NASA

SECTION 17

Michele Lewis

rom: Barnwell, Maria M [Maria.M.Barnwell@boeing.com]
Sent: Friday, December 13, 2002 7:06 PM
To: DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA)
Subject: RE: wing trailing edge


WTREOM_PE-traj.pdf WTREOM-heating.pdf

Here is the PE case with most down body flap deflection as you can see in
the trajectory listing.
<<WTREOM_PE-traj.pdf>> <<WTREOM-heating.pdf>>
Have a nice weekend!

-----Original Message-----
From: DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA)
[mailto:stephen.m.derry@nasa.gov]
Sent: Friday, December 13, 2002 5:54 PM
To: 'Barnwell, Maria M'
Cc: Chao, Dennis C
Subject: RE: wing trailing edge

Thanks very much!

-----Original Message-----
From: Barnwell, Maria M [mailto:Maria.M.Barnwell@boeing.com]
Sent: Friday, December 13, 2002 5:47 PM
To: DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA)
Cc: Chao, Dennis C
Subject: wing trailing edge

Enclosed are the heating plots for our hottest certification case HV48FW57
(248K, 57°, fwd xcg). The body points you want to look at (and we have enclosed in the attachment) are in the wing lower surface:
2960 & 2967 in the 90% span,
2867 & 2871 in the80% and
2770 & 2773 in the 70%

<<all WING-BPTs.pdf>> <<HW48FW57-heating.pdf>>
I didn't extract the specific plots, I'm sending you the whole page. The
other file is to help with the location of the points.

Maria M Barnwell
Phone (281) 853-1785
Fax (281) 853-1610
Email: maria.m.barnwell@boeing.com

Michele Lewis

From: LEVY, VINCENT M. (JSC-EG) (NASA)
Sent: Friday, January 24, 2003 4:51 PM
To: DERRY, STEPHEN M. (STEVE) (JSC-EG3) (NASA); GOMEZ, REYNALDO J. (RAY) (JSC-EG3) (NASA)
Subject: FW: STS-107 Debris Briefing for MMT

Ray- I had in my inbox- in case you wanted electronic copy.

Vincent M. Levy
EG/Aeroscience & Flight Mechanics
Shuttle Division Chief Engineer
281-483-0874 (w)

281-483-1245 (fax)

-----Original Message-----
From: White, Doug [mailto:Doug.White@USAHQ.UnitedSpaceAlliance.com]
Sent: Thursday, January 23, 2003 10:23 PM
To: Wilder, James; Reeves, William D; CURRY, DONALD M. (JSC-ES3) (NASA); SCHOMBURG, CALVIN (JSC-EA) (NASA); LEVY, VINCENT M. (JSC-EG) (NASA); ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Subject: FW: STS-107 Debris Briefing for MMT

Potential tile damage charts for the MMT tomorrow morning. Mike Dunham will pitch these.

Doug White
Director, Operations Requirements
281 282-2879 office
281 282-4438 fax

600 Gemini
Houston, TX 77058

"Never let the fear of striking out get in your way." -Babe Ruth

-----Original Message-----
From: Dunham, Michael J [mailto:Michael.J.Dunham@boeing.com]
Sent: Thursday, January 23, 2003 8:36 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)

Michele Lewis

'om: HALLIDAY, ROBERT W. (DOC) (JSC-NC) (GHG)
ent: Friday, January 31, 2003 2:23 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: RE: Cookoff

Anyway, that particular cartridge won't go off at temps as high as 350 deg. F I believe. I'm here in B15 in the pyro area now for about 1 1/2 years and I left most of my files over in B17. I'll get over there this afternoon and look it up. The MLG Uplock Ctg. has KClO4 and HES 6573 propellant. I think we qualified it to 350 deg due to soakback off the tarmac when the MLG doors are open. That kind of propellant is not extremely sensitive to heat. The HES series of mix can withstand temps up to 260 deg C for four hours. Let's see, 260 C is what?... roughly 500 deg F.? I don't think yo have to worry about it unless it's a pretty good sized hole and the wheel well really heated up. What caused the debris? I haven't heard about this.

