National Aeronautics and Space Administration

Small Satellite Aerocapture for Increased Mass Delivered to Venus and Beyond

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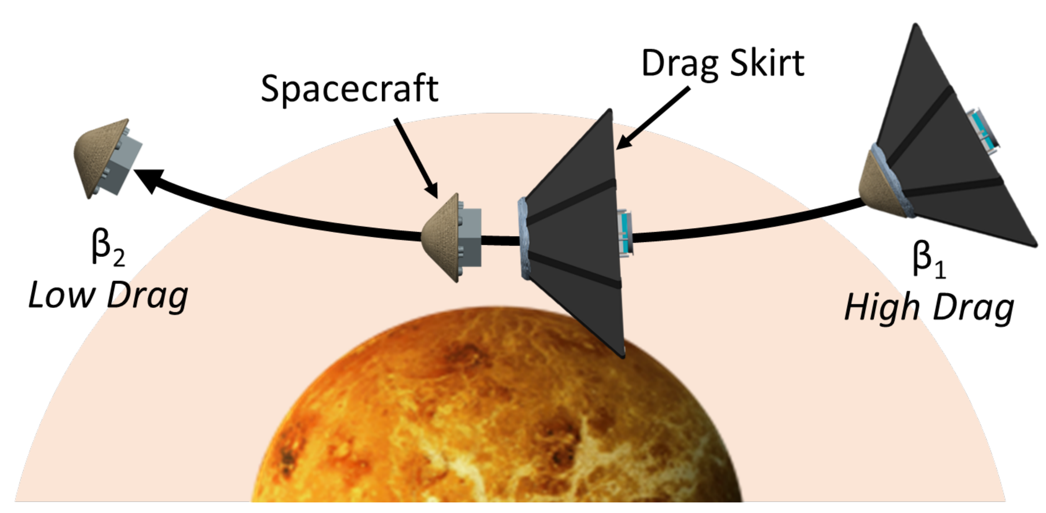
Program: Topic

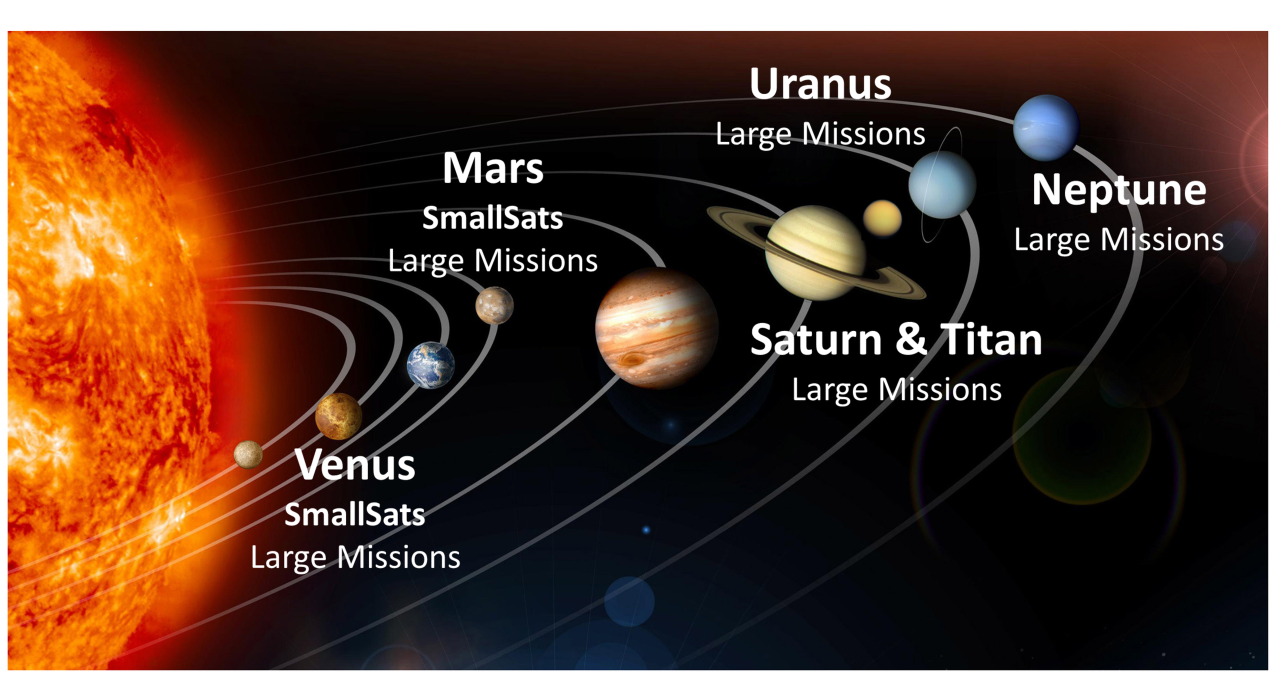
Project Objectives:

- Mature the technology of single-event drag modulation flight control for aerocapture at small satellite scale
- Raise TRL to 4 through simulation and experimental validation



Benefits to NASA and JPL:

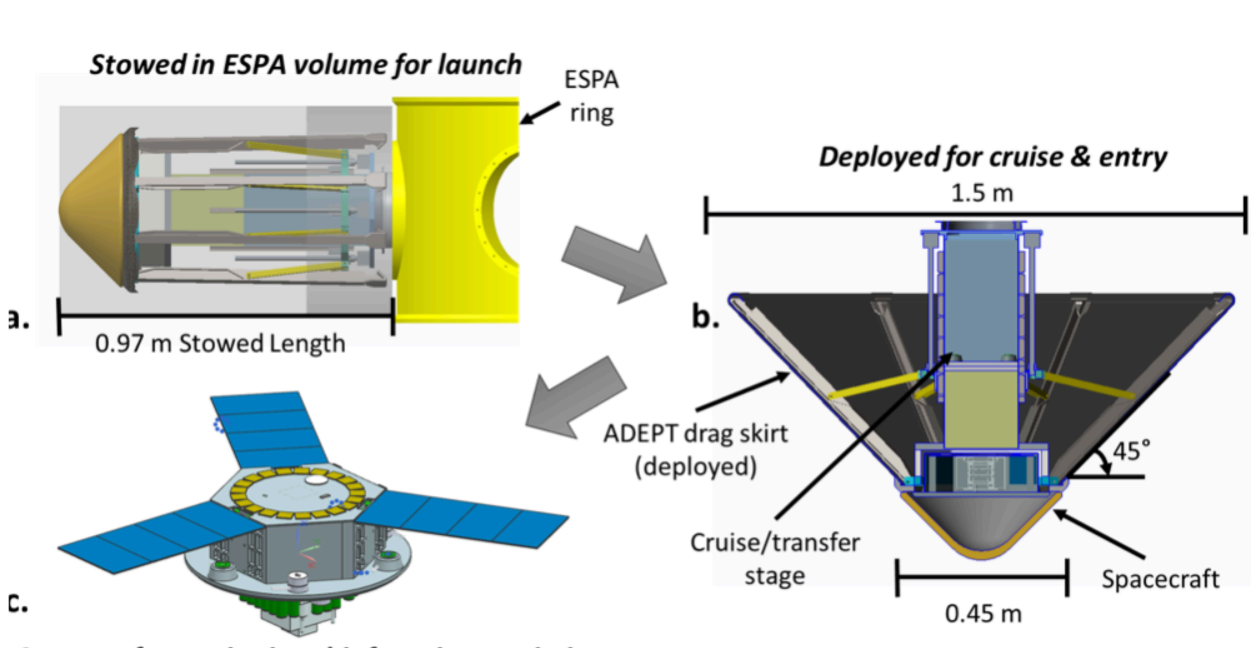
- Free mission architects from the constraints of the rocket equation
- Enable mass-efficient, rapid transit throughout the solar system
- Provide a small satellite platform for Venus and Mars exploration
- Pave the way for large-scale aerocapture implementation at Titan, Uranus, and Neptune



FY19 Results:

Mechanical Deployable Drag Skirt Development

- 1.5m ADEPT drag skirt stows to a diameter of 0.45m
- Ballistic coefficient ratio of 4.7

