSRA also assured that the project will take 12 years to complete with the budget of $33 billion (CHSRA's 2008 Business Plan, 2008). As of 2019 the project was $44 billion over the budget and was 13 years behind the schedule (Nelson & Mozingo,2019).

Lack of Scope Management

Initially in 2008, CHSRA overestimated the forecast of ridership as 65.5 million as base projection and 96.5 million as high projection of intercity riders for 2030. On the other hand, the Due Diligence report published by Reason Foundation in 2008 estimated a base projection of 23.4 million and high projection of 31.1 million intercity riders. This was 64% below the base and 60% below the high projection stated by CHSRA. While in 2012 CHSRA's Business plan updated the ridership forecast for 2035 as 19.6 million as base projection and 31.8 million as high projection with a medium projection of 35.7 million. This projection included both intra-regional and interregional ridership. Thus, the scope of the project was not kept constant that negatively affected the cost and schedule of the project (Vranich and Cox, 2013; CHSRA 2008 Business Plan, 2008; CHSRA 2012 Business Plan, 2012).

Another example of variation in scope amidst the project was that in 2012 CHSRA business plan updated that there will be one stop and the travel time would be three hours minimum while the initial proposed plan was that the train would work non-stop from Los Angeles to San Francisco with traveling time of two hours forty mins (Vranich and Cox, 2013; CHSRA 2008 Business Plan, 2008; CHSRA 2012 Business Plan, 2012).

No focus on Feasibility Analysis

CHSRA had repeatedly claimed that the travel time between Los Angeles to San Francisco will be 2 hours 40 mins. However, in the opinion of Vranich and Cox (2013) such speed would not be achievable under CHSRA's new Phase I blended system. Wherein the blended system involves sharing of the tracks from commuter trains and freight trains and thus the high-speed rail will need to operate at slow speeds. The overall expected speed for the train was 220 mph however with blended system the Transportation Research Board estimated a low scenario of 60 mph and high scenario of 100 mph for urban areas. Another problem with sharing tracks with busy trains is the frequency of train, they could only operate two trains in each direction per hour. This created another problem as the CHSRA had projected its revenue based on operating trains every five or six minutes. Additionally, the speed reduction and increase in travel time affected the ridership numbers which they highly depended on (Vranich and Cox, 2013).

Insufficient Risk Analysis & Project Management

Most of the work was out-sourced to the private consultants. There were only ten employees at the top level who managed and oversaw the whole design of the project. While the consultants managed every aspect of the job like negotiation with framers, directing day-to-day construction, estimating the ridership, and more. The rail authorities were so dependent on the consultants that the offices, computers, and the software that they used, all were either owned or rented by the contractors. The consultants overly underestimated the difficulty of the project and significant part of the work was mismanaged and flawed. CHSRA failed to manage its consultants and failed to evaluate the risk of overly depending on the consultants (Vartabedian,2019).

4.2.3 AIRBUS A380

Airbus A380 is one of the world's biggest commercial airplanes with a maximum seating capacity of 853 seats (Norris and Wagner, 2005). Airbus started working on the making of Airbus A380 in December 2000, the project went through multiple problems, Airbus finally finished the project and delivered its first A380 plane in October 2007. As a result of higher cost of production, penalties and order cancellations, it is estimated that Airbus had a cost overrun of more than $6.8 billion. Airbus was about 18 months behind the schedule for the production on A380 (Nelson, 2020). In 2019, Airbus announced that it will shut down the production of the plane in 2021. As of August 2020, Airbus had a total of 251 orders of which only 242 are delivered (Airbus, 2020). In all, the project had cost overrun of billions of dollars owing to production delay and further reduction in production ending with product termination.

Inadequate Requirement Analysis

One of the main requirements for Airbus A380 was to compete and out-perform the Boeing 747 which was able to carry 500 to 700 passengers based on its model (Wall and Michaels, 2019). In early 2000s, Airbus predicted a demand of 1,200 large aircrafts with more than 400 seats for next two decades (Nelson, 2020). Goal of Airbus A380 was to offer huge aircrafts which was not verified with the stakeholders like airline companies and the airports. Thus, in order to accommodate the huge Airbus A380, London's Heathrow airport went through a multi-million-dollar renovation whereas New York's JFK airport spent over 179 million dollars (Nelson, 2020). Also, the larger size of aircraft prevented it from connecting with smaller-sized airport, which could have resulted into lower sales and eventual production termination (Airbus, 2020).

No focus on Feasibility Analysis

Compared to Boeing 787 Dreamliner with maximum seating capacity of around 200, Airbus A380's ceiling for profit is much higher due to maximum seating capacity of around 850. But in order to make a profit there are certain number of seats that need to be filled. Operation of Airbus A380 would cost anywhere between $26000 to $29000 an hour whereas on the other hand Boeing 787 Dreamliner would cost between $11000 to $15000 an hour (Loeffler,2019). Thus, it was very important for the airlines companies to fill more seats to make profit. Because the airline companies did not think that they could fill that many seats, most of the airline companies did not buy the Airbus A380 aircraft (Nelson, 2020).

Lack of Systems Thinking

One the biggest issue with the A380 was 'terminal space'. Airbus A380 being a huge aircraft needed more terminal space. As the aircraft could carry 500 – 700 passengers, it had 2 entryways which then needed two gangways extending from the same terminal. There are very few airports with those kinds of equipments which made the use of the aircraft limited (Nelson, 2020). Another problem that airports faced with A380 was that due to large number of passengers travelling at the same time, it was extremely difficult to carry out the tasks like ticket processing, checking luggage, and security screening. Airports estimated that it would take almost a day to process every passenger and find their bags if two or more A380 arrived at the same time due to weather or schedule problem (Grabianowski,2005).

Airbus A380 faced a difficult problem in the second-hand market as well. Usually the top-tier airlines buy new planes and use it for around 10 years and then sell them in second-hand market to low budget airlines. But in case of this aircraft, the second-hand market is virtually non-existent as the low budget airlines were not sure if they could make any profit as they would need large number of passengers (Zhang 2018). Thus, most of the planes went straight to being scraped and their spare parts being sold.

Insufficient Systems Integration and Testing

Even before the production, Airbus A380 had a huge problem with its wiring as in its first prototype engineers began to realize that the wire and harness were short during the installation despite being manufactured to the specifications. The root cause of this was later found that the multiple design teams involved used different versions of the CATIA software; a Computer-Aided Design software. British and French teams used CATIA v.5 software whereas German and Spanish teams used CATIA v.4 software (Dorfler and Baumann, 2014). Thus, the aircraft had to strip down all the wiring and redesign them. This added serious delays in the project.

Lack of Risk Analysis and Project Management

Multiple small airline companies across the Europe were merged together and Airbus company was formed (Nelson, 2020). This meant variation in management style, corporate culture and IT systems being used across the organization. This is the reason for the communication and coordination gap between the different design teams during manufacturing of A380. One of the examples was the lack of resolution of the dispute concerning variation in software usage by different design teams by the project manager that resulted into faulty wiring of aircraft (Dorfler and Baumann, 2014).

