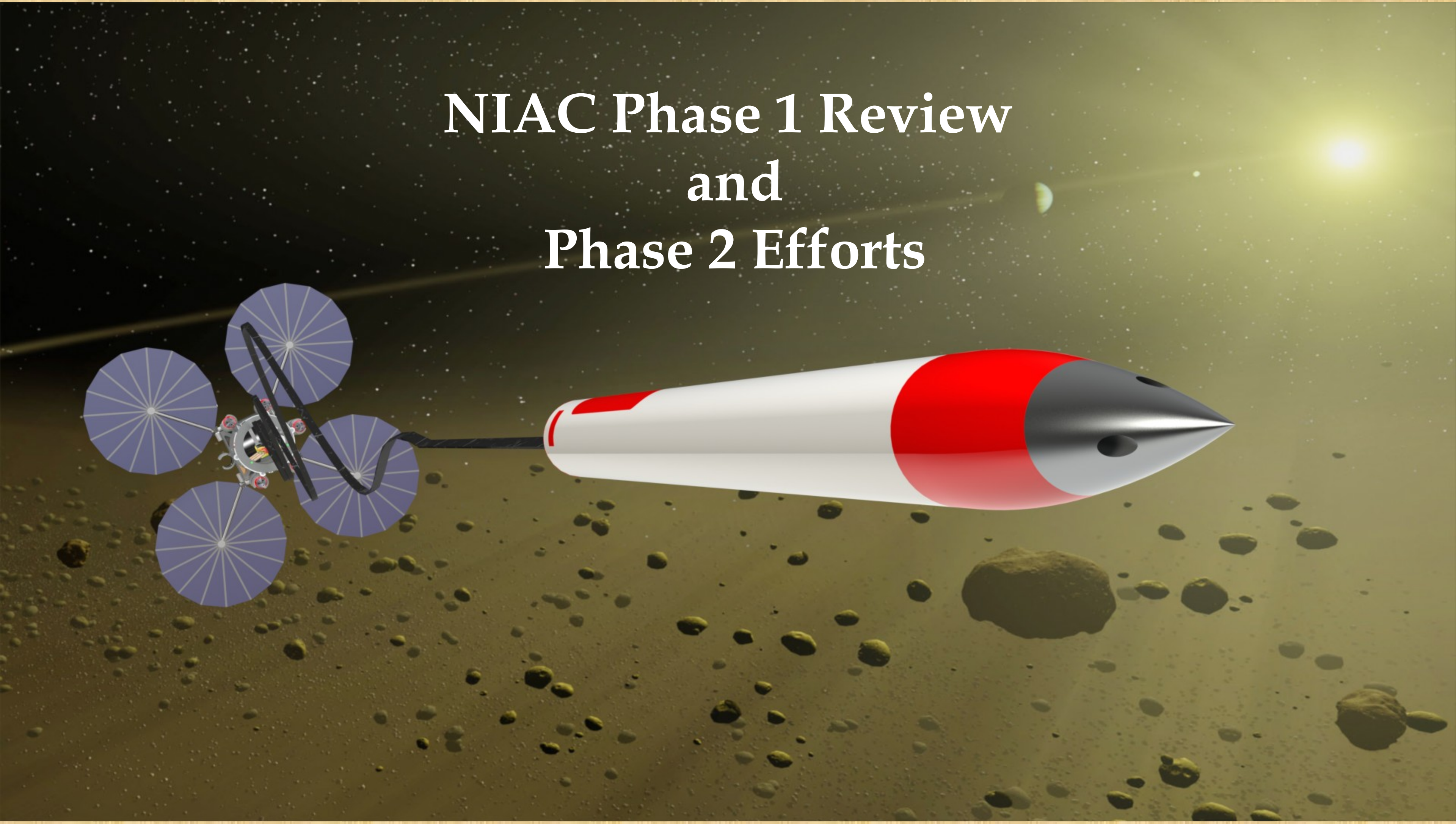
Sample Return Systems for Extreme Environments

R. M. Winglee, C. Truitt, M. Pfaff, R. Hoyt



NIAC Phase 1 Review
and
Phase 2 Efforts

Standard Way: Soft Landing

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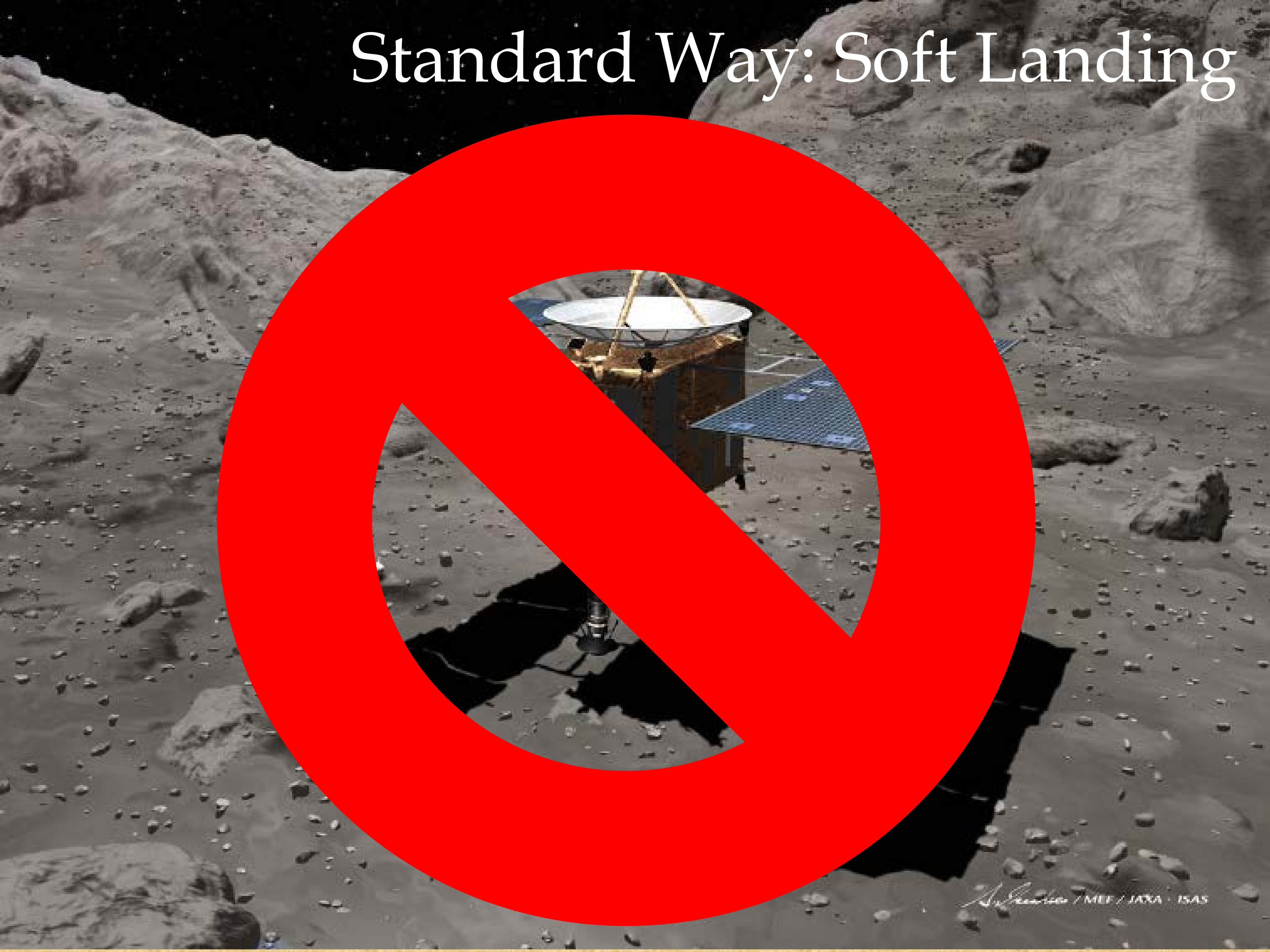
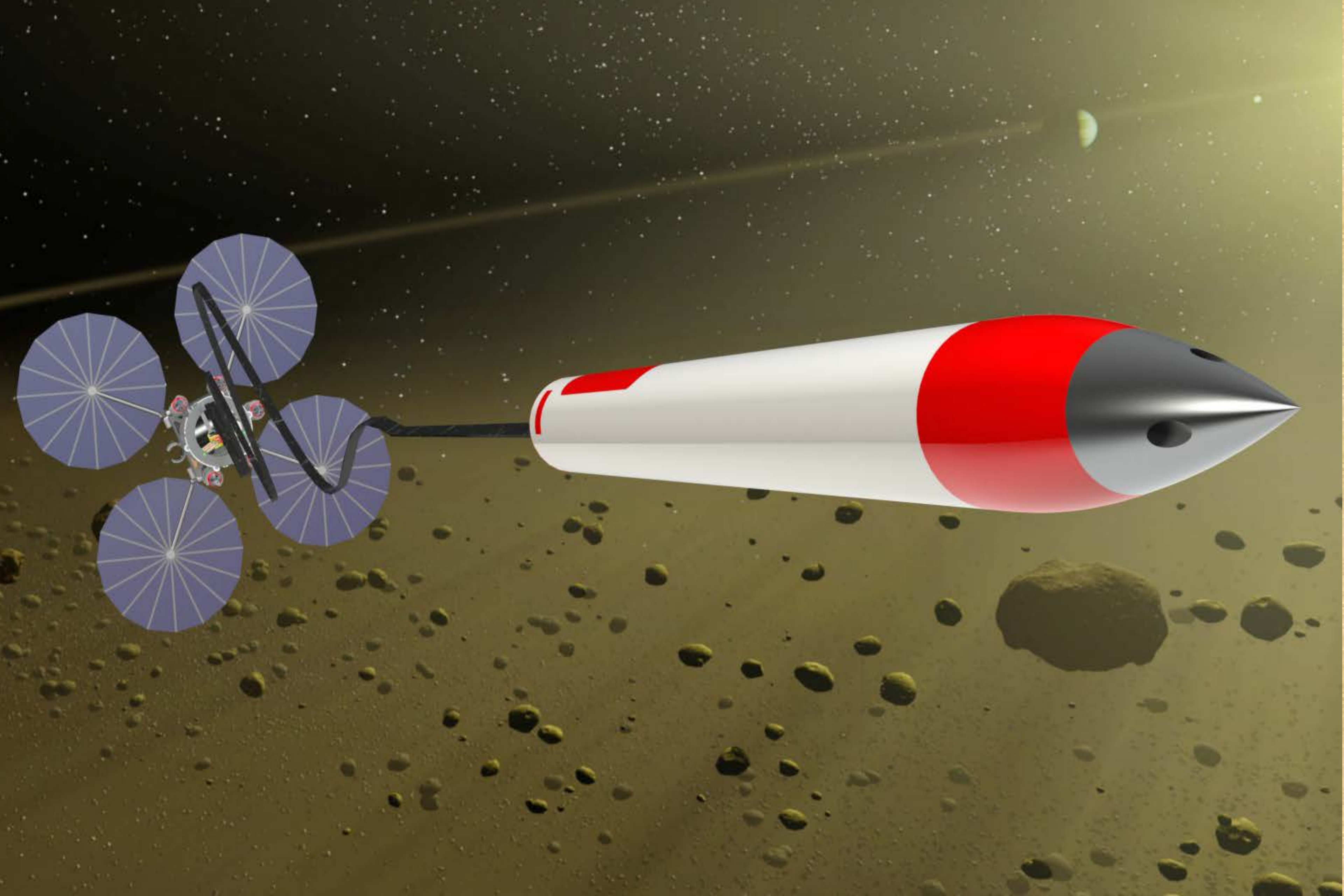
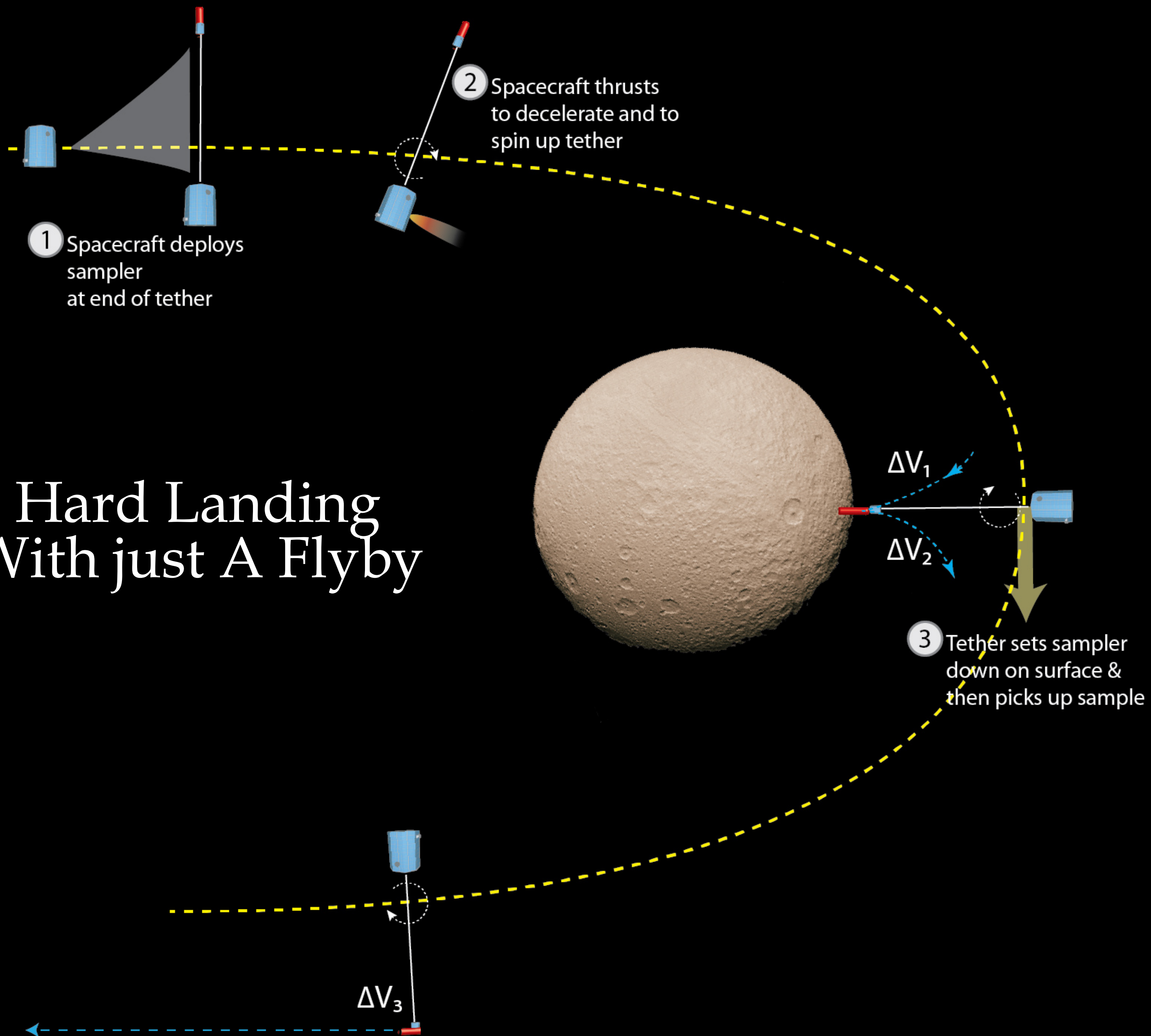


