National Aeronautics and
Space Administration

CxP 72024
Revision C
June 16, 2008

CONSTELLATION PROGRAM
ARES PROJECTS SYSTEM ANALYSIS PLAN (SAP)

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REVISION AND HISTORY PAGE

Status	Revision No.	Description	Release Date
Baseline		Ares Level III PCB Baseline, CE3-00-0023, 9/5/06; CR CLV-VI-012, PCN CE00030	09/15/06
Revision	A	Revision A Approved at Ares Level III PCB. CR: CLV-VI-031; PCN: CE000104; PCBD: CE3-00-0042, 3/2/07. This CR was initiated due to Ares System Requirement Review (SRR) Review Item Discrepancy (RID) #1813.	04/12/07
Revision	B	Rev B update of the Ares SAP (CxP 72024A) to include ADAC-2A lessons learned plus Kaizen event TDS & Trade Study Process recommendations. Revision B Approved at Ares Level III PCB, CR: CLV-VI-053, PCN CE000155; PCBD: CE3-00-0071, 9/6/07.	09/06/07
Revision	C	Revises the Ares SAP to include 1) TDS Process automation, 2) formation of the Integrated Design Analysis Team (IDAT) and associated reorganization of WBS 5.2.4 responsibilities, 3) updated Modeling and Simulation documentation, 4) updated analysis scheduling process, 5) the development of the ADAC Logbook, 6) added analysis fidelity definitions, and 7) changes due to the Level II System Integrated Analysis Plan (SIAP). Revision C Approved at Ares Level III VICB, CR: APO-VI-083, PCN CE000325; VICBD: CE3-01-0029, 6/16/08.	06/16/08

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1.0 INTRODUCTION

1.1 Purpose

The Ares System Analysis Plan (SAP) describes the approach used by the Ares Projects Office to manage the Ares Design Analysis Cycle (ADAC) process and Trade Study Process for the Ares I and Ares V vehicles.

This document also provides the SAP Master Plan for the number of ADACs to conduct before each milestone review during the Ares I and Ares V life cycle. It includes general guidance on ADAC goals and objectives in support of the respective Program Milestones.

The SAP does not, however, define the specific analyses and trades to be conducted during a given ADAC. Those analyses are identified by the performing organizations at the start of each cycle in an ADAC-n Plan, where n is the number (2B, 3, etc.) corresponding to that particular ADAC cycle.

1.2 Scope

The ADAC process is applicable to all Ares Vehicle and Element analyses necessary to support Level III requirements. Analyses performed in support of Level IV requirements are the responsibility of the Elements.

The Ares Trade Study process is applicable to all formal Level III and Level IV trade studies.

1.3 Authority

The Ares SAP is derived from and complements the Constellation Program Systems Integrated Analysis Plan (SIAP) (CxP 70009) and the Ares Systems Engineering Management Plan (SEMP) (CxP 72018). Any conflict between the Ares SEMP and this document will be identified to the Integrated Design Analysis Team (IDAT) for resolution and change.

The various Design Analysis Cycles (DACs) for Constellation, Orion, and Ares are labeled and governed as follows:

- IDAC = Integrated DAC, governed at Level II by the Constellation Program SIAP, CxP 70009.
- ODAC = Orion DAC, governed at Level III by Project Orion's Crew Exploration Vehicle (CEV) Systems Analysis Plan, CEV-T-008.
- ADAC = Ares DAC, governed at Level III by this document, CxP 72024.

1.4 Philosophy

The Ares SAP is constructed to manage the major iterations of the Systems Engineering (SE) process over the Ares Project life cycle via a series of discrete Ares Design Analysis Cycles (ADAC). An ADAC is a controlled activity for managing the conduct of multiple concurrent analyses distributed across a large organization and integrating the results to achieve the stated goals and objectives of the cycle.

For each cycle, as shown in Figure 1.4-1, reference configurations of the baseline requirements and architecture are provided by the requirements and architecture definition processes. Next, the ADAC process is used to plan and conduct the set of analyses and assessments. Finally, the resulting change recommendations are approved by the change control process, which are then fed back into the respective system definition processes. This sequence continues over the system life cycle until a convergence between system requirements and design is achieved. The number of ADACs (iterations) and the scope of each are selected based on the data needs of the various Program milestones.

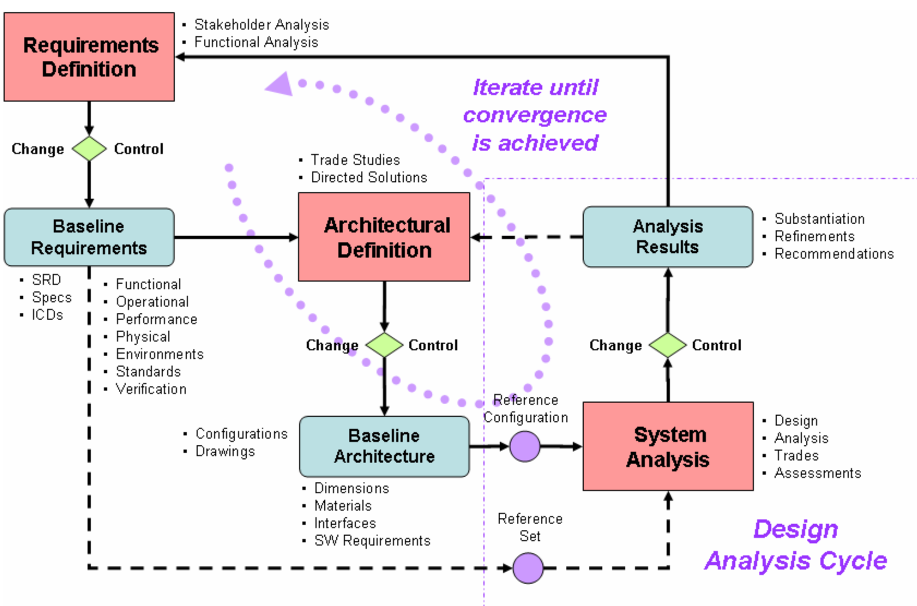

Figure 1.4-1 Role of an ADAC within the SE Process

The tenets of the ADAC process are to ensure that a structured approach is used to define the necessary and sufficient set of analyses, and that a consistent set of initialization data and assumptions are used such that analysis results can be integrated across multiple systems and designs. The ADAC process coordinates and controls the data to the extent required to ensure successful technical integration.

1.5 Update Process

Future updates to this plan shall be processed in accordance with the Configuration Management (CM) Plan for the Ares Project (CxP 72015).

2.0 APPLICABLE DOCUMENTS

The following documents of the date and issue shown form a part of this document to the extent specified herein. "(Current Issue)" is shown in place of the specific date and issue when the document is under the Constellation Program or Ares Projects Office control. The current status of Constellation Program documents shown with "(Current Issue)" may be found at https://ice.exploration.nasa.gov/Windchill/netmarkets/jsp/library/listFiles.jsp?oid=library%7Ewt.inf.library.WTLibrary%3A58345360&u8=1. The current status of Ares Projects office documents shown with "(Current Issue)" may be found at the Ares Home page, https://ice.exploration.nasa.gov/ice/site/ares.

CxP 70002 (Current Issue)	Constellation Design Reference Missions
CxP 70009 (Current Issue)	Constellation Program System Integrated Analysis Plan (SIAP), Volume 1
CxP 72015 (Current Issue)	Ares Configuration Management Plan
CxP 72018 (Current Issue)	Ares Systems Engineering Management Plan
CxP 72019 (Current Issue)	Ares Risk Management Plan
CxP 72265 (Draft)	Ares Modeling & Simulation Integrated Management Implementation Plan

NPR 7120.5 (Current Issue)	NASA Program and Project Management Processes and Requirements
NPR 7123.1A (Current Issue)	NASA Systems Engineering Processes and Requirements
MPR 8060.3 (Current Issue)	Requirements and Design Reviews, MSFC Programs and Projects

3.0 SAP MASTER PLAN AND SCHEDULE

This section provides the SAP Master Plan and Schedule, identifying the baseline set of ADACs required for the Ares development life cycle.

3.1 SAP Master Plan

The approach of the Ares SAP is to converge on a system design that meets the requirements and supports the mission objectives, by means of a series of discrete ADACs.

This succession of ADACs have been arranged to directly support the Ares Projects review milestones, as shown in Figure 2.1-1. The ADACs are also configured to indirectly support the respective CxP Level II and Ares Projects Office Level IV analysis cycles and acquisition milestones.

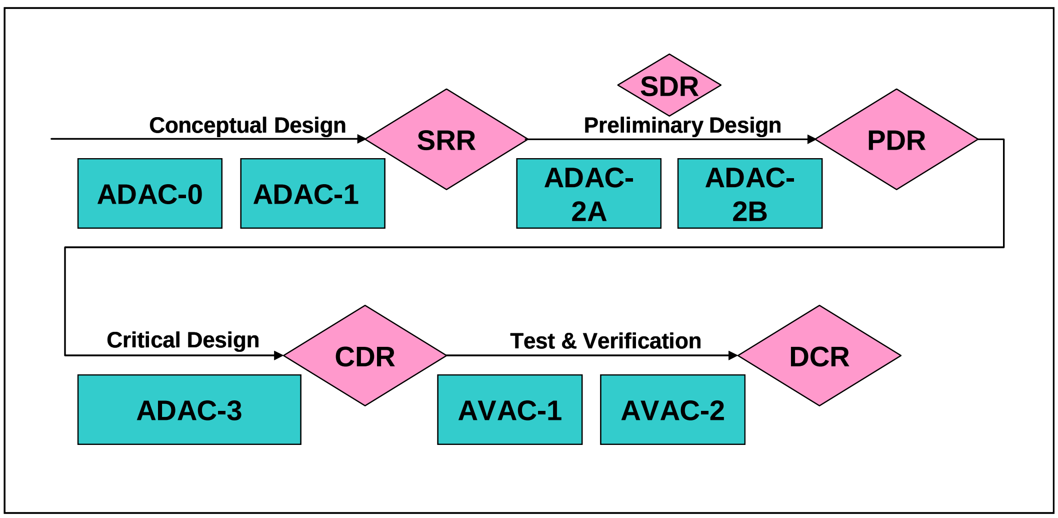

Figure 3.1-1 ADAC Support of Ares Project Reviews

Note that this is only a planning assumption. The intent here is not to rigidly stipulate the number and duration of ADACs in the plan, but rather to depict a sequential progression of ADACs that will allow the Ares Projects Office to define a sequential progression of ADAC objectives and success criteria. Typically, plans change over time, but the objectives and success criteria should still serve as the basis for ADAC planning. The important aspects to address are the relation between ADACs, how they relate to the Project/Program, and how they evolve over time.

Commonly, analysis cycles intended to focus on requirements generation and validation are termed Design Analysis Cycles (DACs). Similarly, cycles focusing on requirements verification are termed Ares Verification Analysis Cycles (AVACs). The Ares Projects Office has elected to maintain the term ADAC for its SRR supporting cycles, but will refer to the Design Certification Review (DCR) supporting cycles as AVACs. This document refers to analysis cycles in general (ADACS and AVACs) as ADACs.

The ADAC conducted just prior to a given review will support the goals and accommodate the entry criteria of that specific review by including the appropriate analysis and required initialization data set. For more details, please see Section 6.1, ADAC Support to Milestone Reviews.

3.2 Master Schedule

3.2.1 Ares Integrated Master Schedule.

The Ares I Projects Office Summary Schedule is provided in CxP 72130, "Ares I Project Milestones." The Ares I Level III Integrated Master Schedule (IMS) is managed by the Ares I Program Planning and Control (PP&C) office following the guidance of the CxP Ares Project Program, Planning, and Control (PP&C) Process Manual. The Work Breakdown Structure (WBS) serves as the framework for the IMS which contains all the discreet tasks and milestones required to complete the Area I scope of work. The Ares I IMS consists of separate, detailed Level IV integrated schedules for each of the Ares Project sub-elements and offices (i.e., Upper Stage, Upper Stage Engine, First Stage, and Flight Integration and Test Office (FITO) as well as the Ares I Vehicle Integration (VI) Office. These schedules are integrated into a single Ares I integrated schedule (Figure 3.2.1-1), currently maintained in the Ares Commons folder on Windchill.

Note: There is no separate ADAC integrated schedule. The Ares I IMS contains all work content, to include ADAC specific and non-ADAC specific schedule content.

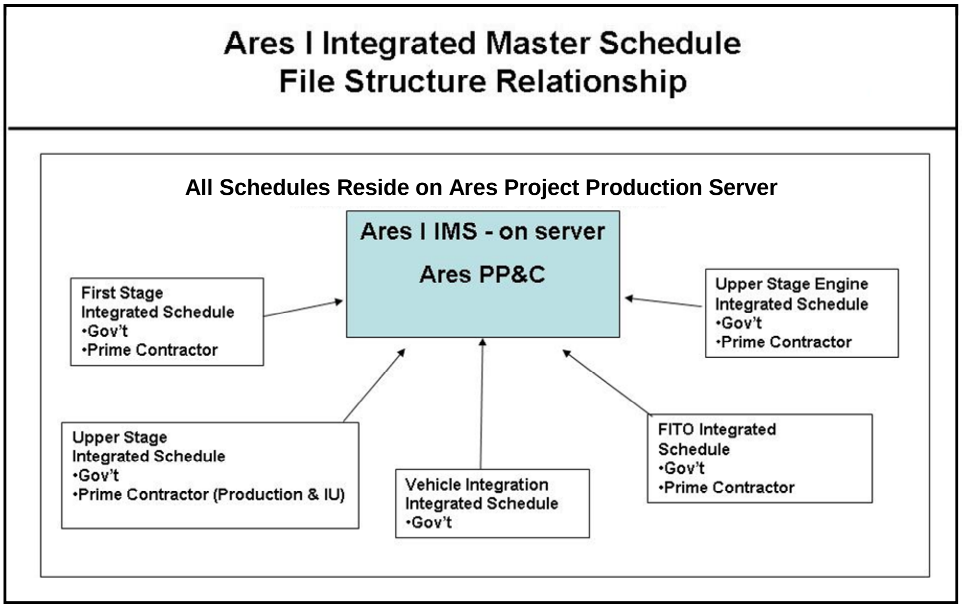

Figure 3.2.1-1. IMS File Structure Relationship

3.2.2 IMS Tasks and Milestones

The Ares I IMS is established such that each integrated schedule is a set of tasks and milestones with durations and established inter-relationships reflecting all Ares I work content. This is constantly evaluated to identify schedule issues and conflicts associated with the completion of critical Ares Project milestones.

A primary purpose of the Ares I IMS is the conduct of critical path evaluations and analyses associated with the Project key control milestones. A control milestone is defined as any milestone reflecting a handoff of results from one project to another. Ares I Project milestones that are controlled by the Constellation Program Office (Level II) are shown in Table 3.2.2-1. These milestones may not be changed without going through the appropriate APO change request process.

This Ares I IMS process ensures that the three prime concerns, 1) Schedule development, 2) schedule maintenance, and 3) schedule reporting are addressed.

Table 3.2.2-1. Ares I Key Control Milestones

LEVEL II NOTIFICATION MILESTONES	
First Stage	**Upper Stage**
• SRR	• SRR
• PDR	• SDR
• CDR	• PDR
• DCR	• Upper Stage DAC 2
• DDCR	• Upper Stage DAC 3
• DM-1	• Upper Stage DAC 4
• DM-2	• CDR
• QM-1	• DCR
• QM-2	• MPTA CF
• QM-3	• MPTA HF
Avionics & TVC	
• Development Test Complete	
Structures	
• Forward Structures STA Test Complete	

3.2.3 Ares I IMS Development

3.2.3.1 General IMS Development

This IMS development process applies to the development of Government In-House schedules (e.g., Vehicle Integration Office). The Ares I PP& C Office does not dictate Element schedule development specifics, but does expect Elements and Offices to use sound schedule practices when statusing or developing their own integrated schedules. This includes the proper use of activity predecessor and successor logic relationship types (e.g., Finish-to-start, Start-to-start, Finish-to-finish, and Start-to-finish). It also makes proper use of task constraints and dedicated field usage, e.g., certain text fields are dedicated for Task Description Sheet (TDS) numbers or management tracked milestones. (Note: The ADAC TDS tasks are not routinely updated to either mirror the IMS or to drive updates to the IMS. Schedule maintenance is performed using the IMS; tasks listed in the IMS have a TDS number reference for easier traceability.)

The Ares I Project and the Marshall Space Flight Center (MSFC) Engineering Directorate (ED) personnel work closely together to ensure all required work content is accurate and thoroughly captured in the Ares I IMS which means including Design Analysis Cycle (DAC) related activities as well as non-DAC related activities. The Ares I Project provides ED with key documentation, e.g., Data Requirements List (DRL), Data

Requirements Descriptions (DRD's), Ares I Control Milestones and WBS work packages, that is used to help define and determine schedule tasks/milestones, schedule durations and schedule relationships.

3.2.3.2 Predecessor-Successor Schedule Relationships

A key aspect of capturing schedule relationships is identifying external predecessor and successor interfaces. An external predecessor is defined as any input to schedule milestone from any other schedule milestone outside their WBS/Element. Likewise, an external successor is defined as any output from a given schedule milestone to any other schedule milestone outside of their WBS/Element. Identification and creation of external predecessor and successor logic relationships is a fundamental part of the schedule development process.

To assist in the formal documentation of external predecessor and successor logic relationships, Constellation has implemented and directed that the Projects employ an automated TDS process (See paragraph 5.1.5). TDSs are used to agree to analysis technical content and schedule need dates. Only after TDS agreements are approved are external predecessor and successor milestones linked in the IMS and flagged accordingly in the appropriate MS Project fields so that it can then be reported on regularly.

For the predecessor and successor milestone relationships that cannot be established due to the unavailability of schedules (e.g., Orion integrated schedule, Constellation integrated schedule, etc.), predecessor and successor milestones are still recognized but instead of linking schedules, the interface milestone need dates are targeted and evaluated as any other milestone during the maintenance phase of the schedule process.

3.2.3.3 IMS Baselining

Once the initial schedule has been developed and logical relationships made, the IMS is baselined. Baselined dates, once set, should not be moved or changed without approval from Ares Management. As part of the schedule baseline process, all Ares I In-House schedules are resource loaded to allow for the implementation of the Earned Value Management System (EVMS) and the analysis of cost and schedule variance. As new tasks are added, they are baselined.

3.2.3 Ares I IMS Maintenance

The baselined Ares I IMS is maintained by verifying/modifying task durations, revising or adding logic ties, adding new tasks or milestones and their associated logic tie, etc. The Ares I PP& C Office does not dictate schedule maintenance specifics, but relies upon Elements/Offices to employ sound schedule practices when statusing or updating their integrated schedules.

Each Element/Office conducts meetings between schedulers and ED product developers in which schedule updates are captured. And, once captured, schedulers incorporate schedule changes into their individual integrated schedules. Due to the schedule structure, when individual integrated schedules are updated, they're integrated into the overall Ares I Project IMS for evaluation and assessment of schedule critical path and external milestone dependencies. Regular schedule maintenance is important in order to have accurate and timely schedule reporting to management.

3.2.4 Ares I Schedule Reporting

Reporting communicates schedule status, progress, issues/concerns and any associated help needed. The Ares I PP& C Office does not provide specific schedule reporting guidelines but does expect each Element/Office to employ sound schedule practices in the development of reporting methods, presentations and metrics. As a minimum, schedule reporting should include:

3.2.4.1. Evaluation of schedule critical paths to include identifying the schedule's total slack associated with schedule paths to any Ares I control milestone

3.2.4.2. Evaluation of key schedule milestones and evaluation of the overall schedule health, e.g., 1) Tasks needing status; 2) Tasks with no predecessor; 3) Tasks with no successor, etc.

3.2.4.3. Evaluation of the key schedule milestones includes the identification, tracking and burn down of Ares I Project Level IV Elements and Ares I VI Office milestones associated with the completion of any Ares I control milestone. When determining what milestones to include, the following criteria should be considered:

- Draft or Interim Release Documents or Products Milestones
- Lower-Level Milestones that are associated with Ares I Control Milestone Products
- External Predecessor and Successor Milestones

3.2.4.4. Evaluation of the overall schedule health of the Ares I IMS and lower level integrated schedules will be conducted and assessed. Table 2.2.4.4-1 below is an example of the type of metrics collected when evaluating the overall schedule health.

Table 3.2.4.4-1 Schedule Health Check

Schedule Health Check

Project Name: CLV_Vehicle Integration

Overall Project Health Status Indicator: 2.8 G | 2.8 G

Schedule Status

Description	Current	Previous	Change (C-P)	
Current Start (Note: earliest activity Early Start Date)	10/1/2007	10/1/2007		
Current Finish (Note: latest activity Early Finish Date)	1/23/2015	1/23/2015	0	0%
Approximate Remaining Work Days	1726	1731	-5	0%
Is this schedule externally linked to other schedules?	N	N		
Status Date	2/29/2008	2/22/2008	7	

Task and Milestone Count (*Note: These counts exclude summary tasks*)

Description	Count	% of Total	Count	% of Total	Change (C-P)	
Total Tasks and Milestones	6792		7187		-395	
Completed Tasks and Milestones	2196	32%	2611	36%	-415	-4%
To Go Tasks and Milestones	4596	68%	4576	64%	20	4%

Logic (*Note: These counts exclude summary and started/completed tasks*)

Tasks and Milestones Without Predecessors	16	0%	G	32	1%	G	16	0%
Tasks and Milestones Without Successors	7	0%	G	16	0%	G	9	0%
Constraints (Note: other than ASAP including deadlines)	3	0%	G	59	1%	G	56	-1%
Summaries with Logic Ties (see note below)	0	0%	G	0	0%	G	0	
Tasks and Milestones Needing Updates	21	0%	Y	17	0%	Y	-4	0%
Actuals after Status Date	0	0%	G	0	0%	G	0	
Tasks marked as Milestones (Note: having a duration of > 0)	0	0%	G	0	0%	G	0	

Note: The summaries with logic ties number is calculated as a percentage of tasks and milestones.

3.2.4.5 Schedule Forum

In addition to developing the appropriate schedule reporting metrics and presentations, the Ares I Project Level IV Elements and VI Office will provide for a recurring schedule forum in which schedule reporting status and metrics are presented. It will follow a timed agenda and include the appropriate Ares I Project Office and MSFC ED personnel. Schedule reporting presentations will be made available at the appropriate WindChill location.

The forum should provide information that ensures schedules are well-developed and accurate in order to maximize the opportunities for the Ares I Management Team to: 1) assess potential schedule impacts; 2) make necessary work around plans and 3) make timely decisions.

4.0 ADAC PROCESS ELEMENTS

The ADAC process is a structured approach to plan, conduct, and manage the complementary engineering tasks needed to characterize the functionality and capability of the

Ares systems. This process is executed for each ADAC to orchestrate the integrated set of system analyses tailored to support the respective program milestone review.

Elements of the process are provided in the following sections:

a. Section 4.1 discusses the ADAC *Process Activities*, identifying the general stages.

b. Section 4.2 identifies ADAC *Process Outcomes*, includes interim & final products.

c. Section 4.3 identifies the ADAC *Roles & Responsibilities* for conducting the process.

d. Section 4.4 identifies the ADAC *Interfacing Processes* that work with this process.

4.1 Process Activities

The process is divided into four main stages: ADAC planning, analysis, issue resolution, and documentation. Figure 3.1-1 represents the flow for planning, conducting, and interpreting the results of an ADAC. A brief discussion of each stage is given below, with details of the process provided in subsequent sections.

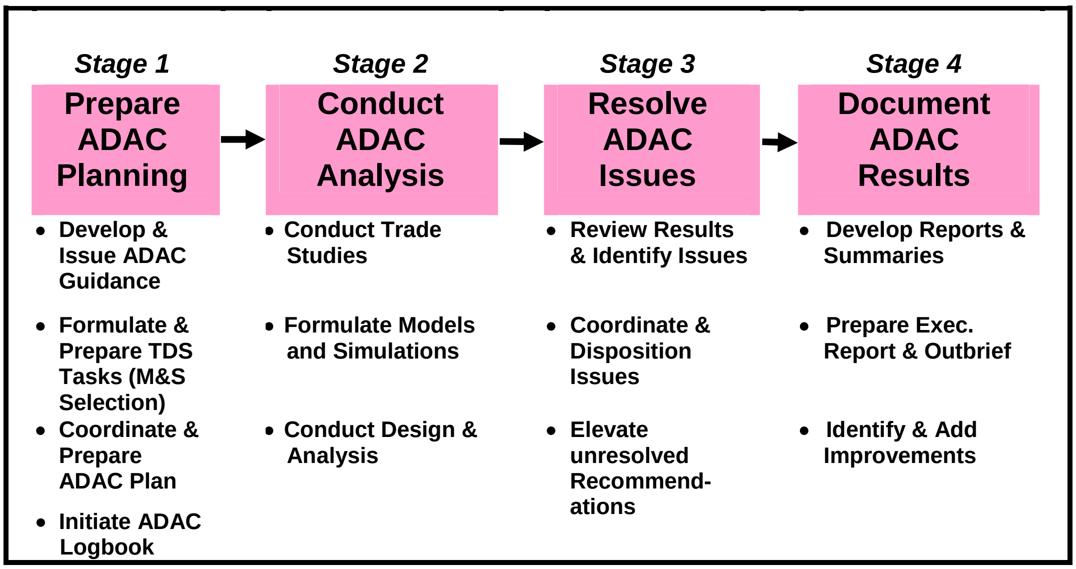

Figure 4.1-1 Stages of the Ares Design Analysis Cycle Process

- ***Stage 1*** – *Prepare ADAC Planning* – In this initial stage, general guidance and primary coordination of key analyses occurs. A schedule identifying the critical path of the ADAC will be provided. Upon approval, the process of formally documenting the inputs and outputs between elements and WBSs can be accomplished by developing task description sheets within the framework defined in the critical path schedule. The IDAT (See 4.3.3.2) then uses the negotiated data to validate requirements coverage, compile the design definition document, ensure the external links between elements' and WBSs' schedules are identified, and produce an ADAC Plan. The associated procedures for this Stage are provided in Section 4.1.

