Aerocapture: An Enabling Technology for Flagship-Class Uranus Orbiter and Probe Mission

Abstract 20

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Background

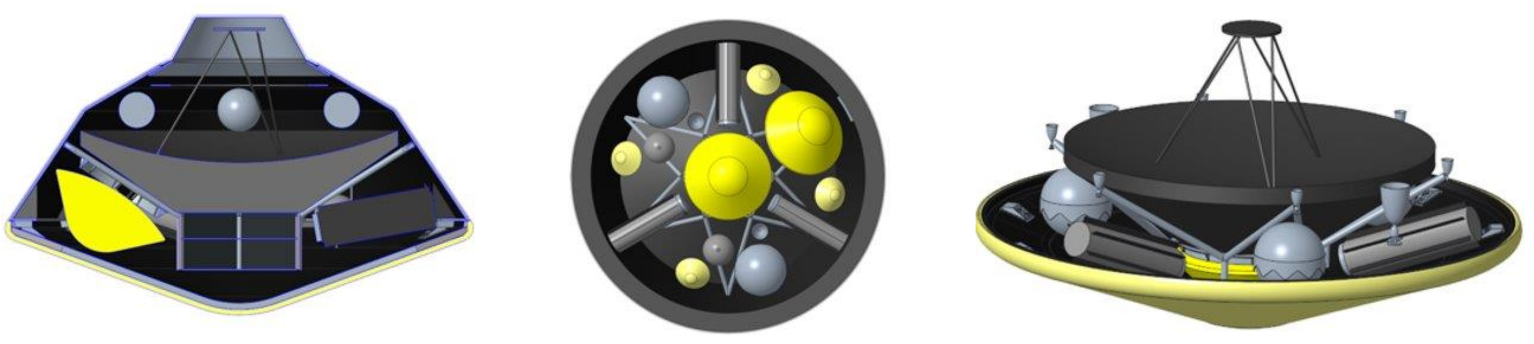
- NASA Space Technology Mission Directorate is funding a two-year Early Career Initiative investigating Uranus aerocapture
- This poster presents Year 2 updates to the design

Updates to Aerocapture Design

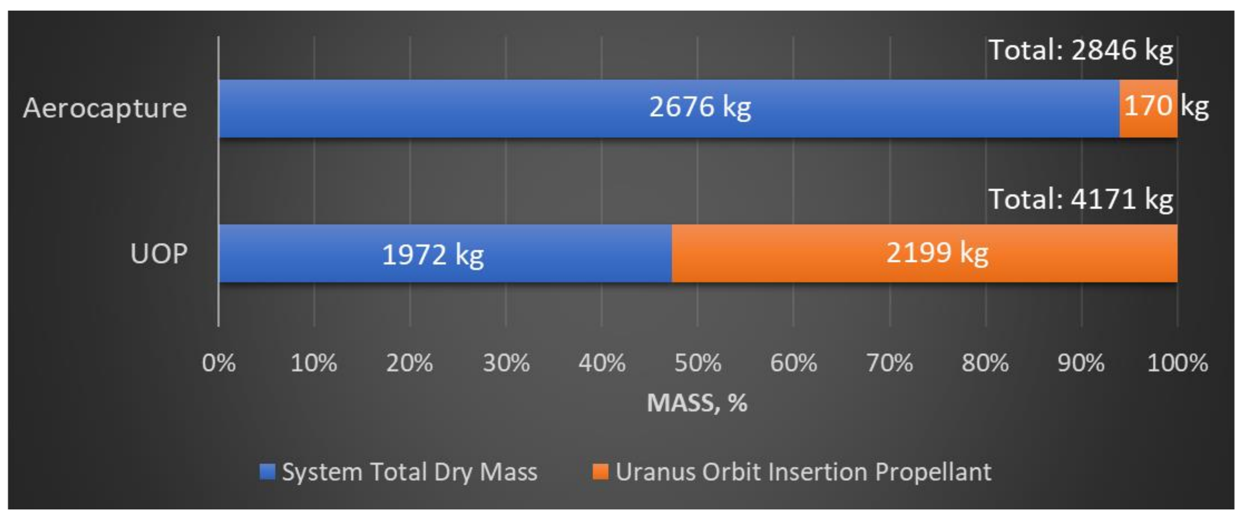
- 4.57 m aeroshell accommodating probe(s)
- TPS sizing for faster arrival trajectories
- 3DOF trajectory sensitivity (MDNAV, Atmosphere, Mass)
- 6DOF aerocapture design (See Abstract 7)

