

National Aeronautics and  
Space Administration




# SCIFLI



## Scientifically Calibrated In-Flight Imagery

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SCIFLI Project Manager  
28 June 2021

The background features a vibrant space scene with a bright sun, a ringed planet, and a crescent moon against a starry sky. A large, semi-transparent blue circle frames the text on the right. On the left, a circular logo for SCIFLI is visible, containing the text 'SCIENTIFICALLY CALIBRATED IN-FLIGHT IMAGERY', 'SCIFLI', 'VERUM VIDERE', and 'NASA LANGLEY'.

Meet SCIFLI, NASA's diehard team of space geeks who chase spacecraft in a quest to capture data on the cutting edge of our collective aerothermodynamic understanding. In the SCIFLI zone, the computational uncertainty bounds are large, the testing envelope exceeds the limits of even the most advanced wind tunnels, and there are no do-overs.

This is screaming through the jagged upper atmosphere at Mach 36. This is mapping heatshield temperatures of manmade meteors while flying 6 miles high above the middle of the Pacific. This is a console in Mission Control, and careful radiance modeling and mission planning and choreographing launch and landing and realtime spaceflight weather and updated spacecraft trajectories and communicating with aircraft via satphone and HF relays and clearances through foreign airspace and liftoff and max Q and entry interface and peak heating and aerobraking and skip trajectories and parachute deployment and splashdown and did I mention there are no do-overs?

**This is vital knowledge that can't be gotten any other way. This is cowboy rocket science. This is SCIFLI.**

# Today's Seminar

Origin Story

What it Takes

TPS Performance - Launch, Staging, Reentry

Contingency Flight Safety Systems

Space Weather

Superfast

Parachutes

Thoughts on Leadership



# What Sets SCIFLI Apart

SCIFLI stands for Scientifically Calibrated In-Flight Imagery.

SCIFLI goes beyond the photo documentation that is the purview of the range, obtaining data sets (in the form of imagery or spectral observations) that are converted to engineering units.

This typically involves infrared imaging for thermal measurements, but may include dynamic behavior and structural response. We have also obtained ultra-high resolution imagery to observe minute details under special conditions.

The SCIFLI team is comprised of individuals with strong backgrounds in aerothermodynamics, instrumentation, image processing, astronomy, test piloting and more. We are a relatively small but very agile Agency-wide team.

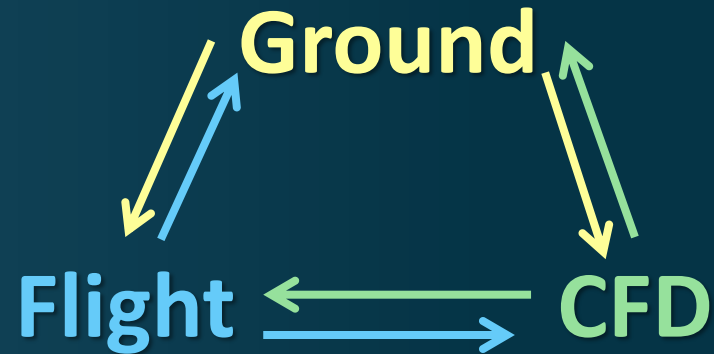
SCIFLI has a proven track record of obtaining remote, non-intrusive, spatially resolved data sets of vehicles in flight from subsonic through high hypersonic velocities.



# What Sets SCIFLI Apart



Flight data sets are critical to advancing understanding of actual vehicle performance, particularly at the edges of the flight test envelope, where extrapolations from ground tests, past flight experiences, and computational predictions have a high degree of uncertainty.



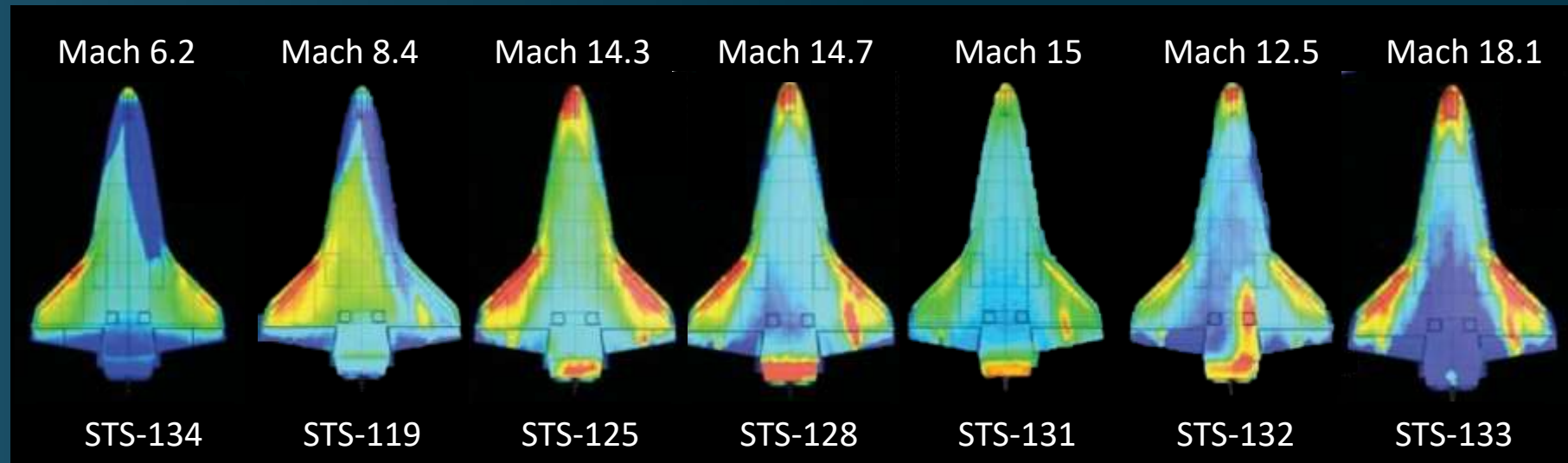
A high probability of mission success requires extensive mission planning, operational experience, and **maintaining complex relationships with people** who possess a wide range of diverse skill sets across multiple agencies and organizations.



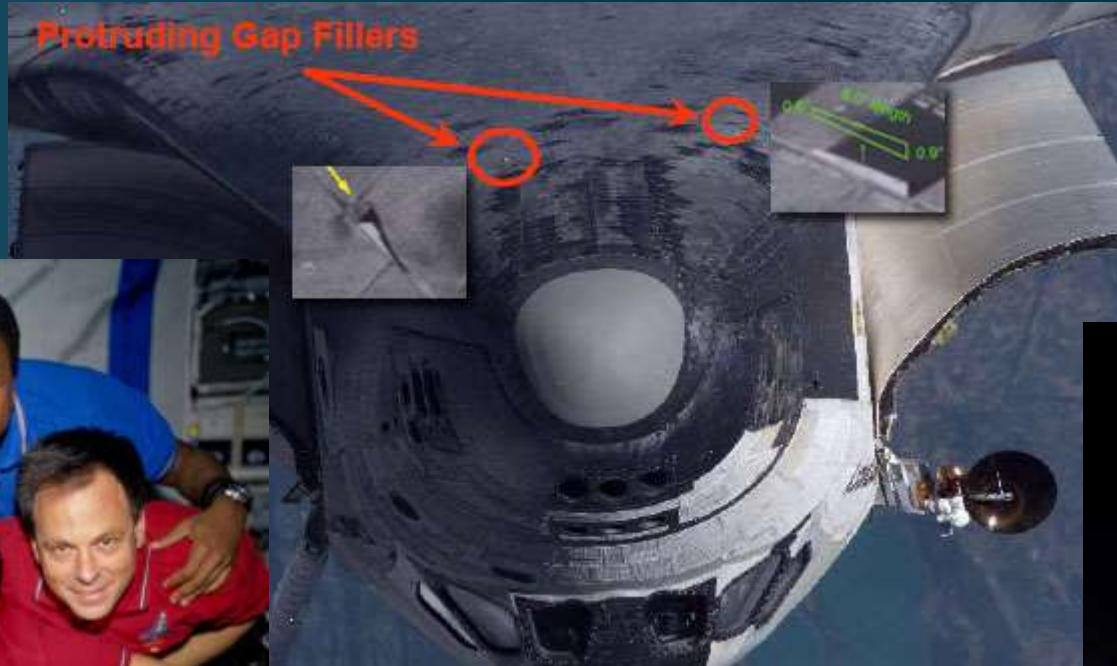
# Origin Story

# Introduction

SCIFLI evolved from the Hypersonic Thermodynamic InfraRed Measurements (HYTHIRM) team, a project which imaged numerous Space Shuttle reentries ranging from Mach 6 to Mach 18.

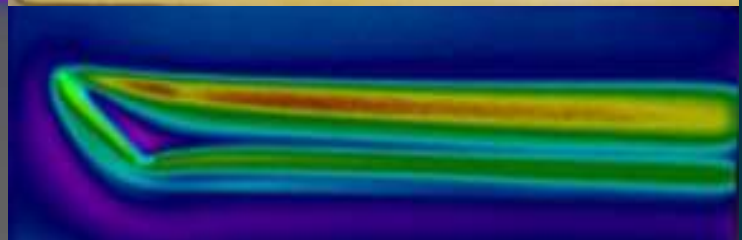
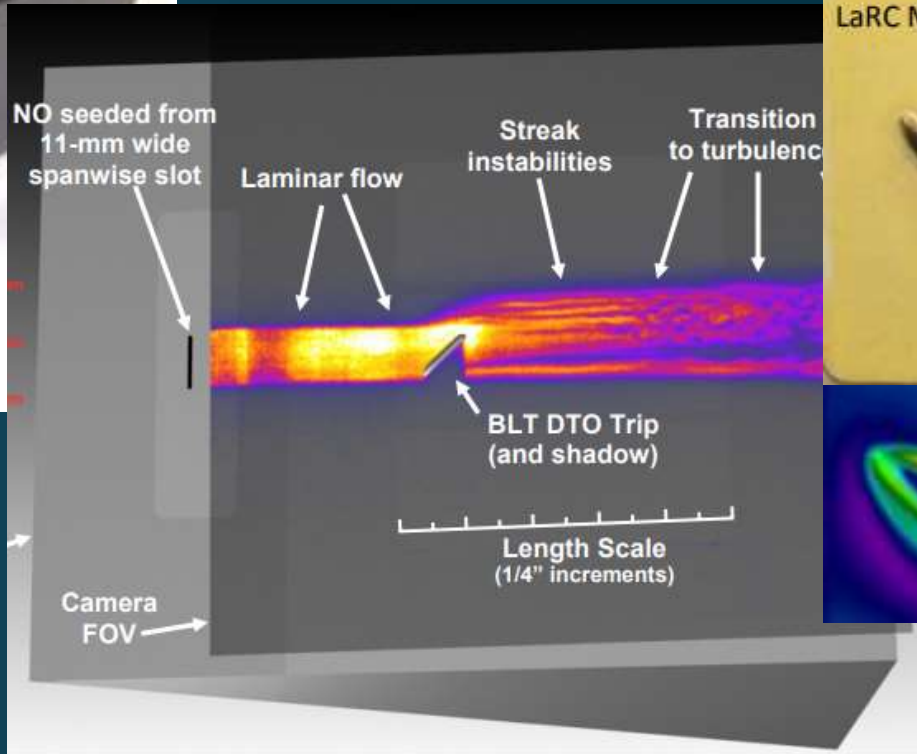
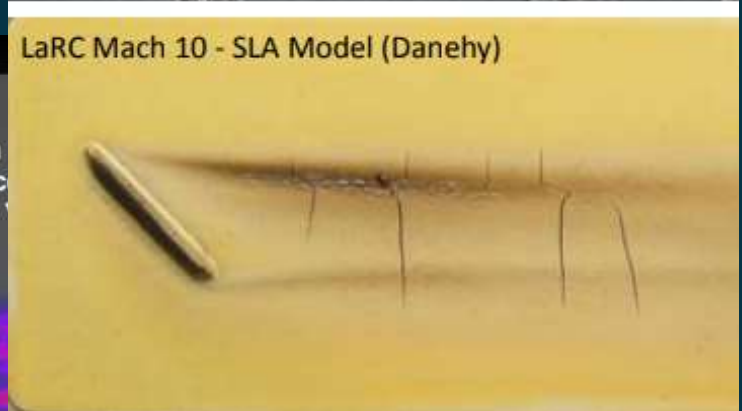


# STS-107 and STS-114

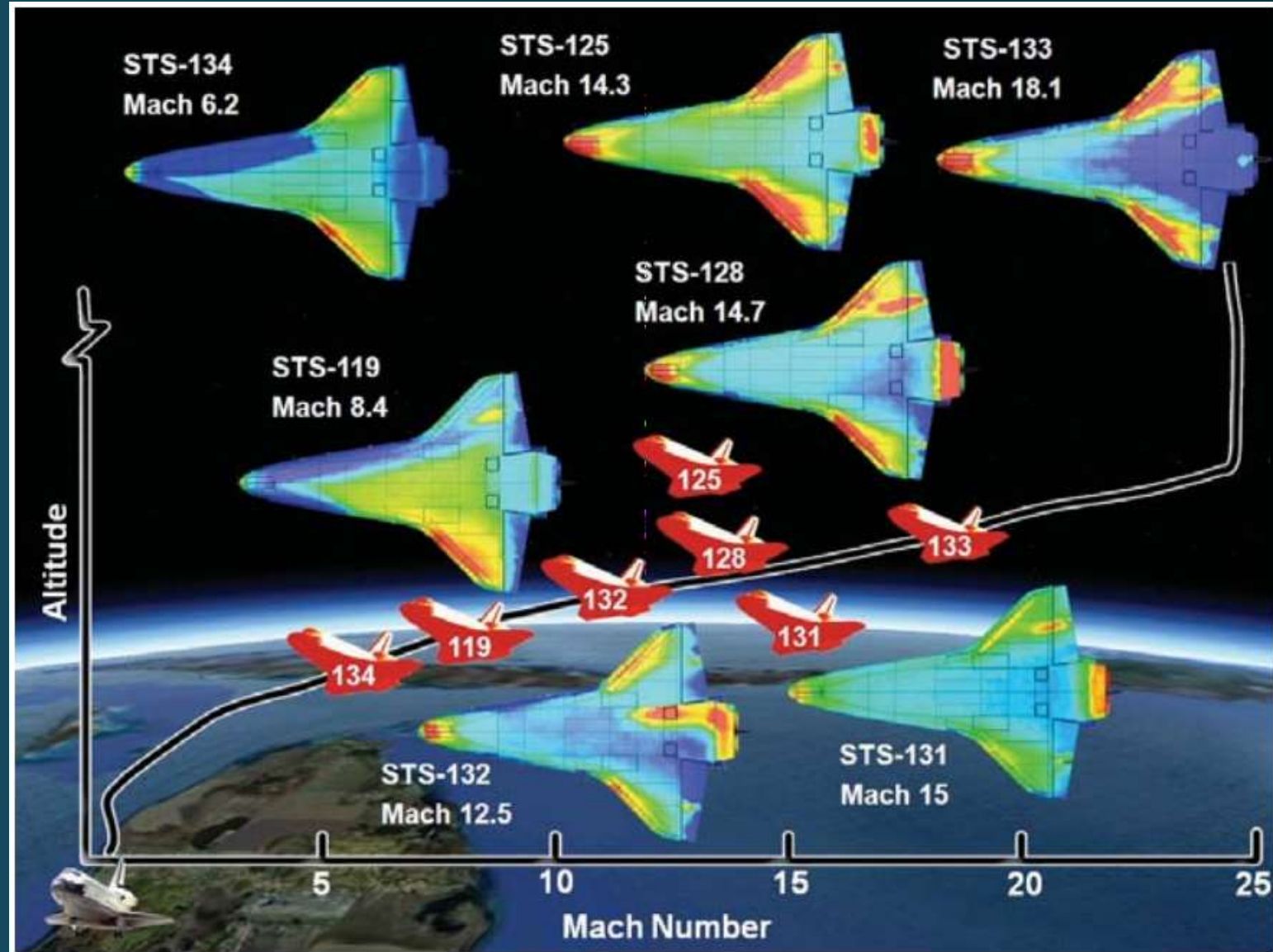


<https://www.nasa.gov/image-feature/remembering-sts-107-and-her-crew>  
[https://www.nasa.gov/returntoflight/crew/EVA\\_gapfiller.html](https://www.nasa.gov/returntoflight/crew/EVA_gapfiller.html)  
[https://www.nasa.gov/images/content/143114main\\_sts114armwalk-lg.jpg](https://www.nasa.gov/images/content/143114main_sts114armwalk-lg.jpg)  
[https://www.nasa.gov/centers/langley/images/content/723947main\\_Horvath2\\_904.jpg](https://www.nasa.gov/centers/langley/images/content/723947main_Horvath2_904.jpg)  
[https://www.nasa.gov/images/content/118271main\\_114\\_crew\\_port\\_hires.jpg](https://www.nasa.gov/images/content/118271main_114_crew_port_hires.jpg)

# But How MUCH Hotter?



# 7 Space Shuttle Program Observations

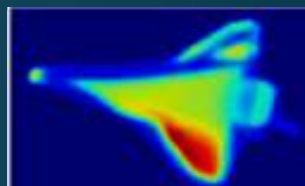


# Introduction

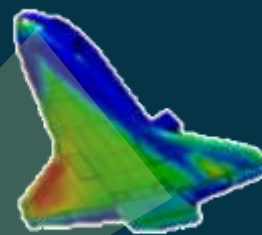
The SCIFLI Team provides *quantitative measurements in engineering units derived from calibrated imagery data*. The data are most often obtained from airborne platforms, but have also been acquired from land- and ship-based assets.



