

TRAJECTORY OPTIMIZATION WITH ADAPTIVE DEPLOYABLE ENTRY AND PLACEMENT TECHNOLOGY ARCHITECTURE

Harish Saranathan

hsaranat@purdue.edu

Sarag J. Saikia, Michael J. Grant, James M. Longuski
School of Aeronautics and Astronautics, Purdue University

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Heavy Mass EDL Challenges on Mars

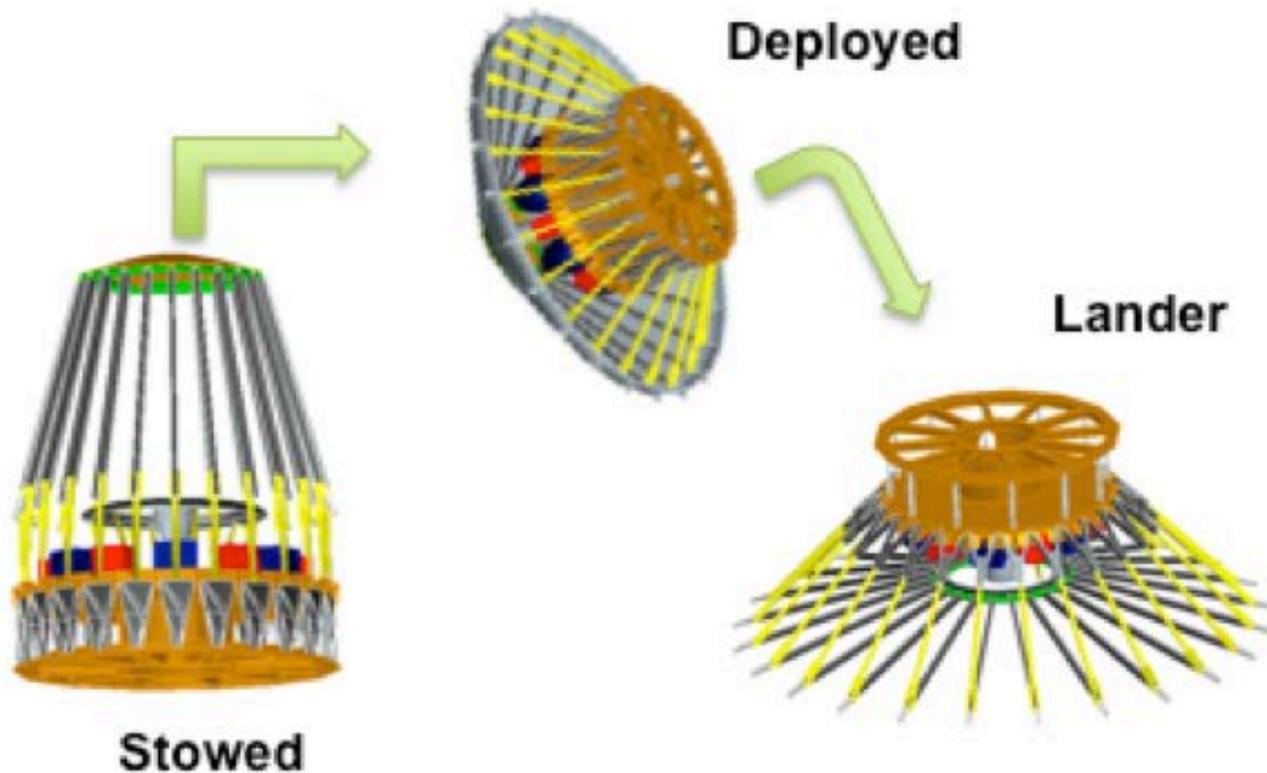
- Human missions require ~50 metric tons delivered payload
- Thin atmosphere
 - Not enough aerodynamic drag
 - Significant heating
- Size (~40 m) of rigid aeroshell is prohibitive
- Current architecture cannot land at higher elevations



Promising technology: mechanically deployed aerodynamic decelerator

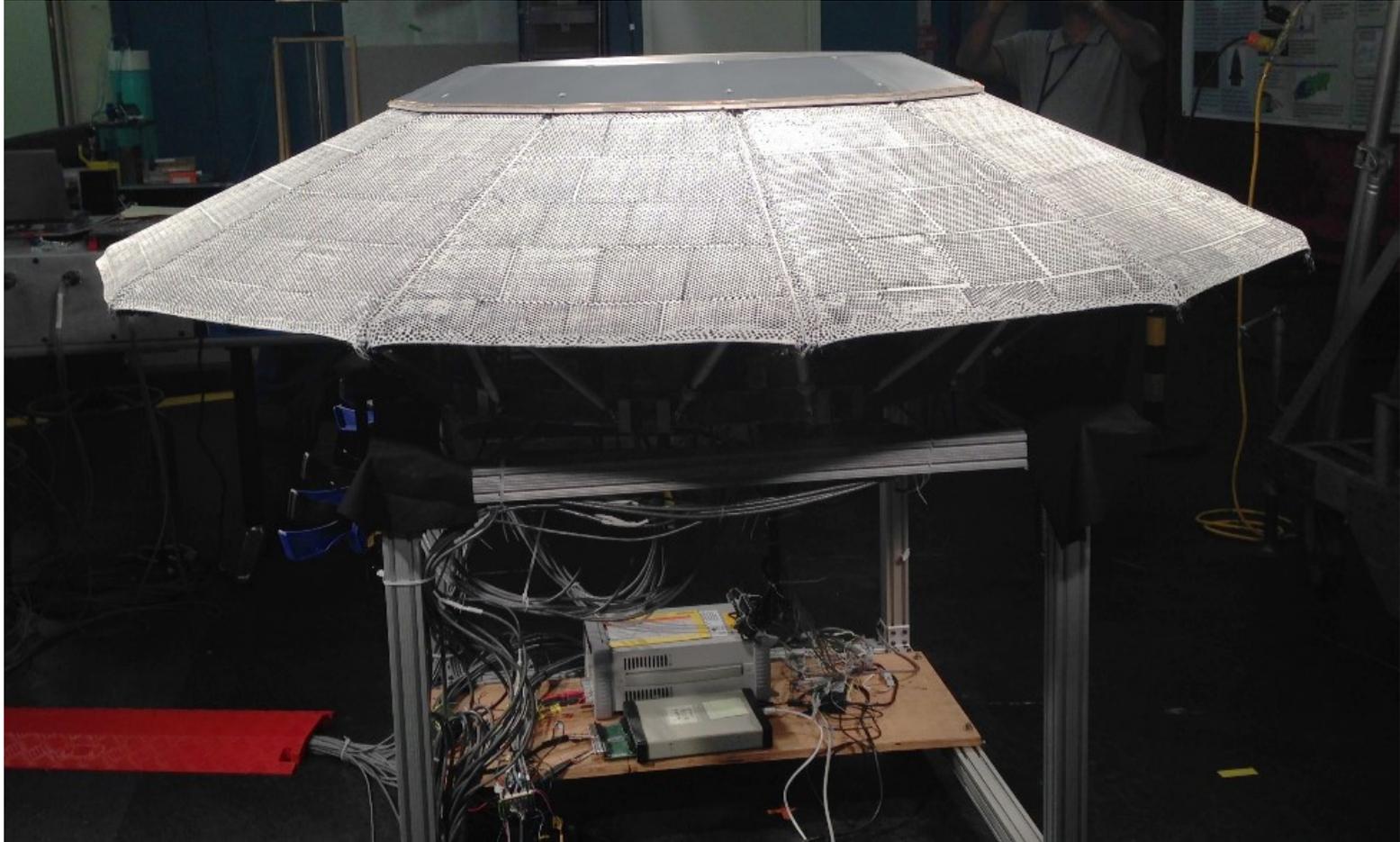
What is ADEPT?