Vehicle Design Considerations

- Package Uranus Orbiter and Probe payload into Mars Science Laboratory-derived aeroshell
- Aerocapture can save 1325 kg in total mass
  - Packaging can allow for additional probes
  - Removing backshell can save additional mass



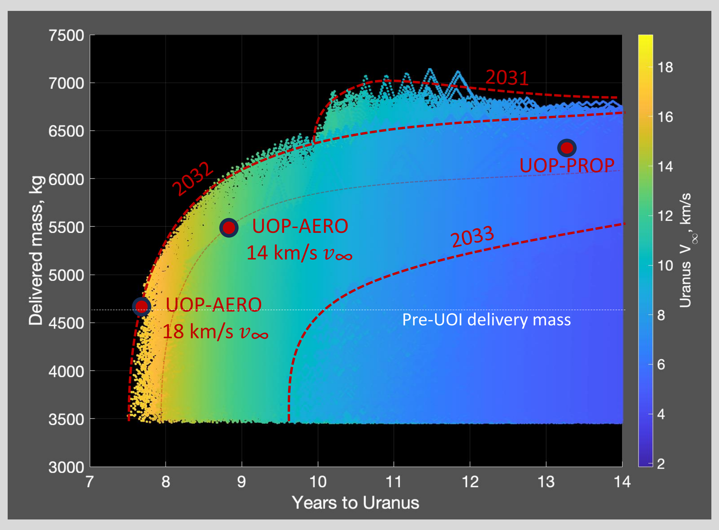
Baseline Packaging   Multi-Probe Option   No-Backshell Option



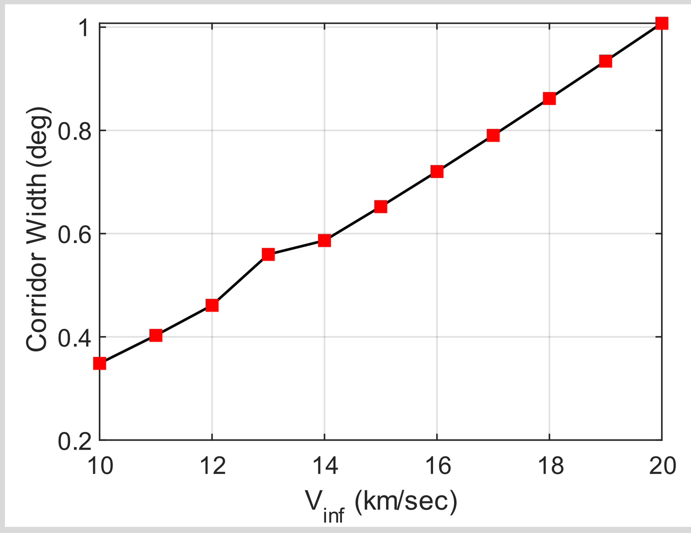
Interplanetary Trajectory Analysis

- Aerocapture can save as much as 5 years in transit time
- Need to estimate upper performance limit of aerocapture

