# Adopting agile practices and techniques in complex traditional engineering project management environment [1]

**Dr Lalamani Budeli**

## Abstract

In recent years, the use of agile practices, tools and techniques has gained momentum, especially in engineering and software projects. Regardless of industry, project management has proven to be a crucial element of a company's efficiency and its eventual success. Agile methodologies take an iterative approach to project development. On the other hand, systems engineering ensures the effective development and delivery of capabilities by using a set of consistent analytic, disciplined, integrated, and technical management processes throughout the program lifecycle while touching many of the other processes across acquisition lifecycle describing the application of agile principles to some systems engineering processes.

Agile system engineering is based on an incremental, iterative approach. Instead of in-depth planning at the beginning of the project, Agile methodologies are open to changing requirements over time and encourages constant feedback from the end-users. The goal of each iteration is to produce a working product. The overall goal of system engineering is to develop and design a system that meets a specific set of requirements (needs) in the guidelines established by the project or program manager (PM).

The purpose of this paper is to demonstrate how adopting agile practices and techniques in a traditional engineering project management environment can assist companies to improve project requirements management to improve overall project benefits.

**Keywords**: Agile practices, traditional engineering project, benefits management

## Introduction

In a traditional engineering environment, sequential procedures are used in various tasks involved in the concept, design and manufacturing of products performed in a defined and conventional order. These processes possess flexibility which leads to drawbacks resulting in severe alterations in the later stages of a project or product development life cycle. The new field of concurrent engineering focuses on working interactively between the various processes in the development. Concurrent engineering concept is that the entire product life cycle needs to be taken into consideration in the initial stage of the cycle and flexibility is of immense importance to the success of the process given the fact that it allows for error correction and

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redesigns to be incorporated in the early design phase without harming the costs, efforts and timelines of the project.

Agile project management is an iterative approach to delivering a project throughout its life cycle which is composed of several iterations or incremental steps towards the completion of a project. The main aim of the agile (iterative approach) is to release benefits throughout the process rather than only at the end of the project. Agile projects display central values and behaviors of flexibility, trust, collaboration and empowerment.

**Research hypothesis**

The following are research hypotheses:

1. Applying agile practices in traditional engineering projects will improve project and product benefit management.
2. Project agile method application in traditional engineering projects will improve project flexibility and decision marking while ensuring that the customer is fully satisfied with the deliverables (Products).

**Research methodology**

According to Mackey and Gass (2015-196), normative research differs from descriptive studies because the target is not only to gather facts but also to point out in which respects the object of study can be improved. Usually, the project even includes planning an approach for carrying out the necessary improvements. Depending on whether the project continues as practical development or not, there are two styles of normative research which are general normative research and normative case study.

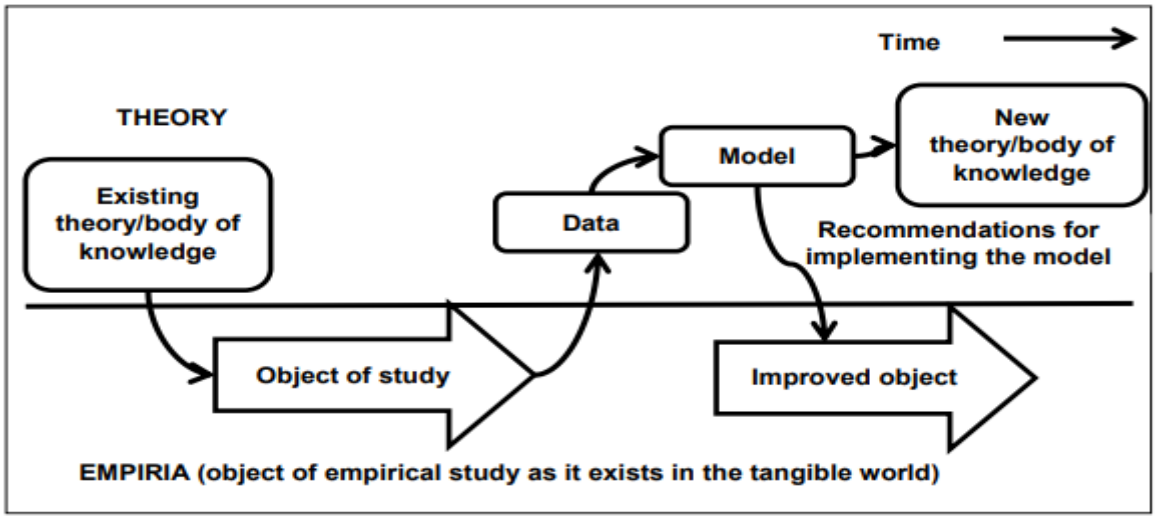


Figure 1 Normative study design (http://www2.uiah.fi/projekti/metodi/178.htm)

Kumar(2019-14) said that a normative study usually includes planning an approach for carrying out the necessary improvements depending on whether the project continues as practical development or not.

