

National Aeronautics and  
Space Administration

**SLS-SPEC-028**

**DRAFT FOR PDR**

**EFFECTIVE DATE: TBD**

**Draft Maturity 75%**

**March 7, 2013**

---

**CROSS-PROGRAM  
INTEGRATED VEHICLE  
STRUCTURAL DESIGN SPECIFICATION**

**Approved for Public Release; Distribution is Unlimited**

*The electronic version is the official approved document.*

*Verify this is the correct version before use.*

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 2 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

**REVISION AND HISTORY PAGE**

Status	Revision No.	Change No.	Description	Effective Date
Draft	-		Draft for PDR of SLS DRD 1406ST-001 for SLS PDR, MSFC 4511 Concurrence on file	TBD

**NOTE:** Updates to this document, as released by numbered changes (Change XXX), are identified by a black bar on the right margin.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 3 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

**TABLE OF CONTENTS**

<b>PARAGRAPH</b>	<b>PAGE</b>
1.0 INTRODUCTION .....	5
1.1 Background.....	5
1.2 Purpose.....	5
1.3 Scope.....	5
1.4 Change Authority/Responsibility.....	6
1.4.1 Document Update.....	6
1.4.2 Drawings Specified By This Document.....	6
2.0 DOCUMENTS.....	7
2.1 Applicable Documents.....	7
2.2 Reference Documents.....	7
3.0 PROGRAM AND ELEMENT PROCUREMENT CONTROL DRAWINGS .....	9
3.1 Specific Procurement Control Note Requirements.....	10
3.2 Purpose/Description of the Program or Element Procurement Control Drawings .....	11
3.2.1 Program and Element OML .....	12
3.2.2 Program or Element GN&C Related Dimensional Attributes .....	12
3.2.3 Program and Element Gross Tolerances .....	12
3.2.4 Interface Information and Other Design Data.....	13
3.3 Installation Drawing Responsibility .....	13
3.4 Change and Release of the Procurement Control Drawing .....	13
4.0 INTEGRATED VEHICLE STRUCTURAL DESIGN .....	15
4.1 Exploration System.....	15
4.2 Launch System Assembly.....	15
4.3 Integrated Launch Vehicle Assembly, SLS .....	15
4.4 Launch Vehicle Assembly, SLS .....	15
4.5 Integrated Launch Vehicle Assembly Envelope and Alignment Drawing.....	15
4.6 Installation Drawing Responsibility .....	16
4.7 Environmental and Operational Effects.....	16

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 4 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

**APPENDIX**

APPENDIX A ACRONYMS AND ABBREVIATIONS AND GLOSSARY OF TERMS .....17

APPENDIX B 10000 SERIES INTEGRATED LAUNCH SYSTEM STRUCTURAL DESIGN DATA ARCHITECTURE .....20

APPENDIX C OPEN WORK .....22

APPENDIX D INTEGRATED LAUNCH SYSTEM .....24

**TABLE**

TABLE B-1. INTEGRATED LAUNCH SYSTEM STRUCTURAL INTERFACE INSTALLATION DRAWING ASSIGNMENTS .....20

TABLE C1-1. TO BE DETERMINED ITEMS .....22

TABLE C2-1. TO BE RESOLVED ISSUES .....22

TABLE C3-1. FORWARD WORK .....23

TABLE D-1. INTEGRATED LAUNCH SYSTEM STRUCTURAL INTERFACE CONTROL DOCUMENTS .....24

**FIGURE**

FIGURE 3-1. RELATIONSHIP OF THE PROGRAM OR ELEMENT PROCUREMENT CONTROL DRAWING TO GENERIC DESIGN DRAWINGS .....10

FIGURE 3-2. RELATIONSHIP OF PROGRAM OR ELEMENT DESIGN DATA TO THE PCDS, NEXT HIGHER ASSEMBLIES, AND INTEGRATED VEHICLE CAD PRODUCTS .....11

FIGURE 3-3. PROGRAM OR ELEMENT GROSS TOLERANCES .....12

FIGURE 3-4. REPRESENTATIVE PROCUREMENT CONTROL DRAWING .....14

FIGURE B-1. 10000 SERIES VEHICLE INTEGRATED LAUNCH SYSTEM DRAWING TREE .....21

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 5 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

## 1.0 INTRODUCTION

### 1.1 Background

Vehicle structural attributes affect vehicle performance and the integration and assembly of hardware systems. The most significant structural attributes are the vehicle's flight surfaces as described in the integrated vehicle outer mold line (OML), guidance, navigation, and control (GN&C) attributes, relevant vehicle attributes such as gimbal points, thrust vectors, etc., and gross alignment and tolerance condition of each Program or Element. Therefore, these structural attributes are required to be specified, managed, and controlled. In order to manage and control the key structural attributes, a structural design data architecture (composed of Program or Element vehicle drawings and computer-aided design (CAD) models) must be established.

The structural design data architecture described herein follows the traditional "drawing tree" hierarchy of structural design integration with exceptions noted for the mandatory maintenance of certain CAD models containing information required for the next higher assembly (NHA).