- ***Stage 2*** – *Conduct ADAC Analysis* – The performing organizations conduct the identified trades, analyses, and assessments to produce the outcomes required to support the respective review and to refine the technical baseline. Prerequisite analysis products are provided to subsystem analyses, which in turn provide component results for integrated system analysis. The associated procedures for this Stage are provided in Section 5.2.
- ***Stage 3*** – *Resolve ADAC Issues* – The assessment of ADAC results typically identifies system performance issues that affect more than one discipline or subsystem. The issues and recommended resolutions are presented in an open forum with all affected disciplines represented. Resultant actions are determined by the timeliness of resolving the issue. The associated procedures for this Stage are provided in Section 5.3.
- ***Stage 4*** – *Document ADAC Results* – In this final stage, analyses and assessments are documented in individual detailed reports. Summaries of each report are compiled in the executive Data Book Summaries within the Integrated Vehicle Design Definition Document (IVDDD). The final presentation and recommended changes to the technical baseline are taken to the control board for review. The associated procedures for this Stage are provided in Section 5.4.

To better understand the scale of the ADAC Stages, a general timeline for an individual ADAC is shown in Figure 4.1-2. This top-level framework is used to develop the detailed schedules for each ADAC. Based on previous manned space program experience, completion of a DAC requires approximately 6 months. Of course, each actual ADAC will vary, based on tasks to be performed and the milestones to support. Note: As analyses are completed, the review of the results begins, producing an overlap of the Analysis, Issue Resolution, and Documentation Stages.

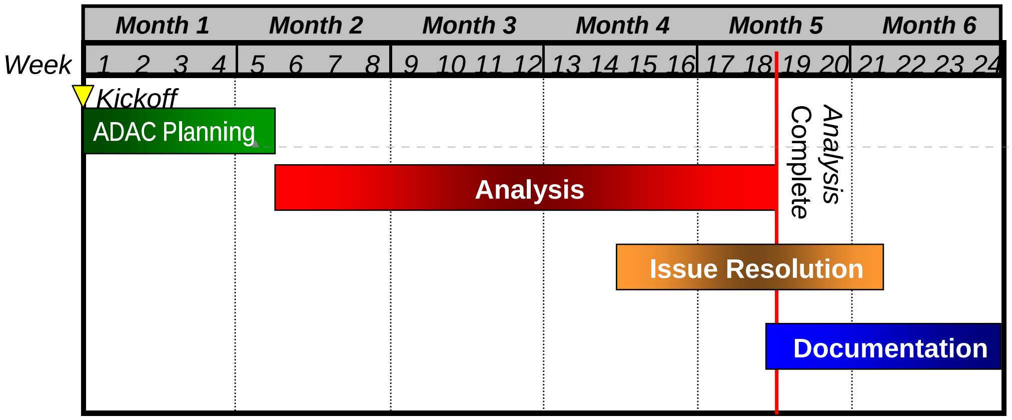

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Figure 4.1-2 General Design Analysis Cycle Timeline [1]

4.2 Process Outcomes

As the mechanism for managing Ares integrated analysis, this process is intended to produce for each ADAC cycle the outcomes identified in Figure 4.2-1 and discussed below:

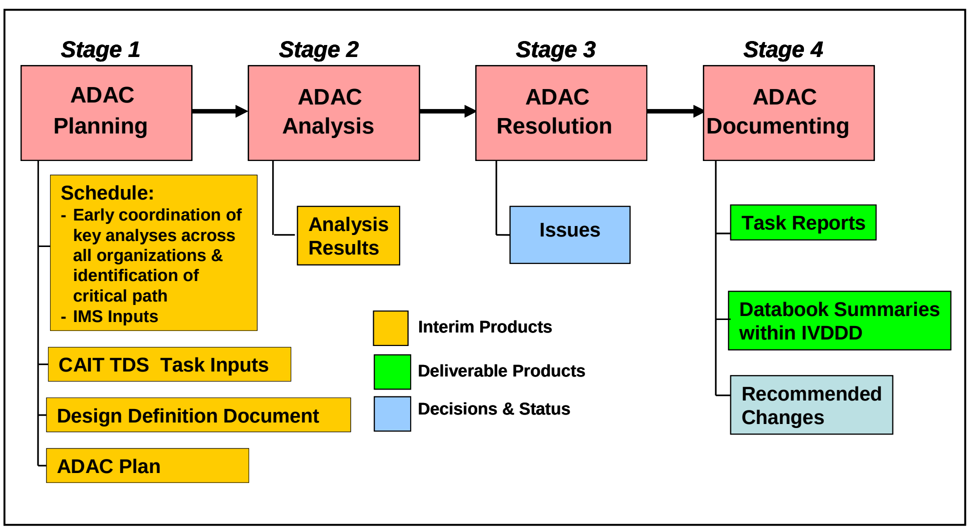

Figure 4.2-1 ADAC Process Outcomes

[1] From the Constellation Program Systems Integrated Analysis Plan (SIAP), CxP 70009, Figure 6.1 – Timeline for an Individual IDAC.

a. Though interim work products used for process decision making and management are not final process outputs, they are retained for historical purposes. These internal documents include:

1. *Task Description Sheet (TDS)* – TDS is a term applied to analysis planning documentation and which is no longer paper-based but is automated and maintained via the Constellation Analysis Integration Tool (CAIT) database application. A key part of the TDS development process is the identification of input and output data items that will be externally linked in the Integrated Master Schedule (IMS). Appendix B has the TDS reference numbering schema while Trade Study TDSs are numbered per Section 7.5, Requirement for a Consistent Trade Study Numbering System.

   [Beginning with ADAC-2 and IDAC-3, Ares and Constellation borrowed the concept of TDSs from the International Space Station program. These paper forms tracked a) who was doing a task, b) for which organization, c) contained a description of the work needed for the task, d) the data inputs required from other organizations and when they were needed, e) the data products resulting from the task and when they would be produced, and f) where those data products would be archived. The forms also listed any risks and/or requirements associated with the work of the analysis. By the end of IDAC-3 and the first half of ADAC-2, the forms had been migrated to the CAIT to allow better access to TDS information as well as the connections among that data and the other databases used to document risks, requirements, and modeling information. While still referred to as TDSs, all documentation of analysis tasks is stored and managed electronically as part of the CAIT database.]

2. *Integrated Vehicle Design Definition Document (IVDDD)* – Used to define the baseline configuration which is the programmatically approved configuration used for budget and schedule planning.

3. *ADAC Logbook* – Used to communicate and track reference configuration, reference environments, and baseline requirements.

4. *ADAC Plan* – Used to define the integrated goals, tasks, and summary schedules.

5. *Analysis Results* – Interim output of ADAC activities used to substantiate requirements and designs, and to identify potential issues.

b. Deliverable products used as the basis for system development decisions and justification, and the communication of results to management and other stakeholders include:

1. *Task Reports* – Documenting baseline decisions and requirements verification.

2. *Data Book Summaries within the IVDDD – A*n executive summary of the activities and results of the ADAC.

c. The systematic refinement of the Ares technical baseline, includes system requirements, architecture, and operational plans, in a coordinated, efficient, and economic manner. More than anything else, this process enables quality control of the integrated analysis activities. These output decisions include:

1. *Change Recommendations* – Presented to the appropriate baseline control boards.[2]

2. *Open issues* – Used as one of the methods for assessing the status of the system.

These outcomes are discussed further in the subsections of Section 5. In addition, tools to support the development of the product outcomes are discussed in Section 6.

4.3 Roles and Responsibilities

The Ares Projects Office includes multiple organizations that will have a stake in analysis methods or results. This section captures the roles and responsibilities of those organizations. The organizational chart of participants and contributors within the ADAC Process is shown in Figure 4.3-1, with a discussion of each member's roles in the paragraphs following. Specific IDAT members and their organizations are listed in Table 4.3.3-1.

[2] For guidance on which board is "appropriate," refer to the Configuration Management Plan for Ares Projects Office (CxP 72015), paragraphs 9.2 and 9.4.

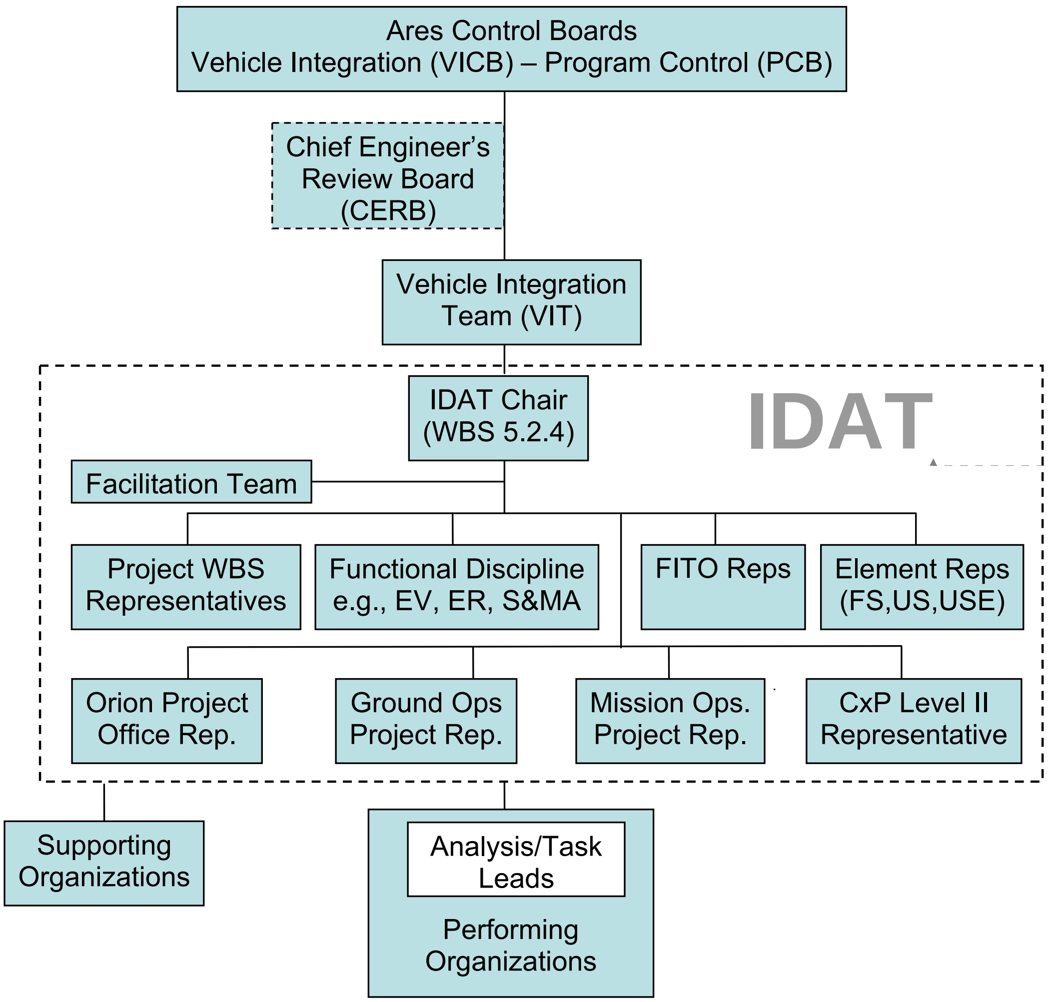

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Figure 4.3-1 Integrated Design & Analysis Team (IDAT) Organizational Model

4.3.1 Level III Control Boards

The Level III control boards (L3CBs), specifically the Vehicle Integration Control Board (VICB) and the Ares Projects Control Board (PCB), are the advocates and decision makers for key control gates within the process, including:

a. Review and approval of the integrated ADAC plan, with attention toward the overall goals, reference configuration, schedule, and directives.

b. Review and direction on the handling of unresolved issues elevated during the analysis stage of the ADAC.

c. Review and approval of the data Type 1 documents containing data generated during the ADAC in terms of meeting the ADAC exit criteria, accepting resulting change recommendations to the technical baseline, and agreement on plans for handling open issues.

4.3.2 WBS 5.2.4 Review

The SAP is applicable to all Ares Projects Office Vehicle Integration (VI) Work Breakdown Structure (WBS) Office analyses for ADAC-related activities. The VI Integrated Design Analysis Office (WBS 5.2.4) initiates the ADAC planning process and reviews all information before being submitted to the Level III boards for approval.

To provide appropriate voice and insight of the VI WBS Offices in the ADAC process, representatives from each team participate in the Integrated Design & Analysis Team.

4.3.3 Integrated Design Analysis Team

The Integrated Design Analysis Team (IDAT) manages the ADAC process activities. This team ensures planning and results are consistent and integrated, addresses cross-cutting issues as they arise, and provides recommendations to the Project review and control boards. More specifically:

a. During the ADAC planning stage, the IDAT plans the ADAC and prepares the ADAC Plan document for approval by Element and Vehicle boards as appropriate.

b. During the ADAC analysis stage, the IDAT reviews results as they are completed to ensure agreement across the team.

c. During the ADAC issue resolution stage, the IDAT resolves multi-discipline technical issues where possible (e.g., no cost or schedule impacts), and refers technical issues to appropriate forums (AFSIG, etc.) as appropriate when a no-impact resolution cannot be identified. Lower level groups should come to the IDAT for issue resolution. But, if resolution cannot be achieved, the issue(s) should be elevated to the VIT, CERB or VICB if required.

d. During the ADAC documentation stage, the IDAT develops the final report and a presentation of the ADAC results for Element and Vehicle boards as appropriate.

e. In addition, the IDAT serves as the primary Ares Projects Office interface to the Level II Analysis Working Group (CxAWG) when working ADAC-related concerns.

f. In general, IDAT products will be taken to the VIT, CERB, and VICB for concurrence and approval, where applicable. Recommendations will be developed for issues and changes that cannot be resolved within the IDAT and will be taken to the VIT, CERB, and VICB for disposition and approval. The VICB, CERB, and VIT shall delegate product approval, and where appropriate, control to the IDAT. IDAT Products include, but are not limited to:

- Ares Project System Analysis Plan (SAP)
- Ares Trade Tree
- Ares Design & Analysis Cycle (ADAC) Plan
- Ares Design & Analysis Cycle (ADAC) Logbook
- Ares Modeling & Simulation Integrated Management Implementation Plan
- Ares Margin Management Plan (MMP)

The requested attendance at each IDAT forum will vary to ensure all pertinent stakeholders are involved in the technical review of particular results and issues. A standing membership exists to ensure continuity of decisions, appropriate facilitation, and direct line communications with project management (via their representatives). The IDAT standing membership includes the following teams and positions as shown in Table 4.3.3-1.

Table 4.3.3-1 IDAT Membership

IDAT Membership	
Position/Representative	**Organization**
Chair:	
IDAT Lead	EV92
IDAT Co-Lead	JP10
Secretariat	
IDAT Administrative Support/Project Coordinator	EV92
Core Team Members	
WBS	
5.2.1 Systems Management	EV94
5.2.2 Requirements and Verification	EV91
5.2.4 Integrated Design & Analysis	EV92/40/30
5.2.5 Operations & Supportability	EO10
5.2.6 Avionics Integration & Vehicle Systems Test	ES12

5.2.7 Crew Safety & Reliability	QD34
5.2.8 Vehicle Integration	EV93
Level IV Elements	
Upper Stage (US)	Project/Engineering
Upper Stage Engine (USE)	Project
First Stage (FS)	Projects/Engineering
Level II	
CxP IDAC	JSC
Level III	
CEV/Orion	JSC
Ground Operations	KSC
Mission Operations	JSC
IDAT Ad Hoc Team members	All

4.3.3.1 Working Group Chair

The Chairperson of the IDAT is responsible for day-to-day coordination of activities, including planning, execution, and reintegration of the ADAC across all VI WBS teams. The chairperson is supported by the Ares Projects Office VI 5.2.4 Product Lead for Integrated Design & Analysis.

4.3.3.2 IDAT Facilitation

The responsibility for facilitation of the SAP lies with the MSFC Spacecraft and Vehicle Systems Department. The IDAT provides the logistics and technical support to the IDAT, including data collection, facilitation of the integrated planning, facilitation of the integration forums, draft of the executive report and presentation, facilitating the review and archiving of task final reports, ensuring the incorporation of task executive summaries to produce IVDDD Data Book Summaries, and implemention of improvements to the ADAC process.

4.3.3.3 Project Representatives

Designees from the WBS organizations within the Ares Vehicle Integration Office, as well as the Flight and Integrated Test Office, will participate in all ADAC planning and review to ensure that the technical, cost, and schedule risk interests of the Ares Projects are considered and addressed. Project representatives also serve as liaisons for the IDAT to their respective Level III Integration Teams (ITs) and/or Working Groups (WG) as required.

Other Level III representatives from the Orion, Mission Systems, and Ground Systems Projects will be included as required to support Ares analysis.

4.3.3.4 Discipline Representatives

Discipline representatives from the MSFC Engineering and Safety and Mission Assurance (S&MA) Directorates, and other Centers assigned lead discipline responsibilities, will participate in ADAC planning and reviews. These engineering disciplines may include, but are not limited to, aerodynamics, structures, thermal, propulsion, avionics, software, operations, safety, risk, and cost engineering. This participation is to ensure that the disciplines have consistent and timely knowledge of peer results and issues, enabling them to identify and address cross-cutting impacts to their respective activities. Discipline representatives also serve as liaisons for the IDAT to their respective engineering boards and panels as required.

4.3.3.5 Element Representatives

Designees from the Level IV Elements, including First Stage, Upper Stage, and Upper Stage Engine Offices, participate in the IDAT to uphold the interests of the Elements and to ensure that the system-level discussions are being flowed down as required. Element representatives also serve as liaisons for the IDAT to their respective Level IV panels, working groups and teams as required.

The following positions, though not IDAT standing members, also play a significant role in planning, execution, resolution, and documentation activities of an ADAC.

4.3.4 Analysis Representatives

For each identified ADAC task (trade, analysis, assessment) the performing organization assigns a Task Lead as the point of contact (POC) for the task effort, who is responsible for task planning, data gathering, meeting schedules, and producing the agreed-to products. The lead oversees the development and negotiation of the TDS task data and works the proper concurrence from the respective performing organization and Product Leads.

4.3.5 Requirements Representatives

Individuals are assigned oversight responsibility for Ares Level III requirements by the Ares Projects Office VI Requirements & Verification Office to ensure that the appropriate level of analysis and assessment is provided for achieving the needed level of maturity. These responsible individuals support the ADAC process by reviewing task planning and results to ensure that the supporting goals are being met.

4.3.6 Performing Organizations

Performing organizations include those teams requested by the Ares Projects Office to conduct specific technical tasks, such as trades, analyses, and assessments, as part of the given ADAC. These teams are sponsored by the Ares Projects Office Vehicle and Element Offices, and other Constellation teams as needed to support Ares development.

These teams are staffed by the MSFC Engineering and S&MA Directorates and by other performing Center organizations as assigned. This staffing includes both civil servants and contractors as authorized to conduct work. Contractor roles are specified by the performing organizations.

These performing organizations provide task leadership and are responsible for developing and documenting the respective individual task plans, performing the analyses, providing interim products as scheduled, followed by presenting interim results and/or issues as they are realized to the IDAT, and finally documenting the assumptions, approach, and results in an individual analysis report.

ADAC performing organization types include, but are not limited to:

a. System (vehicle) level teams that perform prerequisite analyses and then pass the data to the subsystem assessment teams.

b. Subsystem (element) level teams that perform technical trades, analyses, and assessments on the components of the system.

c. System (vehicle) level teams that take component data from the subsystem teams and perform the system integrated analysis.

4.3.7 Supporting Organizations

Some organizations support the ADAC by providing initialization data, such as the reference configuration or other information required by the process. These organizations are invited to participate in the IDAT for overall system integration purposes, and include:

a. The Vehicle Integration Office (JP10), which develops the intended mission objectives.

b. The Vehicle Requirements & Verification Office, which provides the requirements baseline.

c. The Level II Operations Integration Office, which provides the Design Reference Missions per CxP 70007, Constellation Design Reference Missions and Operational Concepts.

4.4 Interfacing Processes

The Ares Projects Office utilizes many technical processes to manage and conduct the activities necessary to execute an Ares Design Analysis Cycle. This section identifies and discusses those external processes that interface with the ADAC process to cover all cycle activities. Note that this section addresses the arrangement of the Ares technical instructions (processes) and not necessarily the division of organizational responsibility.

Understanding these relationships provides clarity to the boundaries of the ADAC process and how it is integrated into the overall Systems Engineering approach. The interface schematic of external processes to the ADAC Process is shown in Figure 4.4-1, with a discussion of each relationship provided below.

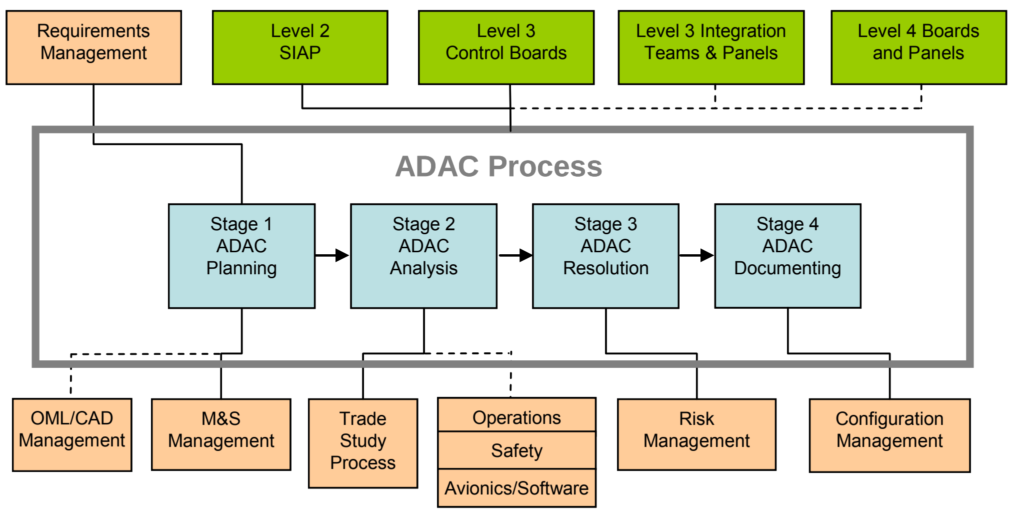

Figure 4.4-1 Technical Processes that Interface with the ADAC

4.4.1 Level II SIAP Process

The current relationship between the Ares SAP process and the Level II Constellation Program Systems Integrated Analysis Plan (CxP 70009) involves the following level of participation by the SAP process:

a. ADAC inputs will be consistent with IDAC inputs, where appropriate.

b. ADAC results and information will be provided in a timely manner to support near-term Level II IDAC efforts, as appropriate.

c. An ADAC will use, as available, results and information generated by a preceding Level II IDAC.

d. The scope of ADAC analyses may be adapted to provide needed results to both Ares and Level II, as appropriate.

The IDAT will maintain the formal relationship with the Level II IDAC process managers. In lieu of a formal agreement, the IDAT Chair will broker levels of participation on a ADAC-by-ADAC basis. The IDAT will coordinate all incoming information and outgoing transmissions.

4.4.2 Level III Change Control

The VICB reviews while the PCB provides directives and makes decisions for the ADAC process from within the Level III Change Control process, per the Configuration Management (CM) Plan for Ares Project (CxP 72015). The IDAT prepares submittals from within the ADAC process using the specified directions for control board requests. The IDAT presents findings, issues, and recommendations to the VICB within the standard control board procedures. Likewise, PCB directives are disseminated according to control board procedures with the official distribution to the ADAC stakeholders coming from the IDAT.

4.4.3 Level III ITs and Panels

The Level III Integration Teams (ITs) and panels have an indirect interface with the ADAC process. The IDAT refers technical issues to appropriate Level III forums (AFSIG, etc.) as appropriate when a no-impact resolution cannot be identified. The Level III forum will carry the issue through to resolution, and if required carry a change forward to the appropriate Vehicle boards.

Performing organizations and their task representatives are responsible for acquiring the necessary Level III panel reviews, as stipulated by those respective processes, prior to submitting plans, issues, and reports to the IDAT within the ADAC process.

4.4.4 Level IV Boards and Panels

The Level IV (Element and Engineering) control boards and panels have an indirect interface with the ADAC process. The IDAT refers technical issues to appropriate Level IV forums [Systems Engineering & Integration Working Group (SEIWG), etc.] as appropriate when a no-impact resolution cannot be identified. The Level IV forum will carry the issue through to resolution, and if required carry a change forward to the appropriate Element boards.

Performing organizations and their task representatives are responsible for acquiring the necessary Level IV reviews and approvals, as stipulated by those respective processes, prior to submitting plans, issues, and reports to the IDAT within the ADAC process.

4.4.5 Requirements Management

A key tenet of the ADAC process is that all trades, analyses, and assessments must focus on establishing valid requirements, refining the system design to meet the requirements, and contributing to the verification of the requirements. Therefore, a strong relationship exists between the ADAC process and the Requirements Management Process, as defined in the Ares Systems Engineering Management Plan (CxP 72018). The Requirements Management process is responsible for:

a. Defining the system requirements and their current status for inclusion in the reference configuration.

b. Having Requirements representatives review the individual and integrated task plans to validate that adequate requirements coverage has been provided for a given set of ADAC goals and objectives, and communicating its position at the IDAT integration forums.

c. Processing changes through the Requirements Management process and disseminating those updates to the ADAC stakeholders when ADAC results lead to Level III control board-approved changes in requirements.

d. Reviewing ADAC requirements verification results, incorporating the information into the Ares verification compliance matrix, and updating all related status databases.

