# NASA

# SECTION 24

# Preliminary Debris Transport Assessment of Debris Impacting Orbiter Lower Surface in STS-107 Mission

## January 21, 2003

Subcontract 1970483303

W.B.S. 1.2.2.1 / 20037

PDRD SC004

Carlos Ortiz (281) 226-5775
Arturo Green (281) 226-5540
Jack McClymonds (714) 372-6753
Jeff Stone (714) 934-1773
Abdi Khodadoust (714) 235-7746



BOEING

# Debris Impacts Orbiter Lower Surface

- **Issue** – At about 82 seconds into the flight, a large piece of debris was seen emanating from the ET bipod area and later seen impacting the Orbiter lower surface tiles

- **Background**
  - Preliminary assessment of debris impact conditions predicted an impact to the Orbiter lower surface at location XO1049, YO185 (results provided on January 17, 2003)
    - Impact Velocity estimated to be 750 ft/sec.
    - Impact Angle estimated to be less than 20 degrees
  - Refinement of the results show reduction of impact angle and impact velocity
  - Analysis methodology and results were presented to the Aero Panel on January 21, 2003
    - Aero Panel concurrence was obtained
    - Aero Panel recommended sending results to Orbiter Program for damage assessment

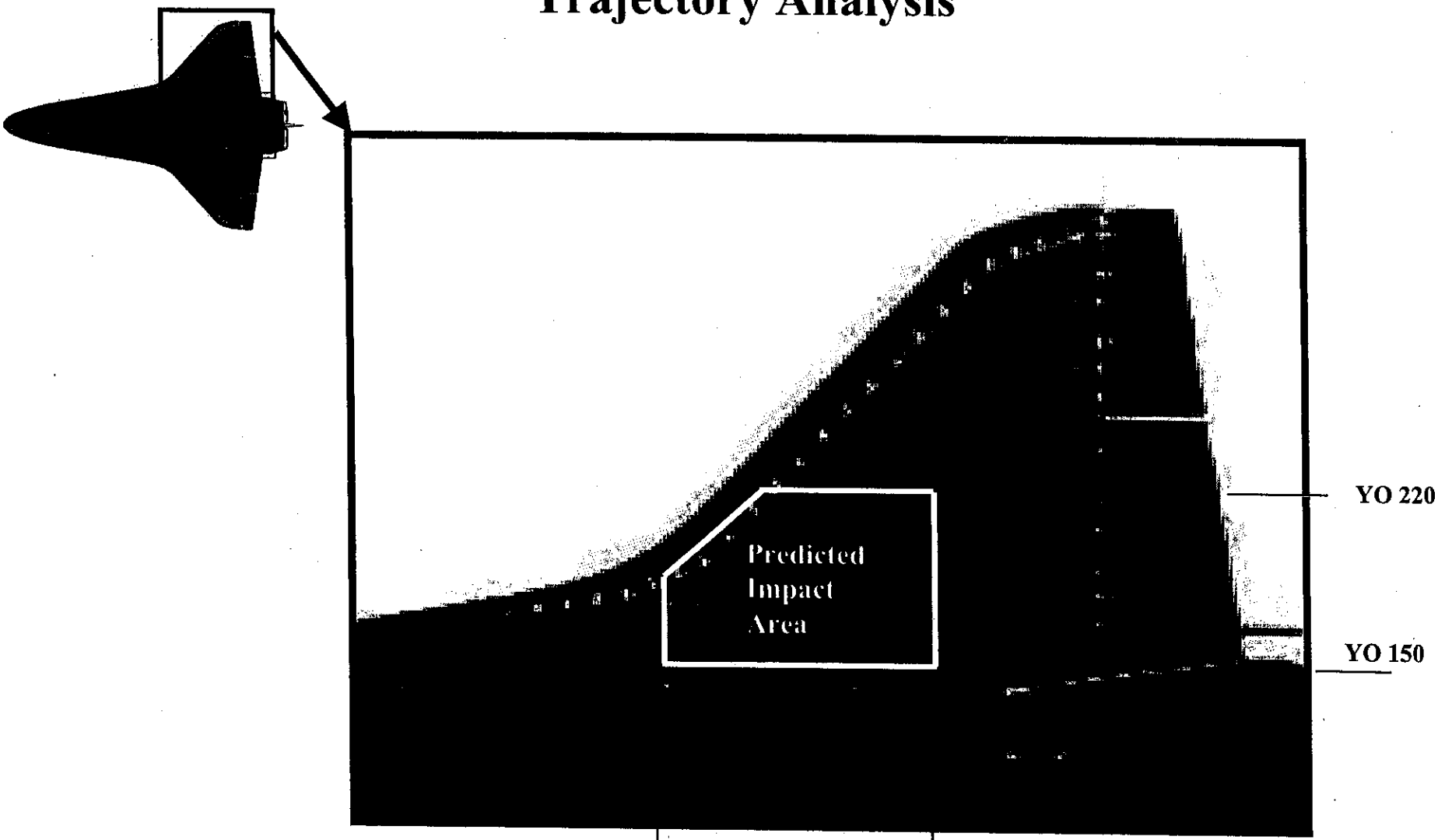
# Debris Impact Conditions to Be Evaluated for Area on Orbiter Lower Surface

