National Aeronautics and
Space Administration

SLS-SPEC-167

BASELINE

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SPACE LAUNCH SYSTEM PROGRAM
IMAGERY SYSTEM REQUIREMENTS DOCUMENT
(ISRD)

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REVISION AND HISTORY PAGE

Status	Revision No.	Change No.	Description	Effective Date
Baseline	-		Baseline (Reference SLS PCBD SV2-01-0060, dated 1/10/13), (CR SLS-00083, PCN SV00171)	1/10/13

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 SCOPE

The information regarding imagery systems captured in this document applies to the Space Launch System (SLS), as managed by the SLS Program (SLSP) Office.

As defined in SLSP System Specification, SLS-SPEC-032, the SLS includes the following major elements:

- Stages (Core Stage and Upper Stage)
- Liquid Engines (Core Stage and Upper Stage)
- Boosters (Solid or Liquid)
- Integrated Spacecraft and Payload Integration Element (ISPE) (Payload Fairings, Payload Adapters, Interim Cryogenic Propulsion Stage (ICPS))

The vehicle will be specifically called out as the SLS Vehicle, as also defined in SLS-SPEC-032.

The scope of this document includes SLS Vehicle Imagery System (VIS) requirements (Section 3), SLS VIS verification activities for each requirement (Section 4), a system-level description of events that require imagery coverage (Section 5), and a system-level functional and operational overview of the SLS VIS (Section 6). Furthermore, the scope of this document is limited to activities associated with the current ESD Flight Manifest (EM1 and EM2) which is the SLS Block 1 configuration. As additional missions and plans are identified, this document will be revised as appropriate.

1.1 Document Overview

The SLSP Imagery System Requirements Document (ISRD) defines the Block 1 configuration of the SLS VIS development and operations, engineering imagery data collection, imagery analysis and integration with the SLS Program, technical teams, Safety and Mission Assurance (S&MA), and Public Affairs Office (PAO).

This document also defines the events and conditions that the SLS Program has deemed appropriate for the imagery systems to monitor in accordance with SLSP System Specification (SLS-SPEC-032) requirement SLS.27. To accomplish these events and conditions vehicle based and ground based imagery resources are needed. At this time, there are no plans for imagery to be obtained from airborne or ship-based assets. This document defines the desired SLS based Fields of View (FOVs) of the integrated SLS to be obtained during timeframes of specific known events and expected conditions, and it also defines the high contrast markings to be installed on Core Stage, Booster and Integrated Spacecraft and Payload Element (ISPE). The SLS VIS to Core Stage imagery data exchange will be documented in the SLSP Stages to Elements Communication and Data Handling (C&DH) Document, STG-AV-0002 and the SLS VIS hardware interface at the Stages/ISPE interface plane will be documented in the SLSP Stages to Integrated Spacecraft and Payload Element (ISPE) ICD, SLS-ICD-029.

SLS functions identified in this document that cross a program level interface with Orion Multipurpose Crew Vehicle (MPCV) and/or Ground Systems Development and Operations (GSDO) are provided as reference only to document the desired needs that the SLS Program will rely on other programs for support. The multi-program agreements are identified in the Imagery Cross-Program Technical Integration Task Agreement, as defined in Exploration System Development (ESD) Systems Engineering Management Plan (SEMP), ESD 10007. The SLS to GSDO inter-program requirements relative to imagery will be identified in SLSP–to-Ground Systems Development and Operations Program (GSDOP) Interface Control Document (ICD), Volume 1, SLS-ICD-052-01 (i.e., functional requirements), the SLSP Mission Support Requirements Document (MSRD), SLS-RQMT-169 (i.e., routing data after on ground to multiple locations), SLS-to-GSDO ICD, Volume 5, SLS-ICD-052-05 (i.e., ground issued pre-launch commands), and the SLS to Communications and Tracking Network (CTN) ICD, SLS-ICD-031 (i.e., health and status telemetry and encapsulation requirements for motion imagery payloads) <**TBR-038**>, as well as the Program Requirements Document (PRD). The SLS to MPCV inter-program requirements relative to imagery will be identified in Orion MPCV to SLS Interface Requirements Document (IRD) MPCV-70026 **<TBR-005>.**

1.2 Change Authority/Responsibility

The National Aeronautics and Space Administration (NASA) Office of Primary Responsibility (OPR) for this document is ES31, managed under the Integrated Avionics and Software (IAS) Discipline Lead Engineer (DLE).

Proposed changes to this document will be submitted by an SLS Program change request (CR) to the SLS Program Control Board (PCB) for disposition <**FW-4**>. All such requests will adhere to the SLS-PLAN-008, SLS Program Configuration Management Plan.

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	Title
ESD 10002B	Exploration Systems Development (ESD) Requirements
MPCV-70026A	Orion Multi-purpose Crew Vehicle (MPCV) Program to Space Launch System (SLS) Interface Requirements Document (IRD)
NPR 8621.1B	Mishap and Close Call Reporting, Investigating, and Recordkeeping
SLS-ICD-029C	Space Launch System Program (SLSP) Stages to Integrated Spacecraft and Payload Element (ISPE) Interface Control Document (ICD)
SLS-ICD-031B	Space Launch Systems to Communications and Tracking Network (CTN) Interface Control Document (ICD)
SLS-ICD-052-01	Space Launch System Program (SLSP)-to-Ground System Development and Operations Program (GSDOP) Interface Control Document (ICD), Volume 1: Functional Interface Definition & SLSP Integrated Vehicle-to-GSDOP Detailed Design
SLS-ICD-052-05 (Baseline Pending)	Space Launch System Program (SLSP)-to-Ground System Development and Operations Program (GSDOP) Interface Control Document (ICD), Volume 5: SLSP-to-GSDOP/Command and Data Handling (C&DH) Detailed Design
SLS-RQMT-169 (Baseline Pending)	Space Launch System Program (SLSP) Mission Support Requirements Document (MSRD)
SLS-SPEC-032B	Space Launch System (SLS) Program System Specification
SLS-SPEC-048A	Cross-Program Integrated Coordinate Systems

2.2 Reference Documents

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

Document Number	Title
ESD 10007A	ESD Systems Engineering Management Plan (SEMP)
SLS-PLAN-008B	Space Launch System Program Configuration Management Plan
SLS-PLAN-009 (Baseline Pending)	SLSP Verification and Validation Plan
SLS-PLAN-020A	Space Launch System Program Concept of Operations (Con Ops) Document
SLS-RPT-037 (Baseline Pending)	Space Launch System Program Integrated Master Timeline (IMT)
SLS-SPEC-097 (Baseline Pending)	Space Launch System Program Avionics Architecture Description Document
STG-AV-0002C	Space Launch System (SLS) Program SLS Stages to Elements Communication and Data Handling (C&DH) Document
STG-AV-0010 (Baseline Pending)	Space Launch System Stages Element Flight Imaging Launch Monitoring Real-time System (FILMRS) Government Furnished Equipment (GFE) Project Implementation Plan
IEEE-Std-802.3-2002	IEEE Standard for Information Technology-Telecommunications and information exchange between systems-Local and metropolitan area networks--Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

3.0 OVERVIEW

The NASA human space flight programs have used imagery over the past decades to evaluate a launch vehicle's system performance and integrity with primary emphasis on safety. Following the events from the Space Shuttle Columbia accident, the roles and responsibilities of the engineering imagery community were evaluated and strengthened. Numerous improvements were established including imagery systems hardware and integration activities of the data findings.

The SLS Program will consider the lessons learned throughout the past programs relative to imagery and will develop the most cost effective imagery solution.

3.1 SLS VIS Description, Architecture, and Roles & Responsibilities

3.1.1 SLS VIS Description

The ESD Requirements Document requires that the Level I architecture include an imagery capability. The requirement is applicable to the three Level II Programs: GSDOP, MPCV and SLS. The SLS VIS provides the portion of the imagery functionality that is allocated to the SLS. This allocation is levied by the ESD Requirements Document.

Functionally, the SLS VIS will collect imagery of the SLS on the pad, at liftoff, and during ascent with emphasis on specific events and timeframes of interest. The SLS VIS will transmit imagery data to the appropriate SLS avionics subsystem for transmission to the ground for distribution, post flight analysis, and subsequent archiving. The SLS VIS system is not designed for use in real time ascent contingency decisions, the VIS supplies imagery only for post flight analyses. Failure of the VIS function will never result in loss of life, vehicle or mission; thus, the system is zero-fault tolerant.

3.1.2 VIS Architecture

The SLS VIS is a distributed system that spans multiple elements of the SLS. The SLS VIS (Block 1 configuration) is made up of three primary subsystems:

- VIS subsystem #1 - that which provides imagery data to the ground through the Core Stage,
- VIS subsystem #2 - that which provides imagery data to the ground through the Interim Cryogenic Propulsion System (ICPS) <**TBR-011**>, and
- VIS subsystem #3 - the reference markings subsystem which consists of the high contrast reference markings located on the SLS elements (Core Stage, Booster and ISPE).

The SLS VIS architecture is shown in Figure 3-1, below. The VIS subsystem #1 provides imagery data to the ground through the Core Stage and is driven by one Camera Control Unit (CCU) that receives power from the Core Stage, receives discrete signals and data (Ethernet auto negotiation) from the Core Stage Command & Telemetry Controller (CTC-1), and transmits imagery data to the CTC-1 for transmission to the ground via Radio Frequency transmitter (not through the 100 Base-Tx hardlines). The CCU does not interface with CTC-2 as the SLS avionics architecture only supports imagery commanding and data downlink through CTC-1 (reference SLS-SPEC-097, Space Launch System Program Avionics Architecture Description Document, for a more detailed explanation of the SLS avionics architecture). The CCU provides power to six external camera assemblies (mounted on the Core Stage) and two internal lighted camera assemblies (mounted on the inside surface of the Launch Vehicle Stage Adapter (LVSA)). The CCU receives imagery data from, all eight of these cameras. Based on the discrete signals from the CTC-1, the CCU will select the appropriate camera(s) for processing and transmission to the CTC-1. The VIS subsystem #1 will transmit imagery data to the Core Stage within the allocated imagery bandwidth in accordance with <**TBD-045**> and will provide a minimum of one live useful view of the SLS during ascent.

The VIS subsystem #2 that provides imagery data to the ground through the ICPS is <**TBD-025**>. Utilization of VIS subsystem #2 would require ICPS down-link through ground stations.

The reference markings subsystem consists of high contrast markings located on the SLS elements both to provide a calibrated reference frame for ground-generated imagery, and to provide a calibrated reference frame to SLS-generated imagery.

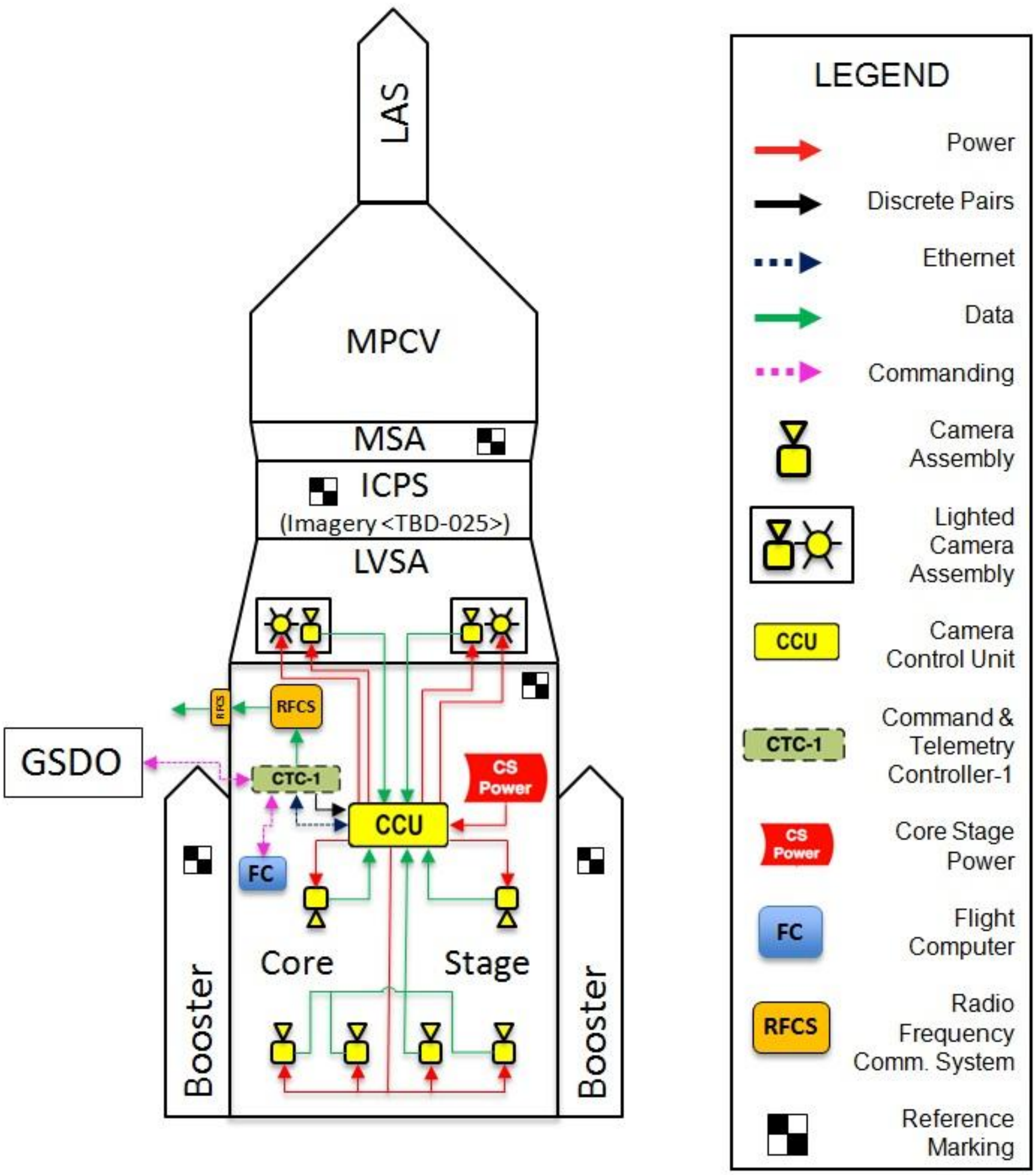

FIGURE 3-1: SLS VIS Architecture

The SLS VIS consists of the following hardware items broken down by each subsystem:

VIS subsystem #1 (which is downlinked through Core Stage avionics) is made up of Government Furnished Equipment (GFE) components referred to as Flight Imaging Launch Monitoring Real-time System (FILMRS), Core Stage provided cabling and mounting, and ISPE provided cabling and mounting, as listed below. Further definition can be found in the SLS Stages Element FILMRS GFE Project Implementation Plan, STG-AV-0010.

VIS Subsystem #1 Components	GFE	Stages	ISPE
CCU (1)	X		
Camera Assembly (6)	X		
Lighted Camera Assembly (2)	X		
Power Cables (CCU-to-Camera Assemblies and CCU-to-Core Stage/ISPE Interface)		X	
Power Cables (Core Stage/ISPE Interface to Lighted Camera Assemblies)			X
Imagery Data Cables (CCU-to-Camera Assemblies and CCU-to-Core Stage/ISPE Interface)		X	
Imagery Data Cables (Core Stage/ISPE Interface to Lighted Camera Assemblies)			X
Camera Assembly Outer Mold Line (OML) fairings required to support camera FOV mounting requirements.		X	
All hardware required to secure or mount the Camera Assembly base plates and CCU to the SLS		X	

VIS Subsystem #1 Components	GFE	Stages	ISPE
structure.			
All hardware required to secure or mount the Lighted Camera Assembly to the SLS structure			X
Power Distribution and Control Unit (PDCU) cable harnesses for the CCU.		X	
100Base-TX Ethernet cables between the CTC-1 and the CCU.		X	
Command discrete pairs between CTC-1 and the CCU.		X	

VIS subsystem #2 (that which is downlinked through ICPS avionics) would utilize the existing ICPS Data Acquisition and Video Integrated System (DAVIS) components, and cabling and mounting, as listed below: <**TBR-011**>):

- <**TBD-025**>

VIS subsystem #3 (High Contrast Reference Markings):

- Markings on external surfaces of Core Stage
- Markings on external surfaces of Booster
- Markings on external surfaces of ISPE (i.e., on the MPCV Stage Adapter (MSA))
- Markings on internal surfaces of ISPE (i.e., on the ICPS)

3.1.3 Roles and Responsibilities

3.1.3.1 Cross Program Imagery Integration Task Team

The Joint Engineering Team for Imagery (JETI) is a cross program integration effort under the authority of the Cross Program Integration Team (CPIT) that will serve as a forum for providing imagery integration services for the MPCV, SLS, and GSDO Programs. The integrated effort provided by the JETI will focus on minimizing cost while ensuring adequate imagery systems are in place to monitor the overall vehicle performance and condition. JETI membership is shown in Figure 3-2.

