University of Southern Queensland
Faculty of Health, Engineering and Sciences

Project Management and Systems Engineering Integration for Increased Efficiency and Effectiveness.

A dissertation submitted by

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Abstract

As our knowledge base become more advance in the areas of Project Management, we should be seeing a larger trend of projects and programs being completed successfully to customer requirements within budget and time constraints, yet media and industry reports suggest that in Australia only 51% of projects are likely to meet the intended goals and business commitment. Project Managers are often undertrained and use methodology that is either outdated or is so broad in its context that it does not give adequate feedback on where risks lie in budget, resource and timeline. Standards such as the PMBOK® of ISO 21500 are used as guidelines in the understanding on the domains of project management but give little in the way for framework for how a Project Manager is to accurately record and work to the desired outcomes of the stakeholders.

The purpose of this research is to utilise the knowledge base and practices of System Engineering to better define and tailor Project Management artifacts so that Project Managers and organisations can make more informed decisions. Hopefully in doing this a secondary objective will be some metric or Key Performance Indicators that will suggest if a project is being managed correctly through the different stages of initiating, planning, implementing, controlling, and closing.

The research will be conducted by the review of all relevant information in the field of Project Management and System Engineering before analysing real projects and project management teams from the Kongsberg Aviation Maintenance Services (KAMS), Maintenance, Repair & Overhaul facilities located in Norway. From there the cumulative date will be presented based on the perspective of the KAMS staff to create a framework with suggested tailoring for optimisation of Project Management.

Keywords: Project Management, Complexity, System Engineering, PMBOK, SEBOK, Tailoring

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With heartfelt gratitude, Ben

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Abbreviations

AS	Australian Standard
AS	Aerospace Standard
CONOPS	Concept of Operations
CRM	Continued Risk Management
CTQ	Critical to Quality
ERP	Enterprise Resource Planning
FFP	Fixed Firm Price
INCOSE	International Council on Systems Engineering
IntP	Integration Plan
IPDT	Integrated Product Development Team
IPPD	Integrated Product and Process Development
ISO	International Organization for Standardization
KAMS	Kongsberg Aviation Maintenance Services
KDA	Kongsberg Defence & Aerospace
KPI	Key Performance Indicator
MBSE	Model Based Systems Engineering
NASA	National Aeronautics and Space Administration
PBL	Performance Based Logistics
PM	Project Management
PMBOK®	Project Management Body of Knowledge
PMI	Project Management Institute
PMO	Project Management Office
PMP	Project Management Plan
PO	Project Office
PP&C	Project Planning & Control
PRA	Probabilistic Risk Assessment
PSpec	Project Specification
RFLP	Requirements, Functional, Logical, Physical
RIDM	Risk-Informed Decision Making
RM	Risk Management
RMP	Risk Management Plan

RVTM	Requirements Verification and Traceability Matrix
SE	System Engineering
SEIT	System Engineering and Integration Team
SEMP	System Engineering Management Plan
SOW	Statement of Work
StRS	Stakeholder Requirements Specification
WBS	Work Breakdown Structure

1 Introduction

1.1 Background

Although current Project Managers have access to a wide range of information, guides and templates there is still reporting all over the world that only around half of all the projects that are run could be deemed a complete success. KPGM International Ltd. (2019 & 2020) reported across their Project Management Survey that only 51% of projects were likely to be delivered to original business intent, 42% were likely to be delivered on time, and only 40% delivered on budget. It was also reported that only 46% of projects are delivered with stakeholder satisfaction. Historically, such information in a Project Organisation would be interpreted that time was spent conducting the wrong task or there was misalignment in intent or mandate. This would have in turn incurred some form of cost and through simple assessment it could be stated that 50% of the cost is not returning any value in the form or success or satisfaction or the Project organisation or the stakeholder. Factors contributing to the may be varied and independent depending on the organisation and the type of project, but there are a number of factors recorded by a 2020 survey by Wellingtone whereby they asked Project Management Staff what PM process added the most value when conducted correctly and how difficult were these processes to execute.

Figure 1Project Management Process value vs. difficulty to generate (Wellingtone 2020)

Results show that Project Management Staff concluded that Stakeholder Engagement, Risk Management, and good Planning all returned value if executed correctly. The results also showed that Benefit Realization, Resource Management, Project Prioritization and Lessons Learned were some of the more difficult processes to master but also show that they are important in a sense of value to the Project Manager. One crossover between Project Management and Systems Engineering is here and has been identified in the NASA Systems Engineering Handbook (Hirshorn, S. 2016). The Wellingtone Survey (2020) identified high value topics of Stakeholder Engagement, Risk Management and Planning have all been identified under the titles Stakeholders, Risks and Schedule as also part of Systems Engineering. The difficult processes of Benefit Realization and Lessons Learned could be correlated with Reviews.

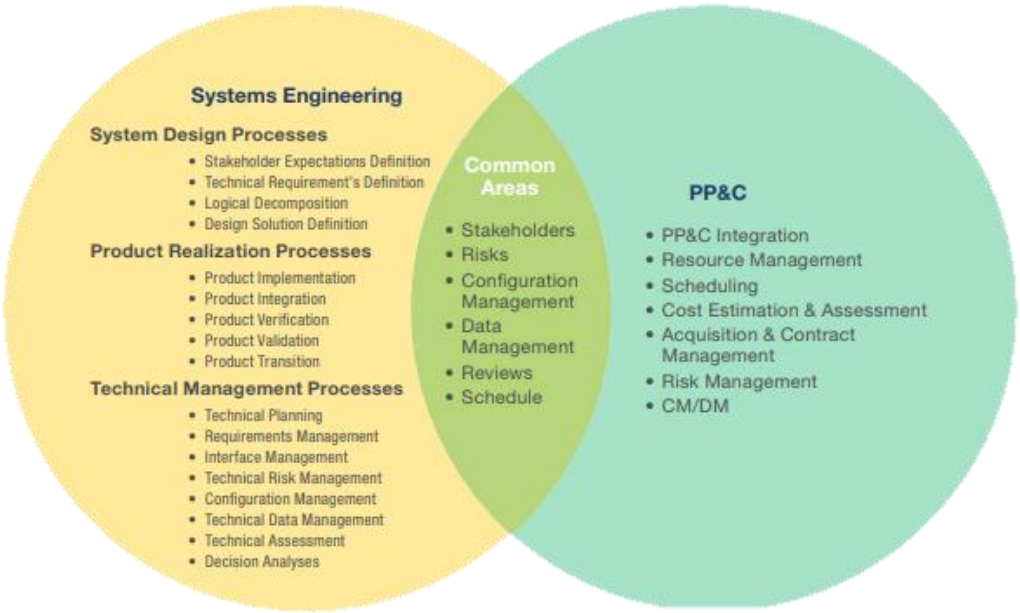


Figure 2 NASA identification of subjects common to System Engineering and Project Planning & Control (Project Management) (Hirshorn, S. 2016)

These common areas between the two (2) disciplines therefore may have differing processes to consider inputs and then execute. With the main consideration of value generation at the forefront the best practice must be considered from both Project Office business area's. As Systems Engineering is heavily focused on understanding all requirements of a product that is to be integrated, techniques, process, and criteria may be transferable to Project Management to reduce variability and contribute to an increased value for the Project Office and the customer.

It is stated in the Systems Engineering Handbook from the International Council of Systems Engineering (INCOSE, 2015) that "Systems Engineering should support Program and Project

Management in defining what must be done and gathering the information, personnel, and analysis tools to elaborate business requirements". This implies that there is more in-depth analysis at the system level then what the Project Manager is exposed too. This is in line with operational norms where a Project Manager is responsible for the delivery of the wholistic project to the stakeholders whereas the Systems Engineering is normally responsible for delivery of a part of the project to the Project Manager. The culmination of this is that the Project Manager is relying on the System Engineer to fill a knowledge gap that might be present. If this connection is not made, which is often the case, the engagement of Systems Engineering principles and techniques may not be engaged in the projects and requirements might be missed.

The Project Management Body of Knowledge, or better known by its acronym as PMBOK Guide (PMI Inc., 2021), is the gathering of all industry inputs from project managers and best practices. As a part of this guide the Project Management Institute states that best practice is to approach project in areas of execution which they define as "Project Domains" (PMI Inc., 2021). The guide then goes on to explain at a high level some of the approaches a Project Manager should take as a part of best practice or industry norm. The below figure shows that these domains and here we can see that the Project Management Body of Knowledge (PMI Inc., 2021) is suggesting that some of the area that have the most effect on project delivery outcomes are also those identified in KGPM Interanion 2019 & 2020 Project Management survey's (KGPM, 2019 & 2020) as having high value or are difficult to achieve.

Figure 3Eight (8) Project Performance Domains that effect project delivery outcomes (PMBOK, 2021)

INCOSE (2015) define a system as “elements, subsystems, or assemblies that accomplish a defined objective. These elements include products …, processes, people, information, techniques, facilities, services and other support elements”. Looking at their visual representation in the figure below each of these areas are represented as a system element. We can see that in the top left corner of the figure that the system is visualised in a similar manner to that of the Project Performance Domains described in the PMBOK Guide (PIM Inc., 2021). INCOSE (2015) move on to show that each of these elements may be treated as a System in their own right and this is one of the main principals of systems engineering. This is a systems thinking perspective which looks at all elements, or elements that are systems in their own right to gain understanding of the interrelation to the whole system of interest. When looking at the project management domains (PMI Inc., 2021) they may be managerially and/or operationally independent of the other domains that mist be covered. In this it then satisfies the definition and architectural principals so a System of Systems (Maier, 1998, as cited in INCOSE, 2015).

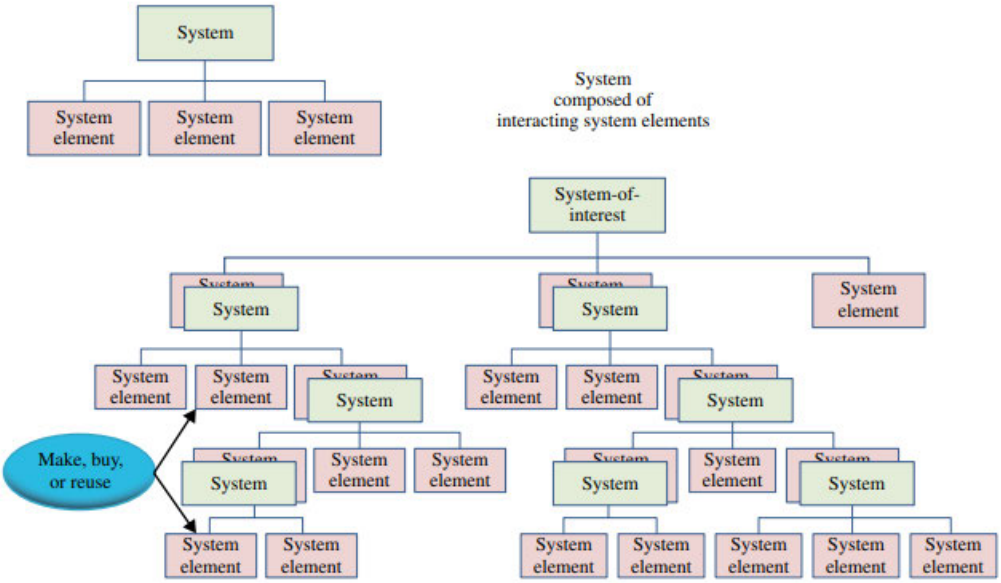


Figure 4 Hierarchy within a system (INCOSE, 2015)

It is now shown that there are a number of connections between Project Management subjects and those of System Engineering. It is also suggested that some of these are areas of project management that are difficult to execute or hold high value within the project which are not being achieved to a high degree of satisfaction for both the Project Manager and Stakeholder. It is therefore suggested that this research primarily explore the ability to use System Engineering techniques and principals in the subject common to both disciplines to give further fidelity and remove variability in Project Management and positively add to the Project Management Body of Knowledge. Secondary the research will seek to identify Project

management frameworks and process tailoring techniques that link to the size and complexity of a project. Thirdly the research will attempt to identify cost benefits for incorporating Systems Engineering practices and process.

The 5 Why's (Ohno, 1988) figure below summarizes through assumption the connection between the problem statement and the possible benefits of introducing some System Engineering practices.

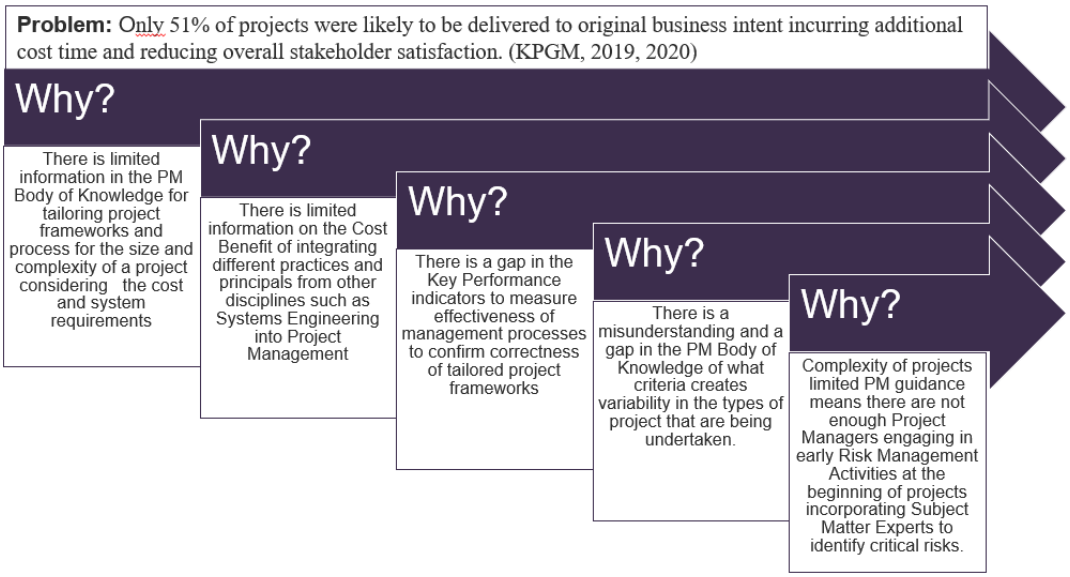


Figure 5 Five (5) Why's analysis with assumption for the causes of the problem statement (Ohno, 1998)

1.2 Project Aims

1.2.1 Scope and Boundaries of the Research

Scope of this research will be limited to the common areas to Project Planning & Control (PM) and System Engineering (SE) identified by NASA (Hirshorn 2016) that align with the Project Management Body of Knowledge Project Performance Domains (PMI Inc. 2021) and the PM process added the most value or were difficult to execute as reported in the Wellingtone Annual Report for the State of Project Management (2020)

Table 1 Nomenclature equivalency for the area of research as defined by NASA (Hirshorn 2016), PMBOK (PMI Inc. 2021), and Annual Report – The State of Project Management (Wellingtone, 2020)

NASA Systems Handbook	PMBOK Project Domains	Wellingtone Annual Report – The State of Project Management

NASA Systems Handbook	PMBOK Project Domains	Wellingtone Annual Report – The State of Project Management
Stakeholders	Stakeholders	Stakeholder Engagement
Risk	Uncertainty	Risk Management
Reviews	Development Approach and Lifecycle	Benefits Realisation
Schedule	Planning	Planning

1.2.2 Primary Aim

The aim of this research is to integrate System Engineering principals, procedures and techniques to develop a framework and criteria that enables Project Managers to tailor project procedures and documentation for optimal project outcomes. More specifically in areas identified in the scope, this project will:

1. Identify the complexity of projects and the need for Systems Thinking.
2. Identify common criteria that causes variability and possibilities to remove or reduce it.
3. Determine areas to improve PM in the zones: Stakeholders, Risk, Review, and Planning.
4. Propose documentation for Project Framework and Tailoring in the areas or Stakeholder Engagement, Risk Management, Benefits Realisation and Planning.

1.2.3 Secondary Aim

It is the secondary aim for this research that the outcomes of the Primary Aim will allow the proposal of some Key Performance Indicators that Project Manager will be able to utilise to optimise the tailoring or project artifacts and support a Cost Benefit Analysis of the Primary Aim

5. Identify Measurement Indicators to quantify successful completion of project requirements, budget and schedule.
6. Propose KPI's to assist in the Cost Benefit Analysis of tailoring project artifacts.
7. Determine value outcomes for the integration of Systems Engineering into Project Management

The Primary and Secondary Aims will be expanded in *Objectives* and reviewed to the extent of the information available in the *Literature Review*. Methodology will propose how to correlate the information from the *Literature Review* and look to add further data and address the missing information in the literature. *Results and Discussion* aims to correlate the available information from the project before presenting *Conclusions*.

1.3 Objectives

The objectives further detail the Primary and Secondary aims.

1.3.1 Define the complexity of projects and the need for Systems Thinking

In order to evaluate a better understanding of the types of challenges that a Project manager faces in there tasking will be to define complexity. Through the review of literature there was a sense that Project Managers feel like what they are controlling is getting more complicated that what it has been historically and that there have been more inputs and outputs to consider now than what they have been before with standards and practices in other domains or professions increasing in turn. It is assumed that by better defining complexity and understanding of what complexity is, Project Managers should see the requirement for more Systems Thinking approach to tasking and what role it can play with reducing preserved complexity in a Project.

1.3.2 Identify common criteria that causes variability and possibilities to remove or reduce it.

This research will seek to identify areas of Project Management that that may produce the most variability at different stages of the project. By identifying where variability might arise there can be concerted effort into risk identification and mitigation to reduce the number of possible outcomes. It is assumed that by reducing the amount of possible outcomes to a situation that Project Managers may be able to give more accurate plans and information in the areas that have been address as concerns in the background and review.

The secondary outcome for this objective is to see where Systems Engineering principals and process my then further reduce variability in a Project by improved and focused efforts on areas that have identified in the project management domains not to a subsequent level.

1.3.3 Determine areas to improve PM in the zones: Stakeholders, Risk, Review, and Planning.

The analysis of the forementioned objectives should determine within the four (4) areas identified in the scope and boundaries of the research where the Systems Engineering principals and practices might be most effective to implement into Project Management. One main objective of this research will be to ensure that areas identified for improvement will become part of the ability for organisations to learn and transfer knowledge through there project managers, procedures and measurements. The basis for this will serve and the input for proposing documentation for a reject framework and tailoring.

1.3.4 Propose documentation for Project Framework and Tailoring in the areas or Stakeholder Engagement, Risk Management, Benefits Realisation and Planning.

In determining areas to improve this research will also suggest a framework that put into practice supporting activities and processes to produce favourable outcomes in the areas that have been identified by the other outcomes. The Documentation and framework will attempt to ensure that for all areas identified that adequate decomposition, interface management and requirements analysis is conducted to reduce variability.

The research in its proposals will attempt to ensure that only those area that will gain from significant value addition for the implementation of these processes be suggested such as not to burden Project Managers with more administrative requirements that may increase cost above the level of value gain.

1.3.5 Identify Measurement Indicators to quantify successful completion of project requirements, budget and schedule.

The research presented is intended to reveal areas that may be measurable to gain data on what methods and processes from Systems Engineering are in fact benefiting the discipline of Project Management. By leveraging system engineering practices, The research will attempt to establish a systematic and objective approach to measuring project performance against key parameters linked to the identified project domains. Where there is a lack of quantifiable measurement areas identified, the analysis will investigate what may be preserved as offing value such as stakeholder relationship. This may be looked at by how an organization or project manager desired to be looked at by the stakeholder verses the stakeholder's perception.

1.3.6 Propose KPI's to assist in the Cost Benefit Analysis of tailoring project artifacts.

This objective is to offer identified KPIs that will attempt to facilitate improvement in decision-making, to allow Project Managers to evaluate the feasibility and return on investment of tailoring project artifacts using System Engineering Techniques. To measure the analysis will require implementation and baselining against a modelled no change situation to attempt to legitimise the data.

For a positive Cost Benefit Analysis, the secondary outcome of this objective would be to improve the Project Management Body of Knowledge with measurement ability in areas that currently might not be giving a detailed pictures of where continuous improvement or further investment might benefit.

1.3.7 Determine value outcomes for the integration of Systems Engineering into Project Management

The final objective of this research will be to access the feasibility of utilising System Engineering principals and techniques in Project Management. Where value benefit may be seen the by an organisation, attempts will be made in real world situations to validate in field practices. Positive results will then be suggested as improvements to the Project Management Body of Knowledge. If the integration of the techniques, framework or tailoring is not seen or perceived to be value adding an assessment will be conducted to inform either the removal of the proposal or the suggestion for further research and iteration.

If this research is deemed to be successful in those areas identified in the scope and boundary of the research, it will be suggested that further areas of Project Management be suggested for assessment to optimise with system engineering techniques.

1.4 Consequential Effects of the Research

There is a positive sense that the outcomes and artifacts from this research when used in conjunction with the Project Management body of Knowledge (PMI Inc., 2021) and ISO 21500 Guidance on Project Management (ISO, 2012) will have a positive effect on the way that a project is managed. There is a sense that the most benefit will come when utilising the proposed outcomes from the start of a project but there may be applications were the research will be able to be retrofitted to existing and ongoing projects.

1.4.1 Academic

The proposed outcomes of the study could be further research into modern Project Management and lay foundations for further System Engineering principals to be used. This may then change the curriculum to how Project Management is taught through university and further education.

1.4.2 Industrial

The proposed outcomes may create more effective and efficient project start-up, through life support, and disposal of products or services. The outcomes of this research may change the Project Management field or occupations to include more engineering techniques. The main objective of this research is to add or supplement the current understanding of Project Management and increase the Project Management Body of Knowledge in a positive way with measured results. The proposed outcomes

may encourage synergies to Industry 4.0 solutions and lead to better oversight and control for Project Managers, Stakeholders and Engineers alike.

1.4.3 Societal

As we saw in the background, there are a number of project that are not achieving their full value, are delayed, overbudget or do not meet the desired requirements. This can reflect negatively socially, especially where the Projects might be tax-payer funded. If this research is successful in taking out some of the variability in cost, schedule and requirements the effect may mean that the stakeholder, consumer or tax-payer is better informed.

1.4.4 Ethical Responsibility

To ensure that all outcomes of this research are in line with what is best for the Australian and global population all proposals from this dissertation will be in line with The Engineers Australia Code of Ethics (Engineers Australia, 2022)

2 Literature Review

2.1.1 Complexity

With almost 7 out of 10 Project Managers stating that their undertakings have become more complex over the last decade (KPMG 2020), the use of the notion “complex” has to explored for correctness in what should be organised project structure with the information that is radially available in the Project Management Body of Knowledge (PMI Inc., 2021). Mitchell states that the definition of complexity is based on the identification of a parameter that is measurable and to date there is no agreeance on which parameter should measured (2011). In this there is the iteration that understanding of complexity is in itself complex. This is due to the parameter that that is trying to measure is that of understanding.

Understanding however is however subjective, and can be reduced through cognitive comprehending of an object/problem/system and our ability to make distinctions, perceptions, or information about it (Ertas 2018). Therefore, Project Managers stating errors in cost and schedule assumptions is due to complexity are really stating there is a lack of understanding inside their

organisation and their project team on the associated risks or variabilities. These risks or variabilities in the project are that which could cause deviations in a budget, schedule or delivery of the requirement to a stakeholder.

It is not however surprising that “complexity” is blamed in these situations as 25% or organisations only sometimes or never create scoping or specifications documents for their projects (Wellingtone 2020). Even when these documents were in place only 60% or project managers were engaging in Risk Management identification and mitigation to better understand the inputs and variability of their project (Wellingtone 2020). If the statistics are lower than 100% for either one of these areas of inside of a project, in turn there will be miss understandings or inability to forecast or predict potential outcomes. With some of the outcomes being hard to quantify such as stakeholder satisfaction or delivery of requirements meeting intention, it is then in turn difficult to measure or baseline what project success or the actual value measurement of Project Management outputs.

Warfeild (1994, cited in Ertas 2018) states that their complexity can be attributed to two distinct aspects: Cognitive Complexity and Situational Complexity. These two fields may further the explanation of issues with project management, but both can be reduced through different ways to increase comprehension and ensure that a broader understanding can reduce variability and risk.

Situational Complexity is attributed to the system being examined. It has been shown in the background of this research that a Project can be seen as a system of systems and that even some elements in that system can be systems in their own right. Therefore, the interface control between these elements is required so that the system is decomposition in a manageable manner. This practice is Systems thinking and has been referred to in the PMBOK (PMI Inc., 2021) under the Project Management Principals as the project manager requiring these skills but gives little insight as to how they should apply it. It can be seen however in the NASA Systems Engineering Handbook (Hirshorn, 2016) that there is a logical decomposition process to make sure there is a system architecture that identifies the elements that meet the stakeholder expectations and what level it needs to be achieved to have a successful project. The practice of this decomposing can induce another level of difficulty into the understanding and communication within a system due to the exponential increase of connections when viewed as a System of Systems. As this research assumes that a project is a System of Systems the addition of these communication line may need to be managed effectively by the project manager or have a system in place that will compensate for the increase.

ISO 21500 (2012) shows an inputs and outputs chart for the different stages of a project but fails in its summary of the intricacies of communication in a project organisation. The number of interactions in a project team may be as high as $\frac{n*(n-1)}{2}$ which in large organisations can make it very convoluted. If stakeholders are then added into the communication matrix the connections may increase significantly. Approximately 40% of project management teams have 6-10 members (Herrin 2022) meaning that there could be as many as 45 lines of communication. As this is an exponential equation the communication lines can become uncontrollable with just the addition of a small number of elements in the system as seen in the figure below. Even with documentation such as a Project Management Plan that controls interaction there may become a point where Integration Leads will need to be used. The intent in this instance is to create multiple smaller groups that only communicate through one (1) point making the system more complex.

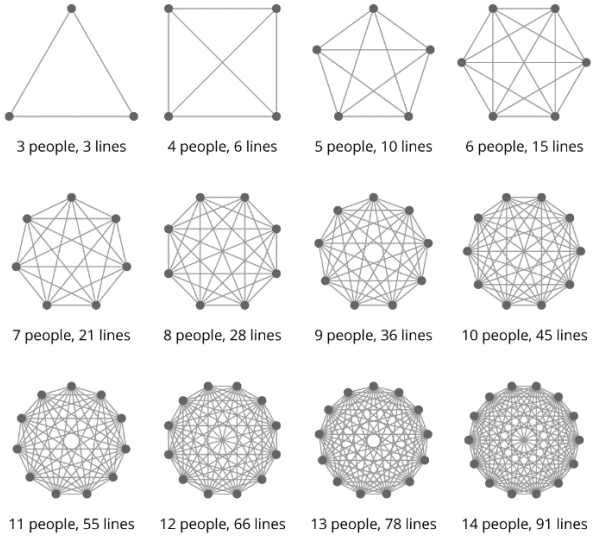


Figure 6 Potential Communication lines dependent on size

Cognitive complexity is the associated complexity as viewed from the observer (Warfeild 1994, cited in Ertas 2018). This comes to the fore when the observer has the inability to understand the project, system, or element that they are trying to work with or in. Therefore, it can be shown that cognitive complexity can be present even where there is no situational complexity as it is only attributed to the observer. Looking for a parameter to describe complexity, understanding should not be used as a yard stick as it is different among the measured population. Understanding can also be argued as a binary measure meaning that if someone does not comprehend something fully then they do not understand. The only way that Project Organisations can ensure there is an assumed level of understanding is through

education in project management practices and by also by ensuring that project management staff have access to the correct processes and subject matter experts which as stated in the background are often the Systems Thinking techniques and System Engineers who must fully comprehend their project of system element.

2.1.2 Project Management

ISO 21500 Describes project management as "the application of methods, tools, techniques and competencies to a project. Project management includes the integration of the various phases of the project life cycle" (2012). Management as a career path was established around the 19th century by the US railroad organisations where they took the US Army's "systematic management" to control schedule, budgets and cargo. In the 20th Century Taylor developed "scientific management" whereby manages used engineers to understand process better to get more from factory workers. Taylor's methods were then adopted in Japan which formed Total Quality Management that was seen around the world after World War II (Johnson 2013). Project Management was born out of necessity after the war in conjunction with operations research and systems engineering. Projects at this time were starting to involve more and advancements in materials, computation and production techniques mean that not only were there novel ideas, the integration of them with other areas was complicated. Project management looked to be the answer, but it did take some time for practices and standards to flow to industry other than military projects where it was being heavily adopted in the 1950's (Johnson 2013)

Project Management is now widely adopted around the world and is a designated profession for a number of individuals with its own curriculum and lucrative job market. Such documents as the PMBOK® and ISO 21500 set the base knowledge for the profession, and as the acronym describes, it is a body of knowledge and has been building since the early days of project management. Organisations such as the Project Management Institute collect the statistics from the project management field and try and promote global standardisation. Moving into the 21st century there is a transition where project management was historically based around an individual or team who was seen to be "organised" and more towards Enterprise Resource Planning Software and Artificial Intelligence to produce suggested solutions to project management problems.

In 2019 the Project Management Institute reported that organisations that had outdated project management techniques or technology has a 18% chance of failure. These applications are not fit for all organisations and projects as there is some application of size is required. Johnson states "There is no

single best method of project management valid across different industries, organizations, or nations" (2013). This could be seen as a narrow view, as project management body of knowledge should not be seen as a method but as a framework and it is therefore the tailoring of the framework for size, complexity, cost and schedule that should become adaptable to all projects. As described in the background of this research the Wellingtone (2020) State of Project Management Report 2020 suggests that this is not actually the case with so many Project Mangers reporting issue with schedule, risk, requirements, and budget.

