SLS Flight Software Agile Development Process
Space Launch System (SLS)

Safe
• Human-rated to provide safe and reliable systems
• Protecting the public, NASA workforce, high-value equipment and property, and the environment from potential harm

Affordable
• Maximum use of common elements and existing assets, infrastructure, and workforce
• Constrained budget environment
• Competitive opportunities for affordability on-ramps

Sustainable
• Initial capability: 70 metric tons (t), 2017–2021
  – Serves as primary transportation for Orion and human exploration missions
• Evolved capability: 105 t and 130 t, post-2021
  – Offers large volume for science missions and payloads
  – Reduces trip times to get science results faster
  – Minimizes risk of radiation exposure and orbital debris impacts

Designed for Beyond Earth Orbit Missions of National Importance
Where is SLS Avionics Located?

- **Launch Vehicle Stage Adapter** (Two Cameras for ICPS Separation)
- **Core Stage Avionics** (Flight Computers, Command and Telemetry Controller, Inertial Navigation Equipment, RF Transmitter)
- **Core Stage Avionics** (Command and Telemetry Controller, Power Distribution, Data Acquisition, Camera Equipment, Liquid Level Sensors, Rate Gyro, RF Transmitter)
- **Core Stage Engine Controllers** (Main Propulsion System Valve Control, Core Stage Thrust Vector Control, Rate Gyro)
- **Booster Avionics**
- **Interim Cryogenic Propulsion Stage Avionics**
- **SLS Block 1 Crew**

For more information, visit [www.nasa.gov/sls](http://www.nasa.gov/sls).
SLS Block I Software Providers

System: Flight Computer (FC)
Type: Byzantine Fault Resilient
Category: Flight Critical
Developer: MSFC In-House
Function: Primary SLS Vehicle Flight Control System

System: Redundant Inertial Navigation Unit (RINU)
Type: Internally Self-Checking Architecture
Category: Flight Critical
Developer: Stages Subcontractor (Honeywell)
Function: Provide Navigation and Flight Control inputs to FCs

System: Rate Gyro Assembly
Type: Internally Self-Checking Architecture
Category: Flight Critical
Developer: Stages Subcontractor (Honeywell)
Function: Provide vehicle rate inputs to FCs

System: Core Stage Engine Controller (CSEC)
Type: Self-Checking Pair of Pairs (Prime/Backup)
Developer: Engines Contractor - Aerojet Rocketdyne (AR)
Category: Flight Critical
Function: Control/Monitor of RS-25 Engine

System: ULA Common Avionics Based
Function: Primary ICPS Flight Control and Health Monitoring
Flight Computer Application Software (FCAS) CSCI is designated as Flight Computer Application Software (FCAS) and provides the flight and pre-flight critical and non-critical software functions necessary for on-pad prelaunch, launch, and ascent of the SLS vehicle.

Green Run Application Software (GRAS) CSCI is designated as Green Run Application Software (GRAS) and executes a pre-defined thrust vector control actuator position profile for the Core Stage (CS) Thrust Vector Controller (TVC) actuators and a pre-defined Core Stage Engine throttle position profile.
Flight Software Development Approach

- Release 11 Delivered to End Users on 9/29/2015 (SLS ASCB Delivery Date)
  - Successful design implementation and test
- Flight Software (FSW) Release 12
  - FSW Release 12 Mission and Fault Management (M&FM) Model delivered on 5/20/2015
  - ARTEMIS 10.2b delivered for Release 12 development
  - FSW Release 12 Sprint 4 in progress
  - FSW Release 12 Test Readiness Review scheduled for 12/9/2015
- Development Approach
  - FSW Release 12 [fully functional version of both GRAS and FCAS – Engineering Release (ER) for both]
  - FSW Release 13 (initial FQT version of GRAS / FCAS)
  - FSW Release 14 (updated FQT version of GRAS / FCAS)
  - FSW Release 15 (defect repairs – as needed)
FSW Test Plan will contain (for each Release):
- Success Criteria (DVO Equivalent)
- Test Procedures
- Test Approaches
- Data Analysis Required
- Environment

The Software Test Report contains detailed test results, as-run test procedures, and associated analysis for FSW Release under test.
Configuration controlled build definition/mgmt. process part of ongoing Build Definition Mgmt. Cycle. Maintained by FSW Deputy Project Lead, controlled by Level II Project Control Board.