4.4.6 Configuration Management

ADAC results will be captured in the respective Data Book Summaries within the Integrated Vehicle Design Definition Document (IVDDD). However, the Configuration Management (CM) Plan for Ares Project (CxP 72015) defines the means for updating the technical baseline. The IDAT will coordinate a presentation of the change for the control boards, using the procedures specified in the CM Plan. Once approved, the modifications will be used by the ADAC Process to update the reference configurations for use in the next ADAC.

The ADAC-produced key documents, including the ADAC Plan, the IVDDD, and the Data Book Summaries within the IVDDD, will be placed under CM control. The detailed task reports will be transmitted under memorandum from the responsible branch chief, or the responsible performing Center Engineering line management, to maintain an audit trail. These products are placed into the Cradle requirements management system (see Section 5.4.1) at the appropriate requirements/architecture information location. All critical information will be in the reports such that there is not a need for an audit trail for presentations and outbriefs, but they will be archived in the Windchill Data Management (DM) environment as required.

4.4.7 Risk Management

A key aspect of the ADAC process is the inclusion of an Issue Resolution Stage. As issues are identified, actions will be taken to resolve them. As issues of high criticality with no simple or immediate resolution are identified, they will be elevated and tracked in the Risk Management database.

At the discretion of the IDAT, those issues should be mapped into the Program-level Risk Management (RM) process, per the Ares Risk Management Plan (CxP 72019). The IDAT will coordinate a presentation of the risk to the Risk Panel, using the specified RM procedures. The appropriate member of the IDAT, depending on the level of impact, will maintain ownership of the risk and currency within the Risk Management database.

Another facet of the interface is that an external risk mitigation plan may call for analyses or assessments to be performed during an ADAC to manage the risk. The Risk Management process will identify those risks and recommend tasks to be performed. These risks will be included in the Design Requirements Compliance Matrix (DRCM) to ensure adequate planning is performed.

4.4.8 Trade Studies

A key activity within the ADAC Analysis Stage is the conduct of Trade Studies. The Ares Trade Study Process is described in Section 7. When conducted within an ADAC, Trade Studies may be initiated anytime during the ADAC Planning, Analysis, or Resolution Stages (Figure 4.1-1), per paragraph 8.10.1, How to Propose the Start of a Formal Trade Study.

4.4.9 Modeling and Simulation Management

The primary enablers for conducting analyses are the system and subsystem models and simulations developed by the the element and vehicle levels of the Ares project. The “Ares Modeling & Simulation Integrated Management Implementation Plan” (CxP 72265) provides the overarching requirements and process used for Ares M&S management.

4.4.9.1 Integration Groups, Panels, Integrated Process Teams / Project Teams, and Functional Teams are responsible for:

a. Selection of M&S for analyses use,

b. M&S configuration management and Verification, Validation and Accreditation (VV&A) planning,

c. Completing the TDS task data survey for selected M&S,

d. Prioritization of M&S for VV&A,

e. Identifying future needs for M&S to include

  - Gaps in existing M&S capabilities requiring NEW work,
  - M&S accreditation needs and a need date, and
  - Revisions to existing M&S to meet future needs

f. Model validation

4.4.9.2 The M&S Management process defines general policies and responsibilities in the following areas below. The goal of these processes is to improve the overall quality of M&S as well as organizational awareness of where and how they are used. The task of actual M&S selection and use resides at the user level along with any associated task management oversight.

a. VV&A of M&S that support "critical" decision-making activities, as identified by the appropriate M&S working group.

b. Approving existing models supporting the Ares reference configuration(s) prior to use in an ADAC.

c. Model configuration management and VV&A planning, outside of the ADAC process.

d. Review and approval of models developed or test-verified during an ADAC, as part of the identified task activities.

Model verification results will be reported to the IDAT, when VV&A is a task (or part of a task) performed during a given ADAC cycle.

4.4.10 Operations and Supportability

As outlined in the Ares Systems Engineering Management Plan (CxP 72018), the Operability and Supportability process (Ares WBS 5.2.5) involves design analysis activities for operations, supportability, availability, and recurring cost. Operations and Supportability efforts in support of each ADAC will be focused on influencing the design for improved operability. Included in this effort is the assessment of operability design metrics for the point design selected for the analysis cycle. The analyses that result will conform to the level of design definition available in each ADAC.

4.4.11 Crew Safety & Reliability

The Crew Safety & Reliability process (Ares WBS 5.2.7) is outlined in the Ares Systems Engineering Management Plan (CxP 72018).

4.4.12 Avionics and Software

As outlined in the Ares Systems Engineering Management Plan (CxP 72018), Avionics Integration & Vehicle Systems Test (AIVST / Ares WBS 5.2.6) provides technical insight and direction for the integrated Ares I avionics and software system. This includes end-to-end vehicle avionics hardware and software architecture definition; internal and external interface definition; integrated system analysis; vehicle Fault Detection, Diagnostics, and Recovery (FDDR) algorithm development; definition of electromagnetic environmental effects (E3) requirements and standards; development of the SIL; and integrated system testing.

Key ADAC support analysis activities and products are implemented concerning vehicle abort conditions, functional fault analyses and electromagnetic environmental effects assessments.

4.4.13 Vehicle Development and Flight Evaluation (VDFE)

Per the Ares Systems Engineering Management Plan (CxP 72018), VI VDFE (WBS 5.2.8 / EV93) is responsible for the general Ares Product Integration process. They are responsible for coordinating the analytical integration of the Ares system as well as the integrated stack (Orion / Ares).

The Development and Flight Planning Team (DFPT), composed of representatives from both WBS 5.2.8 and FITO, is responsible for combining all drawing packages (Ares Elements and VI WBS) within one platform; producing integrated computer aided design (CAD) of the Ares outer mold line (OML), assemblies, and schematics; and supporting FITO activities. These packages provide initial condition data for ADAC planning and analyses.

5.0 ADAC PROCESS PROCEDURES

This chapter breaks down the ADAC Process Stages into their respective procedures, interlacing the associated common tasks, inputs and outcomes, roles and responsibilities, and interfacing technical processes. The procedures of the ADAC process are provided in the following sections:

a. Section 5.1 identifies the tasks performed within the ADAC *Planning Stage*.

b. Section 5.2 identifies the tasks performed within the ADAC *Analysis Stage*.

c. Section 5.3 identifies the tasks performed within the ADAC *Resolution Stage*.

d. Section 5.4 identifies the tasks performed within the ADAC *Documentation Stage*.

In the following sections, the procedures are depicted using swimlane/dataflow charts.

Data inputs to the procedure appear in the "Input" column, procedure tasks and decision points are provided in the "Activities" column, and outputs of the procedure appear in the "Output" column. Responsibility for the tasks and products is designated by placement into the appropriate rows in the "Roles" column.

In each chart, the red "document" icons indicate data products, blue boxes indicate tasks or activities to be performed, green diamonds indicate decision points in the procedure, and yellow "shields" indicate off-page connectors. Flow iterations and terminations are implicit.

5.1 ADAC Planning Stage

This stage produces the coherent integrated plan for conducting the ADAC. This planning is the responsibility of the IDAT and is accomplished with assistance from all teams involved in the performance of ADAC assessments. General guidance (i.e., board dates), critical path identification, summary schedule, and ground rules/assumptions for the ADAC is prepared, and then the performing organizations develop individual task descriptions. The IDAT uses the data to validate requirements coverage and determine the interdependency of the analyses. The IDAT ensures external links are identified in the integrated schedule, compiles the integrated vehicle design definition document, and produces the ADAC Plan. The task flow for this stage is provided in Figure 5.1-1, with details of each task discussed below.

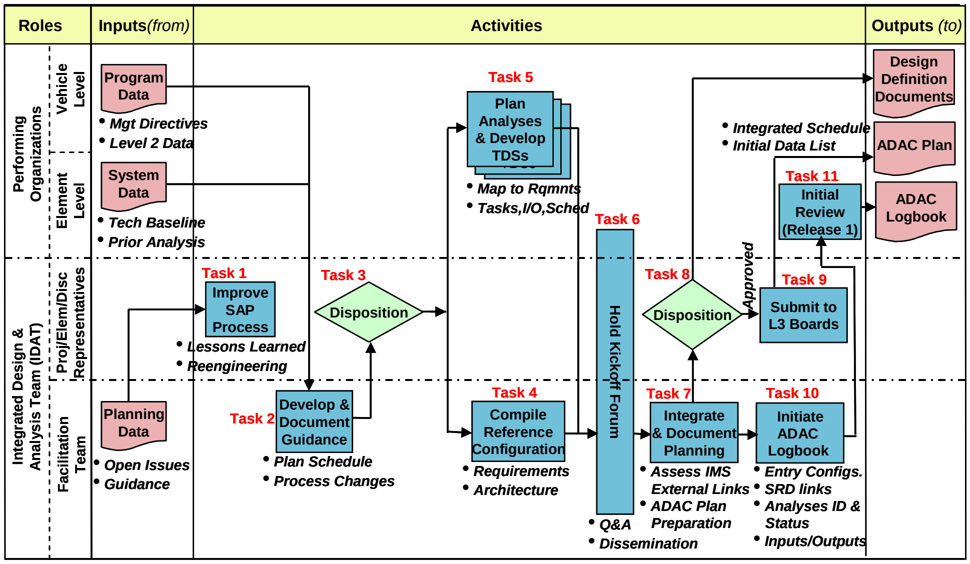

Figure 5.1-1 ADAC Planning Stage Process Flow

5.1.1 Task 1 – Improve SAP Process

Institute process improvements based on previous ADAC process performance issues.

The IDAT will identify, assess, implement, and document improvements to the process. This should take place prior to initiating the next ADAC and as early as immediately following the previous ADAC.

Typically, improvements in quality and efficiency can be realized by small changes in responsibility, governance, and documentation approaches, as the nuances of the process become understood and the implementers become more knowledgeable.

The IDAT will compile the findings, develop a set of recommendations, present them to the VICB/PCB for approval via a formal Change Request (CR). In addition, any metrics needed for the next cycle to better understand the process related issues should be identified, planned, and tracked.

5.1.2 Task 2 – Develop Planning Guidance

Develop and document the ADAC-n planning guidance to ensure a common starting point.

5.1.2.1 The initial set of guidance is based on the general guidance information provided in Section 6 for the variety of ADACs to be conducted. The provided guidance includes:

a. General goals and objectives for each supporting ADAC.

b. Common initialization data, analyses sets, and levels of fidelity for the supporting analyses found within an ADAC.

5.1.2.2 Other sources of planning information include:

a. Results and carry-over issues from the previous ADAC.

b. Current SAP Master Plan and Schedule discussed in Section 2.

c. The list of required technical products associated with the upcoming Program milestone.

d. Level II, Level III, and Level IV Directives, concerning cost, schedules, goals, and assumptions.

5.1.2.3 The IDAT gathers and compiles the data, formulates a recommended plan, and documents, at a minimum, the items specified in the Guidance Template discussed in Section 6.1.1, including:

a. The detailed objectives of the ADAC.

b. A preliminary list of assessments and ADAC ground rules that indicate which disciplines, system elements, and subsystems, are to be the focus of the ADAC.

c. A summary schedule which documents the logically driven critical path for key analyses as well as detailed schedules for the planning and documentation phases including a due date for when all analyses are to be completed.

d. The reference technical baseline and status of open issues from the previous cycle.

5.1.3 Task 3 – Disposition the Guidance

Review and validate the ***ADAC****-n planning guidance prior to general distribution.*

The IDAT will review and validate the specific ADAC guidance package and provide it to the WBS 5.2.4 manager for endorsement. This provides an opportunity for the WBS 5.2.4 manager to make sure that the ADAC planning and overall execution schedule, goals and objectives, ground rules and assumptions, and Level II and III directives have been properly captured and ready for broad distribution. (Note: This guidance is later submitted to Level III control boards for approval as part of the ADAC-n Plan.)

5.1.4 Task 4 – Compile Reference Configuration

Identify, compile, and document the ADAC reference configuration, including directives.

The IDAT will lead the effort to compile, organize, and baseline the Reference Configuration to be used for the upcoming ADAC. This reference configuration should consist of, at a minimum, the items stipulated by the IVDDDs Template and Initialization Data Tables discussed in Section 6.1.4, including:

a. The baseline set of requirements and interface document revisions to be used.

b. The baseline system architecture including operational and physical concepts, functional schematics, product breakdown structure, interface definitions, drawings, Government Furnished Equipment (GFE), etc.

c. The baseline operational environments, including aero, structural, thermal, and power loads, natural environments, etc.

d. The baseline of design data, models, simulations, and mission scenarios that are of known, traceable, and agreed pedigree.

e. Concept of operations including Design Reference Missions (DRMs).

f. Directives on handling missing or dynamic aspects of the baseline.

The IDAT obtains the previous release of the IVDDD and adjusts it per CM change request, based on changes to requirements, architecture, environments, tools, and directives to date. The success of the ADAC is directly related to ensuring that the common data sets provided in the IVDDD and Initialization Data Tables are used by all of the performing organizations. These data sets will be further reflected in the ADAC Logbook which will track changes dynamically throughout the ADAC-n.

5.1.5 Task 5 – Plan Analyses, Begin Detailed Schedule Developments & Develop TDSs

Develop the individual analysis plans and document them using CAIT for the Ares TDS task documentation sub-process (Task 5 of the ADAC Planning Process). Develop the individual analysis detailed schedules which become a part of the IMS.

The performing organizations plan their analytical engineering tasks to accommodate the goals, objectives, and constraints of the ADAC as defined in the guidance package.

The CAIT-based task flow for the Ares TDS task documentation sub-process (Task 5 of the ADAC Planning Process) is provided in Figures 5.1.5-1a and 5.1.5-1b. and followed by an interface table for the flowchart in Table 5.1.5-1. Then, Table 5.1.5-2 provides the CAIT task workflow. The principles and methods for constructing the individual task plans for Ares are discussed in Sections 6.1.2 and 6.1.3. TDS task documentation database input instructions for the CAIT database are shown in Appendix B.

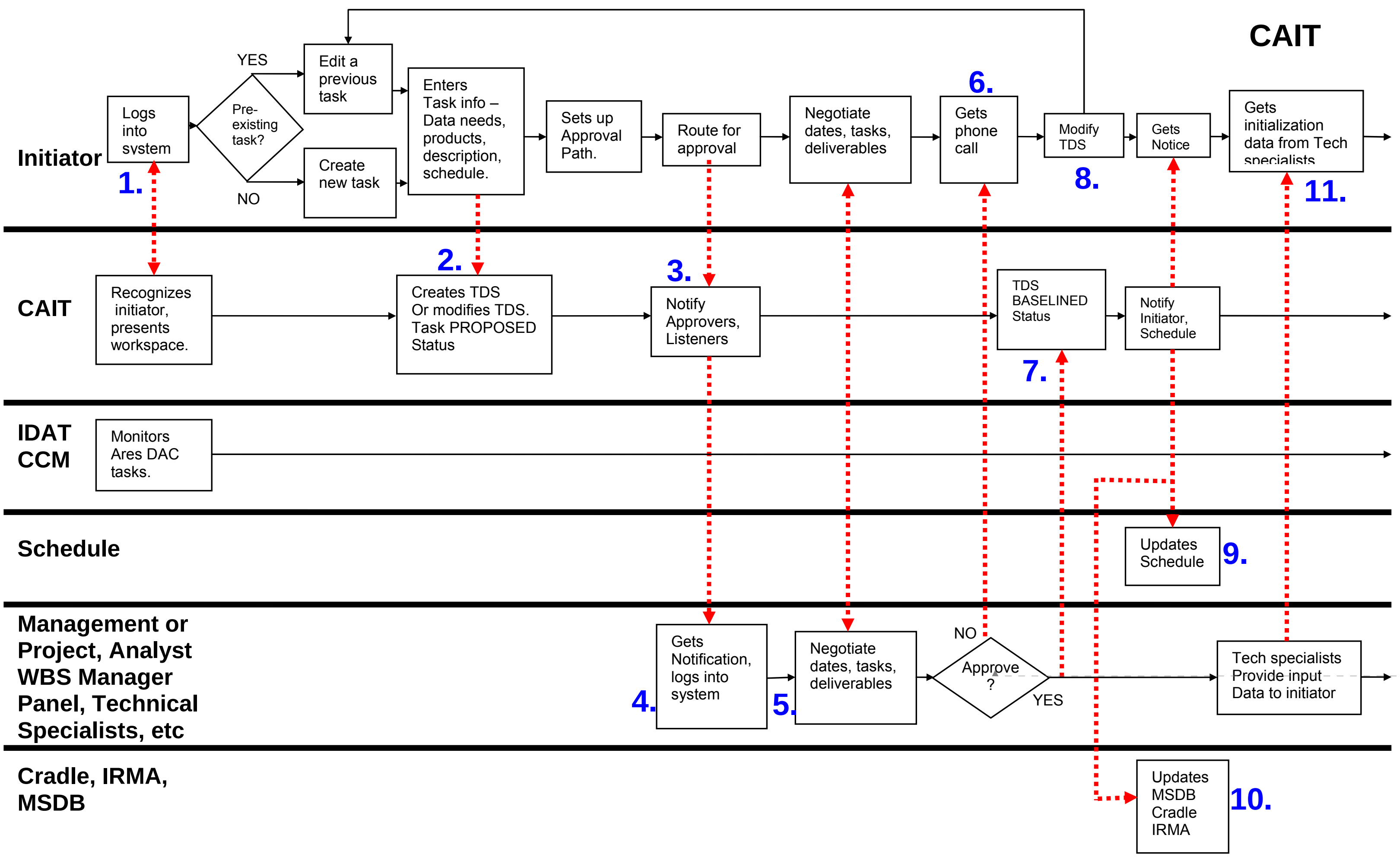

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Figure 5.1.5-1a ADAC Planning Task 5 – Task Documentation Creation & Routing (Flowchart 1 of 2)

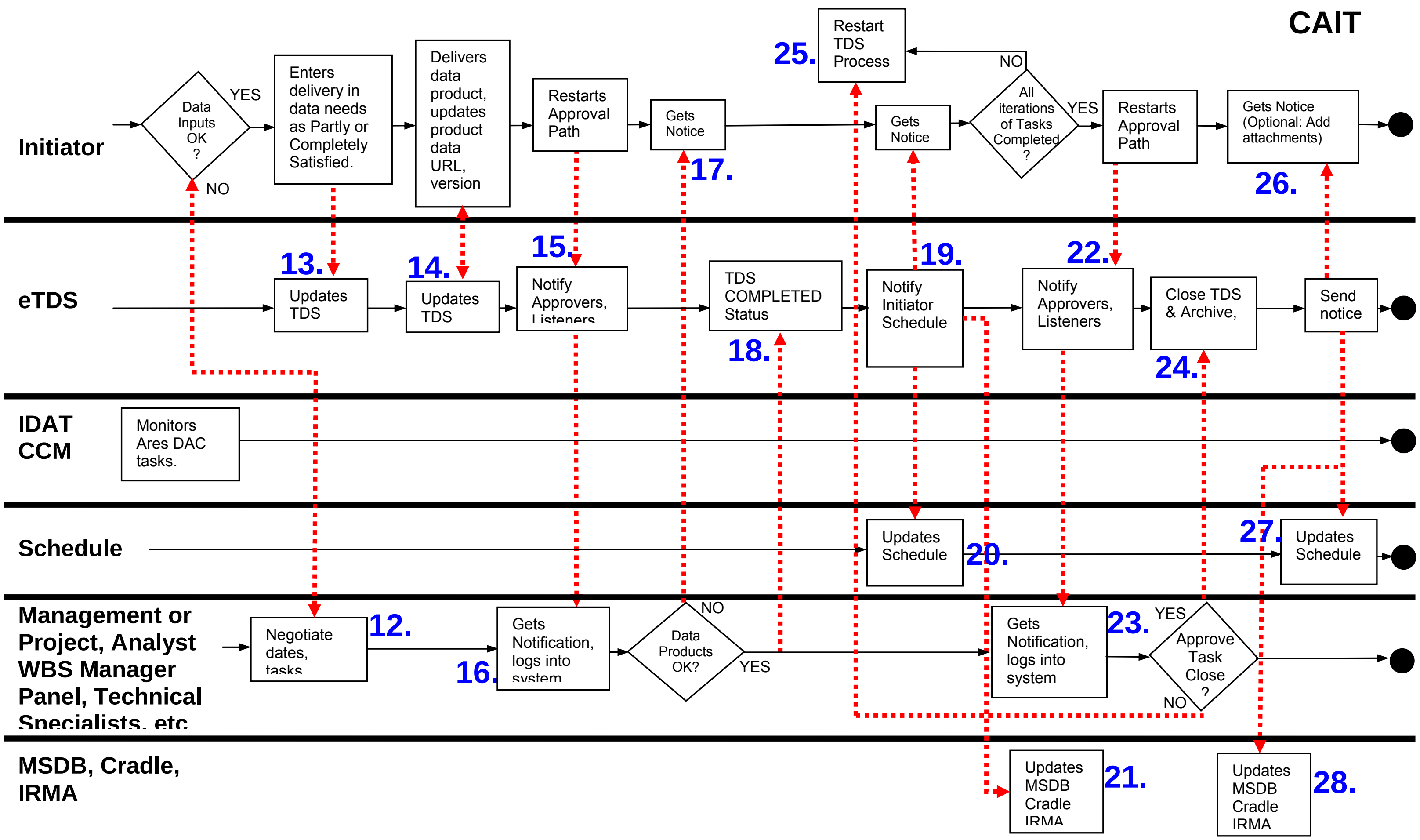


Figure 5.1.5-1b ADAC Planning Task 5 – Task Documentation Completion & Closure (Flowchart 2 of 2)

Table 5.1.5-1 Interface Table for the Ares Task Documentation

#	From	To	Information or product passed	Automated? Method?	Metric?
1	Initiator/CAIT	CAIT/Initiator	User login/ custom workspace	Yes, based on user ID/Org via user interface	Time/date stamp
2	Initiator	CAIT	TDS data, tasks, schedule, products, or redline changes to existing task	Yes, via user interface	Time/date stamp
3	CAIT	Approvers	DRAFT task routed for approval	Yes, email	Time/date stamp
4	Approvers	CAIT	User login/ custom workspace	Yes, via user interface	Time/date stamp
5	Initiator	Approvers	Negotiation of dates, task input data, products.	No, phone call, in person, or email	
6	Approvers	Initiator	Approval denied	Yes and No: user interface logs decision, phone call to initiator to explain it.	Time/date stamp
7	Approvers	Initiator	Task Approved	Yes, email	Time/date stamp
8	CAIT	Initiator	Task Baseline Status	Yes, email	Time/date stamp
9	CAIT	Scheduler	Task Baseline Status	Yes, email	Time/date stamp
10	CAIT	Associated Databases (MSDB, IRMA, Cradle)	Task Baseline Status	Yes, data update	Time/date stamp
11	Tech Specialists	Initiator	Input data for task	Yes or no: email or hard copy	
12	Initiator	Tech specialists	Data inputs not okay	No, email, phone call or personal contact	

13	Initiator	CAIT	Data inputs okay, update task data needs	Yes, user interface	Time/date stamp
14	Initiator	CAIT	Data products updated with delivery info: URL, version, etc.	Yes, user interface	Time/date stamp
15	Initiator	CAIT	Restarts approval path	Yes, user interface	Time/date stamp
16	CAIT	Approvers	Task routed for COMPLETION approval	Yes, email	Time/date stamp
17	Approvers	Initiator	Data products not okay, approval denied	Yes and No: user interface logs decision: phone call, in person, or email	
18	Approvers	Initiator	Task Completed	Yes, email	Time/date stamp
19	CAIT	Initiator	Task COMPLETED Status	Yes, email	Time/date stamp
20	CAIT	Scheduler	Task COMPLETED Status	Yes, email	Time/date stamp
21	CAIT	Associated Databases (MSDB, IRMA, Cradle)	Task COMPLETED Status	Yes, data update	Time/date stamp
22	Initiator	CAIT	All iterations of task are completed. Restart approval path.	Yes, user interface	Time/date stamp
23	CAIT	Approvers	Task routed for CLOSED approval	Yes, email	Time/date stamp
24	Approvers	Initiator	Task interations not completed, approval denied	Yes and No: user interface logs decision: phone call, in person, or	

				email	
25	Approvers	Initiator	Task Closed	Yes, email	Time/date stamp
26	CAIT	Initiator	Task CLOSED Status	Yes, email	Time/date stamp
27	CAIT	Scheduler	Task CLOSED Status	Yes, email	Time/date stamp
28	CAIT	Associated Databases (MSDB, IRMA, Cradle)	Task CLOSED Status	Yes, data update	Time/date stamp

Further details that describe the TDS sub-process depicted in Figure 5.1.5-1 are provided in Table 5.1.5-2 below. (*Please note that the numbers below depict sequential steps only; the numbers do NOT match the numbered steps in Figure 5.1.5-1a or Table 5.1.5-1b.)*

Table 5.1.5-2 CAIT Workflow Outline

CAIT Workflow Outline

1. Need for an analysis is identified by:
   - WBS.
   - A trade study.
   - Level II data request.
   - From a requirement.
   - An analyst.
2. The Product Lead and Engineering line manager verify that an analyst is assigned to the work.
3. Initiator (who may or may not be the actual analyst) obtains a user name and password for the Constellation Analysis Integration Tool (CAIT; https://cait.nis.nasa.gov).
4. Initiator creates a task document (TDS) in CAIT.
5. Initiator sets up and starts the organizational Approval Path for Draft status.
6. CAIT sends TDS to be reviewed and approved by analyst's line manager (usually a branch chief). This review should be completed within 5 working days of the initial notification.
7. If not approved, line manager contacts initiator and reworks TDS.

