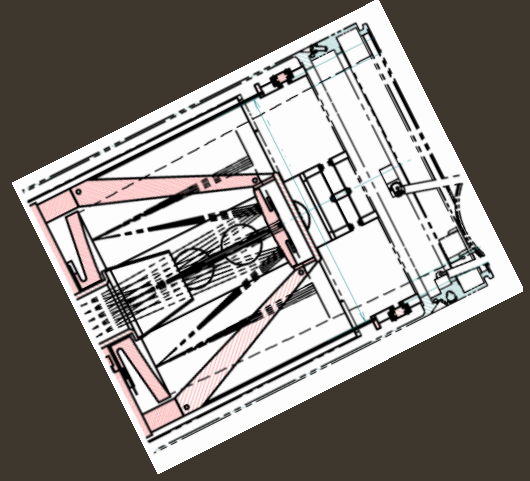
Advanced Athermal Telescope

The Peregrine Falcon Corporation
NASA Mirror Tech Days 2017

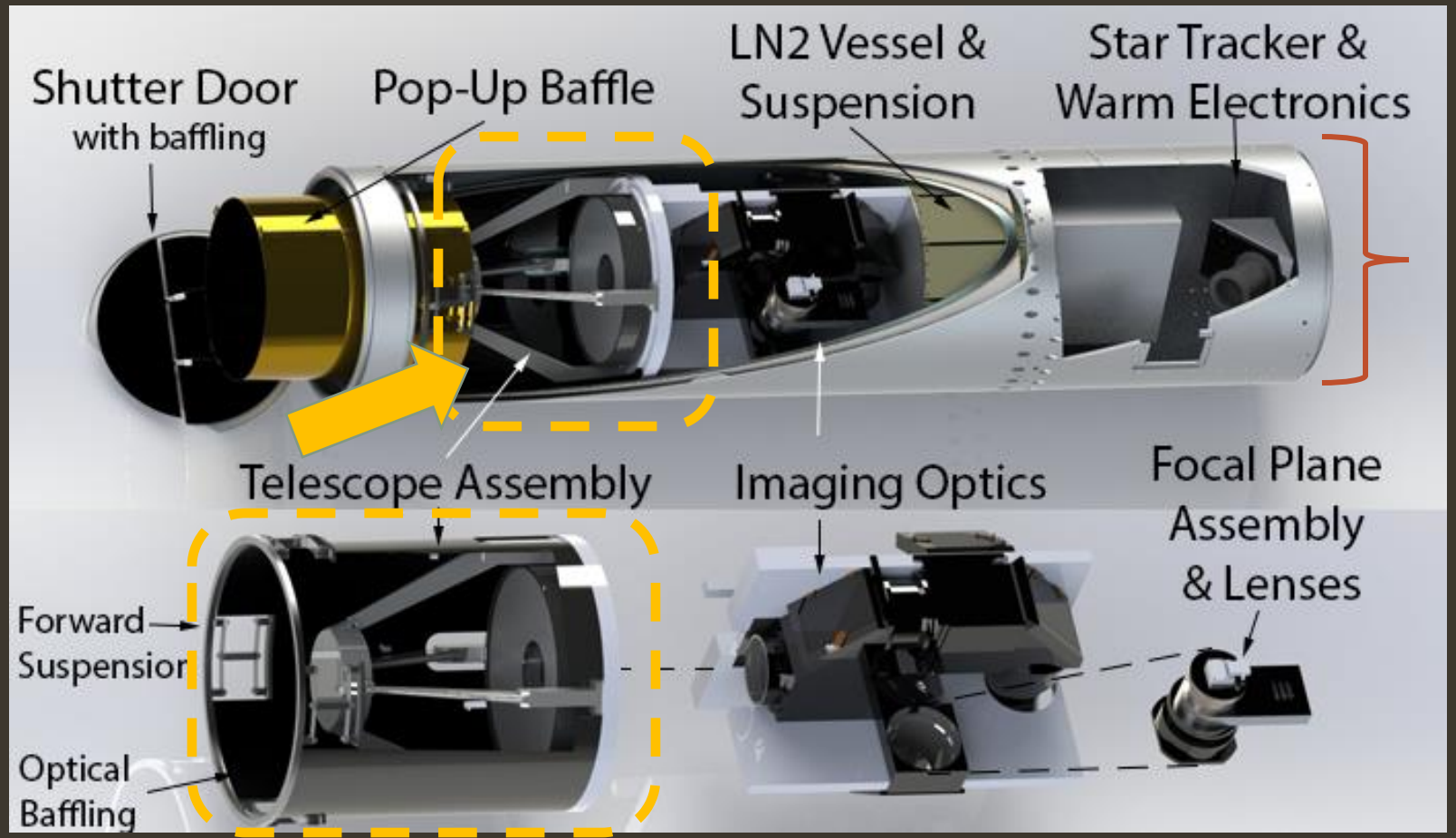


Phase I Objectives

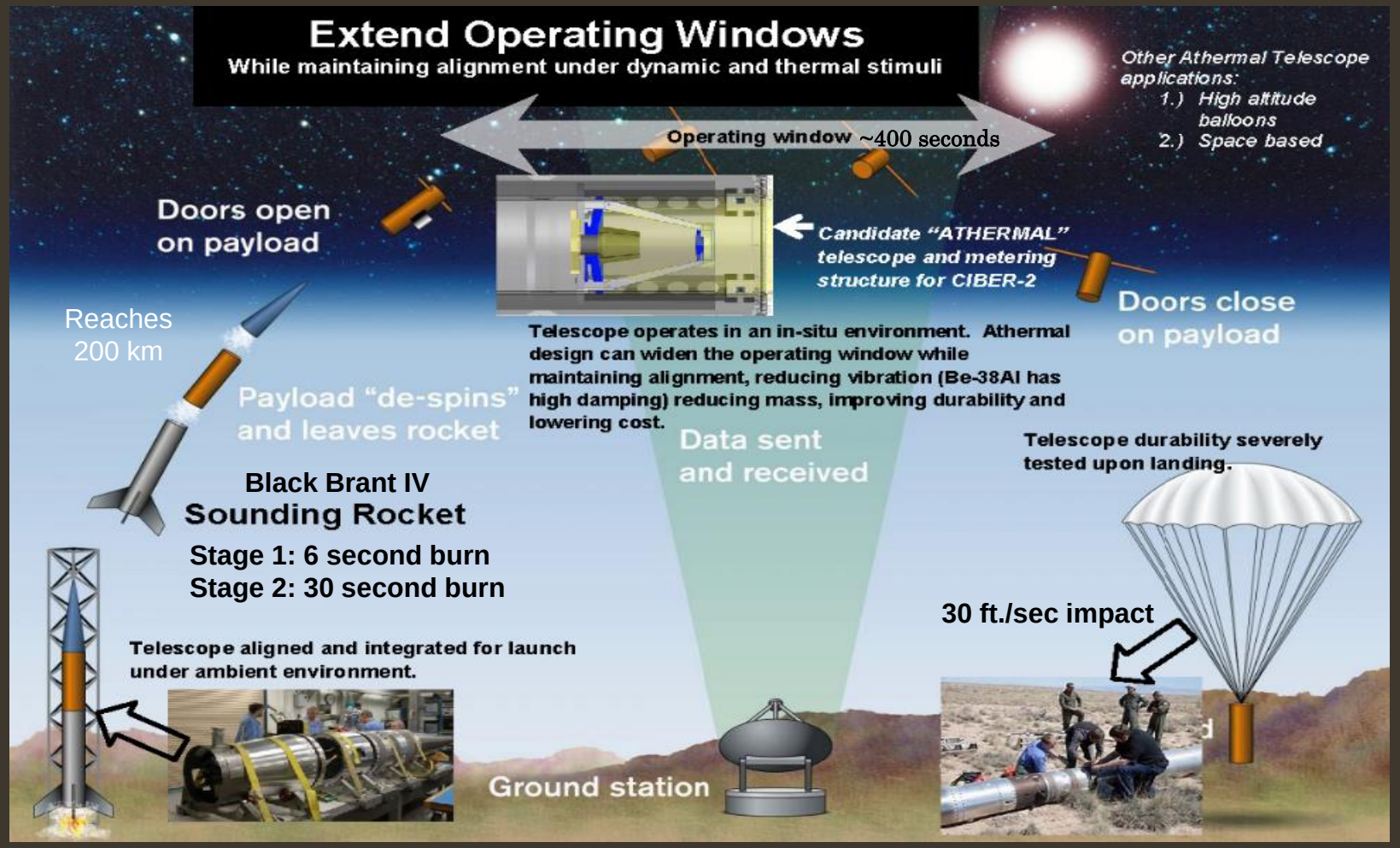
Using the current cosmic infrared background experiment (CIBER-2) parameters as target requirements and Peregrine's advances with Be-38Al / LID Bonding/Electroless Nickel Plating/SPDT:

- Improve performance and structural integrity while reducing mass.
- Provide a high degree of stability under changing thermal and physical environments.
- Physically demonstrate advantage/feasibility.
- Provide an initial Phase II telescope design with 28 cm^2 primary mirror for flight on CIBER-2.

CIBER-2 Observation Instrument



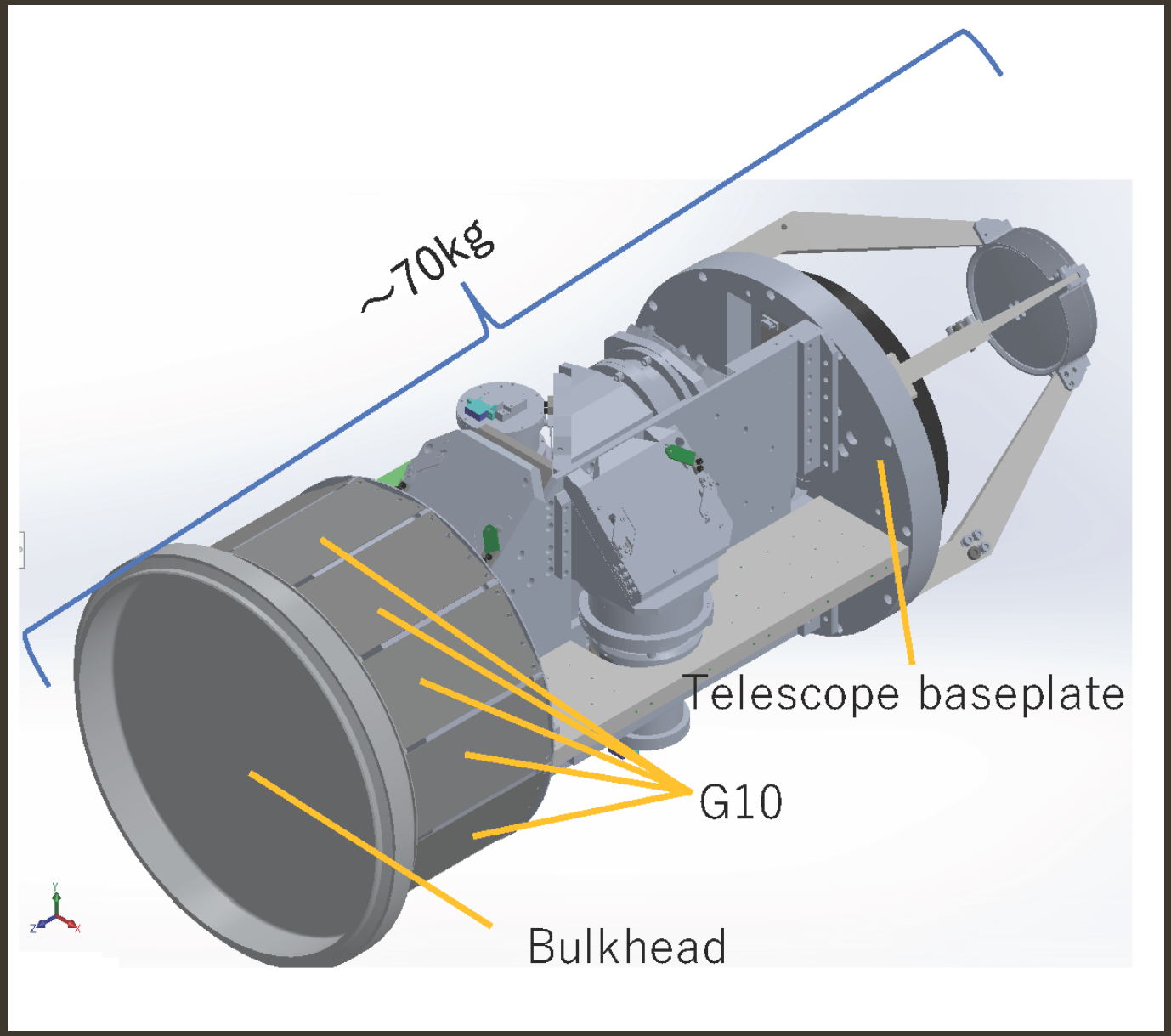
Athermal Telescope Flight Profile – CIBER-2

