

**NASA**

**SECTION 6**



Hypervelocity Impact  
Technology Facility  
Human Exploration Science  
Office SX

### Need As-Flown ATL

Presenter:

Eric Christiansen

Date:

February 5, 2003

- 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)

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# **Backup Slides**

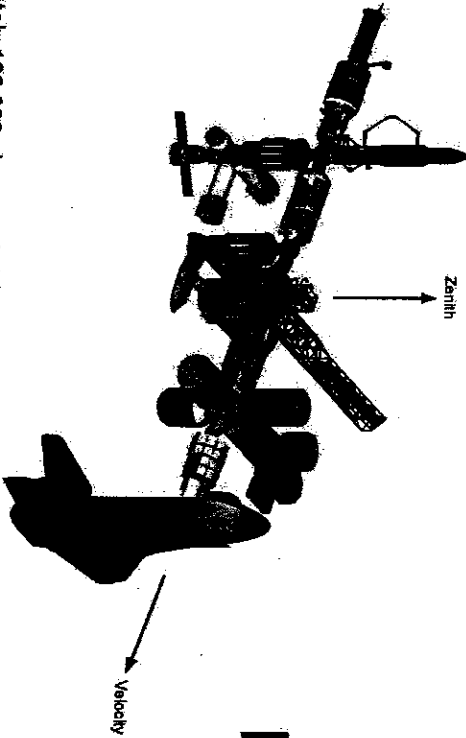
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# NASA/JSC BUMPER-II Meteoroid/Debris Threat Assessment Code

## Spacecraft Configuration (I-DEAS Finite Element Model)

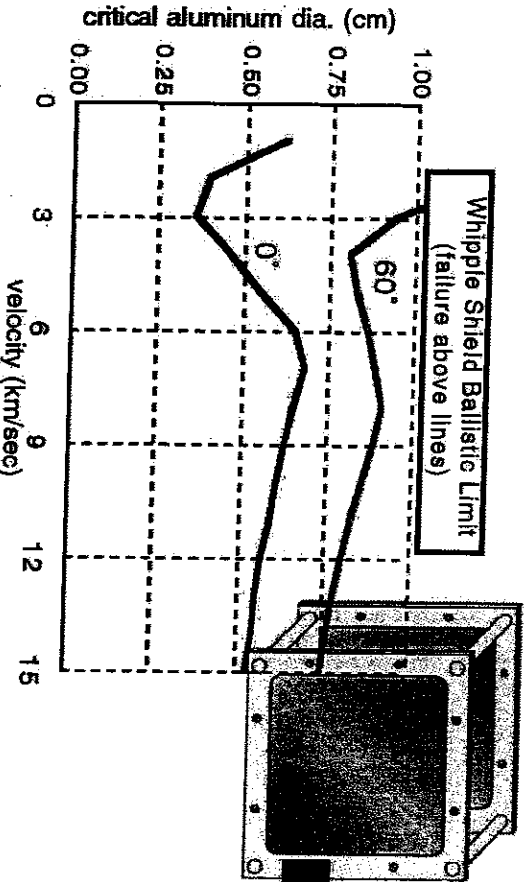
- Describes spatial relationships of spacecraft components
- Defines spacecraft orientation (velocity and zenith directions)
- Defines MOD shield regions



- Approximately 120,000 elements in ISS assembly complete mated configuration FEM

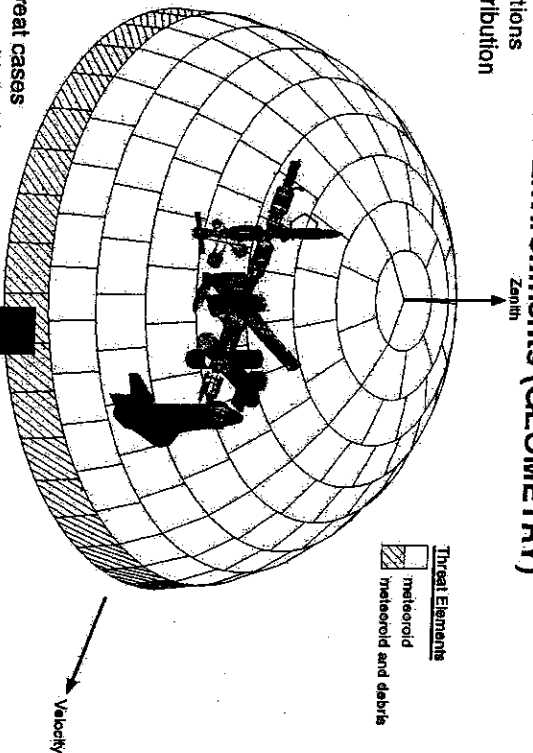
## Critical Particle Diameter Calculation (RESPONSE)