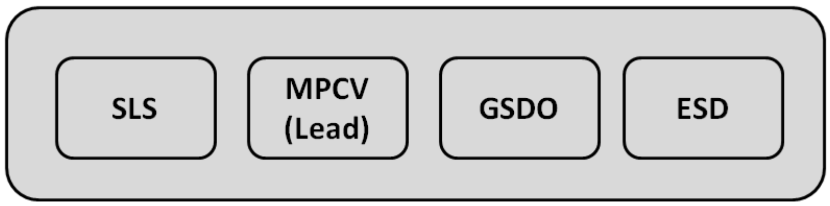

FIGURE 3-2: JETI Membership

3.1.3.2 SLS Engineering Imagery Team

The SLS Engineering Imagery Team (EIT) is managed under the SLS IAS DLE and is responsible for providing end-to-end imagery integration services for SLS. SLS EIT represents SLS on the JETI to ensure the overall imagery system plans are coherent, complementary and cost effective for the integrated vehicle.

3.1.3.3 Image Analysis Team

The SLS Image Analysis Team (IAT) at MSFC is managed under **<TBD-004>** and is responsible for providing technical input to SLS EIT. This team will also be responsible for screening imagery of the SLS during launch, reporting findings based on the imagery analysis, and providing analysis products as defined in section 6.2, Imagery Analysis.

3.1.3.4 Element Prime Contractors/Element Project Offices

Prime contractors for elements that include high contrast reference markings will be responsible for verification activities related to the size and location of the reference markings specified for their elements. The Core Stage prime contractor will be responsible for verification activities related to the FOVs of the VIS as integrated into the Core Stage. The Spacecraft and Payload Integration Office (SPIO) project office will be responsible for verification activities related to the FOVs of view of the VIS as integrated into the ISPE.

3.2 VIS Requirements

This section contains the functional and performance system level requirements for the SLS VIS, which serve as the parent requirements for the ICPS DAVIS, the FILMRS components as integrated into the Core Stage and ISPE, and the reference markings as distributed across the SLS.

3.2.1 SLS VIS Generate Imagery

[SLS.IMG.001] The SLS VIS shall generate time stamped imagery of the events and conditions listed in Section 5.0, Block 1 Mission Critical and Safety Related Events, in accordance with Section 6.1.2.1 (SLS VIS Subsystem #1: Core Stage Down-linked Imagery) and 6.1.2.2 (SLS VIS Subsystem #2: ICPS Down-linked Imagery) <**TBR-011**> of the SLSP ISRD.

Rationale: This is the primary functionality of the SLS VIS in support of the SLS allocation of the Level I ESD R-20 requirement, "The Architecture shall provide audio and motion imagery to the ground”. The SLS VIS subsystems are allocated the motion imagery requirement and not the audio requirement from R-20.

3.2.2 SLS VIS Checkout

[SLS.IMG.002] The SLS VIS shall demonstrate the system functionality at the launch pad required by SLS.IMG.001 <**TBR-040**>.

Rationale: This is a functional requirement intended to buy down risk. For the sake of affordability, requirements for reliability, redundancy and Design for Minimum Risk (DFMR) are not being levied on the SLS VIS. To mitigate the lack of these functional requirements, the full systems checkout prior to launch will at least demonstrate that the system is fully functional at the beginning of the mission.

3.2.3 SLS VIS Subsystem #1 Receive Discrete Signals from the Core Stage

[SLS.IMG.003] SLS VIS subsystem #1 shall receive discrete commands from the Core Stage.

Rationale: SLS VIS subsystem #1 will receive discrete signals from the Core Stage in order that the SLS identified events and conditions be imaged because of the constraints levied on the system (no provisions for SLS hardware recovery and limited bandwidth allocation). Discrete commands are defined in STG-AV-0002, Space Launch System (SLS) Program SLS Stages to Elements Communication and Data Handling (C&DH) Document.

3.2.4 SLS VIS Subsystem #1 Receive Data from the Core Stage

[SLS.IMG.004] SLS VIS subsystem #1 shall receive data from the Core Stage.

Rationale: SLS VIS subsystem #1 will receive data from the Core Stage to establish the Core Stage to SLS VIS subsystem #1 Ethernet link (auto negotiation as defined in IEEE-std-802.3-2002, IEEE Standard for Information Technology-Telecommunications and information exchange between systems-Local and metropolitan area networks--Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications).

3.2.5 SLS VIS Subsystem #1 Provide Imagery to the Core Stage

[SLS.IMG.005] SLS VIS subsystem #1 shall transmit motion imagery data to the Core Stage.

Rationale: SLS VIS subsystem #1 will provide imagery with timing to the Core Stage in order for Core Stage to transmit it to the ground in support of the Level I ESD requirement R-20, "The Architecture shall provide audio and motion imagery to the ground."

3.2.6 SLS VIS Subsystem #2 Provide Imagery to the Ground

[SLS.IMG.006] SLS VIS subsystem #2 shall provide imagery data to the ground <**TBR-011**>.

Rationale: SLS VIS will need to provide imagery to the ICPS in order for ICPS to transmit it to the ground in support of R-20, "The Architecture shall provide audio and motion imagery to the ground." Depending on how the architecture is established, the SLS VIS may need to receive data (timing) and commands (power up, etc...) from the ICPS.

3.2.7 SLS VIS Subsystem #3 Reference Markings

[SLS.IMG.007] The SLS VIS subsystem #3 shall contain reference markings in accordance with Section 6.1.2.3 of the SLSP ISRD.

Rationale: Some of the functional capabilities of the overall imagery architecture (Level I), such as monitoring vehicle clearances from ground structure from liftoff through tower clearance, cannot be performed by SLS vehicle assets, and will be performed by ground assets. In order to provide a reference frame and contribute to the engineering analysis of that imagery, the SLS VIS provides high contrast reference markings in accordance with the SLS ISRD. Additionally, some of the functional capabilities of the SLS VIS (Level II), such as monitoring clearance at booster and ISPE separation, cannot be adequately performed by the separating SLS element assets (boosters, ISPE), so reference markings will be provided on the separating elements in order to provide a reference frame and contribute to the engineering analysis of SLS element separation imagery.

3.2.8 SLS VIS Subsystem #1 Configure Imagery Time Source

[SLS.IMG.008] The SLS VIS subsystem #1 shall configure its time source within 20 ms <**TBR-049**> following receipt of a command.

Rationale: SLS VIS subsystem #1 will provide time stamped imagery to the Core Stage in order for Core Stage to transmit it to the ground in support of the Level I ESD requirement R-20, "The Architecture shall provide audio and motion imagery to the ground." The SLS VIS subsystem #1 time source is used to provide the time stamp for the imagery data. The SLS VIS subsystem #1 must be reset to a predetermined value <**TBD-052**> when commanded. The SLS VIS subsystem #1 must also be able to pause and restart its time source when commanded to accomodate launch countdown holds. All time source changes must occur within 20 ms following receipt of the command in order to establish an acceptable bound on latency between CCU time and SLS Vehicle time for post-processing of the imagery data.

3.2.9 SLS VIS Subsystem #1 Window Protection

[SLS.IMG.008] SLS VIS subsystem #1 shall protect housing windows exposed to the SLS exterior from induced and natural environments during assembly, shipment, integration and system checkout phases without increasing opacity of the windows to more than 25% during these phases.

Rationale: Protecting the SLS VIS subsystem #1 Camera Assembly OML fairing windows and the Lighted Camera Assembly housing windows during phases of assembly, shipment, integration, and system checkout is needed to minimize the amount of damage or contamination to the exposed glass.

Table 3-1 VIS Imagery Requirements Allocations to SLS Elements

Reqmt ID	Title	Booster	Stages	ISPE
SLS.IMG.001	SLS VIS Generate Imagery		√	√
SLS.IMG.002	SLS VIS Checkout		√	√
SLS.IMG.003	SLS VIS Subsystem #1 Receive Discrete Signals from the Core Stage		√	
SLS.IMG.004	SLS VIS Subsystem #1 Receive Data from the Core Stage		√	
SLS.IMG.005	SLS VIS Subsystem #1 Provide Imagery to the Core Stage		√	
SLS.IMG.006	SLS VIS Subsystem #2 Provide Imagery to the Ground			√
SLS.IMG.007	SLS VIS Subsystem #3	√	√	√

Reqmt ID	Title	Booster	Stages	ISPE
	Reference Markings			
SLS.IMG.008	SLS VIS Subsystem #1 Configure Imagery Time Source		√	
SLS.IMG.009	SLS VIS Subsystem #1 Window Protection		√	

4.0 VERIFICATION PROVISIONS

4.1 General

This section identifies activities required to verify that the requirements of Section 3 have been satisfied. Verification approach for the SLS Program is provided in the SLS Verification and Validation Plan, SLS-PLAN-009.

4.2 Verification Matrix

4.2.1 SLS VIS Verification Matrix

The verification requirements for the SLS VIS will be developed by the SLS VIS Preliminary Design Review. A summary of the verification methods with accompanying rationale is shown in Table 4.2.1-1.

Table 4.2.1-1: SLS VIS Requirements Verification Matrix

Requirement Number & Title	Verification Activities	Verification Method(s)						Verification Method Comments
		A	I	D	T	VR	S	
SLS.IMG.001 SLS VIS Generate Imagery	An SLS integrated end-to-end test shall be performed within the SLS Systems Integration Laboratory (SIL) using SLS VIS hardware and software in the flight configuration with an interface to the SLS Core Stage using flight equivalent or emulator hardware. The end-to-end test will exercise the SLS	X			X			An end-to-end test is necessary to show that the integrated SLS VIS can respond to commands, generate imagery, and transmit the generated imagery to the SLS Core

Requirement Number & Title	Verification Activities	Verification Method(s)						Verification Method Comments
		A	I	D	T	VR	S	
	Core Stage to SLS VIS command path as well as the SLS VIS to SLS Core Stage telemetry path (exclusive of RFCS; telemetry path will be measured at output of CTC only). An analysis shall be performed by the **Stages Element** using installation drawings, SLS VIS hardware drawings, and design models to show that the SLS VIS, as integrated onto the SLS Core Stage, can capture the desired FOVs in the flight configuration. An analysis shall be performed by **ISPE** using installation drawings, SLS VIS hardware drawings, and design models to show that the SLS VIS, as integrated onto the ISPE, can capture the desired FOVs in the flight configuration.							Stage for RFCS downlink. This end to end test is limited in scope to output of CTC only. CTC output will be decoded to verify imagery content. Analysis is necessary to show that the integrated SLS VIS is sufficient to image the specified critical and safety related events and conditions within the specified FOVs.
SLS.IMG.002 SLS VIS Checkout	A demonstration shall be performed within the SLS SIL using SLS VIS hardware and software in the flight configuration with an interface to the SLS Core Stage using flight equivalent or emulator hardware. The functional demonstration will show that GSDO can command the SLS Core Stage to perform an SLS VIS checkout, that the SLS Core Stage can internally command the SLS VIS in response to the			X				A demonstration is necessary to prove basic functionality of the command path and the data path in the SLS pre-launch configuration.

Requirement Number & Title	Verification Activities	Verification Method(s)						Verification Method Comments
		A	I	D	T	VR	S	
	GSDO command, and that the SLS VIS can execute the command by generating imagery data and transmitting the imagery data for SLS Core Stage processing.							
SLS.IMG.003 SLS VIS Subsystem #1 Receive Discrete Signals from the Core Stage	A test shall be performed within the SLS SIL using SLS VIS hardware and software in the flight configuration with an interface to the SLS Core Stage using flight equivalent or emulator hardware. The test will exercise the SLS Core Stage to SLS VIS command path to verify that the SLS VIS responds as expected to SLS Core Stage command discrete signals.				X			A test is necessary to show that the integrated SLS VIS can receive and respond to the command discrete signals identified in STG-AV-0002.
SLS.IMG.004 SLS VIS Subsystem #1 Receive Data from the Core Stage	A test shall be performed within the SLS SIL using SLS VIS hardware and software in the flight configuration with an interface to the SLS Core Stage using flight equivalent or emulator hardware. The test will exercise the SLS Core Stage to SLS VIS Ethernet transmission path to verify that the SLS VIS can receive data from the SLS Core Stage.				X			A test is necessary to show that the integrated SLS VIS can receive data from the SLS Core Stage as specified in STG-AV-0002.
SLS.IMG.005 SLS VIS Subsystem #1 Provide	An integrated end-to-end test shall be performed within the SLS SIL using SLS VIS hardware and software in the				X			A test is necessary to show that the integrated SLS VIS can transmit

Requirement Number & Title	Verification Activities	Verification Method(s)						Verification Method Comments
		A	I	D	T	VR	S	
Imagery to the Core Stage	flight configuration with an interface to the SLS Core Stage using flight equivalent or emulator hardware. The end-to-end test will exercise the SLS VIS to SLS Core Stage telemetry path (to include generation of imagery data, transmission of imagery data from the SLS VIS to the SLS Core Stage, and transmission of imagery data internal to the SLS Core Stage – CTC through RFCS).							data to the SLS Core Stage in the proper format as specified in STG-AV-0002.
SLS.IMG.006 SLS VIS Subsystem #2 Provide Imagery to the Ground	An integrated end-to-end test shall be performed within a hardware-in the-loop facility using SLS VIS subsystem #2 hardware and software in the flight configuration. The end-to-end test will exercise the SLS VIS subsystem #2 to ground telemetry path (to include generation of imagery data, transmission of imagery data from the SLS VIS subsystem #2/ICPS to the ground, and decoding of the imagery data).				X			A test is necessary to show that the integrated SLS VIS can transmit data to the SLS Core Stage in the proper format as specified in STG-AV-0002.
SLS.IMG.007 SLS VIS Subsystem #3 Reference Markings	An inspection of the high contrast markings on SLS elements using installation drawings shall be performed by the **Booster Element, ISPE, and Stages Element** to show that the high contrast markings required by this ISRD are		X					An inspection of the design documentation is required to show that the required high contrast markings are

Requirement Number & Title	Verification Activities	Verification Method(s)						Verification Method Comments
		A	I	D	T	VR	S	
	included in the appropriate Element design documents and are located as specified in this ISRD.							correctly located.
SLS.IMG.008 SLS VIS Subsystem #1 Configure Imagery Time Source	A test shall be performed within the SLS SIL using SLS VIS hardware and software in the flight configuration with an interface to the SLS Core Stage using flight equivalent or emulator hardware. The test will verify the ability of the CCU to configure its time source following receipt of command from the CTC.	X			X			A test and analysis are necessary to show that the CCU can set its time source following receipt of command discrete signal(s) as identified in STG-AV-0002.
SLS.IMG.009 SLS VIS Subsystem #1 Window Protection	An inspection of installation drawings shall be performed by the **Core Stage Element** to show that OML fairing window protection are included in the appropriate Element design documents. An inspection of installation drawings shall be performed by the **ISPE** to show that Lighted Camera Assembly housing window protection are included in the appropriate Element design documents. An analysis of the protection solution shall be performed to show that it does not result in a window opacity greater than 25% during assembly, shipment, integration and system checkout phases.)	X	X					An inspection of installation drawings is necessary to show that the covers are part of the VIS design during these phases. Analysis is necessary to show that the solution does not result in window opacity of greater than 25% during the specified phases.

5.0 BLOCK1 MISSION CRITICAL & SAFETY RELATED EVENTS/CONDITIONS

SLS program managers designated a Mission Critical Events and Conditions task team to be led under the direction of IAS DLE to identify the events that SLS needs imagery coverage, with focus on Block 1 configuration beginning at the start of tanking through End of Mission (i.e., ICPS separation from MPCV elements). The task team consisted of members from GSDOP, SLS Systems Engineering and Integration (Systems Engineering, Vehicle Management (VM), Structures and Environments (STE), Propulsion, IAS and Operations), SLS Elements (Stages, Booster, Engine and ISPE), and S&MA.[1] The results of the analysis of the Mission Critical Events and Conditions task team are documented in this section of the SLSP ISRD.