Adaptive Deployable Entry and Placement Technology (ADEPT)



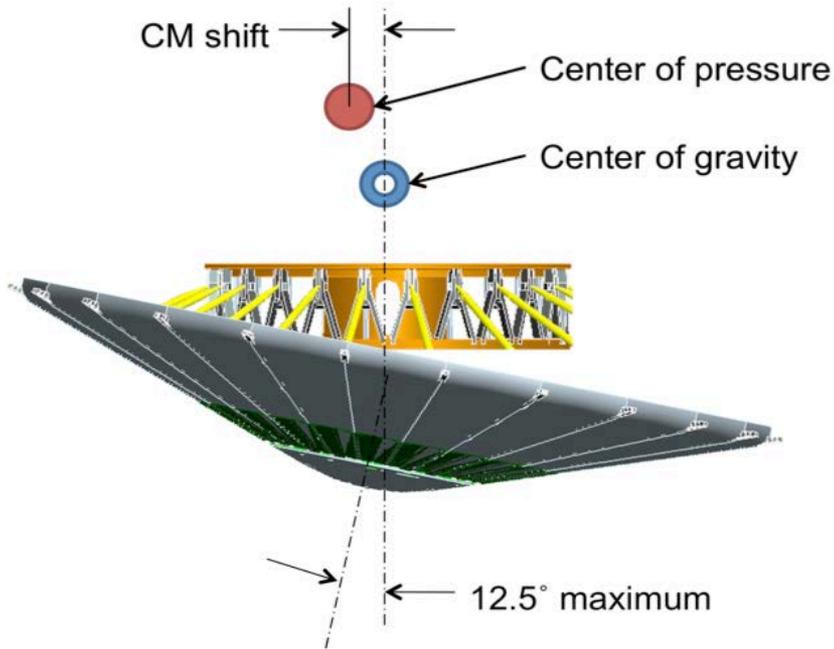
Venkatapathy et al.

