



STS-119 SSP Flight Readiness Review

MS/Donald S. Noah
January 21, 2009



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Agenda

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- **Systems Engineering & Integration**
 - SE&I FRR Roadmap
 - Flight Preparation Readiness
 - Special Topics
 - Commanded Mixture Ratio Update
 - Debris Status
 - Integrated In-flight Anomalies (IFAs)
 - STS-126 Flame Trench Data Report
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 - Radar Status
 - Flight Software Readiness
 - Payload and General Support Computer Readiness
 - Non-Standard Open Work Summary
 - Alternate/Dissenting Opinions
 - Launch On Need (LON)
 - Certificate of Flight Readiness

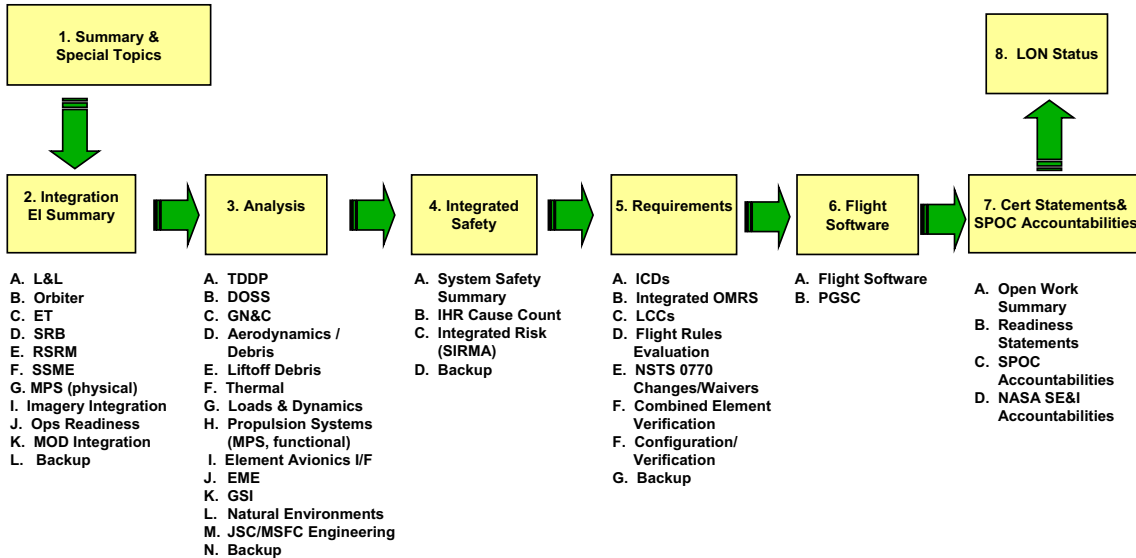




SE&I FRR Roadmap

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Flight Preparation Readiness

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- **All standard Systems Engineering and Integration flight preparation activities have been completed or are planned. Non-standard open work will be addressed.**
 - System requirements verification
 - Design requirements and induced environment updates; verification of element incorporation
 - Integrated vehicle performance evaluation
 - Real-time mission support preparation and certification of personnel as applicable
 - Review and disposition of waivers, deviations, and exceptions
 - Updates to Integrated Hazards baseline
 - Flight Software verification/Payload and General Support Computer (PGSC) Readiness
 - Review of element requirements changes and verifications for integration impacts





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STS-119 FRR Special Topic Debris Status