4.2.4 FIAT 500

In 1983 Fiat exited the US market due to low sales as the brand had a reputation of poor quality (Priddle, 2020). Fiat was relaunched in North America in January 2009 by acquiring 20% stake in Chrysler LLC forming Fiat Chrysler Automobile (FCA). After the relaunch, Fiat cars became available in the US in year 2011. In 2011 Fiat launched five cars including its iconic Fiat 500. Fiat hoped to sell around 50,000 cars in its first year of return. Unfortunately, the highest sales number they reached was 46,121 in 2014 (Eisenstein, 2019). The lowest sales figure was 9,200 in 2019. On 1st September 2019, Fiat announced that it will discontinue the production of Fiat 500 and Fiat 500e in North America and will continue to offer Fiat 500X, Fiat 500L, and Fiat 124 Spider (Fiat Chrysler Automobile, 2019).

Insufficient Requirements Analysis

Big SUVs and pickup trucks have always dominated the American car market. Fiat relaunched in US with an assumption that due to the recession, the fuel prices were high and will remain high which will eventually develop a need in the market to buy their small-sized fuel-efficient cars. This was not entirely wrong assumptions as Fiat was gaining some traction in US market initially but with the recovering of the market, demand for small sized cars collapsed (Eisenstein, 2019).

No focus on Reliability and Quality Management

Fiat’s iconic 500 models faced many reliability and quality related problems from the time of its relaunch. In Consumer Reports’ 2019 brand report card ranking, Fiat was ranked being last. This magazine assessed brands based on the owner satisfaction, reliability and performance (Bomey, 2019). Fiat was also ranked last in J.D. Power’s 2019 U.S Vehicle Dependability Study. This study assessed the performance of three-year-old vehicles over the previous 12 months (Bomey, 2019). It was found that the Fiat was suffering 2.5 times as many problems when compared to the industry leader Toyota and more than twice as many problems when compared to the industry average (Eisenstein, 2019). According to the director of auto testing magazine, “Fiat has consistently bad reliability, the owner satisfaction is low, and they don’t do well on [road] tests,” (Coppola,2019).

Lack of Stakeholder Management

After the relaunch, the stakeholders (FCA US & FCA N.V), investors, and analysts looked to the important key performance indicators of new vehicle sales and the growth trend. In the annual report, FCA N.V explained to the investors that the sales of new vehicles illustrated the demands for its vehicle and company's competitive position in the market. It was also stated that US sales accounted for close to half of FCA N.V's worldwide sales. "FCA US described US sales as a symbol of our continuing success in the marketplace in an article published on its website" (U.S. Securities and Exchange Commission, 2019, p. 2). It was later found out that FCA US was paying dealers to report fake sales to inflate monthly vehicle sales to customers. In addition, fake vehicle sales were also reported by the FCA US Business Centre employees. From 2013 through 2015, dealers and employees informed FCA US of fake sales reporting at its business centres on multiple occasions. Up to mid-2016 FCA US continued to report false sales. In January 2016 a dealer filed a lawsuit alleging that FCA US offered to pay the dealer in return for reporting fake sales, to which FCA N.V publicly denied the allegations (U.S. Securities and Exchange Commission, 2019).

4.2.5 BOEING 737 MAX 8

On 1st December 2010, Airbus announced a new upgrade to its Airbus A320 family which will provide up to 15 percent reduction in fuel consumption with its new Airbus A320 neo aircraft (Airbus,2010). Boeing responded to this by announcing on 30th August 2011 that they will launch a new family of aircraft named Boeing 737 MAX while saying "The 737 MAX will deliver maximum efficiency, maximum reliability and the Boeing Sky Interior will continue to offer maximum passenger comfort." (Boeing, 2011, para. 2). From the initial stages of the project, Boeing was lagging behind the Airbus to launch their aircraft in the market. To get ahead on time, Boeing made series of decisions which are very questionable. The first Boeing 737 MAX aircraft was delivered in May 2017 to Malindo Air (Boeing,2017). Since then there were two crashes, first on October 29, 2018 Lion Air flight JT610 and second on March 10, 2019, Ethiopian Airlines Flight ET302. In total including passengers and crew members 346 lives were lost (Herkert et al.,2020). After being grounded by multiple aviation authorities; on March 13th, 2019 Federal Aviation Administration became the last authority to ground the Boeing 737 MAX aircraft. (Herkert et al.,2020; FAA,2019).

Lack of Requirements Analysis

Boeing wanted to compete with the new Airbus A320 neo which was going to be better by 15 % in fuel consumption in comparison with previous aircrafts. As this was one of the main requirements and they did not want to lose the market share, Boeing was pushing the schedule to get the new 737 MAX as early as possible (Johnston & Harris, 2019). One of the requirements from Boeing 737 MAX was to keep the new plane similar to the old 737, so that the pilots would not need additional training (Johnston & Harris, 2019). They claimed this requirement was fulfilled and advertised accordingly, but it was not the same as they added the new Maneuvering Characteristics Augmentation System (MCAS); a specialized anti-stalling system to their aircraft. Pilots on the Lion Air flying 737 MAX were not even aware of the MCAS system and did not have stimulator training for the situation they faced which resulted into crashing of the aircraft (Johnston & Harris, 2019). Boeing failed to identify the real requirements from the stakeholders to ensure a safe, reliable and value-added product.

Insufficient Feasibility Analysis

Boeing had less time to design, develop, test, and get the aircraft certified as they were competing with A320 neo. In interest of time Boeing decided to use the same chassis of the 737 aircraft and just change its engine with the new LEAP-1B engines which were more efficient but were also bigger and heavier compared to the previous engines used on the 737 aircraft (Johnston & Harris, 2019). This developed a major problem in terms of the instability in the structure as the 737 chassis was not designed to these new engines. Due to this instability, the aircraft's nose was observed to be tilting upwards during its operation (Johnston & Harris, 2019). This resulted into mid-air stalling of the aircraft; a very dangerous scenario for an aircraft. So, to address this problem Boeing developed the MCAS which would read the data (Angle of Attack) from the sensor concerned with the upward motion of the nose and then it would automatically push the nose down. By default, the MCAS system would remain active and monitoring Angle of Attack (AoA) all the time, even if the auto-pilot mode is off. Even if pilot tries to override the system with trim controls, the system would activate itself after 5 seconds (Johnston & Harris, 2019). Thus, this MCAS system was a major component in both of the accidents.

Lack of Human Systems Integration

Boeing claimed that the new 737 MAX was similar to 737 aircraft and the pilots would not need additional training. The whole cockpit in 737 MAX was changed and made digital. Boeing tried to keep the controls in the same place as it originally was, but still it was a huge update for the pilots (Pasztor et al., 2019). Also, MCAS system was added which had the ability to adjust the rear stabilizer to lower the nose of the aircraft. This information concerning MCAS system was kept away from the pilot before the first incident of aircraft crash. In between the first and second crash Boeing updated the manual by giving the instructions to override the MCAS system. But no formal training was provided to the pilots about the system yet Boeing blamed pilots for the accidents (Herkert et al.,2020).

Insufficient Risk management and Reliability Analysis

Although failure of the MCAS system was assessed one level below the "catastrophic" level which was "hazardous" level but there were no particular actions taken to mitigate this risk by Boeing (Gates, 2019). MCAS system used data from only one sensor. Thus, in both the flights the sensor failed and because of that MCAS system received wrong data and it kept on pushing the nose downward which led to accident (Johnston & Harris, 2019). In fact, Boeing 737 MAX had two senores to read AoA but only one was used to feed the data to MCAS system (Herkert et al.,2020). Since the reliability of the MCAS system would rely on the reliability of that particular sensor, to increase the reliability Boeing could have mitigated MCAS system failure risk by using both the sensors to provide ~~the~~ data to the MCAS system. This would have allowed the MCAS system to receive the same input data from both the sensors or prevent the MCAS initiation. This, however, was offered as an option only. This mitigation was not part of the basic plane.

