X-Sender: wbihner@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 28 Jan 2003 10:51:25 -0500
To: "Bryan O'connor" <boconnor@hq.nasa.gov>
From: Bill Bihner <wbihner@hq.nasa.gov>
Subject: Fwd: STS-107 Flight Day 12 Report
Cc: Pete Rutledge <prutledg@hq.nasa.gov>, James Lloyd <jlloyd@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>,
Pepper Phillips <pphillip@mail.hq.nasa.gov>

Bryan,

A new "assessment" on the potential for orbiter damage from ET foam loss. Bottom line is some orbiter structural damage predicted but no safety of flight issue based on this report. Will keep you posted.

Bill

From: SR&QA MER Console <SRQAMer@ems.jsc.nasa.gov>
To: "'srqa-mer listserver'" <SRQA-MER@vesuvius.jsc.nasa.gov>
Subject: STS-107 Flight Day 12 Report
Date: Tue, 28 Jan 2003 09:38:59 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

STS-107 Flight Day 12 Report
GMT 028:15:30

Shift Leads: David Witwer, Brandon Dick, Mike Etchells
Mission Engineer: Dan Zalit (OJT)

The STS-107 mission continues nominally in a 154 x 140 nm orbit with all Orbiter subsystems performing satisfactorily. No new Orbiter issues or anomalies have been reported in the previous 24 hours.

Our MER Manager released the following update on the debris hit on the left wing last during ascent. "Systems integration personnel performed a debris trajectory analysis to estimate the debris impact conditions and locations. This analysis was performed utilizing the reported observations from the ascent video and film. It was assumed that the debris was foam from the external tank. Based on the results of the trajectory analysis, an impact analysis was performed to assess the potential damage to the tile and reinforced carbon carbon (RCC). The impact analysis indicates the potential for a large damage area to the tile. Damage to the RCC should be limited to coating only and have no mission impact. Additionally, thermal analyses were performed for different locations and damage conditions. The damage conditions included one tile missing down to the densified layer of the tile and multiple tiles missing over an area of about 7 in by 30 in. These thermal analyses indicate possible localized structural damage but no burn-through, and no safety of flight issue."

Previous flight day reports discuss the eight MER anomalies listed below.

MER Anomalies:
MER-01 AC2 Phase B Sluggish Current Signature
MER-02 No ICOM B in Spacehab
MER-03 O2 Tank 7 Heater A Failed Off in Manual Mode (ORB)
MER-04 70MM Hasselblad Camera Motor Drive Binds/Jams (GFE)
MER-05 Suspect Fuel Cell Monitoring System (FCMS) Data Cable (GFE)
MER-06 Loss of DR20 Tape Recording and Playback (GFE)
MER-07 LH2 Prevalve Open B Indicator Failed Off
MER-07A MDM FA4 CD-08 CH-00 Has Intermittent Data Hits (ORB)
MER-08 70 mm Hasselblad Camera S/N 1012 Motor Drive Binds/Jams (GFE)

From: "CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)" <carlisle.c.campbell@nasa.gov>
To: "'boconnor'" <boconnor@hq.nasa.gov>
Subject: RE: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case completed
Date: Fri, 31 Jan 2003 09:06:08 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

We are doing great, but it's not like the good old days.

The LaRC Center Director plans to offer their help on this debris impact concern through Bill Readdy, I have heard. We don't have much time left if there is another issue

CCC.

-----Original Message-----
From: boconnor [mailto:boconnor@hq.nasa.gov]
Sent: Friday, January 31, 2003 5:30 AM
To: CAMPBELL, CARLISLE C., JR (JSC-ES2) (NASA)
Subject: Re: FW: STS-107 Wing Debris Impact on Ascent: Final analysis case com pleted

Carlysle,
Thanks for the info. I had heard a little bit of this, but I did not realize so much analysis was required.
How are you doing?
Best,

At 08:53 AM 1/30/2003 -0600, you wrote:
>Bryan,
>
>This is confidential, but I just wanted to be sure that you were aware of
>the potential landing gear door damage.
>
>Carlisle
>
> > -----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
> >
> >

O'C

Bryan O'Connor
Associate Administrator
Office of Safety and Mission Assurance

Mark Kowaleski, 09:10 AM 2/4/2003 -0500, If you need help...

X-Sender: mkowales@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 04 Feb 2003 09:10:10 -0500
To: boconnor@mail.hq.nasa.gov
From: Mark Kowaleski <mkowales@hq.nasa.gov>
Subject: If you need help...

Bryan,

I just wanted to let you know that if you needed someone to be by your side to assist you during your investigation that I am willing and able.

After Jim mentioned you were asking for a bunch of info I figured you could probably use somebody with you to get clutter off your radar screen. I can work in any capacity, even if it is just taking care of your logistics, taking notes, making up charts for you, whatever.

Yesterday at the SMA telecon we got into heated discussion about crew escape. Some of the Boeing escape concepts showed descent effectivity as high 210K feet, but I really had to argue to get most folks to even consider the possibility of crew escape. I replayed in my mind the not-so-warm response I got from the Shuttle Program after I gave the crew escape and M/OD repair capabilty pitch at the SLEP Kick-off meeting. It bothered me so much I shed a tear over it.

As the Board's plans unfold, count me in if you need/want my support. I need to contribute to this.

I hope all is well for you during this difficult time.

Sincerely,

Mark

X-Sender: a.h.phillips@pop.larc.nasa.gov
Date: Fri, 14 Feb 2003 12:51:21 -0500
To: "Pamela F. Richardson" <Pamela.Richardson@hq.nasa.gov>
From: "Alan H. Phillips" <a.h.phillips@larc.nasa.gov>
Subject: Fwd: Euler solutions-Section 6 Removed
Cc: "Peter J. Rutledge" <prutledg@mail.hq.nasa.gov>,
Jim Lloyd <Jlloyd@hq.nasa.gov>

Some CFD results that LaRC is performing in support of JSC investigation activities.

Alan

Date: Thu, 13 Feb 2003 08:26:24 -0500
To: jose.m.caram@nasa.gov, charles.h.campbell@jsc.nasa.gov
From: Charles Miller <c.g.miller@larc.nasa.gov>
Subject: Euler solutions-Section 6 Removed
Cc: "SAUNDERS, MARK P" <M.P.SAUNDERS@larc.nasa.gov>,
"PHILLIPS, ALAN H" <A.H.PHILLIPS@larc.nasa.gov>

Joe and Chuck

The attachment contains Euler solutions performed by Karen Bibb in support of the aerodynamic effort, but may be of keen interest to the aerothermodynamic folks as well. These predictions will be discussed along with Tom Horvath's material which will be sent to you shortly.

Thanks

Charles

FELISA-aeroThermo-2003-02-1.ppt

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Alan H. Phillips
Director, Office of Safety and Mission Assurance
NASA Langley Research Center
5A Hunsaker Loop
Building 1162, Room 112C
Mail Stop 421
Hampton, VA 23681

(757)864-3361 Voice
(757)864-6327 Fax
****

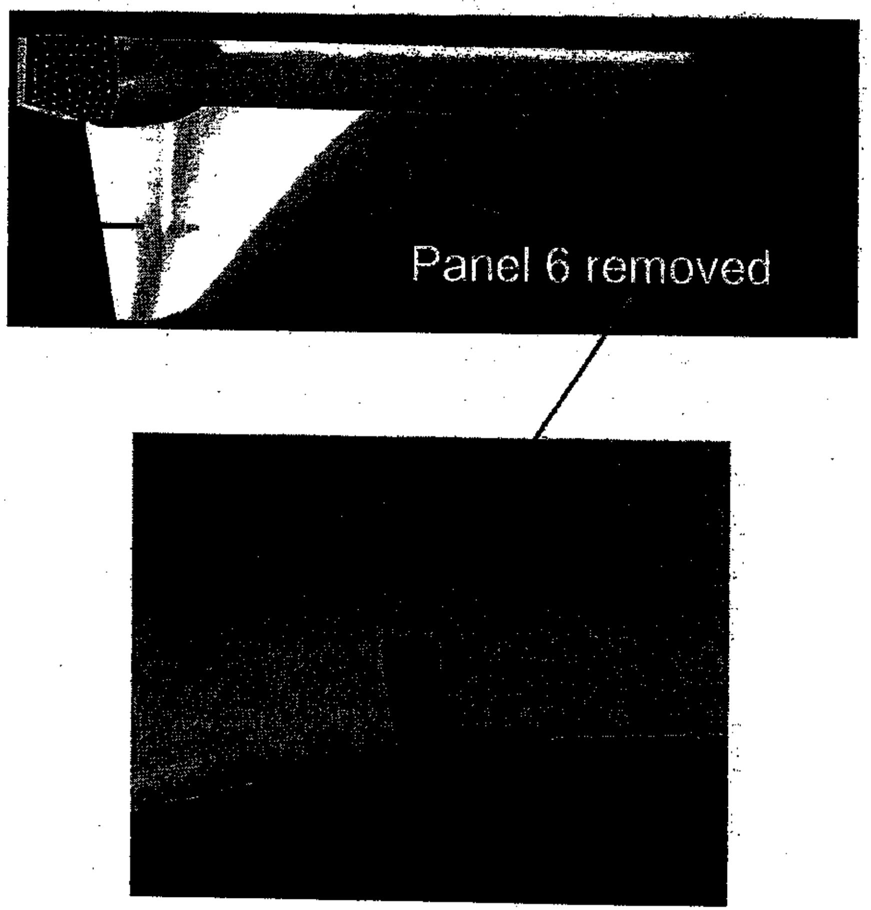
Wing Leading Edge Damage
Inviscid CFD

February 13, 2003

LaRC Aero Team

Analysis Scenario

- Utilize existing computational model of shuttle
- Simulate damage by “removing” panel 6
- Looking for ***qualitative*** aerodynamic effect and flowfield characteristics



Geometry, Meshes, and CFD Methods

- Basline Geometry
  - Built on LAURA structured mesh, via GridTool
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  - Simplified wing tip, base region
  - No control deflections
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  - Lines projected vertically down onto geometry, and removed.
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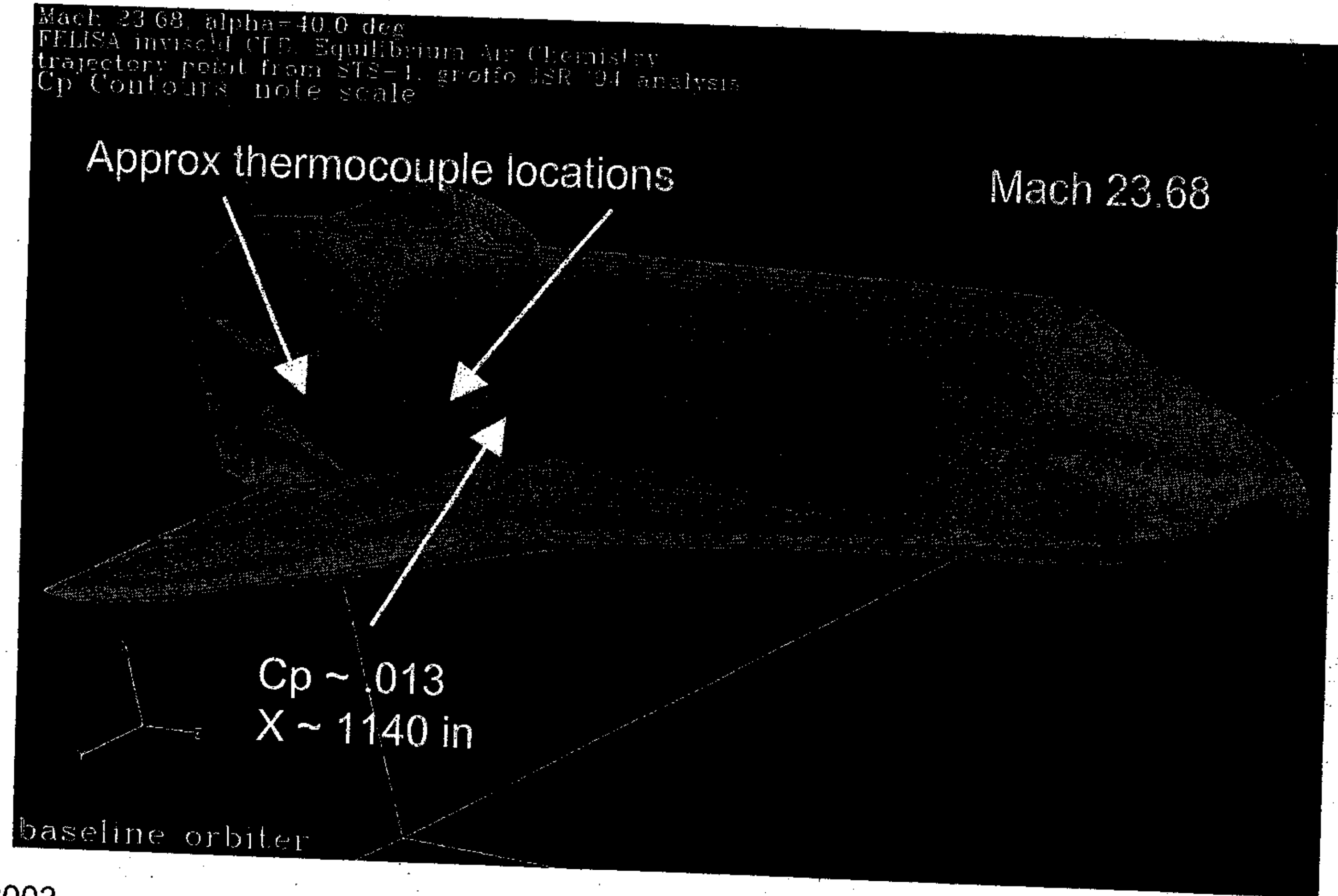
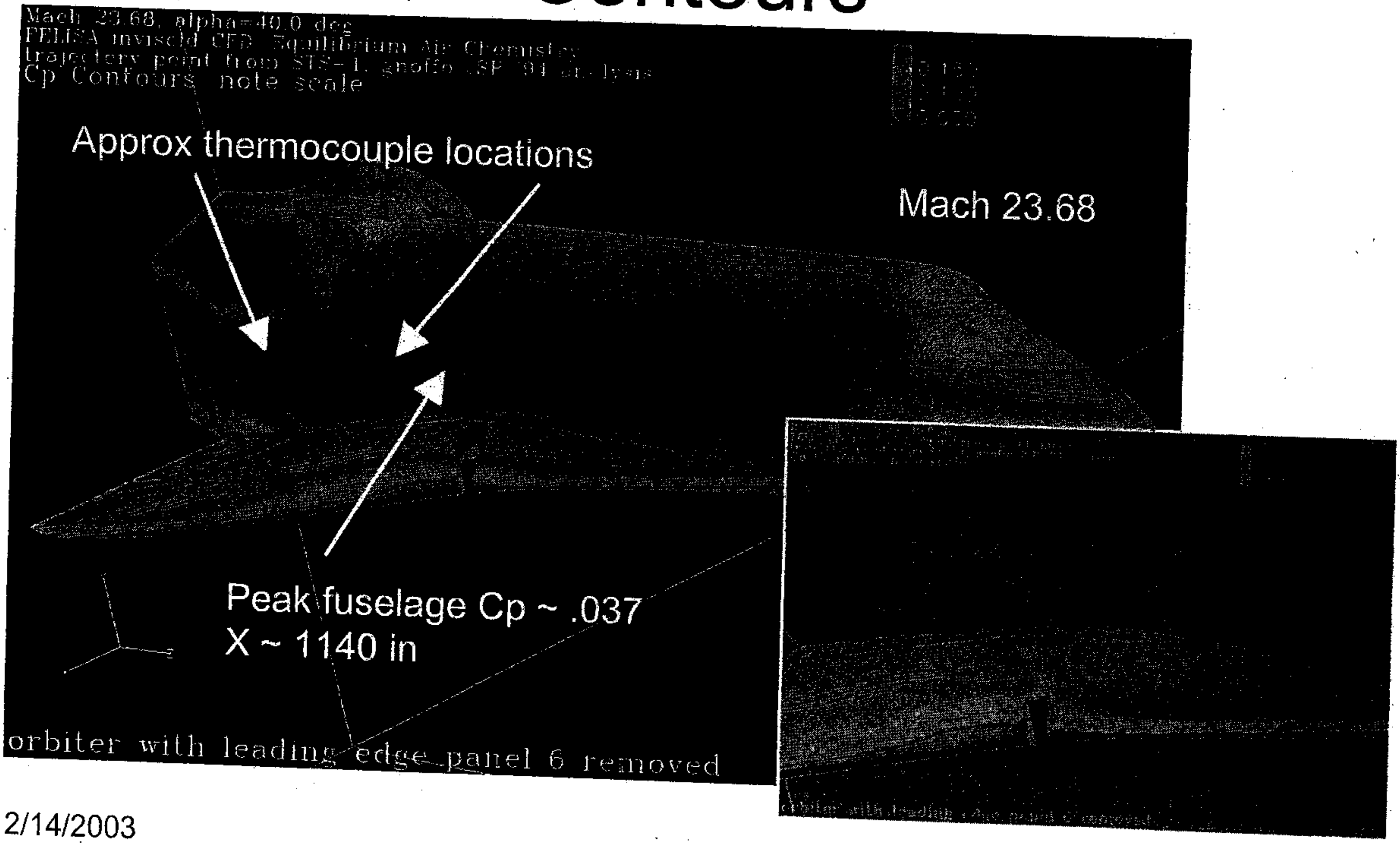
    - Issue with how well complex flow is handled
  - Equilibrium Air Chemistry
- 2 conditions, alpha = 40 deg.
  - from Gnoffo, et. al., JSR '94
  - Mach 23.68, STS-1
  - Mach 18.07, STS-2

Baseline Orbiter, Cp contours



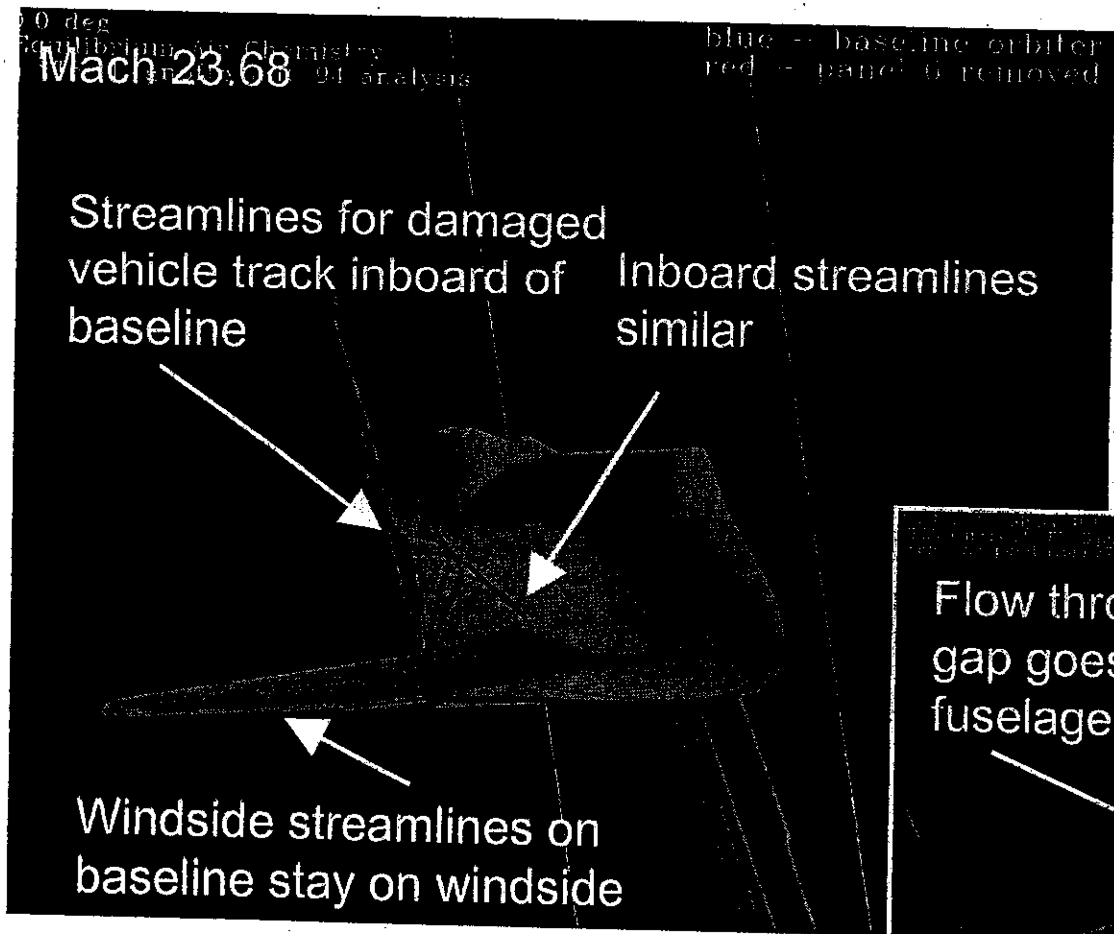
2/14/2003
K. Bibb

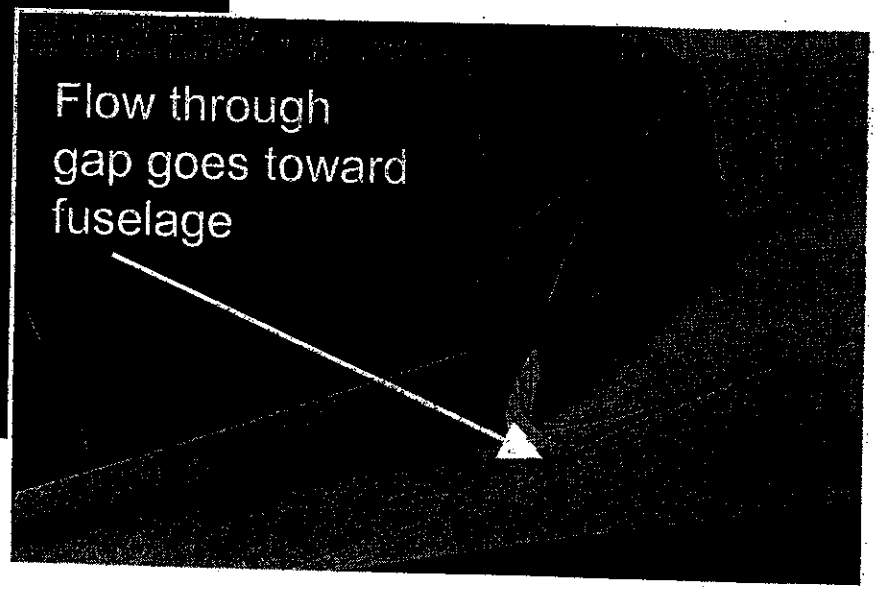
Orbiter with panel 6 removed, Cp Contours