Data collection and calibration



2D Processed Data



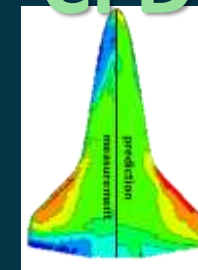
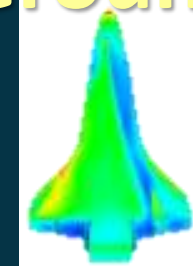
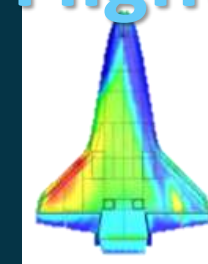
3D Mapping



**Ground**

**Flight**

**CFD**



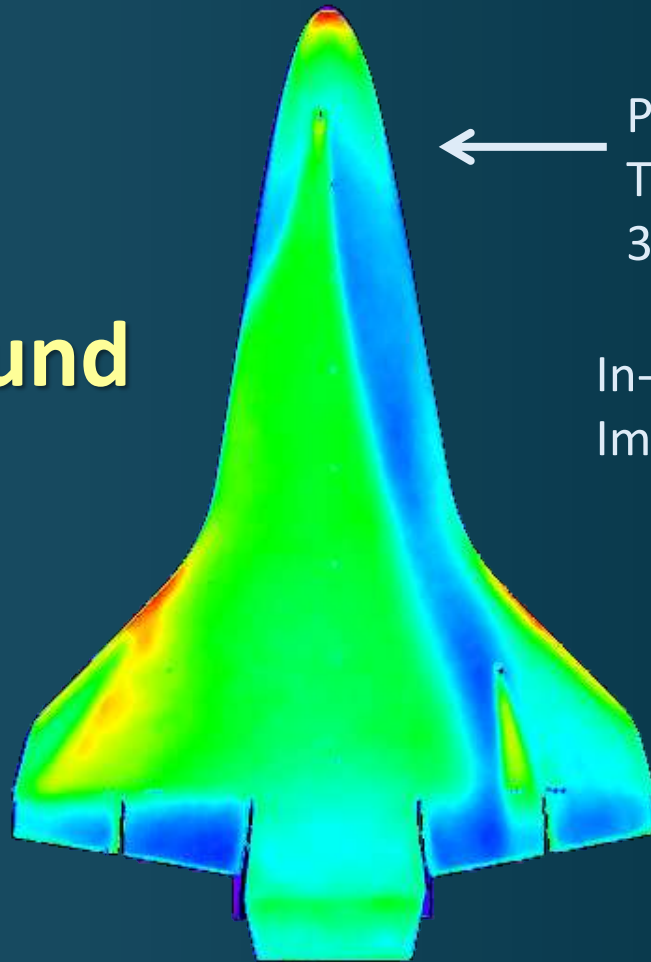
Comparison and  
Model Refinement

# Ground-to-Flight Validation

Provides the connection between computation, ground testing, and flight



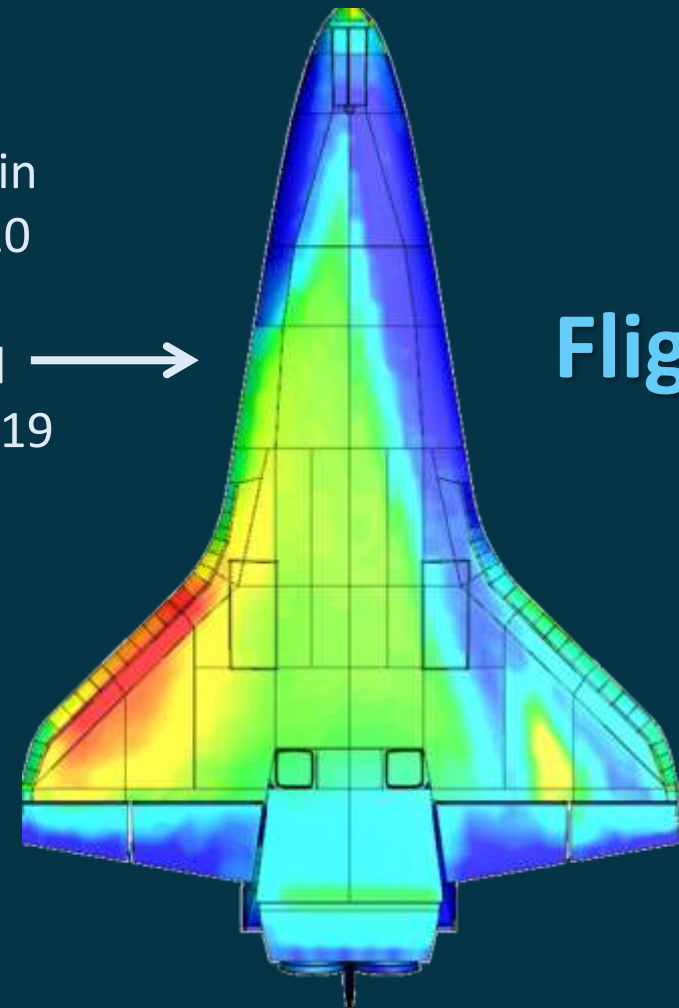
**Ground**



← Phosphor  
Thermography in  
31-Inch Mach 10

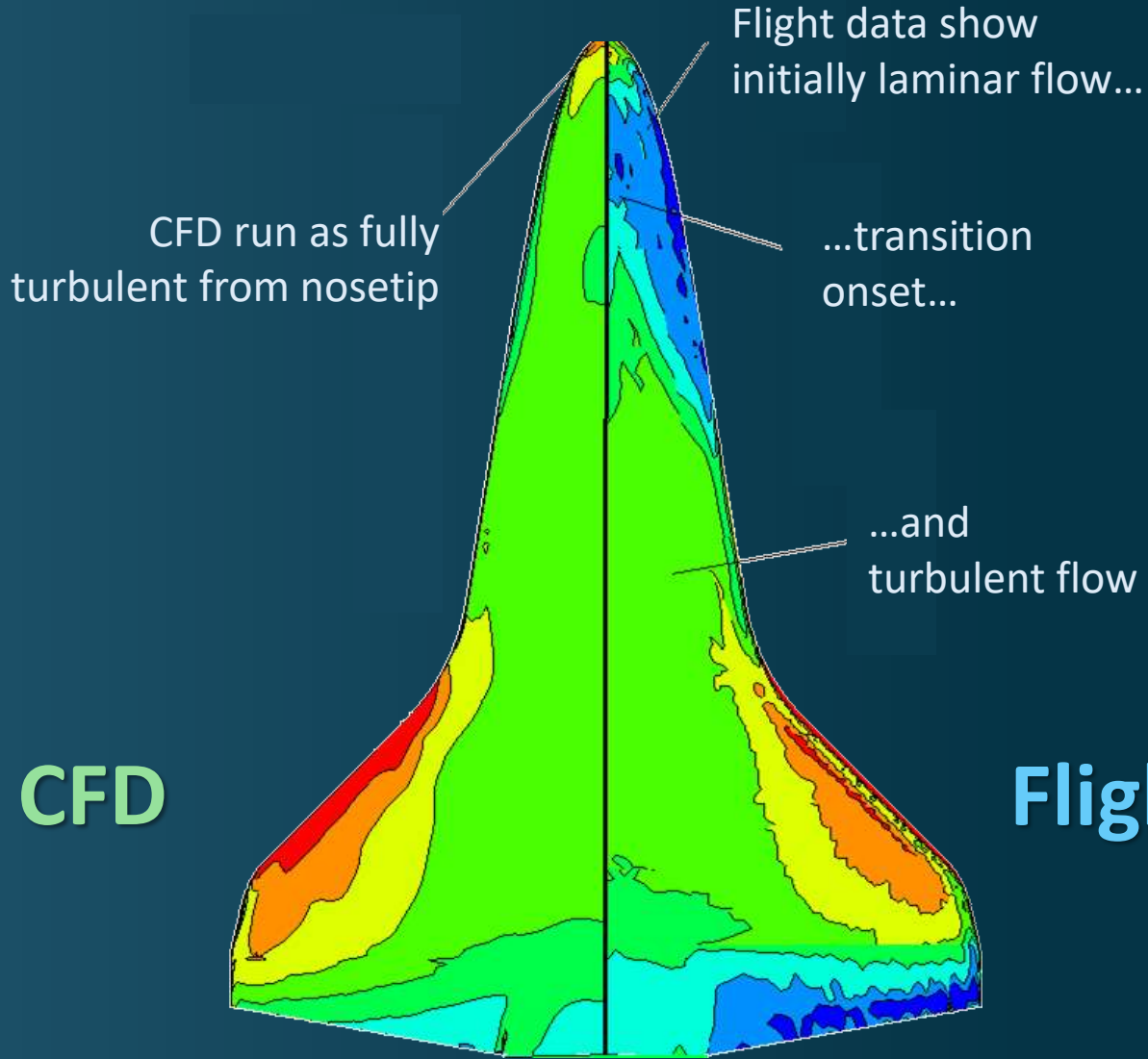
In-Flight Thermal  
Imagery of STS-119 →

**Flight**



# CFD-to-Flight Validation

Provides the connection between computation, ground testing, and flight



**Shuttle orbiter  
boundary layer  
transition**

# Origin Story

2007



2011



2018



2020

2021



# Products & Services

Tailored To Meet Customer Expectations

Imagery Objectives

Virtual Camera Simulations

Radiometric Simulations

Airspace Coordination

Sensor Calibration

Mission Simulations

Mission Operations

Mission Operations Report

Initial Data Assessment

Data Processing & Analysis

Data Report

### Mission Planning

Global Weather

Spatial Performance

Basing Options

Predicted Radiance

Radiance ( $W/m^2/nm$ )

Google Earth

### Mission Execution

Mission Operations

Airspace Coordination

Sensor Calibration

### Data Processing & Analysis

Spectroscopy†

Shock patterns\*

Recovery systems

Plume Interactions

Surface temperature\*

Risk Reduction

Health Monitoring

### Data Products & Reports

JAIAA

JAIAA

JAIAA

JAIAA

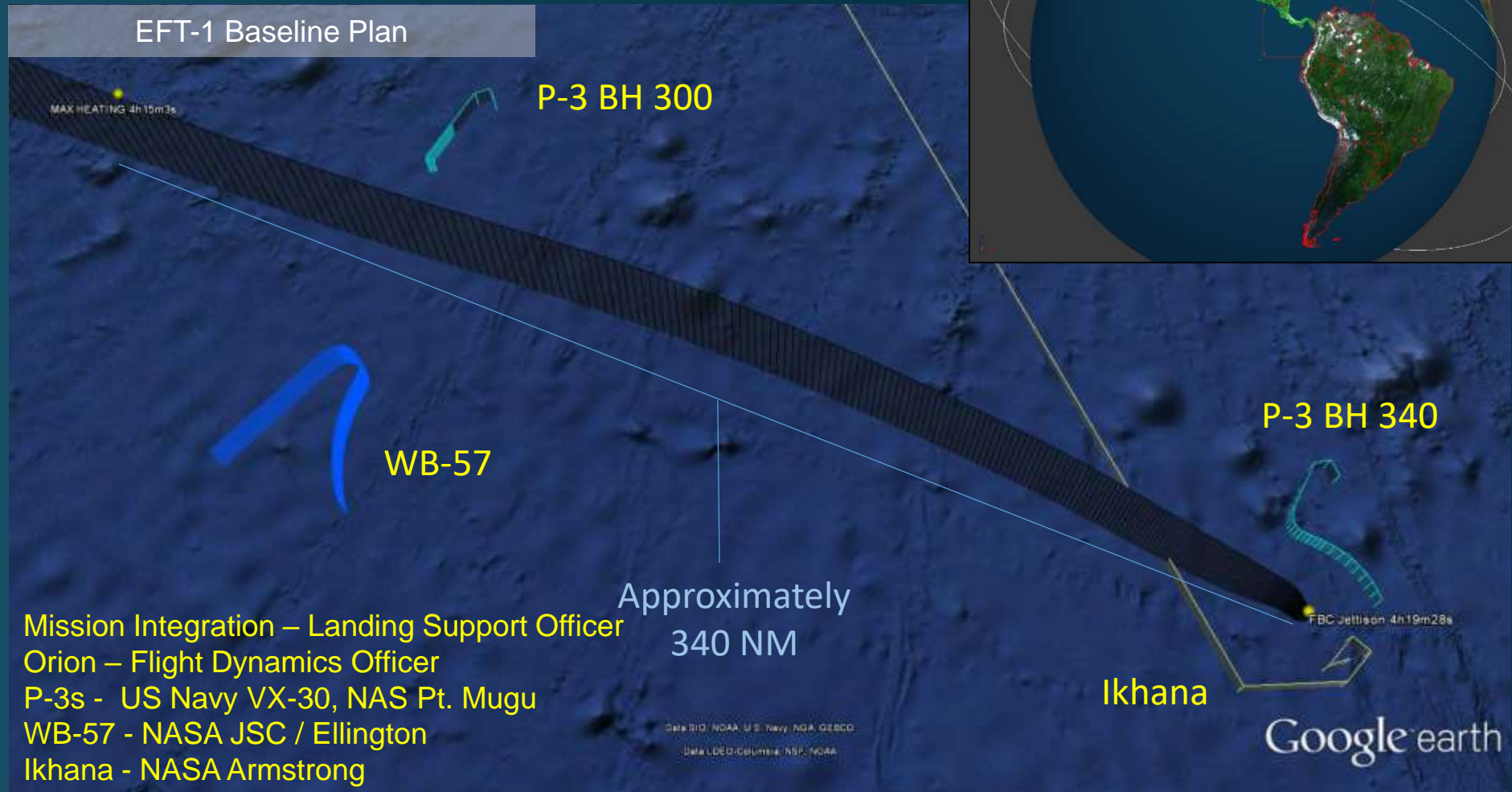
JAIAA

†Image Credit: NASA Ames Research Center

\*Image Credit: US Navy

# Mission Planning and Coordination

SCIFLI works closely with the asset providers to develop and optimize the observation for each individual platform.

