Need as-flown attitude timeline to complete analysis

We need the following MSID output from the ODRC:

- V90U2240C
- V90U2241C
- V90U2242C
- V90U2243C
- V90W2310C
- V90U2641C
- V90U2642C
- V90U2643C
- V90U2644C

For previous as-flown assessments, we used JMEWS to fetch the data in 300 second intervals from Mission Event "A20" (OMS 2 cut/off) through "D01" (APU activation)
Graphical Interpretation of Results (Excel & 1-DEAS)

Computation of Penetrating Flux and PNP (SHIELD)

Critical Particle Diameter Calculation (RESPONSE)

Approximately 18,000 elements in 15 assembly complete meshed configuration FEM

Debris Sizing

Debris Material

Debris Environment (Geometric)

NAS/JSC BUMPER-II Meteoroid/Debris Threat Assessment Code
A facility of the Johnson Space Center

- Flash x-ray systems
- High-speed laser shadowgraph
- High-quality diagnostic equipment
- Exceeds 11 km/s
- Projectiles to velocities in
- Launcher used to accelerate
- Inhibited shaped charge
- Inhibited shaped charge
- To velocities up to 7 km/s
- Two-stage light-gas guns are
- Code

Equations used in BUMPER

Testing provides data to

February 5, 2003
Date

Software Verification

Eric Christiansen
Presenter

Office SX
Human Exploration Science
Technology Facility
Hypervelocity Impact
Mark Matney

Jim Hyde

18 December 2002

ASSESSMENT
METEOROID/ORBITAL DEBRIS
STS-107 Flight Readiness Review
Both Rads Deployed

Port Rads Deployed

Both Rads Stowed

---

- BUMPER Shuttle code w/ ORDEM2000 debris environment model
- 150 Finite Element Model / attitude combinations
- 16 Day Attitude Timeline provided by Andrew Lalich/DO4
- Launch: January 16, 2003

<table>
<thead>
<tr>
<th>Date</th>
<th>Assessment</th>
<th>Office SX</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 5, 2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eric Christiansen</td>
<td></td>
<td>Human Exploration Science</td>
</tr>
<tr>
<td>Presenter</td>
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<td>Technology Facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypervelocity Impact</td>
</tr>
</tbody>
</table>
Probability of 1 or more maneuver alerts is 1 in 5.7 (1 in 6 is typical).

Using the 2x14x14 km "yellow" box

Current Satellite Catalogue analysed to estimate maneuver probability.

February 5, 2003

Eric Christiansen

Presence of HSE

Office

Human Exploration Science

Technology Facility

Hypervelocity Impact

Collision Avoidance Maneuvers
a facility of the Johnson Space Center

1% increase in debris penetrating flux is required.

- Broke up July 9 in a 535 km x 35,445 km, 7.0 deg orbit
- Ariane 2 Rocket body
- Satellite 19122, 1988-040B

Office SX
Human Exploration Science
Technology Facility
Hypervelocity Impact

Breakups

Date: February 5, 2003
Presenter: Eric Christiansen
<table>
<thead>
<tr>
<th>Event</th>
<th>Probability</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9970 1 in 334</td>
<td>0.9968</td>
<td>1 in 315</td>
</tr>
<tr>
<td>0.9968 1 in 61</td>
<td>0.9962</td>
<td>1 in 313</td>
</tr>
<tr>
<td>0.9973 1 in 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9973 1 in 200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

- 88% Window Replacement Risk
- Expected number of Window Replacements
- Probability of no Radiator Leak (both Radii Deployed)
- Probability of no critical penetration
- Probability of no Radiator Leak
- Probability of no critical penetration
- Probability of no Radiator Leak
- Probability of no critical penetration
- Probability of no Radiator Leak
- Probability of no critical penetration

**Guideline:**

- Shuttle
- Preferred at 0.950
- Required at 0.9950

**Risk:**

- STS-107
- 1 in 370
- 1 in 375
- 1 in 370
- 1 in 315
- 1 in 313
- 1 in 313
- 1 in 313
Impact:

- Internal Tracture = 4.0 mm (0.156in)
- Crater Depth = 0.3 mm (0.013in)
- Crater Diam = 2.2 mm (0.086in)

0 Collision Avoidance Maneuvers
Launch: 11/23/02
STS-113 (11A)

- Radiator Panel L4 - 0.4 mm (0.016in) diameter hole in face sheet
- 0 Collision Avoidance Maneuvers
Launch: 10/07/02
STS-112 (9A)
<table>
<thead>
<tr>
<th>Approximate</th>
<th>Shower</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Zenith Hourly Rate</td>
<td>Peak</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Jan 19</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Jan 29</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Alpha Leonids</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Delta Cancri</td>
</tr>
</tbody>
</table>

- Radiator damaging flux over background by 2.8%
- Meteor shower activity will increase the meteoroid window and flux over background by 5.3%
- Meteor shower activity will increase the meteoroid critical penetrating
satellite breakup events.

