

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

From: DOREMUS, ROBERT C. (JSC-DF52) (NASA)
Sent: Tuesday, February 11, 2003 11:14 AM
To: DITTEMORE, RONALD D. (JSC-MA) (NASA)
Cc: HEFLIN, JAMES M., JR (MILT) (JSC-DAB) (NASA)
Subject: RE: Emails

Here is the sequence:

1. Wednesday, 1/29: ES/Carlisle Campbell phoned DF52/ Bob Doremus to discuss the potential impacts to orbiter systems due to the ET foam debris contact with the left wing. Carlisle wanted to specifically discuss the implications on systems for which he is an expert - tires, brakes, landing gear. DF52/Mechanical Systems Group (MMACS) has responsibility on the flight control team for the same systems and has a long time working relationship with Carlisle. Carlisle had seen the Boeing analysis and its conclusion and his approach was "what if the analysis is wrong?" Carlisle e-mailed Bob Doremus a copy of the analysis.



W: STS-107 Debris
Briefing fo...

2. Thursday, 1/30: Carlisle paged Bob Doremus and wanted to know if Bob had seen the analysis before the 1/29 e-mail. DF52 had not. That was not a miscommunication or a problem. EECOM personnel on the 107 team had seen the analysis. EECOM has MCC responsibility for TPS. In a situation where a tile is considered lost, MMACS has responsibility in the MCC to coordinate determining the affected hardware underneath the tile. Since the analysis had determined there would not be burn-through, MMACS was not called on to begin the process of assessing affected equipment. MMACS personnel discussed the analysis with DAB personnel who said that they had seen the analysis from the MMT and did not consider it to be a concern.

Carlisle notified Bob Doremus that he had contacted Bob Daugherty at Langley to discuss potential landing gear issues. Carlisle was concerned that entry heating could damage the LMG tires and cause landing with 2 flat tires. He contacted Daugherty to discuss that scenario. Late in the day, Bob Daugherty e-mailed DF52/David Lechner a note that discussed his own concerns. Bob contacted David Lechner because David currently is the MMACS system lead for landing/decel systems and does most of the coordination with the technical community. Here is the original note from Langley/Bob Daugherty to DF52/David Lechner:



Main Gear Breach
Concerns

3. Friday, January 31: David Lechner was on the MMACS Entry team and worked the FCS checkout shift early Friday morning. He forwarded Bob Daugherty's e-mail to others on the MMACS team. Bob Daugherty is a respected expert on landing gear and his thoughts were taken seriously and discussed by the MMACS team in the following series of notes. This email traffic was internal to the MMACS discipline only. It was considered to be a "what-if" exercise and a continuation of the technical discussion that Bob Daugherty had begun. The MMACS team did not have concerns about the tile impact analysis.



RE: Main Gear
Breach Concerns

4. Later on Friday, David Lechner replied to Bob Daugherty in this e-mail:



RE: Main Gear
Breach Concerns

5. Late Friday afternoon, Carlisle Campbell phoned DF52/Bob Doremus to continue this technical discussion. DF52/David Paternostro was also in the office. Carlisle brought in Bob Daugherty and the 4 discussed the possibility of landing with 2 flat tires. Carlisle said that Howard Law had done an entry sim at Ames (the sim was evidently done on Friday) and that sim showed that the landing with 2 flat tires was survivable. Bob Doremus and David Paternostro expressed some skepticism as to the accuracy of the Ames sim in light of other data (Convair 990 testing), but appreciated the information. All four agreed at the end of the discussion that we were doing a "what-if" discussion and that we all expected a safe entry on Saturday.

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

From: DITTEMORE, RONALD D. (JSC-MA) (NASA)
Sent: Tuesday, February 11, 2003 6:56 AM
To: DOREMUS, ROBERT C. (JSC-DF52) (NASA)
Cc: HEFLIN, JAMES M., JR (MILT) (JSC-DAB) (NASA)
Subject: Emails

Gather the emails where you talked or communicated with Langley and send me a copy so that I can see the traffic and get a feel for the conversations. Thx.

