

Introduction to Entry, Descent, & Landing

AE 1350



Entry, Descent, and Landing (EDL)

- (Re)Entry
 - Entering atmosphere
 - Issues:
 - Surviving heat and accelerations
 - Getting to desired landing location
- Descent
 - Controlled descent through the lower portion of the atmosphere
- Landing
 - Survivable contact with the surface

Performance Metrics

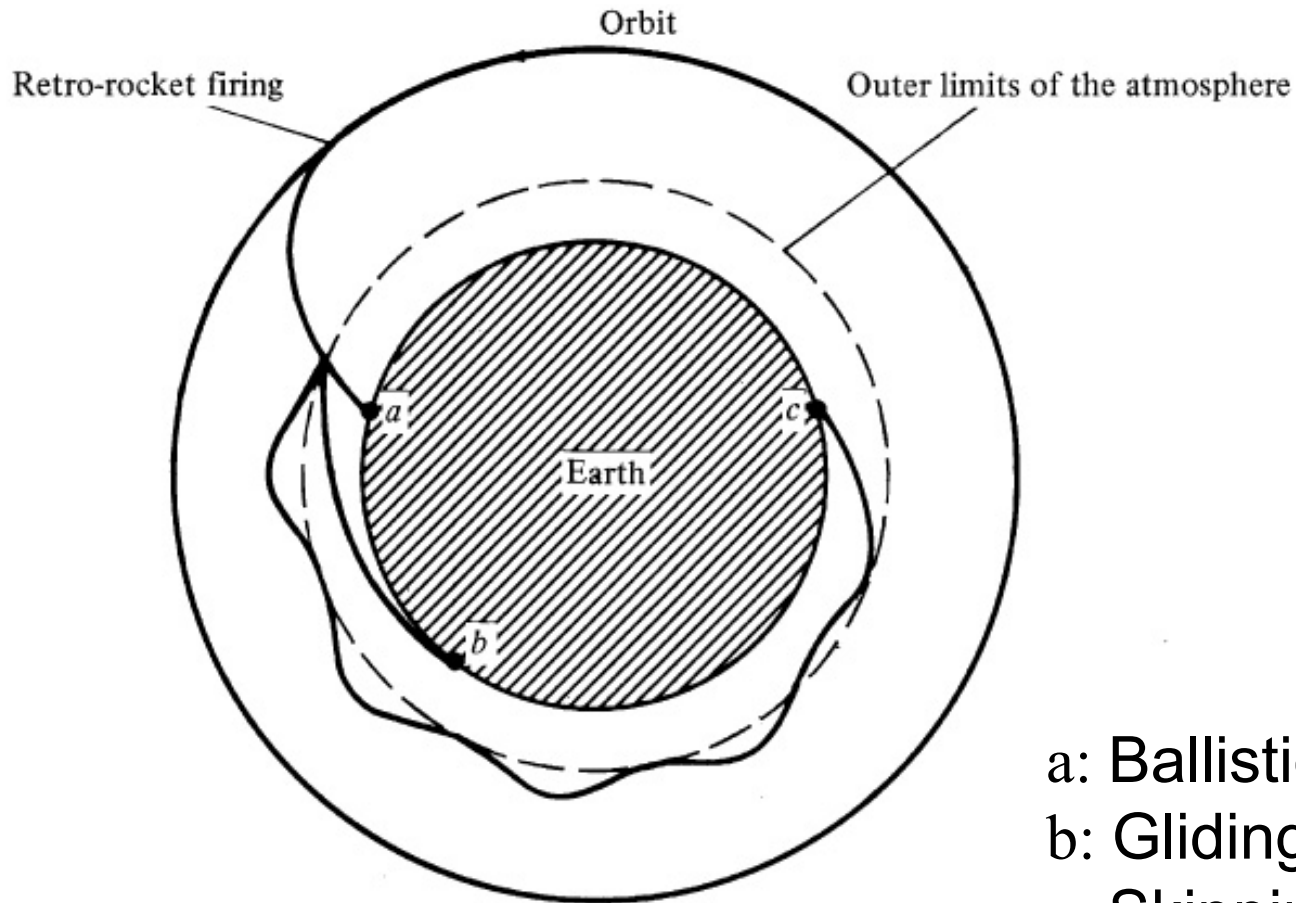
- Heating: heat rate and heat load during entry
- Acceleration: on entry, on parachute deployment, on impact with surface
- Accuracy: unguided, precision, pinpoint, hazard avoidance

Disciplines

- Aerodynamics
- Aerothermodynamics
- Guidance, navigation, and control
- Structures & Materials
- Planetary Science (gravity/atmosphere/surface)
- Propulsion
- Orbital Mechanics

