



CHALMERS
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Project Management through the lens of Artificial Intelligence

A Mixed-Methods Research into How AI
Systems can Support Project Managers to
become more Efficient in their Daily Work

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Abstract

“Artificial intelligence has had much the same effect as Darwin’s theory. Both aroused in some people anxieties about their own uniqueness, value and worth.”

– Herbert A. Simon

Herbert A. Simon painted a very real picture of the perception regarding artificial intelligence systems in the world. Despite wide recognition of the potential benefits of using these systems to improve human lives today, the uncertainty related to new technology as well as the lack of systematic knowledge related to the potential of AI systems has led to a slow progress of development in this regard.

Project management as a function is going through a revolutionary phase of change brought on by the digital era. This, among other factors, has prompted project managers to look towards finding new and creative ways to work better and more efficiently through the use of technology. Artificial intelligence for project management is a specific area of focus that has so far not been looked into and remains largely unexplored, especially in light of the upcoming digital era.

This study is a pioneer in this regard and is an exploratory investigation into how artificial intelligence systems can be used to support project managers with becoming more efficient in their daily work. In order to achieve a preliminary understanding, an online survey first was conducted amongst project managers. The results of the survey were used to supplement the second step in the research process which consisted of semi-structured interviews with project managers to gain an in-depth understanding of the topic as well as to find areas of opportunities which can be used for future research and developments.

The research proved quite fruitful in understanding and establishing the needs of the project managers who were involved directly in this investigation as key stakeholders. The study has also been successful in establishing a foundation for AI scientists to use for the purpose of developing tailored solutions for project managers.

Content

Acknowledgements	2
Abstract.....	3
List of Abbreviations.....	6
List of Figures	7
List of Tables.....	7
1. Introduction	8
1.1. Background	8
1.2. Aim & Purpose	9
1.3. Scope of Research	9
2. Theoretical Framework.....	10
2.1. Industry 4.0	10
2.2. Artificial Intelligence	10
2.2.1. Types of AI Systems.....	11
2.3. Project Management.....	13
2.3.1. Fundamentals of Project Management	14
2.3.2. Future of Project Management.....	16
2.4. Artificial Intelligence for Project Management	18
2.5. SWOT Analysis	19
3. Methodology.....	21
3.1 Research Strategy	21
3.2 Research Design	21
3.3. Research Process	22
3.4. Quality of Research	24
3.4.1. Reliability.....	24
3.4.2. Replicability.....	24

3.4.3. Validity.....	25
3.5. Ethical Considerations	25
4. Results	27
4.1. Survey.....	27
4.1.1. Artificial Intelligence	27
4.1.2. Project Management.....	30
4.1.3. Organizational Business.....	34
4.2. Interviews	36
4.2.1 Project Management.....	36
4.2.2. Artificial Intelligence	44
5. Analysis & Discussion	49
5.1. Needs of the Project Management Community.....	49
5.2. Awareness of Artificial Intelligence Systems	50
5.3. Building Artificial Intelligence Systems for Project Managers.....	52
5.4. Implementing AI for Project Managers in Organizations.....	53
6. Conclusions.....	55
6.1. Recommendations for Future Studies	56
Bibliography.....	58
Appendices	62

List of Abbreviations

AI	Artificial Intelligence
ANI	Artificial Narrow Intelligence
AGI	Artificial General Intelligence
ASI	Artificial Super Intelligence
MIT	Massachusetts Institute of Technology
PM	Project Manager
PwC	PricewaterhouseCoopers
SME	Small and Medium Enterprise
SWOT	Strengths, Weaknesses, Opportunities and Threats

List of Figures

Figure 1: Iron Triangle of Project Management.....	14
Figure 2: Future trends that will have a direct impact on project management (Source: Arup; UCL; APM, 2018, pp.13)	17
Figure 3: Research process for this study	23
Figure 4: Frequency of responses per case organization.....	27
Figure 5: Knowledge distribution amongst project managers regarding AI systems.....	28
Figure 6: Use of AI systems amongst project managers	28
Figure 7: Willingness to use AI systems in the future.....	29
Figure 8: Percentage of AI system use in the case organizations.....	29
Figure 9: Project Management experience level among the respondents.....	30
Figure 10: Types of projects	31
Figure 11: Challenging aspects in project management	31
Figure 12: Aspects of project management where support is needed.....	32
Figure 13: Challenging aspects of project management which could use AI support.....	33
Figure 14: Comparable overview of responses from figures 11, 12 and 13.	33
Figure 15: Responses regarding organizational strategy for dealing with AI systems	34
Figure 16: Responses regarding whether or not the organization should have a strategy for dealing with AI systems.....	35

List of Tables

Table 1: Basics of a SWOT Analysis (Adapted from: Morrison, 2008).....	20
Table 2: Summary of the interviewee reference and case organization background.....	36
Table 3: SWOT Analysis for the future implementation of AI systems.....	52

1. Introduction

Artificial Intelligence (AI) has become one of the most deeply researched and developed technologies in recent years. From smart personal assistants to self-driving vehicles, artificially intelligent systems have swiftly made their way into real world applications and continue to do so at an exponential pace. As AI systems, robots, and cognitive tools become more sophisticated, almost every job is being reinvented, creating what many call the augmented workforce (Arup; UCL; APM, 2018). These developments are leading to a major change in the nature of work and subsequently, in the nature of demands that are arising from the future workforce. A survey conducted by Deloitte among 10,000 HR and business leaders in 140 countries concluded that organizations will have to reanalyze how they design jobs, organize work, and plan for future growth (Schwartz et al., 2017).

A broad range of trends and challenges have a direct impact on the future of project management (Arup; UCL; APM, 2018). Artificially intelligent systems are one of them. There is the wider debate regarding whether project management will remain a profession in its own right or whether it will merge with the wider management practice (Arup; UCL; APM, 2018). Regardless of this and despite the probability that more and more professions will be replaced by increasingly capable systems, the fundamentals of project management will continue to provide an irreplaceably human combination of leadership, integration of specialists, and ethical behaviour.

1.1. Background

Technologies that seemed too theoretical to only exist at most in science fiction movies merely decades ago are a reality in today's world. Self-driving vehicles, talking robots and personal assistants are just a few of the practical examples to illustrate this fact. This fast-paced growth and development has been acutely contextualized by Makridakis (2017) who observed that smartphones today are just as powerful, if not more, as the supercomputers that existed merely a decade ago.

In order to fully realize the potential of technologies to enable efficient growth for the future, it is crucial to understand what is coming next and what is the impact of the latest

industrial revolution on humans and on the planning of the future workforce. While there is immense research into the technical development of AI systems, there is a lack of focus on how these systems will directly impact various functions, such as project management, within an organization.

1.2. Aim & Purpose

At the onset of the inevitably “smarter” future, and due to a lack thereof, the aim of this research is to investigate and analyze how AI systems can help increase the efficiency of project managers within project management. The main research question therefore is: *“How can AI systems support Project Managers to become more efficient in their daily work?”*

The driving factor behind this research is to view artificial intelligence as an ally that can potentially help transform project management as a function in its own right and bring it up to a new level from which project leaders and organizations as a whole can reap maximum benefits. It is also hoped that this research will influence future studies into related aspects for various other functions within an organization.

1.3. Scope of Research

This research will be conducted through the analysis of empirical data via surveys and interviews collected from project managers in various organizations. The scope includes aspects such as identification of challenges that project managers face in their daily operations, gauging the awareness and usage, if any, of artificial intelligence systems and subsequent identification of use cases for the potential incorporation of AI systems into the project management lifecycle.

The research into this focus area is limited to the theoretical review and empirical analysis of the potential management and operational influence of AI systems on project management and does not cover the scientific or technical development of AI systems. This research is also limited to the subjective data collected from project managers relative to the organizational environment they were operating in at the time at which this study was conducted.

2. Theoretical Framework

In this section, scientific research, theoretical frameworks and previous studies relative to the topic of research in this context will be presented to form the background.

2.1. Industry 4.0

The human race is undergoing significant change brought on by the fourth industrial revolution, more commonly referred to as Industry 4.0. From coal-powered steam engines which marked the first industrial revolution, electrification and automation which marked the second industrial revolution to digitization that followed the advent of the internet, marking the third industrial revolution, the progress has been swift and rife with innovation (Brettel et al., 2014). Rüßmann et al. (2015) argue that technological advancements in the fields of digitization, artificial intelligence, augmented reality, big data analytics and internet of things, among a few others, form the fundamental elements upon which Industry 4.0 is being fostered and developed.

This new era has already seen successful real-world testing of self-driving vehicles and human-like robots. The on-going digital transformation has made human-machine interaction within organizations an inevitable reality for the future. It has subsequently led to a swift change in the nature of demands from the future workforce in the face of the very real possibility of humans and machines working side-by-side. Organizations must rethink the ways in which business is conducted in order to remain competitive in a market regularly disrupted by new innovations. Albach et al. (2015) argue that “*managers must adapt their companies under permanent change*” and assert that “late comers” end up fighting to keep up with the rapid pace of changes. The answer, therefore, lies in staying ahead of the curve by investigating the potential of integrating innovative solutions, such as those brought on by artificial intelligence, in to day-to-day business.

2.2. Artificial Intelligence

Artificial intelligence is a branch of the computer science field in which scientists are attempting to develop enhanced intelligence within computer systems (Nilsson, 2010). Russel and Norvig (1995, pp. 5) described AI using one explanation as “*the art of creating*

machines that perform functions that require intelligence when performed by people". Investments into the research and development within this area have grown significantly over the past few years due to the unprecedented benefits for the human-machine collaborative future. 200 AI-related companies raised 1.5 billion US dollars in the market within the first six months of 2016 (Pan, 2016). The practical applications of AI range far and wide, from smart personal assistants to intelligent systems that enable facial recognition, for example. AI supporters regard smart machines as the only hope for ensuring the long-term survival of humankind where as critics or "skeptics" are cautious of the unforeseeable negative impacts of uncontrollable AI (Gurkaynak, Yilmaz and Haksever, 2016).

2.2.1. Types of AI Systems

Artificial intelligence systems have been scientifically classified into three known categories (Gurkaynak, Yilmaz and Haksever, 2016) as follows:

Artificial Narrow Intelligence (ANI): ANI systems, also known as *Weak AI*, are the type of AI that are developed for the purpose of performing a specific task and can only be specialized within a narrow functional area. While such computers or systems can be programmed to make several hundred thousand calculations per second, they are limited in their performance capabilities by the parameters that are pre-defined by their developers (Gurkaynak, Yilmaz and Haksever, 2016).

For instance, IBM developed a supercomputer known as Deep Blue which was programmed to play chess. In February 1996, Deep Blue was pitted against Garry Kasparov, a world reigning chess champion, for the first time. The ANI lost this first match. A rematch was held in May, 1997 in which Deep Blue became the first computer program to defeat a human being. This was a significant milestone for artificial intelligence systems at the time. Deep Blue was capable of identifying and analyzing up to 60 billion moves within a three minute time period generally allowed for contestants to make their next move but it was incapable of learning and could therefore make the same mistakes again and again (Makridakis, 2017). It's programming was based on a simple if-then logic and so the ANI could not evolve beyond it.

IBM went a step further to develop their next supercomputer, Watson, which went on to defeat two reigning champions in the infamous American live-quiz show called Jeopardy in February, 2011. Watson, the product of a 5-year research and development project (TechRepublic, 2018), could not only process and understand the English language, it could also intercept puns to analyze the meaning of clues before providing an answer. The supercomputer was additionally capable of learning from its mistakes (Makridakis, 2017) and certainly took ANI systems to the next level.

