Scientifically Calibrated In-Flight Imaging

NASA Langley Research Center

Enabling Exploration and Advancing Spaceflight Safety

Presented to:

Langley Alumni Association

August 2026

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Flight Data - Enabling Exploration

A History Of Successful Data Capture

Who We Are

The Scientifically Calibrated In-Flight Imagery (SCIFLI) team comprises engineers, scientists, and subject matter experts with a proven track record of delivering flight-truth data sets to government, DoD, commercial, academic, and international partners since 2003.

What We Do

SCIFLI is a success-oriented team that provides engineering datasets to help investigators truly understand the behavior of vehicles under extreme conditions. Our portfolio includes over 80 missions ranging in complexity across all flight regimes.

Capabilities include:

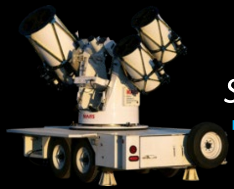
- Live video streaming
- Calibrated thermal imaging
- High-resolution & high-speed imaging
- Super resolution, image enhancement & deconvolution
- Hyperspectral / multispectral imaging

Example Flight Regimes Include:

- Subsonic and transonic drop testing
- Superorbital / deep-space sample return
- LEO and suborbital entry, descent, & landing
- Launch vehicle ascent, booster, & plume phenomena
- Launch abort, early-end-of-mission, flight termination sequence
- Upper atmospheric plasma and charged particle phenomenology

We Design, Develop & Deploy Mission-Specific Imaging Solutions to Answer Engineering Questions.

Ground-based

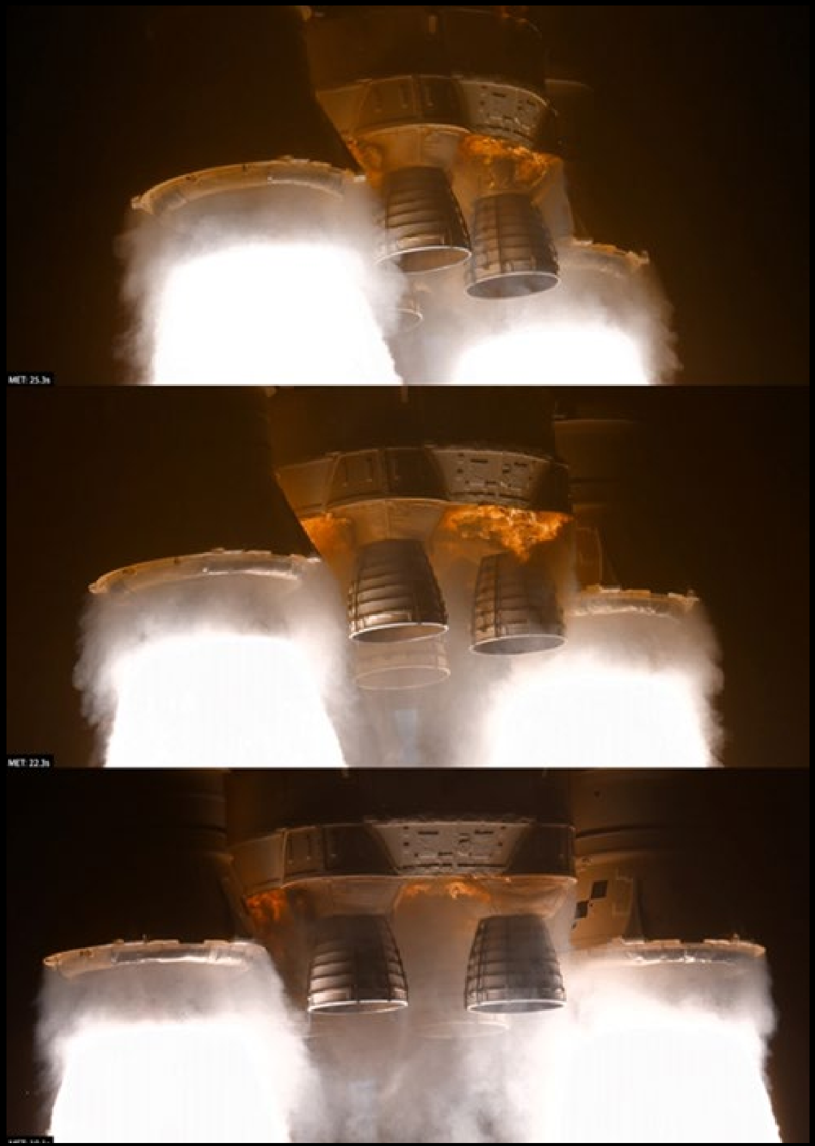


Sea-based

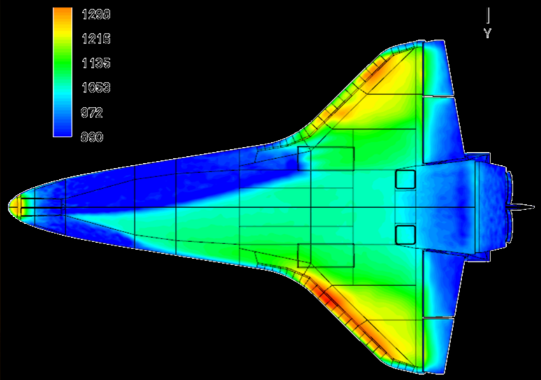
Airborne

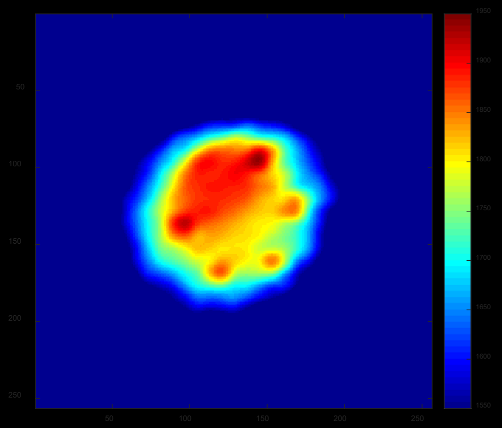
Flight Data to Answer Engineering Questions

High-Speed High-Resolution

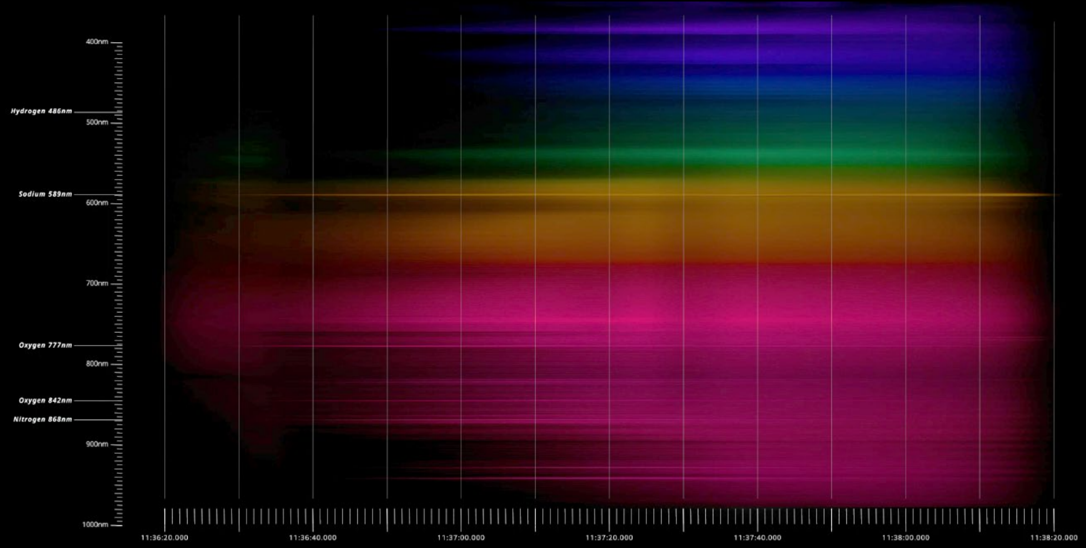


Thermal Imaging





Spectroscopy



- Detailed dynamics (e.g. debris trajectories, rotation rates, event timing)
- Global temperature
- Heat Flux
- Ablation
- TPS performance
- Validate aerothermal predictions

Everything Changes February 1st 2003

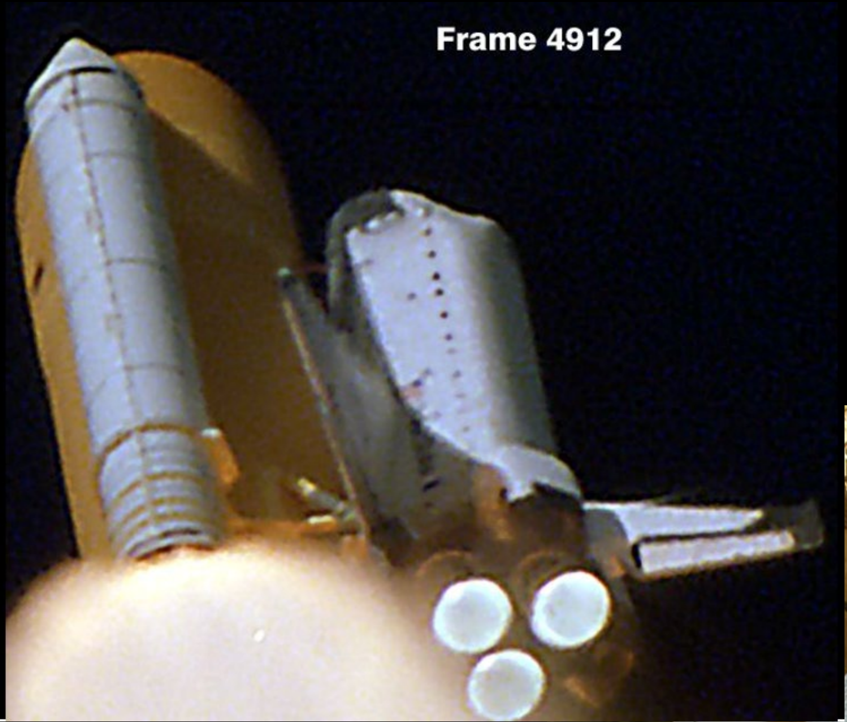
https://www.nasa.gov/image-feature/remembering-sts-107-and-her-crew

Requirements to Return to Flight

- Understand the physical cause
- Mitigate risk from a compromised thermal protection system

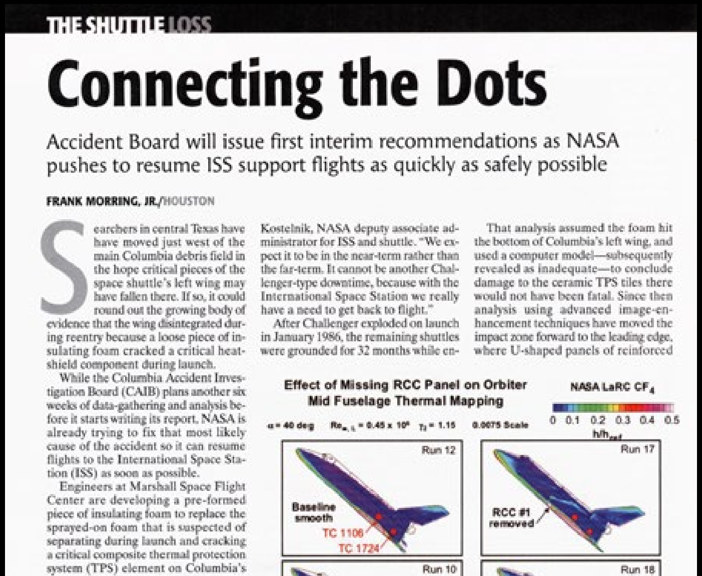
Required tool development by Research Centers

Columbia Accident: STS-107



Tom Horvath in
20-Inch Mach 6

Aviation Week & Space
Technology, 14 April 2003



THE SHUTTLE LOSS

Connecting the Dots

Accident Board will issue first interim recommendations as NASA pushes to resume ISS support flights as quickly as safely possible

FRANK MORRING, JR./HOUSTON

Searchers in central Texas have have moved just west of the main Columbia debris field in the hope critical pieces of the space shuttle's left wing may have fallen there. If so, it could round out the growing body of evidence that the wing disintegrated during reentry because a loose piece of insulating foam cracked a critical heat-shield component during launch.