- SX2 will be on-call during the mission to assess additional attitudes or maneuver warnings will occur.
- There is a 1 in 5.7 probability that one or more collision avoidance leak risk.

- Assessment indicates that the Orbiter is within guidelines for radiator penetration risk.
- Assessment indicates that the Orbiter is within guidelines for critical

February 5, 2003

Eric Christiansen

Presentee: Office SX

Human Exploration Science
Technology Facility

Hydroxology Impact

Summary
Attached is the landing weight briefing to be presented at the MER on Friday, Jan. 24.

<<MER Briefing.ppt>>
4. Landing Gear & Tire
3. Stress
2. Thermal Landing Gear & Tire
1. Flight Control

Landing weight above 233,000 lbs demonstrates that the Orbiter will perform within its capability for an EOM.

**Action Required:** STS-107 mission specific assessments are required to determine weight maximum of 233,000 lbs.

**Concern:** The projected STS-107 EOM landing weight of 233,700 lbs exceeds the NTS 07700 Vol X and Flight Rules Orbiter Vehicle Landing Weight maximum of 233,000 lbs.

**Exceedance:** STS-107 Landing Weight Limit

<table>
<thead>
<tr>
<th>Orbiter/01-24-03</th>
<th>Organization/Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pam Madera</td>
<td>Presenter:</td>
</tr>
<tr>
<td></td>
<td>STS-107</td>
</tr>
</tbody>
</table>
within EOM limits

Detailed thermal/structural evaluation is not required if TSEP results are within EOM limits. Note: Accending approaches are more benign.

<table>
<thead>
<tr>
<th>Description</th>
<th>DR</th>
<th>DL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate DR crossrange</td>
<td>356</td>
<td>383</td>
</tr>
<tr>
<td>Intermediate DL crossrange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9 deg inclination maximum achievable DR crossrange for DL</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>Maximum crossrange capability for DL</td>
<td>770</td>
<td></td>
</tr>
<tr>
<td>Nominal EOM</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
<td></td>
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<tr>
<td>XR</td>
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</tbody>
</table>

(233.7 kN, 1.078 lb in alt/T/D) Thermal: There are no TSEP violations for the following landing conditions.

- Covered by abort certification
- Flight Control: No concern for 1000 lbs exceedance of the 233EOM limit

Discussion: Mission Specific Assessments

---

STS-107 Landing Weight Limit

STS-107

STS-107/Landing Weight Limit

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>Organization</td>
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<tr>
<td>Parm Madera</td>
<td></td>
</tr>
<tr>
<td>Presenter</td>
<td></td>
</tr>
</tbody>
</table>

Exceedance
Available

TCS will update ATL recommendation when new site limits are

ZTV+YAV EOM thermal conditioning

Approximately 10-hr bottom sun prior to 10-hr.

Required

If limits higher, additional bottom sun conditioning may be

If limits lower, no impact

or 3 degE based on 233000 to 235000 IBs, 1079 +/- 1 inch C.

Expected MLC limit change from carpet plots is small (< 2 psia,

Pressure limits

On-orbit thermal conditioning will be performed to protect tire

Landing gear and tires are certified up to about weight limits.

Landing Gear & Tire:

STS-107 Landing Weight Limit

Discussion: Mission Specific Assessments

Exceedance

STS-107 Landing Weight Limit

Organizational/Date: Pan Madera

Presenter: STS-107
Both documents should apply but is not explicitly stated in conditions.

Next P/L's/early mission termination would also result from anomalous exceedences.

Volume X shares no waiver required for ULP downweight.

Under EOM thermal limits it possible descent thermal effects.

Retail (ULP) landing opportunities should be evaluated to minimize NSTS 07700 volume X and flight rules state that unplanned payload.

