NESC Aerosciences Technical Discipline Team Overview & Activities

presented by
Craig Streett, Deputy Team Lead

on behalf of the members of the NESC Aerosciences TDT

NESC Background and Vision

Apollo Saturn V Launch Vehicle

- NESC was established in July 2003 in response to the Columbia accident
- Safety philosophy has 3 tenets:
  - Strong in-line checks and balances
  - Healthy tension
  - “Value added” independent assessment
- NESC provides independent assessment of technical issues for NASA programs and projects
- For the Aerosciences Discipline, these reviews and assessments involve the copious use of CFD.

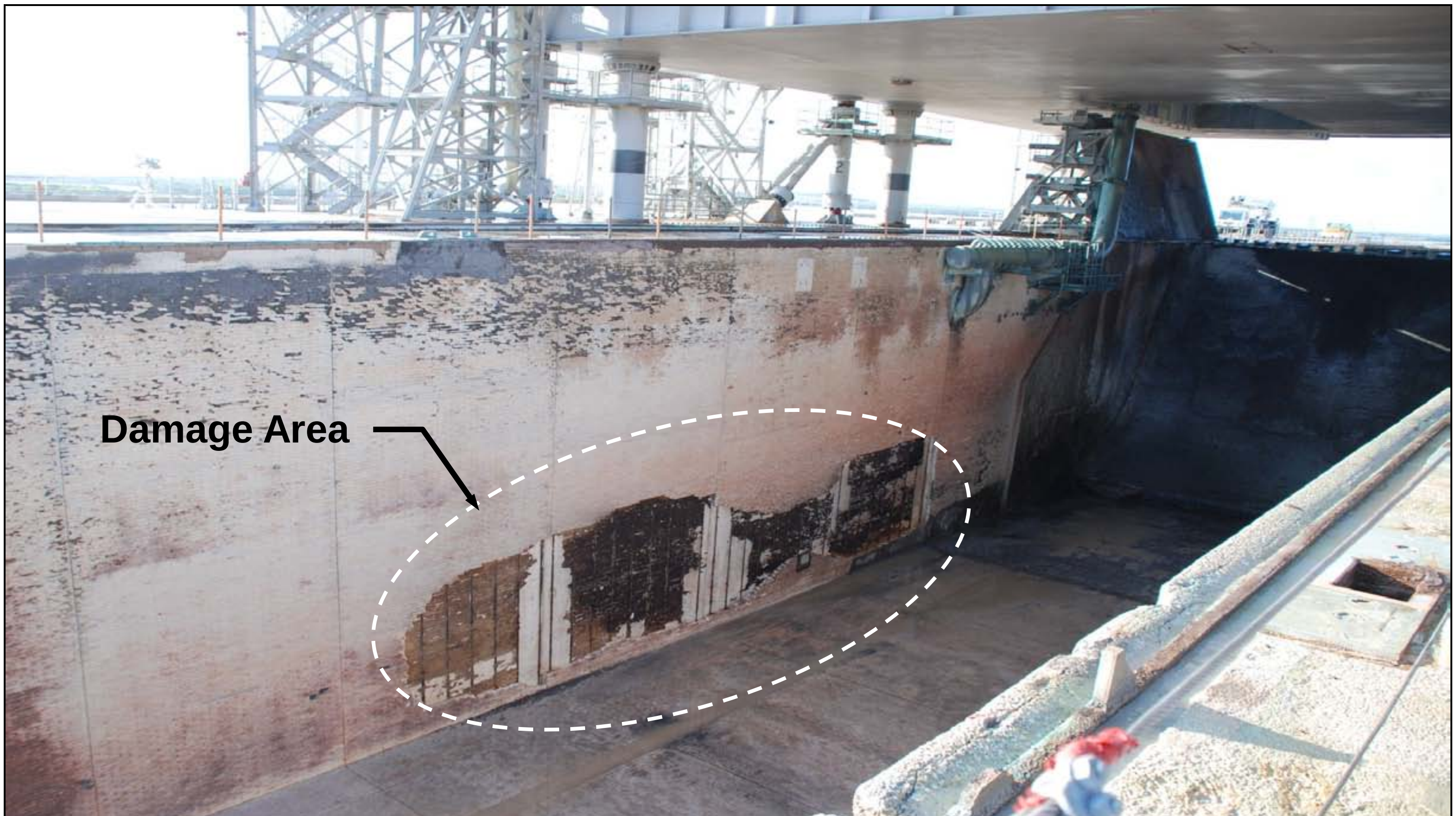
Activities

NESC Aerosciences Technical Discipline Team involvement includes:

- **Peer reviews and independent technical assessments as requested by projects**
  - **Flight project "911 calls"**
  - **In-depth analysis**
- **Periodic state-of-the-discipline assessments**
- **Discipline advocacy and stewardship**
  - **Pathfinding investigations**

