Columbia Action Committee (CAC)
Friday 2-7-03

Meeting Notes

Ashley Stockinger will send all completed reponses to Michael Greenfield.
Michael will review and concur.
Michael will return to Ashley.
Ashley will distribute to source from which the question came.
(A flow diagram is posted on the wall in the CAC illustrates the process).

CAC's task: Perform all HCAT responsibilities dealing with external responses.
HCAT will retain responsibilities dealing with internal responses.

Question (by Michael) : How are we handling companies that send us information and want us to use their products on the Columbia Investigation?

Answer (by Helen- Code L) = Send the information to Code K. They handle small business.

Question (by Michael): How are we handling condolences?
Answer (by Rich Cooper – Code P): These should go to Rich Cooper at Code P. They should not go to the CAC.

Question (by Helen): In the past Code L prepared the briefing book for the administrator. It appears that others are involved (e.g., Code G, Code P). What is Code L's role in the preparation of the briefing book? Seems to be lots of duplication of effort.

Discussion (by Rich Cooper): Yes. We got a call. Glen Mahone asked Code P to assemble background material of the Columbia Investigation to date. That is all information (RTQs) that had already been released and approved. (e.g., on astronauts, their families, etc). We are putting that together for the administrator.

Question (reiterated by Michael): Who has the lead to put together the briefing for the administrator? Where is Code L in the process?

Discussion (Michael): Meeting on Saturday 4-6. Paul Pastorek will go through all the questions in the preparation session.

Discussion (All) – CAC working all approved stuff and putting it into the CAC database. The database will be available to develop the briefing book.

Question (Helen): Who is doing the things in Ashley's memo?
Answer (Michael): It is not CAC's responsibility to send tasks out like through Ashley's memo. Will be done differently.

Discussion (Rich): Code P is taking the approved existing information and making RTQs (this is a subset of Paul P.'s activities). Rich is also trying to get all the RTQs that have already been done (before today), collect them and get them for inclusion in the database. The plan is to print a complete set once this is done.

Discussion (Ashley): No new CAC actions received today.
Discussion (Michael & Helen): Anticipated that there will be many RTQs after Congressional hearing.

Action (given by Michael): Code Q to have RTQs to Michael (and to Ashley Stockinger) by 5:00 close of business today. RTQs do not have to be in standard format for this release.

(Code P provided sample format for RTQ... this was provided to Jim Lloyd after the meeting).

Other information going into the CAC database:

- Press releases
- Mission status reports for each day.
- Budget information
- Transcripts from all televised discussions on Space Shuttle

Sunday there will be a preparation session for the administrator (for Congressional hearing).

J Steven Newman, 04:28 PM 2/7/2003 -0500, Re: Request from NASA HQ

X-Sender: snewman@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Fri, 07 Feb 2003 16:28:07 -0500
To: "Clark-Ingram, Marceia" <Marceia.A.Clark.Ingram@msfc.nasa.gov>
From: J Steven Newman <snewman@hq.nasa.gov>
Subject: Re: Request from NASA HQ
Cc: "Martin, Jolene" <Jolene.J.Martin@nasa.gov>,
"Glover, Steve" <Steve.E.Glover@nasa.gov>,
"Holmes, Steven G" <Steven.G.Holmes@nasa.gov>,
"Clark-Ingram, Marceia" <Marceia.A.Clark.Ingram@msfc.nasa.gov>,
"Munafo, Paul" <Paul.M.Munafo@nasa.gov>, mkowales@hq.nasa.gov,
prutledg@hq.nasa.gov, james Lloyd <jlloyd@hq.nasa.gov>,
Amanda.Goodson@msfc.nasa.gov

Background/ Clarification to Marceia's Note:

Office of Safety & Mission Assurance (OSMA) Programmatic Independent Assessment Team - an ongoing OSMA activity, not specifically a 107 assessment activity. Paul.Munafo will remember working together on the SLWT design verification, Q Independent Assessment in 1997.

This OSMA activity is currently pulling together background info related to ET 93 (see below) specifically to support NASA-wide SMA community, and AA/SMA Bryan O'Connor. I am also pulling together historic CFC/ODS Phase out info from 1990-1994 period during my tenure as Chief Environmental Engineer in the Office of Space Flight.

Please give me a call if you have any questions
Regards/Steve
202-358-1408

At 02:25 PM 2/7/2003 -0600, Clark-Ingram, Marceia wrote:

Hi All,

I received a request today, from QE/Mr. Steve Newman of the Safety Mission Assurance Office at NASA Headquarters. Mr. Newman worked on operational environmental issues for Code M during the early 1990's. He is currently supporting Bryan O'Connor and leading a "Programmatic Assessment Team" for STS-107. This programmatic assessment team is focusing on the phase-out of blowing agents. Mr. Newman has requested information concerning the following:

- What is the name of the foam system on the Orbiter's bi-pod assembly?
- What is the blowing agent that is used in the foam system on the bi-pod assembly?
- What solvent is used to clean the metallic substrate under the foam system on the bi-pod assembly?
  - Is the solvent Methyl Ethyl Ketone (MEK) ?
- What is the process description for cleaning and foam application on bi-pod assembly? Are work instructions available?
- Is this a close-out foam and is it applied at MAF or KSC?

I am aware that the dissemination of information concerning STS-107 is very sensitive. Please provide guidance from (ET or SEA) concerning the appropriate communication flow for addressing this request. I provided Ms. Jolene Martin's phone number to Mr. Newman. I am more familiar with the acreage TPS on the ET and less familiar with foam on Orbiter, however, I will support the request per your direction. Additionally, Mr. Newman has contacted Ms. Amanda Goodson concerning this request.

Thanks,

ED36/Marceia Clark-Ingram
Materials Replacement Technology Team, Lead
256-544-6229
marceia.a.clark.ingram@msfc.nasa.gov

J Steven Newman, 04:28 PM 2/7/2003 -0500, Re: Request from NASA HQ

prichard@hq.nasa.gov, 10:43 AM 2/4/2003 -0500, Fwd: RE: STS-107 Payloads

To: prichard@hq.nasa.gov
From: Pete Rutledge <prutledg@hq.nasa.gov>
Subject: Fwd: RE: STS-107 Payloads
Cc:
Bcc:
Attached:

Pam,

Something Mike Card is pursuing. For the list of things we're doing.

Pete
X-Sender: mcard@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Mon, 03 Feb 2003 18:17:36 -0500
To: pete Rutledge <prutledg@hq.nasa.gov>
From: Michael Card <mcard@hq.nasa.gov>
Subject: Fwd: RE: STS-107 Payloads

Payload data requested, see below. Mike

From: "CIANCONE, MICHAEL L. (JSC-NC) (NASA)" <michael.l.ciancone@nasa.gov>
To: "MORELAND, DEAN (JSC-NC) (NASA)" <dean.moreland-1@nasa.gov>
Cc: "CIANCONE, MICHAEL L. (JSC-NC) (NASA)" <michael.l.ciancone@nasa.gov>,
"CARD, MIKE (JSC-REMOTE)" <mcard@hq.nasa.gov>
Subject: RE: STS-107 Payloads
Date: Mon, 3 Feb 2003 16:26:04 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Dean,

Mike is interested in essentially the same info that we're preparing for others, i.e., the beefed up payload safety summary. In addition, he needs enough info to assess whether or not payloads contributed in some fashion to the loss of Columbia. Please include him on dist when this info becomes available. And reflect on the doc log at that time.

M

-----Original Message-----
From: CARD, MIKE (JSC-REMOTE)
Sent: Monday, February 03, 2003 10:12 AM
To: CIANCONE, MICHAEL L. (JSC-NC) (NASA)
Subject: STS-107 Payloads

Mike, I have been asked to pull together as much background information as possible on STS-107 payloads in anticipation of support for Bryon O'Connor. As a start do you have a complete list of payloads and a summary of respective safety issues, or please tell me where I might find such data. I guess you may be working on a similar type of analysis. Pleae call me 202-358-4481 so that we can talk. thanks. Mike Card

Martha Wetherholt, 04:31 PM 2/4/2003 -0500, Software, mostly, questions for Bryan

X-Sender: mwetherh@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 04 Feb 2003 16:31:23 -0500
To: prutledg@hq.nasa.gov, James Lloyd <jlloyd@hq.nasa.gov>, jlemke@hq.nasa.gov, prichard@hq.nasa.gov
From: Martha Wetherholt <mwetherh@hq.nasa.gov>
Subject: Software, mostly, questions for Bryan
Cc: sbrookov@hq.nasa.gov, pboldon@hq.nasa.gov

Sorry for the massive distribution but it seems everyone needs to know what and to whom we are sending things so here you all go!

This is my first cut at Software type questions and while they are mostly just that, they are not strictly limited to software.

I have not contacted Sharyl Butler as she is directly involved and will input her questions through a different venue, nor have I opened this up to IV&V and other S&MA SA offices yet. This is just your HQ, Code QS, input for the time being.

Martha


Columbia SW Questions plus.doc

Martha S. Wetherholt
NASA HQ Code QS

mwetherh@hq.nasa.gov
(202) 358 - 0470
(202) 358 - 3104 FAX

Wayne R. Frazier, 02:11 PM 2/12/2003 -0500, AFTAC support to CAIB and MIT

X-Sender: wfrazier@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Wed, 12 Feb 2003 14:11:53 -0500
To: jlloyd@hq.nasa.gov, jlemke@hq.nasa.gov, prutledg@hq.nasa.gov
From: "Wayne R. Frazier" <wfrazier@hq.nasa.gov>
Subject: AFTAC support to CAIB and MIT
Cc: prichard@hq.nasa.gov

Several days ago, I received an offer from an ARMY contractor (AFTAC) at Patrick AFB in FL, who indicated they had access to a side looking hyperspectral scanner which could be used to support the CAIB ground debris effort. Thru Bill Hill I had originally put him in touch with the FEMA ops center in Lufkin, but he called me back to indicate that he has not been able to get in contact with anyone there. I gave him Dave Whittle's number and subsequently spoke to Dave Whittle who indicated he would contact him. This cabability is in place and can be flown immediately to support debris location and categorization especially after getting the signatures needed from the pieces already recovered. This offer is free to NASA--all that is needed is a phone call or fax or something from NASA requesting it.

When I talked to Dave Whittle, he indicated he would call him.

Wayne R. Frazier
NASA Headquarters - Code QS
Office of Safety and Mission Assurance
Washington,DC 20546-0001
Ph: 202 358-0588 Fax: 202 358-3104

"Mission success starts with safety"

Pamela Richardson, 12:55 PM 2/7/2003 -0500, 02/07/03 files

X-Sender: prichard@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Fri, 07 Feb 2003 12:55:21 -0500
To: Jim.Lloyd@hq.nasa.gov, Pete.Rutledge@hq.nasa.gov
From: Pamela Richardson <prichard@hq.nasa.gov>
Subject: 02/07/03 files

for distribution, Pam

 Qactions3.doc

 offersofassistance3.doc

 2703.delta.questionsforbryan.doc

 questionsforbryan6.doc

Pamela F. Richardson
Aerospace Technology Mission Assurance Manager
Enterprise Safety and Mission Assurance Division, Code QE
Office of Safety and Mission Assurance, NASA Headquarters
300 E. Street, S. W., Washington, DC 20546
phone: 202-358-4631, fax: 202-358-2778

"The meek can *have* the Earth. The rest of us are going to the stars." --- Robert Heinlein
"We have to learn to manage information and its flow. If we don't, it will all end up in turbulence." --- RADM Grace Hopper

02/07/03, 1:00 PM

Actions in work or completed by the NASA Headquarters Office of Safety and Mission Assurance.

Actions are listed in the chronological order in which they were received along with the action officer and its status as of the date on the top of the page.

1. **02/02/03, 5:13 PM, Mark Kowaleski**
    a. White House request for COFR and PRACA process information.
    b. Worked with and blessed by JSC.
    c. Provided 1-page "Problem Reporting and Corrective Action," and 2-page "Certificate of Flight Readiness Process" to Bill Hill/HCAT 02/02/03, 5:13 PM.
    d. Status: **CLOSED**

2. **02/03/03, 3:49 PM, Lynne Loewy**
    a. Liam Sarsfield (through Michael Greenfield) requested a .pdf version of NPG 8621.1 for Bryan O'Connor. No .pdf version available, but MWord version available.
    b. Worked with Bill Loewy to get .pdf version.
    c. Both versions e-mailed to Liam Sarsfield
    d. Status: **CLOSED**
3. **02/03/03, 4:30 PM, Michael Stamatelatos**
    a. General Kostelnik request for Shuttle PRA information, pre-Columbia accident numbers, status of PRA effort and prediction on possible changes to the numbers due to Columbia.
    b. Working with JSC.
    c. No documents yet.
    d. Status: **OPEN**
4. **02/03/03, 6:17 PM, Mike Card**
    a. Code Q request to Michael Ciancone of JSC to provide payload background information on STS-107 (especially payload safety summary) to HQ/Q for Bryan O'Connor.
    b. Working with JSC.
    c. No documents yet.
    d. Status: **OPEN**
5. **02/04/03, 11:33 AM, Mark Kowaleski**
    a. Working an internal Code Q request to review the ET foam loss assessments prior to Columbia's launch.
    b. Working with JSC and MSFC.
    c. No documents yet.
    d. Status: **OPEN**

6. **02/04/03, 12:19 PM, Jim Lloyd**
    a. Brett Alexander, OSTP, requested a 1-2 pager on escape mechanisms for Shuttle in various flight regimes by 2 PM 02/04. This action should be cleared out of the HCAT.
    b. Working with Bill Hill in the HCAT.
    c. Information cleared by Greenfield and Pace and sent out.
    d. Status: **CLOSED**
7. **02/04/03, 12:37 PM, Michael Stamatelatos, Jim Lloyd, Wayne Frazier**
    a. Legal requested a copy of the 1990 study by Elizabeth Pate-Cornell at Stanford regarding Shuttle Risk Analysis.
    b. Worked within Code Q
    c. Document sent to legal and HCAT.
    d. Status: **CLOSED**
8. **02/04/03, 12:40 PM, Gil White**
    a. HCAT requested a list of hazardous material on STS-107.
    b. Worked within Code Q.
    c. Document sent to Victor Schneider, 02/04/03.
    d. Status: **CLOSED**
9. **02/04/03, 2:11 PM, Mark Kowaleski**
    a. Pete Rutledge requested that Mark collect PAR Process information for our records.
    b. Worked within Code Q.
    c. Files provided to Pam Richardson.
    d. Status: **CLOSED**
10. **02/04/03, 3:39 PM, John Lyver**
    a. 02/01/03, HCAT requested copies of radioactive and hazardous materials on board STS-107.
    b. Worked with KSC.
    c. Documents sent to HCAT 02/03/03.
    d. Status: **CLOSED**
11. **02/04/03, 3:42 PM, Roger Mielec**
    a. Mark Kowaleski requested information from Roger Mielec technical assessments completed by Code QT in the early 90s.
    b. Worked within Code Q.
    c. Documents on tiles, thermal protection and crew escape provided to Mark.
    d. Status: **CLOSED**
12. **02/05/03, 7:19 AM, Jim Lloyd**
    a. Michael Greenfield requested information on changes in NASA (over last decade) using SMA as an example. Wayne had an action to get a Challenger investigation timeline chart. Mark had an action to get information about the COFR process.
    b. Worked within Code Q.
    c. Information provided to HCAT 02/05/03, 6:45 AM.
    d. Status: **CLOSED**
13. **02/05/03, 8:20 AM, Mark Kowaleski**

a. Jim Lloyd requested that Mark provide the schedule of the last five launches, documentation on the ET foam insulation issue on STS-107 and the previous mission that had a foam problem, and the last 5 MSEs.
b. Working with JSC.
c. No documents yet.
d. Status: **OPEN**

14. **02/05/03, 8:28 AM, John Lemke**
    a. Jim Lloyd requested that John Lemke provide a Rogers Commission timeline for the Challenger investigation.
    b. Worked within Code Q.
    c. Powerpoint file provided to Jim Lloyd, 02/05/03, 8:28 AM.
    d. Status: **CLOSED**

15. **02/05/03, 8:29 AM, Faith Chandler**
    a. The HCAT requested information on witness interviewing from Code Q.
    b. Worked within Code Q.
    c. Faith Chandler provided an 11-page document outlining witness interviewing procedures to the HCAT on 02/02/03.
    d. Status: **CLOSED**

16. **02/05/03, 9:03 AM, John Lemke**
    a. Michael Greenfield requested pre-Challenger and post-Challenger (2 charts) safety posture from Code Q.
    b. Worked within Code Q.
    c. John Lemke provided the charts to Michael on 02/05/03, 9:03 AM.
    d. Status: **CLOSED**

17. **02/05/03, 10:21 AM, John Lemke/Jon Mullin**
    a. Jon was asked to assist Code G regarding disaster funding and the NASA policy on donations.
    b. Worked within Code Q.
    c. Jon provided the Federal Response Plan and NPG 8715.2 and suggested donations go to those serving NASA operations on the ground (Salvation Army, Baptist Men, Red Cross, etc.).
    d. Status: **CLOSED**

18. **02/05/03, 11:39 AM, Tom Whitmeyer**
    a. HCAT queried Code Q about NASA's risk assessment approach
    b. Worked within Code Q.
    c. Tom Whitmeyer provided a 2-pager to HCAT on 02/05/03, 7:31 AM titled "Accident and Risk Management in Space Program."
    d. Status: **CLOSED**

19. **02/05/03, 12:07 PM, Jon Mullin**

a. Jon provided information to John Lemke on "General Guidelines for Personnel Health Protection for Field Teams during Recovery of Shuttle Debris"
b. Worked with JSC.
c. Documents provided to Lemke, 02/05/03, 12:07 PM.
d. Status: **CLOSED**

20. **02/05/03, 12:34 PM, Faith Chandler**
    a. Code Q requested that Faith put together a presentation for Code U on NASA policy and procedures for investigation.
    b. Worked within Code Q.
    c. Presentation complete, and presented to Code U 02/06/03, 2:00 PM.
    d. Status: **CLOSED**

21. **02/05/03, 12:44 PM, Jim Lloyd**
    a. Michael Greenfield (for Mr. O'Keefe) requested information on pre- and post-Challenger safety approaches
    b. Worked within Code Q
    c. Provided to Michael Greenfield, 02/05/03, AM
    d. Status: **CLOSED**

22. **02/05/03, 7:52 PM, Jim Lloyd**
    a. Code Q has been tasked to provide information on RTOP funding for Shuttle safety for the past 17 years. Jim sent a message out to the SMA Directors looking for input.
    b. Working with all Centers and Code Q.
    c. No documents yet.
    d. Status: **OPEN**

23. **02/05/03, 8:29 PM, Jim Lloyd**
    a. Jim Lloyd has tasked JSC and Mark Kowaleski to obtain PAR/FRR information about the risks dispositioned during STS-113 from the previous flight with evidence of foam shedding (STS-112).
    b. Working within Code Q and with JSC.
    c. Some documents located (PAR website)
    d. Status: **OPEN**

24. **02/06/03, 12:04 PM, John Lyver**
    a. OSMA is working questions for Mr. O'Keefe's testimony next week before Congress.
    b. Working within Code Q, questions due by COB 02/06/03.
    c. Working.
    d. Status: **OPEN**

25. **02/06/03, 8:23 AM, John Lyver**

a. Michael Greenfield requested an SMA Topical Index for Mr. O'Keefe's Congressional testimony on 2/13.
b. Worked within Code Q.
c. Document provided 02/06/03.
d. Status: **CLOSED**

26. **02/06/03, 11:31 PM, Mark Kowaleski**
a. The HCAT is requesting information on specific crew escape studies. Mark is attempting to collect the information.
b. Working with Code Q and MSFC.
c. In works.
d. Status: **OPEN**

27. **02/06/03, 5:14 PM, Nelson Keeler (IV&V)**
a. The Avionics Software Control Board (ASCB) requested and IV&V assessment to identify any potential software risks should Shuttle flights be delayed for an extended period.
b. IV&V working.
c. In works.
d. Status: **OPEN**

28. **02/07/03, 11:09 AM, Wayne Frazier**
a. Pete Rutledge asked Wayne Frazier to provide a copy of the Agency Contingency Action Plan for Space Operations to various NASA personnel (listed on the e-mail hard copy).
b. Worked within Code Q
c. Electronic copy of plan provided to staff on 02/07/03, 11:09 AM.
d. Status: **CLOSED**

29. **02/07/03, 11:16 AM, Faith Chandler**
a. Pete Rutledge asked Faith Chandler to provide Jim Lloyd with a 1-2 page paper comparing PBMA and Investigation Organizer for forwarding to the CAIB and David Lengyel.
b. Worked within Code Q.
c. Electronic copy of the paper provided to Jim Lloyd on 02/07/03, 11:16 AM.
d. Status: **CLOSED**

02/07/03, 1:00 PM

Offers of assistance submitted to NASA Headquarters Office of Safety and Mission Assurance.