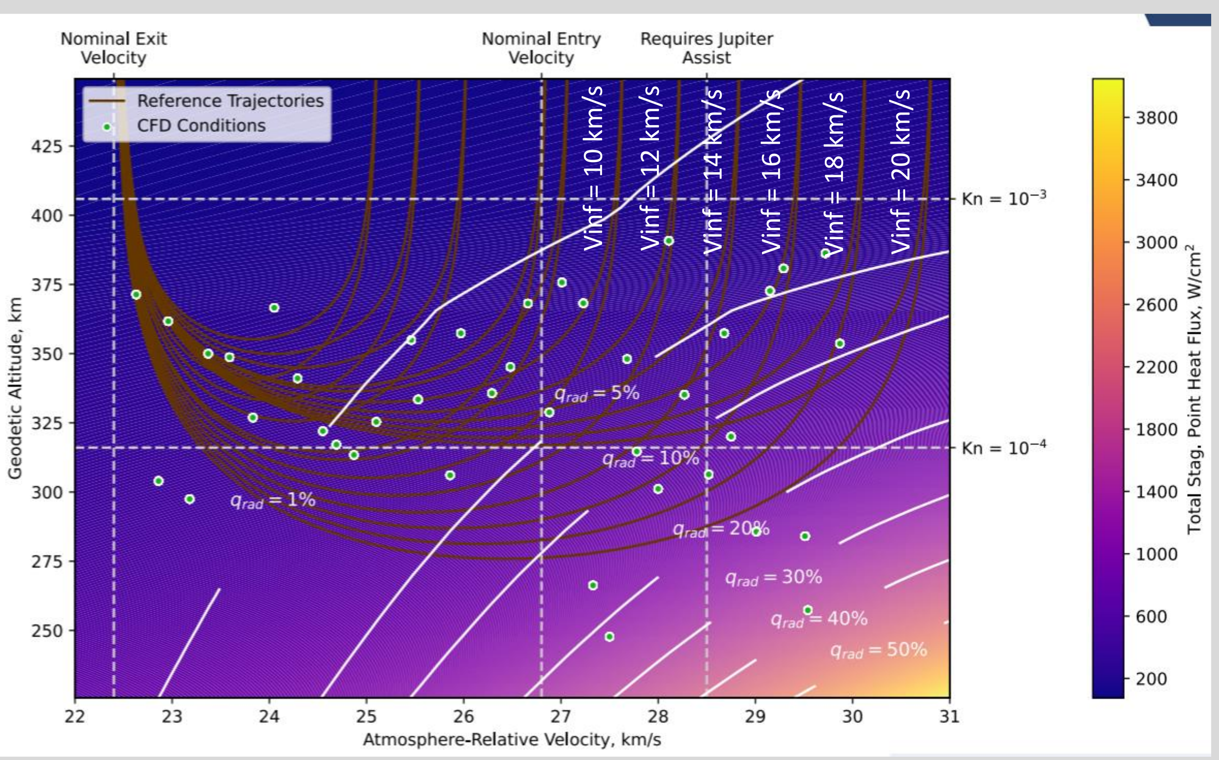
	Launch Year	Cruise (yrs.) UOP Propulsive		Cruise (yrs.) UOP Aerocapture
Jupiter	2031	13.4	Jupiter	9.8
Jupiter	2032	12.8	Jupiter	7.8
No-Jupiter	2033	15.3	Jupiter	10.2
No-Jupiter	2034	15.2	No-Jupiter	12.6
No-Jupiter	2035	-	No-Jupiter	13.5
No-Jupiter	2036	15.3	No-Jupiter	12.7
No-Jupiter	2037	-	No-Jupiter	12.9
No-Jupiter	2038	14.2	No-Jupiter	11.8



Interplanetary trajectory-space contains fast arrival trajectories as high as 20 km/s

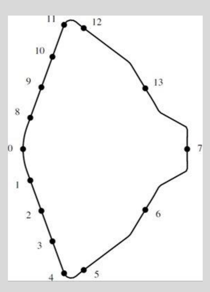


Faster arrival trajectories increases corridor width (control-margin)



