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Back-up charts



Standard Open Work

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	Completion Date
TDDP	
- DOL products (RSRM L-9 day PMBT prediction, actual OMS/RCS loads)	01/30/09
- Change notice (RSRM L-3 day PMBT prediction update)	02/09/09
DOSS	
- L-3 week test / TCDT	01/21/09
- L-7 day SIRB review	02/04/09
- L-2 verification test (incorporate L-8 day TDDP & L-3 day change notice)	02/10/09
GN&C	
- Update FRV results to SIRB	02/04/09
- Normal prelaunch configuration & testing	02/08/09
Loads & Dynamics	
- Normal prelaunch configuration & testing	02/10/09
- Roll-over to Pad A speed report	01/20/09
Rules	
- Assessment of late flight rules changes	02/11/09





Standard Open Work Continued

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	Completion Date
Software	
- Update NIRD CCT	L-3 days
ELVIS	
ET LO2 Camera Open Loop MILA Comm Check	S0009
- Install of Crew Handheld Cameras	S0017
- Install SRB DAS in Fwd Skirt and Battery Charge	L-3 weeks
- Recharge of ET LO2 Camera Battery	T1303
- Cabin Stow of DETTCS Camera IVA Converter Box	L-3 days
- ET LO2 Camera Cover Removal/Window Cleaned	T6446
- SRB Cameras Cover Removal/Windows Cleaned	S007
- ET LO2 Camera Open Loop MILA Comm Check	S007
- Cabin Stow of Crew Handheld Camera Batteries	DOL
Ground Cameras	
- Trackers Towed to Camera Site Locations	L-1 week
- Camera Positioned and Rough Set	L-3 days
- Film Loaded and Final Set	L-2 days
FSW	
- Complementary Load Processing	L-10
- Dump and Compare Processing	L-5
- Disposition DCR to update SSME Chamber Pressure Calibration	01/20/09



Standard Open Continued

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	Completion Date
PGSC	
- L-10 Late Update Disk	02/03/09
- ISODS for Open FIARS	01/28/09
HOSC	
- STS-119 S0056 Cryo Simulation	01/23/09
- HOSC Launch Support Plant Complete	02/06/09
- PCGOAL2, HOSC Voice, Video and Data configured to support launch countdown	02/06/09



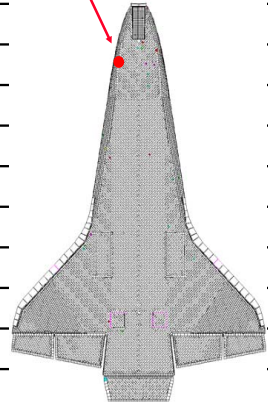


Putty Repair Losses Since RTF

Presenter **MS/D. S. Noah**
 Date **01/21/09** Page **45**

- One putty repair was liberated during STS-126
 - The masses were consistent with the masses provided in NSTS-60559

STS-126 Putty Loss Location

Flight	Losses	<0.0002 lbm	Mass Range (lbm)	Comments	
STS-114	9	2	0.0001-0.0047		
STS-121	5	0	0.0003-0.0021		
STS-115	8	2	0.0000-0.0061		
STS-116	5	0	0.0008-0.0026		
STS-117	10	1	0.0001-0.0120		
STS-118	8	3	0.0001-0.0019		
STS-120	5	0	0.0003-0.0010		
STS-122	2	0	0.0022-0.0059		
STS-123	5	0	0.0004-0.016		
STS-124	2	0	0.0029-0.0065		
STS-126	1	0	0.0045		V070-391018-177 / Defined undercuts are still solid/ There is an adjacent putty repair Outside of the RCC transport area



STS-126 Missing Putty Repair

Presenter **MS2/Edward M. Burns**
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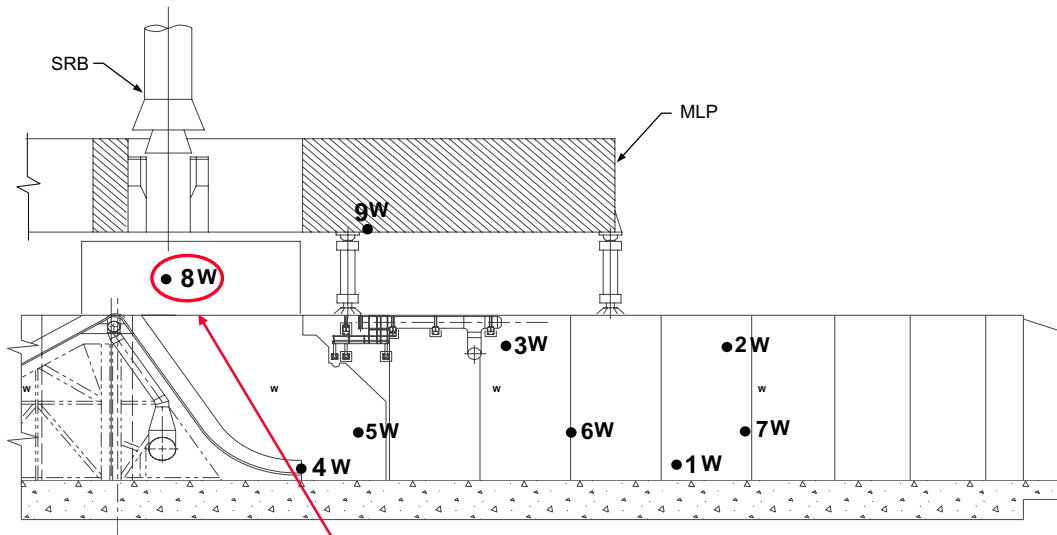
- V070-391018-177
- Missing, defined undercuts still solid
- There is an adjacent putty repair
- Outside of the RCC transport area





