Design Project:

Improved Mortar Deployment Assembly
of the Parachute Deceleration System for
future planet exploration missions

Handed out: 4/4/05
Due: 5/5/5

MER Parachute Decelerator System

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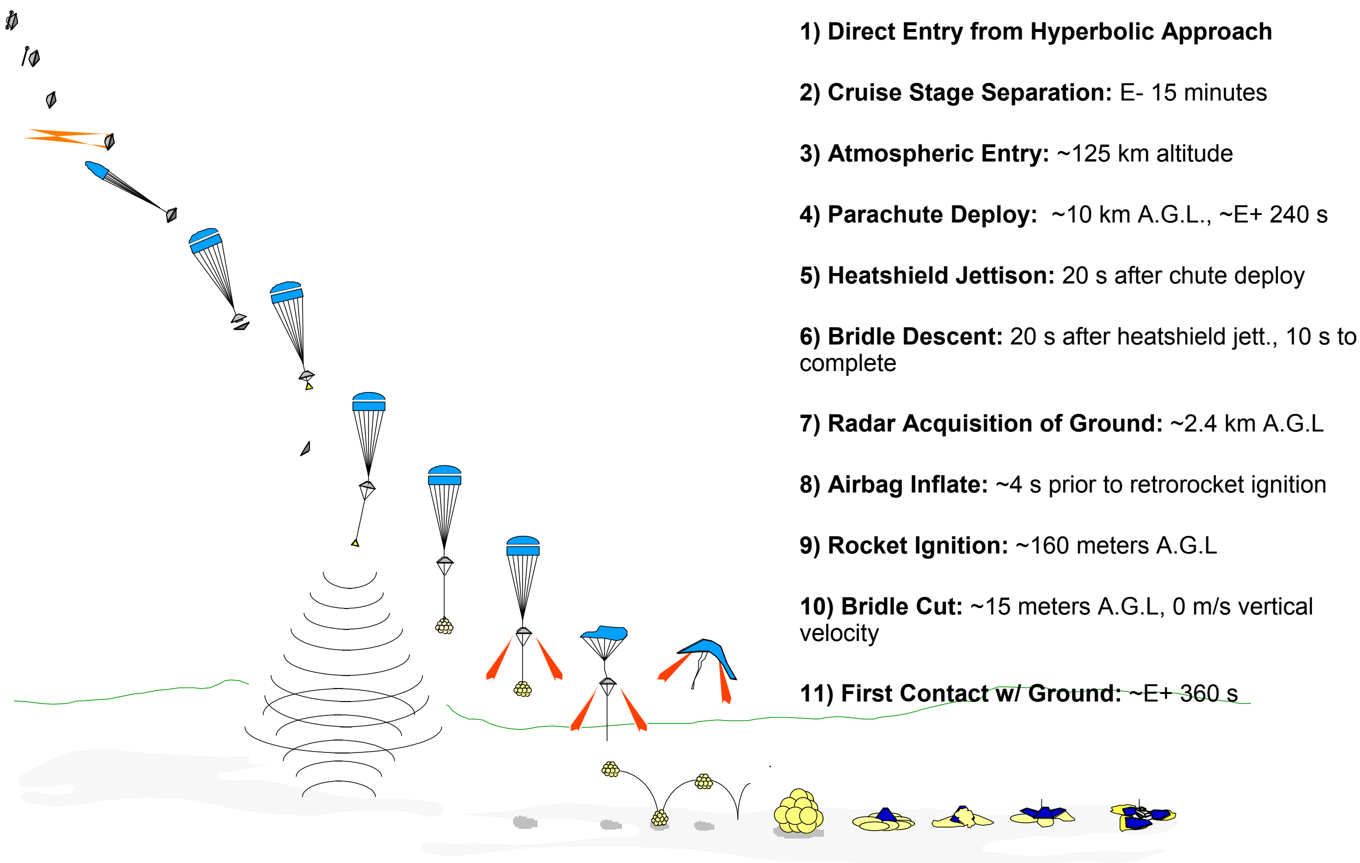
Background

NASA's twin robot geologists, Spirit and Opportunity, the Mars Exploration Rovers, arrived in Mars on January 3 and January 24, 2004, respectively. The Mars Exploration Rover mission is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the red planet (For more information, see the Mission's web site: http://mars.jpl.nasa.gov/mer/overview/).

