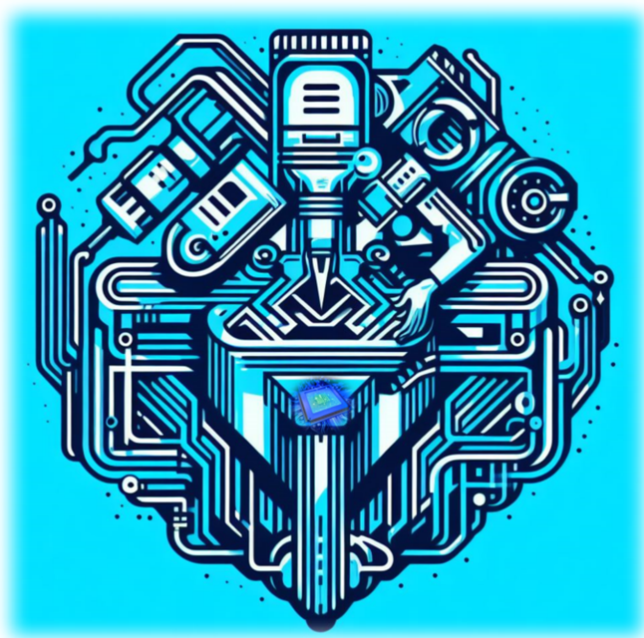
System Engineering Plan (SEP)

Additive Manufacturing Technology Systems in HP Super Semiconductor Manufacturing



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Academic Assignment for ESI 5510 Fundamentals of Systems Engineering

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1.0 Overview

System overview: Additive Manufacturing Technology systems in Semiconductor manufacturing

Introduction:

Additive manufacturing (AM), commonly known as 3D printing, is making significant advances in the semiconductor manufacturing industry. This systems overview explores how additive manufacturing is transforming semiconductor manufacturing, delivering design flexibility, rapid prototyping, waste reduction, customization, and integration with traditional manufacturing methods. system. Every part of the system from the semiconductors or chips, printed circuit boards (PCBs), and final assembly components needs to be designed and tested before it transitions into the MP phase for volume manufacturing and product launch (Manufacturing Optimization for the Electronics Industry: How to Accelerate Product Development and Drive Engineering Efficiency with Instrumental Inc. on AWS | AWS for Industries. (2023, May 30)). Additive manufacturing allows you to build a fluid manifold or a cooling structure that prioritizes function over manufacturing capability. Due to their inflexible form factors, conventional sensor technologies based on bulk semiconductors (such as silicon) are finding it difficult to meet this growing demand. This is because the intrinsic brittleness of bulk inorganic semiconductors prevents them from being deformed or coming into conformal contact with uneven surfaces. Additionally, the cost of bulk inorganic semiconductor devices rises proportionally to their footprint, limiting their viability to a few square millimeters (Sui, X., Downing, J. R., Hersam, M. C., & Chen, J. (2021)).

Executive Summary: System Engineering Plan (SEP): Revolutionizing Additive Manufacturing Technology in Semiconductor Manufacturing

Executive summary: The usefulness of additive manufacturing technology in semiconductor production 3D printing, often known as additive manufacturing, has recently transformed several industries. The advantages this cutting-edge technology offers are not limited to the precision and complexity of the semiconductor manufacturing industry. This synopsis gives a general overview of how additive manufacturing technology is becoming more valuable and practical in the production of semiconductors.

Key benefits of additive manufacturing in semiconductor manufacturing:

1. Flexible design:

Additive manufacturing frees semiconductor designers from the limitations of traditional manufacturing, allowing the design of complex, custom components. A crucial aspect of AM is the continuous enhancement of printing technologies and equipment, it further explores the integration of these AM techniques with emerging technologies, such as robotics, artificial intelligence (AI), and automation, enabling new possibilities in design complexity, customization, and mass production (Fidan, I., Huseynov, O., Ali, M. A., Alkunte, S., Rajeshirke, M., Gupta, A., Hasanov, S., Tantawi, K., Yasa, E., Yilmaz, O., Loy, J., Popov, V., & Sharma, A. (2023)). The flexibility of AM technologies drives innovation in fields such as quantum computing and photonics which elevate the game of innovation and computation power in the future is my strong belief.

2. Rapid prototyping:

This technology speeds up the prototyping process, reducing the time to market for semiconductor products. Rapid prototyping could give a slightly accelerated integration with ongoing methodologies, techniques, and technologies that would help engineers iterate designs quickly, a key advantage in a fast-paced industry. Collaborating with clients on advanced application requirements, working in very short prototyping and production cycles, incorporating advanced materials and material property considerations, and working through precision requirements for products are all part of making additive manufacturing an advanced manufacturing edge for companies transforming to Industry 4.0 (Bell, T. (2023, February 1).

3. Complex geometry:

Design for Additive Manufacturing (DfAM), excels at creating complex structures, micro-parts, and heat sinks, based on this understanding I could see myself implementing DfAM in semiconductor manufacturing for improving the performance and functionality of semiconductors. Collaborating with clients on advanced application requirements, working in very short prototyping and production cycles, incorporating advanced materials and material property considerations, and working through precision requirements for products are all part of making additive manufacturing an advanced manufacturing edge for companies transforming to Industry 4.0 (Bell, T. (2023, February 1).

4. Reduce waste:

AM minimizes material waste by using only what is necessary, in line with sustainability goals and reducing costs. The cost of entry for AM has consistently been falling as the industrial-quality printers are affordable and so are the common materials (Top 10 Advantages of Additive

Manufacturing. (n.d.). Www.ptc.com. https://www.ptc.com/en/blogs/cad/10-additive-manufacturing-advantages).

5. Customization:

Understanding the customization freedom in semiconductor components can be tailored to meet industrial needs ranging from electronics to healthcare and aerospace. It enables faster production speeds and has the potential for the large-scale manufacturing of functional polymer parts. Loughborough University has pioneered and patented the innovative HSS technology, which revolutionizes the 3DP process by enabling the cost-effective, high-volume production of intricate and customizable parts (Nonaka, K., Takeuchi, N., Morita, T., & Pezzotti, G. (2023)).

6. Supply chain efficiency:

Understanding the current global semiconductor shortage and COVID-19 impact on the semiconductor industry, On-demand manufacturing reduces the need for large inventories, streamlines the supply chain, and reduces inventory costs directly impacting the supply chain network and efficiency. Most semiconductor manufacturing facilities (called fabs) operate at around 80% utilization and modify this operating capacity to accommodate fluctuations in demand (Max, T. (2022, August 19). Using the Design of Additive Manufacturing and AddiTech systems I would propose implementing these to manufacture high-performance super semiconductors which would completely manufacture semiconductors in-house from start to finish eliminating the supply chain issues.

7. Integration:

Additive manufacturing complements traditional manufacturing methods, leveraging combined approaches to achieve precision and complexity. I believe that by eliminating the need for large inventories, the system's ability to create parts on demand would progressively help improve the supply chain. By producing parts as needed, manufacturers can reduce waste and storage costs. However, I observed a few challenges and considerations such as material selection, accuracy in design and manufacturing, Quality assurance, IP protection, and compliance with regulations and industry standards.

Conclusion:

AM technology delivers game-changing benefits in semiconductor manufacturing, revolutionizing design, prototyping, waste reduction, customization, and integration with existing processes. Once the challenges are resolved, this sector has enormous potential to shape the future of semiconductor manufacturing. “The needs and challenges of the semiconductor fabrication industry today are directly aligned with what a direct metal solution offers,” Green says. “They have challenges where to push the limits of physics, you’ve got to eliminate uncertainty and noise inside of a system and optimize all the parts of handling, cooling, fluid distribution, light collimation (Griffiths, L. (2021, May 21)).

Purpose of the SEP:

This System Engineering Plan (SEP) is intended to serve as a complete roadmap and framework for the development of a ground-breaking industrial additive manufacturing technology, hereby referred to as "AddiTech." The field of additive manufacturing, also referred to as 3D printing, has advanced tremendously recently, creating both new potential and difficulties. The world's understanding of the manufacturing sector in the areas of art, construction, customization, energy use, medical, product availability, sciences, and waste reduction will alter because of three-dimensional printing. This SEP describes the strategic strategy and techniques for overseeing the

AddiTech project's whole lifecycle, guaranteeing its successful creation, adoption, and ongoing improvement.

Content of the SEP:

The SEP is divided into various components, each of which plays an important role in guiding the project to completion. Here are the key elements of this SEP:

1. Introduction:

In terms of industrial technology, and more specifically the field of additive manufacturing, or 3D printing, the AddiTech initiative is a trailblazing endeavor. This project has the potential to change conventional production techniques and greatly impact the industrial sector. The objectives, scope, and critical importance of the project in determining the future of manufacturing are succinctly described in the following introduction.

Objectives

The main goal of AddiTech is to develop, improve, and use advanced additive manufacturing technology specifically suited to industrial applications. At its core, technology aspires to enable the construction of complex, customized parts, assets, and structures with unprecedented speed, precision, and efficiency. It aims to revolutionize the way businesses plan, create, test, and produce, ultimately delivering the key results listed below:

Improve efficiency:

AddiTech aims to reduce production times and associated costs by streamlining industrial processes. It supports a sustainable industrial production approach by aiming to reduce waste and maximize resource use.

Customization and complexity:

This initiative aims to enable the industry to produce complex and highly personalized components and products by leveraging additive manufacturing capabilities. This will open up new opportunities in several sectors, including healthcare and aviation.

Competitiveness and innovation:

AddiTech's success will put industries at the forefront of innovation. Design iteration and rapid prototyping shorten product development cycles and increase competitiveness in the global market.

Sustainable environment:

By limiting material waste and reducing energy consumption, the project meets sustainability goals, focusing on resource-efficient production.

Relevance in the industrial sector:

The importance of the AddiTech project for industry cannot be overestimated. It highlights the following important factors and signals a fundamental shift in how industries view manufacturing processes:

By utilizing the latest developments in additive manufacturing, AddiTech ushers in a new era of industrial technology.

Competitive advantage:

By being at the forefront of technological innovation and manufacturing agility, companies that adopt AddiTech will gain a significant competitive advantage.

Economic growth:

By encouraging innovation and attracting capital to the industrial sector, this project has the potential to stimulate economic growth.

Environmental responsibility:

AddiTech supports sustainability initiatives and compliance with international environmental goals by maximizing resource use and minimizing waste.

2. System Description:

The AddiTech system is an advanced additive manufacturing technology created to work in conjunction with industrial manufacturing processes currently in use. The system components, their relationships, and their integration with the custom manufacturing process are described in detail in this section. Attached is a system architecture diagram that clearly illustrates the structure and connections of the system.

Components of the AddiTech System

Additive manufacturing units:

Additive manufacturing units form the foundation of the AddiTech system. These devices are high-precision 3D printers equipped with modern material deposition techniques. They are responsible for building each component layer using digital design models.

Digital design workstation:

There are specific digital design workstations in the system. To produce and perfect 3D models for additive manufacturing, these workstations are necessary. They make it easy to convert design requirements into printing instructions.

Processing system:

To manage the many raw materials needed for additive manufacturing, AddiTech uses high-tech processing systems. By ensuring rapid material delivery to printing equipment, these systems minimize downtime.

Quality control station:

To maintain the integrity of manufactured parts, quality control stations are essential. They include people who monitor the quality of printed parts and ensure they meet strict requirements, as well as automated testing tools.

The following processing stations:

Some parts may require additional steps such as surface polishing, heat treatment, or assembly. Post-processing stations are installed in the system at strategic locations to perform these tasks efficiently.

The main nervous system of the AddiTech system is called the centralized control center. It hosts control software that monitors all elements of the system, organizes workflow, and monitors performance in real-time. For system administrators, it also provides remote access and control capabilities.

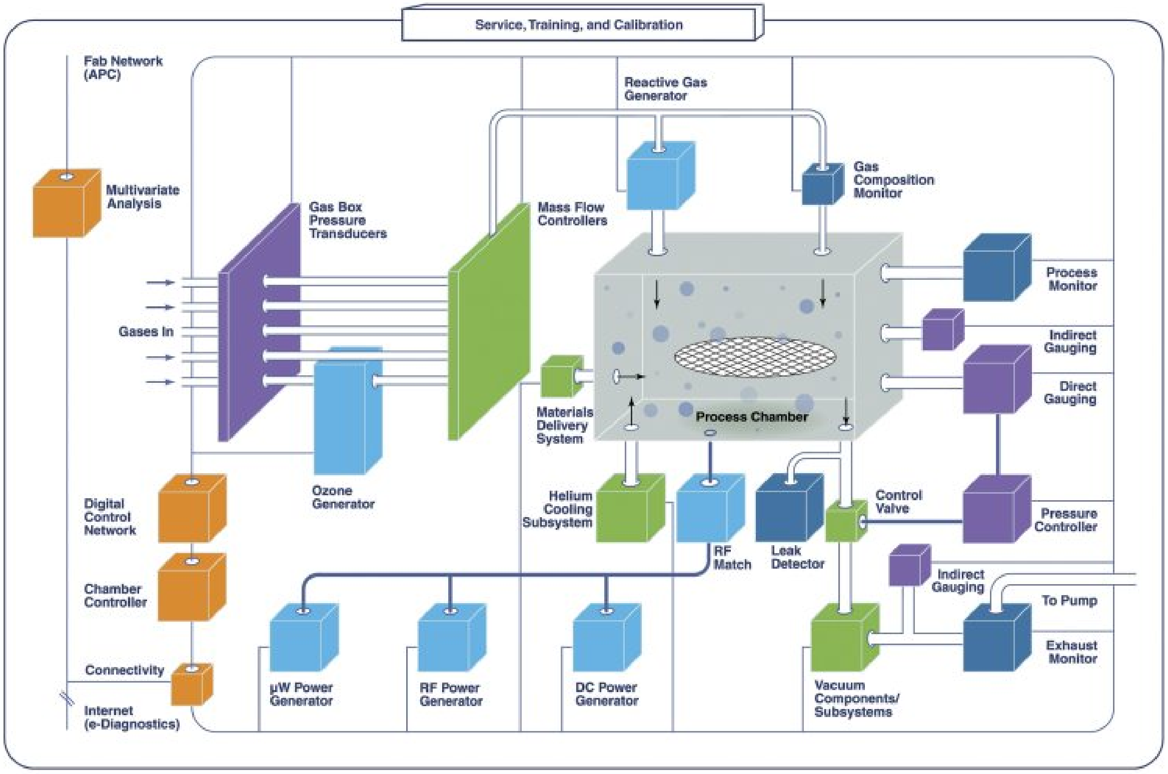
Integration with existing Manufacturing Processes

The AddiTech system is designed to be easily integrated into existing industrial production processes. Many industries include aerospace, automotive, healthcare, and more. can use it. Due to the adaptability of the system, it can be used in conjunction with standard manufacturing techniques and offers the following integration points:

Hybrid Manufacturing: AddiTech can be integrated into hybrid manufacturing strategies that combine additive manufacturing with subtractive techniques such as machining. This combination makes it possible to develop parts with complex shapes and high-quality finishes.

Tooling and Prototyping: The system supports rapid prototyping and tool development. Manufacturers can use AddiTech to quickly create prototypes and molds, reducing time and costs.

System Architecture Diagram for Semiconductor using Additive Manufacturing Technology



Reference image: Semiconductor and Electronics on AWS - High Level - Run Semiconductor Design Workflows on AWS. (September 25, 2023)

The system architecture diagram provides a visual representation of the structure and connections between different parts of the AddiTech system. It highlights key integration points with existing manufacturing processes and demonstrates how data and materials flow through the system.

In short, the AddiTech system is a flexible and comprehensive solution that, by integrating advanced additive manufacturing capabilities, improves industrial production. For companies looking for efficiency, innovation, and customization in their manufacturing processes, this is a powerful tool as it is compatible with existing workflows and provides control accuracy as well as quality assurance.

3. Project management

Important facets of AddiTech project management are covered in further detail in this section of the Systems Engineering Plan (SEP). To ensure the successful development, deployment, and integration of AddiTech solutions, effective project management is crucial. The project's organizational structure, job descriptions, timeline, budget, and resource management plan are all covered in this section.

Organizational structure:

To improve decision-making, expedite communication, and make roles and duties clear, the AddiTech project will adhere to a well-defined organizational structure. It is usually defined using a hierarchy chart that shows how groups or functions report within the organization (ITechGurus Education Solutions. (n.d.)). I would consider this matrix-based organization structure because I find it blends the features of both project-based organizational structure and functional organizational structure.

However, within the project team, these are the primary roles:

Project management:

The project manager oversees managing all aspects of the project, including its planning, execution, and monitoring. They serve as the main point of contact for all issues about the project, ensuring that the goals are met within the set parameters and that risks and issues are controlled.

Systems Engineer:

System requirements, architecture, and integration are all heavily influenced by systems engineers. They collaborate closely with stakeholders, designers, and developers to convert project objectives into specifications.

Design and development team:

The engineers, designers, and software developers on this team oversee developing and perfecting the 3D printers, material handling equipment, and control software that are part of the AddiTech system.

Quality assurance team:

The goal of the quality assurance team is to ensure that system elements and operational procedures adhere to set quality standards. To assure performance and reliability, they go through rigorous testing, inspection, and testing.

Purchasing and supply chain specialists:

These professionals oversee controlling the supply of components and raw materials as well as streamlining the supply chain to guarantee prompt resource delivery.

Post-processing and assembly team:

This team oversees post-processing tasks like heat treating, surface finishing, and, if necessary, part assembly.

Project schedule and progress

To ensure that the AddiTech system is created and integrated efficiently, a carefully defined project timetable is required. Critical path analysis and milestones are included in project schedules, which improve progress monitoring and risk management. Project milestone examples:

1. Project launch
2. Design and development of systems
3. Prototype evaluation
4. Monitoring and testing for quality

5. Adapt to current manufacturing procedures

6. Improve performance.

7. Final testing for acceptance

8. Activation and instruction

9. The project's closure Budgeting and resource management

Project management requires careful attention to both resource management and cost control. The AddiTech project budget will cover expenses for staff, supplies, hardware, software, and facilities. A resource management approach will prioritize managing costs, maximizing resource allocation, and making sure the project stays on budget and does not exceed the predefined functions, variables, and constraints.

4. Analyze needs

A fundamental component in the AddiTech system development process is the needs analysis. To build a comprehensive knowledge of the project's objectives, this phase entails identifying stakeholder demands and system requirements. The connections between these demands and the broader project objectives will be identified and recorded using the traceability matrix.

Key elements of the needs analysis phase include:

Determine what stakeholders' needs are:

thorough analysis of stakeholders' requirements, including those of industrial manufacturers, engineers, and end users, to comprehend their priorities and expectations for AddiTech systems.

The System Need Statement:

Establish the precise system requirements, considering both functional and non-functional factors including performance, reliability, and scalability.

Matrix of traceability:

To ensure that project deliverables meet stakeholder needs, a traceability matrix will be established to tie each need to the specific project goals it supports.

The AddiTech project team seeks to lay a strong foundation for successful system development and deployment by conducting a thorough requirements analysis, ultimately meeting the needs and expectations of many stakeholders.

5. Design and Development

This section of the Systems Engineering Plan (SEP) gives a thorough overview of the AddiTech project's design and development phase. To ensure that the AddiTech system is created, validated, and tested, this phase will involve establishing precise design specifications, creating prototypes, and putting strict testing procedures in place. Be prepared to integrate after receiving care.

Requirements for AddiTech's design specifications:

The design stage at AddiTech is crucial for converting system needs into precise design specifications. These requirements will comprise:

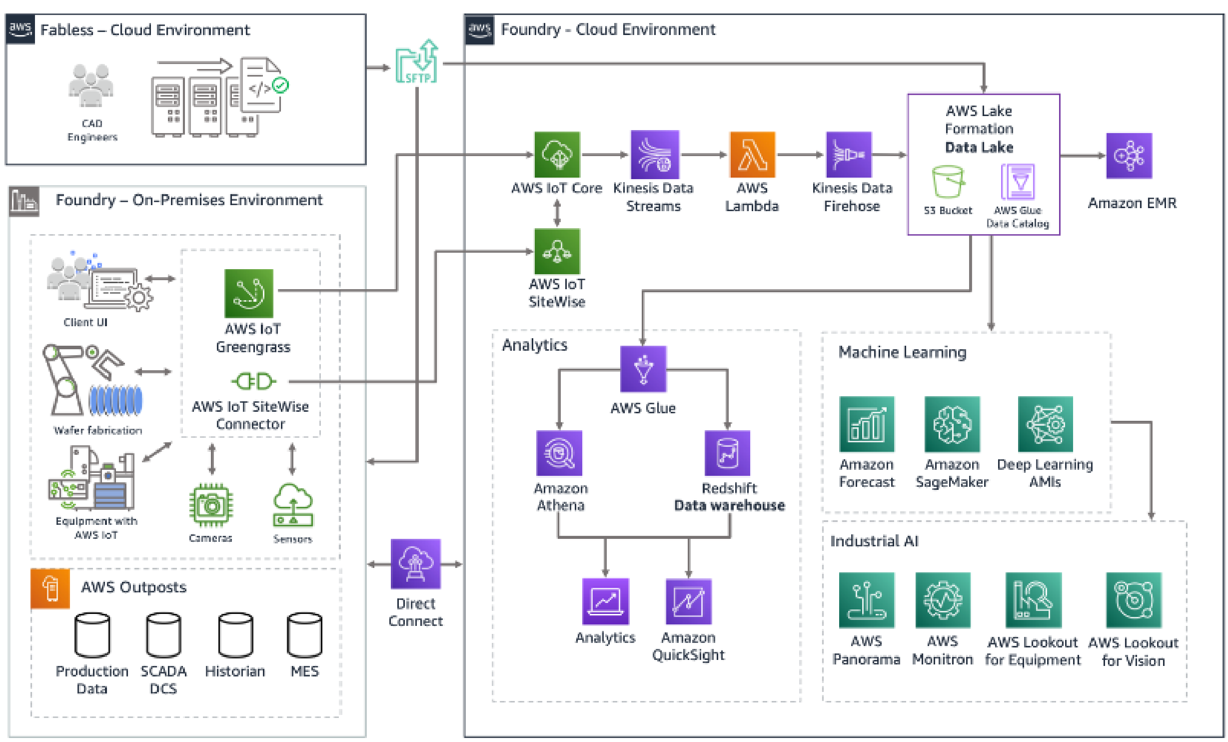
Technical design: Careful planning of 3D printers, processing systems, and other components. Technical drawings, schematics, and CAD models will be produced. Software development involves creating user interfaces, communication protocols, and tools for system monitoring for AddiTech systems.