- **Actions Taken**
  - Defined impacts area based on film observations and debris trajectory modeling
    - Large uncertainty in trajectory computation does not allow a good prediction of the impact area
  - Performed debris trajectory computations to define impact conditions inside impact area.
    - Debris particle emanates from bipod ramp area (XO 389, YO 50)
    - Two debris sizes analyzed:
      - 20" x 10" x 6" (representing flange foam)
      - 20" x 16" x 6" (representing bipod ramp)
    - Debris material considered to be foam (density = 2.4 lb/ft3)
    - Particle subjected to initial lateral motion to simulate lateral loading of bipod ramp
  - Impact conditions inside predicted impact area was derived as follows:
    - Actual Impacts: Particle impact information as computed by the debris trajectory program
    - Near Impacts: Particle velocity obtained for specific points in particle trajectory
    - Debris Database: to define particle impact angles at locations in the landing gear wheel well

# Results Show Low Impact Angles on the Orbiter Lower Surface

- **Results -**
  - Completed evaluating results for trajectory analysis of foam debris of size = 20"x10"x6"
    - Impact velocity inside predicted impact area range between 650 and 730 ft/sec.
      - Impact velocity at wing RCC may vary between 700 and 720 ft/sec.
      - Impact velocity at Landing wheel well varies between 650 and 730 ft/sec.
    - Impact angles can be expected to be larger near wing leading edges because of wing curvature
      - RCC impacts can be as high as 22 degrees in some regions
    - Impact angles at the landing wheel well are expected to be less than 10 degrees
  - Results for trajectory analysis of foam debris of size = 20"x16"x6" are currently under evaluation