Discussion: Next P/L's/Early Mission Termination

**Exceedance**

STS-107 Landing Weight Limit

STS-107
4. Landing Gear & Tire
3. Stress
2. Thermal Landing Gear & Tire
1. Flight Control

Landing weight above 233,000 lbs.

Demonstrate that the Orbiter will perform within its capability for an EOM
mission specific assessments are required to exceed the NSTS 07700, Vol. X and Flight Rules Orbiter Vehicle Landing weight maximum of 233,000 lbs.

Concern: The projected STS-107 EOM landing weight of 233,700 lbs.

Exceedance:

STS-107 Landing Weight Limit
within EOM limits

Detailed thermal/structural evaluation is not required if TSEP results are

Note: Ascenting approaches are more benign

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<tr>
<th>Description</th>
<th>DR</th>
<th>DL</th>
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</thead>
<tbody>
<tr>
<td>Intermediate DR crossover 39 deg inclination</td>
<td>356</td>
<td>383</td>
</tr>
<tr>
<td>Interimmediate DL crossover 39 deg inclination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum achievable DR crossover for DL</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>Maximum crossover capability for DL</td>
<td>770</td>
<td></td>
</tr>
<tr>
<td>Nominal EOM Approach</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

(233,700 Ib, 1,078.8 in, at T/J)

Thermal: There are no TSEP violations for the following landing conditions covered by abort certification.

Flight Control: No concern for 1000 Ibs. Exceedance of the 233K EOM limit.

Discussion: Mission Specific Assessments

<table>
<thead>
<tr>
<th>STS-107 Landing Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceedance</td>
</tr>
</tbody>
</table>

STS-107
Available

TCS will update ALL recommendations when new tire limits are.

ZLV+XAV EOM thermal conditioning required.

- If limits higher, additional bottom-sun conditioning may be
- If limits lower, no impact.

ILS DEGP based on 233000 to 235000 lbs, 1079 +/-1 inch C6

Expected WLG limit change from carpet plot is small ( > 2 psia,
pressure limit)

On-orbit thermal conditioning will be performed to protect tire.

Landing gear and tires are certified up to about weight limits.

Landing Gear & Tire:

Discussion: Mission Specific Assessments

Exceedance

STS-107 Landing Weight Limit

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<td>Pan Madera</td>
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<tr>
<td>Presenter: STS-107</td>
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</tbody>
</table>
Discussion: Next PL/S Early Mission Termination

Exceedance
STS-107 Landing Weight Limit

STS-107

STS-107 Landing Weight Limit
Discussion: Past Experience

STS-107 Landing Weight Limit

Exceedance

STS-107 Landing Weight Limit

STS-107

Pam Madara

Presenter:

Orbiter/01-24-03

Orbit/Orbit

Date:

982.9

8179.8

XCE at T/D

Weight at T/D

Vehicle

Mission

OV-102

233,089

235,286

STS-87

OV-102

STS-83

Vehicle

Mission

Second Flight of Wrap Around Drogue Auto Pilot

STS-87 exceeded limit due to less than expected RCS usage

STS-83 exceeded limit due to early mission termination

Landing weight has exceeded EOM landing weight limit for two missions

Landing weight prediction prior to deceleration burn was below limit
The TSEP results are below EOM limits. A rationale for waiver exists for STS-107 Landing Weight Exceedance if a waiver is required. In nominal EOM weight exceeds 233,000 lbs limit.

**Recommendation:**

<table>
<thead>
<tr>
<th>Organization/Date/Presenter</th>
<th>Exceedance Limit</th>
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</thead>
<tbody>
<tr>
<td>Orliter/01-24-03 Pam Madeira</td>
<td>STS-107 Landing Weight Limit</td>
</tr>
</tbody>
</table>
Landings weight prediction prior to deorbit burn was below limit.

Second Flight of Wrap Around Digital Auto Pilot

ST-S-87 exceeded limit due to less than expected RCS usage.

ST-S-83 exceeded limit due to early mission termination.

<table>
<thead>
<tr>
<th>Year</th>
<th>Score at T/D</th>
<th>Weight at T/D</th>
<th>Vehicle</th>
<th>Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982.9</td>
<td>233.089</td>
<td>07-102</td>
<td>STS-87</td>
<td></td>
</tr>
<tr>
<td>1979.6</td>
<td>235.286</td>
<td>07-102</td>
<td>STS-83</td>
<td></td>
</tr>
</tbody>
</table>

Landings weight has exceeded FOM landing weight limit for two missions.