Material selection: Consider issues including material compatibility, durability, and thermal qualities while choosing materials for the printing process.

System architecture: The integration of diverse parts, data flows, and interfaces is described by a complete system architecture design.

Using these optimized technical designs, proper material selection and system architecture improves the overall design workflow which will be achieved as the result of the design phase. Corrections such as optical proximity correction along with multiple patterning, improve the room for wafer printability. However, as per the CNS, the complexity of mask shape and its geometry can be achieved by "AddiTech" systems by using 3D printing with higher performance supercomputers to achieve better computational designs is my mission statement to achieve better design geometry in this SEP. Making this on a technical level along with AWS cloud-based services such as machine learning, data analytics, IoT and others would accelerate the semiconductor fab, improving the architecture, and using this SEP the deliverables will be achieved and the CNS will be fulfilled.

The reference image shows a design workflow improvement using OPC with AWS enabled Semiconductor design workflow (Accelerate Semiconductor Fab Transformation with AWS | AWS for Industries. (2021, July 6)):



6. Prototyping and Testing

The design and development process includes prototyping, which enables the construction of preliminary versions of the AddiTech system to assess its viability and functionality.

Inspection methods will comprise:

As per the CNS, I would prioritize building working prototypes using 3D printers as the essential AddiTech system parts to test the system's essential features and functions.

Functional testing: Thorough functional testing to make sure the system performs as intended. Testing the 3D printing procedure, material management, and control software are all included in this.

Performance test: Analyze the AddiTech system's performance under various workloads and conditions. Performance standards will be created.

To ensure long-term operating reliability, a test for reliability and durability assesses component reliability and durability.

Risk evaluation and mitigation tactics

Technical, financial, and scheduling risks will be evaluated during the design and development process. A quick response to these hazards will be achieved by developing mitigation techniques. Throughout the project, ongoing risk analyses and updates on mitigation strategies will be done.

7. Testing and integration

The integration procedures for the various AddiTech system components are described in this section. To guarantee that all subsystems operate harmoniously with one another, integration is an essential phase. The upcoming elements are addressed:

Integration of components: A guide for combining 3D printers, material handling equipment, and control software into a single, functional system.

Confirmation and verification testing: Rigorous testing methods to ensure integrated systems perform as expected. All include testing for accuracy, speed, reliability, and compliance with industry standards.

Compliance check: Ensure that AddiTech systems comply with all applicable safety standards, laws, and regulations.

User acceptance testing involves engaging stakeholders and end users during testing to gather feedback and ensure the system meets their needs.

The AddiTech project aims to create a robust and reliable additive manufacturing technology that has the potential to significantly impact the industry by carefully addressing the design, development, integration, and experiment.

8. Quality Assurance

A crucial component of the AddiTech project is quality assurance, which makes sure that the technology constantly complies with specifications and produces excellent outcomes. The methods and procedures used to uphold and enhance AddiTech's quality during its lifetime are covered in this section.

Quality management process:

A detailed description of the quality management process, including quality planning, quality control, and quality improvement, is provided. These processes will be aligned with industry standards and best practices.

Establish quality metrics and key performance indicators (KPIs) to monitor the effectiveness and performance of the AddiTech system. These evaluations will consider factors including print accuracy, system dependability, and availability.

Implement a framework for continuous improvement to find areas that need to be improved and optimized. To promote continual progress, methods for regular review and feedback will be in place.

9. Configuration management

To maintain control over the numerous AddiTech system parts, versions, and revisions, configuration management is crucial. This paragraph focuses on

Configuration control: Establish methods for regulating and managing alterations to system configuration. Version control for hardware, software, and documentation is included here.

Documentation: Ensure that all system elements are completely documented and that changes are tracked in the right way. This includes keeping the configuration base current.

Change Management: Establish a change management procedure to review and accept suggestions for system changes. A risk assessment and an effect assessment will be part of this procedure.

10. Documentation and Reporting

To make sure that project stakeholders are properly informed on the status and performance of the project, effective reporting and documentation methods are required.

Document Control Procedures: To ensure that all project papers are appropriately managed, document control procedures will be devised. This comprises meeting minutes, project timelines, test plans, design specifications, and other associated paperwork.

We'll create a central document store that only authorized team members can access. Version control will be used to keep track of document updates and changes. To keep documents consistent, naming conventions and document templates will be established.

Sensitive or confidential documents will be subject to access restrictions to restrict access to authorized individuals only.

Procedures for document retention will be put in place to make sure that old project files are kept around for future use.

Reporting Mechanisms:

Reporting systems will be chosen so that project sponsors, team members, and stakeholders may receive regular information on the status and performance of the project. other.

Key performance indicators (KPIs), milestones that have been reached, and milestones that are still to come will all be included in project status reports that are created at regular intervals (e.g., weekly, monthly).

To give stakeholders a visual depiction of project progress and data, performance dashboards will be used.

Ad hoc reports can be produced as necessary to address certain problems, hazards, or difficulties that develop throughout the project.

Distribution lists and reporting channels will be set up to ensure that reports get to the right people quickly.

11. Training and Knowledge Transfer:

To make sure that project stakeholders can collaborate with AddiTech successfully, training initiatives will be created and carried out.

Different facets of AddiTech, such as system operations, maintenance, troubleshooting, and security measures, will be covered in the training sessions.

Students will have access to training resources such as manuals, guidelines, and instructional films.

The discussion of knowledge transfer methodologies will guarantee the long-term viability of the technology. This contains techniques for storing crucial AddiTech knowledge. To centralize information about AddiTech, a knowledge repository will be established, enabling team members to quickly access pertinent data.

The AddiTech project seeks to improve communication, transparency, and the overall success of the technology by putting in place reliable document control systems and reporting mechanisms, as well as thorough training and knowledge transfer initiatives.

12. Risk Management:

A crucial component of an AddiTech project is risk management, which focuses on detecting, evaluating, and mitigating potential difficulties and uncertainties. The objective is to manage risk proactively to guarantee project success.

Continuous risk assessment:

Risk identification:

The AddiTech development and execution are subject to potential risks and uncertainties, which the project team will regularly monitor. Technical difficulties, resource limitations, regulatory compliance, market shifts, and unforeseen circumstances can all be risks.

Risk assessment:

Each risk that is identified will go through a rigorous risk assessment process that includes determining its likelihood of happening, potential effects on the project, and expected timing.

Prioritize risks:

Risks will be given priority based on how they might affect the project's goals. Risks with a high priority receive prompt attention and mitigation measures.

Risk mitigation strategy:

High-priority threats will be addressed using mitigation plans. These tactics may consist of process modifications, revisions to the way resources are allocated, backup plans, or methods for transferring risk (such as insurance).

Risk monitoring:

Throughout the project, risks will be regularly tracked. The establishment of key performance indicators (KPIs) and triggers will help to determine when risk events are approaching or taking place.

Make an emergency plan:

Emergency plan:

Plans for unanticipated problems that could interfere with the development or objectives of the project will be developed. These plans will specify the precise steps that must be taken to react to various risky circumstances.

Resource allocation:

To meet unforeseen difficulties, contingency planning may entail reallocating resources, changing project schedules, or reducing the Interface Control Working Group (ICWG)project scope.

Communicate: To guarantee that all project stakeholders are notified when emergency plans are triggered and the reasons for these measures, clear communication channels will be developed.

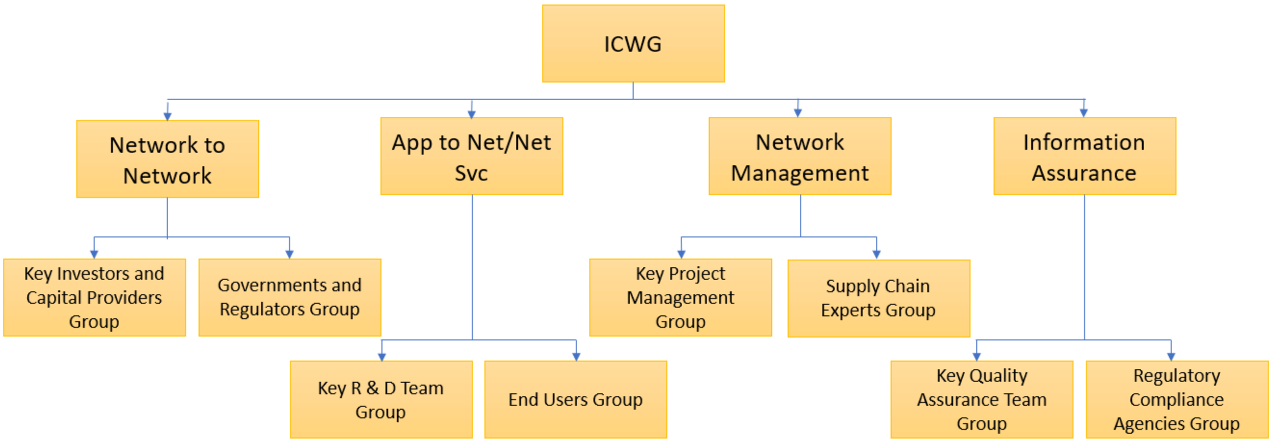
Test and simulate: To ensure that emergency plans are effective in addressing potential dangers, they may occasionally be put through simulations or tabletop exercises.

Interface Control Working Group (ICWG):

The Interface Control Working Group (ICWG) is a technical working group with specialized expertise made up of qualified technical representatives from the interfacing activities and other interested participating organizations. The ICWG serves as a forum to develop and provide interface requirements, as well as to focus on interface detail definition and timely resolution of issues (Interface Management, n.d.). As the specifications for system interface control are created, they are documented and made available to the relevant parties. These interface control specifications are listed in an interface control document and are subject to configuration management. Among the documentation that shows the physical and functional interfaces of related or cooperative systems or components are interface control drawings, interface requirements specifications, and other documents. The goal of the ICWGs or analogous integrated teams is to establish and maintain compatibility between interfacing systems or components, and their output is interface control documentation (Interface Management, n.d.).

Stakeholder	Purpose (Interface)
Key Investors and Capital Providers Group	The success of the project's development and its ability to provide a return on investment is of great importance to the people or organizations who have invested money in the AddiTech project. Therefore, it is considered as a Key Group.
Key R & D Group	The AddiTech system's development and design are the responsibility of the teams. They want to make sure that technology adheres to industry standards, innovation objectives, and requirements. As a result, it is regarded as a Key Group.
Key Project Management Group	They are essential in making sure the project continues track, stays under budget, and accomplishes its objectives. It is therefore classified as a Key Group.
Key Quality Assurance Team Group	This team works to guarantee that the AddiTech system continually generates semiconductor components of the highest quality. They play a crucial role in upholding the highest levels of dependability and quality. It is therefore classified as a Key Group.

The ICWG for the system is presented below in a block diagram representation flow of interfaces:



Customer Need Statement:

- NASA (Government Entity) integrated with SpaceX (Private) company placed a bulk order of High-Performance Super Semicondocutor (HPSS) chips manufactured using an "Additive Manufacturing" System that delivers unmatched high performance for semiconductor applications in aerospace for the Mars Rover.
- Twenty SpaceX systems with a need/demand of HPSS chips manufactured using an "Additive Manufacturing" system are required to be constructed and deployed.
- Launches are to be conducted in Texas, Florida, and California each of the twenty systems is to be launched into space for a space mission to Mars. However, all the products are designed, engineered, developed, and manufactured in one plant which is located in Austin, Texas, and then supplied to Texas, Florida, and California. the respective lauches.
- SpaceX needs all 20 systems to be deployed by the end of 2040.
- A total of $700M has been budgeted by SpaceX for this project over the entire life cycle.

Mission Statement:

The System Engineering Plan (SEP) for "AddiTech" systems in semiconductor manufacturing holds a mission to take the field of industrial additive manufacturing on a revolutionary journey. To establish this cutting-edge technology as a trailblazing force along with AWS services that reinterpret industry conventions and establish new benchmarks for efficiency, customization, competitiveness, and sustainability, our goal is to advance it to the foreground of the global manufacturing landscape.

Acknowledging Transformation

Our purpose is centered on the understanding that the manufacturing sector is about to undergo a significant transformation. We want to lead this transition with AddiTech by using its potential to strengthen industries across the board. The beacon that directs us on the way to achieving our objective is our SEP.

A Thorough Roadmap: The SEP serves as a thorough roadmap that has been painstakingly constructed to guide AddiTech's development, adoption, and continued evolution. It serves as our guide to quality, innovation, and advancement.

Redefining Efficiency: Redefining efficiency in industrial manufacturing is one of our top priorities. Processes are streamlined, production times are shortened, and related costs are minimized through AddiTech's engineering. We create the foundation for a more sustainable and effective manufacturing industry by streamlining resource consumption and reducing waste.

The Art of Customization: AddiTech wants to take the customizing process to entirely new heights. Industries will be able to create intricately designed components and products with highly individualized features thanks to their capabilities in additive manufacturing. In addition to broadening vistas, this creates new chances in industries like healthcare and aviation.

Innovation as the Key to Competitiveness: In our quest for excellence, we understand that innovation is the basis for competitiveness. The success of AddiTech will put industries at the forefront of technological advancement. It will accelerate design iterations and revolutionize prototyping, cutting product development cycles and boosting competitiveness on the global market.

Promoting Sustainability: AddiTech's mission is based on sustainability. This project prioritizes resource-efficient production while aligning with environmental goals by decreasing energy use and material waste. It has the potential to considerably lessen industrial manufacturing's environmental impact.

A Fundamental Shift in How Industries Perceive Manufacturing Processes: We are aware that AddiTech represents more than just a technological improvement; it represents a fundamental change in how industries view manufacturing processes. AddiTech ushers in a new era of industrial technology by utilizing the most recent advancements in additive manufacturing.

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System Architecture Diagram: The SEP includes a diagram of the system architecture as a visual representation. The AddiTech system's architecture and connections are seen in this diagram. It highlights crucial integration points with already-in-use manufacturing processes and shows how data and materials move across the system.

In essence, AddiTech is a versatile and complete solution that improves industrial output through cutting-edge additive manufacturing capabilities. It delivers precision, quality assurance, and control accuracy while seamlessly integrating with existing workflows.

Objectives tree:

Creating a system engineering plan (SEP) objective tree for AddiTech in semiconductor manufacturing involves breaking down tasks and high-level objectives into specific, measurable goals. Below is an objective tree that outlines the primary and secondary goals related to implementing AddiTech in semiconductor manufacturing:

High-level Objective: Revolutionize semiconductor manufacturing with AddiTech systems.

Objective 1: Improve production efficiency.

Reduce production times

- Reduce semiconductor component production time.
- Achieve production time reduction of at least 20%.

Minimize related costs

- Reduce production costs in semiconductor manufacturing.
- Save at least 15% compared to traditional methods.

Optimize resource usage

- Use raw materials and resources effectively.
- Achieve at least a 25% improvement in resource utilization.

Objective 2: Allows for personalization and complexity.

Enables the production of complex components

- Develop the ability to manufacture complex semiconductor components.
- Reach levels of complexity that were previously unattainable.

Personalization is easier

- Customize semiconductor components to meet specific customer requirements.
- Allows customization for 90% of semiconductor orders.

Objective 3: Ensure high-quality output

Meets or exceeds industry standards.

- Ensure that semiconductor components manufactured by AddiTech meet or exceed industry quality standards.
- Maintain a quality rating of 95% or higher.

Objective 4: Ensure scalability and adaptability

Scalability across all production volumes

- Allows AddiTech to adapt to different semiconductor production volumes.
- Achieve seamless scalability from small to large-scale production.

Adapt to changing production needs

- Ensure AddiTech can adapt to changing semiconductor manufacturing requirements.
- Make changes without significant disruption.

Objective 5: Provides a user-friendly interface

Simple user interface

- Developing user-friendly interfaces for semiconductor manufacturing.
- Ensure 90% of users find the interface intuitive and easy to use.

Objective 6: Ensure regulatory compliance

Comply with industry standards and regulations

- Ensure that AddiTech complies with all relevant semiconductor industry standards and regulations.
- Maintain a 100% compliance rate.

Objective 7: Provide technical support and training

Full technical support

- Provides extensive technical support to semiconductor manufacturers using AddiTech.
- Resolve 90% of technical problems within 24 hours.

Effective training program

- Develop training programs for semiconductor manufacturers.
- Ensure 95% of users are trained and proficient in how AddiTech works.

Objective 8: Achieve cost savings

Reasonable implementation

- Makes implementing AddiTech financially viable for semiconductor manufacturers.
- Offer competitive pricing with at least 10% savings on alternatives.

Objective 9: Ensure data security and protect intellectual property.

Strong data security measures

- Implement strong data security protocols to protect intellectual property and sensitive data.
- Maintain data security without major breaches.

Objective 10: Promote environmental sustainability.

Production saves resources

- Maximize resource efficiency in semiconductor manufacturing.
- Reduce material waste and energy consumption by 20%.

Objective 11: Drive innovation in semiconductor manufacturing

Technological advances

- Position semiconductor manufacturers at the forefront of technological innovation.
- Enables rapid design iteration and prototyping, reducing product development cycles by at least 30%.

Objective 12: Promote economic growth

Attract capital to the semiconductor industry

- Attract investment and capital into the field of semiconductor manufacturing.
- Contributed to 5% growth in economic value of the semiconductor industry.

Objective 13: Compliance with international environmental goals

Support international environmental initiatives.

- Align AddiTech's sustainability efforts with global environmental goals.
- Contribute to global initiatives aimed at reducing environmental impact.

This objective tree describes a hierarchy of objectives, starting with the high-level task and moving down to more specific and measurable sub-goals. It provides a structured framework to achieve the overall mission of revolutionizing semiconductor manufacturing through the implementation of AddiTech (OpenAI, 2023).

Stakeholders:

Stakeholders are individuals, groups, or organizations with a vested interest in the success and outcomes of the Systems Engineering Plan (SEP) for AddiTech in semiconductor manufacturing. Identifying and engaging these stakeholders is essential for effective project management and ensuring that technology meets the needs and expectations of different stakeholders. Here is a brief overview of AddiTech SEP's key stakeholders in semiconductor manufacturing:

Key stakeholders

They are the main users of AddiTech systems in semiconductor manufacturing. They have a vested interest in efficiency, profitability, and the technology's ability to meet their specific production requirements.

Research and development team:

Internal stakeholders

The teams responsible for designing and developing the AddiTech system are key players. Their goal is to ensure that technology complies with industry standards, innovation goals, and specifications.

Project management team:

Internal stakeholders

The project management team within the organization is responsible for overseeing the implementation of the SEP. They play a vital role in ensuring that the project stays on schedule, on budget, and achieves predetermined goals.

Quality assurance team:

Internal stakeholders

This team strives to ensure that the AddiTech system consistently produces high-quality semiconductor components. Their role is essential in maintaining standards of quality and reliability.

Supply chain experts:

Internal stakeholders

The supply chain specialist is responsible for managing the flow of components and materials required for AddiTech's manufacturing process. Their effective management is crucial for smooth operations.

Regulatory and compliance agencies:

External stakeholders

Regulators and compliance agencies ensure that AddiTech meets industry standards and safety regulations. Their approval is required for the implementation and use of the technology in semiconductor manufacturing.

End users (consumers of semiconductor components):

External stakeholders

End users of semiconductor components, such as electronics manufacturers, care about the quality and reliability of components manufactured using AddiTech. Their feedback and satisfaction impact the success of the technology.

Investors and capital providers:

External stakeholders

Individuals or organizations that have invested capital in the AddiTech project are very interested in the project's successful development and potential to generate a return on investment.

Environmental organizations:

External stakeholders

Environmental organizations and advocates are concerned about the sustainability aspects of manufacturing technology. They oversee AddiTech's sustainability practices and environmental impact.

Competitors in semiconductor manufacturing:

External stakeholders

Competing semiconductor manufacturers may closely monitor AddiTech's adoption as it may impact their competitiveness. They may seek to adapt or respond to advances in technology.

Regulators and governments:

External stakeholders

Government agencies and bodies are responsible for industry regulations and standards play an important role in shaping the environment in which AddiTech operates. Compliance with government regulations is essential.

Educational and research facilities:

External stakeholders

Academic and research institutions are interested in AddiTech's potential for innovation and contribution to the semiconductor manufacturing sector. They can participate in research collaborations or contribute their expertise.

Environmental group:

External stakeholders

Environmental advocacy groups monitor the environmental impact of manufacturing technologies like AddiTech. They can support sustainable and environmentally responsible practices.

Understanding and engaging these stakeholders throughout the lifecycle of an AddiTech SEP is critical to its success. Effective communication and collaboration and addressing their needs and concerns will contribute to the seamless adoption and integration of AddiTech into semiconductor manufacturing.

2.0 Applicable Documents

NASA's Systems Engineering Handbook, ISO handbook, and the workflow transfer to AWS as a reference point and a high-level architecture for operating semiconductor design processes are shown in the architecture diagram above. The infrastructure running on AWS in this architectural diagram is comparable to that in the prior on-premises environment diagram. You can comprehend the high-level strategy with the aid of this straightforward architecture without having to be familiar with all the specifics of the services that are utilized.

1. https://docs.aws.amazon.com/whitepapers/latest/run-semiconductor-workflows-on-aws/semiconductor-and-electronics-on-aws---high-level.html

2. SYSTEMS ENGINEERING. (n.d.). Retrieved October 1, 2023, from https://www.nasa.gov/wp-content/uploads/2018/09/nasa_systems_engineering_handbook_0.pdfLinks to an external site.

2. Engaging stakeholders and building consensus. (n.d.). Retrieved October 1, 2023, from https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/guidance_liaison-organizations.pdfLinks to an external site.

3. Organizational Chart Templates. (2019). Smartdraw.com. https://www.smartdraw.com/organizational-chart/examples/

Purpose:

To achieve manufacturing of high-performance super semiconductors using “Additive Technology” Systems and AWS cloud to facilitate the effective design, execution, and optimization of semiconductor and electronics manufacturing processes using Additive manufacturing systems and the AWS platform, the HPSS and Electronics Development IFWG was established. To promote innovation and efficiency in the semiconductor and electronics manufacturing sector, this IFWG seeks to ensure alignment with industry best practices, Additive Manufacturing, AWS services, and stakeholder requirements. (Accelerate Semiconductor Fab Transformation with AWS | AWS for Industries. (2021, July 6)).