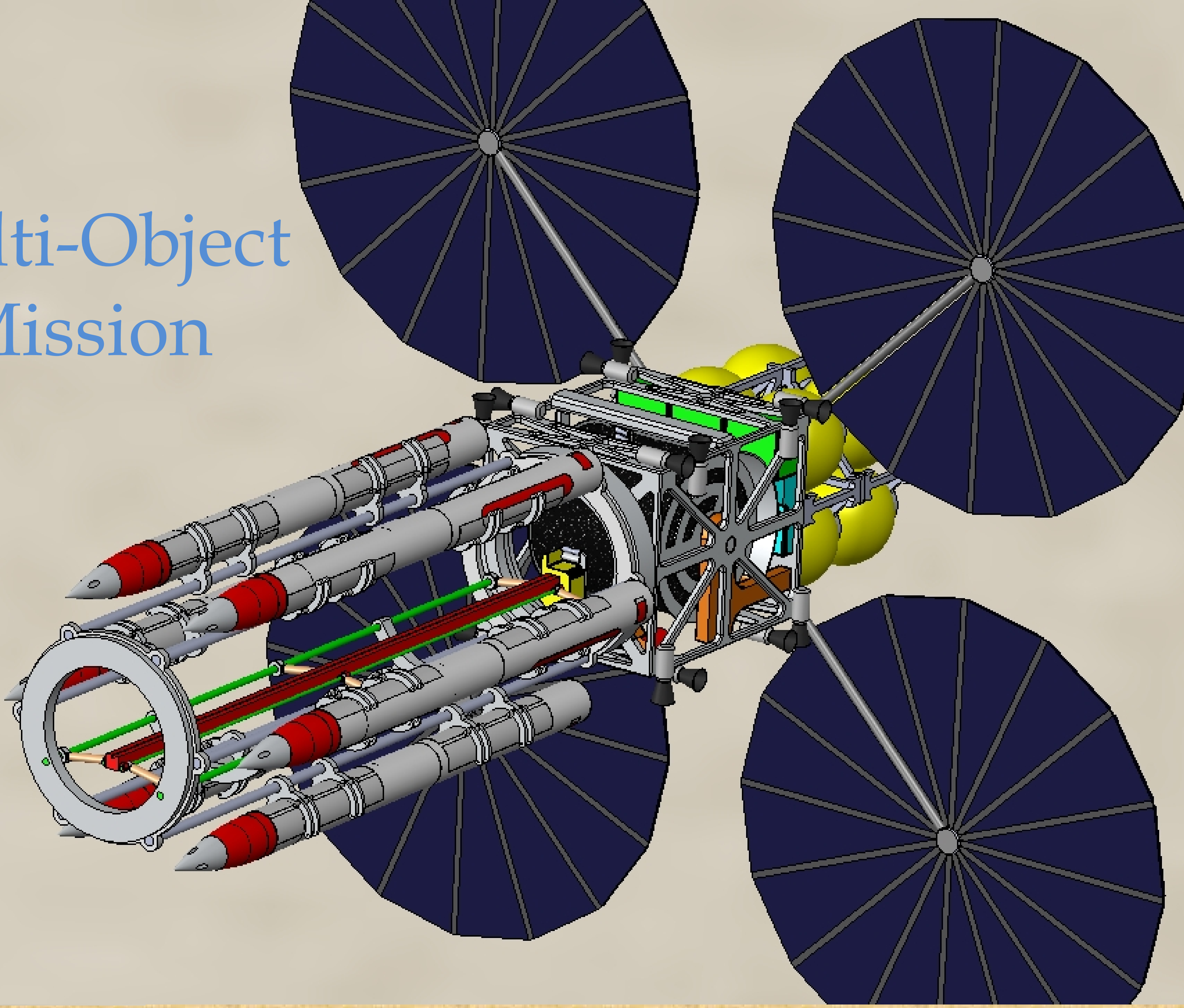
New Way: Hard Impactor

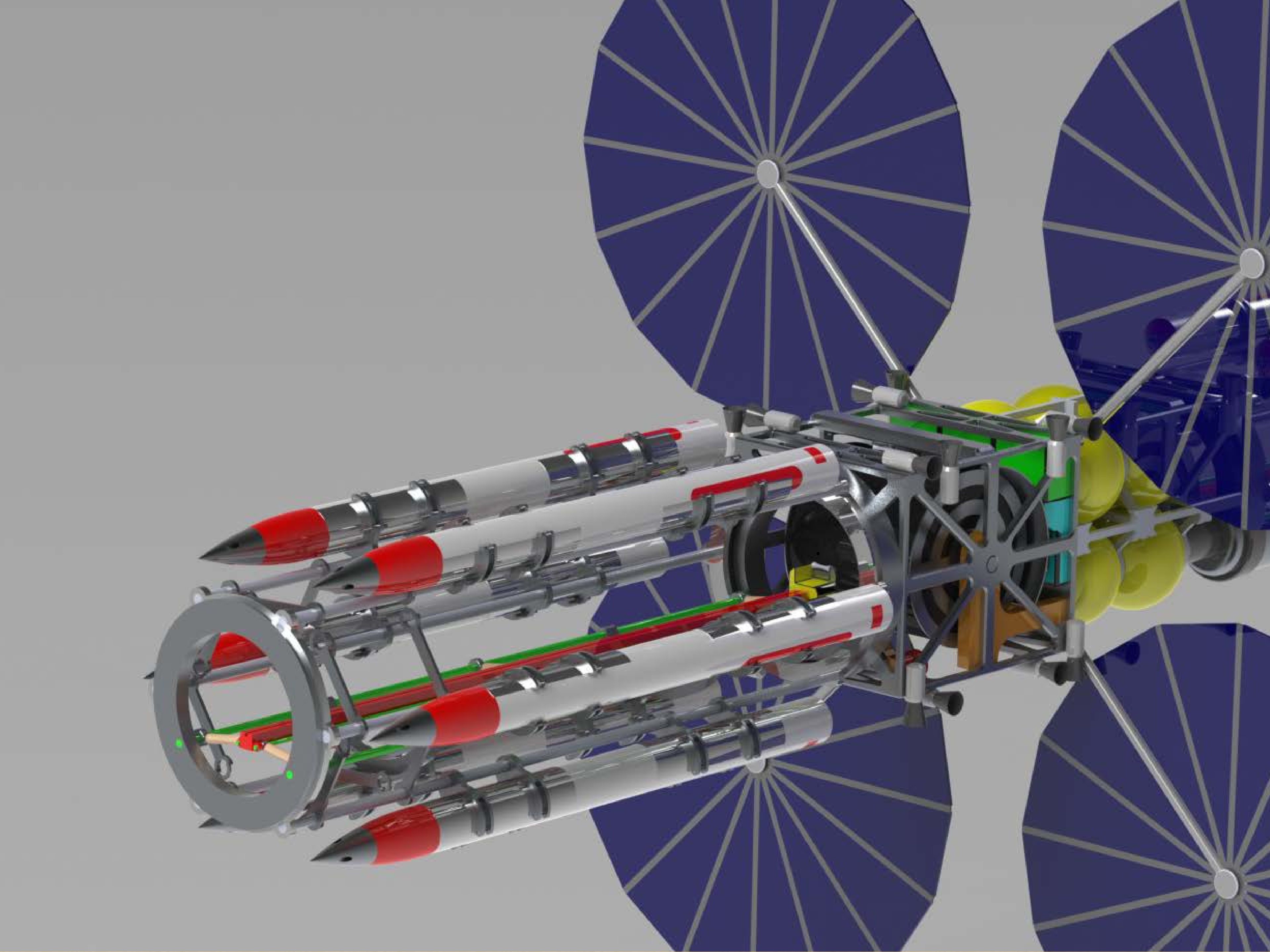


Hard Landing With just A Flyby

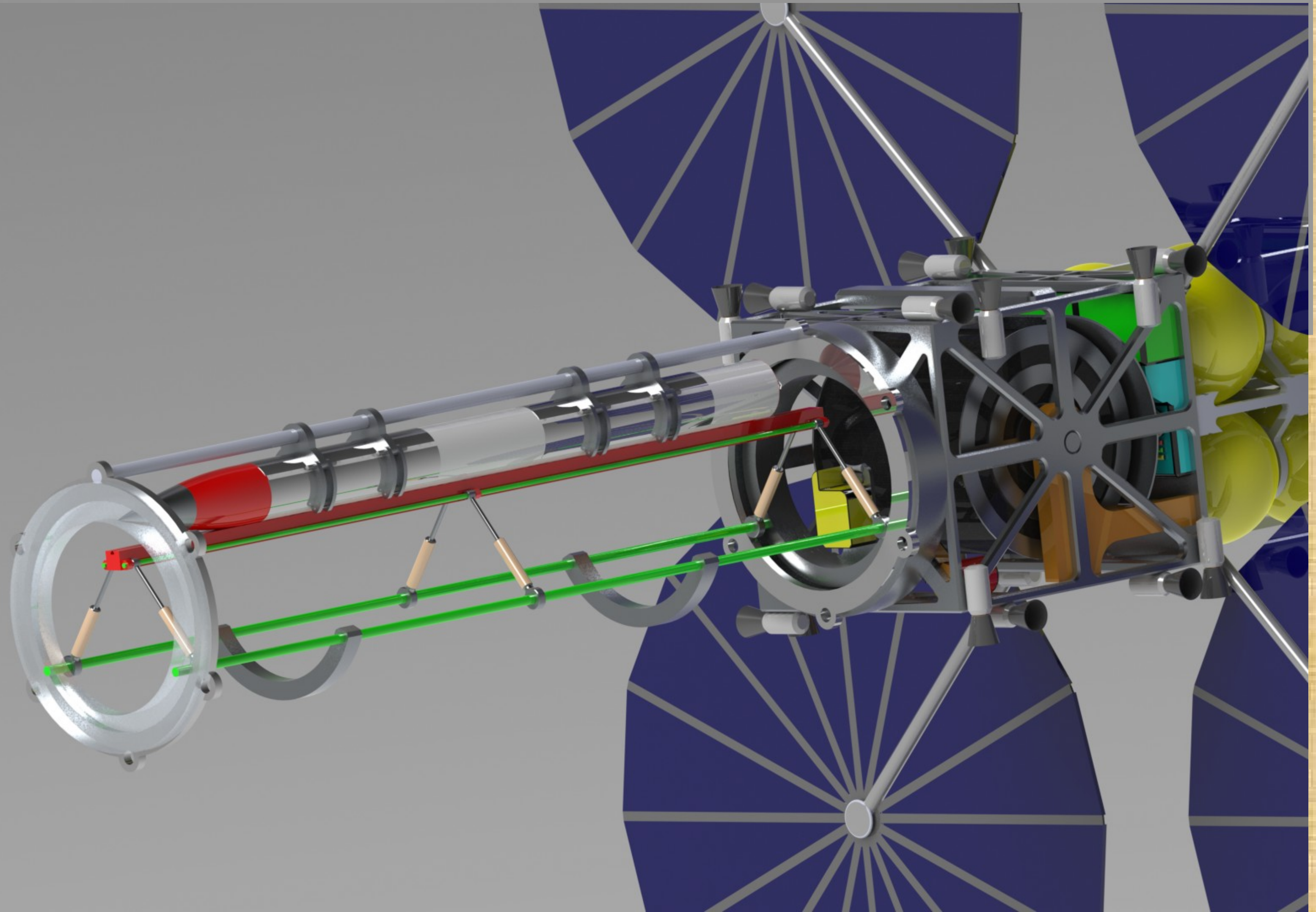