Offers are listed in the chronological order in which they were received. They are separated into offers from NASA personnel and other Government personnel, NASA contractors and outside NASA.

NASA offers:

1. NASA employees:
    a. Steve M. Schenfeld (Steve.M.Schenfeld@nasa.gov)
    b. Mark B. Humphries (Mark.B.Humphries@nasa.gov), SMA, trained in MORT, mishap investigator for NASA and DOE, 17 yrs law enforcement working crime scenes and evidence recovery, worked a pipeline explosion.
    c. Vince Zoby (E.V.Zoby@larc.nasa.gov), experience in Shuttle aerodynamic heating, major PI during the Orbiter Experiments Program.
    d. Dick Powell (R.W.Powell@larc.nasa.gov), significant experience on Shuttle and other entry vehicle trajectory, aeroheating, and flight mechanics analysis.
    e. Charles Miller (C.G.Miller@larc.nasa.gov), significant experience working entry and hypersonic aerodynamics.
    f. Mark Shuart (M.J.Shuart@larc.nasa.gov), head of the LaRC Structures and Materials Competency with experts in structures and materials, including aluminum and composite structures and TPS designs. Responsible for the landing loads facility with expertise in landing gear and tire design.

2. 02/02/03, 9:02 PM, DOE
    a. DOE Accident Investigation Program Manager, Office of Special Projects and Investigations, Corporate Safety Assurance, Environment, Safety and Health, experience with accident investigations.

3. 02/03/03, 2:14 pm, Tom Ambrose, OSMA, DFRC
    a. DFRC sent the following equipment to support the Columbia investigation. The equipment and satellite system phone numbers are in the name of Ralph Anton ($6.75/minute)
        - #2097456 Satellite system including hardware and laptop (1 each, $28K)
        - #2097457 Satellite system including hardware and laptop (1 each $28K)
        - #2097457 Advantage laser system with hardware (1 each $5K)
        - #1648784 GPS mapping kit (1 each $7K)

- #2097488 HP Deskjet printer (1 each $.5K)

4. 02/03/03, 3:40 PM, Lawrence Davis, OSMA, DFRC

    a. Expertise-wise, may be available for any re-entry aerodynamics and controls. He's retired but living in the local area.
    b. Dryden has test-bed aircraft available for any thermal investigative activity.
    c. Our proximity to the Shuttle Modification Facility at Palmdale makes it easy to support any investigation needed there. We understand this was the first flight since the OMM was done there (*Pam input here, I think it was the second).* We also suggest that any records of that activity be impounded. Since that operation has moved to Florida, we are not certain where the records would be kept.
    d. The ER-2's are available for any photographs of the impact areas, including eastern California or along the path for the earliest debris. The DOD photo reconnaissance capability could also be a valuable resource to locate parts earlier in the flight.
    e. Our hazmat and accident investigation personnel can support any activity.
    f. Our proximity to possible debris impact in the California, Nevada or New Mexico areas enables us to react to a search with aircraft, ground vehicles and/or personnel.
    g. The AFFTC has offered their resources to help any efforts.

5. 02/04/03, 9:14 AM, Yuri Gawdiak, Code R

    a. James Williams and Ian Sturken from NASA Ames will arrive in Shreveport late tonight (02/04) to support Vern Ellingtad and will contact him on his cell in the morning. They are bringing laptops that with web access will provide access to InvestigationOrganizer on the Ames server. They will also bring a copy of the software that can be loaded onto a local machine if necessary. They are ready to work with Vern and others to structure the data fields and data relationships to meet the requirements of the investigation. We can then work out the procedures and resources for training and data entry. Yuri Gawdiak will be in contact with them throughout.

6. 02/04/03, 10:50 AM, Patrick Martin, Code QE

    a. Randy Stone, the SRQA Director for the Missile Defence Agency (MDA) offered independent investigation support if desired. Randy has been personally involved with several ELV (Delta) MIBs., 703-693-9051,

7. 02/05/03, 7:52 AM, Faith Chandler, Code QE

a. Darcy Miller (NASA) provided information to Faith Chandler about software for use in crash and crime scene investigation from the OPTIMUS Corporation (AutoDOCS) using GPS technology, piloted with NTSB. Information was sent to the HCAT by Faith 02/05/03.

8. 02/05/03, 10:08 AM, Wayne Frazier, Code QS
   a. Offer of DIA services to overfly the crash site with a hyperspectral scanner (3" resolution for hard objects in vegetation). Various phone calls to other Agencies and this is in the works.

NASA Contractor and Outside NASA:

1. Contractor employees:
   a. Robert G. Alexander (Robert.G.Alexander(DOE accident investigation course, ran two accident investigation boards several years ago.

2. Outside NASA:
   a. colleague and friend of Laurel Clark, medical doctor (former NASA flight surgeon), retired Navy, university professor, expertise in physiological effects of space flight. **Have bio (faxed in) if needed.**
   b. probabilistic risk assessment, quantitative/qualitative risk assessment/management.
   c. Chuck Mertz (650-604-2323, ARC/Hernandez Engineering), safety.

3. 02/02/03, 12:43 PM, Aerospace Corporation Support to Return to Flight

Aerospace Corporation offers the full scope of its resources to contribute to the Shuttle's return to flight. Local Aerospace contact at JSC is Mr. Pete Choban at (281) 483-4890; E-mail: peter.s.choban1@jsc.nasa.gov

- **Organizational characteristics** – Since 1960, Aerospace, a non-profit firm, has focused on solving space problems as a trusted agent for the Government. Aerospace operates an FFRDC for the USAF and NRO ($500M annually) and does not compete with US for-profit firms nor build hardware. We provide technical support to every USAF launch and when necessary, failure investigation. Additionally we support NASA space programs at JSC, KSC, MSFC, JPL, LaRC, GSFC and HQ. Over 2000 scientists and engineers provide all clients the benefit of this cumulative experience.
- **Technical capability**
  a. Full spectrum technical support to the National Security Space program
  b. Image reconstruction and enhancement, extracting faint data for post-launch reviews
  c. Fusion of electro-optic, radar and IR data sets taken from multiple sensors

d. Debris metallurgy, re-entry modeling, analysis and visualization
e. Failure analysis with specialties in metal fatigue and re-entry fragment analysis
f. Materials: Forensics of metal failure and DoD's science lead for LDEF
g. Structural mechanics, fluid mechanics, dynamics and thermal analysis
h. Telemetry analysis and weak signal extraction
i. Launch vehicle communications link analysis during dynamic flight regimes
j. Engines: Hydrazine and cryogenic modeling, simulation and analysis
k. Flight visualization with high fidelity, for example high speed airflow and re-entry
l. Remote sensing engineering insight into National Security Space sensors

- **Unique facilities include:**
  a. Center for Orbital Debris and Re-entry: High fidelity modeling of re-entry breakup
  b. Spacelift Telemetry Acquisition & Reporting System-Analyzes ELV vehicle telemetry from each USAF launch. Provides failure analysis support.
  c. Database of all space program failure mechanisms
  d. Law Enforcement Center-Under direction from US DOJ, assists local law enforcement with forensic analysis methods and accident reconstruction support
  e. $100 M in space investigation tools used to re create accident timelines
- Relevant experience
  a. White House Space Launch Broad Area Review
  b. Integrated multiple observations to produce highly accurate re-entry trajectory for GRO and MIR
  c. Certify flight readiness of all military launches
  d. Independent Assessment support to the ISS

4. 02/05/03, 10:35 AM,
   a. Disabled person, formerly worked for Hughes aircraft suggests putting a net or screen around the top of the ET to keep pieces of foam from hitting the Orbiter.

5. 02/05/03, 11:00 AM, NASDA offer of assistance
   a. of NASDA offers any assistance they possibly can Mark Kowaleski responded back to him thanking him for his gracious offer and that we would, if needed, contact them as well as keep them informed for future missions involving NASDA.

6. 02/05/03, 11:03 AM, Futron Corporation
   a. of Futron offers services of herself and the company in any way they can. and indicates they are standing by.

7. 02/06/03, 6:44 PM, Battelle
   a. -- highly qualified -- twice Commander of the Naval Safety Center, now working at Battelle Memorial Institute (with access to tons of super technology capabilities at Battelle)
   b. -- Former Chairman of the NTSB (during Bush I); currently with Fulbright & Jaworski; former Marine pilot; aviation specialist.
   c. -- former NTSB Investigator In Charge (IIC) -- led the ValuJet investigation and many others in 20 years at NTSB. Now a consultant based in Colorado.

8. 02/06/03, 9:51 AM, System Safety Development Center
   a. a registered Professional Electrical Engineer. He has a Degree in Electrical Engineering from the University of Utah. He is also a Certified Crime Scene Investigator. He has conducted hundreds of accident investigations for over the past forty years, and has taught thousands of people the principles of accident investigation and mishap analysis. is currently the director of the System Safety Development Center (SSDC); a continuation of the SSDC established by the Atomic Energy Commission (AEC). The SSDC has developed and taught the principles of accident investigation to The AEC, IAEC, DOE, DOE Contractors, NASA, OSHA, MSHA, NTSB, other governmental agencies, and industry in the United States and other countries. The SSDC developed the investigation techniques of MORT Charting, Fault Tree Analysis, Barrier Analysis, Change Analysis, Events and Causal Factors Charting, and Root Cause Analysis. The SSDC has been the leader in causal factor determination and corrective action implementation for over three decades.

James Lloyd, 12:45 PM 2/3/2003 -0500, Mike Card Statement - Status

X-Sender: jlloyd@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Mon, 03 Feb 2003 12:45:44 -0500
To: Paul G Pastorek <ppastore@mail.hq.nasa.gov>
From: James Lloyd <jlloyd@hq.nasa.gov>
Subject: Mike Card Statement - Status
Cc: prutledg@hq.nasa.gov

Paul,

Since there seemed to be so much emphasis on this last evening I followed up with Mr. Card this morning about the generation of a statement regarding assessment of damage to Columbia. He is preparing a statement in two versions

I asked him to work that diligently and provide it to someone in Code X that has the proper container to hold it. He is working that with Bob Turner in Code X.

Jim

Lawrence Davis, 12:42 PM 2/4/2003 -0500, CAIB Questions

X-Sender: lawrence_davis@mail.dfrc.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 5.0.2
Date: Tue, 04 Feb 2003 12:42:34 -0500
To: Pete Rutledge <prutledg@hq.nasa.gov>,
"Bryan O'Connor" <boconnor@mail.hq.nasa.gov>
From: Lawrence Davis <lawrence.davis@dfrc.nasa.gov>
Subject: CAIB Questions
X-MIME-Autoconverted: from quoted-printable to 8bit by bolg.public.hq.nasa.gov id QAA22130

Bryan & Pete
Another question & expert list.
1. During my tenure as the X-38 System Safety Engineer, I was exposed to their proposed Attitude Control System. One of the obvious questions was the blending of aerodynamic controls with the ACS as the spacecraft descends. I was surprised by a comment from the JSC engineers that they didn't know much about that blending because the Shuttle had never had to use it, due to the great aerodynamic controls. I'm curious after hearing from Mr. Dittemore that the ACS had fired as the drag built up on the left wing that blending has not been tested and could have caused a bad situation to become worse.

2. The NASA Dryden Flight Loads Laboratory is a unique national laboratory in which structural tests are conducted to support flight research and structures programs. The experienced technical staff provides expertise in test design, test operations, load and stress analysis,thermal analysis, instrumentation, and systems development. Several ovens with programmable control are available in the FLL for thermal exposure of coupons and panels, up to 4 ft 3 in., to a maximum of 2000°F. There are six non cycling-type ovens, which are manually set to maintain temperature. The maximum temperatures for these ovens range from 650°F to 1300°F. Two microprocessor-controlled ovens, with interior dimensions of approximately 2 ft. by 2 ft. by 2 ft. are also available for conducting strain-gage measurement errors to 2000°F. Radiant, conduction, and convection heaters are used in conjunction with the universal testing machines for combined loading and heating of coupons and panels. Key experts in thermal analysis and thermal stress are: analytical: Dr. William Ko, Les Gong, and Gregg Noff; test: Larry Hudson and Lance Richards.

3. We also have experts in atmospheric flight controls: Bob Clarke and Joe Pahle; Flight Dynamics: Chris Nagy; air data: Tom Moes, Tony Whitmore; Parameter Identification: Rich Maine & Tim Moes. We also have people very knowledgeable in flight systems and instrumentation. Jack Ehernberger is an expert in atmospheric science.

John P Castellano, 03:31 PM 2/4/2003 -0500, Support to Bryan

X-Sender: jcastell@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 04 Feb 2003 15:31:32 -0500
To: Pete Rutledge <prutledg@hq.nasa.gov>
From: John P Castellano <jcastell@hq.nasa.gov>
Subject: Support to Bryan
Cc: snewman@hq.nasa.gov

In status briefings Ron D. mentioned that during re-entry the Orbiter Flight Control System saw excursions that exceeded the family of previous experience but within the system margins utilizing elevon and RCS attitude control..The cause of these excursions was attributed to drag on the left wing..possibly due to missing tiles. Additionally it has been reported that the temperature rises measured at various locations (wheel well , left fuselage etc.) were in the neighborhood of 40-50 F not high enough to represent a structural problem.. Previous flights have come home with some very significant tile damage (dings) as well as some missing without causing a problem. Undoubtedly this previous experience is a factor in the analysis and belief that this mission (and potential damage) did not represent a threat to flight safety..

If we postulate that elevated temperatures (up to the point of loss of vehicle) be ruled out as the factor (thus precluding a structural failure) and that the drag on the left side was due entirely to the progressive loss of tiles (unzippering) then at some point in this unzippering the Flight control system authority to safely maintain attitude and control will be become insufficient...

Perhaps some of the Flight Control folks are already looking into running simulations to determine tile loss vs margins since it seems intuitive that at some point in tile loss that the attitude control system will be overwhelmed..and unable to compensate.

James Lloyd, 05:52 PM 2/8/2003 -0500, Fwd: SMA Role in COFR - WEEKEND DRAFT

X-Sender: jlloyd@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Sat, 08 Feb 2003 17:52:53 -0500
To: Michael Greenfield <michael.greenfield@hq.nasa.gov>
From: James Lloyd <jlloyd@hq.nasa.gov>
Subject: Fwd: SMA Role in COFR - WEEKEND DRAFT

Michael,
I believe we are beginning to pull this story together so I am better able to explain the involvement and depth of understanding that, we, the SMA community of NASA had in these decision processes. This is still a work in progress as we need some pieces from Mark Erminger.

Let me know if you have any thoughts or need anything else regarding this today (this evening) or tomorrow. Sorry about the delayed response but I have some people that are pretty depressed about the accident and because of the role that they did play. It's tough to tell a story when it is not a good one.

X-Sender: mkowales@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Sat, 08 Feb 2003 17:44:30 -0500
To: jlloyd@mail.hq.nasa.gov, prutledg@mail.hq.nasa.gov
From: Mark Kowaleski <mkowales@hq.nasa.gov>
Subject: SMA Role in COFR - WEEKEND DRAFT
Cc: rpatrican@hq.nasa.gov, Pepper Phillips <pphillip@hq.nasa.gov>,
mcard@hq.nasa.gov, mark.d.erminger1@jsc.nasa.gov

Jim & Pete,

Here is the first draft.

A few fixes need to be made, but these should be quick.

We'll add Mark Erminger's STS-107 timeline on Monday AM.

Thanks to Mark, Pepper, Mike, and Rich for your help!

Mark

Mark M. Kowaleski
Safety & Mission Assurance Manager
Space Shuttle Program

God bless the crew and families of STS-107.

NASA Headquarters
Code QE, Room 5Y44
300 E Street SW
Washington, DC 20546-0001

EMAIL: mark.kowaleski@hq.nasa.gov
Phone: 202-358-0751
FAX: 202-358-2778

http://www.hq.nasa.gov/office/codeq/

Mission Success Starts with Safety!

Thought for the Day: Never be afraid to try something new.
Remember, amateurs built the ark. Professionals built the Titanic.
^ ^
() ()

James Lloyd, 05:52 PM 2/8/2003 -0500, Fwd: SMA Role in COFR - WEEKEND DRAFT

__/

SOK's PAR talking points1.doc

Jim

James Lloyd, 09:23 AM 2/14/2003 -0500, Tile Work during Major Overhaul of Columbia

X-Sender: jlloyd@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Fri, 14 Feb 2003 09:23:39 -0500
To: yolanda.y.marshall1@jsc.nasa.gov, GarriH@kscems.ksc.nasa.gov
From: James Lloyd <jlloyd@hq.nasa.gov>
Subject: Tile Work during Major Overhaul of Columbia
Cc: boconnor@mail.hq.nasa.gov, pete Rutledge <prutledg@hq.nasa.gov>,
Mark Kowaleski <mkowales@hq.nasa.gov>

I am passing along some information that Mark Kowaleski worked as an action from the Michael Greenfield's CAC yesterday. It was worked jointly with the HCAT. This relates to the question I sent yesterday and is provided for your information. I withdraw my earlier questions to you as it was worked through another mechanism.

Yolanda, Bert,

Another Question:

When Columbia went thru major overhaul were there work instructions issued for tile and RCC work? Were there any anomalies or non-conformances requiring MRB action relating to that tile work?

I know people will probably be researching this, the CAIB will want to ask this, and I don't want anyone to drop what they are doing on this to immediately search the answer but if you know if there was would you let me know?