The Real Look: ADEPT Deployment Test

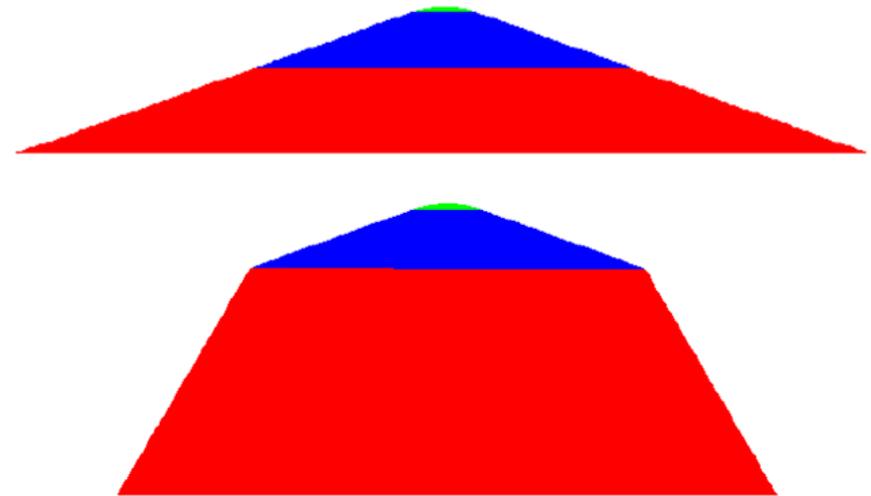


NASA Office of the Chief Technologist

Control Strategies

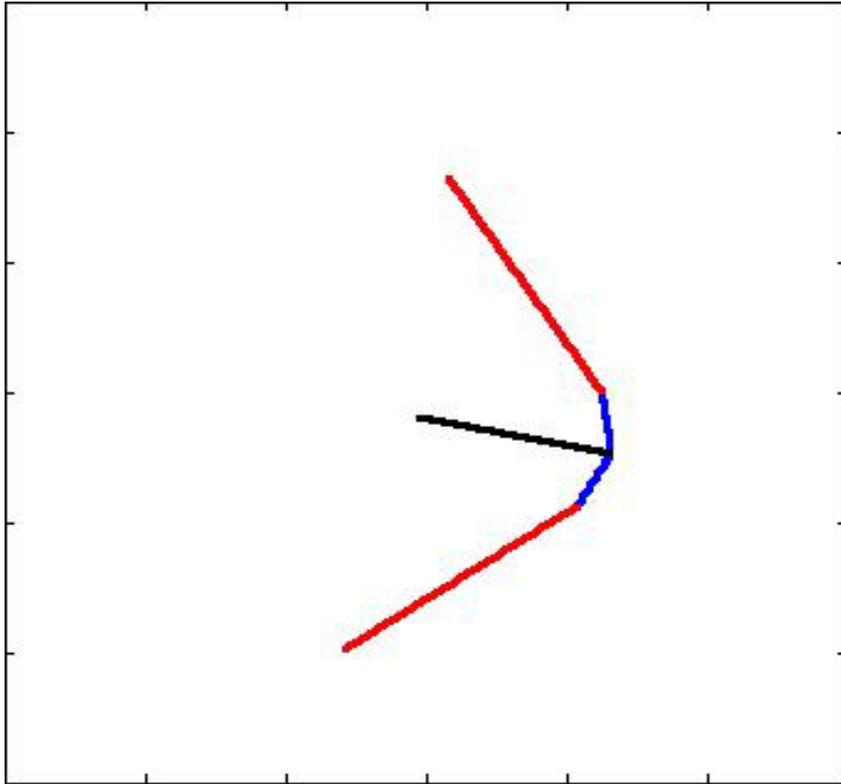


1. Angle-of-attack and bank angle via gimbaling aeroshell

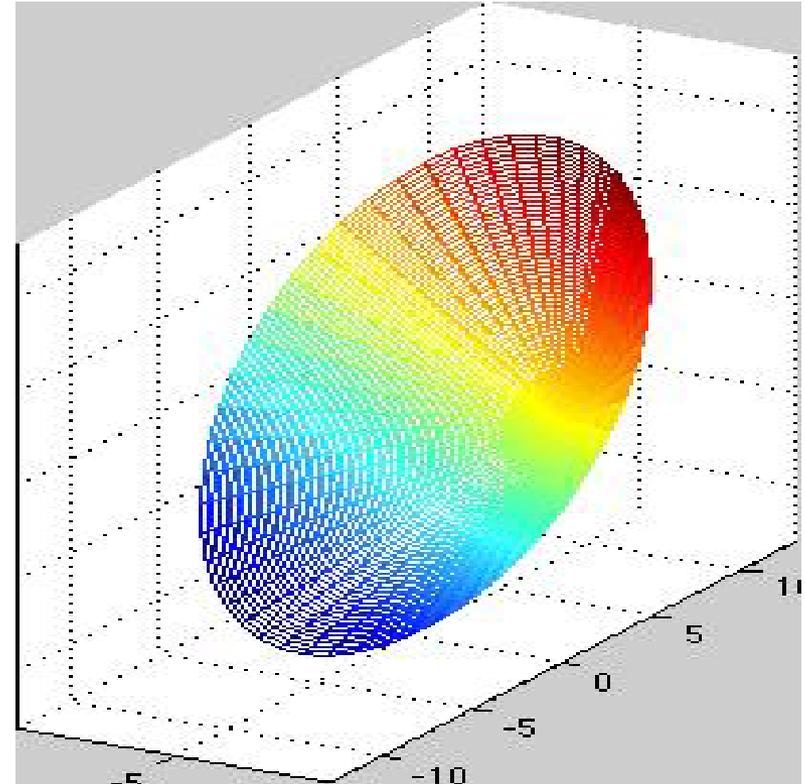


2. Drag modulation

Control Strategies

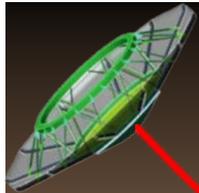


3. Modified Drag Control



4. Angle-of-attack, bank angle, and decelerator angle control

Problem Schematic



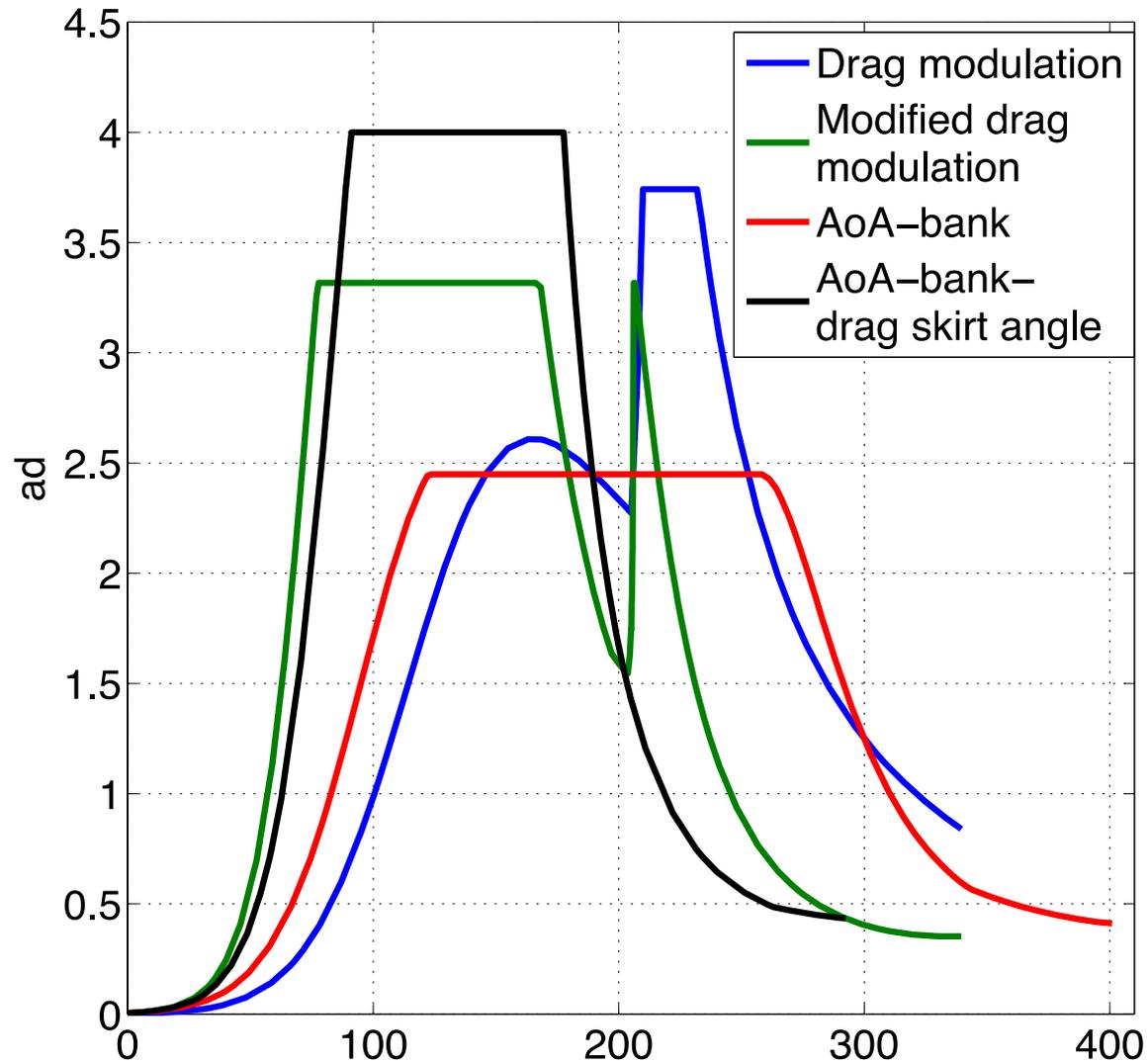
$V_e = 5.6 \text{ km/s}$
 $h_e = 120 \text{ km}$