Multi-Object Mission

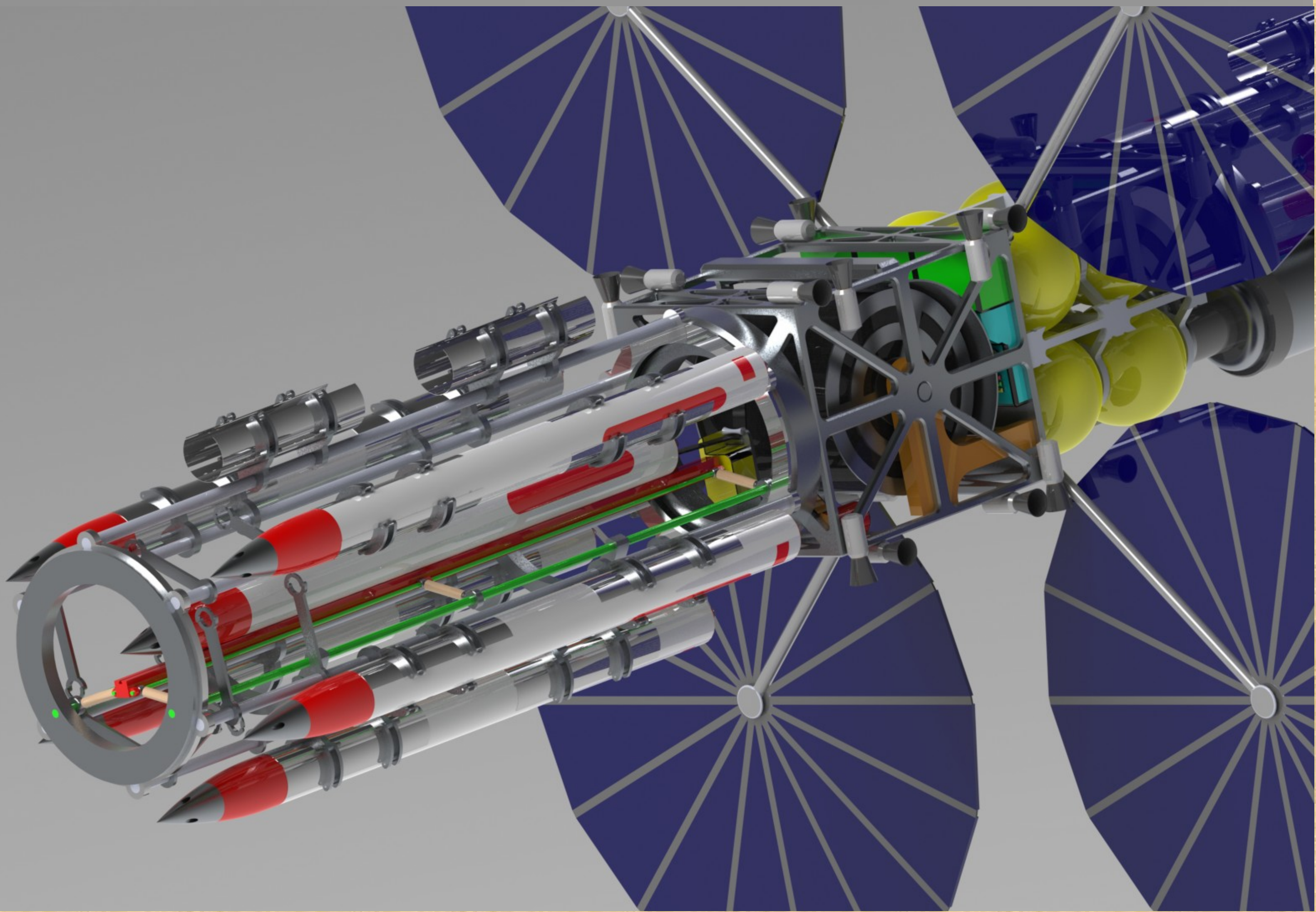




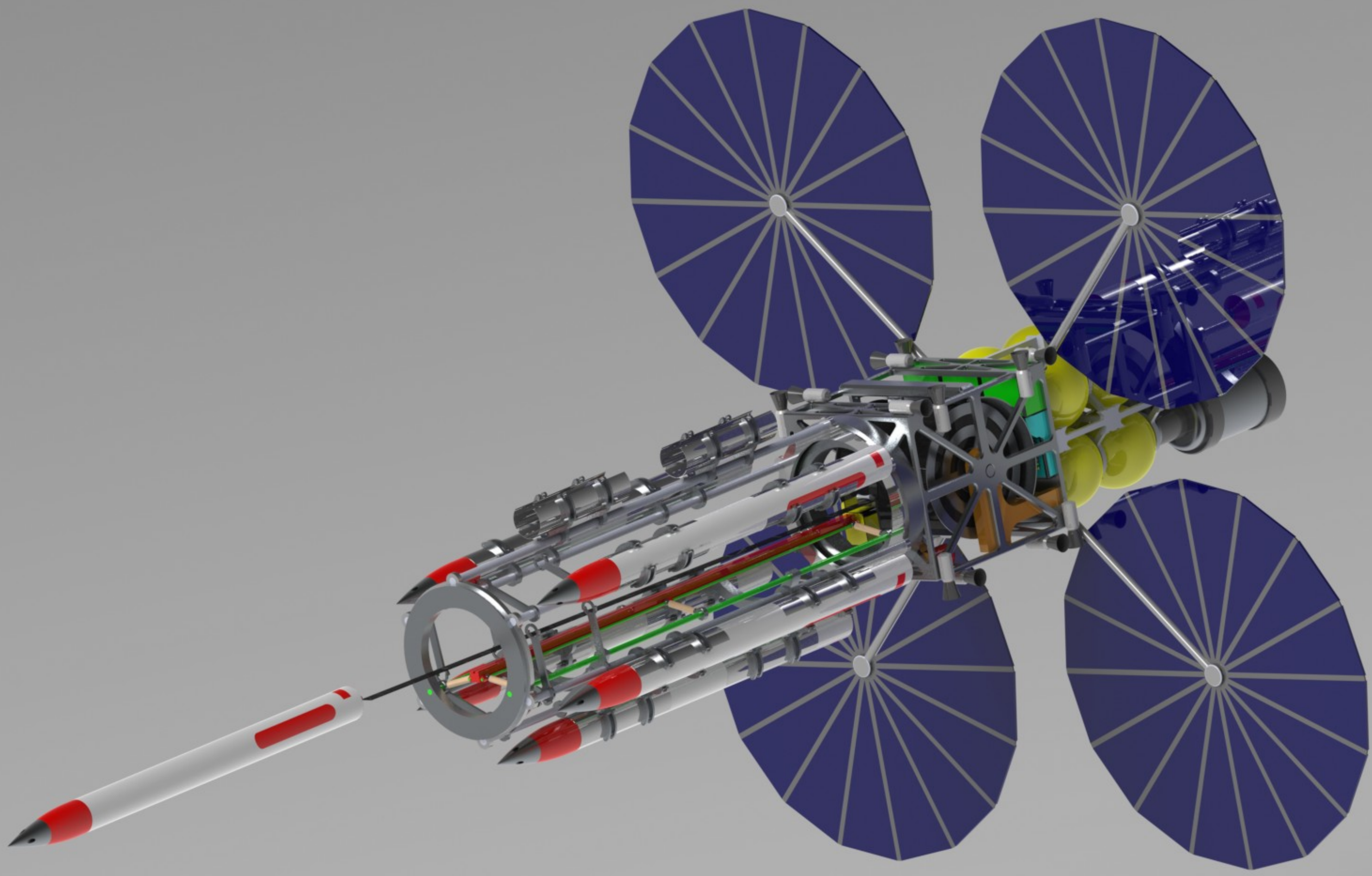
Penetrator Attached to Tether



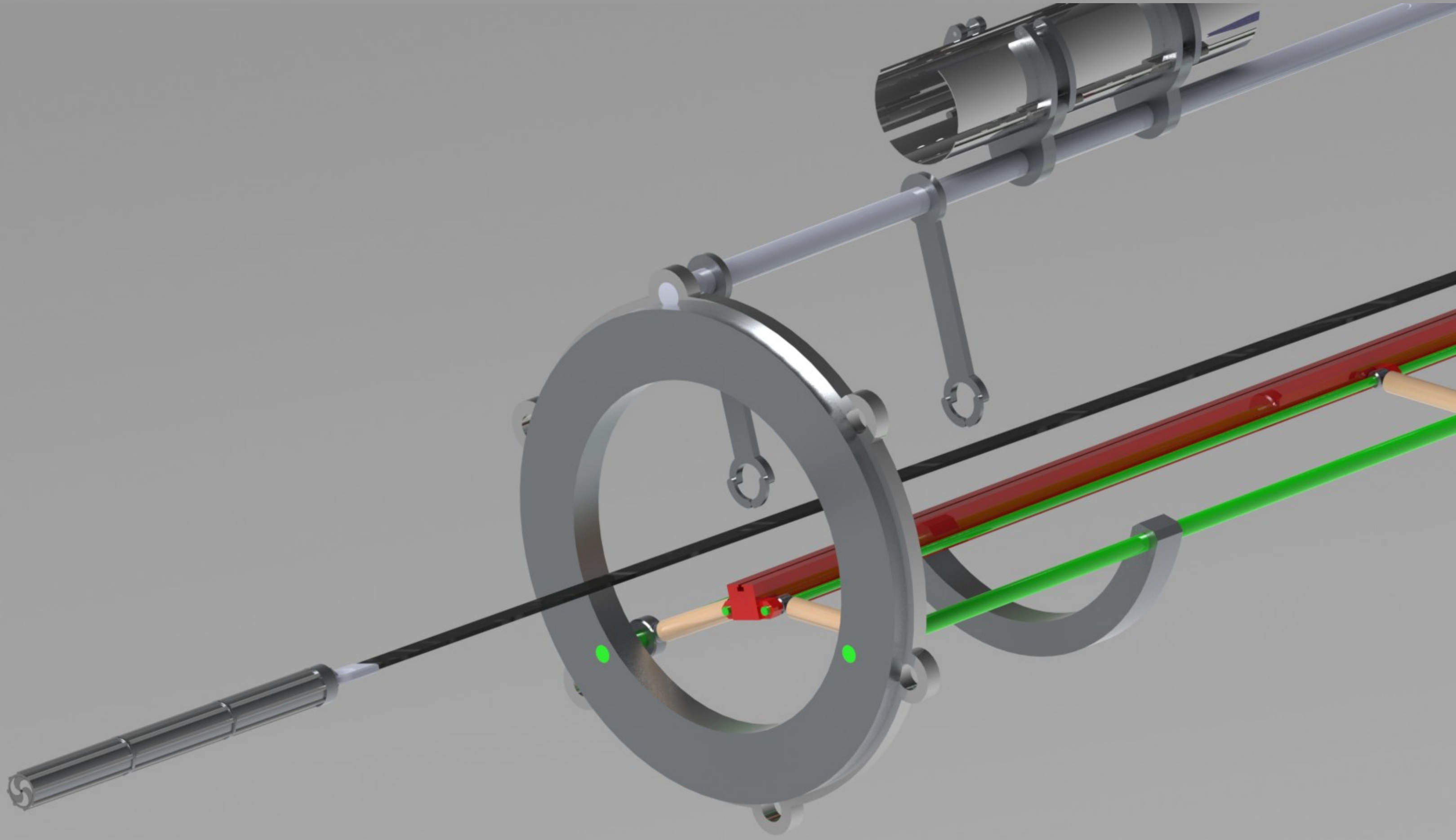
