



**SPACE SHUTTLE PROGRAM**  
**Space Shuttle Systems Engineering and Integration Office**  
NASA Johnson Space Center, Houston, Texas



# **STS-134**

## **SSP Flight Readiness Review**

**MS/Anthony Griffith**  
**March 31, 2011**



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## Agenda

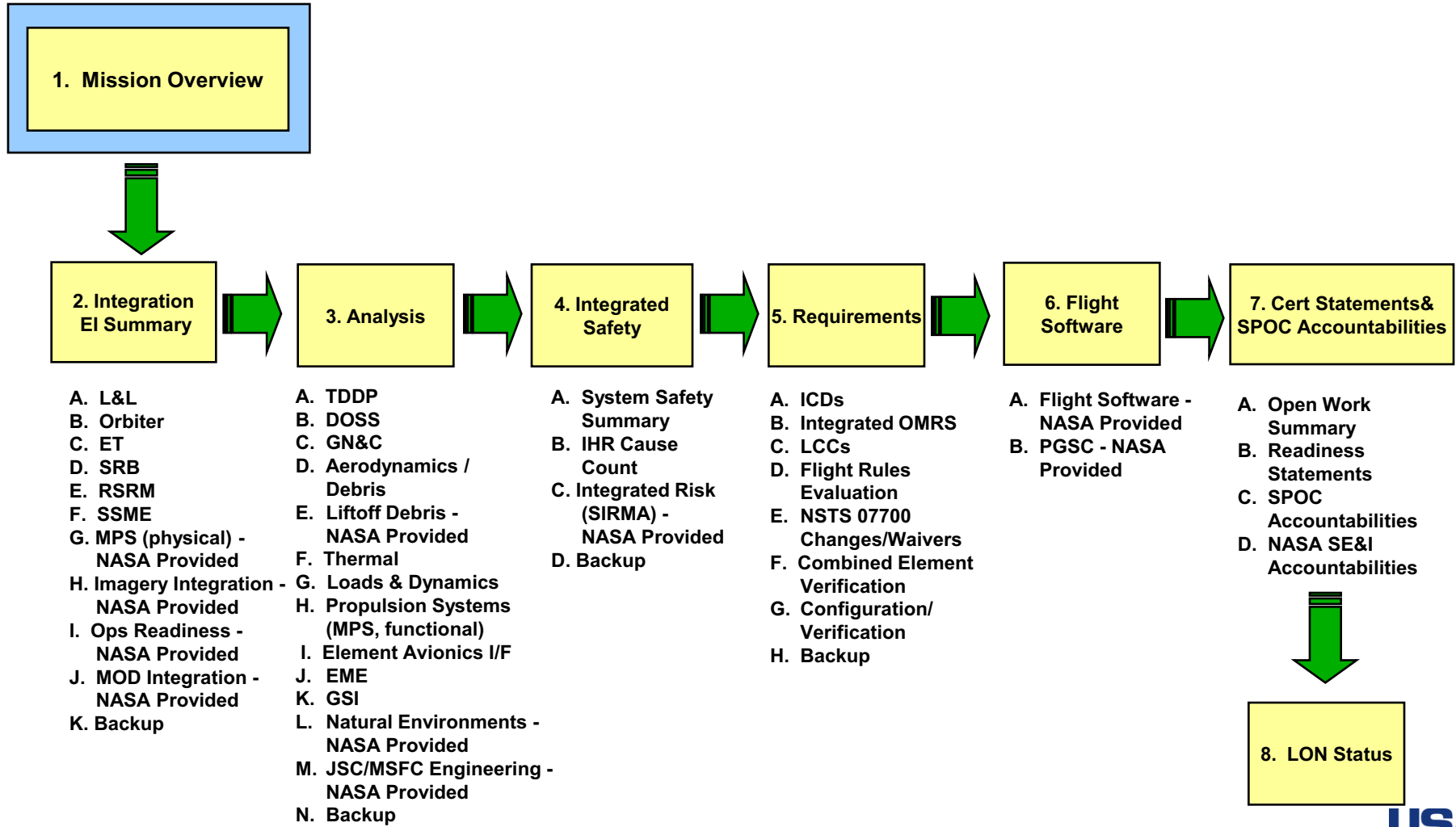
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- **Systems Engineering & Integration**
  - SE&I FRR Roadmap
  - Flight Preparation Readiness
  - Integrated Debris Risk Summary
  - Integrated Hazard Report Summary
  - Integrated In-flight Anomalies (IFAs)
  - Special Topic- PE Certification Impact to Ascent Thermal Environments
  - Imagery Status
  - Radar Status
  - Flight Software Readiness
  - Payload and General Support Computer Readiness
  - Non-Standard Open Work Summary
  - Alternate/Dissenting Opinions
  - Certificate of Flight Readiness
  - Launch On Need (LON)



# 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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<b>STS-134 SSP FRR</b>	Presenter	<b>MS/ Doug Drewry</b>	
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# STS-134 Debris Risk Summary

**Doug Drewry, MS2**  
**Systems Engineering & Integration Office**  
**Space Shuttle Program Office**





<h1>STS-134 Debris Risk Assessment Summary</h1>		Presenter	MS/ Doug Drewry
		Date	3/31/11
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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			6
	REMOTE			23
	IMPROBABLE			7
		MARGINAL	CRITICAL	CATASTROPHIC
		SEVERITY		

**6 Infrequent Causes:**

- Liftoff Debris (AD)
- ET Umbilical Ice (V)
- Orbiter Putty Repair (AK)
- T-0 Umbilical Ice (AO)
- LO2 IFR (I)
- Intertank acreage (G)



**Debris Risk Assessment, 9/2010**

**Six IDBR-01 debris risks remain Infrequent/Catastrophic**

- **Liftoff 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:** Accepted Risk; Closely monitored during pre-launch
- **Putty Repair:** Windows zero impact allowable keeps any impact in the “catastrophic” category, forward work may be used to reduce the likelihood to “Remote”.
- **T-0 Umbilical Ice:** Accepted Risk; NSTS 08303 Updated to include 0.1 lbm allowable external ice
- **LOX IFR:** Implemented NDE of all IFR ramps to screen for large voids
- **ET Intertank Foam Loss:** Changed to Infrequent Catastrophic for STS-128
  - Continued Tensile Testing of ET high risk debris areas to mitigate risk



<b>Issues &amp; Integrated In Flight Anomalies</b>	Presenter	<b>MS/ Doug Drewry</b>	
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**•STS-133-I-002 ET Intertank Stringer Cracks:**

- CLOSED for STS-134 at 3/22/11 SICB

**•STS-133-I-003 Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to PAD Clearance (Liftoff Debris):**

- Reviewed at 3/21/11 DIG
- CLOSED at 3/22/11 SICB

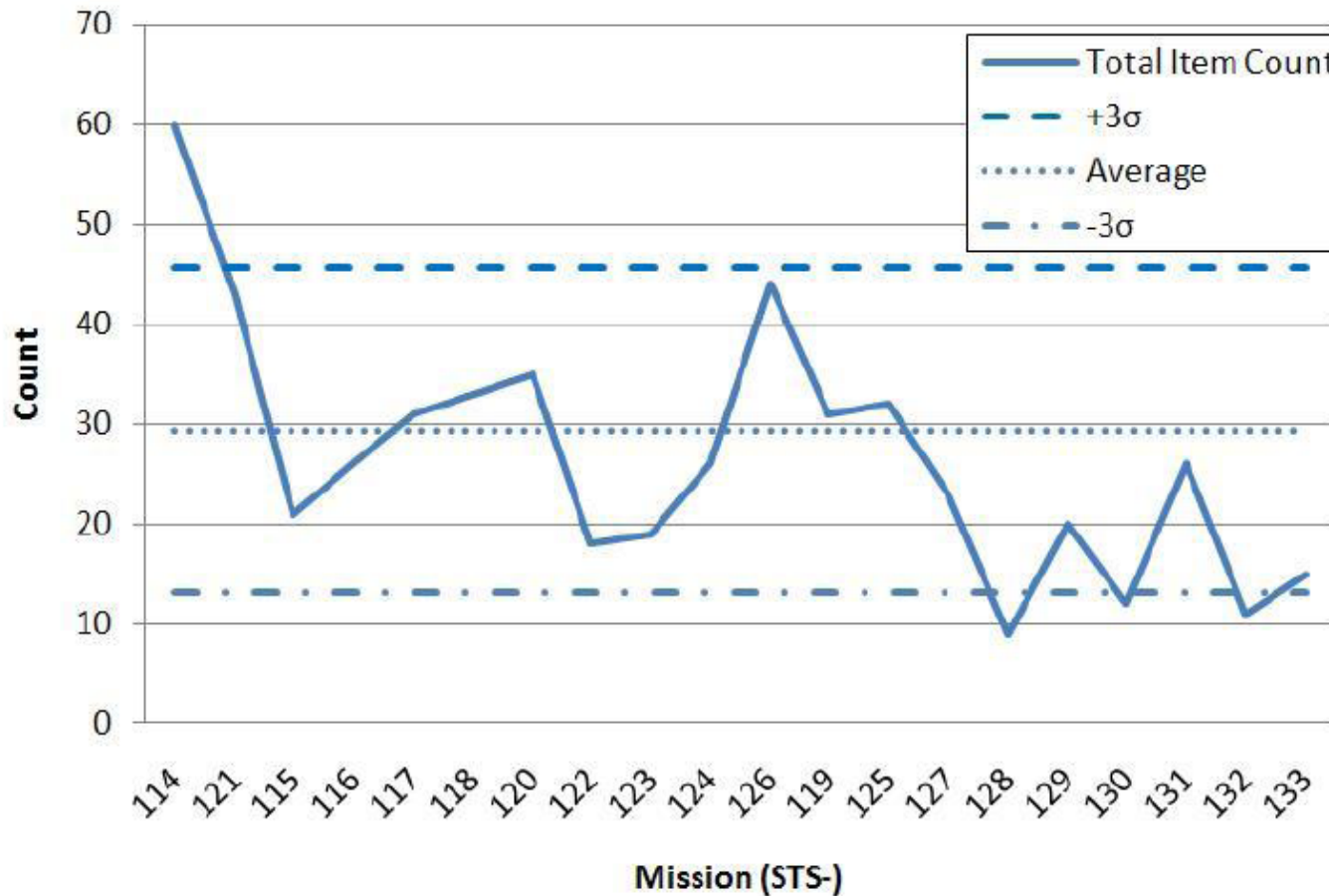
**STS-133-I-004 Debris Released From LH2 Flange Area Near the Bipod:**

- Reviewed technical data for closure at 3/23/11 DIG.
- CLOSED at 3/29/11 SICB.



<b>Liftoff Debris STS-114 thru STS-133: Debris Instance Chronology</b>		Presenter	<b>MS/ Doug Drewry</b>	
		Date	<b>3/31/11</b>	Page <b>8</b>

**Total Item Count Trend**



	Total
Baseline +3σ	45.65
Baseline μ	29.38
Baseline -3σ	13.12
STS-133	15

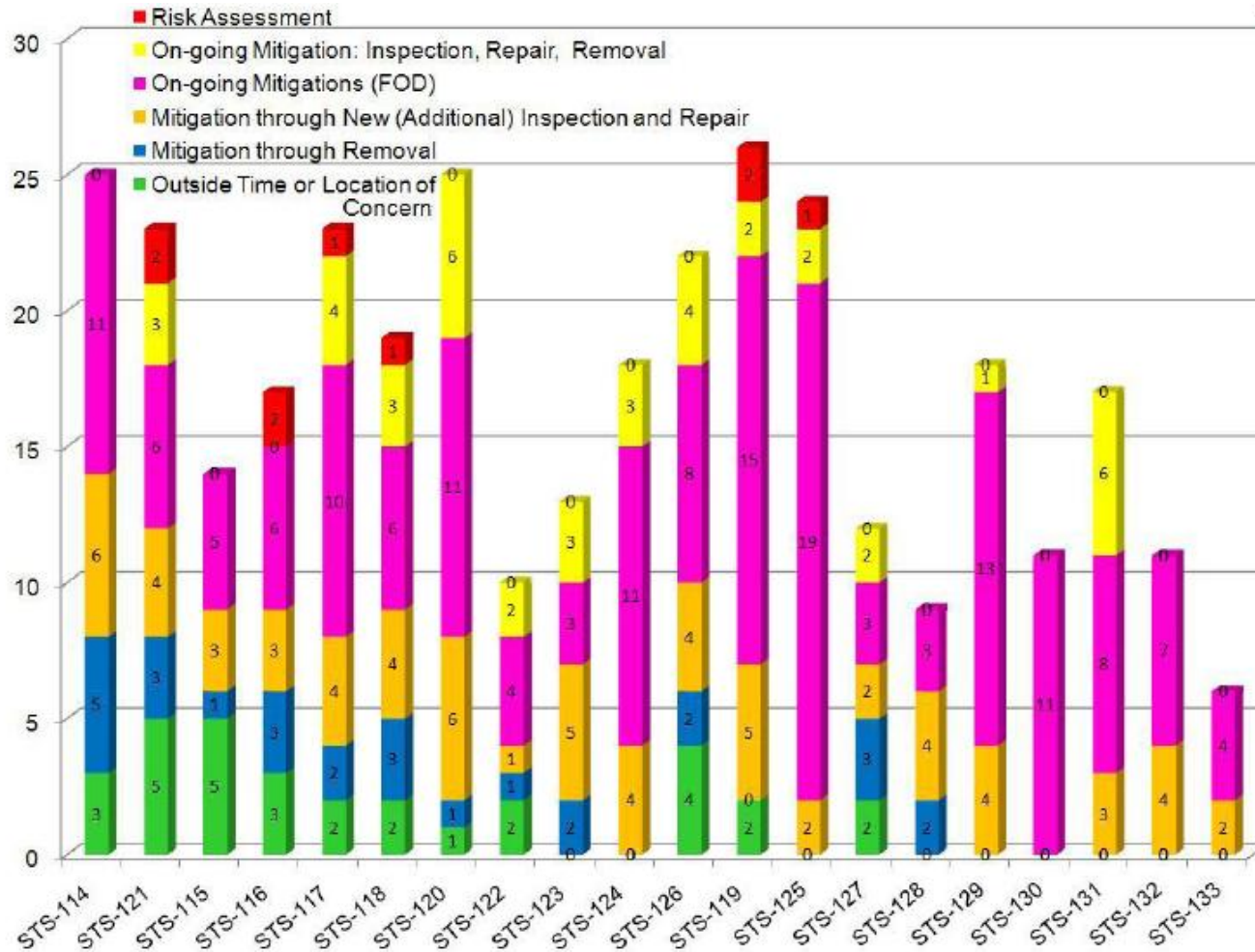
Baseline established with data from STS-114 through STS-127.