***Minimize:* Stagnation-Point Heat Load**

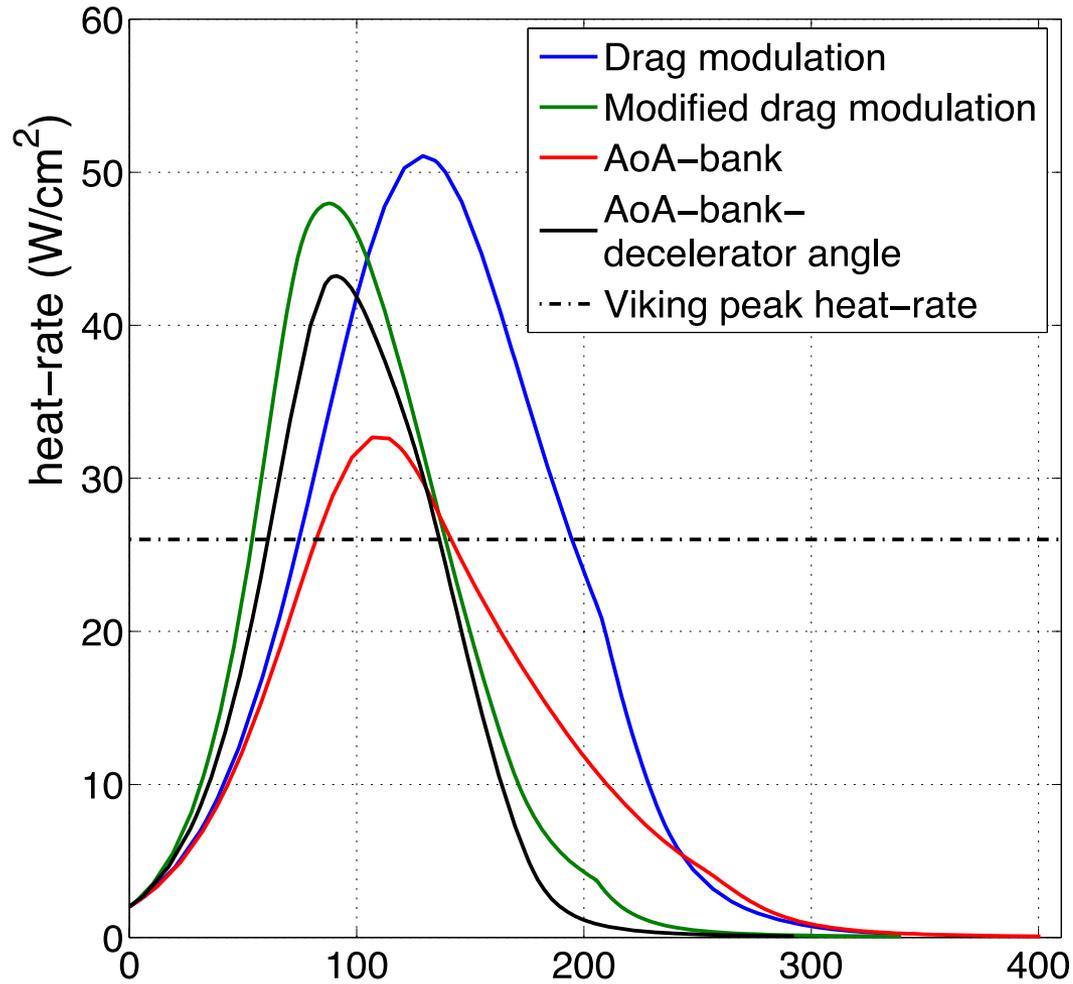
***Constraint:* Peak g-load**

~Mach 1.5

Deceleration

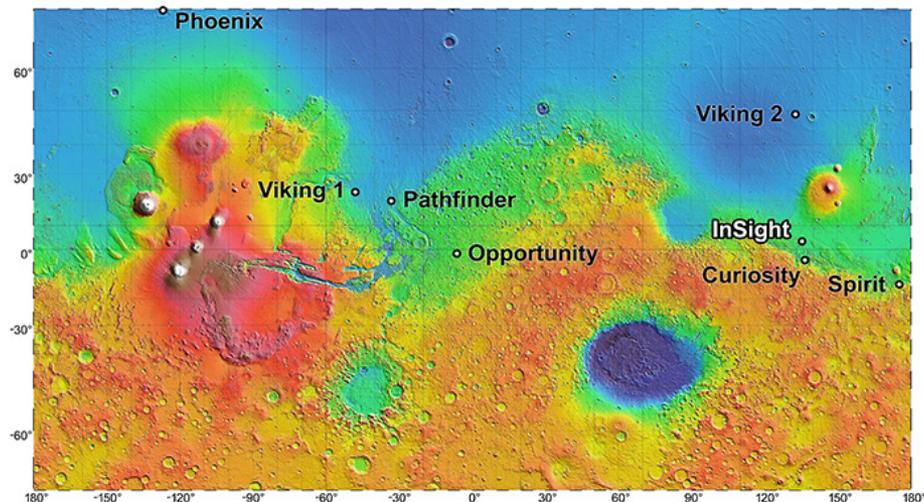
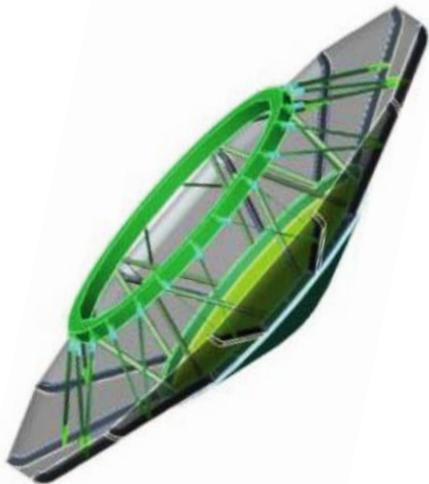


Stagnation-Point Heat Rate



Summary

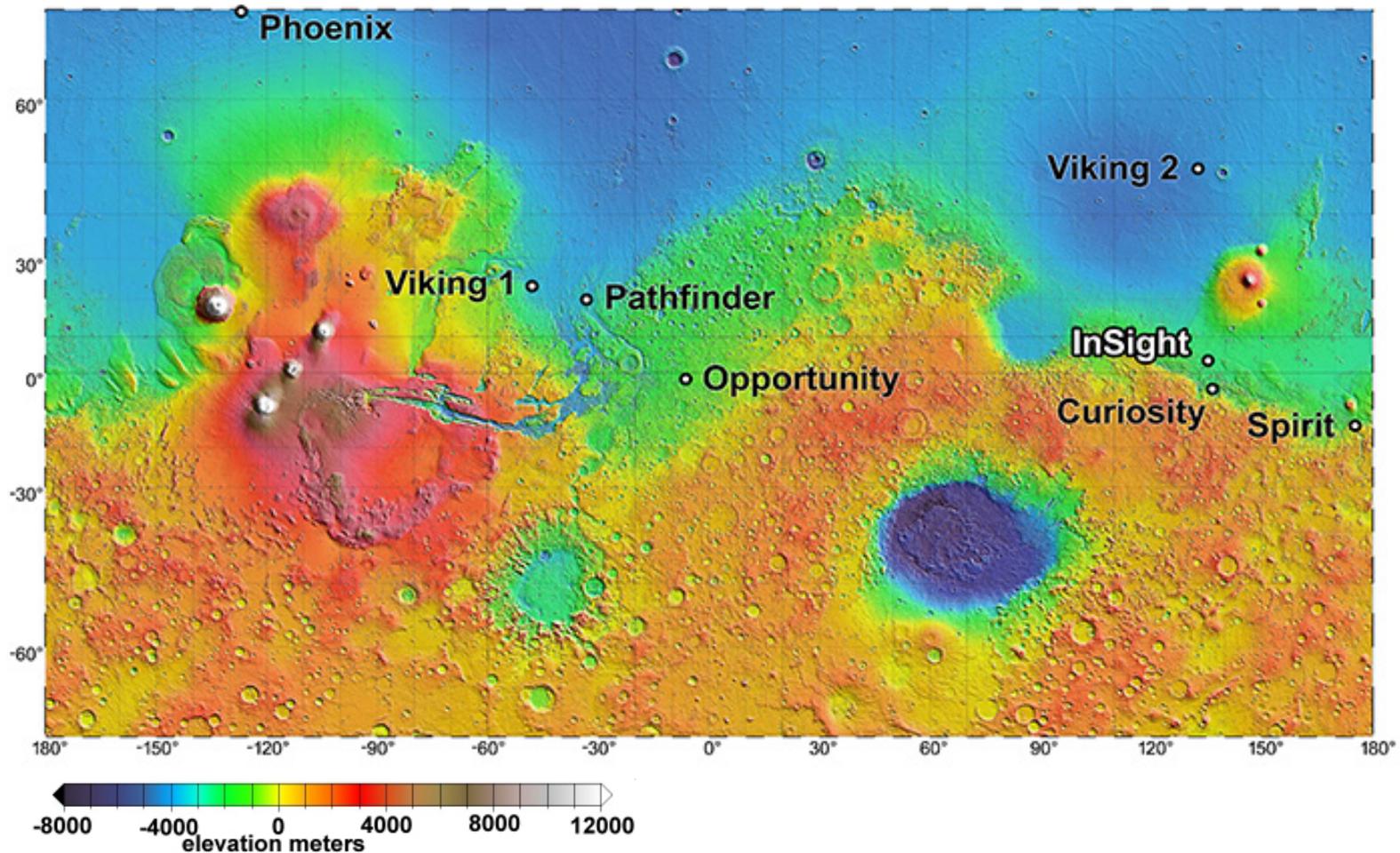
- ADEPT can land heavy mass on Mars
- Four different control strategies are assessed
- g-load constraint enforced
- AoA-bank angle control strategy is attractive
- 3-control strategy is highly complex
- Guidance issue for precision landing is yet to be addressed