Discussion: Past Experience

STS-107 Landing Weight Limit

Exceedance

<table>
<thead>
<tr>
<th>Orbiter/01-24-03 Organization/Date:</th>
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</thead>
<tbody>
<tr>
<td>Pam Madera Presenter:</td>
</tr>
</tbody>
</table>

STS-107
STSB results are below EOM limits

Rationale for waiver exists for STS-107 Landing weight exceedance if

Waiver required if nominal EOM weight exceeds 233,000 lbs limit

Recommendation:

<table>
<thead>
<tr>
<th>STS-107 Landing Weight Limit</th>
<th>Exceedance</th>
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<tbody>
<tr>
<td>Pam Madeira</td>
<td>Present</td>
</tr>
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MAGILL, ANITA L. (JSC-MV) (LM)
SWAN, BOBBIE G. (JSC-CA) (NASA); MAYEAUX, BRIAN M. (JSC-ES4) (NASA);
KRUMREY, CAROLYN M. (JSC-ES6) (NASA); CSRDESK; WHITTLE, DAVID W. (JSC-MA2)
(NASA); HENDERSON, EDWARD M. (MACK) (JSC-MA) (NASA); BENZ, FRANK J. (JSC-EA)
(NASA); OUELLETTE, FRED A. (JSC-MV6) (NASA); GÂYLOIR, STEPHEN G. (STEVE) (JSC-
MT3) (NASA); GRUSH, GENE R. (JSC-EP111) (NASA); 'Gernand, Joseph'; GALBREATH,
GREGORY F. (GREG) (JSC-ES2) (NASA); LANGE, GREGORY A. (JSC-DA8) (NASA);
KAUPP, HENRY J. (JSC-ER3) (NASA); GREENE, JAY H. (JSC-AG) (NASA); HARBOUR,
JEFF P. (JSC-MV) (LM); 'John Mulholland'; SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA);
'Lili Moore'; 'Mike Fuller'; 'Oswald, Stephen'; ROE, RALPH R. (JSC-MV) (NASA);
DITTEMORE, RONALD D. (JSC-MA) (NASA); CREAMER, TIMOTHY J. (TJ) (JSC-CB)
(NASA); HILL, VERNON C. (JSC-MV) (LM); LEVY, VINCENT M. (JSC-EG) (NASA); GUY,
WALTER W. (JSC-ER) (NASA); GERSTENMAIER, WILLIAM H. (BILL) (JSC-OA) (NASA)
CORRECTION 12th Daily Report
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Wednesday, January 22, 2003 4:13 PM
To: SHACK, PAUL E. (JSC-EA42) (NASA)
Cc: SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA); KRAMER, JULIE A. (JSC-EA4) (NASA); MILLER, GLENN J. (JSC-EA) (NASA)
Subject: FW: STS-107 Debris Analysis Team Meeting

Rodney Rocha
Structural Engineering Division (ES-SED)

- ES Div. Chief Engineer (Space Shuttle DCE)
- Chair, Space Shuttle Loads & Dynamics Panel

Mail Code ES2 Phone 281-483-8889

-----Original Message-----
From: Madera, Pamela L [mailto:pam.l.madera@usahq.unitedspacealliance.com]
Sent: Wednesday, January 22, 2003 11:22 AM
To: CURRY, DONALD M. (JSC-ES3) (NASA); ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); LEVY, VINCENT M. (JSC-EG) (NASA); KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA); Nagle, Scott M; Carlos Ortiz (E-mail); GOMEZ, REYNALDO J. (RAY) (JSC-EG3) (NASA); DISLER, JONATHAN M. (JON) (JSC-SX) (LM); Jacobs, William A
Cc: 'Scott Christensen V (E-mail)'; 'Norman Ignacio (Nacho) (E-mail)'; CHAO, DENNIS; Stoner-1, Michael D; 'Carlos Ortiz (E-mail)'; 'Michael J Dunham (E-mail)'; Sebesta, Stephen P; CORONADO, DIANA; "Craig Madden' (E-mail)'; Bell, Dan R.; Gordon, Michael P.; 'Paul A Parker (E-mail)'; ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC); ALEXANDER, ED
Subject: STS-107 Debris Analysis Team Meeting

