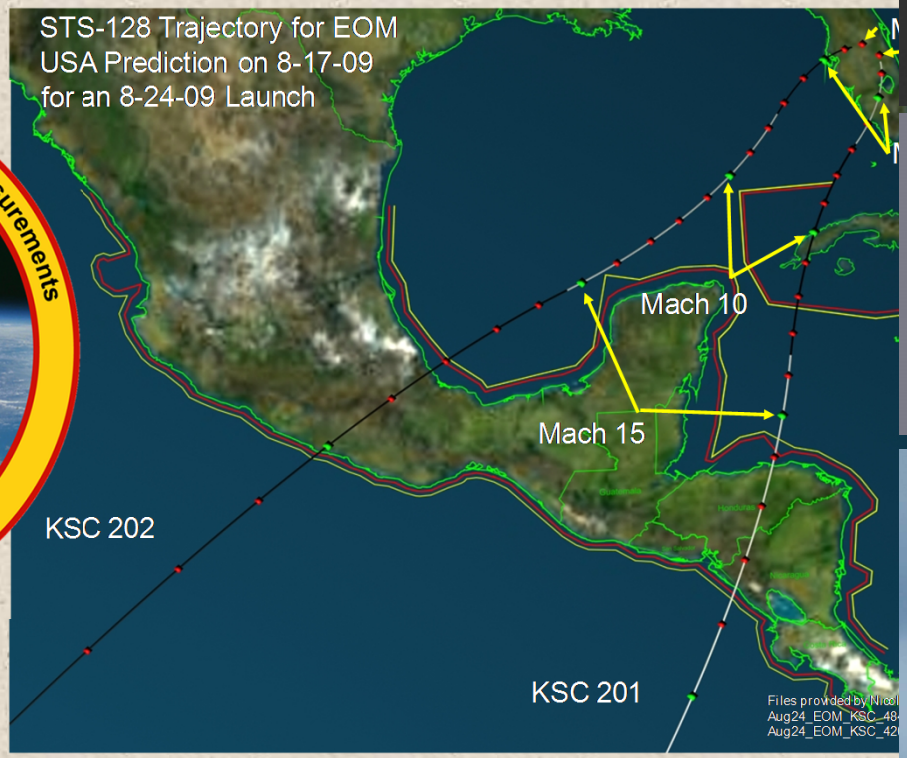
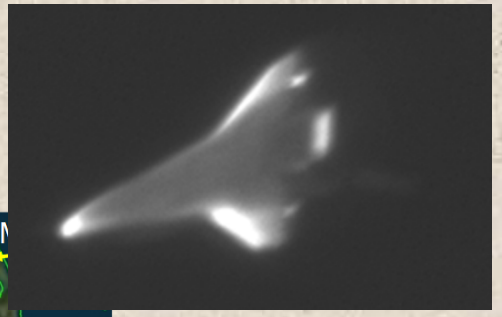
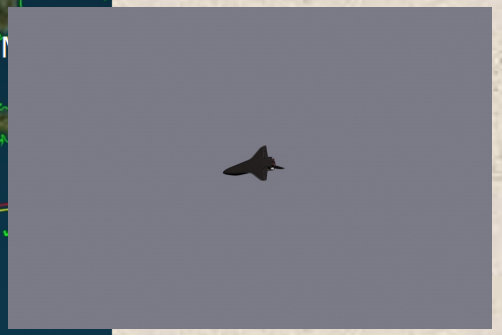
Mission Deployment Planning Overview

Richard J. Schwartz
ATK Space Division
(757) 864-4597
Richard.J.Schwartz@NASA.gov











Introduction

Objectives

Pre-deployment Phase

- Imagine asset database
- Radiance modeling for IR sensor response
- Spatial Resolution modeling
- Geometric considerations
- Point Spread Function
- Unified simulation environment development
- Utilizing EntrySim3D
- Mission Simulations

Deployment Phase

- Mission Execution
- Post -Flight debriefing

Objectives

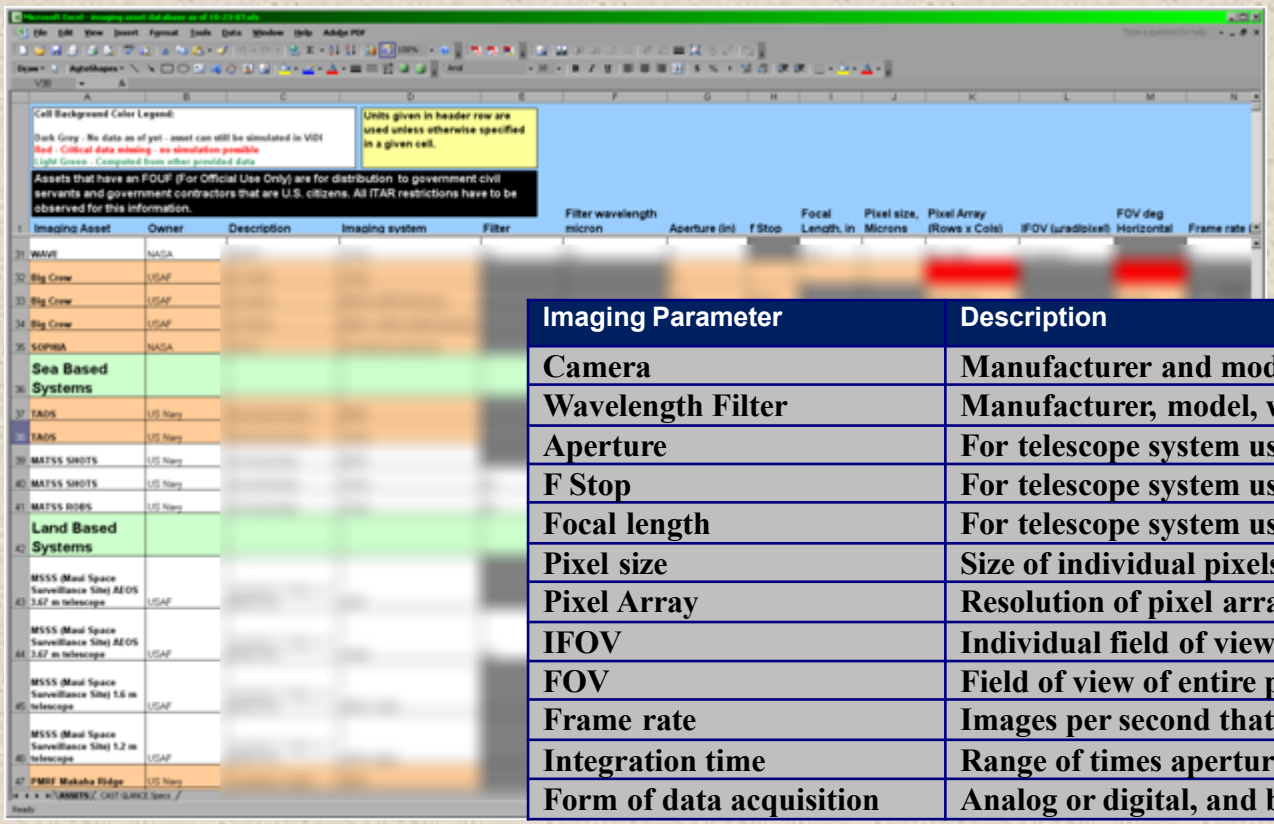
Mission: Obtain infrared imagery of sufficient thermal and spatial resolution to obtain global thermal measurements on the underside of the Space Shuttle during reentry.

Pre-Deployment Phase: Develop mission planning tools, deployment methodologies and partake in simulation training to maximize the chance of a successful data collect from each deployed imaging asset.

Deployment Phase: Utilize mission planning tools to make timely, rational decisions and provide effective communications to the image asset owners in the field. Take lessons learned to enhance future mission deployments.