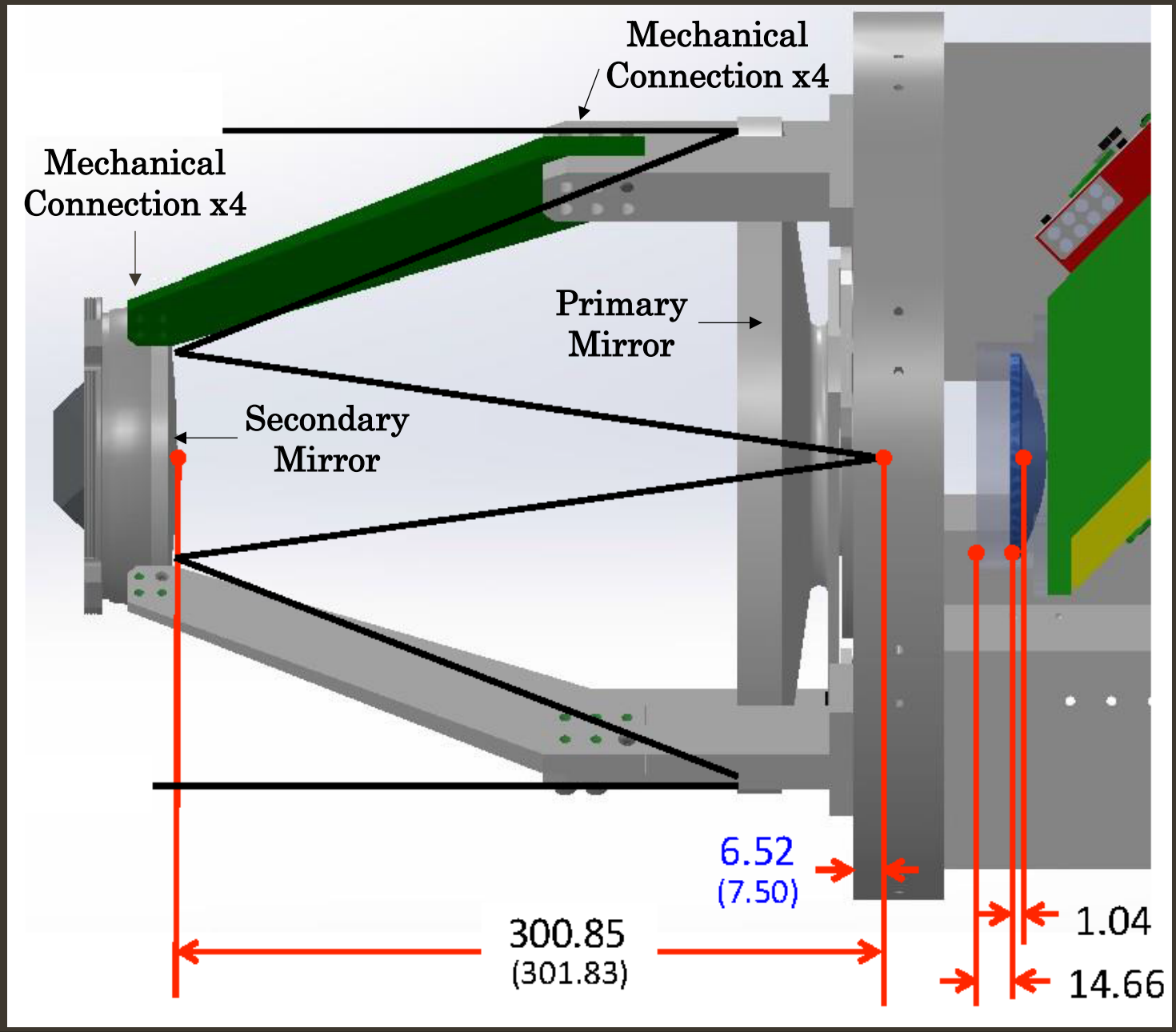


Specification of the CIBER-2 Telescope

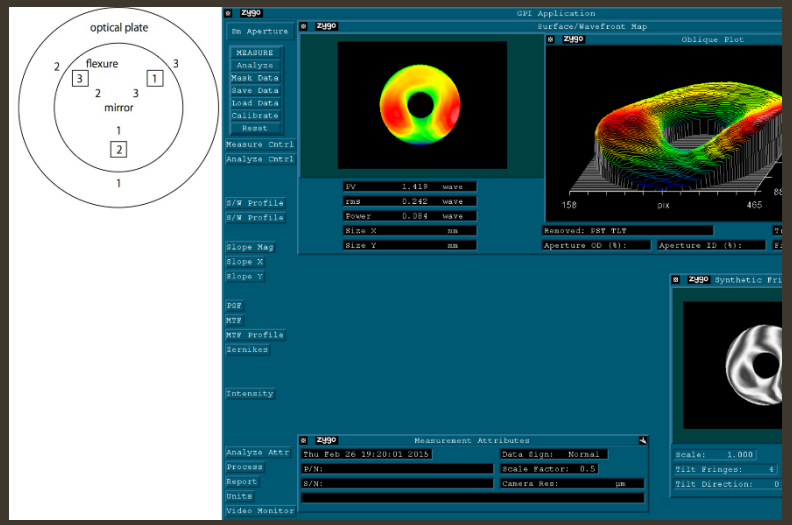
Table 1. Specification of the CIBER-2 telescope.

Telescope type	Ritchey-Chretien
EPD (Entrance Pupil Diameter)	285 mm (at primary mirror)
EFL (Equivalent Focal Length)	930 mm
Arm-S	930.86 mm
Arm-M	929.61 mm
Arm-L	930.02 mm
FNO (F Number)	3.26
Arm-S	3.266
Arm-M	3.262
Arm-L	3.263
FOV (Field of View)	2.3×2.3 degree^2
Detector Format	2048×2048 pixels (Pixel size = 18 μm)
Pixel Scale	4 arcsec / pixel


~70kg
Telescope baseplate
G10
Bulkhead


Mechanical
Connection x4
Mechanical
Connection x4
Primary
Mirror
Secondary
Mirror
6.52
(7.50)
300.85
(301.83)
1.04
14.66

CIBER-2: Baseline Aluminum Mirror



Bread Board Al Model

PV ~1.5 λ
RMS ~ ¼ λ
(Mounting Effects)

Improved Al Mirror

Optimized Al Mirror

PV ~ ½ λ
RMS ~ ⅛ λ
(Mounting Effects)