Artificial General Intelligence (AGI): AGI systems, also referred to as *Human-Level AI* (Goertzel, 2007), represent the type of AI systems that can mimic humans at every level and can, in theory, perform all kinds of tasks that humans can. The theory of these types of “thinking machines” was first posited by Alan Turing (1950) who developed the *Turing Test* to experiment the possibility of Human-Level AI (McCarthy, 2007). The test is formed by arranging a conversational text exchange between:

- A human tester
- Other humans
- AI system being tested

The AI system being tested is developed to simulate and “converse” like a human. If the human tester can successfully distinguish between the test subjects and identify the AI system within the text exchange, the AI system has thereby failed the test and vice versa. The Turing test became a well-known benchmark for future developments of AGI systems and has infamously been regarded as the *Imitation Game*. However, not all AI theorists believe it to be sufficient. Millican et al. (1996) even criticized the test as far as to argue that the race towards computing machinery and intelligence has diverted attention from the much-needed focus on developing AI with intellectual tools as opposed to intellectual statues.

Several experiments conducted over the years and their subsequent findings suggest that activities that are time consuming and tedious for humans, such as complex calculations, can be performed in seconds by AGI systems. However, AI scientists and engineers have found that tasks that are much more simpler for humans such as those which require the inherent utilization of cognitive skills, for example to open a door or to recognize voices, pose a larger challenge for artificial general intelligence systems. This is mainly due to the

difficulty in presenting predetermined conditions for AI systems to identify all the possibilities in any given scenarios which are highly subject to change, and thus become “random scenarios” for the AGI, in the real-world (Gurkaynak, Yilmaz and Haksever, 2016). This requires a new level of development for AI systems, categorized by the terms “machine learning” or “deep learning”, which emphasize the development of AI systems that can think for themselves (Makridakis, 2017).

AGI systems will truly reach maturity when cognitive skills will be fully incorporated into their systematic development to make the execution of “simple human tasks” a real possibility for these supercomputers.

Artificial Super Intelligence (ASI): ASI systems are predicted to be the type of AGI systems that will evolve exponentially to overtake humans in practically every field including science, cognitive thinking and social skills. They also represent the type of AI that will, according to some theorists, “take over” humankind and lead to a phenomena which is infamously known as *singularity*.

There is a certain degree of disparity in the scientific community regarding the predictability of the actual occurrence of the point of singularity. Kurzweil (2005) predicts that singularity could be reached as early as 2045. Gurkaynak, Yilmaz and Haksever (2016) argue that due to the human bias towards linear progress of nature, humans will actually fail to notice the arrival of ASI systems until after they become a part of daily human lives. This means, in essence, that humans may be closer to reaching singularity than anticipated - or vice versa.

2.3. Project Management

The Project Management Institute (PMI, 2018) has defined project management as a “*temporary endeavour undertaken to create a unique product, service or result.*” Seymour and Hussein (2014, pp.233) elaborate that project management as a core function is primarily involved with “*creating an environment where people can work together to achieve a mutual objective, in order to deliver successful projects on time and on budget.*” The ultimate aim is to involve and influence all stakeholders to create something new and

different, and to bring a change, in a rapidly volatile environment (Boddy, 2002). People from different functions of an organization, sometimes even from different organizations, work together in a project team and may not necessarily work together again once the project is over (PMI, 2018).

The advent of project management can be traced as far back as the time when the pyramids of Egypt were built. It is unclear who first coined the terminology to refer to this management function as “project management” but the discipline has been developed and refined over time, with initial strategic uses restricted to the construction industry over 70 years ago. Organizations began applying and documenting specialized tools and techniques to complicated projects in the early 1950’s (Kerzner, 2013).

2.3.1. Fundamentals of Project Management

The basic principles of project management revolve around the infamous constraints, also referred to as the *Iron Triangle*, as illustrated in the figure below:



Figure 1: Iron Triangle of Project Management

Cost: The defined cost, also known as the budget of the project, is an important factor to manage for the project’s success (Wysocki, 2013). It is considered a success factor to complete a project within or below the approved budget. Forecasting plays a major role in developing the budget and often, an estimated budget can determine whether or not a project has the green light to proceed beyond the planning stage (Marle and Vidal, 2016).

Time: Time is related to the specified deadline of the project and is a very critical, uncontrollable aspect of project management. It is inversely related to cost, such that if the specified duration of the project is reduced, the costs to complete the project will increase (Wysocki, 2013). It is key for a project manager to keep the project going on schedule as lost time can not be recovered.

Scope: The scope of a project, also sometimes referred to as the business case or specification, defines the limitations of the project to clarify what is included as well as what aspects are not included in the project (Wysocki, 2013). It is the aspect which is subject to change more often than not and therefore requires constant adaptations of the other critical aspects of the project.

Quality: Quality can be categorized into two types (Wysocki, 2013):

- A. **Product Quality:** This refers to the quality of the deliverable of the project and often requires careful scrutiny to maintain a good output.
- B. **Process Quality:** This refers to the quality of the project management process and focuses the lens on how well-executed the process has been in the past, and how can it be improved (Wysocki, 2013).

Marle and Vidal (2016) assert that ensuring a good quality of the project also means satisfying all the stakeholders who can often hold different opinions regarding the success of a project.

The project management constraints form an independent set such that a change to one aspect affects the others and necessitates changes to one or more aspects within the triangle in order to maintain an equilibrium based on the pre-defined parameters of the project (Wysocki, 2013).

The Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK, 2013) is a universal guide for project management in which five key stages that form the process of project management are defined and explained as follows:

- 1. Project Initiation:** This is the stage in which the benefits of conducting a project are recognized and the project is sanctioned (Kerzner, 2013).

2. **Project Planning:** This is the stage in which the basic parameters, such as those explained in the *Iron Triangle*, of the project are defined, activities are scheduled and risks are evaluated (Kerzner, 2013). The project team is also allocated here.
3. **Project Execution:** The team begins the project work in this stage and the project manager directs and manages the work (Kerzner, 2013).
4. **Project Monitoring and Control:** The progress of the project is tracked and evaluated from the start of the project in this stage. Adjustments are made where needed if it seems like the pre-defined objectives can not be met as planned (Marle and Vidal, 2016).
5. **Project Closure:** This is the last stage of the project management process in which all the activities of the project are finalized, the contract is settled and the finances of the charged numbers are closed (Marle and Vidal, 2016).

Kerzner (2013, pp.3) asserts that successful project management merits the acceptance of the end-result by the customer in addition to being completed within time, within the budget, at the desired level of quality as well through the efficient utilization of resources.

2.3.2. Future of Project Management

The leaders of various organizations have acknowledged that in order to obtain the solution to most of the corporate problems in light of emerging technologies, the management team must make efforts to look at how various activities and functions are managed within the organization. This requires a holistic approach to look deeper within, internally rather externally (Kerzner, 2013). As such, project management is one of the functions for which efforts have been made to re-evaluate, and reorganize activities on a large scale.

One such joint effort in this regard has been made by an organization called Arup, The Bartlett School of Construction and Project Management at University College London, and the Association for Project Management (APM)'s report entitled *Future of Project Management* (Arup; UCL; APM, 2018). The investigation looked into three aspects, one of which evaluated the future through the lens of new megatrends that will undoubtedly affect the project management community (Arup; UCL; APM, 2018). The report highlighted 7 key aspects that will affect the future as shown in the figure below:



Figure 2: Future trends that will have a direct impact on project management. Source: Arup; UCL; APM, 2018, pp.13

The sixth trend highlighted in Figure 2 is regarding automation and human-machine collaboration. The report suggested that smart user interfaces will require changes to workplace structures in order to maintain collaboration and communication, all the while ensuring a good environment for fostering productivity and creativity in the workforce (Arup; UCL; APM, 2018, pp.21). It is also postulated that cognitive human skills such as strategic decision-making, empathy, and communication could become even more valuable, while organizations will have to *“rethink the role of people and provide training to prepare their employees for this new work environment.”* (Arup, 2018, pp.22). The report further concludes that *“businesses might soon start dividing skills and reframing jobs according to, on one hand, essential human skills, and, on the other, nonessential tasks that could be carried out by machines.”*

Another study by PricewaterhouseCoopers (PwC, 2018) has ascertained that AI will undoubtedly transform project management beyond the standard level of data integration and task automation that is generally associated with these systems. According to the report (PwC, 2018), AI will bring project management into a new era which can which will include the use of chat-bot project assistants, machine learning-based project management as well as autonomous project management. The authors state that while AI systems will change how projects are managed and delivered (PwC,

2018) they will still lack the human touch. This will ensure the long-term need for human project managers even in the AI-dominant future because while core project management elements could be replaced by AI systems, the tasks which will require pure cognitive skills such as leadership, empathy, emotional intelligence and negotiation will still require human conduct. The report concludes that AI systems will assist, not replace, project managers, where only those who understand the true value added by AI systems will succeed in the future (PwC, 2018).

These findings paint an interesting picture for the future of project management and highlight that there is a lot of work to be done in order to prepare project managers to work efficiently in the human-machine collaborative environment. Technological innovation will be the core of the future and it is pertinent to prepare well ahead of time. These researches will also be used to analyze and explore opportunities for AI system uses within project management in this study.

2.4. Artificial Intelligence for Project Management

In the pursuit of enabling project managers to become more efficient, experts have already begun developing smart solutions using AI systems to help project managers.

AI enthusiasts from Feature Labs in the US, Accenture and MIT (Feature Labs, 2016) collaborated to develop a smart AI system specially for project managers. The experts made use of training data from 1,762 previous projects where the total number of reports was found to be 438,580, i.e. 249 reports on average for each project. The experts in this project set out to build a predictive model that could identify critical project issues ahead of time so as to help the project managers prepare in advance to deal with the said issues. The developers involved project managers, i.e. the subject matter experts, in this process to ensure that the resulting product catered to solving their problems.

After conducting several discussions with project managers, they designed the system to predict issues four weeks ahead of time and so, previous projects that consisted of training data from at least 28 days were included in the development, testing, and validation stages. As a result, the developers successfully produced a system that made

predictions not only using previous data but using new, live data as well. An interactive user interface (UI) was incorporate into the system to make it compatible for use by small and medium enterprises (SMEs). Project managers can log in to the system and check to obtain predictions regarding his/her projects. Machine learning models to produce the predictions (Feature Labs, 2016) power the system.

The AI scientists believe that the set of problems used to develop this particular application are transferable to a wider range of real world problems, thus making the AI system for project managers quite adaptable for various use cases in the future.

This project is the successful outcome of two sets of stakeholders working closely together to achieve the desired results and will be used as a foundation for recommendations that will be made for AI-led solutions within the project management area for the purpose of this research.

2.5. SWOT Analysis

SWOT is an acronym for **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats. This technique originated sometime in the 1960s and was pioneered by Albert Humphrey during a project at Stanford University to investigate why corporate planning failed (Morrison, 2008). The analysis is a helpful tool for organizations and individuals when it comes to reviewing progress, strategizing, and making decisions for the future. The matrix is designed to enable a dual-overview of aspects as illustrated in the table below:

Table 1: Basics of a SWOT Analysis (Adapted from: Morrison, 2008).

SWOT Analysis	Helpful towards achieving a goal	Risks towards achieving a goal
<p><i>Internal Perspective</i></p> <p>Factors of the organization or individual</p>	<p>Strengths</p> <p>Activities that are working well currently; should be maintained and used as leverage</p>	<p>Weaknesses</p> <p>Activities that are not working well, and should be either improved upon or stopped</p>
<p><i>External Perspective</i></p> <p>Factors of the environment in which the organization or individual operates</p>	<p>Opportunities</p> <p>Activities that are good for the future; should be prioritized and built upon</p>	<p>Threats</p> <p>Activities that are bad for the future, and need a strategy to be managed or countered</p>

As explained in the table above, the SWOT analysis can help identify key factors such as competitive advantages and opportunities for future development while preparing the organization for oncoming threats at the same time. Similarly, it can enable an individual to plan for a fruitful future career path and provide guidelines for distinguishing oneself from competitors.

The SWOT matrix can be applied to project management as a function to investigate the potential opportunities and threats for the future under the microscope of artificial intelligence systems. This feat will be attempted in this research.