-----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) 850-1607
(281) 850-4506 (Fax)
(281) 671-1004 (Pager)

02/26/2003

FEB 26 '03 12:21

From: MCGLOTHLIN, R. R. (KEVIN) (JSC-DF511) (USA);

Sent: Friday, January 31, 2003 3:45 PM

To: 'Anderson, William C'; KLING, JEFFREY V. (JSC-DF511) (USA); DOREMUS, ROBERT C. (JSC-DF52) (NASA); FRIANT, MELVIN E. (JSC-DF511) (NASA); JASON, JERRY P. (JSC-DF52) (NASA); SMITH, KENNETH J. (JSC-DF52) (NASA); ESKOLA, EDWARD W. (JSC-DF52) (USA); DAKE, JANNA J. (JSC-DF52) (NASA); TOTH, ERIK P. (JSC-DF52) (USA); LECHNER, DAVID F. (JSC-DF52) (USA); SNOWDEN, APRIL (JSC-DF52) (USA); LEE, ROY (JSC-DF) (USA); PATERNOSTRO, C. D. (DAVID) (JSC-DF511) (USA); FENG, CHRISTOPHER P. (CHRIS) (JSC-DF) (NASA)

Subject: RE: Main Gear Breach Concerns

If the Console Handbook is to be believed (and it is), the three brake isolation valves (and the extend isolation valve) reside in the aft compartment. The port wheel well contains (aside from the left gear and tires, brake modules, etc.) the two extend valves (#1 and #2) and the NWS switching valve. And the impact did occur on the port side. For a breach in the MLG door or its seals these valves should be considered "at risk" as well. So to draw out the worst case scenario, the tires are flat and/or the gear is slugged and/or there's a huge hole in the wing from the tire explosion, plus there's no nosewheel steering. All equate to a bad day.

Let's surmise just what sort of signature we'd see if a limited stream of hot plasma did get into the well well (roughly from EI + a few minutes until about 200Kft; in other words, a 10 to 15 minute long window). First would be a temperature rise for the tires, brakes, strut actuator, and the uplock actuator return. Tire pressure (and theoretically brake pressures as the fluid temperature increased, though the expansion is small) would rise given enough time, and assuming the tire(s) doesn't get holed. Then the data would start dropping out as the electrical wiring is severed, both to the transducers and the wiring to the valves, etc. (electrical shorts may occur as insulation is eroded away, so EGIL may see something on the bus signatures). Data loss would include that for tire pressures and temperatures, brake pressures and temperatures, prox box indications, and valve (NWS S/V and the EXT VLVs) indications (really only the NWS switching valve, though shorts could produce false 'on' indications for the extend valves). With the extend and brake isolation valves closed there should be no decrease in reservoir quantities. If the gear deploy pyro heats up and fires, and the gear and linkages are not otherwise already severely damaged, then the gear will deploy; this is likely a LOC case so we'll skip it.

What does the alert MMACS/MECH operator do in the event of such a signature as described above? There are only a limited number of choices:

- (1) Do nothing. Assume it's just a bunch of smart transducer failures or that the gear can take the punishment.
- (2) Decide that the gear is probably toast, call for an early enough deploy to allow for a bail-out if required ($M \approx -0.9$), and rely on the (remaining) data or video in order to decide between a bail-out and landing attempt.
- (3) Decide that the gear is toast, that landing is impossible, and call for a bail-out.
- (4) Decide that the gear is toast and recommend a gear-up landing.

I don't think much of option 4 - that's almost certainly a LOC case. Option 3 seems to be extreme (throw away the orbiter) without some supporting data. The other two options are then the real choices and both are risky. If I saw odd signatures in only one or two measurements I'd likely go for #1. However, if there was a wholesale loss of data in the area then I'd recommend #2. Beats me what the breakpoint would be between the two decisions.