Columbia Major Overhaul.doc

Jim

Lawrence Davis, 06:17 PM 2/3/2003 -0500, Re: Support for Bryan O'Connor on Columbia Accident

To: Lawrence Davis <lawrence.davis@dfrc.nasa.gov>
From: Pete Rutledge <prutledg@hq.nasa.gov>
Subject: Re: Support for Bryan O'Connor on Columbia Accident Investigation Board (CAIB)
Cc: Richardson_Pamela
Bcc:
Attached:

Lawrence,

Thank you for the generous, conscientious, and considered response. I believe it's the first from any of the SMA Directors. We will add your contributions to our lists of subject matter experts and questions/issues for Bryan's possible use.

Regards,

Pete

At 09:43 AM 2/3/2003 -0500, you wrote:
Bryan & Pete
All of Dryden is ready to help with whatever is required but here's our immediate thoughts about helping from our Acting Director Bob Meyer and our OSMA staff:
1. Expertise wise Ken Iliif may be available for any re-entry aerodynamics and controls. He's retired but living in the local area.
2. Dryden has test-bed aircraft available for any thermal investigative activity.
3. Our proximity to the Shuttle Modification Facility at Palmdale makes it easy to support any investigation needed there. We understand this was the first flight since the OMM was done there. We also suggest that any records of that activity be impounded. Since that operation has moved to Florida, we are not certain where the records would be kept.
4. The ER-2's are available for any photographs of the impact areas, including eastern California or along the path for the earliest debris. The DOD photo reconnaissance capability could also be a valuable resource to locate parts earlier in the flight.
5. Our hazmat & accident investigation personnel can support any activity.
6. Our proximity to possible debris impact in the California, Nevada or New Mexico area enables us to react to a search with aircraft, ground vehicles and/or personnel. It seems like the astronomer that has photos of a possible event near Bishop, California may provide a time and impact prediction that should be scoured for the earliest clues. It will be worse than a needle in a haystack but again, a tile could have survived and landed in a remote area but easily seen from an aircraft or ground vehicle. Much of that area is restricted to the public and I have had some access previously that might be easier to activate, if an impact area may prove to be inside these areas.
7. A PRADO should be done to establish trend information on tile damage.
8. We understand the LOX tank was an older model. The age and condition of that tank should be investigated and data impounded.
9. The APU's should be investigated since they are critical to powering the flight controls.

Of course, we are all still in shock over the events but are ready to support with whatever assignments deemed necessary by the CAIB. I'll send more thoughts as they are assembled. We have an all-hands now to discuss the events.
God Bless your efforts, Lawrence

At 05:55 PM 2/2/2003 -0500, Pete Rutledge wrote:
SMA Directors,

As you may know, Bryan O'Connor is the Ex-Officio member of the CAIB. Your help is needed. Bryan has asked that each of you think about what you would ask if you were on the CAIB. What issues would you want to investigate? You should e-mail your suggested questions or issues for investigation to Bryan (he has his laptop with him) and me; I will post the collection of questions/issues on the STS-107 PBMA work group site at:

http://107team.intranets.com/login.asp?link=

If you have not yet been invited to join this site, please let me know and I'll get an invitation

sent to you.

Thanks,

Pete

Peter J. Rutledge, Ph.D.
Director, Enterprise Safety and Mission Assurance Division
Acting Director, Review and Assessment Division
Office of Safety and Mission Assurance
NASA Headquarters, Code QE, Washington, DC 20546

ph: 202-358-0579
FAX:202-358-2778
e-mail: pete.rutledge@hq.nasa.gov

Mission Success Starts with Safety!

Alan H. Phillips, 01:37 PM 2/14/2003 -0500, Fwd: Orbiter Mach 6 wind tunnel tests

X-Sender: a.h.phillips@pop.larc.nasa.gov
Date: Fri, 14 Feb 2003 13:37:21 -0500
To: "Pamela F. Richardson" <Pamela.Richardson@hq.nasa.gov>
From: "Alan H. Phillips" <a.h.phillips@larc.nasa.gov>
Subject: Fwd: Orbiter Mach 6 wind tunnel tests
Cc: "Peter J. Rutledge" <prutledg@mail.hq.nasa.gov>,
Jim Lloyd <Jlloyd@hq.nasa.gov>

Some wind tunnel results and information that LaRC is performing in support of JSC investigation activities.

Alan

X-Sender: r.a.wheless@express.larc.nasa.gov
Date: Thu, 13 Feb 2003 13:24:22 -0500
To: m.p.saunders@larc.nasa.gov
From: "Richard A. Wheless" <r.a.wheless@larc.nasa.gov>
Subject: Orbiter Mach 6 wind tunnel tests
Cc: a.h.phillips@larc.nasa.gov

Mark
Please find attached the power point presentation that I made to JSC today. The presentation summarizes the experimental aerothermal work that has been accomplished over the past 4 days of wind tunnel testing. I believe Vince Zoby will be presenting the information to the folks at 1219 today at 4pm. Mike DiFulvio has indicated your interest in coming over to the tunnel sometime. No problem...We will be here today until 8pm tonight and will revert back to a standard shift on friday. Number at the tunnel 45744. Testing will resume next Tuesday...
Hope this helps
Regards,
Tom Horvath

Richard A. Wheless

NCI Information Systems, CLASIC Contract
Senior Graphic Artist
Assigned to;
Aerothermodynamics Branch
NASA Langley Research Center
Hampton, VA 23681-2199
Bldg 1251 Room 227D, MS 408A
(757) 864-4410, (757) 864-8670 FAX
r.a.wheless@larc.nasa.gov

Orbiter_windward_thermal_mappin.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

****

LaRC Wind Tunnel Testing in Support of Orbiter External Aerothermodynamics

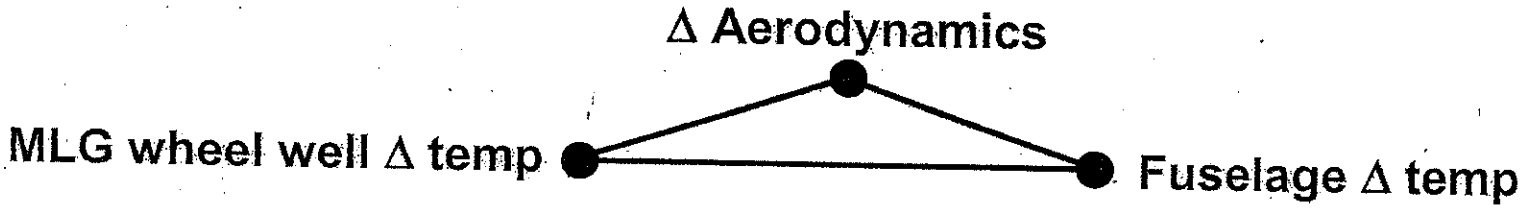
Status Report
February 13, 2003

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

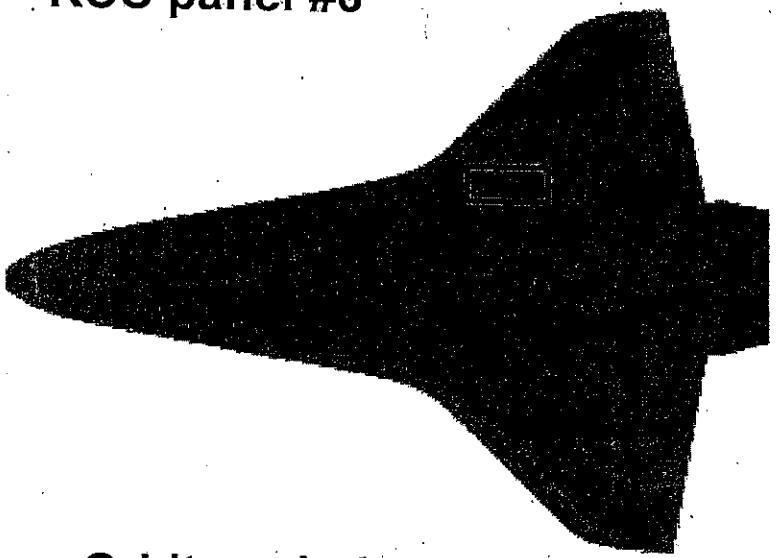
- Closely coupled aerodynamic and heat-transfer ground based testing

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

Wing Leading Edge OML Sensitivity Study

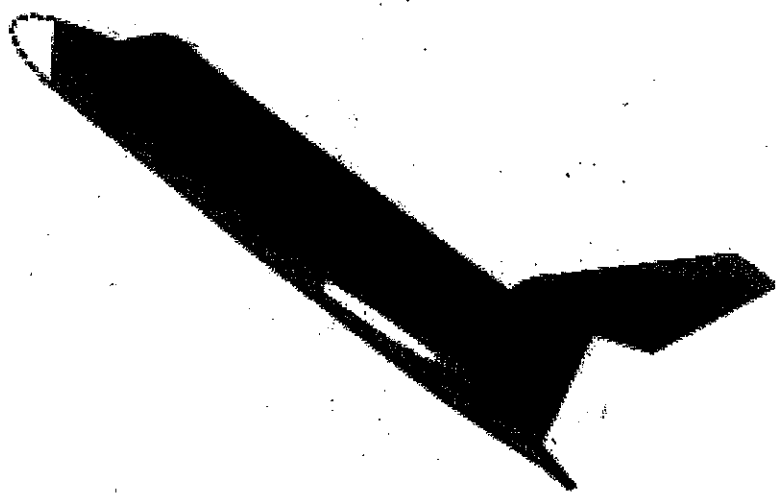
- Tunnel occupancy to date (1-12-03) : 4 days
- Facility: NASA LaRC 20-Inch Mach 6
- Deliverables: Global surface temperature mappings to infer b.l. transition.
  Global heating to determine augmentation levels above laminar levels.

Leading edge protuberance
RCC panel #6



Orbiter windward surface

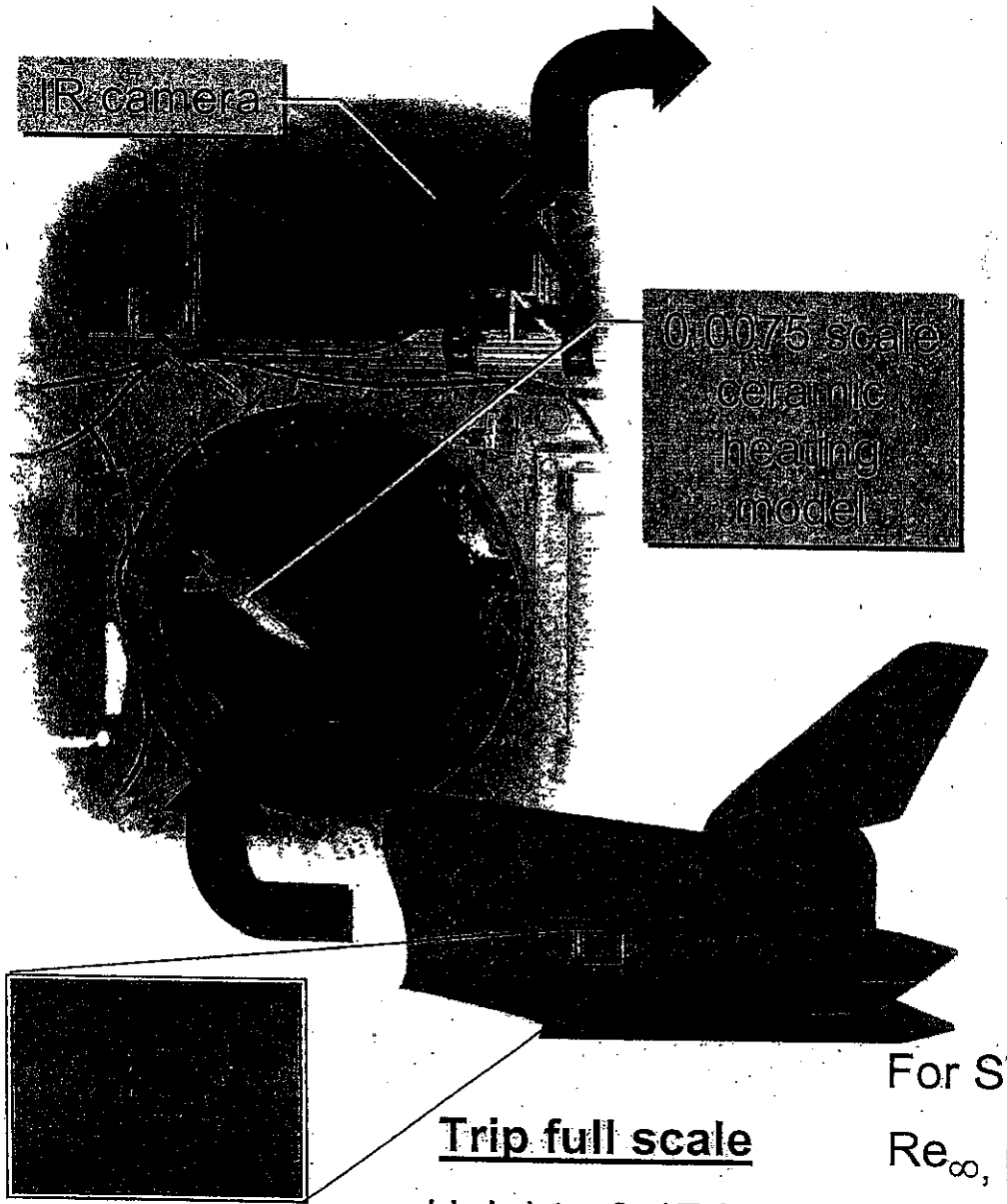
Leading edge cavity
RCC panel #6

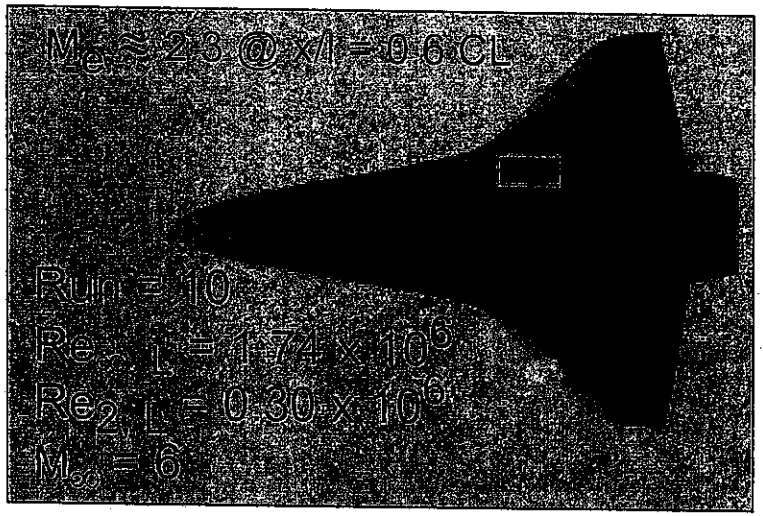


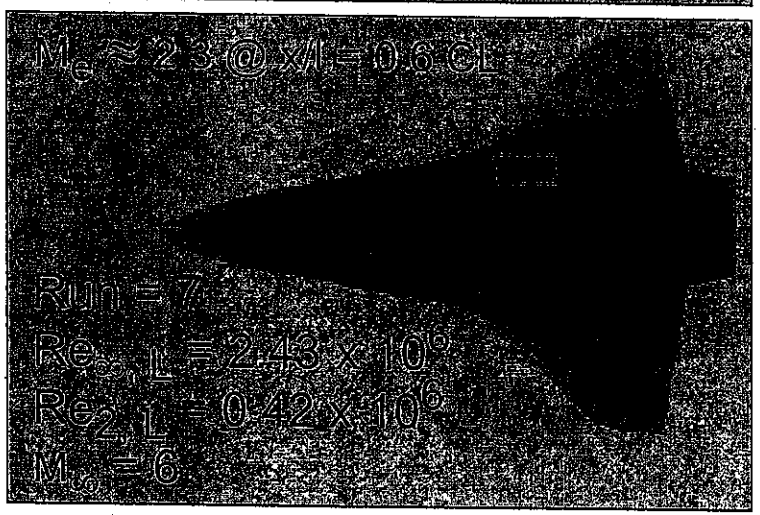
Orbiter side fuselage

ASA Langley
erothermodynamics Branch

Orbiter L.E. Sensitivity Study







Trip full scale

Height 0.47-in
Size 13 x 13-in

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

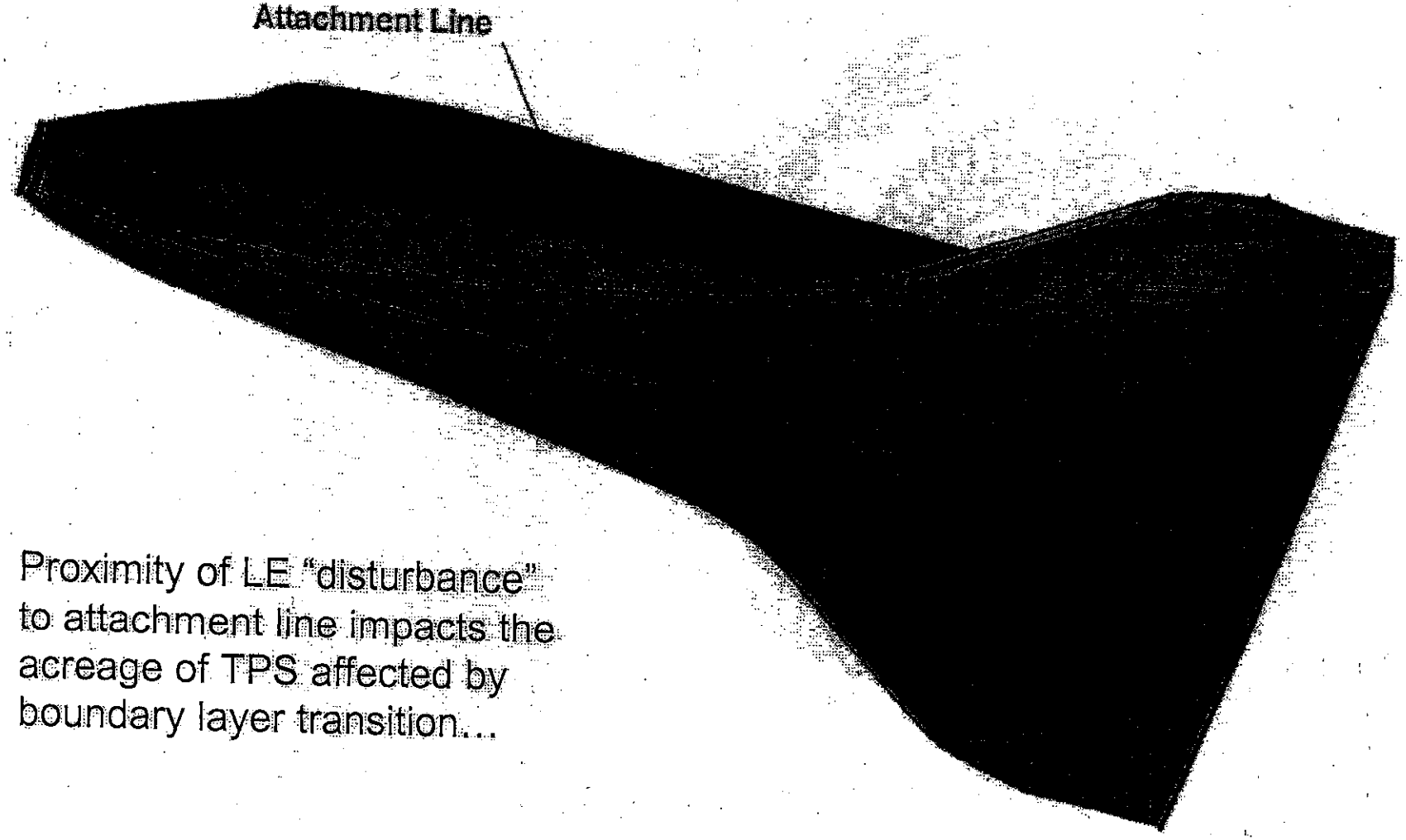
$Re_{\infty, L} \approx 2.4 \times 10^6$
$Re_{2, L} \approx 0.4 \times 10^6$
$M_e \approx 3$ @ x/l = 0.6 CL

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...