# Predicted Impact Area Derived from Film Observations and Trajectory Analysis




STS-107 Debris Impacting Orbiter Wing

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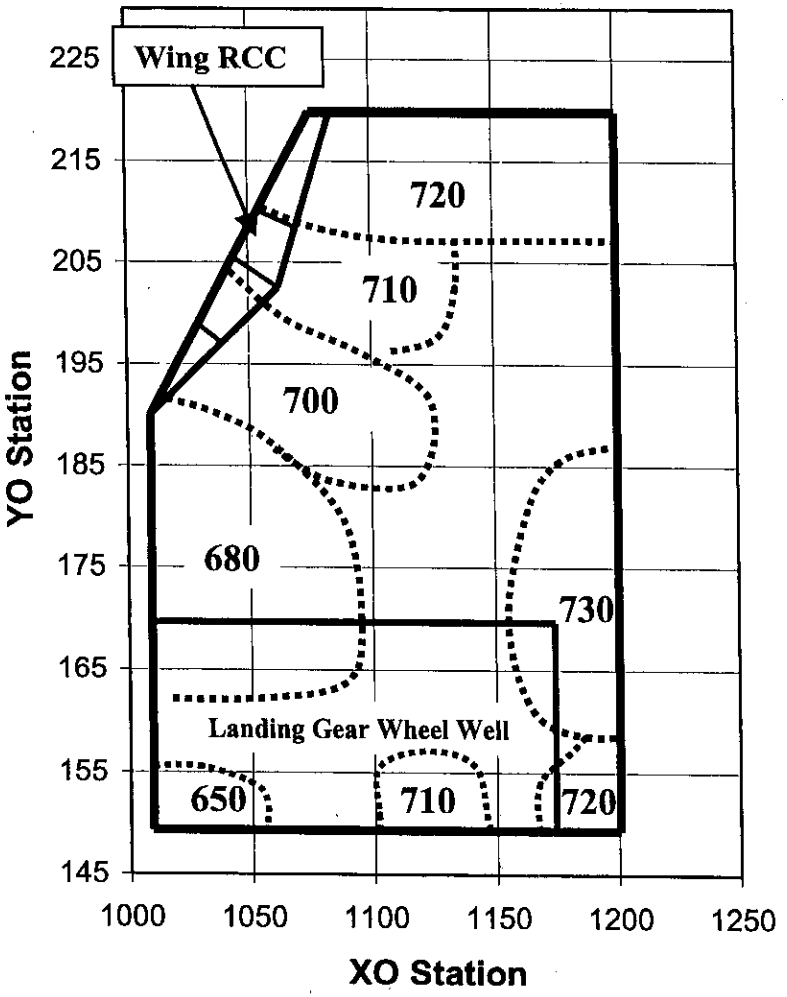
# Velocity and Impact Angle Distribution Inside Impact Area

## (Debris Size = 20" x 10" x 6", Density = 2.4 lb/ft3)

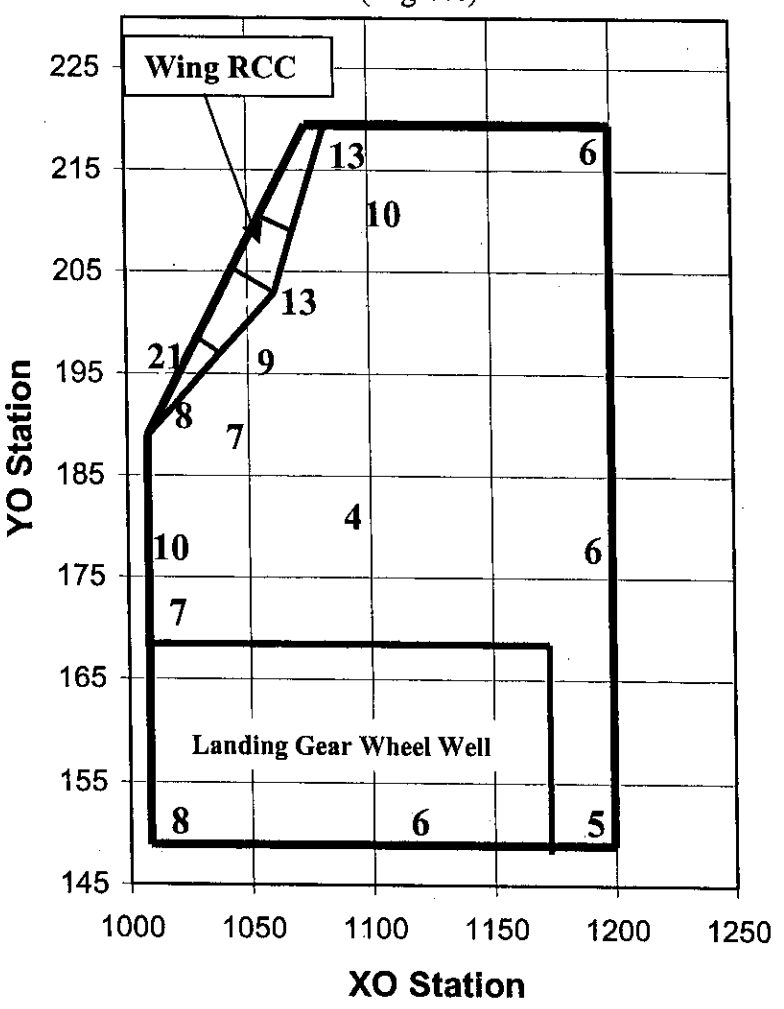
### Impact Velocity

(ft/sec.)