2.1.3 Variability

One of the largest components of ensuring that a project is run to budget and schedule is understanding the stakeholder requirements not only of the product but of the stakeholder business. The PMBOK® (PMI Inc. 2021) has the Stakeholder and Stakeholder Engagement as the first project domain but is very light on the actual process of engagement of the stakeholder and how to drag out the requirements. Compare this to the Stakeholder Expectations Definition Process in the NASA Systems Engineering Handbook (Hirshorn, 2016) and it can be suggested there is much benefit that the Project Management profession could gain from treating the Stakeholder domain as another subsystem in the system of systems that is a project. One portion of the PMBOK that is not defined to a degree which may be a causation to the poor statistics int eh Wellingtone report is that of Stakeholder commitment to their requirements. We can see in the figure below that in the NASA Systems Engineering Handbook (Hirshorn, 2016) that this is explicit and therefor can be used as a measurable target to reduce misunderstanding and variability for the Project Manager.

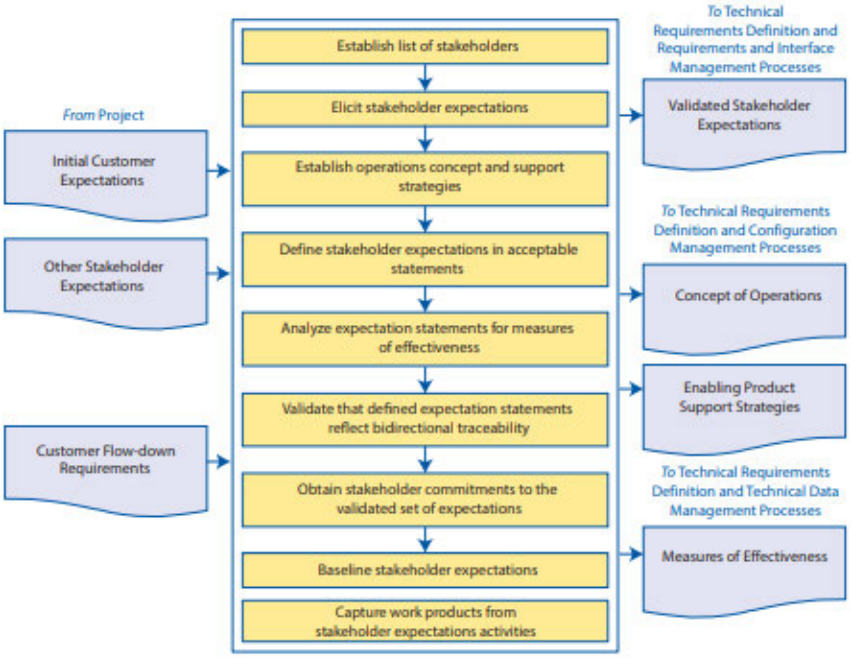


Figure 7 Stakeholder Expectations Definitions Process (Hirshorn, 2016)

Lachhab et al. (2017) states from multiple sources that risk should be considered as uncertainty and "is considered as the effect of the occurrence of unknown situations on project objectives (cost and duration) and should be taken into account". This is the only way that decision making of project management can be made with some knowledge of potential outcomes that can be measured against. All forms of variability therefore can be seen as risk. ISO 21500 (2012) for project management sees the assessment of risk, risk treatment, and risk control being carried out to late to have a valid input for the budget and schedule. Lachhab et al. also go on to explain that the Systems Engineers are the knowledge base or subject matter experts and should be included in the definition of the project during the initiation and planning stages.

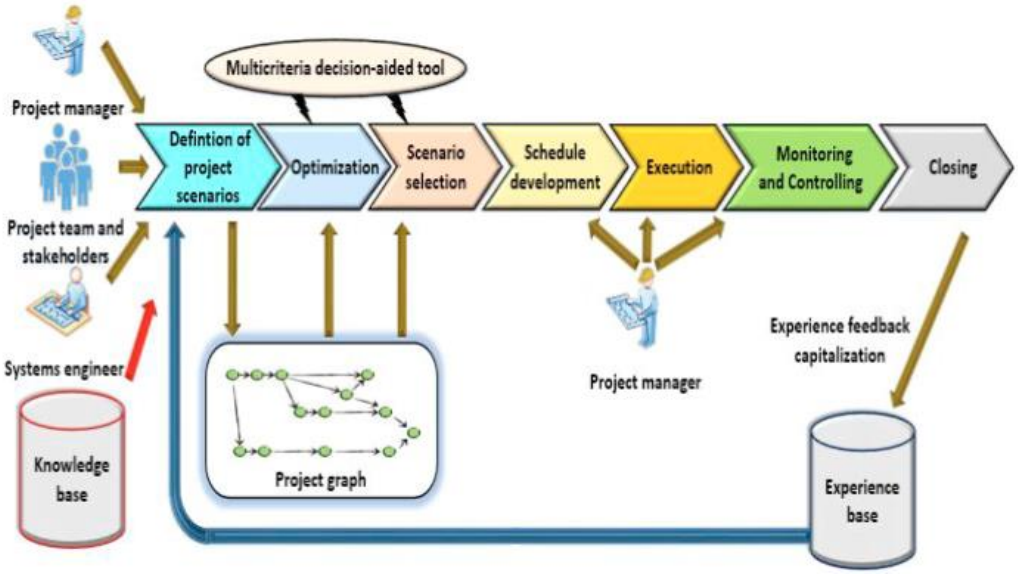


Figure 8 General Framework of integrated SE to PM (Lachhab et al. 2017)

2.1.4 Measurement

The Stare of Project Management Report by Wellingtone (2020) showed a measurement statistical figures from Project Management Staff from 111 Organisations across 26 countries but the data is representative of the perception of the Project Managers rather that data analytics through the survey. This is mostly due to the ease of survey, the restriction of Company Intellectual Property or Proprietary Information, and difficulty to set a measurement standard to access against wholistically.

Although some areas of project success will still have to be measured via perception like, stakeholder relationships and reputation. Other area should be quantifiable more easily if the requirements, inputs, outputs and expectations are better understood and baselined. Looking to the PMBOK (PMI Inc., 2021) there are examples of Key Performance Indicators (KPI's) and some suggestions in what to measure. It can be assumed that if these measurement areas are correct for project management and the Project Management Body of Knowledge there should be better performance statistics that what have been shown in the project management reposts. Historically most of the KPI recording by an organisation is conducting as Lagging Indicators which provide information after the fact. Unfortunately, if the recording organisation does not have a learning organisation or effective continuous improvement plan the Lagging Indicator may not be useful. The other issue with a lagging indicator is that the stakeholder may already be dissatisfied with the result and the measurement is therefore just a report. It is written in the PMBOK (PMI Inc., 2021) that Project Organisations for have as many Leading Indicators as possible giving

forecasts into trends and may give enough time for negative KPI's to be access through root cause analysis to reverse a trend before conclusion of a project or element.

Effective KPIs are wholly based on the requirements that are delivered during the planning of a project. Without effective risk management, stakeholder identification and requirements there will be increase variability in what is trying to be measured and the indicator might not provide accurate information in that may induce unnecessary cost and time. KPI's in themselves are also useless unless they are applied to some kind of improvement, learning or review.

It can be seen that the delivery of a project in all aspects can be that as a delivery of quality across all the project management domains. It can be assumed that though the reduction in quality of one of the Systems of System elements that the overall system may suffer. If the KPI is treated as a health or quality measurement then there may be a link between Statistical Quality Control that may be exploited to give better understanding and improve outcomes of a project. Montgomery (2013) states the "quality is inversely proportional to variability" and that "quality improvement is the reduction of variability in processes and products". Referred to previously in the background and review this research aim is to reduce or better understand variability in Project Management through integrating System Engineering techniques tying these concepts together. One technique used in quality management is the sampling of variables against a baseline or datum. In this way variability can be quantified and analysed statistically and that the statistical methods can then in play a role in quality improvement efforts.

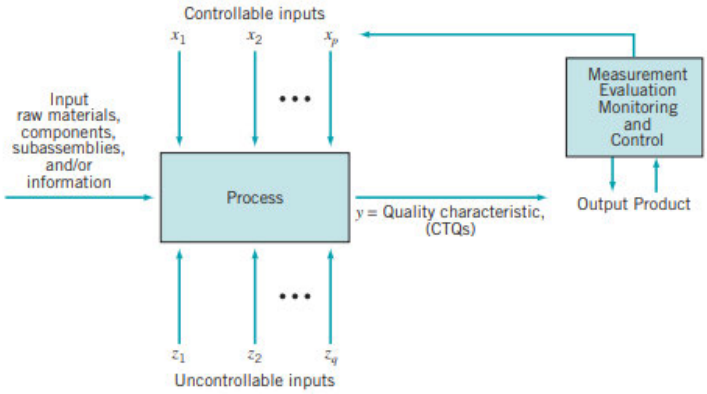


Figure 9 Quality Characteristics output from Process inputs (Montgomery, 2013)

2.1.5 System Engineering

Although a broad subject System Engineering can offer a framework that can have a significant affect on the outcome of a project depending on the integration of the Project Required. Locatelli et al.

(2014) describes that he origin of System Engineering come from around the 1930's but like Project Management, really started to excel once the US Department of Defence contributed to its further development after the second world war with the rise of defence technologies. The reason that there was/is a designation in between Systems Engineering and Project Management was that the DoD saw that is was not enough just for a supplier or in house developer to just deliver a product for service. It was also necessary to deliver the support systems that the product required such as operators, training, maintenance, upgrades and so on. One aspect that System Engineering also focused on that Project Management might have missed was that fact that is looked at the whole product lifecycle instead of just the time leading up to delivery. In this sense Systems Engineering took into consideration potential future requirements and in case made adequate room for upgradeability and continued integrations with partners and other developing products.

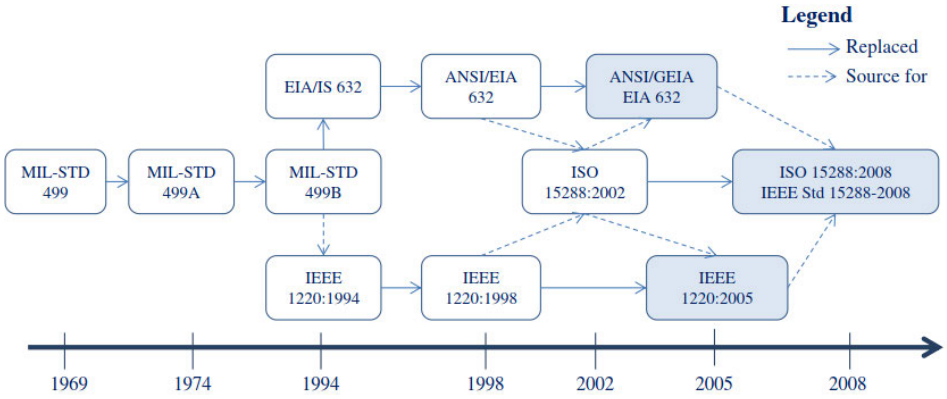


Figure 10 Development of System Engineering Standards (Locatelli et al. 2014)

The INCOSE (2015) definition of System engineering is:

"Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs."

This implicitly states that the upfront effort for analysis through the use of Subject Matter Experts, including both business and technical domains, means that system engineering will deliver a product that complies with requirements if they are clearly stated, documented and the control processes for systems engineering are used. It must then be questioned that if this effort is dedicated to ensuring that the product achieves best value for stakeholders why the same mentality cannot be utilised to ensure that the Project Management of the product or service development cannot also achieve high results in stakeholder satisfaction.

Systems Engineering generally follows the Vee model (INCOSE 2015) which covers the aspects of Requirements Definition, Technical Solution Definition, Design realization, Evaluation, and Product Transition. It can be seen below in the figure that the model represents going down and getting to the root of the requirement before designing and building the product up. One of the most important steps that is often looked over in project management is that of review and verification. System Engineering ensures review through the interactive process of critical review. Boehm et al. (2014) as seen in the Systems Engineering Handbook (INCOSE 2015) adds more to the front matter than many others when it comes to ensuring the commitment to a project and the potential risks associated. Through the Incremental Commitment Spiral Model Boehm et al. push the stake holders into review in initial stages like Exploration, Valuation, Foundation, Development, and Operation commitment reviews in addition to normal deliveries such as Preliminary, Critical, and Final Design reviews. In thinking about the initial steps of the commitment to a System in this way and the utilisation of the Vee Model, Systems Engineers can get a high "buy-in" from the stakeholders and ensure that understanding is disseminated through the team.

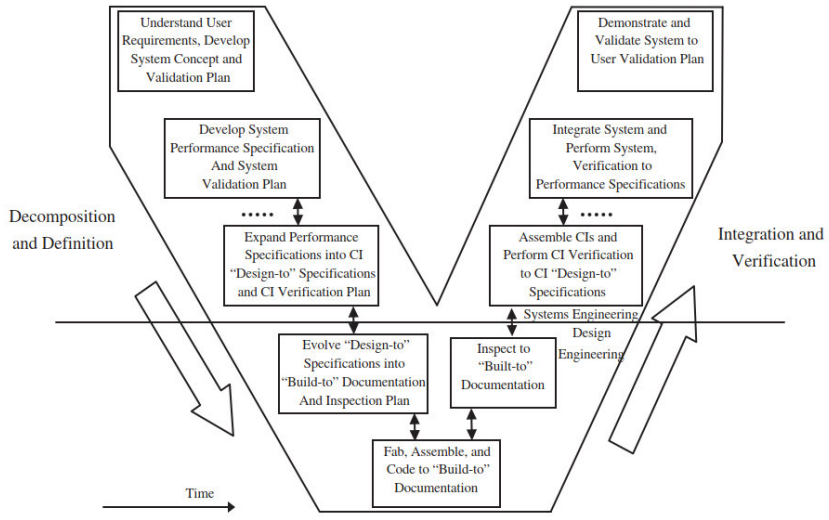


Figure 11 The SE Vee Model (Forsberg and Mooz (1995) seen in Locatelli et al. 2014)

Although Systems Engineering dictates that there should be a high level of effort in the early stages of a Project to define objectives, roles, responsibilities and requirements, its ability to then handle dynamic changes and the development of risk are evident as it allows the Project Organisation to learn though review as the project develops. The literature suggests that through efficient integration of Systems Engineering elements into Project Management better Project Governance will able to be achieved, even if this is just in the form of improved estimation in the early stages of a project. Through their review Locatelli et al. (2014) have suggested four (4) Systems Engineering approaches and six (6) Systems Engineering techniques and tools that may be able to support Project Governance further which are summarised in the following table.

Table 2 SE Approaches, Techniques and Tools with potential benefit to PM (Locatelli 2014)

Systems Engineering Based Governance	SE Approaches	**Systems Thinking** – Understand and analyse the different elements of a system to understand the complete systems, impacts, consequences, complexity, risk, leverage of each individual element and then the system as a whole.
		Open Systems Approach - The open systems approach is a methodology that continuously interacts with its environment or surroundings, adapting and evolving requirements throughout the system's life to cope with changes and new requirements (DoD 2002 seen in Locatelli et al. 2014).
		Multidisciplinary Approach – Ensuring that the Project Scoping team has the necessary skills to make accurate estimations in all stages of the product life cycle
		Top Down and Bottom up Approach – The Vee Model to ensure that all requirements are ascertained and that information is spread throughout the Product team
	SE Techniques and Tools	**Integrated Product Team** – A multidisciplinary group of people who are collectively responsible for delivering a defined product or process (INCOSE 2015).
		System Integration Process - Product integration is the engineering of the subsystem interactions and their interactions with the system environments (both natural and induced).

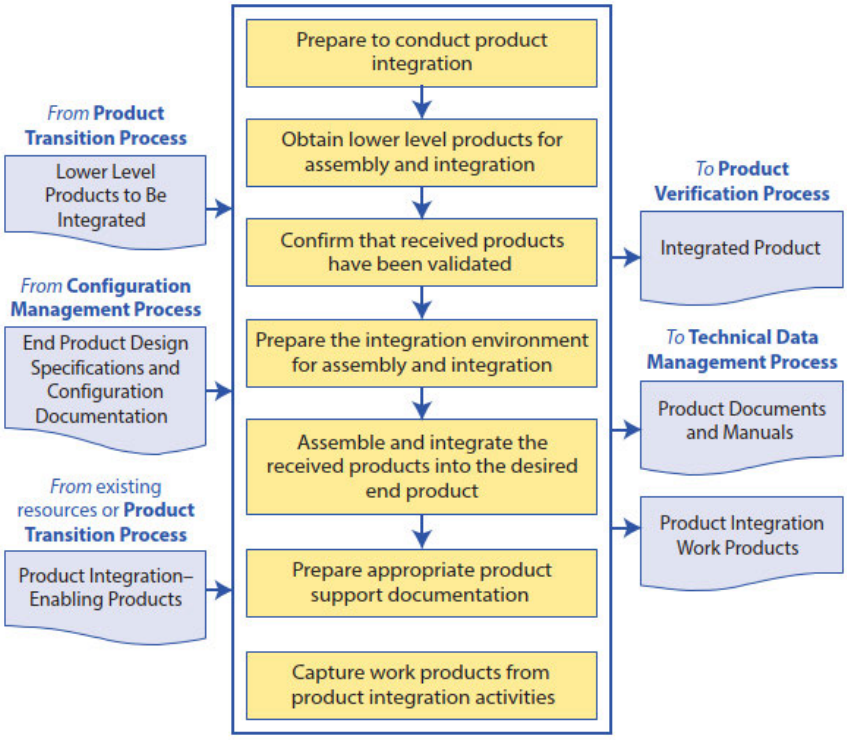


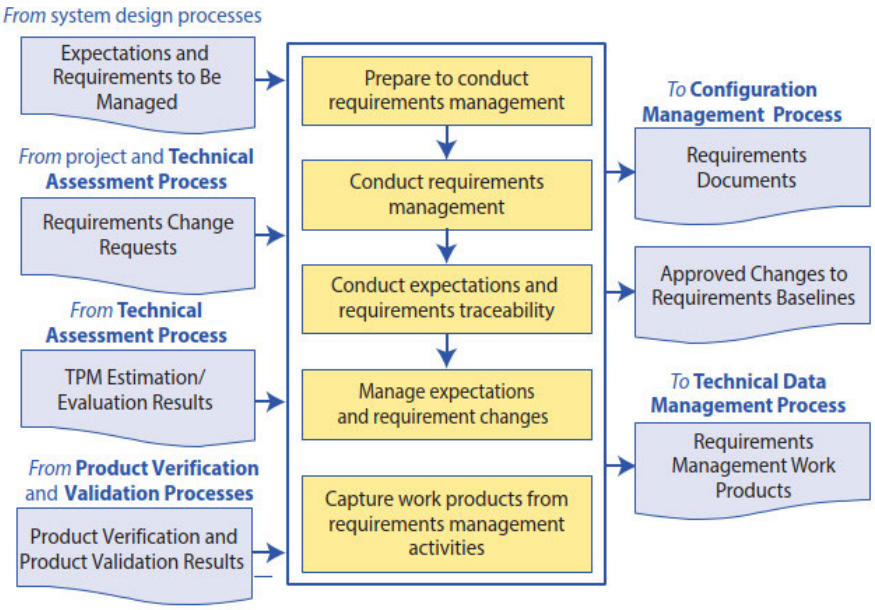
Figure 12 System Integration Process (Hirshorn 2016)

Modelling and Simulation – Can give results to the anticipated systems behaviours. Can be run before development or commitment meaning that they able to assist in the decision-making process. Models and Simulations can also give a good medium for information transfer through the product team

Trade-off analysis - Trade studies identify desirable and practical alternatives among requirements, technical objectives, design, program schedule, functional and performance requirements, and life-cycle costs are identified and conducted (DoD 2001). This also allows the product team to leverage expertise from other SME's outside of their organisation

SE Management Plan - The SEMP is the primary, top-level technical management document for the project and is developed early in the Formulation Phase and updated throughout the project life cycle (INCOSE 2015).

Requirements Management Tools – Requirements management is the only thing that will eventually ensure that the project is able to be measured as a success or not. Gotel and Finkelstein (1994) as seen in Locatelli et al.

		(2014) states requirements management is; *"ability to describe and follow the life of a requirement, in both a forwards and backwards direction"* The backwards direction is also important to ensure that "scope creep" and/or interface change requirements are documented of configuration controlled to ensure that the assessment baseline for the product and the stakeholders is aligned.  *Figure 13 Requirements Management Process (Hirshorn 2016)*

Locatelli et al. (2012) believe that with these aspects of system engineering Project Management and Project Governance will be improved through better planning and control. It can be seen that the wholistic approach to a Project and treating the project management in itself as a system-of-systems will change the point of view of Project Managers drastically. With this approach Systems Engineering can further identify the requirements for tailoring of there documentation dependant on the requirements. NASA (Hirshorn 2016) classify there projects into type ratings based on certain criteria that they determine govern the complexity of the project. These criteria are based around Mission Description, Priority to Strategy, Acceptable Risk Level, National Significance, Complexity, Lifespan, Cost Guidance, Alternative Applications or value addition, Reusability, and Success Criteria. They also go as far to give historical examples of projects and their type to easily identify commonality. Through this they then give a

matrix of all System Engineering documentation that they would expect and what has the potential of tailoring. This in fact shows that the organisation is self-learning and that lessons learned in previous projects can be adapted and applied to future endeavours. It can therefore be seen that Systems Engineering approaches and techniques have great potential to improve the Project Management body of Knowledge and potentially increase responses from project managers and project organisations for Project Management Success.

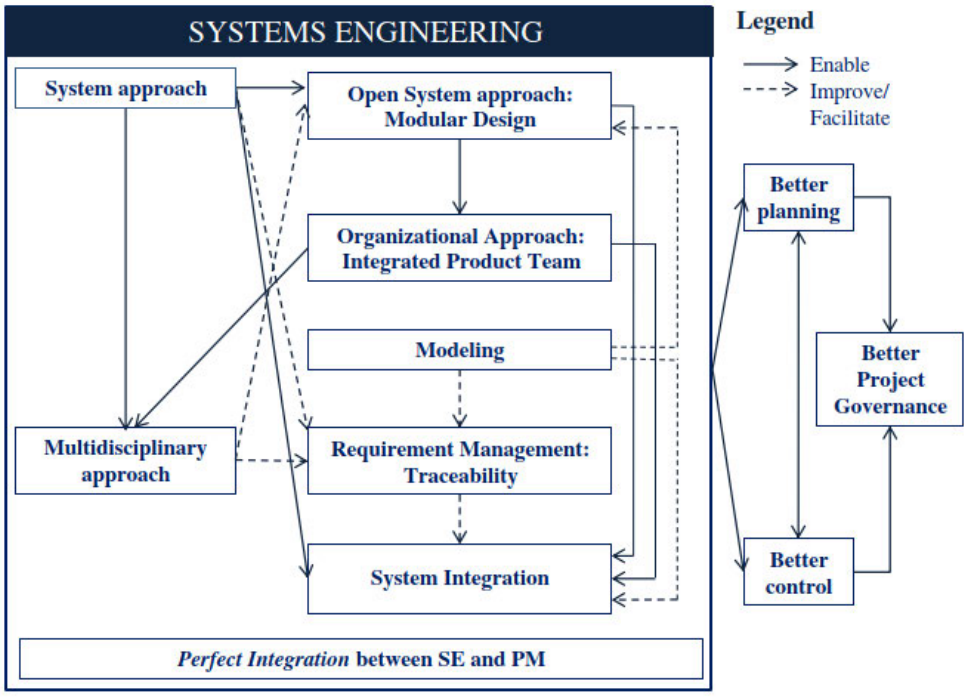


Figure 14 Systems Engineering and its potential effect of Project Governance (Locatelli et al. 2014)

2.1.6 Research Gaps

There is evidence of deficit in the literature identified, in relation to the effectiveness and efficiency gains that System Engineering techniques may provide to the field of Project Management. Noteworthy exclusions in summary include;

- A lack of definition of what makes a project complex, what makes project mangers turn to the explanation of complexity and how Systems Engineering may create more understanding in Project Teams and a learning culture in Project Organisations.
- A lack of further explanation of how the areas in System Engineering that crossover into Project Management may be used to further amplify the effectiveness of Project Governance.

- A lack of distinct documentation or Project Management practices that should be targeted for tailoring using System Engineering Techniques
- No identified links between the utilisation of Systems Engineering techniques in Project Governance and the effect it has on Project Delivery success.
- No identified links between the utilisation of Systems Engineering techniques in Project Governance and positive value generation for Project Managers.

It is a common theme throughout Project Management and project literature that when there are situations or results that do not achieve their desired results or are unexplainable at the time that the project is deemed complex. As stated in Ertas, A (2018) the definition of complexity to date does not have an agreed upon definition. There have been statements that try to base complexity on some form of quantifiable parameter such as *"size, entropy, information content, thermodynamic and information required to construct, computational capacity, statistical complexity"*. This in itself then can not be expanded upon. Taking size as an example, what is it about this parameter that make something complex? A granite stone as compared to a granite boulder are of different sizes but nothing about the construct is different, can the larger be said to be complex? Although moving a granite stone compared to a granite boulder may cause other issues to arise. It can be seen in this presentation of the argument of complexity must have a secondary input to scale the quantifiable parameter. If we take this analogy into Project Management, depending on the organisation they may have the tools or the processes to move the boulder. This may be through the equipment required to move the large weight via System Engineering Tools and Techniques, or via breaking the object into manageable pieces via System Engineering Processes. No literature defines this secondary input for scaling the parameters of complexity.

It can be seen in the literature that multiple researchers and institutions have drawn distinct connection with the possibility of integrating Systems Engineering Techniques into Project Management and project governance. It must be questioned then that will these parallels being drawn and both disciplines having been around for a substantial part of the technical revolution why is it that projects are still seen to be having such low success rates. It is theorised in this research that this may be contributed to the fact that the integration of these techniques is producing controlled scoping and oversight in the product domain of the project meaning "Project Success" while possibly being incorrectly applied to the project governance leading to "Project Management Failure". As the governance of the project has a large influence on the success of the product overall success in both areas can only be somewhat achieved

which could also be interpreted as the causation from the Project Management survey results aforementioned in this research.

Locatelli et al. (2014) has built on the idea from Shenhar and Dvir (1996) that project success and project management success may not be related, stating:

"In our journey toward a comprehensive understanding of project success, one should not confuse any more between project management success and project success. Semantically, project management success refers to efficiency, an internal concern to the project team, and project success embraces concerns for efficiency and effectiveness—in other words, all concerns, whether internal or external, short-term or long-term".

With the current status of results from project management surveys is may be concluded that there is still available room for improvement using system integration techniques for the development of project management and project governance may be available when we look at a project as a System-of-systems. It can be seen that the in-depth nature of the System Engineering techniques to analyse requirements and ensure that all components of a system are integrated in there most efficient manner to achieve overall compliance, can be adapted with the right application for project governance. No literature states how System Engineering techniques may be used in distinctively different ways to achieve both Project and Project Management Success.

The PMBOK (PMI Inc., 2021), ISO 21500 Guidance on Project Management (2012), INCOSE Systems Engineering Handbook (2015), and the NASA Systems Engineering Handbook (Hirshorn 2016), all recommend the same or similar documentation when it comes to Project Management through Project Governance. Reading through the guides there is very little recognition in what should tailored to suite projects that have different requirements especially when it come to how System Engineering techniques may shape Project Management for the better. Locatelli et al. (2014) shows his findings, through literature review, where different Systems Engineering outcomes could potential influence aspects of Project Management like Cost, Quality, Time and Risk but fails to directly correlate how it should be applied in the Project Management profession.

		Reference								
		Ancona and Caldwell (1989)	Gruhl (1992)	Frantz (1995)	Miller et al. (2000)	Kludze (2004)	Honour (2004)	Elm et al. (2008)	Componation et al. (2008)	Honour (2010)
Findings	SE impact on project success	✓	✓	✓	✓	✓		✓	✓	✓
	SE impact on cost		✓	✓		✓	✓		✓	✓
	SE impact on quality			✓		✓	✓		✓	
	SE impact on time			✓		✓	✓		✓	
	SE impact on risk					✓				

Figure 15 Areas identified in literature where SE could assist in areas of PM (Locatelli et al. 2014)

All research has drawn conclusions through academic theory and literature review that the integration of System Engineering with Project Management will achieve better results. Some such as Locatelli et al. (2014) have given examples of project whereby success has been contributed to the application of Systems Engineering but there is not definitive measure that this was the definitive application of Systems Engineering techniques or if it was attributed to an instinctively Systems Thinking Project Manager. Through all the literature that has been disseminated in this research there are no direct value generation benefits or measurable efficiency improvements provided. This is often to the fact that projects are reactive and do not often change until necessary. There is hear an ability to compare then how it is to how it was, but in lieu of running two (2) comparable projects, one using Systems Engineering techniques and one without, it is hard to prove the necessary gains to continue research into this topic. It is hope that this research will be able to identify some assumed targets or Key Performance Indicators to successfully convince the beneficial use of Systems Engineering techniques in Project Management.

3 Methodology

Research has been conducted with the aim of identifying and defining.

- Complexity in Project Management
- Area's where Systems Engineering may reduce variability.
- Measurement area's for the application of KPI's to support CBA

Though this it is hoped that the research may propose;

- Frameworks, Documentation and processes that are measurable, and that improve value in projects by increase effectiveness and efficiency.