-----Original Message-----
From: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Sent: Thursday, January 30, 2003 4:43 PM
To: HALLIDAY, ROBERT W. (DOC) (JSC-NC) (GHG)
Subject: Cookoff

At what temp might the main gear backup pyro actuator fire if accidentally heated due to a hot plasma burn through into the wheel well during entry. The STS-107 debris impact under the left wing has us wildly speculating.

CCC

Michele Lewis

'om: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
ant: Friday, January 24, 2003 3:00 PM
To: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Subject: Persistence

You won't believe how many things are worked under the table or confidentially from the top down. It's like what the richest man in Houston once said, "You can accomplish a lot in this world if you don't mind who gets credit for it."

Michele Lewis

'om: Robert H. Daugherty [r.h.daugherty@larc.nasa.gov]
ent: Thursday, January 30, 2003 6:23 PM
To: LECHNER, DAVID F. (JSC-DF52) (USA)
Cc: M.J.SHUART@larc.nasa.gov; H.M.ADELMAN@larc.nasa.gov; CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Main Gear Breach Concerns

Hi David,
I talked to Carlisle a bit ago and he let me know you guys at MOD were getting into the loop on the tile damage issue. I'm writing this email not really in an official capacity but since we've worked together so many times I feel like I can say pretty much anything to you. And before I begin I would offer that I am admittedly erring way on the side of absolute worst-case scenarios and I don't really believe things are as bad as I'm getting ready to make them out. But I certainly believe that to not be ready for a gut-wrenching decision after seeing instrumentation in the wheel well not be there after entry is irresponsible. One of my personal theories is that you should seriously consider the possibility of the gear not deploying at all if there is a substantial breach of the wheel well. The reason might be that as the temps increase, the wheel (aluminum) will lose material properties as it heats up and the tire pressure will increase. At some point the wheel could fail and send debris erywhere. While it is true there are thermal fuses in the wheel, if ne rate of heating is high enough, since the tire is such a good insulator, the wheel may degrade in strength enough to let go far below the 1100 psi or so that the tire normally bursts at. It seems to me that with that much carnage in the wheel well, something could get screwed up enough to prevent deployment and then you are in a world of hurt. The following are scenarios that might be possible...and since there are so many of them, these are offered just to make sure that some things don't slip thru the cracks...I suspect many or all of these have been gone over by you guys already:

1. People talk about landing with two flat tires...I did too until this came up. If both tires blew up in the wheel well (not talking thermal fuse and venting but explosive decomp due to tire and/or wheel failure) the overpressure in the wheel well will be in the 40 + psi range. The resulting loads on the gear door (a quarter million lbs) would almost certainly blow the door off the hinges or at least send it out into the slip stream...catastrophic. Even if you could survive the heating, would the gear now deploy? And/or also, could you even reach the runway with his nd of drag?
2. The explosive bungies...what might be the possibility of these firing due to excessive heating? If they fired, would they send the gear door and/or the gear into the slipstream?

3. What might excessive heating do to all kinds of other hardware in the wheel well...the hydraulic fluid, uplocks, etc? Are there vulnerable hardware items that might prevent deployment?
4. If the gear didn't deploy (and you would have to consider this before making the commitment to gear deploy on final) what would happen control-wise if the other gear is down and one is up? (I think Howard Law and his community will tell you you're finished)
5. Do you belly land? Without any other planning you will have already committed to KSC. And what will happen during derotation in a gear up landing (trying to stay away from an asymmetric gear situation for example) since you will be hitting the aft end body flap and wings and pitching down extremely fast a la the old X-15 landings? My guess is you would have an extremely large vertical decel situation up in the nose for the crew. While directional control would be afforded in some part by the drag chute...do you want to count on that to keep you out of the moat?
6. If a belly landing is unacceptable, ditching/bailout might be next on the list. Not a good day.
7. Assuming you can get to the runway with the gear deployed but with two flat tires, can the commander control the vehicle both in pitch and lateral directions? One concern is excessive drag (0.2 g's) during TD throughout the entire saddle region making the derotation uncontrollable due to .turated elevons...resulting in nose gear failure? The addition of crosswinds would make lateral control a tough thing too. Simulating this, because it is so ridiculously easy to do (sims going on this very minute at AMES with load-persistence) seems like a real no-brainer.