### Impact Angle

(degrees)




STS-107 Debris Impacting Orbiter Wing

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# More Results Underway

- **Conclusions -**
  - Impact conditions were presented for a debris of size = 20"x10"x6"
    - Impact velocity inside predicted impact area range between 650 and 730 ft/sec.
    - Impact angles can be expected to be larger near wing leading edges because of wing curvature
    - Impact angles at the landing wheel well are expected to be less than 10 degrees
  - Results for trajectory analysis of foam debris of size = 20"x16"x6" are currently under evaluation
    - Preliminary assessment of the data shows impact velocity range between 558 and 700 ft/sec.
    - Impact angles generally low (in same order as those presented for particle size = 20"x10"x6")
    - Expected completion of task is 1/22/03.

# Back-Up

# Results of Impact Analysis for particle size = 20" x 10" x 6"

| XT | YT | ZT | VMAX (ft/sec.) | VX (ft/sec.) | VY (ft/sec.) | VZ (ft/sec.) | IMPANG (degrees) |
|---|---|---|---|---|---|---|---|
| 1755 | 193 | 625 | 690 | 682 | 104 | 20 | 9.0 |
| 1759 | 194 | 630 | 689 | 680 | 107 | 25 | 9.4 |
| 1744 | 190 | 637 | 693 | 683 | 107 | 36 | 8.7 |
| 1755 | 191 | 641 | 698 | 689 | 107 | 41 | 7.8 |
| 1800 | 197 | 648 | 702 | 693 | 105 | 46 | 8.8 |
| 1747 | 190 | 626 | 686 | 677 | 104 | 21 | 7.0 |
| 1769 | 192 | 629 | 682 | 674 | 105 | 23 | 7.1 |
| 1751 | 188 | 637 | 685 | 676 | 105 | 35 | 10.4 |
| 1754 | 188 | 641 | 690 | 681 | 104 | 40 | 7.8 |
| 1754 | 187 | 644 | 694 | 684 | 103 | 44 | 6.6 |
| 1755 | 197 | 627 | 693 | 684 | 107 | 23 | 11.9 |
| 1748 | 195 | 630 | 691 | 682 | 107 | 27 | 13.3 |
| 1756 | 194 | 638 | 699 | 689 | 109 | 37 | 8.9 |
| 1806 | 202 | 645 | 712 | 703 | 109 | 42 | 11.3 |
| 1788 | 199 | 647 | 711 | 701 | 109 | 46 | 10.4 |
| 1762 | 200 | 627 | 700 | 691 | 109 | 24 | 21.5 |
| 1833 | 211 | 633 | 707 | 698 | 110 | 28 | 9.6 |
| 1802 | 204 | 641 | 713 | 703 | 110 | 38 | 12.8 |
| 1790 | 202 | 644 | 711 | 702 | 110 | 42 | 11.3 |
| 1781 | 200 | 647 | 712 | 703 | 108 | 46 | 11.1 |
| 1744 | 186 | 625 | 683 | 675 | 102 | 18 | 6.5 |
| 1718 | 181 | 627 | 673 | 665 | 101 | 22 | 6.0 |
| 1742 | 184 | 636 | 653 | 645 | 98 | 30 | 2.0 |
| 1652 | 169 | 635 | 635 | 627 | 96 | 32 | 0.4 |
| 1593 | 159 | 634 | 611 | 603 | 92 | 34 | 2.0 |
| 1786 | 198 | 621 | 705 | 697 | 104 | 15 | 7.5 |
| 1799 | 201 | 624 | 702 | 694 | 105 | 18 | 7.7 |
| 1758 | 194 | 624 | 691 | 683 | 104 | 20 | 9.1 |
| 1830 | 210 | 617 | 723 | 715 | 106 | 12 | 5.4 |
| 1799 | 205 | 620 | 710 | 702 | 106 | 15 | 7.9 |
| 1790 | 202 | 623 | 707 | 699 | 106 | 17 | 8.1 |
| 1762 | 198 | 625 | 694 | 686 | 107 | 21 | 11.8 |
| 1788 | 196 | 620 | 705 | 697 | 102 | 14 | 7.0 |
| 1798 | 198 | 623 | 698 | 691 | 103 | 17 | 7.2 |
| 1755 | 191 | 624 | 687 | 679 | 103 | 19 | 6.8 |
| 2023 | 238 | 615 | 762 | 755 | 103 | 7 | 1.1 |
| 1830 | 210 | 617 | 723 | 715 | 106 | 12 | 5.4 |

**Michele Lewis**

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

**Sent:** Monday, January 20, 2003 6:47 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 [redacted] to discuss analysis plans for assessing the STS-107 Debris Impact.