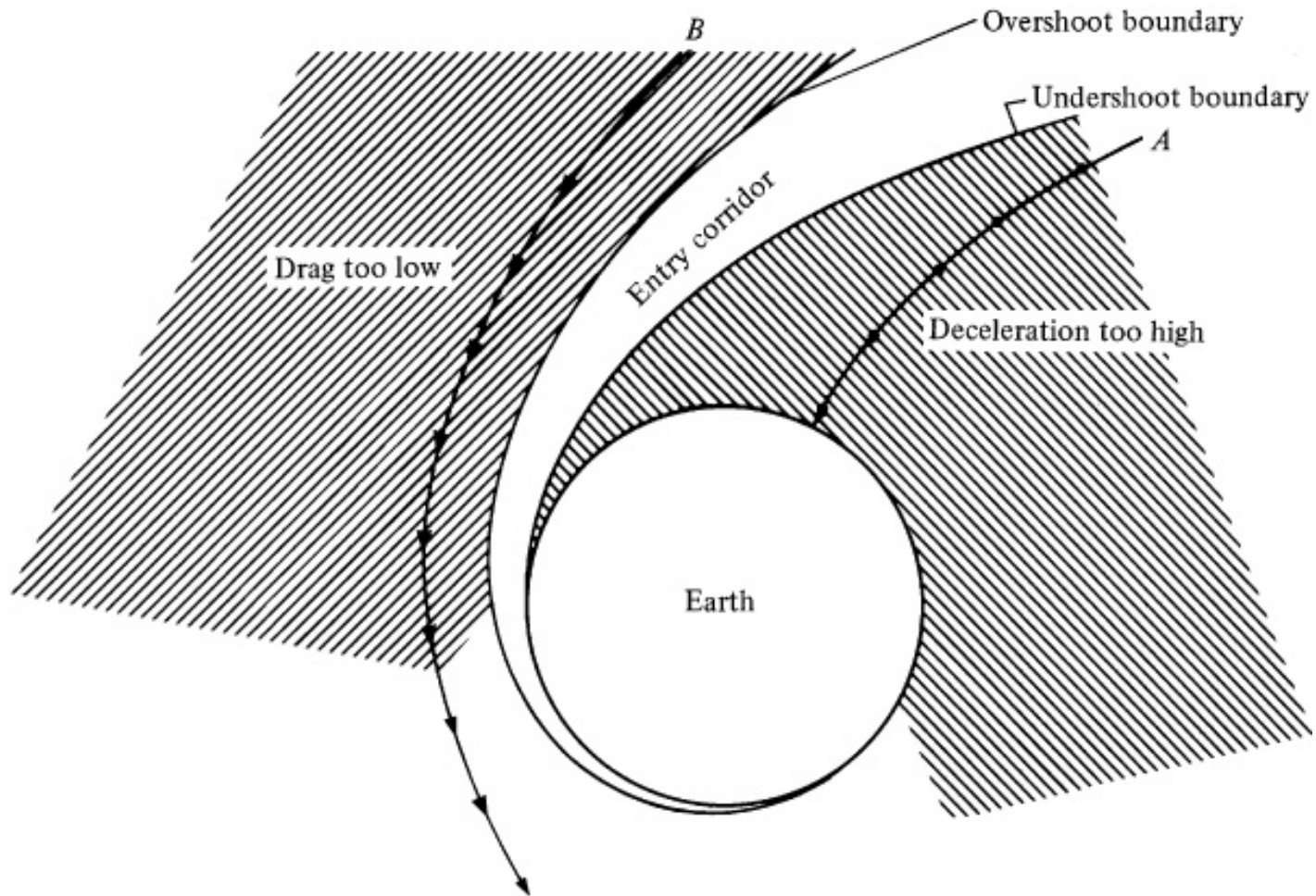


Entry Types

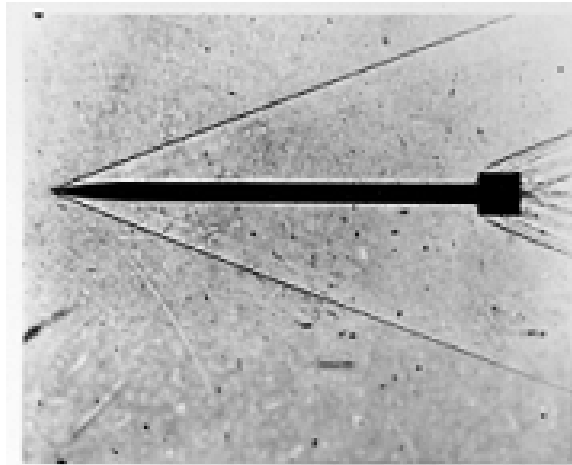


- a: Ballistic
- b: Gliding (Lifting)
- c: Skipping

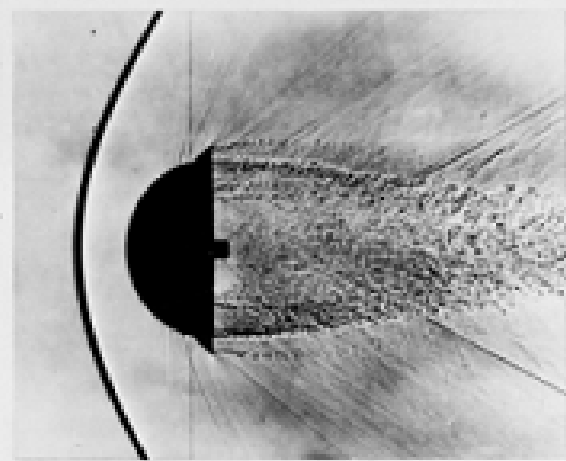
The Entry Corridor



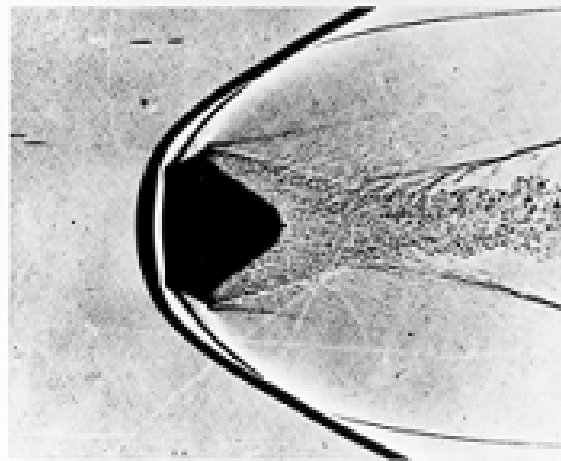
Ballistic Entry Aerodynamics



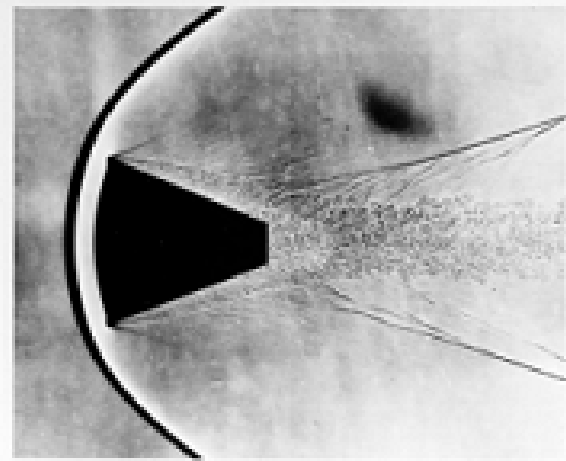