Three different methods have been used to be able to meet the primary and secondary aims of the research:

- Literature review

- Survey, and
- Interviews

To further investigate complexity, the use of Systems Engineering approaches and techniques, what is means to Project Management and how it can be applied both literature review, survey and interviews with practicing project managers have been used. The literature review has led to an area where the definition of complexity is quite vague, although both Project Management and Systems Engineering alike use it in descriptions for variability in their bodies of knowledge. To further understand the application of this term targeted questions have been used in both the survey and interview on how practicing professionals view complexity in Project Organisations.

The results of the three methods will be used to either validate or disprove the use of the term complexity when understanding poor performance in Project Management. This will hopefully lead to a common scaling factor for variables that have historically been labelled as complex, and in turn possibly generate a datum for measurement for other projects.

Throughout all three methods and as they arise, possibility for the integration of Systems Engineering techniques for the better or project management will be investigated. Targeted areas of Systems Engineering will be utilised to create a baseline of information for the research and any other suggestions by participants or in the literature will be brought forward to be potentially entered in the research or to be included in the further work section.

All three methods will hopefully identify common areas and trends as well as any outliers between findings to establish a baseline of information to be the foundation for improvement and development of practices and processes in the Project Management domains. Although all three methods will not be conducted concurrently, the aforementioned literature and any further examples has always been referred to for the validation of results in the survey, interviews or correlation of data.

3.1.1 Literature Review

The literature has been used to summarise and report the main findings, conclusion and discussion points available in the research community currently. The literature review also helps to understand the boundaries of the Project Management issues in questions and seeks to find sources that align for evaluation and critique. Due to the length of the research they literature relating to the topic has been summarised to those points that are deemed to be highly relevant to the area of research in section 2.

Although the organisation of this literature is mostly concentrated in the review, where deemed suitable references will be used to literature throughout the paper to support findings and discussion.

3.1.2 Survey

The survey will be used to extend on the literature review by asking participants key question focussing the four (4) common areas to Project Planning & Control (PM) and System Engineering (SE) identified by NASA (Hirshorn 2016) and the Wellingtone Project Management Survey (2020). The Survey may extend into other areas of Project Management to ascertain connection to the four (4) common areas. A selection of different response types will be used to try and gather information in a format that is easy for the participant to complete in about 30 min. Targeted questions with sliding scale (i.e. selection of 1-7) will be used to be able to compare results effectively between the participants. The survey will also give room for the participants to type their own definitions and understanding for terms such as complexity, integration, and systems engineering to compare the with the literature definitions and between participants.

It is targeted that all active Project Managers at Kongsberg Aviation Maintenance Services AS will participate in the survey portion of the research at a minimum. It is also the intention to make a digital version of the survey that may be sent to the broader network of Project Professionals that are connected to the organisation in some instance, either through projects collaboration or personal connection. The extension to the Kongsberg Aviation Maintenance Services staff will act as a control to validate the core results.

The intent of the survey is to produce quantitative data in relation to the aims of the research to support the hypothesis that Project Managers are struggling in common areas that could be improved by the implementation of System Engineering approaches or techniques. A demonstration of the survey and the results are placed in Annex D. Due to some of the participants preferring to answer in Norsk the original and the translation will be made available.

3.1.3 Interviews

The purpose of the interview will be to develop on the findings and responses from the literature review and the survey. Once the survey results are compared questions will be asked of the interviewee to elaborate on sliding scale responses if they are deemed to be an outlier or if a written response is significantly different to the group. If an outlier is determined to be relevant by the interview response from the participant, it will continue to be used in the findings. If an outlier is seen to be from a

misunderstood question, there will be a chance for correction in the interview. For this period, the interviews will mostly be based with the other Project Managers and Kongsberg Aviation Maintenance Services and therefore may be a reduced volume from the survey participants.

The secondary portion of the interview will be aimed at asking open ended questions about the interviewees views on the four (4) common areas to Project Planning & Control (PM) and System Engineering (SE) identified by NASA (Hirshorn 2016) and the Wellingtone Project Management Survey (2020), the current state of the project organisation, and areas that the participant may see improvement. The interview will then move into the four (4) approaches and six (6) tools of System Engineering identified by Locatelli et al. (2014) and see if the participants see any potential benefit to project management from their inclusion. The last portion on the interview will focus on measurement of value generation and success in project management, the current situation and any areas where they think improvement can be made. All questions have attempted to be asked in a open ended manner such that the participant is not lead to a response. If the participant is unsure of a Systems Engineering approach or technique that is being asked of them, they will be given an opportunity to try to define, a definition will be given to them but then only a response of yes or no will be recorded for their opinion if it would generate improvement to ensure that bias from the interviewer is not involved.

It is the main objective of the interview to validate the survey and the literature review findings and identifying additional advantages and disadvantages to the introduction of Systems Engineering approaches and techniques, and perceptions of these methods in relation to Project Management

The interviews are not recorded due to the fact that some of the interviewees may prefer to communicate in Norsk. Notes from the interviews will be taken in English and required translation of the participants answers will either be translated by the interviewer or a translation service. A demonstration of the interview template and the response note are placed in Annex E.

3.1.4 Analysis and Correlation of findings

Analysis of the findings from all three (3) methodologies will be conducted to access the validity of the data compared to one and other and baselined against the current literature. The results will then be used to determine if the problem statement was valid and if there existed the potential for further investigation on possible solutions.

The results were then used to be able to determine where Systems Engineering Principals, Techniques and Process may be used in Project Management to be able to better quantify variability and give better value in the outcomes of Project Management Success and not just Project Success. Results will be examined further in Section 4: Results and Discussion.

3.1.5 Risk Management Plan

Please see Appendix F for the Project risk management plan

3.1.6 Project Resources

Please see Appendix B for the Project resource Requirements

3.1.7 Timeline

Please see Appendix G for a timeline for the project

4 Results and Discussion

4.1 Complexity of projects and the need for Systems Thinking.

As previously mentioned in the research there is sill a lack of agreement among scholars with the definition of complexity (Ertas, 2018) and what in fact is being measured (Mitchell, 2011). We can see that through the survey conducted by KPMG (2019 & 2020) and Wellingtone (2020) that complexity is stated as the reason for some of the failures in project management but how are we able to attribute causation to something that has historically been ill defined and unmeasurable. KPMG (2020) specifically state that

"successful Project Managers requires more than training and certification in technical project management…the skills most needed to be effective are clearly pointing to the need for the future Project Manager to be more capable in managing complexity."

We can see that in the responses from the surveyed members that all deemed that their project had some form of complexity but none of the descriptions of what they were measuring against as a definition was the same. This in itself is further evidence that one of the main causes of the problem statement approximately half of projects are not being delivered to the original projects intent. The inability to identify requirements leading to further change or poor management of arising change may be the reason that along with the failures in Project Management only 42% of the projects are delivering on the

stakeholders intent. It was seen that during this research that KAMS did not have a adequate requirements analysis or change management process as a part of their Quality Management System (QMS). They did have the required processes for Configuration Management, Process and Capability Change as required in the aviation industry but there was little in the P-180 Project Management Procedure (KAMS, 2023) on how the KAMS analysis and baselines requirements besides the fact that it was up to the Project Manager. The procedure did leverage on processes developed for the KAMS parent organisation Kongsberg Defence and Aerospace (KDA) but as much of their market was the development and manufacture of new products and therefore focuses on the initiation phase it did not necessarily translate into the Maintenance, Repair & Overhaul (MRO) of products during the through-life project phase. These initial factors coupled with the fact that is it is historically complicated to retrofit change to existing projects may be the fact that the difficulty in navigation, measurements and management of requirements and change to requirements is often disguised under the title of complexity.

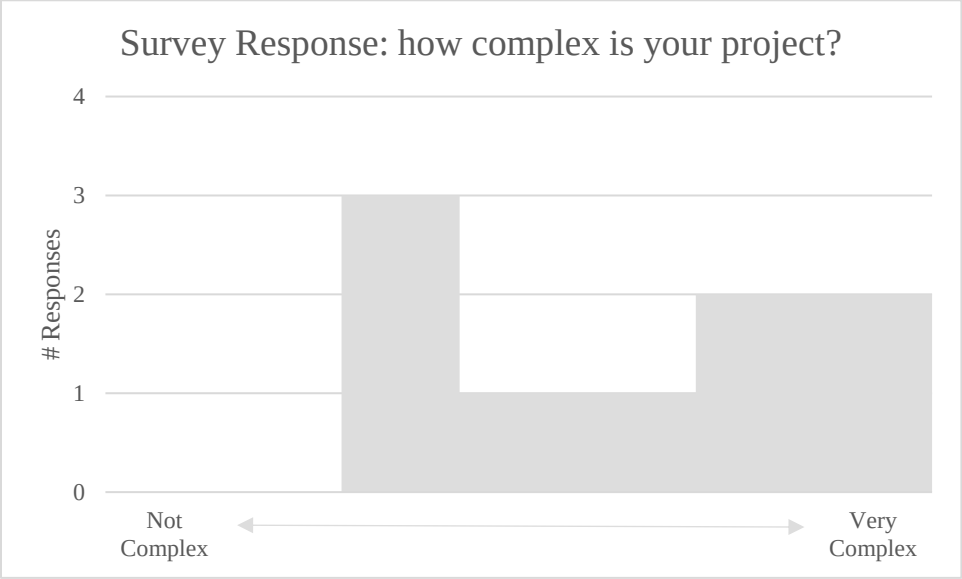


Figure 16 Question 12 Survey Response: How complex is your project?

Participant 4: "*Reliance on different unique tasks, actions and potential stakeholders, each related to different risks and impacts"*

Participant 6: "*Project management involves a lot of stakeholders with different views and understanding of the project, and what it takes to deliver the project according to the contract. It is also a project in continuous change which make it difficult to plan"*

Participant 8: *"The mix of many interests which not necessarily all are aligned."*

The research shows that there are two distinct areas of complexity being situational and cognitive (Warfeild, 1994, cited in Ertas 2018) and to understand better where difficulty comes from we must first define on which side of complexity the unknown lies as they both may be able to be treated with different application of engineering process. For example, situational complexity in Project Management may be addressed with a more robust procedure or the further application of treating a project with many aspects or interlinked stakeholders as a System-of-Systems. Here the application of the System Engineering Principal will mean that the numerical size of basic elements in the system, variety of the elements and relationship between them will all be able to be managed through basic business and system integration processes. The cognitive area is a little harder as it relies more on the human factor and the learning capacity of the Project Manager and Project Team to reduce complexity. The Project Organisation will be able to use such System Engineering processes as Model Based Systems Engineering (MSBE) and the Requirement, Functional, Logical, Physical (RFLP) to be able to transfer information and baseline the cognitive understanding level in the project (Vu, 2015). It is possible that the issue can have attributes laying in both sides a combination of processes may be used to reduce complexity. For example, where a project is so large that it induces situational complexity there may also be cognitive issues as no one person may be able to hold all the information related to producing successful project management.

As the term complexity can be hard to manage and is ill defined in Project Management practices this research proposes for the Project Management Body of Knowledge and other associated Project Management information, guides and procedures to begin using the team variability in its stead. Reasons for this are backed by the meaning of variability in Mathematics particularly statistics, Quality Management and Engineering. In statistics, variance measures variability from the average or mean. This can be aligned to Project Management in the way that requirements should be baselined, set as the average or mean, and any change that would normally be stated as complexity should be labelled as variance. In theory the degree of this variance should be able to be measured by either time, money or resource that will be required to cope with the change. If this change comes from a shift it stakeholder requirements the measurement could be used as a target or milestone of success. If the variance comes from missed requirements or poor estimation in Project Management and Planning, the measurement away from the baseline should lead to continuous improvement of the process, person or team that missed. Communication in both cases should be sent to all stakeholders on how the potential under or over estimate will be managed.

Quality Management uses the same statistical set up for the measurement of successful outputs as that is used in statistical analysis (Montgomery, 2013). Looking again at fig 9. other analogies to project management come forth. Looking at the controllable inputs X_1 to X_n These should be considered as the internal project management processes, the project manages training, the number of resources the project will have. The uncontrollable factors such as additional customer requirements, customer funding, project staff turnover will all cause the Critical-to-Quality (CTQ) or in this case Critical to Project Management score to require further monitoring that could in tern cause additional funding, time or resource requirements. In this instance all efforts of the Project Manager should be made to either turn the uncontrollable variables into those that are either controllable or have the dynamic reactions as a part of the project management plan for these situations such as those that are part of a business continuity plan (ISO, 2019).

Figure 17 Question 13 Survey Response: where you believe the most complexity comes from in your project?

4.2 Causes variability and possibilities to remove or reduce

The survey provided an interesting finding in regard to the definitions and understanding of complexity and variability by the members. All responses stated that there was some level of variability in their projects and stated some of same reasons that where outline when asked about complexity but when questioned on ways to reduce variability two (2) of the respondents stated that, reduction in variability was

not possible while the others stated similar answers to those of complexity. When we compare the leading causes of variability in the survey responses to those of complexity in the table below, we can see that there are four (4) distinct areas that have been grouped that show signs of causing both factors. The two outcomes from this area of the research is that; complexity has a poor definition and is too broad to actually pinpoint the problem; also, variability need a better definition for Project Managers to see that unknowns in the projects are the causation of complex issues. Variability comes from the Latin word *variabilis* which means "to change" (Harper, n.d.). Trying to find the root cause from the survey, and even look into the statistics from some of the external surveys like KPMG (2019 & 2020) or Wellingtone (2020), respondents are not reacting to not knowing or being able to control the variables in their project, including internal items such as procedures and methodology but labelling it complexity. It can easily be explained in the example of a mathematical equation like the basic linier equation $y = mx + c$, m and c are constants such as the finance constraint or the Project Manager but a change in the variable x will give a different result. Projects are not linear equations, and may have hundreds of variables, missing just one will give a different outcome which could be significant. It then should be attempted by all organisations to turn all variables into constants and a start can be with the methodology and procedures which in a way is standardising the equation that will be used.

Figure 18 Question 10 Survey Response: where you believe the most variability/changes comes from in your project?

Table 3 Comparison of survey responses for drivers of complexity vs drivers of variability

Survey: Causes of Complexity	Survey: Causes of Variability
Customer/ Contracts	Customer/ Contracts
Deliveries/ Deliverables	Deliveries/ Deliverables
Schedule	Schedule
Finance/ Budget	Organisational Management/ Support Functions
Organisational Management/ Support Functions	Finance/ Budget
Project Size/ Resources	Processes
Processes	Project Size/ Resources
Other Stakeholders	Other Stakeholders
Risk Management	Project Manager/ Project Team
Project Manager/ Project Team	Risk Management

Historically it has been thought that it is dependant on the size of a project or the number of inputs that a project has will determine if a project will be in constant flux. It can be seen that in the literature that has been reviewed and through the survey responses that variability can come from a number of places. Most respondents to the survey all stated that reduction in complexity all came from adequate communication with the stakeholders and planning. It must be then asked again that if there is guidelines for this in the Project Management Body of Knowledge (PMI Inc., 2021) and most respondents understood that communication and planning where ways to reduce complexity in the project why it could not be executed? The Wellington Project Management survey (2020) showed that only 61% mostly or always applied a set project methodology and that just 35% of respondents were satisfied with the state of Project Management in their organisation, with the bulk of the replies returning somewhat dissatisfied. Six (6) of the nine (9) KAMS respondents stated that the agreed that Project Management in their organisation was effective but only half stated that the procedures in the Quality Management System pertaining to Project Management fit their project. When we also see the response that all nine (9) mostly based their Project Management on internal company procedures it shows the upmost requirement for these procedures to be accurate and reflect best practice in reducing variability and complexity in Project Management to ensure that effectivity of the Project Management and ensure is contributes to the overall project value for the stakeholders.

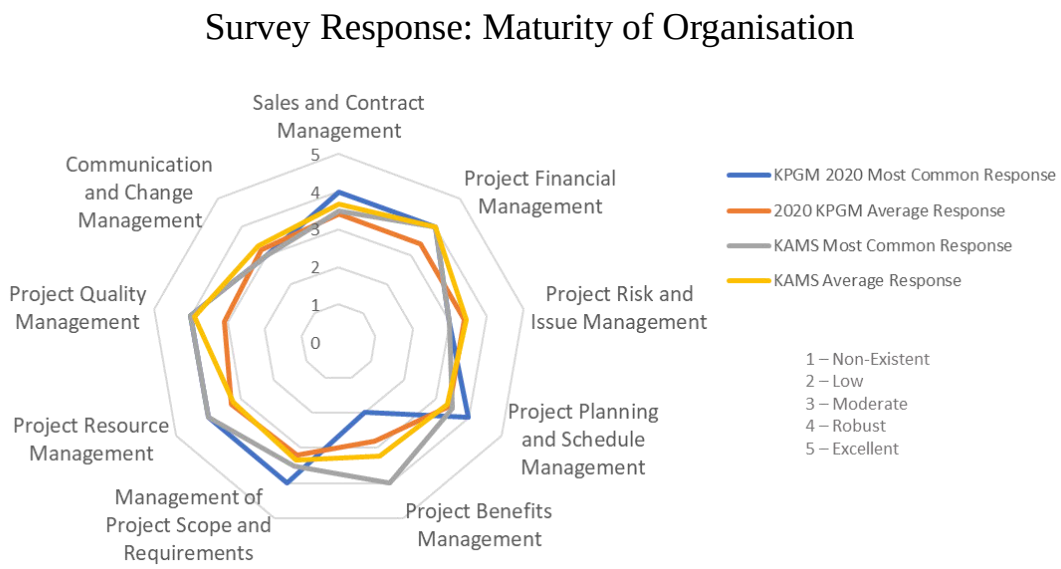


Figure 19 Question 46 Survey Response: What is the maturity level of the following in your organization?

It can be seen in the survey response from the KAMS Project Staff that the average repones for differing levels of maturity in the organisation are comparable to those from the 2020 KPMG Project Delivery Performance survey (KPGM, 2020). It can be seen thought that in many areas across project management both sets of results are showing that organisations only have moderate to robust management processes on the areas that greatly affect the outcome of projects. Highlighted in these results are the emphasised areas of this research including Stakeholder Engagement (Management of Project Scope and Requirements), Risk Management and Planning where both KPMG's 464 respondents with KAMS 9, scored all three (3) areas closer to moderate than robust on average. This overall result shows that the procedures in place to take out variability and complexity in Project Organisation is not at the level it needs to be to ensure Project Management Success. This also confirms the 4th Why in the bases of this research, suggesting that the Project Management Body of Knowledge has a gap in what creates variability in projects and fails to combat this in guides such as the Project Management Body of Knowledge (PMI Inc. 2021) and ISO 21500 Guidance on Project Management (ISO, 2012).

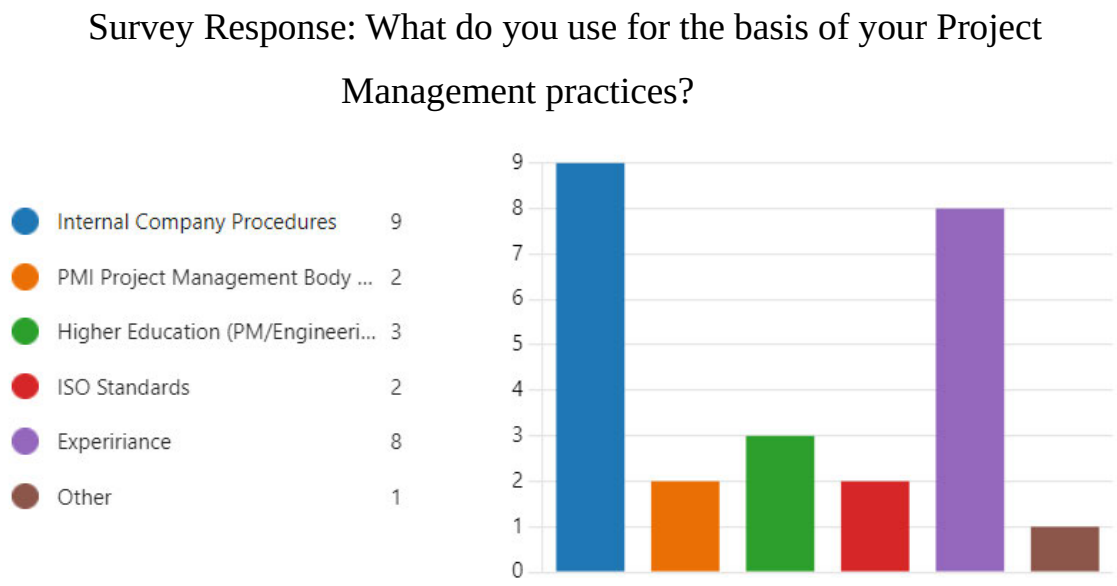


Figure 20 Question 9 Survey Response: What do you use for the basis of your Project Management practices?

Warfeld cites Miller in Ertas (2018) who developed twenty (20) laws of complexity in order to quantify and evaluate complexity. The suggestion of this research it that as a start if Miller's the twenty (20) laws can be distributed between situational and cognitive complexity and a Systems Engineering approach to reduce variability can be attributed to each, then the objective of defining complexity of projects and the need for systems thinking will be at an initial stage for trial among Project Managers. The following is a suggested framework that integrates Systems Engineering into Project Management that that may be utilised by Project Organisation, Management Offices, or Project Managers that should give better guidance that the current Project Management Body of Knowledge on potential reductions in complexity. The below tables, expanded to visible size in Appendix A, show that there is a number of System Engineering Procedures and Process that have been proven on successful projects like NASA Mars Pathfinder (Nicholas, J.M., Steyn, H., 2008, cited in Locatelli, Et al, 2013) which exceeded its mission success parameters by 12 times and distinctly showed that accuracy in requirements were able to reduce complexity and put low cost sensing equipment into space exploration (NASA, 2023)

Table 4 SE Procedures for the Reduction of Situational Complexity in Projects (See Appendix A)

Law of	Brief Description	Business or Mission Analysis Process (INCOSE)	Stakeholder Expectation Definition (NASA)/Stakeholder Needs and Requirements Definition (INCOSE)	Requirements Elicitation Process (INCOSE)	Technical Requirements Definition (NASA)/System Requirements Definition (INCOSE)	Logical Decomposition Process (NASA)/Architecture Definition Process (INCOSE)	Design Solution Definition (NASA)/Design Definition Process (INCOSE)	Technical Planning (NASA)/Project Planning Process (INCOSE)	Project Assessment and Control (NASA)/Project Assessment and Control Process (INCOSE)	Requirements Management (NASA)	Interface Management Process (NASA)/ Interface Management (INCOSE)	Model Based Systems Engineering (MBSE) (INCOSE)	Integrated Product and Process Development (INCOSE)	Technical Risk Management (NASA)/Risk Management Process (INCOSE)	Configuration Management (NASA)/Configuration Management Process (INCOSE)	Technical Data Management (NASA)/Information Management Process (INCOSE)	Technical Assessment (NASA)/Measurement Process (INCOSE)	Decision Analysis (NASA)/Decision Management Process (INCOSE)	Infrastructure Management Process (INCOSE)	Human Resource Management Process (INCOSE)	Knowledge Management Process (INCOSE)	Proposed Benefit
Organisational Linguistics	Communication may not transite between hirachial levels of an organisation due to level language being designed to satisfy level requirments.	x			x	x	x	x	x		x	x	x		x	x		x		x	These Processes will no change that level requirments in an organisation but haveing the correct members involved accross these procedures will make a dictionary of like terms that can be used accross a project to aid translation between levels
Sucess and Failure	Componets that a group require to face complex problems (i.e. Leadership, Financial Support, Component Availability, Environment, Participation, Documentation and Proccess)	x			x		x	x			x	x	x		x	x		x			Majority of these process are to be internally met by the project organisation to ensure that the Project Team has the relevent components to become successful. Reducing Variability by the business understanding that project requirments will make a more cohesive organisation
Structual Underconceptulisation	Lack of complete mapping of the relationship between components of a system effecting the behavior of the components	x	x	x	x	x			x	x	x			x								There processes are used to define the connection between the elements of a system. More effort placed into its mapping at the start of projects will ensure stakeholders are identified and ensure that changes are flowed through the correct paths.
Vertical Incohearance of Organisation	Pre-exhisting organisational patterns and behavior causing lack of alignment, consistancy or clear comunication between hirachial levels	x					x	x	x			x	x					x	x		x	These Processes are designed to make an organisation look internally. If a Project Organisation creates a good foundation but decetralises the computational ability of the workface they may be able to process larger workloads
Inherant Conflict	Differeing groups or inderviduals will disagree on the improtance of differeing aspects due to different backgrounds and ligiustics		x		x	x			x	x	x	x						x				These Process will ensure tat all members know the revevent requirments of the project. IPPD and decision management will allow the priorities and important aspects
Forced Substitution	Personnel substitution in a group in an attempt to induce results	x					x	x				x						x	x	x	x	Althought sometimes nessasary, good project management, HR and Knowledge Management processes should have the right peolple in te right part of the Project Organisation. To reduce complexity in this stage SE Decision Making Process with a foundations from Reuirments set by the scoping processes should push a result.
Limits	Limits that define the relationship and performance of the System or Project	x	x	x			x	x	x									x			Otput artifacts of Techical Planning look in detail iis the Cost Estimates, Shedules and Resorse Requests against the designated requirements of the Project. All processes aroudn that will set the requirments for the Plan. Measurement and Control will ensure that the plan is current, relevaent and accurate.
Requisite Variaty	The number of requisit specifications and design variable that require consideration to obtain desired outcomes		x	x			x		x	x					x			x			Good Scoping, Requirments, and Interface Management should ensure that requirements for the project are followed. In projects where there are alot of specifications to follow the organisation should priorities the infratstuture to support them
Triadic nesessity and suffereancy	Understanding that all complex relationships normally consisit of three (3) relational components at their basic level and that giving to one component to satisfy a connection will take away from the others.			x	x	x				x	x		x	x								SE mapping and modeling may bring the benifit to better understand the ramifications of decisions. Athought there still may need to be comparamise, systems engineering techniques may limit the need for iterations
Diverse Beliefs	Using diverse teams leads to different experiance and trade language that can lead to the inability to cooperate from a unified point of view.			x		x		x			x	x						x				Cetralised Learning such as MBSE and Team Membersbeing involved in Requiremets Finding excersizes should aid to give all a baseline.
Requisite Saliancy	Not all factors affecting a system are of equal weight. Relative importance of factors in a system that will define performance.		x	x	x	x			x		x											Establising Requirements and establishing a system plan will give the information to wight the requirments to the appropriate level.
Gradation	Differeing bodies of Knowlegde arise at different levels of the organisation and it is uncommon for all levels to be used to solve a problem				x			x										x			x	Decision Management Processes will ensure that no matter the level that the problem is solved at, there will always be desseminated infromation througout the Project Team
Induced Groupthink	During time constraints decisions of a group may represent results that have not been thought out properly by all inderviduals. Decisions also may be against the views of inderviuals.						x	x										x				Adequate planning and Project Control should try and reduce the likelihood of complexity from this situation arising. Good decision management protocols and procedure should not allow for decisions to be made when there isn't a quorum. Other tactics like "Devils Advocate" may be required.

Table 5 SE Procedures for the Reduction of Cognitive Complexity in Projects (See Appendix A)

Law of	Brief Description	Business or Mission Analysis Process (INCOSE)	Stakeholder Expectation Definition (NASA)/Stakeholder Needs and Requirements Definition (INCOSE)	Requirements Elicitation Process (INCOSE)	Technical Requirements Definition (NASA)/System Requirements Definition (INCOSE)	Logical Decomposition Process (NASA)/Architecture Definition Process (INCOSE)	Design Solution Definition (NASA)/Design Definition Process (INCOSE)	Technical Planning (NASA)/Project Planning Process (INCOSE)	Project Assessment and Control (NASA)/Project Assessment and Control Process (INCOSE)	Requirements Management (NASA)	Interface Management Process (NASA)/ Interface Management (INCOSE)	Model Based Systems Engineering (MBSE) (INCOSE)	Integrated Product and Process Development (INCOSE)	Technical Risk Management (NASA)/Risk Management Process (INCOSE)	Configuration Management (NASA)/Configuration Management Process (INCOSE)	Technical Data Management (NASA)/Information Management Process (INCOSE)	Technical Assessment (NASA)/Measurement Process (INCOSE)	Decision Analysis (NASA)/Decision Management Process (INCOSE)	Infrastructure Management Process (INCOSE)	Human Resource Management Process (INCOSE)	Knowledge Management Process (INCOSE)	Proposed Benefit
Universal Priors	The understanding that language, reasoning, notationships and the ability to apply this is apparent in the members. New systems/situations that where members have no prior information can therefore be difficult		x		x		x	x	x		x	x							x	x	Good HR and Knowledge Management Processes are key to hiring and retaining the relevant people to the organization. Good training management and distribution of information through practices like MBSE are key to aligning knowledge, especially in new systems
Small Displays	Tendancy for Individuals to accomadate problem to the size of there prefered media (i.e. A4 Paper, Computer Monitor). Limiting display will limit the complexity of problems and hinder conceptulisation			x	x	x		x		x	x				x	x		x			SE trecniquest like MBSE may give the project organisation the background knowledge to beable to decrease the size of the issue to a manageble view with the understanding of percived knowledge. Oter SE processes like Logical Decomposion will ensure that the most important elements are identified and reduce complexity in displaying problems.
Triadic Compatability	Human mind can only deal with seven (7) conceptual components simutaniouly. E.g. three (3) System Elements and four (4) interaction combinations between them.				x	x	x	x		x	x	x			x							Utalising these SE tools the Project Management team should be able to break the Project into considreed elements where Intergration Teams and Leads will spread the Cognative Load and Report Back to the PM or PMO who will act like the SEIT
Validation	The validity of Knowledge within an organisation requires the consensus of te organisation							x			x	x						x	x	x	Much of this lies in the culture of an organisation and in some situations could also be based around the law of induced group think. Good HR process, Knowledge Management and IPPD should reduce variability in this field
Precluded Resolution	The absence of proper discription or modeling of an issue leading to the inability to properly sort th issue itself. Without this it is based on the cnceptualisation on an indervidual member		x	x	x	x					x		x									I could be argueed that there would be alarge benifit in Project Managment adopting the MBSE tecnique to flow information through the Project Organisiton. This coupled wit Logica Decopositon would mean that that the root cause of issue might be more easily identified and issue could be resolved at the appropriate level
Requisite Parsomony	Human can only collect and process information at a cirtain rate					x					x	x			x	x						Although PMBOK write of information sharing and communication through a Project Organisation and Project Manager the SE Handbooks and associated process dive deeper into Data Products, Data Exchange Formats and Information Management Stratergies/Plans. Correct information charing combined with
Uncorrelated Extreams	Learning Proccess starts from different backgrounds meaning that intial perceptions are uncorrelated extreams prior to learnig process		x	x	x						x									x	The requirments leading into MBSE will give a good platfome for theProject Organisation to be able to base the perceved knowedge level on. Reducing unknowns in amoungst the organisational members and ensure that on controlled information is flowed to the members.