Rodney Rocha has conference room 221 in JSC Building 13 available for today's 1:00 PM telecon. Located on second floor. The dial in number is the same as below. I propose the following agenda:

Review of transport analysis (Carlos Ortiz - charts attached)
Discussion of appropriate Particle Size (Ortiz, Disler, all)
Review of Flight Design Plans for Assessing Options (Bill Jacobs)
Status of Impact Damage Assessment (P. Parker)
Status of Thermal Analysis (Norm Ignacio/Dennis Chao)
Approach for stress assessment (Dunham)
Discussion on Need/Rationale for Mandatory Viewing of damage site (All)

<<STS-107 Preliminary Debris Assessment - rev2.ppt>>

Pam Madera
Vehicle and Systems Analysis Subsystem Area Manager
Phone: 281-282-4453

3/19/2003
The Boeing/USA team would like to meet with you Tuesday at 2:00 on meet-me-line number to discuss analysis plans for assessing the STS-107 Debris Impact.

Pam Madera
Vehicle and Systems Analysis Subsystem Area Manager
Phone: 281-282-4453
FYI on forthcoming activity. From USA/Pam Madera and her talking to Boeing contacts:

- It appears that the image folks can only state the impactor is 20 inch max dimension plus/minus 10 inch. It has a max thickness of about 4 inch or so due to the known thicknesses of the ET insulation in the forward bipod area.
- Boeing Load/Stress group is researching if such insulation impacts are in the data base of previous impact tests on Orbiter TPS.

Rodney Rocha

- Division Chief Engineer (DCE), ES-Structural Engineering Division
- Chair, Space Shuttle Loads & Dynamics Panel
- Mail Code ES2 x38889

Madera, Pamela L [mailto:pam.l.madera@usahq.unitedspacealliance.com]

Sent: Monday, January 20, 2003 5:47 PM
To: CURRY, DONALD M. (JSC-ES3) (NASA); ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); LEVY, VINCENT M. (JSC-EG) (NASA); KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA)
Cc: 'Scott Christensen V (E-mail)'; 'Norman Ignacio (Nacho) (E-mail)'; CHAO, DENNIS; Stoner-1, Michael D; 'Carlos Ortiz (E-mail)'; 'Michael J Dunham (E-mail)'; Sebesta, Stephen P; CORONADO, DIANA; "Craig Madden' (E-mail)'; Bell, Dan R.; Gordon, Michael P.; Paul A Parker (E-mail)

Subject: STS-107 Debris Analysis Team Plans

The Boeing/USA team would like to meet with you Tuesday at 2:00 on meet-me-line number to discuss analysis plans for assessing the STS-107 Debris Impact.

Pam Madera
Vehicle and Systems Analysis Subsystem Area Manager
Phone: 281-282-4453

3/19/2003
Another item— I had not sent you.

Bob, Jerry,
I've talked to Calvin Schomburg (NASA/JSC/Engineering) regarding your questions following Monday's MMT. As far as the "zipper effect", the folks did consider it and determined that for the type of damage we expect, it will not be an issue. The following is a summary of what I have told and if you need any more information we can talk again or I can have Calvin get in touch with you (Calvin, if you have any comments, please chime in).

As we discussed on Monday, the predicted worst case damage area is expected to be approximately 7" wide by 30" long. The shape of the area is expected to be "crater like" with a ramp leading in and a ramp leading out. The maximum depth will be perhaps down to the densified layer of the tile (that's what was thermally analyzed). So, there will still be approximately 0.1" of TPS material as well as the SIP and RTV left in the hole. The airflow over this damaged area should not impart sufficient aero loads (side loading) on the tiles to cause additional tiles to come off. At the most, we'd expect to erode away some additional tile material in the hole (the analysis accounts for this). Note also that the highest aero loads occur after peak heating. Also, the thermal analysis indicates that the bondline temperature will remain below the temperature at which the RTV begins to degrade (650F). Therefore, the strength of the RTV should not be compromised.

As for the age issue, Calvin said that the cert life has been extended to 30-years. The way in which they have been able to do this is to remove tiles from the bottom of the vehicle during OMDPs are test the strength of the RTV. He has no concerns about the age of the tile bonding of OV-102.