Subsections 5.1 through 5.15 define the events and conditions with associated rationale, timeframes and specific detail that will comply with the ESD architecture level imagery requirement. Reference the SLSP IMT, SLS-RPT-037 for more information on timeframes where events are listed below. Table 5-1 allocates imagery requirements to the SLS Elements in which camera(s) and high contrast reference markings (i.e., VIS subsystems) will be integrated to provide imagery of the defined events. This table also identifies the SLS Element responsible for down-linking the imagery data. The non-VIS subsystems provided by GSDO and MPCV Programs are also identified in the sections below and in Table 5-1 **<u>for reference only</u>** to identify the imagery related needs that SLS cannot satisfy with SLS based resources alone; agreements between Programs will be documented in the applicable Program to Program requirements documents (ICDs, IRDs, etc…).

5.1 SLS Thermal Protection System (TPS) Integrity

Event Rationale: It is of value to image the integrity of the Core Stage and ISPE TPS during propellant loading through prelaunch, to evaluate if it has deviated from an acceptable configuration. TPS configuration deviations can indicate structural integrity problems as well as issues with the propellant itself**.** This imagery will be used to reduce uncertainty in analysis and provide data for anomalous and potentially catastrophic events.

Time Period: Start of Tanking to Liftoff (T-0sec)**.**

Detailed areas of interest: 360 degree coverage of the Core Stage and ISPE TPS that are not obscured by over laying hardware (i.e., Booster hardware, Liquid Oxygen (LO2) feedlines, pressline, system tunnel, umbilicals, etc.) with ability to resolve defects of 2 inch x 2 inch in size < **TBR-052**> (missing TPS) and <**TBD-053**> in size crack and/or ice formations. External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>.[∇]

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[1] Production and Test opted out due to the scope of the activity.

[∇] SLS identified needs which can only be satisfied by GSDO resources are provided as reference only.

Imagery Data Usage: Real-time monitoring used for inspection and possible decision making prelaunch.

Intended Customer: STE, ISPE, and Stages.

5.2 Hydrogen Igniter System

Event Rationale: It is of value to image the operation and performance of the hydrogen igniter system, also called Radially Outward Firing Igniters (ROFIs). The hydrogen igniter system will provide a means of burning off free-flowing hydrogen and protect the SLS from being subjected to potential fires.

Time Period: 2 to 3seconds before Main Fuel Valve (MFV) opening through T+30sec **<TBR-007>.**

Detailed areas of interest: Inside Core Stage engine bells and around Core Stage engine nozzles, Core Auxiliary Power Unit (APU) exhaust areas, and main Core Stage plume hole monitoring the continuous operation and spray of the ROFIs that are mounted around the launch pad duct **<TBR-033>.** External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>.[∇]

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE.

5.3 Liftoff Vehicle Integrity

Event Rationale: It is of value to image the Core Stage engines during the Launch Countdown Demonstration (LCD) gimbal checkout and also image the SLS during ignition and liftoff for anomalous hardware conditions such as leaks and structural/thermal integrity. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: LCD Engine Gimbal Checkout <**TBR-051**>; T-10sec through Tower Clearance **<TBR-008>.**

Detailed areas of interest: During the LCD engine gimbal checkout, monitor the Core Stage engine bells motion related to ground structure. 360 degree coverage of the Core Stage, Booster and ISPE hardware that are not obscured by over laying hardware (i.e., Booster hardware, LO2 feedlines, pressline, etc.) with ability to resolve structural defects of 2 inch x 2inch in size **<TBR-029>** and <**TBD-053**> in size crack and/or ice formations**.** Thermal integrity monitoring needs to be focused on the following areas booster field joints, Core Stage engine base heat shield <**TBR-043**> to detect anomalies of <**TBD-042**> thermal range. External lighting may be necessary when event occurs in suboptimal lighting conditions. Specific areas have not been identified to detect defects or anomalies to specific size using the VIS assets. The SLS VIS assets will monitor areas that are in the cameras FOVs to the best capability possible.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>[∇] and SLS VIS as defined in Section 6.1.2.1.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, Stages, Booster, ISPE.

5.4 Liftoff Debris (LOD)

Event Rationale: It is of value to image for liftoff related debris which could become plume driven and cause significant or catastrophic damage to the SLS. This includes the debris source (SLS hardware, facility hardware, animals, etc.), driving flow conditions, (Booster Ignition, Core Stage Ignition, etc.), vehicle based impacts (Engine Hardware, General SLS Hardware, etc.), and close calls (debris which travelled in a manner outside of expectations that could have detrimental effects with a slightly different transport). This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: T-7sec through Tower Clearance.

Detailed areas of interest: Launch deck, localized areas around Booster, Core Stage Engines, exit of flame holes/flame trench **<TBR-030>** with the ability to assess LOD <**TBD-054**> minimum size, velocity and impact locations, as applicable**.** External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>[∇], high contrast markings on the ground infrastructure as defined in <**TBD-033**> and high contrast markings on the SLS elements as defined

in section 6.1.2.3.1, 6.1.2.3.2 and 6.1.2.3.3.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, Stages, Booster

5.5 Sound Suppression System

Event Rationale: It is of value to image the activation and performance of the sound suppression system which is used to reduce the vibro/acoustic environmental loading on the SLS. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

[∇] SLS identified needs which can only be satisfied by GSDO resources are provided as reference only.

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Verify this is the correct version before use.

Time Period: T-7sec through Tower Clearance**.**

Detailed areas of interest: Launch deck, plume holes (Boosters and Stages), under plume holes, crest water (water flow mushroom), and tower curtain **<TBR-031>.** External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>.[∇]

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE

5.6 Ground Umbilical Separation and Retraction

Event Rationale: Ground umbilical / connector separation and retraction from the SLS must be completed prior to liftoff to prevent damage. It is of value to image umbilical separation timing and motion relative to the SLS and image proper retraction to monitor for possible re-contact. Re-contact, or lack of separation, could cause significant damage, Loss of Mission (LOM) and/or Loss of Crew (LOC). This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: Liftoff (T-0sec) through Tower Clearance

Detailed areas of interest: All ground to SLS umbilicals that are released during launch **<TBR-032>.** External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033** >[∇].

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: ISPE, STE, VM, Stages, Booster

5.7 On Pad Engine Shutdown / Abort

Event Rationale: It is of value to observe the engine area of SLS for free burning hydrogen or other fires following an on-pad abort. RS-25 engines start and shut down in a fuel rich condition where excess hydrogen is expected to be expelled. This imagery will be used to reduce uncertainty in analysis and provide data for anomalous and potentially catastrophic events.

Time Period: T-10s through 10sec post Engine Shutdown

[∇] SLS identified needs which can only be satisfied by GSDO resources are provided as reference only.

Detailed areas of interest: Inside Core Stage engine bells and around Core Stage engine nozzles, Core APU exhaust areas, and main Core Stage plume hole monitoring the continuous operation and spray of the ROFIs that are mounted around the launch pad duct **<TBR-033>.** External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>[∇].

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, LEO

5.8 SLS Liftoff Clearances

Event Rationale: It is of value for Integrated Validation to measure adequate liftoff clearance of the SLS from the ground launch systems (tower, stabilization arms, umbilicals, Vehicle Support Posts, lightning protection hardware, etc…). Without imagery, measurements of critical clearances between the SLS and ground systems cannot be made. Such measurements allow an increased understanding in acceptable launch conditions. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: T-10sec through Tower Clearance**.**

Detailed areas of interest: Monitor movement of the vehicle during liftoff in order to support post-flight assessment with type and accuracy shown in the following list: **<TBR-034>**:

- Booster Nozzle to Vehicle Support Posts: 3 Degrees of Freedom (DOF) assessments with 0.5 inch accuracy
- Core Stage Engine Section Umbilicals: 2 DOF assessment with 2 inch accuracy
- Tower: 6 DOF assessment with 6 inch accuracy

External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>[∇] and high contrast markings on the SLS elements as defined in section 6.1.2.3.1, 6.1.2.3.2 and 6.1.2.3.3.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE. VM, Stages, Booster, ISPE

[∇] SLS identified needs which can only be satisfied by GSDO resources are provided as reference only.

5.9 Booster Motor Plume

Event Rationale: It is of value to image the SLS Booster plume during ascent to assess for anomalous booster performance. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: Liftoff (T-0sec) through Booster Separation

Detailed areas of interest: Aft section of Booster, Booster plume holes (North), exit of flame trench/flame diffuser (North). Monitor for plume recirculation up the SLS during ascent **<TBR-035>.** External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**> [∇].

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, Booster

5.10 Ascent Vehicle Integrity

Event Rationale: It is of value to image the SLS during ascent to assess the structural integrity of the SLS which could be adversely affected by induced environments or debris (birds, liberated hardware, etc.). During anomalous conditions, it is necessary to identify near misses or catastrophic events that will aid in decision making/problem resolution for future flights. This is particularly important since no SLS hardware will be recovered.

Time Period: Tower Clearance through ICPS/MPCV separation clearance**.**

Detailed areas of interest: From liftoff to tower clearance, GSDO based imagery will be used to monitor the top of the SLS for bird strikes, etc. 360 degree coverage of the Core Stage, Booster and ISPE hardware that are not obscured by over laying hardware (i.e., Booster hardware, LO2 feedlines, pressline, etc…) with ability to resolve defects (e.g., cracks, missing TPS, ice built up) of 2 inch x 2 inch **<TBR-036>**. External lighting may be necessary when event occurs in suboptimal lighting conditions. GSDO based imagery will be used to view the SLS from tower clear until loss of acquisition. During ascent, specific areas have not been identified to detect defects or anomalies to specific size using the VIS assets. The SLS VIS assets will monitor areas that are in the cameras FOVs to the best capability possible.

Imagery Data Provided By: GSDO imagery assets as defined in <**TBD-033**>[∇], and SLS VIS as defined in Section 6.1.2.1 and 6.1.2.2 <**TBR-011**>.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

[∇] SLS identified needs which can only be satisfied by GSDO resources are provided as reference only.

Intended Customer: STE, Stages, Booster, ISPE

5.11 Booster Separation for Re-contact

Event Rationale: It is of value to image the separation and jettison of each booster to monitor for re-contact. Re-contact, or lack of separation, would likely occur at attach points interfaces and could cause catastrophic damage. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: 5 sec prior to Booster Separation (first motion) through + 10s **<TBR-053>.**

Detailed areas of interest: Monitor movement of the boosters during separation in order to support post-flight assessment with type and accuracy shown in the following list: **<TBR-024>**:

- -Z forward attach structure: 3 DOF assessment with <**TBD-049**> accuracy
- –Z aft attach strut: 3 DOF assessment with <**TBD-050**> accuracy

External lighting may be necessary when event occurs in suboptimal lighting conditions.

Imagery Data Provided By: SLS VIS as defined in section 6.1.2.1.6 and 6.1.2.1.7. Markings used on booster as identified in section 6.1.2.3.2.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, VM, Stages, Booster

5.12 Nominal Launch Abort System (LAS) Jettison for Re-contact

Event Rationale: It is of value to image the SLS for re-contact or near misses during the nominal LAS separation event which could cause damage to the SLS. The intent of this event is not to monitor the jettison and trajectory of the LAS, rather monitor SLS hardware for possible LAS related hardware impacts or near misses. A re-contact situation could cause catastrophic damage. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: 5 sec prior to LAS Jettison (first motion) through + 10s **<TBR-054>.** (Note that LAS jettison timing depends on altitude calculations and does not occur at a prescribed time. Thus the start time indicated here must be approximated while in-flight.)

Detailed areas of interest: Specific focus on specific features where there are diameter or geometry changes (Core Stage LO2 Feedlines) of the Core Stage and ISPE hardware <**TBR-025**>:

Imagery Data Provided By: SLS VIS as defined in section 6.1.2.1.2 through 6.1.2.1.5 and 6.1.2.2 <**TBR-011**>.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, Stages and ISPE <**TBR-011**>

5.13 Encapsulated Service Module (ESM) Fairing Jettison for Re-Contact

Event Rationale: It is of value to image the liberated ESM fairings for re-contact or near misses to the SLS. Re-contact, or lack of separation, could cause catastrophic damage. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: 5 sec prior to ESM Jettison (first motion) through + 10s **<TBR-055>.**

Detailed areas of interest: Specific features where there are diameter or geometry changes (Core Stage LO2 Feedlines) of the Core Stage and ISPE hardware <**TBR-026**>.

Imagery Data Provided By: SLS VIS as defined in section 6.1.2.1.2 through 6.1.2.1.5 and 6.1.2.2 <**TBR-011**>.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, Stages and ISPE <**TBR-011**>

5.14 LVSA / ICPS Separation Clearance

Event Rationale: It is of value to measure clearance between the ICPS and the LVSA during separation. Re-contact, or lack of separation, between the ICPS structures and the LVSA could result in catastrophic damage and/or LOM and LOC. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: 5 sec prior to Core Stage / ICPS Separation (first motion) through + 13s**<TBR-056>.**

Detailed areas of interest: The entire external aft circumference of the ICPS engine bell, two umbilical arms inside the LVSA, and the entire internal forward circumference of the LVSA exit plane as the ICPS exit the LVSA structure with the ability to detect clearance with 2 inch accuracy. <**TBR-027**>

Imagery Data Provided By: SLS VIS as defined in section 6.1.2.1.8 through 6.1.2.1.9. Markings on ISPE as defined in section 6.1.2.3.4.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, VM, Stages, ISPE

5.15 Orion Separation Clearance

Event Rationale: It is of value to measure clearance between the MPCV Spacecraft Adapter (SA) and Service Module (SM) during separation <**TBR-048**>. Re-contact, or lack of separation, between the structures may result in catastrophic damage and/or LOM and LOC. This imagery will be used post flight to reduce uncertainty in analysis and provide data of anomalous and potentially catastrophic events.

Time Period: 5 sec prior to Orion Separation (first motion) through Orion Separation clearance **<TBR-057>.**

Detailed areas of interest: **<TBD-022>**

Imagery Data Provided By: SLS VIS as defined in section 6.1.2.2 <**TBR-011**>.

Imagery Data Usage: Post Flight Performance Analysis in support of flight readiness for future flights.

Intended Customer: STE, VM, ISPE

Table 5-1 Block 1 Mission Critical and Safety Related Events Applicability

Event Defined in Section	Core Stages	Booster	Liquid Engine	ISPE	GSDO	MPCV
5.1 SLS TPS Integrity					C	
5.2 Hydrogen Igniter System					C	
5.3 Liftoff Vehicle Integrity					C	
5.4 Liftoff Debris	M	M		M	C,M	
5.5 Sound Suppression System					C	
5.6 Ground Umbilical Sep. & Retr.					C, M	
5.7 On Pad Engine Shutdown/Abort					C	
5.8 SLS Liftoff Clearances	M	M		M	C	
5.9 Booster Motor Plume					C	

Event Defined in Section	Core Stages	Booster	Liquid Engine	ISPE	GSDO	MPCV
5.10 Ascent Vehicle Integrity	C,D				C	
5.11 Booster Sep for Re-contact	C,D	M				
5.12 Nominal LAS Jett for Re-contact	C,D					
5.13 ESM Fairing Jettison for Re-contact	C,D					
5.14 LVSA/ICPS Separation Clearance	D			C,M		
5.15 Orion Separation Clearance **<TBR-048>**				<**TBD-025**>		**<TBD-043>**

"C" defines location (element/program) where camera(s) are required to be installed to support specific events.

"M" defines location (element/program) where high contrast markings are required to be installed to support specific events.

"D" defines which element/program is responsible for downlinking imagery of specific events.

Columns MPCV and GSDO are for information only.

6.0 IMAGERY SYSTEM FUNCTIONAL & OPERATIONAL OVERVIEW

The **<TBD-023>** DLE will be responsible for ensuring imagery analysis of the SLS is completed following each SLS mission. The subsections below discuss the imagery products, expected coverage, data format and distribution, expected analysis and also how the information will be integrated with management and other applicable organizations.

6.1 Imagery Sensors and Systems

This section provides a high-level overview of the imagery sensors and systems that will be used for the SLS Program. The MPCV and GSDO Programs may also use the imagery data discussed in this document, as determined by the MPCV and GSDO Programs.

6.1.1 Ground Systems

The SLS Program will rely on GSDO imagery sensors and systems during pre-launch, liftoff and ascent to provide imagery of the SLS, as identified in Table 5-1 and further defined in **<TBD-033>,** to evaluate system performance and vehicle integrity during post flight evaluations. GSDO requirements to provide SLS imagery will be documented in the Applicable Program to Program documents <**TBR-038**>.

Pre-flight closeout imagery of SLS hardware, pre-flight imagery of instrumentation (OFI and/or DFI) after sensor installation (before being covered with hardware or TPS), SLS processing, integration and rollout, and on pad lightning monitoring are not addressed in this document and will be defined in <**TBD-040**>.

