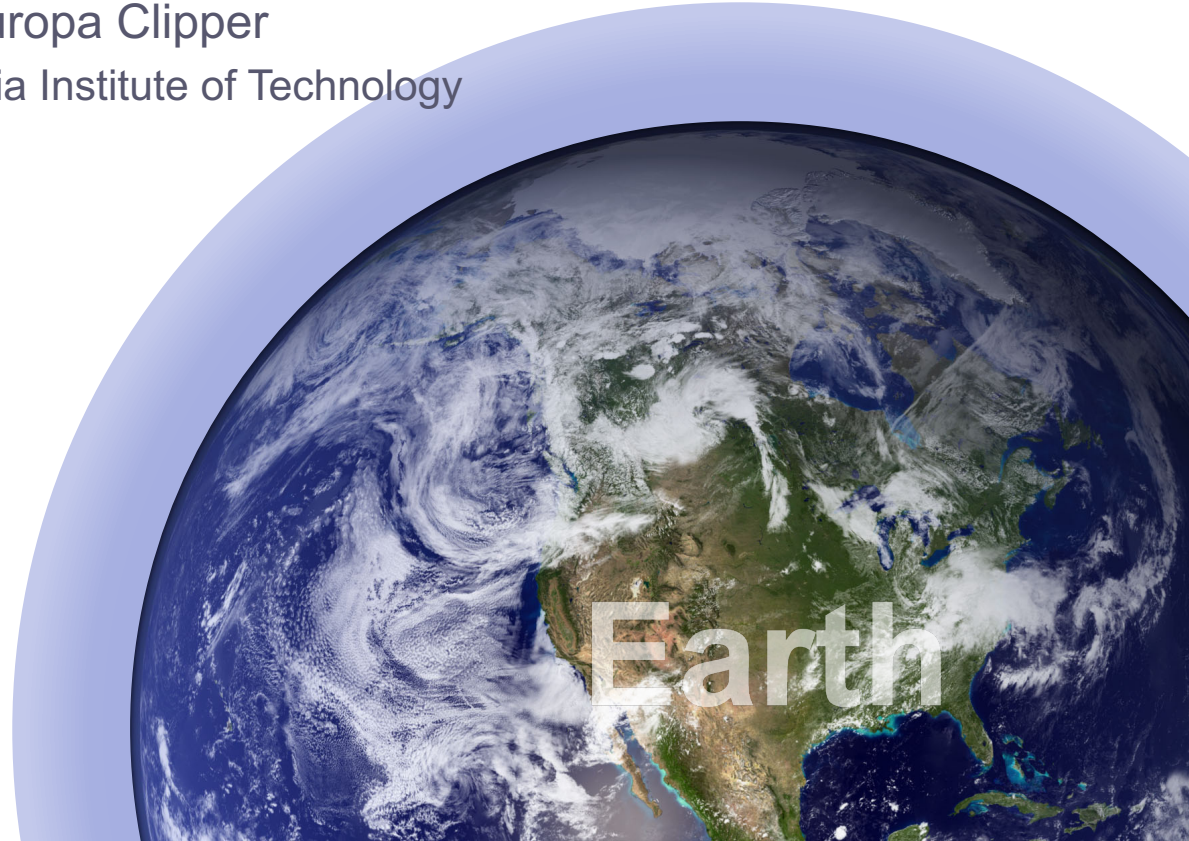
Ballooning as a Crucible for Technology and Teams

Dr. Laura Jones-Wilson
Systems Engineer, Europa Clipper
Jet Propulsion Laboratory, California Institute of Technology



Jet Propulsion Laboratory, California Institute of Technology
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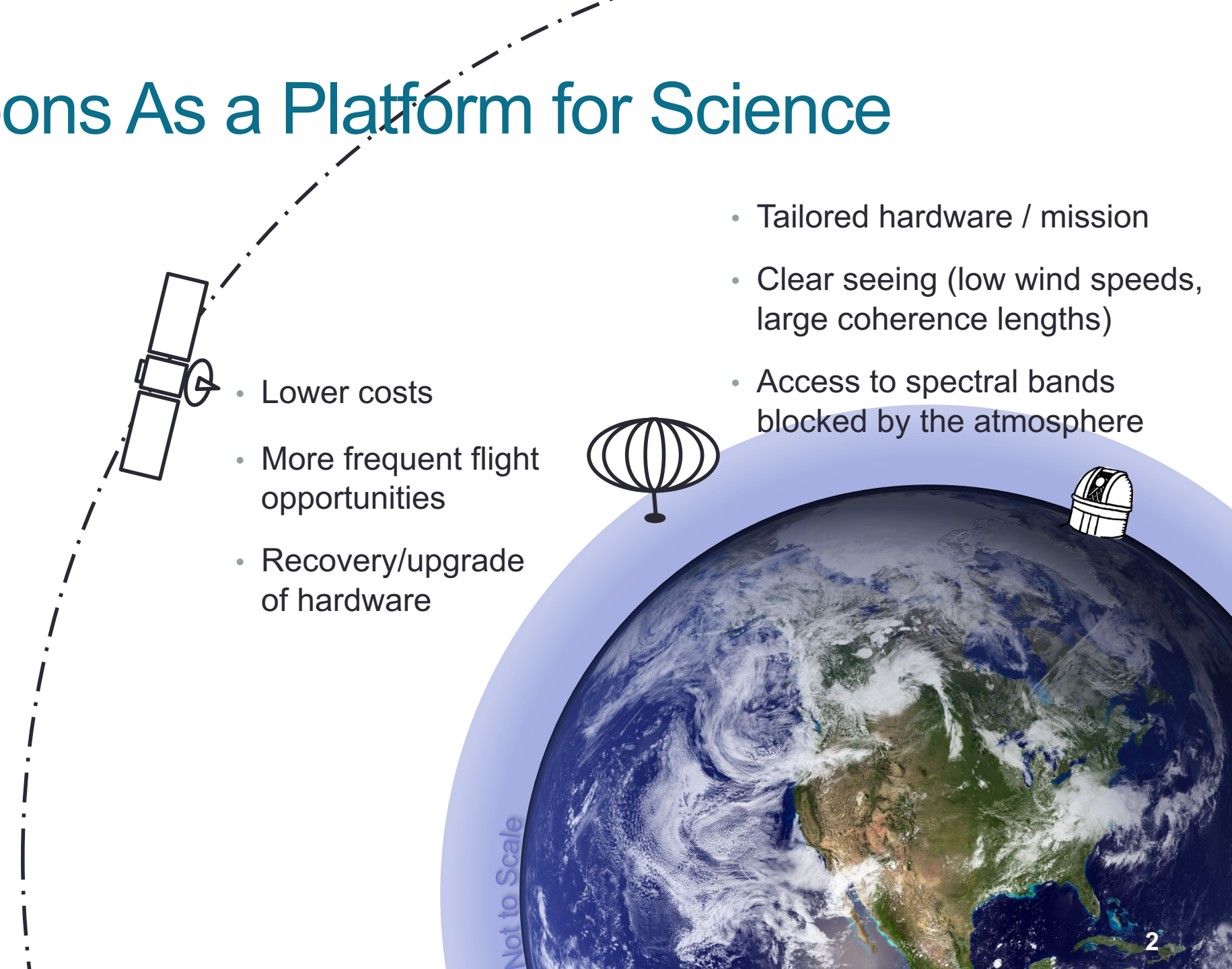
Balloons As a Platform for Science



- Lower costs
- More frequent flight opportunities
- Recovery/upgrade of hardware

- Tailored hardware / mission
- Clear seeing (low wind speeds, large coherence lengths)
- Access to spectral bands blocked by the atmosphere

