National Aeronautics and
Space Administration

DOCUMENT NUMBER: CxP 72018
EFFECTIVE DATE: 25 May 2006

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Constellation Systems Launch Vehicle (CSLV) Systems Engineering Management Plan (SEMP) v1.0

May 25, 2006

Approved for public release. Distribution is unlimited.

DOCUMENT HISTORY LOG

Status	Document Revision	Effective Date	Description
Internal Review	Draft 1	9 Dec 05	See Dec 9 TBD List – Technical, Programmatic, Editorial Review
Internal Review	Draft 2	3 Mar 06	Interim showing locations of TBDs and NPR 7123 (Draft) requirements
Broad Area Review (BAR)	Version 1.0 Draft	11 Apr 06	BAR Draft v1.0
CM Release	Version 1.0 Baseline	25 May 06	Baseline SEMP v1.0 for VICB/PCB

CSLV
SYSTEMS ENGINEERING MANAGEMENT PLAN

Prepared by:

______________________________ ______________________________
Date

Dinah Williams
Lead, MSFC Engineering Planning Team

Concurred by:

______________________________ ______________________________
TBD Date

Approved by:

______________________________ ______________________________
TBD Date

______________________________ ______________________________
TBD Date

______________________________ ______________________________
TBD Date

______________________________ ______________________________
Date

David A. King
MSFC Center Director (or designee)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Purpose and Scope

1.1 Purpose

This System Engineering Management Plan (SEMP) describes the overall technical management and integration activities for the Design, Development, Test, and Evaluation (DDT&E) and deployment of the Constellation Systems Launch Vehicle (CSLV) Project.[1] It is written to provide a technical management plan, system engineering and integration (SE&I) tools and processes that will guide the SE&I activities and assist the Project in keeping within performance goals and cost & schedule requirements of the Constellation Program Office. The CSLV Project and its Elements will function per the guidance and requirements in this document. For conflicts between the Launch Vehicle Project Plan (CxP 70057) and this SEMP, the Project Plan takes precedence. Related applicable requirements are contained in NPR 7120.5C, NASA Program and Project Management Processes and Requirements

The SEMP provides the communication bridge between the project management team and the technical implementation teams and within the technical team. It establishes the framework to realize the appropriate work products that meet the entry and success criteria of the applicable project phases. And it provides management with necessary information for making Systems Engineering (SE) decisions. While the SEMP is focused on DDT&E, it also addresses traceability of stakeholder requirements and supportability across the project lifecycle.

1.2 Scope

The scope of this CSLV Project SEMP applies directly to the Crew Launch Vehicle (CLV) and the Cargo Launch Vehicle (CaLV). Combined, the launch vehicles are designated as CSLV. This SEMP is the plan for the complete, integrated technical effort and incorporates all tasks, including all work to be performed by other MSFC/NASA organizations, in addition to the originating organization.

Involved organizations, panels, boards and their processes, methodology, and deliverable products are identified. Repetitive and/or cyclic processes are expanded to show the process paths and data flow and dissemination within the process.

1.3 SEMP Updates

A SEMP is a "living" document that captures a project's current and evolving systems planning and its relationship with the overall project management effort throughout the life cycle of the system. As such, it is updated regularly to remain current and correct.

[1] An expected outcome or action is identified by "will," and descriptive material by "is" or "are" (or another verb form of "to be").

This SEMP is written in support of the CLV SRR and PDR, and will be updated prior to each subsequent milestone review. Other updates will be performed as needed. The designated Level IV Element teams are required to submit corresponding SEMPs within 45 calendar days of CLV SRR for CSLV Project Office approval. Those SEMPs will be included as appendices to this plan.

2.0 Applicable Documents and Designated Governing Authority

This section of the SEMP lists the documents applicable to SEMP implementation and describes major standards and procedures that the technical effort needs to follow. Specific implementation of standardization tasking is incorporated into pertinent sections of this SEMP.

2.1 Applicable Documents

CxP 00001	Constellation Architecture Requirements Document
CxP 00002	Constellation Design Reference Missions
CxP 70006	CLV SRR Plan
CxP 70013	Constellation SEMP
CxP 70057	Constellation Systems Launch Vehicles Project Plan
CxP 72015	CLV Configuration Management Plan
CxP 72016	CLV Software Configuration Management Plan
CxP 72017	CLV Data Management Plan
CxP TBD	CLV Data Requirements List
CxP 72019	CLV Risk Management Plan
CxP 72020	CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance
CxP 72024	CLV Systems Analysis Plan
CxP TBD	CLV Software Quality Assurance Plan (was CLV-SMA-21105)
CxP 72029	CLV Technical Resource Management Plan
CxP 72034	CLV Systems Requirements Document
CxP 72035	CLV Master Test and Verification Plan
MPR 8060.3	Requirements and Design Reviews, MSFC Programs and Projects
NPR 7120.5C	NASA Program and Project Management Processes and Requirements
NPR 7123.1	NASA Systems Engineering Processes and Requirements
NPR 8705.6	Safety and Mission Assurance Audits, Reviews, and Assessments

2.2 Designated Governing Authority

The governing authority for this document is the MSFC Center Director, or his designee. The Spacecraft and Vehicle Systems Department, under the authority of the Engineering Directorate, is directly authorized and responsible for this plan (see Figure 2.3-1).

2.3 CSLV Organization and Points of Contact

The Constellation Program Office will be responsible for integrating and coordinating all the Constellation Projects, of which CSLV is one, into a working launch system for each mission. Many Constellation Program SEI activities will be performed by the CSLV Project organization on behalf of the Constellation Program.[2] These activities will be linked to the Constellation Program work breakdown structure (WBS) for accountability, but worked under the CSLV Project organization's WBS. There may also be other activities performed by other MSFC Project Offices for the Constellation Program Office as separate tasks from CSLV Project work (e.g., Launch Abort System, Propulsion Subsystem Development, etc.) These activities are outside the scope of this SEMP.

[2] The Launch Vehicle Project is managed by the Exploration Launch Office (ELO) at MSFC.

The management roles and responsibilities of the CSLV Project organization are defined in the Launch Vehicle Project Plan (CxP 70057). The CSLV Project Control Boards (PCBs) are also defined in the Launch Vehicle Project Plan. The SEI roles and responsibilities are defined below. A summary of the functions of the control boards are described in section 5.1.1, with specific board responsibilities and the individual board charters outlined in the CLV Configuration Management Plan (CxP 72015). The Office of Primary Responsibility (OPR) for each of the products is defined in Section 5.0 of this SEMP and the Responsibility Assignment Matrix (RAM) in Appendix C. The Integration Groups (IGs) and Technical Panels (TPs) are detailed in Section 4.1 and Appendix G.

The following paragraphs provide descriptions of the roles and responsibilities for the key technical personnel involved in the CSLV Project. Their assignment will be coordinated with the ELO Project Manager or the VI manager.

The Spacecraft and Vehicle Systems Department (Figure 2.3-1) within the Engineering Directorate will be the group responsible for the management of SEMP development and updates. Within this Department are the Systems Engineering Division and Systems Management Branch (Figure 2.3-2), directly assigned the task of SEMP preparation and revision.

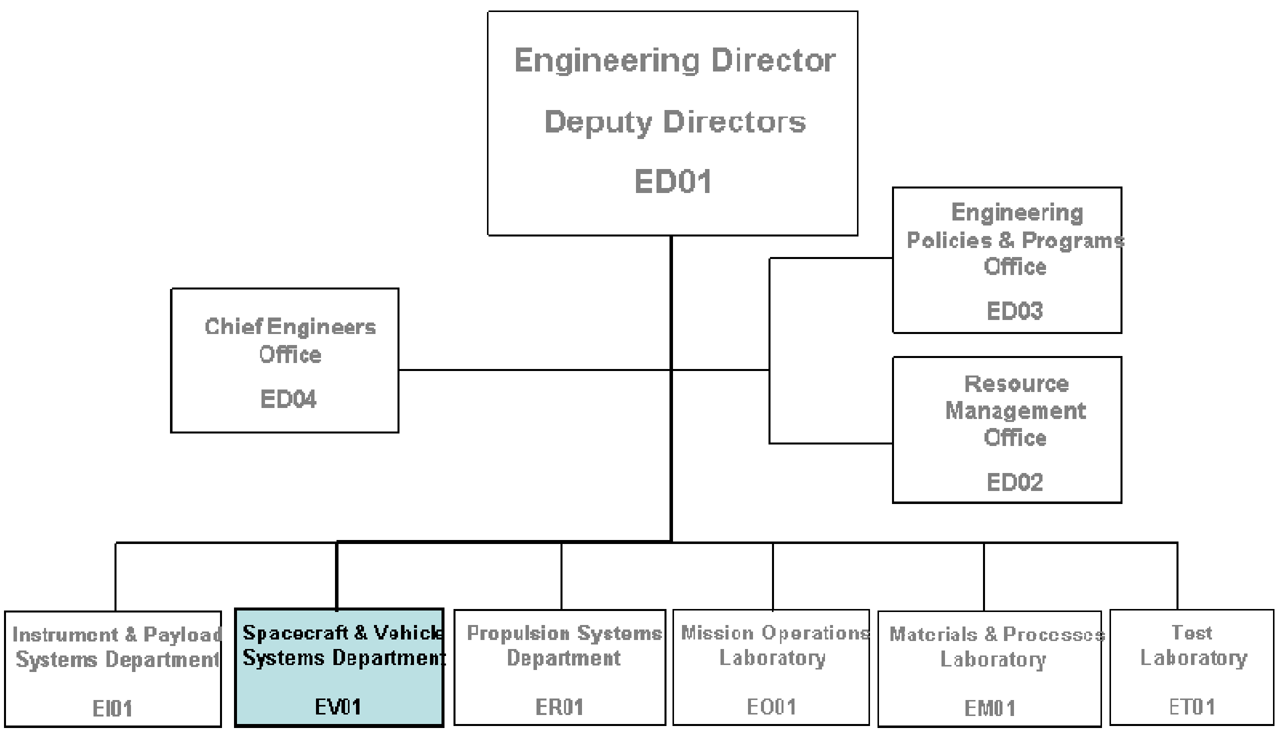


Figure 2.3-1 Spacecraft and Vehicle Systems Department Organization

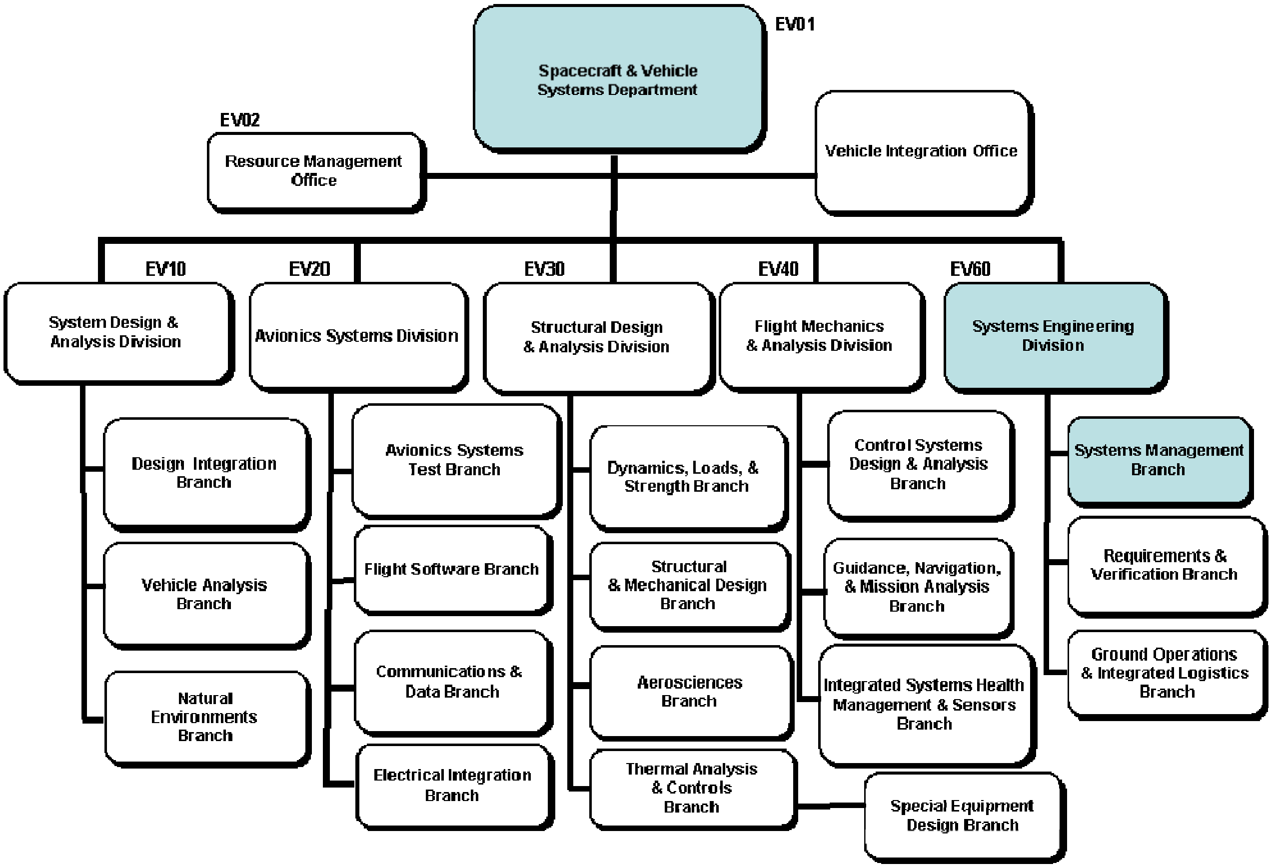


Figure 2.3-2 SEMP Development Organization

The following organizational points of contact within MSFC (Table 2.3-1) are provided for coordination of SE activities relative to this SEMP. Additional POCs will be included as the Project matures.

Table 2.3-1 CSLV Points of Contact

System/WBS Level	POCs
5.2.1 Systems Integration & Control	EV61/Leland Dutro
5.2.2 Systems Requirements & Verification	EV62/DK Hall
5.2.3 Flight Test Integration	EV21/Glen Jones
5.2.4 Integrated Design & Analysis	EV11/Bob Williams
5.2.5 Vehicle Operations & Integration	EV63/Scott Huzar
5.2.6 Avionics Integration & Vehicle Systems Test	EV12/Mark Prill
1st stage	EI62/Randy Forsythe
J-2x	ER21/Kendall Brown
Upper Stage	EV11/Jim Lomas

The Exploration Launch Office (ELO) includes the ELO Project Manager, deputy and support staff (Figure 2.3-3). This level will be responsible for the overall cost, schedule, risk and technical achievement.

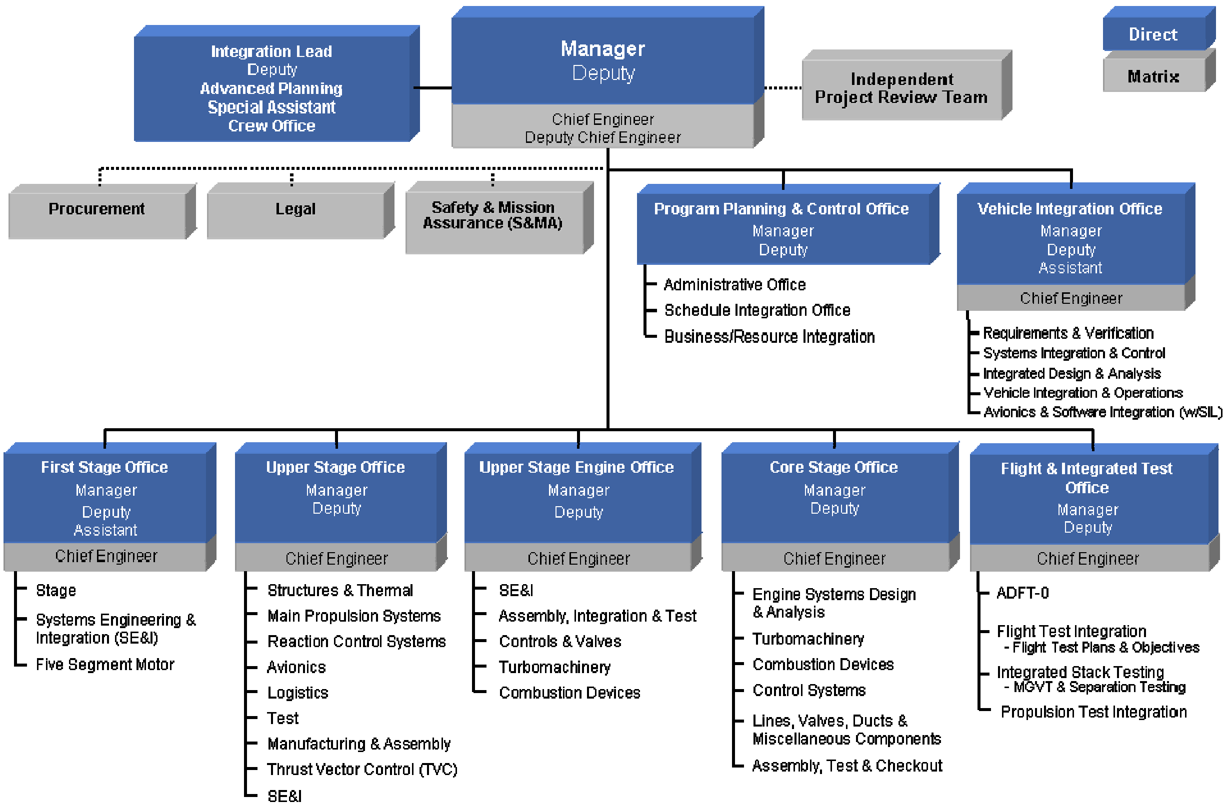


Figure 2.3-3 Exploration Launch Office (ELO)

ELO is divided organizationally to include Vehicle Integration plus four Elements—First Stage (FS), Upper Stage (US), Upper Stage Engine (USE), and Core Stage. The roles and responsibilities of these offices, as they apply to systems engineering management, are described in section 2.4.

Also shown are the relationships of the chief engineers to the respective Elements. The CLV Project Chief Engineer (CE) will work directly with VI and Element CEs to ensure technical excellence and rigor across the CLV Elements. Figure 2.3-4 depicts the VI organization for the CSLV Project.

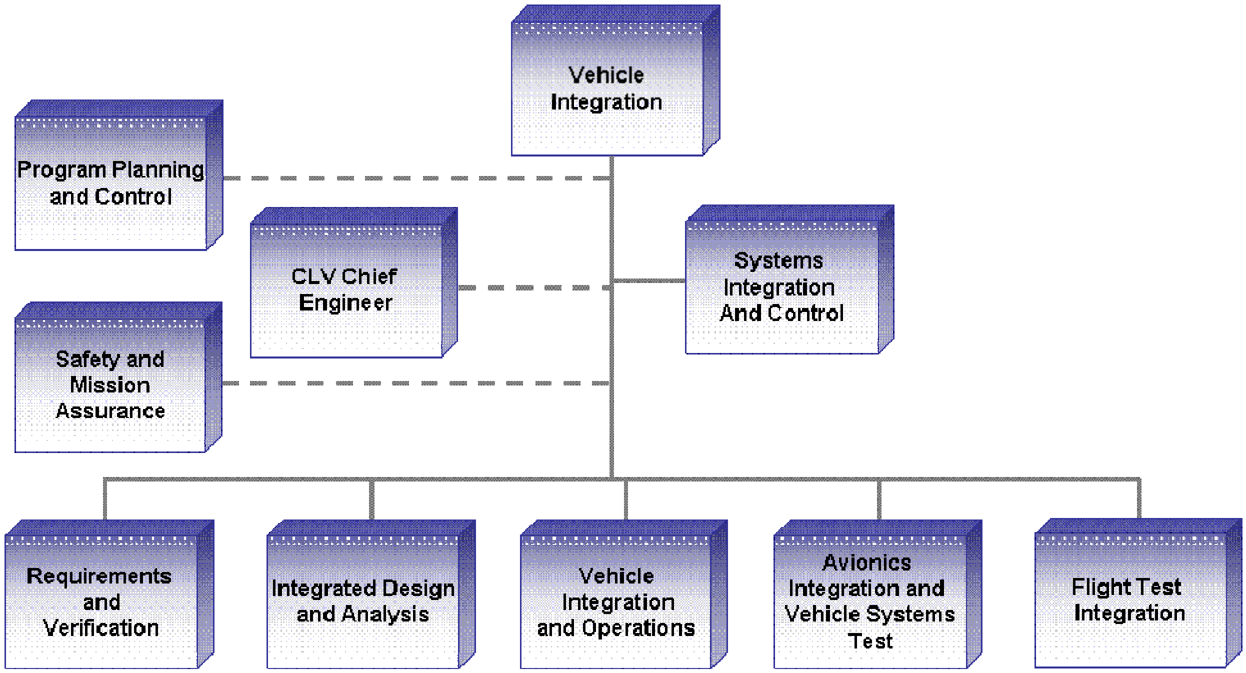


Figure 2.3-4 VI Organization

3.0 Technical Summary

The approach of the CSLV Project is that the Government, specifically NASA and its Centers' support contractors, will provide lead integrator functions. The Government will be responsible for ensuring system integration and performance per validated and verified requirements.

This SEMP will identify what products are due at each of the Project milestones, and which performing organizations will be responsible for each product. This will be shown formally in the Data Requirements List (DRL, CxP #TBD) to be developed from the Responsibility Assignment Matrix in Appendix C. In support of the Level 4 procurement activity, the Data Requirements Descriptions (DRDs) will establish specific data requirements for contractors, as applicable.

This SEMP will also specifically identify the engineering organization, the engineering and project level boards, integration groups, and technical panels -- as well as their relationships. This document will describe how VI and the Element organizations interact with each other and with other Constellation units in order to deliver fully integrated Launch Vehicles – a primary function of SE&I. Any Element-specific technical planning will be documented in updates to this SEMP.

3.1 System Description

The CSLV Project is divided logically into elements by the major hardware groupings and associated management, systems engineering, and integration functions (Figure 3.2-3). The processes described are designed to develop and integrate the Launch Vehicles into verified and validated systems, and safely operate through orbital insertion.

3.2 System Structure

3.2.1 Work Breakdown Structure

The CLV WBS (Figure 3.2-1) is part of the overall System Structure illustrated in the Constellation SEMP (CxP 70013). It provides a framework for the Project hardware/software, management, engineering & integration and will be used to:

- Identify products, processes and data,
- Organize risk management analysis and tracking,
- Enable configuration and data management,
- Organize work packages for management of engineering and S&MA support, work orders and materials/parts ordering, and
- Organize technical reviews and audits.

The WBS will be the formal structure used to develop the system -- and its interfaces -- from concept through operations. Figure 3.2-2 maps the CLV WBS nomenclature to the associated management.

5	Constellation Systems Launch Vehicle Project
5.1	Project Management
5.1.1	Project Mgmt and Administration
5.1.2	Business Management
5.1.3	Contractor Relationships
5.1.4	Technical Reviews
5.1.5	Information Technology Mgmt
5.1.6	Adv Planning & Special Studies
5.2	Vehicle Integration
5.2.1	Systems Integration and Control
5.2.2	Systems Requirements and Verification
5.2.3	Flight Test Integration
5.2.4	Integrated Design and Analysis
5.2.5	Vehicle Integration and Operations
5.2.6	Avionics Integration and Vehicle Systems Test
5.3	S&MA
5.4	Science & Technology
5.5	Payloads
5.6	Aircraft/Spacecraft
5.7	Mission Operations System
5.8	Crew Launch Vehicle
5.8.1	First Stage
5.8.2	Upper Stage
5.8.4	Upper Stage Engine
5.8.4.1	Element Management
5.8.4.2	Government Furnished
5.8.4.3	Prime Contract
5.9	Ground System(s)
5.10	Systems Integration and Testing

Figure 3.2-1 CLV WBS[3]

[3] Core Stage to be added.

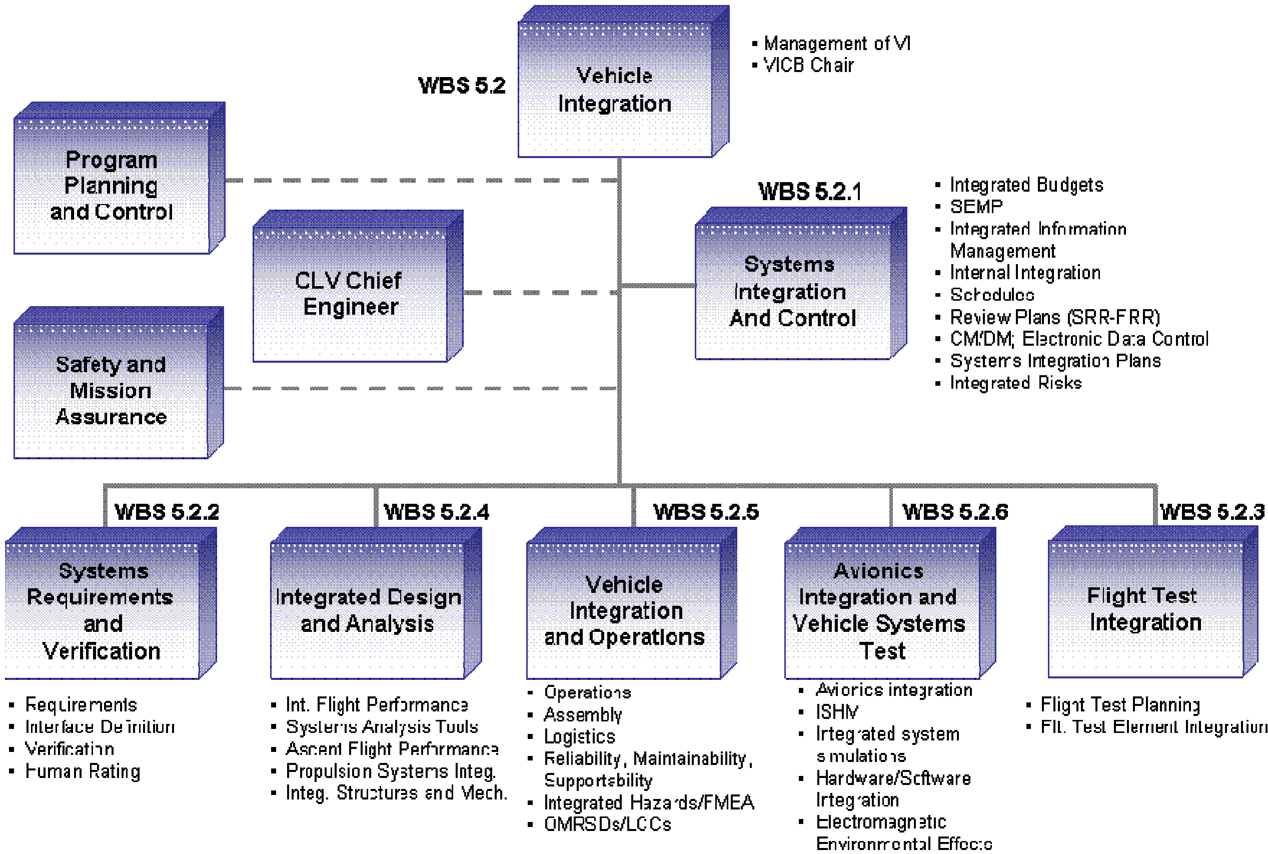


Figure 3.2-2 WBS Management

3.2.2 Launch Vehicles and Architecture

The CLV consists of the vehicle stages integrated with the CEV, as shown in Figure 3.2-3. Specifically,

CLV consists of:

- First stage
  - 1st Stage
  - Forward Frustrum
- Upper Stage (US)
  - Core stage
  - Interstage
  - Forward Skirt
  - Instrument Unit
- Upper Stage Engine

CEV consists of :

- Launch abort system (LAS)
- Crew module (CM)
- Service module (SM)
- Spacecraft Adapter (SA)

The integrated vehicle stack of the CaLV includes:

- Five-segment reusable solid rocket boosters
- Core Stage including Five RS-68 engines

- o Earth Departure Stage (EDS),
- o Lunar Surface Access Module (LSAM)
  - Ascent stage
  - Descent stage
- o Composite shroud

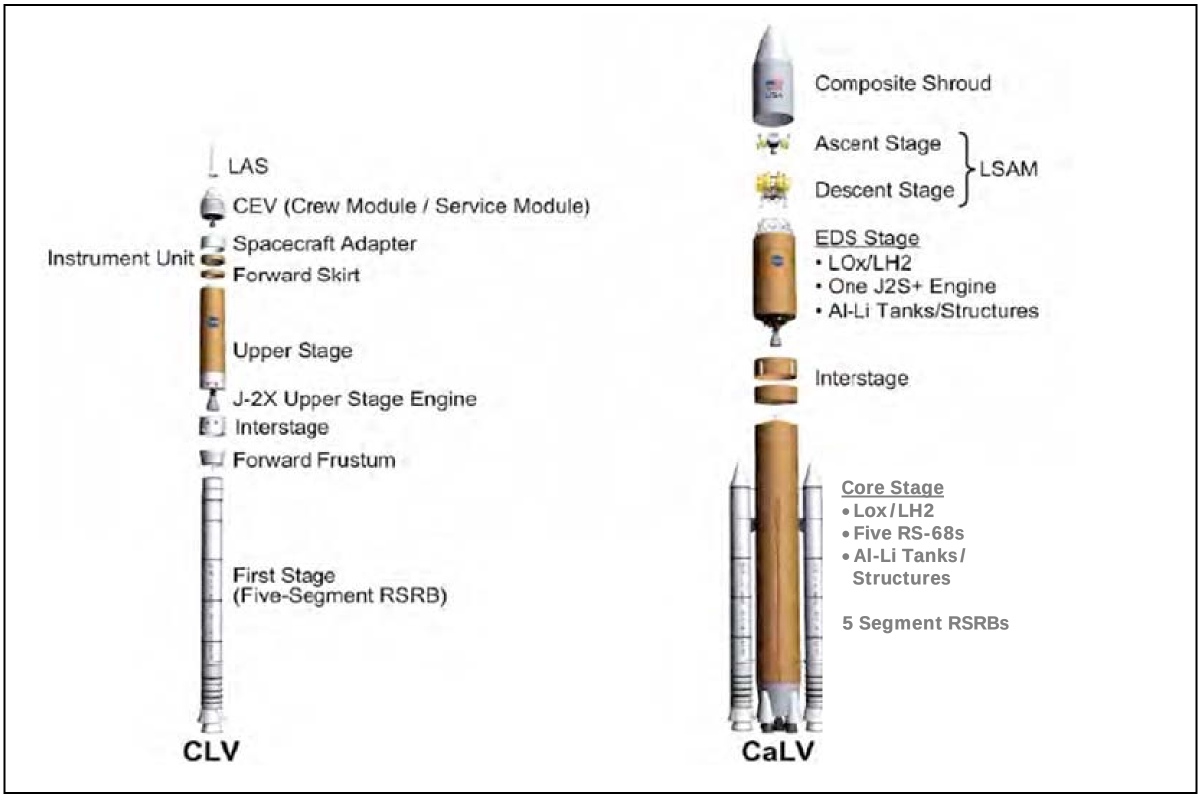


Figure 3.2-3 Expanded view of the CLV and CaLV

For this SEMP, the CLV and CaLV are the systems of interest; however, the comprehensive Constellation architecture is provided below to illustrate the overall mission and the CSLV's role**.** The Constellation Architecture is comprised of Spacecraft, Launch Vehicle, Common Support Services and Destination Surface segments, each of which is broken down as illustrated in Figure 3.2-4 below.

Launch Vehicles will be comprised of the elements that deliver crew and cargo to Earth orbit, as well as trans-lunar trajectories. The CEV will be launched atop a human-rated Crew Launch Vehicle (CLV), which provides safe, reliable transportation of the to Low Earth Orbit (LEO).[4] The Cargo Launch Vehicle (CaLV) is the heavy-lift companion to the CLV, and will provide 125 mT cargo delivery to LEO. Integral to the CaLV will be an Earth Departure Stage (EDS), a restartable stage that performs a portion of the Earth ascent and provides the propulsion to accelerate large cargo from LEO to trans-lunar trajectories.

---

[4] VI will be responsible for delivery of the CEV to orbit; however, spacecraft operations are outside VI's scope of work.