**Existing theory/body of knowledge (Theory)**

Traditional engineering

According to Johnson, Ulseth, Smith and Fox ( 2015-18), engineers perceive themselves as the crossing point between science, technology and business permitting industry to create wealth from scientific and technological developments. Rogers and Duffy (2012-41) understood that environmental considerations have been peripheral and secondary at best and the community becomes more and more demanding forcing engineering systems to comply with all environmental requirements by incorporating them into engineering design in the same integral way that economic considerations are included. Bruegge, Krusche and Alperowitz (2015-67) alleged that, to improve efficiency, engineers continually refine their designs to minimize the use of materials, energy and labor. They also refine their designs to fit into the environment harmoniously and with minimum disruption or degradation of natural ecosystems. According to Špundak (2014-932), engineers apply safety factors in their design to compensate for uncertainties approximately the strength of their structures to compensate for uncertainties about the environmental consequences of their projects. Groves, Jacobsen, Dutta, Trewin and Microsoft Corp ( 2014-7) whispered that such changes imply the need for a new engineering philosophy and ethic and therefore changes to engineering education.

Johnson, Ulseth, Smith and Fox ( 2015-4) assumed that, the engineering design methods change with the changing requirements of the system under consideration. Martínez-Caro and Campuzano-Bolarín (2011-478) supposed that the traditional evolution is no longer fast enough to keep up with the constant demand for new products in rapidly expanding economies. The design process was moved from the manufacturing site to the drawing board where scale drawings were made. Hybertson ( 2016-38) specified that the designer had to achieve in a few hours at the drawing board what once took centuries of adaptation using the scale drawing became the medium for experiment and change.

According to Batool, Motla, Hamid, Asghar, Riaz, Mukhtar and Ahmed (2013-1012), engineering design is built upon a massive engineering science base which includes a comprehensive and detailed analysis of materials and their behavior under a variety of stresses and strains. Kumar and Bhatia (2014-193) showed that engineering design must be built on ecological science and the interrelationships between their products and various ecosystems.

Silva, Fontul and Henriques (2015-10) indicated that traditional engineering projects are planned upfront with a little room of changing requirements. Munassar and Govardhan (2011-14) held that this approach assumes that cost and time are variables and requirements are fixed. Raudberget ( 2011-21) signposted that the rigidity of this method is the reason why it is not

meant for large projects and leaves no scope for changing the requirements once the project development starts.

Traditional project management

Špundak (2014-941) alleged that normative research aims at improvements, which means that it includes evaluation of the present state of things and also of the direction of future development. By definition, evaluation is only possible from somebody's point of view.

According to Salameh (2014-54), traditional methodologies take a step-by-step approach to the project execution were the project goes through the initiation, planning, execution, monitoring straight to its closure in consecutive stages. Hebert and Deckro (2011-27) believed that this approach includes several internal phases that are sequential and executed in a chronological order. Spalek (2016-9) point out that this method is mostly applied where little or no changes are required at every stage of the project, common to the construction and manufacturing industry.