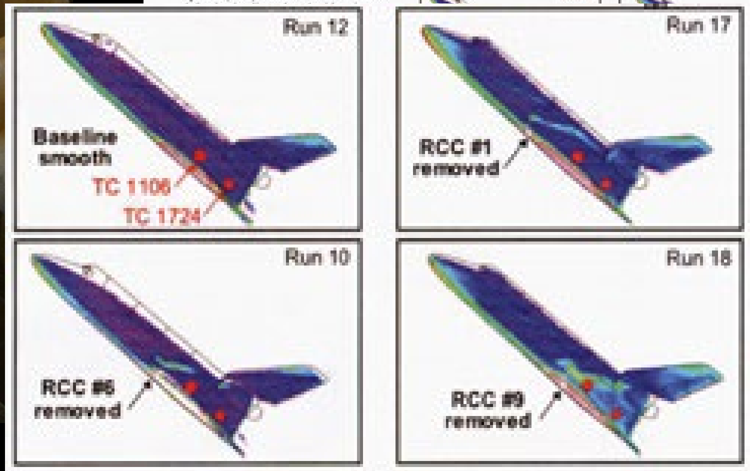
While the Columbia Accident Investigation Board (CAIB) plans another six weeks of data-gathering and analysis before it starts writing its report, NASA is already trying to fix that most likely cause of the accident so it can resume flights to the International Space Station (ISS) as soon as possible.

Engineers at Marshall Space Flight Center are developing a pre-formed piece of insulating foam to replace the sprayed-on foam that is suspected of separating during launch and cracking a critical composite thermal protection system (TPS) element on Columbia's

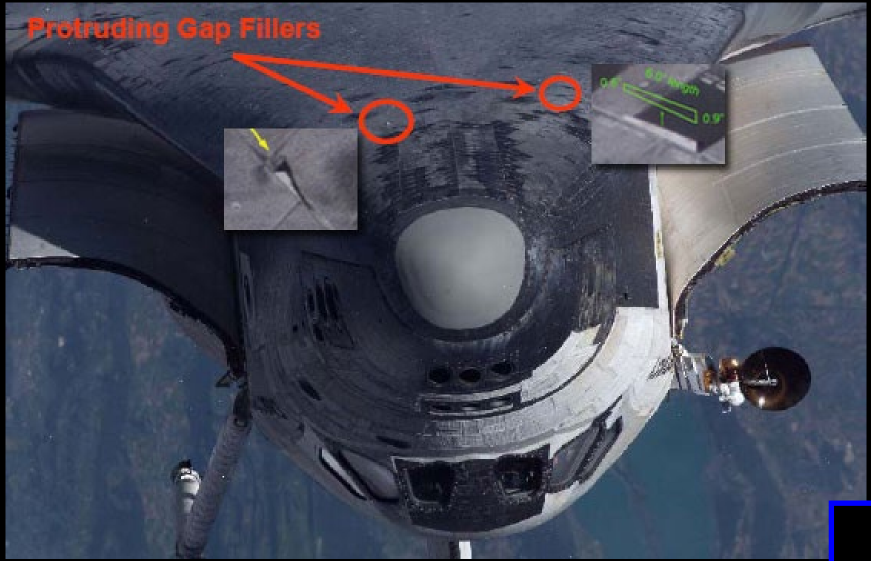
Kostelnik, NASA deputy associate administrator for ISS and shuttle. "We expect it to be in the near-term rather than the far-term. It cannot be another Challenger-type downtime, because with the International Space Station we really have a need to get back to flight."

After Challenger exploded on launch in January 1986, the remaining shuttles were grounded for 32 months while en-

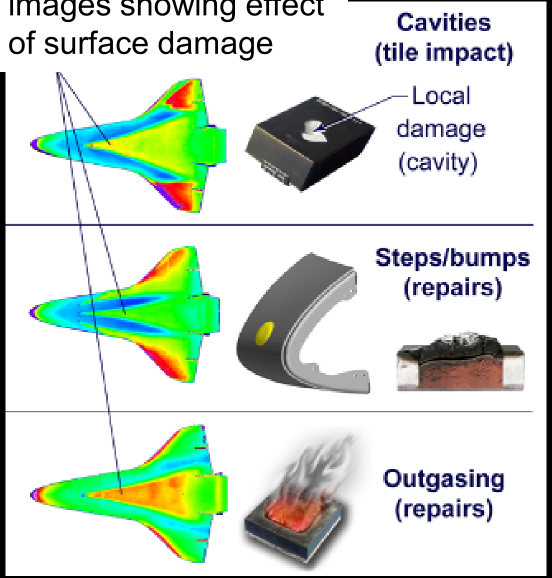
That analysis assumed the foam hit the bottom of Columbia's left wing, and used a computer model—subsequently revealed as inadequate—to conclude damage to the ceramic TPS tiles there would not have been fatal. Since then analysis using advanced image-enhancement techniques have moved the impact zone forward to the leading edge, where U-shaped panels of reinforced



Return-to-Flight: STS-114

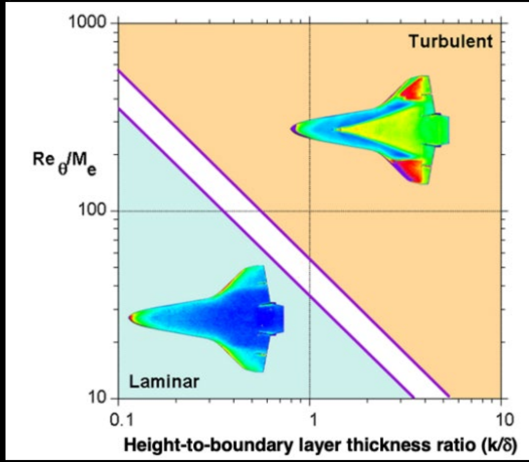


Wind tunnel thermal images showing effect of surface damage



Issue: If transition occurs above Mach 18, the Shuttle may experience unacceptably high internal structural temperatures.

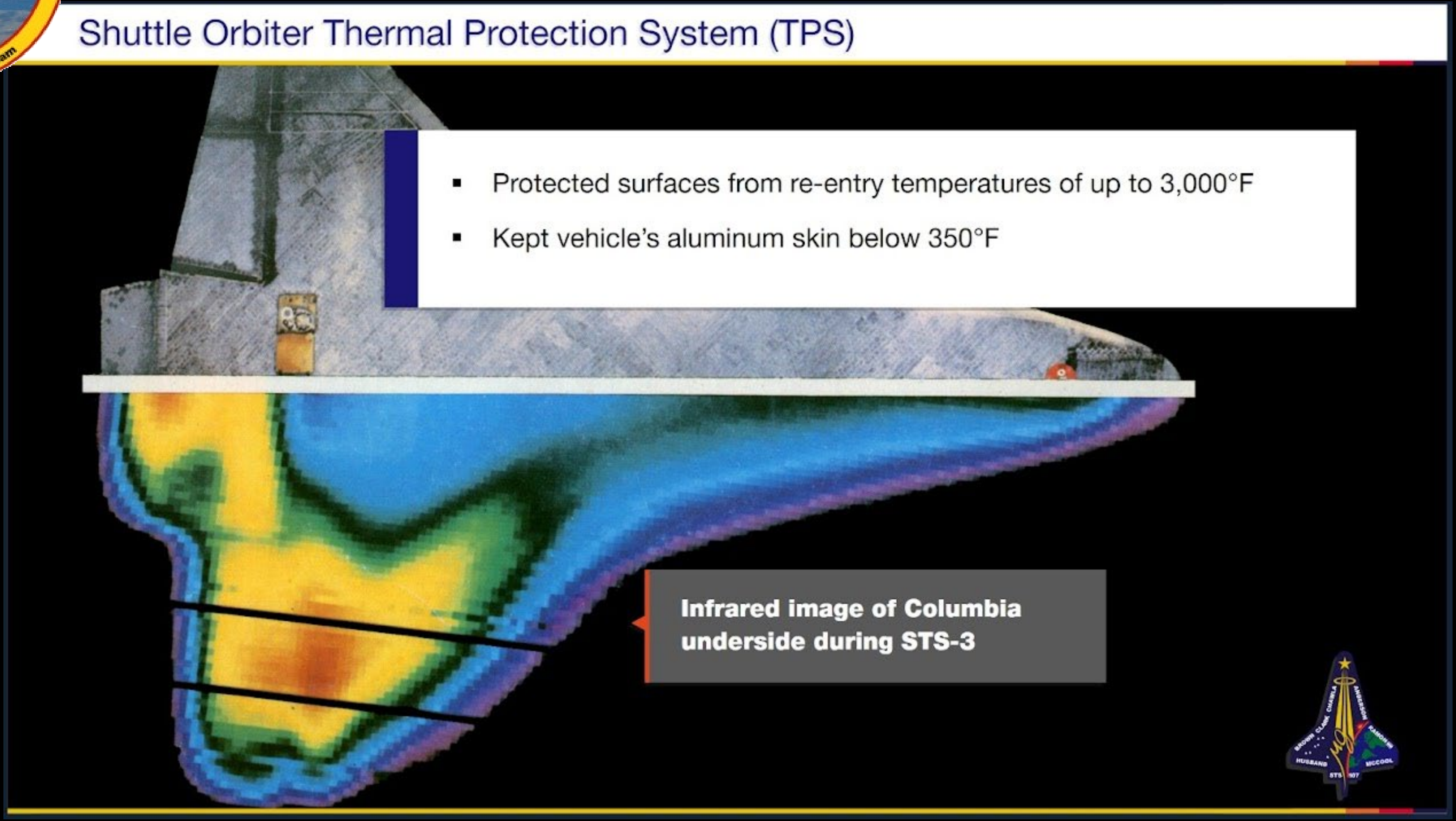
Impact: Development of Shuttle tile damage/repair thresholds that could trigger corrective action.