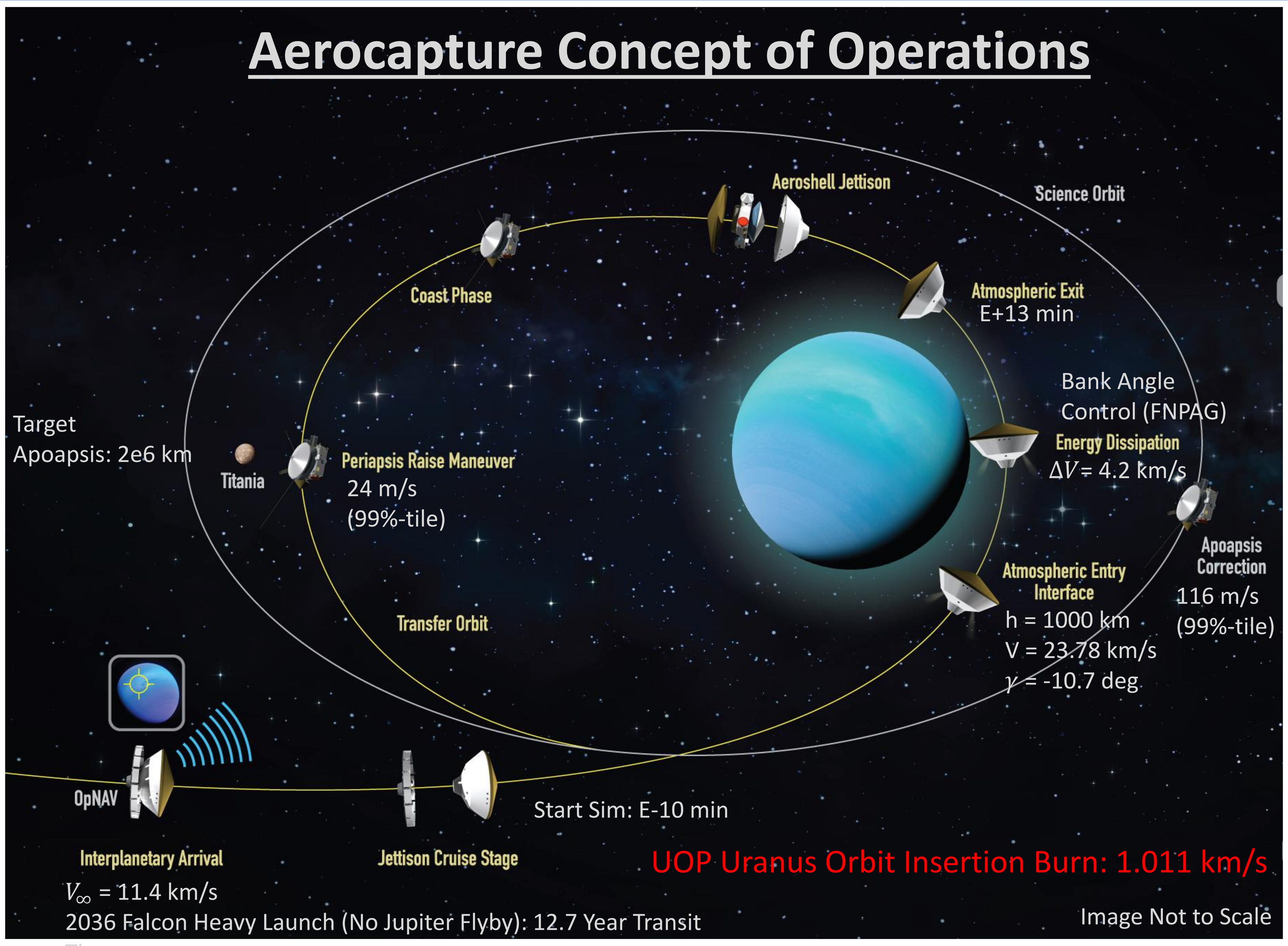
Calculate heating environment for faster arrival trajectories. Radiative heating contribution begins to increase.

C-PICA Margined Sizing (cm)			
Body Point	Vinf14	Vinf16	Vinf18
0	5.34	5.46	5.59
2	4.85	5.01	5.19
4	5.30	5.42	5.55