OBMR Background

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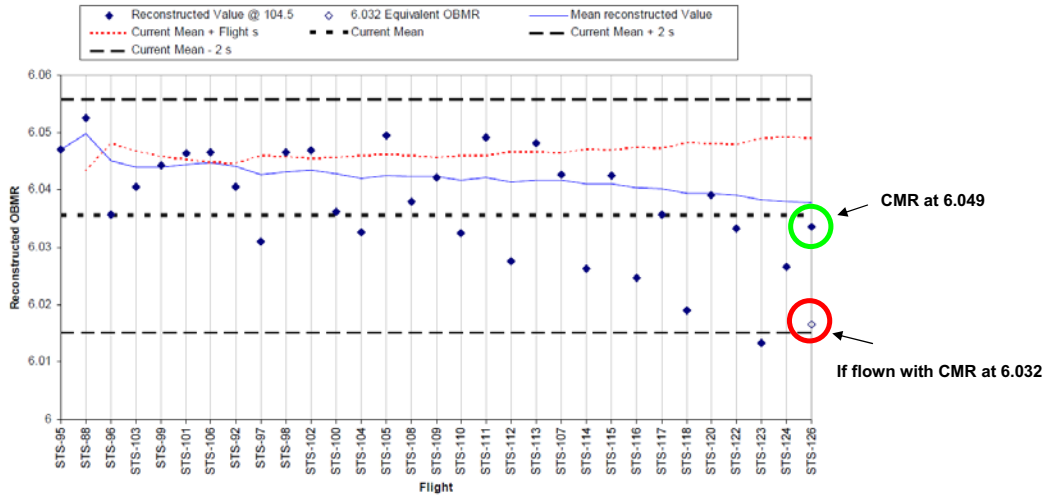
- **Following STS-123, post-flight reconstruction indicated the lowest reconstructed Over Board Mixture Ratio (OBMR) seen to date (-2.7 sigma).**
 - Lower OBMR indicates increased Fuel consumption
 - All available Fuel Bias was consumed on STS-123
- **MS2 requested PWR/SSME, ET project, Orbiter Project, and KSC to identify areas that could cause decrease in OBMR seen in recent flights. Several meetings were held, culminating in a TIM in July 2008.**
- **TIM findings were out-briefed to the SICB (7/22/08) and PRCB (7/24/08)**
 - Orbiter MPS, ET Project, SSME Project, MPS Integration and KSC L&L developed individual fault trees to determine potential contributors to decrease in OBMR
 - No issues with current MPS reconstruction methodology based on review held in 2003
 - No issues identified with Orbiter, ET, SSME or KSC hardware
 - Two issues identified to be contributing to "observed" low OBMR trend
 - SSC A2 test stand bias identified (1996-2003 timeframe)
 - SSMEs and flow meters that were tested during the suspect timeframe may be biased high compared to the rest of the fleet
 - LO2 Purity differences between KSC and SSC masked issue
 - Higher LO2 purity than predicted will cause a decrease in OBMR
 - ALL MPS hardware (SSME, ET, Orb) operating within specification, no flight hardware issues identified
 - This issue is not the result of any element specification violations but reflects the flight derived methodology which increases payload capability
- **SSME Controller Mixture Ratio was increased from 6.032 to 6.049 for STS-126**





Reconstructed SSME OBMR @ 104.5% Power Level, Corrected for C2 Error and 2043 Kf Shift

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- STS-126 SSME Over Board Mixture Ratio (OBMR) reconstruction results @ 104.5% power level
 - The reconstructed OBMR was 6.033, for the first FLT with the controller mixture ratio (CMR) set at 6.049
 - If the CMR had been flown at 6.032, the reconstructed OBMR would have been ~6.016
- STS-119 OBMR prediction is 6.043 @ 104.5% power level (with the CMR set at 6.049)
 - Prediction is based on most recent flight (STS-124) of this SSME cluster (2048, 2051, 2058)



STS-119 Debris Risk Assessment Summary

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(HAZARD SEVERITY LEVEL AND LIKELIHOOD OF OCCURRENCE WITH CONTROLS IN PLACE)

L I K E L I H O O D	PROBABLE			
	INFREQUENT			3
	REMOTE			24
	IMPROBABLE			7
		MARGINAL	CRITICAL	CATASTROPHIC
		SEVERITY		

- 3 Infrequent Causes:**
- Liffoff Debris (AD)
 - ET Umbilical Ice (V)
 - Orbiter Putty Repair (AK)

Debris Risk Assessment, 01/2009

Three IDBR-01 debris risks remain Infrequent/Catastrophic for STS-119

- **Liffoff Debris** is expected to remain at this risk level for the life of the Program due to the diversity of potential Debris sources although rigorous controls have been implemented and continuous vigilance is policy.
- **ET Umbilical Ice:** In progress testing may allow a future reduction to "Remote".
- **Putty Repair:** Windows zero impact allowable keeps any impact in the "catastrophic" category, forward work and flight history may be used to reduce the likelihood to "Remote".