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

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Sunday, January 26, 2003 8:45 PM
**To:** SHACK, PAUL E. (JSC-EA42) (NASA); MCCORMACK, DONALD L. (DON) (JSC-MV6) (NASA); OUELLETTE, FRED A. (JSC-MV6) (NASA)
**Cc:** ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA); GALBREATH, GREGORY F. (GREG) (JSC-ES2) (NASA); JACOBS, JEREMY B. (JSC-ES4) (NASA); SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA); KRAMER, JULIE A. (JSC-EA4) (NASA); CURRY, DONALD M. (JSC-ES3) (NASA); KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); SCHOMBURG, CALVIN (JSC-EA) (NASA); CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
**Subject:** STS-107 Wing Debris Impact on Ascent: Final analysis case completed

As you recall from Friday's briefing to the MER, there remained open work to assess analytically predicted impact damage to the wing underside in the region of the main landing gear door. This area was considered a low probability hit area by the image analysis teams, but they admitted a debris strike here could not be ruled out.

As with the other analyses performed and reported on Friday, this assessment by the Boeing multi-technical discipline engineering teams also employed the system integration's dispersed trajectories followed by serial results from the *Crater* damage prediction tool, thermal analysis, and stress analysis. It was reviewed and accepted by the ES-DCE (R. Rocha) by Sunday morning, Jan. 26. The case is defined by a large area gouge about 7 inch wide and about 30 inch long with sloped sides like a crater, and reaching down to the densified layer of the TPS.

SUMMARY: Though this case predicted some higher temperatures at the outer layer of the honeycomb aluminum face sheet and subsequent debonding of the sheet, there is no predicted burn-through of the door, no breeching of the thermal and gas seals, nor is there door structural deformation or thermal warpage to open the seal to hot plasma intrusion. Though degradation of the TPS and door structure is likely (if the impact occurred here), there is no safety of flight (entry, descent, landing) issue.

Note to Don M. and Fred O.: On Friday I believe the MER was thoroughly briefed and it was clear that open work remained (viz., the case summarized above), the message of open work was not clearly given, in my opinion, to Linda Ham at the MMT. I believe we left her the impression that engineering assessments and cases were all finished and we could state with finality no safety of flight issues or questions remaining. This very serious case could not be ruled out and it was a very good thing we carried it through to a finish.

**Rodney Rocha (ES2) x38889**

- **Division Shuttle Chief Engineer (DCE), ES-Structural Engineering Division**
- **Chair, Space Shuttle Loads & Dynamics Panel**

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Tuesday, January 21, 2003 11:24 AM
**To:** CURRY, DONALD M. (JSC-ES3) (NASA); KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); 'Pam Madera'; LEVY, VINCENT M. (JSC-EG) (NASA)
**Cc:** RICKMAN, STEVEN L. (JSC-ES3) (NASA); MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA); DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA)
**Subject:** 2 PM STS-107 Wing Impact, Conf. Room 154

I will have conf. room 154 available for this subject today.

**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**

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Monday, January 27, 2003 9:44 AM
**To:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA)
**Cc:** CURRY, DONALD M. (JSC-ES3) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA)
**Subject:** RE: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

John,
Yes, I want you and anyone else from ES3 to please review Ignacio Norman's thermal analysis. I do not have it; it was all verbal from our Boeing SSM for Loads/Stress. If we have to, we can convene Boeing Stress/Loads SSM and any others of the analysis team members.