6.1.1.1 Baseline Imagery

GSDO imagery of the SLS will be collected to document the pre-launch configuration of the SLS. This data is separate from the typical closeout photos that are taken as areas of the vehicle are “closed out” for launch. Baseline Imagery provides the pre-launch condition of the external surfaces of the launch vehicle and can be used for comparison of changes in configuration as a result of launch, flight, post-flight, and recovery operations (as applicable). SLS baseline imagery views are defined in **<TBD-034>.** Artificial lighting on the SLS may be required when Baseline Imagery is collected.

6.1.1.2 Walkdown Inspection Imagery

Pre-launch GSDO imagery of the SLS and near-by infrastructure will be collected for use in walk-down inspection activities **<TBR-010>.** Comparison of post-launch conditions against pre-launch imagery will facilitate understanding of changes that happened as a result of launch. SLS walkdown imagery views are defined in **<TBD-035>.** Artificial lighting on the SLS may be required during walk down inspections that occur during non-optimal lighting conditions.

6.1.1.3 Liftoff and Ascent Imagery

GSDO imagery of the SLS will be obtained during initial liftoff and ascent as identified in Table 5-1. Artificial lighting on the SLS may be required when liftoff occurs during non-optimal lighting conditions.

6.1.1.4 Ground Systems Reference Markings <TBR-003>

The GSDO hardware near the SLS will have high contrast reference markings with known surveyed positional information that will be viewable by ground imagery assets currently with applicable SLS markings. These markings will allow the image analysis teams to provide accurate three-dimensional (3D) positional data of the SLS and other objects (i.e. liftoff debris) with respect to the Mobile Launcher and Tower using ground based imagery assets. This data will support model validation relative to liftoff clearances. The need for the ground based reference markings in support of SLS imagery events are identified in Table 5-1. Artificial lighting on the GSDO launch structure and SLS may be required when liftoff occurs during non-optimal lighting conditions.

6.1.2 Block 1 SLS VIS Subsystems

SLS VIS, as defined in Section 3.1, will collect imagery prior to liftoff, through separation and payload deployment phases as appropriate. The following sections define the VIS subsystems and FOVs.

6.1.2.1 SLS VIS Subsystem#1: Core Stage Down-linked Imagery

The SLS VIS segment that will be responsible for providing data to the CTC-1 to be downlinked through the Core Stage avionics consists of six cameras on the Core Stage OML and two cameras internal to the LVSA as shown in Figure 6-1. The following sections define the VIS subsystem#1 camera identifier nomenclature, purpose, FOV and overall operational usage. The Stages CEI Specification <**TBR-044**> and the ISPE CEI Specification <**TBR-045**> will document the installed location of the cameras.

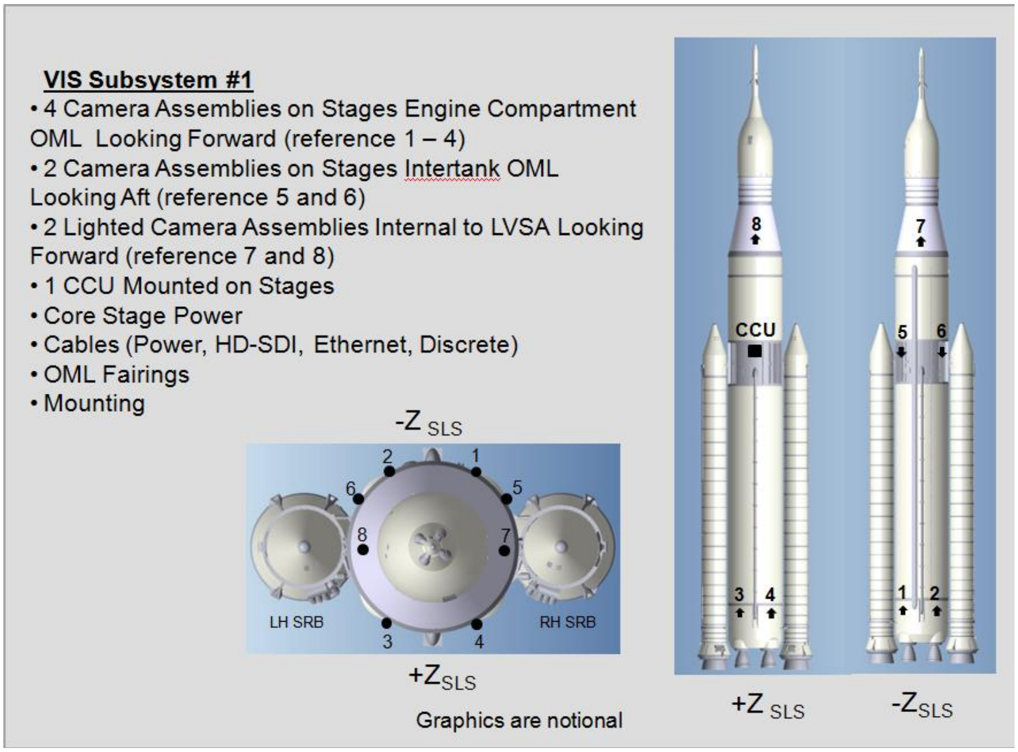

FIGURE 6-1: Block 1 VIS Subsystem #1

6.1.2.1.1 Camera Identifiers

Each VIS subsystem #1 camera is given a five-character name comprised of three alpha characters and two numeric characters (i.e., AAANN).

a) The first character (alpha) identifies the element on which the camera is flown:

   i) S = Stage

   ii) I = ISPE

b) The second character (alpha) identifies the location on which the camera is flown:

   i) E = Engine Section

   ii) I = Intertank

   iii) L = LVSA

c) The third character (alpha) identifies the direction in which the camera is pointing:

   i) A = Aft looking

   ii) F = Forward looking

d) The fourth character (numeric) is assigned as cameras are added to each element (i.e., 1 = the first camera location assigned).

e) The fifth character (numeric) indicated the hardware configuration version from the initial baseline. The number is incremented only if the modification results in a change to the FOV, quality, or visual format of the imagery being obtained. A simple hardware upgrade, with no resulting change to the imagery data, does not warrant a number change.

f) Using the convention above, the VIS#1 cameras are assigned the names:

   i) SEF11 = Stages Engine Section Forward Looking camera #1

   ii) SEF21 = Stages Engine Section Forward Looking camera #2

   iii) SEF31 = Stages Engine Section Forward Looking camera #3

   iv) SEF41= Stages Engine Section Forward Looking camera #4

   v) SIA51 = Stages Intertank Aft Looking camera #5

   vi) SIA61= Stages Intertank Aft Looking camera #6

   vii) ILF71= ISPE LVSA Forward Looking camera #7

   b) ILF81 = ISPE LVSA Forward Looking camera #8

6.1.2.1.2 Camera SEF11

Imagery from camera SEF11 will provide coverage of the SLS vehicle as defined in sections 5.10 (Ascent Vehicle Integrity), 5.12 (Nominal LAS Jettison for Re-contact), and 5.13 (ESM Panel Jettison for Re-contact) of this document.

The FOV for camera SEF11 is defined below and illustrated in Figure 6-2. The red and blue dashed lines indicate the maximum and minimum area of the FOV that must be accommodated to achieve desired resolutions.

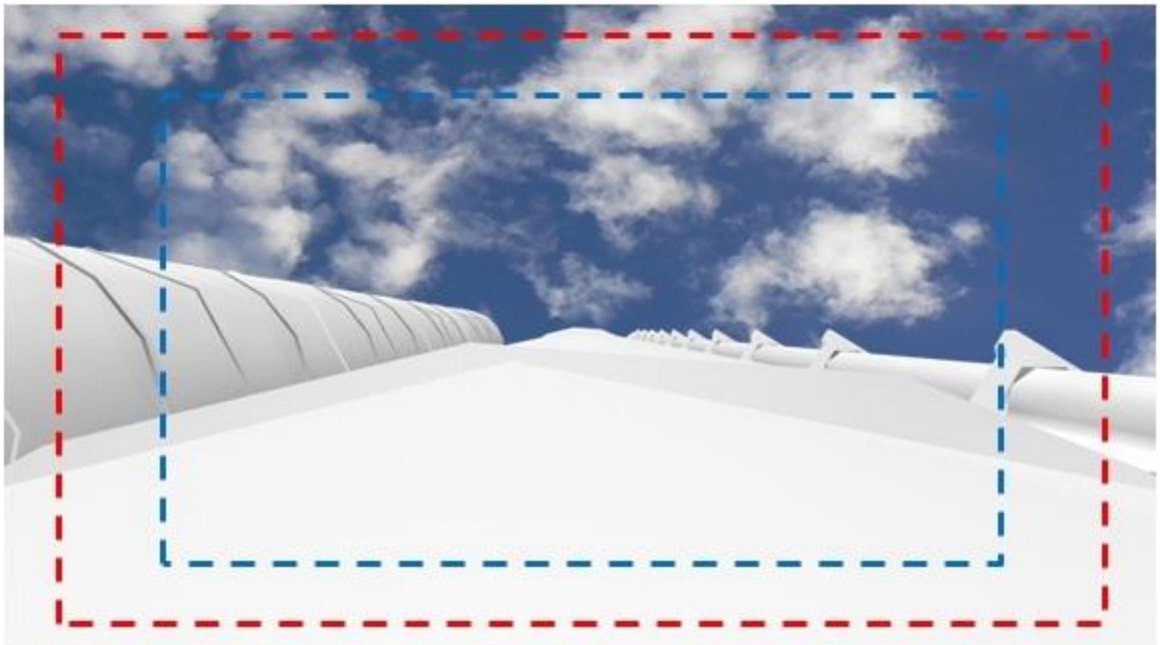

FIGURE 6-2: Block 1 VIS Subsystem #1 SEF11 FOV

FOV Description: *Camera SEF11 configuration will image the Core Stage OML for general vehicle integrity monitoring during ascent, as well as, potential re-contact or near misses by the ESM fairing after ESM fairing jettison, and image the Core Stage OML for potential re-contact or near misses by the LAS. Approximately 30% <**TBR-060**> of the FOV will include non-vehicle (i.e. sky) in order to provide imagery of the ESM fairing during transport.*

Image Capture: *The camera SEF11 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution*:* *The camera SEF11 will resolve features of <**TBD-046**> under ideal laboratory conditions.*

Imagery Timing*: Time stamp will be included in the SEF11 motion imagery such that the imagery can be related back to Mission Elapsed Time (MET) or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera SEF11 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera SEF11 will provide imagery as allowed by natural lighting during daylight or night conditions. Supplemental lighting, other than what may be available from GSDO or SLS vehicle plume, will not be provided by SEF11.*

Synchronization: *The camera SEF11 is not required to be synchronized with other VIS cameras.*

6.1.2.1.3 Camera SEF21

Imagery from camera SEF21 will provide coverage of the SLS vehicle as defined in sections 5.10 (Ascent Vehicle Integrity), 5.12 (Nominal LAS Jettison for Re-contact), and 5.13 (ESM Panel Jettison for Re-contact) of this document.

The FOV for camera SEF21 is defined below and illustrated in Figure 6-3. The red and blue dashed lines indicate the maximum and minimum area of the FOV that must be accommodated to achieve desired resolutions.

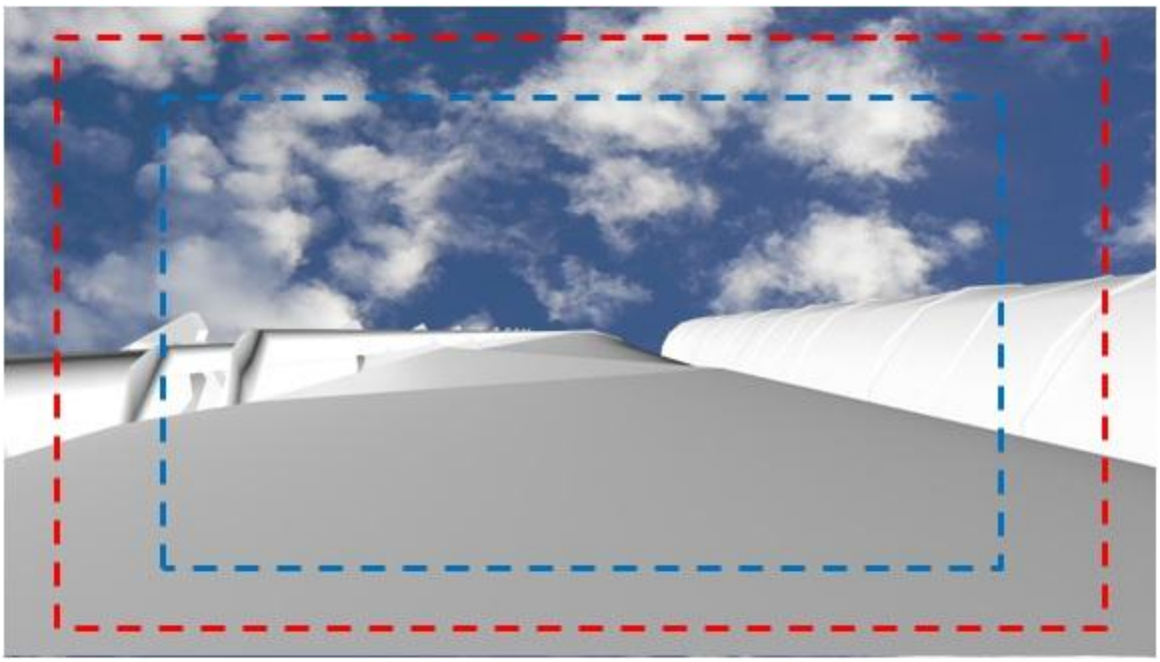

FIGURE 6-3: Block 1 VIS Subsystem #1 SEF21 FOV

FOV Description: *Camera SEF21 configuration will image the Core Stage OML for general vehicle integrity monitoring during ascent, as well as, potential re-contact or near misses by the ESM fairing after ESM fairing jettison, and image the Core Stage OML for potential re-contact or near misses by the LAS. Approximately 30% <**TBR-061**> of the FOV will include non-vehicle (i.e. sky) in order to provide imagery of the ESM fairing during transport.*

Image Capture: *The camera SEF21 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution: *The camera SEF21 will resolve features of <**TBD-046**> under ideal laboratory conditions.*

Imagery Timing: *Time stamp will be included in the SEF21 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera SEF21 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera SEF21 will provide imagery as allowed by natural lighting during daylight or night conditions. Supplemental lighting, other than what may be available from GSDO or SLS vehicle plume, will not be provided by SEF21.*

Synchronization: *The camera SEF21 is not required to be synchronized with other VIS cameras.*

6.1.2.1.4 Camera SEF31

Imagery from camera SEF31 will provide coverage of the SLS vehicle as defined in sections 5.10 (Ascent Vehicle Integrity), 5.12 (Nominal LAS Jettison for Re-contact), and 5.13 (ESM Panel Jettison for Re-contact) of this document.

The FOV for camera SEF31 is defined below and illustrated in Figure 6-4. The red and blue dashed lines indicate the maximum and minimum area of the FOV that must be accommodated to achieve desired resolutions.