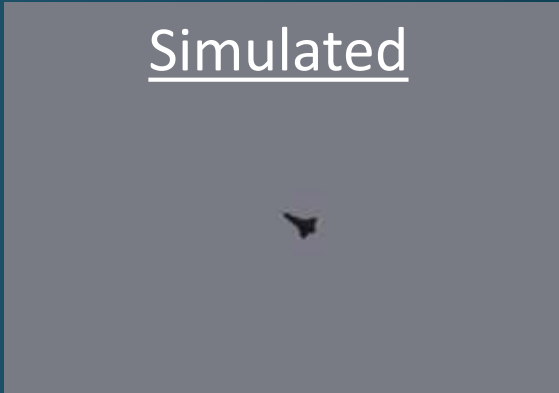


# Imaging: Modeling and Simulation



Simulated

Flight



*Entrysim3D virtual environment is used to determine when and where to look and what we should expect to see.*

## Inputs

Trajectories for target vehicle and imaging asset

Model of target vehicle

Simulated camera(s)

Sensor characteristics

Imaging optics

Asset altitude and location

## Results

Space Shuttle mission STS-128

Navy P-3 Orion aircraft CAST  
GLANCE near infrared images

# Communications Plan: SpaceX CRS-4



## SpaceX Launch Control, Canaveral



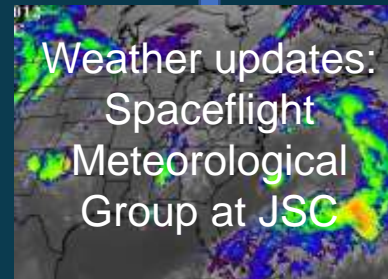
## NASA JSC Mission Control, Houston



Joe Bussenger, SpaceX  
Rich Schwartz, JSC



Land line telephone through mission audio loops



Iridium satphone



### Primary

USAF Cape  
Radio HF routed  
through mission  
audio loops by  
JSC Landing  
Safety Officer

### Secondary

Iridium  
satphone  
(Ku-text  
messaging)



VHF radio



NAVY P-3



NASA WB-57

SpaceX Assets: 2 boats or 1 plane

<https://blogs.nasa.gov/commercialcrew/2018/11/05/spacex-rehearses-helicopter-landing-at-sea/>

[https://www.nasa.gov/returntoflight/launch/wb57\\_chasejets.html](https://www.nasa.gov/returntoflight/launch/wb57_chasejets.html)

<https://ntrs.nasa.gov/api/citations/20130011566/downloads/20130011566.pdf>

**JAXA**



**MARS**  
SCIENTIFIC

**MARS**  
SCIENTIFIC

**ESPO**  
NASA



**SPACEX**

**BOEING**

**SIERRA**  
SPACE



**MARS**  
SCIENTIFIC

**SPACEX**



**JPL**

**SkyRange**

**WORLD VIEW**

**optoknowledge**



**BOEING**

**BOEING**



**SR**  
SOUTHERN RESEARCH

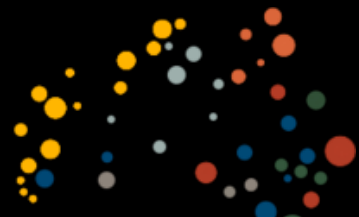


**SPACEX**

**NASA SR**  
SOUTHERN RESEARCH

**Torch**  
TECHNOLOGIES

**TRATS**



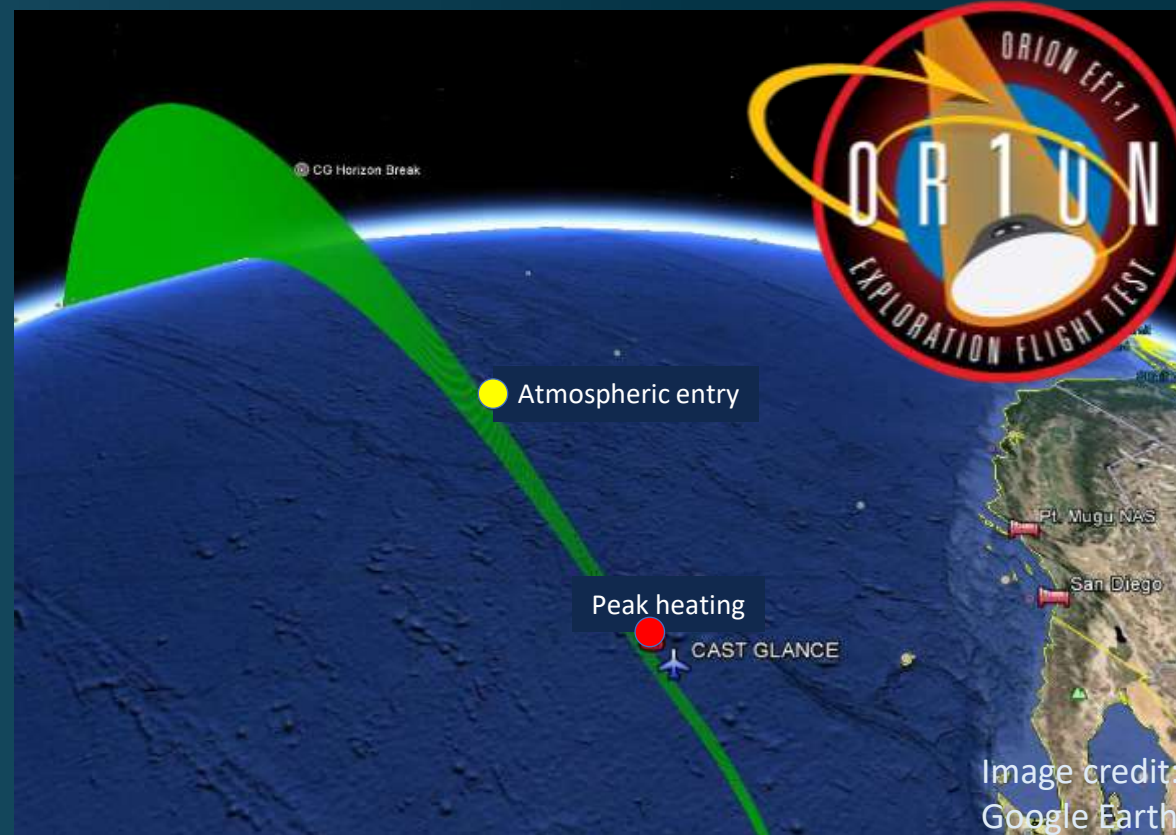
**Australian Space Agency**



# Example Mission: EFT-1

# Spacecraft Trajectory: Define Mission Parameters

## Exploration Flight Test 1 (EFT-1)



Flight path and vehicle orientation determines:

- Optical system cueing (pointing)
- Physical location of imaging system
- Logistics (airspace, transit times, etc.)
- Weather likely to be encountered

# Predict Spatial Resolution



## Synthetic Image of Capsule near the Point of Peak Heating

System = NIR  
Camera = Prosilica  
Pixels = 1024 x 1024  
FOV = 0.21 deg horizontal

Ground Standoff = 29.5 NM  
Slant Range = 37.04 NM  
Elevation = 36.4 deg  
Vehicle Altitude = 159,313 ft

Aircraft view of capsule at peak heating

Perfect imaging

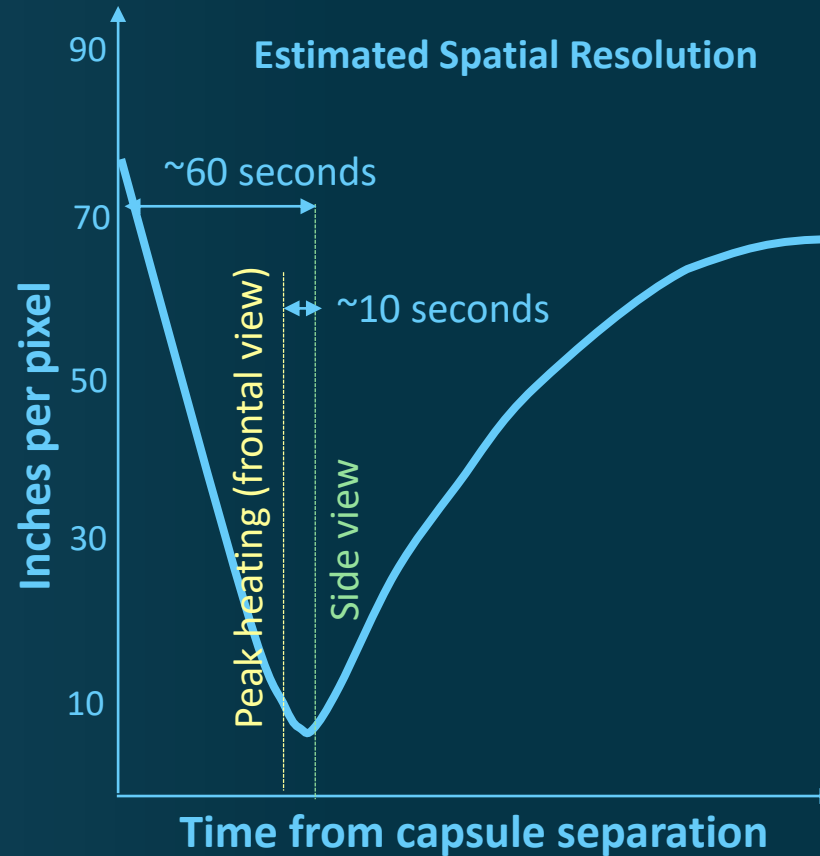


Inches per pixel = 10

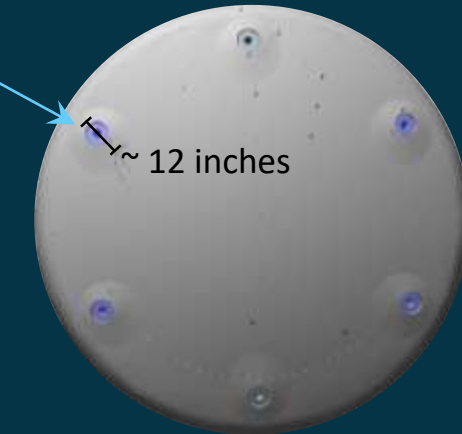
Degradation from atmosphere



Estimated blurring



Compression pad (attachment points)



~ 12 inches

Spatially resolved imagery could be acquired for approximately 60 seconds

# Radiance Modeling: Determine Sensor Settings

SCIFLI provided synthetic imagery to sensor operator of the capsule signature as it would appear on their tracking monitor and recommended integration (exposure) times to avoid saturation.



**Estimate of IR sensor counts  
(Pre-Flight)**



Heat shield thermal signature in the near infrared (NIR) provided good temperature sensitivity

**Actual IR sensor counts  
(In-Flight)**



Advanced situational awareness resulted in no saturated images during desired period of observation

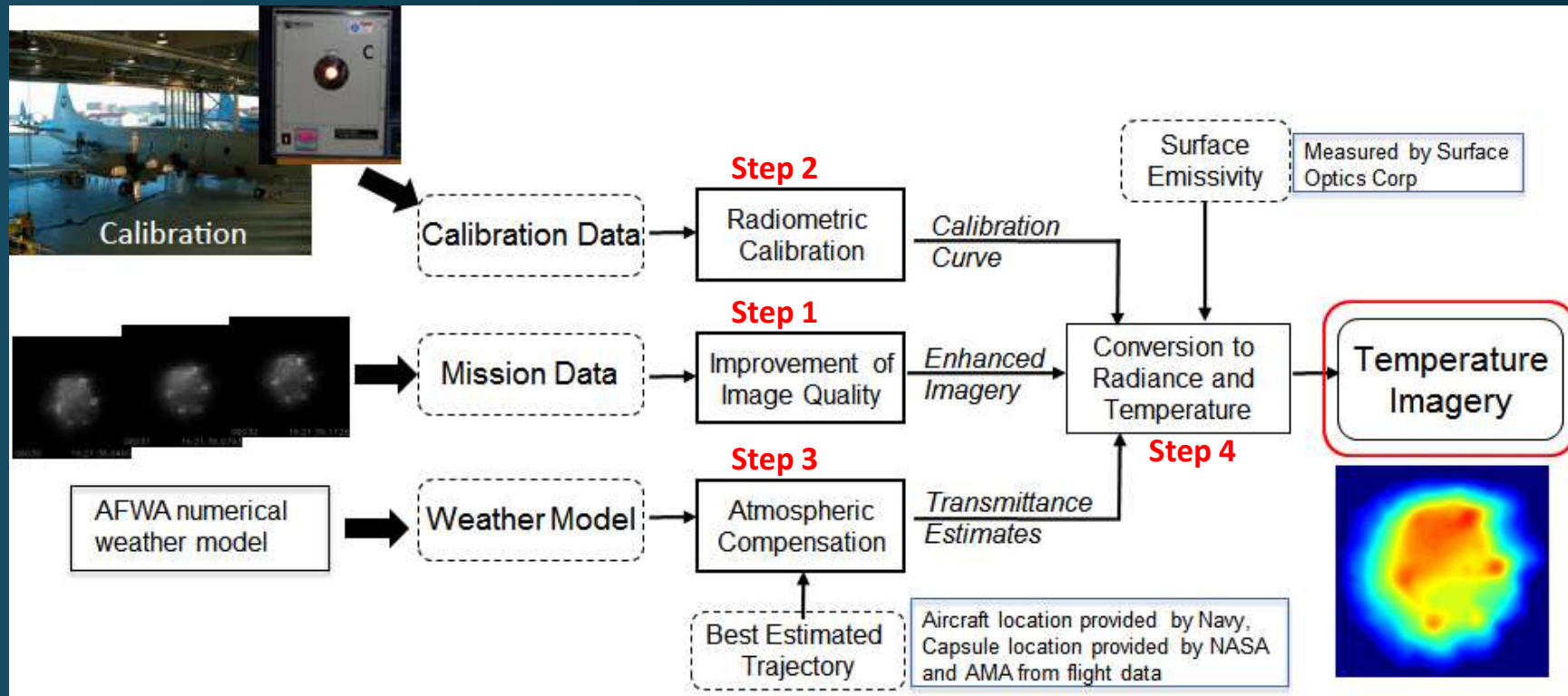
# Image Derived Temperature Maps



<b>Image Frame Number:</b>	7848	8028	8251	8474	8632
<b>Image Frame Time Reference (GMT):</b>	16:21:29.9917	16:21:35.9798	16:21:43.3983	16:21:50.8271	16:21:56.0939
<b>Mach number:</b>	9.91	9.33	8.66	8.04	7.63
<b>Target Range (nmi):</b>	65.1	57.2	49.2	43.3	40.6
<b>Target elevation (deg):</b>	15.4	17.4	20.2	22.7	24.1
<b>Raw Image Pixel Footprint (inches):</b>	17.1	15.0	12.9	11.4	10.7
<b>Capsule apparent pitch (angle of attack;deg):</b>	-19.1	-19.1	-19.2	-19.4	-19.4
<b>Capsule "up" (reference to z-axis; deg):</b>	18	18	18	-7	-9
<b>Capsule bank angle (deg):</b>	30.39	22.21	27.85	38.48	46.46
<b>Angle of l.o.s. to heatshield normal(deg):</b>	11.5	33.5	36.0	44.0	53.0
<b>Peak temperature (deg F):</b>	1940	1843	1760	1718	1643
<b>Minimum temperature (deg F):</b>	~1720	~1630	~1520	~1480	~1400
<b>Temperature (deg F):</b>					

# Data Analysis

Process of extracting temperature data from infrared radiance measurements performed by John Hopkins University Applied Physics Lab (JHU-APL)