Instrumentation Location Points – West Side of SRB Flame Trench

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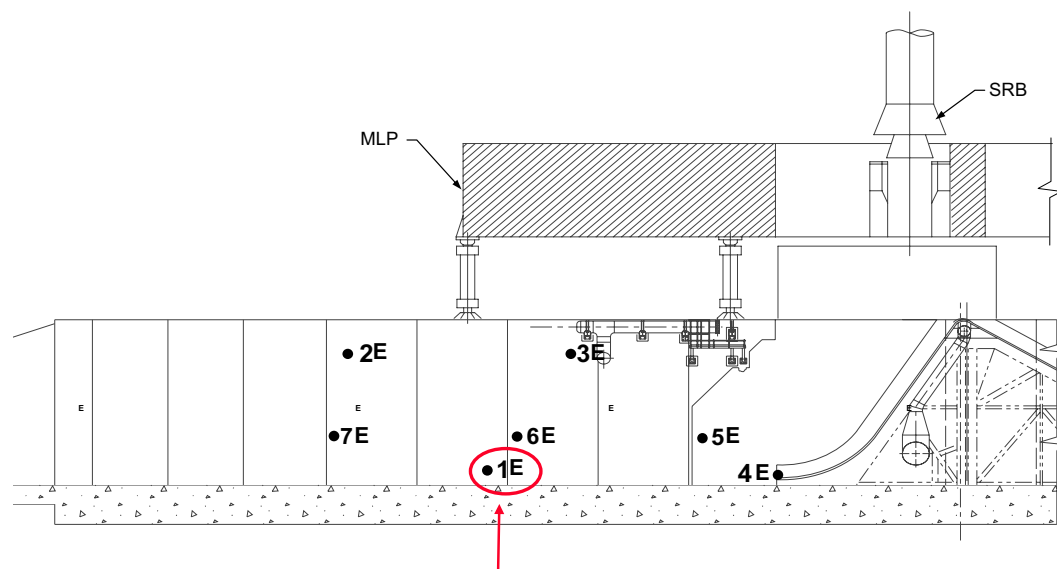


Maximum Pressure (KFDP A007A) = location 8W



Instrumentation Location Points – East Side of SRB Flame Trench

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Minimum Pressure (KFDP A011A) = location 1E





Integrated Hazard Report Changes Since STS-126

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- **IVLD-01 “Exposure to Induced Environment Exceed Structural Capability of SSV “ – S050425JD**
 - Flight Effectivity Update
 - IVLD Status changed from “Closed w/ PRCB action” to “Closed”
 - Changed Risk Matrix block for Remote/Catastrophic from 24 Integrated, 2 Open Work to 26 Integrated
 - Risk Classification unchanged – Accepted Risk



Integrated In-flight Anomalies (IFAs)

Presenter	MS2/Edward M. Burns	
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STS-126-I-001 – SM GPC Failure to Send GCIL Commands

- **Background**
 - On FD1, the MPLM environment checks could not be completed, because the payload signal processor (PSP) could not be configured properly.
 - Failures of the automatic handover of antenna management to Ku-band from S-band and vice versa were also observed.
- **Approach**
 - These two anomalies were failures of automatic moding that was expected to be commanded by the Ground Command Interface Logic (GCIL)
 - OI-33 SCR 93122 “PSP Reject Indicator Fix to DR 122444” inserted a data item into a common data structure (compool) shared by the affected commanding data.
 - The inserted data caused a shift in subsequent data that rendered three downstream commands inaccessible by the I/O processor.
- **Results**
 - STS-119 and STS-127 software patch was released.
 - Plan to fix as source modification for OI-34 systems.
 - Implement corrective action for verification testing.
 - Implement preventative training and coding standards.
- **Status**
 - SICB reviewed and closed IIFA on 1/12/09.