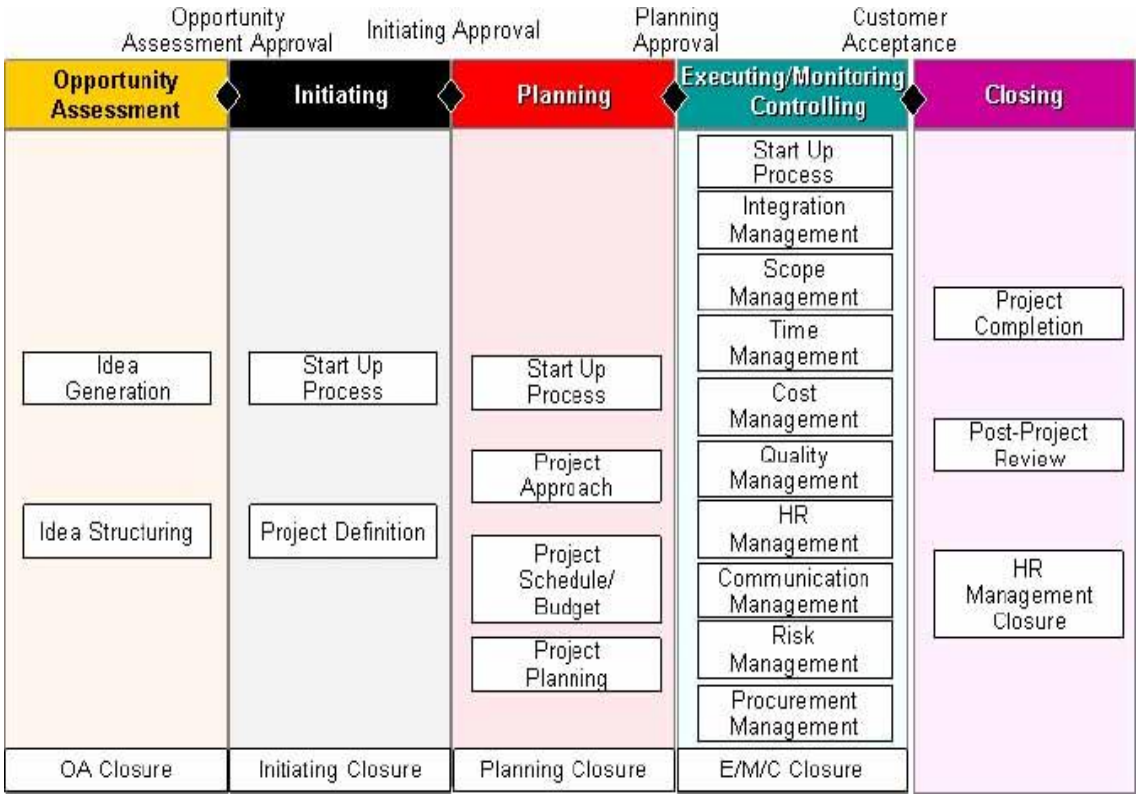


Figure 2 High-Level Overview of Traditional project Methodology (Tarne, 2007-4).

Kaczorowska (2015-1524) whispered that traditional project management views development as a linear sequence of the systems engineering and quality disciplines consist of well-defined activities such as requirements, design, implementation and commissioning. Landry and McDaniel (2016-26) specified that the project management body of knowledge (PmBOK) is the most used guideline in the traditional project management environment. Betta. and Iwko (2019-

24) supposed that the items that are part of the methodology include procedures, guidelines, templates, checklist, definition of roles and responsibilities.

Agile project management

Conforto, Salum, Amaral, Da Silva, and De Almeida (2014-30) understood that agile methodologies take an iterative approach which consists of several smaller cycles – sprint which has a backlog and consists of design, implementation, testing and deployment stages within the pre-defined scope of work. Layton and Ostermiller (2017-145) believed that a potentially shippable product increment is delivered at the end of each Sprint with the features being validated early in the development reducing the chances of delivering a potentially wrong product are significantly lower. The figure below indicates the agile development cycle.

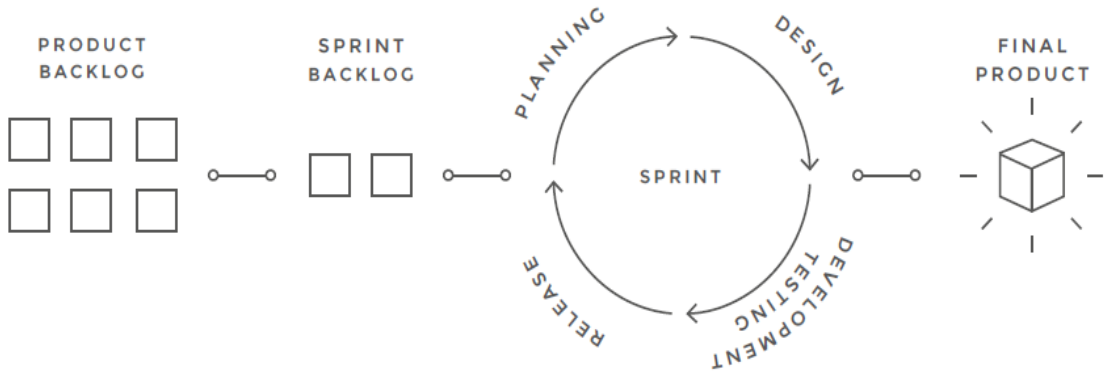


Figure 3 agile development cycle (Cobb, 2011-234)