CAIT Workflow Outline

8. If approved, CAIT sets task at Draft status and contacts Initiator.

9. Initiator restarts Approval Path for Baselined status.

10. CAIT contacts line manager and WBS manager, at a minimum, for work approval on the task. This approval should be completed within 5 working days of the initial notification.

11. CAIT contacts input data providers and informs them of data need. This approval should be completed within 5 working days of the initial notification.

    a. If data is already being provided, they determine if delivery date is adequate.

        i. If delivery date is good, input data providers approve TDS and send delivery date and reference TDS information to Initiator.

        ii. If delivery date is not good (will cause schedule slip or resource issue for requestor), TDS is Non Concur and the WBS and/or discipline managers will work with the data provider and requestor to determine a reasonable solution. They will send new delivery date and any reference TDS information to the Initiator.

    b. If data is not already being provided, the TDS is Non-Concur and the input providers will work to approve and assign resources as appropriate to accommodate the needed work.

12. Once all have approved, CAIT sets task at Baselined status and contacts Initiator and Scheduler.

13. CAIT updates ancillary databases: Cradle, Design Requirements Compliance Matrix (System Requirements Document, Interface Control Documents, Key Driving Requirements), Modeling and Simulation (M&S) Database, IRMA (Risk).

14. TDS Coordinator and IDAT monitor analysis progress through schedule and analyst.

    a. TDS information changes (New content or scope of work changes only) – Begin update loop.

    Technical updates restart complete

    Baseline Approval Path for technical approval.

        Non-technical (POC or org changes, for instance) updates logged by CAIT.

    b. Product deliveries monitored via schedule review.

15. Analyst reports at schedule review that analysis deliverables (may release TDS number) are completed and/or final product is delivered.

CAIT Workflow Outline

16. Initiator restarts Approval Path for Completed status.
17. CAIT contacts line manager for approval on TDS completion.
    a. If not approved, line manager contacts initiator to arrange rework of deliverables.
    b. If approved, CAIT sets task at Completed and contacts Initiator.
18. CAIT updates ancillary databases: Cradle, Design Requirements Compliance Matrix (System Requirements Document, Interface Control Documents, Key Driving Requirements), Modeling and Simulation (M&S) Database, IRMA (Risk).
19. Initiator concludes all work on task for the Design Analysis Cycle under which it was started.
20. Initiator restarts Approval Path for Closed status.
21. CAIT contacts line manager and WBS manager for approval on TDS completion.
    a. If not approved, management contacts initiator to arrange rework of deliverables.
    b. If approved, CAIT sets task at Closed and contacts Initiator.
22. CAIT updates ancillary databases: Cradle, Design Requirements Compliance Matrix (System Requirements Document, Interface Control Documents, Key Driving Requirements), Modeling and Simulation (M&S) Database, IRMA (Risk).

5.1.6 Task 6 – Conduct Kickoff Meeting

Conduct the ADAC-n kickoff meeting with performing organizations and other stakeholders.

The IDAT will conduct a kickoff meeting with the performing organizations to present the guidance for the upcoming ADAC. This provides an opportunity for the IDAT to ensure that the directions have been properly communicated and for the performing organizations to ask questions in the integrated forum. The IDAT will produce the guidance packages and agenda, schedule the meeting, and track any action items or issues arising from the forum.

5.1.7 Task 7 – Integrate and Document Planning

Compile, assess, integrate, negotiate, and document the overall ADAC-n Plan.

Note: This is probably the most important task in the overall Process.

5.1.7.1 The IDAT will gather the data, ensure the assessments have been made, ensure that negotiations to individual tasks are complete, and formulate an integrated plan to document that all activities within the ADAC are consistent, coordinated, and complete. Several assessments are needed in order to determine the initial consistency of the plans and the options for adjustment, including:

a. The TDSs are reviewed to identify and log the individual tasks, associated requirements, required input data, expected products, and stand-alone schedules.

b. All analyses and trade studies should be driven by requirements; therefore, a Design Requirements Compliance Matrix is developed to ensure the adequacy of the planned assessments. It identifies requirements that are not covered, those with unnecessary coverage overlap, and those that may have unneeded coverage, due to the goals for the ADAC having already been achieved in a previous cycle. Note that in some cases, redundant and parallel assessments may be desired for independent validation of results. The Compliance Matrix methodology is discussed in Section 6.1.5. The Requirements representatives review the requirements for appropriate coverage. Changes to requirements coverage responsibility are negotiated with the performing organizations as needed to achieve complete coverage.

c. Use of a consistent set of starting data for the entire Project is essential to successful execution of the process. The sources and pedigree for all requested initialization data are defined for the TDS process. This list is coordinated with the data being defined within the IVDDD in Task 4. Changes to the source and pedigree of initialization data are negotiated with the performing organizations as required to achieve a consistent point of reference for all analyses.

d. The individual TDS task plans are negotiated with the respective performing organizations and task leads until the collection of tasks “fit” together within the specified ADAC period. New plans must be documented in the detailed schedules (IMS) and flagged appropriately.

Note: In some cases, slippage of a task or deliverable to the next cycle is a viable option for coming to closure on a doable integrated plan and schedule for the given ADAC.

5.1.7.2 The IDAT compiles the resulting integrated plan, and documents, at a minimum, the items stipulated by the ADAC Plan Template discussed in Section 6.1.6, including:

a. Restatement of the guidance from Task 2 above, including specific ADAC goals, ground rules, and directives.

b. The list of analyses, trades, and assessments to be performed.

c. The integrated analysis schedule (at a summary level) indicating all tasks and data transfers.

d. The applicable reference configuration via reference to the current IVDDD, incorporating the initialization data list. Any deviations from the Level II IDAC analysis technical baseline should be explicitly noted.

e. Previous ADAC results, via reference, to past Data Book Summaries within the IVDDDs as well as previous ADAC Logbooks.

f. Current open issues.

5.1.8 Task 8 – Disposition the Plan

Review and adjust the ADAC plan as required prior to submittal to the Level III control boards.

The IDAT will review and validate the specific ADAC Plan. This provides an opportunity for the IDAT and the performing organizations to see the integrated picture and the adjustments to initial ground rules, data sets, and individual objectives required to accommodate the overall constraints of the ADAC. The IDAT will schedule the meeting, and track any action items or issues arising from the meeting. The IDAT Chair determines when the plan is ready to go to the WBS 5.2.4 Manager.

5.1.9 Task 9 – Submit to Level III Boards

Obtain Level III control board approval and distribute the plan to stakeholders.

The IDAT develops summary charts for presentation to the control boards. The WBS 5.2.4 Manager submits the ADAC Plan to the Level III control boards, via the control board process specified in the Ares CM Plan. When the IDAT Chair obtains signature approval, the IDAT distributes the approved ADAC Plan to all performing and supporting organizations, and to other identified stakeholders.

5.1.10 Task 10 – Develop ADAC Logbook Draft

Create the initial release of the ADAC Logbook.

The IDAT verifies the ADAC entry baseline configuration and documents it in the Logbook. In addition, the IDAT identifies the analyses that are scheduled to be completed during the current design cycle and records those. For each identified analysis, the specific configuration being used in the analysis, as well as the System Requirements Document (SRD) used, are identified and recorded. As part of the identification process, the current status of the analysis, i.e., Plan, In Work, or

Complete, are recorded. Finally, the "upstream" analyses whose output are used as inputs into the current analyses are identified and tracked in the Logbook.

5.1.11 Task 11 – Publish Release 1 of the ADAC Logbook (APO 1015)

Make the first release of this living document for this ADAC available for use.

Due to the constantly changing nature of this document, it does not go through a formal control board approval process. The initial release is submitted to the discipline engineers and management for review and is then released.

5.2 ADAC Analysis Stage

This stage conducts the planned trades, analyses, and assessments to yield the respective results. This analysis is the responsibility of the performing organizations.

The actual detailed arrangement of tasks performed during this stage is developed for each ADAC in the respective planning stage.

Nevertheless, each specific network can be reduced to the empirical tasks discussed below, based on the general types of data flow relationships. Within this representative group, the system level predecessor analyses flow down data to individual subsystem analyses, which in turn provide roll-up results for integrated system analyses. The task flow for this stage is provided in Figure 5.2-1, with details of each task discussed below.

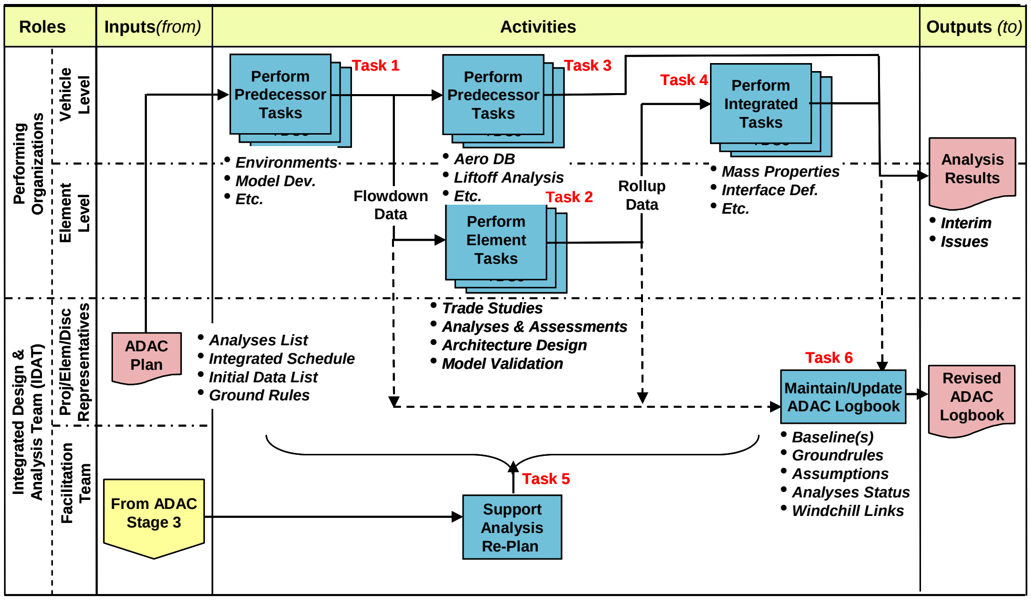


Figure 5.2-1 ADAC Analysis Stage Process Flow

When performing the tasks, the responsible performing organizations should bear in mind:

a. The specific objectives of the analysis as defined in the respective TDS task description.

b. The specific schedule of the analysis as defined in the respective TDS task description and IMS, especially for those analyses in the critical path providing data to successor activities.

c. The responsibility to report expected delays in the analysis, including technical issues, lack of data, or lack of resources before it shows up in the the IMS, if possible.

d. The eventual responsibility for documenting the trades and analyses, thus the need to maintain good documentation and CM/DM throughout the effort.

5.2.1 Task 1 – Perform Predecessor Tasks

Perform any system level predecessor tasks and flow down the results to the subsystem efforts.

Predecessor tasks are those analyses for which the results have broad distribution across the performing organizations. For example, a system-level structural loads analysis yields results that affect the majority of subsystem structural assessments. Within this classification, there may be a local network of interdependency, in which one predecessor analysis passes data to another predecessor analysis that in turn would deliver the cumulative results to a wide range of users. The list of common predecessor tasks includes, but is not limited to:

a. General Design Trajectories and Performance (Flight Mechanics).
b. Guidance and Navigation Design (Guidance, Navigation, and Control).
c. Structural Loads Indicators (Loads and Dynamics).
d. Aerothermal Indicators.
e. General Aerothermal Environments.
f. Terrestrial winds and atmosphere.
g. Operations analysis.

The respective performing organizations perform the predecessor tasks and provide the results (not necessarily in final report format) to the IDAT for distribution to the appropriate receiving performing organizations.

5.2.2 Task 2 – Perform Element Analyses

Perform any Element (subsystem) tasks and forward results as required for system-level roll up.

Element tasks are those trades and analyses performed at the subsystem and component level. This category of tasks has in turn several conditions which further classify the efforts:

a. Tasks that require VI predecessor analysis inputs vs. those that can be performed with just the initialization data. For example, a stress analysis may need to wait on VI loads while the component model can be built independently.
b. Tasks that produce results for roll up at the system level vs. those that are direct outputs of the ADAC process. For example, a component mass properties analysis needs to feed the system aggregate, while the related stress analysis is a defined process product.

Within this classification, there may be a local network of interdependency, in which one Element analysis passes data to another Element analysis, which in turn produces the necessary results. The list of common Element tasks includes, but is not limited to:

a. Structural Design and Analysis (Structural Assessment).

b. Thermal Design and Analysis (Thermal – active and passive).

c. Reaction Control System Design and Analysis.

d. Main Propulsion System Design and Analysis.

e. Avionics Design and Analysis.

f. Software Development.

g. Operations and Logistics Analysis.

h. Thrust Vector Control Design and Analysis (Engine).

i. Material Selection and Manufacturing Processes.

The respective performing organizations do the Element tasks and provide the results (not necessarily in final report format) as required to the developers of the ADAC Logbook.

5.2.3 Task 3 – Perform Vehicle Analyses

Perform any independent Vehicle (system level) analyses or assessments.

Vehicle level tasks are those trades and analyses performed at the system level independent of subsystem activity. These assessments are stand alone activities that are able to directly support Level III requirements. Note that within this classification, however, there may be a local network of interdependency, in which one Vehicle analysis passes data to another, to produce the necessary results. The list of common Vehicle-level tasks includes, but is not limited to, Aero Database development including interim aerodynamic data.

The respective performing organizations perform the Vehicle-level tasks and prepare for the documentation stage.

5.2.4 Task 4 – Perform Integrated Analyses

Compile subsystem results and perform any system-level integrated assessment tasks.

Integrating tasks are those analyses and assessments which aggregate, in bottom-up fashion, system performance and characteristics defined at the subsystem and component levels. For example, mass properties are developed for each component and subsystem, and then rolled up to determine the characteristic at the system level. The list of common integrating tasks includes, but is not limited to:

a. Performance – Mass properties, Power, Thermal, etc.

b. Indicators – Propulsion, Loads, and Thermal.

c. Operability, Manufacturability, Reliability, Maintainability, and Supportability (RM&S).

d. Safety.

e. Technical Risk and Technology Assessment.

f. Engineering and Life Cycle Cost.

g. Interface Definitions.

h. Figures of Merit (FOMs) and Technical Performance Measures (TPMs).

i. Integrated Vehicle Stack Configuration.

The respective performing organizations perform the integrating tasks and prepare for the documentation stage.

5.2.5 Task 5 – Support Analysis Re-plan

Adjust individual plans, as required, to resolve issues identified in the Issue Resolution Stage.

As issues arise during the ADAC, depending on the criticality and complexity of the issue, some resolutions may include making adjustments to the affected tasks to mitigate or eliminate the issue. A constraint on this type of resolution is that the adjustments can be accommodated within the current budget and schedule, and the current goals and technical baseline. (Resolutions that would conflict with this constraint will first be elevated to the control boards.) Adjustments can be either technical or programmatic, and can include, but are not limited to, the following:

a. Changes in IDAT-specified assumptions and ground rules.

b. Adjustments to interim delivery schedules.

c. Changes in the pedigree of data used in assessments.

The IDAT works with respective performing organizations to formulate the re-plan and communicate it to the appropriate stakeholders.

5.2.6 Task 6 – ADAC Logbook Maintenance

Update the Logbook as tasks are completed and when baseline changes.

As the ADAC continues, the project office may release a new baseline. These changes are noted in the Logbook. As analyses are completed, the output and ground rules and assumptions are identified and stored in the ADAC Logbook Windchill site. A link is then established in the Logbook to this documentation, one for the ground rules and assumptions and one for the output information. The status of the analyses are also tracked and changed in the Logbook from “Plan” to “In Work” to “Complete” as appropriate.

5.3 ADAC Issue Resolution Stage

This stage addresses any identified technical or programmatic issues and determines consensus approaches for resolving them. Since system performance issues typically affect more than one discipline or subsystem, the issues and recommended resolutions are presented in an open forum of all affected stakeholders. Resultant actions are determined by the criticality of the issue and the timeliness of resolving it, with the most significant being elevated to the Vehicle (Level III) or Element (Level IV) control boards as appropriate. All issues and resolution plans are tracked over the SAP life cycle. The task flow for this stage is provided in Figure 5.3-1, with details of each task discussed below.

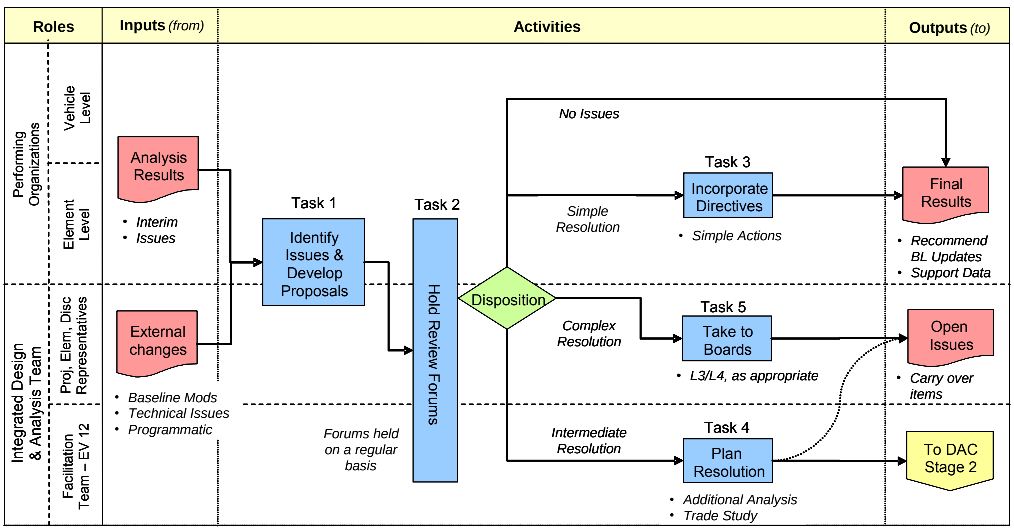


Figure 5.3-1 ADAC Issue Resolution Stage Process Flow

Typically, the Issue Resolution Stage starts in the middle of the Analysis Stage, as scheduled tasks are completed and any associated issues start to surface. It continues well into the Documentation Stage, until all issues have been dispositioned for this ADAC. With a steady stream of results and issues being generated over several months, the IDAT will conduct many review forums on a regular basis as required. As a result, the flow discussed herein represents a single cycle of the sub-process that is repeated multiple times during the ADAC.

5.3.1 Task 1 – Identify Issues & Recommendations

Identify any technical or programmatic issues and develop candidate resolutions to propose.

The performing organizations review their interim results to identify any indicators of technical issues. Typical technical issues can include, but are not limited to:

a. Conflicting requirements, interfaces, concept of operations, etc.

b. Inability to meet a “design to” requirement, within acceptable cost and schedule risk.

c. Inability to achieve performance levels required to verify or validate a requirement.

d. Failure to achieve a specified Technical Performance Measure.

e. Inability to accommodate ADAC technical directives, ground rules, or goals.

The performing organizations also assess their activities for programmatic issues, such as the inability to deliver interim data on time or to meet the overall ADAC schedule, due to missing data, budget constraints, or realized increased complexity of the problem.

Another source of issues is when a significant program change occurs during the execution of a ADAC. An example would be a change in the concept of operations decided by Level II that may impact the reference configuration currently in use. It is important that the integrated set of analyses be considered in response to program changes rather than any single analysis. For that reason, the IDAT will take the lead in coordinating the assessment and response.

When issues are identified or results are complete, the responsible performing organization notifies the IDAT to place them on the IDAT forum agenda, and prepares a briefing package either describing the results or issue. If it is an issue, the briefing should include a description of the problem, its overall impact to the ADAC (to the extent that the performing organization can ascertain it for other analyses), and a set of recommended options for resolving the issue.

5.3.2 Task 2 – Conduct Integration Forum

Present results and issues at the IDAT integration forum and disposition the information.

The IDAT integration forum convenes to review ADAC trades, analyses, and assessments as results become known or as issues are identified. The Performing Organization presents the relevant data. For interim results with no issues, acceptance by the forum “promotes” them to final results.

For review of issues, the data is assessed by the IDAT to determine the impact of the proposed resolution to all disciplines and systems. A plan is developed to resolve the multi-discipline issues. The IDAT integration forum will also assess any significant mid-cycle program changes that occur during an ADAC. Typically, the following three questions will guide the IDAT in formulating a response to programmatic change during an ADAC:

a. Does the decision/change impact the analysis?

b. How would a redirection of the analysis impact schedule?

c. How would a redirection of the analysis impact overall technical integration of ADAC results?

The resolutions will be simple, intermediate, or complex, as determined by the criticality of the issue and the timeliness of the solution. (These categories are defined below.) The IDAT Chair may approve all simple resolution actions and intermediate resolution plans. The WBS 5.2.4 Manager will approve complex resolution approaches. The IDAT tracks the issues and closes them as resolution is achieved.

5.3.3 Task 3 – Incorporate IDAT Recommendations

For issues with simple resolution, execute actions and incorporate the IDAT recommendations.

Simple resolutions are straightforward actions that can be based on real-time judgment, or uncomplicated actions that can be performed off-line to close the issue.

For example, the IDAT may issue a recommendation to change an initial ground rule, or a performing organization may be requested to coordinate results with an external team to close the action.

5.3.4 Task 4 – Develop Re-plan Guidance

For issues with intermediate resolution, develop guidance for the affected analyses.

Intermediate resolutions are those actions that can be performed by the performing organizations within the established ADAC budget and schedule to close the issue.

The IDAT develops guidance for the affected performing organizations on how to modify the current Analysis Stage planning. If required, additional trade studies may also be assigned to produce the data necessary to resolve performance issues to the satisfaction of all affected teams.

For the actual analysis re-planning and execution, return to the ADAC Analysis Stage.

5.3.5 Task 5 – Submit to Level III Control Boards

For issues with complex resolution, present the situation to the L3CB for resolution.

Complex resolutions include one or more of the following resultant conditions, which require the issue to be elevated to the L3CB:

- There is a necessary cost or schedule impact.
- There is a needed change to the technical baseline, including changes or waivers to requirements, changes to the system configuration, or changes in operational plans.
- The issue concerns another Level III Project, including the Orion (Crew Exploration Vehicle), Ground Systems, or Mission Systems Projects.
- There is no apparent best solution, or agreement cannot be reached.

The IDAT prepares an Engineering Change Request (ECR) in accordance with the Ares CM Plan (CxP 72015). The IDAT Chair submits the package to ID&A. The ID&A WBS 5.2.4 manager endorses the request and presents it to the appropriate L3CB for disposition.

Level III directives that have a direct impact to the Elements are presented to the appropriate[3] Level IV boards as required.

5.4 ADAC Documentation Stage

This stage preserves and communicates the results of the ADAC. Analyses and assessments are documented in individual detailed reports. Summaries of each report are compiled in the executive Data Book Summaries within the IVDDD and all open issues are tracked. The final presentation and recommended changes to the technical baseline are taken to the VICB for review. The task flow for this stage is provided in Figure 5.4-1, with details of each task discussed below.

[3] For guidance on which board is "appropriate," refer to Configuration Management Plan for Ares Projects Office (CxP 72015), paragraphs 9.2 and 9.4.

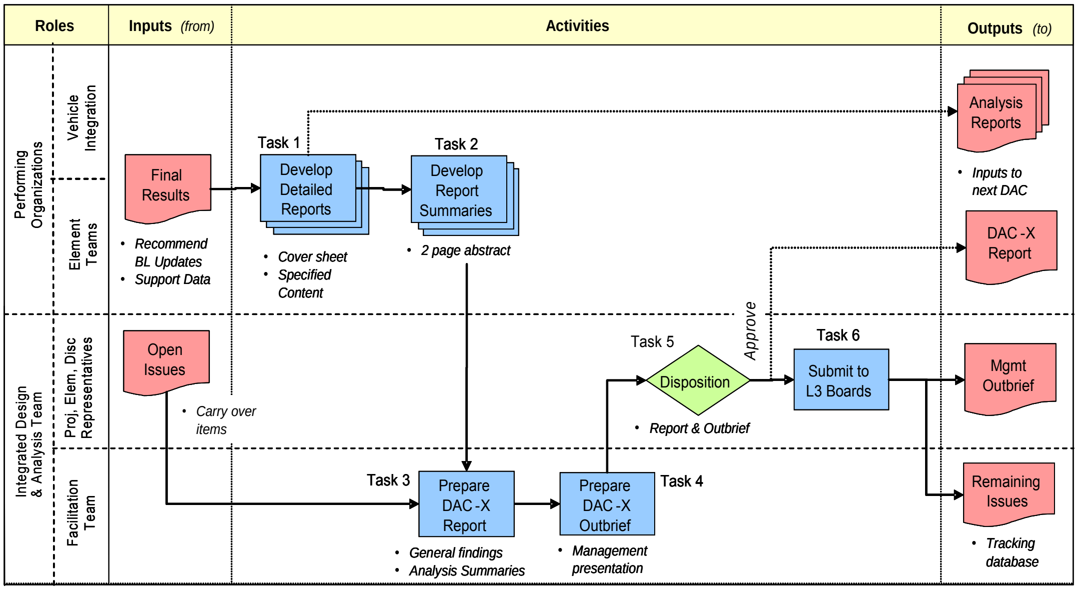


Figure 5.4-1 ADAC Documentation Stage Process Flow

5.4.1 Task 1 – Develop Task Reports

Develop the detailed reports that document the individual analysis activities and results.

The performing organizations develop a final report describing the rationale, the tasks performed, and the results produced. This report will consist of, at a minimum, the items stipulated by the Task Final Report content template discussed in Section 6.4.1, including:

a. Background, Assumptions, and Ground Rules.

b. Supported Requirements – Reason the analysis was performed.

c. Initialization Data – List of data items used as input.

d. Analytical Models and Tools – Including validation/accreditation, CM and DM.

e. Summary of Results – Comparison to requirements, FOM/TPM values.

f. Conclusions, Issues, and Recommendations.