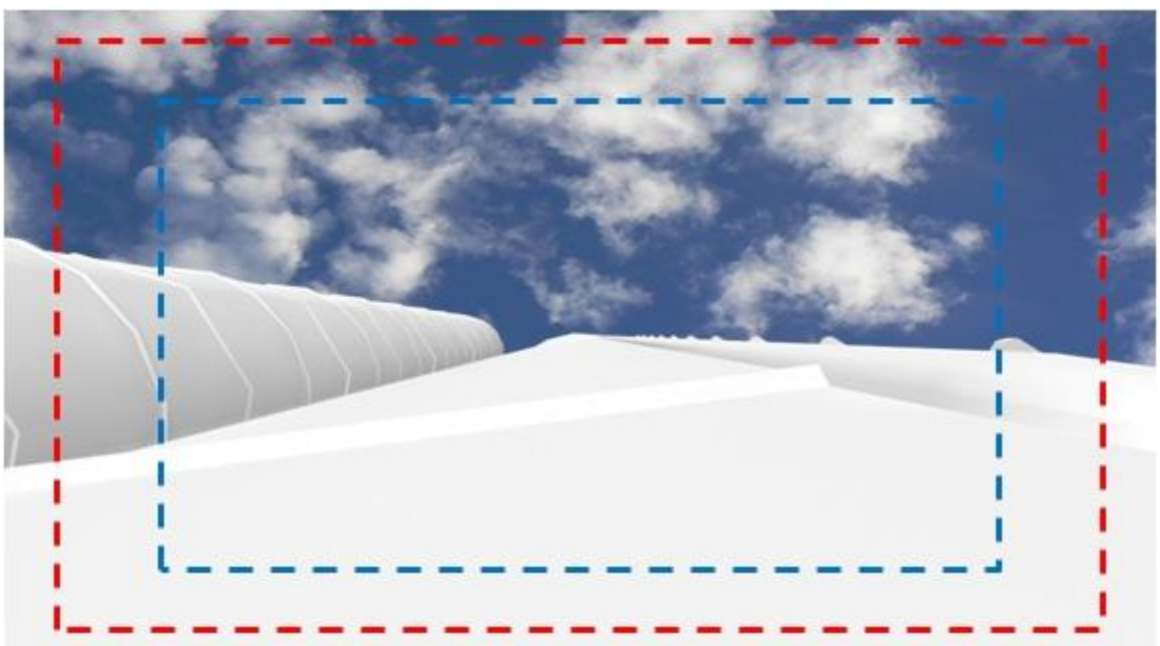

FIGURE 6-4: Block 1 VIS Subsystem #1 SEF31 FOV

FOV Description: *Camera SEF31 configuration will image the Core Stage OML for general vehicle integrity monitoring during ascent, as well as, potential re-contact or near misses by the ESM fairing after ESM fairing jettison, and image the Core Stage OML for potential re-contact or near misses by the*

*LAS. Approximately 30% <**TBR-062**> of the FOV will include non-vehicle (i.e. sky) in order to provide imagery of the ESM fairing during transport.*

Image Capture: *The camera SEF31 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution: *The camera SEF31 will resolve features of <**TBD-046**> under ideal laboratory conditions.*

Imagery Timing: *Time stamp will be included in the SEF31 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera SEF31 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera SEF31 will provide imagery as allowed by natural lighting during daylight or night conditions. Supplemental lighting, other than what may be available from GSDO or SLS vehicle plume, will not be provided by SEF31.*

Synchronization: *The camera SEF31 is not required to be synchronized with other VIS cameras.*

6.1.2.1.5 Camera SEF41

Imagery from camera SEF41 will provide coverage of the SLS vehicle as defined in sections 5.10 (Ascent Vehicle Integrity), 5.12 (Nominal LAS Jettison for Re-contact), and 5.13 (ESM Panel Jettison for Re-contact) of this document.

The FOV for camera SEF41 is defined below and illustrated in Figure 6-5. The red and blue dashed lines indicate the maximum and minimum area of the FOV that must be accommodated to achieve desired resolutions.

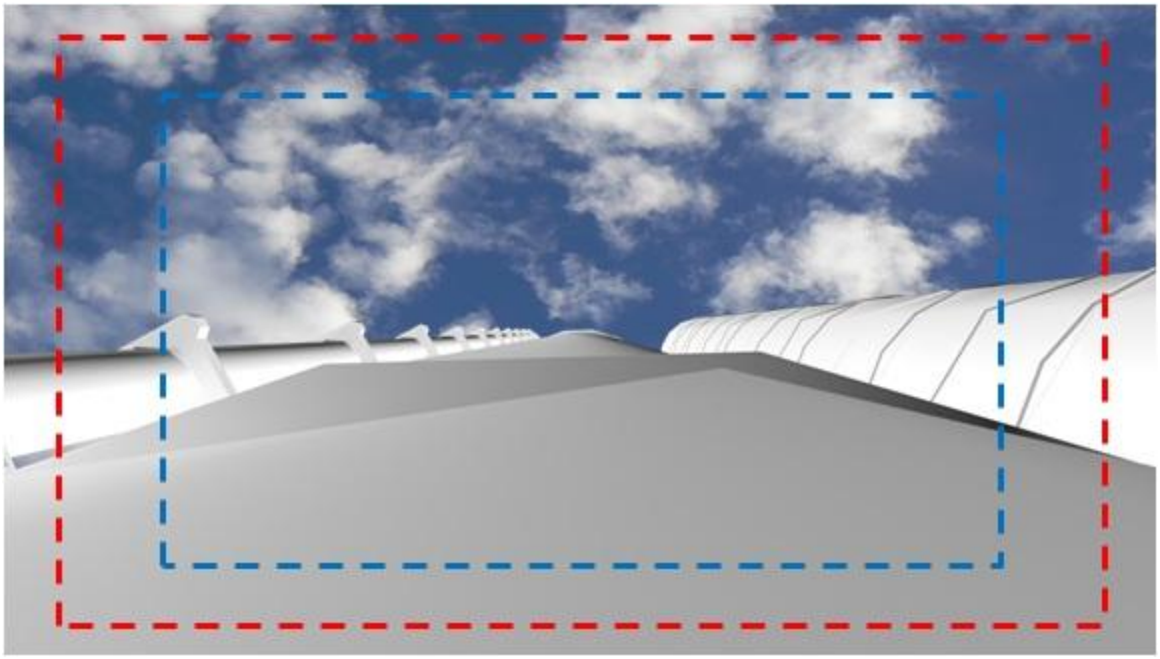

FIGURE 6-5: Block 1 VIS Subsystem #1 SEF41 FOV

FOV Description: *Camera SEF41 configuration will image the Core Stage OML for general vehicle integrity monitoring during ascent, as well as, potential re-contact or near misses by the ESM fairing after ESM fairing jettison, and image the Core Stage OML for potential re-contact or near misses by the LAS. Approximately 30% <**TBR-063**> of the FOV will include non-vehicle (i.e. sky) in order to provide imagery of the ESM fairing during transport.*

Image Capture: *The camera SEF41 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution: *The camera SEF41 will resolve features of <**TBD-046**> under ideal laboratory conditions.*

Imagery Timing: *Time stamp will be included in the SEF41 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera SEF41 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera SEF41 will provide imagery as allowed by natural lighting. Supplemental lighting, other than what may be available from GSDO or SLS vehicle plume, will not be provided by SEF41.*

Synchronization: *The camera SEF41 is not required to be synchronized with other VIS cameras.*

6.1.2.1.6 Camera SIA51

Imagery from camera SIA51 will provide coverage of the SLS vehicle as defined in sections 5.3 (Liftoff Vehicle Integrity), 5.10 (Ascent Vehicle Integrity), and 5.11 (Booster Separation for Re-contact) of this document.

The FOV for camera SIA51 is defined below and illustrated in Figure 6-6. The red and blue dashed lines indicate the maximum and minimum area of the FOV that must be accommodated to achieve desired resolutions.

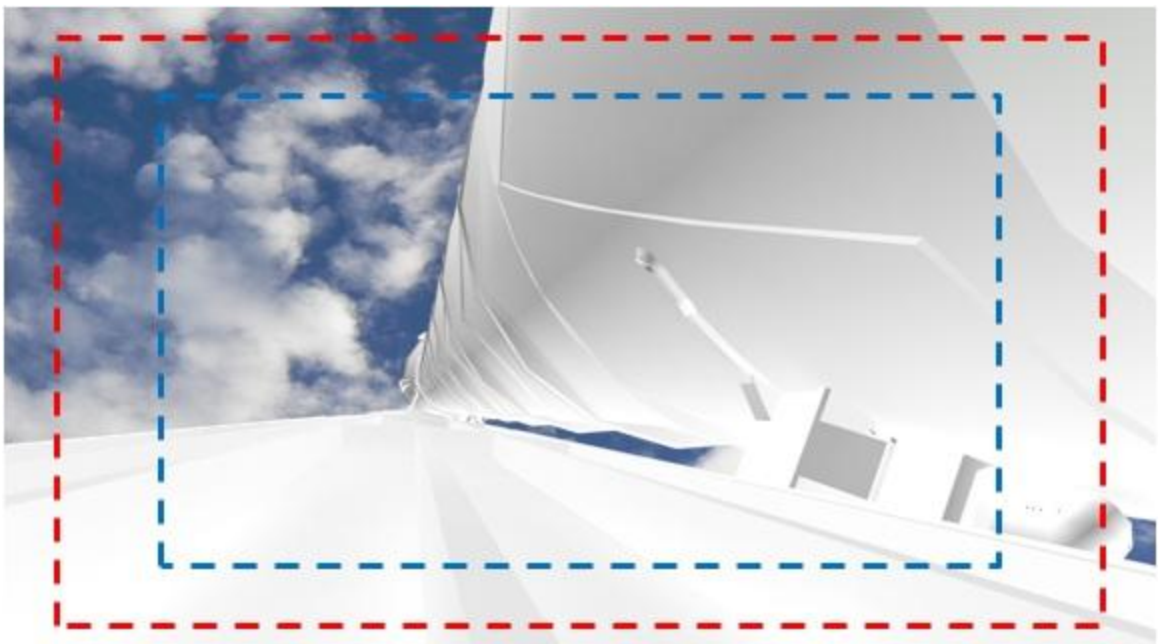

FIGURE 6-6: Block 1 VIS Subsystem #1 SIA51 FOV

FOV Description: *Camera SIA51 configuration will image the RH or LH booster forward and aft attach points on the –Z side of the Core Stage. The camera configuration will image the SLS during ignition through tower clear to monitor the liftoff and early stage of ascent of the SLS. The camera configuration will image the attach points prior to booster separation, and monitor the position of the struts relative to the Core Stage as the separated booster moves in the –Z direction immediately following separation. Approximately 30% <**TBR-064**> of the image will include the background in order to provide a frame of reference for the imagery. The Booster markings as identified in Table 6-2 as BR7, BR8, AR4 and AR6 will be visible in this FOV.*

Image Capture: *The camera SIA51 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution: *The camera SIA51 will resolve features of <**TBD-047**> under ideal laboratory conditions.*

Imagery Timing: *Time stamp will be included in the SIA51 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera SIA51 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera SIA51 will provide imagery as allowed by natural lighting. Supplemental lighting, other than what may be available from GSDO or SLS vehicle plume, will not be provided by SIA51.*

Synchronization: *The camera SIA51 is not required to be synchronized with other VIS cameras.*

6.1.2.1.7 Camera SIA61

Imagery from camera SIA61 will provide coverage of the SLS vehicle as defined in sections 5.3 (Liftoff Vehicle Integrity), 5.10 (Ascent Vehicle Integrity), and 5.11 (Booster Separation for Re-contact) of this document.

The FOV for camera SIA61 is defined below and illustrated in Figure 6-7. The red and blue dashed lines indicate the maximum and minimum area of the FOV that must be accommodated to achieve desired resolutions.

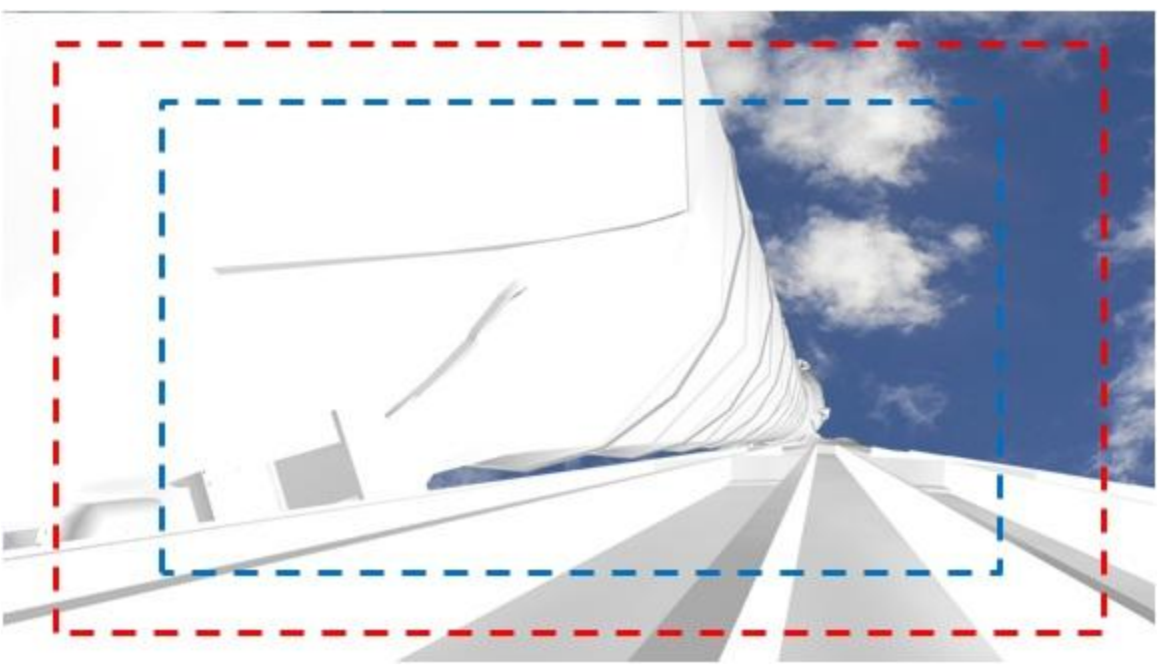

FIGURE 6-7: Block 1 VIS Subsystem #1 SIA61 FOV

FOV Description: *Camera SIA61 configuration will image the RH or LH booster forward and aft attach points on the –Z side of the Core Stage. The camera configuration will image the SLS during ignition through tower clear to monitor the liftoff and early stage of ascent of the SLS. The camera configuration will image the attach points prior to booster separation, and monitor the position of the struts relative to the Core Stage as the separated booster moves in the –Z direction immediately following separation. Approximately 30% <**TBR-065**> of the image will include the background in order to provide a frame of reference for the imagery. The Booster markings as identified in Table 6-2 as BL7, BL8, AL5 and AL8 will be visible in this FOV.*

Image Capture: *The camera SIA61 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution: *The camera SIA61 will resolve features of <**TBD-047**>under ideal laboratory conditions.*

Imagery Timing: *Time stamp will be included in the SIA61 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera SIA61 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera SIA61 will provide imagery as allowed by natural lighting. Supplemental lighting, other than what may be available from GSDO or SLS vehicle plume, will not be provided by SIA61.*

Synchronization: *The camera SIA61 is not required to be synchronized with other VIS cameras.*

6.1.2.1.8 Camera ILF71

Imagery from camera ILF71 will provide coverage of the SLS as defined in section 5.14 (CS/ICPS Separation Clearance) of this document.

The FOV for camera ILF71 is defined below and illustrated in Figure 6-8. Dashed line indicates the most critical area in the FOV that must be accommodated. The following assumptions were made:

- ILF71 and ILF81 are 180 degrees apart.
- ILF71 is located 90 degrees from the ground umbilical interface.
- ILF71 is located away from Core keep out zone.

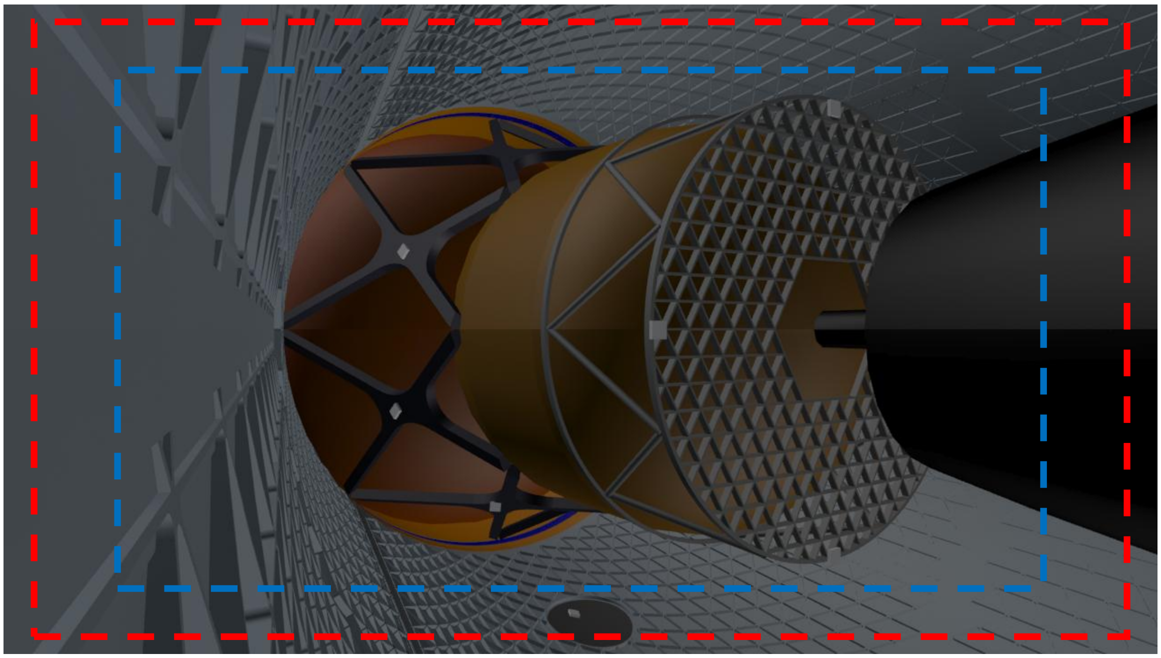

FIGURE 6-8: Block 1 VIS Subsystem #1 ILF71 FOV <TBR-019>

<TBR-019>FOV Description: *Camera ILF71 configuration will image the clearance between the ICPS engine bell and umbilical arm. This camera will also image the clearance between approximately 60% <**TBR-066**> of the external aft circumference of the ICPS engine bell (-Z side) and approximately 60% <**TBR-066**> of the internal forward circumference of the LVSA (-Z side) at the LVSA/ICPS interface during the ICPS separation event from initiation of separation until the ICPS engine bell is clear of the LVSA opening. The ISPE internal markings as identified in Table 6-4 <**TBD-026**> will be visible in this FOV.*

Image Capture: *The camera ILF71 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution: *The camera ILF71 will resolve features of* <***TBD-048***> *under ideal laboratory conditions.*

Imagery Timing: *Time stamp will be included in the ILF71 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame* <***TBR-046***>*). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera ILF71 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera ILF71 will provide imagery as allowed by natural lighting. Supplemental lighting will be provided by ILF71.*

Synchronization: *The camera ILF71 is not required to be synchronized with other VIS cameras.*

6.1.2.1.9 Camera ILF81

Imagery from camera ILF81 will provide coverage of the SLS as defined in section 5.14 (CS/ICPS Separation Clearance) of this document.