According to Cobb (2011-234), agile project management gives importance to customer collaboration, teamwork, and flexibility. Conforto and Amaral ( 2016-10) directed that the methodology follows an iterative approach that focuses more on incorporating customer feedback and continuous releases with every iteration of a development project. Serrador and Pinto ( 2015-1048) purported that agile methodology has the following principles:

- The process the project team will follow is not important but the selection of the project team is. This is due to a belief that the process itself will evolve.
- There are fewer efforts put for documentation because the project teams focus on the features the user can see.
- Using agile methodology, the customer is very involved with the project to ensure that the product meets all design, functional and operational requirements.
- There are two many unknowns during project initiation or early stages of the project which makes it impossible to develop an effective plan.

According to Dybå, Dingsøyr and Moe (2014-288), agile development cycle covers a vast variety of frameworks and techniques, sharing the following values:

- Flexibility – As new requirement are continuously accommodated to improve the overall output, the scope of work continuously change.
- Work breakdown – The project deliverables consist of a small cycle that performs a function that can be tested independently.
- Value of teamwork – Close corporation within teams is required to drive innovation
- Iterative improvements – Continuous interaction with all stakeholders to improve the overall products.
- Cooperation with a client

According to Crowder and Friess (2015-28), it is obvious that agile methodology is not as detailed as the traditional methodology because it supports the idea of individuals and interaction over processes and tools.

**Data collection and analysis**

In a normative research study, the present state of things and the direction of future development are evaluated to improve. The reach finalize by creating a state of things which people continue to accept in the future as well. It is also possible that this improvement need not be achieved right away but at a certain moment in the future.

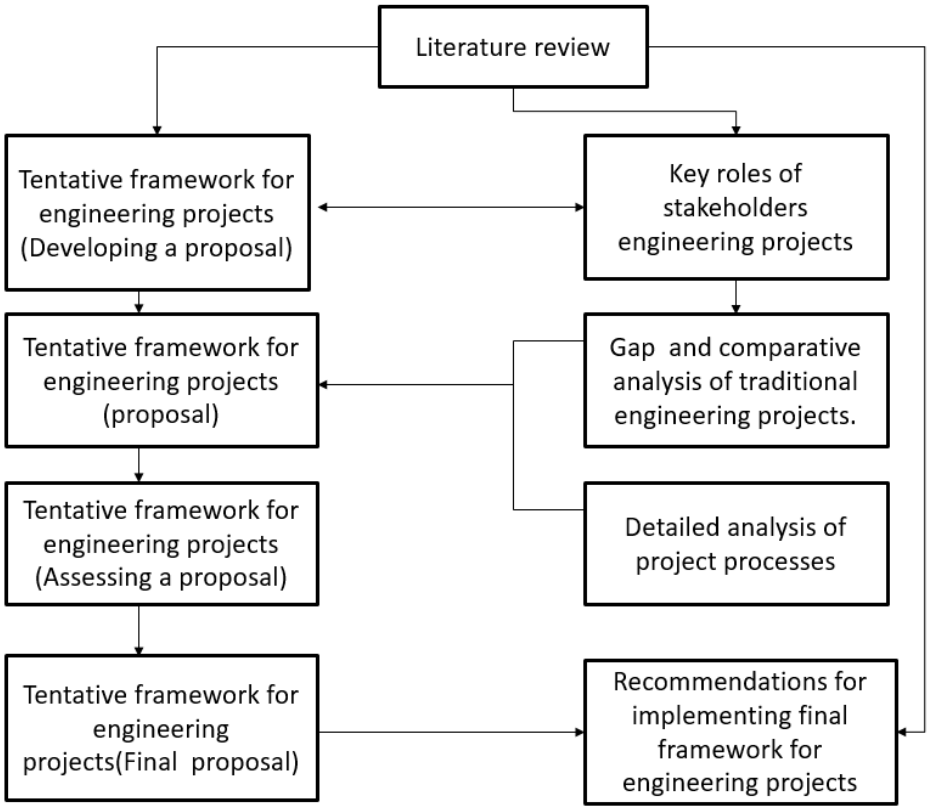


Figure 4 Process followed to develop, recommend for implementation of project framework for engineering project

**Tentative framework for engineering projects (Proposal)**

A tentative project management framework for engineering projects was developed by analyzing and integrating agile project management processes and system engineering processes and their practices, tools and techniques. The tentative project management framework for engineering project was used as a reference document to collect, analyze and record the data to develop a final project management framework for engineering project (Assessing and developing a final proposal).