Many improvements have been made since RTF and Controls are in place to further mitigate all of these causes.

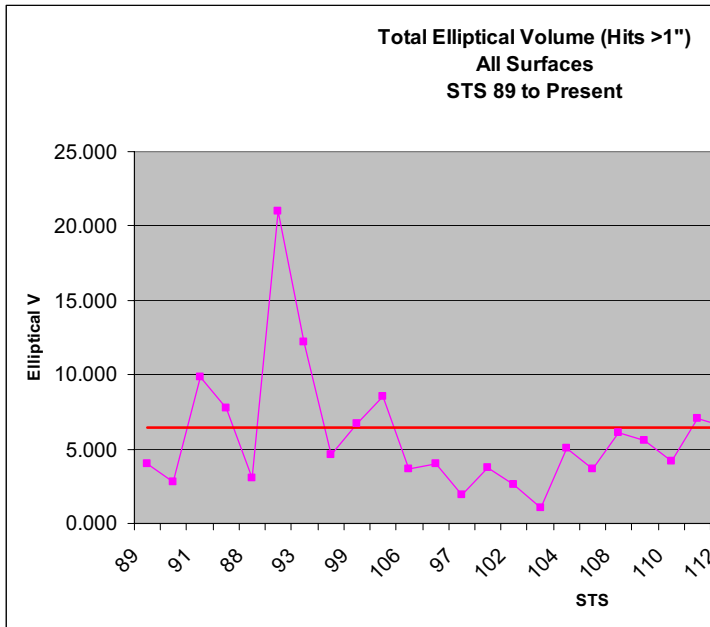




STS-126 Debris Impact Summary

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STS	Elliptical Volume in cubic inches (for damage with any dimension ≥ 1 inch)	Elliptical Volume in cubic inches (All) Post OPF Roll-in
114	3.450	5.120
121	0.628	1.250
115	1.714	1.894
116	2.899	3.891
117	1.980	4.010
118	3.371	10.686
120	1.015	4.003
122	3.485	5.535
123	0.859	1.591
124	1.657	2.469
126	0.977	1.364

Total STS-126 Tile Damages =94	Avg Tile Damages all flights =147.6
Tile Damages Greater than 1" =14	Avg Damages Greater than 1" =29.4



T-0 Umbilical Ice IIFA

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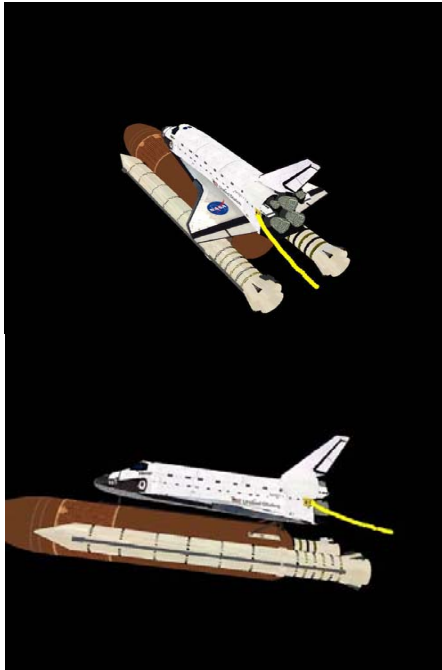
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- During STS-126, at approximately 26.7 seconds, debris was observed to liberate between the LH2 T-0 umbilical and port OMS pod (STS-126-I-002)
 - Imagery analysis concluded that liberated ice measured approximately 11.5" x 2"
 - Imagery and Debris Team trajectory analysis confirmed no contact with the Orbiter
- KSC led IFA resolution to determine root cause for STS-126 T-0 ice formation
- Debris Team requested to perform DTA on STS-126 configuration and initial results presented at special DIG on 1/09/09



STS-126 T-0 Debris Trajectory

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PRA Results for T-0 Umbilical Ice