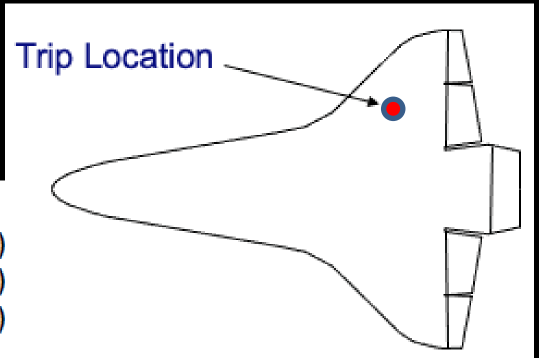
They said it couldn't be done…

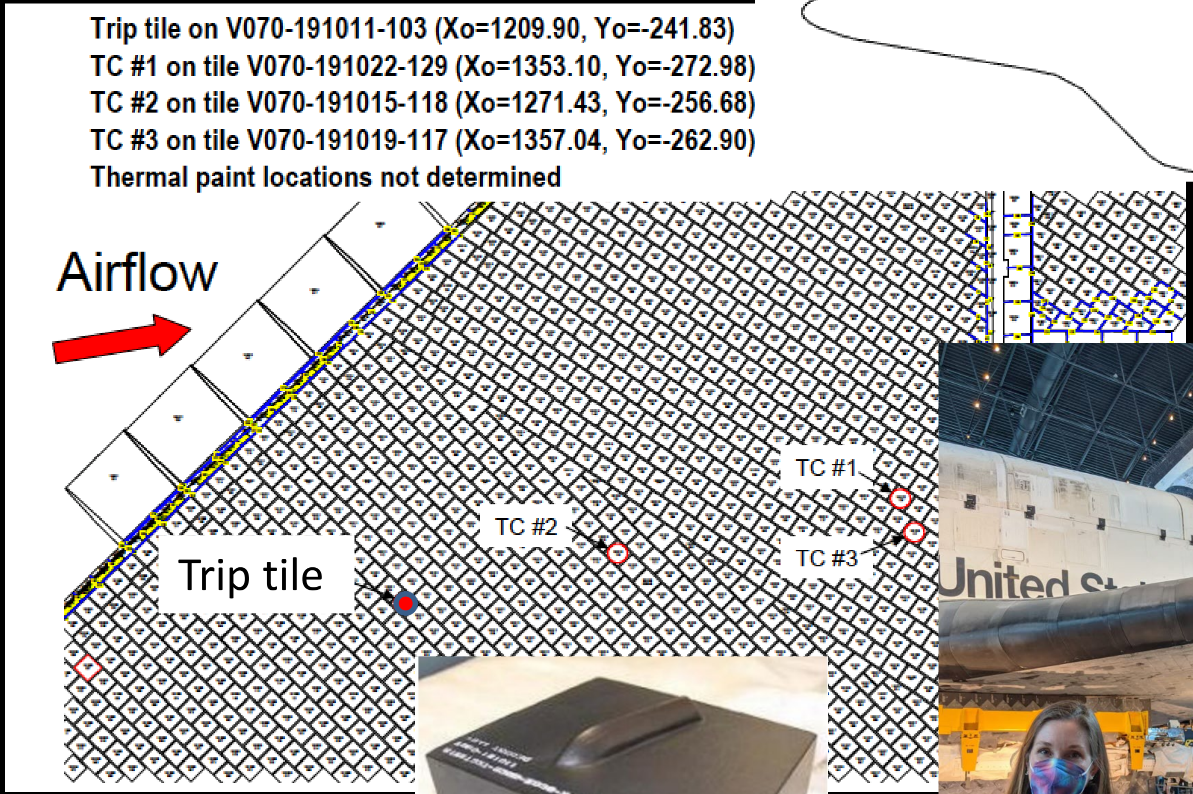
Others had tried and failed

Remote observation proposed to complement limited thermocouple measurements with global temperature data



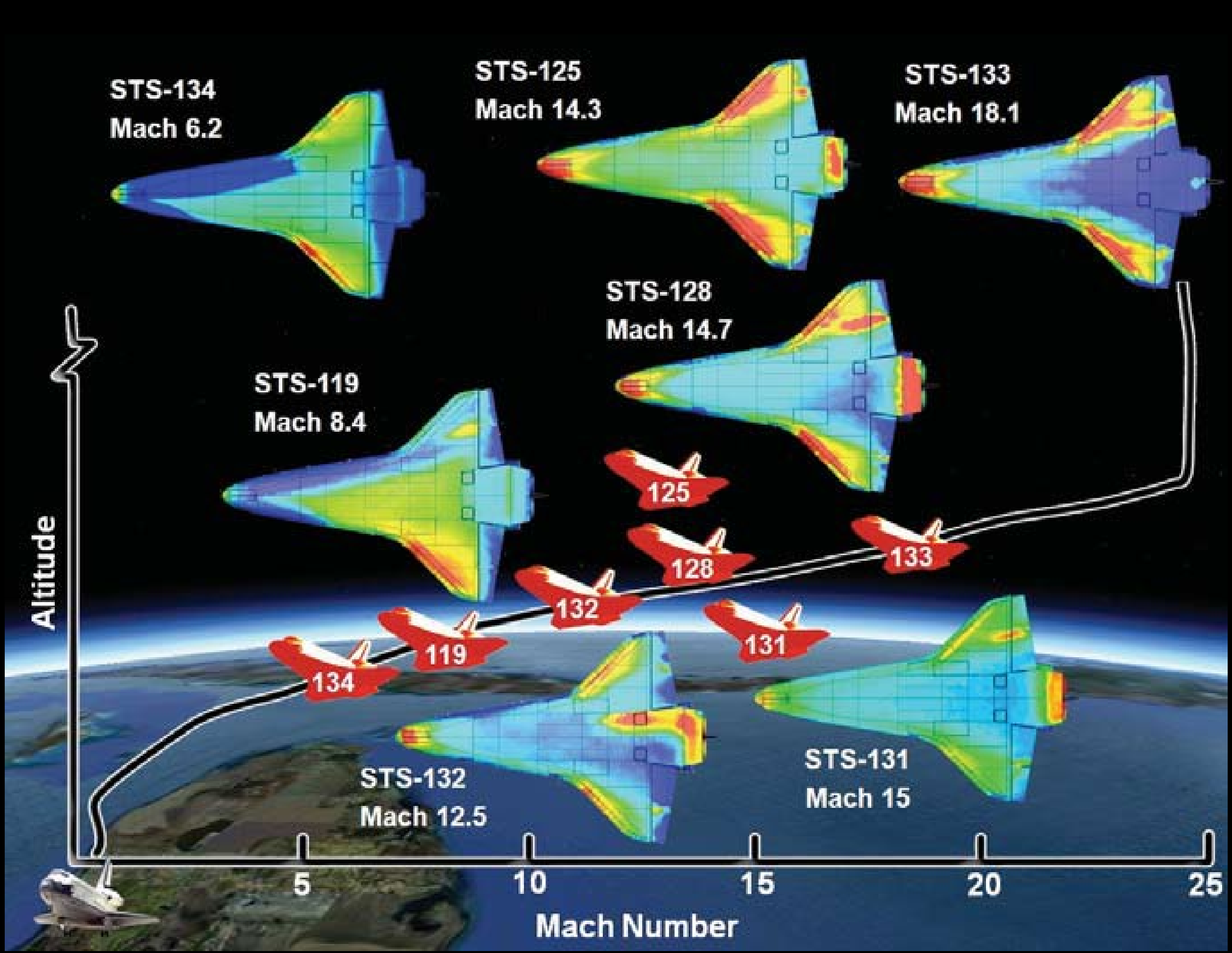
Simulated Damage (Bump), Safe Location



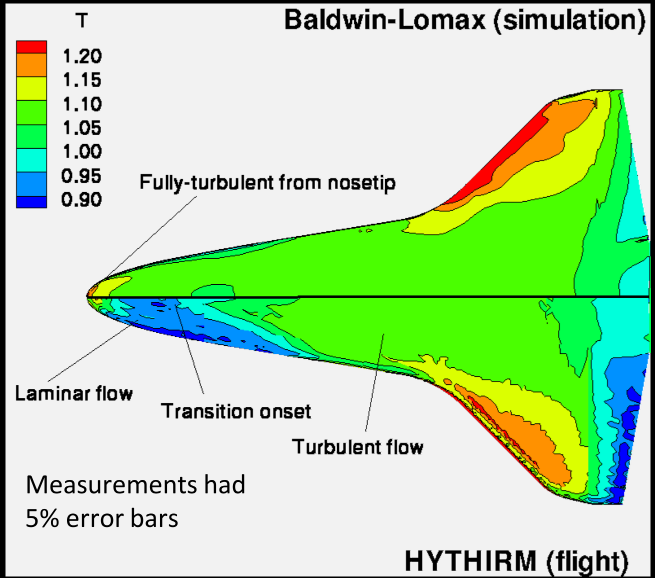


HYTHIRM Orbiter Observations

2009 - 2011



Airborne and ground-based calibrated thermal data from 7 Space Shuttle flights investigating hypersonic turbulence transition.



NASA Airborne Imaging Assets

Using NASA Aircraft to Support NASA Missions

NASA WB-57

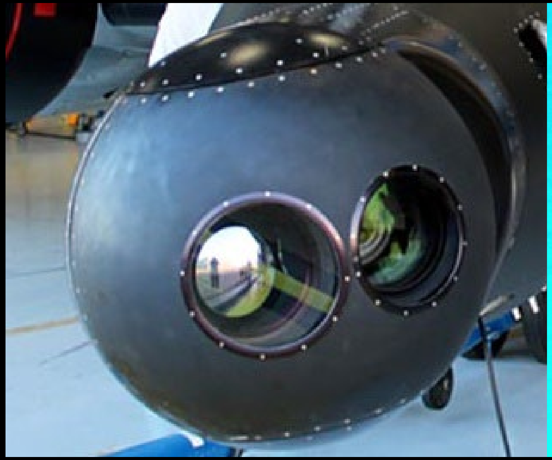
High Altitude, Large Field of Regard

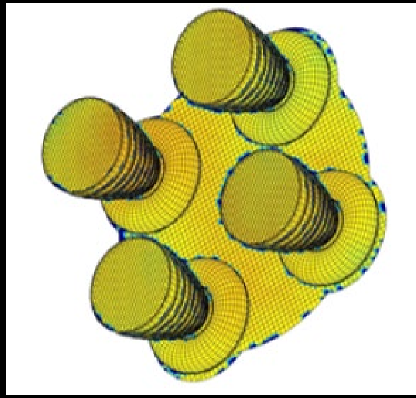
DyNAMITE sensor package:

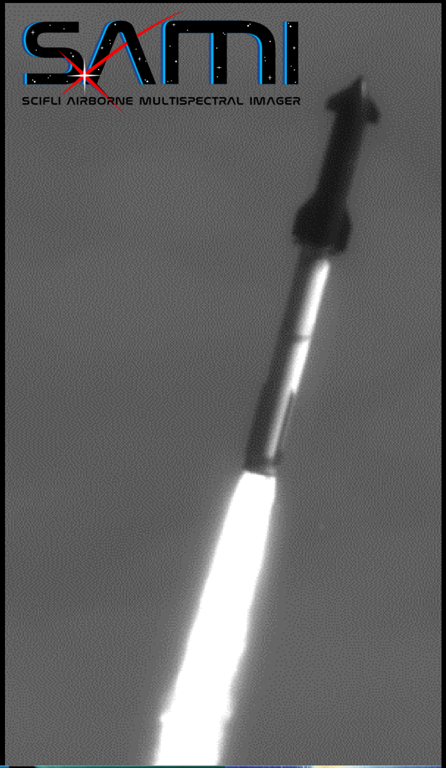
- Visible and MWIR, variable zoom

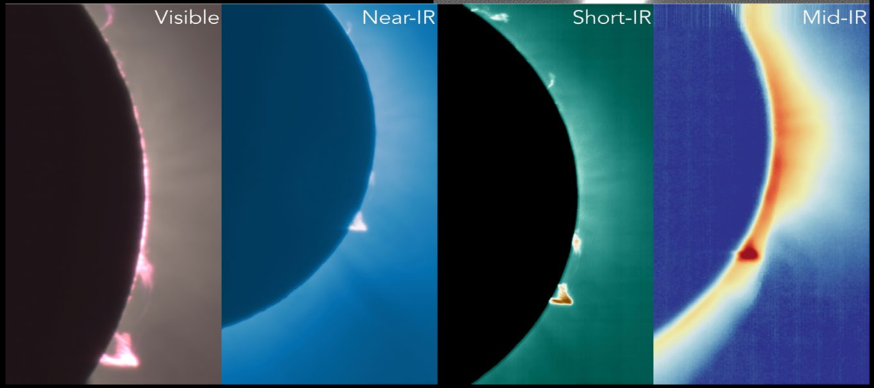
SAMI sensor package:

- Visible and MWIR, variable zoom.
- Multispectral: UV-Vis-NIR-SWIR-MWIR
- 8-in Aperture 1625 mm reflective telescope









Novel Imaging System Development

Extended Range Imaging Capability with Proven Optical Performance

NASA Gulfstream III, IV, V

Long Range, Adaptive Payloads

MIDAS sensor packages:

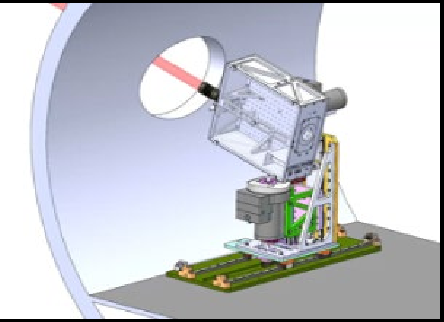
- **UHD:** Ultra High-Definition
  - 2500 mm Reflective Optic
  - VIS / NIR / SWIR capable
  - 4K-6K Resolution
- **Multispectral:** Vis-NIR-SWIR Cluster
  - 1060 mm Optics
  - 4K-6K Resolution
- **Spectrometers:** UV / VIS / NIR / SWIR
  - Wake + Shock Layer Spectral ID
- **SAMI:** VIS / NIR / SWIR / MWIR
  - 8-in Aperture 1625 mm reflective telescope

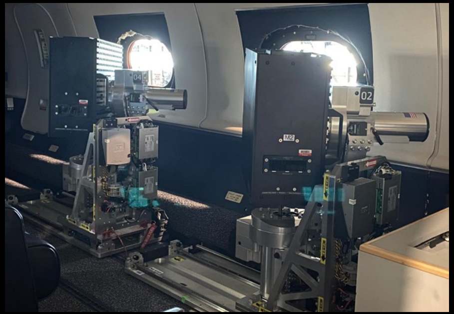
Optical Windows

- Fused silica & Sapphire
- Single-pane Acrylic
- Swappable Frames

MIDAS

MULTISPECTRAL IMAGING & DATA ACQUISITION SYSTEMS





SAMI on Gulfstream V

Moon in 6K Resolution

Hypervelocity Sample Return

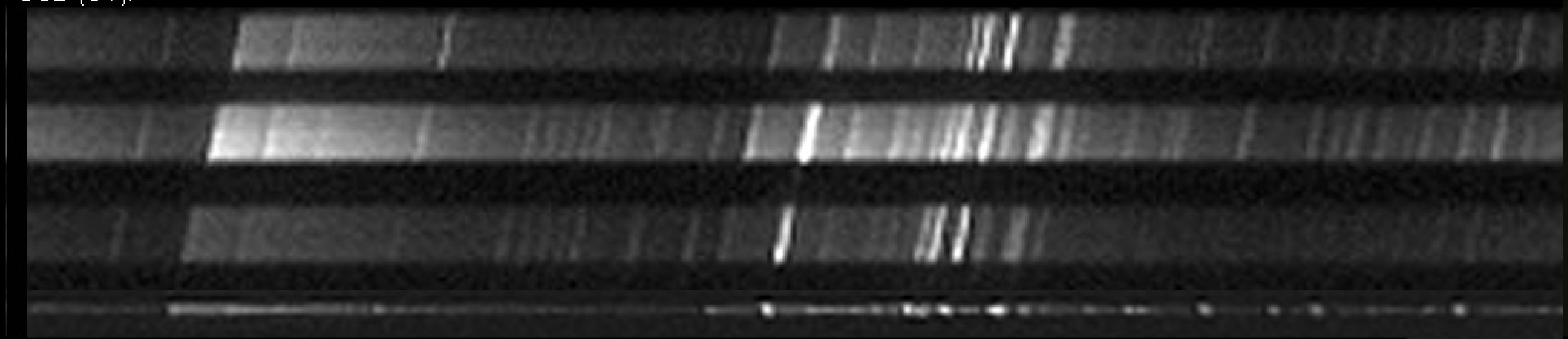
ESA ATV
Stardust
Hayabusa 1
Hayabusa 2
OSIRIS-REx

European Space Agency ATV

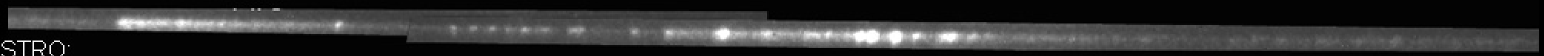
29 September 2008   Automated Transfer Vehicle – destructive reentry

ATV - 1
Jules Verne
MAC

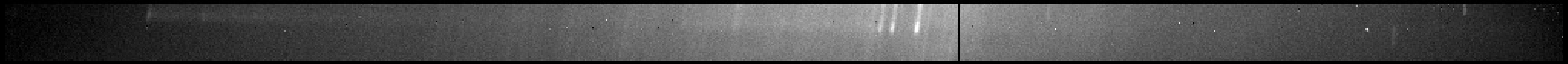
CCD (GV):



Echelle:



ASTRO:



Stardust

15 January 2006

Target: Coma of Comet Wild 2
Aircraft: NASA DC-8
International Partners: JAXA, Univ. Southern Queensland, Univ. Stuttgart
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

Hayabusa

13 June 2010

Target: Asteroid Itokawa

Aircraft: NASA DC-8

International Partners: JAXA, Australia, Germany

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

Courtesy of JAXA

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

Spectral Data for Hypervelocity Entries

International Collaboration in the midst of a Global Pandemic

Hayabusa-2 Reentry

December 6th, 2020

CALSPEC Data Visualization

Location: N520NA Gulfstream III
32.226451° S, 136.444627° W
41,000 Feet Altitude

MARS: Ronald F. Dantowitz
RDantowitz@MarsScientific.com
www.MarsScientific.com
TEL: 602-888-MARS

NASA: Jennifer Inman, PhD
Jennifer.A.Inman@nasa.gov
https://SCIFLI.larc.nasa.gov
TEL: 757.864.8076

Land of Oz

HORIS Mission Summary

Hypervelocity OSIRIS-REx Reentry Imaging & Spectroscopy

Mission Date: **24 SEPT 2023**

Number of Aircraft: **4 – NASA 992, NASA 522, NASA 927, N550TH**

International Partners: **JAXA, UniSQ, HEFDiG/UniStuttgart, RTI Inc.**

Number of Ground Sites: **3 – GOS1, GOS2, GOS3**

Number of Science Payloads: **15+ Spectrometers + Video**

Live Imagery: **Provided by WB-57 via Starlink**

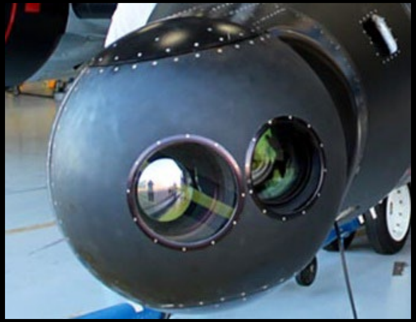
Result: **All Airborne Platforms Captured SRC Reentry Data**

Science - Heliophysics

2024 Solar Eclipse
KiNET-X (KiNetic-scale Energy and momentum Transport eXperiment)

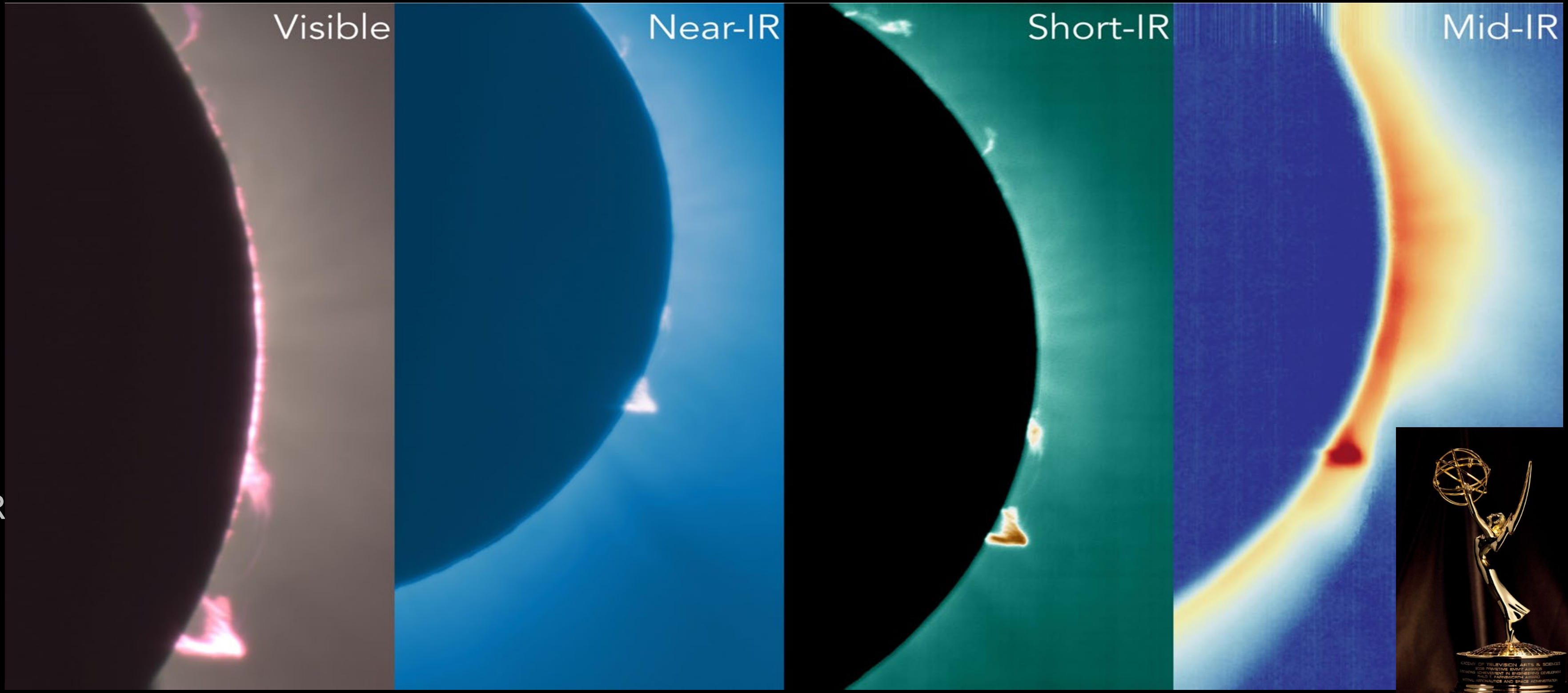
2024 Solar Eclipse

Studying the Solar Corona with Southwest Research Institute



NASA WB-57

High Altitude, Large Field of Regard



DyNAMITE sensor package:

- Visible and MWIR, variable zoom

SAMI sensor package:

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- Multispectral: UV-Vis-NIR-SWIR-MWIR
- 8-in Aperture 1625 mm reflective telescope

Wallops Sounding Rocket Program

Studying the Earth's Ionosphere with University of Alaska Fairbanks

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: 602-888-MARS

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

Commercial Crew

Parachute Testing (40+ Tests)
Boeing Pad Abort Test
Boeing Orbital Flight Test 1 & 2
SpaceX In-Flight Abort
SpaceX Demo 1 & 2
SpaceX CRS & Crew Missions

Boeing Pad Abort Test

04 November 2019

https://www.nasa.gov/press-release/boeing-s-starliner-completes-pad-abort-test-for-commercial-crew

Boeing Orbital Flight Test 1 & 2

Studying the Solar Corona with Southwest Research Institute

Office Space

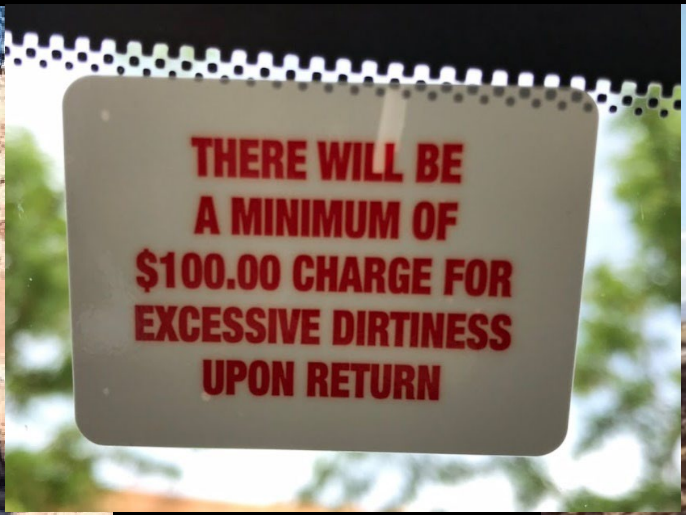
Desert Ops for Parachute Testing

Remote Work

Desert Ops for Parachute Testing

Rough Commute

Desert Ops for Parachute Testing



Getting there is half the fun

Group Pictures

Desert Ops for Parachute Testing

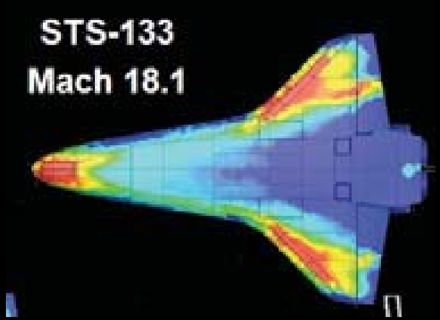
Flight Data Enables Human Exploration

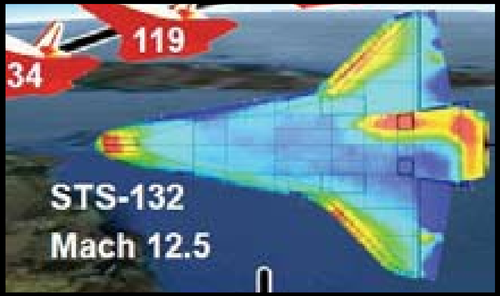
Cmdr. Stephen "Steve" Bowen

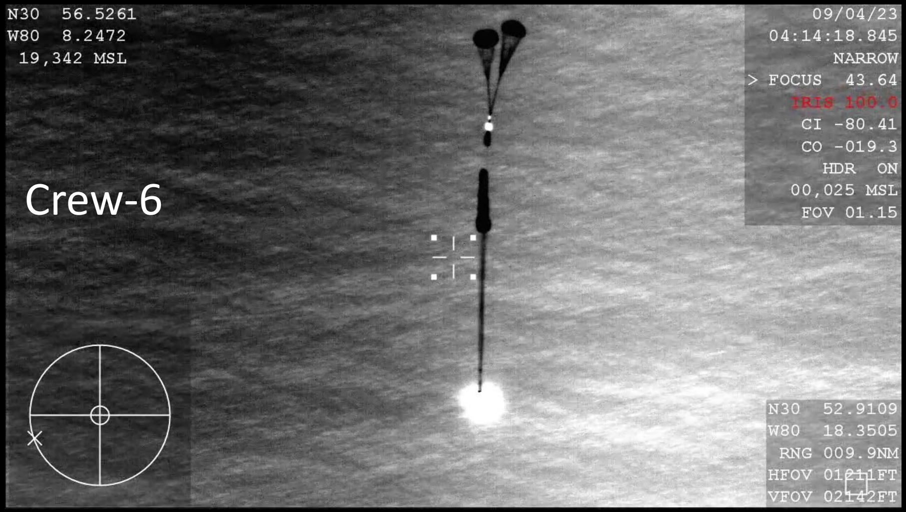
STS-126
STS-132
STE-133
Crew-6