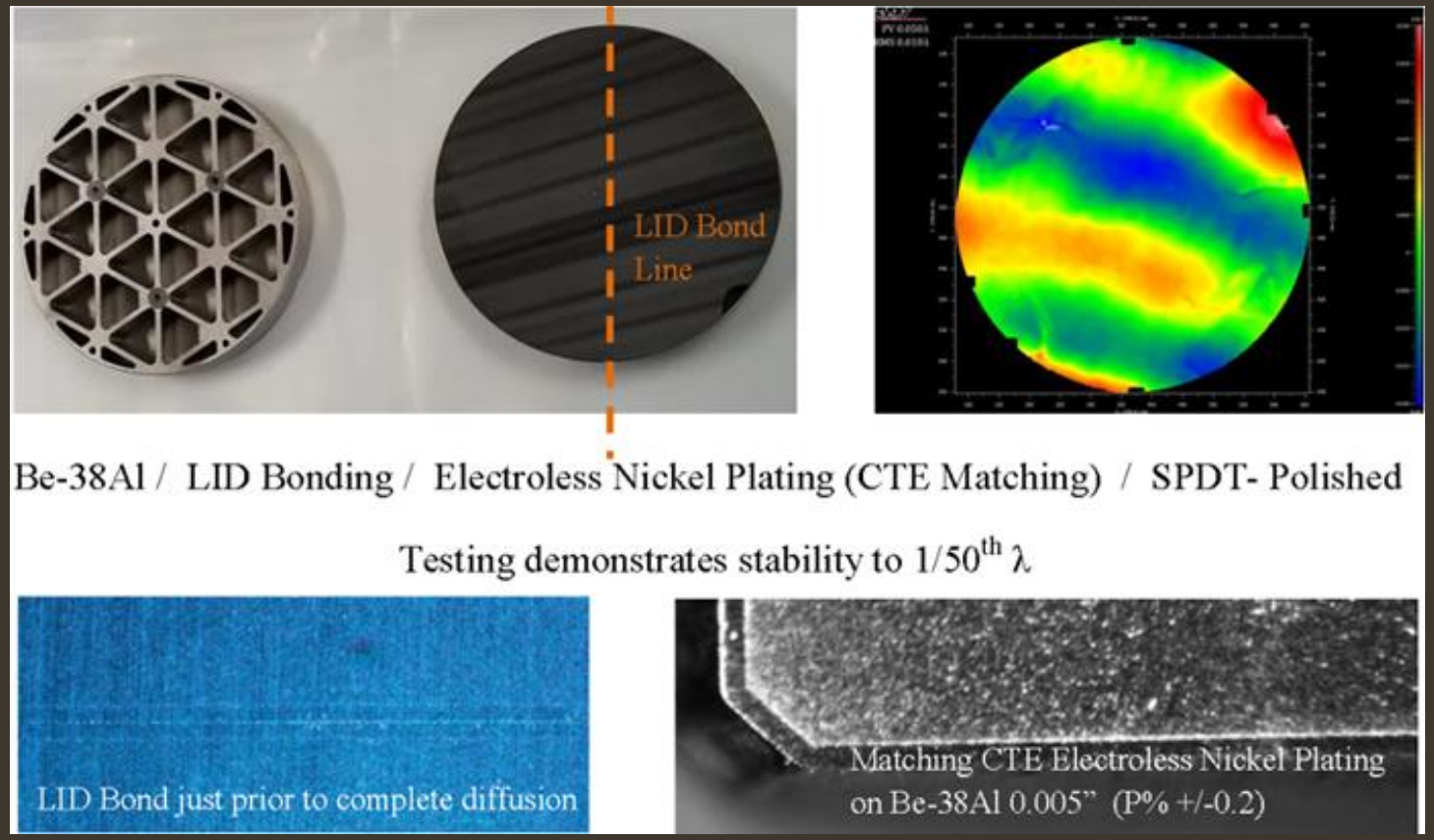
Be-38Al/EN PV 1/20th λ / 30 Å RMS

Current CIBER-2 Baseline Telescope

- All Aluminum
- Primary Mirror P.V. ½ λ, RMS ⅛ λ
- Instrument First Mode ~ 40 Hz
- Stability to 80 K

Recap Athermal Material Approach

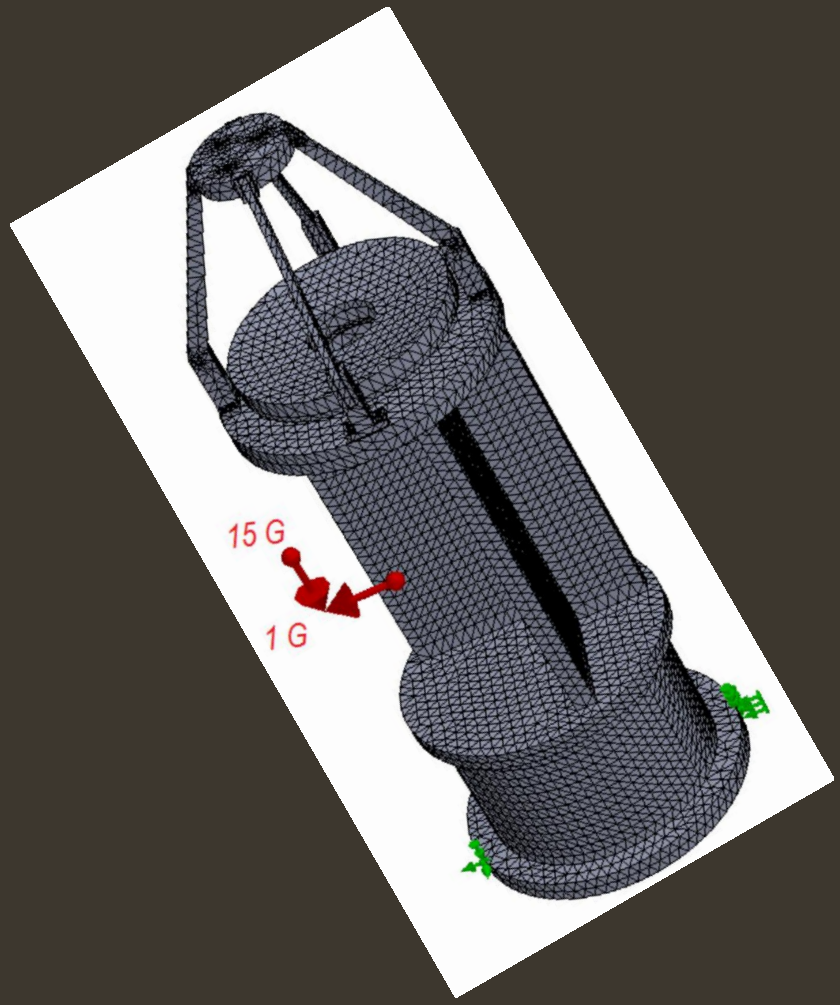
We have developed a material system to provide flight hardware.