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- Decision to perform full DTA and PRA to assess risk for future flights over range of masses and release times
- Initial maximum size of ice that could be formed in the LH2 Carrier Plate provided by KSC was 19.4" x 4" x 1.33" and the total mass was computed to be 2.8 lbm (used in analysis as upward bound / NOTE: KSC max input was revised to 19.4"x3"x1.33" @ 2.11 lbm)
- Deterministic DTA was performed on four different sizes, each run at two densities with mass ranging from 0.059 lbm to 2.793 lbm.
- Probability Risk Assessment was performed only on the higher density cases (47 pcf) over the entire Mach range - MET 15 to 125 seconds at 10 sec. increments
 - Produced impact conditions for major Orbiter elements: Side Fuselage, OMS Pods, OMS Nozzle, Body Flap, Upper Wing, Elevon, and SSMEs
 - RSRB and ET impacts were assessed in Deterministic DTA only
 - Assumed release rate of 1 per flight (simulation of 1000 flights)
- Imagery Team has reviewed LH2 TSM video back to STS-51L for evidence of similar ice
 - PRA Release Rate scaled to be more realistic
- Resultant PRA = 1/nnnn





Integrated In-flight Anomalies(IFAs)

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- STS-126-I-001 – “SM GPC Failure to Send GCIL Commands”
Status: Closed
- STS-126-I-002 – “Debris Released near the LH2 T-0 Plate”
Status: Open
- STS-126-I-003 – “DCS Failure - HDP Plunger Extension (M3) and Other Debris”
Status: Closed
- STS-126-I-004 – “MPS GH2 Pressure Flow Control Valve open with no command”
Status: Open
(To be discussed during Orbiter presentation)
- STS-126-I-005 – “Debris from Multiple HDPs at NSI Firing”
Status: Closed



Integrated In-flight Anomalies(IFAs)

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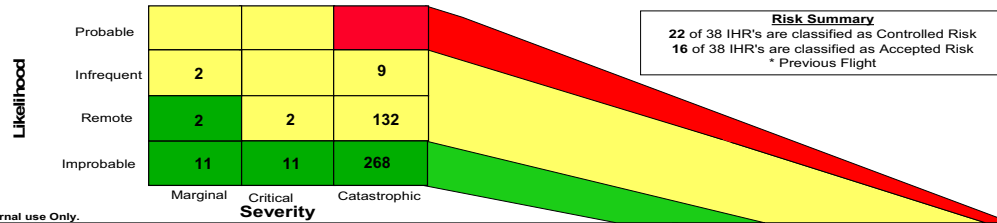
- STS-126-I-006 – “Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Liftoff Debris)”
Status: Closed
- STS-126-I-007 – “Meteorological System Computer (MSC) was non-responsive due to backlog of balloon data”
Status: Closed
- STS-126-I-008 – “ET Top Coat/TPS Adhered to GOX Vent Hood Sealing Surface”
Status: Closed
- STS-126-I-009 – “Helium Pneumatic Pressure Decay”
Status: Closed





Integrated Hazard Risk Matrix

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Hazard Report #	Integrated Hazard Titles	Controlled				Accepted Risk								
		Controlled Risk	remote-marginal	improbable-marginal	improbable-critical	Accepted Risk	probable-marginal	infrequent-marginal	remote-critical	remote-catastrophic	probable-critical	infrequent-critical	improbable-catastrophic	probable-catastrophic
"Accepted Risk" Hazard Reports														
IDBR-01	Ascent Debris Impact to SSV	7			7	27				24			3	
ICOM-01	Adverse Effects due to Intentional RF Environment	2			2	1				1				
IEEM-01	Adverse Electromagnetic Effects (EME)	0			0	18				18				
IGNC-01	Ascent Trajectory Event Anomaly	13			13	1							1	
IMEO-01	Hazardous Environment in the Aft Compartment	0			0	4				1			3	
IMPS-01	Contamination in the Integrated MPS H2 System	0			0	1				1				
IMPS-02	Contamination in the Integrated MPS O2 System	0			0	1				1				
IMPS-03	Improper IMPS configuration during SSME Operation	11			11	3				3				
IMPS-04	Off-Nominal Purges	11			11	1				1				
IMPS-09	Hazardous Environment due to H2 External to SSV	4			4	6				5			1	
INEV-01	Exposure to Natural Environment Exceeds Capability of the Space Shuttle SSV Elements	17	1	1	15	45	1	1	1	42			1	
ISPR-04	SRB Hold Down Post (HDP) System Malfunction	1			1	1				1				
ISPR-05	SRB Umbilical System Malfunction	3			3	1				1				
ITHM-01	Exposure to Thermal Environment Exceed Capability of SSV	15	1	5	2	7	3	1	1	1				
IVLD-01	Exposure to Induced Environments Exceed Structural Capability of SSV	22			22	26				26				
ILIT-01	Adverse Effects of Lightning	0			0	6				6				
Accepted Risk Distribution Totals		(see next page)		145	0	2	2	132	0	0	9	0		