Scope:

The scope of the SEP is achieving the following deliverables:

- SpaceX company has a contract project assigned by NASA (a U.S. government entity) placed a bulk order of High-Performance Super Semiconductor (HPSS) chips manufactured using an "Additive Manufacturing" System and integrated with AWS cloud infrastructure that delivers unmatched high-performance for semiconductor applications in aerospace for the Mars Rover and Orbiter.

- Utilize additive manufacturing as a catalyst for innovation in wafer handling, lithography, metrology, heat exchangers, gas manifolds, and nozzles in semiconductor manufacturing systems. More intricate and effective geometry is feasible with additive manufacturing that is not attainable with traditional techniques. This encourages the development of products that are built for performance rather than for ease of manufacture (Challenges of Additive Manufacturing Why Companies Don't Use Additive Manufacturing in Serial Production, n.d.).
- A game-changer could be the incorporation of additive manufacturing into the semiconductor supply chain. Stronger, lighter components for semiconductor production lines can improve speed and accuracy, boosting productivity for foundries (Suite 4100, E., Ottawa, 500 P. D., ON, & Canada, K. 1C2. (2021, July 13), Semiconductors - Additive Manufacturing Advanced Technologies. Equispheres).

Systems Engineering describes the body of stakeholders as follows:

1. Successfully understanding and defining the mission objectives and the concept of operations are keys to capturing the stakeholder expectations, which will translate into quality requirements and operational efficiencies over the life cycle of the project (NASA Systems Engineering Handbook, 2007).
2. Technically the stakeholders tend to have specific expectations such as goals, needs, objectives, constraints, program authority, development ConOps, success criteria, and other requirements (NASA Systems Engineering Handbook, 2007).
3. In recent years, ISO has seen its work program extend and evolve into new topic areas to be responsive to both current and emerging stakeholder needs and to keep itself as a highly relevant International Standards developer. With this change have come compelling challenges for ISO

regarding its standards development processes, since stakeholder expectations of the ISO system are shifting. All relevant stakeholders should have equal access to participation in the liaison organization’s process for the development of positions, and all stakeholders formally engaged in the liaison organization’s process should be assured of fair and equitable treatment and consideration in that process (ISO - Engaging stakeholders and building consensus, 2010).

High-Performance Super Semiconductor (HPSS) Company Stakeholders in six divisions as follows:

- Stakeholders: Investors - $700 Million investment.
- Investors: NASA, U.S. Federal Government, U.S. Armed Forces, SpaceX, and Industrial Associations.
- Customers:

Government Agencies such as NASA, central and state agencies

SpaceX - Engineering Design and Development

Starlink - Space-based internet communication system

OEMs - Original Equipment Manufacturing companies

Technology companies - "AddiTech" Systems, AWS and others.

- Employees:

Additive Manufacturing project manager

Semiconductor Manufacturing Expert Engineers

Semiconductor Manufacturing Operators

AWS Solutions Architect

Supply Chain and Logistics Specialists

Environmental Compliance Analyst

Research and Development Lead and Other respective departments.

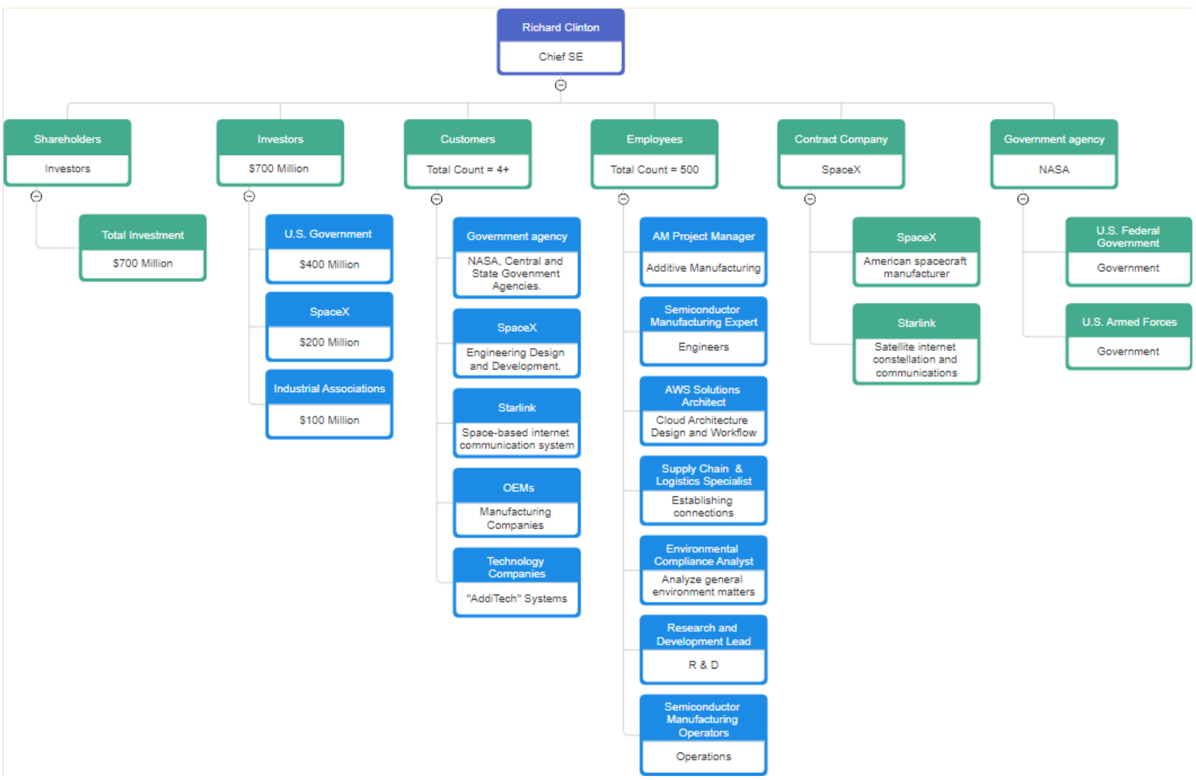
- Contract Company:

SpaceX - American spacecraft manufacturer

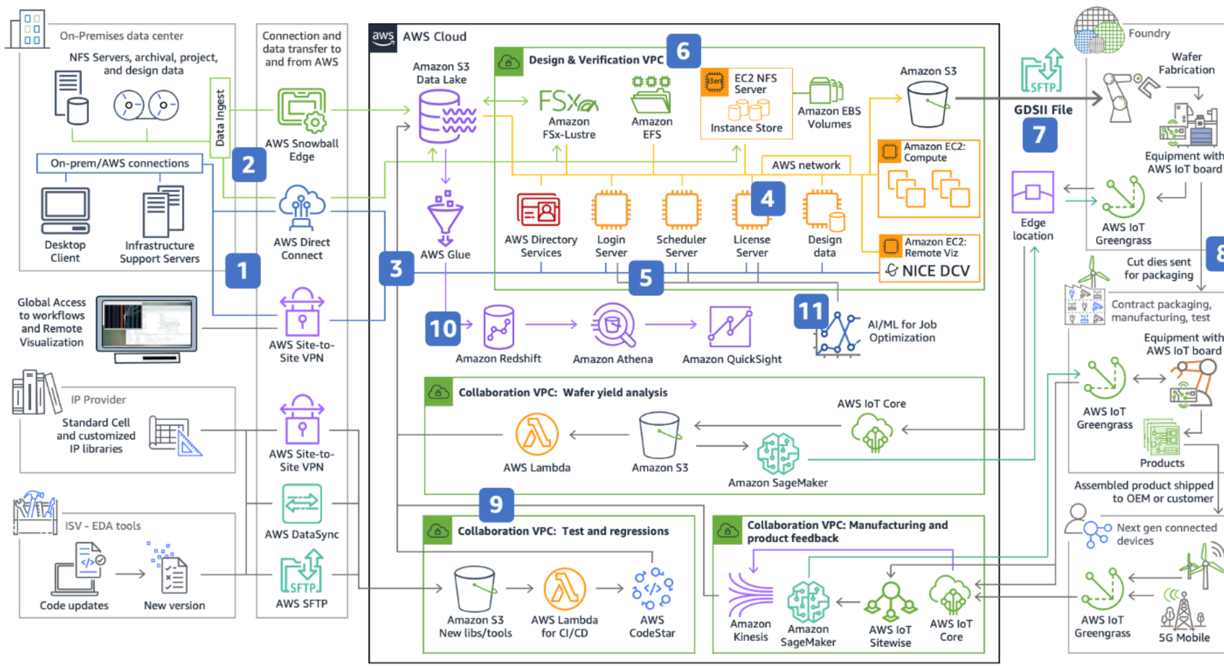
Starlink - Satellite internet constellation and communication systems.

- Government Agency: NASA, U.S. Federal Government, and U.S. Armed Forces.

Interface Working Group (IFWG) Organizational Chart is displayed below for High-Performance Super Semiconductor (HPSS):



3.0 General Description of System Architecture using AWS:



(Above Reference image: Deep dive into the Semiconductor and Electronics on AWS)

4.0 System Engineering Process

Explain the systems engineering process and which model you are using Vee, Spiral, Waterfall, etc. include your rationale.

The System Engineering Plan (SEP) for "AddiTech" systems in "HP Super Semiconductor" manufacturing holds a mission to take the field of industrial additive manufacturing on a revolutionary journey. To establish this cutting-edge technology as a trailblazing force that reinterprets industry conventions and establishes new benchmarks for efficiency, customization, competitiveness, and sustainability, our goal is to advance it to the foreground of the global manufacturing landscape. These semiconductors are designing and developing high-performance ICs for a wide range of space applications, including spacecraft, orbital or planetary satellites, and space exploration missions. The primary advantages of AM over conventional and subtractive manufacturing techniques are design independence, multi-material fabrication capabilities, lower cycle times, reduced tooling costs, and a higher degree of automation. Due to their ubiquitous use in the automotive, aerospace, and biomedical industries, AM technologies have attracted unheard-of attention in recent years. A rather nascent sub-category of AM research is the development of microscale AM processes and tools for primary applications in the semiconductor, MEMS/MOEMS, and medical devices industries (Behera, D., Chizari, S., Shaw, L. A., Porter, M., Hensleigh, R., Xu, Z., Zheng, X., Connolly, L. G., Roy, N. K., Panas, R. M., Saha, S. K., Zheng, X. (Rayne), Hopkins, J. B., Chen, S.-C., & Cullinan, M. A. (2021). However, this is single location plant, but the goal can be enlarged to multiple locations with all the systems that integrate into manufacturing semiconductors using "AddiTech" systems such as structural systems, electrical systems, quality systems, robotics systems, sensor control systems, Electroplating and engraving equipment, power distribution, network, and communication systems are provided below:

Computer-aided design (CAD) software:

CAD software is used to design semiconductors. Electrical engineers use CAD tools to create layouts and diagrams for semiconductor components.

Simulation and modeling software:

These tools are used to simulate and model the behavior of semiconductor devices, ensuring they meet performance specifications.

Programmable logic controller (PLC):

APIs are used to automate and control manufacturing processes, helping to adjust various parameters during production.

3D Printer/Additive Manufacturing Machine:

These machines use additive technology at the heart of the semiconductor manufacturing process. They use electrical systems to deposit or precisely combine each layer of material to create semiconductor components.

Motion control system:

These systems ensure precise movement and positioning of the print head or build platform of the 3D printer to create precise semiconductor structures.

Sensor and response system:

Various sensors, such as temperature sensors and laser scanners, provide real-time information about the printing process, ensuring quality control and accuracy.

Robot system:

In some cases, robotic systems are used to handle materials and facilitate the additive manufacturing process.

Quality control system:

Electrical systems are used to power and control quality control tools such as optical inspection machines, X-ray inspection systems, and electrical testing equipment to ensure the integrity of components sold. guide. Data collection and analysis tools:

The electrical system is used to collect data from various sensors and test equipment. This data is then analyzed to monitor and improve production processes.

Power distribution system:

These systems manage the distribution of electrical energy throughout the manufacturing plant, ensuring that machinery and equipment receive the electrical energy they need.

Heating and cooling system:

Semiconductor manufacturing often requires precise temperature control. The electrical system controls heating and cooling elements to maintain desired temperature conditions. Clean room environmental control system:

Clean rooms used in semiconductor manufacturing rely on electrical systems to filter air, control humidity, and regulate temperature.

Network and communications infrastructure:

A robust communications network is essential for data exchange, process control, and remote monitoring of the production process.

Emergency power backup system:

To ensure continuous production and prevent data loss in the event of a power outage, semiconductor manufacturing facilities often have backup power systems.

Electroplating and engraving equipment:

These machines use electrical processes to deposit or remove material in the semiconductor manufacturing process.

Platelet probes and tests:

These machines use electrical probes to test and validate the functionality of semiconductor devices at various stages of production. Electron microscope:

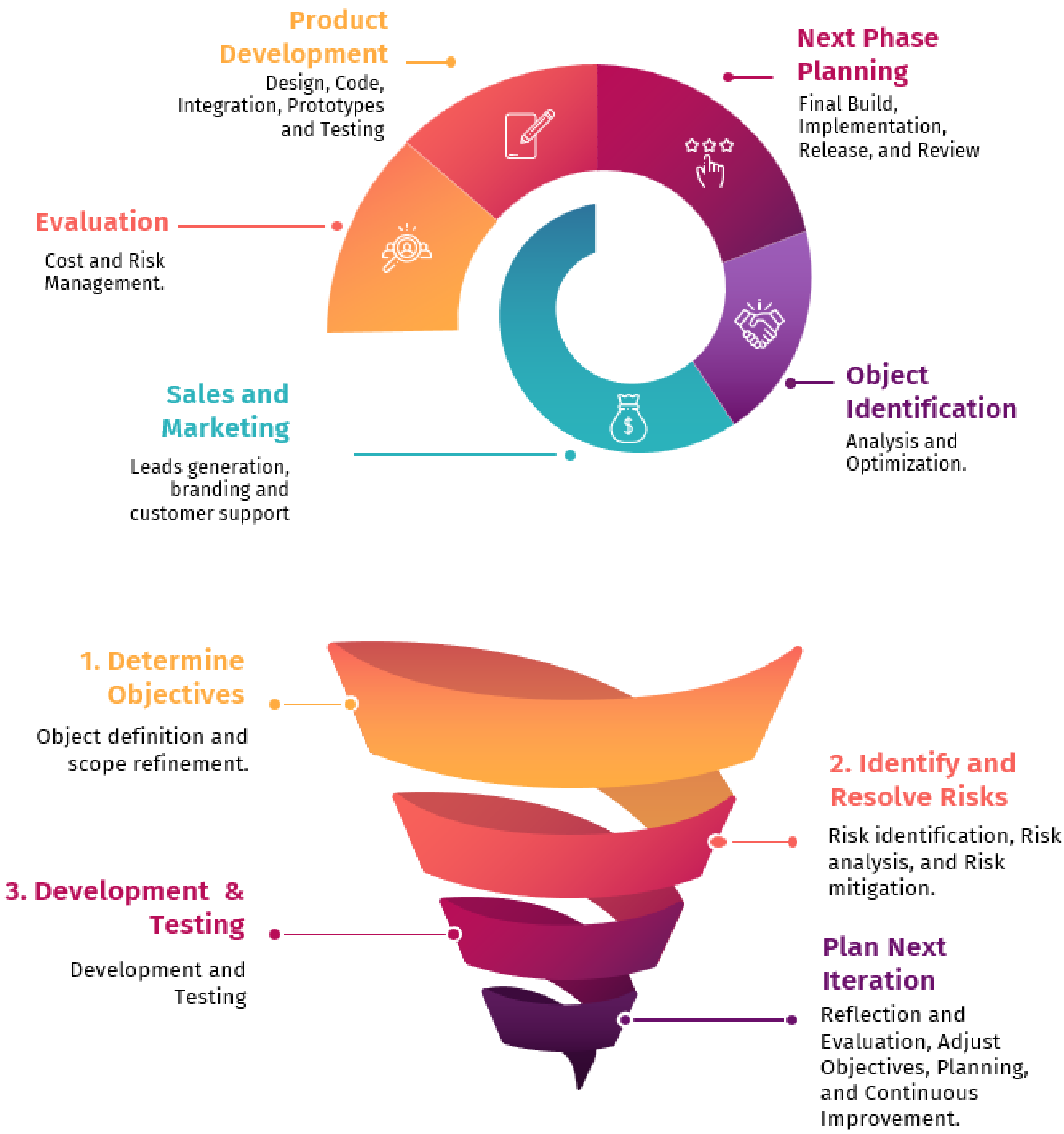
Used for high-resolution imaging and inspection of semiconductor components, electron microscopes depend on electrical systems to operate.

Laser system:

Laser technology is used for a variety of purposes in semiconductor manufacturing, including cutting, engraving, and marking.

The Spiral approach allows for flexibility in risk reduction and requirement adaptation.

Spiral Model:



(Reference template from Google: https://www.slideegg.com/free-spiral-diagram-template)

4.1 System Operational Requirements

Include a table of requirements assuming you received them from the operational test community in establishing your final graded exam for your system.

This data or description will be added after future discussion and testing.

4.2 Maintenance Concept

Include your O-I-D concept for your system including your maintenance requirements in a table.

This data or description will be added after future discussion and testing.

4.3 Technical Performance Measures (TPMs)

Include your 3 TPMs developed from your requirements along with graphs showing the performance targets over time.

This data or description will be added after future discussion and testing.

4.4 Functional Analysis (System Level)

Write about your functional flow block diagram in a few paragraphs and display the FFBD to include your operational flow diagram and maintenance flow diagrams.

Figure 1 below shows the functional flow block diagram (FFBD) of the semiconductor supply chain for the Additive manufacturing technologies systems in High-Performance Super Semiconductor (HPSS) Manufacturing accelerated and secured by AWS cloud.

The five key elements are:

- System Requirements
- Design Data and IP Libraries
- Design Verification and Wafer Fabrication
- Assembly, Testing, and System Maintenance
- Operate the system in the user environment.

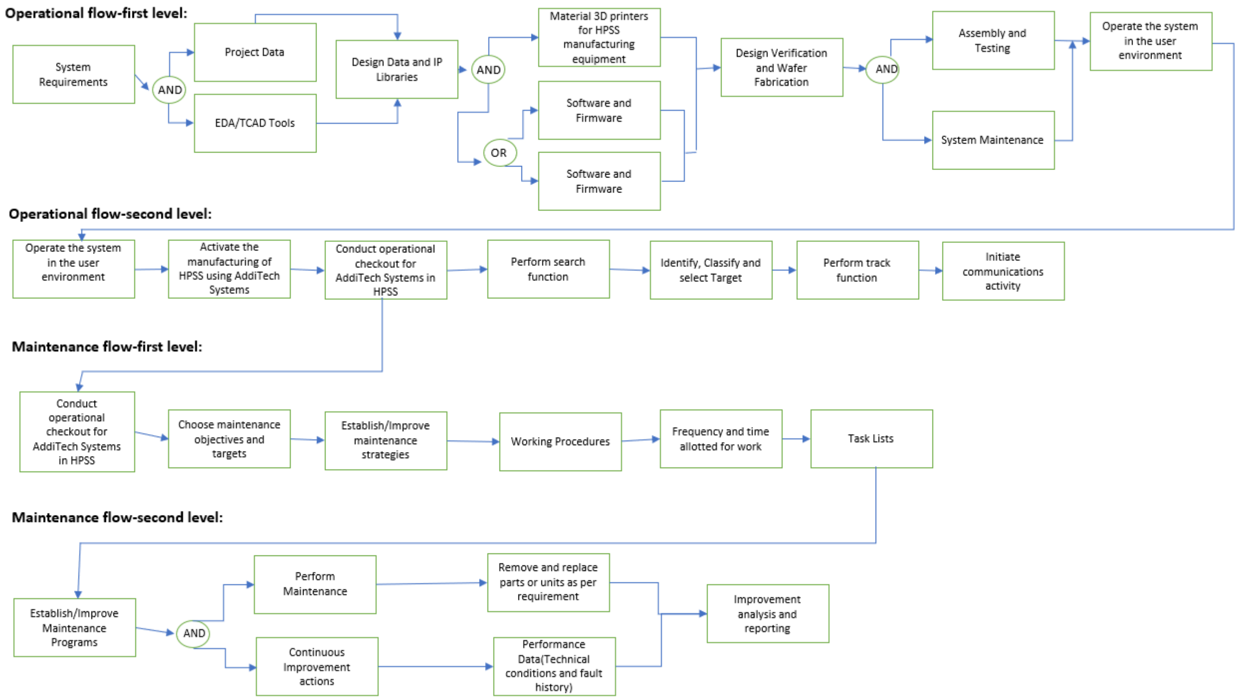


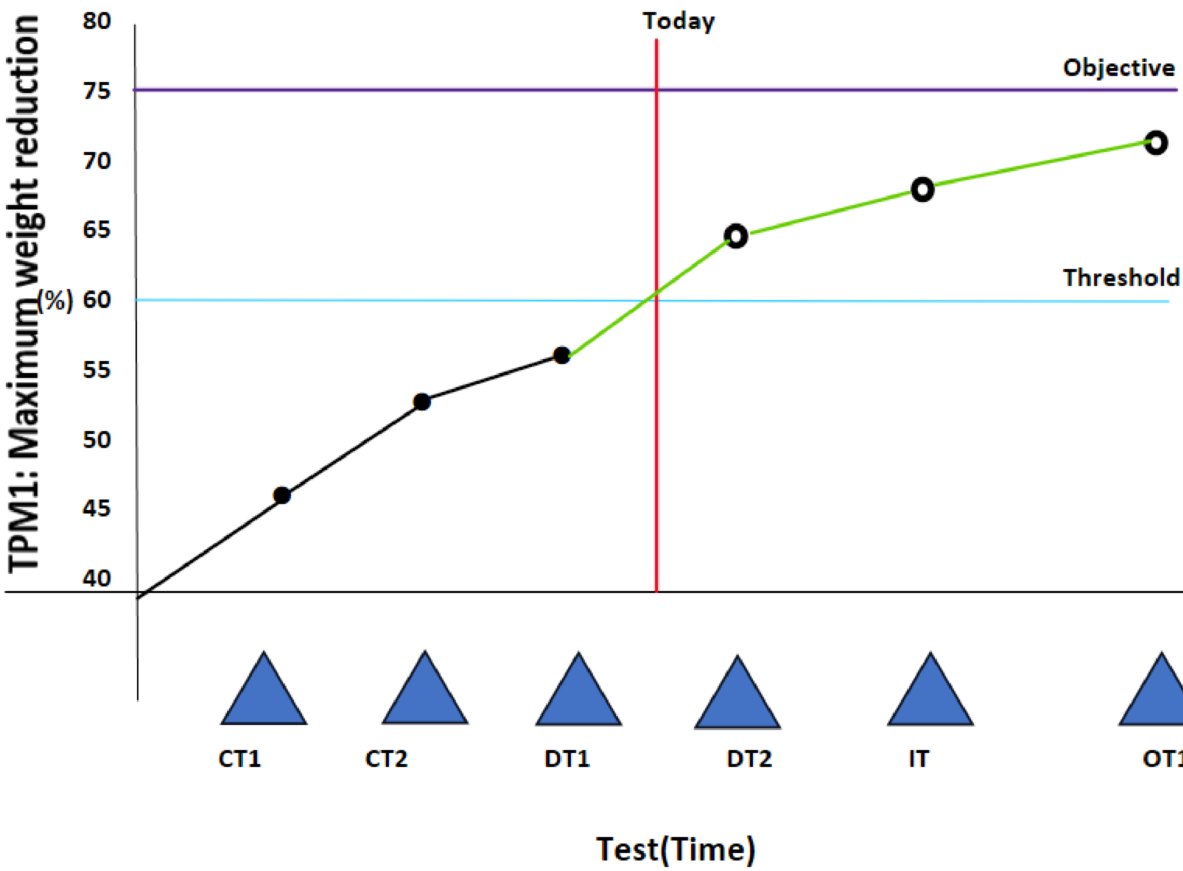
Figure 1 shows ten requirements framed for the Additive Manufacturing Technology Systems in High-Performance Super Semiconductor (HPSS) Manufacturing as a qualitative and quantitative checklist with a system requirement statement and requirements rationale/reference for Mars rovers and Mars orbiters.