**STS-133 debris count is below the baselined average and within family of the last several flights.**





<h1>Tracking and Trending Liftoff Debris IIFA</h1>		Presenter	<b>MS/ Doug Drewry</b>	
		Date	<b>3/31/11</b>	Page

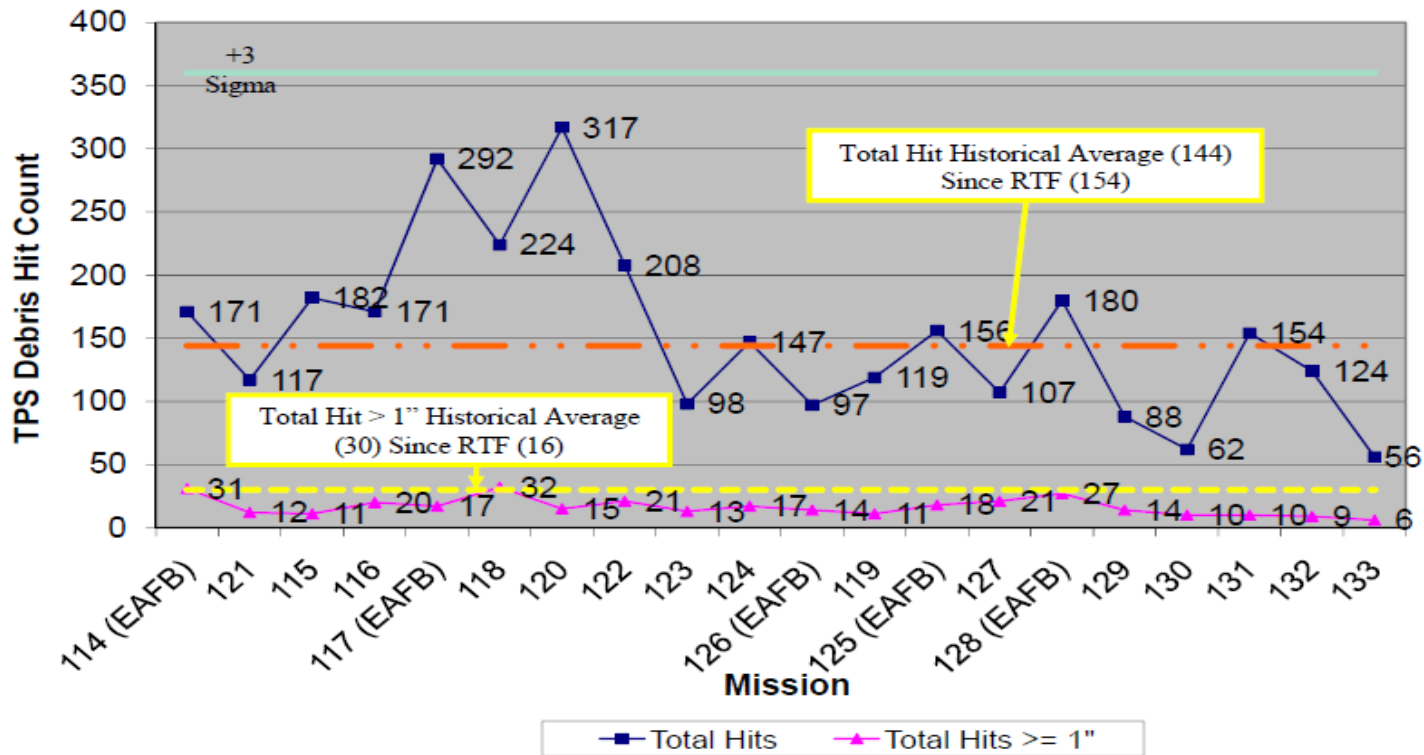


Does Not Include Rust



<b>Orbiter Debris Impact summary STS-133, OV-103</b>		Presenter	MS/ Doug Drewry
		Date	3/31/11
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- Total # of TPS Hits = 56 / TPS Hits w/damage > 1" = 6 (5 lower surface, 1 window)
- Prior to RTF Average for >1" = 30.5 per flight / Average Since RTF = 16 per flight



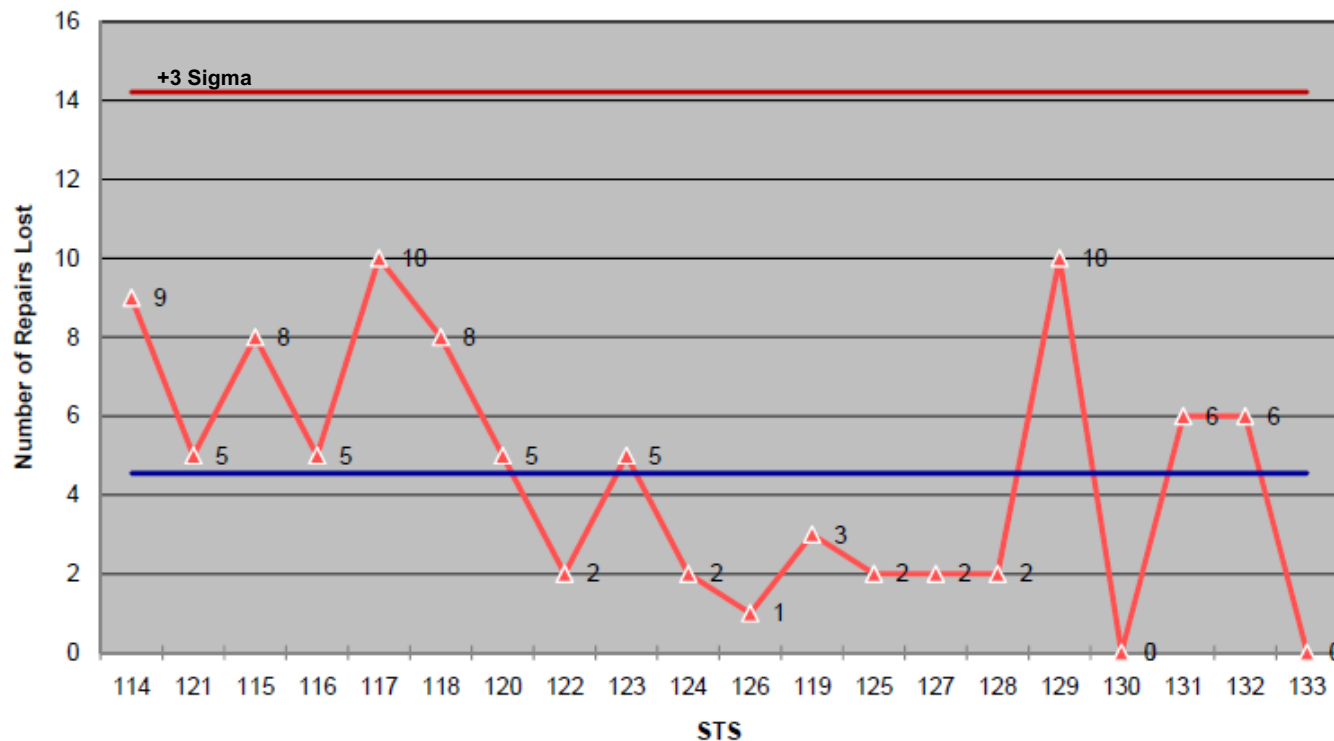
- STS-133 elliptical volume Hits>1" = 0.246 in<sup>3</sup> / RTF Average = 2.192 in<sup>3</sup>
- STS-133 Total elliptical volume ALL Hits = 0.474 in<sup>3</sup> / RTF Average = 3.187 in<sup>3</sup>



<h1>STS-133 Putty Repair Debris Summary</h1>		Presenter	MS/ Doug Drewry
		Date	3/31/11

- TPS putty repairs are listed as expected debris in NSTS 60559
- Putty Repair loss is listed in IDBR-01 as cause AK and carried as an Infrequent/Catastrophic Risk primarily because Windows have zero capability for impacts
  - Since RTF, 3 losses have had transport to windows – largest mass was 0.0009 lbs
- ZERO losses experienced during STS-133

### Missing Putty Repairs Since RTF





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<b>STS-134 SSP FRR</b>	Presenter	<b>MS/ Doug Drewry</b>	
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**STS-133-I-004**

**Debris Released from LH2 Flange Area near the Bipod**



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<b>STS-133-I-004: Debris Released from LH2 Flange Area near the Bipod</b>	<b>Presenter</b> <b>MS/ Doug Drewry</b>
	<b>Date</b> <b>3/31/11</b> <b>Page 13</b>

- **At approximately 231 seconds MET a large piece of TPS foam was released from the ET LH2 Intertank flange area between the bipod struts.**
  - Several smaller particles are also observed related to the primary release.
- **Debris impacted the Orbiter at least four times:**
  - contacts the vehicle near the ET/Orbiter attach point,
  - then contacts the starboard bipod strut and possibly re-contacts the ET,
  - then re-contacts the Orbiter fuselage aft of the bipod.
  - Debris eventually travels along the -Z side of the Orbiter fuselage & may re-contact well aft on the Orbiter belly.
- **No tile damage was noted in on-orbit imagery that could be correlated to these losses**
  - However minor damage to a shave repair on the NLGD documented during the post landing inspection could be related.
- **The foam loss occurred from the upper part of the LH2-to-Intertank Flange closeout and extended into the Intertank Acreage.**
  - Based on available imagery the divot maximum dimensions are Length = 14.9 in., Width = 10.5 in., and Depth = 2.8 inches.
  - CATIA estimated the mass of the total foam loss at 0.154 lbm.
- **Because of the late release time and relatively benign aero environment the initial pop-off velocity is the primary force acting on the Debris**



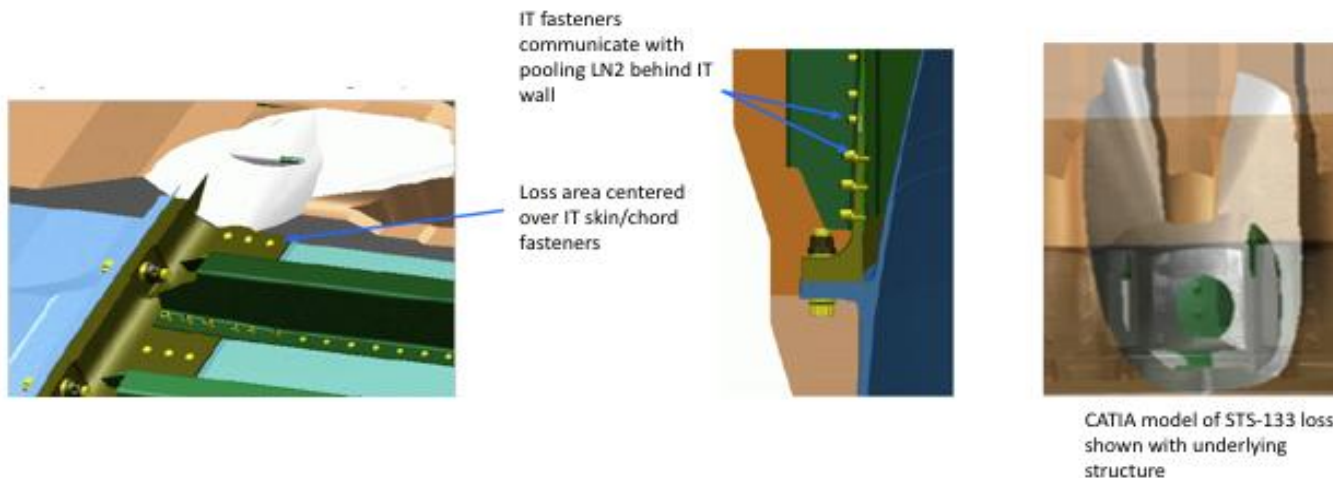
<b>STS-133-I-004: Debris Released from LH2 Flange Area near the Bipod</b>	Presenter	<b>MS/ Doug Drewry</b>	
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- **There is no indication or evidence suggesting that a stringer or possible stringer defect/crack may have been a cause.**
  - The loss site appearance and video footage is consistent with what would be expected from cryo-ingestion.
  - Return-to-Flight design and process improvements were made to mitigate the likelihood of cryo-ingestion as a result of process voids in the TPS foam closeout.
- **Most likely cause of this occurrence is cryo-ingestion into TPS cracks between the tank surface and TPS foam that may have been exacerbated as a result of multiple ET loadings.**
  - These cracks form due to differential coefficients of thermal expansion (CTE) between the TPS and metal structure during tanking.
- **The resulting cracks or “voids” can then act as reservoirs for condensed nitrogen purge gas that is ingested from the intertank through structural leak paths (such as rivets).**
  - During ascent, the reservoir begins to warm due to substrate heating from reduced liquid levels inside the tank.
- **If the original leak path is not sufficient to vent the buildup of gas, pressure builds inside the reservoir causing additional TPS crack growth and/or TPS loss.**