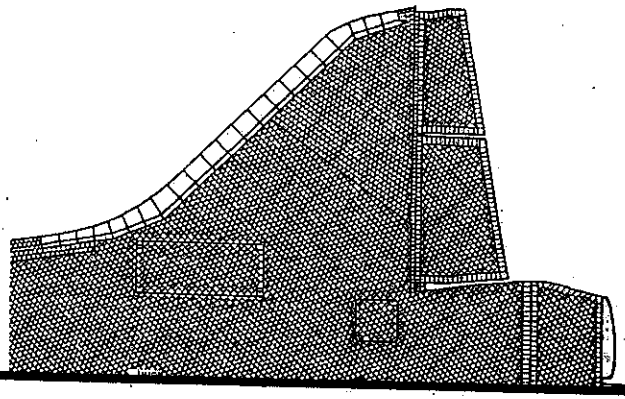
Hamilton/LaRC/AB 2/11/03

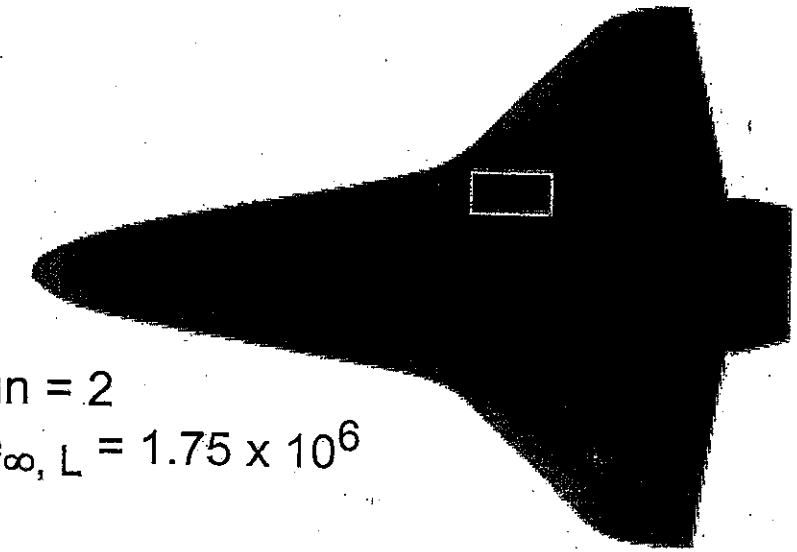
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

α = 40 deg Baseline 0.0075 Scale

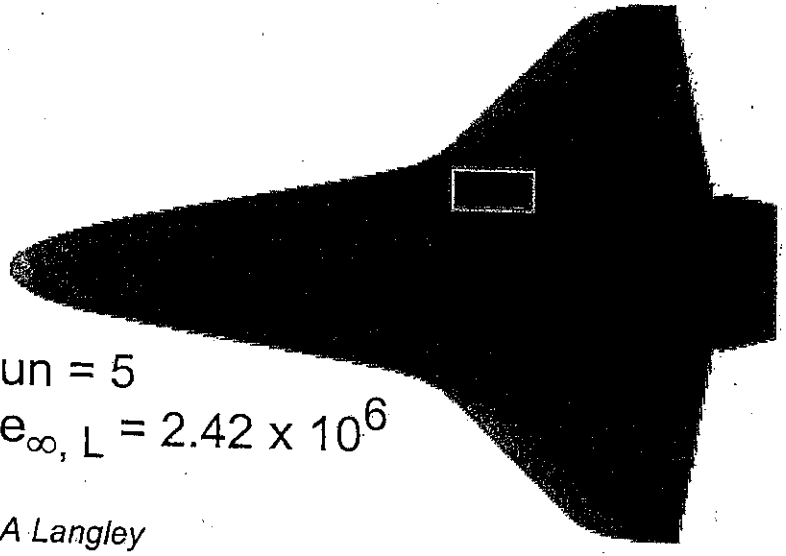
	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13





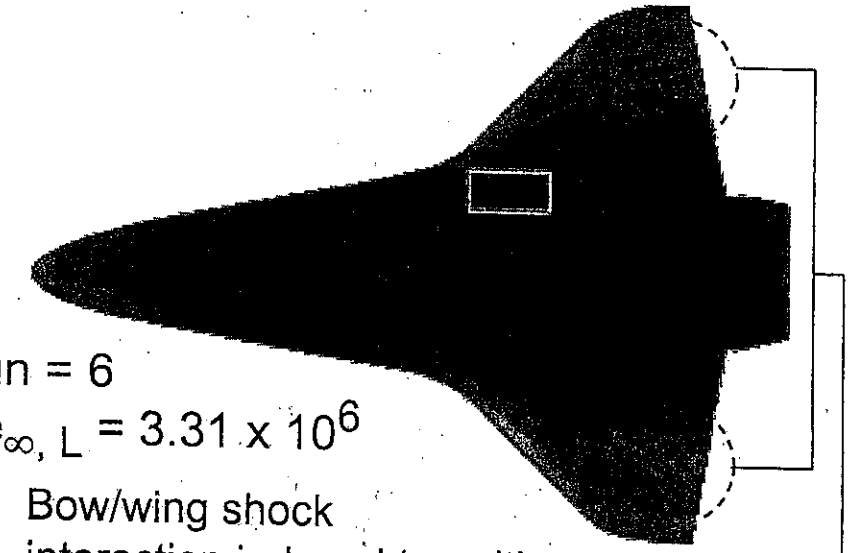
Run = 2

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



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

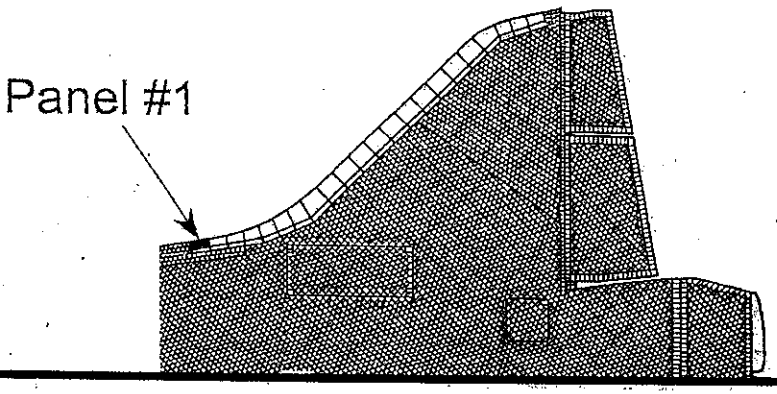
ASA Langley
erothermodynamics Branch

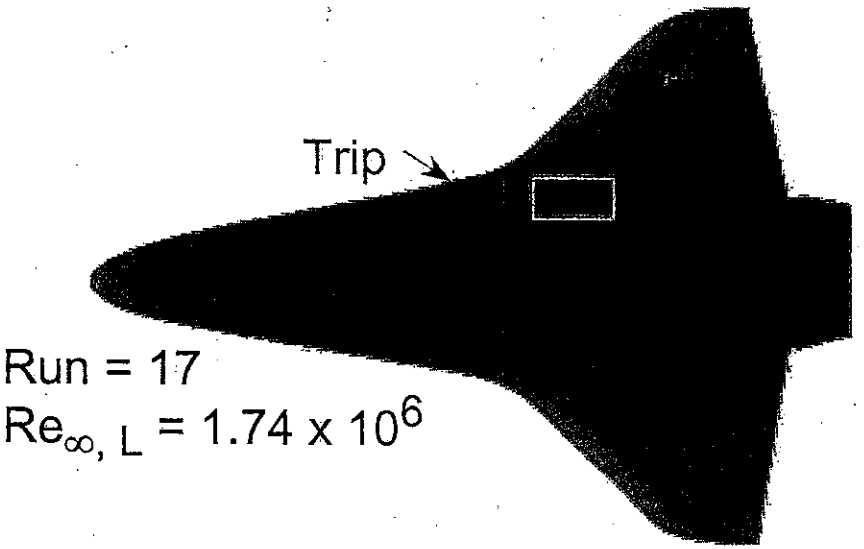
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

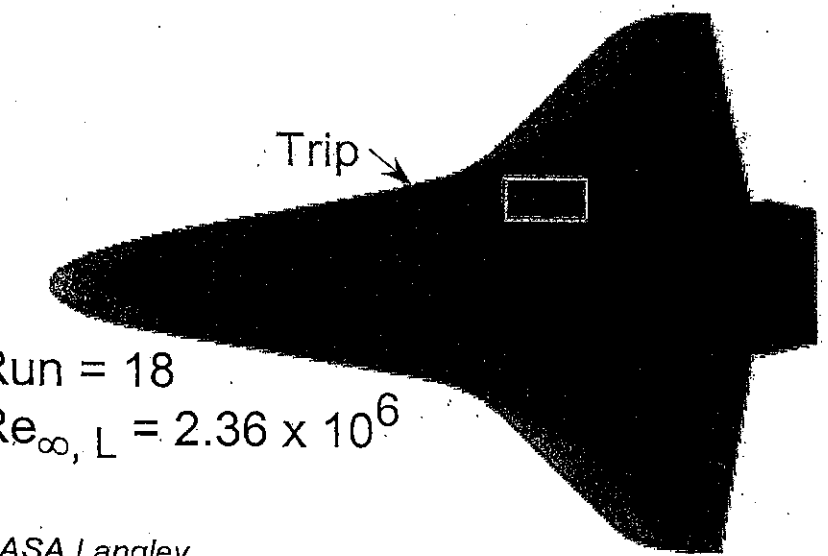
NASA LaRC 20-Inch Mach 6 Air

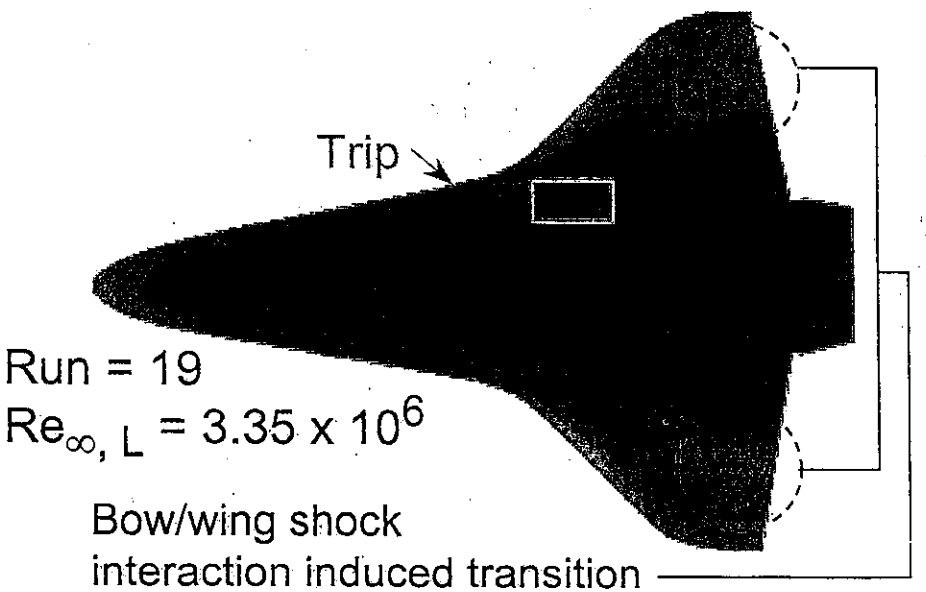
α = 40 deg Panel # 1 0.0075 Scale

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









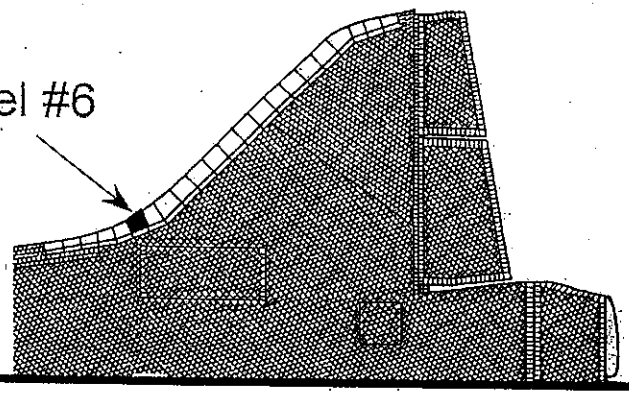
ASA Langley
erothermodynamics Branch

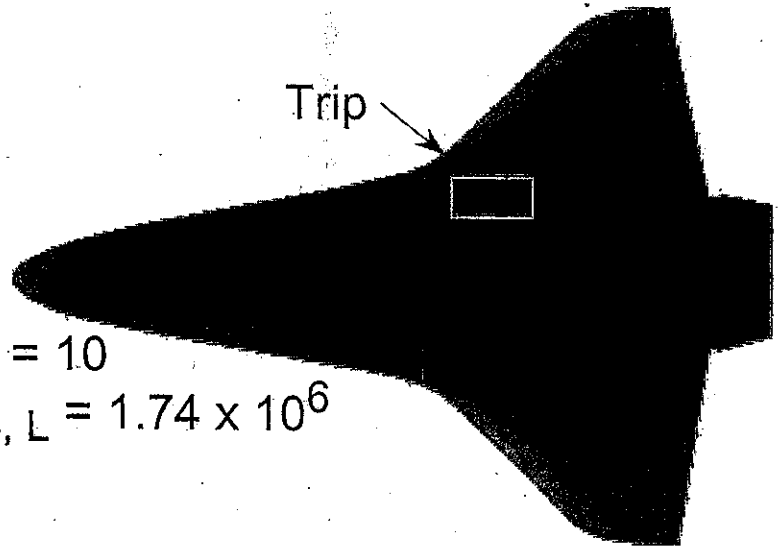
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

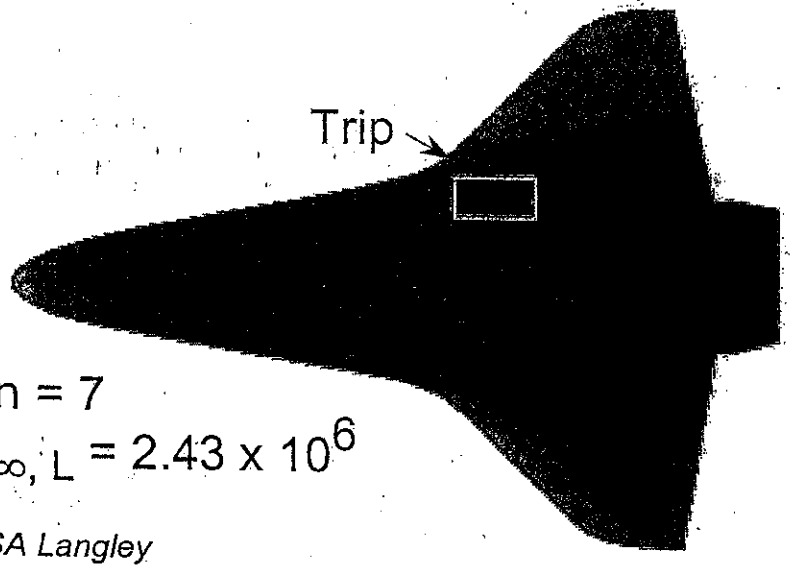
NASA LaRC 20-Inch Mach 6 Air

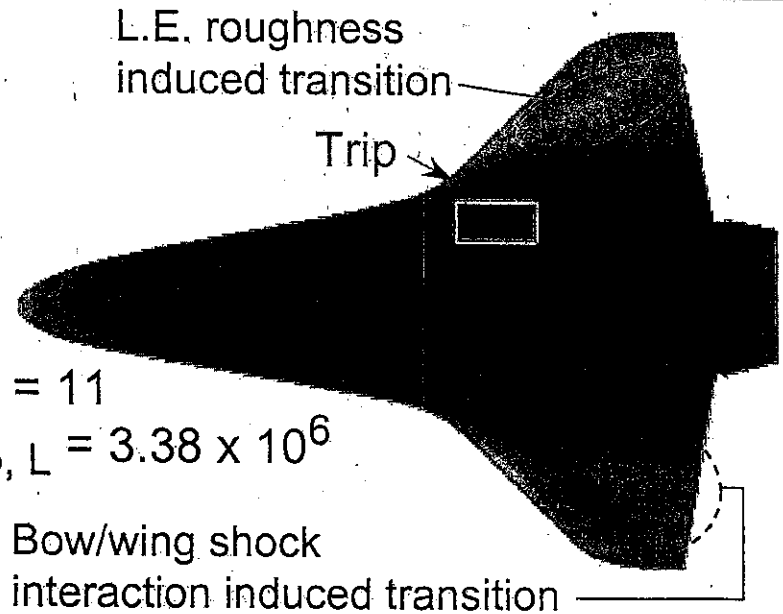
α = 40 deg Panel # 6 0.0075 Scale

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









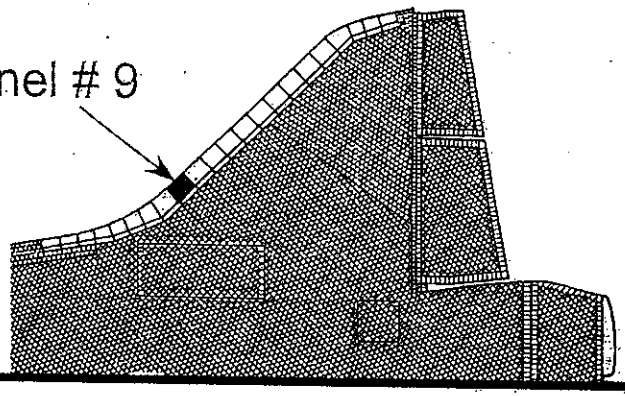
NASA Langley
Aerothermodynamics Branch

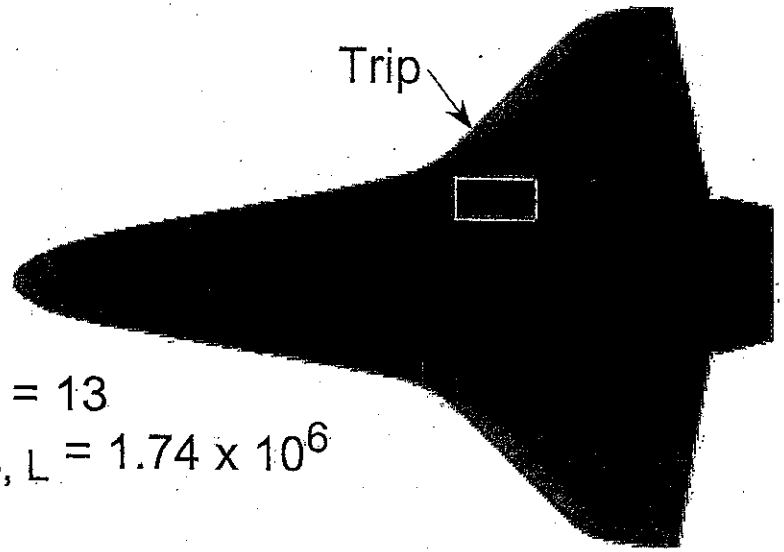
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