INCOSE Guide for Writing Requirements

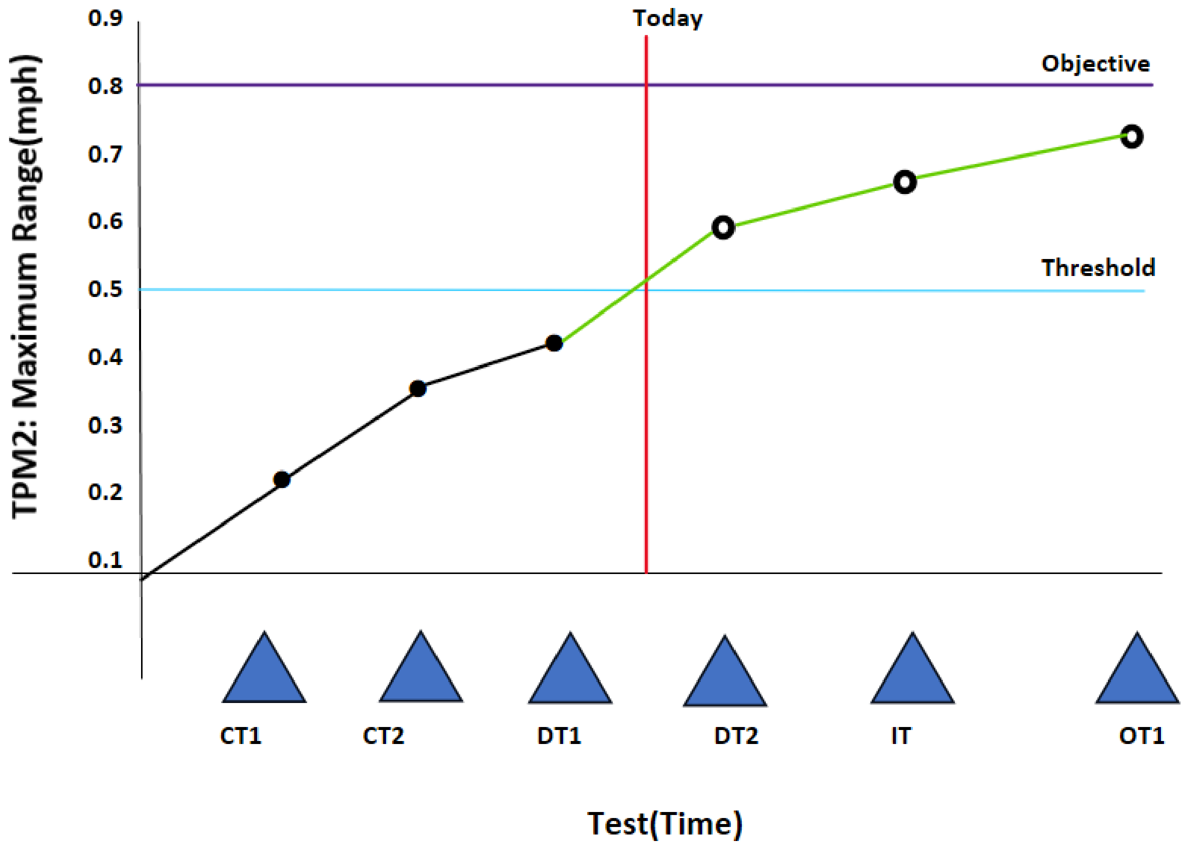
	System Requirement Statement	Necessary	Implentation Independ	Unambiguous	Complete	Singluar	Feasible/Achievable	Verifiable	Correct	Conforming	Requirement Rationale/Reference
1	Up to 60% less weight has been removed from parts and components as a result of the additive manufacturing s	✓	✓	✓	✓	✓	✓	✓	✓	✓	Overall part and component weight reduction by 60%. proto3000. (2021, November 23). 4 Advantages of Additive Manufacturing for Aerospace. Proto3000. https://proto3000.com/3d-printing/4-advantages-of-additive-manufacturing-for-aerospace/#:~:text=Additive%20manufacturing%20means%20little%20or
2	Additive manufacturing system uses less or no tooling, uses less energy, and uses fewer raw materials.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Uses less tooling, less energy, and fewer rat materials (proto3000, 2021).
3	Additive manufacturing allows you to optimize the strength-to-weight ratio.	✓	✓	✓	✓	✓	✓	✓	✓	✓	How additive manufacturing helps the semiconductor industry - Make Parts Fast. (n.d.). Www.makepartsfast.com. Retrieved October 6, 2023, from https://www.makepartsfast.com/how-additive-manufacturing-helps-the-semiconductor-industry/#:~:text=Additive%20manufacturing%20allows%20you%20to%20build%20a%20fluid%20manifold%20or
4	You can create a fluid manifold or cooling structure using additive manufacturing systems in semiconductor manufacturing that puts function before manufacturing efficiency.	✓	✓	✓	✓	✓	✓	✓	✓	✓	How additive manufacturing helps the semiconductor industry - Make Parts Fast. (n.d.). Www.makepartsfast.com. Retrieved October 6, 2023, from https://www.makepartsfast.com/how-additive-manufacturing-helps-the-semiconductor-industry/#:~:text=Additive%20manufacturing%20allows%20you%20to%20build%20a%20fluid%20manifold%20or
5	3D printed heat exchangers can deliver thermal cycling -184°F to 248°F and Helium leak to be less than 1x10-8 GHe SCC/sec.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Ultrasonic Additive Manufacturing helps keep electronics warm in space - Make Parts Fast. (n.d.). Www.makepartsfast.com. https://www.makepartsfast.com/ultrasonic-additive-manufacturing-helps-keep-electronics-warm-in-space/
6	Using an additive manufacturing ultrasonic system, a pressure proofing of 330 PSI can be achieved.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Ultrasonic Additive Manufacturing helps keep electronics warm in space - Make Parts Fast. (n.d.). Www.makepartsfast.com. https://www.makepartsfast.com/ultrasonic-additive-manufacturing-helps-keep-electronics-warm-in-space/
7	Communication, Data Handling, Navigation, Positioning Systems, Imaging and Sensing Technologies.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Semiconductors in Space Exploration: Enabling the Next Frontier. (2023, July 12). Vyrian - Your Primary Source of Semiconductors, Connectors and LEDs. https://www.vyrian.com/semiconductors-in-space-exploration/
8	Using additive manufacturing technology systems in high-performance super semiconductors manufacturing with AWS cloud integration shall improve long-range remote sensing of the Martian atmosphere.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Menzies, R. T., Cardell, G., Chiao, M., Esproles, C., Forouhar, S., Hemmati, H., & Tratt, D. (1999). Development of Prototype Micro-Lidar using Narrow Linewidth Semiconductor Lasers for Mars Boundary Layer Wind and Dust Opacity Profiles. Tenth Biennial Coherent Laser Radar Technology and Applications Conference. https://ntrs.nasa.gov/citations/20000013031
9	The system shall attain a maximum speed of 0.5 mph	✓	✓	✓	✓	✓	✓	✓	✓	✓	mars.nasa.gov. (n.d.). Rover Wheels. Mars.nasa.gov. https://mars.nasa.gov/mars2020/spacecraft/rover/wheels/#:~:text=Rover%20Speed&text=The%20rover%20has%20a%20top
10	The system shall use Grade-5 Titanium (Carpenter's Ti 6Al-4V) material providing a higher yield strength of 135KSI at a minimum 15% elongation in highly stressed conditions.	✓	✓	✓	✓	✓	✓	✓	✓	✓	Mars Rover Instrument Is Manufacturing Challenge, 3D Printing Victory. (2023, October 5). Www.additivemanufacturing.media. https://www.additivemanufacturing.media/articles/mars-rover-instrument-is-manufacturing-challenge-3d-printing-victory

The TPM1: Maximum weight reduction (%) vs Test(time)

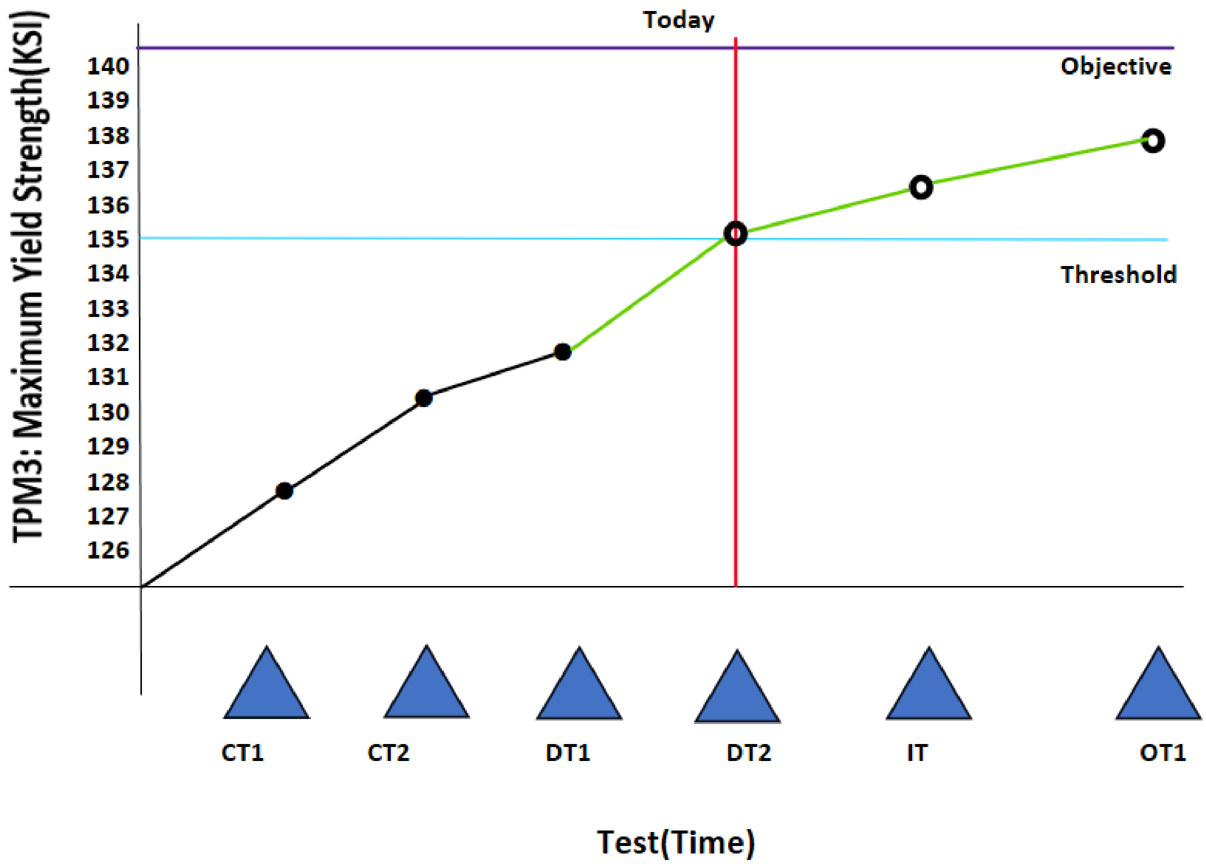
Figure 2. Shows the Maximum weight reduction using Additive Manufacturing Technology Systems for HPSS manufacturing shall reach 60%(Threshold) and 80%(Objective). The validation method conducts analysis and testing at all levels of requirements.



The TPM2: Figure 3 provided below shows that the system shall attain a maximum speed of 0.5 mph (Threshold) and 0.8 mph (Objective) of the rover on autopilot mode. Speed increased by 0.4 mph due to a 60% reduction in weight by using composite materials and design geometry by additive manufacturing technologies generating maximum range.



TPM3: Figure 4 provided below shows that the system shall use Grade-5 Titanium (Carpenter's Ti 6Al-4V) material providing a higher yield strength of 135KSI at a minimum 15% elongation in highly stressed conditions. The yield strength of the system is 135KSI(Threshold) and 140(Objective).



4.5 Allocation of Requirements

Show your 3 allocated requirements and write about each one here.

This data or description will be added after future discussion and testing.

4.6 System Synthesis, Analysis, and Design Optimization

Discuss your design and AoA including an MCDM matrix of options and criteria.

This data or description will be added after future discussion and testing.

4.7 System Test and Evaluation

Discuss your Test and Evaluation strategy including a CT, DT, and OT period along with the key entry and exit criteria of each.

This data or description will be added after future discussion and testing.

4.8 Construction/Production Requirements

How many systems will be produced over the life cycle? Explain any rationale for quantity and show where globally they will be deployed with a visual representation.

This data or description will be added after future discussion and testing.

4.9 System Utilization and Sustaining Support

Describe the sparing philosophy and what kind of support infrastructure, personnel, and facilities are required to support your maintenance strategy and concept with an O-I-D perspective.

This data or description will be added after future discussion and testing.

4.10 System Retirement and Material Recycling/Disposal

Describe your system plan to retire the capability, identify disposal requirements, and any assumptions made for this period.

This data or description will be added after future discussion and testing.

5.0 Technical Program Planning, Implementation, and Control

Technical Program Reviews across the life cycle and how they will be managed.

This data or description will be added after future discussion and testing.

5.1 Program Requirements/Statement of Work

Show a brief statement of work.

This data or description will be added after future discussion and testing.

5.2 Organization (Customer/Producer/Supplier Structure and Interrelationships)

Display a list and graphic of vendors and suppliers that are integral to the system architecture.

This data or description will be added after future discussion and testing.

5.2.1 Producer/Contractor Organization (Project/Functional/Matrix)

Display the lead Contractor organization and the required structure that aligns with the Government IPT.

This data or description will be added after future discussion and testing.

5.2.2 System Engineering Organization

Identify key roles and responsibilities and job descriptions of those on the systems engineering staff at the key Contractor.

This data or description will be added after future discussion and testing.

5.2.3 Program Tasks

Key tasks should be aligned to the program objectives tree of the overall system at the Contractor level.

This data or description will be added after future discussion and testing.

5.2.4 Supplier Requirements

What are the key Contractor supplier requirements and how do they translate into the partitioned and allocated requirements?

This data or description will be added after future discussion and testing.

5.3 Key Organizational Interfaces

From your list of stakeholders, create an Interface Working Group (IFWG). Explain each member of the IFWG, their role, and the interface they control.

This data or description will be added after future discussion and testing.

5.4 Work Breakdown Structure (WBS)

Provide a WBS for your system at least to the third level.

This data or description will be added after future discussion and testing.

5.5 Project Schedule and Milestone Charts

Depict your Schedule and Milestones for your system life cycle such as Figure . Define all milestones including Initial Operational Capability (IOC) and Final Operational Capability (FOC) in terms of deliverable requirements.

Lifecycle Phases and Milestones for AddiTech Systems to design and develop HP Super Semiconductors Manufacturing:

Lifecycle Phase 1: Begins in Spring 2030

Material Solution Analysis (MSA) - Milestone A:

Program Initiation

- Description: Initiation of the AddiTech program in the first step of the life cycle which is material solution analysis, setting the groundwork for the development and evaluation phases. In this material solutions analysis phase, a study of requirements will be performed which addresses the customer need statement, parameters, and variables, and a checklist will be prepared to ensure all the requirements are met with the allocated overall budget. Additive manufacturing allows you to optimize the strength-to-weight ratio (How additive manufacturing helps the semiconductor industry, September 24, 2023).
- Approval to proceed with the development of AddiTech systems.

Concept Refinement

- Description: Refinement of the AddiTech concept, including system requirements and initial design considerations. Semiconductors are designed using CAD software. Layouts and schematics for semiconductor components are created using CAD tools by electrical engineers. These tools are used to simulate and model semiconductor device activity to make sure it complies with performance requirements. APIs are used to automate and regulate industrial processes, enabling the adjustment of numerous production factors.

- Confirmation of the system's feasibility and readiness for the next phase.

Technology Demonstration

- Description: In this stage, Demonstration of key technologies and capabilities essential for AddiTech systems are performed.
- Assessment of technology readiness for further development.

In the Completion of phase 1, the deliverables such as the development of SEP initiates, Cost analysis of the life cycle, and Initial SRR will be initiated and performed and TRL will also be carried out at level 2

Lifecycle Phase 2: Completion in 2032

Technology Maturation and Risk Reduction and Risk Reduction (TMRR) - Milestone B:

System Design Review

- Description: At this stage of the life cycle the comprehensive AddiTech system design, architecture, and technology readiness review will be conducted, risk will be reduced and the system will be updated with the solutions associated with the risk reduction considering the budget, addressing with stakeholders and other qualitative and quantitative resources.
- Approval to proceed with detailed design and prototyping.

Prototype Development

- Description: Development and testing of AddiTech prototypes to validate system functionality and performance. Rapid prototyping is possible at this stage using additive manufacturing. The core of the semiconductor manufacturing process is additive technology, which is used by 3D printing machines. To make semiconductor components, they accurately deposit or mix each layer of material using electrical systems.

- Evaluation of prototype success and readiness for full-scale development.

Risk Reduction and Testing

- Description: Ongoing risk reduction efforts and testing to address any identified issues. The identified issues will be rectified and all the corresponding errors, lag in the overall systems, and risks will be reduced, and a progressive stage will be achieved here in this phase of TMRR by the end of 2034.
- Confirmation of risk reduction and readiness for the next phase.

At the end this phase 2, the completion would include: Continiuous SEP development, the secondary SRR is performed and evaluated along with the completion of SFR and PDR. TRL level will be noted at level 4.

Lifecycle Phase 3: Completion in 2035

Engineering and Manufacturing Development (EMD) - Milestone C:

Critical Design Review (CDR)

- Description: In-depth review of the critical design aspects of AddiTech systems. All the design aspects and manufacturing processes will go through a critical review for design optimization and perfection. As a result of the previous stage, rapid prototyping and testing have accelerated the design curve allocating more time in critical review. All the engineering and manufacturing development systems will be reviewed completing rigorous analysis, simulations, schematics, software code, and test results.
- Approval to proceed with manufacturing and production.

Low-Rate Initial Production (LRIP)

- Description: Initial production of AddiTech systems at a limited scale for further testing and evaluation. All the challenges, questions, and improvements will be addressed here along with constructive and productive testing and evaluation with risk reductions.

- Assessment of LRIP success and readiness for full production. After careful engineering and manufacturing development, it will be transferred to the production and deployment phase where a full-scale model will undergo production for final deployment. Aerosol Jet Printing (AJP) and Selective Laser Sintering (SLS) are AM Technologies Enabling Semiconductor Manufacturing (Markets, R. and. (2022, December 13).

Lifecycle Phase 4: Completion in the year 2038

Production and Deployment - IOC

Full-Rate Production

- Description: Transition to full-scale production of AddiTech systems for deployment.
- Confirmation of production capability and readiness for deployment.

Deployment

Initial Operational Capability (IOC)

- Description: Initial deployment of AddiTech systems to designated locations.
- Evaluation of system performance and operational capability.

Lifecycle Phase 5: Final Completion in the year 2040

Fully Operational factory/factories will be played out across Austin, Texas by the end of 2040 with an overall budget of $700 Million.

Operations and Support (O&S) and Disposal - FOC

Full Operational Capability (FOC)

- Description: Achievement of full operational capability for AddiTech systems.
- Confirmation of sustained operational success.

Disposal

System Disposal

- Description: Planning and execution of the responsible disposal of AddiTech systems at the end of their lifecycle.
- Completion of disposal activities and assessment of environmental impact. After the FOC accomplishment, the final unit will be delivered in 2040.

Additive manufacturing for semiconductor devices provides many of the benefits found in other products, and these devices can be incorporated into 3D-printed PCBs and other electronics (Additive Manufacturing for Semiconductor Devices and Its Impact on R&D, 2023).

