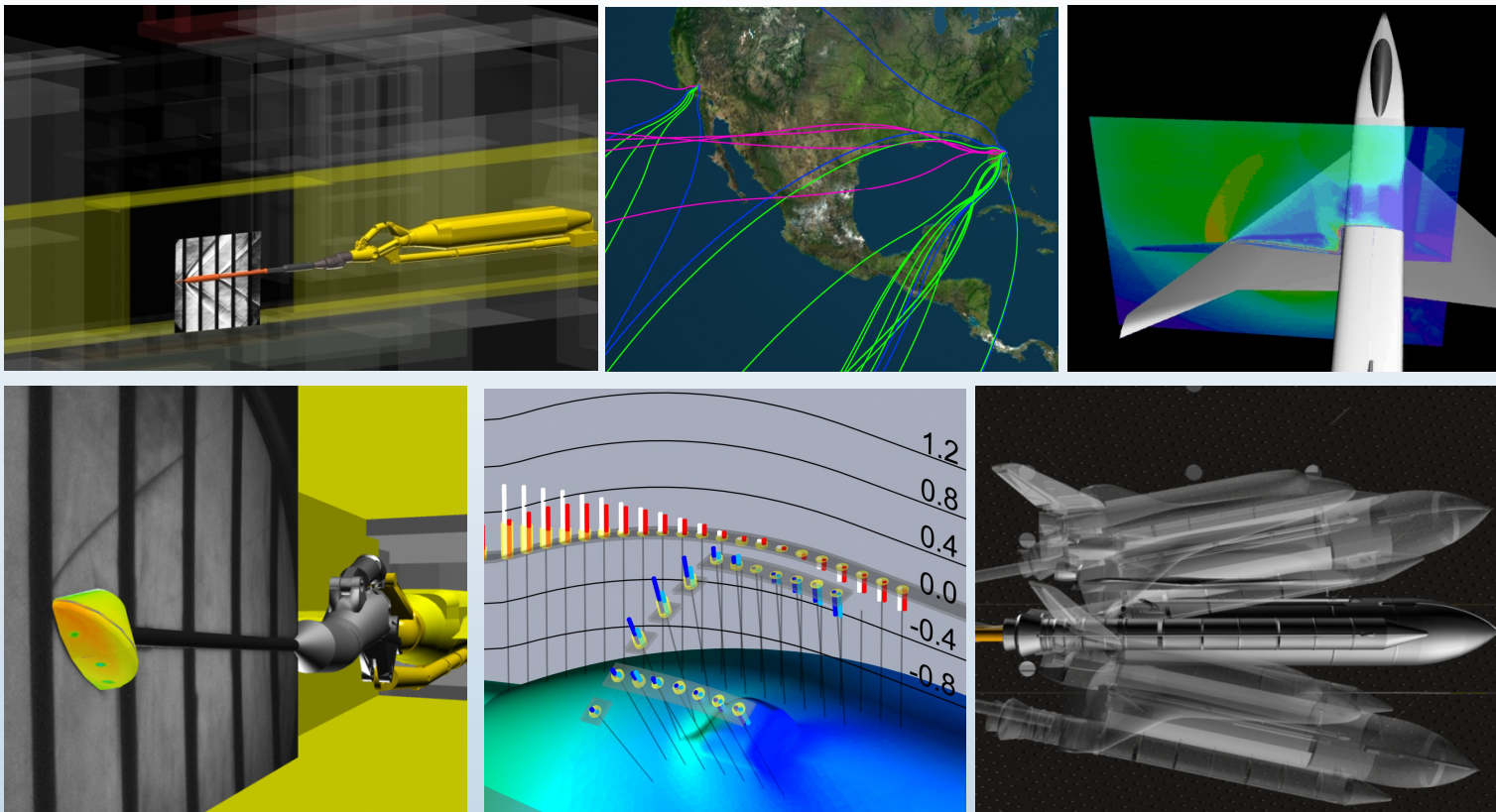


Virtual Diagnostics Interface

ViDI - An Overview of Capabilities



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ATK Space Division, supporting the
Advanced Sensing and Optical Measurement Branch
NASA Langley Research Center
Hampton, VA

Introduction

*Veni, **vidi**, vici*
I came, **I saw**, I conquered
Julius Caesar

Virtual Diagnostics Interface - ViDI

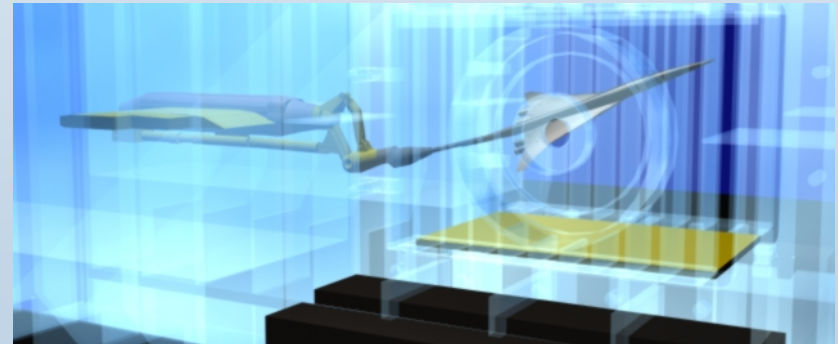
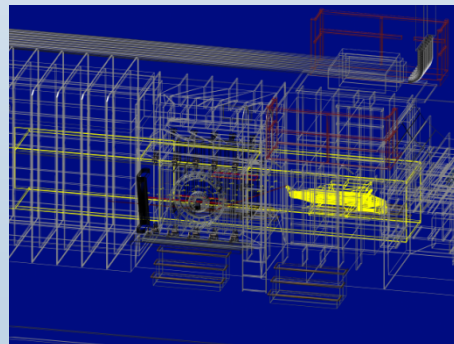
- What is ViDI?
- How is ViDI applied?
 - Pre-test planning,
 - Real Time Data Visualization,
 - Post Test Data Unification – Experimental and Computational.
- Where is ViDI going?
 - Expansion of current capabilities, physics based simulations,
 - HYTHIRM – Hypersonic Infrared imaging Mission planning and data analysis including a Space Shuttle flight experiment.

What is ViDI?

The Virtual Diagnostics Interface is a **methodology** designed to solve a variety of aerospace testing problems through the use of visualization.

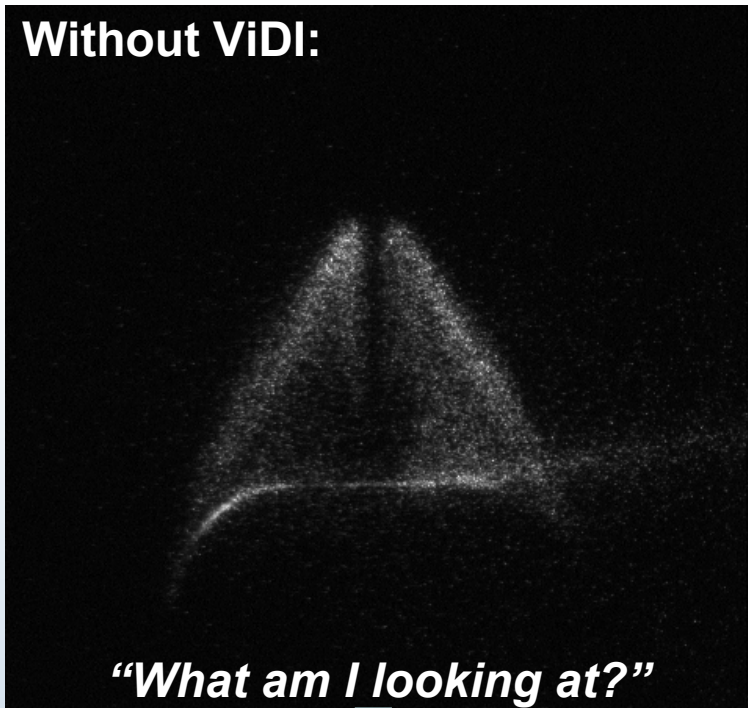
The primary tools of ViDI are;

- Three-dimensional computer modeling and visualization programs (primarily COTS).
- Two-dimensional image processing software (COTS and in-house developed).
- Customized user interfaces for easy and rapid data visualization manipulation (developed in-house).



What is ViDI?

Without ViDI:

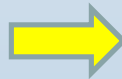


“What am I looking at?”

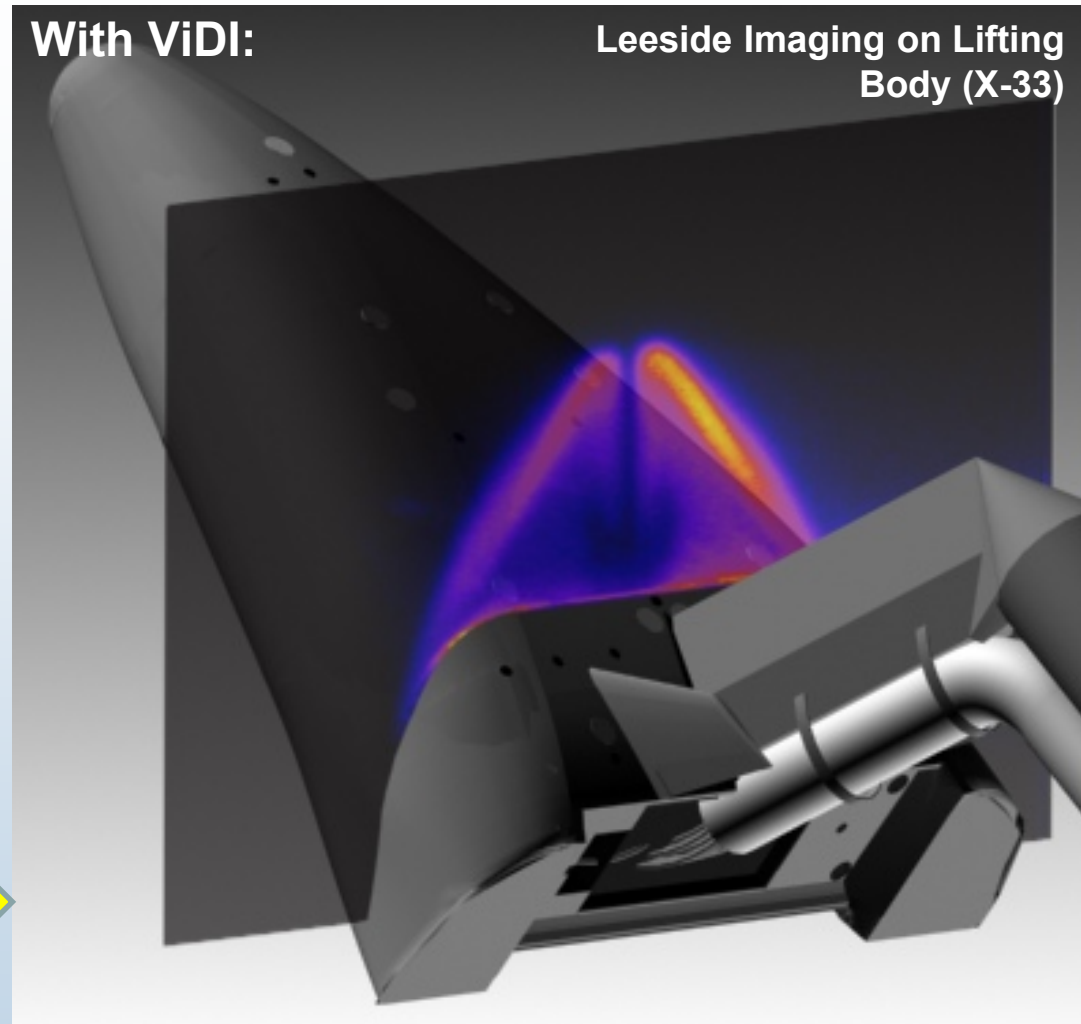


ViDI data visualization includes;

- 2-D Image de-warping
- 2-D Image averaging
- 2-D image false coloring
- 3-D Mapping to virtual model



With ViDI:

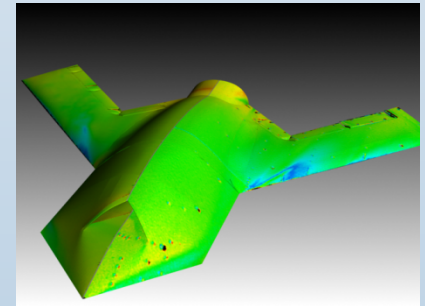
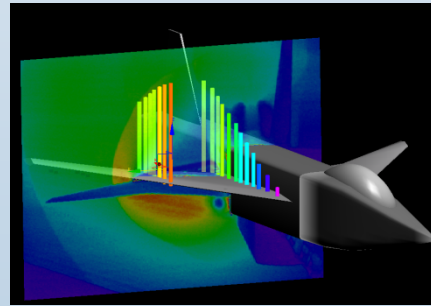
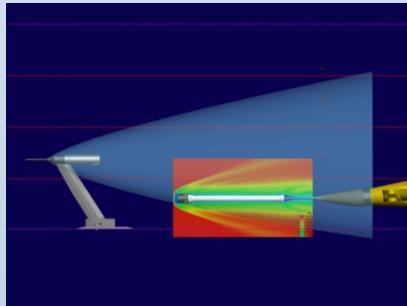


Planar Laser Induced Fluorescence (PLIF) data from
Dr. Paul Danehy, NASA LaRC, ASOMB

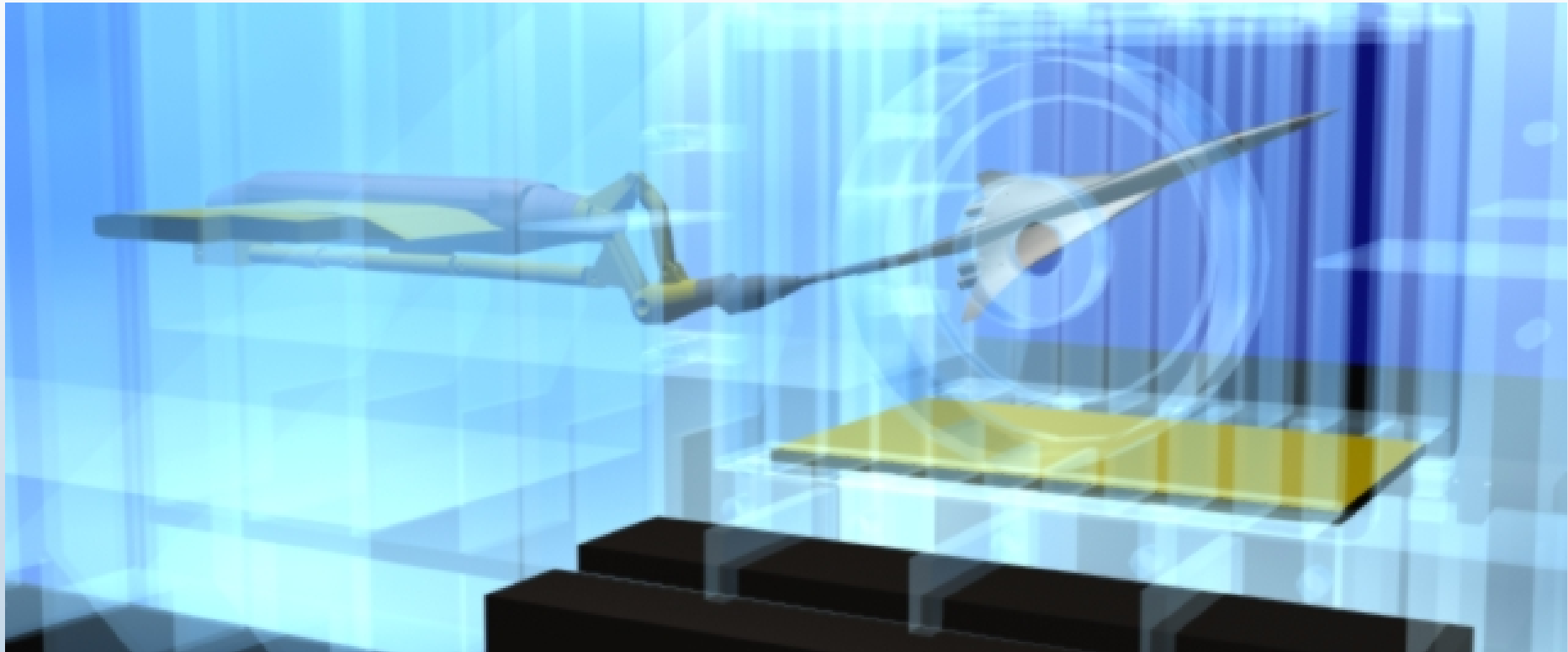
What is ViDI?

The *ViDI* methodology allows researchers to interact with an experiment in a realistic, physics based three-dimensional virtual environment.

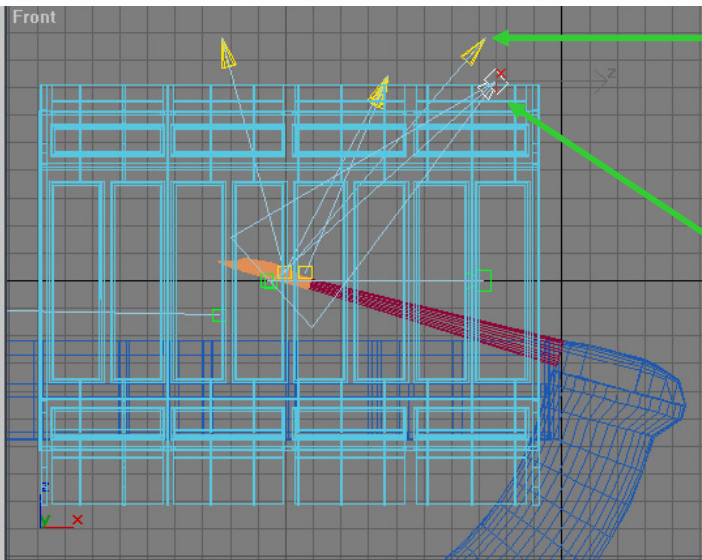
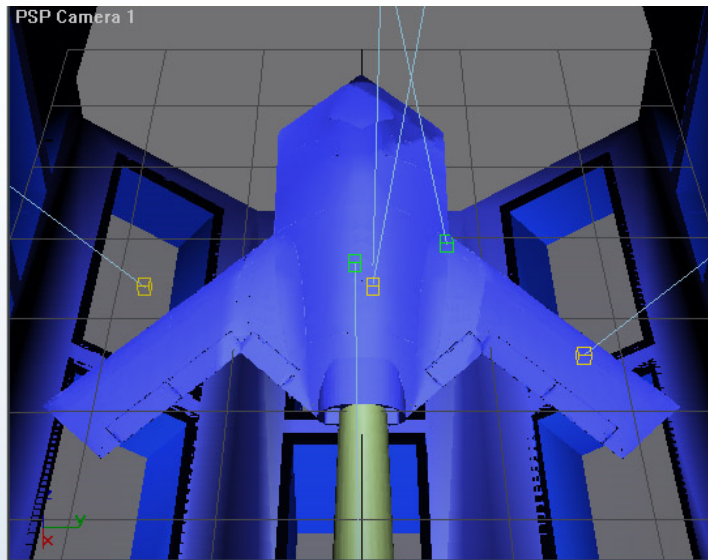
- **Before the Test** – Fully explore the test environment and determine limitations of the instrumentation to the environment,
- **During the Test** – Monitor megabytes of data from disparate sources in real-time to rapidly determine conformity of results to predictions as well as instrumentation performance,
- **After the Test** –
 - Use for advanced data visualization,
 - Determine causes of anomalous results – *experimental forensics!*



Pre-Test Planning



Pre-test Planning



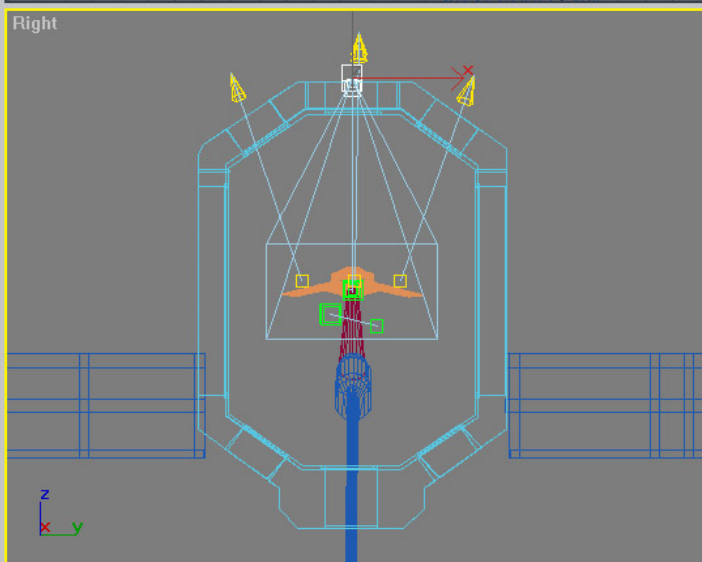
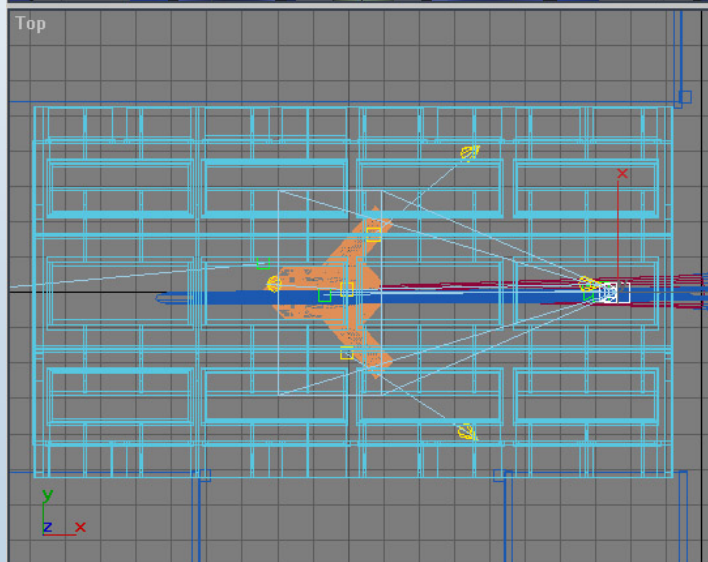
4 blue lights with
 30° full angle

