From: "Sweeney, Christopher J (ISI)" <SweeneyCJ@navair.navy.mil>
To: "Bihari Brian (E-mail)" <Brian.Bihari@lmco.com>,
"Cason Kyle (E-mail)"
<kyle.cason@west.boeing.com>,
"Dailey Peter (E-mail)"
<Peter.Dailey@lmco.com>,
"Daugherty Bob (E-mail)"
<r.h.daugherty@larc.nasa.gov>,
"Digon Ed (E-mail)"
<Ed.Digon@West.Boeing.com>,
"Harder Jim (E-mail)"
<james.r.harder@usahq.unitedspacealliance.com>,
"Hobaugh Charlie (E-mail)" <charles.o.hobaugh1@jsc.nasa.gov>,
"Homan Jeff (E-mail)" <jhoman@mail.arc.nasa.gov>,
"Johnson Greg (E-mail)"
<gregory.c.johnson1@jsc.nasa.gov>,
"Law Howard (E-mail)"
<howard.g.law1@jsc.nasa.gov>,
"Peters Jeff (E-mail)"
<jeffrey.p.peters1@jsc.nasa.gov>,
"Sterling Mike (E-mail)"
<michael.r.sterling1@jsc.nasa.gov>,
"Tanita Thomas (E-mail)"
<Thomas.Tanita@West.Boeing.com>,
"Veile Mark (E-mail)"
<mark.a.veile1@jsc.nasa.gov>
Subject: Thoughts and Prayers
Date: Mon, 3 Feb 2003 07:39:58 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

All,

I wanted to send to all of you the thoughts and prayers from myself and my family regarding the Columbia tragedy. I hope that each of you can take pride in the importance of what you do and how much it means to the country, even if it takes an accident for everyone to realize that.

My two sons, 4 and 2, have been fascinated with the space shuttle and space for a year. I think Mitch said it best on Saturday when he told Abby and I that, "Now the astronauts will not need the space shuttle to go up to heaven, they are already there."

God Bless,
Chris

Daugh. - 1

Daugh-2

E-mail withheld due to disclosure statement attached to message stating that information contained in message is privileged, confidential and protected from disclosure.

Daugh-3

E-mail withheld due to disclosure statement attached to message stating that information contained in message is privileged, confidential and protected from disclosure.

X-Sender: h.m.adelman@pop.larc.nasa.gov
Date: Mon, 3 Feb 2003 13:13:29 -0500
To:
From: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
Subject: Response to questions about Columbia
Cc: "Shuart, Mark" <m.j.shuart@larc.nasa.gov>

SDB:

The Competency Office has advised us that should we receive any inquiries from personnel outside the Agency (e.g. the media) we are to refer them to the Office of External Affairs or the SMC (Mark Shuart.) If we receive any requests from within NASA for support, consulting, etc. we are to refer the request to the SMC. Finally, any documentation or correspondence from us must go through Mark. As you can imagine, we all stand ready to cooperate on the investigation in anyway we can. We just need to be sure to keep the Competency Office "in the loop" on all of our actions.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Daugh. -4

X-Sender: h.m.adelman@pop.larc.nasa.gov
Date: Tue, 4 Feb 2003 11:05:59 -0500
To:
From: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
Subject: Response to questions about Columbia (CORRECTION)
Cc: "Shuart, Mark" <m.j.shuart@larc.nasa.gov>

SDB:

*The Competency Office has advised us that should we receive any inquiries from personnel outside the Agency (e.g. the media) we are to refer them to the Office of External Affairs.

*If we receive any requests from within NASA for support, consulting, information, etc., we may respond but be sure to inform the branch office and the SMC.

*As you can imagine, we all stand ready to cooperate on the investigation in anyway we can. We just need to be sure to keep the Competency Office "in the loop" on all of our actions.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Daugh. - 5

X-EM-Version: 5, 0, 0, 0
X-EM-Registration: #3003520714B31D032830
Reply-To: [redacted]
X-Mailer: EarthLink MailBox 5.0.7.9 (Windows)
From: [redacted]
To: "Bob Daugherty" <r.h.daugherty@larc.nasa.gov>,
"Tom Yager" <t.j.yager@larc.nasa.gov>
Subject: Shuttle accident
Date: Fri, 7 Feb 2003 16:47:12 -0500

FOIA EXEMPTION (B)(6)

Hey Guys, both at home and abroad:

What would be the effect if a shuttle main-gear tire had a blowout while stored in its wing cavity?

I cannot think of why such a thing would happen, but it seems that it wouldn't be a good event.

Regards,

[redacted]

--[redacted]
---[redacted]
--- EarthLink: The #1 provider of the Real Internet.

Daugh.-6

[redacted] 08:48 AM 2/10/2003, Re: Shuttle accident

To: [redacted]
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Shuttle accident
Cc:
Bcc:
Attached:

Hi Bob,

Feel free to call me and we'll talk.
bob

FOIA EXEMPTION (B)(6)

At 04:47 PM 2/7/2003, you wrote:

Hey Guys, both at home and abroad:

What would be the effect if a shuttle main-gear tire had a blowout while stored in its wing cavity?

I cannot think of why such a thing would happen, but it seems that it wouldn't be a good event.

Regards,

[redacted]

---[redacted]
---[redacted]
--- EarthLink: The #1 provider of the Real Internet.

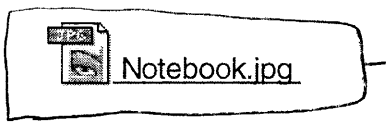
Daugh.-7

From: <AHostetler@timesdispatch.com>
To: R.H.DAUGHERTY@larc.nasa.gov
Subject: tires
Date: Mon, 10 Feb 2003 16:24:17 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

Mr. Daugherty: I understand that you have been involved in projects at Langley using the Advanced Dynamics Landing Facility to test new radial tires for Michelin. I have been told that during the Columbia's recent, tragic mission that Langley responded to a request from Johnson for information on what to do if a tire was blown during the shuttle's landing. Could you please direct me to someone with the ADLF who could confirm and/or elaborate on Johnson's request and Langley's role in that?

Many thanks,

A.J. Hostetler
Science Writer
Richmond Times-Dispatch
P.O. Box 85333
Richmond, VA 23293
ahostetler@timesdispatch.com
804-649-6355 (o)
804-775-8059 (fax)



This was an empty file attached to e-mail.

Daugh. - 8

From: <AHostetler@timesdispatch.com>
To: r.h.daugherty@larc.nasa.gov
Subject: RE: tires
Date: Mon, 10 Feb 2003 17:36:44 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

Thank you for your response. Since I sent my e-mail to you, I have heard from Keith, who has been helpful.

Again, thank you,
aj

A.J. Hostetler
Science Writer
Richmond Times-Dispatch
P.O. Box 85333
Richmond, VA 23293
ahostetler@timesdispatch.com
804-649-6355 (o)
804-775-8059 (fax)

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: 2/10/2003 5:37 PM
To: Hostetler, A.J.
Cc: M.J.SHUART@larc.nasa.gov; H.M.ADELMAN@larc.nasa.gov; HENRY, H KEITH
Subject: Re: tires

Ms. Hostetler,

Thank you for your inquiry of us here at the Aircraft Landing Dynamics Facility. The person best able to respond to your inquiry would be Mr. Keith Henry in our Public Affairs Office which is part of our Office of External Affairs. Mr. Henry may be reached by email at the following address:

H.K.HENRY@LaRC.NASA.GOV

or by telephone at (757) 864-6120

Our Public Affairs Office will be happy to assist you in any way they can.

Very Best Regards,
Bob Daugherty

At 04:24 PM 2/10/2003, you wrote:
Mr. Daugherty: I understand that you have been involved in projects at Langley using the Advanced Dynamics Landing Facility to test new radial tires for Michelin. I have been told that during the Columbia's recent, tragic mission that Langley responded to a request from Johnson for information on what to do if a tire was blown during the shuttle's landing. Could

Daugh.-9

you please direct me to someone with the ADLF who could confirm and/or elaborate on Johnson's request and Langley's role in that?

Many thanks,

A.J. Hostetler
Science Writer
Richmond Times-Dispatch
P.O. Box 85333
Richmond, VA 23293
ahostetler@timesdispatch.com
804-649-6355 (o)
804-775-8059 (fax)

To: <AHostetler@timesdispatch.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: tires
Cc: M.J.SHUART@LaRC.NASA.GOV, H.M.ADELMAN@LaRC.NASA.GOV, "HENRY, H KEITH" <H.K.HENRY@LaRC.NASA.GOV>
Bcc:
Attached:

Ms. Hostetler,

Thank you for your inquiry of us here at the Aircraft Landing Dynamics Facility. The person best able to respond to your inquiry would be Mr. Keith Henry in our Public Affairs Office which is part of our Office of External Affairs. Mr. Henry may be reached by email at the following address:

H.K.HENRY@LaRC.NASA.GOV

or by telephone at (757) 864-6120

Our Public Affairs Office will be happy to assist you in any way they can.

Very Best Regards,
Bob Daugherty

At 04:24 PM 2/10/2003, you wrote:
> Mr. Daugherty: I understand that you have been involved in projects at Langley using the Advanced Dynamics Landing Facility to test new radial tires for Michelin. I have been told that during the Columbia's recent, tragic mission that Langley responded to a request from Johnson for information on what to do if a tire was blown during the shuttle's landing. Could you please direct me to someone with the ADLF who could confirm and/or elaborate on Johnson's request and Langley's role in that?
>
> Many thanks,

A.J. Hostetler
Science Writer
Richmond Times-Dispatch
P.O. Box 85333
Richmond, VA 23293
ahostetler@timesdispatch.com
804-649-6355 (o)
804-775-8059 (fax)

Daugh.-10

X-Sender: h.k.henry@pop.larc.nasa.gov
Date: Mon, 10 Feb 2003 19:53:08 -0500
To: <AHostetler@timesdispatch.com>
From: "H. Keith Henry" <h.k.henry@larc.nasa.gov>
Subject: Fwd: Re: tires
Cc: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>,
M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov

Hello, AJ. You and I covered this in our telephone conversation earlier this evening. I will be asking follow-up questions for you and a couple other folks tomorrow.

keith

X-Sender: r.h.daugherty@pop.larc.nasa.gov
Date: Mon, 10 Feb 2003 17:37:15 -0500
To: <AHostetler@timesdispatch.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: tires
Cc: M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov

Ms. Hostetler,

Thank you for your inquiry of us here at the Aircraft Landing Dynamics Facility. The person best able to respond to your inquiry would be Mr. Keith Henry in our Public Affairs Office which is part of our Office of External Affairs. Mr. Henry may be reached by email at the following address:

H.K.HENRY@LaRC.NASA.GOV

or by telephone at (757) 864-6120

Our Public Affairs Office will be happy to assist you in any way they can.

Very Best Regards,
Bob Daugherty

At 04:24 PM 2/10/2003, you wrote:
Mr. Daugherty: I understand that you have been involved in projects at Langley using the Advanced Dynamics Landing Facility to test new radial tires for Michelin. I have been told that during the Columbia's recent, tragic mission that Langley responded to a request from Johnson for information on what to do if a tire was blown during the shuttle's landing. Could you please direct me to someone with the ADLF who could confirm and/or elaborate on Johnson's request and Langley's role in that?

Many thanks,

Daugh. - 11

A.J. Hostetler
Science Writer
Richmond Times-Dispatch
P.O. Box 85333
Richmond, VA 23293
ahostetler@timesdispatch.com
804-649-6355 (o)
804-775-8059 (fax)

--

****
H. Keith Henry 757-864-6120
M.S. 115 fax 864-8199
Deputy, Office of Public Affairs h.k.henry@larc.nasa.gov
NASA, Langley Research Center
Hampton, VA 23681-2199 http://oea.larc.nasa.gov/
****

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Newspaper article
Cc:
Bcc:
Attached:

Carlisle,
Well, a little info keeps coming out around here...I hear the press may file Freedom of information acts to get copies of emails...this article was in this morning's paper around here...click on the link and you can read it. Our management had put together "canned" responses to possible questions that might arise. The article makes (of course) a bigger deal out of the interactions between us than really occurred...but it isn't too terribly hosed up. You and I have been promoted to "officials". I can't find the video that showed the other view angle on the debris..but will keep looking..it was on the MSNBC web site and they may have rotated that video off of the site...looked around and couldn't find it where I remembered it. I'll let you know if I find it.
See ya,
Bob

http://www.dailypress.com/news/dp-48910sy0feb11,0,6697959.story?coll=dp%2Dheadlines%2Dtopnews

Daugh. - 12

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Video
Cc:
Bcc:
Attached:

Found it... go to this web site:

http://www.msnbc.com/news/867318.asp?0cb=-716134520

And look down at the "Investigating the Cause" heading
There are 6 videos in this section...use the right carrot button and select the 2nd video...it will pop up a video player and the video is 1:39 long. The view we spoke about is about 12 seconds into the video and you can replay that section as much as you like.
Call me after you see it.
take care,
Bob

Daugh. - 13

X-EM-Version: 5, 0, 0, 0
X-EM-Registration: #3003520714B31D032830
Reply-To: [redacted]
X-Mailer: EarthLink MailBox 5.0.7.9 (Windows)
From: [redacted]
To: "Bob Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Tires
Date: Tue, 11 Feb 2003 9:43:58 -0500

Bob,

Appreciate the speedy reply concerning my inquiry about tires. Will be in touch.

I see that Shuttle tires are on the front page of this morning's Daily Press.

Regards,

[redacted]

---[redacted]
---[redacted]
--- EarthLink: The #1 provider of the Real Internet.

FOIA Exemption (b)(6)

Daugh. - 14

To: m.l.blosser@larc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Schematics
Cc:
Bcc:
Attached:

http://spaceflight.nasa.gov/shuttle/reference/sodb/

Daugh. - 15

To: m.l.blosser@larc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Videos
Cc:
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\Desktop\E212.mpg; C:\Documents and Settings\eudora\attach\Debris.ppt;

Attachments are currently on Columbia web site.

http://www.msnbc.com/news/867318.asp?0cb=-716134520

Daugh. - 16

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: My Timeline
Cc:
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\ALDF Timeline.doc; *Attachment currently on Columbia Web Site.

Carlisle,
I was asked to prepare a timeline of all my interactions on the subject and email traffic into and out of here. The attachment is that timeline and I've included as much verbage as I could to try to properly put into context what my recollection was of what happened, how, and why. My Director for Structures fully agreed that you should have a copy of this so here it is.
Take care my friend.
Bob

From: "Schleck, Dave" <DSchleck@dailypress.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: Questions
Date: Wed, 12 Feb 2003 11:55:06 -0600
X-Mailer: Internet Mail Service (5.5.2655.55)

Mr. Daugherty,

I'm working with Keith Henry on a story we're running tomorrow about your e-mail to Langley. I'll be interviewing Mr. Droyer this afternoon. Here are the questions I've provided in advance to Keith. Feel free to assist Doug or Keith with answers to the questions below. If my questions seem off-base, I do not mind being re-directed.

Sincerely,
Dave Schleck
Senior Reporter
Daily Press
Phone: (757)247-7430
E-mail: dschleck@dailypress.com
7505 Warwick Blvd.
Newport News, VA 23607
Fax: (757)245-8618

-----Original Message-----
From: Schleck, Dave
Sent: Wednesday, February 12, 2003 12:51 PM
To: 'h.k.henry@larc.nasa.gov'
Subject: Questions

Keith,

Here are some questions for Langley:
What specific events during the Columbia mission (the foam debris, and/or other specific anomalies) did Lechner or JSC say triggered this request for tire scenario information from Langley?
Did the first call/contact from JSC come on Jan. 27 or Jan 28? NASA has reported both dates.
How has Daugherty worked with Lechner before (where, when, on what issues)?
How long has Daugherty been at NASA Langley? (back in 1980s)
Did NASA LAngley ever get any indication from JSC that any the scenarios/concerns that Daughtery shared were new ideas that they had never considered?
When JSC approached NASA about looking into this tire scenario, did Langley question why NASA was still asking about thermal protection issues when NASA officials had already decided that debris analysis was "inconsequential"?

Daugh. - 19

Now that the catastrophe happened, what do you think as you read back through this e-mail. Do you think some of the things Daugherty's predicted could have led to Columbia's demise? In other words, it is possible that Daugherty could have been right?

Here are some questions meant for Broakus at NASA headquarters, but perhaps Mr. Dwoyer may be able to assist:
Beyond the last 10 minutes of the flight, was there evidence of something unusual going on inside the wheel well. All I know is debris hit underside of left wing near wheel well, was there more?
If team had decided inconsequential, than why were they still asking questions about tile damage relating tire exploding?
In your lead-in, you mention thermal analysis. Just so we're on the same page, tell me what the thermal analysis was - in general?
Thermal analysis was complete on Jan 27, right?
The e-mail also mention debris impact analysis - are they the same thing?
And JSC contacted Langley on JAn. 28, which is a day later than what Langley told me Monday.
FIrst sentence of Daugherty response: Who is Carlisle?
First graph of Daugherty e-mail: What does MOD stand for?
What is the contigency plan if the shuttle's wheels fail to deploy - belly landing?
Ditch/bail out? How would that work?
Scenario 1: What does he mean...until THIS came up? What is the slip stream?
Scenario 2: What are explosive bungies?
Scenario 3: Who is HOward Law?
Could some of these "scenarios" be what ended up happening to Columbia.
What is it like for NASA officials to read through an e-mail like this after the catastrophe?
Can we get complete thread before/after this e-mail?

Is there anyone at Langley who would know if the photo below shows a Columbia shuttle tire (to me it looks like some sort of tank, not a tire, but it's worth a stab)?

<<debris.jpg>>


debris.jpg

debris.jpg (461x720x16M jpeg)

Date: Wed, 12 Feb 2003 13:48:15 -0500
To: r.h.daugherty@larc.nasa.gov
From: "Katherine A. Barnstorff" <k.a.barnstorff@larc.nasa.gov>
Subject: Associated Press article

NASA Questioned Shuttle's Ability to Land

52 minutes ago

Add Science - AP to My Yahoo!

By TED BRIDIS, Associated Press Writer
WASHINGTON - A NASA (news - web sites) engineer weighed the possibility of a "catastrophic" failure resulting from extreme heat on the shuttle Columbia's tires despite assurances days earlier that possible damage to insulating tiles near the landing gear wouldn't imperil the crew.

In internal e-mails released by NASA on Wednesday, one safety engineer, Robert H. Daugherty, warned that extreme temperatures during a fiery descent could cause the wheel to fail and the tire to burst inside Columbia's wheel well.

"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," Daugherty wrote to officials at Johnson Space Center. He added that such an internal blast "would almost certainly blow the door off the hinges or at least send it out into the slip stream - catastrophic."

Daugherty acknowledged his concerns were "over the top in many ways," but added that, "this is a pretty bad time to get surprised and have to make decisions in the last 20 minutes."

He cautioned in his e-mail, "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."

Since Columbia's breakup over Texas, senior NASA officials have expressed repeated confidence in conclusions by engineers at The Boeing Co., its contractor, that the shuttle could return safely despite the risks of damage to delicate thermal tiles on its left wing that might have occurred on liftoff.

In prepared testimony for a congressional hearing Wednesday, NASA Administrator Sean O'Keefe wrote to lawmakers that during the 16-day mission, "we had no indications that would suggest a compromise to flight safety."

Daugh. - 20

An internal assessment by Boeing experts on Jan. 23 - seven days after liftoff - predicted "safe return indicated," even if the foam insulation that fell from Columbia's external fuel tank had caused "significant tile damage."

But NASA confirms that officials from the Space Center called experts Jan. 27 - four days later - at its Langley research facility in Hampton, Va., to ask what might happen if the shuttle's tires were not inflated when it attempted to land.

Daugherty's e-mail, sent Jan. 30 in response to the telephone inquiry, considered the risks that an explosion in Columbia's wheel well from overheating could damage other important systems inside, prevent one side's landing gear from lowering, require a risky belly-landing or force the crew to bail out.

A bailout would be "not a good day," Daugherty wrote. But attempting to fly the shuttle with only one side's gear lowered would be worse: "You're finished."

A Boeing executive said on Tuesday that these kinds of follow-up discussions weren't unusual.

"Many times we generate a report and it generates a question somebody else notices," said Michael I. Mott, Boeing's vice president and general manager of NASA systems. "These are ongoing things, and we never give up and declare victory and move on. They are continuously reviewed to make sure we haven't missed something."

NASA spokesman Keith Henry said an engineer from Langley responded that excessive heating due to failure of the shuttle's thermal protection system could cause damage to Columbia's wheel and tire, which could prevent pilots from lowering the gear at landing.

Officials at Johnson acknowledged that was an important concern, Henry said.

Such an inquiry for Langley researchers involving the safety of a shuttle's tires was unprecedented, Henry said Tuesday. He said that NASA, in its questions, did not specify which tires it was worried about.

Among the earliest warning signs aboard Columbia in the minutes before its destruction was an unusual heat buildup of about 30 degrees inside the left wheel well. Investigators have said they are confident the tire inside didn't deflate, but they have been unable to explain the mysterious readings.

Boeing's study assumed the foam debris struck part of Columbia's left wing, including its

toughened leading edge and thermal tiles covering the landing gear. It concluded the shuttle would have a "safe return capability," although it cautioned about some of the assumptions engineers used in their predictions.

One expert wrote that Columbia's "flight condition is significantly outside of test database," because engineers were relying on scientific models involving impacts from chunks of foam 3 cubic inches in size. Officials believe the foam that struck Columbia was 1,920 cubic inches.

NASA officials have defended the analysis.

"I am convinced that what we looked at in real time, discussions that went on, were painstakingly dealt with," said Milt Heflin, chief of the flight director's office. "I have sat through many discussions on nuts and bolts and washers to great excruciating detail, and there's absolutely no reason for me to believe that this was shortchanged at all."

Shuttle program manager Ron Dittemore said last week that safety conclusions were presented to Columbia's commander, Rick Husband, and that he "was perfectly satisfied with the explanation."

Mott said Boeing recognizes that its engineering analysis will be "scrubbed six ways to Sunday" by investigators trying to determine why Columbia disintegrated as it returned from its 16-day mission.
"There was a very rigorous process applied involving some of the top technical talent on this planet," Mott said. "We thought we were going to bring Columbia safely home. We believed that then, we believe that now. We think that analysis was right on."

--

Kathy Barnstorff
Public Affairs Office
Mail Stop 154
1 West Reid St
NASA Langley Research Center
Hampton, Va. 23681-2199

757 864-9886
k.a.barnstorff@larc.nasa.gov

X-Sender: h.m.adelman@pop.larc.nasa.gov
Date: Wed, 12 Feb 2003 14:08:51 -0500
To:
From: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
Subject: Fwd: Any contacts in past

Date: Wed, 12 Feb 2003 13:33:31 -0500
To: d.l.dicus@larc.nasa.gov, J.S.HARRISON@larc.nasa.gov,
E.R.GENERAZIO@larc.nasa.gov, t.e.noll@larc.nasa.gov,
B.PERRY@larc.nasa.gov, h.m.adelman@larc.nasa.gov,
L.G.HORTA@larc.nasa.gov, s.j.scotti@larc.nasa.gov,
d.r.ambur@larc.nasa.gov, C.A.POUPARD@larc.nasa.gov,
C.C.CANNON@larc.nasa.gov, D.M.HEATH@larc.nasa.gov,
M.P.NEMETH@larc.nasa.gov, j.b.ransom@larc.nasa.gov,
e.j.siochi@larc.nasa.gov, s.r.cole@larc.nasa.gov,
j.h.starnes@larc.nasa.gov, i.s.raju@larc.nasa.gov
From: "Mark J. Shuart" <m.j.shuart@larc.nasa.gov>
Subject: Any contacts in past

Folks,
One of the questions that came up today was, has LaRC ever been contacted before while a Shuttle mission was underway. Thanks for any info you have.....Mark

Let me know if the answer is yes.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Daugh. - 21

From: "Ted Bridis" <tbridis@ap.org>
To: <r.h.daugherty@larc.nasa.gov>
Subject: AP
Date: Wed, 12 Feb 2003 14:48:13 -0500
Organization: The Associated Press
X-Mailer: Microsoft Outlook, Build 10.0.4510
Importance: Normal
X-MIMETrack: Itemize by SMTP Server on CTCMail1/TheAP(Release 5.0.9a |January 7, 2002) at 02/12/2003 02:40:25 PM,
Serialize by Router on CTCMail1/TheAP(Release 5.0.9a |January 7, 2002) at 02/12/2003 02:40:25 PM,
Serialize complete at 02/12/2003 02:40:25 PM,
Itemize by SMTP Server on APRelay1/TheAP(Release 5.0.9a |January 7, 2002) at 02/12/2003 02:34:19 PM,
Serialize by Router on APRelay1/TheAP(Release 5.0.9a |January 7, 2002) at 02/12/2003 02:34:53 PM,
Serialize complete at 02/12/2003 02:34:53 PM

Mr. Daugherty, I understand that HQ public affairs has decided it would not facilitate any contacts between employees and reporters. However, HQ also indicated it would not interfere w/ employees who want to speak with us.

Frankly, I don't know whether you're inclined to have such a conversation about your 1/30 e-mail on the JSC tire inquiry, and I don't want to seem pushy.

But I am eager to hear from anyone with relevant information or anyone who can help present material in context (ie, explaining that your e-mail was describing "absolute worst-case scenarios"). Above all, we're trying to portray what happened and what might have happened accurately.

Thanks for your consideration,
Ted Bridis, staff writer
The Associated Press
2021 K St., NW, Suite 600
Washington, DC 20006
(202) 776-9462, voice
(202) 822-2182, fax
(202) 236-5158, cell
(703) 730-3064, home
Personal e-mail: ted@bridis.net
http://bridis.net/contact

Daugh. - 22

From: "O'brien, Miles" <Miles.Obrien@turner.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: might we have a brief chat
Date: Wed, 12 Feb 2003 15:31:25 -0500
X-Mailer: Internet Mail Service (5.5.2656.59)

Bob -

Trying to put your e-mail of the 30th into proper context. Some non-attribution guidance would be appreciated.

When might be a good time for me to call?

Miles O'Brien
CNN Atlanta

404-827-5114

Daugh. - 23

[redacted]03:31 PM 2/12/2003, Wheel well Tire blowout during SR-71 program

X-Sender: [redacted]
X-Mailer: QUALCOMM Windows Eudora Version 5.1.1
Date: Wed, 12 Feb 2003 15:31:54 -0500
To: D.L.Dwoyer@larc.nasa.gov
From: [redacted]
Subject: Wheel well Tire blowout during SR-71 program
Cc: R.H.Daugherty@larc.nasa.gov, [redacted]

FoIA exemption (b)(6)

Doug, Robert-

You might be interested to know that there was an in-flight blowout of an SR-71 tire during the late 60's at Beale AFB., with near catastrophic results. I was an Air Force engineer in the program at the time and participated in the analysis and investigation. These tires (400 psig) were inside an insulated can when retracted. Both fuel and hydraulic lines were routed through the wheel well on this aircraft. The blowout occurred after a heavyweight refused takeoff was followed by a successful takeoff with insufficient time for the tire sidewalls to cool.

Pieces of the can appeared to have become missiles with the following results:

1) Three of the four hydraulic systems were lost. Fortunately, the one remaining was a flight control system.
2) Cracked fuel lines and/or tank- when the gear was lowered, the chase pilot saw a gush of fuel from the wheel well.
3) I do not remember the details of the structural damage. There was damage, but this is a titanium airframe. We sometimes also had trouble with door uplock adjustment resulting in elevated wheel well temperatures due to gaps at high Mach.

There should be an incident report somewhere in the Air Force archives that could be used to extrapolate possible damage if the shuttle tires exploded due to heating.

I hope that this lead is useful. I would appreciate being informed if that turns out to be the case.

[redacted]
Major, USAF (retired)

[redacted]

FoIA Exemption (b)(6)

Daugh. -24

X-Sender: h.m.adelman@pop.larc.nasa.gov
Date: Wed, 12 Feb 2003 16:01:26 -0500
To:
From: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
Subject: Handling Media Contacts

SDB:

Just a reminder. Any reporters who contact you concerning the Columbia accident are to be referred to Keith Henry in the Office of External Affairs 864-6120.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Daugh. -25

To: "Ted Bridis" <tbridis@ap.org>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: AP
Cc: H.K.HENRY@LaRC.NASA.GOV
Bcc:
Attached:

Mr. Bridis,

Thank you for your inquiry of us here at the Aircraft Landing Dynamics Facility. The person best able to respond to your inquiry would be Mr. Keith Henry in our Public Affairs Office which is part of our Office of External Affairs. Mr. Henry may be reached by email at the following address:

H.K.HENRY@LaRC.NASA.GOV

or by telephone at (757) 864-6120

Our Public Affairs Office will be happy to assist you in any way they can.

Very Best Regards,
Bob Daugherty

At 02:48 PM 2/12/2003, you wrote:
Mr. Daugherty, I understand that HQ public affairs has decided it would not facilitate any contacts between employees and reporters. However, HQ also indicated it would not interfere w/ employees who want to speak with us.

Frankly, I don't know whether you're inclined to have such a conversation about your 1/30 e-mail on the JSC tire inquiry, and I don't want to seem pushy.

But I am eager to hear from anyone with relevant information or anyone who can help present material in context (ie, explaining that your e-mail was describing "absolute worst-case scenarios"). Above all, we're trying to portray what happened and what might have happened accurately.

Thanks for your consideration,
Ted Bridis, staff writer
The Associated Press
2021 K St., NW, Suite 600
Washington, DC 20006
(202) 776-9462, voice
(202) 822-2182, fax
(202) 236-5158, cell
(703) 730-3064, home
Personal e-mail: ted@bridis.net
http://bridis.net/contact

To: "O'brien, Miles" <Miles.Obrien@turner.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: might we have a brief chat
Cc: H.K.HENRY@LaRC.NASA.GOV
Bcc:
Attached:

Mr. O'brien,

Thank you for your inquiry of us here at the Aircraft Landing Dynamics Facility. The person best able to respond to your inquiry would be Mr. Keith Henry in our Public Affairs Office which is part of our Office of External Affairs. Mr. Henry may be reached by email at the following address:

H.K.HENRY@LaRC.NASA.GOV

or by telephone at (757) 864-6120

Our Public Affairs Office will be happy to assist you in any way they can.

Very Best Regards,
Bob Daugherty

At 03:31 PM 2/12/2003, you wrote:

Bob -

Trying to put your e-mail of the 30th into proper context. Some non-attribution guidance would be appreciated.

When might be a good time for me to call?

Miles O'Brien
CNN Atlanta

404-827-5114

Daugh. -27

From: "Ted Bridis" <tbridis@ap.org>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: RE: AP
Date: Wed, 12 Feb 2003 16:12:11 -0500
Organization: The Associated Press
X-Mailer: Microsoft Outlook, Build 10.0.4510
Importance: Normal
X-MIMETrack: Itemize by SMTP Server on CTCMail1/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 04:04:25 PM,
Serialize by Router on CTCMail1/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 04:04:26 PM,
Serialize complete at 02/12/2003 04:04:26 PM,
Itemize by SMTP Server on APRelay1/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 03:58:20 PM,
Serialize by Router on APRelay1/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 03:58:51 PM,
Serialize complete at 02/12/2003 03:58:51 PM

Robert, thanks for your response. I've been in touch with Keith Henry over the past several days on this issue, and he has been unusually helpful. I asked him today by phone whether it would be alright to solicit an interview with you, and he suggested sending you e-mail with my contact information.

Again, if you're inclined at all to talk, in whatever capacity you're comfortable with (on the record, on background, or even off the record just to point out something right or wrong in news reports, etc.) I would be very happy to speak with you, especially about your 1/30 tire concerns.

Rgds,
Ted Bridis, staff writer
The Associated Press
2021 K St., NW, Suite 600
Washington, DC 20006
(202) 776-9462, voice
(202) 822-2182, fax
(202) 236-5158, cell
(703) 730-3064, home

Daugh. - 28

To: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Handling Media Contacts
Cc:
Bcc:
Attached:

Hi Howard,
Am getting a million as you can imagine. All are being referred to Keith. Am gonna put a message on my (incessantly ring) phone to direct people to Keith. As you recall, I have leave scheduled for tomorrow and Friday and this is a very good time to exercise that so I'll be off then. Please reinforce to Jeanne that I would not like my cell phone number given out to anyone but you guys can absolutely call me. I know I don't have to say that but figured I would. Thanks alot.
Bob

At 04:01 PM 2/12/2003, you wrote:
SDB:

Just a reminder. Any reporters who contact you concerning the Columbia accident are to be referred to Keith Henry in the Office of External Affairs 864-6120.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Daugh. -29

X-Sender: h.m.adelman@pop.larc.nasa.gov
Date: Wed, 12 Feb 2003 16:56:50 -0500
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
From: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
Subject: Re: Handling Media Contacts

Bob:

Message understood. Have a good few days off.

Howard

Hi Howard,
Am getting a million as you can imagine. All are being referred to Keith. Am gonna put a message on my (incessantly ring) phone to direct people to Keith. As you recall, I have leave scheduled for tomorrow and Friday and this is a very good time to exercise that so I'll be off then. Please reinforce to Jeanne that I would not like my cell phone number given out to anyone but you guys can absolutely call me. I know I don't have to say that but figured I would. Thanks alot.
Bob

At 04:01 PM 2/12/2003, you wrote:
SDB:

Just a reminder. Any reporters who contact you concerning the Columbia accident are to be referred to Keith Henry in the Office of External Affairs 864-6120.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808

Daugh. - 30

Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

X-Sender: h.m.adelman@pop.larc.nasa.gov
Date: Wed, 12 Feb 2003 16:56:50 -0500
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
From: "Howard M. Adelman" <h.m.adelman@larc.nasa.gov>
Subject: Re: Handling Media Contacts

Bob:

Message understood. Have a good few days off.

Howard

Hi Howard,
Am getting a million as you can imagine. All are being referred to Keith. Am gonna put a message on my (incessantly ring) phone to direct people to Keith. As you recall, I have leave scheduled for tomorrow and Friday and this is a very good time to exercise that so I'll be off then. Please reinforce to Jeanne that I would not like my cell phone number given out to anyone but you guys can absolutely call me. I know I don't have to say that but figured I would. Thanks alot.
Bob

At 04:01 PM 2/12/2003, you wrote:
SDB:

Just a reminder. Any reporters who contact you concerning the Columbia accident are to be referred to Keith Henry in the Office of External Affairs 864-6120.

Thanks,
Howard

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808
Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

Dr. Howard M. Adelman
Head, Structural Dynamics Branch
NASA Langley Research Center
Mail Stop 230
Building 1293B, Room 131 Phone: (757) 864-2804
4B West Taylor Street FAX: (757) 864-8808

Hampton, VA 23681-0001 Email: h.m.adelman@larc.nasa.gov

From: "Mozingo, Joe" <JMozingo@herald.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Date: Wed, 12 Feb 2003 17:18:42 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

Robert,

I am working on a story reconstructing the decision-making at JSC during the Columbia mission for the Miami Herald and the Knight Ridder wire. I would like to interview --on the record or just for background's sake -- if you would consent, to flesh out some of the points you made in the e-mail. Among other questions, I am trying to determine if these issues were ever raised to the Mission Management Team. I also am not quite clear on who asked you to address these issues with the TPS and the landing gear and when. Did the Anamoly Resolution Team raise the issue, or did you just know someone in the loop who had concerns and relayed them to you? All of this would help us greatly in clarifying what happened and how reservations about safety move through the chain of command. Any help you could provide would be vastly appreciated.

Joe Mozingo
305-376-2035
cell-305-992-6509
fax-305-376-5287
jmozingo@herald.com

From: "Ted Bridis" <tbridis@ap.org>
To: <r.h.daugherty@larc.nasa.gov>
Subject: FW: tire
Date: Wed, 12 Feb 2003 17:19:41 -0500
Organization: The Associated Press
X-Mailer: Microsoft Outlook, Build 10.0.4510
Importance: Normal
X-MIMETrack: Itemize by SMTP Server on CTCMail1/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 05:11:57 PM,
Serialize by Router on CTCMail1/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 05:11:58 PM,
Itemize by SMTP Server on APRelay2/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 05:09:18 PM,
Serialize by Router on APRelay2/TheAP(Release 5.0.9a |January 7, 2002) at
02/12/2003 05:09:51 PM

Could you tell me whether you have any insights into this? An AP photographer accompanied search teams in Texas, and a National Guard/EPA team recovered this.

-----Original Message-----
From: Ted S. Warren [mailto:twarren@ap.org]
Sent: Wednesday, February 12, 2003 5:15 PM
To: Ted Bridis
Subject: tire


tire small not for the wire.jpg

Daugh. - 33

tire small not for the wire.jpg (720x482x16M jpeg)

From: "Gold, Scott" <Scott.Gold@latimes.com>
To: "'R.H.DAUGHERTY@LaRC.NASA.GOV'" <R.H.DAUGHERTY@larc.nasa.gov>
Subject: Los Angeles Times article
Date: Wed, 12 Feb 2003 14:48:10 -0800
X-Mailer: Internet Mail Service (5.5.2653.19)

Mr. Daugherty,
My name is Scott Gold. I'm the Houston bureau chief with the Los Angeles Times. I'm working on an article for tomorrow morning's newspaper about the email exchange you were a part of re: potential tile damage. Can you take a minute to either talk to me on the phone or email me to further characterize this discussion? I can be reached at 713 302 9279 or scott.gold@latimes.com. Thanks for your time and consideration. Take care,
Scott Gold

Daugh.-34

From: "Mozingo, Joe" <JMozingo@herald.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: e-mails
Date: Wed, 12 Feb 2003 18:58:32 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

I realize NASA won't let anyone talk, which is stifling the flow of info and leaving far too much for speculation. And I am guessing by your e-mails that you are someone who speaks his mind. Would you please consider talking to me on background so we can give a clearer, true version of events to the public. Again, your name would not be used in the article or in any conversation. We go to great measures to protect sources and I have never burned one. Please call me at 305-376-2035, cell-305-992-6509, or fax-305-376-5287. Thank you.

Joe Mozingo
Investigative Reporter, Miami Herald/Knight Ridder/

From: "Mozingo, Joe" <JMozingo@herald.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: e-mails
Date: Wed, 12 Feb 2003 18:58:32 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

I realize NASA won't let anyone talk, which is stifling the flow of info and leaving far too much for speculation. And I am guessing by your e-mails that you are someone who speaks his mind. Would you please consider talking to me on background so we can give a clearer, true version of events to the public. Again, your name would not be used in the article or in any conversation. We go to great measures to protect sources and I have never burned one. Please call me at 305-376-2035, cell-305-992-6509, or fax-305-376-5287. Thank you.

Joe Mozingo
Investigative Reporter, Miami Herald/Knight Ridder/

Daugh. -36

Daugh-37

E-mail withheld due to disclosure statement attached to message stating that information is to aid in the investigation of the Columbia mishap and should only be distributed to personnel actively involved in the investigation.

X-EM-Version: 5, 0, 0, 0
X-EM-Registration: #3003520714B31D032830
Reply-To: [redacted]
X-Mailer: EarthLink MailBox 5.0.7.9 (Windows)
From: [redacted]
To: "Bob Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Tire blowout
Date: Thu, 13 Feb 2003 7:53:22 -0500

FOIA Exemption (b)(6)

Hi, [redacted]

Saw a familiar likeness on the front page of this morning's Daily Press.

I should have figured that you were way ahead of me on the Shuttle tire blowout issue.

If they wanted a candid, thoughtful, intelligent answer, they certainly asked the right person when they asked you. I would have expected nothing less from you.

Apparently NASA has you embargoed, but I imagine that is going to be difficult to do in the long run.

With Yager in Japan, I suppose you are the "lone ranger" at ALDF. Won't be long before no one will be left there to answer anyone's questions. Sad, sad, . . .

Regards,

[redacted]

---[redacted]
--[redacted]
--- EarthLink: The #1 provider of the Real Internet.

Daugh - 38

X-Sender: m.a.ohara@pop.larc.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 5.0.2
Date: Thu, 13 Feb 2003 08:16:52 -0500
To: M M Skora <M.M.Skora@larc.nasa.gov>, <Mary.M.Skora@nasa.gov>,
chris Rink <c.p.rink@larc.nasa.gov>
From: "Michael A. O'Hara" <m.a.ohara@larc.nasa.gov>
Subject: News
Cc: bob Daugherty <r.h.daugherty@larc.nasa.gov>

See http://www.msnbc.com/news/871645.asp?0cv=CB10

THE ENGINEER, Robert Daugherty of NASA's Langley Research Center in Hampton, Va., sent the e-mail to a colleague at the Johnson Space Center in Houston on Jan. 30. NASA released the exchange today.

If there were a failure of the heat shielding of the wing in the area of the wheel well, Daugherty wrote, "at some point the wheel could fail and send debris everywhere. ... 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 e-mails are the first known documentation that anyone at NASA detailed a specific scenario during the mission in which damage to the heat shield might lead to disaster.

Michael A.O'Hara
Office of Business Development
Mail Stop 200
3 Langley Boulevard
Hampton, VA 23681-2199

Office: (757) 864-8455
Fax: (757) 864-8314
m.a.ohara@larc.nasa.gov

Daugh. -39

Subject: FW: 34 Shuttle debris pictures from Texas
Date: Thu, 13 Feb 2003 08:38:10 -0500
Thread-Topic: 34 Shuttle debris pictures from Texas
Thread-Index: AcLS781xCVP4XdltS66VtAXJH+SodAAdTsRA
From: "Simpkins, Terry" <Terry.Simpkins@msiusa.com>
To: "Bruce Jackson (E-mail)" <bruce@jaxfam.com>,
"Bob Daugherty (E-mail)" <R.H.DAUGHERTY@larc.nasa.gov>

Don't know if you have seen this site yet.

****

Terry W. Simpkins
Applications Director
Measurement Specialties
757-766-4278
terry.simpkins@msiusa.com
****

I just got this from an "internal source":
34 online pictures of Shuttle debris sent by someone who lives in the Nacogdoches, Texas area. Many if not most of these photos I have not seen anywhere else (although I have not been looking hard at all either).

http://www.picturetrail.com/gallery/view?p=12&uid=904355&gid=1652603

Rumor has it this site may not be up long; I have no idea if that rumor is credible or not...

Ken Sletten

Daugh. -40

X-Sender: w.b.grant@larc.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Thu, 13 Feb 2003 10:06:44 -0500
To: R.H.DAUGHERTY@larc.nasa.gov
From: "William B. Grant" <w.b.grant@larc.nasa.gov>
Subject: NY Times

Hi,
I have a copy of today's NY Times with the story on your e-mail if you would like it.
Bill

William B. Grant
Lidar Applications Group, Atmospheric Sciences Research
NASA Langley Research Center, MS 401A
Hampton, VA 23681-2199
Phone: 757-864-5846; FAX 757-864-7790
mailto:W.B.Grant@larc.nasa.gov

See Lidar HomePage at:
http://asd-www.larc.nasa.gov/lidar/lidar.html

Daugh.-42

Date: Thu, 13 Feb 2003 09:48:49 -0600
From: "Jim Murphy" <murph@murphymotorsports.com>
Reply-To: <murph@murphymotorsports.com>
To: <r.h.daugherty@larc.nasa.gov>, <david.f.lechnerl@jsc.nasa.gov>,
<m.j.shuart@larc.nasa.gov>
CC: <carlisle.c.campbell@nasa.gov>
Subject: CNN Article on Your E-mail
X-Mailer: <IMail v7.10>

Dear Gentlemen:

A very brief note of support to you. I am sure that none feel the loss of Columbia and her crew as dearly as those of you intimately involved in the program.

I, along with my friends and family, have the utmost confidence that the root cause of this incident will be found, addressed, and the program will continue onwards. I lost friends in the crew, but I know they had confidence in your team, so I share it now.

I also wanted to note to you that I thought it was irresponsible for CNN to post a copy of your internal correspondance, including your e-mail addresses, on their web site. As an engineerand a pilot myself, I understand how/where discussions like this fit into things. I fear that not everyone who might write you will be as supportive as I.

Jim Murphy
Brookline, NH

Daugh. -44

Subject: Hello Bob
Date: Thu, 13 Feb 2003 11:04:46 -0500
Thread-Topic: Hello Bob
Thread-Index: AcLTef86pYO76j8mEdehlwCw0lBclw==
From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
X-OriginalArrivalTime: 13 Feb 2003 16:04:47.0082 (UTC) FILETIME=[A1523CA0:01C2D379]

FOIA EXEMPTION (b)(6)

Might you be the same Bob Daugherty who was an Air Force officer at the Air Force Flight Dynamics Laboratory in the 1960's or 1970's? I was at the 50 Megawatt Facility 1965-1969, and back in Flight Mechanics Division 1972-1978.
After seeing your name in an ABC News report online this morning I was able to go to the NASA page and eventually got to your original email of January 31. I think you were right on. Based upon the degree of concern indicated, I am surprised that JSC didn't switch to a landing at Edwards where a wheels-up belly landing on the lake might have been attempted if severe damage to the wheelwell/gear was indicated by then. Unfortunately, the damage was greater than that. Was wheelwell instrumentation output lost before it might have indicated tire failure?
I am amazed that Air Force cinetheodolite cameras were not employed to check for possible tile/leading edge damage (maybe they were, but is classified and hasn't been reported).
I'm certain that you are very busy as a result of the publicity. If you ever get up to the Washington, DC area, I'd like to get together.
I'm helping the Navy upgrade the self-defense missile capability on their Amphibious Assault ships standing off Pakistan, Yemen, and Kuwait. Fortunately, the bad guys haven't gotten close enough to take a shot or ram them with explosives-laden boat.
A reply would be much appreciated when you get the time.
Keep up the great technical work!

>[redacted]
>
>
>
>
>
>

Daugh. -45

X-Sender: r.s.pappa@pop.larc.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Thu, 13 Feb 2003 11:05:20 -0500
To: Bob Daugherty <r.h.daugherty@larc.nasa.gov>,
Howard Adelman <h.m.adelman@larc.nasa.gov>,
Mark Shuart <m.j.shuart@larc.nasa.gov>,
Tom Noll <t.e.noll@larc.nasa.gov>,
Keith Henry <h.k.henry@larc.nasa.gov>
From: "Richard S. Pappa" <r.s.pappa@larc.nasa.gov>
Subject: Fwd: Today on SPACE.com -- Thursday, February 13, 2003

I assume you've already seen this article posted on-line. Just wanted to be sure... It just arrived in my mail box.

Richard

SpaceFlight:

* NASA E-mail Discussed Landing Disaster Scenarios
http://www.space.com/missionlaunches/sts107_email_030212.html

A NASA engineer advised mission controllers two days before shuttle Columbia's landing to be ready to make tough choices in the final minutes just in case heat shield tiles on the landing gear door were damaged during launch.

Daugh. -46

Subject: FW: E-mail warned of potential shuttle damage
Date: Thu, 13 Feb 2003 10:21:50 -0600
X-MS-Has-Attach: yes
Thread-Topic: E-mail warned of potential shuttle damage
Thread-Index: AcLTb6kslhfz6edjRUK74WD5N4MP4AAC//uQ
From: "Peterson, Alan" <Alan.Peterson@boeing.com>
To: "Bob Daugherty" <r.h.daugherty@larc.nasa.gov>

FYI

> -----Original Message-----
> From: Hashimoto, Rick
> Sent: Thursday, February 13, 2003 8:53 AM
> Subject: E-mail warned of potential shuttle damage
>
>
> > <<E-Mail.pdf>>
> E-mail warned of potential shuttle damage
>
> 2/13/2003 1:55 AM
>
> HOUSTON, Feb. 13 (UPI) -- A safety engineer, asked to consider
> problems resulting from debris hitting the shuttle Columbia,
> warned that damage in the craft's wheel well could lead to
> "catastrophic" outcomes.
>
> Columbia broke apart during re-entry minutes short of its
> scheduled landing Feb. 1 in Florida. The craft's disintegration
> resulted in the deaths of the seven astronauts on board.
>
> While NASA officials say no reason for the catastrophe has been
> found -- or ruled out -- much attention has been paid to an
> incident about 80 seconds after Columbia left the ground Jan. 16,
> in which a piece of debris hit the shuttle's left wing.
>
> NASA decided the debris did little damage but officials still
> asked for potential outcomes.
>
> Robert Daugherty, an engineer at the NASA Langley Research Center
> in Hampton, Va., said he was "erring on the side of absolute
> worst-case scenarios" in his Jan. 30 e-mail message to David
> Lechner, a contractor on the team responsible for Columbia's
> mechanical and crew systems.
>
> Daugherty outlined several possibilities involving the shuttle's
> wheels, including the gear failing to deploy and an explosion in
> the wheel well.
>
> Describing the latter scenario, Daugherty wrote, "The resulting

Daugh. - 47

> 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."
>
> The engineer wrote that the wheel itself could "fail" and create
> "much carnage in the wheel well, something could get screwed up
> enough to prevent deployment and then you are in a world of
> hurt."
>
> James Heflin, NASA mission operations chief flight director told
> The New York Times that Daugherty was "what-iffing, which is some
> we do a lot of." Other NASA engineers had already decided that
> the Jan. 16 collision with the debris had not caused serious
> damage.
>
> Heflin, the Times reported, said, "The conclusion was that we
> didn't have a safety-of-flight issue."
>
> Daugherty also offered possibilities should the landing gear not
> deploy, saying consideration should be given to shuttle flight
> capabilities with one gear down and one up, landing with neither
> gear deployed and "If a belly landing is unacceptable,
> ditching/bailout might be next on the list. Not a good day."
>
> It was in the final minutes before scheduled landing that NASA
> noticed sensors in the left wheel well giving unusual readings or
> not working at all. Daugherty said he was offering his series of
> potential outcomes because "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."
>
> The safety engineer concluded his e-mail message with:
> "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."
>
> NASA made Daugherty's e-mail message available Wednesday on its
> Web site.
>

>
>
>
> ==========
>
> NASA E-Mail Exchange Notes 'Worst-Case Scenarios'
>
> Wed Feb 12, 9:58 PM ET

>
> WASHINGTON (Reuters) - Two days before shuttle Columbia
> disintegrated over Texas, NASA engineers discussed possible
> "worst-case scenarios" if the craft's left landing gear had been
> damaged by falling debris just after liftoff.
>
> "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," Robert
> Daugherty of NASA's Langley Research Center in Virginia wrote in
> an e-mail to David Lechner at Johnson Space Center on Jan. 30,
> with copies to other NASA officials.
>
> The e-mail exchange, released on Wednesday by NASA, was
> characterized by NASA flight director Milt Heflin as typical of
> discussions during shuttle missions.
>
> Heflin said in a telephone news conference that he was unaware of
> the e-mail exchange until Feb. 3, two days after Columbia broke
> up as it streaked across Texas at the end of a 16-day mission.
> All seven astronauts were killed.
>
> Leroy Cain, who was the entry flight director when the shuttle
> lost contact with ground controllers, said he only became fully
> aware of the e-mails until Wednesday.
>
> Both Cain and Heflin said the questions raised by the e-mail
> discussion did not reach them during the flight because the
> concerns were addressed by engineers and were found not to be a
> hazard to flight safety.
>
> Daugherty acknowledged at the outset, "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."
>
> He then went on to mention such possibilities as the craft's
> tires blowing up inside the wheel well, excessive heating
> affecting hardware inside the wheel well, a landing on two flat
> tires and a belly-landing in case neither wheel deployed.
>
> "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," Daugherty wrote. "You can count on us to
> provide any support you think you need."
>
> In an e-mail sent on Jan. 31, Lechner thanked Daugherty for the
> "candid remarks," which he said had sparked "valuable
> discussion." He concluded, "Like everyone, we hope that the
> debris impact analysis is correct and all this discussion is mute

> (sic)."
>
> Foam insulation from the shuttle's external fuel tank appeared to
> fall and strike the shuttle's left wing about 80 seconds after
> liftoff, and investigators have focused on this as they searched
> for debris on the ground, with special emphasis on finding parts
> of the left wing.
>

>
> ==========
>
> NASA Engineer Warned of Tire Catastrophe
>
> Thu Feb 13, 5:05 AM ET
>
> By TED BRIDIS, Associated Press Writer
>
> WASHINGTON - A NASA safety engineer wrote two days before
> Columbia's mysterious breakup about risks to the shuttle from
> "catastrophic" failures caused by tires possibly bursting inside
> the spacecraft from extreme heat during its fiery descent, the
> space agency disclosed.
>
> Robert H. Daugherty, responding to an inquiry from Johnson Space
> Center, cautioned in an e-mail to NASA colleagues that damage to
> delicate insulating tiles near Columbia's landing gear door could
> cause one or more tires inside to burst, perhaps ending with
> catastrophic failures that would place the seven astronauts "in a
> world of hurt."
>
> Such an explosion inside Columbia's belly, Daugherty predicted,
> could blow out the gear door and expose the shuttle's unprotected
> innards to searing temperatures as it raced through earth's
> atmosphere.
>
> On the same day NASA disclosed the contents of Daugherty's e-
> mail, searchers near Hemphill, Texas, about 140 miles northeast
> of Houston, recovered what they believed to be one of Columbia's
> tires. It sustained a massive split across its tread, but it was
> impossible from photographs to know whether the tire was damaged
> aboard Columbia or when it struck the ground.
>
> NASA officials in Washington said Wednesday they could not
> confirm the tire was the shuttle's.
>
> In his e-mail, which included remarkably strident language,>
> Daugherty wrote that even if astronauts survived the heat, the
> blast could damage critical systems inside the wheel compartment,

> prevent the landing gear on one side from lowering, necessitate a
> risky belly landing or force the crew to bail out.
>
> Bailing out would be "not a good day," he wrote. But attempting
> to fly the shuttle with only one side's landing gear lowered
> would be worse: "You're finished."
>
> Flight Director Leroy Cain said Wednesday that investigators were
> confident the gear door did not fall off in flight because such a
> failure would have been indicated on sensor readings.
>
> Other NASA officials have cited mysterious sensor readings in the
> wheel well moments before Columbia's breakup but have said they
> were confident the tire didn't burst inside the shuttle.
>
> Daugherty acknowledged these were "absolute worst-case
> scenarios," adding, "I don't really believe things are as bad as
> I'm getting ready to make them out." But he defended raising the
> issues in e-mail to avoid a "gut-wrenching decision" days later
> during Columbia's descent.
>
> Daugherty on Wednesday referred questions about his concerns to a
> NASA spokesman. Agency officials indicated they did not want
> reporters to speak with Daugherty because accident investigators
> had not yet questioned him. NASA disclosed the contents of his e-
> mail Wednesday.
>
> The e-mail from Daugherty, an engineer at NASA's Langley research
> facility in Hampton, Va., was prompted by a telephone call Jan.
> 27 from experts at the Johnson Space Center in Houston who asked
> what might happen if Columbia's tires were not inflated when it
> attempted to land.
>
> The inquiry from Johnson has attracted interest because it came
> four days after engineers at The Boeing Co., a contractor,
> assured NASA that Columbia could return safely despite damage to
> left wing tiles that might have occurred on liftoff.
>
> Senior NASA officials said Daugherty's concerns were part of a
> "what-if" analysis by a small group of engineers who already had
> been assured that Columbia would land safely. They acknowledged
> that concerns about threats to the shuttle's tires were not
> passed along to NASA flight directors.
>
> Milt Heflin, chief of the flight director's office, said
> Daugherty and others involved in the tire questions "were happy
> with the analysis and the work that was done" by Boeing. "They
> were continuing to do more what-if'ing."
>

> An e-mail back to Daugherty the next day from a Johnson Space
> Center engineer, David F. Lechner of the United Space Alliance
> LLC, another NASA contractor, thanked Daugherty for his "candid
> remarks." He said they "generated extremely valuable discussion
> in our group."
>
> "We hope the debris impact analysis is correct and all this
> discussion is mute," Lechner wrote.
>
> Another Langley employee, Mark J. Shuart, responded by e-mail
> later that day, "Looks like they believe all this has been
> addressed." His message was time-stamped about 20 hours before
> the shuttle disintegrated.
>
> Senior NASA officials have repeatedly expressed confidence in
> Boeing's conclusions, which predicted "safe return indicated"
> even if foam insulation that fell from Columbia's external fuel
> tank had caused "significant tile damage." That study assumed
> foam debris struck part of Columbia's left wing, including its
> toughened leading edge and the thermal tiles covering the landing
> gear.
>
> Testifying at a joint congressional hearing Wednesday, NASA
> Administrator Sean O'Keefe told lawmakers that during Columbia's
> 16-day mission, "there were no abnormalities that would suggest a
> problem. If there was any indication, they would have showed up."
>
> Among the earliest warning signs aboard Columbia in the minutes
> before its demise was an unusual heat buildup of about 30 degrees
> inside the left wheel well. Investigators have said they are>
> confident the tire inside didn't deflate, but they have been
> unable to explain the readings.
>

>
>
> ==========
>
> NASA engineer's e-mail warned of possible disaster
>
> Thursday, February 13, 2003
> 5:46 AM EST (1046 GMT)
>
> JOHNSON SPACE CENTER, Texas (CNN) -- An e-mail passed between
> NASA engineers two days before the fatal breakup of the space
> shuttle Columbia discussed worst-case scenarios involving tiles
> on the orbiter's underbelly that may have been damaged shortly
> after liftoff, specifically dealing with failures in the wheel
> well.

>
> Robert Daugherty, an engineer, outlined several scenarios in his
> e-mail to David Lechner, who worked with the shuttle's mechanical
> systems. They were based on possible outcomes of tile damage the
> orbiter may have suffered only 80 seconds after it lifted off
> from Kennedy Space Center January 16.
>
> When they analyzed video of the liftoff a day later, NASA
> officials noticed what they believe was a piece of foam breaking
> off the external tank and glancing off the underside of the
> shuttle's left wing.
>
> "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," Daugherty wrote in his January
> 30 e-mail. "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."
>
> As the shuttle streaked across the sky February 1 toward its
> landing site in Florida, controllers at Johnson Space Center in
> Houston remarked that sensors inside the wheel well showed higher
> temperature readings. Other sensors were shutting down, one by
> one.
>
> Minutes later, the shuttle broke up, killing all seven crew
> members.
>
> In his e-mail, Daugherty theorized that the shuttle's landing
> gear may not deploy if there was "a substantial breach of the
> wheel well."
>
> "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," his missive said.
>
> NASA Administrator Sean O'Keefe, testifying before a joint
> committee of Congress earlier Wednesday, said that nothing during
> the mission hinted at the impending disaster.
>
> "During the 16-day STS-107 mission, we had no indication that
> would suggest a compromise in flight safety," he told lawmakers.
> (Full story)
>
> In his e-mail, Daugherty ran through several horrific scenarios,
> including having the landing gear door blow off its hinges,
> having only part of the landing gear functioning for touchdown,
> or trying to land the shuttle on its belly.
>

> "If belly landing is unacceptable, ditching/bailout might be next
> on the list. Not a good day," he wrote.
>
> CNN Space Correspondent Miles O'Brien pointed out that
> communications such as this are common between engineers, whose
> jobs involve developing such scenarios and solutions.
>
> The shuttle team ultimately decided that any possible damage from
> the foam was not serious.
>
> Meanwhile, the Columbia Accident Investigation Board arrived at
> Kennedy Space Center Wednesday to look at the debris that has
> been trucked there from collection fields in eastern Texas and
> western Louisiana. (Full story)
>
> The pieces will be laid out in a large hangar on a huge grid
> taped to the floor -- a grid in the shape of the Columbia.
> Investigators are trying to place the debris on the grid site
> where it would have been on the orbiter.
>
> O'Keefe had asked the board to render a conclusion in 60 days, if
> it can, as to what exactly brought the shuttle down. The board
> has indicated it may ask for more time.
>
>
>
>
>
> ==========
>
> Feb. 13, 2003, 7:00AM
>
> E-mail raised bleak options
>
> By DAN FELDSTEIN and MARK CARREAU
>
>
>
> Columbia could be "in a world of hurt" if thermal tiles
> protecting the left wheel were compromised, a NASA engineer wrote
> two days before the shuttle was destroyed.
>
> At the time of the e-mail message, written by an employee in
> Virginia, Boeing engineers and NASA mission managers already had
> concluded that falling debris had not seriously harmed Columbia's
> left wing and wheel well on liftoff.
>
> But midlevel flight controllers were still concerned enough to

> seek his opinion, the note reveals.
>
> An independent board is investigating whether insulation from the
> orbiter's external fuel tank actually did start the chain of
> events that brought down the shuttle.
>
> NASA officials said Wednesday that the Jan. 30 note was never
> disclosed to Columbia's flight director or other senior Mission
> Control officers. But they said they weren't troubled by that
> because their best analysis was that the tile above the wheel
> well had not been seriously damaged.
>
> "It was them just `what-iffing.' They were happy with the
> (debris) analysis and the work that was done during the mission.
> They understood that. They felt comfortable with that," said
> chief flight director Milt Heflin, who did not learn of the note
> exchange until two days after the Columbia disaster.
>
> The bleak analysis was written by Robert Daugherty, an expert on
> the shuttle's landing gear system from NASA's Langley Research
> Center. In candid detail, he spoke of the "carnage" that would
> occur if the wheel area overheated during re-entry. Temperatures
> outside the orbiter reach 3,000 degrees, and only the thermal
> tiles protect its sensitive systems.
>
> Daugherty acknowledges his scenarios were "absolute worst-case,"
> but still urged Mission Control to "seriously consider" the
> possibility of landing with the landing gear retracted or getting
> the astronauts to try to parachute out. He said it would be
> "irresponsible" not to be prepared.
>
> The recipient of the e-mail at Johnson Space Center, David
> Lechner, an employee of United Space Alliance, thanked Daugherty
> and wrote, "Like everyone, we hope that the debris impact
> analysis is correct and all this discussion is mute (sic)."
>
> Investigators have taken great pains to say they have no idea yet
> what brought down Columbia. But one of many scenarios being
> considered is that the debris analysis wasn't correct.
>
> Daugherty wrote that Mission Control ought to be ready just in
> case. If the wheel well heated up too much because tile was
> compromised, the aluminum wheel would overheat and the tires
> could explode, he said.
>
> Daugherty offered several scenarios:
>
> · If the tires blew up, the landing gear door would blow off into
> the hypersonic airstream and lead to destruction of the orbiter.