Pre-Deployment Phase

Pre-Mission Planning



Database of airborne, sea And land based imaging assets

Imaging Parameter	Description
Camera	Manufacturer and model
Wavelength Filter	Manufacturer, model, wavelength range
Aperture	For telescope system used
F Stop	For telescope system used
Focal length	For telescope system used
Pixel size	Size of individual pixels
Pixel Array	Resolution of pixel array
IFOV	Individual field of view of a single pixel
FOV	Field of view of entire pixel array
Frame rate	Images per second that can be acquired
Integration time	Range of times aperture can be open
Form of data acquisition	Analog or digital, and bits per pixel if digital

Aircraft Parameter	Description
Ceiling	Maximum altitude for imaging mission
Endurance	Time aircraft can spend aloft
Cruise speed	Airspeed for transit to target area
Range	Maximum distance able to travel (no wind consideration)

Pre-Mission Planning

- Careful consideration of several criteria are required in order to ensure mission success. These include:

1. Vehicle IR radiance
2. Obtainable spatial resolution
3. Degradation due to diffraction, imperfect optics and atmosphere
4. Understanding of mission operational environment

- Integration of predictive tools for radiance and spatial modeling into a unified mission planning tool, EntrySim3D.
- EntrySim3D is a product of ViDI, Virtual Diagnostics Interface, a technology for simulation and visualization in an interactive three-dimensional virtual environment.

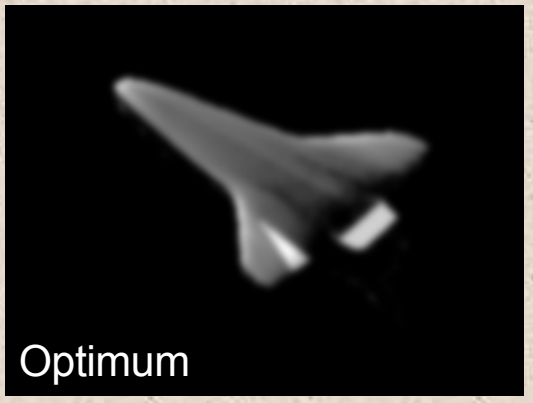
Radiance Modeling

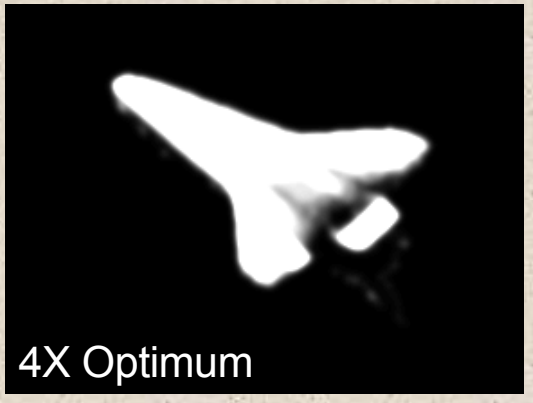
Radiance modeling predicts the number of photons (energy) reaching each pixel of a sensor.

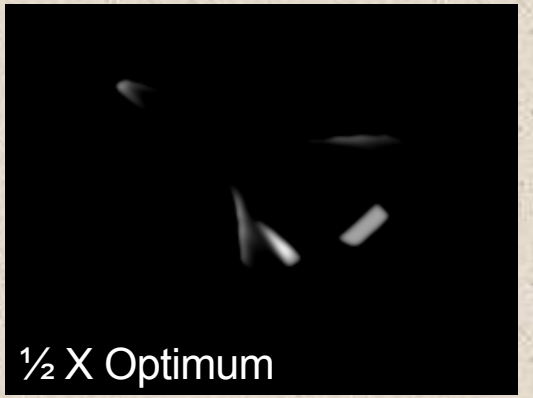
Used to determine:

- Camera exposure
- Camera/framegrabber gain
- Neutral density filter requirements

Radiance modeling also plays an important role in determining when an object emerges from the “IR horizon” and becomes clearly visible.







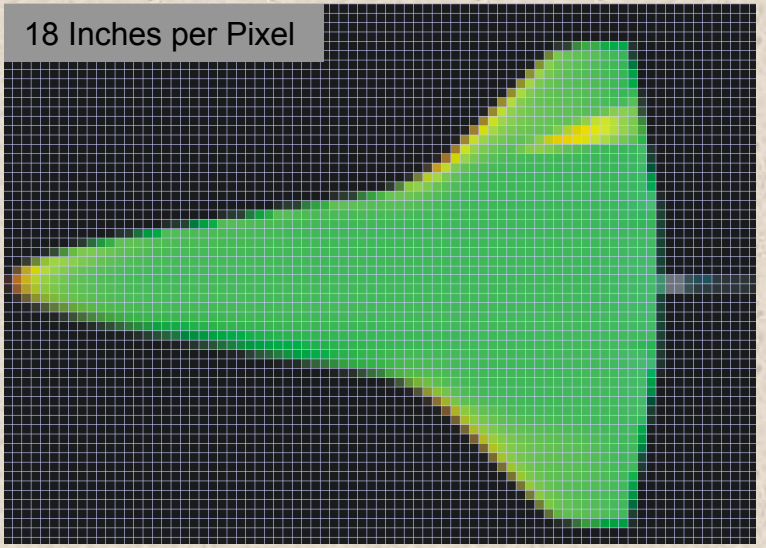
Spatial Modeling - Resolution

Spatial resolution is a function of:

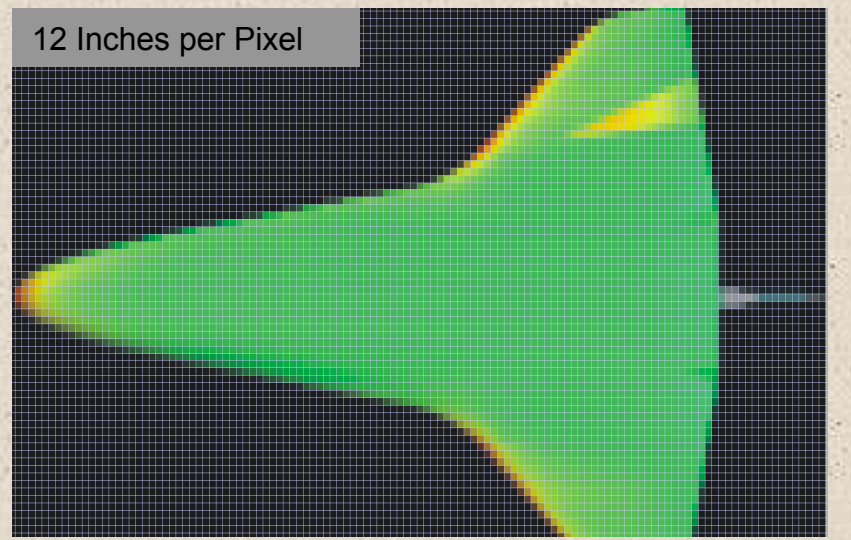
Camera focal length
Imager resolution
Distance to target
Angle to surface normal

Spatial resolution modeling is part of the ViDI mission planning toolset.

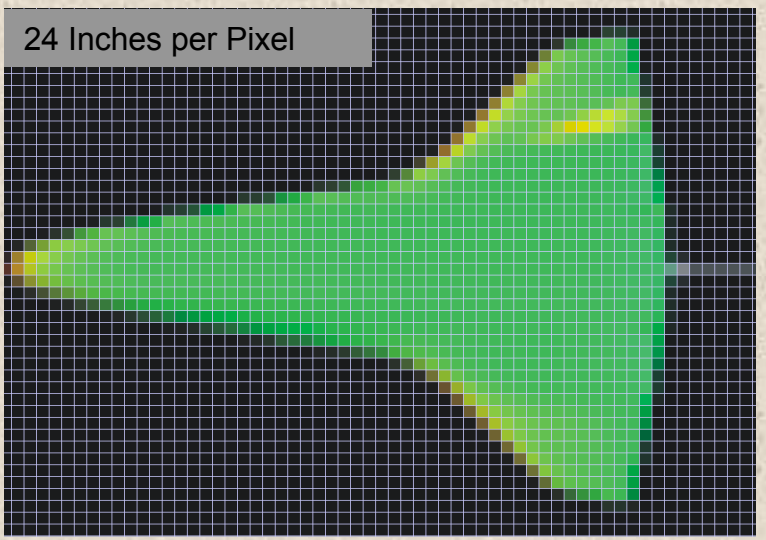
18 Inches per Pixel



12 Inches per Pixel



24 Inches per Pixel



Spatial Modeling – Point Spread Function

All images will contain blur due to

- Diffraction
- Lens distortion
- Imperfect Focus
- Optical bench motion
- Atmospheric scintillation
- Turbulence around airframe (airborne)

The blurring due to diffraction can be determined computationally, all other sources are dependent on conditions during acquisition and have to be approximated. A Gaussian blur image processing technique is used to simulate the expected blur of the image.