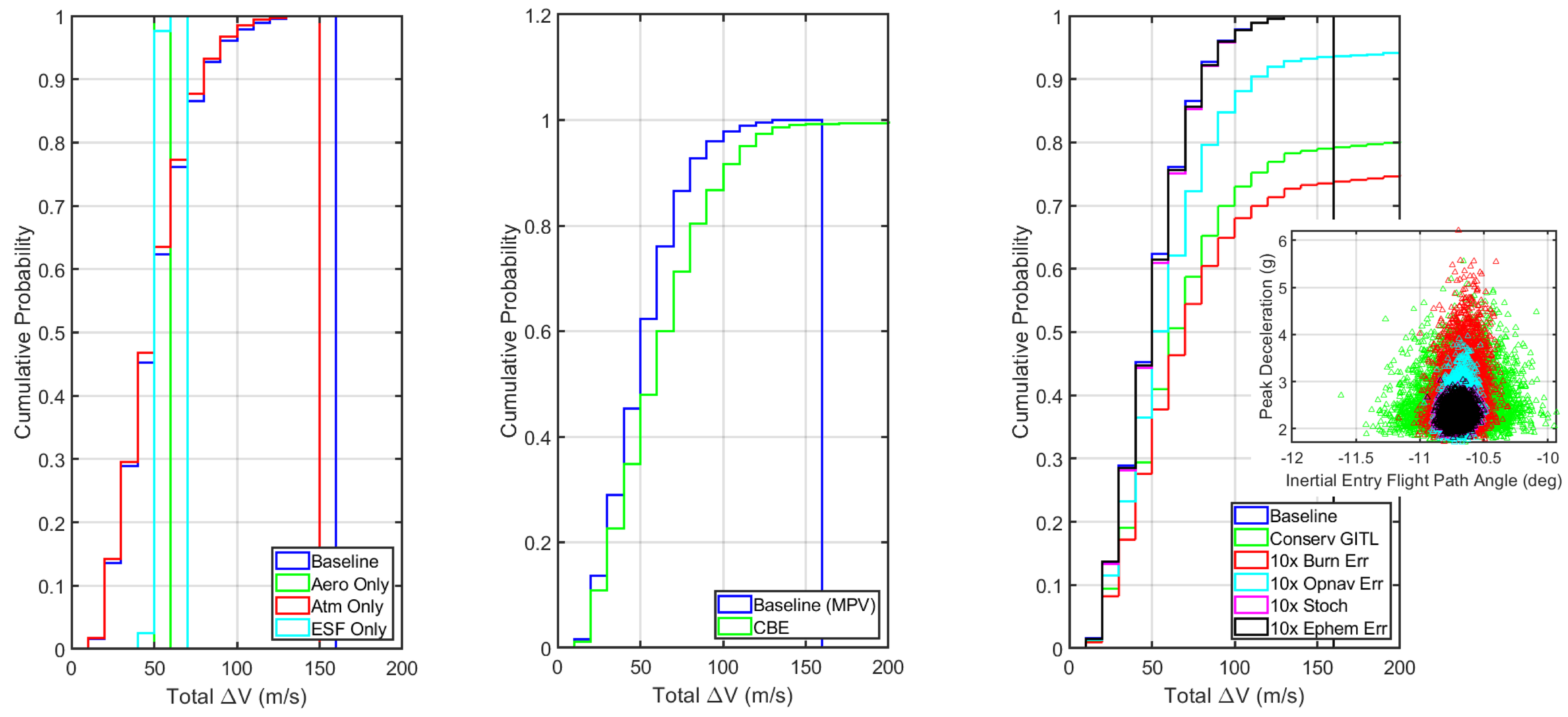
C-PICA thickness grows quickly in higher heating environments. C-PICA tested to environments of V_{∞} = 18 km/s. This gives an upper-estimate of how fast entry speeds can current aerocapture design tolerate.