The performing organizations collect the data, organize the information, and document it in a user specified format, but adhering to the report content template. They acquire any internal approval specified by the respective sponsoring organizations and submit the report to the IDAT for review and archiving. The task reports will be transmitted under memorandum from the responsible branch chief to maintain an audit trail. The report is placed into the Cradle requirements management system at the appropriate requirements/architecture information location. A reference to the reports will be added to the ADAC Logbook along with an appropriate Windchill URL.

5.4.2 Task 2 – Prepare Executive Summaries

Prepare an Executive Summary of each task report for the overall Data Book Summaries within the IVDDD.

The performing organizations abridge the report to produce a one to two page Task Executive Summary and then provide it to the IDAT for inclusion into the Ares-wide Data Book Summaries within the IVDDD. This summary could simply be the abstract from the respective Task Final Report. (In theory, the summary is produced after the report; but, in practice, performing organizations may develop the summary first to accommodate delivery schedules.)

5.4.3 Task 3 – Prepare Data Book Summaries within the IVDDD

Compile the data and develop the draft executive Data Book Summaries within the IVDDD.

The IDAT compiles the task summaries along with other ADAC information to produce the Data Book Summaries within the IVDDD. This report should consist of, at a minimum, the items stipulated by the Data Book Summaries within the IVDDD template discussed in Section 6.4.3, including:

a. Assumptions and Ground Rules.

b. Supported Requirements – Compliance matrix.

c. Initialization Data – List of data items used as input.

d. Task Executive Summaries.

e. Running summary of issues status and/or closure rationale.

f. Recommended changes to the baseline.

g. Overall results, findings, conclusions, and recommendations.

5.4.4 Task 4 – Prepare ADAC Outbrief

Prepare an outbrief presentation of the Data Book Summaries within the IVDDD for program management review.

The IDAT develops summary charts of the Data Book Summaries within the IVDDD for presentation to the Level III control boards, and other program management forums as required. The IDAT reviews the outbrief to ensure that the key tenets of the report have been properly included. All critical information will be in the reports, such that there is not a need for an audit trail for presentations and outbriefs, but they will be archived in the Windchill data management environment.

5.4.5 Task 5 – Disposition the Report and Outbrief

Review the Data Book Summaries within the IVDDD and outbrief to ensure that they adequately communicate the results.

The IDAT will review the Data Book Summaries within the IVDDD. This provides an opportunity for the IDAT and the performing organizations to see the integrated activities, results, issues, conclusions, and recommendations of the ADAC. The IDAT will distribute the documents for comment, and then schedule the meeting to integrate the remarks. The IDAT Chair determines when the report is ready for submittal and to be referenced in the ADAC Logbook.

5.4.6 Task 6 – Submit to Level III Boards

Present the findings to the L3CB and receive approval that the ADAC exit criteria have been met.

The WBS 5.2.4 Manager submits the Data Book Summaries within the IVDDD to the L3CB, via the Ares CM Plan. When the IDAT Chair obtains signature approval, the IDAT distributes the approved Data Book Summaries within the IVDDD to all performing and supporting organizations and other identified stakeholders, and then archives the file.

6.0 PROCESS SUPPORT TOOLS

This chapter discusses the tools, including templates and methodologies identified in the ADAC Process Procedures, used to support ADAC administrative activities including:

Collecting or identifying the analyses to be performed.
Documenting the relationships of data providers and users.
Scheduling the analyses.
Tracking action items and issues.
Organizing the data required and/or produced by the analyses.

6.1 Planning Tools

The following tools are used during the ADAC Planning Stage.

6.1.1 Planning Guidance Content

Task 2 in the ADAC Planning Stage involves the development of ADAC planning guidance by the IDAT for the performing organizations in how to align their individual plans to the overall ADAC objectives. The format is free form. At a minimum, the guidance should include the items defined in Table 5.1.1-1.

Table 6.1.1-1 ADAC Guidance Requirements

Guidance Package
1.0 Objectives for the ADAC
2.0 Technical Baseline for the start of the ADAC
2.1 Requirements baseline 2.2 Operations concept 2.3 System architectures
3.0 Global Ground Rules, Constraints, and Assumptions
4.0 Schedule Information
4.1 Detailed ADAC Planning & Documentation Schedule
4.2 Summary Level Schedule of Entire ADAC
4.3 Critical Path of Key Analyses
5.0 Open Issues Status from Previous ADACs
6.0 Initial Assessment List for Known Analysis Products

6.1.2 Task Planning Methodologies

6.1.2.1 Task 5 in the ADAC Planning Stage stipulates the planning of individual tasks for the ADAC by the performing organizations. The principles of this planning activity include:

a. Tasks can consist of any related activity needed to make decisions: Analysis, Assessment (use of similarity, engineering judgment, or other qualitative approaches), Trade Studies, or even Model development (to support future analyses).

b. TDS tasks are focused around the analysis and not necessarily the supported requirements or the task products. A single task may contain one or multiple networked analyses.

c. Tasks should be aligned with, either directly or indirectly, supporting the requirements over the life cycle (e.g., feasibility, validation, solution, verification).

d. A single TDS task may support multiple requirements; conversely, a single requirement should not be supported by multiple TDSs. This is because there is an inherent last step of combining the multiple analyses that has to be scheduled and assigned responsibility. Other predecessor tasks, however, can provide input to the supporting task.

There are two basic methods for constructing an analysis approach: the distinct analyses method or the collective analyses method, as exemplified in Figure 6.1.2-1. Both methods effectively represent Task Logic Networks (TLNs), and analogous Verification Logic Networks (VLNs) – the “chain of events” required to support a requirement.

In this construct, the Analysis Representatives (TDS Task Initiators) develop and manage the TDS task, and the Requirements Representatives (Designees) agree to the TLNs and accept the final products. As the requirement sponsor, their judgement is the primary consideration.

The considerations for selection include:

a. Method 1 allows discrete responsibilities to be defined when the work is performed by several organizations or the interim data supports multiple successor tasks.

b. Method 2 has clear TLN responsibility and guarantees that integration of the work and data are addressed throughout the activity, ensuring no “surprises down the road.”

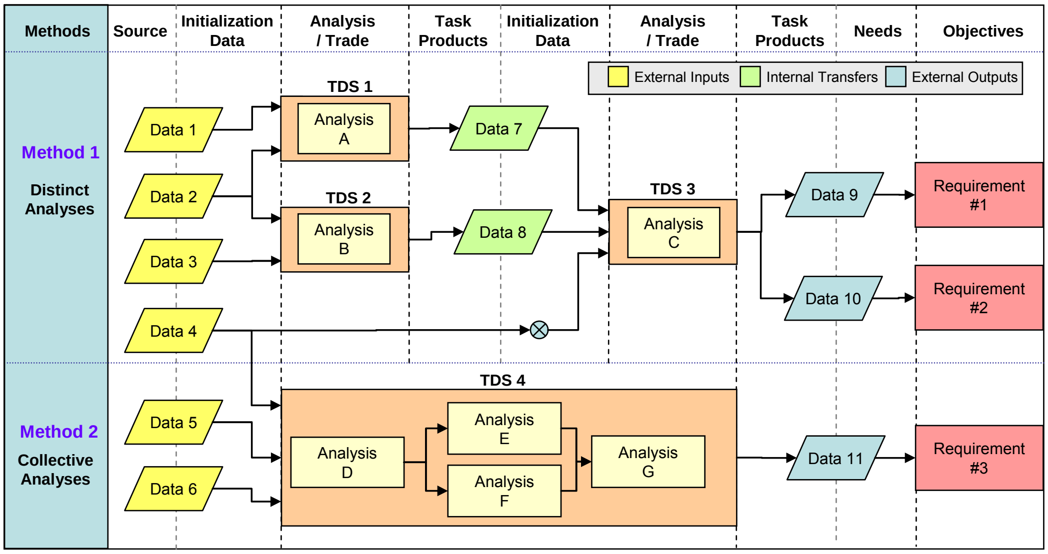


Figure 6.1.2-1 Task Planning Methodologies Example

6.1.3 Task Description Documentation

Task 5 in the ADAC Planning Stage calls for using the ADAC Task Description database (CAIT). The TDS task description will serve as the formalized agreement between the performing organization and Ares Vehicle Integration for ADAC products and required inputs. Inputs listed in the TDS will also be captured in the schedule (IMS) so that analysis and progress can be tracked. The TDS contains several sections of information that communicate responsibility, supported requirements, activities, needed inputs, technical products, and delivery dates. A basic task description outline is depicted in Appendix B along with a description of other data requested within the database.

The Ares IDAT will monitor tasks involving inputs or outputs between different projects/external CxP organizations with representatives from those projects or organizations as noted in Section 4.3.3.3, Project Representatives. If issues arise from a task that concerns another Level III Project, that issue will be addressed for resolution collaboratively between the responsible Level III Working Groups. Unresolved Level III issues, and any Level II to Level III issues, will be elevated to the Level II CxP for resolution.[4]

[4] This paragraph was added per Ares I Change Request (CR) #CLV-VI-031 in response to System Requirements Review (SRR) Review Item Discrepancy #1813. The CR was approved by the Vehicle Integration Control Board on March 26, 2007, and by the Ares Projects Control Board on March 29, 2007.

6.1.4 Reference Configuration Initialization Data

Task 4 in the ADAC Planning Stage involves the compilation of the reference configuration. A tool for documenting the configuration is the Initialization Data Table, which identifies the resource information and tools required to conduct a specific ADAC. It includes a description of the data and the provider, identifiers such as document or model number, and the need date of data or resources. An example Initialization Data Table is provided in Table 6.1.4-1.

Generally this table can be built directly from the CAIT Data Flow Report or Integrated Master Schedule.

Table 6.1.4-1 Initialization Data Table

INITIALIZATION DATA REQUIRED			
Data Number	**Data Description**	**Document Number**	**Date**
0001	Ares I DAC-1/2 Integrated Vehicle Design Definition Document (IVDDD)	CxP 72070	09-12-2006
0102	SRD – System Requirements Document for Crew Launch Vehicle	CxP 72034	Pending SRR Pre-baseline

The other method used to define the reference configuration is with the Integrated Vehicle Design Definition Document (IVDDD) and/or the ADAC Logbook from the previous/ongoing ADAC which includes the baseline architecture description of the vehicle and the latest set of performance and environments data. The set of contents for the IVDDD is provided in the Data Requirement Description (DRD) for CxP 72070, Cradle ID number #177. The DRDs are stored in the Cradle software tool. To retrieve a copy, contact the NASA MSFC Engineering Planning Team.

6.1.5 Integrated Planning Methodologies

Task 7 in the ADAC Planning Stage involves the assessment of TDS task data to formulate the integrated plan. This assessment involves two major tasks: assessment of Design Requirements Compliance and an assessment of external links that have been made and documented in the IMS according to approved TDSs.

6.1.5.1 Design Requirements Compliance

Requirements compliance compares/evaluates the complement of TDS task documention against the baseline set of requirements (this could be performed at any level) to ensure that each requirement has sufficient assessment or analysis for

obtaining the goals of the given ADAC milestone as well as setting the stage for downstream activities and milestones. The tool developed to perform this assessment is the Design Requirements Compliance Matrix (DRCM), CxP 72031. It's recommended that the Excel DRCM spreadsheet be used for data entry that's posted on ICE Windchill at:
https://ice.exploration.nasa.gov/Windchill/netmarkets/jsp/folder/view.jsp?oid=folder%7Ewt.folder.SubFolder%3A356144621&u8=1

An initial assessment is performed to identify requirements that obviously do not need assessment during this cycle according to the specific goals to be achieved and the level of maturity of the requirement data. For the remaining applicable requirements, the collection of analyses to be performed is mapped against them to assess coverage. This assessment may expose several types of improper coverage that will need to be negotiated with the performing organizations, including:

a. Requirements that have no analysis applied to them, creating a potential gap in achieving overall ADAC goals.

b. Requirements with redundant coverage, resulting in potential needless effort.

c. Requirements that are determined to already have the associated data needed to meet the goals of the specific ADAC, but for which analysis is being conducted anyway, resulting in potential needless effort.

d. Analysis being performed that cannot be aligned to any requirements.

e. Analysis being performed to eliminate TBDs/TBRs in the requirement development process that will be needed to satisfy ADAC and milestone objectives.

f. Analyses being performed to address identified program risks.

g. The DRCM also performs a second check to identify that all requirements are planned to be satisfied in the upcoming ADAC milestones as preparatory activities for later activities (i.e., verification and validation).

The DRCM can also be used to check the ties between requirements and deliverables for milestones.

6.1.5.2 Schedule Integration

The TDS tasks capture individual task schedules in tabular format. Schedule integration is performed by the VI scheduling team with support from the IDAT team to produce a logically-linked schedule with cross links across WBSs and Ares Elements. As the integrated schedule is developed from the logic network of tasks defined within CAIT, overlaps and overruns are identified and need to be negotiated with the performing organizations. This generalized, overall approach is shown in Figure 6.1.5.3-1.

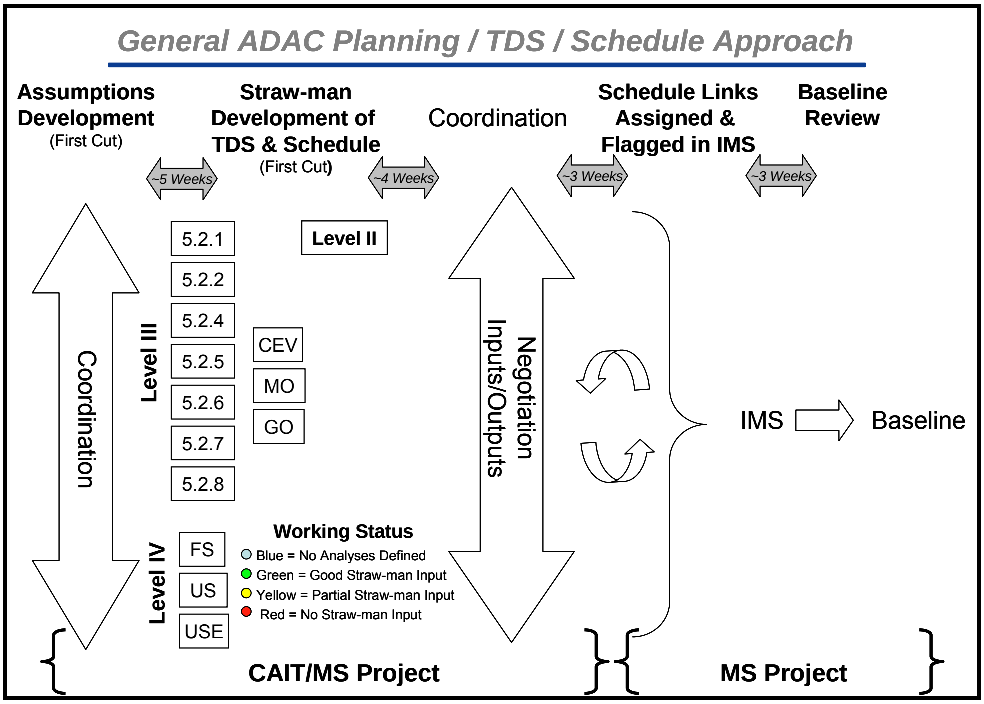


Figure 6.1.5.3-1 General ADAC Planning / TDS / Schedule Approach

6.1.6 ADAC Plan Template

Task 7 in the ADAC Planning Stage also includes the documentation of the integrated ADAC Plan. The major elements of the ADAC plan are shown in Figure 6.1.6-1. The set of contents for the ADAC Plan is provided in the Data Requirement Description (DRD) for CxP 72137, Cradle ID number #1024. The DRDs are stored in the Cradle software tool. To retrieve a copy, contact the NASA MSFC Engineering Planning Team. Note that aspects of the Guidance developed in Section 6.1.1 are incorporated, as well as the documented TDS tasks discussed in Section 6.1.2. The ADAC Process description, Reference Configuration information (IVDDD), and previous ADAC results are found in separate documents and included by reference.

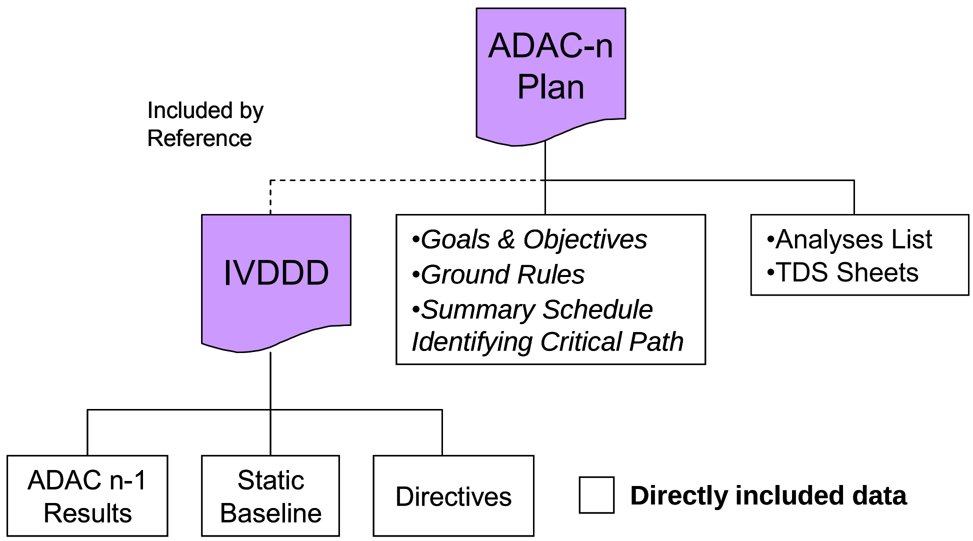


Figure 6.1.6-1 ADAC Plan Elements and Outline

6.1.7 ADAC Logbook (as a planning tool)

Tasks 10 and 11 in the ADAC Planning Stage involve the creation and distribution of the initial release of the ADAC Logbook for the current ADAC. The Ares I ADAC Logbook is an Excel workbook that documents the analyses being performed between major project reviews, such as between SDR and PDR. The Logbook primarily documents the specific configurations used in the various analyses being performed during the current design cycle. Additionally, it provides a list of the current baseline configurations and also provides HTML links to the Ground Rules and Assumptions (GR&A) and output data for each analysis in the ICE/Windchill database. The Logbook is designed to be continually updated with the most current information and is thus subject to frequent change.

The Logbook provides a matrix for tracking the analyses occurring during the current design cycle and their associated configurations. The analyses to be completed during this design cycle are listed across the top, sorted by Work Breakdown System (WBS) element. The left side of the matrix provides the configuration of the vehicle broken down by element and sub-element. The relevant versions of each sub-element are further identified. The information in the matrix then identifies the version of each sub-element, i.e. the specific configuration, being used by each analysis. Also identified is the version of the System Requirements Document (SRD) being used. This enables engineers and management to understand the consistency of inputs from other analyses with the current baseline configuration.

A sample ADAC Logbook configuration template is shown in Figure 6.1.7-1. Only one set of analyses under WBS 5.2.2 is shown in the example. There are also columns (Not shown) for analyses under WBS 5.2.4, 5.2.5, 5.2.6, and 5.2.7.

	ADAC LOGBOOK EXAMPLE						Configuration				WBS 5.2.2		
WBS Element							ADAC-2B Entry Baseline	Current Baseline	Refer-ence	Delta	Natural Environments (.5)		
Analysis Name						NOTE: Linked to analyses data in Windchill.	AMD-002 8/14/2007	AMD-006 2/27/2008	2/1/2008		DSNE	DSNE Rev. A	NEDD
G&A:	(Ground Rules / Assumptions)					NOTE: Linked to GR&A worksheet.					DSNE GR&A	DSNE Rev. A GR&A	NEDD GR&A
Status	(Plan, In-Work, or Complete)										Complete	Complete	Complete
Data	(N/A, RFI, RFTU, DBI)										RFTU	RFTU	RFTU
Rqmts	SRD Rev-A						x				x	x	x
	SRD Rev-B							x	x				
	SRD Rev-C												
Stack	Orion		Sub Element		Configuration						See Note 5	See Note 5	See Note 5
			Launch Abort System (LAS)										
					LAS XXX		obe						
					LAS-YYY		obe						
					LAS-ZZZ		obe						
			Crew Module (CM)										
					CEV-123-A		obe						
					CEV-123-B		obe						
					CEV-123-C		obe						

				CEV-123-B	obe						
				CEV-123-C	obe						
			Service Module (SM)								
				CEV-123-A	obe						
				CEV-123-B	obe						
				CEV-123-C	obe						
			Spacecraft Adapter (SA)								
				CEV-123	obe						
				CEV-123-A	obe						
				CEV-123-B	obe						
		Upper Stage									
			Instrument Unit (IU)								
				CLV-4	obe						
				US MASS #3	obe						
				US-DAC-2A Exit	x						
			Upper Stage Core								
				CLV-4	obe						
				US MASS #3	obe						
				US-DAC-2A Exit	x						
			Interstage								
				CLV-4	obe						
				US MASS #3	obe						
				US-DAC-2A Exit	x						
			ReCS								

				US MASS #3	obe						
				DAC2A_E	x						
				US MASS #4							
				DAC-2B-S Rev. C							
			Ullage Motor								
				US MASS #3	obe						
				US-DAC-2A Exit	x						
				US MASS #4							
			BDM								
				US MASS #3	obe						
		Upper Stage Engine (USE)									
			J-2X								
				Thrust Level: XXX,XXX lbs Lunar YYY,YYY lbs ISS	obe						
				Layout X.X	obe						
				Layout Y.Y	x						
				Layout Z.Z		x	x				
		First Stage									
			RSRMV Thrust Trace								
				RSRMV-XXXXX	obe						
				RSRMV-YYYYYU	obe						
				RSRMV-XXXXX (ISS)	x	x					
				RSRMV-YYYYY (Lunar)			x				
			Frustum								
				XX deg	obe						

				YY deg	x	x	x				
			Nozzle								
				ER=Y.YY(Standard) (ISS)	x	x					
				ER=Z.Z (Extended) (Lunar)			x				
			BDM (Qty-X)								
				US-DAC-2A	obe						
				BDM Thrust Trace	x						
			BDM (Qty –Y)								
				BDM Thrust Trace		x	x				
			RoCS		x						
				DAC-2A							
				XXX lbf			x				
				US MASS #XA		x					
				DAC-2B-S Rev. X							
Ops	Gnd Ops	KSC	VAB		x	x	x				
			Mobile Launcher				x				
			Pad								
				39A							
				39B	x	x	x				
			GSE		x						
	Misson Ops		ISS		x						
			Lunar				x				
			Lunar Outpost								

Figure 6.1.7-1 ADAC Logbook Example

6.2 Analysis Tools

The Trade Studies Process is used during the ADAC Analysis Stage.

Tasks 1 through 4 in the ADAC Analysis Stage involve conducting the Trade Studies, analyses, and assessments of the ADAC. The Ares Trade Study Process, described in Section 7, guides the planning, conduct, reporting, and approval of Trade Study activities. The governance and documentation of trades within an ADAC are discussed in Section 5.3. The Ares Trade Study Process provides information on development of selection rules based on the Ares Figures of Merit, also included in the Trade Study document.

6.3 Documentation Tools

The following tools are used during the ADAC Documentation Stage.

6.3.1 Task Report Template

Task 1 in the ADAC Documentation Stage involves the compilation and documentation of the individual task reports by the respective performing organizations. The associated task report is free format, but must contain a minimum set of information, including the specific assumptions, data, and models and simulations used, the activities performed, and the results, conclusions, issues, and recommendations of the activities. The Task Report outline and content are shown in Figure 6.3.1-1. Initial modeling and simulation survey data captured within CAIT during the TDS task development and approval process (ADAC Planning, Stage 1, Task 5) should be referenced as applicable.

TDS Task Number & Title	[Title]
Author	[Name and organization of the author]
Date	[Date]
	SUMMARY OF ANALYSIS
Background	[This paragraph describes the reason the assessment was performed, the use of the results, and the benefits to the program, including relevancy to requirements]
Assumptions & Groundrules	[This section lists the assumptions made and the rationale]
Initialization Data	[List of data items used as an input, including source, version (if applicable), and date of the data]
Discussion	[This paragraph identifies the analysis methods]
Analytical Models & Tools	[This paragraph should name the analytical models used in this analysis and, if specifically developed for this analysis, their inputs, outputs and limitations should be described. Evidence of model certification should be included and a description of the model and data configuration control and location.]
Summary of Results	This paragraph will summarize the results of the analysis. The results should be compared with requirements where applicable.]
Conclusions & Issues	[This paragraph should summarize the effect of this analysis on the program and describe briefly any issues remaining.]
Recommendations	[This paragraph will propose recommendations for resolution of issues.]
Requirements Validation Forms	[Attached completed requirement validation forms including any proposed from/to language for proposed changes to the requirements.]
References	[memos, documents, etc.; if any]
Acronym List	[Acronyms and expansions of acronyms]

Figure 6.3.1-1 Task Report Content [5]

6.4.2 Task Executive Summary

Task 2 in the ADAC Documentation Stage involves the abridgment of the respective task report into a Task Executive Summary for inclusion into the Data Book Summaries

[5] From the Constellation Program Systems Integrated Analysis Plan (CxP 70009), Figure 2.5 – Final Report Content.

within the IVDDD. The summary should be only one to two pages long and follow the same basic outline as the task report described above.

6.4.3 Template for the Data Book Summaries within the IVDDD

Task 3 in the ADAC Documentation Stage involves the compilation and documentation of the executive technical analyses and results from an ADAC in executive-level Data Book Summaries within the IVDDD by the IDAT. For an example, refer to the Ares I IVDDD (CxP 72070) that was produced between ADAC-1 and ADAC-2A.

Note: The requirement for standalone ADAC Reports (Cradle ID #1047) to summarize the technical analyses and results from an ADAC was deleted within the previous revision (Rev. B) of this plan.