> At the least, the drag on the spacecraft might not allow it to
> reach the runway at Kennedy Space Center in Florida.
>
> · The heat might also detonate the explosive charges stowed in
> the wheel well designed to dislodge the gear doors on landing
> approach if mechanical systems failed. That would deploy the
> wheels at 200,000 feet, with the same result.
>
> · Excessive heating might affect hydraulic fluid or other systems
> in the well, possibly preventing the landing gear from deploying
> at all.
>
> If one gear did not deploy at the normal moment, just seconds
> from the runway, and the other side did deploy, the
> "asymmetrical" condition would destroy the shuttle on landing,
> Daugherty wrote.
>
> If the shuttle attempted a landing on its belly, the shuttle's
> backside flaps would hit first and pitch the crew compartment up>
> front violently down onto the runway.
>
> To avoid a belly landing, the crew could always bail out. "Not a
> good day," Daugherty wrote.
>
> The risky maneuver -- as yet untried in flight -- involves
> waiting until the shuttle is below 20,000 feet, blowing open a
> hatch, deploying a long pole that allows the astronauts to slip
> outward on hooks to avoid the wing. At the end of the pole, they
> would free-fall with parachutes.
>
> As it happened, all the preparation wouldn't have mattered. The
> astronauts never got anywhere close to landing or bailout.
>
> "Nobody tried to deal with or even consider that we were going to
> have a catastrophic event because they knew they could not do
> anything about it," Heflin said.
>
> Heflin said about a dozen engineers were in on the discussions
> surrounding Daugherty's e-mail. He said informal e-mail was
> simply the modern equivalent of having phone discussions of
> various scenarios.
>
> The discussions reached as high as the flight controller in
> charge of mechanical, maintenance, arm and crew systems, one of
> the many controller seats in the main Mission Control room,
> Heflin said.
>
> But the flight director for shuttle re-entry, essentially the
> manager of the room, did not know about the discussions until

> Wednesday, he said.
>
> While Heflin and the flight director, LeRoy Cain, both said the
> discussion was normal, a former senior flight controller said he
> found the note unusual.
>
> While it was good that a controller was still anxious and seeking
> other opinions, the normal channel wouldn't be a casual e-mail
> between colleagues, said Don Puddy, a 37-year Johnson Space
> Center employee.
>
> "There's a very formal mechanism that one goes through" to
> analyze scenarios, he said, so that all opinions and concerns are
> known to everyone.
>
> Reached by the Chronicle Wednesday, Daugherty declined comment.
> Carlisle Campbell, a veteran NASA controller who was e-mailed a
> copy of Daugherty's message, also declined to comment.
>
> "I'm sure I'm going to have to testify," he said.
>
>
> ==========
>
>
> Engineer foresaw US shuttle disaster two days ahead
>
> WASHINGTON (AFP) Feb 13, 2003 -- Two days before the end of the
> US space shuttle Columbia, a NASA engineer raised the possibility
> of a catastrophe caused by the overheating of landing gear, which
> he said was likely to result in a potentially disastrous tire
> blowout while the spacecraft was re-entering the Earth's
> atmosphere.
>
> In an internal memorandum dated January 30 and titled "Main Gear
> Breach concerns", which was made public late Wednesday by the
> National Aeronautics and Space Administration, the engineer,
> Robert Daugherty, considered the possibility that debris that is
> believed to have damaged the left wing of Columbia during takeoff
> could have also seriously damaged the door of the wheel well.
>
> Eighty seconds after Columbia's launch on January 16, a chunk of
> insulating foam separated from the central external fuel tank
> located under the belly of the shuttle. The foam struck
> protective tiles under the left wing of Columbia.
>
> Between January 20 and January 27, engineers held a series of
> meetings to evaluate the extend of the damage to the tiles caused
> by the debris.

>
> On January 28, flight managers concluded the impact had not hurt
> the shuttle to the point endangering its re-entry into the
> atmosphere.
>
> But two days later, Daugherty, whose opinion had been requested,
> shared his concern with the flight managers.
>
> The foam, he explained, could have damaged the door of the wheel
> well, thus exposing the landing gear made of aluminum to enormous
> outside temperatures.
>
> "The reason might be that ... the wheel (aluminum) will lose
> material properties as it heats up and the tire pressure will
> increase," he wrote. "At some point the wheel could fail and send>
> debris everywhere."
>
> Daugherty suggested that the wheel might degrade in strength
> enough and burst.
>
> "It seems to me that with that much carnage in the wheel well,
> something could get screwed up enough to prevent deployment (of
> the wheel), and there you are in a world of hurt," he pointed
> out, raising the possibility of the shuttle crash landing on its
> belly.
>
> Daugherty also suggested that overheating could set off small
> explosive charges designed to help deploy the landing gear in the
> event of it getting stuck, and damage other parts such as
> hydraulic systems.
>
> David Lechner of United Space Alliance, a NASA subcontractor, to
> whom the e-mail was addresses, gave the following response: "I
> really appreciate your candid remarks... Your input is
> beneficial. Like everyone, we hope that the debris impact
> analysis is correct and all this discussion is moot."
>
> NASA did not make any comment as it released the document. But it
> is possible to say its publication at this stage of the
> investigation was certainly not accidental because the scenario
> it paints sends chills down the spine.
>
> According to NASA, the first anomalies leading to the shuttle's
> disintegration were reported in the wheel well as Columbia
> hurtled towards the Earth at the speed of more than 21,000
> kilometers (12,600 miles) an hour.
>
> Mission control in Houston detected abnormal variations of
> temperatures in the hydraulic systems of the left landing gear,

> then a sudden loss of data from all of the wing.
>
> At that same moment, an alarm went off on the screen in front of
> Columbia's commander, Rick Husband, apparently indicating
> problems with tire pressure.
>
> He pushed a button, indicating he had taken note of it, a signal
> that was immediately relayed to ground control.
>
> At this moment, a controller in Houston called the shuttle
> acknowledging the message on the pressure of the tires.
>
> Husband started to respond but then radio went silent.
>
>
>
> ==========
>
> February 13, 2003
>
> NASA Engineer Warned of 'Catastrophic' Scenarios Internal e-mail
> sent two days before reentry says the shuttle could be in a
> 'world of hurt.'
>
> By Scott Gold, Times Staff Writer
>
> HOUSTON -- A NASA engineer warned two days before the Columbia
> disintegrated that the space shuttle could be in a "world of
> hurt" if it was sufficiently damaged by a chunk of foam
> insulation that struck it during liftoff, copies of the space
> agency's internal e-mails revealed Wednesday.
>
> An e-mail outlining "catastrophic" scenarios was written Jan. 30,
> two weeks after a 2.7-pound piece of foam insulation fell from an
> external fuel tank and struck the shuttle near its left wing. It
> was written by Robert H. Daugherty, a veteran project engineer at
> NASA's Langley Research Center in Hampton, Va., the nation's
> oldest civilian aeronautics laboratory.
>
> Responding to an informal inquiry from NASA officials in Houston,
> Daugherty surmised that the insulation could have damaged
> Columbia's protective heat-resistant tiles or otherwise could
> have penetrated the craft near its wheel well. If so, the extreme
> heat encountered during reentry could burst at least one of the
> tires making up the shuttle's landing gear, Daugherty contended.
>
> "It seems to me that with that much carnage in the wheel well,
> something could get screwed up enough to prevent deployment [of
> landing gear], and then you are in a world of hurt," Daugherty

> wrote in the e-mail, which was initially sent to four mid-level
> NASA officials as part of a broader exchange involving about 12
> NASA engineers and analysts. "What might excessive heating do to
> all kinds of other hardware in the wheel well? ... Do you belly
> land? ... If a belly landing is unacceptable, ditching/bailout>
> might be next on the list. Not a good day."
>
> The e-mail made it only to the desks of senior NASA
> administrators at the Johnson Space Center in Houston after the
> accident, space agency officials said Wednesday. The shuttle
> broke apart over Texas as it reentered the lower atmosphere Feb.
> 1, killing its seven-member crew.
>
> Through a NASA spokesman, Daugherty declined requests for an
> interview. NASA officials said they were shielding him from the
> media largely because of the possibility that he might have to
> testify before an independent panel investigating the Columbia
> accident.
>
> On Wednesday evening, NASA downplayed the significance of the e-
> mail exchange, describing it as the informal banter - even
> busywork - typical of the engineers who work at NASA
> installations around the country.
>
> "We do that all the time," said Leroy Cain, NASA's flight
> director for the mission. "That's how we train - we train for the
> worst case.... I frankly expect my folks to be doing this kind of
> thing. If you are not thinking about the next thing, you are not
> doing your job. It's not just a technique. It's a mind-set."
>
> Also, officials pointed out that Daugherty based his argument on
> the premise that the insulation had caused extensive damage to
> the shuttle's tiles or the cover of its wheel well. Senior NASA
> officials did not agree with that premise at the time - and, to a
> degree, still don't.
>
> Cain, who said he was not aware of the e-mail exchange until
> earlier this week, added that if Daugherty or other engineers
> felt that these scenarios were a realistic threat to the crew or
> the shuttle, they would have called him or another senior NASA
> administrator. That never happened, he said.
>
> "They are duty-bound to bring that to our attention," Cain said.
> "And we are duty-bound to sit down and listen to what they have
> to say. They didn't come forward."
>
> The e-mail exchange raises questions about how confident NASA
> felt at the time about its conclusion that the foam damage was
> "insignificant."

>
> The foam incident occurred Jan. 16, about 80 seconds after
> liftoff when the shuttle was traveling at 1,900 mph. Engineers
> noticed it while reviewing launch film the next day.
>
> Concerned, NASA asked officials at the Boeing Co. to assess the
> potential damage the piece of foam could have had on the shuttle,
> particularly on the ceramic tiles that protect it from the high
> temperatures encountered during reentry. Boeing, in partnership
> with Lockheed Martin Corp., has the prime contract for
> maintaining and operating the shuttle.
>
> Boeing responded on Jan. 23 that even if the foam insulation had
> caused "significant tile damage," it would not imperil the crew.
> That report was prepared by five analysts in Houston and
> California. It concluded that the 20-inch-wide piece of foam
> insulation could have affected a large portion of the left side
> of the shuttle, particularly its wing and wheel well, and that
> the chunk would have struck at a velocity of more than 550 feet
> per second.
>
> Under the worst-case scenario that engineers could devise, the
> insulation would have damaged a patch of heat-resistant tiles -
> but engineers predicted a "safe return."
>
> The shuttle recorded a series of temperature spikes and sensor
> failures in and near its left wing in the minutes before it broke
> apart. One of the sharpest temperature spikes was recorded near
> the left wheel well, investigators have said. Cain conceded
> Wednesday that his first thought after mission control lost
> communication with the shuttle was of the foam insulation
> accident and the possible damage it might have caused.
>
> However, Boeing and NASA have said they stand by the Jan. 23
> analysis, and last week, top NASA officials said the foam
> insulation incident, although it was the most obvious hitch in
> the mission - and one they're studying again - was not believed>
> to have led to the shuttle's destruction. Engineers throughout
> the space agency, officials said, were also comfortable with the
> diagnosis.
>
> "Boeing stands behind the work that the engineers did in the foam
> debris impact study," company spokesman Dan Beck said Wednesday.
> "These engineers are some of the best in the world. They did a
> very thorough, rigorous job."
>
> Even after the Boeing report, however, some NASA engineers
> apparently still felt that more analysis could be done on whether
> the insulation could have directly hit the shuttle's wheel well,

> where its landing gear is stored during the mission, officials
> said Wednesday.
>
> On Jan. 27, four days after receiving the Boeing report, NASA
> officials informally called engineers at Langley Research Center
> for further analysis of the potential impact of the insulation on
> the shuttle's tires. NASA had called Langley for advice about
> tire safety in the past, said Langley spokesman Keith Henry, but
> never during a mission.
>
> Daugherty wrote his e-mail in response to NASA's calls to
> Langley, officials said Wednesday. In the e-mail, Daugherty was
> quick to point out that he was "erring way on the side of
> absolute worst-case scenarios."
>
> "I don't really believe things are as bad as I'm getting ready to
> make them out," he wrote. "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" of flight.
>
> Daugherty got a response the next day from David F. Lechner, a
> NASA official in Houston who works on the agency's mechanical,
> maintenance, arm and crew systems team. No one outside the team
> received a copy of the e-mail exchange until after the accident,
> officials said Wednesday.
>
> "I really appreciate your candid remarks," Lechner wrote on Jan.
> 31. "Like everyone, we hope that the debris impact analysis is
> correct and all this discussion is moot."
>
> Other e-mails and calls were part of the discussion, but they
> were unavailable Wednesday.
>
> Daugherty also suggested that NASA conduct tests at its Ames
> Research Center in Mountain View, Calif., on whether the shuttle
> could land with its landing gear down but with "two flat tires."
> NASA said Wednesday that it was not sure whether the tests were
> done.
>
> Daugherty has performed extensive analysis for NASA since the
> 1980s.
>
> In 1995, for instance, he partnered with the Michelin Aircraft
> Tire Corp. in Charlotte, N.C., to analyze the durability of
> radial tires designed for jumbo jetliners and, potentially, for
> the eventual development of new, supersonic transportation. In
> 1997, he examined a modification of the space shuttle's runway at
> Kennedy Space Center in Florida.
>

> Cain said that if NASA had been able to confirm damage to the
> shuttle's landing gear or tires, it would have considered either
> a belly landing or asking its crew to bail out of the craft.
>
> Bailing out, however, would not have been an option in this case.
> Astronauts wear parachutes as part of their standard uniforms
> during reentry, said NASA spokesman James Hartsfield. If they
> have to bail out, they are instructed to slide down a pole that
> ensures they are clear of the wing before they let go.
>
> However, Hartsfield said astronauts can bail out only if the
> craft is flying at an altitude below 50,000 feet. Columbia never
> made it below 200,000 feet.
>
> Times staff writer Peter Pae contributed to this report.
>
>
>
>
> ==========
>
> Engineer warned of shuttle tire risk E-mail was sent 2 days
> before Columbia disaster
>
> By Jeremy Manier
> Tribune staff reporter
> February 13, 2003
>
> WASHINGTON -- A NASA technician warned in an e-mail sent two days
> before Columbia was destroyed that damage to heat-resistant tiles>
> could make the wheel well doors blow out during re-entry, with
> potentially "catastrophic" results.
>
> Robert H. Daugherty, a shuttle landing gear expert at NASA's
> Langley Research Center in Virginia, said in the e-mail--released
> Wednesday by NASA--that such damage could affect both the
> shuttle's ability to land safely and its aerodynamics during
> flight.
>
> "Could you even reach the runway with this kind of drag?"
> Daugherty wrote in the e-mail, sent Jan. 30.
>
> The e-mail was just one small contribution to an ongoing
> evaluation during the flight of whether foam insulation seen
> hitting the shuttle on take-off had compromised the safety of
> Columbia and its crew.
>
> The engineer's warnings seem hauntingly prescient when they pose
> the possibility of damage to the tires in the left wheel well,

> which is what sensors indicated in the minutes before the break-
> up.
>
> Also, the Orlando Sentinel, citing internal NASA documents,
> reported late Wednesday that one sensor indicated Columbia's left
> landing gear was down and locked 26 seconds before communication
> broke off. Other sensors, however, did not indicate the gear had
> deployed. Landing gear deploying could be one consequence of the
> kind of damage Daugherty warned of, experts said.
>
> But the ultimate importance of the e-mail might only be known if
> investigators determine the cause of the crash, and investigators
> are exploring the foam as only one of many possible causes.
>
> NASA officials swiftly discounted the e-mail's importance,
> describing it as part of a "what-if" dialogue between technicians
> trying to anticipate any contingency. Because Daugherty's
> scenario was considered so unlikely, his e-mail never made it to
> the highest command levels, said Milt Heflin, chief of the
> shuttle flight director's office.
>
> Other engineers already had concluded that the foam that struck
> Columbia's left wing during liftoff posed no safety risk, so
> there was nothing extra the shuttle crew should do to prepare for
> the landing-gear problems Daugherty's memo primarily warned
> about, Heflin said.
>
> "[The technicians] decided there was nothing else to do, and they
> put it behind them," Heflin said during a news conference
> Wednesday.
>
> Moreover, the shuttle's sensors did not indicate that the wheel
> well door blew off at any point during re-entry, said Leroy Cain,
> flight director for Columbia.
>
> Yet several of Columbia's left tire pressure sensors went off-
> line about 30 seconds before communications with the shuttle
> broke off.
>
> Heflin said the memo was distributed among a group of about a
> dozen technical experts, including at least one flight controller
> overseeing the landing gear and other mechanical systems. It did
> not reach the Mission Management Team, NASA said in a statement.
>
> Even Daugherty, who could not be reached Wednesday, downplayed in
> his Jan. 30 e-mail the chance that his scenario might come true.
>
> "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," Daughery wrote.
>
> Most of the e-mail dealt with problems tire loss might cause
> during Columbia's final approach and landing--a point that proved
> irrelevant to the ship's destruction at 207,000 feet.
>
> But Daugherty also pondered what might happen if both tires in
> the left wheel well blew up, causing the well doors to break off
> at high speed and expose more of the shuttle insides to the heat
> of re-entry.
>
> "Even if you could survive the heating, would the gear now
> deploy?" Daugherty wrote. Shuttle experts say the landing gear is
> designed to lower by gravity alone in an emergency--potentially
> ruining the ship's aerodynamics during a critical stage of
> descent.
>
> NASA officials have consistently said they believe it's possible
> but unlikely that an impact of foam from the external tank led to>
> the disaster.
>
> Cain said Wednesday that when the first anomalous sensor readings
> appeared from the left wing during Columbia's re-entry, he
> considered the foam that had hit the shuttle 16 days earlier.
>
> "The first thing that entered my mind was the fact that we had
> taken a debris strike on the left wing," Cain said.
>
> Engineers at Boeing performed an independent assessment for NASA
> of possible damage from the foam strike and determined it was not
> a safety threat. Those assessments were "enough to ensure we had
> as much knowledge as we possibly could to ascertain the safe
> return of the crew," Mike Mott, vice president and general
> manager of human space flight at Boeing, said in an interview
> Tuesday.
>
> Heflin and Cain of NASA said Wednesday that they still feel the
> team gauging damage from the foam reached the right conclusions.
>
> Shuttle pilots always train for the possibility that they could
> lose a tire or two during re-entry, Heflin and Cain said. But
> Daugherty expressed concern in his e-mail that the consequences
> of losing the tires might be even worse than expected.
>
> "People talk about landing with two flat tires. ... I did too
> until this came up," Daugherty wrote. "If a belly landing is
> unacceptable, ditching/bailout might be next on the list. Not a
> good day."
>

> Daugherty repeatedly cautioned that he was outlining an unlikely
> worst-case scenario.
>
> "Admittedly this is over the top in many ways," he wrote, "but
> this is a pretty bad time to get surprised and have to make
> decisions in the last 20 minutes."
>
> Copyright © 2003, Chicago Tribune
>
>
> ==========
>
>
> February 13, 2003
>
> Engineer Warned of Dire Effects of Liftoff Damage
>
> By JOHN SCHWARTZ and JOHN M. BRODER
>
> HOUSTON, Feb. 12 - Two days before the Columbia broke apart, a
> NASA safety engineer warned of the possibility of "catastrophic"
> consequences if damage from the foam insulation that struck the
> shuttle in liftoff allowed the heat of re-entry to penetrate the
> wheel well and burst the shuttle's tires.
>
> But because other NASA officials had concluded by then that the
> foam could not have caused extensive damage, no one acted on the
> engineer's concerns.
>
> The engineer, Robert H. Daugherty, who works at NASA's Langley
> Research Center in Hampton, Va., was responding to a request to
> assess the potential impact of damage to the sensitive heat-
> shielding tiles around the shuttle's wheel well. In an e-mail
> message to engineers at the Johnson Space Center at Houston, Mr.
> Daugherty laid out what he called the "absolute worst-case
> scenarios."
>
> He said that if temperatures increased markedly in the wheel
> well, the shuttle's wheels could fail and the tires explode.
>
> "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," Mr. Daugherty wrote.
>
> Mr. Daugherty said the pressure in the wheel well "would almost
> certainly blow the door off the hinges or at least send it out
> into the slip stream - catastrophic." NASA released copies of the
> engineer's warnings on its Web site this morning.
>

> Also today, Sean O'Keefe, the agency's administrator, testified
> in the first Congressional hearing into the shuttle disaster,
> and in response to criticism NASA rewrote the charter of the
> board investigating the disaster in ways it said would ensure
> the panel's autonomy.
>
> Concerning the e-mail warning from the engineer, James M. Heflin
> Jr., NASA mission operations chief flight director, said today
> that Mr. Daugherty was merely "what-iffing, which is something
> we do a whole lot of." He said that midlevel NASA engineers had
> been satisfied that the foam had not done serious damage to the
> shuttle and therefore did not pass Mr. Daugherty's warnings up>
> the chain of command.
>
> "The conclusion was that we didn't have a safety-of-flight
> issue," Mr. Heflin said.
>
> When a reporter asked whether the e-mail message and discussion
> were going to become critical parts of the Columbia
> investigation, Mr. Heflin replied, "No, sir."
>
> Mr. Daugherty's e-mail message was addressed to David F. Lechner,
> a contractor's employee on the Johnson Space Center team
> responsible for mechanical, maintenance and crew systems on the
> Columbia. Copies were sent to three other midlevel NASA
> officials.
>
> Mr. Daugherty and the recipients of his message did not respond
> to e-mail messages and telephone calls today. NASA made Mr.
> Heflin and Leroy Cain, the flight director, available to respond
> to questions about the e-mail message.
>
> NASA published Mr. Daugherty's message on its Web site in
> response to continuing questions about the quality of work done
> to assess the potential harm from the separation of a chunk of
> foam insulation 81 seconds after the Columbia lifted off on Jan.
> 16.
>
> It is not known whether a wheel failed or the landing gear door
> came off during re-entry. The loss of a door would have raised
> alarms on the shuttle and on the ground, Mr. Heflin said.
>
> Among the earliest signs of trouble in the shuttle's return to
> Earth was a rise in temperature in its left wheel well.
> Suspicion has focused on the left wing because of a sequence of
> failures of sensors and unexplained temperature spikes at
> numerous places on the wing and adjacent fuselage. In the final
> minute of the flight, four tire pressure sensors and a tire
> temperature sensor failed as well.

>
> NASA engineers assessing the possible effects of the foam debris
> hitting the wing were not able to pinpoint where it hit or the
> extent of the damage to the tiles but concluded that damage
> would probably be minimal and would not imperil the craft or the
> crew.
>
> Mr. Lechner, in an e-mail message sent on Friday, Jan. 31,
> thanked Mr. Daugherty for his candid remarks and said his
> message had been discussed at the Johnson Space Center.
>
> On Jan. 27, the 12th day of the mission, an engineer in Houston
> called Mr. Daugherty to ask what effect a deflated tire might
> have on the shuttle's return to Earth. Mr. Daugherty had worked
> on tire safety issues in the past and had been involved in
> experiments that led to the use of radial tires on the shuttle
> and to alterations of the runways to make landings safer.
>
> But this was the first time in memory that a question about a
> tire had been put to Langley engineers during a mission, said
> Keith Henry, a spokesman for Langley.
>
> Mr. Daugherty's Jan. 30 response was directed to Mr. Lechner and
> used colorful andd urgent language to describe scenarios of
> failure. He said, "I am admittedly erring wayy on the side of
> absolute worst-case scenarios and I don't really believe things
> are ass bad as I'm getting ready to make them out."
>
> But he added that looking to worst cases was necessary and that
> "to not be ready for a gut-wrenching decision" if problems were
> detected would be irresponsible.
>
> "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" of a shuttle flight, Mr. Daugherty wrote.
>
> Failure of the tires, he wrote, could cause an "explosive"
> decompression in the confined compartment that could result in a
> quarter of a million pounds of pressure on the landing gear
> door.
>
> Mr. Daugherty then discussed the problems that would remain "even
> if you could survive the heating," which included detonation of
> explosive door bolts, loss of hydraulic fluids, landing gear
> that would not deploy and severe tire damage.
>
> He said little was known about how the shuttle would fly with one>
> set of wheels down and one up. He raised the possibility of
> trying to land the shuttle on its belly, or landing with two

> tires blown. The consequences of each were not appealing, he
> said.
>
> "If a belly landing is unacceptable," he wrote, "ditching/bailout
> might be next on the list. Not a good day."
>
> The tiles around the wheel wells had long been seen as a
> potential Achilles' heel on the shuttle fleet. In their study of
> the foam impact and its possible effects during the mission,
> Boeing engineers considered the possibility that multiple tiles
> might have been knocked off near the left wheel well, one of the
> most vulnerable parts of the shuttle.
>
> But the engineers did not predict what would happen under that
> scenario in their Jan. 23 report to NASA. Instead, they wrote
> that "multiple tile missing analysis is ongoing."
>
> One former NASA engineer, Victor E. Holloman, said he suspected a
> problem with the wheels in the first days after the shuttle
> disaster. Mr. Holloman, a consulting engineer and accident
> investigator who worked on issues of stability and control in the
> shuttle program from 1986 to 1994, said in an interview today
> that the risk identified by Mr. Daugherty - that the tires, if
> overheated, might explode with a force that could damage other
> shuttle systems and disrupt the shuttle's aerodynamic stability -
> was a well-known concern.
>
> The e-mail discussion about the Daugherty message was shared
> among about a dozen midlevel engineers at NASA, said Mr. Heflin,
> the flight director. Mr. Cain, the flight director, said today
> that continuing to chew over safety questions even after a
> situation had been declared safe was part of the space agency's
> culture.
>
> "We train for the worst case," Mr. Cain said. "It's not just a
> technique. It's a mind-set."
>
> In the hearing on the shuttle disaster today, members of both
> parties complained that the nine-member panel investigating the
> loss of the shuttle was not independent enough to conduct a
> credible inquiry.
>
> NASA rewrote the board's charter tonight, eliminating "any
> requirement" that the board seek the space agency's approval to
> conduct aspects of the inquiry. But in the new charter, "task
> force team members" are still to be approved by NASA officials,
> leaving unchanged a crucial provision that some lawmakers had
> objected to.
>

> The board, led by retired Adm. Harold W. Gehman Jr., was in
> Florida today, inspecting the hangar at the Kennedy Space
> Center, where the shuttle wreckage will be assembled and
> cataloged. Admiral Gehman said the board would look for the
> immediate cause or causes of the crash and examine NASA's
> management of the entire shuttle program.
>
>
>
> ==========
>

 E-Mail.pdf

Attachment: E-mail.pdf

To: d.l.dwoyer
From: "Mark J. Shuart" <m.j.shuart@pop.larc.nasa.gov>
Subject: Fwd: RE: Main Gear Breach Concerns
Cc:
Bcc:
X-Attachments:

Doug,

Here's the latest from JSC on the damage to the orbiter tiles. Looks like they believe all has been addressed.....Mark

From: "LECHNER, DAVID F. (JSC-DF52) (USA)" <david.f.lechner1@jsc.nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Cc: M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov,
"CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
Subject: RE: Main Gear Breach Concerns
Date: Fri, 31 Jan 2003 12:17:34 -0600

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
(281) 483-1685

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: Thursday, January 30, 2003 5:23 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 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 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 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

Reply-To: "Rick w/Harvest Energy" <rn@harvestenergy.us>
From: "Rick w/Harvest Energy" <rn@harvestenergy.us>
To: <r.h.daugherty@larc.nasa.gov>
Subject: Flight Safety
Date: Thu, 13 Feb 2003 14:20:29 -0600
X-Mailer: Microsoft Outlook Express 6.00.2800.1106
X-AntiAbuse: This header was added to track abuse, please include it with any abuse report
X-AntiAbuse: Primary Hostname - host16.dnsdomain.net
X-AntiAbuse: Original Domain - larc.nasa.gov
X-AntiAbuse: Originator/Caller UID/GID - [0 0] / [0 0]
X-AntiAbuse: Sender Address Domain - harvestenergy.us

Dear Robert Daugherty

Admittedly I do not know a lot about the shuttle safety program. But it stuck me that tile inspection is not done before re-entry.

So a suggestion.

How do you know if there are broken or missing heat shields tiles after a launch?

Install a video camera on a tether with its own propulsion system. -- After orbit is established the camera could be let out of the shuttle to do a pre programmed scan of the heat shield tile area. This could be remotely monitored by ground crew or by astronaut.

What to do if heat shield tiles are missing or damaged?

Send a couple of slabs of the heat shield material to the space station along with a computerized cutting saw that would use digital patterns supplied by ground control to cut or form new pieces.

Basically make the space station a repair station.

Emergency docking adapters and space-walk suits could be stored in a locker at the space station.
Sincerely
Rick Nurrie
President

Harvest Energy Ltd
4870 South Lewis Ave Suite 180
Tulsa OK 74105
Tel 800-775-6887 Ext. 45
Fax 918-683-2466
RN@HarvestEnergy.us

Daugh. - 48

From: "McKinnon, Charles N" <charles.n.mckinnon@boeing.com>
To: r.h.daugherty@larc.nasa.gov
Subject: FW: Returned mail: User unknown
Date: Thu, 13 Feb 2003 13:52:52 -0800
X-Mailer: Internet Mail Service (5.5.2650.21)

-----Original Message-----
From: Mail Delivery Subsystem [mailto:Mailer-Daemon@larc.nasa.gov]
Sent: Thursday, February 13, 2003 1:27 PM
To: charles.n.mckinnon@boeing.com
Subject: Returned mail: User unknown

The original message was received at Thu, 13 Feb 2003 16:26:44 -0500 (EST)
from blv-smtpout-01.boeing.com [130.76.32.69]

----- The following addresses had permanent fatal errors -----
<r.H.daugaugherty@larc.nasa.gov>

----- Transcript of session follows -----

This message has been returned to you because at least one of the
recipients you specified was not known to the LaRC E-Mail Post Office.

If the person you are trying to contact is listed below, you may
resend your electronic mail to their address (if one is available),
or contact the person by phone.

=== R.H.DAUGAUGHERTY@LaRC.NASA.GOV ===

Telephone # Name Electronic mail address
------------ ------------------------
---
757 864-1309 DAUGHERTY, ROBERT H R.H.DAUGHERTY@LaRC.NASA.GOV

---

550 <r.H.daugaugherty@larc.nasa.gov>... User unknown

----- Original message follows -----

Return-Path: <charles.n.mckinnon@boeing.com>
Received: from blv-smtpout-01.boeing.com (blv-smtpout-01.boeing.com
[130.76.32.69])
by post.larc.nasa.gov (pohub4.6) with SMTP id QAA14454

Daugh. -49

for <r.H.daugaugherty@larc.nasa.gov>; Thu, 13 Feb 2003 16:26:44 -0500 (EST)
Received: from stl-av-01.boeing.com ([192.76.190.6])
by blv-smtpout-01.boeing.com (8.9.2/8.8.5-M2) with ESMTP id NAA09752
for <r.H.daugaugherty@larc.nasa.gov>; Thu, 13 Feb 2003 13:26:42
-0800 (PST)
Received: from slb-hub-01.boeing.com (localhost [127.0.0.1])
by stl-av-01.boeing.com (8.9.3/8.9.2/MBS-AV-02) with ESMTP id
PAA20732
for <r.H.daugaugherty@larc.nasa.gov>; Thu, 13 Feb 2003 15:26:41
-0600 (CST)
Received: from xch-swbh-01.sw.nos.boeing.com (xch-swbh-01.sw.nos.boeing.com
[129.172.87.56])
by slb-hub-01.boeing.com (8.11.3/8.11.3/MBS-LDAP-01) with ESMTP id
h1DLQe803536
for <r.H.daugaugherty@larc.nasa.gov>; Thu, 13 Feb 2003 13:26:40
-0800 (PST)
Received: by xch-swbh-01.sw.nos.boeing.com with Internet Mail Service
(5.5.2650.21)
id <151DNPNZ>; Thu, 13 Feb 2003 12:08:24 -0800
Message-ID:
<9C2F3AD0B86DC94B987EC4FB97C7A3240A0BB38B@XCH-SW-08.sw.nos.boeing.com>
From: "McKinnon, Charles N" <charles.n.mckinnon@boeing.com>
To: "r.h.daugherty@larc.nasa.gov" <r.H.daugaugherty@larc.nasa.gov>
Subject: Shuttle tires-Columbia
Date: Thu, 13 Feb 2003 12:08:21 -0800
MIME-Version: 1.0
X-Mailer: Internet Mail Service (5.5.2650.21)
Content-Type: text/plain;
charset="iso-8859-1"

Dear Robert,

Have just been made aware of your very profound thoughts re the "ticking-time-bombs", the shuttle high pressure tires. Please put several "gold stars" on your chart!

When first joining Boeing in Sep 97, I was assigned to writing Corrective Action Records on shuttle instrumentation. This included responsibility for pressure and temperature transducers on the tires. As a former multi-engine pilot in USAF (SAC), and member of Wing Safety Board, was immediately very aware of the dangers the shuttle tires posed. Came up with a [redacted] solution, which was disclosed to patent team and my supervisors. My immediate supervisor accused me of wasting time, and told me to forget it and get back to CAR closeouts. Analysis and physical modeling was continued on my own time, in my garage workshop.

FOIA exemption (b)(4)

As a result of reading your recent thoughts in this morning's Boeing News, I have requested the Boeing patent folks to officially pursue the issue.

THANKS FOR YOUR INSPIRATION! There is a way to mitigate some of the failure scenarios of the shuttle landing operations.

Please consider me one of your supporting colleagues in these matters.

Would be delighted to hear back from you, and look forward to making a contribution for safety.

Charles N. McKinnon, PhD, PE

Subject: You have my admiration
Date: Thu, 13 Feb 2003 14:11:10 -0800
Thread-Topic: You have my admiration
thread-index: AcLTrMghDl6UgWJoT0uNxfRQwiPJwg==
From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
X-OriginalArrivalTime: 13 Feb 2003 22:11:47.0169 (UTC) FILETIME=[E650DD10:01C2D3AC]

I read your email regarding your risk analysis in the shuttle break up&(sorry to see these sorts of things become so public; I can sympathize!)

I wanted to say that it is a wonderful thing to see that we have people like you who are thinking so deeply about these kinds of scenarios, and talking the risks to elevate their concerns.

Of course, the eventual outcome was horrible, but I can t help believe that your mail helped people think through the problem more fully.

I hope you and the rest of the team are coping OK. I m sure its hard. But your work is greatly appreciated.

[redacted]

FoIA Exemption (b)(6)

Daugh. - 50

From: <Tmorgan@nbc12.com>
To: r.h.daugherty@larc.nasa.gov
Cc: Tmorgan@nbc12.com
Subject: Interview request
Date: Thu, 13 Feb 2003 17:21:27 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

Hello Mr. Daugherty,
I'm a reporter at WWBT, NBC-12 in Richmond. I've been covering the shuttle Columbia disaster including how it has impacted Langley Research Center. I've already spoken with Langley public relations about requesting an interview with you and I realize you do not want to give one at this time but when you are ready I'd like to sit down with you and talk to you about the email concerning the shuttle's landing gear. I would like to do a one-on-one interview rather than taking part in an all out press conference. Please let me know what you think. Thank you.

Sincerely,
Tara Morgan

Daugh. -51

Subject: Nice job
Date: Thu, 13 Feb 2003 15:08:21 -0800
Thread-Topic: Nice job
Thread-Index: AcLTtM0DCnG1KS8TS3uwFZprs3mSng==
From: "Travis, Matt" <matt.travis@boeing.com>
To: <r.h.daugherty@larc.nasa.gov>
X-OriginalArrivalTime: 13 Feb 2003 23:08:20.0900 (UTC) FILETIME=[CD231E40:01C2D3B4]

Hi Bob
I imagine you are deluged with emails, so I don't expect an answer to this one for some time.

When John came by my desk days ago and mentioned that the tire was stowed near the leading edge, I immediately blurted out 'tire burst' to him. This is before I had ready any of the paper trail from your email. It must have been one of those intuitive flashes, because I didn't read it on the news.
I am proud of you that you brilliantly foresaw the tragic scenario that ultimately unfolded.
I asked John if anything could have been done when your observations were made, and he said no.

Today I asked John if there was a way to have manually dumped tire pressure from the cockpit. I reasoned that if there was, then the scenario you described with an overpressure and blowing the gear door off could have been avoided. The crew could have watched for an abnormal temperature rise
and then manually deflated the tires.

John indicated there wasn't such a means, but he encouraged me to write to you with it as a suggestion for an after accident safety review consideration. Regardless if it is shown that tire burst did cause the accident, the scenario of plasma hitting a tire and causing a burst is a very real scenario as you pointed out. Therefore it might be a good idea to address that in the future. Those tires are bombs. There should be some way to neutralize their energy from inside the cockpit.

Time spent flyfishing for trout is not subtracted from the sum total hours of life - and on a warm summer evening hatch it is often added...

Matt Travis *** *
Associate Technical Fellow
Computational Methods, Modeling, And Dynamics
(425)-342-7802, MS 0E-AT

Daugh. - 52

Date: Thu, 13 Feb 2003 15:30:27 -0800
To: david.f.lechner1@jsc.nasa.gov
From: "andrey.b.sergeyevsky" <andrey@mail1.jpl.nasa.gov>
Subject: Left landing gear down in picture
Cc: r.h.daugherty@larc.nasa.gov, NASANews@hq.nasa.gov,
Aron.A.Wolf@jpl.nasa.gov

--

Dear Mr.Lechner:
Now that Mr. Daugherty's e-mail has become public I think it is timely to bring up my e-mail to NASA columbiaimages@nasa.gov of 2/8/03. There I noted that the TWO LUMPS on the SILHOUETTE photo's left wing's leading edge could be the projection of the TWIN WHEELS of the left landing gear if it were in the DOWN position. I rolled and yawed my little shuttle model with the left landing gear in DOWN or PARTIAL DOWN position to get the TWO LUMPS at exactly the right place as on the famous SILHOUETTE photo. Whatever "the flight data including gear position indicators.." {Re:03-072, Statement by the Columbia Accident Investigation Board, of today} may show, it could be flawed, since much of the circuitry already burned - a PICTURE is BETTER than 10000 words (chinese proverb).

As an afterthought it seems that something protrudes partially under the nose cone of the shuttle as well.

The whole scenario fits very well together - ice/foam impinges on the left landing gear door tiles, creates a passage for hot plasma at entry time, it overheates the wheel well interior and the pyros fire the left gear into deploying. Asymmetric aerodynamic loads tear the shuttle apart...

The rest is history. Terribly sad...

Sincerely yours Andrey B.Sergeyevsky, at JPL since 1972.

Daugh. -53

From: "Schleck, Dave" <DSchleck@dailypress.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: Breaking News From NASA - PLease Help
Date: Thu, 13 Feb 2003 17:32:46 -0600
X-Mailer: Internet Mail Service (5.5.2655.55)

Mr. Daugherty,

This was just announced...We're looking at your e-mail and wondering how this latest statement from NASA might jive with your scenario. We hope you will give us a call, 897-2057, to discuss this tonight. Could it be, that the "breach" mentioned below is the tires bursting in the wheel well?

Sincerely,
Dave Schleck
Senior Reporter
Daily Press
Phone: (757)247-7430
E-mail: dschleck@dailypress.com
7505 Warwick Blvd.
Newport News, VA 23607
Fax: (757)245-8618

Steve Nesbitt Columbia Accident Investgation Board (Phone: 713/301-9571)
Feb. 13, 2003
RELEASE: 03-072
Note: The CAIB has asked NASA for administrative support to release information to the public and the media. The following statement was provided by the CAIB for release.
Statement by the Columbia Accident Investigation Board (Feb. 13, 2003)
Thermal Analysis Shows Hot Plasma Possible in Columbia Left Wheel Well Area
Preliminary analysis by a NASA working group this week indicates that the temperature indications seen in Columbia's left wheel well during entry would require the presence of plasma (super heated gas surrounding the orbiter during re-entry).
Heat transfer through the structure as from a missing tile would not be sufficient to cause the temperature indications seen in the last minutes of flight.
Additional analysis is underway, looking at various scenarios in which a breach of some type, allowing plasma into the wheel well area or elsewhere in the wing, could occur.
Other flight data including gear position indicators and drag information does not support the scenario of an early deployment of the left gear.
The search continues for possible debris from Columbia in the western U.S., but as of early Thursday, no debris further west than Ft. Worth, Texas has been confirmed as Shuttle-related.
- end -

Daugh.-54

Reply-To: <rbuggy@rogers.com>
From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
Subject: Your E-mail Warning...
Date: Thu, 13 Feb 2003 20:09:29 -0500
X-Mailer: Microsoft Outlook, Build 10.0.4510
Importance: Normal
X-Authentication-Info: Submitted using SMTP AUTH LOGIN at fep02-mail.bloor.is.net.cable.rogers.com from [24.112.98.151] using ID <rbuggy@rogers.com> at Thu, 13 Feb 2003 20:09:26 -0500

FOIA EXEMPTION (b)(6)

Bob - you were right on!

So much for computer analysis of all the possibilities. You'd think that with the severity of the situation they would have spent a lot more time checking the damage out the old fashioned way "by eyeball". Perhaps the Space Station could have been used to "board" the guys until a rescue mission could have been launched!

Sincerely,

[redacted]

Daugh-55

From: [redacted]
Date: Thu, 13 Feb 2003 22:34:10 EST
Subject: (no subject)
To: R.H.DAUGHERTY@larc.nasa.gov
X-Mailer: 8.0 for Windows sub 234

Mr. Daugherty,

I have just read the e-mail that you wrote concerning your thoughts on possible problems with Columbia's landing. I have been a faithful follower of the space program for quite some time now, and believe that the "worst case scenarios" of which you spoke indeed proved to be true.

What do you believe was the root cause for the breakup of the orbiter? Do you think it was the debris from the ET impacting on the orbiter's left wing or perhaps a collision with some object on orbit? I have heard several statements, one of which was from Norm Thagard, saying that the thermal insulation from the ET could not have caused any appreciable damage to the tiles on Columbia.

I am very interested to know what your thoughts on this are.

Thank you for your time and kind attention.

[redacted]

FOIA Exemption (b)(6)

Daugh. -56

From: "Peter G" <peter@ecoluxint.com>
To: <r.h.daugherty@larc.nasa.gov>
Subject: Need more like you.
Date: Fri, 14 Feb 2003 18:14:13 +0700
X-Mailer: Microsoft Outlook Express 5.00.2615.200

Hi Bob ;

Heartfelt condolences. Read your email about wheel well tiles on the Nasa web site. A true aerospace engineer. We need more guys like you in charge.

Best Regards,

Peter Guagliano
Director of Engineering
Ecolux International Co. Ltd.
Thailand
www.ecoluxint.com

Daugh.-57

Date: Fri, 14 Feb 2003 09:28:03 -0600
Thread-Index: AcLUPaoabChlkjDxTWahUXKnptOL1Q==
From: "Canter, Douglas B." <Douglas.B.Canter@conocophillips.com>
To: <r.h.daugherty@larc.nasa.gov>
X-OriginalArrivalTime: 14 Feb 2003 15:28:03.0611 (UTC) FILETIME=[AA5CFEB0:01C2D43D]

I've seen your email of 30 January on the web. I know you are terribly sorry that your concerns appear to have been proven justified on the following Saturday.

I just wanted to say as a fellow engineer that I thought your email was a remarkably good piece of technical writing documenting a fine piece of engineering reasoning.

This tragedy (and your note) has given me a renewed appreciation for the incredible complexity of what you folks do and the technical challenges you face.

Rgds, Doug

Doug Canter
Staff Engineer
Exploration Production Technology
ConocoPhillips
Dubai 1022
600 N. Dairy Ashford
Houston Texas 77079-1175

* Tel (281) 293 6822 (office)
  (832) 573 9805 (mobile)
* Fax: (281) 293 6193
* Email: douglas.b.canter@conocophillips.com <mailto:douglas.b.canter@usa.conoco.com>

Daugh.-58

X-Sender: p.a.davis@pop.larc.nasa.gov
Date: Fri, 14 Feb 2003 14:49:49 -0500
To: r.h.daugherty@larc.nasa.gov
From: Pamela Davis <p.a.davis@larc.nasa.gov>
Subject: Fwd: Shuttle Debris

Bob,

Saw the article in the paper about your involvement in the Shuttle accident investigation. The following website was forwarded to me and shows some close up views of tire and landing gear debris. Thought it might help. Have to wade through a lot of other debris pics though.

Pamela

Shuttle Debris
http://www.picturetrail.com/gallery/view?p=12&uid=904355&gid=1652603

Daugh. - 59

[redacted], 03:53 PM 2/14/2003, Shuttle MLG gear doors ??

Date: Fri, 14 Feb 2003 21:53:42 +0100
From: [redacted]
Subject: Shuttle MLG gear doors ??
To: m.j.shuart@larc.nasa.gov, david.f.lechner1@jsc.nasa.gov,
r.h.daugherty@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov,
carlisle.c.campbell@nasa.gov
Cc: [redacted]
X-Mailer: Microsoft Outlook, Build 10.0.2627
Importance: Normal

FOIA Exemption (b)(6)

Dear Sir

I read with utmost interest your e-mail from the NASA website (i.e. e-mail of 31 January 2003). I have some questions you may easily answer, as they puzzle me. I am an engineering manager at the Dutch Space Structures and Mechanical division called Dutch Space in Leiden . The Netherlands : We are as a company involved in mechanisms for solar arrays, for the European Robotic Arm on the ISS, but also in launch vehicles such as the ARIANE 5 and also such as re-entry vehicles rudders like the hot rudder of the X-38 vehicle of which we delivered the rudders via ESA to NASA .

I know you are very busy with the FAR, so if you have no time I understand completely. Just trying to think in parallel&&.(maybe along the complete wrong track, but that s typical for FMECA and FAR analyses, I would say)

First of all, I understand that the doors are closed by a special procedure, using a kind of broom stick to close the doors. Is this correct&&.?? Apparently, the doors then fall into an over-centre lock.??

- How is this controlled and how is it guaranteed that the doors are 100% closed but that there is no such a play in the mechanism or in the door levers, such that a partially opening could occur ??.
- A small opening of the doors could occur unnoticed if the switches are ill set, still the doors could be blocked by the over center locking mechanism. A partly opening may not be critical (TBC/ Acoustics and sinus and random vibrations) during the ascent, but will be very critical during re entry&&..A gap in reentry technology is devastating.
- As the temperature sensors in the wheel bay go off-line, or even out of order, one could think that the cable bundle for the telemetry is subjected to degradation / abrasion. Is it possible by evaluating **the sequence** in telemetry drop-out to determine which part of the cable gets the intense heat (twisted cable may give an indication of the spot??)
- Is there a duct running from the leading edge to the wheel bay?? As the leading edge is damaged (is this confirmed yet ??) some gaseous plasma could reach the inner wheel bay?? How?

Daugh. - 60

- Are there any other places other than the wheel bay (but close by) of which the temperature has been monitored and show erroneous telemetry readings?

Other question related to the tiles:

- Have impact damage analyses also been executed on so called degraded tiles i.e. tiles which have been used more times or bond line for thermal expansion compensation of which the bond line has been hardened due to thermal cycling effects??

Sincerely yours

[redacted]

Engineering Manager

Structures & Mechanical Systems

[redacted]

From: <[redacted]>
Date: Sat, 15 Feb 2003 04:14:44 EST
Subject: Fwd: Shuttle Gear Door Memo
To: r.h.daugherty@larc.nasa.gov
X-Mailer: AOL 4.0 for Windows 95 sub 120

Return-path: <[redacted]>
From: [redacted]
Full-name: [redacted]
Message-ID: <11.a24ae79.2b7f5dd5@aol.com>
Date: Sat, 15 Feb 2003 04:09:41 EST
Subject: Shuttle Gear Door Memo
To: r.h.daugherty@larg.nasa.gov
MIME-Version: 1.0
Content-Type: text/plain; charset="US-ASCII"
Content-Transfer-Encoding: 7bit
X-Mailer: AOL 4.0 for Windows 95 sub 120

FOIA exemption (b)(6)

Bob,
I just read the memo that you wrote about the possible problems with the landing gear of the space shuttle. I just want you to know that the dedication to mission and attention to detail that you show is inspiring. I have always been a big supporter of NASA and it is in large part due to the fact that you guys show such excellence and committment in your work. I think that one of the tragedies of the STS program is that if you fly often enough something bad is eventually going to happen. With the Challenger, there were bad management decisions that were made and I believe that that was an accident that was due in part to a management problem. I think that with the loss of the Columbia (it still sounds strange to hear "loss of Columbia"), that it falls more into the area of risk probabilities than poor management. These are dark days for sure, but I wanted to let you know that I am still a supporter and that I back you guys 100%. The fact that you wrote the memo and put such thought into something that you viewed as a long shot....but still wanted examined just in case...is evidence of how detail oriented you are and look for the hidden problem that could come back to haunt you later. It looks as though you may have hit the nail on the head with your devil's advocate worst case scenario assessment...I for one want to congradulate you on a job well done. It is due to such attention to detail that we have been able to fly so often and so safely. Keep up the good work. I would fly with you guys tomorrow!!! Let's find the problem fix it and get back in space.

Hail Columbia,
[redacted]

Daugh. -61

From: "Bob Ducey" <bobducey@ubtanet.com>
To: <carlisle.c.campbell@nasa.gov>, <r.h.daugherty@larc.nasa.gov>,
<david.f.lechner1@jsc.nasa.gov>, <m.j.shrart@larc.nasa.gov>
Subject: News Release from Dryden
Date: Sat, 15 Feb 2003 09:07:55 -0700
X-Mailer: Microsoft Outlook IMO, Build 9.0.2416 (9.0.2911.0)
Importance: Normal

Hello Gentlemen,

Below is a copy of a News Release from Dryden that I m sure you are aware of.

I just wanted to make sure!

Bob Ducey

Roosevelt, UT

bobducey@ubtanet.com

NASA Dryden News Releases

DRYDEN F-15B SUPPORTS SHUTTLE EXTERNAL TANK INSULATION TESTS

January 28, 1999

Release: 99-01

Flight tests at the NASA Dryden Flight Research Center, Edwards, Calif., recently demonstrated that a **new type of insulation foam used on the Space Shuttle's giant external tank remains intact under some of the dynamic environments seen during the initial stage of the Shuttle's ascent.**

Mimicking a Space Shuttle launch profile, an F-15B research aircraft based at NASA Dryden flew a series of missions to evaluate the dynamic response characteristics of the new insulation material. The Shuttle External Tank Experiment involved six research flights over a two-week period by Dryden's F-15B in partnership with NASA's Marshall Space Flight Center, Huntsville, Ala., and the Michoud Assembly Facility near New Orleans, La.

"This experiment was a perfect example of the versatility of the F-15B and its Flight Test Fixture," said Dave

Daugh.-62

Richwine, Dryden's F-15B project manager. "It shows how we can customize our capability for any particular experiment's requirements."

The experiment was part of an effort to determine why small particles of spray-on foam insulation flaked off of the inter-tank section of the external fuel tank on Space Shuttle mission STS-87 as the Shuttle ascended. The new lightweight insulation material was developed to comply with an EPA mandate to reduce ozone-depleting chemicals released into the atmosphere. **Although such flaking or erosion of the insulation off the external tank posed no safety hazard to the Shuttle or its crew, engineers wanted to determine its cause to prevent future maintenance and operational problems.** The flights aboard Dryden's F-15B were just one of many tests to which the new insulation material is being subjected.

Initial results of the flight tests at Dryden, which were designed **to replicate the pressure environment the Shuttle encounters in the first 65 seconds after launch, indicate the new foam survived the tests in perfect shape, with no evidence of flaking or erosion found.**

For the tests on Dryden's F-15B, test panels covered with the foam insulation were mounted on the left side of the Flight Test Fixture that is carried underneath the aircraft's center fuselage. Six different panel configurations were flown one on each flight. Five of the panels were covered with the insulation now used on the sidewalls of the Shuttle's external tank, while one was covered with an alternate formulation of slightly higher density that is used on the dome atop the tank. While several panels were left in wavy as-sprayed configurations, others were finely machined to duplicate the thrust panel rib structure of the thrust panels where the solid rocket boosters are attached to the new "super-lightweight" external tanks now flown on Shuttle missions. Four panels had the ribs aligned with the airflow, while two others had the ribs mounted vertically in order to simulate the complex airflow around the Shuttle and its external tank during its ascent.

On each flight, Dryden research pilot Dana Purifoy flew the F-15B through a series of side-to-side yaw maneuvers beginning at 7,300 feet altitude. He then increased speed and altitude in a stair-step approach, finally zooming up to 61,000 feet at speeds of up to Mach 1.5 (1.5 times the speed of sound) before descending for landing.

"It was important that the F-15B could match part of our (shuttle launch) profile, and it does a fantastic job of doing that," said aerodynamicist Roy Steinbock of Lockheed-Martin Michoud Space Systems, staff engineer on the experiment.

"Our main goal was to try to match the dynamic pressure history (that the external tank encounters during a shuttle launch). The Dryden F-15B can match the high-altitude, low-pressure environment that the Shuttle encounters, and can test a multitude of Mach numbers in (one) flight. That's something we cannot do anywhere else--we can't replicate that in a wind tunnel."

"Marshall's objectives included flying at Mach 1.5, reaching 60,000 feet and completing six research flights in two weeks," added Richwine. "We were proud to be able to meet Marshall's performance and schedule objectives for this experiment."

"The successful completion of the tests at Dryden, along with wind tunnel testing at the Arnold Engineering Development Center in Tullohoma, Tenn., hot gas testing at Marshall and a multitude of other tests, has given us additional data to further improve the foam insulation on the Space Shuttle's External Tank," said Parker Counts, Marshall's Space Shuttle External Tank program manager. "This was a fine example of the team work between NASA centers and other government agencies."

--nasa--

To: "Harder, James R" <James.R.Harder@boeing.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: CNN News Story
Cc:
Bcc:
Attached:

Hi Jim,
Yes, that was one hell of a bad Saturday. Thanks for thinking of us and sending this email. I can't imagine how tough it was for you guys right there in the middle of it. Headquarters received this email through my management chain and after who knows what kind of discussions took place between HQ, media, and the like, HQ decided to release it on Wednesday. I must say I've had quite an education since then. Feel free to call me and we can talk if you'd like. Take care,
Bob

E-mail withheld due to disclosure statement attached to message stating that information is to aid in the investigation of the Columbia mishap and should only be distributed to personnel actively involved in the investigation.

Daugh.-63

[redacted], 11:50 AM 2/17/2003, Re: Tire blowout

To: [redacted]
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Tire blowout
Cc:
Bcc:
Attached:

FOIA Exemption (b)(6)

Hi Bob,
You are too kind. Thanks for this nice email. Sorry for not responding to you in more detail last week but the only answer I could have given you was the stand-by "talk to public affairs". Yep...I have gotten quite an education in the past few days I can assure you! Feel free to call me anytime.
Take care!
Bob

At 07:53 AM 2/13/2003, you wrote:

Hi, [redacted]

Saw a familiar likeness on the front page of this morning's Daily Press.

I should have figured that you were way ahead of me on the Shuttle tire blowout issue.

If they wanted a candid, thoughtful, intelligent answer, they certainly asked the right person when they asked you. I would have expected nothing less from you.

Apparently NASA has you embargoed, but I imagine that is going to be difficult to do in the long run.

With Yager in Japan, I suppose you are the "lone ranger" at ALDF. Won't be long before no one will be left there to answer anyone's questions. Sad, sad, . . .

Regards,

[redacted]

--[redacted]
---[redacted]

Daugh-64

--- EarthLink: The #1 provider of the Real Internet.

To: "William B. Grant" <w.b.grant@larc.nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: NY Times
Cc:
Bcc:
Attached:

Hi Bill,
What a nice offer...thank you. Yes, if the offer's still good I'd love to have a copy. I'm at MS 497.
Thanks alot.
Best regards,
Bob

At 10:06 AM 2/13/2003, you wrote:
> Hi,
> I have a copy of today's NY Times with the story on your e-mail if you would like it.
> Bill
>
> ---
> William B. Grant
> Lidar Applications Group, Atmospheric Sciences Research
> NASA Langley Research Center, MS 401A
> Hampton, VA 23681-2199
> Phone: 757-864-5846; FAX 757-864-7790
> mailto:W.B.Grant@larc.nasa.gov
>
> See Lidar HomePage at:
> http://asd-www.larc.nasa.gov/lidar/lidar.html
>
> ---

Daugh.-65

To: [redacted]
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: CNN Article on Your E-mail
Cc:
Bcc:
Attached:

FOIA EXEMPTION (b)(6)

[redacted]

Thank you so much for your kind words here. Please accept my condolences for your loss of friends in the crew as well.
With my regards,
Bob Daugherty

At 10:48 AM 2/13/2003, you wrote:

Dear Gentlemen:

A very brief note of support to you. I am sure that none feel the loss of Columbia and her crew as dearly as those of you intimately involved in the program.

I, along with my friends and family, have the utmost confidence that the root cause of this incident will be found, addressed, and the program will continue onwards. I lost friends in the crew, but I know they had confidence in your team, so I share it now.

I also wanted to note to you that I thought it was irresponsible for CNN to post a copy of your internal correspondance, including your e-mail addresses, on their web site. As an engineerand a pilot myself, I understand how/where discussions like this fit into things. I fear that not everyone who might write you will be as supportive as I.

[redacted]
Brookline, NH

Daugh. - 66

To: "Richard S. Pappa" <r.s.pappa@larc.nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Fwd: Today on SPACE.com -- Thursday, February 13, 2003
Cc:
Bcc:
Attached:

Thanks Richard. I hadn't seen this particular article...it is one of the better written ones. Thansk again.
Bob

At 11:05 AM 2/13/2003, you wrote:
I assume you've already seen this article posted on-line. Just wanted to be sure... It just arrived in my mail box.

Richard

SpaceFlight:

* NASA E-mail Discussed Landing Disaster Scenarios
http://www.space.com/missionlaunches/sts107_email_030212.html

A NASA engineer advised mission controllers two days before shuttle Columbia's landing to be ready to make tough choices in the final minutes just in case heat shield tiles on the landing gear door were damaged during launch.

Daugh.-67

To: "Travis, Matt" <matt.travis@boeing.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Nice job
Cc:
Bcc:
Attached:

Hi Matt,

well, yes, have gotten quite a few emails as you can imagine. Reporters at doors, etc, bushes...yep. And most I can't respond to but I didn't want to leave you hanging. Thanks for your kind words...
No doubt your suggestions are worthy of discussion after all the dust settles. Hopefully enough physical and data evidence will come together to accurately piece together the entire accident. Would love to talk more but until the investigation is done its definitely premature to say what happened or to speculate much. You guys take care and I hope to talk to you and John soon.
See ya,
Bob

At 06:08 PM 2/13/2003, you wrote:
Hi Bob
I imagine you are deluged with emails, so I don't expect an answer to this one for some time.

When John came by my desk days ago and mentioned that the tire was stowed near the leading edge, I immediately blurted out 'tire burst' to him. This is before I had ready any of the paper trail from your email. It must have been one of those intuitive flashes, because I didn't read it on the news.
I am proud of you that you brilliantly foresaw the tragic scenario that ultimately unfolded.
I asked John if anything could have been done when your observations were made, and he said no.

Today I asked John if there was a way to have manually dumped tire pressure from the cockpit. I reasoned that if there was, then the scenario you described with an overpressure and blowing the
gear door off could have been avoided. The crew could have watched for an abnormal temperature rise
and then manually deflated the tires.

John indicated there wasn't such a means, but he encouraged me to write to you with it as a suggestion for an after accident safety review consideration. Regardless if it is shown that tire burst did cause the accident, the scenario of plasma hitting a tire and causing a burst is a very real scenario as you pointed out. Therefore it might be a good idea to address that in the future. Those tires are bombs. There should be some way to neutralize their energy from inside the cockpit.

Time spent flyfishing for trout is not subtracted from the sum total hours of life - and on a warm summer evening hatch it is often added...

Daugh.-68

Matt Travis *** *
Associate Technical Fellow
Computational Methods, Modeling, And Dynamics
(425)-342-7802, MS 0E-AT

From: [redacted]
To: <david.f.lechner1@jsc.nasa.gov>
Cc: <robert.h.daugherty@larc.nasa.gov>, <R.H.DAUGHERTY@larc.nasa.gov>
Subject: Fw: Main Gear Breach Concerns re: Columbia STS 107 (01/30/03 e-mail) - Please FWD to R.H.DAUGHERTY@larc.nasa.gov
Date: Mon, 17 Feb 2003 16:11:30 -0600
X-Mailer: Microsoft Outlook Express 6.00.2600.0000

FYI.
Please forward to Bob Daugherty.