4.2.6 RESULTS OF FIVE UNSUCCESSFUL PROJECT'S CASE STUDIES

Below are the tabulated results from the above case studies of five unsuccessful projects. The table below helps to connect the practices with respect to the case studies. Since the table below is for case studies of unsuccessful project, the practices have affected the project negatively, which is the reason behind the project's failure.

Table 2 - Results of five unsuccessful project's case studies.

Practices	**Failed projects**				
	Denver VA hospital	**California High-speed rail**	**Airbus A380**	**FIAT 500**	**Boeing 737 MAX 8**
Lack of Requirements Analysis	✓		✓	✓	✓
No Focus on Feasibility Analysis	✓	✓	✓		✓
Insufficient Risk Management	✓	✓	✓		✓
Lack of Scope Management	✓	✓			
Inadequate Staffing Policy	✓				
Slow Decision-Making Process	✓				
Lack of Systems Thinking	✓		✓		
Insufficient Project Management		✓	✓		
Insufficient Systems Integration			✓		✓
Insufficient Systems Testing			✓		
No Focus on Reliability Analysis				✓	✓
No Focus on Quality Management				✓	
Lack of Stakeholder Management.				✓	

4.2.7 OVERALL CASE STUDY DATA

The practices which are listed in Table 1 and Table 2 can be combined with other practices as some of the practices are very broad in context and can incorporate the other practices as shown.

Table 3 – Critical Success Practices and its sub-set.

Critical Practices	Sub-set of Critical Practices
Scope management	Lack of Scope Management
Cost & Schedule Management	Timely Resolution of Cost and Schedule Issues
Human Systems Integration	Focused Human Machine Integration
Training employees	Training Employees - Human Resource Management
Risk management	Focus on Risk Management
	Insufficient Risk Management
Feasibility analysis	Continuous Feasibility analysis
	No Focus on Feasibility Analysis
Systems Thinking	Focused Systems Thinking
	Lack of Systems Thinking
Integration & Testing	Insufficient Systems Integration
	Insufficient Systems Testing
Effective planning and Decision Making	Focused Planning
	Inadequate Staffing Policy
	Slow Decision-Making Process
Requirements analysis	Continuous Requirements Analysis
	Focus on Customer/User Objectives
	Lack of Requirements Analysis
Quality and Reliability analysis	Focus on Quality Management
	No Focus on Reliability Analysis
	No Focus on Quality Management
Project management	Sub-Contractor Management
	Communication Management
	Integrated Information Practices
	Focus on Stakeholder Management
	Insufficient Project Management
	Lack of Stakeholder Management.

Table 4 - Results of case studies after combining practices

Critical practices	Successful projects					Failed projects				
	Apple's iPhone	**Toyota's Camry**	**Refurbishing Heathrow Airport Terminal 1**	**Project: Indra's Automated Vote-Counting system in Norway**	**Hong Kong Natural Gas Pipeline**	**Denver VA hospital**	**California High-speed rail**	**Airbus A380**	**FIAT 500**	**Boeing 737 MAX 8**
Scope management						X	X			
Project management			✓	✓	✓		X	X	X	
Risk management		✓	✓	✓	✓	X	X	X		X
Feasibility analysis	✓					X	X	X		X
Requirements analysis	✓	✓	✓			X		X	X	X
Cost & Schedule Management			✓			X				
Systems Thinking	✓		✓			X		X		
Integration & Testing								X		
Human Systems Integration	✓									X

Critical practices	**Successful projects**					**Failed projects**				
	Apple’s iPhone	**Toyota’s Camry**	**Refurbishing Heathrow Airport Terminal 1**	**Project: Indra’s Automated Vote-Counting system in Norway**	**Hong Kong Natural Gas Pipeline**	**Denver VA hospital**	**California High-speed rail**	**Airbus A380**	**FIAT 500**	**Boeing 737 MAX 8**
Quality and Reliability analysis		✓			✓				X	X
Training employees		✓		✓						
Effective planning and Decision Making			✓		✓	X				

Thus, the major practices determined were incorporated in the survey questionnaire.

4.3 SURVEY

Qualtrics, a web-based survey and data collection tool provided by Colorado State University, was used for questions, data gathering, and analysis. The survey was created and reviewed by the CSU Institutional Research Board prior to release. The targeted participants were working individuals and Colorado State University Systems Engineering graduate students, members of Project Management Institute's Mile-Hi chapter and within author's professional network who voluntarily responded via a link to the Qualtrics survey. CSU's Systems Engineering graduate student population is comprised primarily of working professionals in technical and management roles in diverse industrial sectors. A total of 150 responses were received from the USA, India, Germany, Canada and Singapore.

The survey, comprising eight questions, was conducted to validate the critical success practices that were identified from the case studies. Among these eight questions, five questions were intended in order to gain information regarding the participant's profession, years of experience, certification possessed, type of industry working with, and role in the firm. Three other questions were related to ranking of the critical practices. The practices that were identified by conducting the case studies were used in these questions. The questions were divided further to ascertain which types of practices – technical or managerial were important. Although this was a targeted survey, the wide diversity of people and business sectors provided needed information.

4.3.1 SURVEY QUESTIONS AND RESPONSES

Below are the responses of all the eight questions which were on the survey. Among these eight questions, Q1 to Q5 was intended to capture responders background information on which the responders are categorized. Whereas Q6 to Q8 identifies the rating and ranking of the critical practices.

Q.1 What is your profession? Participants could choose more than one option.

Category	# of Responses
Managers	41
Technical Professionals	82
Director	14
Other	28

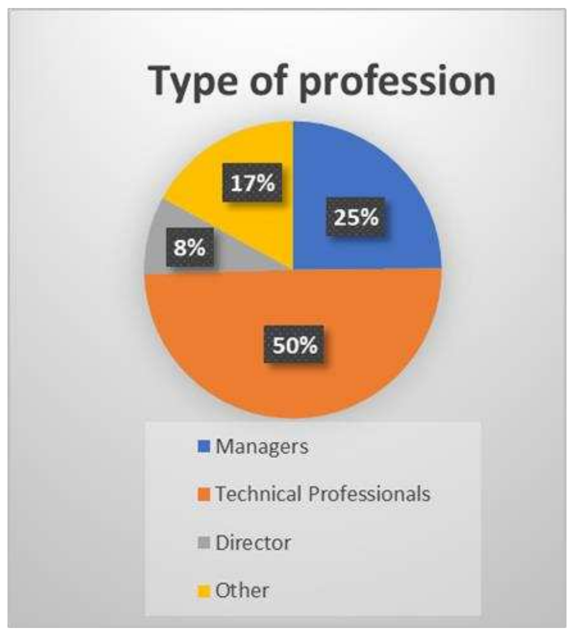

Figure 1 - Professional background of participants.

Q.2 In what general type of industry are you currently employed? Participants could choose all that apply.