Product content for release driven by:
- Functional capabilities needed for release identified
- Available source product maturity evaluated
- Gap analysis performed between items (1) and (2)
- Deficiencies/issus identified and addressed
- Capability/content included in release (or provided in later release) depending upon outcome of item (4) analysis
Agile Development

Incremental Development Activities

- SW Design/Code/Integrate (6 Month)
- Requirements Decomposition
- Detail Design
- Implement
- Static Analysis & Unit Test
- Peer Review
- Integrate & Test
- Incremental Development Process
- Build Definition Mgmt Cycle
- Project Planning
- Develop Requirements
- External Stakeholder input Integration

Plan ➔ Execute ➔ Deliver

Informal/Formal Testing (SDF)

Develop Test Approaches/Procedures

Release to SIF/SIL

Dev tag

Development and execution phase activities:
- Develop Test Approaches/Procedures
- Execute testing
- Informal/Formal Testing (SDF)
- Release to SIF/SIL
- Develop Test Approaches/Procedures
- Execute testing
- Informal/Formal Testing (SDF)
- Release to SIF/SIL

Requirements

Backlog

- Peer Review
- Integrate & Test
- Static Analysis & Unit Test
- Detail Design
- Implement
- Requirements

Incremental Development Process

External Stakeholder input Integration

Project Planning

Develop Requirements

Build Definition Mgmt Cycle

Informal Testing (4 Months)

Formal Testing (2 Mo)
**SLS FSW Test & Verification**

Dry run development and peer evaluations ensure STPr(s) are ready for FQT.

STPr release planning and tracking module contains requirements and STPr trace.

STPr consolidated module containing requirement logical groupings and test cases.

Heritage STPrs become candidates for future regression FQT activities.

**SRB:** System Review Board  
**STPr:** Software Test Procedures
FSW Release Activities

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<thead>
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**FSW Release 12.0**

**Preparation Planning for Release 12.0**
- Planning and Content Definition Complete

**FSW Release 12.0 Code, Integration and Test**
- M&FM Algorithms for FSW 12.0
- GN&C Algorithms for FSW 12.0
- ARTEMIS 10.2 Deliveries
- Software Sprints
  - Sprint Integrations
  - Test Dry Runs and Integration for FSW 12.0
- SDF Ready for Test
- FSW 12.0 TRR
- Testing of FSW 12.0
  - Functional Test Report for Release 12.0

**FC Software Version Description Document (SVD)**

**FSW 12.0 Product Release (FCA/PCA)**

**Release 12.0 FSW FQT to SRB**

**Release 12.0 Buy-off, CM/DM**

**Release 12.0 FQT Software (Delivery to ASCB)**
Defect Tracking

Defects

- Captured in the Serena Business Manager (SBM) Change Requests (CRs) System managed by development organization.
  - Analysis for root cause performed
  - Assigned to appropriate team to resolve
  - Assigned to a release
  - Closed with release testing
FSW Release 11 Test Results

**Test Approach Development**

- 26 STPrs require unique test runs
- The remaining 24 STPr use data from common test run

**R11 Blackbox STPr Dry Run**

- 6/19/15 97% BG
- TP complete

**R11 FQT Execution**

- FQT Run (Plan) vs FQT Run (Actual)

**R11 FQT Analysis and Archive Complete**

- FQT Complete: 8/12/15

- FQT Analysis Complete (Plan) vs FQT Analysis Complete (Actual)
- Archive Complete (Actual)
<table>
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<tr>
<th>Module/Element</th>
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**Data as of 9/16/15**

- Each cell is a measure of completeness (maturity)
- Weight sum of each major FSW process area
  - Requirements
  - Design
  - Implementation
  - Verification

**Low Maturity**

- <33%
- 0.33–0.66
- >34 and <65%
- 0.66–0.99
- >66% and <100%
- 0.99–1.00
- FQT (100%)

**High Maturity**

- 1.00–1.00
- FQT (100%)