Integrated In-flight Anomalies (IFAs)

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STS-126-I-002 – Debris Released from near the T-0 Plate

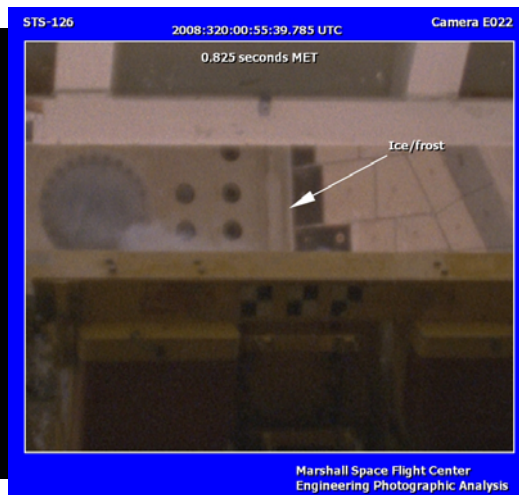
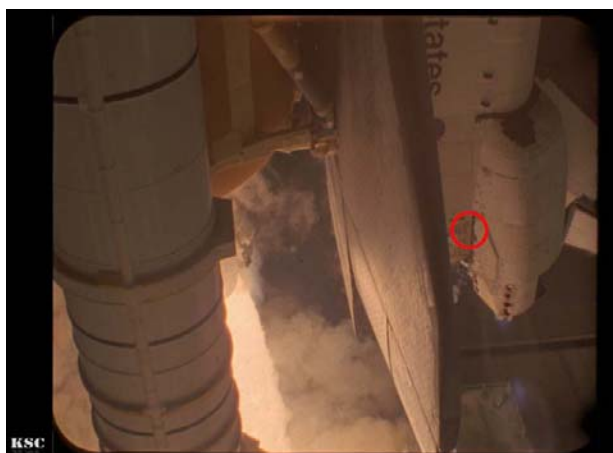
- **Background**
 - Ice/frost debris, 11.5" x 2" in size, was observed to liberate from the orbiter near the location of the Liquid Hydrogen (LH2) T-0 umbilical at ~27 seconds MET. In this area.
- **Approach**
 - Purge test on MLP 1 LH2 Tail Service Mast (TSM) Umbilical Helium flow test completed.
 - Inspection of T-0 Umbilical Carrier plate perimeter seal interface on OV-103 T-0 Plate completed.
 - Debris Transport Analysis (DTA) of ice/frost release in work to characterize risk.
 - Fault Tree Analysis and Block closure is in work.
 - Assessing Ground Support Equipment (GSE) H/W and process options to prevent ice/frost or have it liberate at/before T-0.
- **Status**
 - DTA, fault tree, and GSE assessments in work.
 - ECD: 1/20/09



Integrated In-flight Anomalies (IFAs)

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STS-126-I-002 – Debris Released from near the T-0 Plate (Cont)



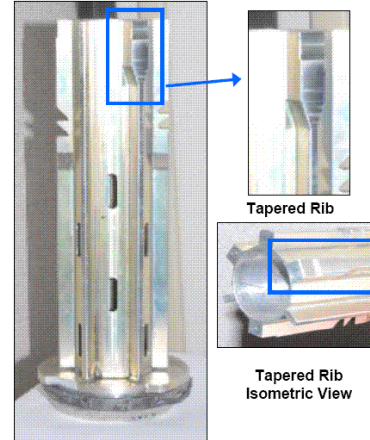


Integrated In-flight Anomalies (IFAs)

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STS-126-I-003 – Aft Skirt Hold Down Post (HDP) #3 Debris Containment System (DCS) Anomaly

- **Background**
 - DCS plunger and spring exited through bore hole and became lift-off debris.
- **Approach**
 - SRB design change added additional mechanism (tapered rib) to retain spring/plunger assembly in the event of failure of the primary retention design (plunger shoulder).
- **Results**
 - Certification tests complete. Documentation in work.
- **Status**
 - Awaiting Field Engineering Change approval before closing IIFA
 - Potential waiver on primary retention design (plunger shoulder) factor of safety
 - ECD: 1/20/09



Plunger Feature Utilized for Stop Block



Integrated In-flight Anomalies (IFAs)

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STS-126-I-004 – MPS GH2 Pressure Flow Control Valve open with no command

- **Background**
 - Unpredicted liquid hydrogen (LH2) ullage pressure change during STS-126 ascent caused by failed Engine 2 Flow Control Valve (FCV) poppet.
 - Allowed excess gaseous hydrogen to enter External Tank (ET) ullage.
 - No violation of ET structural limits.
 - Pressurization system designed to tolerate 1 “stuck valve” failure of an FCV into either low or high flow.
 - Poppet head breakage experienced on STS-126 allowed approximately 80% of high flow past valve (valve was in low flow position). Remaining two FCVs compensated for failed valve.
 - Larger poppet head breakage could allow flow greater than normal open/high flow.
 - If poppet breaks in high flow position greater than normal, high flow will occur.





