



National Aeronautics and
Space Administration



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ARES I-X

SYSTEMS ENGINEERING MANAGEMENT PLAN
(SEMP)

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REVISION AND HISTORY PAGE

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the Ares I-X SEMP is to define the approach to planning and executing the Systems Engineering activities associated with the Ares I-X mission.

1.2 SCOPE

The Ares I-X Systems Engineering Management Plan (hereafter referred to as the SEMP) is intended to describe common processes used in the development, assembly and operation of the Ares I-X flight system and associated ground systems. This document applies to the entire Ares I-X mission team. This document does not replace detailed systems engineering processes used for Integrated Product Team-level development.

The Ares I-X SEMP is intended to provide greater detail on how the Ares I-X mission team will perform systems engineering during the development of the Ares I-X systems and will cover:

- Processes and procedures involved in the Ares I-X systems engineering function
- Products of the Ares I-X systems engineering function
- The technical review process for Ares I-X work products
- Communication across the Ares I-X development team
- Ares I-X requirement and interface development and management

The SEMP will be used in conjunction with the Ares I-X Configuration Management Plan (AIX-SYS-CMP), and the Ares I-X Safety, Reliability and Quality Assurance Plan (A11-SYS-SMA) to provide the systems engineering management practices to which the Ares I-X mission team will adhere. In addition, the SEMP uses the NASA Systems Engineering Processes and Requirements (NASA Procedural Requirements, NPR-7123.1), which is mandatory but tailorable for systems engineering management processes.

The Ares I-X Flight Test Plan (CxP 70127) provides mission flight test objectives, constraints, requirements, roles and responsibilities and deliverables. Any duplication of information contained in the Ares I-X Flight Test Plan is unintended and in the event that it occurs the Ares I-X Flight Test Plan takes precedence over the SEMP.

1.3 CHANGE AUTHORITY RESPONSIBILITY

Proposed changes to this document shall be submitted by Ares I-X Change Request (CR) to the XCB for consideration and disposition.

The appropriate NASA Office of Primary Responsibility (OPR) identified for this document is the Ares I-X Mission Management Office (MMO).

2.0 ARES I-X DOCUMENTS

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2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

NPR 7120.5D NASA Program and Project Management Processes and Requirements
NPR 7123.1A Systems Engineering Procedural Requirements

2.2 REFERENCE DOCUMENTS

The following documents contain supplemental information to guide the user in the application of this document.

CxP 70127 Ares I-X Flight Test Plan
AI1-SYS-MIP Ares I-X Mission Implementation Plan
AI1-SYS-DDD Ares I-X FTV Design Definition Document
AI1-SYS-CMP Ares I-X Configuration Management Plan
AIX-SYS-DMP Ares I-X Data Management Plan
AI1-SYS-RMP Ares I-X Risk Management Plan
AI1-SYS-SQA Ares I-X Safety, Reliability and Quality Assurance Plan
AI1-SYS-SRD Ares I-X FTV System Requirements Document
AI1-SYS-GDRD Ares I-X Ground Development Requirements Document
CxP 70XXX Ares I-X Flight Test SR&QA Requirements
AI1-SYS-AIT Ares I-X Assembly, Integration, and Test Plan
AI1-SYS-MVP Ares I-X Master Verification Plan
AI1-SYS-RVP Ares I-X Requirements Verification Plan
AI1-SYS-SRR Ares I-X Systems Requirements Review Plan
AI1-SYS-PDR Ares I-X Preliminary Design Review Terms of Reference
AI1-SYS-CDR Ares I-X Critical Design Review Terms of Reference
AIX-SYS-ILS Ares I-X Integrated Logistics Support Plan

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- CxP 70036 Constellation Environmental Qualification and Acceptance Testing Requirements
- NASA RP-1370 Training Manual for Elements of Interface Definition and Control
- SP-610S NASA Systems Engineering Handbook
- NASA RP-1370 Training Manual for Elements of Interface Definition and Control

3.0 ARES I-X ORGANIZATION

The Ares I-X Flight Test Plan (CxP 70127) describes the roles and responsibilities of the Ares I-X mission team. The mission team includes a Mission Management Office (MMO), a Chief Engineer function, a Safety and Mission Assurance (S&MA) function, a Systems Engineering and Integration (SE&I) Office and seven Integrated Product Teams (IPTs). The Ares I-X mission is organized as follows:

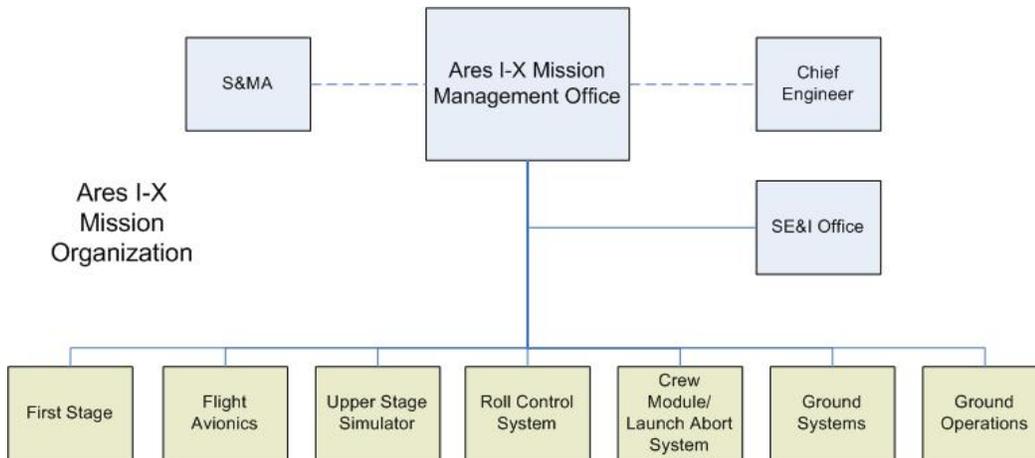


FIGURE 3-1 ARES I-X MISSION ORGANIZATION

3.1 KEY SYSTEMS ENGINEERING ROLES AND RESPONSIBILITIES

Below are systems engineering roles and responsibilities of the different Ares I-X teams. There are many programmatic roles and responsibilities that are not listed in this plan.

3.1.1 MMO

The MMO will lead an Ares I-X Control Board (XCB) for all technical decisions, manage all mission risks, manage the integrated schedule and manage safety issues from the S&MA team. The MMO maintains the Flight Test Plan from which the Ares I-X product requirements are derived. If it is deemed that NASA standards cannot be met for valid

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reasons, the MMO will work to obtain the necessary waivers. The MMO defines the configuration and risk management policies via Ares I-X Configuration Management Plan and the Ares I-X Risk Management Plan.

3.1.2 Ares I-X Chief Engineers

The Ares I-X mission has two Chief Engineers (CEs), one for the flight test vehicle and one for ground operations. The CE for the flight test vehicle will be the primary interface to the Mission Manager for technical issues and will also coordinate the efforts of the personnel in Chief Engineers Office. These personnel are assigned from the Center-level engineering organizations. The CEs are supported by the integrated product teams' lead engineers and appropriate technical expertise and resources from NASA Centers and the NASA Engineering and Safety Center (NESC). The CEs are strictly independent of the mission management office and are free to conduct their business with due concern for safety and mission success. General guidance on the role of a CE can be found in NPR 7120.5D. The specific roles and responsibilities of the CEs for Ares I-X include:

- a. Assure whether the resultant flight test vehicle and ground operations satisfies technical requirements;
- b. Ensure suitable standards, specification and design criteria are properly imposed, implemented and verified, including independent analyses when warranted;
- c. Maintain real-time communications with the mission and appropriate institutional engineering resources to ensure timely access to mission information, impending decisions, and analysis or verification results by the technical authorities, including peer chief engineers, such as Ares I elements.
- d. Establish a structure to provide engineering guidance and support to SE&I and the IPTs, including the assignment of lead engineers, whose activities relate to technical, test, production, quality, systems engineering, safety, risk management and configuration management. Lead engineer responsibilities include to:
 1. Provide technical oversight and leadership for SE&I and the IPT;
 2. Provide technical guidance to the IPT manager;
 3. Assure technical practices, standards, processes and tools are employed and suitable, current and compliant with NASA, Center and mission policies;
 4. Maintain communication and consultation with the prime/support contactor counterparts;
 5. Provide technical assessments including technology readiness level and technology development needs;
 6. Conduct technical review assessments;