**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**

## Michele Lewis

**From:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA)
**Sent:** Monday, January 27, 2003 11:35 AM
**To:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Cc:** ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA); GALBREATH, GREGORY F. (GREG) (JSC-ES2) (NASA); JACOBS, JEREMY B. (JSC-ES4) (NASA); CURRY, DONALD M. (JSC-ES3) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); SCHOMBURG, CALVIN (JSC-EA) (NASA); CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA); MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)
**Subject:** RE: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

I talked to Ignacio about the analysis he ran. In the case he ran, the large gouge is in the acreage of the door. If the gouge were to occur in a location where it passes over the thermal barrier on the perimeter of the door, the statement that there is "no breeching of the thermal and gas seals" would not be valid. I think this point should be clarified; otherwise, the note sent out this morning gives a false sense of security.

*John Kowal*

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

-----Original Message-----
**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Sunday, January 26, 2003 7:45 PM
**To:** SHACK, PAUL E. (JSC-EA42) (NASA); MCCORMACK, DONALD L. (DON) (JSC-MV6) (NASA); OUELLETTE, FRED A. (JSC-MV6) (NASA)
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- **Chair, Space Shuttle Loads & Dynamics Panel**

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Monday, January 27, 2003 2:19 PM
**To:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA)
**Subject:** RE: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

I go the total story on no breech from our Loads/Stress SSM, who had talked to Ignacio earlier. We can certainly re-visit this, of course.

**Rodney Rocha**
**Structural Engineering Division (ES-SED)**
- **ES Div. Chief Engineer (Space Shuttle DCE)**
- **Chair, Space Shuttle Loads & Dynamics Panel**

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## Michele Lewis

**From:** MCCORMACK, DONALD L. (DON) (JSC-MV6) (NASA)
**Sent:** Monday, January 27, 2003 6:32 AM
**To:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Cc:** OUELLETTE, FRED A. (JSC-MV6) (NASA); SHACK, PAUL E. (JSC-EA42) (NASA)
**Subject:** RE: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

Rodney,
I thought that I mentioned to the MMT that we had run all but one case, although it may have not been clearly stated. I'll make sure that she understands that this final case has been completed.
Don

-----Original Message-----
**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Sunday, January 26, 2003 7:45 PM
**To:** SHACK, PAUL E. (JSC-EA42) (NASA); MCCORMACK, DONALD L. (DON) (JSC-MV6) (NASA); OUELLETTE, FRED A. (JSC-MV6) (NASA)
**Cc:** ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA); GALBREATH, GREGORY F. (GREG) (JSC-ES2) (NASA); JACOBS, JEREMY B. (JSC-ES4) (NASA); SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA); KRAMER, JULIE A. (JSC-EA4) (NASA); CURRY, DONALD M. (JSC-ES3) (NASA); KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); SCHOMBURG, CALVIN (JSC-EA) (NASA); CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
**Subject:** STS-107 Wing Debris Impact on Ascent: Final analysis case completed

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

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Wednesday, January 22, 2003 12:24 PM
**To:** RICKMAN, STEVEN L. (JSC-ES3) (NASA); JACOBS, JEREMY B. (JSC-ES4) (NASA)
**Subject:** FW: ET Foam Loss

The original question from Linda Ham/SSP.

**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:** WALLACE, RODNEY O. (ROD) (JSC-MS2) (NASA)
**Sent:** Wednesday, January 22, 2003 11:01 AM
**To:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); LEVY, VINCENT M. (JSC-EG) (NASA); GOMEZ, REYNALDO J. (RAY) (JSC-EG3) (NASA); 'White, Bob'; 'Nagle, Scott'
**Cc:** RICHART, JENE A. (JSC-MS2) (NASA); ESS, ROBERT H. (BOB) (JSC-MS2) (NASA)
**Subject:** FW: ET Foam Loss

Do you guys think we can answer Lambert's question? I gave him my thoughts, but I would like yours.
-----Original Message-----
**From:** AUSTIN, LAMBERT D. (JSC-MS) (NASA)
**Sent:** Wednesday, January 22, 2003 10:36 AM
**To:** WALLACE, RODNEY O. (ROD) (JSC-MS2) (NASA)
**Subject:** FW: ET Foam Loss

can we develop a rationale that would support or put a limit on this?????
-----Original Message-----
**From:** HAM, LINDA J. (JSC-MA2) (NASA)
**Sent:** Wednesday, January 22, 2003 9:33 AM
**To:** AUSTIN, LAMBERT D. (JSC-MS) (NASA); ROE, RALPH R. (JSC-MV) (NASA)
**Subject:** ET Foam Loss

Can we say that for any ET foam lost, no 'safety of flight' damage can occur to the Orbiter because of the density?