<b>STS-133-I-004:</b>		Presenter <b>MS/ Doug Drewry</b>	
<b>Debris Released from LH2 Flange Area near the Bipod</b>		Date <b>3/31/11</b>	Page <b>15</b>

- CATIA Model Showing STS-133 TPS Loss**

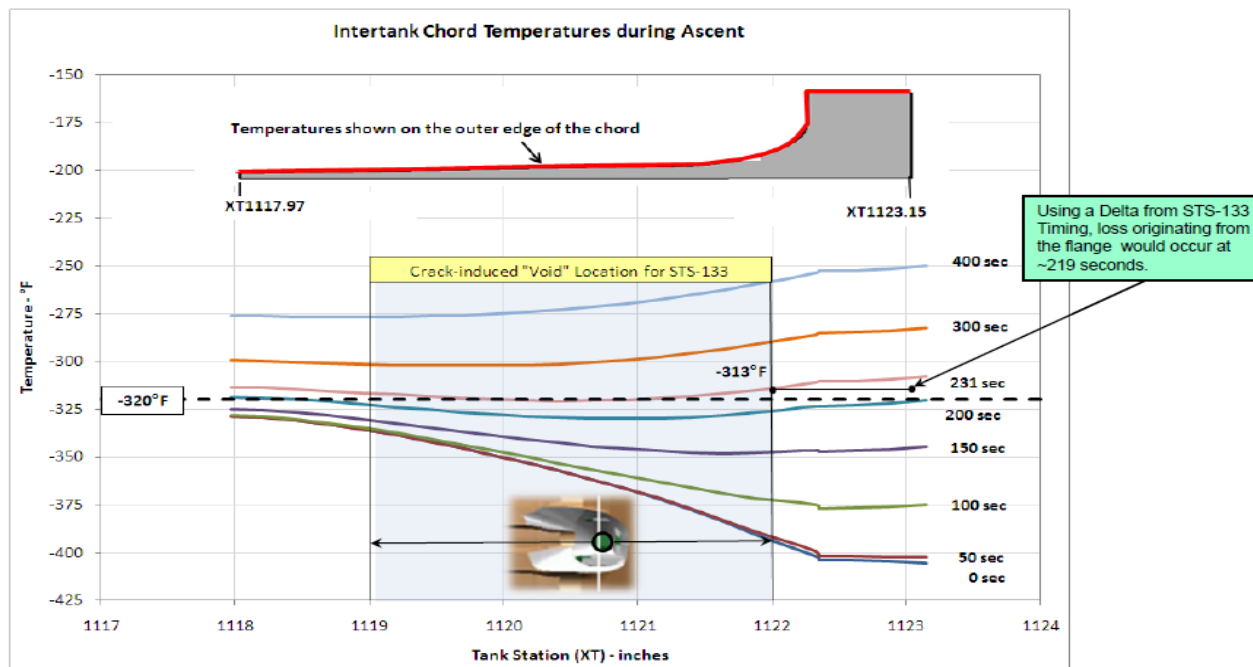


- Footprint of the base of the divot encompasses two or possibly three fasteners that pass through both the lower chord and skin.**
- These fasteners provide a leak path to the pooling LN2 that forms in the Intertank/LH2 flange area.**



<b>STS-133-I-004:</b>		Presenter	MS/ Doug Drewry
<b>Debris Released from LH2 Flange Area near the Bipod</b>		Date	3/31/11
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- As shown in the thermal assessment, the entire Intertank Chord remains below the saturation temperature of N<sub>2</sub> at 1 atm (-320°F) through 190s MET.



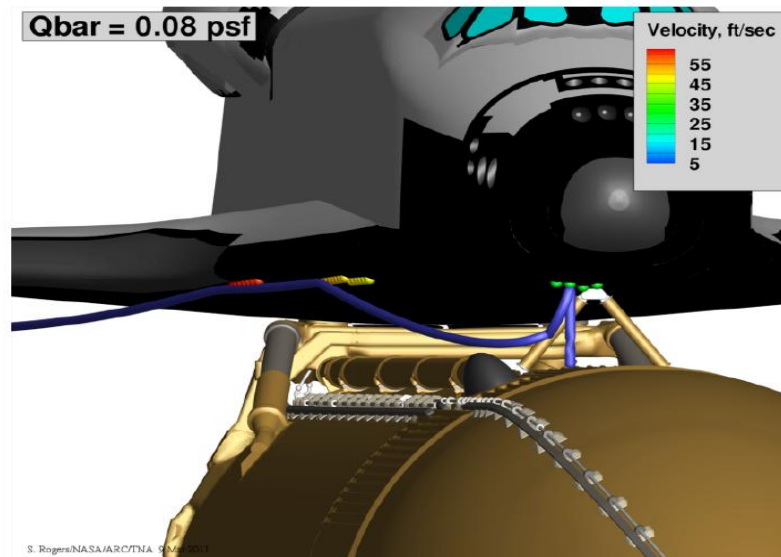
- At the time of the STS-133 foam loss, the highest predicted temperature in the void was -313°F (consistent with a nitrogen saturation pressure of 23 psia).
- Foam debris originating at the Intertank chord would be expected to occur no earlier than 190 sec. if it occurred at an internal void pressure of 1 atm





<b>STS-133-I-004:</b>		Presenter	<b>MS/ Doug Drewry</b>
<b>Debris Released from LH2 Flange Area near the Bipod</b>		Date	<b>3/31/11</b>
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- **This is a known failure mode with a well understood mechanism**
  - Proposed mitigations were not implemented in RTF flange modifications due to marginal benefits, risk of unintended consequences, and since considered a low debris risk (late time of release)
- **Aero and Transport analysis has shown there is a low probability of experiencing significant TPS damage from these late releases.**
  - STS-133 analysis indicated all impacts were below the TPS threshold and no damage was predicted.



- **Analysis is substantiated by 2006 SSP Aero Panel Study that indicated no critical damage to Orbiter Tile or RCC for debris smaller than 0.4 lbm. after 166 sec. MET.**
- **Pop-off velocities were reviewed for small to large masses and all remained below Orbiter damage thresholds.**



<b>STS-133-I-004:</b>		Presenter	<b>MS/ Doug Drewry</b>
<b>Debris Released from LH2 Flange Area near the Bipod</b>		Date	<b>3/31/11</b>
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- **Current NSTS 60559 Risk Assessment Mass for LH2-to-Intertank Flange closeout Cryo-ingestion is 0.041 lbm.**
  - Based on max expected voids within TPS only
  - Does not address structural gap/LN2 leak paths through the chord, skin and/or fasteners
- **ET Project is initiating CR (S063545AW) to add an additional failure mechanism to NSTS 60559 for the LH2 Intertank Flange Closeout which will include a risk assessment mass for Cryo-Ingestion due to structural /LN2 leak paths of 0.220lbm.**
  - Based on ET-137's loss model (~.154 lbm) with minor modifications:
    - Foam -loss forward "run-out" extended  $\frac{3}{4}$ "
    - Larger exposed substrate area (exposed base center XT 1120.095)
    - Additional 20% uncertainty factor
  - Consistent with flight history and comparable to LH2 IFR and Adjacent Acreage Crack/Cryo-Pumping 0.25 lbm assessed release mass
- **A VTL item was added to update IDBR-01 with the NSTS 60559 identifier as well as adding the 2006 SSP Aero Panel study to the acceptance rationale.**
- **Integrated IFA was closed at 3/29/2011 SICB.**



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**STS-134**  
**SSP Flight Readiness Review**  
**Integrated Hazard Report**  
**and**  
**Integrated In-flight Anomalies**  
**Summary**

**MS3/JJ Hill**  
**March 31, 2011**



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## Integrated Hazard Report Changes Since STS-133

Presenter	MS3/J. Hill	
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- IDBR-01 Ascent Debris Impact to SSV
  - Routine Update
  - Updated to include most relevant PRA set per cause
  - All IIFA closures removed from background section and replaced with a link to PRACA
  - Added ET-122 rationale to the applicable Causes
  - Updated Reference section
  - Updated Fault Tree to Revision J
  - Updated mass distribution, rate of release and time of release distributions for LH2 and LO2 IFR Ramps
  - Updated mass distribution, rate of release for LH2 and time of release distributions Adjacent Acreage
  - No change in overall risk classification: **ACCEPTED RISK**



## Integrated Hazard Report Changes Since STS-133

Presenter MS3/J. Hill

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- **IMPS-09 Hazardous Environment due to H2 External to Space Shuttle Vehicle**
  - Routine Update
  - Updated Hazardous Condition Description to correct transfers in from ISPR-02
  - Updated Cause E to transfer to Integrated Control ISPR-02 instead of ET Hazard Report S.06
  - Updated Fault Tree (Rev H) to capture Cause E transfer change
  - Updated Flight Effectivity to STS-134 through STS-999
  - No change in overall risk classification: **ACCEPTED RISK**



## Integrated Hazard Report Changes Since STS-133

Presenter	MS3/J. Hill	
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- **ISPR-02 ET Vent Arm System (ETVAS) Umbilical System Malfunction**
  - Routine Update
  - Updated Acceptance Rationale section to include risk trade associated with vent valve cycling to mitigate a H2 leak at the GUCP
  - Update ISPR-02 Cause Z to eliminate reference to ice formation and by adding additional integrated controls and verifications and new element controls for H2 leakage at the GUCP
  - Update ISPR-02 Cause AQ to more accurately address ice suppression
  - Update Background section to include GUCP Leak Investigation IFA STS-133-I-001 closure rationale
  - Update flight effectivity to STS-134 through STS-999
  - Update signature approval page
  - No change in overall risk classification: **CONTROLLED**



## Integrated In-Flight Anomalies (IIFAs) Summary

Presenter	MS3/J. Hill	
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- **STS-133-I-001, Hydrogen Leak at ET Ground Umbilical Carrier Plate (GUCP)**
  - Status – Closed
- **STS-133-I-002, ET Intertank Stringer Crack**
  - Status – Closed for STS-134 only
- **STS-133-I-003, Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Liftoff Debris)**
  - Status – Closed
- **STS-133-I-004, Debris Released From LH2 Flange Area Near the Bipod**
  - Status – Closed
- **STS-133-I-005, Debris Observed Near Right SRB Nozzle**
  - Status – Closed



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## Integrated In-flight Anomalies(IFAs)

<b><u>IFA Number: Title</u></b> <b>Description</b>	<b><i>STS-134 Status and Rationale</i></b>
<ul style="list-style-type: none"> <li>▪ <b><u>STS-133-I-001, Hydrogen Leak at ET Ground Umbilical Carrier Plate (GUCP)</u></b></li> <li>▪ During the launch attempts of STS-127/ET-137 on November 5<sup>th</sup>, 2010, hydrogen leak detectors 23 and 25 located at the ET/GUCP interface observed leakage exceeding the Launch Commit Criteria (LCC) Haz-09 limit of 40,000 ppm. Consequently, the launch was scrubbed.</li> </ul>	<ul style="list-style-type: none"> <li>• Following the scrub, a GUCP leak investigation team, developed a working theory that leakage occurred between the flight and ground sides of the quick disconnect (QD) assembly as a result of misalignment of the QD causing side loading of the flight seal.</li> <li>• After STS-127, hardware modifications (larger guide pins) and procedural changes (use of concentricity measurement tool) were made to minimize initial misalignment and reduced potential for movement during assembly.</li> <li>• For STS-134, the ground probe will be “clocked” to offset the concentricity measurement of the GUCP.</li> <li>• The LCC (HAZ-09) use leak detectors (LD 23 and 25) to monitor the interface.</li> <li>• In addition, ISPR-02 specifies controls for umbilical fluid system failures prior to T-0 sep due to leakage above the lower flammability limit.</li> <li>• <b>Status – Closed</b></li> </ul>