3. Methodology

This section consists of a detailed explanation of the research method, design as well as process that was chosen to conduct this study. The parameters involved for ensuring a good quality of research as well as ethical considerations that were made during the research design will also be explained to ensure that this study fulfilled the necessary criterion to be considered as that of good quality.

3.1 Research Strategy

The two fundamental forms of research strategies are:

1. Quantitative: This is the type of research which implies quantification in the collection and analysis of data and usually employs a deductive method of reasoning which has the following process flow (Bryman and Bell, 2015):
Theory -> Hypothesis -> Data Collection -> Findings -> Hypothesis Confirmed or Rejected -> Revision of Theory
2. Qualitative: This research strategy involves more focus on words rather than on quantification and employs an inductive method of reasoning which is basically the opposite of deductive reasoning (Bryman and Bell, 2015). The outcome of a deductive reasoning process usually leads to the formation of a new theory.

In this study, a mixed strategy has been used which involved both, quantitative as well as qualitative methods with no specific focus on the reasoning methods due to the lack of a theory in this specific focus area which was identified during the theoretical review phase. The research approach will be detailed further in the subsequent sections.

3.2 Research Design

The nature of this study is highly exploratory as it aims to establish an understanding of how, if at all, can AI systems be used to benefit project managers in improving the efficiency of their daily working lives. This research objective is considered to be exploratory also due to the fact that there is currently non enough research or theoretical

ground work in this specific area of focus at the time during which this study was conducted.

The research design employed in this study can be regarded as similar to a cross-sectional design. This type of research is usually conducted at a specific point in time in order to collect quantitative or quantifiable data using multiple case studies (Bryman and Bell, 2015, pp. 53). Bryman and Bell (2015) assert that a case can be considered to be a single person, organization, location or even an event. In order to obtain a broad overall perspective, it was deemed important to collect data from multiple project managers from within various organizations in order to identify patterns and make connections where possible. Therefore, the cross-sectional design was deemed fit for this study.

3.3. Research Process

The theoretical review which was done at the beginning of this study lead to the identification of a major lack of existing theories or frameworks with regards to the role and impact of new and emerging technologies on specific competence areas such as project management. It was also established that there is not enough existing research and development focus on how an emerging technology such that of AI systems could help project managers specifically.

Therefore, in order to ensure that an accurate understanding of project managers' needs and wants could be established and subsequently used to develop a strategy relative to AI systems, this mixed-methods research design was divided into two parts:

1. **Online Survey:** The first step in this research process was conducted using a survey which was distributed online to project managers. In this survey, the questions were divided into three categories:
 - a. Project Management
 - b. Artificial Intelligence
 - c. Organizational Business

The survey was carried out amongst project managers in various organizations belonging to a wide range of industries to gather a broad perspective. The nature of the questions in the survey were defined across a wide spectrum for the project managers (Appendix A), some requiring them to provide either Yes/No answers while some enabling multi-select options as well as options to add their own answers.

The results of the survey were then used to identify trends and were also used to develop the questions for the second part of the research process which is explained next.

2. Interviews: An interview guide (Appendix B) was developed with semi-structured interview questions with the following categories:

- a) Project Management
- b) Artificial Intelligence

The in-depth interviews were conducted with 9 project managers, all of whom answered the survey, and who belong to 5 different organizations.

The entire research process is illustrated in the Figure below:

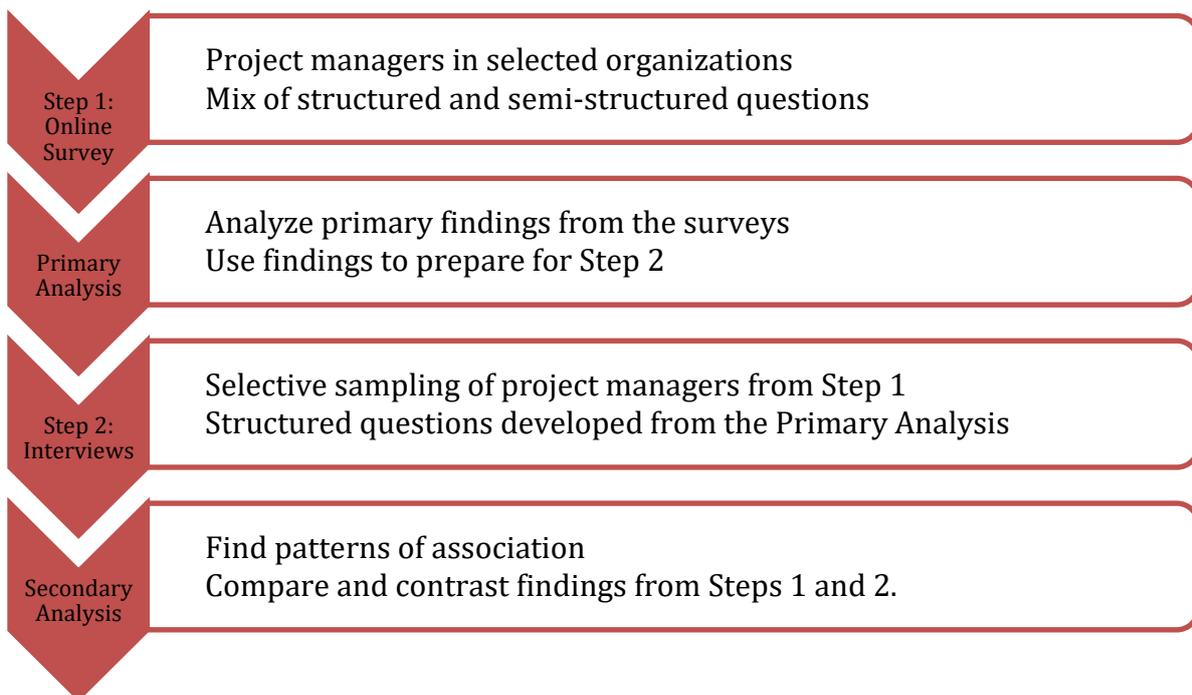


Figure 3: Research process for this study

The findings from Steps 1 and 2 of the research process were compared and analyzed in order to understand the needs of the project managers, identify areas of opportunities within the area of artificial intelligence that could be used to help them, as well as to identify strengths, weaknesses and threats towards future implementations of AI systems for project managers.

3.4. Quality of Research

According to Bryman and Bell (2015, pp. 41), there are three important criteria for evaluating the quality of business and management research: reliability, replication, and validity.

3.4.1. Reliability

This term refers to whether or not the research design for a study is consistent and is often related to whether or not the results of a study are repeatable (Bryman and Bell, 2015). One of the more prominent factors when considering if a measure is reliable or not is known as *Stability*. This means that if a research method is applied to a group at one point in time and then reapplied to the group at another point in time, the emerging results should theoretically have little or no variation to them (Bryman and Bell, 2015, pp. 158). These factors are, more often than not, considered as measurements of quality for quantitative research methods.

The online survey, which was conducted during this study, resulted in responses that were gathered over a period of nearly 2 months. Since the respondents did not receive any additional information about the study during this period, this measure can be considered as reliable. However, if the online survey was to be repeated a year later, it could be argued that the respondents' knowledge about AI systems could have changed over that period and therefore their answers could vary at the new point in time. This means that this measure of the study can not be regarded as stable.

3.4.2. Replicability

Bryman and Bell (2015) describe reliability to be closely related to *Replicability*, i.e. the ease of replicating the methods of research used in one study for the purpose of

conducting another study (Bryman and Bell, 2015, pp. 41-42). In this regard, if a researcher does not describe the research process in good detail, it will be impossible for another researcher to replicate it.

The research strategy, design, and process used in this study have been detailed thoroughly in sections 3.1, 3.2, and 3.3 of this report. The survey (Appendix A) as well as interview guide (Appendix B) are also available for reuse by future researchers. Therefore, this study can be considered as highly replicable and reliable.

3.4.3. Validity

Bryman and Bell (2015, pp. 159) describe validity as “... *the issue of whether or not an indicator (or set of indicators) that is devised to gauge a concept really measures that concept.*” This definition is also used more specifically to describe Measurement Validity. Validity is quite related to reliability such that if a measure is not reliable, it can not be valid (Bryman and Bell, 2015, pp. 42).

Since the reliability of this study was successfully established earlier in this section, it can be concurrently stated that this study is valid. The research strategies employed to answer the main research question proved conclusive and successful in doing so at the end of study.

3.5. Ethical Considerations

There are several ethical considerations which were taken into account while conducting this study.

Before conducting the online surveys, all respondents were assured of confidentiality, such that their responses would be presented in an overall context without any connection to their personal background or organizations. In the presentation of results, the personal data of the respondents was anonymized and only aspects such as their experience levels and industrial background were used for relativity. The respondents were also assured that the survey was being conducted for research and educational purposes only.

Before conducting the interviews, all respondents were informed about the process which involved recording of the conversations which would only be used for transcription of the interviews to ensure accuracy of the data before its analysis. The purpose of this study was also made clear to everyone prior to the interviews. The respondents were assured that all their private data and company information would be completely anonymized and this was followed through in the presentation of results.

The findings of this study do not implicate any specific individual or organization and are intended to be used to support the project management professional community as a whole.

4. Results

The results of the survey and case interviews will be presented and commented on in this section of the report.

4.1. Survey

A total of 56 respondents with project management experience in diverse fields from various organizations responded to the survey and the results are presented in this section.

A summary of the frequency of responses from each case company characterized by the nature of their core business is illustrated in Figure 4 below:

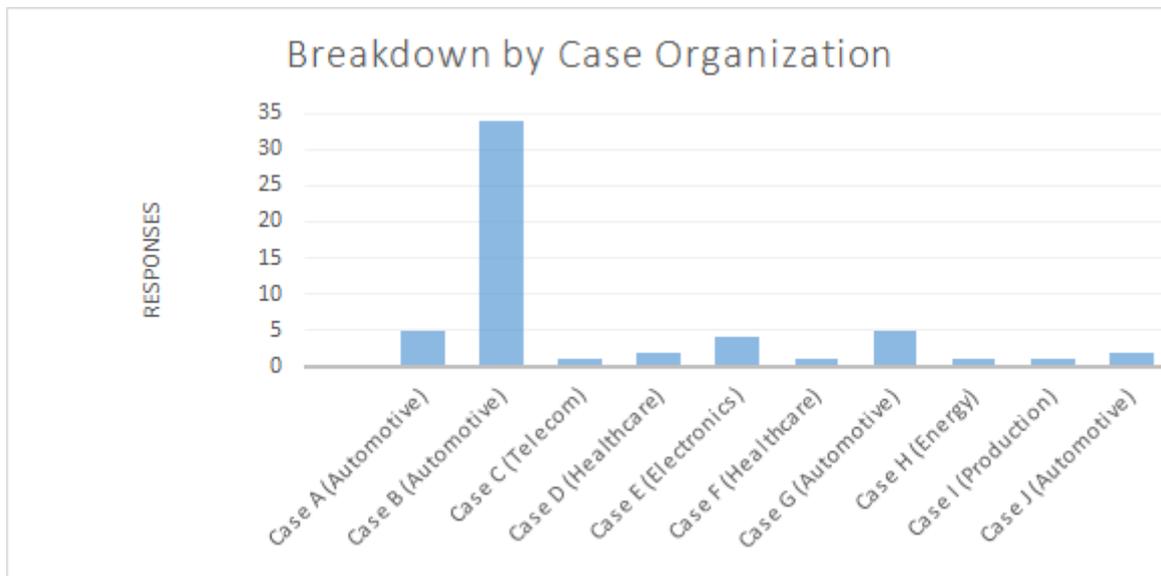


Figure 4: Frequency of responses per case organization

4.1.1. Artificial Intelligence

This section of the survey was designed to assess the level of knowledge of AI systems amongst the project managers, among other aspects such as the current extent of use and willingness to use AI systems in the future.