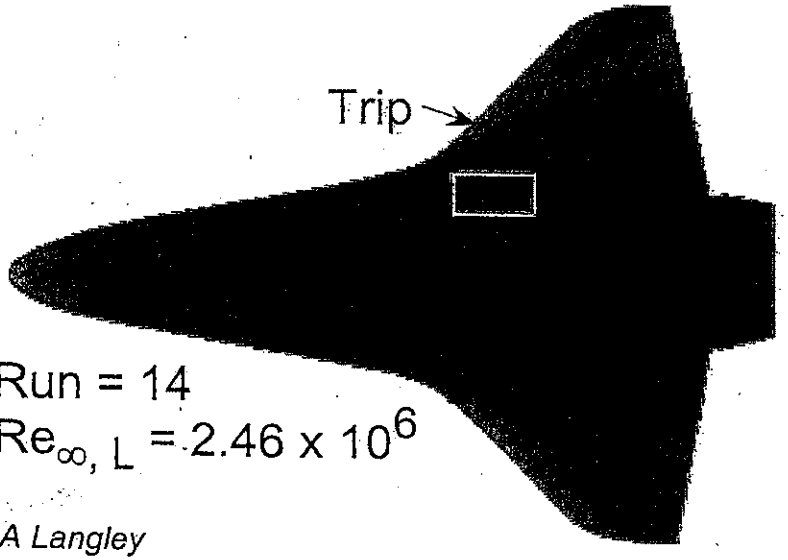
α = 40 deg Panel # 9 0.0075 Scale

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

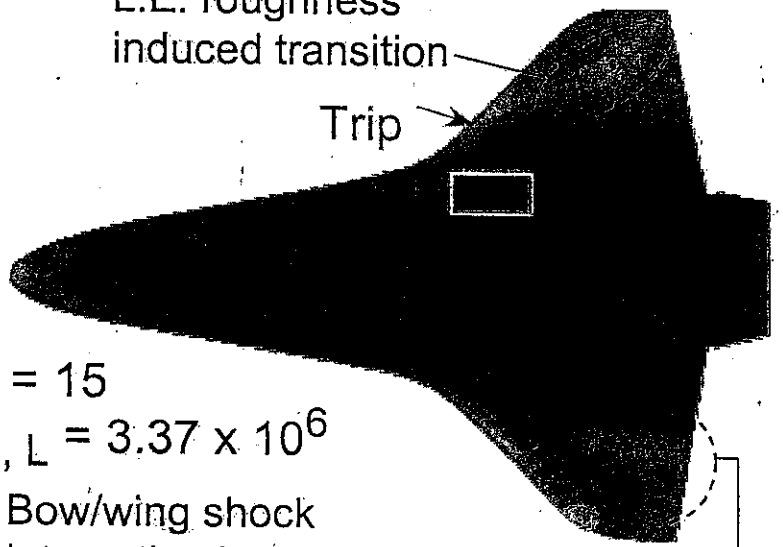




Run = 13
$Re_{\infty, L} = 1.74 \times 10^6$



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



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

Bow/wing shock
interaction induced transition

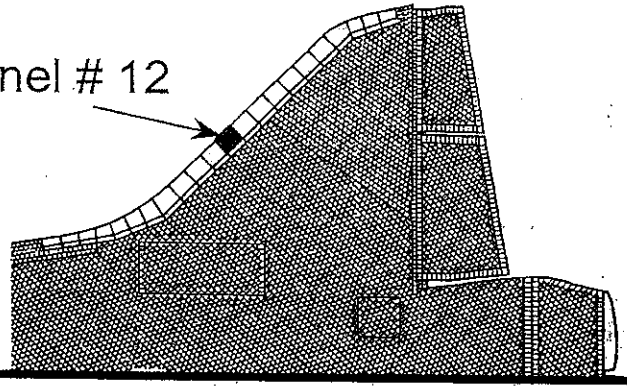
ASA Langley
erothermodynamics Branch

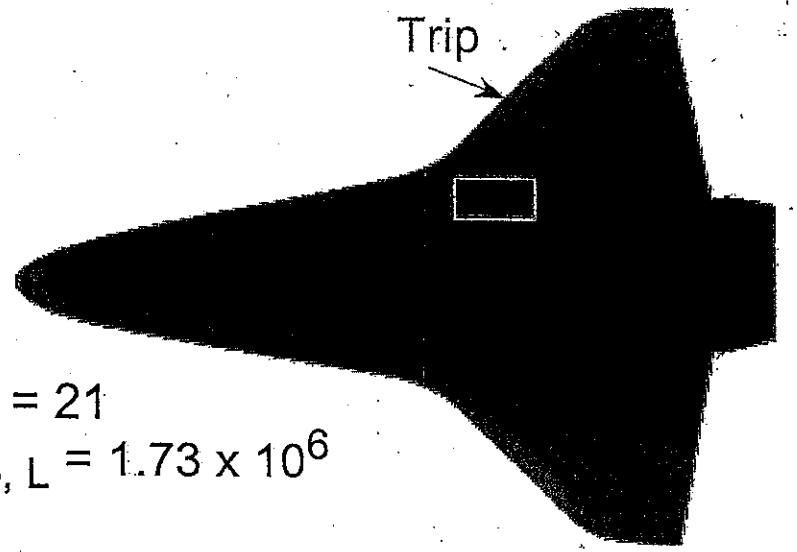
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

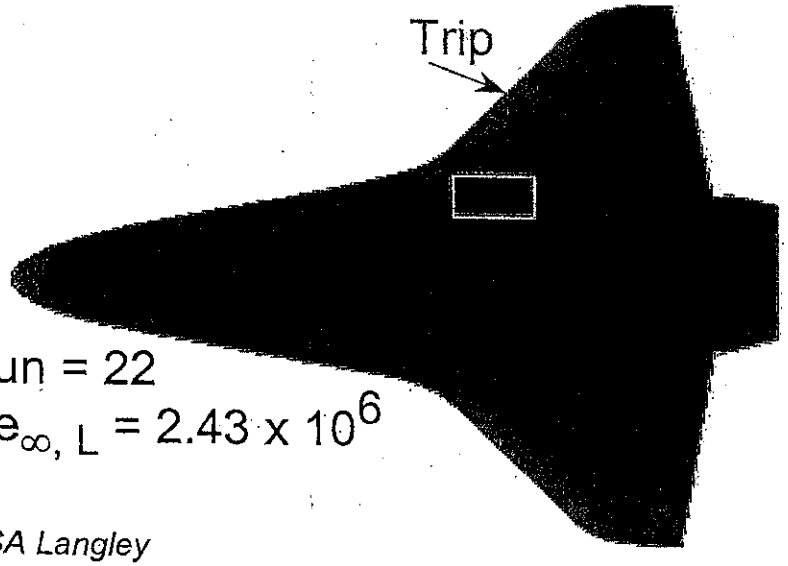
α = 40 deg Panel # 12 0.0075 Scale

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

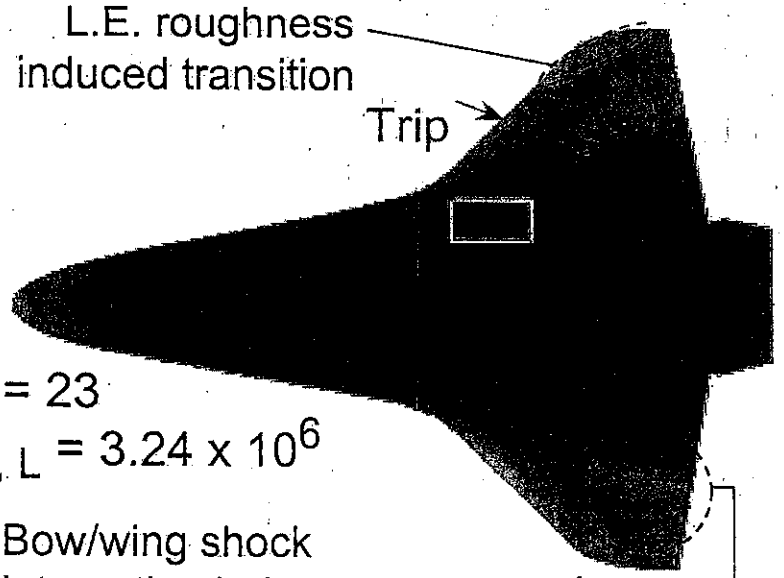




Run = 21
$Re_{\infty, L} = 1.73 \times 10^6$



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



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

Bow/wing shock
interaction induced transition

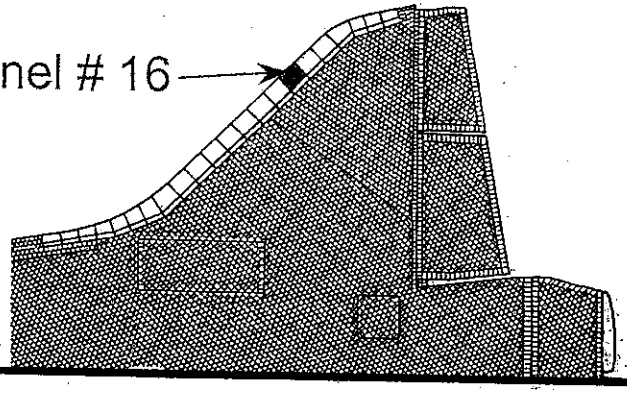
ASA Langley
erothermodynamics Branch

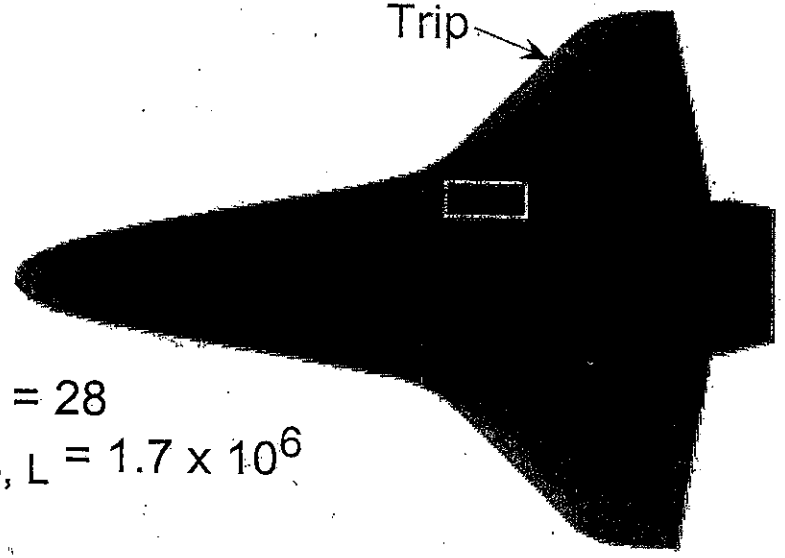
Effect of L.E. Roughness on Orbiter Windward Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

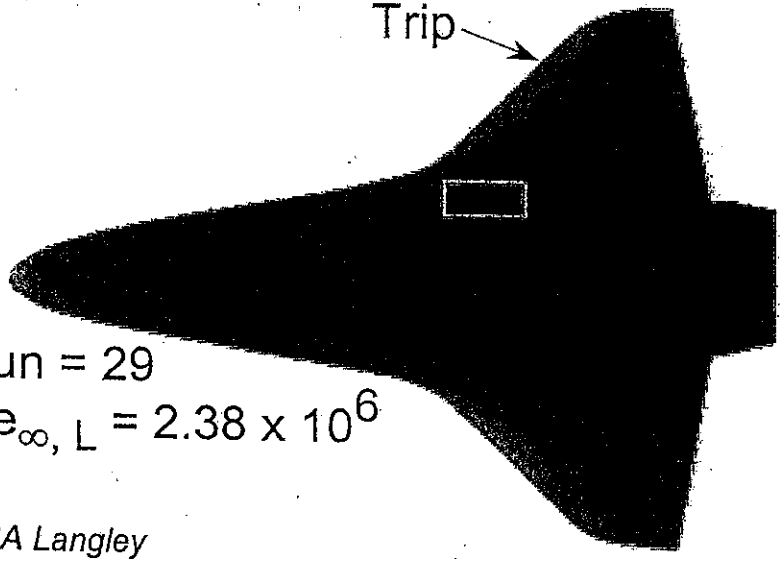
α = 40 deg Panel # 16 0.0075 Scale

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

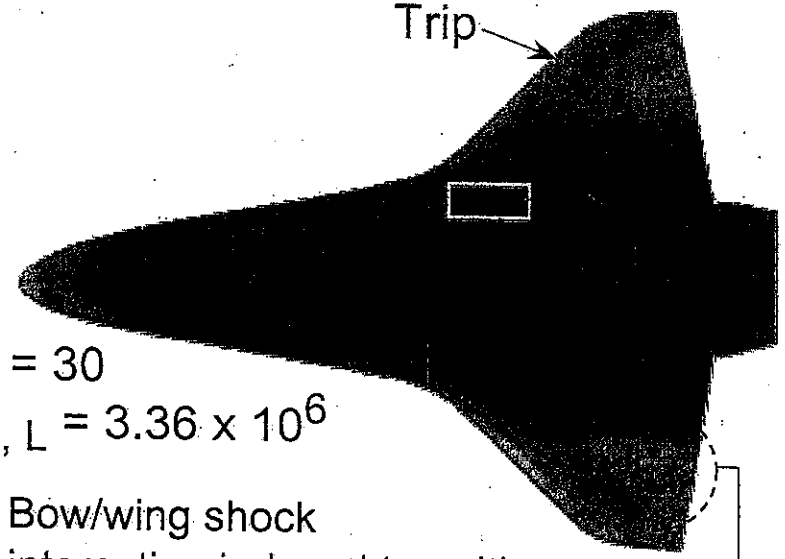




Run = 28
$Re_{\infty, L} = 1.7 \times 10^6$



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



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

Bow/wing shock
interaction induced transition

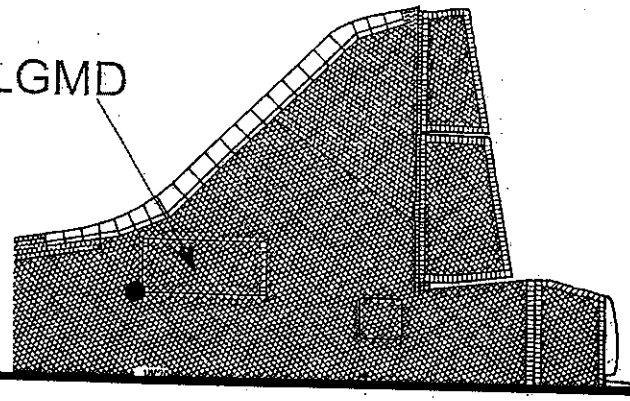
ASA Langley
erothermodynamics Branch

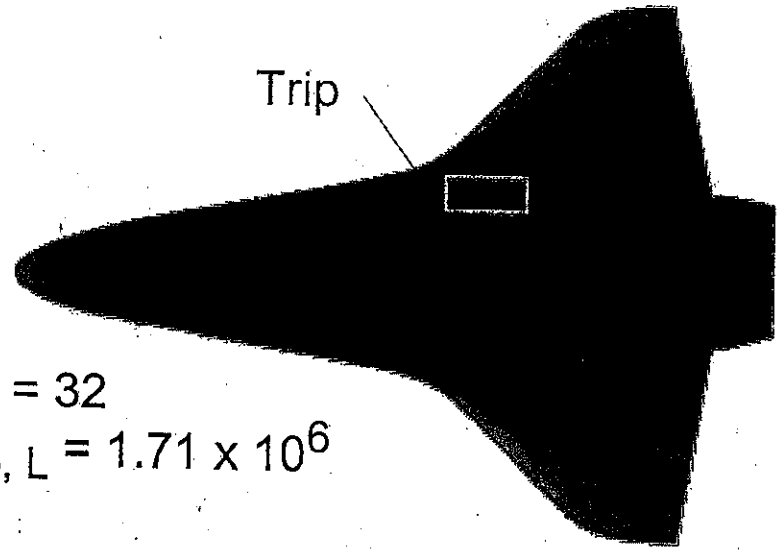
Effect of L.E. Roughness on Orbiter Windward Heating

NASA LaRC 20-Inch Mach 6 Air

α = 40 deg Inboard LGMD 0.0075 Scale

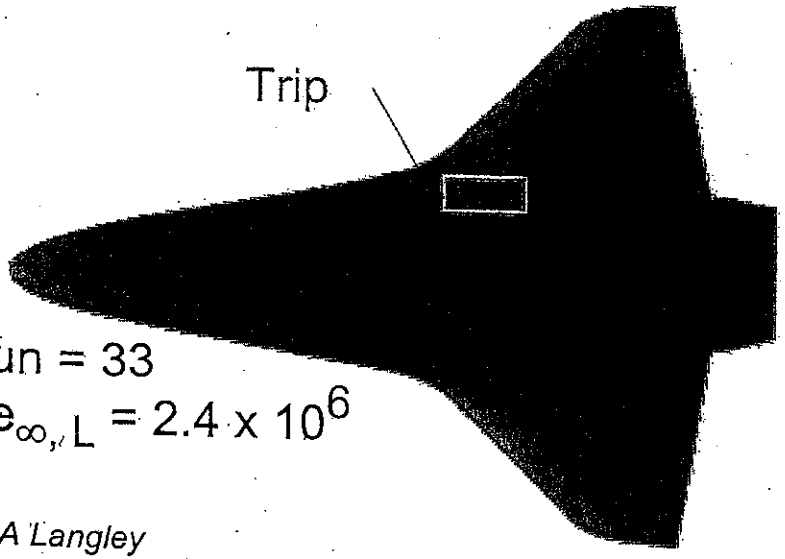
	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.005x0.005	7x7