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7. Evaluate and make recommendations/decisions on IPT trade studies plans, selection criteria, analyses and final trade results;
 8. Support the risk management processes;
 9. Develop IPT specific contingency plans;
 10. Promote technical quality assurance
 11. Ensure IPT interfaces are compatible with external systems;
 12. Support the Ares I-X Engineering Review Forum
 13. Support integration groups and technical panels through membership and participation according to charters;
- e. Serve as a member of the XCB and provide engineering recommendations to the XCB chair;
 - f. Serve as a member of the Ares I-X Systems Engineering Review Forum;
 - g. Serve as members of integrated product team major design review boards;
 - h. Participate in mission major design reviews;
 - i. Ensure FMEA and hazard analyses are an integrated part of the design process;
 - j. Approve resolution of non-conformances at the mission level;
 - k. Participate in risk management process;
 - l. Coordinate with engineering organizations and ensure appropriate level of engineering leadership and expertise involvement;
 - m. Consult with external technical boards, such as the Ares I boards and working groups;
 - n. Provide input to integrated product team-level engineering review boards, at technical interchange meetings and for special technical issues topics to ensure safety;
 - o. Approve all variances written against approved technical requirements, specifications, standard or technical process or method at the mission level;
 - p. Maintain communication and consultation with the prime/support contractors;
 - q. Ensure that efforts are made to communicate the experience gained and results obtained to other technical experts;
 - r. Institute special investigations or reviews deemed prudent for mishaps, incidents, failures; risk quantification or system understanding;
 - s. Attest the design and system configuration meet technical requirements by signing instruments such as board decision documents and flight test readiness reviews.

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- t. Ensure compatible interfaces of the flight test vehicle and the ground operations and external systems; and
- u. Serve as the Technical Authority for flight readiness of the Ares I-X mission.

3.1.3 SE&I

As per the Ares I-X Flight Test Plan, the primary responsibility for systems engineering and integration for the Ares I-X mission is the responsibility of the SE&I Office. The SE&I Office reports directly to the Ares I-X Mission Manager. The SE&I Office provides direct support to the MMO Project Integration Manager for certain functions such as CM/DM and RM to reduce duplication of effort. The SE&I Office will also provide Integrated Design and Analysis (ID&A) capability for the MMO. The SE&I Office is organized as follows:

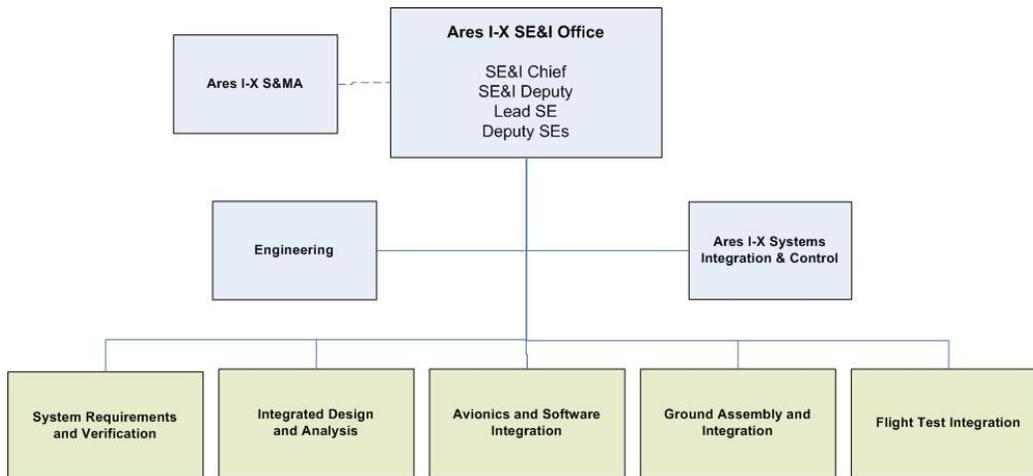


FIGURE 3.1.3-1 SE&I ORGANIZATION

The Ares I-X SE&I Office is responsible for the integration of the Ares I-X flight test system and its resultant integrated performance (both flight and ground systems). In order to meet the responsibilities defined in the Ares I-X Flight Test Plan, SE&I Office will:

- a. Provide technical and programmatic status and issues to the MMO.
- b. Lead development, flow down, and maintenance of the Ares I-X flight system requirements.
- c. Lead development, flow down, and maintenance of the Ares I-X ground system requirements.
- d. Perform integrated technical analysis via the Integrated Design and Analysis (ID&A) teams.

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- e. Manage development and maintenance of Interface Control Documents (ICDs) and Interface Requirements Documents (IRDs).
- f. Develop verification plans and requirements for system-level requirements.
- g. Manage system-level technical commodities/resources (i.e. power, mass, bandwidth).
- h. Implement and lead technical integration forums.
- i. Maintain and status the Ares I-X issue list via a weekly SE&I Tag-up with the IPT managers
- j. Provide and enforce policies on requirements management, trade studies, and engineering analysis.
- k. Provide technical review in support of the Ares I-X Control Board (XCB).
- l. Provide technical leadership of integrated issues to resolution.
- m. Confirm verification of product requirements.
- n. Lead Ares I-X System Assembly, Integration, and Test activities.
- o. Develop an Integrated Logistics Support Plan for Ares I-X.
- p. Develop and implement the review content, entry and exit criteria, and the review process for integrated Ares I-X milestone reviews.
- q. Identify post flight analysis and reporting requirements for vehicle performance as well as environmental loads and lead the development of these products.
- r. Provide flight data and analysis reports to the Ares 1 program.
- s. Support Ares I technical panels.
- t. Develop launch commit criteria.
- u. Provide technical integration with the range.
- v. Support reviews called by the Ares I-X Chief Engineers
- w. Develop and provide drawings for IPT to IPT assemblies.

3.1.4 Safety and Mission Assurance (S&MA)

For the Ares I-X mission, there are two S&MA Leads at the Mission Management level. One S&MA Lead will focus on the flight test vehicle and another will focus on ground operations and ground systems. The S&MA lead for the flight test vehicle will be the primary interface to the mission manager for S&MA issues and will coordinate overall S&MA activities for the Ares I-X mission. These personnel are assigned from the Center-level S&MA organizations and are independent from the Ares I-X mission management chain. S&MA Leads will elevate S&MA issues that cannot be resolved at

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an Ares I-X mission level. The S&MA Leads are supported by the SE&I S&MA personnel and integrated product teams S&MA lead engineers with appropriate technical expertise and resources from NASA Centers. As defined in the Ares I-X Flight Test Plan, the S&MA will support Ares I-X systems engineering by:

- a. Develop and maintain mission level S&MA plans
- b. Develop and maintain Critical Item Lists
- c. Develop and maintain integrated mission hazards analysis and fault trees
- d. Assure that the project-accepted S&MA requirements are implemented and verified.
- e. Verify that systems, ground and facility safety requirements are complied with
- f. Provide a single interface POC for the OS&MA and CxP SR&QA.
- g. Provide an independent review of all S&MA activities.
- h. Define mandatory government inspection points
- i. Perform concurrent independent analyses of design activities for safety related items.
- j. Directs S&MA personnel within the IPTs.
- k. Supports the non-advocacy review process.
- l. Provides status of S&MA activities within the SE&I Office and the IPTs
- m. Evaluate change, deviation, and waiver requests and provide recommended dispositions

For a detailed description of the S&MA organization and its Roles and Responsibilities see the Ares I-X Safety, Reliability and Quality Assurance Plan.