FOIA EXEMPTION (b)(6)

----- Original Message -----
From: [redacted]
To: m.j.shuart@pop.larc.nasa.gov
Cc: [redacted]
Sent: Monday, February 17, 2003 4:03 PM
Subject: Main Gear Breach Concerns re: Columbia STS 107 (01/30/03 e-mail) - Please FWD to R.H.DAUGHERTY@larc.nasa.gov

Dear Mr. Daugherty,

I write to you directly to thank you for the extremely relevant information you had sent to NASA mission control just 2 days prior to the tragic loss of the Columbia Crew and vehicle. It seems, that your observations of Jan.30, 2003 were not only timely and accurate, but unfortunately "prophetic", which adds credible evidence to the investigation. Although, I'm not an expert in the field myself, I worked in the aviation industry for several years, while training for a pilot's license. I am also a scholar in a humanities field, which requires extensive travel internationally and in consequence, I've always followed closely NTSB inquiries into airline accidents. After reading your e-mail on Feb.12 (NASA press-release) re: potential damage to the LMG tires, and probable consequential sequence of events, even of a catastrophic level due to earlier substantial breach of wheel well (81sec.of launch - foam fragment damages left wing/ shuttle skin, exposing it to plasma at re-entry) I have spent the last few days intensively analyzing available data on the shuttle tragedy and archival material from the NTSB web-site re: tire-damage related accidents. At this time, the only analogy, that I can offer, though somewhat far-fetched, is the disastrous take-off of the Air France Concorde supersonic jet on July 25, 2000. I have included below a few excerpts from press-releases re: Concorde crash, that I thought you might find interesting, in support of your theory and the scenarios you presented in your analysis. As a researcher I wish to bring this information to your attention (my comments are italicized), since you have displayed such concern and expertise in this subject:

1) excerpt after ABC News (July 30, 2000): "Concorde supersonic jets had at least a dozen blown tire incidents before the crash of an Air France Concorde earlier this week, according to safety reports obtained by ABCNews.com from U.S. aviation agencies and accounts by British Airways. Evidence released Friday by French authorities suggests a tire blowout during takeoff of the Air France Concorde at Paris' Charles de Gaulle airport **initiated a sequence of events** that led to the crash Tuesday (...). *(I'm aware that there's a major difference here: tire blow-out at Concorde's take-off, max. cruising speed inflight - Mach 2, while Columbia was traveling at Mach 23 at an altitude of 231,304 ft upon landfall at California coast, RMC)*

Debris from a blown tire can rupture fuel tanks and fuel lines and be sucked into engines, which are uniquely located above the open landing gear on a Concorde.(...) *(the engine & fuel tanks on the shuttle are located well behind and above the wheel well, although in close proximity to it and to the hydraulic lines, electrical wiring...etc., RMC)*

French authorities said Friday they believe one tire and possibly two burst as the Concorde was accelerating down the runway.(...) But a ruptured tire on a Concorde can be especially serious, experts say, because of the aircraft's unique design, which allows it to cruise at twice the speed of sound.(...)The most serious incident occurred at Washington's Dulles International Airport in **June 1979,**

Daugh. - 69

when two tires blew out on the left landing gear (!). Debris punctured three fuel tanks, **severed hydraulic lines and electrical wires (!)** (*emphasis added, RMC*), and damaged the No. 2 engine. Fuel poured out of the wing, but didn't catch fire. http://abcnews.go.com/sections/world/DailyNews/concordesafety_000729.html

2) excerpt after BBC News.com (July 28, 2000): "Concorde has experienced **"potentially catastrophic" problems with tyres** prior to Tuesday's fatal crash, according to US safety officials.(...) In Washington, the National Transportation Safety Board (NTSB) has released details of four incidents in which Air France Concordes blew tyres on take-off.(...) In 1981, the NTSB said that in June 1979 an Air France Concorde experienced blow-outs of tyres numbers five and six on the left-hand side while taking off from Washington's Dulles Airport. **Tyre debris and wheel shrapnel, it said, resulted in damage to number two engine, the puncture of three fuel tanks and the severance of several hydraulic and electrical wires. A large hole was also torn in the skin of the top wing." (!)** (*emphasis added, RMC*)http://news.bbc.co.uk/1/hi/world/europe/856173.stm

3) excerpt from safe-skies.com (Sept. 1, 2002): "The July 25 accident shows that the **destruction of a tire**, an event that we cannot say will not recur, **had catastrophic consequences in a short period of time, preventing the crew from rectifying the situation**. UN-grounding the Concorde will be difficult!" http://www.safe-skies.com/concorde_crash.htm *(There was nothing that the Columbia crew could have done had they been aware of this last-minute potentially fatal danger, but how can we continue to resign shuttle crews to such helplessness?)*

In terms of Columbia's tires: we know, thusfar, that one of its radial tires has been recovered near Hemphill, Texas as confirmed by NASA. Has it been determined which of the shuttle's tires was found and if the incurred damage was the result of a rupture inflight, or as a result of impact when it fell to the ground?

Mr. Daugherty, I appreciate your patience in reviewing this communication from a concerned, but keen observer. I am still dealing with the extreme grief I feel over this terrible loss and I wish I could do more to help in the investigative process. I've also been tuning in daily to NASA briefings and those of CAIB. Please feel free to call on me or to forward this information to the appropriate individuals at NASA. Sometimes, the observations of an outsider can bring some relevance or validity to issues at hand. It is my constant prayer that the future will bring more thorough preventive measures for shuttle crew safety and concrete escape contingency plans for the crew in event of any type of safety breach. The latter should, in my opinion, be of utmost importance to address and resolve (whatever the monetary cost involved), before the next manned-shuttle mission takes flight. It is unacceptable, in my opinion, to send people into space, who are willing to risk their lives, without the possibility of giving them realistic options for survival (e.g. reaching a safe bailout altitude; ejections seats...etc.) when faced with such danger as was the experience of the unforgettable Columbia Seven.
God bless you and your colleagues. Godspeed with the investigation!

Thank you again for your work and please stay in touch, if possible.

Respectfully yours,

[redacted]

Intellectual Property Coordinator
Legal Department
[redacted]
E-mail: [redacted]
Direct dial: [redacted]

From: [redacted]
To: <david.f.lechner1@jsc.nasa.gov>
Cc: <robert.h.daugherty@larc.nasa.gov>, <R.H.DAUGHERTY@larc.nasa.gov>
Subject: Fw: Main Gear Breach Concerns re: Columbia STS 107 (01/30/03 e-mail) - Please FWD to R.H.DAUGHERTY@larc.nasa.gov
Date: Mon, 17 Feb 2003 16:11:30 -0600
X-Mailer: Microsoft Outlook Express 6.00.2600.0000

FYI.
Please forward to Bob Daugherty.

FOIA EXEMPTION (b)(6)

----- Original Message -----
From: [redacted]
To: m.j.shuart@pop.larc.nasa.gov
Cc: [redacted]
Sent: Monday, February 17, 2003 4:03 PM
Subject: Main Gear Breach Concerns re: Columbia STS 107 (01/30/03 e-mail) - Please FWD to R.H.DAUGHERTY@larc.nasa.gov

Dear Mr. Daugherty,

I write to you directly to thank you for the extremely relevant information you had sent to NASA mission control just 2 days prior to the tragic loss of the Columbia Crew and vehicle. It seems, that your observations of Jan.30, 2003 were not only timely and accurate, but unfortunately "prophetic", which adds credible evidence to the investigation. Although, I'm not an expert in the field myself, I worked in the aviation industry for several years, while training for a pilot's license. I am also a scholar in a humanities field, which requires extensive travel internationally and in consequence, I've always followed closely NTSB inquiries into airline accidents. After reading your e-mail on Feb.12 (NASA press-release) re: potential damage to the LMG tires, and probable consequential sequence of events, even of a catastrophic level due to earlier substantial breach of wheel well (81sec.of launch - foam fragment damages left wing/ shuttle skin, exposing it to plasma at re-entry) I have spent the last few days intensively analyzing available data on the shuttle tragedy and archival material from the NTSB web-site re: tire-damage related accidents. At this time, the only analogy, that I can offer, though somewhat far-fetched, is the disastrous take-off of the Air France Concorde supersonic jet on July 25, 2000. I have included below a few excerpts from press-releases re: Concorde crash, that I thought you might find interesting, in support of your theory and the scenarios you presented in your analysis. As a researcher I wish to bring this information to your attention (my comments are italicized), since you have displayed such concern and expertise in this subject:

1) excerpt after ABC News (July 30, 2000): "Concorde supersonic jets had at least a dozen blown tire incidents before the crash of an Air France Concorde earlier this week, according to safety reports obtained by ABCNews.com from U.S. aviation agencies and accounts by British Airways. Evidence released Friday by French authorities suggests a tire blowout during takeoff of the Air France Concorde at Paris' Charles de Gaulle airport **initiated a sequence of events** that led to the crash Tuesday (...). (*I'm aware that there's a major difference here: tire blow-out at Concorde's take-off, max. cruising speed inflight - Mach 2, while Columbia was traveling at Mach 23 at an altitude of 231,304 ft upon landfall at California coast, RMC)*

Debris from a blown tire can rupture fuel tanks and fuel lines and be sucked into engines, which are uniquely located above the open landing gear on a Concorde.(...) *(the engine & fuel tanks on the shuttle are located well behind and above the wheel well, although in close proximity to it and to the hydraulic lines, electrical wiring...etc., RMC)*

French authorities said Friday they believe one tire and possibly two burst as the Concorde was accelerating down the runway.(...) But a ruptured tire on a Concorde can be especially serious, experts say, because of the aircraft's unique design, which allows it to cruise at twice the speed of sound.(...)The most serious incident occurred at Washington's Dulles International Airport in **June 1979,**

Daugh.-70

when two tires blew out on the left landing gear (!). Debris punctured three fuel tanks, **severed hydraulic lines and electrical wires (!)** (*emphasis added, RMC*), and damaged the No. 2 engine. Fuel poured out of the wing, but didn't catch fire. http://abcnews.go.com/sections/world/DailyNews/concordesafety_000729.html

2) excerpt after BBC News.com (July 28, 2000): "Concorde has experienced **"potentially catastrophic" problems with tyres** prior to Tuesday's fatal crash, according to US safety officials.(...) In Washington, the National Transportation Safety Board (NTSB) has released details of four incidents in which Air France Concordes blew tyres on take-off.(...) In 1981, the NTSB said that in June 1979 an Air France Concorde experienced blow-outs of tyres numbers five and six on the left-hand side while taking off from Washington's Dulles Airport. **Tyre debris and wheel shrapnel, it said, resulted in damage to number two engine, the puncture of three fuel tanks and the severance of several hydraulic and electrical wires. A large hole was also torn in the skin of the top wing." (!)** (*emphasis added, RMC*)http://news.bbc.co.uk/1/hi/world/europe/856173.stm

3) excerpt from safe-skies.com (Sept. 1, 2002): "The July 25 accident shows that the **destruction of a tire**, an event that we cannot say will not recur, **had catastrophic consequences in a short period of time, preventing the crew from rectifying the situation**. UN-grounding the Concorde will be difficult!" http://www.safe-skies.com/concorde_crash.htm *(There was nothing that the Columbia crew could have done had they been aware of this last-minute potentially fatal danger, but how can we continue to resign shuttle crews to such helplessness?)*

In terms of Columbia's tires: we know, thusfar, that one of its radial tires has been recovered near Hemphill, Texas as confirmed by NASA. Has it been determined which of the shuttle's tires was found and if the incurred damage was the result of a rupture inflight, or as a result of impact when it fell to the ground?

Mr. Daugherty, I appreciate your patience in reviewing this communication from a concerned, but keen observer. I am still dealing with the extreme grief I feel over this terrible loss and I wish I could do more to help in the investigative process. I've also been tuning in daily to NASA briefings and those of CAIB. Please feel free to call on me or to forward this information to the appropriate individuals at NASA. Sometimes, the observations of an outsider can bring some relevance or validity to issues at hand. It is my constant prayer that the future will bring more thorough preventive measures for shuttle crew safety and concrete escape contingency plans for the crew in event of any type of safety breach. The latter should, in my opinion, be of utmost importance to address and resolve (whatever the monetary cost involved), before the next manned-shuttle mission takes flight. It is unacceptable, in my opinion, to send people into space, who are willing to risk their lives, without the possibility of giving them realistic options for survival (e.g. reaching a safe bailout altitude; ejections seats...etc.) when faced with such danger as was the experience of the unforgettable Columbia Seven.
God bless you and your colleagues. Godspeed with the investigation!

Thank you again for your work and please stay in touch, if possible.

Respectfully yours,

[redacted]

Intellectual Property Coordinator
Legal Department
[redacted]
Direct dial: [redacted]

X-EM-Version: 5, 0, 0, 0
X-EM-Registration: #3003520714B31D032830
Reply-To: [redacted]
X-Mailer: EarthLink MailBox 5.0.7.9 (Windows)
From: "[redacted]
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Tire blowout
Date: Mon, 17 Feb 2003 17:51:40 -0500

Bob,

Good to hear from you.

FoIA Exemption (b)(6)

I thought today was a holiday.

I suppose NASA never sleeps.

Regards,

[redacted]

----- Original Message -----
From: Robert H. Daugherty
To: [redacted]
Sent: 2/17/2003 11:50:22 AM
Subject: Re: Tire blowout

Hi Bob,
You are too kind. Thanks for this nice email. Sorry for not responding to you in more detail last week but the only answer I could have given you was the stand-by "talk to public affairs". Yep...I have gotten quite an education in the past few days I can assure you! Feel free to call me anytime.
Take care!
Bob

At 07:53 AM 2/13/2003, you wrote:

Hi, [redacted]

Saw a familiar likeness on the front page of this morning's Daily Press.

I should have figured that you were way ahead of me on the Shuttle tire blowout issue.

If they wanted a candid, thoughtful, intelligent answer, they certainly asked the right person when they asked you. I would have expected nothing less from you.

Daugh - 71

Apparently NASA has you embargoed, but I imagine that is going to be difficult to do in the long run.

With Yager in Japan, I suppose you are the "lone ranger" at ALDF. Won't be long before no one will be left there to answer anyone's questions. Sad, sad, . . .

Regards,

[redacted]

[redacted]
--- EarthLink: The #1 provider of the Real Internet.

---[redacted]
---[redacted]
--- EarthLink: The #1 provider of the Real Internet.

X-Sender: w.b.grant@larc.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 18 Feb 2003 08:15:43 -0500
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
From: "William B. Grant" <w.b.grant@larc.nasa.gov>
Subject: Re: NY Times

Hi,
I just put it in an envelope for you.
Bill

At 01:17 PM 2/17/2003 -0500, you wrote:
Hi Bill,
What a nice offer...thank you. Yes, if the offer's still good I'd love to have a copy. I'm at MS 497.
Thanks alot.
Best regards,
Bob

At 10:06 AM 2/13/2003, you wrote:
Hi,
I have a copy of today's NY Times with the story on your e-mail if you would like it.
Bill

William B. Grant
Lidar Applications Group, Atmospheric Sciences Research
NASA Langley Research Center, MS 401A
Hampton, VA 23681-2199
Phone: 757-864-5846; FAX 757-864-7790
mailto:W.B.Grant@larc.nasa.gov

See Lidar HomePage at:
http://asd-www.larc.nasa.gov/lidar/lidar.html

William B. Grant
Lidar Applications Group, Atmospheric Sciences Research
NASA Langley Research Center, MS 401A
Hampton, VA 23681-2199
Phone: 757-864-5846; FAX 757-864-7790
mailto:W.B.Grant@larc.nasa.gov

See Lidar HomePage at:

Daugh - 72

http://asd-www.larc.nasa.gov/lidar/lidar.html

From: "Schleck, Dave" <DSchleck@dailypress.com>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: Columbia E-mail
Date: Wed, 19 Feb 2003 14:14:25 -0600
Importance: high
X-Mailer: Internet Mail Service (5.5.2655.55)

Mr. Daugherty,

I still would like to talk with you sometime about your e-mail. I assume public affairs has cautioned you. But I'm not sure if that caution is a total prohibition against speaking with reporters.

This is in the interest of writing the most fair, accurate story possible. We will continue to cover this issue with more stories.

I'm sure all the attention this has brought isn't fun for you. Hang in there. I'm trying to be as polite as possible, despite pressure from my editor. ;-)

Sincerely,
Dave Schleck
247-7430

Daugh.-03

To: "Schleck, Dave" <DSchleck@dailypress.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Columbia E-mail
Cc: H.K.HENRY@LaRC.NASA.GOV
Bcc:
Attached:

Mr. Schleck,

I absolutely appreciate you wanting to get as much information as possible to provide a fair and accurate story. At this point in time, the proper approach for me is to provide any information I have to the Columbia Accident Investigation Board at their request. Please feel free to continue to interface with Mr. Keith Henry regarding any questions about these events you may have.
Sincerely,
Bob Daugherty

At 03:14 PM 2/19/2003, you wrote:
Mr. Daugherty,

I still would like to talk with you sometime about your e-mail. I assume public affairs has cautioned you. But I'm not sure if that caution is a total prohibition against speaking with reporters.

This is in the interest of writing the most fair, accurate story possible. We will continue to cover this issue with more stories.

I'm sure all the attention this has brought isn't fun for you. Hang in there. I'm trying to be as polite as possible, despite pressure from my editor. ;-)

Sincerely,
Dave Schleck
247-7430

Daugh.-74

Subject: Florida Today
Date: Wed, 19 Feb 2003 17:15:15 -0500
Thread-Topic: Florida Today
Thread-Index: AcLYZGEJiFFR8EQ5EdeFBgABAkDtbQ==
From: "Oliveri, Frank" <FOLIVERI@brevard.gannett.com>
To: <r.h.daugherty@larc.nasa.gov>
X-OriginalArrivalTime: 19 Feb 2003 22:15:16.0585 (UTC) FILETIME=[619DB590:01C2D864]

Mr. Daugherty:

Understanding the information you provided to David Lechner was worst case, it's remarkably similar in some respects to what appeared to happen from the limited data available.
I was wondering if you have seen similar anomolies before that had forced you to consider such dire circumstances in the past? Was this analysis done before?
Frank Oliveri
Florida Today

Daugh. - 05

To: "Oliveri, Frank" <FOLIVERI@brevard.gannett.com>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Florida Today
Cc: H.K.HENRY@LaRC.NASA.GOV
Bcc:
Attached:

Mr. Oliveri,

At this point in time, the proper approach for me is to provide any information I have to the Columbia Accident Investigation Board at their request. Please feel free to interface with Mr. Keith Henry of our Public Affairs Office (757 864-6120) regarding any questions about these events you may have.
Sincerely,
Bob Daugherty

At 05:15 PM 2/19/2003, you wrote:
Mr. Daugherty:

Understanding the information you provided to David Lechner was worst case, it's remarkably similar in some respects to what appeared to happen from the limited data available.
I was wondering if you have seen similar anomolies before that had forced you to consider such dire circumstances in the past? Was this analysis done before?
Frank Oliveri
Florida Today

Daugh. - 76

To: "William B. Grant" <w.b.grant@larc.nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: NY Times
Cc:
Bcc:
Attached:

Bill,
Got it this afternoon...thanks a whole lot...quite an article!
take care.
Bob

At 08:15 AM 2/18/2003, you wrote:
Hi,
I just put it in an envelope for you.
Bill

At 01:17 PM 2/17/2003 -0500, you wrote:
Hi Bill,
What a nice offer...thank you. Yes, if the offer's still good I'd love to have a copy. I'm at MS 497.
Thanks alot.
Best regards,
Bob

At 10:06 AM 2/13/2003, you wrote:
Hi,
I have a copy of today's NY Times with the story on your e-mail if you would like it.
Bill

William B. Grant
Lidar Applications Group, Atmospheric Sciences Research
NASA Langley Research Center, MS 401A
Hampton, VA 23681-2199
Phone: 757-864-5846; FAX 757-864-7790
mailto:W.B.Grant@larc.nasa.gov

See Lidar HomePage at:
http://asd-www.larc.nasa.gov/lidar/lidar.html

William B. Grant
Lidar Applications Group, Atmospheric Sciences Research

Daugh. - 77

Subject: RE: Florida Today
Date: Wed, 19 Feb 2003 18:00:54 -0500
Thread-Topic: Florida Today
Thread-Index: AcLYaHCT/ukoZ0IPTK2hSsUDH+VHAQAAd01w
From: "Oliveri, Frank" <FOLIVERI@brevard.gannett.com>
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
X-OriginalArrivalTime: 19 Feb 2003 23:00:55.0093 (UTC) FILETIME=[C1E4DE50:01C2D86A]

Thanks for responding at all. I realize this a very difficult time for you and your colleagues.
Our hearts here went out to everyone involved.
Good luck in your work.

FO

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: Wednesday, February 19, 2003 5:44 PM
To: Oliveri, Frank
Cc: H.K.HENRY@larc.nasa.gov
Subject: Re: Florida Today

Mr. Oliveri,

At this point in time, the proper approach for me is to provide any information I have to the Columbia Accident Investigation Board at their request. Please feel free to interface with Mr. Keith Henry of our Public Affairs Office (757 864-6120) regarding any questions about these events you may have.
Sincerely,
Bob Daugherty

At 05:15 PM 2/19/2003, you wrote:
>Mr. Daugherty:
>
>Understanding the information you provided to David Lechner was worst
>case, it's remarkably similar in some respects to what appeared to happen
>from the limited data available.
>I was wondering if you have seen similar anomolies before that had forced
>you to consider such dire circumstances in the past? Was this analysis
>done before?
>Frank Oliveri
>Florida Today

Daugh.-78

X-Sender: h.k.henry@pop.larc.nasa.gov
Date: Wed, 19 Feb 2003 18:04:02 -0500
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
From: "H. Keith Henry" <h.k.henry@larc.nasa.gov>
Subject: Re: Columbia E-mail
Cc: M.M.SKORA@larc.nasa.gov

Got it.
keith

Mr. Schleck,

I absolutely appreciate you wanting to get as much information as possible to provide a fair and accurate story. At this point in time, the proper approach for me is to provide any information I have to the Columbia Accident Investigation Board at their request. Please feel free to continue to interface with Mr. Keith Henry regarding any questions about these events you may have.
Sincerely,
Bob Daugherty

At 03:14 PM 2/19/2003, you wrote:
Mr. Daugherty,

I still would like to talk with you sometime about your e-mail. I assume public affairs has cautioned you. But I'm not sure if that caution is a total prohibition against speaking with reporters.

This is in the interest of writing the most fair, accurate story possible. We will continue to cover this issue with more stories.

I'm sure all the attention this has brought isn't fun for you. Hang in there. I'm trying to be as polite as possible, despite pressure from my editor. ;-)

Sincerely,
Dave Schleck
247-7430

--
****

H. Keith Henry 757-864-6120
M.S. 115 fax 864-8199
Deputy, Office of Public Affairs h.k.henry@larc.nasa.gov
NASA, Langley Research Center
Hampton, VA 23681-2199 http://oea.larc.nasa.gov/

****

Daugh. -79

X-Sender: h.k.henry@pop.larc.nasa.gov
Date: Wed, 19 Feb 2003 18:04:49 -0500
To: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
From: "H. Keith Henry" <h.k.henry@larc.nasa.gov>
Subject: Re: Florida Today
Cc: M.M.SKORA@larc.nasa.gov

Got it.
keith

Mr. Oliveri,

At this point in time, the proper approach for me is to provide any information I have to the Columbia Accident Investigation Board at their request. Please feel free to interface with Mr. Keith Henry of our Public Affairs Office (757 864-6120) regarding any questions about these events you may have.
Sincerely,
Bob Daugherty

At 05:15 PM 2/19/2003, you wrote:
Mr. Daugherty:

Understanding the information you provided to David Lechner was worst case, it's remarkably similar in some respects to what appeared to happen from the limited data available.
I was wondering if you have seen similar anomolies before that had forced you to consider such dire circumstances in the past? Was this analysis done before?
Frank Oliveri
Florida Today

--
****

H. Keith Henry 757-864-6120
M.S. 115 fax 864-8199
Deputy, Office of Public Affairs h.k.henry@larc.nasa.gov
NASA, Langley Research Center
Hampton, VA 23681-2199 http://oea.larc.nasa.gov/

****

Daugh. -80

[redacted] 09:53 PM 2/19/2003, Space station visual inspection of orbiter

Reply-To: [redacted]
From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
Subject: Space station visual inspection of orbiter
Date: Wed, 19 Feb 2003 20:53:27 -0600
X-Mailer: Microsoft Outlook Express 6.00.2800.1106

FOIA Exemption (b)(6)

I read an email posted on the internet web site that contained your address and hoped that you would answer a couple of questions.

Would it be possible for the crew of the space station to visually inspect the space shuttle exterior on future missions?

If damage is located could the crew of the orbiter stay in orbit or join the crew of the space station until any problem is resolved?

Is it possible for a high powered vehicle (not the orbiter) to reenter the atmosphere without heating up?

I hope that everything will be done to continue our valuable space program.

I am a veteran of the USAF.(aircraft mechanic)
Currently the manager of Information Technologies at [redacted]
Thank you for taking the time to read this email.

Respectfully,

[redacted]

Daugh. -81

Cheryl Cleghorn, 01:21 PM 2/28/2003, ACTION REQUIRED - Columbia STS-107 FOIA Request

X-Sender: c.w.cleghorn@pop.larc.nasa.gov
Date: Fri, 28 Feb 2003 13:21:59 -0500
To: R.H.DAUGHERTY@larc.nasa.gov, M.J.SHUART@larc.nasa.gov,
H.M.ADELMAN@larc.nasa.gov
From: Cheryl Cleghorn <c.w.cleghorn@larc.nasa.gov>
Subject: ACTION REQUIRED - Columbia STS-107 FOIA Request
Cc: w.t.mcmurry@larc.nasa.gov

Bob, Howard & Mark,

LaRC's Freedom of Information Act (FOIA) Office has received a new FOIA request (see below) for all e-mail and written or faxed correspondence to/from you from January 16 through February 19, 2003, regarding or referencing the STS-107 Columbia launch, its mission or resulting accident.

ACTION:

In order to comply with this request:

1. Conduct a search of materials in your possession and work area that is responsive to this request and **submit it to LaRC's FOIA Officer in Bldg. 1153, Room 201, by COB March 5.** Please remember you have a legal duty to thoroughly review records and computer files and e-mail in your possession and to accurately and completely identify and produce all responsive records.

2. Flag any information in the responsive documentation that you believe would be inappropriate for release, and indicate why it should not be released. The Center will not release flagged materials without thoroughly considering your concerns and conducting an appropriate legal review of your concerns and applicable laws and regulations.

3. If you have no responsive documents, please submit a "No Records" response via e-mail to c.w.cleghorn@larc.nasa.gov by COB March 5.

All documentation generated in response to this request will receive legal review by LaRC's Office of Chief Counsel for determination of "releasability" in accordance with applicable laws and regulations. If you have any questions regarding this request, contact Cheryl Cleghorn (FOIA Office) at 864-2497 or Tom McMurry (Office of Chief Counsel) at 864-3708.

Thank you for your cooperation in this matter.

Cheryl Cleghorn
LaRC FOIA Officer

Reply-To: <jkelly@flatoday.net>
From: "John Kelly" <jkelly@flatoday.net>
To: <foia@hq.nasa.gov>, <foia@larc.nasa.gov>, <foia@jsc.nasa.gov>
Cc: <mreed@brevard.gannett.com>
Subject: Florida Today FOIA Request - Correspondence regarding damage to Columbia between Langley and Johnson centers

Daugh-82

Date: Wed, 19 Feb 2003 10:12:11 -0500
X-Priority: 3 (Normal)
Importance: Normal
FOIA REQUEST

John L. Kelly
Space Team Leader
Florida Today
1 Gannett Plaza
Melbourne, Florida 32941-9000
321-242-3660

February 19, 2003

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
Headquarters, Washington DC
Langley Research Center, Hampton, VA
Johnson Space Center, Houston, TX
Attn: FOIA Officers

FOIA REQUEST

Dear FOI Officer:

Pursuant to the federal Freedom of Information Act, 5 U.S.C. s. 552, I request access to all electronic mail and written or faxed correspondence involving the following NASA and/or contractor employees from Jan. 16th through present day regarding or referencing the STS-107 Columbia launch, its mission or resulting accident:

- Robert H. Daughterty, H.M. Adelman and M.J. Shuart at Langley Research Center.
- Leroy Cain, Milt Heflin, Ron Dittemore, David Lechner and Carlisle Campbell at Johnson Space Center.

This request includes files, analysis or documents attached to any electronic, written or faxed correspondence.

I agree to pay reasonable duplication fees for the processing of this request in an amount not to exceed $100. However, please notify me prior to your incurring any expenses in excess of that amount. If the documents are available in electronic format, we will accept electronic versions of the records in any standard word processing or raw text format. In such a case, the documents could be mailed or sent via electronic mail to jkelly@flatoday.net or jkelly3rd@msn.com.

As a representative of the news media I am only required to pay for the direct cost of duplication after the first 100 pages. Through this request, I am gathering information on the shuttle ascent and reentry safety issues.

This information is being sought on behalf of Florida Today for dissemination to the general public.

As allowed under the law, please waive any applicable fees. Release of the information is in the public interest because it will contribute significantly to public understanding of government operations and activities. If my request is denied in whole or part, I ask that you justify all
deletions by reference to specific exemptions of the act. I will also expect you to release all segregable portions of otherwise exempt material.

I, of course, reserve the right to appeal your decision to withhold any information or to deny a waiver of fees. As I am making this request as a journalist and this information is of timely value, I would appreciate your communicating with me by telephone, rather than by mail, if you have questions regarding this request. Please provide expedited review of this request which concerns a matter of urgency. As a journalist, I am primarily engaged in disseminating information.

The public has an urgent need for information about space shuttle safety. I certify that my statements concerning the need for expedited review are true and correct to the best of my knowledge and belief. I look forward to your reply within 20 business days, as the statute requires.

If these records are made publicly available during the course of the space shuttle investigation, or already have been, please let me know who I or someone from our staff should contact about picking them up.

Thank you for your assistance.

Very truly yours,

John L. Kelly
Space Team Leader
Florida Today
1 Gannett Plaza
Melbourne, Florida 32941-9000
321-242-3660
--

CHERYL CLEGHORN
Public Affairs Specialist
NASA Langley Research Center
Office of External Affairs
PHONE: (757) 864-2497

FAX: (757) 864-7732

http://www.larc.nasa.gov

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Post-Launch Film Review - Day 1
Date: Mon, 27 Jan 2003 14:04:04 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----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

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

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

107film1.pdf

E212.mpg

Daugh - 83

STS-107 POST LAUNCH FILM REVIEW
KSC Photo/Video Analysis Team
17 January 2003

Anomalies

1. At approximately 80-84 seconds (accurate timing off of film will be done tomorrow) after T-0 a large piece of debris is observed striking the underside (-Z) of the LH wing of the orbiter. The debris appears to originate from the area of the –Y bipod attach point on the external tank. (E-208, E-212) No damage to orbiter TPS is apparent. Further analysis will continue.

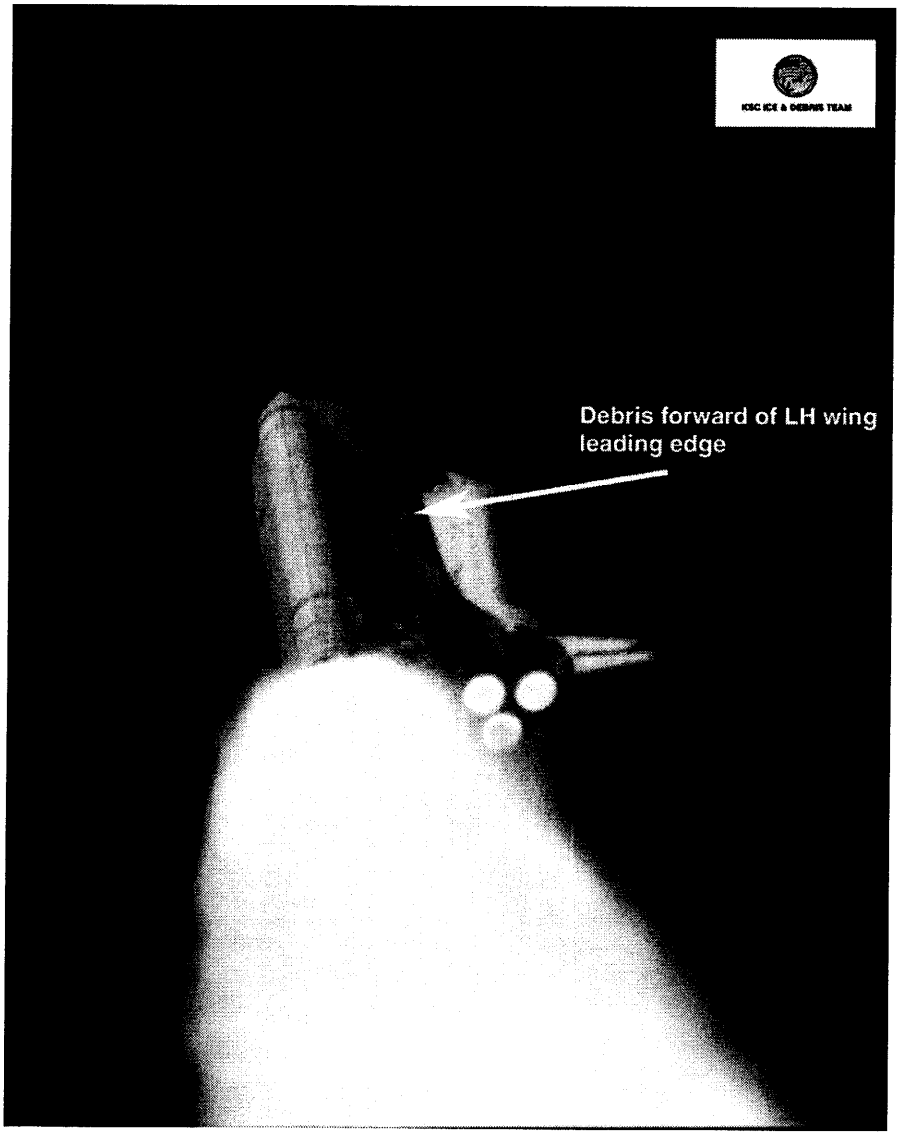


Photo 1.

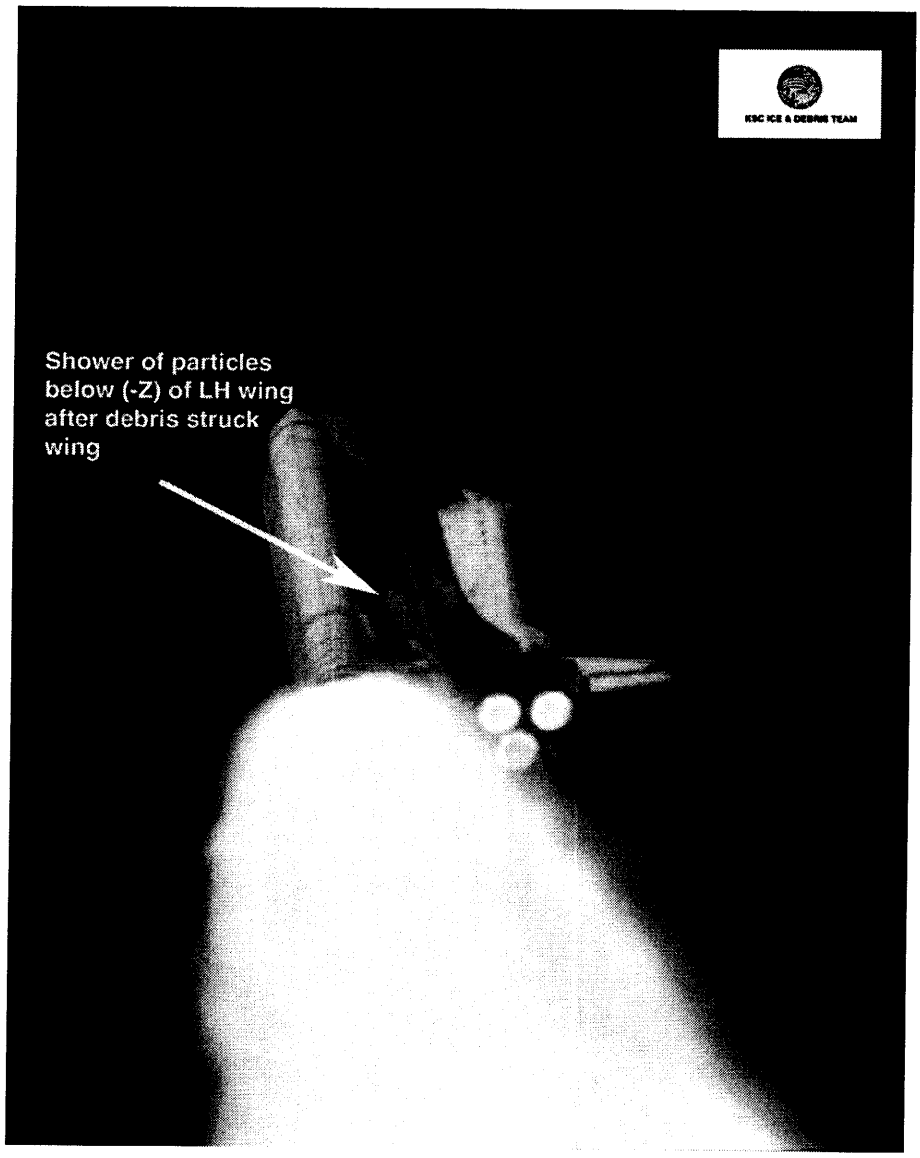


Photo 2.

2. Approximately 33 seconds after T-0 several particles are observed falling away from the –Z portion of the LH SRB ETA ring. Particles are probably pieces of the instafoam closeout on the ETA ring. (E-220, E-222, E-223, E-224)

Observations

Forward RCS paper covers were observed falling aft during early ascent. Several pieces can be seen falling over LH and RH wings. (E-52, E-222)

GUCP separation and retraction appeared normal. (E-33, E-34, E-39)

Ice particles from the GH2 disconnect fell at T-0. (E-33)

Umbilical purge barrier baggie material fell during ascent. (E-31, E-52, E-207, E-222, E-223)

SRB separation appeared normal. (E-208, E-212)

Particles of SRB aft-skirt instafoam fell along side the SRB plume during ascent. (E-223)

SSME Mach diamond formation sequence was 3-2-1. (E-76, E-77)

Numerous flashes occurred in SSME plume during ascent. (E-208, E-220, E-222, E-223)

Ice particles fell from ET/ORB umbilicals after lift-off. No impact to orbiter lower surface was noted. (E-31, E-52, E-63)

Charring on the ET aft dome was typical. (E-212)

Numerous pieces of facility debris entered field of view after vehicle cleared tower. (E-31, E-36).

Light frost and GOX vapors were present on –Y ET louver. (E-40)

Throat plug material ejected from SRB exhaust hole after T-0. No contact with vehicle. (E-52)

Notes

Review of high-speed films will continue on Saturday, January 18, 2003.

Armando Oliu

NASA – KSC

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Debris Briefing for MMT
Date: Mon, 27 Jan 2003 14:06:03 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Friday, January 24, 2003 10:32 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA); RICHART, JENE A. (JSC-MS2) (NASA)
Cc: MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)
Subject: FW: STS-107 Debris Briefing for MMT

Here is the Orbiter thermal/stress assessment. I do not have the system integration (Carlos Ortiz/Boeing) debris trajectory analysis charts yet. Both were presented to MER team and MMT this morning. There is good potential for tile replacement and maybe local overheating of structure, but no burn-through. Though the assessment states, so far, that no safety of flight issues exist, there is open work on one more case, the MLG Door tiles. The MER team understood this open work, but in my opinion the MMT with Linda Ham did not get the full message of open work remaining.

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: 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
877 497-0336 pager
8774970336@archwireless.net
600 Gemini
Houston, TX 77058

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

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

Daugh. - 84

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)
(281)-621-1924 (Pager)


Debris.ppt

Orbiter Assessment of STS-107 ET Bipod Insulation Ramp Impact

P. Parker

D. Chao

I. Norman

M. Dunham

January 23, 2003

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**

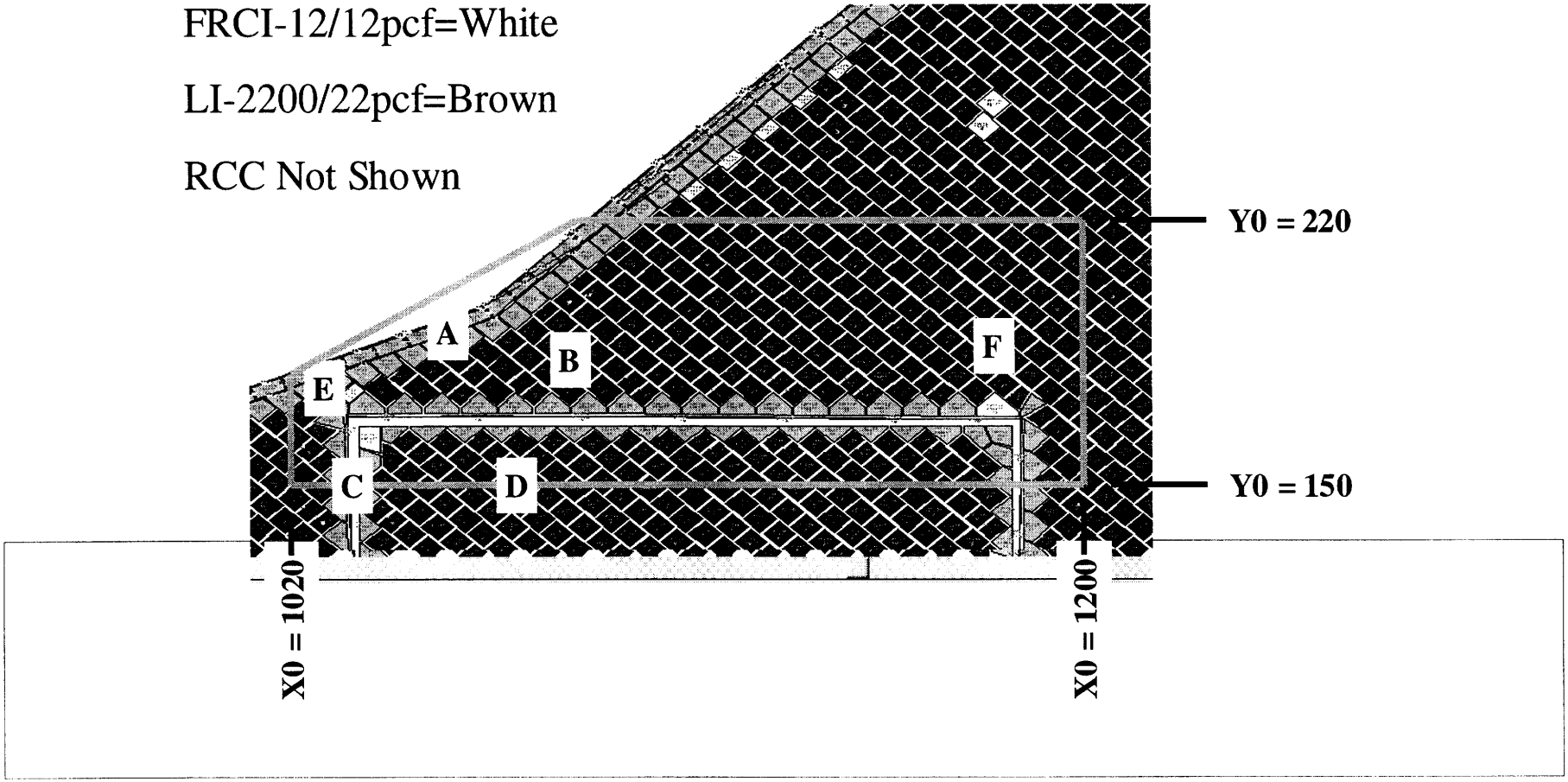
System Integration Inputs Were Matched Against Orbiter Tile/RCC to Determine Critical Locations

LI-900/9pcf=Black

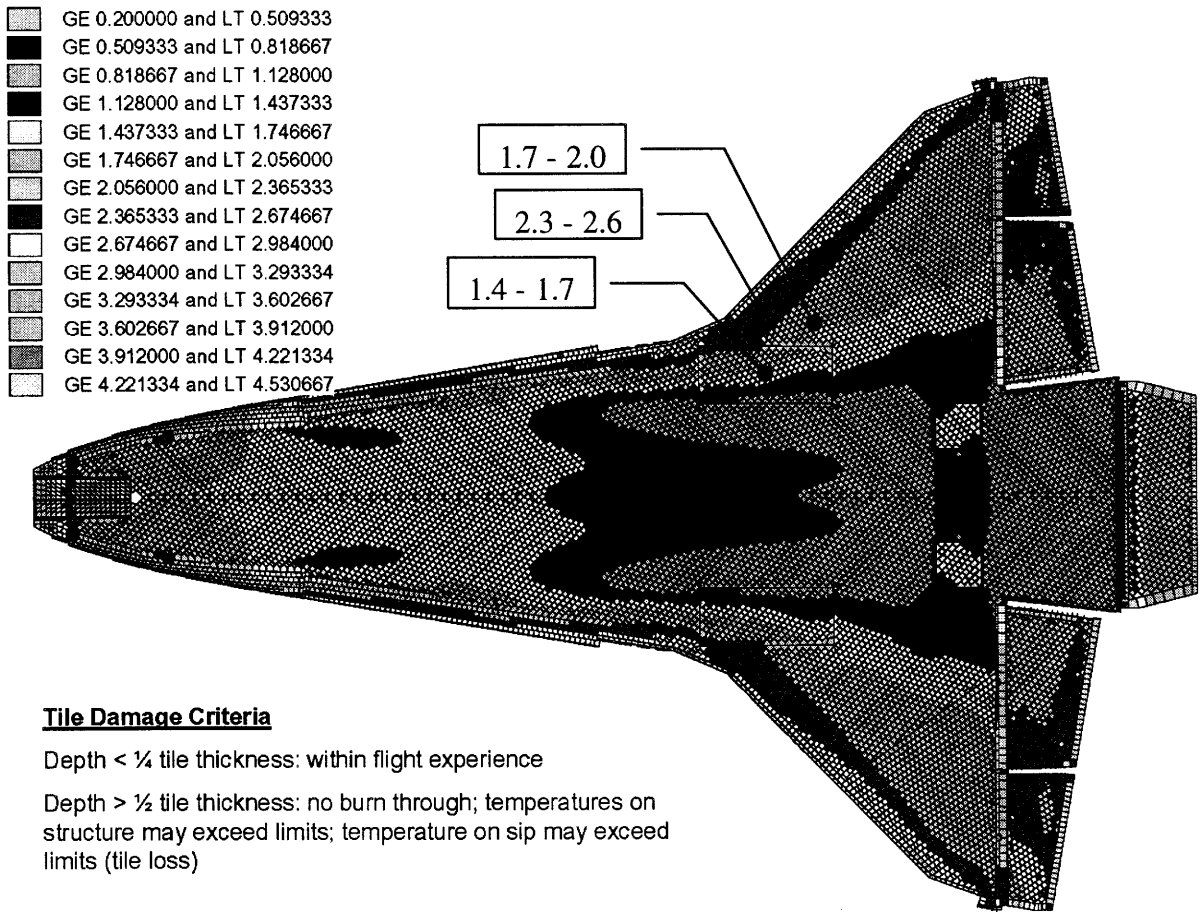
FRCI-12/12pcf=White

LI-2200/22pcf=Brown

RCC Not Shown



Tile Thickness



Tile Damage Criteria

Depth < ¼ tile thickness: within flight experience

Depth > ½ tile thickness: no burn through; temperatures on structure may exceed limits; temperature on sip may exceed limits (tile loss)

Damage Results From "Crater" Equations Show Significant Tile Damage

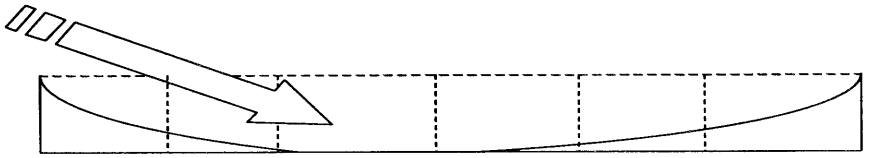
- "Crater" indicates that multiple tiles would be taken down to densified layer
  - However, program was designed to be conservative due to large number of unknowns
  - Crater reports damage for test conditions that show no damage

Tile Information		Location			Impactor		Calculated Damage		
Type	Thickness	Letter	X	Y	Angle	Velocity	Depth	Length	Width
9 lb	2.6 - 2.8	A	1060	190	13	720	4.7	25.8	7.2
22 lb	2.6 - 2.8	A	1060	190	13	720	3.2	25.8	7.2
9 lb	2.3 - 2.4	B	1090	180	6	700	2.8	31.9	7.2
9 lb	2.0 - 2.4	C	1036	150	8	680	3.3	29.8	7.2
22 lb	2.0 - 2.4	C	1036	150	8	680	2.3	28.6	7.2
9 lb	1.9 - 2.0	D	1075	150	8	710	3.4	32.2	7.2
12 lb	2.8 -3.1	E	1029	177	10	680	2.9	19.0	2.4
22 lb	2.8 -3.1	E	1029	177	10	680	2.6	19.0	2.4
9 lb	1.7	F	1184	182	6	730	2.8	32.8	2.4

Damage data and tile thickness are given in inches.

Debris Size = 20" x 16" x 6"

(Density = 2.4 lb/ft^3)



Review of Test Data Indicates Conservatism for Tile Penetration

- **The existing SOFI on tile test data used to create Crater was reviewed along with STS-87 Southwest Research data**
  - **Crater overpredicted penetration of tile coating significantly**
    - **Initial penetration to described by normal velocity**
      - Varies with volume/mass of projectile (e.g., 200ft/sec for 3cu. In)
    - **Significant energy is required for the softer SOFI particle to penetrate the relatively hard tile coating**
      - Test results do show that it is possible at sufficient mass and velocity
    - **Conversely, once tile is penetrated SOFI can cause significant damage**
      - Minor variations in total energy (above penetration level) can cause significant tile damage
  - **Flight condition is significantly outside of test database**
    - **Volume of ramp is 1920cu in vs 3 cu in for test**

(Potentially) Similar STS-50 Impact Demonstrates that Damage is Possible

- Damage to aft lower tile (0.5"d x 9"L x 4" W) on wing was found after STS-50 landing; wheel well camera also observed missing ET bipod ramp insulation similar in size
- Small variation in energy input could substantially increase damage
- Incidence angle for STS-107 is predicted higher than STS-50

Volume = 1920in3

L (in)	d (in)	V (ft/sec)	Angle	Vadj (in/sec)	Flt Damage	damage (depth)	Normal Energy	
20	6	**700**	**3.2**	69	**0.50**	0.53	100%	STS-50 (estimated conditions)
20	6	770	3.2	116		0.75	121%	STS-50 plus 10% velocity
20	6	700	5.2	361		1.60	264%	STS-50 plus 2 deg incidence angle
20	6	600	3.2	2		0.05	73%	STS-50 "threshold"
20	6	720	10	1100		3.37	1024%	STS-107
20	6	788	10	1243		3.66	1228%	STS-107 + 10% energy
20	6	914	10	1505		4.16	1650%	STS-107 + 50% energy
20	6	720	10	700		2.49	551%	STS-107 with V* = 800

V*	C	density (SOFI)	density (tile)	Strength (tile)	
400	0.0195	0.0014	0.0052	53	219912

Volume	V* (in/sec)	Ratio	power	V* (ft/sec)	
0.11	650	1.0	3.5	542	test
0.33	450	0.8		375	test
1.00	320	0.8		267	test
3.00	250	1.0		208	test
1920	40	1.0		33	flight

Volume vs V* (velocity to penetrate tile coating)

RCC Predicted Damage at Incidence Angles Greater than 15 Degrees Based on Ice Database

Impactor		Damage
Angle	Velocity (fps)	Depth (in.)
5	720	0.11
10	720	0.18
15	720	0.23
20	720	0.28
25	720	0.33

Debris Size = 20" x 10" x 6"

Density = 2.4 lb/ft^3

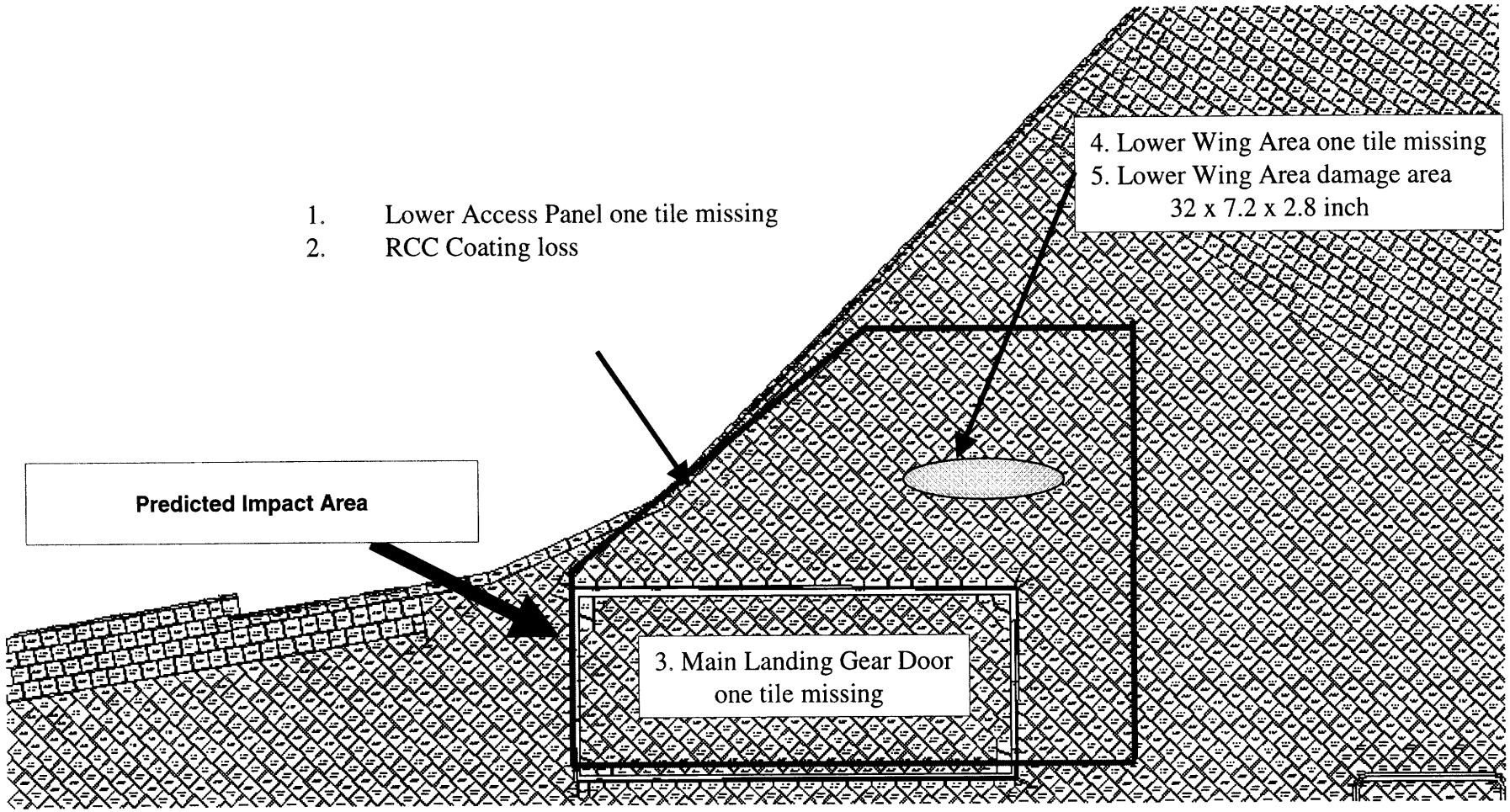
45° angle of wing was taken into account

Nominal panel thickness is 0.233 in.