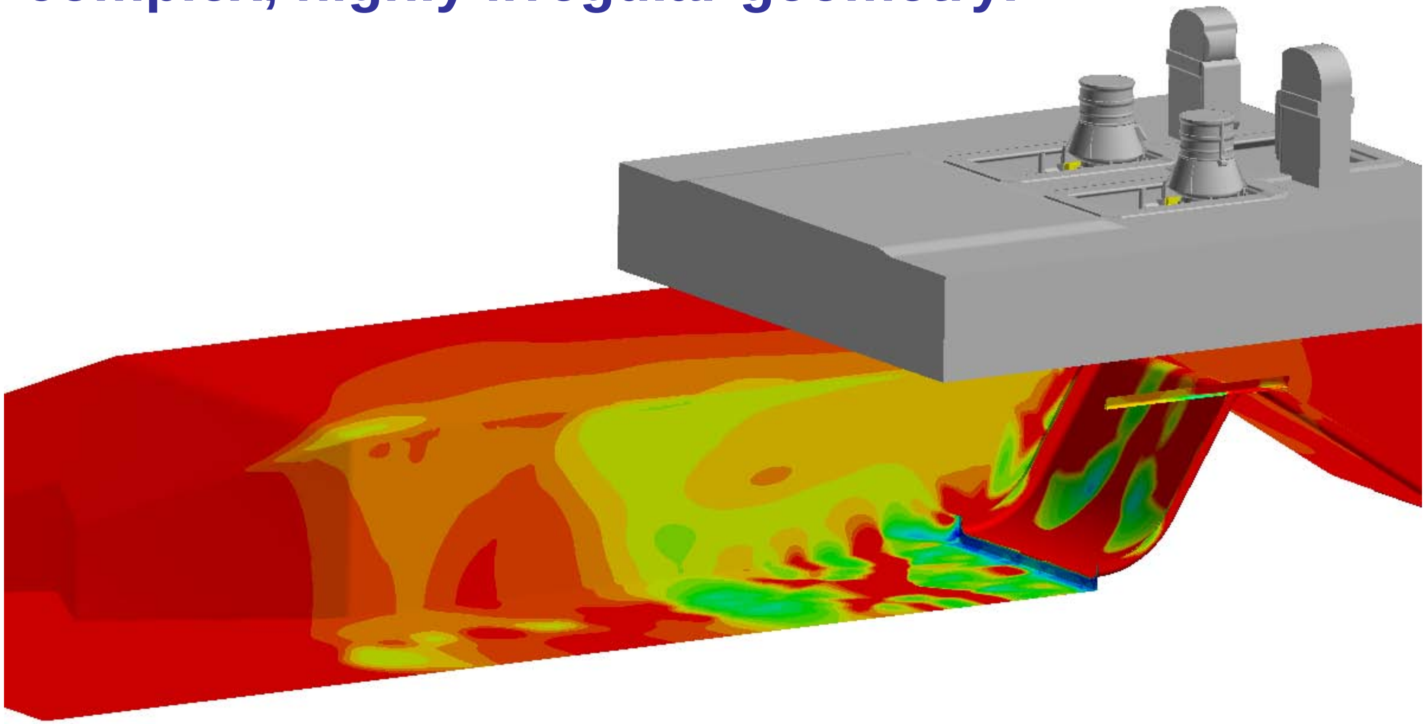
STS-124 Launch
May 13, 2008

- Over 3500 20 lbm (9 Kg) flame retardant bricks were liberated from the East Wall of the Pad 39A Flame Trench

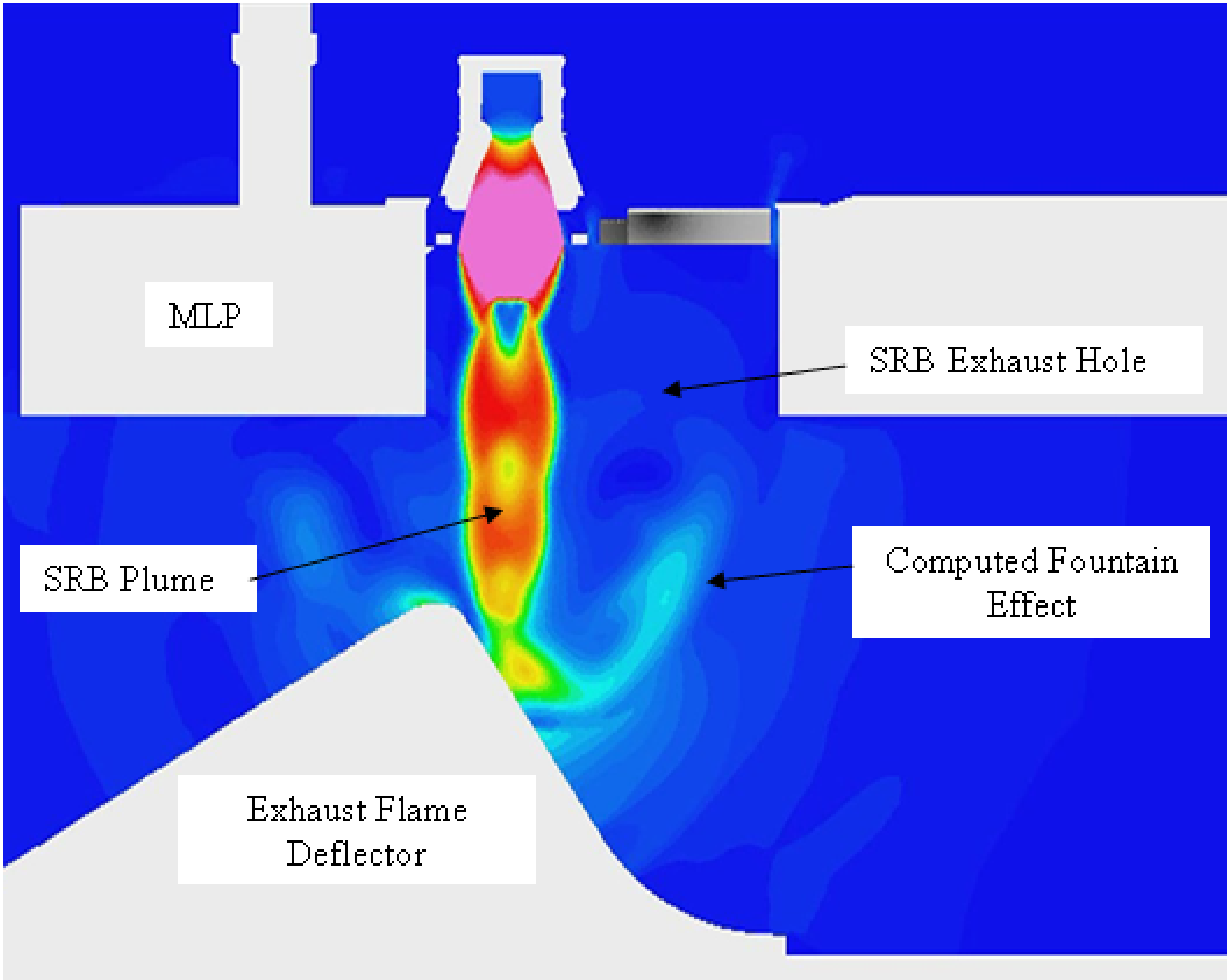


Flame Trench CFD

- **Time dependent CFD conducted to predict Ignition Over Pressure (IOP) loads on trench walls during launch.**
  - **Problem involves chemically reacting plumes, high volume water deluge for acoustics suppression, and complex, highly irregular geometry.**