And since the ill-fated X-15 (that "broke in half" - actually it bent until it hit the ground; the two pieces didn't separate) has been mentioned twice already, I'll add this excerpt from the Dryden web site:

The first accident happened early in the program, when an engine explosion occurred during engine start, and the pilot was forced to land at the launch lake. Not all of the propellants

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jettisoned; also, the oil in the nose strut had become aerated. Thus, the aircraft was heavyweight and the nose strut did not provide the shock absorption it was designed for. In spite of this, the damage was minor and the airplane was back in the air in three months with a modified nose strut able to handle the landing loads.

See the attached photo.

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

From: Anderson, William C [mailto:williamc.anderson@nasa.gov]

Sent: Friday, January 31, 2003 2:08 PM

To: KLING, JEFFREY V. (JSC-DF511) (USA); DOREMUS, ROBERT C. (JSC-DF52) (NASA); MCCLUNEY, R. K. (KEVIN) (JSC-DF511) (NASA); FRIANT, MELVIN E. (JSC-DF511) (NASA); JASON, JERRY P. (JSC-DF52) (NASA); SMITH, KENNETH J. (JSC-DF52) (NASA); ESKOLA, EDWARD W. (JSC-DF52) (USA); DAKC, JANNA J. (JSC-DF52) (NASA); TOTH, ERIK P. (JSC-DF52) (USA); LECHNER, DAVID F. (JSC-DF52) (USA); SNOWDEN, APRIL (JSC-DF52) (USA); LEE, ROY (JSC-DF) (USA); PATERNOSTRO, C. D. (DAVID) (JSC-DF511) (USA); FENG, CHRISTOPHER P. (JSC-EC) (NASA)

Subject: RE: Main Gear Breach Concerns

First, why are we talking about this on the day before landing, and not the day after launch? To quote Paul Dye, this is another "Burning Rocks Syndrome" (for the new folks, supposedly a week before we went to the Moon on Apollo 11 -- yes, we went to the Moon -- a scientist popped up with a concern about what would happen if the moon rocks beneath the lander caught fire from the retro rockets). Anyway, if there were evidence on this flight that we were missing tiles/RCC, I might be worried.

Here are my off-the-cuff thoughts on this (real experts may vary, but I pretty much agree with Kevin).

If there were an explosion in the wheel well with the gear up and locked, I would think the wing panel structure would break before the gear uplocks would be broken. If the door blew open instead it would likely separate from the gear attach points. If the wing is off, or has a big hole in it, you're not going to make the runway, and the gear question is moot. If the leak were fast, but not explosive, the wheel well is vented, and even with the vent doors closed, I don't believe a tire or two would overpress the midbody.

Aren't all three Brake Isol valves (hence all 3 Hyd Systems) in the same wheel well? However, I believe they are in the STBD well, and we are talking about the Port side well this time from the video I saw (could be wrong about that). If you lost all the hydraulics, you won't have to worry about whether to deploy the gear, or ditch, etc. Bailout is your only option (probably won't even be able to do that).

What I always heard about ditching (back when we were looking at Escape options in '87-'88), was that the vehicle would break on initial impact, with the payload coming through the back of the cabin (definitely not a good day).

To bally land (without the above happening), you would have to land at near 0 deg. alpha, which would require a much higher speed at TD than normal, since this "airplane" has very little wing area. Drag chute & rudder might keep it pointed the right way for a while, but the crown in the runway is pretty pronounced, and the vehicle may skid right off, but at a lower speed.

I don't understand the scenario where the wheel blows due to material degradation. After watching one set of fuse plugs blow after getting the wheel white hot from using the brakes on the test stand, I don't see where a wheel is going to fail first, unless you have a very small plasma jet focused just right, like a cutting torch. That would fail just like a thermal plug, so I don't see the wheel shrapnel concern. Maybe for the tire.