The lifecycle stages during the 10-year program for the biggest semiconductor facility across Austin, Texas consisting of a total of 20 systems are shown in the accompanying chart illustration. A thorough explanation of each phase and the requirements for moving on to program development are also provided:

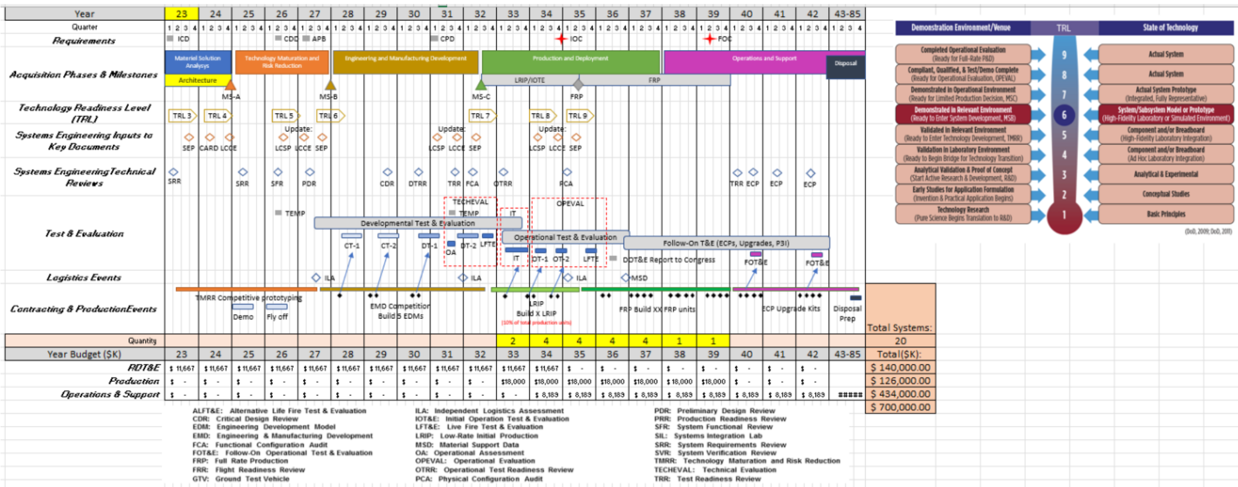
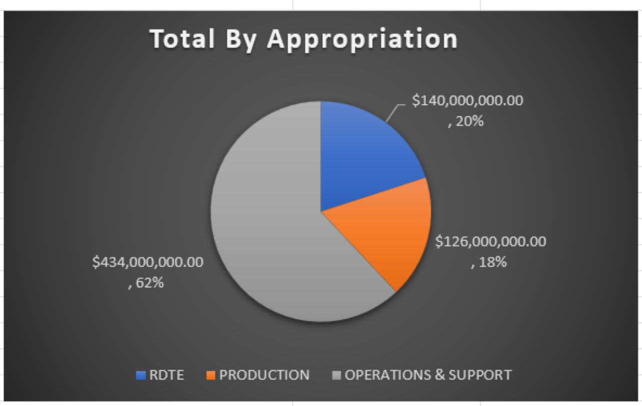


FIGURE 1. SYSTEM SCHEDULE AND MILESTONES

The Life Cycle Cost Estimate provided for a single HP Semiconductor using an Additive Manufacturing plant with an estimated overall budget of $700M is provided below:

Total Budget from Customer Need Statement:	$ 700,000,000.00				
Appropriations	**Percentage**	**Total by Percentage**	**Total Years of Phase**	**By Year**	**($K)**
RDTE	20%	$ 140,000,000.00	12	$ 11,666,666.67	$ 11,667
PRODUCTION	18%	$ 126,000,000.00	7	$ 18,000,000.00	$ 18,000
OPERATIONS & SUPPORT	62%	$ 434,000,000.00	53	$ 8,188,679.25	$ 8,189
	100%	$ 700,000,000.00			

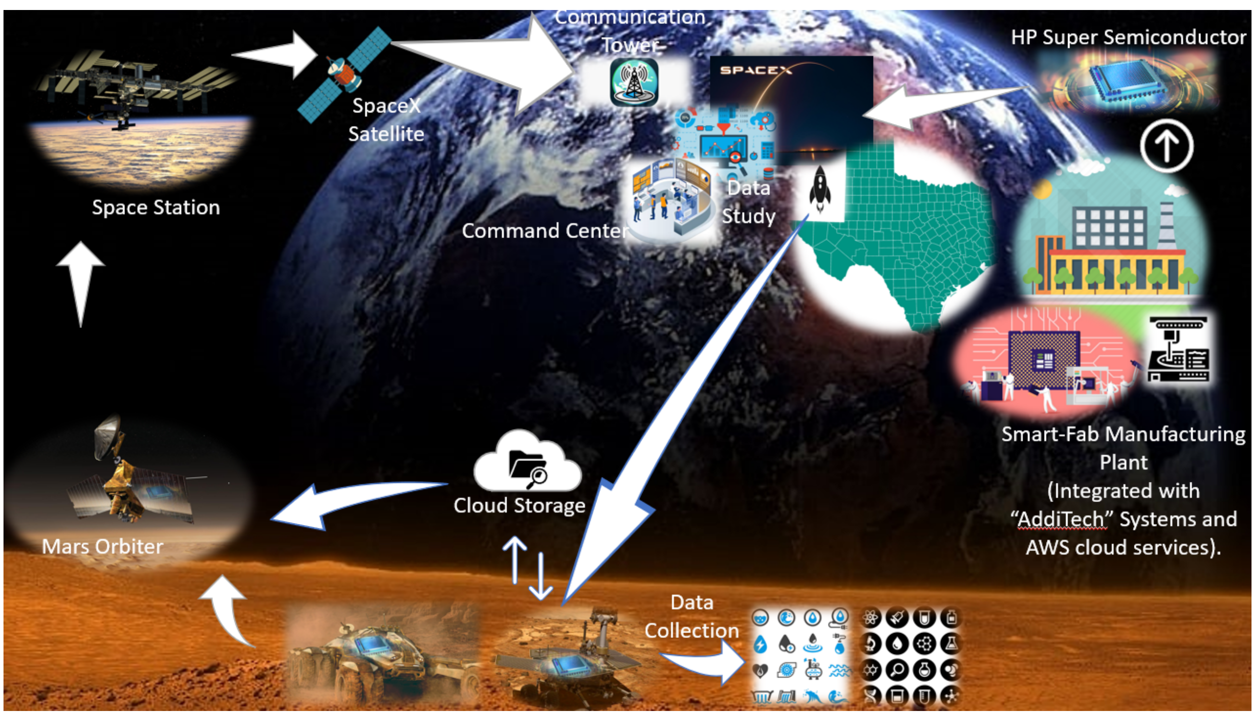


A Customer Needs Statement (CNS) is developed below:

Customer Need Statement (CNS)		Major Key Takeaways in CNS:
Who	SpaceX company placed a bulk order of High-Performance Super Semicondocutor (HPSS) chips manufactured using an "Additive Manufacturing" System which delivers unmatched high performance for semiconductor applications in aerospace for the Mars Rover.	**SpaceX**
What	Twenty SpaceX systems with a need/demand of HPSS chips manufactured using an "Additive Manufacturing" system are required to be constructed and deployed.	**20 systems**
Where	Launches are to be conducted in Texas, Florida, and California each of the twenty SpaceX systems is to be launched into space for a space mission to Mars. However, all the products are designed, engineered, developed, and manufactured in one plant which is located in Austin, Texas and then suppied to Texas, Florida and California. the respective lauches.	**Texas**
When	The SpaceX needs all 20 systems to be deployed by the end of 2040	**NLT 2040**
How much ($)	A total of $700M has been budgeted by SpaceX for this project over the entire life cycle.	**$700M LCCE**

Operational View-1:

OV-1 for the Additive Manufacturing Technology Systems in High-Performance Super Semiconductor Manufacturing for the Mars Rovers and Mars Orbiters:



Replacing the process of cutting the wafers from a 99.99% pure silicon salami-shaped bar and ensuring great smoothness, it is possible to speed up the deposition process by using 3D printers, allowing thin films of conducting, isolating, or semiconducting materials to be created by 3D printers by the needs of the current geometrical structure. Using additive technology, the positive and negative types of photoresist coating will be applied to the wafer to provide a thin, uniform, and consistent covering. From here, lithography, etching, ion implantation, and packaging are performed to produce semiconductors more quickly and effectively. This is done while integrating the AWS cloud and accelerating the entire Smart Fab facility. The total chip manufacturing process is accelerated by 3D printing electrical parts including resistors, transistors, capacitors, antennas, radio frequency (RF) devices, etc. The AM technologies that make it possible to manufacture HPSS include selective laser sintering (SLS), aerosol jet printing (AJP), digital light processing (DLP), and stereolithography (SLA).

The following includes the key features of the High-Performance super semiconductor (HPSS) using Additive Manufacturing Technology in the rover and orbiter:

1. Computing and Controlling: To improve processing, command execution, control algorithms, and data storage, the HPSS will be deployed and integrated into the rover's onboard computers and control systems. The HPSS uses artificial intelligence (AI) to power its automated driving, impediment detection, and reporting functionalities.

2. Communication: The rover's communication systems, which are made up of transmitters, receivers, and signal processing circuits, are improved by the HPSS and allow the rover to send and receive data and commands to and from Earth.

3. Sensors and Instrumentation: To gather and process information about the Martian environment, the HPSS is employed in sensors and equipment found in cameras, spectrometers, and other instrumentation.

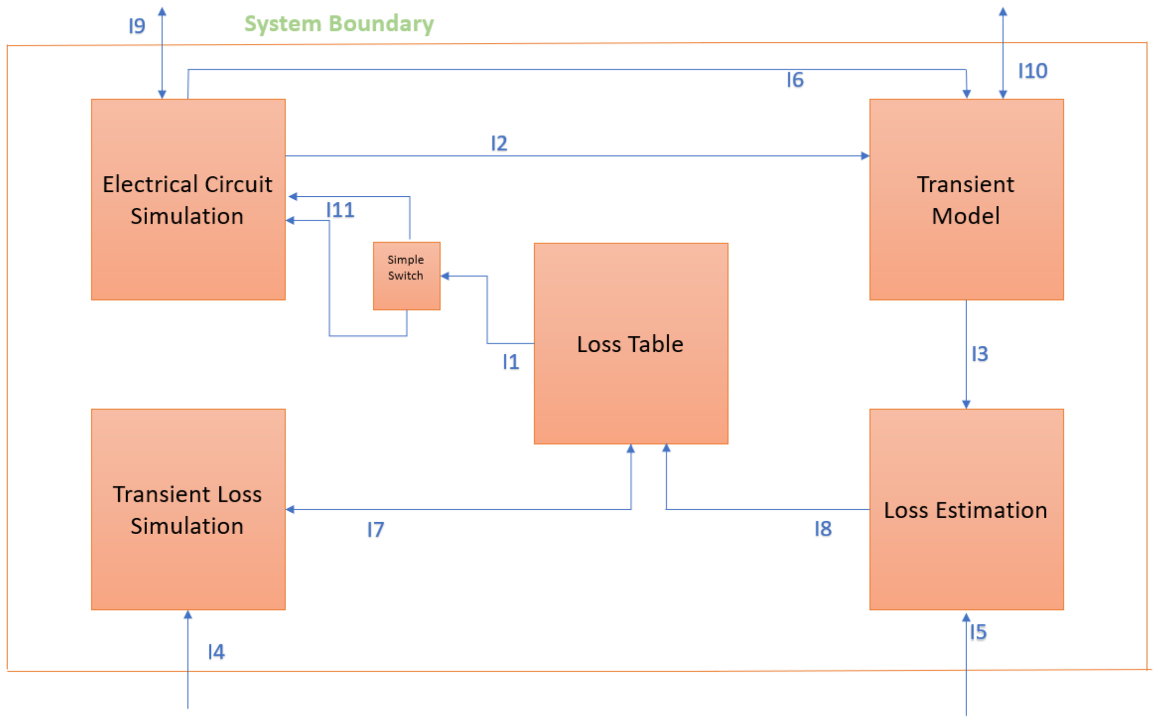
4. Power Management: The rover's power management systems, which include voltage regulators, power converters, and battery charging circuits, are equipped with the HPSS. The HPSS aids in effectively managing and distributing electricity from the rover's radioisotope thermoelectric generators or solar panels.

5. Motor Control: With AI-powered self-driving and obstacle-handling capabilities, the HPSS enhances motor driving and control and enables accurate control of the rover's wheels, robotic arm, and other moving parts.

Other Key deliverables: The rover and orbiter perform the below operations and achieve the following deliverables.

- Describe the main differences in a sequence of Martian sedimentary rocks' stratigraphic, sedimentologic, and facies compositions.
- Recognize the minerals and rocks found in a deep subterranean groundwater environment.
- Recognize interactions between the Martian surface's water, rock, and atmosphere and how they have evolved through time.
- Analyze the temporal and spatial petrogenesis of the igneous rocks on Mars.
- Analyze and describe carbon, taking into account any potential organic and pre-biotic chemistry.
- Analyze the likelihood that any observed life forms are alive or were just a short time ago.

The Schematic Block Diagram (SBD) of the online simulation system of power semiconductor losses in PSCAD (Power Systems Computer Aided Design) is provided in Figure 1 below.



The interface description is as follows:

I1. Operating Conditions

I2. Operating Range

I3. Switching Waveform

I4. Online Simulation

I5. Offline Simulation

I6. Device Parameters

I7. Transient Loss Simulation Flow

I8. Loss Estimation Flow

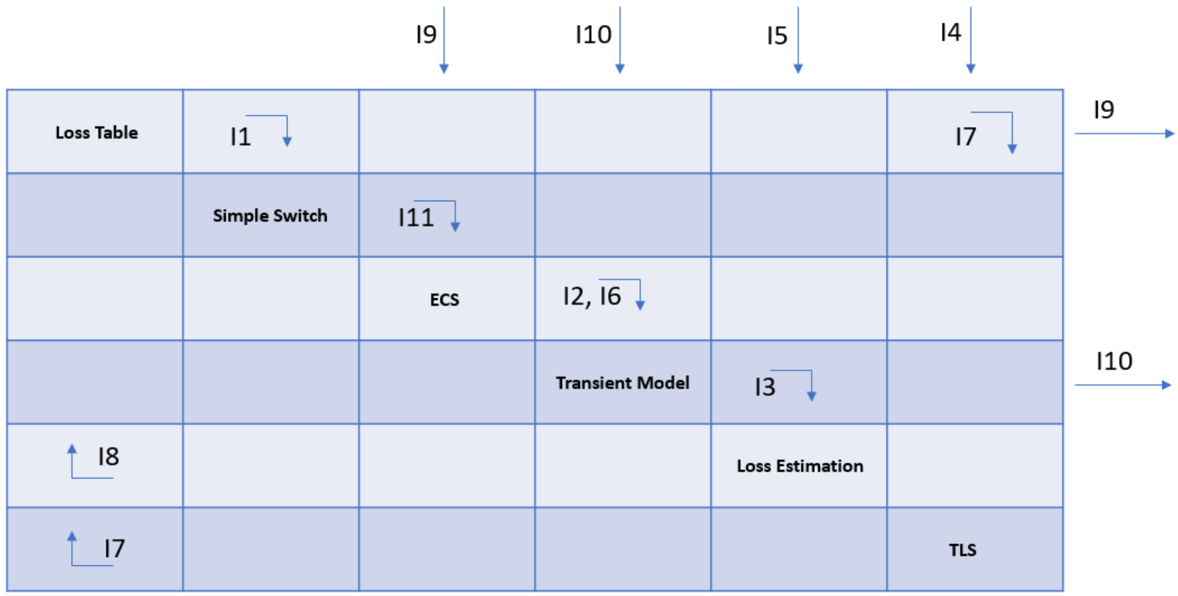
I9. Power Input and Voltage Check

I10. Data or Power Lines.

I11. Switch to circuit flow for further simulation.

Please see Figure 1 provided below, which is the N^2 diagram for the online simulation system of power semiconductor losses in PSCAD (Power Systems Computer Aided Design).

Figure 1: N^2 diagram



The interface description is as follows:

I1. Operating Conditions

I2. Operating Range

I3. Switching Waveform

I4. Online Simulation

I5. Offline Simulation

I6. Device Parameters

I7. Transient Loss Simulation Flow

I8. Loss Estimation Flow

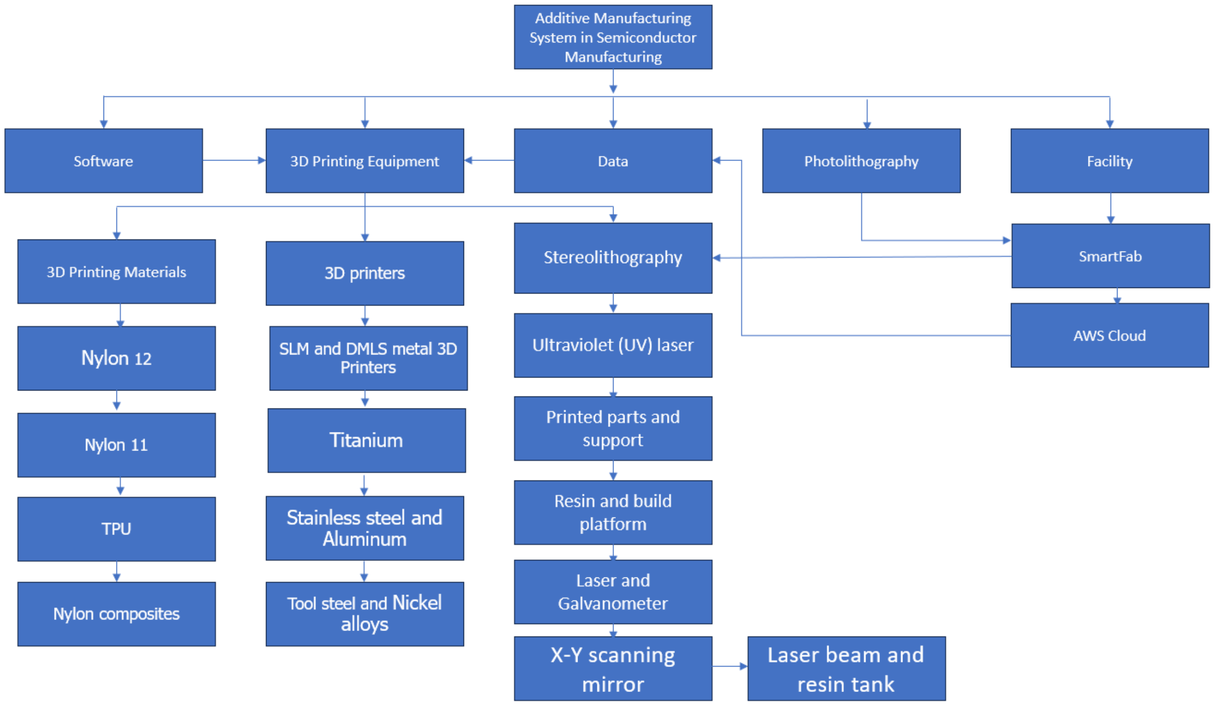
I9. Power Input and Voltage Check

I10. Data or Power Lines.

I11. Switch to circuit flow for further simulation.

Note:
ECS: Electrical Circuit Simulation
TLS: Transient Loss Simulation

5.6 Product Entity Diagram



Multi-Criteria Decision-Making (MCDM) Analysis of Alternatives:

From the Additive Manufacturing Systems in semiconductor manufacturing, I have selected 3D printing materials as a subsystem from the product entity diagram to create a Multi-Criteria Decision (MCDM) Analysis of Alternatives (AoA). There are five alternatives: Nylon 12, Titanium, Stainless Steel, Aluminum, and Selective laser melting (SLM) metal. The MCDM Analysis of Alternatives (AoA) has five criteria: Risk Index, Cost, Thermal Conductivity, Hardness, and Resistivity. The original data is converted into normalized data in the 3D printing materials subsystems and WSD and WPM are created with calculations performance scores and ranking. Analyzing the five alternatives based on the criteria utilizing the Weighted Sum Model (WSM) and Weighted Product Model (WPM) determined that the preferable materials are titanium(Rank 1) and Nylon-12(Rank 2) in both cases followed by stainless steel(Rank 3), aluminum(Rank 4), and SLM metal(Rank 5) as per the ranking based on the performance scores.

Figure 1: Original Data

3D printing materials sub-system

Criteria (is better)	Lower is better	Lower is better	Higher is better	Higher is better	Higher is better
Weight(Wj)	0.20	0.25	0.15	0.20	0.20
Alternatives	Risk Index(I)	Cost($)	Thermal Conductivity (N/M-K)	Hardness (N/MM)	Resistivity (ΩM)
Nylon 12	1.60	250	4.65	16.25	22.83
Titanium	1.85	180	3.86	8.28	65.85
Stainless Steel	3.48	200	6.92	10.25	20.25
Aluminum	1.45	265	2.10	5.55	25.25
Selective laser melting (SLM) metal	1.23	255	1.25	6.86	30.25

Figure 2: Normalized Data

Criteria (is better)	Lower is better	Lower is better	Higher is better	Higher is better	Higher is better
Weight(Wj)	0.20	0.25	0.15	0.20	0.20
Alternatives	Risk Index(I)	Cost($)	Thermal Conductivity (N/M-K)	Hardness (N/MM)	Resistivity (ΩM)
Nylon 12	0.76	0.72	0.671	1	0.346
Titanium	0.66	1	0.557	0.509	1
Stainless Steel	0.35	0.9	1	0.630	0.307
Aluminum	0.84	0.67	0.303	0.341	0.383
Selective laser melting (SLM) metal	1	0.78	0.180	0.422	0.459

Figure 3: Weighted Sum Model (WSM)

Criteria (is better)	Lower is better	Lower is better	Higher is better	Higher is better	Higher is better		
Weight(Wj)	0.20	0.25	0.15	0.20	0.20		
Alternatives	Risk Index(I)	Cost($)	Thermal Conductivity (N/M-K)	Hardness (N/MM)	Resistivity (ΩM)	Performance score	Rank
Nylon 12	0.152	0.18	0.100	0.20	0.0692	0.7012	2
Titanium	0.132	0.25	0.083	0.101	0.20	0.766	1
Stainless Steel	0.07	0.225	0.15	0.126	0.0614	0.6324	3
Aluminum	0.168	0.167	0.045	0.068	0.0766	0.524	5
Selective laser melting (SLM) metal	0.20	0.195	0.027	0.0844	0.0918	0.5982	4

Figure 4: Weighted Product Model (WPM)

Criteria (is better)	Lower is better	Lower is better	Higher is better	Higher is better	Higher is better		
Weight (Wj)	0.20	0.25	0.15	0.20	0.20		
Alternatives	Risk Index (I)	Cost ($)	Thermal Conductivity (N/M-K)	Hardness (N/MM)	Resistivity (ΩM)	Performance score	Rank
Nylon 12	0.946	0.921	0.941	1	0.808	0.662	2
Titanium	0.920	1	0.915	0.873	1	0.734	1
Stainless Steel	0.810	0.97	1	0.911	0.789	0.564	3
Aluminum	0.965	0.904	0.836	0.806	0.825	0.484	5
Selective laser melting (SLM) metal	1	0.939	0.773	0.841	8.555	0.521	4

Testing and evaluation (T&E):

Testing and evaluation (T&E) are an important process to evaluate the performance, reliability, and safety of different systems, products, or technologies. This involves systematically reviewing and validating these elements to ensure they meet specific requirements and operate as intended. T&E helps identify defects, weaknesses, or areas for improvement, allowing developers to make necessary adjustments before final deployment. This involves designing and running tests, simulations, and evaluations to collect data and evaluate the functionality, durability, and effectiveness of the product. T&E is essential across multiple industries, including aerospace, military, automotive, and technology, ensuring that products and systems meet quality standards and perform optimally (Test & Evaluation Overview, n.d.).

