\

Systems Engineering Management Plan (SEMP)

Team Members:

Ayyappan Pillai, Vishal

Kreitzer, Jacob

Lnu, Godwin Mathew Abraham

Metta, Akhil

Instructor:

Dr. Henry Lester

ENM 505 SP23

Table of contents

1.0 Introduction

This document will outline the overall Systems Engineering Management Plan (SEMP) for the project. Topics to be included in this document are the general technical requirements, featuring the system architectures and technical controls, as well as the engineering and resource management activities included in the system. This document will also feature the schedule, outline the organizational structure of roleplayers, and highlight the technical performance measures that will be used to measure the system's progress. The SEMP will close with some of the technical activities that will be performed in the project, including the change process, gate review process, and enabling elements of the system. This SEMP is subject to change throughout the project as the different technical processes described here are performed and observed for their effect on the system.

2.0 Program Technical Requirements

The section below will briefly highlight the technical requirements that will be necessary for the system. The systems architecture and boundaries will be discussed, as well as the different interfaces that will occur between the system and different stakeholders.

2.1 Architecture and Interface control

There are several varying types of architecture that will be employed in this system. The aim of this section is to list all functional, physical, and enterprise architectures. This section will also describe how users and stakeholders will interface with the system throughout its lifecycle. The first and most important of all architectures will be the physical architectures used to manufacture, distribute, and upkeep of the system. These architectures will be the facilities in which most system technical activities will occur, as well as the many stages of the system life cycle. The necessary physical architecture for this project includes a manufacturing facility for R&D, testing, and production to occur within. Stakeholders outside of this realm of the project, such as aftermarket support (mechanics), will require the necessary information infrastructure to communicate with system development and design to support the system long term. The manufacturing facility should be in a favorable location to support end users within the United States and should have ample room to produce enough in order to meet the demand. Other types of architecture that will be used to support the physical architecture will be an Enterprise Resource Planning system (ERP), which will assist in the planning of manufacturing as well as quality control. This can also be used as a port for enterprising processes that will occur between vendors who wish to purchase and use the system products. The ERP system will also be a critical interface for the system, as it will allow project managers (PMs) and different operational personnel to interface with the system and directly manage schedules and system processes. These architectures will support the system's mission throughout its lifecycle and will be pivotal to all stakeholders involved.

2.2 Technical Certifications

There will be several technical certifications for which the system will need to be engineered. The overarching standard that the system will adhere to in its development is ISO 15288; this will be the base framework for all decisions and requirements in the system. To ensure that proper quality management is built into the system, the project will adhere to ISO 9001 for quality management. Following this standard will create quality at the source of all decisions in the system and is a standard way of integrating quality management. Additionally, human resources will ensure that all systems engineers used in this project will be qualified to the INCOSE Certified Systems Engineer Professional (CSEP) level. Adhering to standards and the guidelines that they present will help the system develop better over its lifecycle and ultimately lead to a better quality product.

3.0 Engineering & Resource Management

Engineering and resource management are vital aspects of the Systems Engineering Management Plan (SEMP), which involves the allocation and management of various resources, such as financial, technical, and human resources, necessary for the engineering activities of a system. It is crucial to manage these resources effectively to ensure the project's successful completion. Blanchard and Fabrycky (2011) state that engineering and resource management are essential components of the SEMP, which outlines the management approach for a system engineering project, including the system engineering process, project team roles and responsibilities, resource allocation, and risk management.

To ensure effective engineering and resource management, a structured approach is necessary that considers the project's interdependencies and constraints, such as defining the project scope, identifying required resources, and developing a plan to allocate and manage these resources throughout the project lifecycle (Buede, 2016). In essence, the SEMP's engineering and resource management component is critical to successfully completing a system engineering project.

In the 1990s, Harley-Davidson's management made a strategic decision that had a significant impact on the company's growth. They recognized that their brand name, rather than their motorcycles, was their most valuable asset. Consequently, the company shifted its focus from manufacturing to marketing and invested in initiatives aimed at building and strengthening their brand (Bartlett & Nanda, 1996).

3.1 Technical Schedule and Schedule Risk Assessment

Blanchard and Fabrycky (2011) explain that the technical schedule is an elaborate schedule that delineates the technical tasks required for the system engineering project. The schedule contains task descriptions, durations, dependencies, and resources needed to complete each task. The technical schedule is vital in managing the project timeline and ensuring that technical activities are completed in the correct order.