# Integrated In-Flight Anomalies (IIFAs)

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<p><b><u>IFA Number: Title</u></b> <b>Description</b></p>	<p><b>STS-134 Status and Rationale</b></p>
<ul style="list-style-type: none"> <li>▪ <b><u>STS-133-I-002: ET Intertank Stringer Crack</u></b></li> <li>▪ TPS crack observed on the LO2 Intertank (IT) flange closeout at Xt-852 on Panel 2.</li> <li>▪ Subsequent NDE following the 12/17/10 tanking test revealed additional cracks on Panel 6.</li> </ul>	<ul style="list-style-type: none"> <li>• ET-137 cracked stringers were repaired.</li> <li>• Radius block modification were implemented on all accessible stringers.</li> <li>• ET-137/STS-133 was loaded and launched successfully on 2/24/11.</li> <li>• Suspect material lots identified during the STS-133 investigation were not used on ET-122 (STS-134).</li> <li>• Radius block mods were performed on the LO2 flange end of ET-122 (STS-134).               <ul style="list-style-type: none"> <li>• No impact of radius block mods on integrated loads.</li> </ul> </li> <li>• No indication that the loss at the LH2 flange is due to a stringer crack (STS-133-I-004); it has the characteristics of a cryoingestion loss.</li> <li>• No significant increase in the risk of TPS release due to re-spray in areas of stringer mods.</li> <li>• <b>Status – Closed for STS-134 only</b></li> </ul>



## Integrated In-Flight Anomalies (IIFAs)

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<p align="center"><u>IFA Number: Title</u></p> <p align="center">Description</p>	<p align="center"><b>STS-134 Status and Rationale</b></p>
<p>▪ <b><u>STS-133-I-003: Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Liftoff Debris)</u></b></p> <p>▪ Multiple pieces of debris were found on pad post-launch that include liberated pad hardware, and foreign object debris.</p>	<ul style="list-style-type: none"> <li>• Risk Assessment indicates that given the proposed mitigations, observed debris poses no appreciable increase in risk.</li> <li>• Liftoff debris risk is currently characterized as infrequent, catastrophic due to significant uncertainties in controls and significant limitations in analysis.</li> <li>• Debris release has been mitigated for identified potential sources of critical debris by performing repairs and adding inspections for system-level components. Ongoing mitigations include FOD awareness, attrition-based hardware removal, routine inspections and monitoring for facility corrosion.</li> <li>• Facility debris larger than allowable fell from drain holes of both TSMs on MLP-3 during STS-133 liftoff.</li> <li>• KSC will implement mitigation to prevent MLP-3 TSM drain holes from liberating mass exceeding the NSTS-60559 allowable.</li> <li>• <b>Status – Closed</b></li> </ul>



# Integrated In-Flight Anomalies (IIFAs)

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<p align="center"><u>IFA Number: Title</u></p> <p align="center">Description</p>	<p align="center"><b>STS-134 Status and Rationale</b></p>
<p>▪ <b><u>STS-133-I-004: Debris Released From LH2 Flange Area Near the Bipod</u></b></p> <p>▪ At approximately 231 seconds MET, a large piece of TPS foam was released from the ET LH2 Intertank flange area between the bipod struts.</p> <p>▪ Debris impacted the Orbiter at least four times, however, no tile damage was noted in on-orbit imagery that could be correlated to these losses.</p>	<ul style="list-style-type: none"> <li>• The foam loss occurred from the upper part of the LH2-to-Intertank Flange closeout and extended into the Intertank Acreage.             <ul style="list-style-type: none"> <li>• Because of the late release time and relatively benign aero environment, the initial pop-off velocity is the primary force acting on the Debris.</li> </ul> </li> <li>• There is no indication or evidence suggesting that a stringer or possible stringer defect/crack may have been a cause.</li> <li>• The loss site appearance and video footage is consistent with what would be expected from cryoingestion.</li> <li>• This is a known failure mode with a well understood mechanism.</li> <li>• ET Project has initiated a CR to update NSTS 60559 with a new debris risk mass for cryoingestion after 190 seconds.</li> <li>• <b>Status – Closed</b></li> </ul>



## Integrated In-Flight Anomalies (IIFAs)

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<p align="center"><u>IFA Number: Title</u></p> <p align="center">Description</p>	<p align="center"><b>STS-134 Status and Rationale</b></p>
<p>▪ <b><u>STS-133-I-005: Debris Observed Near Right SRB Nozzle</u></b></p> <p>▪ At approximately 11 seconds MET, a single piece of light-colored, linearshaped, flexible debris was first observed near the RH SRB thermal curtain (IIFA STS-133-I-005, NIRD 133-010)</p> <p>▪ No external debris sources are observed to travel toward the RH SRB thermal curtain area during liftoff/ascent.</p>	<ul style="list-style-type: none"> <li>• Elements were polled for possible debris sources.</li> <li>• There is no specific “most-probable” source due to exhaustive evaluation and unusual appearance of debris</li> <li>• Proximity/timeframe indicate SRB or L&amp;L as source, but no specific candidate for actual material exists.</li> <li>• Debris Integration Group has indicated that this occurrence posed no threat to the vehicle.</li> <li>• IIFA closed as a unexplained anomaly.</li> <li>• <b>Status – Closed</b></li> </ul>



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## Space Shuttle Systems Engineering and Integration Office

NASA Johnson Space Center, Houston, Texas



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## Integrated Hazard Risk Matrix

Likelihood	Probable			
	Infrequent	2	12	
	Remote	2	132	
	Improbable	11	267	
		Marginal	Critical	Catastrophic
		<b>Severity</b>		

**Risk Summary**  
 22 of 38 IHR's are classified as Controlled Risk  
 16 of 38 IHR's are classified as Accepted Risk  
 \* Previous Flight

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Hazard Report #	Integrated Hazard Titles	Controlled					Accepted Risk						probable-catastrophic			
		Controlled Risk	remote-marginal	improbable-marginal	improbable-critical	improbable-catastrophic	Accepted Risk	probable-marginal	infrequent-marginal	remote-critical	remote-catastrophic	probable-critical		infrequent-critical	infrequent-catastrophic	
																
	<b>"Accepted Risk" Hazard Reports</b>															
IDBR-01	Ascent Debris Impact to SSV	7				7	29					23			6	
ICOM-01	Adverse Effects due to Intentional RF Environment	2				2	1					1				
IEME-01	Adverse Electromagnetic Effects (EME)	0					18					18				
IGNC-01	Ascent Trajectory Event Anomaly	13				13	1								1	
IMEO-01	Hazardous Environment in the Aft Compartment	0					4					1			3	
IMPS-01	Contamination in the Integrated MPS H2 System	0					1					1				
IMPS-02	Contamination in the Integrated MPS O2 System	0					1					1				
IMPS-03	Improper IMPS configuration during SSME Operation	10				10	4					4				
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					
MLD-01	Exposure to Induced Environments Exceed Structural Capability of SSV	22				22	26					26				
ILIT-01	Adverse Effects of Lightning	0					6					6				
	<b>Accepted Risk Distribution Totals</b>						(see next page)	148	0	2	2	132	0	0	12	0





## Integrated Hazard Risk Matrix Count Changes

Presenter	MS3/J. Hill	
Date	03/31/11	Page 31

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



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# **STS-134**

## **SSP Flight Readiness Review**

### **PE Certification Impact to**

### **Ascent Thermal Environments**

**March 31, 2011**



Pre-decisional. Internal Use Only.







## **STS-133 Orbiter Peak Heat Rate Exceedances**

Presenter	<b>USA/Joe Craft</b>	
Date	<b>03/31/11</b>	Page 33

- **Found during the Post Flight reconstruction were Ten Orbiter Wing Leading Edge (WLE) peak heat rate exceedances occurred late in the trajectory during the rarified, non-continuum flow regime**
  - Peak heat rates occurred from MET 495 sec to 505 sec
  - Orbiter Project reviewed and cleared exceedances using the certification entry heating environments which drive the Orbiter WLE design
- **Software program (XF0002) calculates non-continuum heating by multiplying a rarefaction factor to the continuum heating calculation**
- **STS-133 was launched out of plane, requiring additional steering during the second stage that resulted in the vehicle flying at a Beta of approximately  $-4^\circ$  for an extended period of time**
  - In plane launches typically fly at a beta of approximately  $0^\circ$  during this phase
  - The non-zero beta increased the Effective Flow Angle (EFA) for the body points with exceedances and caused their non-continuum heating to be higher
  - Per design, PE Certification trajectories have beta's of  $\pm 10^\circ$  during this phase that should envelope STS-133 trajectory



## PE Certification Heating Environments

Presenter	USA/Joe Craft	
Date	03/31/11	Page 34

- **The alpha/beta combination that is selected from the matrix search does not maximize the rarefaction factor for non-continuum, rarefied flow**
  - Coding errors in these subroutines of XF0002 software lead to the selection of an alpha/beta combination that does not maximize the PE Certification heating when flying in non-continuum, rarefied flow
    - Effectively eliminates alpha/beta envelopes by setting EFA to 0°
  - The main heating routine of XF0002 does not contain these errors – it only affects the selection of alpha/beta angles from dispersed trajectories in the non-continuum regime
- **These software routines are not used for Day-of-Launch work or in the reconstruction assessments**



# Thermal Issue Resolution Options

Presenter	<b>USA/Joe Craft</b>
Date	<b>03/31/11</b>
	Page 35

OPTION	PROS	CONS
<b>1) Do Nothing</b>	<ul style="list-style-type: none"> <li>No Products, Tools, or Analysis Changes</li> <li>Supports In-Plane Launch</li> </ul>	<ul style="list-style-type: none"> <li>DOL Constraint: In-Plane Launch only</li> <li>Early/Late Launch Potential for ET/Orbiter Heating &gt; PE Cert During Ascent</li> </ul>
<b>2) Mission Specific Certification</b>	<ul style="list-style-type: none"> <li>Standard Flight Margin Assessment (FMA) Product Development and Verification</li> <li>Supports Launch Window of <math>\pm 5</math> Min</li> <li>No Products to Hardware Elements</li> <li>All Body Points <math>\leq</math> PE Cert Values</li> </ul>	<ul style="list-style-type: none"> <li>Critical Math Model (CMM) Tool Revisions to Eliminate Code Errors</li> <li>NSTS 07700, Vol. X Waiver, Heating Design Criteria</li> <li>Develop and Implement New DOL Thermal (S9) Rule</li> <li>DOSP Waiver to Lockdown requirement for new Thermal (S9) rule</li> <li>CoFR Exception for PI (if not completed in time)</li> </ul>
<b>3) Performance Enhancement (PE) Certification Update</b>	<ul style="list-style-type: none"> <li>Supports Launch Window of <math>\pm 5</math> Min</li> <li>No Impact to DOSP or DOLILU Ops</li> <li>Standard but Expedited Product Development</li> </ul>	<ul style="list-style-type: none"> <li>CMM Tool Revisions to Eliminate Code Errors</li> <li>New Products to Orbiter, ET Elements for Body Points &gt; Existing PE Cert</li> <li>CoFR Exception for PI, Orbiter, and ET (if not completed in time)</li> </ul>



## Preliminary Thermal Environment Results Summary

Presenter	USA/Joe Craft	
Date	03/31/11	Page 36

- **PE Certification was selected by the Program as the best approach**
  - Limited the PE Certification run matrix based on current manifest (in back up)
- **Impacts to Elements:**
  - **ET**
    - 23 heat load exceedances on mainly nose cone area
    - Thermal Panel discussions suggest new environment within element capability
    - ET analysis is in work
  - **Orbiter**
    - Wing Leading Edge (WLE) has ~25 heat rate and ~91 heat load exceedances
    - WLE exceedances are in family with STS-133 mission assessment and expected to be cleared by comparison with hardware temperature limit
    - RTLS case caused small exceedances to five OMS Pod loads Body Points (BP) (max increase 2.41%) and fourteen Vertical Tail loads BP (max increase 3.33%)
    - Orbiter analysis is in work

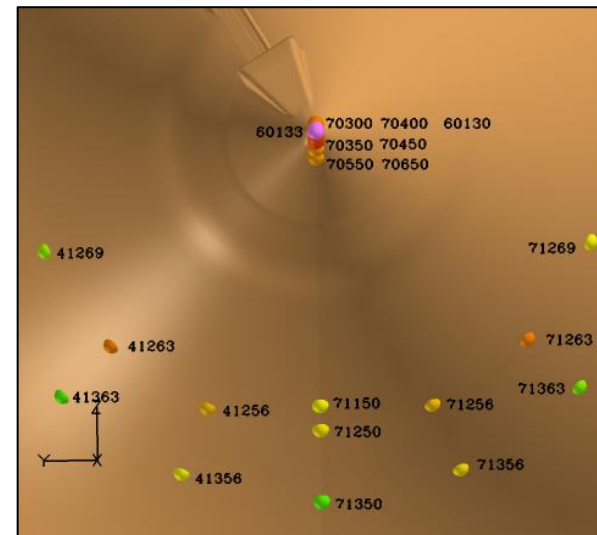
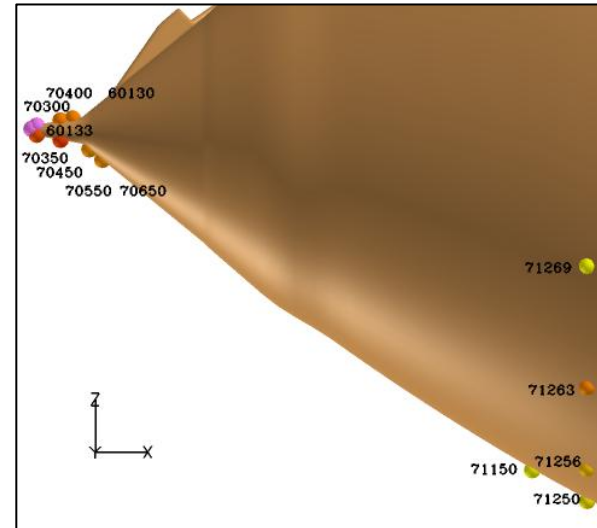