2/14/2003
K. Bibb

Streamlines – frontal view

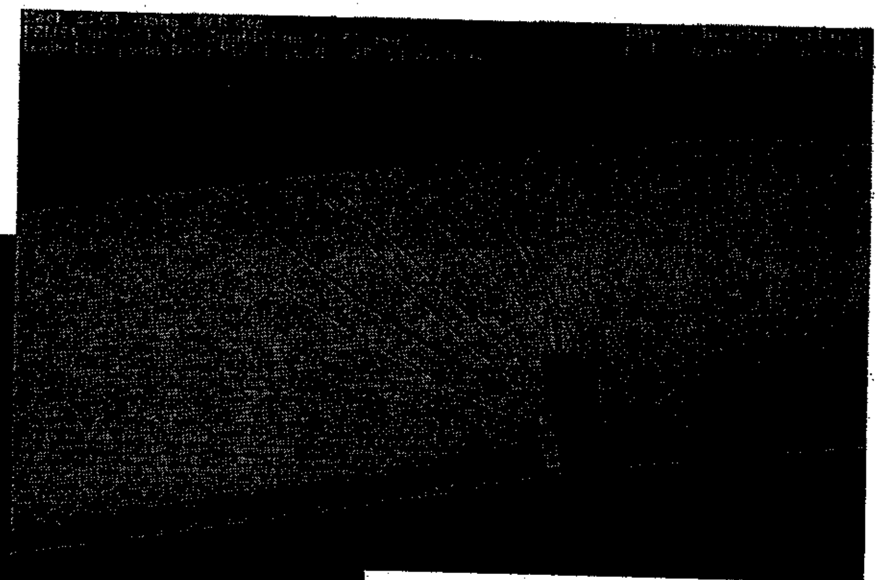


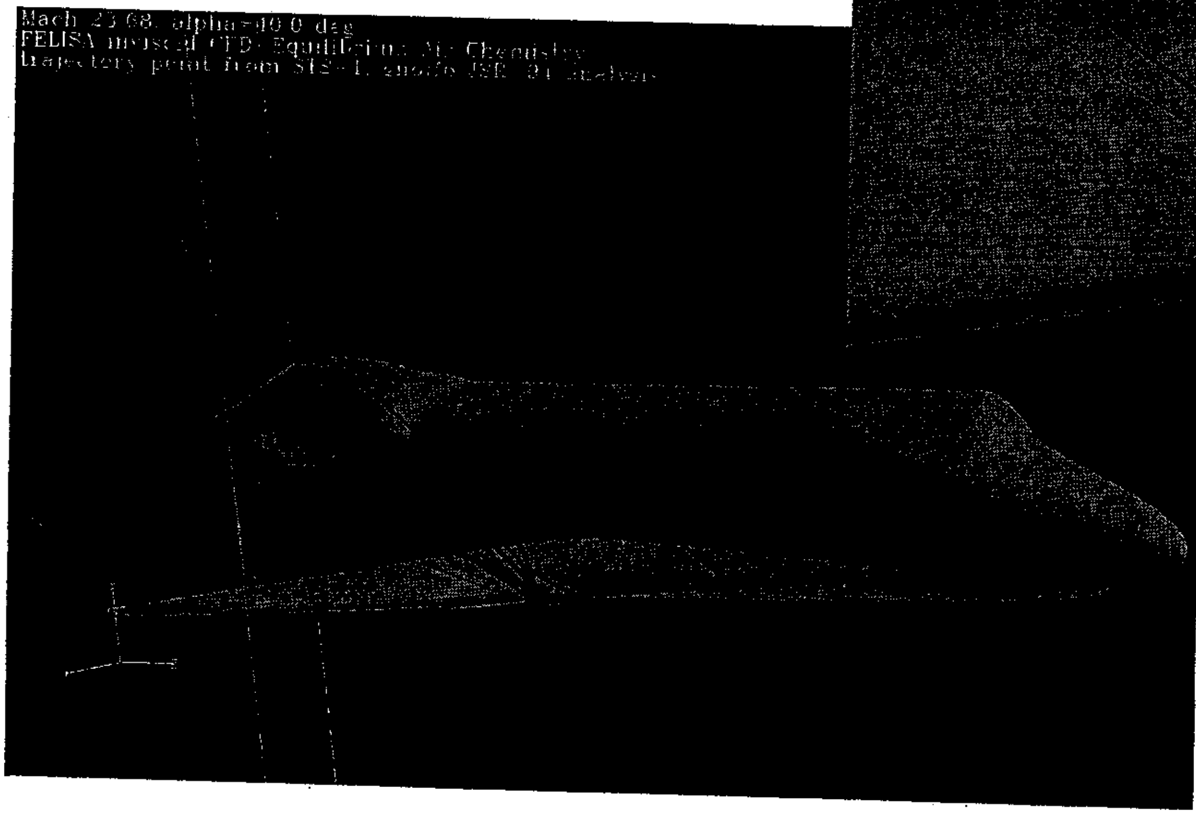


Blue – Baseline Orbiter
Red – Panel 6 removed

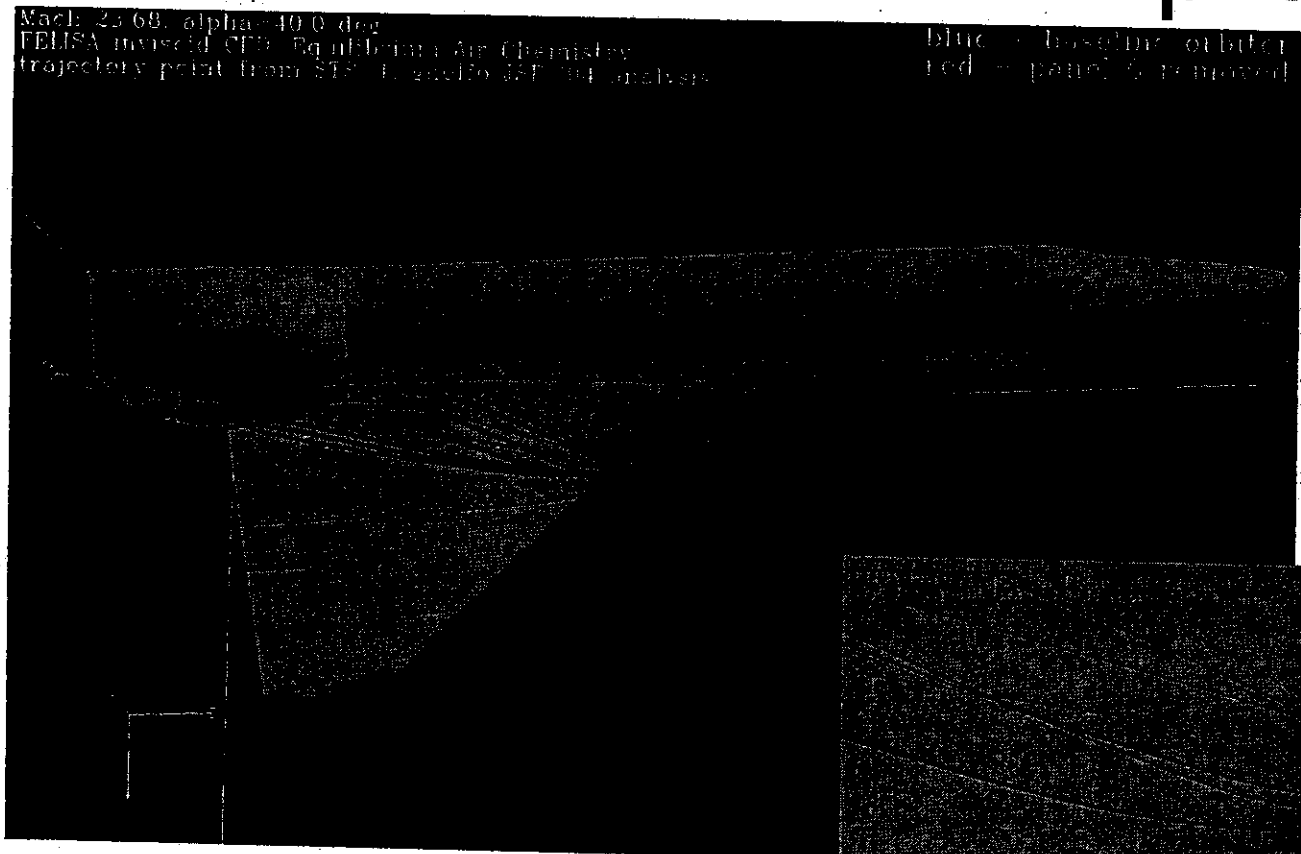
Streamlines – Side View

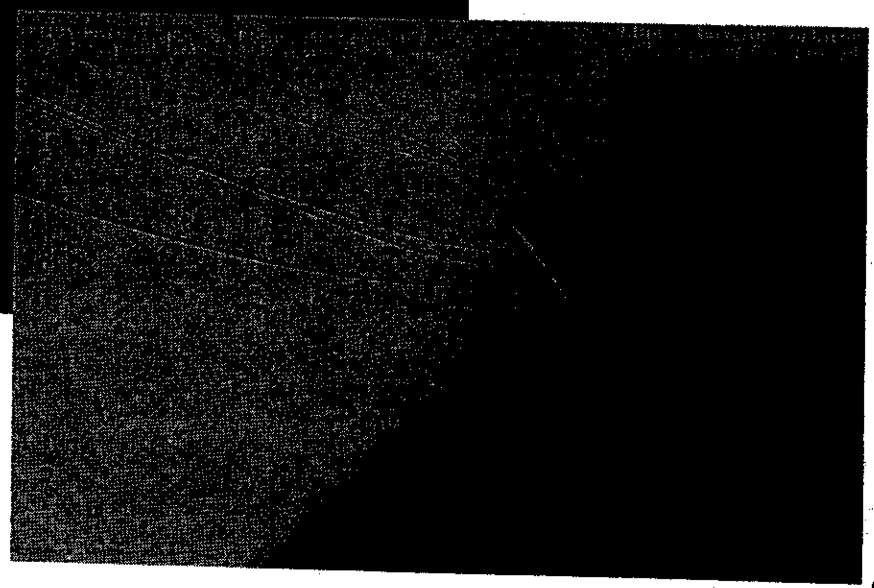
Blue – Baseline Orbiter
Red – Panel 6 removed





Streamlines – Top View





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K. Bibb

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Backup slides

Planform coordinates

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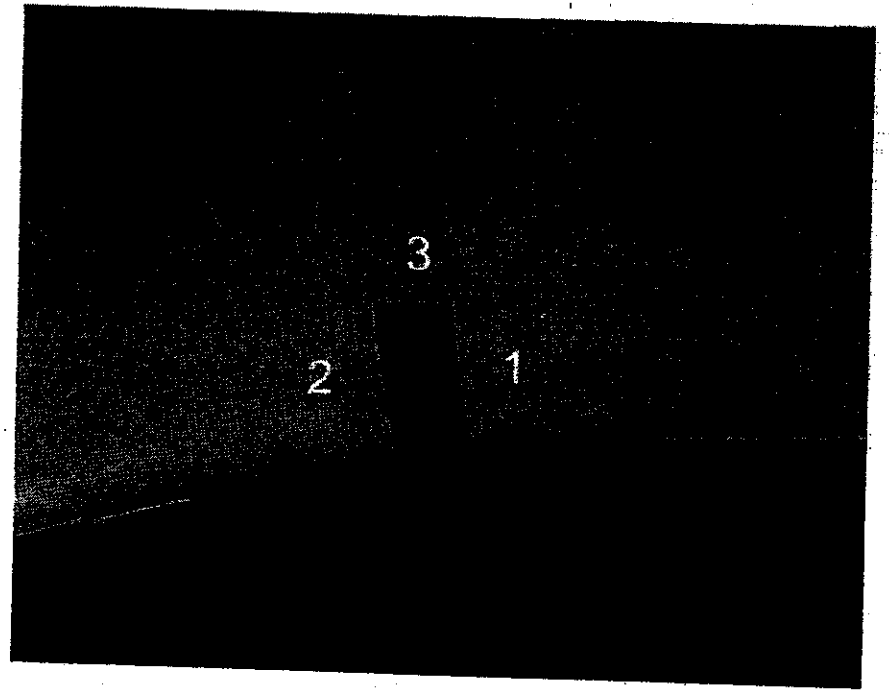

X-Sender: a.h.phillips@pop.larc.nasa.gov
Date: Fri, 14 Feb 2003 12:51:24 -0500
To: "Pamela F. Richardson" <Pamela.Richardson@hq.nasa.gov>
From: "Alan H. Phillips" <a.h.phillips@larc.nasa.gov>
Subject: Fwd: Euler solutions-Section 6 Removed
Cc: "Peter J. Rutledge" <prutledg@mail.hq.nasa.gov>,
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Some CFD results that LaRC is performing in support of JSC investigation activities.

Alan

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Subject: Euler solutions-Section 6 Removed
Cc: "SAUNDERS, MARK P" <M.P.SAUNDERS@larc.nasa.gov>,
"PHILLIPS, ALAN H" <A.H.PHILLIPS@larc.nasa.gov>

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Thanks

Charles

FELISA-aeroThermo-2003-02-1.ppt

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Alan H. Phillips
Director, Office of Safety and Mission Assurance
NASA Langley Research Center
5A Hunsaker Loop
Building 1162, Room 112C
Mail Stop 421
Hampton, VA 23681

(757)864-3361 Voice
(757)864-6327 Fax
****

Wing Leading Edge Damage
Inviscid CFD

February 13, 2003

LaRC Aero Team

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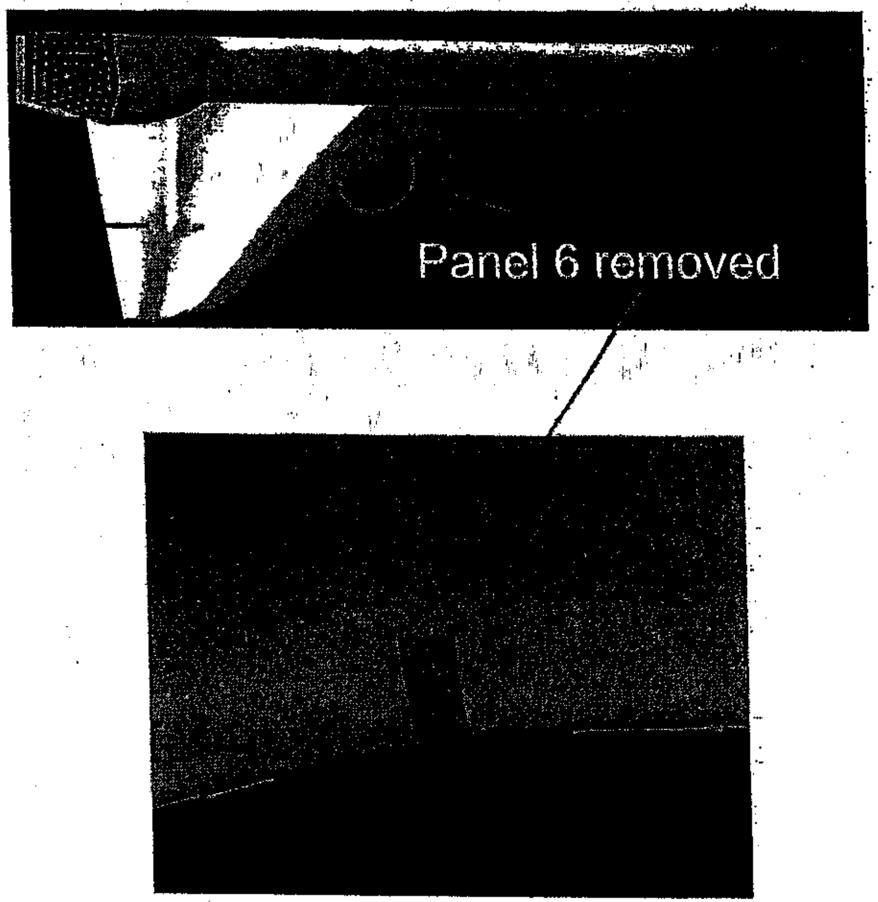

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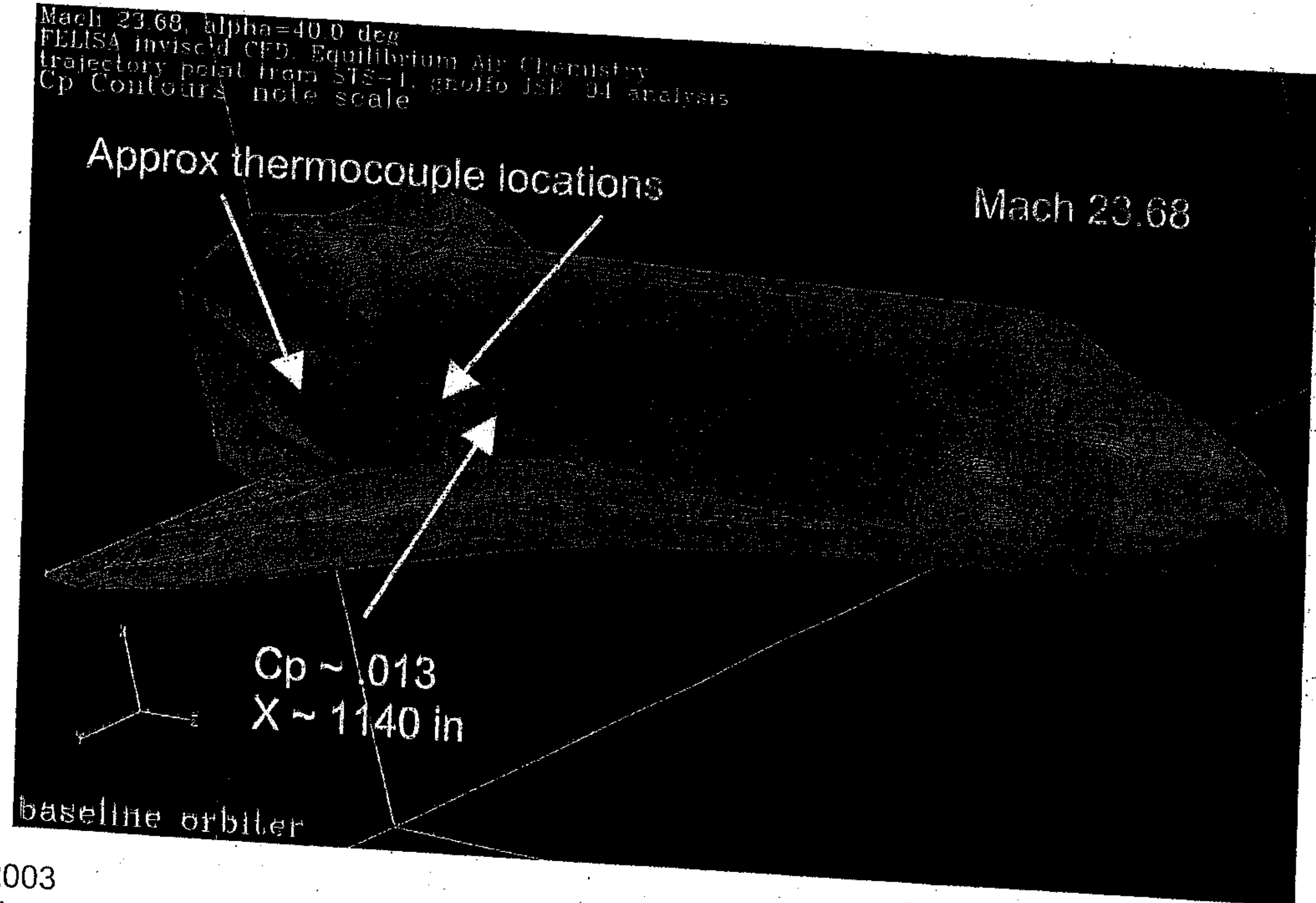
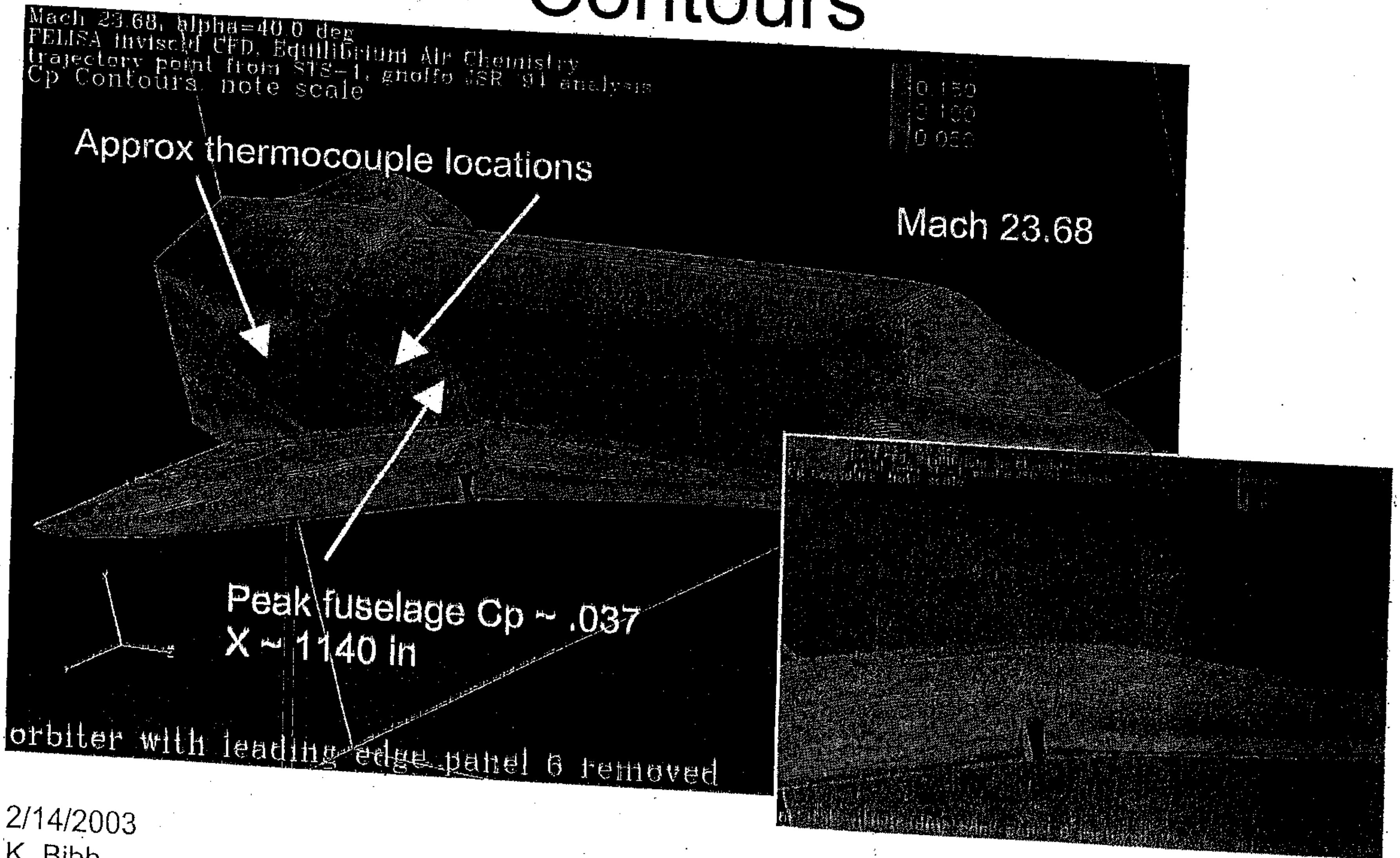


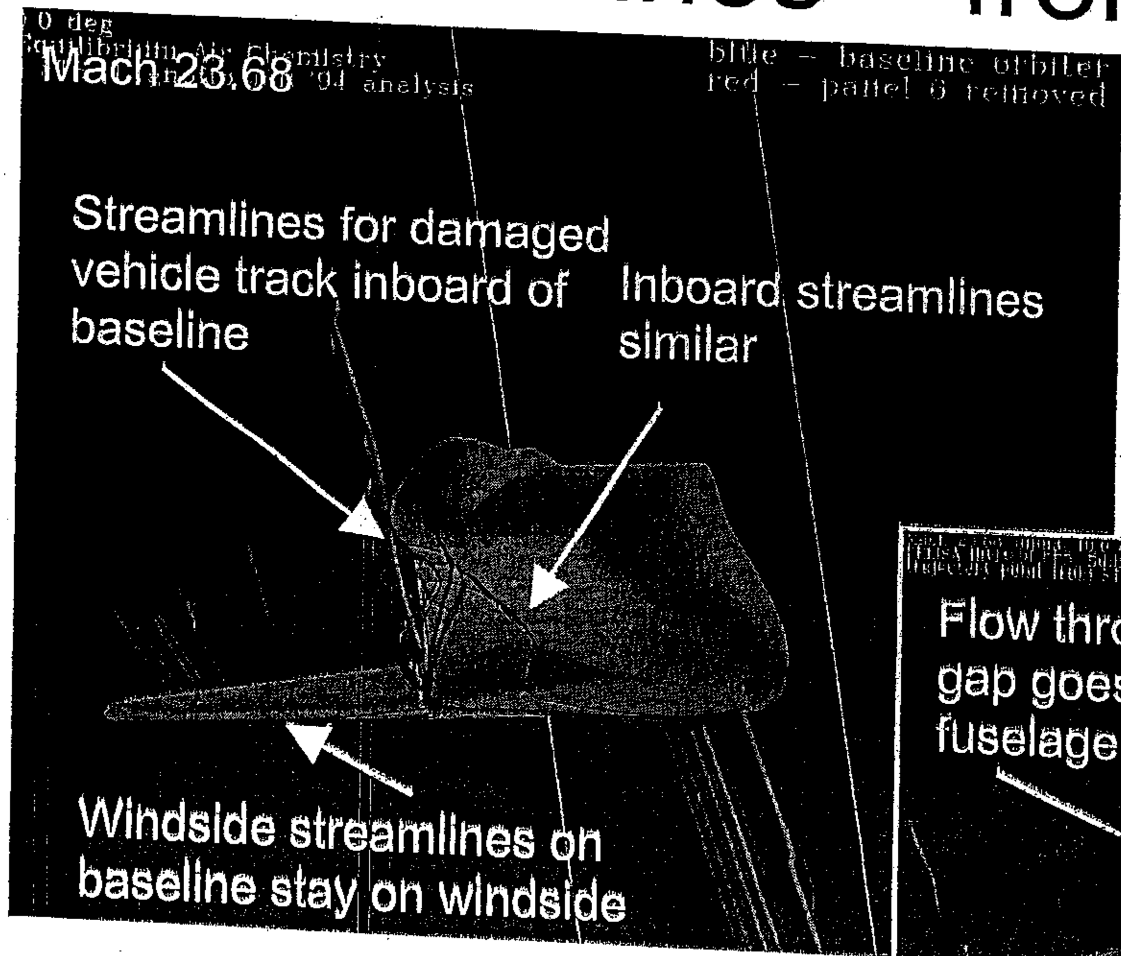
2/14/2003
K. Bibb

Orbiter with panel 6 removed, Cp Contours



2/14/2003
K. Bibb

Streamlines – frontal view



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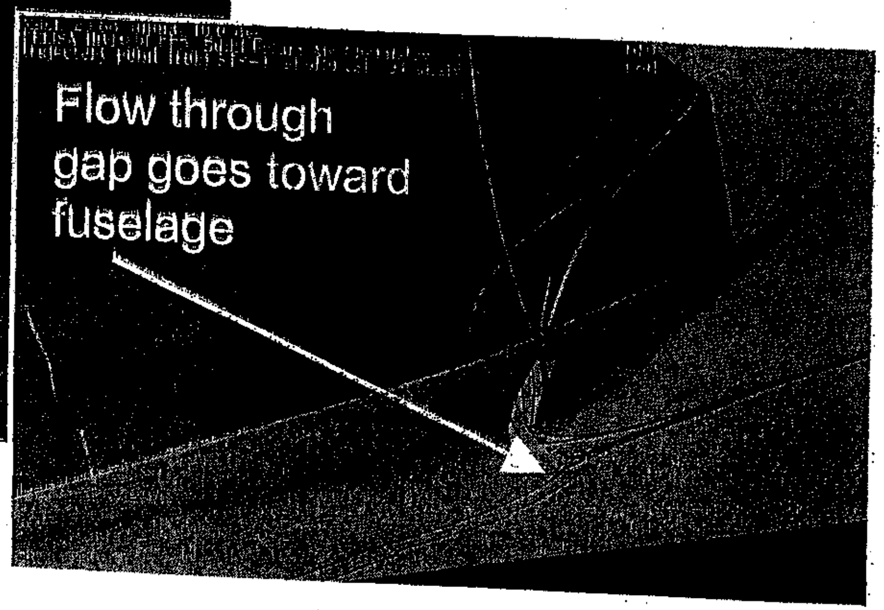