Conversely, Schedule Risk Assessment is a process that evaluates the potential risks that may affect the project schedule. The procedure entails identifying potential risks, assessing their probability and impact, and creating strategies to manage or mitigate the risks (Hillson & Murray-Webster, 2012). The Schedule Risk Assessment is crucial in managing project risks and ensuring that the project stays on track.

When used together, the Technical Schedule and Schedule Risk Assessment form a unified approach to managing the project schedule. Project managers can effectively manage the project timeline, identify potential schedule risks, and develop strategies to mitigate those risks by creating a detailed Technical Schedule and conducting a Schedule Risk Assessment.

In 1983, Harley-Davidson initiated a significant overhaul of its engine and transmission systems, known as the Evolution Project. The project's Technical Schedule comprised comprehensive particulars regarding the order, timing, and length of the design, development, and testing phases. The schedule also identified crucial paths and dependencies, such as the requisite for novel manufacturing equipment and materials. The Technical Schedule played a pivotal role in guaranteeing that the Evolution Project was successfully accomplished within the prescribed timeframe and budgetary constraints (Girdler, 1994).

3.2 Engineering and Integration Risk Management

SEBoK clarifies that Engineering Risk Management is a process that involves identifying, assessing, and managing risks associated with the engineering aspects of the system, encompassing design, development, and testing (INCOSE, 2020). This process aims to ensure that the system satisfies its performance and functionality requirements while effectively managing technical feasibility, reliability, and maintainability risks.

On the other hand, Integration Risk Management is the process of identifying, assessing, and managing risks linked to the integration of the system's components and subsystems (INCOSE, 2020). Integration risks may arise from component incompatibilities, incorrect interfaces, or insufficient communication protocols. By managing integration risks, project managers can ensure the efficient integration and operation of the system's components.

Taken together, Engineering and Integration Risk Management processes ensure the effective design, development, and integration of the system, as well as the identification and management of potential risks throughout the project lifecycle.

During the late 1970s, Harley-Davidson's competitors adopted cutting-edge technologies, including liquid cooling, to manufacture more robust motorcycles, which compelled Harley-Davidson to modernize its engines for sustained competitiveness. However, the task posed considerable engineering risks, which the company aimed to mitigate by devising a comprehensive plan that encompassed rigorous testing and validation. The culmination of this initiative was the Evolution engine, which the company launched in 1984 and marked a remarkable improvement over its predecessor (Girdler, 1994).

3.3 Technical Organization: Roles and Responsibilities

The Technical Organization is a critical component of the Systems Engineering Management Plan (SEMP), responsible for executing the technical activities associated with the system engineering process. According to the Guide to the Systems Engineering Body of Knowledge (SEBoK), the Technical Organization comprises multiple roles, each with distinct responsibilities (INCOSE, 2020).

Key roles and responsibilities of the Technical Organization in the SEMP include:

- System Engineer: accountable for ensuring that the technical aspects of the system are appropriately designed, developed, and integrated, and that the system meets the specified requirements.
- Specialty Engineers: responsible for providing expertise in specific technical areas, such as electrical engineering, software engineering, or mechanical engineering.
- Technical Project Manager: responsible for managing the technical aspects of the project, including budget, schedule, and resources.
- Technical Team: responsible for executing the technical activities associated with the system engineering process, including design, development, testing, and integration.
- The Technical Organization is also accountable for coordinating with other organizations and stakeholders, such as the Project Management Office, the Customer, and the System Users.

The Harley Davidson Company provides a range of technical roles, one of which is the Manufacturing Engineer. The Manufacturing Engineer is a technical organization role tasked with designing and implementing manufacturing processes that guarantee consistent quality and efficiency. For instance, Harley-Davidson Motors hired Jim Fisher as a Manufacturing Engineer in the early 2000s, and he played a pivotal role in enhancing the company's manufacturing processes and reducing costs (Greeley, 2015).

3.4 Relationship with External Technical Organizations

According to the International Council on Systems Engineering (INCOSE), the relationship with external technical organizations is an essential aspect of systems engineering. This relationship involves collaborating with other organizations, such as suppliers, customers, and regulatory bodies, to ensure the project's success. The INCOSE states that this collaboration can help to align the project with industry standards and best practices, as well as provide access to specialized technical expertise that may be needed to complete the project.

External technical organizations can provide valuable support and guidance throughout the project lifecycle. For example, suppliers can offer insight into the availability and capabilities of new technologies, while customers can provide feedback on project requirements and expectations. Regulatory bodies can provide guidance on compliance with industry regulations and standards.