The FOV for camera ILF81 is defined below and illustrated in Figure 6-9. Dashed line indicates the most critical area in the FOV that must be accommodated. The following assumptions were made:

- ILF71 and ILF81 are 180 degrees apart.
- ILF81 is located 90 degrees from the ground umbilical interface.
- ILF81 is located away from Core keep out zone.

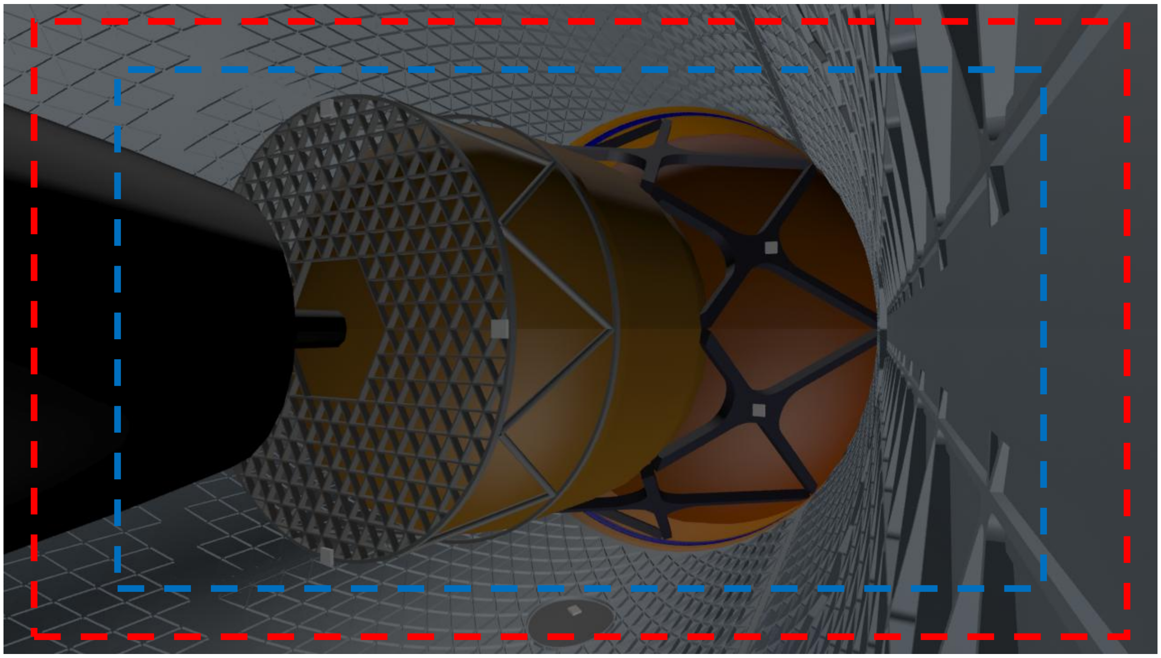

FIGURE 6-9: Block 1 VIS Subsystem #1 ILF81 FOV <TBR-020>

<**TBR-020**>**FOV Description:** *Camera ILF81 configuration will image the clearance between the ICPS engine bell and umbilical arm. This camera will also image the clearance between approximately 60% <**TBR-067**> of the external aft circumference of the ICPS engine bell (+Z side) and approximately 60% <**TBR-067**> of the internal forward circumference of the LVSA (+Z side) at the LVSA/ICPS interface during the ICPS separation event from initiation of separation until the ICPS engine bell is clear of the LVSA opening. The ISPE internal markings as identified in Table 6-4 <**TBD-026**> will be visible in this FOV.*

Image Capture: *The camera ILF81 FOV will be captured at minimum frame rate of 29.97 fps progressive scan at full resolution.*

Resolution*: The camera ILF81 will resolve features of <**TBD-048**> under ideal laboratory conditions.*

Imagery Timing*: Time stamp will be included in the ILF81 motion imagery such that the imagery can be related back to MET or another common time format. If timing is overlaid on the image frame it should not obscure the event being monitored (i.e., placed in upper right corner of frame <**TBR-046**>). Timestamp will have a resolution (precision) of 0.01 seconds.*

Color: *The camera ILF81 will be in color (to include the primary colors red, green, and blue).*

Lighting: *The camera ILF81 will provide imagery as allowed by natural lighting. Supplemental lighting will be provided by ILF81.*

Synchronization: *The camera ILF81 is not required to be synchronized with other VIS cameras.*

6.1.2.1.10 VIS Subsystem #1 Operational Usage

The fundamental operational usage of the VIS subsystem #1 is shown in Figure 6-10 which captures the imagery of specific events as defined in Section 5.0. The required operational time during specific events is not listed in the figure below, but references the applicable section of this document where that detail is defined. A minimum of one live (e.g., near real-time) view will be transmitted to Core Stage for downlink during all times after the VIS subsystem #1 is in a flight operational state, as illustrated below. Additionally, imagery may be captured and locally recorded on the CCU for later downlink after the specific event has actually occurred but prior to the system deactivation. Figure 6-10 distinguishes between live and buffered views, and does not preclude the system for providing more imagery other than what is shown. In the event of a pad or ascent abort scenario, the VIS subsystem #1 may operate differently. These scenarios will be further developed and documented at a later time.

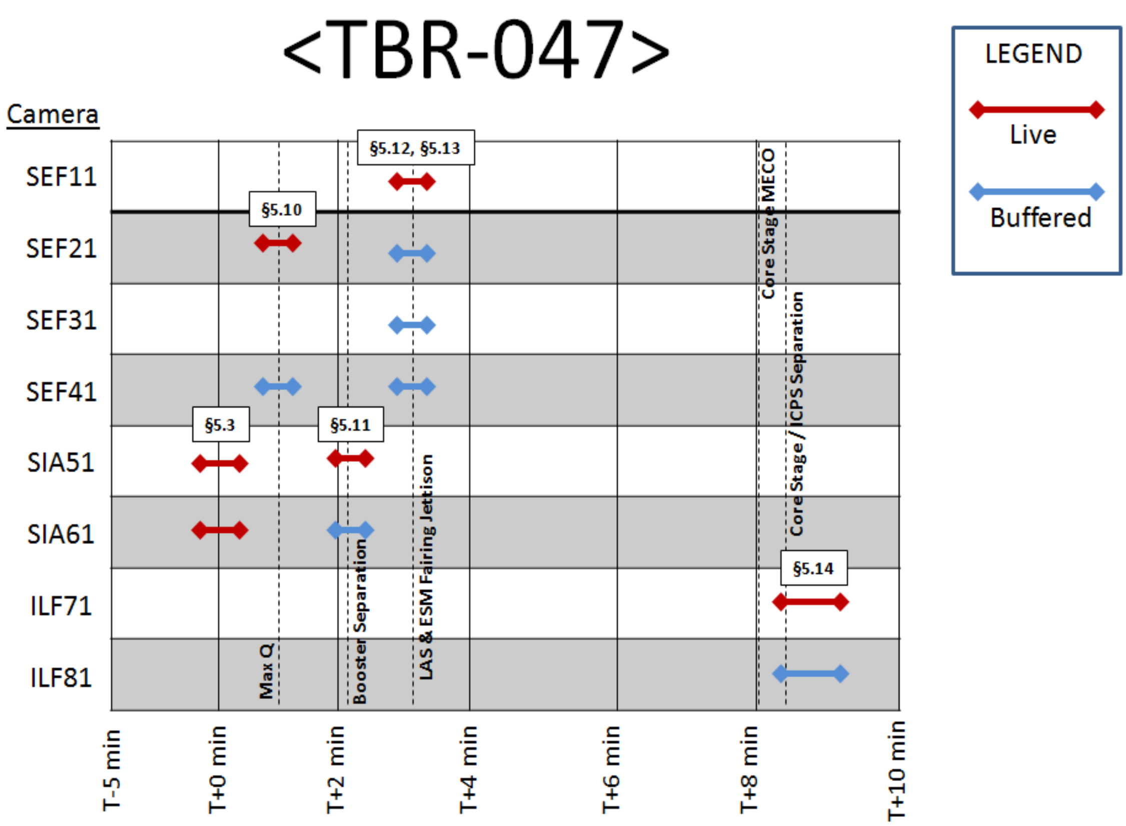

FIGURE 6-10: Block 1 VIS Subsystem #1 Nominal Operational Usage

6.1.2.2 SLS VIS Subsystem#2: ICPS Down-linked Imagery

The SLS VIS Subsystem #2 will be responsible for down-linking data through the ICPS **<TBD-025>.**

6.1.2.3 SLS VIS Subsystem #3: SLS Reference Markings

The SLS will have high contrast reference markings that will be viewable by GSDO imagery assets as well as specific vehicle based cameras. The markings on the OML of the SLS will allow the analysis teams to provide accurate positional data of the SLS during liftoff and ascent using GSDO (markings and cameras) assets. The SLS-ICD-052-01 <**TBR-038**> will document SLS imagery requirements that are satisfied by GSDO assets that generate images using SLS markings for reference. Specific markings on the Boosters will be used in assessing Booster re-contact/clearance with the Core Stage using VIS subsystem #1 (SIA51 and SIA61). Markings internal to the ISPE will be used to evaluate the separation clearance between the ICPS and LVSA using VIS subsystem #1 (ILF71 and ILF81).

The locations of the reference markings were chosen based on the Design Analysis Cycle-2 (DAC-2) SLS model. Significant changes to the OML of the SLS may require changes in the placement of the reference markings.

Constraints:

- Two styles of reference markings are being used on SLS as shown in Figure 6-11 and are identified in the sections below. In addition to the two styles shown below, a stripe is also identified to be installed on the left hand booster, but is not shown in Figure 6-11 below.

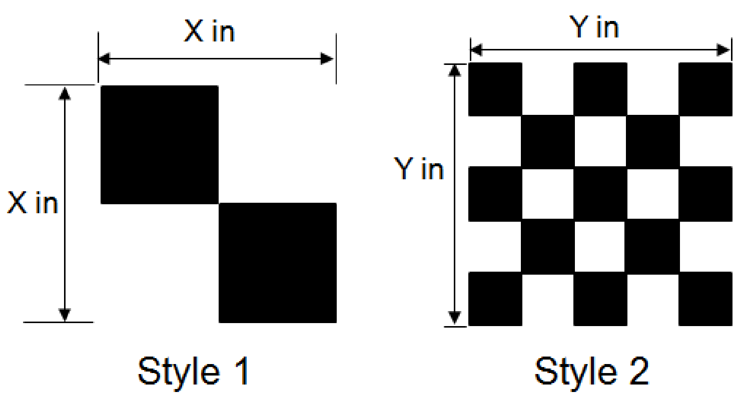

FIGURE 6-11: Reference Markings Styles

- All reference markings will be of high contrast (black and white) (heritage) and need to be placed on relatively smooth surfaces (placed on either flat or curved surfaces, avoiding edges or protuberances).
- The locations for the reference markings are identified in Tables 6-1 through 6-4 below for Stages, Booster and ISPE in terms of SLS coordinates (X_t and Angle) based on the

center point of each reference marking (Style 1 and Style 2), in accordance with Cross-Program Integrated Coordinate Systems, SLS-SPEC-048.

- The location for the stripe is identified in Table 6-2 and is listed in terms of thickness of the stripe (X_t) centered on an X_t location in terms of SLS coordinates. The nearby reference markings will be overlaid on the stripe and not obscured by the stripe.
- All reference markings when installed will be axis aligned in the vertical axis (i.e., all points on the top edge of the reference marking will be at the same X_t location and all points on the bottom edge of the reference marking will be at the same X_t location). It is undesirable that the reference markings be tilted on the mating surfaces.
- All reference markings will be surveyed after installation in either SLS coordinates or Element coordinates and made available to SLS EIT. <**FW-2**>

6.1.2.3.1 Core Stage Reference Markings

The Core Stage OML reference markings are defined in Table 6-1 and illustrated in Figure 6-12 (not all markings are shown). The following marking identifiers are used in Table 6-1 below:

- The first character (alpha) identifies the element where the marking is located (C = Core Stage)
- The second character (numeric) gives a unique number for the markings (1, 2, 3, etc).

Table 6-1: Core Stage Reference Markings <TBR-050>

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage
C1	1	36 x 36 ± 1	2560 ± 1 <**TBR-050**>	0 ± 1	§5.4, 5.8
C2	1	36 x 36 ± 1	2560 ± 1 <**TBR-050**>	90 ± 1	§5.4, 5.8
C3	1	36 x 36 ± 1	2560 ± 1 <**TBR-050**>	180 ± 1	§5.4, 5.8
C4	1	36 x 36 ± 1	2560 ± 1 <**TBR-050**>	270 ± 1	§5.4, 5.8

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage
C5	1	36 x 36 ± 1	3175± 1 <**TBR-050**>	10 ± 1	§5.4, 5.8
C6	1	36 x 36 ± 1	3175 ± 1 <**TBR-050**>	170 ± 1	§5.4, 5.8
C7	1	36 x 36 ± 1	4450 ± 1 <**TBR-050**>	10 ± 1	§5.4, 5.8
C8	1	36 x 36 ± 1	4450 ± 1 <**TBR-050**>	170 ± 1	§5.4, 5.8