3.1.5 Integrated Product Teams

There are seven (7) Ares I-X IPTs. They are listed below:

- a. Ground Operations (GO)
- b. Ground Systems (GS)
- c. First Stage (FS)
- d. Upper Stage Simulator (USS)
- e. Roll Control System (RoCS)
- f. Avionics
- g. Crew Module/Launch Abort System Simulator (CM/LAS)

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These IPTs are responsible for the development and delivery of the Ares I-X hardware and operational systems as defined in the Ares I-X Flight Test Plan. The IPTs will perform the following systems engineering functions:

- a. Provide technical and programmatic status and issues to the MMO and SE&I Office.
- b. Support SE&I with a Systems Engineer representative from the IPT.
- c. Support MMO S&MA with an S&MA representative from the IPT.
- d. Support MMO Chief Engineers with a Lead Engineer from the IPT.
- e. Develop and perform maintenance of element requirements.
- f. Develop verification plans for element-level requirements.
- g. Implement documented element-level systems engineering processes.
- h. Conceptual, preliminary, and detailed design of the element, including relevant ground support equipment, development models (i.e. breadboards, brassboards, engineering models), and all sub-systems.
- i. Confirm verification of element-level requirements.
- j. Support the SE&I Office in the verification of integrated requirements.
- k. Provide Quality Assurance during development.
- l. Procurement and Fabrication of the Ares I-X elements and its subsystems.
- m. Management of allocated element-level technical resources (i.e. power, mass, bandwidth).
- n. Participate and support SE&I in the development of interface requirements and design.
- o. Participate in system-level integration forums.
- p. Identify and manage IPT level risks.
- q. Identify integrated risks.
- r. Develop and maintain element-level assembly, integration and test plans.
- s. Support reviews called by the Ares I-X Chief Engineers

3.2 EXTERNAL INTERFACES

The following organizations interface with SE&I and the IPTs for Ares I-X mission development. For more detailed information on Ares I-X roles and responsibilities see the Ares I-X Flight Test Plan.

3.2.1 Ares Project Office (APO) Vehicle Integration (VI)

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The SE&I Office will interface with the APO VI by providing a representative to the Ascent Flight Systems Engineering Group (AFSIG), the Ares I Design and Analysis Working Group (DAWG) and the Vehicle Integration Control Board (VICB). The SE&I Chief will interact with the APO VI Manager to ensure customer expectations are met. APO VI expectations will be documented in a similitude document that will give guidance to the Ares I-X mission developers. Ares I-X representatives will participate in regular AFSIG, DAWG and VICB meetings and present Ares I-X technical information as appropriate. The AFSIG, DAWG and VICB provide a means to ensure the Ares I-X and Ares I remain technically coordinated and are meeting customer expectations.

3.2.2 Launch Constellation Range Safety Panel (LCRSP)

The SE&I Office provides a technical point of contact (POC) to the Launch Constellation Range Safety panel (LCRSP) for Ares I-X mission. The Ares I-X Mission Manager is the approving authority for any agreements on range safety issues via the recommendation of the SE&I Chief, the CEs and S&MA.

4.0 TECHNICAL SUMMARY

The Ares I-X is a developmental test flight to provide design information for the Ares I launch system. When operational, the Ares I launch system is intended to provide a more reliable/lower cost system for providing human access to space than current systems. Note that the Ares I-X is not a prototype of the Ares I. Although the Ares I-X looks like the Ares I by design, it is not intended to become a human-rated vehicle. The Ares I-X will provide specific data to improve the Ares I final design.

For cost and schedule reasons, the Ares I-X will use existing components to the greatest extent possible. This includes a Reusable Solid Rocket Booster (RSRB) first stage from the shuttle program, various avionics components from the Atlas V program, a roll control system based on components from retired ballistic missiles and ground systems from the shuttle program. Existing systems will be referred to as heritage systems. The Ares I-X System Requirements Documents will define the policies for heritage product development and for new product development.

The Ares I-X Flight Test Plan (FTP) provides specific flight test objectives and a high-level system description from which all technical requirements for the Ares I-X mission are derived. Key mission requirements and constraints on the mission team include:

- a. Keep the outer mold line as close as possible to the Ares I design
- b. Design the vehicle with similar static and dynamic characteristics as the Ares
- c. Use an existing shuttle RSRB as the main propulsive element
- d. Provide flight data before the Ares I Critical Design Review (CDR) to affect design
- e. Use Ares I Guidance, Navigation and Control (GN&C) algorithms for flight control
- f. Provide Launch and Recovery experience for Ares I planning

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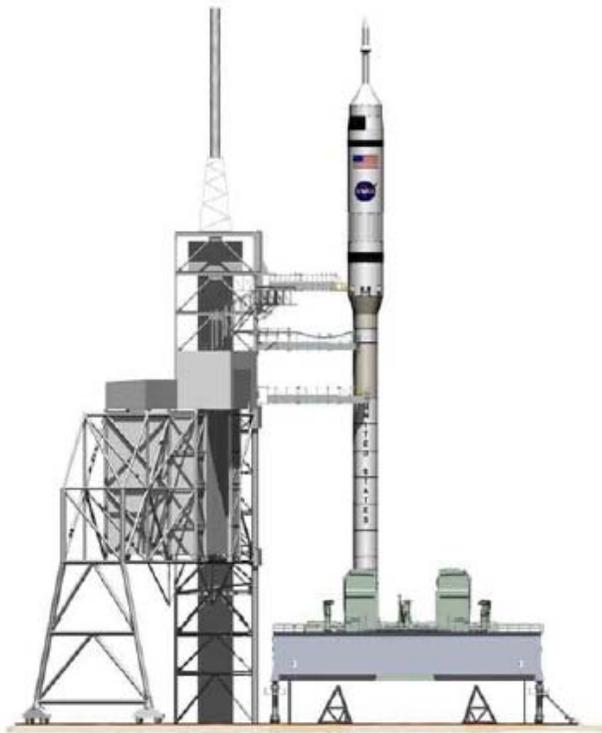
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4.1 ARES I-X SYSTEM DESCRIPTION

For mission definition and formulation purposes, Ares I-X is defined at the highest level in terms of two systems: The Flight Systems and the Ground Systems. These Systems have been broken into seven products to be developed by Integrated Product teams (IPTs). The flight system IPTs are: Crew Module/Launch Aborts System (CM/LAS) simulator, Upper Stage Simulator (USS), Roll Control System (RoCS), First Stage (FS), and Flight Avionics. The ground systems are: Ground Systems (GS) and Ground Operations (GO). The GS consists of facility modifications and new development. The GO consists of existing facilities and services.

The flight system requirements are described in the Ares I-X Flight Test Vehicle (FTV) Systems Requirements Document (SRD). The requirements for the ground systems are described in the Ares I-X Ground Systems Requirements Document (GSRD) and the Operational Test Requirements (OTRs) for ground operations are described in the Ares I-X Assembly, Integration, and Test Plan (AIT).

For a detailed system description see the referenced technical documentation in section 2.2.



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FIGURE 4.1-1 ARES I-X ON THE LAUNCH PAD

4.2 ARES I-X WORK BREAKDOWN STRUCTURE (WBS)

The Ares I-X WBS is maintained by the Ares I-X Business Manager using the Primavera Cost Manager. The Business Manager works with each IPT to organize and structure the WBS in a manner effective for tracking cost and schedule performance.

Configuration control of the WBS is managed by analyzing weekly variance reports. The Business Manager produces a report indicating the configuration control levels of the WBS. The IPT Business Analysts and Schedule Analysts have the ability to adjust the WBS information that falls below the baselined levels specified the Ares I-X Business Manager. Changes at and above the specified WBS levels must be agreed to by the schedule team and will be reported to the Business Manager for approval.

This WBS is integrated into the Ares I-X Integrated Master Schedule (IMS) and is maintained using the Primavera software application.

The Lead Schedule Analyst will lead weekly meetings which will include Schedule Analysts from each IPT and SE&I. As needed, project team members are invited to attend. At these meetings, schedule management and integration issues are discussed and problems resolved.

IPT and SE&I Schedule Analysts communicate directly with technical personnel to ensure the WBS and IMS reflect the actual work required. IPT and SE&I Schedule Analysts maintain their sections of the IMS and provide analysis reports as required by MMO and the IPT and SE&I management.

Updates to the baselined IMS are approved at the XCB via the process described in the Ares I-X Configuration Management Plan. These updates are released to the Ares I-X mission team to help them prioritize their work. The latest baseline schedule report will be maintained in Windchill in a dedicated folder controlled by the Lead Schedule Analyst so that the link remains constant for team members needing the information.

The overall Ares I-X product breakdown is defined in the AIT. The assembly trees contained in the AIT will define the drawings required for assembly of the FTV and will also identify what organization is responsible for those drawings.

4.3 ARES I-X PLANNING CONTEXT

Ares I-X product development will follow a standard development life cycle where a high level system is defined and eventually decomposed into low level details in which the parts are developed and tested and eventually integrated back up into a working system. This will be described in the technical process section. Because the Ares I-X system contains many existing components, not all elements will be at the same level of maturity at system level milestone reviews.

