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SPACE LAUNCH SYSTEM PROGRAM (SLSP) MANUFACTURING AND ASSEMBLY OPERATIONAL SEQUENCES REPORT

REVISION AND HISTORY PAGE

Status	Version No.	Change No.	Description	Release Date
Draft	-	-	Initial Draft of SLS DRD 1406OP-010 for SLS PDR, MSFC 4511 Concurrence on file	Draft 04/30/13

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

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1.0 INTRODUCTION

The Space Launch System Program (SLSP) operational sequences in this document apply to the SLS system as managed by Marshall Space Flight Center (MSFC) for the SLS Office. The operational sequencess are a reflection of the current plans for vehicle and ground systems design.

1.1 Purpose

This document will provide SLS approved manufacturing operational sequences for the purposes of:

1) Facilitating SLS review of the planned vehicle operations.
2) Enabling detailed program, engineering and mission analysis as the SLSP moves forward to maturity.
3) Enabling the SLSP managers to capture launch campaign details.
4) Enabling the SLS Program Office to plan schedules and deliveries.
5) Enabling SLS designers & manufacturing to evaluate/improve system effectiveness & reduce cost.

1.2 Scope

The SLSP Manufacturing and Assembly Operational Sequences is a SLS Program Category 2 reference product that describes the SLS vehicle processes during manufacturing and through transportation to GSDO for vehicle integration. Readers should refer to Element-provided data for baseline decisions.The SLSP Manufacturing and Assembly Operational Sequences contains:

1) Operational sequences for SLS manufacturing that are reflective of the baselined vehicle designs.
2) Ground rules, constraints, and assumptions used to create the Operational Sequences.

1.3 Document Overview

The Manufacturing and Assembly Operational Sequences Report content is organized in 4 sections:

SRB Manufacturing

RS-25 Manufacturing

Core Stage Manufacturing

ISPE Hardware Manufacturing

1.4 Change Authority/Responsibility

The NASA Office of Primary Responsibility (OPR) for this document is Marshall Space Flight Center (MSFC) EO40.

Changes to this document shall be controlled at the OPR level using processes defined by the OPR and the Operations discipline lead engineer (DLE).

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein. Unless otherwise stipulated, the most recently approved version of a listed document shall be used. In those situations where the most recently approved version is not to be used, the pertinent version is specified in this list.

Document Number/ Revision	Effective Date	Document Title
SLS-PLAN-020	09/27/2012	SLSP Concept of Operations Document, Rev A
SLS-SPEC-032	6/28/2012	SLSP Vehicle Specification, Rev B

3.0 SLSP OPERATIONAL SEQUENCES

The SLSP operational sequences are compilation of data that is pulled together to produce an integrated description of the SLS vehicle manufacaturing events. Manufacturing and Transportation data is collected from the elements and their associated documentation. This includes any activities that are planned to be performed by the element after the hardware has been shipped to Kennedy Space Center (KSC), but prior to the SLS Element turnover to Ground Systems Development and Operations (GSDO) for SLS vehicle integration. Vehicle integration data describing the tasks/activities conducted after element turnover to GSDO are captured in the Ground Operations Planning Database (GOPDb) and the details are not repeated here.

Figure 3.0-1 illustrates the overall SLS vehicle processing to support the first flight. The schedule depicted in this graphic assumes contingency operations are occurring during the vehicle integration and pad operations, but does not include a learning curve that will likely be encountered for the first flight.

Note that the SLS Program utilizes both cross-program Integrated Mission Analysis (IMA) Phases for cross-program communication/integration as well as Internal SLS Phases and Modes for internal SLS Vehicle operations. Both of these sets of phases and the relationship between them can be found within the SLSP Concept of Operations Document, SLS-PLAN-020 (will be included in Rev B of the SLSP Con Ops).

