National Aeronautics and Space Administration



5...4...3...2...1... SPACE LAUNCH SYSTEM

SLS Flight Software Agile Development Process

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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





SLS Evolution Overview



Where is SLS Avionics Located?

Booster Avionics Interim Cryogenic Propulsion Stage Avionics

Booster Avionics 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 Avionics — (Main Propulsion System Valve Control, Core Stage Thrust Vector Control, Rate Gyro)

Core Stage Engine Controllers







SLS Block | Software Providers



SLS CSCIs

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 onpad 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)



Flight Software Requirements Verification



Development Process



- 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/issues identified and addressed
 - Capability/content included in release (or provided in later release) depending upon outcome of item (4) analysis



Agile Development



SLS FSW Test & Verification



10/27/2015

FSW Release Activities				2016										
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FSW Release 12.0		19 🔶									\Rightarrow	22		
Preparation Planning for Release 12.0		26	26											
Planning and Content Definition Complete														
FSW Release 12.0 Code, Integration and Test		19									\Rightarrow	22		
M&FM Algorithms for FSW 12.0		19												
GN&C Algorithms for FSW 12.0			19	r	lota			Varified						
ARTEMIS 10.2 Deliveries		Ŵ		4		1	0.2.1	9						
Software Sprints		19	1 5	2	20 3 <	3	15 4		25					
Sprint Integrations			6	1	17 2	1	3	12	7 Dev. Ta	g 12.4				
Test Dry Runs and Integration for FSW 12.0							26	25 12	11 .4 ₇					
SDF Ready for Test									√3					
FSW 12.0 TRR														
Testing of FSW 12.0									14		1	18		
Functional Test Report for Release 12.0											19	22		
FC Software Version Description Document (SVD)						5			DFT 23	F	inal V	23		
FSW 12.0 Product Release (FCA/PCA)											24	15		
Release 12.0 FSW FQT to SRB											1	15		
Release 12.0 Buy-off, CM/DM												16	30	
Release 12.0 FQT Software (Delivery to ASCB)													30	



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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



Flight Software Maturity (R11 – R13)

Data as of 9/16/15

				Planned Maturity													Actual Maturity																								
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ee		is/nc	54%	62%	75%	88%	100%	100%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	100%	0%	0%	46%	50%	52%	60%	74% 8	% 9	% 97	85%	85%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
pq		acd	35%	62%	69%	72%	72%	72%	72%	71%	79%	87%	88%	88%	88%	88%	88%	88%	88%	100%	0%	0%	18%	22%	40%	52%	69% 6	3% 6	1% 694	6 69%	69%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
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RA A		oshm	35%	62%	75%	88%	100%	100%	88%	72%	72%	72%	72%	72%	72%	72%	72%	88%	88%	100%	14%	14%	27%	27%	23%	52%	69% 6	9% 8	1% 699	6 69%	69%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
O	_	infra	49%	62%	70%	74%	76%	76%	74%	74%	74%	74%	74%	74%	76%	76%	85%	88%	88%	100%	0%	0%	37%	38%	41%	45%	70% 7	1% 9	% 97	6 73%	71%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
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2		uni	48%	48%	51%	51%	51%	51%	60%	62%	68%	73%	76%	76%	81%	83%	83%	85%	87%	100%	0%	0%	48%	51%	54%	51%	56% 5	5% 5	1% 564	6 57%	58%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
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2		CSE	48%	48%	51%	51%	51%	51%	60%	62%	66%	71%	73%	73%	81%	83%	85%	87%	88%	100%	23%	24%	46%	56%	45%	45%	48% 5	2% 5	% 529	6 58%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
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		qmm	48%	48%	51%	51%	51%	51%	60%	72%	72%	72%	72%	72%	74%	76%	82%	85%	88%	100%	0%	0%	49%	54%	45%	45%	49% 4	9% 4	1% 499	6 64%	72%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		mm	42%	42%	45%	45%	45%	45%	54%	55%	59%	66%	68%	68%	70%	80%	85%	87%	88%	100%	0%	.0%	45%	50%	56%	52%	58% 5	B% 5	1% 58	6 60%	61%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		gnc	42%	42%	47%	47%	4%	47%	56%	54%	54%	54%	54%	54%	64%	78%	84%	85%	88%	100%	43%	38%	41%	43%	43%	43%	49% 4	9% 4	1% 49	6 45%	45%	0%	0%	0%	0%	0%	0%	0%	0%	0%	09
		30	34%	34%	37%	37%	37%	37%	47%	45%	39%	41%	41%	42%	67%	79%	85%	87%	88%	100%	16%	16%	27%	28% 2	29%	29%	32% 3	2% 3	% 32	6 34%	34%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		090	42%	42%	47%	47%	47%	47%	56%	54%	54%	54%	54%	54%	60%	69%	72%	88%	88%	100%	11%	11%	38%	38%	40%	40%	43% 4	3% 4	1% 439	6 25%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Each cell is a measure of completeness																					low	hio	h																	

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