Miller (cited in Ertas, 2018) suggests it with the complexity law of Vertical Incoherence of Organization, this is also shown in another way in Van Marrewijk (2005) and summarised well in Locatelli (2013) whereby if the Project Manager and their project team do not have the ability to use firm procedures and progress, taking it upon themselves to conduct the method correctly with consequence, they will never have the emotional investment into the Project. Van Marrewijk states this as the “Control

Figure 21 SE Procedures for the reduction of Situational Complexity in Projects

and Commitment" of a project where if the Project Organisation has too much say in problem solving or the management of a project the project manager of delegates in the project organisation will loose there caring to contribute to the problem solving. This show that the process that are put in place by a Project Organisation must have some hierarchical control and decentralisation or delegation of decision making and responsibility. This will have the expected flow on effect that deeper analysis of requirements, variables, and risks will take place due to the fact that the responsibility will now be on the individual and they may not feel like they have the organisation to hide behind. In this sense the Project Organisation will also have a greater responsibility to the subordinates to provide them with the infrastructure to be able to succeed in a methodical and measure way. This is another area where the distinct practices of Systems Engineering may assist in reducing variability.

It has already been stated that without up to date Project Management procedures and tools that 18% of projects are likely to fail from the outset. In an age of the rapid rise of technology and software and the obsolescence of a product in shorter timeframes there is an inherent addition of variability for the management of projects. Consequently, there is need to ensure that the methodology is taught instead of the tool itself. For example, respondents of the survey stated that only three (3) out of the eight (8) respondents stated that the used the company approved planning software when controlling their projects and had said that they did not have a Project Specification or Project Management Plan which is part of the KAMS P-180 Project Management Process. Some Project Managers as part of the survey took projects that had been around before the re-write of the P-180 procedure and service projects that had been going on for a number of years but this still means that any previous practices either did not have these documents as part of their requirement or they we not completed. It can be seen that when the tools and processes are not in place that it is only the experience of the Project Manger that governs the generation and accuracy of project artifacts that are designed to limit variability.

Out of the four areas cross over areas that this study it looking into; Stakeholders, Risk, Review and Planning, Customer and Schedule were in the top two (2) groups for the leading cause of complexity and variability the KAMS result did correlate with the Wellingtone survey (2020) although it does look like there are some highlighted areas that do need to be addressed. Change Management looks like a difficult but valuable process in the view of the KAMS Project Managers which when refereeing to what has been written in the complexity definition seems to align as it did not look like there was a robust procedure as a part of the KAMS Quality Management System for dealing with Chang control outside of physical system configuration management. Planning/ Scheduling seems to have a higher value and difficulty for KAMS than what has been attributed in the Wellingtone report (2020). This also is in line

with the KAMS Project Managers stating that not all are using the KAMS company approved planning software in their projects. One area that does seem to stand out is the Stakeholder engagement has been given a significantly less value for KAMS than that of the other results. This is an interesting finding as for both souses or complexity and sources of variability Customer/ Contracts was placed at the top and almost every respondent stated that "scope change" was the definition of variability in their project. When looking at the response to survey question 25: What process do you use to define customer and other stakeholder requirements?, every respondent had a different answer. There seems to be a correlation between the perceived value verses lack of standardised procedure that may be causing the apparent complexity and variability inside the stakeholder domain. How the results were compared was by scaling the chart provided in the Wellington Survey (2020) and overlaying the averages of the KAMS Survey.

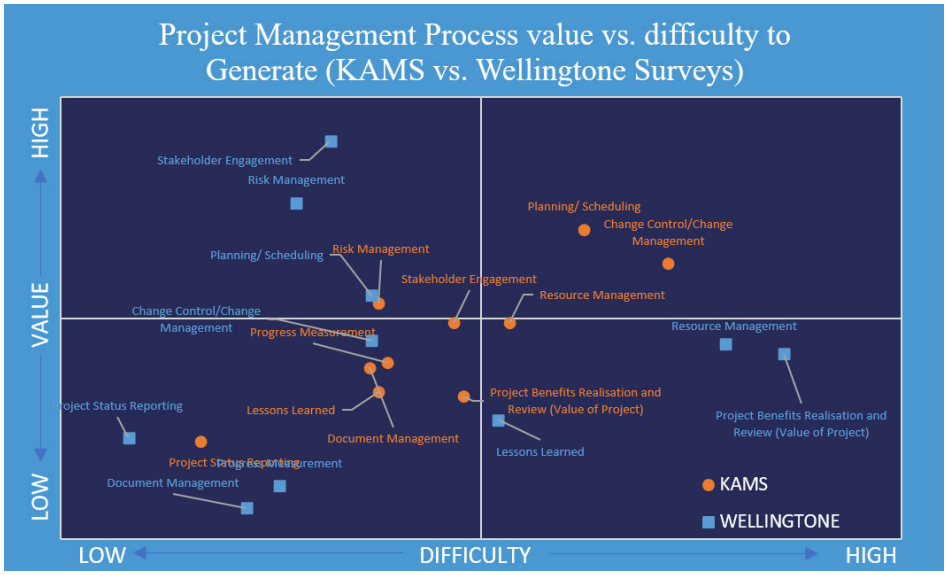
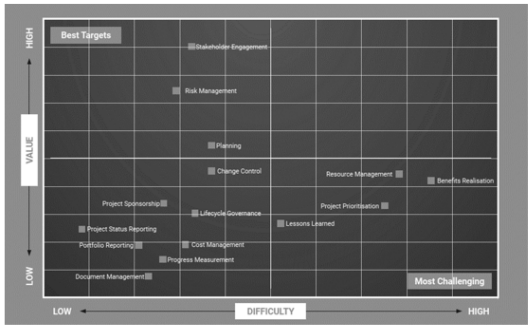


Figure 22 Project Management Process Value vs. difficulty to generate (KAMS vs. Wellingtone (2020))



Valuable										AVG KAMS Valuable	Est. WELLINGTONE Valuable
Planning/ Scheduling	9	9	8	8	7	7	7	6	2	7.0	5.5
Change Control/Change Management	9	9	8	7	7	5	5	4	2	6.2	4.5
Risk Management	8	7	6	6	6	6	5	2	2	5.3	7.6
Resource Management	9	9	7	6	5	3	2	2	1	4.9	4.4
Stakeholder Engagement	9	8	8	8	7	3	1	0	0	4.9	9
Progress Measurement	9	7	6	4	3	3	2	1	1	4.0	1.2
Document Management	8	6	5	4	4	4	4	0	0	3.9	0.7
Lessons Learned	8	5	5	4	3	3	1	1	0	3.3	2.7
Project Benefits Realisation and Review (Value of Project)	9	6	5	3	3	2	1	0	0	3.2	4.2
Project Status Reporting	5	4	4	3	2	1	1	0	0	2.2	2.3

Difficult										AVG KAMS Difficult	Est. WELLINGTONE Difficult
Planning/ Scheduling	9	9	9	6	6	6	5	3	3	6.2	3.7
Change Control/Change Management	9	8	8	8	7	7	7	6	5	7.2	3.7
Risk Management	7	6	5	5	4	4	2	1	0	3.8	2.8
Resource Management	9	9	8	8	5	5	2	1	1	5.3	7.9
Stakeholder Engagement	9	8	8	7	6	4	0	0	0	4.7	3.2
Progress Measurement	9	6	6	4	3	3	2	1	1	3.9	2.6
Document Management	7	6	5	5	3	3	3	1	0	3.7	2.2
Lessons Learned	8	7	5	4	3	2	2	2	1	3.8	5.2
Project Benefits Realisation and Review (Value of Project)	9	7	7	4	4	4	4	2	2	4.8	8.6
Project Status Reporting	8	3	2	1	1	0	0	0	0	1.7	0.8

Figure 23 Wellingtone Project Management chart (2020) scaled for measurement and KAMS Survey responses for Value vs Difficulty.

4.3 Areas System Engineering can improve Project Management:

4.3.1 Stakeholders

One of the largest components of ensuring that a project is run to budget and schedule is understanding the stakeholder requirements. Not only limited to those of the product but of the stakeholder business and engagement level. The PMBOK® (PMI Inc. 2021) has the Stakeholder and Stakeholder engagement as the first project domain but is very light on the actual stakeholder engagement and how to drag out the requirements. Compare this to the Requirements Analysis Process in ISO 15288 (ISO, 2002) there is much benefit that the Project Management profession could gain from treating the Stakeholder domain as another subsystem in the system of systems.

The Project Management Body of Knowledge only has 2 main statements when it comes to stakeholder engagement. For stakeholder identification it states:

"High-level stakeholder identification may be carried out prior to forming the project team. Detailed stakeholder identification progressively elaborates the initial work and is a continuous activity throughout the project." (PMI Inc. 2021)

and for understand and analyse it says;

"Once stakeholders are identified, the project manager and the project team should seek to understand stakeholders' feelings, emotions, beliefs, and values. These elements can lead to additional threats or opportunities for the project outcomes. They can also change quickly, and as such, understanding and analyzing stakeholders is an ongoing action." (PMI Inc. 2021)

In reading this there is the suggestion that Stakeholders will be source of variability throughout the project but the only measurement advice to the Project Manager that the PMBOK (PMI Inc., 2021) give is to have a "productive working relationship" with he stakeholders.

In Comparison, ISO 15288 Systems engineering - System life cycle processes (ISO, 2002) and the further in depth, ISO 29148 Systems and software engineering -Life cycle processes - Requirements engineering (ISO, 2011) have detailed process on how to, identify and engage with stakeholders to elicit requirements and ensure that variability is reduced. The "feeling" aspect of the stakeholder that the PMBOK (PMI Inc., 2021) is describing that may produce complexity may be partially out of the control of the Project Manager and Project Organisation but does not mean that this variable should be a complete

unknown. ISO 29148 (ISO, 2011) takes the identification of stakeholder parameters to a deeper level. After the stakeholder has been identified through a documented process called Stakeholder requirements Specification of (StRS) whereby before the product or service requirements are extracted, the Project Manager looks at the stakeholder in question to try and better understand there impact to the project. The Stakeholder Requirements Specification analyses topics such as: Stakeholder purpose, Stakeholder scope, Stakeholder overview, Stakeholders, Stakeholder environment, Stakeholder Goals and Objective, Stakeholder model, Information environment , Stakeholder processes, Stakeholder operational policies and rules, Stakeholder operational constraints, Stakeholder operation modes, Stakeholder operational quality, Stakeholder structure, Operational concept, Operational scenarios, and Project constraints. The project manger might not have all the exact answers for each of the topics mentioned but just having the process to consider them could potentially elicit further risks or opportunities and may lead to the reduction in variability. Further, it may also give deeper meaning to the emotive words used in the PMBOK (PMI Inc. 2021).

The other potion that the stakeholders give to the project is the product, service, time and financial requirements. Both the PMBOK (PMI Inc., 2021) and ISO 21500 (ISO, 2012) are severely lacking when it comes to giving information on elicit the requirements from different stakeholders t the project and then in turn what to do with then once they are extracted. The PMBOK only speaks of extracting requirements twice in the stakeholder engagement domain. Instead, it has place the requirements elicitation under the deliverables title in the Delivery Performance domain. ISO 21500 seems to be even less effective placing it under the definition of scope procedure, and only give the project manager the guidance of:

"The purpose of Define scope is to achieve clarity of the project scope, including objectives, deliverables, requirements and boundaries, by defining the end state of the project." (ISO, 2012)

It can now be seen that with such little value placed in the application of engaging the stakeholders, understanding their requirements, and developing relationships and procedures for the continued monitoring of evolving information, the Project Manager will induce both cognitive and situational complexity into their project and increase the number of undefined variables and unknowns. This is most likely the reason that KGPM (2020) reported that only 52% of projects are delivered with stakeholder satisfaction.

4.3.2 Risk

When looking at the research conduced by KPGM in the 2019 and 2020 Project Management Surveys one of the main issues suggested as to why Project Management fails is the failure to engage

early with Subject Matter Experts for Risk Identification and analysis. This is often due to the failure of Project Management Offices to adequately staff Project Teams during initial investigation exercises. Many Project practitioners think that this is expected of them negate unnecessary cost before the promise of contract or work. With what is now understand about the results from the KPGM Surveys (2019, 2020) it could be argued that this is a failure to invest by the project organisation may be contributing to the fact that Projects are only half the time generating the required value for all parties. If compared the amount of investment for a group of SME's on a Project Team to conduct a thorough read through and correct Risk Identification and Analysis exercise the financial outlay to get the correct insight may only be the fraction of cost of a contractual change order or the overall value of the project for the parties.

Although document like the Project Management Institute's The Standard for Risk Management in Portfolios, Programs, and Projects (2019) states that early identification was one of the keys to success. The results of the survey showed that although all project managers felt like they had a medium or better understanding of risk in their Project, only half identified that the risks were recorded properly and most stated that just 1-3 people were used to identify the risks. If one of those members was the project manager, it only leaves room for a max of two (2) SME's to assist in risk identification. Most said that they utilised the correctly identified company procedure to manage risk in the project. Upon investigation of the KDA-TMPL-0055_Risk_Assessment_Tool_KAMS that all Kongsberg Aviation Maintenance Services Project Managers are using it was seen that many of the recorded risk were identified in the incorrect manner as stated in the PMBOK (2017) and The Standard for Risk Management in Portfolios, Programs, and Projects (2019). This is historically accurate for all Risk Identification that isn't supported by academia. Many that rely on education outside the Engineering and Academic realms often do not construct the correct risk statement when identifying risk. International Standard 21500 Guidance on project management (ISO 2012) and the PMBOK (PMI Inc. 2021) state that risks should be identified but it is only in lower lever documentation that is shows how this is to be constructed. It could be said that most of the project managers in the survey had recorded the Risk (Uncertainty) but failed to identify the Cause (Fact or Condition). When this is the case it is often the fact that Project Team Members will find it difficult to identify Cost, Technical, Safety and Schedule impacts as the uncertainty may grow outside the bounds of the initial cause.

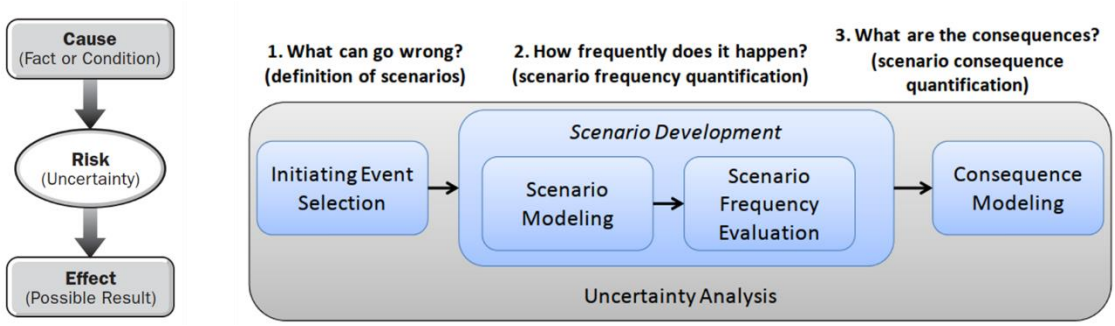


Figure 24 Triplet Risk Identification points; Standard for Risk Management in Portfolios, Programs, and Projects (PMI Inc. 2019) vs Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners (Stamatelatos & Homayoon, 2011)

It is important that Project Managers and Project Teams set a concise structure to identify all risk and ensure that they are measured on the same scale. The PMI Inc. Standard for Risk Management in Portfolios, Programs, and Projects (2019) calls for a structure where the risk statement is made of Cause, Risk and the Effect. We can see that in the figure taken from both the Project Management Institute (PMI Inc. 2019) and from NASA (Stamatelatos & Homayoon, 2011) both identify the triplet of risk identification but the NASA Systems Handbook (Hirshorn, 2016) goes further to point out the actual procedure and gives good example and process to Risk Identification and Management. Hirshorn (2016) states that in 2008, NASA moved away from the traditional Risk Management (RM) through Continued Risk Management (CRM) and incorporated Risk-Informed Decision Making as well. Risk-Informed Decision Making (RIDM) as described in the Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners (Stamatelatos & Homayoon, 2011) state that the RIDM is "intended to inform systems engineering (SE) decisions (e.g., design decisions) through better use of risk and uncertainty information, such as that resulting from PRA, in selecting alternatives and establishing baseline performance requirements". The RIDM's ability to assist in decision making in a project by statistical analysis of risk has the ability to reduce variability in a project by ensuring that all decisions are data driven. This does however mean that additional resources will have to be used during the risk Identification and Analysis phase to ensure that all alternatives are correctly investigated. It may be seen how this Risk Management technique, that at NASA is designated to assist Systems Engineers, may be used in Project Management, but will require further education of practising Project Staff and changes in the learning curriculum for dedicated Project Management courses.

Trough review the best approach for Risk Management is that of NASA (Stamatelatos & Homayoon, 2011) whereby there is a combination of Risk-Informed Decision Making and Continuous Risk Management. If we see it in a timeline and commonality of the identified risk we may be able to apply where the best technique may be applied and assist in the tailoring, schedule an level of effort in risk

identification, Looking at common risk that is identified through multiple projects such as human factor risks, application of the CRM technique will be suitable unless there is a designated effort to reduce the risk further that the standard of the Project Management Organisation or governing Health and Safety laws require. CRM will ensure that the risk is identified and continuing iterations of Identify, Analyse, Plan, Track, Control will continue until the risk is either as-low-as-reasonable-practical/possible or removed. RIDM should be instigated where there are Risks that are new to the business, where outcomes are hard to identify, or where a Risk's Cause may be reduced with Alternative methods. In all of these scenarios there RIDM process will cause concerted effort from the Project Management team to ensure that correct information is fed into the statistical model to give the best solution. One major assistance where the Systems Engineering Technique of RIDM will help Project Management is by taking further consideration than the PMBOK (PMI Inc. 2021) and ISO 21500 (ISO 21500) is the frequency of risk. It works with the assistance of Event Trees (ET) and Event Sequence Diagrams (ESD) to determine the potential conditions, uncertainties and results and used statistical analysis to provide a probability of the event.

Scenario	Description of Scenario (See Figure 3-7)	Cut Set	Symbol	Meaning	Probability	Total
3	Hydrazine Leak, Isolated Promptly but Avionics Fail Anyway	1	IE	Leak	1.0E-2	1.0E-7
			/A1	Avionics fail even after successful isolation	1.0E-5	
9	Hydrazine Leak, Detection Failure Leading to Isolation Failure, Avionics Failure	2	IE	Leak	1.0E-2	1.0E-7
			PP	Common cause failure of pressure transducers	1.0E-4	
			/A2	Avionics fail after unsuccessful isolation	1.0E-1	
		3	IE	Leak	1.0E-2	1.0E-7
			CN	Controller fails	1.0E-4	
			/A2	Avionics fail after unsuccessful isolation	1.0E-1	
		4	IE	Leak	1.0E-2	1.0E-9
			P1	Pressure transducer 1 fails	1.0E-3	
			P2	Pressure transducer 2 fails	1.0E-3	
			/A2	Avionics fail after unsuccessful isolation	1.0E-1	
6	Hydrazine Leak, Detection Succeeds but Isolation Fails, Avionics Failure	5	IE	Leak	1.0E-2	1.0E-4
			L	Leak occurs upstream of isolation valves	1.0E-1	
			/A2	Avionics fail after unsuccessful isolation	1.0E-1	
		6	IE	Leak	1.0E-2	9.0E-7
			/L	Leak occurs downstream of isolation valves	9.0E-1	
			V2	Isolation valve V2 fails to close	1.0E-3	
			/A2	Avionics fail after unsuccessful isolation	1.0E-1	
		7	IE	Leak	1.0E-2	9.0E-7
			/L	Leak occurs downstream of isolation valves	9.0E-1	
			V1	Isolation valve V1 fails to close	1.0E-3	
			/A2	Avionics fail after unsuccessful isolation	1.0E-1	
					Total	1.02E-4

Figure 25 Example: RIDM Probability Matix for Scenarios Leading to "Loss of Vehicle" and Their Associated Frequencies Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners (Stamatelatos & Homayoon, 2011)

Depending of the timeframe that is determined by the project manager can assist in the efforts for where resources are distributed. For example if we look at the F135 Project for Kongsberg Aviation Maintenance Services AS. If we take a risk suck as;

As a result of lack of experienced mechanics causing incorrect configuration of a F135 Engine Module, risk may occur, which would lead to a Quality Escape with attached Financial, Schedule and Safety effects.

Normally this would be split into 3 areas to determine the impact individually of Schedule, Cost and Safety but it can be seen that they are all different if accessed on different time scales. If it is stated that the project goes over 50 years than the likely hood for a problem with inexperience will be higher in year 1 than in year 10 driving a different probability and potentially different decision making. This it why that after a risk is identified through the RIDM process it should always transfer to CRM until wither the Risk is retired or another decision needs to be made. It was observed that the procedure for KAMS stated that risk was only to be taken over the financial year meaning that effective statistical analysis will be able to be implemented in the process to give more accurate exposure and reduce variability for the Project Manager.

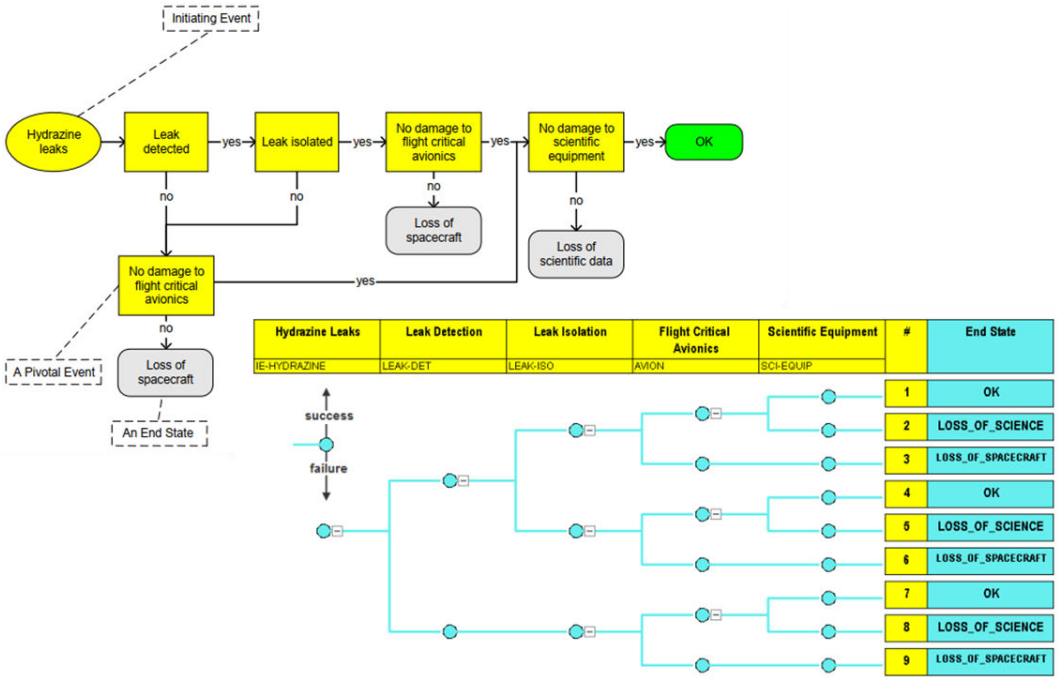


Figure 26 Event Tree (ET) and Event Sequence Diagram (ESD) form Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners (Stamatelatos & Homayoon, 2011)

4.3.3 Review

When looking at the meaning of review, it really means to talk about or revisit information/data to see if it hold validity with expectations and the original planning. In a Project Organisation sense this will historically look at deliverable, schedule and cost and if any one or all of those indicating factors are correct then the review is deemed successful and may not incite change. Normally in project organisation

the key indicators are something that is made internally or with the customer and has imbedded the inherent characteristics of the project organisation. Looking at Miller in Ertas (2018) 20 Laws to measure complexity we can see that trough he laws of Gradation, Group Think and Vertical Incoherence there is an imbedded sub context in all organisations that my leak into the way that they measure performance or convince stakeholders that they are performing. If we focus on the Law of Groupthink, an organisation who operates to a set of Project Management procedures that satisfy internal KPI's may think that they are effective in project management while looking internally without the ability besides outside stakeholders to challenge. We can see that even though there may be this challenge, Project Organisations are failing to hear the customer need resulting in only 46% of projects being to the stakeholder requirement (KGPM 2019) and only 51% meeting the original business intent (KPGM 2020). This should not be possible if review is effective, there may be areas where wither the Project Organisation or the external stakeholders are dissatisfied but the trend is too low. This may be due to the fact that Project Managers are potentially only reviewing the product and not the Project Management success itself.

From the nine (9) survey respondents over half said they were running independent project reviews to assess for performance of project management delivery and only two (2) of nine (9) stated that they score the effectiveness of there Project Management in the delivery of their requirements. All stated it was easy to measure success in their project and most relied on customer satisfaction or contractual targets as the datum to measure success. Again, this looks to be a product focused approach and may not be indicative to relay the success of project management or the ongoing organisational learning that should happen from the outcomes of project management.

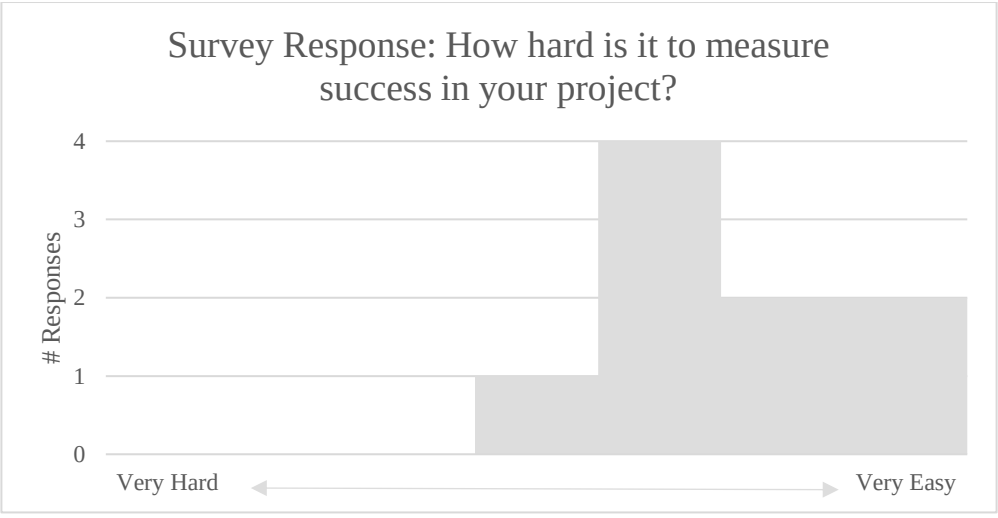


Figure 27 Question 32 Survey Response: How hard is it to measure success in your project?