Admittedly this is over the top in many ways but this is a pretty bad time to get surprised and have to make decisions in the last 20 minutes. You can count on us to provide any support you think you need.
Best Regards,
Bob

Michele Lewis

om: MARAIA, ROBERT J. (JSC-ES1) (NASA)
Sent: Friday, January 31, 2003 11:39 AM
To: DL ES Division
Subject: Landing tomorrow

ksc256_long.gif

Tomorrow's landing at KSC has 2 landing opportunities, on orbit 255 and then 256. The second opportunity would make the orbiter visible to us at about 9:30 am our time, in the southern sky. Sorry the ground track map isn't very good.

ksc256_long.gif

Michele Lewis

From: SMITH, JAMES P. (JSC-ES2) (NASA)
Sent: Wednesday, January 22, 2003 8:15 AM
To: DL ES2 Branch; DL ES2 Contractors
Subject: FW: STS-107 Post-Launch Film Review - Day 1

Watch the video first and see if you can spot anything.

-----Original Message-----
From: Pedraza, Michael A [mailto:michael.a.pedraza@usago.ksc.nasa.gov]
Sent: Tuesday, January 21, 2003 8:35 PM
Subject: STS-107 Post-Launch Film Review - Day 1

Michael Pedraza
Storekeeper/Expediter
MSC-44 RPSF
USK-337
Phone 861-6452
Fax 861-0374

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«¯¯·.¸ *Supply & Support*.¸.·¯¯»
(¸.·º (¸..·'* *'·..¸¸..·'* *'·..¸) º·.¸)

Attached is the Day 1 report and an MPG of Anomaly #1.

Michele Lewis

From: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Sent: Thursday, January 30, 2003 5:38 PM
To: SERIALE-GRUSH, JOYCE M. (JSC-EA) (NASA)
Subject: FW: STS-107 Post-Launch Film Review - Day 1

-----Original Message-----
From: SMITH, JAMES P. (JSC-ES2) (NASA)
Sent: Wednesday, January 22, 2003 7:15 AM
To: DL ES2 Branch; DL ES2 Contractors
Subject: FW: STS-107 Post-Launch Film Review - Day 1

Watch the video first and see if you can spot anything.

-----Original Message-----
From: Pedraza, Michael A [mailto:michael.a.pedraza@usago.ksc.nasa.gov]
Sent: Tuesday, January 21, 2003 8:35 PM
Subject: STS-107 Post-Launch Film Review - Day 1

Michael Pedraza
Storekeeper/Expediter
MSC-44 RPSF
USK-337
Phone 861-6452
Fax 861-0374

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«"" ·.¸ *Supply & Support*.¸·.·"" »
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Attached is the Day 1 report and an MPG of Anomaly #1.

Michele Lewis

From: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Sent: Friday, January 24, 2003 3:33 PM
To: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Subject: FW: STS-107 Landing Weight Status

-----Original Message-----
From: Hoffman, Thomas L [mailto:Thomas.L.Hoffman@boeing.com]
Sent: Thursday, January 23, 2003 3:49 PM
To: LECHNER, DAVID F. (JSC-DF52) (USA)
Subject: RE: STS-107 Landing Weight Status

Dave,
Thanks for the information. I wasn't aware of the possible 4 day extension. That would salvage that weekend!
BTW The way I understand it if the mission is extended beyond 18 days then this pushes the envelope for landing test data gathered. These are in the EDO category and there is a reduction in the flight rules for crosswind to 12 kt maximum to account for possible pilot fatigue/long exposure to zero g, etc. I think I saw this buried in flight rule A2-6.
TH