INITIAL CONCEPT



BLUNT BODY CONCEPT 1953



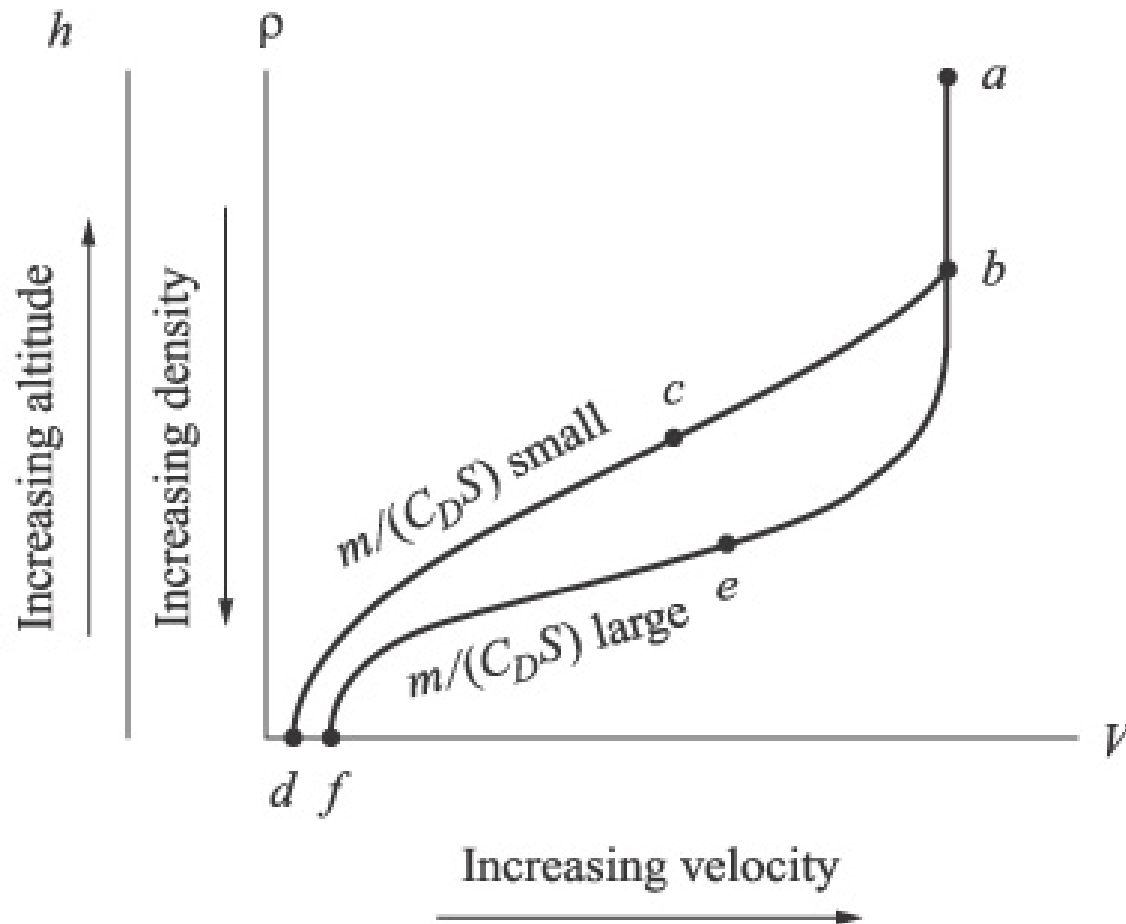
MISSILE NOSE CONES 1953-1957



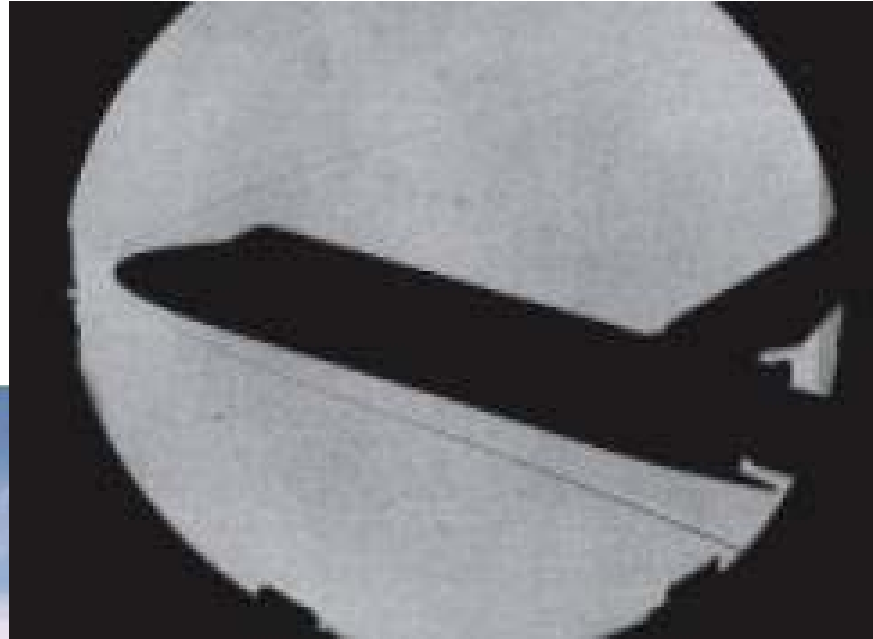
MANNED CAPSULE CONCEPT 1957

Ballistic Coefficient

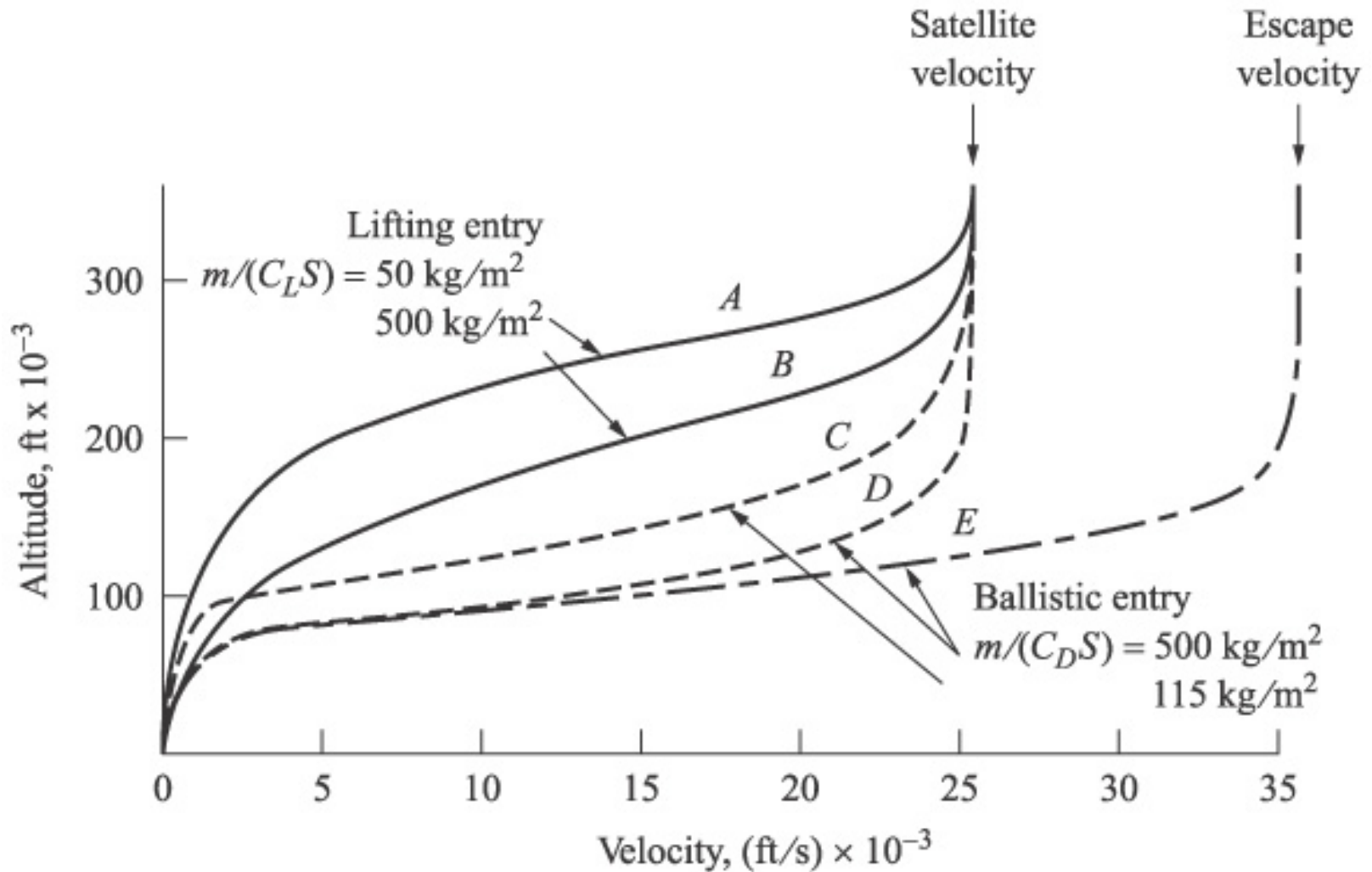
$$\beta = \frac{m}{C_D S} \quad \text{Ballistic Coefficient}$$