Integrated Hazard Risk Matrix

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"Controlled Risk" Hazard Reports															
IARO-01	Aerodynamics Environment not per Specified Design	1			1	0									
IEPD-01	Inability to Power Critical Functions	8		3	5										
IFSI-01	ET/SRB System Interface Failure	6			6	0									
IFSI-02	ET/Orbiter System Interface Failure	10			10	0									
IFSI-03	SSME/Orbiter System Interface Failure	14			14	0									
IFSI-04	Outer Mold Line Configuration Error	3			3	0									
IFSW-01	Flight Software Generic Problems can cause loss of vehicle command and control	1			1	0									
IFSW-02	Erroneous Inputs to Flight Software can cause loss of vehicle command and control	9			9	0									
IMEO-02	Malfunction of Integrated Hydraulic System (Systems 1, 2 and 3)	4			4	0									
IMEO-03	SSME Nozzle/OMS Pod/ Body Flap Interference	2			2	0									
IMPS-05	Over pressurization of the Integrated MPS H2 System	7			7	0									
IMPS-06	Under pressurization of the Integrated MPS H2 System	7			7	0									
IMPS-07	Over pressurization of the Integrated MPS O2 System	7			7	0									
IMPS-08	Under pressurization of the Integrated MPS O2 System	7			7	0									
IMPS-12	Excessive O2 from ET/Orbiter/SSME External to SSV	7			7	0									
IMPS-15	LO2 Geyser Event during Cryo Loading	8			8	0									
IMPS-16	Loss of MPS He System	4			4	0									
IMPS-17	Inadvertent SSME Shutdown	3			3	0									
IPYR-01	Pyrotechnic System Malfunction	11			11	0									
ISPR-02	ET Vent Arm System (ETVAS) Umbilical System Malfunction	14			14	0									
ISPR-03	Tail Service Mast (TSM) T-0 Umbilical System Malfunction	40		5	6	29	0								
IVLD-02	System Instability Results In Structural Failure of SSV	13			13	0									
Controlled Risk Distribution Totals		292	2	11	11	268	145	0	2	2	132	0	0	9	0





**Integrated Hazard Risk Matrix
 Reduction Count**

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- **Infrequent Catastrophic**
 - None
- **Remote Catastrophic**
 - None
- **Improbable Catastrophic**
 - None



**SRB Flame Trench Static Pressure Measurements
 Comparison to Design Environments**

Presenter	MS2/Edward M. Burns	
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- **Static pressure design environment was defined at the 6/21/08 Joint Aero/Loads Panel and approved at the 8/19/08 SICB**
 - Crush: 115 psig
 - Burst: -10 psig
 - Reference PRCBD 052158DQ
- **10 static pressure sensors were installed on Pad A to measure the SRB flame trench environment during launch**
 - 6 on the west side and 4 on the east side
- **STS-126 flame trench instrumentation maximum (crush) and minimum (burst) static pressure data shows no violation of design environment**

Sensor #	max psig	min psig
• KFDPA007A	91.46	-2.34
• KFDPA011A	8.28	-6.79





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STS-119 FRR Imagery Status



Imagery Hardware ELVIS	Presenter	MS/David Melendrez	
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ET LO2 Feedline Camera (ET-127)

- No issues following ET/SRB stack swap from STS-125
- On schedule with remaining planned nominal checkouts
- **ET LO2 Feedline Camera ready to support. No open issues.**