Remember that an X-15 broke in half on one landing (misjudged height above deck, and landed hard)

Bill

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

02/26/2003

FEB 26 '03 12:22

281 244 5165 PAGE.007

From: KLING, JEFFREY V. (JSC-DF511) (USA)

~~mailto:Jeffrey.V.Kling@NASA.gov~~

Sent: Friday, January 31, 2003 9:38 AM

To: DOREMUS, ROBERT C. (JSC-DF52) (NASA); MCCLUNEY, R. K. (KEVIN) (JSC-DF511) (NASA); FRIANT, MELVIN E. (JSC-DF511) (NASA); JASON, JERRY P. (JSC-DF52) (NASA); SMITH, KENNETH J. (JSC-DF52) (NASA); ESKOLA, EDWARD W. (JSC-DF52) (USA); DAKE, JANNA J. (JSC-DF52) (NASA); TOTH, ERIK P. (JSC-DF52) (USA); LECHNER, DAVID F. (JSC-DF52) (USA); SNOWDEN, APRIL (JSC-DF52) (USA); LEE, ROY (JSC-DF) (USA); PATERNOSTRO, C. D. (DAVID) (JSC-DF511) (USA); ~~William C. Anderson @NSA HQ~~; FENG, CHRISTOPHER P. (JSC-EC) (NASA)

Subject: FW: Main Gear Breach Concerns

These are all interesting questions that some smart people in the engineering community could go investigate if they have not already. Here's my take on it from an operations perspective.

First of all, if there is a serious breach in the wheel well and we are concerned about the wheel (aluminum) properties changing to the point that the wheel fails then there must also be a concern with the wing structure (also aluminum). If the tires exploded and the gear door was forced open, I would bet that the gear is coming down/off with the door. Remember they are mechanically linked. I would lean toward a bailout recommendation if I thought the door blew off (loss of door telemetry and loss of tire pressures and other instrumentation) and the gear could not be verified down and locked on that side.

If there was hot plasma sneaking into the wheel wells, we would see increases in our landing gear temperatures and likely our tire pressures. If we actually saw our instrumentation in the wheel wells disappear during entry then I suspect that the gear will not deploy anyway because the wires that control the pyros and all the hydraulic valves would burn up too. Ultimately our (MMACS) recommendation in that case is going to be to set up for a bailout (assuming the wing doesn't burn off before we can get the crew out). The rest of the cases are great big what-ifs. We can manage the drag from any early gear deploy if it happens before MACH 1. Any burn-through damage would be discovered well before that.

I would like to hear what engineering has come up with regarding the nose gear slap down on a concrete runway with two flat tires on one side. If we don't break the nose gear at slap down, the lateral control is not a concern as long as we have nose wheel steering. The Flight Dynamics folks have already analyzed this case for us. If you think slapdown is bad with 2 flat tires, you're really not going to like the slap down in a "belly landing". Belly landings are worse than the flat tires case in my opinion.

Comments?

02/26/2003

FEB 26 '03 12:23

281 244 5155 PAGE.003

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

From: LECHNER, DAVID F. (JSC-DF52) (USA)

Sent: Friday, January 31, 2003 2:13 AM

To: KLING, JEFFREY V. (JSC-DF511) (USA); JASON, JERRY P. (JSC-DF52) (NASA)

Subject: FW: Main Gear Breach Concerns

We will need to address Bob Daugherty's concerns.

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

From: Robert H. Daugherty [mailto:robert.h.daugherty@nasa.gov]

Sent: Thursday, January 30, 2003 5:23 PM

To: LECHNER, DAVID F. (JSC-DF52) (USA)

Cc: M.J.SHUART [mailto:mjshuart@nasa.gov]; H.M.ADELMAN [mailto:hmadelman@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 everywhere. While it is true there are thermal fuses in the wheel, if the 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 this kind 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

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FEB 26 '03 12:24

281 244 3165 PAGE.209

- 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 ala 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 saturated 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

02/26/2003

FEB 26 '03 12:24

281 244 5165 PAGE.210

Sent:

To:

Cc:

Subject:

Thursday, January 30, 2003 5:23 PM

LECHNER, DAVID F. (JSC-DF52) (USA)

M.J.SHUART@larc.nasa.gov; H.M.ADELMAN@larc.nasa.gov; CAMPBELL, CARLISLE C.,

JR (JSC-ES2) (NASA)

Main Gear Breach Concerns

Hi David,

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Best Regards,

Bob

From: LECHNER, DAVID F. (JSC-DF52) (USA)
Sent: Friday, January 31, 2003 12:18 PM
To: 'Robert H. Daugherty'
Cc: 'M.J.SHUART [REDACTED]'; 'H.M.ADELMAN [REDACTED]'; CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: RE: Main Gear Breach Concerns

Bob,

I really appreciate the candid remarks. As always your points have generated extremely valuable discussion in our group. Thank you. We have been discussing and continue to discuss the all possible scenarios, signatures and decisions. Your input is beneficial. Like everyone, we hope that the debris impact analysis is correct and all this discussion is mute.

David F-M Lechner
Space Shuttle Mechanical Systems
Mechanical, Maintenance, Arm & Crew Systems (MMACS)
United Space Alliance, Johnson Space Center
[REDACTED]

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

From: Robert H. Daugherty [mailto:rdougherty@jsc.nasa.gov]
Sent: Thursday, January 30, 2003 5:23 PM
To: LECHNER, DAVID F. (JSC-DF52) (USA)
Cc: M.J.SHUART [REDACTED]; H.M.ADELMAN [REDACTED]; CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
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31 January 2003

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
To: 'Bill Heitzman' <[REDACTED]>,
"Porter, Michael T" <[REDACTED]> 'Tom Hoffman'
<[REDACTED]>,
"ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA)" <[REDACTED]>,
"ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)" <[REDACTED]>,
"LECHNER, DAVID F. (JSC-DF52) (USA)" <[REDACTED]>
Cc: "DOREMUS, ROBERT C. (JSC-DF52) (NASA)" <[REDACTED]>
'Bob Daugherty' <[REDACTED]>
"LAW, HOWARD G. (JSC-EG) (NASA)" <[REDACTED]>
Subject: Ames Sim runs with two blown tires before landing
Date: Fri, 31 Jan 2003 14:59:01 -0600

Howard Law just reported to us that he had completed the short series of landing sims with two blown tires before landing. This was to answer our concerns in case this scenario might occur during a worst case landing for STS-107. He cautioned us that these runs had inaccuracies but they were the best they could do on short notice. Just the same, the overall results were thought to be generally plausible.

The results showed that this condition was survivable/controllable. Even nose slapdown was within limits.

Two pilots flew the 4 to 6 landings--two were truncated before stop.

Inaccuracies in the sim included: No wing tip dragging forces near the end of the run and an inaccurate grind away rate on the wheel/brake/strut on the failed side during slideout (affecting roll angle). The coefficient of friction during slideout was thought to be accurately represented.

With Mark Hammerschmidt's/EG4 permission, this information was passed on to Bob Doremus/DF5 of MOD.

January 28, 2003

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"

~~<carlisle.campbell@nasa.gov>~~

To: "Robert H. Daugherty" <~~robert.daugherty@nasa.gov~~>

Subject: RE: Tile Damage

Date: Tue, 28 Jan 2003 13:29:58 -0600

I have not heard anything new. I'll let you know if I do.

CCC

In reply to:

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

From: Robert H. Daugherty [~~mailto:robert.daugherty@nasa.gov~~]

Sent: Tuesday, January 28, 2003 12:39 PM

To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)

Subject: Tile Damage

Any more activity today on the tile damage or are people just relegated to crossing their fingers and hoping for the best?