In this and upcoming planet exploration missions, usually a Parachute Deceleration Subsystem (PDS) delivers the landing vehicle in the planet atmosphere, to a point and flight condition where Rocket Assisted Descent and Airbag Impact Attenuation Systems can complete the descent to the surface, as shown in the Operational Sequence Figure.



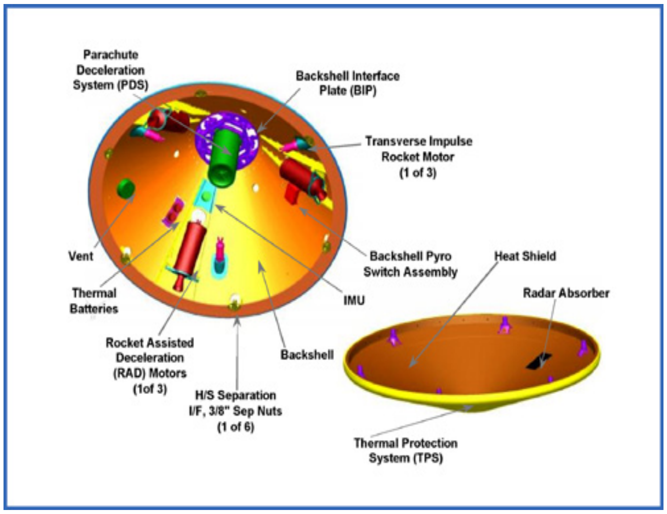
Operational Sequence

The Parachute Deceleration System consists of two main subsystems: the Parachute Assembly and the Mortar Deployment Assembly. The Parachute Assembly's role is to:

- Decelerate the Entry Vehicle from supersonic flight conditions
- Establish stable vertical trajectory to permit Heat Shield jettison and Lander deployment
- Provide final descent velocity and stability for Rocket Assisted Descent and Airbag Impact Attenuation Systems

The Mortar Deployment Assembly:

- Interfaces with Backshell structure
- Provides deceleration parachute structural attachment points
- Packages and protects the Deceleration Parachute Assembly
- Ejects the packed parachute from the stowed configuration
- Accelerates parachute beyond the recirculating wake for controlled and reliable inflation



- Parts of the Aeroshell

The current design used in the MER Entry, Descent and Landing system, is based on the Mars Pathfinder and Viking Mission. Notwithstanding its success, it is accepted that future exploration missions will demand optimized designs in terms of weight and overall performance.

• Statement and objectives

The main goal of this project is to design a Mortar Deployment Assembly with a reduced weight assuming the design requirements of the MER mission in terms of function, loads and overall mission conditions. A summary of the main requirements is given below. Additional details are given in the accompanying slides.

Material information:

The materials can be initially assumed as in the base design (MER) and modified as necessary to achieve design goals.

Geometrical information:

The geometry can be initially assumed as in the base design (MER) and modified as necessary to achieve design goals.

Load Information

Estimated MER Design Loads

Loads have increased because of increase in chute area and deployment conditions.

Preliminary Estimates:

Mortar Reaction Load: 17,000 lb

(MPF = 11,000 lb)

Peak Inflation Load: 12,500 lb

(MPF = 7,904 lb)

(@ maximum dynamic pressure condition of 783 Pa,
M = 1.9, 825 kg entry vehicle)

Preliminary Design Criteria

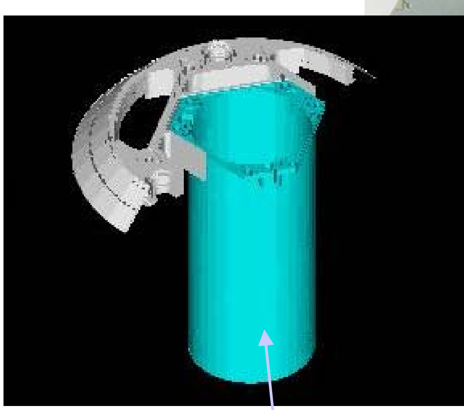
The new design of the mortar subsystem should satisfy or exceed the criteria in the MER design with a reduced weight. The design goal will be achieved by modifications to the geometry of the assembly or by a judicious choice of materials:

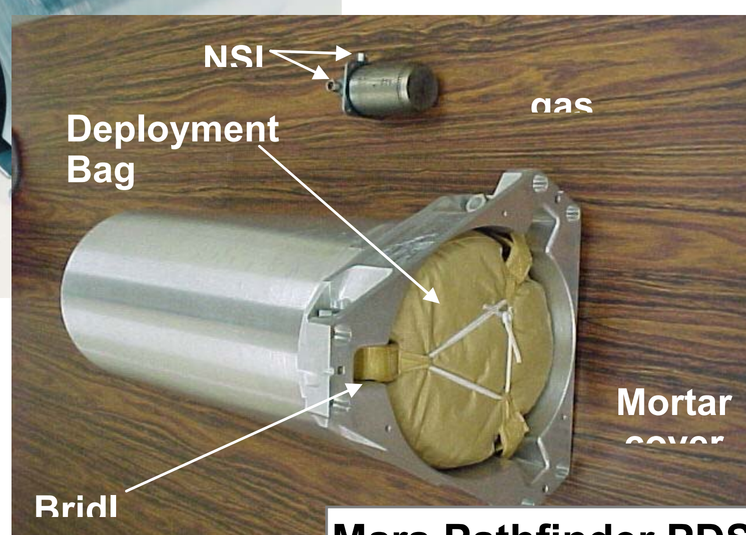
Mortar System -

- Design Heritage
  - Mars Explorer Rover (MER) Mortar
  - Deployer Subsystem (MDS) design will be based on the successful Mars Pathfinder Mortar Deployer System (MDS) developed by General Dynamics (formerly Primex/Olin) as part of the Pioneer Aerospace team
- Major Requirements Summary
  - 100 ft/s < muzzle exit velocity < 130 ft/s (Mars)
  - Dual initiators for gas generator
  - Operational temperature range: -35C ± 10C
  - Ejection mass of 34.5 lbm (37 lbm max)
  - Max parachute opening load 15,000 lbf
- Principal Similarities - Pathfinder vs. MER
  - Same propellant, initiators and design approach
  - Very similar parachute deployment velocity
  - Development, LAT and qualification approach
- Principal Differences - Pathfinder vs. MER
  - Deployment mass (34.5 lbm vs. 21.5 lbm)
  - Parachute volume (1620 in.^{3} vs. 953 in^3)
  - Larger parachute inflation load (15,000 lbf vs. 12,000 lbf - MSP01)

Mortar System Design in MER compared to MPF:

- OD increase from 8.4" to 10.9" (nominal)
- Gas Generator
  - 12 grams of WC230 (same as previous)
  - Design change to improve manufacturability proposed - exterior cap configuration to improve access for burst shim braze
  - 2 Each NSI (CFE)
- Cover
  - Same design approach
- Mortar Tube
  - Same design approach
  - Will interface with Backshell Interface Plate (changes identified)
  - Structural evaluation will result in increased load/pressure capability for some features





Mars Pathfinder PDS

2.5 " diam. increase from MPF for 40% area

The Job

Your team's job is to provide the complete specifications of your proposed design for the Mortar Deployment Assembly configuration, including all the dimensions of the geometry of the mortar tube, cover, joint solution proposed (rivets, bolts), materials used and the weight and cost of the resulting structure.

The structural analysis will be carried out using commercial finite element software. The assumptions and limitations of the analysis should accompany the report.

Present your results in an engineering report (please, double-space to make commenting and correcting easier) containing the following items:

Executive summary

Problem statement

Methodology, assumptions

Results and conclusions:

Geometry

Material selection

Recommendations for manufacturing

Details of the finite element analysis including discretization, element type, compute meshes, material models and properties, analysis type, etc should be provided in an appendix. Note the appendix constitutes a significant part of the report where you will show your skills using the finite element method for conducting structural analysis.