- Protection capability



## Meteoroid & Debris Environments (GEOMETRY)

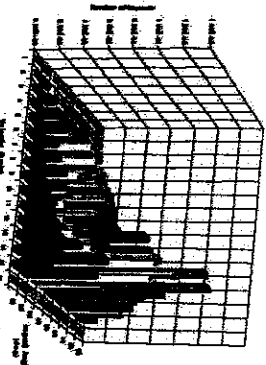
- Threat directions
- Velocity distribution
- Shadowing



- 90 debris threat cases and 149 meteoroid threat cases assessed for each element in the FEM

## Computation of Penetrating Flux and PNP (SHIELD) Graphical Interpretation of Results (EXCEL & I-DEAS)

Space Station Orbital Debris Threat Assessment					
Station Region	Impact Risk From 1mm <sup>3</sup> Debris	Date of Impact	Probability No Penetration	Order of Penetration	Order of Penetration
FGB	0.9896336	1/214	0.9896341	1/224	1/224
Service Module	0.9896335	1/1605	0.9896796	1/1612	1/1612
Node 2	0.990465	1/105	0.990666	1/825000	1/825000
Hub Module	0.985074	1/28	0.989823	1/828	1/828
Lab Module	0.985522	1/88	0.989022	1/1023	1/1023
CRV	0.987443	1/391	0.989839	1/8223	1/8223
TOTALS	0.894622	1/15	0.983132	1/146	1/146





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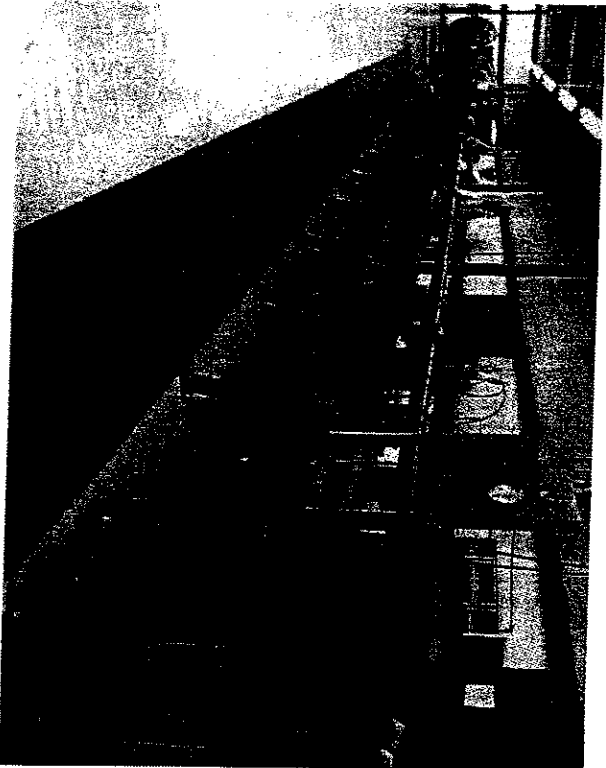
## Software Verification

Presenter:

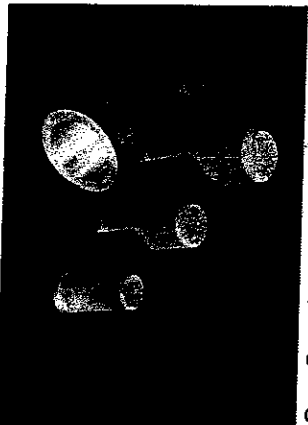
Eric Christiansen

Date:

February 5, 2003



JSC WSTF Two stage light-gas gun.



SWRIs Inhibited  
Shaped Charge  
Launcher.