Penetrator Attached to Tether



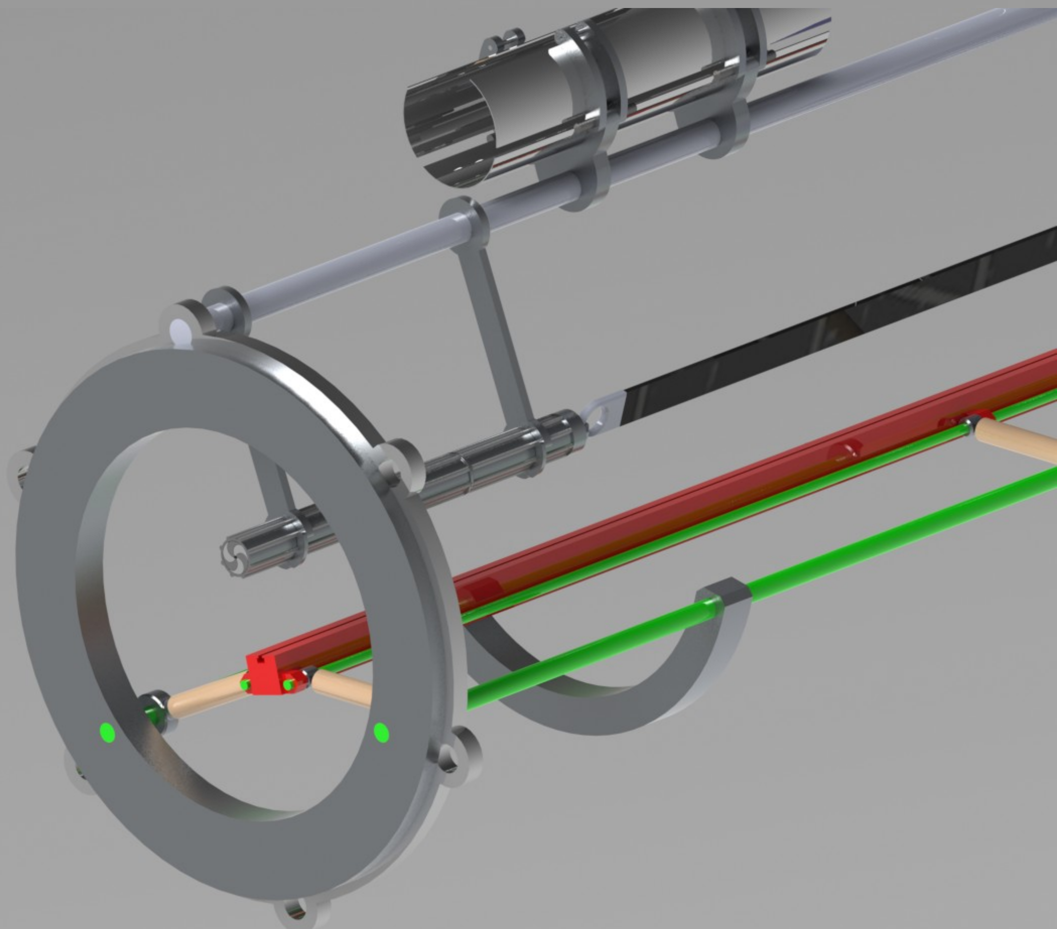
Penetrator and Tether down to Target



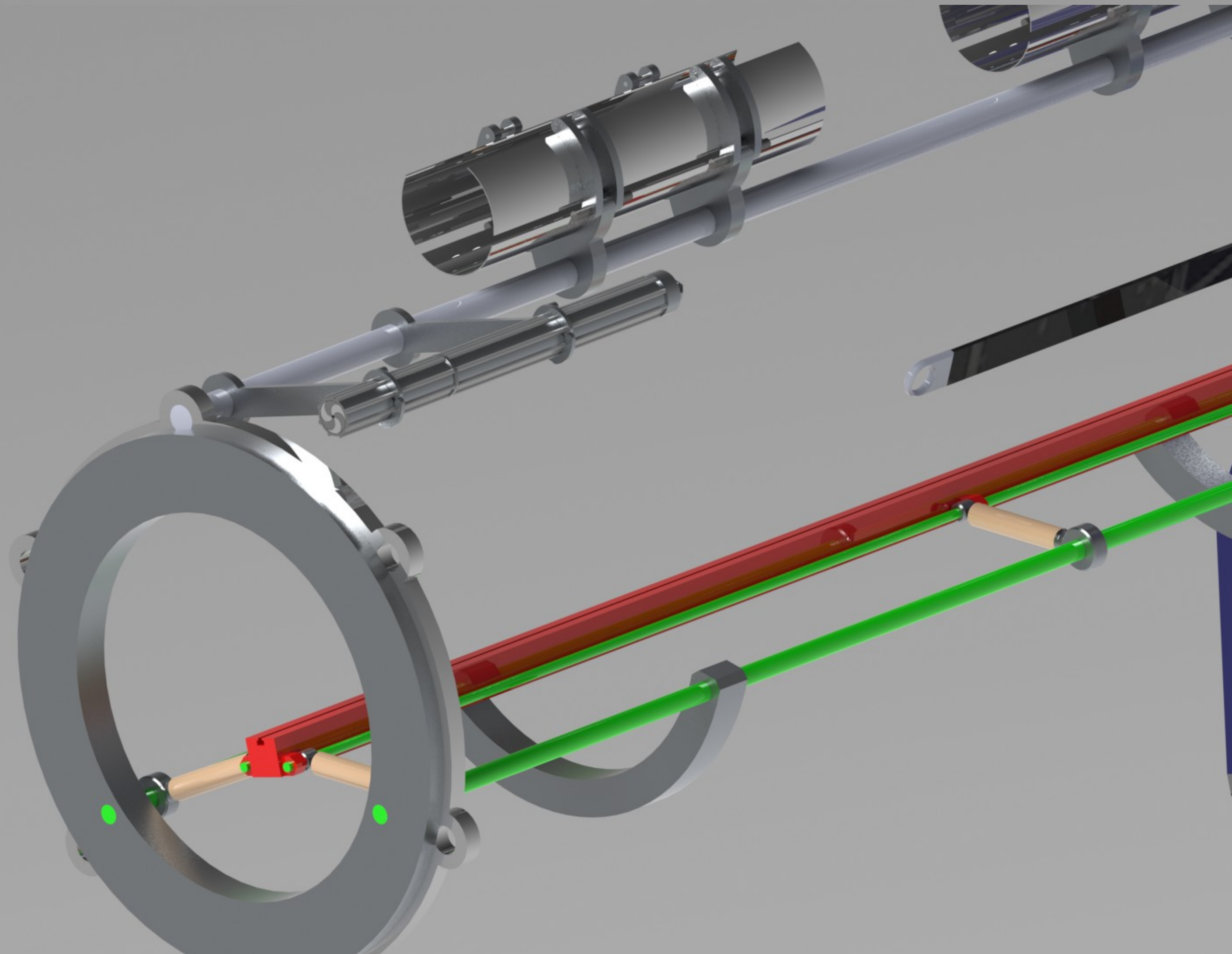
Tether pulls the sample back onto spacecraft