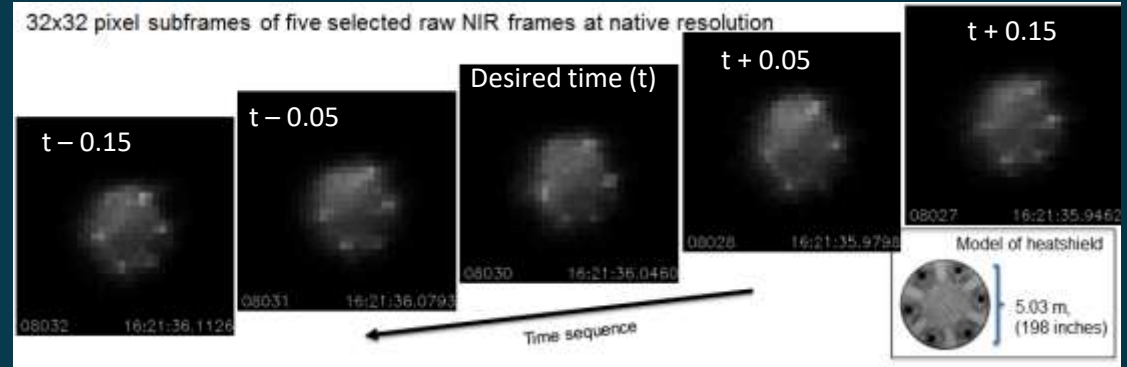


# Step 1: Data Conditioning

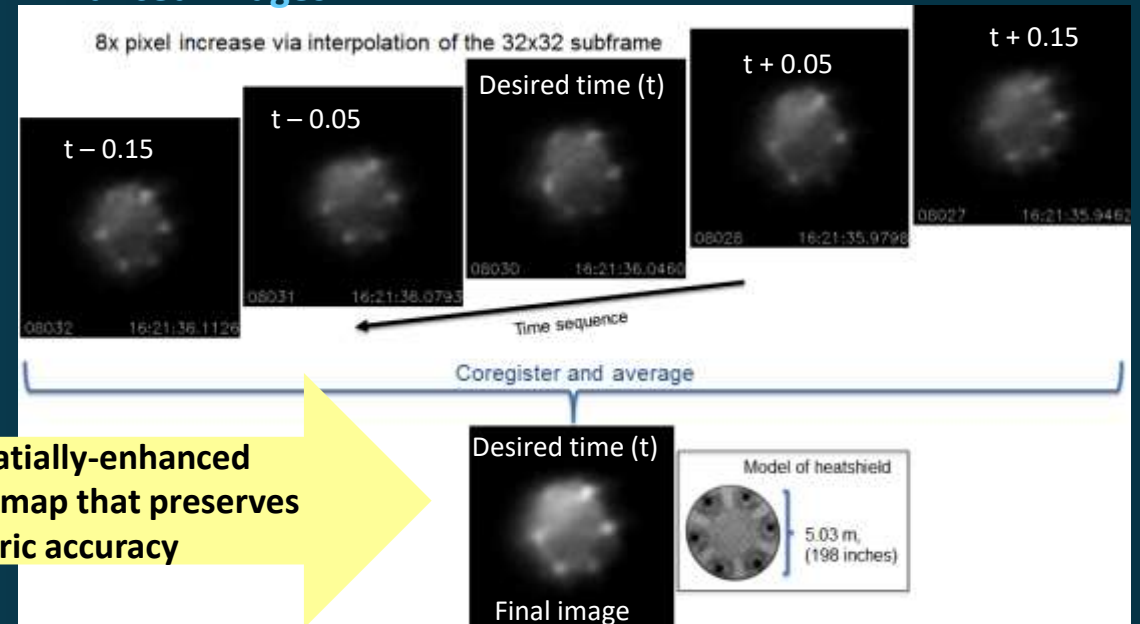


- Identify general time with minimal jitter and atmospheric blurring, free of clouds and no reaction control jet firings
- Select 5 quality frames within  $\sim 0.3$  sec of this time
- Increase effective spatial resolution with interpolation (8x)

## Native images

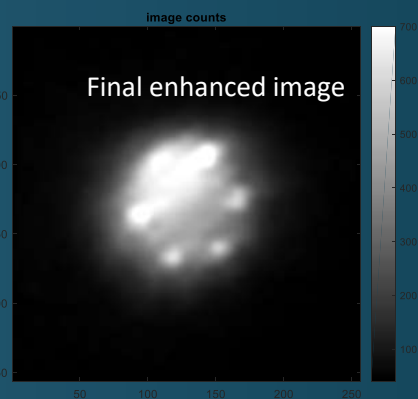


## Enhanced images

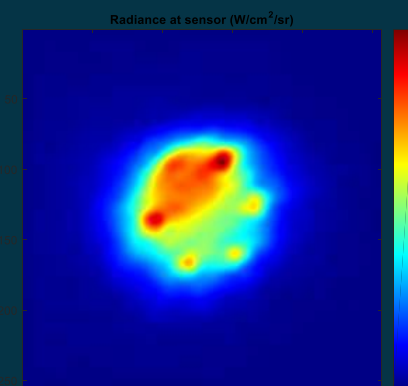
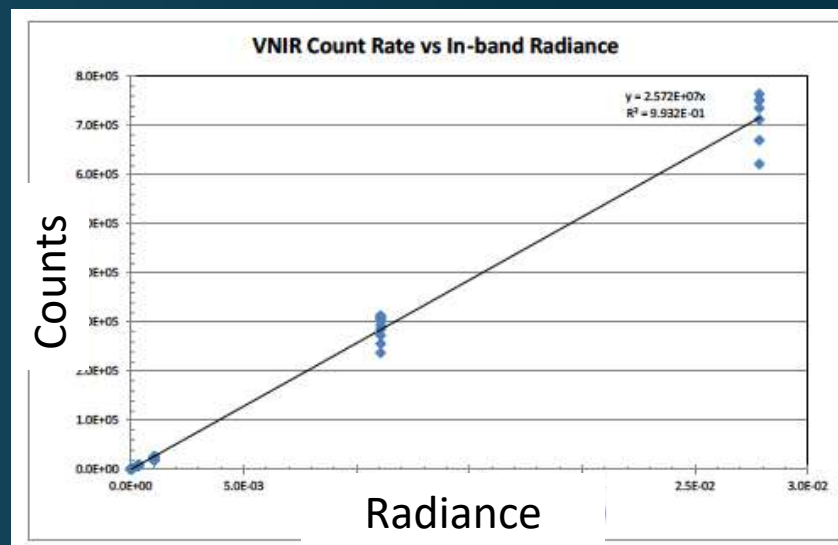


Single spatially-enhanced intensity map that preserves radiometric accuracy

# Step 2: Apply Radiometric Calibration

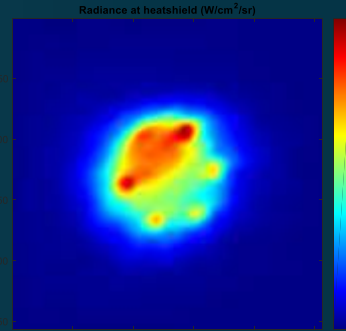


Counts measured at infrared sensor focal plane array



Irradiance measured at infrared sensor focal plane array

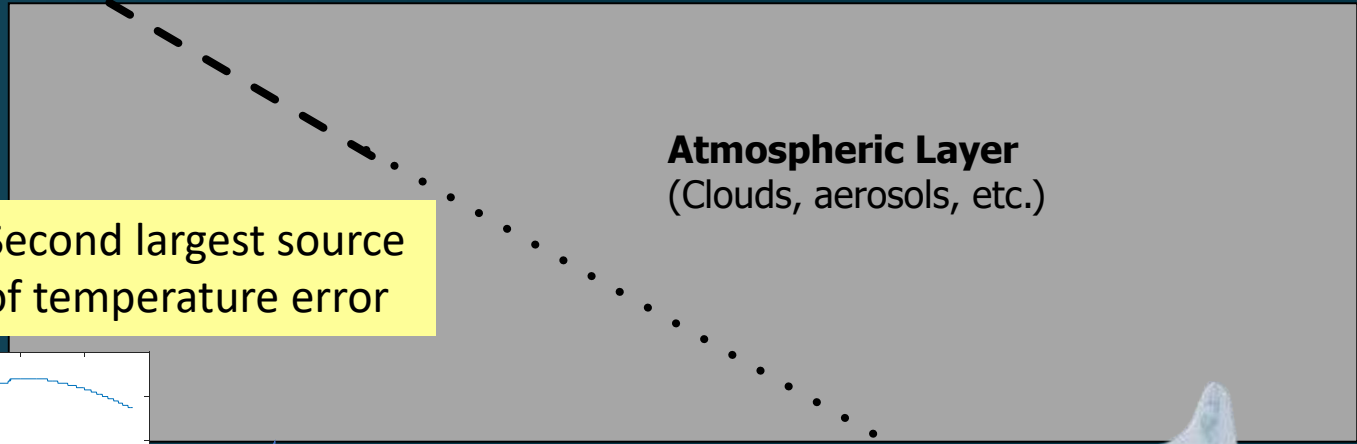
# Step 3: Atmospheric Compensation



Irradiance from heat shield

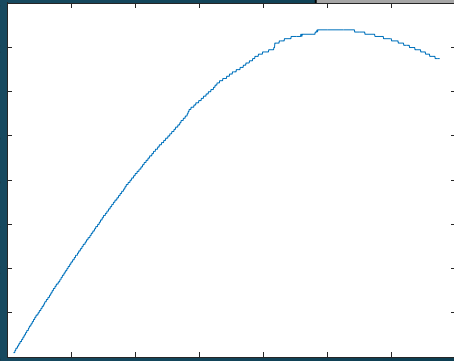
We want irradiance from heat shield surface

Second largest source of temperature error

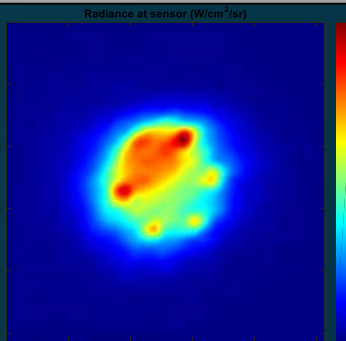


Atmospheric Layer (Clouds, aerosols, etc.)

Line of sight atmospheric transmittance



Time



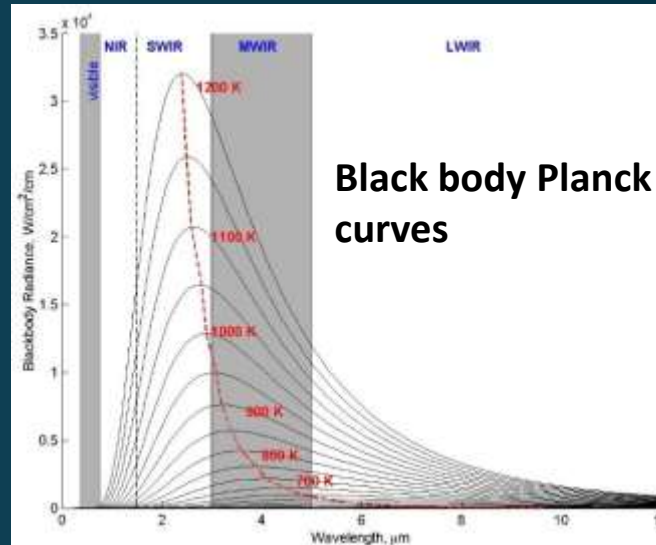
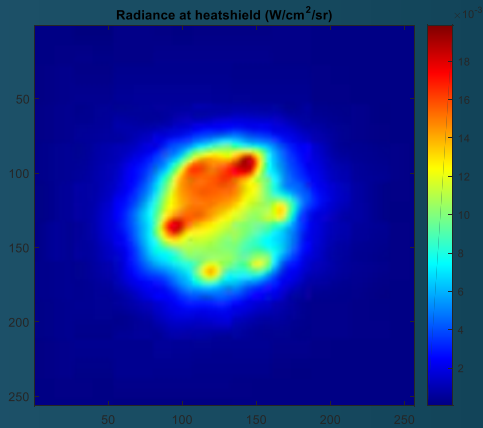
We made irradiance measurement at sensor focal plane array



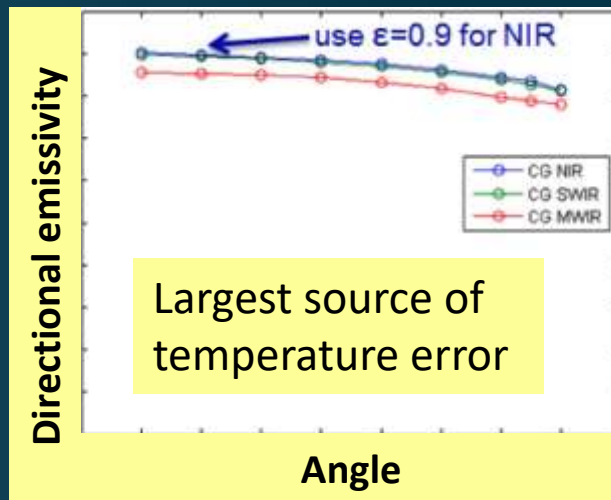
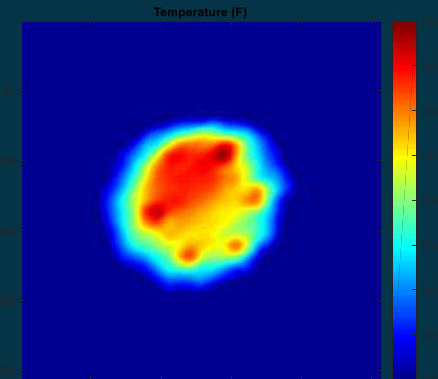
# Step 4: Conversion to Temperature



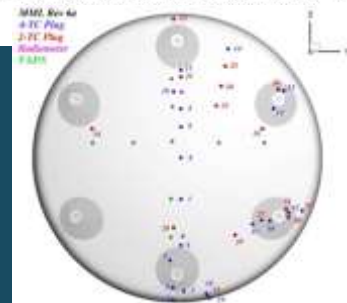
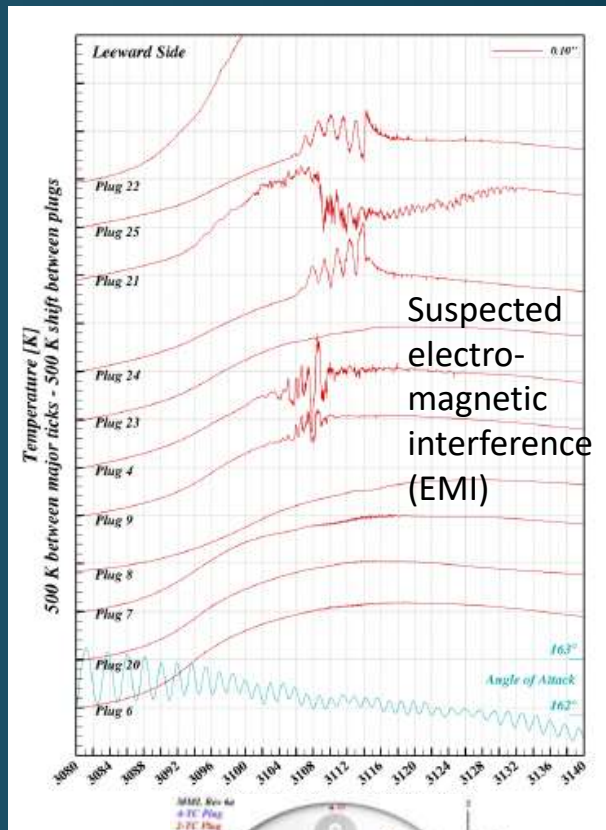
Irradiance from heat shield