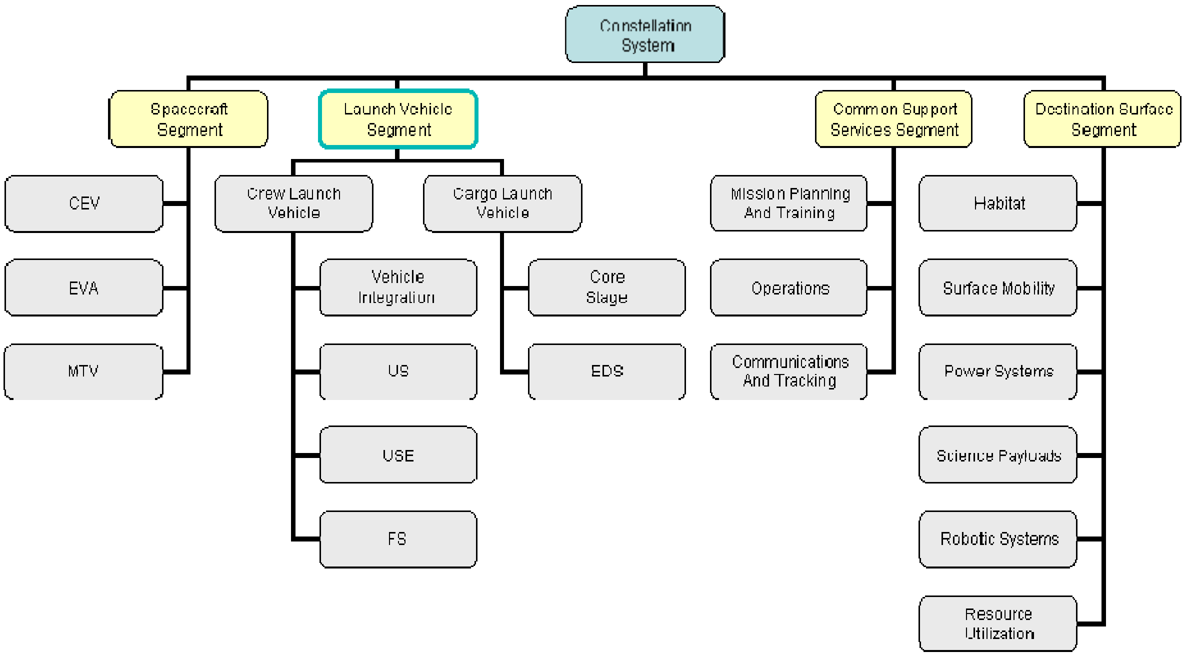


Figure 3.2-4 Constellation Architecture System Hierarchy

Common Support Services (CSS) is a grouping which includes the ground facilities and space-based assets that will provide mission support to vehicle processing, mission planning, crew training, launch, flight control, communication, tracking, and crew and return vehicle recovery. As the program matures, this grouping will evolve to reflect management and procurement strategies.

Destination Surface Segment (DSS) is also defined in the current version of the CARD (CxP 00001, Constellation Architecture Requirements Document). It will include the systems in dashed boxes above: habitats, power systems, surface mobility (i.e. rovers), payloads, robotic systems, resource utilization systems that support the crewmembers.

3.3 Planning Context

The CSLV Project will technically integrate, manage, and control the CLV DDT&E and deployment in sequential life cycle phases, as illustrated in Figure 3.3-1. This integration will be managed through the organization and requirements management processes delineated in this document.

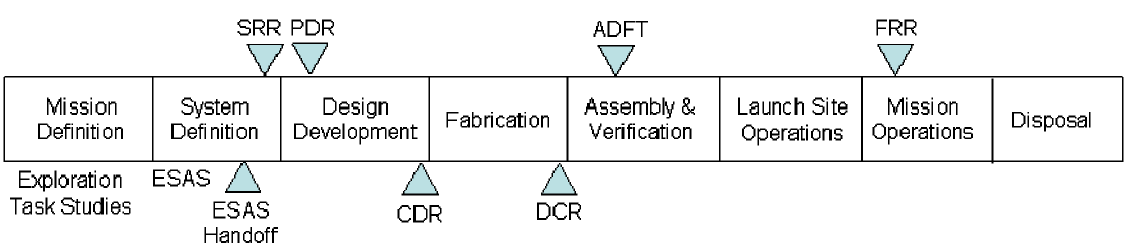


Figure 3.3-1 CLV Project Phases & Milestones

Constellation Program and Element milestones exist as inputs and outputs to the CLV life cycle, as shown in the Integrated Master Schedule (CxP #TBD). Lower-level milestone activities will be developed by each Element consistent with CLV Project milestones (see Appendices for Element details -- TBD).

Technical reviews and activities are planned throughout the Life Cycle and are driven by the milestones below.

1. SRR: System Requirements Review for CLV
2. PDR: Preliminary Design Review for CLV
3. CDR: Critical Design Review for CLV
4. DCR: Design Certification Review for CLV
5. ADFT-1: Atmospheric Development Flight Test 1 [5]
6. OFT-1: Orbital Flight Test 1
7. OFT-2: Orbital Flight Test 2
8. ISS–1: First Flight of the CLV to the International Space Station (ISS)

NPR 7123.1, NASA Systems Engineering Processes and Requirements, is the top level document governing Technical Reviews. It should be noted that while meeting the intent of NPR 7123, the life cycle strategy for CLV has been tailored from the standard milestone set prescribed by the NPR. The MCR objectives have been satisfied by the Exploraton Systems Architecture Study (ESAS). Objectives of Systems Definition Review (SDR) will be met by CSLV participation and support to the Program level SDR. The CLV will establish feasible final concepts with respect to technical performance -- and the indirect parameters of cost and schedule -- by the CLV system-level PDR.

3.4 Technical Assessments

This SEMP provides the framework to realize the appropriate work products that meet the entry and exit criteria of the applicable project life-cycle phases & reviews. It also provides management with necessary information for technical and administrative decisions.

3.4.1 Constellation Program Technical Reviews

CSLV Vehicle Integration (VI) will have lead responsibility for Launch Vehicle participation in the Constellation, CLS, CEV, MSS and GSS SRRs and will support and participate in the Constellation SDR. Technical support, including the Discipline Technical Warrant Holders (DTWHs) will be assigned from the engineering organizations—coordinated with the CSLV CE—to participate in these reviews.

3.4.2 CLV Technical Reviews/Events

The CSLV VI team will be responsible for the planning and conduct of all CSLV technical reviews. All reviews will have a review plan and be conducted using an automated RID tool that is identified in the CLV CDM Plan. All reviews will comply with MPR 8060.3, Requirements and Design Reviews, MSFC Programs and Projects, and the

[5] ADFT-1 is described herein as the first flight test, pending test plan development for ADFT-0. See section 3.4.2.

CLV CDM Plan. The Pre-board will be co-chaired by the CLV Chief Engineer (or designee) and CSLV VI representative. The Board will be co-chaired by the CSLV Project Manager and CxP Representative.

Technical reviews will occur relative to the maturity of the associated technical baselines as opposed to calendar milestones. They will be conducted in a top-down sequence from the system, to Element, to subsystem, to component level, as required. Control gate reviews (PDR, CDR, DCR, FRR, etc.) will be conducted in a bottoms-up sequence from component, to subsystem, to Element, to system-level, as required. A key entry criterion for each review will be verification that the previous level review has been satisfactorily completed. For the SRR, entry and success criteria are detailed in the CLV SRR Plan (CxP 70006). A roadmap for SRR shows the CxP review milestones and CSLV SRR preparation plans as of the writing of this SEMP in Figure 3.4-1 below. The SEMP will be updated and distributed prior to each milestone review to portray the current SE&I Management processes, products, roles and responsibilities.

SRR: System Requirements Review for CLV

The objective of the CLV SRR will be to determine the adequacy of the system requirements and the optimization, correlation, completeness, and risks associated with the allocated technical requirements. The SRR will demonstrate that the CARD requirements have been properly analyzed, functionally decomposed, allocated, and validated and assure that the CLV Systems Requirements Document is clear, achievable, responsive and appropriate to fulfill the mission needs.

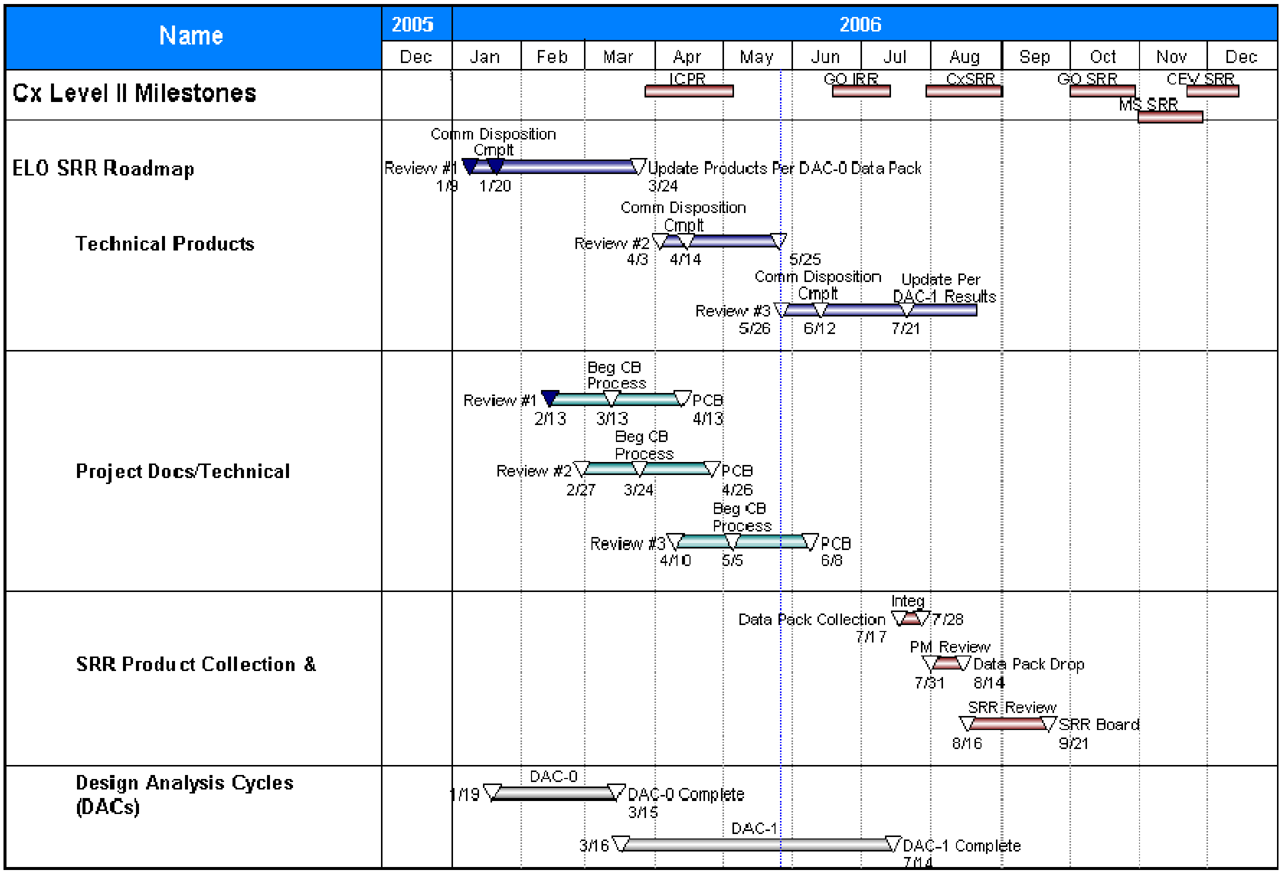


Figure 3.4-1 SRR Roadmap (reference updated IMS – not included herein)

PDR: Preliminary Design Review for CLV

The overall objective of the CLV PDR will be to demonstrate that the preliminary design meets all system-level requirements with acceptable risk. It will show that the best design option has been selected (based on documented trade studies and design analysis cycles), interfaces identified, and verification methods satisfactorily planned. It will also establish the basis for proceeding with detailed design. As a result of successful completion of the PDR, the "design-to" baseline will be approved and authorization to proceed to final design will be granted.

CDR: Critical Design Review for CLV

The purpose of the CDR will be to exhibit the complete system design in full detail, ascertain that technical problems and design anomalies have been resolved, and ensure that the design maturity justifies the decision to initiate fabrication/manufacturing, integration, and verification of Mission hardware and software. After successful completion of the CDR, the "build-to" baseline, production, and verification plans will be approved. Approved drawings will be released and authorized for fabrication. Successful completion of the CDR will also authorize coding of deliverable software (according to the "build-to" baseline and coding standards presented in the review), and system qualification testing and integration. All open issues must be resolved with closure actions and schedules.

DCR: Design Certification Review for CLV

The purpose of the DCR will be to ensure that qualification demonstrated design compliance with functional, performance, human rating, interface, and induced environment requirements. The DCR will follow the system CDR and will occur after qualification tests and modifications to resolve qualification-related actions. The DCR will address the design requirements, make an as-designed comparison, assess what was built to meet the requirements and review substantiation.

The DCR also will determine what requirements were met, will review significant problems encountered, and will assess remedial actions taken. All open issues must be resolved with closure actions and schedules. Principal review objectives will be to:

- Confirm that the verification results met functional, performance; human rating, interface, and induced environment requirements, and that test plans and procedures were executed correctly in the specified environments.
- Certify that traceability between test articles and production articles is correct, including name, identification number, and current listing of all waivers.
- Identify any incremental tests required or conducted owing to design or requirements changes since test initiation and resolve associated issues

Ascent Development Flight Test (ADFT)-0

ADFT-0 is TBD pending test plans and objectives from the Flight Integration and Test Office formed in May 2006. In the interim, ADFT-1 is described below as the first test flight. Future SEMPs will be updated accordingly.

ADFT-1:

ADFT-1 will be the first CLV test flight. It will be an unmanned test flight utilizing a CLV final design First Stage and staging systems. The other principle vehicle elements will consist of high fidelity simulators of Upper Stage, Upper Stage Engine, CEV and LAS. Since the ADFT team will be in a facility modification/development posture for the pad and MLP systems during this period, the intent will be to minimize ground-provided services, systems, and assets. The mission will test/exercise several segments of the overall launch complex and vehicle. ADFT-1 mission details include:

- Integration/stacking processing capability to include development test (US to first stage, CM to SM, CSM to US, LAS to CSM);
- Full flight of the first stage through separation and recovery (no Upper Stage Engine firing and operation);
- CM/LAS high altitude abort demonstration with water touchdown and recovery of the CM;
- MCC will be in a ‘follow-via-telemetry only’ mode;
- Ground facility/systems-to-first stage interface development test.

Orbital Flight Test (OFT) -1 :

OFT #1 will be the second test flight of the CLV. It will be an unmanned test flight utilizing a CLV final design First Stage and staging systems. Other principal vehicle elements will consist of an active proto-flight unit for Upper Stage and J2X engine and CEV/LAS that will have full propellant load for the SM. OFT #1 mission details include:

- First flight from full capability CLV launch services/complex;
- Lunar DRM insertion inclination, best achievable ellipse;
- Long duration burn of CSM OME to high apogee orbit at EOM;
- CSM test vehicle short duration orbital flight test + orbital maneuvering/targeting;
- Hi-speed return velocity demo of heat shield;
- Nominal CONUS site landing/recovery demonstration;
- NASA-provided developmental flight instrumentation;
- First flight MCC/LCC full critical command and control systems (TLM and COMMAND).

OFT-2:

OFT #2 will be the third test flight of the CLV. It will be an unmanned test flight utilizing a CLV final design Booster Stage, Upper Stage, and Upper Stage Engine. The CEV/LAS vehicle elements will utilize a CSM test segment that replicates the final segment design. OFT #2 mission details include:

- CSM test vehicle long duration (1-2 month) orbital flight test;
- Orbital maneuvering/rendezvous demonstration with ISS (no dock);
- First 51.6 launch azimuth;
- LEO entry, fail-safe (e.g. ballistic downmode) navigation/flight control condition to water recovery off coast of California;
- NASA-provided developmental flight instrumentation.

ISS–1: First Flight of the CLV to the ISS with Humans, Flight Readiness Review (FRR–5)

ISS–1 will be the first flight of the CLV to the ISS with a human crew. The purpose of the FRR for the ISS-1 flight is to examine verification results (including all previous flights) to ensure compliance with all systems and performance requirements for a safe and successful launch in the ISS–1 configuration. This FRR will occur after the CLV has been configured for launch. As a result of successful FRR completion, technical and procedural maturity will exist for CLV launch and flight authorization and, in some cases, initiation of CLV operations. Principal review objectives will be to:

- Receive certification that flight operations can safely proceed with acceptable risk (Certification of Flight Readiness (CoFR) is issued)
- Confirm that the CLV and support elements are properly configured and ready for launch.

- Establish that all interfaces are compatible and function as expected.
- Establish that the CLV state supports a launch "go" decision based on go/no-go criteria.

3.4.3 Technical Reviews

The CLV Element reviews will be coordinated with VI and will compliment the CLV integrated technical reviews appropriately, as documented in the Element technical review plans. These reviews will meet the requirements of the CLV CM Plan (CxP 72015) and the CLV DM Plan (CxP 72016). Their scope, objectives, and processes will be clearly documented in the review plan(s). A common electronic Review Item Discrepancy (RID) system will be used for all Element technical reviews. For in-house (MSFC) developed Elements, reviews will comply with MPR 8060.3, Requirements and Design Reviews.

3.4.4 CLV Work Products

The Responsibility Assignment Matrix (Appendix C) details the linkage between the CLV products, the responsible organization, project phase and level of maturity. It is mapped to the CLV Document Tree in Appendix E. The Data Requirements List (DRL) will be developed from this set of products and data. CxP document numbers are specified throughout this SEMP.

3.5 Boundary of Technical Effort

3.5.1 CLV Project Systems Engineering Functions

Systems Engineering and SE Management planning will minimize physical, functional and command/data integration problems, as they relate to CLV system boundaries. Element technical teams will have control over those problems within the boundaries of their Element scope, whereas VI will have control over issues crossing Element boundaries as defined by the CLV WBS (Figure 3.2-1). Likewise, influences on the system which are outside the CLV WBS system boundary will require special attention and interfaces with external organizations such as CEV or LAS.

Activities within the CLV WBS system boundary include:

- Design, development, test and verification of the integrated CLV
- CLV Integrated avionics and software development
- CLV requirements and verification control
- Interface control between CLV Elements
- CLV integrated performance assessment
- Resource margin management for the CLV elements
- CLV systems safety engineering
- CLV range safety design implementation

- CLV Control Boards and Integration Groups/Technical Panels
- CLV integrated ground test planning and development
- CLV flight test planning and development
- CLV systems simulation and test plan implementation
- CLV logistics and transportation
- CLV support to ground and flight operations
- Certification of Flight Readiness for CLV
- CLV flight hardware recovery and disposal
- CLV post-flight evaluation
- Guidance and flight control system development

Activities which will not be CLV Stack Integration responsibilities include (for example):[6]

- Management or oversight of CLV, LMS, ECAN Project responsibilities
- Integration or performance predictions after CEV separation from stack
- Natural environments definition during the on-orbit/lunar mission phases
- Non-CLV Project level test, analysis, verification responsibilities (e.g., LAS specific flight testing)
- Approval authority for Level III Project-Project interface concerns

These functions will be accomplished by organizations using a team structure made up of various boards, panels and groups as described in Section 4.0.

3.5.2 Constellation Program Systems Engineering Functions

The following SE functions have been assigned to the CLV Project by the Constellation Program:

- Integrated vehicle performance from liftoff through orbital insertion, including
  - Defining all induced flight environments
  - Verifying performance of integrated vehicle (aerodynamic, aerothermal, loads, acoustics, electromagnetic effects, guidance and control, day of launch i-loads, etc.)
- Integrated systems safety engineering during liftoff and ascent including identifying and controlling hazards that are the result of system interactions (excludes scope within the CEV boundary)
- Define and implement an integrated vehicle systems simulation and test capability
- Flight test planning and development for the integrated stack
- Management of Control Boards and Integration Panels responsible for integrated launch vehicle performance during liftoff and ascent (with co-chairs from other Centers as appropriate)[7]

[6] CLV Vehicle Integration will support additional Level II tasks over and above stack integration as mutually agreed upon with Level II (e.g., CM/DM functions, Natural Environments definition and design documentation, system simulation and modeling, Human Rating Plan beyond ascent phase).

- Certification of Flight Readiness for the integrated stack
- Post-flight evaluation for the integrated stack

These activities will include overall responsibility for the CLV stack including performance analysis, analytical integration, physical integration, verification and certification of readiness for launch. They will remain Level II functions, but are delegated to MSFC ELO with accountability to Level II. Some tasks will be further delegated to other Centers.

3.6 Cross References

Systems Engineering documents which were not included in Applicable Documents, but were valuable references in development of this SEMP include:

- SP-6105, NASA Systems Engineering Handbook
- MSFC-HDBK-3173, MSFC System Engineering Handbook
- MSFC-HDBK-2221, Verification Handbook Vol 1: Verification Process
- INCOSE Systems Engineering Measurement Primer, March 1998
- Systems Engineering Plan (SEP) Preparation Guide v1.0, DoD, November 2005
- System Validation and Verification course notes, UAH Professional Development, Dr. David Gunther, 2005
- Space Transportation Programs and Projects Office (STPPO) Systems Engineering Manual Version I, September 16, 2005
- "Risk Assessment Report / Root Source Analysis (RoSA)", March 2006, Nix/Brown, CxP 72079
- White Paper: "Recommendations for Documents Management in ICE Systems Engineering", March 2006, Suman Chakrabarti

[7] Abort scenario not included.

4.0 Technical Effort Integration

This section contains a description of how the various inputs to the technical effort will be integrated into a system that meets cost, schedule, and performance objectives. Figure 4.0-1 below illustrates the system requirements and subordinate requirements / documents that will serve as inputs for an integrated set of products and processes.

The point of illustrating the documents and requirements below is to highlight the significance of the key deliverables produced by the coordinated effort among the WBS groups, Element teams, and functional/matrix personnel. These teams are described below.

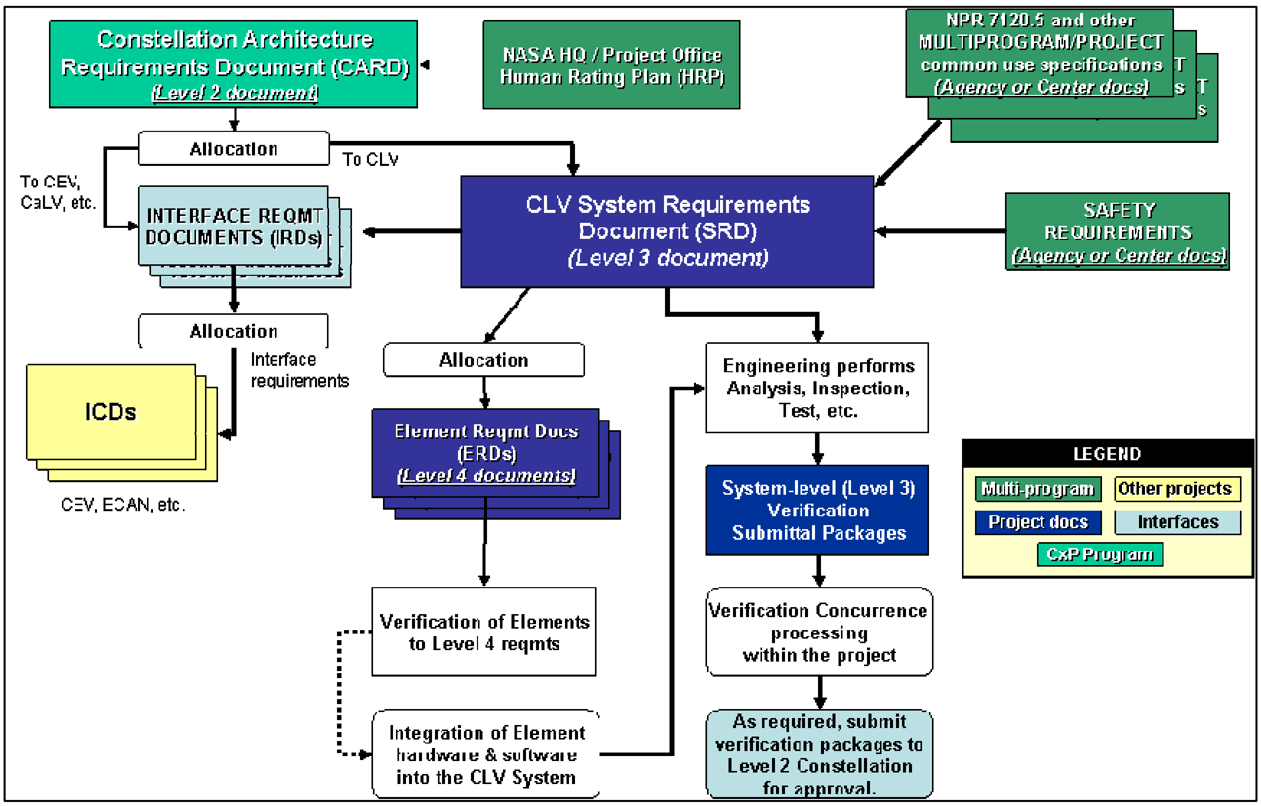


Figure 4.0-1 Specification inputs for Technical Effort Integration

4.1 Responsibility and Authority

As shown in Figure 4.1-1, CLV responsibilities will be divided among Vehicle Integration and the CLV Elements (1st Stage, Upper Stage, etc.). VI responsibilities are further subdivided among WBS Managers (SIC, R&V, etc.). The WBS Managers will be supported by the Engineering Directorate (ED). Within the ED, the EV Engineering Implementation Manager will integrate the efforts of Work Package Managers (WPMs), who directly support the WBS Managers. The work packages are organized along the lines of the VI WBS structure. The WPMs will manage the day to day engineering activities in support of the WBS Managers.

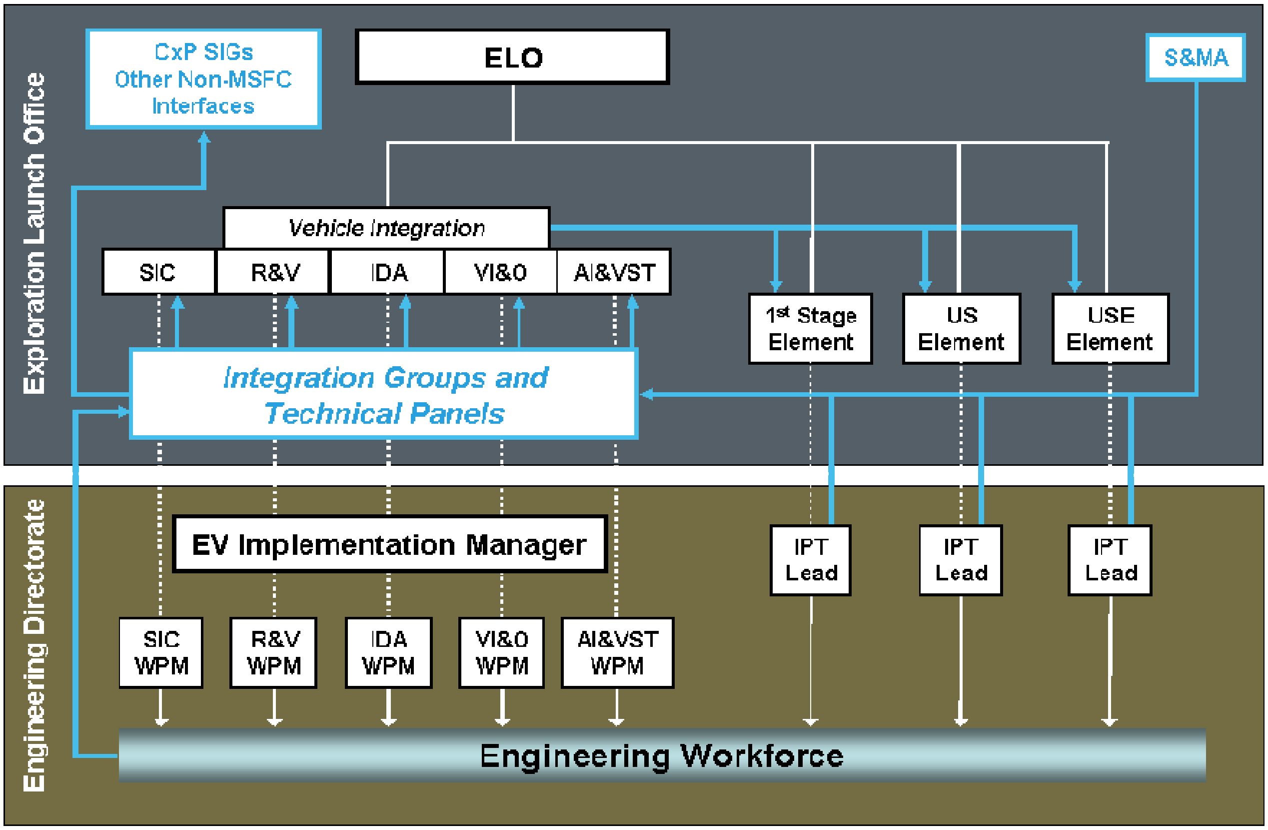


Figure 4.1-1 CSLV Team Organization and Communications Pathways

Horizontal and vertical integration is achieved through the Vehicle Integration Control Board (VICB), which is chaired by the VI Manager, and staffed by the VI Chief Engineer, the VI WBS Managers, the Element SEI Managers, and S&MA. The VICB is supported by functional and matrixed personnel assigned by line organizations to Integration Groups & Technical Panels. IGs and TPs function as integration and engineering forums to promote communication and to coordinate the technical activities of the various organizations and Elements. An IG is typically led by the VI WBS Manager who deals with several related technical disciplines. Discipline specific problems and issues are coordinated by the TPs. IGs and TPs will have membership from ELO, S&MA, ED, the Elements, and other projects (such as CEV) as required. They are chartered by the VICB. Specific integration groups are shown in Figure 4.1-2 and described in Appendix G.

Issues affecting multiple Elements and disciplines will flow down from the CLV Project and/or CLV VI WBS Managers to the IGs and then to their TPs for assessment and proposed resolutions (issues may also originate from ED, S&MA, or within the panels and groups themselves) They will review and provide recommendations to the WBS managers on technical issues related to vehicle integration. They will not assign work, unless the VI WBS Manager chairs the group or panel directing the work. Decision making will be encouraged by these subject matter experts as they make analytical and experience-based conclusions to support the requestor; but their recommendations and advice are not configuration controlled products.

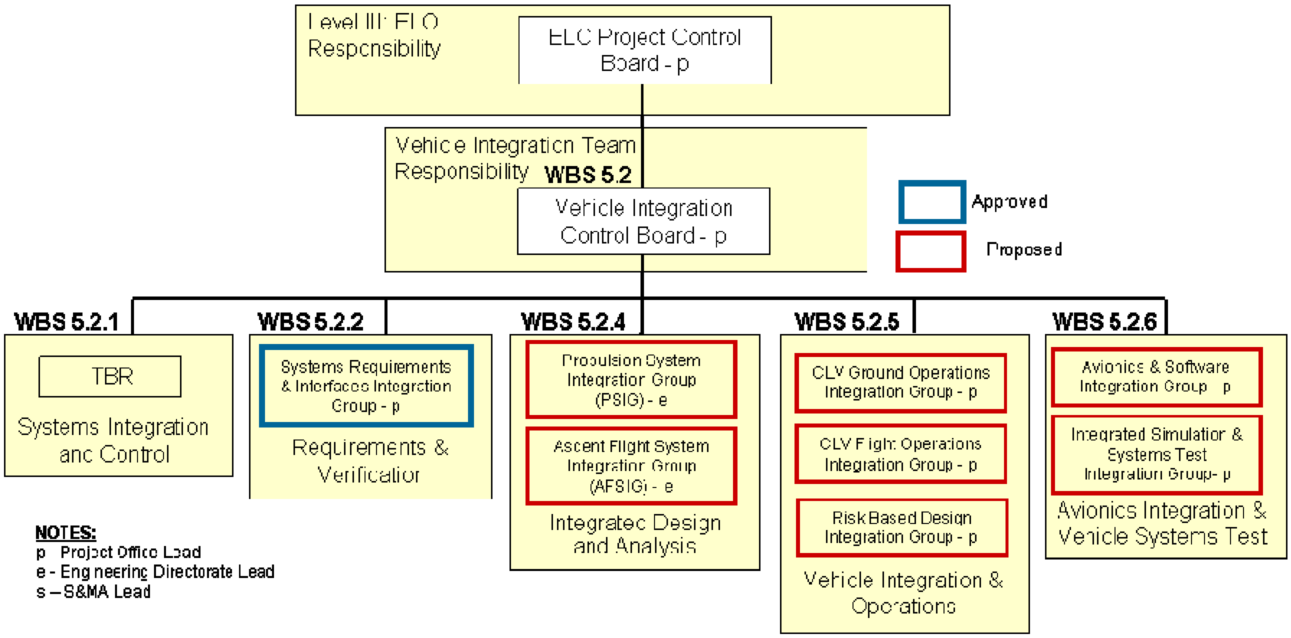


Figure 4.1-2 CLV Project Integration Groups and Technical Panels

Since there will be ED representatives on the Technical panels, regular communication and minor work efforts can take place within the panels and subordinate working groups[8]. However, if new or significant work is required, a request for that work must go through the appropriate Project representative (VI WBS Group Lead, Element SE&I Manager) to approve the use of resources from their budgets.

The Technical Panels will recommend to the Integration Groups, who report to VI WBS Managers. They in turn will make recommendations to the VICB, which will recommend to the CLV Project, with Vehicle Engineering Review Board (VERB) concurrence. The VERB is chaired by the CLV Chief Engineer, and serves as an independent engineering panel on integrated vehicle issues. Actual decisions, based on VICB recommendation, will be made by the Project, via the Project Control Board (PCB). Issues confined to the scope of a specific Element are reviewed by the Element Engineering Review Boards (ERBs) and then forwarded directly to the PCB, without going through the VICB. These workflow processes and decisional authority chains,, in conjunction with Project Office, S&MA, Engineering, Element, interfacing projects(CEV) and CxP involvement, are illustrated in Figure 4.1-3 and Figure 4.1-4 below.