Sample stored on spacecraft

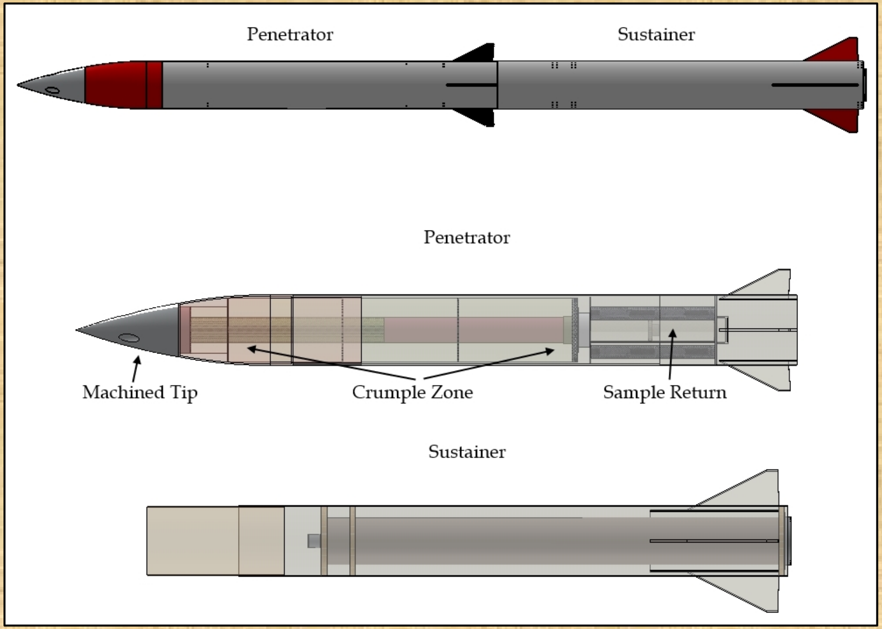


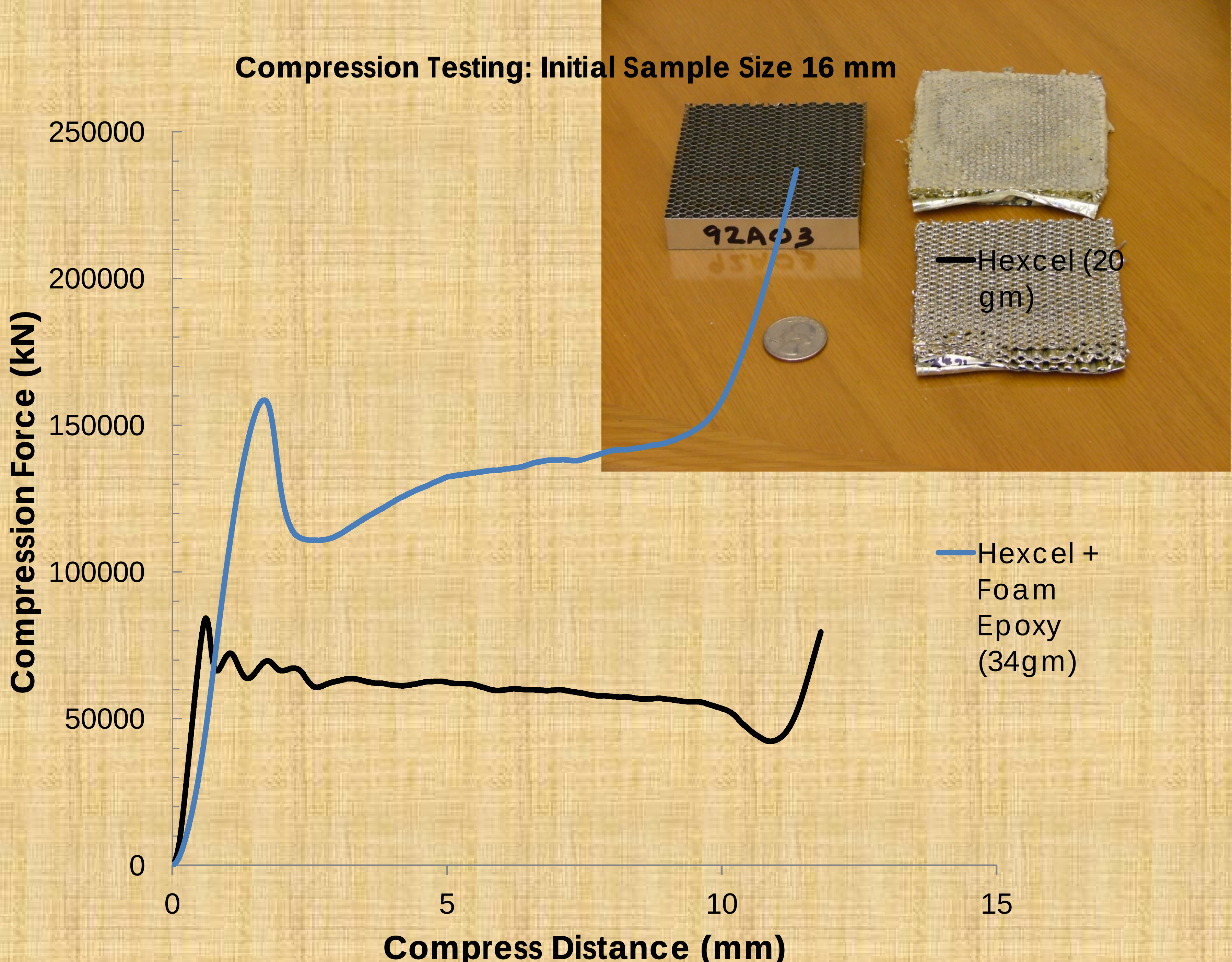
Tether is Readied for Next Sample



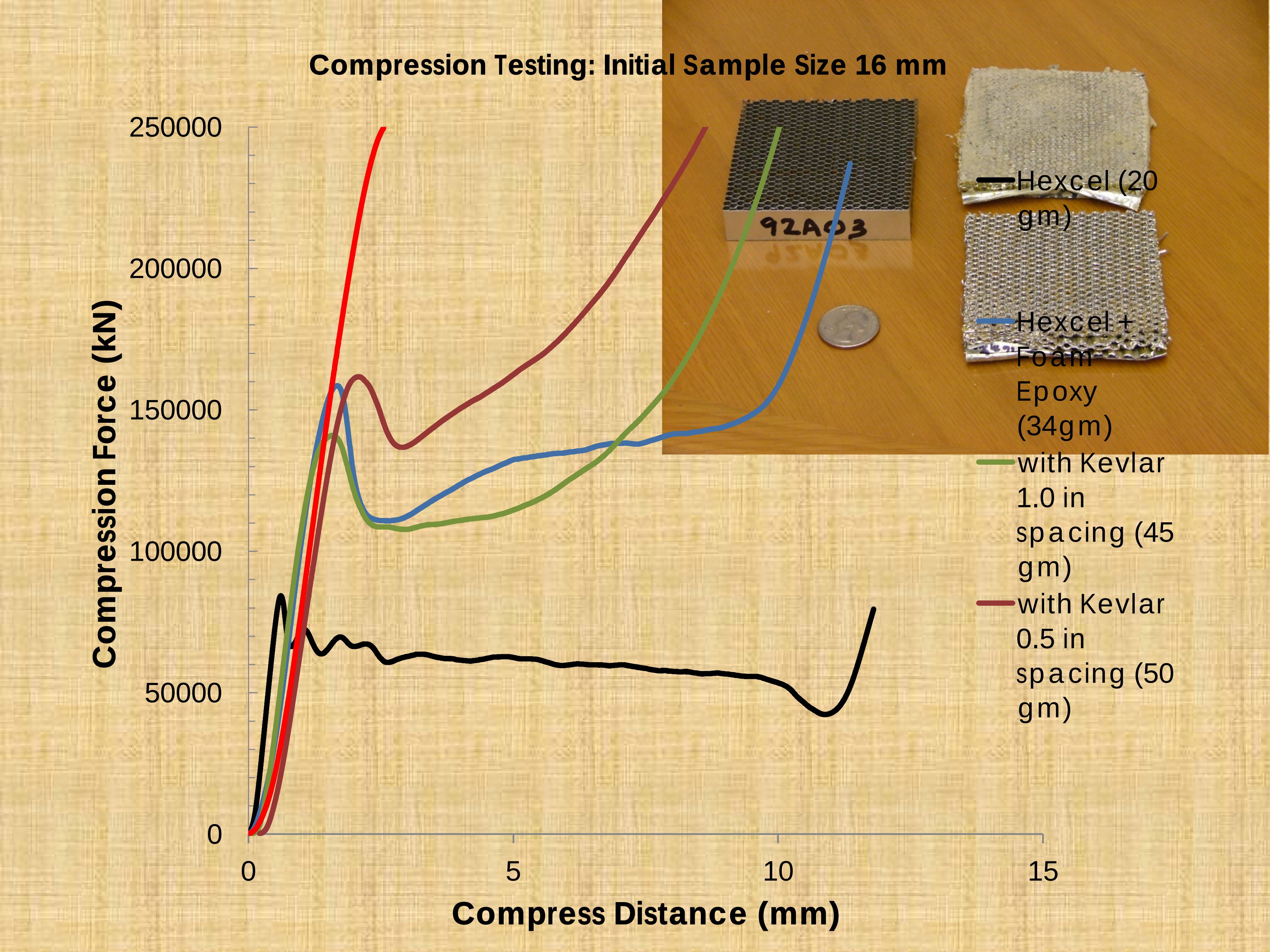
Key Innovations

- Development of Energy Absorbing Material for High Velocity Impacts
- Tether retrieval for survivable electronics not required
- Detailed Computer simulations
- Ground testing of the system





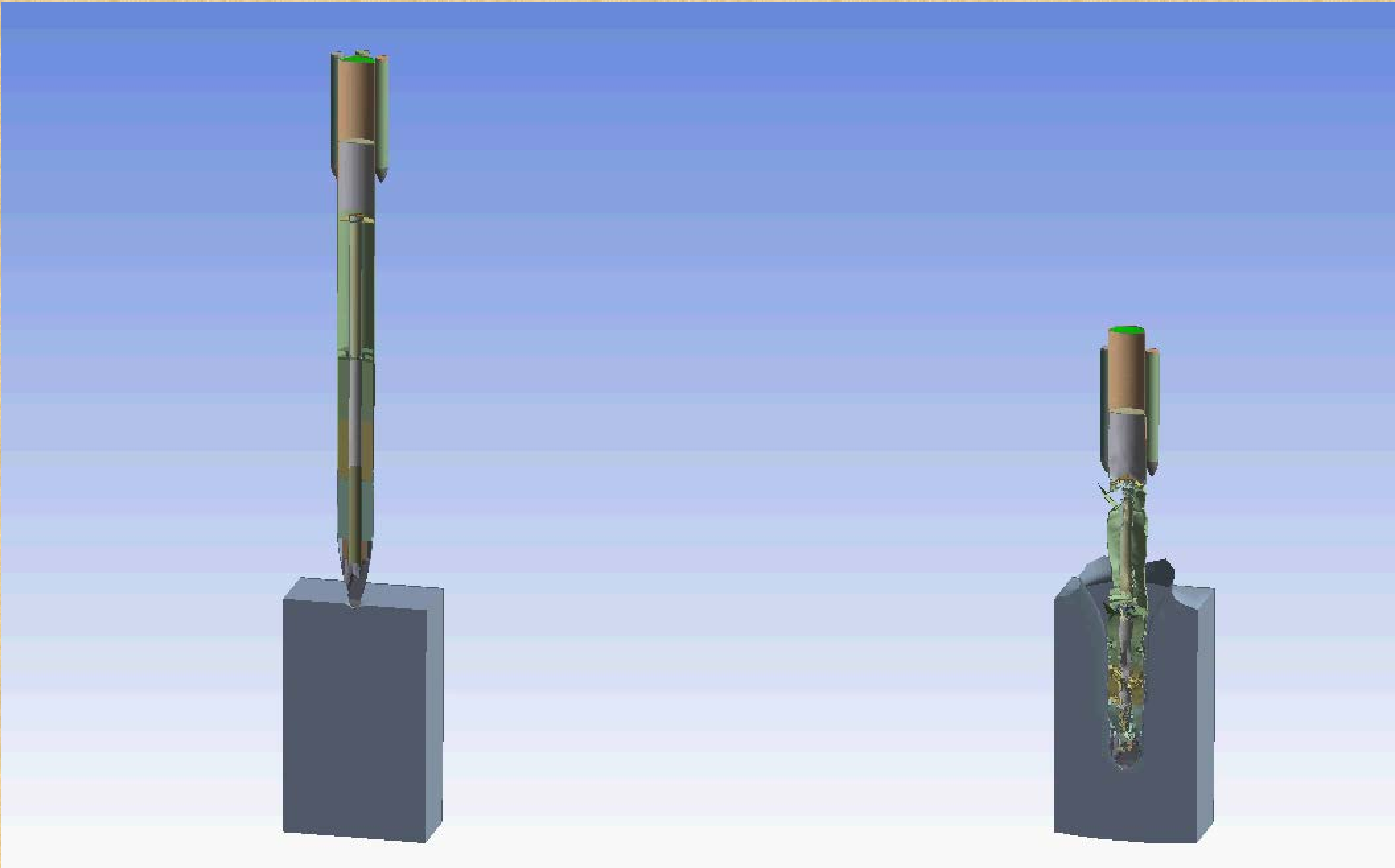