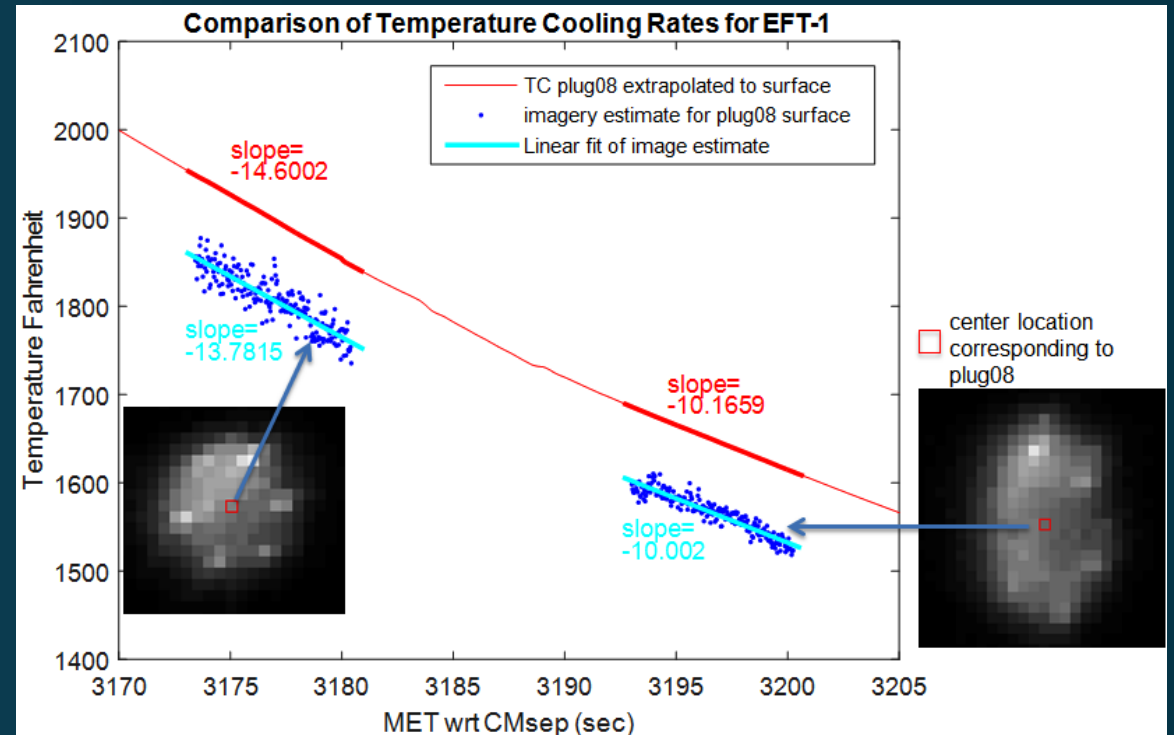
Surface temperature of heat shield



# Comparison to Other (Onboard) Flight Data



TC plug08



- Cooling rates (slopes) between TC and image derived temperature measurement are nearly identical
- Suggests temperature difference between measurement techniques is a bias error
- Remote imagery not susceptible to EMI effects



# TPS Performance – Launch, Staging, Reentry

# Launch: Plume-Induced Flow Separation

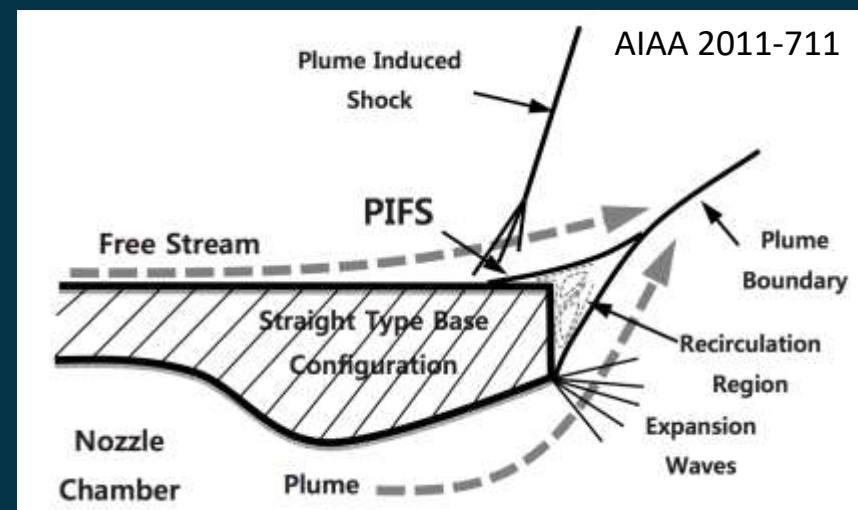


Seen on Saturn V – “dirty” kerosene flames are visible\*

\*The Airborne Lightweight Optical Tracking System (ALOTS) was used to observe the flow separation location on the Saturn V AS-506 (Apollo 11) vehicle in flight.

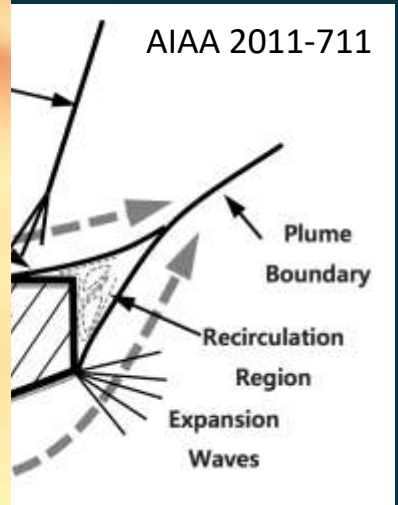
Flight data needed for validation of design models and the accurate assessment of thermal margin

SCIFLI will use infrared imaging to look for PIFS on SLS during Artemis I launch – invisible  $H_2/O_2$  flames





# aration

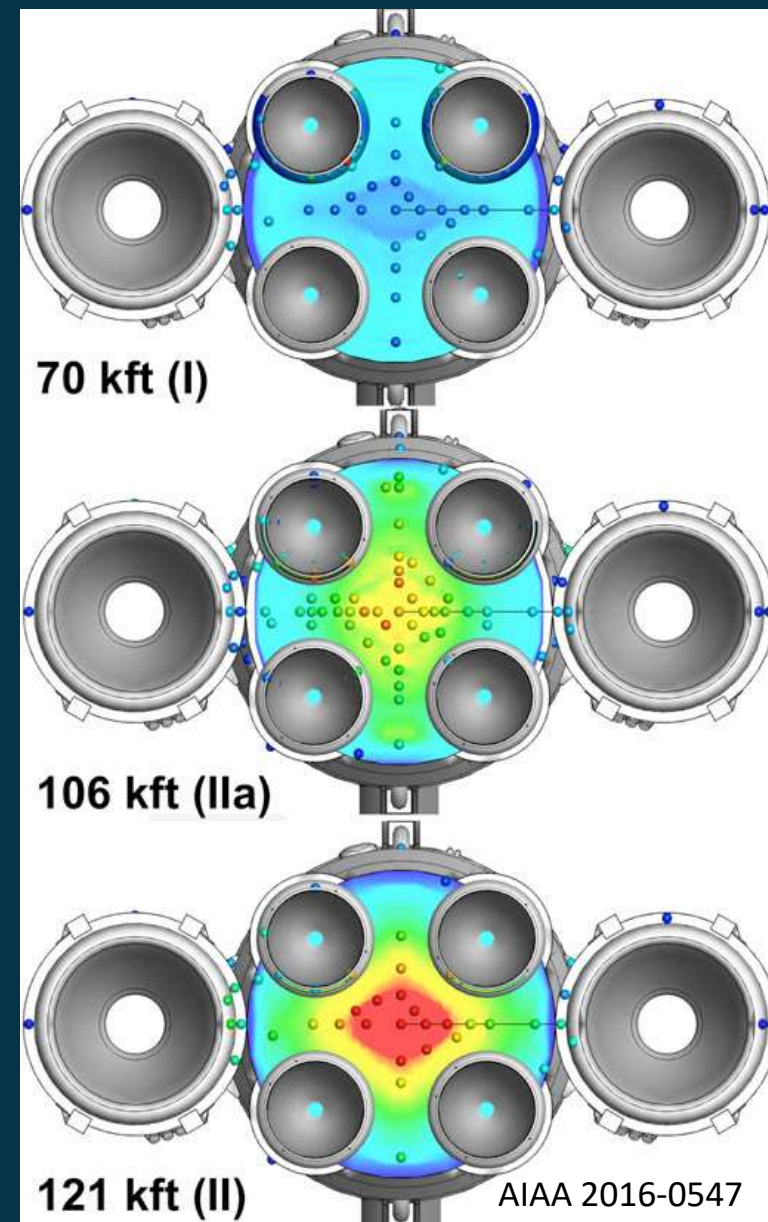


# Launch: SLS Core Stage Base Heating

- Baseflow physics expected to be significantly different than Saturn V, Delta IV Heavy, Atlas V, Falcon 9, and Falcon Heavy
- Experimental test data at CUBRC indicated higher base heating than predicted by CFD
- Flight data needed for validation and accurate assessment of thermal margins



SCIFLI tasked with making thermal measurements of SLS Core Stage base region during Artemis I launch

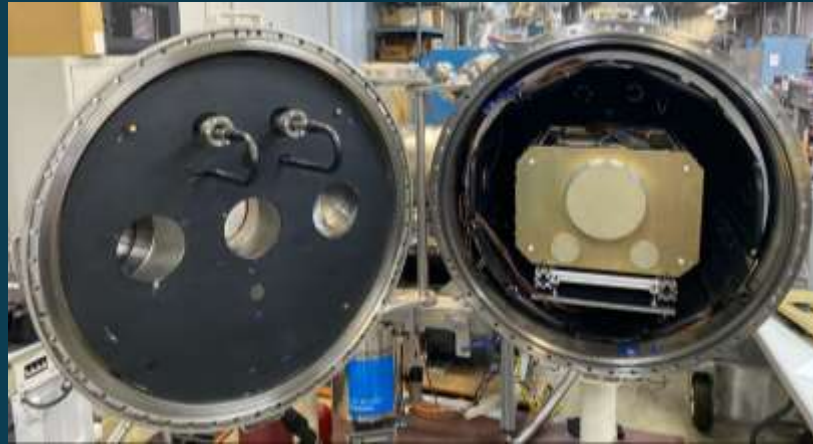




# SAMI

SCIFLI AIRBORNE MULTISPECTRAL IMAGER

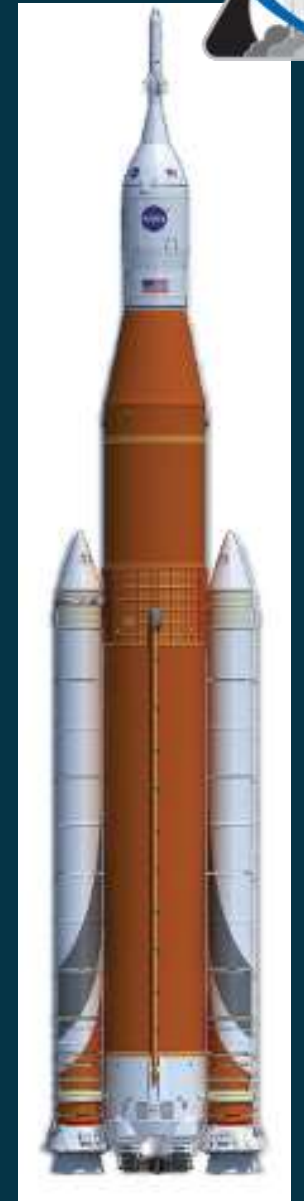
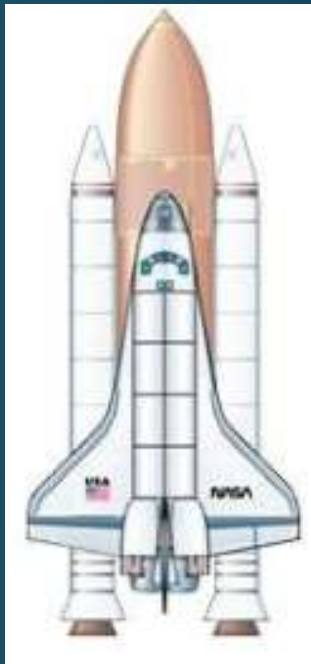
- State of the art sensors UV / Vis / IR
- Customizable narrowband filters
- Wide field of view – tracking
- Narrow field of view – spatial resolution



# Staging: Solid Rocket Booster Separation



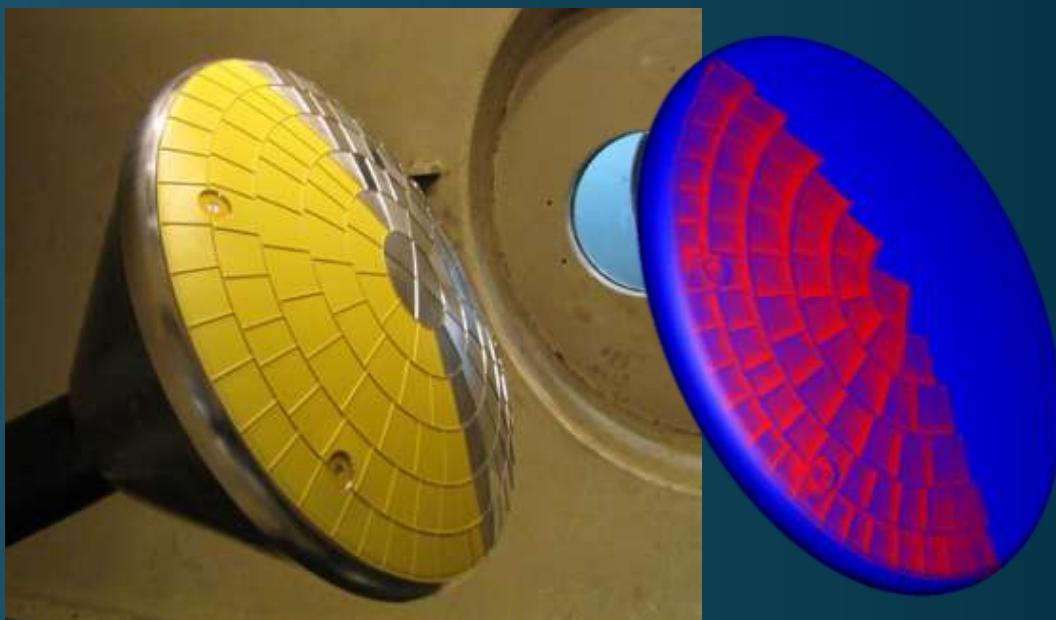
- Space Shuttle design – SRBs extended below main engines
- SLS design – SRBs are even with core stage
- CFD shows potential for re-contact after SRB separation
- SCIFLI tasked with imaging SRB separation during Artemis I
- Working with SpaceX on staging observations



# Reentry: Peak Heating



- New heatshield design—segmented ablator.
- Shuttle embedded thermocouples exhibited anomalous behavior and delivered unreliable, discrete surface temperature results
- SCIFLI actively seeking funding to conduct thermal observation

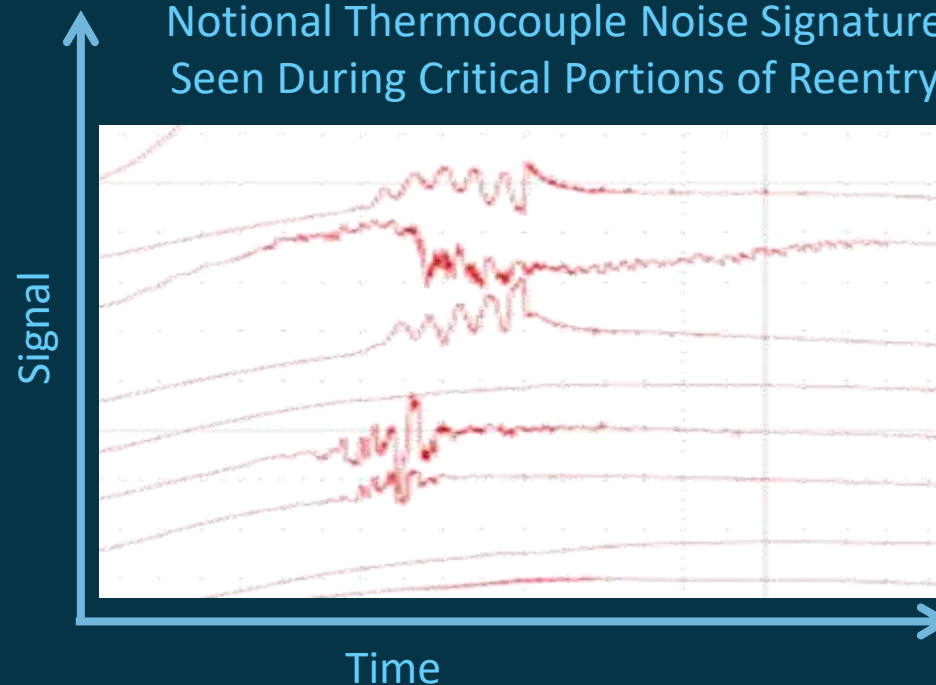


[https://www.nasa.gov/centers/ames/images/content/671692main\\_MarsScienceLabHeatshield017a%5B2%5D.jpeg](https://www.nasa.gov/centers/ames/images/content/671692main_MarsScienceLabHeatshield017a%5B2%5D.jpeg)  
Testing representative block-TPS layouts in 20-Inch Mach 6 with global phosphor thermography