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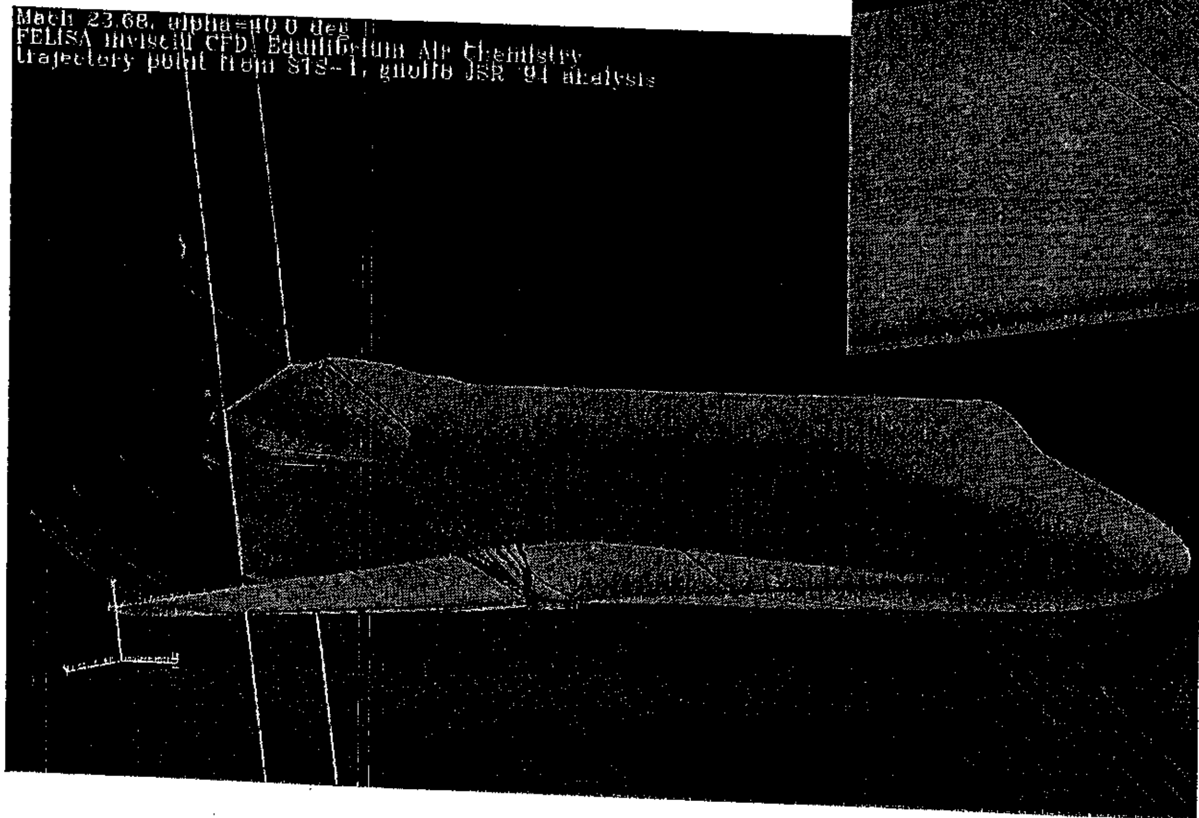
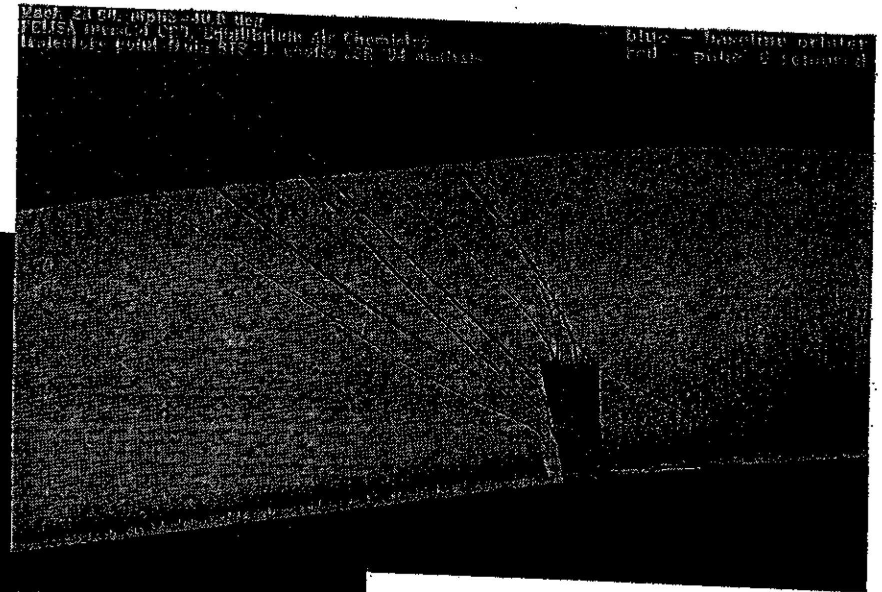
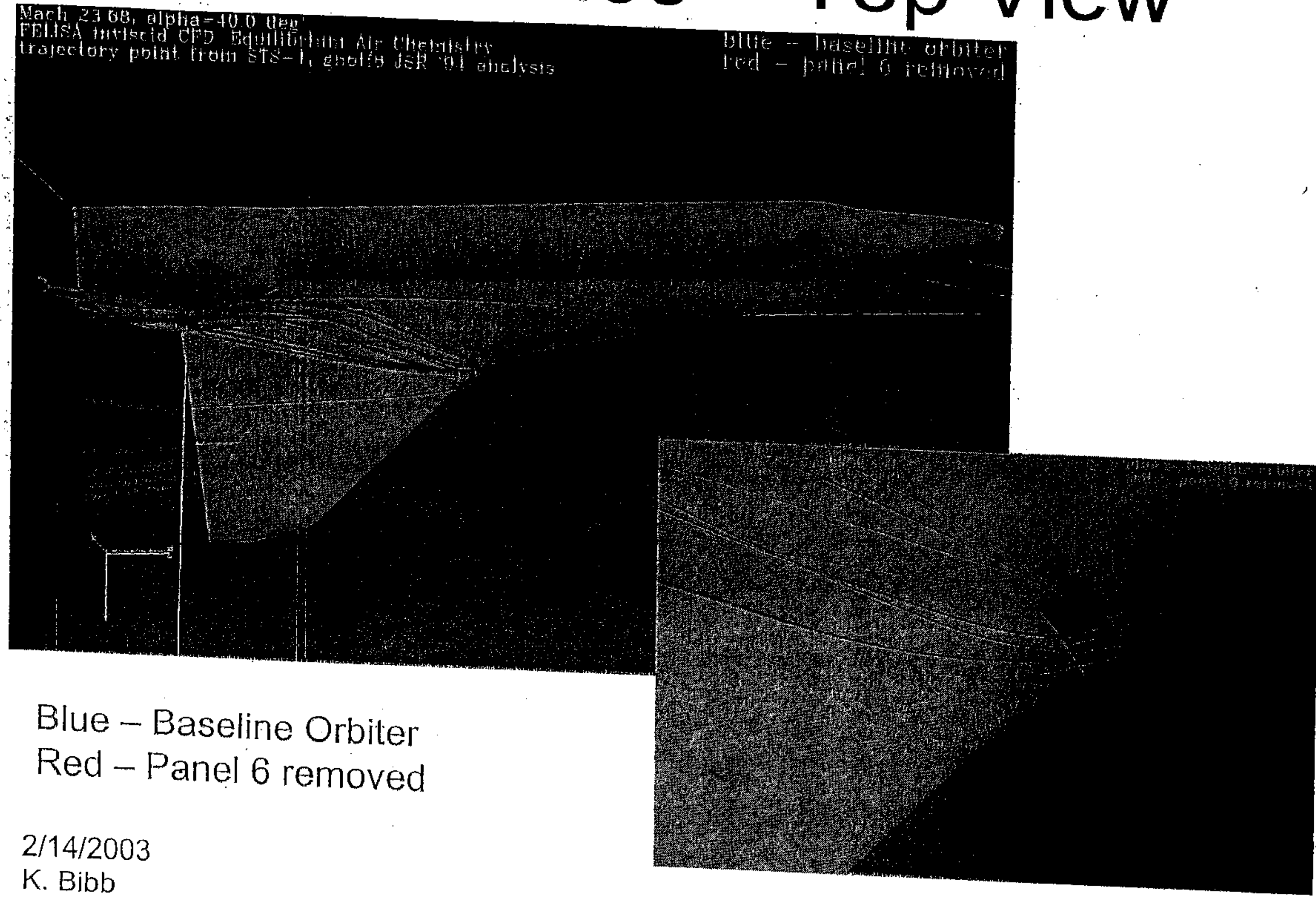




2/14/2003
K. Bibb

Streamlines – Top View



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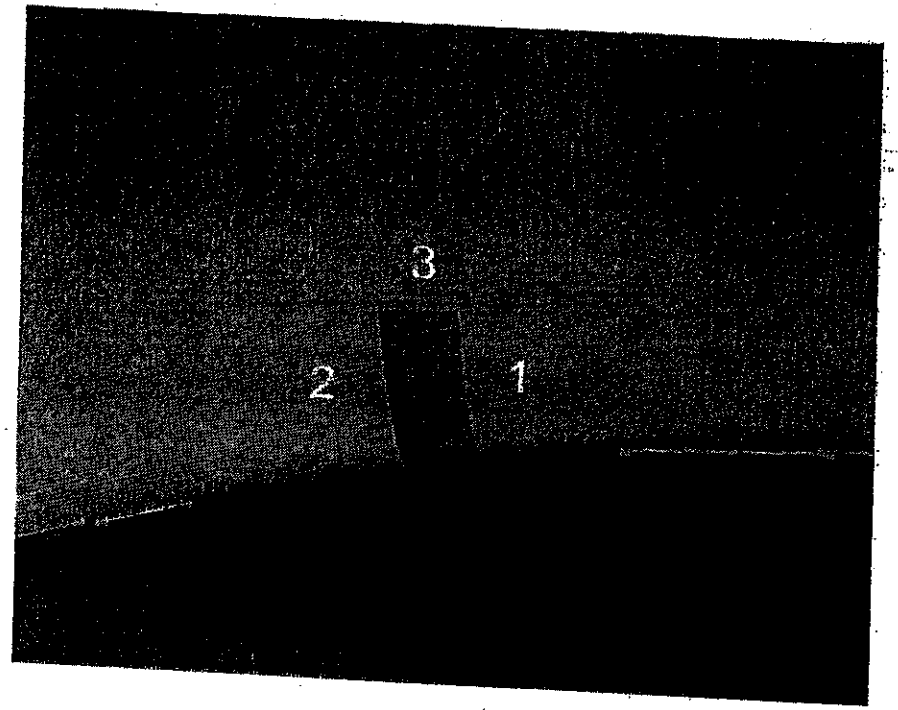

X-Sender: mkowales@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Fri, 24 Jan 2003 12:49:46 -0500
To: prutledg@mail.hq.nasa.gov, jlloyd@mail.hq.nasa.gov,
mgreenfi@mail.hq.nasa.gov, boconnor@mail.hq.nasa.gov,
wbihner@mail.hq.nasa.gov, gwhite1@mail.hq.nasa.gov,
rpatrican@hq.nasa.gov, mcard@hq.nasa.gov, prichardson@hq.nasa.gov,
fchandle@mail.hq.nasa.gov
From: Mark Kowaleski <mkowales@hq.nasa.gov>
Subject: STS-107 Status Report for January 24

The STS-107 mission continues to go well. Research activities in the SpaceHab module comprising 80+ experiments are going well. Consumables margins continue to exceed predictions and will contribute to a higher than expected landing weight.

Analysis of the landing weight determined that it may be very close to the 233,000-pound certification limit (expected to be near 233,600 lbs). Ground controllers and the Mission Evaluation Room (MER) engineers will continue to monitor cryo consumption to better estimate end-of-mission landing weight.

At the MMT today they discussed the analysis that is taking place:
-Payload interfaces (OK) -Landing gear and tires (OK) -Steering (OK) -Thermal at bondline (TBD but expected to be OK) -Reentry trajectory (OK) -Main engine nozzle loading (TBD but expected to be OK) - also, consumables during landing phase is being reassessed.

Prior history of high landing weights:
STS-90 was right at 233K
STS-87 at 233,090
STS-83 at 235,286 (early mission termination due to fuel cell problem)

Evaluation of the debris seen in the video and film review determined that there may be significant tile damage; however, not to the extent that would result in burnthrough or catastrophic failure. The evaluation also determined that there should be no adverse effect to the RCC panels due to the angle (glancing) of potential impact predicted.

My thoughts: If the damage was any worse, we could have been looking at a real serious problem (rekindles the "on-orbit repair capability" discussion). We won't know the real extent of the damage until the orbiter comes back and we unload the detailed photographs. Leading theory is that the foam originated from the bipod ramp vicinity (this was issue for STS-112 and discussed at length at STS-113 FRR). If from bipod area, then this is 4th instance of major foam from that area (STS-112, 32, and 50). Build paper is being reviewed for the last few and next few tanks - nothing out-of-family has turned up with regard to foam application.

Mark

From: "ERMINGER, MARK D. (JSC-NC) (NASA)" <mark.d.erminger@nasa.gov>
To:
Subject: Shuttle Standup Notes 1/23/03
Date: Thu, 23 Jan 2003 08:21:00 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

STS-114 (OV-104) 3/1/03
* Payload Bay Doors closed
* Aft close-outs complete
* VAB rollout Wednesday morning

STS-115 (OV-105) 5/23/03
* FRCS installation complete
* OMS Crossfeed drain
* Preps for pod removal
* RMS removal in work
* MPS feedline inspections

VAB
* STS-114 stack close-outs

Stennis
* Battleship flowliner 520 second test completed
* Will boroscope strain gauges and then run another test on Monday
* Gen Kostelnick, Art Stevenson, STS-113 crew, and John Young observed the test

SSME
* All Stennis test data on the engine was nominal

USA Booster
* Post flight reviews look good so far
*
* Motor
* Post flight review is going well
* Test firing 1 PM MST today
*
* ET
* Gen Kostelnick visited MAF yesterday
* Are working the debris issue
* We know generally where the debris came from
* We will have to wait until the Orbiter gets back
*
* USA Orbiter
* Vehicle is doing well on orbit
* Working debris analysis
* BSTRA TIM next week at MSFC
* Will focus on plans for OV-103
* Are developing a tool to inspect the 12" lines

Vehicle Engineering
* OMM Review next week

USA Integration
* Debris analysis completed a couple of runs looking at 20x10x6 and 20x16x6
* Provided input area, velocity, and impact to Orbiter

EVA
* 6 Hr 51 Min EVA on Station last week

Upgrades
* SLEP Summit kicked off last week

Hale
* STS-114 Orbiter Rollout Review Tuesday

Ham
* Flight is going well
* Working end of mission weight because of extra cryo
* Are controlling Spacehab temperature and humidity with the Orbiter
* MMT tomorrow, Monday and Thursday
* Landing is Saturday 7:49 AM CST

Other info after the meeting
* The STS-114/ULF-1 FRR may slip to 2/19 or 2/20

From: "ERMINGER, MARK D. (JSC-NC) (NASA)" <mark.d.erminger@nasa.gov>
To:
Subject: Shuttle Standup Notes 1/30/03
Date: Thu, 30 Jan 2003 08:11:18 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

STS-114 (OV-104) 3/1/03
* Rollout to OPF
* In the process of Orbiter to ET Mate
* Rolling to the pad on Wed 0700
* Potential of heavy weather Wed afternoon and may roll earlier

STS-115 (OV-105) 5/23/03
* Fuel Cell 1 R/R
* Preps for right OMS pod removal

OV-103
* OMM

Stennis
* 580 second test on Engine 0526
* 11th start of Pratt 11
* Another test today

SSME
* Data looked good on the last test

USA Booster
* Continuing to gather test on the ETA Ring
* ESD is working FOD Awareness
* They found some potential FOD in the bottom of a motor on the liner
(paint and wood chip)
*
* ET
* Nothing new on TPS issue
*
* USA Orbiter
* The vehicle is working great
* Ready for landing on Saturday
* OMM Review today

Vehicle Engineering
* BSTRA review at MSFC today
* 12" tool development is more challenging
* Cockpit review at Owego next week

Segert
* Successfully launched Delta 2
* That was one of the flights in our way

Ham
* Working hard to get the cameras out on the runway to process for foam loss review
* Weather looking good for landing Saturday 8:15 CST

X-Sender: wbihner@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Mon, 13 Jan 2003 08:57:28 -0500
To: "Bryan O'Connor" <boconnor@hq.nasa.gov>
From: Bill Bihner <wbihner@hq.nasa.gov>
Subject: Weather Outlook for STS-107
Cc: Michael Greenfield <mgreenfi@hq.nasa.gov>,
Pete Rutledge <prutledg@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>

The CCAFS weather folks are saying 95% go for weater for launch on Thursday. The SMG forecasts for RTLS and TAL weather are also forecast "Go"

Bill

X-Sender: wbihner@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Fri, 17 Jan 2003 09:47:10 -0500
To: "Bryan O'Connor" <boconnor@hq.nasa.gov>
From: Bill Bihner <wbihner@hq.nasa.gov>
Subject: STS-107 Mission Status
Cc: Pete Rutledge <prutledg@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>

The STS-107 mission is going very well.

SRB reported that the SRBs were slightly hotter than normal and that the foward skirt buckled on water impact. SRBs will be back to the port today and open assessment will start Monday.

Launch pad damage was nominal.

The crew is on the timeline for sleep periods and payload activity. The MER reported two issues/funnies that they are working and neither have mission impact so far:

During the pre-launch/post-insertion time period, AC2 phase B exhibited sluggish current increase during motor operation on three motors. The first occurrence of the sluggish performance was noted at T-31 seconds, and the second and third occurrences were noted during the post-insertion activities. AC2 phases A and C would increase to their expected values, but phase B would increase only to about half of expected value, then recover to the expected value within about a second. The affected motors are: vent doors 8 and 9, Ku-band deploy motor 2, and port payload bay door open motor 2. There was no impact to motor drive times. There is no common circuit breaker/motor control assembly. All other motor signatures analyzed were nominal, some of which are powered from the same circuit breaker/motor control assemblies as the affected motors.

During Spacehab activation, the crew reported that transmissions from the Orbiter on the intercommunications (ICOM) B loop were not being heard in the Spacehab module. Communications on the ICOM A loop were satisfactory. This loss of redundancy should not affect the continuing mission operations.

The next MMT will be on Tuesday, January 21.

Bill

X-Sender: wbihner@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Fri, 31 Jan 2003 08:38:41 -0500
To: "Bryan O'Connor" <boconnor@hq.nasa.gov>
From: Bill Bihner <wbihner@hq.nasa.gov>
Subject: STS-107 Mission Status
Cc: Jim Lloyd <jlloyd@hq.nasa.gov>, Pete Rutledge <prutledg@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>,
Richard Patrican <rpatrica@hq.nasa.gov>,
Gil White <gwhite1@hq.nasa.gov>

Bryan,

The item below was also discussed at yesterday's MMT meeting. The bottom line is that after early problems with pump 1, they switched to pump 2 and cooling in the Hab became a non-issue. Yesterday they reported a nearly doubling in the blockage with the pump 2 system over the last 48 hours and were concerned that they might need to shut pump 2 down and go back to pump 1. If we can't control cooling in the Hab, then we will definitely lose science. So, although we have consumables enough to support landing through Wed, Feb 5, if this becomes an issue, they may want to land earlier, even if it means an EDW landing. Right now its not an issue and landing first opportunity is still scheduled for Saturday around 0915 EST and weather looks favorable. Will keep you posted.

Bill

NEW: MER-009 (Spacehab Water Loop Flow Degradation ORB). The payload heat exchanger and total flow rates for the Spacehab water loop have been steadily decreasing throughout the mission; the Spacehab water pump outlet pressure is also decreasing; pump 2 was initially run but the switch to pump 1 was made early in the mission; t/s post-landing to determine if Orbiter hardware is the cause of the problem or has in any way been impacted by the problem; the hardware consists of the payload heat exchanger and the water lines leading to and from the interface panel.

X-Sender: wbihner@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Wed, 22 Jan 2003 11:25:13 -0500
To: "Bryan O'connor" <boconnor@hq.nasa.gov>
From: Bill Bihner <wbihner@hq.nasa.gov>
Subject: STS-107 cooling problems information
Cc: Pete Rutledge <prutledg@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>,
Richard Patrican <rpatrica@hq.nasa.gov>

Bryan,

Here's how the Press is characterizing the STS-107 payload cooling system problem.

Bill

Article from Florida Today, Jan 21, 11:13 PM:

Shuttle cooling system fails
By Chris Kridler
FLORIDA TODAY
CAPE CANAVERAL -- The crew of Columbia is a little warmer after multiple cooling system malfunctions on the shuttle Tuesday. A day's worth of data was lost on one of about 80 experiments on board, but the crew's scientific research should not be endangered by the problem, said Phil Engelauf of mission control in Houston. "We don't believe there's going to be a loss of science by the end of mission," he said. "We think we'll have recovered everything." The cooling equipment for Spacehab, the research module in the shuttle's payload bay, creates condensation, much as a house's air conditioner does. Because there's no gravity, the water can't just flow into the tank. The equipment that diverts the water flooded, possibly because of a blockage, and malfunctioned. An alternate system was crippled by an apparent electrical short. The orbiter now is supplying cool air for both the shuttle and Spacehab, Engelauf said, and the crew is comfortable. The experiments, however, could use more cooling. The astronauts will adjust valves on lines under Spacehab's floor to try to increase the flow of cooling water to the experiments. The temperature on the shuttle is usually about 72 degrees, but it peaked at 84 before falling back to about 76, Engelauf said. The crew reaches Spacehab through a tunnel that leads from the orbiter's middeck. The experiment that lost data Tuesday is designed to evaporate urine to filter out impurities and create drinking water. It needs a lot of cooling. It's a test for a system planned for the International Space Station. In an unrelated problem, a tray jammed on an experiment examining growth of bacteria and fungi in microgravity. Specimens on that tray were lost, mission scientist John Charles said. The experiment's five remaining trays are intact. Mission controllers also are working around frequent crashes of a ground system processing some of the data from

Spacehab. The scientific data can be recorded when there's a crash, Engelauf said, so there's no loss of information. "It's largely an inconvenience at this point, but it isn't costing us any science," he said. Despite the problems, the crew is doing well, Engelauf said. "They all seem to be very happy with the conduct of the science, with the interaction between the crew and the ground," he said.