---

[8] Working group details are not provided in this SEMP since WGs are invoked as a routine work activity.

An additional VI responsibility will be technical staff training in the SE processes provided herein. Space Launch and Transportation Systems (SLaTS) and Lessons Learned courses will be required for all EV personnel. Likewise, the Systems Engineering Manual (SEM) has been developed into a website for SE training, development and general reference. The internet version will be known as the Systems Engineering Guide (SEG) and the web address is TBD.

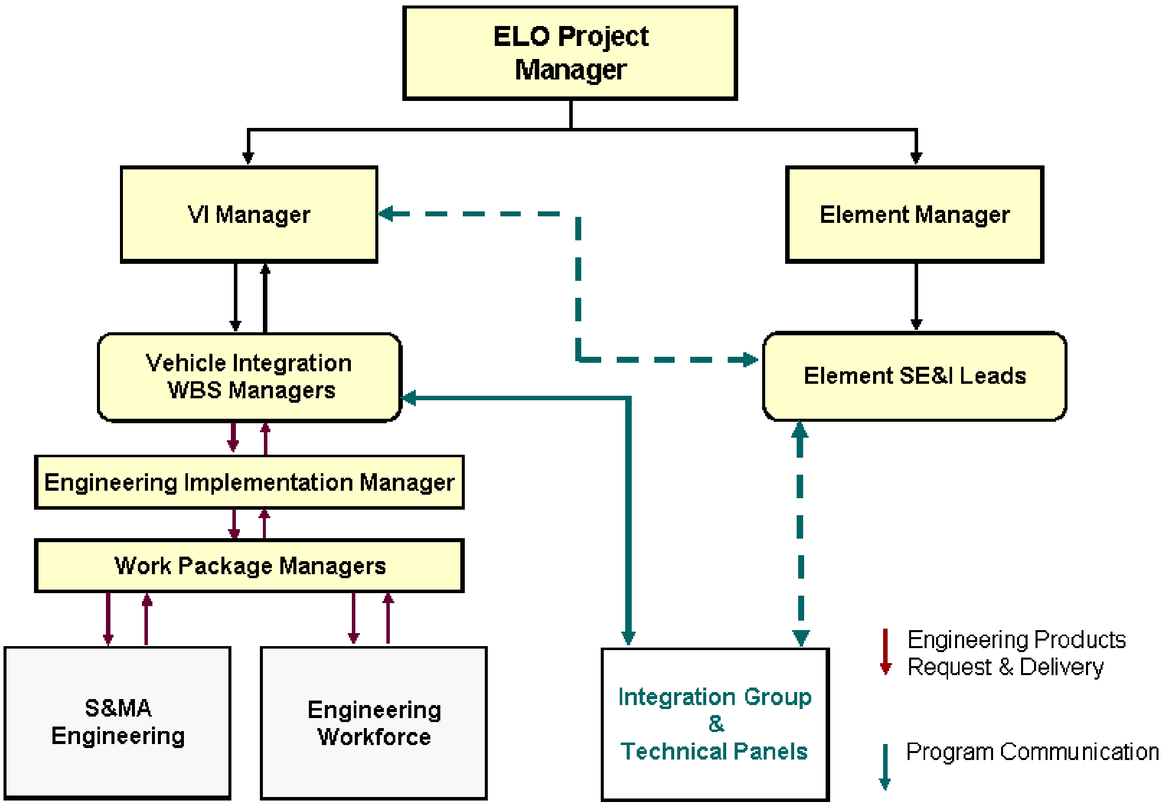


Figure 4.1-3 SE&I Work Flow Process

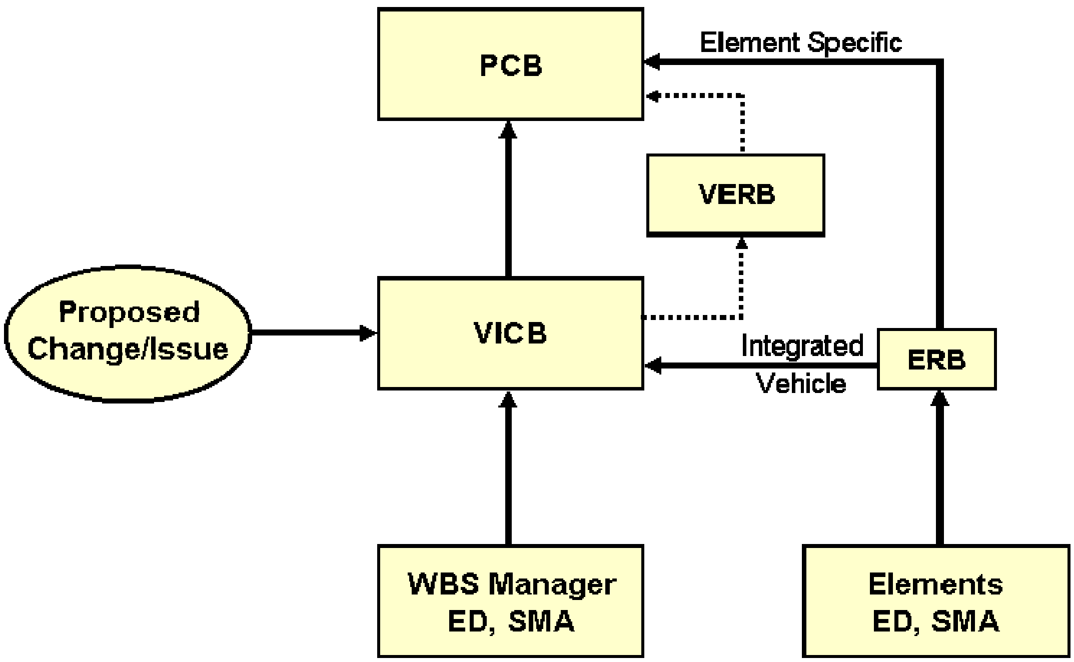


Figure 4.1-4 CLV Decision Authority

4.2 Technical Communication Integration

This SEMP describes the communication bridge between the project management team and the technical implementation teams and within technical teams. For the CLV Project, VI WBS managers will be responsible for the integration between all the IGs, and the IGs will be responsible for the integration of the TPs. Integration responsibility includes consistently communicating within and among the IGs and the TPs. The specific approach to internal communications among IGs, TPs, and IPTs (Level IV) is left up to their leadership; however, all data management of the communication will meet the requirements in the CLV DM Plan (CxP 72016). This includes the use of the approved servers for all project documentation development and reviews.

Technical communications will ensure an integrated and life cycle balanced set of system products and process solutions which satisfy the CARD requirements. WBS Managers will coordinate the development and implementation of the IMP, IMS, SEMP, Technical Review Plans, the Risk Management Plan (RMP), and the Configuration Management Plan. They will be responsible for critical path analyses using the IMS in an effort to optimize the allocation and utilization of resources (personnel, hardware, software, equipment, facilities). The results of the critical path analyses will be briefed at all major reviews. WBS Managers will ensure that SE tools for performing risk management, EVMS, requirements traceability, RID disposition, and metrics analysis are used by all integrated teams. Their specific responsibilities include:

- Executing and managing a structured systems engineering approach that provides a life cycle balanced set of system product and process solutions.
- Performing system requirements analysis, allocation, traceability, and tracking achievement of the system requirements using requirements management tools.
- Facilitating the development and completion of entry and success criteria for major performance-related program reviews as they relate to technical issues.
- In conjunction with other integrated teams, conduct trade studies and design analyses that consider cost, schedule, and performance as independent variables.
- Performing risk management activities– proactively looking for new or emerging risks, performing technical risk assessments, developing risk mitigation plans, and tracking technical risk status using risk management tools.
- Developing Engineering Change Proposals (ECPs) in conjunction with Element integrated teams, to support modifications.
- Managing development and production of metrics used by all teams to assess and manage progress.

The CSLV Project Manager is the customer of SEI assessments and other products. WBS Managers will perform the traditional management tasks of planning, organizing, staffing, directing, monitoring and controlling. This will facilitate achievement of the design that meets the system technical requirements and constraints while balancing effectiveness, cost, schedule and risk. WBS Managers will share a common set of important project functions with project management in the form of inputs to and outputs from project management, which include the following:

- Planning and management of a fully integrated technical effort necessary to achieve program objectives via the IMP, SOW, WBS, and EVMS, among others.
- Instituting and managing all necessary integrated development methods to ensure that information channels are always open, team activities are coordinated, and conflicts resolved in a timely manner and at the appropriate level.
- Ensuring a comprehensive and systematic approach to “lessons learned” for the program.
- Provision for control and assessment of progress by conducting technical reviews, configuration management, data and product management, interface management, risk management and test.
- Supporting analyses, trade studies, modeling and simulation, prototyping and research to optimize system design and minimize program risk.
- Supporting development of all necessary methods, processes and data products to ensure that the system can be built, tested, deployed, operated and supported throughout its life cycle.
- Provide data necessary to support timely and informed decisions by project management.

Figure 4.1-1, presented previously, depicts the communication integration from the CSLV Project Office down to the Engineering workforce and to the Element level. It is an illustration of formal and informal technical communications. Formal communications will occur among the CLV Project, Boards, WBS Managers, Work Package Managers, Engineers, Groups & Panels, and Element IPTs. Informal lines of communication will occur across the Technical Panels with their associated Integration Groups.

4.3 CSLV Project SEI Roles

This section defines the roles and responsibilities of the SEI functions within each organization under the CSLV Project Office.

4.3.1 CLV Chief Engineer (CE)

The CSLV Project includes a principal Chief Engineer and a network of Element-level Chief Engineers who are appointed by the MSFC Director with concurrence by the Agency Chief Engineer. These personnel are matrixed from the MSFC Engineering Directorate and are supported with appropriate technical expertise and resources by MSFC and the NASA Engineering and Safety Center (NESC). The term "Chief Engineer" in this section applies to any appointee within this context, knowing that the principal Chief Engineer is the final technical authority for flight readiness of the CLV and CaLV systems.

The CLV Chief Engineer is responsible for communicating technical excellence and exercising technical authority for the activities to which assigned. The Chief Engineer evaluates the validity of all requirements and requirements changes, and assures that the proper control board is involved in all decisions involving requirements or implementation of requirements. Ultimately, the CLV Chief Engineer, who is a peer to the Project Manager for technical decision-making, assesses launch readiness from the standpoint safe flight and ground operations, and indicates approval by signing off on Flight Readiness Review (FRR) documentation. The appeal process incorporates an independent path through the technical chain of authority to the Office of the Chief Engineer for issue resolution. Given below are specific roles and responsibilities leading up to FRR.

The Chief Engineer ensures that the Project has identified and imposed appropriate technical requirements and that the functional system is safe and operationally reliable, and signifies such by signature on instruments such as change requests, waivers/variances documents, and Certificates of Flight Readiness (COFR). Paramount criteria for carrying out these duties include both an in-depth understanding of the system and an up-to-date knowledge of CSLV Project technical work in progress to make sound, responsible technical decisions and to determine whether the appropriate technical requirements and resources are being applied. While the Chief Engineer is responsible for ensuring that suitable specifications and standards have been integrated and adopted by the Project, the MSFC Engineering Directorate leaders and personnel are actively engaged in helping determine that requirements and associated standards are appropriate to ensure safe flight. This approach provides a framework for checks and balances between the Project and the independent engineering function, in partnership with Safety and Mission Assurance.

The Chief Engineer is responsible for approving all variances written against approved technical requirements, or any technical process or method that may affect safety, by signing documents provided by the Element Chief Engineer's Review Board, or the VERB. When a variance is written against a technical requirement, the Chief Engineer engages the appropriate engineering leaders and institutional engineers through the Chief Engineer's Review Board, the VERB, and the Engineering Management Council. As an independent voice within the CSLV Project, the Chief Engineer draws on the technical expertise of engineering leaders when requirements are in question and at any time it is deemed appropriate to ensure flight safety through the VICB, as well as the Engineering Management Council. These processes are documented in the MSFC Technical Excellence and Technical Authority Implementation Plan.

The Chief Engineer is responsible for determining whether the resultant launch vehicle design satisfies stated technical requirements. This requires a solid understanding of the design; an in-depth comprehension of the failure scenarios, Failure Modes and Effects Analyses (FMEAs), Critical Items Lists (CILs), and hazard analyses; and the ability to perform trend analyses and risk assessments and incorporate the results into a final technical product that includes the associated technical risk. Products such as FMEA and hazard reports are delivered to the Chief Engineer for review and approval. These are archived in the Project's Windchill database.

Approval of the FMEA, CIL, and hazard and risk analyses is the Chief Engineer's responsibility. The Chief Engineer also approves the technical methodologies used to develop these products by certifying the final reports / documentation and ensuring incorporation into the Project. The Chief Engineer influences decisions about the requirements at all major Project design reviews (e.g., System Requirements Review, Preliminary Design Review, Critical Design Review, Design Certification Review, and Flight Readiness Review) and attests that the design and system configuration to that date meets the technical requirements for safe flight by signing off instruments such as pre-board and/or board decision documents, FRR statements, and the CoFR.

The Chief Engineer provides timely day-to-day judgments on a range of technical issues pertaining to the Project. This input is provided to Program and Project-level ERBs, at Technical Interchange Meetings (TIMs), and for special technical issue topics to ensure that safety is an integral factor in the vehicle design. The Chief Engineer enforces the concept that FMEA and hazards analyses are an integrated part of the design process, not developed after the design is complete. The Chief Engineer maintains real-time communications with the Project and MSFC engineering resources to ensure timely access to Project information, impending decisions, and analysis or verification results by the technical authorities, including the Program and Project Chief Engineers and the MSFC Director. The Chief Engineer documents all methodologies, actions/closures, and decisions. Signatures of all parties participating in the decision-making process should appear on the review board documentation signature sheets. Records of decisions and information on which the decisions were based must be maintained. The Project Data/Configuration Management process and system are used for archival purposes.

The Chief Engineer is responsible for ensuring that the Project provides documents to the appropriate party, including both decisions and lessons learned (see the CSLV Project Knowledge Management Plan for more details). All precedent-setting decisions are documented (e.g., expanded technical envelopes, sensitivity data, and technical requirements that supersede other imposed requirements). The Chief Engineer ensures that efforts are made to communicate the experience gained and results obtained to other technical experts. Included in the documentation are the circumstances surrounding the issue, technical positions (including dissenting opinions), and the logic used for final decision-making. Lessons learned and associated recommendations form the basis for changing or improving technical requirements that may be applicable to other programs and projects.

In some cases, the Chief Engineer may request that the Project initiate special investigations if further evaluation or testing is deemed prudent for risk quantification, if technical boundaries may have been exceeded, or if alternate technical options may be required to solve a complex issue. These investigations are negotiated with the Project and draw upon institutional engineering support through the original funding channel. In special cases, the Chief Engineer may request that the NESC lead independent investigations.

As stated earlier, the Chief Engineer works with engineering managers to define the resources necessary to support all required technical excellence/technical authority activities, providing budget and working agreement input to the Project and the Engineering Directorate. The Chief Engineer also relies on, and coordinates the work of, MSFC engineers, Safety and Mission Assurance personnel, and other Agency experts who perform the Project’s technical work in order to understand the system requirements and the vehicle design for informed decision-making. These “doers” are the most important information sources for the Chief Engineer, as they perform the necessary evaluations, analyses, tests, and process evaluations that identify safety risks.

Note: The Engineering Directorate’s roles and responsibilities for Upper Stage, US Engine and 1st Stage will be described in the attached Element SEMPs (TBD).

4.3.2 CLV Vehicle Integration (VI)

VI will provide overall technical integration, including coordinating, planning, and executing engineering tasks, for both in-house NASA-developed and contracted activities. VI is also responsible for the CLV stack integration (excluding CEV, ECAN, LMS interface control) throughout the CLV Project life cycle. This includes integrated vehicle performance through orbital insertion, recovery of the first stage, and reentry of the upper stage. In this role, VI will coordinate and manage all design and engineering activities between contractors and NASA. It will ensure that CLV system integration and testing activities between the Elements are successfully incorporated into the CLV Project flow.

VI activities will be coordinated across participating NASA Centers to foster integrated execution of essential functions and activities. The VI will be responsible for ensuring that consistent engineering practices and assumptions are implemented, in addition to solving technical issues and substantiating that test activities are technically correct. VI will also be responsible for allocating requirements to the Elements and ensuring that requirements have been correctly validated, decomposed, allocated, and that the verification requirements are properly defined to ensure that the system design meets requirements. The Elements will be responsible for these activities at Level IV.

In addition, VI will be responsible for:

- Supporting development of CLV Element level.
- CLV Element to Element [organizational] Interface management.
- Planning for and conducting milestone reviews.
- Maintaining insight into CLV Project and contractor product readiness for the reviews.
- Management and disposition of integrated system and performance risks.
- Ensuring the successful integration of the system, Elements, and subsystems when crossing Element interfaces.
- Managing the ongoing integration of advanced development of technology and infrastructure with system design evolution.

Reference paragraph 5.1.1.1 for CLV Control Board descriptions.

4.3.3 Element SEI *[for information only]*

The role of Element SEI Managers will be to provide technical management and control of the integrated engineering effort for each Element. For example, they will be involved in a capacity similar to that of Level III VI WBS Managers in the Requirements Validation activities shown in Figure 5.1-4. Specific roles and responsibilities and Systems Engineering processes are detailed in each Element SEMP, to be attached as appendices to this SEMP in future versions.

4.4 Vehicle Integration WBS Groups

In addition to those already described in section 4.2, roles and responsibilities of the VI WBS Managers are listed in Figure 4.4-1 below.

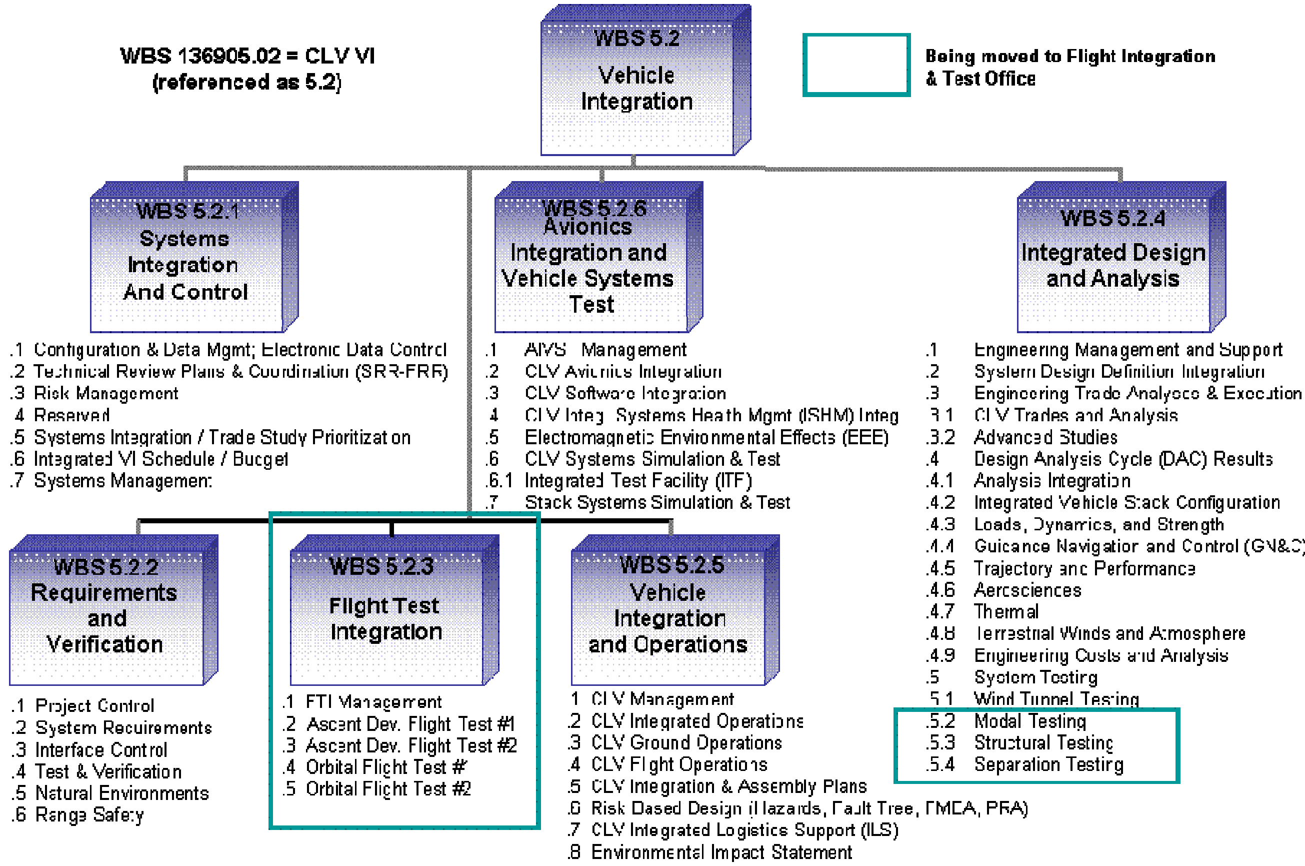


Figure 4.4-1 Vehicle Integration WBS Groups – Roles and Responsibilities

4.5 Support Organizations

Organizations supporting VI include the Engineering Directorate, Safety and Mission Assurance, and Contractors as required.

4.5.1 Engineering Directorate (ED) Support

The day to day engineering support for VI will be provided by the MSFC Engineering Directorate (ED) as shown previously in Figure 2.3-1. Most of this support will be provided by the Spacecraft and Vehicle Systems Department (EV01) and the Propulsion Systems Department (ER01). Requests for support are issued by the WBS Managers to the VI Implementation Manager within the EV Integration Office shown earlier in Figure 2.3-2.

The EV Implementation Manager then coordinates the work provided through Work Package Managers (WPMs) from the various Divisions within the EV and other ED Departments. Specific EV Implementation Manager support includes:

- Coordinates work requests submitted by VIE WBS Managers and assigns Work Package Managers (WPMs) from the various Divisions within the EV, ER and other ED Departments.
- Monitors activities by the WPMs to assure a consolidated ED approach to VI engineering support.
- Assures appropriate review of engineering deliverables through the ED line management and Technical Panels prior to delivery to the project.
- Assures integration of ED recommendations and products for integrated vehicle prior to delivery to the project, including DAC and Trade issue resolutions.

In addition to ongoing engineering support, the ED provides staff for the Technical Panels and Integration Groups as requested by the WBS Managers. Analyses that are performed on request by the IGs and TPs shall be approved by the WBS Manager and corresponding WPM. WPMs manage and coordinate engineering support to VI WBS Managers through the EV Implementation Manager.

ED provides review of individual engineering work products through review by line management at the Branch and/or Division Level, based upon the criticality and complexity of the products (TBC). Technical products are further reviewed by the Technical Panels and Integration Groups prior to presentation to the VICB (as shown previously in Figures 4.1-3 and 4.1-4). In addition, the VI CE and CLV CEs are responsible for ensuring adequacy of engineering products. One mechanism for accomplishing this review is through the VERB, which has authority to review VICB recommendations prior to their presentation to the CLV PCB. The VICB can also raise issues to the MSFC Engineering Management Council if needed.

Engineering support provided to the Elements will be addressed in the individual Element SEMPs.

4.5.2 Safety and Mission Assurance (S&MA)

S&MA will lead and/or provide technical support in the areas of reliability, maintainability, system safety, quality assurance and supportability analyses. More specifically, S&MA will chair and participate in all IGs involved with reliability, maintainability, and safety (including Range Safety) products/analysis. In addition, S&MA will perform surveillance and inspection of all in-house Government and contracted design, manufacturing, and testing activities to ensure compliance with project requirements and controls that affect product quality and personnel safety. S&MA will also monitor work at other NASA sites and contractors via representation defined in the SR&QA Plan.

The CSLV Project requires SR&QA processes be established IAW NPR 8705.6 Safety and Mission Assurance Audits, Reviews, and Assessments and the CLV SR&QA Plan, CxP 72020. Safety, health, and environmental hazards will be continually assessed throughout the life cycle of the Project. Hazards and risk status will be tracked in a database. Mitigation will be performed to the maximum extent possible. Residual risks will be accepted at the appropriate management level depending on the severity of the risk.

4.5.3 Contractor Integration

Contractors used by the CLV Project will be fully integrated with NASA engineering through the use of Integrated Product Teams at the Element level. Further discussion and definition of the processes used for Contractor integration will be included in the Element specific appendices to this SEMP (TBD).

4.5.4 CxP Level II System Integration Groups

The SIGs for Level II are presented for reference in Figure 4.5-1. Organizational interfaces between these SIGs, Vehicle Integration, and IGs & TPs is shown in Figure 4.5-2 below.

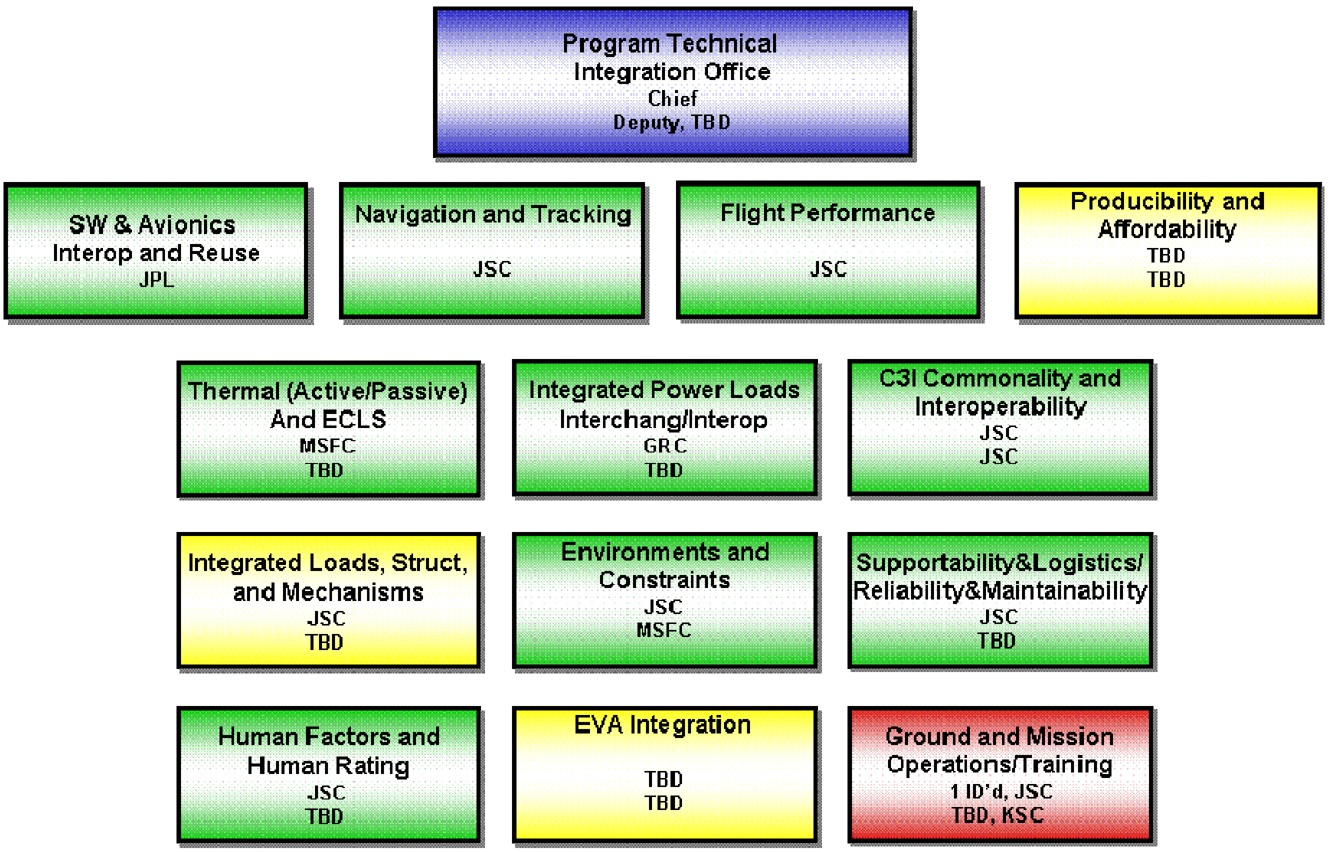


Figure 4.5-1 Program Technical Integration Office --Technical Integration Leads and SIGs

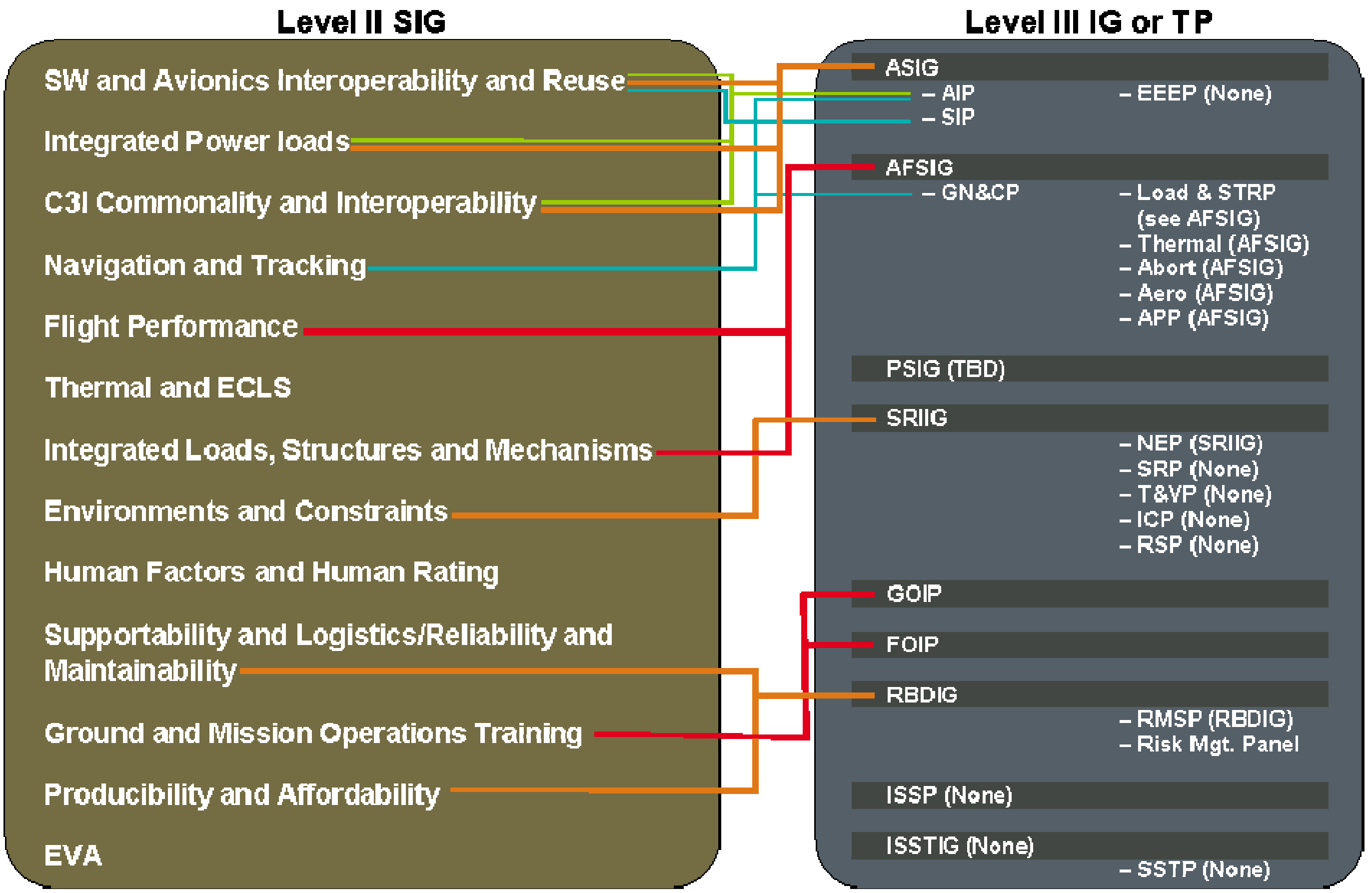


Figure 4.5-2 Level II / VI Organizational Interfaces

5.0 Common Technical Processes Integration

The CLV systems engineering engine incorporates a rigorous, top-down procedure where:

- System requirements are derived from stakeholder needs,
- Designs are realized from system requirements, and
- Products are realized and transitioned following design implementation.

Figure 5.0-1 depicts this procedure from left to right in the Engine for Systems Engineering from NPR 7123.1.