### 1.2 Purpose

This document, the Cross Program Integrated Vehicle Structural Design Specification, specifies the integrated vehicle structural design, establishes the data architecture for the Programs and Elements comprising the launch vehicle, payload, or spacecraft, and the structural interfaces with ground systems. Further, this document assigns responsibilities for the preparation and maintenance of drawings and CAD models comprising the integrated vehicle structural design. The intent is to keep a unified approach to allow CAD models and drawings to flow upward into an integrated structural design.

### 1.3 Scope

This document applies to the Ground Systems Development and Operations (GSDO) Program, the Orion Multi-Purpose Crew Vehicle (MPCV) Program, and the Space Launch System (SLS) Program including the Core Stage Element, Booster Element, and the Integrated Spacecraft and Payload Element (ISPE). This document establishes the structural design data architecture, the associated CAD drawing and model relationships, and the control and communication of the integrated vehicle structural design to various vehicle, Program, or Elements, and ground systems design, analysis, and integration functions.

This document applies to the following specific products: Program or Element assembly drawings, Program or Element installation drawings, procurement control drawings (PCDs), integrated vehicle-level assembly drawings, integrated vehicle-level OML drawings, integrated vehicle-level alignment drawings, and to the associated CAD models from which the previously mentioned drawings are derived.

SLS-SPEC-028 supersedes SLS-SPEC-049, SLSP Integrated Vehicle Outer Mold Line Specification. All configurations prior to the release of SLS-SPEC-028 are captured in SLS-SPEC-049. Once SLS-SPEC-028 becomes effective, SLS-SPEC-028 becomes the Integrated Vehicle Structural Design Specification (and thus has governance over OML specifications)

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 6 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

from that point forward. At that point, SLS-SPEC-049 will remain the unchanged artifact of prior configurations.

## **1.4 Change Authority/Responsibility**

The NASA Office of Primary Responsibility (OPR) for this document is Marshall Space Flight Center (MSFC) EV30, Structural Design and Analysis Division.

Proposed changes to NASA controlled documents, models, and drawings described herein will be submitted by an SLS Program change request (CR) to the Program-defined control board for disposition. All such requests will adhere to the SLS-PLAN-008, SLS Program Configuration Management Plan.

### **1.4.1 Document Update**

This document shall be updated as required.

### **1.4.2 Drawings Specified By This Document**

Changes to drawings and/or CAD models specifically called out in this document shall refer to this document for baseline documentation affected, and/or NHA, and/or associated CAD models when processing any change request.

Also note: NASA-produced drawings called out by this document (which specify the element and vehicle design configuration) contain the base drawing and dash number. Revision and effectivity information is captured within the configuration management (CM) system.

Drawings specified by this document, SLS-SPEC-028, are shown in Appendix B, Figure B-1.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 7 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

## 2.0 DOCUMENTS

### 2.1 Applicable Documents

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The pertinent version is specified in this list.

None

### 2.2 Reference Documents

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

ASME Y14.41M	Digital Product Definition Data Practices
ASME Y14.5M-1994	Dimensioning and Tolerancing
MPCV-T-029600	Orion-MPCV to SLS Interface Control Document-Hardware
MSFC-HDBK-3644	Design Product Packages for Launch Vehicle Integration Handbook
MSFC-STD-2806	MSFC Tailing Standard for the GDRM Tenth Edition
MSFC-STD-3528	MSFC Technical Standard Computer-Aided Design (CAD) Standard
MSFC-STD-555	MSFC Engineering Documentation Standard
NASA/SP-2007-6105	NASA Systems Engineering Handbook
NASA-STD-T-0007	NASA Computer-Aided Design Interoperability Standard
SLS-ICD-052	Space Launch System (SLS) to Ground Systems Development and Operations (GSDO), Volume 1 through 5
SLS-PLAN-004	Space Launch System Program (SLSP) Data Management Plan (DMP)
SLS-PLAN-008	Space Launch System Program (SLSP) Configuration Management Plan (CMP)
SLS-PLAN-035	Space Launch System Program (SLSP) Assembly and Integration Plan

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 8 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

SLS-PLAN-099	Space Launch System Program (SLSP) Verification and Validation Plan
SLS-RQMT-014	Space Launch System Program (SLSP) Safety and Mission Assurance (S&MA) Requirements
SLS-SPEC-048	Space Launch System Program (SLSP) Integrated Vehicle Coordinate Systems

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 9 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

### 3.0 PROGRAM AND ELEMENT PROCUREMENT CONTROL DRAWINGS

The integrated launch vehicle is composed of components designed and procured from several different sources. In order to integrate these components, CAD models and information from each Program or Element must be transferred to the integrated assembly and integration organization (MSFC Structural and Mechanical Design Branch/EV32), and configuration controlled. The integrated assembly and integration organization will use the information provided by each Program or Element to generate PCDs for this purpose.

The Program and Element PCDs are used to specify the structural design attributes required for assembly/integration at the NHA. PCDs are used to document the vehicle configuration without full specificity of each and every Program or Element component. PCDs are also used where the Program or Element is managing the configuration within a contractor controlled configuration management system.