Ground Network & TV

- All ground stations (JDMTA, MILA, WFF, PDL) configured for nominal ISS trajectory
- **Ground Network ready to support. No open issues.**

SRB Cameras

- No issues following ET/SRB stack swap from STS-125
- ET Attach Ring (ETAR) cameras, Forward Skirt Aft Pointing (FSAP) cameras, ET Observation cameras, Data Acquisition System (DAS) recorders, and Solid State Video Recorders (SSVRs) hardware installed, closeouts complete, on schedule with nominal checkouts
- **SRB Cameras ready to support. No open issues.**

Digital ET Thermal Protection System (DETTPS) Camera & Flash

- Configured for NIGHT to optimize exposure on shadowed areas of ET
- Two image downlinks requested (standard ops from now on)
- Two-step exposure bracketing (0EV and +1EV) will again be used (successfully first flown on STS-126)
- Fourth flight of Flash. Operated nominally on STS-126
- **DETTPS Camera and Flash ready to support. No open issues.**

Crew Handheld Cameras

- Digital still camera – no issues.
- Canon G1 HD camcorder – troubleshooting continues on dropped video observed on STS-126.
- HD video problem may be related to DTV mux buffer in OV105. Problem not reproduced during testing in OV103.
- Video may be downlinked analog at expense of resolution. Or, HD video may be downlinked via ISS. HD video can still be played back post-landing.
- **HD Video issue no constraint to flight. Crew Handheld Cameras ready to support.**

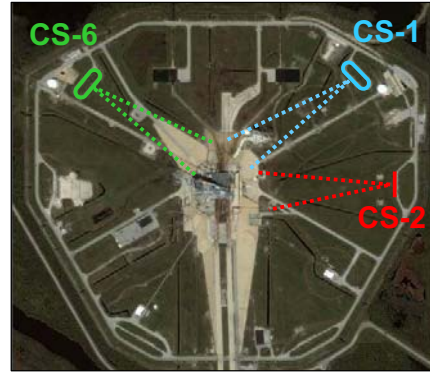




Imagery Hardware Ground		Presenter MS/David Melendrez
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Ground Cameras

- Cameras configured nominally – no issues being worked
- Two new fixed (no tracking) high speed 35mm film cameras to be deployed, one each at CS-2 and CS-6, intended to improve coverage of the pad for liftoff debris for trajectory assessments
- New IR cameras – first used on STS-126 – focusing on SRB flame trench and liftoff debris will again be deployed at CS-1, CS-2, and CS-6
- IR cameras performed well on STS-126 and provided data for liftoff debris analyses
- **Ground Cameras ready to support. No open issues.**



Lighting Predicts, Feb 12 – Mar 31		Presenter MS/David Melendrez
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Launch

- February 12: **DAYLIGHT**
- February 13 – March 15: **DARK**
- March 16 – 31: **DAYLIGHT**

Post ET-Sep Mnvrs

- February 12 – 21: Nominal +X, Nominal Pitch
- February 22 – March 17: Nominal +X, No Pitch
- March 18 – 31: Nominal +X, Nominal Pitch

ET Sep Imagery

- February 12 – 17: **DAYLIGHT**
- February 18 – March 16: **DARK**
- March 17 – 31: **DAYLIGHT**

Handheld ET (post-pitcharound) Imagery

- February 12 – 19: **DAYLIGHT**
- February 20 – 21: **DAYLIGHT, Non-Optimal**
- February 22 – March 17: **DARK**
- March 18 – 19: **DAYLIGHT, Non-Optimal**
- March 20 – 31: **DAYLIGHT**

MOD, SE&I Agreements for Crew HH ET Photography

1. Pitch mnvr for handheld ET photography will not be attempted if nominal photography time is dark.
2. Pitch mnvr will not be performed "late"
3. Pitch mnvr and ET handheld photography will not be attempted on LON mission





Summary	Presenter MS/David Melendrez	
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- No imagery related issues are being tracked as a constraint for flight.
- Imagery Integration personnel, facilities, systems, and hardware are configured or are on schedule with standard open work per the nominal checkout plan.
- Imagery team is ready to support STS-119.