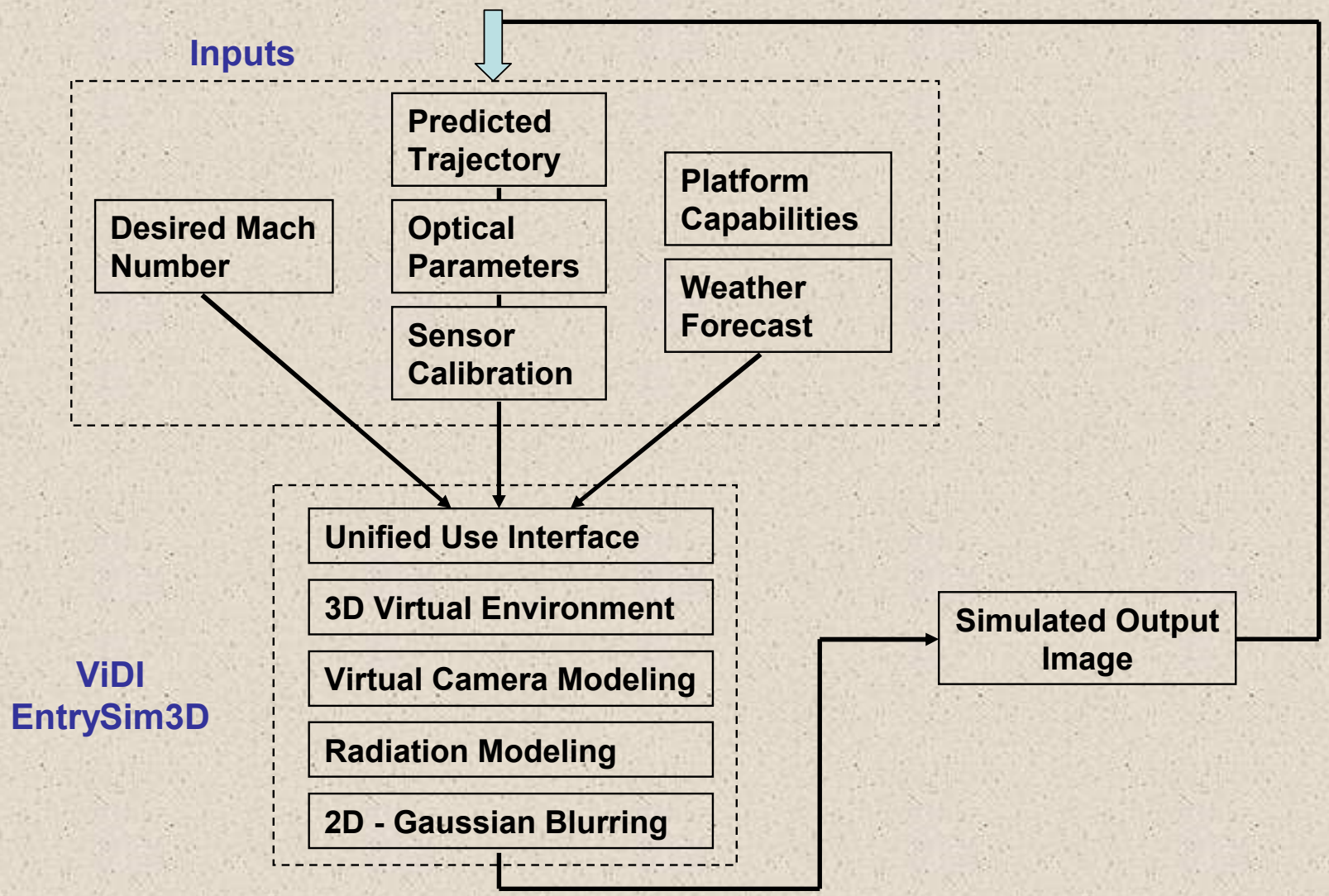


No blur, "perfect" image



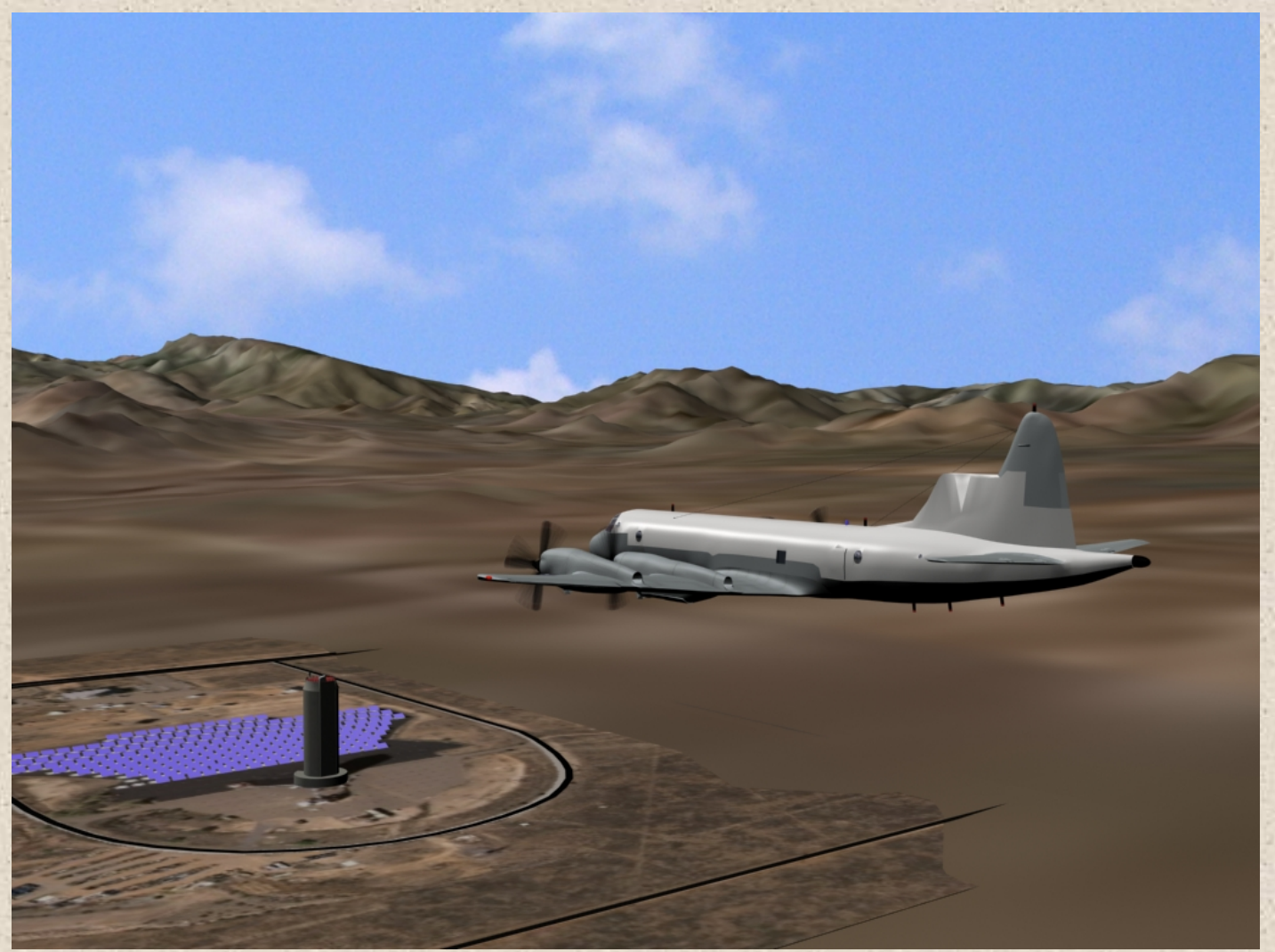
5 pixel Gaussian blur

Mission Planning Schematic

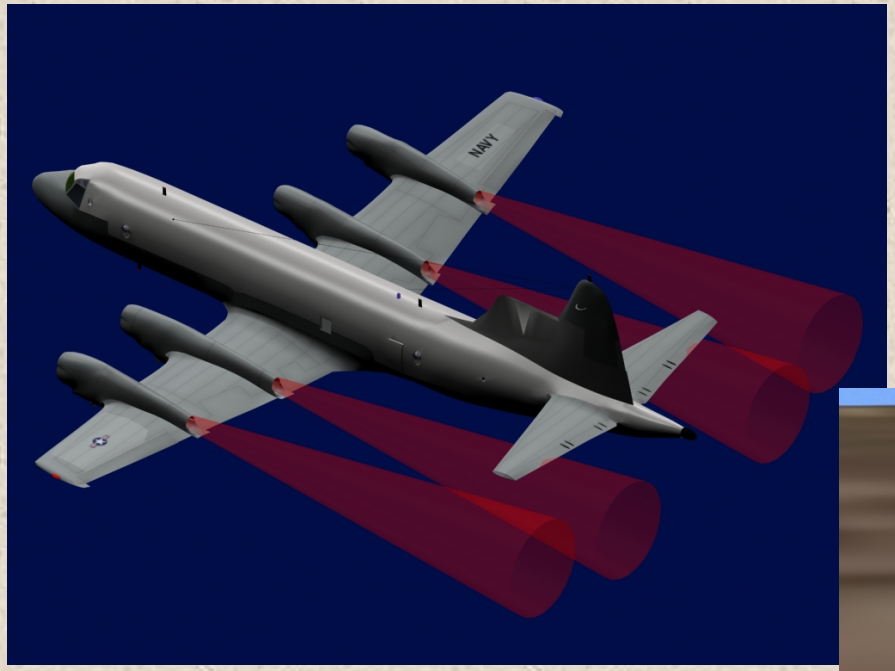


Aircraft platform

We can model the aircraft platform as required. This work supported early