The Program or Element PCD specifies the OML configuration; the location of GN&C related dimensional attributes, and key interfaces. Refer to Figure B-1 of Appendix B for the location of the Program or Element PCDs within the 10000 Series Vehicle Integrated Launch System Drawing Tree.

The Program or Element PCD is depicted in the flight configuration with all installations included. Examples of the installations to be included are access doors, close-out assemblies, thermal protection systems (TPSs), attachment hardware, loose parts kits, etc.

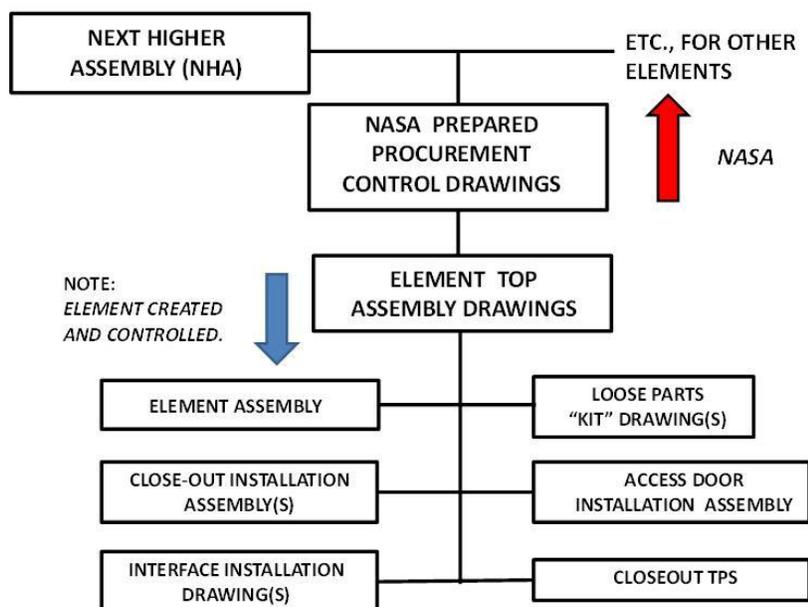
Similarly, CAD models representing the OML, etc., submitted by the Program or Element to the NHA are configured to represent the “as assembled” flight configuration.

Thus, the Element (or Program defined) PCD governs the referred to Program or Element top assembly drawing(s) with all associated installations (such as installation drawings or kit drawings). All forward work and assembly responsibilities required for each Program or Element will be assigned.

Figure 3-1 depicts the PCD relative to a generic program or element drawing (data) architecture.

In summary, the PCD is:

- Generated by the integrated assembly and integration organization/MSFC-EV32, using information obtained from existing data requirement descriptions (DRDs).
- Approved for an Element through the SLS Chief Engineer’s Control Board (CECB).
- Approved for Programs through the Joint Integration Control Board (JICB).
- Used to create the integrated vehicle CAD models and drawings from CAD models and information contained in each PCD.



**Figure 3-1. Relationship of the Program or Element Procurement Control Drawing to Generic Design Drawings**

*Note: Kit and installation drawings are the responsibility of that Program or Element. Element drawings listed are for reference only.*

### 3.1 Specific Procurement Control Note Requirements

As a minimum, Program or Element PCDs will contain the following types of notes modified as required.

- Suggested source of supply:
  - Element Contractor Name.
  - Element Contractor Address.
  - Element Contractor Cage Code.
  - Part number (Element Contractor Technical Specification or part number).
- Alignment and guidance, navigation, and control point information is contained in the Integrated Launch Vehicle Assembly Envelope and Alignment Drawing.
- The CAD model associated with this drawing defines the nominal element OML.
- Applicable interface control document (ICD) reference notes.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 11 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

- This drawing meets the requirements of SLS-SPEC-028. Changes to this drawing shall adhere to SLS-SPEC-028 for documentation affected and the associated CAD models.

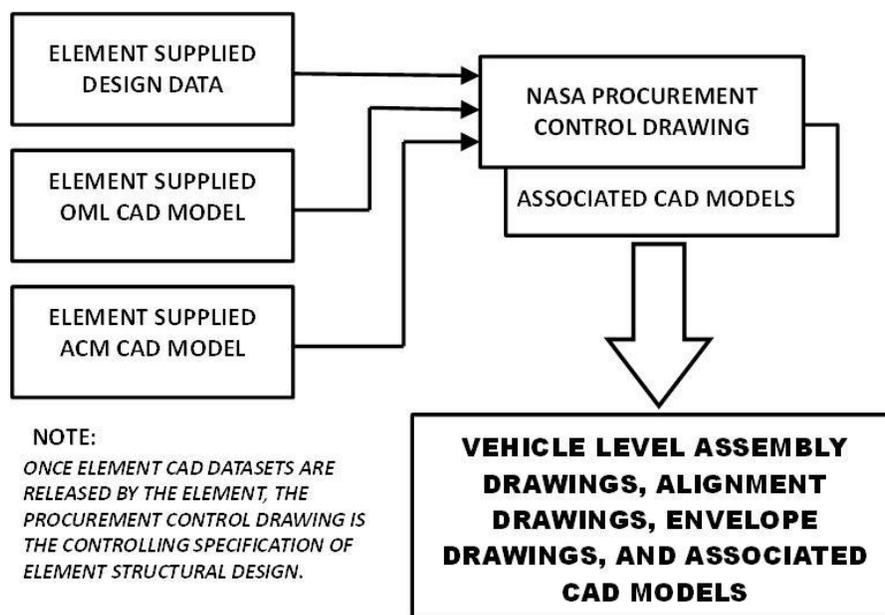
### 3.2 Purpose/Description of the Program or Element Procurement Control Drawings