# ET Total Heat Load BP Exceedances

Presenter **USA/Joe Craft**

Date **03/31/11**

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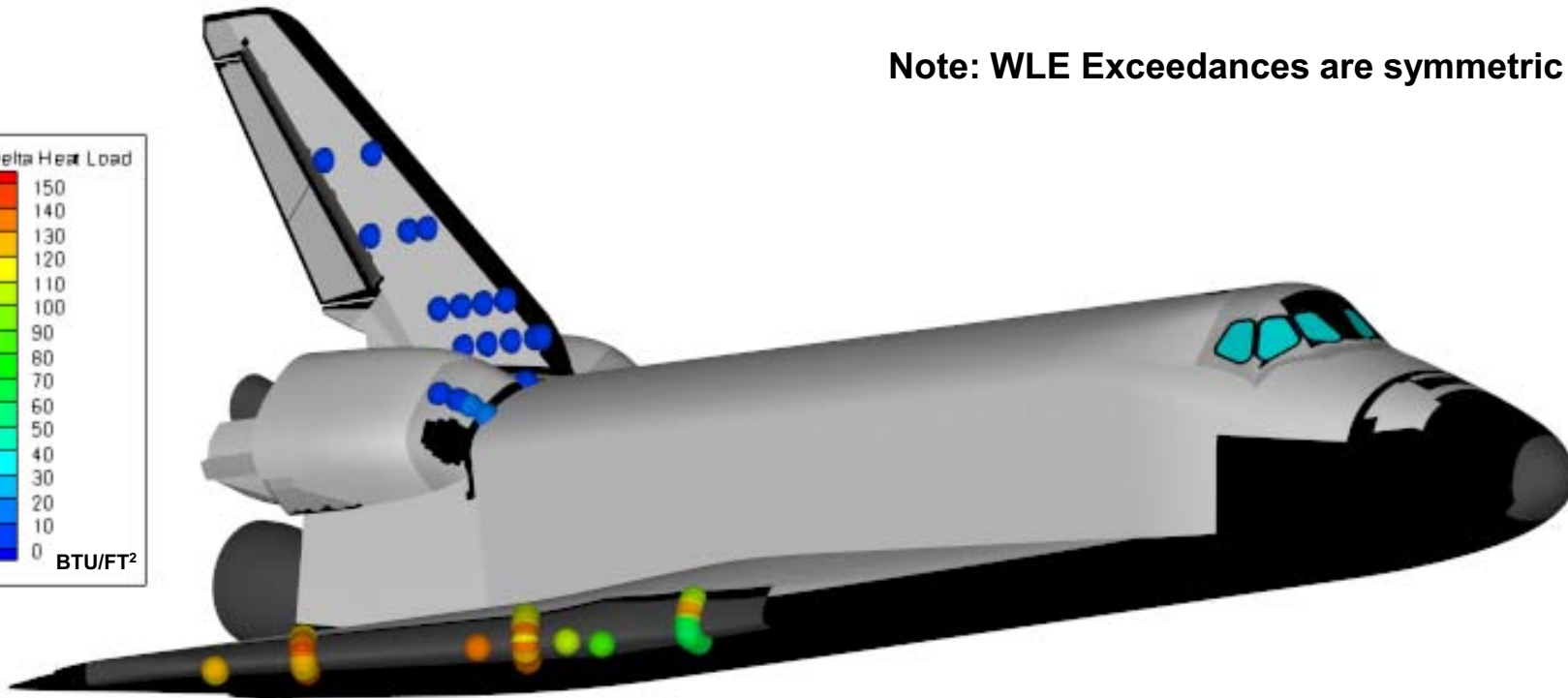
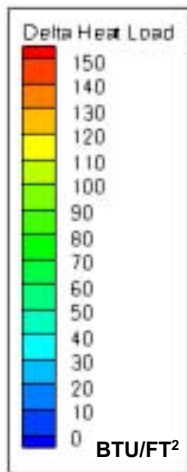




# Orbiter Total Heat Load BP Exceedances

Presenter	USA/Joe Craft	
Date	03/31/11	Page 38

Note: WLE Exceedances are symmetric





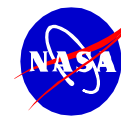
## Summary and Forward Work

Presenter	USA/Joe Craft	
Date	03/31/11	Page 39

- **STS-133 reconstruction found the Orbiter Wing Leading Edge exceedances caused by an error in the creation of PE Certification Heating**
  - Coding errors caused the calculation of PE Certification heating to use an incorrect alpha/beta combination that does not maximize heating in non-continuum, rarefied flow
- The PE Certification approach was selected using trajectories that are representative of configurations to be flown on the next two missions
- Formal delivery of new environments to ET and Orbiter was on 3/25/11 (PRCBD S052158FB)
- Elements reported results to the SICB OSB on 3/30/11
  - All new PE Certification Environments were cleared by the Orbiter and ET Elements
- CR to update thermal CMMs ECD: post STS-134



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# STS-134

## SSP Flight Readiness Review

March 31, 2011



**MS3/Brenda Eliason**



Pre-decisional. Internal Use Only.







**Imagery Hardware**  
**ELVIS**

Presenter	<b>MS3/B ELIASON</b>	
Date	<b>3/31/11</b>	Page 41

**ET LO2 Feedline Camera (ET-122)**

- Camera system installed and on schedule with nominal checkouts
- **Ready to support. No open issues.**

**Ground Network & TV**

- Nominal ground network and TV truck status
- **Ready to support. No open issues.**

**SRB Cameras (BI-145)**

- STS-133 RH SRB DAS did not record video of thrust panel (IFA STS-133-B-001)
  - Problem attributed to connector contact contamination/excessive potting
  - For STS-134, new DAS controllers/connectors will be built up for both boosters to prevent recurrence
- **Ready to support. No open issues.**

**Crew Handheld Digital Still and HD Video Cameras**

- STS-133 crew did not take post-separation HH imagery of ET
- Expect dark conditions 19 – 20 April
- **Ready to support. No open issues.**

**Digital ET Thermal Protection System (DETTPS)**

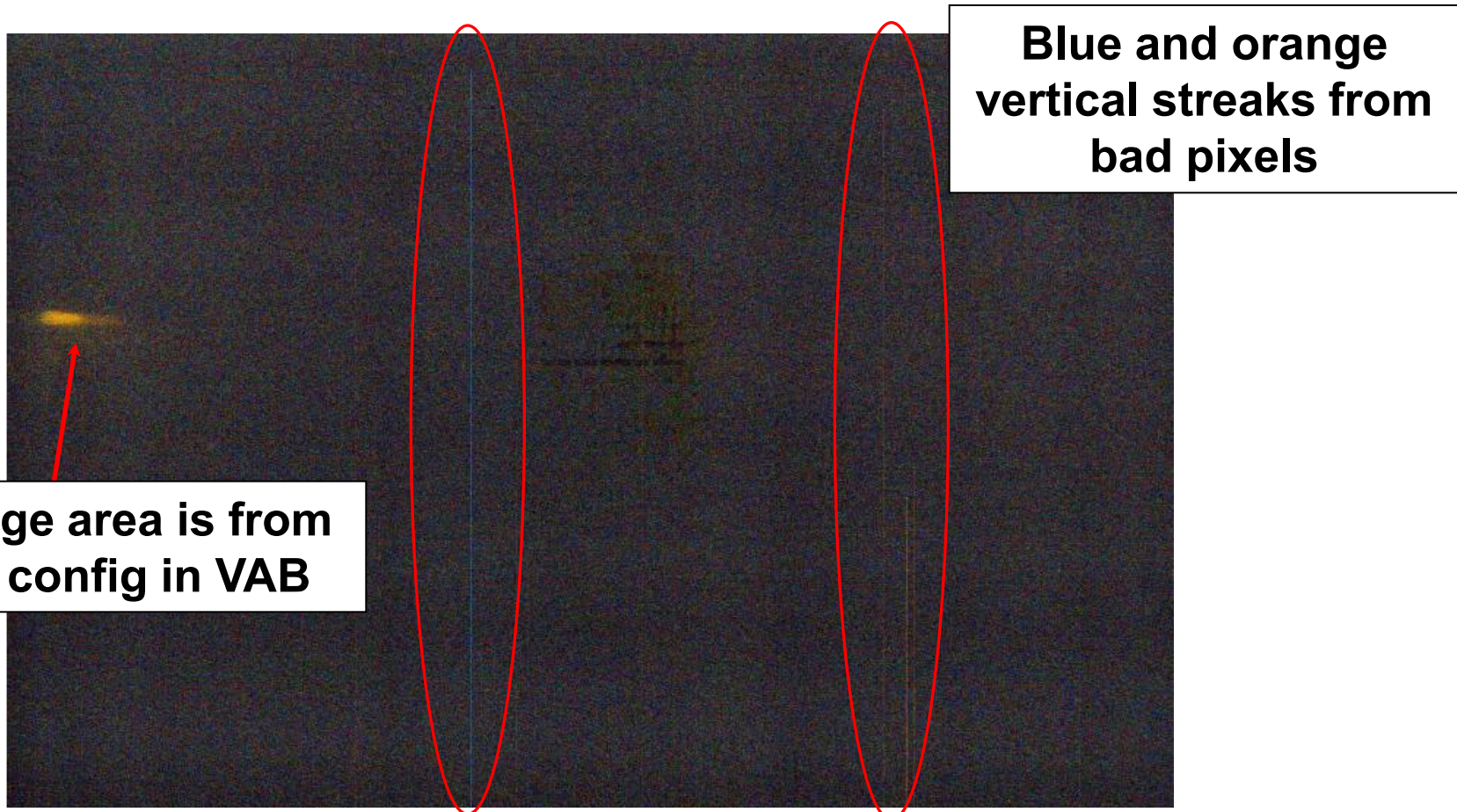
- Camera configured for **Daylight** settings through 29 May
- Images expected to show several faint vertical streaks (bad pixels)
  - Similar to last flight of this unit (STS-130) – see next chart
- **Ready to support. No open issues.**

<p><b>DETTPS Camera Settings</b></p> <ul style="list-style-type: none"> <li>• <b>Daylight:</b> <ul style="list-style-type: none"> <li>• f/8, ISO 100, 1/250</li> <li>• Bracketing: 0EV=f/8, +1EV= f/5.6</li> </ul> </li> <li>• <b>Night</b> <ul style="list-style-type: none"> <li>• f/2.8, ISO 200, 1/250</li> <li>• Bracketing 0EV=f/2.8, +1EV= f/2.0</li> </ul> </li> </ul>
--



**STS-134 DET TPS**  
**Enhanced VAB Test Image**

Presenter	MS3/B ELIASON	
Date	3/31/11	Page 42



**Orange area is from  
test config in VAB**

**Blue and orange  
vertical streaks from  
bad pixels**

Pixel defects are most apparent when extreme contrast enhancement is applied to image. They are not a concern or hindrance for ET TPS assessments.