Integrated In-flight Anomalies (IFAs)

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STS-126-I-004 – MPS GH2 Pressure Flow Control Valve open with no command (Cont)

- **Approach**
 - Orbiter to install best available FCVs for STS-119. Definition of 'best' uncertain as root cause undefined.
 - Assess failure scenarios to determine risk posture.
 - CFD flow and acoustic analysis in work to define internal damage due to FCV failure debris
 - Structural failure of ET due to ignition of H2 vented from ET vent valve
 - Under pressurization of ET
 - Flight rationale will consist of Orbiter hardware assessment of future FCV failures in combination with an understanding of integrated effects of failures.
- **Results**
 - Hardware analysis and integrated failure scenario assessments in work
- **Status**
 - Preliminary assessment of integrated failure scenarios
 - IIFA ECD: 1/20/09



Integrated In-flight Anomalies (IFAs)

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STS-126-I-005 –Debris from Multiple HDPs at NSI Firing

- **Background**
 - During the review of imagery from the launch of STS-126, an increase in smoke and debris was observed ejecting from the area of the Debris Containment Systems (DCS) of Holddown posts: 1, 2, 5, 6 and 7 during NSI firing.
- **Approach**
 - The hardware functioned as expected.
 - The imagery community cannot positively identify the source of the debris, but has concluded the amount of smoke is consistent with other flights.
 - STS-126 had a unique configuration with the firing lines tape wrapped within inches of the NSI connector which is internal to the DCS.
 - The debris is most likely attributed to possible firing line tape, drifting material from HBOI remnants, and/or foreign debris surrounding the HDP.
- **Results**
 - Particle motion and size indicates an acceptable mass for NSTS 60559.
 - KSC GO requested procedure clarification for tape installation on the firing lines and inspection of area around HDP for foreign debris.
- **Status**
 - SICB reviewed and closed IIFA on 1/12/09.





Integrated In-flight Anomalies (IFAs)

Presenter	MS2/Edward M. Burns	
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STS-126-I-006 – Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance

- **Background**
 - IIFA consists of multiple debris occurrences related to ground processing systems and procedures.
- **Approach**
 - Debris type/source is identified and assigned to the associated ground system.
 - KSC systems disposition each debris occurrence related to that particular system.
- **Results**
 - Twenty-two of twenty-four items dispositioned.
- **Status**
 - Two items remain to be dispositioned.
 - Norplex tag debris (K-032)
 - NIRD-036 (K-101) – Complete debris identification and characterize risk relative to current debris risk baseline
 - ECD: 1/20/09



Integrated In-flight Anomalies (IFAs)

Presenter	MS2/Edward M. Burns	
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STS-126-I-007 – Meteorological System Computer (MSC) was non-responsive due to backlog of balloon data

- **Background**
 - The Met-System Computer (MSC) was non-responsive and had to be rebooted.
 - Since all balloon data must go through the MSC, the resulting back-log caused a reboot and loss of Jimsphere data.
- **Approach**
 - Balloon priorities were established, which should help alleviate the strain on the MSCs.
 - Because the high-res data typically requires more edits than the Jimspheres, the removal of most of the high-res from real-time editing should help the wind editor keep the data moving.
 - Cape Winds will plan to send only three balloons to the QC terminal at a time.
- **Results**
 - Balloon priorities will be documented in the PRD.
 - Cape Winds will update their console procedures as required.
- **Status**
 - SICB reviewed and closed IIFA on 1/12/09.





Integrated In-flight Anomalies (IFAs)

Presenter	MS2/Edward M. Burns	
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STS-126-I-008 – ET Top Coat/TPS Adhered to GOX Vent Hood Sealing Surface

- **Background**
 - During GOX vent arm retraction, the GOX vent seal adhered to the LOX tank topcoat resulting in the loss of topcoat and a small amount of TPS.
 - Topcoat adhesion and loss during GOX vent arm retraction has been observed on previous missions.
 - TPS loss has also been observed, but less often.
- **Approach**
 - There were no requirement violations due to this event.
 - Liberated foam did not pose a risk to the vehicle during liftoff and ascent.
 - Resulting divot was enveloped by the hail damage repair sustained on STS-124
- **Results**
 - Analysis showed no TPS loss above allowables.
- **Status**
 - SICB reviewed and closed IIFA on 1/12/09.



Integrated In-flight Anomalies (IFAs)

Presenter	MS2/Edward M. Burns	
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STS-126-I-009 – Helium Pneumatic Pressure Decay

- **Background**
 - Helium pneumatic pressure decay noted during ascent was greater than the expected thermal effects.
 - Loss of helium would impact ability to perform main engine pneumatic shut-down and purges.
- **Approach**
 - Conduct flow test to assess Orbiter valve.
 - Replace defective valve.
 - Assess potential for contamination, associated failure modes and impacts.
 - Identify and evaluate worst case scenarios due to contamination and hardware failure and associated impacts, to determine risk posture.
- **Results**
 - Suspect valve identified.
 - Contamination and hardware failure impact assessments in work.
- **Status**
 - ECD: 1/20/09