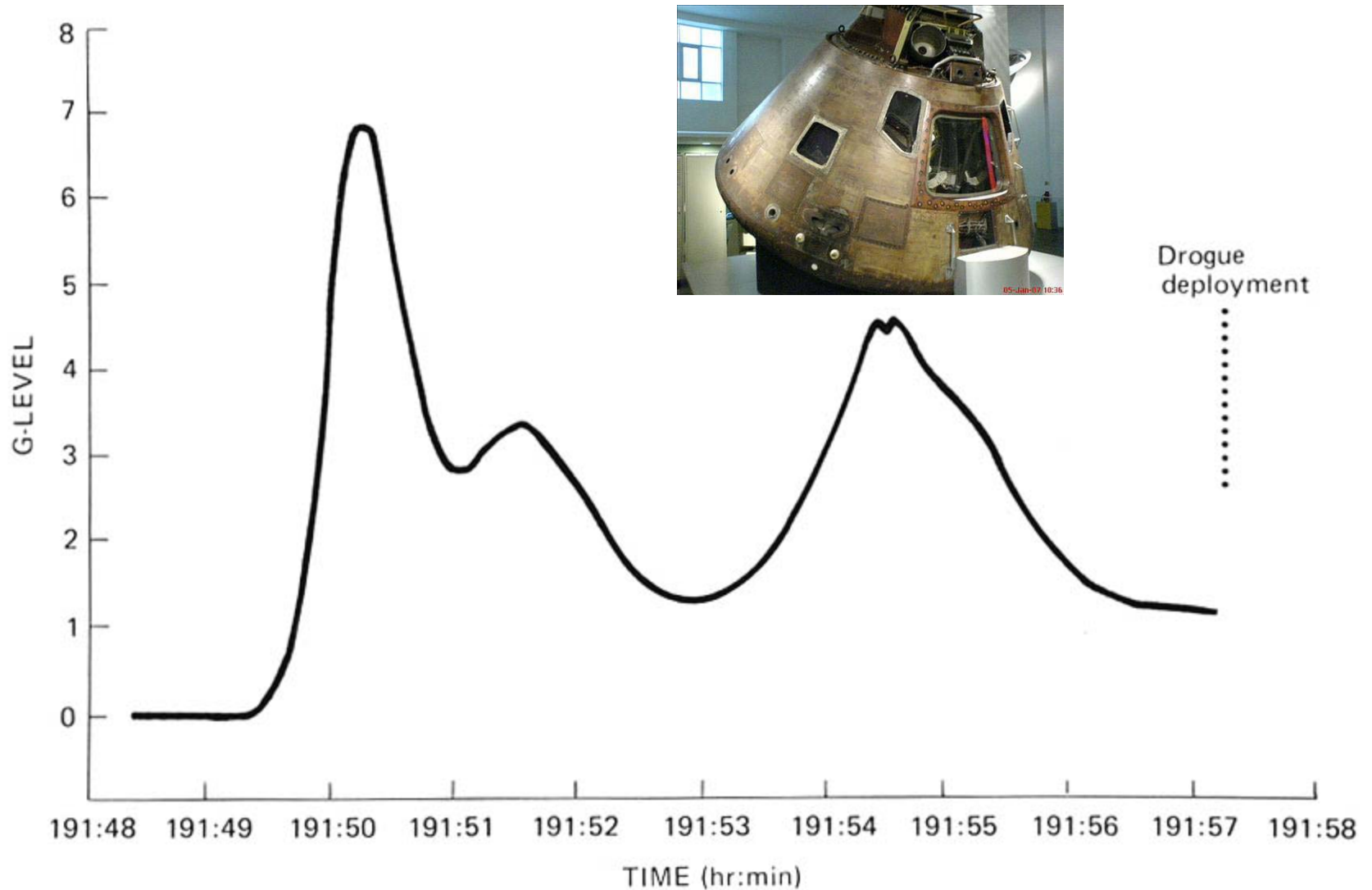
Lifting Entry Aerodynamics



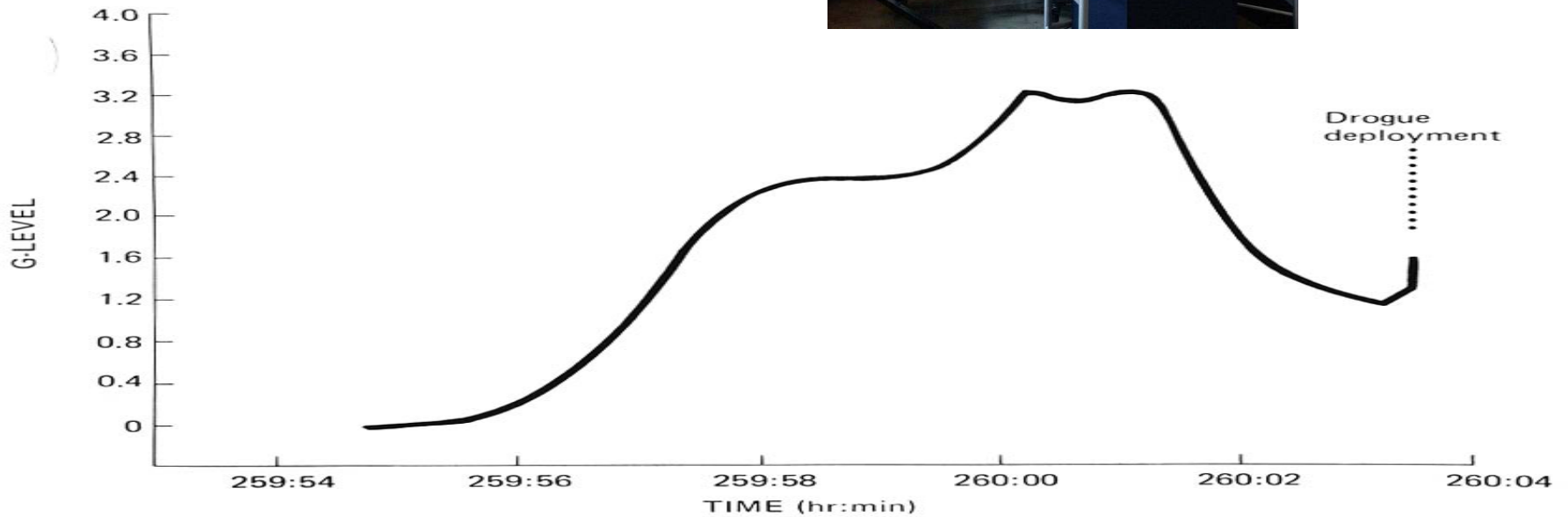
Lifting vs. Ballistic