When looking into the review stage of a Project it is all set by the scoping and planning phases. It has already been discussed in this study that there are several Systems Engineering techniques and procedures that may have more influence on drawing out Project Organization and Customer requirements than those of traditional Project Management like in the PMBOK (PMI Inc. 2021) and ISO Guides (ISO 2012). Systems Engineering Procedures such as Technical Requirements Definition (Hirshorn 2016) and System Requirements Definition (INCOSE 2015) will assist the Project Manager in setting the baseline for setting the baseline for the Project but also the targets for the Project Management review. ISO 21500 Guidance on project management (ISO 2012) shows the interaction and outputs of a Project and states that a project should be constantly reviewed, although the word review is only mentioned eight (8) times throughout the whole document. The PMBOK (PMI Inc. 2021) states and shows that there is the same interaction in more of a gantt style chart but only has stated review at the end of stages. There is little in the way of Key Decision Points (KDP) or continuous monitoring and review. The PMBOK (PMI Inc. 2021) go as far as to mention that under the project management principal "Recognize, Evaluate, and Respond to System Interactions" that systems thinking is key attribute needed to effectively monitor and respond during different project phases and states as an outcome that will give better "alignment of project goals and objectives to the customer organization's goals, objectives, and vision"

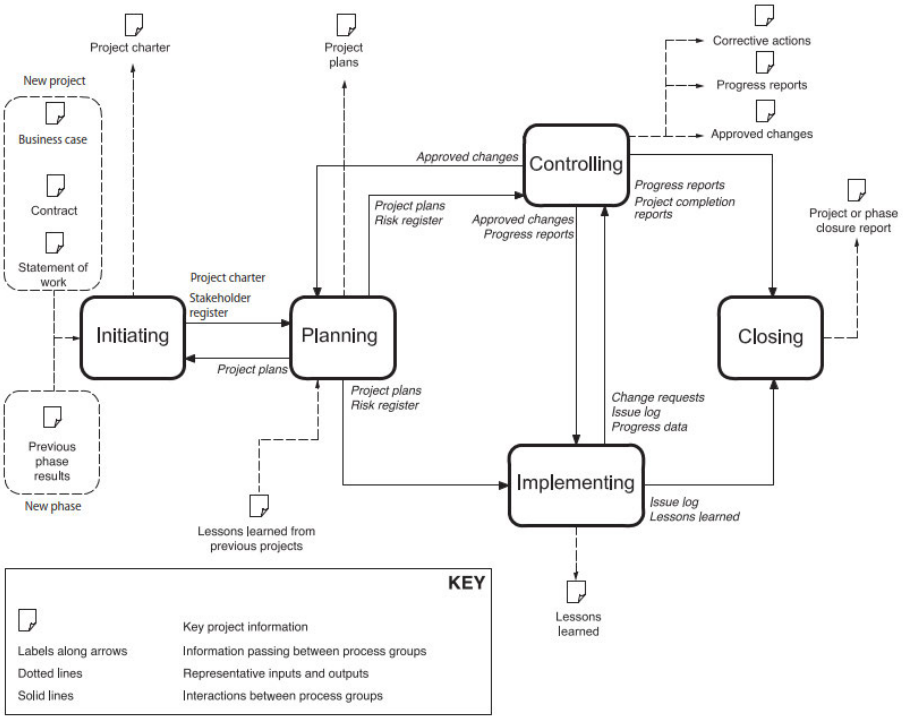


Figure 28 ISO 21500 Process group interactions with representative inputs and outputs (ISO 2012)

The main statement through both Project Management and Systems Engineering is that there needs to be feedback loops throughout projects and design to ensure that decision making, schedules and requirements are being met. The INCOSE Systems Engineering Handbook states under common approaches to the Process Assessment and Control Process that "what gets measured gets done, but, projects should avoid the collection of measurement that is not used in decision making". There are however measurements that might not be being conducted currently that might aid in the delivery of Project Management or internal learning of the Project Organisation that may not necessarily effect the overall outcome of the delivery of the project/product itself. Out of the survey conducted of the Kongsberg Aviation Maintenance Services Project Managers over all they believed that Project Benefits Realisations and Review was not as difficult as the population of Project Managers who responded to the Wellingtone Survey (2020) whereby is was scaled that the Wellingtone response had a score of 8.6/10 verses that of KAMS with 4.8/10. This may be through the due to the fact that the KAMS ERP and Clocking system records the utilisation and timings of a project for the Project Manager and only has to review the information of correctness at the end of the month. The PMBOK (PMI Inc. 2021) states that the lagging indicator to KPI's will not allow the Project Manager to actively adjust to a problem issue before it becomes permanent. To ensure that the Project Manager has enough leading information more KPI's need tot be recorded on more of a regular interval to ensure that modelling and extrapolation of the data can be crated. Even though the lagging indicators in the KAMS system were automatically recoded by the ERP system, many of the project managers didn't feel like they were used effectively to generate improvements. There are many ways that Systems Engineering Processes will help with review in Project Management but the results from this research show that the initial review area that will benefit from Systems Engineering Procedures and Processes is that for setting the requirements and the baseline that the Project Managers will be able to review against.

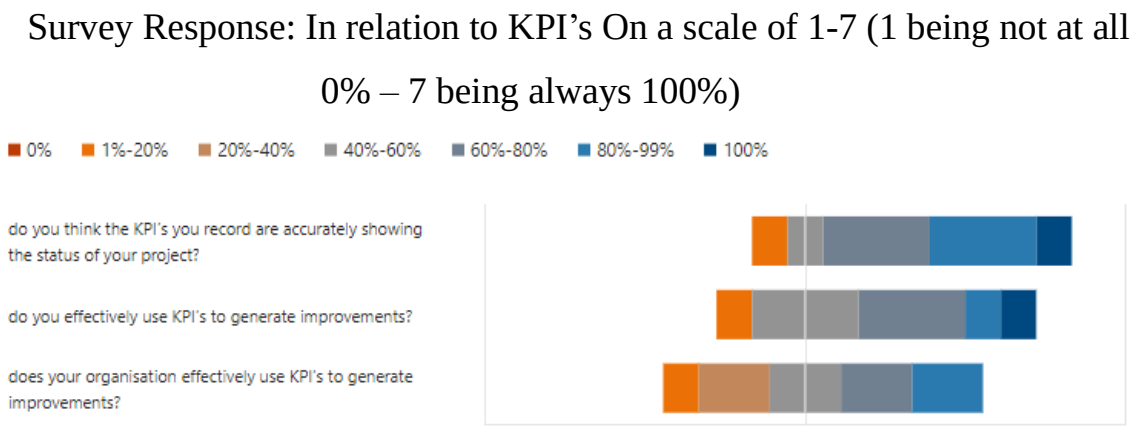


Figure 29 Question 36 Survey Response: In Relation to KPI's On a scale of 1-7 (1 being not at all 0% – 7 being always 100%)

4.3.4 Planning

There is good amount information in both the Project Management literature and the Systems Engineering Literature on planning and scheduling although like in the previous cases it is limited to a high-level overview in the Project Management guides. Planning, behind Stakeholder Engagement and Risk Management is the most valuable process for a Project Manager and it can be stated that it drives better outcomes in both the RM and Stakeholder Engagement activities if conducted correctly. Plans and Schedules are also living documents and need to be adapted throughout the period of the project where the Project Team see fit. I is always important however to ensure that there is always a reference to go back to for the ability to ultimately measure the success, failure or change in criteria to a project. The project plan is the story of what was to be verses what actually happened and should be managed accordingly. Here Millers law of complexity and how to measure complexity (Miller cited in Ertas 2018) come into play again. The Law of Organisational Linguistics is ever apparent in planning as at different levels there is information that is important to different members. For example, at a higher-level Project Management, organisation executives, or the finance team might want to forecast future years requirements, earning or workload whereas someone like operational, technical, or integration staff might want to be at the task level. This shows the importance of the Work Breakdown Structure (WBS) and its ability to "roll-up" through the organisation to provide all levels with the information required over their required period. The figure bellow shows this situation in a diagram where all points of the organisation will require some form of the plan and WBS and it is the requirement of the Project Manager and the Project Planner to deliver the Control Accounting where all the factors that are previously mention in this research such as scope, cost, schedule an risk are integrated.

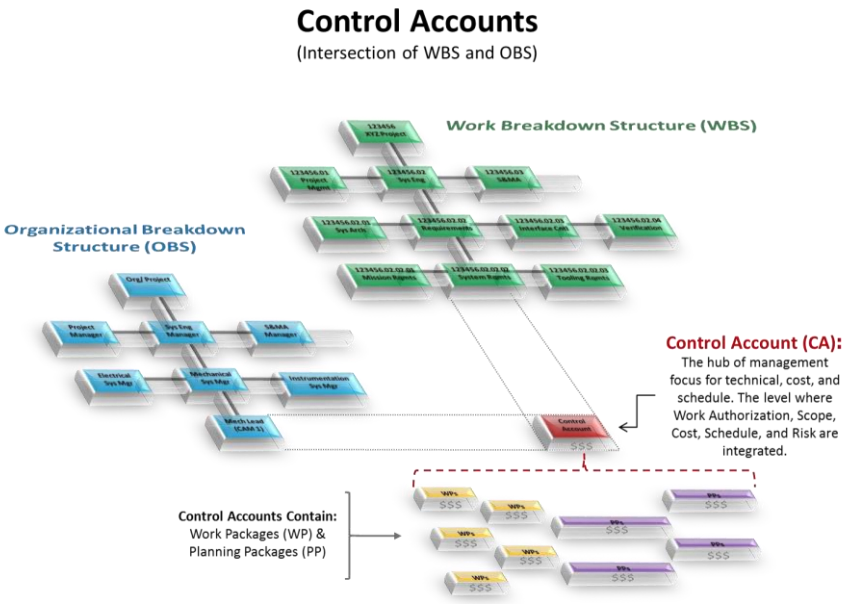


Figure 30 Control Accounting delivered by Project Managers and Project Planners (NASA 2021)

The KAMS Survey delivered some results that show that there may be improvement that can be conducted inside the organisation. Planning and Scheduling was seen to be the second most difficult task for the organisation, average score of 6.2/10, whereby it for the rest of the Wellingtone surveyed population (2020) if fell reasonably mid pack with scaled score of 3.7/10. It is also interested when reviewing fig Figure 22 Project Management Process Value vs. difficulty to generate (KAMS vs. Wellingtone (2020)), that the other difficult processes that KAMS members identified is Change Management and Resource Allocation which are both directly related to Planning and the actual recordings against a baseline. Both surveys placed their value of the Plans and Scheduling at a similar level. It was also reported in the survey that over half of the respondents were not using the planning tool that has been implemented by the company to interact with the ERP system meaning that there are some additional areas of information to report Project Management success are being missed. When asked about baselining their Project Plans and ensuring that the correct documentation is available only half stated that they had the background information and baselining was not completed every time. It is unknow at this time if there is a hard link but it is seen that through the research this may mean why it is easier for the KAMS Project Managers to report on their projects as they don't have the baselines requirements metrics to reference and delta in the projects.

Survey Response: In relation to KPI's On a scale of 1-7 (1 being not at all 0% – 7 being always 100%)

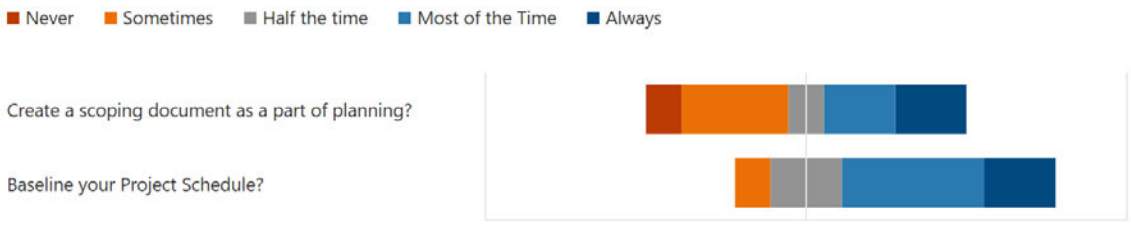


Figure 31 Question 39 Survey Response: When planning your project, do you…

The Key requirement to accurate plans and scheduling in Systems Engineering is the understanding the inputs that are required to be considered. INSOCE Systems Engineering (INCOSE 2015) states to incorporate the early into the planning phase to ensure that they areas of risk are designated the correct attention and that any skipping or taking shortcuts in the planning phase will have a flow on to all other procedures and outcomes of the Project including the Project Management. Again, with the SE Systems thinking approach, the breakdown of elements into manageable size, and the emphasis that Systems Engineering has on correctly identifying and recording organizational and stakeholder

requirements it could be said that pre-planning work that takes into consideration System Engineering principles and practices should deliver a plan with more fidelity. The extension of this continuing to be a correct and measurable plan is the active review by the Project Management and Project Planning staff, the security of the recorded baseline and accuracy for any requirement changes or actuals for the project. It is stated very specifically in the ISO 15288 Systems engineering — System life cycle processes (ISO 2002) how to elicit requirements from stakeholders and in the process record them in documents such as a Statement of Work (SOW), a Work Breakdown Structure (WBS) Dictionary or a Final Requirements Verification and Traceability Matrix (RVTM). This is not only to ensure that the initial planning is correct but also to ensure that any requirement changes are recorded and prove that any shift in plan is justifiable to the change. Traditionally, project also suffer from "scope-creep" this is where additional tasks or deliverables are added but are not great enough to insight a requirement change in themselves. Project Managers and Project Planners must be wary of scope-creep as a small amount here and there can add up to large cost and resource requirements over the life of the project.

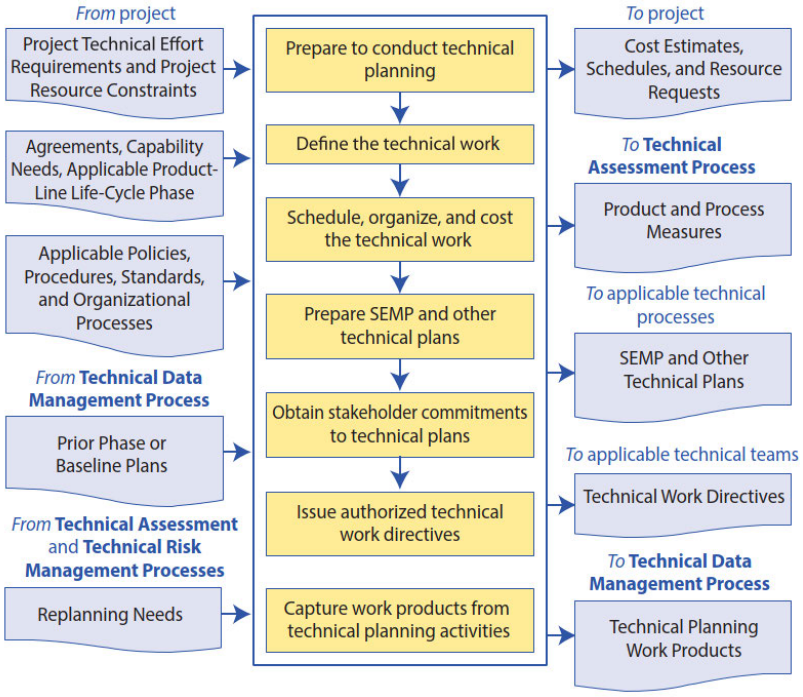


Figure 32 Technical Planning Process NASA Systems Engineering Handbook (Hirshorn 2016)

If we link the results from the KAMS survey to the problem statement that started this research, we can see the direct connection into the statement that only 51% of projects are likely to meet the intended goals and business commitment. Most of the issue was in relation to being over budget and take longer than originally expected. Looking at the KAMS responses over 50% of the Project Mangers stated

that they had underestimated the cost and schedule/time usage for their respective projects. Underestimating is most of the time seen as worse than overestimating as the mantra around cost and schedule overruns has negative connotations and overestimating is often seen as "savings" even though both situations are in fact negative to overall project management success. Most of the KAMS project managers believed that their estimates were in 25% of the actual and although in a visual this may look like there is little variation, when analysing from an accountant or operation standard this could be stated to be an excessive amount. Many of the current KAMS contracts are moving to Fixed Firm Price (FFP) on Performance Based Logistics (PBL) contracts, this means that a 25% underestimation on cost for the project would mean that the project would run at a significant loss for the term of the contract or the period of performance.

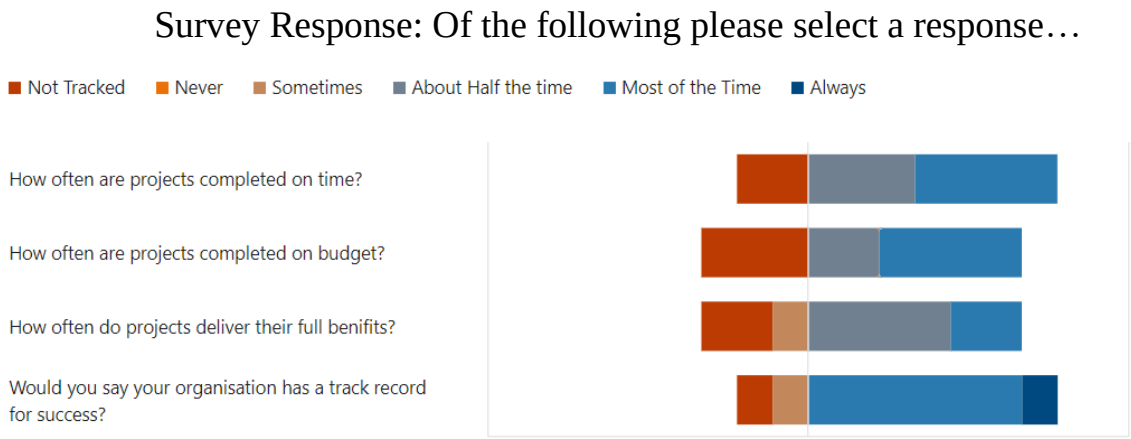


Figure 33 Question 42 Survey Response for the delivery of Project Management in KAMS

4.4 Documentation for Project Framework and Tailoring:

In the Project Management Body of Knowledge (PMI Inc. 2021) it identifies 75 Project Management artifacts that assist in the project control and governance. All projects may not need all the artifacts but depended on the project,, product type and stakeholder requirements some projects might need a significant number of them. The project artifacts identified span the life of the project, some are required at start up while others such as reports and visuals are required in the execution phase. In all cases the artifacts are living documents and should be review periodically to ensure that they still align with the project objectives, the stakeholder requirements and the Project Organisations goals. In this statement there should always be a baseline to ensure that accurate measurement can be taken and there should be a adequate change management process to ensure that all revisions are accepted and distributed

correctly to the relevant partiers. It is suggested though the review or literature that Project Organisations have template of their required project artifacts to the lowest level of fidelity in line with their organisation, Project Management, and Systems Engineering guides. In theory this should lead to tailoring whereby deletion of non-required sections should still end with documentation that is standardised and linking to other artifacts in the governance of the project.

In all instances for project organisations there will be tailoring of documentation and artifacts to ensure that it meets not just the Project Management needs but the needs of the Project organisation. The only advice that the ISO 21500 Guidance on project management gives to the Project Manager is that some of the processes described in the standard may need tailoring when appropriate but gives no further insight. The PMBOK (PMI Inc. 2021) describes tailoring as "to maximize value, manage constraints, and improve performance by using "just enough" processes, methods, templates, and artifacts to achieve the desired outcome from the project." The PMBOK (PMI Inc. 2021) gives further information this time in how the tailoring process is to work and even gives question to the Project Manager to induce consideration on the appropriateness of tailoring processes and procedure in the project domains but does not go far enough with advice on the further consideration or what document will actually be affected as an outcome.

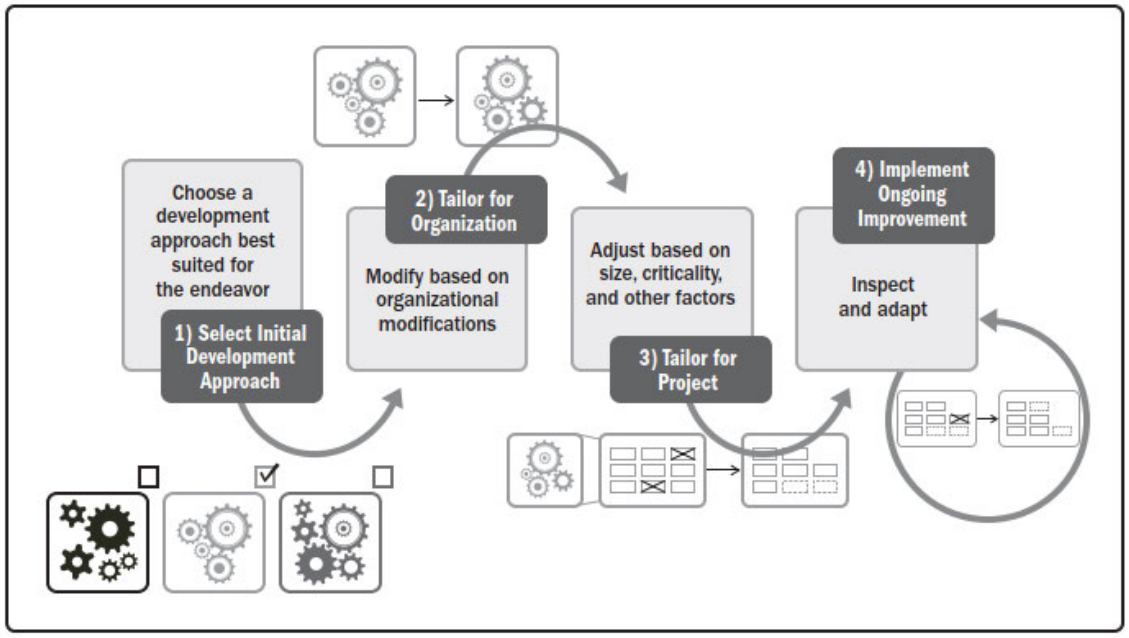


Figure 34 PMBOK (PMI Inc. 2021) Project Tailoring Process.

There may be no such thing as perfect tailoring for a project as requirements will change throughout the lifecycle of a project. We can see from the figure of the PMBOK Project Tailoring Process the last step is ongoing improvement and is almost iterative in nature. As an organisation the project

management process and tailoring should also be iterative in nature and the Project Organisation should learn from every tailoring outcome to ensure that best practice is used for like projects in the future. As there is not final answer to tailoring and it does reach a point that the achievement of 100% correct tailoring is never achievable there should be a framework as to get Project Managers to a state of overarching governance that takes into consideration basic aspects of their project in the shortest time possible. This is not the case looking at the literature that leaves the question open to the Project Manager and expects them to be able to understand the balance between benefit of tailoring fidelity or moving into executing the project. For this reason it should be considered by the Project Management Institute and International Standards Organisation to reconsider the approach when guiding Project Mangers in the tailoring of project artifacts.

If we look the problem of tailoring from a Systems Engineering perspective we should look at each artifact and the area that it governs as a individual piece of the system, it has a performance margin that it needs to deliver and it needs to integrate with other artifacts as required. Like in any system, tailoring producing overperformance of a project governance artifact may lead to cost and schedule overrun and in some cases may drag up other areas and induce overperformance in other areas compounding the issue. Underperformance of the artifact may reduce cost and schedule for the initial creation but may cause flow on effect further downstream where inefficiencies may then negate the saving or cause overruns. The balance is therefore required to be found by interactive process and set by the highest level of Project Organisation and Stakeholder requirements in place for the individual project. To ensure this happens in a timely manner as a base this research suggest the following framework based on a similar systems used in Systems Engineering at NASA (Hishorm 2016). The Project is suggested to be given a project type that relates to the factors of significance to a Project Organisation. This type will then be used to set the tailoring requirements for the Project Organisations Artifacts. As previously mentioned the highest requirement of the Project Organization or the Stakeholder should set the level of the type and tailoring of documents should only be conducted where the framework suggests in the initial instance otherwise in may lad to an unlinked and under performing project governance system. The following table shows a suggested framework to be able to set the project type.

Table 6 Project Type Selection Framework

Criteria	Type A	Type B	Type C	Type D	Type E	Type F
Description of Project	Large Scale Project with Design Production/ Manufacture or Maintenance	Large Scale Project with Design Production/ Manufacture or Maintenance	Medium Scale Project with Design Production/ Manufacture or Maintenance	Medium Scale Project with Production/ Manufacture or Maintenance	Small Scale Project with Design Production/ Manufacture or Maintenance	Small Scale Project with Production/ Manufacture or Maintenance
Stakeholder Interaction	Significant Transdisciplinary Human interaction outside of the Project Organisations Norms	Significant Transdisciplinary Human Interaction Inside of the Project Organisations Norms	Some Transdisciplinary Human Interaction Inside of the Project Organisations Norms	Limited Transdisciplinary Human Interaction Inside of the Project Organisations Norms	Interaction Only within the Project Organisation and the customer	Interaction Only within the Project Organisation
Priority	High	High	Medium	Medium	low	low to very low
Risk Level (Risk Appetite)	Very Low (Minimized Risk)	Low Risk	Medium	Medium to High	High	Very High
Safety Constraints	Very High	High	Medium	Medium	Low	Very Low
Legal and Standards Constraints	Very High	High	Medium	Medium	Low	Very Low
Environmental constrains	Significant	High	Moderate	Low	Minor	Very Low
Organisational Significance	Very High	High	Medium	Medium to Low	Low	Very Low
Project Life	Long. > 10 Years	Long. > 5 Yeas	Medium. 2-5 Years	Short < 2 Years	Short < 2 Years	N/A
Financial Significance (% of Project Organisation Revenue)	100%	>50%	>10%	>5%	>1%	<1%
Alternatives or Like Projects in Market	No Alternatives or like Projects	Few Alternatives or like Projects	Some Alternatives or like Projects	large amount of Alternatives or like Projects	Significant amount of Alternatives or like Projects	Significant amount of Alternatives or like Projects
Delivery Constraints	Must Deliver exactly on all Project requirement areas	Must Deliver on all Project requirement areas with the potential of minor compromise	Must Deliver on most Project requirement areas with the potential of compromise	Must Deliver on most Project requirement areas with the potential of compromise	Must Deliver on most Project requirement areas with the potential of some compromise	Must Deliver on some Project requirement areas with the potential of significant compromise

After the selection of the project type is taken by the Project manager and agreed upon by the Project Organisation tailoring can occur inline with the Project management Artifact Tailoring Table. This is designed using the 75 artifacts mentioned in the PMBOK (PMI Inc. 2021) and aligning the description of the artifact with the significance criteria laid out by the project type selection. The less significant the Project Organisation Criteria for the type of project selected, the more room for tailoring to the correct level for the project governance artifact to ensure that only appropriate time and effort is spent on those areas in alignment with the project type. All Project management Artifacts that are designated if required should have little impact on the project type significance criteria and may be completely removed if not listed in the requirements of the project.

Table 7 Tailoring Framework for Type Selected Projects

Project Management Artifact	Type A	Type B	Type C	Type D	Type E	Type F
Strategy Artifacts:						
Business case	Full	Full	Full	Full	Tailor	Tailor
Project brief	Full	Full	Full	Full	Tailor	Tailor
Project charter	Full	Full	Full	Tailor	Tailor	Tailor
Project vision statement	Full	Full	Full	Tailor	Tailor	N/A
Roadmap (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Log and Register Artifacts:						
Assumption log	Full	Full	Full	Full	Tailor	Tailor
Backlog (if Required)	Full	Full	Full	Full	Tailor	Tailor
Change log	Full	Full	Full	Full	Tailor	Tailor
Issue log	Full	Full	Full	Tailor	Tailor	N/A
Lessons learned register	Full	Full	Full	Tailor	Tailor	N/A
Risk-adjusted backlog	Full	Full	Full	Tailor	Tailor	N/A
Risk register	Full	Full	Full	Tailor	Tailor	N/A
Stakeholder register	Full	Full	Full	Tailor	Tailor	Tailor
Plan Artifacts:						
Change control plan	Full	Full	Full	Full	Tailor	Tailor
Communications management plan	Full	Full	Full	Tailor	Tailor	N/A
Cost management plan	Full	Full	Full	Tailor	Tailor	N/A
Iteration plan (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Procurement management plan	Full	Full	Full	Tailor	Tailor	N/A
Project management plan	Full	Full	Full	Full	Tailor	Tailor
Quality management plan	Full	Full	Full	Full	Tailor	Tailor
Release plan (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Requirements management plan	Full	Full	Full	Full	Tailor	Tailor
Resource management plan	Full	Full	Full	Tailor	Tailor	N/A
Risk management plan	Full	Full	Full	Tailor	Tailor	N/A
Scope management plan	Full	Full	Full	Tailor	Tailor	N/A
Schedule management plan	Full	Full	Full	Tailor	Tailor	N/A
Stakeholder engagement plan	Full	Full	Full	Full	Tailor	Tailor
Test plan (if Required)	Full	Full	Tailor	Tailor	Tailor	Tailor
Baseline Artifacts:						
Budget	Full	Full	Full	Full	Tailor	Tailor
Milestone schedule	Full	Full	Full	Tailor	Tailor	N/A
Performance measurement baseline	Full	Full	Full	Tailor	Tailor	N/A
Project schedule	Full	Full	Full	Tailor	Tailor	N/A
Scope baseline	Full	Full	Full	Full	Tailor	Tailor
Hierarchy Chart Artifacts:						
Organizational breakdown structure (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Product breakdown structure (if Required)	Full	Full	Full	Full	Tailor	Tailor
Resource breakdown structure (if Required)	Full	Full	Full	Tailor	Tailor	N/A

Risk breakdown structure (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Work breakdown structure	Full	Full	Full	Full	Tailor	Tailor
Visual Data and Information Artifacts						
Affinity diagram (if Required)	Full	Full	Tailor	N/A	N/A	N/A
Burn chart (if Required)	Full	Full	Tailor	Tailor	Tailor	N/A
Cause-and-effect diagram (if Required)	Full	Full	Full	Tailor	N/A	N/A
Cycle time chart (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
Cumulative flow diagram (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
Dashboard	Full	Full	Full	Tailor	Tailor	N/A
Flow chart (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Gantt chart	Full	Full	Full	Tailor	Tailor	N/A
Histogram (if Required)	Full	Full	Tailor	Tailor	Tailor	N/A
Information radiator (if Required)	Full	Full	Tailor	Tailor	Tailor	N/A
Lead time chart (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Prioritization matrix (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Project schedule network diagram	Full	Full	Full	Tailor	Tailor	N/A
Requirements traceability matrix	Full	Full	Full	Full	Tailor	Tailor
Responsibility assignment matrix	Full	Full	Full	Tailor	Tailor	Tailor
Scatter diagram (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
S-curve (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
Stakeholder engagement assessment matrix	Full	Full	Tailor	Tailor	N/A	N/A
Story map (if Required)	Full	Tailor	Tailor	Tailor	N/A	N/A
Throughput chart (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
Use case (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
Value stream map (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Velocity chart (if Required)	Full	Full	Tailor	Tailor	N/A	N/A
Report Artifacts:						
Quality report	Full	Full	Full	Full	Tailor	Tailor
Risk report	Full	Full	Full	Full	Tailor	Tailor
Status report	Full	Full	Full	Full	Tailor	Tailor
Agreements and Contracts:						
Fixed-price	Full	Full	Full	Full	Tailor	Tailor
Cost-reimbursable (if Required)	Full	Full	Full	Full	Tailor	Tailor
Time and materials	Full	Full	Full	Full	Tailor	Tailor
Indefinite time indefinite quantity (IDIQ) (if Required)	Full	Full	Full	Tailor	Tailor	N/A
Other agreements (if Required)	Full	Full	Full	Tailor	Tailor	Tailor
Other Artifacts:						
Activity list	Full	Full	Tailor	Tailor	Tailor	N/A
Bid documents	Full	Full	Full	Full	Tailor	Tailor
Metrics	Full	Full	Full	Full	Tailor	Tailor
Project calendars (if Required)	Full	Full	Full	Full	Tailor	Tailor
Requirements documentation	Full	Full	Full	Full	Tailor	Tailor
Project team charter	Full	Full	Full	Tailor	Tailor	N/A
User story (if Required)	Full	Full	Tailor	Tailor	N/A	N/A

4.5 Measurement Indicators to quantify success

Out of the project managers surveyed in the by Willingtone (2020) 54% did not have access to real-time project KPIs with 1/3 spending 1 or more days manually collating project reports. This is unfortunately historically true for organisations but should be improving with the implementation of further ERP systems to the market and a more computer literate Project Management demographic coming into the workforce. As stated previously in the research, only those measurement areas that are required to effect change should be captured.