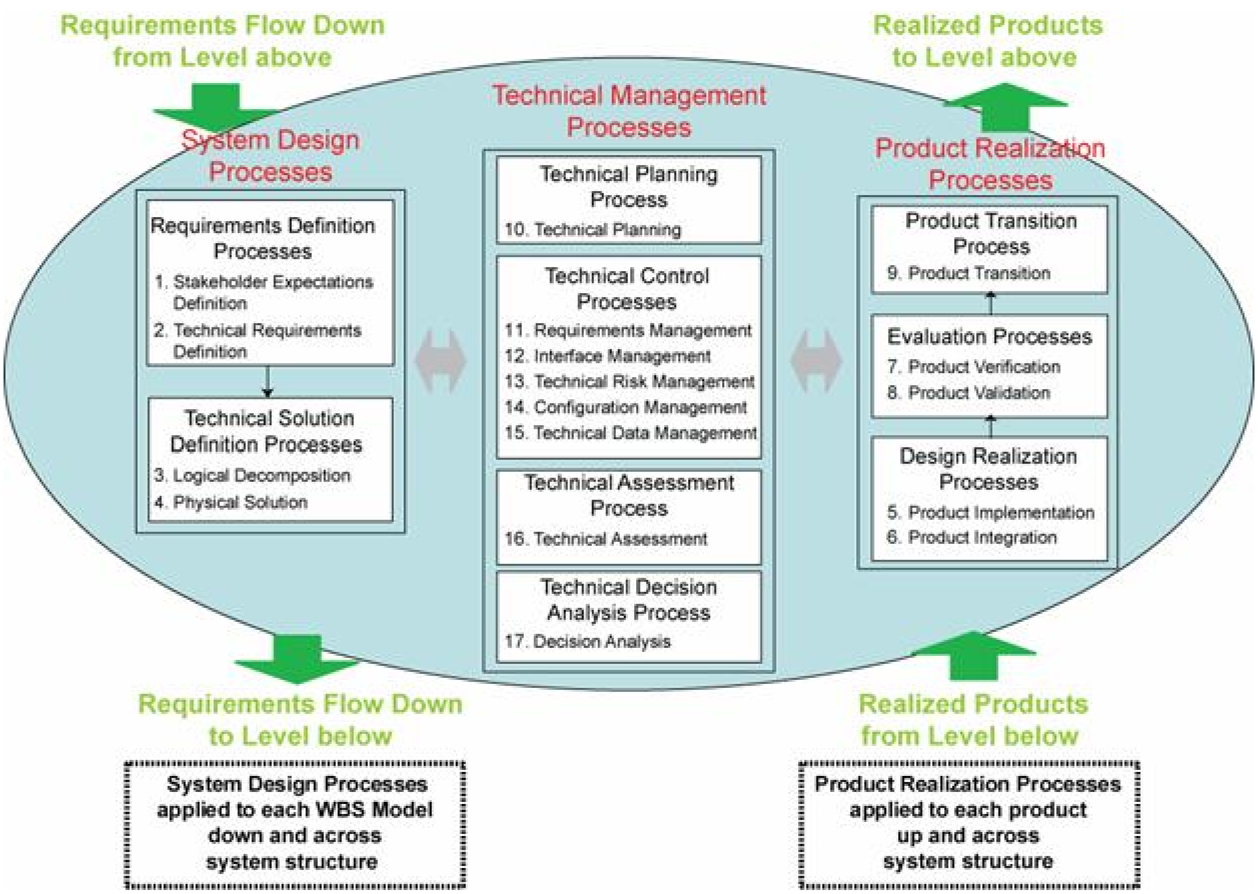


Figure 5.0-1 Engine for System Engineering

System requirements and control are implemented from the top down and products are realized and verified from the bottom up. Technical management processes are integral to the development of systems and products. Feedback loops are not shown, however the processes are generally iterative and recursive.

5.1 System Design

System Design processes constitute the early stages of the SE Engine. They include the formation of requirements from user/stakeholder needs and will be evolved to more clear, coherent and complete statements for design realization and product transition.

5.1.1 Stakeholder Expectations Definition

The President's Vision for Space Exploration, the Constellation Design Reference Missions (CxP-00002) and the CARD (CxP-00001) provide the primary stakeholder requirements for the CSLV Project. The Constellation Requirements Formulation Team (RFT) is chartered by the Constellation Program to develop, review and approve Constellation level products prior to their release to the Projects. The RFT is chaired by the Constellation Deputy Program Manager and staffed by representatives from all the major organizations of the Program including the Project Offices. VI supports the RFT in developing those requirements and providing them to the CSLV Project for implementation. The flow of these stakeholder requirements is shown in Figure 5.1-1.

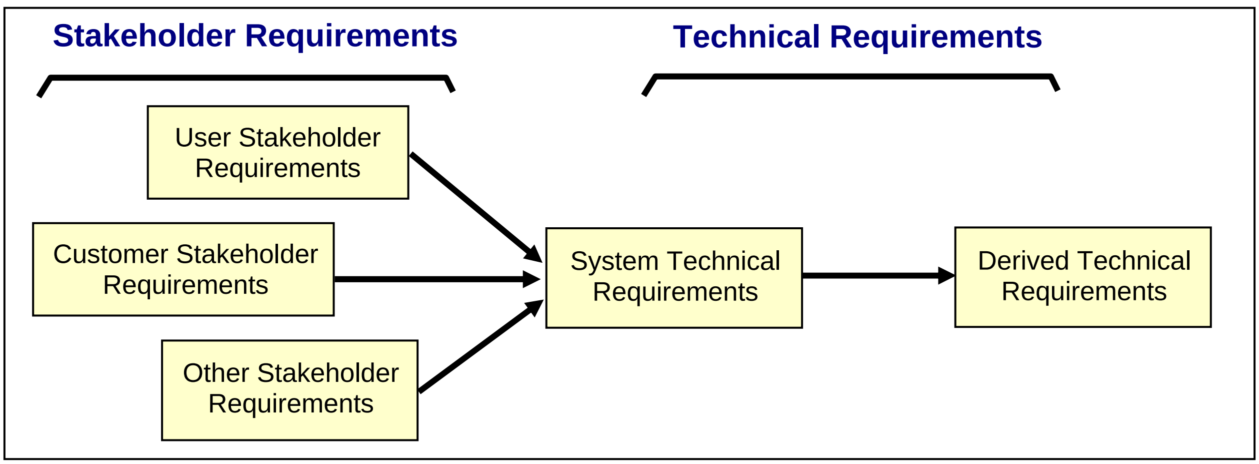


Figure 5.1-1 Flow of Stakeholder Requirements

5.1.2 Technical Requirements Definition

Requirements will come from various sources including Levels I and II (ESAS), the Concept of Operations, and through discussions with the user regarding the mission to be performed   The requirements will be documented in the SRD. Figure 4.0-1 depicted the requirements flowdown, hierarchy and baseline documents.

Definition of technical requirements will involve converting needs, goals and objectives (NGOs) to technical requirements – to capture constraints and conduct requirements analysis and traceability. Special attention will be given to demonstrating satisfaction of Technical Performance Measures (TPMs) defined for each NGO during conduct of this process. Analysis of the WBS will support the development and confirmation of NGOs and TPMs. The

CLV WBS is critical for organizing the project and systems engineering in support of CLV requirements definition. The system architecture provides the structure for the WBS, which will help define work packages.

Requirements analysis will be the first step in requirements definition It is the process of determining what the CLV system "must do", "how well it has to do it", and under what conditions and in what environments the mission must be performed. Requirements analysis will include:

- Analysis of Missions and Environments
- Identification of Functional Requirements
- Definition and Refinement of Performance and Design Constraint Requirements
- Identification of safety issues evident or derived from the above.

5.1.3 Requirements Validation

Requirements validation will ensure each technical requirement is properly defined via the following characteristics: *Specific, Verifiable, Achievable, Agreed to,* and *Realistic*. Analysis will be done to assess the ability of the Design Analysis Cycle (DAC) initial baseline design to meet the requirements within technical and programmatic constraints.

Requirements validation for CLV will be accomplished via 1) the validation process shown in Figure 5.1-2 and 2) the Design Analysis Cycle (DAC) described below and in paragraph 5.1.4.2. This approach will provide integrated project and technical responsibility for requirements inclusion and corresponding validation. It will ensure that every requirement is validated by a product and that every product supports a requirement. It will also promote maturity in the future definition of work activities. Details captured in the data requirements (DRs) will establish that products are appropriate to support the reduction of schedule risk. This approach will provide specific definition and maintenance of roles and responsibilities, as shown in Figure 5.1-3.

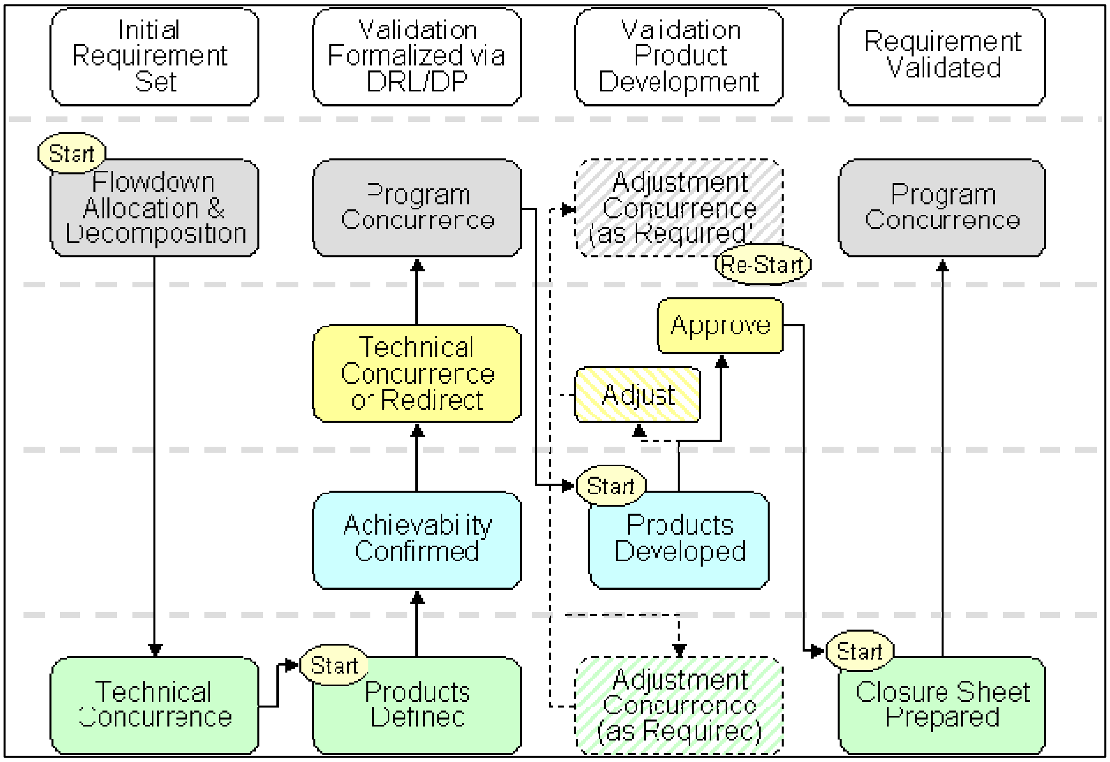


Figure 5.1-2 VI Requirements Validation Process

Technical Independence is achieved via three avenues:

- Line Management Concurrence of Validation Requirements and Products (Branch, Division, Director)
- Technical Panel Concurrence of Validation Requirements and Products
- Final results are an integration of subsystem analyses (no discipline owns the total)

Requirements will be updated preliminarily during the process and indicated via TBR (TBR removed upon closure sheet approval).

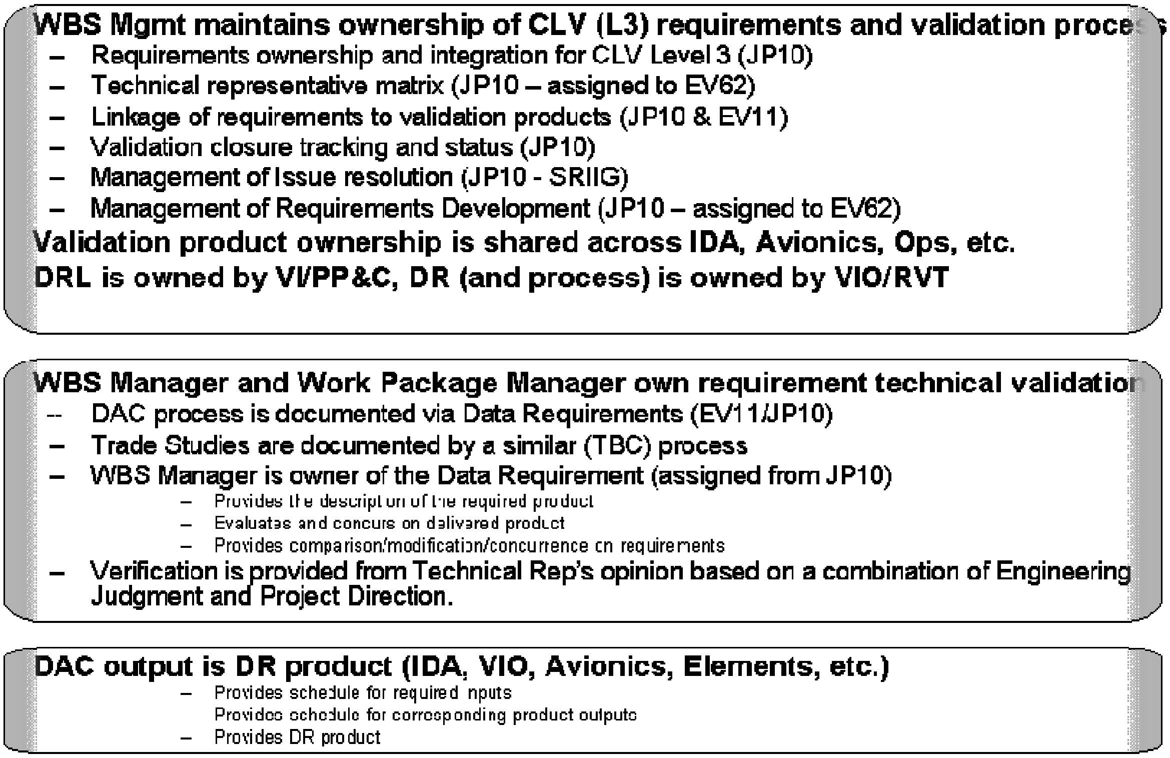


Figure 5.1-3 VI Requirements Validation Roles & Responsibilities

5.1.4 Logical Decomposition

The traditional systems engineering approach for developing models has been *Functional Analysis*. For the early stages of CLV, this approach will be supported by the development of Functional Flow Block Diagrams and the Functional Decomposition methods described below. As the Project evolves, the decomposition approach will be a combination of various approaches tailored to CLV. The application of the various analyses will be dependent on system type (e.g. hardware, software), size and functional complexity.

Other types of analyses have been developed to support logical models and may be subsequently applied. For reference:

> *Each method favors particular system types and development activities and has advantages and disadvantages. For example, the Structured Analysis, which includes context diagrams, control/data flows, data dictionaries, entity-relationships diagrams, and state transition diagrams, will be applied in development of complex software intensive systems. Another type, the Object Oriented Analysis using Use Case/Unified Modeling Language (UML), will be applied in the development of information systems and other software applications.*

The approach for CLV will be a functional analysis at the system level and Object Oriented Analysis for the software elements (Figure 5.1-4). Since multiple approaches will be used, traceability must be maintained across methodologies.

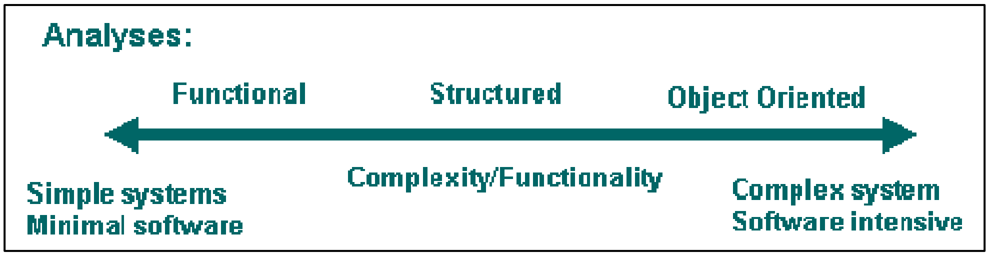


Figure 5.1-4 Logical Decomposition Scale

The SRIIG will translate SRD requirements into specific hardware and software design criteria. It will continue the decomposition process by defining lower-level functional and performance requirements; i.e. system level to subsystem level, to component level, to specific hardware or software end items.

5.1.4.1 Functional Architecture Model (includes FFBDs)

Functional Flow Block Diagrams (FFBDs) will be used in the allocation of functions and the development of functional requirements. Systems Engineering standards include the use of FFBDs for modeling system behavior when performing systems functional analyses. The diagrams will allow the definition of function sequences, concurrency, conditions, inputs, and outputs. This will be done in a hierarchy, so that low level behavior preserves higher level behaviors. The FFBD diagrams will be used to define system behavior sufficiently to enable a discrete event simulation to predict system timelines and resource usage.

The development of FFBDs will therefore 1) support the Functional Analysis process, 2) provide a check on the completeness of the Requirements, and 3) provide inputs to the System Tradeoff process by identifying choices in system behavior which impact component-level Requirements.

5.1.5 Design Solution Definition

Reference Figure 4.0-1 for related flow diagram.

Baseline Identification

Requirements baselines will be established at the appropriate technical reviews, beginning with the development of functional and performance baselines at the SRR. Further, these baselines will progress through the development of the allocated baselines at PDR, which will lead to the product baseline at the time of hardware and software configuration item acceptance. Following approval, each baseline will be put under configuration control.

Functional Baseline

The functional baseline will contain the system-level requirements related to performance, interfaces, logistics, personnel, deployment, and key functional requirements – as well as the verification required to demonstrate achievement of those specified characteristics. The functional baseline will be composed of the validated requirements from the CARD flowed down to the SRD and IRDs.

Allocated Baseline

The allocated baseline will flow the validated functional requirements to the ICDs and ERDs at the Element level. This will consist of documents below the functional and performance baselines that serve to focus Element-level performance requirements, interface definition and development characteristics. The requirements allocated or derived in this baseline must trace to those identified in the functional baseline as an entry criteria for PDR.

An important consideration in the allocation process will be mass margin and how it is allocated to the CLV Elements and indirectly to CEV. Likewise, the mass estimation process must be viable. Such allocations will be IAW the CLV Technical Resource Management Plan. All allocated/derived requirements will be verified through Analysis, Inspection, Test, etc.

Product Baseline

The product baseline will be established following hardware and software verification and configuration item acceptance. After approval, each baseline will be put under configuration control. The level at which products are verified, accepted and baselined for VI will be determined by the verification activities required for product acceptance (see Section 5.2.3).

5.1.5.1 Design Synthesis

The Requirement & Verification Team will perform requirements decomposition to the subsystem level to ensure design completeness, define each component, and control the interfaces among subcomponents. The use of the Cradle database and disciplined configuration and data management will ensure requirements traceability.

During the design synthesis cycle, the team will also identify technologies to be developed to meet a specific design need. After available commercial approaches have been reviewed, a technology development activity will be proposed to the CSLV Project Office. Any proposed technology for CLV must correspond to a design that addresses a specific requirement. In addition to technology, safety and the criticality of the functional failure modes and effects (FFME), and testability will be assessed for each potential component or subcomponent design solution.

The Element-level contractors will initiate this activity with their proposals. Since this is a combined developmental and non-developmental item (NDI) effort, the contractor will propose a hardware/software configuration using currently existing components where possible. Subsequent to contract award, any design changes will be evaluated using the systems engineering process in terms of managing performance and trade studies.

5.1.5.2 Design Analysis Cycle

A CLV Systems Analysis Plan (SAP)(CxP 72024) will be prepared in part from the direction provided in this SEMP. The SAP will outline the Design Analysis Cycle (DAC) objectives, goals and fidelity of analyses as illustrated in Figures 5.1-5 and 5.1-6 below. Analysis Cycles will be planned to support the schedule and objectives of Project reviews. Review objectives can be found in NPR 7123, in this SEMP, and in the specific review plans.

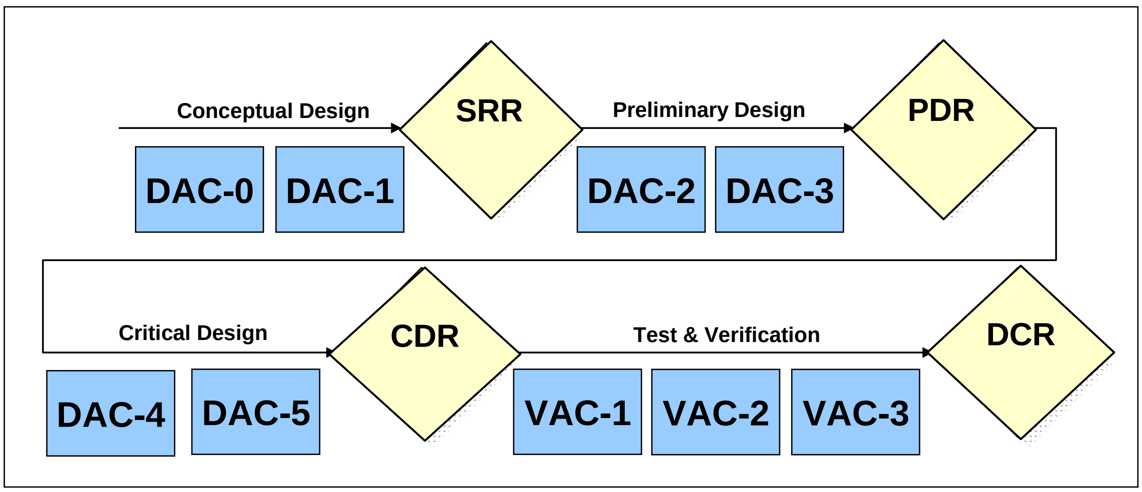


Figure 5.1-5 Top Level Analysis Cycle Roadmap

The Design Analysis Cycle process will be a cyclical execution of a planned set of complementary engineering analyses and trade studies to characterize the capability and functionality of CLV systems. The process will be divided into four main functions: DAC planning, analysis, issue resolution, and documentation as shown in Figure 5.1-6 and described below.

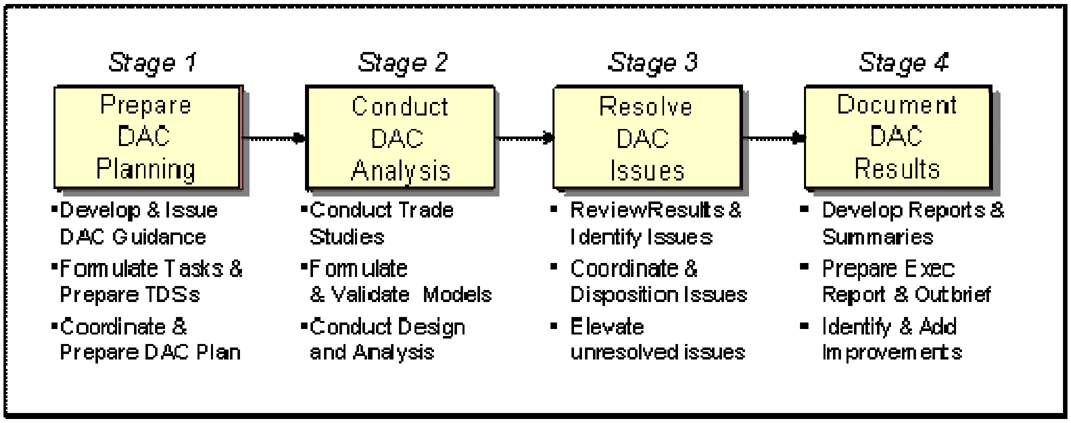


Figure 5.1-6 Stages of the Design Analysis Cycle Process

- Stage 1 - Prepare DAC Planning – In this initial stage, general guidance for the DAC will be prepared, and the performing organizations will develop individual task descriptions. An integration team will then use the data to validate requirements coverage, compile the data definition document, develop the integrated detailed schedule and produce a DAC Plan.

- Stage 2 - Conduct DAC Analysis – The performing organizations will 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 will be provided to subsystem analyses, which in turn will provide component results for integrated system analysis.

- Stage 3 - Resolve DAC Issues - The assessment of DAC results typically will identify system performance issues that affect more than one discipline or subsystem. The issues and recommended resolutions will be discussed by the Design Analysis Working Group (DAWG), which after concurrence by the EV Director, reports to the IDA WBS Manager, and then to the VICB.

- Stage 4 - Document DAC Results - In this final stage, analyses and assessments will be documented in individual detailed reports. Summaries of each report will be compiled in the executive DAC Report and all open issues will be tracked in the issues database. The final presentation and recommended changes to the technical baseline will be taken to the VICB and PCB for formal review.

The first baseline of the SAP will include the top-level plan for the system of DACs through PDR. Subsequent revisions will address DAC conduct through the lifecycle of the program. Refer to Figure 5.1-7 for CLV documentation flow pertaining to DAC planning and to the SAP.

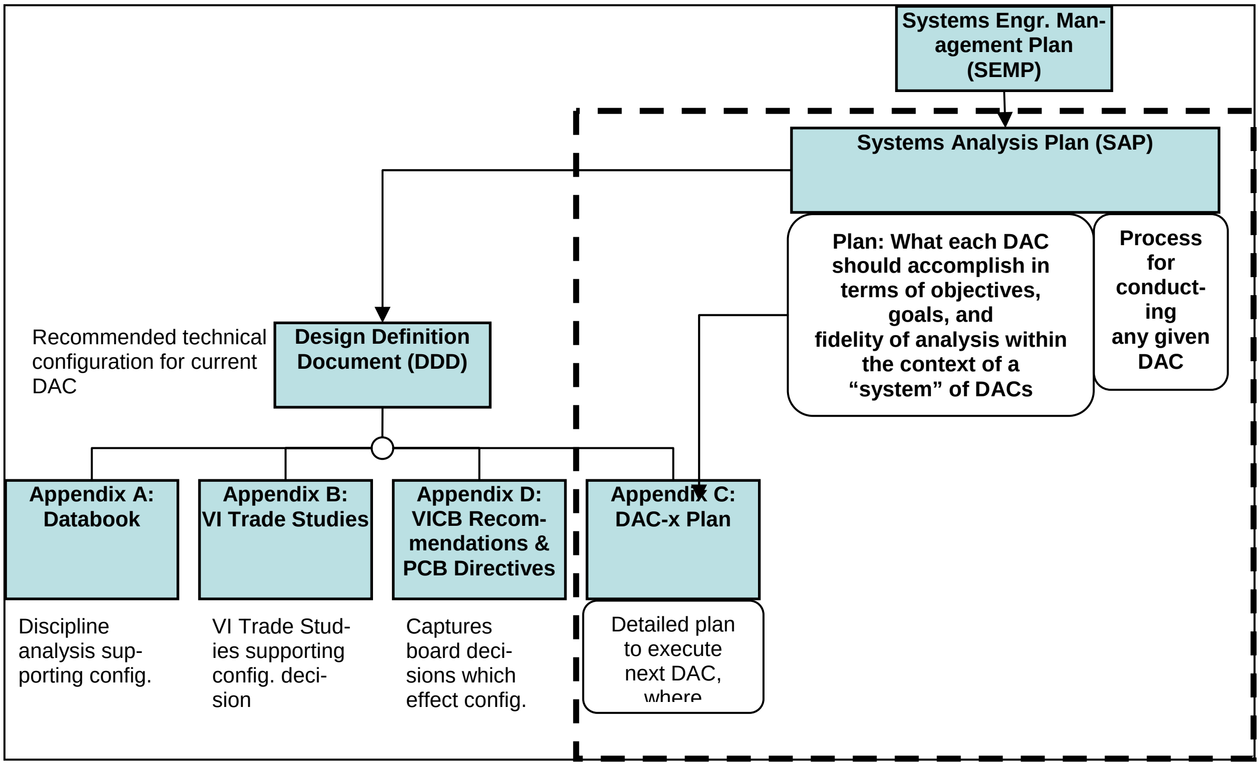


Figure 5.1-7 CLV Documentation Flow for DAC

5.1.5.3 Vehicle Integrated Performance Assessment

The VIPA process will be described in future versions of this SEMP. In general, the outcomes associated with completing this process will provide a design solution that (1) will be implemented through further development of subsystems, off-the-shelf procurement or reuse, coding, or fabrication, and (2) will provide the basis for the assembly and integration of subsystem products into end products required for verification.

5.1.5.4 Book Manager's Role

The Requirements Book Manager's role is as follows:

- Serve as member of Requirement & Verification Team (Systems Engineer / Manager for Book of Focus)
- Maintain List of WBS Managers responsible for each requirement
- Plan, Coordinate, and Integrate Uncertainty Resolution (TIMs, Working Groups, etc.)
- Integrate/Incorporate Pre-Screening During Broad Reviews
- Review and Concur Closure Packages Developed by WBS Managers, Work Package Managers and their Technical Representatives
- Track Open and Closed Work and Prepare Weekly Package to SRIIG on Status
- Incorporate Periodic Book Updates in Preparation for SRR

The book manager's primary responsibilities are depicted in Figure 5.1-8 below:

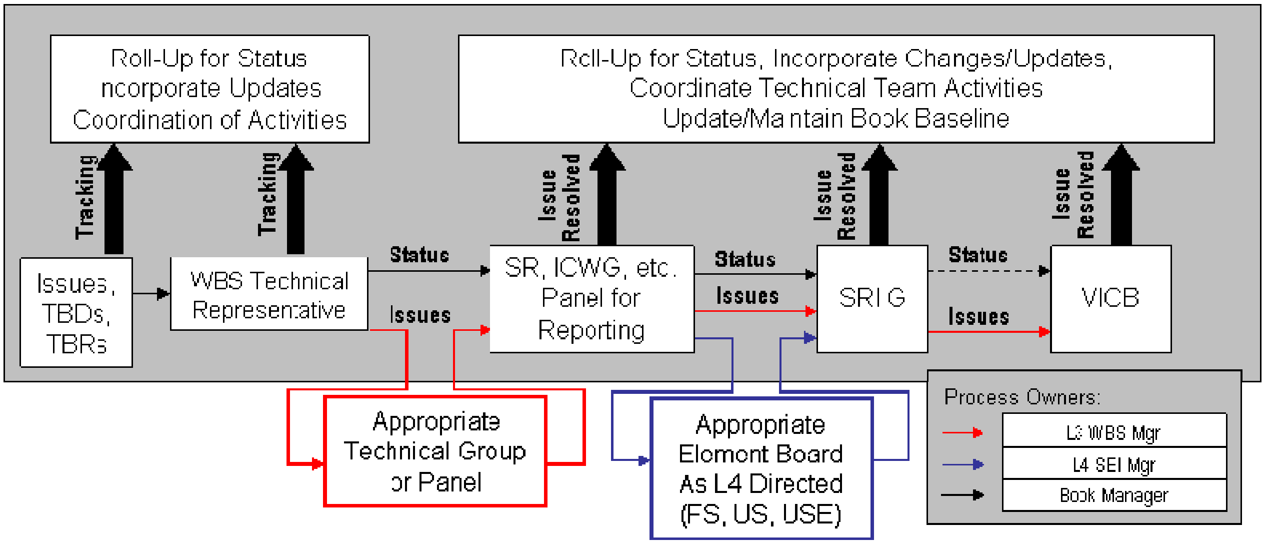


Figure 5.1-8 Book Manager Primary Areas of Responsibility

As shown, requirements issues are progressively submitted to Level 3 technical boards or panels and to Level 4 Element boards. This ensures identification/resolution of technical issues among independent groups to support analysis of problems determined at each stage.

5.1.5.5 Trade Study Process

The CLV Trade Study Process will be documented as a chapter within the CLV Systems Analysis Plan (CxP 72024). It will communicate the Project's intent to conduct formal trade studies in a coordinated manner. The process will also help the Project review and disposition the Trade Study Lead's recommendation -- whether to keep the Design Analysis Cycle (DAC) Point of Departure (POD) "as-is" or change to the subsequent DAC architecture.

The Trade Study Process will only apply to formal, pre-planned trades and will not apply to normal engineering analyses being worked to mature the intended vehicle design. However, the process is designed so typical engineering analyses, upon completion, may also drive out the need for a FROM-TO configuration Engineering Change Request (ECR). In such a case, the "Justification for Change" section in the analyst's ECR will address the technical content outlined in the SAP Appendix entitled "Outline – Trade Study Recommendation Report".

Definition of a Formal Trade

A formal trade study for CLV is defined as a pre-planned effort to evaluate alternatives to the DAC POD. It may require extra resources beyond the mainline design allocation. See criteria and applicability in Tables 5.1-1 and 5.1-2.

Table 5.1-1 Formal Trade Study Criteria

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

Table 5.1-2 Applicability of the CLV Trade Study Process

CLV Level	Applicable?
Level 3 Vehicle Integration	Yes
Level 4 Elements	Yes
Level 5 or below	No. Elements will decide what aspects of this process, if any, to apply to Level 5 and below.

<u>Goals of the CLV Trade Study Process</u>

It is the intent of this process to be flexible enough to promote engineering skills and judgment, while at the same time maintaining quality of information to justify a DAC POD configuration FROM-TO engineering change request. As a result, the process goals include:

- Establish consistent trade study numbering system between VI and the Elements.
- Provide a set of common outlines (for required technical content, not writing style) to be utilized for key trade study products:
  - Trade Study Request Form
  - Trade Study Plan
  - Trade Study Recommendation Report
- Establish governance philosophy to differentiate which trades should be governed at Level 3 by the Vehicle Integration Control Board (VICB)/Program Control Board (PCB) or at Level 4 by the Elements' Engineering Control Board (ECB).
- Provide for a uniform system-level trade tree.