TRL 4 to 7

Stable to 1/50th λ, 30 angstrom RMS, high modulus material 193 GPa vs. 69 GPa

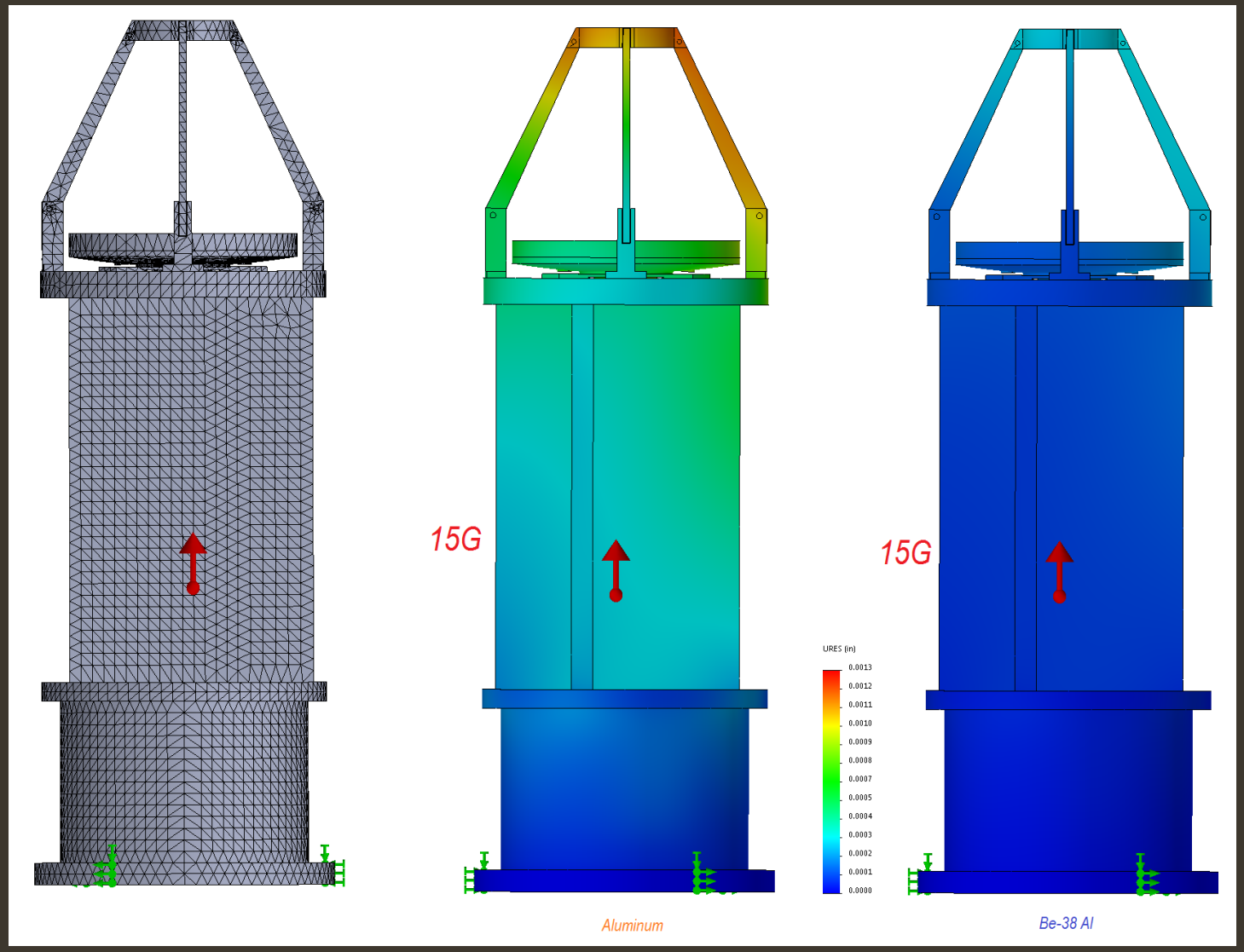
Simplified Model to Speed Simulation Runs