Camera – no specific
lens specified yet

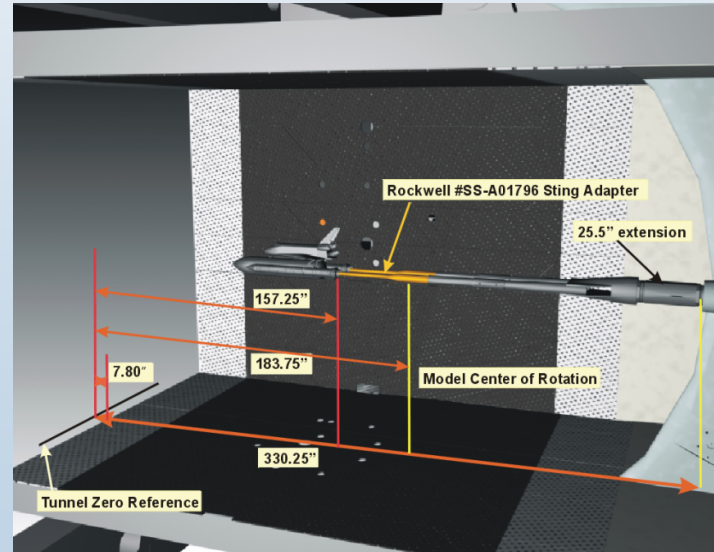
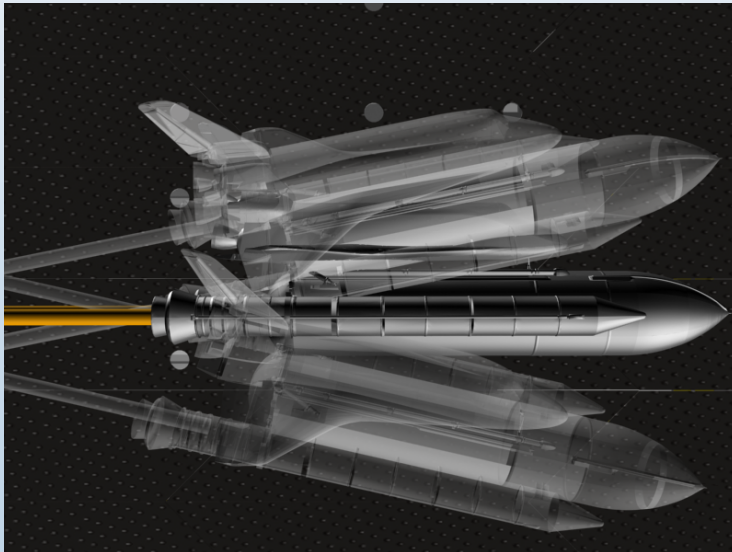
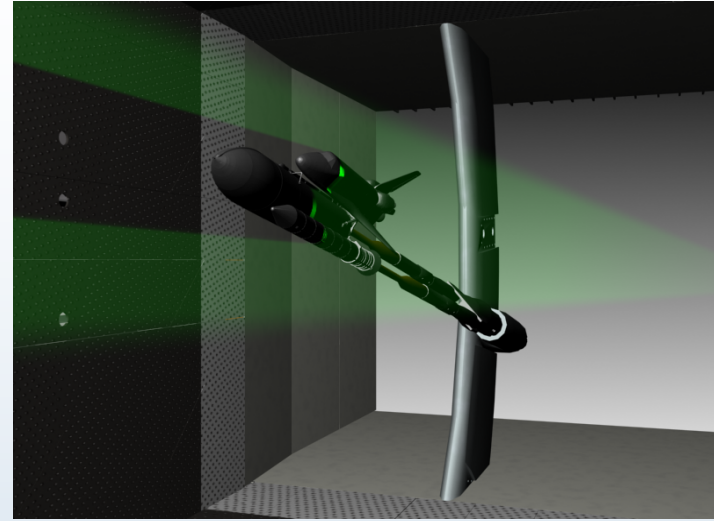
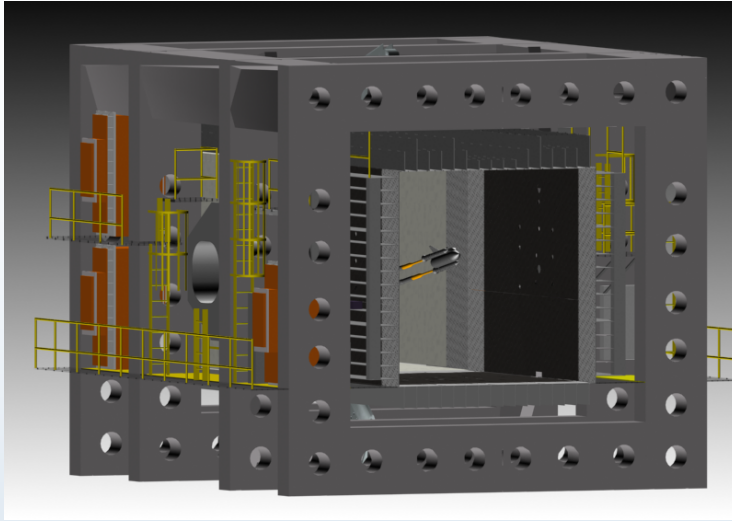
Model shown at

$15^\circ \alpha$

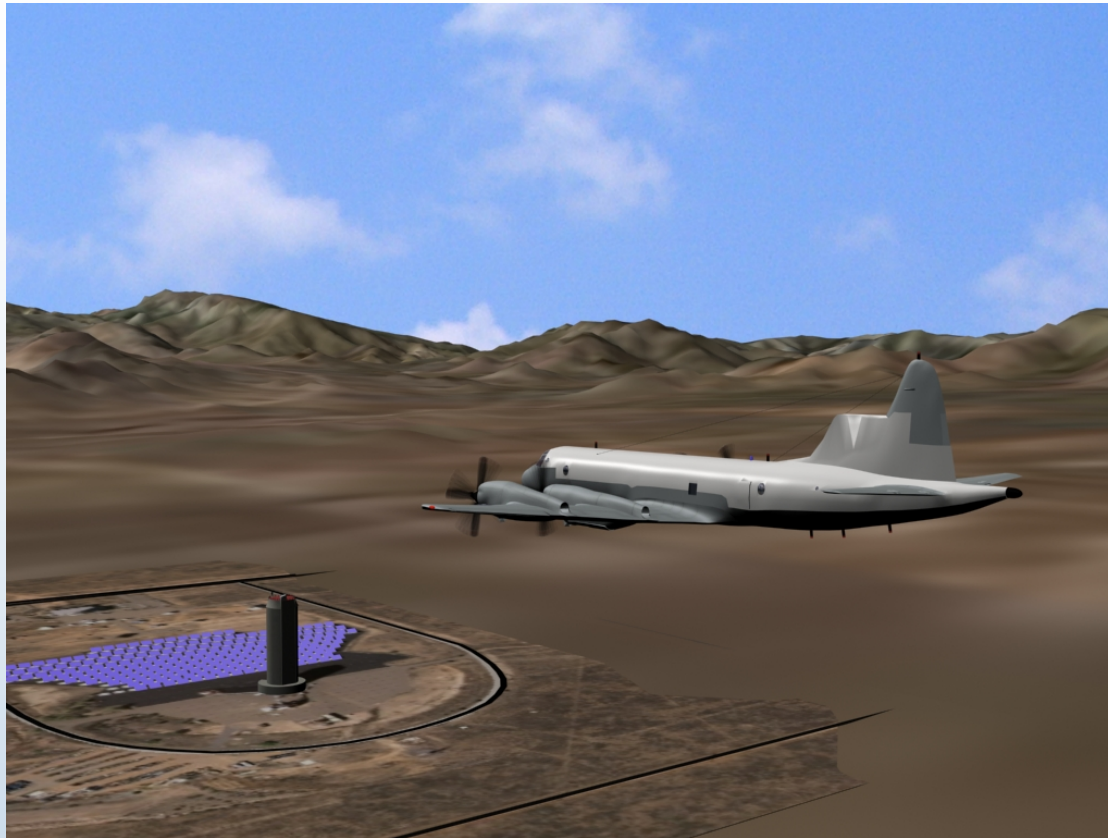
$0^\circ \beta$



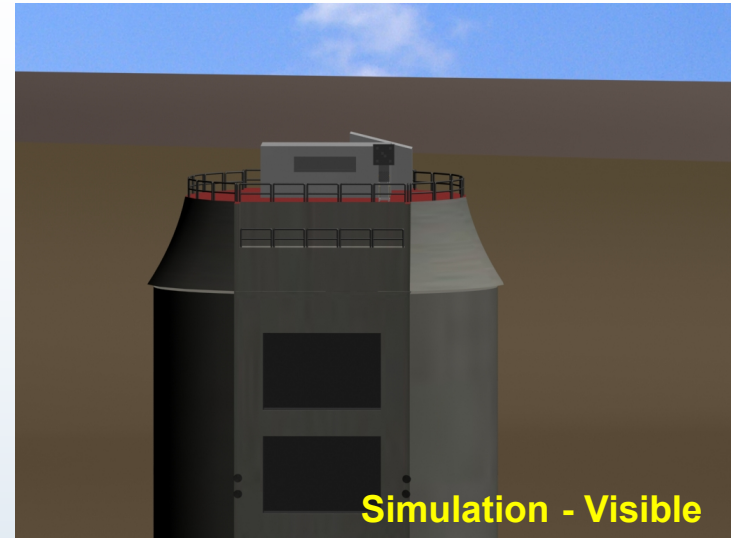
Shuttle RTF in AEDC 16T



HYTHIRM Solar Tower Test

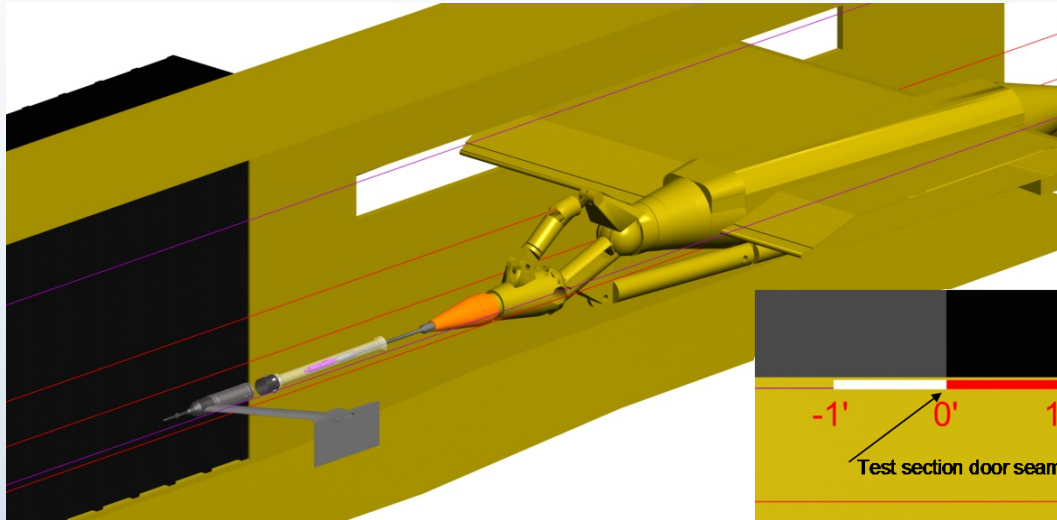


ViDI was used for planning tests for IR Sensor calibration in support of IR imaging of the Space Shuttle during reentry at the Sandia National Solar Tower Test Facility.

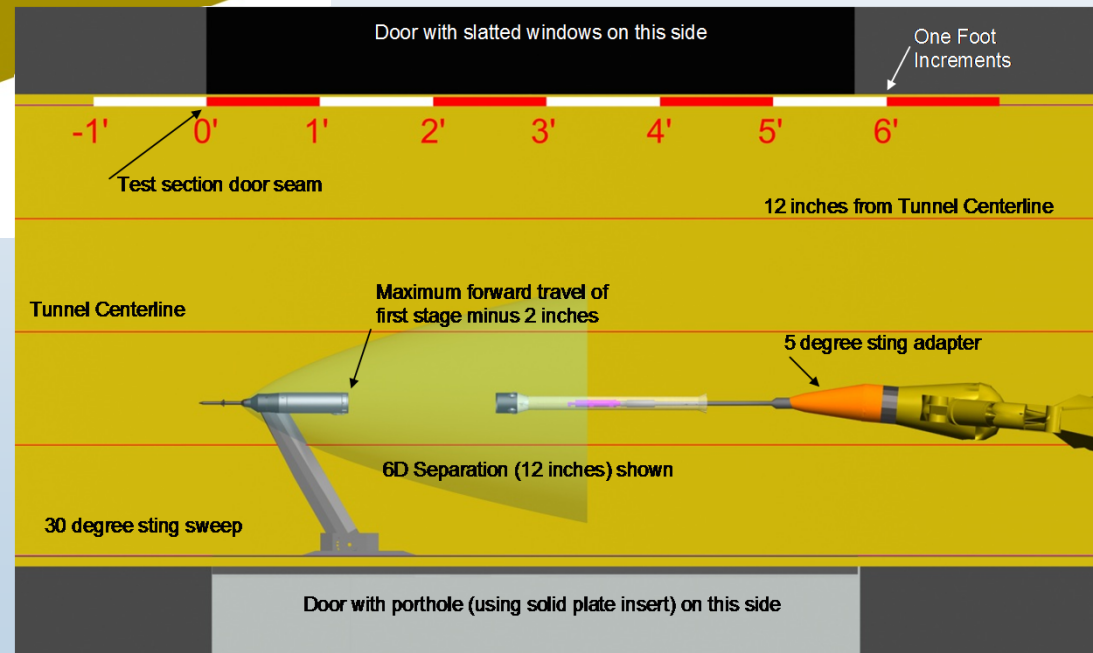


Ares Stage Separation in LaRC UPWT

Task: Determine optimal setup in order to maximize differences in the angles of angle of attack and separation distance of the two stages of the booster rocket.