Balloons As a Platform for Science

Implications for Technology

Demo Technology for Ballooning Systems Bound for Other Worlds

Demo New Instrument/ Sensing Concepts

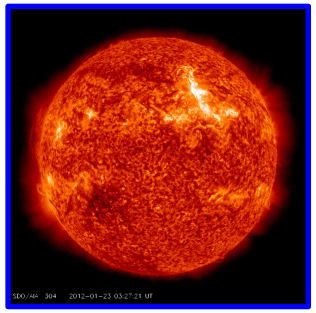
Test in Upper Atmosphere as an Analogue for Other Environments

Improve Ballooning Platform Technology

Earth Science

Planetary Science

Astronomy



Heliophysics

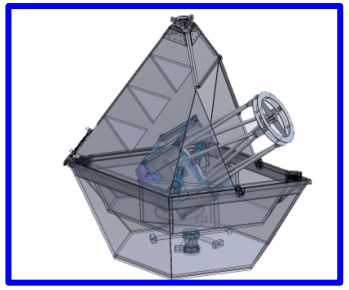
Balloons As a Platform for Technology

Demo Technology for Ballooning Systems Bound for Other Worlds

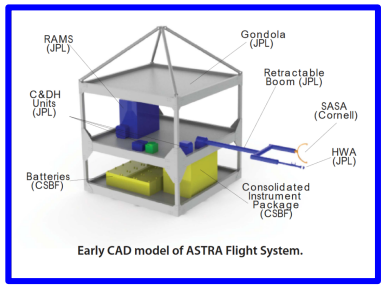
Demo New Instrument/ Sensing Concepts

Test in Upper Atmosphere as an Analogue for Other Environments

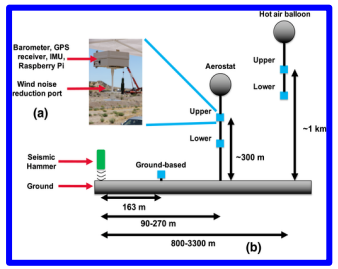
Improve Ballooning Platform Technology



Advance pointing technology for balloon platforms (e.g., BIT-STABLE)



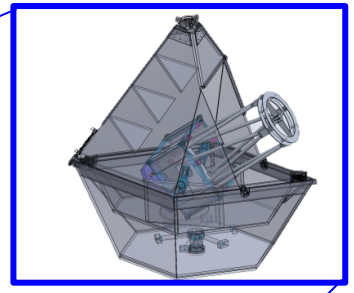
Use upper atmosphere as analog for Martian environment (e.g., ASTRA)



Develop novel sensing techniques (e.g., Infrasound remote sensing of Venus seismic activity)

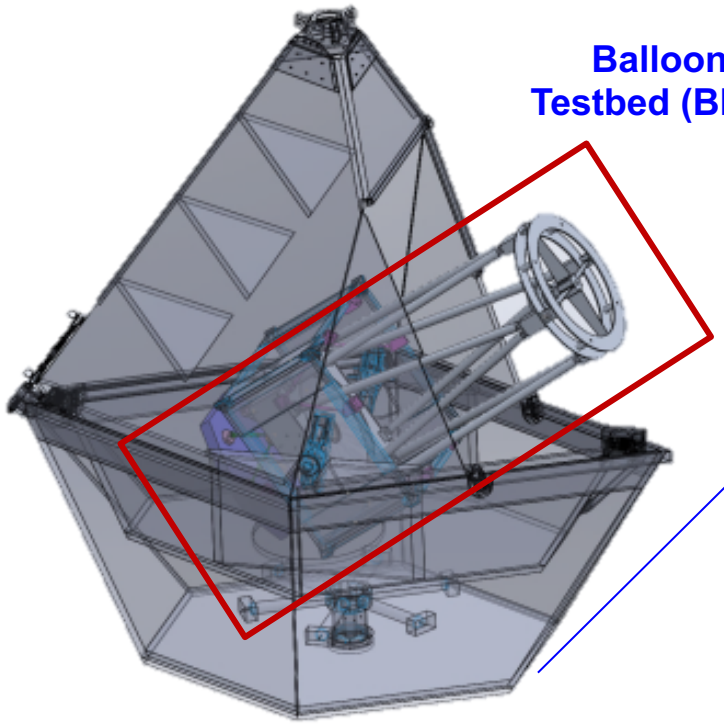
Demo new detector technology (e.g. ASCOT)

Balloons As a Platform for Technology



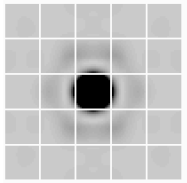
Advance pointing technology for balloon platforms (e.g., BIT-STABLE)

Balloon-borne Imaging Testbed (BIT) (Univ. of Toronto)



Sub-arcsecond Telescope and BaLloon Experiment (STABLE) (JPL/ UK Consortium)

STABLE's Top-Level Objectives



Point Spread Function

Demonstrate 100 milliarcsec stability over at least 60 seconds (1-σ per axis)
Given coarse-stage pointing to within 2 arcsec over 120 seconds