RCC is clearly capable of withstanding impacts of at least 15 degrees; relative softness of SOFI (compared to ice) would indicate greater capability

- Maximum reported angle of 21 degrees is not an problem
  - Looking at using Window ice and RTV data as an analog

Thermal Analysis Assessment of Debris Impacted Lower Surface in STS-107 Mission Locations



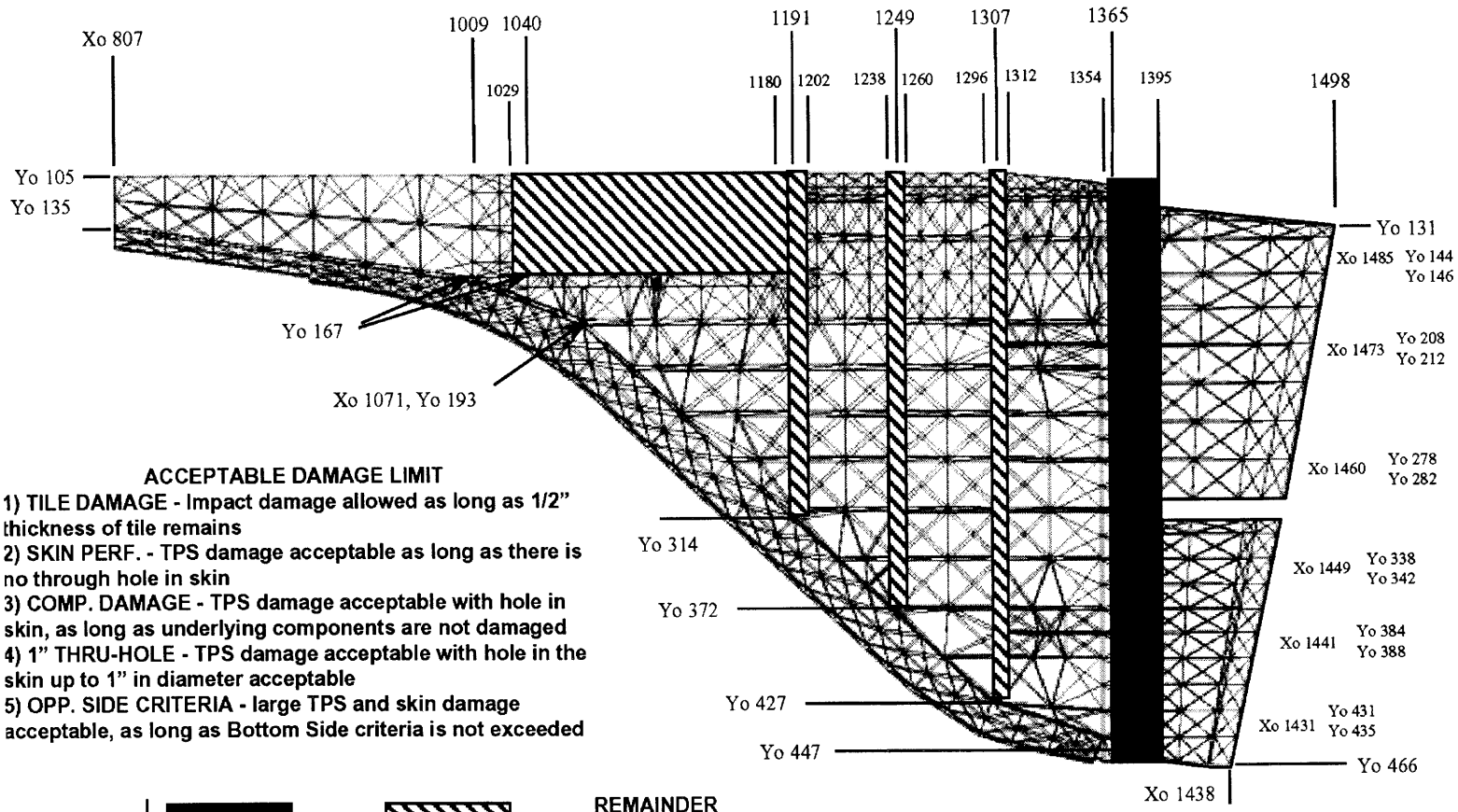
Impacted Lower Surface Location Thermal Predictions

Case	Location	Assumptions	Results
1	Access Panel (one tile missing)	Loss to last layer of TMM Densified layer ~ .2 inches	Temperature of Al Tube Carrier 790 °F No issue
2	RCC Panel 9 Lower Flange OML (Coating Missing)	Coating loss and Carbon substrate exposed	Substrate thickness: 0.193 inches Loss .09 inches No issue
3	Main Landing Gear Door (one tile missing)	Loss to last 2 layers of TMM Densified layer ~ .4 inches	Temperature of Structure 540 °F No issue
4	Lower Wing Area (one tile missing)	Loss to last 2 layers of TMM Densified layer ~ .4 inches	Temperature below 350 °F design req. No issue
5	Lower Wing Area (32 x 7.2 x 2.8 inch) Damage	Loss to last layers of TMM Densified layer ~ .2 inches	
6	Main Landing Gear Door (several tiles Lost)	Loss to last layers of TMM Densified layer ~ .2 inches	

Structural Assessment Provides for Intact Contingency Landing with Damaged Tiles

- Criteria for M/OD study were to assess on-orbit risk that cannot be controlled
- Study allowed for significant degradation beyond design criteria
  - Structural temperatures well beyond 350F design (due to loss of tile)
    - Repair of structure required
  - Small holes in structure, allowing internal plasma flow, were permissible if not in critical area
    - Not expected for STS-107
  - Factor of Safety not maintained for design conditions
  - Critical subsystems were included in evaluation
    - Wing has few subsytems except in landing gear box and elevon cove
    - Wing spars are considered critical structures
- Conditions identified to ensure intact contingency landing

Wing Lower Surface M/OD Failure Criteria



ACCEPTABLE DAMAGE LIMIT

1) TILE DAMAGE - Impact damage allowed as long as 1/2" thickness of tile remains
2) SKIN PERF. - TPS damage acceptable as long as there is no through hole in skin
3) COMP. DAMAGE - TPS damage acceptable with hole in skin, as long as underlying components are not damaged
4) 1" THRU-HOLE - TPS damage acceptable with hole in the skin up to 1" in diameter acceptable
5) OPP. SIDE CRITERIA - large TPS and skin damage acceptable, as long as Bottom Side criteria is not exceeded

AREA			REMAINDER OF WING
Top Side	3) COMP. DAMAGE	3) COMP. DAMAGE	5) OPP. SIDE CRITERIA
Bottom Side	1) TILE DAMAGE	2) SKIN PERF.	4) 1" THRU-HOLE

Summary and Conclusion

- Impact analysis ("Crater") indicates potential for large TPS damage
  - Review of test data shows wide variation in impact response
  - RCC damage limited to coating based on soft SOFI
- Thermal analysis of wing with missing tile is in work
  - Single tile missing shows local structural damage is possible, but no burn through
  - Multiple tile missing analysis is on-going
- M/OD criteria used to assess structural impacts of tile loss
  - Allows significant temperature exceedance, even some burn through
    - Impact to vehicle turnaround possible, but maintains safe return capability

<u>Conclusion</u>

- Contingent on multiple tile loss thermal analysis showing no violation of M/OD criteria, safe return indicated even with significant tile damage

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Debris Analysis Team Meeting
Date: Mon, 27 Jan 2003 14:14:10 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Thursday, January 23, 2003 7:59 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>>

Daugh. - 85

Pam Madera
Vehicle and Systems Analysis Subsystem Area Manager
Phone: 281-282-4453
Pager: 877-254-8252
(I can receive a short alpha numeric page by addressing e-mail to:
877-254-8252@archwireless.net)

-----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: 281-282-4453
Pager: 877-254-8252
(I can receive a short alpha numeric page by addressing e-mail to:
877-254-8252@archwireless.net)


STS-107 Preliminary Debris Assessment - rev2.ppt

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

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

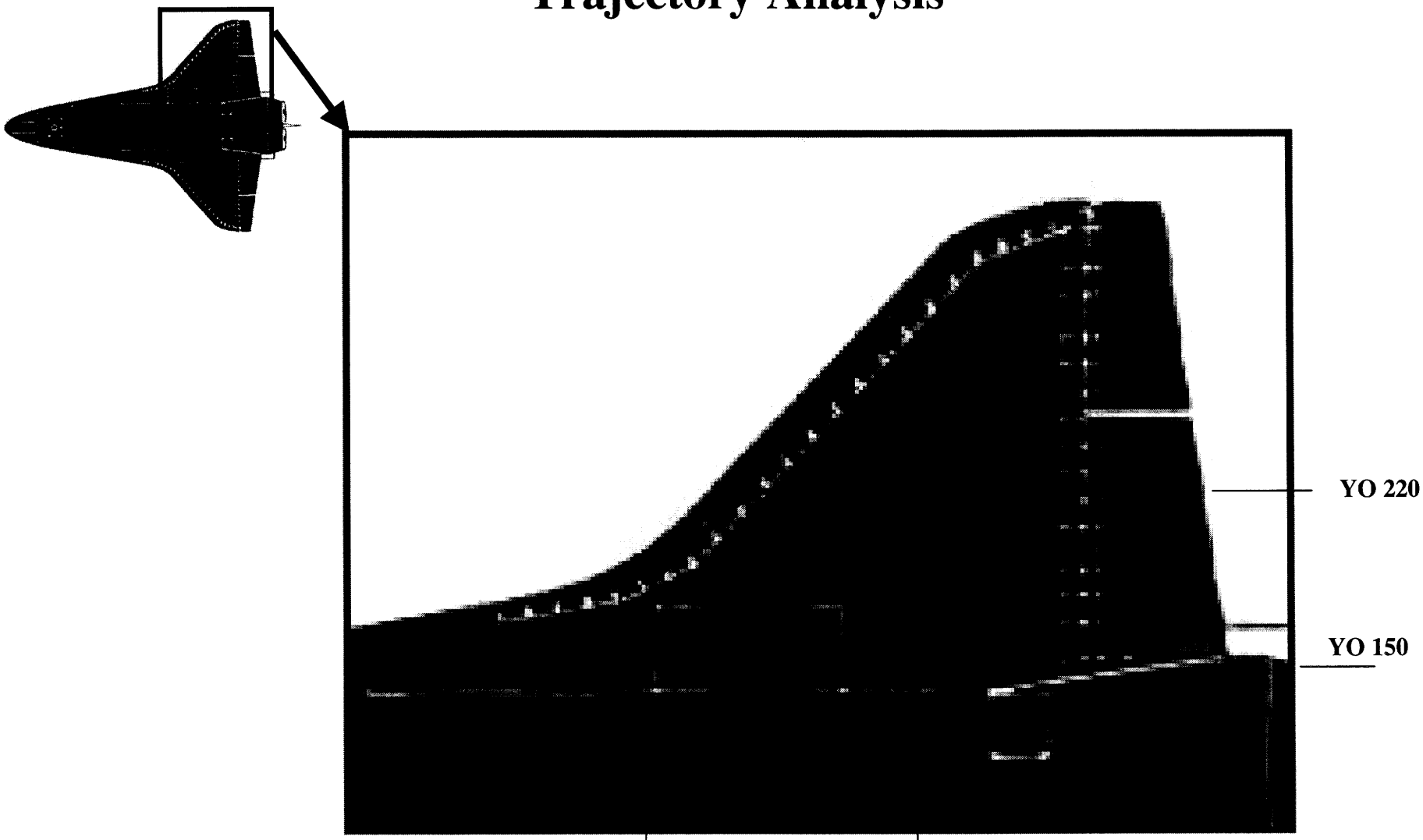
Debris Impact Conditions to Be Evaluated for Area on Orbiter Lower Surface

- **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

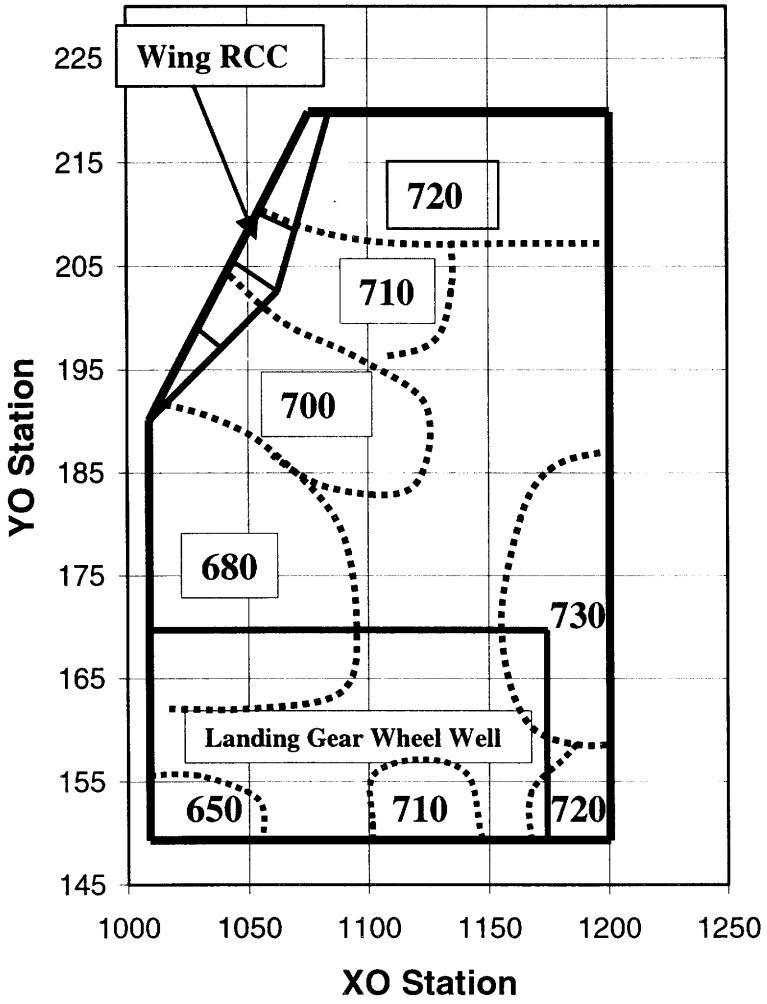


Velocity and Impact Angle Distribution Inside Impact Area

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

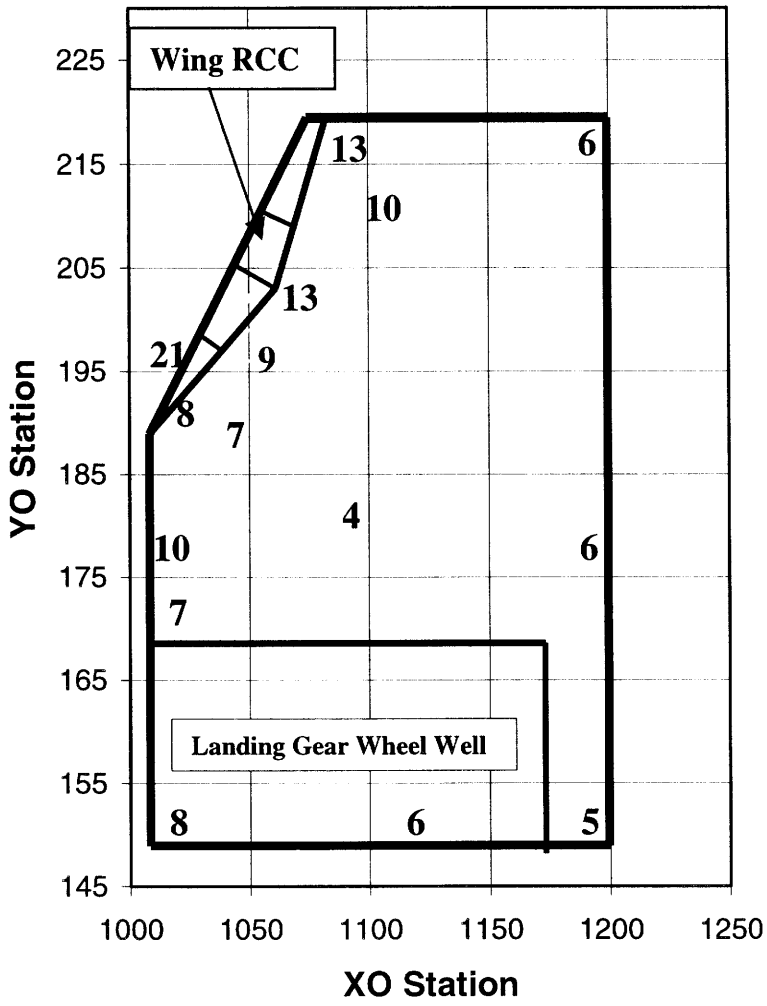
Impact Velocity

(ft/sec.)



Impact Angle

(degrees)



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

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case com
pleted
Date: Mon, 27 Jan 2003 14:16:52 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

> -----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 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)
> 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
>

Daugh. - 86

> 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
>
>

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <robert.h.daugherty@nasa.gov>
Subject: Video you sent
Cc:
Bcc:
Attached:

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

At 03:04 PM 1/27/2003, you wrote:

-----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.

Daugh.-87

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: Video you sent
Date: Mon, 27 Jan 2003 15:59:53 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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.

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

At 03:04 PM 1/27/2003, you wrote:

-----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.

Daugh. - 88

To: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)" <carlisle.c.campbell@nasa.gov>
From: "Robert H. Daugherty" <robert.h.daugherty@nasa.gov>
Subject: Re: FW: Video you sent
Cc:
Bcc:
Attached:

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

At 04:59 PM 1/27/2003, you wrote:

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.

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

At 03:04 PM 1/27/2003, you wrote:

-----Original Message-----
From: SMITH, JAMES P. (JSC-ES2) (NASA)

Daugh. - 89

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.

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Tile Damage
Cc:
Bcc:
Attached:

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

Daugh.-90

To: "SHUART, MARK J" <M.J.SHUART@LaRC.NASA.GOV>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Foam and Tile
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\eudora\attach\Debris.ppt; C:\Documents and Settings\eudora\attach\E212.mpg; Attachment on Columbia Web Site

Mark...attached are two files that I've received regarding the concern about ET foam around the orbiter bipod support coming off and possibly damaging tiles ... perhaps around the main gear doors. So far, our involvement has been one of providing the current model of drag associated with landing with two tires flat prior to touchdown and some thought exercises of what might happen if the wheel well were burned into....something that is arguably very unlikely. Interestingly, in the powerpoint pitch, they talk about a test in which the "crater" caused by an impact test dug out 3 cubic inches of tile. They say their estimated "flight condition" is 1920 cubic inches of "crater". Hopefully I'm reading that wrong, but as they say...that is way outside their test database. No official request has been made upon us at this time. And there is no formal simulation going on as far as I know regarding landing with two tires flat prior to touchdown...its just a coincidence that landing with ONE tire flat is being simulated right now at the Ames VMS in astronaut training where they are using our newest load-persistence model so it is a very convenient time to look at two tires flat if they can squeeze it in. Will keep you informed as I hear more...if I do.
Bob

Daugh. - 91

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: RE: Tile Damage
Date: Tue, 28 Jan 2003 13:29:58 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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

CCC

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.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

Daugh. - 92

To: "SHUART, MARK J" <M.J.SHUART@LaRC.NASA.GOV>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Tile Damage Update
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached:

Hi Mark,
Nothing terribly new but a few things talked about today with some folks at the Ames VMS. Apparently the current "official" estimate of damage is 7 inches by 30 inches by half the depth of the tiles down to the densified level. One of the bigger concerns is that the "gouge" may cross the main gear door thermal barrier and permit a breach there. No way to know of course. A JSC colleague and I talked to the sim guys and are urging them to simulate a landing with two tires flat prior to touchdown...it is as simple as hitting a software button and simply doing it...but since no Orbiter Program Management is "directing" the sim community to do this it might need to get done "at night". An anecdote they told us is that this was already done by mistake this week and the commander lost control of the vehicle during our load-persistence simulations. It seems that if Mission Operations were to see both tire pressure indicators go to zero during entry, they would sure as hell want to know whether they should land gear up, try to deploy the gear, or go bailout...we can't imagine why getting information is being treated like the plague. Apparently the thermal folks have used words like they think things are "survivable", but "marginal".
I imagine this is the last we will hear of this.
Take care,
Bob

Daugh. -93

To: "LECHNER, DAVID F. (JSC-DF52) (USA)" <david.f.lechner1@jsc.nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Main Gear Breach Concerns
Cc: M.J.SHUART@LaRC.NASA.GOV, H.M.ADELMAN@LaRC.NASA.GOV, carlisle.c.campbell1@jsc.nasa.gov
Bcc:
Attached:

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 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

Daugh. - 94

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

From: "LECHNER, DAVID F. (JSC-DF52) (USA)" <david.f.lechner1@jsc.nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Cc: M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov,
"CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
Subject: RE: Main Gear Breach Concerns
Date: Fri, 31 Jan 2003 12:17:34 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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
(281) 483-1685

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: Thursday, January 30, 2003 5:23 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

Daugh. - 95

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 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 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

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bill Heitzman'" <william.j.heitzman@usahq.unitedspacealliance.com>,
"'Porter, Michael T'" <Michael.Porter@West.Boeing.com>,
"'Tom Hoffman'"
<thomas.l.hoffman@boeing.com>,
"ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA)" <joseph.e.rogers@nasa.gov>,
"ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)" <alan.r.rocha@nasa.gov>,
"LECHNER, DAVID F. (JSC-DF52) (USA)" <david.f.lechner1@jsc.nasa.gov>
Cc: "DOREMUS, ROBERT C. (JSC-DF52) (NASA)" <robert.c.doremus@nasa.gov>,
"'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>,
"LAW, HOWARD G. (JSC-EG) (NASA)" <howard.g.law@nasa.gov>
Subject: Ames Sim runs with two blown tires before landing
Date: Fri, 31 Jan 2003 14:59:01 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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.

Daugh. - 96

To: "SHUART, MARK J" <M.J.SHUART@LaRC.NASA.GOV>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Sensor Data Update
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached:

Mark,
This email is to followup our conversation from this morning since I mentioned that I'd relay any info I can on initial indications from various sensors. There is always the danger of jumping to conclusions but these are the facts as I've gathered from press conferences and other conversations:

Times are only approximate:

---:53 left inboard, outboard elevon temps off scale low (off scale low suggests data systemic problem more so than actual increased temps)
---:56 left main gear wheel well temp, brake line temp, and tire temps INCREASED
---:58 bond line temps left side wing off scale low
---:59 left inboard and left outboard tires...all temp, all pressures off scale low
---:59:30 left main gear down indication
---:00 all vehicle data lost

When and if I hear more I'll let you know.
Take care,
Bob

Daugh. - 97

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'McClain James G Civ 46 OG/OGM/OL-AC'" <James.McClain@wpafb.af.mil>
Cc: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>,
"'Porter, Michael T'"
<Michael.Porter@West.Boeing.com>,
"'Tom Hoffman'"
<thomas.l.hoffman@boeing.com>,
"ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)" <alan.r.rocha@nasa.gov>
Subject: RE: Columbia accident
Date: Mon, 3 Feb 2003 12:44:51 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Thanks. I generally agree with your scenario. We had wondered about the same event happening. To cover a similar scenario as yours but with less carnage, we were able to get some tests run last week at the Ames Sim to determine if the orbiter can land with two tires already blown. Results showed that the crew can control this condition during landing, but of course the 2 pilots already knew what was coming at them during the landing.

I will pass your suggestion around to Porter, Hoffman, Daugherty, and Rocha and get their comments. Thanks again. I will get back with you.

Carlisle

-----Original Message-----
From: McClain James G Civ 46 OG/OGM/OL-AC
[mailto:James.McClain@wpafb.af.mil]
Sent: Monday, February 03, 2003 12:15 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Columbia accident

Carlisle,

I just want you to know that I/we have been thinking about the Columbia accident since it happened, and have been following the NASA news releases the last 2 days. One of the first things I thought about, as I'm sure you did also, was the possibility that a tire/wheel explosion could have contributed to the breakup of the vehicle.

Today I see the pictures on CNN of the debris hitting the underside of Columbia 80 seconds after launch in the vicinity of the left gear door. Also, the information about temperature rise and loss of sensors in the left gear bay during the last few minutes of controlled flight. As an outsider looking in, there appears to be circumstantial evidence that whatever damage occurred during launch resulted in burn-through, possibly into the left gear bay, during hypersonic flight over Texas. The hot plasma jetting into the

Daugh. - 98

gear bay and hitting the tire/wheel assembly could quite possibly cause the tire to explode, it being the softest/weakest link in the pressure vessel. The resultant pressure wave could easily have blown the door off and caused structural damage, initiating the breakup.

Today we are thinking about how to setup and conduct a test to simulate such an event, in the event NASA's evidence leads in that direction. I don't think it would be particularly difficult to design such a test, or even particularly dangerous. Maybe something as simple as a blow torch directed against an inflated tire sidewall would work. An array of pressure sensors mounted around the test article at various distances and positions could record the pressure wave. We have done such tests in the past, where we failed the tire carcass by mechanical methods. In the case of those tests, we were collecting pressure wave data for the design of our own test equipment, to ensure appropriate hardness against tire explosions.

I know you'll let me know if you think there's any way LGTF can help with the scientific aspects of the investigation. For now, I just wanted you to know that we're thinking about you.

Deepest sympathy and prayers for the families.

Regards,

J Greer McClain
46 OG/OGM/OL-AC
Landing Gear Test Facility
Phone: (937) 255-1609 DSN: 785-1609
FAX: (937) 255-0973
james.mcclain@wpafb.af.mil

To: M.J.SHUART@LaRC.NASA.GOV
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Fwd: RE: Columbia accident
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached:

Mark,
Our counterparts at Wright Labs in Dayton offer here to help JSC out with testing in the event NASA decides to do failed tire testing. Thought their scenario would interest you since it is identical to our concern last week.
Bob

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'McClain James G Civ 46 OG/OGM/OL-AC'" <James.McClain@wpafb.af.mil>
Cc: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>,
"'Porter, Michael T'"
<Michael.Porter@West.Boeing.com>,
"'Tom Hoffman'"
<thomas.l.hoffman@boeing.com>,
"ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)" <alan.r.rocha@nasa.gov>
Subject: RE: Columbia accident
Date: Mon, 3 Feb 2003 12:44:51 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Thanks. I generally agree with your scenario. We had wondered about the same event happening. To cover a similar scenario as yours but with less carnage, we were able to get some tests run last week at the Ames Sim to determine if the orbiter can land with two tires already blown. Results showed that the crew can control this condition during landing, but of course the 2 pilots already knew what was coming at them during the landing.

I will pass your suggestion around to Porter, Hoffman, Daugherty, and Rocha and get their comments. Thanks again. I will get back with you.

Carlisle

-----Original Message-----
From: McClain James G Civ 46 OG/OGM/OL-AC
[mailto:James.McClain@wpafb.af.mil]
Sent: Monday, February 03, 2003 12:15 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Columbia accident

Daugh.-99

Carlisle,

I just want you to know that I/we have been thinking about the Columbia accident since it happened, and have been following the NASA news releases the last 2 days. One of the first things I thought about, as I'm sure you did also, was the possibility that a tire/wheel explosion could have contributed to the breakup of the vehicle.

Today I see the pictures on CNN of the debris hitting the underside of Columbia 80 seconds after launch in the vicinity of the left gear door. Also, the information about temperature rise and loss of sensors in the left gear bay during the last few minutes of controlled flight. As an outsider looking in, there appears to be circumstantial evidence that whatever damage occurred during launch resulted in burn-through, possibly into the left gear bay, during hypersonic flight over Texas. The hot plasma jetting into the gear bay and hitting the tire/wheel assembly could quite possibly cause the tire to explode, it being the softest/weakest link in the pressure vessel. The resultant pressure wave could easily have blown the door off and caused structural damage, initiating the breakup.

Today we are thinking about how to setup and conduct a test to simulate such an event, in the event NASA's evidence leads in that direction. I don't think it would be particularly difficult to design such a test, or even particularly dangerous. Maybe something as simple as a blow torch directed against an inflated tire sidewall would work. An array of pressure sensors mounted around the test article at various distances and positions could record the pressure wave. We have done such tests in the past, where we failed the tire carcass by mechanical methods. In the case of those tests, we were collecting pressure wave data for the design of our own test equipment, to ensure appropriate hardness against tire explosions.

I know you'll let me know if you think there's any way LGTF can help with the scientific aspects of the investigation. For now, I just wanted you to know that we're thinking about you.

Deepest sympathy and prayers for the families.

Regards,

J Greer McClain
46 OG/OGM/OL-AC
Landing Gear Test Facility
Phone: (937) 255-1609 DSN: 785-1609
FAX: (937) 255-0973
james.mcclain@wpafb.af.mil

M.J.SHUART@LaRC.NASA.GOV, 02:05 PM 2/11/2003, Timeline and Email Traffic to/from ALDF

To: M.J.SHUART@LaRC.NASA.GOV
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Timeline and Email Traffic to/from ALDF
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\ALDF Timeline.doc; Attachment currently on Columbia web site

Mark,
Attached is a single file with the info we spoke about this morning. Will be back in the office in the morning.
Bob

Daugh. - 100

Timeline, Email Traffic, and Comments Regarding ALDF Personnel Involvement with STS 107 Columbia Flight

Bob Daugherty

January 27, 2003 Monday

Received a telephone call from Carlisle Campbell at JSC...works for the engineering directorate in Mechanical Systems...involved with doors, hatches, landing gear, etc for the Orbiter. Have worked with Carlisle for almost 20 years on landing and tire-related issues. He asked if I had heard about the issue with foam debris impacting the orbiter during ascent and I replied I had not. He filled me in on the issue, and mentioned that "people" were talking about not knowing exactly where the impact location was on the bottom of the orbiter but that some people mentioned that the gear door might be a vulnerable place to get damaged because of the nature of the thermal seal there. He mentioned that there had been lots of analysis, that the analysis said they didn't think there was a safety of flight issue, but that the gear door was in the "predicted target zone" of the impact. He emailed me two powerpoint documents that discussed the analysis and showed the predicted impact area. He mentioned the fact that "people" were throwing around possible worst-case scenarios regarding landing with two flat tires. This was the main reason for talking to us since we have previously provided JSC and the simulation folks, years ago, with models for just such a landing (not for the reason of them failing due to thermal damage...but just for covering all the bases and not caring why they might be flat). It just so happened that this very week, the astronaut training session at the Ames VMS was occurring where we already were looking at the effects of landing with one tire flat (again, the reason for such was not important), and whether or not the second tire on the strut would fail due to overload. We have done a lot of work on a load-persistence model we developed here at Langley and that was being evaluated. The astronauts were also looking for ground handling techniques that could help prevent the second tire from failing if they had a single tire flat at touchdown. So Carlisle and I knew the simulation community was in a position to very easily and quickly simulate a landing with two flat tires. We discussed the fact that "orbiter management" had not approved such simulations...I can't say whether its because they hadn't yet been approached or they just didn't think it was appropriate since the analysis of the thermal damage did not suggest a safety of flight concern. We then got Howard Law , JSC, Guidance and Control simulation engineer on the phone who was at Ames helping to run the load-persistence testing and asked him about whether they could easily do the simulation we thought would be good to do (the two flat tires) since it is just good engineering practice to simulate anything you can to gather contingency information. We discussed what their simulations had shown during the load persistence runs where the second tire had failed and now you were sliding on two flat tires. We determined that at low speed they were not using our models for drag correctly so I went and got together some old model information for sliding on a dragging strut and faxed him a flow chart for that model out at Ames. We also discussed the fact that some people at JSC were of the opinion that acquiring more information and visualizing the damage area was a good thing to pursue and talked about the options regarding ground based telescopes, EVA's, etc. This discussion was simply two engineers talking...nothing special since neither of us have any expertise in this area. He mentioned that at that point there were no plans to

visualize the damage since the orbiter had no arm, an EVA is very difficult due to the location underneath and lack of hand-holds, and that some thought that ground based telescopes might not have the resolution needed for a good view. We agreed that we thought it made good engineering sense to visualize the damage but were of the opinion that since folks higher up than us were pressing that issue we would not stick our nose in their business...we were just two engineers talking amongst ourselves.

January 27, 2003 Monday

Received several emails from Campbell showing the powerpoint presentations on the tile damage, and a video of the impact of the debris taken from behind the left wing (impact itself hidden from view):
Email subject lines:

Date: Mon, 27 Jan 2003 14:04:04 : STS-107 Post-Launch Film Review - Day 1
Date: Mon, 27 Jan 2003 14:06:03 FW: STS-107 Debris Briefing for MMT
Date: Mon, 27 Jan 2003 14:14:10 FW: STS-107 Debris Analysis Team Meeting
Date: Mon, 27 Jan 2003 14:16:52 FW: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

I then watched the video and replied with the following email:
Date: Mon, 27 Jan 2003 4:35 Video you sent

Carlisle then replied with the following email:
Date: Mon, 27 Jan 2003 15:59:53 FW: Video you sent

Faxed the dragging strut model to Howard Law on the same day Jan 27, 2003 late in the afternoon.

January 28, 2003 Tuesday

I sent the following email to Campbell:
Date: Tue, 28 Jan 2003 1:38 pm Tile Damage

I sent the following email to Mark Shuart to inform him of what was going on after he called me to inquire regarding things he had heard:
Date: Tue, 28 Jan 2003 2:15 pm Foam and Tile

And Carlisle replied with the following email:
Date: Tue, 28 Jan 2003 13:29:58 RE: Tile Damage

January 29, 2003 Wednesday

Had a three way telephone call with Carlisle Campbell and Howard Law and other folks at Ames VMS to discuss progress on the load-persistence simulations. After that we

asked if Howard Law had been officially "asked" or "cleared" to do any simulations to support getting some "background" information in the simulator regarding what might happen if one were to land with two flat tires. Nobody had ever expressed any knowledge that the main gear door was actually involved in the damage area but we just felt that we should do everything we could to get as much info as possible to cover as many bases as possible.

I sent the following email to Mark Shuart to inform him of what was going on:
Date: Wed, 29 Jan 2003 3:51 pm Tile Damage Update

January 30, 2003 Thursday

In late afternoon I had a telephone conversation with Campbell who mentioned that they had been in a Landing Gear PRT (Problem Resolution Team?) meeting...this is a normal meeting not related to the issue at hand, I don't believe. They have them probably weekly whether they're flying or not I think. Apparently there were some comments by the Mission Operations folks about the thermal issue and them having to do some talking about making sure they had as many contingency plans figured out as possible since everybody wants to be ready for anything. Since Carlisle and I had been talking, we discussed as many bad things regarding the main gear as we could think of and it became apparent to me after doing some calculations that if the tires failed in the wheel well the door would be blown off and there could be big problems. Other things we discussed were the pyros that help deployment as a backup...etc. I asked Carlisle if he thought it was appropriate to voice these scenarios to MOD guys and he agreed it was a good thing so that we felt like we had done our best job or helping the system not let some worst-case scenarios slip thru the cracks.

I sent the following email to David Lechner at JSC (he's associated with the Mission Operations Directorate (MOD) and we've worked together often)

Date: Thurs, 30 Jan 2003 6:22 pm Main Gear Breach Concerns

January 31, 2003 Friday

I received a telephone call from David Lechner thanking me for voicing the scenarios in the email and he said they were having all kinds of discussions about being ready for various contingencies so that they would be ready to advise the Mission Management Team if necessary for them to make any decisions they may have to during entry. I can't speak for David, but I had no actual concern that anything disastrous would occur. We discussed a belly landing at length and why that apparently is considered to be a loss-of vehicle event.

I received the following email from David Lechner in response to my email the night before:
Date: Fri, 31 Jan 2003 12:17:34 RE: Main Gear Breach Concerns

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Post-Launch Film Review - Day 1
Date: Mon, 27 Jan 2003 14:04:04 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----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

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

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

107film1.pdf

E212.mpg

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Debris Briefing for MMT
Date: Mon, 27 Jan 2003 14:06:03 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Friday, January 24, 2003 10:32 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA); RICHART, JENE A. (JSC-MS2) (NASA)
Cc: MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)
Subject: FW: STS-107 Debris Briefing for MMT

Here is the Orbiter thermal/stress assessment. I do not have the system integration (Carlos Ortiz/Boeing) debris trajectory analysis charts yet. Both were presented to MER team and MMT this morning. There is good potential for tile replacement and maybe local overheating of structure, but no burn-through. Though the assessment states, so far, that no safety of flight issues exist, there is open work on one more case, the MLG Door tiles. The MER team understood this open work, but in my opinion the MMT with Linda Ham did not get the full message of open work remaining.

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: 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
877 497-0336 pager
8774970336@archwireless.net
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)
(281)-621-1924 (Pager)

Debris.ppt

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Debris Analysis Team Meeting
Date: Mon, 27 Jan 2003 14:14:10 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Thursday, January 23, 2003 7:59 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
Pager: 877-254-8252
(I can receive a short alpha numeric page by addressing e-mail to:
877-254-8252@archwireless.net)

-----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: 281-282-4453
Pager: 877-254-8252
(I can receive a short alpha numeric page by addressing e-mail to:
877-254-8252@archwireless.net)

STS-107 Preliminary Debris Assessment - rev2.ppt

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case com
pleted
Date: Mon, 27 Jan 2003 14:16:52 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

> -----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 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)
> 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
>
>

Aircraft Landing Dynamics Facility
Langley Research Center
Hampton, VA 23681-2199

FACSIMILE TRANSMISSION

TO: Howard Law
FAX NUMBER: 650 604 7484
TELEPHONE NUMBER: _____
LOCATION: _____

FROM: _____
TELEPHONE NUMBER: (757)_____
FAX NUMBER: (757) 864-8090

COMMENTS: DRAGGING STRUT
MODEL - FLOW CHART -
COULDN'T FIND PLOT

Number of pages including lead: 6

Signature: Bob D Date: 1/27/03

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia
23665

NASA

Reply to Attn of 497

TO: NASA Johnson Space Center
Attn: VA/Richard Colonna, Manager, STS
Orbiter and GFE Projects Office

FROM: 497/Aerospace Technologist, Impact Dynamics Branch, SDD

SUBJECT: Results of Roll-on-Rim Capability Tests

A series of tests have been completed at the Langley Research Center's Aircraft Landing Dynamics Facility (ALDF) to determine the roll-on-rim capability of the Orbiter main wheel. Both a standard flight wheel inner half and a modified inner wheel half were tested. In addition, data were gathered to identify the behavior of a deflated tire during and after touchdown. This information is helpful in simulating a landing if a tire has deflated in orbit, a highly unlikely condition.

Because of the vertical load capability of the ALDF, only inner wheel halves were tested to identify their failure modes. This allowed full-scale loads to be applied to the wheel bead flanges. In our opinion, this testing mode does not compromise the validity of the results.

A standard flight wheel had previously been rolled on the B.F. Goodrich dynamometer wheel at rated load and at a speed of approximately 10 mph. It developed a crack and lost a small portion of bead flange after about 4,000 ft. and the test was stopped. The dynamometer surface was smooth steel. A similar test was conducted at the ALDF with a standard inner wheel half loaded to half the rated load. The surface was a simulated KSC runway. After about 650 ft., a portion of the bead flange failed and during the next revolution, the wheel half completely collapsed.

The first high-speed test involved landing a standard inner wheel half and observing its behavior. The wheel half was landed at a sink rate of 2.6 ft./sec. and forward speed of 150 kts. A rubber strap was attached to the wheel to facilitate spin-up and minimize wheel spin-up damage. Vertical load was about 25,000 lb. during this test. During spin-up and within the first 25 ft. of roll, the bead flange zippered off in 4 in. pieces. Ten feet later, the bead seat flange area and tube well disintegrated. Down load buffers, which limited travel of the drop test carriage, prevented the load from being applied to the wheel center section following wheel flange failure.

The next test was run to examine what benefit could be gained by using an inner wheel half with a much stronger bead flange (at a weight penalty of about 4 lbs. per inner wheel half). Touchdown conditions on this wheel half were 157 kts. groundspeed and 2.8 fps sink rate. This wheel survived spin-up and was loaded to about 65,000 lb. After about 130 ft., the wheel half disintegrated. Rolling resistance during this test was 5 percent of wheel vertical load.

The next test was designed to investigate the roll-on-center section capability of the wheel after the bead flanges and tube well have failed, but the center section did not spin-up and the wheel was skidded down the runway. The test speed was 159 kts. and the vertical load was about 70,000 lb. During the 450 ft. long slide, about 3 in. of wheel was worn away, and the friction coefficient was about .2.

The last test involved landing and rolling out on a tire deflated before the test to simulate a tire that has deflated in the wheel well either on the launch pad or in orbit. The conditions of this test included a ground speed of 157 kts. and a sink rate of 2.8 fps. Vertical load was maintained at 70,000 lb. The flat tire rolled approximately 1,050 ft. and produced a friction coefficient between .15 and .20. The tire disintegrated after a roll of 1,050 ft. Thereafter, the wheel rolled for 500 ft. on the intact beads that remained attached to the wheel. Rolling resistance while on the beads was .1.

These results indicate that no significant roll-on-rim capability is present in either the standard or modified inner wheel half. It appears that wheel failure at speeds of 160 kts. will undoubtedly result in some damage to the orbiter due to flying debris. Unfortunately, no method of predicting this damage is known. Most of the highest energy debris should be found in the 30-90 degree arc behind the wheel, with 90 degrees being vertical. Tire failure will result in the loss of large pieces of the 200 lb. tire, and prediction of these trajectories is also impossible.

A set of guidelines for predicting wheel failure along with an event flow chart is enclosed. Note that some of the events are only engineering judgments based on extremely limited test data.

It is assumed that some portion of this data along with the 1/3 scale skid results will be used to determine where to land the orbiter should a flat tire be detected in orbit. Although some damage to the orbiter is likely during a concrete runway landing with a flat tire, the unknown behavior of the tire and wheel on the lakebed surface during failure coupled with the lack of friction coefficient data on the lakebed surface at high bearing pressures is cause for concern. If flat tire lakebed landings are being considered, it is recommended that, at a minimum, tests be conducted at a lakebed site using a bare wheel loaded to 120,000 lb. using the towable load cart available at Edwards Air Force Base. If the wheel fails at low speed, then failure at high speed is almost certain. If the wheel simply digs in, then no information is gained as to high speed behavior. This test is inexpensive and capable of producing data that could help in the decision of where to land if an orbiter tire has lost pressure.

If you have any questions, feel free to contact Sandy Stubbs or me at FTS 928-2796.

Robert H. Daugherty

Enclosures
Set of Guidelines
Flowchart

cc (w/o Encl.):
101/Files
118/SD
244/SDD
497/IDB
497/RHDaugherty

NASA JSC
CB/JCasper
ES4/BHolder
ES6/CCampbell
EH221/HLaw
GA/BDO'Connor

B. F. Goodrich Co.
Aerospace and Defense Div.
Attn: J. Warren
P.O. Box 340
Troy, OH 45373

Rockwell International
AC19/MPorter
12214 Lakewood Blvd.
Downey, CA 90241

GUIDELINES FOR SIMULATING TIRE FAILURES

DEFINITIONS:

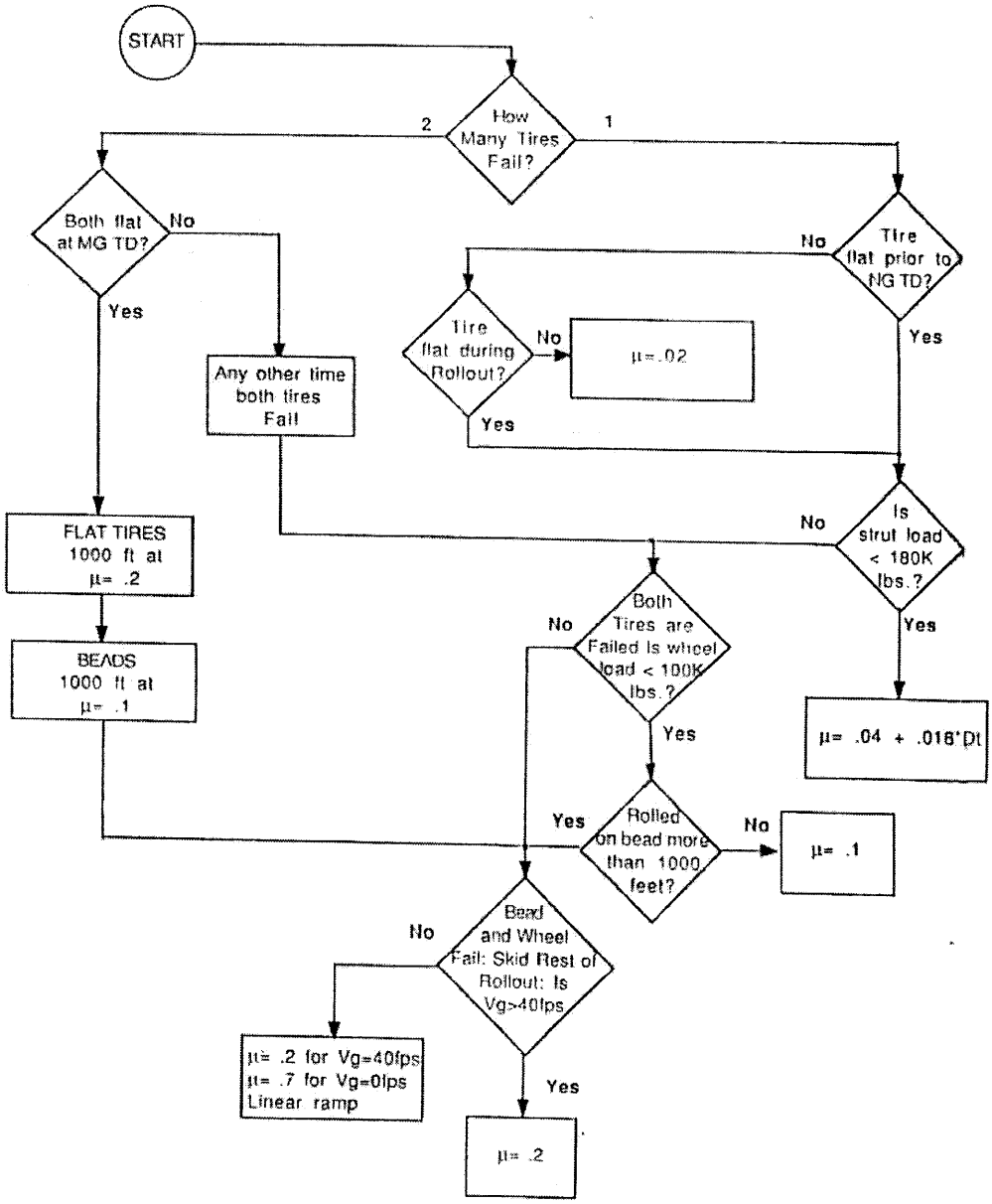
"GOOD" TIRE:	One that is inflated
"FLAT" TIRE:	One that has lost air but did not blow up due to overload
"FAILED" TIRE:	One that has : Blown up due to overload or Disintegrated due to flat tire roll.

1. Rolling on a "GOOD" TIRE: $\mu = .02$
2. Rolling on a "FLAT" TIRE: $\mu = .2$
3. Rolling on the bead: $\mu = .1$
4. Rolling on the rim flange or center section: $\mu = .05$
5. Skidding on center section, brake parts, axle, etc.: $\mu = .2$
6. Below about 40 fps, number 5 above ramps from $\mu = .2$ to $\mu = .7$ as speed approaches 0.

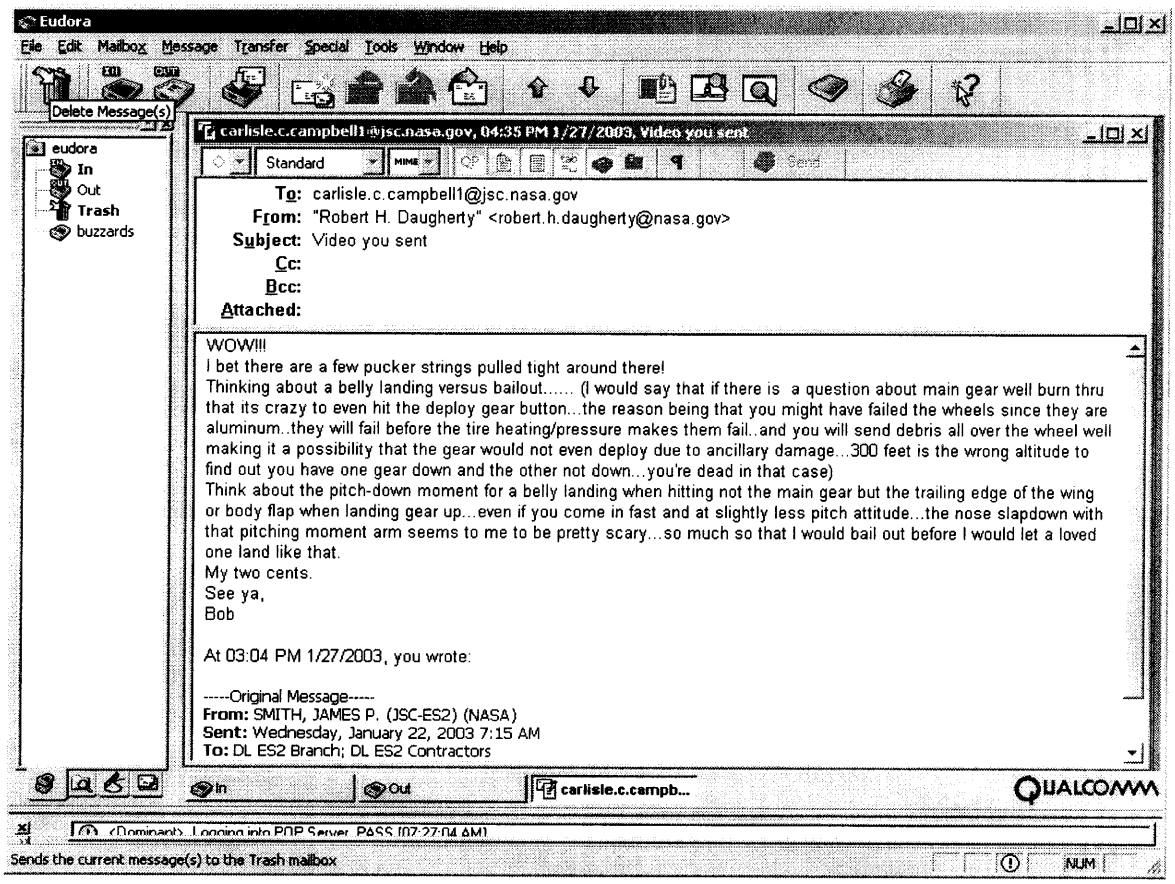
COMMENTS

NOTE: * indicates lower confidence than other comments

1. Flat tires can survive 1000' if loaded 70K or less.
2. Good tires loaded above 180K fail immediately.
3. *Failed tires roll on beads for 1000' if wheel loads are < 100K.
4. *If rolling on beads and wheel loads exceed 100K, then bead fails and rim flange breaks in 50'.
5. Center section may survive any length (flowchart assumes 0 length).
6. *For 1 good tire and 1 flat tire and strut load <180K then strut drag $\mu = .04 + .016$ x deflection of good tire.



Note: Dt = Deflection of good tire : should range from 0 to 10 in.


Eudora
File Edit Mailbox Message Transfer Special Tools Window Help
Delete Message(s)
eudora
In
Out
Trash
buzzards
carlisle.c.campbell1@jsc.nasa.gov, 04:35 PM 1/27/2003, Video you sent
Standard
To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <robert.h.daugherty@nasa.gov>
Subject: Video you sent
Cc:
Bcc:
Attached:
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
At 03:04 PM 1/27/2003, you wrote:
-----Original Message-----
From: SMITH, JAMES P. (JSC-ES2) (NASA)
Sent: Wednesday, January 22, 2003 7:15 AM
To: DL ES2 Branch; DL ES2 Contractors
In
Out
carlisle.c.campb...
QUALCOMM
Sends the current message(s) to the Trash mailbox
NUM

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: Video you sent
Date: Mon, 27 Jan 2003 15:59:53 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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.

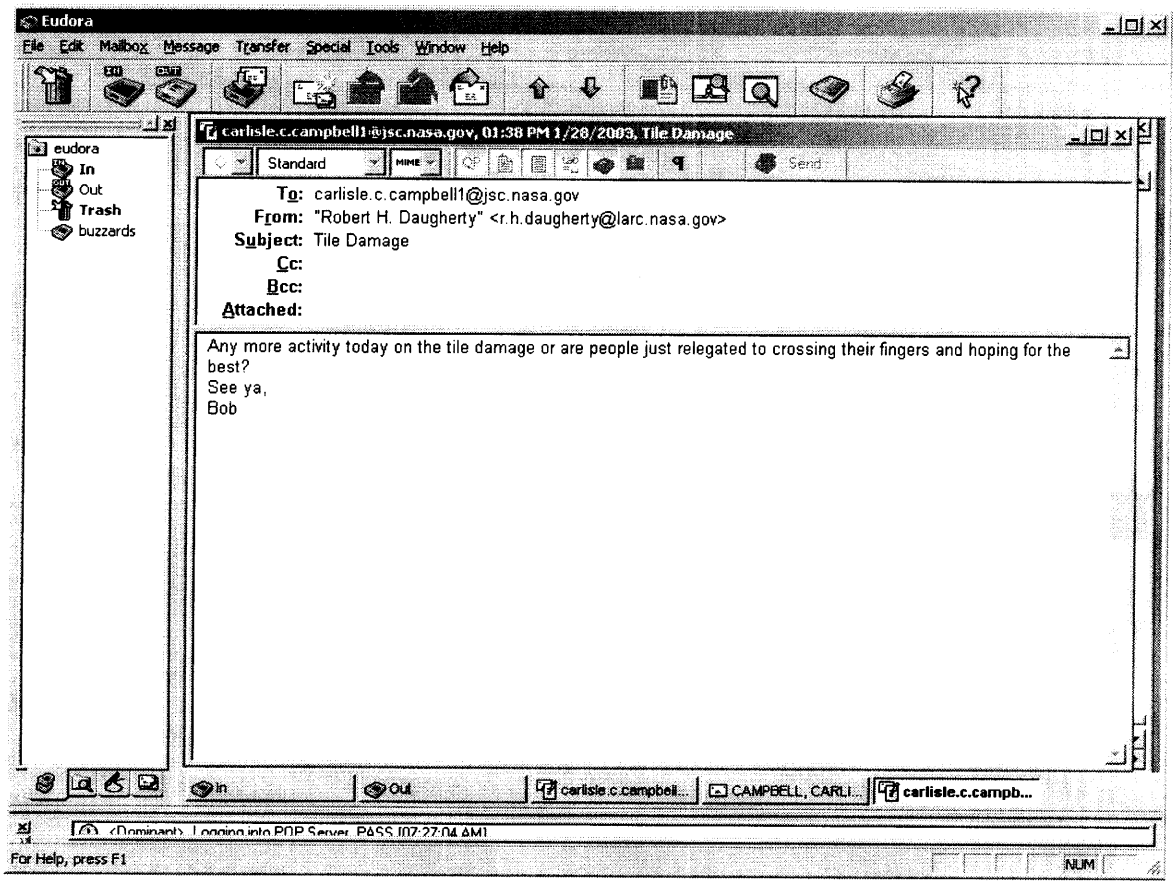
The LaRC ditching model tests 20 some years ago showed that the Orbiter was the best ditching shape that they had ever tested, of many. But, our structures people have said that if we ditch we would blow such big holes in the lower panels that the orbiter might break up. Anyway, they refuse to even consider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

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
>
> At 03:04 PM 1/27/2003, you wrote:

-----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.


Eudora
File Edit Mailbox Message Transfer Special Tools Window Help
eudora
In
Out
Trash
buzzards
carlisle.c.campbell1@jsc.nasa.gov, 01:38 PM 1/28/2003, Tile Damage
Standard
MIME
Send
To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Tile Damage
Cc:
Bcc:
Attached:
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
In
Out
carlisle.c.campbell...
CAMPBELL, CARLI...
carlisle.c.campb...
For Help, press F1
NUM

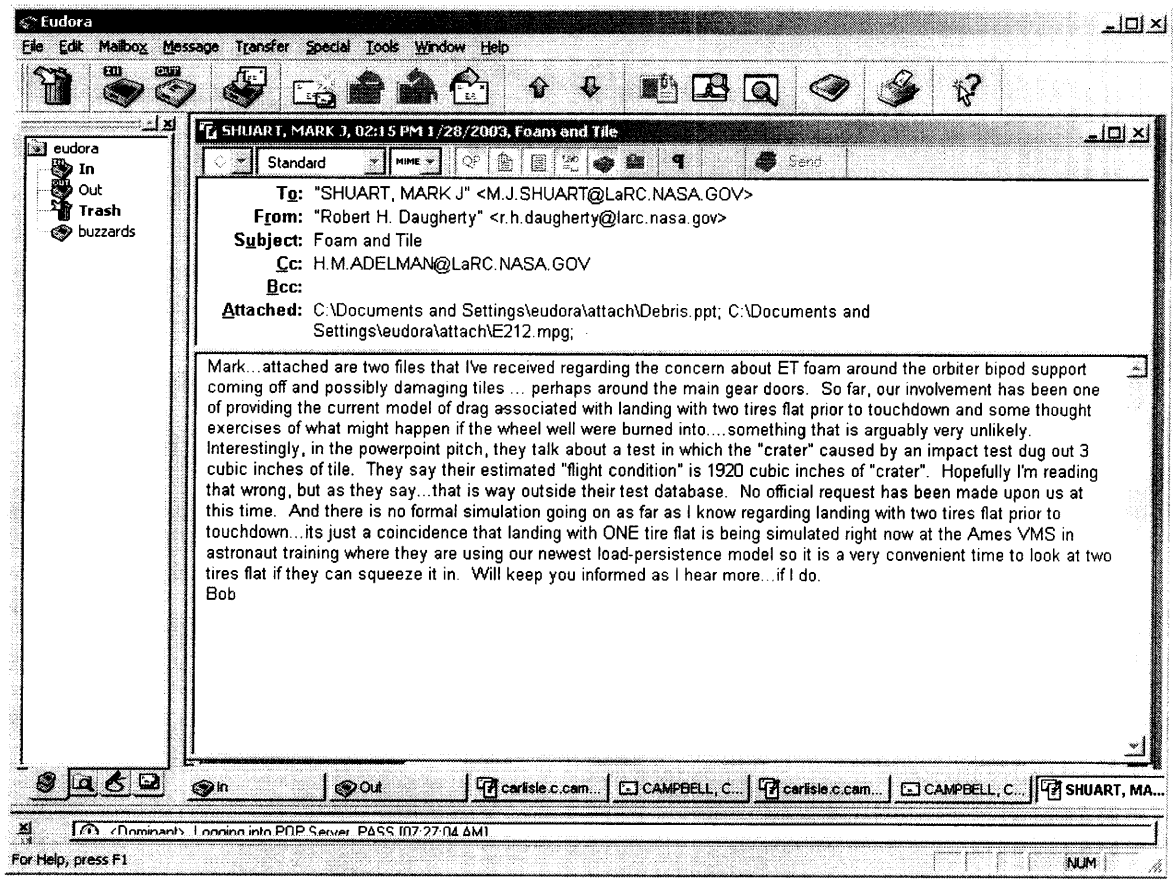
From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: RE: Tile Damage
Date: Tue, 28 Jan 2003 13:29:58 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

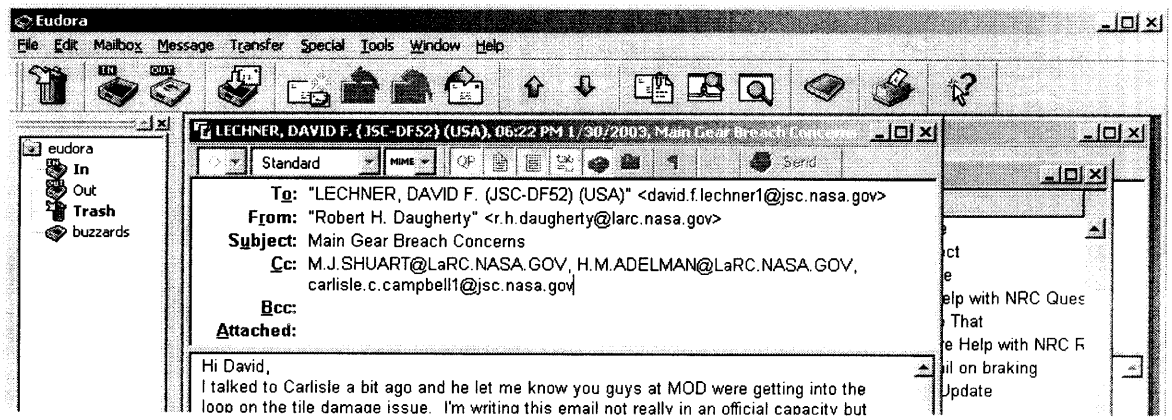
I have not heard anything new. I'll let you know if I do.