Compression Testing: Initial Sample Size 16 mm
Compression Force (kN)
250000
200000
150000
100000
50000
0
0
5
10
15
Compress Distance (mm)
Hexcel (20 gm)
Hexcel + Foam Epoxy (34gm)
92A03



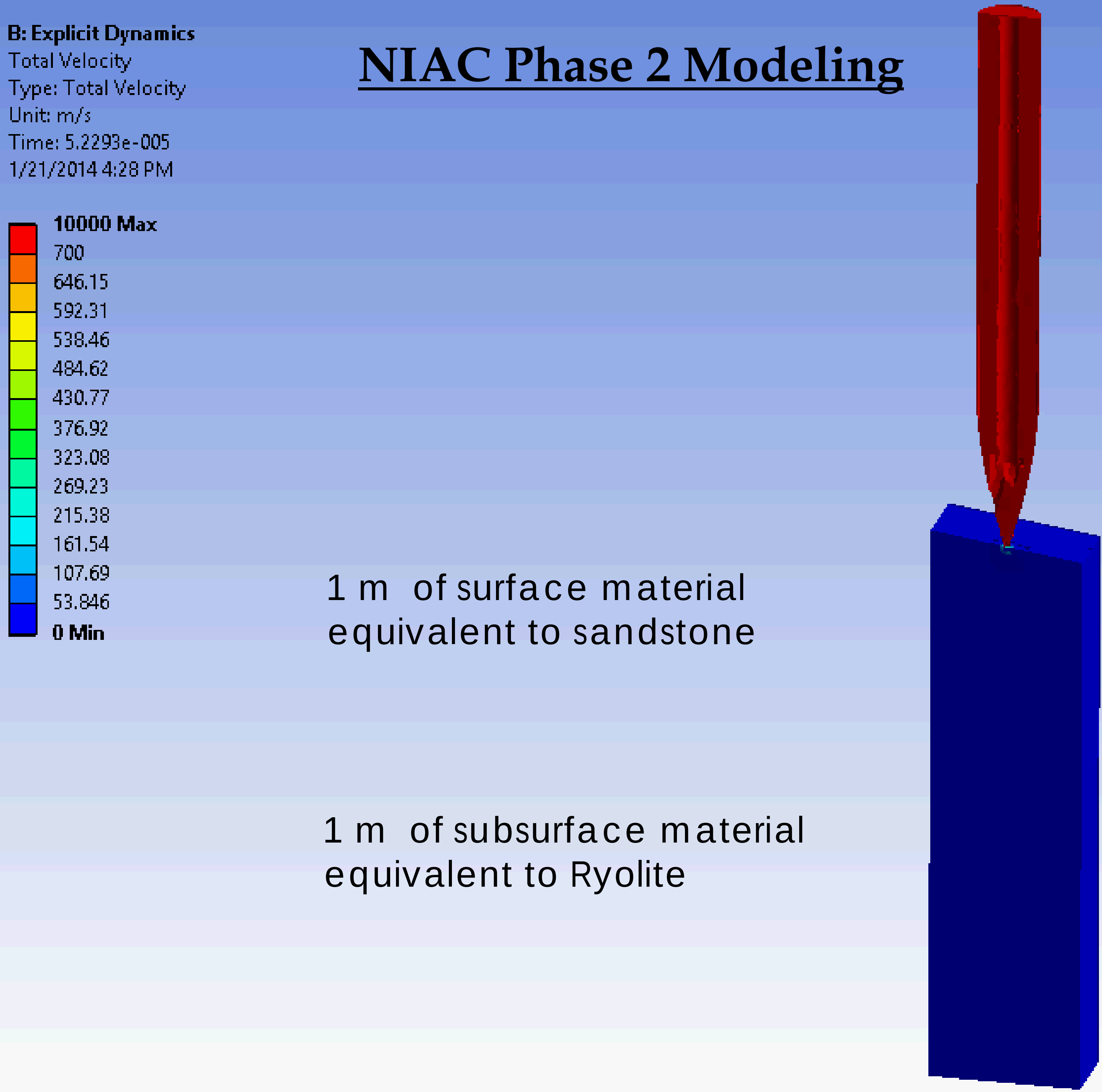
Compression Testing: Initial Sample Size 16 mm
Compression Force (kN)
250000
200000
150000
100000
50000
0
0
5
10
15
Compress Distance (mm)
Hexcel (20 gm)
Hexcel + Foam Epoxy (34gm)
with Kevlar 1.0 in spacing (45 gm)
with Kevlar 0.5 in spacing (50 gm)
92A03