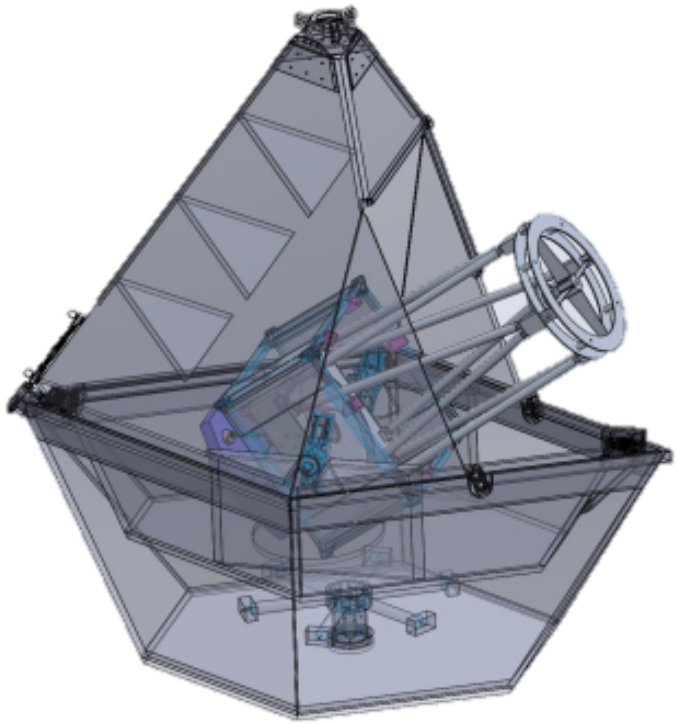
Using a point source of light

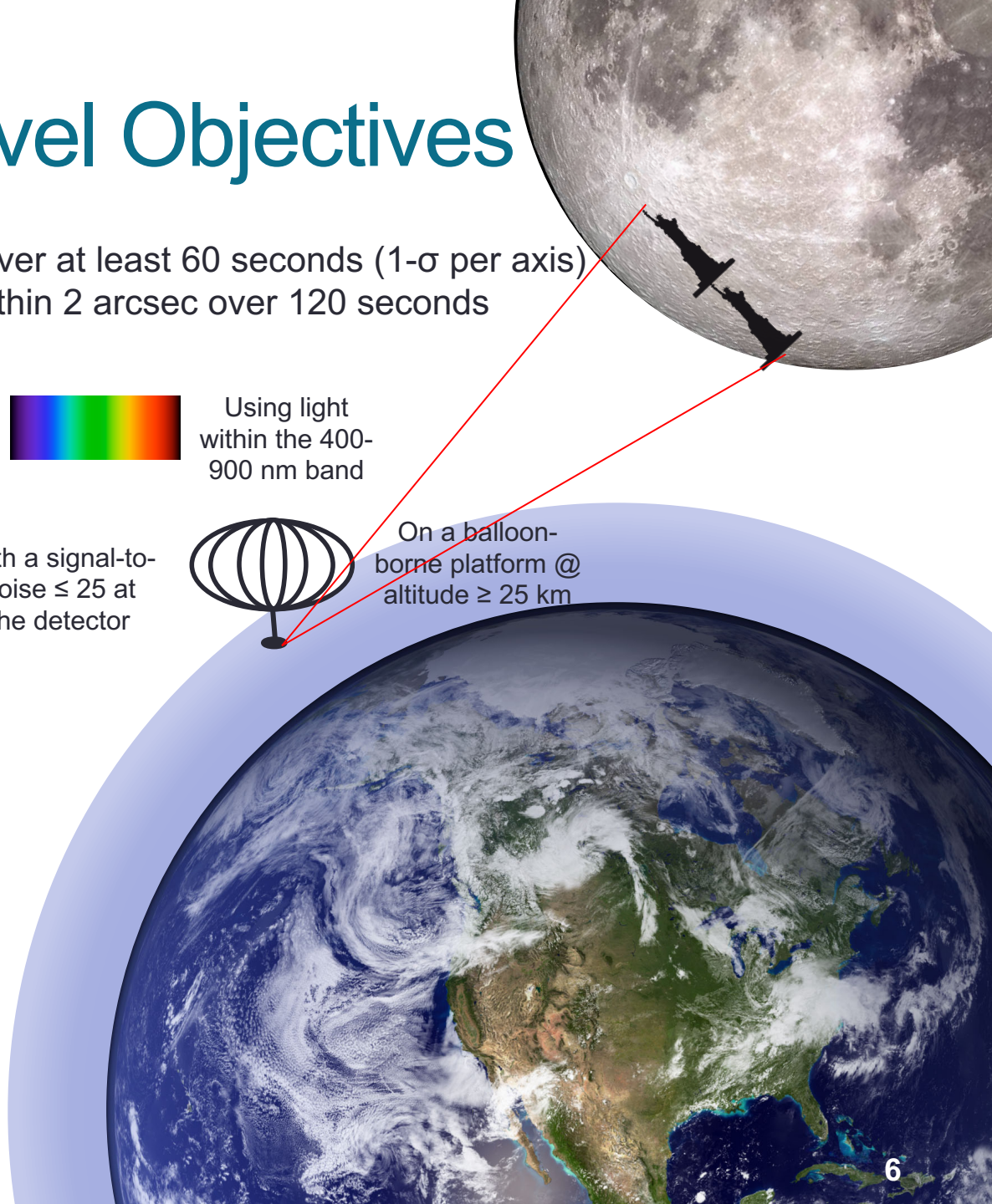
Using light within the 400-900 nm band

$$\mathrm{SNR} = \frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}}$$

With a signal-to-noise ≤ 25 at the detector

On a balloon-borne platform @ altitude ≥ 25 km





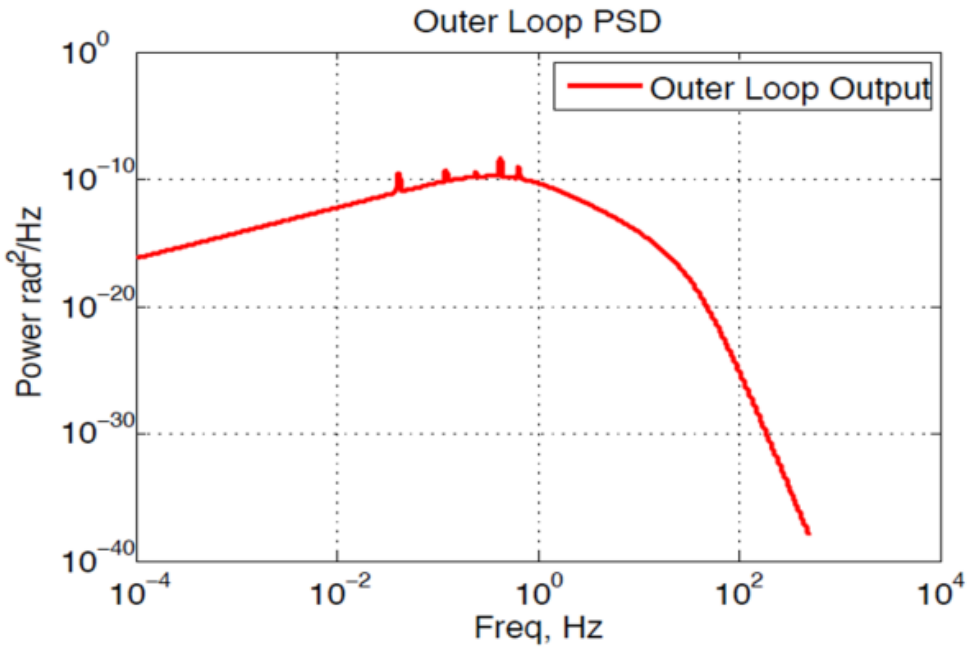
Main Environmental Challenges

Maintain image quality over 80°C temperature range (hot case vs cold case)