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STS-119 FRR Radar Status





Debris Radar Configuration for STS-119:

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• STS-119 NDR Configuration:

- 1 MCR C-band radar
- 2 NASA X-band radars
 - NASA #1 on SRB vessel *Liberty Star*
 - NASA #2 on *Runnymede-Class* ARMY LCU
 - No change to ship positions from STS-126
- Operational SRB tracking, following ASTT, by both X-bd radars
- Ascent team training continues
- NDR Readiness will be reviewed again 1/28/09



NDR Issues During STS-126:

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NDR-C1 Radar:

Problem: Did not support launch due to ER reported interference

Resolution: Updating the ER PRD to reflect the following topics

- All supporting radars to participate in future phasing checks
- Change the phase pointing location to be more flight-like (from Jimspheres to pad static point)
- Review and update, where possible, the phasing slot assignment table
- ER and NDR jointly develop more comprehensive troubleshooting procedures for use in case interference is observed in the future
- ER and NDR jointly agree on pre-flight testing to build confidence in these changes

NDRX-3 Radar:

Problem: System Sensitivity Appeared Low

Resolution: Pre-Launch Preparations will include a comparison to X4 sensitivity, and resolve pedestal differences

NDRX-4 Radar:

Problem: None Reported





STS-119 NDR Ops Changes:

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- **Mission Plan:**
 - Eliminate 100Kw power step
 - On-the-fly LNA gain switching following ASTT
 - Improved pre-flight calibrations and performance awareness by analysts
- **C-band Ops:**
 - Local insight available for phasing slot positions as independent cue to ER timing. Range PRD updated to reflect new phasing requirements
 - Protect 20 v/m for all on-orbit debris tracks, remove EVA tracking restriction
 - Improve SV delivery responsiveness to MCC-H for orbital debris
 - Investigate automated power stepping via digital power programmer
- **X-band Ops:**
 - Onload/Offload X4 at hanger AF, sortie from Army pier
 - Updates to RTP software made to X3 during STS-126 will be incorporated into X4 for STS-119
 - Nominal Plan is for X4 to track the boosters from 150-310 MET, and X3 from 270-420 MET
 - Improve cross-network performance of pointing tools to assist ship operators for loss of voice comm from NDROC



Readiness for STS-119:

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- **Team Readiness**
 - Complete, both ascent and analysis teams ready
- **Facility Readiness**
 - Complete
- **Radar Readiness**
 - NDR-C1 - GREEN – pending completion of interference testing with ER
 - NDR-X3 - GREEN – pending prep maintenance period
 - NDR-X4 - GREEN





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STS-119 FRR Flight Software Readiness



STS-119 FLIGHT SOFTWARE SUMMARY

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- **Second flight of PASS and BFS Operational Increment 33 (OI-33) and MEDS Integrated Display Processor (IDP) / Multifunction Display Unit Function (MDUF) combination (VI 6.00/5.00)**
 - STS-119 flight system includes a PASS patch to correct the Ground Command Interface Logic (GCIL) commanding error encountered during STS-126 (DR 126366)
 - Patch insures that the GPC I/O Processor can access the commands required for:
 - Automatic moding between S-Band and Ku-Band communications
 - Automatic PSP moding between RF and Umbilical communications
- **Tenth flight of MAGRS-3S Link 613-9966-007 GPS FSW**
 - No changes from STS-126 software





In-Flight Anomalies

Presenter USA/John Magley

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- Two anomalies were observed during Flight Day 1 of STS-126 and were documented by IFA STS-126-I-001
 - Both anomalies were failures of automatic moding that was expected to be commanded by the Ground Command Interface Logic (GCIL)
 - Automatic transition between S-Band and Ku-Band communications did not occur
 - Automatic PSP moding from RF communications to umbilical communications did not occur
 - Operational workarounds were used for the affected functions during flight
- Investigation revealed a software error that was introduced on OI-33 and documented in PASS DR 126366
 - An OI-33 change displaced three GCIL command words in a common data store rendering them inaccessible by the GPC I/O Processor
 - Result was that unintended data was sent to the GCIL rather than the expected commands