HYTHIRM efforts for calibration of the optical sensors at the Sandia national Solar Tower Test Facility in Albuquerque, NM.



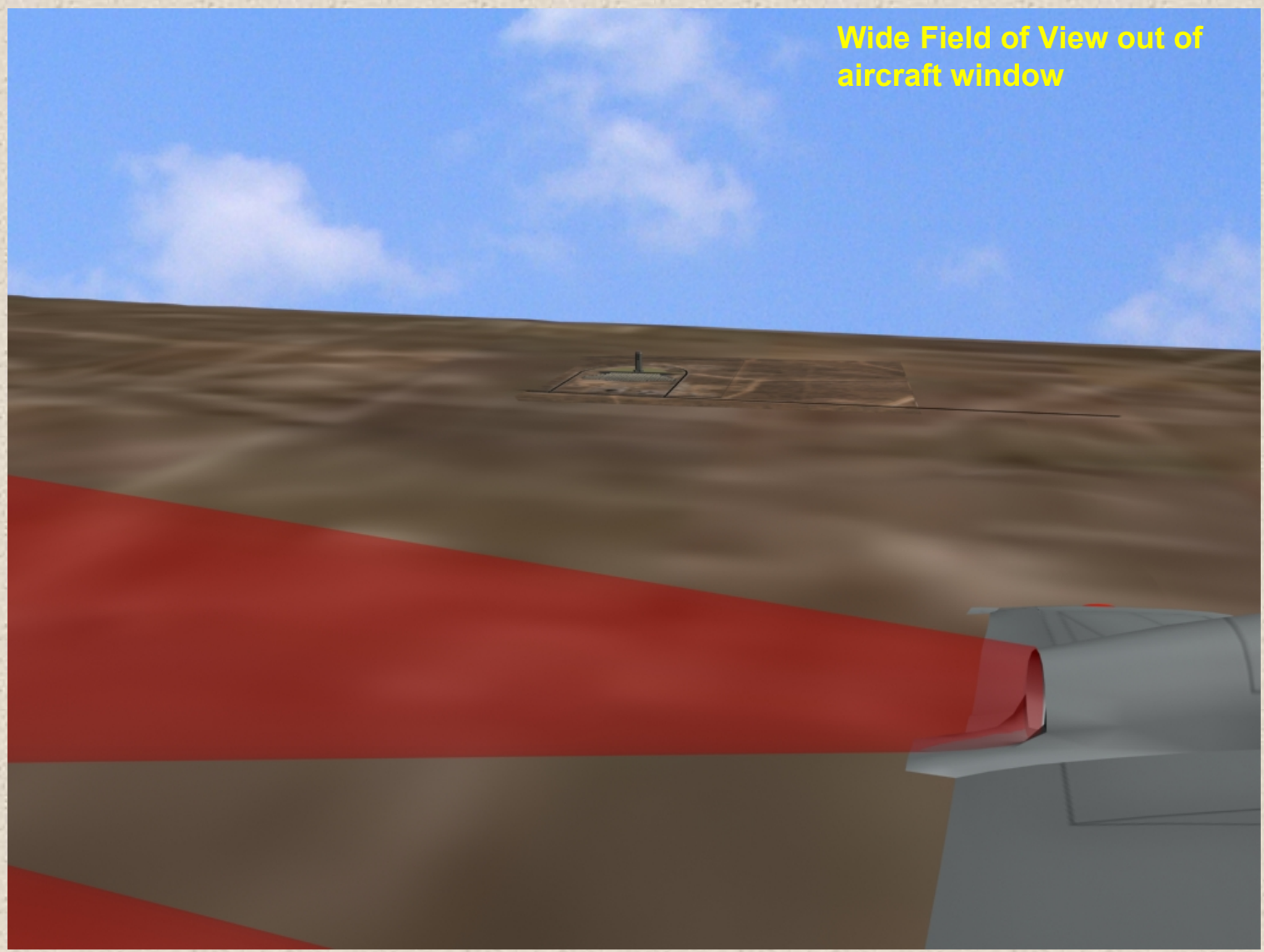
Platform



Hot exhaust plumes are depicted by transparent red cones. They must be outside of the field of view of the optical sensors.