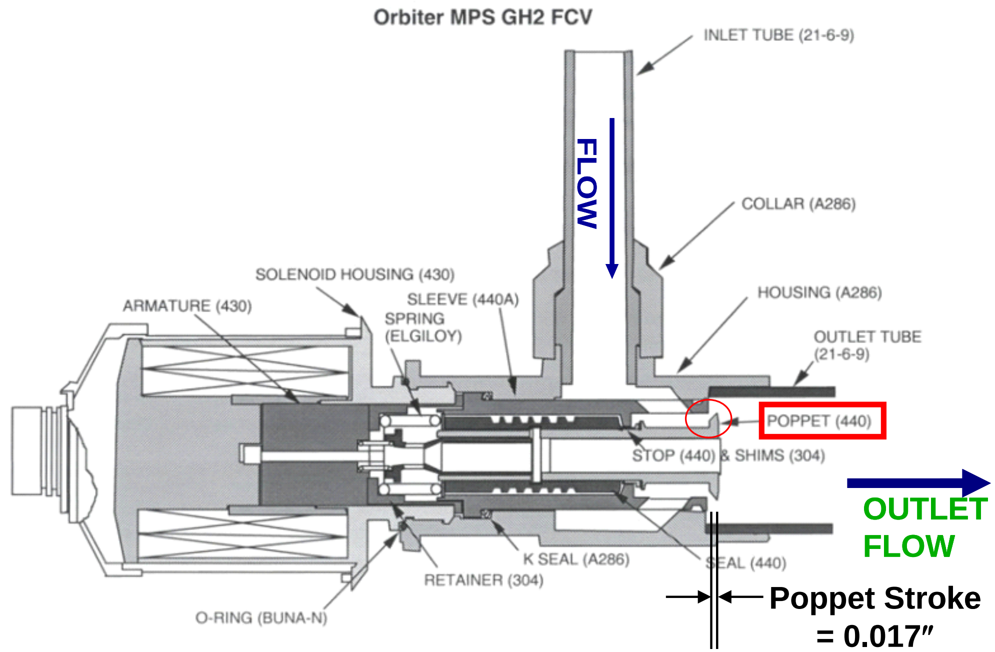
SRB Plume CFD



STS-126
November 14, 2009

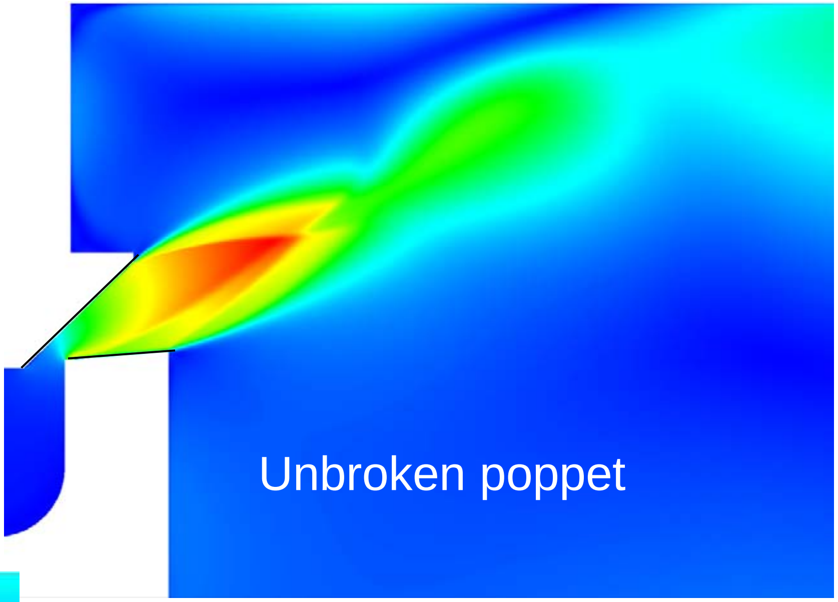
GH2 Flow Control Valve Poppet Failure

- **During ascent one of three GH2 Flow Control Valves (FCV) transitioned from low-flow to high-flow without command.**
- **FCV provides GH2 pressurant to Shuttle External Tank (ET).**
- **Poppet valve failure led to concerns over ET over-pressurization and GH2 leakage due to damage from failed poppet debris.**



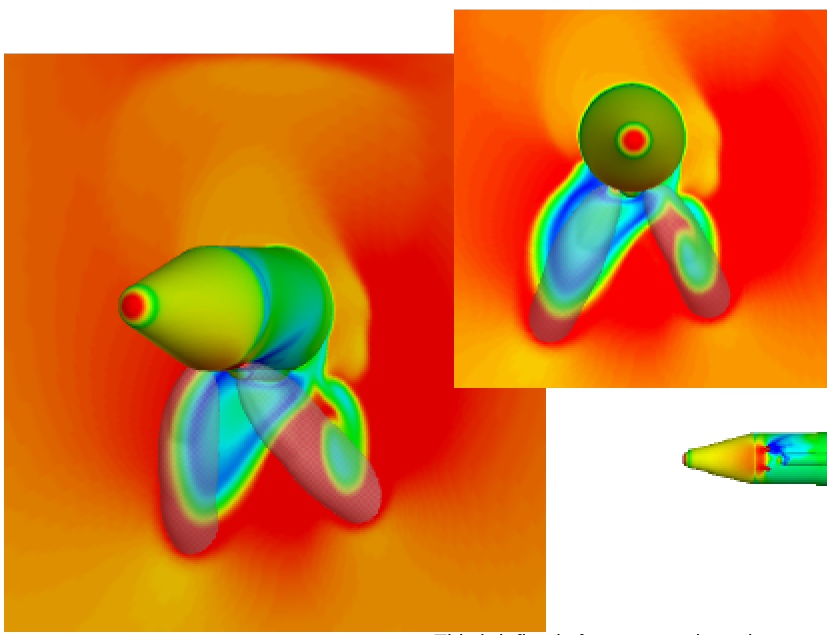
FCV Poppet CFD

- Time-accurate CFD employed to predict flowfield parameters in pipes downstream of FCV to support ET pressurization studies and debris transport.
- Flow of GH2 in a pipe.
  - High pressure ratios.
  - Highly irregular geometry.

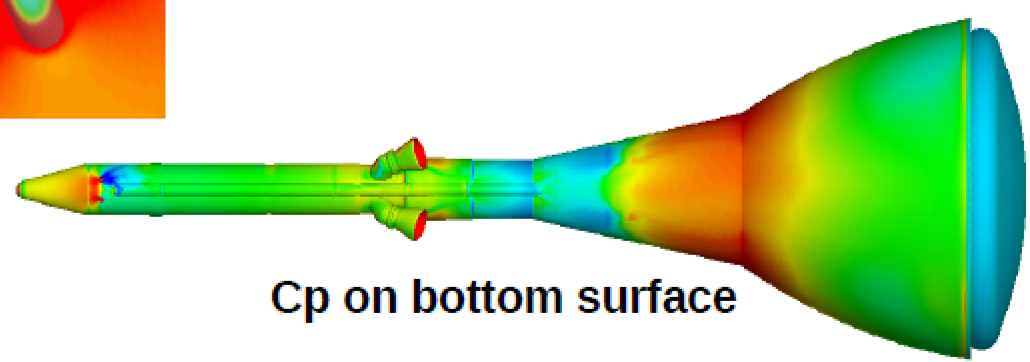


Orion LAV ACM Plume Asymmetry

- **Geometry and propulsion are symmetric left/right, so flow should be symmetric.**
- **Steady CFD shows ACM plume asymmetry at some transonic flight conditions.**
  - Adversely impacts ACM pitch effectiveness and adds a yaw component.
- **CAP Team requested NESC to investigate whether this is physically viable or a CFD software artifact.**
- **NESC formed a team to investigate the problem using different CFD codes and formulations to determine if the phenomenon is consistently predicted by other methods.**