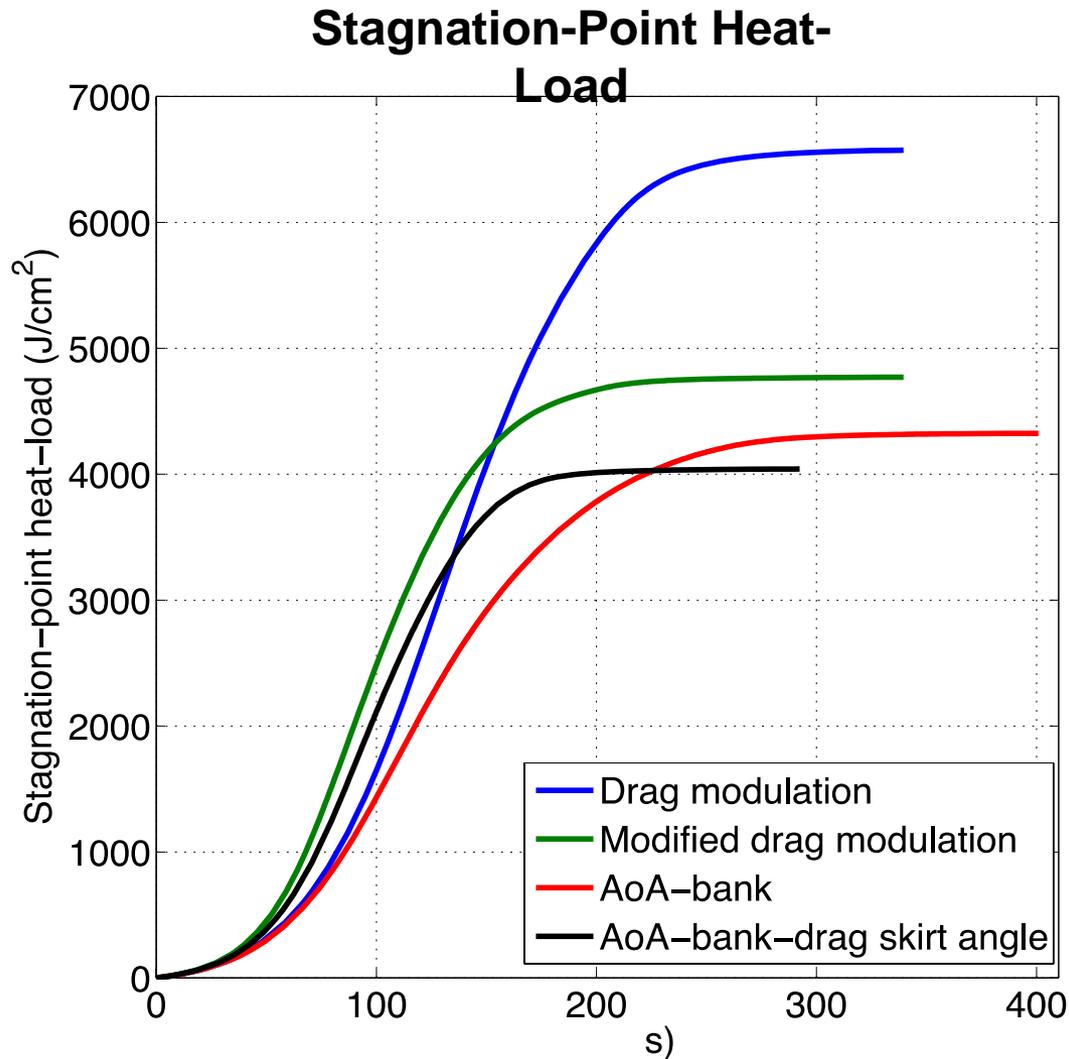
BACKUP

Heavy Mass EDL Challenges on Mars

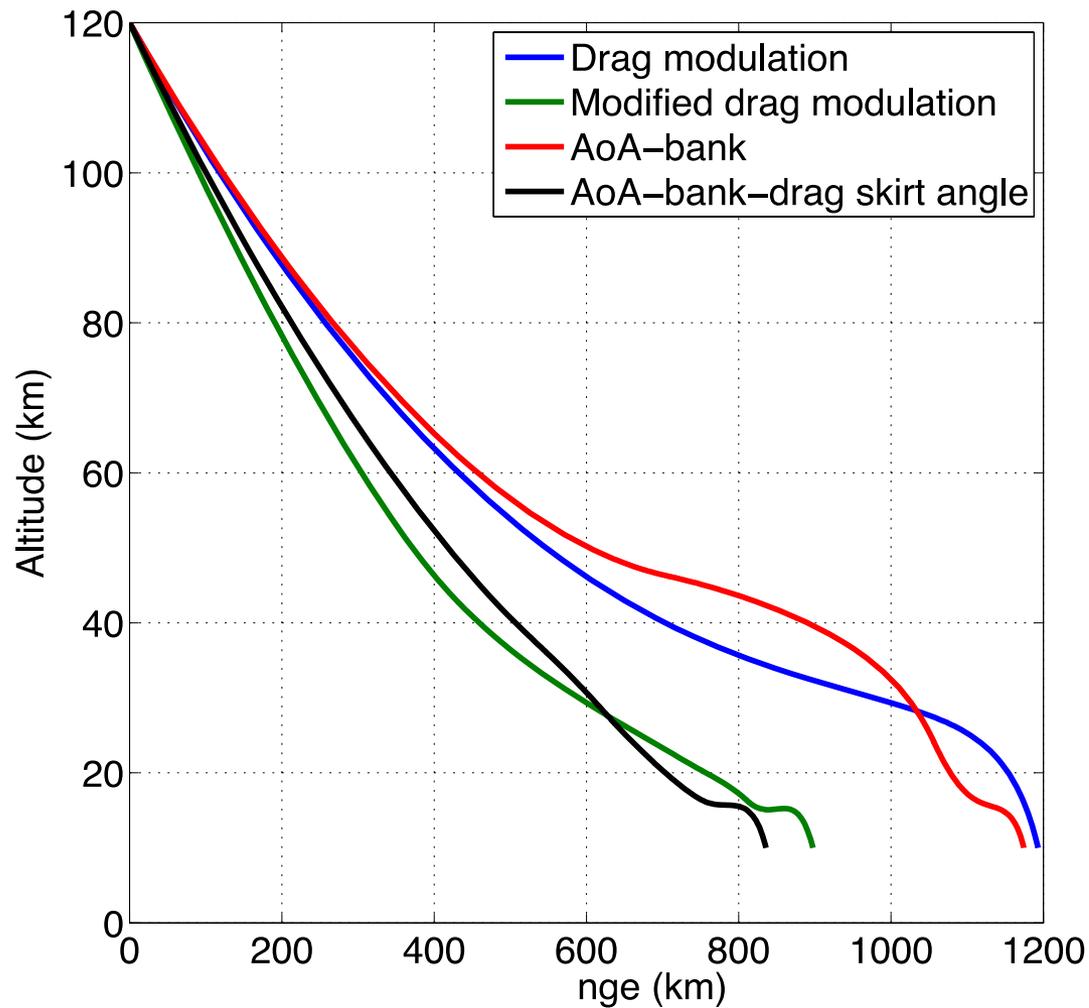
Current architecture cannot land at high MOLA altitudes