Cut away view of the NASA LaRC Unitary Plan Wind Tunnel

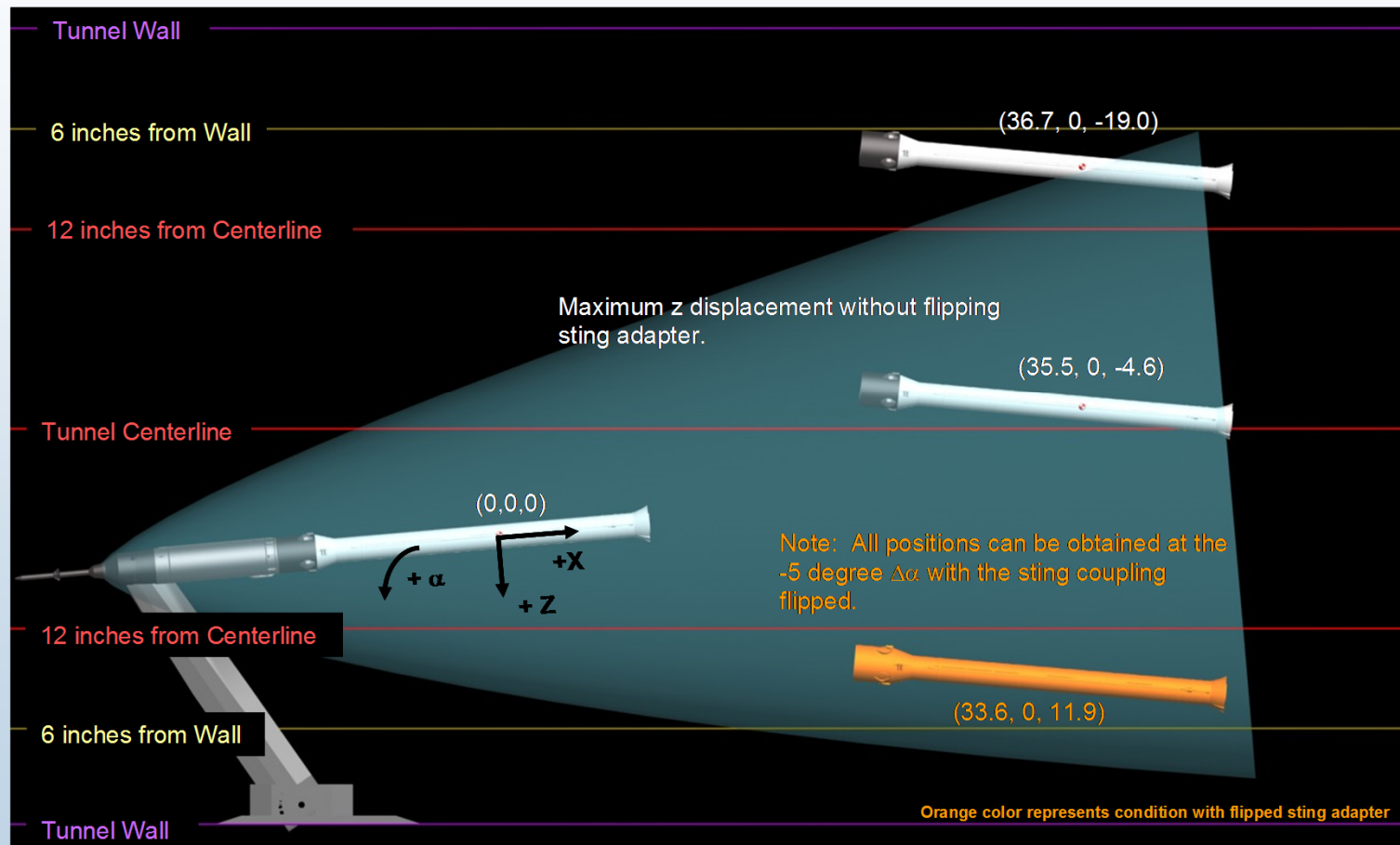


Ares Stage Separation in LaRC UPWT

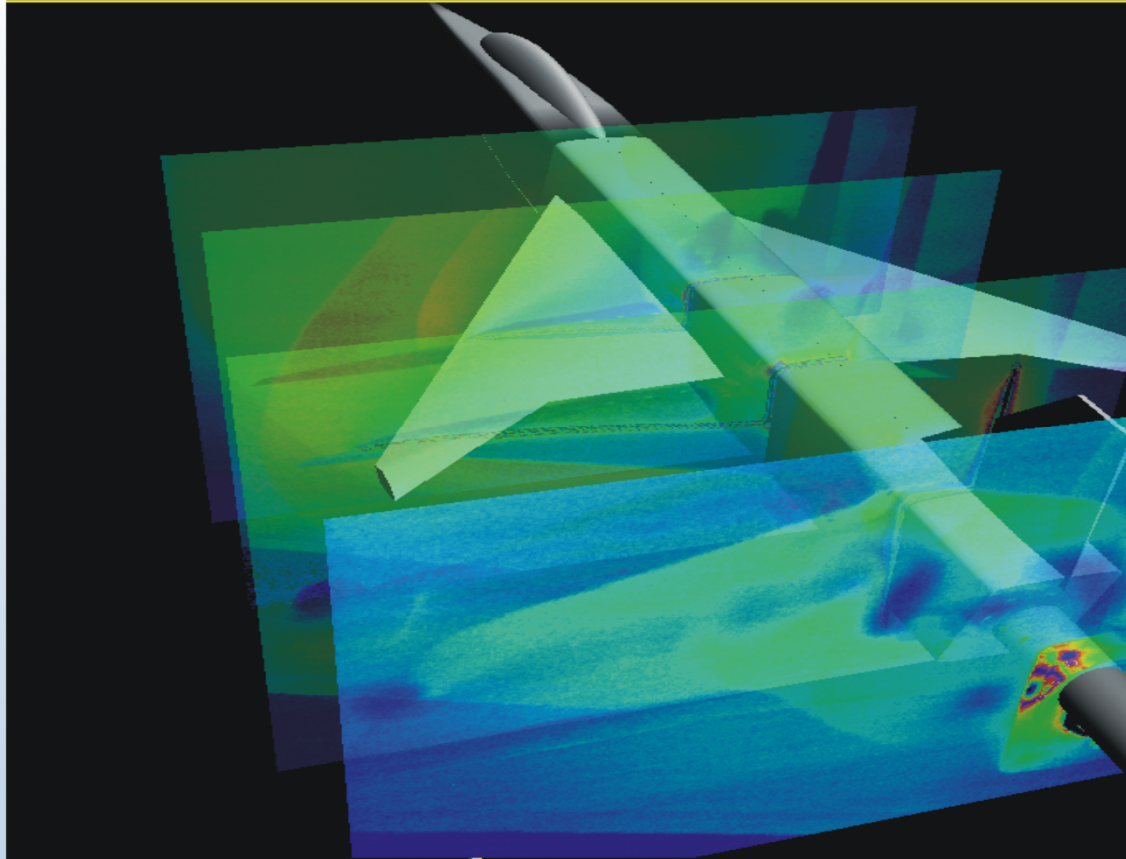
Rendering represents coordinates of the maximum displacements possible based on the wind tunnel strut supporting the first stage at a given angle of attack.

Second Stage $\alpha = 5$ deg, $\Delta\alpha = -10$ deg

All co-ordinates represent the first stage CG, are in inches, and are in the MODEL reference system.



Real-Time Data Visualization



Real Time Data Visualization

LiveView3D is capable of accepting video imagery and displaying it in real time in an interactive virtual environment. Existing flow visualization techniques can be greatly enhanced by placing the data *in-situ*. Data is also recorded for later playback in the interactive environment, or creation of movie files for distribution.

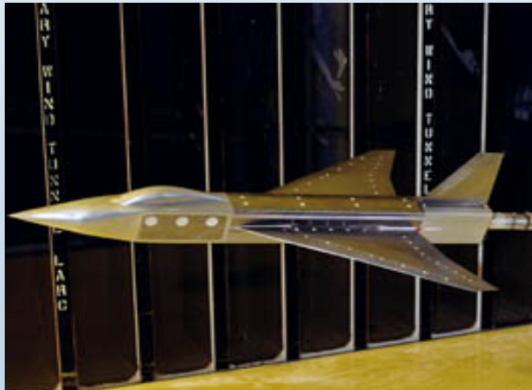
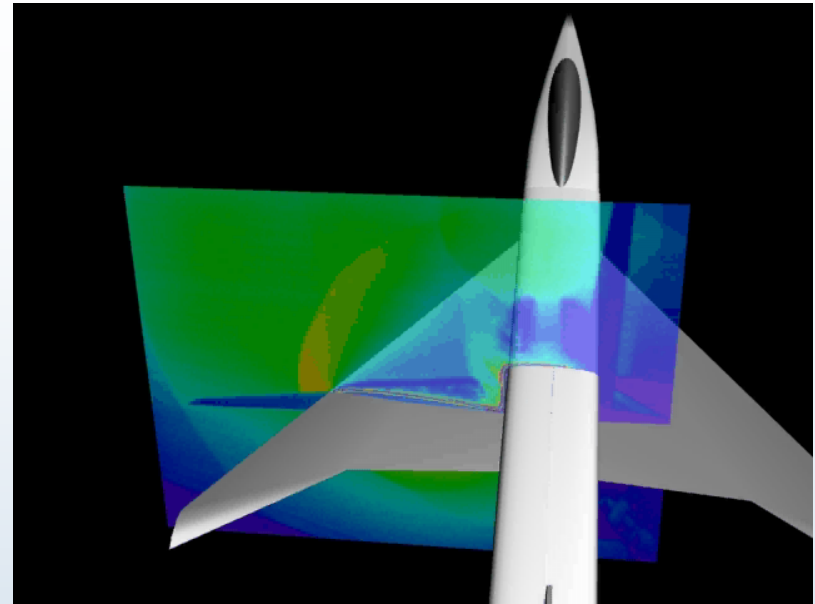
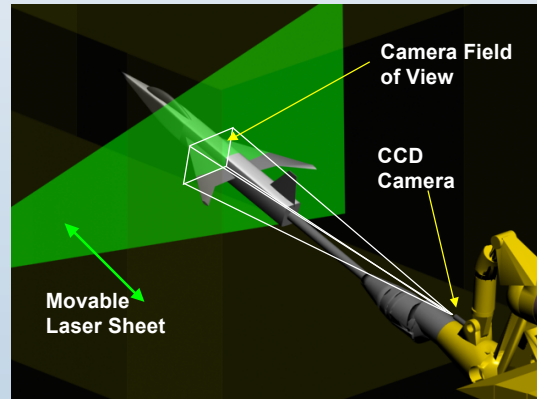
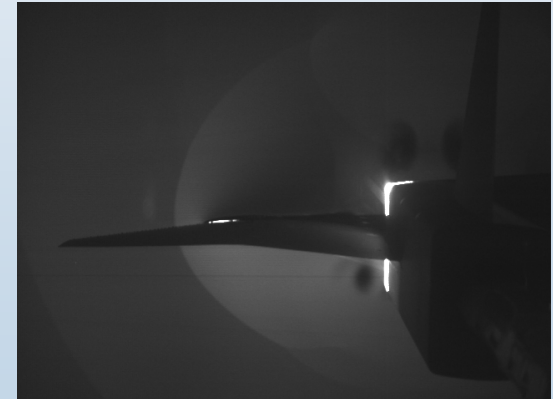