Mach Contours and Species iso-surface

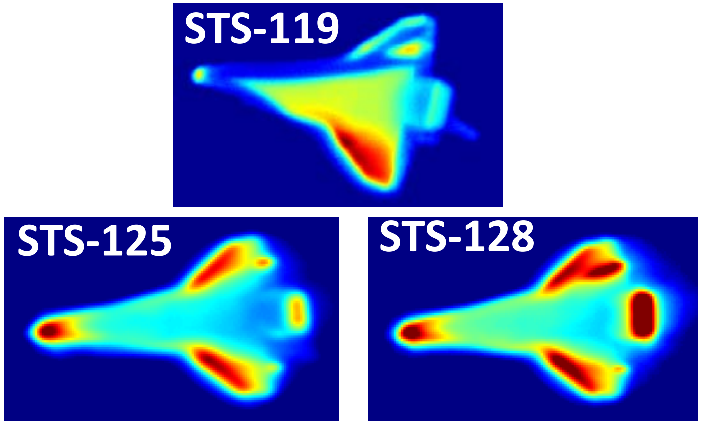


Cp on bottom surface

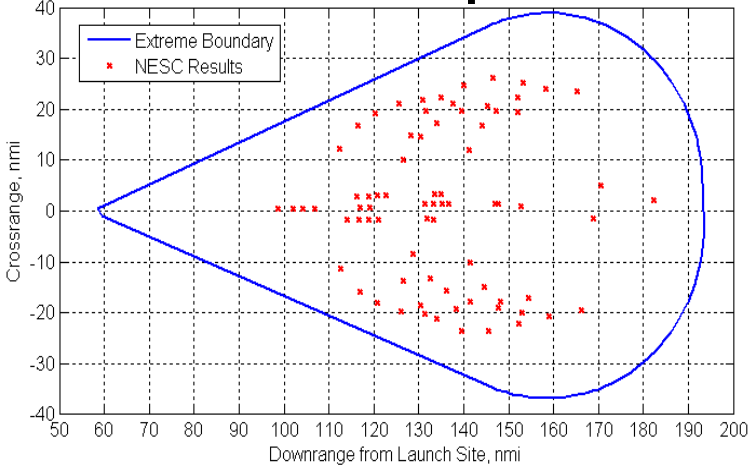
Aerosciences TDT Flight Support

- Shuttle Transportation System.
  - BLT DTO and Remote Imaging.
  - STS-130 Flipper Door Seal Anomaly.
- Ares I-X
  - DFI advocacy and support.
  - Aero database review – Ground Wind Loads and Liftoff Transition Aero
  - Aeroacoustics analysis
  - Upper stage breakup debris support.
  - Rollout loads support.
- Hayabusa Reentry
  - Entry Imaging Review
- MLAS
  - Full aero Support through flight.
  - Post-flight report in review.

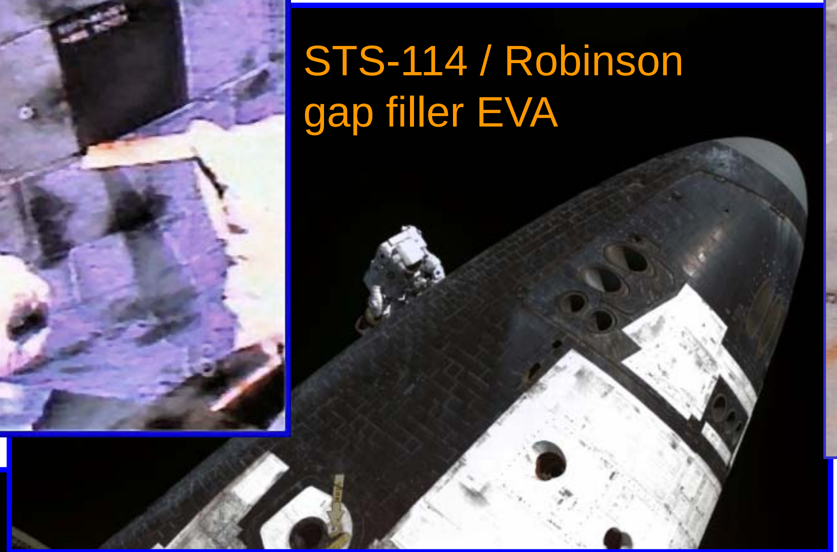
Shuttle Remote Imaging

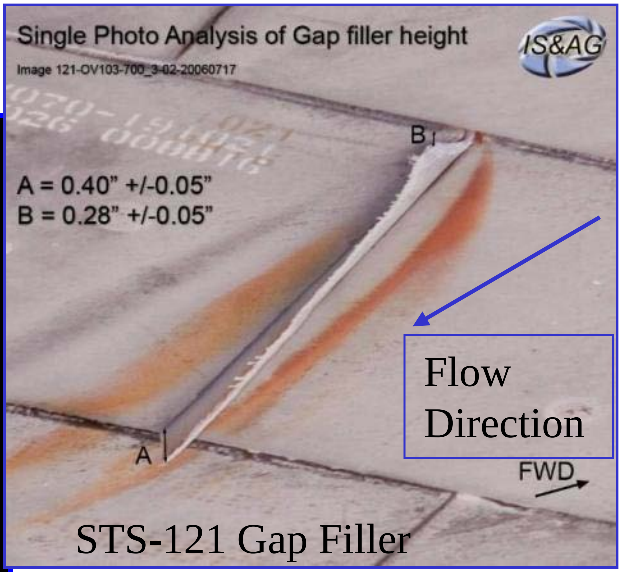


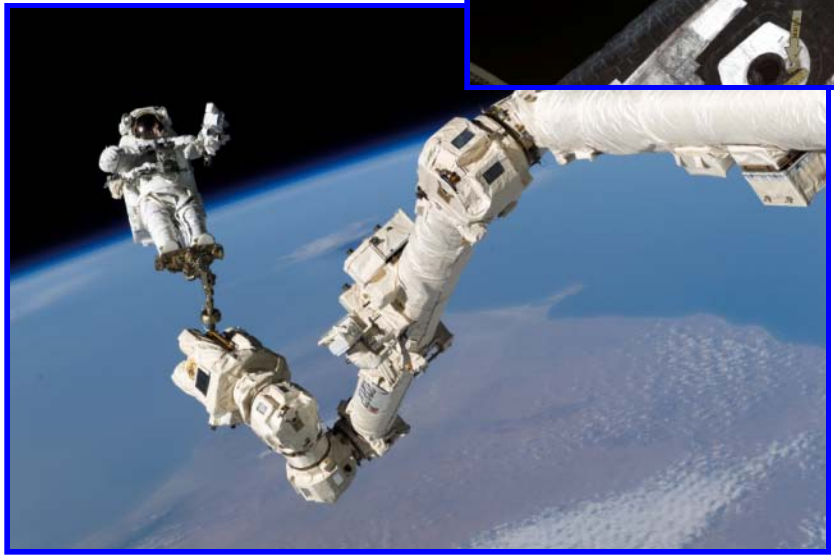
Ares I-X Upper Stage Breakup Debris Footprint



Hypersonic BL Transition Flight Testing







- Entry aerothermodynamics is the driving environment for entry vehicle design and thermal response.
- We do not have sufficient understanding of the physics to establish accurate high Mach/high enthalpy turbulent heating environments.
- Directly scalable ground testing does not currently exist in this regime.