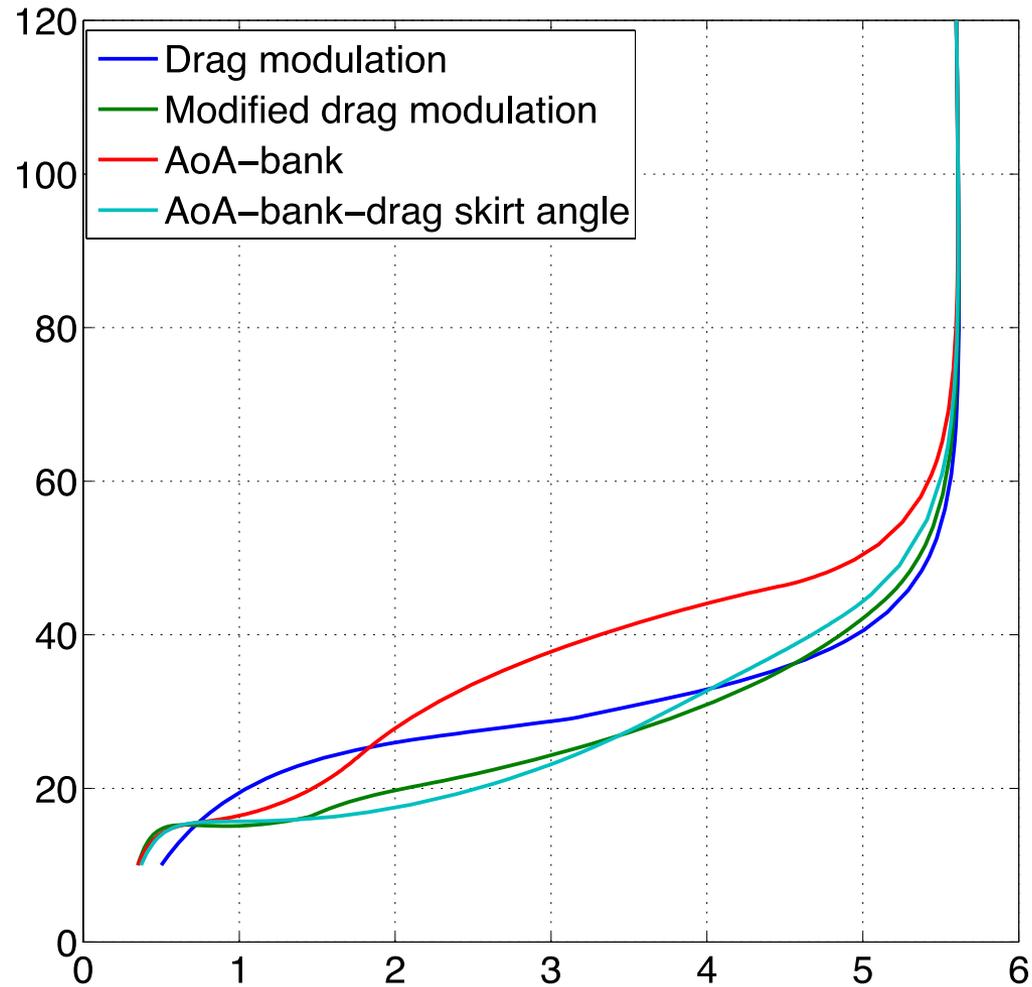
Stagnation-Point Heat-Load



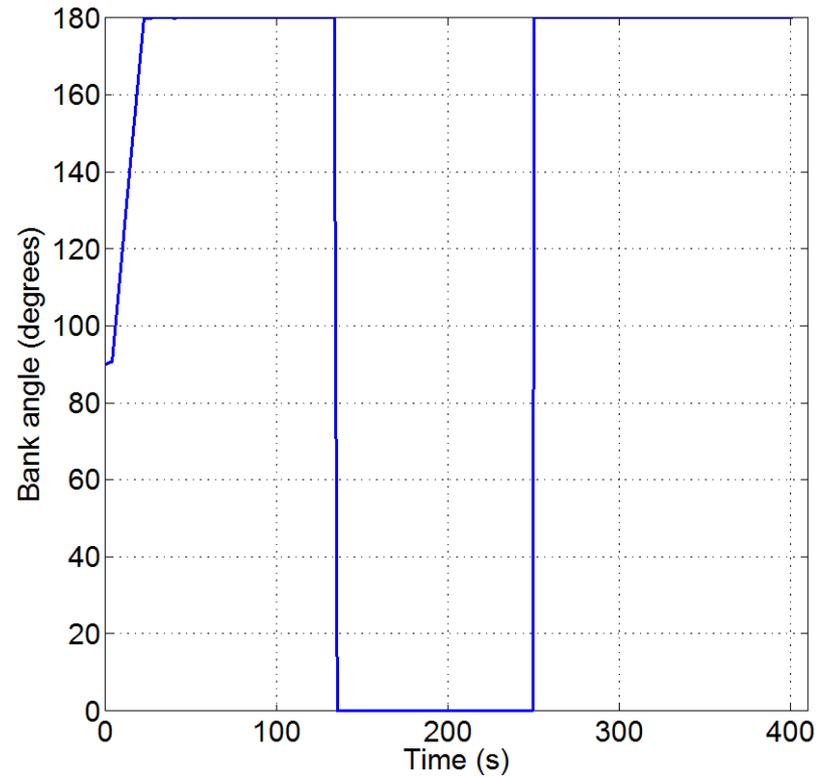
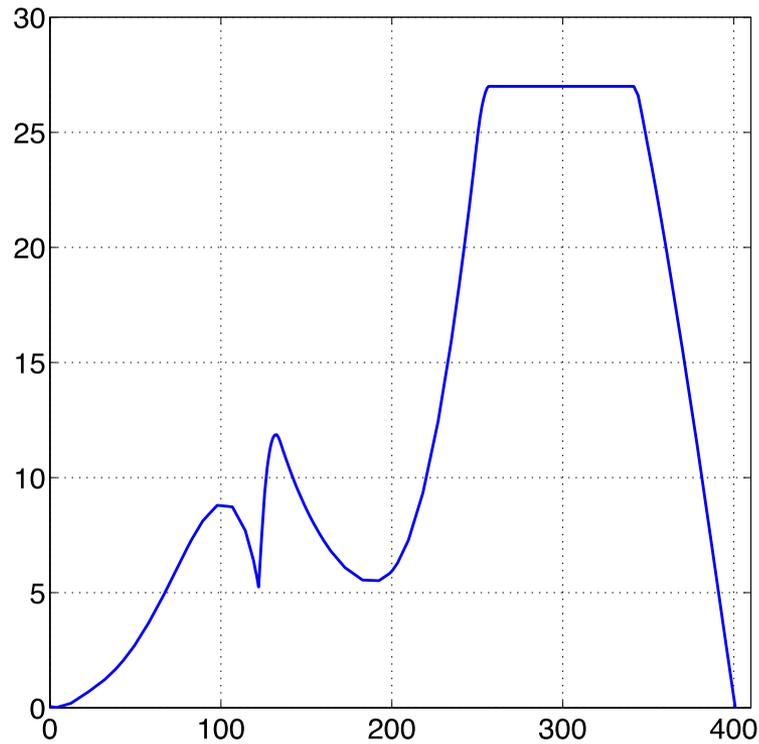
Downrange