— Testing provides data to develop and verify ballistic limit equations used in BUMPER code

- Two stage light-gas guns are used to accelerate projectiles to velocities up to 7 km/s
- Inhibited shaped charge launcher used to accelerate projectiles to velocities in excess of 11 km/s
- High quality diagnostic equipment
  - high speed laser shadowgraph cameras
  - flash x-ray systems
    - used to verify the projectile's integrity and velocity before and during target impact

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# **STS-107 Flight Readiness Review METEOROID/ORBITAL DEBRIS ASSESSMENT**

**18 December 2002**

**Jim Hyde**

**Mark Matney**

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### Assessment

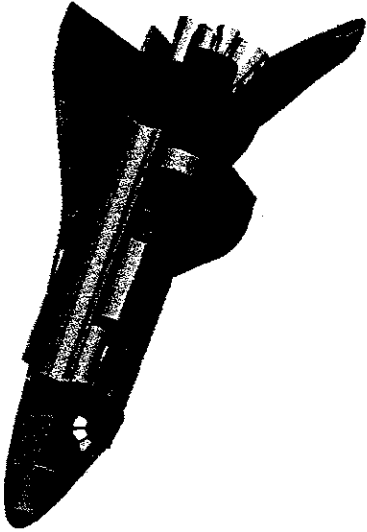
Presenter:

Eric Christiansen

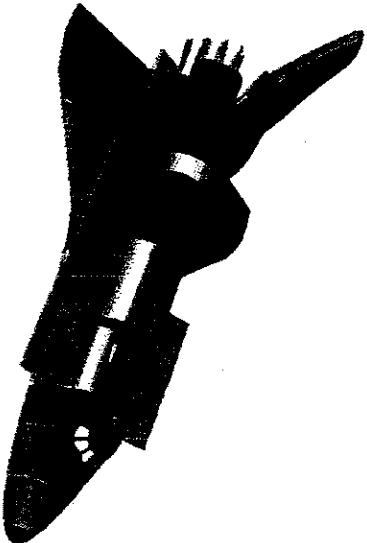
Date:

February 5, 2003

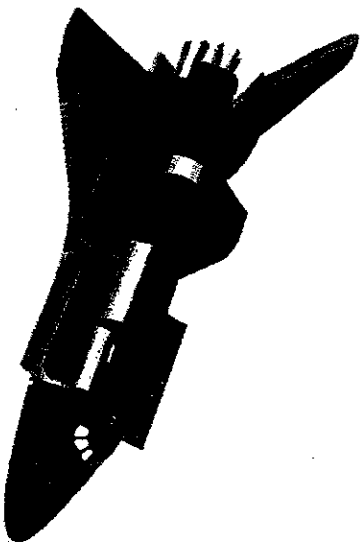
- Launch: January 16, 2003
- 16 Day Attitude Timeline provided by Andrew Lalich/DO4
- 150 Finite Element Model / attitude combinations
- BUMPER-Shuttle code w/ORDEM2000 debris environment model



Both Rads Stowed



Port Rad Deployed



Both Rads Deployed





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**Collision Avoidance Maneuvers**

**Presenter:**

**Eric Christiansen**

**Date:**

**February 5, 2003**

- **Current Satellite Catalogue analyzed to estimate maneuver probability using the 2x14x14 km “yellow” box**
- **Probability of 1 or more maneuver alerts is 1 in 5.7 (1 in 6 is typical)**







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### **Breakups**

**Presenter:**

**Eric Christiansen**

**Date:**

**February 5, 2003**

- **Satellite 19122, 1988-040B**
  - Ariane 2 rocket body
  - broke up July 9 in a 535 km x 35,445 km, 7.0 deg orbit
- **1% increase in debris penetrating flux is required.**





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### Meteoroid Showers

**Presenter:**

Eric Christiansen

**Date:**

February 5, 2003

- Meteor shower activity will increase the meteoroid critical penetrating flux over background by 5.3%
- Meteor shower activity will increase the meteoroid window and radiator damaging flux over background by 2.8%

Shower	Peak	Approximate Zenith Hourly Rate
Delta Cancrids	Jan 19	11
Alpha Leonids	Jan 29	7





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### Meteoroid/Orbital Debris Risk Assessment Results