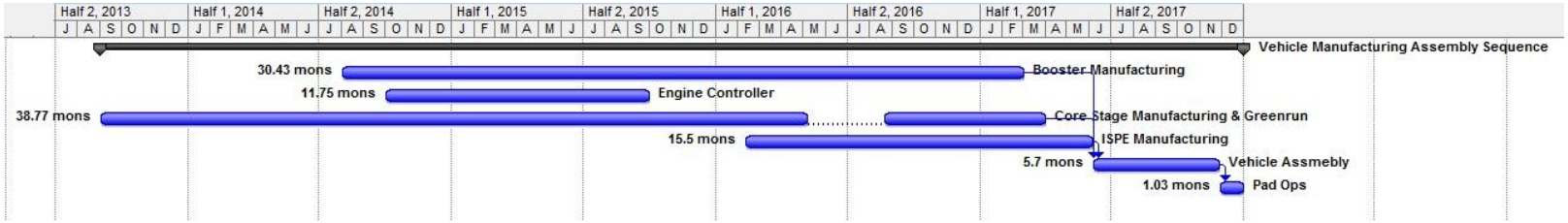

Figure 3.0-1 Overview of SLS Vehicle Processes

3.1 Manufacturing and Transportation

Element manufacturing and transportation processes are under the control of the individual element program offices at level 3, but must coordinate with the cross-program level 2 requirements and milestones. The SLSP Manufacturing and Assembly Operational Sequences makes an attempt to capture these schedules to provide a complete understanding of the processes required to manufacture and deliver SLS elements for vehicle integration.

3.1.1 Solid Rocket Booster Manufacturing and Transportation

The SLS 5-Segment Solid Rocket Boosters (SRB) are manufactured by Alliant Techsystems Incorporated (ATK) in Utah. Manufacturing processes are Space Shuttle heritage with design upgrades to the 5-segment booster. Upon completion of the motor segment manufacturing ATK Utah, the booster segments are transported via railcar to KSC for integration.

Ground Rules, Constraints, and Assumptions for SRB Manufacturing and Transportation:

- SLS vehicle Block1 configuration.
- Manufacturing flows are at a high level and capture the predicted durations for the manufacturing processes.

Figure 3.1.1-1 illustrates the booster processes to manufacture two five-segment boosters supporting an SLS Block 1 vehicle launch. This includes the motor segment manufacturing performed at ATK Utah as well as the forward assembly and aft skirt processing that are performed at the Booster Fabrication Facility (BFF), but still considered part of booster manufacturing.

The critical path for these operations is the manufacturing of the motor segments (82 weeks) and the customer inspection, loading, and shipping of the completed segments to KSC (8.6 weeks).

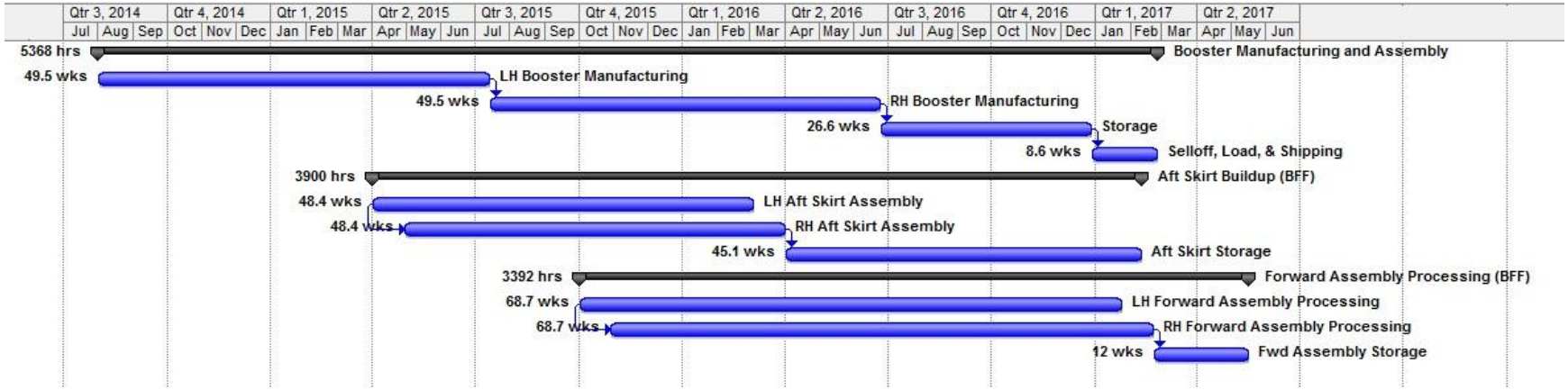

Figure 3.1.1-1 SLS 5-Segment Booster Manufacturing & Transportation Sequence (Preliminary)

3.1.2 RS-25 Engine Manufacturing and Transportation

The RS-25 engine is a staged combustion cycle engine, using liquid oxygen (LOX) and liquid hydrogen (LH2) for propellants. The RS-25 is designed to operate as a highly reliable, high-performance, single start, throttleable booster engine. The RS-25 for the SLS vehicle application is an adaptation of the Space Shuttle Main Engine (SSME) used by the Space Shuttle program. The adaptation of the RS-25 for SLS makes use of existing engine assets, minimizing redesign effort and modification cost.