Photo of test configuration in wind tunnel



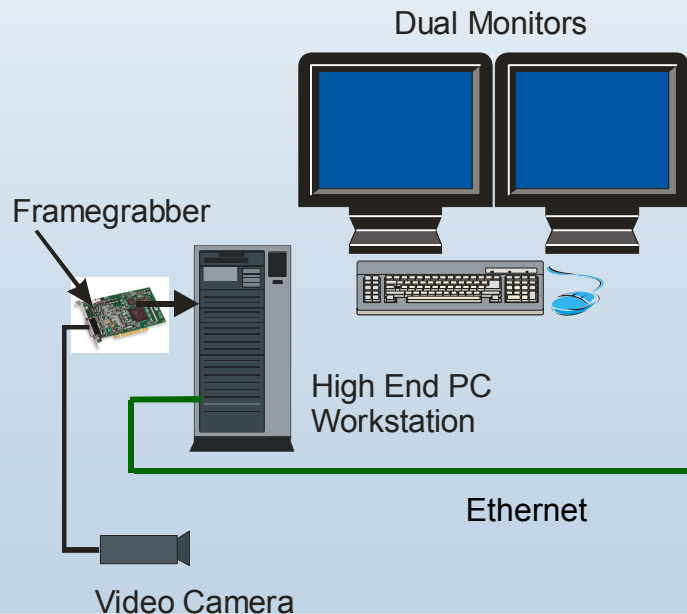
Typical laser light sheet flow visualization



Video display without ViDI

Real Time Data Visualization

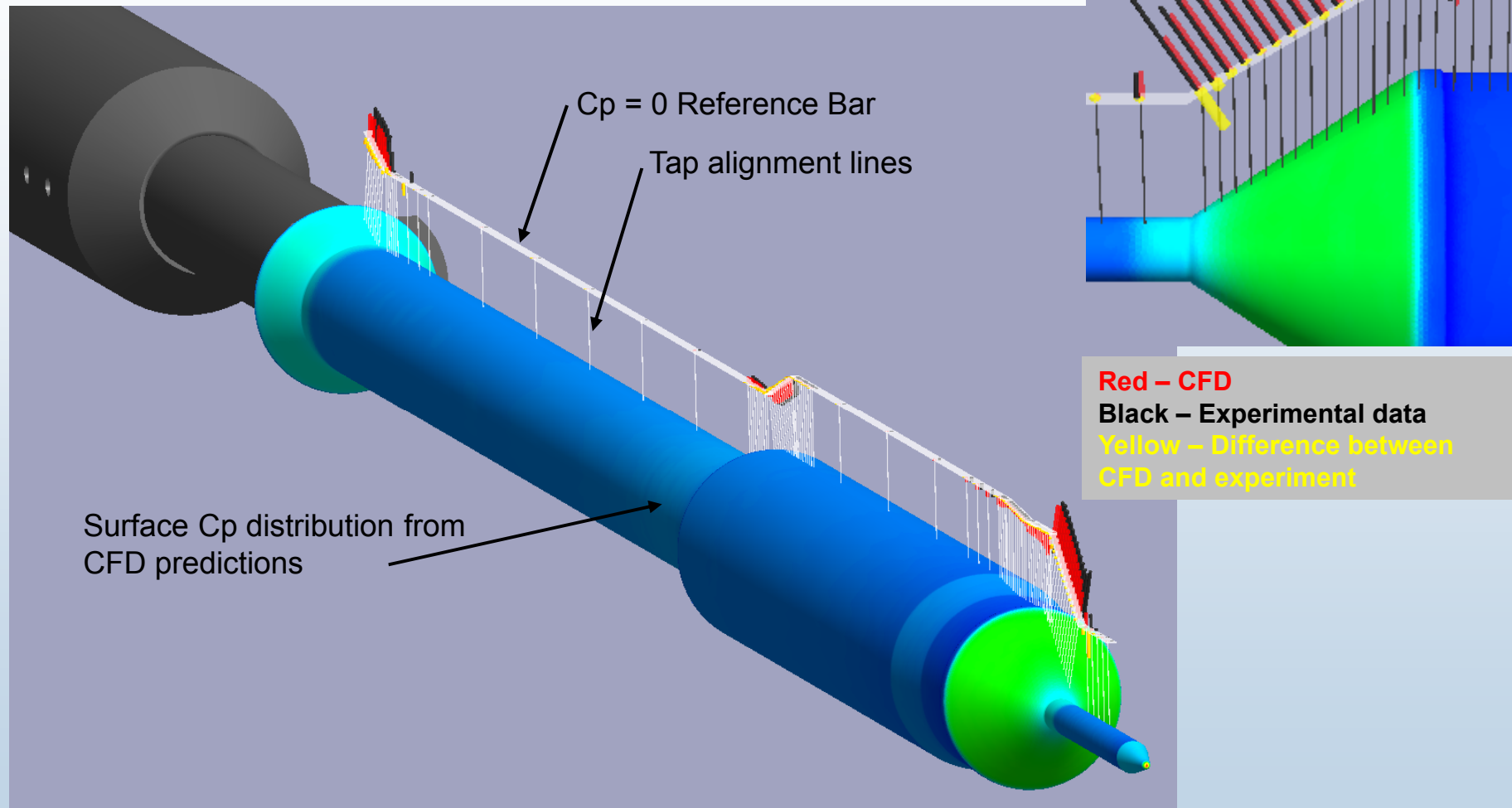
LiveView3D was expanded to incorporate data from the wind tunnel data acquisition system (DAS) via Ethernet. Current system is capable of accepting up to 500 channels of data from the DAS (DAS limitation).



Tunnel Data Acquisition System (DAS)

Real Time Data Visualization

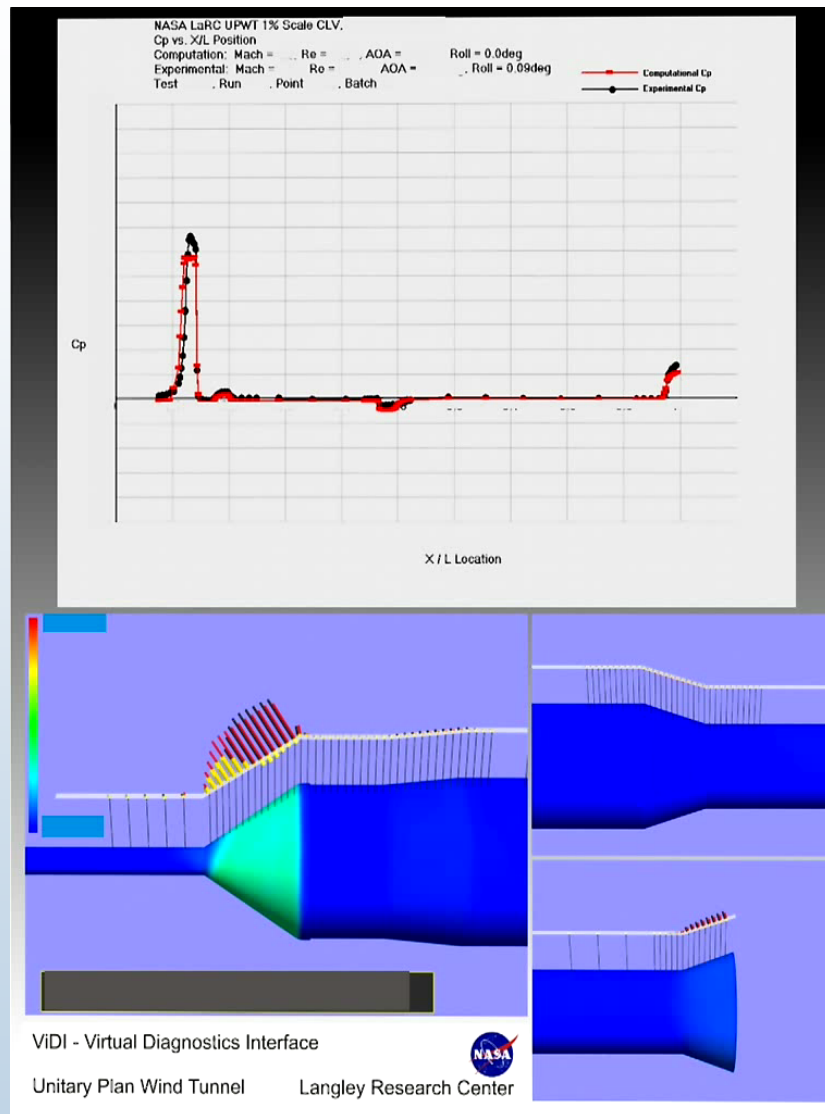
Surface pressure taps



Real Time Data Visualization

Final output –

The 2-D plots and 3-D renderings are combined into a single image depicting the Cp data and predictions for the selected pressure taps.



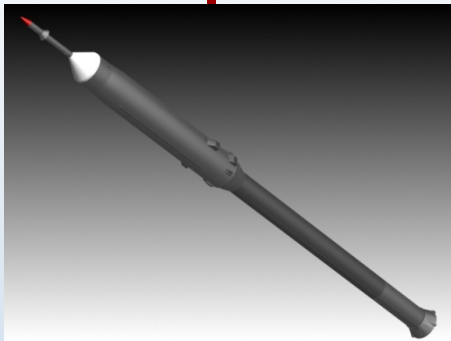
Value to researchers:

- Easy to pick out one bad data channel from hundreds
- Changes in experiment can be made based on data comparison, unexpected results
- Combining disparate data sources allows researchers to make physics-based “cause and effect” connections.

Real Time Data Visualization Setup

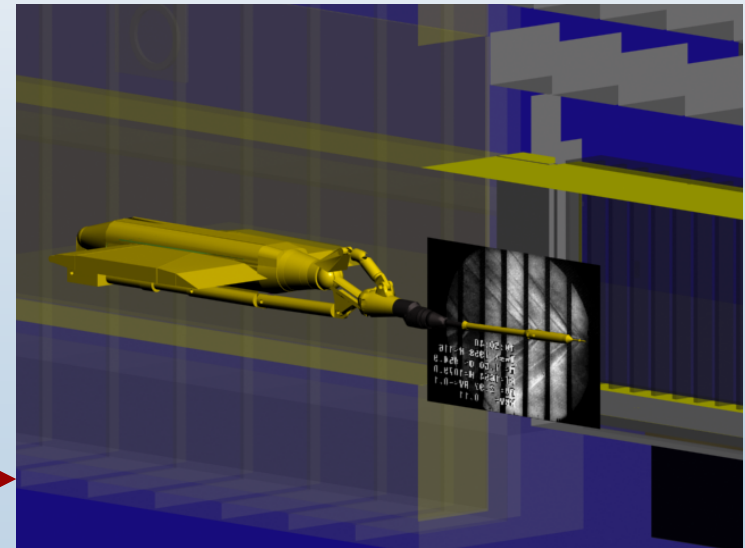
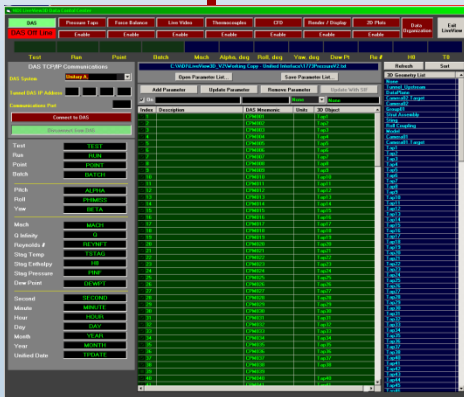


Pre-existing CAD model of the facility – 3 weeks to create (one – time job)