In-Flight Anomalies

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- Full Root cause and oversight analysis has been performed and reviewed by the SASCB community and the NESC
 - Vulnerability to this problem was introduced in 1989 with the failure to explicitly protect the impacted data from future alignment shifts (standards violation)
 - Detailed code inspection missed the unintentional impact to functions that should not have changed
 - Enhancements to standards, inspection guidance, and analyst training are complete or in work
 - Regression testing and training did not identify the problem
 - Partially due to a successful execution of the automatic antenna handover function under test-specific circumstances
 - Enhancements to FSW and SAIL regression test processes, procedures, and training are complete or in work
 - STS-119 software has been audited for similar errors – none found
 - Corrective and preventive actions will be tracked to completion with the Flight Software Office (FSO)
- Root cause analysis and patch were accepted at the 1/15 PRCB





FSW READINESS SUMMARY

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- **Integrated Avionics Verification (IAV) is complete**
 - A total of 20 test cases were performed in the Shuttle Avionics Integration Laboratory (SAIL) and successfully analyzed in support of STS-119
 - Includes 3 test cases to support verification of the GCIL commanding patch
- **SAIL facility will be in a condition of readiness for mission support**
- **Formal Software Readiness Review (SRR) was conducted on 01/08/09**
 - No known constraints
- **With the completion of planned open work, FSW will be ready to support STS-119 launch**



Launch on Need Status

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- **In the event of call-up, the STS-127 flight software products would be flown on OV-105**
- **Completion of the development and verification of flight-specific FSW products for STS-127 will be performed in time to support the 05/13/09 target LON date**
- **Formal Software Readiness Review to be conducted after call-up**





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STS-119 FRR

Payload and General Support Computer Readiness



PGSC Configuration Summary / Milestones

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• Hardware and Software Summary

- The Payload and General Support Computers (PGSC) were developed to enhance crew situational awareness.

STS-119 will be the twelfth flight of the IBM ThinkPad A31p PGSC

- 6 PGSC units
- Seventh flight of the A31p Docking Station
- Fourth flight of Netgear Wireless Access Point.
 - Note: No network issues observed during **STS-126**
- First flight to use Payload Max for the 48 Mbps data rate through OCA2A
- Second flight to use WAP Interconnect to utilize ISS KU-Band (when docked)

• PGSC Milestones



*FD1 Late Update to be performed at KSC by ground support personnel





Summary of Non-standard Open Work

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	Completion Date
System Safety	
- SICB approval, STS-126-I-002, Debris release near the LH2 T-O plate	01/20/09
- SICB approval, STS-126-I-003, DCS failure – HDP plunger extension (M3) & other debris	01/20/09
- SICB approval, STS-126-I-004, MPS GH2 pressure flow control valve open with no command	01/20/09
- SICB approval, STS-126-I-006, Unexpected/expected debris exceeding mass	01/20/09
- SICB approval, STS-126-I-009, Helium Pneumatic Pressure Decay	01/20/09
Systems ICDs	
- Approval of IRN/ICD: IO-3355/13M15000, Waiver of G6 accelerometer data	01/20/09



Alternate/Dissenting Opinions

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- **Alternate/dissenting opinions were actively solicited at the SE&I STS-119 Pre-FRR.**
 - No dissenting opinions were identified.





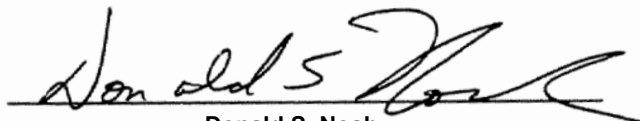
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- SE&IO has identified no technical or schedule constraints in support of LON requirements for STS-119 using the SSP baseline “Fly the Next Flight” approach



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The Space Shuttle Program, Systems Engineering and Integration Office’s Flight Preparation Process Plan, documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness have been satisfied. Required products and other responsibilities identified in NSTS 08117, paragraph 8.5.12 and Appendix M, have been or will be scheduled for completion. All technical functions and responsibilities are ready and the Systems Engineering and Integration Office is prepared to sign the Certificate of Flight Readiness for STS-119, pending completion of open work.



Donald S. Noah
 Manager Systems Engineering and Integration Office