See ya,

Bob

27 January 2003

Message-ID: <0EF628A1BDDB0147AFB39A87970E05C801035E73@jsc-mail05.jsc.nasa.gov>

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"

To: 'Bob Daugherty'

Subject: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

Date: Mon, 27 Jan 2003 14:16:52 -0600

Forwarding Message:

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

> From: KOWAL, T. J. (JOHN) (JSC-ES3) (NASA)

> Sent: Monday, January 27, 2003 10:35 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 breaching 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

> [REDACTED]

Forwarding Message

> -----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 breaching 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) [REDACTED]
> * Division Shuttle Chief Engineer (DCE), ES-Structural Engineering
> Division

27 January 2003

From: "Robert H. Daugherty" <~~robert.h.daugherty@nasa.gov~~>
To: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<~~ccampbell@nasa.gov~~>
Subject: Re: FW: Video you sent
Date: Mon, 27 Jan 2003 16:02:27 -0600

I agree completely. Seems to me that the benefit of an EVA to go look at damage has more pros than cons. Can't imagine that an astronaut (even on a crappy tether arrangement) would cause MORE damage than he is going out to look for!

See ya,
Bob

In reply to:

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<~~ccampbell@nasa.gov~~>
To: "Robert H. Daugherty" <~~robert.h.daugherty@nasa.gov~~>
Subject: RE: Video you sent
Date: Mon, 27 Jan 2003 15:49:11 -0600

Thanks. That's why they need to get all the facts in early on--such as look at impact damage from the spy telescope. Even then, we may not know the real effect of the damage.

The LaRC ditching model tests 20 some years ago showed that the Orbiter was the best ditching shape that they had ever tested, of many. But, our structures people have said that if we ditch we would blow such big holes in the lower panels that the orbiter might break up. Anyway, they refuse to even consider water ditching any more--I still have the test results[
Bailout seems best.

27 January 2003

From: Robert H. Daugherty [mailto:robert.h.daugherty@nasa.gov]
Sent: Monday, January 27, 2003 3:35 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Video you sent

WOW!!!

I bet there are a few pucker strings pulled tight around there!

Thinking about a belly landing versus bailout..... (I would say that if there is a question about main gear well burn thru that its crazy to even hit the deploy gear button...the reason being that you might have failed the wheels since they are aluminum..they will fail before the tire heating/pressure makes them fail..and you will send debris all over the wheel well making it a possibility that the gear would not even deploy due to ancillary damage...300 feet is the wrong altitude to find out you have one gear down and the other not down...you're dead in that case)

Think about the pitch-down moment for a belly landing when hitting not the main gear but the trailing edge of the wing or body flap when landing gear up...even if you come in fast and at slightly less pitch attitude...the nose slapdown with that pitching moment arm seems to me to be pretty scary...so much so that I would bail out before I would let a loved one land like that.

My two cents.

See ya,

Bob

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

From: STICH, J. S. (STEVE) (JSC-DAB) (NASA)
Sent: Wednesday, January 29, 2003 2:30 PM
To: SHANNON, JOHN P. (JSC-DAB) (NASA)
Subject: FW: Shuttle Support

The story that I heard is that Wayne got the DOD folks at KSC and Patrick spun up so they or Lambert Austin (rumor) turned on requests for data from USSTRAT and other resources. The SSP did not want any data and in fact there was never a formal MOD request made from the FDOs or the Flight Director. I told Roger Simpson that we appreciated the USSSTRAT support on this issue during a phone conversation on Wednesday or Thursday of last week. I told them that we did not require the data on this mission and that they could turn off their system which was in high gear to get the data. In hindsight I probably should have let them go since they had worked it very hard on the USSTRAT end and they may not respond as well next time since we "cried wolf on STS-107".

Roger is trying to make sure that there is a clear path for these requests per this note below.