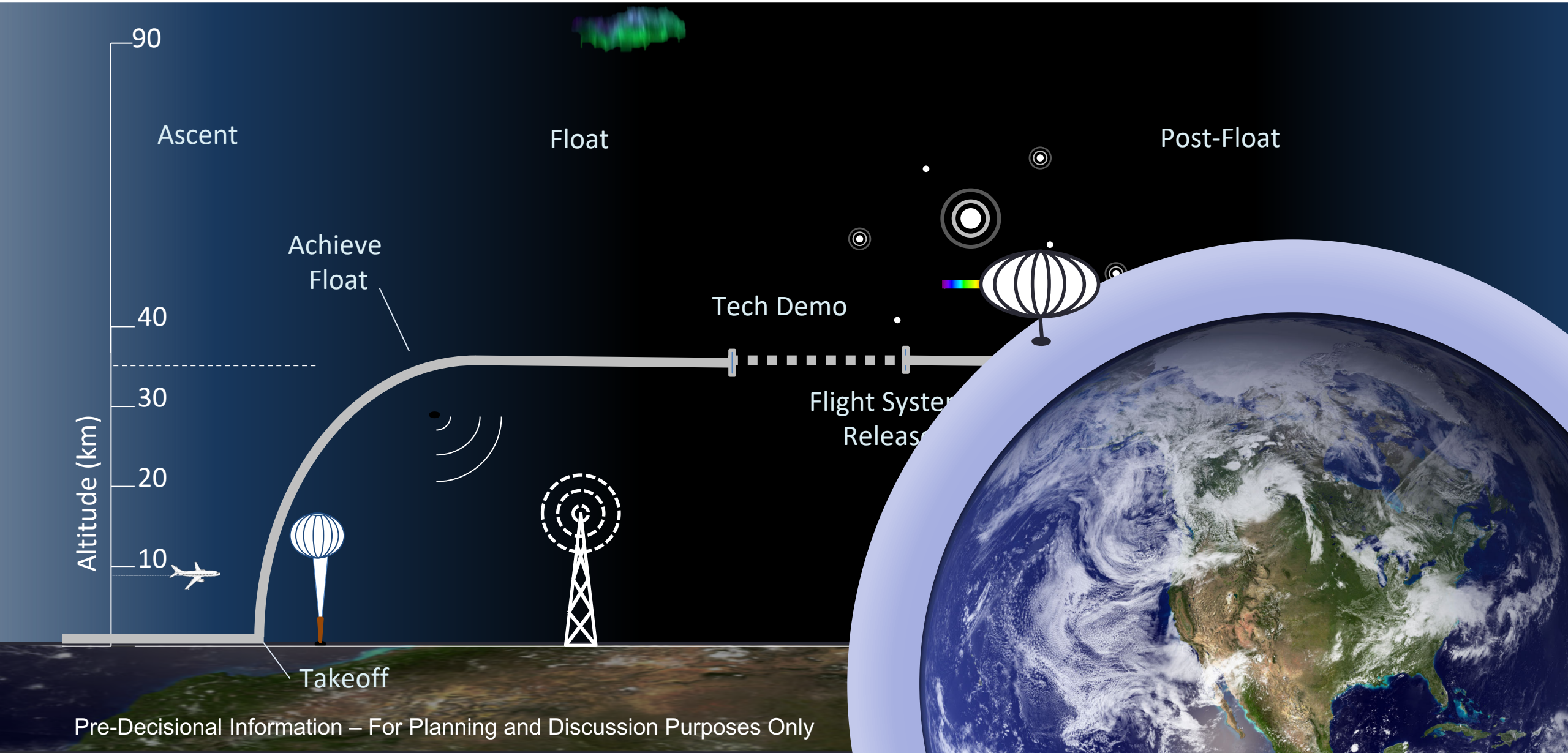
Thermal

Reject (often high-frequency) disturbances from environment, including motors, reaction wheels etc. on gondola