The Program or Element PCD documents and controls the approved Program or Element configuration. The Program or Element PCD contains only the structural design attributes that are required for assembly/integration at the NHA as well as the vehicle alignment and control information needed for integrated vehicle design and analysis.

The Program or Element PCD is constructed from data items (drawings, CAD models, data files, etc.) which are furnished by the Program or Element through agreed-upon data exchange processes. The PCD serves to document the Program or Element structural design and feeds this information to vehicle design drawings at the NHA, as shown in Figure 3-2.

Any change to information controlled by the PCD is categorized as a Class 1 change.

For a more in-depth discussion of the terminology to follow, refer to MSFC-HDBK-3644, Design Product Packages for Launch Vehicle Integration.



**Figure 3-2. Relationship of Program or Element Design Data to the PCDs, Next Higher Assemblies, and Integrated Vehicle CAD Products**

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 12 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

### 3.2.1 Program and Element OML

The Program or Element's OML will be specified by the PCD and associated CAD model (which is produced by the Program or Element). The nominal, or perfect form, dimensions will be documented by the model; form tolerances and reference dimensions will be given on the drawing.

The Program or Element OML drawing will be depicted in the flight configuration with all attaching hardware, close-outs, etc., in place. Therefore, the Program or Element CAD model will include all of these features.

### 3.2.2 Program or Element GN&C Related Dimensional Attributes

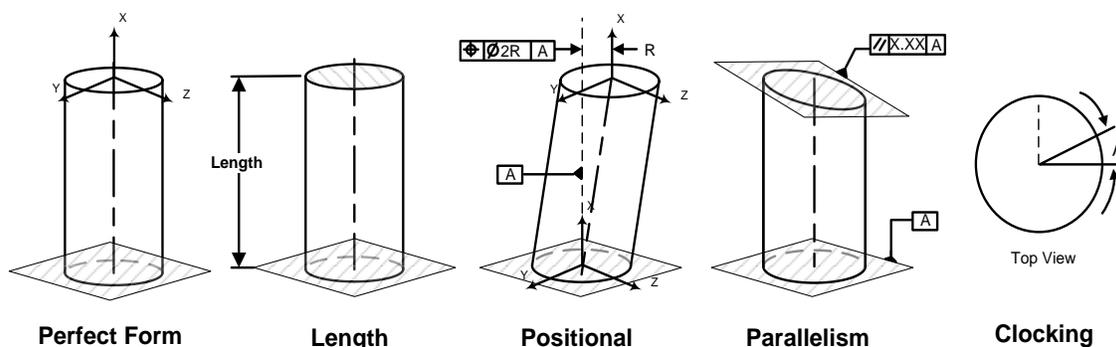
The GN&C-related dimensional attributes include the location and tolerance condition of structural design attributes associated with flight guidance and control. Examples of these attributes include: thrust vectors, gimbal points, sensors, actuator attachment points, tank centroids, etc.

This dimensional data will be on the PCD. The associated CAD model for these attributes is the Program or Element-produced alignment control model (ACM).

Where applicable, a distinction shall be made for environmental, thermal, or loading effects.

### 3.2.3 Program and Element Gross Tolerances

The Program or Element gross dimensional tolerances should be reported as shown by example in Figure 3-3. These ICDs surfaces shall be used by the integrated assembly and integration organization to publish the off-nominal vehicle stack envelope. This product will be coordinated with the Program or Element OML products. This product only includes normal manufacturing and assembly tolerances, and does not include any number of environmental or loading effects. The Program or Element gross tolerances are required for vehicle assembly and GN&C analysis.



**Figure 3-3. Program or Element Gross Tolerances**

*Note:* These tolerances will be defined on the PCD.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 13 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

### 3.2.4 Interface Information and Other Design Data

#### 3.2.4.1 Interfaces

Program or Element CAD model submissions will contain ICD reference data which are used to verify vehicle and launch system ICDs. These ICDs are controlled by the documents listed in the table in Appendix D. The ICDs will be referenced on the PCD; the ICD-related CAD models are archived by the vehicle design function (see Section 4.0). The Program or Element-produced CAD models associated with interface definition are the interface control model (ICM) and the interface detail product (IDP), which define the individual interfaces.