Skipping Entry: Apollo 10



Near Ballistic Entry: Apollo 7

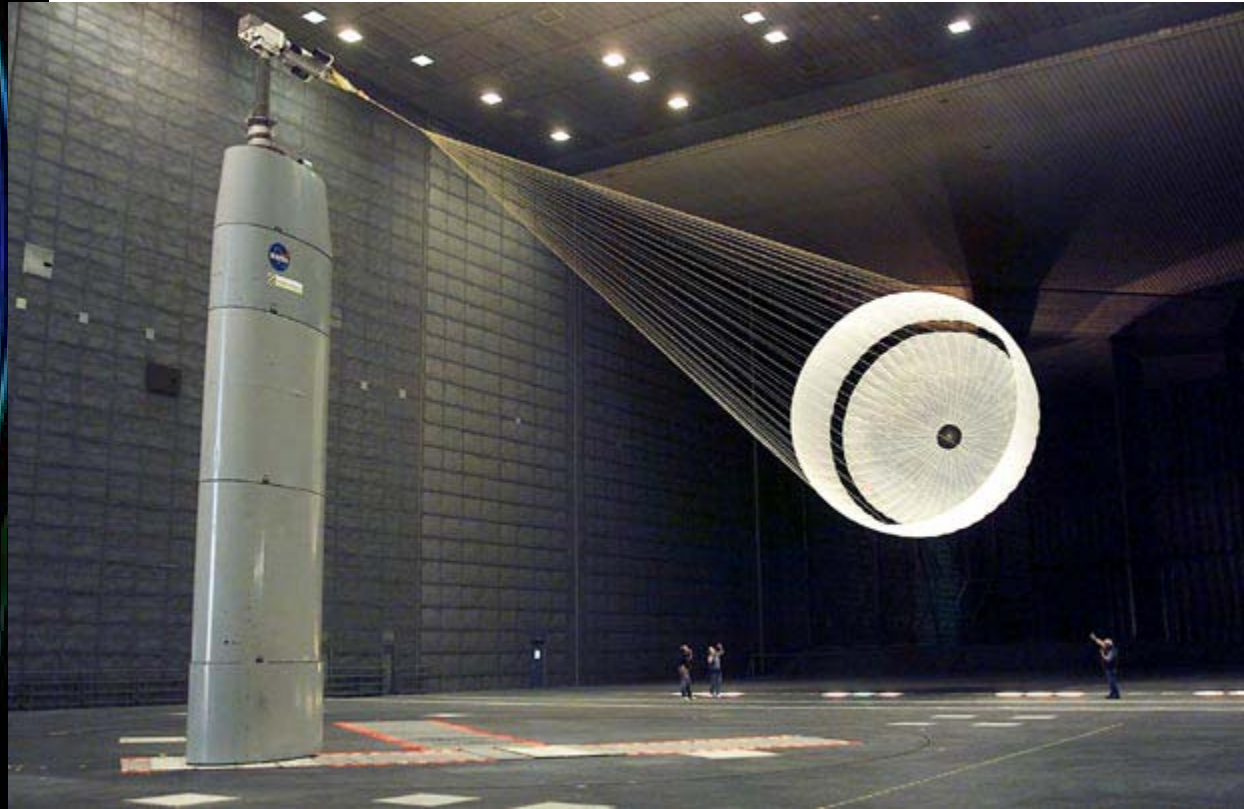
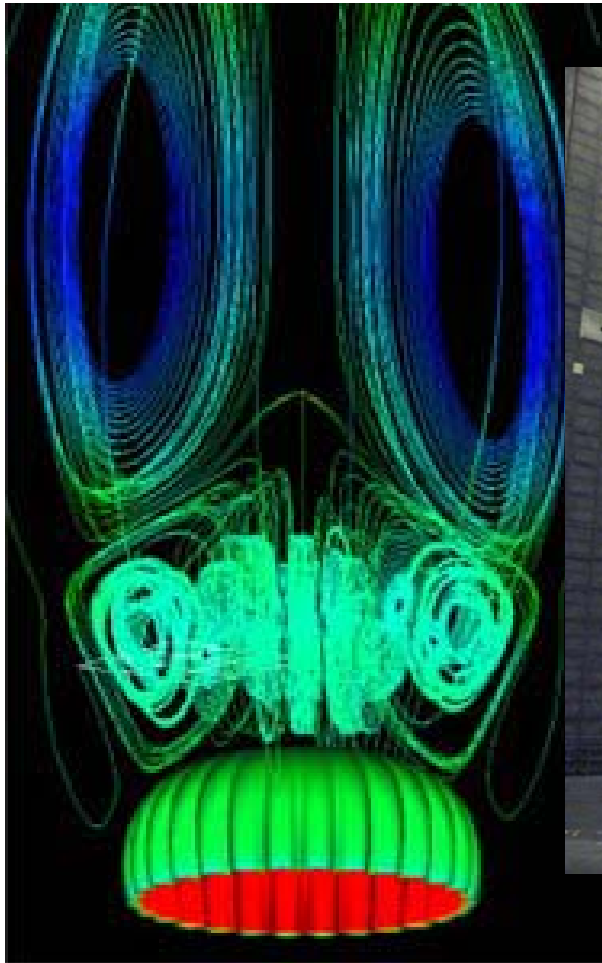