Dynamic

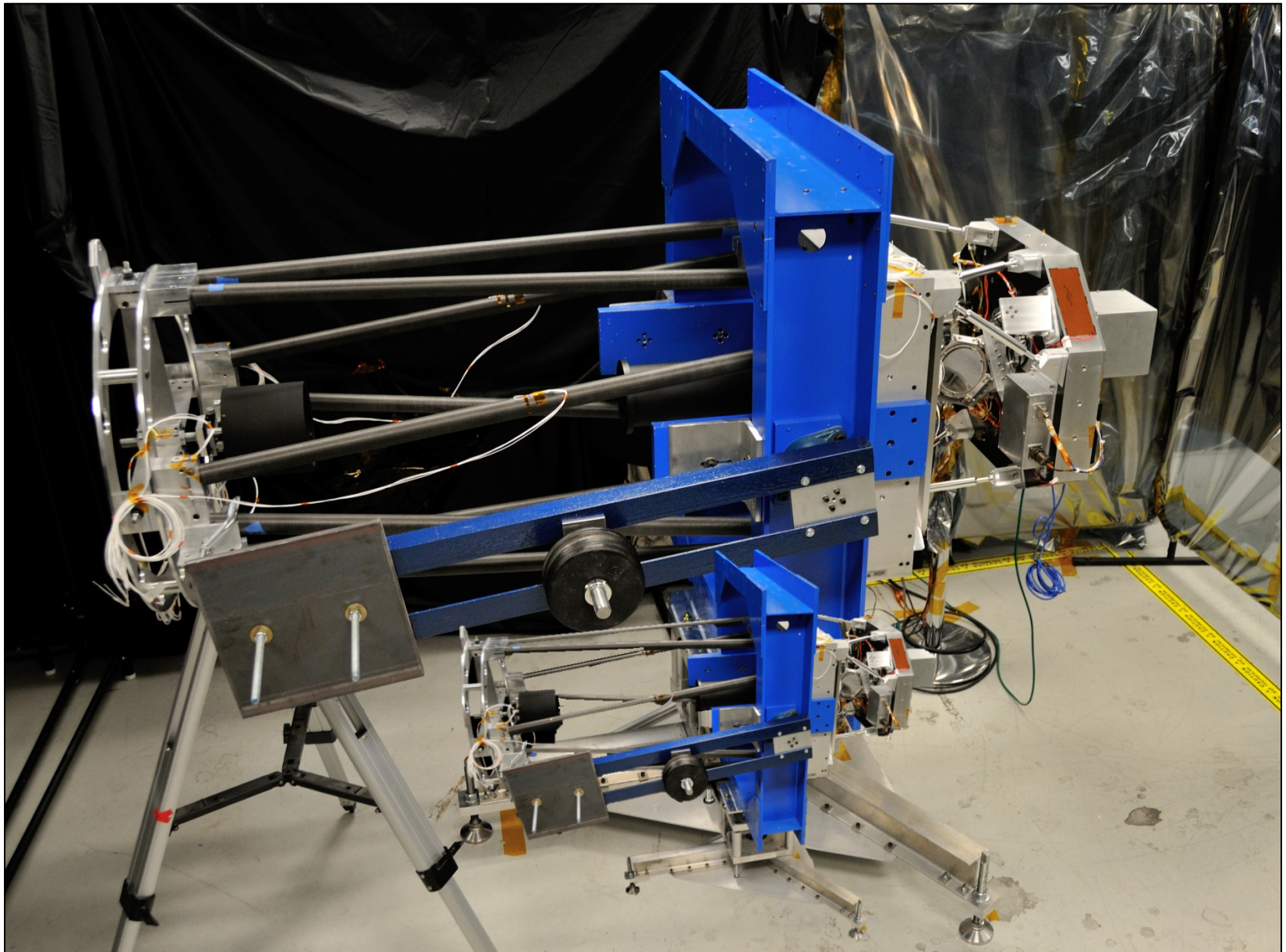


BIT-STABLE Mission Concept

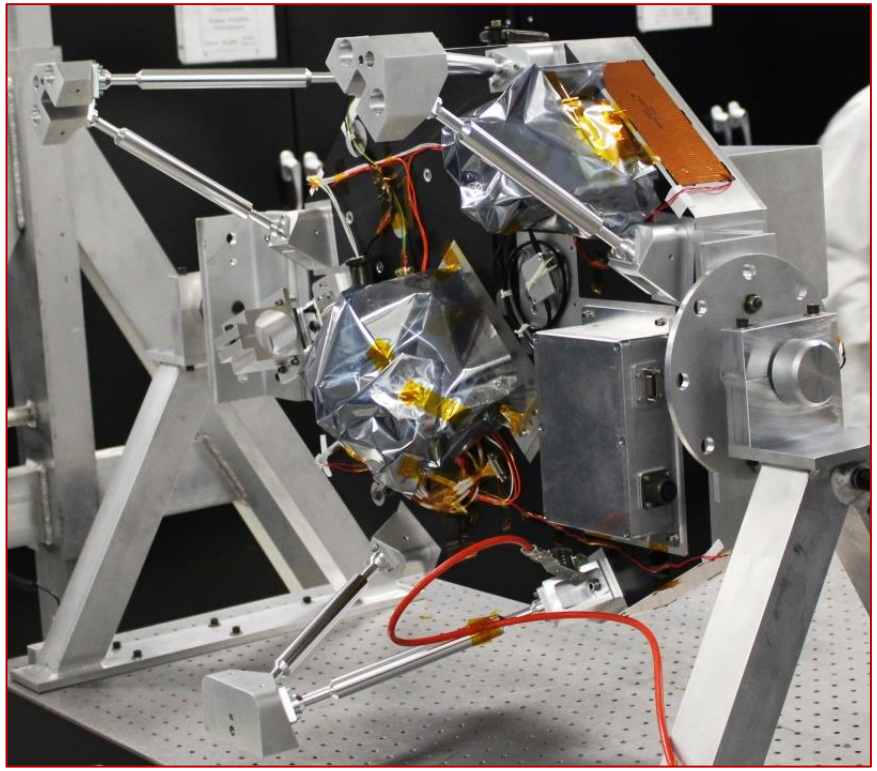


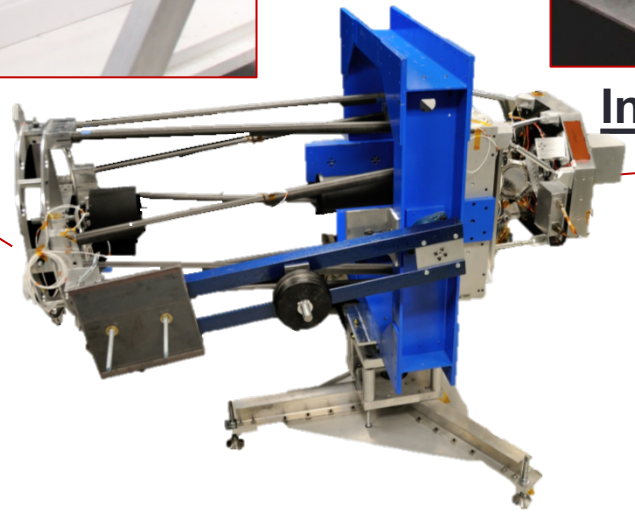
Pre-Decisional Information – For Planning and Discussion Purposes Only

STABLE Hardware



STABLE Hardware

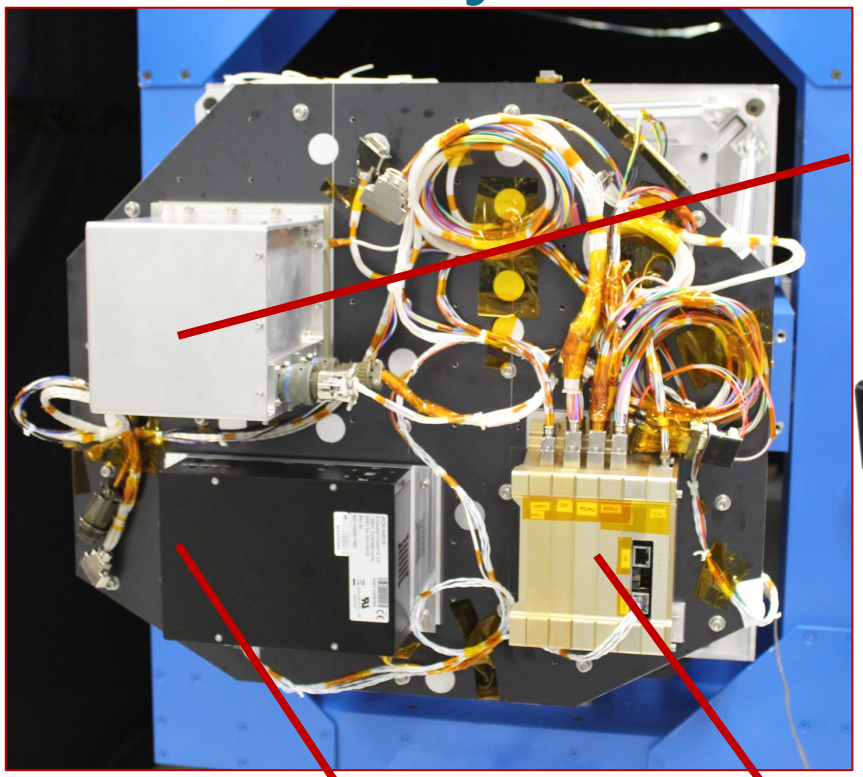




Telescope

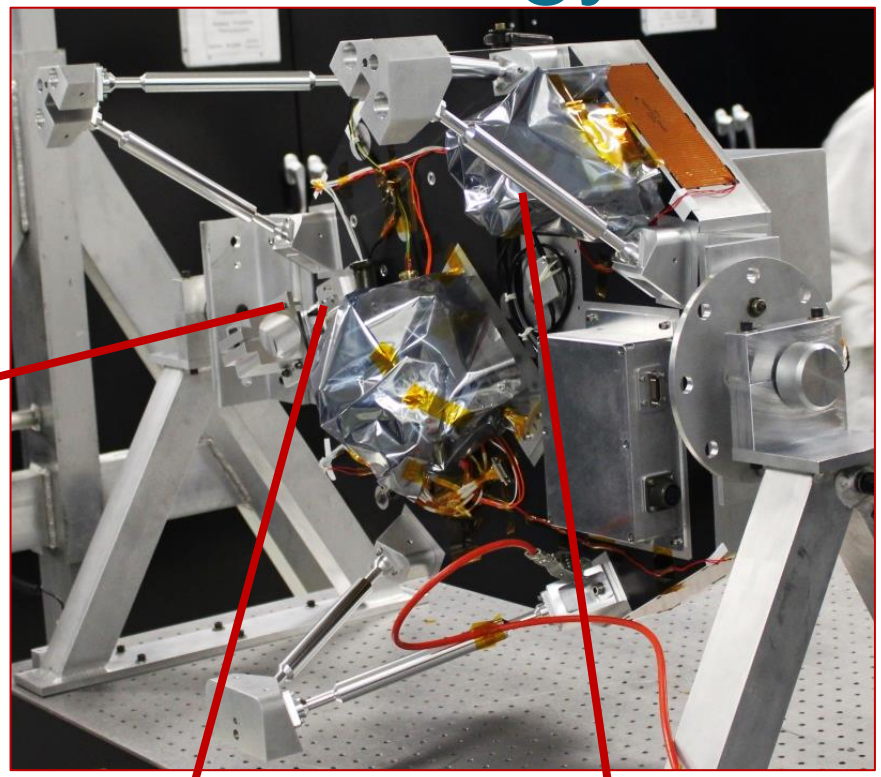
Integrated Optical Bench Assembly

Key Hardware in STABLE's Technology



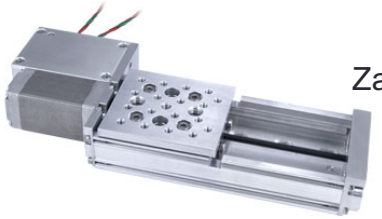
Attitude Rate Sensor (ARS)
Applied Technology Associates
Multi-Axis ARS Dynapak

Fine Guidance Camera
University of Durham,
Basler A2320



Fine Guidance Camera Computer (FGCC)
Advantech PCM-9363,
ACK-A001E chassis

Command and Data Handling Assembly (CDH),
SpaceMicro P400,
ADC/DAC, Ethernet,
Power Card



Refocusing Stage
Zaber Technologies Inc.
T-LSM050A-SV1

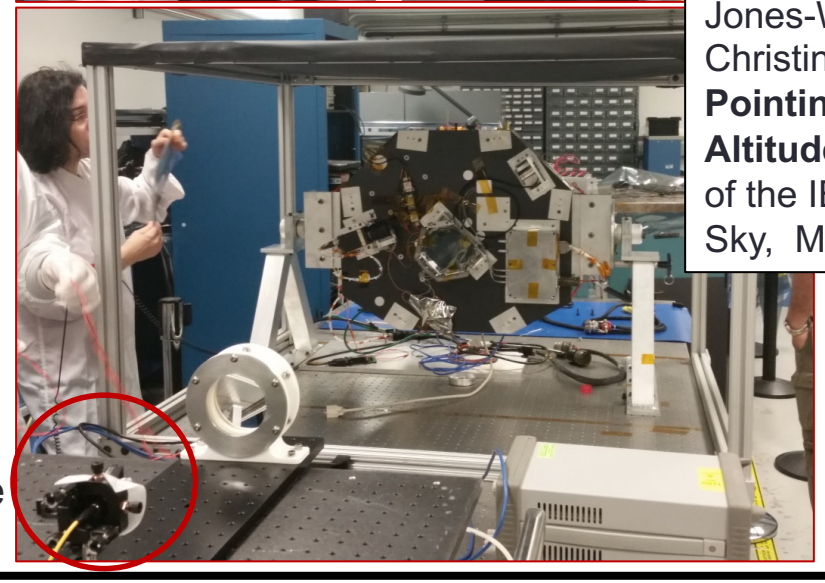
Fast Steering Mirror (FSM)
Physik Instrumente
Actuator S-330
Edmund Optics Mirror
64-019