X-Sender: wbihner@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Wed, 22 Jan 2003 10:02:42 -0500
To: "Bryan O'connor" <boconnor@hq.nasa.gov>
From: Bill Bihner <wbihner@hq.nasa.gov>
Subject: Fwd: STS-107 FD06 Report
Cc: Pete Rutledge <prutledg@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>,
Richard Patrican <rpatrica@hq.nasa.gov>,
James Lloyd <jlloyd@hq.nasa.gov>

STS-107 Flight Day 06 Report

Shift Leads: Doug McMullen, Richard Foster, Denise Londrigran
Mission Engineer: Dan Zalit (OJT)

The STS-107 mission is progressing nominally and all Orbiter subsystems are performing satisfactorily. The Orbiter consumables remaining are above the levels required for completion of the planned mission.

One item currently under investigion is the Space Shuttle Main Engine (SSME) 3 liquid hydrogen (LH2) prevalve (PV6) open indicator "A" that initially failed to the off state at 016:17:25 GMT (00:01:46 MET). Four additional data dropouts of this same measurement have been observed in the last five days. The measurement in question is provided to the general purpose computer (GPC) via multiplexer/demutiplexer (MDM) flight aft (FA) 4 Card 08 Channel 00. Review of all measurements routed through the same MDM card and channel revealed four liquid oxygen (LO2) Pogo Valve Open indications that had also failed to the off state. Of the nine measurements that indicated a failed off state, only one LO2 and one LH2 indication occurred at the exact same time. The investigation of the cause of these indications is underway.

Shuttle held two meetings to address the SpaceHab Humidity/Water Separator Assembly (WSA) problems. Shuttle and Payload safety attended. There were two issues that the flight director wanted to address, (1) water loop valve modulation to reduce the temperature/humidity, and (2) an IFM to remove water and possible debris from RS#1, and an electrical troubleshooting. After the Valve Modulation didn't yield expected results the Program has decided to go ahead with the WSA IFM, which will repair one of the failed water separators, it is currently being modified to suit the current situation. A copy of the most current rev is at the console. The crew will continue to try and attain better results using the Valve Modulation, but the program will probably look more to trying to recover one of the water separators if possible. The IFM will require MT approval before proceeding. Execution of the IFM at this time is TBD.

There is one new MER anomaly

MER Anomalies:
MER-01 AC2 Phase B Sluggish Current Signature
MER-02 No ICOM B in Spacehab
MER-03 O2 Tank 7 Heater A Failed Off in Manual Mode (ORB)
MER-04 70MM Hasselblad Camera Motor Drive Binds/Jams (GFE)
MER-05 Suspect Fuel Cell Monitoring System (FCMS) Data Cable (GFE)
MER-06 Loss of DR20 Tape Recording and Playback (GFE)
MER-07 LH2 Prevalve Open B Indicater Failed Off

X-Sender: mkowales@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Sat, 08 Feb 2003 09:54:57 -0500
To: James Lloyd <jlloyd@hq.nasa.gov>, boconnor <boconnor@hq.nasa.gov>
From: Mark Kowaleski <mkowales@hq.nasa.gov>
Subject: Re: Space Shuttle Columbia Tragedy
Cc: prichard@hq.nasa.gov, prutledg@hq.nasa.gov, jlemke <jlemke@hq.nasa.gov>,
mark Kowaleski <mkowales@hq.nasa.gov>,
michael Greenfield <michael.greenfield@hq.nasa.gov>

Not sure if Michael Greenfield approved yet, but it is in the Columbia Action Center's (CAC) database, at least in this draft form.

At 09:12 AM 2/8/2003 -0500, James Lloyd wrote:
Bryan,
Some interesting information that you will probably be interested in reading. Mark K. sent it to me and it came from (approved by?) the Columbia Action Center led by Michael G.

"Safety is priority one" is embedded in this and I am not going to spend any time explaining the foible of that statement, i. e. it isn't a trade point - it's a fundamental value. The paragraph includes some anecdotal observations to underscore the statement. The paper, I am sure, was written by a budgeteer. I feel like we are constantly tilting at that wind mill and too no avail. If people are even listening they still are not understanding the distinction. Sorry for the rant but it's a minor frustration that I can't seem to communicate this so it's understood.

Jim

X-Sender: mkowales@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Mon, 10 Feb 2003 08:18:32 -0500
To: linda.j.ham@nasa.gov
From: Mark Kowaleski <mkowales@hq.nasa.gov>
Subject: Fwd: stress/thermal analysis request
Cc: stuart.l.mcclung@nasa.gov, boconnor@mail.hq.nasa.gov,
jlloyd@mail.hq.nasa.gov, prutledg@mail.hq.nasa.gov,
mark.d.erminger1@jsc.nasa.gov, yolanda.y.marshall@nasa.gov

Hello Linda,

I work for Bryan O'Connor as the HQ Shuttle Safety Manger in Code Q. Stuart McClung said that I needed to request the STS-107 TPS Muli-Tile Loss Thermal Analysis data package from you (see note below). I have been trying to get this document for over a week and no one seems to either want to part with it or locate it.

We have the Foam Transport Assessment and the TPS Damage Assessment from Boeing. The requested analysis is referenced in the conclusion of the Boeing Orbiter TPS Assessment, dated 1-23-03.

Would you please get me a copy of the thermal analysis? We need it for the NASA Administrator's talking points for his testimony on Wednesday.

Mark

From: "MCCLUNG, STUART L. (JSC-MV6) (NASA)" <stuart.l.mcclung@nasa.gov>
To: "'mkowales@mail.hq.nasa.gov'" <mkowales@mail.hq.nasa.gov>
Subject: stress/thermal analysis request
Date: Sat, 8 Feb 2003 17:41:18 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Mark, cut and pasted the note I sent to Linda, and the guys on the affected team.

stu

We provided HQ/Mark Kowaleski with copies of the 1/23 and 1/24 presetations on the debris impact and Orbiter assessment. They have requested the thermal analysis that is referenced on the last page in the conclusion. I've talked with McCormack and Rodney and they walked me thru the review of the analysis, and noted that we do not have copies of the acutal analysis that Mike and his team performed. Normal routine, actually.

HQ has requested copies of the analysis, and in my opinion, more for completeness than any of their own review. Fred told me that as of today, these type of requests need to go thru the MRT, so I'm going to direct Mark to make the request thru that route, but I'd suggest that Mike and co., be ready for the request.

From: "ERMINGER, MARK D. (JSC-NC) (NASA)" <mark.d.erminger@nasa.gov>
To:
Subject: Shuttle Standup Notes 2/10/03
Date: Mon, 10 Feb 2003 14:14:17 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Dittemore
* Met with CAIB for a couple of days last week
* They will be here Mon and Tuesday, KSC Wednesday, then MSFC and MAF
* We are making progress. We are getting a lot of data from the field
* We are working hard on the fault trees and testing plans
* Visited Barksdale yesterday

Ham
* On Saturday the MRT talked about processes

STS-114 (OV-104)
* In a maintenance mode

STS-115 (OV-105)
* Fuel Cell #1 installed
* Removing Right OMS pod tomorrow for structural inspections
* MPS system testing

OV-103
* Very busy with OMM Activity
*
* VAB
* Booster buildup for STS-117

Stennis
* Finished post test inspections on Engine 0526

USA Booster
* Supporting Independent team at MSFC
*
* Motor
* Working Group in Utah looking at nozzles and paper
* Flex Boot tear problem in work
*
* ET
* Have 5 test proposals
* Looked at areas at MAF that we would like to re-open
*
* USA Orbiter
* Working to get Palmdale team populated early this week

Vehicle Engineering
* CAU Team was in Owego all week

* Have some hardware technical issues
* Have plans and schedules to solve those problems
* Significant Finds - ET Sep Camera from umbilical well
* Upper atmosphere scientists in over the weekend
* Are pushing Fault Tree out in front to drive testing

Systems Integration
* Will have a draft schedule for the MRT tomorrow
* Integration Management Review here Thursday

HQ
* In a press to put together answers to the questions from O'Keefe Congressional testimony on Wednesday

Kostelnick
* We can defer CAU Review if it gets in the way

Hale
* Expect 3 trucks on Wednesday for the Reconstruction Team
* The Salvation Army has been feeding our people in Lufkin 3 meals per day

Ham
* Have an Org Chart to show how we report to the CAIB
* All data from working groups must go through the MRT before it goes to the CAIB

Galvez ISS
* ISS decision point is 2/13 on whether they want to launch 2 or 3 crew members on the next Soyuz flight to ISS
* The next Station mission will be ULF-1

ERMINGER, MARK D. (JSC-NC) (NASA), 09:21 AM 2/6/2003 -0600, Shuttle Standup Notes 2/6/03

From: "ERMINGER, MARK D. (JSC-NC) (NASA)" <mark.d.erminger@nasa.gov>
To:
Subject: Shuttle Standup Notes 2/6/03
Date: Thu, 6 Feb 2003 09:21:07 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Dittemore
* Meeting with the Columbia Accident Investigation Board (CAIB) today at 8 AM
* As of today, the MRT and MIT will be under the CAIB
* Task Force led by Frank Buzzard will be the Admin arm of the CAIB

Ham
* MRT will be at 10 AM today
* Hope to move to Bld 1 on Monday
* Will start asking for formal charts
* Requests for interviews from the press need to go through Ron Dittemore
* FOIA requests need to go through Linda Ham and the CSR

Dittemore
* Have pre-approved certain people to be able to talk to the media about background info
* The investigation will not involve every single person and he understands their desire to participate
* Managers need to keep the program going and not conflict with the investigation
* Infrastructure revitalization, SLEP, Training, and other things would be good things to work on

MSFC
*

STS-114 (OV-104)
* Finished Orbiter ET Mate and Shuttle Interface Test

STS-115 (OV-105)
* Fuel Cell installed

OV-103
* Mods and inspections
*

SSME
* One more test at Stennis on the flowliner

USA Booster
* SRB IA Team looking at hardware and paperwork
* Will start processing flight hardware today
*

* Motor
* RSRM IA Team is at KSC this week and Utah next week
*
* USA Orbiter
* Engineering team is looking at OV-104 in VAB Payload Bay Moisture requirement
* Working the design of the BSTRA tool

Vehicle Engineering
* Deep into data review
* Data request go through the MER

USA Integration
* Integration Management Review next week in Houston

KSC
* Memorial Service at KSC on Friday

USA Flight Ops
* All MCC and Training systems back on line

MOD
* ISS support continues
* Will start training again next week

Upgrades
* Direction from HQ on SLEP Summit to maintain dates in March
* Support for each of the panels varies
* Will decide for sure next week

HQ
* Memorial at the National Cathedral at 10 EST today

USA
* Working optimum use of vehicles to support the manifest

Dittemore
* Asked the manifest people to work options assuming 4/1 or 6/1 resumption of flights

X-Sender: a.h.phillips@pop.larc.nasa.gov
Date: Thu, 27 Feb 2003 16:43:19 -0500
To: "Pamela F. Richardson" <Pamela.Richardson@hq.nasa.gov>
From: "Alan H. Phillips" <a.h.phillips@larc.nasa.gov>
Subject: LaRC Wind Tunnel Testing Results
Cc: "Peter J. Rutledge" <prutledg@mail.hq.nasa.gov>,
Jim Lloyd <Jlloyd@hq.nasa.gov>

Pam/Jim/Pete:

Attached is a report that summarizes work that the LaRC aerothermal guys have performed working with the Ralph Roe team at JSC. It is my understanding that these results have been briefed to the folks at JSC.

Alan

Horvath.pdf

--

****

Alan H. Phillips
Director, Office of Safety and Mission Assurance
NASA Langley Research Center
5A Hunsaker Loop
Building 1162, Room 112C
Mail Stop 421
Hampton, VA 23681

(757)864-3361 Voice
(757)864-6327 Fax

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LaRC Wind Tunnel Testing in Support of Orbiter External Aerothermodynamics

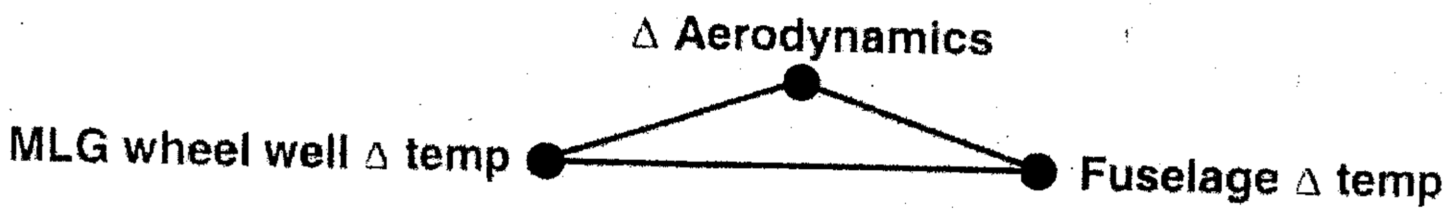
Status Report
February 13, 2003

Thomas J. Horvath
Aerothermodynamics Branch
NASA Langley Research Center

LaRC Near Term Experimental Aerothermodynamic Support

Objective

- Provide rapid assessment of localized OML shape changes on Orbiter aerothermodynamics and aerodynamics



Motivation

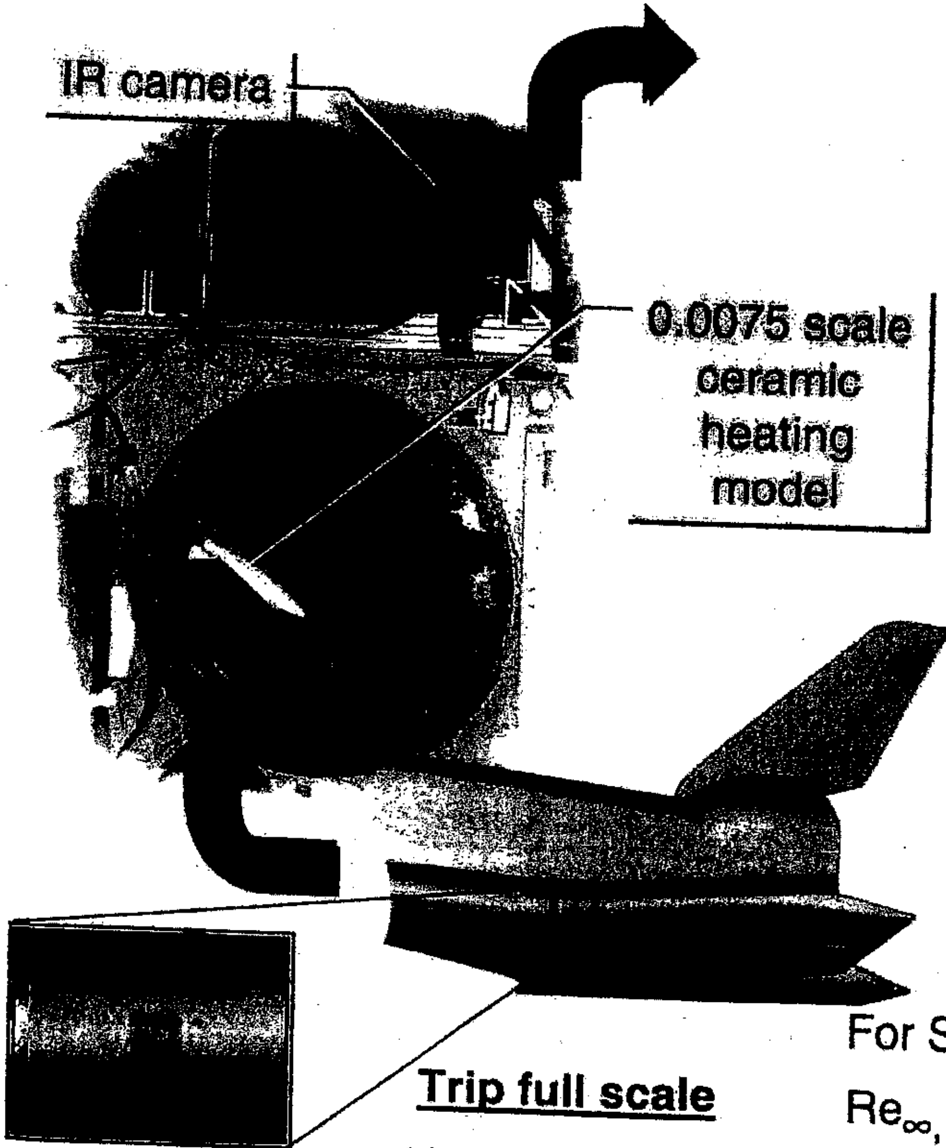
- Most failure scenarios involve leading edge/acreage TPS damage

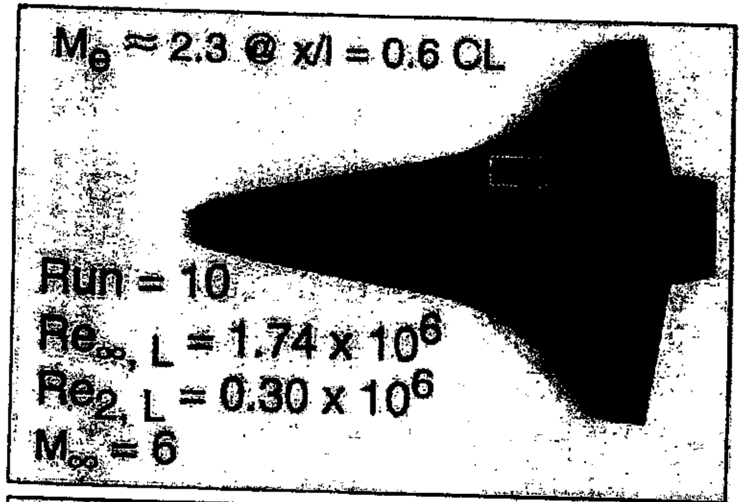
Approach

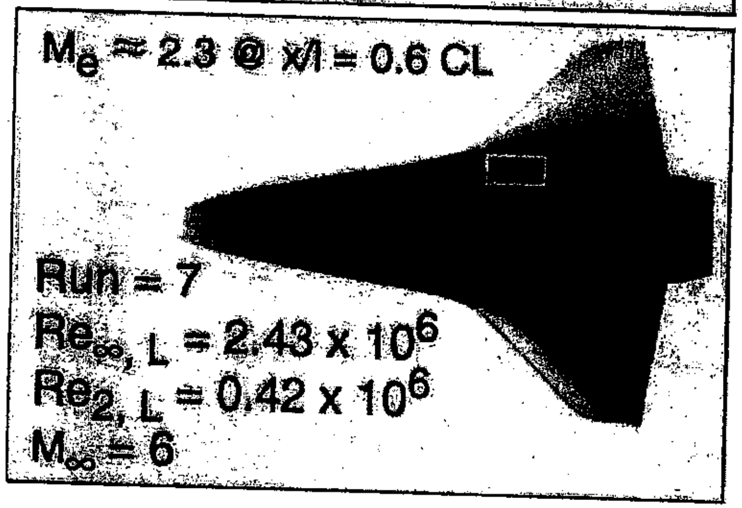
- Closely coupled aerodynamic and heat-transfer ground based testing

Simulated surface discontinuity	Aero	MLG wheel well	Fuselage
Protuberance	Asymm b.l. transition	Laminar/turb heating augmentation	Heating augmentation
Cavity	Asymm b.l. transition	Laminar/turb heating augmentation	Heating augmentation

Orbiter L.E. Sensitivity Study







Trip full scale

Height 0.47-in
Size 13 x 13-in

For STS-28 Early Transition $M_\infty = 17.9$

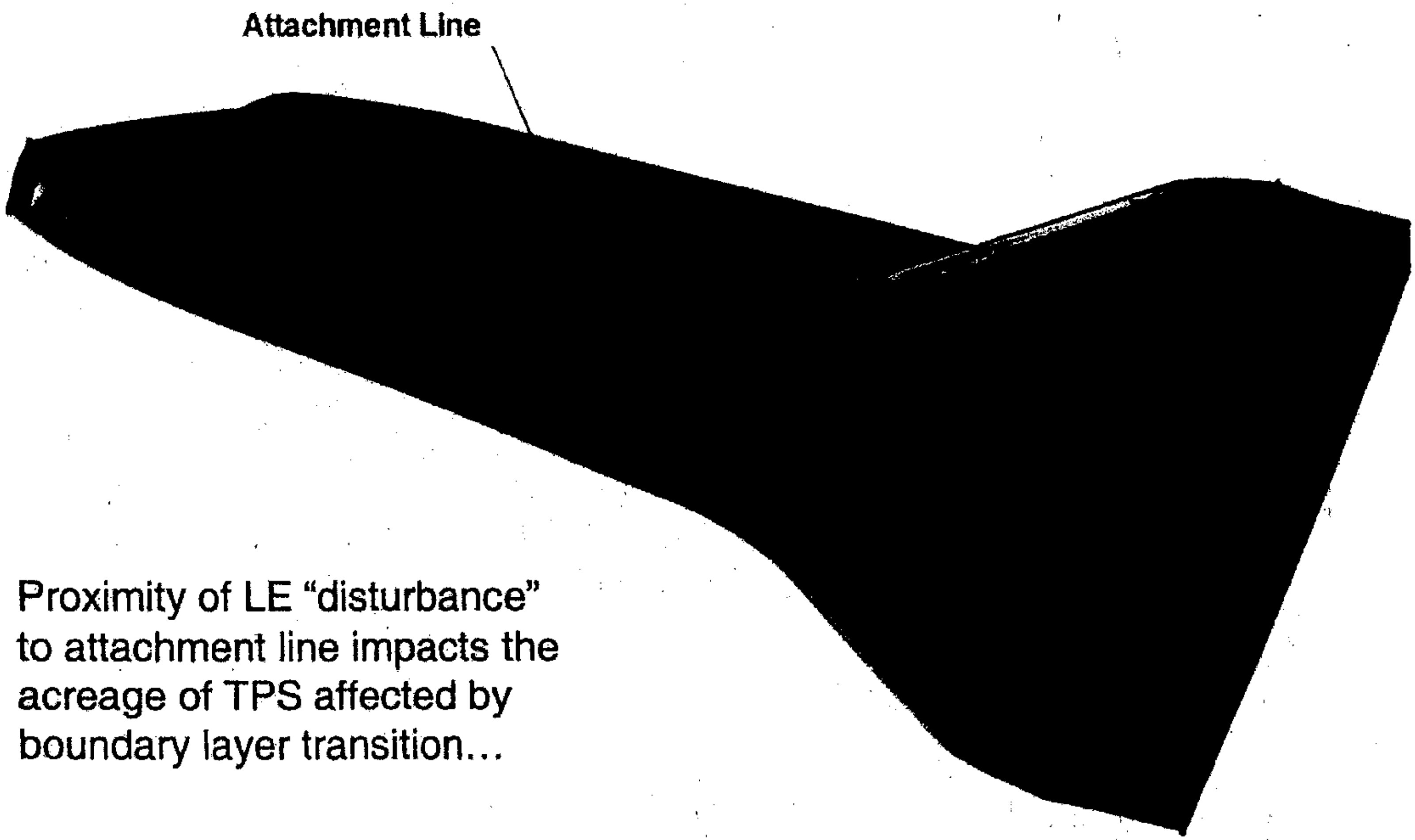
$Re_{\infty, L} \approx 2.4 \times 10^6$
$Re_{2, L} \approx 0.4 \times 10^6$
$M_e \approx 3$ @ x/l = 0.6 CL

} Bouslog, OEX Aerothermo Sym 1995

NASA Langley
Aerothermodynamics Branch

Shuttle Orbiter Surface Streamlines

LAURA Inviscid $M_\infty = 6$, $\alpha = 40$ deg



Proximity of LE "disturbance" to attachment line impacts the acreage of TPS affected by boundary layer transition…