Reference the SAP for details related to these goals.

Overview of the CLV Vehicle Integration (VI) Trade Study Process

Figure 5.1-9 illustrates, at a top-level, the CLV Trade Study Process for Vehicle Integration (VI) at Level 3 and the Elements at Level 4. The Level 4 Elements will have the freedom to construct their own trade study process, in more detail, as long as it meets the requirements listed above.

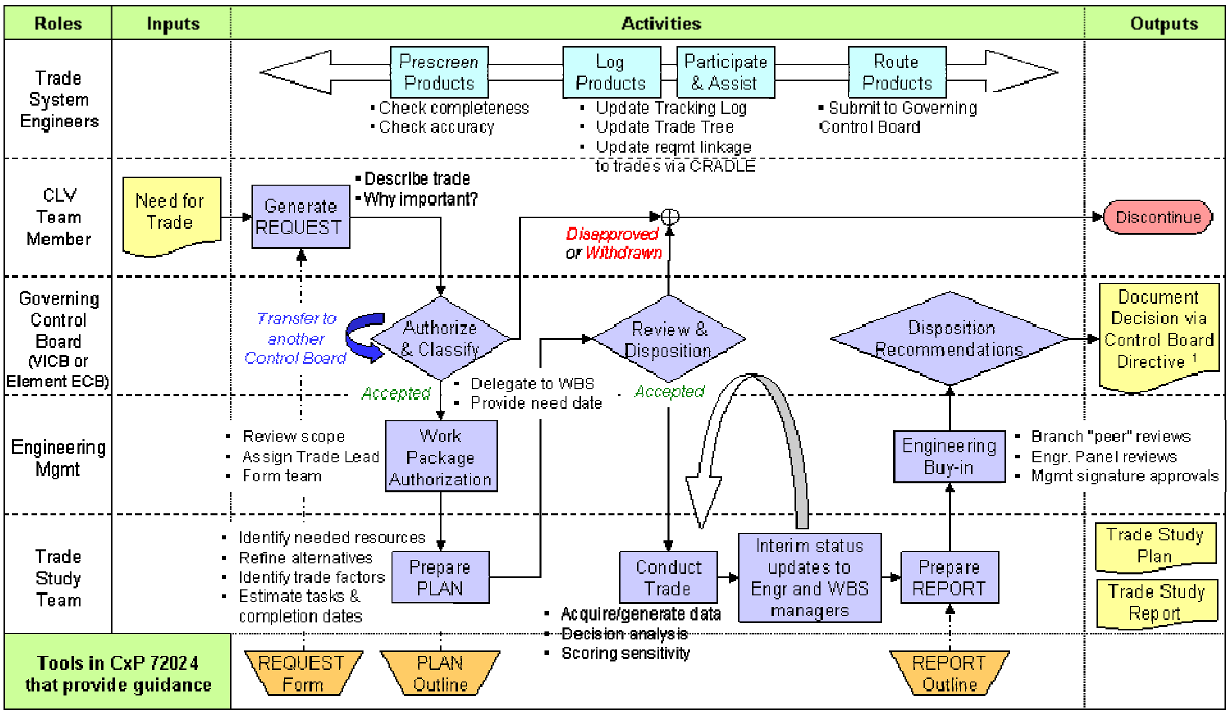


Figure 5.1-9 CLV Trade Study Process Flowchart for Level 3 VI & Level 4 Elements

The Trade Study Process chapter in the SAP provides a detailed description for each step in the flowchart, including information on roles and responsibilities.

5.2 Product Realization

Product Realization will be comprised of four processes: (1) product implementation or product integration, (2) product verification, (3) product validation, and (4) product transition. “Requirements” verification and validation were discussed earlier. Preliminary planning for these processes is described in the following sections. These processes will be further developed and documented in later versions of the SEMP.

5.2.1 Product Integration

Hardware and software integration across Elements will be managed by VI through the Interface Control Documents (ICDs) between/among Elements. The Vehicle Integration & Operations Group will have the responsibility for developing and maintaining the ICDs. The CLV PCB approves and baselines the ICDs. ICDs internal to an Element will be managed by the Element PCBs as described in the specific Element appendix to this SEMP (TBD).

VI, through AI&VST will support a systems integration laboratory (SIL) for the initial integration and checkout of H/W & S/W items. The SIL will be capable of providing all the stimuli necessary to exercise modes and functions of the Avionics items (see Figure 5.2-1) up to the CEV interface. The AI&VST WBS is responsible for ensuring all the necessary wiring and cabling to interconnect the Avionics items to match the actual vehicle installation. The Avionics capability will then be exercised as an integrated system prior to installation and checkout on the vehicle. User Operator participation in the SIL will begin as soon as avionics components, and associated CEV interface H/W and S/W, are installed and checked out. The CLV SIL will be used for risk reduction work, user involvement, and future integration and qualification of configuration changes. Specific HWIL and S/W configurations are TBD.

SILs will be established at various NASA centers, including MSFC. A CLV SIL will be located within one of the SIL facilities to conduct total system integration following the Element S/W and HWIL activities. The location of the CLV SIL is TBD.

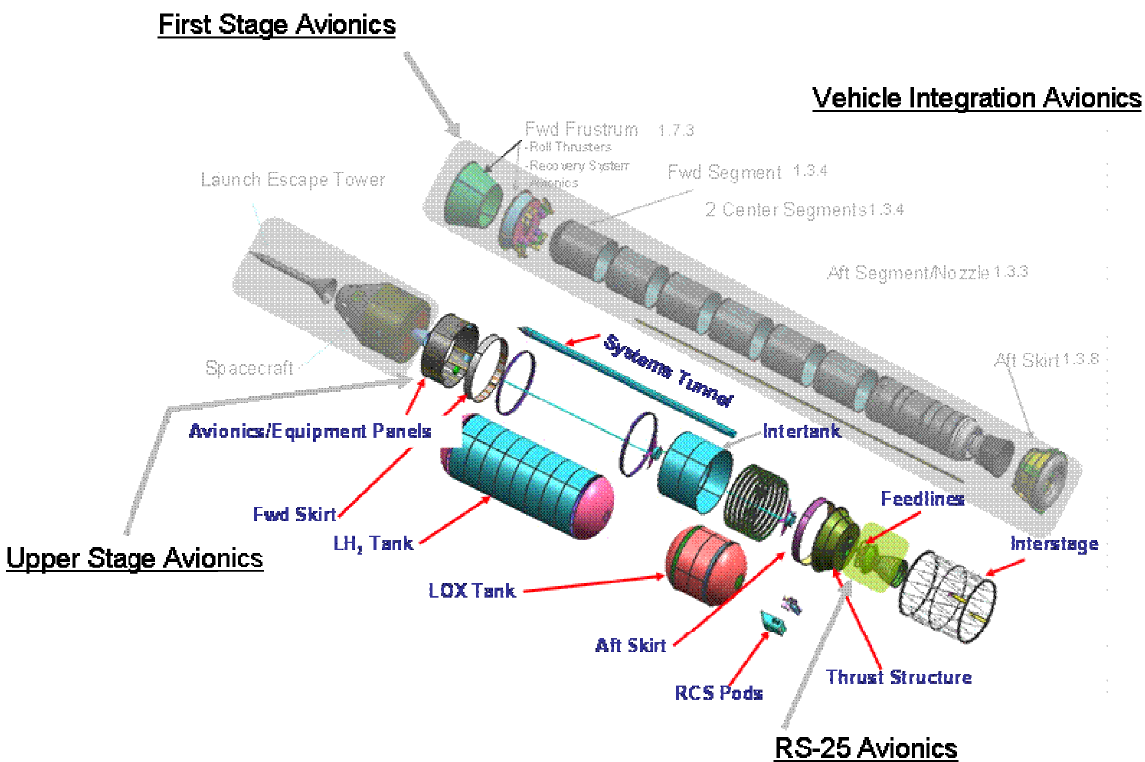


Figure 5.2-1 CLV Avionics Breakout

Satisfactory completion of this effort will provide a fully integrated end product that (1) satisfies its specified requirements, and (2) if required to be validated prior to delivery, conforms to its related acquirer requirements.

End product physical integration will ensure that: (1) internal and external interfaces for the composite end product (including user, operator and maintainer interfaces, and voice/data communications) function according to specified requirements; (2) defined states, modes, dynamic allocations or other operational switching functions perform as required; and (3) and designed overload conditions, reduced operational levels, or designed-in degraded mode of operations are included.

5.2.2 Software Integration

The integration of software into the CLV system is vital to the success of the Constellation Program. Software systems engineering processes will be conducted in parallel with the hardware DDT&E processes. Software will undergo a similar validation of requirements, performing trade studies to lead the functional decomposition to the sub-elements of the software. The approach to integrating the software with the hardware is to have software products fully integrated for the technical reviews. The software will be reviewed as part of the integrated package at the CLV SRR, PDR, CDR, DCR, and all flight reviews.

All CLV Project entities (both NASA and contractors) will work with GSFC to arrange performance of Independent Verification and Validation (IV&V) for applicable software, as required in NPD 8730.4, Software Independent Verification and Validation (IV&V) Policy. This will be documented in the CLV SW Independent Verification and Validation Plan. CLV Element management will maintain cognizance of this activity as defined in their software verification planning IAW CxP TBD, CLV Software Quality Assurance Plan. Software development and testing will be performed consistent with the provisions of the CLV Software Development Plan (SDP).

5.2.3 Product Verification

The CLV Project verification activities are described in the CLV Master Test and Verification Plan. VI will manage and control the development of the Assembly and Verification requirements via the R&V WBS. This includes the development of the verification requirements matrices for the specifications and IRDs, utilizing the Cradle database tool. Once the levels, phases, and methods to verify requirements are defined, the detailed assembly and verification requirements (i.e. success criteria) will be derived. The requirements will include the qualification and acceptance assessment requirements (similarity, analysis, inspection, demonstration, and validation of records) for the CLV, CLV Elements and all subsystems. Elements are responsible for their verification, and will supply the appropriate verification data to VI utilizing the Cradle database tool.

The V&V process to meet the CLV System requirements will begin with identifying the verification approach, defining the methods of verification, defining the success criteria , establishing information required to show compliance with each requirement, developing verification procedures, establishing the verification environment, conducting the evaluation and reporting the results. CRADLE will be used to track this information. Each Element will have their own V&V Plan, which will be loaded into CRADLE and provide links back to requirements for verification. Descriptions of each test method are defined below.

Demonstration

Demonstration will consist of a functional verification in which the observation of events is the predominant vehicle. Measurements are not usually required. When appropriate, it will include the actual exercise of software along with appropriate drivers, simulators (including interface simulators), or integrated hardware to verify compliance with requirements.

Inspection

Inspection will consist of visual examination, physical manipulation, or measurement (as applicable) of documentation, hardware, or software to verify compliance with requirements..

Analysis

Analysis will consist of the examination of applicable attributes of existing documentation, hardware, software, and recorded data to verify compliance with requirements. Analysis will include verification by investigation, mathematical analysis, and sampling the collection of measured data and observing test results with calculated, expected values to establish conformance with stated requirements.

Test

Test will consist of the collection of analysis of data obtained from the actual exercise of hardware and/or software in either a controlled or an operational environment as appropriate. Actual input stimuli and/or stimuli obtained from drivers or simulators will be employed as appropriate. Comparison of the tested characteristics with performance and operational requirements success criteria is the means employed to verify compliance with requirements.

Simulation

Simulation will include verification through the use of mathematical models incorporated into a simulation which replicates the following: the operation or performance of the equipment being evaluated; the threat which the equipment must operate against; the environment in which the equipment must operate; and combinations of the equipment, threat, and environmental simulators.

Similarity

Similarity is the process of assessing by review of prior acceptance data, or hardware configuration and applications, that 1) the article is similar or identical in design and 2) the manufacturing process to another article has previously been qualified to equivalent or more stringent specifications.

It is recommended that MSFC-HDBK-2221 be referenced for other methods.

5.2.4 Product Validation

Each validation plan will contain the test description, test approach, test location, test conditions and success criteria for each requirement. The validation test plans will be loaded into the CRADLE system and provide links back to requirements for validation.

Additional V&V attributes and activities will be incorporated into SEMP updates and the Test and Evaluation Master Plan (TEMP).

5.2.5 Product Transition

The Transition process will result in products delivered to the appropriate destinations, in the required condition for operation by the user, and for the appropriate training of installers, operators, or maintainers of the products. For CSLV, transition occurs upon separation of the CEV from the integrated stack. For the CLV Elements, product transition occurs when the Elements are delivered for integration, and all verification and safety issues have been officially closed (TBC). Product Transition will be more fully described in later versions of the SEMP.

5.3 Technical Management

Technical management includes configuration and data management, project control boards, risk and requirements management, technical assessments and reviews, and technical work packages maintenance. This will include updating the CSLV SEMP as the project and processes evolve.

5.3.1 Technical Planning

The CLV Project and its Elements will prepare appropriate plans to complete the SE&I processes. Systems engineering plans, to include SEMPs, will address the scope of the technical effort required to develop the system. The basic questions of "who will do what" and "when" must be answered. A technical plan will describe what must be accomplished, how systems engineering will be done, who is responsible, and how the effort will be monitored and controlled. Plans to develop include the following:

a) Engineering Plan; for the CLV Project this is the CLSV SEMP. The Software Development Plan (SDP) is similar to a SEMP for the software component of CLV. For CLV Elements that are procuring software intensive systems, a computer resources life cycle management plan is recommended.

b) Risk Management Plan; The development of the Risk Management Plan will support Risk Analysis and is based on the Risk Management Strategy. The Risk Management Plan will address Risk Identification, Risk Analysis, Risk Assessment, and Risk Handling. Plans for a Risk Management Board and Risk Reporting will be defined.

c) Testing is the principle method of verification. The various test plans include the following:

- TEMP (Test & Evaluation Master Plan)
- Formal Development Test Plans
- Qualification Test Plans

- Acceptance Test Plans
- Analysis Plans
- Master Validation and Verification Plan
- Test Plans
- SW IV&V Plan

d) Configuration Management Plan

e) Data Management Plan

f) Safety & Mission Assurance Plan

g) Document List, Document Tree, Data Requirements Descriptions, Data Procurement Documents

h) Knowledge Management Plan

5.3.2 Technical Performance Measurement (TPM)

In support of Technical Planning, the CLV team will compile a formal hierarchy of performance measurements to include TPMs. To ensure requirements traceability, the CLV hierarchy will begin with the SRD and Needs, Goals & Objectives (NGOs) for allocation/derivation of Technical Performance Measures (TPMs) (Figure 5.3-1). A fundamental principle of CLV metrics development will be to maintain the hierarchy among user-level measures (NGOs) and lower level metrics (TPMs) (Table 5.3-1). This will preclude development of performance indicators in the absence of stakeholder input.

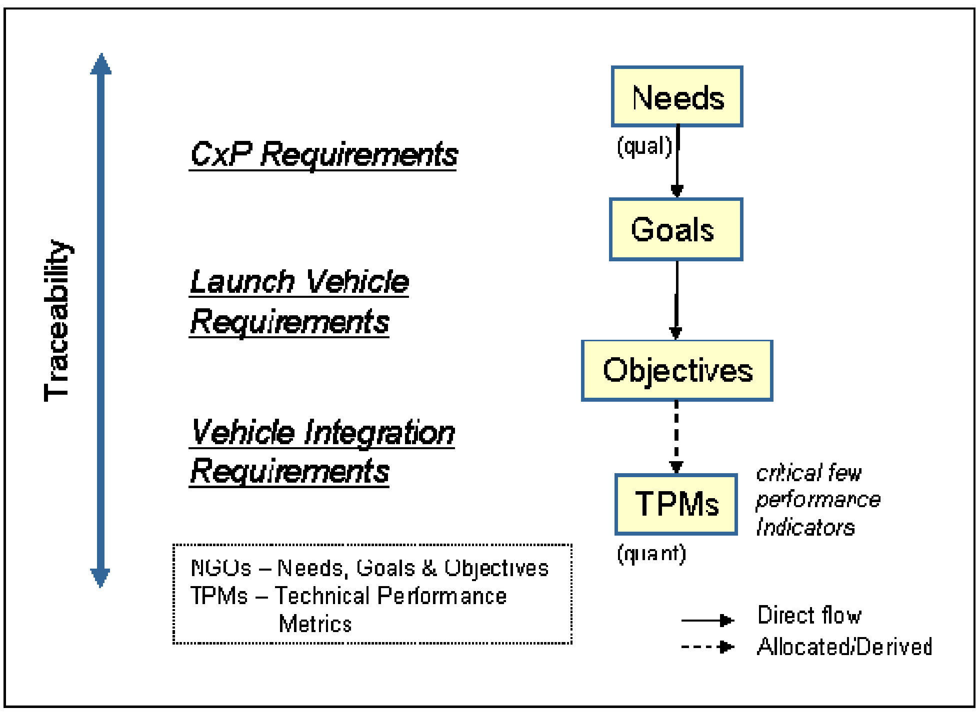


Figure 5.3-1 Measures / Metrics Hierarchy

Table 5.3-1 Technical Performance Measures (TPMs) -- *Preliminary*

Associated SRD Requirement	TPM Description	Threshold Value	Goal Value	Integration Group
3.2.3.1	Loss of Mission	0.319444444 (TBR) 50% Confidence	1:TBD w/ TBD% confidence	RBDIG
N/A	Recurring Cost	$TBD/Flight	$TBD/Flight	RBDIG
3.2.1.1.1, 3.2.1.1.2, 3.2.1.2.1	Mass to Orbit Injection Point	45,415 lbm (20.6 mT) (ISS cargo)	59,966 lbm (27.2 mT) (Exploration)	AFSIG
3.2.7.3	Time to launch ready after final element arrival at launch site	TBD	TBD	VI&O / RBDIG
3.2.5.1.1	Launch Probability exclusive of weather conditions	TBD	98% TBR 50% Confidence	RBDIG
3.2.3.2	Launch Probability due to natural environments	TBD	98% TBR 50% Confidence	RBDIG
N/A	CaLV Payload Mass	LSAM+ EDS+ Crewed CEV	LSAM+ EDS+ Crewed CEV	AFSIG

TPMs will be:

- selected by Team leads as tools to measure progress/changes;
- traceable to the CLV SRD or NGOs;
- based on:
  - Requirements,
  - Functions,
  - Risks,
  - EVM Criteria,
  - Best Practices;
- used for status and decision making;
- allocated to Element team leads;
- used to drive and support trades and analyses; and
- prioritized through correlation to technical risks as identified by CLV Risk Management.

The CLV Project's TPM effort will be coordinated by Requirements and Verification WBS 5.2.1 to provide monitoring of selected CLV hardware, system and software performance parameters. These identified TPMs will be documented in the Launch Vehicle Project Plan and future revisions of this document. The IGs and TPs may recommend additional TPMs. Those shall be coordinated with the VI and the Requirements & Verification WBS -- and appropriately documented. They will be reported to the CSLV Project Office on a quarterly or as-needed basis.

5.3.3 Requirements Management

Requirements management is the process of controlling the identification, allocation, and flow down of requirements from the system level to the module or part level. The process will be managed based on Data Requirements whereby VI, through the SRIIG, will allocate requirements to the WBS managers, and therefore to the Engineering Work Package managers (or the Element SE&I managers). The VICB will consider these managers responsible for development of the requirements, ensuring feasibility assessment, ensuring the requirement is verifiable, and has an adequate verification method. Technical Representatives will be assigned to each of the requirements from Engineering to perform much of the tasks. They will be accountable back through the responsible Work Package/WBS manager (or the SE&I). The WBS manager will be responsible for ensuring the upward integration with Level II but can utilize the Work Package managers and Technical Representatives, as appropriate. For further details, reference the Master Test and Verification Plan (MTVP) (CxP 72035). *[Note: The Level II planned implementation for requirements ownership is thru the SIGs]*.

Requirements management activities concentrate on assuring the requirements and specifications are met to the customer's satisfaction. Requirements management includes gathering, organizing, documenting, implementing, maintaining, sustaining, controlling configuration, verifying and managing changes. The CLV will use commercially available and/or Government developed tools (e.g., CRADLE) to improve both productivity and quality. An example CRADLE repository for requirements management is shown in Table 5.3-2.

The overall responsibility for requirements management and its processes is given to the CLV VI's Requirements and Verification WBS. However, as previously described in section 5.1, The R&V WBS will allocate requirements to the WBS managers, and therefore to the Engineering Work Package managers (or the Element SE&I managers) who maintain responsibility for ensuring requirements are validated, and later verified.

The R&V WBS will develop the Master Test and Verification Plan that describes the entire CLV Project verification and validation strategy and methodology. All of the participants in the CLV Project will provide varying degrees of support to requirements management activities throughout the life cycle of the CLV. Therefore, a requirements management process will provide assurance that:

- Responsibilities for requirement identification, traceability, documentation, and verification are established.
- Each requirement is correctly identified.
- Standards for format and content of requirements are followed.
- Traceability is provided throughout the lifecycle stages including well-defined entry and exit criteria for each stage.
- Requirements are easily traced from the source to allocated components and back.

- A process is in place to manage changes to requirements, including appropriate automated tool support for the configuration management.
- Requirements are validated to ensure they are an accurate representation of the customer's needs.
- Products are validated to prove that the product performs its intended functions correctly (reference the Master Test and Verification Plan).

Table 5.3-2 CRADLE Repository for Requirements Management *(for reference only)*

Requirements:

CLV System Level Requirements	REQ-CLV
1st Stage Element Level Requirements	REQ-1st Stage
US Element Level Requirements	REQ-US
USE Element Level Requirements	REQ-USE
CLV/CEV Level II IRD	REQ-J2
CLV/GOE Level II IRD	REQ-LVL3 IF
US/1st Level III IRD	REQ-LVL4 IF
US/USE Level III IRD	REQ-LVL4 IF
LAS	REQ-
US Subsystem Level Requirements	REQ-USE

Other Data:

ConOps	ConOps
DSNE	DSNE
Document Sections (Headings) for all books	Doc Section
Issues, Actions, TBDs, TBRs, suggested new requirements, suggested requirement changes	Issues
Technical Representatives	POCs (TBR for 1st stage)
OPRs	POCs

Queries under Team folder:

Technical Representatives, OPRs	List of POCs
	POCs & Reqts & Issues
	POCs & Interfaces
CLV data	CLV (Requirements)
	Doc Section (Headings)
	CLV_Issue Links (Requirements, POCs and associated Issues)
	SRD CLV Doc Section & Links (Document Sections and associated Requirements)
	POC & Reqts & Issues
1st Stage	1st Stage (Requirements)

	Doc Section - SRD 1st (document sections)
	SRD 1st Doc Sec & links (Document Sections and requirements)
	POC & reqts & issues
US	US (Requirements)
	Doc Section - SRD US
	SRD US Doc Sec & links (document sections and reqts)
	POC & reqts & issues
USE	USE (Requirements)
	Doc Section - SRD USE (document sections)
CLV/GOE	Doc Section - IRD CLV to GOE (document sections)
	IRD CLV to GOE (requirements)
	POC & interfaces
CLV/CEV	Doc Section - IRD CLV to CEV (document sections)
	IRD CLV to CEV (requirements)
	POC & interfaces

An updated SRD will describe the Functional Baseline Requirements as validated at the System Requirements Review (SRR). Traceability tools such as CRADLE will be used to verify correct flow from the document. Additional decomposition will be performed to lower level segment specifications and ICDs, also utilizing CRADLE. The SRD is the highest level technical document that forms the basis for all subordinate documents identified in the document tree (Appendix E). Per the Configuration Management Plan, all changes to the baseline will require an Engineering Change Notice (ECN) for review and approval.

5.3.4 Interface Management

IRDs and ICDs will be the basis for documenting the technical interface control -- for hardware and software between Element interfaces -- and for performing vehicle integration. External IRDs and ICDs (such as CLV to CEV, CLV to ECANs) will be controlled by the Constellation Program. Internal IRDs and ICDs (such as Upper Stage to First Stage, Upper Stage to Upper Stage Engine) will be controlled by the CSLV Project.. These internal IRDs and ICDs will be generated by VI, in coordination with the Element SE&I Managers, assisted by Element contractors in preparation and review. Integration test plans will be prepared for vehicle integration testing from Element ICDs, hardware/software design documentation, and related technical and operational descriptions.

The VI WBS Managers will interface with the Level II organization as illustrated in Figures 5.3-2 through 5.3-4. This will assist in many areas of integration, but specifically this multi-project approach will be needed to produce the Interface Requirements Documents (IRDs) between the projects.

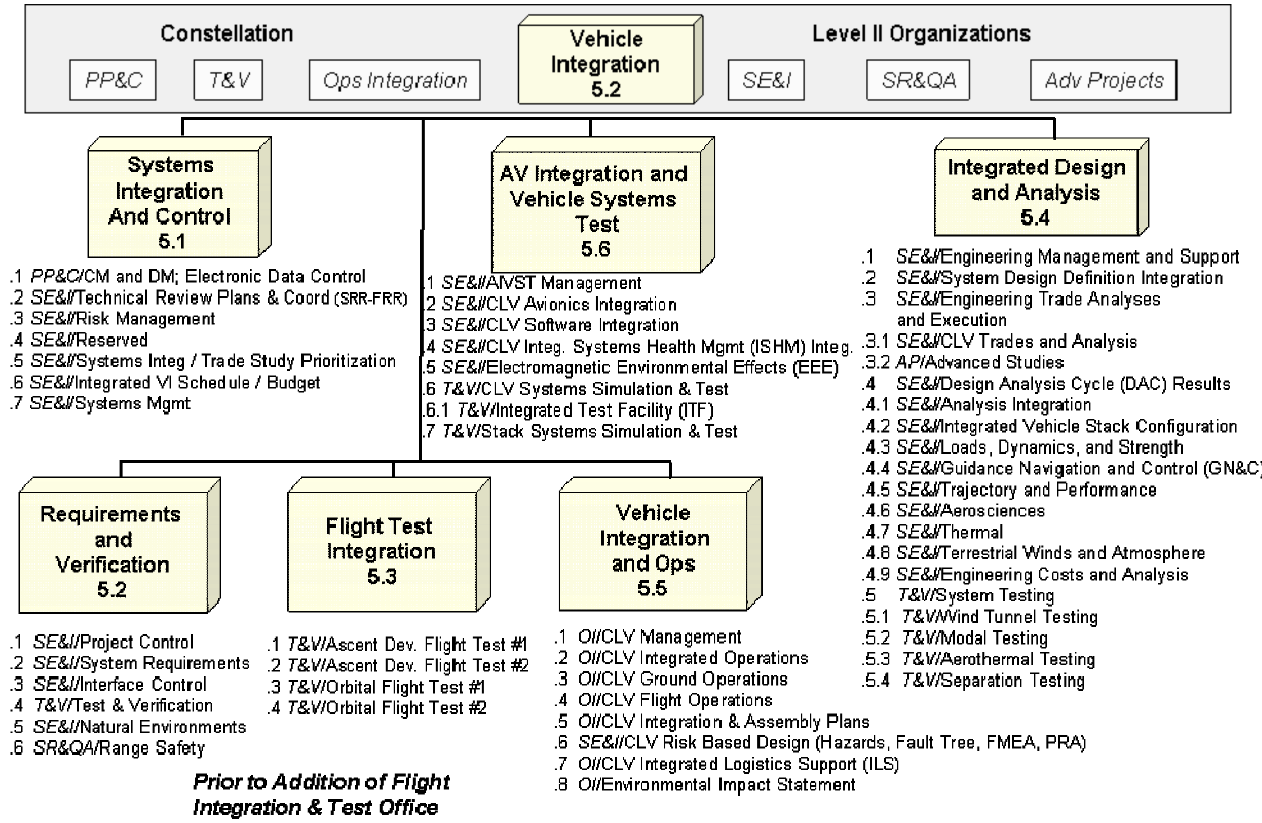


Figure 5.3-2 VI WBS Map to CxP Office

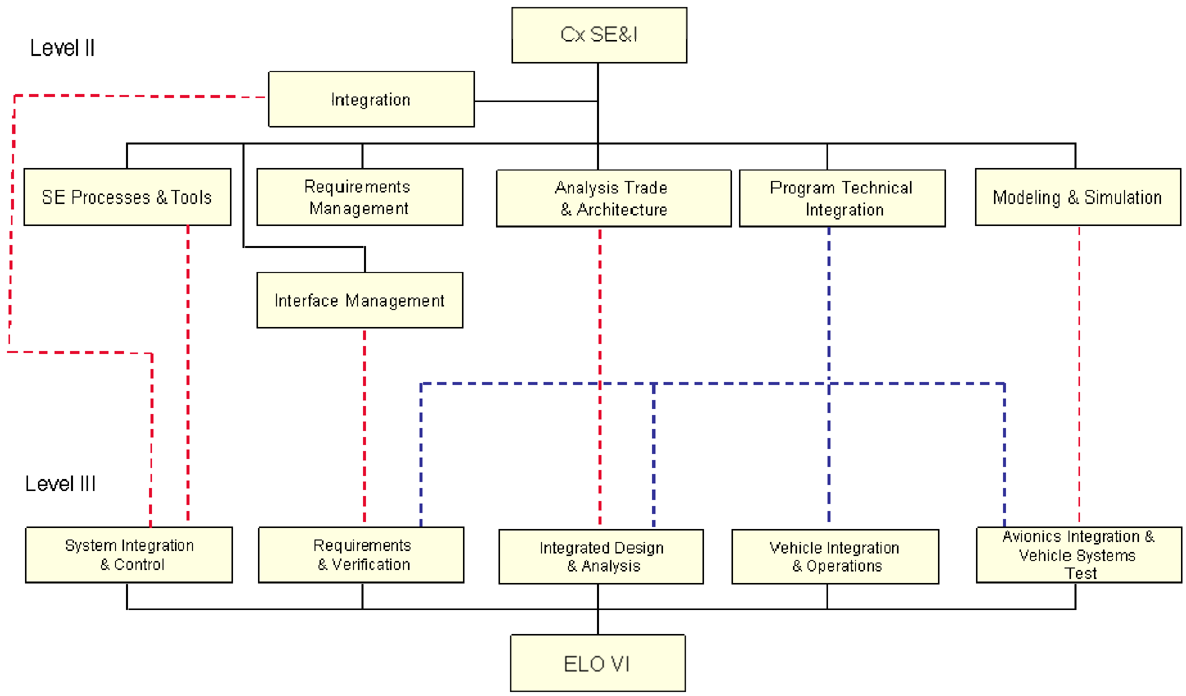


Figure 5.3-3 ELO VI to Level II SE&I Interactions

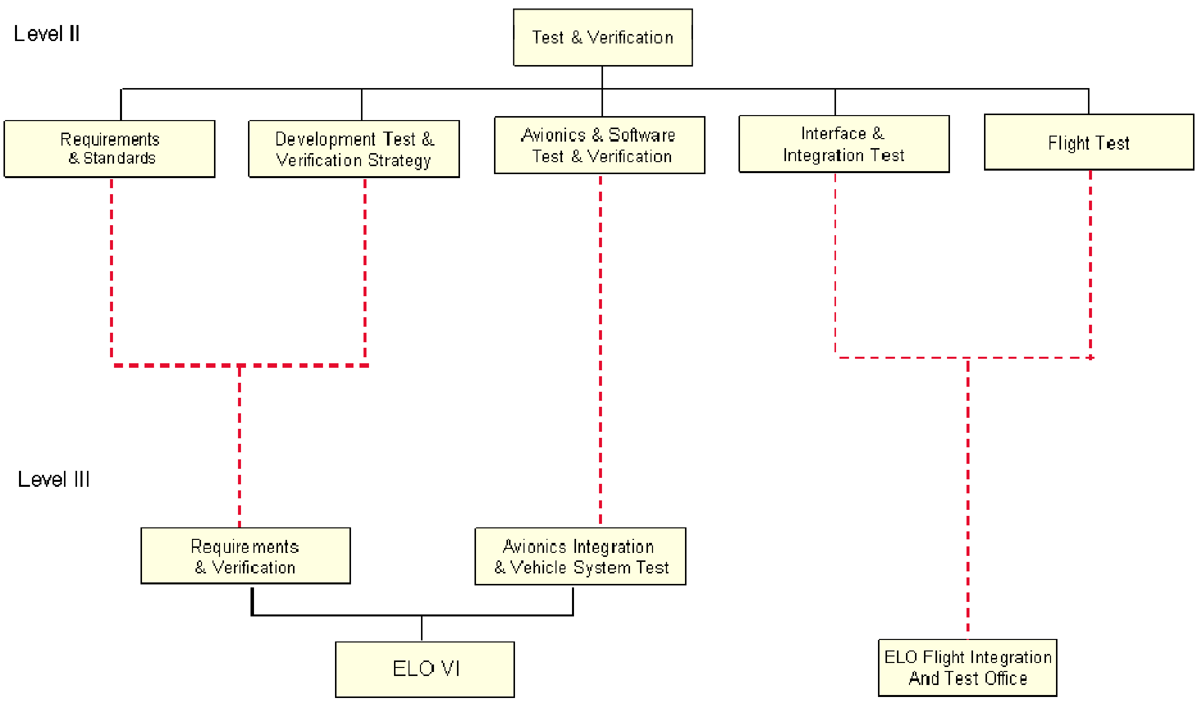


Figure 5.3-4 ELO to Level II T&V Interactions

The Integration Groups described in section 4.1 will interface with the Level II System Integration Groups to facilitate vertical integration., as presented in Figure 4.5-2

The CLV Project will have shared responsibility with Element Leads for the integration and logistics of all component hardware and software, regardless of existing qualification basis. The systems engineering products and processes comprise the fundamental building blocks for implementing systems integration across the teams. These include the WBS and the full spectrum of requirements management methodologies.