Model-based systems engineering presents a vision of systems engineering where precise specification of requirements, structure, and behavior meet larger concerns such as safety, security, reliability, and performance in an agile engineering context. This model-based systems define the properties of entire systems while avoiding errors that can occur when using traditional textual specifications.

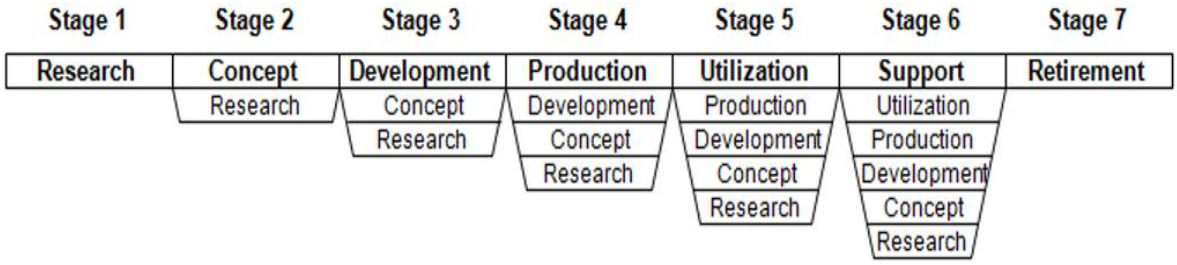


Figure 5 Framework for an agile system engineering life cycle model

**Agiles systems methods**

This model helps engineers to understand that the necessary and sufficient conditions for agility, different approaches to it, and underlying relationships, performance couplings, and principles. Engineering systems are under pressure to adapt to a changing environment that increases competition, expose the organization to both physical and cyberattack. The ability to adapt well enough as conditions change, especially in the presence of uncertainty, is valued. Systems (including developmental and life cycle management) that adapt well enough, in time, cost, and effectiveness. As environmental change or uncertainty increases, agility can mean survival.

**Results**

Systems engineering ensures the effective development and delivery of capabilities by using a set of integrated, disciplined, and consistent analytic and technical management processes throughout the program lifecycle. While systems engineering touches many of the other processes across this acquisition lifecycle. The implementation framework for agile practices in engineering project can be shown as in the figure below:

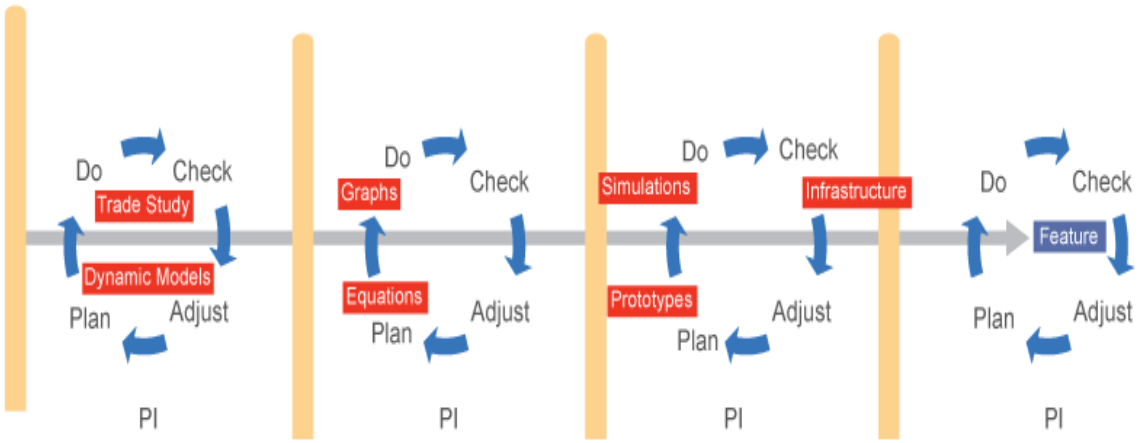


Figure 6 Models and learning cycles (https://www.scaledagileframework.com/model-based-systems-engineering)

## Proposed agile system life cycle model

Agile model-based systems engineering (MBSE) is the practice of developing a set of related system models that help define, design, analyze, and document the system under development. These models provide an efficient way to virtually prototype, explore, and communicate system aspects, while significantly reducing or eliminating dependence on traditional documents. The diagram below indicates the agile system life cycle model.