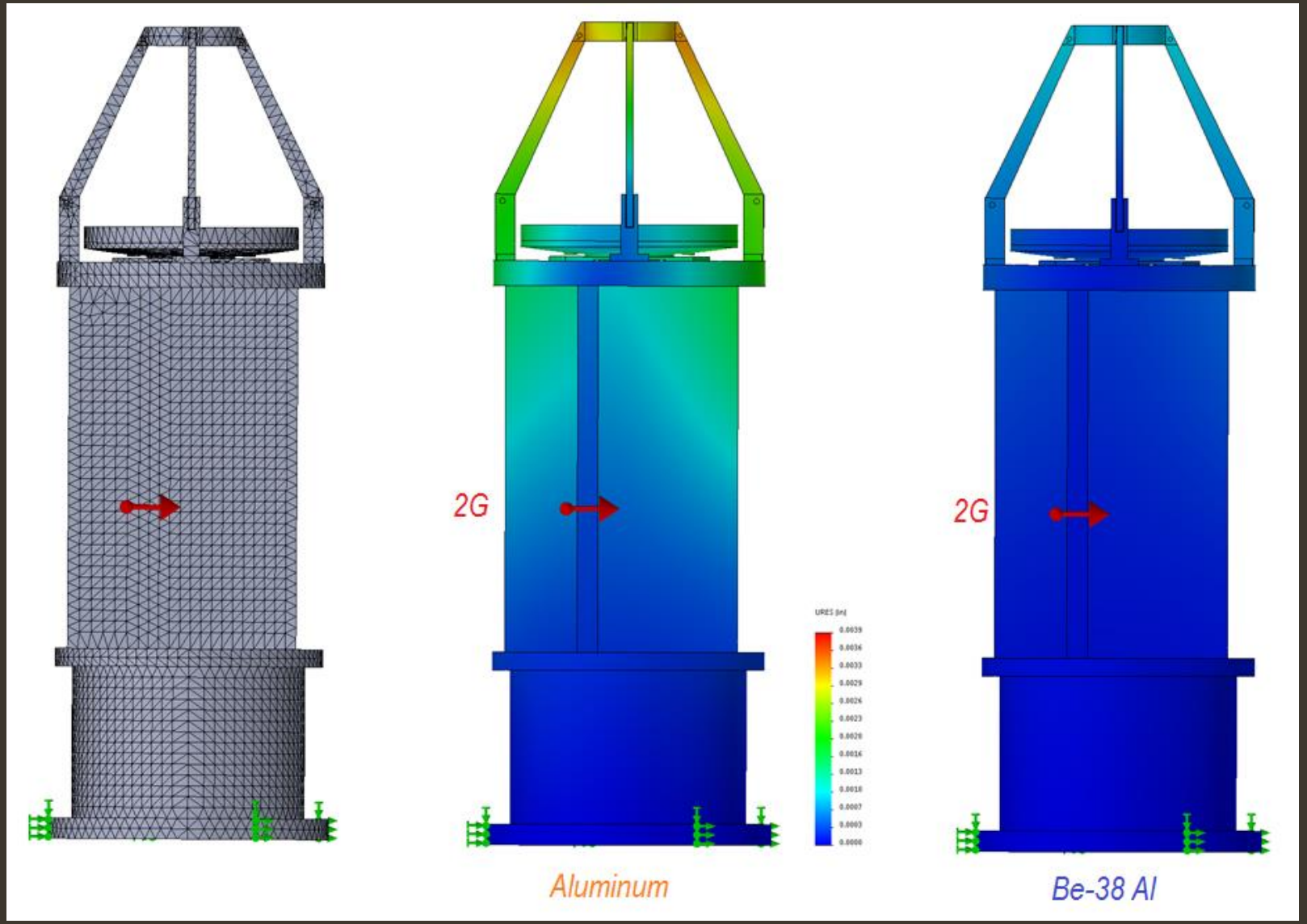
Material Property Data for Analysis

Property	Aluminum 6061T6	Be-36Al (AMS7911)	Be-38Al / 6061T6
Mass Density, g/cc	2.70	2.10	77.8%
Modulus of Elasticity, GPa	69	193	279.7%
Yield Strength, MPa	255	193	75.7%
Coefficient of Thermal Expansion, ppm/°C	22.9	13.9	60.7%
Thermal Conductivity, W/m K	170	210	123.5%
Poisson's ratio	0.33	0.17	51.5%
Specific Stiffness (Modulus/Density)	25.6	91.4	357%