Hamilton/LaRC/AB 2/11/03

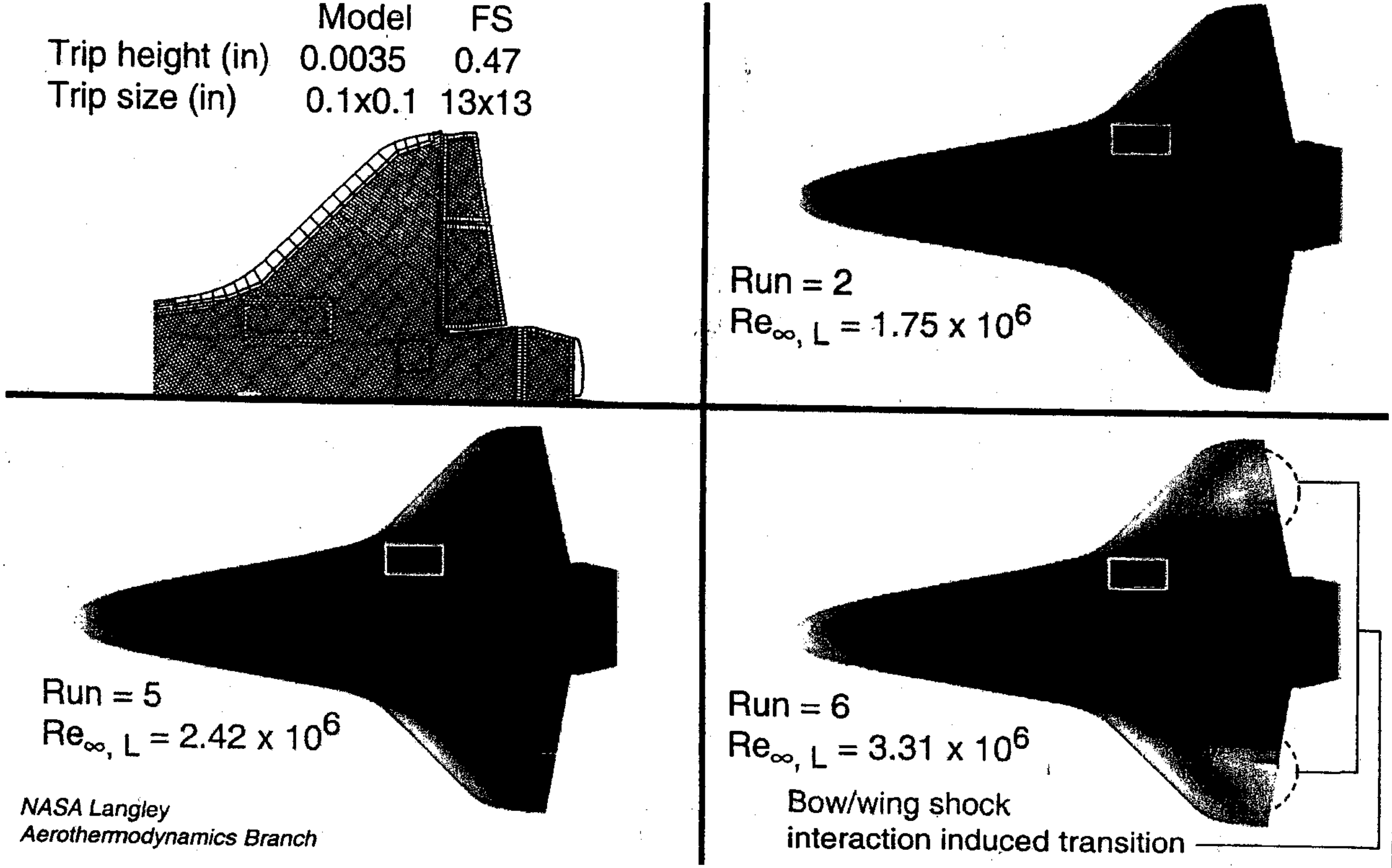
NASA Langley
Aerothermodynamics Branch

Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

α = 40 deg   Baseline   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

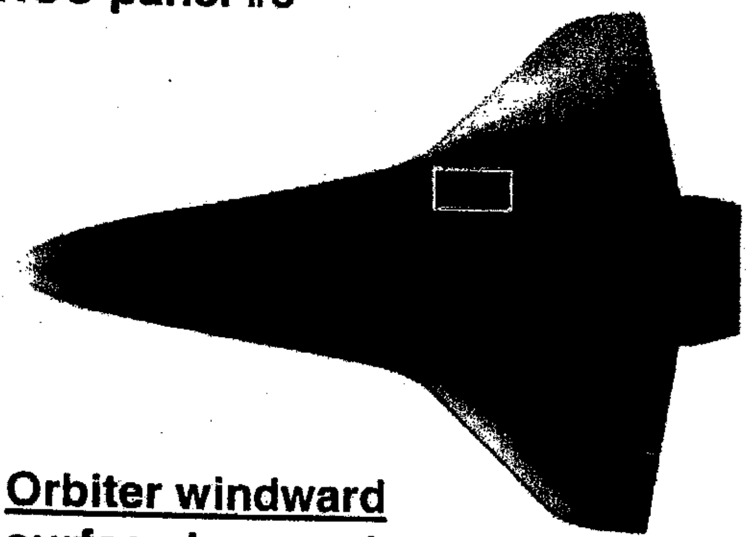


NASA Langley
Aerothermodynamics Branch

Wing Leading Edge OML Sensitivity Study

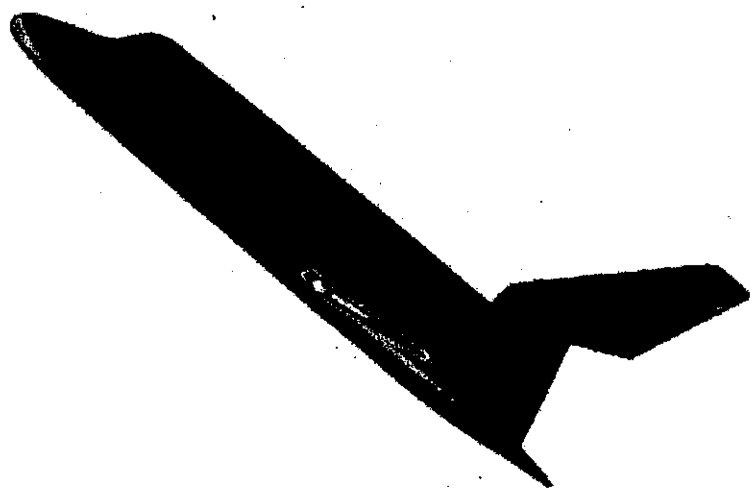
- Tunnel occupancy to date (2-12-03) : 4 days
- Facility: NASA LaRC 20-Inch Mach 6
- Deliverables: Global surface temperature mappings to infer b.l. transition. Global heating to determine augmentation levels above laminar levels.

Leading edge protuberance RCC panel #6



Orbiter windward surface temperatures

Leading edge panel cutout RCC panel #6



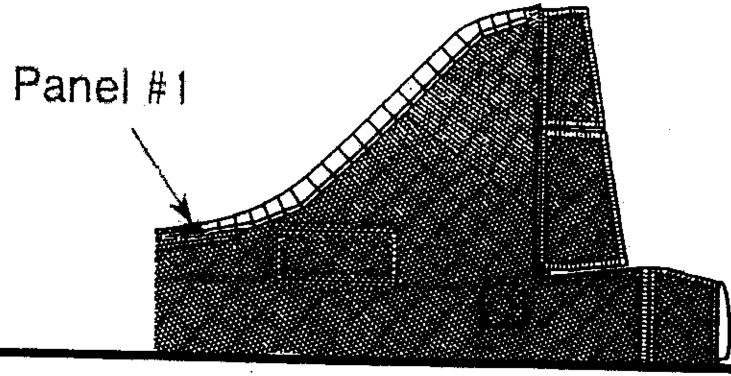
Orbiter side fuselage heating

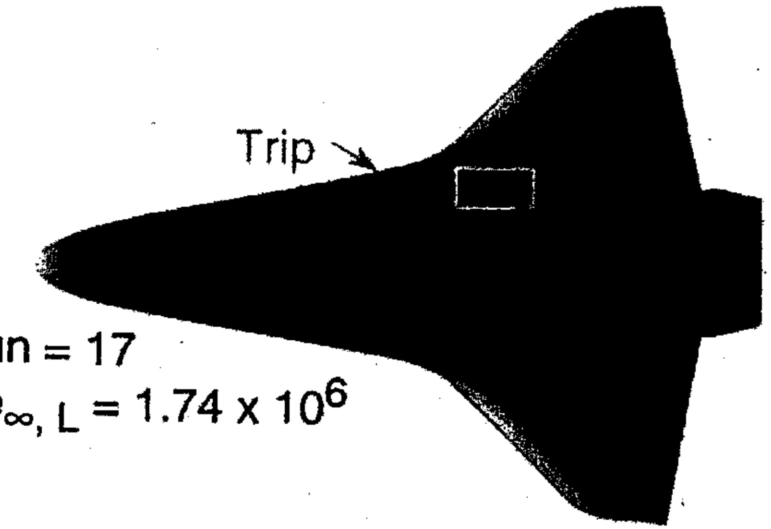
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

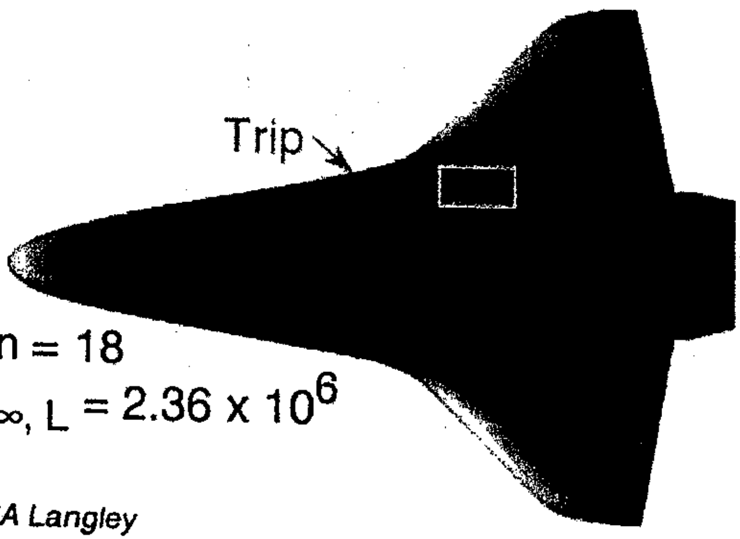
α = 40 deg Panel # 1 0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

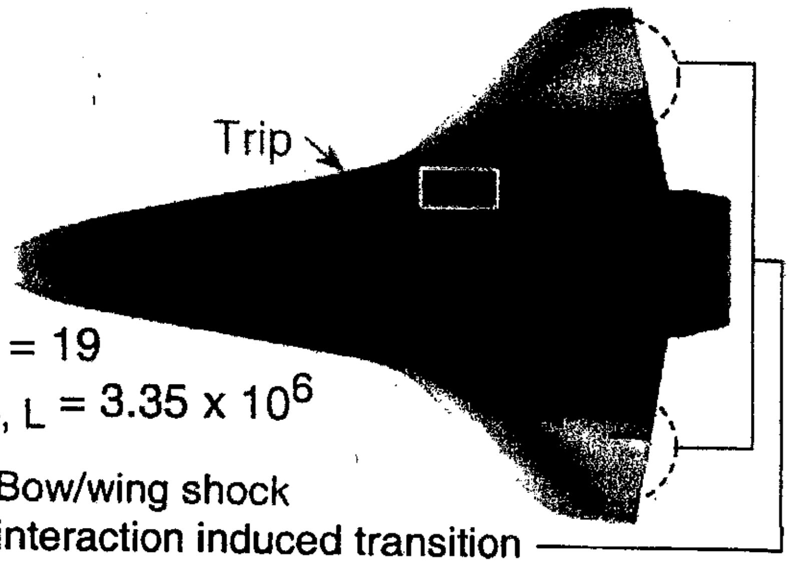




Run = 17
$Re_{\infty, L} = 1.74 \times 10^6$



Run = 18
$Re_{\infty, L} = 2.36 \times 10^6$



Run = 19
$Re_{\infty, L} = 3.35 \times 10^6$

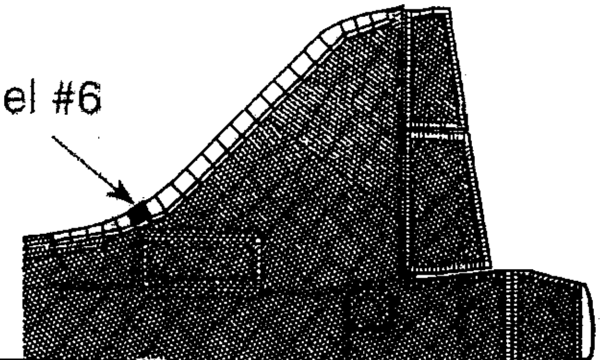
NASA Langley
Aerothermodynamics Branch

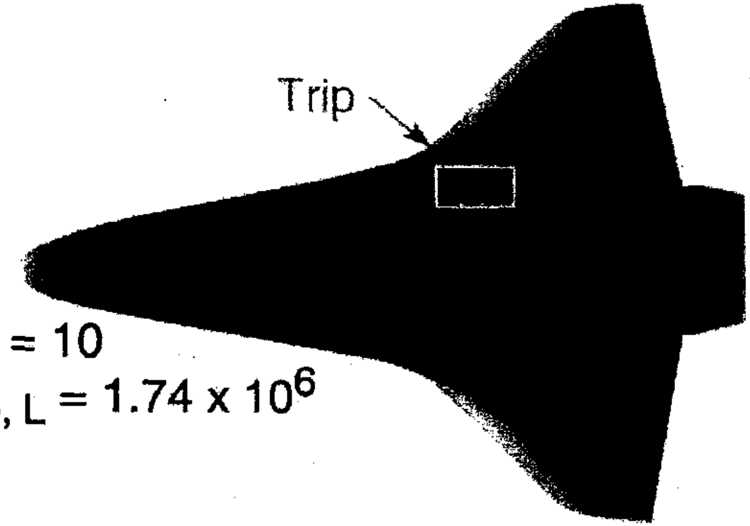
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

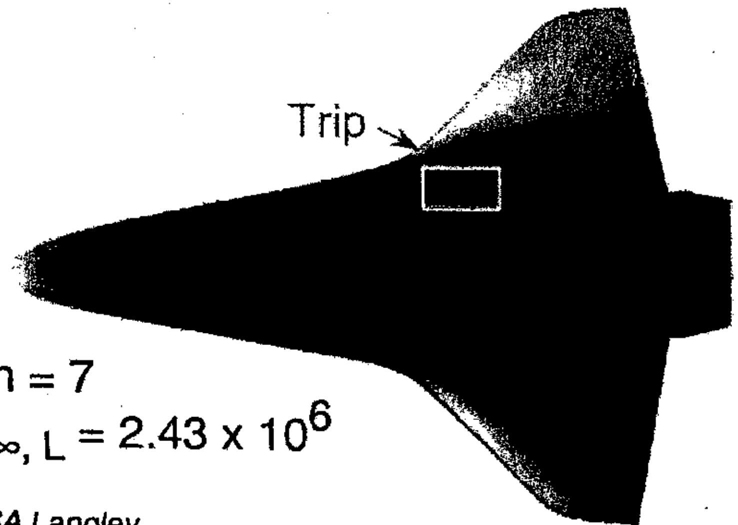
α = 40 deg   Panel # 6   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

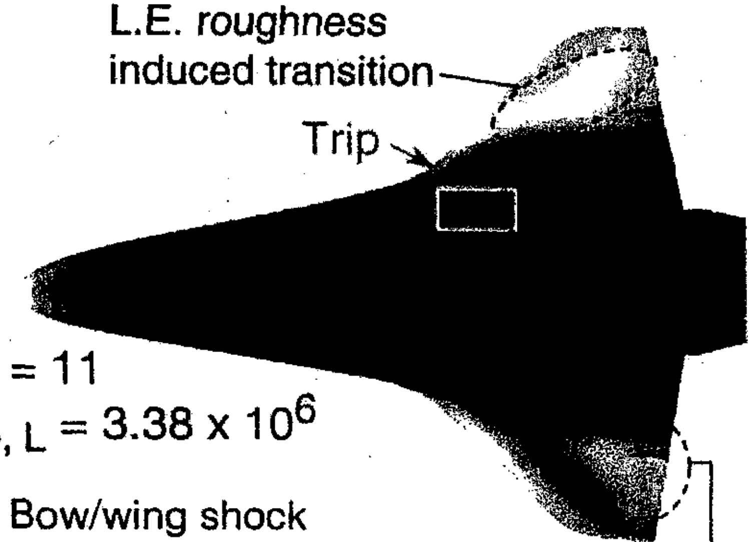




Run = 10
$Re_{\infty, L} = 1.74 \times 10^6$



Run = 7
$Re_{\infty, L} = 2.43 \times 10^6$



Run = 11
$Re_{\infty, L} = 3.38 \times 10^6$

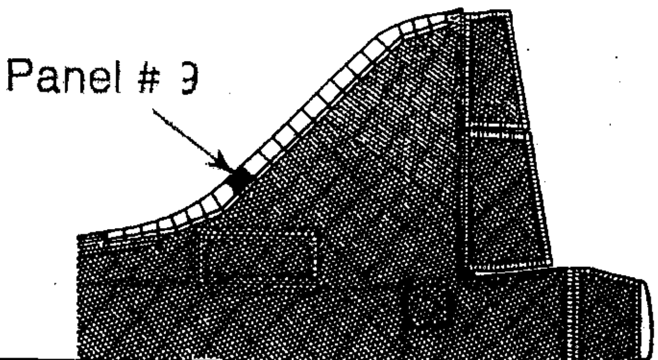
*NASA Langley
Aerothermodynamics Branch*

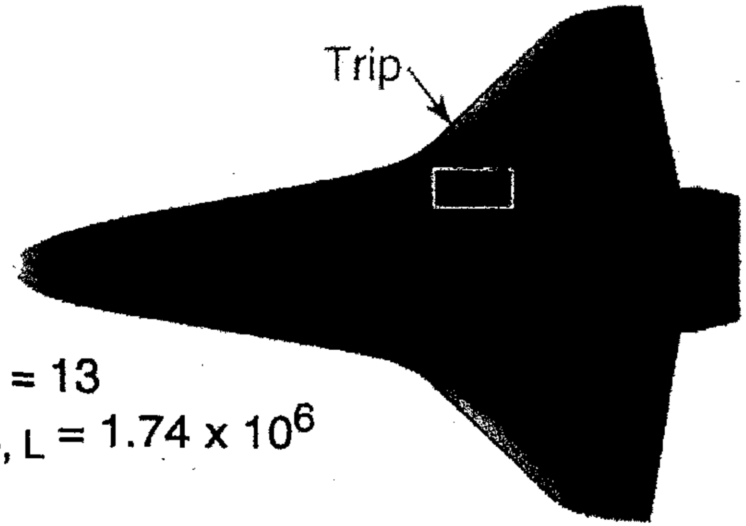
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

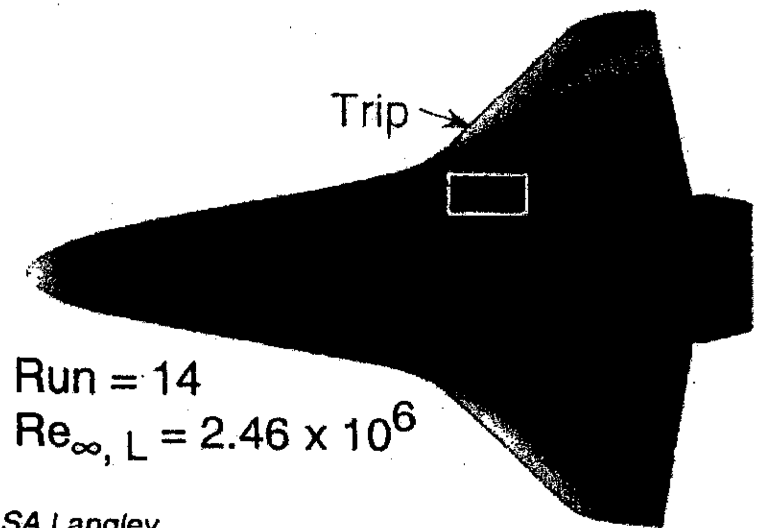
α = 40 deg   Panel # 9   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

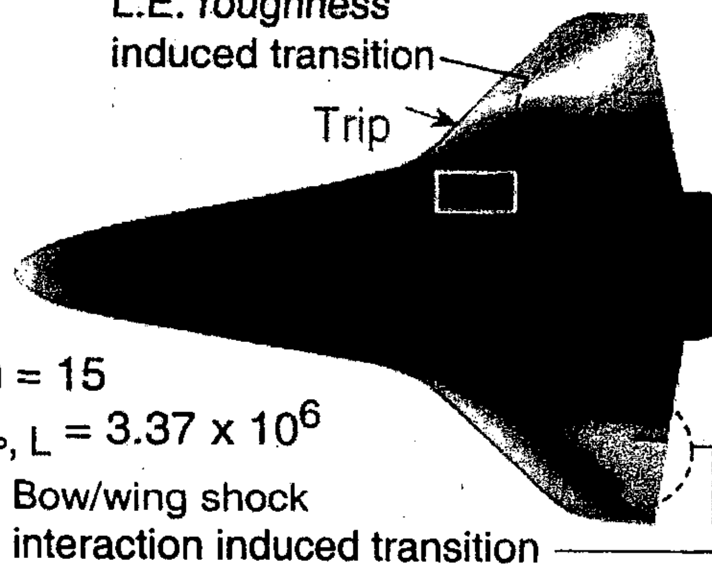




Run = 13
$Re_{\infty, L} = 1.74 \times 10^6$



Run = 14
$Re_{\infty, L} = 2.46 \times 10^6$



Run = 15
$Re_{\infty, L} = 3.37 \times 10^6$

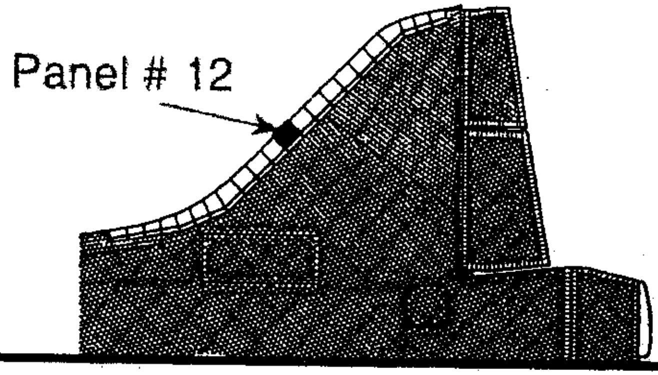
NASA Langley
Aerothermodynamics Branch

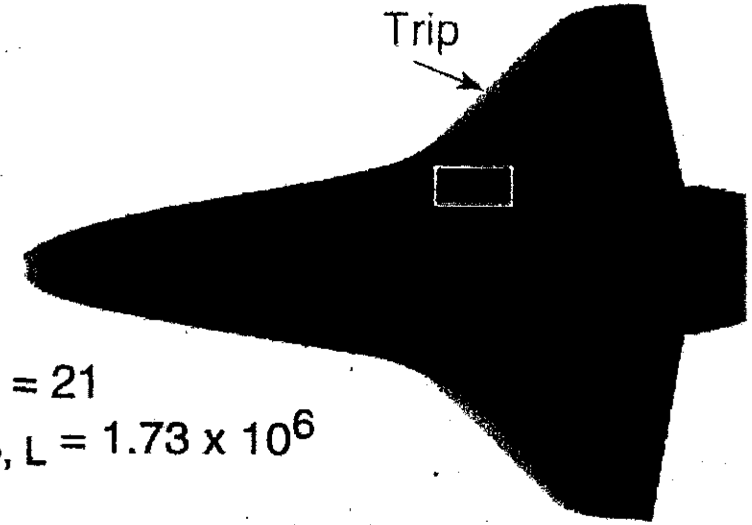
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

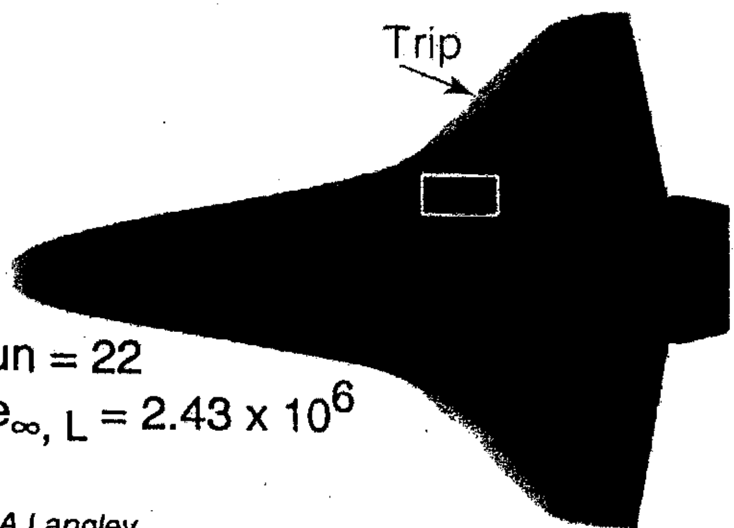
α = 40 deg   Panel # 12   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