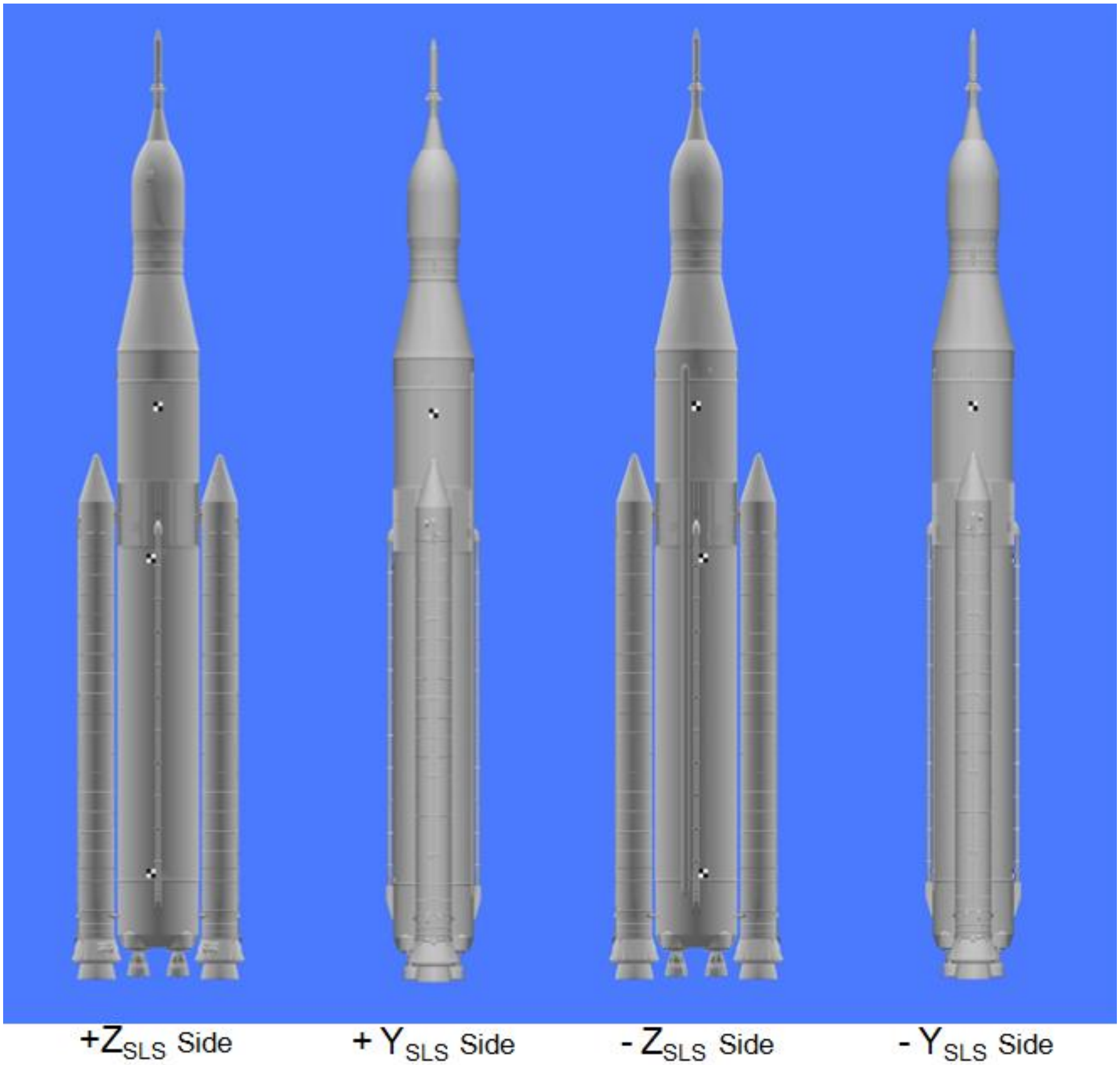

FIGURE 6-12: Core Stage Reference Markings <TBR-050>

6.1.2.3.2 Booster Reference Markings

The Booster OML reference markings are defined in Table 6-2 and illustrated in Figure 6-13 (not all markings are shown) <**TBR-022**>. The following marking identifiers are used in Table 6-2 below:

- The first character (alpha) identifies the element where the marking is located (B = Booster, A = Aft Skirt)

- The second character (alpha) distinguishes between Right I and Left (L) Booster.
- The third character (numeric) gives a unique number for the markings (1, 2, 3, etc). One exception, S is used to identify the stripe on the Left Booster.

Table 6-2: Booster Reference Markings <TBR-022>

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage
BR1	1	36 x 36 ± 1	3110 ± 1	0 ± 1	§5.4, 5.8
BR2	1	36 x 36 ± 1	3110 ± 1	180 ± 1	§5.4, 5.8
BR3	1	36 x 36 ± 1	2970 ± 1	270 ± 1	§5.4, 5.8
BR4	1	36 x 36 ± 1	4575 ± 1	0 ± 1	§5.4, 5.8
BR5	1	36 x 36 ± 1	4575 ± 1	180 ± 1	§5.4, 5.8
BR6	1	36 x 36 ± 1	4745 ± 1	270 ± 1	§5.4, 5.8
BR7	2	20 x 20 ± 1	2970 ± 1	108 ± 1	§5.4, 5.8, 5.11
BR8	2	20 x 20 ± 1	3030 ± 1	115 ± 1	§5.4, 5.8, 5.11
BL1	1	36 x 36 ± 1	3110 ± 1	0 ± 1	§5.4, 5.8
BL2	1	36 x 36 ± 1	2970 ± 1	90 ± 1	§5.4, 5.8
BL3	1	36 x 36 ± 1	3110 ± 1	180 ± 1	§5.4, 5.8
BL4	1	36 x 36 ± 1	4575 ± 1	0 ± 1	§5.4, 5.8
BL5	1	36 x 36 ± 1	4745 ± 1	90 ± 1	§5.4, 5.8
BL6	1	36 x 36 ± 1	4575 ± 1	180 ± 1	§5.4, 5.8
BL7	2	20 x 20 ± 1	2970 ± 1	252 ± 1	§5.4, 5.8, 5.11

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location Angle$_{SLS}$ (Degrees)	Reference Event for Usage
BL8	2	20 x 20 ± 1	3030 ± 1	245 ± 1	§5.4, 5.8, 5.11
AR1	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	-20 ± 1 <**TBR-022** >	§5.4, 5.8
AR2	1	6 x 6 ± 1	4865 ± 1 <**TBR-022**>	0 ± 1 <**TBR-022**>	§5.4, 5.8
AR3	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	20 ± 1 <**TBR-022**>	§5.4, 5.8
AR4	1	36 x 36 ± 1	4760 ± 1 <**TBR-022**>	120 ± 1 <**TBR-022**>	§5.4, 5.8, 5.11
AR5	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	160 ± 1 <**TBR-022**>	§5.4, 5.8
AR6	1	36 x 36 ± 1	4760 ± 1 <**TBR-022**>	180 ± 1 <**TBR-022**>	§5.4, 5.8, 5.11
AR7	1	6 x 6 ± 1	4865 ± 1 <**TBR-022**>	180 ± 1 <**TBR-022** >	§5.4, 5.8
AR8	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	200 ± 1 <**TBR-022** >	§5.4, 5.8
AL1	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	-20 ± 1 <**TBR-022** >	§5.4, 5.8
AL2	1	6 x 6 ± 1	4865 ± 1	0 ± 1	§5.4, 5.8

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

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage
			<**TBR-022**>	<**TBR-022** >	
AL3	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	20 ± 1 <**TBR-022** >	§5.4, 5.8
AL4	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	160 ± 1 <**TBR-022** >	§5.4, 5.8
AL5	1	36 x 36 ± 1	4760 ± 1 <**TBR-022**>	180 ± 1 <**TBR-022** >	§5.4, 5.8, 5.11
AL6	1	6 x 6 ± 1	4865 ± 1 <**TBR-022**>	180 ± 1 <**TBR-022** >	§5.4, 5.8
AL7	1	6 x 6 ± 1	4775 ± 1 <**TBR-022**>	200 ± 1 <**TBR-022** >	§5.4, 5.8
AL8	1	36 x 36 ± 1	4760 ± 1 <**TBR-022**>	240 ± 1 <**TBR-022** >	§5.4, 5.8, 5.11
BLS	Stripe	24 ± 1	2970 ± 1	0 to 360	§5.3, 5.10

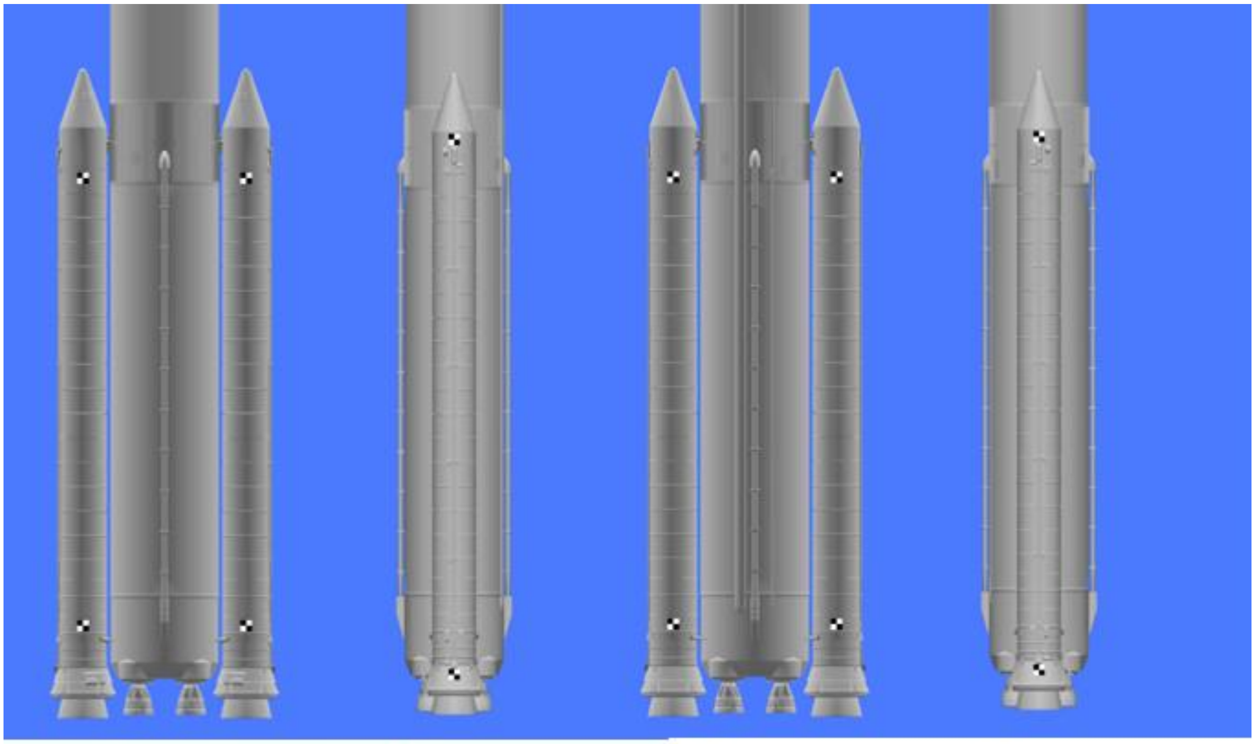

FIGURE 6-13: Booster Reference Markings <TBR-022>

6.1.2.3.3 ISPE OML Reference Markings

The ISPE OML reference markings are defined in Table 6-3 and illustrated in Figure 6-14 <**TBR-023**>. The following marking identifiers are used in Table 6-3 below:

- The first character (alpha) identifies the element where the marking is located (I = ISPE)
- The second character (numeric) gives a unique number for the markings (1, 2, 3, etc).

Table 6-3: ISPE OML Reference Markings <TBR-023>

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage
I1	1	36 x 36 ± 1	1870 ± 1 <**TBR-023**>	45 ± 1	§5.4, 5.8

Marking ID	Marking Style	Marking Size (inch x inch)	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage
I2	1	36 x 36 ± 1	1870 ± 1 <**TBR-023**>	135 ± 1	§5.4, 5.8
I3	1	36 x 36 ± 1	1870 ± 1 <**TBR-023**>	225 ± 1	§5.4, 5.8
I4	1	36 x 36 ± 1	1870 ± 1 <**TBR-023**>	315 ± 1	§5.4, 5.8

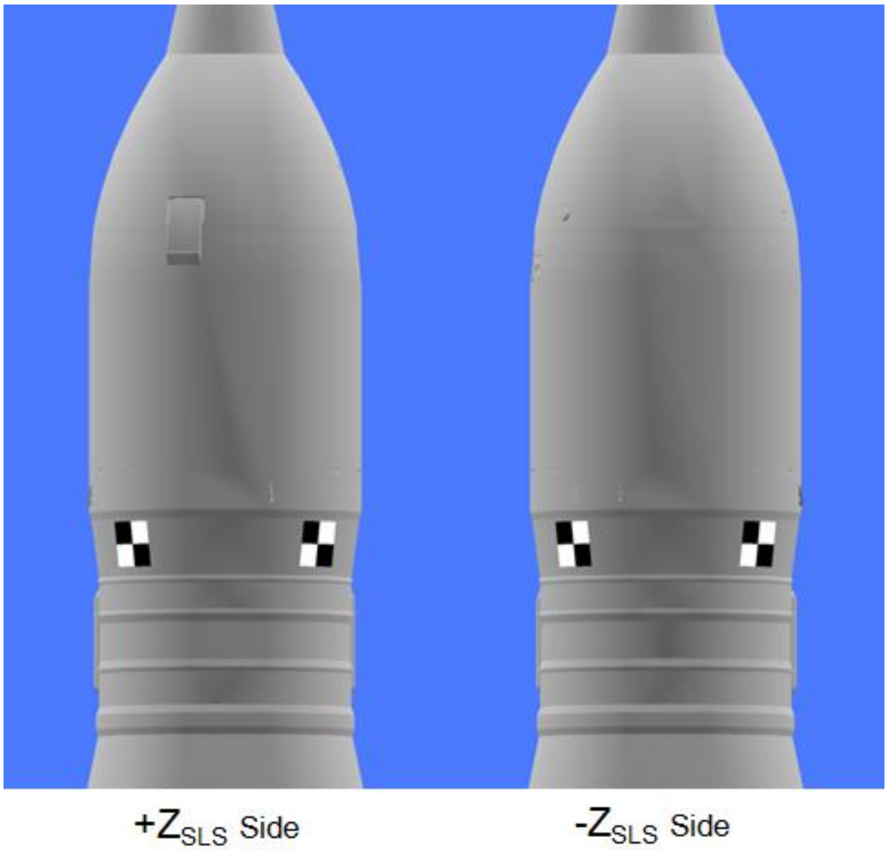

FIGURE 6-14: ISPE OML Reference Markings <TBR-023>

6.1.2.3.4 ISPE Internal Reference Markings

The ISPE internal reference markings are defined in Table 6-4 and illustrated in Figure 6-15 <**TBR-037**>.

Table 6-4: ISPE Internal Reference Markings <TBD-026>

Marking ID	Marking Style	Marking Size	Center Point Location X_{SLS} (inches)	Center Point Location $Angle_{SLS}$ (Degrees)	Reference Event for Usage

<TBD-026>

FIGURE 6-15: ISPE Internal Reference Markings

6.1.3 Airborne Imagery Systems

There are no planned airborne assets required for SLS imagery.

6.1.4 Ship-Based Imagery Systems

There are no planned ship-based assets required for SLS imagery.

6.1.5 Other Assets

Imagery from payload customers (manned and/or unmanned) that provide unique views of the SLS may also be made available for assessment. **<TBR-058>.**

6.1.6 Data Distribution System

The SLS pre-flight and flight imagery data will be transmitted to the ground, recorded, and distributed to analysis teams at the Marshall Space Flight Center (MSFC) as documented in the MSRD. This data will be used for analysis purposes and will be in a format and of a quality suitable for the analysis performed.

Live video of select feeds will be provided to GSDO, MPCV, SLS, ESD, and Public Affairs as defined in <**TBD-033**>.

6.2 Imagery Analysis

The imagery analysis teams will review the imagery data of the SLS events and conditions identified in Section 5.1 – 5.15 and will provide, at a minimum, the following preplanned analysis products based on the imagery provided:

- Ground umbilical separation and clearance from the SLS

- Vehicle Support Posts separation and clearance
- Vehicle drift off pad
- Vehicle roll **<TBD-031>**
- Booster separation and clearance
- Core Stage TPS Integrity
- ICPS separation and clearance from LVSA (Block 1)
- ICPS separation and clearance from MPCV(Block 1) <**TBD-022**>

The timeframe in which the analysis products listed above need to be completed is <**TBD-051**>.

Additional analyses will be performed at the request of SLS Program and technical teams when anomalous events are observed. In the event of a mishap, imagery will be used to aid the investigation activities by investigating authority in accordance with NPR 8621.1B Mishap and Close Call Reporting, Investigating, and Recordkeeping.

6.3 Flight Evaluation

6.3.1 Reporting of Imagery Findings

The information identified during the imagery screening and/or analysis activities will be made available to the SLS Program, technical teams, and S&MA teams as appropriate. Any imagery related issues or concerns observed from a launch will be assessed and closure rationale provided by appropriate SLS technical teams in support of the next flight activities and launch.

Imagery observations that are made of the GSDOP launch complex hardware, MPCV or other payload customers will be made available to the applicable Programs and teams.

6.3.2 Assess Imagery System Performance

Following each mission, the imagery system performance will be evaluated to determine if any changes (additions, deletions, modification) need to be made prior to the next flight. Significant changes that are implemented, pending SLS Program approval, will be reflected in this document's subsequent revisions, and to the appropriate requirements documents as applicable.