Programmatically, systems engineering will be employed across the teams as a function of common performance metrics, including EVMS performance indexes as well as risk management metrics.

5.3.5 Technical Risk Management

The Risk Management (RM) process will be a critical component of the CSLV Project. RM will identify circumstances or issues that could threaten the success the CLV Project, and provide plans to avoid or to reduce the impact to acceptable levels (mitigation strategies). Risk Management is not just the process and tools of the monthly report—it is a mindset of how to conduct all project activities. The identification of risks, and the mitigation strategies shall be the responsibility of every member of the CLV team. The CLV Project shall use Active Risk Manager

(ARM) risk tool. The specifics of the CLV RM process are found in the CLV Risk Management Plan (CxP 72019). In general, the CLV Risk Management Plan will contain the following guidelines:

- CLV risk management process and procedures
- Identification categories.
- Likelihood and potential consequence criteria.
- Validation criteria and process.
- CLV Risk Management responsibilities.

In addition, the Plan provides general guidance for conducting Risk Analyses, develop a consistent approach to conducting the risk analyses with CLV SEI System Analysis Group, and provide guidance for developing risk mitigation plans/strategies. All Risk Management Reports shall meet the requirements in the Launch Vehicle Project Plan.

Major emphasis will be given to risk identification[9], as the effectiveness of the risk process is highly dependent on the ability to identify potential risks. In addition to the more classical risk identification methods typically used, the risk identification process will include a Root Source Analysis (RoSA) to comprehensively determine risks arising from critical assumptions and capability shortfalls in the underlying technical capability. Results from RoSA assessments (or an approved alternate) will include, among other things:

- Risks from critical, unverified programmatic and technical assumptions.
- Risks from shortfalls or gaps in the underlying technical capability needed to define, design, integrate, validate, fabricate, verify, and operate the CLV and its respective Elements (e.g., analysis tools not validated for the application, incomplete or outdated databases, tribology issues, non-destructive evaluation for nozzle inspection not available, unverified fabrication process and shortfalls in verification capability).
- Independent validation of the achievability of requirements. This is to be accomplished in conjunction with the SRR and PDR.
- Independent validation of Technology Readiness Levels (TRLs) stated by the designers.
- It is a CSLV Project requirement that comprehensive, quality risk assessments, status information and issues, including the results from RoSA assessments, be submitted in support of major reviews and decision points.

[9] The CLV Candidate Top Risk List was presented to the CLV PCB on 2/16/06. Title changes were made and a software development risk was added to the list. The PCB concluded with the assignment of risk owners for each of the Top 12 Launch Vehicle Project Risks. This assignment action formally began the CLV Risk Management process.

5.3.6 Configuration Management

Configuration Management (CM) provides a formal and disciplined approach for defining and documenting requirements, control changes, provide current and accurate baseline accounting and supporting the verification process to assure that the final products meet the baseline requirements.

CM is inherent to, and required by, good engineering and program management practices. Failure to implement the proper level of CM can result in the loss of the definition and control of the required baselines and inability to ensure that the delivered products satisfy the Government's requirements.

A single Launch Vehicle Project CM program will be developed for and applicable to all elements of the Launch Vehicle Project, and supporting organizations, and will be defined in the Launch Vehicle Project Configuration Management Plan, CxP72015. This CM program will address the five major elements of CM: (1) CM planning, (2) configuration identification, (3) change control, (4) change tracking and status accounting, and (5) verification. CxP 72015 will define the requirements, procedures, processes, tools and associated organizational roles and responsibilities for the establishment and control of the respective baselines of the Launch Vehicle Project Control Board (Level III) and the Launch Vehicle Project Elements' control boards (Level IV). The plan will also address the relationship of the MSFC control boards and the Constellation Program Control Board (Level II). There will also be a Software Configuration Control Board. The hierarchical structure of these control boards is shown in Figure 5.3-6. The requirements of CxP72015 will satisfy the requirements of CxP70100, Configuration Management Plan for Constellation program, NPR 7120.5, NASA Program and Projects management Processes and Requirements, MPR 8040.1, Configuration Management, MSFC Programs/Projects, and MIL-HDBK-061, Configuration management Guidelines

Each Launch Vehicle Project/element board will have its own distinct and controllable baseline. The Launch Vehicle Project Control Board baseline will be allocated by the Level II Constellation Program Control Board, and the Launch Vehicle Project Elements' Control Boards' baselines will be allocated by the Launch Vehicle Project Control Board. Each control board will be solely responsible for its specific baseline, but must assure that it does not authorize any change, deviation or waiver that is part of, or applicable to, a higher control board's baseline. Such proposed changes must be elevated to the higher level control board with a recommended disposition. The respective technical and programmatic baselines will be formally documented in requirements documents/specifications in accordance with normal MSFC engineering and programmatic practices, and applicable contractual Data Procurement Documents.

Each Launch Vehicle Project/element board will have an engineering review board (ERB), chaired by the respective chief engineer, responsible for providing the technical evaluation and disposition recommendation for each proposed change to the respective baselines. The Vehicle Integration Control Board (VICB) will serve as the "engineering review board" for system level changes under the auspices of the Launch Vehicle Project Control Board. Additionally, to ensure that engineering can provide an independent assessment of system level changes, the CLV Chief engineer will chair the Vehicle Engineering Review Board (VERB), which if in agreement with the technical recommendations of the VICB, will concur with the VICB, and if in non-agreement with the VICB will either non-concur or present the change to the MSFC Engineering Management Council for establishment of the MSFC engineering position, which will be forwarded to the launch Vehicle Project control board.

The respective baselines will be developed and placed under formal CM control incrementally. These baselines will be the products of successful design reviews and audits (SRR, PDR, CDR, FCA and PCA). Additionally changes to the baselines may occur throughout the project life cycle on an as-needed basis.

The Launch Vehicle Project, and its elements and supporting MSFC organizations will use the electronic automated CMII system for formal change proposal submittals and distribution, evaluations, control board dispositions and implementation directions (via formal directives) and closure of implementation actions, and will provide current and accurate records of the Launch Vehicle Project Control Board's and the Launch Vehicle Project Elements' Control Boards' baselines for the life of the program. CMII will track and status each change proposal/request, deviation and waiver, and associated actions, from receipt by the CM Receipt Desk throughout the evaluation phase, control board disposition phase, and the implementation of control board directions. This system will provide various management reports defining the authorized baselines, outstanding actions, delinquent actions, pending changes, etc.

Each change proposal/request, deviation or waiver received by the CM Receipt Desk will be viewed by the Screening Group to determine the effected elements, assign the change package engineer, and determine the mandatory organizations required to evaluate the change and provide technical and programmatic impacts, and assign the scheduled evaluation due dates and the respective control board(s) due date(s). The Screening Group will be co-chaired by a representative of the Vehicle integration Office and Engineering, and its membership will include representatives of each element and S&MA.

Prior to the transfer of the Upper Stage Design to a prime contractor, appropriate design baseline definition will reside in the MSFC Design and Data management System, and the "as-built" definition of any manufactured hardware at MSFC will reside in the MSFC As-built Configuration status System.

The appropriated CM requirements will be contractually imposed on the MSFC prime contractors, and sub-contractors.

5.3.7 Technical Data Management

Technical data will be identified, collected, formatted and controlled under the CSLV Project Office and under the Constellation Program Office. This data will be used to derive information in supporting the program/project activities and the development of the products. This includes all data used and generated in the technical analyses and may include data on new designs, data from existing systems, manufacturing data, human factors, health management data - all data and information needed for comparative, predictive and legacy analyses. The CLV Project shall have a data and information repository within ICE/Windchill that will include the data and versions, source identification, and control specifications. Further specific requirements will be in the CLV CM Plan (CLV-CM-20100) and the CLV DM Plan (CLV-DM-20200). Guidelines for distribution of CLV Project data will be applied, as required, IAW International Traffic in Arms Regulations and Export Control Laws (see Project Plan). All presentations of CLV engineering activities (e.g., AIAA papers) must be reviewed by the CSLV Project Office prior to presentation.

ICE/Windchill will allow efficient distributed data access and control. A depiction of the CLV Technical Data Management process (notional) is shown in Figure 5.3-5 below. The initiation of the process flow is authoritative data sources; whether NASA or MIL standards or regulations, project-specific plans, or heritage documentation. From those sources a producer of the data will design, create or otherwise generate a data product to subsequently be managed by an administrator. The administrator catalogs, configures and stores the data for the consumer. This user will require search and access methods to evaluate and employ the data. Finally, a sponsor or authority will approve the data which will be allocated and incorporated, as appropriate, into the originally-produced product. An examiner will serve the role of V&V and interface with the other data owners/users as shown. The arrows depict the two-way workflow whereby data is delivered or proposed and feedback is provided through data review and concurrence. Section 7.2, Engineering Methods and Tools, outlines CLV-specific Data Management including the use of CRADLE and Windchill -- repositories for the technical data.

The CLV Data Procurement Document (DPD) will set forth the data requirements in each Data Requirements Description (DRD) and will govern that data required by the DPD for the Upper Stage contract. The contractor will furnish data defined by the DRDs listed on the Data Requirements List by category of data and made a part of the DPD. This data will be prepared, maintained and delivered to NASA in accordance with the requirements set forth within the DPD. Both the DRDs and DPD will be provided in future versions of this SEMP.

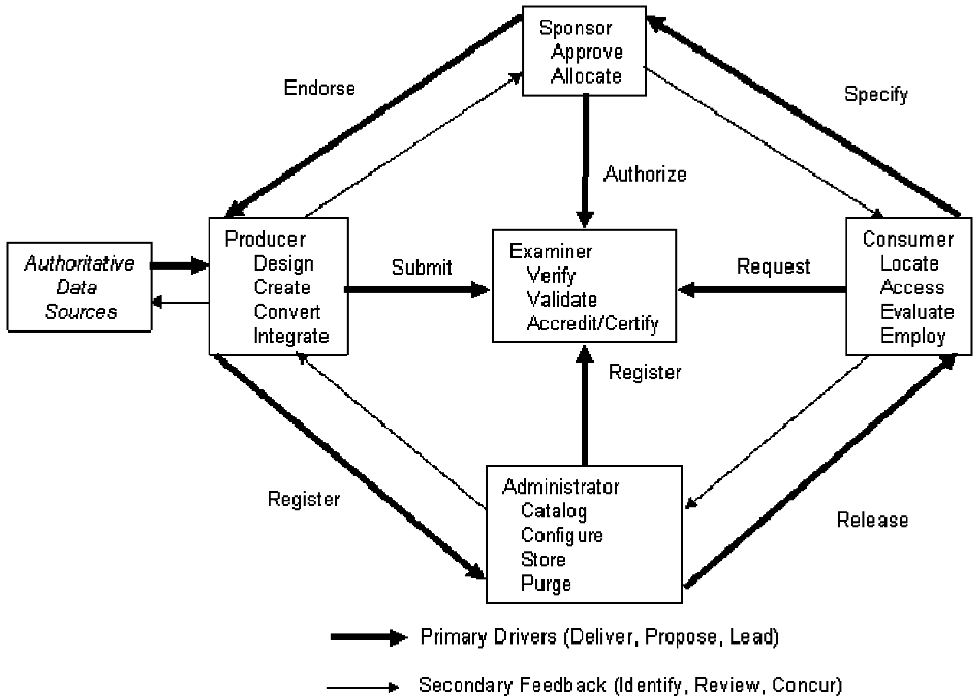


Figure 5.3-5 Technical Data Management process -- ***NOTIONAL***

5.3.8 Board Organizational Structures

5.3.8.1 CLV Project Control Board Structure

The CLV Project will manage several Element Projects that use a mix of contractor and NASA in-house workers. Some aspects of the Element may be NASA-led or contractor-led with NASA oversight / support. The general structure of the CLV Project control board is shown in Figure 5.3-6. For the purposes of configuration control, the in-house development effort will be treated as if it is a contracted effort. In the place of procurement, the engineering work package managers will issue changes to the scope, cost and schedule of the efforts to engineering managers with the approval of the appropriate PCB. All changes to the scope of an Element's work, whether contracted or in house, will come through the Element Project Managers for approval, prior to authorization being given to perform the work. This authorization of work, or authorization of changes to work, will be performed using the normal NASA project control board structure.

The CLV Project, through the Launch Vehicle Project Plan, will charter a Project Control Board (PCB) to establish and control the CLV functional baseline, work authorization and to provide a forum for decisions on integration issues. The CLV PCB will be chaired by the CLV Project Manager or CLV Deputy Project Manager. The objectives and responsibilities of this Board include:

- Manage functional baseline of CLV Project.
- Establish allocation to CLV Element Requirements.
- Manage CLV-Level ICDs
- Decision authority on Element Integration Issues.
- Establish Official CLV Project recommendations to Constellation Program boards (TBD).
- Approve CLV Project risks, risk mitigation plans, and risk closure.

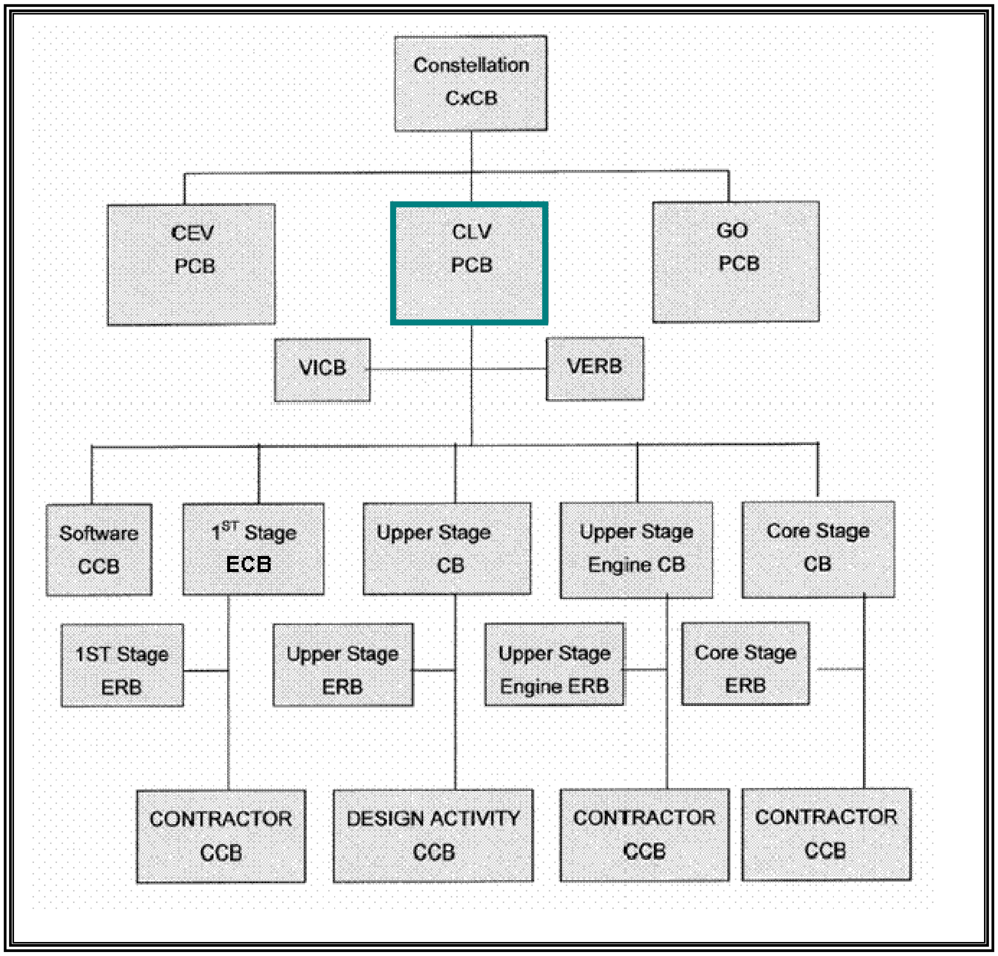


Figure 5.3-6 Control Board Flow Diagram

The CLV PCB will function with the VICB, chaired by the CLV VI manager with the CLV CE as a member. The objectives and responsibilities of this board are:

- Screen all technical issues going to the CLV PCB.
- Provide a recommendation for all CLV integration issues.
- Provide an initial assessment of schedule and cost for all recommendations to the CLV PCB.

The VICB will be the review body that provides a forum for open discussion of all technical and/or integration issues above and between the CLV elements. The goal of the VICB is to allow for full review of all issues for completeness, engineering rigor, and procedural correctness in order to arrive at an integrated recommendation from the CLV team to forward to the CLV PCB for a decision. The VICB will have a charter through the Launch Vehicle Project Plan to formally establish its formulation with scope, board/review members, and formal delegation of authority from the CLV PCB.

5.3.8.2 CLV Project Control Board (PCB)

The CLV PCB will be the CLV Project's requirements and configuration control board. The chairman of the Board will be the CLV Project Manager.

The members of the CLV Project Control Board will be the CEV Project manager, First Stage Project manager, CLV Project manager, Upper Stage Engine Project manager, Upper Stage Project manager, CLV Chief Engineer, CLV Safety and Mission Assurance Director, and Center Work Package Engineering Representatives.

The PCB will integrate and control the VICB, the three Element ERBs and the Element PCBs. The PCB will assign to the VICB the following:

a) The initial baseline of the SEMP will be done by the CLV PCB. All future changes will be controlled by the VICB.
b) IRDs and Interface Control Documents (ICDs) between the Elements will be baselined by the CLV PCB. All future changes will be controlled by the VICB.
c) The CLV Systems Requirement Document (SRD) (CxP 72034) and Element SRDs (CxP TBD) will be baselined by the CLV PCB. All future changes will be controlled by the VICB.

Further specific delegation of responsibilities from the CLV PCB to the VICB is contained in the VICB charter as documented in Appendix G.

5.3.8.3 CLV Vehicle Integration Control Board (VICB)

The CLV VICB will be the CLV VI Manager's integration review board. The VICB will function as a preboard to the CLV PCB. The VICB will approve all integration topics prior to presentation to the CLV PCB. The chairman of the VICB will be the manager of CLV VI. The VICB will be responsible for the technical adequacy of the resolution of all integration issues. The VICB will be responsible for final approval and control of ground rules and assumptions for the start of each integrated DAC. The VICB will maintain the current CLV integrated design configuration as a point of departure for each integrated DAC and updates it with the results of each integrated DAC. Final design configurations for major reviews will be baselined by the VICB for each review.

The CLV Chief Engineer may convene preboard meetings for the VICB as appropriate to discuss technical approaches and recommendations prior to presentation to the VICB as a whole.

VICB membership will include:

Project Office	**Engineering**
Chairman	VI CE
Secretary	VI Eng Impl Mgr
SI&C	1st Stage SE&I
R&V	US SE&I
FTI	J-2X SE&
ID&A	EV10
VI&O	EV60
Avionics	ER20
1st Stage SE&I	
US SE&I	
USE SE&I	
S&MA	
JSC/Crew	
JSC/CEV	
KSC/LMS	
LaRC	
GRC	
Others as required	

5.3.8.4 Vehicle Engineering Review Board (VERB)

Reference VERB Charter in Appendix G.

5.3.8.5 Element Engineering Review Board (EERB)

Reference EERB description in Appendix H.

5.3.9 Technical Assessment

The Project will be an event-driven effort consisting of major project and developmental assessments culminating in project and technical reviews mandated by NASA in NPR 7123.1 and MPR 8060.3: Requirements and Design Reviews, MSFC Programs and Projects (also reference section 3.4.2). All major CLV Reviews will have a review plan providing details of conduct and content for each review. These reviews will be the focus of this section on technical assessment.

The VI PM will use the technical reviews to assess overall project progress. Not only will the technical configuration be reviewed but all technical reviews will include a review of the various “ilities” including test, quality, production, configuration management, schedule status, etc. The Functional and Allocated Baselines will also be reviewed and assessed.

Given the proposed "hybrid" nature of CLV through partial utilization of heritage components, the program will undertake both CI-based design reviews and assess qualification bases of integrated subsystems. Should the program move forward with CI's which have not previously been subjected to design reviews commensurate with the expected CLV environments, appropriate assessments (e.g. Technology Readiness Levels (TRLs)) will be conducted.

Participation in CLV technical program reviews will include representatives from the user community with pertinent and relevant technical experience – (i.e., requirements, operations, training, logistics, etc.) as well as expertise from within the testing community and individuals with mission operations knowledge. Additionally, expertise will be drawn from other independent technical experts from within the NASA community representing the various Specialty Engineering functions

Risk status will be briefed at all technical reviews and represents review entrance criteria. The reviews will include a presentation of identified risks, their respective risk abatement plans for medium and high program-level risks, and will include risk mitigation burn-down graphs. Participants of this review will be able to provide comments to the risk presentation to be considered for modification of the risk plans. It should be noted however that risk management will be an ongoing process and that the presentation at this review will be a snapshot of risk status. The CLV Project's risk management processes will be conducted by the various integrated teams and will be accountable to periodic Risk Review Boards.

Technical review data packages should be available from contractors not less than TBD days prior to the planned review. Further, briefing packages are expected to be provided not less than TBD days prior to the planned review. These periods of time are necessary in order to allow participants an adequate amount of time to become familiar with the review topics, status and issues.

5.3.10 Decision Analysis

Refer to the CLV Systems Analysis Plan for Decision Analysis description.

6.0 Technology Transition

The Constellation Program will be set up with Projects that are parallel to the CSLV Project, such as the CEV, Mission Operations, Ground Operations, and other Advanced Development Projects. Formal interaction between these projects will be through the Constellation Program Office. The technical interfaces between the CLV and the other Constellation Projects will be defined and documented in the interface requirements documents (IRDs) controlled by the Constellation Program.

Issues/risks that occur during the CSLV Project life cycle may warrant consideration for inclusion in the technology development activities that are being conducted by the Constellation Program or in other parallel projects to CLV. Requests or suggestions for additional tasks must be driven by risks and be accompanied by analysis of risk mitigation to the Element and the CLV system as a whole. Risk mitigation shall include a thorough analysis of technical performance, maintainability, reliability, supportability, operability, and testability. Any formal request for technology development tasks must go through the related technical review and a formal CSLV Project approval process (CSLV PCB). Communication and interaction is encouraged between the CSLV Project team members and the Advanced Development activities to identify areas for integration opportunities. For example, CLV personnel may be part of the reviews for an Advanced Development Project, and the Advanced Development Project team members may be part of the risk mitigation assessments for CLV issues and risks.

CLV may require significant technology development to accomplish its required missions, since new systems & subsystems will be implemented. The RSRM has increased from four to five segments and the RS-25 engine is being replaced with the J-2x. One of the Systems Engineering tasks for CLV will be a detailed technology assessment with allocation of risks and associated technology readiness levels TRLs to all subsystems and components.

7.0 Additional SE Functions and Activities

7.1 System Safety

Systems Safety Engineering processes (reference SR&QA Plan) are being conducted through the RBD IG described in 7.3.1.

7.1.1 Fault Tree/Event Sequence Analysis

Fault Tree Analysis (reference SR&QA Plan) is being conducted through the RBD IG described in 7.3.1.

7.1.2 Hazards Analysis

Hazards analysis (reference SR&QA Plan) is being conducted through the RBD IG described in 7.3.1.

7.2 Engineering Methods and Tools

The Integrated Collaborative Environment (ICE) will be the primary means for support integration and will include the tools specified in Table 7.2-1. ICE provides a suite of System Engineering tools to facilitate SE&I process and product development.

Windchill provides the project collaboration capability needed for project management and integration. Specifically, it allows users to access Web-based content including scheduled meetings, document updates, data management, configuration management, subject matter expertise, et.al. Programmatic documents and Plans will generally be developed using standard word processing applications and downloaded to Windchill.

CRADLE provides 1) requirements, verification & validation tracking, 2) and an integration and modeling tool for linking diverse engineering data to requirements. CRADLE also supports document development, and will be used to develop technical products suitable for database applications (such as the SRD, IRDs, ICDs, Doc Tree, DRL). In addition, informal review of the products can be conducted in CRADLE. For this version of the SEMP, official document review and configuration management of all data products will be performed in Windchill._For documents created in CRADLE, this is accomplished by exporting the CRADLE document to Windchill.

ARM will be the primary Risk Management tool, supporting the tracking and assessment of risks and related mitigation status.

SE Functions supported by these tools are shown in Table 7.2-1. SE Tool interfaces are shown in Figure 7.2-1 and Windchill/CRADLE document flows in Figure 7.2-2. Additionally, EV62 has developed a Review Process and Instructions manual, entitled *03 April Exploration CLV Review v1.0,* to assist with informal document reviews using CRADLE.

Table 7.2-1 Systems & Project Engineering Tools in ICE

Name	Systems Engineering Functions Supported	Comments
CRADLE	1) Manage requirements development 2) Define and display requirements traceability 3) Define and display the intended behavior of a system using FFBDs 4) Define and display traceability between FFBDs and requirements.	Used to develop the latest Level 3 CLV requirements. This tool supports modeling, traceability, document generation & maintenance, and export to Word & Excel formats.
Active Risk Manager (ARM)	1) Support risk communication, 2) Document, track, and report risks and concerns. 3) Provide a framework to implement the CRM paradigm and the policies outlined in the Risk Mgmt Plan.	Used to record all risk information in the ARM risk database. The risk database is accessible by all Project personnel via the Web. Once a risk has been assigned to someone, only that person shall have the authority to update the risk information. The progress of the Risk Mitigation Plan is tracked in the ARM waterfall charts.
Windchill	ProjectLink 1) Integration with Microsoft Office applications, and the Windows desktop 2) Real time visibility to current documents, parts, and plan information 3) Real-time group collaboration, both inside and outside firewall 4) Operates with Pro/ENGINEER and Windchill PDMLink for incorporation of product information in cross-enterprise activities PDMLink 1) Master data management repository 2) Connects to multiple desktop applications and Enterprise Resource Planning systems. 3) Controls and automates typically product change management processes 4) Operates with Pro/ENGINEER and Windchill ProjectLink for collaboration on data acquisition and product information	ProjectLink Collaboration software for sharing documented resources across the team, inside or outside of the firewall. Provides web based collaboration tools for group product development. PDMLink Product data management (PDM) tool allowing developers to control and manage product data from a single digital source.

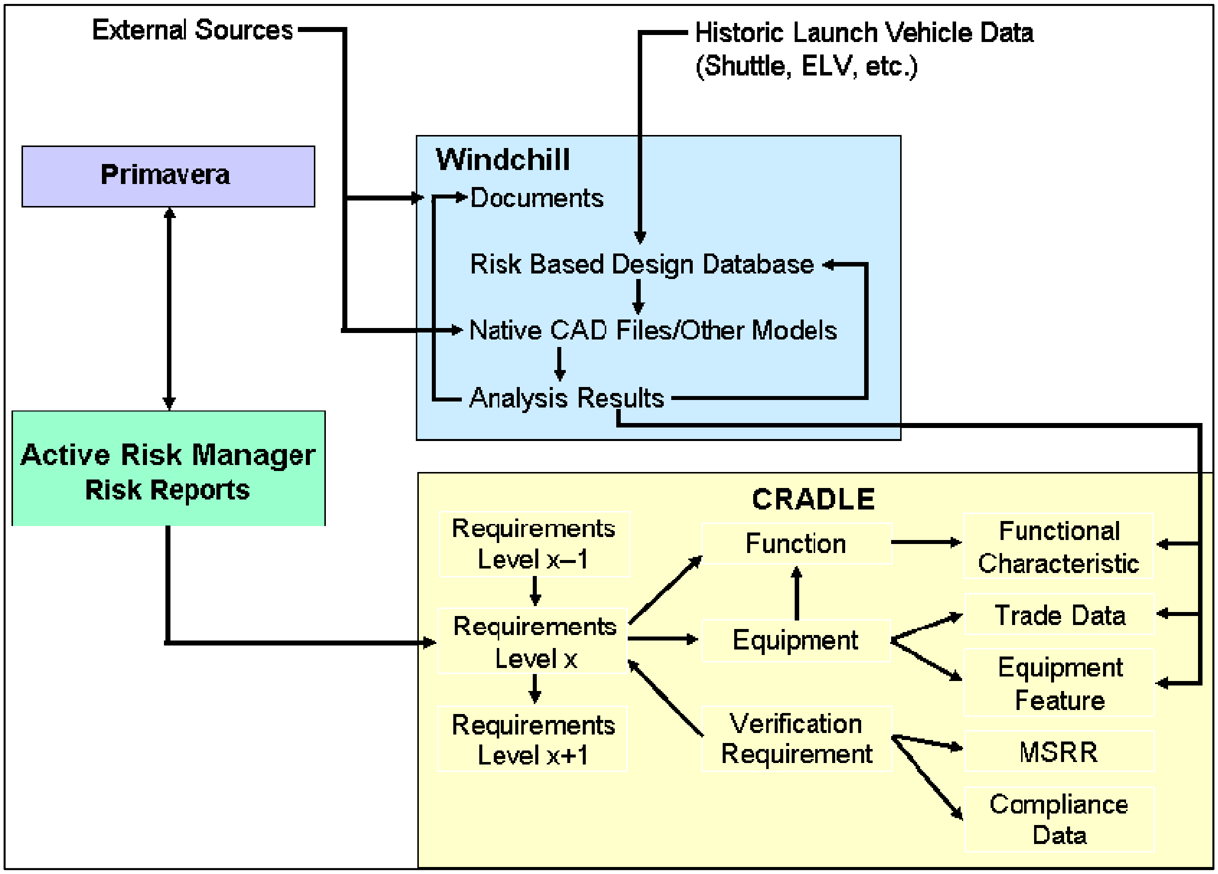


Figure 7.2-1 ICE Interface Diagram

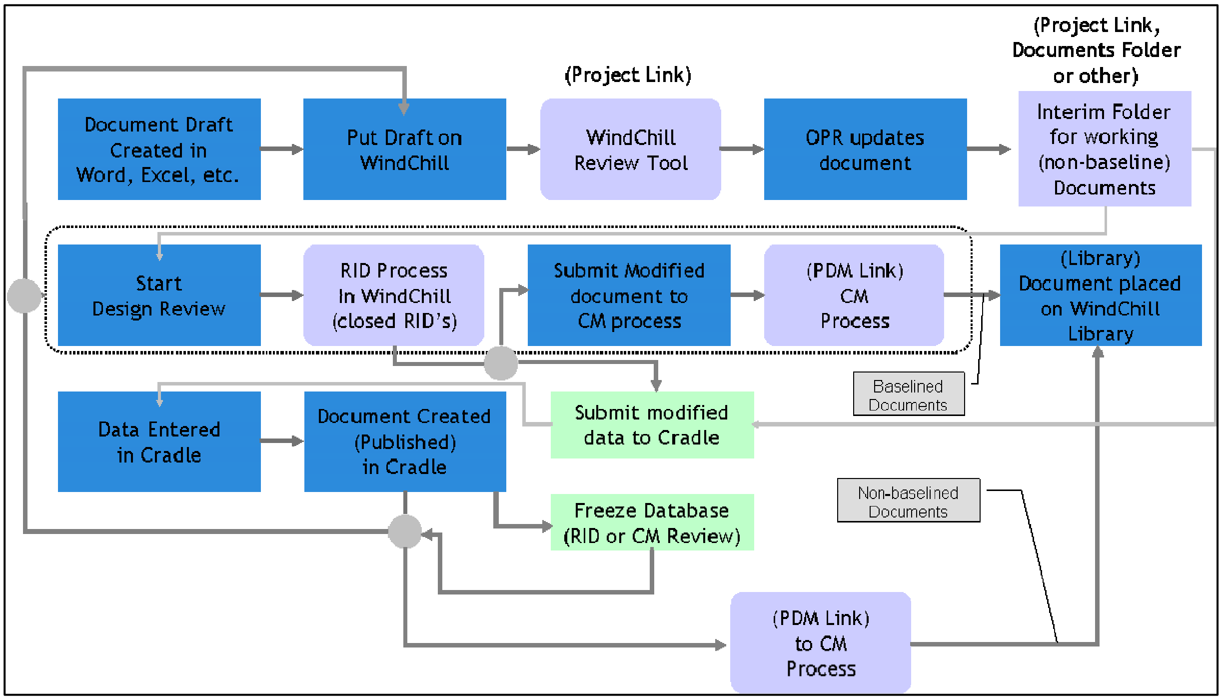


Figure 7.2-2 Windchill/CRADLE Document Review Process

Combined, these tools will provide the requirements management, risk management and document/data management capabilities required for a collaborative, organized Systems Engineering project.