-----Original Message-----
From: LECHNER, DAVID F. (JSC-DF52) (USA)
[mailto:david.f.lechner1@jsc.nasa.gov]
Sent: Thursday, January 23, 2003 3:22 PM
To: Hoffman, Thomas L
Subject: STS-107 Landing Weight Status

Tom,

Several variables have lead to an increase over predicted prelaunch down weights (including launching into a higher orbit thus requiring less burns,
better cooling with radiators than expected, ect...) Without any corrective
actions, current predictions calculate a down weight violation by 657 lbs
violating the 233,000 lbs down weight spec. This equates to a worst case
End Of Mission (EOM) weight of 233,657 lbs with an X-c.g. of 1079.93 inches.

The c.g. has actually moved aft, improving the EOM pressures for the Main
Landing Gear tires. Current tire pressures and temperatures for NEOM are
333 psi / 9 deg F and Anytime Deorbit of 305 psi / -28 deg F.

Since cryo and prop weight are dynamic while on-orbit, no decision will made
until Landing-4 days. Additionally, talks of 4 days extension are circulating. Extension days, of course, would eliminate the situation entirely.

The increase over pre-mission values include: 600 lbs prop, 408 lbs cryo and
85 lbs non-prop for an KSC Orbit 255 opportunity. Several options are

available to reduce cryo including operation of prop pod heaters, high-load
EECOM duct heaters and hydraulic circ pumps. Prop dumps can also be made
rior to entry.

More of the story will unfold at L-4 days. There are several options with
minimum time impacts to eliminate down weight concerns.

David F-M Lechner
Space Shuttle Mechanical Systems
Mechanical, Maintenance, Arm & Crew Systems (MMACS)
United Space Alliance, Johnson Space Center
(281) 483-1685

Michele Lewis

'om: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
ent: Friday, January 24, 2003 1:05 PM
To: 'Porter, Michael T'
Subject: FW: STS-107 Landing Weight Status

-----Original Message-----
From: Hoffman, Thomas L [mailto:Thomas.L.Hoffman@boeing.com]
Sent: Thursday, January 23, 2003 3:49 PM
To: LECHNER, DAVID F. (JSC-DF52) (USA)
Subject: RE: STS-107 Landing Weight Status

Dave,
Thanks for the information. I wasn't aware of the possible 4 day extension. That would salvage that weekend!
BTW The way I understand it if the mission is extended beyond 18 days then this pushes the envelope for landing test data gathered. These are in the EDO category and there is a reduction in the flight rules for crosswind to 12 kt maximum to account for possible pilot fatigue/long exposure to zero g, etc. I think I saw this buried in flight rule A2-6.
TH

-----Original Message-----
From: LECHNER, DAVID F. (JSC-DF52) (USA)
[mailto:david.f.lechner1@jsc.nasa.gov]
Sent: Thursday, January 23, 2003 3:22 PM
To: Hoffman, Thomas L
Subject: STS-107 Landing Weight Status

Tom,

Several variables have lead to an increase over predicted prelaunch down weights (including launching into a higher orbit thus requiring less burns,
better cooling with radiators than expected, ect...) Without any corrective
actions, current predictions calculate a down weight violation by 657 lbs
violating the 233,000 lbs down weight spec. This equates to a worst case
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Landing Gear tires. Current tire pressures and temperatures for NEOM are
333 psi / 9 deg F and Anytime Deorbit of 305 psi / -28 deg F.

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EECOM duct heaters and hydraulic circ pumps. Prop dumps can also be made
prior to entry.

More of the story will unfold at L-4 days. There are several options with
minimum time impacts to eliminate down weight concerns.