Prior to integration at MAF, the RS-25 will be stored, maintained and modified at Stennis Space Center (SSC), Mississippi. Modifications include new controller development, tests and check-out. The RS-25 engine will be acceptance tested at SSC prior to being shipped to MAF for integration with the SLS core stage.

Ground Rules, Constraints and Assumptions for the RS-25 Engine Manufacturing and Transportation:

- The RS-25 Engines for the initial 4 SLS flights are adapted from heritage Shuttle Program hardware.
- The engines will be hot-fired at SSC as a part of the acceptance testing process prior to being shipped by truck to MAF for integration into the Core Stage. Initial delivery of 4 engines to support the first flight is scheduled for late FY15.

Figure 3.1.2-1 Illustrates the RS-25 engine manufacturing and acceptance testing flow for the first SLS flight vehicle. The development and testing schedule is planned for 11 months.

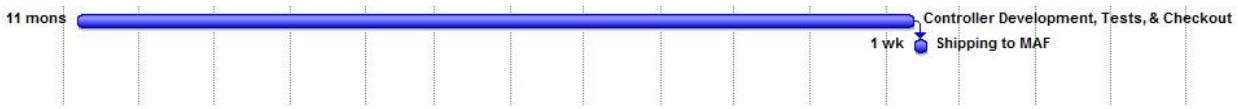

Figure 3.1.2-1 RS-25 Manufacturing & Transportation Sequence

3.1.3 Core Stage Manufacturing and Transportation

The SLS Core Stage is manufactured by the prime contractor at the Michoud Assembly Facility (MAF) in Louisiana. Upon completion the Core Stage is transported via barge to Stennis Space Center (SSC) in Mississippi for the Core Stage and Core Stage Engine Integrated System Test (Green Run). At the completion of the testing, the Core Stage will be refurbished and will then be shipped via barge to KSC for integration with the SLS stack.

Ground Rules, Constraints and Assumptions for Core Stage Manufacturing and Transportation:

- SLS vehicle Block 1 configuration.
- The Core manufacturing sequence assumes a probable schedule for manufacturing processes as reflected in the Core Stage PDR.

- The Green Run processes reflected are the output of an initial value stream mapping exercise between the element and SSC personnel. Although it represents the best available data, it should be viewed as a first-cut draft.

Figure 3.1.3-1 illustrates the SLS Core Stage manufacturing and Green Run process flow for the first SLS flight vehicle. The planned manufacturing flow includes approximately 33 months for the stage manufacturing and six months for Green Run testing and refurbishment.