Optical Performance

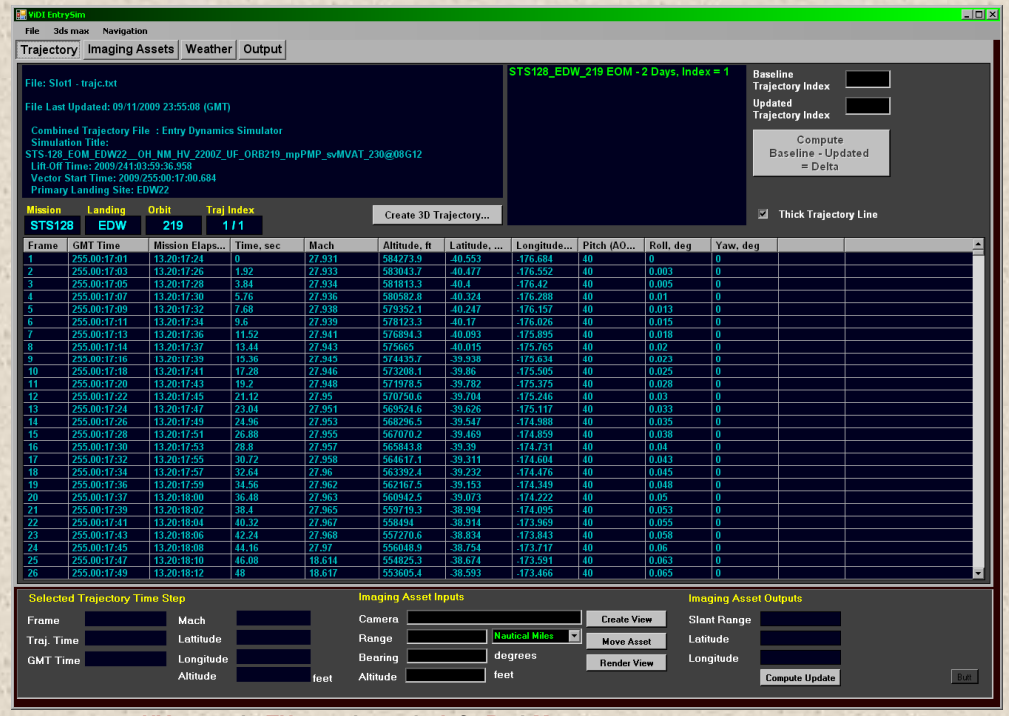


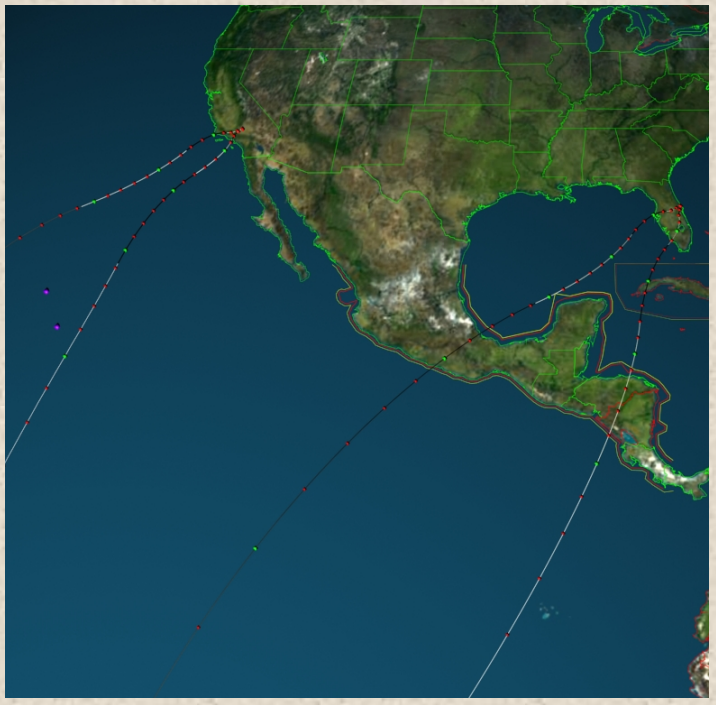
Deployment Phase

HYTHIRM

The ViDI tools are designed to bring together a variety of disparate data sets into a unified, easy to understand data visualization in support of real time Space Shuttle flight operations.

- Trajectory predictions – Flight Dynamics Officer
- Weather – Space Flight Meteorology Group
- Aircraft Operations – US Navy CAST GLANCE and VX-30 Squadron
- Airspace Restrictions / Foreign Airspace – FAA, SENEAM, State Department
- Science Objectives – Principal Investigator, Tom Horvath, LaRC





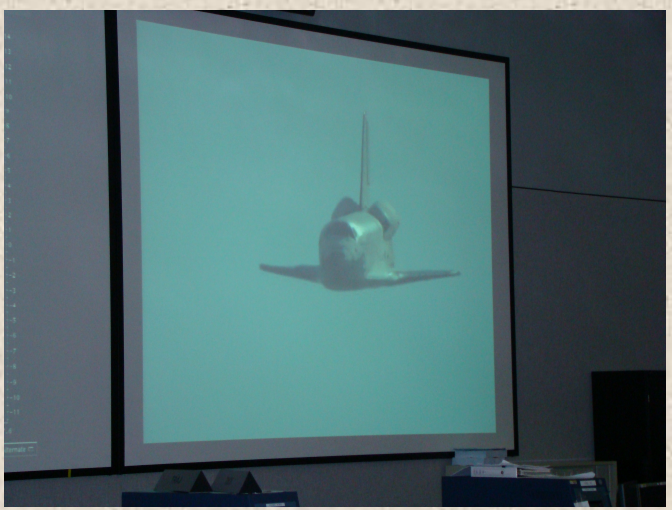
Real-Time Mission Coordination

Mission coordination from Mission Control Center in Houston continues with real time updates to the CAST GLANCE aircraft via VHF and Sat phone to fine tune positioning up to the last few minutes of closest approach.