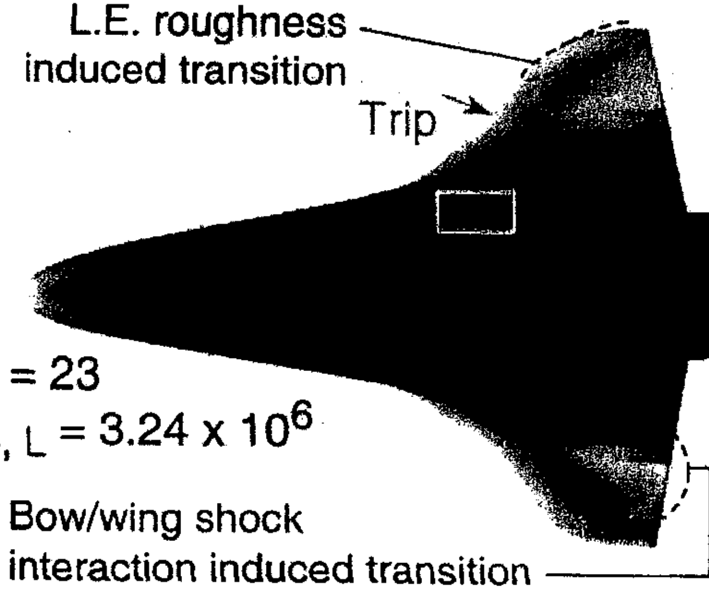




Run = 21
$Re_{\infty, L} = 1.73 \times 10^6$



Run = 22
$Re_{\infty, L} = 2.43 \times 10^6$



Run = 23
$Re_{\infty, L} = 3.24 \times 10^6$

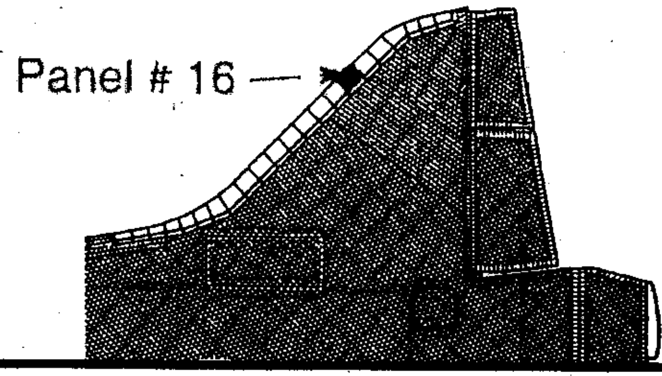
NASA Langley Aerothermodynamics Branch

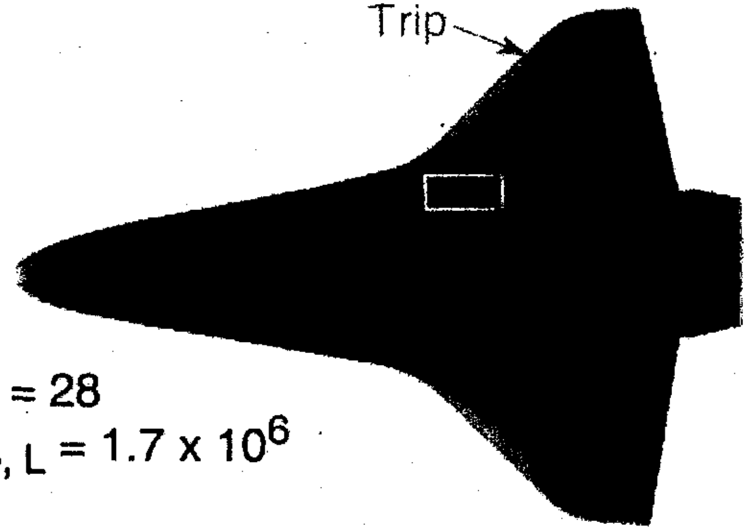
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

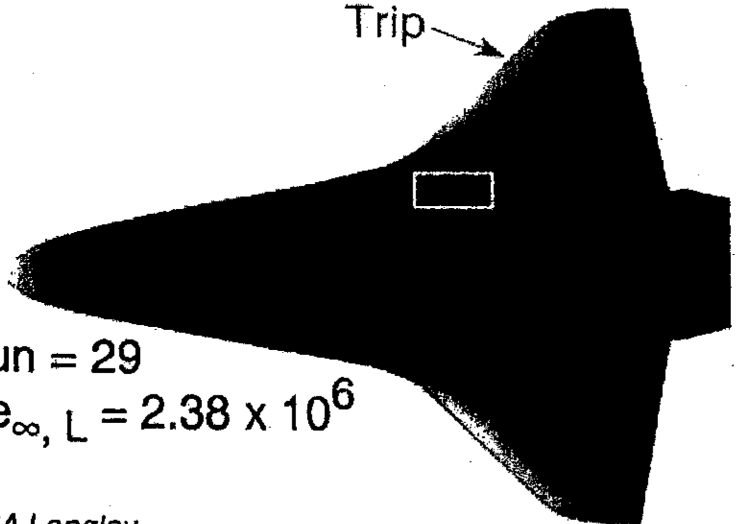
α = 40 deg   Panel # 16   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

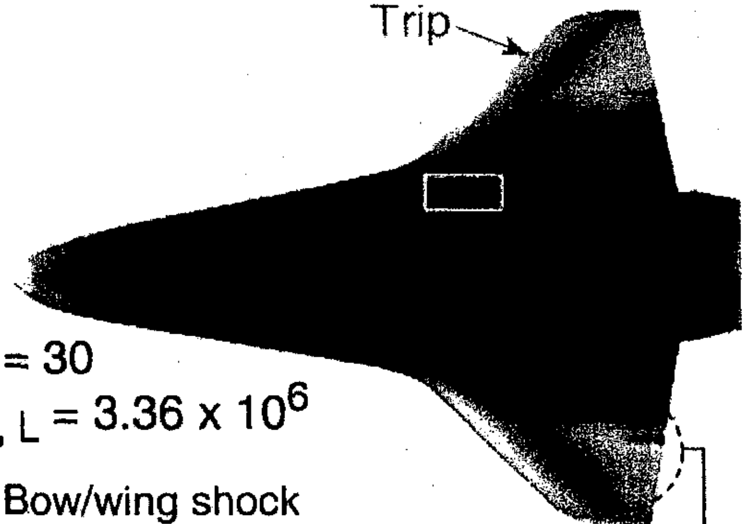




Run = 28
$Re_{\infty, L} = 1.7 \times 10^6$



Run = 29
$Re_{\infty, L} = 2.38 \times 10^6$



Run = 30
$Re_{\infty, L} = 3.36 \times 10^6$

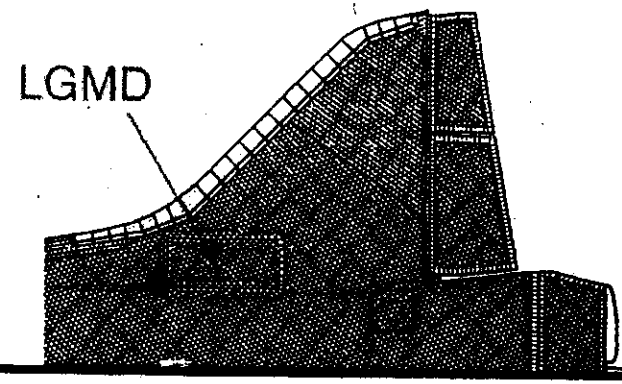
NASA Langley
Aerothermodynamics Branch

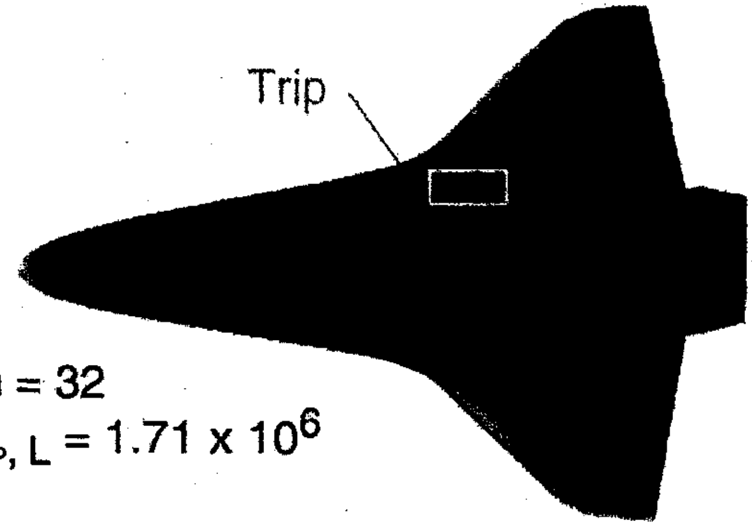
Effect of Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

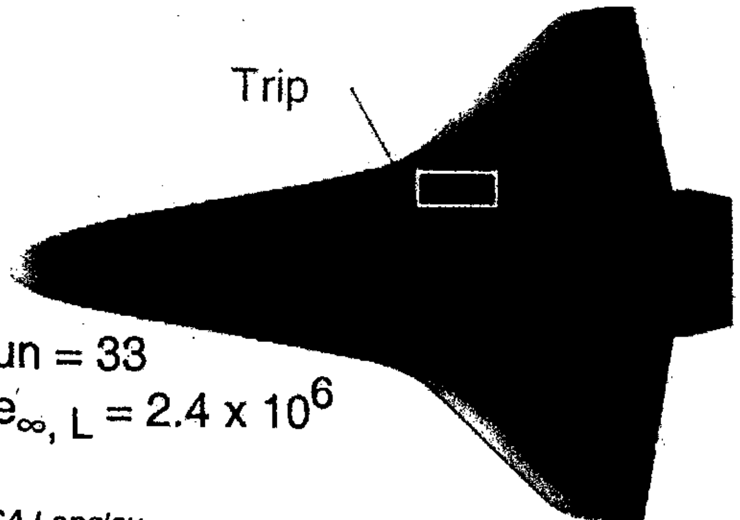
$\alpha = 40$ deg   Inboard LGMD   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.05x0.05	7x7

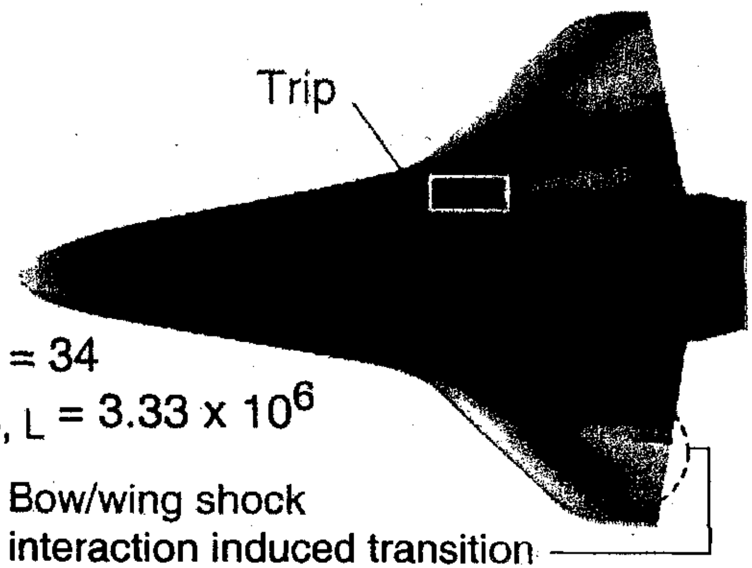




Run = 32
$Re_{\infty, L} = 1.71 \times 10^6$



Run = 33
$Re_{\infty, L} = 2.4 \times 10^6$



Run = 34
$Re_{\infty, L} = 3.33 \times 10^6$

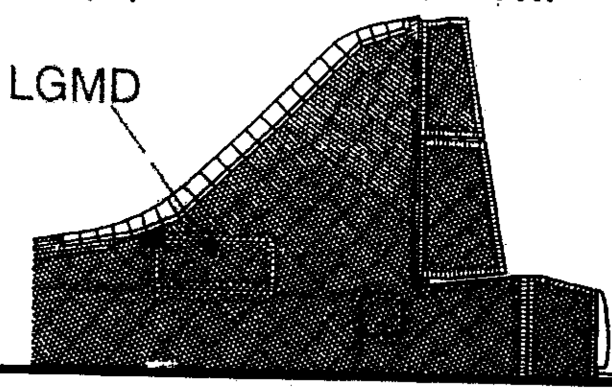
NASA Langley
Aerothermodynamics Branch

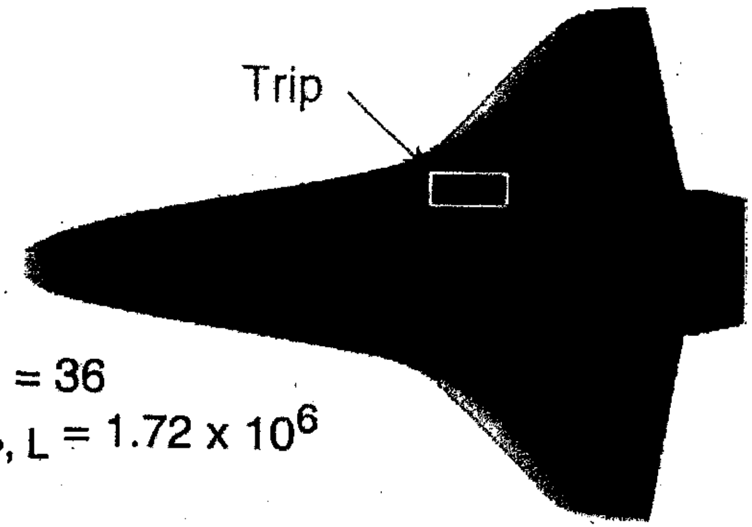
Effect of Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

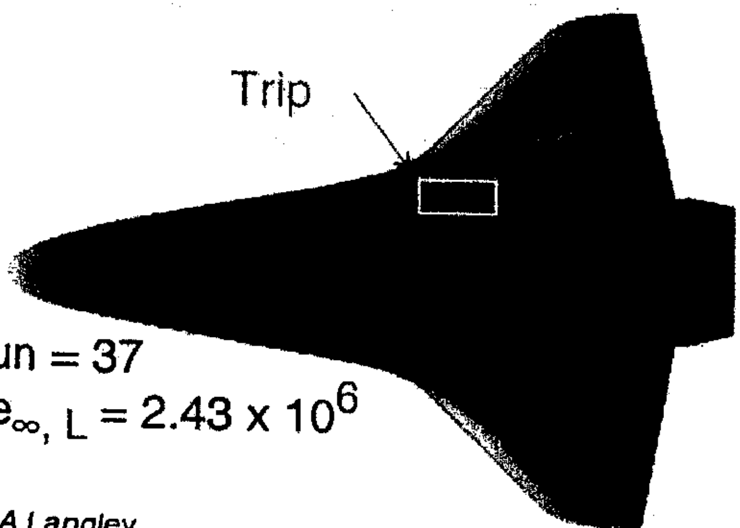
α = 40 deg   Outboard LGMD   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.05x0.05	7x7

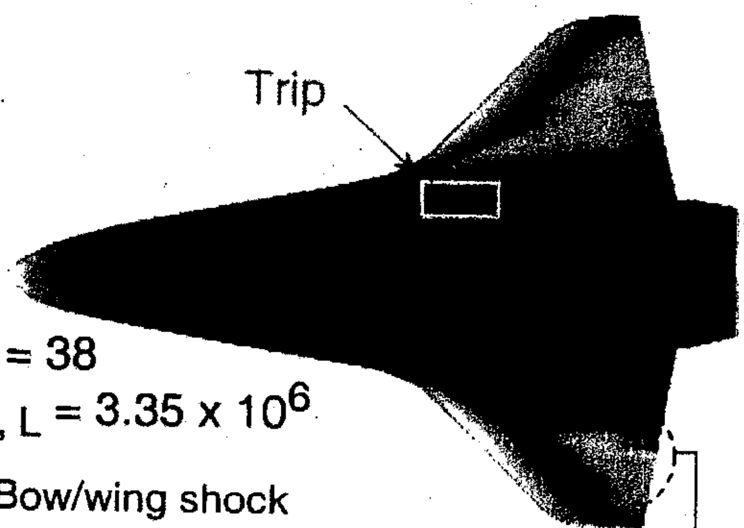




Run = 36
$Re_{\infty, L} = 1.72 \times 10^6$



Run = 37
$Re_{\infty, L} = 2.43 \times 10^6$



Run = 38
$Re_{\infty, L} = 3.35 \times 10^6$

Bow/wing shock
interaction induced transition

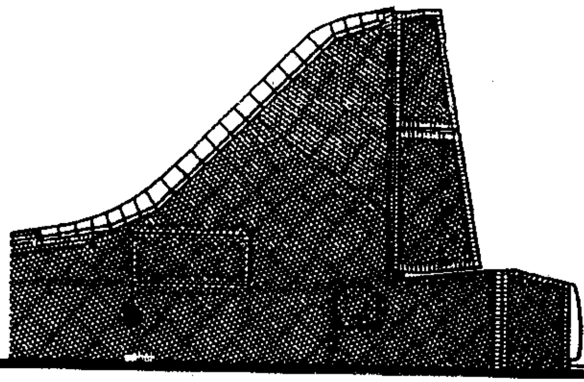
NASA Langley
Aerothermodynamics Branch

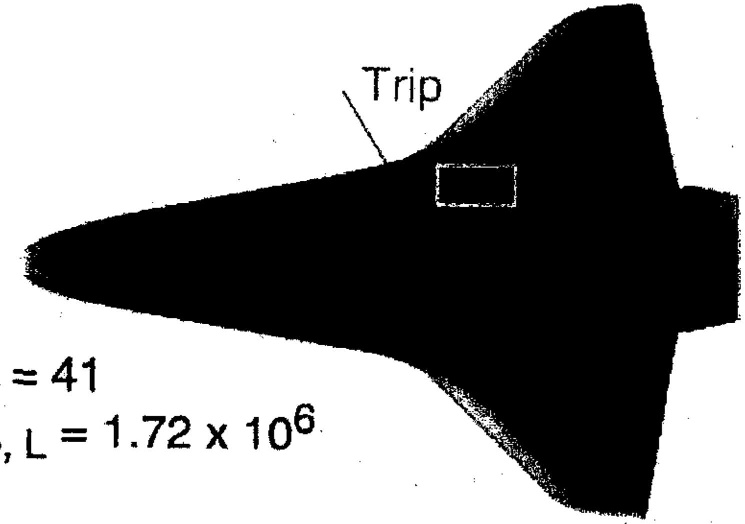
Effect of Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

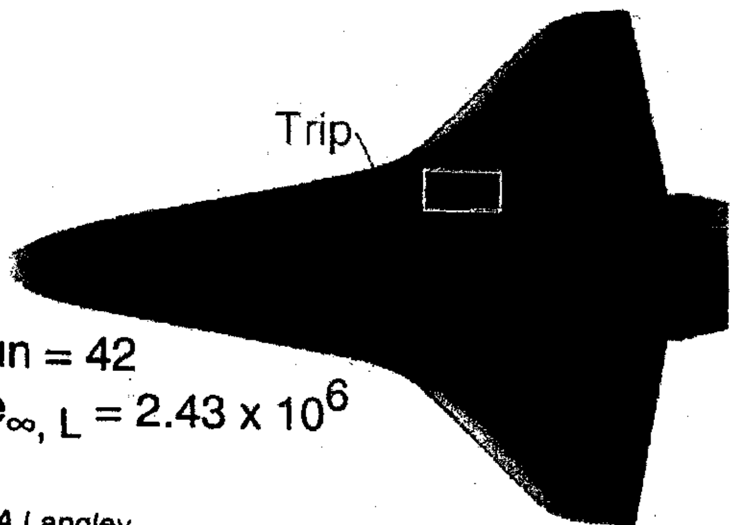
α = 40 deg   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.05x0.05	7x7

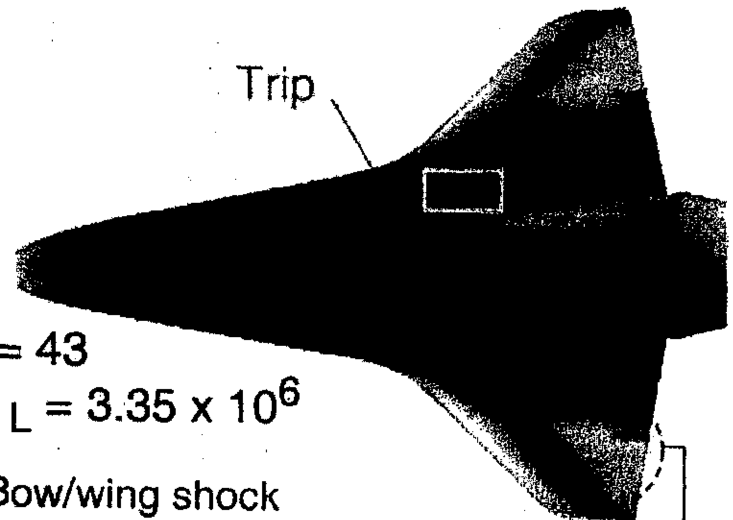




Run = 41
$Re_{\infty, L} = 1.72 \times 10^6$



Run = 42
$Re_{\infty, L} = 2.43 \times 10^6$



Run = 43
$Re_{\infty, L} = 3.35 \times 10^6$

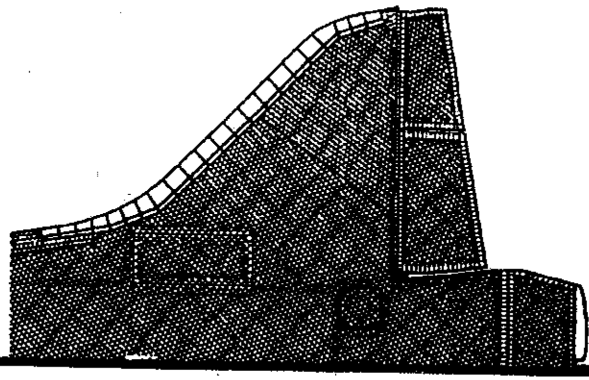
NASA Langley
Aerothermodynamics Branch

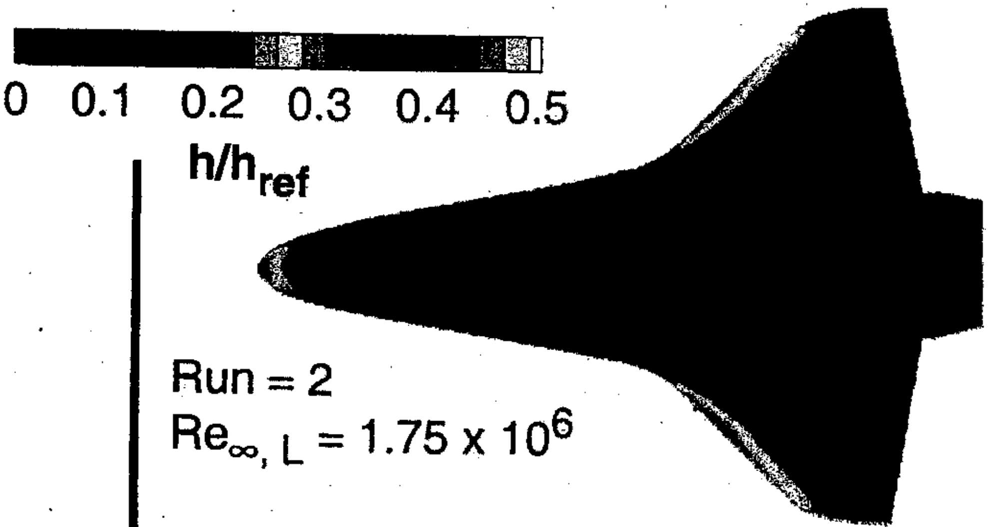
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

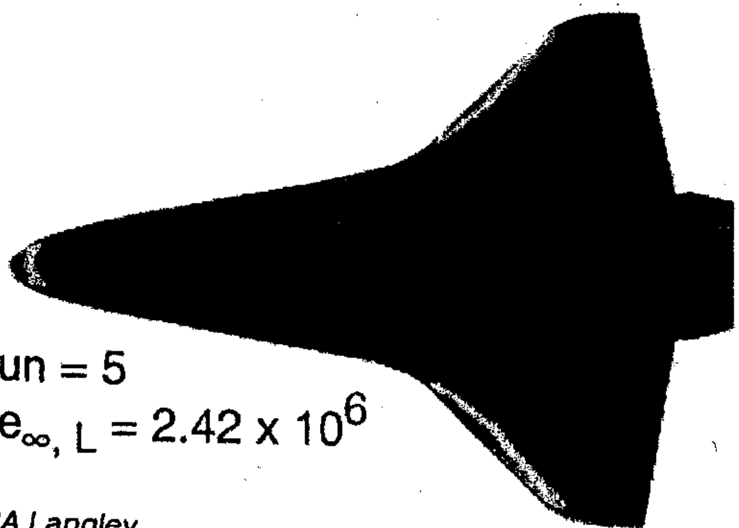
$\alpha = 40$ deg **Baseline** **0.0075 Scale**