One of the very first questions (Yes/No) was about determining the awareness of AI systems among the project managers and the response is illustrated in Figure 5 below:

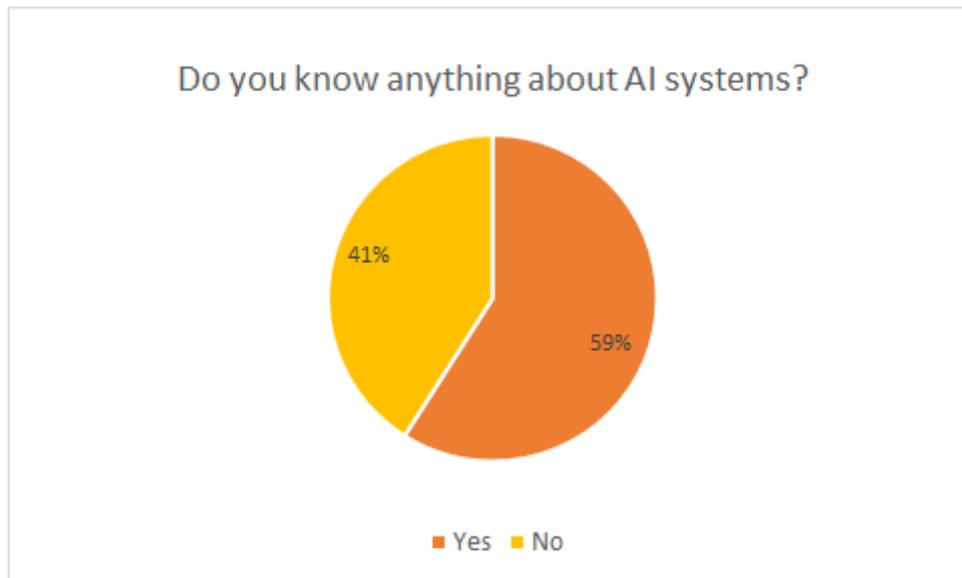


Figure 5: Knowledge distribution amongst project managers regarding AI systems

This statistical division took an interesting shift as shown in Figure 6 when project managers were asked if they use any AI systems:

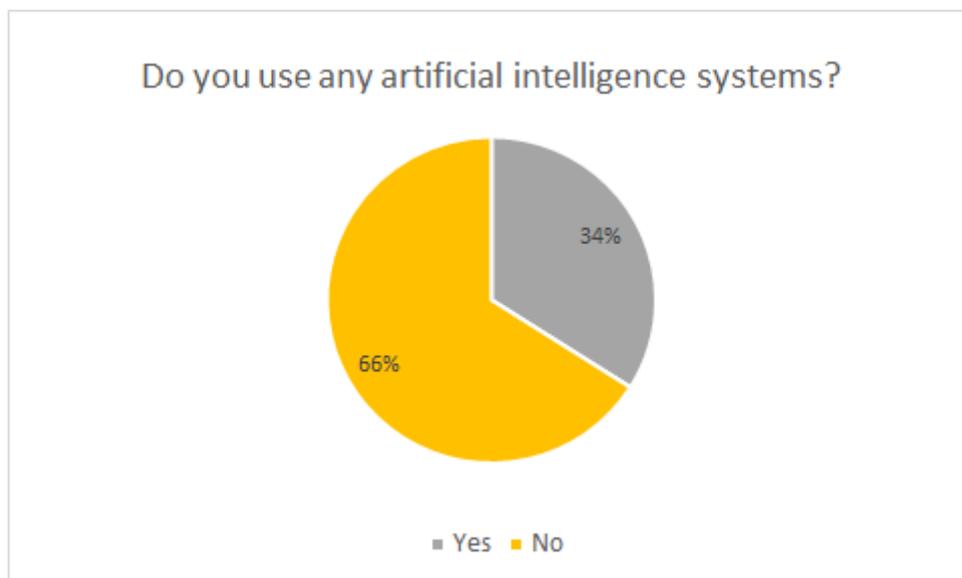


Figure 6: Use of AI systems amongst project managers

By extrapolating the data from the responses to the two questions from Figures 5 and 6, it was found that out of the 59% (33) respondents who have knowledge of AI, 48.4% (16) actually make use of AI systems while 51.5% (17) of the project managers do not make use of any.

The 34% of respondents who do not use any AI systems were further asked if they would like to use any AI systems in the future and their response is illustrated in Figure 7 as follows:

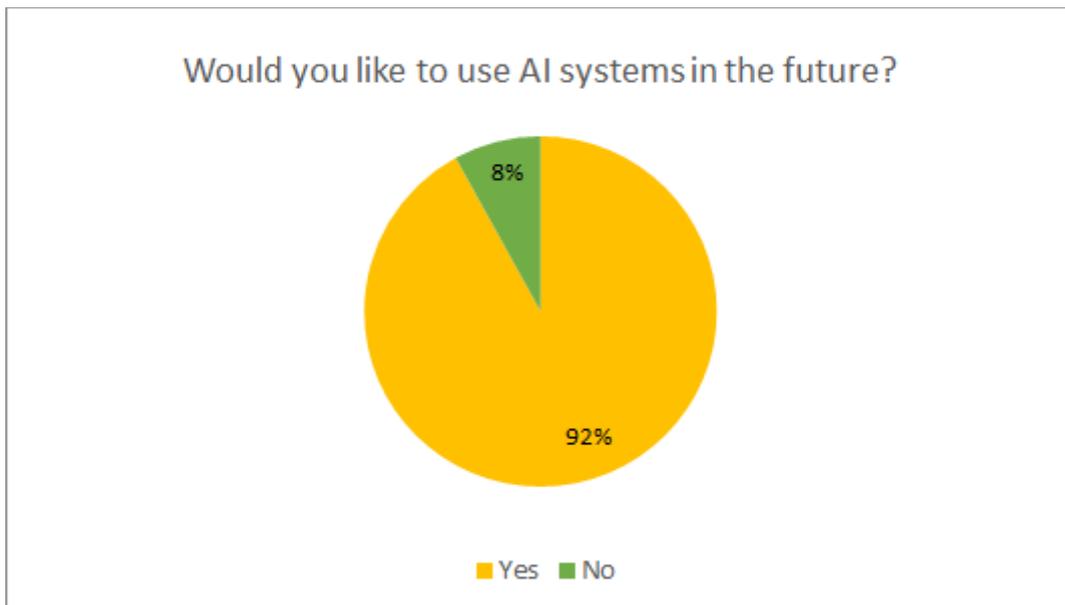


Figure 7: Willingness to use AI systems in the future

When asked about whether or not AI systems were used within their respective organizations, the project managers' response was divided as follows:

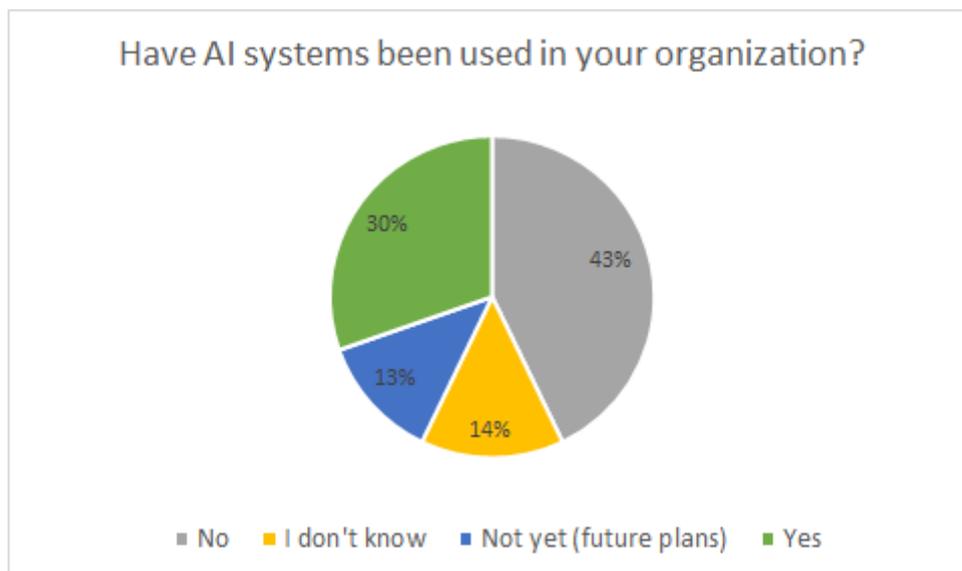


Figure 8: Percentage of AI system use in the case organizations

43% of the project managers believe that AI systems were not being used in their organizations, 30% believe that the systems were being used in their organizations while 13% believe that there are plans for bringing AI systems into use within their

organizations in the future. 14% of the project managers were not aware of the state of AI system use in their organizations.

4.1.2. Project Management

This section of the survey consisted of questions mainly about project management. To begin with, the experience level of the project managers was gauged and the results are as follows:

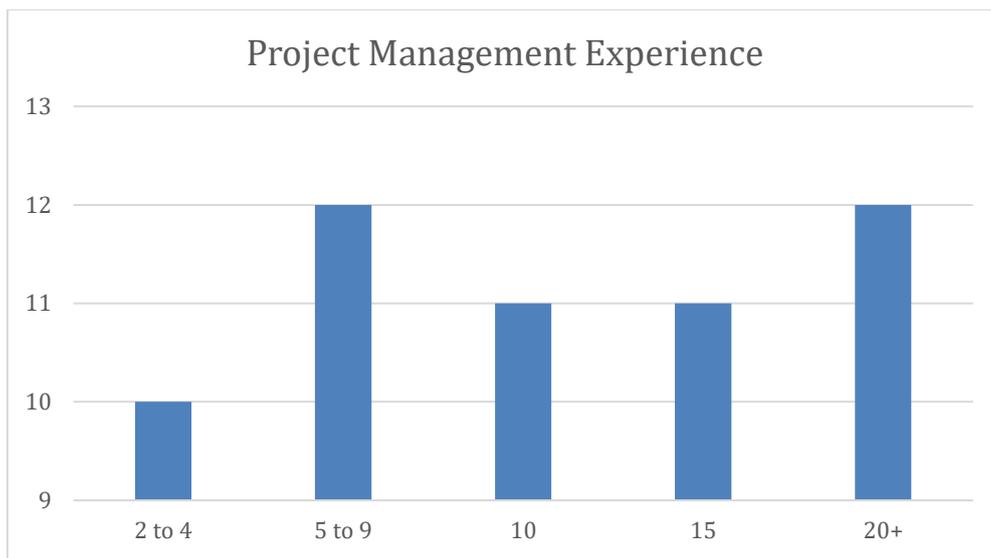


Figure 9: Project Management experience level among the respondents

12 out of 56 project managers have more than 20 years of experience within project management, 11 have 15 years of experience, 11 have 10 years of experience, 12 have experience ranging between 5 to 9 years while 10 have project management experience ranging between 2 to 4 years.

Furthermore, the project managers responded about the nature of their projects as follows:

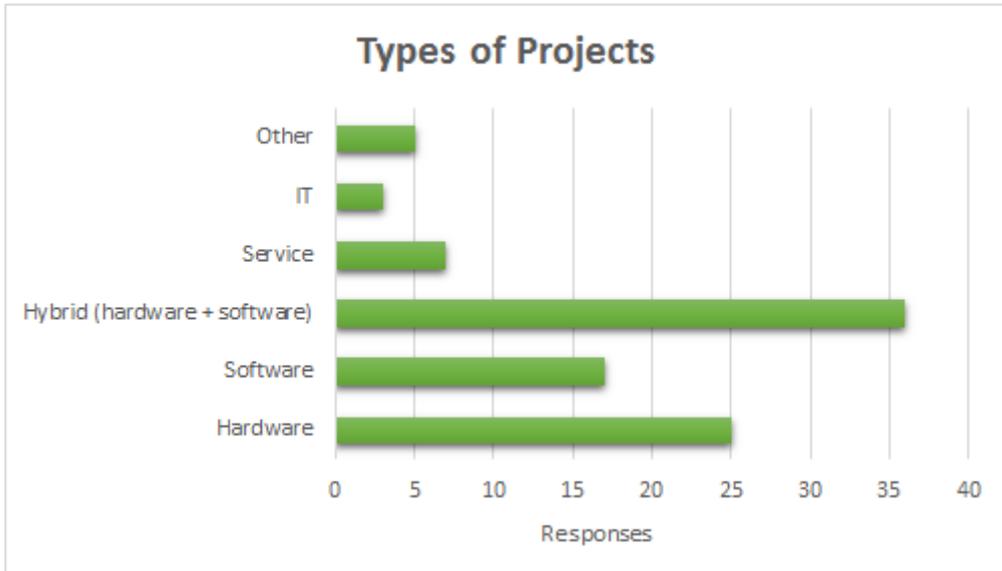


Figure 10: Types of projects

The project managers in this study have a wide range of experience within various kinds of projects, as illustrated in Figure 10. The answer in the survey allowed them to select multiple options to establish an understanding of the range of possibilities, with the highest responses found for the Hybrid (hardware + software) option.