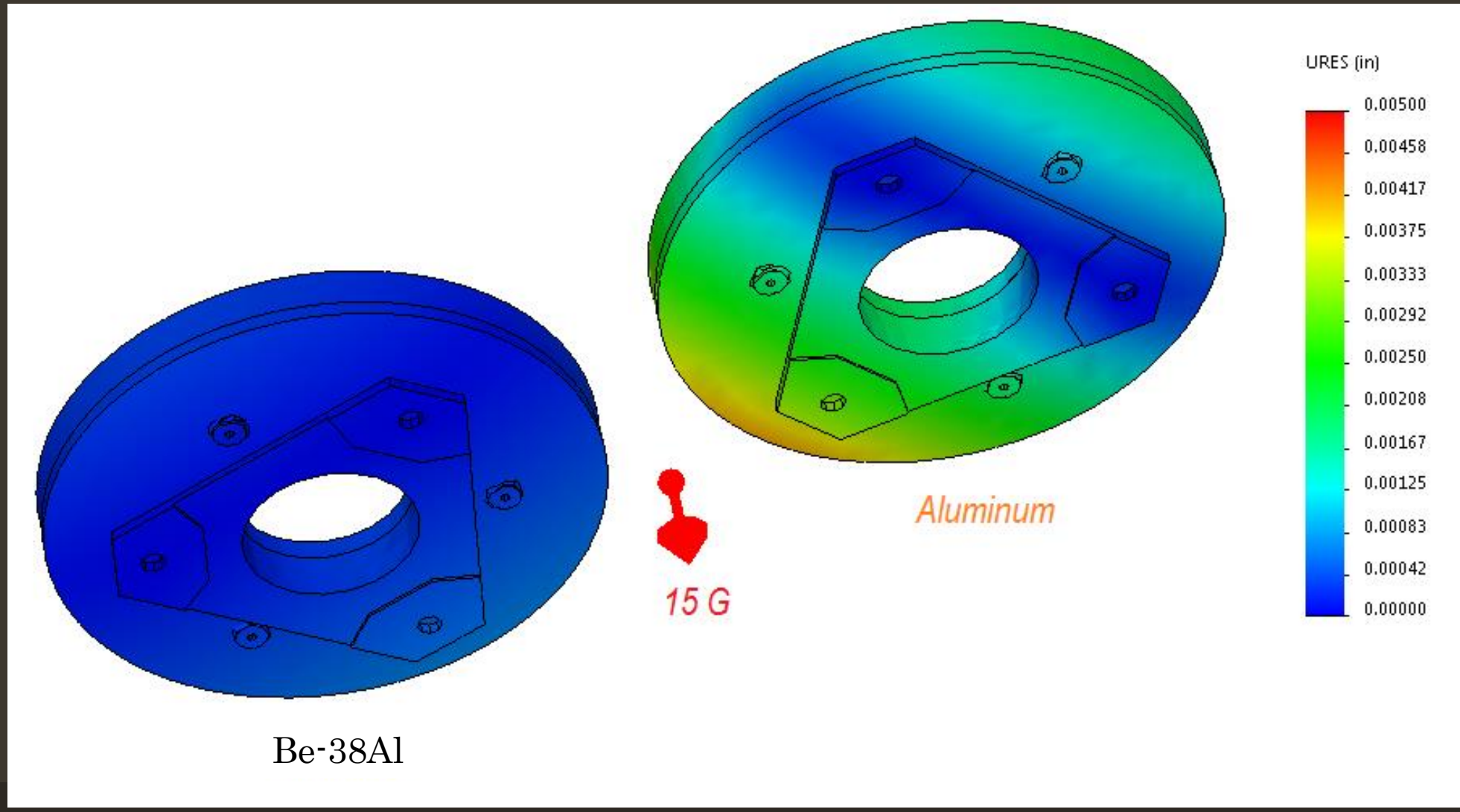
Launch Loads



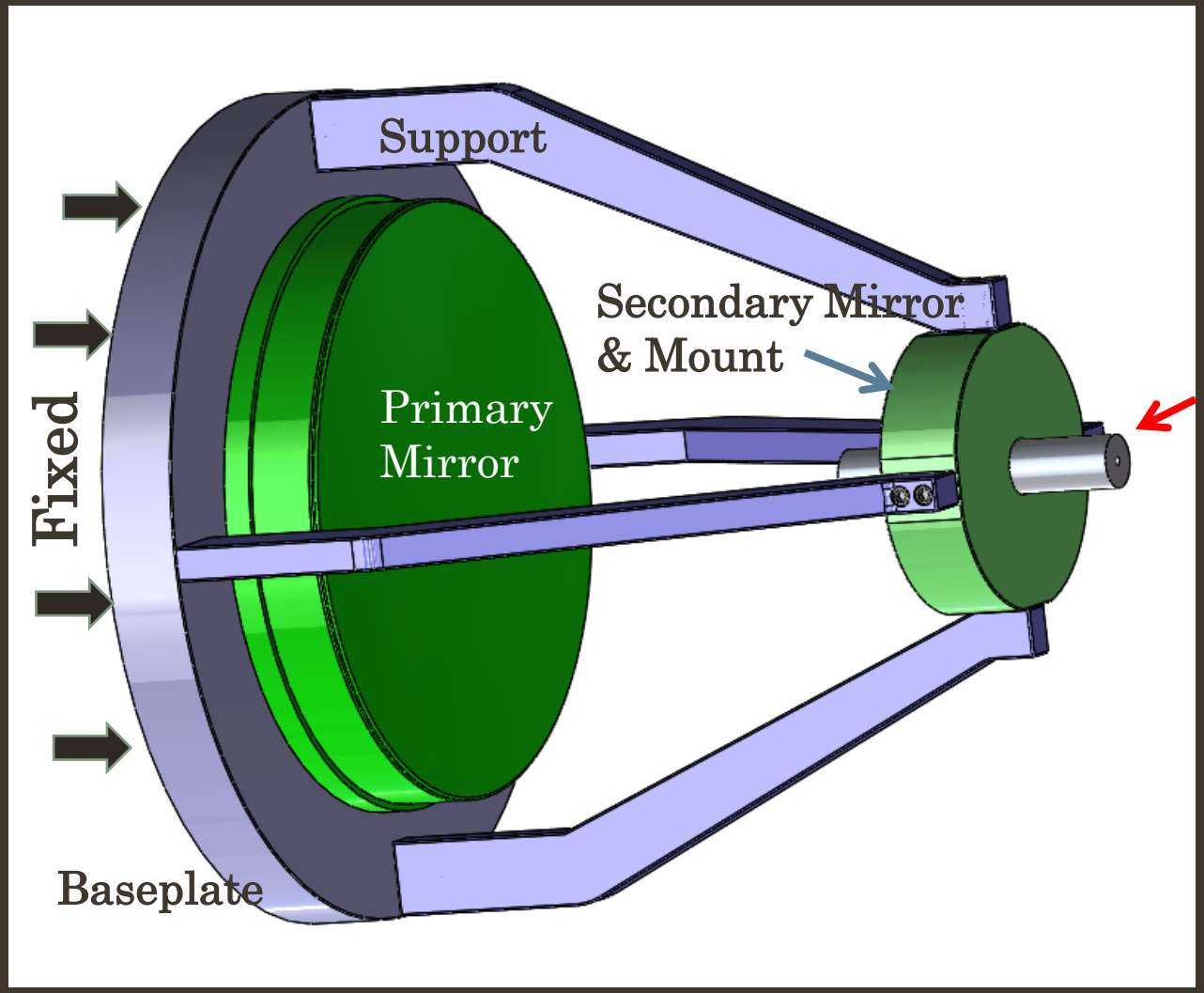
Landing Load



Primary Mirror – Al vs. Be-38Al



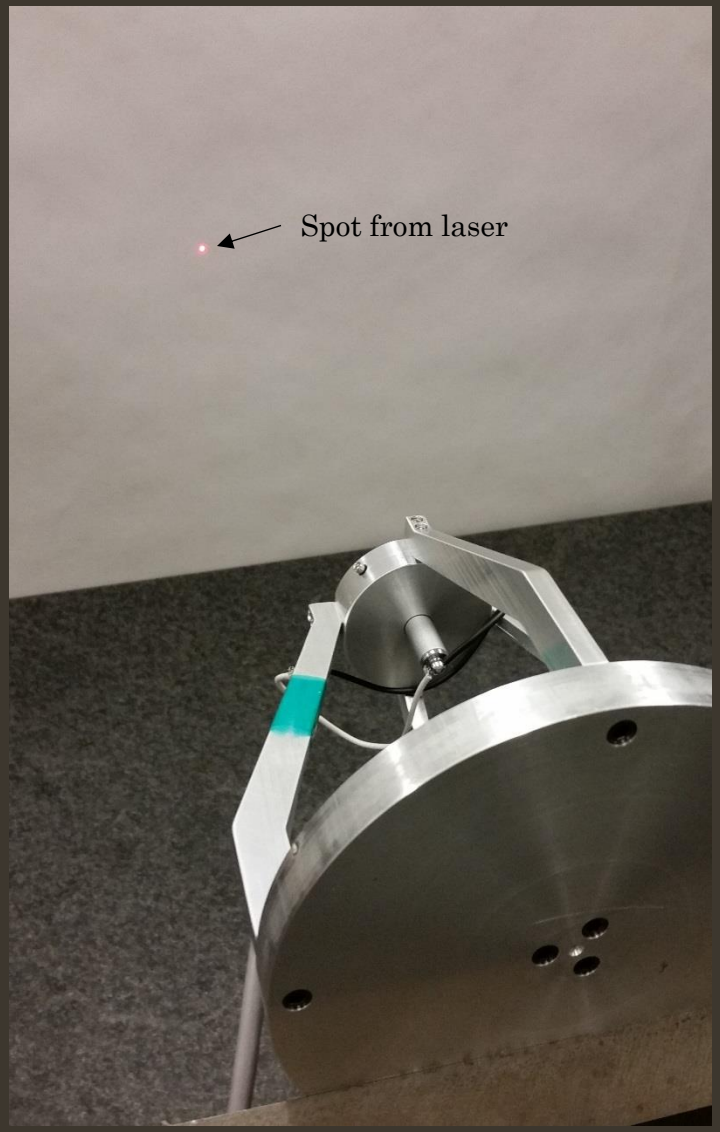
Phase I Mock-Up for Testing



Laser

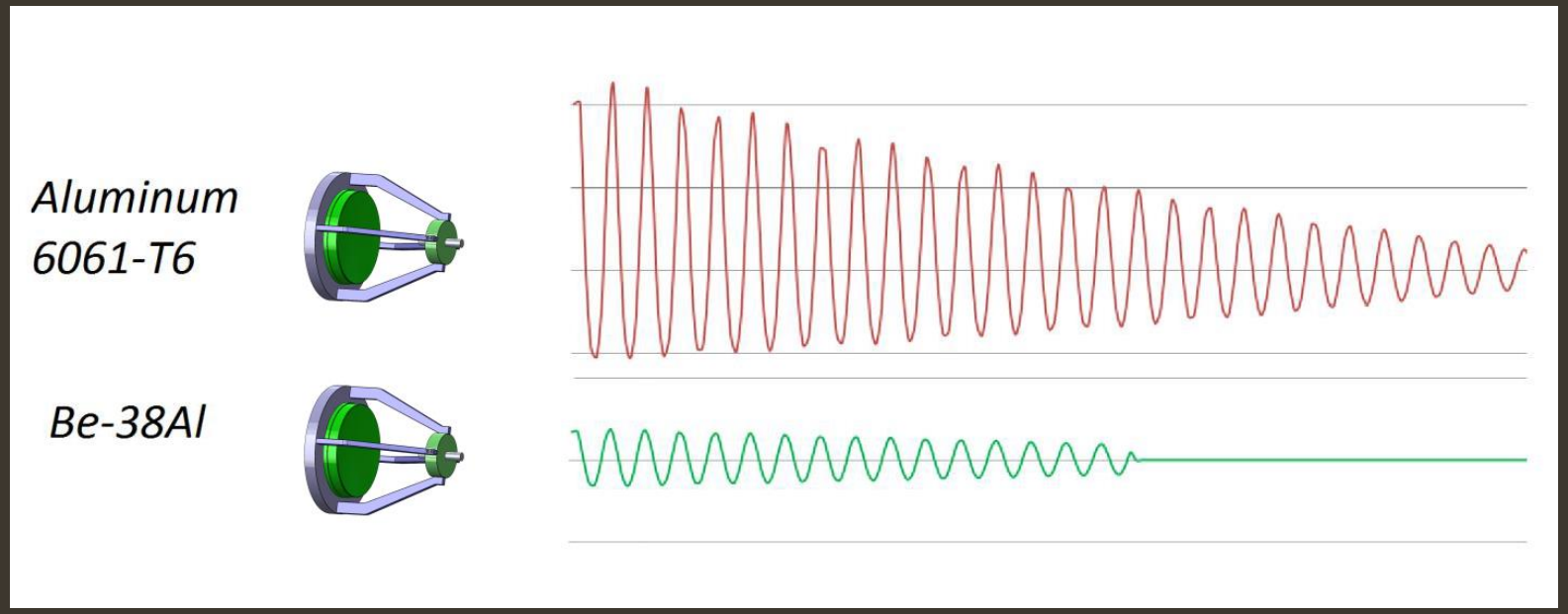
Vibration, damping,
and thermal gradient.

Assembled Test Unit

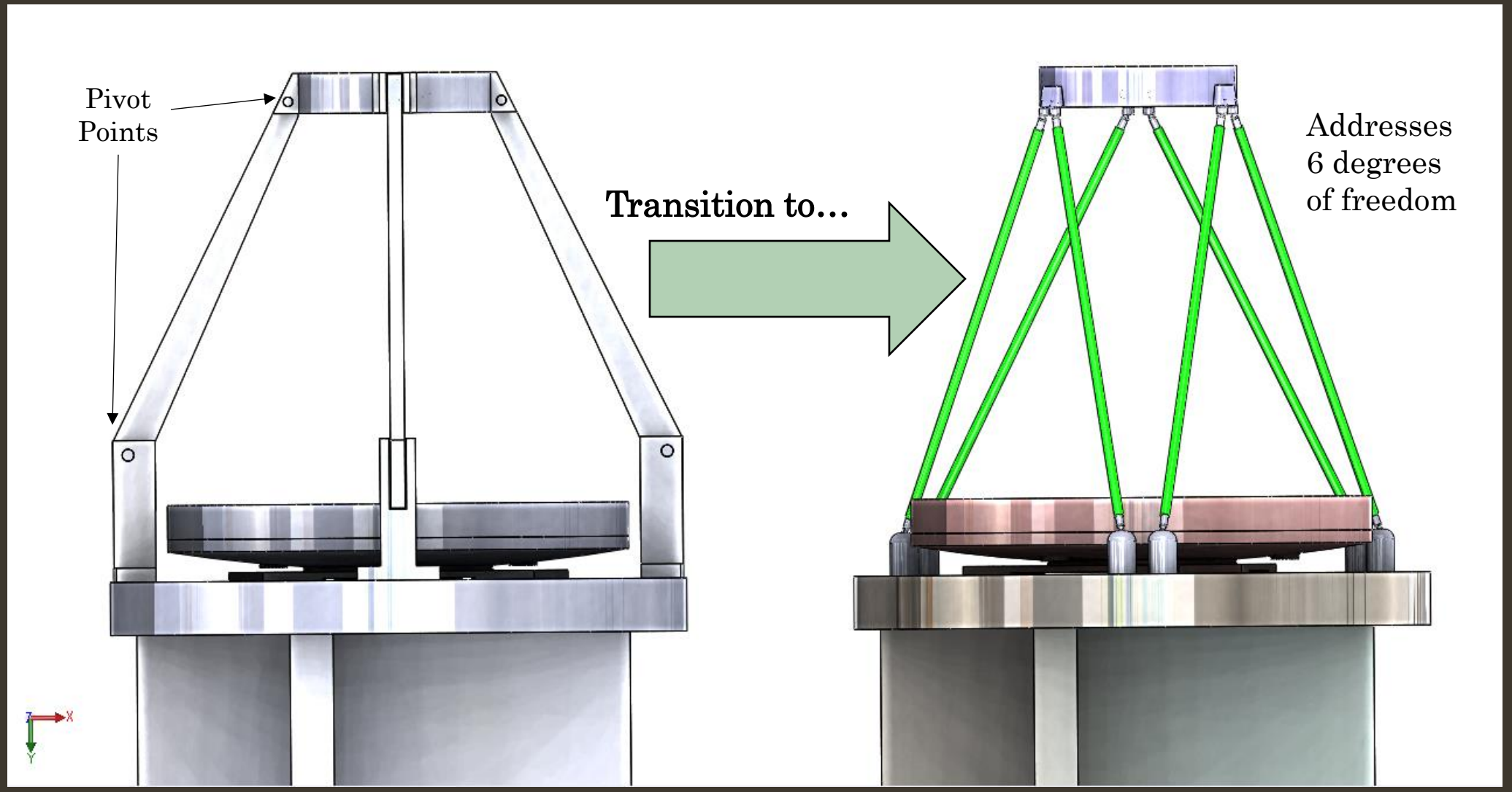


Vibration Set-Up

Vibration/Damping Comparisons



Parallel Design Study: Stewart Platform



Mass Budget
Baseline Al vs. Direct Substitute Be-38Al (25% Reduction)

	Aluminum	Be-38Al
Base Plate	20.35 lbs.	15.6 lbs.
Primary Mirror	7.67	4.4
SM_Support 1, 2, x4	4.00	3.0
Cassegrain Baffle, Baffle Base	2.07	2.07
SM_Support 10,11	1.81	1.4
Aperture Mask	1.04	1.04
Flexures	0.84	0.84
Secondary Mirror	0.83	0.65
Cal Lamp	0.22	0.22
Field Stop	0.01	0.01
Total	38.84 lbs.	29.23 lbs.

Phase II Objectives

- Mature initial design of Phase I to a critical design for build, test, and flight under Phase II using Be-38Al / LID Bonded / Electrical Nickel / SPDT – Polish.
- Verify primary and secondary mirror precision and alignment at ambient and 80K.
- Build and test engineering telescope for qualification testing on board a sounding rocket.
- Build, test and deliver a proto-flight telescope.