6.4.4 ADAC Outbrief Template

Task 5 in the ADAC Documentation Stage involves the summation of the Data Book Summaries within the IVDDD into an outbrief presentation for communicating results to the Level III and Level IV control boards and other program management forums. The initial outbrief should follow the basic outline of the Data Book Summaries within the IVDDD. Following the first presentation, the VICB will identify what they want presented. The IDAT will modify the ADAC Outbrief Template accordingly.

6.4.5 ADAC Logbook (as a process support tool)

Task 6 in the ADAC Analysis Stage involves updating the ADAC Logbook with links to analyses' outputs as they are completed. The Logbook provides in each column links to the document that best provides the GR&A for that analysis (See Figure 6.1.7-1). The cell marked "Analysis Name GR&A" is a link to the worksheet titled "ADAC-2B_GR&A_Links". This worksheet provides a link to the GR&A for each analysis.

The Logbook also provides a link to the output data for each completed analysis. This is the link in the cell that identifies the name of the analysis.

Engineers can then use this information as a method of obtaining the input information that they need for their analysis.

7.0 SUPPORT TO PROGRAM PHASES

Task 2 of the ADAC Planning Stage involves the development of the ADAC-n Guidance. This section is provided to facilitate the guidance preparation by defining the common goals, objectives, required data, and analyses of a given ADAC as needed to support a specific Program Milestone Review.

Guidance information for ADACs supporting Program Milestones is provided in the following sections:

a. Section 7.1 identifies the general *ADAC Support to Milestone Reviews*, including the major goals and objectives of the supporting ADACs.

b. Section 7.2 identifies the common *Analyses Needed to Support ADACs*, including data, analyses, and level of analysis fidelity required for an ADAC supporting the various milestones.

c. Section 7.3 identifies *Other Considerations*, including common guidance and lessons learned.

7.1 ADAC Support to Milestone Reviews

The goals and objectives of each ADAC are established to provide the necessary data to support the respective milestone reviews. Based on the respective review goals, the level and maturity of the analyses conducted during each ADAC increases with each successive phase of the program. In addition, the focus of the analyses shifts from ADAC to ADAC according to the categories of analysis activity identified in Table 7.1-1.

Table 7.1-1 Supporting ADAC Objectives

Categories	Requirements	Environments	Architecture	Operations	Models	Verification	Cost	Risk
SRR	X	X					X	X
SDR	X	X	X				X	X
PDR	X	X	X	X	X	X	X	X
CDR		X	X	X	X	X	X	X
DCR				X	X	X		X

The general goals, objectives, and outcomes of the standard NASA Program Milestone Reviews are provided in:

- NASA Procedural Requirement (NPR) 7123.1A, "Systems Engineering Procedural Requirements," Appendix F.
- Marshall Procedural Requirement (MPR) 8060.3 "Requirements and Design Reviews, MSFC Programs and Projects."

The specific entrance and success criteria for each Ares milestone will be derived from these parent requirements by the Project and documented in a dedicated review plan (e.g., Ares I Preliminary Design Review Plan) before each review.

7.2 Analyses Needed to Support ADACs

This section identifies the common data, analyses, and levels of analysis fidelity required to support the series of ADACs. Much of the specific initialization data and types of analyses are common across successive ADACs. This occurs for two reasons. First, it commonly takes several cycles to study a range of problems and make the final decisions. Second, some analyses must be iterated across the life cycle, requiring successive increases in fidelity, ultimately to the point of verification closure.

7.2.1 Initialization Data

Initialization data is the general set of data commonly required to start an ADAC effort. Common initialization data for the ADACs associated with the Project milestone reviews are provided in Table 7.2.1-1. Some data may be draft versions (D) early in the program, while most are released versions (X) which may be updated between reviews. Any updates to released versions will be processed via formal change request in accordance with the Ares CM Plan (CxP 72015).

An ADAC Logbook may transcend more than one ADAC. However, beginning with the initialization data, it is updated and revised throughout the specific ADAC as analysis results are produced. Since the intent of the Logbook is to have the most current design and analysis data, a succeeding ADAC Logbook may, initially, have few differences from its predecessor.

The specific set of documents to be delivered for each Ares milestone will be identified in a dedicated review plan (e.g., Ares I Preliminary Design Review Plan) before each review.

Table 7.2.1-1 Initialization Data

	SRR	SDR	PDR	CDR	DCR
Program Criteria					
Figures of Merit (Concept)	X				
Design Evaluation Criteria	X	X	X	X	
Program Requirements					
Design Reference Missions	X	X	X		
Level 1 Requirements	X	X	X	X	
Level 2 Requirements (SRD)	D	X	X	X	
Operations Concept Document	D	X	X	X	
System Requirements					
System Specifications	D	X	X	X	
Environmental Specifications	D	X	X	X	
Human System Standards	D	X	X	X	
Specification Tree			D	X	
Interface Control Documents			D	X	X
Design-To Specifications			D	X	X
Vendor H/W & S/W Specifications			D	X	X
System Architecture					
Technology Development Plan	X	X	X		
Systems Concepts & Architecture	D	X	X		
Hardware & Software List		D	X	X	
Build-To Specifications				D	X
Development Test Results (if available)		X	X	X	X
Payload to Carrier Integration Plan			D	X	X
Manufacturing Processes Requirements				D	X
Process Data					
Prior IDAC Results		X	X	X	X

7.2.2 Essential Analyses

The essential analyses that are required to meet the goals and objectives for each Ares milestone review will be derived from the parent requirements in NPR 7123.1A and MPR 8060.3, documented in a dedicated plan before each ADAC begins (e.g., the Ares I ADAC-2 Plan), and then updated before each milestone review (e.g., the Ares System Definition Review Plan).

7.2.3 Analysis Fidelity Matrix

Classes of analyses in some of the technical or functional areas will be performed during each ADAC. The level of information or design fidelity (or maturity) to support the objectives of the ADAC and ultimately the goals of the milestone review will vary. Thus target levels of fidelity for each technical or functional discipline and area □eleco be established as general objectives for each ADAC, as conceptually illustrated in the Figure 6.2.3-1. Appendix F lists general fidelity maturity definitions by WBS.

Projected & Target Levels of Fidelity (LOF) for Analyses from a System Lifecycle Perspective

Discipline in Ares-1 VI FY-07 WBS: **5.2.4.5 Integrated Vehicle CAD**

(green) = Project's Target LOF expectations per NASA SP-6105
(yellow) = The Technical Disciplines' LOF objective supporting the project milestone

Ares-1 Lifecycle Review Milestones:

Work Breakdown Structure: NASA SP-6105 Levels	Ares-1 WBS Levels	SRR	ADAC-2A	SDR	ADAC-2B	PDR	ADAC-3	CDR	AVAC-1	AVAC-2	DCR
3 System/Project	Ares-1	2-3	2	4	2-3	4	3-4	4			4
4 Element	Upper Stage	0-1	2	2-3	2-3	4	3-4	4			4
5 Subsystem	Core	0-1	2	2-3	2-3	4	3-4	4			4
6 Assembly	LOX Tank	0-1	2	2-3	2-3	4	3-4	4			4
7 Subassembly	Aft Dome	0-1 (crit. items)	2	0-1	2-3	2-3	3-4	4			4
8 Part	Slosh Baffle			0-1 (crit. items)	2-3	0-1	3-4	4			4

Engineering T&V (SDR through DCR)
Qualification & Acceptance T&V (CDR through DCR)
Integration T&V (AVAC-2 through DCR)

"Target" color coding/scale	
4	= Final
2-3	= Preliminary
0-1	= Conceptual
	= N/A

Traceability: The Project Target LOF's were derived from NASA Systems Engineering Handbook, NASA SP-6105, June 1995, Section 3.7.2, Figure 8 "The NASA Program/Project Life Cycle Process Flow", pp35 39. At the bottom of the figure are several snapshots that depict the product maturity at points during a Program/Project lifecycle. The legend shows a solid gray bar for "Conceptual", a hashed bar for "Preliminary", and a blue bar for "Final/Approved".

Level of Fidelity (LOF) Definitions from the Technical Analysis Discipline

0	Parametric, empirical or analytic geometry model. Spreadsheets.
1	External & major internal components modeled such as propellant tanks, payload bay, propulsion, etc. for volume, area and key linear dimensions. Simple geometry models - 10's of parts.
2	All major parts geometrically defined and assembled. Includes parts such as dome gores, major valves, large lines, but not bracketry or smaller lines. Significant geometry models - 1,000-10,000's of parts.
3	All major parts and most small parts geometrically defined. Includes down to the level of bolts and electrical connectors. Extensive geometry models - 100,000-1,000,000's of parts.
4	All parts fully defined and released for manufacture. Detailed product definition models - 1,000,000's of parts.

Figure 7.2.3-1 Example of ADAC Analysis Fidelity Matrix for One Discipline

7.3 Other Considerations

Some Lessons Learned from the conduct of the ADAC process on other programs include the following:

a. The tailored ADAC process should be incrementally improved. After each ADAC, there is a potential to incorporate lessons learned for the next ADAC.

b. If faced with a choice, it is generally more important to use consistent data than the most recent data.

c. If the ADAC process created unnecessary bureaucracy, then the process is not being implemented correctly—the process allows for and promotes flexibility.

8.0 TRADE STUDY PROCESS

The Project's intent is to conduct formal trade studies in a coordinated manner. The Trade Study Process helps the project review and disposition the Trade Study Lead's recommendation, whether that be to keep the ADAC Point of Departure (POD) "as-is" or to make a change to the next ADAC's architecture.

The Ares Trade Study Process only applies to formal, pre-planned trades. It does not apply to normal engineering analyses that mature the mainline vehicle design. However, the process recognizes that mainline engineering analyses, after they are complete, may also drive out the need for a FROM-TO configuration Engineering Change Request (ECR).[6] In that case, the "Justification for Change" section in the analyst's ECR should address the technical content outlined in Appendix D "Required Outline – Trade Study Report."

8.1 Definition of a "Formal" Trade Study

A formal trade study for Ares is defined as a pre-planned effort to evaluate alternatives to the ADAC POD. It may require extra manpower or resources beyond the mainline design allocation.

Differentiator	Normal Engr. Analyses	Formal Trades
Used to establish a POD architecture/configuration (i.e., to mature TBDs in the design configuration)?	Yes	No, in general, that should be part of the mainline design maturation
Focus of effort	Focused on the present ADAC's POD architecture and the maturation of that architecture	Focused on possible alternatives to the present ADAC POD configuration
May require extra manpower or funding resources beyond the mainline design allocations to evaluate alternatives	No	Yes

[6] MSFC Form 2327 "MSFC Engineering Change Request (ECR)" or the equivalent.

8.2 Applicability of the Ares Trade Study Process

Ares Level	Applicability of the Ares Trade Study Process
Level III Vehicle Integration	Yes
Level IV Elements	Yes
Level V or below	No. Elements may decide what aspects of this process, if any, to apply.

Section 8.11 provides an executive overview of the Elements' Level V Trade Study Process.

8.3 Governance Philosophy for Formal Ares Level III & IV Trades

The ultimate decision-making authority for a trade will be the Level III Vehicle Integration Control Board (VICB) and/or Ares Projects Control Board (PCB) IF:

a. It affects interface functional allocations or significantly impacts interface design between Elements. An interface impact will be considered significant if it drives an ECR to the Interface Control Document (ICD) between Elements.

b. It affects the launch vehicle's Outer Mold Line (OML) or system performance.

c. It causes an Element to exceed their allocation (of mass, power, etc.).

Proposed trades that do not meet these "rules of thumb" may be transferred by the VICB to a Level IV Element for study. The Level IV Element Control Board (ECB) and/or Element Engineering Review Board (ERB) will then decide whether or not to accept the proposed trade.

a. If an Element's ECB and/or ERB accept the proposed trade, the Ares VI Trade Space Manager(s) will record the Element's tracking number and will then hand over responsibility for tracking that trade to the Element's Trade Space Manager(s).
    - The new Element-level trade will remain under the jurisdiction of the Element-level ECB and/or ERB unless it is later determined that the trade impacts VI criteria as identified above.
    - The VICB retains the right to request status updates from the Elements.

b. If an Element's ECB and/or ERB does not accept the proposed trade or transfer it to Level V or below, that disposition will be reported back to the VICB with their rationale for non-concurrence.

8.4 Trade Study Process Goals

The goals of the Ares Trade Study Process are to:

a. Establish a consistent trade study numbering system between VI and the Elements.

b. Provide a set of common outlines (for required technical content, not writing style) to be utilized for key trade study products:
   - o Trade Study Plan.
   - o Trade Study Recommendation Report.

c. Define the top-level Trade Study Criteria that, if applicable, should be considered in the study's set of trade factors.

d. Define the minimum set of mandatory representatives to be included on each Trade Study Team.

e. Establish the governance philosophy to differentiate which trades should be governed at Level III by the Vehicle Integration Control Board (VICB)/Projects Control Board (PCB) or at Level IV by the Element Control Board (ECB) and/or Element Engineering Review Board (ERB).

f. Require trades to summarize their scope (point of departure configuration and alternatives they studied) within their individual trade trees.

The Level IV Elements will have the freedom to construct their own trade study process, as long as it synchronizes with the requirements listed above.

It is the intent of this process to be flexible enough to give working-level engineers enough thinking space to exercise their engineering skills and judgment, while at the same time remaining tight on the quality of information required to justify an ADAC POD configuration FROM-TO engineering change request.

8.5 Requirement for a Consistent Trade Study Numbering System

Ares Trade Studies will be numbered in the format CLV-TS-**-###, or CaLV-TS-**-###, where:

a. CLV denotes Ares I (the Crew Launch Vehicle) and CaLV denotes Ares V (the Cargo Launch Vehicle).

b. TS denotes a Trade Study.

c. ** denotes the Element acronym.
   - o For CLV (Ares I) use:
     - ▪ "VI" for a Level III Vehicle Integration (VI) trade.

- "US" for a Level IV Upper Stage (US) trade.
- "USE" for a Level IV Upper Stage Engine (USE) trade.
- "FS" for a Level IV First Stage trade.

o For CaLV (Ares V), use an acronym representing the Ares V Level IV Element

d. ### denotes a sequential number, e.g., 001, 002, 003, etc.

Tracking numbers will be assigned after the trade study proposal (draft Trade Study Plan) is approved in accordance with Section 8.10.2.1.

The intent is to give each Element's Trade Space Manager the freedom to assign their own trade study tracking numbers for "formal" Level IV trades and below, as long as (for Level IV, at least) the numbers are consistent with the "CLV-TS-**-###" or "CaLV-TS-**-###" format.

8.6 Requirement for Common Product Outlines

Ares VI and the Elements will utilize a common outline for the following Level III and Level IV trade study products that are delivered by the working level engineer:

a. Trade Study Plan (Appendix C).

b. Trade Study Report (Appendix D).

8.6.1 Applicability

The outlines are only required for Level III and Level IV trades. The Elements are free to decide what they want to do for Level V and below. Section 8.11 provides an executive overview of the Elements' Level V Trade Study Process.

The list does not include presentation charts or other documentation products that the Trade Study Leads may have to prepare, because it is not the intent of this Trade Study Process to formally mandate an outline for anything other than the three products identified above.

The outlines for the Trade Study Plan and Trade Study Report specify required technical content but do not mandate format. Document formatting standards, if any, will be specified by the Ares Configuration Management Plan (CxP 72015).

8.6.2 Rationale

The goal is to maintain consistency from trade-to-trade. Additionally, when an engineer delivers a trade study product, like the final Trade Study Report, he should be able to utilize the same outline regardless of whether they present their results to the Vehicle

Integration Control Board (VICB), Upper Stage Element Control Board (ECB), First Stage ECB, etc.

8.7 Trade Study Criteria

This section defines the top-level Ares Trade Study Criteria that, if applicable, should be considered in the trade study's set of trade factors. This top-level list was derived from the FOMs that were defined at the Project level.

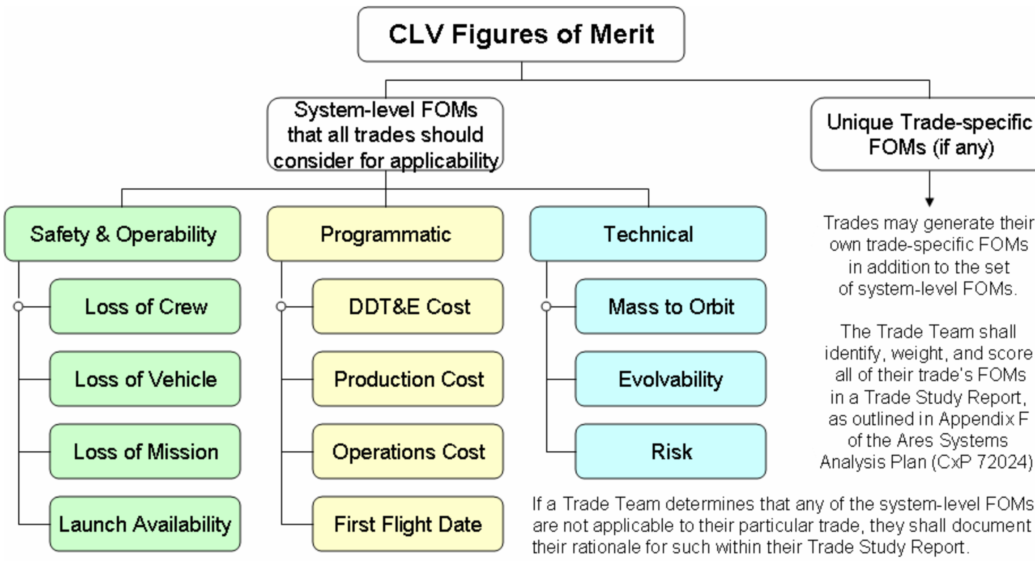


Figure 8.7-1 Trade Study Criteria

The top-level Trade Study Criteria include:

a. Loss of Crew – The probability of occurrence of a catastrophic event that leads to loss of life of a flight or ground crew member.

b. Loss of Vehicle – The probability of occurrence of an event that leads to loss of a reusable crew/cargo transportation system element after launch commit.

c. Loss of Mission – The probability of occurrence that the crew/cargo transportation fails to meet its critical mission objects.

d. Launch Availability – The probability that the Ares I/V will be ready for launch within the launch window for the mission. This includes ground operations that lead up to the launch.

e. Design, Development, Test & Evaluation (DDT&E) Cost – The cost associated with system development. This includes all qualification activities, including development hardware and dedicated test articles and facilities. For protoflight articles, the cost of the prototype is counted against production, and only the cost of refurbishment for flight is counted against DDT&E.

f. Production Cost – The (recurring) cost of manufacturing flight hardware and software including acceptance testing.

g. Operations Cost – The (recurring) cost of personnel and facilities associated with ground and flight operations, including sustaining engineering.

h. First Flight Date – Schedule date for launch readiness for the first flight of the Ares I/V. This includes completion of all DDT&E and ground operations activities, including launch site hardware and software integration testing.

i. Mass-to-Orbit – The mass delivered to the destination orbit for the mission. Note: Mass allocations in the specifications will be in the form of liftoff mass.

j. Evolvability – The growth path(s) for the system to adapt to changes in mission architecture elements, or technologies. Note: This is a qualitative metric in general; however, if reference mission deltas or technologies are defined, then this measure can be quantified as cost.

k. Risk – Uncertainty associated with achieving programmatic, technical, or safety and operability goals and requirements. As a figure of merit, this measure will be determined as a part of the risk management process. As a trade study criteria, this measure will consist of identification and quantification of the relative impacts to Ares I/V risk associated with a given option in the trade study.

8.8 Requirement for Mandatory Representatives on Trade Study Teams

At a minimum, all Level III and Level IV trade study teams will include as mandatory representatives:

a. Trade Study Lead.

b. Individuals who can represent the top-level Trade Study Criteria defined in Section 8.6.

   - A Safety & Mission Assurance (S&MA) engineer to represent the “Safety” criteria.
   - An Operations & Supportability engineer to represent “Operability” criteria.

- o A representative from the Ares Projects Office for the "Programmatic" criteria.
- o An Engineering Directorate representative for the "Technical" criteria.

c. Orion Project representation if the interface between Orion and Ares I is involved in the trade.

Trade study teams will also need to be populated by the technical experts needed to perform the trade and to develop a good recommendation.

The list of Trade Team members and the disciplines they represent will be included in both the Trade Study Plan and the Trade Study Report as shown in Appendices E and F.

8.9 Trade Tree

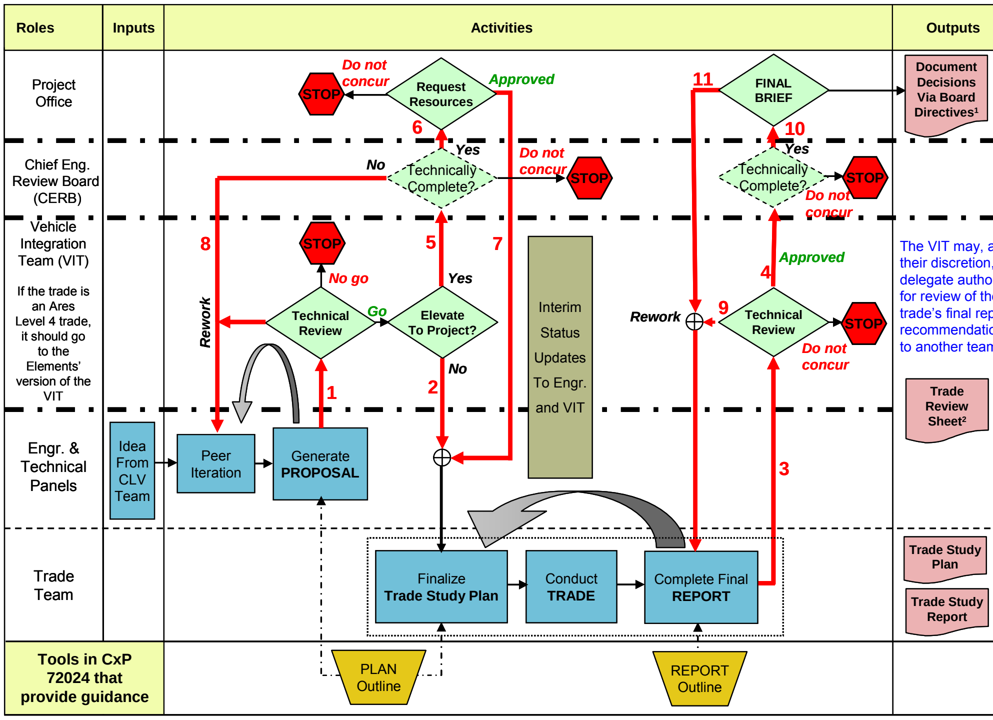
Each trade study team will be responsible for constructing a trade tree that summarizes their Point of Departure (POD) configuration, alternatives that they considered to be in scope during the trade, and their trade study's final recommendations.

The trade tree will be included in each trade's proposed plan and their final report as shown in Appendices E and F.

8.10 Overview of the Ares Trade Study Process

Figure 8.10-1 illustrates, at a top-level, the Ares Trade Study Process for VI at Level III and the Elements at Level IV. The Elements will have the freedom to construct their own trade study process in more detail, as long as it synchronizes with the requirements listed within Section 8.0.

Section 8.11 provides an overview of the Elements' Level V Trade Study Process.



• Process iterations and terminations are implicit.

•The Level 4 Elements will have the freedom to construct their own process, in more detail, as long as it synchronizes with the top-level process above.