When asked about the most challenging aspects of project management, the responses were diverse as shown in Figure 11 below:



Figure 11: Challenging aspects in project management

The most challenging aspects include budgeting (44.6% response rate), change management (42.9%), risk management (41.1%), resource management (33.9%), project planning (32.1%), and stakeholder management (30.4%).

The response grid varied a little when project managers were asked about the aspects of project management that they need additional support with:

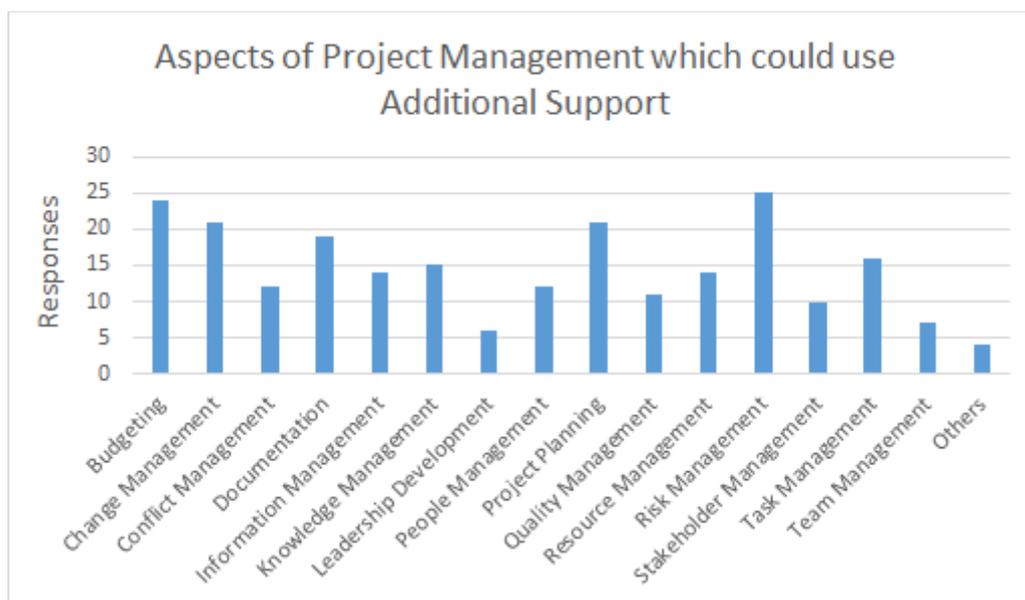


Figure 12: Aspects of project management where support is needed

Here, the most prominent aspects include risk management (44.6%), budgeting (42.9%), change management and project planning (37.5% each), as well as documentation (33.9%).

The response grid further shifted when project managers were asked about the aspects within project management that could use artificial intelligence support to increase efficiency:

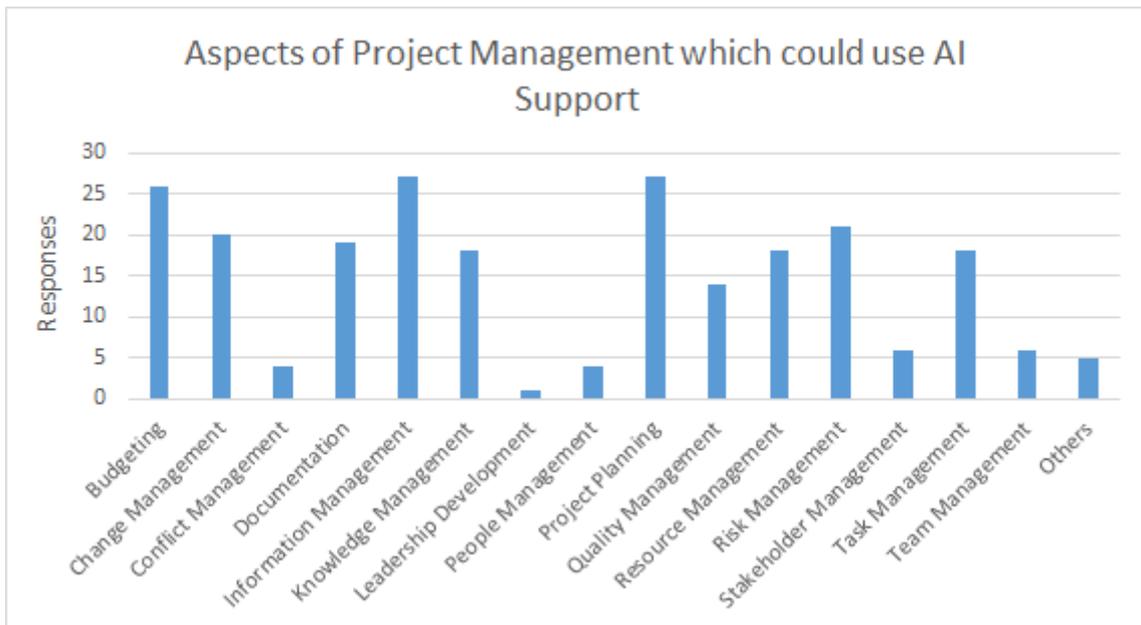


Figure 13: Challenging aspects of project management which could use AI support

The most prominent aspects here were found to be information management and project planning (both with a response rate of 48.2%), budgeting (46.4%), risk management (37.5%), change management (35.7%), documentation (33.9%), knowledge management, resource management and task management with a response rate of 32.1% each.

The graph in Figure 14 below provides a comparable overview of the response rates for all three questions related to challenging aspects within project management:

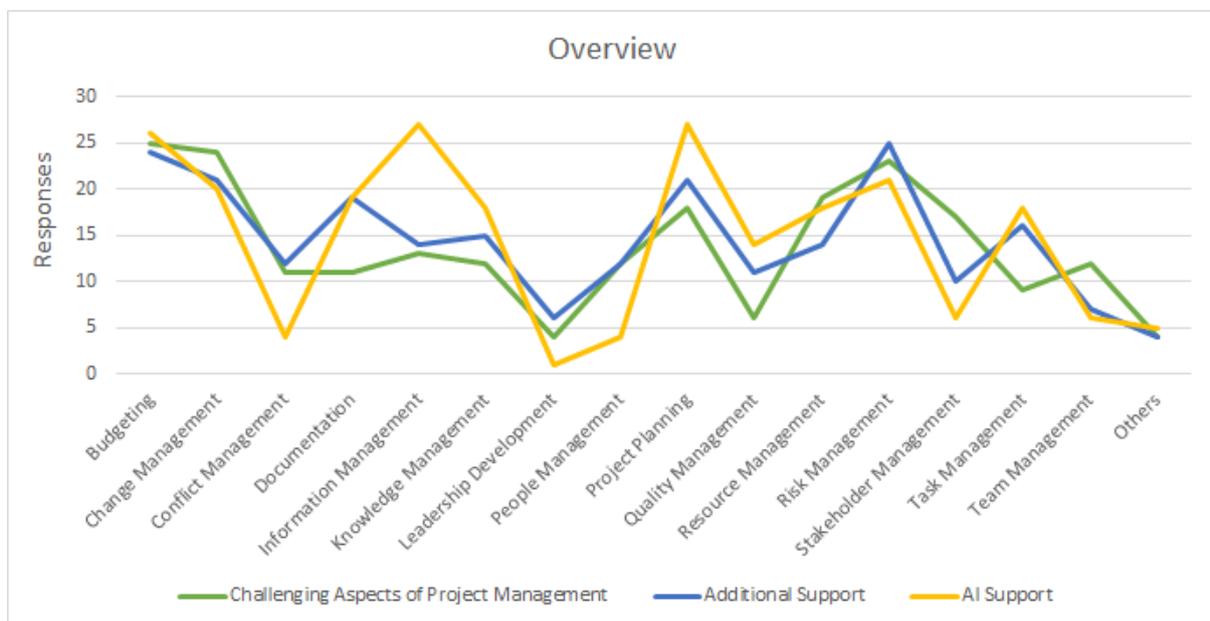


Figure 14: Comparable overview of responses from figures 11, 12 and 13.

Surprisingly, there is a vast difference between the project management aspects that project managers believe will require AI support as compared to those which they believe require additional support as shown in Figure 14. The reasons for these differences will be observed further and discussed in the next section.

4.1.3. Organizational Business

This section of the survey consisted of questions to gauge the current level of readiness within the organization regarding the adoption of artificial intelligence systems.

When asked about whether or not their organization had a business strategy in place for AI systems, the project managers responded as follows:

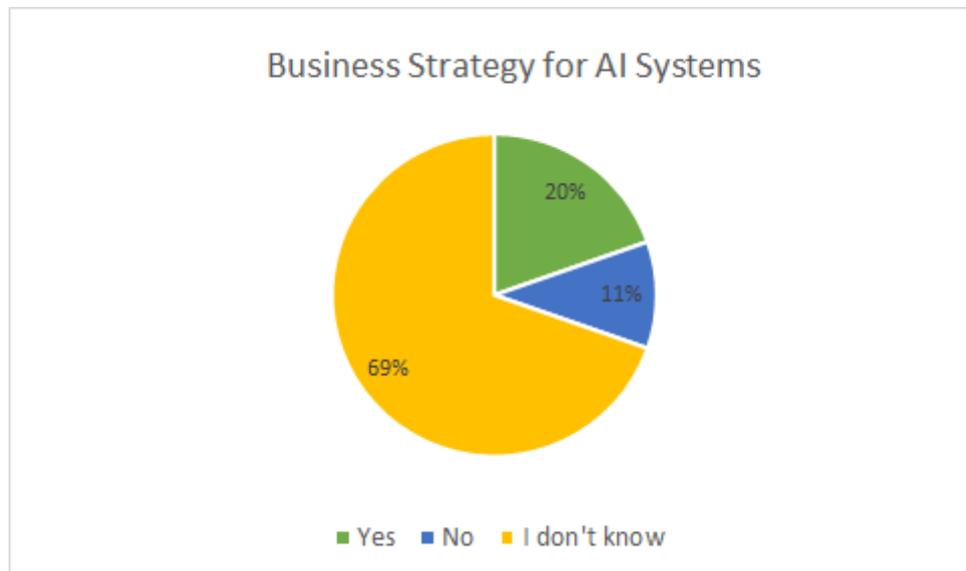


Figure 15: Responses regarding organizational strategy for dealing with AI systems

The vast majority (69%, i.e. 45 project managers) is unaware of whether or not the organization has a strategy in place for dealing with artificial intelligence systems advancements.

