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## **SLSP HUMAN FACTORS ANALYSIS**

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## **1.0 INTRODUCTION**

### **1.1 Purpose**

The Human Factors analysis evaluates the vehicle design for the ground crew touch points (i.e., human interfaces) that will be accessed during assembly and integration that cross an interface. It will not address Element specific tasks from the outer mold line to the interior of the vehicle. The document analyzes the design of ground crew touch points in combination with the task to be performed and the surrounding work environment to ensure that tasks can be successfully completed and the human engineering requirements have been implemented in compliance with SLS-RQMT-161, SLSP Human Systems Integration Requirements.

### **1.2 Scope**

The analysis contained in this document is limited to the ground crew touch points on the SLS Vehicle during assembly and integration tasks at the Vehicle Assembly Building (VAB) that is outside the scope of the SLS elements.

### **1.3 Change Authority/Responsibility**

The NASA Office of Primary Responsibility (OPR) for this document is EV74/Systems Analysis Branch. Changes to this document shall be controlled at the OPR level using processes defined by the OPR.

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## 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.

SLS-RQMT-161            Space Launch Systems (SLS) Program Human Systems Integration Requirements

### 2.2 Reference Documents

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

FAA-HF-STD-001            Federal Aviation Administration Human Factors Design Standard

MIL-HDBK-1908            Definitions of Human Factors Terms

MIL-STD-1472F            Department of Defense Design Criteria Standard: Human Engineering

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### 3.0 BACKGROUND

The following sections will analyze the ground crew touch points for the identified assembly and integration tasks for compliance with SLS-RQMT-161, SLSP Human Systems Integration Requirements. Each section contains the requirements applicable to the ground crew worksite, any assumptions used in the worksite analysis, the support equipment needed, and the analysis. The sections will assess the external vehicle interfaces with which the ground crew must interact and ground crew task that cross an interfaces (i.e., cabling from one Element/Program to another). The worksite analysis will address the ground crew task to be performed, the physical and visual access needed to perform the task, the constraints of the surrounding environment, and the capabilities and limitation of the human.

### 3.1 Analysis

The analyses in the following sections will systemically describe how ground personnel will interact with the vehicle to understand how the demands of the task match with the human capabilities. High level functions are reduced to individual tasks and then to the lowest level step to understand the demands of the task.

#### 3.1.1 Orion to MSA Integrated Functions

The tasks that will be addressed as part of this activity include aligning Orion to the Multi-Purpose Crew Vehicle Spacecraft Adapter (MSA), removing alignment pins, accessing cables that cross the interface from Orion to the MSA after mating, and installing fasteners on the flange.

##### 3.1.1.1 Orion to MSA Alignment

Applicable requirements: SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-001>

##### 3.1.1.2 Alignment Pin Removal

Applicable requirements: SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes  
SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-002>

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### 3.1.1.3 Fastener Installation

Applicable requirements: SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-012 - Displays Within Direct Field of View  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes  
SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-003>

### 3.1.1.4 Cable Access

Applicable requirements: SLS-HSIR-001 – Ground Processing Worksites  
SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-013 – Labeling  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes  
SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-004>

## 3.1.2 Core Stage to LVSA Integrated Functions

The tasks that will be addressed as part of this activity includes aligning Launch Vehicle Spacecraft Adapter (LVSA) to Core Stage, removing alignment pins, accessing cables that cross the interface from LVSA to Core Stage after mating, and installing fasteners on flange.

### 3.1.2.1 LVSA to Core Stage Alignment

Applicable requirements: SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-005>

### 3.1.2.2 Alignment Pin Removal

Applicable requirements: SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes

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### SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-006>

#### 3.1.2.3 Fastener Installation

Applicable requirements: SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-012 – Displays Within Direct Field of View  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes  
SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-007>

#### 3.1.2.4 Cable Access

Applicable requirements: SLS-HSIR-001 – Ground Processing Worksites  
SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-013 – Labeling  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes  
SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-008>

### 3.1.3 Booster to Core Stage Integrated Functions

The tasks that will be addressed as part of this activity include the alignment of the Core Stage to the Booster, visual inspection of the hardware on each side of the interface to verify it is ready for mating, mating of the Forward Attach, electrical cross over assemblies, and Aft Attach struts to the Core Stage.