Contractor Test 1 (CT-1): Initiation of Contractor Test 1 (CT-1) must occur early in the system life cycle. As previously reported, the launch of CT-1 for additive manufacturing systems in semiconductor manufacturing is planned for the end of the first quarter of 2028. This phase will mainly focus on information analytics through modeling and simulation. The implementation of Technical Performance Measures (TPM) will begin, and their evaluation will be carried out. Technical evaluation and analysis will be performed to predict certain characteristics of additive manufacturing systems for semiconductor manufacturing, using established cloud technologies such as the AWS Cloud.

Contractor Test 2 (CT-2): Contractor 2 testing will continue using the prototype model along with follow-up testing from CT-1 and additional testing of environmental conditions, technical data verification, and testing and evaluation personnel. CT-2 falls in the Q1 and Q2 of financial year 2029 in the phase “Engineering and Manufacturing Development” and will be the next test that addresses all the findings from CT-1, as well as incorporating hardware and software prototypes. The functionality of semiconductors produced using additive manufacturing will be tested and optimal thermal management in semiconductor manufacturing will be achieved using AI-powered generative design and additive design prototypes.

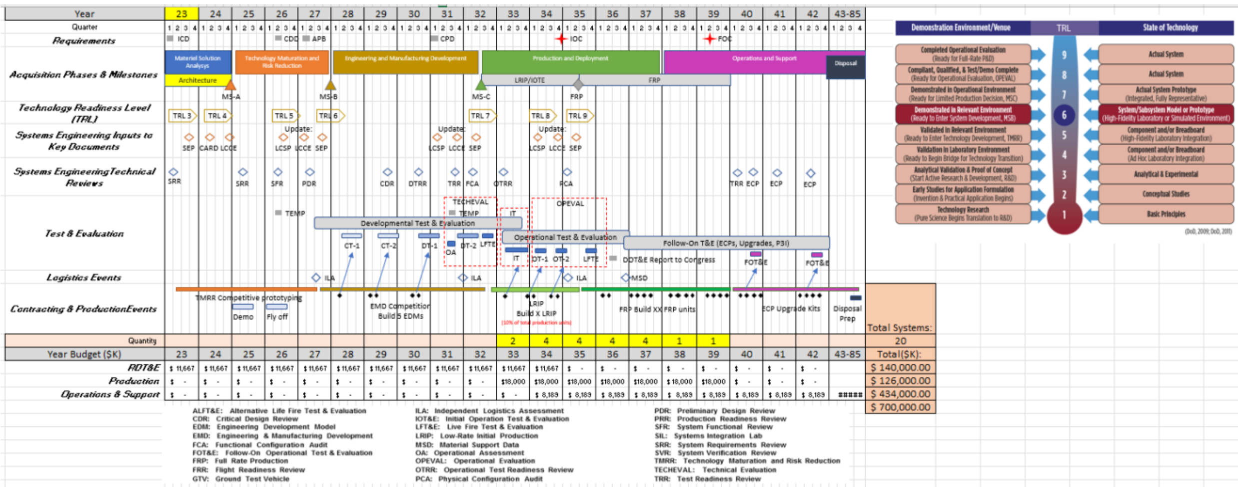
Development Test 1 (DT-1): Deployment of DT-1 in the second and third quarters of 2030 will allow the program to move into the developmental testing phase. DT-1 is used to assess the system's functionality and pinpoint any issues or requirements that may arise. This happens in the life cycle's engineering and manufacturing development phases. Usually, a system prototype is used for this. Environmental testing, reliability testing, maintainability testing, and technical data verification are a few examples of these tests.

Development Test 1 (DT-2): Developmental Testing II will continue to build upon the testing and findings in DT-1 with the addition of more integrations on semiconductor manufacturing using additive manufacturing. DT-2 takes place during the phase "Engineering and Manufacturing Developments" by the end of the year 2031 and in the initial year of 2032. In this developmental testing phase, the prototype goes through rapid testing and multiple test iterations to make sure that the requirement criteria are met. After the DT-2, the prototype is ready for full-fledged production and enters the "Production and Deployment" stage.

Operation Test 1 (OT-1) and Operation Test 2 (OT-2): In OT-1 and OT-2, the operation testing takes place in the phase “Production and Deployment”. In this operational testing, the effectiveness and suitability of a capability or asset and its subsystems for users to carry out the missions for which they are intended to be used, as well as the evaluation of the testing's outcomes, are to be ascertained through testing the capability or asset and its subsystems under conditions similar to those in which they will be deployed (Definition: Operational Test and Evaluation from 14 USC § 581(12) | LII / Legal Information Institute, n.d.).

In 2034, from Q1 to Q4, and in Q1 of 2035, the operational testing and evaluation are carried out for the deployment of 20 systems in total followed by “Operations and Support” and "Disposal". For the first time, the system's parts—prime equipment, software, and support components—are all operated and assessed together. A rigorous assessment of all significant interfaces—that is, common functions and their interfaces—between the various systems and inside a specific SOS configuration is also a part of this testing process. The system is often assessed by several simulated operating exercises, where performance, efficacy, compatibility between the main mission-oriented system segments and the support parts, and other factors are considered (Blanchard & Blybler, 2016).

Additive Manufacturing Systems in High-Performance Semiconductor Manufacturing/Fabrication (AMS-HPSM) Product Life Cycle Schedule:



5.7 Program Cost (Projections/Reporting)

This data or description will be added after future discussion and testing.

5.9 Program Monitoring and Control

What type of governance will be used in your system and program? Consider using Earned Value Management tools and leadership skills.

This data or description will be added after future discussion and testing.

6.0 Engineering Specialty Integration (Identification of Key Engineering Specialties, How They Relate to System Engineering, and Their Interrelationships with Each Other)

6.1 "Functional" Engineering (e.g., Electrical, Mechanical, Structural, Industrial, etc.)

6.2 Software Engineering

6.3 Reliability Engineering

6.4 Maintainability Engineering

6.5 Human Factors Engineering

6.6 Safety Engineering

6.7 Security Engineering

6.8 Manufacturing and Production Engineering

6.9 Logistics and Supportability Engineering

6.10 Disposability Engineering

Think about what if any rare earth elements, disposal methods, early design features that can be recycled, reused, upgraded, etc.

6.11 Quality Engineering

6.12 Environmental Engineering

6.13 Value/Cost Engineering

6.14 Other Engineering Disciplines (as appropriate)

This data or description will be added after future discussion and testing.

1. Five Reliability, Maintainability, and Availability (RMA) requirements:

The emphasis is on guaranteeing the dependability, simplicity of maintenance, and continuous availability of the additive manufacturing processes when evaluating Reliability, Maintainability, and Availability (RMA) requirements in the context of additive manufacturing in semiconductor manufacturing. The following five RMA specifications are unique to semiconductor manufacturing additive manufacturing:

1. Maintainability of Additive Manufacturing Equipment: Determining maintenance schedules, preventive maintenance protocols, and the availability of essential components for repair or replacement are all included in this. I have observed by reading the Reliability, Maintainability,

and Availability (RMA) Handbook that a key factor involved in maintainability is Mean Downtime which is an operational performance measure that includes all sources of system downtime, including corrective maintenance, preventive maintenance, travel time, administrative delays, and logistics supply time (Reliability, Maintainability, and Availability (RMA) Handbook, 2014).

2. Availability of Additive Manufacturing Processes: To reduce downtime, specify the expected uptime, locate any possible bottlenecks, and create backup or redundancy plans. To guarantee continuous availability, this may entail using real-time monitoring and predictive maintenance strategies. The NIST Measurement Science Roadmap for Additive Manufacturing identifies in-process sensing, monitoring, and real-time control of AM processes as the primary enablers to decrease variability in AM processes and consequently improve production throughput and product quality (“Real-Time Monitoring and Control of Additive Manufacturing Processes,” n.d.).

3. Reliability of Printed Components: Considering the parts' failure rates, performance in stressful or extreme situations, and anticipated lifespan. For AM, reliability is dependent on one’s machine, material, and a robust or well-weathered procedure to carry out the process (Achieving Consistency and Reliability in Additive Manufacturing | 2018-04-16 | Quality Magazine, n.d.). Improving the dependability of the produced components may entail choosing the right material, adjusting printing settings, and using post-processing methods.

4. Quality Assurance and Process Control: Strong quality control procedures should be implemented to guarantee the dependability of semiconductor components printed using 3D technology. To guarantee the integrity and caliber of the printed parts, this entails inspection and testing procedures, including non-destructive testing techniques. To keep the additive

manufacturing process consistent and repeatable, take into account process control measures. The largest obstacle to the broad use of additive manufacturing (AM) technologies for metal components in the aerospace industry, according to many studies, is quality assurance and control. One approach to overcome this challenge is to implement in-situ process monitoring and inspection systems to enhance the quality of the printed parts and AM processes (Achieving Consistency and Reliability in Additive Manufacturing | 2018-04-16 | Quality Magazine, n.d.). These technologies enable minimized variances in AM processes and the consequent product quality and production throughput.

5. Life-Cycle Support and Documentation: This includes writing comprehensive handbooks for the upkeep and operation of equipment as well as troubleshooting and maintenance and offering maintenance staff and operators training courses to guarantee correct handling throughout the life cycle. For a comprehensive understanding of the environmental sustainability of Additive manufacturing processes, all the required inputs and outputs need to be considered across the different life cycle stages of an additive manufacturing product (Title Life-Cycle Assessment of Semiconductors, n.d.).

2. Environmental Stress Screening (ESS) plan:

Environmental Stress Screening (ESS) is a testing procedure used in the production of semiconductor and electronic parts to find flaws and weaknesses that could cause problems later on in the system's operational life. It is part of the manufacturing process and is therefore performed on 100% of the items manufactured (2015-09-02T14:27:16-04:00November 26th & Post, n.d.). Even though conventional ESS techniques are well-established, there are some considerations when applying ESS to additive manufacturing in the semiconductor industry. In the context of additive manufacturing in semiconductor manufacturing, the following are important factors to take into account for System Environmental Stress Screening:

Material Qualification:

Goal: Confirm that the materials used in additive manufacturing are dependable.

ESS Method: To make sure that the 3D-printed materials can survive the environmental difficulties involved in semiconductor manufacturing processes, test the materials under various stress conditions. This could entail exposure to chemicals, high or low humidity, and extreme temperatures. From the perspective of the product's user, the two biggest drawbacks are the reduced mechanical qualities and susceptibility to environmental influences that arise while using produced goods (Głowacki et al., 2022).

Printed Component Reliability Testing:

Goal: Assess the dependability of semiconductor components printed using 3D printing.

ESS Method: Heat cycling, vibration, and other environmental stresses that mimic the printed components' circumstances in their operational life should be applied to the components. Keep an eye out for any indications of warping, delamination, or other structural flaws.

For additive manufacturing in semiconductor manufacturing, a strong System Environmental Stress Screening procedure must be put in place to guarantee the dependability and functionality of 3D-printed parts in electronic systems. It is necessary for qualified AM operators and machines to oversee the use of AM equipment in these conditions (Standardization Roadmap for Additive Manufacturing VERSION 1.0 PREPARED by the America Makes & ANSI Additive Manufacturing Standardization Collaborative (AMSC), 2017).

3. Role of the Failure Mode, Effect, and Criticality Analysis (FMECA):

Failure Mode, Effect, and Criticality Analysis (FMECA): To identify potential design weaknesses through a system analysis approach considering all possible ways in which a component can fail (the modes of failure), the possible causes for each failure, the likely frequency of occurrence, the criticality of failure, the effects of each failure on system operation (and on various system components), and any corrective action that should be initiated to prevent (or reduce the probability of) the potential problem from occurring in the future (Blanchard & Blybler, 2016).

Identification of Failure Modes:

Finding probable failure modes unique to the additive manufacturing process is the first step in the FMECA process. This includes being aware that, in contrast to conventional manufacturing techniques, 3D printing could introduce novel failure modes. The semiconductor manufacturing team can proactively address possible issues that may arise during the printing of semiconductor components by identifying failure modes. The FMECA documents the most critical risks of failure in a system design, determines the effect of each failure on the product, and ranks each failure according to its detectability, severity, and probability of occurrence (Martinez-Marquez et al., 2020).

Assessment of Failure Effects:

Every identified failure mode's impact on printed components, the manufacturing process, and the system is evaluated by FMECA. Improved risk mitigation techniques are made possible by an understanding of the effects of potential failure modes. The FMECA thus facilitates the identification of preventive and corrective actions for risk mitigation leading to higher quality, enhanced safety, and higher reliability (Martinez-Marquez et al., 2020). It aids in the prioritization of crucial failure modes that might seriously impair the reliability and performance of semiconductors.

Criticality Analysis:

Critical analysis is a component of FMECA that ranks failure modes according to their probability and severity. One common way to express criticality is as a risk priority number (RPN). Allocating resources and efforts to address the most critical failure modes is guided by prioritization. By addressing the most significant risks first, it reduces the possibility of disastrous failures.

Continuous Improvement:

Since maintenance must now guarantee maximum uptime at the lowest possible cost, it has evolved into a separate strategic function. Therefore, expertise, strict and ideal maintenance management, as well as ongoing improvements to reliability and maintainability, are required to guarantee equipment availability (Nabdi, 2016). By promoting constant observation, evaluation, and improvement of the additive manufacturing process, FMECA is a continuous improvement tool rather than a one-time event. FMECA makes it easier to adapt risk mitigation strategies and incorporate lessons learned into future manufacturing practices as technologies advance and more is discovered about the additive manufacturing process.

Documentation and Knowledge Transfer:

Comprehensive documentation of potential failure modes, their effects, criticality evaluations, and related risk mitigation techniques are produced as a result of FMECA. Teams that are currently and in the future working on semiconductor component additive manufacturing can use this documentation as a knowledge base. It facilitates training, knowledge transfer, and institutional memory preservation about possible risks and how to manage them.

4. Level of Repair Analysis (LORA), Maintenance Task Analysis (MTA):

Level of Repair Analysis (LORA) in Additive Manufacturing for Semiconductor Manufacturing:

A system's or its parts' ideal level for maintenance operations, such as replacements and repairs, can be ascertained using the Level of Repair Analysis (LORA) methodical process. When it comes to semiconductor manufacturing and additive manufacturing, LORA is essential to optimizing the maintenance plan for 3D-printed parts. Through the analysis of variables like repair complexity, skill requirements, and resource availability, LORA assists semiconductor manufacturers in making well-informed decisions regarding the location and mode of action for maintenance. This involves determining whether specific repairs are better handled by specialized outside services, at a dedicated maintenance facility, or on-site. LORA makes sure that maintenance activities are productive, economical, and in line with the overall objectives of system performance. LORA seeks to determine an optimal provision of repair and maintenance facilities to minimize overall life-cycle costs (Level of Repair Analysis (LORA), n.d.).

Maintenance Task Analysis (MTA) in Additive Manufacturing for Semiconductor Manufacturing:

A thorough analysis of the tasks required to maintain a system or its components throughout its life cycle is known as maintenance task analysis or MTA. Another reason to use MTA is to capture knowledge across your organization (Maintenance Task Analysis (MTA), n.d.). MTA focuses on comprehending the maintenance tasks related to 3D-printed semiconductor components in the context of additive manufacturing for semiconductor manufacturing. This entails determining the regular upkeep, examinations, and remedial measures required to guarantee the dependability and durability of the printed components. MTA assists producers of semiconductors in creating thorough maintenance plans, schedules, and resource allocations. MTA helps to create efficient training programs for maintenance staff and supports the establishment of a strong maintenance infrastructure for additive manufacturing processes in semiconductor manufacturing by outlining the precise steps and skill requirements for each maintenance task.

5. Anthropometrics:

Anthropometrics can help ensure that operators and maintenance staff can easily access, utilize, and safely use the equipment in additive manufacturing systems for semiconductor manufacturing.

Workspace Ergonomics:

Analyzing anthropometrics facilitates the design of workspaces that take operators' physical characteristics and motions into account. To guarantee the additive manufacturing system operates comfortably and effectively, reach, height, and clearance must all be considered (Design and Inquiry - 1.1a Anthropometrics, n.d.).

Control Panel Design: Control panel design is informed by anthropometric data, which guarantees that buttons, screens, and interfaces are arranged at ergonomic heights and separations. This improves the system's overall usability, lessens operator fatigue, and increases operator comfort.

Safety Measures and Emergency Controls: The location of safety precautions and emergency controls is determined by anthropometric data, which guarantees that they are accessible and functional in an emergency. For the operators' general safety when using the additive manufacturing system, this is essential.

Material Loading and Unloading: The design of spaces where materials are inserted into or removed from the system is influenced by anthropometrics. This involves considering the accessibility and height of material feed mechanisms to reduce the possibility of strain or injury during the loading and unloading procedures.

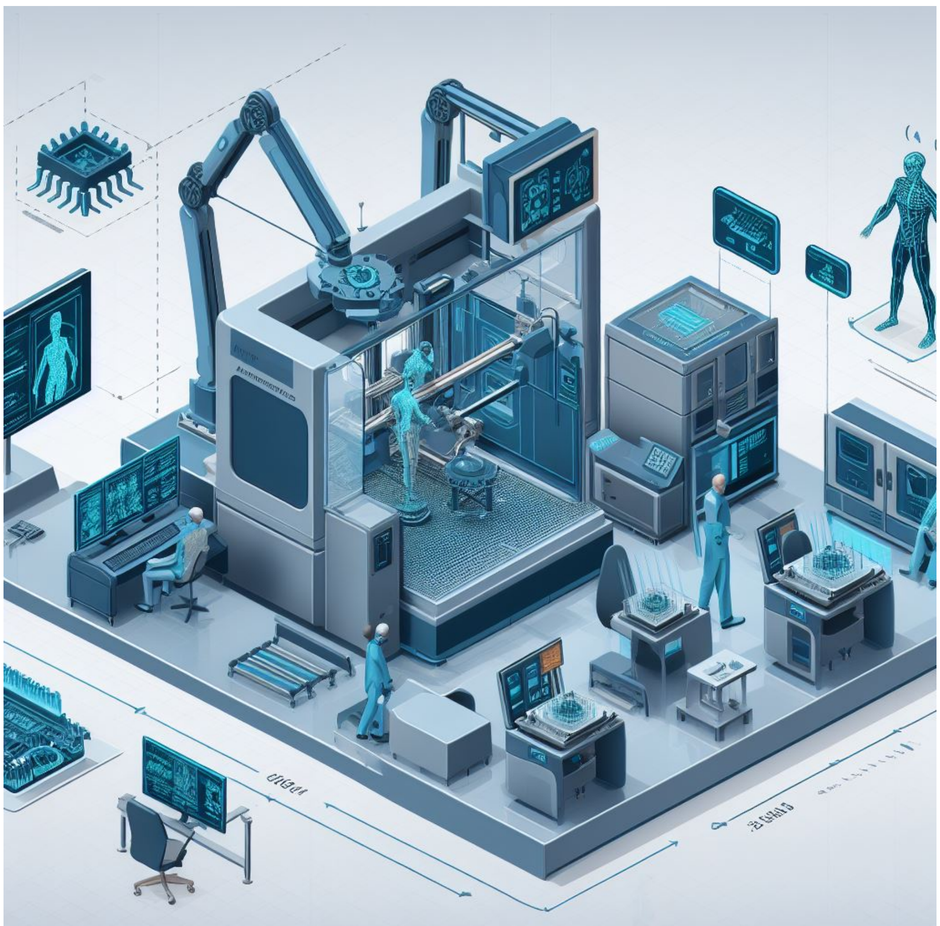


Figure: (*Bing*, n.d.)

6. System Safety (how to handle hazards regarding the human, hardware, and software):

System Safety for Additive Manufacturing in Semiconductor Manufacturing: In additive manufacturing, system safety for semiconductor production requires a thorough approach to recognize, evaluate, and reduce possible risks involving people, hardware, and software. Here is a systematic guide to managing these risks:

Identification of Hazards:

Software Risks:

Software Validation: Check and confirm that the software for additive manufacturing works as intended and doesn't introduce any errors that could endanger user safety.

Cybersecurity Precautions: Put strong cybersecurity measures in place to guard against unauthorized access, manipulation, and interference with the additive manufacturing system.

Hardware Risks:

Equipment Inspection: Examine the additive manufacturing system's hardware parts regularly to look for wear, damage, or possible weak points.

Material Handling: Provide safe practices for the handling of materials used in additive manufacturing, considering handling guidelines, flammability, and toxicity.

Human Risks:

Task Analysis: To find possible risks associated with people interacting with the additive manufacturing system, perform a task analysis. This covers duties like emergency response, maintenance, operation, and setup.

Training and Competency: Make certain that maintenance staff and operators have received the necessary training to operate the additive manufacturing system and are knowledgeable about safety precautions.

Risk Assessment:

Human Risks:

Ergonomic Assessment: To detect and reduce risks associated with operator posture, repetitive activities, and possible musculoskeletal problems, perform ergonomic assessments.

HMI, or human-machine interface, Examine the HMI's design to make sure the controls are simple to use, and the visual cues are clear.

Hardware Risks:

Failure Modes Analysis: To determine possible failure scenarios and their effect on safety, conduct failure modes analysis on hardware components.

Material Compatibility: To avoid chemical reactions or material degradation, determine whether materials used in additive manufacturing are compatible with hardware components.

Software Risks:

Extensive Testing: To detect and reduce potential software-related risks, extensively test the additive manufacturing software under varied circumstances.

Version Control: Make sure that only verified and authorized software versions are being used by implementing version control procedures.

Hazard Mitigation:

Human Risks:

Workplace Design: Make sure that adequate lighting, ventilation, and comfortable working conditions are provided by designing workspaces with ergonomics in mind.

Training for Emergency Response: Offer thorough instruction on emergency response protocols, which should include evacuation plans and shutdown procedures.

Hardware Risks:

Preventive Maintenance: To address possible hardware problems before they become problems, put in place a preventive maintenance program.