Hope this helps. If not, let me know.
Don
More than 100 Externals Tanks have flown
with only 3 documented instances of
significant foam loss on a bipod ramp

- Safety of Flight Issue
- ET TPS Foam loss over the life of the Shuttle
- Background

- Bipod housing STA closeout
- Bipod ramp (≈ 4" X 5" X 12") exposing the foam was lost on the STS-112/ET-115-Y
The ET is safe to fly with no new concerns (and no added risk)

- Probability of loss of ramp TPS is no higher/no lower than previous flights
- No change in inspection / process control / post application handling, etc
- Ramp form application involves craftsmanship in the use of validated application processes
- Each performed by experienced practitioners (all over 20 years)
- All ramp closeout work (including ET-112 and ET-116) was
- Equipment changes over the last 60 ETs (flight)
- The Orbiter has not experienced "Safeguards with bidpod ramp foam loss"
- Current bidpod ramp closeout has not been changed since STS-54 (ET-51)

STS-112/115 Bidpod Ramp Foam Loss

Rationale for Flight

Space Shuttle Projects Office (MSFC)
The Boeing/USA team would like to meet with you Tuesday at 2:00 on meet-me-line number to discuss analysis plans for assessing the STS-107 Debris Impact.

Pam Madera
Vehicle and Systems Analysis Subsystem Area Manager
Phone: 281-282-4453
From: SCHOMBURG, CALVIN (JSC-EA) (NASA)
Sent: Sunday, February 16, 2003 10:25 AM
To: OUELLETTE, FRED A. (JSC-MV6) (NASA)
Subject: FW: Answer to Tile Questions

Thank you!

Subject: RE: Answer to Tile Questions

Bob, Jerry,
I've talked to Calvin Schomburg (NASA/JSC/Engineering) regarding your questions following Monday's MMT. As far as the "zipper effect", the folks did consider it and determined that for the type of damage we expect, it will not be an issue. The following is a summary of what I have told and if you need any more information we can talk again or I can have Calvin get in touch with you (Calvin, if you have any comments, please chime in).

As we discussed on Monday, the predicted worst case damage area is expected to be approximately 7" wide by 30" long. The shape of the area is expected to be "crater like" with a ramp leading in and a ramp leading out. The maximum depth will be perhaps down to the densified layer of the tile (that's what was thermally analyzed). So, there will still be approximately 0.1" of TPS material as well as the SIP and RTV left in the hole. The airflow over this damaged area should not impart sufficient aero loads (side loading) on the tiles to cause additional tiles to come off. At the most, we'd expect to erode away some additional tile material in the hole (the analysis accounts for this). Note also that the highest aero loads occur after peak heating. Also, the thermal analysis indicates that the bondline temperature will remain below the temperature at which the RTV begins to degrade (650F). Therefore, the strength of the RTV should not be compromised.

As for the age issue, Calvin said that the cert life has been extended to 30-years. The way in which they have been able to do this is to remove tiles from the bottom of the vehicle during OMDPs and test the strength of the RTV. He has no concerns about the age of the tile bonding of OV-102.

Hope this helps. If note, let me know.

Don
Calvin,

Attached is the file on 107 meteoroid/debris risks (based on FRR ATL) with the charts I showed you this morning on meteoroid/debris risks. We'll finalize it after we get the as-flown ATL.

Risk_breakdown
n.ppt

Eric
281-483-5311
Preliminary (Based on FRR ATL)

STS-107 Meteoroid/Debris Risk Breakdown
### Critical Impact Risks: Based on FRP Attitude Timeline (ATL) Critical Impact Risks:

- For each zone of the vehicle
- Failure criteria and ballistic limit equations (based on hypervelocity impact data) defined
- Previously port/standboard risks combined
- Shuttle geometry model modified to determine risks for port and standboard wing zones

<table>
<thead>
<tr>
<th>Odds of Critical Penetration</th>
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<tbody>
<tr>
<td>1 in 2400</td>
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<tr>
<td>1 in 2500</td>
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<tr>
<td>1 in 370</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability of No Penetration</th>
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</thead>
<tbody>
<tr>
<td>0.9958</td>
</tr>
<tr>
<td>0.9968</td>
</tr>
<tr>
<td>0.9973</td>
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</tbody>
</table>

(WLE, bottom, top)
Standboard Wing only
(WLE, bottom, top)
Port Wing only
Overall Vehicle