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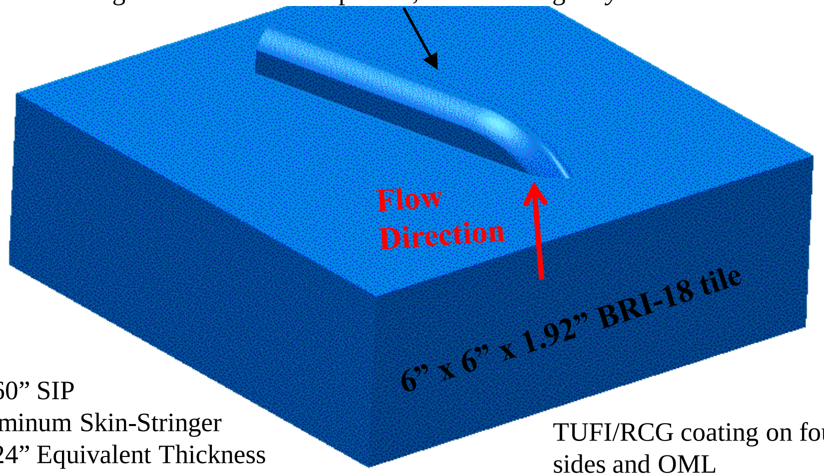
OV-103 HDWR Modifications

Protuberance Tile

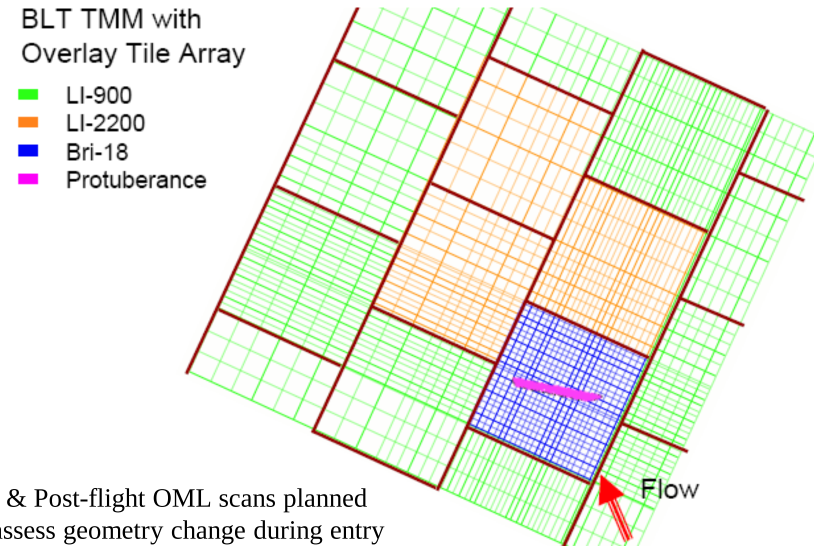
Protuberance is 4” long, 0.376” thick, 0.25” height
13 deg offset from the tile pattern, RCG coating *only*



0.160” SIP
Aluminum Skin-Stringer
0.124” Equivalent Thickness

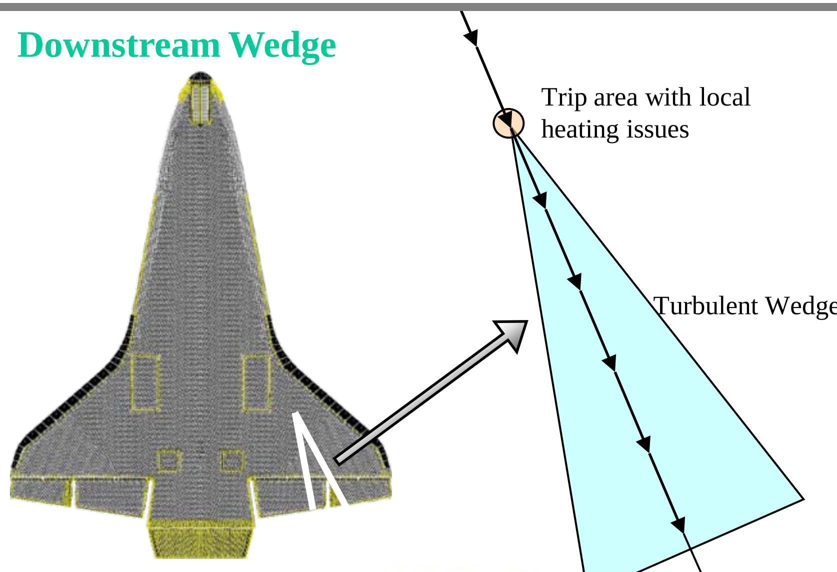
TUFI/RCG coating on four sides and OML

Local Area

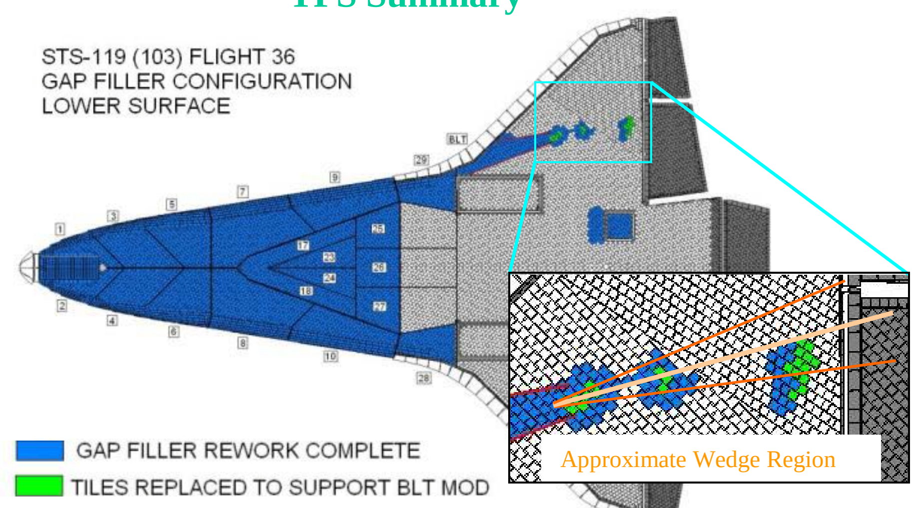


Pre & Post-flight OML scans planned to assess geometry change during entry

Downstream Wedge



TPS Summary



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STS-119 Temperature Map Image