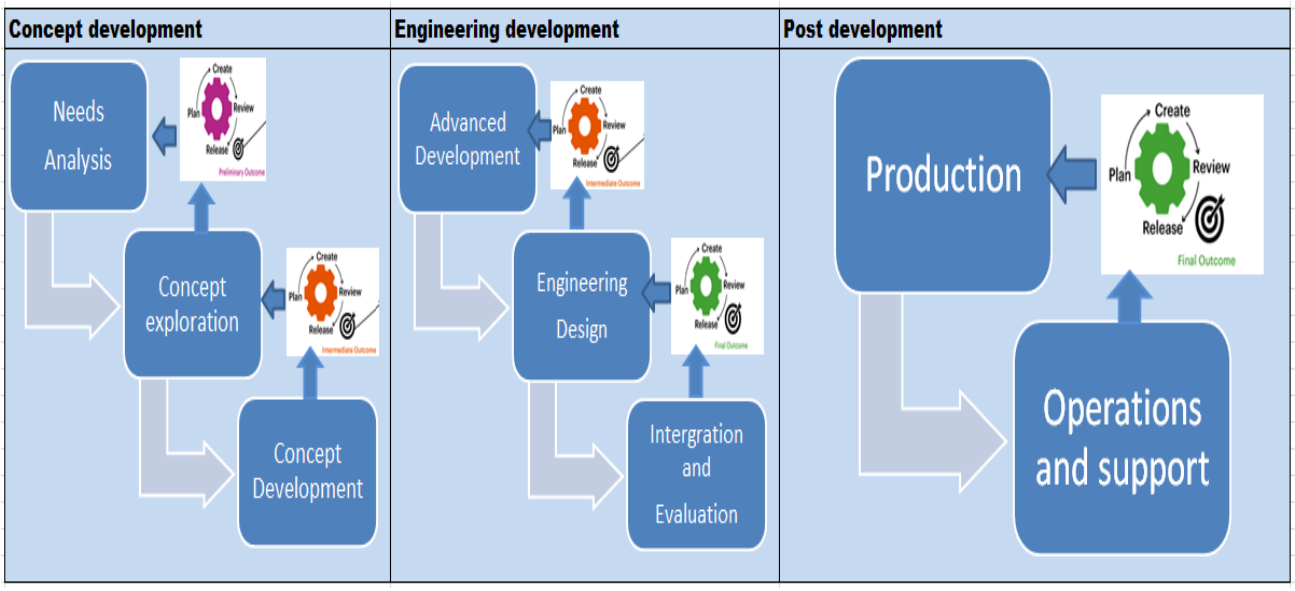


Figure 7 Proposed agile system life cycle model

**Agile implemention framework for engineering projects**

An effective agile systems engineering process must converge on sufficient completion of each of the primary stages to warrant the transition to the next primary stage, presumably on schedule and budget regardless of how flexible or rigid these might be. The figure below show a Proposed engineering project implementation framework.

Table 1 Proposed engineering project implementation framework

| **Stages** | **Concept analyses** | **Engineering development** | **Post development** |
|---|---|---|---|
| | | | |
| **1** | **Needs analysis** | **Advanced development** | **Integration and evaluation** |
| Plan | Technical innovation and deficiency management plan | Defined concept and functional specification detailed | Develop integrations and evaluation plan |
| Develop | operational analysis and technology assessment | Subsystem definition and component specifications | **Integration MAP** |
| Review | System studies | Risk management | Production specifications |
| **Release** | System effectiveness capabilities | Validated developed model and design specifications | Production system |
| **2** | **Concept exploration** | **Engineering development** | **Production and deployment** |
| Plan | Effectiveness and capabilities | Component testing | System delivery |
| Develop | Requirement development and analysis | Component engineering | Tooling and tests equipment |
| Review | Feasibility experiments | Specialty engineering | Production and acceptance |
| Release | Candidate concept, performance requirements | Engineered components | installed operational system |
| **3** | **Concept development** | **Integration and evaluation** | **Operations and support** |
| Plan | Concept and performance requirement plan | Test and evaluation plan | system operational plan |
| Develop | Functional and physical architect | System integrations | Performance analysis framework |
| Review | Alternatives analysis | operational evaluation and system tests | installed operational system |
| Release | Functional specification and defined system concept | Production specifications | operations and maintenance documents |

**Findings**

The proposed agile systems life cycle model has been developed in this study to provide complex engineering project governance using the agile method. The implementation framework details how agile sprints will be effected in different phases of the system life cycle. The research findings for each research hypothesis as outlined in the research hypothesis, are analyzed in the following paragraph.