The 45 project managers who answered 'No' or 'I don't know' in the previous question were further asked if they think their organization should have a strategy in place for using AI systems in the future and their response was as follows:

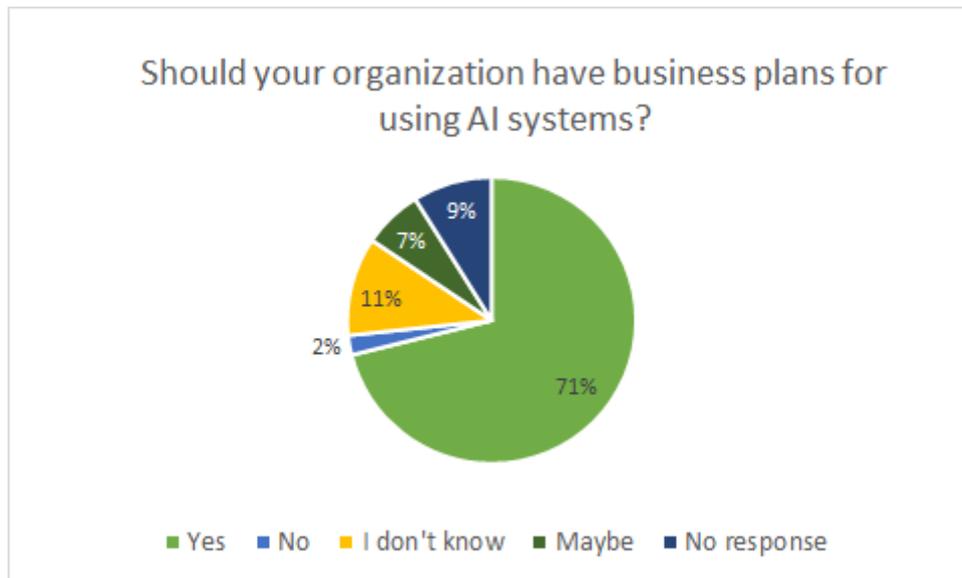


Figure 16: Responses regarding whether or not the organization should have a strategy for dealing with AI systems

Majority of the project managers (71%) believe that their organization should have a strategy in place for dealing with AI systems.

4.2. Interviews

In this section, key themes from the interviews will be presented. The initial results of the survey were used to identify trends, form interview questions, and to select project managers based on varying experience levels. Thus, 9 project managers from 5 different organizations were interviewed and will be referred to in this report as follows:

Table 2: Summary of the interviewee reference and case organization background

Project Manager Reference	Company	Industry
PM 1	Case E	Electronics
PM 2	Case B	Automotive
PM 3	Case B	Automotive
PM 4	Case D	Healthcare
PM 5	Case B	Automotive
PM 6	Case C	Telecommunications
PM 7	Case B	Automotive
PM 8	Case A	Automotive
PM 9	Case B	Automotive

This section is divided into two parts with reference to the interview guide (Appendix B) which was used to interview the project managers: Project Management & Artificial Intelligence. The main themes from the responses were subsequently identified and presented relative to each of the categories as follows.

4.2.1 Project Management

The following key aspects were found to be the most challenging areas within project management for the 9 project managers in this investigation:

1. Project Planning
2. Resource Management
3. Budgeting
4. Quality Management
5. Change Management

The aim of this part of the interview section was multifaceted as follows:

- to understand how the interviewees manage projects currently
- to identify key challenges in the project management and handling processes

During the in-depth discussions of each of the five project management process areas mentioned above, a few themes relative to the current challenges of their work emerged to be the most common amongst most of the interviewees. The key themes are presented in subsections and discussed as follows.

Manual & Repetitive Tasks

Most of the project managers highlighted that several aspects of the various project management process elements require manual precision and tend to be repetitive in nature. For instance, one project manager explained the handling of project planning as follows:

“We have excel file. I don’t think it’s more that I have to say. I mean you have to do everything manually. Whatever you change. It will be manually changed and if we’re working with different project, we have to change every time for different project and it’s, I mean, this is not connected to any of the activities that the rest of the team that is affected of this change is doing. So everything has to be done manually..” (PM 3, Case B).

PM 3 also explained a similarly manual process for budgeting:

“... what we are doing right now based on the first design of the project, we are making the business case. We calculate the business case and then... there are several phases that Customer B is trying the design yeah. So after each phase we have the release, the freeze, and then we make the calculation, and the business case updates. So we take all the changes, we calculate them and we update the business case. So this is on this level, we manage the business case, we see how it is between the phases yeah, whether it was up or down with the business case.”

It is clear from this that despite the existing use of tools to make budget calculations, the inherent nature of this process element is reliant on manual work.

This was reiterated by another project manager:

“... Let’s say, there are tools available and what we’re trying to do is working with successive methods which is a sort of budgeting matrix, where you have the absolute lowest and the absolute highest and the most likely. And just split it up into as many different points and items possible and then you get it out and then you get the probability curve out of it and see what is the probability that you would like to go for. Is it 100%, which means the highest

in all ends? Do you accept to go for 50-50? And ofcourse, from a portfolio point of view, if you accept 50-50, then the total amount ends up there somewhere while if you go for the 100%, the total amount will be much, much higher. This is used, sometimes... It's done in excel, it's an internally developed template.” (PM 4, Case D).

PM 8 presented an interesting viewpoint regarding the nature of budgeting for financial follow ups. Despite the fact that the case company utilizes an application for the purpose of making calculations, the system itself requires heavy manual input, explained as follows:

“... we have systems which are support systems, but are actually needing a lot of work to feed the system. So me and some of the colleagues, I would say most of the colleagues think, it's not so much support. We need to feed the system with figures we don't need ourselves, but financial follow up needs it. And they are supposed to support the projects and business control, financial control. But we believe it's more of, we need to feed them (the system) more than they feed us.” (PM 8, Case A).

This calls into question whether the purpose of the system in this case is being realized as it seems to instead be causing double work for the users. There seems to be a redundancy when it comes to realizing the purpose of the existing application.

PM 6 discussed the manual nature of the quality management process element:

“I think depending on what we mean with quality management, because of course there is quality management in how well you run a project and there's quality for the product, but what we are looking into is how can we use it for the products. So a better, quicker understanding of logs of course... It's a lot of manual work by say smart people you know, but people who know the area and sometimes we have to rerun, say, ask the customer if it's the customer who found the error and they provide whatever logs that all automatically comes and we still can't find it. And then we ask them, OK, can you please rerun it with this parameter, that way.. with another parameter, that way. And of course they cannot always do that because they don't want to do that in the live network. So then we tried to reproduce it. OK, let's run it the same way. Uh, so in that way it's cumbersome.” (PM 6, Case C).

It is noteworthy here that the nature of challenges experienced by the project managers vary from industry to industry.

Manual work and repetitive handling is a highly common theme for the change management process element. One project manager explained:

"Yeah, it's the same procedure. Keeping track, trying to keep track during meetings, phone calls, Lyncing. Not the best way. Maybe but try to run a change tracking file, or, or actually we have a change tracking file, but it's also in excel. So it's maybe not the, the best format." (PM 2, Case B).

Another project manager stated:

"...We have the change management or change requests where we have a template which we are filling in. And also the consequences and so on and it should be decided by the sponsor to recommendation from the project manager and decision from the sponsor. So that is the procedure. And once it's used, it works well. The problem is the discipline..." (PM 4, Case D).

This highlights the lack of motivation, thus poor discipline, to continuously enter information specially when it comes to a multitude of changes that possibly occur in a short time frame.

Constant Tracking & Changes

Several project management process elements are affected by unplanned and unpredictable changes due to which constant tracking is inevitably needed to ensure a smooth operation. One project manager explained how this is done in project planning using basic applications and through regular human input:

"We have different process, but I mean, mainly it's to keep track on, on MS Project to see for planning, I would say... We have, I have three meetings which is standard every week it's, or actually, it's four. And yeah, we're following up and go through the timing and see that nothing is falling behind." (PM 2, Case B).

PM 3 elaborated on the challenge of managing changes in the project plans as follows:

"I am on the meeting, I have to inform, let's say sales, that because we are late with the drawings, you will not be able to do your job and then sales have to go to who they deliver the output and talk to them. And this is not happening because if we are working with so

many projects, you don't have time for such things. So there is no any automation, there is no any link in between what different people are doing and how this affects. Because of one milestone, different areas are affected. Everything has to be coordinated manually through them at different meetings. And just imagine that the person is not coming to the meeting, then he or she misses the information and there you already have a risk for the project. Just like a human error. So here is a big, big potential for improvement.” (PM 3, Case B).

Another project manager discussed the often immeasurable consequences of late changes on the planned budget of a project:

“... But as we mentioned before, there are many late changes coming, which are not in my budget yeah. So now I have to balance and I have to see, do I have money to spend more on those changes? Are they approved by customer and even if they approved by customer, then they are not approved by my management. So then I have to update the business case again and then, it's not always so easy to see how this will affect until you make the complete update of the business case because we don't have and here, the artificial intelligence would be great because we don't know how every change affect my business case...” (PM 3, Case B).

One project manager discussed the need for a smart application or system to not only analyze the impact on the planned budget due to changes but to also reduce the dependency on human-level expertise which can often be limiting towards managing this process element in its own right:

“And then you do more, let's say, based on experience and the offer, quotations, and so on. But it's, having this method in a system, helping you out and if you are really good, you should have, beside the system, you could have a library of a lot of previous projects and previous experience (which tells you) this is normally costing that and that, and this is very risky and hard, high estimates and here you should be a little bit more careful and so on.. So having a little bit of knowledge incorporated into the system as well.. Which in our case, is sitting in the minds of the people.” (PM 4, Case D).

This was reiterated and the impact was further explained by PM 3 as follows:

“... And then of course, what can be expected if there is down (with the budget), then we have to go back and then we have to go through every change and try to see what has negatively

affect on the change and everything has to be done manually. We have to basically go through every change. So imagine if I have 200 changes, I have to go through every change, see what is the content of the change, and try to find out how it is going to affect (the business case and budget). And this is something that number one, we almost never have time for this. Number two, it's a very difficult job, because it's going through all this many changes to try to understand the change. So to dig really deep into the details. And then in the end, I mean I'm still, it's too light to effect. This is the biggest problem for me because even if I do this job, I still am standing in front of my management and I'm saying my business case is now, I don't know, minus those x Euros you wrote down, which is not acceptable by them..." (PM 3, Case B).

The change management process element is heavily affected by the challenge of managing changes. One project manager explained it as follows:

"Also, same here, since, since we are tracking this basically once a week, so if we have the meeting on Tuesday, it's not, it's seven days to next meeting and, and, the biggest challenge is to, to understand what's happening in between so we don't lose the important or important time. So, but in the same time, you can't have follow up everyday either. So." (PM 2, Case B). Another project manager mentioned the impact of several late changes as follows: "... Many changes, very late, very often that means that we will have huge amount of change management that we will have to be able to deal with in the different projects." (PM 3, Case B).

PM 4 elaborated on the subsequent impact of seemingly minor changes, especially if they are not dealt with in due time: *"It's like we say, scope creep is a disease that you have in all projects and that will always happen. And I think it doesn't really matter what type of projects you're running, it will always be a kind of scope creep in them. What we have to do is to be aware of it, we have to, and what we are doing is that we are managing the bigger changes with a kind of a change request and approved change request process. The problem is, what I'm trying to say yes the small ones is a disease that when you don't manage them, when you don't catch up with them, and summarize and see how big is the total scope creep now, maybe it's just every single one is minor but in total, they can grow and be significant. And the other one is when you have the bigger changes that you really do the consequence analysis, again coming back to the triple constraints. When you change something, it will*

have an impact somewhere. And the problem is that maybe we are a little bit too optimistic and we see a possibility, we see here we have an option to do something better and tend to forget about the consequences and of course it hits you later.” (PM 4, Case D).

Prioritizing Between Multiple Tasks & Projects

It is not uncommon to have tasks going on in parallel during any phase of a project. Such tasks are often interconnected and rely on one another to be completed before the next one can begin. A delay in one task can cause subsequent delays for the others. This is a key challenge in project planning as explained by a project manager:

“The key challenge is that people is not coming week after week saying that, okay, (this will be done) next week, next week or, and to have the momentum and to have everybody alert that even if we have some parts that are, or some tasks that needs focus, high focus now or attention, we can't lose focus and attention on the other, other things, that is maybe lower prioritization but are going on in parallel.” (PM 2, Case B).