## Imagery Hardware *non-ELVIS*

Presenter **MS3/B ELIASON**

Date **3/31/11**

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### Airborne Cameras

- HYTHIRM/Cast Glance is working entry support planning
- **No open issues.**

### Orbiter MiniCam

- STS-133:
  - Imagery observed LO2 IFR 676 TPS liberation (ref NIRD 133-013, ~112sec MET)
  - Exposure settings will be same as STS-133, intended for remaining flights, day or night
- **Ready to support. No open issues.**





## Imagery Hardware *Ground*

Presenter **MS3/B ELIASON**

Date **3/31/11**

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### Ground Cameras

- Patrick Distant Object Attitude Measurement System (DOAMS) camera focus quality issue
  - Mitigation is to add tracker at Cocoa Beach DOAMS, as was done for STS-133
  - This plan is expected for STS-135 as well
- Experimental cameras at FSS 275-ft level and around the pad (e.g., CS2, CS3) to investigate new techniques
  - Not for operational use or analysis
- **Ready to support. No open issues.**

### Photo Targets

- STS-133 FSS and MLP-3 targets performed as expected
  - Differences in placement (expected vs. actual) require survey of re-installed targets
- Most survived the STS-133 launch intact
- Thermal degradation on some targets (as expected)
- All FSS and MLP-2 targets are installed for STS-134
  - Survey complete 3/23/11; report expected week of 3/28/11



## Lighting Predictions, April 19 – May 30

Presenter **MS3/B ELIASON**

Date **3/31/11**

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### Launch\*

- Apr 19: **DAYLIGHT, Non-Optimal**
- Apr 20 – May 22: **Daylight**
- May 23 – May 30: **DARK**

### Post ET-Sep Mnvr\*

- Apr 19 – Apr 20: **Nominal +X\*\*, No Pitch**
- Apr 21 – May 30: **Nominal +X, Nominal Pitch**

### ET Sep Imagery \*

- Apr 19: **DAYLIGHT, Non-Optimal**
- Apr 20 – May 28: **DAYLIGHT**
- May 29: **DAYLIGHT, Non-Optimal**
- May 30: **DARK**

\*\* For launch on Apr 19, 20: MOD may execute modified +X (20 sec) vs. the nominal (11 sec) burn

### Handheld ET (post-pitcharound) Imagery\*

- Apr 19 – Apr 20: **DARK**
- Apr 21: **DAYLIGHT, Non-Optimal**
- Apr 22 – May 30: **DAYLIGHT**

\* Based on December reference trajectory; minor adjustments possible

### 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



**CoFR Products & Readiness**

Presenter **MS3/B ELIASON**

Date **3/31/11**

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- All 20 STS-133 NIRD Reportables have been Closed with supporting rationale
- STS-134 Imagery Readiness Review was held with the IATs and hardware teams on 3/21/11

Area of Responsibility	Statement	Status
Operations Integration Plan	NSTS 60540, Operations Integration Plan, Rev B approved at 06/27/06 SICB. End-to-end readiness level of hardware, procedures, tools, and facilities have been assessed to ensure Open Work and issues will be resolved prior to flight.	Ready
Engineering Image Analysis Products, Training, and Staffing	Imagery engineering analysis, and “I-Squared” SE&I personnel and tools are ready to support STS-134.	Ready
Imagery Laboratory Readiness	Imagery labs at JSC, KSC, and MSFC have the required capabilities and configurations to support anticipated and unexpected analysis.	Ready
Camera Hardware Readiness	All ground and vehicle requirements for imagery and other data collection assets have been implemented for flight and associated operational readiness has been demonstrated.	Ready



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# **STS-134**

## **SSP Flight Readiness Review**

### **Radar Status**

**MS/Joe Hamilton**



Pre-decisional. Internal Use Only.



## **Debris Radar Configuration for STS-134:**

Presenter **MS/J.A. Hamilton**

Date **3/25/11**

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### • **STS-134 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
- Operational SRB tracking, following ASTT, by both X-bd radars
- NDR Readiness scheduled 3/30/11.







**NDR Issues During STS-133:**

Presenter MS/J.A. Hamilton	
Date 3/25/11	Page 49

**NDR-C1 Radar:**

Problem: Pre-mission calibration indicated an error applying Phase Compensation Tables (PCTs) at some power settings. PCT's were not used for this mission resulting in slight degradation in data quality.

Resolution: Could not duplicate, cause unknown. PCT's worked properly at all power settings for 3/11/11 Delta launch.

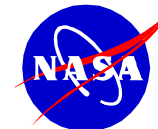
**NDRX-3 Radar:**

Problem: None.

**NDRX-4 Radar:**

Problem: None.





## **Readiness for STS-134:**

Presenter **MS/J.A. Hamilton**

Date **3/25/11**

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- **Team Readiness**
  - Complete, both ascent and analysis teams ready
  - Training new team members for transition
- **Facility Readiness**
  - Complete
- **Radar Readiness**
  - NDR-C1 – GREEN
  - NDR-X3 - GREEN
  - NDR-X4 - GREEN





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# **STS-134**

## **SE&IO Pre-Flight Readiness Review**

### **Flight Software**



Pre-decisional. Internal Use Only.





## STS-134 FLIGHT SOFTWARE SUMMARY

Presenter USA/John Magley

Date 03/25/11

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- **Seventh flight of PASS and BFS Operational Increment 34 (OI-34)**
  - No logic changes from previous flight software systems
- **Seventh flight of MEDS Multifunction Display Unit Function (MDUF) VI 6.00 and fifth flight of MEDS Integrated Display Processor (IDP) VI 7.01**
  - No changes from previous flight software
- **Eighth flight of MAGRS-3S Link 613-9966-008 GPS FSW**
  - No changes from previous flight software



## **FSW READINESS SUMMARY**

Presenter **USA/John Magley**

Date **03/25/11**

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- **Integrated Avionics Verification (IAV) is complete**
  - **A total of 17 cases were executed and analyzed in support of STS-134**
    - **Included testing of full flight system (PASS/BFS STS-134/OI-34 with flight-specific I-Loads; MEDS VI 7.01/6.00 (IDP/MDUF); MAGRS-3S Link 8; and SSME AD08/DA05 software)**
- **SAIL facility will be in a condition of readiness for mission support**
- **Formal Software Readiness Review (SRR) was conducted on 03/10/11**
  - **No known constraints**
- **With the completion of planned open work, FSW will be ready to support STS-134 launch**



## LAUNCH ON NEED STATUS

Presenter USA/John Magley

Date 03/25/11

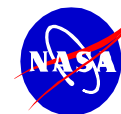
Page 54

- In the event of call-up, the STS-135 flight software products would be flown on OV-104
  - Some flight software products have been or will be generated as STS-335 products
    - These are authorized for use on STS-135 by SASCB direction (SCR 98119 and associated product release documentation)
  - OI-34 STS-335 [STS-135] Base 2 Load and associated products
  - Flight specific I-Load patches for STS-335 [STS-135] (full payload bay)
  - OI-34 compatible MEDS IDP and MDUF software (VI 7.01/6.00)
  - MAGRS-3S Link 8
- Completion of the development and verification of flight-specific FSW products for STS-135 will be performed in time to support the 06/28/11 target launch date
- Formal Software Readiness Review to be conducted after call-up





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# **STS-134**

## **SSP Flight Readiness Review**

### **PGSC**



Pre-decisional. Internal Use Only.







## Payload and General Support Computer Readiness – STS-134

Presenter	MS4/E. Jones	
Date	Mar 2011	Page 57

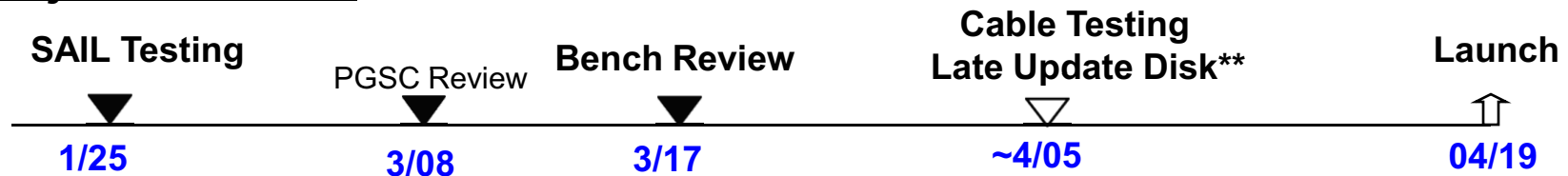
### ▪ Hardware and Software Summary

- STS-134 will be the thirteenth flight of the IBM ThinkPad A31p PGSC
  - 8 PGSC units + 1 Backup (Stowed) (None currently planned for ISS transfer)
    - *Note: AMS laptop is payload dedicated; Not attached to PGSC network*
  - Fifteenth flight of the A31p Docking Station (OCA and WinDecom)
  - Thirteenth flight of Netgear Wireless Access Point.
    - *Note: No network issues observed during STS-133*
  - New software
    - STORMM

### ▪ IFA Summary

1. **OCA Hard drive**– hard drive replaced with backup. OCA returned to nominal operations.
  - *IFA closed; Post-flight testing confirmed damage. Drive removed from flight inventory*

### ▪ Major Milestones



\*\*FD1 Late Update may be performed on ground at an earlier date



## Alternate/Dissenting Opinions

Presenter	MS/Anthony Griffith	
Date	03/31/11	Page 58

- **Alternate/dissenting opinions were actively solicited at the SE&I STS-134 Pre-FRR.**
  - No dissenting opinions were identified.



## CoFR Endorsement

Presenter	MS/Anthony Griffith	
Date	03/31/11	Page 59

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-134, pending completion of open work.

/s/Donald S. Noah

Donald S. Noah  
Manager Systems Engineering and Integration Office



## LON Status

Presenter	MS/Anthony Griffith	
Date	03/31/11	Page 60

- **SE&I has identified no technical or schedule constraints in support of LON requirements for STS-134 using the SSP baseline “Fly the Next Flight” approach**



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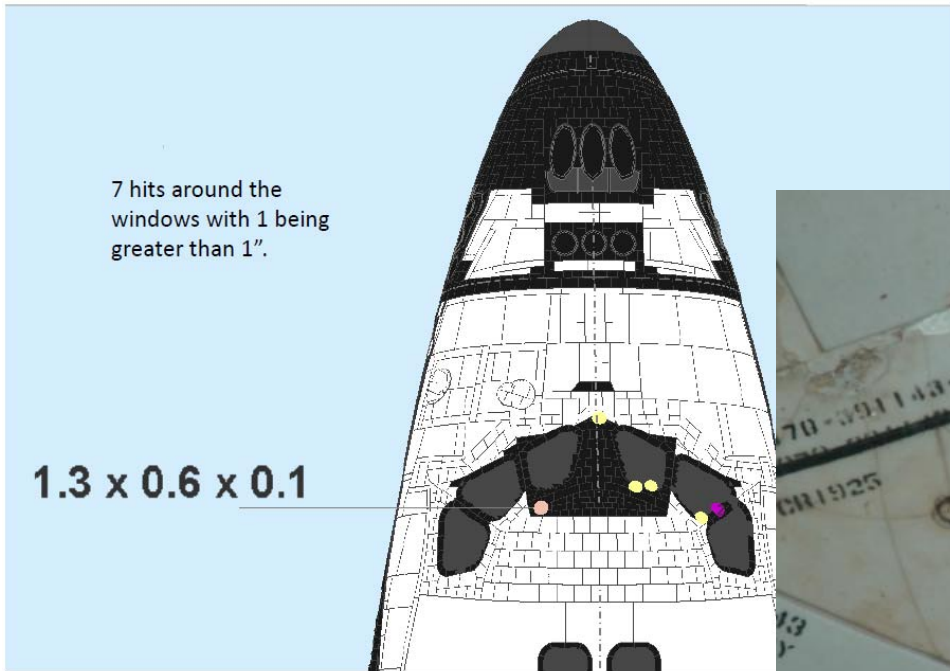
Pre-decisional. Internal Use Only.

Presenter	MS/Anthony Griffith	
Date	03/31/11	Page 61

# Back-up charts



<h1>STS-133 TPS Damage</h1>		Presenter	MS/ Doug Drewry
		Date	3/31/11

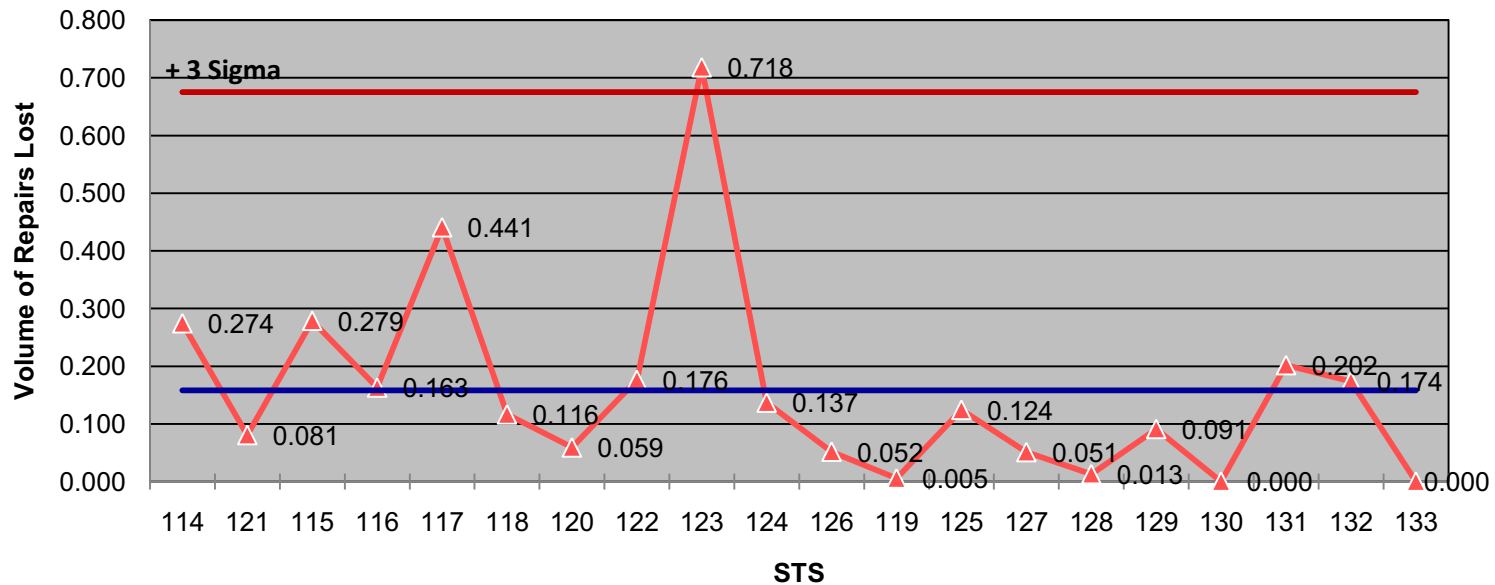




<h1>STS-133 Putty Repair Debris Summary</h1>	Presenter	MS/ Doug Drewry	
	Date	3/31/11	Page 63