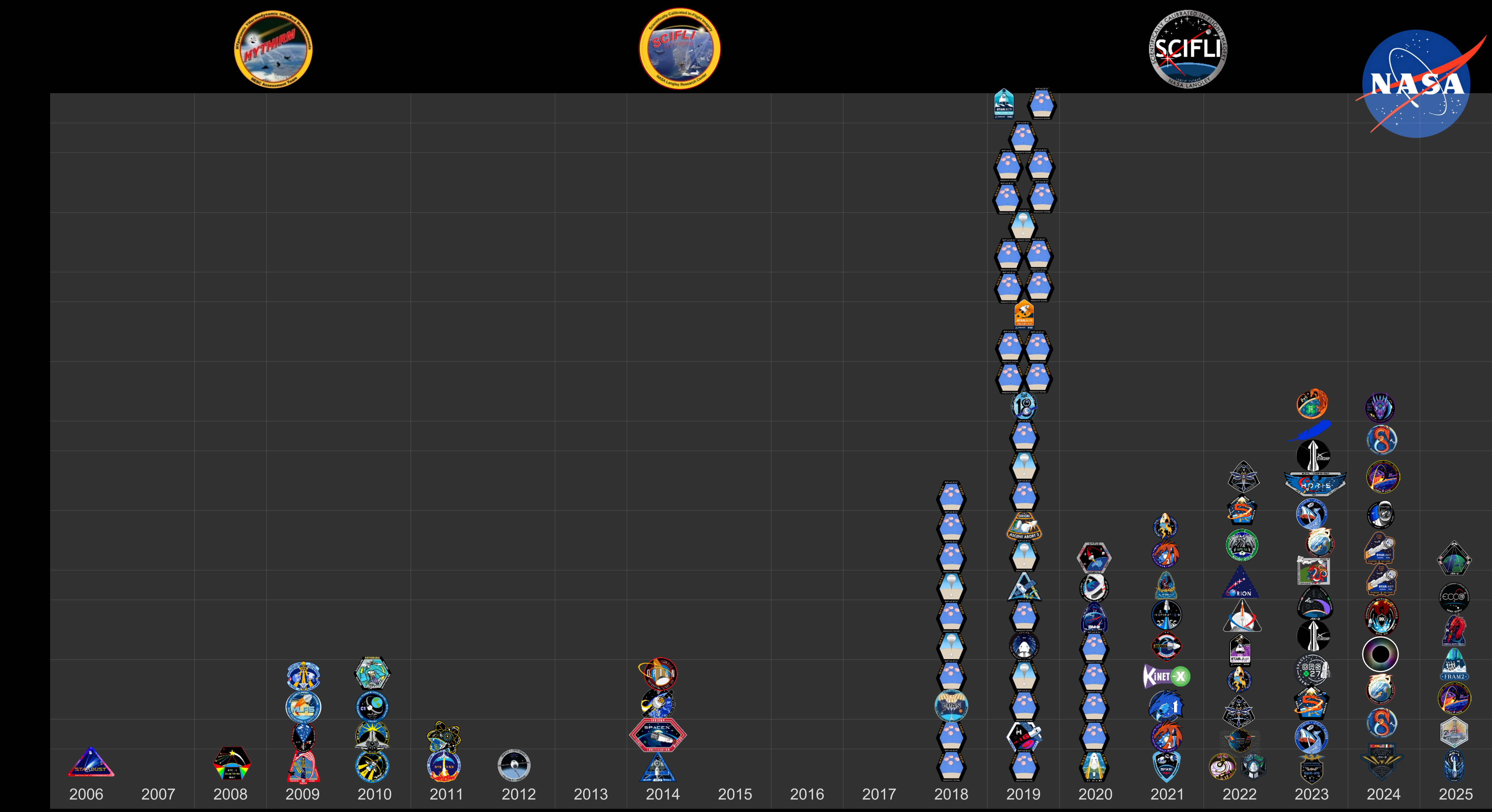
Lt. Col. Bob "Farmer" Hines

Crew-4







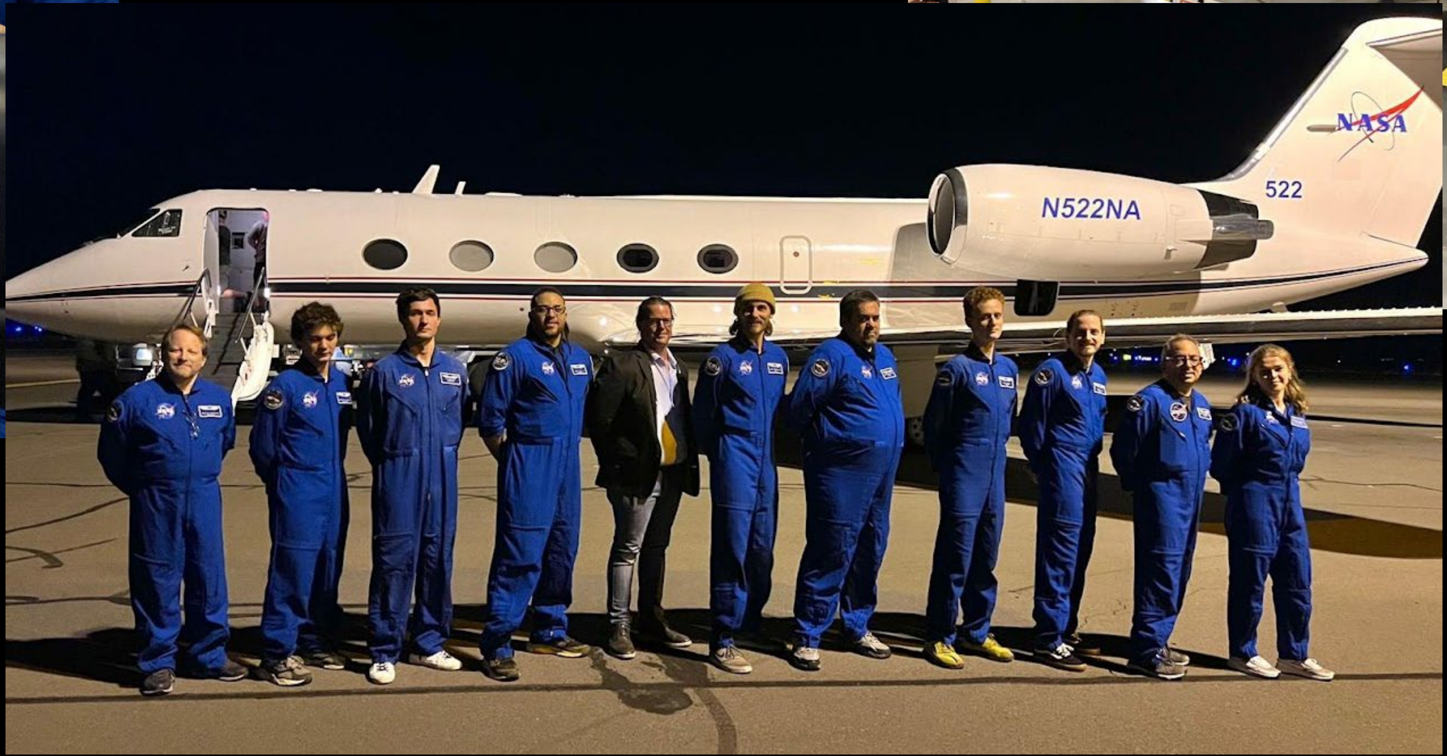

HYTHIRM
SCIFLI
SCIFLI
NASA
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

Emerging Partnerships

New Shepard
Starship
LOFTID (Low-Earth Orbit Flight Test of an Inflatable Decelerator)
New Glenn
Dream Chaser?

SLIM – SCIFLI LOFTID Imaging Mission

Low-Earth Orbit Flight Test of an Inflatable Decelerator



SpaceX Starship

Launch and (almost) reentry

Emerging Partnerships

Data to Accelerate Development

Artemis

MLAS
CPAS
AA-2
EFT-1
Artemis I
Artemis II

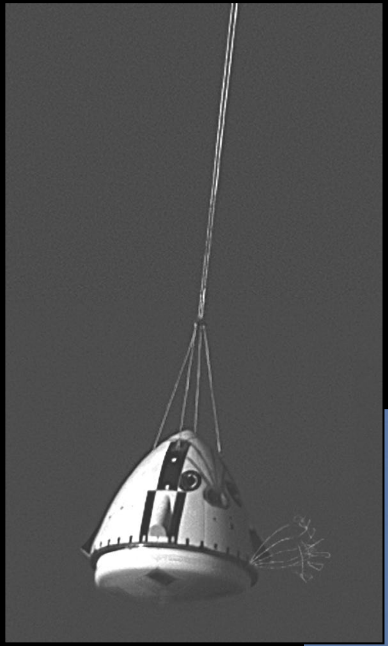
SCIFLI Artemis Program Support

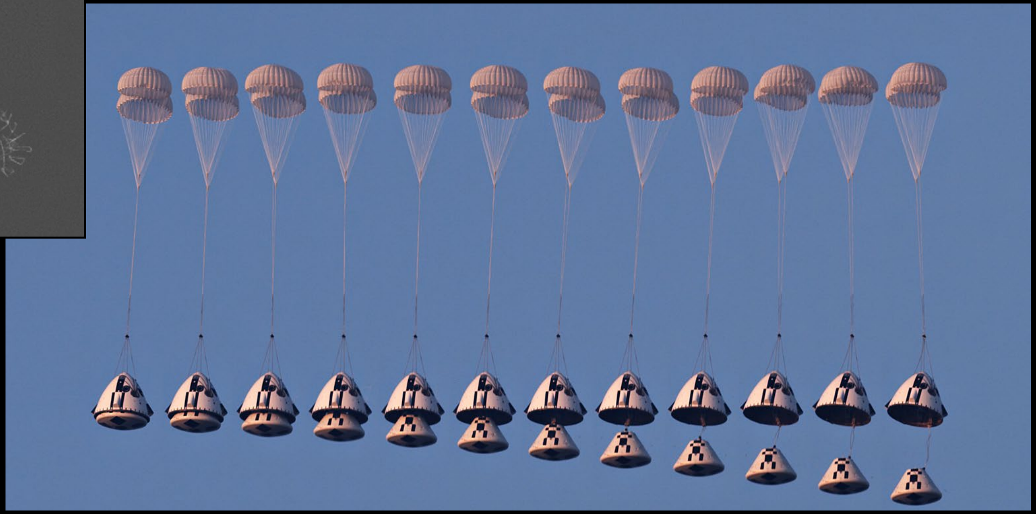
Key Capability for Enabling Exploration

MLAS
July 2009

CPAS
June 2018

AA-2
July 2019

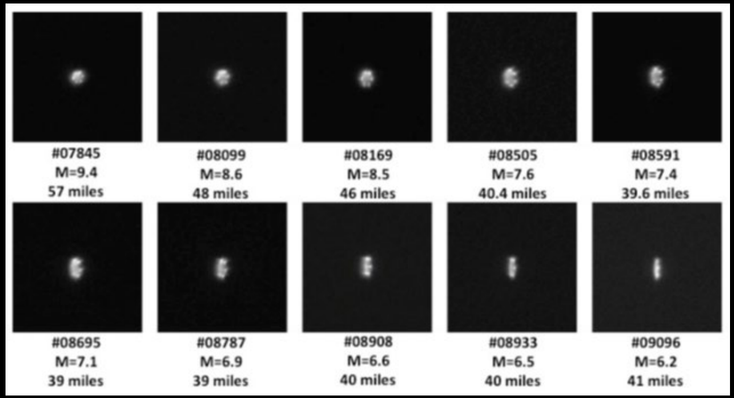


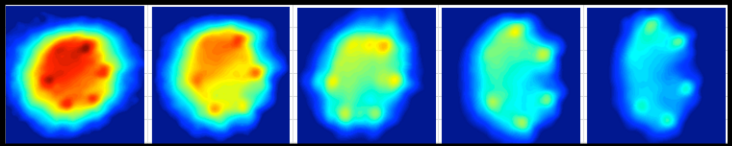


SCIFLI Artemis Program Support

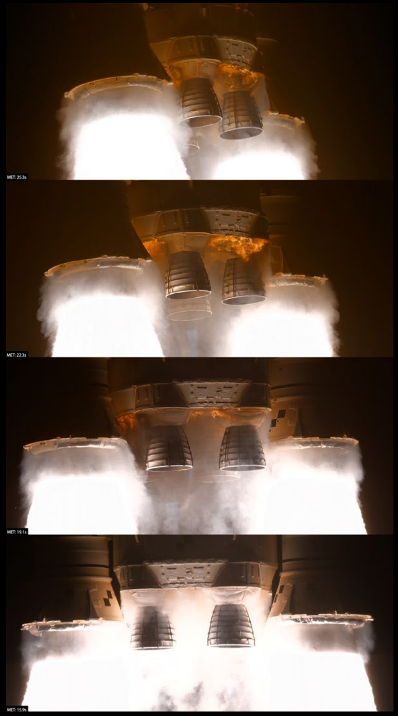
Key Capability for Enabling Exploration

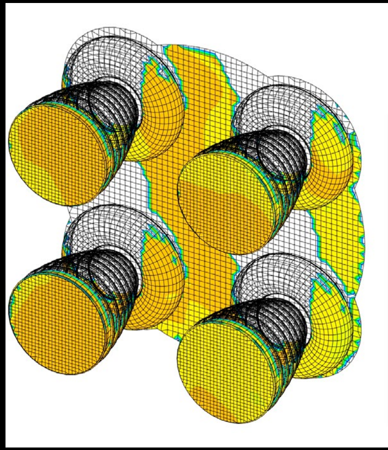
EFT-1
December 2014

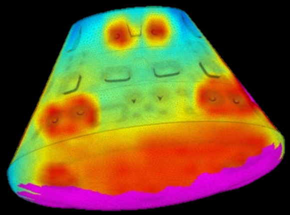




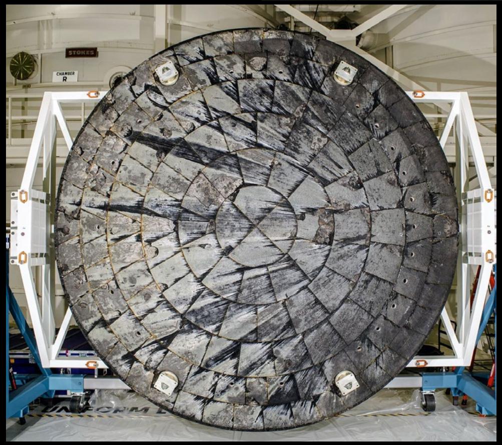
Artemis I
November 2022







Artemis II
February 2026



Exploration Flight Test 1

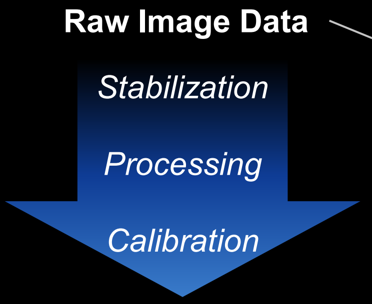
Calibrated Measurements of Orion's Thermal Protection System