An instance where a prioritization issue that affected the planning between several projects was described by a project manager as follows:

“...There is our project that the engineering, when they are making the change, it's the change management. So there is a lot of changes coming for every project here. And then we have to then judge which projects go first because then it means that those changes, they have to be calculated as the number, priority one, two, three etc. Already at this stage, this is the human judgement. We're meeting and maybe then who screams the highest and then gets priority number one. So then already here, we have problems, but even if we take it on the site, then we have to wait until those changes are calculated... And we had a situation that there is one, the one customer that they have like XYZ changes that has to be done within two weeks. Normally they have calculated that it takes three months, but now they have to do it in two weeks, which is of course impossible. But what do they do then because they have stopped the project? So then if the decision from the top management comes, do this as a first, then all our projects and all our activities are stopped because of this. And since there is no artificial intelligence that can show how this will affect all other projects because otherwise it would be like already all other projects are red (not doing well) and the system would warn us beforehand.. But you see this, we don't have it.” (PM 3, Case B).

PM 2 (Case B) provided an example of a scenario where several tasks running in parallel can be difficult to manage, where the focus on higher priority tasks inevitably overshadowed the other tasks:

“I mean for one of my groups, we have four different groups. The first group is prioritization one and then we have prioritization two. And people tend to focus only on the prioritization one. It has the biggest, it should have the biggest focus, but still we need to not fall behind on the other things. So yeah, that's an example of that.” (PM 2, Case B).

The resource management process element is also affected by prioritization issues. PM 1 (Case E) discussed how multiple projects running in parallel can pose a challenge when it comes to managing resources:

“... I will say that resource management is probably the part which we have the biggest problems with today and that's both, for line managers as well as for project managers, that we are having problems with and get very splitted. People are working in many projects and we have to switch around and that don't create continuity and we don't create passion (due to this issue)...”

Inefficient Internal Systems & Process Flows

Internal systems that are difficult to understand make the process of preparing a budget rather daunting and tedious as explained by a project manager below:

“... And you have rather bad systems. I mean the interfaces are very bad. Could be done much, much simpler. So it takes a long time to feed the system for people in the project and also there's a feeling that did we do it right, or because people have to ask each other, do you know how to do this because you can't figure out by just seeing it and they also, I mean there could be one person or two persons at Case A taking care of all of that. But then the line function wants to be slim, the project (team) has to manage that and then they'll put everything else in the project and people dealing with this five hours a week instead of 40 hours a week. Okay maybe depending on the size of the project, maybe one two hours a week and they'd be never be experts because the systems and interfaces are too complicated.” (PM 8, Case A).

Another project manager described how a standard system built for quality management can often be futile towards the completion of a task due to the complicated nature of processes behind it:

"It's not very easy to use (the system) or easy to grasp because when it was set up, it was set up very close to the standard, which means that the standard is quite general and it's hard to adapt to your daily work. There's no examples in the standard and so on. And this process is set up in a similar way, so there's not much, it's not easy to.. If you set up a new project and you try to follow the processes there, it's very hard. So what you end up doing is you go to another project that has been running for a while and (ask) can we use all your documents that you've set up for managing quality and you copy what they did in that project. That's how we set up our project and I think that's what most people do because if you only tried to follow the processes, it's close to impossible. So that's one area where we can do a lot of improvement." (PM 7, Case B).

4.2.2. Artificial Intelligence

In this section, the project managers were asked about their views on the impact of artificial intelligence on businesses and how, if at all, AI systems could help them with the operational issues in project management which were highlighted and described in the previous section. The aim was to deep dive and find pathways towards a solution that matches the onset of the AI revolution.

Overall Impact of AI Systems

The project managers had mixed views on the potential impact of AI systems on business in general as well as on project management specifically. Most of them were more than hopeful that AI systems could be used to reinforce the project management function as a whole which in turn could positively impact the ways in which they conduct business.

One project manager discussed how AI systems could be used to reduce manual work and improve the speed of working and further highlighted how an organization's size could impact the speed at which new technologies can be adopted:

"I think it is going to have a big difference (on businesses), which I think, you know, some people get scared. I like new things. I think we'll find out good ways of using it. So I think it's going to be great, to much faster, gets to a lot of things... I think it can change the businesses

because instead of maybe having these big companies where a lot of money who can invest a lot, maybe you can go faster with AI, you can speed up. So, it's going to increase the speed of a lot of development. We're going to figure out things a lot quicker. I think that's going to be really cool and that opens up for a lot of different companies to start and surpass. You don't have to have 20 years of experience in how to do this. Maybe you can, you know, with AI you can learn so fast. So I think it opens up the field for new players and for all of us to develop faster. That's one thing.” (PM 6, Case C).

A couple of the project managers highlighted the ambiguity when it comes to viewing artificial intelligence through the lens of project management. There is also a lack of clarity regarding the types and classifications of artificial intelligence systems as expressed by one project manager below:

“So, usually when you see a system, you always, many times you don't think this is AI. So when I started to fill in this survey, it was hard to find examples, but after I've thought a little bit more now.. Of course I've used a lot of AI systems but you don't think of them as AI. So any system that could automate a day to day work... So, so you usually don't think of it as AI but automation. If you can automate things and digitize things, that would be great. So it's very wide area, so it's hard to pick one thing. ” (PM 7, Case B).

It is apparent from the discussion that follows that the potential uses of artificial intelligence beyond the traditional scope of self-driving vehicles could still be unclear to many:

“I guess if you look at the nomenclature, I think self-driving vehicles are not artificial intelligence. They have sensors and they react on the sensor input in a certain way so they don't take their own decisions. It's all program. I think when it's artificial intelligence, it's when they kind of interpret the information and take their own decision based on not predefined parameters. So I guess those vehicles are not artificial... I think it (AI) could help us to be much more efficient.” (PM 8, Case A).

Potential Uses of AI & Solution Proposals

The project managers had mixed responses when discussing the types of AI systems and the scope of their potential uses. One project manager envisioned a smart system to

reduce manual work and in turn increase available that could be spent on solving more pressing matters as described below:

“It has to be very much feasible that (to show) how this will affect if I change something. Now I have to count everything. If I have three weeks delay, I have to go and change manually for every department here and they have to change the internal... So yeah, and if we have artificial intelligence, everything is then connected, everything is in one place and you have all the links that gives you the possibility that you have an overview roadmap where you see where do you have the critical milestones, whether it works or not, and then you focus on those you see what to do to be able to make it green. Yeah. That is. And that is really. And then instead, the timing that I'm losing on this, I can use for what we call the portfolio management really to see...” (PM 3, Case B).

“Maybe it's because when I think about artificial intelligence, I think a lot about large data volumes and making sense of it. But of course, maybe if we include automation, then that there could be more. I think we have lousy tools as a line manager, I think I had a lot better tools as a project manager and now I go nuts, but I think that can be just, you know, they should be fixed by, by combining them or so I have one where we look at salaries.” (PM 6, Case C).

Another project manager described an example of a smart personal assistant that could replace the mundane and manual tasks that people inevitably end up spending more time on than needed:

“And actually I met one guy, he was a presenter and he worked in this area of how can AI support project management and he took a very good example. So it was like scheduling meetings, so today you have good tools for scheduling meetings in your email, but his vision was that you would like to have it like a tool that you only say schedule a meeting with his project team next week on Monday or Tuesday for one hour and invite all the project team. That's the only thing you have to do. Right? And that could be an example of an AI system that could support you with that task. And I've talked about that with some of my colleagues. So to find a free spot in all calendars, that's not a hard task to do, but if you have to make some decisions because maybe that guy is not as busy as he looks like. So maybe this meeting will be more important to make decisions like that. You need an AI system. And we can have a meeting with all the team members except for one and who is the key participant for that

meeting and who is not really needed. To make decisions like that, I think you need an AI system. But just to find an empty spot which is free in all, that's a nice task. But if you have to make some decisions about who to include or not and maybe do some negotiations like can you not come to this meeting instead so 'that's something like an AI system could do.' (PM 7, Case B).

AI for Operational Use

Most of the project managers were able to provide specific solution proposals when discussing how AI systems could help them with the issues that they face within project management. One such example of a smart system that can integrate several project management process elements to simplify their overall handling is described by a project manager as follows:

"So I guess many of what I've already said. First of all, the complete project planning well connected with the risk assessment with change management and resource management. This will simplify extremely for the project. We will be able to work much more with strategic portfolio management, instead of focusing on the small basic steps within the planning because this is what takes time..." (PM 3, Case B).

One project manager explained that AI systems could be built to support several project management elements as follows:

"And specially within those three fields where I think the budgeting is maybe the easiest one. And as I said, with gathering both, the experience and good examples and so on. And linking that directly into the system and way you do the budgeting and so on and that could help. Risk management, it's for sure, I mean there are, you could see it in the FMEA and so on. There is a lot of manual work in there and of course that could be done more efficiently. And also coming out with the conclusions and more simple, coming out with also a presentation material and so on which could help... And change management, both on keeping track and having a simple way of handling them and recording them " (PM 4, Case D).

Another project manager highlighted the value that could be harvested from the use of past and present project data that is stored in abundance to no avail and needs a smart system to enable its usability for future projects:

“There I can imagine that if you look at big enough data or large enough amount of data, then maybe AI could be helpful... So we have so many sites and of course we have phone conferences, video conferences, but it would be even funnier and these, there are these on youtube that you have this little robot going around and you see the face of your colleague, in that way that could actually be fun...” (PM 6, Case C).

In general, all of the project managers were highly willing and encouraging towards the prospect of having smarter solutions using AI systems as stated by one below:

“I mean, I would be interested in anything where it could be supporting, of course, it's just where I see maybe the biggest potential right now (within information management). But with anything, I mean...” (PM 9, Case B).

5. Analysis & Discussion

In this section, the results of the empirical data will be analyzed and discussed relative to the theoretical framework which was presented earlier in this study. In doing so, the main findings of this investigation will be highlighted and discussed to pose recommendations for the future.

5.1. Needs of the Project Management Community

It is evident from the results of the survey as well as the interviews that there are several aspects within project management which are challenging for project managers due to a variety of reasons. The key underlying issues within most of the project management process elements were identified to be the following:

- I. Manual & Repetitive Tasks
 - Project planning, budgeting, quality and change management.
- II. Constant Tracking & Changes
 - Project planning, budgeting and change management.
- III. Prioritization Between Multiple Tasks & Projects
 - Project planning and resource management.
- IV. Inefficient Internal Systems & Process Flows
 - Budgeting and quality management.

One of the more problematic grounds in all the four aforementioned issues is the manual, repetitive and inefficient nature of operation of each of the project management process elements discussed in the interviews. In this regard, all of the interviewees expressed the need for smart, AI-based solutions that could help reduce the inefficiencies in their day-to-day project management operations. This is very much in line with the results obtained from the survey where *92% of the respondents expressed their willingness to use AI systems in the future.*

These empirical aspects makes a strong business case for smart and artificially intelligent solutions to be implemented within various specific process elements of project

management to replace the monotonous and repetitive nature of work while allowing project managers to focus the lens on the more pressing matters of their job.

While analyzing the comparable overview provided figure 14 from the survey results in more detail, it was found that the respondents' collective beliefs about the aspects of project management which could be supported by AI were inclined more towards those process elements - information management, for example - which could be enhanced or supported by smart technology rather than those which are likely to require humane or more cognitive input - such as conflict management and negotiation skills. This finding seems to be on par with Arup's (2018, p. 22) conclusion that human skills will become more valuable in the futuristic work environment where artificially intelligent systems will take over the systematic aspects of the project managers' job. It indicates a certain level of awareness as well as acceptance within the project management community towards the inevitable influence of artificial intelligence on their job role as well as workplace environment in the future.

