Adaptive Deployable Entry Placement Technology (ADEPT) Development for Small Sat Class Venus Missions

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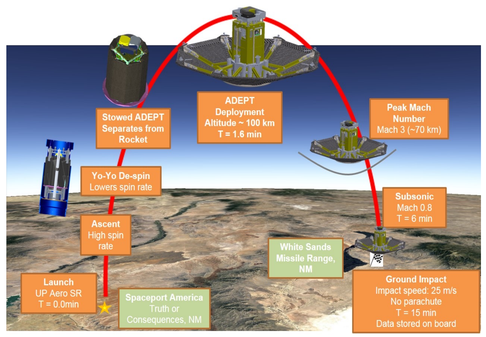
Background and Goal

The Adaptable, Deployable Entry and Placement Technology (ADEPT) is a novel approach for entry vehicle design. Similar to an umbrella, it is stowed during launch and deployed prior to entry. ADEPT employs a high performance, 3-D woven, carbon fabric to serve as the primary surface of the mechanically deployed system. The successful ADEPT sounding rocket flight test matured the 1 m Class ADEPT in the areas of deployment and structural integrity, and provided aerodynamic flight characteristics of the ADEPT open-back configuration from Mach 3 to Mach 0.3.

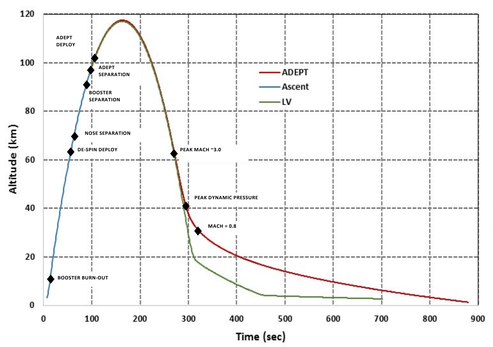
Aerocapture uses the aerodynamic drag from a single hyperbolic atmospheric pass to provide the delta-V needed for orbit insertion. Studies suggest that, compared to propulsive orbit insertion, aerocapture could increase delivered payload by 70% at Venus. Drag modulation aerocapture, which shows promise of being simpler and more cost-effective than the more-often studied lift modulation methods, uses in-flight transformations of an entry vehicle's drag area to control the amount of deceleration produced during an atmospheric pass. In single-event drag modulation, a drag device is jettisoned after the appropriate deceleration. ADEPT, due to its unique ability to fold and unfold, is being considered for this SmallSat class payload mission applications.

Sub-Orbital Flight Test Description

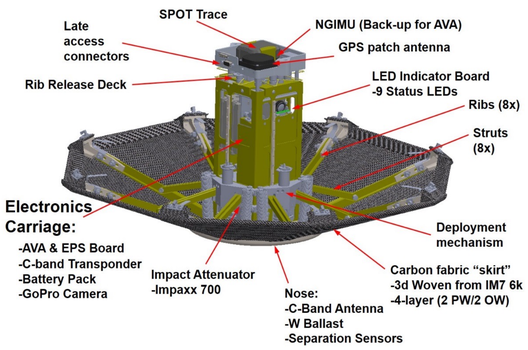
Concept of Operations



Predicted Timeline



SR-1 Vehicle Configuration



ADEPT SR-1 Sub-Orbital Flight Test Results Summary

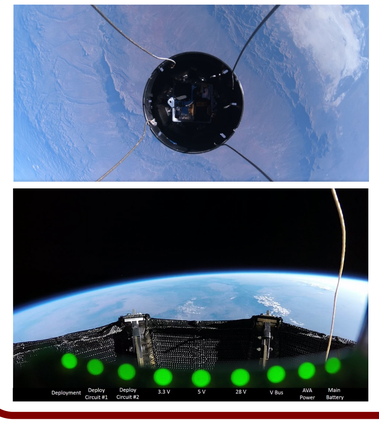
Key Performance Parameters		
Performance Parameter	Threshold Value	Project Goal
Exo-atmospheric deployment to an entry configuration of the 1m-class ADEPT.	Less than fully locked condition resulting in shape with less than 70-degree forebody cone angle.	Full, locked deployment before reaching 80 km altitude on descent, to 70-degree fore body cone angle achieving 6x greater drag area.
Aerodynamic stability without active control of the 1m-class ADEPT in a flight configuration.	Does not tumble prior to M=0.8 while decelerating from peak Mach # (when Mach number is decreasing after passing through peak Mach number).	ADEPT does not tumble* before ground impact; Sign of pitch damping coefficient (Cmq) is determined; FF-CFD simulation tool is validated