David F-M Lechner
Space Shuttle Mechanical Systems
Mechanical, Maintenance, Arm & Crew Systems (MMACS)
United Space Alliance, Johnson Space Center
(281) 483-1685

Michele Lewis

om: Hoffman, Thomas L [Thomas.L.Hoffman@boeing.com]
ent: Thursday, January 30, 2003 10:08 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: FW: STS-107 Deorbit Opportunities Table

LANDTBL107.X
LS

> -----Original Message-----
> From: Leba, Anthony T
> Sent: Wednesday, January 29, 2003 1:05 PM
> To: Smith, Ruben A; Heinol, Chip C; Hoffman, Thomas L; Goodmark, Jeffrey A
> Subject: FW: STS-107 Deorbit Opportunities Table
>
>
>
> > <<LANDTBL107.XLS>>
>

STS-113 LANDING TABLE

	TIG ORB	TIG MET	TIG CST	LAND MET	LAND GMT	LAND CST	XRNG	SITE
	Saturday, February 1							
EOM	255	15/21:39	07:17	15/22:36	032/14:15	08:15	7DL	KSC
	256	15/23:05	08:43	16/00:02	032/15:41	09:41	234DR	
	256	15/23:07	08:46	16/00:05	032/15:44	09:44	165DR	
	256	15/23:13	08:51	16/00:10	032/15:49	09:49	701DL	KSC
	257	16/00:39	10:17	16/01:36	032/17:15	11:15	561DL	
	Sunday, February 2							
EOM+1	270	16/20:01	05:40	16/20:59	033/12:38	06:38	357DR	KSC
	271	16/21:30	07:08	16/22:27	033/14:06	08:06	159DR	
	271	16/21:36	07:14	16/22:33	033/14:12	08:12	188DL	
	272	16/23:02	08:40	16/23:59	033/15:38	09:38	162DL	
	272	16/23:04	08:43	17/00:02	033/15:41	09:41	331DL	NOR
	273	17/00:36	10:14	17/01:33	033/17:12	11:12	751DL	
	Monday, February 3							
EOM+2	286	17/19:58	05:36	17/20:55	034/12:34	06:34	227DR	KSC
	287	17/21:26	07:05	17/22:24	034/14:03	08:03	46DR	
	287	17/21:32	07:11	17/22:30	034/14:09	08:09	382DL	
	288	17/22:58	08:37	17/23:56	034/15:35	09:35	307DL	
	288	17/23:01	08:39	17/23:58	034/15:37	09:37	510DL	

prepared by the MISSION SUPPORT ROOM

Subject: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case com pleted
Date: Wednesday, January 29, 2003 2:40 PM
From: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA) <carlisle.c.campbell@nasa.gov>
To: "'jeff.homan@arc.nasa.gov'" <jeff.homan@arc.nasa.gov>, "LAW, HOWARD G. (JSC-EG) (NASA)" <howard.g.law@nasa.gov>

> -----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
>
> 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
>
>