Category	# of Responses
Manufacturing	16
Aerospace	21
Automobile	2
Energy	7
Information Technology	41
Defense	24
Academic	15
Other	50

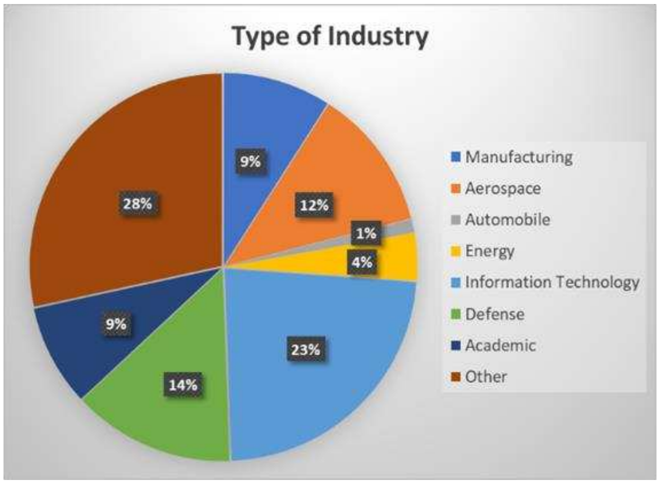

Figure 2 - Industrial background of the participants.

Q.3 What is your total industrial work experience?

Category	# of Responses
0 to 5 years	37
5 to 10 years	25
10 to 20 years	35
more than 20 years	53

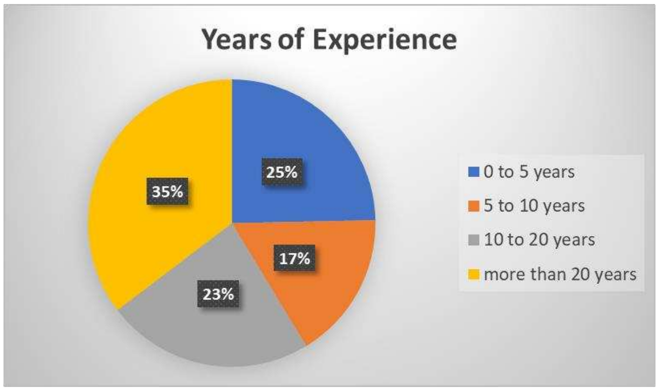

Figure 3 - Working experience of participants.

Q.4 How do you identify yourself? Participants could choose all that apply.

Category	# of Responses
Engineer	78
Project manager	57
Technical manager	34
Manager	21
Other	19
Marketing/Sales	6
Manufacturing engineer	0

Figure 4 - Participant's role in their industry.

Q.5 Do you possess any certification related to Project management or Systems Engineering?

Participants could check all that apply.

Category	# of Responses
PMI certificate	61
INCOSE certificate	3
NO	88

Figure 5 - Participants possessing INCOSE or PMI certification.

Q.6 Rate the following technical practices with respect to their importance in project success.

Table 5 - Rating of technical practices with respect to project success.

Technical practices	Not applicable	Least important	Important	Highly important	Crucial
Feasibility analysis	6	5	66	44	29
Requirements Identification	3	1	19	47	80
Systems Thinking	5	7	55	60	23
Systems Integration	5	2	49	56	38
Systems Testing	6	1	26	64	53
Human Systems Integration	6	11	56	53	24
Quality & Reliability analysis	5	3	43	66	33

Q.7 Rate the following Managerial practices with respect to their importance in project success.

Table 6 – Rating of managerial practices with respect to project success results.

Managerial practices	Not applicable	Least important	Important	Highly important	Crucial
Scope management	0	1	41	63	45
Project management	0	0	33	72	45
Risk management	2	3	35	68	42
Requirements management	1	4	31	58	56
Cost Management	1	5	41	69	34
Schedule Management	0	3	44	74	29
Project Planning	0	5	38	59	48
Decision Making	0	1	35	65	49
Skilled personnel	0	3	46	57	44
Systems Engineering	4	5	53	58	30

Q.8 Rank the practices which are most beneficial to your organization with respect to the challenges your organization face.

Table 7 - Ranking of the critical success practices results.

Practices	Ranks												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Scope management	23	19	18	13	14	5	9	6	6	8	6	11	2
Project management	8	13	22	11	9	14	9	9	9	14	11	8	3
Risk management	9	13	14	15	17	12	20	6	10	11	7	6	0
Requirements management	21	17	14	18	18	14	11	6	10	3	3	5	0
Feasibility analysis	12	7	11	11	16	14	8	20	11	10	8	10	2
Quality & Reliability analysis	3	11	11	8	10	5	17	21	15	13	17	8	1
Human Systems Integration	3	8	5	10	7	12	10	18	11	19	16	18	3
Decision Making	10	14	9	9	11	16	20	12	15	8	7	7	2
Planning	14	16	6	16	5	18	11	10	16	8	5	13	2
Systems Thinking	13	6	12	9	10	12	4	15	11	18	20	7	3
Systems Test and Integration	8	9	11	11	12	11	9	9	13	16	19	11	1
Systems Engineering	9	6	7	7	10	7	11	6	13	10	20	34	0
Other	7	1	0	2	1	0	1	2	0	2	1	2	121

Participant Characterization

Of all the responders, 75% were technical professionals and managers. 50% held technical professional positions. 8% held director position where 17% selected "other" professions which included students, technical program manager, professors, and executive/senior directors.

Of all the responders, 49% were employed in information technology, defense areas, and aerospace industrial sectors. The "other" choice, selected by 28% of responders, included industrial sectors like finance, telecommunications, textiles, intellectual property, pharmaceutical, health care, banking, construction, agriculture, and transportation.

In responding to the question regarding having certification, 88 responds were negative. Of all the 64 responders with certification, 61 responders were holding PMI certificates, two held both PMI and INCOSE Systems Engineering Professional (SEP) certification and one responder held only an INCOSE SEP. The most prevalent certification among responders was PMI Project Management Professional.

Of all the responders, 52% were either managers, project managers or technical manager. Whereas 36% respondents were engineers. Among the remaining 12% of responders; 3% were from marketing/sales whereas 9% identified themselves in other roles; researcher, program manager, scientist, pilot, business analyst, and as consultant.

Fifty-three of the responders were with more than 20 years of working experience. 37 responders had less than 5 years of working experience. 35 out of 60 responders had a work experience in between 10 to 20 years, while other 25 responders were with 5 to 10 years of work experience.

4.3.2 SURVEY ANALYSIS AND RESULTS

Two types of data analysis methods were used in this study. Relative Importance Index (RII) method was used to analyze Q.6 and Q.7 as these two questions were Likert scale-based questions. Henry Garrett Ranking method was used to analyze the data from Q.8 which is a ranking question. Of particular interest is any relationship there may be to years of experience, profession, or certification in ranking the critical success practices.

4.3.2.1 RELATIVE IMPORTANCE INDEX

Data from the survey of Q.6 and Q.7 was analyzed to rank the technical and managerial practices. The ranking of these practices was then sub-divided based on various aspects of participant's background (Q.1 to Q.5). To rank the practices Relative Importance Index method was used. RII is used to identify the importance of practices when Likert scale is used to collect the responses. To use RII it is important to covert the level of importance scale to a weightage scale, this is done by considering “Not applicable” as 1, “Least important” as 6, “Important” as 11, “Highly important” as 16 and “Crucial” as 21.

RII is calculated as below –

$$RII(\%) = \frac{\sum W}{A \times N} * 100$$

Where $0 \leq RII \leq 100$.

W is the weightage given to the particular practice by the responder which will be between 1-21.