Terminal Descent Under Parachute

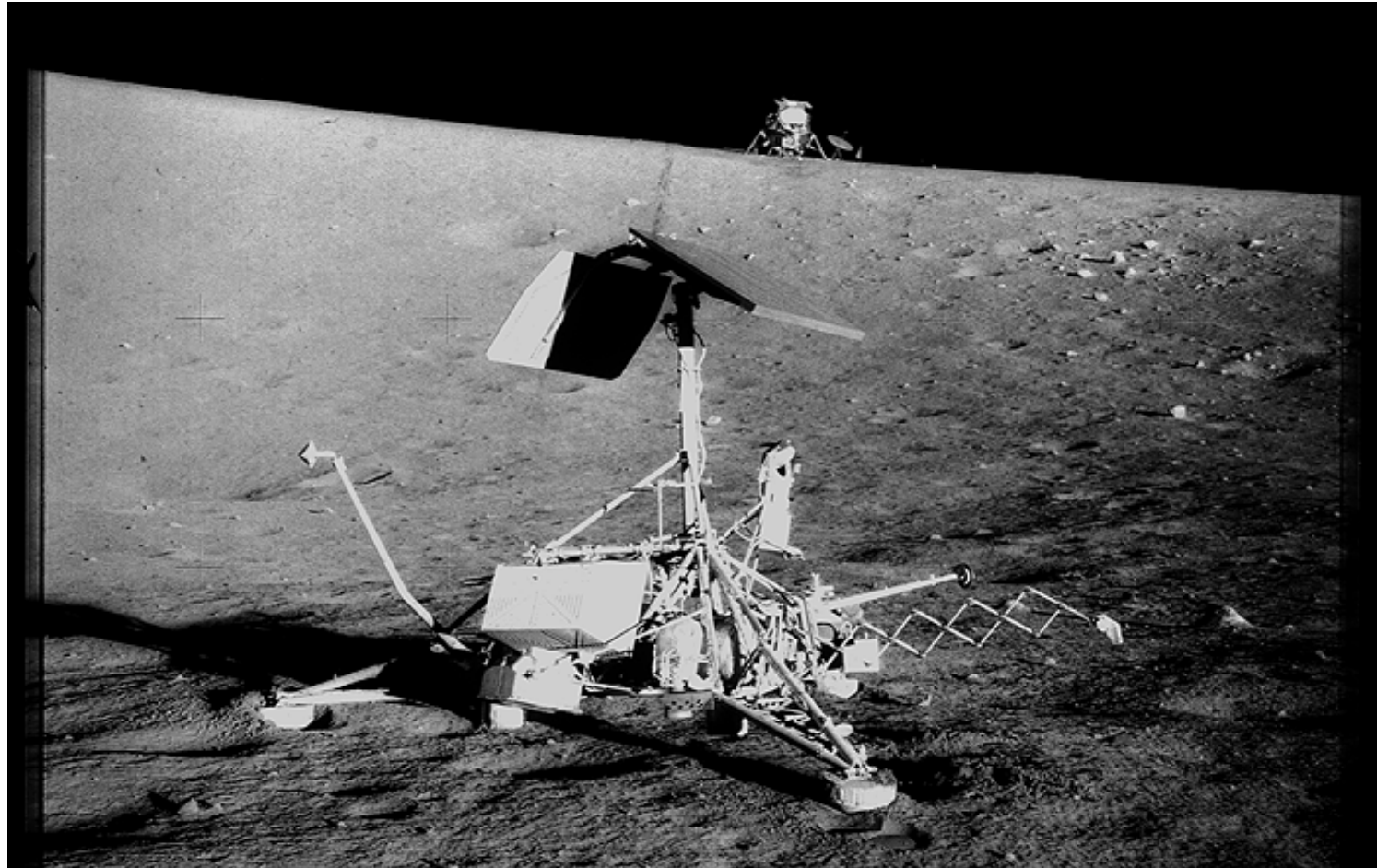
- Deceleration & minimize descent rate
- Control flight path
- Control descent rate
(different ballistic coefficient ad different times)
- Provide stability (drogue)



Parachute Modeling and Testing

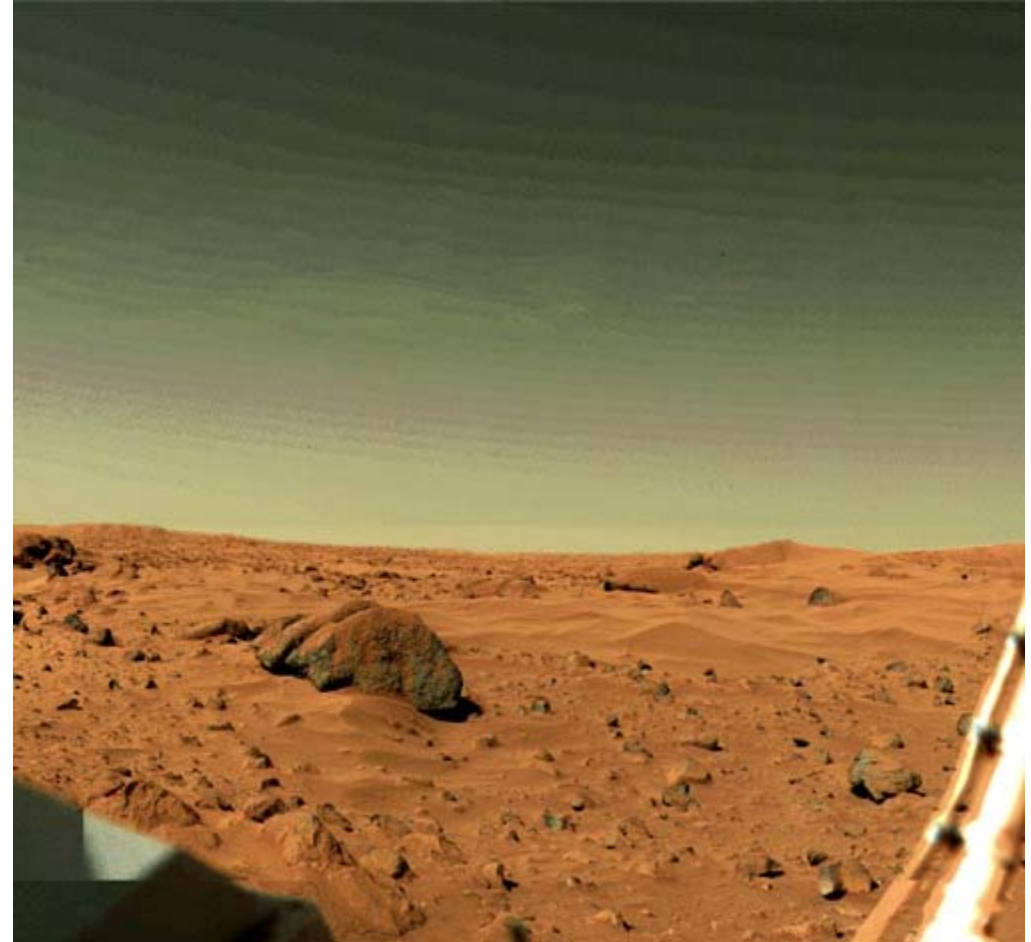
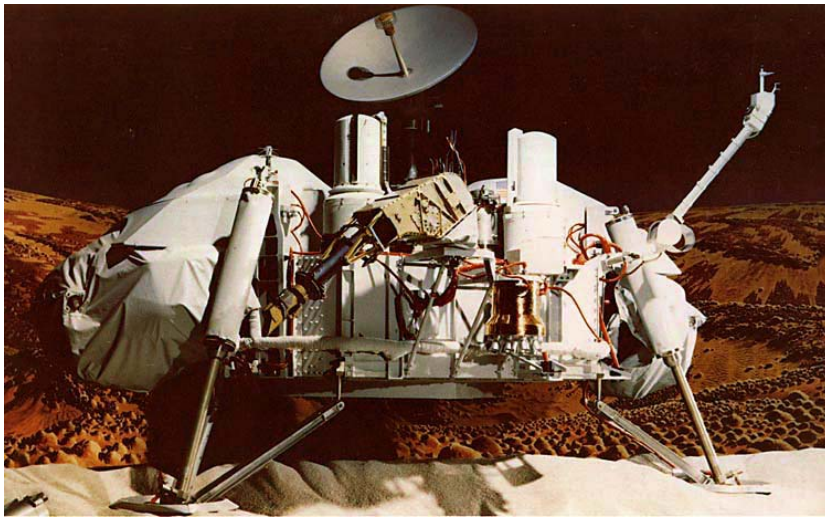