Presenter:  
Eric Christiansen

Date:  
February 5, 2003

	STS-107 <u>Risk</u>	Shuttle <u>Guideline</u>
Odds of critical penetration	1 in 370	1 in 200
Probability of no critical penetration	0.9973	0.9950
Odds of radiator leak (both rads DEPLOYED)	1 in 315	1 in 61
Probability of no radiator leak	0.9968	0.9837
Expected number of window replacements	2.1	
Window replacement risk	88%	

**NOTE:**

Odds of radiator leak (both rads STOWED)

Probability of no radiator leak

1 in 334

0.9970





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## Summary

Presenter:

Eric Christiansen

Date:

February 5, 2003

- Assessment indicates that the Orbiter is within guidelines for critical penetration risk.
- Assessment indicates that the Orbiter is within guidelines for radiator leak risk.
- There is a 1 in 5.7 probability that one or more collision avoidance maneuver warnings will occur.
- SX2 will be on-call during the mission to assess additional attitudes or satellite breakup events.





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### Recent Flights

Presenter:

Eric Christiansen

Date:

February 5, 2003

### • STS-112 (9A)

- Launch: 10/07/02
- 0 Collision Avoidance Maneuvers
- Radiator Panel L4 – 0.4mm (0.016in) diameter hole in facesheet

### • STS-113 (11A)

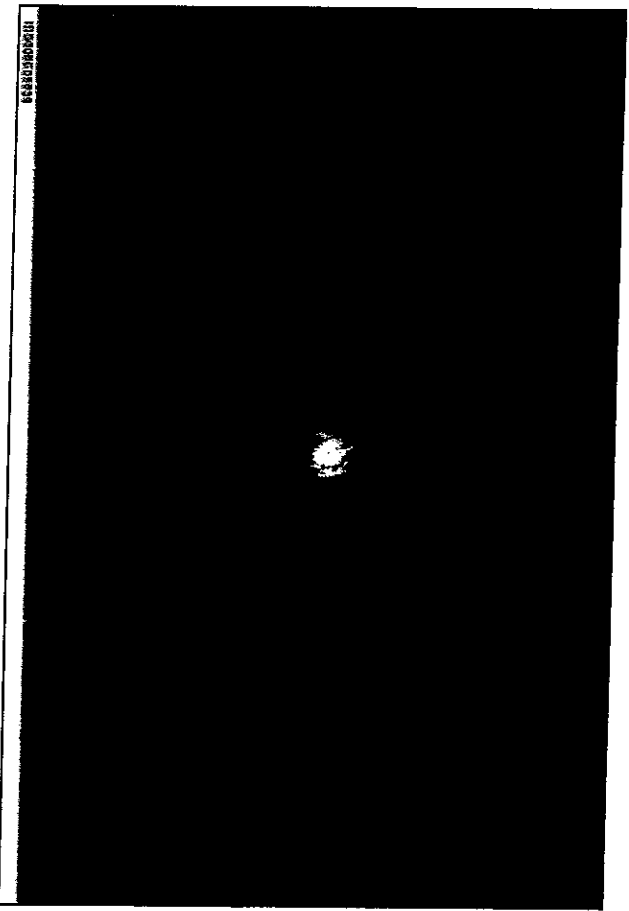
- Launch: 11/23/02
- 0 Collision Avoidance Maneuvers

#### W111 Impact →

Crater diam = 2.2mm (0.088in)

Crater depth = 0.3mm (0.013in)

Internal fracture = 4.0 mm (0.156in)



**Michele Lewis**


---

**From:** SHACK, PAUL E. (JSC-EA42) (NASA)  
**Sent:** Tuesday, January 21, 2003 10:56 AM  
**To:** SHACK, PAUL E. (JSC-EA42) (NASA); ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA)  
**Cc:** KRAMER, JULIE A. (JSC-EA4) (NASA); MILLER, GLENN J. (JSC-EA) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)  
**Subject:** RE: STS-107 Debris Analysis Team Plans

Somebody else had the same recollection. Here's the ET FRR charts:

-----Original Message-----

**From:** SHACK, PAUL E. (JSC-EA42) (NASA)  
**Sent:** Tuesday, January 21, 2003 9:33 AM  
**To:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA)  
**Cc:** KRAMER, JULIE A. (JSC-EA4) (NASA); MILLER, GLENN J. (JSC-EA) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)  
**Subject:** RE: STS-107 Debris Analysis Team Plans

This reminded me that at the STS-113 FRR the ET Project reported on foam loss from the Bipod Ramp during STS-112. The foam (estimated 4X5X12 inches) impacted the ET Attach Ring and dented an SRB electronics box cover.