To establish a relationship with external technical organizations, INCOSE recommends that project managers identify potential collaborators early in the project planning phase. This allows for the development of a comprehensive strategy for collaboration, including the identification of key stakeholders and the establishment of communication channels.

In conclusion, the relationship with external technical organizations is a crucial aspect of systems engineering and can help ensure the success of complex engineering projects. By collaborating with other organizations, project managers can access specialized technical expertise, align the project with industry standards, and gain valuable feedback from key stakeholders.

3.5 Technical Performance Measures (TPMs) and Metrics

Technical Performance Measures (TPMs) and Metrics are essential components of the Systems Engineering (SE) process, as they provide quantitative and qualitative information on the technical performance of a system or product. INCOSE (2015) defines TPMs as “metrics used to assess progress in meeting technical requirements, accomplished through objective measures of the system’s characteristics or capabilities”. TPMs enable the evaluation of technical progress and identify potential risks that may impact the system’s performance. Metrics, on the other hand, are “specific measures of a system's or product's characteristics that may be used to determine how well the system or product is satisfying its requirements” (INCOSE, 2015).

The use of TPMs and Metrics throughout the SE process helps to ensure that technical requirements are being met and that the product or system is performing as intended. TPMs and Metrics can be applied to various stages of the SE process, including design, development, testing, and implementation. By establishing clear and measurable TPMs and Metrics at each stage, SE teams can ensure that they are on track to achieve the system’s technical objectives.

Furthermore, TPMs and Metrics can be used to facilitate communication and collaboration between different stakeholders involved in the SE process. By providing a common language for technical performance evaluation, TPMs and Metrics enable stakeholders to make informed decisions based on objective data.

In summary, Technical Performance Measures (TPMs) and Metrics are crucial tools for evaluating the technical performance of a system or product throughout the SE process. By providing objective and measurable information, TPMs and Metrics ensure that technical requirements are met, risks are identified, and stakeholders are able to make informed decisions.

4.0 Technical Activities and Products

According to INCOSE (2015), Technical Activities and Products refer to the work performed during the development of a complex engineering project. These activities and products encompass all of the technical work, from requirements definition to verification and validation. They include the development of system architectures, designs, requirements, and testing plans. Technical products can also include documentation, such as technical manuals, user guides, and other related materials.

The development of technical activities and products is a critical aspect of systems engineering. They provide a structured approach to managing the technical work required to complete a project. Technical products serve as a means of communicating information between the various stakeholders involved in a project. These stakeholders can include customers, suppliers, developers, and other stakeholders.

The development of technical activities and products should follow a structured and disciplined process to ensure that they meet the project's requirements and quality standards. This process includes the use of techniques such as modeling, simulation, and prototyping to help validate the technical work. The process should also include the use of Technical Performance Measures (TPMs) and metrics to assess the technical work's progress and ensure that it meets the project's objectives.

In conclusion, Technical Activities and Products are the core of systems engineering, and they are essential for the successful completion of complex engineering projects. By following a structured and disciplined process, technical activities and products can help ensure that the project meets its objectives, quality standards, and customer requirements.

4.1 Results of Previous Technical Process Activities

The results of the technical process activities show both the requirements for the specified frame and how those requirements were changed to create an effective frame. The results of using the necessary product provide the necessary services. The outcomes encourage the continuation of those services even after the frame is no longer required or in use. (Bahill & Gissing, 1998)

Understanding the developments in systems engineering (SE) and having the flexibility to respond to new opportunities and challenges are essential for the creation of inclusive, efficient, and sustainable SE practices. SE practitioners can adapt their practices and procedures to meet new challenges and take advantage of new opportunities thanks to ongoing research and collaboration between researchers, practitioners, and educators. According to a study, from 2000 to 2015, the emphasis placed on software, economics, management, and systems theory in SE journal papers changed. A different study looked at ten trends in SE processes to see how they affected software. While different analytical techniques were used and the topics of analysis did not entirely overlap, a bibliographic analysis was also conducted to support the findings of the literature review. (Bhatia & Mesmer, 2019)

Leading motorcycle manufacturer Harley-Davidson is updating its name and line of goods to reflect shifting market trends and consumer preferences. To appeal to younger generations who are more environmentally conscious, the company has invested in electric motorcycles and released its first electric motorcycle, LiveWire. Additionally, it is investigating fresh business strategies and alliances, like working with ride-sharing companies and researching different forms of transportation like e-bikes and scooters. Harley-Davidson demonstrates its dedication to innovation and sustainability by foreseeing market trends and adapting to them, and by doing so, it positions itself to lead innovation in the transportation industry. (CNBC, 2021)