Landing: Powered



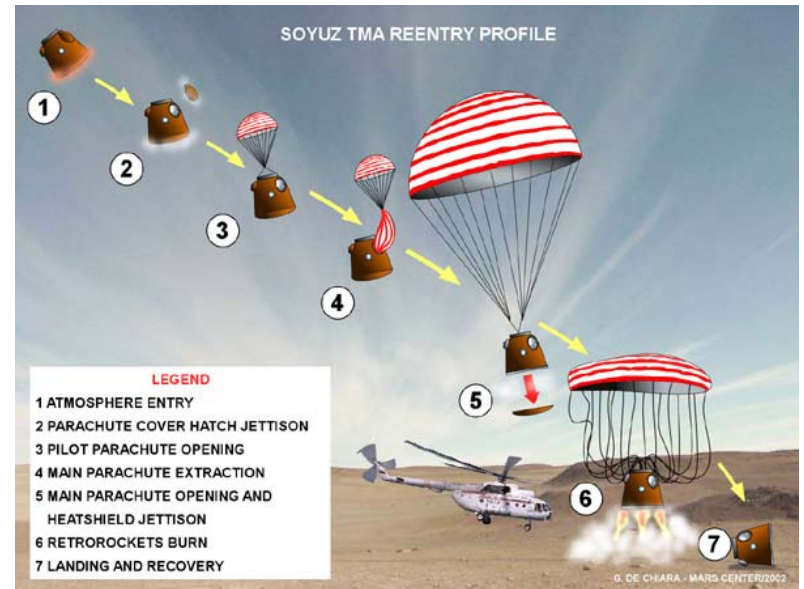
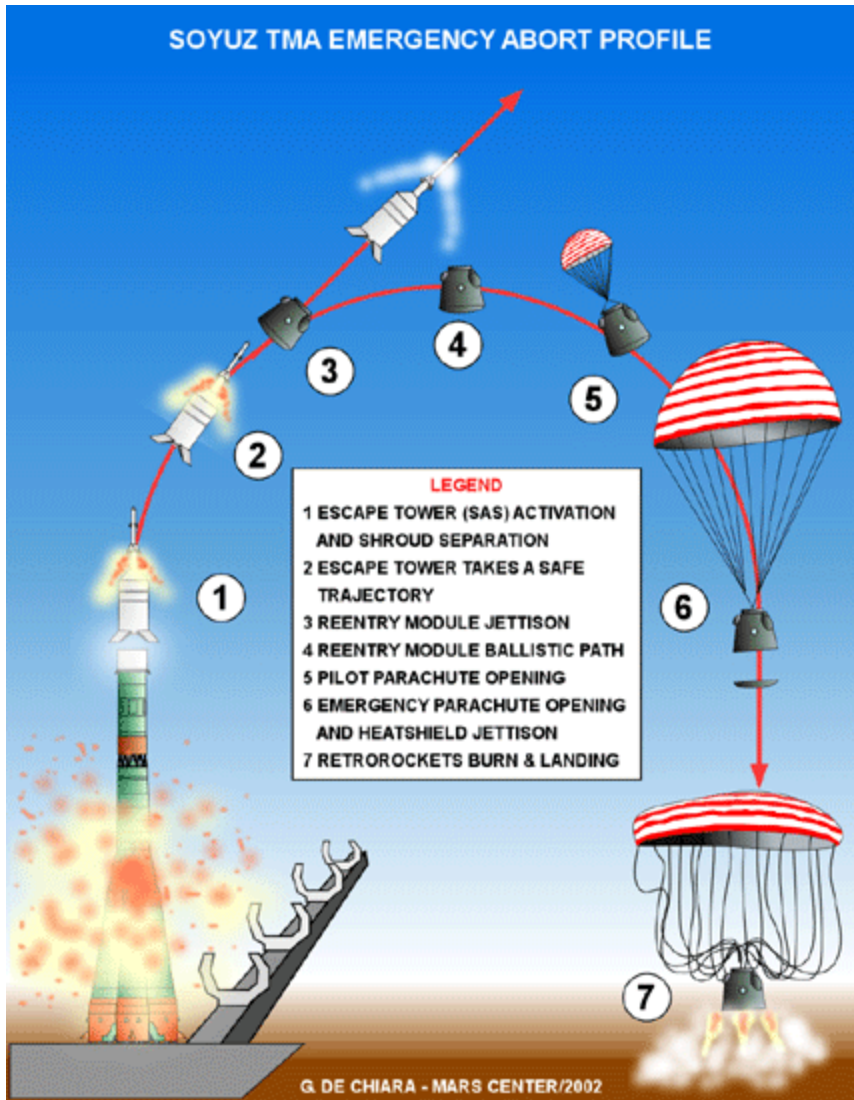
This image shows the Surveyor 3 spacecraft, which landed on 20 April 1967, and in the background the Apollo 12 lunar module. The lunar module landed about 180 meters from Surveyor.