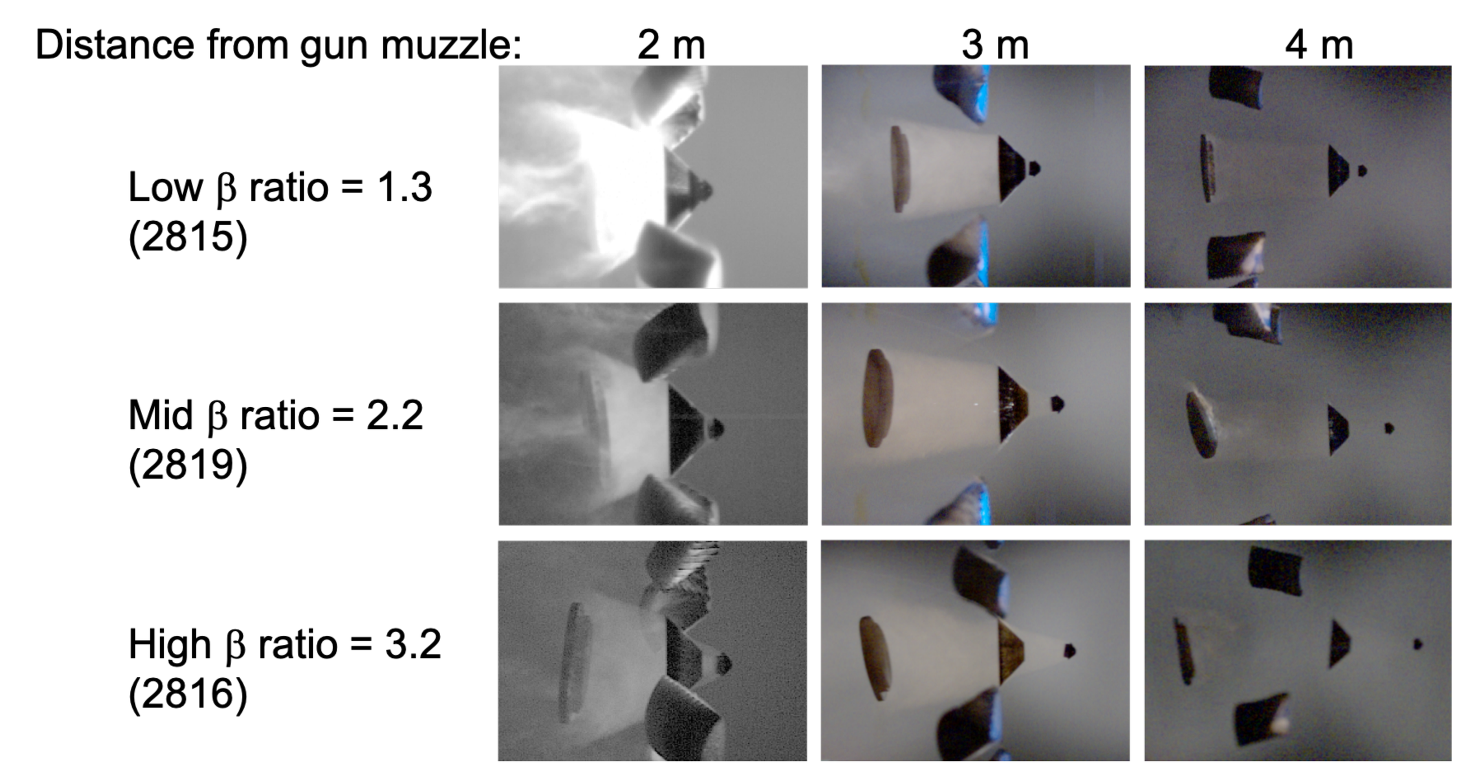


FY19 Results:

Ballistic Range Testing

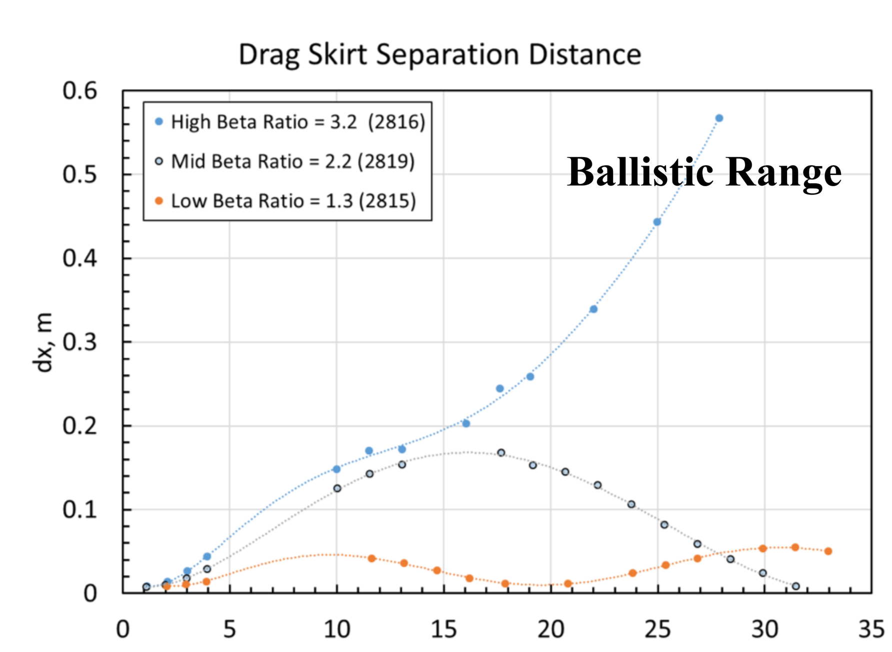
- Experimentally demonstrated clean separation and stable flight for sufficiently high ballistic coefficient ratio
- Identified ballistic coefficient ratios at which recontact can occur

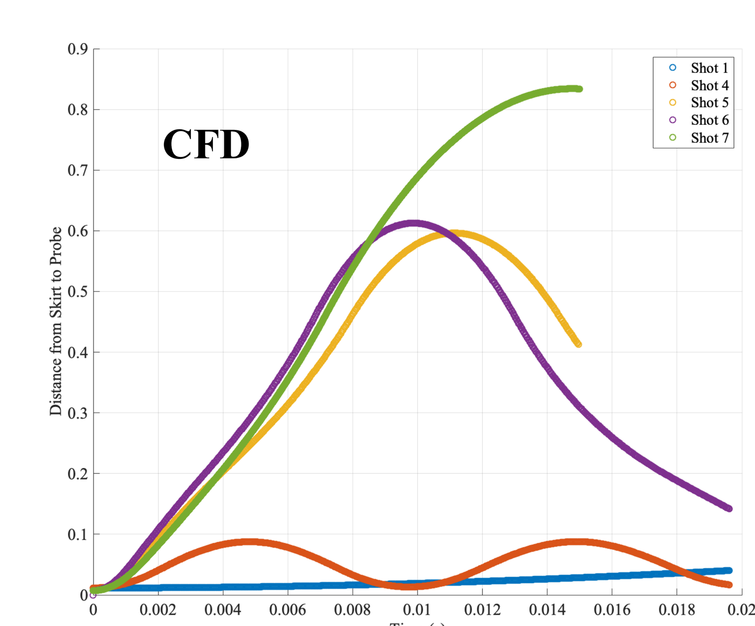
Shot #	at launch Speed (km/s)	Mach number	Re_D (Flight System)	Re_D (Drag Skirt)	β_2/β_1	free stream P_∞ (atm)	ρ_∞ (kg/m^3)	T_∞ (K)	ρ_∞ (kg/m^3)	Drag Skirt
2815	3.272	12.17	4.55E+05	1.79E+06	1.3	0.150	2.712E-01	297	2.712E-01	Axisymmetric Steel
2818	3.217	11.97	4.48E+05	1.77E+06	1.3	0.150	2.717E-01	296	2.717E-01	Axisymmetric Steel (repeat)
2817	3.233	12.04	4.51E+05	1.79E+06	1.4	0.150	2.721E-01	296	2.721E-01	ADEPT Steel
2819	3.305	12.32	4.64E+05	1.83E+06	2.2	0.150	2.725E-01	295	2.725E-01	Axisymmetric Titanium
2820	3.247	12.07	7.54E+05	2.96E+06	2.2	0.250	4.520E-01	297	4.520E-01	Axisymmetric Titanium (higher freestram density)
2816	3.023	11.26	4.23E+05	1.67E+06	3.2	0.150	2.724E-01	296	2.724E-01	Axisymmetric Aluminum
2821	3.390	12.61	2.08E+05	8.19E+05	3.2	0.066	1.191E-01	296	1.191E-01	Axisymmetric Aluminum (lower freestram density)
2822	3.287	12.25	4.61E+05	1.82E+06	3.4	0.150	2.725E-01	295	2.725E-01	ADEPT Aluminum