CCC

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.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


Eudora
File Edit Mailbox Message Transfer Special Tools Window Help
eudora
In
Out
Trash
buzzards
SHUART, MARK J, 02:15 PM 1/28/2003, Foam and Tile
Standard
Send
To: "SHUART, MARK J" <M.J.SHUART@LaRC.NASA.GOV>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Foam and Tile
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\eudora\attach\Debris.ppt; C:\Documents and Settings\eudora\attach\E212.mpg;
Mark...attached are two files that I've received regarding the concern about ET foam around the orbiter bipod support coming off and possibly damaging tiles ... perhaps around the main gear doors. So far, our involvement has been one of providing the current model of drag associated with landing with two tires flat prior to touchdown and some thought exercises of what might happen if the wheel well were burned into....something that is arguably very unlikely. Interestingly, in the powerpoint pitch, they talk about a test in which the "crater" caused by an impact test dug out 3 cubic inches of tile. They say their estimated "flight condition" is 1920 cubic inches of "crater". Hopefully I'm reading that wrong, but as they say...that is way outside their test database. No official request has been made upon us at this time. And there is no formal simulation going on as far as I know regarding landing with two tires flat prior to touchdown...its just a coincidence that landing with ONE tire flat is being simulated right now at the Ames VMS in astronaut training where they are using our newest load-persistence model so it is a very convenient time to look at two tires flat if they can squeeze it in. Will keep you informed as I hear more...if I do.
Bob
In
Out
carlisle.c.cam...
CAMPBELL, C...
carlisle.c.cam...
CAMPBELL, C...
SHUART, MA...
For Help, press F1
NUM



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 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 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

From: "LECHNER, DAVID F. (JSC-DF52) (USA)" <david.f.lechner1@jsc.nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Cc: M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov,
"CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
Subject: RE: Main Gear Breach Concerns
Date: Fri, 31 Jan 2003 12:17:34 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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
(281) 483-1685

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: Thursday, January 30, 2003 5:23 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 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 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 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

To: M.J.SHUART@LaRC.NASA.GOV
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Timeline and Email Traffic to/from ALDF
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\ALDF Timeline.doc; — Attachment currently on Columbia Web Site

Mark...this is a resend...sorry but I didn't get your message till just now (Wed morn, 7:10)...my email says it went out yesterday at 2:05....maybe it got lost in the system somehow.
Bob

Mark,
Attached is a single file with the info we spoke about this morning. Will be back in the office in the morning.
Bob

Daugh. - 101

To: M.J.SHUART@LaRC.NASA.GOV
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Public Charts Of Sensor Data
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\Columbia Sensor Timeline Charts.ppt;

Hi Mark,
Attached is a powerpoint file with about 25 charts off of a public NASA spaceflight site that shows sensor data with indicators of what's "good" data, both nominal and off-nominal, and also sensor system failures. Very interesting...especially if you scroll through the charts somewhat quickly.
Bob

Daugh. - 102

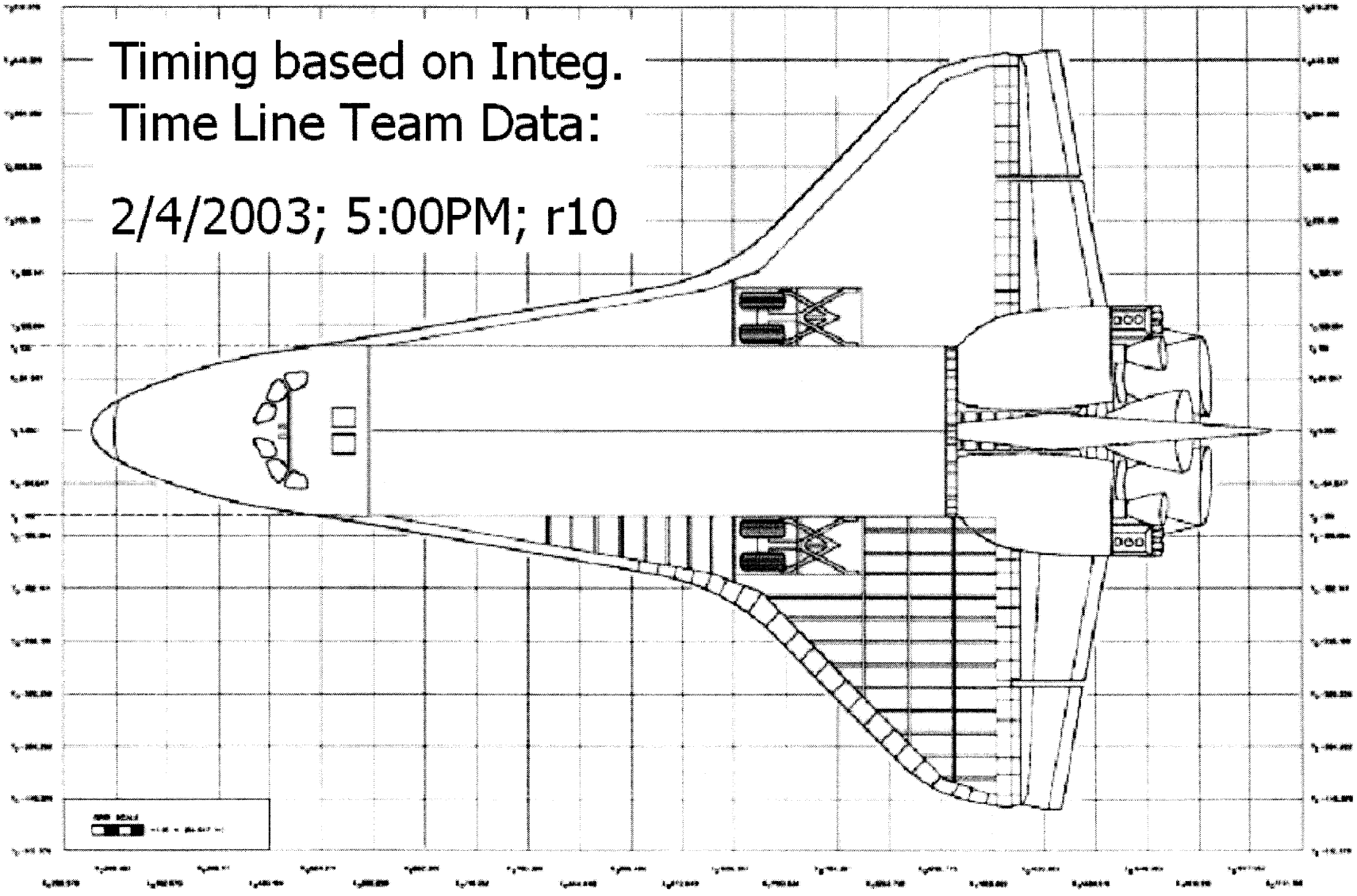
All times preliminary

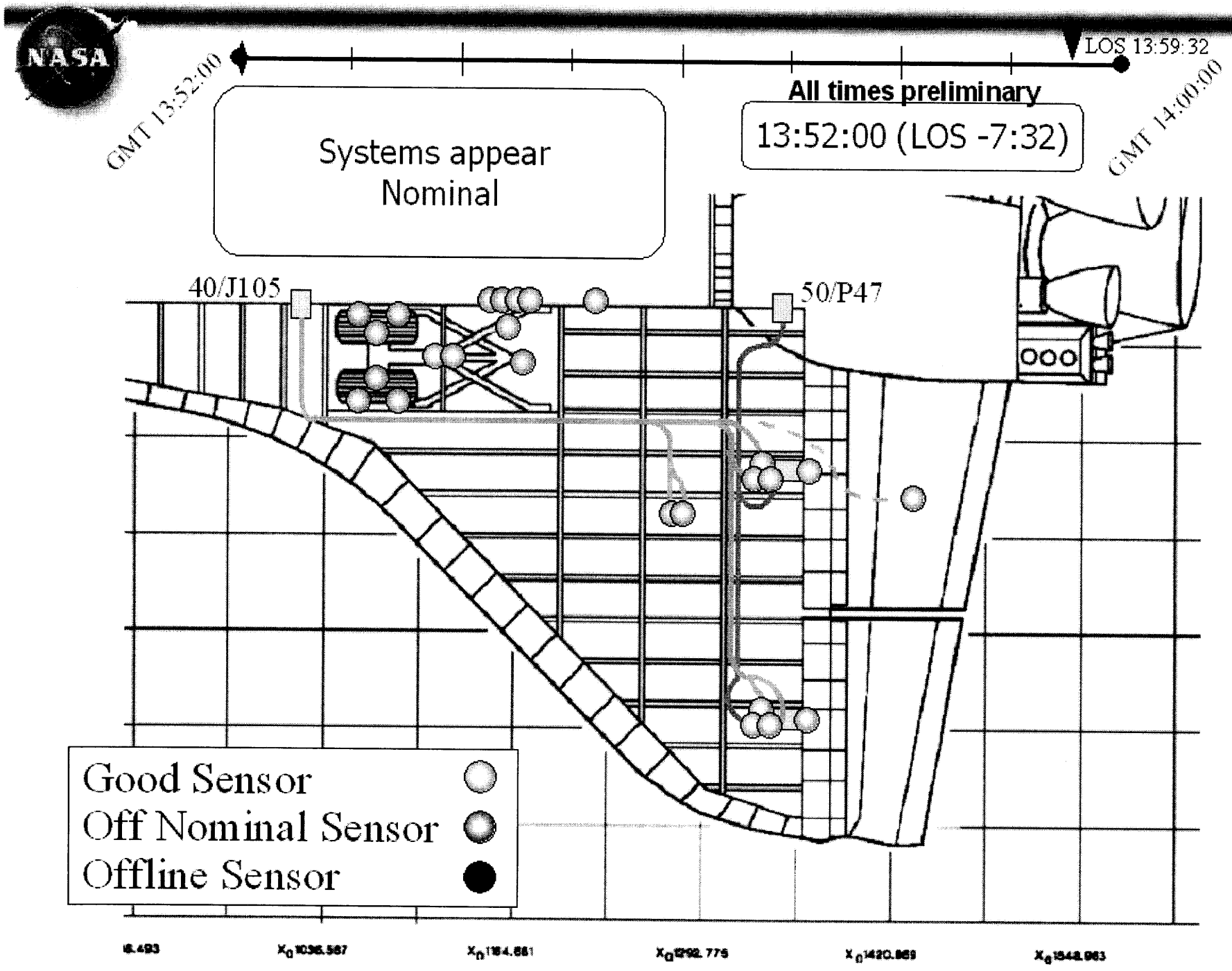
GMT 13:52:00

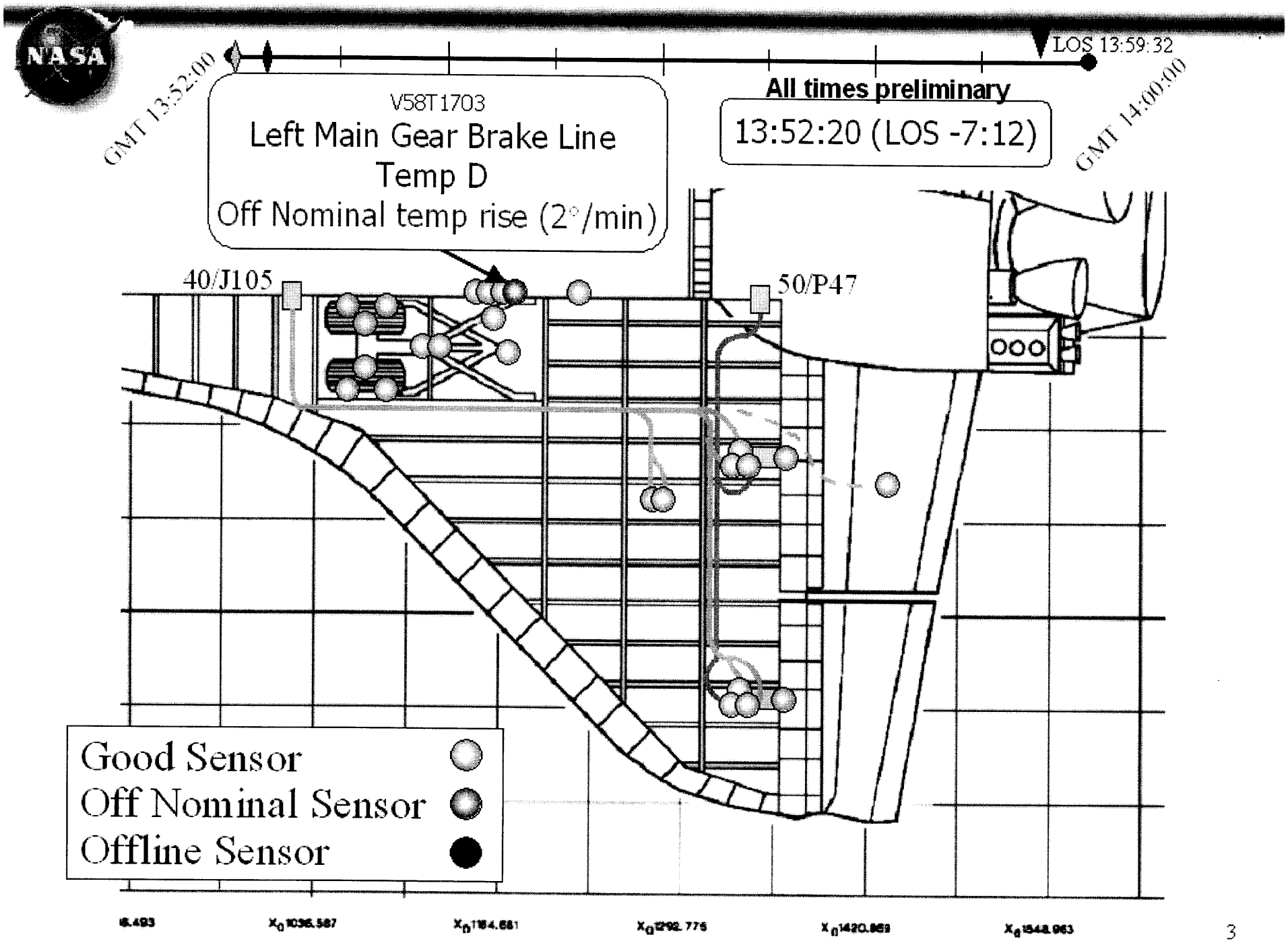
LOS 13:59:32

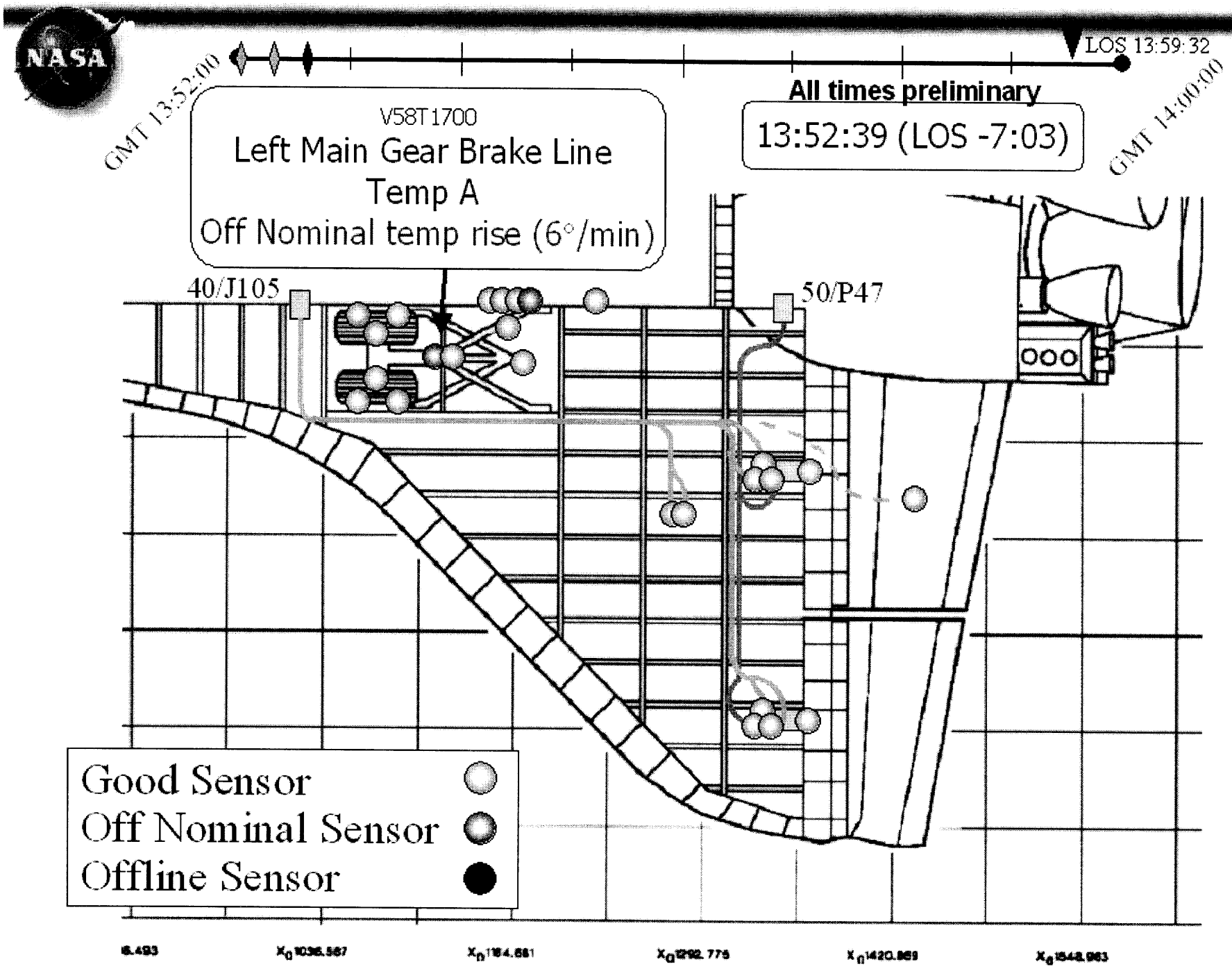
GMT 14:00:00

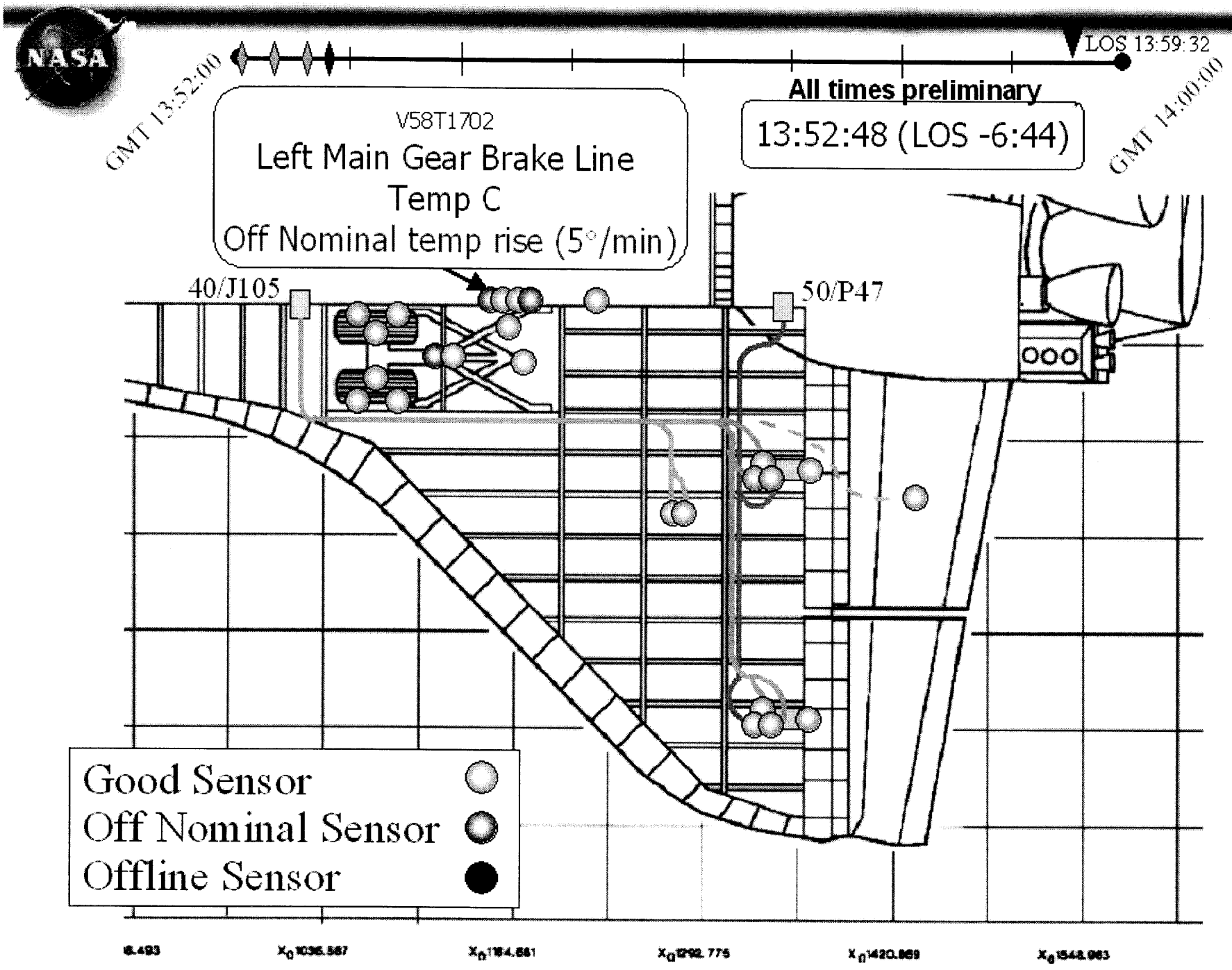
Shuttle X-Y Axis Plane

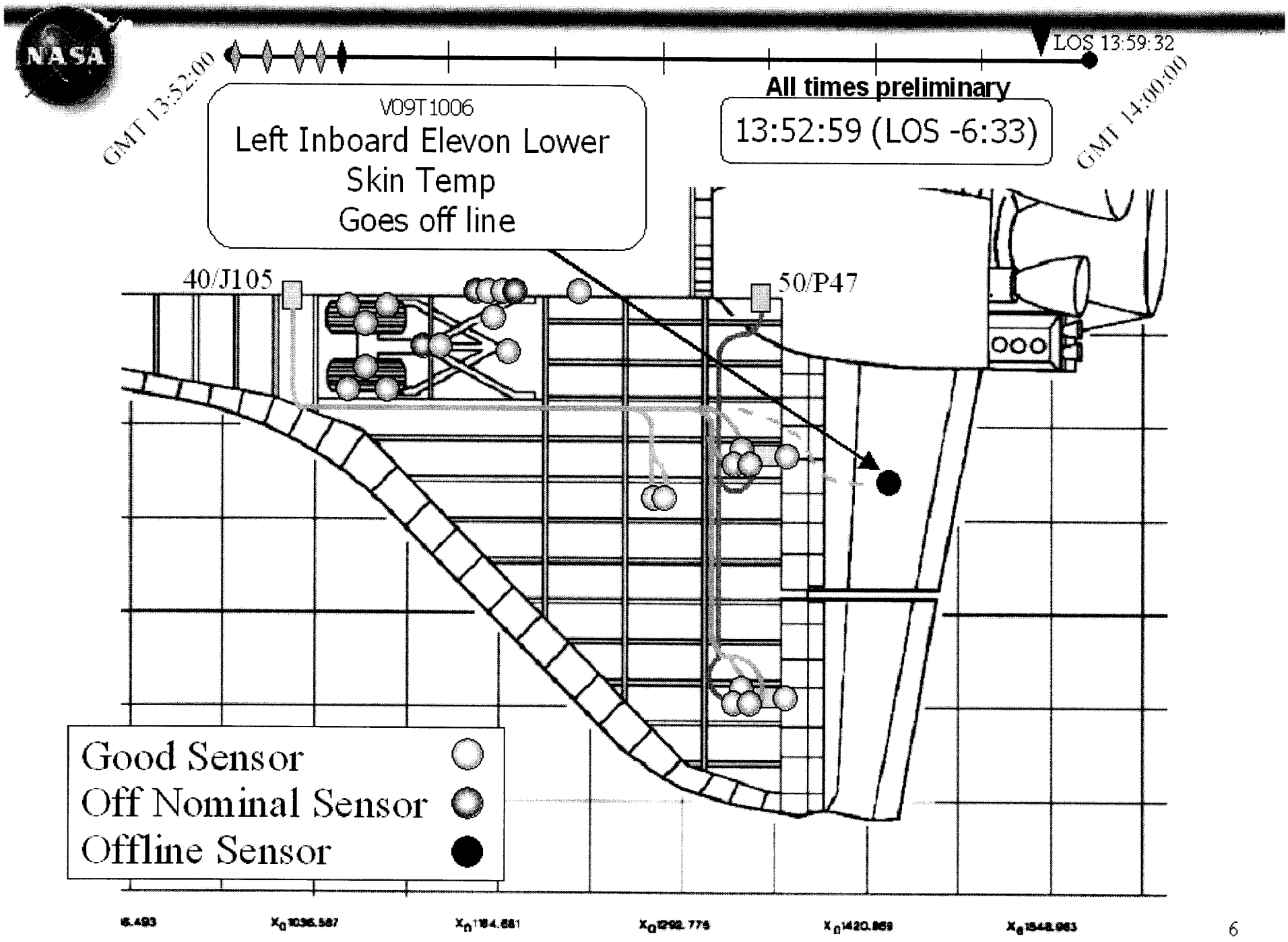


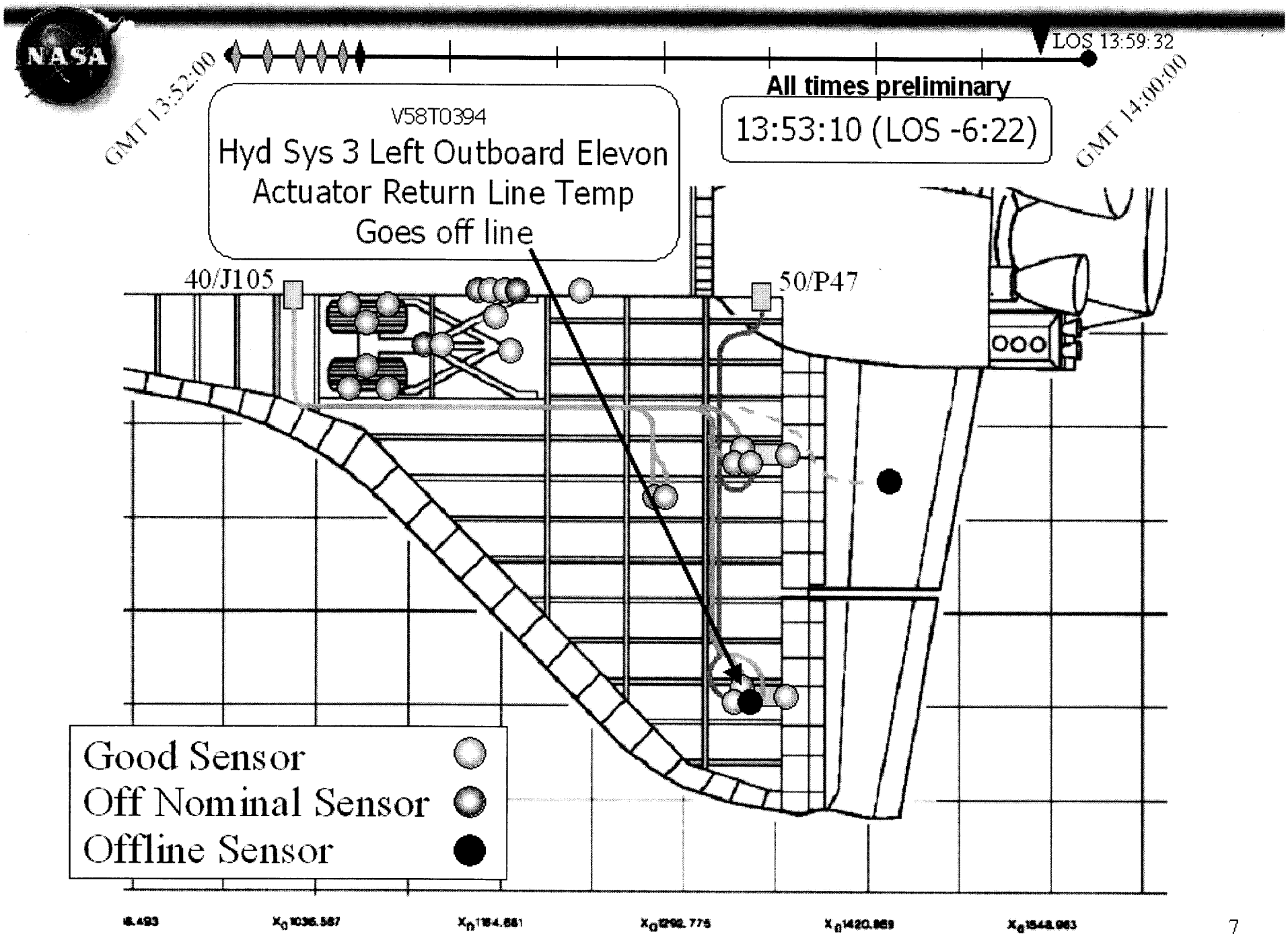

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:52:00 (LOS -7:32)
Systems appear Nominal
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

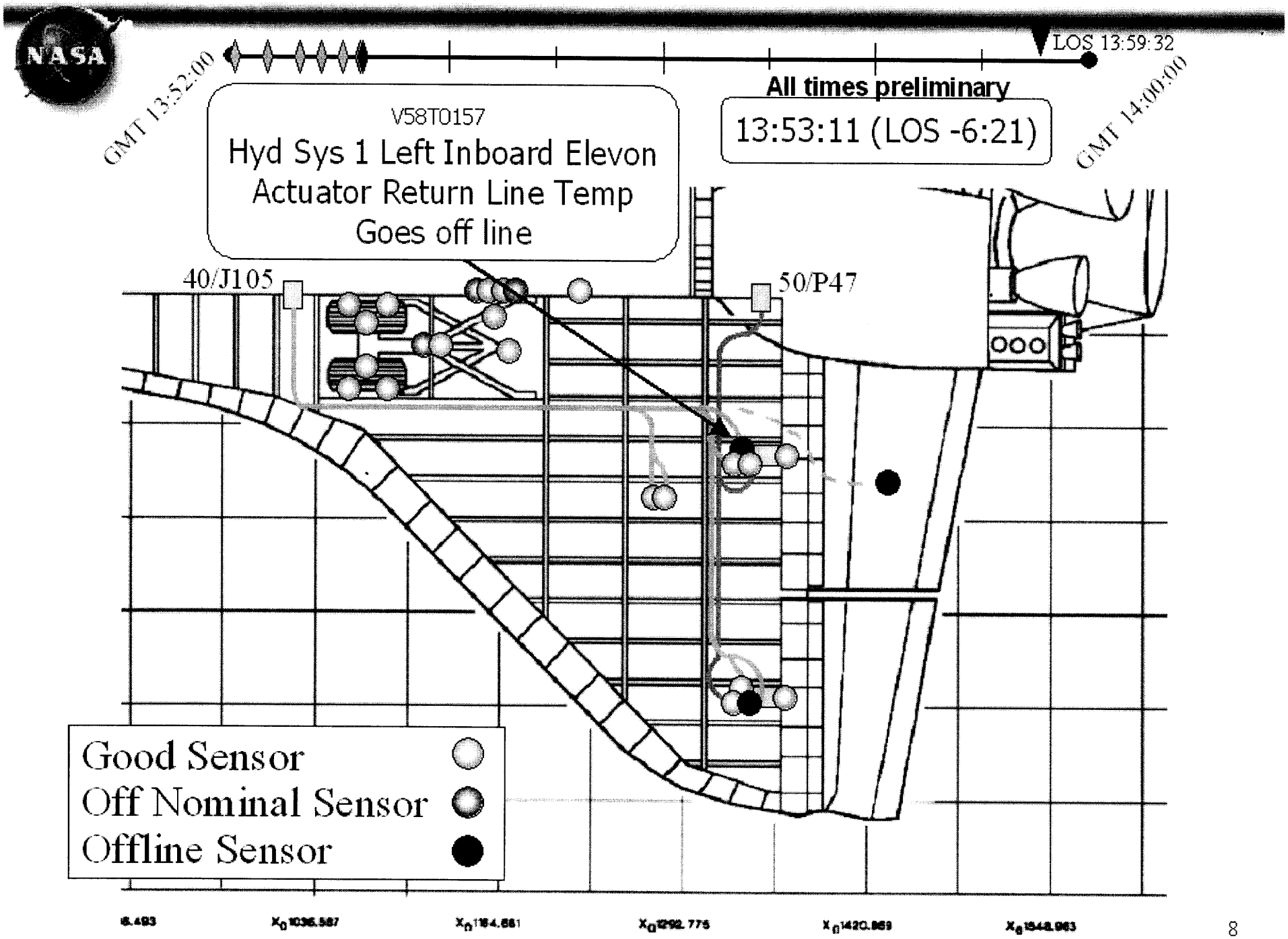

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:52:20 (LOS -7:12)
V58T1703
Left Main Gear Brake Line
Temp D
Off Nominal temp rise (2°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

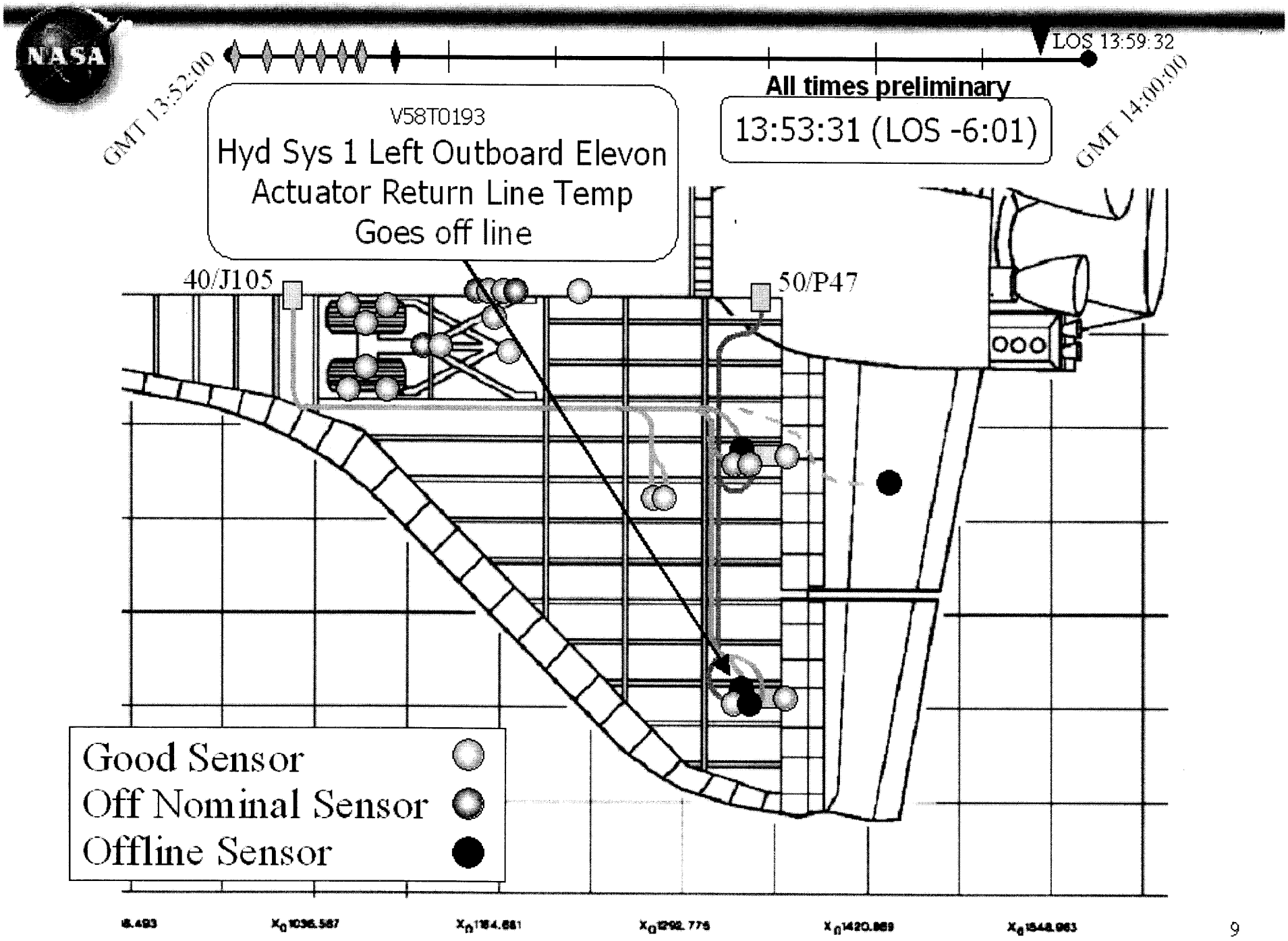

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:52:39 (LOS -7:03)
V58T1700
Left Main Gear Brake Line
Temp A
Off Nominal temp rise (6°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

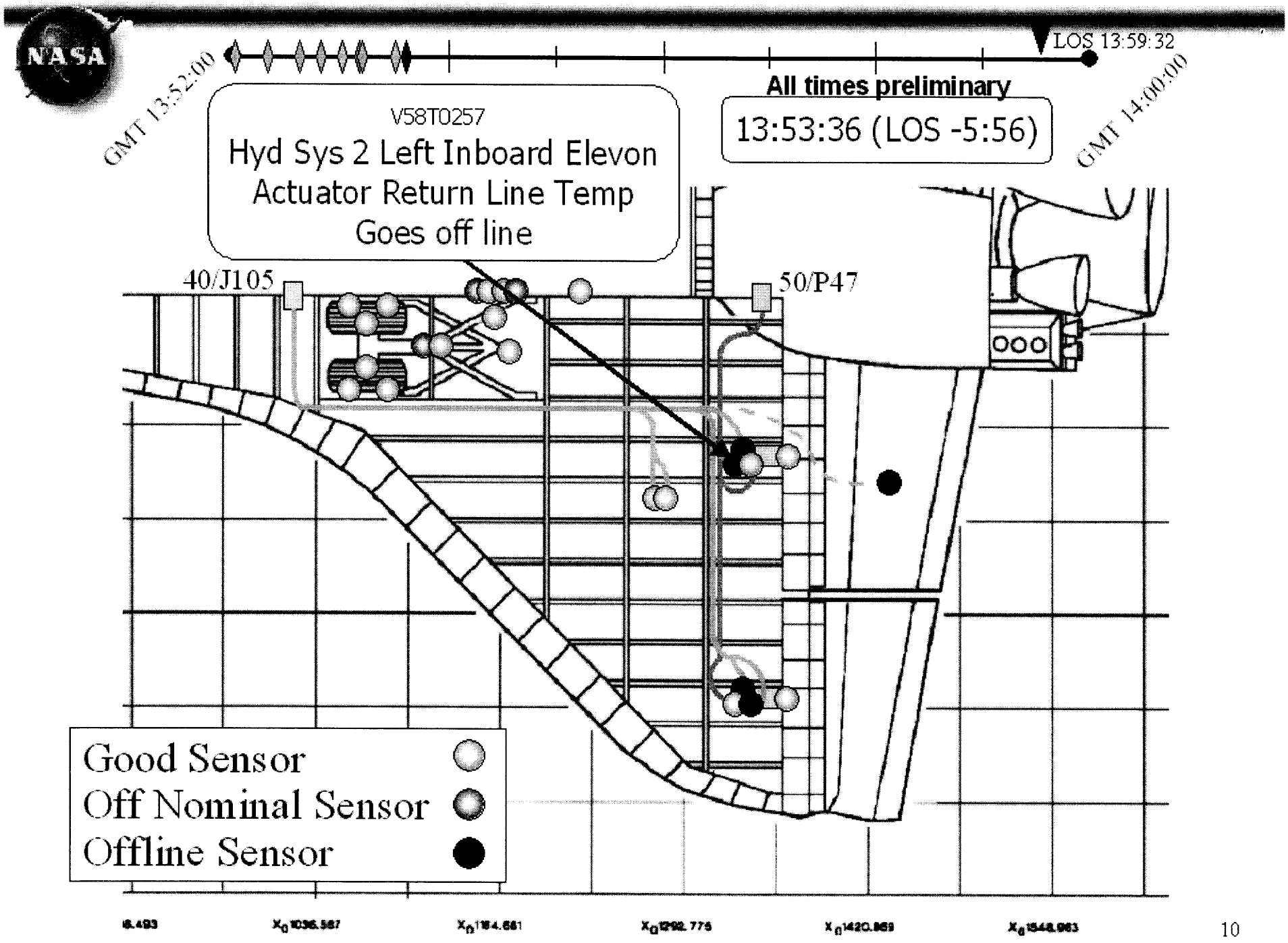

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:52:48 (LOS -6:44)
V58T1702
Left Main Gear Brake Line
Temp C
Off Nominal temp rise (5°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

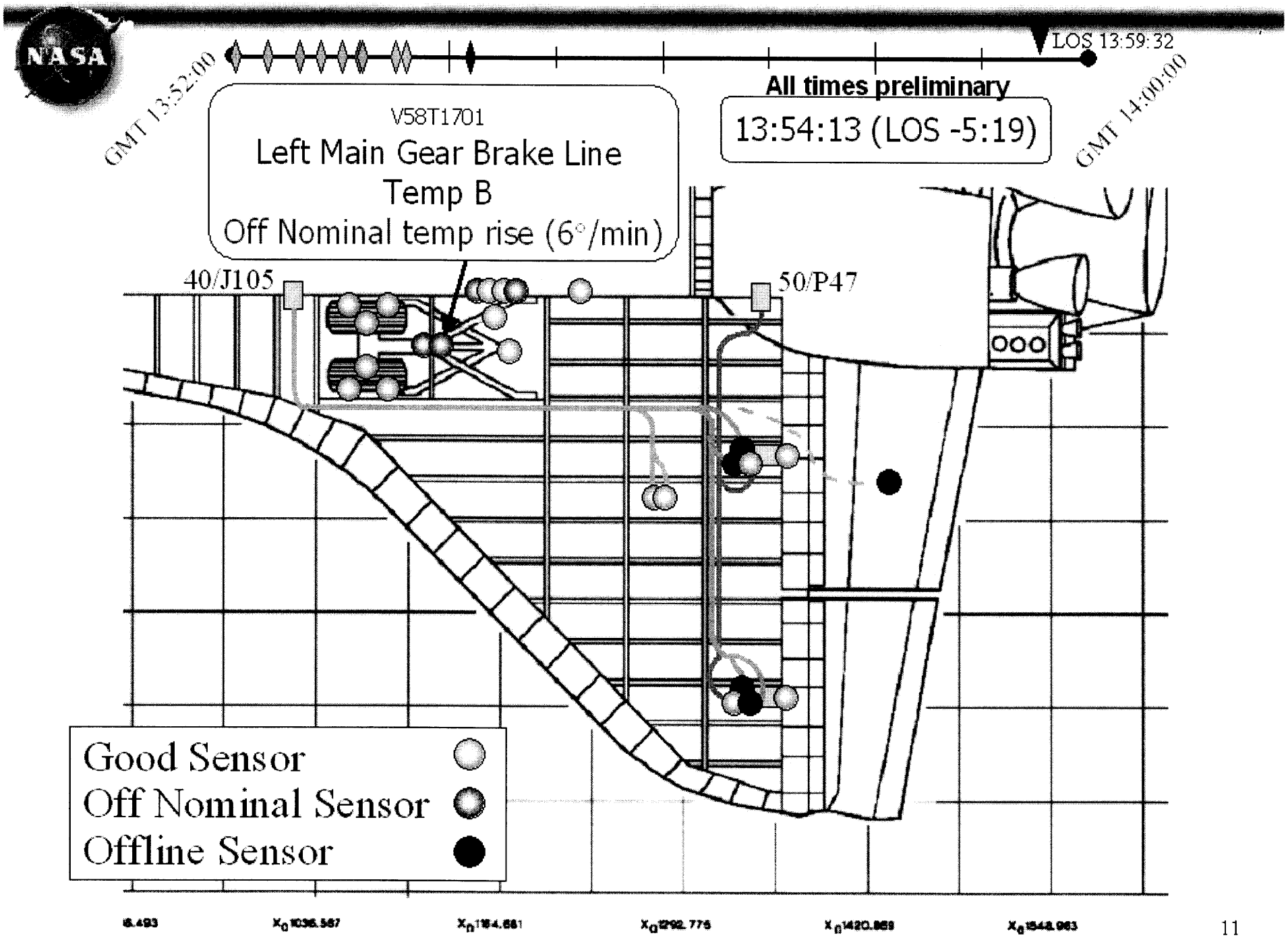

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:52:59 (LOS -6:33)
V09T1006
Left Inboard Elevon Lower
Skin Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

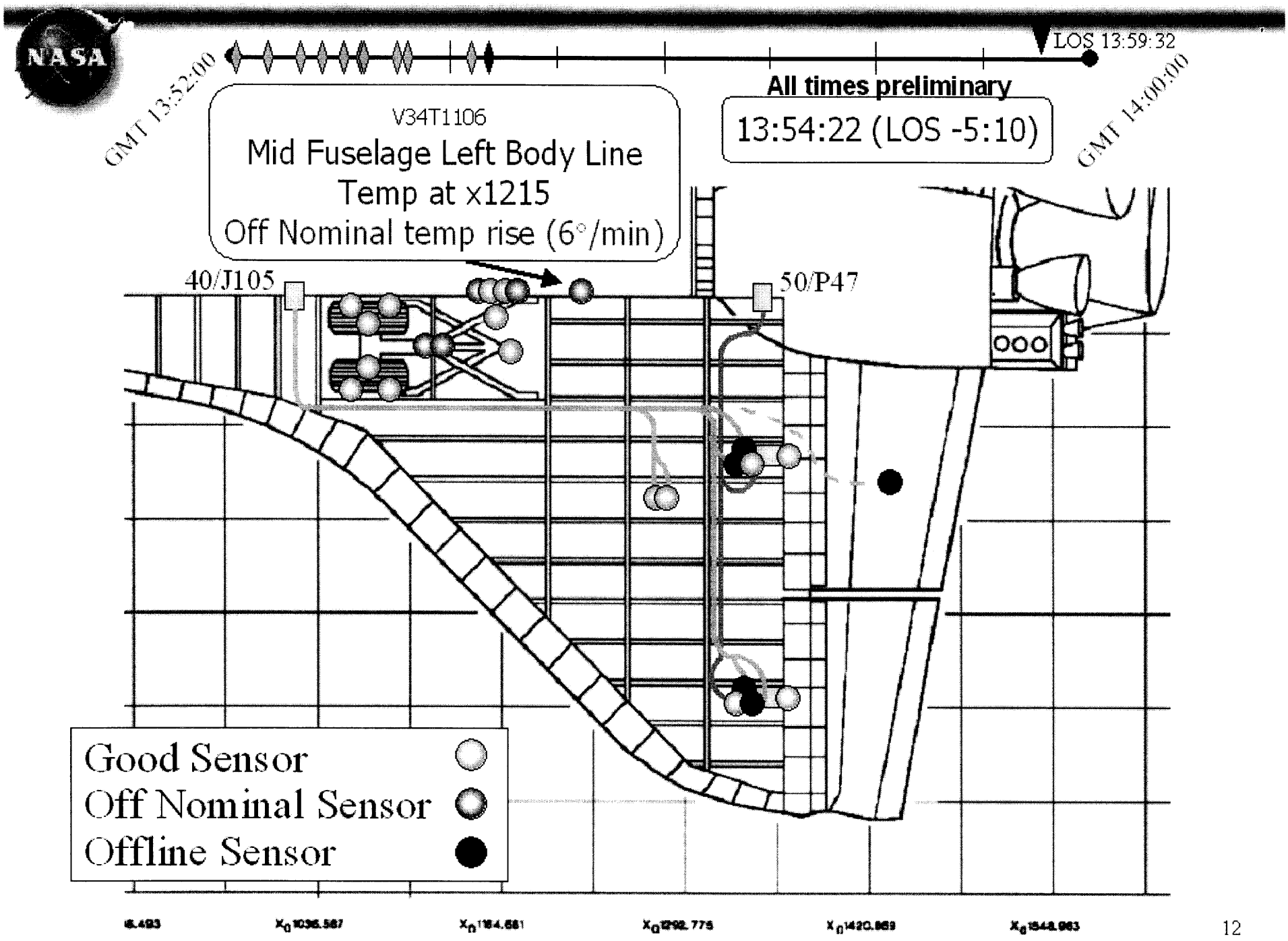

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:53:10 (LOS -6:22)
V58T0394
Hyd Sys 3 Left Outboard Elevon
Actuator Return Line Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

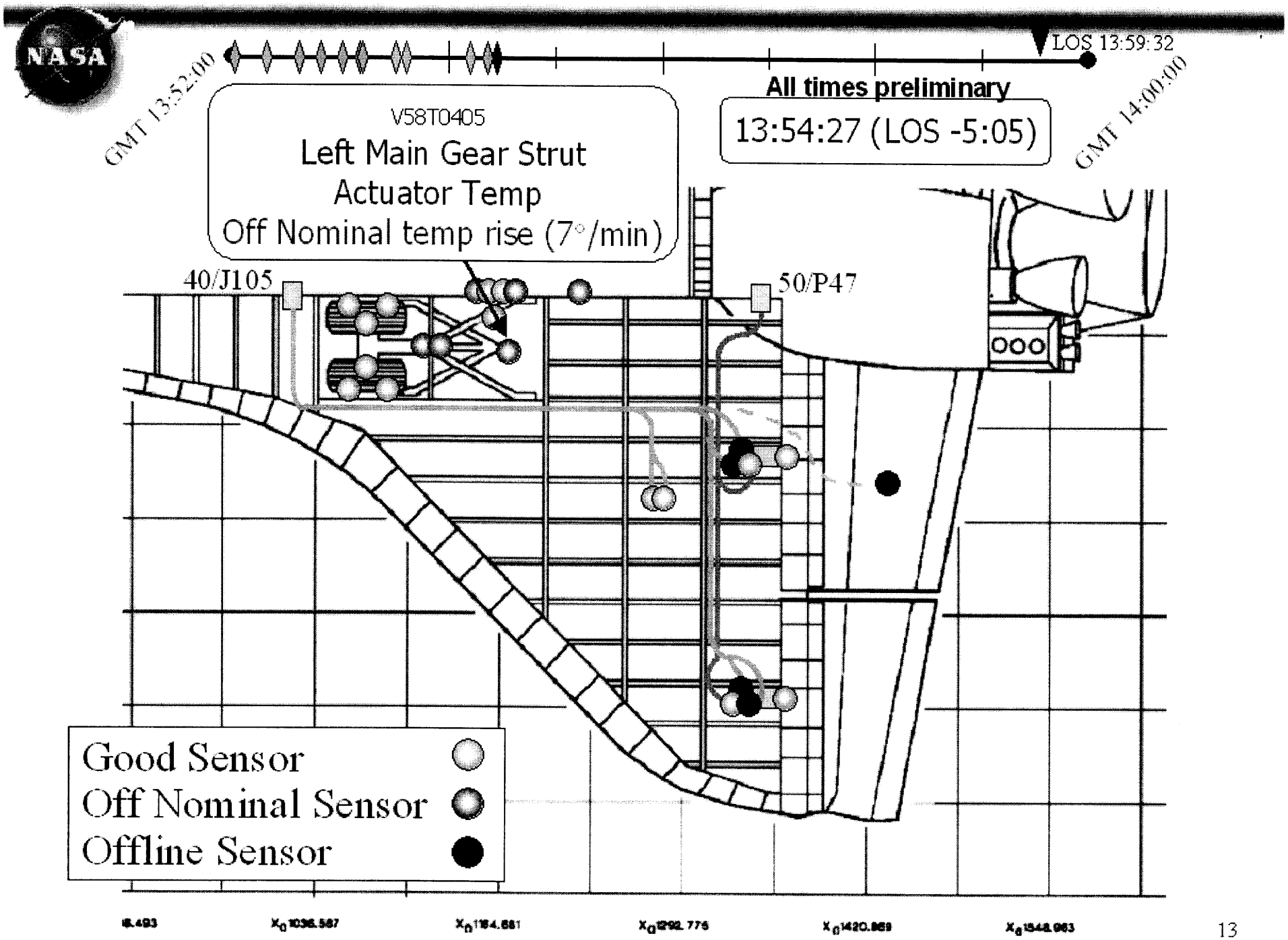

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:53:11 (LOS -6:21)
V58T0157
Hyd Sys 1 Left Inboard Elevon
Actuator Return Line Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

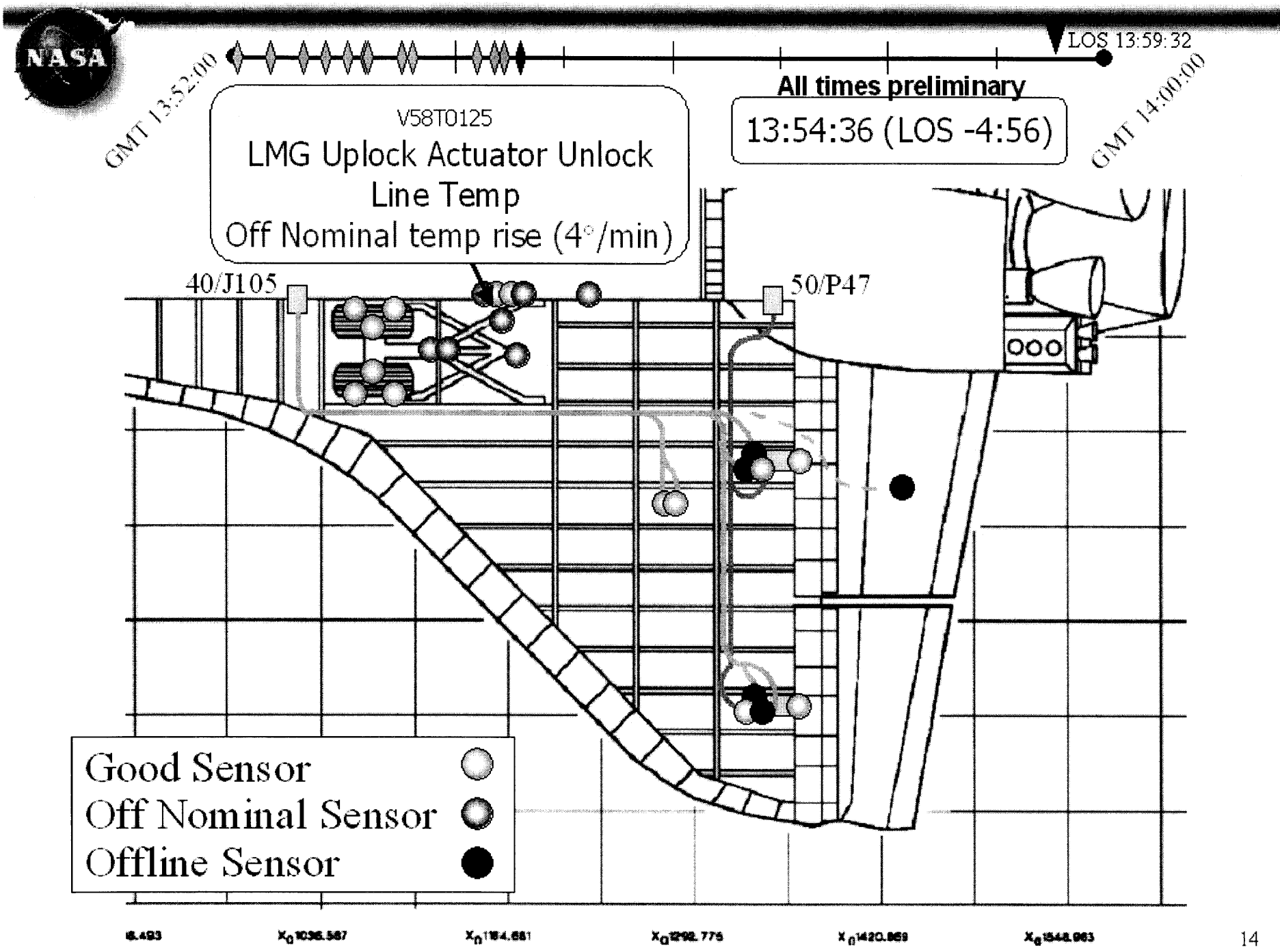

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:53:31 (LOS -6:01)
V58T0193
Hyd Sys 1 Left Outboard Elevon
Actuator Return Line Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

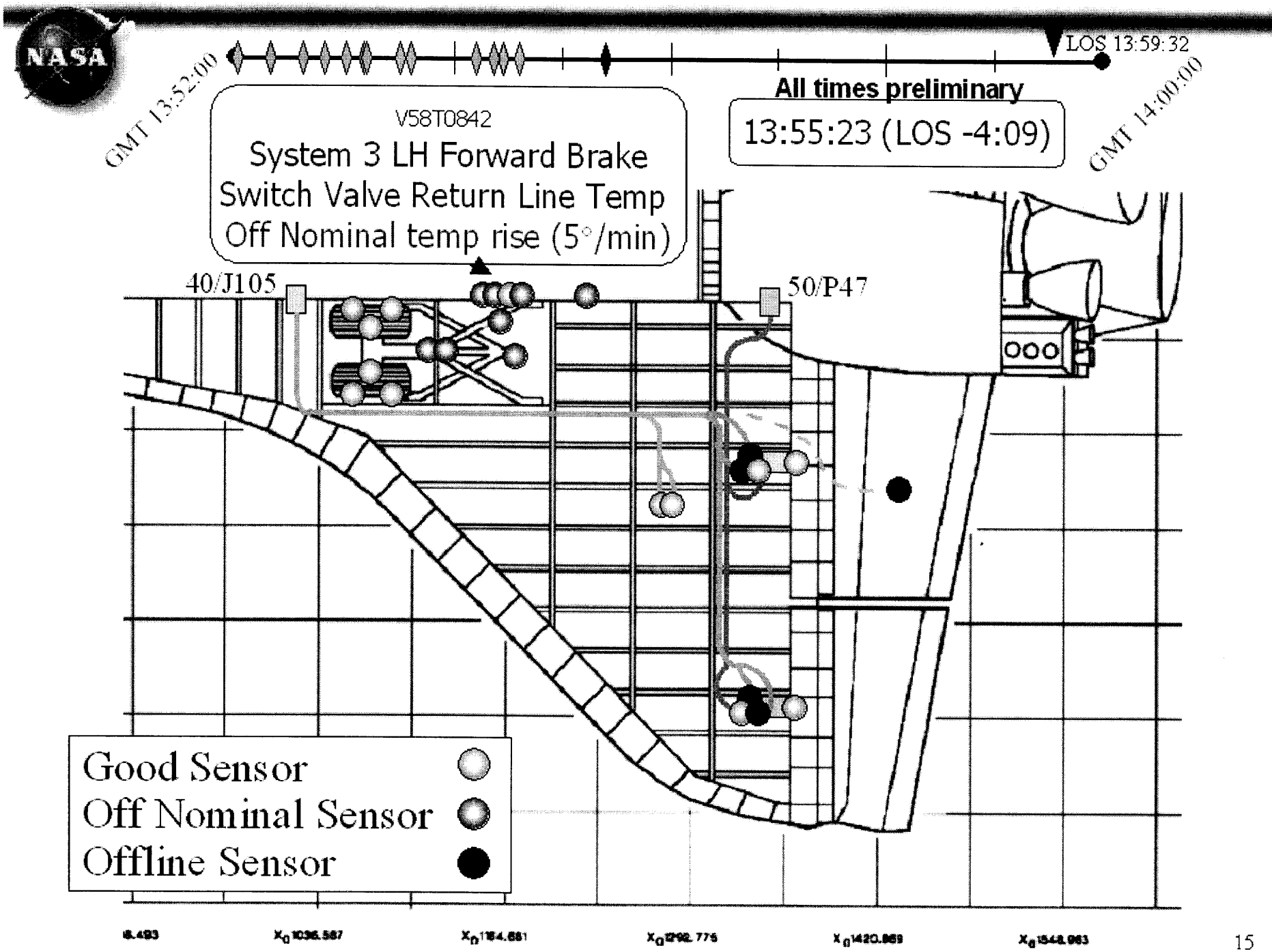

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:53:36 (LOS -5:56)
V58T0257
Hyd Sys 2 Left Inboard Elevon
Actuator Return Line Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

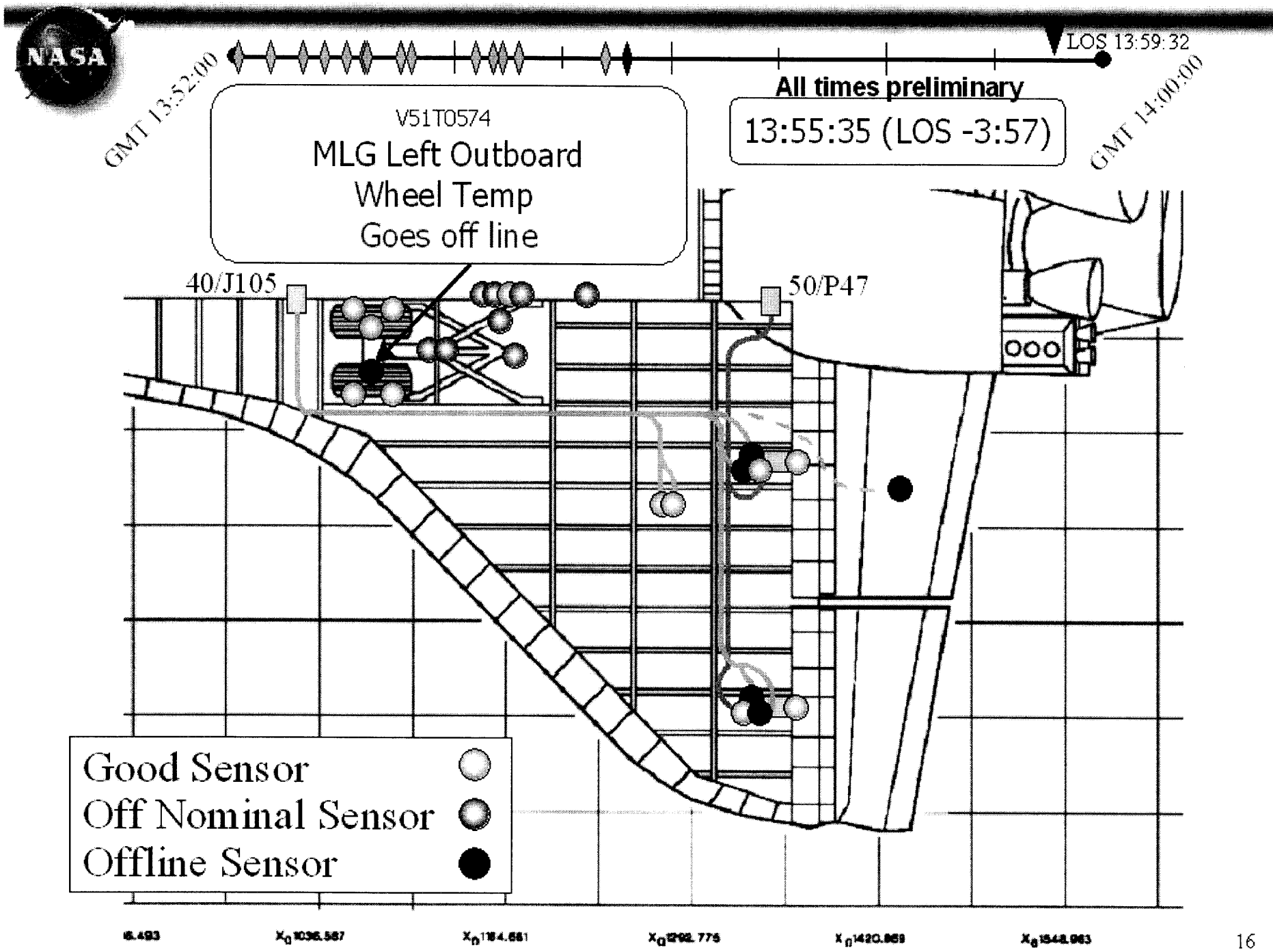

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:54:13 (LOS -5:19)
V58T1701
Left Main Gear Brake Line
Temp B
Off Nominal temp rise (6°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

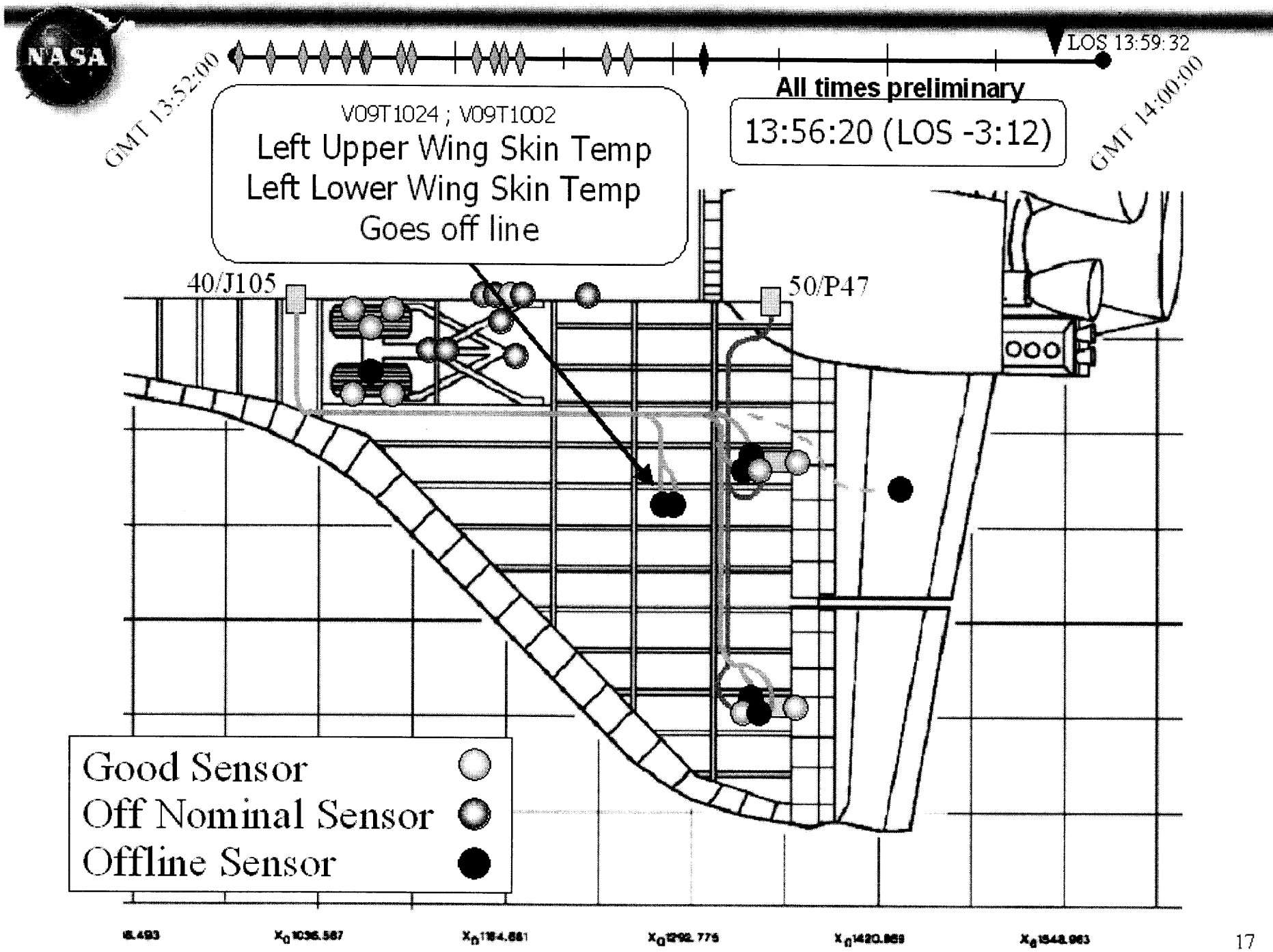

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:54:22 (LOS -5:10)
V34T1106
Mid Fuselage Left Body Line
Temp at x1215
Off Nominal temp rise (6°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