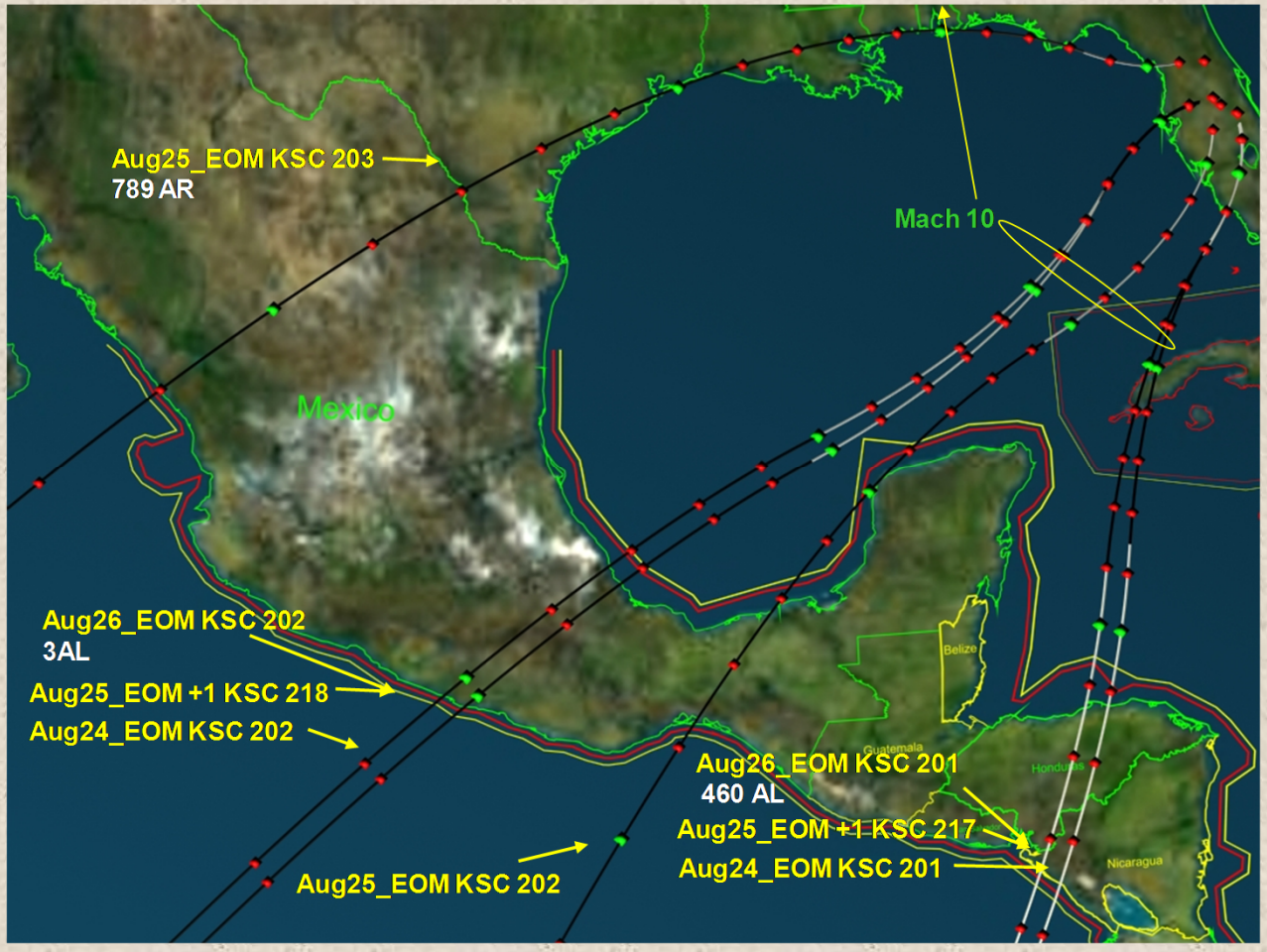








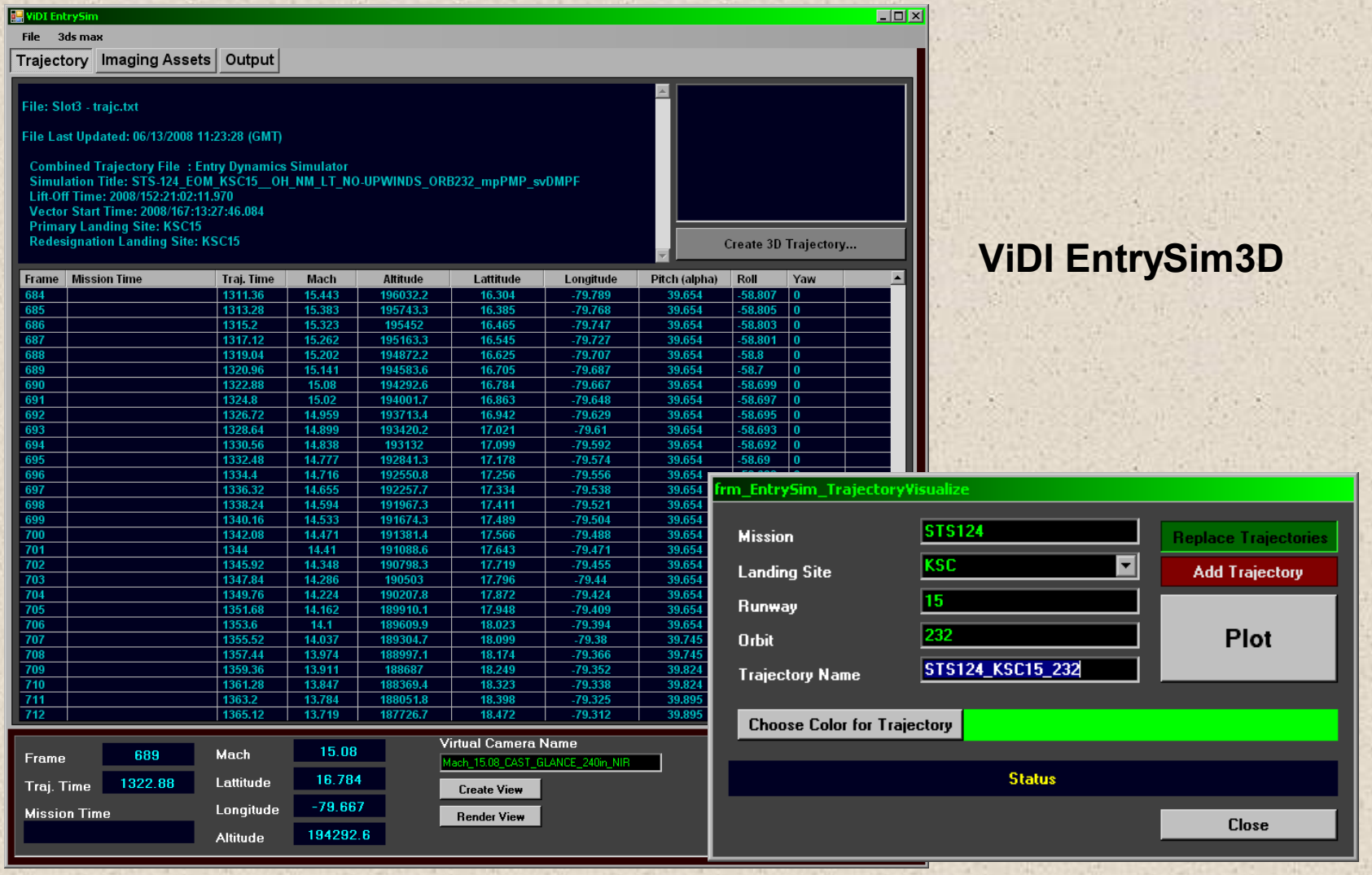
STS-128 Trajectories to KSC



Early predicted trajectories into KSC – yeah, it landed at Edwards!

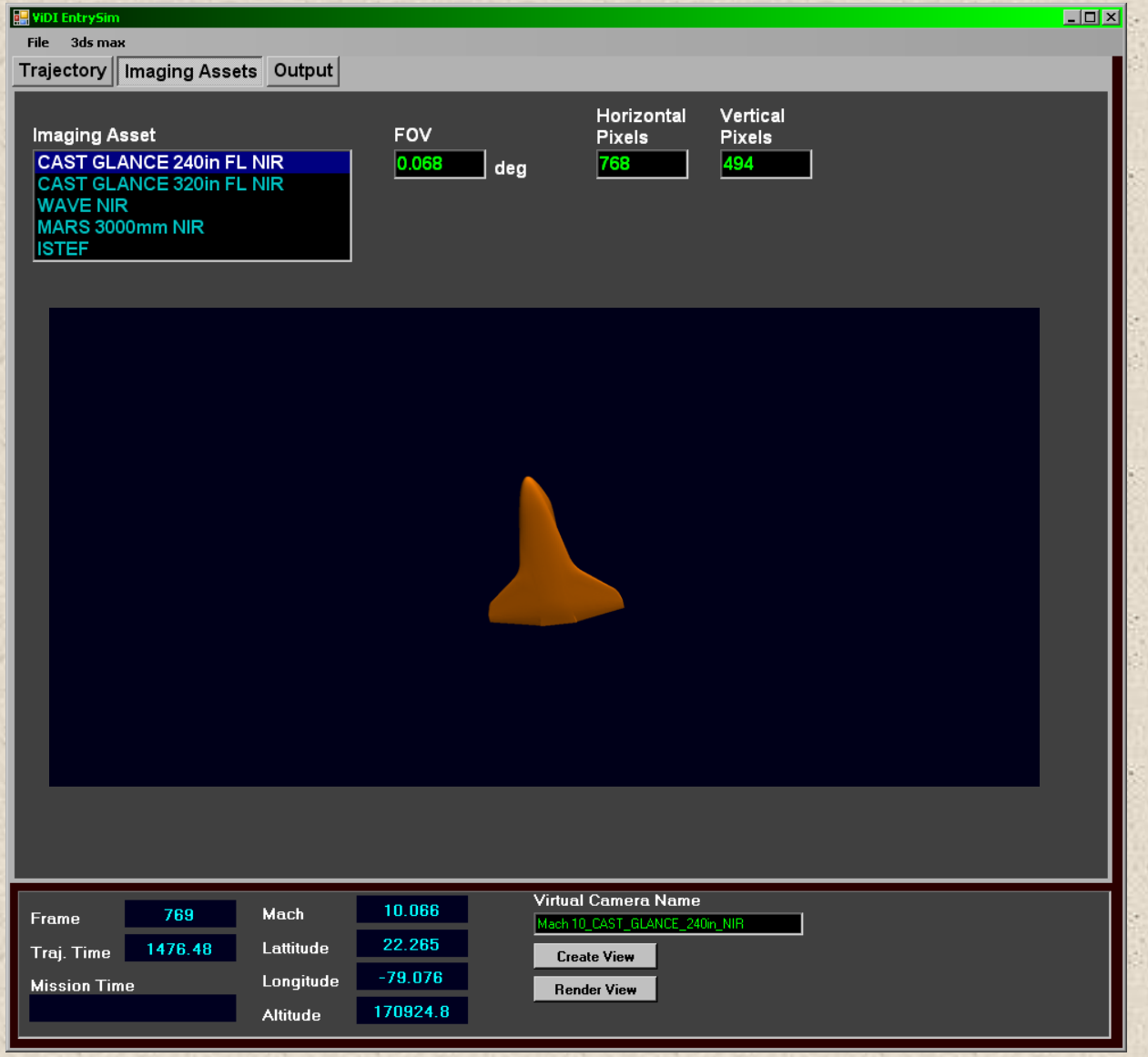
Re-planning continued to the last hours due to the dynamic nature of the operations.