4.2 Planned SE activities for the Technical Process Activities

Developing complex products that meet user needs, advance society, and protect the environment can be challenging for engineers. It is critical to integrate and apply technological activities iteratively throughout the system life cycle, including synthesis, analysis, and evaluation, in order to close the knowledge and cost gaps during the initial design phases. (Ruiz-Minguela et al., 2020)

Design traceability is also crucial to preventing knowledge and investment loss across projects and project life cycle phase boundaries. To measure system performance and aid in decision-making, key metrics must be established in addition to a thorough list of requirements and evaluation standards. Decision-making methods based on matrices are frequently used by engineers. Synthesis, analysis, and evaluation should be integrated throughout the life cycle of the system to prevent knowledge and investment loss. (Ruiz-Minguela et al., 2020)

Stakeholder analysis, prioritization, and performance metrics are areas where SE can help support the development of cutting-edge technologies. More research is needed to determine the relative significance of functional requirements and their interactions. (Ruiz-Minguela et al., 2020)

Where Harley Davidson is concerned, the company wants to speed up and optimize its product development process by using a modular approach to product design, which will allow for more flexible and agile development. They also intend to increase their use of advanced manufacturing techniques and invest in digital technologies to streamline their production processes. To increase productivity and reduce costs, they are also prioritizing supply chain improvements. (Harley-Davidson, n.d.)

4.3 Requirements Developments and Change Process

Efficient management of engineering change requirements is crucial for successful product development in various industries, including manufacturing. Harley-Davidson, for instance, recognized the need for change to remain competitive and satisfy the evolving needs of its customers. Successful management of ECRs helps companies shorten product redesign time, reduce costs, and add value to their products. However, managing ECRs can be a challenging task since they can occur at any stage of the product development cycle. Managing ECRs in batches with appropriate sequencing results in better outcomes compared to handling them individually. The order in which ECRs are executed significantly impacts the lead time of the product development process. (Ullah et al., 2017)

To maintain its position in the market and adapt to changing customer demands, Harley Davidson underwent a significant change process. The business acknowledged the need for change and started a comprehensive program to boost operational effectiveness, raise product quality, and improve customer service. The management of requirement changes and the execution of the change process were crucial to the organizational transformation's success. It stresses the significance of using a methodical and structured process to include all pertinent parties and effectively explain the change to all staff members. Organizations that use effective change management can adapt to shifting environments and keep a competitive edge. (UKEssays, 2018)

4.4 Gate/Technical Reviews

Gate/Technical Reviews are an important aspect of the Systems Engineering Management Plan (SEMP). It is a formal document that sets forth the management methodology for a complex engineering project. The goal of these reviews is to check that the project is moving forward as planned, identify any difficulties or issues that must be promptly addressed, and guarantee that it is on track to fulfill its objectives.

There are various stages of Gate/Technical Reviews, such as:

- Objective Assessment: Gate/technical evaluations provide an unbiased assessment of technology activity and products in development.
- Goals and criteria: To assess the technical activity or product, each gate/technical review should have certain objectives and criteria.
- Documentation Review: Prior to the gate/technical review, all relevant documents should be examined.
- Peer review: A team of subject-matter experts (SMEs) who aren't intimately implicated in the result of activities or product should perform the gate/technical review.
- Resolution of problems: The gate/technical review shall highlight any concerns or problems and make recommendations for their resolution.
- Verification and validation: During the gate/technical review, ensure that the technical operation or product satisfies the set standards and functions as intended.
- Formal procedure: Gate/technical reviews should follow a defined and repeatable formal methodology. This promotes consistency and serves as a foundation for ongoing progress.
- Risk management: Refers to the method of identifying and managing project hazards. Stakeholder Involvement: Stakeholders can engage in the development phase through gate/technical evaluations.