- OPO/TPS PRT continues risk reduction steps
- Inspection/repair procedures strengthened to identify suspect repairs
  - Areas with transport to windows/RCC undergo tactile evaluation
  - Where repairs have transport to Windows or RCC tighter restrictions limit masses
  - Tiles with large repairs are being removed in critical areas FWD of the RCC and windows per CHIT

### Missing Putty Repair Total Volumes Since RTF





## Integrated Hazard Report Changes Since STS-133 (Delta FRR)

Presenter	MS3/J. Hill	
Date	03/31/11	Page 64

- IMPS-01 “Contamination in the Integrated MPS H2 System” was updated to document increase in risk associated with IPR133V-0070 where PV-13 was incorrectly configured open.
  - A safety issue briefing (SIB) was presented to the November 18th PRCB, acknowledging some additional likelihood of contamination.
    - SIB Flight Effectivity for STS-133
  - CR S050425KC was approved with mods at the January 18<sup>th</sup> SICB and OSB PRCB.
  - IMPS-01 Cause F updated to document nominal drain configuration does not allow LH2 flow through the unfiltered 4” recirculation line.
    - Included OMRSD S00E00.250 MPS LH2 Detank Valve Config. as a control.
    - Cause F remains Remote Catastrophic
  - Change Flight Effectivity to STS-134 through STS-999
  - No change to overall IMPS-01 Classification of ACCEPTED RISK



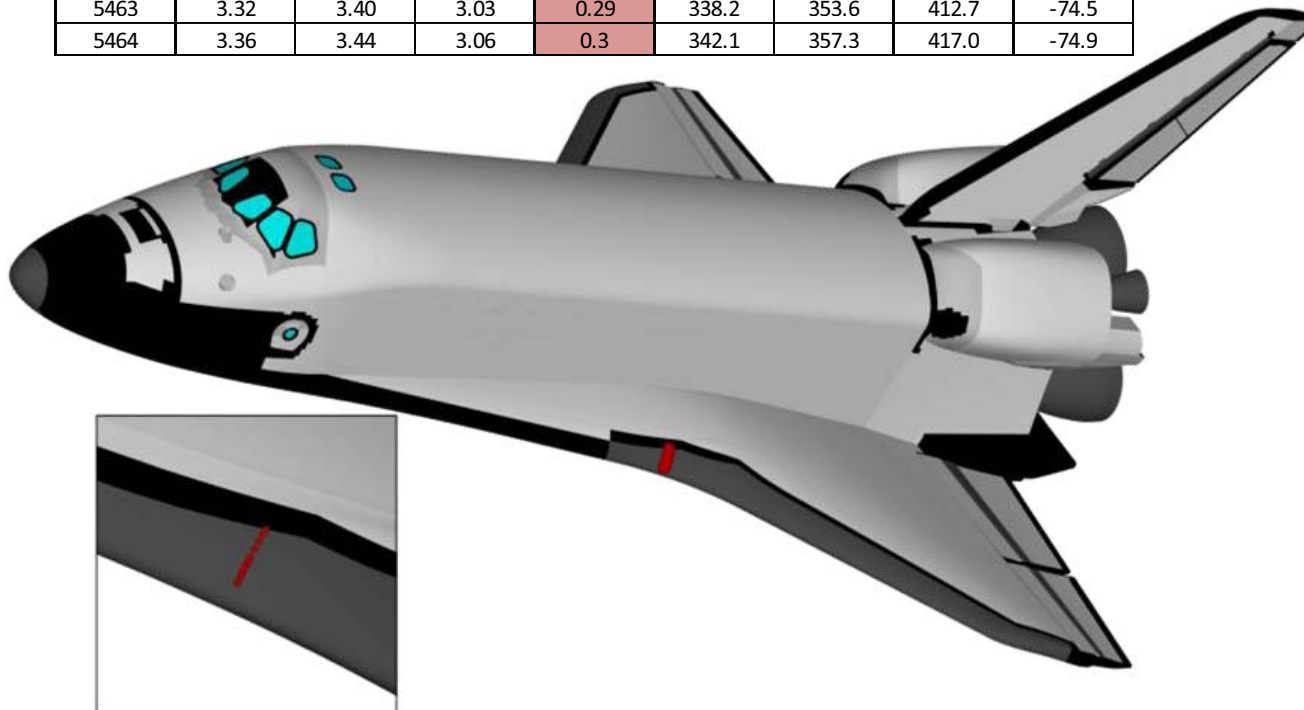


**STS-133 L+2 day Orbiter Peak Heat Rate Exceedances**

Presenter	<b>USA/Joe Craft</b>
Date	<b>03/31/11</b>
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**NOTE:**  
 Body points on both the port and stbd. side of Orbiter exceeded PECERT. Values shown in table are maximized between port and stbd.

Body Point	Peak Heat Rate (BTU/ft <sup>2</sup> -s)				Total Heat Load (BTU/ft <sup>2</sup> )			
	STS-133 L+15	STS-110 BET	PECERT	Delta (STS-133 & PE)	STS-133 L+15	STS-110 BET	PECERT	Delta (STS-133 & PE)
5455	4.83	4.83	4.64	0.19	467.1	485.4	595.8	-128.7
5456	4.45	4.44	3.95	0.5	442.9	456.8	547.9	-105.0
5457	4.20	4.19	3.73	0.47	420.5	434.6	512.1	-91.6
5458	3.98	4.01	3.57	0.41	402.4	415.9	486.5	-84.1
5459	3.84	3.87	3.45	0.39	388.2	401.6	467.0	-78.8
5460	3.73	3.76	3.35	0.38	376.8	390.1	453.0	-76.2
5461	3.56	3.60	3.21	0.35	359.6	373.0	439.1	-79.5
5462	3.42	3.49	3.11	0.31	348.2	363.2	424.3	-76.1
5463	3.32	3.40	3.03	0.29	338.2	353.6	412.7	-74.5
5464	3.36	3.44	3.06	0.3	342.1	357.3	417.0	-74.9





**Corrected Coding Errors in PE Certification in STS-133 reconstruction**

Presenter	<b>USA/Joe Craft</b>	
Date	<b>03/31/11</b>	Page 66

**NOTE:**  
 Values shown in table  
 are maximized  
 between port and stbd.

Body Point	Peak Heat Rate (BTU/ft <sup>2</sup> -s)				
	STS-133 L+15 Minute Trajectory	Existing PECERT	Delta (STS-133 & Existing PE)	Modified PECERT	Delta (STS-133 & Modified PE)
5455	4.83	4.64	0.19	5.24	-0.41
5456	4.45	3.95	0.5	5.24	-0.79
5457	4.20	3.73	0.47	5.08	-0.88
5458	3.98	3.57	0.41	4.80	-0.82
5459	3.84	3.45	0.39	4.59	-0.75
5460	3.73	3.35	0.38	4.44	-0.71
5461	3.56	3.21	0.35	4.21	-0.65
5462	3.42	3.11	0.31	4.05	-0.63
5463	3.32	3.03	0.29	3.93	-0.61
5464	3.36	3.06	0.3	3.97	-0.61

PE Certification heating eliminates exceedances  
 for the STS-133 L+15 minute trajectory with  
 Corrected Coding

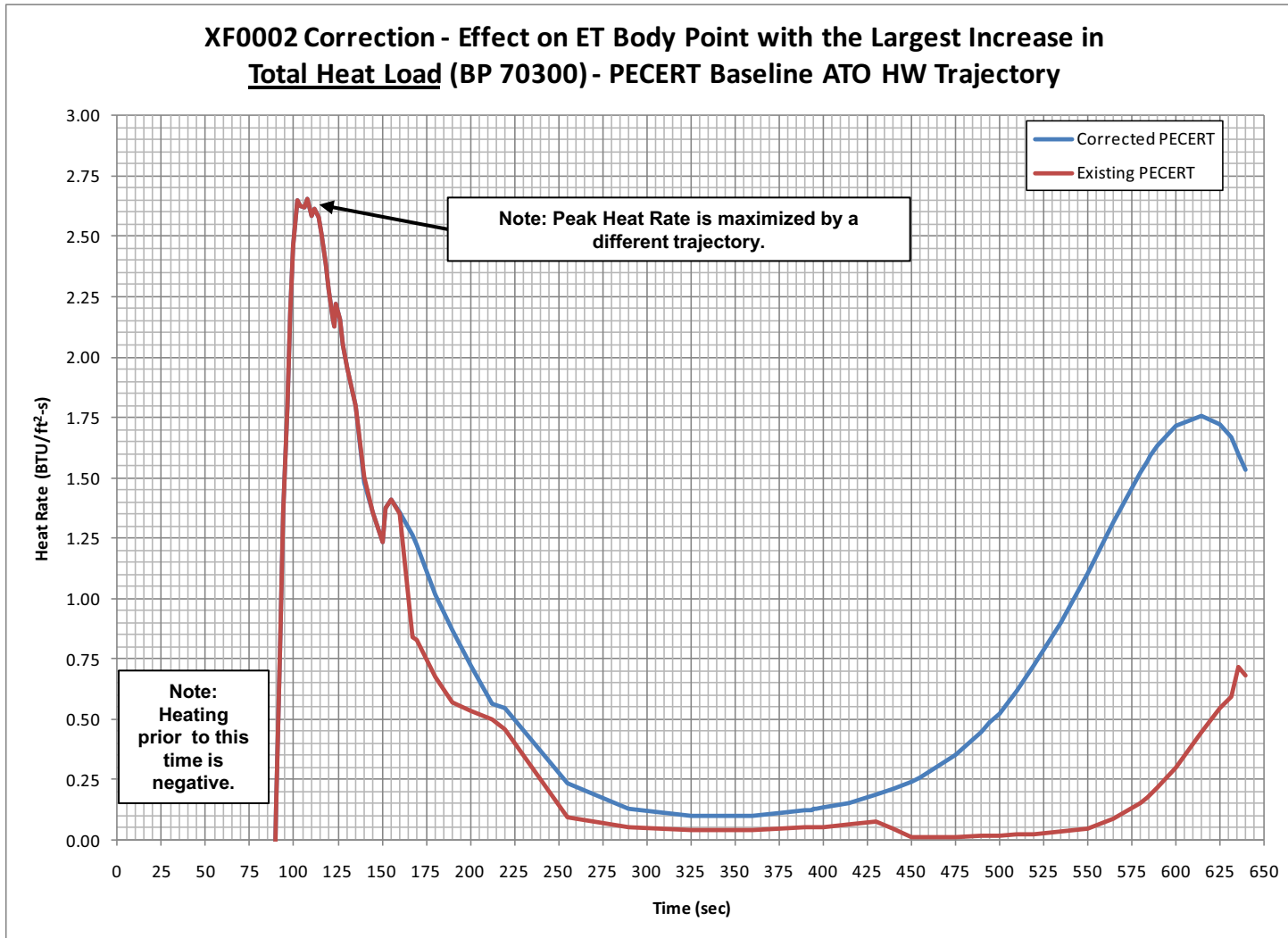


## Corrected PE vs. Existing PE

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Largest ET  
 Heat Load  
 Increase is  
 (BP 70300)  
 Hot Wall  
 ( $T_w=1110^\circ R$ )  
 Heating Time  
 History

**XF0002 Correction - Effect on ET Body Point with the Largest Increase in  
 Total Heat Load (BP 70300) - PECERT Baseline ATO HW Trajectory**

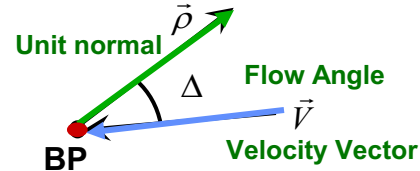




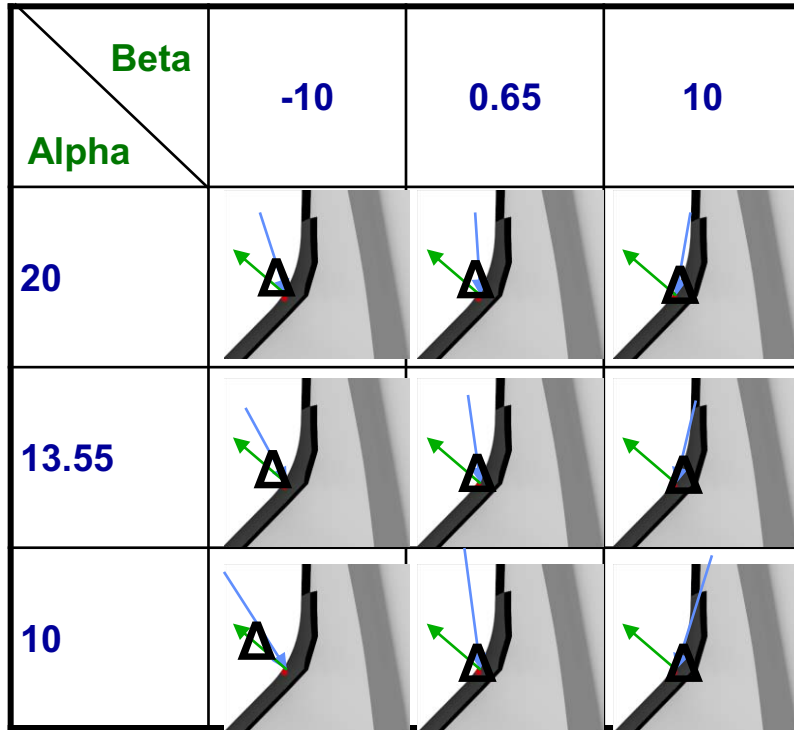
# Illustrative Effective Flow Angle Calculation Error