N is the total number of responses, in this case 150.

A is the maximum weight used in the survey which in this case is 21.

For example, if the sum of weights to a hypothetical practice “x” is 2150.

Thus,

$$RII\ (\%) = \left(\frac{2150}{150 \times 21}\right) * 100$$

$RII\ (\%) = 68.25\ \%$

Similarly, all the values of RII were calculated and the practices were ranked accordingly.

4.3.2.2 ANALYSIS BASED ON YEARS OF EXPERIENCE.

The four categories of experience were listed as 0 to 5 years, 5 to 10 years, 10 to 20 years, and more than 20 years. Results of the analysis based of these categories are as follow –

Table 8 - Results based on responders with 0 to 5 years of experience

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	0	1	19	9	8	67.82
Requirements Identification	0	0	5	13	19	85.20
Systems Thinking	0	1	18	13	5	66.54
Systems Integration	0	1	17	14	5	67.18
Systems Testing	0	1	6	21	9	76.83
Human Systems Integration	0	3	18	13	3	62.68
Quality & Reliability analysis	0	1	9	17	10	75.55
Managerial Factors						
Scope management	0	0	17	14	6	69.11
Project management	0	0	9	19	9	76.19
Risk management	1	0	10	15	11	74.90
Requirements management	0	0	7	18	12	79.41
Cost Management	0	1	9	18	9	74.90
Schedule Management	0	1	12	18	6	71.04
Project Planning	0	2	9	13	13	76.19
Decision Making	0	0	9	15	13	78.76
Skilled personnel	0	1	14	14	8	71.04
Systems Engineering	0	1	15	15	6	69.11

Table 9 - Results based on responders with 5 to 10 years of experience

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	2	0	9	9	5	66.67
Requirements Identification	2	0	10	5	8	68.57
Systems Thinking	2	0	8	10	5	67.62
Systems Integration	2	0	9	8	6	67.62
Systems Testing	2	0	7	7	9	72.38
Human Systems Integration	2	3	10	7	3	58.10
Quality & Reliability analysis	2	0	8	11	4	66.67
Managerial Factors						
Scope management	0	1	8	12	4	70.48
Project management	0	0	10	12	3	69.52
Risk management	0	0	7	13	5	74.29
Requirements management	0	2	10	8	5	67.62
Cost Management	0	3	9	7	6	67.62
Schedule Management	0	1	7	15	2	69.52
Project Planning	0	1	6	13	5	73.33
Decision Making	0	1	6	11	7	75.24
Skilled personnel	0	1	10	10	4	68.57
Systems Engineering	0	1	13	8	3	64.76

Table 10 - Results based on responders with 10 to 20 years of experience

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	1	2	14	10	8	67.35
Requirements Identification	0	1	3	13	18	85.03
Systems Thinking	0	3	10	21	1	65.99
Systems Integration	0	0	11	14	10	75.51
Systems Testing	1	0	7	17	10	76.19
Human Systems Integration	2	2	11	13	7	66.67
Quality & Reliability analysis	2	1	11	13	8	68.71
Managerial Factors						
Scope management	0	0	9	16	10	76.87
Project management	0	0	6	16	13	80.95
Risk management	1	0	10	15	9	73.47
Requirements management	1	2	7	16	9	72.79
Cost Management	1	0	10	19	5	70.75
Schedule Management	0	1	10	17	7	72.79
Project Planning	0	2	11	12	10	72.79
Decision Making	0	0	7	20	8	76.87
Skilled personnel	0	0	9	15	11	77.55
Systems Engineering	1	1	15	14	4	65.31

Table 11 - Results based on responders with more than 20 years of experience

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	3	2	24	16	8	63.16
Requirements Identification	1	0	1	16	35	90.12
Systems Thinking	3	3	19	16	12	66.31
Systems Integration	3	1	12	20	17	73.50
Systems Testing	3	0	6	19	25	80.68
Human Systems Integration	2	3	17	20	11	68.10
Quality & Reliability analysis	1	1	15	25	11	72.15
Managerial Factors						
Scope management	0	0	7	21	25	84.28
Project management	0	0	8	25	20	81.58
Risk management	0	3	8	25	17	77.54
Requirements management	0	0	7	16	30	86.52
Cost Management	0	1	13	25	14	75.74
Schedule Management	0	0	15	24	14	75.74
Project Planning	0	0	12	21	20	79.78
Decision Making	0	0	13	19	21	79.78
Skilled personnel	0	1	13	18	21	78.89
Systems Engineering	3	2	10	21	17	73.50

4.3.2.3 BASED ON THE ROLE IN THE FIRM –

The five categories of role in the firm were Engineers, Engineering managers, Project Managers, Marketing/Sales, and Other. Results of the analysis based of these categories are as follow –

Table 12 - Results based on responders' role in firm - Engineer

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	0	3	25	12	9	65.50
Requirements Identification	0	0	7	16	26	85.42
Systems Thinking	0	2	22	19	6	66.47
Systems Integration	0	1	18	17	13	72.79
Systems Testing	0	1	10	21	17	78.62
Human Systems Integration	0	5	22	18	4	62.59
Quality & Reliability analysis	0	1	14	23	11	73.76
Managerial Factors						
Scope management	0	0	18	22	9	71.82
Project management	0	0	15	18	16	76.68
Risk management	0	0	12	24	13	76.68
Requirements management	0	1	10	22	16	78.13
Cost Management	0	2	15	21	11	72.30
Schedule Management	0	2	15	24	8	70.85
Project Planning	0	4	15	19	11	70.36
Decision Making	0	1	17	16	15	74.25
Skilled personnel	0	0	19	17	13	73.28
Systems Engineering	0	0	21	17	11	71.33

Table 13 - Results based on responders' role in firm - Engineering manager

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	2	1	14	12	7	66.27
Requirements Identification	1	0	7	13	15	79.50
Systems Thinking	2	0	11	15	8	70.24
Systems Integration	2	0	8	13	13	75.53
Systems Testing	2	0	5	17	12	76.85
Human Systems Integration	2	2	14	12	6	64.29
Quality & Reliability analysis	3	0	11	13	9	68.92
Managerial Factors						
Scope management	0	1	11	15	9	73.54
Project management	0	0	8	20	8	76.19
Risk management	1	1	9	16	9	72.88
Requirements management	0	2	10	13	11	74.21
Cost Management	1	2	6	15	12	75.53
Schedule Management	0	1	12	14	9	72.88
Project Planning	0	0	13	10	13	76.19
Decision Making	0	0	9	20	7	74.87
Skilled personnel	0	0	10	16	10	76.19
Systems Engineering	2	2	11	13	8	67.59

Table 14 - Results based on responders' role in firm - Project manager

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	3	1	20	15	10	65.99
Requirements Identification	1	1	2	12	33	88.82
Systems Thinking	2	4	18	21	4	62.59
Systems Integration	2	1	17	22	7	67.44
Systems Testing	3	0	5	22	19	78.62
Human Systems Integration	3	2	16	17	11	67.44
Quality & Reliability analysis	1	2	14	23	9	70.36
Managerial Factors						
Scope management	0	0	8	20	21	82.51
Project management	0	0	8	22	19	81.54
Risk management	0	1	9	23	16	78.62
Requirements management	1	1	7	16	24	82.02
Cost Management	0	1	14	26	8	72.30
Schedule Management	0	0	12	28	9	74.73
Project Planning	0	1	8	22	18	80.08
Decision Making	0	0	9	20	20	81.54
Skilled personnel	0	3	13	17	16	74.73
Systems Engineering	2	3	16	20	8	66.47