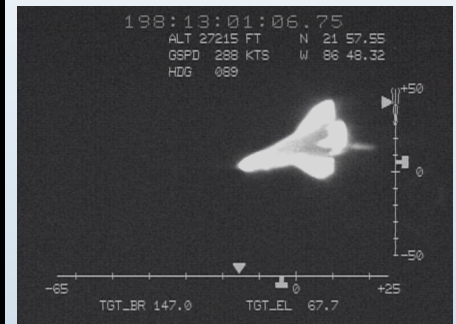
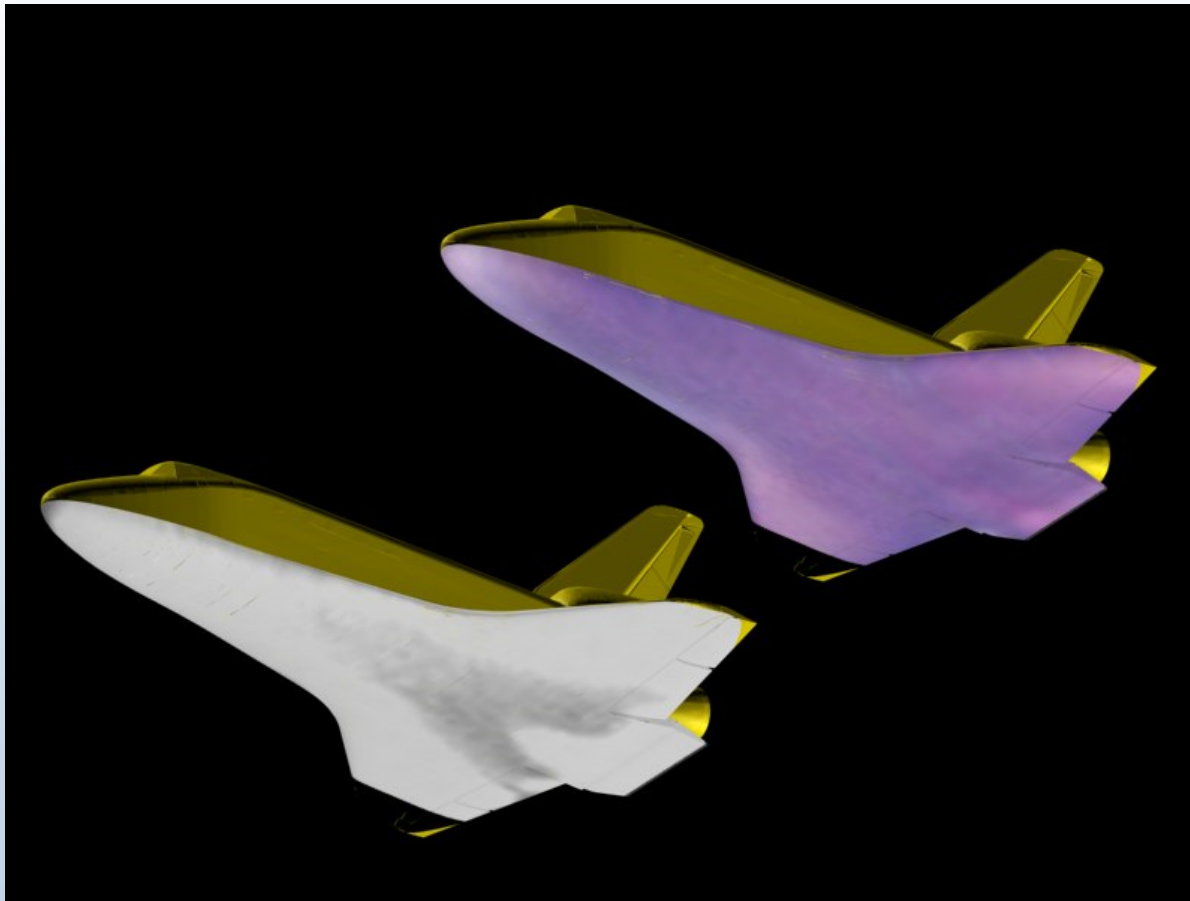


Import IGES CAD model from designer, clean up translated geometry, merge and scale with facility – 1 hour

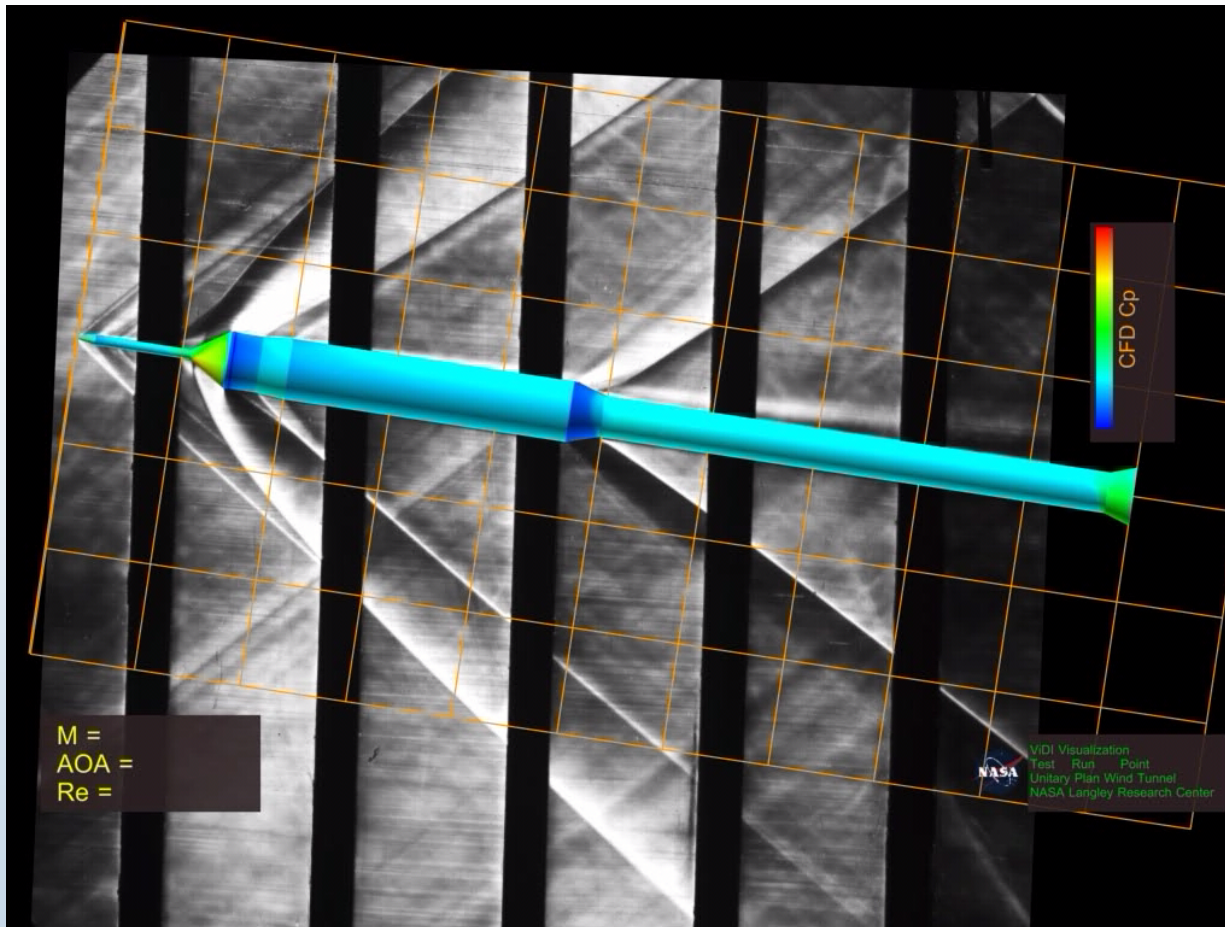
Configure LiveView3D to communicate desired DAS parameters – 3 hours



Post-test Data Visualization



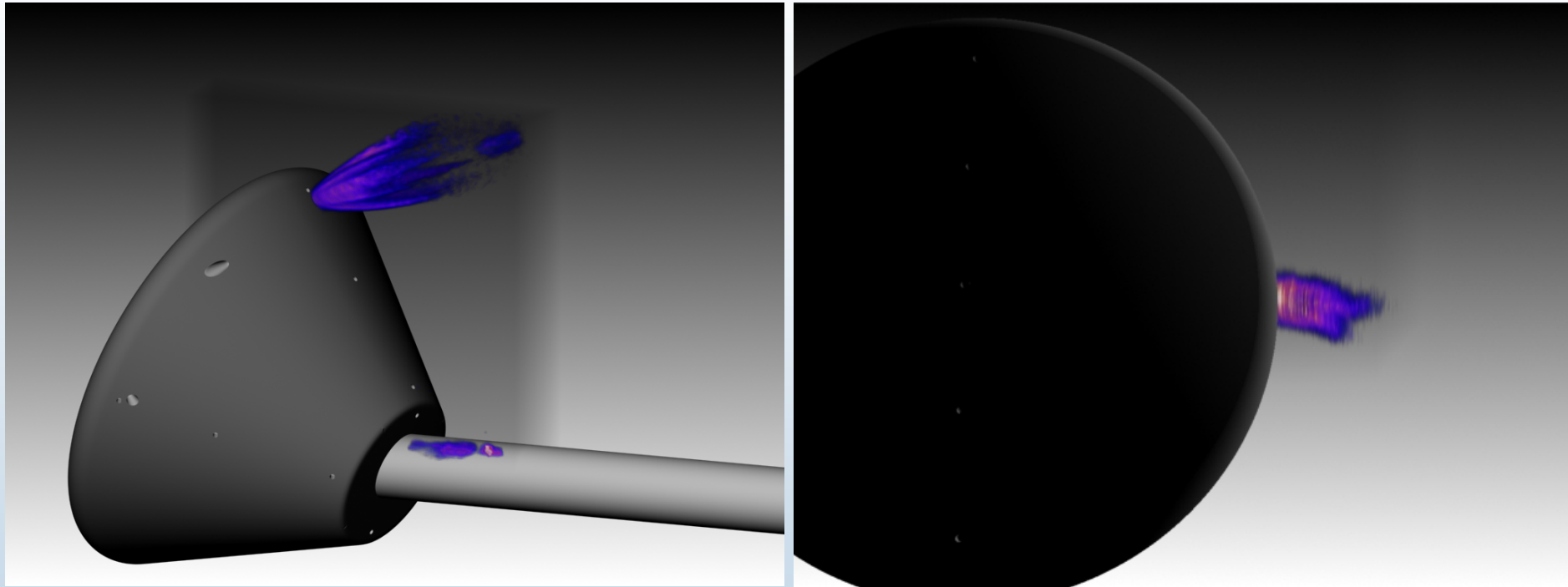
Data Analysis



The schlieren image is mapped into the virtual environment along with the CFD prediction of flowfield density. The CFD derived Cp distribution is mapped to the surface of the booster rocket.

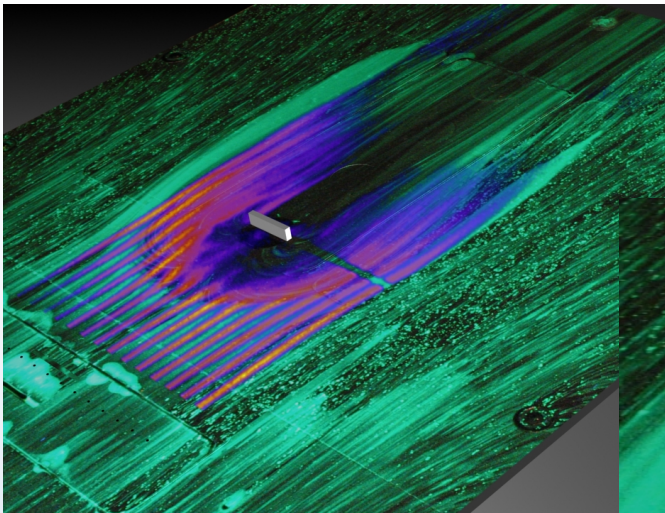
PLIF Volume Renderings

Hundreds of individual “slices” of the flow were stacked together to create a “volume-like” three-dimensional depiction of the thruster jet using PLIF data.