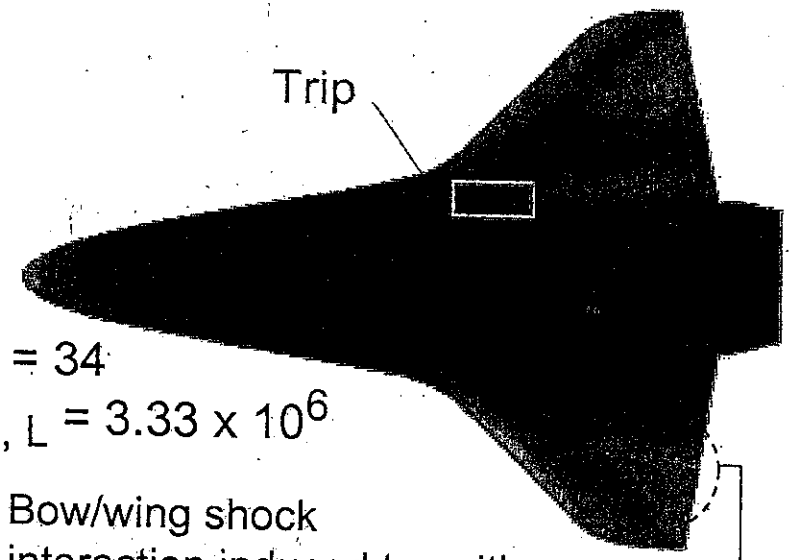
Run = 32

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



Run = 33

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



Run = 34

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

Bow/wing shock
interaction induced transition

ASA Langley
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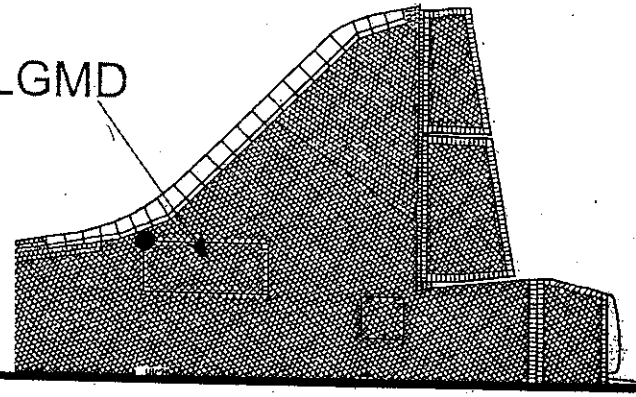
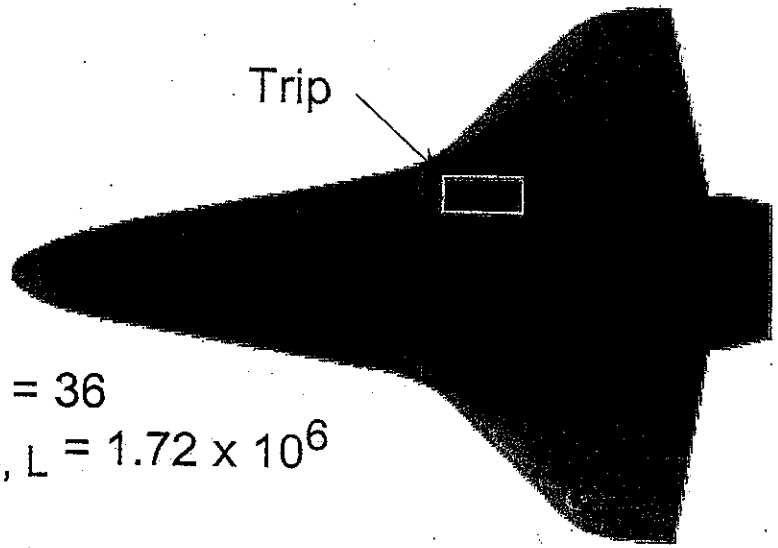
Effect of L.E. Roughness on Orbiter Windward Heating

NASA LaRC 20-Inch Mach 6 Air

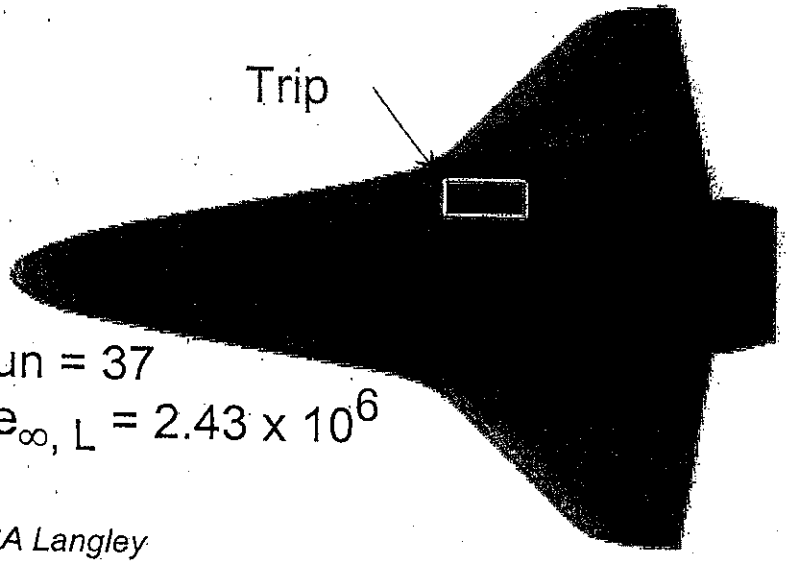
α = 40 deg Outboard LGMD 0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.005x0.005	7x7

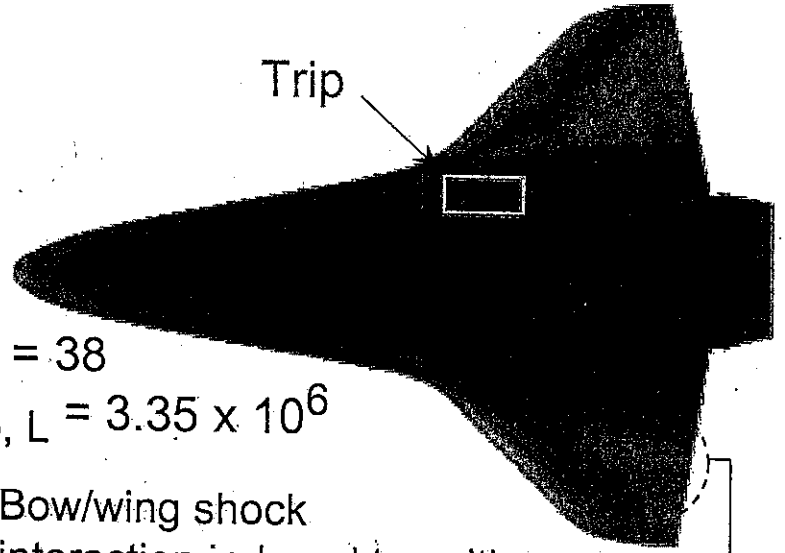




Run = 36
$Re_{\infty, L} = 1.72 \times 10^6$



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

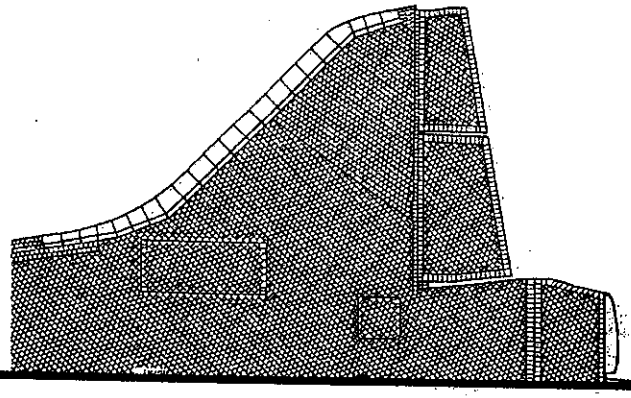
NASA Langley
Aerothermodynamics Branch

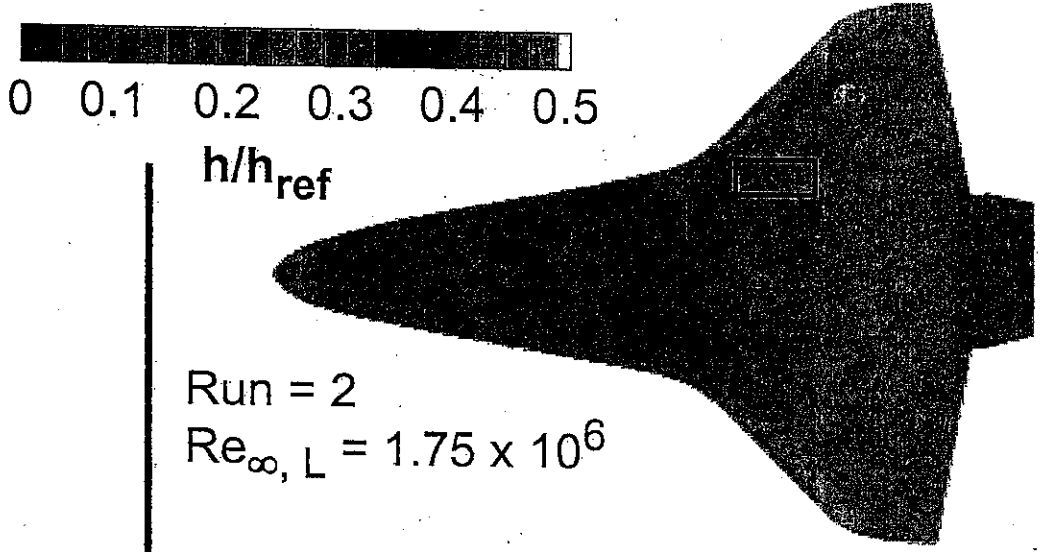
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

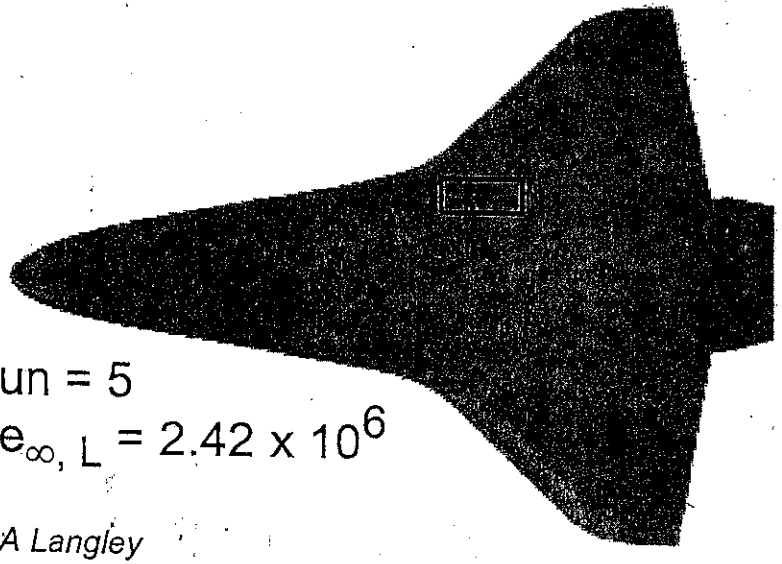
α = 40 deg Baseline 0.0075 Scale

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

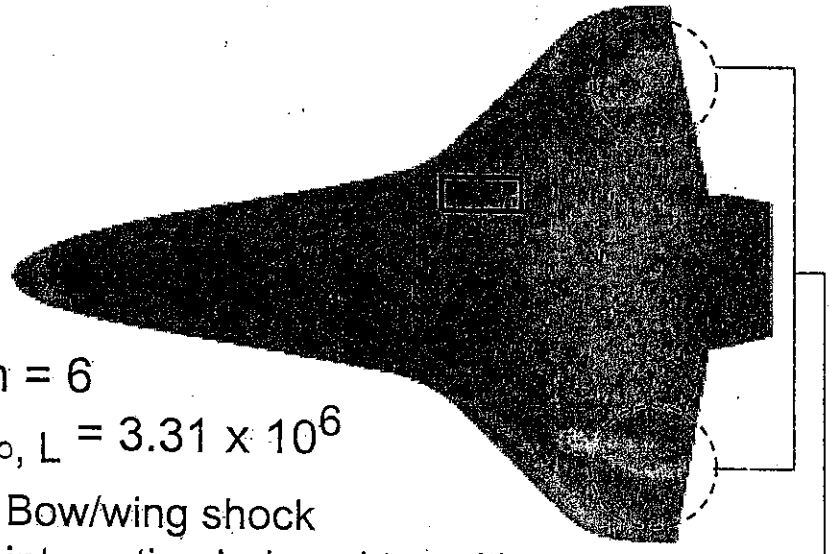




Run = 2
$Re_{\infty, L} = 1.75 \times 10^6$



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

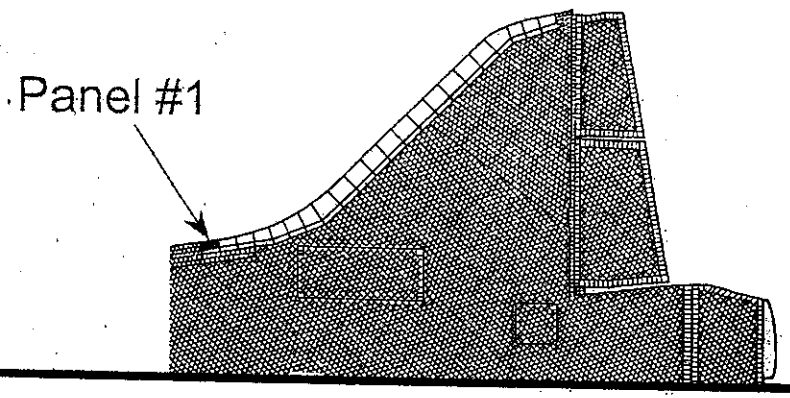
ASA Langley
erothermodynamics Branch

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

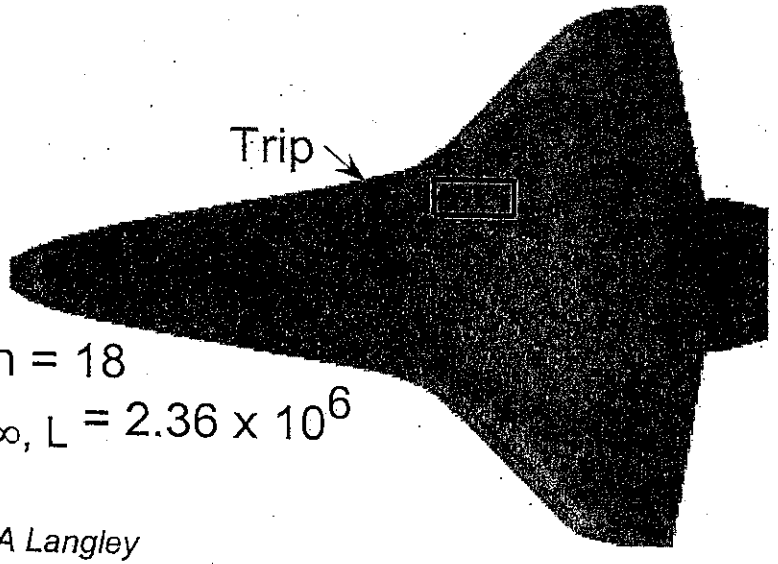
NASA LaRC 20-Inch Mach 6 Air

α = 40 deg Panel # 1 0.0075 Scale

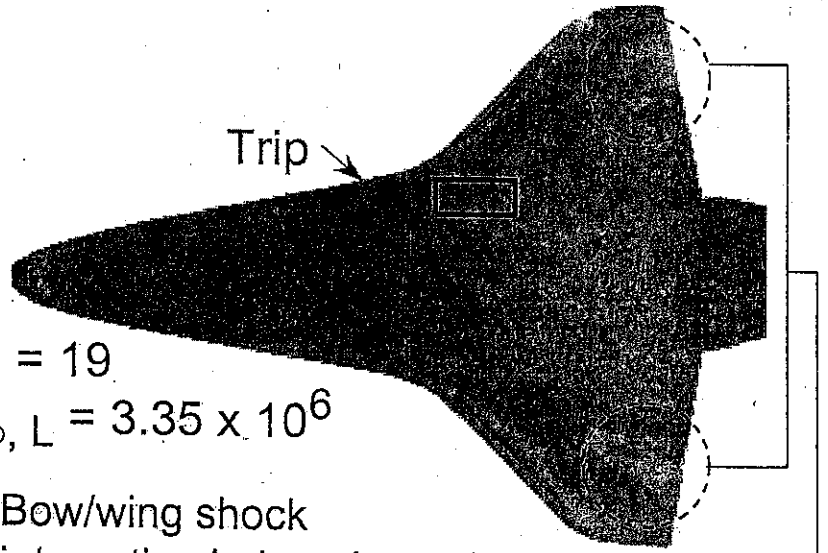
	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13



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



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



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

Bow/wing shock
interaction induced transition

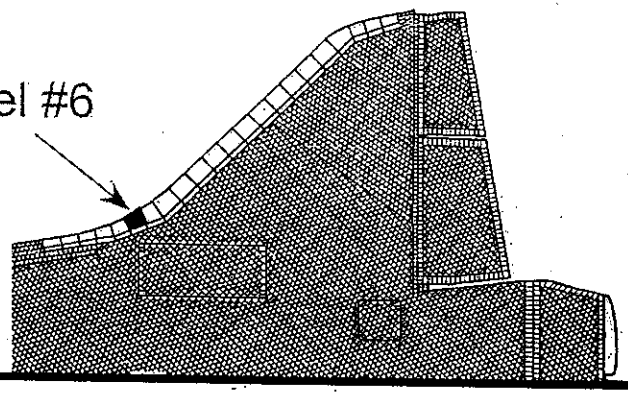
NASA Langley
Aerothermodynamics Branch

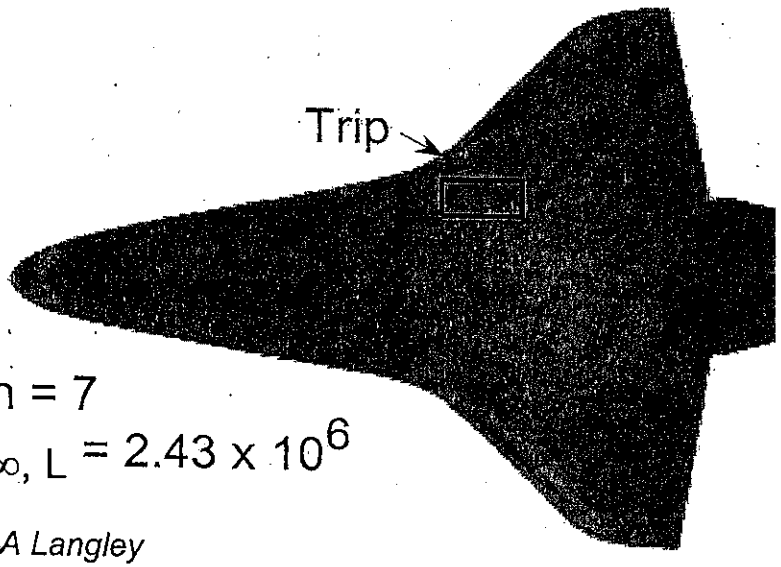
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