Furthermore, this finding, when analyzed in conjunction with the survey results where 41% of the respondents answered that they *do not know anything about AI systems* and a further 34% stated that they *do not use any AI systems* lead to the observation that there is a lack of knowledge regarding the potential uses of AI systems amongst project managers. This was reaffirmed during the interviews when several project managers stated that while they were willing to use AI systems to support themselves with project management, they were unable to provide more concrete arguments in support for what such a smart system could look like. This finding leads to the an important recognition here that educating the project management community of the benefits and risks of utilizing such systems for their daily work is paramount towards ensuring a future in which human-machine collaboration can be regarded the successful norm.

5.2. Awareness of Artificial Intelligence Systems

41% of the 56 respondents of the survey asserted that they *did not know anything about AI systems*, while 34% stated that they *did not use any AI systems* at the time during which the survey was conducted. This is an intriguing finding and was put into perspective by

various project managers who explained during the interviews that the survey questions prompted them to think outside the box. In doing so, the interviewees later realized that they had actually been aware of what AI systems are and in fact had even been using them - for example, the virtual assistant Siri in smartphones which is a type of an ANI system (Gurkaynak, Yilmaz and Haksever, 2016).

These findings acutely represent the lack of knowledge or the misconceptions regarding AI systems amongst respondents. The perceived usage of these systems is rather different from the state of the actual use; the perceived use is limited in their minds to the development of self-driving vehicles more often than not, whereas the actual use of AI systems is already prevalent in their lives, albeit more often limited to the use of ANIs. In a broader context, this also means that the actual potential and use of AI systems could be unrealized and underestimated by the project managers who were a part of this study.

14% of the respondents also stated that they were *unaware of the use of AI systems within their organizations*, while a further 69% stated that were *unaware of whether or not their organizations have a business strategy in place for AI system use*. These figures reaffirm that there is much work that still needs to be done in order to educate professionals and realign organizations with new strategies that will be needed to ensure their survival in the digital age. In this regard, it will be crucial for project managers and AI scientists to work closely together to understand the needs, opportunities and to overcome the challenges that will arise in the process of adopting and using AI systems - this is very much in line with the successful outcome of the project executed by Schreck et. al (2016) which can also be regarded as a proof of concept for project management AI.

A SWOT analysis of the potential impact of the aforementioned findings on the future implementation of AI systems from the project managers' perspective is illustrated below:

Table 3: SWOT Analysis for the future implementation of AI systems

S: Need for more efficient solutions	W: Lack of technical knowledge of AI systems
O: Willingness to use AI systems	T: Pre-existing processes & established norms in an organization

In order to fully harvest the benefits out of an AI implementation in the future, it will be crucial to leverage the strengths and opportunities while effectively managing the weakness and threats through education, training, as well as strategic change management initiatives within organizations to weed out inefficient process and systems.

5.3. Building Artificial Intelligence Systems for Project Managers

Several issues and challenges within project management have been highlighted during the course of this study that have the potential to be supported by artificial intelligence systems. The results obtained from the survey and interviews have enabled the establishment of a clear need and opportunity for AI systems to be used for improving the efficiency of project managers in their daily work. This can be done in several ways which are recommended as follows.

First, the application developed by Feature Labs (2016) is a successful proof of concept of an AI system built specifically for helping project managers predict key issues ahead of time using live project data. In its essence, this is an example of an AGI built for project management (Gurkaynak, Yilmaz and Haksever, 2016). The operations of this application could be adapted for use in other project management process areas such as project planning as well as change management. The challenge with successfully implementing such an application will be with ensuring the accurate consolidation and input of live project data (Atlassian, 2017). This solution will significantly reduce the inefficiencies caused due to the manual, repetitive nature of project management tasks and will take pressure off of project managers to constantly track changes.

Second, AI-based chat-bot or virtual project assistants can be utilized to further help project managers with aspects such as project planning, budgeting as well as resource management. While no reported use cases have emerged that could enable the use of

these functionalities in one application, AI-based applications such as Fireflies and Stratejos (PwC, 2018) currently exist to serve the individual process elements without interconnectivity. The next step would be to integrate these AGI applications to enable a package solution for project managers. This solution could support project managers with prioritization between various tasks and projects more efficiently than is done so currently.

Furthermore, project management AI- or autonomous project management (PwC, 2018) - will seek to serve the much larger purpose of taking over project management activities by evaluating and analyzing the project environment as well as key stakeholder behaviors. While this predicted-evolution in project management may seem much like the window for ASIs (Gurkaynak, Yilmaz and Haksever, 2016) to enter into the picture, experts at PwC (2018) postulate that it is still unlikely for purely self-driven artificial project managers to take over in the next couple of decades. This is also in line with Makridakis' (2017) conclusions in his revised paper.

5.4. Implementing AI for Project Managers in Organizations

In order to ensure effective utilization of project management AI, it is crucial to start at the management level of an organization. While project managers have established a clear need as well as demand for using AI-based project management solutions, any efforts in a high technology implementation of this nature will prove futile without the approval as well as direct involvement of executive management in this process.

In this regard, various aspects need to be evaluated and thus, recommendations derived from the key findings of this study are as follows:

- Evaluate, develop and implement business strategies for artificial intelligence systems to be used in the workplace.
- Identify and eliminate (or reduce where feasible) the use of inefficient internal applications and process flows.
- Increase awareness via education and training of project managers regarding the potentials of artificial intelligence for project management.

- Educate and train all employees regarding the benefits of artificial intelligence as well as the workplace for the future.
- Involve AI scientists within each business unit of the organization to identify potentials for improvement and future implementations.
- Enable a co-operative and integrative environment between project managers and AI scientists to ensure accurate matching of needs-based solution development.

While there is still some way to go before artificial intelligence systems will become an actively supportive element for today's project management workforce, developing and implementing strategies based on the aforementioned suggestions will ensure a smooth and fruitful transition into the new era for all stakeholders involved.

6. Conclusions

The aim of this study was to answer the research question: *How can artificial intelligence systems help project managers become more efficient in their daily work?* The underlying purpose was to investigate and understand the struggles that project managers face today, as well as to explore and establish a foundation for the areas of opportunities in which AI systems could support them in these struggles and to highlight the threats in this regard. The research proved quite successful in achieving these aims.

The results from the mixed-method research approach allowed the identification of the following 5 project management areas which hold the most potential for AI system support:

1. Project Planning
2. Resource Management
3. Budgeting
4. Quality Management
5. Change Management

Additionally, the 4 key issues which project managers face within the five aforementioned aspects were identified as follows:

1. Manual & Repetitive Tasks
2. Constant Tracking & Changes
3. Prioritizing Between Multiple Tasks & Projects
4. Inefficient Internal Systems & Process Flows

These findings, when investigated further, proved that there are several areas of opportunities within project management where AI systems could be developed to support project managers. The need for this was confirmed by all of the project managers who were interviewed as a part of this study. An existing project management AI solution for risk analysis and risk management was also found and can ultimately be used to strengthen the business case in support for the development and use of AI in other project management elements.

Several key insights about the views and knowledge of project managers regarding AI systems were also established during the course of this study. One significant finding is that the project managers in this study have a highly positive inclination towards using AI systems in their daily work. The business demand, therefore, is quite high. Another finding relates to the lack of awareness concerning AI systems within the project management community which could significantly inhibit the systematic AI utilization for this specific function in the future. It is crucial for organizations to tackle this by educating project managers about AI as well as by employing AI scientists who can drive the organization's technological strategies to ensure positive growth in the upcoming digital era for project management.

In order for organizations to successfully implement AI-based solutions and ensure efficient human-machine collaboration in the future, it is vital to develop and implement strategies specifically designed for enabling the digitalization of workplaces. The existing project management AI solutions in this regard form a good starting point for building scalable models for the future. The future workplace will inevitably involve humans and machines working side by side and the survival of organizations relies on embracing this heavily changing environment as early as possible to manage it effectively.

6.1. Recommendations for Future Studies

Several challenges were identified during the course of this research. These will be explained and used as motivation to form the basis for recommendations for future studies as follows:

- There is a major lack of scientific research that relates to AI solutions being developed for specific functions such as project management. This is an area that needs more focus, especially in light of the fact that more and more job roles are predicted to be supported by technologies in some form or the other. Therefore, the first recommendation for future research is to study AI-based solutions for specific functions purely from a scientific perspective.

- There are currently very few AI-based solutions that cater to the needs of specific job functions such as that of project managers. In this regard, a second recommendation is to develop an AI-based solution for specific functions such as those highlighted within project management in this study.
- There are no scientific theories that help understand how a technology that hasn't been fully understood or developed yet can actually affect functions that are traditionally reliant on cognitive input or human interactions. Therefore, a third recommendation is to develop a theory to help understand the impact of technologies on such functions.
- This study did not take into account the management-level perspectives when it comes to developing and implementing AI-based solutions for specific functions in an organization. A fourth recommendation here is to conduct a study by taking into account both – top-down and bottom-up - approaches within a specific organization to look at how AI-based solutions could be implemented and what are the threats or hindrances that could arise towards doing so.

There are immense opportunities for future research in this area of focus within AI for project management which could help humans understand how to work well with AI-based systems - if utilized effectively for the future.

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Appendices

Appendix A: Online Survey

The survey can be accessed online [here](#).

Appendix B: Interview Guide

Category	Questions	Description
I. Background & Experience	<ol style="list-style-type: none"> 1. Education 2. Please state your current position 3. Please explain your responsibilities on the job. 4. Please state the department you are currently working in. 5. What does your department do? 	The interviewee's background and current experience are gathered for establishing relevance into the research. The data will be used to compare and contrast experiences and opinions.
II. Company Background	<ol style="list-style-type: none"> 1. Please explain your company's business 2. How would you explain your company's vision for the next 5 years? 	This section is for gathering deeper insight into the nature of business and strategic goals of the company. The data will be used to understand the company's focus areas for the future.
III. Project Management	<ol style="list-style-type: none"> 1. How long have you been managing projects? 2. What kinds of projects have you worked in/ lead? 3. What are the processes used to manage projects in your department? 4. What technology do you currently use to help you manage projects? 	This section is to establish a deeper understanding of processes within a specific department as well as the types of tools and resources utilized specifically for project management.

<p>IV. Artificial Intelligence</p>	<ol style="list-style-type: none"> 1. Do you know what is Artificial Intelligence? 2. Can you give any examples of AI systems? 3. What do you think about AI systems and their impact on the future workforce? 4. Does your company work with AI? <ol style="list-style-type: none"> a) If yes, please explain how? 5. Have you ever used AI to help you with your work? <ol style="list-style-type: none"> a) If yes, please explain how? b) If not, please answer questions 6 and 7. 6. Do you want to use AI to help you with your work? 7. How do you think you could use AI? 	<p>This section is for the following purposes:</p> <ul style="list-style-type: none"> • Establish the current level of knowledge about AI • Establish the current state of usage of AI within the company • Establish the willingness for AI usage in the future • Establish the potential areas for AI usage in the future
<p>V. Challenges</p>	<ol style="list-style-type: none"> 1. Which aspects do you find most challenging when leading and managing projects? 2. Do you think AI systems can be used to help project managers? <ol style="list-style-type: none"> a) If yes, please explain how? b) If not, please explain why? 3. In a recent survey, 60% of the projects managers have stated that they could use additional help with risk management. Do you have any thoughts on that? 	<p>This section is for the following purposes:</p> <ul style="list-style-type: none"> • Identify and establish areas within project management that can be helped by AI systems • Gather deeper insights into how AI systems can actually help project managers

	<p>4. Repeat question 3 for budgeting, resource management, project planning, documentation & information management?</p>	
<p>VI. Future Opportunities & Management</p>	<p>1. What would you need in order to initiate a project to develop AI systems to help with specific elements within project management at your company?</p> <p>2. Does your organization support the adoption of a new technology?</p> <ul style="list-style-type: none"> a) If yes, please explain how? b) If no, what are the key challenges in doing this? 	<p>This section is to help understand what needs to be implemented in an organization before it can adopt or use a new AI-based technology and the potential challenges with implementing AI in the workplace in the future</p>