Landing: Powered



Viking 1 and Viking 2 landers on Mars

Landing: Powered



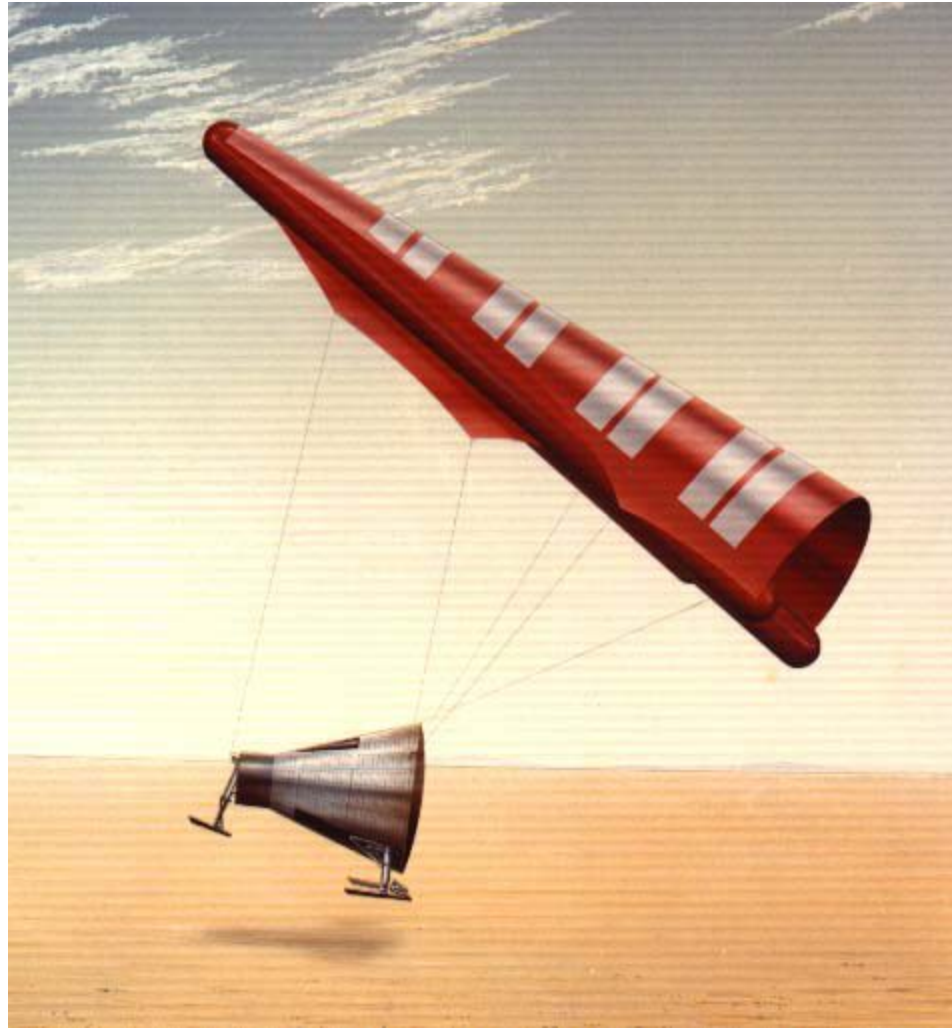
Soyuz System

Landing: Lifting



Space Shuttle

Landing: Lifting



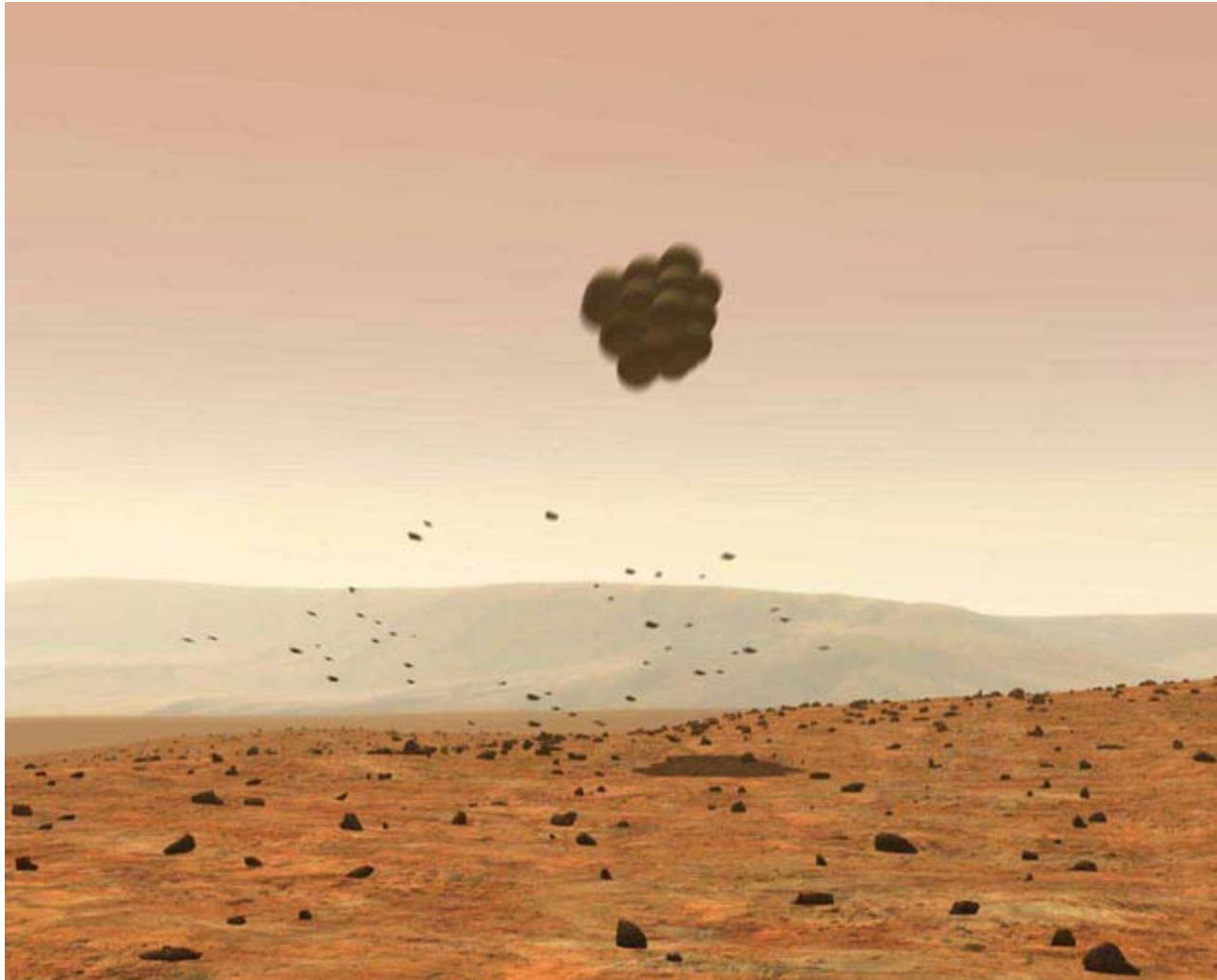
Rogallo Wing: Concept for
Gemini Program

Landing: Parachute & Water



Mercury, Gemini, Apollo

Landing: Rockets & Bags



Mars Pathfinder, Mars
Exploration Rover (MER)

Video: Mars Science Laboratory



Future Challenge: Deliver Aircraft