Install safety guards and interlocks to block access to potentially dangerous areas while the machine is operating.

Software Risks:

Frequent Updates: To fix vulnerabilities and keep software up to date with the newest security patches and updates.

Implement access control procedures to prevent unauthorized individuals from using the software for additive manufacturing.

Continuous Monitoring and Improvement:

Human, Hardware, and Software Hazards:

Incident Reporting: To learn from mistakes and carry out corrective measures, set up a system for documenting and looking into incidents about software, hardware, and human safety.

Continuous Risk Assessment: To keep up with advancements in technology, procedures, or laws, review risks regularly, and update safety protocols.

A strong system safety framework can be created by methodically addressing risks about people, hardware, and software in additive manufacturing for semiconductor manufacturing. This increases worker safety, lowers the possibility of mishaps, and enhances the general dependability and effectiveness of the additive manufacturing process.

7. Security (both physical and cyber posture):

Security Position in Semiconductor Manufacturing for Additive Manufacturing Systems:

Addressing both the physical and cyber aspects is necessary to ensure the security of additive manufacturing systems in semiconductor manufacturing. Strong security measures are integrated to help protect intellectual property, stop unwanted access, and guarantee the integrity of the manufacturing process. 3D printing has the potential to revolutionize manufacturing and there is substantial concern for the security of the storage, transfer, and execution of 3-D models across digital networks and systems (Bridges et al., 2015). An extensive synopsis of the security posture is provided below:

Physical Security:

Control of Access:

Secure Access Points: To limit physical access to the additive manufacturing facility, install controlled access points with authentication methods like key cards or biometric identification.

Monitoring Systems:

Install a thorough network of closed-circuit television (CCTV) cameras to keep an eye on the entire facility, paying particular attention to areas where additive manufacturing systems are located.

Layout of the Facility:

Restricted Areas: Make sure that only authorized personnel have access to vital equipment by designing the layout of the facility to include restricted areas for additive manufacturing systems.

Cybersecurity:

Security of Networks:

Installing strong firewalls and intrusion detection systems (IDS) will shield the additive manufacturing network from hackers and illegal access.

Safe Interaction:

Encrypted Communication: To avoid eavesdropping and manipulation, make sure that all communications between external devices and additive manufacturing systems are encrypted.

Control of Access:

Use role-based access control (RBAC) to limit access to digital systems by allocating permissions by duties and roles associated with a job.

Security of Software:

Frequent Updates and Patching: Apply the most recent security patches to address vulnerabilities in all software components, including additive manufacturing software.

Backups of data:

Frequent Backups: To aid in recovery in the case of a cyber incident, make regular backups of important data, such as design files and process data.

Audits of security:

Frequent Audits: To evaluate the efficacy of security precautions, find weaknesses, and make adjustments, conduct routine cybersecurity audits.

Supplier Protection:

Safe Supply Chain: Set security guidelines for vendors to guarantee that parts and software used in additive manufacturing systems adhere to cybersecurity regulations.

8. Disposability and Environmental impacts:

Disposability and Environmental Impacts of Additive Manufacturing Technology Systems in Semiconductor Manufacturing:

Disposability:

Selection of Material:

Selecting recyclable or environmentally benign materials for additive manufacturing. Taking into account biodegradable or biobased materials for specific uses.

Design for Recycling:

Applying modular design principles into practice to make it easier to disassemble components and separate materials for recycling. improving the ease of disassembly and material separation using standardized connections and interfaces.

Marking and Identification:

By making it easier to sort, and label components with the materials that were used, you can help with the recycling process.

Reduction of Dangerous/Hazardous Substances:

Reduction in the number of hazardous materials used in the additive manufacturing process to ensure environmentally friendly disposal of end-of-life materials.

Environmental Impacts:

Material Waste Reduction:

Designing parts to maximize material utilization during additive manufacturing while minimizing waste. Using additive manufacturing (AM) has been shown to reduce material use in final parts by 35–80%. According to recent publications, AM will make it possible to fabricate customized products locally and on demand, which will cut down on material waste and shipping (Jung et al., 2023).

Energy Efficiency:

To minimize environmental impact and lower overall energy consumption, optimize additive manufacturing processes for energy efficiency.

Regionalized Manufacturing:

Localized production can be made possible by using additive manufacturing, which will lessen the need for long-distance transportation and its negative environmental effects.

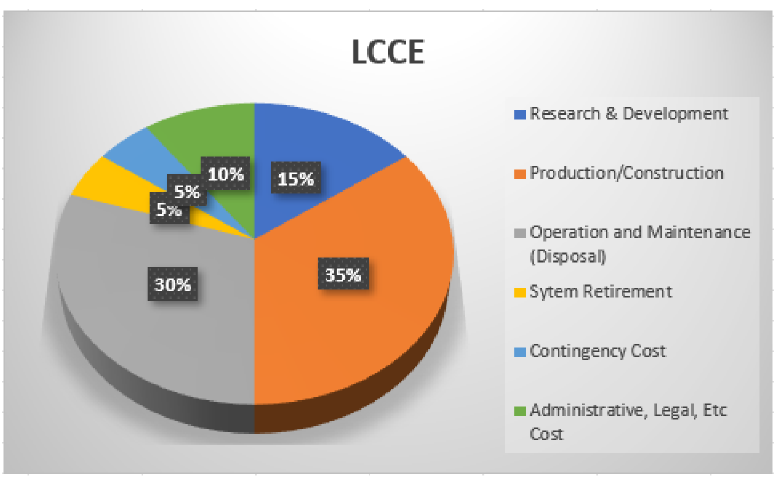
Water Conservation:

Reduce the amount of water used in additive manufacturing by implementing water-efficient manufacturing techniques and considering closed-loop systems.

Businesses can support sustainable practices by incorporating disposability considerations and giving environmental impacts top priority in additive manufacturing for semiconductor manufacturing. While adhering to more general sustainability objectives, additive manufacturing operations can reduce their environmental impact by utilizing eco-friendly materials, effective procedures, and a lifecycle approach. Maintaining the forefront of environmentally responsible manufacturing practices in additive manufacturing requires ongoing evaluations and efforts toward continuous improvement.

9. ROM LCCE:

	Life Cycle Year																				
Cost Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total ($)
Configuration A																					
Research & Development	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	5,250,000	105,000,000
Production/Construction	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	245,000,000
Operation and Maintenance	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	10,500,000	210,000,000
Sytem Retirement	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	35,000,000
Contingency Cost	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	35,000,000
Administrative, Legal, Etc Cost	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	70,000,000
Total Cost ($)	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	700,000,000



Model-based systems engineering (MBSE):

"Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing through development and later life cycle phases" (Hart et al., 2015). Based on my research I have gained a deep understanding that it is a comprehensive method of systems engineering known as "Model-Based Systems Engineering" (MBSE) that makes use of visual models to represent, interpret, and convey intricate system interactions and architectures. I have learned that it is important on a foundational level that using MBSE provides a strategic advantage throughout the program's life cycle in the context of additive manufacturing in semiconductor manufacturing. Initially, MBSE makes it easier to define and manage requirements precisely by giving them a visual representation that improves traceability and clarity. I have also observed based on my readings that MBSE facilitates dynamic system modeling during the development stages, which helps find and fix possible problems. MBSE helps configuration management as the program develops, guaranteeing consistency and enabling methodical modifications. Based on my overall research and studying multiple readings I can strongly say as a systems engineer that through the implementation of lifecycle traceability, MBSE creates a strong foundation for tracking and responding to changing needs and advances in technology. This all-encompassing strategy promotes continuous improvement, lowers risks, and improves collaboration—thereby establishing MBSE as a crucial methodology for optimizing additive manufacturing processes at the graduate level of sophistication in semiconductor manufacturing.

Key design reviews such as system requirements review (SRR), preliminary design reviews (PDR), and critical design review (CDR):

Key design reviews are essential to the success of the entire system development process in the context of additive manufacturing in semiconductor manufacturing. System Requirements Review (SRR), Preliminary Design Review (PDR), and Critical Design Review (CDR), each linked to baselines, are commonly included in the design review process.

System Requirements Review (SRR):

The purpose of the first design review, or SRR, is to make sure that the system requirements are understood thoroughly, clearly, and concisely. It entails a careful analysis of the functional requirements, which specify the general capabilities and behavior of the system (Olivier & De Weck, n.d.).

Timetable/Schedule: Early in the project, soon after the first system requirements are established, the SRR is usually carried out. This phase lays the groundwork for later design work.

Preliminary Design Review (PDR):

Preliminary design review (PDR) is the process that comes after the functional requirements have been established. It entails examining the initial design that converts these requirements into the system architecture (Preliminary Design Review (PDR), n.d.). Along with outlining how subsystems will meet the functional requirements, it also includes an assessment of the requirements that have been assigned.

Timetable/Schedule: PDR is carried out as the design develops and the system architecture is finalized. It guarantees that the design is headed toward achieving the overall goals and specifications.

Critical Design Review (CDR): CDR is a thorough analysis that concentrates on the product baseline and looks at the intricate design (PDR and CDR Assessments – ASD(MC), 2017). It evaluates if the comprehensive design satisfies the assigned specifications, considering factors related to testing, manufacturing, and other implementation facets. CDR guarantees that the design is developed and prepared for use.

Timetable/Schedule: CDR is usually carried out right before the implementation phase begins, following the completion of the detailed design. It shows that the design is clearly defined and that any modifications made after the CDR must have a solid basis.

Baselines:

Functional Baseline: The SRR establishes the functional baseline, which serves as a precise definition of the system's functional requirements. It describes the intended functions of the system but doesn't go into detail on how those functions will be carried out.

Timetable/Schedule: Early in the project, the functional baseline is established following the SRR.

Allocated Baseline: The allocated baseline, which is connected to the PDR, shows how the system requirements are distributed among components or subsystems. It offers an early design that satisfies these allotments and directs more in-depth design work later.

Timeline/Schedule: During the PDR stage, the assigned baseline is created to make sure the design complies with the assigned requirements.

Product Baseline: The system's final detailed design is represented by the product baseline, which is connected to the CDR. With all the paperwork required for testing, manufacturing, and verification, the system can be constructed and used exactly as intended.

Timetable/Schedule: During the CDR, the product baseline is finalized, indicating the change from design to implementation.

I have encountered that regarding additive manufacturing in semiconductor production, these design reviews and baselines are essential for guaranteeing the efficiency, dependability, and manufacturability of the additive manufacturing techniques used. In addition to managing risks and facilitating a methodical transition from requirements to a fully functional and implementable product, they offer structured milestones for evaluating the evolving design.

Configuration Management (CM): The management strategy known as configuration management (CM) entails determining, recording, and auditing an item's functional and physical characteristics as well as recording the item's configuration, and managing changes to both the item and its documentation.

As a governance process for guaranteeing consistency between logical and physical assets in the context of business operations, configuration management (CM) is a component of system engineering. Every configuration item (CI), its dependencies, and the documentation of its functional capabilities are all targets of configuration management (CM). System administrators, and software specialists—particularly developers and technical professionals—are the main users of it to confirm how changes made to one CI affect other CIs or systems. As more resources are built for the product, which must be error-free, CM is crucial for scalability and time savings. Lack of CM could lead to missed opportunities to automate tasks and remove any human abstraction layer, costing money, time, and resources that were used to build the system infrastructure.

CCB also known as the configuration control board is a team of experts in charge of overseeing and authorizing modifications to documentation, firmware, software, and hardware at every stage of an information system's development and operation (Editor, n.d.). The CCB decides whether to accept or reject suggested changes after considering all relevant information. To make decisions, it is necessary to balance the risks and rewards of each change, take stakeholder input into account, and make sure the project's objectives are met. It is the CCB's responsibility to create and manage configuration baselines. A baseline is an image of the configuration of the system taken at a particular moment in time. To ensure consistency and traceability, changes are assessed in comparison to these baselines. Documentation about configuration is managed and controlled under the direction of the CCB. This comprises test plans, design specifications, drawings, and other records that specify how the system is configured. For system management to be effective, documentation must be accurate and current. The proposed changes are subject to risk assessment and management by the CCB. This entails taking into account possible effects on standard compliance, safety, dependability, and system performance. Minimizing risks while enabling required changes is the aim.

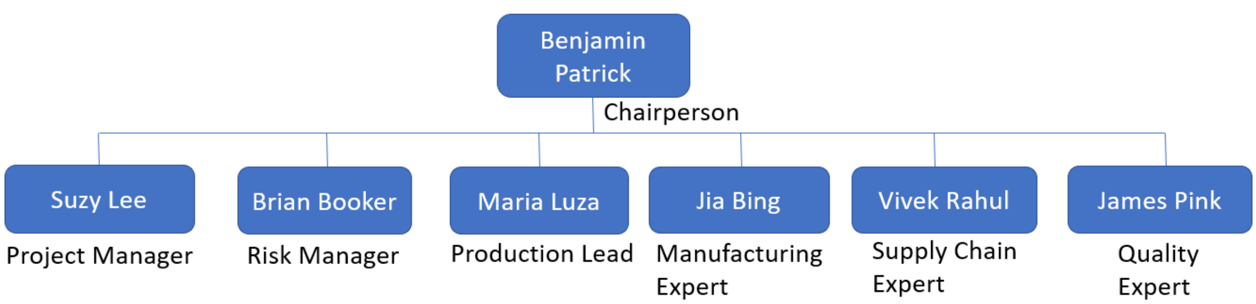
In systems engineering, the Configuration Control Board (CCB) is essential for monitoring and controlling configuration changes to a system over its whole life. A key governance body in systems engineering, the Configuration Control Board is responsible for managing, approving, and methodically evaluating configuration changes for systems. It is essential to preserve the system's performance, consistency, and integrity throughout its lifetime.

Configuration Management (CM) will be methodically applied throughout the system life cycle in the context of additive manufacturing in semiconductor manufacturing to guarantee control and traceability of changes. An essential function of the Configuration Control Board (CCB) will be to assess and approve suggested modifications, such as Engineering Change Proposals (ECPs). An organized procedure including documentation, impact analysis, and approvals will be developed for accounting for ECPs over their whole life cycle. To maintain consistency and alignment with project objectives, this process will conform to defined baselines, including the functional, allocated, and product baselines. Proposed modifications will be assessed by the CCB according to how they affect the requirements of the system, the performance of the system, and additive manufacturing procedures. Additive manufacturing in semiconductor manufacturing can efficiently manage changes, uphold configuration baselines, and guarantee the integrity of system design and implementation by incorporating strong Configuration Management practices.

11.0 Risk Management

Risk Management Board (RMB)

The collaborative and cross-functional approach to risk management shown in this block diagram reflects the variety of expertise needed to handle the unknowns and difficulties related to additive manufacturing in semiconductor manufacturing. The purpose of each member's role is to help identify, analyze, and mitigate risks in a methodical manner over the life cycle of the project.

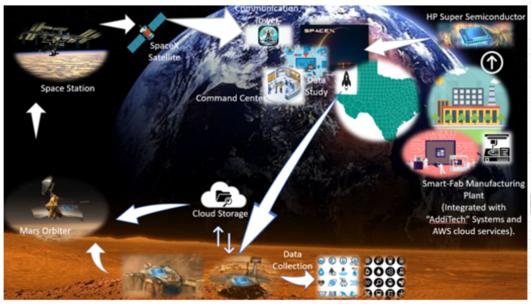


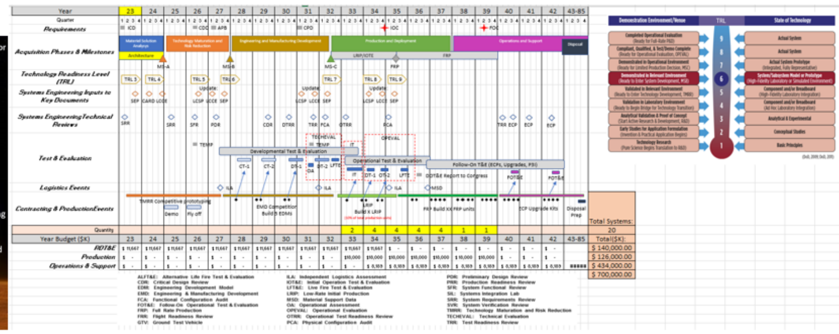
System Overview and Schedule

System Description: NASA (Government Entity) integrated with SpaceX (Private) company placed a bulk order of High-Performance Super Semiconductor (HPSS) chips manufactured using an "Additive Manufacturing" System that delivers unmatched high-performance for semiconductor applications in aerospace for the Mars Rover. Twenty SpaceX systems with a need/demand for HPSS chips manufactured using an "Additive Manufacturing" system are required to be constructed and deployed. Launches are to be conducted in Texas, Florida, and California each of the twenty systems is to be launched into space for a space mission to Mars. However, all the products are designed, engineered, developed, and manufactured in one plant which is located in Austin, Texas, and then supplied to Texas, Florida, and California. the respective launches. The SpaceX needs all 20 systems to be deployed by the end of 2040. A total of $700M has been budgeted by SpaceX for this project over the entire life cycle.

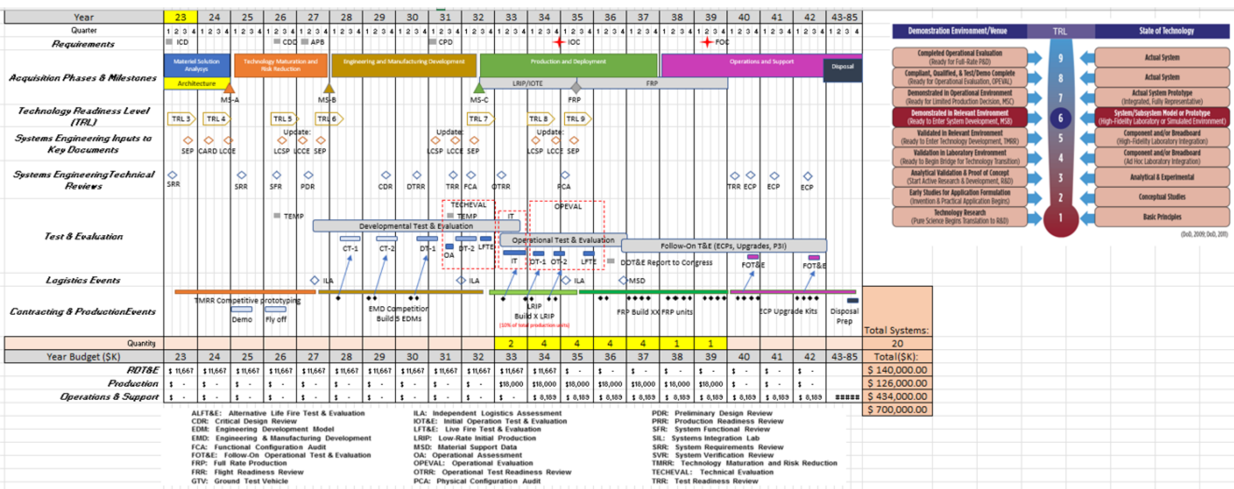
Risk Management Board (RMB) will meet every quarter to review all risks in the program.

OV-1





Program Schedule



Summary of Risk Identification

The following risks were identified in our program using a risk register system in Excel to keep track of all risks over the life cycle of the program's life cycle

Risk ID	Date of Risk Entry	Risk Retire Dat	POC	Risk Statement	Realization Date	Event Effected	Cost	Sched	Tech	Prob.	Liklihood
001	9/29/2023	9/29/2024	L.D.Richard Clinton	Supply Chain Disruption due to the shortage of raw material	1-Jan-2024	Manufacturing	30	30	1	80%	4
002	9/29/2024	9/29/2025	L.D.Richard Clinton	Equipment Breakdown in 3D printing machines	1-Jan-2025	Production	2	15	1	50%	3
003	9/29/2025	9/29/2026	L.D.Richard Clinton	Regulatory compliance issues in additive manufacturing	1-Jan-2026	Manufacturing	80	45	1	70%	7
004	9/29/2026	9/29/2027	L.D.Richard Clinton	Intellectual property infringement in 3D printing technology	1-Jan-2027	Technology	150	60	1	80%	8
005	9/29/2027	9/29/2028	L.D.Richard Clinton	Environmental impact concerns in Manufacturing	1-Jan-2028	Manufacturing	4	40	1	60%	6
006	9/29/2028	9/29/2029	L.D.Richard Clinton	Cybersecurity threats in 3D printing technology	1-Jan-2029	Technology	3	50	1	70%	7
007	9/29/2029	9/29/2030	L.D.Richard Clinton	Design flaws in additive manufacturing process	1-Jan-2030	Manufacturing	120	45	1	70%	7
008	9/29/2030	9/29/2031	L.D.Richard Clinton	Fluctuation in energy supply for additive manufacturing	1-Jan-2031	Manufacturing	80	40	2	60%	6
009	9/29/2031	9/29/2032	L.D.Richard Clinton	Geopolitical instability affecting material availability	1-Jan-2032	Supply Chain	150	60	1	80%	8
010	9/29/2032	9/29/2033	L.D.Richard Clinton	Equipment Obsolescence in Additive Manufacturing	1-Jan-2033	Technology	130	50	1	50%	8
011	9/29/2033	9/29/2034	L.D.Richard Clinton	Unplanned Downtime due to 3D printer malfunction	1-Jan-2034	Manufacturing	80	35	2	50%	7