4.4 ARES I-X TECHNICAL MILESTONES AND PRODUCTS

4.4.1 Ares I-X Milestone Reviews

Comment [Kempton1]: This will be updated to reflect latest changes to FTP in the next revision.

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Ares I-X design review planning is the responsibility of the SE&I Office and will include the following milestone reviews: a Systems Requirements Review (SRR), a Preliminary Design Review (PDR), a Critical Design Review (CDR), and a Flight Readiness Review (FRR). The content of these reviews will be consistent with the guidance of NPR 7120.5D and NPR 7123.1A. The conduct, structure, and content of each review will be described in a milestone review plan that will be developed by the SE&I Office and baselined at least 8 weeks prior to the subject review. The minimum maturity of high level work products will be specified in the milestone review plans. The review plans will be tailored as appropriate for a developmental test flight and approved by the XCB. The specific milestone review plans are:

Ares I-1 Systems Requirements Review Plan (A11-SYS-SRR)

Ares I-X Preliminary Design Review Terms of Reference (AIX-SYS-PDR)

Ares I-X Critical Design Review Terms of Reference (AIX-SYS-CDR)

In addition to the above milestone reviews that focus on system design, there will be individual IPT Design Certification Reviews followed by a system-level Design Certification Review where verification information will be reviewed to show that Ares I-X requirements have been met. TBD will be the Designated Governing Authority for these milestone reviews and other responsibilities as described in NPR 7123.1A.

An Ares I-X Mate Review will be held prior to Ares I-X stacking and a Flight Test Readiness Review (FTRR) will occur shortly before launch. These reviews will be coordinated by the MMO. The FTRR demonstrates that the FTV was stacked, integrated, and tested correctly and that the vehicle and ground systems are ready for flight. The FTRR will require each IPT lead, the Chief Engineers, the S&MA Leads, the SE&I Chief and Mission Manager concur that the system is ready for launch.

4.4.2 Ares I-X Element Work Products and Technical Reviews

The IPTs will develop element-level requirements from allocations provided in the Ares I-X SRDs. The IPTs will also support development of IRDs and ICDs with the other IPTs that interface with their system of interest. The IPTs will conduct design reviews to support each Ares I-X Milestone Review. IPTs will review the entrance criteria for Ares I-X milestone reviews to ensure they comply. Open issues will be reviewed by the Mission Manager to determine whether to proceed with system level milestone reviews.

IPT Lead Systems Engineers will provide notification of their IPT Design reviews to the Ares I-X Mission Manager, Chief Engineers, Lead Systems Engineers of all the IPTs, SE&I and the S&MA Leads. An Ares I-X CE or their designee will have membership on the review board panel. The content and planning for the IPT design reviews is determined by the IPT but should follow predefined processes. Information from the IPT design reviews must be made available to the Ares I-X development team so that they can provide feedback to the review panel.

IPT-level systems engineers are also required to maintain documentation on their internal peer reviews and track actions and discrepancies to closure. The IPT Systems

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Engineers and IPT Managers are responsible for notifying the MMO and SE&I of any open items that may affect the system performance, cost, safety and/or schedule.

The IPTs will perform Pre-Ship reviews prior to shipment. These reviews will be described in the Ares I-X Integrated Logistics Support Plan.

Waivers to IPT level process requirements will be handled by the IPT Manager through the IPT level processes. The IPT Manager will notify the Ares I-X CE of any waivers that are approved at the IPT level and provide justification for the waiver.

4.4.3 Post Flight Data Analysis and Delivery

The SE&I Office will collate collected flight data and provide it to the Ares I program design team for use in Ares vehicle design. The primary customer for this data is the Vehicle Integration Manager for the APO.

In order to develop reports on performance and environmental loads, SE&I will prepare a Best Estimated Trajectory (BET) using day of flight data. The BET will be used in evaluation of the flight data taken from Development Flight Instrumentation (DFI) and Operational Flight Instrumentation (OFI). SE&I will validate the flight data by comparison against analytical predictions based on the BET.

A preliminary data analysis will be released as soon as possible following flight. The final validated flight data and comparisons against predictions will be compiled and delivered to the APO VI Office for their use in the Ares I design process. The post flight reporting delivery schedule is specified in the Ares I-X Flight Test Plan.

4.5 ARES I-X PLANNING DOCUMENTS

The documents listed in this section will provide in-depth or greater detail about the engineering and review processes described herein and are provided as source information for the reader. The documents will be provided as required to support the product development activities.

AI1-SYS-IMP: Ares I-X Mission Implementation Plan

AI1-SYS-AIT: Assembly Integration, and Test Plan

AI1-SYS-MVP: Ares I-X FTV Master Verification Plan

AI1-SYS-RVP: Ares I-X FTV Requirements Verification Plan

AIX-SYS-RMP: Ares I-X Risk Management Plan

AIX-SYS-ILS: Ares I-X Integrated Logistics Support Plan

AI1-SYS-CMP: Ares I-X Configuration Management Plan

AIX-SYS-DMP: Ares I-X Data Management Plan

AI1-SYS-SMA: Ares I-X Safety Reliability and Quality Assurance Plan

AI1-SYS-IMS: Ares I-X Integrated Master Schedule

5.0 ARES I-X INTEGRATION

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The SE&I Office is responsible for all the Vehicle Integration activities between IPTs to ensure a successful flight test. Roles and responsibilities assigned to the SE&I Office by the Mission Manager are documented in the Ares I-X Flight Test Plan.

5.1 ARES I-X TECHNICAL INTEGRATION WITH ARES I

The SE&I Office includes systems engineers and technical discipline experts who are responsible for the Integrated Design and Analysis (ID&A) activities necessary to ensure a technically successful mission. Technical analysis and sensor selection with relevance to Ares I will be coordinated with the APO AFSIG and the APO DAWG to enable the Ares Vehicle Integration (VI) Office to track Ares I-X technical similitude to Ares I. The Ares VI Manager and/or designees will attend Ares I-X milestone reviews.

5.2 ARES I-X TECHNICAL FORUMS

Technical forums will be developed to provide a means to communicate technical issues and to develop a focused set of work products. All technical forums will develop a charter to identify their objectives, work products, membership and roles and responsibilities. A record of the meetings will be written and distributed to the members for review. The charters, minutes and actions from these forums will be placed in meeting minute folders and actions tracked for the specific working groups on the Ares I-X Windchill site. Technical forums will be disbanded when they have accomplished their mission. The current forums are described below:

5.2.1 Ares I-X Systems Engineering Review Forum (SERF)

The SERF is a forum for reviewing Ares 1-X technical information for correctness. The SERF will ensure technical products have agreement from the Ares I-X Lead Systems Engineer, the Ares I-X Chief Engineers, the IPT Systems Engineers, the IPT Lead Engineers and also the SE&I technical leads. Technical experts will be brought in as needed to present material and answer technical questions. The SERF determines whether an issue should be elevated to the XCB in the form of a CR.

General guidelines for the SERF include:

- Review material will be provided to reviewers so that there is adequate time to review the material.

- The SE&I Lead Systems Engineer will lead the SERF.

- Reviewers are expected to review the material prior to the review and should contact the producer of the material with questions.

- The SERF lead will reschedule the forum if it is apparent the reviewers have not adequately reviewed the material.

- There will be a secretariat who will take attendance, minutes and actions.

Detailed procedures for CM of products at the SERF are found in the Ares I-X CMP (A11-SYS-CMP).

5.2.2 Ares I-X Engineering Review Board (ERB)

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As technical authority for Ares I-X, the Flight Chief Engineer and Ground Chief Engineer are accountable for technical adequacy of products and services. The Ares I-X ERB provides a means by which engineering reviews are performed on Ares I-X. The ERB provides concurrence/non-concurrence and recommendation on the technical adequacy of flight test launch vehicle content from the NASA IPT participants and its contractors. The ERB is also used as part of the structured process to identify, mitigate, and manage the risks associated with Ares I-X engineering.

The ERB provides an open forum for the discussion, analysis, and disposition of engineering-related issues. The scope of the ERB includes engineering topics or issues related to, or having a bearing on, any flight or ground system, facility, equipment, operation, or procedures. The ERB is intended to give the Ares I-X engineering community a voice that bridges across both NASA and contractor internal and external organizational lines of responsibility. Topics or issues brought to the ERB can originate from within; or other agencies, organizations, or contractors.