Table 15 - Results based on responders' role in firm - Marketing/Sales

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	0	0	4	0	0	52.38
Requirements Identification	0	0	2	2	0	64.29
Systems Thinking	0	0	2	2	0	64.29
Systems Integration	0	0	1	2	1	76.19
Systems Testing	0	0	2	1	1	70.24
Human Systems Integration	0	0	2	2	0	64.29
Quality & Reliability analysis	0	0	2	1	1	70.24
Managerial Factors						
Scope management	0	0	1	2	1	76.19
Project management	0	0	2	2	0	64.29
Risk management	1	0	0	1	2	70.24
Requirements management	0	0	2	2	0	64.29
Cost Management	0	0	1	2	1	76.19
Schedule Management	0	0	1	2	1	76.19
Project Planning	0	0	0	3	1	82.14
Decision Making	0	0	0	4	0	76.19
Skilled personnel	0	0	1	2	1	76.19
Systems Engineering	0	0	1	3	0	70.24

Table 16 - Results based on responders' role in firm - Other

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	1	0	3	5	3	70.24
Requirements Identification	1	0	1	4	6	80.16
Systems Thinking	1	1	2	3	5	72.22
Systems Integration	1	0	5	2	4	68.25
Systems Testing	1	0	4	3	4	70.24
Human Systems Integration	1	2	2	4	3	64.29
Quality & Reliability analysis	1	0	2	6	3	72.22
Managerial Factors						
Scope management	0	0	3	4	5	80.16
Project management	0	0	0	10	2	80.16
Risk management	0	1	5	4	2	66.27
Requirements management	0	0	2	5	5	82.14
Cost Management	0	0	5	5	2	70.24
Schedule Management	0	0	4	6	2	72.22
Project Planning	0	0	2	5	5	82.14
Decision Making	0	0	0	5	7	90.08
Skilled personnel	0	0	3	5	4	78.17
Systems Engineering	0	0	4	5	3	74.21

4.3.2.4 BASED ON CERTIFICATION POSSESSED –

The two categorizes of responder possessing certification were with INCOSE/PMI certification, and with no certification. Results of the analysis based of these categories are as follow –

Table 17 - Results based on responder possessing INCOSE/PMI certification

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	3	4	26	17	12	64.29
Requirements Identification	1	1	1	12	47	91.94
Systems Thinking	3	6	24	21	8	61.98
Systems Integration	3	1	19	23	16	70.81
Systems Testing	4	0	8	24	26	78.49
Human Systems Integration	3	4	23	20	12	65.44
Quality & Reliability analysis	2	2	20	29	9	68.13
Managerial Factors						
Scope management	0	0	9	22	31	84.64
Project management	0	0	11	26	25	81.57
Risk management	0	3	13	24	22	77.34
Requirements management	1	1	8	22	30	82.72
Cost Management	0	1	17	31	13	73.89
Schedule Management	0	1	13	36	12	75.04
Project Planning	0	2	12	22	26	80.03
Decision Making	0	0	14	23	25	80.41
Skilled personnel	0	2	18	22	20	75.42
Systems Engineering	4	3	21	25	9	64.67

Table 18 - Results based on responder possessing no certification

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Feasibility analysis	3	1	40	27	17	66.99
Requirements Identification	2	0	18	35	33	78.63
Systems Thinking	2	1	31	39	15	69.70
Systems Integration	2	1	30	33	22	71.86
Systems Testing	2	1	18	40	27	76.46
Human Systems Integration	3	7	33	33	12	64.29
Quality & Reliability analysis	3	1	23	37	24	73.48
Managerial Factors						
Scope management	0	1	32	41	14	70.78
Project management	0	0	22	46	20	75.65
Risk management	2	0	22	44	20	74.03
Requirements management	0	3	23	36	26	75.38
Cost Management	1	4	24	38	21	72.40
Schedule Management	0	2	31	38	17	71.32
Project Planning	0	3	26	37	22	73.48
Decision Making	0	1	21	42	24	76.46
Skilled personnel	0	1	28	35	24	74.57
Systems Engineering	0	2	32	33	21	72.13

4.3.2.5 RESULTS FOR THE ENTIRE SURVEY –

Below are the results of the analysis without considering any categories.

Table 19 - Results for the entire survey without any categories

Practices	Not applicable	Least important	Important	Highly important	Crucial	RII %
Technical Factors						
Requirements Identification	3	1	19	47	80	84.13
Systems Testing	6	1	26	64	53	77.30
Systems Integration	5	2	49	56	38	71.43
Quality & Reliability analysis	5	3	43	66	33	71.27
Systems Thinking	5	7	55	60	23	66.51
Feasibility analysis	6	5	66	44	29	65.87
Human Systems Integration	6	11	56	53	24	64.76
Managerial Factors						
Requirements management	1	4	31	58	56	78.41
Project management	0	0	33	72	45	78.10
Decision Making	0	1	35	65	49	78.10
Scope management	0	1	41	63	45	76.51
Project Planning	0	5	38	59	48	76.19
Risk management	2	3	35	68	42	75.40
Skilled personnel	0	3	46	57	44	74.92
Cost Management	1	5	41	69	34	73.02
Schedule Management	0	3	44	74	29	72.86
Systems Engineering	4	5	53	58	30	69.05

4.3.2.6 HENRY GARRETT RANKING METHOD

Data from the survey for Q.8 was analyzed to rank the practices which are most beneficial to their organization with respect to the challenges they face. To rank the practices, Henry Garrett Ranking method is used by following the steps mentioned below.

1. Calculate the Percent Position value.

   This value was calculated by using the following formula (Dhanavandan, 2016).

$$Percent\ position = \frac{100\ (Rij - 0.5)}{Nj}$$

Where, Rij is rank given for the ith variable by jth respondents

Nj is number of variables ranked by jth respondents which is 13 in this case.

2. Once the percent position values are calculated, Garret Values are found by using the "Garrett Ranking conversion table" (Refer appendix B).
3. Next step is to multiply the ranks with the Garret Values and total sum for each practice is calculated.
4. Lastly the average scores are calculated for each practice and they are ranked accordingly.

Results are shown in Table 20.

Table 20 - Ranking of the practices based on Henry Garrett Ranking method.

Practices	Average score	Rank
Requirements management	60.34	1
Scope management	58.65	2
Risk management	55.06	3
Planning	53.72	4
Decision Making	53.26	5
Project management	53.20	6
Feasibility analysis	52.43	7
Systems Thinking	50.33	8
Systems Test and Integration	49.89	9
Quality & Reliability analysis	49.02	10
Human Systems Integration	45.72	11
Systems Engineering	45.36	12
Other	22.01	13

The survey provided an additional option to the participants to include a critical success practice which is not listed in the options. Below are the results of the practices that were not identified by case studies but are important according to the participants.

- Cost Tracking/EV
- Validation
- Project timeline
- Human Resource Management
- Resource Management
- Documentation
- Regulatory Compliance
- Funding and prioritization with competing projects
- Company support
- Cost Analysis
- ROI Confirmation
- Road map
- Time and skill management
- Security Plan
- Communication
- Status Reporting

5 RESULTS

Objective 1. What are the real practices that contribute to a project/product success or failure?