Their charts stated "ET TPS foam loss over the life of the Shuttle program has never been a 'Safety of Flight' issue". They were severely wirebrushed over this and Brian O'Conner (Associate Administrator for Safety) asked for a hazard assessment for loss of foam.

The suspected cause for foam loss is trapped air pockets which expand due to altitude and aerothermal heating.

-----Original Message-----

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)  
**Sent:** Monday, January 20, 2003 8:47 PM  
**To:** SHACK, PAUL E. (JSC-EA42) (NASA); SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA)  
**Cc:** KRAMER, JULIE A. (JSC-EA4) (NASA); MILLER, GLENN J. (JSC-EA) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)  
**Subject:** FW: STS-107 Debris Analysis Team Plans

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**

**Michele Lewis**

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**From:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA)  
**Sent:** Tuesday, January 21, 2003 11:16 AM  
**To:** SCHOMBURG, CALVIN (JSC-EA) (NASA)  
**Subject:** FW: STS-107 Debris Analysis Team Plans

FYI, I hope you're aware of all that is going on.

*John Kowal*

ES3/Thermal Branch  
NASA-Johnson Space Center  
(281) 483-8871

-----Original Message-----

**From:** 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

: 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)

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*Pam Madera*

Vehicle and Systems Analysis Subsystem Area Manager

Phone: 281-282-4453



**Michele Lewis**

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**From:** Bell, Dan R. [DRBell@xch-bsco-06.ksc.nasa.gov]  
**Sent:** Monday, January 27, 2003 3:17 PM  
**To:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA)  
**Subject:** FW: STS-107 Debris Briefing for MMT



Debris.ppt

-----Original Message-----

From: Fuller, Mike J.  
Sent: Monday, January 27, 2003 11:44 AM  
To: Gordon, Michael P.; Bell, Dan R.  
Subject: FW: STS-107 Debris Briefing for MMT

-----Original Message-----

From: Fuller, Mike J [mailto:mike.j.fuller@boeing.com]  
Sent: Monday, January 27, 2003 7:23 AM  
To: Sheehan, Gerald; Fuller, Mike J  
Subject: FW: STS-107 Debris Briefing for MMT

> -----Original Message-----

> From: Dunham, Michael J  
> Sent: Thursday, January 23, 2003 9:36 PM  
> To: EXT-Madera, Pamela L; EXT-White, Doug; Alvin Beckner-Jr  
> (E-mail); Bo  
> Bejmuk (E-mail); David Camp (E-mail); Douglas Cline (E-mail); Ed  
> Alexander  
> (E-mail); Frances Ferris (E-mail); Garland Parlier (E-mail); John  
> Mulholland (E-mail); Mark Pickens (E-mail); Michael Burghardt  
> (E-mail);  
> Mike Fuller (E-mail); Norm Beougher (E-mail); Scott Christensen V  
> (E-mail); Steve Harrison (E-mail)  
> Subject: STS-107 Debris Briefing for MMT

>  
> <<Debris.ppt>>

>  
> Michael J. Dunham  
> Boeing/Orbiter SSM - Stress, Loads and Dynamics  
> (281)-853-1697  
> (281)-853-1525 (Fax)

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**Orbiter Assessment of STS-107 ET Bipod  
Insulation Ramp Impact**

**P. Parker**

**D. Chao**

**I. Norman**

**M. Dunham**

**January 23, 2003**



## Order of Analysis

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- **Orbiter assessment of ascent debris damage includes**
  - **Evaluation of potential for debris to damage tile and RCC**
    - ◆ **Program “Crater” is official evaluation tool**
      - Available test data for SOFI on tile was reviewed
      - No SOFI on RCC test data available
    - ◆ **Even for worst case, SLP and densified tile layer will remain when SOFI is impactor**
  - **Thermal analysis of areas with damaged tiles**
    - ◆ **Thermal analysis will predict potential tile erosion and temperatures on structure**
  - **Structural assessment based on thermal environment defined above**
    - ◆ **Basis is previous Micrometeoroid and Orbital Debris (M/OD) study performed in 1996**