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

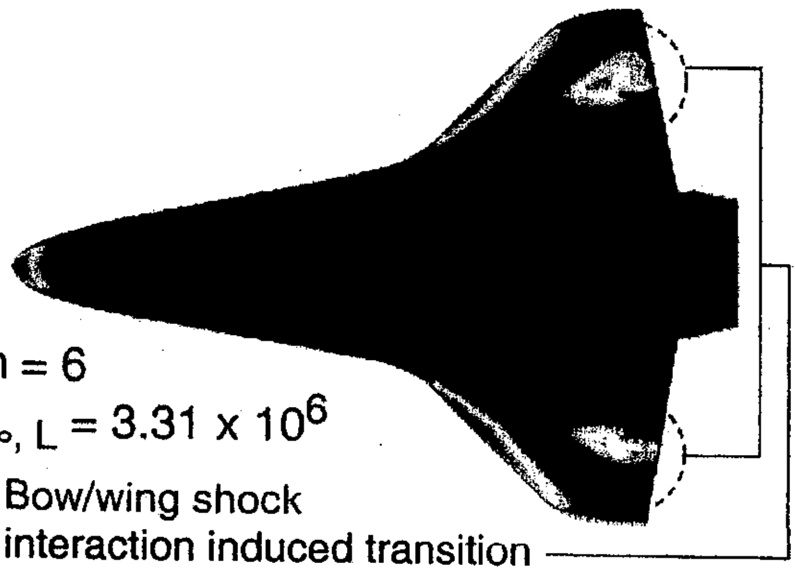




Run = 2
$Re_{\infty, L} = 1.75 \times 10^6$



Run = 5
$Re_{\infty, L} = 2.42 \times 10^6$



Run = 6
$Re_{\infty, L} = 3.31 \times 10^6$

Bow/wing shock
interaction induced transition

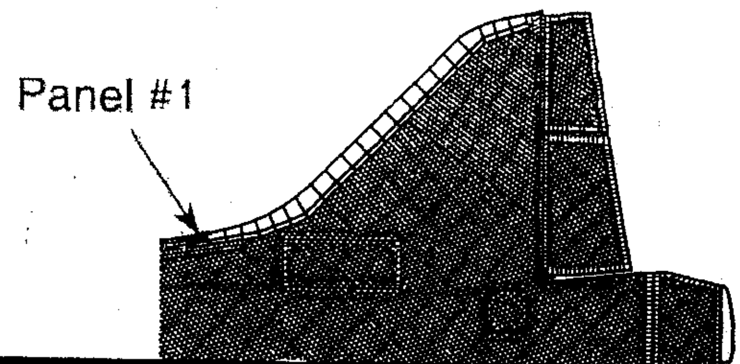
NASA Langley
Aerothermodynamics Branch

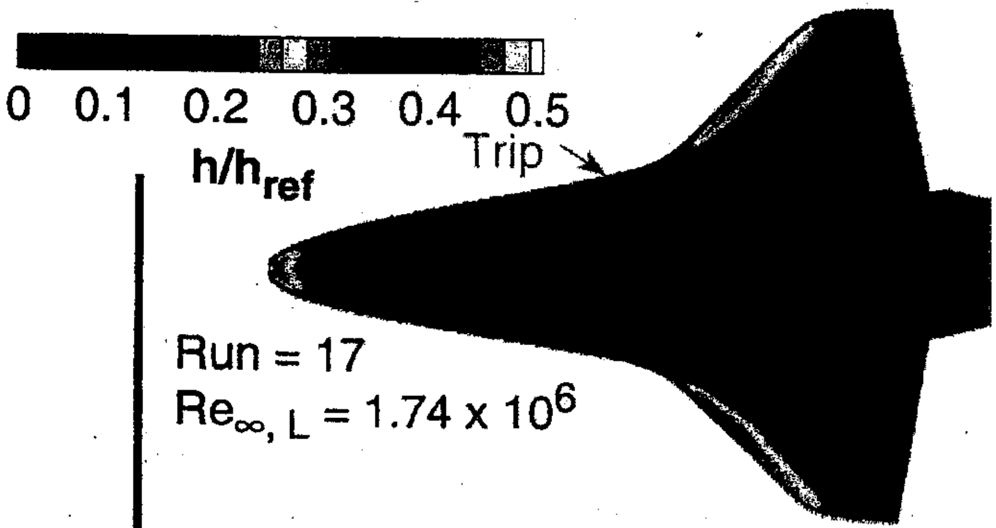
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

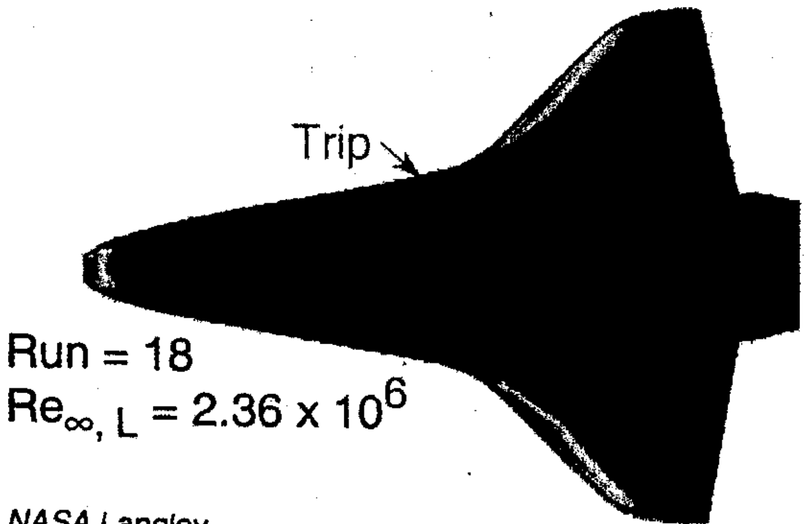
NASA LaRC 20-Inch Mach 6 Air

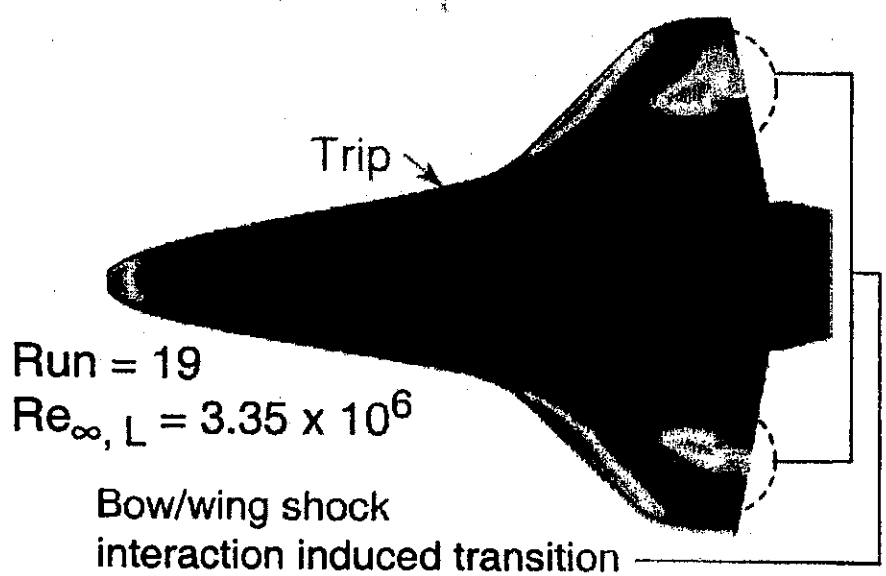
α = 40 deg   Panel # 1   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13









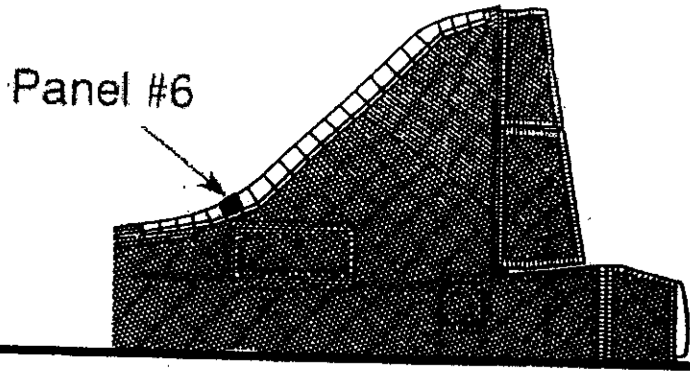
NASA Langley
Aerothermodynamics Branch

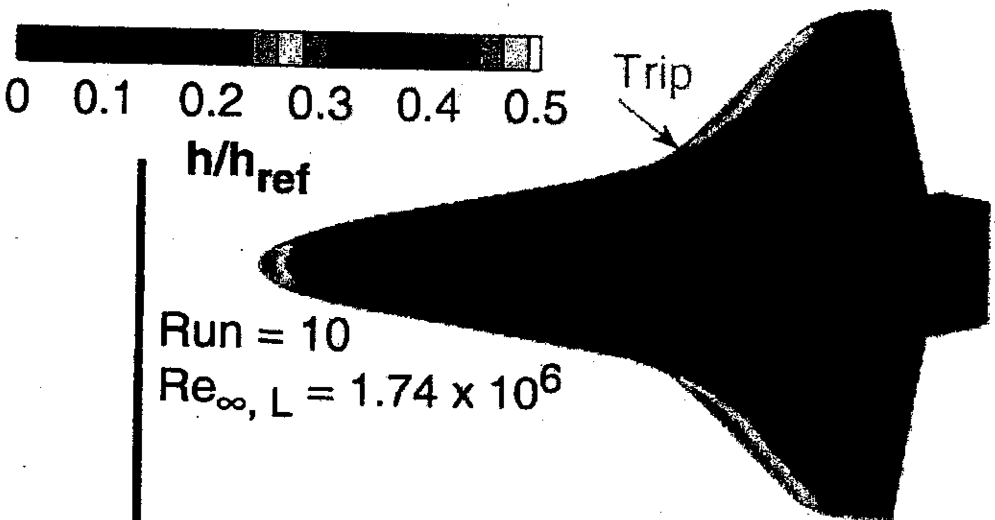
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

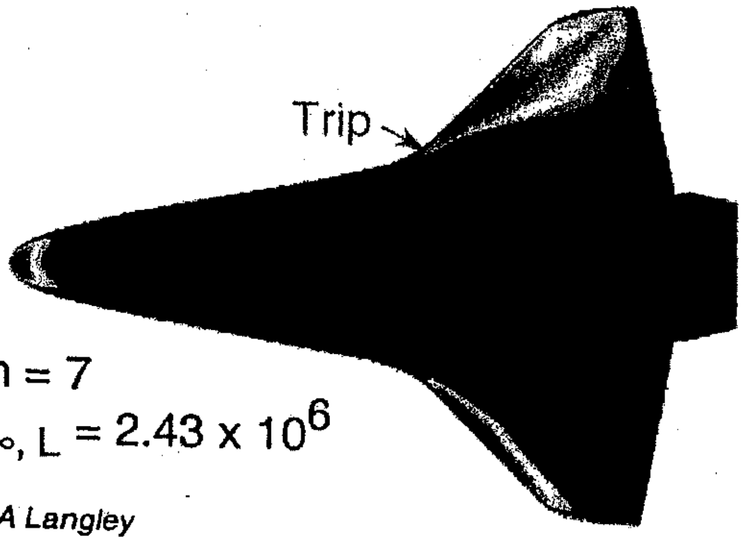
α = 40 deg　　Panel # 6　　0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

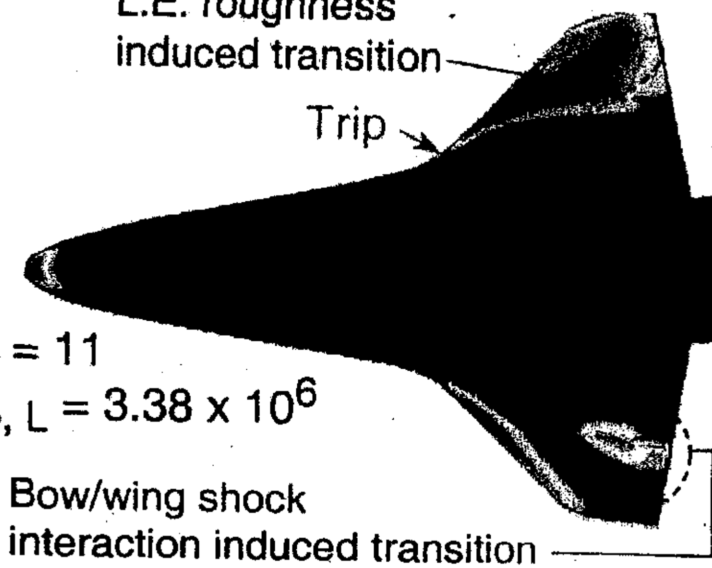




Run = 10
$Re_{\infty, L} = 1.74 \times 10^6$



Run = 7
$Re_{\infty, L} = 2.43 \times 10^6$



Run = 11
$Re_{\infty, L} = 3.38 \times 10^6$

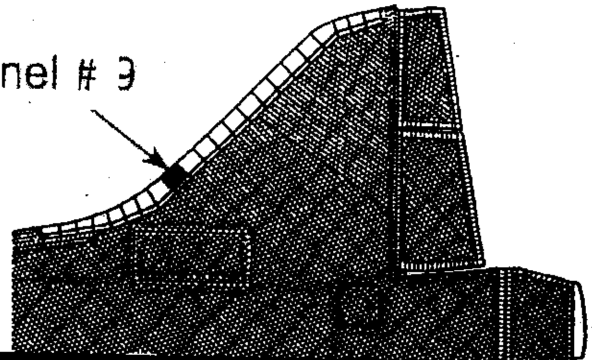
NASA Langley
Aerothermodynamics Branch

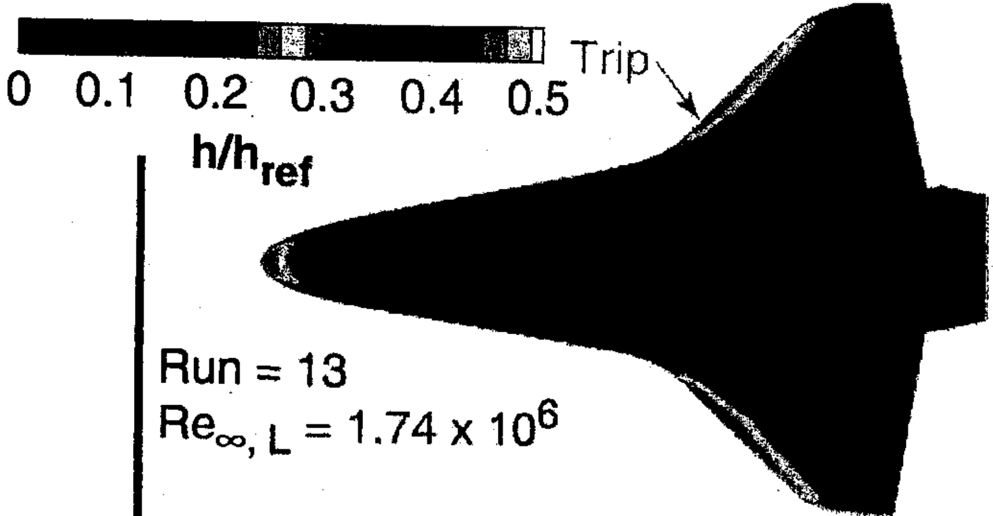
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

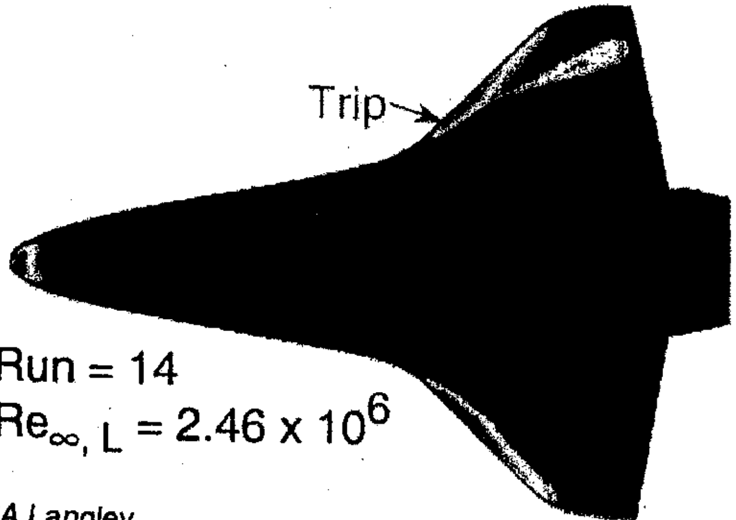
α = 40 deg   Panel # 9   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

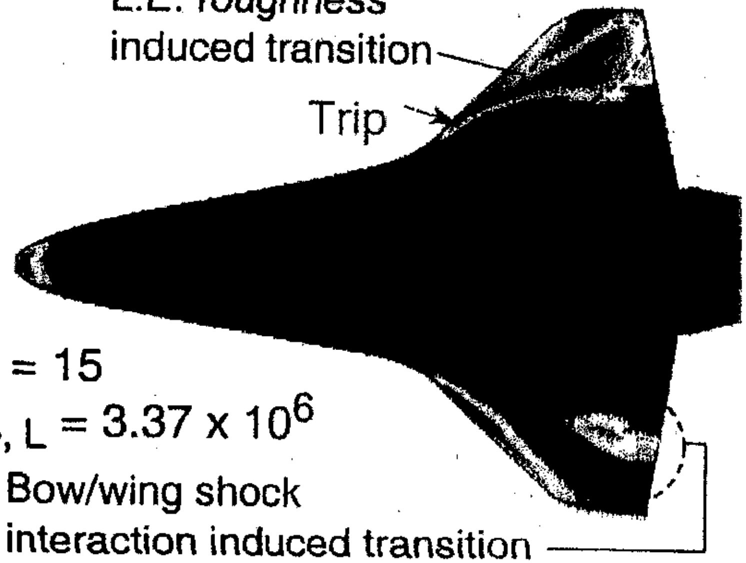




Run = 13
$Re_{\infty, L} = 1.74 \times 10^6$



Run = 14
$Re_{\infty, L} = 2.46 \times 10^6$



Run = 15
$Re_{\infty, L} = 3.37 \times 10^6$

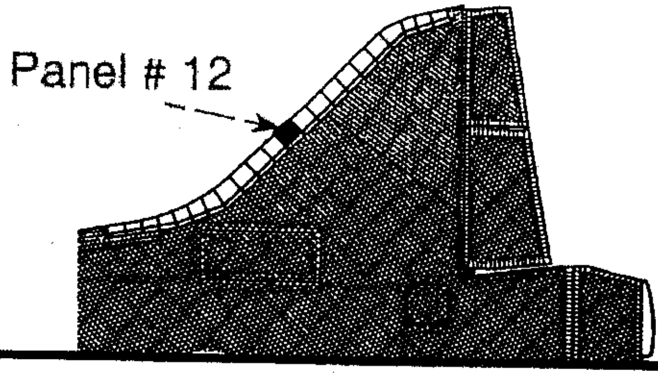
NASA Langley
Aerothermodynamics Branch

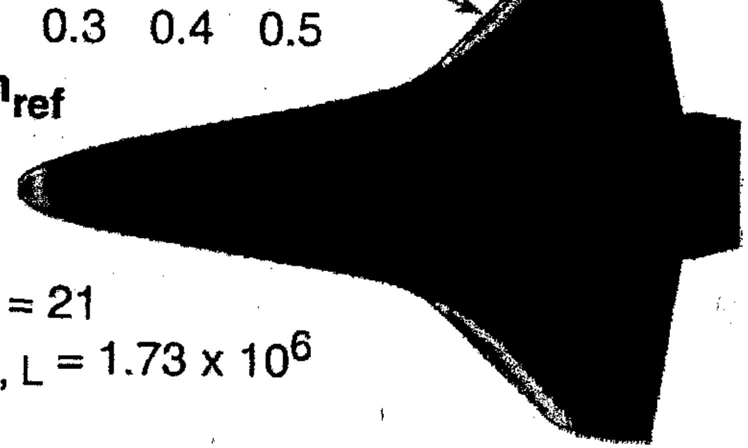
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

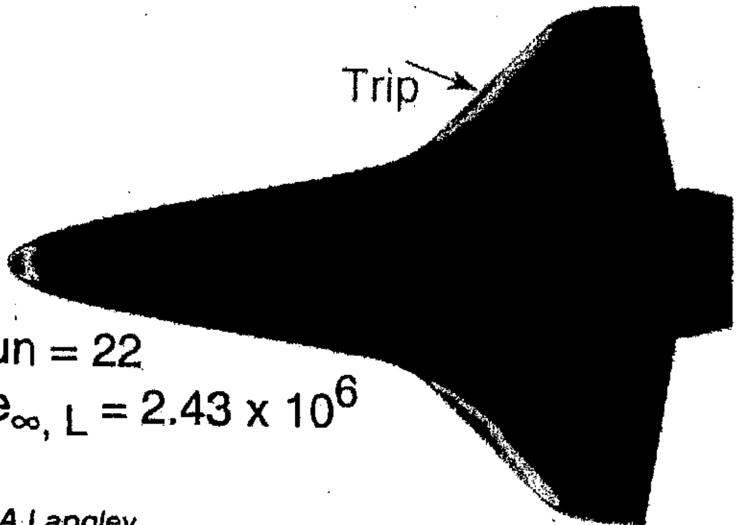
α = 40 deg   Panel # 12   0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

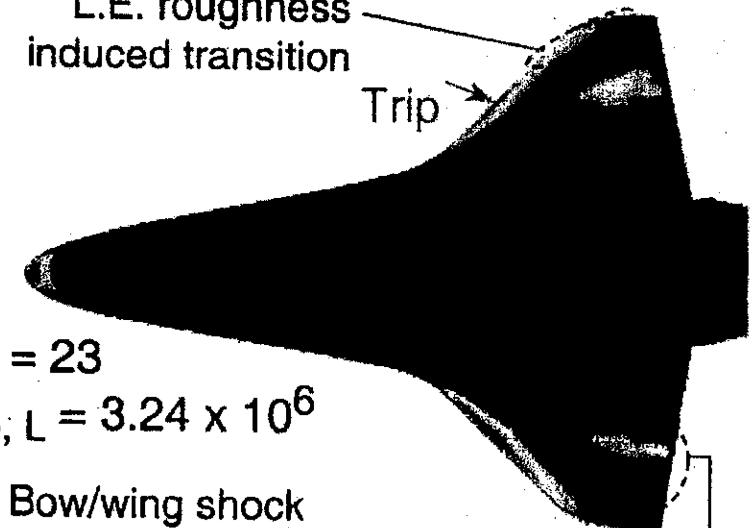




Run = 21
$Re_{\infty, L} = 1.73 \times 10^6$



Run = 22
$Re_{\infty, L} = 2.43 \times 10^6$



Run = 23
$Re_{\infty, L} = 3.24 \times 10^6$

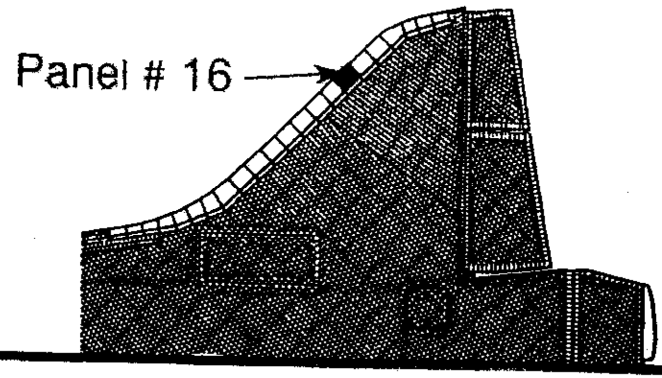
NASA Langley
Aerothermodynamics Branch

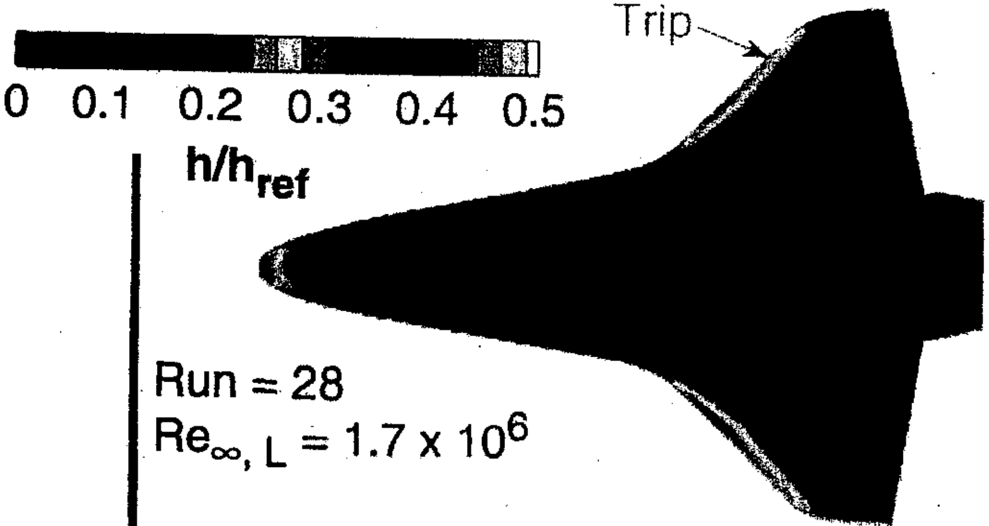
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