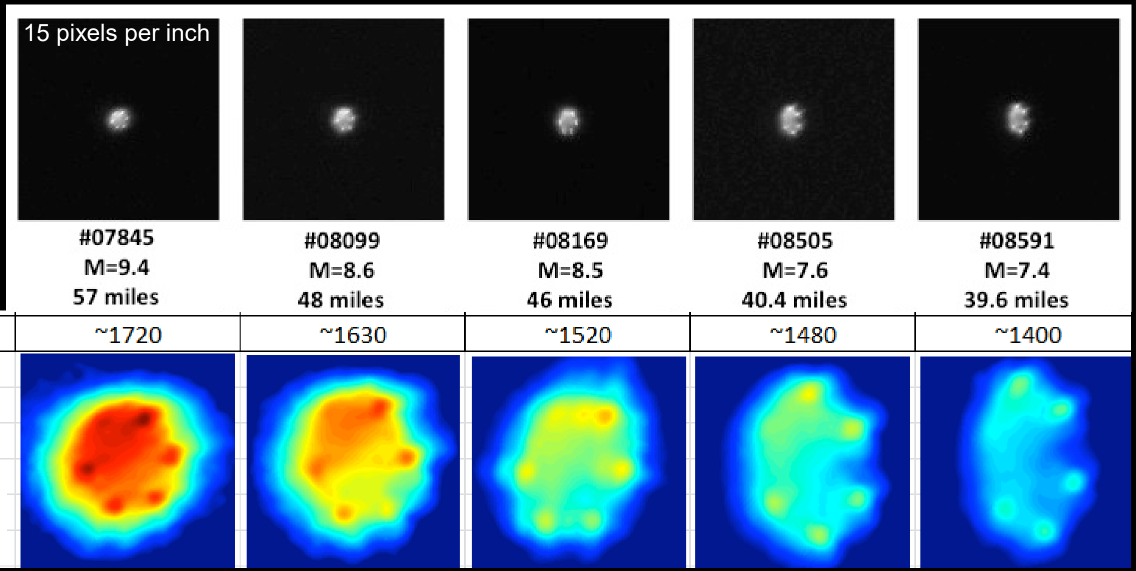
Imaging Platform: VX-30 Cast Glance P-3
Imaging Objectives: Calibrated thermal imagery of peak heating
Sensor Package: 8-inch Prosilica NIR camera with 1024 x 1024

Mission Highlights:

- Significant cloud cover forced the observation to the south
- Thermal imagery provided global heating maps to compare with DFI data
- Applied Shuttle-era HYTHIRM concept to Orion capsule TPS

Navy P-3 Imaging Platform



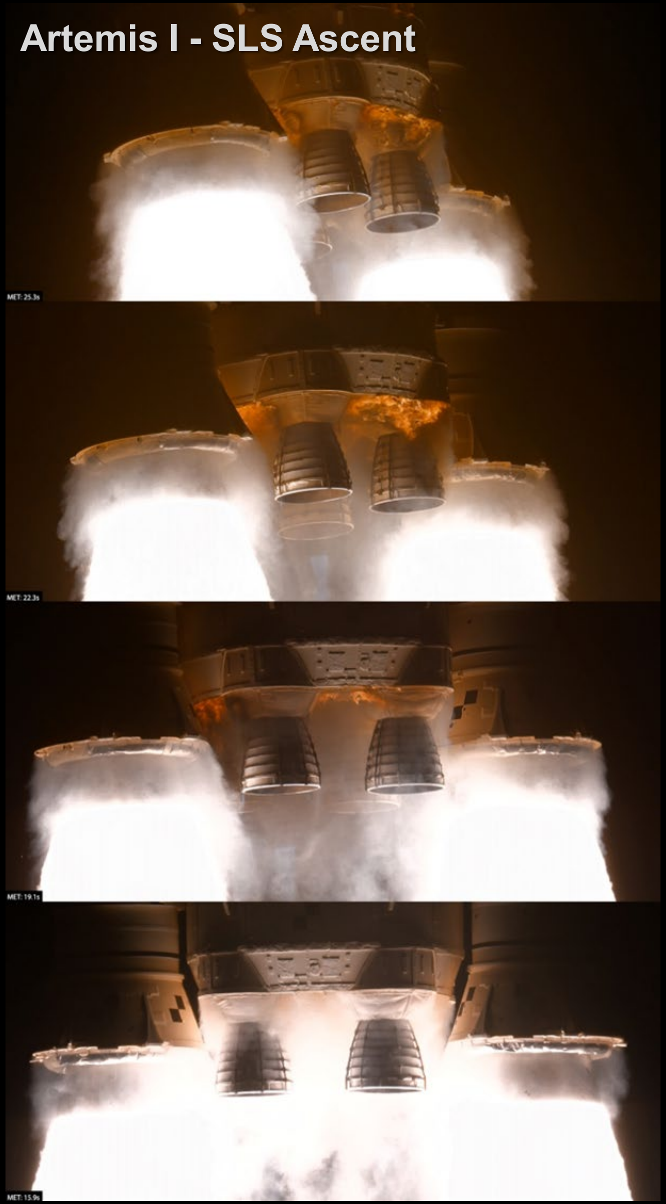


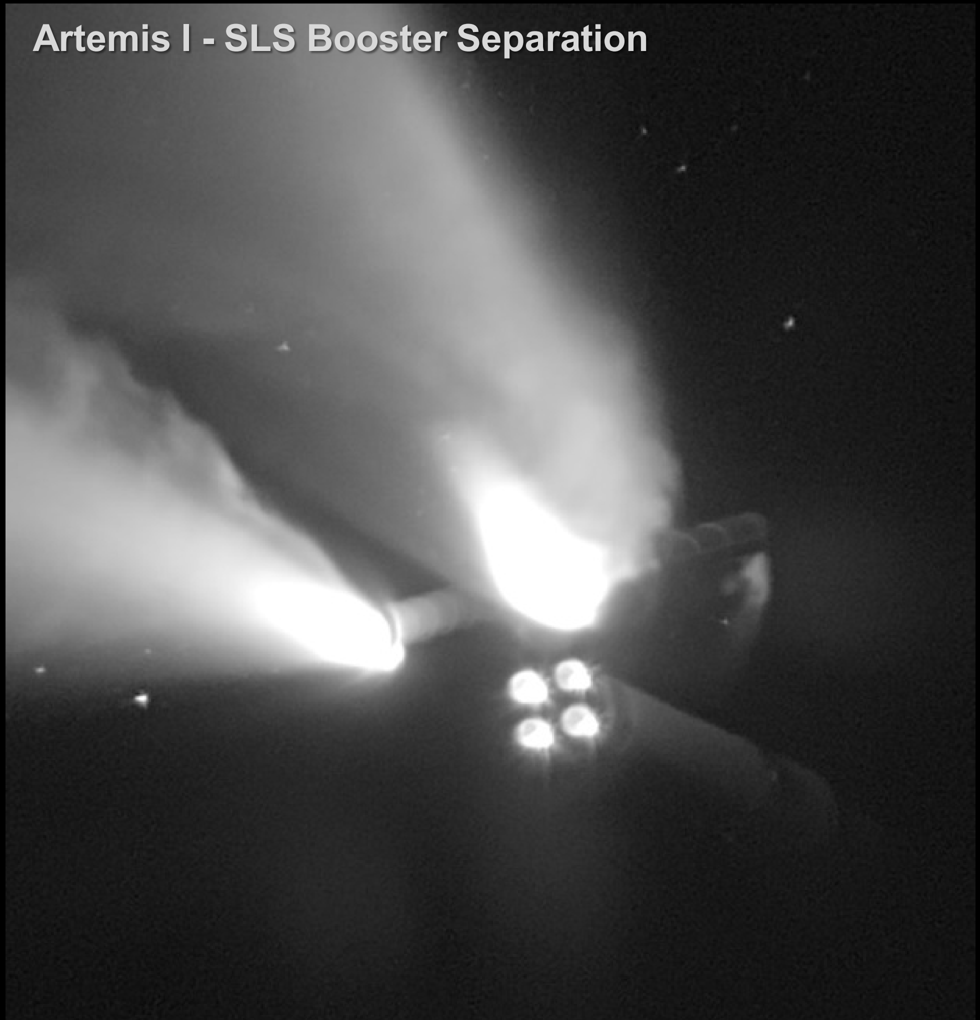
Artemis I – Space Launch System

Ultra High-Definition Imagery of SLS During Ascent

Long Range Trackers

- Direct-drive gimbals provided exceptional tracking stability and image quality.
- Strong evidence of thermal protection system (TPS) outgassing
- Hypalon paint and cork combustion and smoke entrainment were observed during the AR01 flight between T+0 seconds to T+75 seconds prior to the peak heating recirculation regime. *(Mehta, et al, 2024)*





Ground-Based Sensor Platforms:

- 2200 x 3060 image (NIR)
- Slant Range = 197, 281 feet / 32.5 Nmi / 60 km
- **Spatial Resolution = 4.1 inches / pixel**

Artemis I – Space Launch System

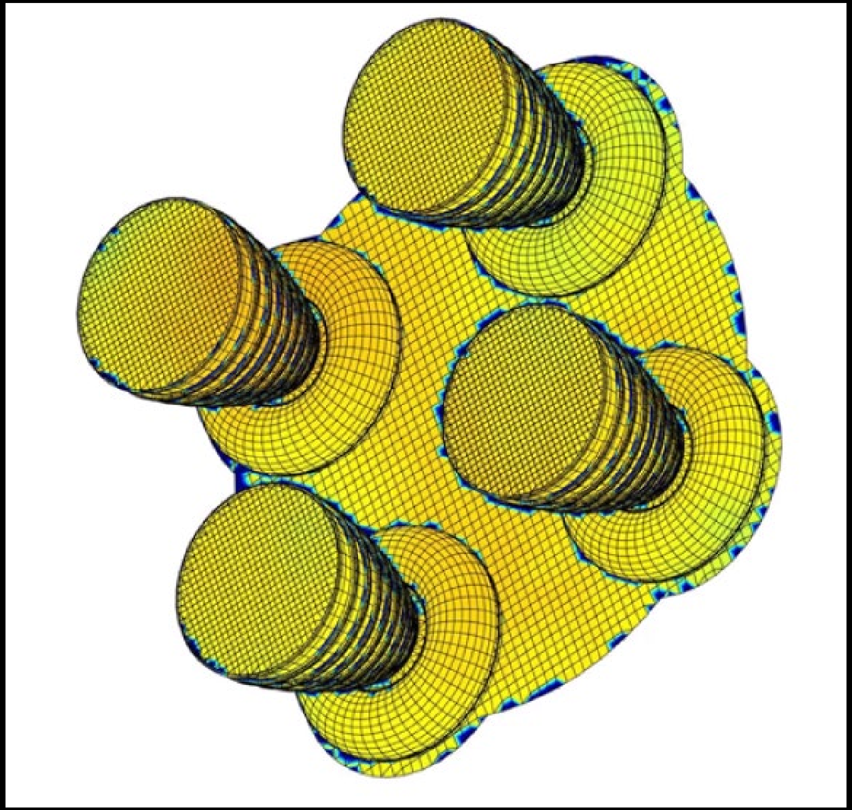
SLS Base Heat Shield Temperatures Derived From Calibrated Airborne Imagery