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)

**Sent:** Thursday, January 23, 2003 8:59 AM

**To:** SHACK, PAUL E. (JSC-EA42) (NASA); SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA); KRAMER, JULIE A. (JSC-EA4) (NASA); CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA); MILLER, GLENN J. (JSC-EA) (NASA)

**Subject:** FW: STS-107 Debris Analysis Team Meeting

FYI.

**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

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

**From:** Madera, Pamela L

**Sent:** Monday, January 20, 2003 5:47 PM

**To:** CURRY, DONALD M; ROCHA, ALAN RODNEY; LEVY, VINCENT M; KOWAL, T JOHN; DERRY, STEPHEN M

**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

**Michele Lewis**

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**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)

**Sent:** Monday, January 20, 2003 9:47 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**
- **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

**Michele Lewis**

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)

**Sent:** Wednesday, January 22, 2003 6:56 PM

**To:** FOGT, VINCENT A. (JSC-ES2) (NASA); RICHART, JENE A. (JSC-MS2) (NASA); LARSEN, CURTIS E. (JSC-MS2) (NASA); 'erica.e.bruno@usahq.unitedspacealliance.com'; TAYLOR, DENEEN M. (JSC-ES2) (NASA)

**Subject:** FW: STS-107 Revised Landing Weight

Does this possibility of STS-107 Orbiter landing weight exceedance cause any impacts to the Orbiter/cargo interface landing loads? Thanks.

**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 5:49 PM
**To:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Subject:** FW: STS-107 Revised Landing Weight

Rodney,
The action that was given to our area from the MER is to say what would be required to waive the 233000 lb downweight limit and to discuss what downweight exceedances have occurred in the past. The weight that I was informally told was about 233,700 lbs. No work is turned on right now - they just want to know what would be required.

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

-----Original Message-----
From: Davies, Tim [mailto:tim.davies@boeing.com]
Sent: Wednesday, January 22, 2003 1:25 PM
To: Hoffman, Thomas L; Heinol, Chip C; Goodmark, Jeffrey A; Coronado, Diana; EXT-Chang, Yuan-chyau ; EXT-Hong, Andrew E; Reynolds, Daniel F; Gonzales, Guadalupe; Tran, John Q; Belknap, Shannon; Norman, David; EXT-Madera, Pamela L; Christensen, Scott V; Alexander, Ed C; Carvajal, Olman; Norman, Ignacio; Chao, Dennis C; Russell, David J; Tidwell, Stephen D; Andrews, Bill; EXT-Thomas, Samuel J
Subject: STS-107 Revised Landing Weight

All,

Attached is the flight note which FDO released updating the predicted landing weight. I have not received revised tire limits for these predictions. The preflight NEOM tire limits of 335 psia (11degF) are based on a 232,600 lb. Note that the 657 lb violation is for the downweight limit (233,000 lb); not the same as the limit for the NEOM tire prediction. The predicted landing weights will fluctuate over the next few days so the flight director has asked that no additional analysis be performed until landing -4 days.

I will provide updates as they become available.

<<FOFN146.pdf>>

Tim Davies
Boeing - Orbiter TCS
281.483.3919 (MER)

**MCC FLIGHT NOTE - FOFN146**

To FLIGHT, CAPCOM, FAO
From FDO-MAMCDONA
Vehicle OV 102 Flight ID STS-107
Title Potential EOM Downweight Violation

Date 01/22/2003 MET 6/00:43
Status Info_Only Req'd N/A
EFN# FOFN146 Rev

Based on the latest predictions for end-of-mission (EOM) mass properties, the orbiter is expected to exceed the 233,000 lb downweight limit (FR A4-159 ORBITER LANDING WEIGHT) by 657 lbs. The increased downweight can be attributed to overmodeling of propellant and cryogenic usage in pre-mission analysis. An additional 600 lbs of propellant, 468 lbs of cryogenics, and 85 lbs of "non-prop" quantities are expected above the pre-mission values for the KSC255 de-orbit opportunity.