Testing STABLE's Performance

Passive Test

Optical Table

Light Source

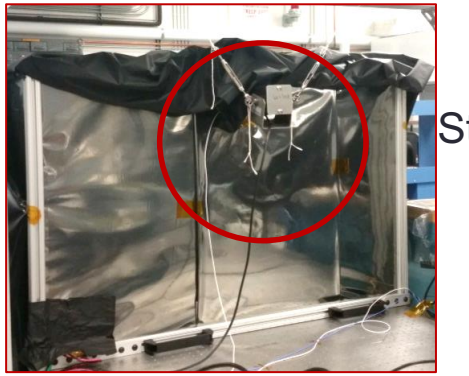


Light Source

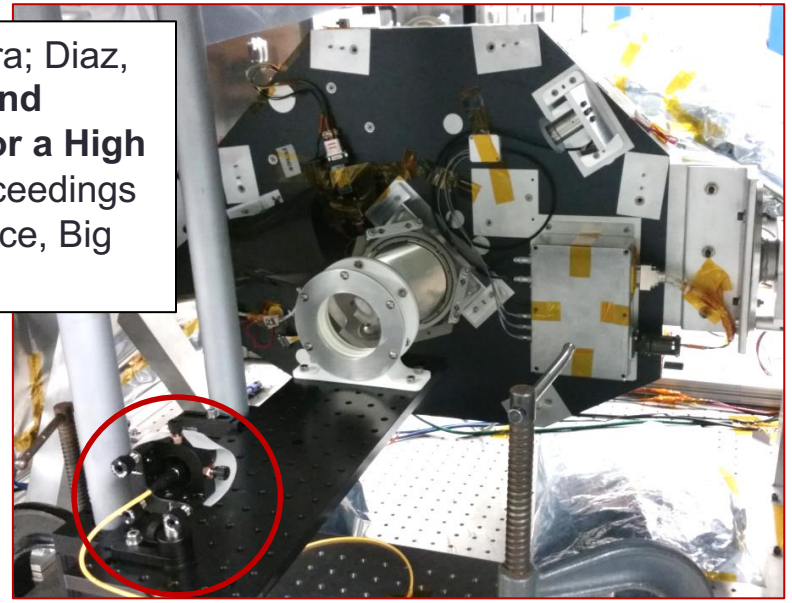
Optical Table

Stinger Test

Stinger



Stinger

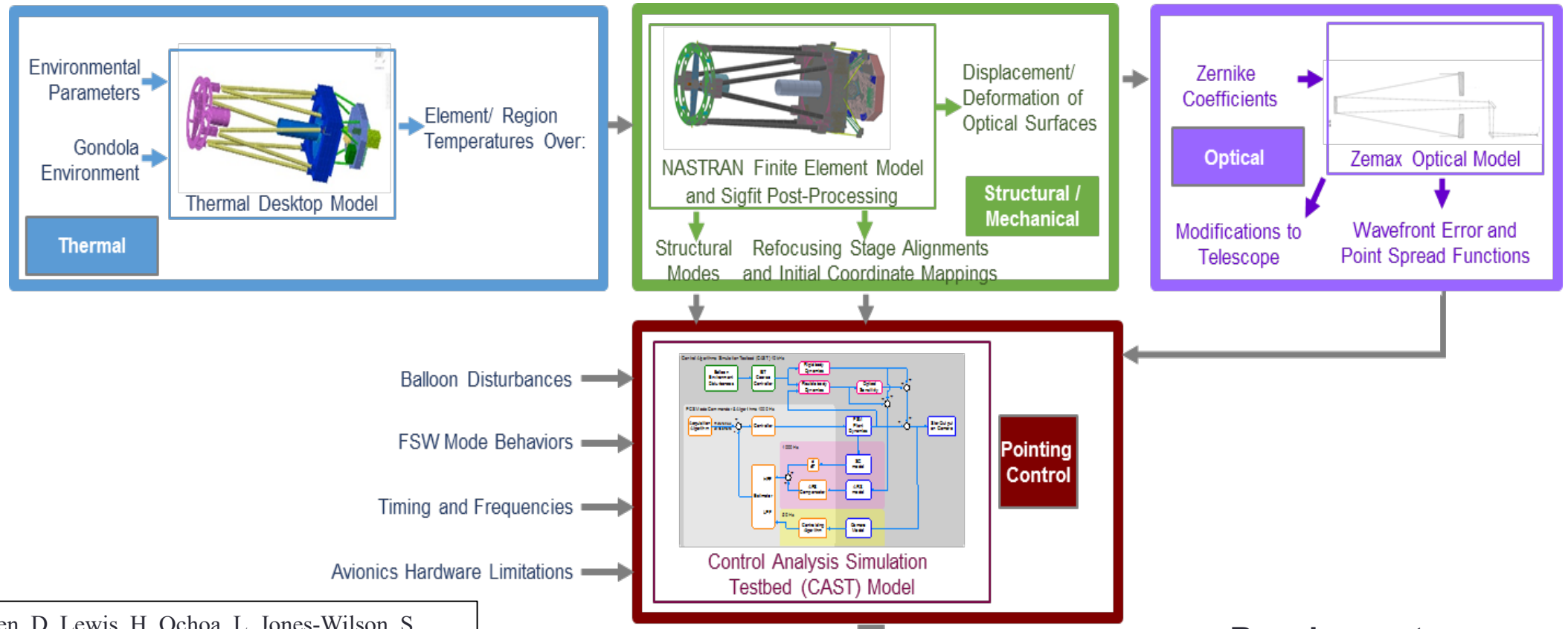


Light Source

Optical Table

Jones-Wilson, Laura; Susca, Sara; Diaz, Christina; et.al. "**A Sub-Arcsecond Pointing Stability Fine Stage for a High Altitude Balloon Platform**" Proceedings of the IEEE Aerospace Conference, Big Sky, MT, Mar 4 – 11 2017.