Risk ID	Consequence	Current Risk Index	Risk Exposure	Color	Initial Risk Ind	MitigationStep 1	Mitigation Step Completion Date	RI after Mitigation Step	MitigationStep 2	Mitigation Step Completion Date	RI after Mitigation Step	MitigationStep 3
001	20.0	80	16.3	16.2667	15	Diversify suppliers to decrease risk for $200K	1-Jan-24	8	Improve supply chain visibility	2-Jan-24	9	Develop local sourcing
002	10.0	44	8.5	8.555	14	Regular Maintenance	1/1/2025	7	Implement predictive maintenance	1/2/2025	8	Equipment redundancy
003	10.0	44	10.0	10.555	12	Conduct thorough regulatory compliance training	1/1/2026	8	Real-time compliance monitoring system implementation	1/3/2026	7	Regularly update team in evolving regulations
004	11.0	50	10.0	14.7773	10	Conduct IP awareness programs for the team	1/1/2027	7	Solidification of legal agreements with technology providers	1/2/2027	4	Invest in advanced cybersecurity measures
005	10.0	40	10.0	10.5557	11	Implementation of eco-friendly additive manufacturing practices	1/1/2028	6	Collaborate with environmental agencies for guidance	1/2/2028	5	Regularly monitor and report on environmental metrics
006	10.0	60	10.0	5.8886	12	Robust cybersecurity protocols implementation	1/1/2029	6	Conduct regular cybersecurity training for the team from technical departments to management departments	1/2/2029	3	Engage external cybersecurity experts for periodic audits
007	10.0	50	10.0	6.778	10	Implement advanced design validation processes	1/1/2030	5	Conducting rigorous design simulations	1/2/2030	4	Engage external design experts for reviewws
008	7.0	40	5.0	8.7768	15	Implement energy storage solutions	1/1/2031	7	Explore alternative energy sources	1/2/2031	4	Collaborate with energy providers for stable supply
009	10.0	30	6.0	6.88	12	Diversify material sources and establish local suppliers	1/1/2032	8	Regularly monitor geopolitical developments	1/2/2032	2	Establishing strategic partnerships with stable suppliers
010	10.0	50	5.0	10.887	10	Regularly update and replace outdated machinery	1/1/2033	7	Invest in future-proof equipment	1/2/2033	3	Establish partnerships with equipment suppliers for timely updates
011	4.0	60	4.0	8.99	10	Implement proactive maintenance schedules	1/1/2034	6	Invest in predictive maintenance technologies	1/2/2034	4	Establish redundant 3D pritning capabilities

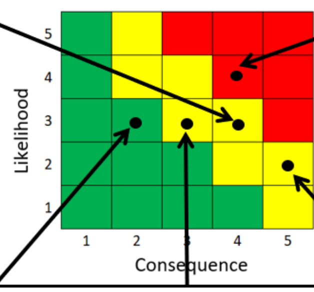
Top Five Risks

ID: 1
Type: Supply Chain Risk
Risk if/then statement: Supply Chain Disruption due to the shortage of raw material

Mitigation Method:
1. Diversify suppliers to decrease risk for $200K
2. Improve supply chain visibility
3. Develop local sourcing

ID: 5
Type: Manufacturing Risk
Risk if/then statement: Environmental impact concerns in Manufacturing

Mitigation Method:
1. Implementation of eco-friendly additive manufacturing practices
2. Collaborate with environmental agencies for guidance
3. Regularly monitor and report on environmental metrics



ID: 2
Type: Production Risk
Risk if/then statement: Equipment Breakdown in 3D printing machines

Mitigation Method:
1. Regular Maintenance
2. Implement predictive maintenance
3. Equipment redundancy

ID: 3
Type: Manufacturing Risk
Risk if/then statement: Regulatory compliance issues in additive manufacturing

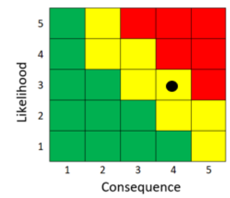
Mitigation Method:
1. Conduct thorough regulatory compliance training
2. Real-time compliance monitoring system implementation
3. Regularly update the team in evolving regulations

ID: 4
Type: Design Risk
Risk if/then statement: Design flaws in the additive manufacturing process

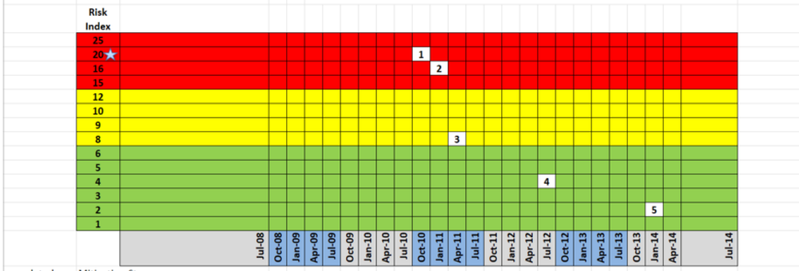
Mitigation Method:
1. Implement advanced design validation processes
2. Conducting rigorous design simulations
3. Engage external design experts for reviews

Risk 1

ID: 1
Type: Manufacturing Risk
Risk if/then statement: Supply Chain Disruption due to the shortage of raw material



RISK ID #1 Risk Title: Supply Chain Risk If/Then Statement : Supply Chain Disruption due to the shortage of raw material

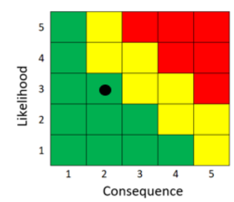


completed /funded	Mitigation Steps:		Est. Complete
funded	1	Diversify suppliers to decrease risk for $30M	Nov-10
funded	2	Improve supply chain visibility at a cost of $20M	Mar-11
funded	3	Develop local sourcing risk at a cost of $10M	Jun-11
funded	4	Advanced Supply Chain Analytics and AI implementation at a cost of $15M	Sep-12
funded	5	Research and Development for Material Alternatives at a cost of $10M	Mar-14

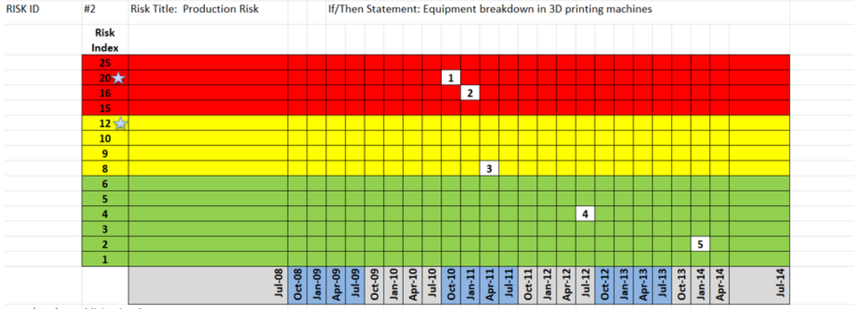
Mitigation Step	Cost
1	$30 M
2	$20 M
3	$10 M
4	$15 M
5	$10 M
Total	**$85 M**

Risk 2

ID: 2
Type: Production Risk
Risk if/then statement: Equipment Breakdown in 3D printing machines



RISK ID #2 Risk Title: Production Risk If/Then Statement: Equipment breakdown in 3D printing machines

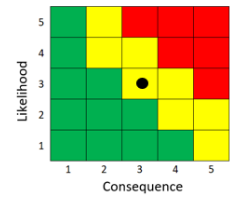


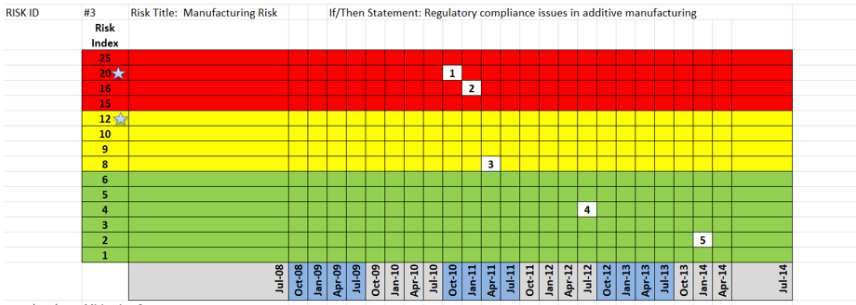
completed /funded	Mitigation Steps:		Est. Complete
funded	1	Regular Maintenance to lower risk at cost of $8 Million	Nov-10
funded	2	Implement predictive maintenance to lower risk at cost of $6 Million	Mar-11
funded	3	Equipment redundancy/Backups for machines to lower risk at a cost of $10 Million	Jun-11
funded	4	Advanced Diagnostic and Monitoring Systems to lower risk at a cost of $8 Million	Sep-12
funded	5	Research and Development in Durable Equipment Design to lower risk at a cost of $5 Million	Mar-14

Mitigation Step	Cost
1	$8 M
2	$6 M
3	$10 M
4	$8 M
5	$5 M
Total:	**$37 M**

Risk 3

ID: 3
Type: Manufacturing Risk
Risk if/then statement: Regulatory compliance issues in additive manufacturing



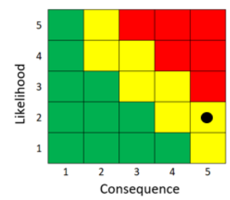


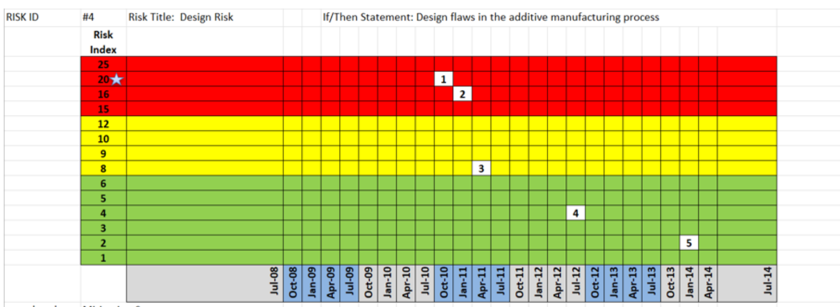
completed /funded	Mitigation Steps:		Est. Complete
funded	1	Conduct thorough regulatory compliance issues in additive manufacturing to lower risk for $8Million	Nov-10
funded	2	Real-time compliance monitoring system implementation to lower risk at a cost of $10 Million	Mar-11
funded	3	Regularly update the team on evolving regulations to lower risk at a cost of $6 Million	Jun-11
funded	4	Advanced Diagnostic and Monitoring Systems to lower risk for $8 Million	Sep-12
funded	5	Research and Development in Durable Equipment Design to lower risk at a cost of $5 Million	Mar-14

Mitigation Step	Cost
1	$8 M
2	$10 M
3	$6 M
4	$8 M
5	$5 M
Total:	**$37 M**

Risk 4

ID: 4
Type: Design Risk
Risk if/then statement: Design flaws in the additive manufacturing process



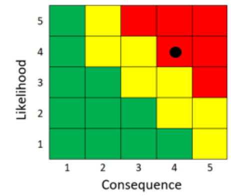


completed /funded	Mitigation Steps:		Est. Complete
funded	1	Implement advanced design software for design and validation processes to lower risk at a cost of $12 Million	Nov-10
funded	2	Conducting rigorous design simulations to lower risk at a cost of $10 Million	Mar-11
funded	3	Engage external design experts for reviews to lower risk at cost of $7 Million	Jun-11
funded	4	Advanced Software for Design and Simulation to lower risk at cost of $12 Million	Sep-12
funded	5	Research and Development in Material Science to lower risk at a cost of $10 Million	Mar-14

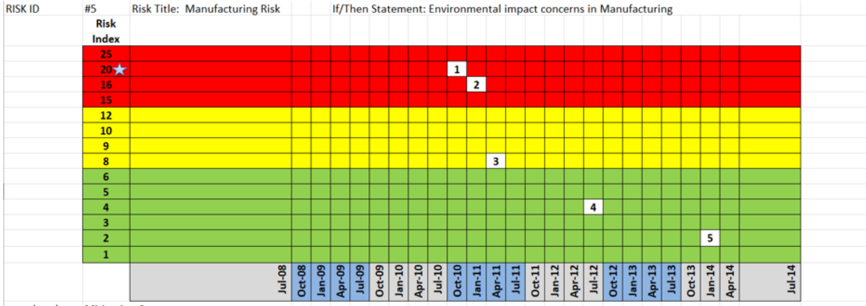
Mitigation Step	Cost
1	$12M
2	$10M
3	$7M
4	$12M
5	$10M
Total:	**$51M**

Risk 5

ID: 5
Type: Environmental Risk
Risk if/then statement: Environmental impact concerns in Manufacturing



RISK ID #5 Risk Title: Manufacturing Risk If/Then Statement: Environmental impact concerns in Manufacturing



completed /funded	Mitigation Steps:		Est. Complete
funded	1	Implementation of eco-friendly additive manufacturing practices to lower risk at a cost of $15 Million	Nov-10
funded	2	Collaborate with environmental agencies for guidance to lower risk at cost of $5 Million	Mar-11
funded	3	Regularly monitor and report on environmental metrics to lower risk at a cost of $10 Million	Jun-11
funded	4	Adoption of sustainable raw materials to lower risk at cost of $12 Million	Sep-12
funded	5	Waste management and recycling systems to lower risk at cost of $8 Million	Mar-14

Mitigation Step	Cost
1	$15M
2	$5M
3	$10M
4	$12M
5	$8M
Total:	**$50M**

Work Breakdown Structure

1.1 Additive Manufacturing Technology System in Semiconductor Manufacturing

1.1.1 Supply Chain Disruption due to the shortage of raw materials

1.1.1.1 Supplier Relationship Management

1.1.1.2 Inventory management

1.1.1.3 Market analysis and forecasting

1.1.2 Equipment breakdown in 3D printing machines

1.1.2.1 Preventive maintenance

1.1.2.2 Operator training

1.1.2.3 Backup systems and contingency planning

1.1.3 Regulatory compliance issues in additive manufacturing

1.1.3.1 Compliance monitoring

1.1.3.2 Staff training and awareness

1.1.3.3 Documentation and Reporting

1.1.4 Design flaws in the additive manufacturing process

1.1.4.1 Design review and testing

1.1.4.2 Feedback and continuous improvement

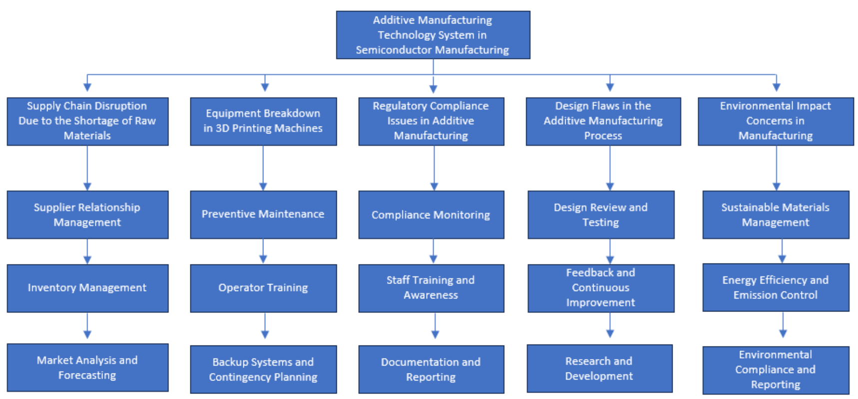
1.1.4.3 Research and Development

1.1.5 Environmental impact

1.1.5.1 Sustainable Materials Management

1.1.5.2 Energy efficiency and emission control

1.1.5.3 Environmental compliance and reporting



Mitigation Budget Summary

In summary, the program requests $260 Million to mitigate the risks identified and broken down by yearly needs.

Risk ID	Mitigation Steps	2023	2024	2025	2026	2027	Total ($K)
Risk 1	5 mitigation steps funding required:	$30M	$8M	$8M	$12M	$15M	$73M
Risk 2	5 mitigation steps funding required:	$20M	$6M	$10M	$10M	$5M	$51M
Risk 3	5 mitigation steps funding required:	$10M	$10M	$6M	$7M	$10M	$43M
Risk 4	5 mitigation steps funding required:	$15M	$8M	$8M	$12M	$12M	$55M
Risk 5	5 mitigation steps funding required:	$10M	$5M	$5M	$10M	$8M	$38M
TOTAL:		$85M	$37M	$37M	$51M	$50M	**$260M**

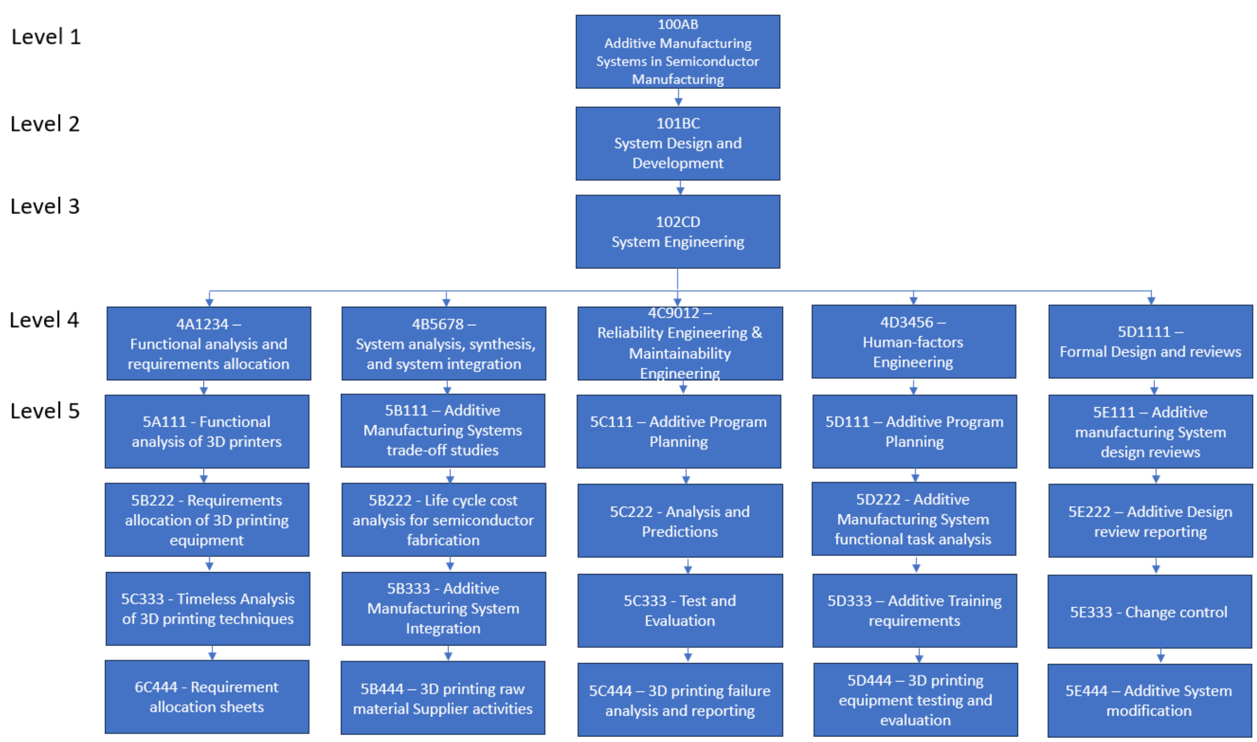
Contract Work Breakdown Structure and Contract Type Selection:

In the semiconductor sector, creating a Contract Work Breakdown Structure (CWBS) for additive manufacturing systems is a complex, multi-layered procedure. The first step is to address the system requirements, which include determining the precise needs for additive manufacturing, examining the requirements to make sure they comply with industry norms, consulting relevant parties for confirmation, and formally recording these requirements. Developing technical requirements such as resolution and precision, determining design restrictions, securing required approvals, and completing documentation are all part of the system specifications step.

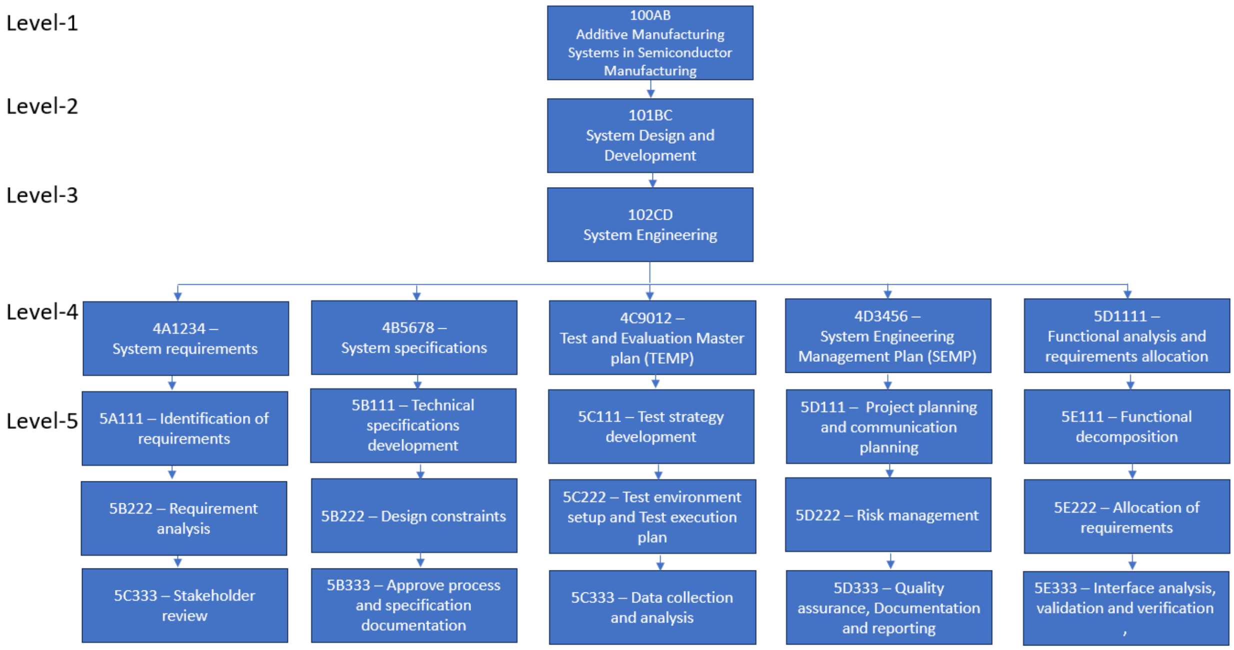
The creation of a test plan that details phases and procedures is the first step in creating the crucial Test and Evaluation Master Plan. Important actions in this phase include setting up a test environment, carrying out a thorough test plan, gathering and evaluating data, and recording findings. This plan guarantees that the system satisfies requirements for dependability and quality.

Project planning, risk management, quality control, efficient communication, and frequent documenting and reporting are all covered in the System Engineering Management Plan. This all-encompassing management strategy guarantees that risks are reduced, quality is preserved, and communication is open. The process of dissecting the system into manageable functions, assigning requirements to each, examining interfaces, producing a traceability matrix, and organizing validation and verification are the final steps in functional analysis and requirement allocations. During this stage, it is made sure that every component of the system has been tested and designed to fulfill certain requirements.

Conceptual design and advanced planning phase for additive manufacturing systems in semiconductor manufacturing:



Preliminary system design phase for additive manufacturing systems in semiconductor manufacturing:



In summary, developing a CWBS for semiconductor manufacturing projects using additive manufacturing techniques requires careful planning, rigorous testing, detailed documentation, and comprehensive management. Each phase, from system requirements to functional analysis, is critical to project success. The process focuses not only on technical precision, but also on strategic foresight, collaboration, and a commitment to innovation to drive advances in semiconductor manufacturing through additive manufacturing technology.

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