Aerocapture Concept of Operations



Aerocapture Sensitivity Analysis

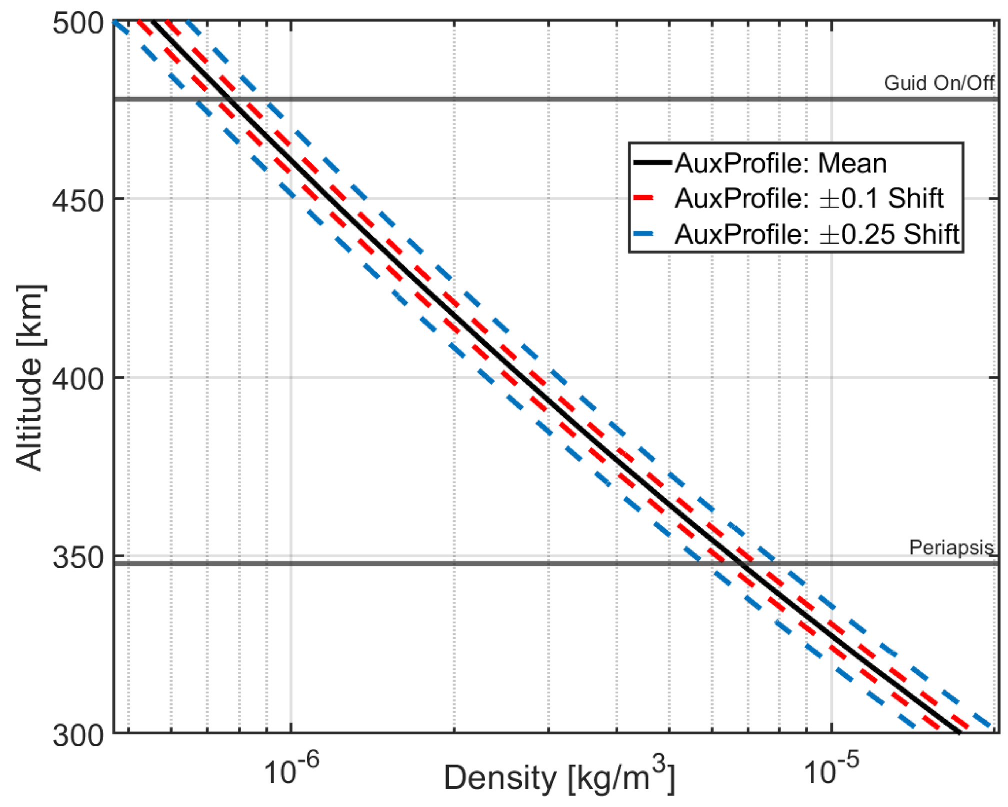
- Utilize Program to Optimize Simulated Trajectories 2 for Monte Carlo Analysis
- Compare sensitivities to Baseline



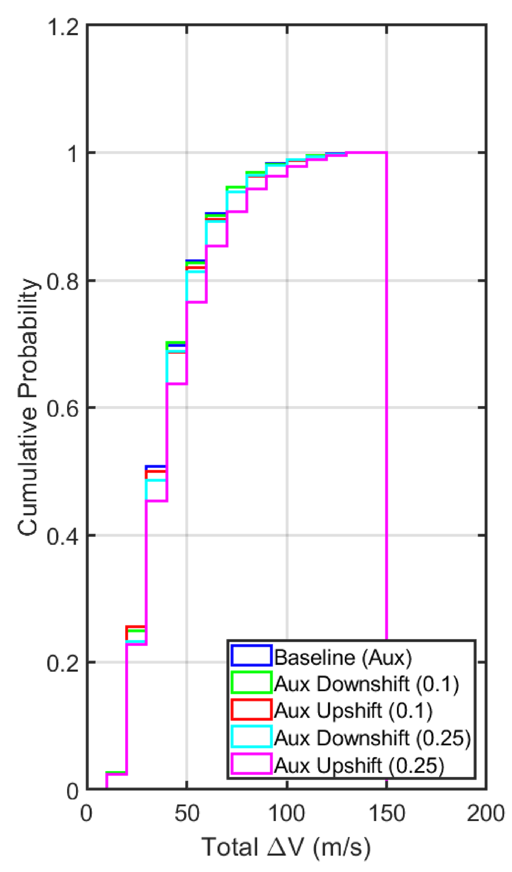
One-Variable at a Time identifies atmosphere dispersions as main driver for aerocapture performance

Testing robustness of guidance with different mass properties (CBE vs MPV). Guidance is insensitive to this difference