- with blurring correction -

Calibrated using preflight blackbody calibration from ISTEF

Emissivity estimated from same correlations used in APL radiance modeling

Atmospheric attenuation estimated using preflight APL radiance model

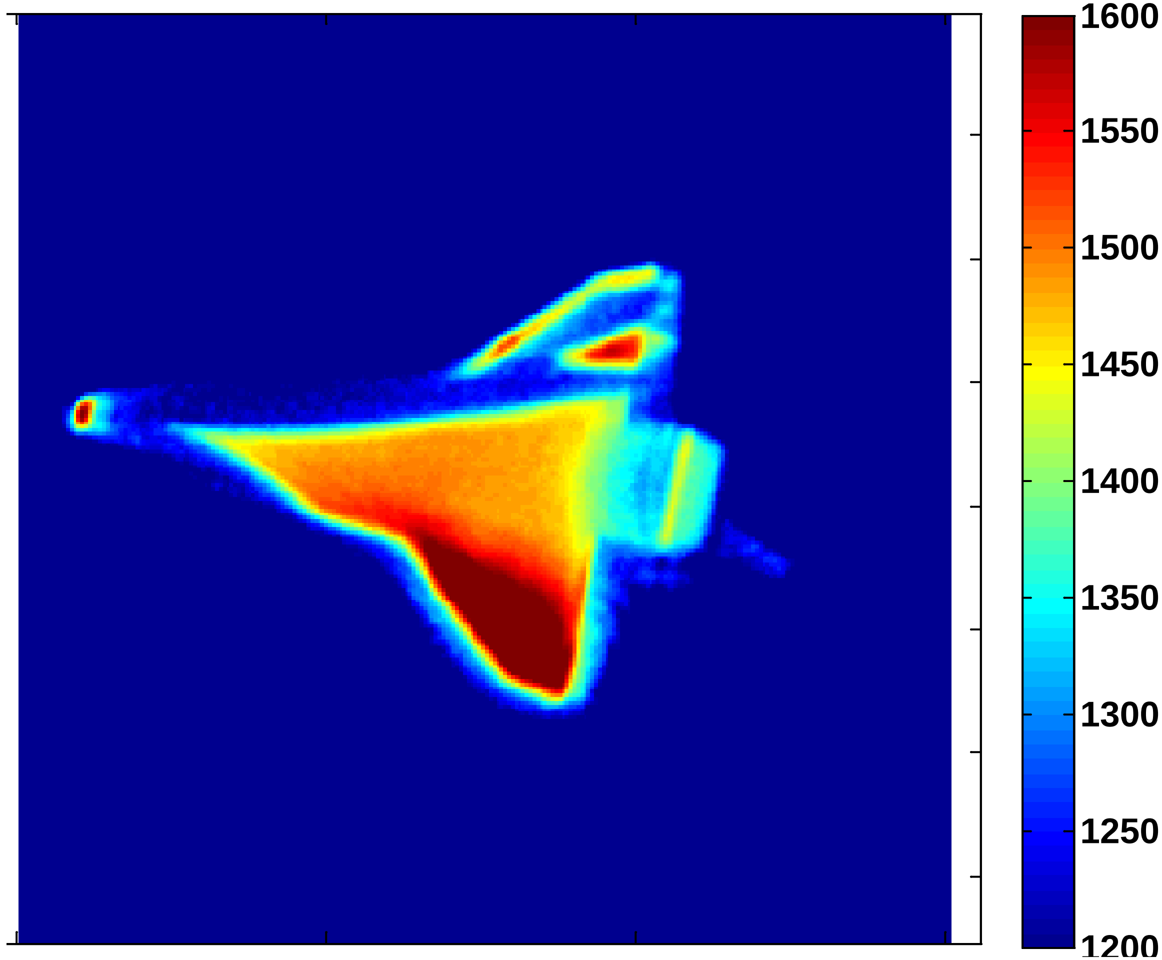
Background and Dark Count estimated and removed.

Length estimated from IFOV and range.

Blurring estimated as Gaussian PSF with 3.5 pixel FWHM based upon star calibrations

28 Mar 2009 19:01:52.532 UTC (near closest approach)

Temperature (F)



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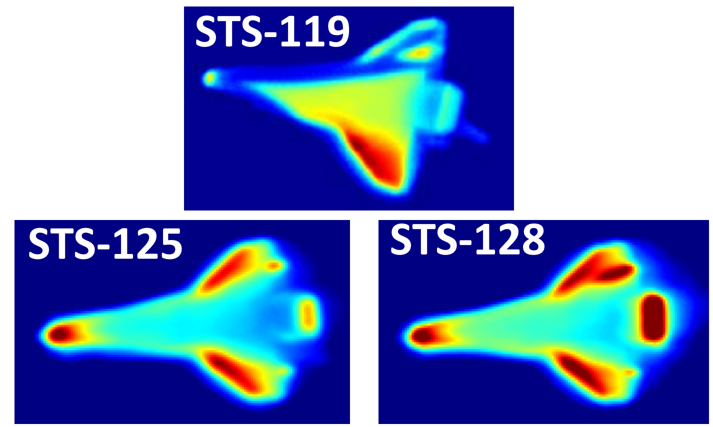
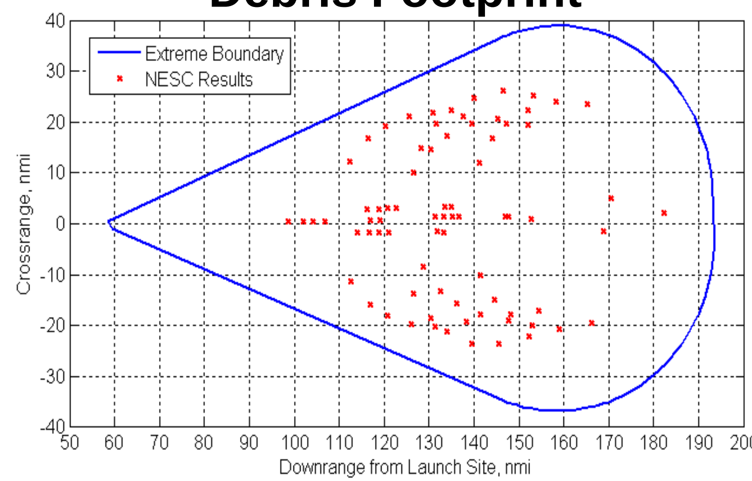
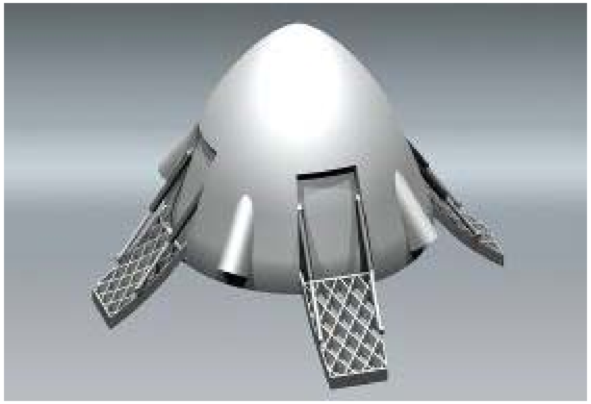


Ares I-X Upper Stage Breakup Debris Footprint

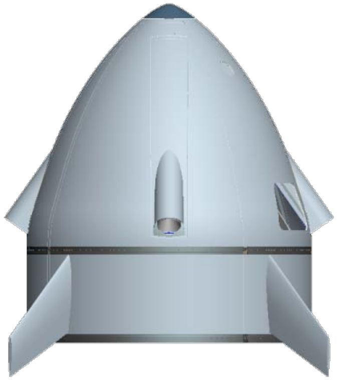


MLAS Objective System Concept

Notional Objective Concept	Corresponding Abort Configuration
	

NASA's Associate Administrator Scott Horowitz asked the NESC to develop, design, and test an alternate design as risk mitigation for the Crew Exploration Vehicle (CEV) Launch Abort System (LAS) concept.