Mission Planning Tools



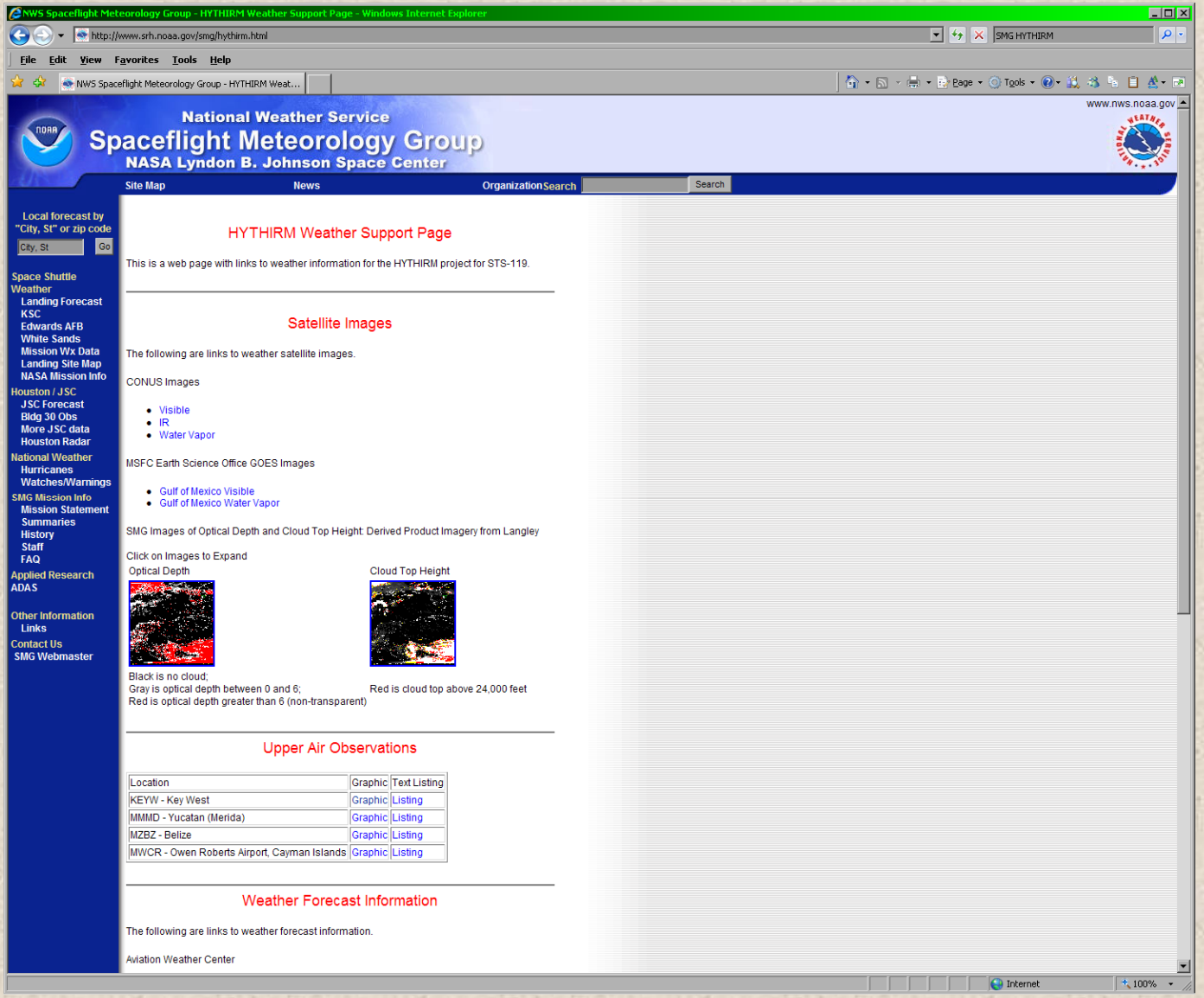
ViDI EntrySim3D

Mission Planning Tools



Spaceflight Meteorology Group (SMG) Support

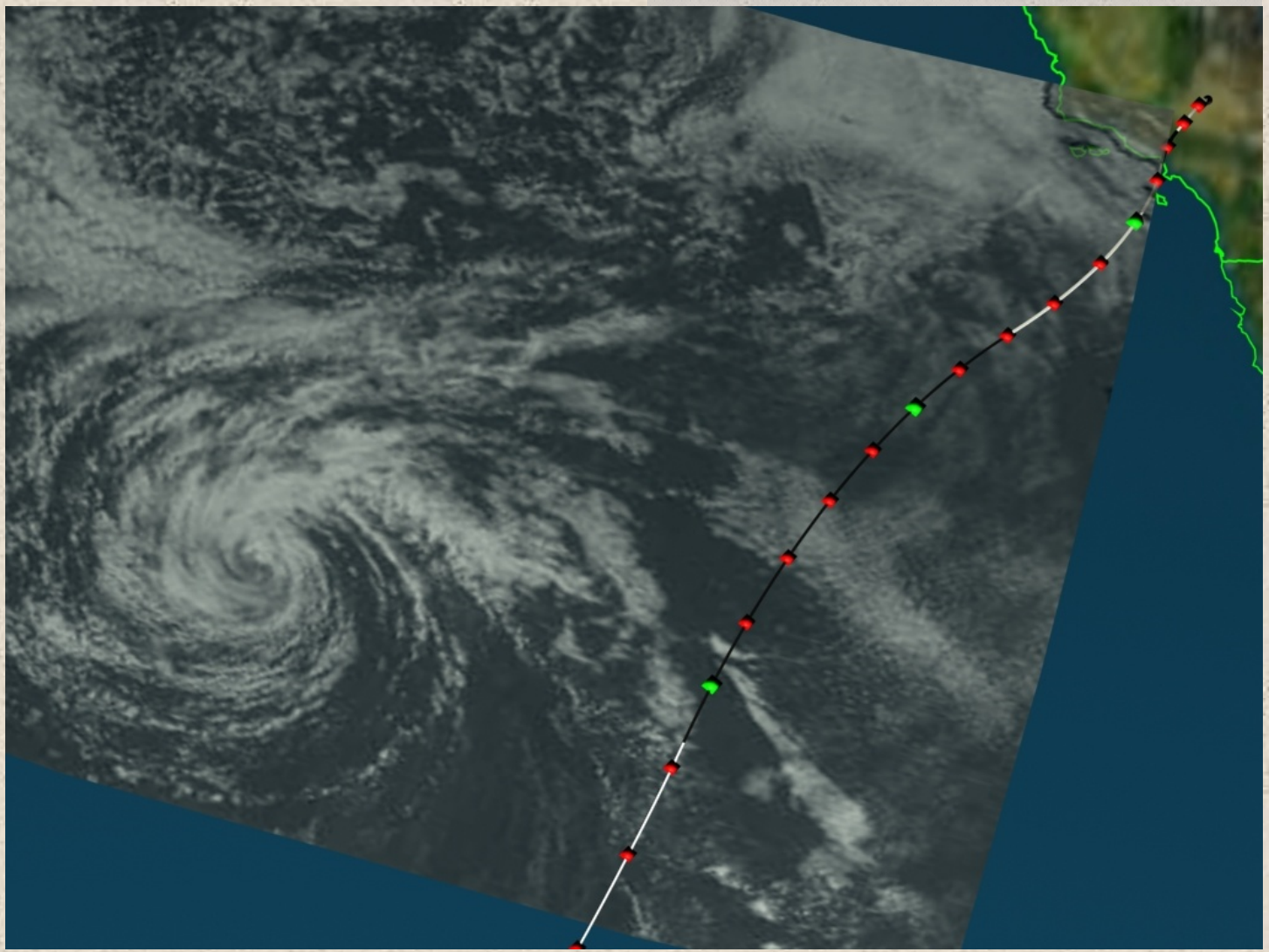
HYTHIRM receives custom weather briefings in person by SMG up to 3 times a day as well as a special web page providing updated weather specifically for our needs.