Approximate reentry Mach numbers:

- Shuttle: 25
- EFT-1: 28
- Apollo: 36
- **Artemis I: 40**

Notional Thermocouple Noise Signature Seen During Critical Portions of Reentry



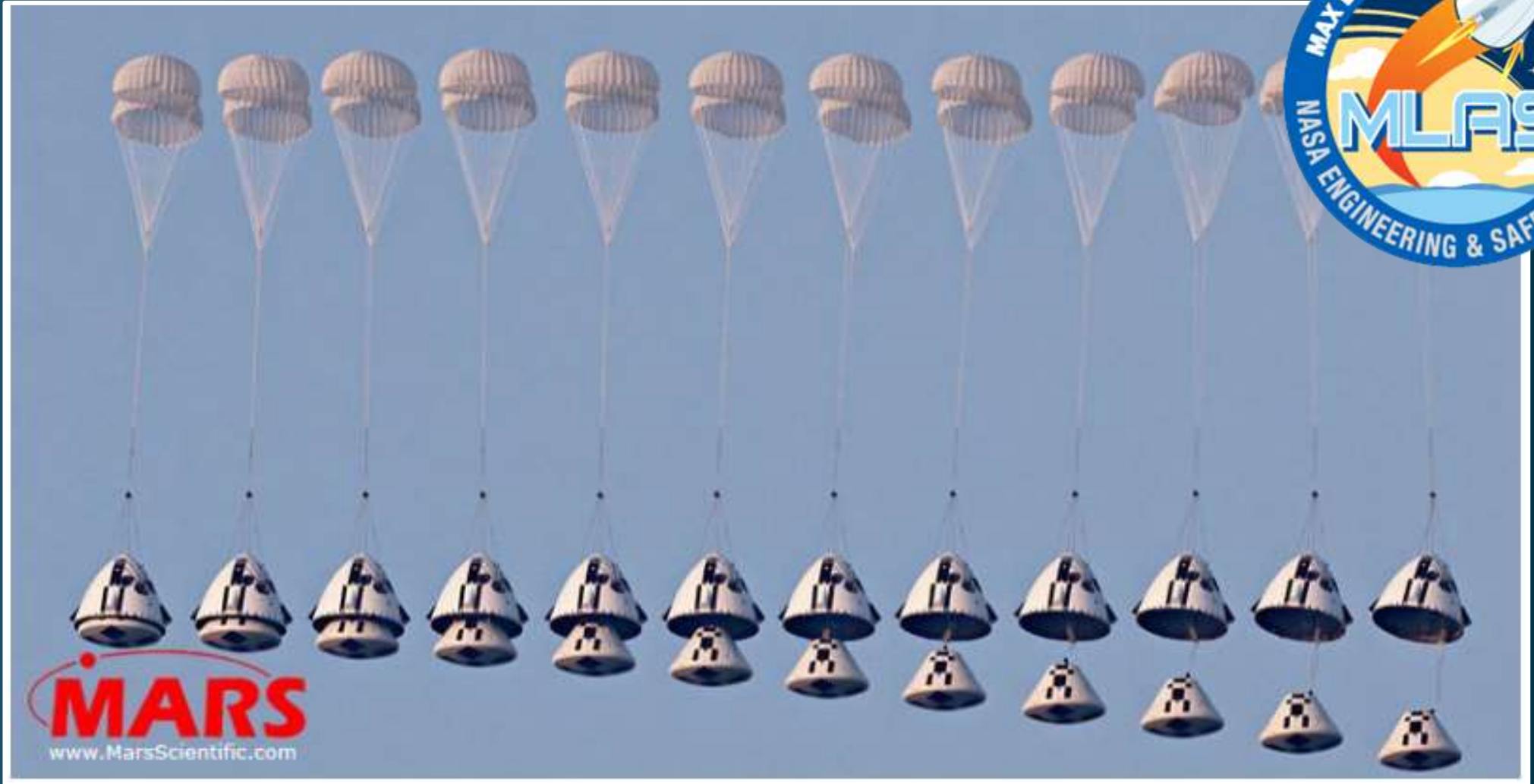
Behavior has been observed on:

- Shuttle Orbiter
- Dragon Capsule
- Orion Capsule



# Contingency Flight Safety Systems

# Orion Max Launch Abort Test (MLAS)



08 July 2009

# Soyuz MS-10 Launch Abort (Expedition 57)



11 Oct 2018



NASA/Bill Ingalls - [images-assets.nasa.gov/image/NHQ201810110007/NHQ201810110007~orig.tif](https://images-assets.nasa.gov/image/NHQ201810110007/NHQ201810110007~orig.tif)

NASA/Bill Ingalls - [images-assets.nasa.gov/image/NHQ201810110018/NHQ201810110018~orig.tif](https://images-assets.nasa.gov/image/NHQ201810110018/NHQ201810110018~orig.tif)

# Orion Ascent Abort 2 (AA-2)

02 July 2019



Photo credit: Tom Parent

Photo credit: NASA/Tony Gray and Kevin O'Connell

<https://blogs.nasa.gov/aa2/>



# Boeing Pad Abort Test (PAT)

04 November 2019



# SpaceX In-Flight Abort (IFA)

19 January 2020



NASA/Tony Gray

<https://www.flickr.com/photos/nasakennedy/49420609803/in/photostream/>



# Space Weather

# KiNET-X

Kinetic-scale energy and momentum transport experiment

16 May 2021

**KiNET-X**  
May 17th, 2021 (UTC)

**MARS**  
SCIENTIFIC

**MARS 2: Wide-Band Quick-Look**

**Location: N520NA**

Captured: 3840 x 2160, 24 FPS

Replayed: 1920 x 1080, 24 FPS (Real-Time)

MARS: Ronald F. Dantowitz  
RDantowitz@MarsScientific.com  
www.MarsScientific.com  
TEL: 802-888-MARS

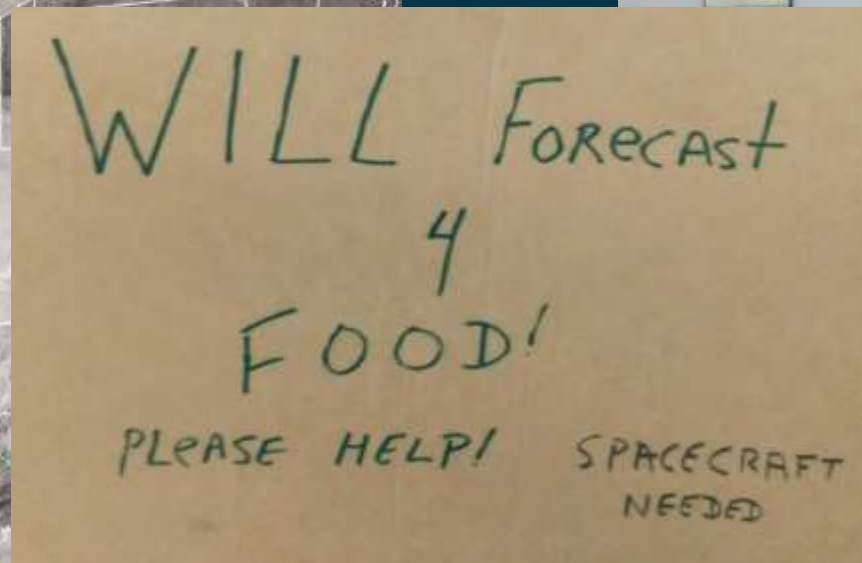
NASA: Carey F. Scott  
Carey.F.Scott@NASA.gov  
<https://SCIFLI.larc.nasa.gov>  
TEL: 757.864.8076



# Weather: Spaceflight Meteorology Group (SMG)

SMG provides detailed forecasts for all aspects of the mission including transit flights, road travel, dress rehearsals, launch sites, recovery sites, and potential observation locations.

**The contributions from SMG are critical to mission success**





# Super Fast

# Stardust



**Target:** Coma of Comet Wild 2

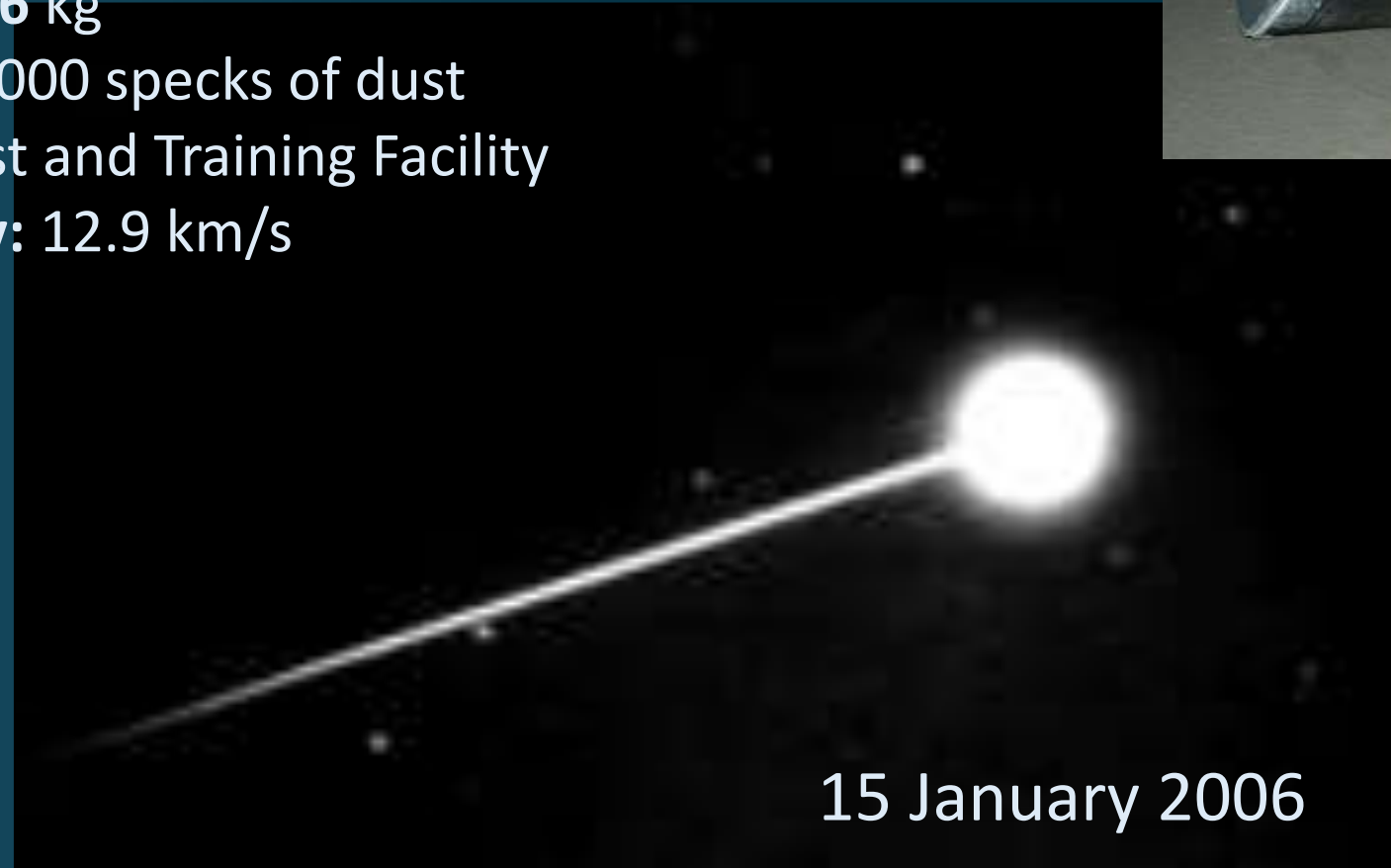
**Capsule Diameter:** 0.81 m

**Capsule Mass:** 46 kg

**Sample:** >1,000,000 specks of dust

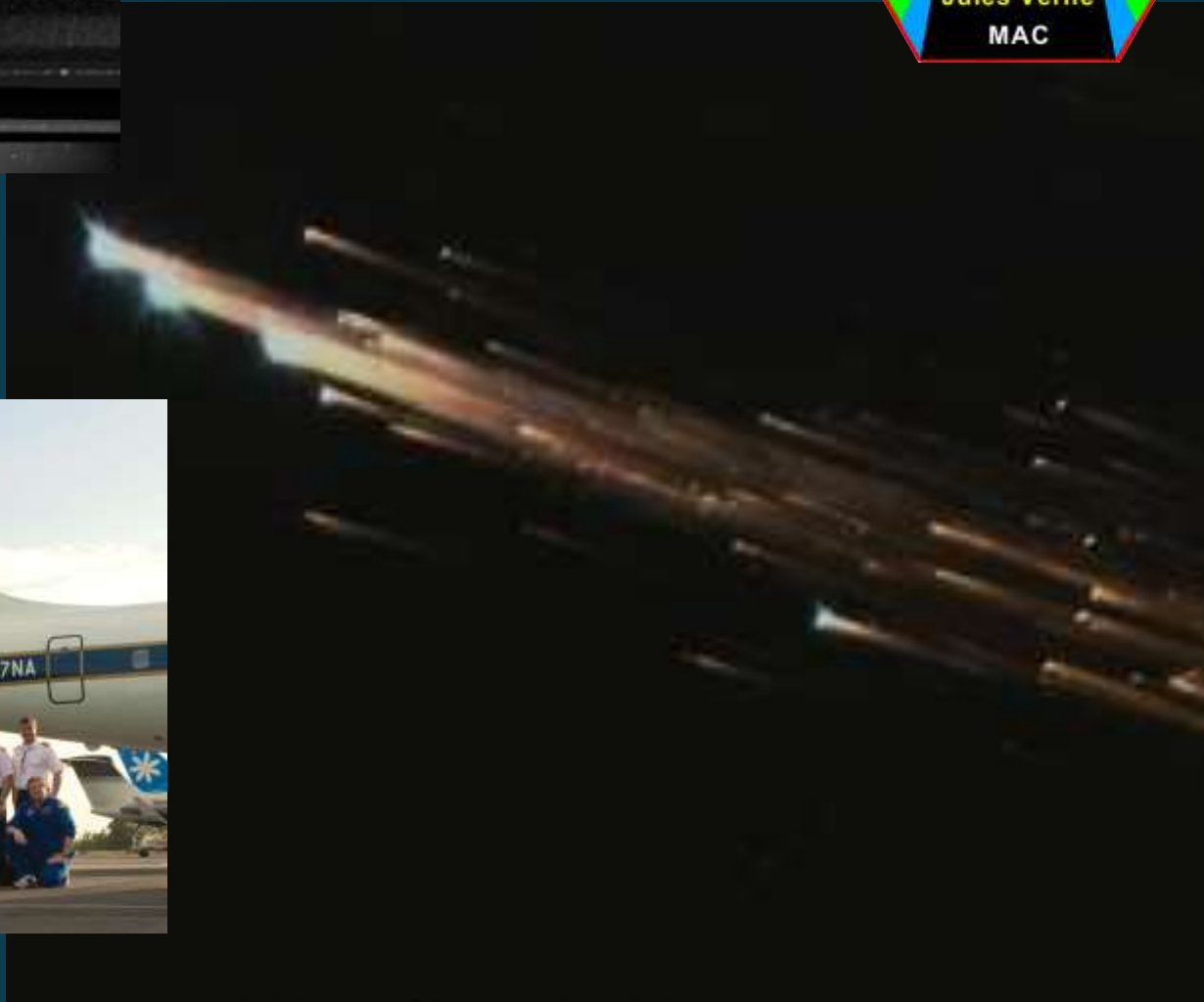
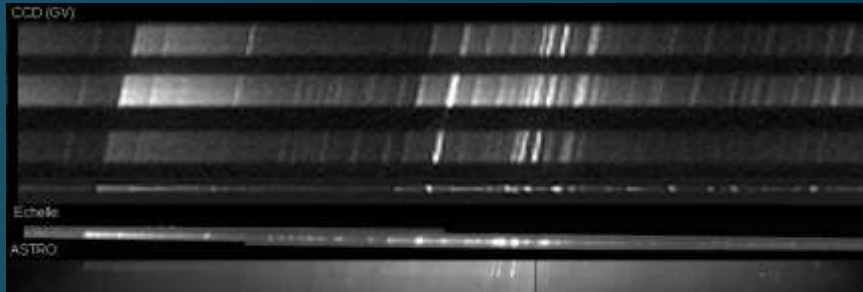
**Return:** Utah Test and Training Facility