NIAC Phase 2 Modeling

Without Energy Absorbing Material, System will Crumple
(simulations using ANSYS material package)



NIAC Phase 2 Modeling



Field Test: Nevada March,2013

NIAC Phase 1 Results

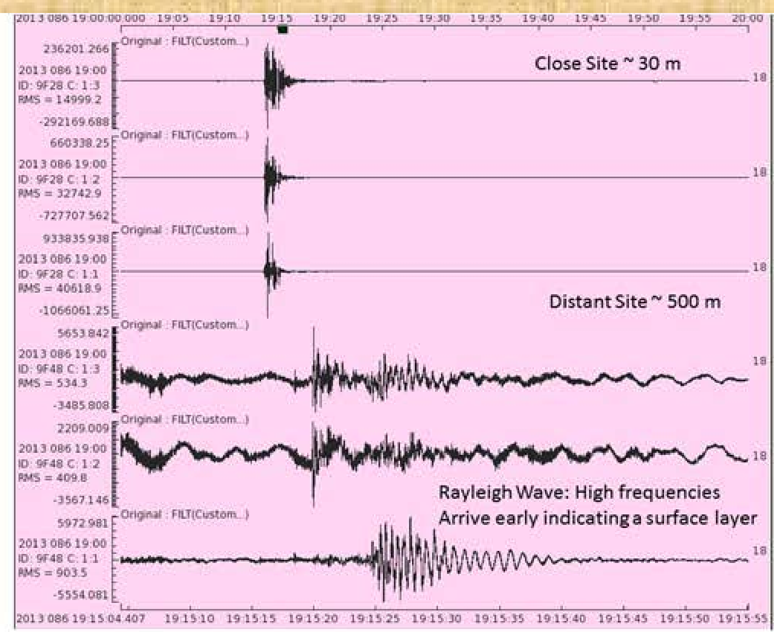
- Gravedigger 1: impact velocity <200 m/s
- Impact angle ~30˚ from normal, penetration depth ~5 ft
- Feed ports failed to open due to low velocity
- A post-impact analysis of the penetrator showed it remained almost completely intact, despite the impact angle.

NIAC Phase 1 Results

- Gravedigger 2 successful test of Rockite system and feed ports
- Penetrator impacted at ~400 m/s, to depth of ~7 ft though motor punched through the penetrator
- Seismic Signal detected at 2 stations – 50 m and 500 m

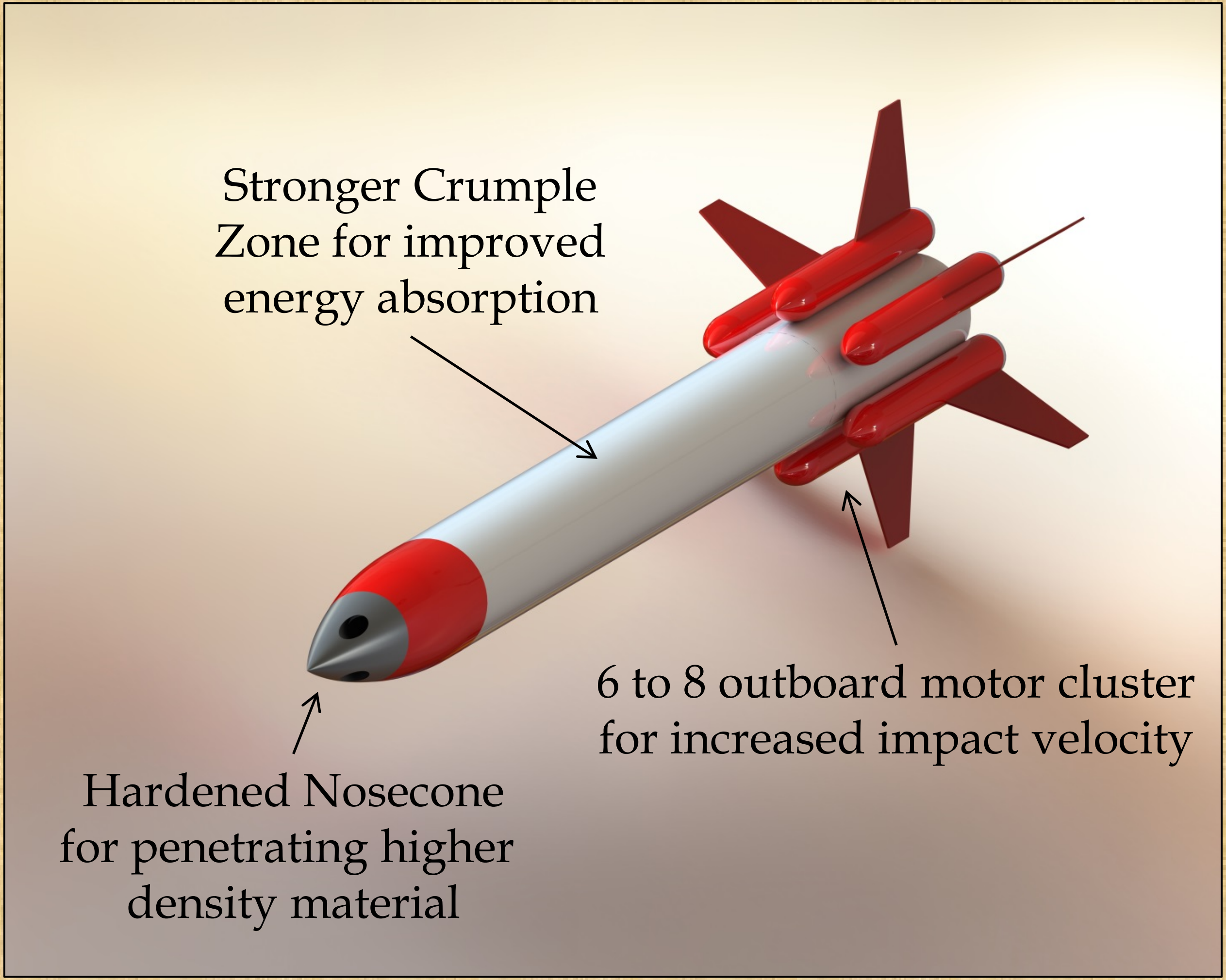
"Gravedigger 2" Impact Series

Impact Site 2 with Seismometer



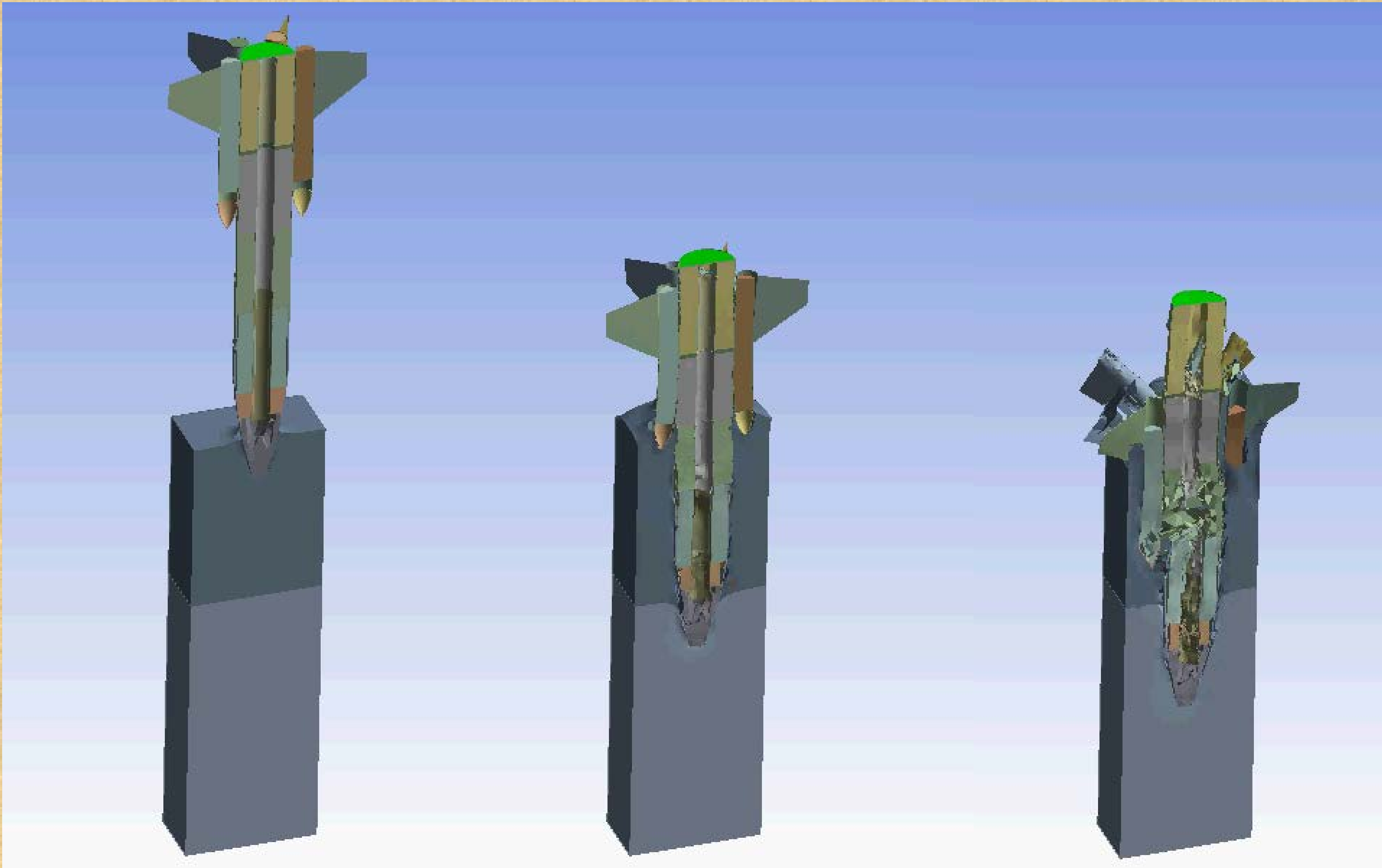
NIAC Phase 2 :Faster and Harder, July 2014