7.3 Specialty Engineering

7.3.1 Risk-based Design

This section discusses roles and responsibilities in the risk-based design area – specifically Reliability, Maintainability, Supportability, System Safety, Manufacturability, Operability and Affordability. There exists a significant interrelationship in these efforts in each of the analysis products serving as inputs to other analyses. The term used for integrating these efforts in these disciplines for CLV is Risk Based Design (RBD) (ref. CLV Risk-Based Design Program Plan (CxP TBD)). In this context, risk is defined as any threat to life, property or mission that arises from the design, manufacture, operation, maintenance and support of the CLV. Because of these possible sources of risk, the disciplines enumerated above are included in the RBD process.

RBD will utilize S&MA approved processes established through NPR 8705.6, Safety and Mission Assurance Audits, Reviews, and Assessments. In addition, RBD will comply with the S&MA-subordinate requirements for RMS specified in the CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance Plan, CxP 72020.

The objective of risk-based design is to identify, characterize and design out, mitigate or flag for management action risk within the Element designs. Key to developing a risk-based design activity is the integration of risk identification and characterization within the design process. The risk based design approach will be used to prioritize allocation of resources to design solutions based on the reduction of overall system risk as described below.

For RBD, and System Safety, NASA and the contractor, where applicable, will utilize FMEA, Hazards Analysis and associated fault trees and functional flows to identify areas of risk within the Element design. Each design risk area will be addressed relative to all creditable failure modes and/or hazard conditions that apply over the operational phases of the Element. These risk areas will be addressed in terms of "root cause analysis" and "physics of failure" analysis to identify the driving factors relating to the failure or hazard events. The risk within the Element will be rank ordered in order to prioritize those that will provide the greatest reduction in integrated Element risk. Probabilistic design analysis will be performed to aid in the characterization of the relative degree of risk associated with each condition.

Consistent with standing NASA policy, the implementer will first address the risk from a design standpoint with the objective of eliminating or reducing the likelihood or impact of the risk. Where multiple failure modes exist the implementor will identify the driving or dominant failure mode as a function of likelihood and severity of the impacts of the failure mode. All design changes will be analyzed from the standpoint of their relative impact on the "overall" system risk. The level of analysis undertaken will be based on the fidelity of the data and models available but in all cases will be to a level where the "root cause" of the risk can be identified.

Risk allocations will be considered as points of departure only with the actual risk of the System/Element being established via a 'bottoms up analysis". Uncertainty analyses will be performed for all risk calculations and within each risk space sensitivity analysis will be performed to provide a better understanding of the limits associated with the design/risk envelope.

Risk based design activity will be an integral part of the normal design process and will be addressed at all design levels from the component to the Element level. Where dominate failure modes can not be designed out the design will incorporate specific provisions to address the points of risk, such provision may include but not be limited to, operating constraints, monitoring systems, relief provisions etc.

Each design package will include an identification and quantification of the various risk associated with the design. Additionally, the package will include all provisions and analyses associated with the elimination, mitigation and control of design risk.

As part of the risk-based design activities, a risk-based design plan will be developed.

7.3.1.1 Risk Integration Groups and Technical Panels

Integration of RMS and other discipline analyses and products will be a critical activity in the development of a new Exploration System. RMS activities and analyses will be performed at numerous levels of the program and will have to be integrated at both the CLV and exploration system levels. The RBD activity will be organized through an Integration Group in the VI&O Office, under which there will be permanent panels.

In order to support integration it is essential that all projects are consistent in approach, ground-rules and assumptions. The RBD IG will be responsible for developing the analysis approaches and methodologies, tools, and data requirements. The integration groups are not intended to be directive in nature, but rather to serve as a forum for discussion and concurrence among the discipline engineers on the approach to performing necessary analyses and analytical integration.

Membership in the technical panels will include discipline engineers responsible for integration as well as those assigned to the various projects, including both civil servant, mission services and prime contractor personnel.

The primary objective of the RBD IG is to provide policy, steering and guidance for the implementation of a risk-based design approach in the CLV/CaLV projects. The RBD IG will establish, in consultation with members from all program elements, standard ground rules, approaches and assumptions, processes and procedures, data, tools and models in order to minimize analytical integration difficulties.

A focus of the risk-based design approach is the integration of the disciplines enumerated above in the design of the CLV and CaLV. To this end the RBD IG includes in its organization a Reliability and Maintainability Panel, a Safety Panel, a Supportability and Operability Panel, and a Manufacturability and Affordability Panel. Through these panels the RBD IG will provide integrated vehicle level analyses and provide support to the CLV Element designers in the appropriate discipline areas.

The responsibility to report risks or issues will belong to every individual assigned to the CLV Project and its Elements, whether or not the individuals are assigned to an engineering line organization or a project office. However, this responsibility is especially important for the IGs and the TPs. In many cases, these individuals will be the first to notice an issue that affects cost and schedule and will be the first to report an issue as a risk or problem. Program cost and schedule will be considered constraints that must not be exceeded, while the system performance requirements must be met or exceeded. Any indication during CLV life cycle that any System or Element requirements will go unmet, or that the cost /schedule constraints may be exceeded (as denoted in the Launch Vehicle Project Plan), will be treated as Project risk. Such risk will be managed in accordance with the CLV Risk Management Plan.

7.3.2 Reliability Engineering

Reference CxP 72020, CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance (SR&QA) Plan.

7.3.3 Failure Modes and Effects Analyses (includes Critical Items List)

Reference CxP 72020, CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance (SR&QA) Plan.

7.3.4 Maintainability

Reference CxP 72020, CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance (SR&QA) Plan.

7.3.5 Operability Engineering

Reference CxP 72020, CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance (SR&QA) Plan.

7.3.6 Supportability Engineering

Reference CxP 72020, CLV Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance (SR&QA) Plan.

7.3.7 Manufacturability Engineering

Engineering will follow a discipline which influences the design process beginning with the initial design and lasting throughout the life cycle of the program, process, or activity to assure the hardware production and refurbishment system meets system availability and recurring cost metrics. Manufacturability data and statistics will be collected and reported. Participation by the manufacturability engineer in the design process will assure requirements development, tracking and allocation; trade support, design optimization to manufacturability metrics, and design criteria development. Technical performance metrics will be reported. Focus will be on test, demonstration and verification from a manufacturability perspective.

7.3.8 Affordability Engineering

Engineering will follow a discipline which influences the design process beginning with the initial design and lasting throughout the life cycle of the program, process, or activity to assure the launch system (vehicle, launch facilities, GSE, personnel) meets system recurring cost metrics. Affordability data and statistics will be collected and reported. Participation by the affordability engineer in the design process will assure requirements development, tracking and allocation; trade support, design optimization to affordability metrics, and design criteria development. Technical performance metrics will be reported. Focus will be on test, demonstration and verification from a manufacturability perspective.

7.4 Technical Decision Support

The CSLV Project will encounter many situations where the SEI and engineering team members will need to support another party in making a key technical decision. This will occur during the CLV Project execution during Non Advocate Reviews, and key CLV Program/Project management decisions. Another new area of technical support is to the new NASA Independent Technical Authority (ITA) process that came out of the Columbia Accident Investigation Board report [CAIB Recommendation 7.5-1].

"A primary objective of the ITA is to ensure that cost and schedule pressures do not unduly affect the decision-making process and inadvertently compromise technical decisions necessary for safe and reliable operations. To that end, the ITA is the owner of all technical requirements and participates with the programs/projects in setting both engineering standards and program-/project-derived technical requirements. The ITA evaluates technical variances, functions as the approval authority for all variances to requirements that the ITA determines may affect safety, and is a signatory to the Certification of Flight Readiness (CoFR)."

As per the NASA wide ITA process, the CSLV Project will implement the ITA through the CLV Chief Engineer, who will be the System Technical Warrant Holder (STWH). The CLV Chief Engineer will be responsible for determining how many of the Discipline Technical Warrant Holders (DTWH) the CSLV Project will have and which specific Work Breakdown Structure (WBS) levels need DTWH. The CLV Chief Engineer will also negotiate with the appropriate centers which DTWH are involved at what reviews, analyses and WBS levels. The CLV Chief engineer (as the STWH) has ownership of the requirements, the CSLV Project Manager has responsibility for the execution of those same requirements (likewise the Element STWH and the Element managers).

The CLV Chief Engineer, in exercising ownership of technical requirements, will ensure that the program/project has identified and imposed appropriate technical requirements to ensure a functional system that is safe and operationally reliable. The CLV Chief Engineer will signify such by signature. Paramount criteria for carrying out this duty will include both an understanding of the system in sufficient detail, and a current knowledge of the technical work occurring in the program to make sound, responsible technical decisions when determining the appropriate technical requirements on the program/project.

Ownership of technical requirements will include ownership of specifications and standards. While the CLV Chief Engineer will have the overall responsibility for ensuring that appropriate specifications and standards have been integrated and adopted by the program/project, the CLV Chief relies on the DTWH(s) or the Discipline Trusted Agents (DTrA) to determine that requirements and their associated standards are appropriate to ensure safe and reliable flight.

The CLV Chief Engineer will be responsible for approving, by signature, all variances written against approved technical requirements or any technical process or method that may affect safe and reliable operations.

8.0 Integration with the Project Plan & Technical Resource Allocation

8.1 Role and Responsibilities of CSLV Project Management (PM)

Figure 2.3-3 depicted the current CSLV Project organization including the PM and staff. The VI Project Manager will have total life cycle management responsibility for the Crew Launch Vehicle system. This will include management responsibilities for integration, modification, production, verification and validation, risk management, fielding, training, support, operations, and disposal. As such, the PM exercises programmatic, technical, and financial control of the project. The VI Manager will coordinate with the CLV Chief Engineer who will provide guidance and oversight to ensure that Systems Engineering policies and standards are flowed to and followed by the various Level III and IV organizations.

8.2 Role and Responsibilities of VI Chief Engineer

The VI Chief Engineer, subordinate to the PM, has complete technical authority for the CLV Project. In this capacity, the Chief Engineer also has responsibility for engineering processes and products. The Chief Engineer's responsibilities include, but are not limited to, the WBS, TPMs, EVMS, risk management, the specification tree and all technical project reviews. The Chief Engineer has overall responsibility for technical, test, production, quality, systems engineering, safety, and configuration management. The Chief Engineer will work with the embedded Systems Engineers from panels and groups to ensure mission-ready standards are met on time in support of the various program milestones. The Chief Engineer is also responsible for requirements management as well as risk management processes. Risk management will be performed using the Active Risk Manager (ARM) tool. This tool has been tailored for the CLV structure and tiered requirements flowdown which will be ensured by the CLV Project. Also reference section 4.3.1.

8.3 Authorities, Responsibilities and Integration Across Government and Contractor Boundaries

The selected Element contractors will be obligated to execute the workscope contained in the SOW which meets the requirements of the CARD and SRD. The Government team will exercise oversight responsibilities and ensure that the contractor maintains a course of action which will result in successful execution of the contract, providing products with the best possible value to the Government. Data Product Descriptions (DPDs) are an example of this requirement as non-standard formats and applicable content for data products can impact cost and schedule.

It is outside the Government team's role to give direction regarding every step the contractor takes in satisfying the contract; however, integrated team involvement by Government representatives will improve insight into the process and emerging baseline and allow the Government to assist the contractor in mitigating risk and identifying issues for resolution.

The intent will be to create a single team of Government and contractor representatives, where applicable, working together for on-time delivery of the CLV system which satisfies the requirements of the SOW. Every contractor team lead will have a Government counterpart working closely to achieve integrated team objectives. The Government representative will serve as a regular, active, productive team member and is expected to participate in all integrated team activities with full access to all engineering work products via internet tools. The Government representatives share responsibility with the contractor for identification of emerging issues and for proper interpretation of management indicators and their implications for changes in execution course. Government representatives do not have the authority to grant relief to the contractor for any contracted requirement. Any recommended changes to the contract by a technical team member will be coordinated through the Contract Officer.

Should program review entrance criteria not be met prior to the date of the respective review, the Government representative has the authority to delay the beginning of that review until entrance criteria are satisfied. The Government representative also has the authority to recommend that a review be closed if all work has been completed in good order, or to hold a review open if exit criteria are not met. Checklists for each technical review will be established; before a review begins, the respective review checklist must be signed by the VI PM and Chief Engineer.

In the event that a Government representative is unable to come to agreement with the contractor's integrated lead counterpart regarding a substantive issue, the issue will be elevated to the next level integration team lead for resolution.

On a quarterly basis, a cognizant Government representative will provide a status to VI to depict the current management indicators, significant achievements for the past quarter, current issues, risk and risk mitigation status, significant activities planned for the next quarter and identification of any "help needed". Charts will be structured to reflect incremental progress since the last quarter.

8.4 Government Insight into Subcontractor Efforts

Major subcontractors will be included in the Element integrated teams to increase visibility into their efforts. Flow-down of the requirement to collect subcontractor metrics and allow Government access to these metrics will be performed to increase visibility into the progress of efforts being conducted by the subcontractors. Metrics to be used will be similar, if not the same, as those discussed in paragraph 2.2.5.3.

8.5 Organization of Integrated Teams

The CSLV Project will be managed through the hierarchical structure described in Section 4.0. This approach uses multidisciplinary teams to optimize design & integration, manufacturing, and supportability processes. As a result, the individual integrated teams described previously are linked to promote enterprise-wide systems engineering processes. See Appendix G for related information on team charters.

Appendices

Appendices are included to provide a glossary, acronyms and abbreviations, and information published separately for convenience in document maintenance. Included are: (a) information that is pertinent to multiple topic areas (e.g., description of methods or procedures); (b) charts and proprietary data applicable to the technical efforts required in the SEMP; and (c) a summary of technical plans associated with the project.

Appendix A – Glossary [1]

Anomaly	A deviation from the norm.
Applicable Document	Document relevant to SEMP implementation which describes major standards and procedures that the technical effort must follow.
Architecture	The structure of components, their relationships, and the principles and guidelines governing their design and evolution over time [DoD Integrated Architecture Panel, 1995, based on IEEE STD 610.12]
Ascent	The function of liftoff from the Earth (or mission destination) surface, to spacecraft insertion into Earth/destination orbit.
Assembly	Two or more parts of subassemblies joined together to form a complete unit, structure, or other article.
Automated	Control or execution of a process, equipment or system with no human interaction, not excluding the capability for manual intervention/ commanding; however, manual intervention/commanding is explicitly not required to accomplish function.
Autonomous	Defined as a flight vehicle or space asset operating independent of external communication, commands or control (i.e., commands from mission control on Earth). Autonomous operations can be fully automated or require some degree of manual commanding/intervention by the onboard crew.
Cargo Launch Vehicle	Launch Vehicle delivering: 1) crew systems equipment needed to establish destination surface systems and support destination operations and 2) payloads which include research and technology demonstration equipment required to meet defined mission objectives; and returning 3) equipment and regolith/rock samples that must be delivered to Earth for analysis.
Common Support Services	The ground facilities and space-based assets that provide mission support to vehicle processing, mission planning, crew training, launch, flight control, communication, navigation, and crew and return vehicle recovery.
Component	Subsystem, assembly, or subassembly of an end item.
Contingency	A possibility that must be prepared for; a future emergency.
Control	Refers to the act of manipulating elements in order to execute the mission.
Crew	Any human onboard the spacecraft after the hatch is closed for flight or onboard the spacecraft involved in the operation of a mission.
Crew Exploration Vehicle (CEV)	The assembly for the Exploration Architecture that provides crew habitation and maintenance functions from launch to the intended destination and return to the Earth surface. Intended destinations include the International Space Station (ISS), Lunar Orbit, and Mars mission staging points in Earth vicinity. The CEV

[1] Reference CxP Glossary from Constellation SEMP CxP 70013

	includes the necessary propulsive acceleration capability to return the mission crew from the destination for direct entry at Earth return. The CEV includes capability for rendezvous with other necessary mission elements (e.g. ISS, LSAM) and un-crewed operation both in lunar orbit and while attached to the ISS. The CEV (Crew Exploration Vehicle) comprises the service module, crew module, and LAS.
Crew Launch Vehicle (CLV)	Human-rated vehicle that will deliver CEV into mission-specific Earth Ascent Target Orbit. The Crew Launch Vehicle comprises the first stage, upper stage, upper stage engine, and shroud (if needed)
Constellation Systems Launch Vehicle (CSLV)	The combined CLV & CaLV configuration as an integrated launch system for Moon and Mars exploration.
Disarm	The procedure that renders a hazardous system or subsystem inoperative to preclude premature operation and the potential effects. Disarming allows safe handling, transport, testing, and storage of the system or subsystem and can be reversed by simple actions.
Disposal	The act of getting rid of excess, surplus, scraps, or salvages property under proper authority. Disposal may be accomplished by, but not limited to, transfer, donation, sale, declaration, abandonment, or destruction.
Element	Physical entities, such as the Upper Stage, that have functional capabilities allocated to them necessary to satisfy system-level mission objectives within the Exploration architecture. Elements can perform all system functions within a mission phase, or through mated operations with other exploration elements (e.g. Crew Exploration Vehicle, Earth Departure Stage and Lunar Surface Access Module.
Flight Vehicle	A vehicle, which is generally composed of multiple elements, for transporting persons or things to a location outside of the Earth's atmosphere.
Ground Support Equipment	All non-flight equipment (mobile or fixed) required to support the Ground Operation and Maintenance (O&M) of a system. This includes associated multiuse support items, ground-handling and maintenance equipment, tools, meteorology and calibration equipment, and manual/Automatic Test Equipment (ATE).
Integration Group	Integration Groups provide forums to facilitate horizontal and vertical integration across all Launch Vehicle Elements, with the Constellation Program Office (CxPO), Safety and Mission Assurance (S&MA), Engineering Directorate (ED), and contractors. As part of the Launch Vehicle Project they serve as forums for communication, review, and provide recommendations to the Vehicle Integration WBS managers. They are chaired by a VI WBS Manager or designee. They are funded by the WBS Manager. They are organized as multi-disciplinary groups and are typically supported by Technical Panels. IGs have membership from ELO VI, S&MA, ED and the other CLV Element as required. They are established by the VICB.
Interstage	The section of a rocket between two stages, such as the spacing ring between the first and second stage of the Saturn V.

Logistics Support	An approach that enables disciplined, unified and iterative management of support considerations into system and equipment design. Logistics support includes development of support requirements that are related to readiness objectives, to design, and to each other. Requirements in turn drive acquisition of required support; logistics support is then employed during the operational phase.
Measure	The result of counting or otherwise quantifying an attribute of a process, project or product. Measures are numerical values assigned to attributes according to defined criteria. The raw data from which indicators are calculated. Some examples of these are size, cost and defects
Metric (Indicator)	1) A measure or combination of measures that provides insight into an issue or concept. Indicators are often comparisons, such as planned versus actual measures, which are usually presented as graphs or tables. Indicators can describe the current situation (current indicators) or predict the future situation (leading indicators) with respect to an issue.
Reference Document	Cross references to appropriate non-technical plans that interface with the technical effort.
Software	Computer instructions or data, stored electronically. Systems software includes the operating system and all the utilities that enable the computer to function. Applications software includes programs that do real work for users, such as word processors, spreadsheets, data management systems, and analysis tools. Software can be Commercial Off-The-Shelf (COTS), Contractor developed, Government Furnished, or combinations thereof.
Sustain	A Design and Logistics activity to determine whether out-of-spec conditions are acceptable on a temporary or permanent basis, to address obsolescence of components, to develop standard repair procedures that will return failed components to print or to an acceptable condition, and to design approved enhancements to the item. "Sustain" is performed on existing Program items. "Design and Develop" is performed on newly approved Program items, and transitions to "Sustain" following item acceptance.
System	A set or arrangement of interdependent elements/segments that are used to accomplish mission objective(s). The aggregate of the ground elements, flight elements, and workforce required for functions such as crew transportation or cargo delivery.
Tailoring	The documentation and approval of the adaptation of the requirements of a particular document to specific program or project needs. The results of such activity must be formally documented and approved by the cognizant AA's at a level appropriate to the particular requirements being tailored.
Technical Authority	The responsibility, authority, and accountability to establish, monitor, and approve technical requirements, products and policy for safe and reliable operation. [http://pbma.hq.nasa.gov/ita/index.html]

Technical Conscience	Technical conscience is the personal responsibility of engineers to provide safe and reliable technical products, coupled with an awareness of the avenues available to raise and resolve technical concerns.
Technical Panel	TPs provide a forum to address discipline-specific technical problems defined and assigned by Integration Groups, engineering support, CLV Elements, or within the panel itself. The panels provide technical review, advice and recommendations to the Integration Groups. TP input to IGs assure issues and technical products have been technically validated, comply with regulations, and meet CLV Element and VI requirements and milestones. TPs will have membership from WLO VI, S&MA, ED and the other Elements as required. The membership of the panel is funded through their Work Package Manager as normal work. Technical Panels are established by the VICB. The Panel Chairperson is appointed by the WBS Manager.
Technical Resource	A measure of a physical quantity of an engineering design value used to describe a consumable resource that can be budgeted, allocated and drawn on when needed during the design phase. Examples of this are Mass, Electrical Power and Energy, and Command and Data Management.
Technical Warrant Holder	A proven subject matter expert with mature judgment, who will operate from a technical authority budget independent from program budgets and program authority.
Upper Stage	A second or later stage in a multistage rocket.
Validation	A qualitative determination that the operation of a subsystem, subassembly, or component is satisfactorily performing its function to support operations. Validation is accomplished by review of ground or flight data and does not provide assurance that the operation is within performance specification limits.
Verification	The process of proving or demonstrating that requirements have been satisfactorily met through design and/or operational elements.
Working Groups	Wags will be formed on an ad hoc basis to perform specific tasks assigned by IGs, TPs, steering committees, or managers. The scope, membership and length of their activities will be under the purview of the IG, TP or organization that forms them. Working Groups are funded through WBS Managers or Work Package Managers.

Appendix B – Acronyms [2]

ADFT	Atmospheric Development Flight Test
AFSIG	Ascent Flight System Integration Group
AI&VST	Avionics Integration and Vehicle Systems Test
AR	Acceptance Review
ARM	Active Risk Manager
ASIG	Avionics and Software Integration Group
C3I	Command, Control, Communications and Information
CARD	Constellation Architecture Requirements Document
CCB	Configuration Control Board
CDR	Critical Design Review
CE	Chief Engineer
CEV	Crew Exploration Vehicle
CIL	Critical Items List
CLS	Crew Launch System
CLV	Crew Launch Vehicle
CSLV	Constellation Systems Launch Vehicle
CSM	Crew Service Module
CM	Configuration Management
COFR	Certificate of Flight Readiness
DAC	Design Analysis Cycle
DAWG	Design Analysis Working Group
DCR	Design Certification Review
DDD	Design Data Document
DDT&E	Design, Development, Test & Evaluation
DM	Data Management
DMP	Data Management Plan
DPD	Data Product Descriptions
DRL	Data Requirements List
DRD	Data Requirements Description
DTWH	Discipline Technical Warrant Holder
E3	Electromagnetic Environmental Effects
ECAN	Exploration Communications and Navigation System
ECB	Element Control Board
ECN	Engineering Change Notice
ECR	Engineering Change Request
ECLS	Environmental Control and Life Support
ED	Engineering Directorate
ELO	Exploration Launch Office
EOM	End of Mission
EMI	Electromagnetic Interference
ERB	Engineering Review Board
ESAS	Exploration Systems Architecture Study
EVA	Extra-Vehicular Activity
FMEA	Failure Mode and Effect Analysis
FOIP	Flight Operations Integration Group
FTA	Fault Tree Analysis
FRR	Flight Readiness Review
FS	First Stage

[2] Reference CxP Acronym List from Constellation SEMP CxP 70013

GN&C	Guidance, Navigation, and Control
GOIP	Ground Operations Integration Group
GSE	Ground Support Equipment
GSS	Ground Support System
H/W	Hardware
HWIL	Hardware-in-the-loop
IAW	In Accordance With
ICD	Interface Control Document/Drawing
IDA	Integrated Design and Analysis
IG	Integration Group
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IPT	Integrated Product Team
IRD	Interface Requirements Document
ISS	International Space Station
ITA	Independent Technical Authority
ITAR	International Traffic in Arms Regulations
IV&V	Independent Verification & Validation
LAS	Launch Abort System
LEO	Low Earth Orbit
LMS	Launch and Mission Support
MCC	Mission Control Center
MCR	Mission Concept Review
MIL	Military
MTVP	Master Test and Verification Plan
NAR	Non-Advocate Review
NGO	Needs, Goals & Objectives
NPD	NASA Policy Directive
OFT	Orbital Flight Test
OME	Orbital Maneuvering Engine
OPR	Office of Primary Responsibility
PCB	Program/Project Control Board
PDR	Preliminary Design Review
PM	Project Manager
POC	Point of Contact
PRA	Probabilistic Risk Assessment
PSIG	Propulsion System Integration Group
RAM	Responsibility Assignment Matrix
RBDIG	Risk-based Design Integration Group
RM	Risk Management
RV	Requirements and Verification
S&MA	Safety and Mission Assurance
SA	Spacecraft Adapter
SE	Systems Engineering
SEI	System Engineering and Integration
SEMP	System Engineering Management Plan
SI&C	System Integration and Control
SIG	System Integration Group
SLaTS	Space Launch and Transportation Systems course
SM	Service Module
SR&QA	Safety, Reliability, Maintainability, Supportability (RMS), and Quality Assurance
SRIIG	System Requirements and Interfaces Integration Group
SRD	System Requirements Document

SRR	System Requirements Review
STD	Standard
STPPO	Space Transportation Program/Project Office
S/W	Software
TA	Technical Authority
TBC	To be confirmed
TBD	To be determined
TBR	To be resolved
TIM	Technical Interchange Meeting
TLM	Telemetry
TP	Technical Panel
TPM	Technical Performance Metric/Measurement
TRL	Technology Readiness Level
US	Upper Stage
USE	Upper Stage Engine
V&V	Verification and validation
VI	Vehicle Integration
VICB	Vehicle Integration Control Board
VIO	Vehicle Integration and Operations
WBS	Work Breakdown Structure
WG	Working Group

Appendix C - Project Responsibility Assignment Matrix (RAM)

Lv3 Broad Area Rev List 11 April

Cradle #	Name	CLV Doc Number	Project Lead	Book Mgr	1st Milestone	1st Maturity	2nd Milestone	2nd Maturity	3rd Milestone	3rd Maturity	4th Milestone	4th Maturity	5th Milestone	5th Maturity	Description
7	CLV Concept of Operations	CLV-OP-20800	Rhodes	Joel Best	Lvl 3 - SRR	Baseline									
8	CLV Project Plan	CLV-MA-20000	Armstrong	H Snow	Lvl 3 - SRR	Baseline									
9	CLV Functional FMEA	CLV-SMA-21109	Nix	R Christenson	Lvl 3 - SRR	Draft									
10	Integrated Logistics Support Plan (ILSP)	CLV-LS-20600	Nix	S Huzar / J Neely	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
11	CLV Software Development Plan	CxP 72027	Monell	EV/Meg Stoud; EV/Darrell Bailey	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
13	CLV S/W Configuration Mgt Plan	CLV-CM-20101	Monell	EV/Meg Stoud; EV/Darrell Bailey	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
14	CLV Avionics H/W & S/W Integration Plan	CLV-SE-20907	Monell	B Feltner	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
15	Mass and CG Allocation (input to CLV & Element SRDs)	CLV-SE-20925	J Anderson	G Beech	Lvl 3 - SRR	Draft									
16	SEMP	CLV-SE-20900	D Williams	J Rice	Lvl 3 - SRR	Baseline									
17	SR&QA Plan	CLV-SMA-21100	Nix	V Strickland	Lvl 3 - SRR	Baseline									
18	Configuration Management Plan	CLV-CM-20100	Taylor	B Anglin	Lvl 3 - SRR	Baseline									
19	CLV E3 Control Plan	CLV-SE-20908	Monell	M McCollum	Lvl 2 - SRR	Draft	Lvl 3-SRR	Update	Lvl 2-PDR	Baseline	Lvl 3-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
20	CLV SRD	CLV-SE-20901	Langford	M Bailey	Lvl 3 - SRR	Baseline									

Cradle #	Name	CLV Doc Number	Project Lead	Book Mgr	1st Milestone	1st Maturity	2nd Milestone	2nd Maturity	3rd Milestone	3rd Maturity	4th Milestone	4th Maturity	5th Milestone	5th Maturity	Description
22	Master Verification Plan and Test Plan	CLV-VR-21300	Langford	D Prsha	Lvl 3 - SRR	Baseline									
23	CLV Risk Management Plan	CLV-MA-20002	J Taylor	V Kulpa	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
24	Stack Drawings		D Anderson	S Rowe	Lvl 3 - SRR	Draft									
25	Instrumentation Prog & Command List	CLV-SE-20924	Monell	D Bailey	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
26	CLV Systems Analysis Plan (SAP)	CxP 72024, CLV-SE-20906	Terry Taylor	P Luz	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
27	Schematics		D Anderson	S Rowe	Lvl 3 - SRR	Draft	Lvl 3-PDR	Complete (Not CLV PCB Controlled)							
30	Data Management Plan	CLV-CM-20200	Taylor	B Anglin	Lvl 3 - SRR	Baseline									
31	CLV SRR Plan	CLV-SE-20902	Taylor	D Williams B McKemie	Lvl 3 - SRR	Baseline									
33	CADRE (Updated Cost)	CLV-MA-20006	Pollard	Stone-Towns	Lvl 3 - SRR	Draft									
34	Supportability Analysis Reports	CLV-LS-20601	Nix	S Huzar	Lvl 3 - SRR	Draft									
38	Level III Margin Management Plan	CLV-SE-20909	J Taylor	G Beech	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
41	CLV Operations Sequence Timeline Flow	CLV-OP-20801	Rhodes	S Huzar	Lvl 3 - SRR	Draft									
42	Aerodynamics Analysis Report	CLV-SE-20931	D Anderson	L Huebner	Lvl 3 - SRR	Draft									
44	Integrated Fracture Analysis Report	CLV-DE-20304	D Anderson	G Swanson	Lvl 3 - SRR	Draft									

45	Integrated CLV Trade Studies Report	CLV-SE-20932	D Anderson	P Luz	Lvl 3 - SRR	Draft	Lvl 3-PDR	Update							
46	CLV Drawing Tree		Anderson	S Rowe	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
47	CLV Structural Loads Analysis Report (?)	CLV-SE-20933	D Anderson	D McGhee	Lvl 3 - SRR	Draft	Lvl 3-PDR	Update							
48	Structural Loads Data Book Guidelines and Dev Plan	CLV-SE-20910	D Anderson	D McGhee	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
49	CLV Thermal Analysis Report	CLV-SE-20934	D Anderson	L Turner	Lvl 3 - SRR	Draft	Lvl 3-PDR	Update							
50	Thermal Environmental Guidelines	CLV-DE-20300	D Anderson	T Dollman	Lvl 3 - SRR	Draft	Lvl 2 PDR	Baseline							
51	Material Usage Agreement	CLV-MP-20701	D Anderson	R Carruth	Lvl 3 - PDR	Baseline									
52	Manned SC Rec for Materials & Processes		D Anderson												Is this a Level 2 or 3 document??
53	Blast and Over Pressure Analysis Report	CLV-SE-20935	D Anderson	M Seaford	Lvl 3 - SRR	Draft	Lvl 3-PDR	Complete (Not CLV PCB Controlled)							
54	Debris Assessment Plan	CLV-SE-20911	D Anderson	A Droege	Lvl 3 - PDR	Baseline									
56	CLV Thermal Development Plan	CLV-SE-20912	D Anderson	T Dollman	Lvl 3 - SRR	Draft									
57	Thermal Environments Data Book	CLV-SE-20928	D Anderson	M D'Anostino	Lvl 3 - SRR	Draft	Lvl 3-PDR	Complete (Not CLV PCB Controlled)	Lvl 3-CDR	Update					
58	Attitude Control System Report	CLV-SE-20936	D Anderson	C Hall	Lvl 3 - SRR	Draft									
60	Acoustics Environments Data Book	CLV-SE-20929	D Anderson	M Seaford	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
62	CLV Acoustics Analysis Report	CLV-SE-20937	D Anderson	M Seaford	Lvl 3 - SRR	Draft	Lvl 3-PDR	Complete (Not CLV PCB Controlled)							

63	Electrical Power Control Plan	CLV-SE-20913	D Anderson	R White	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
64	Critical Math Models Identification and Plan	CLV-SE-20914	D Anderson	P Luz	Lvl 3 - SRR	Baseline									
66	Electromagnetic Environmental Effects Requirements	CLV-SE-20923	D Anderson	M McCollum	Lvl 3 - SRR	Baseline									
67	EEE Parts Control Plan	CLV-DE-20303	Monell	B Feltner	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
68	CLV GN&C System Design Document	CLV-SE-20938	D Anderson	M West	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
69	Lightning Protection Plan	CLV-SE-20915	Monell	M McCollum	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
71	CLV Modeling, Simulation & Support Plan	CLV-S/W-21202	Monell	M Prill	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Update	
77	Maintainability Analysis Report	CLV-SMA-21114	Nix		Lvl 3 - SRR	Draft									
85	FMEA/Hazards Format & Content	CLV-SE-20930	Nix	B Funderburg	Lvl 3 - SRR	Draft									
91	Materials Interface Usage List (MIUL)	CLV-MP-20702	D Anderson	D Wells	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
93	CLV Communication Plan	CLV-SE-20916	Armstrong	Pam Cross	Lvl 2 - SRR	Baseline									
94	Probabilistic Risk Assessment (PRA) Plan	CLV-SMA-21101	Nix	F Safie	Lvl 3 - SRR	Baseline									
99	Materials and Processes Control Plan	CLV-MP-20700	D Anderson	R Carruth	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
102	GN&C Analysis Report	CLV-SE-20939	D Anderson	J Hanson	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
105	Independent S/W Validation and Verification Plan	CLV-S/W-21201	Monell	D Bailey	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline	Lvl 3-CDR	Final (No further updates expected)					