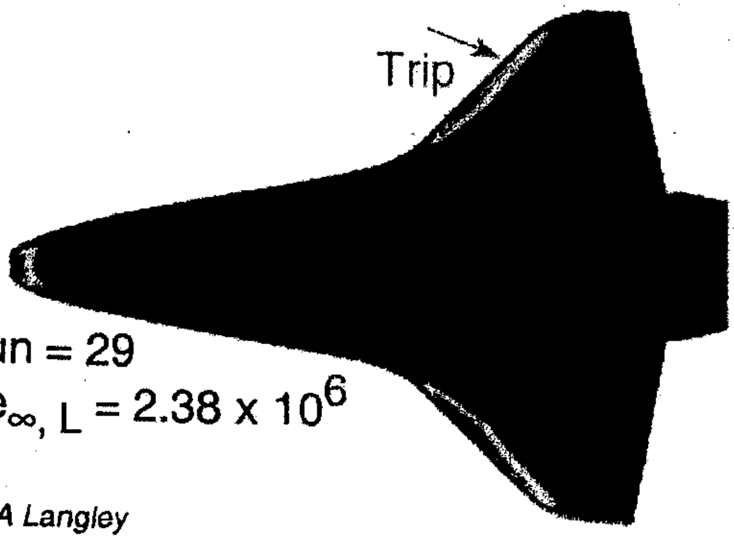
$\alpha = 40$ deg   **Panel # 16**   **0.0075 Scale**

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13

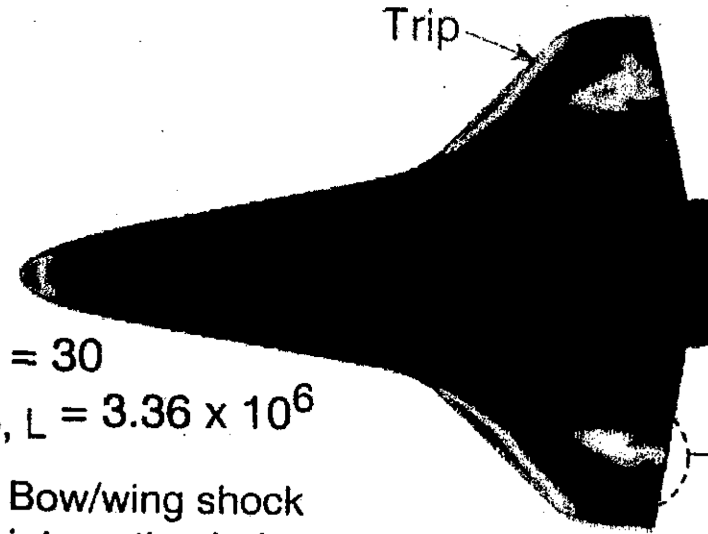




Run = 28
$Re_{\infty, L} = 1.7 \times 10^6$



Run = 29
$Re_{\infty, L} = 2.38 \times 10^6$



Run = 30
$Re_{\infty, L} = 3.36 \times 10^6$

Bow/wing shock
interaction induced transition

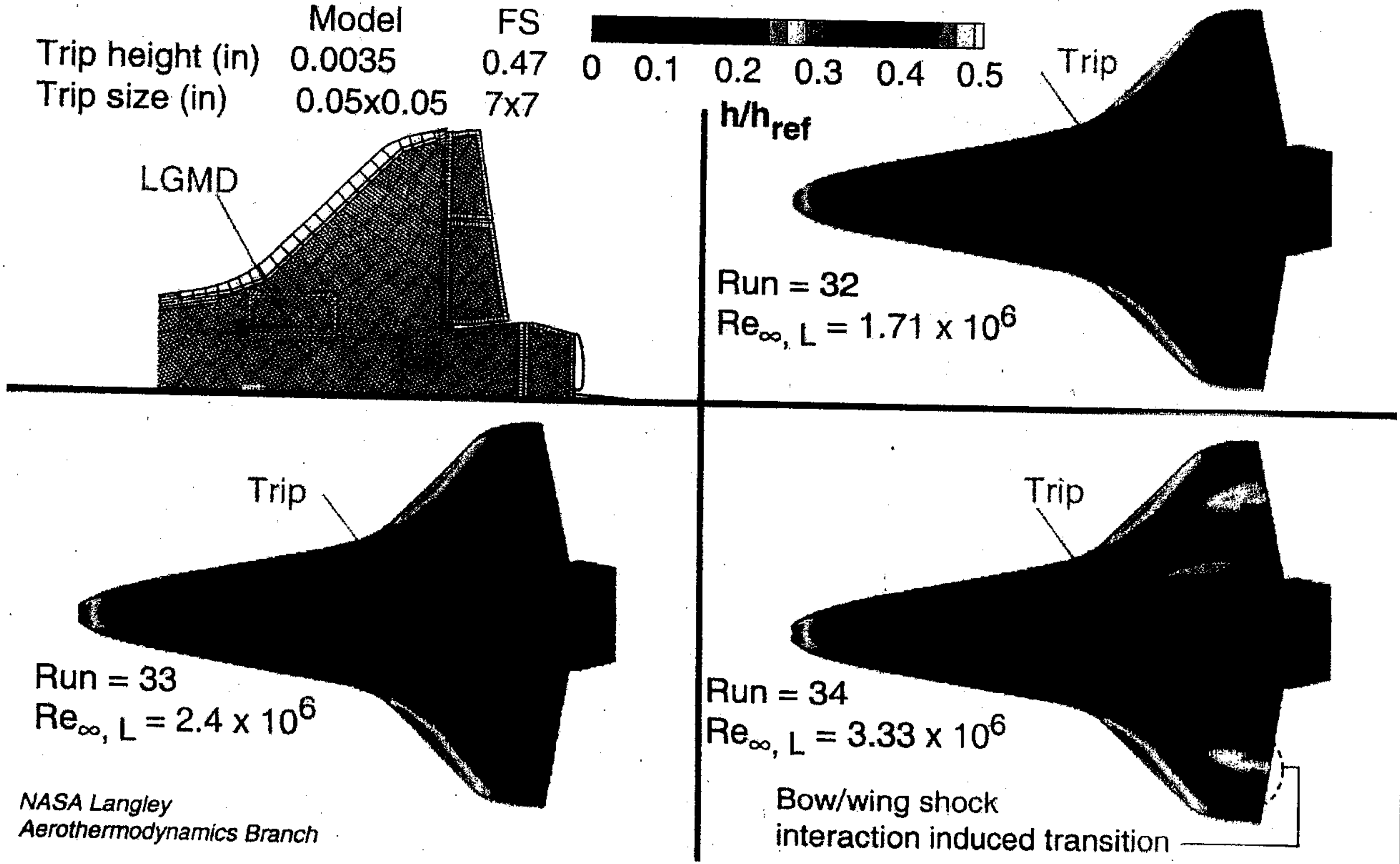
NASA Langley
Aerothermodynamics Branch

Effect of Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

$\alpha = 40$ deg **Inboard LGMD** **0.0075 Scale**

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.05x0.05	7x7



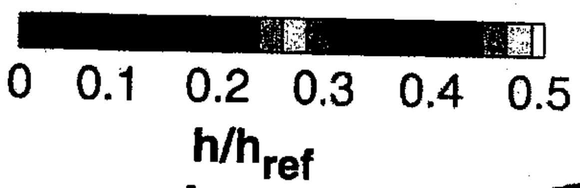
NASA Langley
Aerothermodynamics Branch

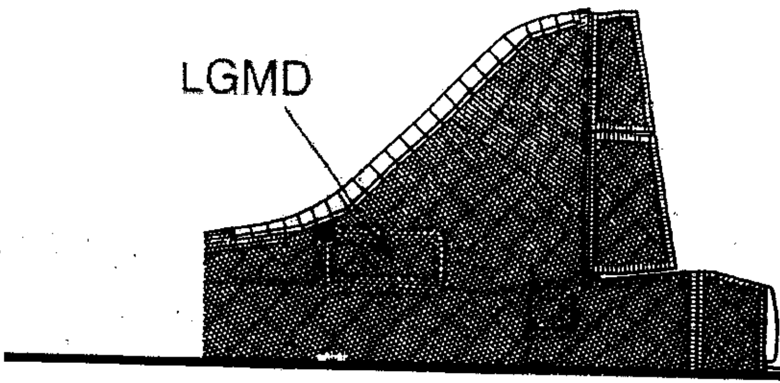
Effect of Roughness on Orbiter Windward Nondimensional Heating

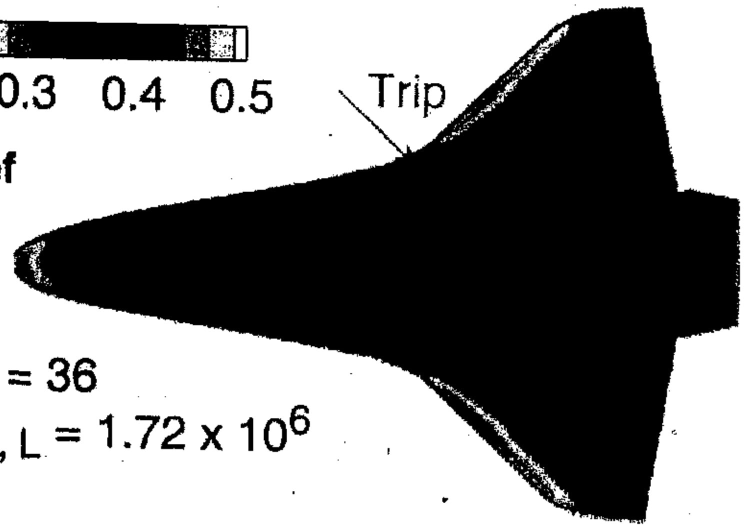
NASA LaRC 20-Inch Mach 6 Air

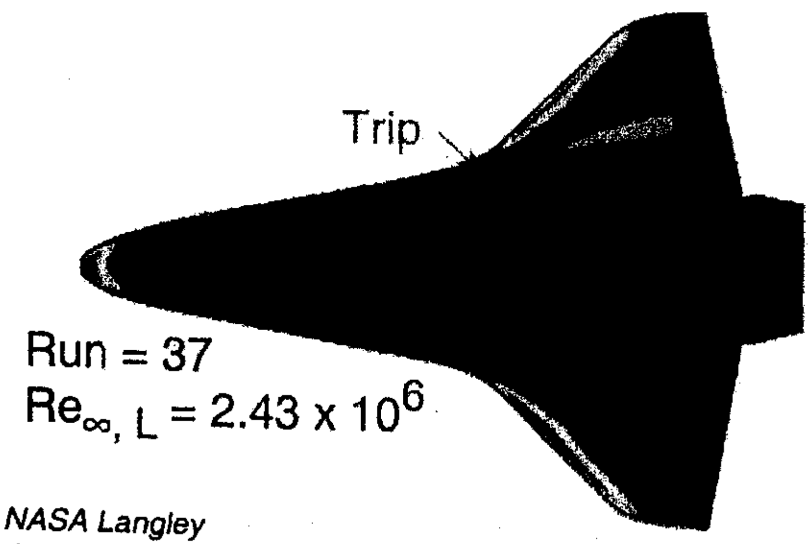
α = 40 deg   Outboard LGMD   0.0075 Scale

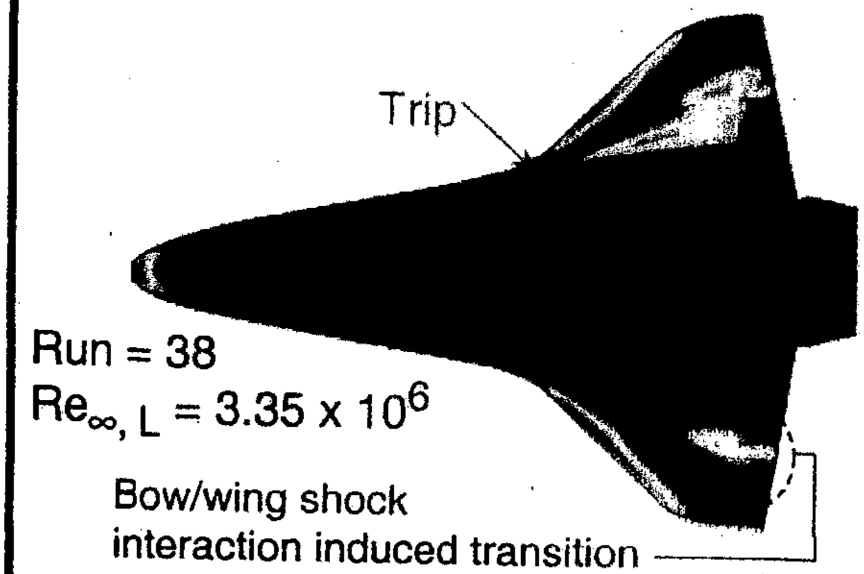
	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.05x0.05	7x7











NASA Langley
Aerothermodynamics Branch

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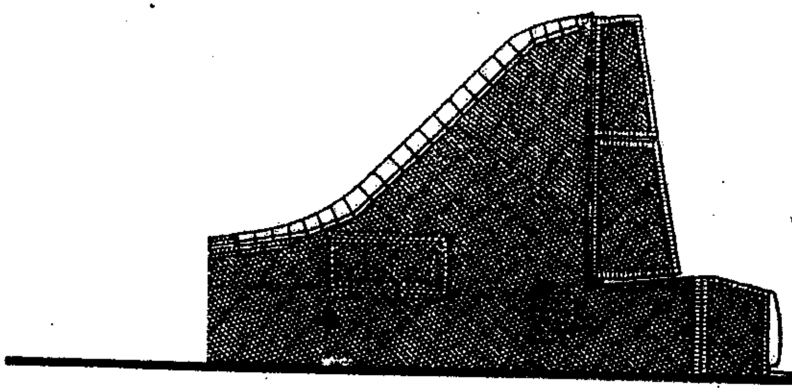

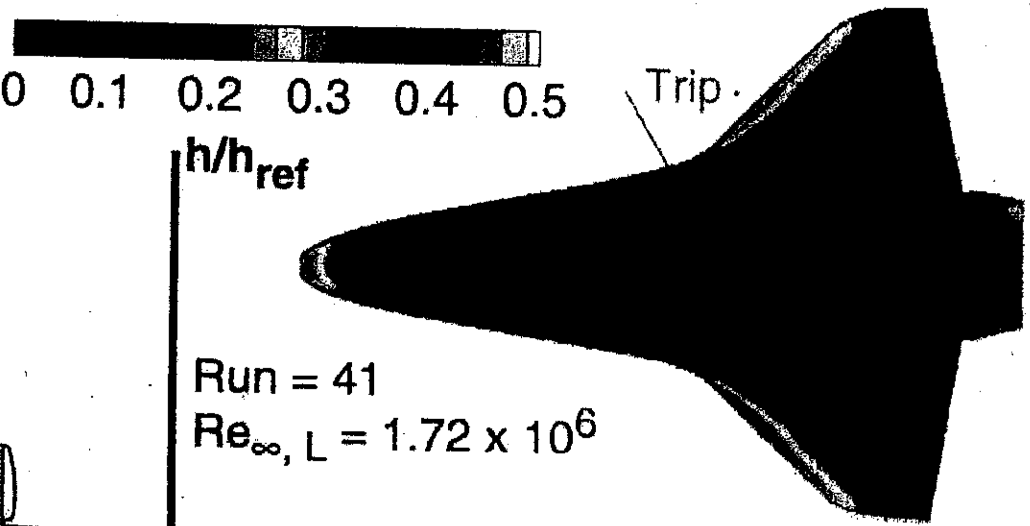

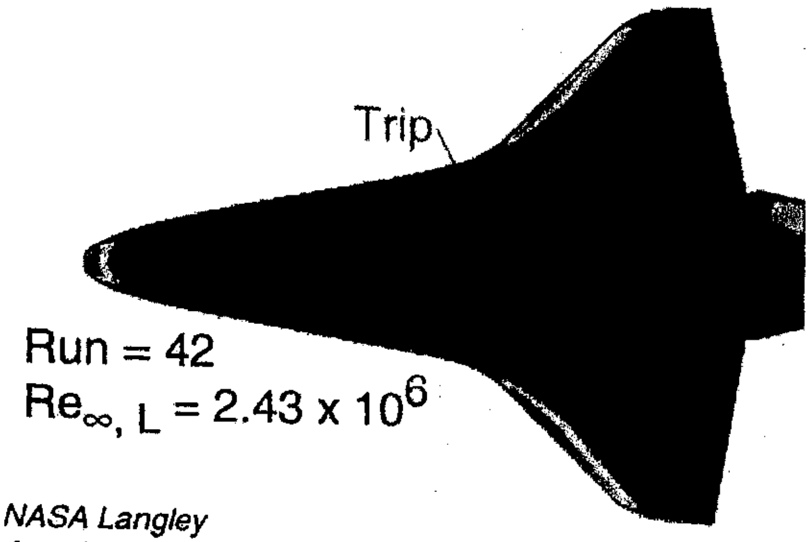

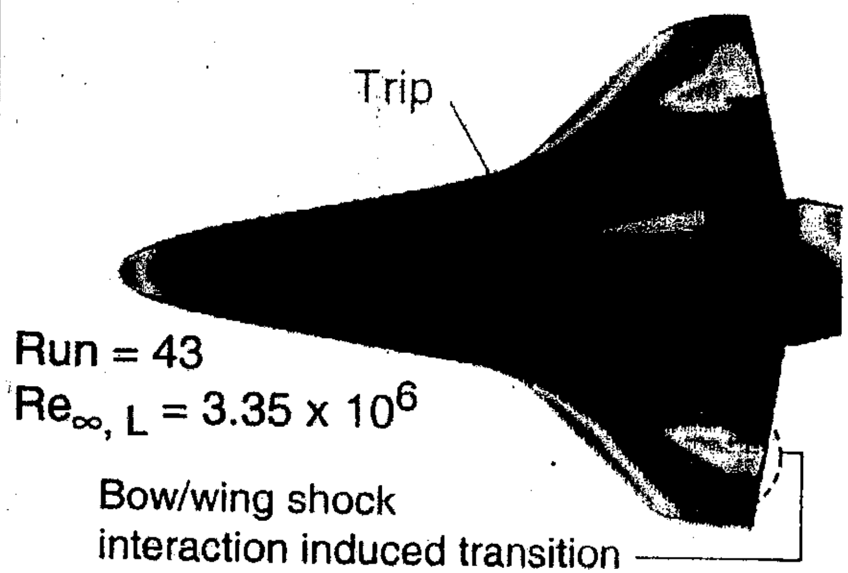

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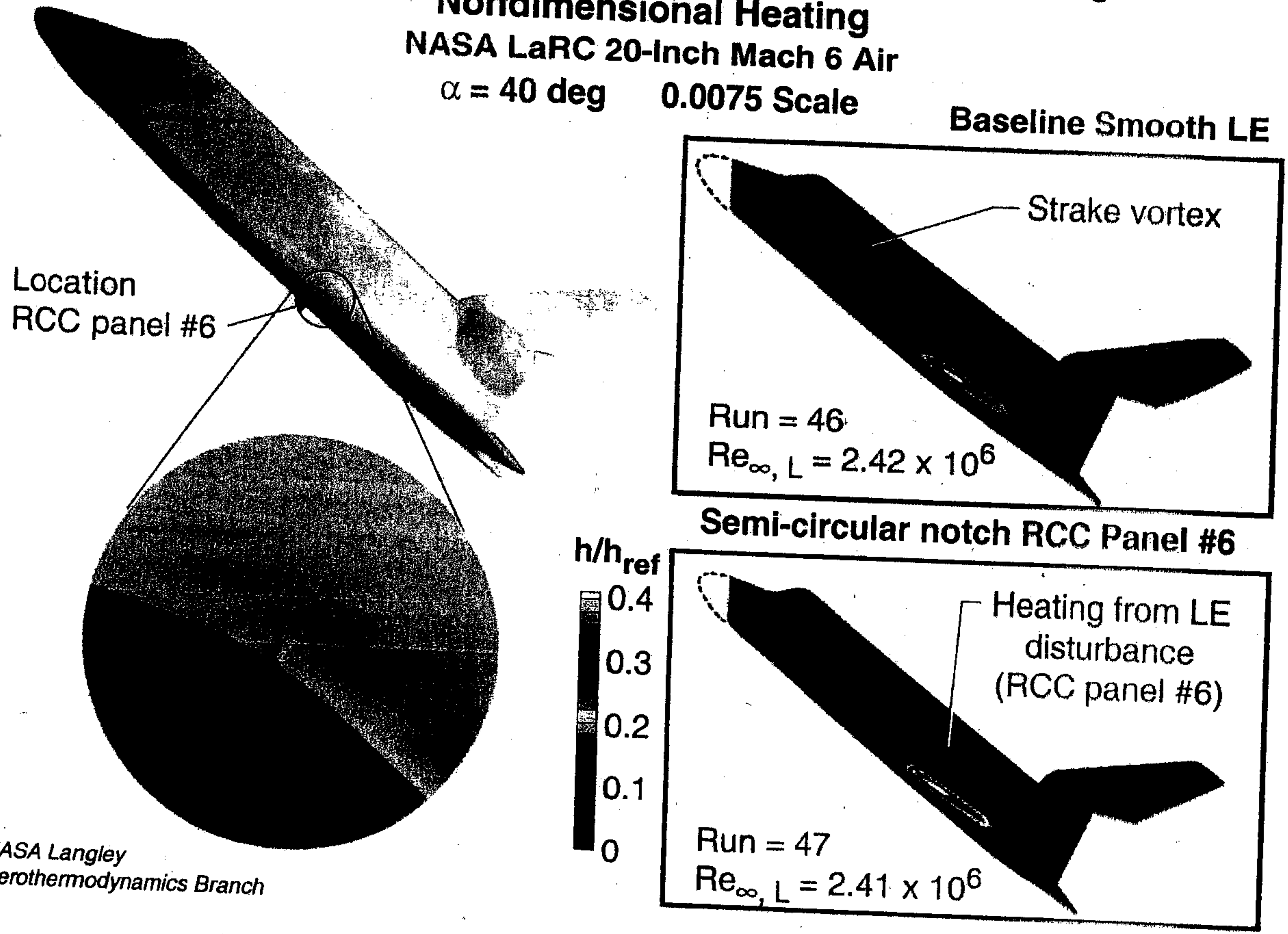
Effect of RCC Panel #6 L.E. Cavity on Orbiter Fuselage Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

α = 40 deg 0.0075 Scale



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Summary

- OML shape changes along wing LE and in vicinity of MLG produce by-pass boundary layer transition near freestream flight length Reynolds number
- Wing heating augmentation a factor of 2 to 3 above laminar values
  - "Healthy" TPS tiles should provide adequate temperature margins
  - Adequate margins for damage/compromised TPS?
- Surface cavity at RCC panel #6 produced externally driven heating augmentation on Orbiter fuselage

Future Plans

- Aerodynamic increments on ceramic heat-transfer model/metallic aero model
  - Asymmetric transition via cavities/protuberances

- Aerothermal/transition tests in LaRC 20-Inch Mach 13-18 Simulator
  - Location of wing/bow shock interaction more appropriate to flight
  - Low Reynolds number more appropriate to flight

- Correlation of roughness induced transition along wing LE and MLG using Re_k, Re_θ/M_e. Comparison with existing Orbiter correlations (Berry, Bouslog, Reda etc).

- Reproduce "early transition" event associated with STS-28 and STS-73 in wind tunnel to provide insight into extrapolation to flight

- Cavity flows [missing tile(s)]