The predicted downweight of **233,657** lbs (EI weight = 234216 lbs) assumes the following:

1. The current propellant management plan is executed, which calls for less interconnected attitude maneuvers. This preserves OMS propellant for EOM, rather than RCS. Any additional OMS above the de-orbit steep cost can be wasted during the de-orbit burn if required.
2. The current cryogenic management plan is executed, which calls for EOM margin to be preserved in the aft tanks. This results in no OMS or RCS ballast required for EOM.
3. Cryogenic usage is based on the current SpaceHab power models. An additional 260 lbs should be added to the orbiter downweight for EGIL's worst case predictions at EOM. This would result in an EI weight of 234476 lbs, and downweight of 233,917 lbs.

The Entry Flight Director met with the Entry FDO Wednesday morning, 1/22, to discuss this issue and decided not to initiate any additional analysis until landing minus four days. The orbit FDOs will continue to monitor the situation and notify the team of any significant changes to the current predictions.

O3 FDO/Mark McDonald

Attachment(s): -none-

[redacted]

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Wednesday, January 29, 2003 10:36 AM
**To:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); CURRY, DONALD M. (JSC-ES3) (NASA)
**Cc:** RICKMAN, STEVEN L. (JSC-ES3) (NASA); 'Mike Dunham'
**Subject:** FW: STS-107 Debris Analysis Team Meeting - Post Landing Data Collection

FYI and I am sure the TPS team at the landing will start to catalog tile damage, as usual. Could they also collect other data, such as impact incident angle too to aid the impact-damage predictor model?

**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:** ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC)
**Sent:** Wednesday, January 29, 2003 9:03 AM
**To:** 'Madera, Pamela L'; 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; SCHOMBURG, CALVIN (JSC-EA) (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)'; ALEXANDER, ED
**Subject:** RE: STS-107 Debris Analysis Team Meeting - Post Landing Data Collection

Hello All,
I was wondering if the team will collect extensive tangible empirical tile/RCC data(length, width, depth, incident angle, etc.) from the vehicle to facilitate debris analysis with SOFI, "crater program", & TMM ?

Thanks.
SSE: TPS/LESS/RCC, etc.

## Michele Lewis

**From:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
**Sent:** Monday, January 20, 2003 12:24 AM
**To:** SHACK, PAUL E. (JSC-EA42) (NASA); 'Woodworth,Warren'
**Cc:** KOWAL, T. J. (JOHN) (JSC-ES3) (NASA); MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA); RICKMAN, STEVEN L. (JSC-ES3) (NASA); ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA)
**Subject:** RE: Impact Damage Reports

Paul,
This is all I know and maybe you already have been getting the photo summaries from Jon Disler. Disler's imaging analysis group seems to be the focus of all initial information and will issue another report Monday. It looks as if Carlos Ortiz/Boeing sys. integ. (not ours of JSC) is standing by to be turned on, if necessary, to do some kind of transport analysis. Mike Dunham is aware and can do impact analysis if and when we know more.

I assume the MER is plugged into Jon Disler's periodic reports? Is there a chit in work for the crew to try see the top side of the left wing somehow? We know the RMS and RMS Cameras are not available, but what about the left side hatch little window (in the mid-deck)?

I talked briefly to ES3/Thermal Branch engineers on Friday about potential damage to the wing and where the worst heating would occur on entry. The answer is the bottom side, of course, and the closer to the root or glove is worse than outboard. For info for mission ops decision options, I asked about higher cross-range entry trajectories, as would occur on a hypothetical second or third de-orbit entry compared to the first de-orbit opportunity. The predicted heating would be somewhat higher (but not a lot higher they say) for the second de-orbit try with additional cross-range. I don't know about heating from a third de-orbit attempt to the same landing site.


**Rodney Rocha**

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


-----Original Message-----
**From:** SHACK, PAUL E. (JSC-EA42) (NASA)
**Sent:** Sunday, January 19, 2003 5:23 PM
**To:** ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); 'Woodworth,Warren'
**Subject:** Impact Damage Reports

If you guys have anything info on the debris impact assessment, would you please forward. Thanks


RE: STS-107 JSC STS-107
ıg Range Trackinch Film Scree