127	Functional Flow Block Diagrams Report	CLV-SE-20940	Langford	M Alford	Lvl 3 - SRR	Complete (Not CLV PCB controlled)									
133	Fracture Control Requirement	CLV-DE-20301	Anderson		Lvl 3 - SRR	Baseline									
135	Acoustic Env. Data Book Guidelines & Dev Plan	CLV-SE-20918	D Anderson	M Seaford	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
136	Aerodynamic Data Guidelines & Dev Plan	CLV-SE-20919	D Anderson	L Huebner	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
138	Design Analysis Cycle Plan	CLV-SE-20920	D Anderson	B Williams	Lvl 3 - SRR	Baseline									
139	Contamination Control Plan	CLV-SE-20921	D Anderson	A Droege	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
140	Mass Properties Control Plan	CLV-SE-20922	D Anderson	G Beech	Lvl 3 - SRR	Baseline									
142	Integrated Hazard Analysis/Fault Tree Analysis	CLV-SMA-21111	Nix	J Weatherholt	Lvl 3 - SRR	Draft									
149	PRACA	CLV-SMA-21113	Taylor		Lvl 3 - SRR	Draft									
150	Reliability Analysis Report	CLV-SMA-21102	Nix	R Christenson	Lvl 3 - SRR	Draft									
151	QA Plan	CLV-SMA-21104	Taylor		Lvl 3 - SRR	Baseline									
152	Software QA Plan	CLV-SMA-21105	Monell	D Bailey	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 3-CDR	Final (No further updates expected)			
165	CLV CDR Plan	CLV-SE-20904	Taylor	D Williams B McKemie	Lvl 3 - PDR	Draft	Lvl 3-CDR	Baseline							
166	CLV PDR Plan	CLV-SE-20903	Taylor	D Williams B McKemie	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
167	CLV FRR Plan	CLV-SE-20905	Taylor	D Williams B McKemie	Lvl 3 - CDR	Draft	Lvl 3-FRR	Baseline							

169	CLV Development Plan	CLV-MA-20001	Armstrong		Lvl 2 - SRR	Baseline									
173	CLV Specification Tree	CLV-SE-20941	Taylor		Lvl 4 - SRR	Draft									
177	Integrated Vehicle Design Definition Doc	CLV-SE-20926	D Anderson	D Krupp	Lvl 3 - SRR	Draft	Lvl 3-PDR	Baseline							
178	First Stage - Upper Stage IRD	CLV-IRD-20400	Langford	P Wallace	Lvl 3 - SRR	Baseline	Lvl 4-SRR	Update	Lvl 4-PDR	Update					
179	Requirements Traceability Matrix Report	CLV-SE-20927	Langford	M Bailey	Lvl 3 - SRR	Complete (Not CLV PCB controlled)	Lvl 4-SRR	Update							
180	ICD 1st Stage to Upper Stage	CLV-ICD-20500	Langford		Lvl 3 - PDR	Baseline									
181	IRD Upper Stage to Engine	CLV-IRD-20401	Langford	S Forrester	Lvl 2 - SRR	Draft	Lvl 3-SRR	Baseline							
182	ICD Upper Stage to Engine	CLV-ICD-20501	Langford		Lvl 3 - PDR	Baseline									
262	Structural Loads Data Book	CLV-SE-20910	Anderson	D. McGhee											
263	Acoustic Env. Data Book	CLV-SE-20918	Anderson												
264	Aerodynamic Data Book	CLV-SE-20919	Anderson												
265	Launch Availability Analysis		Sexton / Rhodes	Huzar											
266	CLV Assembly Concept Drawing/ Models		Sexton / Rhodes	Huzar	Lvl 3 - PDR	Draft									
267	Spectrum Management Plan		Monell	E124/Matt McCollum	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Baseline	Lvl 4-PDR	Update	Lvl 3-CDR	Final (No further updates expected)	
268	Knowledge Management Plan	CxP 72027	Kulpa	T Dollman											
269	CLV Ground Ops Plan	CLV-OP-20802	Sexton / Rhodes												
270	CLV Safety Analysis Report		Taylor												

366	Integrated Master Schedule		Sexton												
438	CLV Software Reference Architecture Document		Monell	M Stroud D Bailey											
439	IP&CL Development Plan	CLV-SE-20924	Monell	D Bailey	Lvl 3 - SRR	Draft	Lvl 4-SRR	Update	Lvl 3-PDR	Update	Lvl 3-CDR	Baseline	Lvl 3-FRR	Final (No further updates expected)	
440	Functional Fault Analysis Document		Monell	M Watson											

441	CLV Trade Study Process	CxP 72025 MSFC-PLAN-3489	T. Taylor	P Luz	Lvl 3 - SRR	Baseline	Lvl 3-PDR	Update							The purpose of this docur is to communicate the Cre Launch Vehicle (CLV) Tra Study Process so that the project can conduct propo trade studies in a coordina manner that will clearly al the project to review and d sition the Trade Study Lea recommendation, whethe be to keep the Design Ana Cycle (DAC) Point of Dep (POD) “as-is” or to make a change to the next DAC’s chitecture. This process only applies trade studies to propose possible FROM-TO engin ing change request to the sign Analysis Cycle (DAC configuration. This proces does not apply to the norm engineering analyses that being worked to mature th mainline vehicle system d This process shall apply t Level 3 trade studies and Level 4 Element trade stu CLV Level 4 Elements ma decide what aspects of th process, if any, to apply to trade studies at Level 5 or below. The goal of the CLV Trade Study Process is to provid set of common outlines to utilized for key trade study products and to establish governance philosophy to differentiate which trades should be governed at the level by the Vehicle Integr Control Board (VICB) or th Element level by the Elem Engineering Control Boar (ECB).

442	Ascent Development Flight Test (ADFT) Test Plan		S Davis	M Boyd	Lvl 3 - SRR	Draft									
443	CLV Document Tree		J Taylor	R Erickson	Lvl 3 - SRR	Baseline	Lvl 3-PDR	Update							The Document Tree is a graphic output from the C Database (NOTE/Docume 2,3,4). The graphic can b produced with any of the ment attributes that are m tained in the document ta of the database.
444	CLV Subsystems Electromagnetic Characteristics Req'ts		Monell	M McCollum	Lvl 3 - PDR	Baseline									
445	CLV Avionics Development Plan		Monell	B Feltner											
446	CLV Avionics Reference Architecture Document		Monell	B Feltner											
447	CLV Avionics System Verification Plan		Monell	B Feltner											
448	CLV Avionics Equipment List		Monell	B Feltner											
449	CLV ESD Control Plan		Monell	B Feltner											
450	AVIST Applicable Standards List		Monell	B Feltner											Avionics Verification and grated System Test (AIVS
451	System Integration Lab (SIL) Con Ops Document		Monell	G Jones											
452	System Integration Lab (SIL) Requirements Document		Monell	G Jones											
453	System Integration Lab (SIL) Design Document		Monell	G Jones											
454	System Integration Lab (SIL) H/W Development Plan		Monell	G Jones											

455	System Integration Lab (SIL) S/W Development Plan		Monell	G Jones											
456	System Integration Lab (SIL)-CLV Interface Control Document		Monell	G Jones											
457	System Integration Lab (SIL) Integration Plan		Monell	G Jones											
458	System Integration Lab (SIL) CM Plan		Monell	G Jones											
459	System Integration Lab (SIL) Verification and Test Plan		Monell	G Jones											
460	System Integration Lab (SIL) IT Security Plan		Monell	G Jones											
461	Upper Stage Element Specification		Shelton		Lvl 3 - SRR	Draft									
462	First Stage Element Specification		Hester		Lvl 3 - SRR	Draft									
463	US Engine Element Specification		Ise		Lvl 3 - SRR	Draft									
464	EEE Parts Obsolescence Plan		Monell	B Feltner											
475	CaLV SRD		Langford												
476	CaLV Analysis Report <Placeholder>		D Anderson												
477	CaLV Integrated Vehicle Design Definition Doc		D Anderson												
478	CaLV Con Ops		S Rhodes												
479	CaLV Engine Spec		J Roman												
480	CaLV / CLV Commonality Assessment		Langford												
482	CLV Auto Sequence Timeline		D Anderson												

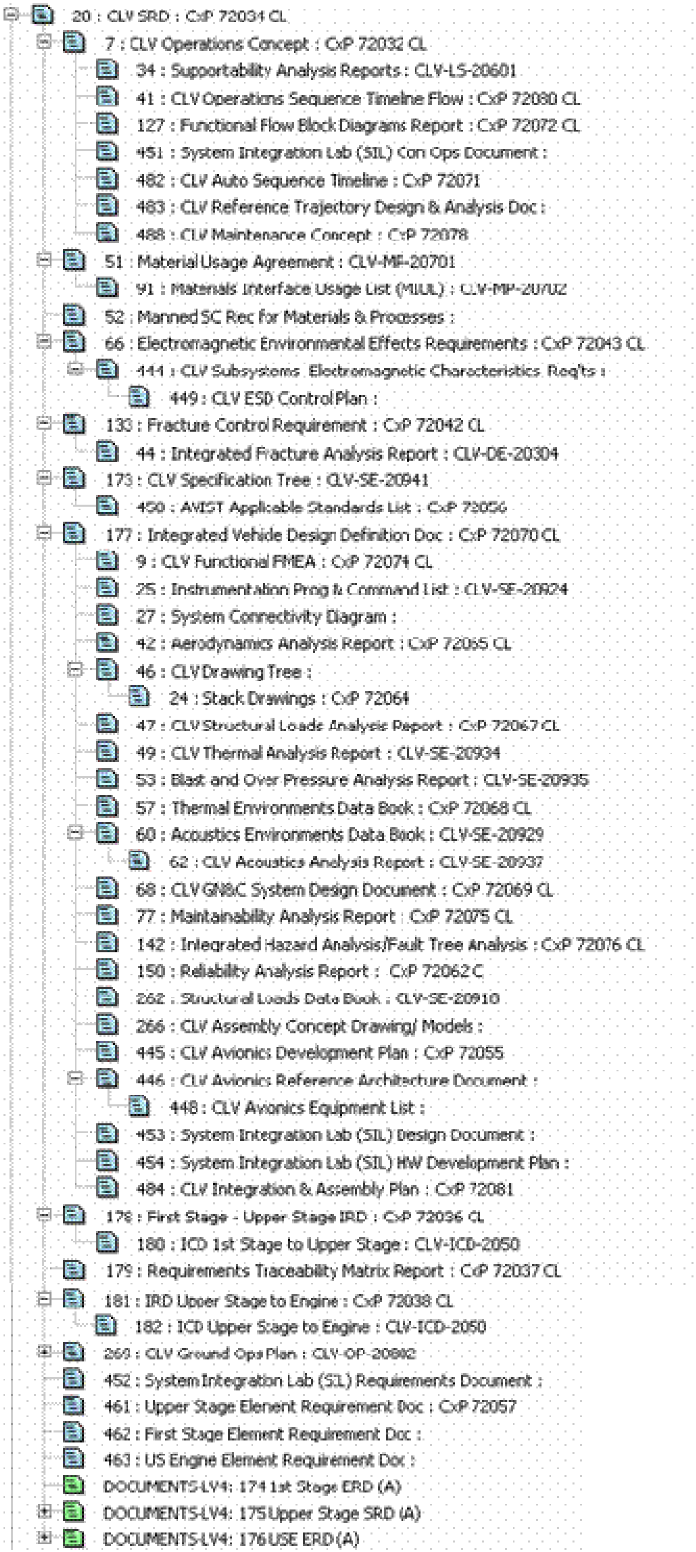
483	CLV Reference Trajectory Design & Analysis Doc		D Anderson	Mark Phillips											
484	CLV Integration & Assembly Plan		S Rhodes												
485	Risk Assessment Report / Root Source Analysis (RoSA)		Nix												
486	CLV Ground Support Eqmt (GSE Rqmts Doc)		S Rhodes												
487	CLV Logistics Support Analysis (LSA) Report		Nix												
488	CLV Maintenance Concept		Nix												
489	CLV Environmental Impact Statement		S Rhodes												
490	CLV Avionics Architecture		Monell												
491	CLV Software Architecture		Monell												
500	Work Breakdown Schedule (WBS)														
517	CLV Design Analysis Cycle-1 (DAC-1) Design Definition Docume	CxP 72026	D Anderson	R Williams											

Appendix D - Waivers

This Appendix contains all approved Waivers to the approved Center/mission directorate implementation plan requirement for the SEMP.

Not applicable for this version of the SEMP.

Appendix E – CLV Document Tree -- Technical side of Level 3 (5/12/06 version)



Appendix F – WBS Dictionary (TBD)

Appendix G – Level 3 Board, Technical Panel, and Integration Group Charters

Existing charters for the:

- Vehicle Integration Control Board,
- Vehicle Engineering Review Board,
- Risk Management Panel,
- Flight System Safety Panel,
- Systems Management Integration Group,
- Systems Requirements and Interfaces Integration Group,
- Test & Verification Panel, and
- Interface Control Panel

are shown below in the required template form. Remaining charters (e.g. Integration Groups) will be provided in SEMP updates.

Vehicle Integration Control Board (VICB) Charter – DRAFT

JP10 April 18, 2006

TO: Distribution

FROM: JP10/Jim Reuter

SUBJECT: Establishment of MSFC Crew Launch Vehicle (CLV) Vehicle Integration Control Board (VICB)

This charter establishes the CLV Vehicle Integration Control Board (VICB). The VICB is responsible for reviewing, guiding, and integrating the NASA and contractor technical work and products associated with the CLV flight and ground systems. The VICB Chairman is the CLV Vehicle Integration Office Manager.

The VICB is responsible for integration across all technical areas of the CLV Project. The VICB activities emphasize technical trades, requirements impacts, and data exchanges between the projects/elements/contractors for design, development, and operations activities. The VICB is responsible for defining and managing system-level requirements. This activity requires implementation, review, and evaluation of the systems analysis, trade studies, test planning, data analysis, and the interfaces necessary to complete the definition of the integrated flight and ground systems and assure compliance with the integrated CLV system requirements.

The management of the flight and ground systems integration is the responsibility of the MSFC CLV Vehicle Integration Office. The VICB is the mechanism by which the manager of the MSFC CLV Vehicle Integration Office assures the active participation of Systems Engineering and Integration, projects, elements, and support organizations.

The Vehicle Integration Control Board is responsible for the following:

Technical integration across the technical management areas of the CLV Project, involving all flight disciplines: aerodynamics; flight performance; loads and structural dynamics; electromagnetic effects; tracking and communications; acoustics; guidance; navigation and control integration; integrated propulsion and fluids; environmental control and life support subsystem design; thermal design (active and passive); integrated avionics; system and cargo integration; interfaces; and day-of-launch requirements.

Evaluating the technical adequacy and completeness of the activities associated with the integration of the flight systems for the CLV Project utilizing the institutional, contractor, and NASA centers resources, as required.

Performing periodic reviews of the CLV flight operations for compliance and compatibility with the integrated system requirements, identifying any system or performance deficiencies and initiating corrective action.

Performing periodic reviews of the status of flight systems under development. The reviews will ensure that development activities have adequate coordination and flow of input/output data across the technical interfaces and meet CLV requirements and/or milestones.

Providing a flight readiness statement relative to disposition of issues including generic certification issues.

The Vehicle Integration Control Board membership is as follows:

Responsibility	**Primary**	**Alternate(s)**
Chairman	JP10/Jim Reuter	JP10/Jim Taylor
Secretary	Colsa/Kenny Johnson	NP21/Bill Anglin
CLV Chief Engineer	NP01/Joe Brunty	
Safety & Mission Assurance	QD11/Van Strickland	
Systems Integration & Control	NP70/Jim Taylor	
Avionics Integration	JP10/Don Monell	
Integrated Design & Analysis	JP10/David Anderson	
Vehicle Integration & Opns.	JP10/Jeff Sexton	
Requirements & Verification	JP10/Gary Langford	
1st Stage SE&I Lead	JP20/Zena Hester	
Upper Stage SE&I Lead	JP30/Joey Shelton	
Upper Stage Engine SE&I Lead	JP40/William Greene	
Engineering Dir./Propulsion	ER01/Preston Jones	
Engineering Directorate	EV01/Paul McConnaughey	
JSC/Crew Representative	CB/Alan Poindexter	
JSC/CEV Representative	TBD	
KSC/LMS Representative	TBD	
LaRC Representative	TBD	
GRC Representative	TBD	
Other – As Required		

Time and location of the VICB meetings will be established by agenda and distributed by the Configuration & Data Management Office.

Revisions to this charter will be published as required when roles and responsibilities are further defined.

Jim Reuter
Manager
MSFC CLV Vehicle Integration Office

Vehicle Engineering Review Board (VERB) Charter

National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

ED04 April 10, 2006

TO: Distribution

FROM: ED04/Neil Otte

SUBJECT: **Amendment** to the Crew Launch Vehicle (CLV) Vehicle Engineering Review Board (VERB) Charter Membership

This memorandum supersedes memorandum ED04, dated March 17, 2006, which formally established the Crew Launch Vehicle (CLV) Vehicle Engineering Review Board (VERB), in accordance with MPR 8040.1. As technical authority for MSFC, engineering is accountable for technical adequacy of its products and services. The VERB provides the means to which MSFC engineering reviews and provides concurrence/non-concurrence on the technical adequacy of recommendations from the CLV Vehicle Integration Control Board (VICB). The VERB will perform the technical accountability function; the VICB shall remain the mechanism for technical integration.

The VERB Chairman shall determine the appropriate level of engineering management review for all deliverables and changes submitted for VERB review. Items receiving a non-concurrence by the VERB shall be forwarded to the MSFC Engineering Management Council (EMC) for disposition prior to submittal to the CLV Project Control Board (PCB).

The CLV Chief Engineer shall be the VERB Chairman. Primary VERB members, or designated alternates, shall be in attendance at all meetings, either in person, or via VTC/WebEx. The VERB may be convened as a face-to-face forum or concurrences/non-concurrences provided via an automated system, at the discretion of the Chairman.

The VERB Secretariat shall be responsible for the administration of the VERB (meeting agenda, minutes, action item tracking, etc.).

The VERB membership is as follows:

Responsibility	Primary	Alternate
Chairman	Neil Otte	Joe Brunty
Secretariat	Kathy Graham	Sid Stephenson
ED/Engineering Dir. Mgmt.	Alex Priskos	TBD
EI/Instrument & Payload Systems Dept.	Steve Pearson	Nelson Parker
EM/Materials & Processes Lab	Ralph Carruth	TBD
EO/Mission Operations Lab	Ann McNair	Jay Onken
ER/Propulsion Systems Dept.	Preston Jones	Steve Rodgers

RISK MANAGEMENT PANEL CHARTER

PURPOSE	**The Risk Management Panel (RMP) is established to provide a formal group focused on managing risk. Its purpose is to assess risks that have been nominated by project personnel and to periodically examine the overall CSLV project for risks that may need attention.** ***Periodically access the health of the risk management process.**
SCOPE OF WORK	**Candidate risks are presented to the Panel by an originator through a Risk Summary Worksheet, to ensure consistency and completeness. The Panel then applies risk analysis techniques to establish the risk as significant and valid. Further, the responsible IPTs develop appropriate risk mitigation plans and schedules and implement same, subject to the oversight and review by the Risk Management Panel.** ***Addresses the CSLV Project risks, including its elements and project offices.**
INTERFACES	**The RMP typically reports to senior project leadership when there are risks that require a higher level of attention, and works with elements on nominated and open risks.**
DESCRIPTION OF TASKS	**The RMP will perform oversight of the following Risk Management activities:** **- Implement Project Strategy** **- Analyze/Prioritize Risks (i.e. CSLV Top N Risk List)** **- Internal Risk Management (Cost/Sch/Tech/Safety Performance)** **- Monitor risk mitigation plan performance and advise project leadership of issues as appropriate** **-Monitor the health of the risk management process** **-Work with the project knowledge manage to ensure lessons learned are captured**

RISK MANAGEMENT PANEL CHARTER

RESPONSIBILITIES	**The RMP will implement the CSLV Risk Management Plan, collecting, assessing and ranking candidate risks. The Panel will maintain interfaces with Senior Leadership and elements for the conduct of higher-level project decisions and lower-level risk identification and mitigation. Panel decision making includes the following options:** ***accept, accept and escalate, accept and summarize, reject (handle as issue), reject (need more information), or reject.***
AUTHORITY	**The RMP is chaired by the CSLV Chief Engineer and CSLV Risk Manager or designees.**
ACCOUNTABILITY	**The RMP is accountable to the VI Manager and CSLV Project Manager.**
PRODUCTS	**Products of the Panel include risk management database, risk management briefings and reports, and risk mitigation assignments.**
APPROVAL	______________________ **CSLV Project Manager** ______________________ **VI Manager** ______________________ **Chief Engineer** ______________________ **Risk Manager**

RISK MANAGEMENT PANEL CHARTER

TEAM COMPOSITION	**Core Team Members**: • **Chief Engineer** • **Risk Manager** • **Business Management** • **Safety & Mission Assurance** • **Program Planning & Control Office** • **Element Chief Engineers** • **Element Systems Engineer & Integration Leads** • **Element Risk Management Officers** • **Panel Secretariat** **Associate Team Members**: • **Prime Contractors RMO**

Flight Safety System Panel

PURPOSE	**The Flight Safety System Panel (FSSP) is established to provide a formal group focused on managing range compliance issues across all CLV and VI elements. Its purpose is to address issues and establish priorities that involve multiple and/or competing interests.**
SCOPE OF WORK	**The FSSP provides a forum for the coordination of range safety compliance issues within the VI and the ELO. The FSSP provides periodic reviews of the status of CLV and its range compliance progress to the Systems Requirements And Interfaces Integration Group SRIIG. The reviews will assure that range safety compliance activities have adequate coordination and flow of input/output data across the technical interfaces and meet CLV milestones.**
INTERFACES	**The FSSP typically reports to senior project management in the SRIIG when there are integration issues or priorities that require a higher level of attention, and works with VI leads and Engineering representatives on open issues. The FSSP Chair is the Launch Vehicle Project Representative to the Launch Constellation Range Safety Panel (LCRSP). The LCRSP is the integrated NASA and United States Air Force 45th Space Wing Range Safety panel, chartered to interface and negotiate Constellation Range issues for the Constellation Program.**
DESCRIPTION OF TASKS	**The FSSP will support the following Vehicle Integration activities:** **- Provide forum for closure of range requirement issues** **- Provide integration of for Launch Vehicle range safety requirements between the Launch Vehicle Elements, and report progress to the LCRSP for integration with the Constellation elements.** **-Approval of interim versions of documentation used to demonstrate range compliance prior to presentation to SRIIG and eventually the LCRSP.**
RESPONSIBILITIES	**The Panel will maintain interfaces with the SRIIG, LCRSP, and Engineering for the conduct of higher-level project decisions and lower-level issue resolution and prioritization of integrated range safety compliance activities.**
AUTHORITY	**The FSSP is chaired by the Launch Vehicle Range Safety Representative, as designated by the Chair of the SRIIG.**

Flight Safety System Panel

ACCOUNTABILITY	**The FSSP is accountable to the SRIIG.**
PRODUCTS	**Products of the Panel include the "AFSPCMAN 91-710 Tailored for the CLV Project Range Users Requirements Document"; and the interface with the LCRSP.**
APPROVAL	**SRIIG Chair** ____ **Engineering Directorate** ____ **FSSP Chair** ____ **TBD** ____
TEAM COMPOSITION	**Core Team Members:** **VI Team Leads (5)** **VI Engineering Directorate Representative** **Associate Team Members:**

SYSTEMS MANAGEMENT INTEGRATION GROUP	
PURPOSE	**The Systems Management Integration Group (SMIG) is established to provide a formal group focused on managing issues across all CLV and VI elements. Its purpose is to address issues and establish priorities that involve multiple and/or competing interests.**
SCOPE OF WORK	**The SMIG will provide a forum for the coordination of integration issues within the VI element. The SMIG provides periodic reviews of the status of CLV trade studies under development for the ELO Project and provides status on risks to budget and schedule. The reviews will assure that development activities have adequate coordination and flow of input/output data across the technical interfaces and meet CLV requirements and/or milestones.**
INTERFACES	**The SMIG typically reports to senior project management (VICB) when there are integration issues or priorities that require a higher level of attention, and works with VI leads and Engineering representatives on open issues.**
DESCRIPTION OF TASKS	**The SMIG will support the following Vehicle Integration activities:** **- Provide forum for closure of integration issues with the Vehicle Integration element** **- Make Decisions within Budget** **- Analyze/Prioritize Vehicle Trade Studies** **- Monitor VI schedule performance and advise project management of issues as appropriate**
RESPONSIBILITIES	**The Panel will maintain interfaces with the VICB and Engineering for the conduct of higher-level project decisions and lower-level issue resolution and prioritization of integrated design activities. The SMIG will also charter Working Groups (WG) for specific issues as required to ensure integration across appropriate elements.**

ACCOUNTABILITY	**The SIP is accountable to the VICB.**
PRODUCTS	**Products of the Panel include design prioritization lists, trade study briefings and reports, and issue assignments for resolution.**
APPROVAL	__________________ **VICB Chair** __________________ **Engineering Directorate** __________________ **SMIG Chair** __________________ **TBD**
TEAM COMPOSITION	**Core Team Members:** **VI Team Leads (5)** **VI Engineering Directorate Representative** **MSFC Chief Engineer Representative** **Associate Team Members:**

SYSTEMS REQUIREMENTS AND INTERFACES INTEGRATION GROUP	
PURPOSE	**The Systems Requirements and Interfaces Integration Group (SRIIG) is established to provide a multilateral forum to manage the development and implementation of requirements and verification across all Crew Launch Vehicle (CLV) and Vehicle Integration (VI) elements. As part of the CLV Project Office, its purpose is to maintain consistency in both requirements and verification methodologies between the Constellation Program Office (CxPO), CLV Project Office and the CLV Elements.**
SCOPE OF WORK	**The SRIIG is the parent approval forum for five requirements and verification panels (System Requirements, Interfaces, Verification, Induced Environments and Flight Safety). All CLV requirements and verifications are the responsibility of this Group.**
INTERFACES	**The SRIIG reports to senior project management (VICB) on status of normal work progress and issues or priorities that require a higher level of attention. Work is typically integrated with other VI leads, Engineering representatives, Constellation Program Office and CLV Element Offices.**
DESCRIPTION OF TASKS	**The SRIIG will support the following VI activities:** **- Provide a forum for status and closure of requirements and verification work and issues within VI portion of CLV** **- Make VI-related expenditure decisions within budget** **- Coordinate technical support required to maintain a valid and cognizant set of requirements/verification within the bounds of Program and Project guidelines** **- Monitor VI schedule performance and advise project management of issues as appropriate**
RESPONSIBILITIES	**The Panel will maintain interfaces with the VICB and Engineering for the conduct of higher-level project decisions and lower-level issue resolution and prioritization of integrated requirements and verification activities.**
AUTHORITY	**The SRIIG is chaired by the Manager or Deputy Manager of the Requirements and Verification Team or his designee.**
ACCOUNTABILITY	**The SRIIG is accountable to the VICB.**
PRODUCTS	**Products of the Panel include design prioritization lists, trade study briefings and reports, and issue assignments for resolution.**

SYSTEMS REQUIREMENTS AND INTERFACES INTEGRATION GROUP		
APPROVAL	**VICB Chair** **SRIIG Chair**	**Engineering Directorate** **TBD**
TEAM COMPOSITION	**Core Team Members:** +**Panel Leads (5)** **CLV Element SE&I Representatives (3)** **VI Engineering Directorate Representative** **Associate Team Members:**	

TEST AND VERIFICATION PANEL	
PURPOSE	**The Test and Verification Panel (TVP) is established to provide a forum to manage verification issues across all Crew Launch Vehicle (CLV) and Vehicle Integration (VI) elements. Its purpose is to develop the Level III verification process and to maintain consistency in the verification methodologies among Constellation, CLV and VI elements.**
SCOPE OF WORK	**The TVP will provide a forum for the coordination of verification issues within the VI. The TVP will assess verification requirements, procedures development and verification activities to ensure T&V policy, guidelines, and requirements standards are met.**
INTERFACES	**The TVP reports to the System Requirements and Interfaces Integration Group (SRIIG) when there are verification issues that require a higher level of attention. TVP also works with VI leads and elements on verification requirements, procedures, activities and issues.**
DESCRIPTION OF TASKS	**The TVP will support the following VI activities:** **- Provide process for performing Level III verification** **- Provide implementation instructions for verification activities** **- Oversee Section 4.0 development of requirement documents and make recommendations to SRIIG** **- Review V&V activities for CLV elements** **- Coordinate Verification Closure Notices in Cradle**
RESPONSIBILITIES	**The TVP will maintain interfaces with the SRIIG, VICB, and Engineering for the conduct of higher-level project decisions and lower-level issue resolution and prioritization of integrated verification activities.**
AUTHORITY	**The TVP is chaired by the Manager of the Verification Team or his/her designee.**
ACCOUNTABILITY	**The TVP is accountable to the SRIIG.**

TEST AND VERIFICATION PANEL

PRODUCTS	**Products of the Panel include:** • **Assessment and recommendation of verification requirements above Element level** • **T&V policies, guidelines, standard requirements, and interface verification** • **Recommend approval of waivers, exceptions, and variance for verification requirements** • **Approves testing policy, and technical approaches to verification**
APPROVAL	**SRIIG Chair Engineering Directorate** **VICB Chair TBD**
TEAM COMPOSITION	**Core Team Members:** **CLV Element Representatives (3)** **Element Interface Representative (1)** **Engineering Directorate Representative (3)** **Engineering Verification Team (4)** **Associate Team Members:** **CEV Project Office (1)** **Ground Operations (1)**

INTERFACE CONTROL PANEL

PURPOSE	**The Interface Control Panel (ICP) is established to provide the means for identifying, defining, documenting and controlling the interfaces at level 3 of the CLV. It also Provides the means for changing the interfaces as required by the evolution of the design and for resolving interface incompatibilities.**
SCOPE OF WORK	**The IFP will guide management, control and documentation of all system functional and physical interfaces. It will establish interface control policies and procedures.**
INTERFACES	**TBD**
DESCRIPTION OF TASKS	**The ICP will support the following VI activities:** **- Establish IRD/ICD/ICN submittal/approval schedules** **- Establish other schedules such as data exchanges, problem resolutions and fit checks** **- Maintain list of authorized program CLV IRDs and ICDs** **- Review and coordinate all Engineering Change Proposals (ECPs) which affect interfaces** **- Identify interface impacts due to a requirement change, introduction of new interfaces or modification of existing interfaces**
RESPONSIBILITIES	**TBD**
AUTHORITY	**TBD**
ACCOUNTABILITY	**TBD**

INTERFACE CONTROL PANEL

PRODUCTS	**Products of the Panel include:** • **CLV Interface Control Plan which documents I/F control policies and procedures and provides guidelines for writing interface requirements and templates for preparing, revising and processing the interface documentation** • **Identification of participants for the I/F control process and their responsibilities** • **I/F management schedule**
APPROVAL	**ICP Chair** | **TBD** **TBD** | **TBD**

INTERFACE CONTROL PANEL

TEAM COMPOSITION	**Chair – Sandy Forrester** **Secretariat – Thurmon Allen** **1st Stage Project SE&I (as required)** **Upper Stage Project SE&I (as required)** **Upper Stage Engine SE&I (as required)** **LSSE's (as required)** • **Structures and Thermal** • **Propulsion** • **Avionics** • **Integ./Test Hardware** • **Mfg./Assembly** • **Logistics** **SM&A Rep – Jon Wetherholt** **Risk Management Rep – Marcie Kennedy**

Appendix H -- Element ERB Description

The Element ERB will be responsible for managing the technical characteristics of the Element. The ERB will coordinate with and route issues and changes that affect other Elements or other Projects to the VICB for further disposition. These issues may be routed to the VICB before or after approval of the Element PCB at the discretion of the Element Project manager. Final design configurations for major reviews are approved by the ERB and forwarded to the VICB for final approval prior to each review. The ERB is chaired by the Element Chief Engineer. The ERB will be responsible for the following ongoing activities:

- Final approval and control of ground rules and assumptions for the start of each Element DAC.
- Maintaining the current design configuration as a point of departure for each Element DAC and updating it with the results of each Element DAC
- Managing risk management activities of the Element
- Establishing and prioritizing the Engineering Top 10 risks and publishing the list periodically
- Acting as the Element Material Review Board (MRB) for the Element.
- Acting as preboard to the Element PCB.

The members of the Element ERB will be the Element Chief Engineer, Center Work Package Engineering Representatives, contractor representatives, VI Group representatives (TPs or IGs), Warrant Holders, or the appropriate designees.