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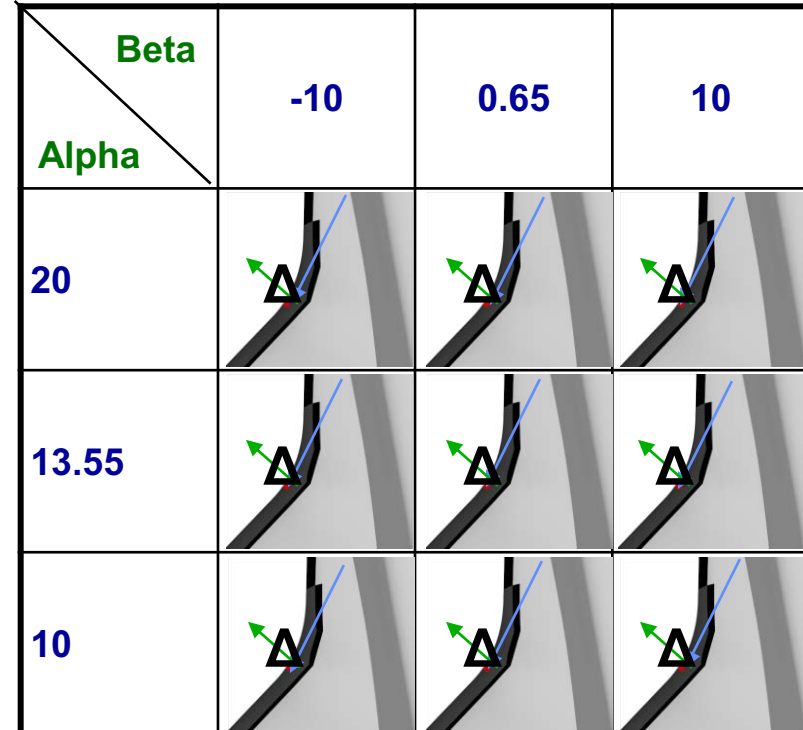
Code should calculate a different Effective Flow Angle (EFA) for each Alpha/Beta combination to search



Errors in the code essentially results in the Effective flow angle to be the same for all Alpha/Beta conditions (~0 )



As Specified by Databook



As implemented in Baseline XF0002

Vectors drawn for illustrative purposes only



## Limited PE Certification Trajectories

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- For the limited PE Cert approach, only PE Cert trajectories that are representative of configurations to be flown on the next two flights were analyzed
  - Analyzed:
    - Baseline No-Fail, RTLS, TAL, ATO
    - 1<sup>st</sup> Stage TAL
    - Late TAL and Delayed TAL – ONLY 51.6° Inclination, 104.5% Power Level TAL Flights to Moron or Zaragoza
    - Istres TAL – Only Heavy Payload Flights
  - Not Analyzed
    - 54nm MECO – all flight modes
    - No Roll to Heads Up – all flight modes
    - 109% Intact Abort – all flight modes
    - Late TAL and Delayed TAL – 28.5°, 39°, or 57° Inclination; 106% or 109% Power Level, and TAL Flights to Ben Guerir
    - Istres TAL – Light Payload Flights



## DOLILU Operational Support System

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- **NSTS 08329, Vol VIII, DOSP update to clarify Contingency Procedure R for potential USA/Boeing vehicle loads comparison differences for indicators FO1 and FOA.**
- **SICB approved CR S052550PP on 3/22/11.**
  - **FO1 limit value to return to 100% (vs. 94% for STS-133)**
  - **Sources of load indicator calculation differences identified and quantified**
  - **6% mis-compare allowable (vs. 4% baseline) for FO1 and 5% mis-compare allowable for FOA acknowledges known USA/Boeing calculation differences**



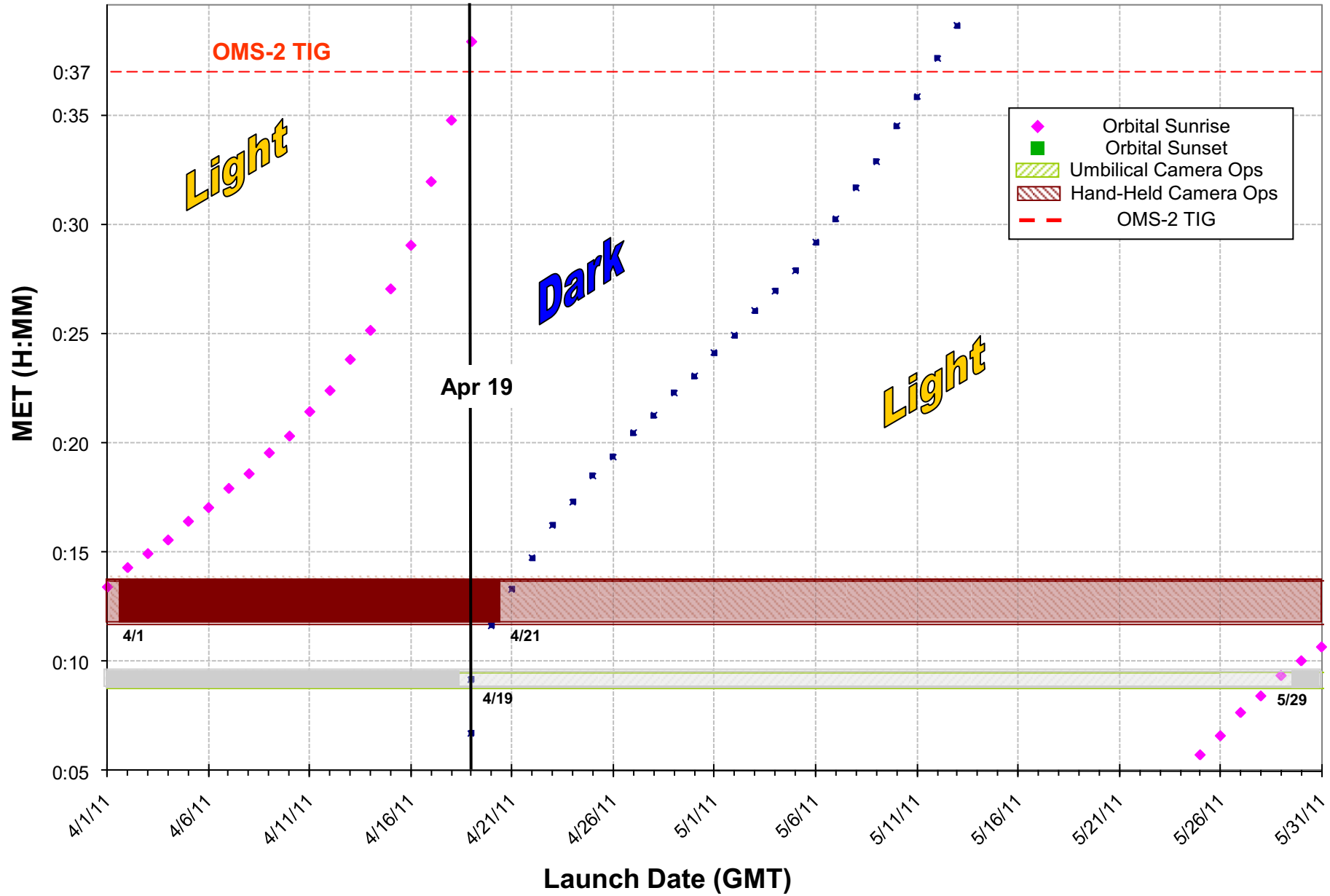
## DOLILU Operational Support System

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- **Background**
- **During Dec 20, 2010 weather SIM indicator FO1 produced a 5% mis-compare on the L-3:35 balloon. Violated DOSS rule and indicated a NO-GO condition. Investigation initiated.**
- **S052550PN updated DOLILU Contingency Procedure R prior to STS-133**
- **STS-134 Rationale**
- **Investigation completed and determined cause of the mis-compare**
  - **Conversion of moments due to inertia**
    - **USA: Incorrectly divides by gravity when converting slugs\*ft<sup>2</sup>/sec<sup>2</sup> to in\*lb**
  - **Orbiter c.g. and moments of inertia**
  - **Mission Specific values vs. static c.g. values**
- **Exception to Contingency Procedure R revised to document the understanding of the mis-compare and to remove some conservatism from the rule**
- **Change reviewed and approved by the DOWG and Loads Panel**

# Lighting Predicts

Pre-decisional. Internal Use Only.



Data provided by DM/Angela Lenort based on DEC 2010 ISS Reference Trajectory.







**Lighting Predicts (cont.)**

Presenter	<b>MS3/B ELIASON</b>	
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Launch Date (2011 GMT)	Launch	Umbilical Ops (8:46 - 9:30 MET)	Hand-Held Ops (11:43 - 13:43 MET)	Pitch-Up Maneuver
Apr 01	DARK	DARK	Partly DAYLIGHT	Yes
Apr 02 - Apr 18	DARK	DARK	DARK	No
Apr 19	Partly DAYLIGHT	Partly DAYLIGHT	DARK	
Apr 20	DAYLIGHT	DAYLIGHT	DARK	
Apr 21	DAYLIGHT	DAYLIGHT	Partly DAYLIGHT	Yes
Apr 22 - May 22	DAYLIGHT	DAYLIGHT	DAYLIGHT	
May 23 - May 28	DARK	DAYLIGHT	DAYLIGHT	
May 29	DARK	Partly DAYLIGHT	DAYLIGHT	
May 30	DARK	DARK	DAYLIGHT	

Data provided by DM/Angela Lenort  
 based on DEC 2010 ISS Reference Trajectory.





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 NASA Johnson Space Center, Houston, Texas



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**STS-134 Standard Open Work**

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	ECD
<b>TDDP</b> <ul style="list-style-type: none"> <li>- TDDP-DOL (Supports DOL Products)</li> <li>- TDDP Change Notice (RSRM L-3 Day PMBT Prediction Update)</li> </ul>	04/11/11 04/15/11
<b>DOSS</b> <ul style="list-style-type: none"> <li>- L-3 Week Test / TCDT</li> <li>- L-7 Day SIRB Review</li> <li>- L-3 Verification Test (Incorporate DOL TDDP &amp; L-4 Day Change Notice)</li> </ul>	04/01/11 04/12/11 04/15/11
<b>GN&amp;C</b> <ul style="list-style-type: none"> <li>- Update FRV Results to SIRB</li> <li>- Normal Prelaunch Configuration &amp; Testing</li> </ul>	04/12/11 04/15/11
<b>Loads &amp; Dynamics</b> <ul style="list-style-type: none"> <li>- Final CE Weight &amp; CG Assessment</li> <li>- Normal Prelaunch Configuration &amp; Testing</li> </ul>	03/28/11 04/15/11
<b>Flight Rules</b> <ul style="list-style-type: none"> <li>- Assessment of Late Flight Rule Changes</li> </ul>	04/19/11



**STS-134 Standard Open Work**

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	<b>ECD</b>
<b>Software</b> - Update NIRD CCT	L-3 Days
<b>ELVIS</b> - Cabin Stow of Crew Handheld Cameras - SRB DAS Install in Fwd Skirt* - Recharge of ET LO2 Camera Battery* - Cabin Stow of DETTPS Camera IVA Converter Box - ET LO2 Camera Cover Removal / Window Cleaned - SRB Cameras Cover Removal / Windows Cleaned - ET LO2 Camera Open Loop MILA Comm Check - Cabin Stow of Crew Handheld Camera Batteries	S0017 S5009 T1303* L-3 Days T6446† S0007 S0007 DOL
<b>Orbiter GFE</b> - Minicam bracket/camera installation/alignment - Minicam system functionality verification - Minicam alignment verification	L-21 Days L-3 Days DOL
<b>Ground Cameras</b> - Trackers Towed to Camera Site Locations - Cameras Positioned and Rough Set - Film Loaded and Final Set	L-1 Week L-3 Days L-1 Day

\* Prior to ordnance ops, usually at L-1 week

† Prior to RSS retract, usually at L-1 day



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	<b>ECD</b>
<b>FSW</b> <ul style="list-style-type: none"><li>- Complementary Load Processing</li><li>- Dump and Compare Processing</li></ul>	L-10 L-5
<b>PGSC</b> <ul style="list-style-type: none"><li>- L-14 Late Update Disk</li><li>- L-14 Cable Testing</li></ul>	04/05/11 04/05/11



## STS-134 SYSTEM LEVEL WAIVERS

Presenter USA/John Magley

Date 03/25/11

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- No changes or waivers to NSTS 07700 Vol X impacting software for STS-134
- No new software-induced waivers to NSTS 07700 Vol X