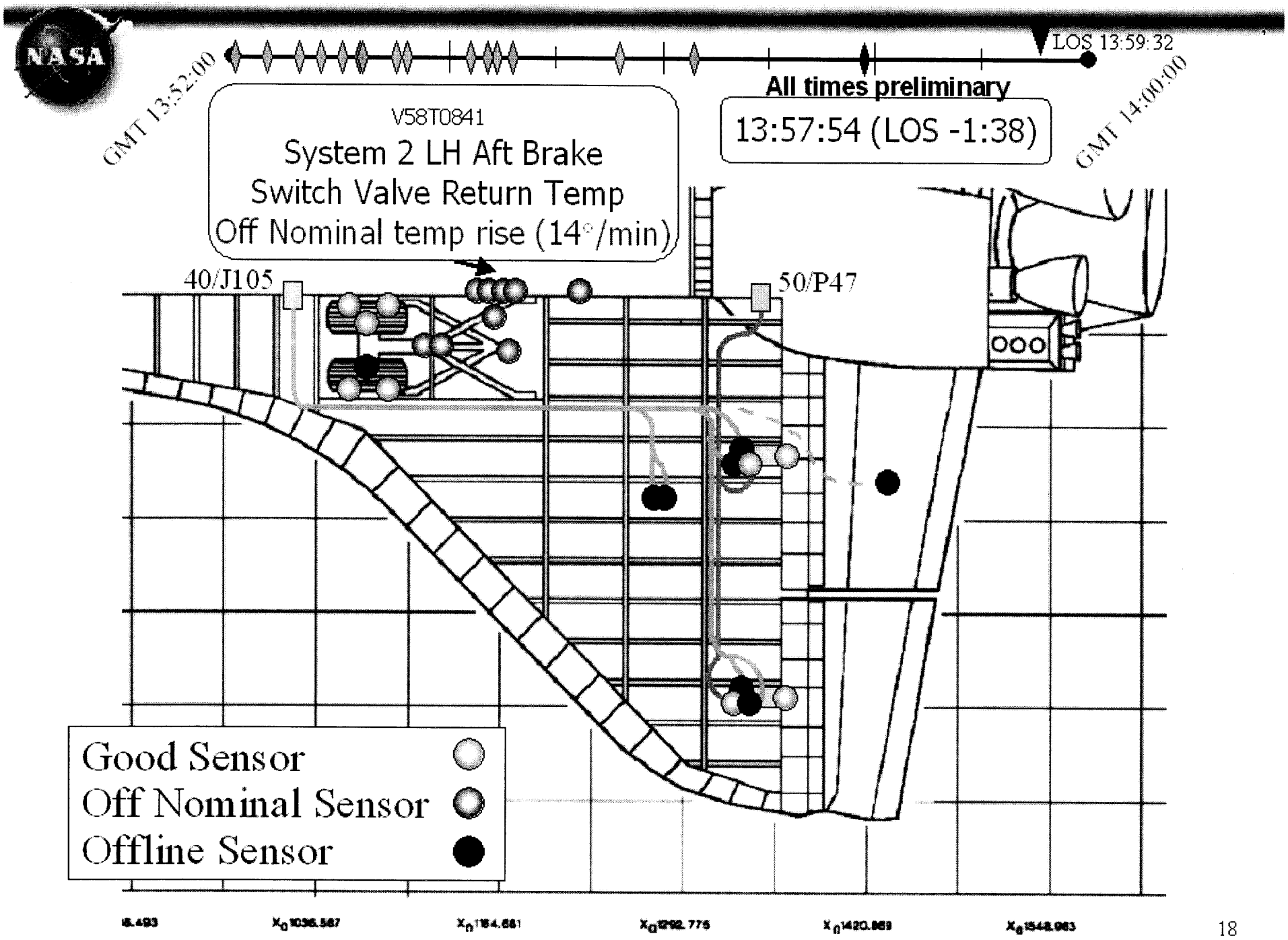

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:54:27 (LOS -5:05)
V58T0405
Left Main Gear Strut
Actuator Temp
Off Nominal temp rise (7°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

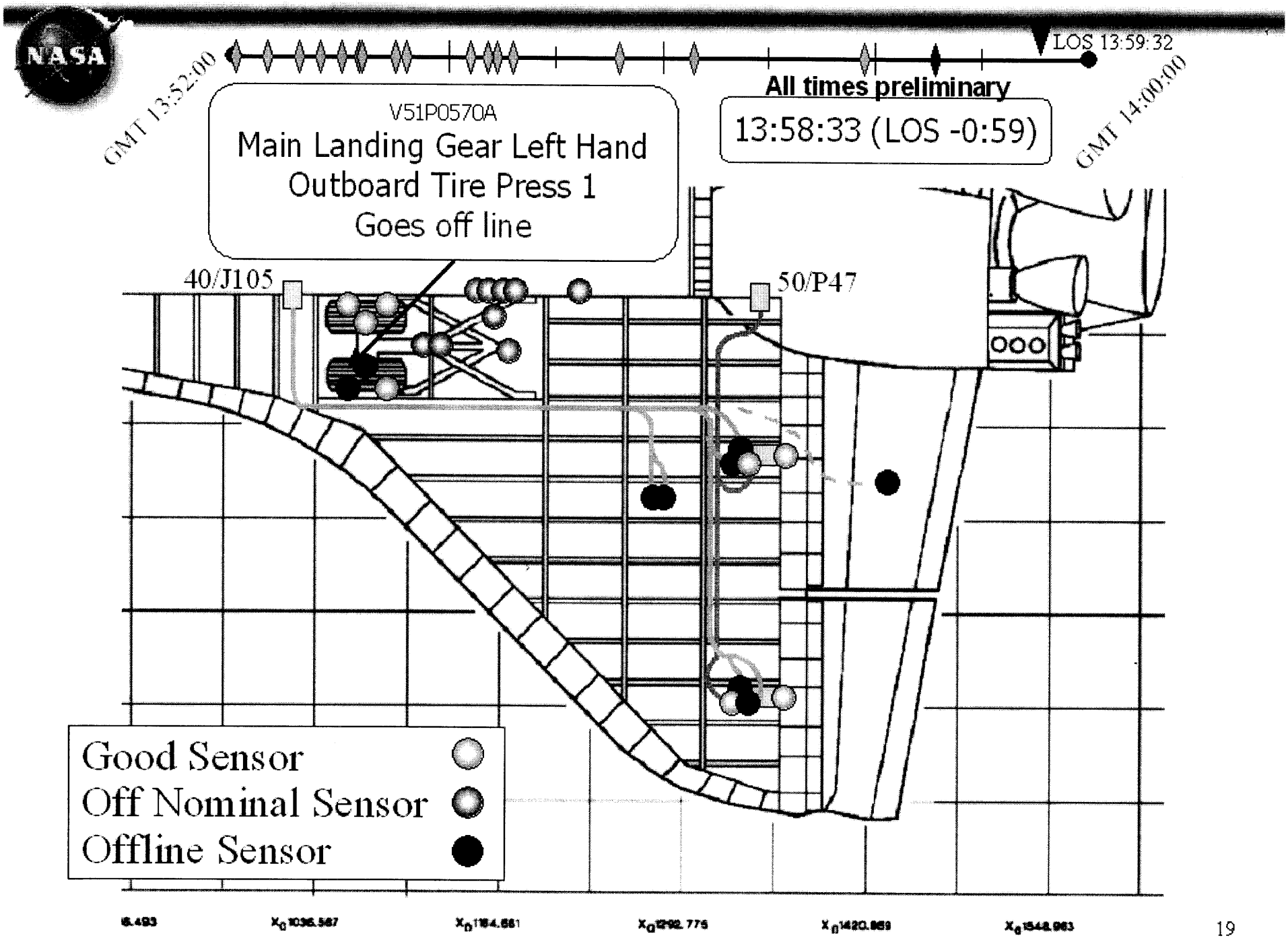

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:54:36 (LOS -4:56)
V58T0125
LMG Uplock Actuator Unlock Line Temp
Off Nominal temp rise (4°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

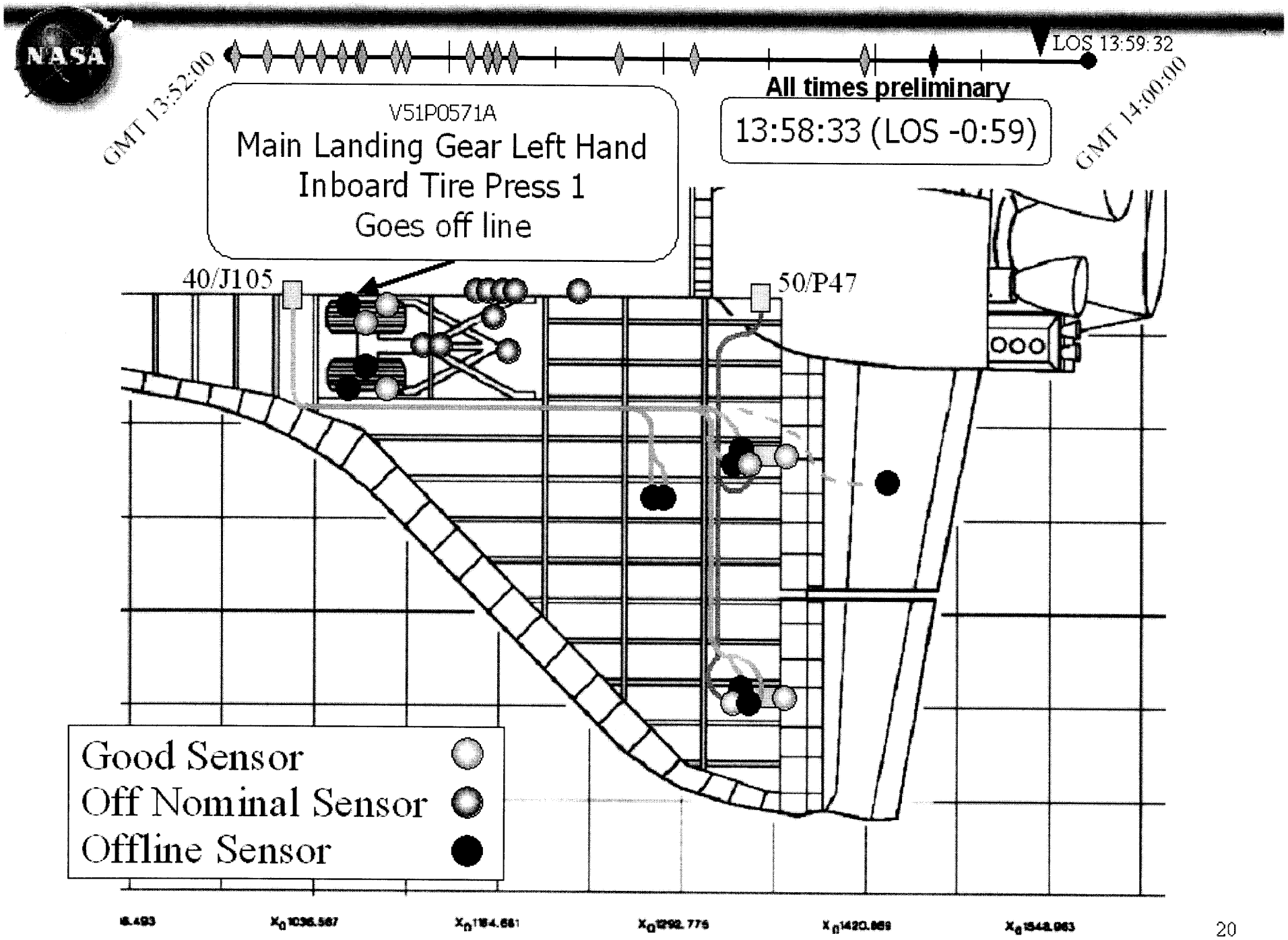

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:55:23 (LOS -4:09)
V58T0842
System 3 LH Forward Brake
Switch Valve Return Line Temp
Off Nominal temp rise (5°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

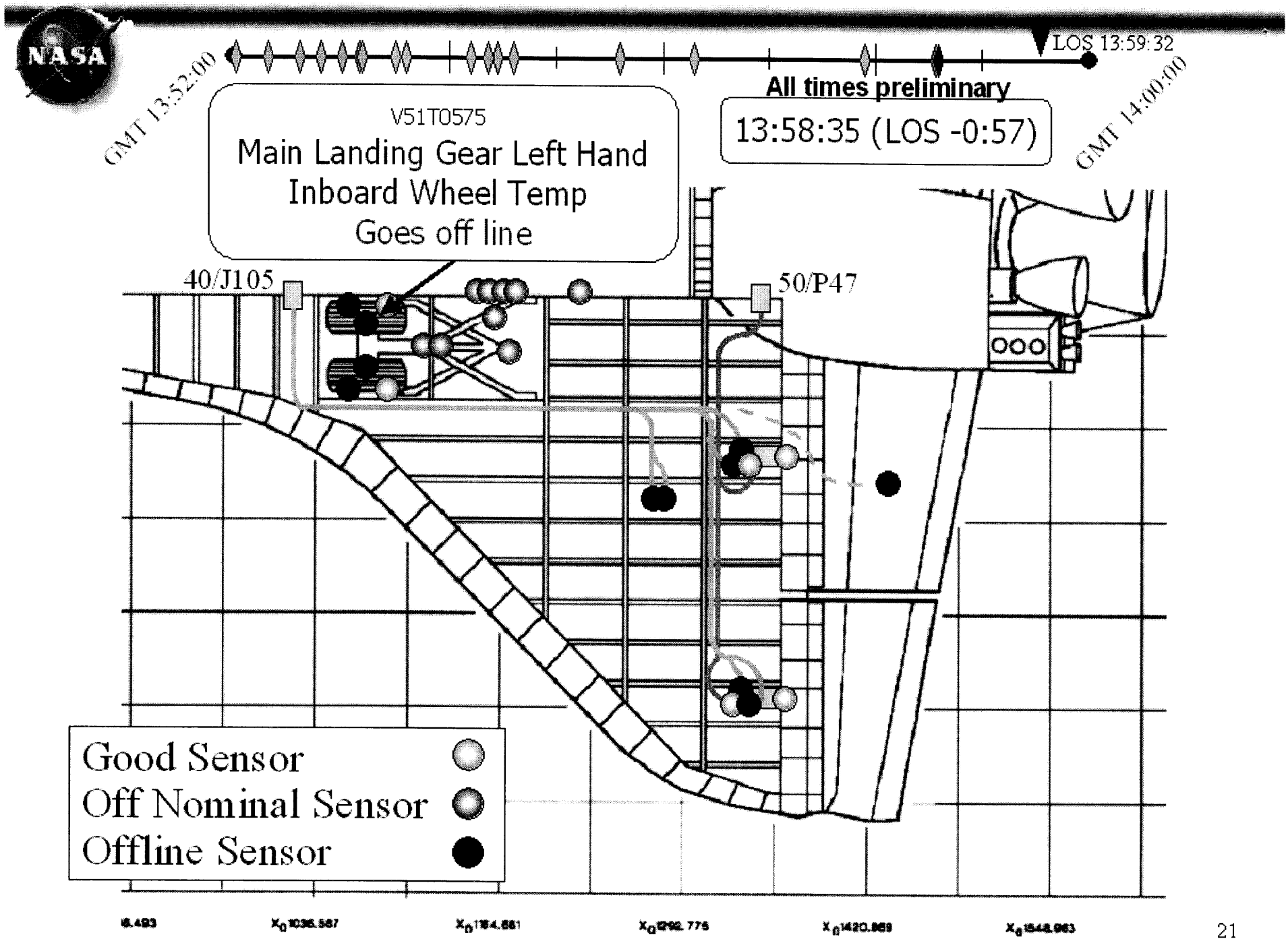

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:55:35 (LOS -3:57)
V51T0574
MLG Left Outboard
Wheel Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

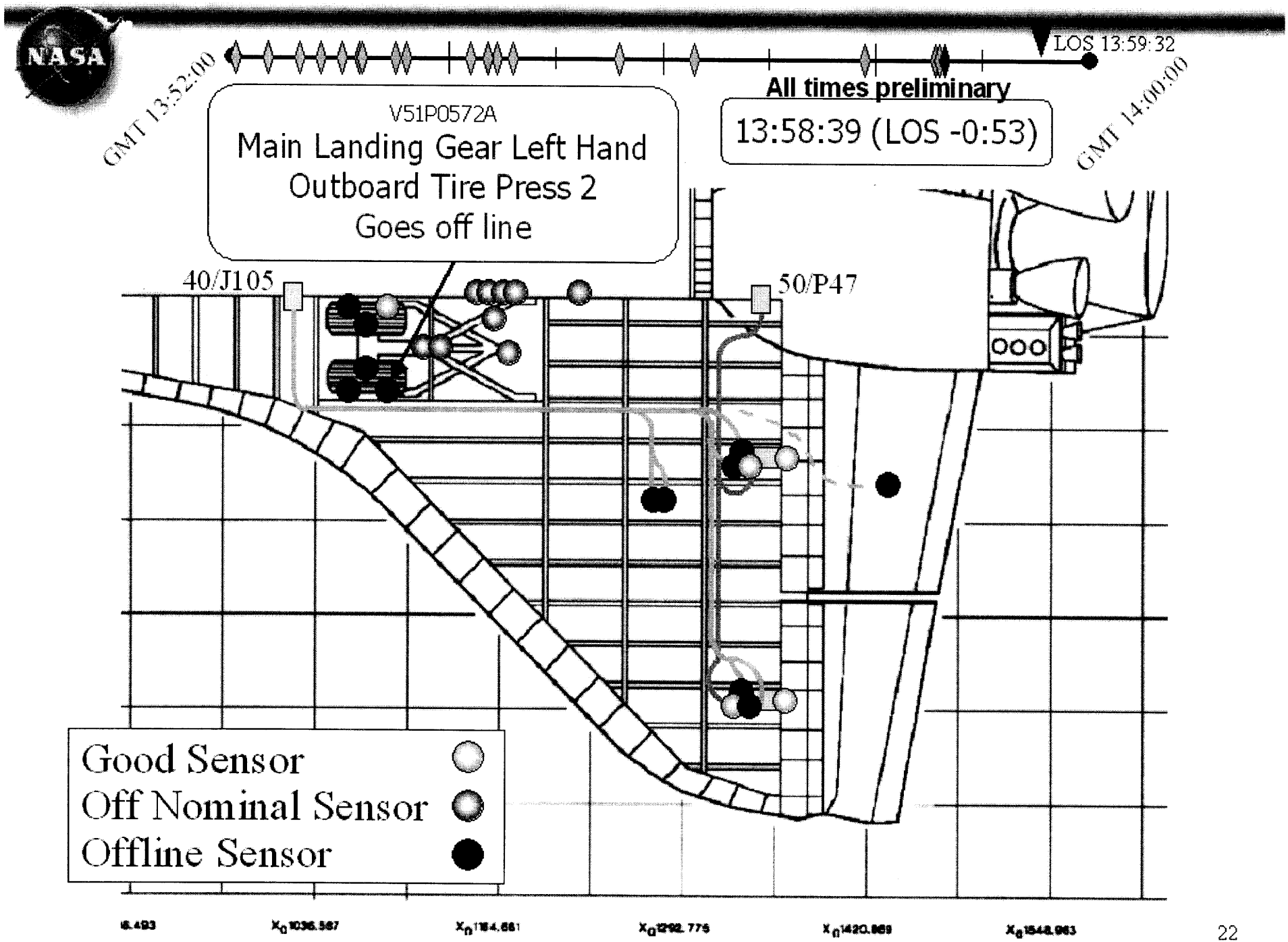

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:56:20 (LOS -3:12)
V09T1024 ; V09T1002
Left Upper Wing Skin Temp
Left Lower Wing Skin Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

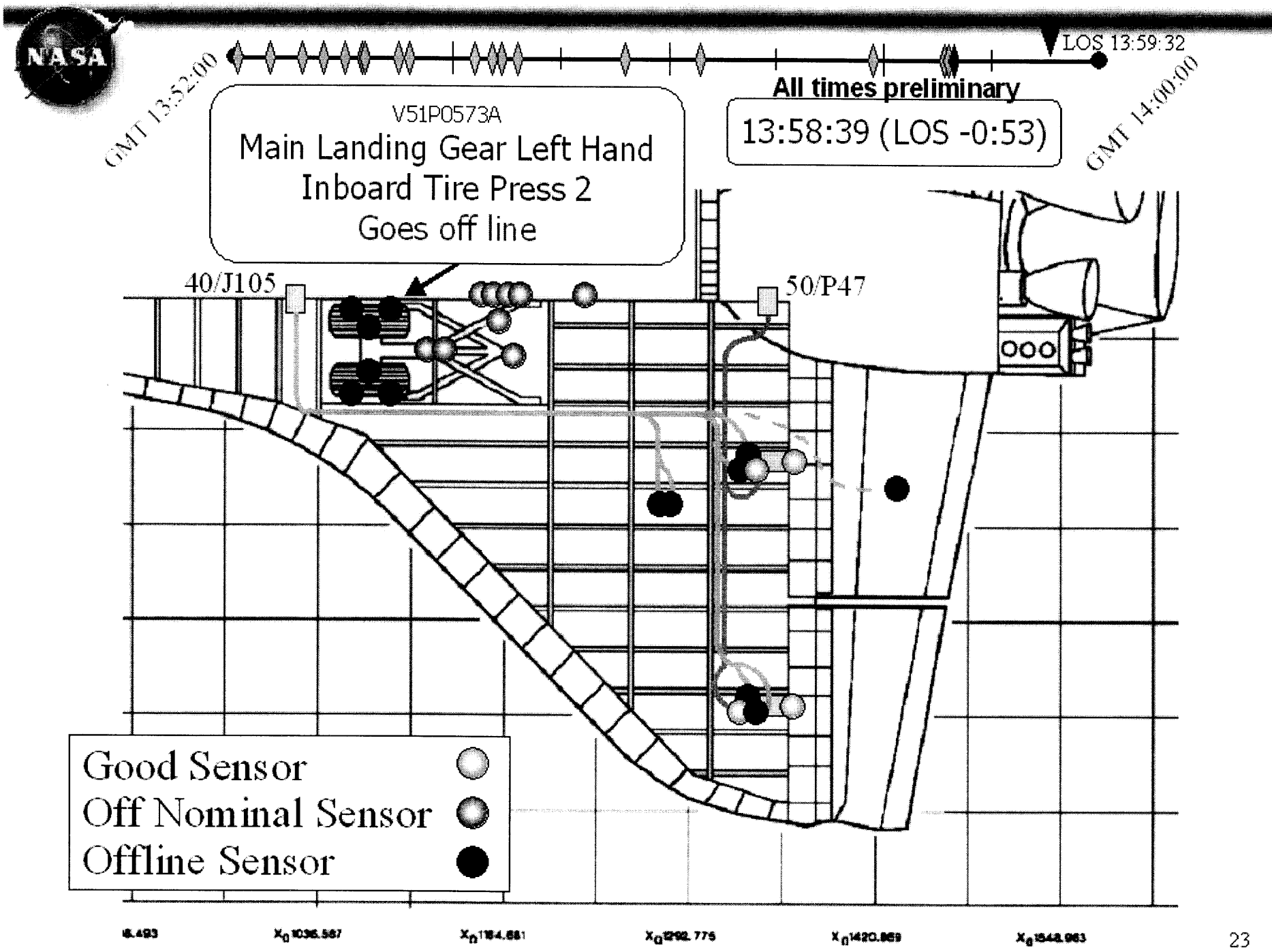

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:57:54 (LOS -1:38)
V58T0841
System 2 LH Aft Brake
Switch Valve Return Temp
Off Nominal temp rise (14°/min)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

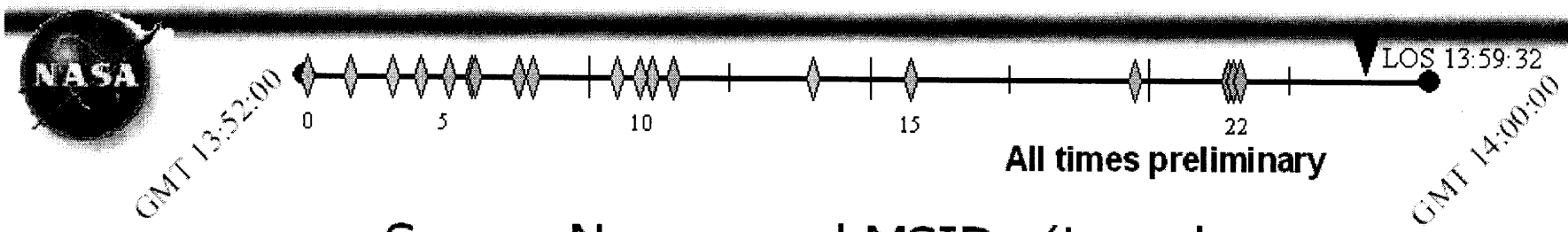

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
V51P0570A
Main Landing Gear Left Hand
Outboard Tire Press 1
Goes off line
13:58:33 (LOS -0:59)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor


GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
V51P0571A
Main Landing Gear Left Hand
Inboard Tire Press 1
Goes off line
13:58:33 (LOS -0:59)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor


GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:58:35 (LOS -0:57)
V51T0575
Main Landing Gear Left Hand
Inboard Wheel Temp
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor

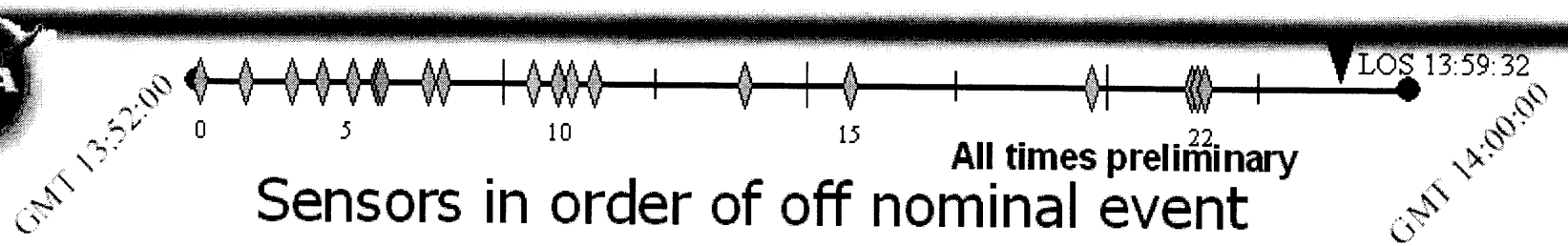

GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
V51P0572A
Main Landing Gear Left Hand
Outboard Tire Press 2
Goes off line
13:58:39 (LOS -0:53)
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor


GMT 13:52:00
LOS 13:59:32
GMT 14:00:00
All times preliminary
13:58:39 (LOS -0:53)
V51P0573A
Main Landing Gear Left Hand
Inboard Tire Press 2
Goes off line
40/J105
50/P47
Good Sensor
Off Nominal Sensor
Offline Sensor



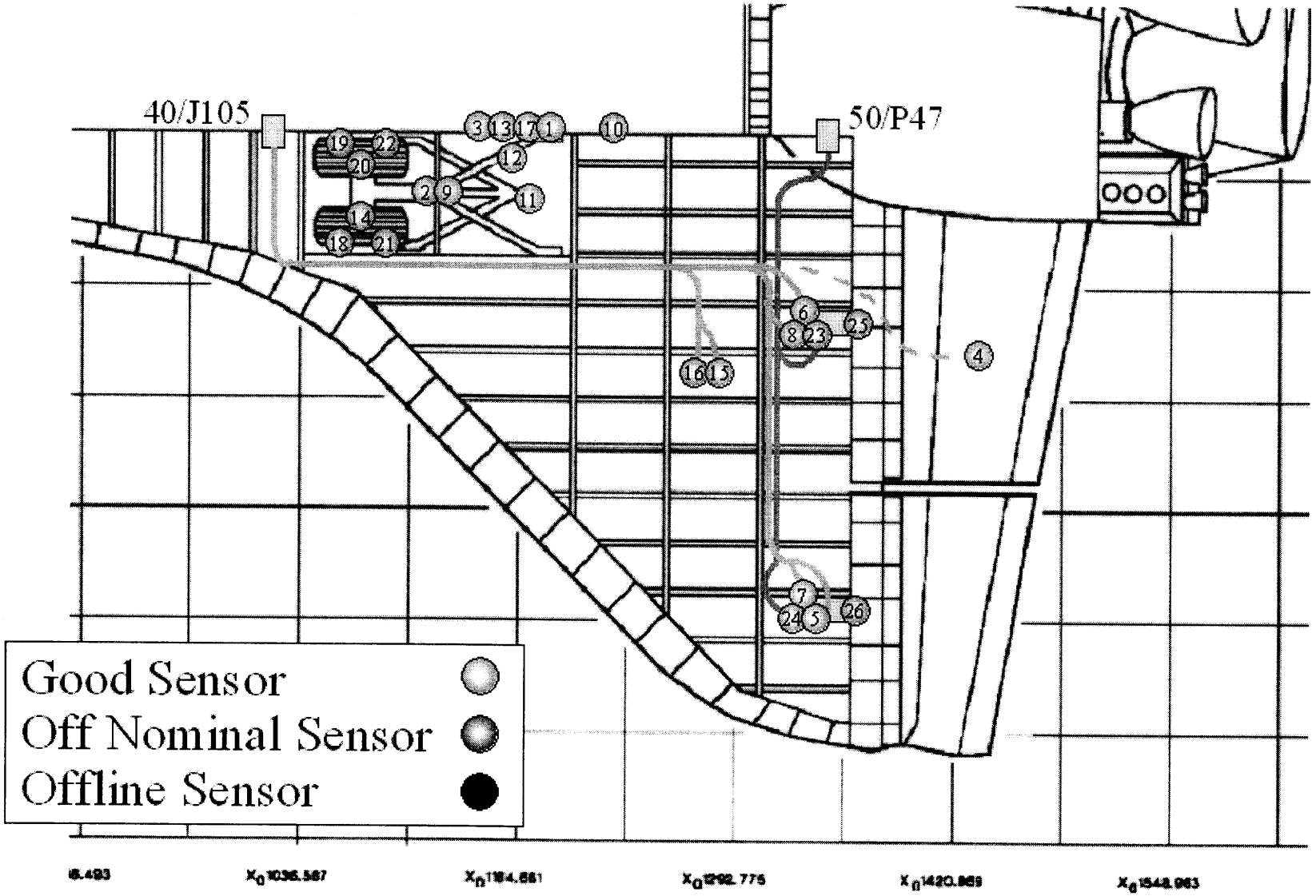
Sensor Names and MSIDs (in order of off nominal event)

No.	Measurement Nomenclature	MSID	No.	Measurement Nomenclature	MSID
1	LMG Brake Line Temp D	V58T1703A	14	MLG LH Outbd Wheel Temp	V51T0574A
2	LMG Brake Line Temp A	V58T1700A	15	LH UPR Wing Skin Temp	V09T1024
3	LMG Brake Line Temp C	V58T1702A	16	LH LWR Wing Skin Temp	V09T1002
4	LH Inbd Elev LWR Skin Temp	V09T1006	17	Hyd 2 LH Aft Brake Sw Vlv Rtn Ln T	V58T0841A
5	Hyd Sys 3 LOE Rtn Ln T	V58T0394A	18	MLG LH Outbd Tire Press 1	V51P0570A
6	Hyd 1 LH Inbd Elvn Actr Rtn Ln T	V58T0157A	19	MLG LH Inbd Tire Press 1	V51P0571A
7	Hyd Sys 1 LOE Rtn Ln T	V58T0193A	20	MLG LH Inbd Wheel Temp	V51T0575A
8	Hyd 2 LH Inbd Elvn Actr Rtn Ln T	V58T0257A	21	MLG LH Outbd Tire Press 2	V51P0572A
9	LMG Brake Line Temp B	V58T1701A	22	MLG LH Inbd Tire Press 2	V51P0573A
10	M-Fus Lt BL Temp at 1215	V34T1106	23	Hyd Sys 3 LH Inbd Elvn Rtn Ln Temp	V58T0833A
11	L Main Gear Strut Actuator Temp	V58T0405A	24	Hyd Sys 2 LH Otbd Elvn Rtn Ln Temp	V58T0883A
12	Hyd Sys 1 LMG Uplk Actr Unlk Ln T	V58T0125A	25	Hydr Sys LH Inbd Elvn Actr Temp	V58T0830A
13	Hyd 3 LH Fwd Brake Sw Vlv Rtn Ln T	V58T0842A	26	Hydr Sys LH Outbd Elvn Actr Temp	V58T0880A



All times preliminary

Sensors in order of off nominal event



Date: Wed, 12 Feb 2003 16:01:38 -0600
From: [redacted]
Subject: Main landing Gear
To: r.h.daugherty@larc.nasa.gov
X-Mailer: Microsoft Outlook Express 6.00.2800.1106

Information withheld under FOIA exemption (b)(6)

This is an educated observation of the high-definition military photo of the shuttle Columbia as it flew over an Air Force base in New Mexico on Feb 1:
In your investigations, please consider that the main landing gear under the left wing was somehow in the down position. At the angle at which the photo was taken, the tires of the landing gear would appear before the leading edge of the left wing. It is more likely that the two "bumps" on the front edge of the left wing were the two tires rather than damage. Damage would most likely appear as missing wing. The dark smoke behind the wing is probably smoke from the burning tires. The high temperatures near the left landing gear makes sense since the landing gear doors were open. It also makes since that signals were lost at other area of the wing, because the fire in the wheel well burned through the nearby control wires. This also explains the excessive drag on the left side. It was only a matter of time before the extra drag put the shuttle out of control.

Daugh. - 103

[redacted] 05:07 PM 2/12/2003, Fw: Main Landing Gear

Date: Wed, 12 Feb 2003 16:07:14 -0600
From: [redacted]
Subject: Fw: Main Landing Gear
To: r.h.daugherty@larc.nasa.gov
X-Mailer: Microsoft Outlook Express 6.00.2800.1106

Information withheld under FOIA exemption (b)(6)

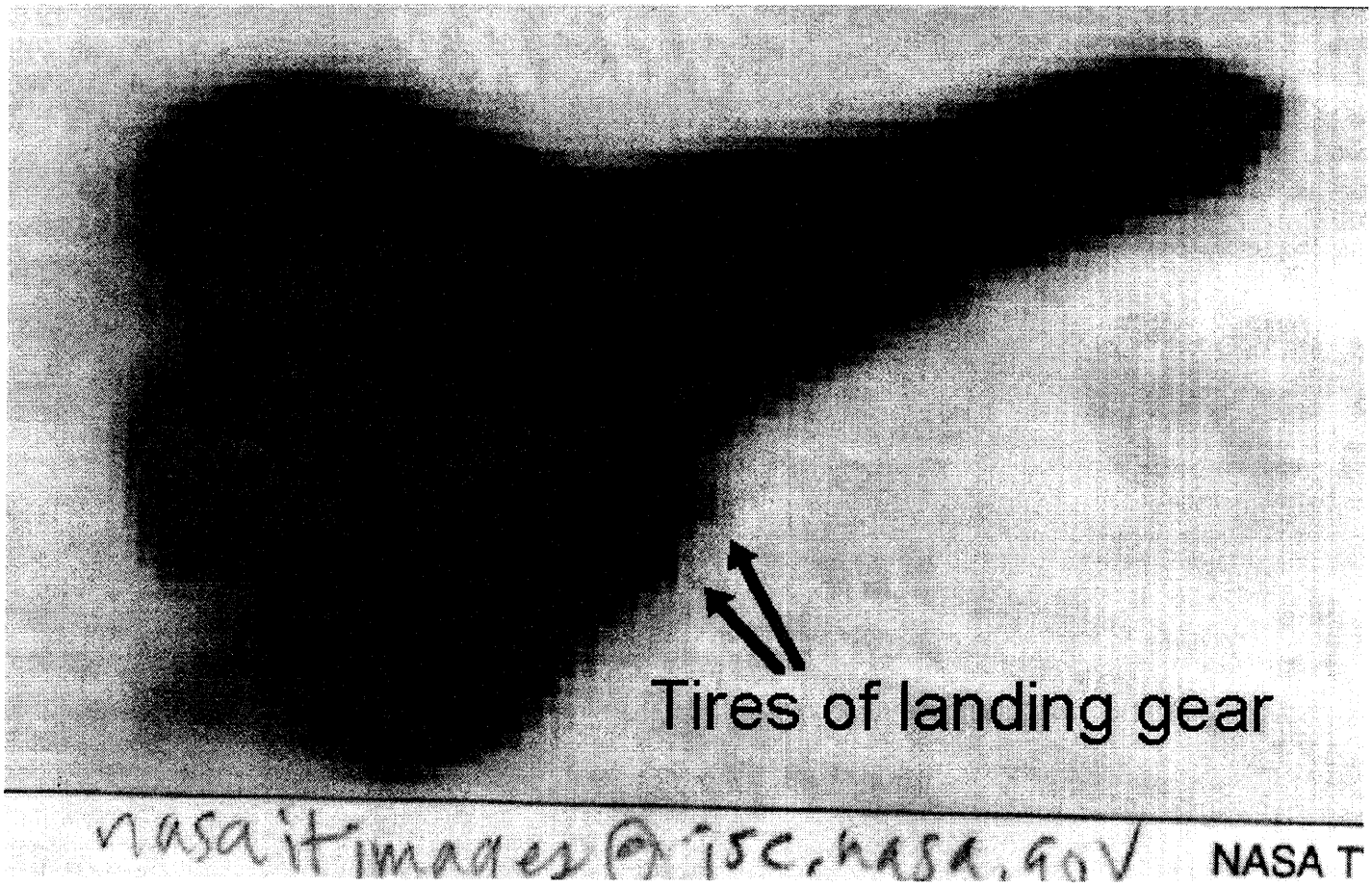
This is an educated observation of the high-definition military photo of the shuttle Columbia as it flew over an Air Force base in New Mexico on Feb 1:
In your investigations, please consider that the main landing gear under the left wing was somehow in the down position. At the angle at which the photo was taken, the tires of the landing gear would appear before the leading edge of the left wing. It is more likely that the two "bumps" on the front edge of the left wing were the two tires rather than damage. Damage would most likely appear as missing wing. The dark smoke behind the wing is probably smoke from the burning tires. The high temperatures near the left landing gear makes sense since the landing gear doors were open. It also makes since that signals were lost at other area of the wing, because the fire in the wheel well burned through the nearby control wires. This also explains the excessive drag on the left side. It was only a matter of time before the extra drag put the shuttle out of control.

[redacted]


columbia.jpg

Daugh. - 104

columbia.jpg (700x459x256 jpeg)



[redacted] **04:00 AM 2/13/2003, Shuttle landing gear**

From: [redacted]
Date: Thu, 13 Feb 2003 04:00:56 EST
Subject: Shuttle landing gear
To: r.h.daugherty@larc.nasa.gov, m.j.shuart@larc.nasa.gov,
david.f.lechner1@jsc.nasa.gov
X-Mailer: Thunderbird - Mac OS X sub 23

FOIA Exemption (b)(6)

As a concerned supporter of the space program, I hope that you will take a moment to look at the attached image. It seems to explain to so-called "jagged" edge of the left wing seen in the blurry AF telescope picture. The image seems to be consistent with current theories regarding the left landing gear.

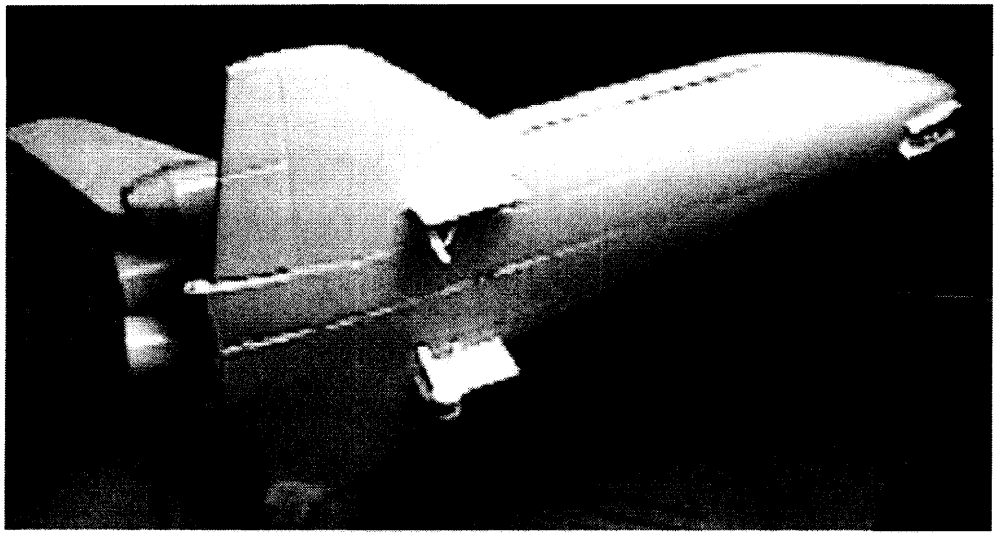
Sincerely yours,

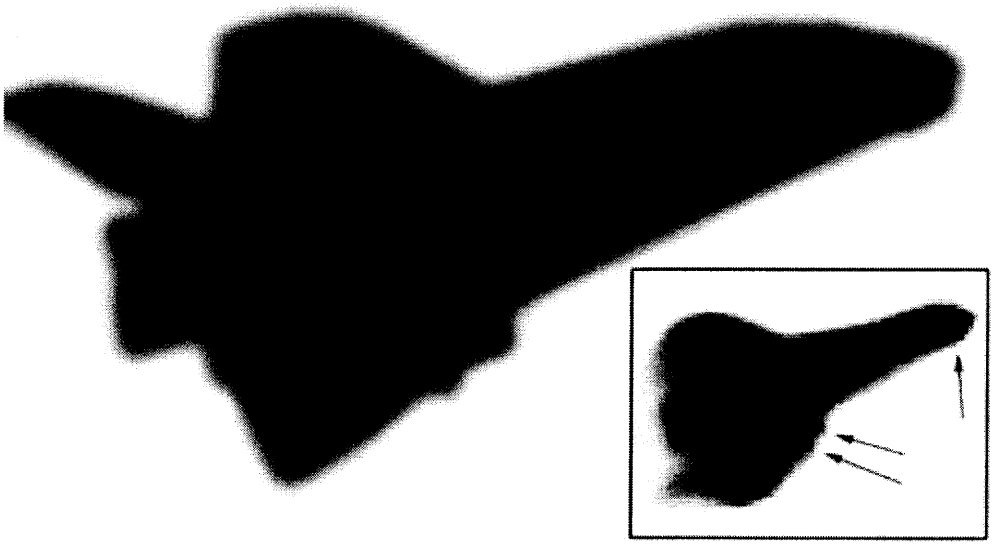
[redacted]


compShuttle.jpg

Daugh. - 105

compShuttle.jpg (488x576x16M jpeg)





From: "LENZER, BRUCE L. (JSC-JA) (DYN)" <bruce.l.lenzer1@jsc.nasa.gov>
To: "'r.h.daugherty@larc.nasa.gov'" <r.h.daugherty@larc.nasa.gov>
Subject: Gear Door Breach
Date: Thu, 13 Feb 2003 11:41:42 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

> Dear Mr. Daugherty:
>
> I've been sharing my views of a possible gear/tire breach scenario prior
> to learning of your e-mail. I believe the theory is sound that heat and
> pressure on the wheels (tires) and ancillary equipment in the wheel well
> caused a catastrophic event. This makes sense. Added heat to the air
> molecules inside a tire at that altitude on a decent would have rapidly
> and substantially increased air pressure in the tires. Burst of a tire in
> the wheel well would have certainly caused a catastrophic failure.
> Resulting stress would've significantly affected the structure and
> airframe on the left side.
>
> I think these theories as to what happened or might've happened will get
> the investigations team closer to the root cause faster. Excessive heat
> build up that rapidly, almost certainly had to come from the loss of
> tiles. The question remains did the damage at lift off cause enough
> significant tile damage or was there a secondary incident....e.g.:
> collision with space debris?
>
> I'm just a temporary contractor at JSC. I don't work on the MOD side.
> Aerospace and aviation are among my side hobbies. I'm a certified Scuba
> diver. Therefore, knowing the mechanics of boyles law of pressure is what
> led me to conclude a tire may have exploded in the Columbia wheel well
> during its re-entry and decent.
>
> Respectfully,
> Bruce Lenzer, CVS
> Certified Value Specialist & Team Facilitator
>
>
>

Daugh. - 108

[redacted], 02:02 PM 2/13/2003, tile/foam impact analysis

X-Originating-IP: 66.82.48.1
From: "[redacted]
To: <r.h.daugherty@larc.nasa.gov>
Subject: tile/foam impact analysis
Date: Thu, 13 Feb 2003 13:02:46 -0600
X-Mailer: Microsoft Outlook Express 6.00.2800.1106
X-OriginalArrivalTime: 13 Feb 2003 19:02:11.0324 (UTC) FILETIME=[69C8ABC0:01C2D392]

Dear Mr. Daugherty,

I am a geophysicist with an interest and some expertise in impact events, and not associated with the media. It strikes me that, based on the discussion in the NASA press conferences, that the analysis of the the foam/tile impact event was probably a purely kinetic analysis, i.e. a calculation based on the velocity, mass and structural characteristics of a particle striking an object. These computations are common in calculating the effects of "space junk" impacts. What I strongly suspect is missing is a computation involving the potential aerodynamic forces involved in the foam impact which might have driven the foam more forcefully into the shuttle tiles. If the very complex and chaotic aerodynamic forces of a tumbling fragment of foam material interacting with the slipstream of the vehicle as it approached sonic velocity were not included in the event analysis, the forces imparted to the tile covered structure would likely have been seriously underestimated.

I have read the preliminary reports generated by the Boing team on 1/21 and there indeed seems to be no mention of the consideration of aerodynamic forces. Only mass, size velocity, location and angle of impact seem to have been input into the analysis program "CRATER". I am inclined to believe that CRATER is an orbital debris damage simulator but I have been unable to obtain any information on that program.

Are you familiar with the analysis that was done at that time and can you confirm my suspicions that aerodynamic forces relevant to the debris impact were not considered? Also, if you could point me to sources documenting the CRATER program, I would greatly appreciate it.

[redacted]

Information withheld under FOIA exemption (b)(6)

Daugh. - 109

X-Originating-IP: [67.25.255.106]
From: [redacted]
To: <R.H.DAUGHERTY@larc.nasa.gov>
Subject: FW: Columbia Disaster
Date: Thu, 13 Feb 2003 11:08:51 -0800
X-OriginalArrivalTime: 13 Feb 2003 19:09:19.0265 (UTC) FILETIME=[68DB4910:01C2D393]

Dear Robert,

Saw your name in my paper today regarding the Columbia disaster and thought I would take the opportunity of sending you an email on the subject. So far I have not received a reply, but I am going to keep trying.

With regards,

[redacted]

------ Original Message -----
From: [redacted]
Sent: Tue, Feb 11, 2003 5:49pm
To: [redacted]
Subject: Columbia Disaster

*Information withheld under FoIA exemption (b)(6)

Mr. Ron Dittemore
Shuttle Program Manager
NASA Johnson Space Center
Houston, TX 77058

Dear Mr. Dittemore:

According to the papers there seems to be a major difference of opinion between you and some other NASA engineers as to whether catastrophic damage to the themal insulation tiles could have been caused by foam debris impacting the tiles at high speed. You presently have three shuttles that are now grounded until the problem is resolved. WHY NOT CONDUCT A DEFINITIVE GROUND TEST BY FIRING A COMPARABLE HUNK OF FOAM INTO THE LEADING EDGE OF ONE OF THE SHUTTLE WINGS AT THE SAME RELATIVE VELOCITY AS EXPERIENCED ON THE COLUMBIA? If you are correct, then no damage should occur. However, if major damage results, then the root cause of the Columbia disaster has been found and we can start thinking about how to fix the problem. Using one of the remaining shuttles for the test would seem to be preferred over trying to simulate conditions as these tiles and their bonds would have about the same exposure history to re-entry conditions as Columbia.

Assuming the above tests indicate the root cause, one solution to the problem might be to add a bonded rubber sheeting to cover all critical tiles on the shuttle. The rubber thickness would act as a protective shock absorber during launch and would burn off during the early stages of re-entry. The effectiveness of the rubber could, of course, be tested on one or more of the modified shuttles by additional debris impact firings. In addition, the rubber to tile bonding could be pretested

Daugh. - 110

for peeling in any high velocity wind tunnel to simulate launch conditions.

NASA photos show the piece of insulation debris impacting the shuttle wing leading edge. FROM THE PHOTOGRAPHS WHAT IS THE ESTIMATED RELATIVE IMPACT VELOCITY OF THE DEBRIS PIECE? It is assumed this relative velocity,v, would be considerably less than the shuttle air speed as the piece would still have a considerable forward velocity at the impact point. From the papers the estimated weight of the piece of foam is about 2 1/2 pounds. Taking the worst case impact scenario it is assumed that the impact was headon with the edge of the piece of bond debris striking perpendicular to the shuttle wing leading edge and with the kinetic energy of the debris piece concentrated in a relatively small area of contact. It would appear this impact condition could be closely simulated by using a small cannon explosion driving a piston that propells a section of foam insulation. The explosive charge driving the piston would be adjusted to provide a piston exit velocity of v. The weight of piston plus foam section would be the same 2 1/2 pounds. Sufficient foam would be provided so that the kinetic energy of the foam plus piston would be dissipated during impact (the piston's motion would be stopped before it impacted the leading edge of the wing).

Sincerely,

[redacted]

X-Mailer: MIME-tools 5.41 (Entity 5.404)
Date: Thu, 13 Feb 2003 11:13:14 -0800 (PST)
From: [redacted]
To: r.h.daugherty@larc.nasa.gov
Subject: Left landing gear bay door
Reply-To: [redacted]
X-Originating-Ip: [66.58.236.131]

*Information Withheld under FOIA exemption (b)(6)

Hello Mr. Daugherty,

I've attached a rough outline for a model, which apparently you've already explored to some extent, that I think the data tend to point to. I sent it to NASA on 2/6/03, not that I expect anyone to pay attention to it, but in the hopes that some personnel there would be further inclined to inquire in this direction. Since you have explored this area already, I thought you might like to know that others have come to similar conclusions independently post-event.

Cordially,

[redacted]

Daugh. - 111

[redacted] 02:27 PM 2/13/2003, Take two - Landing gear bay door

X-Mailer: MIME-tools 5.41 (Entity 5.404)
Date: Thu, 13 Feb 2003 11:27:17 -0800 (PST)
From: [redacted]
To: r.h.daugherty@larc.nasa.gov
Subject: Take two - Landing gear bay door
Reply-To: [redacted]
X-Originating-Ip: [66.58.236.131]

*Information withheld under FOIA exemption (b)(6)

Hello again Mr. Daugherty,

I've attached a rough outline for a model, which apparently you've already explored to some extent, which I think the data tend to point to. I sent it to NASA on 2/6/03, not that I expect anyone to pay attention to it, but in the hopes that some personnel there would be further inclined to inquire in this direction. Since you have explored this area already, I thought you might like to know that others have come to similar conclusions independently post-event.

Cordially,

[redacted]

Landing gear bay door theory.doc

Daugh. - 112

STS - 107

Structural instability in the left landing gear bay door as the critical causal factor leading to catastrophic yaw rate or shear stress - a model supported by available data.

Abstract

The scope of this paper will show that the data available [to this individual] from STS-107 upon entry interface to loss-of-signal indicates a loss of structural integrity in the left landing gear bay door, and other peripheral damage as a result, leading to catastrophic Yaw rate induced by drag. The specific timeline of events will be shown to support this model as it follows from the data recorded. CFD modeling for this scenario, given the known data, should allow for data fitting, and therefore either eliminate components of this model altogether or compel further analysis in this direction, working back through the impact of insulating foam to the initial launch of STS – 107.

Data Time-line & Outline

1) Insulating foam from the external fuel tank impacted the Columbia ~80 seconds after lift-off in the approximate area of sensor malfunction and temperature anomalies recorded during entry.

2) Aerodynamic drag post-impact was a decreasing factor in proportion to air density while achieving escape velocity. Conversely, aerodynamic drag was an increasing factor during entry.

3) During entry sensors began malfunctioning in a cascade after the last roll reversal banking left, when the unhinged lip of the left landing gear bay door was exposed to the highest aerodynamic forces and heating in the direction the door was engineered to open.

4) A small breach in the bay door seal is congruent with the temperature rises recorded in the landing gear compartment and adjacent sections of the fuselage just prior to loss-of-signal. Damaged or missing tile(s) do not account for the recorded heating.

5) A breach in the bay door seal would account for loss of sensor information within the compartment over time and can be arrived at through CFD data fitting.

6) A breach in the bay door seal would account for increasing aerodynamic drag, and therefore Yaw rate, recorded prior to loss-of-signal.

7) Loss-of-signal, and the concomitant breakup of Columbia occurred following the highest aerodynamic forces encountered during entry, and at a velocity sufficient to produce catastrophic structural failure in the orbiter given sufficient Yaw rate.

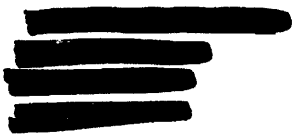
Summary

The theoretical structural instability in the left landing gear bay door area - due to fatigue, impact with insulation foam, an unknown object, or combinations thereof - is still indeterminate at this time. However, the impact of insulation foam from the external fuel tank during lift-off is compelling given the area of failure. Further, all of the data available fit this theoretical model.

This outline represents a basic model for catastrophic yaw rate initiated and/or induced by a malfunctioning/ damaged landing gear bay door, and peripheral areas. Though not zero, the probability that any other phenomenon *as a causal factor* would fit this data is very low.

I strongly urge NASA personnel to inquire further in this direction.

Sincerely,



STS – 107 (from Ward F Ward...rhd)

Structural instability in the left landing gear bay door as the critical causal factor leading to catastrophic yaw rate or shear stress - a model supported by available data.

Abstract

The scope of this paper will show that the data available [to this individual] from STS-107 upon entry interface to loss-of-signal indicates a loss of structural integrity in the left landing gear bay door, and other peripheral damage as a result, leading to catastrophic Yaw rate induced by drag. The specific timeline of events will be shown to support this model as it follows from the data recorded. CFD modeling for this scenario, given the known data, should allow for data fitting, and therefore either eliminate components of this model altogether or compel further analysis in this direction, working back through the impact of insulating foam to the initial launch of STS – 107.

Data Time-line & Outline

1) Insulating foam from the external fuel tank impacted the Columbia ~80 seconds after lift-off in the approximate area of sensor malfunction and temperature anomalies recorded during entry.

2) Aerodynamic drag post-impact was a decreasing factor in proportion to air density while achieving escape velocity. Conversely, aerodynamic drag was an increasing factor during entry.

3) During entry sensors began malfunctioning in a cascade after the last roll reversal banking left, when the unhinged lip of the left landing gear bay door was exposed to the highest aerodynamic forces and heating in the direction the door was engineered to open.

4) A small breach in the bay door seal is congruent with the temperature rises recorded in the landing gear compartment and adjacent sections of the fuselage just prior to loss-of-signal. Damaged or missing tile(s) do not account for the recorded heating.

5) A breach in the bay door seal would account for loss of sensor information within the compartment over time and can be arrived at through CFD data fitting.

6) A breach in the bay door seal would account for increasing aerodynamic drag, and therefore Yaw rate, recorded prior to loss-of-signal.

7) Loss-of-signal, and the concomitant breakup of Columbia occurred following the highest aerodynamic forces encountered during entry, and at a velocity sufficient to produce catastrophic structural failure in the orbiter given sufficient Yaw rate.

Summary

The theoretical structural instability in the left landing gear bay door area - due to fatigue, impact with insulation foam, an unknown object, or combinations thereof - is still indeterminate at this time. However, the impact of insulation foam from the external fuel tank during lift-off is compelling given the area of failure. Further, all of the data available fit this theoretical model.

This outline represents a basic model for catastrophic yaw rate initiated and/or induced by a malfunctioning/ damaged landing gear bay door, and peripheral areas. Though not zero, the probability that any other phenomenon *as a causal factor* would fit this data is very low.

I strongly urge NASA personnel to inquire further in this direction.

Sincerely,

[redacted]

Reply-To: [redacted]
From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
Subject: Columbia Photos
Date: Thu, 13 Feb 2003 17:43:59 -0800
X-Mailer: Microsoft Outlook 8.5, Build 4.71.2377.0
Importance: Normal

*Information Withheld under FOIA exemption (b)(6)

Robert,

Please forgive me for sending you an unsolicited email, but I believe I'm seeing something in these manipulated images which may substantiate your theories.

This photo is a thermal image taken by the Starfire telescope and distributed by MSNBC on their web site. I cleaned it up (still fuzzy, though), inverted it and increased the contrast and offset adjusted it to reveal temperature variations in the underside of Columbia.

Until I read your email, I had a neat picture and didn't see any new information in it. But I reprocessed the original last night to show any abnormal thermal signatures near the left wheel well. Note the dark red patch near the left wheel well. It appears to me to be something very hot. Admittedly, this is a reprocessed JPEG of a fuzzed-up declassified thermal image, but there is still some data in there and it appears to be real.

I hope that viewing these images will get your team access to the original Starfire imagery so the real high resolution thermal imagery can be analyzed to reveal what happened to Columbia.

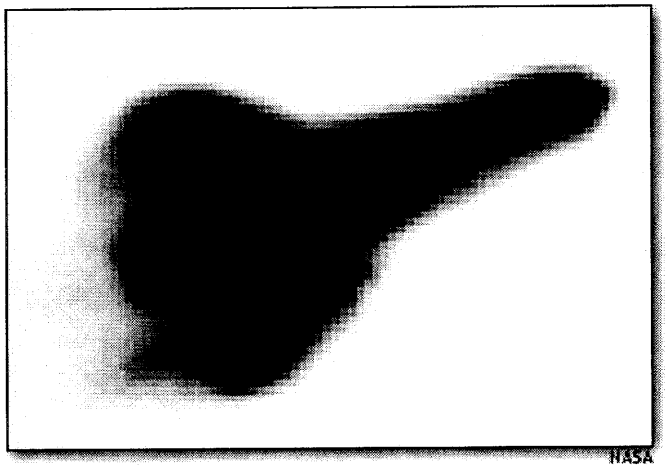
Best regards,
[redacted]
[redacted]
Cell [redacted]

Original NASA-MSNBC Image.jpg

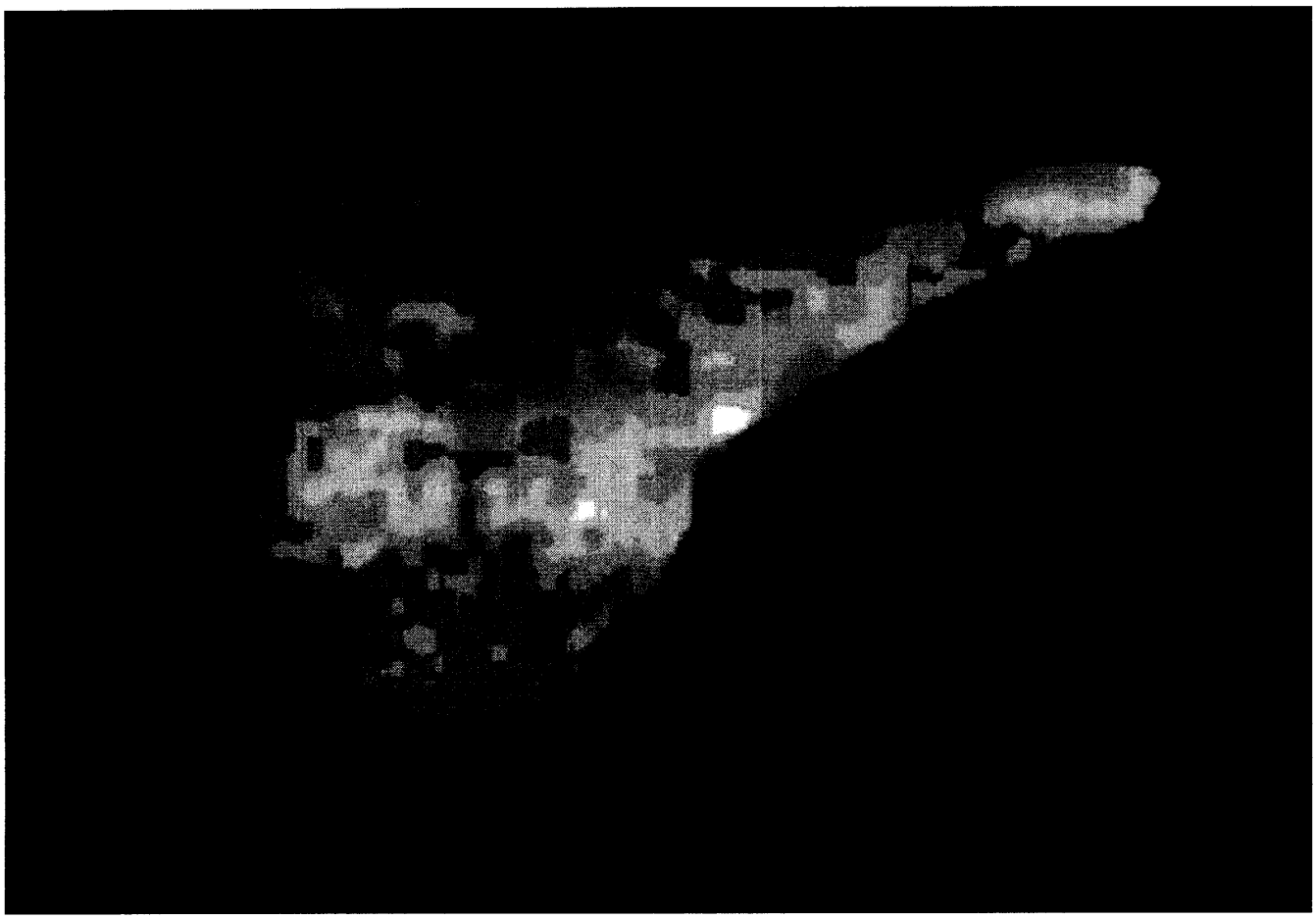
Inverted Gaussian Blurred (10) Original Scaled Contrast Enhanced NASA-MSNBC Image.jpg

Daugh. -113

Original NASA-MSNBC Image.jpg (330x233x16M jpeg)



Inverted Gaussian Blurred (10) Original Scaled Contrast Enhanced NASA-MSNBC Image.jpg
(660x466x16M jpeg)



From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Dick Scholtz'" <Dick.Scholtz@us.michelin.com>,
"'Bob Daugherty'"
<r.h.daugherty@larc.nasa.gov>,
"'Bill Heitzman'"
<william.j.heitzman@usahq.unitedspacealliance.com>,
"'Goodmark, Jeffrey A'" <Jeffrey.Goodmark@SW.Boeing.com>,
"'Tom Hoffman'"
<thomas.l.hoffman@boeing.com>,
"'Porter, Michael T'"
<Michael.Porter@West.Boeing.com>
Subject: FW: Tire Photo
Date: Fri, 14 Feb 2003 09:12:57 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: Young, Michael L [mailto:michael.l.young@usago.ksc.nasa.gov]
Sent: Thursday, February 13, 2003 8:45 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Tire Photo

Carlisle

Here are the photo I promised. The balance strip measured 8 in X 3.45 in. I hope this helps.