**Reentry Velocity:** 12.9 km/s



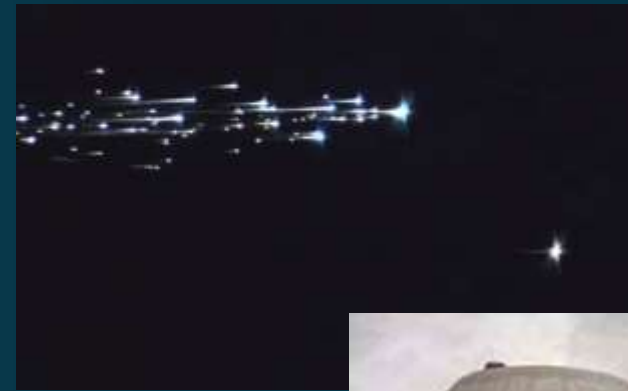
# European Space Agency ATV

29 September 2008



# Hayabusa

13 June 2010



Courtesy of JAXA

<https://ntrs.nasa.gov/api/citations/20160000307/downloads/20160000307.pdf>

**Target:** Asteroid Itokawa

**Capsule Diameter:** 0.4 m

**Capsule Mass:** 16.3 kg

**Sample:** ~1,500 rocky particle grains

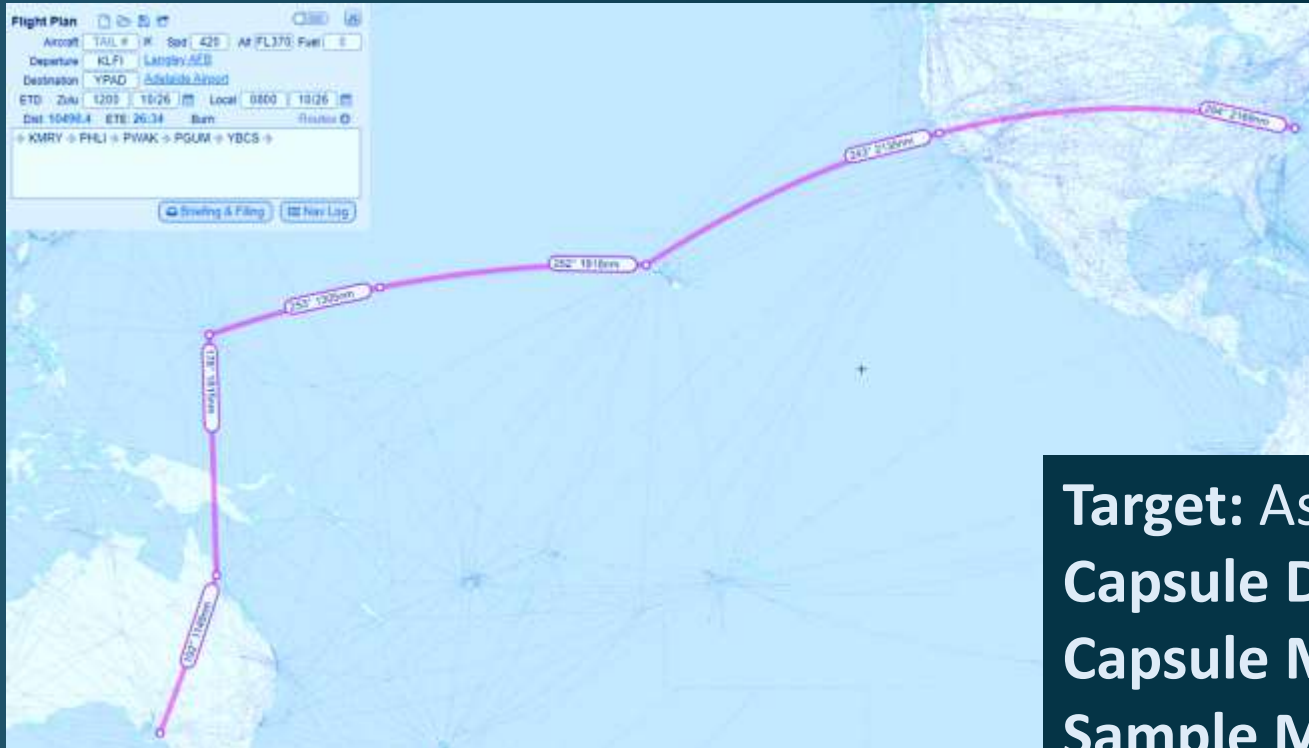
**Return:** Woomera Prohibited Area, Australia

**Reentry Velocity:** 12.2 km/s

# Hayabusa 2: SHARC

SCIFLI Hayabusa 2 Airborne Reentry Observation Campaign

05 December 2020



**Target:** Asteroid Ryugu

**Capsule Diameter:** 0.40 m

**Capsule Mass:** 16.3 kg

**Sample Mass:** 5.4 grams

**Return:** Woomera Test Range, Australia

**Reentry Velocity:** 12 km/s



# OSIRIS-REx

Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer

24 September 2023



**Target:** Asteroid Bennu

**Capsule Diameter:** 0.81 m

**Capsule Mass:** 46kg

**Sample Mass:** >60 grams

**Return:** Utah Test and Training Range

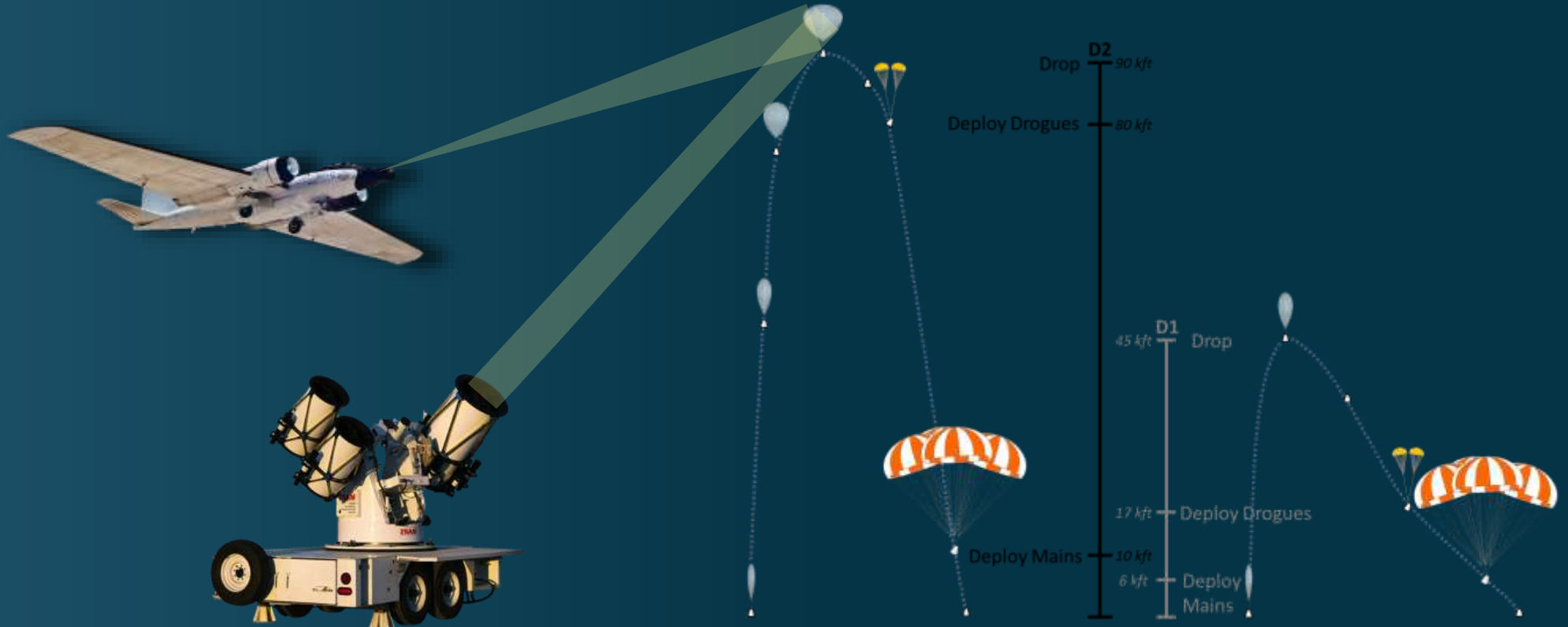
**Reentry Velocity:** 12.2 km/s



# Parachutes

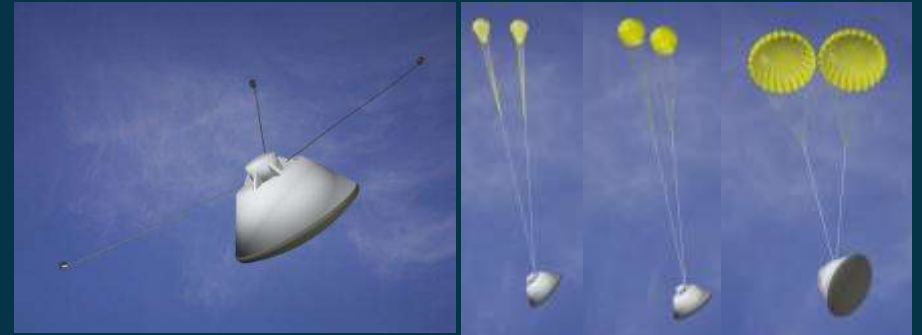
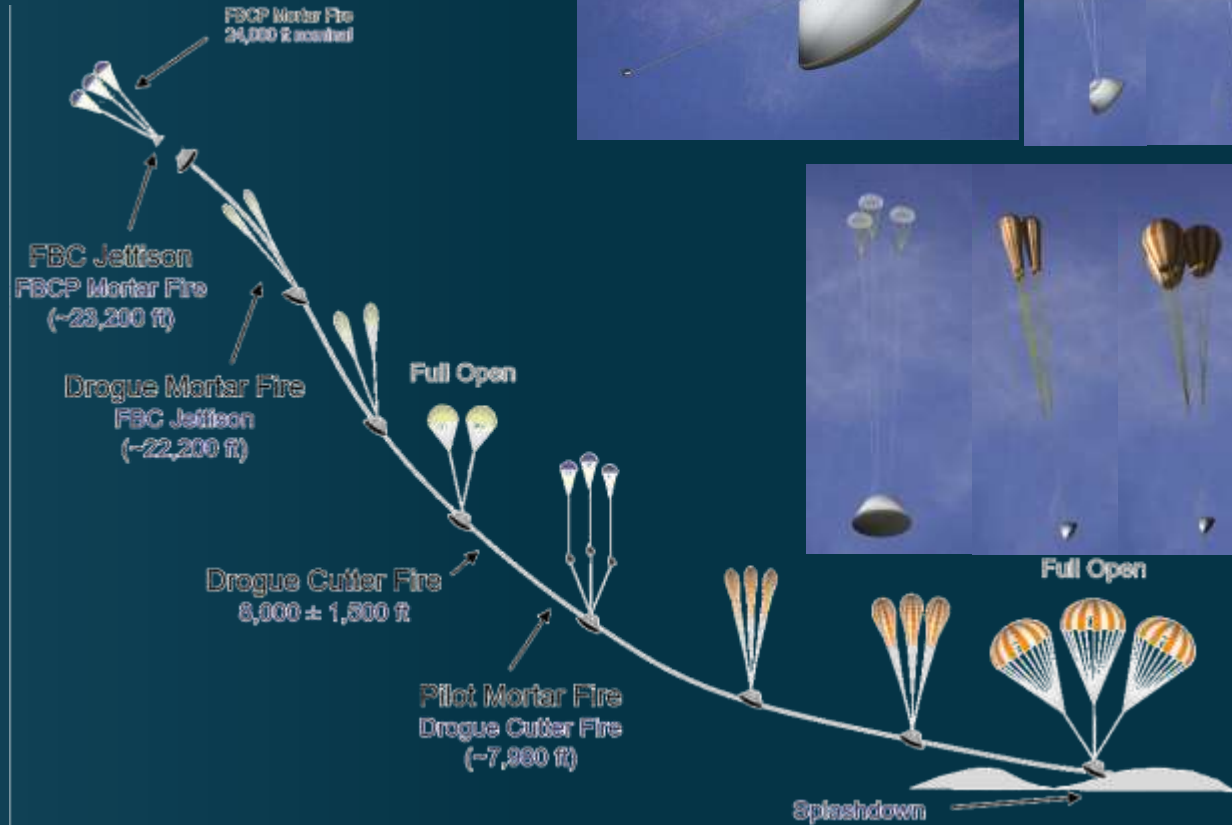
# Commercial Crew Parachute Testing

- Parachutes represent one of the largest drivers of “loss of crew” risk
- Dynamic and difficult to fully model
- Requires extensive flight testing
- High altitude and high speed performance is especially challenging
- Over 50 missions since February 2018 (!)



# Artemis I: Orion Parachute Deployment

SCIFLI tasked with observation of Forward Bay Cover (FBC) deployment, parachute deployment sequence, and splashdown





# Office Space



















# Encounters with Non-Humans











# Transportation



**THERE WILL BE  
A MINIMUM OF  
\$100.00 CHARGE FOR  
EXCESSIVE DIRTINESS  
UPON RETURN**



Getting there is half the fun!!!!