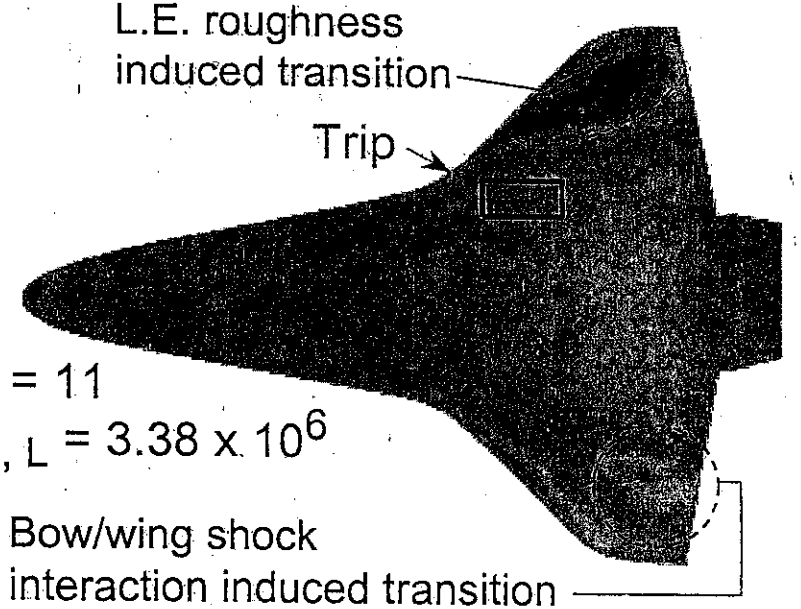
NASA LaRC 20-Inch Mach 6 Air

α = 40 deg Panel # 6 0.0075 Scale

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







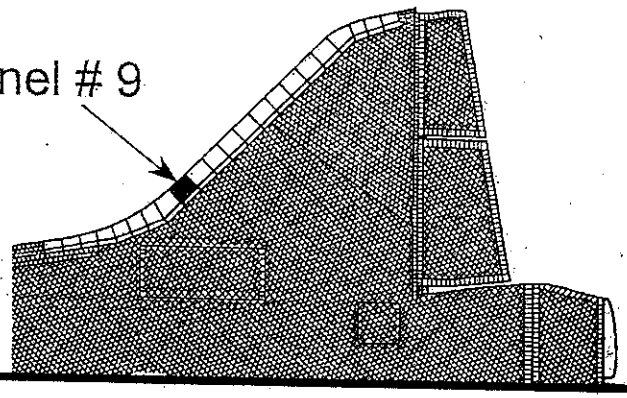
NASA Langley
Aerothermodynamics Branch

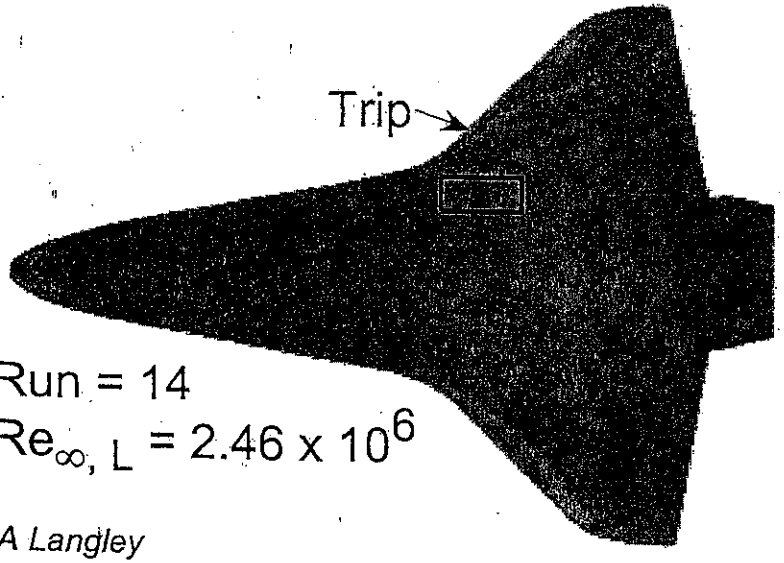
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

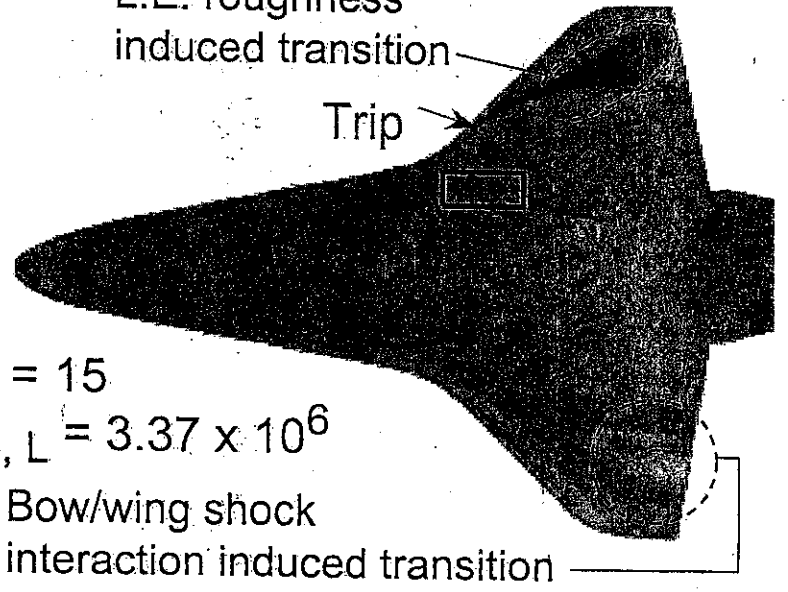
NASA LaRC 20-Inch Mach 6 Air

α = 40 deg **Panel # 9** **0.0075 Scale**

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







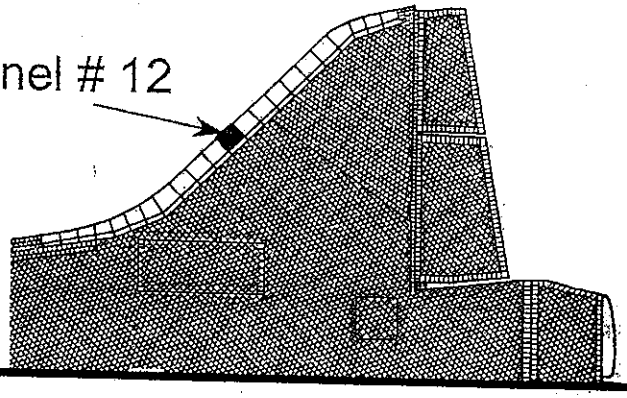
ASA Langley
erothermodynamics Branch

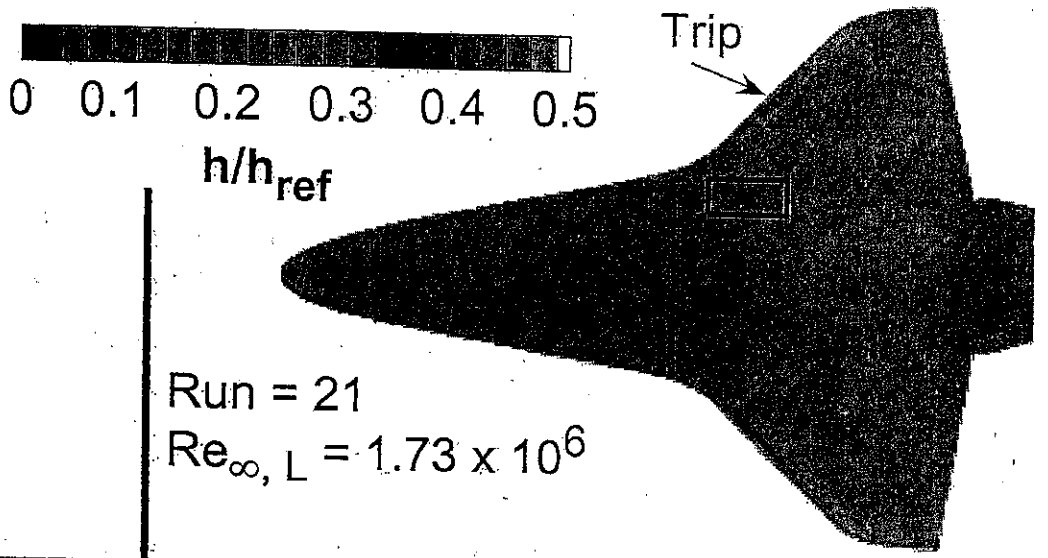
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

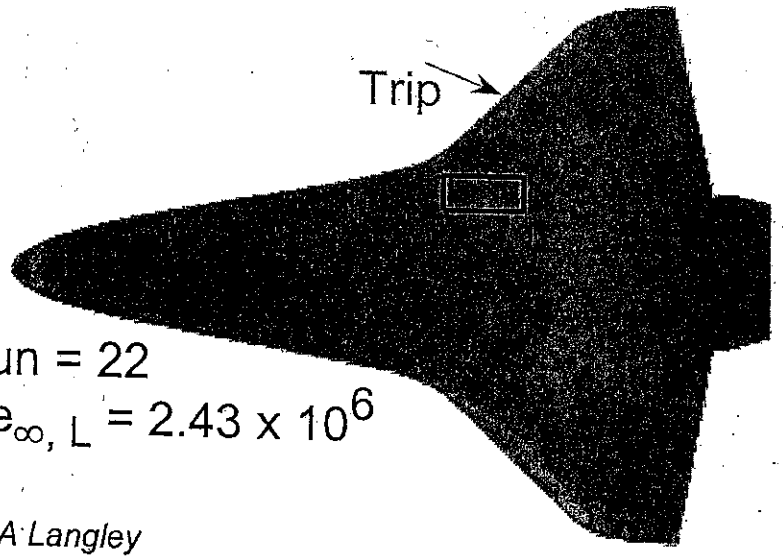
NASA LaRC 20-Inch Mach 6 Air

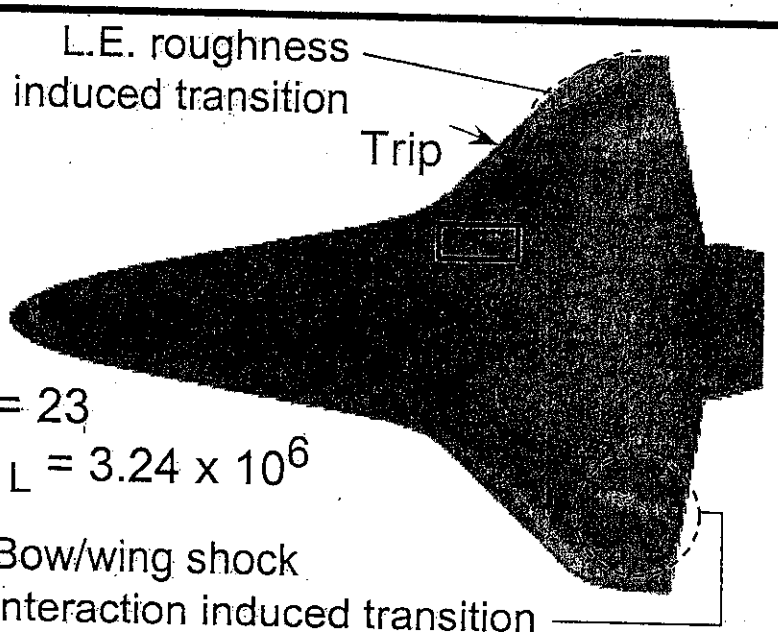
α = 40 deg Panel # 12 0.0075 Scale

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









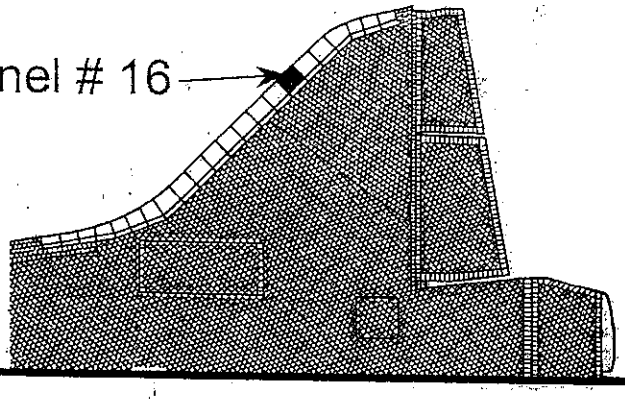
NASA Langley
Aerothermodynamics Branch

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

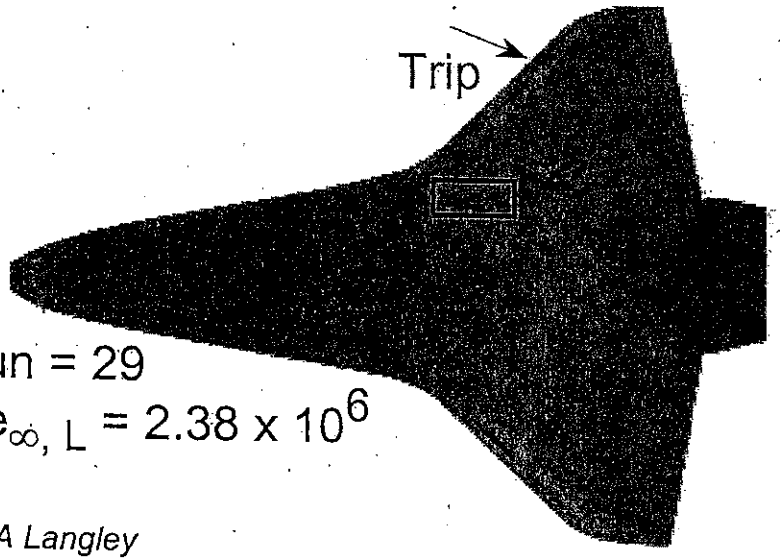
NASA LaRC 20-Inch Mach 6 Air

α = 40 deg Panel # 16 0.0075 Scale

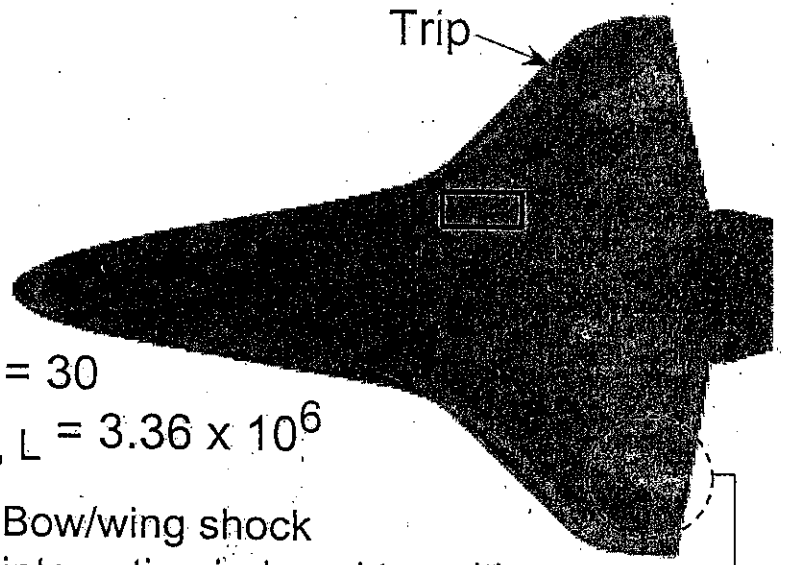
	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.1x0.1	13x13



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

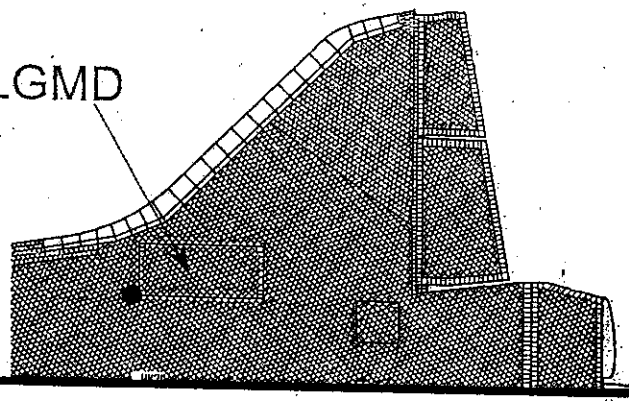
NASA Langley
Aerothermodynamics Branch

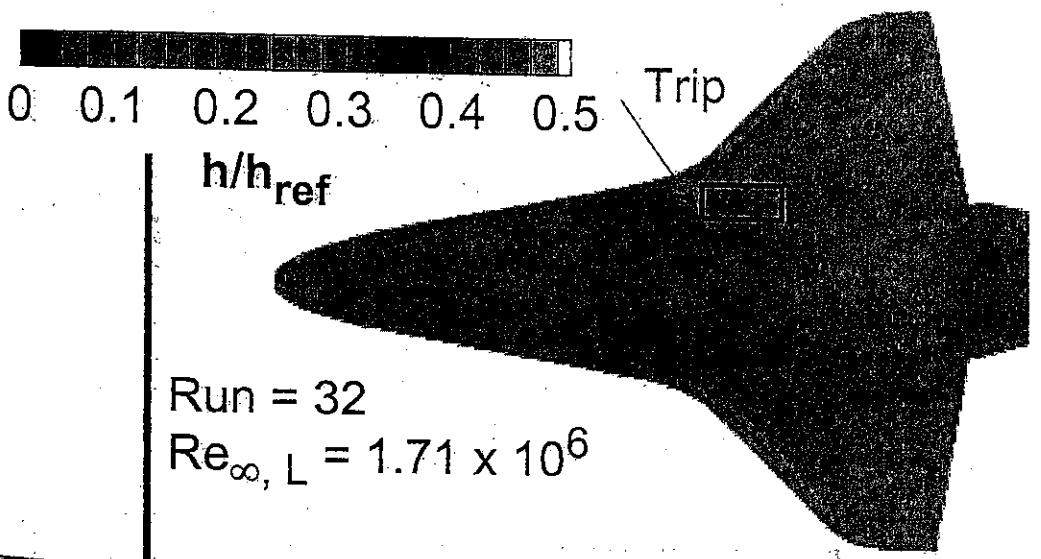
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

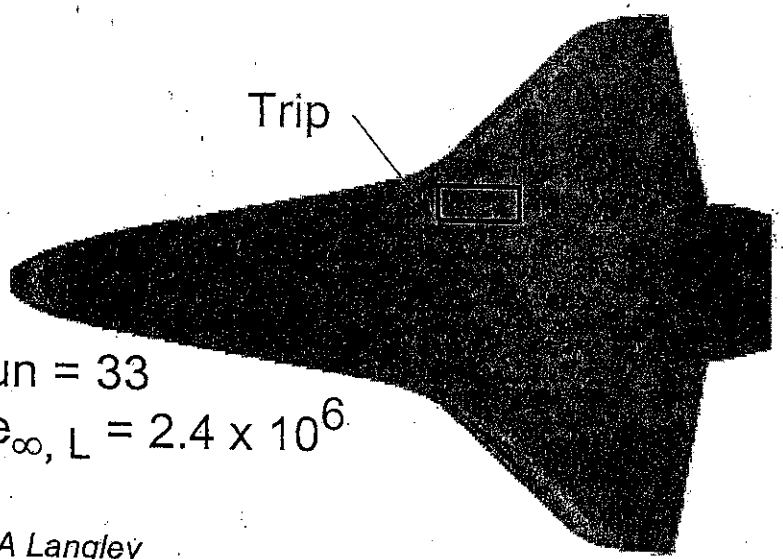
NASA LaRC 20-Inch Mach 6 Air

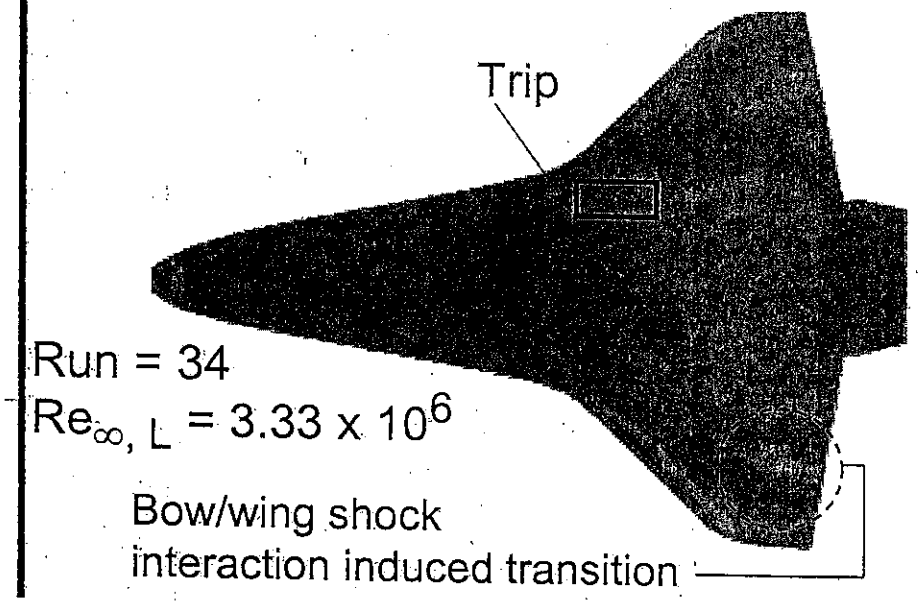
α = 40 deg Inboard LGMD 0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.005x0.005	7x7