Figure 8.10-1 Ares Trade Study Process

Table 8.10-1 Interface Table for the Trade Study Process Flowchart (Figure 8.10-1)

Line	From	To	Information	Format	Method
1	Generate Proposal Who. [a] The Trade	Technical Review (of the Trade Study Proposal) Who. The	[a] Trade Study Proposal (a draft Trade Study Plan)	Content will be provided per the outline in CxP 72024 Ares SAP Appendix C	E-mail

Line	From	To	Information	Format	Method
	Initiator [b] Signees on the Trade Review Sheet	Vehicle Integration Team (VIT) for Ares Level III trades If the trade is an Ares Level IV trade, it should go to the Element's version of the VIT	[b] Trade Review Sheet	MS Word form	Hand-carry or scan for e-mail
2	Elevate to Project? No Who. VIT or an Element's Level IV equivalent after Product Lead resource assessment	Finalize Trade Study Plan Who. Trade Team	Trade Review Sheet signed by the VIT or an Element's Level IV equivalent, noting that the Trade Proposal was approved	MS Word form	Hand-carry or scan for e-mail
3	Complete Final Report Who. [a] The Trade Team [b] Signees on the Trade Review Sheet	Technical Review (of the Trade Study Report) Who. VIT or a VIT-delegated Integration Team (IT) for Ares Level III trades. If the trade is an Ares Level IV trade, it should go to the Element's version of the VIT.	[a] Trade Study Report	Content will be provided per the outline in CxP 72024 Ares SAP Appx F	E-mail
			[b] Trade Review Sheet	MS Word form	Hand-carry or scan for e-mail

Line	From	To	Information	Format	Method
4	Technical Review (of the Trade Study Report) Who. VIT or an Element's Level IV equivalent. *NOTE: The VIT may, at their discretion, delegate authority for reviewing the trade's recommendations to another IT.*	Final Brief (CERB review for approval is optional.) Who. The governing control board in the Ares Projects Office	Trade Review Sheet signed by the VIT or VIT-delegated IT for Level III trades, or an Element's equivalent for Level IV trades, that approves the technical merit of the trade and its recommendations	MS Word form	Hand-carry or scan for e-mail
Approval Loop if the Trade Study Proposal is elevated to the Project to request resources before execution is authorized					
5	Elevate to Project? Yes. (CERB review & approval is optional.) Who. VIT or an Element's Level IV equivalent after Product Lead resource assessment	Request Resources Who. The governing control board in the Ares Projects Office	Trade Review Sheet signed by the CERB, VIT or an Element's Level IV equivalent, that approves technical merit and concurs with Product Lead assessment that additional resources will be required to do trade	MS Word form	Hand-carry or scan for e-mail
6	Elevate to Project? Yes. (CERB con-currence action) Who. VIT or Element's Level IV equivalent after Product Lead resource assessment	Request Resources Who. The governing control board in the Ares Projects Office	Trade Review Sheet signed by the CERB or Element's Level IV equivalent, that approves technical merit and concurs with Product Lead assessment that additional resources will be required to do trade	MS Word form	Hand-carry or scan for e-mail

Line	From	To	Information	Format	Method
7	Request Resources Who. The governing control board in the Ares Projects Office	Finalize Trade Study Plan Who. Trade Team	Control Board Directive approving the Trade Proposal and approving (either fully or partially) the request for resources	MSFC Form 2312 or the Ares equivalent	Hand-carry or scan for e-mail
Kickback Loops					
8	Technical Review (of the Trade Study Proposal) Who. CERB, VIT or an Element's Level IV equivalent	Peer Iteration Who. Trade Initiator	Trade Review Sheet after the actions for rework are recorded on it	MS Word form	Hand-carry or scan for e-mail
9	Technical Review (of the Trade Study Report) Who. VIT or an Element's Level IV equivalent. *NOTE: The VIT may, at their discretion, delegate authority for reviewing the trade's recommendations to another IT.*	Complete Final Report Who. Trade Team	Trade Review Sheet after the actions for rework are recorded on it	MS Word form	Hand-carry or scan for e-mail
10	Optional Technical Review (of the Trade Study Report) Who. CERB or an Element's Level IV equivalent. *NOTE: The CERB may, at their discretion, delegate authority for reviewing the trade's recommendations to another ERB or IT.*	Final Brief (CERB review for approval is optional.) Who. The governing control board in the Ares Projects Office	Trade Review Sheet signed by the CERB or a delegated IT or ERB for Level III trades, or an Element's equivalent for Level IV trades, that approves the technical merit of the trade and its recommendations	MS Word form	Hand-carry or scan for e-mail

Line	From	To	Information	Format	Method
11	Final Brief Who. The governing control board in the Ares Projects Office	Complete Final Report Who. Trade Team	Control Board Directive with any actions for rework recorded on it	MSFC Form 2312 or the Ares equivalent	Hand-carry or scan for e-mail

8.10.1 How to Propose the Start of a Formal Trade Study

Formal Ares Trade Studies may be initiated by any individual or any Element within the Project, assuming a formal trade study is warranted per the definition (Section 8.1), applicability (Section 8.2), and governance philosophy (Section 8.3) for formal trades. The Ares Team Member will prepare a trade study proposal (a draft Trade Study Plan per Appendix C) and then ask their line management for a peer review. If their management deems it necessary, they may also do a peer review of the proposal through one or more of the Ares technical panels (e.g., Ascent Flight Systems Integration Group). The Initiator will then submit their trade proposal to a system-level technical review board, the Vehicle Integration Team (VIT) for Level III trades or an Element's version of the VIT for Level IV trades, for review per Figure 8.10-1.

8.10.2 System-Level Technical Review

After a trade study proposal (a draft Trade Study Plan) is peer reviewed by the Initiator's line management and any technical panels that they deem necessary, it will be submitted to a system-level technical review board, the Vehicle Integration Team (VIT) for Level III trades or an Element's version of the VIT for Level IV trades.

The Chairperson of the VIT (or the Element's Level IV equivalent) may determine on a trade-by-trade basis how much representation is needed from each of the engineering organizations to assess the adequacy of a proposed trade's draft plan or an active trade's final results. A Trade Review Sheet (like the one shown in Appendix E) or an equivalent instrument will be used to record the results and recommendations from the review.

- The Trade Review Sheet includes signatures for the relevant Work Breakdown Structure (WBS) Manager and Product Lead. The names on the sheet should be changed to match the Ares WBS that will "own" the proposed trade or that "owns" the trade-in-progress. The appropriate WBS Manager from the Project Office and their Product Leads from the Engineering Directorate will assess whether the resources requested by the Trade Study Proposal (a draft Plan) or the resources requested for implementing the recommendations within the Trade Study Report fit within appropriate Work Package resource bounds and constraints.

- The VIT Chairperson should also make sure that the Trade Review Sheet (or equivalent instrument) captures the recommendations from any technical panel(s) that originated the trade study or that were responsible for an engineering discipline peer review of the Trade Study Proposal (a draft Plan) or Report before it was presented to the VIT.
- The VIT Chairperson will have the authority to identify, at his/her discretion, as few (for expediency) or as many (for completeness) signatories for each trade on a case-by-case basis.

8.10.2.1 First Technical Review: Trade Study Proposals

When a formal trade is proposed, the VIT or an Element's Level IV equivalent will review its technical merit. The Chairperson with support from the relevant Work Package Manager(s) for the trade will then determine whether it should be elevated to the Project's governing control board with a request for resources. Even if more resources are not required, the Chairperson may use discretion to exercise the option to request a courtesy review by the Project.

8.10.2.2 Second Technical Review: Final Trade Study Reports

When a formal trade is finished, the VIT or an Element's Level IV equivalent will review the trade's recommendations. The Chairperson may also use discretion to exercise the option to delegate authority for technical review of the trade's recommendations to another Integration Group (IG). In either case, the Chairperson will remain responsible for ensuring that the trade study's recommendation(s) and the responsible IG's review are forwarded to the Project's governing control board for a decision.

8.10.3 Finalize Trade Study Plan, Conduct Trade, and Complete Final Report

Trade Study Teams and Leads will conduct trades utilizing the good engineering practices provided by their organization. A handy reference that may help the Trade Study Leads and provide guidance on conducting a trade is the NASA "Systems Engineering Handbook," NASA SP-6105, June 1995, Section 5.1, The Trade Study Process.

Note that Section 8.6 of the SAP requires that the documentation for all trade studies follow the outlines provided in Appendix C for Trade Study Plans and Appendix D for Trade Study Reports.

A trade study TDS task description documented in CAIT is required as an addendum to the Trade Study Plan. The task description will be entered into CAIT as soon as possible after the trade study proposal is approved by the VIT.

8.10.4 System-Level Project Review

If the Chairperson of the VIT (or an Element's Level IV equivalent) determines that a trade study proposal (draft Trade Study Plan) needs to be elevated to the Project with a request for resources or if the Chairperson decides to exercise the option to request a courtesy review by the Project, it will be submitted to the Ares VICB for Level III trades or the appropriate Ares ECB for Level IV trades.

The final recommendations from an active formal trade study, when it is finished, will always be submitted to the VICB (or ECB for Level IV trades) for a Project review.

The Chairperson of the VICB (or ECB for Level IV trades) may determine on a trade-by-trade basis how much representation is needed from each of the project and Engineering organizations to assess the adequacy of a proposed trade's draft plan or an active trade's final results. A formal Control Board Directive, MSFC Form 2312 or the equivalent, will be used to record the results and recommendations from the review.

8.11 The Elements' Level V Trade Study Processes – Executive Overviews

This section provides an executive overview of the Elements' Level V Trade Study Processes, plus a pointer to the Elements' documentation for more information. *In the event of a conflict between the text provided below and the Elements' documentation of their Level V Trade Study Processes, the Elements' documentation will take precedence*.

8.11.1 Upper Stage Element – Level V Trade Study Process

The Upper Stage Element handles Level V trades through the Upper Stage (US) SEIWG. Significant trades that may impact other subsystems are presented in the SEIWG to the Integrated Product Teams (IPTs). Integration issues are worked in the SEIWG, and if there is a major issue or design impact it goes to the ERB for the Chief Engineer to resolve.

For details, please refer to the Upper Stage Systems Engineering Management Plan (SEMP), Section 5.1.4.1, Trade Study Process.

8.11.2 Upper Stage Engine Element – Level V Trade Study Process

The Upper Stage Engine (J–2X) Element Office, working through the J–2X prime contractor Pratt & Whitney Rocketdyne (PWR), will implement a process for managing and tracking trade studies based on the work delineated in Figure 8.11.2-1. This process will be applied to all major trade studies at the engine system and component level. At a minimum, the process records the purpose of each trade study, reference configuration, options considered, key assumptions, methods used, and quantitative results. Utility curves will be applied as appropriate as the basis for comparing options. Trade studies will be documented as trade study reports with Microsoft PowerPoint charts as backup containing the information regarding engine performance, reliability and system safety, development and recurring costs, schedule impacts, and operability.

Further detail regarding the J–2X trade study process can be found in PWR document RD06-139, "SEMP for the J–2X Rocket Engine Development Project," Section 3.3.

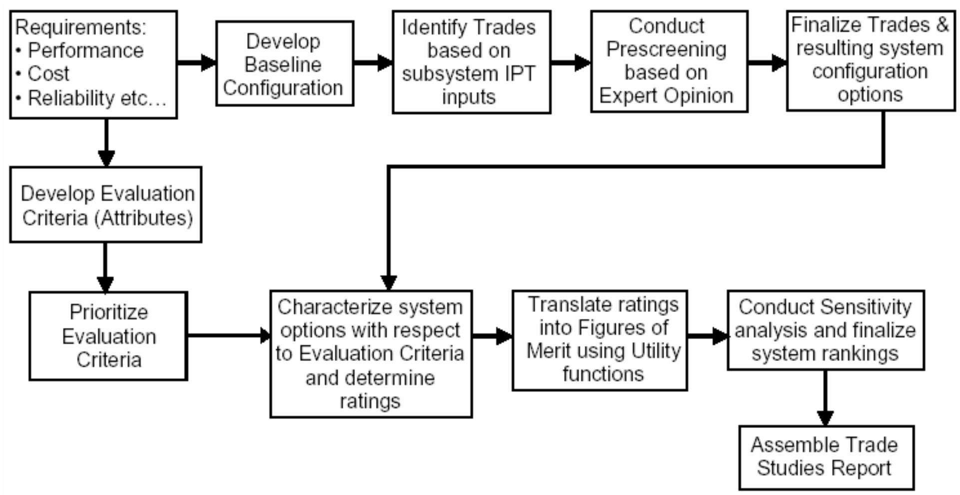


Figure 8.11.2-1. Process Flow for J-2X System Trade Studies

8.11.3 First Stage Element – Level V Trade Study Process

The First Stage Trade Study Process Plan (Appendix F of the First Stage SEMP) defines the process by which Level IV and Level V trade studies will be conducted. The process is mandatory for all Level IV trade studies and recommended for Level V trade studies.

A First Stage Level IV trade study is defined as a trade study where the results will cause a change in the first stage configuration, performance, or interface, or the trade study results will impact the form, fit, or function of more than one first stage subsystem or component.

A First Stage Level V trade is defined as a trade study where the results will have significant impact to a single first stage subsystem or component, and impacts form, fit, or function of the subsystem or component.

Level V trade studies do not require Level IV Engineering Review Board approval/classification prior to initiation, but will be classified and approved by the appropriate First Stage subsystem manager.

Level V trade study recommendations will be presented to the appropriate First Stage subsystem manager for acceptance or approval. The status and results of the trade study will also be presented to the First Stage Chief Engineer and S&MA representatives during the weekly First Stage engineering technical □elecom. If deemed necessary, the Chief Engineer may direct that the trade study results be briefed at the First Stage ERB and other management review boards.

8.11.4 Core Stage Element – Level V Trade Study Process

The Core Stage Trade Study Process will be defined in the Core Stage SEMP. The Level V trade studies process will be divided into two processes:

a. One for the RS–68 engine studies, conducted by the prime contractor.

b. The other process will be applicable for the other Level V studies conducted by the NASA in-house personnel.

8.12 Role of the Trade Space Manager

The Trade Space Manager(s) will prescreen trade study proposals (draft plans) and reports for accuracy and completeness. They will facilitate, if necessary, the submittal of such to the appropriate technical integration groups and the Project's control boards.

The Trade Space Managers do not have the authority to make approval or non-approval decisions, although they may provide a recommendation to the technical integration groups and the Project's control boards.

If a proposed trade study receives approval to move forward, the Trade Space Manager(s) will log it, assign a tracking number to it, and will follow its progress until it is completed or discontinued. They should assist the various Trade Study Leads and remain aware of each trade's alternatives, FOMs, and technical details. If they notice any conflicts or benefits between trades, they should communicate and coordinate such with all relevant parties.

Appendix A
Acronyms and Abbreviations

ADAC	Ares Design Analysis Cycle
AFSIG	Ascent Flight Systems Integration Group
AVAC	Ares Verification Analysis Cycle
CAIT	Constellation Analysis Integrated Tool
CaLV	Cargo Launch Vehicle (Ares V)
CDR	Critical Design Review
CEV	Crew Exploration Vehicle (Orion)
CLV	Crew Launch Vehicle (Ares I)
CM	Configuration Management
CR	Change Request
CxAWG	Constellation Analysis Working Group
CxP	Constellation Program
DAC	Design Analysis Cycle
DAWG	*Design & Analysis Working Group (Obsolete. Replaced by Integrated Design & Analysis Team – IDAT)*
DCR	Design Certification Review
DDT&E	Design, Development, Test & Evaluation
DM	Data Management
DRCM	Design Requirements Compliance Matrix
DRD	Data Requirement Description
DRL	Data Requirements List
DRM	Design Reference Mission
ECB	Element Control Board
ECR	Engineering Change Request
ED	Engineering Directorate (at NASA MSFC)
ERB	Engineering Review Board
ESMD	Exploration Systems Mission Directorate
EV	Spacecraft and Vehicle Systems Department (at NASA MSFC)
EVMS	Earned Value Management System
FEA	Finite Element Analysis

FOM	Figure of Merit
FS	First Stage
GFE	Government Furnished Equipment
GN&C	Guidance Navigation & Control
H/W	Hardware
HTML	Hypertext Markup Language
ICD	Interface Control Document
ID&A	Integrated Design & Analysis
IDAC	Integrated Design Analysis Cycle (for Level II Constellation)
IG	Integration Group
IPT	Integrated Product Team
IRD	Interface Requirements Document
IVDDD	Integrated Vehicle Design Definition Document
KDR	Key Driving Requirements
L3CB	Level III Control Board
LOF	Level of Fidelity
M&S	Modeling and Simulation
MPR	Marshall Procedural Requirement
MS	Microsoft
MSFC	Marshall Space Flight Center
NAR	Non Advocate Review
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirement
ODA	Operability Design and Analysis
ODAC	Orion Design Analysis Cycle
OML	Outer Mold Line
OWI	Organizational Work Instruction
PCB	Project Control Board
PCBD	Project Control Board Directive
PDF	Portable Document Format
PDR	Preliminary Design Review

POC	Point of Contact
POD	Point of Departure
PWR	Pratt & Whitney Rocketdyne
RAC	Requirements Analysis Cycle
RID	Review Item Discrepancy
RM	Risk Management
RM&S	Reliability , Maintainability and Supportability
S&MA	Safety and Mission Assurance
S/W	Software
SAP	System Analysis Plan
SDR	System Definition Review
SE	System Engineering
SEIWG	Systems Engineering & Integration Working Group
SEMP	Systems Engineering Management Plan
SIAP	System Integrated Analysis Plan
IG	Integration Group
SRD	System Requirements Document
SRR	Systems Requirements Review
SW	Software
T&V	Test & Verification
TBD	To Be Determined
TBR	To Be Resolved
TDS	Task Description Sheet
TLN	Task Logic Network
TPM	Technical Performance Measure
TS	Trade Study
UID	Unique Identifier
US	Upper Stage
USE	Upper Stage Engine
VI	Vehicle Integration
VICB	Vehicle Integration Control Board

VIT	Vehicle Integration Team
VLN	Verification Logic Network
VV&A	Verification, Validation, and Accreditation
WBS	Work Breakdown Structure
WG	Working Group
WP	Work Package

Appendix B
TDS Task Documentation Database Input Instructions

This is the top level data required to document Design Analysis Cycle tasks in the CAIT database. Additional detail can be provided under some subheadings:

URL: **HTTPS://CAIT.NIS.NASA.GOV**

MAIN SUMMARY FOR: [TASK NUMBER: EX: CLV-XX-XXXX]
[TASK TITLE]

Introduction

Attribute	Description
Description	TDS Title, Description, and Technical Approach. Includes: What is the objective of the effort (e.g., “the analysis will…”), How it will be accomplished (e.g., “the analysis will be done by…”), Ground rules and assumptions should also be explained here.
Purpose-Method	Purpose – Validate a Requirement, Design Analysis, Analyze Mission Concept, Analyze Future System(s) Design(s), Other Methodology – Analysis, Trade Study, Assessment. Completion Criteria – if known.
Reference	Links to Reference Documents, if needed
POC	POCs, Sponsoring and Performing Orgs
Reference Missions	Design Reference Missions (DRMs) – per the Constellation OpsCon/DRM Rev B
Mission Phases	Mission Phases(MPs) – per the Constellation Drawing Tree.
System Elements	System Elements(SEs) – per the Constellation Drawing Tree.

Management

Attribute	Description
Approval Path	Setup Approval Path – based on Ares and internal organizational preferences
Schedule	Schedule for all tasks in documentation
Priority	TDS Priority – used by Constellation
Status	TDS Status – superceded by Approval Path if that is used. Ares has four current states for tasks: Draft – Approved by engineering management. Baselined – schedule deliverables approved by all stakeholders; task logged as in-work, in the schedule. Completed – all the task products are submitted and accepted. Closed – all iterations of the task are completed and will not be redone.
Lock	Lock TDS – set to prevent changes to completed tasks.
Analysis Activities	Plan Activities Internal to TDS – used for tasks with multiple subsets of activities
Copy TDS	Copy/Transfer this TDS – used to move task data to new DAC.

Data

Attribute	Description
Input Data	Input Data and Data Needs – data required by the task to begin or complete work, specifically data required from another organization within Ares or another project within Constellation. Data created or exchanged internal to an org does not need to be tracked here.
Product Data	Product Data – data produced by the task, including intermediate data drops that will be available for other organizations to use and the final archived product location.

Links

Attribute	Description
Requirement	Links to Requirements – system requirements for which the task or analysis will be providing relevant data.
Risk	Links to Risks – risks for which the task or analysis will be providing relevant data.
Model	Models required for the task or analysis – includes physical models, computer simulations, and mathematical models used for data collection or refinement.
Issue	Issues – Constellation issues for which the task or analysis will be providing relevant data.
Resource	Resources required for the TDS Analysis – Constellation resource tracking.
Board_Association	Boards Associated with the TDS – Responsible board or panel if those entities decide to track relevant tasks and analyses through the database.

Appendix C Required Outline – Trade Study Plan

This appendix is referenced by the Ares Systems Analysis Plan (CxP 72024B), specifically:

- Section 8.10.1 How to Propose the Start of a Formal Trade Study
- Figure 8.10-1 Ares Trade Study Process

Formal Ares Trade Studies may be initiated by any individual or any Element within the project, assuming a formal trade study is warranted per the definition (Section 8.1), applicability (Section 8.2), and governance philosophy (Section 8.3) for formal Ares Level III & 4 trades.

Outline for an Ares Trade Study Plan (required per CxP 72024 Section 8.6)

1.0 SCOPE/PURPOSE
- 1.1 Introduction
  - 1.1.1 Governance[7]
  - 1.1.2 Summary of Proposed Trade and Objectives
  - 1.1.3 Why Trade is Important[8]
- 1.2 Ares Design Analysis Cycle (ADAC) Point of Departure (POD) Requirements
  - 1.2.1 Relevant Requirements[9]
  - 1.2.2 Other Ground Rules, Assumptions, and Constraints

2.0 TRADE TREE
- 2.1 POD Configuration[10]
- 2.2 Initial Set of Trade Alternatives[11]

3.0 TRADE METHODOLOGY
- 3.1 Trade Factors[12]
- 3.2 Decision Analysis Method to Be Used
- 3.3 Planned Weighting for Each Trade Factor
- 3.4 Plan to Perform Weighting Factor Sensitivity Analysis

4.0 REQUIRED RESOURCES
- 4.1 Trade Team Members[13]
- 4.2 Other Resources[14]

5.0 TASKS AND SCHEDULE[15]

6.0 DELIVERABLES

APPENDIX A: Task Description Sheet (TDS) for the Trade[16]

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[7] Identify the Trade Study tracking number and title (CxP 72024 Section 8.5) and the Governing Control Board (CxP 72024 Section 8.3).
[8] What are the key issues or problems that justify the start of this trade?
[9] Please include the bibliographical information for the applicable requirement documents.
[10] Please identify which Ares Design Analysis Cycle (ADAC) and documents specify the point of departure configuration.
[11] Depict the alternatives in Trade Tree format, if at all possible.
[12] Figures of Merit, key performance parameters.
[13] Organization, engineering discipline, and name.
[14] Unique facilities, outputs from other studies, money, etc.
[15] Analysis to be performed and performing organization.

Appendix D
Required Outline – Trade Study Report

This appendix is referenced by the Ares Systems Analysis Plan (CxP 72024B), specifically:

- Figure 8.10-1 Ares Trade Study Process
- Section 8.10.2.2 Second Technical Review: Final Trade Study Report

Trade Study Leads will prepare a trade study recommendation report per the outline below. They will submit this report to their engineering management for review and approval, after which they will submit it to the project's governing control board for approval. This report is only required for Level III and IV trades. The Element are free to decide what they want to do for Level V and below.

<u>Outline for an Ares Trade Study Report (required per CxP 72024 Section 8.6)</u>

1.0 SCOPE/PURPOSE
- 1.1 Introduction
  - 1.1.1 Governance[17]
  - 1.1.2 Summary of Proposed Trade and Objectives
  - 1.1.3 Why Trade is Important[18]
- 1.2 Ares Design Analysis Cycle (ADAC) Point of Departure (POD) Requirements
  - 1.2.1 Relevant Requirements[19]
  - 1.2.2 Other Ground Rules, Assumptions, and Constraints

2.0 TRADE TREE
- 2.1 POD Configuration[20]
- 2.2 Trade Alternatives[21]
- 2.3 Preview of Trade Study's Recommendation[22]

3.0 TRADE FACTORS
- 3.1 Applicable Trade Factors[23]
- 3.2 Definition of Each Trade Factor[24]
- 3.3 Unit of Measure for Each Trade Factor
- 3.4 Pass-Fail Criteria for Each Trade Factor

4.0 DATA ANALYSIS
- 4.1 Fidelity of Analysis[25]
- 4.2 Technical Data[26]

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[16] The template for the TDS task and instructions are provided in CxP 72024 Appendix B.
[17] Identify the Trade Study tracking number and title, WBS organization to which assigned, and Governing Control Board.
[18] The key issue or problem that drove the trade.
[19] Identify the bibliographical information for the applicable requirement documents.
[20] Identify which ADAC cycle and any documents that specify the current configuration.
[21] Depict the alternatives in Trade Tree format, if at all possible.
[22] Specify whether the trade recommends implementing a FROM-TO change or keeping the POD as-is.
[23] Figures of merit, key performance parameters.
[24] Along with the equation used to calculate it, if applicable.
[25] How analyzed, models used.

5.0 DECISION ANALYSIS AND TRADE RESULTS

5.1 Trade Factors Used in the Decision Analysis
5.2 Weighting Assigned to Each Trade Factor and Sensitivity Analysis
5.3 Final Score and Rank for Each Alternative
5.4 Intangible Factors and Risks

6.0 MEMBERS OF THE TRADE STUDY TEAM[27]

7.0 BOTTOM LINE RECOMMENDATION[28]

[26] Summary of the technical data gathered or generated for each trade factor (the raw data could be included in an appendix).
[27] Organization, engineering discipline, and name.
[28] Recap/Expand upon Section 3.3, Preview of Trade Study's Recommendation, and include Minority Reports, if applicable.

Appendix E
Example "Trade Review Sheet for Ares Level III Formal Trade Studies"

This appendix depicts an example of a Trade Review Sheet that could be used by the Vehicle Integration Team (VIT) to review proposed Trade Study Plans and final Trade Study Reports.

DATE:

The following Trade Study Proposal (a draft Plan) was reviewed per Section 8 in the Ares Systems Analysis Plan (CxP 72024). This Trade Review Sheet only applies to formal Trade Studies as defined by CxP 72024, Section 8.1, Definition of a "Formal" Trade.

Trade Tracking #	Trade Study Title	Trade Study Lead(s)
CLV-TS-VI- *Status:* ***PROPOSED***		

The Ares Vehicle Integration Team (VIT) is responsible for reviewing formal Level III Trade Studies as established by CxP 72024, Section 8.3, "Governance Philosophy."

- When a formal Level III trade is proposed, the VIT will review its technical merit. They will then determine whether it should be elevated to the Project's governing control board with a request for resources. Even if more resources are not required, the VIT may optionally request a courtesy review.
- When a formal Level III trade is finished, the VIT may review the trade's recommendations or, at their discretion, delegate authority for review of the trade's recommendations to another Integration Group (IG). In either case, the VIT will remain responsible for ensuring that the trade study's recommendation(s) and the responsible IT's review are forwarded to the Project's governing control board for consideration.

If necessary, review by relevant Project's governing control board *Ares Level 3 Vehicle Integration Control Board (VICB)*		RECOMMENDATION		
		Concur	Do not concur	Other
☒ ______________________	________ Date	☐	☐	☐
☒ ______________________	________ Date	☐	☐	☐

Comments:

Ares Vehicle Integration Team (VIT)		RECOMMENDATION		
		Concur	Do not concur	Other
☒ ______________________	________ Date	☐	☐	☐

Ares Vehicle Integration Team (VIT)		RECOMMENDATION		
		Concur	Do not concur	Other
☐	Date	☐	☐	☐

Comments:

The names below should be changed to match the Ares Work Breakdown Structure (WBS) that will "own" the proposed trade or that "owns" the trade-in-progress. The appropriate WBS Manager from the Project Office and their Work Package Manager(s) from the Engineering Directorate will assess whether the resources requested by the Trade Study Proposal (a draft Plan) or the resources requested for implementing the recommendations within the Trade Study Report fit within appropriate Work Package resource bounds and constraints.