Proving STABLE Works Analytically

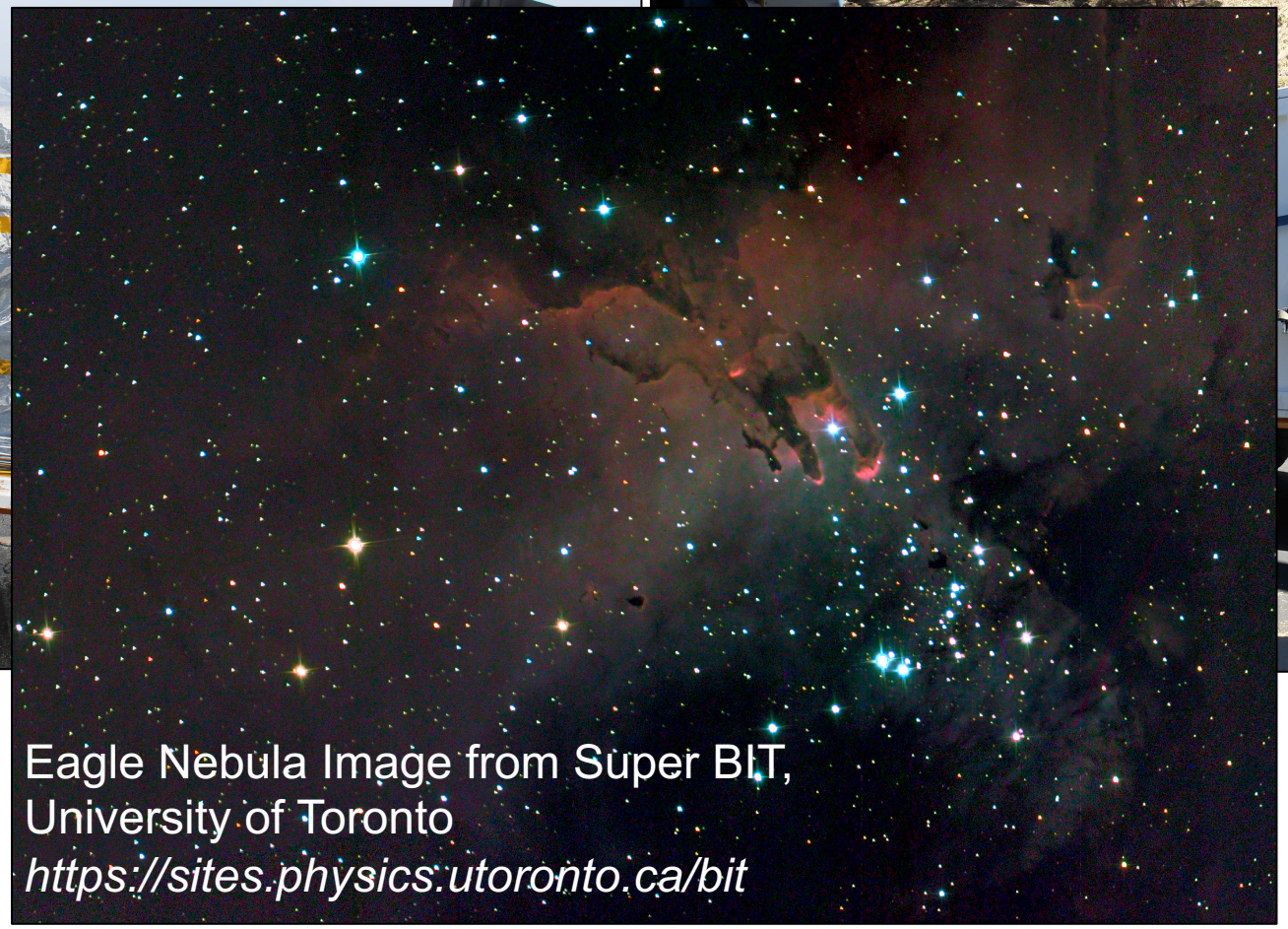


Pointing Stability Predicted:
94.5 milliarcseconds over 60 seconds (1-σ)

Requirement:
Demonstrate 100 milliarcsec stability over at least 60 seconds (1-σ per axis)

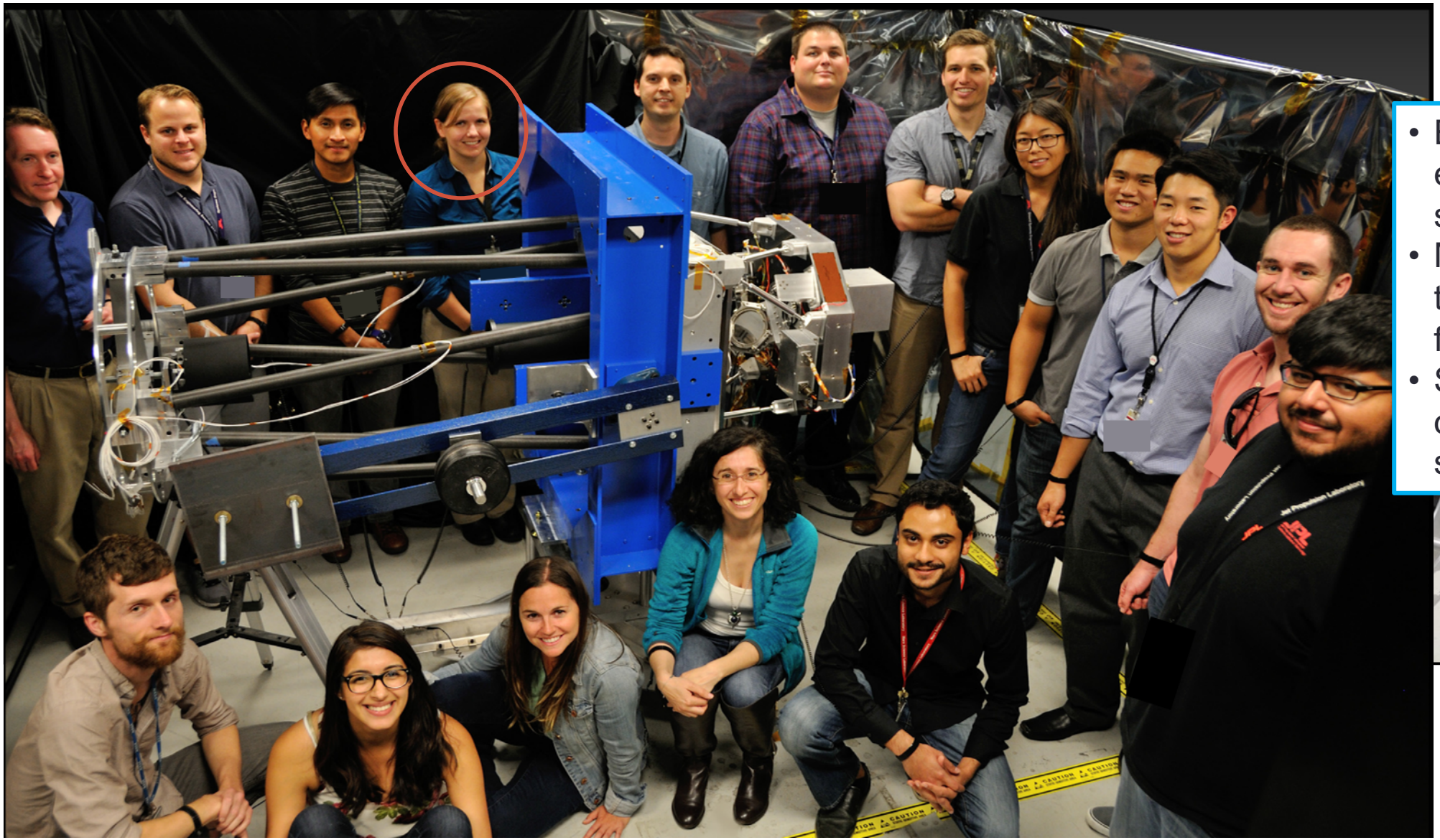
M. Borden, D. Lewis, H. Ochoa, L. Jones-Wilson, S. Susca, M. Porter, R. Massey, P. Clark and B. Netterfield, "**Thermal, Structural, and Optical Analysis of a Balloon-Based Imaging System,**" *Astronomical Society of the Pacific* Volume 129, Number 973, Jan. 19, 2017