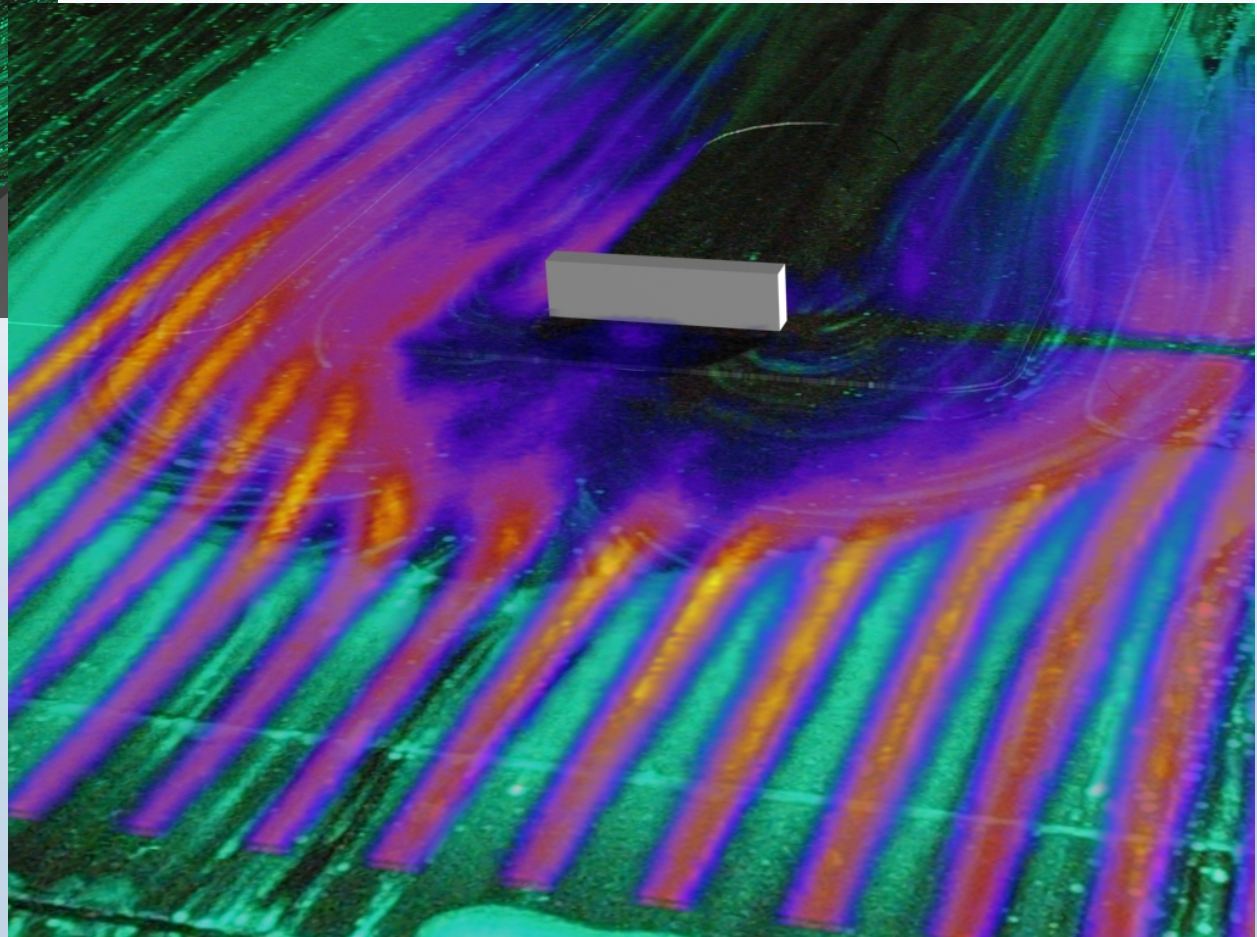


PLIF Data Visualization

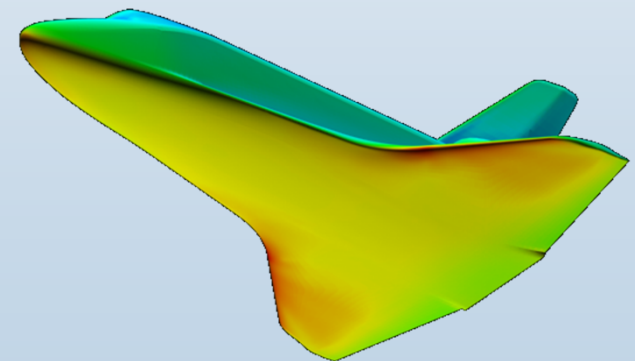
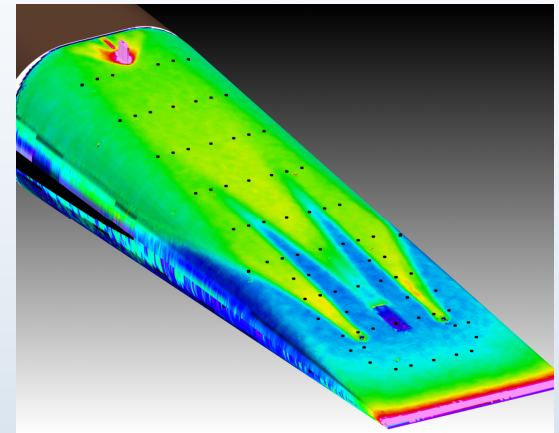
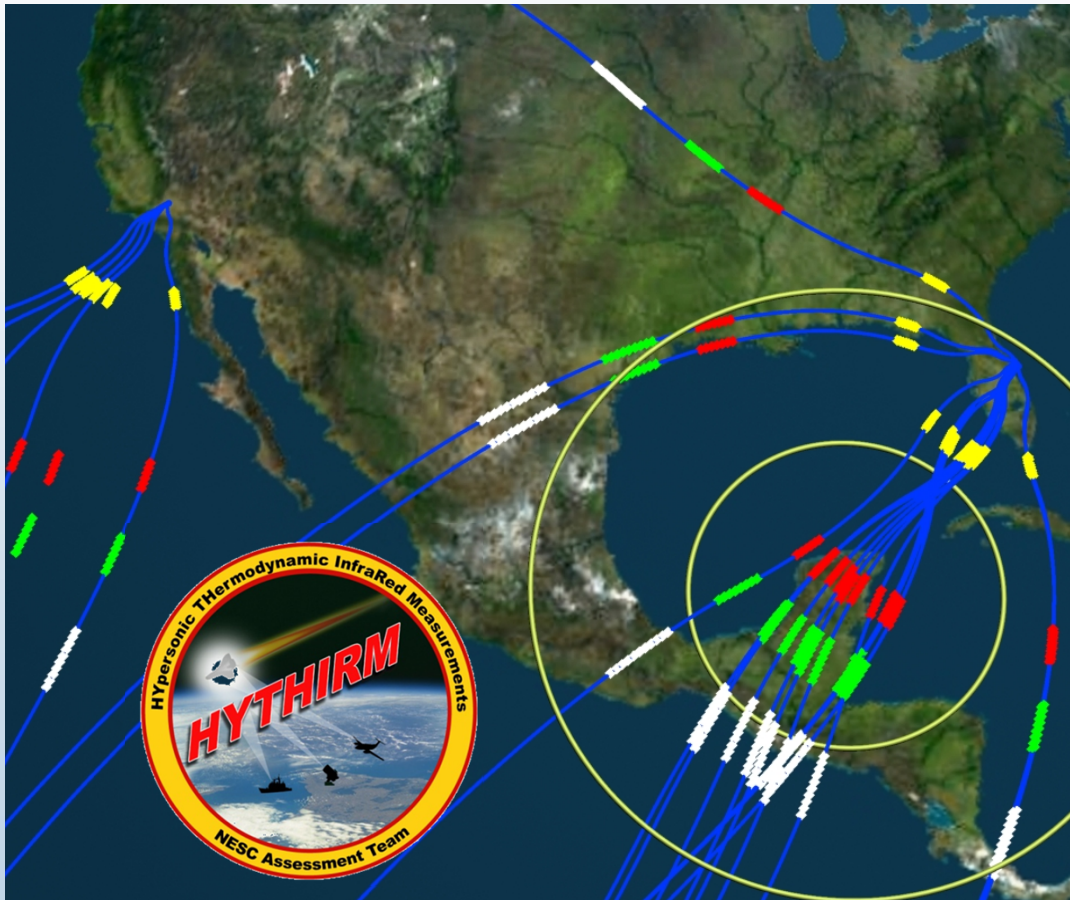
Hypersonic boundary layer trip wind tunnel experiment on flat wedge model using on surface oil flow and off surface PLIF visualizations.



Green data is the oil flow image mapped to the surface, the rainbow streaks are off body PLIF data superimposed to scale in the virtual environment.



Hypersonic Thermodynamic Infrared Measurements (HYTHIRM)



Goal – Use a three-dimensional virtual environment to simulate the performance of imaging assets for observing the thermal characteristics of boundary layer transition on the Space Shuttle during re-entry.

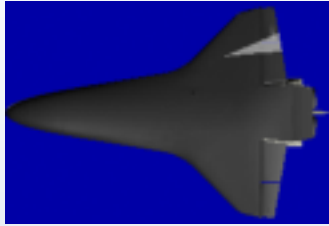
The simulation will;

- Optimize the deployment of land, sea or airborne imaging assets.
- Ensure adequate spatial resolution of infrared imagery of the orbiter underside.
- Provide rapid turn-around times to encompass dynamic challenges such as wave-offs, alternate landing sites, restricted airspace and weather conditions.

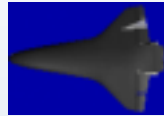
HYTHIRM - Shuttle

Information quality as a function of imaging system spatial resolution

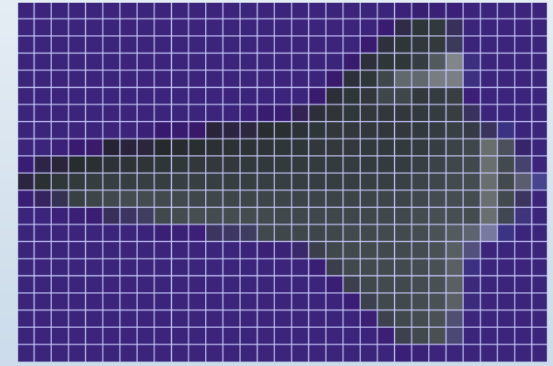
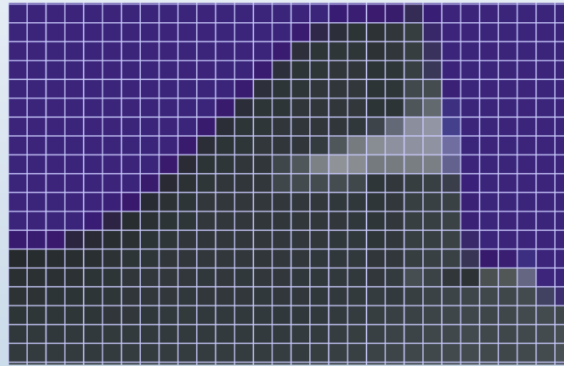
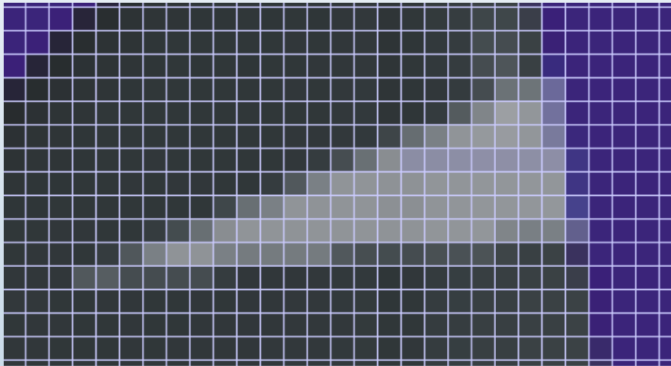
12 inches per pixel