#### 3.2.4.2 Other Data

In addition to CAD models previously defined, other data or data formats may be required to produce integrated vehicle-level integration products and/or PCDs. This could include any tolerance spreadsheets, drawings, documents, tanking tables, etc., necessary to produce the items listed above.

### 3.3 Installation Drawing Responsibility

Installation drawing responsibilities are given in Table B-1, Appendix B.

### 3.4 Change and Release of the Procurement Control Drawing

Information contained in the PCDs will be coordinated with the individual Program or Elements to define the baseline of information required by Level II (the integrated vehicle design function). An authorized representative from the appropriate Program or Element will concur with the PCDs prior to submission to the CECB or JICB. MSFC Form 4511, SLS Data Concurrence Sheet, shall be used to document Program and Element concurrence. The Program or Element models and CAD used in generating the PCD will be documented in the release paperwork for the PCD.

Any additional approvals to the NASA-prepared PCD are <TBD-001>.

Figure 3-4 depicts a representative PCD for the Booster Element.

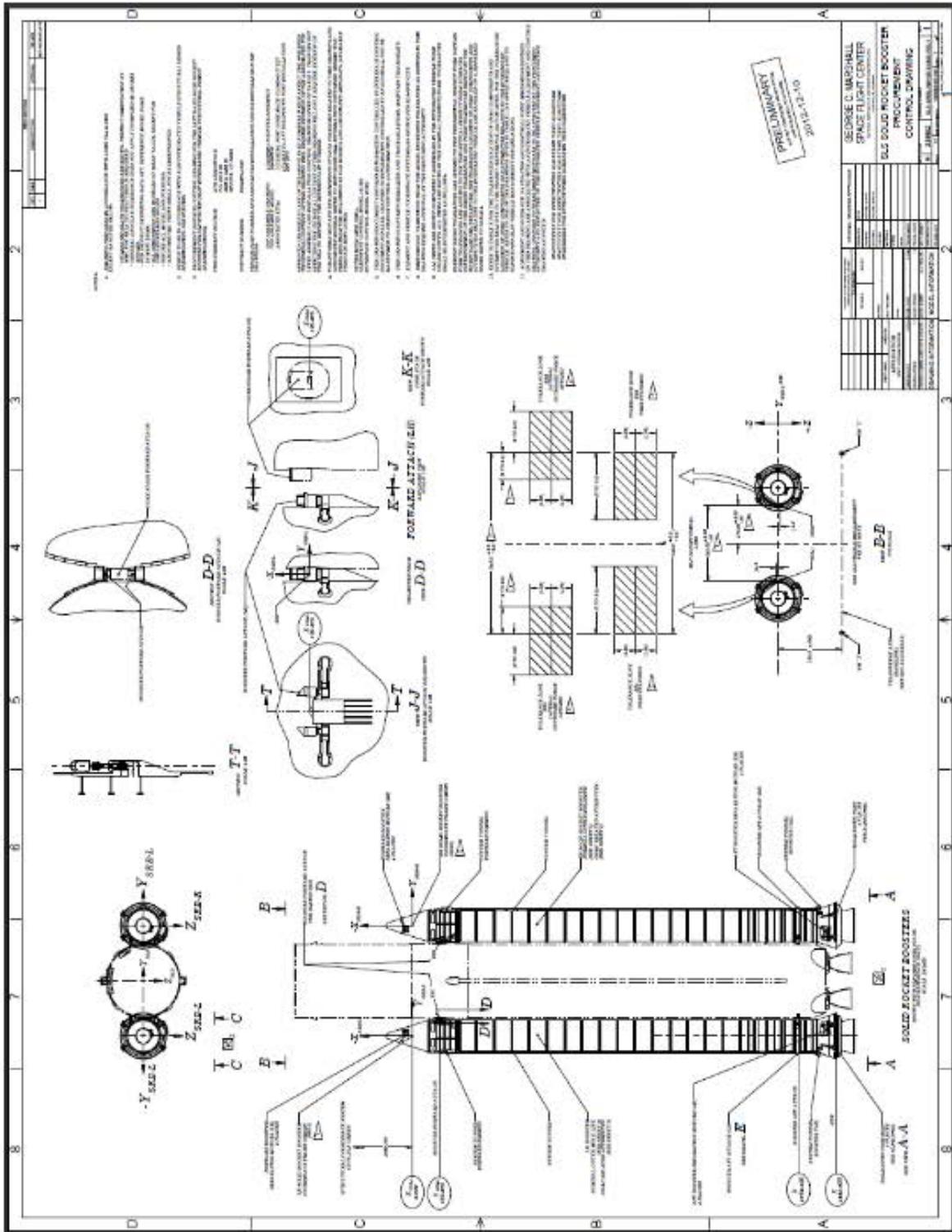


Figure 3-4. Representative Procurement Control Drawing

The electronic version is the official approved document.  
Verify this is the correct version before use.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 15 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

## **4.0 INTEGRATED VEHICLE STRUCTURAL DESIGN**

The integrated vehicle structural design drawings and associated CAD models are constructed from the same Program- or Element-supplied CAD model datasets and dimensional information used to construct the Program or Element PCDs or top assembly drawings (as applicable). The following paragraphs describe the individual structural design drawings. Refer to the applicable integrated vehicle configuration specific appendix for further detail, the assignment of base drawing numbers, and the location of each drawing/data item within the data architecture.