The ERB is led by the Ares I-X Flight Chief Engineer and the Ares I-X Ground Chief Engineer, who serve as co-chairmen. ERB membership includes Integrated Product Teams and SE&I Lead Engineers, Assistant Chief Engineers for Ares I-X Flight and Ground, and MMO S&MA Lead. The ERB is to be supported by the SE&I Lead System Engineer.

The Ares I-X IPT S&MA Leads and IPT Lead Systems Engineers will support the ERB when requested.

The ERB convenes on a regular basis with the System Engineering Review Forum (SERF) to discuss engineering topics. Meetings are cancelled if no agenda items are scheduled. Special formal ERB meetings can be held at various times and locations. Formal meeting minutes are to be taken and action items assigned and tracked to closure, as determined by the NASA Ares I-X Chief Engineers.

The ERB meeting format is intended to promote free and open interchange of technical information between participants, with the goal of producing the best possible engineering decisions. Dissenting opinions are encouraged to be brought forward and discussed. Supporting material can range from engineering notes to presentations and can include drawings, sketches, photographs, and/or hardware, as applicable. The preferred format for supporting material is electronic file format to facilitate archival into windchill.

During the ERB, dissenting opinions will be documented in the meeting minutes with the following information:

1. Topic (or agenda item) under discussion
2. Name, function, affiliation, and contact information of the individual registering the dissenting opinion
3. Nature of the dissenting opinion, together with the approach the individual proposes for resolution

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4. Disposition of the dissenting opinion, together with actions required. Dispositions will be categorized as follows: (a) Accepted; (b) Accepted for further study (an action item is required for tracking); (c) Rejected, with applicable rationale accepted by the individual having the dissenting opinion; (d) Rejected, with applicable rationale not accepted by the individual having the dissenting opinion (requires elevation to successively higher levels, as needed); and (e) Withdrawn by dissenter).

5.2.3 Ares I-X Systems Interface and Integration Working Group (SIIWG)

The SIIWG is chaired by the SE&I Requirements and Verification Manager. The SIIWG is responsible for development and documentation of the hardware and software interfaces between the flight and ground systems and also the interfaces between the elements. The SIIWG will also develop integration test plans for element-to-element interfaces. Interface issues not resolved in the SIIWG will be elevated to the SE&I Lead System Engineer. Membership includes representatives from each IPT, and SE&I as selected by SIIWG chair.

5.2.4 Ares I-X Systems Operations Working Group (SOWG)

The purpose of the SOWG is to provide a mechanism to plan and negotiate the details of Ares I-X element logistics, integration, system verification testing. The SOWG is chaired by the Ground Assembly and Integration Manager. The goal of the SOWG is to develop an assembly sequence, negotiate the roles and responsibilities for assembly and to ensure ground and launch operations are completed as scheduled. The SOWG is responsible for coordinating development of the Ares I-X Assembly, Integration, and Test Plan and for coordinating the development of Operational Test Requirements. Membership includes representatives from all IPTs and SE&I.

5.2.5 Ares I-X Launch Commit Criteria Working Group (XLCCWG)

The XLCCWG is a forum for discussion of all Integrated Vehicle Launch Commit Criteria. The XLCCWG will coordinate technical efforts related to Launch Commit Criteria development, integration and verification. The XLCCWG will also provide technical support to the SE&I Office to assist in negotiations between Launch Commit Criteria stakeholders. The XLCCWG is lead by the Flight Test Integration Manager. Membership includes representatives from all the IPTs and SE&I.

5.2.6 Other Forums

Other forums may be established from time to time at the Mission Manager's discretion. These Forums will have a specific focus and will exist only so long as the specific need exists.

5.3 INTEGRATED TECHNICAL TEAMS

Ares I-X is composed of several integrated teams that provide expert technical support. The roles and responsibilities of some of the key technical teams are described below.

5.3.1 Integrated Design and Analysis (ID&A) Teams

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The ID&A teams are managed at the SE&I Office by the ID&A Manager. Currently the following ID&A teams exist: Structural Loads Team, Thermal Loads Team, Aerodynamic Loads Team, Guidance, Navigation and Control (GN&C) Team, Trajectory Team, and the Demonstration Flight Instrumentation (DFI) Team. Technical expertise is brought in as needed, but all ID&A teams have a core discipline lead to coordinate the development of work products among its members. Products developed by the ID&A teams include the Ares I-X Loads Data Books that define the loads that the FTV will experience during ground operations and flight operations as well as presentation materials to support decisional briefings. These Loads Data Books will provide designers with the data they need to design and purchase components. All ID&A products are to be reviewed at the Systems Engineering Review Forum and if there are no significant technical issues found, they are then sent with a recommendation to the XCB.

The ID&A teams will also develop Technical Analysis Reports (TARs) that support the data books. The ID&A manager will ensure that TARs are peer reviewed by technical experts independent of the project. The TARs and the results of the peer reviews will be presented at the Systems Engineering Review Forum for approval to use. TARs are kept under configuration control as per the Ares I-X Configuration Management Plan.

ID&A team members communicate directly with their counter parts in the IPTs with regular teleconferences. These teleconferences are lead by the discipline leads. The ID&A teams also present information to a wider audience via the technical forums and the SERF.

5.3.2 Engineering Development Fixture (EDF) Team

The EDF team works for the MMO and provides support for integrating 3D models across the IPTs. In order to reduce interface problems the IPT designers will provide CAD model updates to the EDF team supporting the MMO at least once a month (Additional submittals may be needed to keep pace with design changes). The EDF team will assemble the models to create a virtual vehicle. They will analyze the integrated vehicle and look for possible interface, safety, and assembly issues. The EDF team lead will provide a monthly report on interface issues identified and resolution status to the Ares I-X Chief Engineers and the SE&I Lead Systems Engineer.

6.0 ARES I-X COMMON TECHNICAL PROCESSES

The Ares I-X Project Integration Manager is responsible for developing the integrated processes that will be used by the Ares 1-X mission team. Guidance for these processes was obtained from the NASA Systems Engineering Handbook (SP-610S Oct 9, 2003).

The integrated processes will be approved via the XCB approval process. The Ares I-X Chief Engineers and S&MA are responsible for ensuring the approved processes are implemented.

6.1 ARES I-X DESIGN DEFINITION PROCESS

Flight Systems

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The Ares I-X flight system architecture is defined in the Ares I-X FTV Design Definition Document (DDD). The DDD will be maintained by the SE&I Office and will be updated throughout the project lifecycle to stay current with the current Ares I-X FTV Design Analysis Cycles (DACs). The DDD will provide a common reference point for the flight and ground system developers.

DAC schedules and content are defined by the SE&I Integrated Design and Analysis (ID&A) team lead to provide technical milestones at a lower granularity than the mission level milestone described later. Updates to the DDD will be released at the beginning of each Ares I-X FTV DAC which last approximately two to three months. These updates will be reviewed at the Ares I-X Systems Engineering Review Forum prior to release to the elements for use as a reference. At the CDR the DDD will document the final baselined architecture of the Flight Test Vehicle.

The current design is also documented in the interface documents and in the drawings provided by the elements and provided to team members by the EDF team.

Design information from IPT milestone reviews, ID&A analysis of the designs and the latest Ares I-X drawings are to be made available on the Ares I-X Windchill site which is managed by the MMO.

Ground Systems

The Ares I-X ground system architecture is defined in the AIT. The AIT will be maintained by SE&I representatives with input from all the IPTs. These updates will be reviewed at the Ares I-X Systems Engineering Review Forum prior to release to the elements for use as a reference.

The DDD and AIT document will be provided as a reference document at milestone reviews.

Interfaces

Interface development will be managed and enforced through the SIIWG. This will include Flight System to Ground System Interfaces and Element to Element Interfaces.

6.2 ARES I-X PRODUCT VALIDATION

The IPTs will validate their work products by inviting personnel from MMO, the Chief Engineers Office, the SE&I Office, discipline experts and the other IPTs to all of their major reviews. Also the element-level requirements must be approved by members of the XCB.

At the mission level, the review panels for the milestone reviews described earlier include representatives from the Ares I development teams as well as external stakeholders.

Discrepancies between customer expectations and the current implementation are handled as formal Requests For Action (RFAs). RFAs are tracked until completion and are required to be closed by the next milestone review.