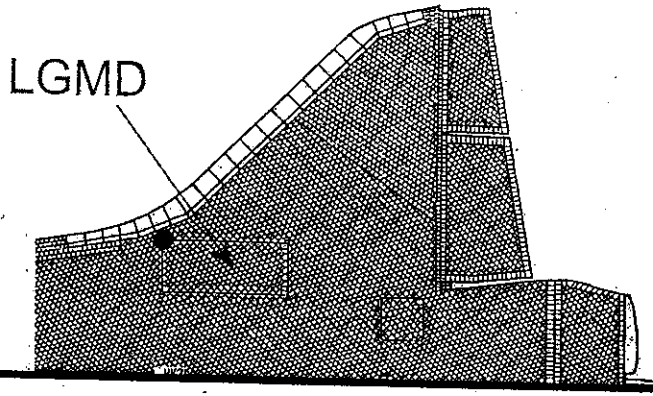
NASA Langley
Aerothermodynamics Branch

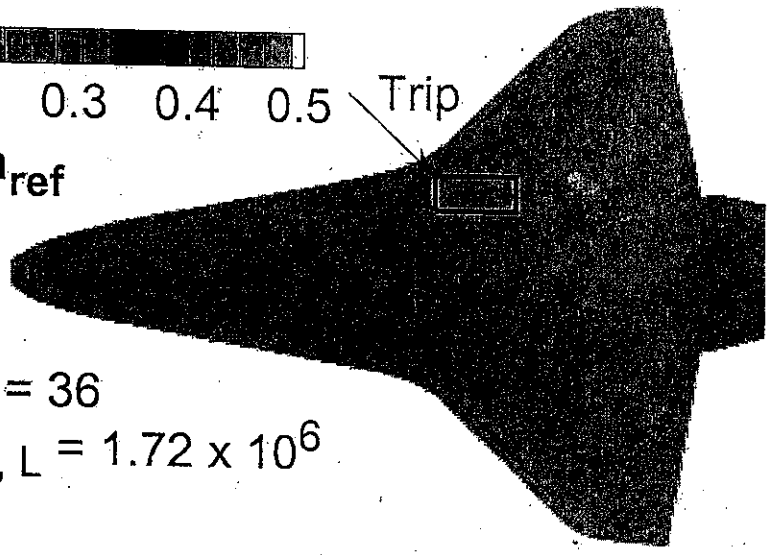
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

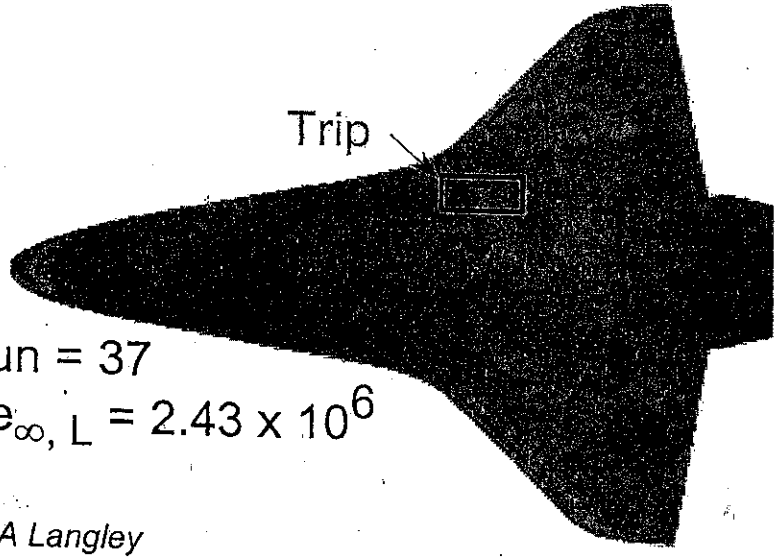
α = 40 deg Outboard LGMD 0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.005x0.005	7x7

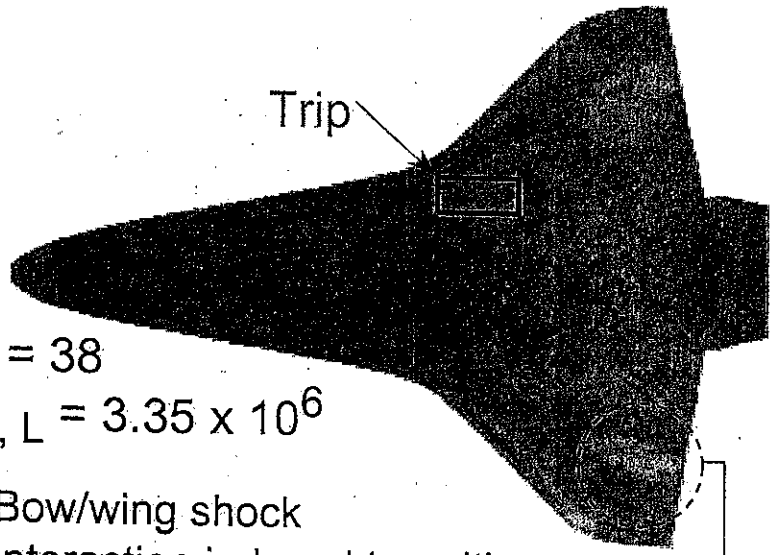




Run = 36
$Re_{\infty, L} = 1.72 \times 10^6$



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

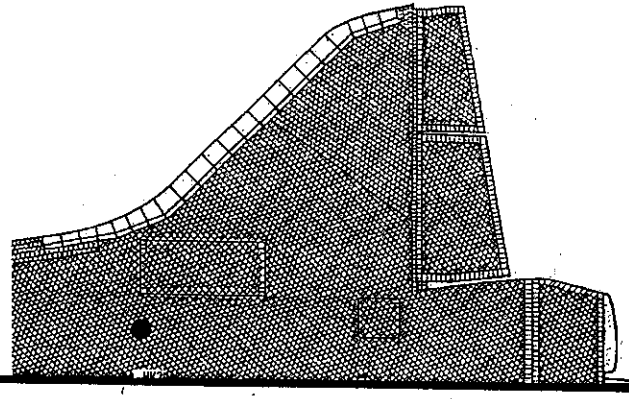
NASA Langley
Aerothermodynamics Branch

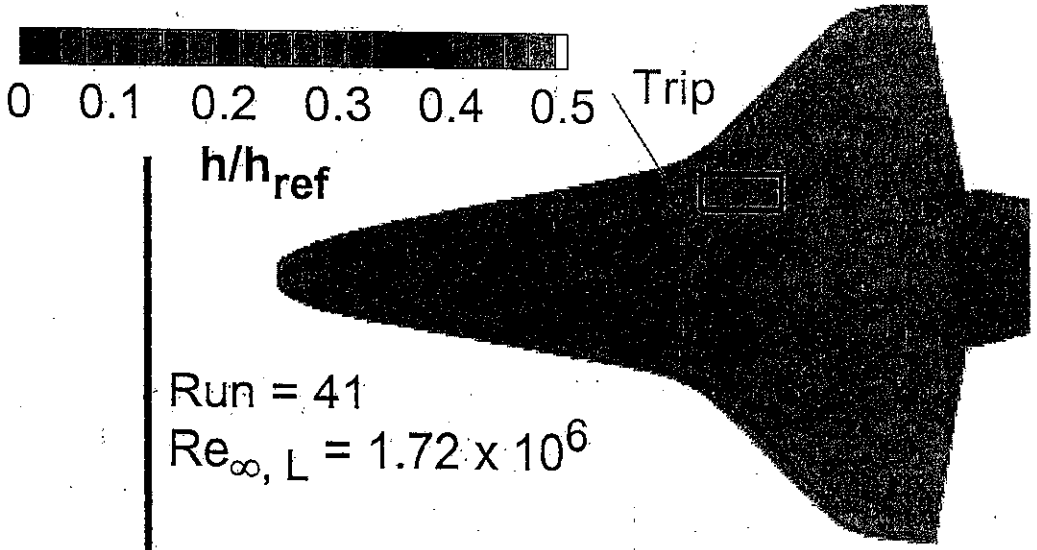
Effect of L.E. Roughness on Orbiter Windward Nondimensional Heating

NASA LaRC 20-Inch Mach 6 Air

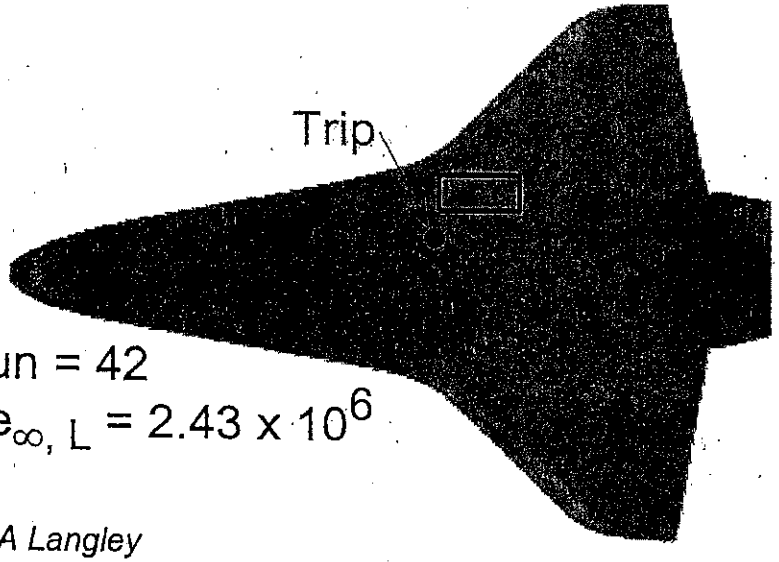
α = 40 deg 0.0075 Scale

	Model	FS
Trip height (in)	0.0035	0.47
Trip size (in)	0.005x0.005	7x7

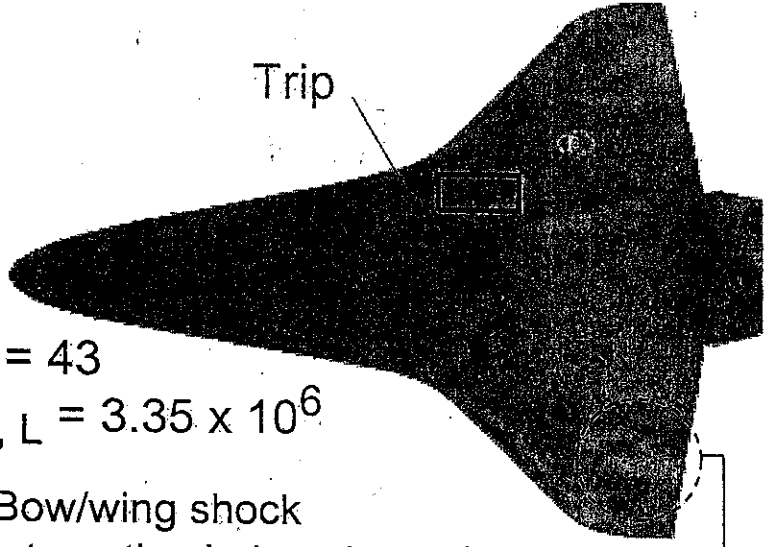




Run = 41
$Re_{\infty, L} = 1.72 \times 10^6$



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



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

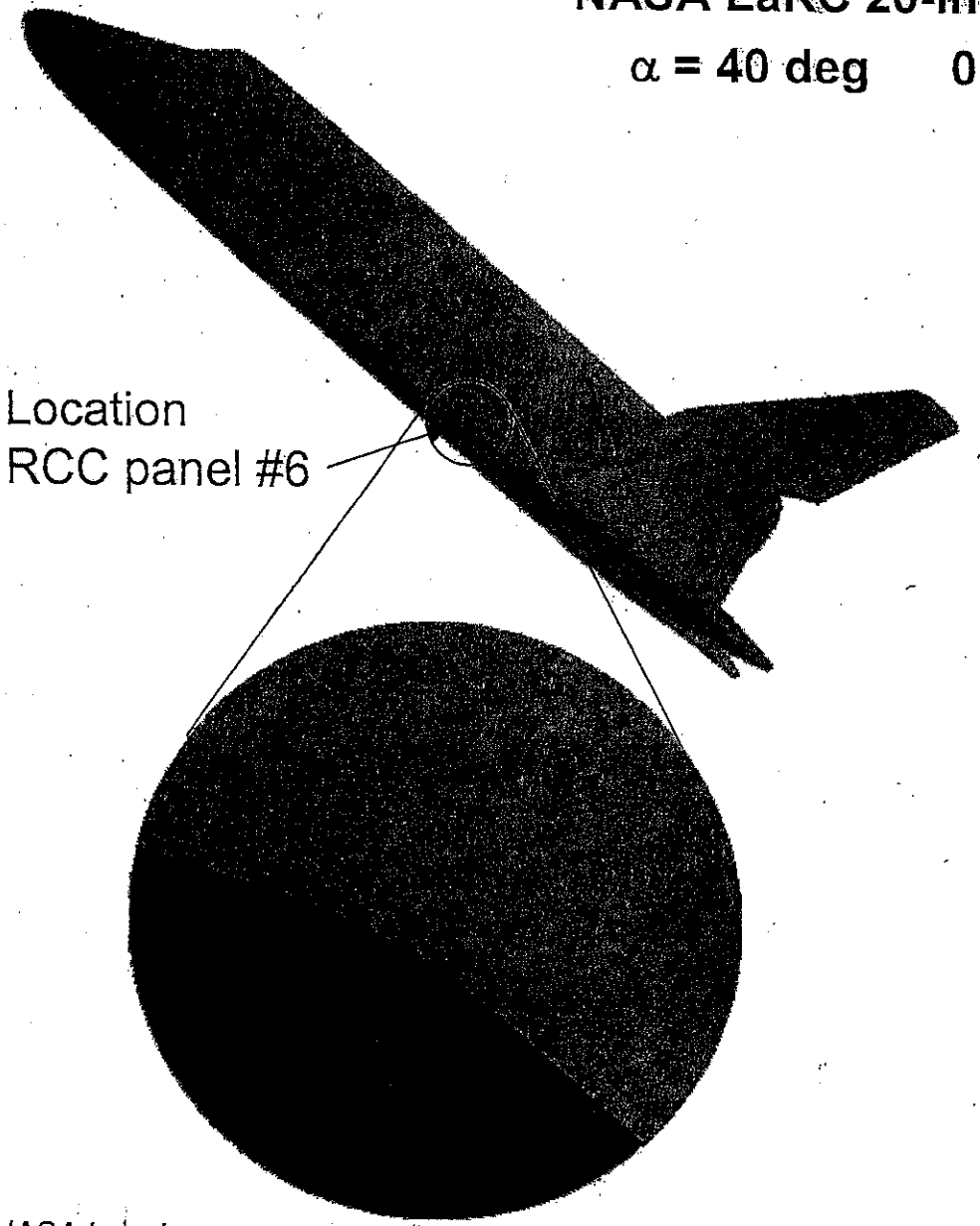
Bow/wing shock
interaction induced transition

NASA Langley
Aerothermodynamics Branch

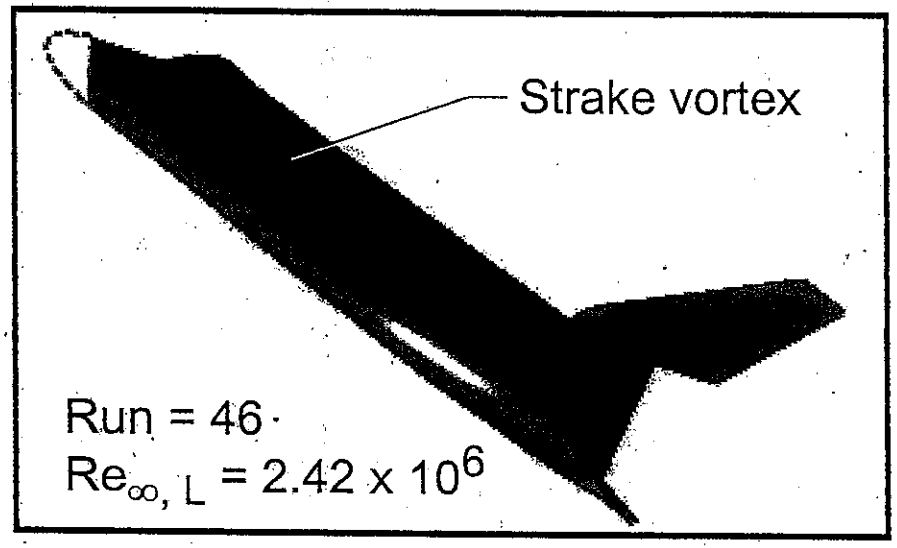
Effect of RCC Panel #6 L.E. Cavity on Orbiter Fuselage Thermal Mapping

NASA LaRC 20-Inch Mach 6 Air

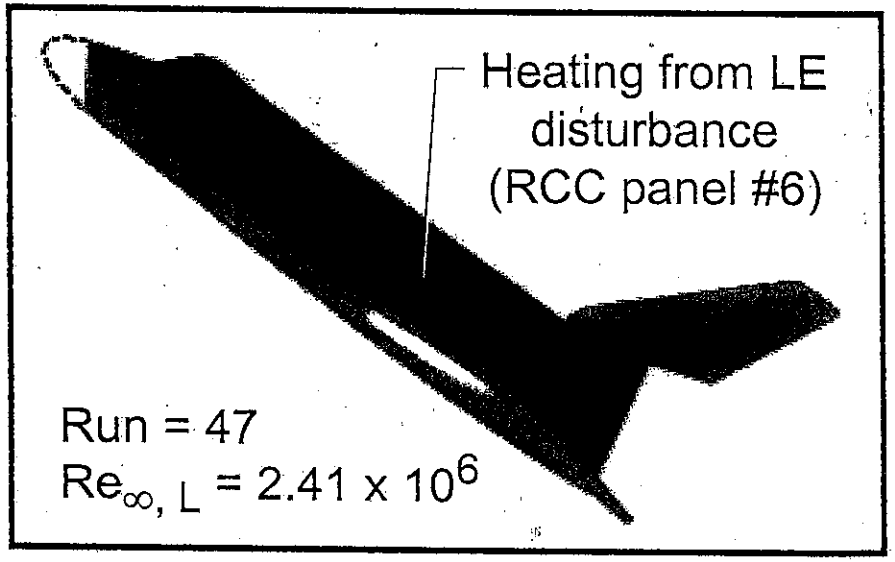
α = 40 deg 0.0075 Scale



Baseline Smooth LE



RCC Panel #6 "Notch"



NASA Langley
Aerothermodynamics Branch

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 heating-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)]