- Integrated propulsion/fairing w/ TVC for abort boost
- Deployed / separable passive grid or planar fins for aerodynamic stabilization during coast, may be fairing or ring mounted
- Drogue parachutes to reorient CM and establish separation conditions



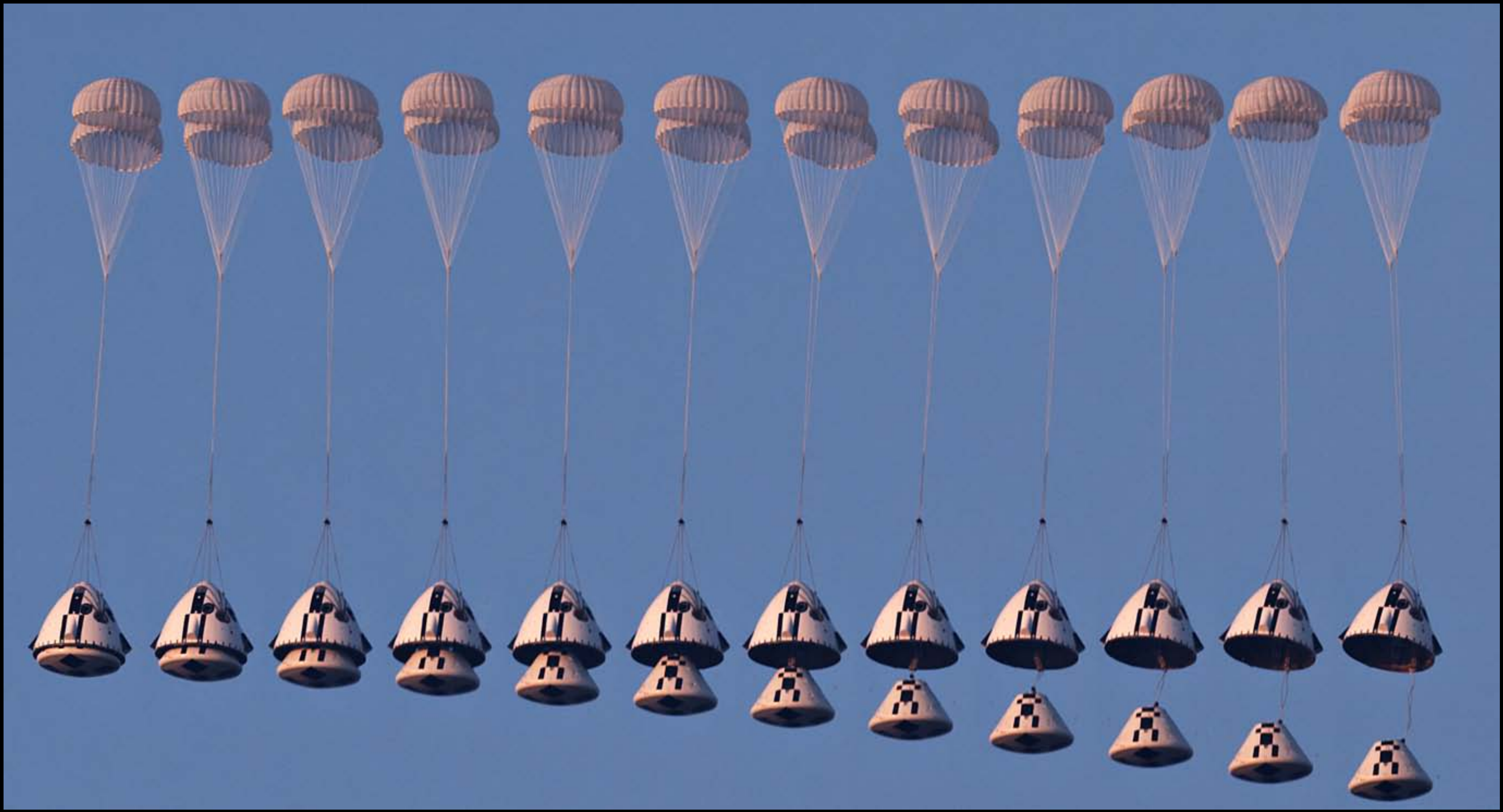
Successful Flight Test!

Mobile Aerospace Reconnaissance System (MARS)

CLAY CENTER OBSERVATORY 2002

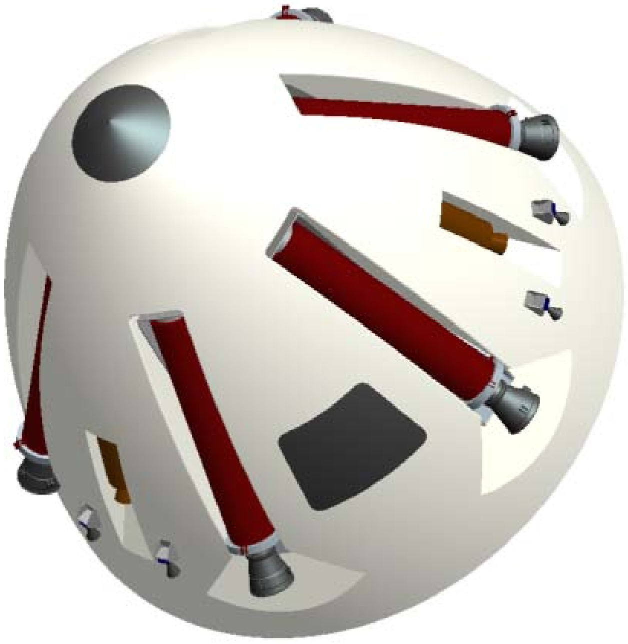
M A R S
Mobile Aerospace
Reconnaissance System

POC: Ron Dantowitz (dantowitz@dexter.org)
Director, MARS Program
Director, Clay Center Observatory



The Next Steps

- MLAS II
  - Pad abort of an Objective System concept.
    - Currently all-powered concept.
    - 6 TVC abort motors.
    - 6 RCS motors.
  - Team leadership formed and beginning conceptual design.
- FTD Projects
  - Aero-Assist Demonstrator.
- Aerosciences Technology Initiatives.