4.5.1 Project Requirements

Quantifying success in the identification of relevant project requirements is crucial for ensuring that a project aligns with stakeholder needs and objectives. NASA's System Engineering Handbook (Hirshorn 2016) has a checklist for writing requirements that may be reversed to give an index against success for each individual requirement. Based on the checklist and other systems engineering procedures identified in both INCOSE (INCOSE 2015) and NASA (Hirshorn 2016) Systems Engineering Handbooks the following may be considered for measurement areas to quantify the successful integration of Systems Engineering Principles and Procedures as opposed to those that are available in Project Management Standards and guides.

4.5.1.1 Requirement Completeness and Documentation Quality

Measure the percentage of identified requirements in the baseline requirements document compared to the total requirements at review stages of the project like design reviews or Project management reviews. A higher initial completeness percentage indicates more thorough requirement identification. An upward trending percentage between reviews might state that change management process is effective. A downward trending percentage might mean that Stakeholder Engagement, Communication Plan, or Change management Plan might be failing. In this instance further investigation may be required to remedy the issue. Assess the quality of requirement documentation, including organization, format, and clarity of the Requirements Management Plan and the Requirements Traceability Matrix. Well-documented requirements are easier to work with.

4.5.1.2 Requirement Clarity and consistency

Assess the clarity and unambiguity of each requirement. Clear and easily understandable requirements contribute to project success. Requirements clarity can be assessed in accordance with the NASA Requirements Checklist in the NASA Systems Engineering Handbook (Hirshorn 2016) or at a

basic level by having a number of members read the requirement and compare understanding. Ambiguity, contradiction with other requirements or misses in the checklist could mean that Stakeholder Engagement or Requirements Identification and Analysis process might be failing.

4.5.1.3 Stakeholder Satisfaction

Gather feedback from stakeholders to gauge their satisfaction with the identified requirements. High satisfaction levels are an indicator of successful requirement identification. Low Satisfaction levels could mean that Stakeholder Engagement or Requirements Identification and Analysis process might be failing.

4.5.1.4 Requirement Traceability and Validity

Evaluate how well each requirement is traced back to specific project objectives or stakeholder needs through the Requirements Traceability Matrix. Effective traceability is essential for project success. Any Requirement that has been added but is not traceable back to the Statement of Work or the Project Organisation can be deemed a non-requirement and may not be valid, therefore, the cost and time of any performance to that requirement could be recorded as a loss and a reduction in the value in the Delivery of Project Management.

4.5.1.5 Requirement Change Requests, Scope Creep and Change Control

Measure the frequency and nature of requirement change requests after the initial identification process. Assess throughout the project if there is any scope creep from the original baseline Requirements Document and Statement of Work. A decrease in change requests may indicate successful requirement identification but it also may indicate unauthorized scope creep. An Increase in change requests may indicate unidentified variability and risk in the project or a poor execution of the original Requirements Identification.

4.5.2 Budget

Budget will have to be identified through internal Project Organization Procedures but there are some generic KPIs that may be utilised t measure budget accuracy. When integrating Systems Engineering Principles and Processes into the Project Management Budget domain, what is really being stated is if all requirements and risk was correctly identified to set an accurate budget and financial forecast. It has been identified in this research that there needs to be more information available for project management on the topic of Estimation but that has been identified as further work. Any Budget upside or downside can

only directly be contributed to human error, incorrect estimation or misidentification of Risk or Requirements. The flowing are some suggested measurement areas taking into consideration both the PMBOK (PMI Inc. 2021) and the NASA Systems Engineering Handbook (Hirshorm 2016).

4.5.2.1 Budget Accuracy, Cost Estimation Precision, Budget Contingency Usage, Cost Savings and Avoidance

Measure the accuracy of the initially identified budget compared to the actual project costs at regular intervals. A smaller variance between the estimated and actual budget indicates successful budget identification. At the next level evaluate how well cost estimates were for completed tasks and feed information back into the forecast. At the overall level if any contingency money has been used it is correct in its use but indicates a missed variable, risk or requirements but the Project Team. On the other side cost savings achieved by optimizing resource allocation and avoiding unnecessary expenses should be tracked and either go into contingency or into the hands of the stakeholders.

4.5.2.2 Budget Adherence

Evaluate how closely the project adheres to the approved budget over time. High adherence indicates effective budget management. Low adherence could mean poor Stakeholder Engagement, poor planning, missed requirements, risks or variables.

4.5.3 Value outcomes for the integration of Systems Engineering into Project Management

The ability to measure the value of the integration of System Engineering Principles and Procedures into Project Management may only be effectively measure across the industry over a larger period of performance. After the implementation of Systems Engineering Principles and Procedures into project management it would be the hope that poor Project Management delivery satisfaction scores and Project Management value generation for the stakeholders goes up. The following are potentially some internal techniques that may be used by a Project Organisation to measure successful integration in their program. Again, the only issue is that if you do not have an identical project or something that is like to compare or reference to some of the indicators may not be correct.

4.5.3.1 Project Objectives Achievement and On-Time-Delivery

Measure the extent to which the project meets its defined objectives and goals within the allotted deadline for on-time -delivery. Systems engineering integration should contribute to better alignment with project objectives and a more accurate deliverables plan.

4.5.3.2 Quality Improvement

Measure the impact on project deliverable quality. Systems engineering integration should result in higher-quality outcomes and fewer defects or issues. If there is a downward trend during review their may be complacency creeping into the organization. There may also be a new requirement that is missed that causes rework or additional quality tasks.

4.5.3.3 Risk Reduction

Using the risk matrix technique quantify the reduction in project risks achieved through systems engineering practices. This can include a decrease in unexpected issues or variability and better risk management.

5 Conclusions

5.1 Conclusions

Systems Engineering principles and procedures play a pivotal role in enhancing Project Management efficiency and effectiveness and by embracing systems engineering there may be an opportunity to increase the overall value of project management delivery above the reported 51% over the recent years.

First and foremost, Systems Engineering promotes a holistic approach to Project Management. It emphasizes the interconnections of various project elements and considers how changes in one area may impact others. This holistic perspective enables Project Managers to identify potential risks and opportunities early in the project's lifecycle. By addressing these concerns proactively, the Project Team can minimize the likelihood of costly delays and unexpected setbacks overall reducing variability and complexity in the outcomes.

Additionally, systems engineering offers a structured framework for defining project objectives and requirements. It encourages thorough analysis and documentation of stakeholder needs, ensuring that the Project Team and Project Organisation has a clear understanding of what is expected. This clarity in

requirements minimizes the chances of miscommunication, misunderstandings, and scope creep. As a result, Project Managers can effectively set expectations and maintain alignment with project stakeholders while also ensuring that there is a marked baseline to measure against for any necessary or actual change.

Systems Engineering also promotes robust Risk Management and implements Risk-Informed Decision Making. It encourages the earlier identification of potential risks and variability and provides the Project Manager with the necessary information to develop mitigation strategies or focus efforts and resources. By systematically addressing these identified risks, Project Managers can reduce the project's vulnerability to unexpected disruptions, cost overruns, schedule impacts and reduce variability and complexity in the project. Systems Engineering also emphasizes the importance of traceability and configuration management. It ensures that all project artifacts, from requirements to design documents, are linked and tracked throughout the project's lifecycle. This traceability provides Project Managers with an audit trail, which is instrumental in maintaining project consistency and compliance. It also facilitates change control, enabling Project Managers to assess the impact of proposed changes and make informed decisions.

In conclusion, Systems Engineering Principles and Procedures are necessary for project managers striving to enhance Project efficiency and effectiveness. By adopting a holistic approach, defining clear project requirements, proactively managing risks, promoting collaboration, and emphasizing traceability and configuration management, Project Managers may be able to navigate projects with high levels of variability with more confidence that the end delivery will achieve Project Organisation and Stakeholder satisfaction levels much greater than the currently stated 51%. These principles, documents, framework and measurement indicators should empower Project Managers to make informed decisions, reduce the likelihood of costly errors, and ultimately deliver successful projects on time and within budget. Project Managers will be able to move away from blaming complexity to embracing variability management.

5.2 Recommendations

The single largest recommendation of this research is to encourage Project Managers, the Project Management Institute and the International Standards organisation to move away from the term complexity in all documentation and guides. The term complexity is not able to be referenced to a datum as this research shoes and therefore should not be able to be referred as to why a project may be successful or not. All sections of guides and procedures are suggested to change from complexity to variability

management and ensure that the Project Organisations and Project Managers understand and comprehend the reason and significance of the change.

It can be seen in this research that with further transdisciplinary interaction in Project Teams and systems thinking, project should now be thought of as a system-of.-systems. This will require further focus in Project Management education on the importance of integration leads and communication management. Project Management Education facilitators are recommended to review the curriculum of Project Management and start to further include language and processes from transdisciplinary areas to ensure that the Project Manager will understand how to be main systems integrator in a project that is treated as a system-of-systems.

For universities and project institutes the awareness of the poor results in the delivery of Project Management should be recognised and integrated into the curriculum for Engineering and Business Administration degrees. Only with acknowledgement of the problem will the Project Management and Engineering communities be able to come up with desired solutions to be able to facilitate better results for Project Organisations and Stakeholders.

If the further integration of Systems Engineering is folded into the Project Management Profession, It is recommended that organisations like the Project Management Institute or KPMG run further surveys of the Engineering and Project Management communities over the coming years with standardised ground rule, assumptions and questions to ensure that a trend may be monitored and improving to validate any findings.

5.3 Further Work

With the tight time frame of the study period it was not possible to survey or interview the number of project mangers that would have been desirable to release better statistical results. There is also some outcomes of the survey that may be directly driven from the organisation the respondents work for which may not align with he general population of project management. Although this is evidence that better standardization is required to be give in project management standards and guides it also suggests that the is further procedural work for Project Management that needs to be conducted inside Kongsberg Aviation Maintenance Services.

Whilst looking into literature on planning and being that one of the issues brought up in the problem statement is cost and more specifically cost overrun, it is suggested that there should be further

work conducted into the alignment of Estimating from Project Management and see if there are any shortfalls or links that need to be strengthened inside the Project Management when it comes to financial assessment. Du to the strong tie to requirements and governance and compliance documents there may also be further connection with Systems Engineering Principles and Procedures which may help in assisting with Financial Estimation and in turn aid overall Project Management.

As this research provides the first framework to be able to quickly and generically "type" a project and understand how its significant criteria will effect the tailoring of project artifact, further work should be invested into ensuring that the significant criteria of the project types is confirmed, corrected or expanded as this might be the basis for further standardisation of Project Management and Project Artifact templates. Once the Project Significance Criteria is set then the Project Artifact Tailoring framework must be confirmed. This will provide an area of difficulty in the further work as the application of the framework in itself will only be able to be measured for effectiveness against Project Organisation norms or experience, unless there is an identical project or ones that are like enough to prove the comparison of a treated and untreaded project against the recommendations of this research.

To ensure that the effectiveness of the tailoring process is fully encourages there should be further effort placed into the generation of standard templates, processes for generation, areas open to tailoring for Project Management Artifacts. During the establishment of these standards there should be hand-in-hand the generation of a Project Management Artifacts Integration Map. This would mean that the theory of making a high fidelity template and tailoring by deletion will not interrupt necessary connections with other project artifacts and may influence the sections in documentation that is open for tailoring. This research was aiming to develop some documentation in the areas of Stakeholder Engagement, Risk Management, Benefit Realisation, and Planning but failed to adequality find the time.

The last recommendation for further work into the subject area of Systems Engineering integration into Project Management. There are still a number of synergies that are yet to be fully uncovered.

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7 Annexes

7.1 Annex A – SE Processes for Complexity/Variability Reduction

Law of	Brief Description	Business or Mission Analysis Process (INCOSE)	Stakeholder Expectation Definition (NASA)/Stakeholder Needs and Requirements Definition Process (INCOSE)	Technical Requirements Definition (NASA)/System Requirements Definition (INCOSE)	Logical Decomposition (NASA)/Architecture Definition Process (INCOSE)	Design Solution Definition (NASA)/Design Definition Process (INCOSE)	Technical Planning (NASA)/Project Planning Process (INCOSE)	Project Assessment and Control (INCOSE)	Requirements Management (NASA)	Interface Management Process (NASA)/ Interface Management (INCOSE)	Model Based Systems Engineering (MBSE) (INCOSE)	Integrated Product and Process Development (INCOSE)	Technical Risk Management (NASA)/Risk Management Process (INCOSE)	Configuration Management (NASA)/Configuration Management Process (NCOSE)	Technical Data Management (NASA)/Information Management Process (NCOSE)	Technical Assessment (NASA)/ Measurement Process (INCOSE)	Decision Analysis (NASA)/Decision Management Process (INCOSE)	Infrastructure Management Process (INCOSE)	Human Resource Management Process (INCOSE)	Knowledge Management Process (INCOSE)	Proposed Benefit
Organisational Linguistics	Communication may not translte between hirachial levels of an organisation due to level language being designed to satisfy level requirments.	X			X	X	X	X	X		X	X	X		X	X		X		X	These Processes will no change that level requirments in an organisation but haveing the correct members involved accross these procedures will make a dictionary of like terms that can be used accross a project to aid translation between levels
Suucess and Failure	Componets that a group require to face complex problems (I.e. Leadership, Financial Support, Component Availiability, Environment, Participation, Documentation and Proccess)	X			X		X	X			X	X	X		X	X		X			Majority of these process are to be internally met by the project organisation to ensure that the Project Team has the relevent components to become successful. Reducing Variability by the buisness understanding that project requirments will make a more cohesive organisation
Structual Underconceptulisation	Lack of complete mapping of the relationship between components of a system effecting the behavior of the components	X	X	X	X	X			X	X	X			X								There processes are used to define the connection between the elements of a system. More effort placed into tis mapping at the start of projects will ensure stakeholders are idetified and ensure that changes are flowed through the correct paths.
Vertical Incohearance of Organisation	Pre-exhisting organisational patterns and behavior causing lack of alignment, consistancy or clear comunication between hirachial levels	X					X	X	X			X	X					X	X		X	These Processes are designed to make an organisation look internally. If a Project Organisation creates a good foundation but decetralises the computational ability of the workface they may be able to process larger workloads
Inherant Conflict	Differeing groups or inderviduals will disagree on the improtance of differeing aspects due to different backgrounds and liguistics		X		X	X			X	X	X	X						X				These Process will ensure tat all members know the revevent requirments of the project. IPPD and decision management will allow the priorities and important aspects
Forced Substitution	Personnel substitution in a group in an attempt to induce results	X					X	X				X						X	X	X	X	Althought sometimes nessasary, good project management, HR and Knowledge Management processes should have the right peolple in te right part of the Project Organisation. To reduce complexity in this stage SE Decision Making Process with a foundations from Reuirments set by the scoping processes should push a result.
Limits	Limits that define the relationship and performance of the System or Project	X	X	X			X	X	X										X			Otput artifacts of Technical Planning look in detail iis the Cost Estimates, Shedules and Resorse Requests against the designated requirements of the Project. All processes aroudn that will set the requirments for the Plan. Measurement and Control will ensure that the plan is current, relevaent and accurate.
Requisite Variaty	The number of requisit specifications and design variable that require consideration to obtain desired outcomes		X	X			X		X	X					X				X			Good Scoping, Requirments, and Interface Management should ensure that requirements for the project are followed. In projects where there are alot of specifications to follow the organisation should prioroties the infratstuture to support them
Triadic nesessity and suffereancy	Understanding that all complex relationships normally consisit of three (3) relational components at their basic level and that giving to one component to satisfy a connection will take away from the others.			X	X	X				X	X		X	X								SE mapping and modeling may bring the benifit to better understand the ramifications of decisions. Athought there still may need to be comparamise, systems engineering techniques may limit the need for iterations
Diverse Beliefs	Using diverse teams leads to different experiance and trade language that can lead to the inability to cooperate from a unified point of view.			X		X		X			X	X						X				Cetralised Learning such as MBSE and Team Membersbeing involved in Requiremets Finding excersizes should aid to give all a baseline.
Requisite Saliancy	Not all factors affecting a system are of equal weight. Relative importance of factors in a system that will define performance.		X	X	X	X			X		X											Establising Requirements and establishing a system plan will give the information to wight the requirments to the appropriate level.
Gradation	Differeing bodies of Knowlegde arise at different levels of the organisation and it is uncommon for all levels to be used to solve a problem				X			X										X			X	Decision Management Processes will ensure that no matter the level that the problem is solved at, there will always be deseminated infromation througout the Project Team
Induced Groupthink	During time constraints decisions of a group may represent results that have not been thought out properly by all inderviduals. Decisions also may be against the views of inderviuals.						X	X										X				Adequate planning and Project Control should try and reduce the likelihood of complexity from this situation arising. Good decision management protocols and procedure should not allow for decisions to be made when there isn't a quorum. Other tactics like "Devils Advocate" may be required.

Law of	Brief Description	Business or Mission Analysis Process (INCOSE)	Stakeholder Expectation Definition (NASA)/Stakeholder Needs and Requirements Definition Process (INCOSE)	Technical Requirements Definition (NASA)/System Requirements Definition (INCOSE)	Logical Decomposition (NASA)/Architecture Definition Process (INCOSE)	Design Solution Definition (NASA)/Design Definition Process (INCOSE)	Technical Planning (NASA)/Project Planning Process (INCOSE)	Project Assessment and Control (INCOSE)	Requirements Management (NASA)	Interface Management Process (NASA)/ Interface Management (INCOSE)	Model Based Systems Engineering (MBSE) (INCOSE)	Integrated Product and Process Development (INCOSE)	Technical Risk Management (NASA)/Risk Management Process (INCOSE)	Configuration Management (NASA)/Configuration Management Process (NCOSE)	Technical Data Management (NASA)/Information Management Process (NCOSE)	Technical Assessment (NASA)/ Measurement Process (INCOSE)	Decision Analysis (NASA)/Decision Management Process (INCOSE)	Infrastructure Management Process (INCOSE)	Human Resource Management Process (INCOSE)	Knowledge Management Process (INCOSE)	Proposed Benefit
Universal Priors	The understanding that language, reasoning, relationships and the ability to apply this is apparent in the members. New systems/situations that where members have no prior information can therefore be difficult		X		X		X	X	X		X	X							X	X	Good HR and Knowledge Management Processes are key to hiring and retaining the relevant people to the organization. Good training management and distribution of information through practices like MBSE are key to aligning knowledge, especially in new systems
Small Displays	Tendancy for Inderviduals to accomadate problem to the size of there prefered media (i.e. A4 Paper, Computer Monitor). Limiting display will limit the complexity of problems and hinder conceptulisation			X	X	X		X		X	X				X	X		X			SE trecniquest like MBSE may give the project organisation the background knowledge to beable to decrease the size of the issue to a manageble view with the understanding of percived knowledge. Oter SE processes like Logical Decomposion will ensure that the most important elements are idetified and reduce complexity in displaying problems.
Triadic Compatability	Human mind can only deal with seven (7) conceptual components simutaniouly. E.g. three (3) System Elements and four (4) interaction combinations between them.				X	X	X	X		X	X	X			X							Utalising these SE tools the Project Management team should be able to break the Project into considreed elements where Intergration Teams and Leads will spread the Cognative Load and Report Back to the PM or PMO who will act like the SEIT
Validation	The validity of Knowledge within an organisation requires the consensus of te organisation							X			X	X							X	X	X	Much of this lies in the culture of an organisation and in some situations could also be based around the law of induced group think. Good HR process, Knowledge Management and IPPD should reduce variability in this field
Preculded Resolution	The absence of proper discription or modeling of an issue leading to the inability to properly sort th issue itself. Without this it is based on the cnceptualisation on an indervidual member		X	X	X	X					X			X								I could be argueed that there would be alarge benifit in Project Managment adopting the MBSE tecnique to flow information through the Project Organisiton. This coupled wit Logica Decoposition woulld mean that that the root cause of issue might be more easily identified and issue could be resolved at the appropriate level
Requisite Parsomony	Human can only collect and process information at a cirtain rate					X					X	X			X	X						Although PMBOK write of information sharing and communication through a Project Organisation and Project Manager the SE Handbooks and associated process dive deeper into Data Products, Data Exchange Formats and Information Management Stratergies/Plans. Correct information sharing combined with
Uncorrelated Extreams	Learning Proccess starts from different backgrounds meaning that initial perceptions are uncorrelated extreams prior to learnig process		X	X	X						X										X	The requirments leading into MBSE will give a good platfome for theProject Organisation to be able to base the perceved knowedge level on. Reducing unknowns in amoungst the organisational members and ensure that on controlled information is flowed to the members.

7.2 Annex B - Project Specification

For	Benjamin Powell
Title	Project Management and Systems Engineering Integration for increased efficiency and effectiveness
Major	Mechanical Engineering
Supervisors	Dr Steven Goh FIEAust, CPEng, EngExe, NER, APEC Engineer, IntPE(Aus) | EngD, MPA, MBA (Tech Mgt), BEng (Hons)
Sponsorship	Kongsberg Aviation Maintenance Services AS, Norway
Confidentiality	Documentation produced by this project may contain KONGSBERG information which is proprietary and confidential. Any disclosure, copying, distribution or use is prohibited if not otherwise explicitly agreed with KONGSBERG in writing. Any authorised reproduction in whole or in part, must include this legend. © 2019 KONGSBERG – All rights reserved.
Enrolment	ENG4111 – EXT S1, 2023 ENG4112 – EXT S2, 2023
Project Aim	**Primary:** It is the aim that by investigating the Project Management guides and identifying the type of project, documents set, and criteria this proposed research will develop a framework that will allow Project Managers to tailor like project for best results. **Secondary:** Outcome of this standardisation then will be to make some Key Performance Indicators that the Project Manager will be able to utilise to adjust the amount of tailoring of project artifacts to achieve optimisation and improve statistics on the completion of project that meet requirements, budget and schedule.

Programme

1. Secondary Literature review (primary conducted as an annotated bibliography as part of ENG4110 assignment 1)
2. Gather and review historical project information from Kongsberg Aviation Maintenance Services AS to determine any shortfalls, inconsistencies, opportunities, or data to assist in the research project.

3. Investigate industry data collection to try and validate Kongsberg Aviation Maintenance Services AS historical data and ensure that the subjects, information and interviewees from KAMS will be appropriate.
4. Tailor a questionnaire and interview members of KAMS to gain their understanding of the current state of Project Management and areas of concern for them. Correlate against industry to ensure that the result is not biased. (e.g. number of times same theme is mentioned in research papers vs. concern of interviewee)
5. Liaise with USQ supervisor to corroborate if data gained from Literature Review, Industry, Questionnaire, and Interview is truly valid.
6. Correlate results of interviews and run a Collect, Choose, Create and Commit activity too develop initial documents for Project Framework, Tailoring and Measurement,
7. If possible, apply the developed document to an actual project in KAMS. If not access the document retrospectively against a current project and identify areas for enhancement.
8. Run interviews again with the development documents and identify areas of improvement.
9. Adjust Documentation as required and fix a baseline for where revision of documents will have to follow a complete review cycle.
10. Liaise with USQ supervisor to present final document pack for endorsement of field trial.
11. Liaise with KAMS Director of Project Management to present final document pack for endorsement of field trial.
12. If available and time permitting, select a trial project to gain actual data from the use of the tailored project document set to demonstrate its accuracy.
13. Collect and exhibit all data. Present Conclusions, Assumptions and Recommendations.

7.3 Annex C – Project Specification – Resources

Resources

There is limited physical resources required for this research due to the nature of the project.

Financial:

Nil

Time:

- There will need to be some time set aside during work to be able to conduct interviews with KAMS staff members. This will impact both the Project that I work in and other for the company. Interviews will be approximately 42 hours in total (2 x 3-hour interviews for each Project Manager)
- Faculty Time (Dr Steven Goh)
    - 2 x 2-hour Progress/Validation sessions
    - 1 x 2 Hour Pre-Submission session

Facilities:

Specific Facilities that will be required to be accessed are:

- KAMS Main Offices, Fetveien 80-84, 2001 Kjeller, Norway
- KAMS F135 MRO&U Depot, Flyplassen 55, 1580 Rygge, Norway

Alternate locations that may be visited (If not possible MS Teams)

- KAMS Bødo, Olav V gate, 8004 Bødo, Norway
- KAMS Evenes, Harstad/Narvik Lufthaven, 8536 Evenes, Norway
- KAMS Bardufoss, Bardufoss Flyplass, 9325 Bardufoss, Norway

Software:

MS Office Suite

MS Project (Project Plan and Progress Report)

PDFxChange (PDF Editor, Supplied with KAMS computer)

Documentation:

Kongsberg Aviation Maintenance Services historical/current Project Data

Kongsberg Aviation Maintenance Services historical/current financial data

Kongsberg Defence & Aerospace current Project Management Procedures

Various ISO/AS Standards (Either available through KAMS or USQ)

7.4 Annex D – Survey

Survey - Project Management

The intent of the survey is to produce quantitative data in relation to the aims of Benjamin Powell's research to support the hypothesis that Project Managers are struggling in common areas that could be improved by the implementation of System Engineering approaches or techniques.

This is a contributing factor towards Benjamins Honours Project for his BENH Degree in Mechanical Engineering

Please be honest in the results of the survey. Some participants may be asked to contribute with an interview in the future but all results and responses will be kept confident.

Any Conclusions arising from this survey that may assist in Project Management Body of Knowledge will be submitted through the University of Southern Queensland. Redacted findings may be made available to organisations through express written permission on the participants and the data holder (Benjamin Powell)

This should take no longer than 30 mins. Thank you in advance.

* Required

* This form will record your name, please fill your name.

Consent and Start

1. In your invitation you would have recieved a consent form, please sign (Digitally or Physically) an upload here. Once you have uploaded, click next to begin the

Upload file

File number limit: 1 Single file size limit: 10MB Allowed file types: Word, Excel, PPT, PDF, Image, Video, Audio

Participant Details

2. Full name *

3. Position *

4. Organisation *

5. Start Date at your Organisation *

6. How may Years of experiance do you have in Project Management? *

- ◯ 0-3
- ◯ 3-5
- ◯ 5-10
- ◯ 10-15
- ◯ >15

7. Projects your are currently/previously responsible for? *

8. Pick one project you are responsible for as the reference for this survey. *

9. What do you use for the basis of your Project Management practices? *

- [ ] Internal Company Procedures
- [ ] PMI Project Management Body of Knowledge
- [ ] Higher Education (PM/Engineering/MBA)
- [ ] ISO Standards
- [ ] Expeririance
- [ ] Other

Process Value vs Difficulty

Of the following in the questions bellow, which Process adds the most value to your project when conducted properly and how difficult is the process it integrate properly

10. Rank the Following Project Management Processes from most valuable to least valuable for the successful outcome of your projects (1 being most valuable – 10 being least valuable) *

- Change Control/Change Management
- Document Management
- Lessons Learned
- Planning/ Scheduling
- Progress Measurement
- Project Benefits Realisation and Review (Value of Project)
- Project Status Reporting
- Resource Management
- Risk Management
- Stakeholder Engagement

11. Rank the Following Project Management Processes from most difficult to least difficult to achieve with your understanding of project management (1 being most difficult – 10 being easiest) *

- Change Control/Change Management
- Document Management
- Lessons Learned
- Planning/ Scheduling
- Progress Measurement
- Project Benefits Realisation and Review (Value of Project)
- Project Status Reporting
- Resource Management
- Risk Management
- Stakeholder Engagement

Complexity and Variability

Both topics of complexity and Variability are sometimes hard to answer. Please try your best and follow up might be asked for in an interview.