Karl
Cell
936-465-6915

<<MLG Tire 31_34665N 93_86159W.jpg>> <<DSCN0028.JPG>>

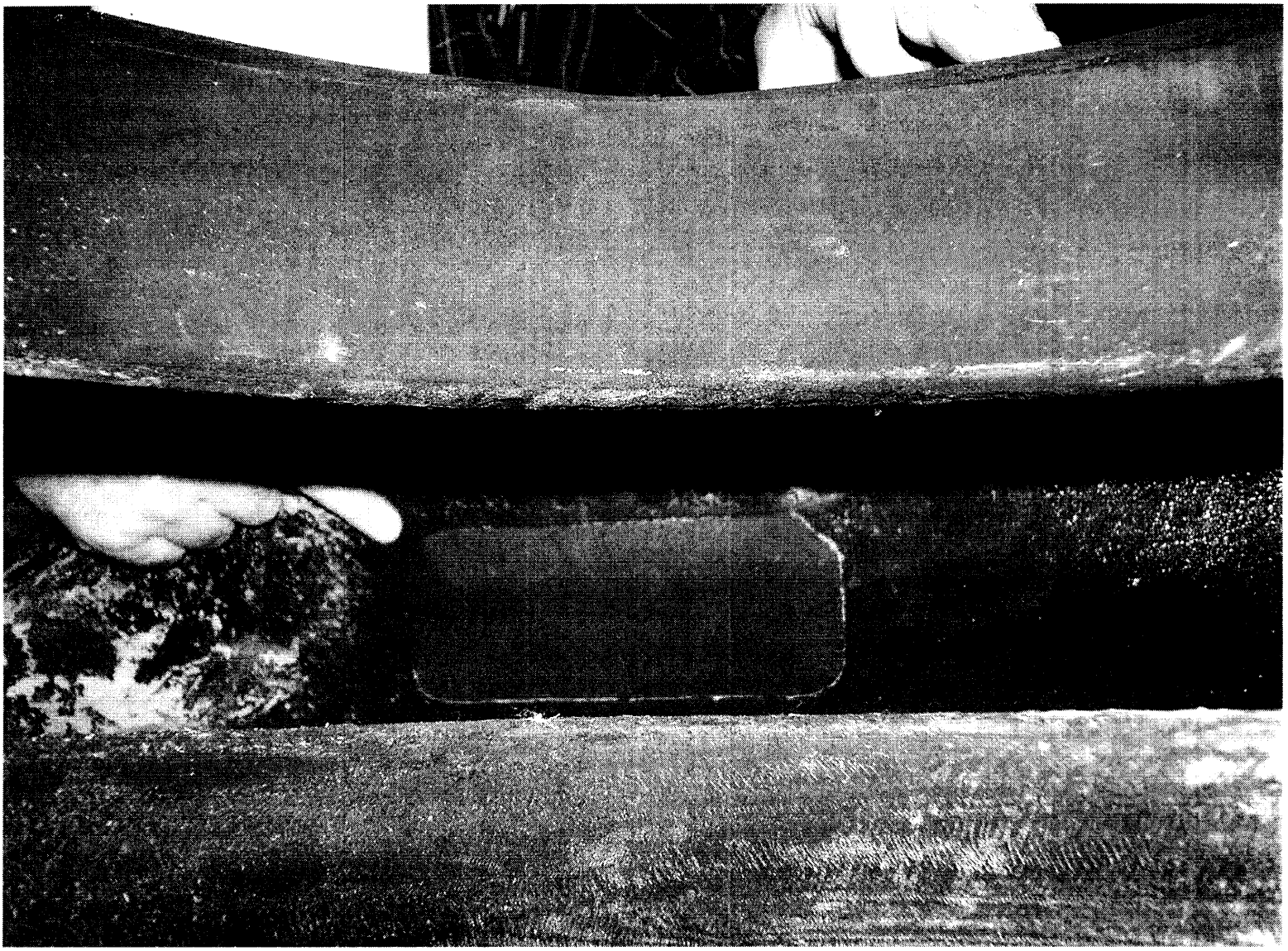

MLG Tire 31_34665N 93_86159W.jpg


DSCN0028.JPG

Daugh. - 114

MLG Tire 31_34665N 93_86159W.jpg (1024x768x16M jpeg)

DSCN0028.JPG (2560x1920x16M jpeg)



From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>,
"'Dick Scholtz'"
<Dick.Scholtz@us.michelin.com>,
"'Greer McClain'"
<james.mcclain@va.afrl.af.mil>,
"'Porter, Michael T'"
<Michael.Porter@West.Boeing.com>,
"'Tom Hoffman'"
<thomas.l.hoffman@boeing.com>,
"'Goodmark, Jeffrey A'"
<Jeffrey.Goodmark@SW.Boeing.com>
Cc: "'Cipolletti, John P '" <IMCEAMAILTO-
john+2Ep+2Ecipolletti+40usago+2Eksc+2Enasa+2Egov@ems.jsc.nasa.gov>,
"POHL, H. K. (KARL) (JSC-EX) (NASA)" <h.k.pohl@nasa.gov>,
"'Young, Michael L'" <michael.l.young@usago.ksc.nasa.gov>
Subject: FW: Tire at KSC
Date: Fri, 14 Feb 2003 10:53:28 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

This is the other tire, with two balance patches. If you can identify it's location on the Orbiter, just contact Cipolletti via e-mail if you don't get Karl Pohl.

I'll be gone this afternoon and we get a holiday Monday.

CCC

-----Original Message-----
From: Cipolletti, John P [mailto:john.p.cipolletti@usago.ksc.nasa.gov]
Sent: Friday, February 14, 2003 10:21 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Tire at KSC

Attached is a photo of balance patches of tire at KSC.

<<tire.jpg>> <<tirebalance.jpg>>

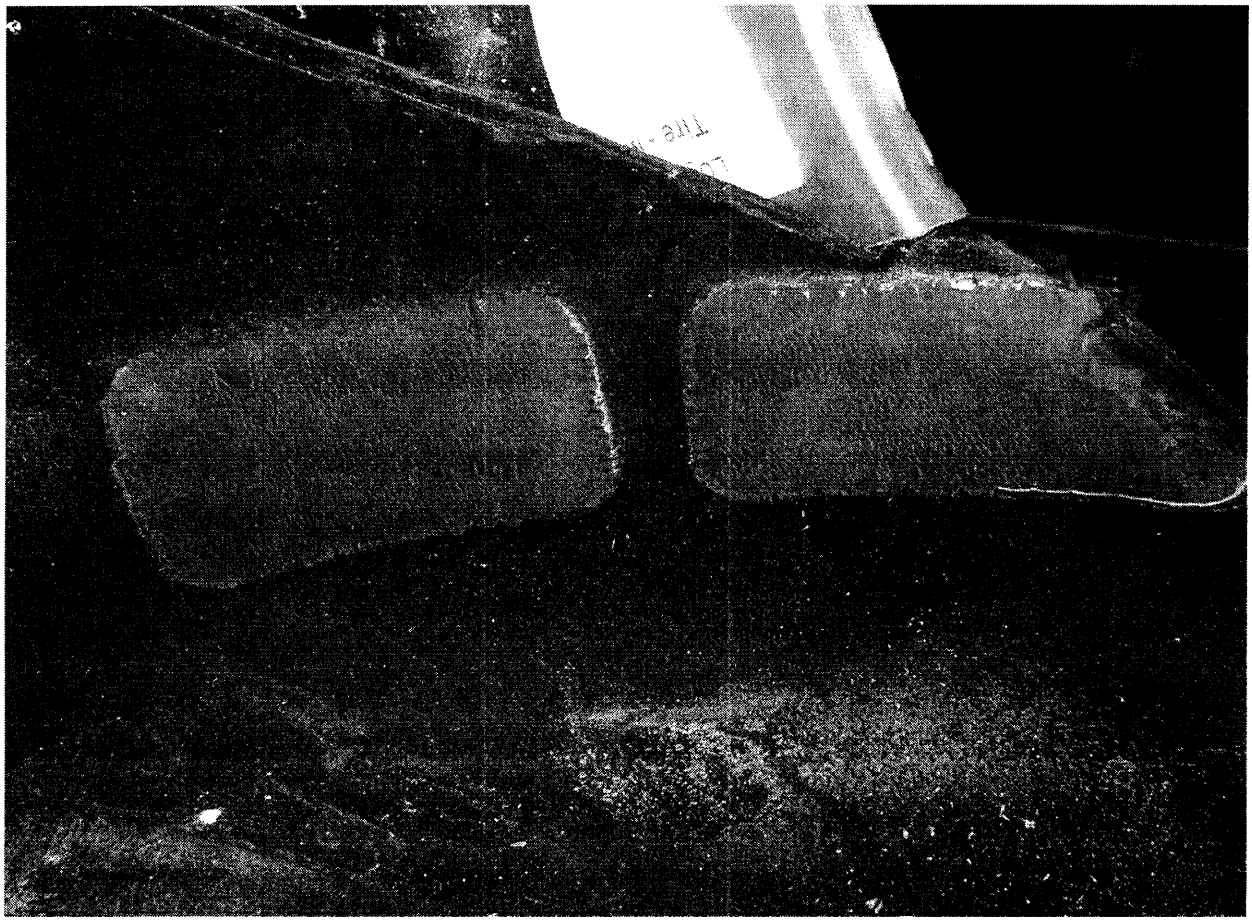
tire.jpg

tirebalance.jpg

Daugh. - 115

tire.jpg (2048x1536x16M jpeg)

tirebalance.jpg (2048x1536x16M jpeg)



From: Buck David T Contr 46 OG/OGM/OL-AC <David.Buck@wpafb.af.mil>
To: "Bob Daugherty (E-mail)" <r.h.daugherty@larc.nasa.gov>,
"Carlisle Campbell (E-mail)" <carlisle.c.campbell1@jsc.nasa.gov>,
"Dick Scholtz (E-mail)" <Dick.Scholtz@us.michelin.com>,
"Mike Porter (E-mail)" <michael.t.porter@boeing.com>,
"Tom Hoffman (E-mail)" <thomas.l.hoffman@boeing.com>
Cc: Haas Gordon L Contr 46 OG/OGM/OL-AC <Gordon.Haas@wpafb.af.mil>,
Heard James M Civ 46 OG/OGM/OL-AC <James.Heard@wpafb.af.mil>,
McClain James G Civ 46 OG/OGM/OL-AC <James.McClain@wpafb.af.mil>
Subject: Tire Balance Pad Pictures
Date: Fri, 14 Feb 2003 14:21:03 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)

I received this e-mail from Greer earlier this afternoon. He asked me to put together some information and respond. I was actually already putting together information for Dick Scholtz, so I just added to it. The attached PowerPoint file contains balance pad pictures for all four main tires. These pictures are from the shearography film. I removed the fringe lines so that the pad positions in the tire may be easier to see.

The tire with two balance pads is SN 0171U02005, LGTF Code No. 504-N. According to the information I have, this tire was on the left main landing gear - outboard. Someone please check that.

Please let me know if you have any further questions, or need more information. Please forward this e-mail to others who should get it. I didn't have all the addresses. Hopefully this information will help identify the tires.

Dave Buck
Landing Gear Test Facility
Wright-Patterson AFB
937-252-8028

-----Original Message-----
From: McClain James G Civ 46 OG/OGM/OL-AC
Sent: Friday, February 14, 2003 12:13 PM
To: Buck David T Contr 46 OG/OGM/OL-AC
Subject: FW: Tire at KSC

Looks like they found another tire. This one has two balance pads. Try to identify it from the films, if possible.

Greer

-----Original Message-----
From: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA) [mailto:carlisle.c.campbell@nasa.gov]
Sent: Friday, February 14, 2003 11:53 AM
To: 'Bob Daugherty'; 'Dick Scholtz'; 'Greer McClain'; 'Porter, Michael T'; 'Tom Hoffman'; 'Goodmark, Jeffrey A'
Cc: 'Cipolletti, John P '; POHL, H. K. (KARL) (JSC-EX) (NASA); 'Young, Michael L'
Subject: FW: Tire at KSC

This is the other tire, with two balance patches. If you can identify it's location on the Orbiter, just contact Cipolletti via e-mail if you don't get Karl Pohl.

Daugh. - 122

I'll be gone this afternoon and we get a holiday Monday.

CCC

-----Original Message-----
From: Cipolletti, John P [mailto:john.p.cipolletti@usago.ksc.nasa.gov]
Sent: Friday, February 14, 2003 10:21 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Tire at KSC

Attached is a photo of balance patches of tire at KSC.

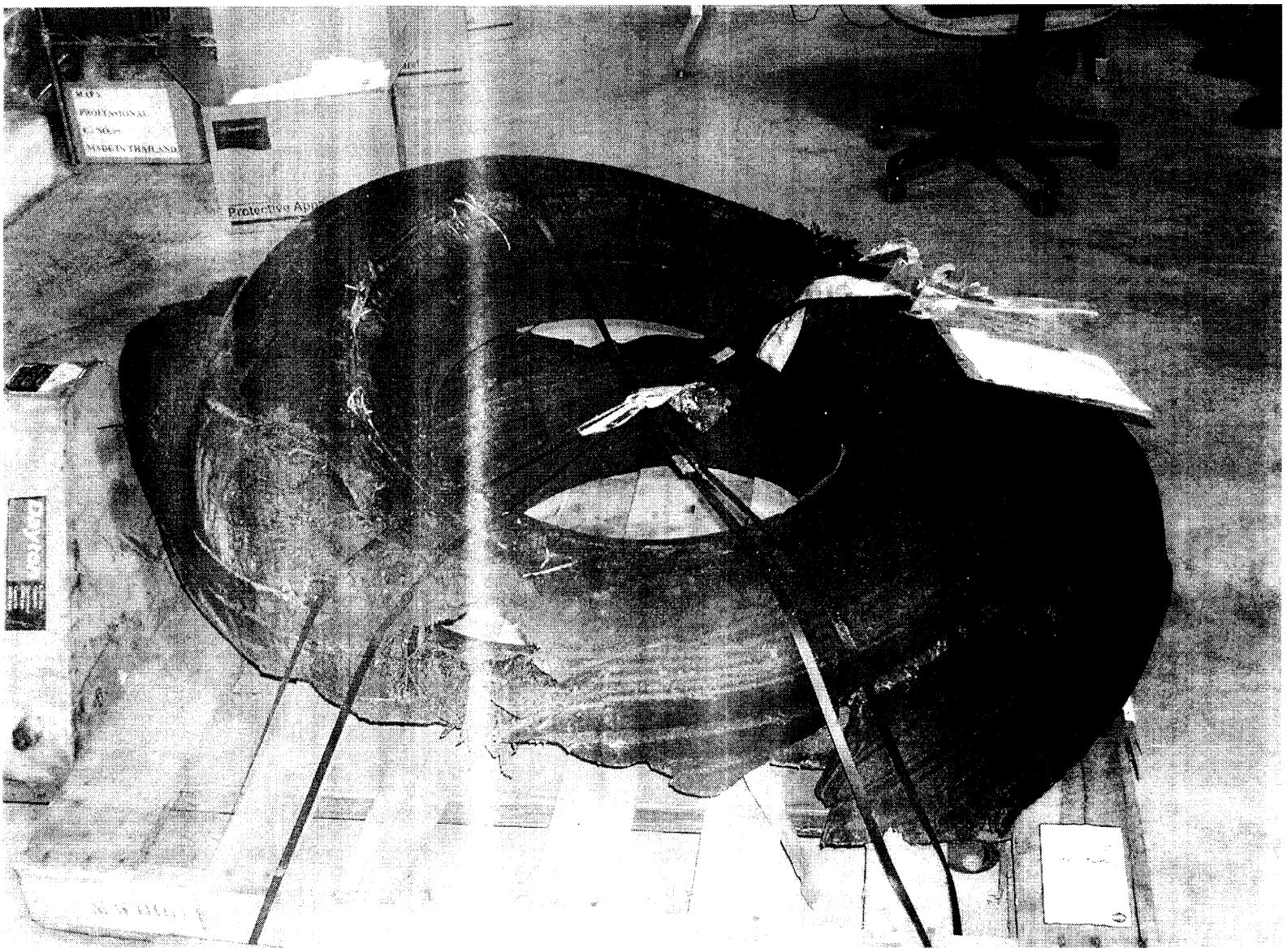
<<tire.jpg>> <<tirebalance.jpg>>

tire1.jpg

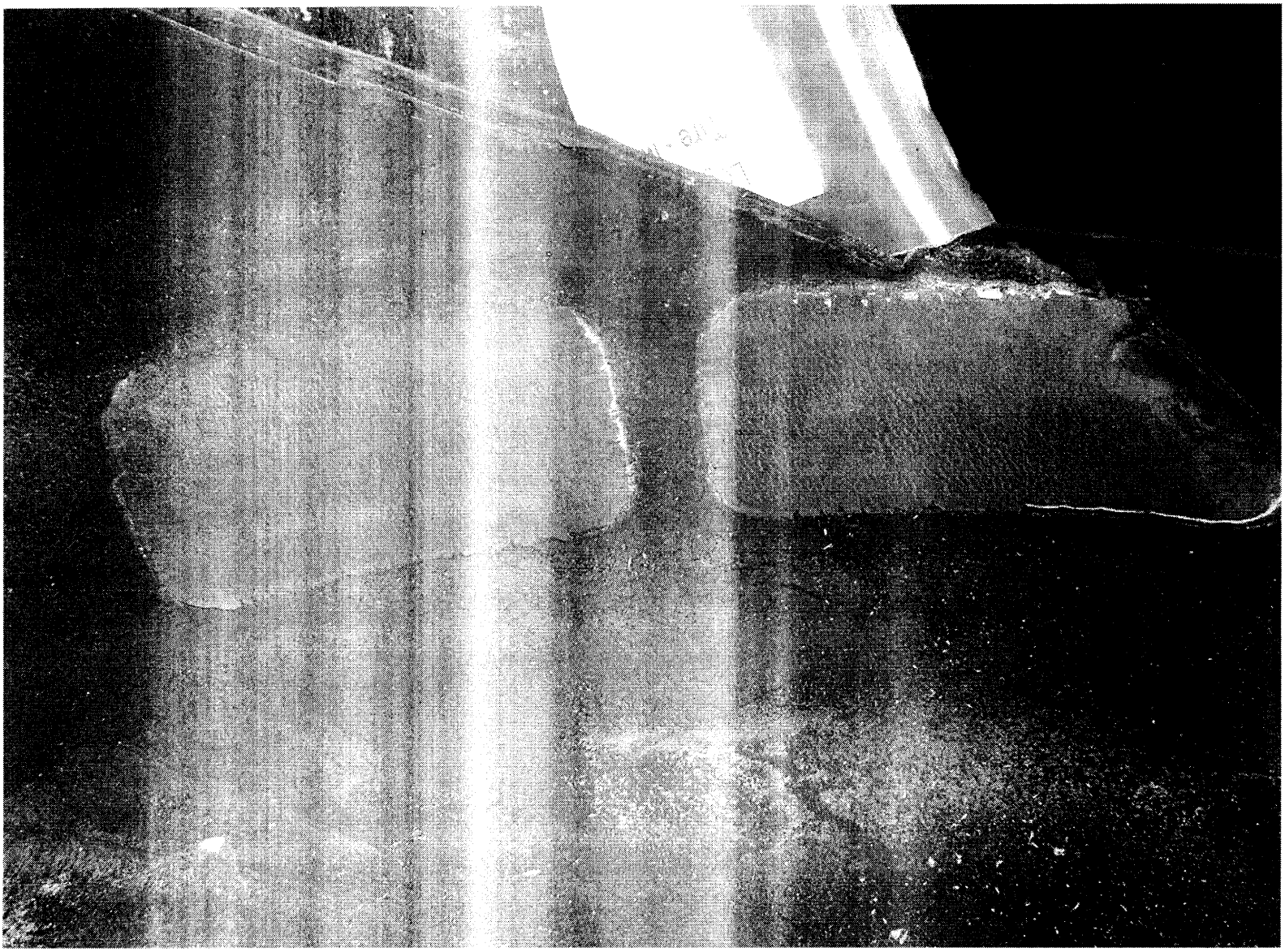
tirebalance1.jpg

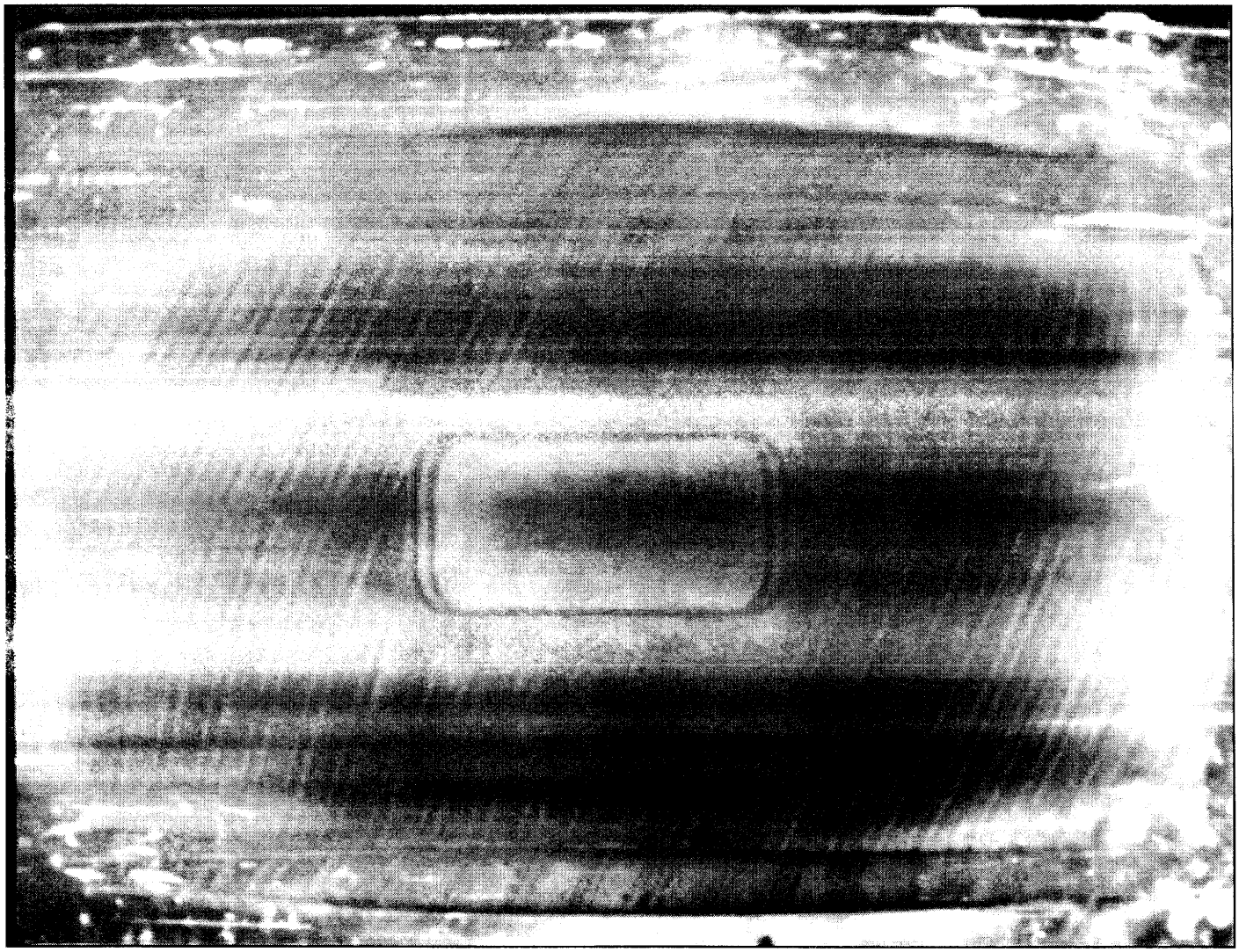
Main Tire Balance Pads.ppt

tire1.jpg (2048x1536x16M jpeg)



tirebalance1.jpg (2048x1536x16M jpeg)

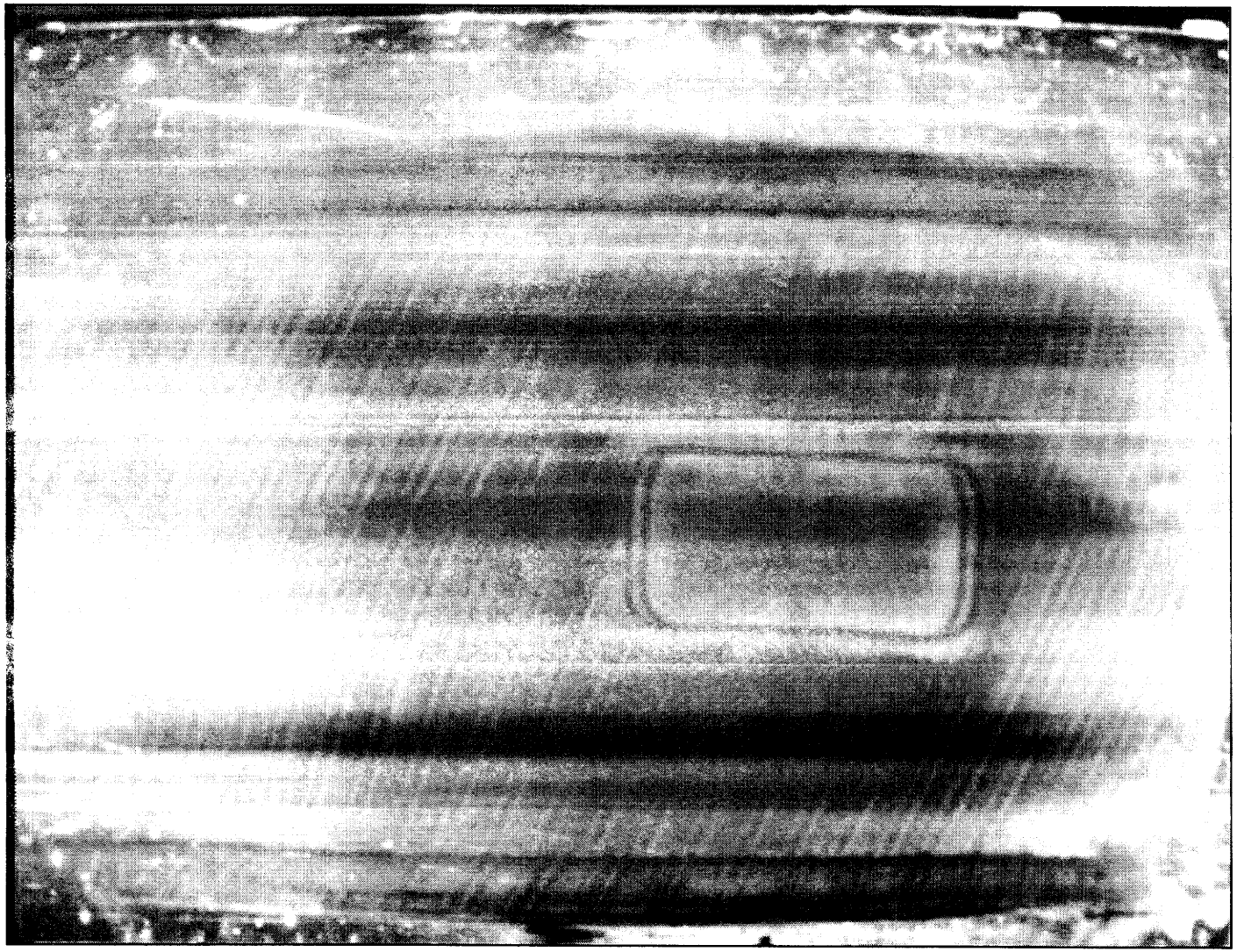




Orbiter Main Tire 44.5x16.0-21/34 Part No. MC194-0007-0007

Tire Serial No. 0169U02008 LGTF Tire Code No. 500-N

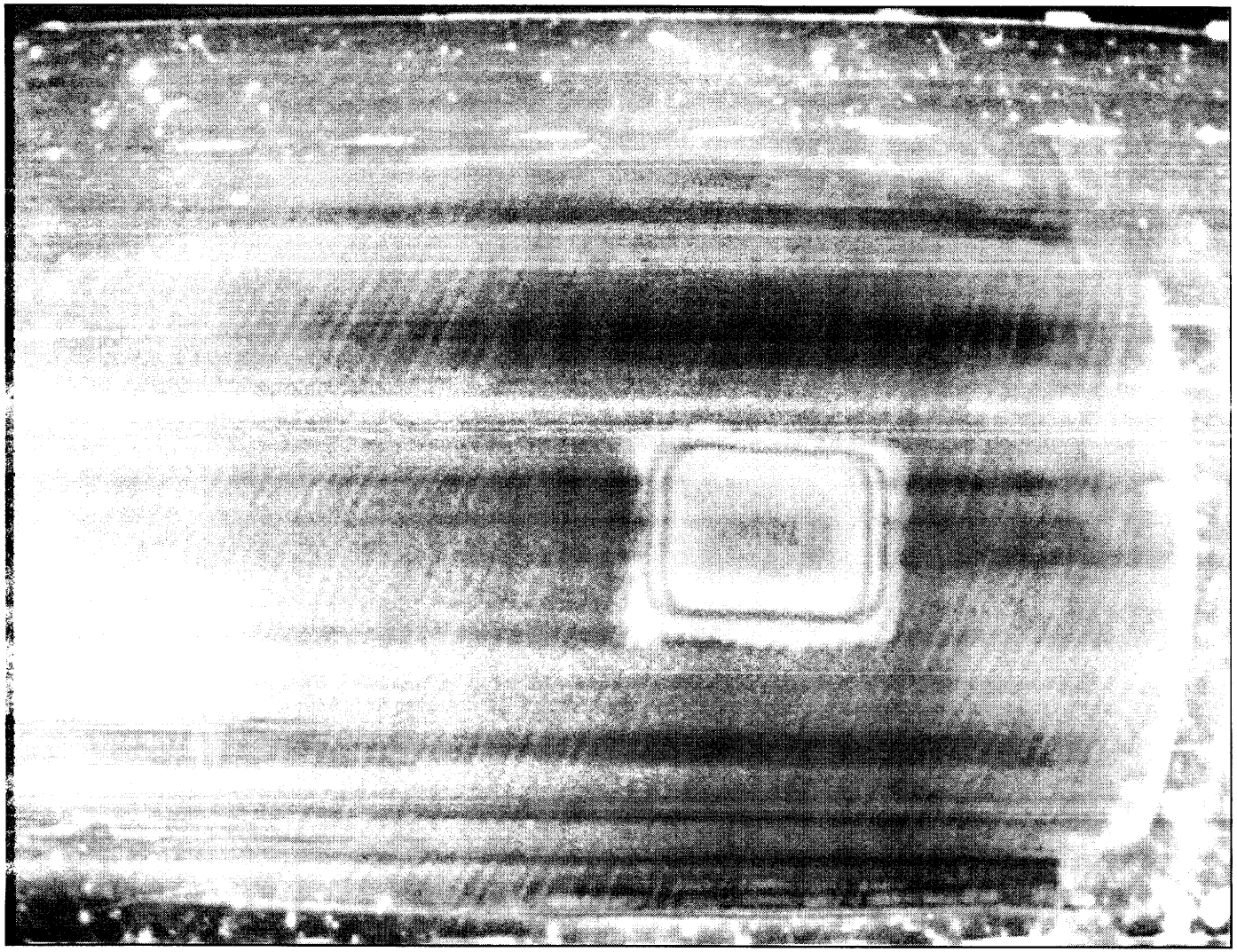
Balance Pad: 6 ounce pad located approximately 270 degrees from the serial number.



Orbiter Main Tire 44.5x16.0-21/34 Part No. MC194-0007-0007

Tire Serial No. 0170U02002 LGTF Tire Code No. 501-N

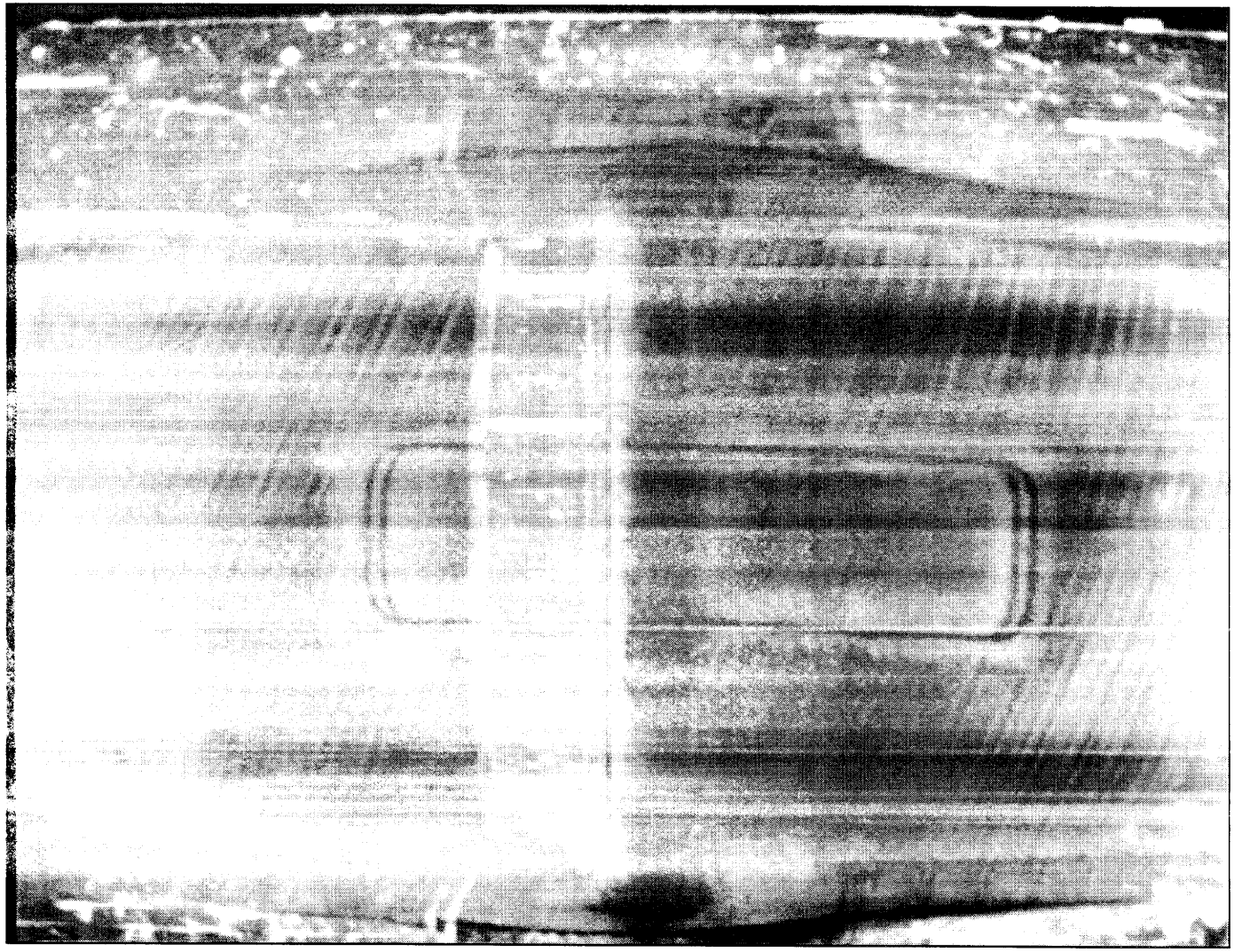
Balance Pad: 6 ounce pad located approximately 270+ degrees from the serial number.



Orbiter Main Tire 44.5x16.0-21/34 Part No. MC194-0007-0007

Tire Serial No. 0171U02004 LGTF Tire Code No. 503-N

Balance Pad: 3.5 ounce pad located approximately 180+ degrees from the serial number.



Orbiter Main Tire 44.5x16.0-21/34 Part No. MC194-0007-0007

Tire Serial No. 0171U02005 LGTF Tire Code No. 504-N

Balance Pads: 5 and 6 ounce pads located approximately 135 degrees from the serial number. Part of one pad is obscured by the bead spreader bar and shadow.

Date: Sun, 16 Feb 2003 23:36:21 -0600
From: [redacted]
X-Mailer: Mozilla 4.7 [en]C-CCK-MCD EBM-Compaq (Win95; U)
X-Accept-Language: en
To: r.h.daugherty@larc.nasa.gov
Subject: [Fwd: Why a cloud, not a stream, of foam debris?]

*Information Withheld under FoIA exemption (b)(6)

(Sorry if you get two copies; email that I tried to send you yesterday apparently wasn't addressed correctly.)

I hope you don't mind me writing to you about this. I doubt there's an official address for public comments.

I was just looking again at the before-and-after pictures of the chunk of foam, and suddenly realized: why is there a big cloud right it hits? Before it hit the wing, it was in one piece. As it hit the wing, it was assumed that it disintegrated or powderized--harmlessly. But if powder is coming from a point on a wing that's moving fast, shouldn't it essentially form a stream? The airflow should be pretty much laminar, right? Obviously there'd be turbulence following the spacecraft, but it looks like at this point the cloud wasn't even past the tail yet. How is it that the cloud is several times wider than the point of impact only a few milliseconds after impact in laminar flow? The impact must have produced a pretty big explosion, and/or produced some high-density pieces, and/or spun the chunk of foam rapidly (implying a solid hit) to have the pieces overcome the effects of the airstream and spread out so quickly.

The pictures I'm looking at are at
http://www.chron.com/cs/CDA/story.hts/space/1764392

(I've also emailed this question to Sheila Widnall.)

Thanks,
[redacted]

--
[redacted] http://xenophilia.org
Center for Responsible Nanotechnology (co-founder) http://CRNano.org

Daugh. - 123

[redacted] 11:53 AM 2/17/2003, Left Gear Failure

From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
Subject: Left Gear Failure
Date: Mon, 17 Feb 2003 11:53:48 -0500
X-Mailer: Microsoft Outlook Express 5.50.4133.2400

*Information withheld under FOIA exemption (b)(6)

Sir,

I realise you must get a lot of crackpot mail, but bear with me for a few sentences please. I, like the nation, have watched the shuttle event investigation. I have a theory.

My theory depends on schetchy info concerning the waste water valve location. If it is in the leading edge of the left wing area, read on.

I believe the separated tank insulation may have damaged or plugged the valve and fractured numerous tiles. The damaged valve allowed water to accumulate in the tile fractures and around the tiles themselves. The heating and cooling action of the black underside alternately exposed to the sun in orbit caused the ice expansion to further damage and infiltrate the tiles. Upon re-entry, the ice purged explosively. Not enough to hurt the orbiter, but to dislodge tiles and expose the skin. Once a breach formed, plasma heated the main gear area to failure and the door fell open. Disaster ensued. With the failure of the wing, the orbiter rolled inverted and the cargo doors failed.

I agree that no single event caused the loss of Columbia, I believe it was a culminative failure.

What do you think?

[redacted]

Daugh. - 124

[redacted], 02:23 PM 2/17/2003, Re: tile/foam impact analysis

To: [redacted]
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: tile/foam impact analysis
Cc: H.K.HENRY@LaRC.NASA.GOV
Bcc:
Attached:

Information Withheld under FOIA exemption (b)(6)

Mr. [redacted],

Thank you for your email. I'm not knowledgeable about the CRATER analysis with regard to its origins and limitations. If you'd like to contact our public affairs office who might be able to direct you to Johnson Space Center's Public Affairs Office you may contact Mr. Keith Henry at the following email address:
H.K.HENRY@LaRC.NASA.GOV

With Best Regards,
Bob Daugherty

At 02:02 PM 2/13/2003, you wrote:
Dear Mr. Daugherty,

I am a geophysicist with an interest and some expertise in impact events, and not associated with the media. It strikes me that, based on the discussion in the NASA press conferences, that the analysis of the the foam/tile impact event was probably a purely kinetic analysis, i.e. a calculation based on the velocity, mass and structural characteristics of a particle striking an object. These computations are common in calculating the effects of "space junk" impacts. What I strongly suspect is missing is a computation involving the potential aerodynamic forces involved in the foam impact which might have driven the foam more forcefully into the shuttle tiles. If the very complex and chaotic aerodynamic forces of a tumbling fragment of foam material interacting with the slipstream of the vehicle as it approached sonic velocity were not included in the event analysis, the forces imparted to the tile covered structure would likely have been seriously underestimated.

I have read the preliminary reports generated by the Boing team on 1/21 and there indeed seems to be no mention of the consideration of aerodynamic forces. Only mass, size velocity, location and angle of impact seem to have been input into the analysis program "CRATER". I am inclined to believe that CRATER is an orbital debris damage simulator but I have been unable to obtain any information on that program.

Are you familiar with the analysis that was done at that time and can you confirm my suspicions that aerodynamic forces relevant to the debris impact were not considered? Also, if you could point me to sources documenting the CRATER program, I would greatly appreciate it.

[redacted]

Daugh.-125

From: [redacted]
To: "'R.H.Daugherty@LaRC.NASA.GOV'" <R.H.Daugherty@larc.nasa.gov>
Subject: Columbia photo
Date: Mon, 17 Feb 2003 13:27:12 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Dear Mr. Daugherty,

FOIA Exemption (b)(6)

Regarding the telescopic picture of the shuttle Columbia as it passed over Kirtland New Mexico on Feb 1:

I think this picture contains more information than people realize.

It appears that this photo was taken from a vantage point off to the right side of the shuttle's ground track.

Given the ratio of the wingspan to the length in the photo, we can estimate that the shuttle's underside was tipped away from a straight-on view by approximately 30-35 degrees....

Considering this apparent orientation, I think it is plausible that the "jaggedness in the wing's leading edge" is actually the silhouette of the left landing gear and door in a lowered position.... We are seeing the lower front corner of the door, and part of the wheels, projecting beyond the wing's leading edge.

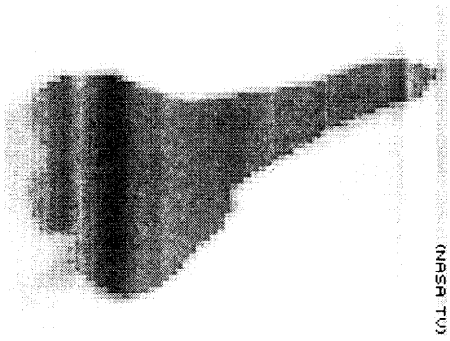
A quick look at, or shadow projection of, a shuttle model with lowered landing gear in the same orientation might be an interesting check.

[redacted]

ShuttleAirForceBMP.bmp

Daugh. - 126

ShuttleAirForceBMP.bmp (220x168x16M bmp)



From: [redacted] *Information Withheld under FOIA exemption (b)(6)
To: <Johnny.F.Stephenson@msfc.nasa.gov>
Cc: <r.h.daugherty@larc.nasa.gov>
Subject: Fuel Tank Mesh
Date: Mon, 17 Feb 2003 20:44:49 -0500
X-Mailer: Microsoft Outlook Express 6.00.2800.1106
X-Authentication-Info: Submitted using SMTP AUTH at out005.verizon.net from [151.203.245.46] at Mon, 17 Feb 2003 19:44:53 -0600

Dear Mr. Stephenson and Mr. Daugherty,

As I read the saddening reports on the Columbia loss I thought to share with you my thoughts on a way to contain the fuel tank foam debris which you might find helpful.

To my limited understanding these debris due to foam separation are inevitable. One way to contain these debris can be incorporating a mesh that will be embedded in the outer surface of the fuel tank's foam. Such mesh which will run the full extent of the fuel tank and could trap the foam debris preventing them from damaging adjacent structures on take off.

The mesh could be made from a resin that can withstand the tanks extreme temperatures it could be added to the outside of the foam before it cures after it was poured on the tank.

I have no doubt that you and your team have thought of this and better ideas but for the slim chance that you will find the idea helpful in your admirable work I thought to share it with you.

With outmost respect to your calling,

[redacted]

[redacted]

Daugh. -127

[redacted]

To: m.l.blosser@larc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Files For Sensor Studies
Cc:
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\columbia sensor wire locations Rev 2.ppt; C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\VDM P04 REV 2.ppt; C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\Copy of Copy of 2-11 Roe Presentation - Part III.ppt; C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\Quant Report Presentation Rev 0.ppt; C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\Copy of 2-11 Roe Presentation - Full Part II.ppt; C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\2-11 Roe Presentation - Full Part 1.ppt; C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\VDM Status 2-11-03.ppt;

See email # Daugh-117 for attachment

See email # Daugh-118 for attachment

See the following emails for attachments:

Daugh-117
Daugh-118
Daugh-119
Daugh-120

Daugh.-128

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: [Fwd: Why a cloud, not a stream, of foam debris?]
Cc:
Bcc:
Attached:

*Information Withheld Under FOIA exemption (b)(6)

Carlisle,
One of the emails I received with an interesting question.
Bob

Date: Sun, 16 Feb 2003 23:36:21 -0600
From: [redacted]
X-Mailer: Mozilla 4.7 [en]C-CCK-MCD EBM-Compaq (Win95; U)
X-Accept-Language: en
To: r.h.daugherty@larc.nasa.gov
Subject: [Fwd: Why a cloud, not a stream, of foam debris?]

(Sorry if you get two copies; email that I tried to send you yesterday apparently wasn't addressed correctly.)

I hope you don't mind me writing to you about this. I doubt there's an official address for public comments.

I was just looking again at the before-and-after pictures of the chunk of foam, and suddenly realized: why is there a big cloud right it hits? Before it hit the wing, it was in one piece. As it hit the wing, it was assumed that it disintegrated or powderized--harmlessly. But if powder is coming from a point on a wing that's moving fast, shouldn't it essentially form a stream? The airflow should be pretty much laminar, right? Obviously there'd be turbulence following the spacecraft, but it looks like at this point the cloud wasn't even past the tail yet. How is it that the cloud is several times wider than the point of impact only a few milliseconds after impact in laminar flow? The impact must have produced a pretty big explosion, and/or produced some high-density pieces, and/or spun the chunk of foam rapidly (implying a solid hit) to have the pieces overcome the effects of the airstream and spread out so quickly.

The pictures I'm looking at are at
http://www.chron.com/cs/CDA/story.hts/space/1764392

(I've also emailed this question to Sheila Widnall.)

Thanks,
[redacted]

--

[redacted] [redacted] http://xenophilia.org
Center for Responsible Nanotechnology (co-founder) http://CRNano.org

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Fwd: Columbia Photos
Cc:
Bcc:
Attached: C:\Documents and Settings\eudora\attach\Original NASA-MSNBC Image.jpg;C:\Documents and Settings\eudora\attach\Inverted Gaussian Blurred (10) Original Scaled Contrast Enhanced NASA-MSNBC Image.jpg;

Another interesting email.
Bob

*Information Withheld under FOIA exemption (b)(6)

Reply-To: [redacted]
From: [redacted]
To: <r.h.daugherty@larc.nasa.gov>
Subject: Columbia Photos
Date: Thu, 13 Feb 2003 17:43:59 -0800
X-Mailer: Microsoft Outlook 8.5, Build 4.71.2377.0
Importance: Normal

Robert,

Please forgive me for sending you an unsolicited email, but I believe I'm seeing something in these manipulated images which may substantiate your theories.

This photo is a thermal image taken by the Starfire telescope and distributed by MSNBC on their web site. I cleaned it up (still fuzzy, though), inverted it and increased the contrast and offset adjusted it to reveal temperature variations in the underside of Columbia.

Until I read your email, I had a neat picture and didn't see any new information in it. But I reprocessed the original last night to show any abnormal thermal signatures near the left wheel well. Note the dark red patch near the left wheel well. It appears to me to be something very hot. Admittedly, this is a reprocessed JPEG of a fuzzed-up declassified thermal image, but there is still some data in there and it appears to be real.

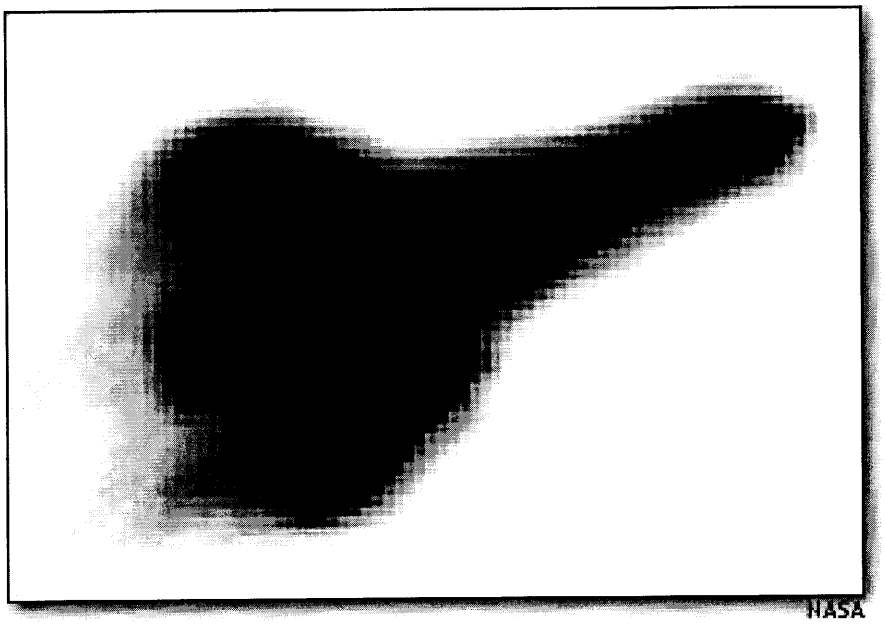
I hope that viewing these images will get your team access to the original Starfire imagery so the real high resolution thermal imagery can be analyzed to reveal what happened to Columbia.

Best regards,
[redacted]

Daugh. -130

Attachment:

Original NASA-MSNBC Image jpg



Attachment: Inverted Gaussian Blurred(10)

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Fwd: Shuttle landing gear
Cc:
Bcc:
Attached: C:\Documents and Settings\eudora\attach\compShuttle.jpg;

See e-mail #Daugh-105 for attachment.

Another interesting email.
Bob

From: [redacted]
Date: Thu, 13 Feb 2003 04:00:56 EST
Subject: Shuttle landing gear
To: r.h.daugherty@larc.nasa.gov, m.j.shuart@larc.nasa.gov,
david.f.lechner1@jsc.nasa.gov
X-Mailer: Thunderbird - Mac OS X sub 23

As a concerned supporter of the space program, I hope that you will take a moment to look at the attached image. It seems to explain to so-called "jagged" edge of the left wing seen in the blurry AF telescope picture. The image seems to be consistent with current theories regarding the left landing gear.

Sincerely yours,

[redacted]

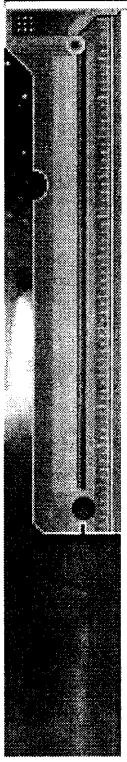
FOIA exemption (b)(6)

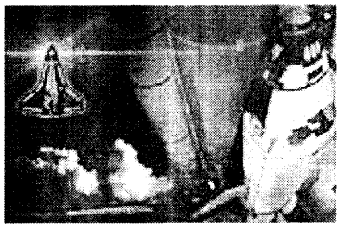
Daugh. - 131

To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Sound
Cc:
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\sts107_sound_030216.html;

Carlisle,
Attached is a file on a story regarding an "explosion" that was picked up where they talk about an "equivalent" of several sticks of dynamite. very interesting.
Bob

Daugh. - 132





Sound Waves May Help Columbia Probe

By Andrew Bridges
Associated Press Science Writer
posted: 10:45 pm ET
16 February 2003

SPACE CENTER, Houston (AP) -- Recordings made by instruments sensitive to sound below the threshold of human hearing may help investigators build a timeline of any uncharacteristic movements made by the space shuttle Columbia minutes before it broke apart, scientists say.

The instruments also captured an explosion high over Texas that one scientist said could have been Columbia's cabin rupturing.

As parts of Columbia began to break off as the shuttle streaked across the West, the flight behavior of the normally streamlined spacecraft would have changed. Those changes would have generated distinctly different patterns of sound waves compared to previous shuttle flights.

The patterns, recorded on the ground by instruments in Texas, Nevada and elsewhere in the West, are now being examined as part of the Columbia disaster investigation.

Any abnormal patterns can help investigators establish the timing of events as the shuttle entered the Earth's atmosphere Feb. 1, said Keith Koper, a geophysicist at Saint Louis University in Missouri.

Investigators already know from sensor data sent from the shuttle in its final minutes _ supported by eyewitness reports, photographs and video footage _ that Columbia's cascade of problems began while the spacecraft was still over the Pacific Ocean.

The sensors indicated increasing heat as well as increased drag on shuttle's left wing, suggesting it was somehow damaged, perhaps from the impact of a chunk of hard foam that broke off the external fuel tank and hit the wing shortly after liftoff Jan. 16.

Investigators have said they suspect that data mean Columbia was already dropping debris over the West several minutes and hundreds of miles before it broke apart high over Texas. All seven crew members were killed.

One array of the sound-sensitive instruments, located near Big Bend National Park in southwest Texas, recorded sound waves from Columbia as it was over West Texas indicating an explosion equivalent to a few pounds of TNT, said Eugene Herrin, a geophysicist at Southern Methodist University.

"Our guess is that it could have been caused by a rapid decompression, which is what would have happened if you ruptured the crew compartment," Herrin said.

He said an initial analysis of data collected in Columbia's wake by another array of microbarometers outside Mina, Nev., showed ``unusual'' patterns when compared to data from other shuttle flights passing overhead. The instruments record minute pressure changes caused by infrasound, or sound waves below about four cycles per second that are inaudible to humans.

"There was something about this one. I am not going to speculate that we see are oscillations in the shock wave that we don't normally see. Whether that's diagnostic or not, that's a NASA call," Herrin said.

Space agency spokesman William Jeffs said Sunday that NASA would consider the information in the shuttle investigation.

Search crews have yet to find any confirmed shuttle debris more than 250 miles west of Fort Worth. A concentrated search in a canyon east of Albuquerque, N.M., on Saturday turned up nothing from the shuttle, officials there said.

Earthquake instruments throughout the West also picked up vibrations produced by Columbia's supersonic flight overhead, said Andrew Michael, a U.S. Geological Survey geophysicist in Menlo Park, Calif. That data also was sent to NASA.

Such seismic data was used to study the bombing of the U.S. embassy in Nairobi, the sinking of the Russian submarine Kursk and the collapse of the World Trade Center towers.

More Stories

- Complete Coverage of the Columbia Disaster Investigation
- No Signs of Shuttle Debris in New Mexico Hills
- Columbia Investigation Board Hits the Road
- Columbia Flight Director Recalls Day of Tragedy
- Columbia FAQ: Hard Questions, Simple Answers and the Latest News

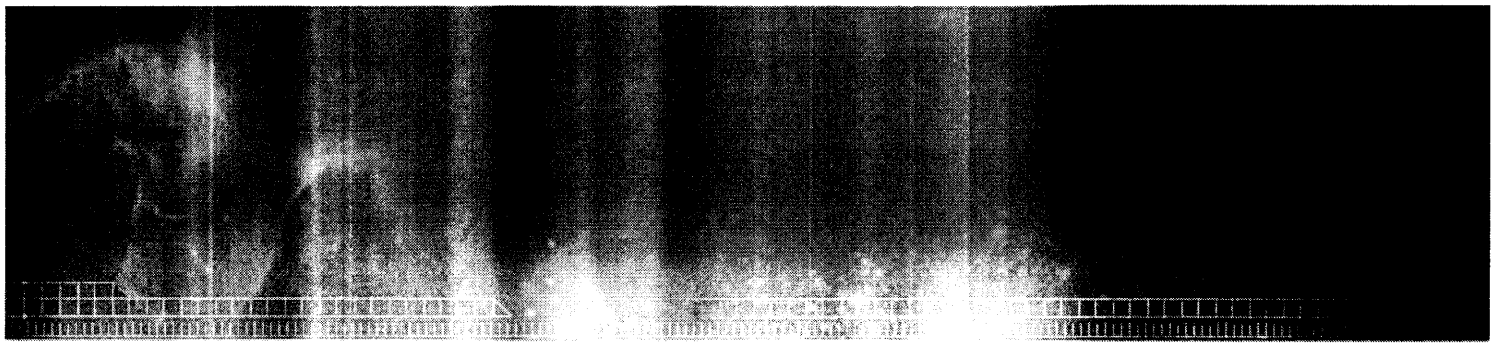
Related Links

- NASA's Human Spaceflight Web Site
- Looking Back at the 1986 Challenger Disaster
- NASA's STS-107 Space Research Web Site
- More space news from FLORIDA TODAY

SPACE TOP STORIES

- Radio Star: ALMA Telescope to See Stellar Birth, Galactic

- Powerful Space Bursts Reflect Two Ways to Make Black Holes
- Complete Coverage of the Columbia Disaster Investigation
- Molten Aluminum Found on Columbia Tiles
- Set Your MP3s Free with cd3o's C300
- NASA: No Internal Shuttle Policy Changes Ahead of Probe Findings
- SPACE.com: More News Headlines



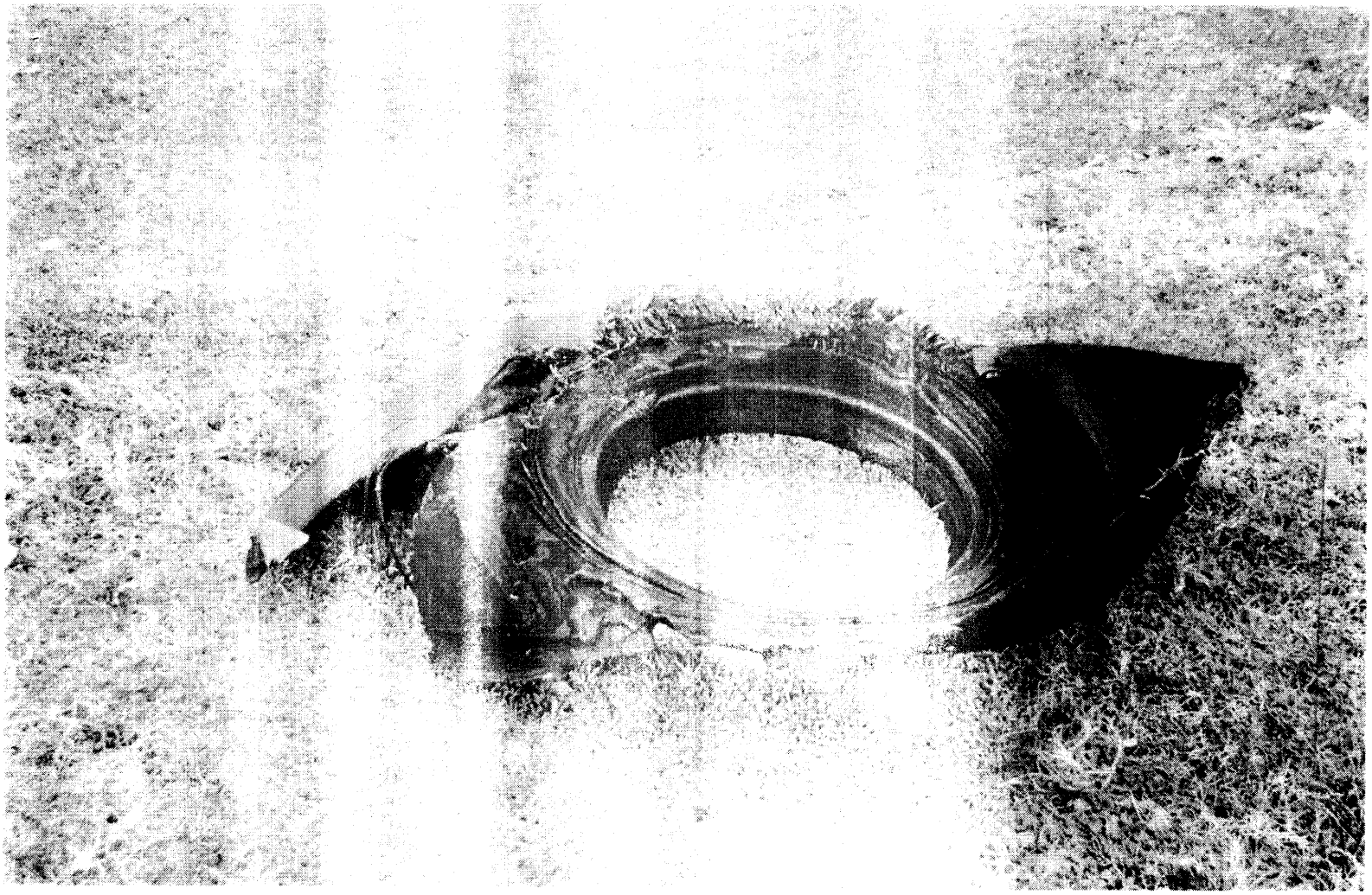
From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: more tire photos
Date: Tue, 18 Feb 2003 13:07:30 -0600
Importance: high
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: Hoffman, Thomas L [mailto:Thomas.L.Hoffman@boeing.com]
Sent: Tuesday, February 18, 2003 9:20 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: FW: more tire photos
Importance: High

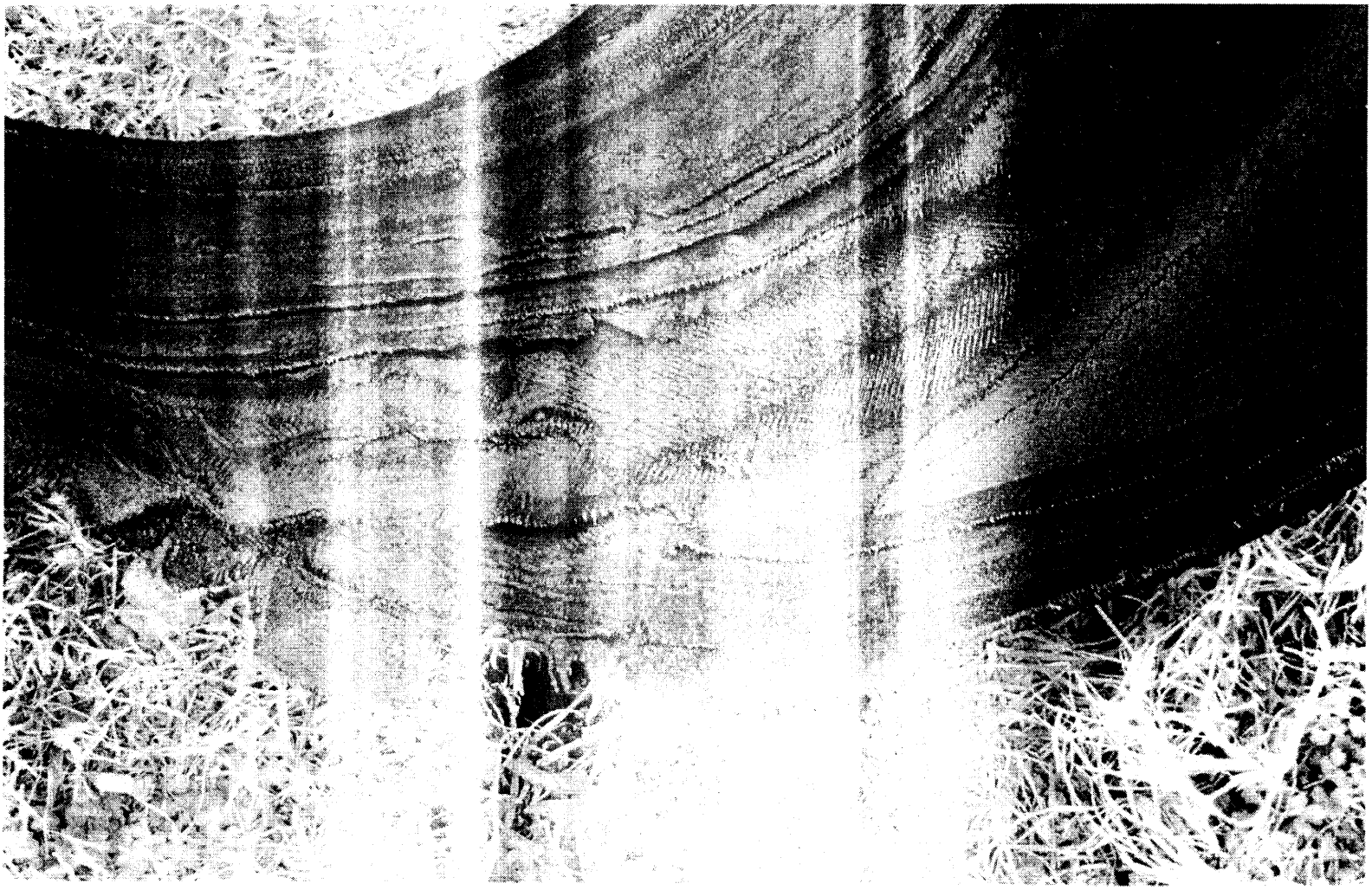
> -----Original Message-----
> From: Hoffman, Thomas L
> Sent: Tuesday, February 18, 2003 8:51 AM
> To: Dick Scholtz (E-mail)
> Subject: more tire photos
> Importance: High
>
>
> > <<jsc2003e06137_nr.zip>>
> Tom Hoffman
> Boeing Subsystem Manager
> Landing/Deceleration System
> Orbiter Vehicle Engineering
> (281) 853-1638
>
>


jsc2003e06137_nr.zip

Daugh. - 133



jsc2 3e06138_nr.jpg (1716x1128x16M jpeg)



To: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)" <carlisle.c.campbell@nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: FW: more tire photos
Cc:
Bcc:
Attached:

thx carlisle....curious as to your opinion...I've got mine.
Bob

At 02:07 PM 2/18/2003, you wrote:

-----Original Message-----
From: Hoffman, Thomas L [mailto:Thomas.L.Hoffman@boeing.com]
Sent: Tuesday, February 18, 2003 9:20 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: FW: more tire photos
Importance: High

> -----Original Message-----
> From: Hoffman, Thomas L
> Sent: Tuesday, February 18, 2003 8:51 AM
> To: Dick Scholtz (E-mail)
> Subject: more tire photos
> Importance: High
>
>
> > <<jsc2003e06137_nr.zip>>
> Tom Hoffman
> Boeing Subsystem Manager
> Landing/Deceleration System
> Orbiter Vehicle Engineering
> (281) 853-1638
>
>

Daugh. - 135

To: john.barry-1@nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Email Traffic From Robert Daugherty
Cc: M.J.SHUART@LaRC.NASA.GOV, H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\ALDF Timeline.doc; - Timeline on Columbia Web Site

Maj. General Barry,
Please find attached a document my management asked me to prepare which outlines the email traffic into and out from myself regarding the events in the week prior to the Columbia accident. I have added verbiage detailing the telephone conversations I had as best as I could recall them. Looking forward to discussing this information with you this evening at 5:30 CST. I may be reached at [redacted] Lt. Clark has my cell phone number if I cannot be reached at the above number for some reason.