4.5 Design Consideration & Constraints

Design considerations and constraints are an essential component of Harley-Davidson's Systems Engineering Management Plan (SEMP). They provide a framework for establishing design criteria and restrictions to guarantee that the finished product meets client expectations and operates as intended. The following are the primary design concerns and restrictions for Harley-Davidson's SEMP:

- Customer requirements: The needs and requirements should be reflected in the design considerations and constraints.
- Regulatory requirements: Design considerations and restrictions must be in accordance with applicable laws, rules, and standards.
- Technical requirements: Technical requirements such as productivity, dependability, maintainability, and safety should be reflected in design considerations and constraints.
- Design considerations and constraints: Design considerations and constraints should examine any restrictions or constraints such as cost, schedule, resources, and technology.
- Trade-offs in design: Any trade-offs between opposing needs or requirements should be identified by the design considerations and constraints.
- Design verification and validation: Verification and validation activities should be included in design considerations and constraints to guarantee that the final product fulfills the established criteria and functions as intended.
- Documentation: To guarantee consistency and traceability, the design considerations and limitations should be documented and kept up to date throughout the project.

Overall, customer demands, regulatory compliance, technical requirements, design restrictions and trade-offs, and documentation are among the design considerations and constraints in the Systems Engineering Management Plan (SEMP). These factors contribute to the end product meeting customer expectations, being safe and reliable, complying with appropriate laws and regulations, and being built within the project limits.

4.6 Enabling Elements/Infrastructure

Harley-Davidson is a well-known motorcycle company that has a solid Systems Engineering Management Plan (SEMP) in place to handle its complicated engineering projects. One of the important components of the SEMP that contributes to the project's success is the Enabling Elements/Infrastructure. The following are some major topics about Enabling Elements/Infrastructure in Harley-Davidson's SEMP:

- Infrastructure for communication: Harley-Davidson is aware of the value of excellent communication in keeping all stakeholders up to date on the progress and problems of the project. In order to do this, the business set up a communication infrastructure that consists of frequent project status meetings, strategy development, and a project website.
- Information management: Effective information management is essential for any engineering projects, and Harley-Davidson has put protocols and procedures in place to guarantee this.
- Tools and resources: One of Harley Davidson's SEMP's Elements/Infrastructure is the employment of suitable tools and resources to assist the engineering project.
- Risk management: It understands the value of risk management and has put in place methods to detect, analyze, and minimize risk all throughout the life cycle of the project.

- Training and development: Harley-Davidson have created development and training initiatives to guarantee that all stakeholders have all the essential skills and expertise to participate effectively in the project.

In summary, Harley-Davidson’s SEMP Enabling Elements/Infrastructure component contains a variety of procedures, tools, and resources that enable successful interaction, information management, risk management, and training and development.

5.0 Acronyms

- ERP: Enterprise Resource Planning system
- PM: Project Managers
- CSEP: Certified Systems Engineer Professional
- SEMP: Systems Engineering Management Plan
- SE: Systems Engineering
- INCOSE: International Council on Systems Engineering
- TPMs: Technical Performance Measures
- SMEs: Subject Matter Experts
- ERP: Enterprise Resource Planning system
- ECR: Engineering change request (ECR)

Work Cited

Dodaf architecting overview. AcqNotes. (2021, July 13). Retrieved March 5, 2023, from https://acqnotes.com/acqnote/tasks/architecting-overview

Se standards. INCOSE. (n.d.). Retrieved March 5, 2023, from https://www.incose.org/about-systems-engineering/se-standards

The DoDAF Architecture Framework Version 2.02. DODAF: DOD architecture framework version 2.02; DOD deputy chief information officer. (n.d.). Retrieved March 5, 2023, from https://dodcio.defense.gov/Library/DoD-Architecture-Framework/

Bartlett, C. A., & Nanda, A. (1996). Harley-Davidson, Inc. Harvard Business School Case, (9-496-015)

Blanchard, B. S., & Fabrycky, W. J. (2011). Systems engineering and analysis. Pearson Education.

Buede, D. M. (2016). The engineering design of systems: Models and methods John Wiley & Sons

Girdler, A. (1994). Harley-Davidson: The American motorcycle Motorbooks International

Greeley, B. (2015) Lean manufacturing and the Harley-Davidson turnaround American Journal of Industrial and Business Management, 5(7), 400–406.

Harley-Davidson (2020). Harley-Davidson, Inc. 2020 Annual Report Retrieved March 4, 2023, from https://investor.harley-davidson.com/static-files/c4a3d3dc-34f9-4f94-b8ee-3d3a633b6d2e

Hillson, D., & Murray-Webster, R. (2012). Understanding and managing risk attitude. Routledge.

International Council on Systems Engineering (INCOSE) (2020). Systems Engineering Body of Knowledge (SEBoK), Version 2.4. Retrieved from https://www.sebokwiki.org/wiki/Engineering_Risk_Management.