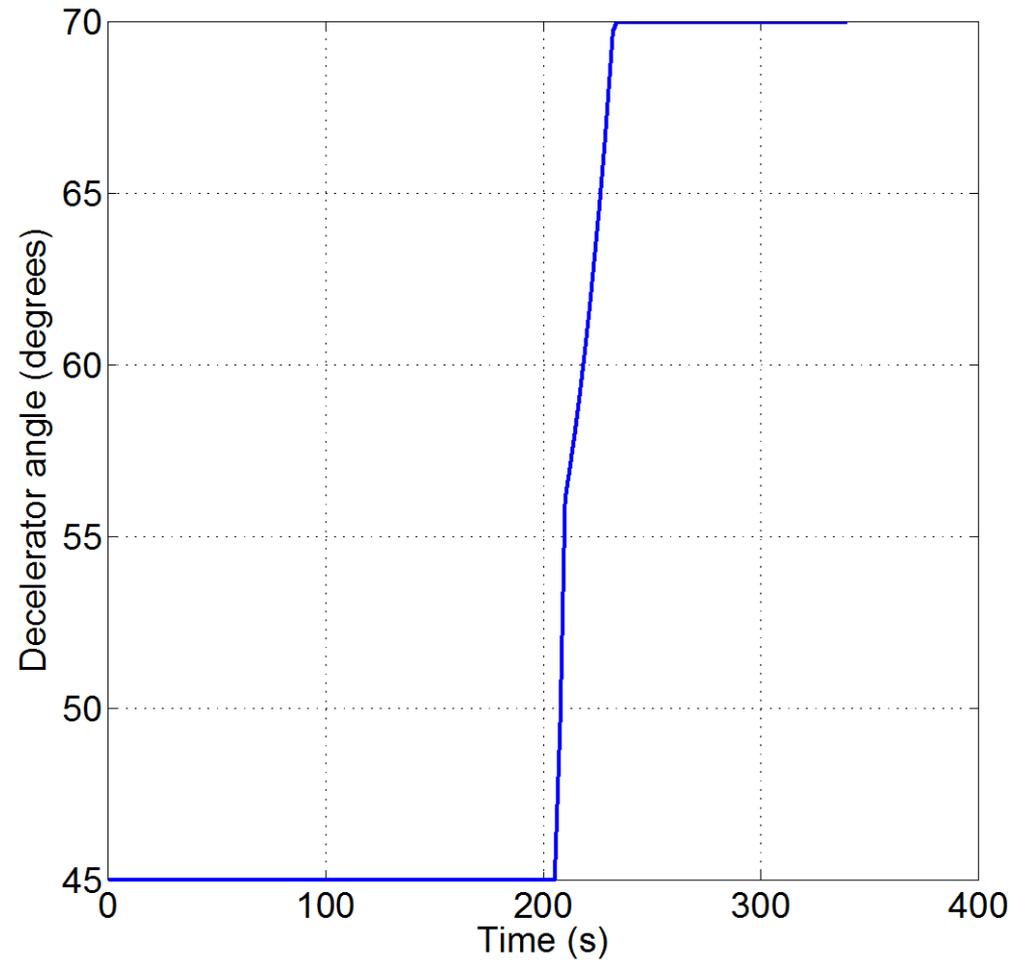
Altitude-Velocity



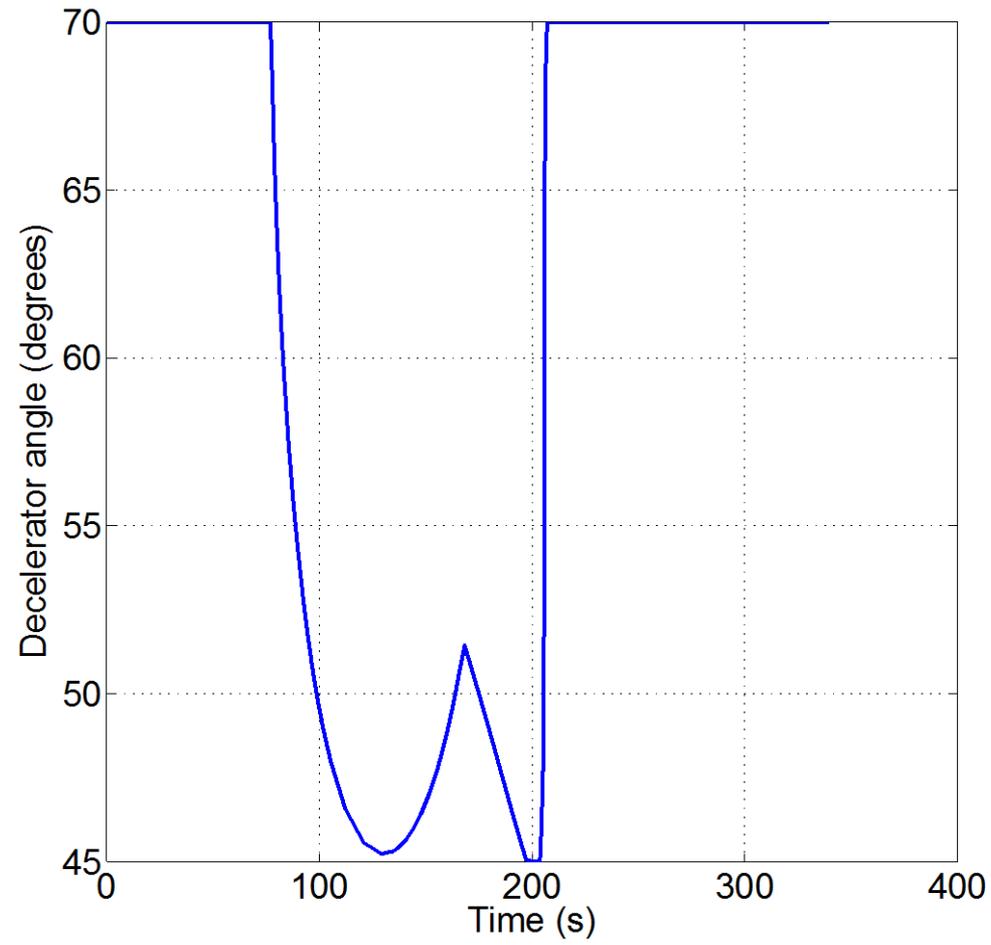
Control History: AoA-Bank Angle Control



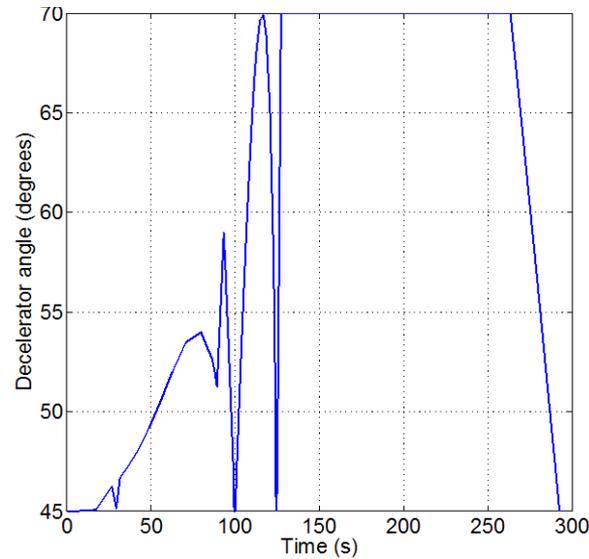
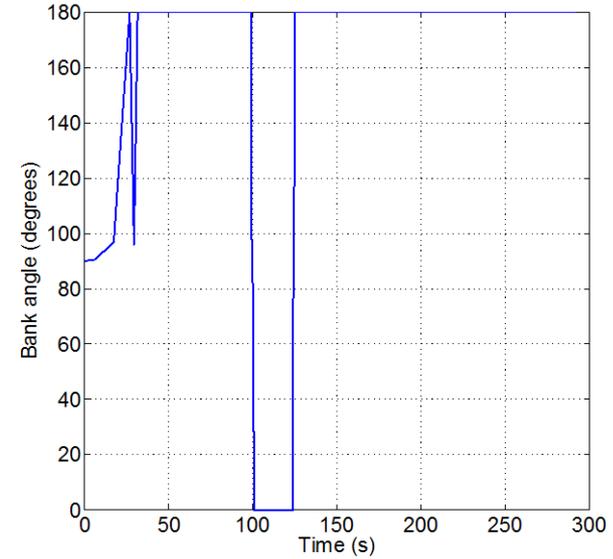
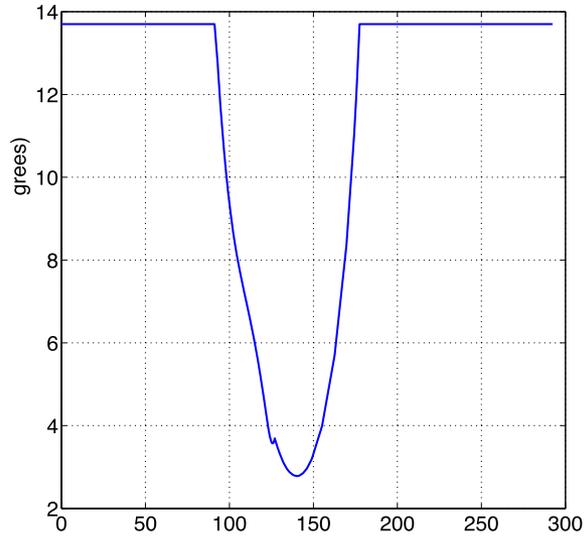
Drag Modulation



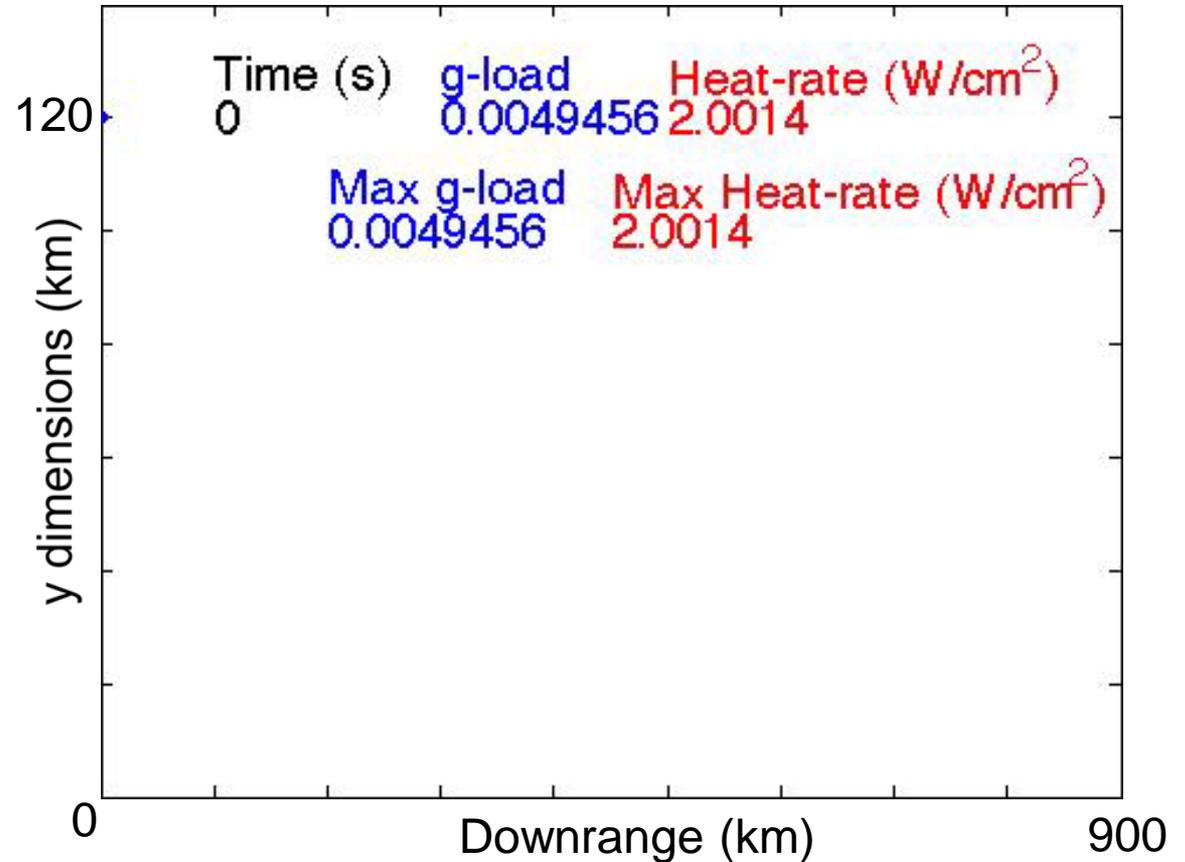