The following is a generic description of MSFC-EV32 prepared integrated vehicle structural design drawings.

### **4.1 Exploration System**

This is the assembly of the Launch System Assembly on the pad. This drawing consists of the Launch System Assembly, GSDO Integrated Mobile Launcher (ML) and Pad, and GSDO Launch Vehicle to Ground Installation.

### **4.2 Launch System Assembly**

If there is an addition of the Orion MPCV to the vehicle, it is depicted in the Launch System Assembly drawing.

### **4.3 Integrated Launch Vehicle Assembly, SLS**

This is the assembly of the MPCV Spacecraft Adapter (MSA) Top Assembly, Interim Cryogenic Propulsion System (ICPS) PCD, ISPE Installation and Close-out, and the Launch Vehicle Assembly, SLS.

### **4.4 Launch Vehicle Assembly, SLS**

This assembly consists of the Core Stage PCD, Launch Vehicle/Spacecraft Adapter (LVSA) Top Assembly, Flight Software, and Solid Rocket Boosters PCD.

### **4.5 Integrated Launch Vehicle Assembly Envelope and Alignment Drawing**

The Integrated Vehicle Envelope and Alignment Drawing is the integrated vehicle's nominal OML, static envelope (or gross tolerance envelope), dynamic envelope, GN&C-related dimensional data, as well as any mandatory verification. This drawing is associated to the perfect form OML, the perfect form ACM, the perfect form ICM and IDPs, as well as any additional data such as tolerance reports and deflection data. This drawing is prepared by the Integrated Vehicle Design function at MSFC-EV32.

This drawing and associated CAD models shall always be maintained within the CM system even though it does not appear in the assembly/build architecture. Refer to Figure 3-1 for the association of CAD models to both the top assembly and the envelope and alignment drawing.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 16 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

Refer to Figure 3-2 for the relationship of ICD-related CAD data to the integrated launch system structural design data architecture.

#### **4.6 Installation Drawing Responsibility**

Installation responsibilities are given in Appendix B.

#### **4.7 Environmental and Operational Effects**

The superimposed effects from operational or environmental conditions (loading, self weight, tanking, thermal, etc.) on the integrated vehicle will be addressed by NASA (<**TBD-002**>) with inputs from each Program or Element and ground systems as requested (<**TBD-003**>). This should be reported in a similar process as described in Section 3.2.3.

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 17 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

## APPENDIX A ACRONYMS AND ABBREVIATIONS AND GLOSSARY OF TERMS

### A1.0 ACRONYMS AND ABBREVIATIONS

ACM	Alignment Control Model
ASME	American Society of Mechanical Engineers
C&DH	Communications and Data Handling
CAD	Computer-Aided Design
CECB	Chief Engineer's Control Board
CI	Configuration Item
CM	Configuration Management
CMP	Configuration Management Plan
CR	Change Request
CTN	Communications and Tracking Network
DMP	Data Management Plan
DRD	Data Requirement Description
GDRM	Global Drawing Requirements Manual
GFE	Government Furnished Equipment
GN&C	Guidance, Navigation, and Control
GN2	Gaseous Nitrogen
GSDO	Ground Systems Development and Operations
GSDOP	Ground Systems Development and Operations Program
GSE	Ground Support Equipment
HDBK	Handbook
ICD	Interface Control Document
ICM	Interface Control Model
ICPS	Interim Cryogenic Propulsion System
IDP	Interface Detail Product
ISPE	Integrated Spacecraft and Payload Element
JICB	Joint Integration Control Board
LVSA	Launch Vehicle Spacecraft Adapter
ML	Mobile Launcher
MPCV	Multi-Purpose Crew Vehicle
MS	Mission Systems
MSA	MPCV Spacecraft Adapter

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 18 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

MSFC	Marshall Space Flight Center
NHA	Next Higher Assembly
OML	Outer Mold Line
OPR	Office of Primary Responsibility
PCD	Procurement Control Drawing
RQMT	Requirement
S&MA	Safety and Mission Assurance
SLS	Space Launch System
SLSP	Space Launch System Program
SLSS	Space Launch System Stages
SPEC	Specification
STD	Standard
TBD	To Be Determined
TBR	To Be Resolved
TPS	Thermal Protection System
VSP	Vehicle Support Post