12. On a scale of 1-7 how complex is your project? *

	Not Complex (1)	2	3	4	5	6	Extremely Complex (7)
Complexity	◯	◯	◯	◯	◯	◯	◯

13. Rank from 1-10 where you believe the most complexity comes from in your project *

- Customer/ Contracts
- Deliveries/ Deliverables
- Finance/ Budget
- Organisational Management/ Support Functions
- Processes
- Other Stakeholders
- Project Manager/ Project Team
- Project Size/ Resources
- Schedule
- Risk Management

14. How many connections (communication lines) do you have directly related to the management of your project? *

- ◯ 0-5
- ◯ 5-10
- ◯ 10-15
- ◯ 15-20
- ◯ >20
- ◯ Other

15. On a scale of 1-7, do you think other members in your organisation understand your project? *

	No Understading (1)	2	3	4	5	6	Fully Understand (7)
Organisational Understanding	◯	◯	◯	◯	◯	◯	◯

16. In your own words, define Complexity in relation to Project Management. *

17. Do you have any ideas to reduce complexity in Project Management?

18. On a scale of 1-7 (1 No Variation – 7 Constant Variation)how much does your project vary requirements over time? *

	No Variation in Req's (1)	2	3	4	5	6	Constant Variation in Req's (7)
Variability	◯	◯	◯	◯	◯	◯	◯

19. Rank from 1-10 where you believe the most variability/changes comes from in your project *

- Customer/ Contracts
- Deliveries/ Deliverables
- Finance/ Budget
- Organisational Management/ Support Functions
- Processes
- Other Stakeholders
- Project Manager/ Project Team
- Project Size/ Resources
- Schedule
- Risk Management

20. In your own words, define Variability. *

21. Do you have any ideas to reduce variability in Project Management?

Stakeholder Engagement

Stakeholder Engagement is an area that is identifies in both Project Management and System Engineering areas of responsibility.

22. From 1-7 (1 no understanding – 7 complete understanding) how well do you understand the customer and other stakeholder requirements for your project? *

	Not Understood (1)	2	3	4	5	6	Completely understood (7)
Customer and Stakeholder Requirements	○	○	○	○	○	○	○

23. Are the customer requirements all in the contract and addressed clearly? if No, put what document in other? *

Please select at most 2 options.

- ☐ Yes
- ☐ No
- ☐ Other

24. Are the requirements recorded somewhere other than the contract? (place where in the other box if yes) *

- ☐ Yes
- ☐ No
- ☐ Other

25. What process do you use to define customer and other stakeholder requirements? *

26. What process do you use to manage change in requirements? *

Risk Management

Risk Management is an area that is identifies in both Project Management and System Engineering areas of responsibility.

27. From 1-7 (1 no understanding – 7 complete understanding) how well do you understand the risks associated with your project? *

	Not Understood (1)	2	3	4	5	6	Completely understood (7)
Customer and Stakeholder Requirements	◯	◯	◯	◯	◯	◯	◯

28. Are all the risks recorded somewhere accurately in line with your organisations process? *

- ◯ Yes
- ◯ No

29. How many participants are involved in risk identification in your project? *

- ◯ 1
- ◯ 1-3
- ◯ 3-5
- ◯ 5-10
- ◯ >10

30. What process do you use to define risks in your project? *

31. What process do you use to manage change in risks in your project? *

Benefit Realisation

Benefit Realisation is an area that is identifies in both Project Management and System Engineering areas of responsibility. In other literature it may be called Review or Development Approach and Life Cycle.

32. From 1-7 (1 Hard – 7 easy) how hard is it to measure success in your project? *

	Very Hard	Hard	Somewhat Hard	Average	Somewhat Easy	Easy	Very Easy
How hard is it to measure success in your project?	◯	◯	◯	◯	◯	◯	◯

33. What do you use as the datum/baseline for measurement of success? *

- ◯ Historical Data and Norms
- ◯ Organisation KPI Targets
- ◯ Target from Customer Contract
- ◯ Customer Satisfaction
- ◯ Financial Targets
- ◯ Schedule Targets
- ◯ Other

34. Do you record and score the effectiveness of the Project Management in your project? *

- ◯ Yes
- ◯ No

35. Do you when making decisions: *

- ◯ Project future KPI's and use them to make decisions?
- ◯ Use after the fact/actual KPI's to make decisions?

36. On a scale of 1-7 (1 being not at all 0% – 7 being always 100%) *

	0%	1%-20%	20%-40%	40%-60%	60%-80%	80%-99%	100%
do you think the KPI's you record are accurately showing the status of your project?	◯	◯	◯	◯	◯	◯	◯
do you effectively use KPI's to generate improvements?	◯	◯	◯	◯	◯	◯	◯
does your organisation effectively use KPI's to generate improvements?	◯	◯	◯	◯	◯	◯	◯

Planning

Planning is an area that is identifies in both Project Management and System Engineering areas of responsibility.

37. Do you use the organisation approved planning software for your project planning? if No, what do you use? *

- [ ] Yes
- [ ] No
- [ ] Other

38. What technique do you use to plan your project? *

Please select at most 3 options.

- [ ] Project Evaluation & Review Technique (PERT)
- [ ] Critical Path Method (CPM)
- [ ] Agile Planning
- [ ] Milestone Planning
- [ ] Work Breakdown Structure (WBS)
- [ ] Gantt Chart
- [ ] Historical Organisational Planning
- [ ] Other

39. When planning your project, do you: *

	Never	Sometimes	Half the time	Most of the Time	Always
Create a scoping document as a part of planning?	○	○	○	○	○
Baseline your Project Schedule?	○	○	○	○	○

40. On a scale of 1-7 (1 not accurate – 7 completely accurate) *

	Not Accurate	More than 200% off	More than 100% off (less than 200%)	More Than 50% off (less than 100%)	Within 25% of Estimate	With 10% of Estimate	Completely Accurate
a) how accurate are the estimations for Schedule/ time usage in your project?	○	○	○	○	○	○	○
b) how accurate are the cost estimations in your project?	○	○	○	○	○	○	○

41. For question 37 a) and b) are your plans over estimated, under estimated or completely accurate? (in relation to the % that you have answered) *

	Under Estimated	Over Estimated	Completely Accurate
a) Schedule/ time usage	○	○	○
b) Cost	○	○	○

42. Of the following please select a response *

	Not Tracked	Never	Sometimes	About Half the time	Most of the Time	Always
How often are projects completed on time?	○	○	○	○	○	○
How often are projects completed on budget?	○	○	○	○	○	○
How often do projects deliver their full benifits?	○	○	○	○	○	○
Would you say your organisation has a track record for success?	○	○	○	○	○	○

Documentation

43. Does you project have the following documents, Are they used effectively? *

	Yes, Used Effectivly	Yes, Not Effective	Being Developed	No, But needed	Not Required	Unsure
Configuration Management Plan	◯	◯	◯	◯	◯	◯
Contract	◯	◯	◯	◯	◯	◯
Contract Compliance Review Matrix	◯	◯	◯	◯	◯	◯
Data Management Plan	◯	◯	◯	◯	◯	◯
Project Gate/Design Reviews	◯	◯	◯	◯	◯	◯
Information Depository	◯	◯	◯	◯	◯	◯
Logistics Management Plan	◯	◯	◯	◯	◯	◯
Master Schedule	◯	◯	◯	◯	◯	◯
Previous/ Current Handover Records	◯	◯	◯	◯	◯	◯
Project Data List	◯	◯	◯	◯	◯	◯
Project Management Plan	◯	◯	◯	◯	◯	◯
Project Specification	◯	◯	◯	◯	◯	◯
Quality Management Plan	◯	◯	◯	◯	◯	◯
Requirements Management Document	◯	◯	◯	◯	◯	◯

Resource Management Plan	○	○	○	○	○	○
Risk and Opportunity Management Plan	○	○	○	○	○	○
Statement of Work	○	○	○	○	○	○
Statement of Work Compliance Review Matrix	○	○	○	○	○	○
Systems Engineering Management Plan	○	○	○	○	○	○
Work Breakdown Structure	○	○	○	○	○	○

Current state and Challenges in your organisation.

44. On a scale of 1-7 (7 good-1 bad) do you believe that Project Management processes in your organisation fit your project? *

	Very Poor	Poor	Fair	Averarage	Good	Very Good	Excellet
Project Management Processes in your Organisation	◯	◯	◯	◯	◯	◯	◯

45. Do you think? *

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
More Project Management Staff are required in your organisation?	○	○	○	○	○
Project Management adds value to a project?	○	○	○	○	○
Project Management is just a required overhead for a project?	○	○	○	○	○
Project Management is Effective in your organisation?	○	○	○	○	○
Measurable critical success factors are always or often defined at the outset of projects?	○	○	○	○	○
Project Review is effective in your organisation?	○	○	○	○	○

46. What is the maturity level of the following in your organisation? *

	Non-Existant	Low	Moderate	Robust	Excellent
Sales and Contract Management	○	○	○	○	○
Project Financial Management	○	○	○	○	○
Project Risk and Issue Management	○	○	○	○	○
Project Planning and Schedule Management	○	○	○	○	○
Project Benefits Management	○	○	○	○	○
Management of Project Scope and Requirements	○	○	○	○	○
Project Resource Management	○	○	○	○	○
Project Quality Management	○	○	○	○	○
Communication and Change Management	○	○	○	○	○

47. On a scale from 1-7 (1 No Challange - 7 Very Challenging) What are the Larges Project Management Challenge in your organisation today? *

	Not Challenging (Easy) [Never]	2	3	4	5	6	Very Challenging (Hard) [Always]
Attempting to run to many projects?	○	○	○	○	○	○	○
Doing Wrong Project (Lack of Strategic Alignment)	○	○	○	○	○	○	○
Frequent Changes to Scope	○	○	○	○	○	○	○
Inconsistency in PM approach	○	○	○	○	○	○	○
Ineffectively implementation of Project Management Solution	○	○	○	○	○	○	○
Lack of appropriate software	○	○	○	○	○	○	○
Lack of Governance	○	○	○	○	○	○	○
Lack of Planning Skills	○	○	○	○	○	○	○
Lack of Project Funding	○	○	○	○	○	○	○
Lack of Senior Management Support	○	○	○	○	○	○	○
Lack of visibility of Project Status	○	○	○	○	○	○	○
Poor Pre-Project	○	○	○	○	○	○	○

Project Process	○	○	○	○	○	○	○

48. Do you run independent Project reviews to access performance of delivery? *

- ○ Yes
- ○ No
- ○ Unsure

Poorly Trained Project Managers	○	○	○	○	○	○	○
Organisation Structure	○	○	○	○	○	○	○
Demanding Customer	○	○	○	○	○	○	○
Poor Information Flow Top Down	○	○	○	○	○	○	○
Poor Information Flow Bottom Up	○	○	○	○	○	○	○

7.5 Annex E – Survey Results

Survey - Project Management

9	54:47	Active
Responses	Average time to complete	Status

1. At the end of the survey by clicking "Submit" you give consent OR In your invitation you would have received a consent form, please sign (Digitally or Physically) an upload here. Once you have uploaded, click next to begin the

1
Responses

Latest Responses
ENG4111 - Consent form Questionnaire_Jan Bratland.pdf

2. Full name

9
Responses

Latest Responses
[redacted]

3. Position

9
Responses

Latest Responses
"Project Manager"
"Program Director"
"Production Manager"

4. Organisation

9
Responses

Latest Responses
"F-35 & Fixed Wing "
"Kongsberg Aviation Maintenance Services| "
"KAMS - Kongsberg Aviation Maintenance Services AS"

5. Start Date at your Organisation

9
Responses

Latest Responses
"2020-06-01"
"2019-11-03"
"1982-08-02"

6. How may Years of experiance do you have in Project Management?

0-3	1
3-5	2
5-10	2
10-15	1
>15	3

7. Projects your are currently/previously responsible for?

9
Responses

Latest Responses
"HT/VT and Component-maintenance "
"Multiple Subsea projects in Oil and Gas + multiple aviation r..."
"Production of aircraft parts"

8. Pick one project you are responsible for as the reference for this survey.

9
Responses

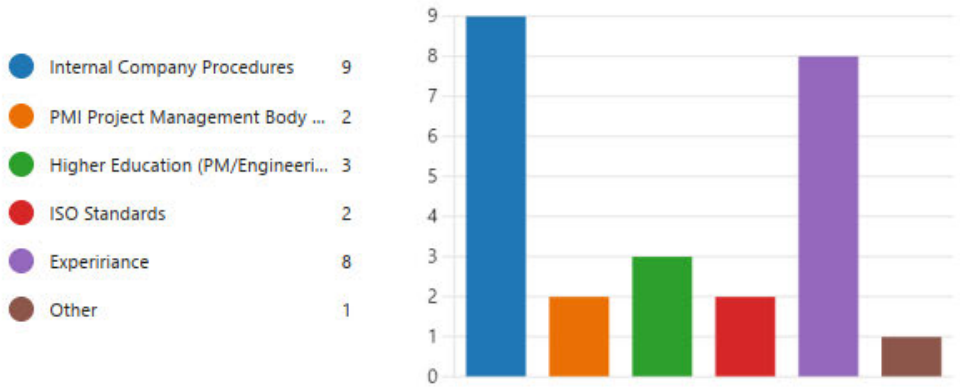
Latest Responses

"HT/VT"

"Kaombo Subsea Production System"

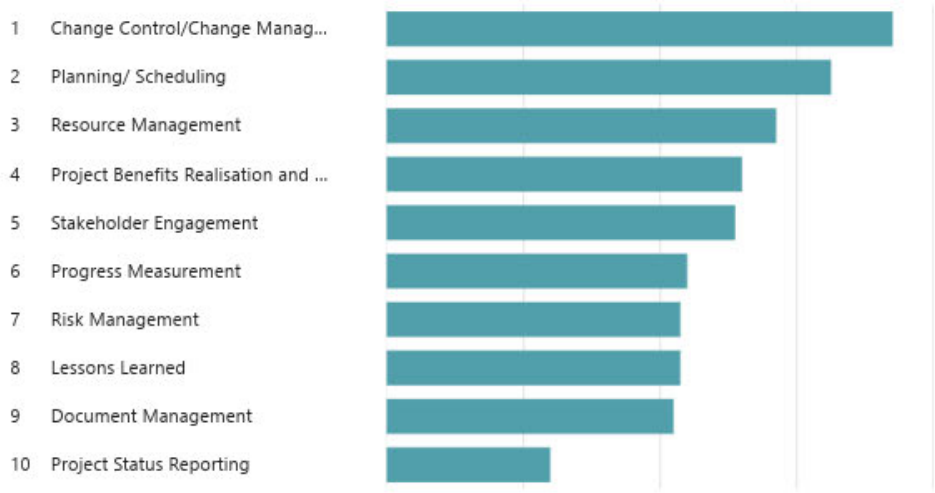
"Production of aircraft parts"

9. What do you use for the basis of your Project Management practices?

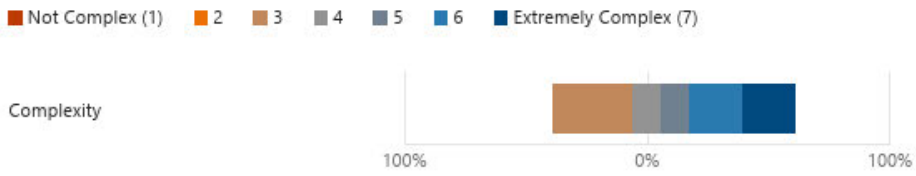


10. Rank the Following Project Management Processes from most valuable to least valuable for the successful outcome of your projects (1 being most valuable – 10 being least valuable)

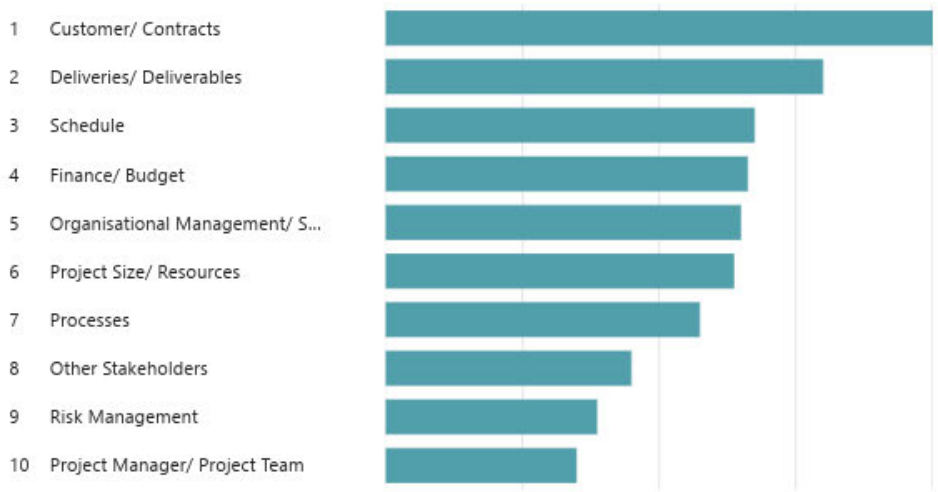
11. Rank the Following Project Management Processes from most difficult to least difficult to achieve with your understanding of project management (1 being most difficult – 10 being easiest)



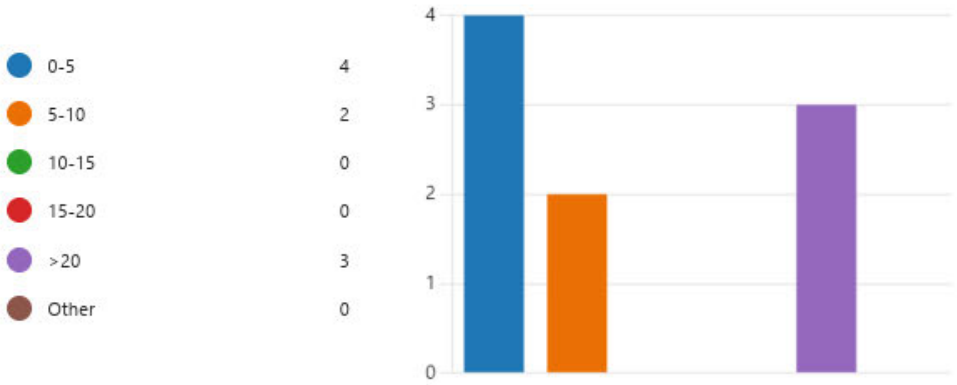
12. On a scale of 1-7 how complex is your project?



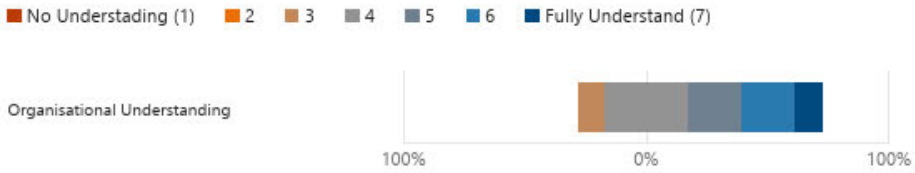
13. Rank from 1-10 where you believe the most complexity comes from in your project



14. How many connections (communication lines) do you have directly related to the management of your project?



15. On a scale of 1-7, do you think other members in your organisation understand your project?



16. In your own words, define Complexity in relation to Project Management.

9
Responses

Latest Responses

"I define project complexity as the combination of project vari...

"The mix of many interests which not necessarily all are align...

"Many hundreds of activities in the production"

17. Do you have any ideas to reduce complexity in Project Management?

9
Responses

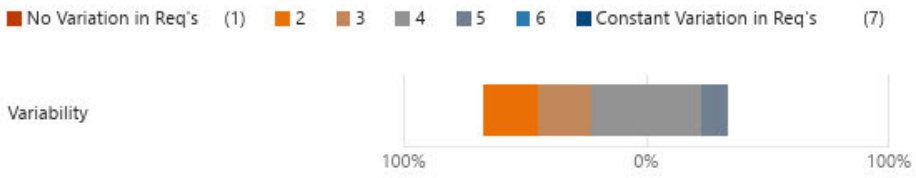
Latest Responses

"My take is that the best way to manage or reduce complexit...

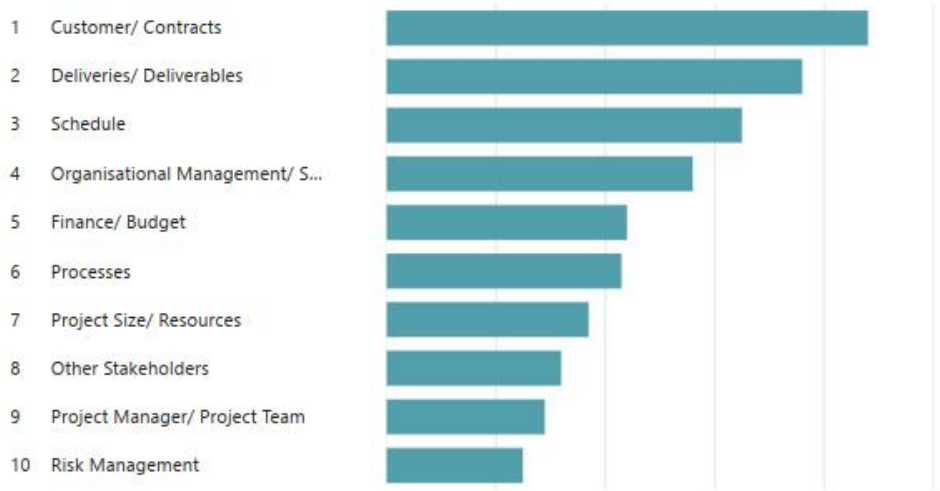
"Planning and communication"

"Prima Vera Planning tool to be introduced to handle the co...

18. On a scale of 1-7 (1 No Variation – 7 Constant Variation)how much does your project vary requirements over time?



19. Rank from 1-10 where you believe the most variability/changes comes from in your project



20. In your own words, define Variability.

9
Responses

Latest Responses

"Something that changes over time."

"Scope change"

"Changes of configuration of the products"

21. Do you have any ideas to reduce variability in Project Management?

9
Responses

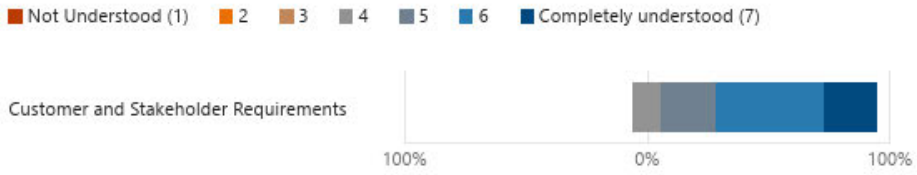
Latest Responses

"Proper risk management, good structures for document/file ...

"Investing in the project definition phase reduces the chance ...

"Demand from the Customer, not possible to reduce variability"

22. From 1-7 (1 no understanding – 7 complete understanding) how well do you understand the customer and other stakeholder requirements for your project?



23. Are the customer requirements all in the contract and addressed clearly? if No, put what document in other?

24. Are the requirements recorded somewhere other than the contract? (place where in the other box if yes)

25. What process do you use to define customer and other stakeholder requirements?

9
Responses

Latest Responses

"Organizational "know-how". HTVT has a long history at KA...

"contract review at start up"

"Quality Management system many processes describe what ...

26. What process do you use to manage change in requirements?

9
Responses

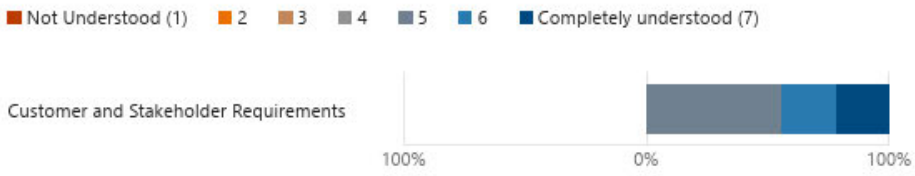
Latest Responses

"All contract changes are handled in accordance with P-126 ...

"Change Management process"

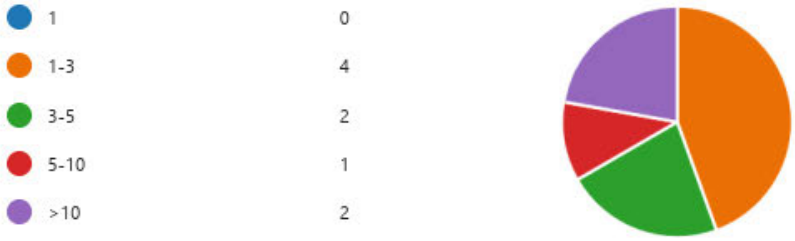
"Configuration management process"

27. From 1-7 (1 no understanding – 7 complete understanding) how well do you understand the risks associated with your project?



28. Are all the risks recorded somewhere accurately in line with your organisations process?

29. How many participants are involved in risk identification in your project?



30. What process do you use to define risks in your project?

9
Responses

Latest Responses

"KDA-TMPL-0055_Risk_Assessment_Tool_KAMS"

"Risk & Opportunity Management process"

"Risk matrix for KAMS"

31. What process do you use to manage change in risks in your project?

9
Responses

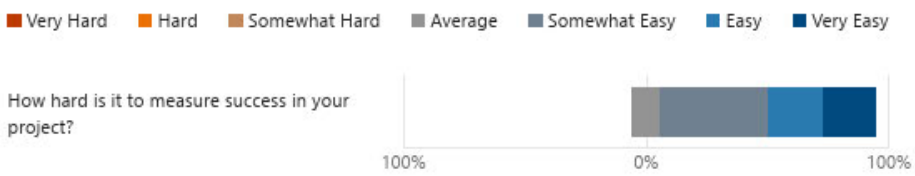
Latest Responses

"Business review sessions with Program Director in accordanc...

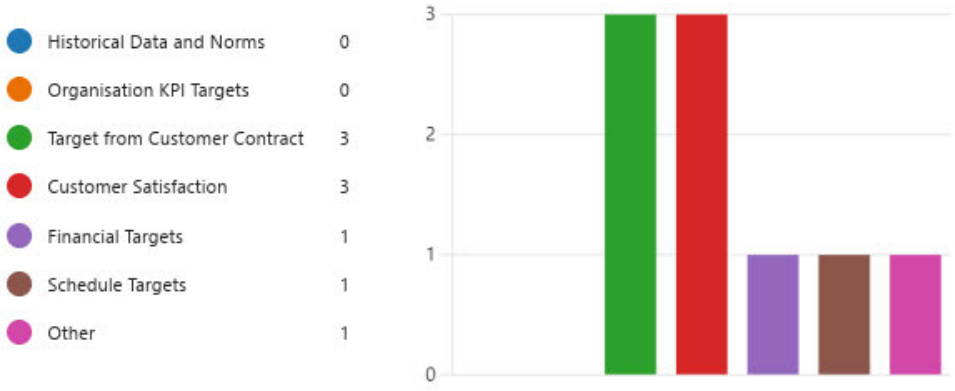
"Monthly business reviews"

"Risk management Process - AS9100 related"

32. From 1-7 (1 Hard – 7 easy) how hard is it to measure success in your project?



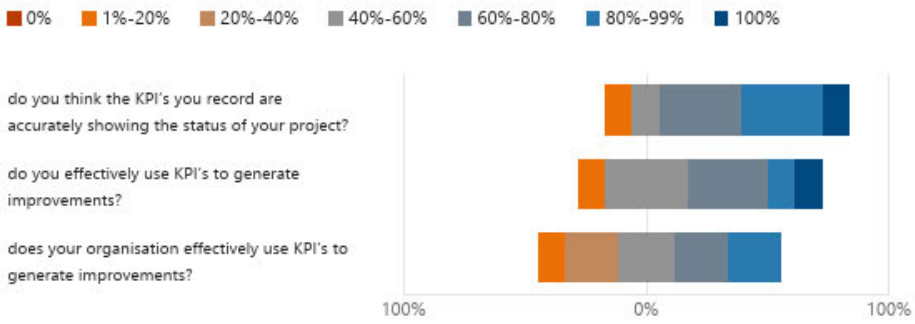
33. What do you use as the datum/baseline for measurement of success?



34. Do you record and score the effectiveness of the Project Management in your project?

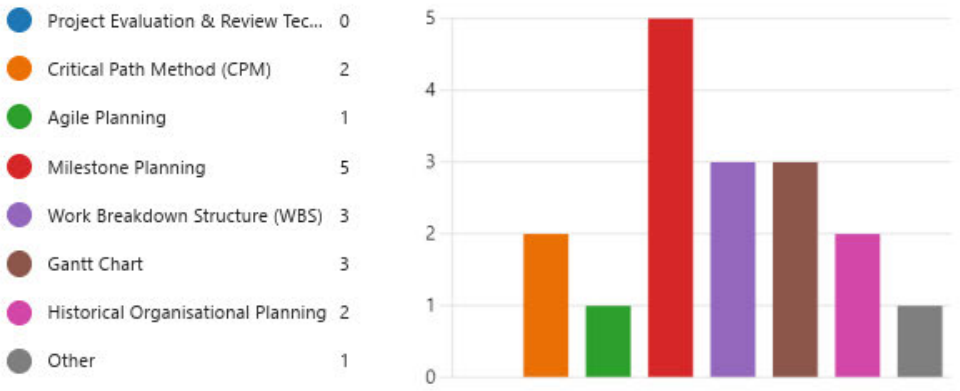
35. Do you when making decisions:

36. On a scale of 1-7 (1 being not at all 0% – 7 being always 100%)

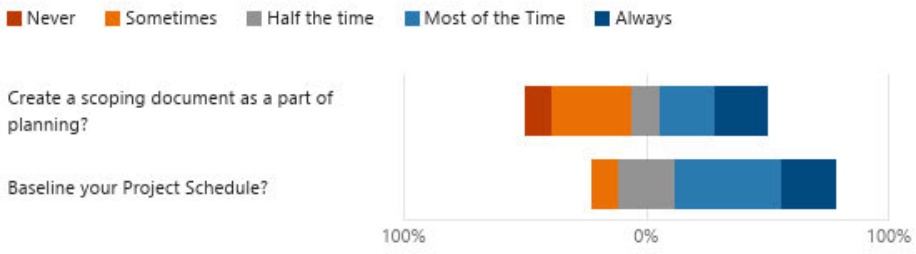


37. Do you use the organisation approved planning software for your project planning? if No, what do you use?

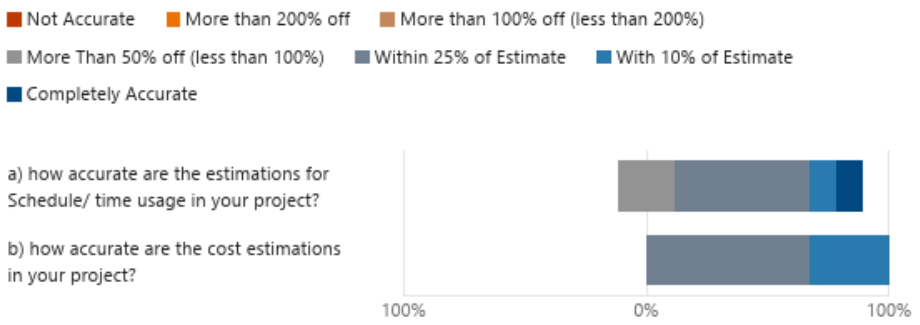
38. What technique do you use to plan your project?