6.4 Archival

SLS imagery products will be archived in accordance with **<TBD-001>** document**.**

APPENDIX A
ACRONYMS AND ABBREVIATIONS
AND GLOSSARY OF TERMS

A1.0 ACRONYMS AND ABBREVIATIONS

2DOF	Two Degrees of Freedom
3D	Three Dimensional
3DOF	Three Degrees of Freedom
6DOF	Six Degrees of Freedom
APU	Auxiliary Power Unit
CCU	Camera Control Unit
Con Ops	Concept of Operations
CR	Change Request
CS	Core Stage
CTC	Command & Telemetry Controller
CTN	Communication & Tracking Network
DAVIS	Data Acquisition and Video Integrated System
DFMR	Define for Minimum Risk
DLE	Discipline Lead Engineer
EIT	Engineering Imagery Team
ESD	Exploration Systems Development
ESM	Encapsulated Service Module
FILMRS	Flight Imaging Launch Monitoring Real-time System
FOV	Field of View
GFE	Government Furnished Equipment
GSDO	Ground Systems Development & Operations
GSDOP	Ground Systems Development & Operations Program
HD-SDI	High-Definition Serial Digital Interface
IAS	Integrated Avionics and Software
IAT	Image Analysis Team
ICD	Interface Control Document
ICPS	Interim Cryogenic Propulsion System
IIT	Integration Task Team
IMT	Integrated Master Timeline
IRD	Interface Requirement Document

ISRD	Imagery System Requirements Document
ISPE	Integrated Spacecraft & Payload Element
JETI	Joint Engineering Team for Imagery
LAS	Launch Abort System
LCD	Launch Countdown Demonstration
LO2	Liquid Oxygen
LOC	Loss of Crew
LOD	Liftoff Debris
LOM	Loss of Mission
LVSA	Launch Vehicle Stage Adapter
MET	Mission Elapse Time
MFV	Main Fuel Valve
MPCV	Multi-Purpose Crew Vehicle
MSA	MPCV Stage Adapter
MSFC	Marshall Space Flight Center
MSRD	Mission Support Requirements Document
NASA	National Aeronautics and Space Administration
OML	Outer Mold Line
OPR	Office of Primary Responsibility
PAO	Public Affairs Office
PCB	Program Control Board
PDCU	Power Distribution & Control Unit
PRD	Program Requirements Document
ROFI	Radially Outward Firing Igniter
S&MA	Safety and Mission Assurance
SA	Spacecraft Adapter
SEMP	Systems Engineering Management Plan
SLS	Space Launch System
SLSP	Space Launch System Program
SM	Service Module
SPIO	Spacecraft and Payload Integration Office
STE	Structures & Environments
TBD	To Be Determined
TBR	To Be Resolved
TPS	Thermal Protection System

VIS	Vehicle Imagery System
VM	Vehicle Management

A2.0 GLOSSARY OF TERMS

Term	Description
Ascent	The first motion of the launch vehicle from the pad until orbit insertion. (Ref: SLS-PLAN-020, paragraph A2.0)
Flight	The sequence of events that takes place between first motion (hardware lifts off the pad) and disposal of the stages. (ref: SLS-PLAN-020, paragraph 5.5)
Liftoff	The first part of the ascent phase. The sequence of events beginning when the integrated launch vehicle separates from the launch pad, and ending with tower clearance.
Separation	The sequence of events that takes place when two elements or two spacecraft physically disconnect from one another. <**TBR-059**>

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	6.4	Determine where details will be documented relative to SLS imagery archival. No cost considerations have been evaluated due to lack of maturity.
TBD-004	3.1.3.3	Determine where MSFC IAT is managed.
TBD-022	5.15, 6.2	Determine ICPS/Orion Separation areas of interest for analysis
TBD-023	6.0	Determine which DLE will be responsible for ensuring analysis is completed following each SLS mission.
TBD-025	3.1.2, Figure 3-1, Table 5-1 ,6.1.2.2	Determine details of the VIS subsystem #2 which is downlinked through ICPS. Note: The use of ICPS RFCS for downlink of imagery is not in SLSP baseline.
TBD-026	6.1.2.1.8, 6.1.2.1.9,Table 6-4, Figure 6-15	Determine markings internal to ISPE to be used to evaluate separation clearances between ICPS and LVSA. Consider the placement of high contrast markings such that markings will not be obscured/impacted by icing or frosting of the cryo-loaded elements (including ICPS).
TBD-031	6.2	Determine whether Vehicle Roll will require detailed image analysis
TBD-033	5.1-5.10, 6.1.1, 6.1.6	Determine where GSDO-SLS imagery functionality will be further defined.
TBD-034	6.1.1.1	Determine where SLS Baseline imagery views are defined. No cost considerations have been evaluated due to lack of maturity.
TBD-035	6.1.1.2	Determine where SLS walkdown imagery views are defined
TBD-040	6.1.1	Determine where closeout imagery and imagery taken of instrumentation is defined. No cost considerations have been evaluated due to lack of maturity.

TBD	Section	Description
TBD-042	5.3	Determine the thermal range of defects to detect thermal integrity anomalies
TBD-043	Table 5-1	Determine what if any resources on MPCV will be used to monitor the ICPS/Orion separation
TBD-045	3.1.2	Determine correct reference to VIS subsystem #1 bandwidth allocation
TBD-046	6.1.2.1.2 - 6.1.2.1.5	Determine the resolution requirement for SEF11 - SEF41
TBD-047	6.1.2.1.6 and 6.1.2.1.7	Determine the resolution requirement for SIA51 and SIA61
TBD-048	6.1.2.1.8 and 6.1.2.1.9	Determine the resolution requirement for ILF71 and ILF81
TBD-049	5.11	Determine accuracy for detecting clearance between the Core/Booster -Z forward attach hardware
TBD-050	5.11	Determine accuracy for detecting clearance between the Core/Booster -Z aft strut hardware
TBD-051	6.2	Determine when preplanned analysis products need to be completed after launch.
TBD-052	3.2.8 [SLS.IMG.008]	Resolve CCU clock initialization method (set to zero or set to predetermined time)
TBD-053	5.1, 5.3	Determine characteristics of crack and ice formation that needs to be detected by imagery system monitoring TPS integrity monitoring. This action will be coordinated through the JETI.
TBD-054	5.4	Determine minimum size of LOD object that needs to be resolvable.

B2.0 TO BE RESOLVED

Table B2-1 lists the specific To Be Resolved (TBR) 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 B2-1. To Be Resolved Issues

TBR	Section	Description
TBR-003	6.1.1.4	Reference Markings on the ground hardware.
TBR-005	1.1	Resolve issue of where to identify requirements for imagery functions that cross the SLS-MPCV interface (as appropriate)
TBR-007	5.2	Resolve Time period for imaging the Hydrogen Igniter System

TBR	Section	Description
TBR-008	5.3	Resolve Time period for imaging the liftoff vehicle integrity
TBR-010	6.1.1.2	Resolve walk-down imagery inspection activities
TBR-011	3.1.2, 3.2.1, 3.2.6, 5.10, 5.12, 5.13, 5.15	Resolve imagery planning to be installed and downlinked through the ICPS avionics system. Note: The use of ICPS RFCS for downlink of imagery is not in SLSP baseline.
TBR-019	6.1.2.1.8 & Figure 6-8	Resolve the FOV for camera ILF71
TBR-020	6.1.2.1.9 & Figure 6-9	Resolve the FOV for camera ILF81
TBR-022	*6.1.2.3.2, Table 6-2 & Figure 6-13*	Resolve the Booster high contrast markings locations
TBR-023	*6.1.2.3.3 & Table 6-3, Figure 6-14*	Resolve the ISPE high contrast markings locations. Consider the placement of high contrast markings such that markings will not be obscured/impacted by icing or frosting of the cryo-loaded elements (including ICPS).
TBR-024	5.11	Resolve areas of interest to monitor for Booster Separation Re-contact event.
TBR-025	5.12	Resolve areas of interest to monitor for Nominal LAS Jettison Re-contact event.
TBR-026	5.13	Resolve areas of interest to monitor for ESM Panel Jettison event.
TBR-027	5.14	Resolve areas of interest to monitor for CS/ICPS Separation event.
TBR-028	Figure C-1	Resolve SLS imagery requirement traceability
TBR-029	5.3	Resolve Liftoff Vehicle Integrity areas of interest. Determine the 2inch by 2inch size (and accuracy) of structural defects that need to be resolved by imagery systems. This action will be worked through JETI.
TBR-030	5.4	Resolve LOD area of interest
TBR-031	5.5	Resolve sound suppression areas of interest
TBR-032	5.6	Resolve ground umbilical separation and retraction areas of interest.
TBR-033	5.2, 5.7	Resolve On Pad Engine Shutdown / Abort areas of interest.
TBR-034	5.8	Resolve Liftoff clearances areas of interest.
TBR-035	5.9	Resolve Booster Motor Plume areas of interest.
TBR-036	5.10	Resolve Ascent Vehicle Integrity areas of interest
TBR-037	6.1.2.3.4	Resolve internal markings on ISPE. Consider the placement of high contrast markings such that markings will not be obscured/impacted by icing or frosting of the cryo-loaded elements (including ICPS).

TBR	Section	Description
TBR-038	1.1, 6.1.1, 6.1.2.3	Resolve issue of where to identify requirements for imagery functions that cross the SLS-GSDO interface (as appropriate)
TBR-040	3.2.2	Resolve when SLS VIS checkout will occur once the SLS is at the launch pad.
TBR-043	5.3	Resolve the areas that need to be monitored for thermal integrity
TBR-044	6.1.2.1	Resolve where installed camera coordinates will be documented in Core Stage documentation
TBR-045	6.1.2.1	Resolve where installed camera coordinates will be documented in ISPE documentation
TBR-046	6.1.2.1.2 – 6.1.2.1.9	Resolve location in frame where overlaid time stamp will be acceptable and not interfere with critical areas of FOV
TBR-047	6.1.2.1.10	Resolve the operational usage of the VIS subsystem #1
TBR-048	5.15, Table 5-1	Resolve the need for imagery of the Orion separation downlinked from the ICPS. Pending input from MPCV.
TBR-049	3.2.8 [SLS.IMG .008]	Resolve time associated to how the CCU will configure its time reference following receipt of a CTC discrete.
TBR-050	6.1.2.3.1, Table 6-1, Figure 6-12	Resolve the placement of high contrast markings such that markings will not be obscured/impacted by icing or frosting of the cryo-loaded vehicle.
TBR-051	5.3	Resolve timeframe to monitor LCD Engine Gimbal checkout. This action will be coordinated through the JETI.
TBR-052	5.1	Resolve the 2inch x 2inch size (and accuracy) of defects that need to be detected by cameras monitoring TPS integrity on the SLS. This action will be coordinated through the JETI.
TBR-053	5.11	Confirm that Booster Separation & Re-contact imaging takes place from Booster Separation through Booster Separation + 10s
TBR-054	5.12	Confirm that Nominal LAS Jettison & Re-contact imaging takes place from LAS Jettison through LAS Jettison + 10s
TBR-055	5.13	Confirm that ESM Panel Jettison & Re-contact imaging takes place from LAS Jettison through LAS Jettison + 10s
TBR-056	5.14	Confirm that CS/ICPS Separation Clearance Imaging takes place from CS/ICPS Separation through CS/ICPS Separation + 13s
TBR-057	5.15	Confirm that ICPS/Orion Separation Clearance imaging takes place from ICPS / Orion Separation through ICPS Orion Separation + 10s
TBR-058	6.1.5	Confirm whether imagery from payload customers may also be made available for assessment.
TBR-059	A2.0	Confirm that separation is defined as “The sequence of events that takes place when two elements or two programs physically disconnect from one another.”
TBR-060	6.1.2.1.2	Determine how much of the FOV should contain "non-vehicle" hardware (i.e. sky)
TBR-061	6.1.2.1.3	Determine how much of the FOV should contain "non-vehicle" hardware (i.e. sky)
TBR-062	6.1.2.1.4	Determine how much of the FOV should contain "non-vehicle" hardware (i.e. sky)

TBR	Section	Description
TBR-063	6.1.2.1.5	Determine how much of the FOV should contain "non-vehicle" hardware (i.e. sky)
TBR-064	6.1.2.1.6	Determine how much of the FOV should contain "non-vehicle" hardware (i.e. sky)
TBR-065	6.1.2.1.7	Determine how much of the FOV should contain "non-vehicle" hardware (i.e. sky)
TBR-066	6.1.2.1.8	Determine how much of the FOV will contain ICPS nozzle and LVSA exit plane
TBR-067	6.1.2.1.9	Determine how much of the FOV will contain ICPS nozzle and LVSA exit plane

B3.0 FORWARD WORK

Table B3-1 lists the comments dispositioned as Forward Work (FW) during the SLS Program ISRD review cycle. These items will continue to be worked as the SLS Program progresses and will be addressed in an upcoming revision should a change be required.

Table B3-1. Forward Work Items

FW	Section	Description
FW-1	Figures 6-2, 6-3, 6-4, 6-5, 6-6, 6-7, 6-8, 6-9	Investigate whether the FOV's can be adequately verified as-is, or if the constraints need to be specified differently to ensure they are sufficiently verifiable
FW-2	6.1.2.3	Determine where and who will provide survey of markings after installation. Survey of markings after installation has not been cost impacted by Booster, SPIO and Stages elements. Depending on the outcome of the FW-2, tolerance may be added to the placement of marking locations.
FW-4	1.2	Determine approach for capturing imagery related cross program content in other documentation and re-assess impacts that may have on change control authority of this ISRD.
FW-5	5.6	Consider if imagery is required for future flights (past EM-1 and EM-2).

APPENDIX C
IMAGERY REQUIREMENTS TRACEABILITY

ESD has identified imagery as a requirement in ESD 10002, Exploration Systems Development (ESD) Requirements (R-20, with applicability to SLS) to be used for engineering purposes and also public outreach, and allocates them to the SLS. The SLS Systems Specification SLS-SPEC-032 requirement SLS.27 allocates all SLS imagery functionality to the elements (Core Stage, Booster and ISPE) through the SLSP ISRD which serves as the parent of the imagery requirements for SLS, as shown in Figure C-1. SLS VIS requirements identified in Section 3.2 will be decomposed and allocated to Core Stage, Booster and ISPE elements, as appropriate.

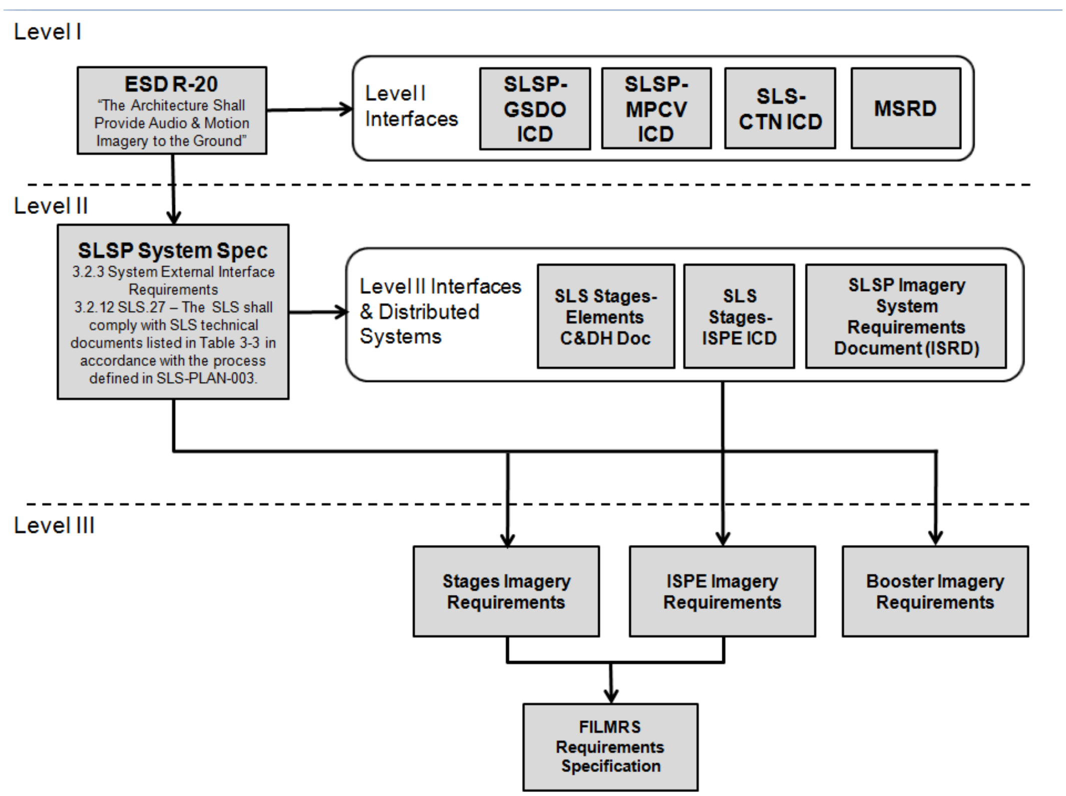

Figure C-1: SLS Imagery Requirements Traceability<TBR-028>