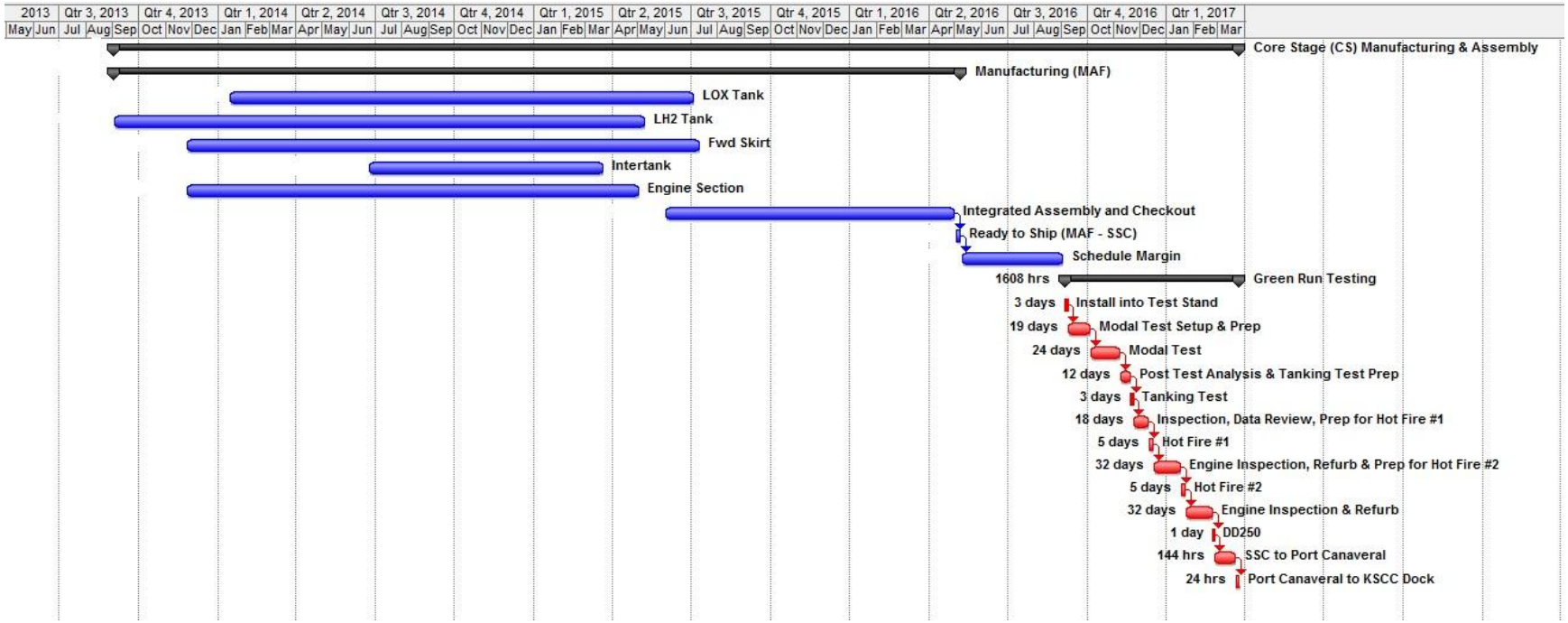

Figure 3.1.3-1 SLS Core Stage Manufacturing & Transportation Sequence

3.1.4 ISPE Manufacturing and Transportation

The Integrated Space Craft and Payload Element (ISPE) hardware elements consist of the Launch Vehicle Stage Adapter (LVSA), the Interm Cryogenic Propulsion Stage (ICPS), and the MPCV Stage Adapter (MSA). All of the ISPE hardware is under the oversight of the Space Craft and Payload Integration Office (SPIO), but the separate elements may be provided by separate contractors each having their own development process and schedule. As of the SLS PDR, no contract has been let for the LVSA, so this section will focus on the ICPS and MSA elements.

All information with respect to the LVSA is TBD pending the selection of a vendor **<TBD-001>.**

The ICPS stage is being developed by United Launch Alliance (ULA) in Decatur, Alabama. The stage will be assembled at the ULA Decatur facility and shipped, via barge, to a ULA facility at Cape Canaveral, FL. Manufacturing is completed at Cape Canaveral facility and the ICPS is rotated to a vertical orientation prior to being transported by truck to the KSC Multi Payload Processing Facility (MPPF) where the off line processing will be performed.

The MSA is being designed and manufactured at MSFC. After manufactauring complete, the adapter is shipped by truck to KSC for integration with the SLS stack.

Ground Rules, Constraints and Assumptions for the ISPE hardware Manufacturing and Transportation:

- SLS vehicle Block 1 configuration.
- The MSA manufacturing sequence is the result of an initial planning exercise by SPIO and should be viewed as a first-cut draft of the MSA manufacturing draft.
- The ICPS manufacturing has not yet been made available
- The LVSA manufacturing sequence is TBD pending selection of a prime contractor.

Figure 3.1.4-1 illustrates the SLS ISPE manufacturing and transportation process flow for the first SLS flight vehicle. ISPE hardware manufacturing is planned for approximately XX months **<TBD-001>.**