Resource Assessment by the WBS Manager & Work Package Mgr for *Select from Drop-down list*		WITHIN PRESENT RESOURCE BOUNDS/CONSTRAINTS?		
		Yes	No	Other
☐ Work Breakdown Structure (WBS) Manager	Date	☐	☐	☐
☐ Work Package Manager	Date	☐	☐	☐

Comments:

The names below may be changed to match the technical panel(s) that originated the trade study or that were responsible for an engineering discipline peer review of the Trade Study Proposal (a draft Plan) or Report before it was presented to the VIT.

NOTE: The VIT Chairperson will have the authority to identify, at his/her discretion, as few (for expediency) or as many (for completeness) signatories for each trade on a case-by-case basis.

Peer Review by Relevant Technical Panel(s)		RECOMMENDATION		
		Concur	Do not concur	Other
☒ Chairperson:	Date	☐	☐	☐
☒ Chairperson:	Date	☐	☐	☐
☐ Chairperson:	Date	☐	☐	☐

Comments:

Appendix F
Technical Discipline Analysis Fidelity Definitions

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
WBS 5.2.2.6 Range Safety	0	Tailoring of Air Force's Range Safety requirements(AFSPCMAN91-710) and performance of analysis work
	1	Technical review of tailored Air Force's Range Safety requirements (AFSPCMAN91-710) and NASA required analysis results with NASA personnel and the Air Force 45th Space Wing personnel.
	2	All tailored Range Safety requirements incorporated into the applicable Ares I requirements documents.
	3	All NASA required analysis completed.
	4	All Air Force analysis complete and Range Safety information available for launch.
WBS 5.2.4.3 Vehicle Integrated Analyses (Mass Properties)	0	> 90% Estimated (E1) or better aggregate maturity
	1	> 25% Layout or better (E2-A7) aggregate maturity> 85% Layout (E2)
	2	> 25% Preliminary Design or better (C3-A7) aggregate maturity> 85% Preliminary Design (C3)
	3	> 25% Released Drawings or better (C4-A7) aggregate maturity
	4	> 95% of aggregate maturity of dry weight categorized as Actual (A5-A7)
WBS 5.2.4.4 System Loads, Dynamics, & Strength ***◊Loads & Dynamics subset***	0	Parametric or historical equations adjusted to level 1 or higher for similar technology and vehicle configuration.
	1	1-D bending loads analysis based on structural theory of beams, shell, etc… with non-optimums based on level 2 or higher results.
	2	Limited 3-D finite element analysis (FEA) for all major load events, input data and forcing functions at level 3 or higher fidelity, dynamic models shall have sufficient fidelity to capture the dynamic behavior of the vehicle in the frequency range of interest, uncertainty factors reduced and only applied where needed due to inappropriate maturity, and verification level of structural models and forcing functions used to calculate the loads.
	3	Limited 3-D FEA for all major load events, input data and forcing functions at level 4 or higher fidelity, dynamic models shall have sufficient fidelity to capture the dynamic behavior of the vehicle in the frequency range of interest, uncertainty factors reduced and only applied where needed due to inappropriate maturity and verification level of structural models and forcing functions used to calculate the loads.
	4	3D FEA for all major load events for system, elements and components; input data and forcing functions based on data or flight data, test correlated finite element models.
WBS 5.2.4.4 System Loads, Dynamics, & Strength ***◊Stress subset***	0	Parametric or historical structural equations adjusted to level 1 or higher for similar technology and vehicle configuration.
	1	Analysis based on structural theory of beams, shell, etc., with non-optimums based on level 2 or higher results. FEMs being built based on design. Iterations being made to/from design engineers.
	2	Limited 3-D FEA (<20,000 nodes) for all major load cases, structure sized to allowables, non-optimums determined empirically or analytically. FEMs continue to mature. Inputs made for part selection (bolt size/material/etc.). Also some inputs made to Fracture Mechanics discipline.
	3	3-D FEA (>20,000 nodes) for all major load cases, structure sized to allowables, non-optimums determined empirically or analytically. Margins of safety calculated for all safety critical structures and secondary structures. Inputs used based on better fidelity models and load cases.
	4	3D FEA (>100,000 nodes) for all major load cases, structure sized to allowables, non-optimums determined empirically or analytically. Margins of safety all positive for load cases.
WBS 5.2.4.5 Integrated Vehicle CAD	0	Parametric, empirical or analytic geometry model. Spreadsheets.
	1	External & major internal components modeled such as propellant tanks, payload bay, propulsion, etc. for volume, area and key linear dimensions. Simple geometry models - 10's of parts.
	2	All major parts geometrically defined and assembled. Includes parts such as dome gores, major valves, large lines, but not bracketry or smaller lines. Significant geometry models – 1,000–10,000s of parts.
	3	All major parts and most small parts geometrically defined. Includes down to the level of bolts and electrical connectors. Extensive geometry models – 100,000–1,000,000s of parts.
	4	All parts fully defined and released for manufacture. Detailed product definition models - 1,000,000's of parts.
WBS 5.2.4.6.1 Aerodynamics	0	Scaled empirical.
	1	Linear/impact methods.
	2	Experimental data utilizing ground test models. Computational results utilizing Navier–Stokes CFD tools that may or may not have validated against similar configurations and at similar conditions.

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
	3	Experimental data with high-fidelity ground test models. Computational results utilizing high-fidelity, Navier–Stokes CFD tools that have been validated against ground test results for similar configurations and at similar conditions.
	4	Flight test data for similar configuration over similar trajectories as expected for Ares manned flights.
WBS 5.2.4.6.2 Thermal Environments (Aerothermo-dynamics)	0	Parametric or Historical
	1	Simplified methods based on engineering correlations, often implemented via an Excel spreadsheet
	2	Semi-empirical method. Portions of the physics are modeled based on 1D or 2D calculations, the remainder is modeled with ground and/or flight empirical data.
	3	Engineering code analysis. Either generic or specific math models with full physics models and marching plume codes. Based on industry standard or JANNAF codes.
	4	CFD analysis or engineering code validated with wind tunnel or flight data, axisymmetric engineering plume codes for first or second stage radiation, or a combination of CFD and engineering codes.
WBS 5.2.4.6.3 Acoustic Environments	0	Scaled or empirical analysis using spreadsheets or MATLAB®
	1	Scaled or empirical analysis using spreadsheets or MATLAB® plus some wind tunnel test results
	2	Scaled wind tunnel test data.
	3	Updated scaled wind tunnel test data.
	4	Updated scaled wind tunnel test data verified with flight data (Ares I-1)
WBS 5.2.4.6.4 Venting Analyses	0	Historical references (Shuttle, Saturn)
	1	Analysis based on external pressure data (at angle of attack = 0 only and no protuberances) predicted from CFD that may or may not have been validated against similar configurations and at similar conditions.
	2	Analysis based on external pressure data from 2 sources: a) predicted from CFD solutions that may or may not have been validated against similar configurations and at similar conditions (at angle of attack = 0 only and no protuberances). b) wind tunnel pressure test without protuberances.
	3	Analysis based on external pressure data from 2 sources: a) predicted from CFD solutions that have been validated against similar configurations and at similar conditions (at angle of attack = 0 only and no protuberances). b) wind tunnel pressure test with protuberances.
	4	Analysis based on external pressure data from 2 sources: 1-predicted from CFD solutions that have been validated against similar configurations and at similar conditions (angle of attack effects with protuberances). 2- wind tunnel pressure test with protuberances.
WBS 5.2.4.7 Integrated Acoustic Environments	0	Preliminary Predictions: Scaling methods, Vehicle Acoustics Environment Prediction Program (VAEPP), Broadwell and Tsu
	1	Comparison Method Predictions: Launch Acoustics and Ignition Overpressure Prediction (LAIOP)
	2	Reduction Background Information: water suppression research
	3	Different Geometry Trends: proposed mobile launched trends (LAIOP Software)
	4	Improved Predictions: CFD, distributed sources method
WBS 5.2.4.8 Thermal Interface Analyses	0	Hand calculations, spreadsheet calculations with low fidelity design information (e.g., conceptual sketches). Usage of applicable heritage data.
	1	Hand calculations, spreadsheet calculations or simplified finite difference/finite element math models with moderate fidelity design information (e.g., preliminary CAD models of design, but very little detail of interfaces).
	2	Preliminary geometric math model (if applicable) and corresponding finite difference/finite element math models with moderate/high fidelity design information (e.g., PDR-level drawings and CAD models of design, but lacking detail in some areas). Thermal Environments and avionics details at PDR level.
	3	Geometric math model (if applicable) and corresponding finite difference/finite element math models with high fidelity design information (e.g., near CDR-level drawings and CAD models of design). Thermal Environments and avionics details at CDR level. Model correlated to development testing to anchor critical assumptions as necessary. Best estimate material characterization of thermo-optical properties, thermo-physical properties, ablation available from Materials Engineering
	4	Geometric math model (if applicable) and corresponding finite difference/finite element math models with high-fidelity design information (e.g., released drawings and CAD models of design). Thermal environments anchored to wind tunnel data. Avionics details based on component functional and acceptance testing. Correlated to component, subsystem, and system-level thermal balance test data to anchor critical assumptions, as necessary. Full material characterization of thermo-optical properties, thermo-physical properties, ablation available from Materials Engineering.
WBS 5.2.4.9 GN&C	0	Static Controllability Analysis

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
	1	Single Axis Rigid Body Analysis
	2	Single Axis Rigid Body Plus Slosh
	3	Single Axis Rigid Body Plus Slosh Plus Flex Modes
	4	6-DOF with flex and slosh included.
WBS 5.2.4.10 Trajectory & Performance	0	Rocket equation or energy methods (path following) simulation
	1	Optimized Trajectory
	2	Optimized Trajectory, 3-DOF Nominal Performance
	3	Optimimized Trajectory, 3-DOF Dispersed Performance
	4	Optimized Trajectory, 6-DOF Dispersed Performance.
WBS 5.2.5.3 Ground Operations	0	Parameteric ,historical data and conceptual/notional design information used to identify vehicle system and element level ground processing groundrules and assumptions
	1	Parameteric ,historical data and conceptual/notional design information with system and element level requirements included to identify ground processing flows to a level that supports identification CLV system level ground operations requiremnts
	2	PDR level design information included in flows. Flows developed to level of fidelity that supports the identification of GSE and other launch site support requirements. Some level of assumptions still exists based on PDR design maturity. Integrated Test and Checkout initial flows identified.
	3	CDR level design information included in flows. Flows developed to level of fidelity that work instructions can begin to be developed. Test and Checkout flows defined with minimal assumptions.
	4	Flow developed to a level that all processing tasks have been identified and no assumptions remain. All test and C/O activities have been identified. All verification task have been identified
WBS 5.2.5.6 Integrated Logistics Support (ILS)	0	None or limited description and definitions of hardware and the ILS Support System infrastructure and support system procedures and policies; No existing Comparison System of similar function to establish a baseline data base for supportability analysis and supportability modeling activities
	1	Limited description and definitions of hardware and the ILS Support System infrastructure and support system procedures and policies; No existing Comparison System of similar function to establish a baseline data base for supportability analysis and supportability modeling activities; however, similarity in maintenance procedures allows for basic non-parametric analysis
	2	Limited description and definitions of hardware and the ILS Support System infrastructure and support system procedures and policies; Comparison System exists of similar functions to establish a baseline for modeling activities; This allows for basic parametric analysis utilizing supportability modeling and life cycle cost modeling (i.e. COMPASS and CASA models)
	3	Hardware description and definitions are more mature for subassemblies and the ILS Support System infrastructure and support system procedures and policies are more mature; Comparison system is no longer required and supportability analysis and supportability modeling activities are conducted utilizing RAM values developed for subsystems using engineering estimates. This allows for mature parametric analysis utilizing supportability modeling and life cycle cost modeling (i.e., COMPASS and CASA models) and for high-fidelity decision making on support system infrastructure requirements.
	4	Hardware description and definitions are mature for all hardware and the ILS Support System infrastructure and support system procedures and policies are in place; Final decisions are made for support system and funding obligated to be put in place. Supportability modeling and life cycle cost modeling (i.e., COMPASS and CASA models) are utilized to determine investment strategies to optimize Operations & Supportability costs requirements.
WBS 5.2.6.2 Avionics Integration	0	Concepts for C&DH systems and power systems established. Rough models developed. Some major/key driving requirements identified.
	1	Conceptual design developed/established and conceptual/preliminary models developed/finalized. Majority of requirements identified (including design requirements and verification requirements) and baselined. Concepts for breadboard/brassboard developed and reviewed. Preliminary analyses conducted.
	2	Models to be used for final analysis validated. Qualification/acceptance criteria/parameters established and baselined. Breadboard/brassboard developed and in use. Analyses continue using more mature inputs and validated models.
	3	All analyses completed using baselined sanctioned parameters/inputs. Models updated/revalidated and used in analysis activities. Qualification unit developed and some testing performed.
	4	All analyses completed using "as built" or conservative parameters (updates based on development/qualification testing results). All verification completed, reviewed and closed out. All hardware/software completed acceptance tests, inspections, etc. completed and bought off. All acceptance and qualification testing has been completed.

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
WBS 5.2.6.3 Software Integration	0	Concepts and requirements for Software necessary to support command, control and monitor (including key driving requirements) are identified.
	1	Requirements (design and verification) finalized. Implementation of requirements broken down and allocated. System capabilities assessed. Command/telemetry requirements initially defined and reviewed.
	2	Qualification and acceptance requirements finalized. Some coding begins. Implementation of requirements continue to be broken down and allocated. Documentation of software design/development being developed. System capabilities assessed. Command/telemetry requirements finalized. Hardware and test beds for software validation and verification assessed and determined. Command/telemetry databases for Flight/Ground/Mission Systems continue to be refined.
	3	Ongoing coding continues. Implementation of requirements continues to be broken down and allocated. Documentation of software design/development continue to be developed. Some use of test beds, simulators made or planned. Initial software CM is beginning. Command/telemetry databases for Flight/Ground/Mission Systems continue to be refined.
	4	Software completes validation and verification. Verification of requirements completed along with reports showing compliance. Command and telemetry data bases for Flight, Ground and Mission systems completed and validated/verified.
WBS 5.2.6.4 Fault Detection, Diagnostics, and Recovery (FDDR)	0	Concepts for FDDD established. Rough models developed. Some major/key driving requirements identified.
	1	Conceptual design implementation developed/established and conceptual/preliminary models developed/finalized. Majority of requirements identified (including design requirements and verification requirements) and baselined. Capability of avionics breadboard/brassboard concepts reviewed. Preliminary analyses of host system made to confirm acceptability conducted.
	2	Models to be used for final analysis validated. Qualification/acceptance criteria/parameters established and baselined. Breadboard/brassboard evaluated and some time allocated to FDDR for evaluation and use. Analyses continue using more mature inputs and validated models. Follow-on activities divided into Crew Abort, Pad Diagnostics, and Fleet Supportability for development of final products.
	3	Analyses completed using baselined sanctioned parameters/inputs for Crew Abort. Analyses for Pad Diagnostics and Fleet Supportability continuing towards completion. Models updated/revalidated and used in analysis activities. Qualification unit developed and some testing ongoing.
	4	All analyses completed using "as built" or conservative parameters (updates based on development/qualification testing results). All verification completed, reviewed and closed out. All hardware/software completed acceptance tests, inspections, etc. completed and bought off. All acceptance and qualification testing has been completed using validated hardware/software.
WBS 5.2.6.5 Electromagnetic Environment Effects (EEE)	0	Requirements (design and verification) developed. No modelling performed at this time. Support for trades and top level compatibility/suitability assessments performed. Need for models of elements and components coordinated with the element/component developers.
	1	Requirements (design and verification) finalized. Some modeling work planned/identified for the critical items. Models of elements and components provided by the element/component developers. Review of available data to ensure compliance when material/part selection is made.
	2	Modeling/analysis ongoing based on inputs from element/component developers and/or discipline/IPT members. Qualification and acceptance testing requirements finalized. Models of elements and components provided by the element/component developers. Continue review of available data to ensure compliance when material/part selection is made.
	3	Modeling/analysis ongoing based on inputs from element/component developers and/or discipline/IPT members. Completed the definition of all Qualification and acceptance testing requirements. Some qualification and compatibility testing initiated. Models of elements and components provided by the element/component developers. Material/part selection for compliance is completed and will be monitored.
	4	Oversight of all verification testing (qualification, acceptance) completed. Modeling/analysis completed based on as-built test results/data. Models of elements and components provided by the element/component developers and are expected to be final ones.. Continue review of available data to ensure compliance when material/part selection is made.
WBS 5.2.7.2 Safety	0	(Phase A) The safety analysis should identify all potential hazards, hazardous events and hazard causes inherent in the design reference missions (DRM) and concept of operations to assist in development of safety requirements for eliminating, reducing, or controlling the risk. The safety analysis should identify all potential catastrophic hazards and crew survival solutions of each proposed architecture design. Completed documentation should include a system level PHL, identification of hazard evaluation methods to be utilized, and draft system level FTA. Other hazard analysis methods such as Subsystem Hazard Analyses (SSHA), Element Hazard Analysis (EHA), and Integrated Hazard Analysis (IHA) should be initiated by the end of this analysis phase.

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
	1	(Phase B) – A majority of hazard analyses (SSHA, EHA, IHA) should have a high level of maturity. Other hazard analyses such as Operating and Support Hazard Analyses (O&SHA), Software Hazard Analysis (SWHA), and range-related analyses should identify all potential hazards, hazardous events, and hazard causes related to those areas of the design. The safety analysis should be a top-down analysis which identifies all hazards, causes, and a majority of controls (85%+) at the Subsystem, Element, and Integrated System levels. Element and Integrated System Hazard Reports should contain system descriptions, ground rules for the analysis, an overview of the operational concept, mission timelines, historical background data, a list of any hazards that were evaluated and excluded from further analysis, and an indication of risk of each hazard. Approval of the Hazard Reports through a Phase I Safety Review and communication of issues and actions at PDR are indications of successful completion.
	2	(Phase C) – All hazard analyses, including O&SHA and SWHA, and hazard reports should be completed by updating the analyses to include FMEA and CIL information, detailed system information, and system changes. The hazard analyses and reports should reflect the final as-built design and operations of the system/end item to assure that all appropriate hazard controls and crew survival capabilities have been defined and implemented in design documentation, that specific control verification methods have been identified, and all issues identified at either the Phase I Safety Review and PDR have been resolved. Approval of the Hazard Reports through a Phase II Safety Review and communication of issues and actions at CDR are indications of successful completion.
	3	(Phase D) The safety analysis and review process has evaluated the effectiveness of hazard controls, effectiveness of crew survival capabilities, results of the verification activity, and results of any failure analysis. Identify any areas where additional controls or verification is necessary to reduce safety risks to acceptable levels. All verification and test planning should be finalized, including result reviews, for both hardware and software. A majority (90 - 95% +) of safety verifications should be completed. Approval of the updated Hazard Reports through a Phase III Safety Review and presentation to the System Acceptance Review of any open issues or actions.
	4	(Phase E) – Safety analyses and reviews continue to assure Hazard Reports and the associated data elements are maintained and current. Documented plans exist to provide real time risk assessments and obtain information necessary to: identify new operational risks or risks associated with operational or procedural changes, ensure acceptable operational controls, evaluate proposed design changes, identify adverse trends based on failure experiences, review of anomalies from post-flight analyses, and maintenance activities. The safety program must continually have effective means of communicating safety issues to program engineering and management, and also independently to higher levels of management within NASA. Continually update and obtain approval of any changes to Hazard Reports based on design or procedural changes.
WBS 5.2.7.2 Ares Failure Modes and Effects Analysis (FMEA)	0	Initial functional FMEA (pre-PDR)
	1	Preliminary hardware level FMEA in development where design detail is available, expanded functional FMEA where design detail is not available. (PDR)
	2	Preliminary hardware level FMEA updated to reflect available design definition, identification of retention rationale for critical items in development and coordination. (PDR to CDR)
	3	Detailed hardware level FMEA reflecting “as-designed” configuration approved by Level III, CIL in development with rationale for retention for all critical items (post CDR)
	4	Detailed hardware level FMEA/CIL updated to reflect “as-built” configuration with retention rationale developed and approved through Level III for all critical items (FRR)
WBS 5.2.7.3 Ascent Risk	0	
	1	(Phase B) – A majority of the risk models for Ares Ascent phase should have a high level of maturity. These models should represent the system designs and should be integrated to assess the risk for each of the ascent mission phases. The SAPHIRE PRA Computer code and Statistical analyses software such as Crystal ball should be used to identify the important risk areas and their likelihood of occurrence. The Probabilistic Risk Assessment should be completed according the NASA Cx PRA methodology document. The Space Shuttle PRA and Cx PRA databases should be used to provide the failure rates for the assessment. Common cause failures should be accounted for in all systems. The risk analysis, its methodologies, and the ground rules and assumptions for each system should be described in detail in the risk assessment report. Sensitivity and uncertainty analyses should also be performed to support trade studies for a variety of system designs and to provide support to model integration Cx PRA and guidance to the Elements (Level IV).
	2	(Phase C) – The PRA should be completed according the NASA CxPRA methodology document. The PRA should reflect the final as-built design and operation of the systems. The PRA analysis should account for the latest Hazards and FMEAs provided by the Hazards and FMEA reports. The systems/subsystems/components failure data and the common cause failures should be updated to represent the actual elements and test history. Human error should also be identified, assessed, and

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
		incorporated within the Ares PRA. The PRA should have a high level of maturity and should have the capability to provide risk figures of merit for all of the ascent phases of the mission including launch and abort scenarios. The risk estimates and models should be well documented, reviewed, and approved for future use to provide inputs about areas for improvement, to reduce the risk, and to provide support to model integration CxPRA and guidance to the Elements (Level IV).
	3	
	4	
WBS 5.2.7.4 Integrated Aborts	0	Concepts for Integrated Aborts established. Overarching principles developed. Some major/key driving requirements identified.
	1	Conceptual design implementation developed/established and conceptual/preliminary models developed/finalized. Majority of requirements identified (including design requirements and verification requirements) and baselined. Portfolio of abort-related integrated analyses identified.
	2	Analysis portfolio for integrated abort functional capability established and validated. Qualification/acceptance criteria/parameters established and baselined. Integrated Aborts Technical Performance Measures identified for evaluation and use. Analyses continue using more mature inputs and validated models.
	3	Analyses completed using baselined and sanctioned parameters/inputs for Integrated Abort. Analyses for Integrated Stack abort scenarios and performance continuing towards completion. Models updated/revalidated and used in analysis activities. Abort-related Integrated Stack TPMs and Candidate Launch Commit Criteria identified and validated.
	4	All analyses completed using "as-built" or conservative parameters (updates based on development/qualification testing results). All verification completed, reviewed and closed out. All hardware/software completed acceptance tests, inspections, etc. completed and bought off. All acceptance and qualification testing has been completed using validated hardware/software. Abort-related Launch Commit Criteria complete.
WBS 5.2.5.9 Cost	0	Parametric estimate using CERs derived from space vehicle and aircraft historical data, based on weight and technology complexity factors in accordance with the fidelty level of the design concept. General mission classifications are chosen as analogous datapoints and default values are accepted for unknown input parameters. Business case developed using economic theory and methods, based upon standard financial metrics within the space/aeronautical industry. Cost estimate is normally considered at the 50% confidence level.
	1	Parametric estimate using CERs derived from space vehicle and aircraft historical data, based on weight and technology complexity factors in accordance with the fidelty level of the design concept. Limited information is known; therefore, analogous datapoints chosen for majority of subsystems are based on general mission classifications. Input parameters may be based on default values. Business case developed using economic theory and methods, based upon standard financial metrics within the space/aeronautical industry. Cost estimate is normally considered at the 51-60% confidence level.
	2	Cost estimates at the subsystem level using analogy and/or CERs, as appropriate. Level of design is equivalent to the preliminary design stage. Input parameters may be based on default values. Business case developed using economic theory and methods, based upon standard financial metrics within the space/aeronautical industry. Cost estimate is normally considered at the 60–69% confidence level.
	3	Cost estimates at the subsystem level using vendor quotes, analogy, and/or CERs, as appropriate. Level of design is equivalent to the critical design stage. Most input parameters are known. Business case developed using economic theory and methods, based upon standard financial metrics for the prime contractor. Cost estimate is normally considered at the 70–85% confidence level.
	4	Cost estimates at the subsystem/component level using vendor quotes, bottoms-up, analogy, and/or CERs as appropriate. Design is complete, and production has started with long lead items. Business case developed using economic theory and methods, based upon standard financial metrics for the prime contractor. Cost estimate is normally considered greater than 85% confidence level.
WBS 5.2.8 Integration & Assembly Plans	0	Basic assembly and human factors concepts defined.
	1	Simple geometry models of the upper stage, first stage, buildings, platforms, railings, and other GSE. Assembly operations and human factors analyses check for basic geometry fits and ingress/egress through access doors, etc.
	2	Significant geometry models (1,000–10,000s of parts) for the upper stage, first stage, buildings, platforms, railings, and other GSE. Assembly operations and human factors analyses have identified basic tooling requirements. Ingress/egress, reachability, and assembly problems identified.
	3	Extensive geometry models (100,000–1,000,000s of parts) for the upper stage, first stage, buildings, platforms, railings and other GSE. Assembly operations and human factors analyses have been performed for all the necessary assembly tasks. Tooling needs identified.

Technical Discipline	Analysis Fidelity Levels (0-4)	Analysis Fidelity Definitions
	4	All geometry for flight hardware and support hardware defined and released for manufacture, procurement, or modification of facilities. Fully detailed model-based instructions have been developed for all assembly operations.