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

From: SIMPSON, ROGER D. (JSC-DM) (NASA)
Sent: Thursday, January 23, 2003 12:01 PM
To: 'ronald.hughes@spacecom.smil.mil'; 'robert.graves@spacecom.smil.mil'; 'david.lfflander@spacecom.smil.mil'; 'douglas.sersun@spacecom.smil.mil'
Cc: 'roger.simpson@spacecom.smil.mil'; 'linda.marchione@spacecom.smil.mil'; 'rodney.bumett@spacecom.smil.mil'; 'mcarthurj@spacecom.smil.mil'; STICH, J. S. (STEVE) (JSC-DAB) (NASA); ENGELAUF, PHILIP L. (JSC-DAB) (NASA); 'Newberry Stan SES AFSPC/NASA'
Subject: Shuttle Support

Col Ifflander and others,

Thank you for the enthusiastic response to the request for Shuttle support yesterday. Your quick response in arranging support was exceptional and we truly appreciate the effort and apologize for any inconvenience the cancellation of the request may have caused. I know that future requests will be met with the same effort.

Let me assure you that, as of yesterday afternoon, the Shuttle was in excellent shape, mission objectives were being performed and that there were no major system problems identified. The request that you received was based on a piece of debris, most likely ice or insulation from the ET, that came off shortly after launch and hit the underside of the vehicle. Even though this is not a common occurrence it is something that has happened before and is not considered to be a major problem.

The one problem that this has identified is the need for some additional coordination within NASA to assure that when a request is made it is done through the official channels. The NASA / USSTRAT (USSPACE) MCA identifies the need for this type of support and that it will be provided by USSTRAT. Procedures have been long established that identifies the Flight Dynamics Officer (for the Shuttle) and the Trajectory Operations Officer (for the International Space Station) as the POCs to work these issues with the personnel in Cheyenne Mountain. One of the primary purposes for this chain is to

1

make sure that requests like this one does not slip through the system and spin the community up about potential problems that have not been fully vetted through the proper channels.

Two things that you can help us with is to make sure that future requests of this sort are confirmed through the proper channels. For the Shuttle it is via CMOC to the Flight Dynamics Officer. For the International Space Station it is via CMOC to the Trajectory Operations Officer. The second request is that no resources are spent unless the request has been confirmed. These requests are not meant to diminish the responsibilities of the DDMS office or to change any previous agreements but to eliminate the confusion that can be caused by a lack of proper coordination.

Again, thank you for the support and we know that when the need arrives USSTRAT, CMOC, and the DDMS office will respond the same as they did for this one, with enthusiasm and a timely response.

Roger D. Simpson
NASA Resident Office, Colorado Springs
United States Strategic Command West
Peterson AFB, CO 80914-3090

~~XXXXXXXXXXXX~~
~~XXXXXXXXXXXX~~ pager

From: FOSTER, ANDY (JSC-NC) (GHG)
Sent: Tuesday, January 21, 2003 8:05 PM
To: SR&QA MER Console
Subject: FW: STS-107 Debris Analysis Team Plans

If you look in the Console Actions section of the Stuff book, you'll find the hazard report mentioned in this note and several others that relate.

From: BALU, BRIAN K. (JSC-NC) (SAIC)
Sent: Tuesday, January 21, 2003 5:28 PM
To: SR&QA MER Console
Cc: FOSTER, ANDY (JSC-NC) (GHG); DYER, KEITH W. (JSC-NC) (SAIC)
Subject: FW: STS-107 Debris Analysis Team Plans

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

From: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC)
Sent: Tuesday, January 21, 2003 4:42 PM
To: BALU, BRIAN K. (JSC-NC) (SAIC); BROWNE, DAVID M. (JSC-NC) (NASA)
Cc: HATAMLEH, OMAR (JSC-NC) (SAIC)
Subject: RE: STS-107 Debris Analysis Team Plans

Hello All,
Per discussions today:

- Similar occurrence on STS-27,50, 87
- Damage Assessment being performed
- MOD Risk Mitigation being performed
- Program request for on-orbit picture of OV-102 underside per DOD
- Trajectory Analysis being performed (preliminary exist)
- JSC RCC Arc -Jet impact: test report being reviewed
- Confirmed ET BI-pod origin for foam particle: (~20"x20"x2" & ~20"x20"x6") with density of 2.4 pcf.
- Particle velocity ~750 ft./sec. & Incident angle ~ 20 deg.
- Secondary particle impact not an issue
- Orbiter Hazard Report(249) rev. C being reviewed - "Structural Overheating By TPS Damage/Failure"
- Meeting again @ 1:00pm on 1-22-03(Wed.)