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The ID&A team will also provide data to support validation of the Ares I-X, especially on similitude issues to ensure the FTV provides the data that the Ares I customer needs to support their design process.

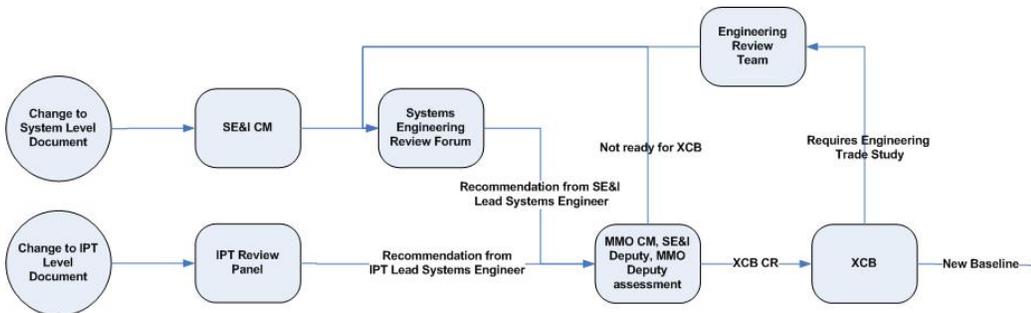
Validation is concluded after the mission by providing the Ares I development teams with analysis and data that helps them to refine their designs.

6.3 ARES I-X TECHNICAL MANAGEMENT

6.3.1 Ares I-X Control Board (XCB)

Technical approval of Ares I-X documentation and decisions will be via the XCB. Membership on the XCB includes the Mission Manager and deputies, the Chief Engineers, the SE&I Chief, the IPT Managers and the S&MA Lead. The charter letter for the XCB is maintained by the Mission Manager and a link to it will be provided in the Ares I-X Configuration Management Plan.

Incoming change requests to the XCB will be coordinated by a screening committee which consists of the MMO Project Integration Manager, the KSC MMO Deputy, and the SE&I Deputy Chief. The screening committee will perform goodness checks on the CR and determine its validity. Upon approval from the Screening Committee the XCB Secretariat will place the CR on the XCB agenda queue and identify mandatory evaluators. It is the responsibility of the CR's sponsor to certify that the products going to the XCB have been internally reviewed and approved for board review.



Ares I-X Technical Approval Process

FIGURE 6.3.1-1 TECHNICAL APPROVAL PROCESS

6.4 ARES I-X PRODUCT REQUIREMENTS MANAGEMENT

Ares I-X System Requirements will be developed through flow down of test objectives and constraints from the Ares I-X Flight Test Plan (CxP 70127). Ares I-X System Requirements will be documented in the Ares I-X FTV SRD and the GSRD, and allocated to the IPTs.

The Ares I-X SRDs will be tailored using the format recommended in MIL-STD 490. The IPT-level requirements will use this tailored format also. IPT-level requirements will be allocated to the subsystem-level if needed. IPT product requirements will use the same

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requirement attributes as those used in the Ares I-X system level documents to promote consistency. IPT product requirements will be documented as “elements” in Element Requirements Documents (ERDs).

The SRD will be baselined prior to the Ares I-X SRR and will be approved after SRR is successfully completed. The Milestone review panels include representatives from the Ares Program Office who will use the data derived from the Ares I-X mission.

Once the SRD and ERD baselines are established, requirements traceability and attributes will be managed via the Cradle software tool. For each requirement documented in an Ares I-X requirements document, a Cradle object will be created and will be linked to its parent and child requirements. The Cradle tool will also be used to track verification of requirements through all development phases and launch operations.

SRDs and ERDs will be based on product requirements, which describe the qualities the product will have. SRDs and ERDs will not contain programmatic requirements, procedures, or provider deliverable tasking (SOW type language).

The convention used for requirements documents will be as follows: **Shall** - Used to indicate a binding requirement, **Should** - Used to indicate a desired goal, **Will** - Used to indicate a statement of fact. Every requirement containing a "shall" is binding and will be verified. Rationales and goals are non-binding and “wills” and statements of fact are binding. Goals are included to guide trade studies and will be addressed at design reviews and TIMs.

For traceability and maintenance, every requirement will have a unique identification number that is not reused in the event that the requirement is deleted.

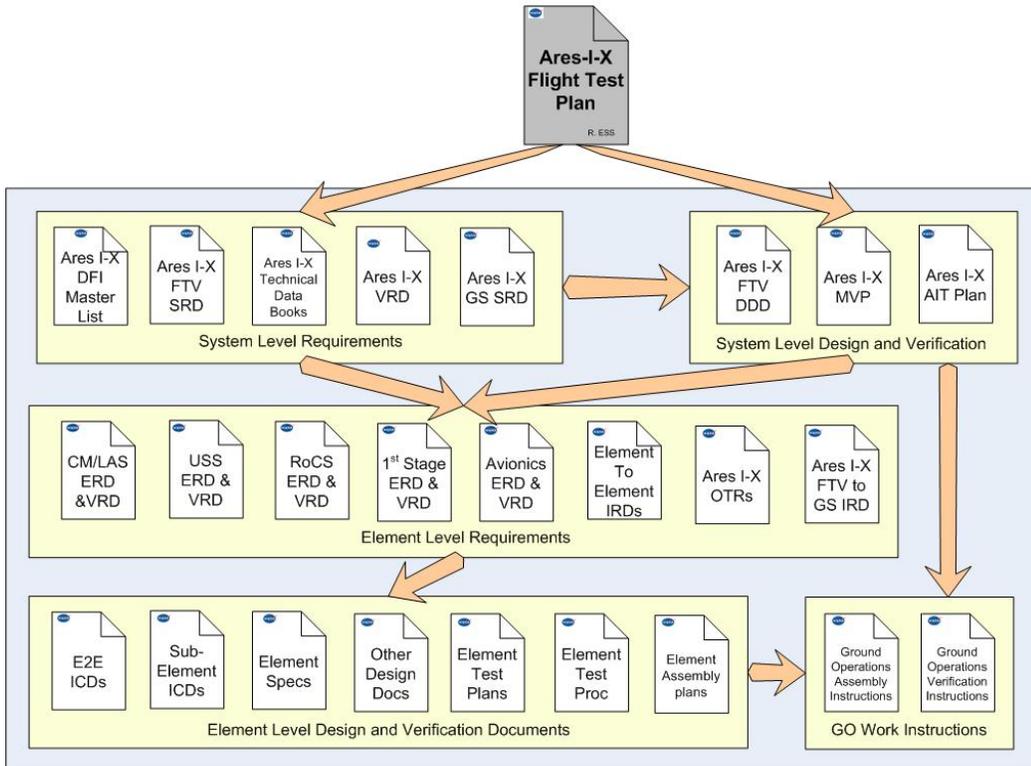


FIGURE 6.4-1 ARES I-X DOCUMENTATION HIERARCHY

A rationale is included for each requirement. The rationales are intended to provide clarification, justification, purpose, and/or source of the requirement. They are not requirements and only provide supporting information. Other attributes recommended include: Trace represents the parent requirement or the source of the requirement (The SRD will provide the parent requirements for the ERDs). Allocation points to the next level down and the responsible group (Elements) for further requirement decomposition. Verification states what method this requirement will employ for verification (Options are test, demonstration, analysis, and inspection.) Priority shows a rating of importance for the requirement on a scale of 1 to 3. One means that it is essential, mandatory and non-negotiable. Two means that it enhances the product and is useful to the customer but can be deferred or modified. Three is desirable at a low cost and is the first requirement reviewed when de-scoping.

The process, strategy and implementation of product requirement verification will be described in the Ares I-X FTV Master Verification Plan (MVP) and the Ares I-X Ground Systems MVP. The MVPs will provide a verification timeline based on the Ares I-X FTV assembly and integration schedule. For each verification item, the MVP will identify the approving authority.

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The Ares I-X FTV and ground systems Verification Requirements Documents (VRDs) will provide the verification requirements to implement what is described in the MVP. For each requirement in the SRDs, a Verification Requirement, Measurement Requirement, Success Criteria, and Rationale will be provided. The VRD will restate the method and provide a detailed verification requirement e.g. - A modal test will be performed on the USS. e.g. - A thermal analysis will be performed.