The practices that contribute to the project/product to be successful or failure were identified by the case studies and validated by survey. The list of 12 practices that were identified are tabulated as follows –

Table 21 - List of practices identified.

Scope management	Systems Thinking
Project management	Integration & Testing
Risk management	Human Systems Integration
Feasibility analysis	Quality and Reliability analysis
Requirements analysis	Training employees
Cost & Schedule Management	Effective planning and Decision Making

Objective 2. Among the identified practices, what is the level of importance that these practices hold in terms of benefits to an organization for its project's/product's success when compared to each other?

The level of importance that the above practices hold in a project's/product's success was evaluated by using Henry Garrett Ranking Method. The tabulated result of the practices with their ranking are listed under section 4.3.2.5 with Table 20. The top five practices observed in a project's/product's success are Requirements management (1^{st}), Scope management (2^{nd}), and Risk management (3^{rd}), Planning (4^{th}), and Decision making(5^{th}). It was also observed that Decision making's and Project management's average score (according to Garret Ranking method) are nearly identical with a difference of 0.06. This implies 'Decision Making' and 'Project Management' practices hold equal level of importance when compared to other practices.

Objective 3. What are the technical practices that contribute to the project/product success? and **Objective 4.** What are the management practices that contribute to the project/product success?

The technical practices and managerial practices that contribute to the project/product success were ranked by using RII tool. The tabulated result of the practices with its relative importance are listed under section 4.3.2.4 with table number 19. Top five important Technical practices in a project's/product's success are Requirements Identification (1^{st}), Systems Testing (2^{nd}), Systems Integration (3^{rd}), Quality and Reliability analysis (4^{th}), and Systems Thinking (5^{th}). Top five Managerial practices in a project's/product's success are Requirements management (1^{st}), Project management as well as Decision Making (2^{nd}), Scope Management (3^{rd}), Project Planning (4^{th}), and Risk Management (5^{th}).

It was observed that the relative importance index of Project Management was same as that of Decision Making. This implies both these practices are equally important and thus are ranked second.

Objective 5. What are the top five Technical practices surveyed that contribute to success as evaluated separately based on 1) years of experience of the participants, 2) role of the participant in the organization, and 3) if the participant possesses a certificate in PMI or INCOSE?

Ranking of these practices are based on the value of RII calculated under section 4.3.2.2 - 4.3.2.4. Practices that have similar RII values are ranked equally. Table number 23-25 shows the tabulated results of top five technical practices based on the working experience of participants, role of the participants in the firm, and on whether the participants possess a certificate in PMI or INCOSE.

Table 22 - Top 5 Technical Practices based on Years of experience

Rank	Years of experience			
	0 to 5 years (37 responses)	5 to 10 years (25 responses)	10 to 20 years (35 responses)	20 plus years (53 responses)
1	Requirements Identification	Systems Testing	Requirements Identification	Requirements Identification
2	Systems Testing	Requirements Identification	Systems Testing	Systems Testing
3	Quality & Reliability analysis	Systems Integration, Systems Thinking	Systems Integration	Systems Integration
4	Feasibility analysis	Feasibility analysis, Quality & Reliability analysis	Quality & Reliability analysis	Quality & Reliability analysis
5	Systems Integration	Human Systems Integration	Feasibility analysis	Human Systems Integration

Among the top five technical practices based on years of working experience, four practices (Requirements Identification, Systems Testing, Quality and Reliability analysis, and Systems Integration) are common in all 4 categories. This implies that the views on technical practices are not based on years of experience.

Table 23 - Top 5 Technical practices based on Role in the Firm

Rank	Role in the Firm				
	Engineer (49 responses)	**Engineering Manager (36 responses)**	**Project Manager (49 responses)**	**Marketing/ Sales (4 responses)**	**Other (12 responses)**
1	Requirements Identification	Requirements Identification	Requirements Identification	Systems Integration	Requirements Identification
2	Systems Testing	Systems Testing	Systems Testing	Systems Testing, Quality & Reliability analysis	Systems Thinking, Quality & Reliability analysis
3	Quality & Reliability analysis	Systems Integration	Quality & Reliability analysis	Requirements Identification, Systems Thinking, Human Systems Integration	Feasibility analysis, Systems Testing
4	Systems Integration	Systems Thinking	Systems Integration, Human Systems Integration	Feasibility analysis	Systems Integration
5	Systems Thinking	Quality & Reliability analysis	Feasibility analysis	-	Human Systems Integration

It is observed that top two technical practices for 'Engineers', 'Engineering Managers', and 'Project Managers' are the same practices holding same ranks; Requirements Identification (1^{st}) and Systems Testing (2^{nd}). Another observation is that among the top 5 practices, five practices (Requirements Identification, Systems Testing, Quality and Reliability analysis, Systems Integration, and Systems Thinking) are common in all five categories. This implies that the views on technical practices are not based on the role of responders in their firm.

Table 24 - Top 5 Technical practices based on certification possessed

Rank	Certification possessed	
	No (88 responses)	Yes (62 responses)
1	Requirements Identification	Requirements Identification
2	Systems Testing	Systems Testing
3	Quality & Reliability analysis	Systems Integration
4	Systems Integration	Quality & Reliability analysis
5	Systems Thinking	Human Systems Integration

Among the top five practices, four practices (Requirements Identification, Systems Testing, Quality and Reliability analysis, and Systems Integration) are common in both the categories. This implies that the views on technical practices are not based on the weather responder possess INCOSE/PMI certification or not.

Objective 6. What are the top five Managerial practices surveyed that contribute to success as evaluated separately based on 1) years of experience of the participants, 2) role of the participant in the organization, and 3) if the participant possesses a certificate in PMI or INCOSE?

Ranking of these practices is based on the value of RII calculated under section 4.3.2.2 - 4.3.2.4. Practices that have similar RII values are ranked equally. Table number 26-28 shows the tabulated results of top five managerial practices based on the working experience of participants, role of the participants in the firm, and on whether the participants possess a certificate in PMI or INCOSE.

Table 25 - Top 5 Managerial Practices based on years of experience

Rank	Years of experience			
	0 to 5 years (37 responses)	**5 to 10 years (25 responses)**	**10 to 20 years (35 responses)**	**20 plus years (53 responses)**
1	Requirements management	Decision Making	Project management	Requirements management
2	Decision Making	Risk management	Skilled personnel	Scope management
3	Project management / Project Planning	Project Planning	Scope management, Decision Making	Project management
4	Risk management, Cost Management	Scope management	Risk management	Project Planning, Decision Making
5	Schedule Management	Project management	Requirements management, Schedule Management, Project Planning	Skilled personnel

It is observed that views on the managerial practices do change with years of experience. Among the top five practices, only three practices (Decision Making, Project Management, and Project planning) are common in all four categories. It was also observed that responder with 0 to 5 and responder with more than 20 years of working experience ranked ‘Requirements management’ in first place. On the other hand, responder with 5 to 10 years of experience think ‘Decision Making’ practice is most important. Whereas responders with 10 to 20 years of experience think ‘Project Management’ practice is most important managerial practice.