## A2.0 GLOSSARY OF TERMS

Term	Description
<b>Configuration Item (CI)</b>	A CI is an aggregation of hardware and/or software that satisfies an end-use function and is designated for separate CM. For example, any item requiring logistics support and designated for separate procurement is a CI.
<b>Effectivity</b>	Effectivity defines the as-designed configuration where the design or change is authorized to be applied. MSFC designates effectivity by alpha-numeric identifiers that represent the CI and units of the CI. The effectivity unit identifiers may correlate to an event or range of events (flight(s), mission(s), test(s), etc.) where those unit configurations are planned to be applied. Effectivity is NOT equivalent to as-built serial numbers, lot numbers, or calendar dates. Effectivity for subordinate components of an assembly are assigned to be equal to or greater than the effectivity where the component is used.
<b>Element Design Data</b>	The configuration of each element's design will be controlled by a Space Launch System (SLS) procurement control drawing (PCD) or a top-level assembly drawing (as applicable). The procurement control drawing and associated model will document/specify the element outer mold line (OML), and the significant dimensional parameters associated with guidance, navigation, and control

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 19 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

<b>Term</b>	<b>Description</b>
<b>Outer Mold Line (OML)</b>	<p>(GN&amp;C), interfaces, and assembly alignments (all of which are required by Integrated Design and Analysis functions).</p> <p>The OML is an accurate single surface, water-tight contiguous body representing the nominal designed hardware in the launch and/or flight configuration. The model should include all thermal protection system (TPS) and close-out assemblies. Small fasteners should be omitted and small holes should be filled. Cavity regions (volumes between stage elements, or volumes subjected to venting, but otherwise removed from the ascent flow-stream) should be simplified. For these regions it is only necessary to replicate the general shape and volume of the cavity region. Machined webs, ribs, bosses, orthogrid patterns, small lines, etc., may be omitted. Internal components or volume may be represented by a simulated volume.</p>
<b>Significant Dimensional Parameters</b>	<p>A dimensional parameter is significant relative to the integrated vehicle structural design if its verification affects an integrated vehicle interface, integrated vehicle analysis function, and/or integrated vehicle assembly.</p>

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 20 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

**APPENDIX B**  
**10000 SERIES INTEGRATED LAUNCH SYSTEM**  
**STRUCTURAL DESIGN DATA ARCHITECTURE**

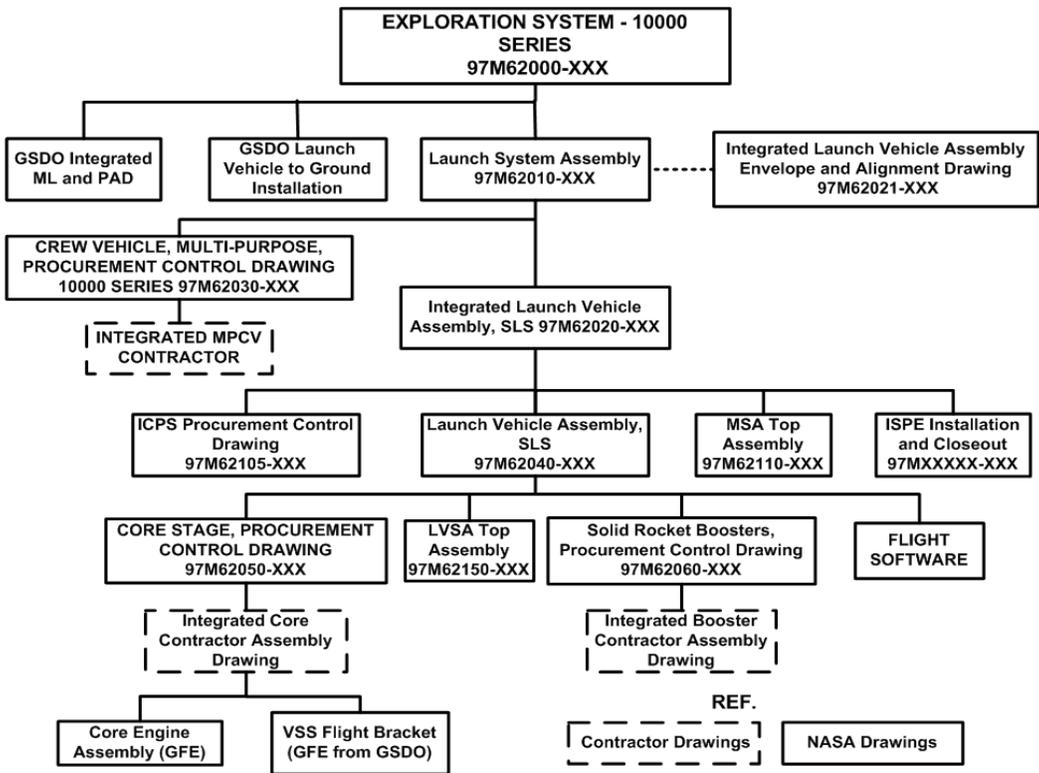
**Table B-1. Integrated Launch System Structural Interface  
Installation Drawing Assignments**