Ares I-X System Level Verification Flow

For the GS/Element Verification Flow replace "FTV" with GS or the appropriate Element

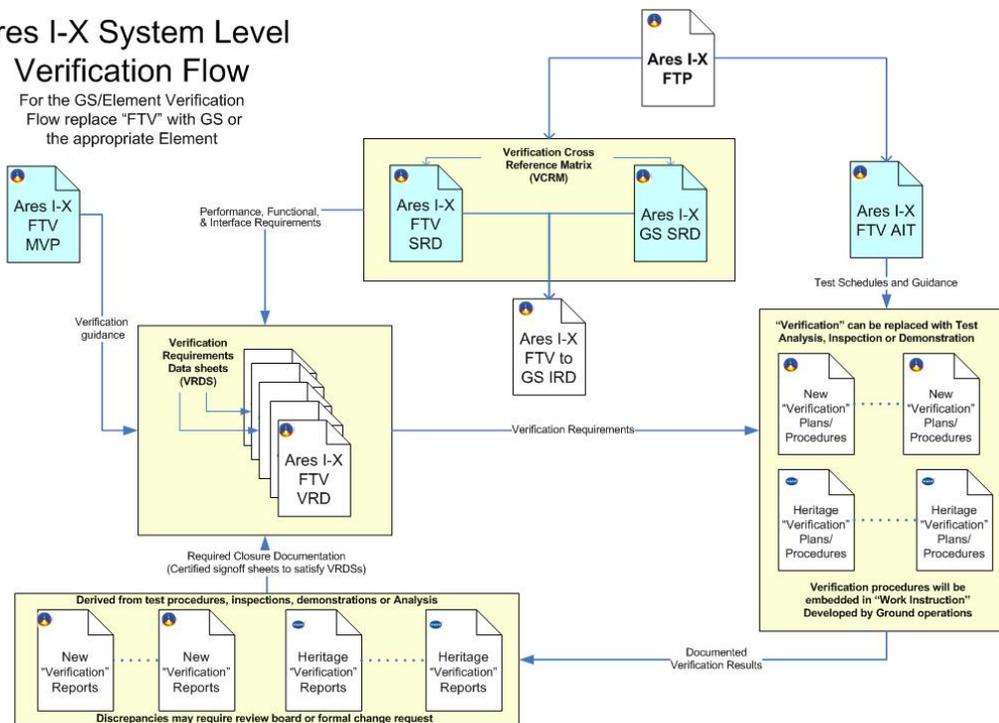


FIGURE 6.4-2 ARES I-X SYSTEM LEVEL VERIFICATION FLOW

Note: The verification process described is to verify that the design meets the product requirements. The process for verifying that the work has been done correctly is described in the Assembly, Integration and Test Plan.

6.5 ARES I-X INTERFACE MANAGEMENT

Coordination, communication and issue resolution of the Ares I-X interfaces are handled initially within the SIIWG. Issues that cannot be agreed to at the SIIWG can be brought forward to the SERF to develop a recommendation for the XCB where the decision will be made.

Ares I-X interfaces can be categorized into two types: IPT-to-IPT Interfaces, and Sub-element interfaces. Each type is managed differently.

IPT to IPT Interfaces – There will be five IPT to IPT Interface Requirements Documents (IRDs) developed to define the interfaces between the elements. They are

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the FTV to GS IRD, the CM/LAS-to-USS IRD, the USS-to-RoCS IRD, the USS-to-First Stage IRD, and the Avionics-to-FTV ICD.

Each of these interface documents will have a document custodian at SE&I, who is independent of the design organizations. The interface custodian will schedule and coordinate TIMS for developing interface definitions and tabletop reviews for document quality.

An interface book manager will coordinate the inclusion of technical information into the interface document while maintaining consistent formats with the other interface documents.

Interface developers will follow guidance tailored from NASA Reference Publication 1370 (Training Manual for Elements of Interface Definition and Control) for format and content. The SE&I Requirements and Verification Manager will provide guidance and approve exceptions to the recommended formats for the interface documents.

Each interface requirement in the interface requirements documents should have traceability to a requirement in each of the respective requirements documents. The interface custodian will verify this prior to requesting that an engineering review board be held.

To prevent the baselining of interface documents getting delayed by a few areas that require more maturity, the interface documents will be approved by sections. Once the book manager feels that specific sections are mature, each party will be requested to review those specific sections for approval. If they agree then the sections are frozen and submitted to the SE&I CM for a SERF. Once sections are reviewed by the SERF and recommended as ready for XCB they will require a Change Request be submitted to affect changes. A table will be provided in the interface document that lists sections as baselined, review pending, or draft. Baselined sections may not have TBDs/TBRs. Interface issues that arise between the elements can be discussed at the weekly SIIWG.

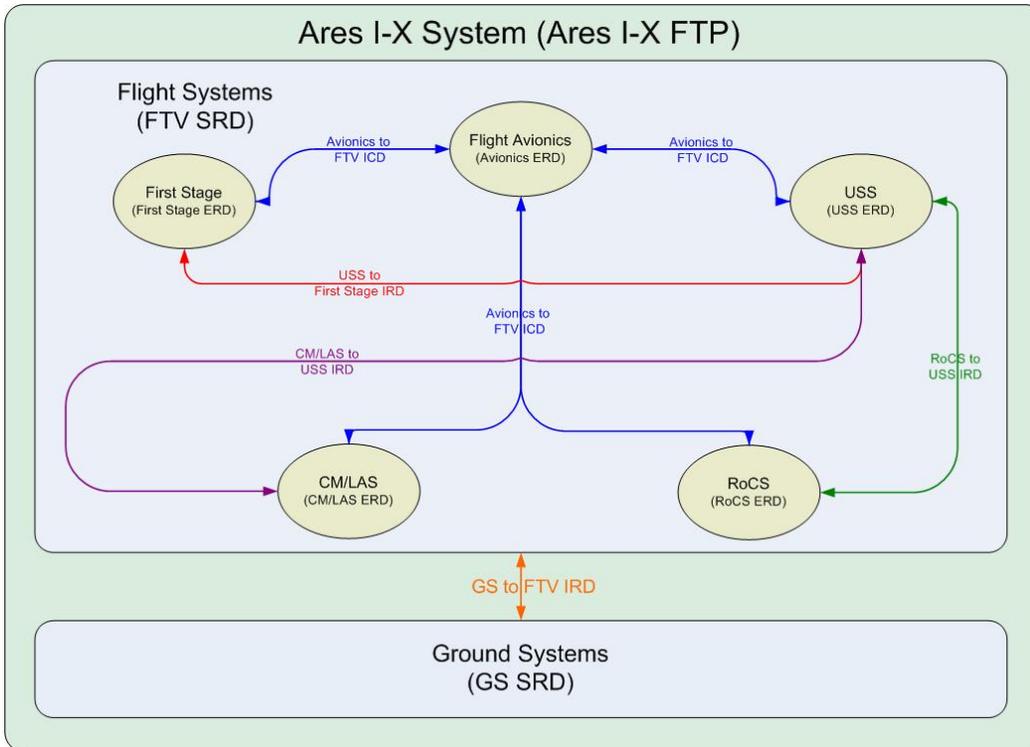


FIGURE 6.5-1 ARES I-X SYSTEM

Sub-element Interfaces - Sub-element interfaces completely contained within an IPT are managed at the IPT level.

All technical data that describes the interfaces between the elements or between the FTV and GS will be specified in English units.

6.6 TRADE STUDIES AND ENGINEERING ANALYSIS

Trade Studies and Engineering Analyses are analytical activities initiated by the SE&I Lead Systems Engineer or the Mission Manager via the XCB to resolve technical problems. For studies that require multiple disciplines and elements or a significant amount of work, a plan will be developed by the Ares I-X ID&A Manager or the applicable technical lead. Trade study plans will have clear objectives, options, and criteria by which the options will be assessed.

Prior to initiation, system-level Trade Studies and Engineering Analysis Plans must be approved by the Mission Manager. Trade studies and engineering analysis reports will be prepared by a discipline lead engineer and signed off by the Ares I-X ID&A Manager before submittal to the Ares I-X SERF or XCB. After trade study and technical analysis reports are approved they will be placed on Windchill. The Ares I-X ID&A Manager will track all Trade Studies and Engineering Analyses and provide status at reviews.