Mission Planning Tools

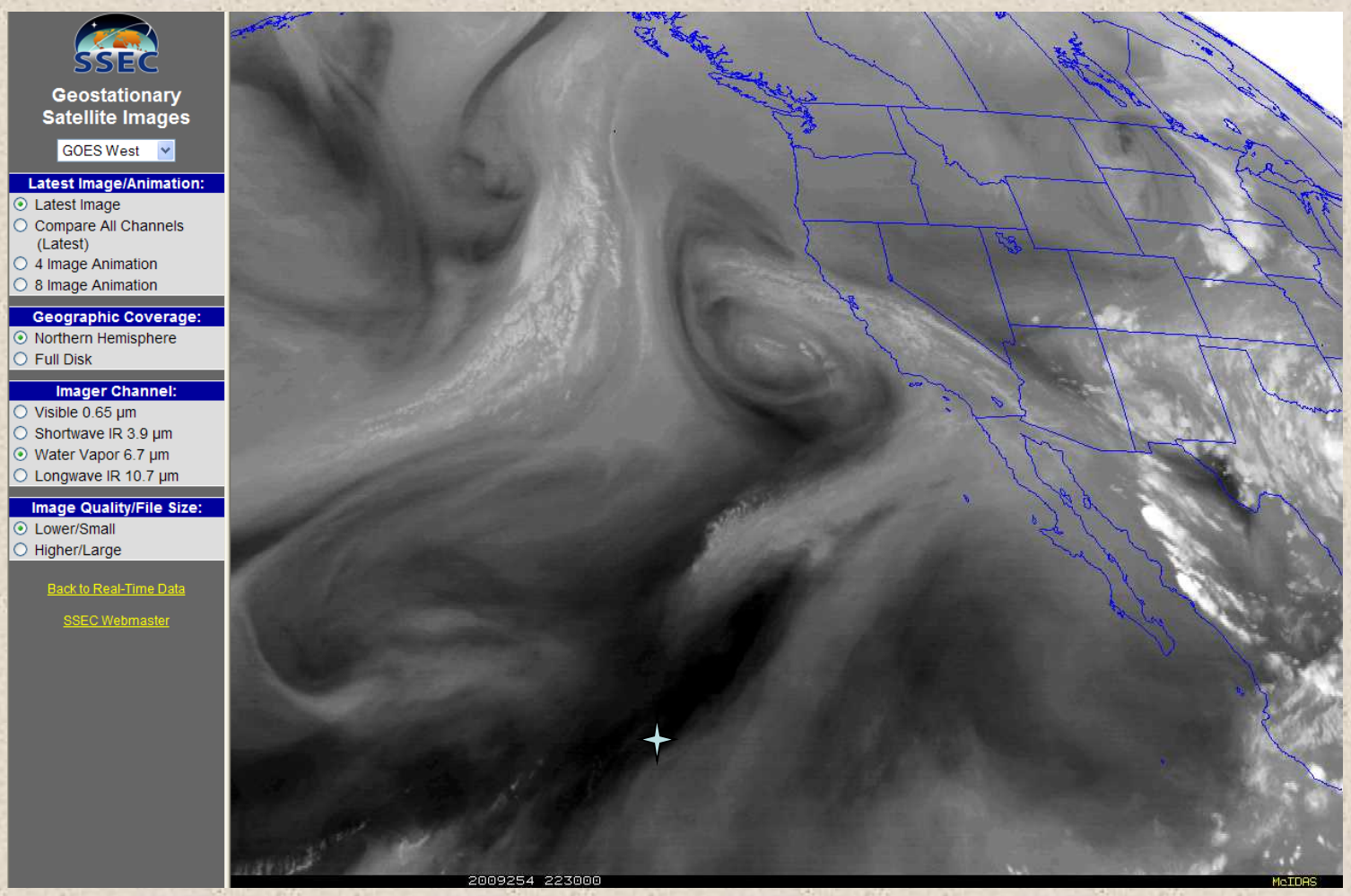
SMG provided weather imagery is easily incorporated into the mission planning visualization using our customized software.

Hurricane Linda – STS-128

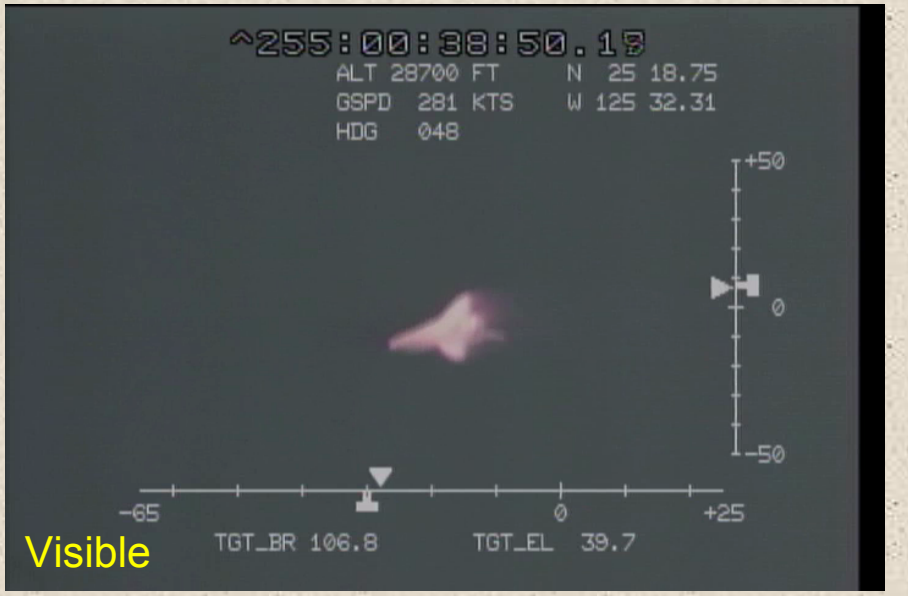


Mission Planning Tools

Additional weather information provided by APL in real time. HYTHIRM looses direct SMG support about 8 hours prior to landing due to SMG support for landing.



Virtual Camera Simulation – STS-128

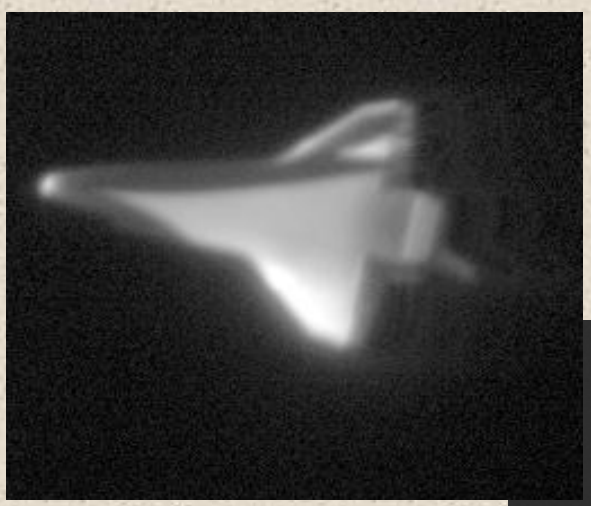


Unprocessed imagery from CAST GLANCE, STS-128, September 11, 2009

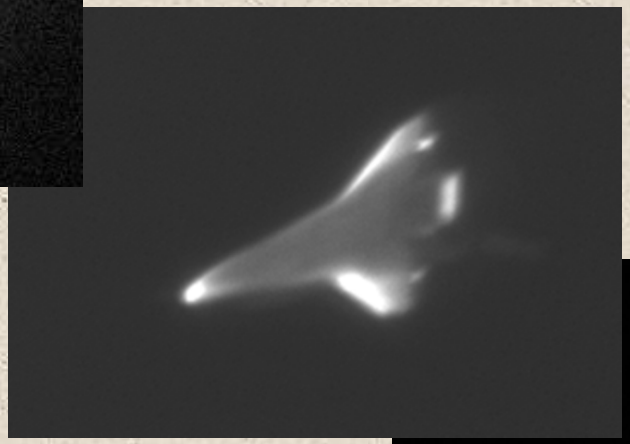


ViDI Visualization matches the actual camera's field of view and camera pixel resolution

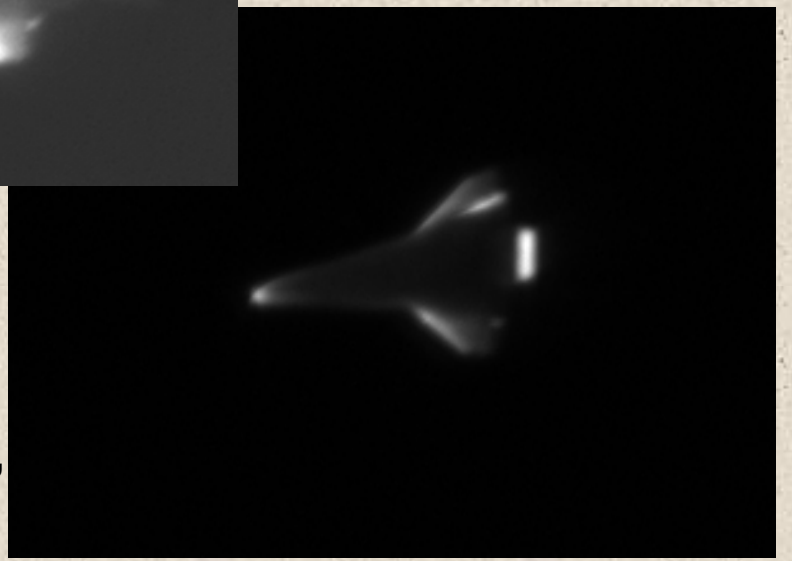
HYTHIRM – 3 for 3!



STS-119, March 2009, Mach 8.5



STS-125, July 2009, Mach 15



STS-128, September 2009, Mach 15