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

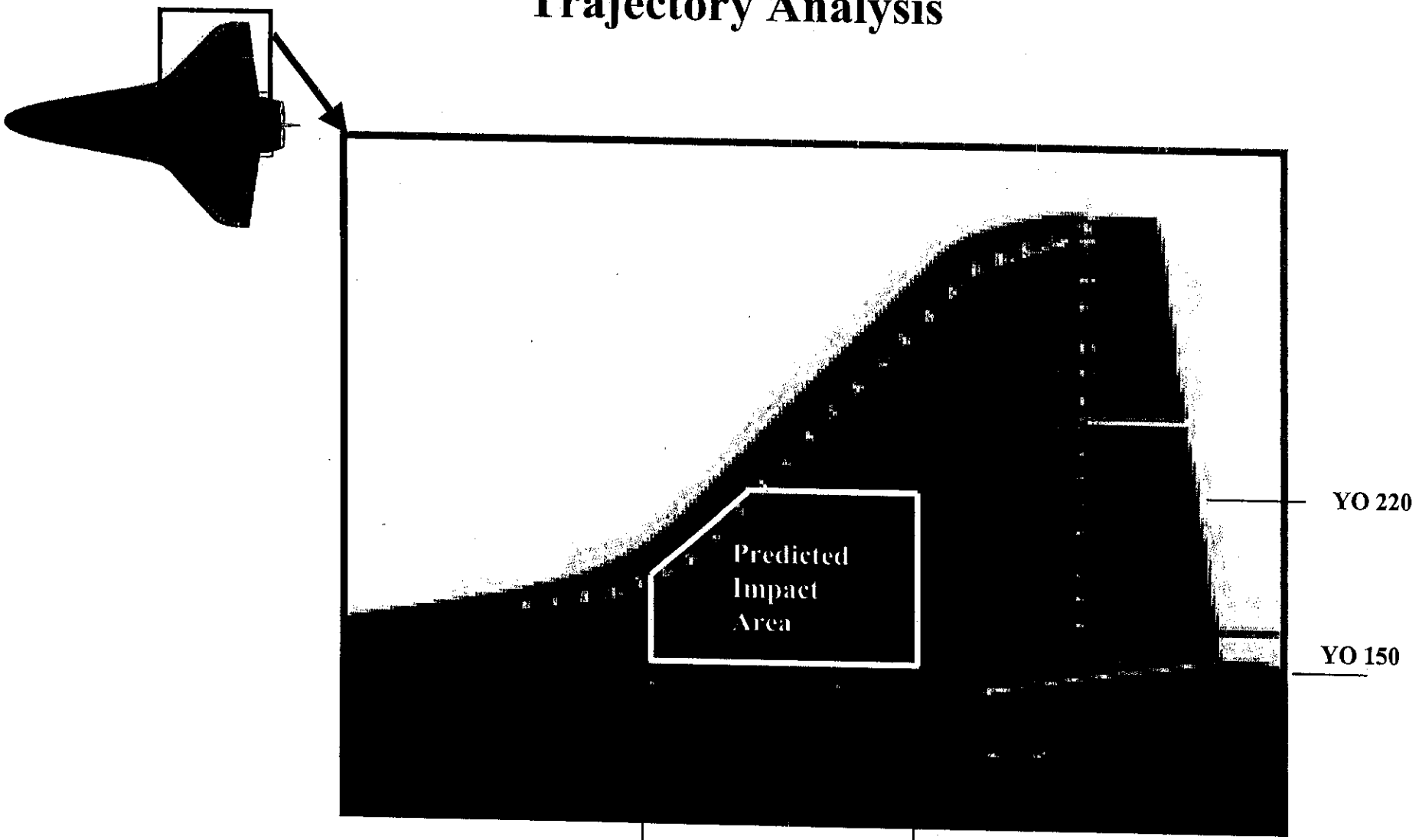
Debris Impact Conditions to Be Evaluated for Area on Orbiter Lower Surface