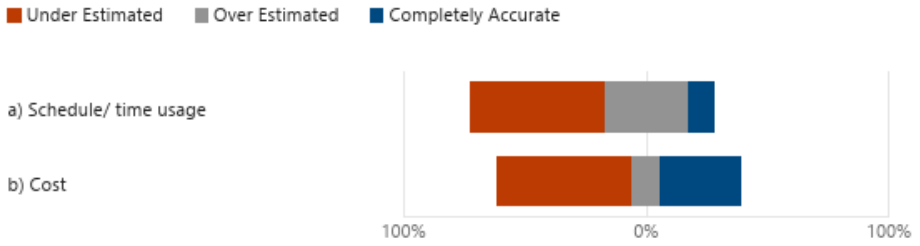
39. When planning your project, do you:



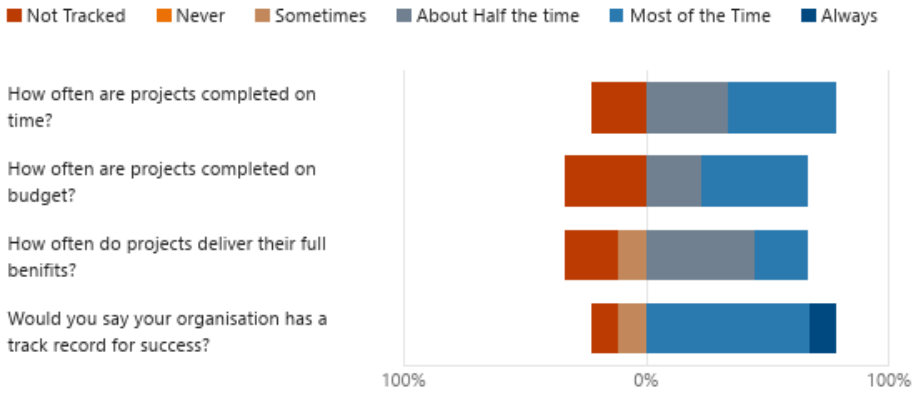
40. On a scale of 1-7 (1 not accurate – 7 completely accurate)



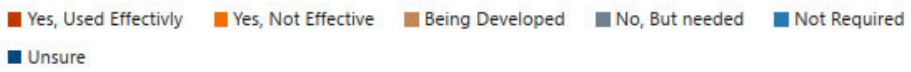
41. For question 37 a) and b) are your plans over estimated, under estimated or completely accurate? (in relation to the % that you have answered)

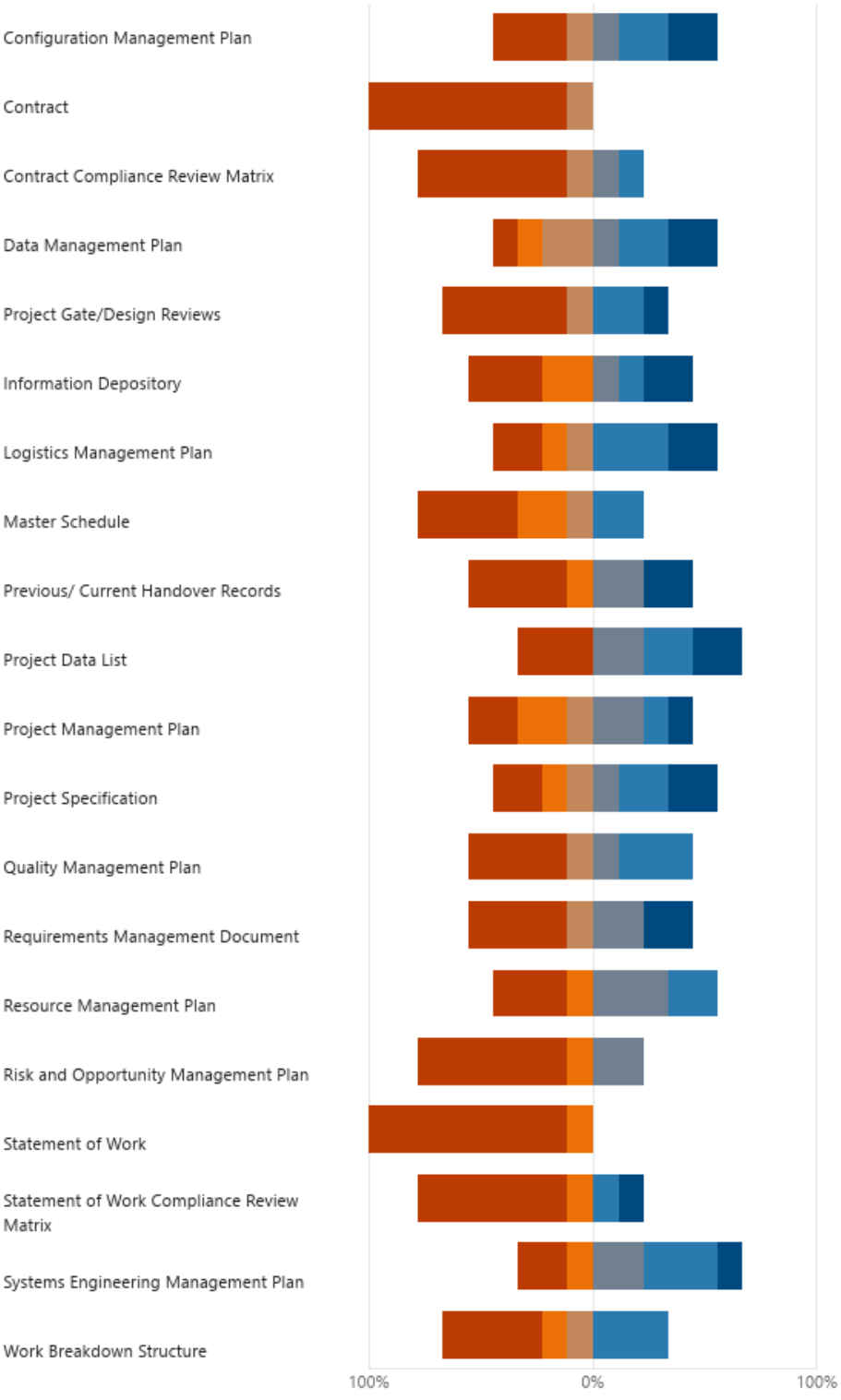


42. Of the following please select a response

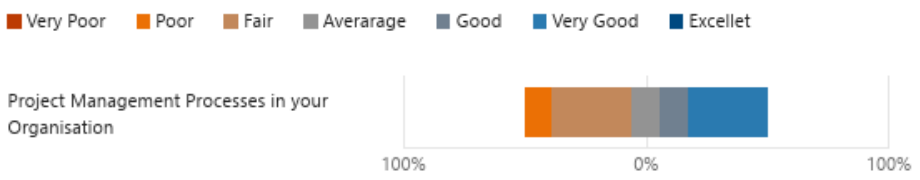


43. Does you project have the following documents, Are they used effectively?

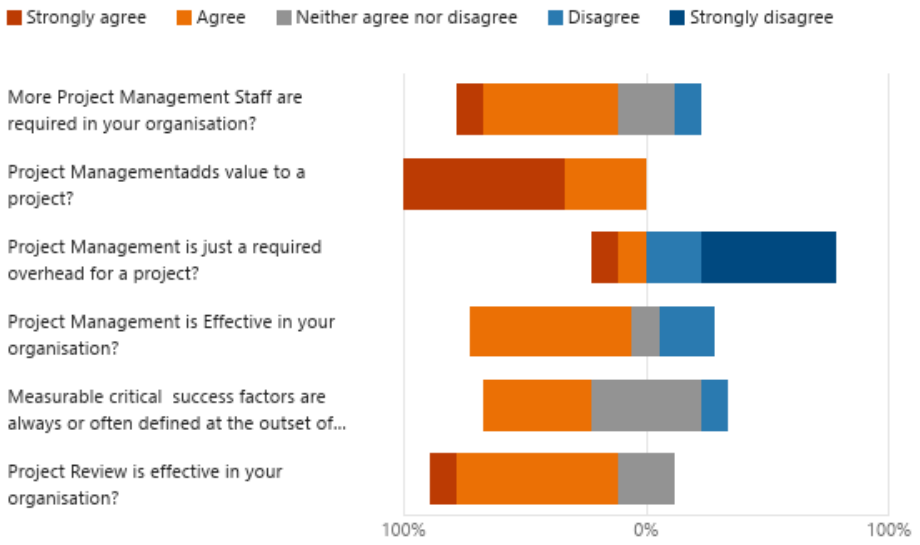



Configuration Management Plan
Contract
Contract Compliance Review Matrix
Data Management Plan
Project Gate/Design Reviews
Information Depository
Logistics Management Plan
Master Schedule
Previous/ Current Handover Records
Project Data List
Project Management Plan
Project Specification
Quality Management Plan
Requirements Management Document
Resource Management Plan
Risk and Opportunity Management Plan
Statement of Work
Statement of Work Compliance Review Matrix
Systems Engineering Management Plan
Work Breakdown Structure
100%
0%
100%

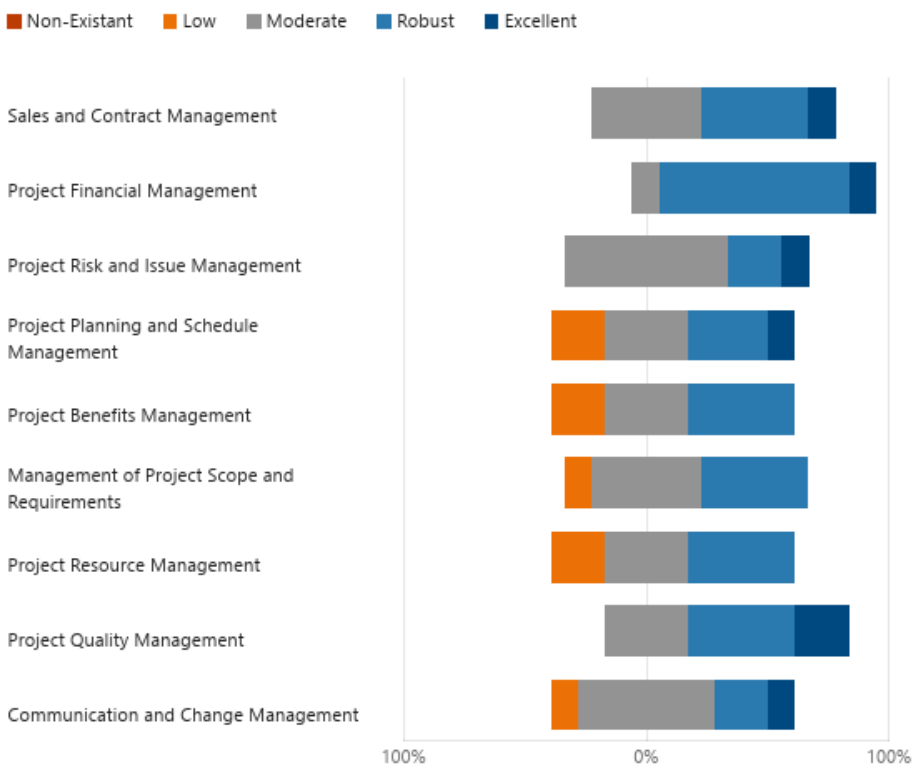
44. On a scale of 1-7 (7 good-1 bad) do you believe that Project Management processes in your organisation fit your project?



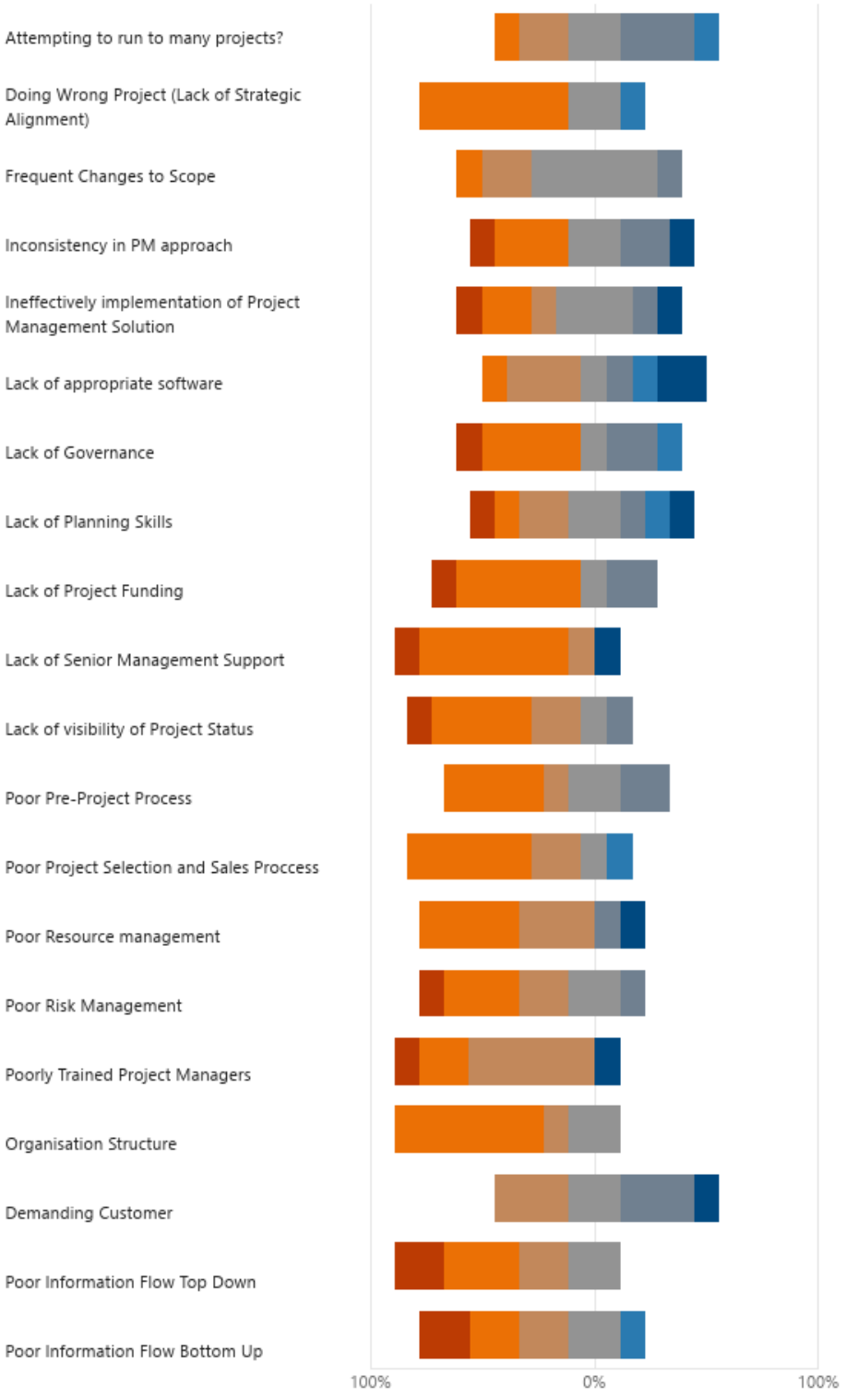
45. Do you think?



46. What is the maturity level of the following in your organisation?



47. On a scale from 1-7 (1 No Challange - 7 Very Challenging) What are the Larges Project Management Challenge in your organisation today?


Attempting to run to many projects?
Doing Wrong Project (Lack of Strategic Alignment)
Frequent Changes to Scope
Inconsistency in PM approach
Ineffectively implementation of Project Management Solution
Lack of appropriate software
Lack of Governance
Lack of Planning Skills
Lack of Project Funding
Lack of Senior Management Support
Lack of visibility of Project Status
Poor Pre-Project Process
Poor Project Selection and Sales Proccess
Poor Resource management
Poor Risk Management
Poorly Trained Project Managers
Organisation Structure
Demanding Customer
Poor Information Flow Top Down
Poor Information Flow Bottom Up
100%
0%
100%

48. Do you run independent Project reviews to access performance of delivery?

Yes	4
No	5
Unsure	0

7.6 Annex F – Risk Management Plan

Project Management and Systems Engineering Integration for Increased Efficiency and Effectiveness

University of Southern Queensland **Offline Version**

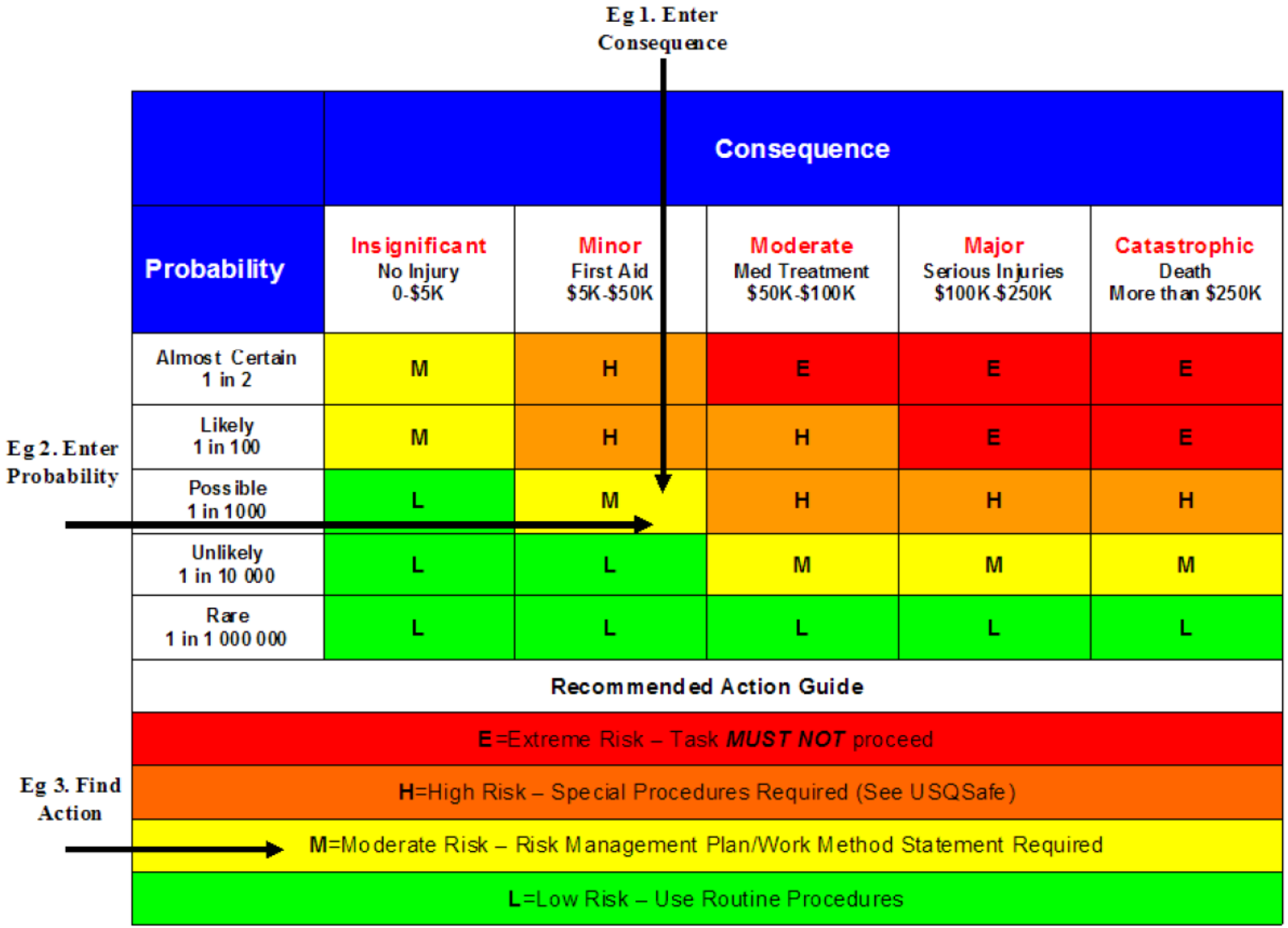
USQ Safety Risk Management System

Note: This is the offline version of the Safety Risk Management System (SRMS) Risk Management Plan (RMP) and is only to be used for planning and drafting sessions, and when working in remote areas or on field activities. It must be transferred to the online SRMS at the first

Safety Risk Management Plan – Offline Version			
Assessment Title:	ENG4111 & ENG4112 Reseach Project - Benjamin Powell	Assessment Date:	17/10/2022
Workplace (Division/Faculty/Section):	Kongsberg Aviation Maintenance Services AS, Norway	Review Date:(5 Years Max)	13/03/2023

Context			
Description:			
What is the task/event/purchase/project/procedure?	ENG4111 & 4112 Reseach Project - Project Management and Systems Engineering Integration for increased efficiency and effectiveness		
Why is it being conducted?	Final Submission-BENH		
Where is it being conducted?	Kongsberg Aviation Maintenance Services AS, Flyplassen 55, Rygge, Norway		
Course code (if applicable)	ENG4111 & 4112	Chemical name (if applicable)	N/A
What other nominal conditions?			
Personnel involved	Benjamin Powell		
Equipment	nil		
Environment	Industrial Aviation Workshop and Office Environment		
Other			
Briefly explain the procedure/process	Reseach will be conducted into the application of a developed framwork for project management based on system engineering principles and techniques		
Assessment Team - who is conducting the assessment?			

Assessor(s)	Professor Thiru Aravinthan, Dr Wahid Ferdous
Others consulted:	ering Integration for Increased Efficiency and Effectiveness Stephen Goh



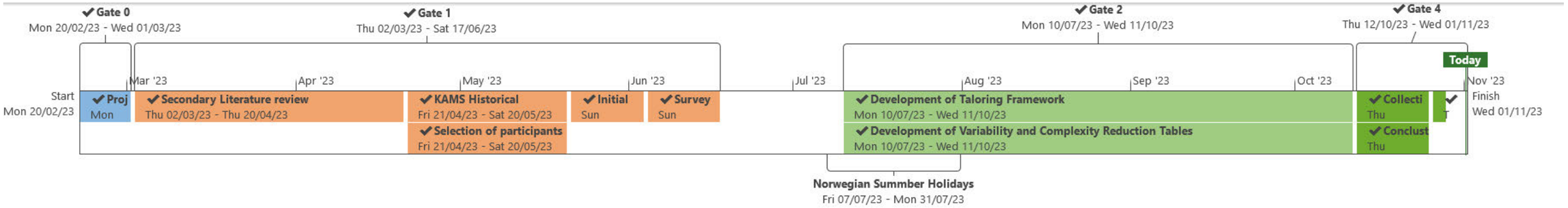
Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
Hazards: From step 1 or more if identified	***The Risk:*** What can happen if exposed to the hazard without existing controls in place?	***Consequence:*** What is the harm that can be caused by the hazard without existing controls in place?	***Existing Controls:*** What are the existing controls that are already in place?	***Risk Assessment:*** Consequence x Probability = Risk Level			***Additional controls:*** Enter additional controls if required to reduce the risk level	***Risk assessment with additional controls:***			
				Probability	**Risk Level**	**ALARP? Yes/no**		**Consequence**	**Probability**	**Risk Level**	**ALARP? Yes/no**
Example											
Working in temperatures over 35º C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy.	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
Extended Hours to fit in work and University	Increased drowsiness and stress levels	Minor	Stable diet and sleep schedule. Breaks in work and study	Almost Certain	Low	No	If benefits can be sold to the business there may be work time that can be dedicated to the research reducing the overall time burden	Minor	Likely	Moderate	Yes
Personnel injury caused by working with chemicals used during maintenance work. Risk of exposure to chemicals with high risk of cancer, and with mutagenic	Short-term or long-term injury.	Major	Mandatory use of protective equipment when handling harmful chemicals. All chemicals have a risk analyse done in EcoOnline before being released for use.	Unlikely	High	Yes	Risk in Eco Online needs to be performed with a substitution evaluation. Evaluation done in EcoOnlie. Closed out. Identify any chemicals requiring a user registration.	Major	Rare	Low	Yes

Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
Hazards: From step 1 or more if identified	***The Risk:*** What can happen if exposed to the hazard without existing controls in place?	***Consequence:*** What is the harm that can be caused by the hazard without existing controls in place?	***Existing Controls:*** What are the existing controls that are already in place?	***Risk Assessment:*** Consequence x Probability = Risk Level			***Additional controls:*** Enter additional controls if required to reduce the risk level	***Risk assessment with additional controls:***			
				Probability	**Risk Level**	**ALARP? Yes/no**		**Consequence**	**Probability**	**Risk Level**	**ALARP? Yes/no**
Example											
Working in temperatures over 35º C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy.	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
properties.											
Loud noises in the workshops harmful to hearing. Can cause permanent hearing damage.	Injuries to personnel. Damaged hearing, and tinnitus due to exposure of high sharp noise, or high level noise over time.	Moderate	Mandatory use of protective equipment.	Possible	Moderate	No	mandatory site EHS training.	Moderate	Unlikely	Moderate	Yes
Traveling to different KAMS locations to conduct interviews / Analysis	Driving in ice and snow conditions in Norway. Fatigued Driving due to work and study hours	Major	Mandatory Breaks, Appropriate vehicle and allotment of time to drive	Rare	Moderate	No	Utilization of company email and MS teams to limit traveling in the winter months	Major	Rare	Low	Yes
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No

Step 5 - Action Plan (for controls not already in place)			
Additional controls:	*Resources:*	*Persons responsible:*	*Proposed implementation date:*
If benefits can be sold to the business there may be work time that can be dedicated to the research reducing the overall time burden		Benjamin Powell	13/03/2023
Risk in Eco Online needs to be performed with a substitution evaluation. Evaluation done in EcoOnlie. Closed out. Identify any chemicals requiring a user registration.	This is ongoing with my Quality Representative at the facility and is my responsibility to be up to date for all employees	Benjamin Powell	17/10/2022
mandatory site EHS training	Conducted when i started at the site in March 2021	Benjamin Powell	Click here to enter a date.
Utilization of company email and MS teams to limit traveling in the winter month	Ongoing	Benjamin Powell	Click here to enter a date.

Step 6 - Approval					
Drafter's name:	Benjamin Powell			Draft date:	13/10/2022
Drafter's comments:	The risk associated with this research project is very low as it s mostly computer and office based work. In saying this the workplace is deemed as a high risk workplace within Norwegian Law. There are three (3) risk matrix that are compiled for the Norwegian F135 Depot where i as the project Manager are responsible for two (2). Business risk and WHS risk. Although the risk associated with the project is minimal, the ongoing work i do in concurrently will be conducted within the bounds of the KAMS Risk management plan and policy.				
Approver's name:		Approver's title/position:			
Approver's comments:					
I am satisfied that the risks are as low as reasonably practicable and that the resources required will be provided.					
Approver's signature:				Approval date:	Click here to enter a date.

7.7 Annex G – Timeline



Task Mode	Task Name	Duration	Start	Finish
✓	**Gate 0**	**10 days?**	**Mon 20/02/2**	**Wed 01/03/2**
✓	Project Proposal	10 days?	Mon 20/02/2	Wed 01/03/2
✓	Acceptance of Project Proposal	0 days	Wed 01/03/2	Wed 01/03/2
✓	**Gate 1**	**108 days**	**Thu 02/03/23**	**Sat 17/06/23**
✓	Secondary Literature review	50 days	Thu 02/03/23	Thu 20/04/23
✓	KAMS Historical information reaseach and data gathering	30 days	Fri 21/04/23	Sat 20/05/23
✓	Selection of participants & interview questions	30 days	Fri 21/04/23	Sat 20/05/23
✓	Initial Survey of Participants	14 days	Sun 21/05/23	Sat 03/06/23
✓	Survey Results Review and Correlation	14 days	Sun 04/06/23	Sat 17/06/23
✓	**Gate 2**	**94 days?**	**Mon 10/07/2**	**Wed 11/10/2**
✓	Development of Taloring Framework	94 days?	Mon 10/07/2	Wed 11/10/2
✓	Development of Variability and Complexity Reduction Tables	94 days	Mon 10/07/23	Wed 11/10/23
✓	**Gate 4**	**21 days**	**Thu 12/10/23**	**Wed 01/11/2**
✓	Collection and Presentation of Data	14 days	Thu 12/10/23	Wed 25/10/2
✓	Conclustions, Assumptions and Recommendations	14 days	Thu 12/10/23	Wed 25/10/2
✓	Finalisation and Editing	3 days	Thu 26/10/23	Sat 28/10/23
✓	Submission	0 days	Wed 01/11/2	Wed 01/11/2
	Extra	**25 days?**	**Fri 07/07/23**	**Mon 31/07/2**
	Norwegian Summber Holidays	25 days?	Fri 07/07/23	Mon 31/07/2

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