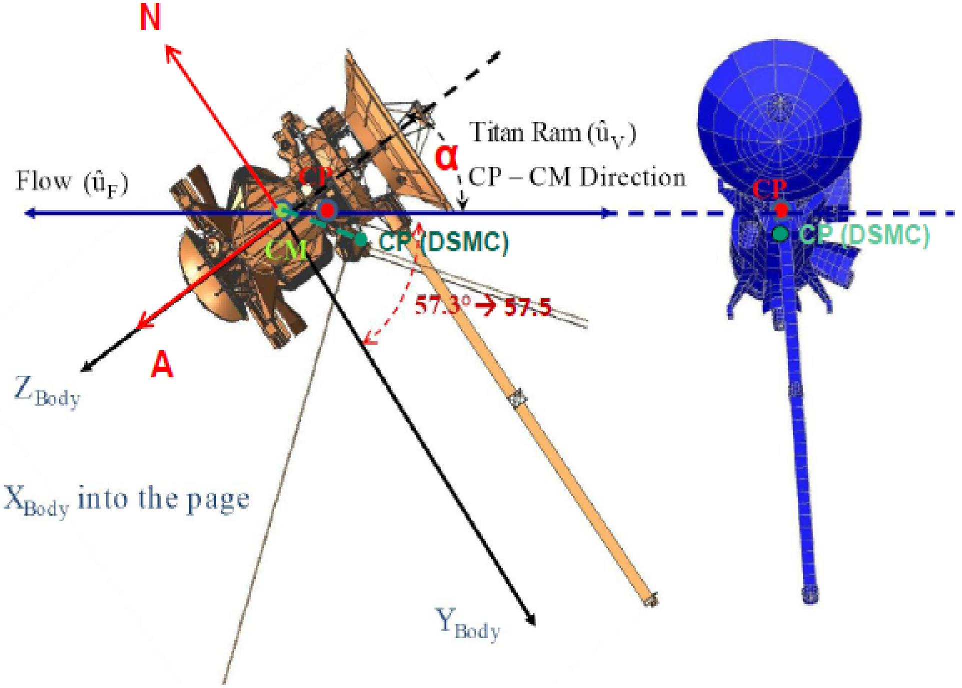
Aerosciences TDT Flight Support

- **Orion PA-1 (pad-abort system)**
  - **Aero database review via CAP Peer Review.**
  - **Loads and environments review.**
    - **With Loads and Dynamics TDT.**
  - **Identified need to perform fundamental plume-nearfield vibroacoustics tests**

- **Cassini Titan-70 km flyby**
  - **DSMC simulations and Titan atmospheric modeling.**

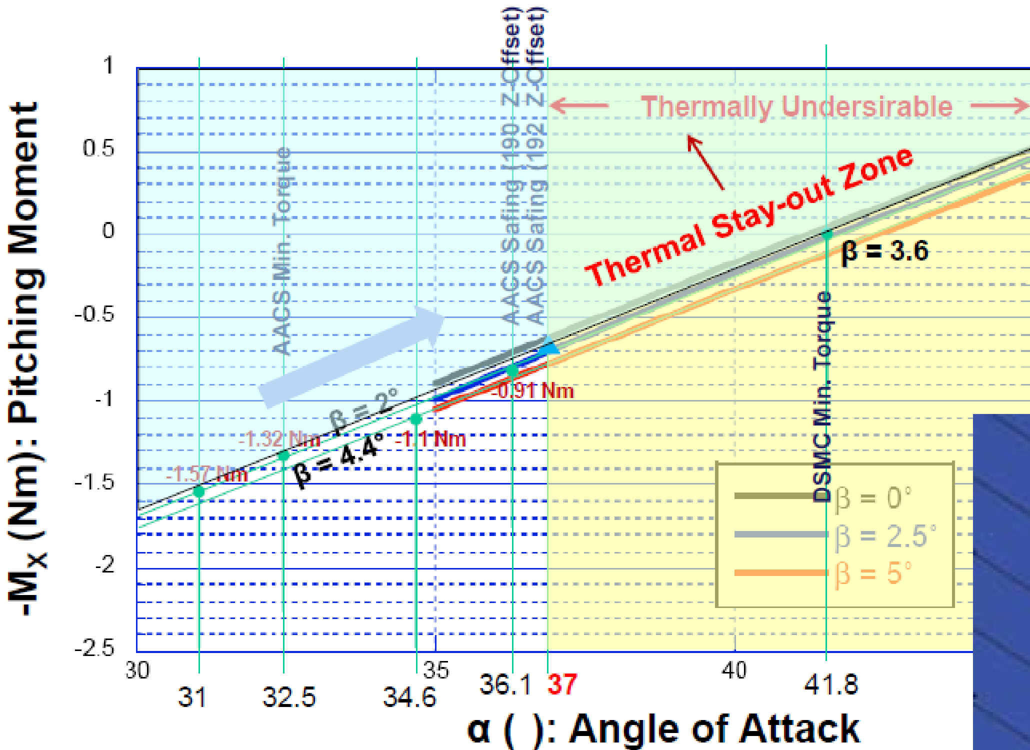
Cassini Titan -70 Km Flyby

- Proposed to pass Titan at 880 Km altitude.
  - 70 Km lower than the lowest previous pass.
  - Concern over increased duty cycle of RCS.
  - Could cause a spacecraft tumble.
- Free molecular flow used to predict aero for previous passes.
  - Lower altitude results in transitional flow.
- Direct Simulation Monte Carlo (DSMC) required for this type of flow.
- Atmospheric density modeling also becomes an issue.
  - TitanGram adapted to modeling atmospheric density for this pass.
- Thermal analysis also performed

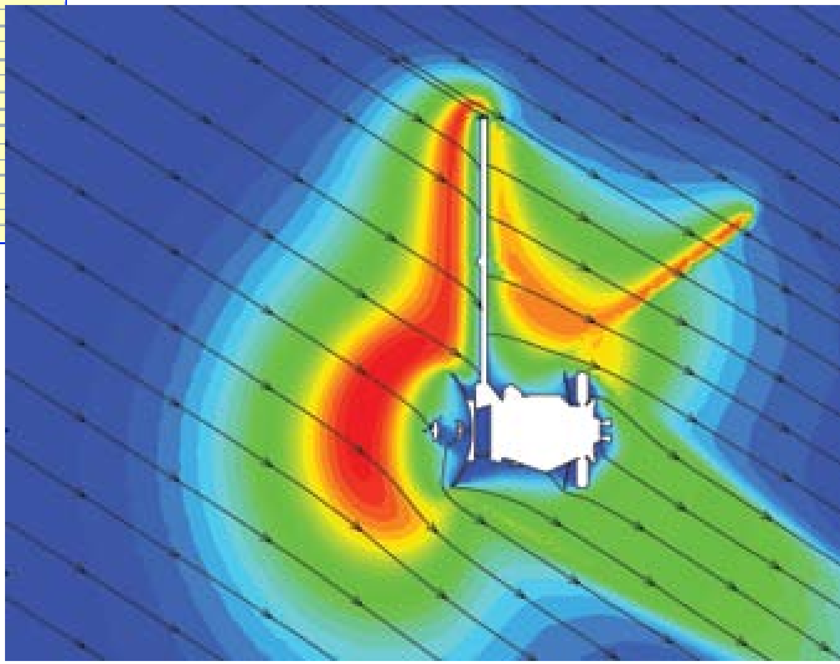


Cassini -70 Km Results

Pitching Moment vs. Angle of Attack



Cassini DSMC Simulation



Summary

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