- **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

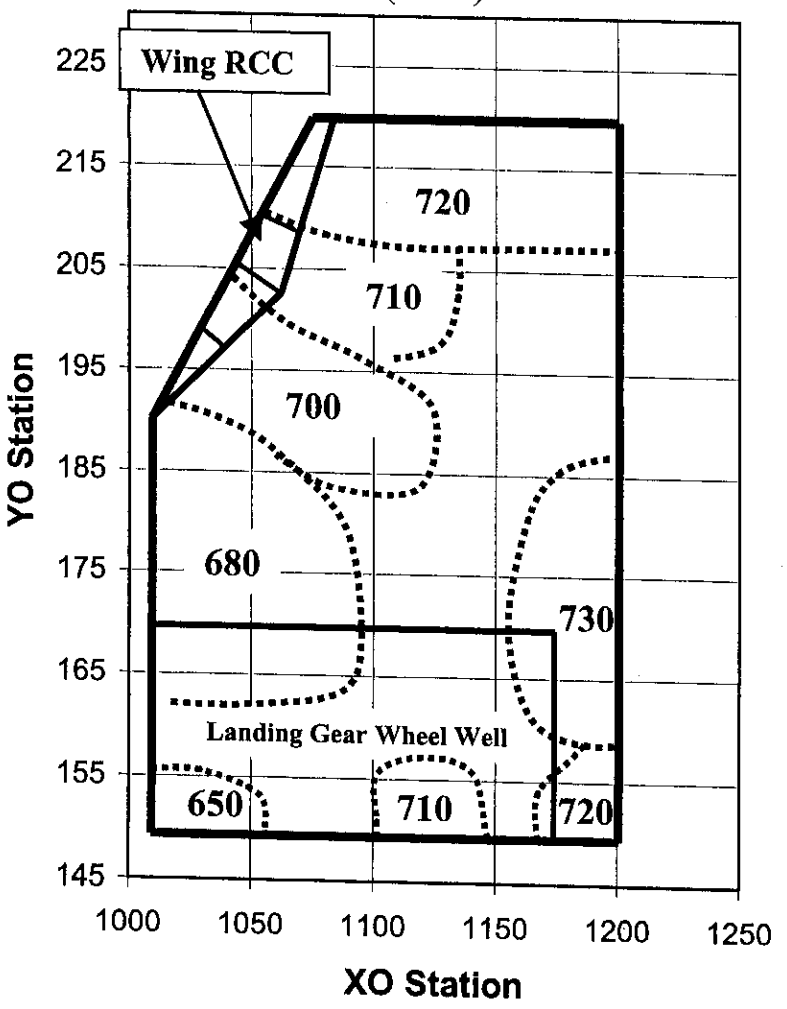
BOEING

Velocity and Impact Angle Distribution Inside Impact Area

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

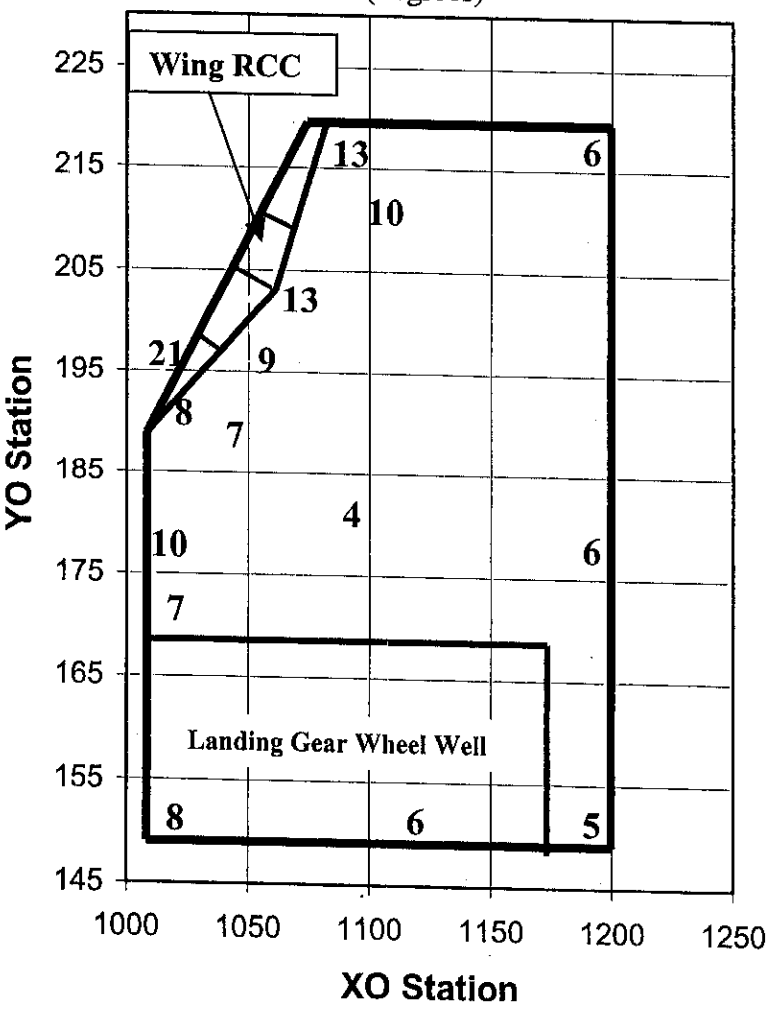
Impact Velocity

(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	16	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

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Orbiter Assessment of STS-107 ET Bipod Insulation Ramp Impact

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January 23, 2003

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Order of Analysis

- **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, SIP 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 Micrometeriod and Orbital Debris (M/OD) study performed in 1996**