Results Summary

- KPP-1: Project goal met- Desired aerodynamic shape all the way to the ground
- KPP-2: Threshold goal of vehicle not tumbling prior to M=0.8 achieved
- ADEPT SR-1 was dynamically stable through M=0.8
- The vehicle and all data products stored onboard the vehicle were recovered
- Increase in roll rate prior to encountering transonic flow was unexpected

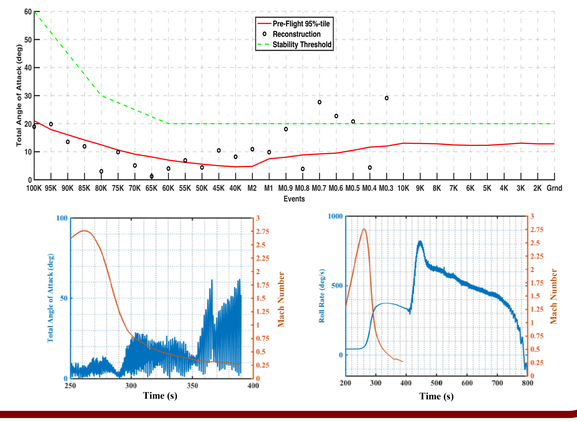
ADEPT SR-1 Sub-Orbital Flight Test Results

In-Flight Still Frames from GoPro Video Cameras

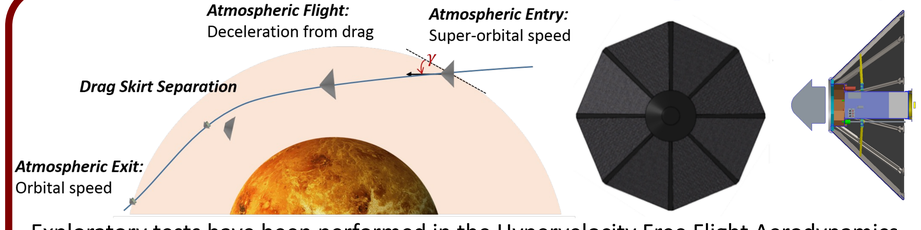


Recovery Operations in White Sands Missile Range

Preliminary Post-Flight Reconstruction



Drag Modulated Aerocapture Development



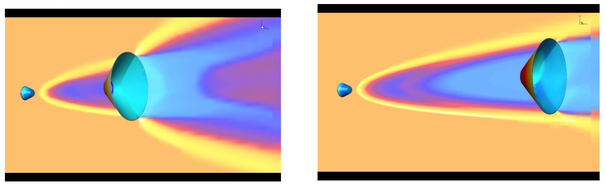
Exploratory tests have been performed in the Hypervelocity Free Flight Aerodynamics Facility at NASA Ames

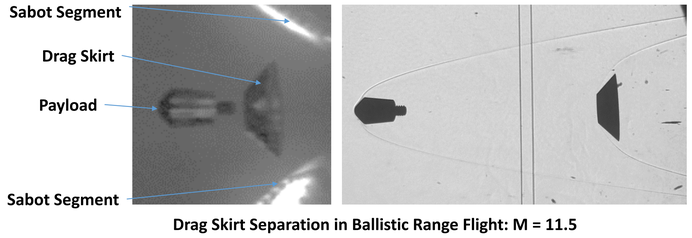
- Ballistic range has been modified to image the separation event.
- Test articles based on final study design to be fabricated and tested by the end of FY19.

Multi-body aerodynamic simulations have been performed using Cart3D

- Separation of the drag skirt from the center body during the atmospheric flight is a critical event.
- The desire is for the separation to be simple and avoid re-contact of components.

Sequence of Frames from Cart3D Simulation of Drag Skirt Separation

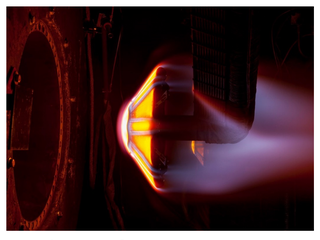




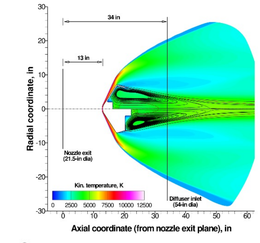
Drag Skirt Separation in Ballistic Range Flight: M = 11.5

ADEPT Future Work

System Level Aerothermal Ground Testing



Venus Aerothermal Conditions Achievable



- Test conditions for Venus Entry conditions
- Advance interface materials and seals
- Characterize payload environments
- Improve thermal response design codes
- Evaluate lightweight structural ribs
- Assess novel 3d Spider weave manufacturing approach