**Hypothesis 1**

$H_0$ : Applying agile practices in traditional engineering project will not improve project and product benefit management.

$H_1$ : Applying agile practices in traditional engineering project will improve project and product benefit management.

The results indicate that new non-traditional activities in the engineering fields hypothetically have a positive impact on conventional systems engineering models in terms of stimulating invention. Agile software engineering, agile project management, agile software systems are rising rapidly and are gaining popularity in design thinking and has developed new successful application, redefining basic engineering principles. The results also indicate that agile system engineering will help deliver benefits on an ongoing basis during the project by classifying and concentrating on slight incremental operational versions of the agreed expected result. It is also evident that agile system engineering methods will help to decompose the system engineering strategy into prioritized engineering expected benefits and pace their project delivery in an agreed manner. Agile methods aim to deliver benefits in a controlled stream. This approach goes a long way in reviewing the engineering benefits management process in every sprint which will increase the overall project benefits. During sprint meetings, updates are done and the benefits management reviews are approved.

**From the above results $H_1$ : Is accepted - 1. Applying agile practices in traditional engineering projects will improve project and product benefit management.**

**Hypothesis 2**

$H_0$ : Project agile method application in traditional engineering projects will not improve project flexibility and decision marking while ensuring that the customer is fully satisfied with the deliverables (Products).

$H_1$ : Project agile method application in traditional engineering projects will improve project flexibility and decision marking while ensuring that the customer is fully satisfied with the deliverables (Products).

The advantage of using agile methods in system engineering is that it follows a non-sequential approach during execution and delivers systems deliverables from one phase to another rather than delivering the final product at the end of a project. This means that part of a project can be open for use while others are under contraction ensuring that defects are identified and addressed on time. The proposed system implementation framework indicates that flexibility is the basis of agile development methodology. For an organization to adapt to changes and still have the ability to deliver a successful product, it is important to identify where flexibility lies on the system and account for it in different life cycle stages of the system ensuring that it is built into the agile

development process which will improve the organization able to adapt to changes while delivering a successful product.

In traditional system engineering methods such as the V-model or waterfall model, the lack of flexibility in various phases of the system life cycle lead to increased investment and extended delivery dates while such changes are welcomed while using agile methods. This is because, using agile methods ensure that the systems development backlog is prioritized as per the needs of the owners. The results also indicate that using agile methods, decision-making is transparent, collaborative and iterative which means that stakeholders are updated on assigned tasks at regular intervals, they give feedback, and the team knows what needs to be changed or improved. This ensures that all project stakeholders are well aware of the latest development on a project and changes are made earlier using very limited resources as compared to traditional methods where extensive resources and approvals are required before changes can be made.

**From the above results $H_1$ : Is accepted - Project agile method application in traditional engineering projects will improve project flexibility and decision marking while ensuring that the customer is fully satisfied with the deliverables (Products).**

**Conclusion**

Engineering system value management is the balance between the satisfaction of the needs and the resources used to achieve this satisfaction, the greater the satisfaction and the lower the resources used to satisfy them, the higher the value. Systems values are often assessed based on their robustness, adaptability, and agility. A robust system should not produce radical departures from its expected behavior in response to small changes to its operating input, internal state, or external environment, but an adaptive system changes in the face of perturbations to maintain some kind of invariant state by altering its properties or modifying its environment.

An agile system shall have the property of being able to change, or to be changed, rapidly and cost-effectively. Systems engineering practices must be vigorous and adapted within any organization, and attention to integrating new methods will keep systems engineering relevant in today's challenging environment of rapidly evolving technologies and extreme competition. As opposed to conflicting with traditional approaches of systems engineering, these newer techniques can be adapted and amalgamated in a more agile systems engineering process.

**Biography**

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