8/17/18

MARS

SCIFLI

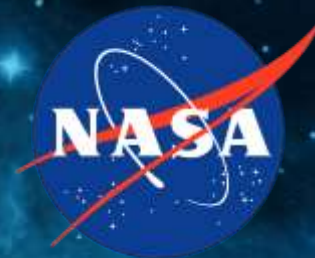
JUN California 8EKK453  
dmv.ca.gov

PLEASE  
HANDLE WITH CARE  
FRAGILE









# Desert Dining









# Accomodations





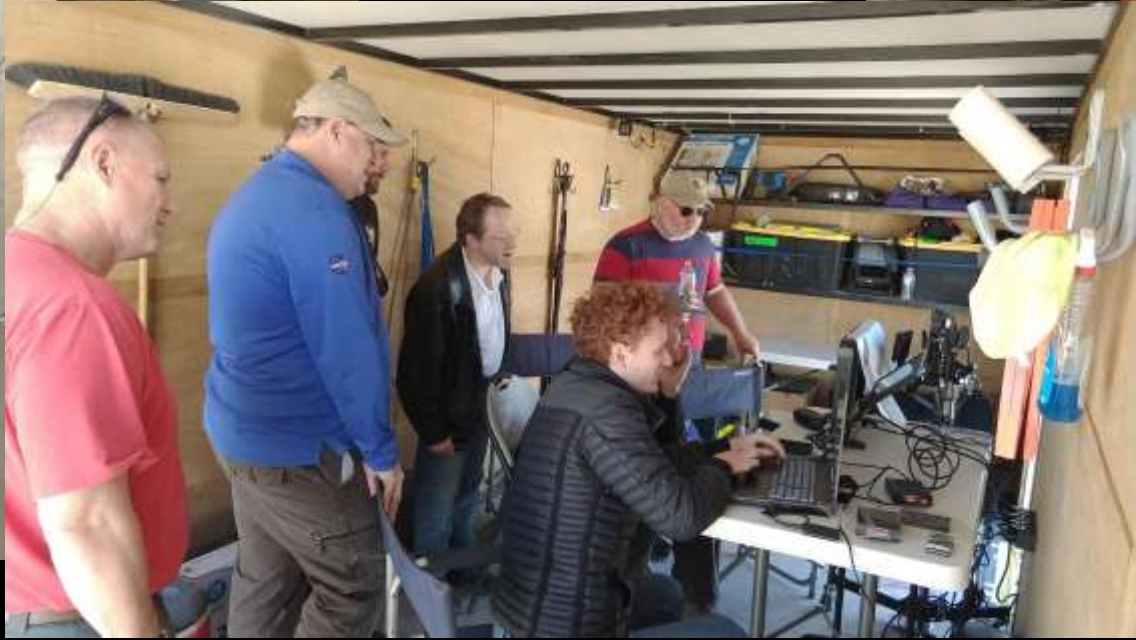
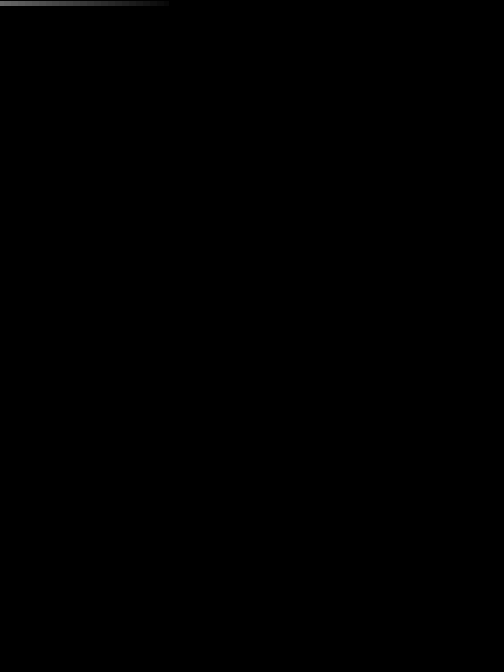






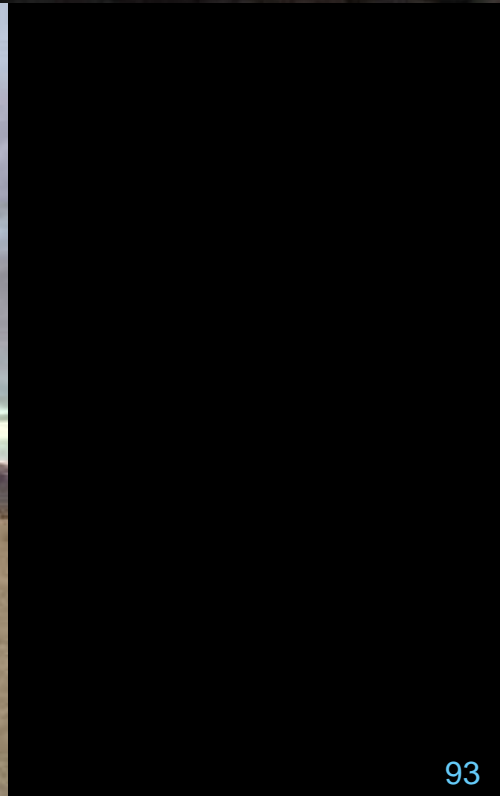


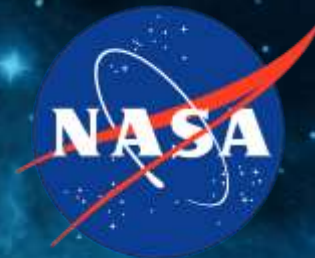




# Thoughts on Leadership Style







# BACKUP

# Parting thoughts



...when a flight test involves unique conditions (e.g. a new or extreme flight profile), and innovative vehicle design, or in the case of a developmental flight test laying the groundwork for future vehicle design, **“every effort should be made to acquire engineering data for these flights so that the full value of them can be realized by the Agency and engineering community at large.”**  
*NASA Engineering Safety Center perspective on flight instrumentation*

What was the cost associated with the two Hypersonic Test Vehicle (HTV-2) mishap investigations?



- Multiple Agencies involved
- 100's of wind tunnel runs
- 1+ years; 100+ personnel

...when we have a small failure on even an un[crew]ed flight test, **we spend sometimes years studying our navel to figure out what could possibly have gone wrong** before we've got the nerve to fly again.

*Mark Lewis, Former AIAA President / former Air Force Chief Scientist*

“Prior to [the second HTV] flight, the technical team completed the most sophisticated simulations and extensive wind tunnel tests possible. **But these ground tests [and simulations] have not yielded the necessary knowledge.** Filling the gaps in our understanding of hypersonic flight in this demanding regime requires that we be willing to fly.”

*Regina Dugan, DARPA Director*

# Proven Capability

A History Of Successful Data Capture

## Who We Are

The Scientifically Calibrated In-Flight Imagery (SCIFLI) team is a multi-organizational team comprised of engineers, scientists and subject matter experts with a proven track record of delivering flight-truth datasets for Agency, commercial, DoD, and International customers.

The SCIFLI team has conducted over 60 successful observation campaigns, including developmental parachute testing, demonstration/validation missions of new spacecraft, and operational crewed spaceflight missions.

## What We Do

SCIFLI is a success-oriented team that provides unique, engineering data of spacecraft and spacecraft systems in an actual flight environment to support verification of engineering design tools, vehicle health monitoring analyses, and validation and certification of spacecraft.

Capabilities include:

- High-resolution, high-speed imaging
- Calibrated multispectral thermal imaging
- Hyperspectral imaging
- Live streaming video

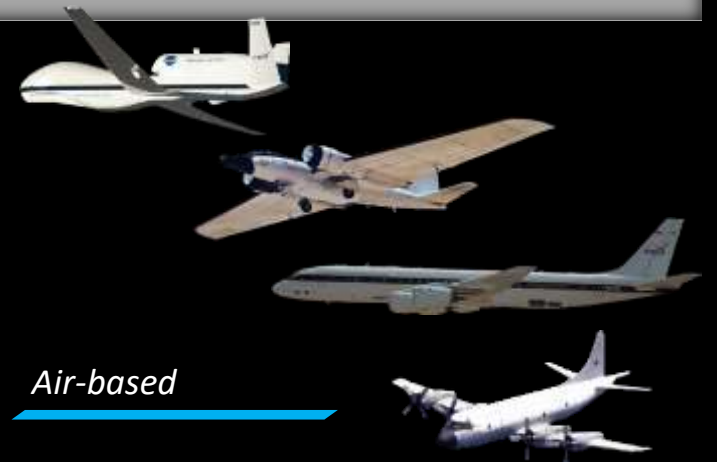
Ground-based



Sea-based

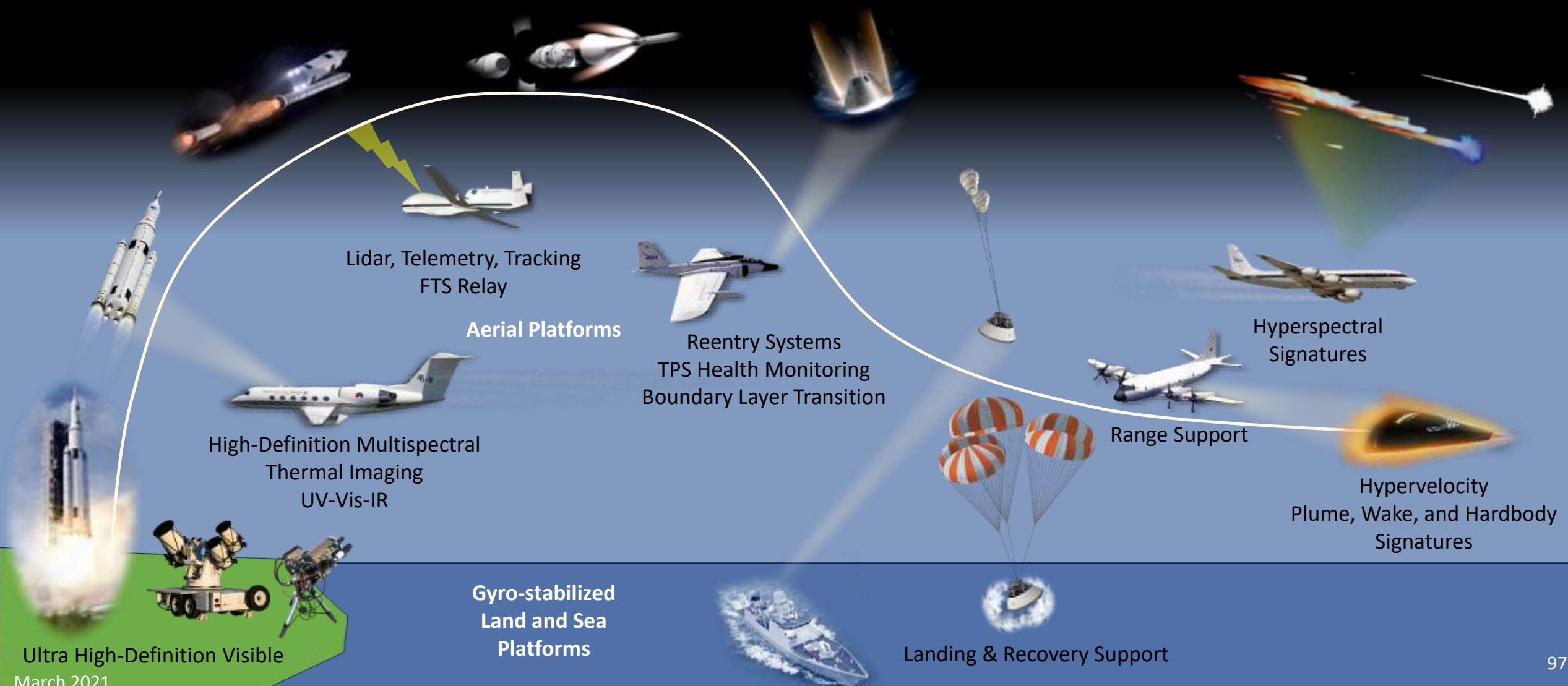


Air-based



# Mission-Driven Imaging Solutions

Highly Customizable Mission Architectures For Critical Data Capture



# Host Platforms



## Airborne

WB-57 (NASA JSC)

P-3 Orion (Navy)

G-III and G-IV (NASA LaRC, JSC, AFRC)

DC-8 (NASA AFRC)

Global Hawk (NASA AFRC)



## Ground-Based

Mobile Aerospace Reconnaissance System (MARS)

Telescience Research and Technology Support (TRaTS)



## Seaborne

TRaTS

MARS housed in gyrostabilized system



# Electro-Optical Imagers



## DyNAMITE (Day Night Airborne Motion Imagery for Terrestrial Environments)

Full motion gimbal mounted sensor package in nosecone of WB-57 at JSC/Ellington

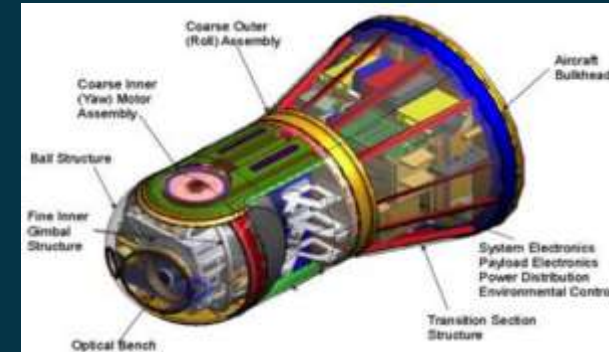
MWIR and Visible



## Cast Glance

Gyro-stabilized gimballed mirror and 7-inch telescope plus computer aided pointing system, mounted in P-3 Orion aircraft at Pt. Magu, CA

Visible, NIR, SWIR, MWIR



## HAARTS (High-fidelity Automated Airborne Reconfigurable Tracking System)

Sensor package that will be installed on the NASA Global Hawk uncrewed air vehicle

## SAMI (SCIFLI Airborne Multispectral Imager)

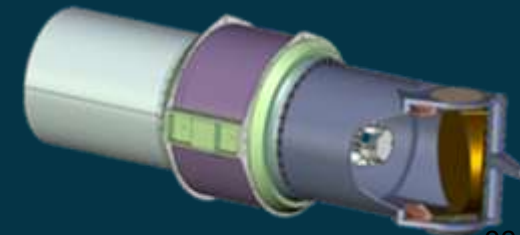
Sensor package to be installed on NASA Langley aircraft



## MARS (Mobile Aerospace Reconnaissance System)

Ground-based or gyrostabilized Kineto Tracking Mount (KTM) for ground or ship-based telescopic surveillance of aerospace vehicles

Visible, Infrared, Spectrographic, Hyperspectral



# Partners

NASA

Langley Research Center

Aerothermodynamics Branch

Advanced Measurement and Data Systems Branch

Space Technology and Exploration Directorate

Direct-funded contractors



# The SCIFLI Team



Tom Horvath,  
Principal Investigator



Jennifer Inman,  
Project Manager



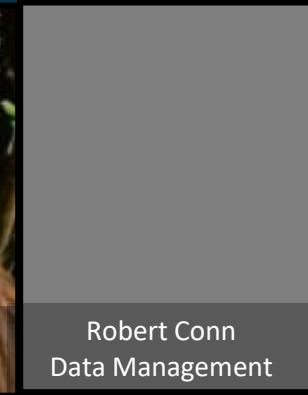
Carey "CJ" Scott  
Deputy PI



Rich Schwartz  
Mission Coordinator



Meaghan McCleary  
Mission Operations



Robert Conn  
Data Management



Melinda Cagle  
Project Manager



Robbie Kerns  
Project Management  
Support



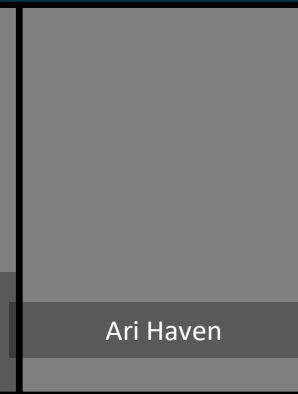
Nicole Hintermeister  
Project Scheduler



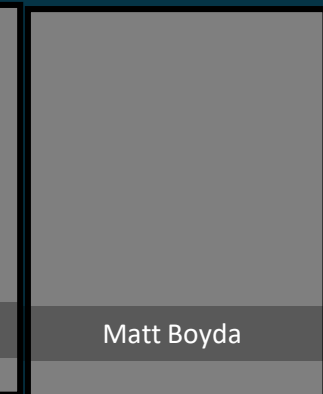
Harry Verstynen,  
retired NASA test pilot  
Asset Coordinator



Jeff Doughty  
Project Financial  
Analyst



Ari Haven



Matt Boyda

# Partners

## NASA

### Langley Research Center

- Aerothermodynamics Branch
- Advanced Measurement and Data Systems Branch
- Space Technology and Exploration Directorate
- Direct-funded contractors
- Aeronautics Research Mission Directorate Project Office
- HU-25 Falcon Jet aircraft

### Johnson Space Center/Ellington Field

- Spaceflight Meteorology Group
- Image Science & Analysis Group
- WB-57 High-Altitude Research / Airborne Science Program
- Flight Operations Division

### Armstrong Flight Research Center

- Global Hawk

### Ames Research Center

## Commercial

Opto-Knowledge Systems, Inc. (OKSI)

MARS Scientific (Mobile Aerospace Reconnaissance System)

- Analytical Mechanics Associates (AMA)
- The Aerospace Corporation

## Academia

Johns Hopkins Applied Physics Laboratory (APL)

## Department of Defense

Naval Air Systems Command (NAVAIR)

Air Test and Evaluation Squadron 30 (VX-30) and Cast Glance

## Non-Profit

Southern Research Institute (DYNAMITE sensor package)