From: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC)
Sent: Tuesday, January 28, 2003 4:15 PM
To: 'Norman Ignacio (Nacho) (E-mail)'
Subject: STS-107 Tile-Skin Impact TMM Update

Hello.

I heard on the TPS PRT today that there was an updated thermal math model that was discussed this past Sunday. I guess the model now predicts a skin temperature of ~ 700 deg. F ? I last saw charts that reflect ~500 deg. F. Can I get a copy of these charts ?

Thanks

SSE:TPS/LESS/RCC, etc.
~~203-437-7030~~

From: Norman, Ignacio [mailto:ignacio@boeing.com]
Sent: Wednesday, January 29, 2003 7:24 AM
To: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC)
Subject: RE: STS-107 Tile-Skin Impact TMM Update

The Thermal analysis was done to support the possibly impacted lower surface of the orbiter on the STS-107 mission. Two areas were assessed for large area damage. One was on in the area between the Main Landing Gear Door and the Wing leading edge, this area structure temperatures were in the 500 degree range. The other large damage area where thermal analysis was performed were on the Main Landing gear door and the top face sheet of the honeycomb AL structure got above 700. The results were forwarded to the Boeing stress folk on thermoelastic effects and results were reported to NASA and USA. I do not know I the Boeing stress folk created any charts.

Ignacio Norman

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

From: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC)
[mailto:ishmael@boeing.com]
Sent: Tuesday, January 28, 2003 4:15 PM
To: Norman, Ignacio
Subject: STS-107 Tile-Skin Impact TMM Update

Hello,

I heard on the TPS PRT today that there was an updated thermal math model that was discussed this past Sunday. I guess the model now predicts a skin temperature of ~ 700 deg. F? I last saw charts that reflect ~500 deg. F. Can I get a copy of these charts?

Thanks

SSE:TPS/LESS/RCC, etc.

~~001-488-1100~~

From: SCHOMBURG, CALVIN (JSC-EA) (NASA)
Sent: Wednesday, January 29, 2003 9:40 AM
To: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC); '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'
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

This hit will be recorded just like ever other hit on the vehicle-the debris team will record it-the tile team will record it and it will be reported in the post-flight report.(what is recorded is location-tiles hit and what was the size of the hit, etc).

-----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 SOFT, "crater program", & TMM ?

Thanks.

SSE: TPS/LESS/RCC, etc.

From: Bell, Dan R. ([REDACTED])
Sent: Wednesday, January 29, 2003 1:19 PM
To: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC)
Subject: RE: STS-107 Debris Analysis Team Meeting - Post Landing Data Collection

George,

We should have preliminary information available within a few hours of landing. We will send out a link to the PRT distribution where the runway report will be posted.

Thanks,
Dan Bell
TPS SSM
(321)861-4617

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

From: ISHMAEL, MOHAMED I. (GEORGE) (JSC-NC) (SAIC) [mailto:[REDACTED]]
Sent: Wednesday, January 29, 2003 10:03 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.

02/26/2003

FEB 26 '03 12:35

281 244 5165 PAGE 027

From: Madera, Pamela L. ([REDACTED])
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: [REDACTED]

Pager: [REDACTED]

[REDACTED] (to receive a short alpha number page by addressing e-mail to [REDACTED])

-----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 877-668-7953 P/C 276237 to discuss analysis plans for assessing the STS-107 Debris Impact.

Pam Madera

Vehicle and Systems Analysis Subsystem Area Manager

Phone: [REDACTED]

02/26/2003

FEB 26 '03 12:05

281 244 5165 PAGE 028