Computational Fluid Dynamics

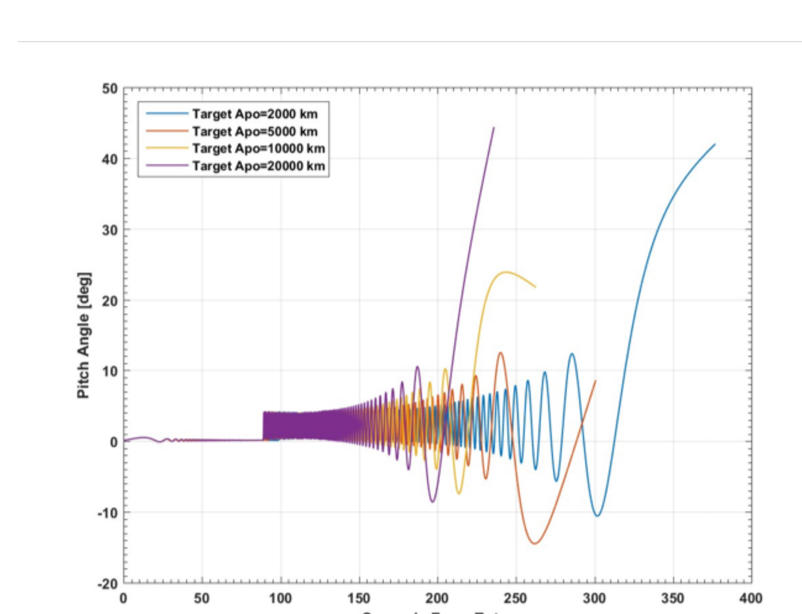
- CFD simulations performed in Cart3D compare well with testing data

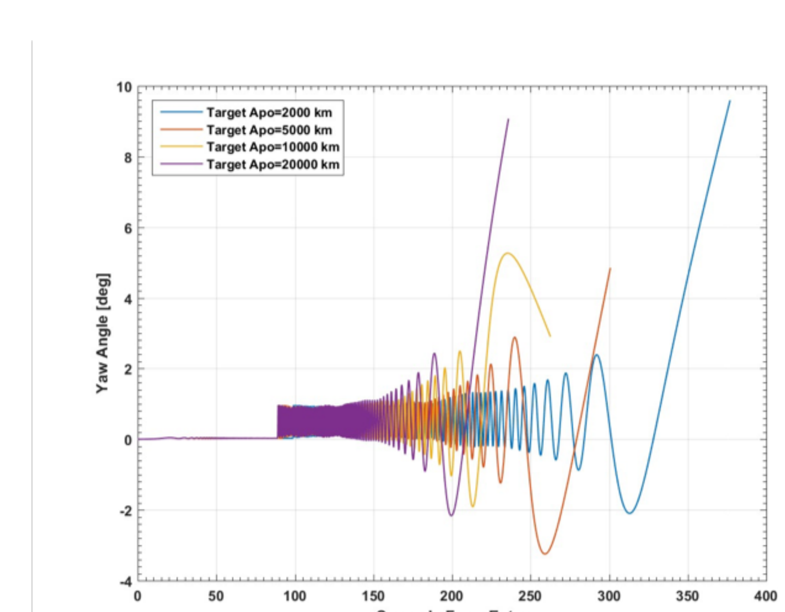




6DOF simulation in DSENDS

- Small pitch and yaw angles at time of separation suggest minimal tipoff risk during drag skirt separation





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Publications:

- Austin et. al., "SmallSat Aerocapture: Breaking the Rocket Equation to Enable a New Class of Planetary Missions," 70th International Astronautical Conference, October 2019. (In Work)
- Wilder, M., et al, "Ballistic Range Testing of Hypersonic Separation Dynamics for Drag Modulation Aerocapture," IEEE Aerospace Conference, 2020. (In Work)

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