24 inches per pixel

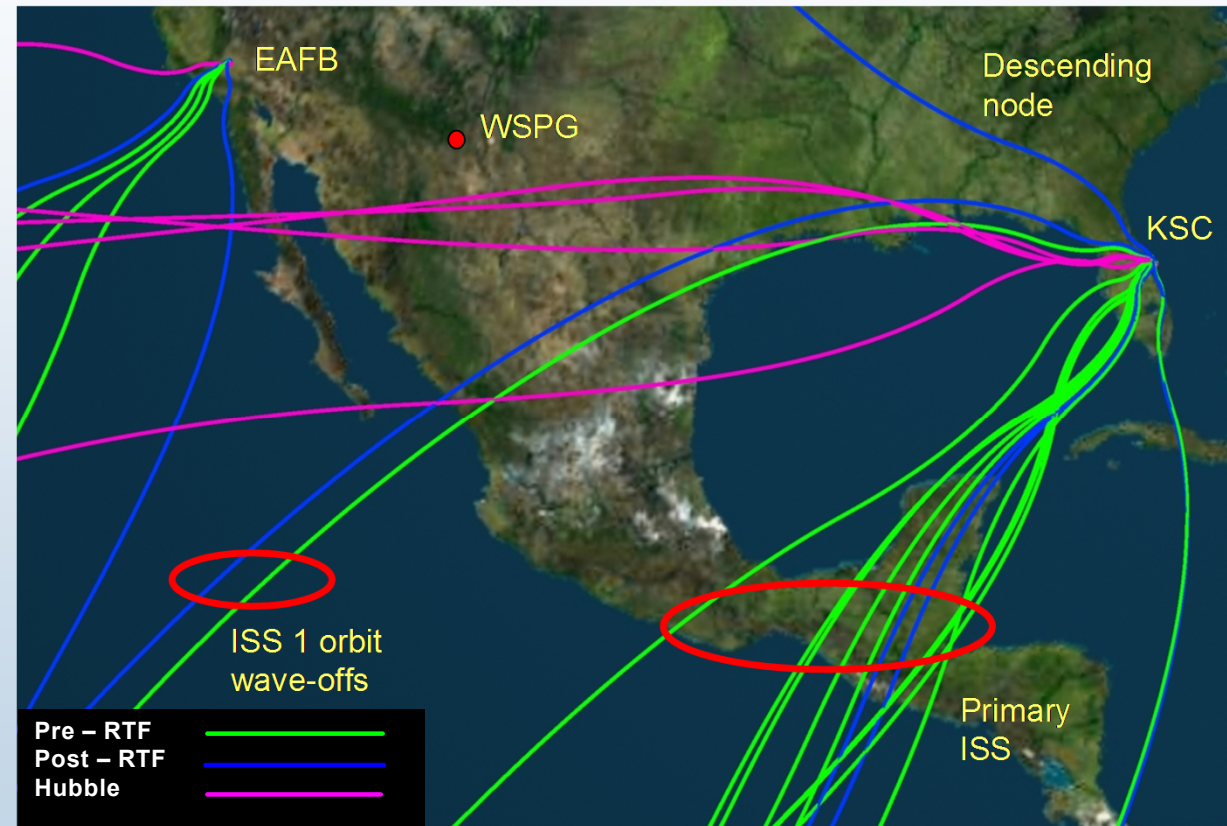


48 inches per pixel



HYTHIRM - Shuttle

Space Shuttle Reentry Trajectories from best estimated trajectory data for all missions returning from the International Space Station, ISS, (51.6 deg inclination) and the Hubble Space Telescope (28.5 deg inclination).



Constraints

Shuttle ground track

- Launch delays
- On-orbit damage disposition
- Mission extensions
- Wave-off protection

Imaging

- Sun exclusion
- Target acq. & tracking (day/night)
- Image exposure/filter
- Resolution/slant range
- Crew duty and aircraft loiter time
- Shuttle orientation
- Air space restrictions
- Non US deployment

HYTHIRM - Shuttle

NASA WB-57 WAVE aircraft, NIR

FOV = 0.22 deg, 640 x 512 Pixels, Alt. 45K ft, 163.4 inch focal length

Orbiter Flight Parameters

Trajectory time 1309.44 sec

M = 15.037

Alpha = 40.268 deg

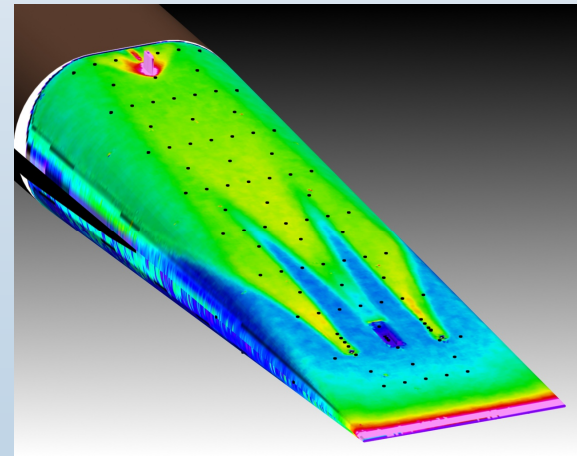
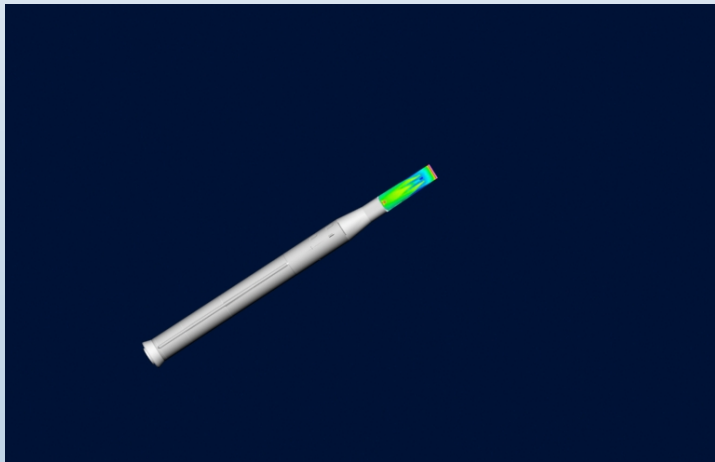
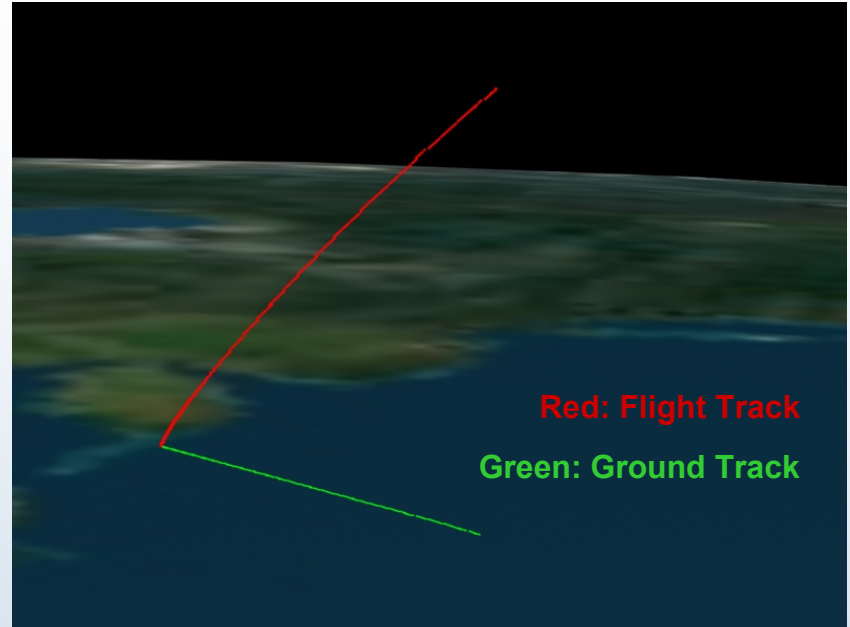
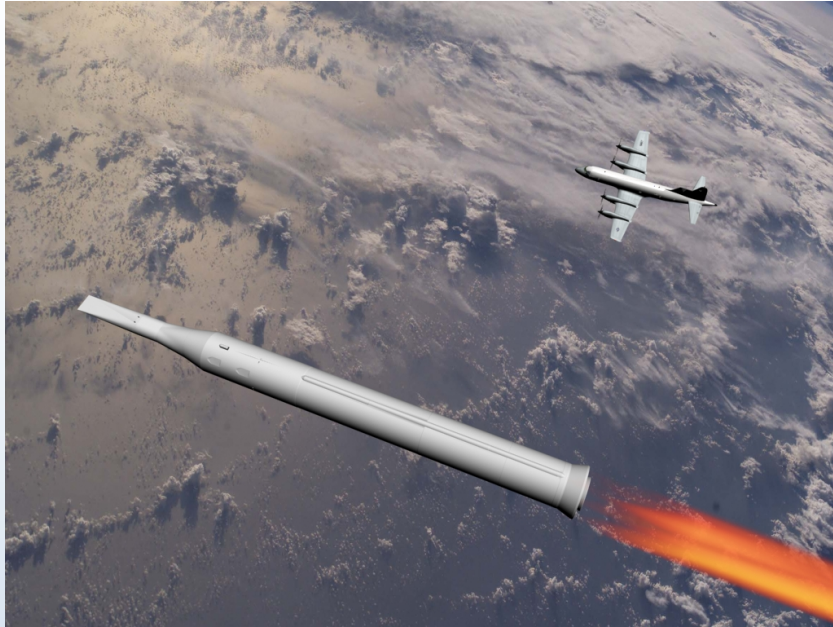
Roll = -65.614 deg

Alt = 188323.2 ft

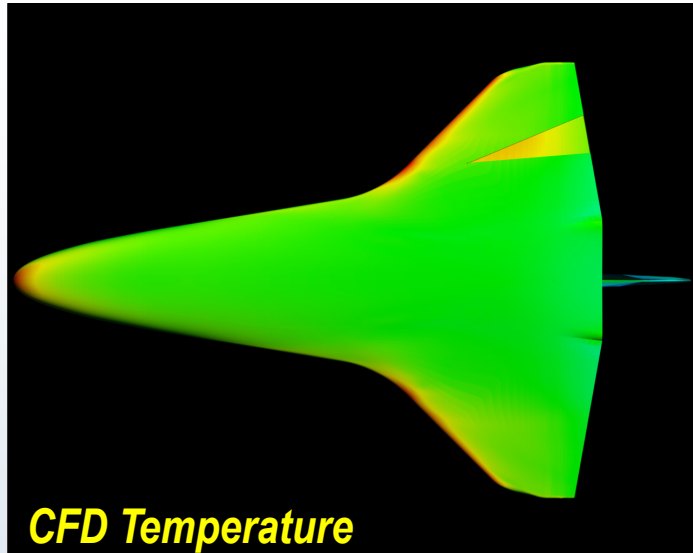


8.25 inches per pixel

HYTHIRM - HYBOLT

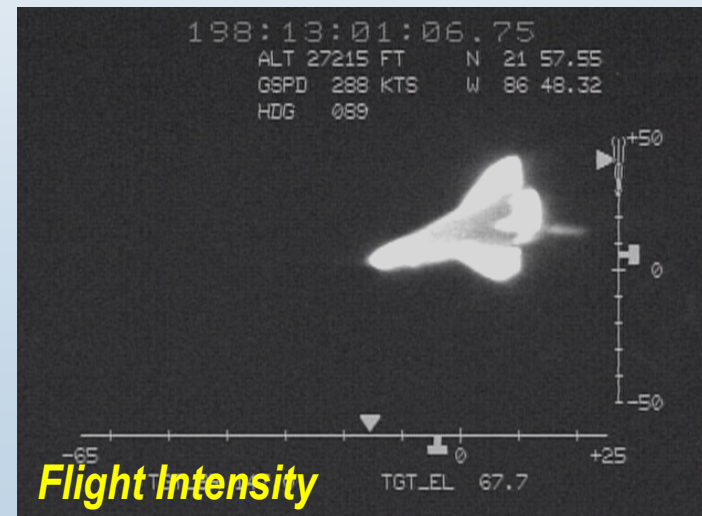


HYTHIRM - Radiance



The goal is to transform the CFD derived temperature information into a prediction of the sensor response to the received irradiance within a given band of wavelengths as a function of wavelength, temperature, geometry and detector positioning.

Work in Progress



Where is ViDI Going?

Expand Current Capabilities;

- Expand interoperability with computational methods
- Update software to current industry standards (Microsoft Visual Studio based interfaces),
- Add requested features, remote computing ability
- Expand library of tools (added CAD capabilities, computer languages, etc.)

Physics Based Modeling and Simulation

- Model sensor response based on virtual environment “initial conditions” for a variety of sensors

HYTHIRM

- Expand capabilities and apply to wide variety of experimental and operational hypersonic vehicles.