- Phase 2 will be lifted by tethered balloon to 2500 ft.



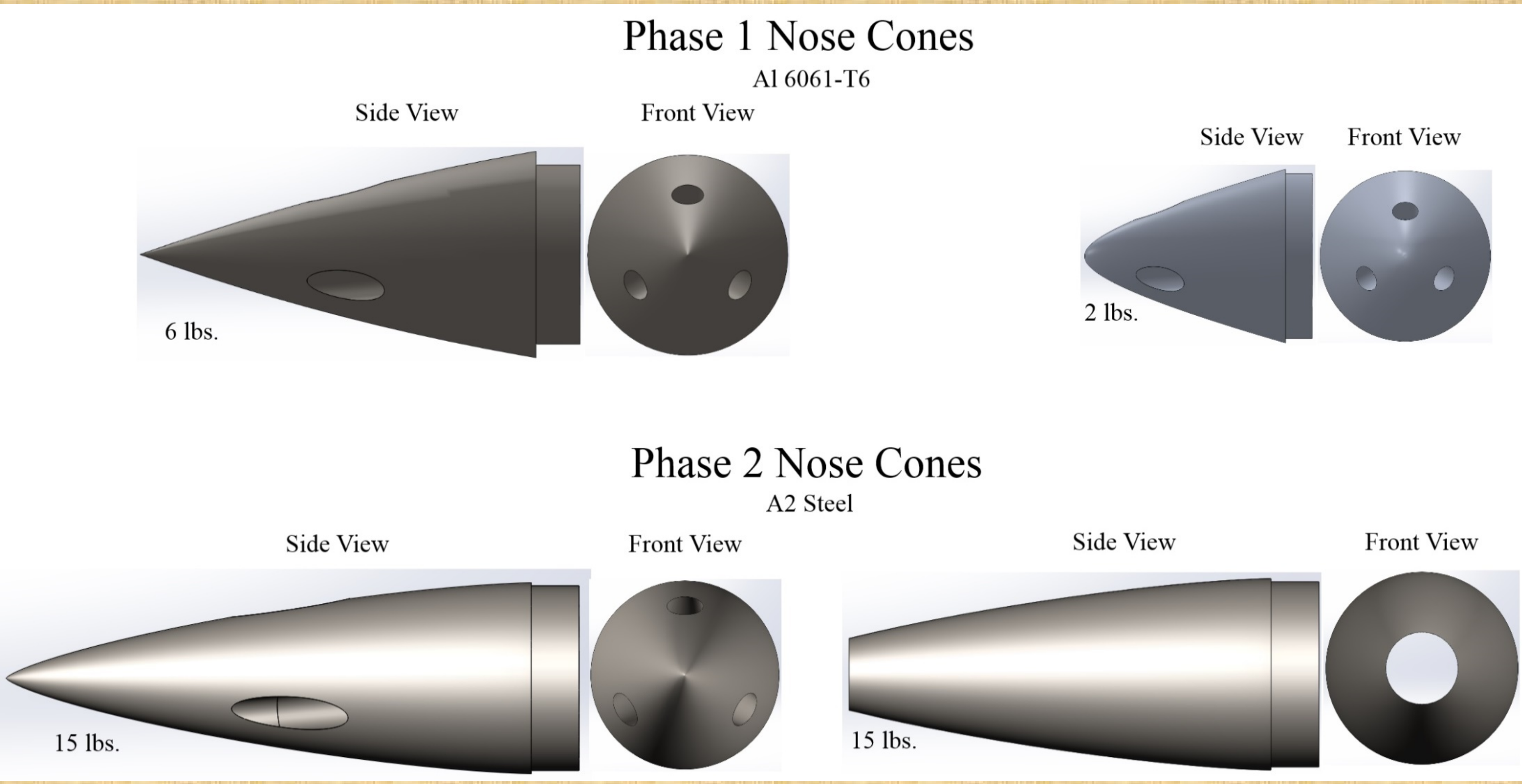
NIAC Phase 2 : Impact Testing, July 2014

Naval Air Weapon Station, CA – Into Rocky Terrain



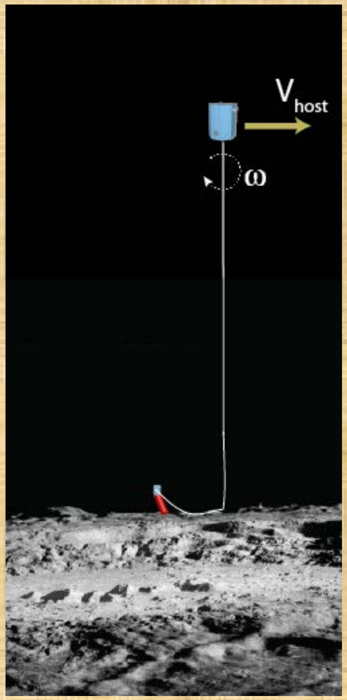
NIAC Phase 2 Optimization of Impactor

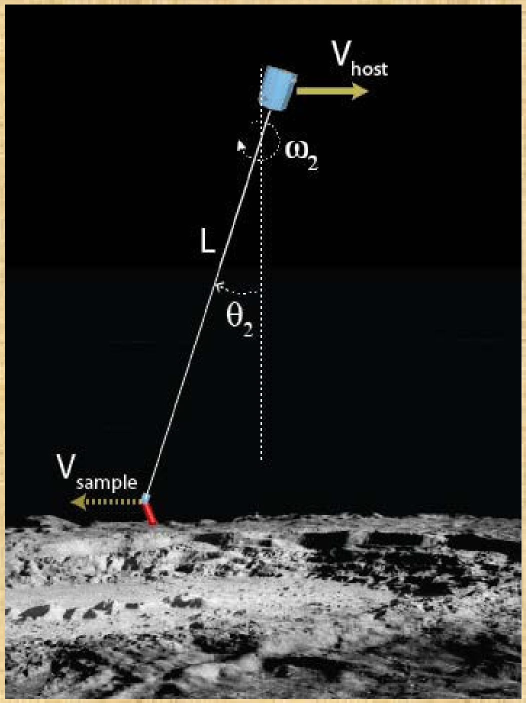
Two Types of Coring: surface to middle, middle to depth.

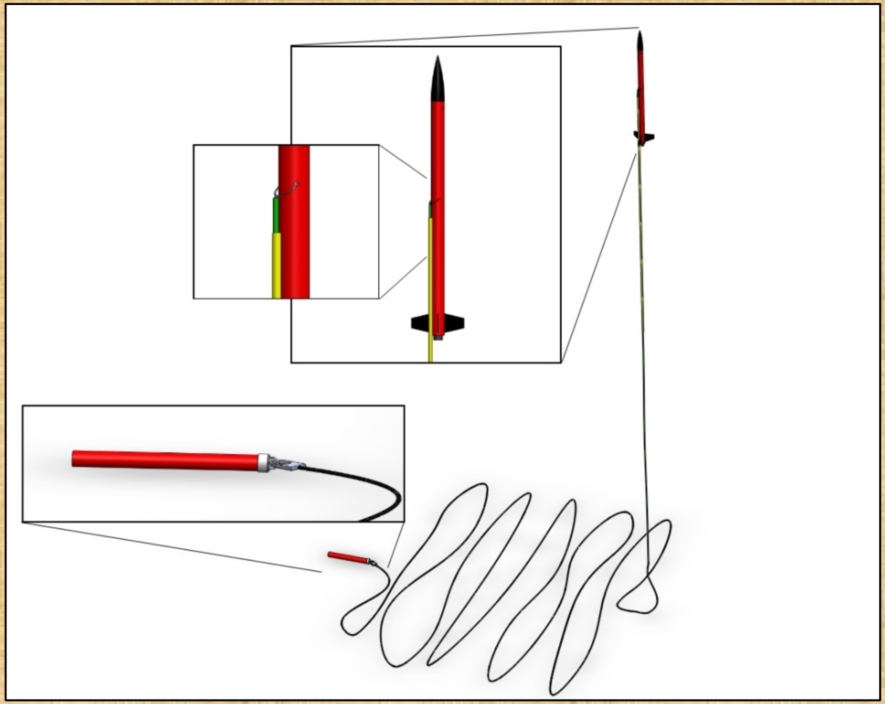


NIAC Phase 2: Tether Pull

- **Standard launch will test tether capacity under supersonic velocities: Black Rock, NV, March 2014**
- **Rocket will be tethered to filled Sample Return Casing on surface of playa**
- **Test is made difficult due to heating of the tether by the rocket motor**







Sample Return from Extreme Environments

- With NIAC Support, Concept has become close to reality despite ones initial reaction to survivability of supersonic impacts

- Advances in Energy Absorbing material allows survivability of interior components up to impact speeds of 1 km/s

- Tether recovery should allow return of core samples of a few kg

- Computer modeling indicates the objectives are doable

- Initial field testing looks promising and more field testing to occur into summer of 2014 and into 2015.