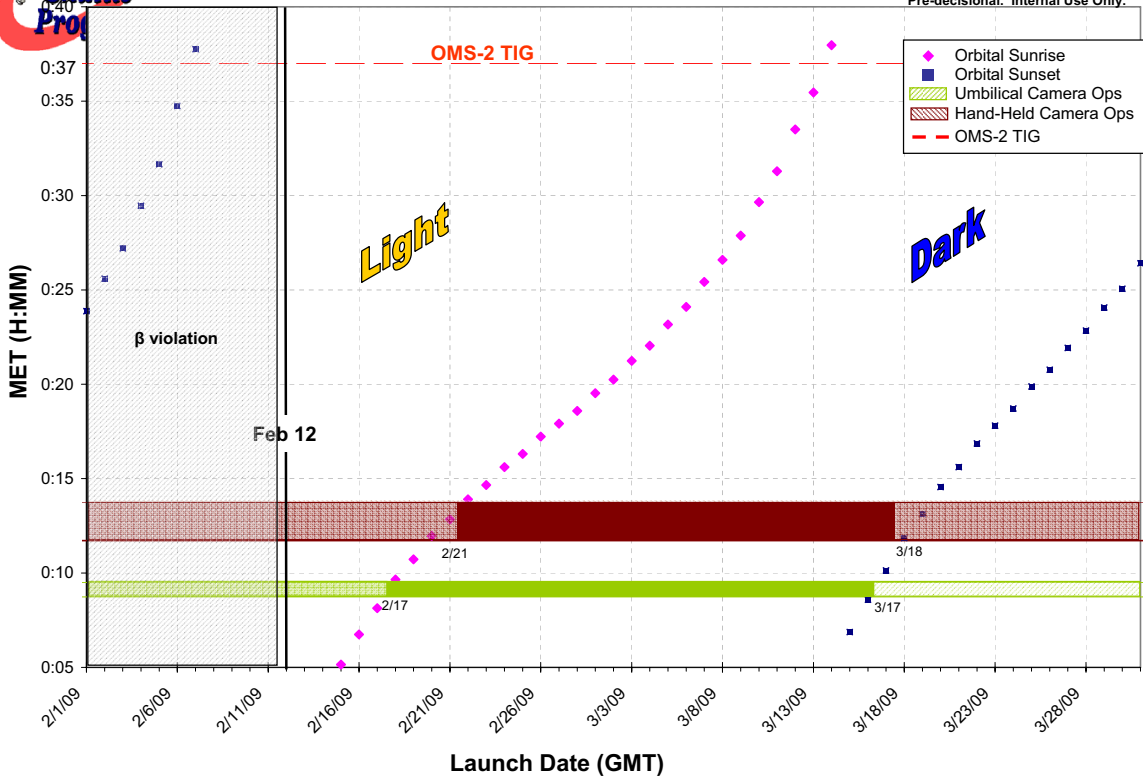




Signal Failure of Main Engine 1 G6 Flange Accelerometer

Presenter	MS2/Edward M. Burns	
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- IRN/ICD: EC-3355/ICD-13M15000 (Main Engine) ECD: 01/20/09
- Effectivity: STS-119
- Description: This IRN waives the ICD requirement to provide G6 flange accelerometer engine vibration data to the Orbiter MADS recorder. This IRN is in response to Action (3-1) on Directive S053299NZ.





Launch Date	Launch	Umbilical Ops	Hand-Held Ops	Pitch-Up
(2009 GMT)		(8:46 - 9:30 MET)	(11:43 - 13:43 MET)	Maneuver
Feb 1 - Feb 11	DAYLIGHT	DAYLIGHT	DAYLIGHT	Yes (β violation)
Feb 12	DAYLIGHT	DAYLIGHT	DAYLIGHT	Yes
Feb 13 - Feb 17	DARK	DAYLIGHT	DAYLIGHT	
Feb 18 - Feb 19	DARK	DARK	DAYLIGHT	
Feb 20 - Feb 21	DARK	DARK	Partly DAYLIGHT	No
Feb 22 - Mar 15	DARK	DARK	DARK	
Mar 16	DAYLIGHT	DARK	DARK	Yes
Mar 17	DAYLIGHT	DAYLIGHT	DARK	
Mar 18 - Mar 19	DAYLIGHT	DAYLIGHT	Partly DAYLIGHT	Yes
Mar 20 - Mar 31	DAYLIGHT	DAYLIGHT	DAYLIGHT	

Pre-decisional. Internal Use Only.



Pre-decisional. Internal Use Only.