STABLE's Legacy



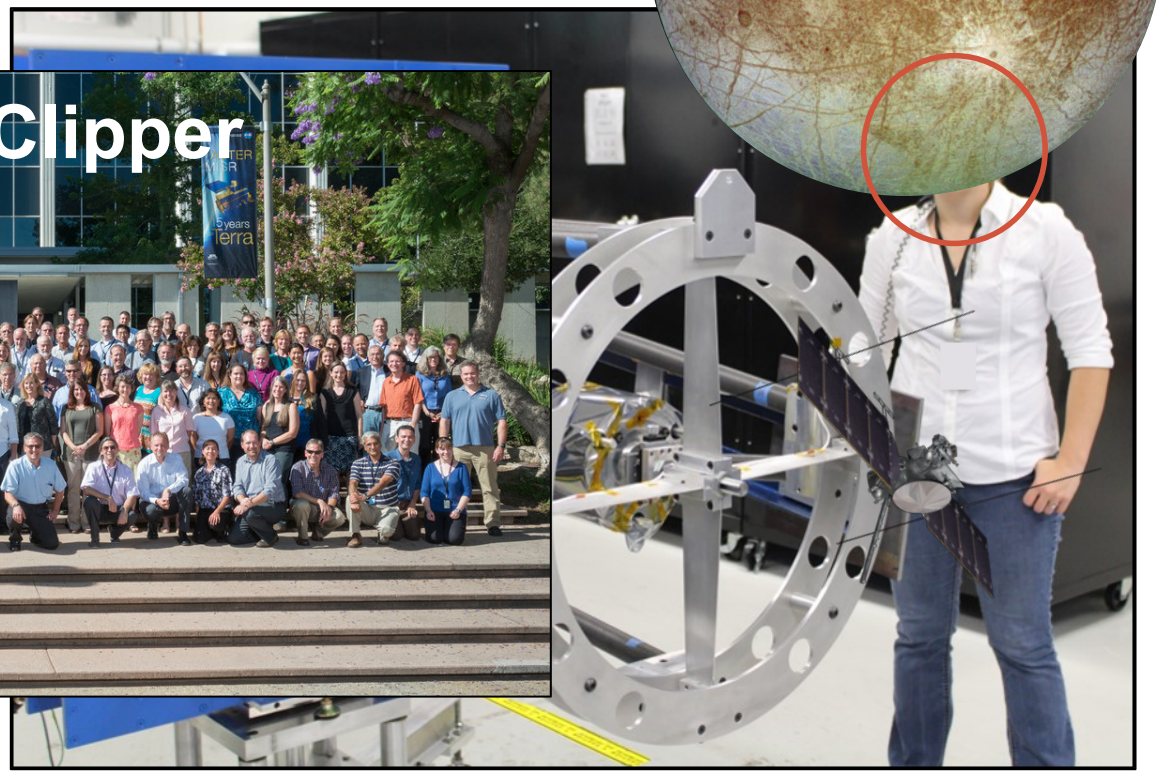
Eagle Nebula Image from Super BIT, University of Toronto
https://sites.physics.utoronto.ca/bit

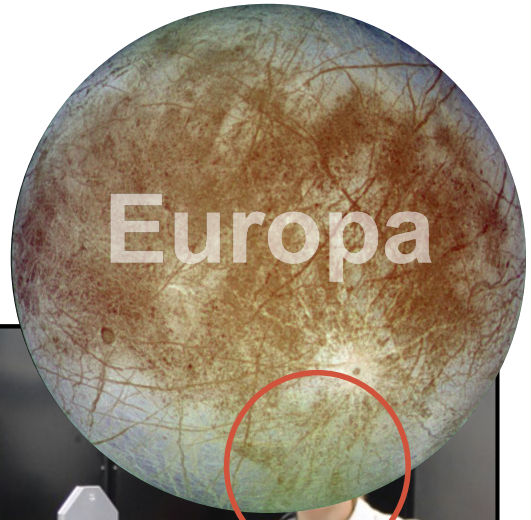
STABLE's Legacy: Team Training



- Exposure to end-to-end missions on shorter timescales
- More opportunities to interface with flight hardware
- Systems exposure on a manageable scale

STABLE's Legacy: Career



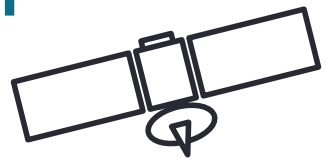


Ballooning As a Platform For Learning

Balloons as a Pathfinder

Credits: NASA/Wallops BPO
Pre-Decisional Information – For Planning and Discussion Purposes Only

Balloons As a Platform for Exploration



Can offer higher resolution remote sensing than orbiters

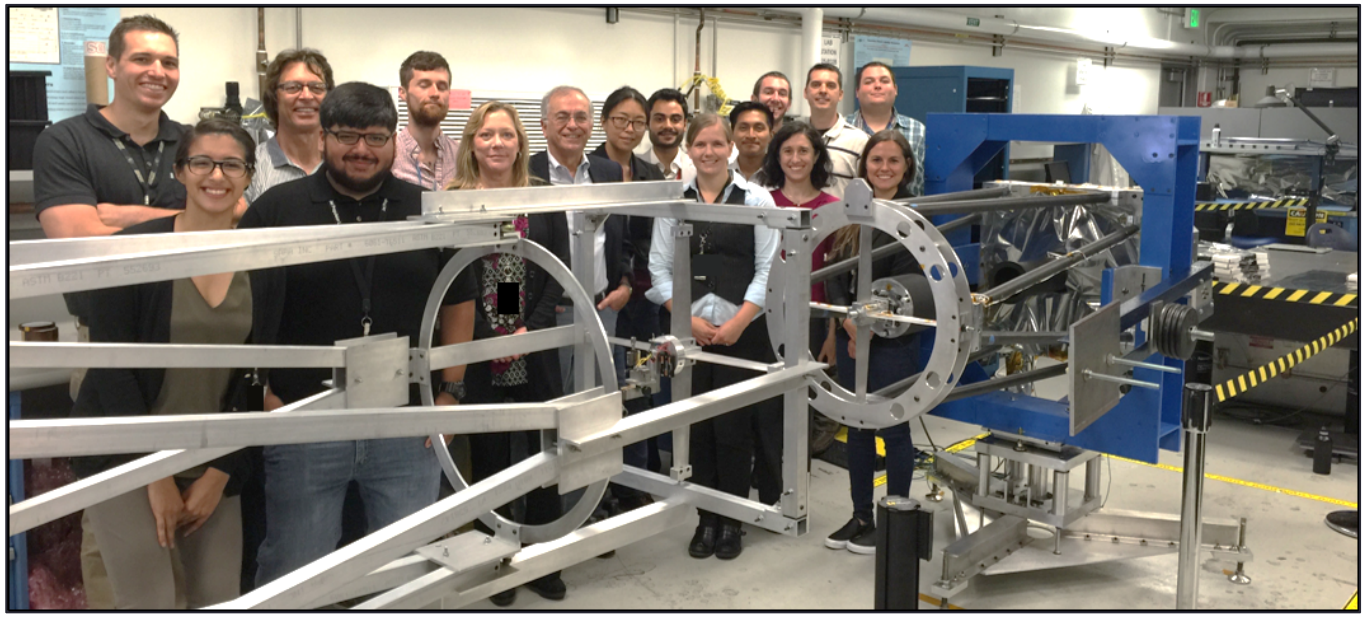
One of the only ways to collect data along a vertical column

Cover more horizontal distance

Ability to revisit locations over time

Provides more diverse coverage over regions

Balloons As a Platform for Exploration

Balloon missions are valuable contributors to NASA's mission to pioneer the future in space exploration and scientific discovery

They also serve as important crucibles for training the next generation of explorers