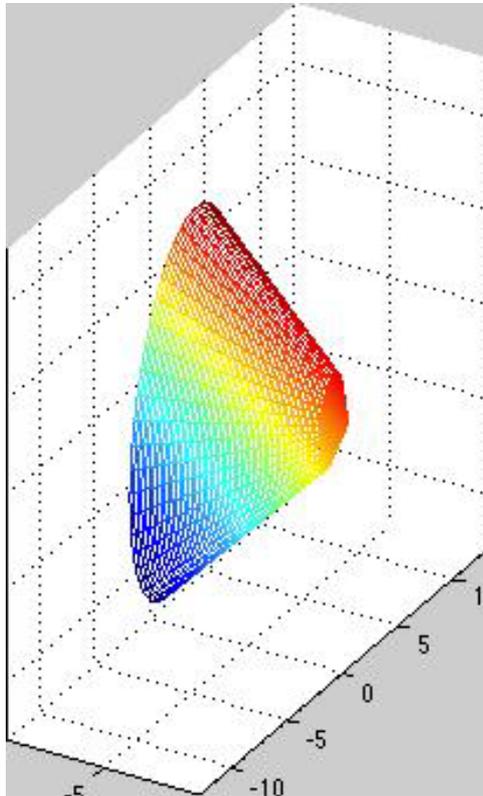
Modified Drag Modulation



AoA-Bank-Decelerator Angle Control



AoA-Bank-Decelerator Angle Control



Vehicle

Decelerator angle (degrees)	Angle-of-attack	Bank angle (degrees)
45.0157	13.7	89.9994

Modified Drag Modulation

Vehicle cross-section