Best Regards,
Bob Daugherty

FOIA Exemption (b)(6)

Daugh. - 136

Date: Tue, 18 Feb 2003 17:36:49 -0500
To: [redacted]
From: "Mark J. Shuart" <m.j.shuart@larc.nasa.gov>
Subject: Re: Main Gear Breach Concerns re: Columbia STS 107 (01/30/03 e-mail) - Please FWD to R.H.DAUGHERTY@larc.nasa.gov
Cc: r.h.daugherty@larc.nasa.gov

Dear Ms[redacted]

Thank you for your comments and the information. I have passed them on to NASA Headquarters for consideration.

Information deleted under FOIA Exemption (b)(6)

Mark J. Shuart, PhD
Director for Structures & Materials
NASA Langely Research Center
Hampton, VA 23681

==========

Dear Mr. Daugherty,

I write to you directly to thank you for the extremely relevant information you had sent to NASA mission control just 2 days prior to the tragic loss of the Columbia Crew and vehicle. It seems, that your observations of Jan.30, 2003 were not only timely and accurate, but unfortunately "prophetic", which adds credible evidence to the investigation. Although, I'm not an expert in the field myself, I worked in the aviation industry for several years, while training for a pilot's license. I am also a scholar in a humanities field, which requires extensive travel internationally and in consequence, I've always followed closely NTSB inquiries into airline accidents. After reading your e-mail on Feb.12 (NASA press-release) re: potential damage to the LMG tires, and probable consequential sequence of events, even of a catastrophic level due to earlier substantial breach of wheel well (81sec.of launch - foam fragment damages left wing/ shuttle skin, exposing it to plasma at re-entry) I have spent the last few days intensively analyzing available data on the shuttle tragedy and archival material from the NTSB web-site re: tire-damage related accidents. At this time, the only analogy, that I can offer, though somewhat far-fetched, is the disastrous take-off of the Air France Concorde supersonic jet on July 25, 2000. I have included below a few excerpts from press-releases re: Concorde crash, that I thought you might find interesting, in support of your theory and the scenarios you presented in your analysis. As a researcher I wish to bring this information to your attention (my comments are italicized), since you have displayed such concern and expertise in this subject:

1) excerpt after ABC News (July 30, 2000): "Concorde supersonic jets had at least a dozen blown tire incidents before the crash of an Air France Concorde earlier this week, according to safety reports obtained by ABCNews.com from U.S. aviation agencies and accounts by British Airways. Evidence released Friday by French authorities suggests a tire blowout during takeoff of the Air France Concorde at Paris' Charles de Gaulle airport **initiated a sequence of events** that led to the crash Tuesday (...). (*I'm aware that there's a major difference here: tire blow-out at Concorde's take-off, max. cruising speed inflight - Mach 2, while Columbia was traveling at Mach 23 at an altitude of 231,304 ft upon landfall at California coast, RMC)*

Debris from a blown tire can rupture fuel tanks and fuel lines and be sucked into engines, which are uniquely located above the open landing gear on a Concorde.(...) *(the engine & fuel tanks on the shuttle are located well behind and above the wheel well, although in close*

Daugh.-137

proximity to it and to the hydraulic lines, electrical wiring...etc., RMC)

French authorities said Friday they believe one tire and possibly two burst as the Concorde was accelerating down the runway.(...) But a ruptured tire on a Concorde can be especially serious, experts say, because of the aircraft's unique design, which allows it to cruise at twice the speed of sound.(...)The most serious incident occurred at Washington's Dulles International Airport in **June 1979, when two tires blew out on the left landing gear (!)**. Debris punctured three fuel tanks, **severed hydraulic lines and electrical wires (!)** (*emphasis added, RMC*), and damaged the No. 2 engine. Fuel poured out of the wing, but didn't catch fire. http://abcnews.go.com/sections/world/DailyNews/concordesafety_000729.html

2) excerpt after BBC News.com (July 28, 2000): "Concorde has experienced "**potentially catastrophic" problems with tyres** prior to Tuesday's fatal crash, according to US safety officials.(...) In Washington, the National Transportation Safety Board (NTSB) has released details of four incidents in which Air France Concordes blew tyres on take-off.(...) In 1981, the NTSB said that in June 1979 an Air France Concorde experienced blow-outs of tyres numbers five and six on the left-hand side while taking off from Washington's Dulles Airport. **Tyre debris and wheel shrapnel, it said, resulted in damage to number two engine, the puncture of three fuel tanks and the severance of several hydraulic and electrical wires. A large hole was also torn in the skin of the top wing." (!)** (*emphasis added, RMC*)http://news.bbc.co.uk/1/hi/world/europe/856173.stm

3) excerpt from safe-skies.com (Sept. 1, 2002): "The July 25 accident shows that the **destruction of a tire**, an event that we cannot say will not recur, **had catastrophic consequences in a short period of time, preventing the crew from rectifying the situation**. UN-grounding the Concorde will be difficult!" http://www.safe-skies.com/concorde_crash.htm *(There was nothing that the Columbia crew could have done had they been aware of this last-minute potentially fatal danger, but how can we continue to resign shuttle crews to such helplessness?)*

In terms of Columbia's tires: we know, thusfar, that one of its radial tires has been recovered near Hemphill, Texas as confirmed by NASA. Has it been determined which of the shuttle's tires was found and if the incurred damage was the result of a rupture inflight, or as a result of impact when it fell to the ground?

Mr. Daugherty, I appreciate your patience in reviewing this communication from a concerned, but keen observer. I am still dealing with the extreme grief I feel over this terrible loss and I wish I could do more to help in the investigative process. I've also been tuning in daily to NASA briefings and those of CAIB. Please feel free to call on me or to forward this information to the appropriate individuals at NASA. Sometimes, the observations of an outsider can bring some relevance or validity to issues at hand. It is my constant prayer that the future will bring more thorough preventive measures for shuttle crew safety and concrete escape contingency plans for the crew in event of any type of safety breach. The latter should, in my opinion, be of utmost importance to address and resolve (whatever the monetary cost involved), before the next manned-shuttle mission takes flight. It is unacceptable, in my opinion, to send people into space, who are willing to risk their lives, without the possibility of giving them realistic options for survival (e.g. reaching a safe bailout altitude; ejections seats...etc.) when faced with such danger as was the experience of the unforgettable Columbia Seven.

God bless you and your colleagues. Godspeed with the investigation!

Thank you again for your work and please stay in touch, if possible.

Respectfully yours,

[redacted]

Intellectual Property Coordinator
Legal Department
[redacted]
E-mail: [redacted]
Direct dial: [redacted]

--
Mark J. Shuart, PhD
Director for Structures & Materials
NASA Langely Research Center
Hampton, VA 23681

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>,
"ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)" <alan.r.rocha@nasa.gov>
Subject: FW: Door RMLG found
Date: Wed, 19 Feb 2003 09:32:15 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: Hoffman, Thomas L [mailto:Thomas.L.Hoffman@boeing.com]
Sent: Wednesday, February 19, 2003 9:15 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Door RMLG found

[redacted]

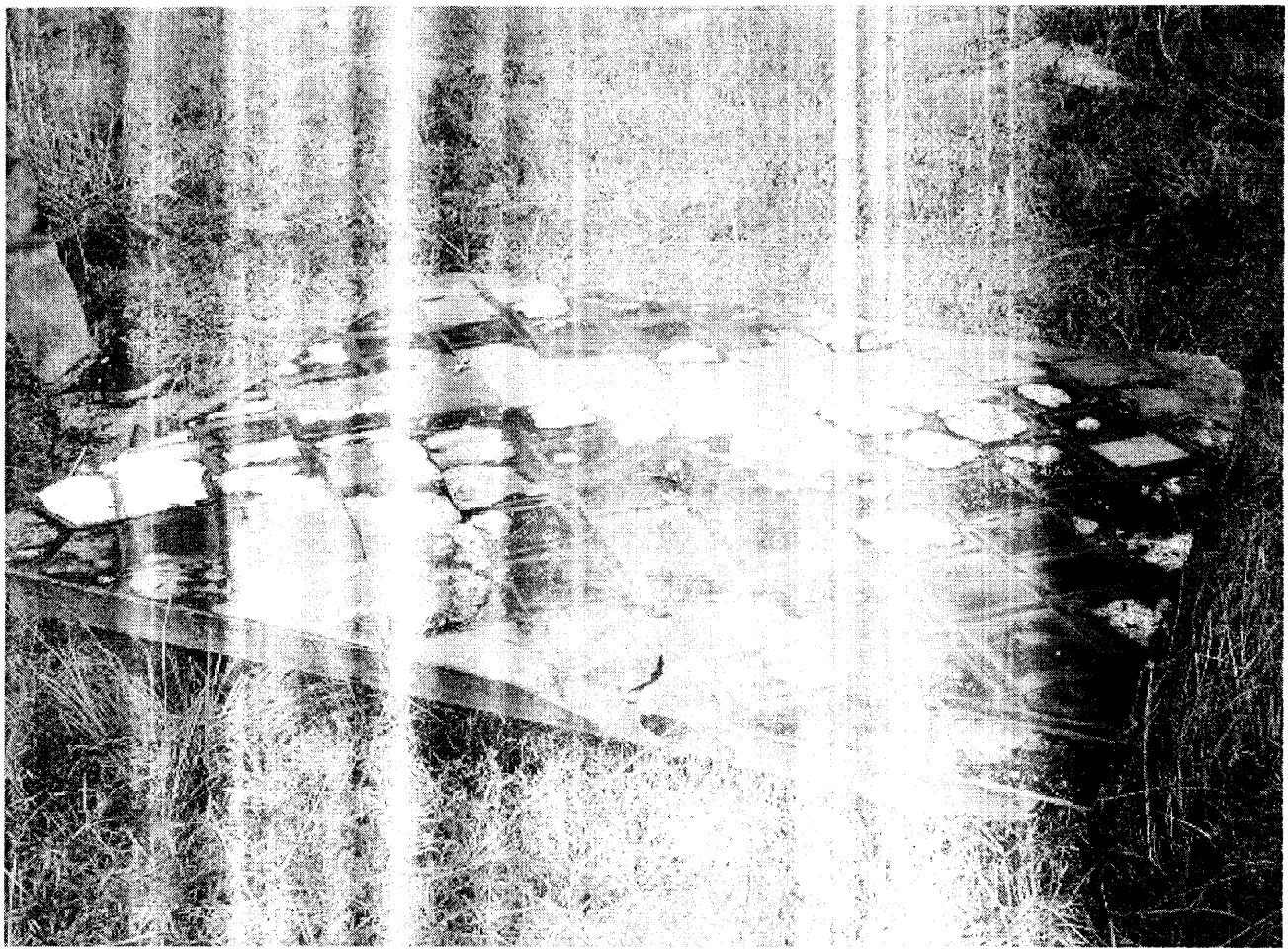
Tom Hoffman
Boeing Subsystem Manager
Landing/Deceleration System
Orbiter Vehicle Engineering
(281) 853-1638

<<jsc2003e03926_nr.jpg>>

jsc2003e03926_nr.jpg

Daugh. - 139

jsc[illegible] 03e03926_nr.jpg (640x480x1[illegible] jpeg)



From: "BARRY, JOHN (JSC-MA) (NASA)" <john.barry-1@nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Cc: M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov
Subject: RE: Revision Of Daugherty's ALDF Timeline Document
Date: Wed, 19 Feb 2003 12:20:05 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Bob--thanks. Got it.

JB

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: Wednesday, February 19, 2003 8:20 AM
To: BARRY, JOHN (JSC-MA) (NASA)
Cc: M.J.SHUART@larc.nasa.gov; H.M.ADELMAN@larc.nasa.gov
Subject: Revision Of Daugherty's ALDF Timeline Document

General Barry,

It was my pleasure to speak with you yesterday evening. As you recall, at the very beginning of our conversation I mentioned that as I read over the timeline document I had prepared earlier, it struck me that an email I had remembered writing (though its existence was listed in the timeline) had not actually been reproduced in the package. I've added that email into this revised document. It is on page 21 of the document and is a note I sent to my Director for Structures with some comments to update him on how it seemed "things" were going regarding the simulations we thought were important.

Please feel free to contact me at any time at my office number [redacted] 757-864-1309 or my cell phone number [redacted]. I look forward to assisting the Board in any way possible.

Best Regards,
Bob Daugherty

FOIA Exemption (b)(6)

Daugh.-140

-----Original Message-----
From: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA) [mailto:carlisle.c.campbell@nasa.gov]
Sent: Wednesday, February 19, 2003 12:33 PM
To: Hoffman, Thomas L; Porter, Michael T; 'Les Boatright'; 'Don Schiffleger'; Goodmark, Jeffrey A; ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA); 'Bob Daugherty'
Cc: ROGERS, JOSEPH E. (JOE) (JSC-ES2) (NASA)
Subject: FW: Landing Gear

Daugherty and I were looking at this and it may be revealing. Go back and look at photo #10 in this series. I believe that this will give us a great clue as to whether or not the gear was up and locked in place while the high rate heating/melting was occurring. Look at the melt pattern on the lower torque arm boss/sleeve and on the wheel speed sensor wire hole boss. (The "sag" in the torque arm boss was machined there originally). Could the gear have been up during high melting rates?

CCC

-----Original Message-----
From: Porter, Michael T [mailto:michael.t.porter@boeing.com]
Sent: Friday, February 14, 2003 12:01 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA); Hoffman, Thomas L
Subject: FW: Landing Gear

-----Original Message-----
From: Collins, Thomas E
Sent: 14 February, 2003 7:38 AM
To: Porter, Michael T
Subject: Landing Gear

I would like to talk to you about this.

Thomas E. Collins
Orbiter M&PE Subsystem Manager
Boeing HSF&E
(714)372-5195

To: Marny Skora <m.m.skora@larc.nasa.gov>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Re: Fwd: Per your request
Cc:
Bcc:
Attached:

Thx Marny.
Take care,
Bob

At 03:41 PM 2/19/2003, you wrote:
Date: Fri, 14 Feb 2003 10:51:05 -0500
To: mbraukus@mail.hq.nasa.gov
From: Marny Skora <m.m.skora@larc.nasa.gov>
Subject: Per your request
Cc:
Bcc:
X-Attachments: :Macintosh HD:432448:Interview with Bob Daugherty to:

See e-mail # Daugh-148 for - Attachment

--

****
Marny Skora
Head, Office of Public Affairs
NASA Langley Research Center
Mail Stop 115, Bldg 1219, Rm 303
11 Langley Blvd.
Hampton, VA 23681
(757) 864-6121

To: john.barry-1@nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Revision Of Daugherty's ALDF Timeline Document
Cc: M.J.SHUART@LaRC.NASA.GOV, H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\r.h.daugherty\My Documents\Bobs Work\Orbiter\Columbia Accident\ALDF Timeline_Rev A.doc;

General Barry,

It was my pleasure to speak with you yesterday evening. As you recall, at the very beginning of our conversation I mentioned that as I read over the timeline document I had prepared earlier, it struck me that an email I had remembered writing (though its existence was listed in the timeline) had not actually been reproduced in the package. I've added that email into this revised document. It is on page 21 of the document and is a note I sent to my Director for Structures with some comments to update him on how it seemed "things" were going regarding the simulations we thought were important.

Please feel free to contact me at any time at my office number 757-864-1309 [redacted] my cell phone number [redacted] I look forward to assisting the Board in any way possible.

Best Regards,
Bob Daugherty

FOIA Exemption (b)(6)

Daugh. - 138

Timeline, Email Traffic, and Comments Regarding ALDF Personnel Involvement with STS 107 Columbia Flight

Revision A...included Jan 29 email to Shuart ...listed but failed to copy email itself into document...pg 21

Bob Daugherty

January 27, 2003 Monday

Received a telephone call from Carlisle Campbell at JSC...works for the engineering directorate in Mechanical Systems...involved with doors, hatches, landing gear, etc for the Orbiter. Have worked with Carlisle for almost 20 years on landing and tire-related issues. He asked if I had heard about the issue with foam debris impacting the orbiter during ascent and I replied I had not. He filled me in on the issue, and mentioned that "people" were talking about not knowing exactly where the impact location was on the bottom of the orbiter but that some people mentioned that the gear door might be a vulnerable place to get damaged because of the nature of the thermal seal there. He mentioned that there had been lots of analysis, that the analysis said they didn't think there was a safety of flight issue, but that the gear door was in the "predicted target zone" of the impact. He emailed me two powerpoint documents that discussed the analysis and showed the predicted impact area. He mentioned the fact that "people" were throwing around possible worst-case scenarios regarding landing with two flat tires. This was the main reason for talking to us since we have previously provided JSC and the simulation folks, years ago, with models for just such a landing (not for the reason of them failing due to thermal damage...but just for covering all the bases and not caring why they might be flat). It just so happened that this very week, the astronaut training session at the Ames VMS was occurring where we already were looking at the effects of landing with one tire flat (again, the reason for such was not important), and whether or not the second tire on the strut would fail due to overload. We have done a lot of work on a load-persistence model we developed here at Langley and that was being evaluated. The astronauts were also looking for ground handling techniques that could help prevent the second tire from failing if they had a single tire flat at touchdown. So Carlisle and I knew the simulation community was in a position to very easily and quickly simulate a landing with two flat tires. We discussed the fact that "orbiter management" had not approved such simulations...I can't say whether its because they hadn't yet been approached or they just didn't think it was appropriate since the analysis of the thermal damage did not suggest a safety of flight concern. We then got Howard Law , JSC, Guidance and Control simulation engineer on the phone who was at Ames helping to run the load-persistence testing and asked him about whether they could easily do the simulation we thought would be good to do (the two flat tires) since it is just good engineering practice to simulate anything you can to gather contingency information. We discussed what their simulations had shown during the load persistence runs where the second tire had failed and now you were sliding on two flat tires. We determined that at low speed they were not using our models for drag correctly so I went and got together some old model information for sliding on a dragging strut and faxed him a flow chart for that model out at Ames. We also discussed the fact that some people at JSC were of the opinion that acquiring more information and visualizing the damage area was a good thing to pursue and talked about the options regarding ground based telescopes, EVA's,

etc. This discussion was simply two engineers talking...nothing special since neither of us have any expertise in this area. He mentioned that at that point there were no plans to visualize the damage since the orbiter had no arm, an EVA is very difficult due to the location underneath and lack of hand-holds, and that some thought that ground based telescopes might not have the resolution needed for a good view. We agreed that we thought it made good engineering sense to visualize the damage but were of the opinion that since folks higher up than us were pressing that issue we would not stick our nose in their business...we were just two engineers talking amongst ourselves.

January 27, 2003 Monday

Received several emails from Campbell showing the powerpoint presentations on the tile damage, and a video of the impact of the debris taken from behind the left wing (impact itself hidden from view):
Email subject lines:

Date: Mon, 27 Jan 2003 14:04:04 : STS-107 Post-Launch Film Review - Day 1
Date: Mon, 27 Jan 2003 14:06:03 FW: STS-107 Debris Briefing for MMT
Date: Mon, 27 Jan 2003 14:14:10 FW: STS-107 Debris Analysis Team Meeting
Date: Mon, 27 Jan 2003 14:16:52 FW: STS-107 Wing Debris Impact on Ascent: Final analysis case completed

I then watched the video and replied with the following email:
Date: Mon, 27 Jan 2003 4:35 Video you sent

Carlisle then replied with the following email:
Date: Mon, 27 Jan 2003 15:59:53 FW: Video you sent

Faxed the dragging strut model to Howard Law on the same day Jan 27, 2003 late in the afternoon.

January 28, 2003 Tuesday

I sent the following email to Campbell:
Date: Tue, 28 Jan 2003 1:38 pm Tile Damage

I sent the following email to Mark Shuart to inform him of what was going on after he called me to inquire regarding things he had heard:
Date: Tue, 28 Jan 2003 2:15 pm Foam and Tile

And Carlisle replied with the following email:
Date: Tue, 28 Jan 2003 13:29:58 RE: Tile Damage

January 29, 2003 Wednesday

Had a three way telephone call with Carlisle Campbell and Howard Law and other folks at Ames VMS to discuss progress on the load-persistence simulations. After that we asked if Howard Law had been officially "asked" or "cleared" to do any simulations to support getting some "background" information in the simulator regarding what might happen if one were to land with two flat tires. Nobody had ever expressed any knowledge that the main gear door was actually involved in the damage area but we just felt that we should do everything we could to get as much info as possible to cover as many bases as possible.

I sent the following email to Mark Shuart to inform him of what was going on:
Date: Wed, 29 Jan 2003 3:51 pm Tile Damage Update

January 30, 2003 Thursday

In late afternoon I had a telephone conversation with Campbell who mentioned that they had been in a Landing Gear PRT (Problem Resolution Team?) meeting...this is a normal meeting not related to the issue at hand, I don't believe. They have them probably weekly whether they're flying or not I think. Apparently there were some comments by the Mission Operations folks about the thermal issue and them having to do some talking about making sure they had as many contingency plans figured out as possible since everybody wants to be ready for anything. Since Carlisle and I had been talking, we discussed as many bad things regarding the main gear as we could think of and it became apparent to me after doing some calculations that if the tires failed in the wheel well the door would be blown off and there could be big problems. Other things we discussed were the pyros that help deployment as a backup...etc. I asked Carlisle if he thought it was appropriate to voice these scenarios to MOD guys and he agreed it was a good thing so that we felt like we had done our best job or helping the system not let some worst-case scenarios slip thru the cracks.

I sent the following email to David Lechner at JSC (he's associated with the Mission Operations Directorate (MOD) and we've worked together often)

Date: Thurs, 30 Jan 2003 6:22 pm Main Gear Breach Concerns

January 31, 2003 Friday

I received a telephone call from David Lechner thanking me for voicing the scenarios in the email and he said they were having all kinds of discussions about being ready for various contingencies so that they would be ready to advise the Mission Management Team if necessary for them to make any decisions they may have to during entry. I can't speak for David, but I had no actual concern that anything disastrous would occur. We discussed a belly landing at length and why that apparently is considered to be a loss-of vehicle event.

I received the following email from David Lechner in response to my email the night before:

Date: Fri, 31 Jan 2003 12:17:34 RE: Main Gear Breach Concerns

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Post-Launch Film Review - Day 1
Date: Mon, 27 Jan 2003 14:04:04 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----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

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

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

107film1.pdf

E212.mpg

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Debris Briefing for MMT
Date: Mon, 27 Jan 2003 14:06:03 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Friday, January 24, 2003 10:32 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA); RICHART, JENE A. (JSC-MS2) (NASA)
Cc: MADDEN, CHRISTOPHER B. (CHRIS) (JSC-ES3) (NASA)
Subject: FW: STS-107 Debris Briefing for MMT

Here is the Orbiter thermal/stress assessment. I do not have the system integration (Carlos Ortiz/Boeing) debris trajectory analysis charts yet. Both were presented to MER team and MMT this morning. There is good potential for tile replacement and maybe local overheating of structure, but no burn-through. Though the assessment states, so far, that no safety of flight issues exist, there is open work on one more case, the MLG Door tiles. The MER team understood this open work, but in my opinion the MMT with Linda Ham did not get the full message of open work remaining.

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: 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
877 497-0336 pager
8774970336@archwireless.net
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)
(281)-621-1924 (Pager)

Debris.ppt

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Debris Analysis Team Meeting
Date: Mon, 27 Jan 2003 14:14:10 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

-----Original Message-----
From: ROCHA, ALAN R. (RODNEY) (JSC-ES2) (NASA)
Sent: Thursday, January 23, 2003 7:59 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
Pager: 877-254-8252
(I can receive a short alpha numeric page by addressing e-mail to:
877-254-8252@archwireless.net)

-----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: 281-282-4453
Pager: 877-254-8252
(I can receive a short alpha numeric page by addressing e-mail to:
877-254-8252@archwireless.net)

STS-107 Preliminary Debris Assessment - rev2.ppt

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case com
pleted
Date: Mon, 27 Jan 2003 14:16:52 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

> -----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 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)
> 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
>
>

Aircraft Landing Dynamics Facility
Langley Research Center
Hampton, VA 23681-2199

FACSIMILE TRANSMISSION

TO: Howard Law
FAX NUMBER: 650 604 7484
TELEPHONE NUMBER:
LOCATION:

FROM:
TELEPHONE NUMBER: (757)
FAX NUMBER: (757) 864-8090

COMMENTS: DRAGGING STRUT
MODEL — FLOW CHART —
COULDN'T FIND PLOT

Number of pages including lead: 6

Signature: Bob D Date: 1/27/03

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia
23665

NASA

Reply to Attn of 497

TO: NASA Johnson Space Center
Attn: VA/Richard Colonna, Manager, STS
Orbiter and GFE Projects Office

FROM: 497/Aerospace Technologist, Impact Dynamics Branch, SDD

SUBJECT: Results of Roll-on-Rim Capability Tests

A series of tests have been completed at the Langley Research Center's Aircraft Landing Dynamics Facility (ALDF) to determine the roll-on-rim capability of the Orbiter main wheel. Both a standard flight wheel inner half and a modified inner wheel half were tested. In addition, data were gathered to identify the behavior of a deflated tire during and after touchdown. This information is helpful in simulating a landing if a tire has deflated in orbit, a highly unlikely condition.

Because of the vertical load capability of the ALDF, only inner wheel halves were tested to identify their failure modes. This allowed full-scale loads to be applied to the wheel bead flanges. In our opinion, this testing mode does not compromise the validity of the results.

A standard flight wheel had previously been rolled on the B.F. Goodrich dynamometer wheel at rated load and at a speed of approximately 10 mph. It developed a crack and lost a small portion of bead flange after about 4,000 ft. and the test was stopped. The dynamometer surface was smooth steel. A similar test was conducted at the ALDF with a standard inner wheel half loaded to half the rated load. The surface was a simulated KSC runway. After about 650 ft., a portion of the bead flange failed and during the next revolution, the wheel half completely collapsed.

The first high-speed test involved landing a standard inner wheel half and observing its behavior. The wheel half was landed at a sink rate of 2.6 ft./sec. and forward speed of 150 kts. A rubber strap was attached to the wheel to facilitate spin-up and minimize wheel spin-up damage. Vertical load was about 25,000 lb. during this test. During spin-up and within the first 25 ft. of roll, the bead flange zippered off in 4 in. pieces. Ten feet later, the bead seat flange area and tube well disintegrated. Down load buffers, which limited travel of the drop test carriage, prevented the load from being applied to the wheel center section following wheel flange failure.

The next test was run to examine what benefit could be gained by using an inner wheel half with a much stronger bead flange (at a weight penalty of about 4 lbs. per inner wheel half). Touchdown conditions on this wheel half were 157 kts. groundspeed and 2.8 fps sink rate. This wheel survived spin-up and was loaded to about 65,000 lb. After about 130 ft., the wheel half disintegrated. Rolling resistance during this test was 5 percent of wheel vertical load.

The next test was designed to investigate the roll-on-center section capability of the wheel after the bead flanges and tube well have failed, but the center section did not spin-up and the wheel was skidded down the runway. The test speed was 159 kts. and the vertical load was about 70,000 lb. During the 450 ft. long slide, about 3 in. of wheel was worn away, and the friction coefficient was about .2.

The last test involved landing and rolling out on a tire deflated before the test to simulate a tire that has deflated in the wheel well either on the launch pad or in orbit. The conditions of this test included a ground speed of 157 kts. and a sink rate of 2.8 fps. Vertical load was maintained at 70,000 lb. The flat tire rolled approximately 1,050 ft. and produced a friction coefficient between .15 and .20. The tire disintegrated after a roll of 1,050 ft. Thereafter, the wheel rolled for 500 ft. on the intact beads that remained attached to the wheel. Rolling resistance while on the beads was .1.

These results indicate that no significant roll-on-rim capability is present in either the standard or modified inner wheel half. It appears that wheel failure at speeds of 160 kts. will undoubtedly result in some damage to the orbiter due to flying debris. Unfortunately, no method of predicting this damage is known. Most of the highest energy debris should be found in the 30-90 degree arc behind the wheel, with 90 degrees being vertical. Tire failure will result in the loss of large pieces of the 200 lb. tire, and prediction of these trajectories is also impossible.

A set of guidelines for predicting wheel failure along with an event flow chart is enclosed. Note that some of the events are only engineering judgments based on extremely limited test data.

It is assumed that some portion of this data along with the 1/3 scale skid results will be used to determine where to land the orbiter should a flat tire be detected in orbit. Although some damage to the orbiter is likely during a concrete runway landing with a flat tire, the unknown behavior of the tire and wheel on the lakebed surface during failure coupled with the lack of friction coefficient data on the lakebed surface at high bearing pressures is cause for concern. If flat tire lakebed landings are being considered, it is recommended that, at a minimum, tests be conducted at a lakebed site using a bare wheel loaded to 120,000 lb. using the towable load cart available at Edwards Air Force Base. If the wheel fails at low speed, then failure at high speed is almost certain. If the wheel simply digs in, then no information is gained as to high speed behavior. This test is inexpensive and capable of producing data that could help in the decision of where to land if an orbiter tire has lost pressure.

If you have any questions, feel free to contact Sandy Stubbs or me at FTS 928-2796.

Robert H. Daugherty

Enclosures
Set of Guidelines
Flowchart

cc (w/o Encl.):
101/Files
118/SD
244/SDD
497/IDB
497/RHDaugherty

NASA JSC
CB/JCasper
ES4/BHolder
ES6/CCampbell
EH221/HLaw
GA/BDO'Connor

B. F. Goodrich Co.
Aerospace and Defense Div.
Attn: J. Warren
P.O. Box 340
Troy, OH 45373

Rockwell International
AC19/MPorter
12214 Lakewood Blvd.
Downey, CA 90241

GUIDELINES FOR SIMULATING TIRE FAILURES

DEFINITIONS:

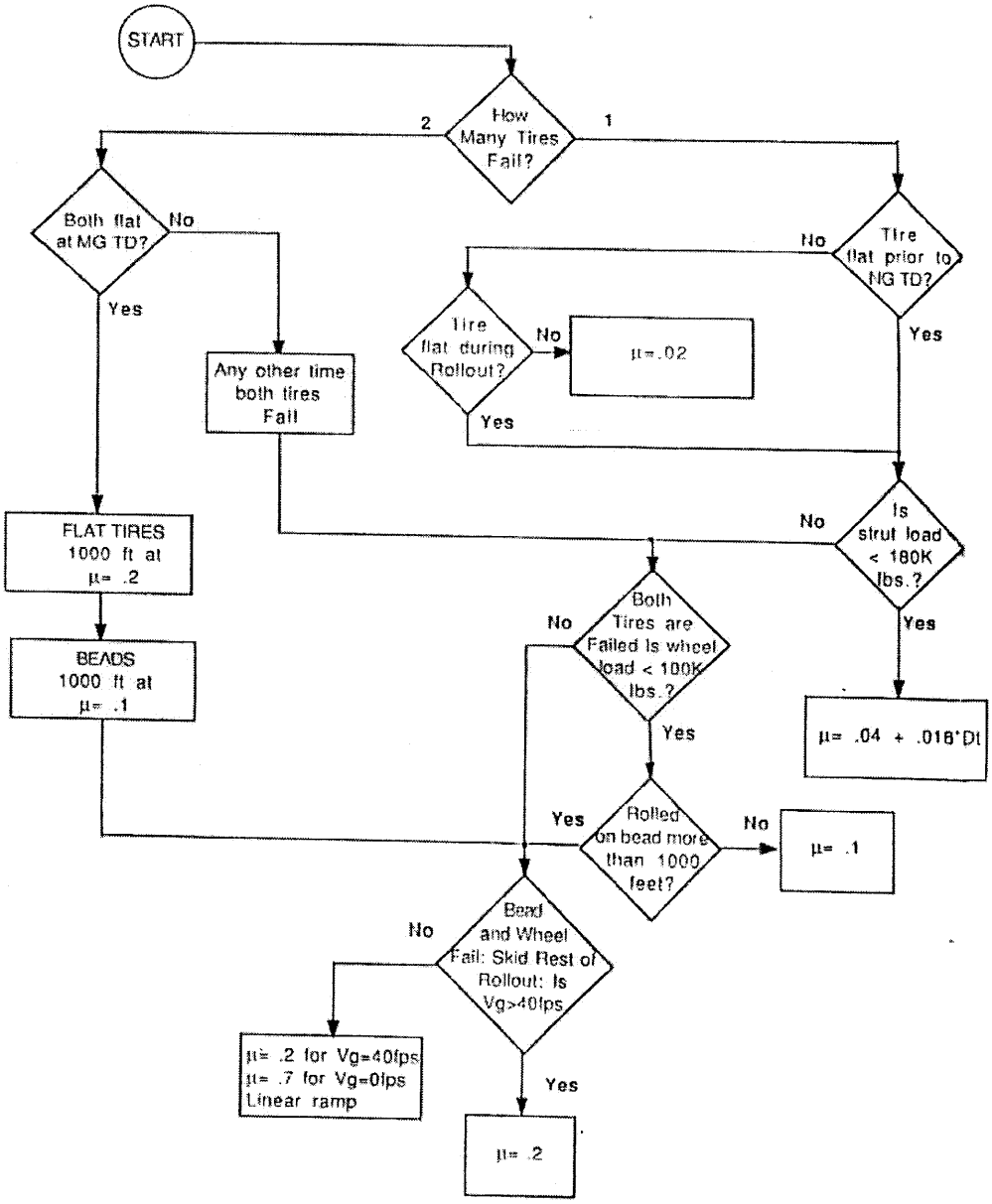
"GOOD" TIRE:	One that is inflated
"FLAT" TIRE:	One that has lost air but did not blow up due to overload
"FAILED" TIRE:	One that has : Blown up due to overload or Disintegrated due to flat tire roll.

1. Rolling on a "GOOD" TIRE: $\mu = .02$
2. Rolling on a "FLAT" TIRE: $\mu = .2$
3. Rolling on the bead: $\mu = .1$
4. Rolling on the rim flange or center section: $\mu = .05$
5. Skidding on center section, brake parts, axle, etc.: $\mu = .2$
6. Below about 40 fps, number 5 above ramps from $\mu = .2$ to $\mu = .7$ as speed approaches 0.

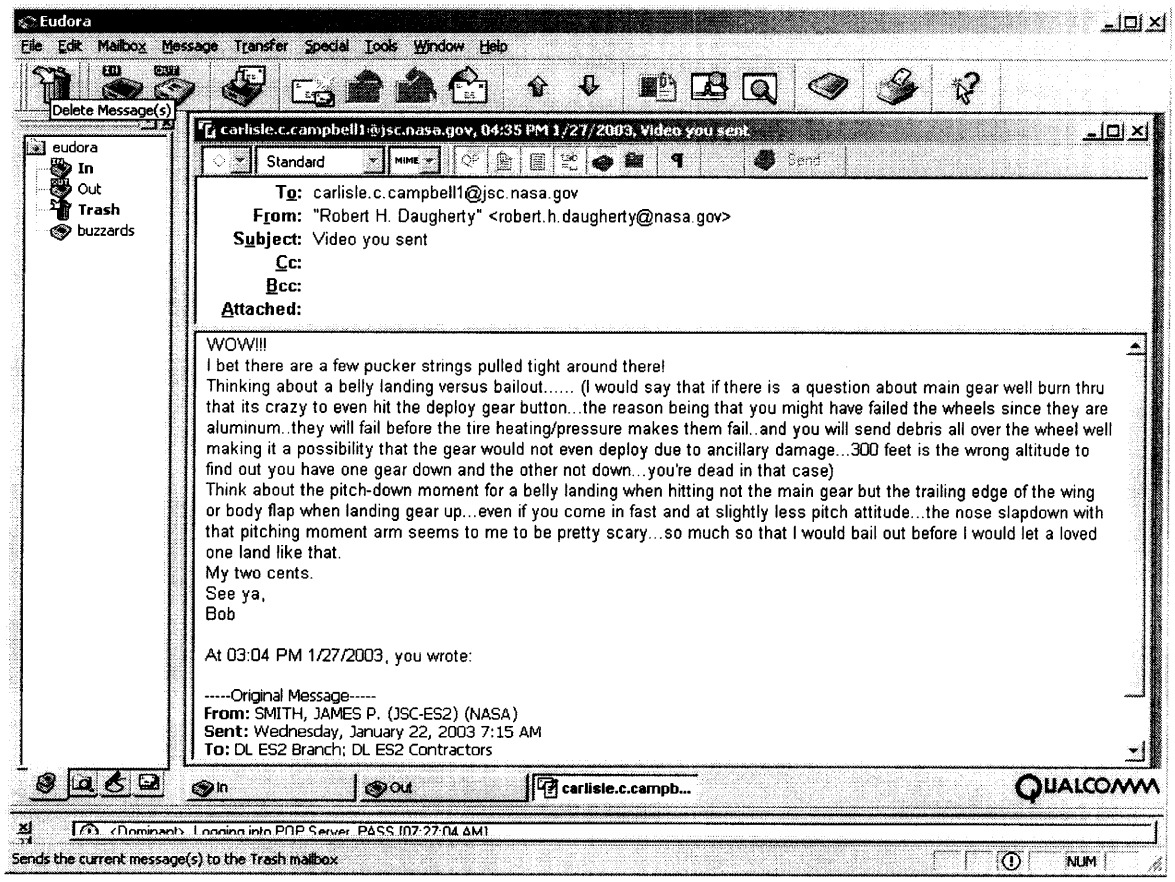
COMMENTS

NOTE: * indicates lower confidence than other comments

1. Flat tires can survive 1000' if loaded 70K or less.
2. Good tires loaded above 180K fail immediately.
3. *Failed tires roll on beads for 1000' if wheel loads are < 100K.
4. *If rolling on beads and wheel loads exceed 100K, then bead fails and rim flange breaks in 50'.
5. Center section may survive any length (flowchart assumes 0 length).
6. *For 1 good tire and 1 flat tire and strut load <180K then strut drag $\mu = .04 + .016 \times$ deflection of good tire.



Note: Dt = Deflection of good tire : should range from 0 to 10 in.


Eudora
File Edit Mailbox Message Transfer Special Tools Window Help
Delete Message(s)
eudora
In
Out
Trash
buzzards
carlisle.c.campbell1@jsc.nasa.gov, 04:35 PM 1/27/2003, Video you sent
Standard
To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <robert.h.daugherty@nasa.gov>
Subject: Video you sent
Cc:
Bcc:
Attached:
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
At 03:04 PM 1/27/2003, you wrote:
-----Original Message-----
From: SMITH, JAMES P. (JSC-ES2) (NASA)
Sent: Wednesday, January 22, 2003 7:15 AM
To: DL ES2 Branch; DL ES2 Contractors
In
Out
carlisle.c.campb...
QUALCOMM
Sends the current message(s) to the Trash mailbox
NUM

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Bob Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: FW: Video you sent
Date: Mon, 27 Jan 2003 15:59:53 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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.

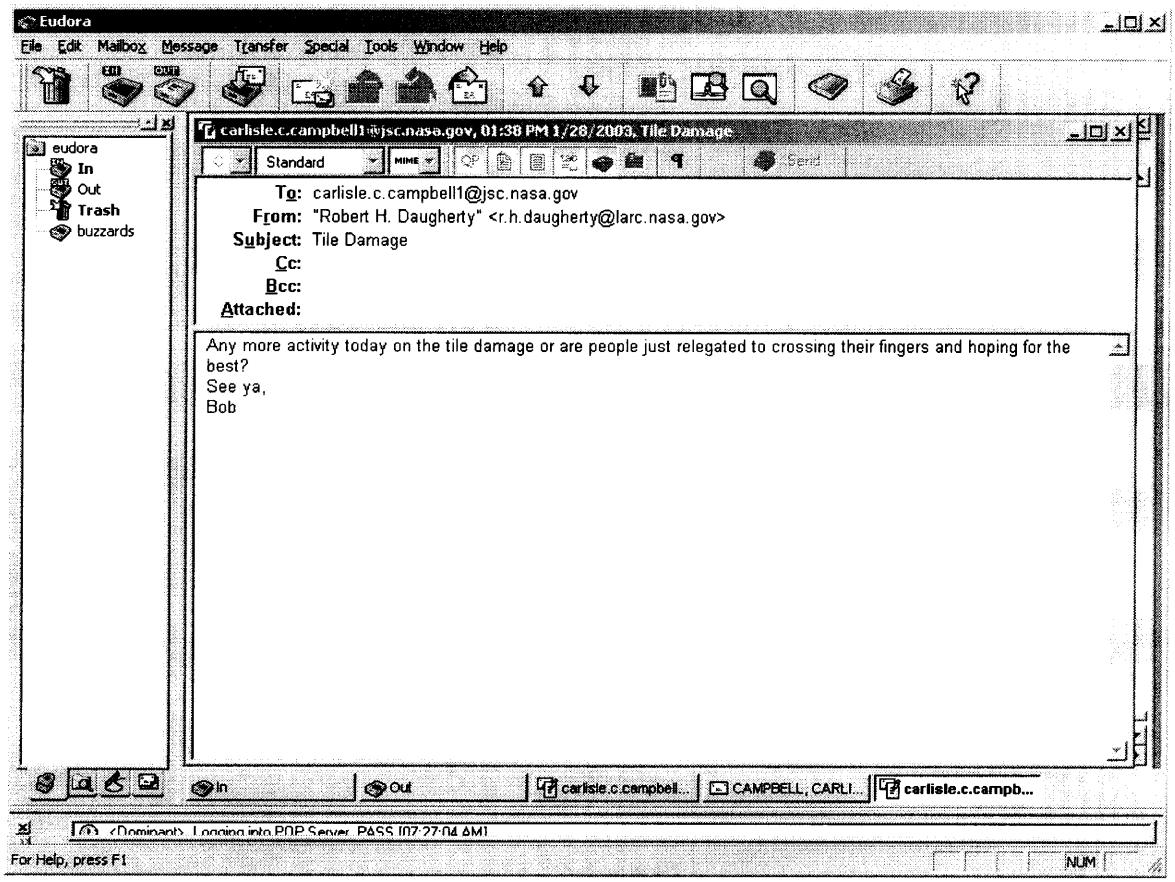
From: Robert H. Daugherty [mailto:robert.h.daugherty@nasa.gov]
Sent: Monday, January 27, 2003 3:35 PM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Video you sent

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

At 03:04 PM 1/27/2003, you wrote:

-----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.


Eudora
File Edit Mailbox Message Transfer Special Tools Window Help
eudora
In
Out
Trash
buzzards
carlisle.c.campbell1@jsc.nasa.gov, 01:38 PM 1/28/2003, Tile Damage
Standard
To: carlisle.c.campbell1@jsc.nasa.gov
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Tile Damage
Cc:
Bcc:
Attached:
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
In
Out
carlisle.c.campbell...
CAMPBELL, CARLI...
carlisle.c.campb...
For Help, press F1
NUM

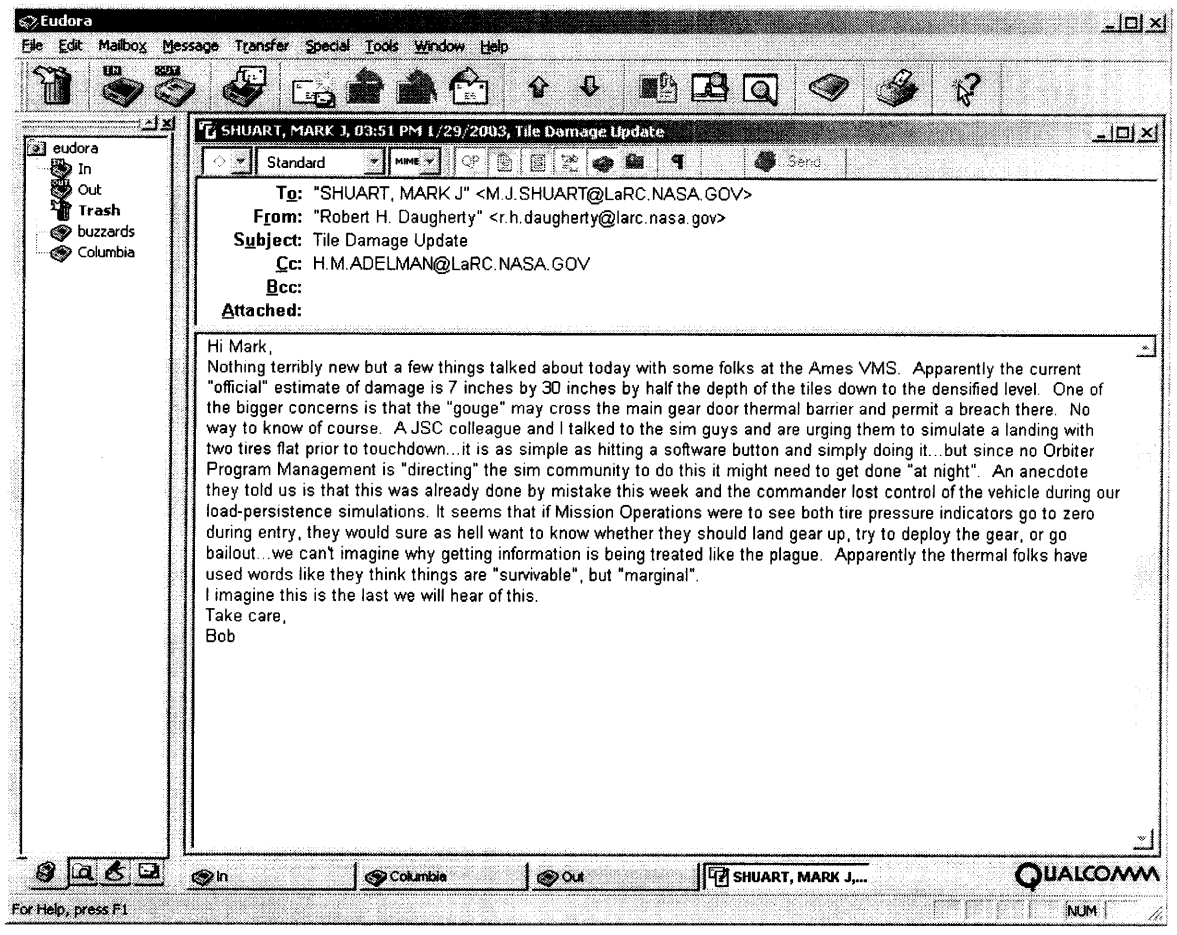
From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Subject: RE: Tile Damage
Date: Tue, 28 Jan 2003 13:29:58 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

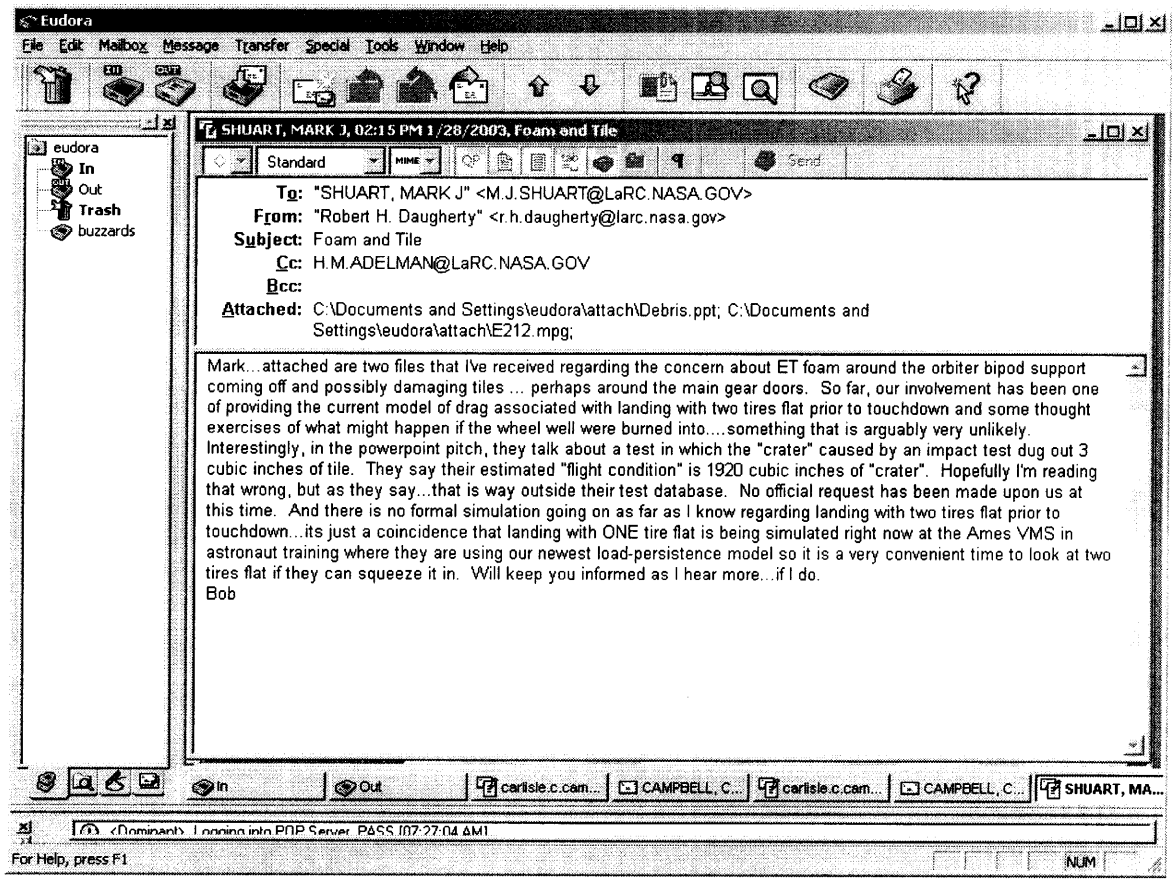
I have not heard anything new. I'll let you know if I do.

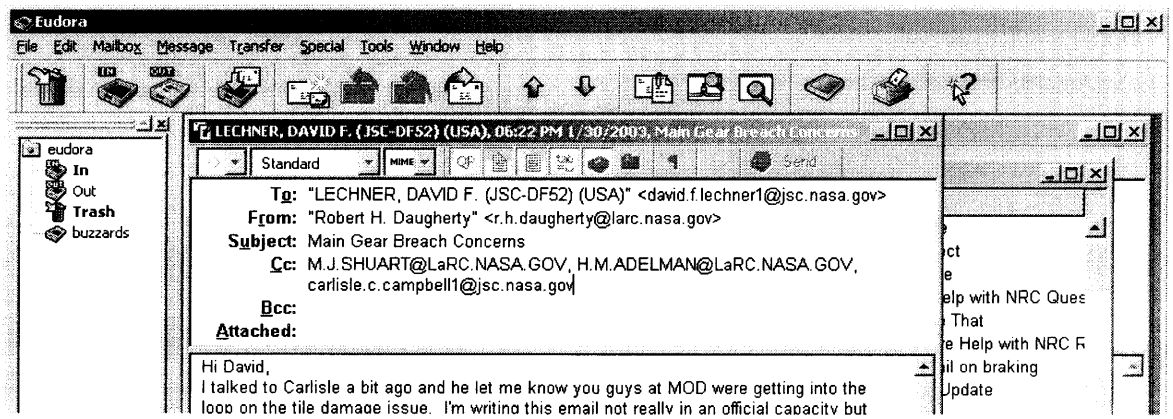
CCC

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.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




Eudora
File Edit Mailbox Message Transfer Special Tools Window Help
eudora
In
Out
Trash
buzzards
SHUART, MARK J, 02:15 PM 1/28/2003, Foam and Tile
Standard
Send
To: "SHUART, MARK J" <M.J.SHUART@LaRC.NASA.GOV>
From: "Robert H. Daugherty" <r.h.daugherty@larc.nasa.gov>
Subject: Foam and Tile
Cc: H.M.ADELMAN@LaRC.NASA.GOV
Bcc:
Attached: C:\Documents and Settings\eudora\attach\Debris.ppt; C:\Documents and Settings\eudora\attach\E212.mpg;
Mark...attached are two files that I've received regarding the concern about ET foam around the orbiter bipod support coming off and possibly damaging tiles ... perhaps around the main gear doors. So far, our involvement has been one of providing the current model of drag associated with landing with two tires flat prior to touchdown and some thought exercises of what might happen if the wheel well were burned into....something that is arguably very unlikely. Interestingly, in the powerpoint pitch, they talk about a test in which the "crater" caused by an impact test dug out 3 cubic inches of tile. They say their estimated "flight condition" is 1920 cubic inches of "crater". Hopefully I'm reading that wrong, but as they say...that is way outside their test database. No official request has been made upon us at this time. And there is no formal simulation going on as far as I know regarding landing with two tires flat prior to touchdown...its just a coincidence that landing with ONE tire flat is being simulated right now at the Ames VMS in astronaut training where they are using our newest load-persistence model so it is a very convenient time to look at two tires flat if they can squeeze it in. Will keep you informed as I hear more...if I do.
Bob
In
Out
carlisle.c.cam...
CAMPBELL, C...
carlisle.c.cam...
CAMPBELL, C...
SHUART, MA...
For Help, press F1
NUM



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 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 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

From: "LECHNER, DAVID F. (JSC-DF52) (USA)" <david.f.lechner1@jsc.nasa.gov>
To: "'Robert H. Daugherty'" <r.h.daugherty@larc.nasa.gov>
Cc: M.J.SHUART@larc.nasa.gov, H.M.ADELMAN@larc.nasa.gov,
"CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)"
<carlisle.c.campbell@nasa.gov>
Subject: RE: Main Gear Breach Concerns
Date: Fri, 31 Jan 2003 12:17:34 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

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
(281) 483-1685

-----Original Message-----
From: Robert H. Daugherty [mailto:r.h.daugherty@larc.nasa.gov]
Sent: Thursday, January 30, 2003 5:23 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 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 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 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

X-Sender: m.m.skora@express.larc.nasa.gov
Date: Wed, 19 Feb 2003 15:41:16 -0500
To: R.H.DAUGHERTY@larc.nasa.gov
From: Marny Skora <m.m.skora@larc.nasa.gov>
Subject: Fwd: Per your request

Date: Fri, 14 Feb 2003 10:51:05 -0500
To: mbraukus@mail.hq.nasa.gov
From: Marny Skora <m.m.skora@larc.nasa.gov>
Subject: Per your request
Cc:
Bcc:
X-Attachments: :Macintosh HD:432448:Interview with Bob Daugherty to:


Interview_with_Bob_Daugherty_to.doc

--

****

Marny Skora
Head, Office of Public Affairs
NASA Langley Research Center
Mail Stop 115, Bldg 1219, Rm 303
11 Langley Blvd.
Hampton, VA 23681
(757) 864-6121

Daugh. - 148

Interview with Bob Daugherty to clarify points in Jan. 30 e-mails

* . . . it might need to get done "at night."
  - •as engineers (JSC colleague and BD) thought the proposed situation – landing with two flat tires prior to touchdown -- important enough to get as much info as possible
  - •doing the simulation was easy to do
  - •BD didn't know what was involved in getting approval for the sim
  - •BD did know that one could not just jump in with a request in the middle of a planned day
  - •both engineers felt the sims "ought to be done, it was important, we ought to do it"
  - •agreed to run the sims "when and if you can" → at night
  - •BD doesn't know if the sim runs were requested officially or not

*Did the simulations take place?
  - •yes, several runs (4-6) took place Friday, Jan. 31
  - •results – very encouraging, showed that orbiter could make a successful landing with two flat tires

*. . . "we can't imagine why getting information is being treated like the plague."
  - •admits he is an expert only in tires/landing gear
  - •as a typical engineer, he believes that it is necessary to do exhaustive studies, to do everything possible to understand the magnitude of any situation

*Who is Howard Law?
  - •guidance and control engineer at JSC
  - •heavily involved in entry and landing simulations
  - •one of the "smartest guys BD has ever met"

*BD message
  - •does not want his e-mails to be couched as a warning
  - •believed landing with 2 flat tires was not right question
  - •e-mails presented his depiction of the worst case events that could help form the basis of contingency planning
  - •response from JSC – these are things that have already been addressed
  - •BD doesn't feel his e-mails were ignored

mms2/13/03