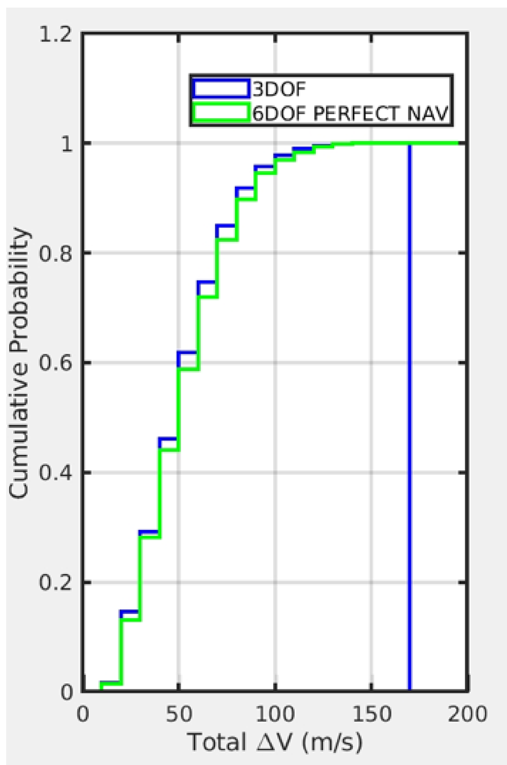
Assess different MDNAV error sources to understand which error source aerocapture performance is the most sensitive to

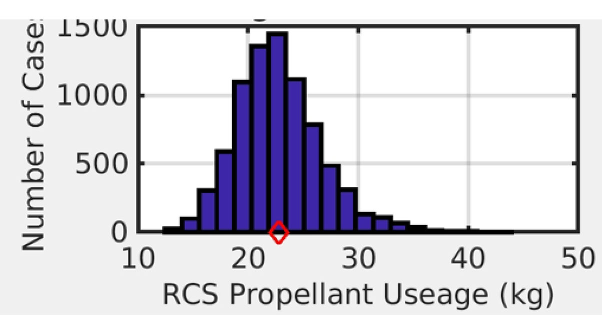


Shift up/down the mean density profile by a prescribed scale height to understand how resilient aerocapture is.

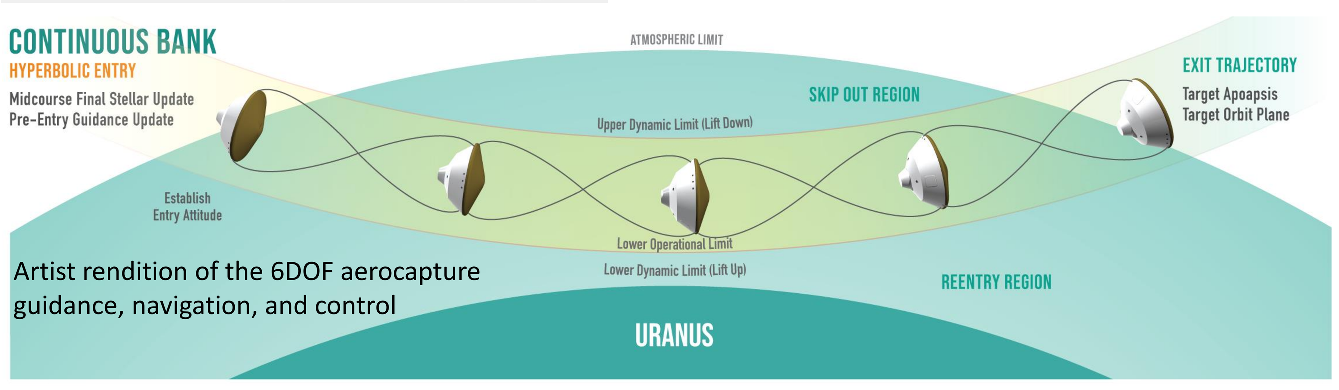


Guidance can sufficiently adjust to scale height shifts as high as 0.25 km





6DOF simulations produce similar results to baseline 3DOF. <50 kg RCS propellant needed for attitude control



Artist rendition of the 6DOF aerocapture guidance, navigation, and control

- **Overall, aerocapture is very robust to a variety of dispersion sources**

Project Conference Papers (Scan)

Overview · MDNAV · Performance · GNC · Aerodynamics · Aerothermal · TPS · Aeroshell