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6.7 TECHNICAL RISK MANAGEMENT

Ares I-X Risk Management is defined in the Ares I-X Risk Management Plan (AIX-SYS-RMP) which is developed by the Ares I-X Risk Management Officer (RMO) and approved by the Mission Manager. Ares I-X will use the CxIRMA risk management tool to manage mission level risks.

6.8 CONFIGURATION MANAGEMENT

Details of the Ares I-X Configuration Management (CM) process are described in the Ares I-X Configuration Management Plan.

The MMO Project Integrator will be responsible for the management of system level Ares I-X documentation. System level documentation includes: System and element-level requirements, interface and verification documents, documents defining integrated performance, MMO level processes and plans, and system level assembly, integration and test plans. IPTs are responsible for configuration management of all element-level documentation not directly controlled by the MMO.

As part of the CM process, an Ares I-X Ascension List will be maintained by the SE&I Office. The list will have sections for: Documents, Technical Analysis Reports, Drawings, and Data Files. Attributes will include: Name, CI number, Description, Owner, Version, location of document, required level of review, and sensitivity. To ensure they have the latest approved versions of Ares I-X documentation; developers will reference the Ares I-X Configuration Item (CI) List which is widely distributed each week to the team. The Ares I-X Configuration and Data Management Plan provides more details on the document list and naming conventions and includes the change request process for all CI and documents.

6.9 TECHNICAL DATA MANAGEMENT

The Ares I-X mission team will utilize a web-based tool (Windchill) for archival and distribution of Ares I-X documentation (including meeting minutes, trade studies and reports, action items, schedules, project review materials, etc.), risk management, and configuration management. The structure and content of the information on Windchill is controlled by the Ares I-X Data Manager. The Ares I-X Configuration Management Plan provides a description of the data structure on Windchill as well as access and security procedures.

The Data Management Plan will describe how items such as documents, drawings, models and simulations will be uniquely identified and tracked. The plan will also include formats for technical design data and data files to promote compatibility across the Ares I-X IPT design teams.

The AIT will contain drawing trees that specify what organization is responsible for the development and delivery of drawings at each level of integration.

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6.10 WAIVERS AND DEVIATIONS

Waivers to the technical processes defined in this SEMP or to system level requirements must be approved at the XCB. The specific process for requesting, approving, and documenting waivers is TBD (TBD-2).

If there are waivers needed to meet Constellation level process requirements they will be brought forward by the MM.

7.0 TECHNOLOGY TRANSITION

All Ares I-X technical data will be made available to APO design teams through periodic informational briefings and a formal flight test data report. The Ares I-X technical discipline teams will also perform post processing on the Ares I-X flight data and work with the Ares I design team to understand the implications to the Ares I designs.

All Ares I-X organizations will archive technical data, documents, trade studies, anomalies, rational for decisions and review minutes to provide future projects with information that allows lessons learned to be extracted as recommended by NPR 7123.1A.

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**APPENDIX A
ACRONYMS AND ABBREVIATIONS
AND GLOSSARY OF TERMS**

A1.0 ACRONYMS AND ABBREVIATIONS

AFSIG	Ascent Flight Systems Integration Group
AIT	Assembly, Integration, and Test Plan
APO	Ares Project Office
BET	Best Estimated Trajectory
CDR	Critical Design Review
CE	Chief Engineer
CI	Configuration Item
CM/LAS	Crew Module/Launch Abort System
CMP	Configuration Management Plan
CxP	Constellation Program
DAC	Design Analysis Cycle
DAWG	Design Analysis Working Group
DDD	Design Definition Document
DFI	Demonstration Flight Instrumentation
EDF	Engineering Development Fixture
ERD	Element Requirements Document
FITO	Flight and Integrated Test Office
FS	First Stage
FTP	Flight Test Plan
FTRR	Flight Test Readiness Review
FTV	Flight Test Vehicle
GN&C	Guidance, Navigation and Control
GS	Ground Systems
GSE	Ground Support Equipment
ICD	Interface Control Document
ID&A	Integrated Design and Analysis
IMS	Integrated Master Schedule
IPT	Integrated Product Team
IRD	Interface Requirements Document
IRMA	Integrated Risk Management Application
XLCCWG	Ares I-X Launch Commit Criteria Working Group
MMO	Mission Management Office
MOA	Memorandums of Agreement
MVP	Master Verification Plan

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NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirements
OFI	Operational Flight Instrumentation
OML	Outer Mold Line
OTR	Operational Test Requirement
PDR	Preliminary Design Review
RoCS	Roll Control System
RSRB	Reusable Solid Rocket Booster
S&MA	Safety and Mission Assurance
SEMP	Systems Engineering Management Plan
SERF	Systems Engineering Review Forum
SIIWG	System Interface and Integration Working Group
SOWG	System Operation Working Group
SOWs	Statements of Work
SRD	System Requirements Document
SRR	System Requirements Review
TAR	Technical Analysis Report
TBD	To Be Determined
TBR	To Be Resolved
TIMs	Technical Interchange Meetings
TIN	Technical Information Notice
TRR	Test Readiness Review
USS	Upper Stage Simulator
VI	Vehicle Integration
VRD	Verification Requirements Document
VRDS	Verification Requirements Data Sheet
WBS	Work Breakdown Structure

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A2.0 GLOSSARY OF TERMS

Term	Description

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APPENDIX B OPEN WORK

B1.0 TO BE DETERMINED

Table B1-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBD item is numbered based on the section where the first occurrence of the item is located as the first digit and a consecutive number as the second digit (i.e., <TBD 4-1> is the first undetermined item assigned in Section 4 of the document). As each TBD is solved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

TABLE B1-1 TO BE DETERMINED ITEMS

TBD	Section	Description
1	4.4.1	Provide DGA for milestone reviews.
2	6.1	Develop process for identifying, approving, and documenting mission level waivers.

B2.0 TO BE RESOLVED

Table B2-1 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBR issue is numbered based on the section where the first occurrence of the issue is located as the first digit and a consecutive number as the second digit (i.e., <TBR 4-1> is the first unresolved issue assigned in Section 4 of the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

TABLE B2-1 TO BE RESOLVED ITEMS

TBR	Section	Description

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**APPENDIX C
MAPPING TO SEMP OUTLINE IN NPR 7123.5**

Description	NPR 7123.5	A11-SYS-SEMP
<u>Purpose and Scope</u>	<u>D.4.2</u>	<u>1.1, 1.2</u>
<u>Applicable Documents</u>	<u>D.4.3</u>	<u>2.1, 2.2</u>
<u>Technical Summary</u>	<u>D.4.4</u>	<u>4.0</u>
<u>System Description</u>	<u>D.4.4.1</u>	<u>4.1</u>
<u>System Structure</u>	<u>D.4.4.2</u>	<u>4.2</u>
<u>Product Integration</u>	<u>D.4.4.3</u>	<u>3.0, 3.1, 3.2</u>
<u>Planning Context</u>	<u>D.4.4.4</u>	<u>4.3, 4.4</u>
<u>Boundary of Technical Effort</u>	<u>D.4.4.5</u>	
<u>Cross References</u>	<u>D.4.4.6</u>	<u>4.5</u>
<u>Technical Effort Integration</u>	<u>D.4.5</u>	<u>5.0 - 5.3</u>
<u>Responsibility and Authority</u>	<u>D.4.5.1</u>	<u>5.1 - 5.3, 3.1</u>
<u>Contractor Integration</u>	<u>D.4.5.2</u>	<u>3.1, 5.2</u>
<u>Support Integration</u>	<u>D.4.5.3</u>	<u>4.2, 6.1, 6.6, 6.9</u>
<u>Common Technical Process Implementation</u>	<u>D.4.6</u>	<u>6.0, 6.1</u>
<u>Technology Insertion</u>	<u>D.4.7</u>	<u>7.0</u>
<u>System Safety</u>	<u>D.4.8.1</u>	<u>3.1</u>
<u>Engineering Methods and Tools</u>	<u>D.4.8.2</u>	<u>6.9</u>
<u>Specialty Engineering</u>	<u>D.4.8.3</u>	
<u>Integration with the Project Plan</u>	<u>D.4.9</u>	<u>1.2</u>
<u>Waivers</u>	<u>D.4.10</u>	
<u>Appendices</u>	<u>D.4.11</u>	<u>Appendices</u>

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