Table 26 - Top 5 Managerial Practices based on Role in the Firm

Rank	Role in the Firm				
	Engineer (49 responses)	**Engineering Manager (36 responses)**	**Project Manager (49 responses)**	**Marketing/ Sales (4 responses)**	**Other (12 responses)**
1	Requirements management	Project management, Project Planning, Skilled personnel	Scope management	Project Planning	Decision Making
2	Project management, Risk management	Cost Management	Requirements management	Scope management, Cost Management, Schedule Management, Decision Making, Skilled personnel	Requirements management, Project Planning
3	Decision Making	Decision Making	Project management, Decision Making	Systems Engineering, Risk management	Scope management, Project management
4	Skilled personnel	Requirements management	Project Planning	Project management, Requirements management	Skilled personnel
5	Cost Management	Scope management	Risk management	-	Systems Engineering

It is observed that among the top five practices, only three practices (Decision Making, Project Management, and Requirements Management) are common in all five categories. Whereas all the five categories holding the first rank were found to be different. This implies that views on the managerial practices do change with the responder's roles in their firms.

Table 27 - Top 5 Managerial practices based on certification possessed

Rank	Certification possessed	
	No (88 responses)	**Yes (62 responses)**
1	Decision Making	Scope management
2	Project management	Requirements management
3	Requirements management	Project management
4	Skilled personnel	Decision Making
5	Risk management	Project Planning

It is observed that 'Decision Making' is ranked first by the responders without certification. Whereas 'Scope Management' is ranked first by the responders with certification. Thus, large variation in terms of ranking the practices was observed between responders possessing and not possessing certifications. Further, among the top five practices, only three practices (Decision Making, Project Management, and Requirements Management) are common in both the categories. This implies that views on the managerial practices may be influenced on the responder's certification.

6 CONCLUSION AND FUTURE SCOPE

The research conducted was able to fulfill the aim and objectives by answering all the research questions. Ten case studies were conducted with five case studies of successful projects and five case studies of unsuccessful projects. Practices that contributed in success/failure of the project were identified by these case studies. These practices were then refined and combined to get a list of 12 critical success practices (Table 21) that contributes in project's/product's success. These practices were then validated by conducting a survey with working professionals and graduate students as focus groups (150 responses). The primary reason behind conducting the survey was to validate the identified practices. The survey was also used to find the relative importance of the practices with respect to product/project success and to rank those practices which would benefit an organization for its project's/product's success. Data from the survey was analyzed by using Relative Importance Index method and Henry Garrett ranking method to rank the practices. Observations were drawn on the results of the analysis.

The critical success practices (Table. 3) which were identified through case studies were validated by the conducted survey as none of the practices identified achieved high number of 'Not applicable' or 'Least important' ratings. Through the survey, this study also captures and understands the views of people from different background and experience (Table 22-27). It was also observed that top six beneficial practices to an organization for its project's/product's success, the top six important practices for a product's/project's success identified by Project managers and those identified by responders with PMI certification are same set of practices. It was also observed that 81.63 % of project managers had PMI certification. Thus, it can be said that the PMI certification/education helps to target right practices to address for a product's/project's success. It was also observed that top six beneficial practices to an organization for its project's/product's success are all managerial practices. This implies that improvement in Managerial practices is the current need for organizational benefit.

Thus, in conclusion the study was able to identify, evaluate and rank the critical success practices for a wide range of projects/product and gain understanding regarding the importance of practices from the perspectives of working professionals with diverse background.

Further research on exploring/developing, existing or new management tools to improve the adoption of these identified practices for more successful projects would be beneficial.

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APPENDIX A: SURVEY QUESTIONNAIRE

Q.1 What is your profession? pick all which apply

a) Manager

b) Technical Professional

c) Director

d) Other:______________________________________

Q.2 In what general type of industry are you currently employed? Please select all that apply.

a) Manufacturing

b) Aerospace

c) Automobile

d) Energy

e) Information Technology

f) Defense

g) Academic

h) Other:__________________________________

Q.3 What is your total industrial work experience?

a) 0 to 5 years

b) 5 to 10 years

c) 10 to 20 years

d) More than 20 years

Q.4 How do you identify yourself? Please select all that apply.

a) Engineer

b) Manager

c) Marketing/ Sales

d) Manufacturing engineer

e) Project manager

f) Technical manager

g) Other:____

Q.5 Do you possess any certification related to Project management or Systems Engineering? click all that apply

a) PMI certification

b) INCOSE SE certification

c) No

Q.6 Please rate the following **technical** factors with respect to their importance in terms of project success. (Here project success could be generalized as achievement of the predetermined project goal on time, within budget and ensuring respective stakeholder's satisfaction.)

	Not applicable	**Least important**	**Important**	**Highly important**	**Crucial**
Feasibility analysis					
Requirements Identification					
Systems Thinking					
Systems Integration					

	Not applicable	Least important	Important	Highly important	Crucial
Systems Testing					
Human Systems Integration					
Quality & Reliability analysis					

Q.7 Please rate the following **management** factors with respect to their importance in terms of project success. (Here project success could be generalized as achievement of the predetermined project goal on time, within budget and ensuring respective stakeholder's satisfaction.)

	Not applicable	Least important	Important	Highly important	Crucial
Scope management					
Project management					
Risk management					
Requirements management					
Cost Management					
Schedule Management					
Project Planning					
Decision Making					
Skilled personnel					
Systems Engineering					

Q.8 In your organization, improvements in what area would be most beneficial Please rank them on the scale 1 to 13, where 1 being biggest challenge.

______ Scope management

______ Project management

______ Risk management

______ Requirements management

______ Feasibility analysis

______ Systems thinking

______ Quality & Reliability analysis

______ Human Systems Integration

______ Decision Making

______ Planning

______ Systems Test and Integration

______ Systems Engineering

______ Other

______________________________END OF SURVEY____________________________

APPENDIX B: GARRETT RANKING CONVERSION TABLE

This table is used to calculate the Garrett values from percent position values. (Dhanavandan, 2016).

GARRETT RANKING CONVERSION TABLE

The conversion of orders of merits into units of amount of "socres"

Percent	Score	Percent	Score	Percent	Score
0.09	99	22.32	65	83.31	31
0.20	98	23.88	64	84.56	30
0.32	97	25.48	63	85.75	29
0.45	96	27.15	62	86.89	28
0.61	95	28.86	61	87.96	27
0.78	94	30.61	60	88.97	26
0.97	93	32.42	59	89.94	25
1.18	92	34.25	58	90.83	24
1.42	91	36.15	57	91.67	23
1.68	90	38.06	56	92.45	22
1.96	89	40.01	55	93.19	21
2.28	88	41.97	54	93.86	20
2.69	87	43.97	53	94.49	19
3.01	86	45.97	52	95.08	18
3.43	85	47.98	51	95.62	17
3.89	84	50.00	50	96.11	16
4.38	83	52.02	49	96.57	15
4.92	82	54.03	48	96.99	14
5.51	81	56.03	47	97.37	13
6.14	80	58.03	46	97.72	12
6.81	79	59.99	45	98.04	11
7.55	78	61.94	44	98.32	10
8.33	77	63.85	43	98.58	9
9.17	76	65.75	42	98.82	8
10.06	75	67.48	41	99.03	7
11.03	74	69.39	40	99.22	6
12.04	73	71.14	39	99.39	5
13.11	72	72.85	38	99.55	4
14.25	71	74.52	37	99.68	3
15.44	70	76.12	36	99.80	2
16.69	69	77.68	35	99.91	1
18.01	68	79.17	34	100.00	0
19.39	67	80.61	33		
20.93	66	81.99	32		