#### 3.1.3.1 Core Stage to Booster Alignment

Applicable requirements: SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-009>

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### **3.1.3.2 Core Stage Inspection**

Applicable requirements: SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-010>

### **3.1.3.3 Booster Mating Interface Inspection**

Applicable requirements: SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-011>

### **3.1.3.4 Core Stage to Booster Mating**

Applicable requirements: SLS-HSIR-001 – Ground Processing Worksites  
SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-013 – Labeling  
SLS-HSIR-018 – Work Envelope Volumes  
SLS-HSIR-019 – Reach Envelope Volumes  
SLS-HSIR-020 – Ground Crew Visual Access

Detailed task steps: <TBD-012>

### **3.1.3.5 Access for Electrical Cross Over Assemblies**

Applicable requirements: SLS-HSIR-001 – Ground Processing Worksites  
SLS-HSIR-005 – Sharp Edges  
SLS-HSIR-013 – Labeling  
SLS-HSIR-018 – Work Envelope Volumes  
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Detailed task steps: <TBD-013>

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## APPENDIX A ACRONYMS AND ABBREVIATIONS AND GLOSSARY OF TERMS

### A1.0 ACRONYMS AND ABBREVIATIONS

LVSA	Launch Vehicle Spacecraft Adapter
MSA	Multi-Purpose Crew Vehicle Spacecraft Adapter
OPR	Office of Primary Responsibility
PDR	Preliminary Design Review
VAB	Vehicle Assembly Building

### A2.0 GLOSSARY OF TERMS

Term	Description
Access	Providing visual or physical entry or touching of equipment to ground personnel before flight.
Accessible	An item is considered accessible when it can be operated, manipulated, serviced, removed, or replaced by the suitably clothed and equipped user with applicable body dimensions conforming to the anthropometric range and database specified by the procuring activity or if not specified by the procuring activity, with applicable 5th to 95th percentile body dimensions. Applicable body dimensions are those dimensions which are design-critical to the operation, manipulation, removal, or replacement task.
Task Analysis	Task analysis is an activity that breaks a task down into its component levels. It involves 1) the identification of the tasks and subtasks involved in a process or system, and 2) analysis of those tasks (e.g., who performs them, what equipment is used, under what conditions, the priority of the task, dependence on other tasks). The focus is on the human and how they perform the task, rather than the system. Results can help determine the displays or controls that should be developed/used for a particular task, the ideal allocation of tasks to humans vs. automation, and the criticality of tasks, which will help drive design decisions.
Worksite	Assumed to be the volume and architecture where the ground operator or maintainer can directly interface physically and/or visually with the equipment necessary to accomplish work. An area where an operator or maintainer performs work. Worksite includes controls, displays, limiting structure, and peripheral hardware and equipment that positively or negatively impact the work to be

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**Term**

**Description**

accomplished. (See MIL-HDBK-1908, Definitions of Human Factors Terms; see also the definitions of Workstation and Work Area.)

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## APPENDIX B OPEN WORK

### B1.0 TO BE DETERMINED

Table B1-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within 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	3.1.1.1	Detailed steps to align Orion to MSA alignment
TBD-002	3.1.1.2	Detailed steps to perform alignment pin removal
TBD-003	3.1.1.3	Detailed steps to perform fastener installation
TBD-004	3.1.1.4	Detailed steps associate with accessing the cable harness
TBD-005	3.1.2.1	Detailed steps to align LVSA to Core Stage alignment
TBD-006	3.1.2.1	Detailed steps required to perform alignment pin removal
TBD-007	3.1.2.2	Detailed steps required to perform fastener installation
TBD-008	3.1.2.3	Detailed steps associate with accessing the cable harness
TBD-009	3.1.3.1	Details steps to align Booster to Core Stage alignment
TBD-010	3.1.3.2	Detailed steps to perform Core Stage inspection before mating
TBD-011	3.1.3.3	Detailed steps to perform Booster inspection before mating
TBD-012	3.1.3.4	Detailed steps to perform Booster to Core Stage mating
TBD-013	3.1.3.5	Detailed steps to perform Booster to Core Stage cable mates