<b>Installation Drawing Responsibilities</b>	
<b>Interface</b>	<b>Responsibility</b>
Booster to Core Stage Forward Attachment Interface Installation	Booster
Booster to Core Aft Attachment Interface Installation	Booster
Booster Access Panel and Door Close-out Installation and Close-outs	Booster
Booster to Core Electrical and Pyrotechnic Transfer Line Interface Installations	Booster
Aft Skirt Umbilical, GN <sub>2</sub> Purge Installation	GSDO
Vehicle Stabilization System Installation	GSDO
Vehicle Support Post (VSP) Bearing to Shoe Installation	GSDO
VSP Shoe to Retainer to Shoe	GSDO
VSP Blast Shield to Skirt Surface	GSDO
Core Stage to Launch Vehicle Spacecraft or Payload Adapter Structural and Electrical Interface Installations	Core Stage
Core Stage to Launch Vehicle Spacecraft Adapter or Payload Adapter TPS Close-out	Core Stage
Core Stage Umbilical Installations	Core Stage
Core Stage Access Panel and Door Installation and Close-out	Core Stage
MPCV to MPCV Spacecraft Adapter (MSA) Structural Interface Installation	MPCV
MPCV to MSA TPS Close-out Installation	MPCV
MPCV Access Panel and Door Installation and Close-outs	MPCV
MPCV Umbilical Installations	MPCV
Launch Vehicle Spacecraft Adapter (LVSA) to Interim Cryogenic Propulsion System (ICPS) Installations and Close-outs	ISPE
ICPS Stage to MSA Installations and Close-outs	ISPE
ISPE Stage Umbilical Installations	ISPE
ISPE Stage Access Panel and Door Installations and Close-outs	ISPE

**Notes:**

1. Program or Element top assemblies specified by a PCD will show all flight hardware items to be installed during integrated vehicle assembly. Examples include: code plugs, access doors, closeouts, TPS

- applications, etc. Any hardware not installed at the time of hardware acceptance will be identified by forward work with the accompanying installation drawing.
2. Program or Element procurement control drawings will not include any ground support equipment (GSE) or non-flight hardware items.
  3. Installation drawing responsibilities include structural analysis associated with that installation, including bolted joints analysis and thermal analysis of external TPS.



**Figure B-1. 10000 Series Vehicle Integrated Launch System Drawing Tree**

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 22 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

## APPENDIX C OPEN WORK

All resolved To Be Determined (TBD) s, To Be Resolved (TBR), and forward work items should be listed on the CR the next time the document is updated and submitted for formal review, and that will serve as the formal change record through the configuration management system.

### C1.0 TO BE DETERMINED

Table C1-1 lists the specific TBDs items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within carets. The TBD item is sequentially numbered as applicable (i.e., <TBD-001> is the first undetermined item assigned in the document). As each TBD is resolved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

**Table C1-1. To Be Determined Items**

TBD	Section	Description
TBD-001	3.4	Any extra NASA approvals for PCDs
TBD-002	3.2.4	Environmental or Operational Analysis performed by
TBD-003	3.2.4	Inputs required for analysis

### C2.0 TO BE RESOLVED

Table C2-1 lists the specific TBRs issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within carets. The TBR issue is sequentially numbered as applicable (i.e., <TBR-001> is the first unresolved issue assigned in the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

**Table C2-1. To Be Resolved Issues**

TBR	Section	Description
TBR-001		

### C3.0 FORWARD WORK

Table C3-1 lists the specific forward work items identified during this document’s CR review and evaluation. Each item is given a sequential number using a similar format to that for the TBDs and TBRs. For each item, include the section number(s) of this document that the open

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 23 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

work will impact, and in the Description include the specific number of the comment from the Change Evaluation (CE), i.e., CE-10, CE-27. Do not include a placeholder for forward work items in the body of the document; list them only in Table C3-1.

**Note:** If there are no forward work items, do not include this subsection in your document.

**Table C3-1. Forward Work**

FWD	Section	Description
FWD-001		Update document with new vehicle configurations as required

Space Launch System (SLS) Program/Project	
Revision: Draft for PDR	Document No: SLS-SPEC-028
Effective Date: TBD	Page: 24 of 24
Title: Cross-Program Integrated Vehicle Structural Design Specification	

## APPENDIX D INTEGRATED LAUNCH SYSTEM

**Table D-1. Integrated Launch System Structural Interface Control Documents**

Number	Title
MPCV-T-029600	Multi-Purpose Crew Vehicle (MPCV) to Space Launch System (SLS) Hardware Interface Control Document (ICD)
MPCV-T-029601	Multi-Purpose Crew Vehicle (MPCV) to Space Launch System (SLS) Communication and Data Handling (C&DH)
SLS-ICD-029	Space Launch System Program (SLSP) Stages to Integrated Spacecraft and Payload Element (ISPE) Interface Control Document (ICD)
SLS-ICD-031	Space Launch System Program (SLSP) to Communications and Tracking Network (CTN) Interface Control Document (ICD)
SLS-ICD-039	Space Launch System Program (SLSP) Stages to Engines(s) Interface Control Document (ICD)
SLS-ICD-052	Space Launch System Program (SLSP) to Ground Systems Development and Operations Program (GSDOP) Interface Control Document (ICD)
STG-AV-ICD-0002	Space Launch System Stages (SLSS) to Element Communication and Data Handling (C&DH) Document SLS to Mission Systems (MS) Interface Control Document (ICD)