SAMI Provides Temperature History of Base Heat Shield

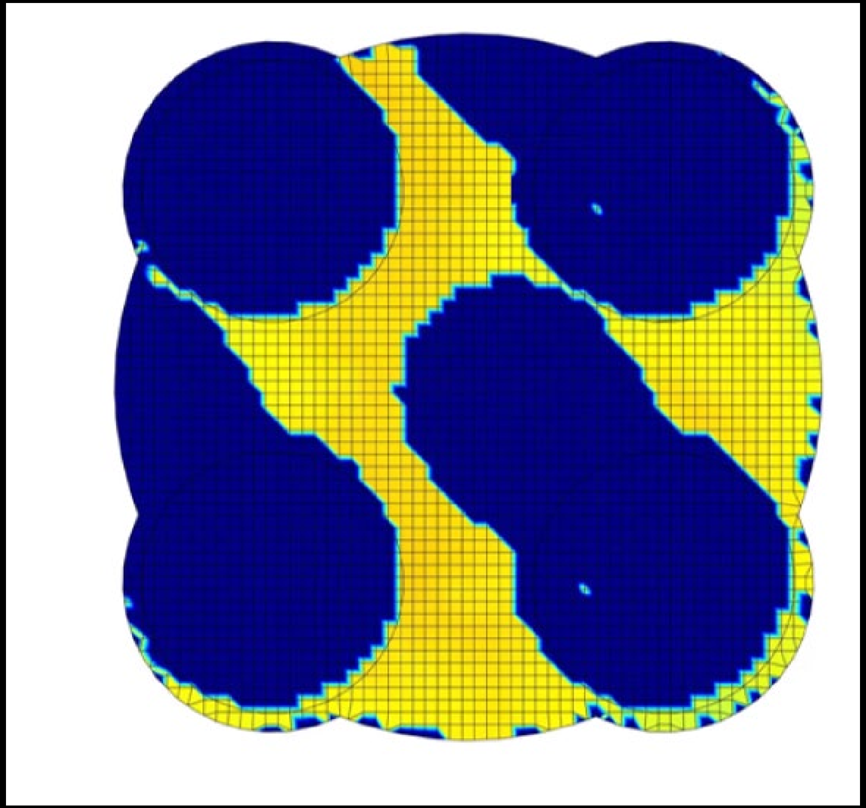
- 271 frames of temperature data were acquired and processed.
- SAMI airborne measurements and DFI data answered engineering questions about TPS surface temperature vs. base gas temperature.

$$U_{max} = 7.8\%$$

3D Temperature Map



Temperature Time History

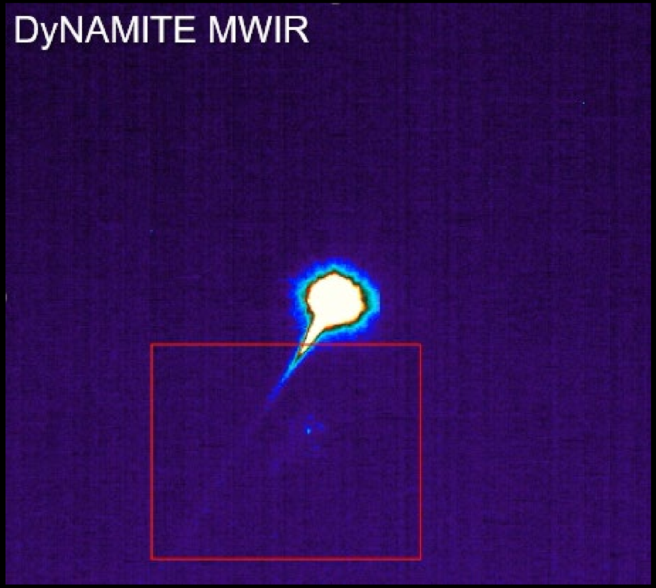


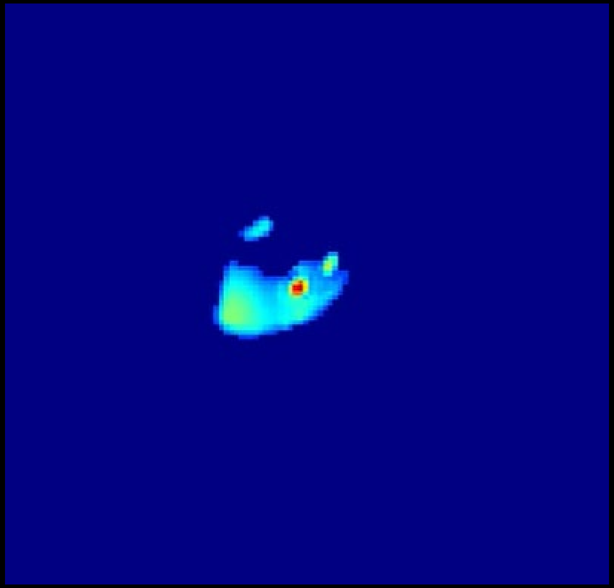
Artemis I – Orion EDL

Unique View of Multiple Char Loss Events & Parachute Deploy Sequence

High-Altitude Imaging with WB-57

- Analysis of the raw video from WB-57 resulted in the identification of multiple instances of apparent char loss events. Most of the events occur prior to FBC Jettison.
- These events can be seen most clearly in the DyNAMITE MWIR channel.
- A notable event appears during the main parachute transition to Full-Open. This event is described as an ‘anomaly.’
- SCIFLI generated calibrated temperature data on the Orion backshell for the later phase of EDL.





On Deck

Artemis II: SLS Launch and Orion Reentry

Artemis II – Space Launch System

Ultra High-Definition Imagery of SLS During Ascent

Long Range Trackers

- SCIFLI has been tasked by EGS to coordinate qty(6) medium and long-range tracker sites for Artemis II ascent.
- MARS Scientific has been selected to provide the imaging assets to meet EGS / SLS / Orion imagery requirements for launch.
- MWIR + NIR + VIS sensors to provide excellent imagery and debris assessment.
- Providing 4K live views from UCS-9 and UCS-15 for NASA broadcast.

Site	Category	Range to Pad, miles
UCS-9	**Prime**	**2.7**
UCS-10	Backup	6
UCS-15	**Prime**	**3.4**
Apollo Beach	**Prime**	**18.5**
Ponce	**Prime**	**35**
NOTU Berm	**Prime**	**14.3**
UCS-19	Backup	13.5
UCS-20	Backup	13.5
Patrick DOAMS	**Prime**	**27**

Artemis II – Orion EDL

Continuous Coverage Intended to Meet Multiple Orion Flight Test Objectives

Imaging Mission Objectives:

1. Imagery of peak heating with the best possible spatial resolution (<13 in/pix).
2. Imagery of peak char loss with the best possible spatial resolution. (<13 in/pix).
3. Imagery of the Orion heatshield with the best possible spatial resolution prior to parachute deployment. (<5 in/pix).
4. Imagery of the Orion vehicle with the best possible spatial resolution during parachute deployment.

Targeted Outcomes:

- ❑ TPS model refinement & validation for 4800nmi downrange capability
- ❑ Parachute system surveillance and anomaly detection from high-altitude platform

ORION

1. Peak Heating
2. Peak Char Loss
3. Image of HS before chute deploy
4. Image of Parachute Deploy

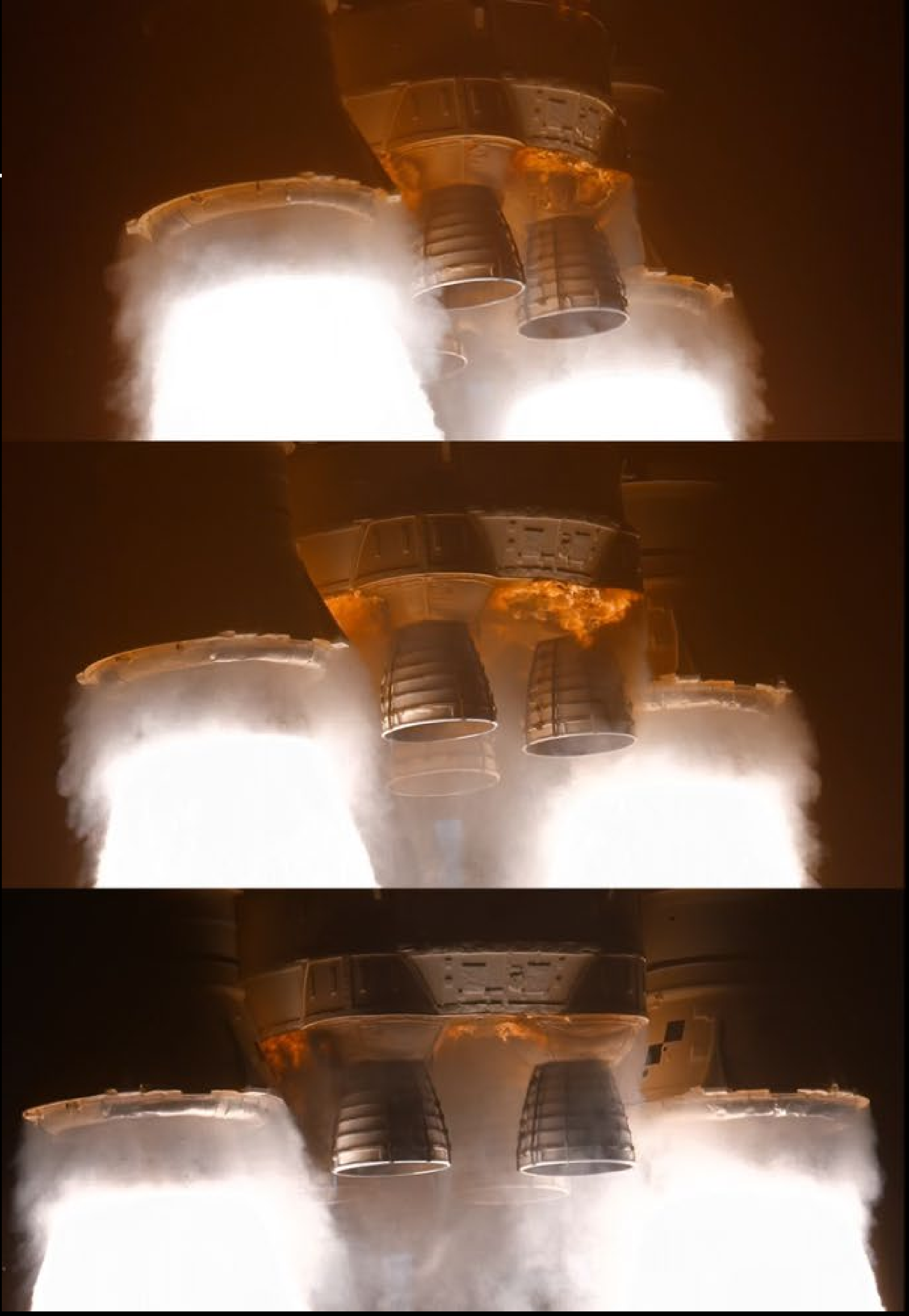
Artemis II – Orion EDL

Variety of Sensors Required to Meet All Objectives

Preliminary Asset Configuration:

- ❑ Nighttime entry will reduce overall imagery data → highest resolution systems are NIR / VIS
- ❑ 4-aircraft option approved in August 2025 → mission planning is ***on-going***

	AIRCRAFT #1	AIRCRAFT #2	AIRCRAFT #3	AIRCRAFT #4
Preliminary Aircraft Selection	JSC G-V (NASA 95)	AFRC G-IV (NASA 814)	Cast Glance C-20 (BH 500)	WB-57 (N927NA)
Primary Imaging Goal	Peak Heating	Peak Char Loss	Late Stage	Parachutes
Basing Location	Southern California	AFRC	Point Mugu	Southern California



Artemis-1

November 16th, 2022

MARS SCIENTIFIC

MARS Medium Field Color

Location: UCS9

Captured: 3840 x 2160, 120 FPS
Replayed: 3840 x 2160, 60 FPS (1/2x Slow-Motion)

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Questions?