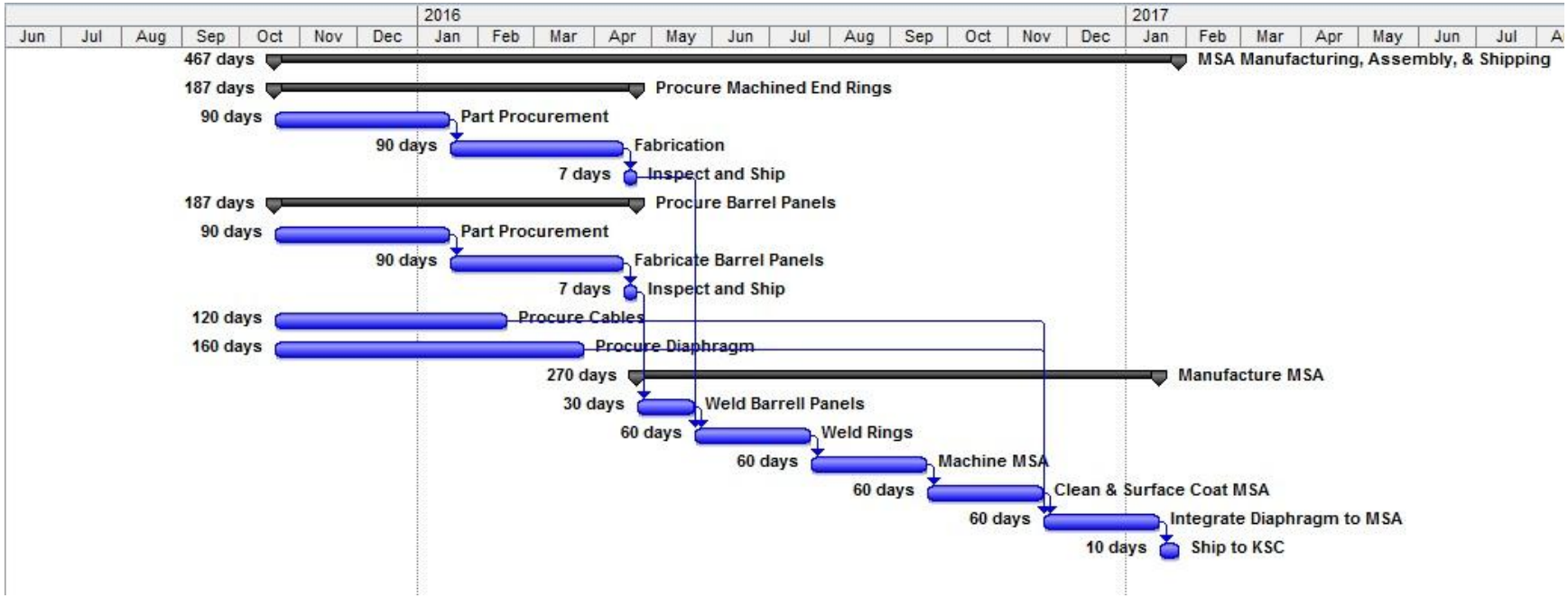

Figure 3.1.4-1 SLS ISPE Manufacturing & Transportation Sequence

3.2 SLS Vehicle Integration and Launch Preparations

SLS vehicle integration and launch preparations are performed at KSC and include off-line processing, vehicle integration, integrated vehicle testing, Pad operations, and launch countdown. The high-level sequence for these activities is provided below:

- Element Off-line Processing (unique flows for each element)
- Vehicle Stacking
- Modal Test
- Umblilcal Mating and Preparations for Integrated Vehicle Tests
- Integrated Vehicle Testing
- Initial Rollout and Wet Dress Rehearsal
- Rollback to VAB
- FTS Testing and Final Closeouts
- Rollout for Launch
- Pad Operations
- Countdown

The detailed flows and task descriptions associated with each of these tasks are captured in the Ground Operations Planning Database (GOPDb). The database is an on-line tool maintanined by Ground Systems Development and Operations (GSDO) and can be accessed from the following site: https://sls-mpcv.ksc.nasa.gov/gopdbflex/release/index.cfm. Access to the site can be obtained through NASA's Identity and Access Management Tool (https://idmax.nasa.gov/idm/user/dashboard/home.jsp).

APPENDIX A
ACRONYMS AND ABBREVIATIONS

A1.0 Acronyms and Abbreviations

ATK	Alliant Techsystems Incorporated
CDR	Critical Design Review
DLE	Discipline Lead Engineer
FTS	Flight Termination System
GOPDb	Ground Operations Planning Database
GSDO	Ground Systems Development and Operations
ICPS	Interim Cryogenic Propulsion System
ISPE	Integrated Spacecraft and Payload Element
KSC	Kennedy Space Center
LH2	Liquid Hydrogen
LOX	Liquid Oxygen
LVSA	Launch Vehicle Stage Adapter
MAF	Michoud Assembly Facility
MPPF	Multi Payload Processing Facility
MSA	MPCV Stage Adapter
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
PDR	Preliminary Design Review
SLS	Space Launch System
SLSP	Space Launch System Program
SPIO	Spacecraft and Payload Integration Office
SRB	Solid Rocket Booster
SSC	Stennis Space Center
SSME	Space Shuttle Main Engine

APPENDIX B
OPEN WORK

B1.0 TO BE DETERMINED

Table B1-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within 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 B1-1. To Be Determined Items

TBD	Section	Description
TBD-001	3.1.4	The manufacturing events for the ISPE hardware are unknown due to a lack of approved data regarding the ICPS and pending the selection of the LVSA contractor.