IFA STS-126-I-001 Causal Analysis

Presenter	USA/John Magley	
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- **PASS DR 126366 (IFA STS-126-I-001) addresses an issue with improper commanding from Systems Management (SM) to the Ground Command Interface Logic (GCIL) controller**
- **All GCIL commands must be issued as two consecutive command words**
 - A reset (ALL ZERO) command that sets up the GCIL to receive a new configuration
 - A set (DATA) command that contains the new configuration command
- **During the STS-126 flight it was discovered that a change on OI-33 could cause three incorrect command words to be issued**
 - The DATA word commanding Payload Signal Processor (PSP) port moding from the Payload Interrogator (PI) to umbilical commanding
 - The DATA word commanding PSP port moding from the umbilical to PI commanding
 - The ALL ZERO word sent prior to both PSP moding commands and prior to automatic handovers between Ku-Band to S-Band communication
 - The DATA words for the Ku-Band/S-Band handovers were not affected
- **Operational workarounds were used for the affected functions during STS-126**
- **MMT Action 126-MMT-001 was assigned to Flight Software to provide a root cause analysis for this anomaly to the PRCB**





IFA Causal Analysis: Development

Presenter	USA/John Magley	
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- **A maintenance trap was set by the implementation of OI-20 SCR 89468B (1989)**
 - Did not use methods to automatically force output data alignment on even addresses, violating the intent of a programming standard in force at the time (and still in force)
 - Placed warnings in code comments indicating need for monitoring of these addresses when subsequent changes were made
 - One warning was placed at a location following the compool change history that (at the time) would always be seen by teams making a subsequent change
- **A compool change on OI-29 (2000) rendered the one obvious warning ineffective**
 - Lack of space forced the change history for that and subsequent changes to the bottom of the compool
 - The alignment warning was not moved and therefore was not as obvious as before
 - The compool is fairly large and extensively commented
 - 130 lines between code changed on OI-33 and nearest affected parameter
 - 200 lines between code changed on OI-33 and the warning after the old change history



IFA Causal Analysis: Development

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- **An OI-33 SM software change (SCR 93122 – PSP Reject Indicator Fix to DR 122444) added one halfword of data in the middle of an SM data compool**
 - SCR 93122 (2007) corrected an issue with downlist visibility of PSP command rejection indications
- **The data insertion shifted some of the following data in the compool to an offset one address higher than before the change**
- **The affected command words are required to be on even addresses because they are output data (an Input/Output Processor (IOP) addressing restriction)**
 - Referred to as “fullword alignment”
 - The shift moved them to odd addresses, so the IOP when attempting to access these addresses actually accessed the data at the next lower even address
 - I.e., if the IOP was instructed to pick up output data from address 0277, it actually output the data at address 0276
- **The affected command words ARE NOT DIRECTLY RELATED to the function changed on OI-33 and the logic that controls the issuing of these commands WAS NOT MODIFIED on OI-33**
- **OI-33 reviews, inspections, and development testing missed the induced alignment problem**





IFA Causal Analysis: Development

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- **Development Root Cause 1**
 - The OI-20 development team apparently interpreted the wording of the standard (“... output buffers must be forced to fullword alignment”) to require that the compool data layout result in fullword alignment, but not that programming techniques should be used to “lock down” that alignment
- **Corrective and Preventive Actions (Dev Cause 1)**
 - Audit the Primary Flight Software to identify all other cases where output data locations are not automatically forced to fullword alignment
 - Record all identified instances of these outputs as entries in the Action Item Data Base (AIDB) for the associated compools or modules
 - Development processes require examination of these AIDB entries during development, and again during design/code inspections, when a compool/module is modified
 - Does not rely on code comments
 - Modify the development edit panels to pop up a warning when a compool or module with one of the identified outputs is opened
 - This audit has also confirmed that no instances of improperly aligned outputs remain undetected in OI-33 flight systems
 - Modify the wording of the existing standard to clarify intent



IFA Causal Analysis: Development

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- **Development Root Cause 2**
 - Developers and inspectors have not been provided with sufficient guidance for identifying problems that can result from a data insertion or deletion in the middle of a compool
 - Avoiding data location shifts was widely followed as good practice, but was not documented as such
 - No formal training describes the potential pitfalls of downstream data location shifts
 - No inspection checklist items or related guidance clearly remind developers/inspectors of specific impacts to consider
- **Corrective and Preventive Actions (Dev Cause 2)**
 - Audit OI-34 changes (complete with no issues – STS-128 deltas in work)
 - Enhance programming standards by prohibiting data changes within a compool that result in location shifts to existing parameters
 - Exceptions would require approval from an internal review board
 - Standard will describe the additional analysis required if an exception is to be granted
- **Additional Actions**
 - Training for all developers and inspectors on the audits, tool modifications, and updated standards





IFA Causal Analysis: FSW Verification

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- **The Development Test and Level 6 (detailed) verification philosophies focus on verification of changed code or code that was directly impacted by a change (e.g., impacted by an interface change)**
 - The functions affected by the problem did not fit the criteria for detailed Level 6 testing on OI-33
- **General health testing of SM and VU functions that should not have been affected by code changes is an intended function of Vehicle Cargo Systems (VCS) Level 7 system integrity testing and to some extent VCS Level 8 reconfiguration testing**
- **There is no closed-loop modeling support for the affected functions in the Software Production Facility (SPF)**
 - This means extra steps are required for a tester to detect a problem in GCIL commanding compared to, for example, detecting a problem in the commands to GNC effectors
 - There are test scripting capabilities in the SPF that can ease the collection and analysis of these command outputs to devices lacking direct model support



IFA Causal Analysis: FSW Verification

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- **Review of the Level 6 testing for OI-33 SCR 93122 revealed one missed opportunity to detect DR 126366**
 - One test step required the generation of a PSP Port Mode Reject status
 - Given the absence of a GCIL model, the test produced the expected response (no change in selection)
 - The actual (incorrect) output to the GCIL was not examined at the time of the test
 - the PSP port mode function itself was not being verified
- **The affected functions were not exercised in the OI-33 VCS Level 7 tests or in the STS-126 VCS Level 8 tests**
 - The current VCS Level 7 process documents a requirement to update the health tests to include new or modified functions
 - This requirement has been effective over the last several OIs
 - However, review of the health tests against SM and VU requirements has determined that there are gaps in the coverage of functions that were added many years ago
 - Includes the functions impacted by DR 126366





IFA Causal Analysis: FSW Verification

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- **FSW Verification Root Cause 1**
 - Outputs from SM and VU functions to devices that are not supported by SPF models (e.g., the GCIL) were not routinely monitored to verify they are still correct after (apparently) unrelated code changes
- **Corrective and Preventive Actions (Ver Cause 1)**
 - Add test script commands to standard VCS Level 6 and 7 test setups that support easy monitoring of correct outputs
 - Based on modifications/extensions to the test scripting that was used to facilitate verification of the Remote Control Orbiter capabilities



IFA Causal Analysis: FSW Verification

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- **FSW Verification Root Cause 2**
 - VCS health testing did not include coverage of the affected functions
- **Corrective and Preventive Actions (Ver Cause 2)**
 - Review OI-33 VCS Level 7 tests, STS-126 VCS Level 8 tests, SAIL tests, and STS-126 flight experience and identify any functions that have not been demonstrated to operate on OI-33
 - Health test of Freon Loop Accumulator Quantity Monitor function completed with no issues found
 - Perform similar review for STS-125 considering unique functions that may be used in the Hubble mission vs. the flown OI-32 ISS missions
 - Any additional testing to be performed in line to STS-125 Delta SRR
 - Modify the VCS Level 7 tests to ensure coverage of functions currently in use
 - Add a process requirement that the appropriate subset of the VCS Level 7 health tests be run on any flight system with a Class 1 (non-reconfiguration) SM or VU source change
 - Testing would be required to complete in line to flight SRR





IFA Causal Analysis: FSW Verification

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- **Changes to the VCS Level 8 process or tests are not recommended at this time**
 - Current VCS Level 8 tests are focused on the reconfiguration data and the reconfigured VCS functions
 - VCS Level 8 testing relies heavily on automatic test case generation and analysis driven by the input reconfiguration data
 - The new VCS Level 7 requirement for flight systems will serve the purpose of system integrity testing for VCS Class 1 changes
- **Additional Actions**
 - Training for all VCS verification analysts on updated Level 7 tests and process change



IFA Causal Analysis: IAV Testing/ SAIL

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- **SAIL does have GCIL and PSP hardware that is used during testing**
- **IAV testing typically uses models for parts of the Ku-Band and S-Band systems**
 - There are some limitations to the models, but nothing affecting the ability to test the affected functions
- **IAV OI-33 core testing did perform a test that explicitly verified the automatic Ku-Band to S-Band handover function**
 - Function worked, but only because the handover command was the first one issued after the GCIL decoders were turned on via uplink
 - The decoder select output also has zeros in the 9 bits that the GCIL interprets as the reset (ALL ZERO) command
 - A separate ALL ZERO command is not required for the first command only
 - The SM computer sent the correct set (DATA) command for the handover
- **The IAV testing did not have a documented requirement to verify the correct operation of**
 - The automatic S-Band to Ku-Band handover
 - The automatic PSP port moding function





IFA Causal Analysis: IAV Testing/ SAIL

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- **The Ku-Band to S-Band handover verification test had setup steps that included an automatic S-Band to Ku-Band handover**
 - The handover did not occur and was manually worked around
 - Test deviation was recorded
 - This was not a step with a formal “verify” requirement
- **The Ku-Band to S-Band handover did not occur the first time it should have in the test run**
 - The test run was suspended after the failed handover and then later restarted at a point prior to the expected handover
 - The restart included the GCIL reset that permitted the handover to succeed in the restarted run
- **Steps in the run following the successful Ku-Band to S-Band handover incidentally established the conditions for another automatic handover back to Ku-Band**
 - This handover also did not occur
 - The failure was not noticed because there was again no formal “verify” requirement



IFA Causal Analysis: IAV Testing/ SAIL

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- **None of the Ku-Band/S-Band handover failures were documented in SAIL anomaly reports**
 - At least two of them were noted during the runs and should have been documented
 - Factors contributing to this oversight:
 - The misleading success of the verified Ku-Band to S-Band handover
 - A history of problems with this part of the test on previous OIs that were not due to FSW problems
 - The lack of changes on OI-33 that overtly impacted the handover logic
- **The OI-33 core testing did not exercise the automatic PSP port moding function**
 - Payload test began with the control switch in PANEL with umbilical selected
 - Forced PSP output to the umbilical
 - All STS-126 payload commands were to the umbilical configuration
 - Port moding was not required during the SAIL testing
 - STS-126 flight configuration had control switch in COMMAND and the PSP initialized with PI selected
 - Port moding was required one time in-flight





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- **IAV and SAIL Root Cause 1**
 - SAIL Standard Operating Procedure (SOP 2.23 Anomaly Processing) was not followed
 - The two noted cases of failed Ku-Band/S-Band handovers should have eventually resulted in SAIL Interim Discrepancy Reports (IDRs) that would have to be analyzed for potential FSW problems
 - The team incorrectly assumed the Ku-Band/S-Band handover problems were the same as the non-FSW problems encountered previously
 - Reinforced by the successful handover in the test
- **Corrective and Preventive Actions (IAV/SAIL Cause 1)**
 - Training for all SAIL test participants to reinforce the requirement to strictly adhere to the SAIL IDR process
 - Briefings for all test participants (SAIL personnel, IAV test sponsors and CB representatives) have been completed
 - All SAIL test personnel are required to pass an annual SAIL SOP examination to maintain certification
 - Testing has been updated to ensure questions on anomaly writing procedures are included in each exam



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- **IAV and SAIL Root Cause 2**
 - Differences between the flight configuration and event sequences and the SAIL tests masked some opportunities to detect DR 126366
 - In flight, a different switch configuration and sequence of GCIL commands revealed the PSP port moding problem
 - In flight, a Ku-Band/S-Band handover command that was not the first one to the GCIL revealed the automatic handover problem
- **Corrective and Preventive Actions (IAV/SAIL Cause 2)**
 - Review test procedures and update where possible to make them more flight-like
 - Add steps to verify automatic Ku-Band/S-Band handovers in both directions (complete)
 - Modify payload commanding switch configuration (complete)
 - Other changes as identified
 - When splitting tests on the same day, specify that no box should be reset between runs





IFA Causal Analysis: Field Use

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- **Both INCO and KSC report that the PSP port moding function was not exercised during STS-126 training simulations or STS-126 vehicle processing**
 - Would have seen that effect of the problem
 - This function is now typically only used once per flight (at most)
 - There was one missed opportunity to detect the PSP port moding problem during an SMS development run
 - The PSP port mode rejection was not noted at the time
- **The Ku-Band/S-Band handover problem was not seen during SMS simulations due to a limitation in the SMS GCIL model**
 - The SMS model does not require an ALL ZERO command before a DATA command
 - It only looks for and responds to a DATA command
 - Updates to the SMS MDM model to output the ALL ZERO command and the SMS GCIL model to check the ALL ZERO command have been informally developed and tested
 - Formal authorization to incorporate these changes is in work



Causal Analysis Summary

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- **A full root cause analysis has been performed on PASS DR 126366**
 - Causes contributing to the introduction of the DR have been identified
 - Causes contributing to the failure to detect the DR in FSW Verification and Integrated Avionics Verification have been identified
- **Effective corrective and preventive actions have been identified**
 - Actions to verify no similar problems remain undetected
 - Actions to prevent reoccurrence of this type of problem
 - The identified actions are complete or actively in work
 - All actions are being tracked to completion by the Flight Software Office (FSO)





Integrated Hazard IFSW-01

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- **Integrated Hazard IFSW-01 (Flight Software Problems Can Cause Loss of Vehicle Command and Control) classifies the possibility of a FSW problem causing a catastrophic in-flight event as “improbable”**
 - Hazard is controlled by
 - The PASS FSW development and verification processes
 - The presence of an independently developed and verified Backup Flight System (BFS)
 - Additional confidence from Independent Verification and Validation (IV&V) and shelf life accumulated during SMS training runs
- **An increased risk assessment is not indicated and updates to IFSW-01 are not recommended as a result of this investigation**
 - The mechanism for introducing the error was unique
 - Introduction in Crit 1 software was even less likely due to architectural differences between the GNC and SM FSW
 - Analysis has confirmed that no other examples exist in the FSW
 - Health test functional coverage and SPF model support for testing Crit 1 software do not have the gaps or limitations identified in VCS testing



DR 126366 Fix Plan

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- **The SASCB has approved fixing DR 126366 on all remaining OI-33 and OI-34 flights**
 - Patch implementations on STS-119 and STS-127
 - Patch will place the affected output commands in correctly aligned memory locations in patch space and modify the code to obtain the commands from the new locations
 - Patch is straightforward, only impacts the affected functions, and is fully testable
 - Source implementations on STS-128 and subsequent OI-34 flight systems
 - No change to STS-125 or STS-400 is required
 - Problem is not present on OI-32
- **STS-119 Details**
 - UPF patch available – 12/15/08
 - SAIL testing complete – 12/22/08
 - STS-119 Comp Load Mass Memory release – 02/02/09

