System Design for Phoenix EDL

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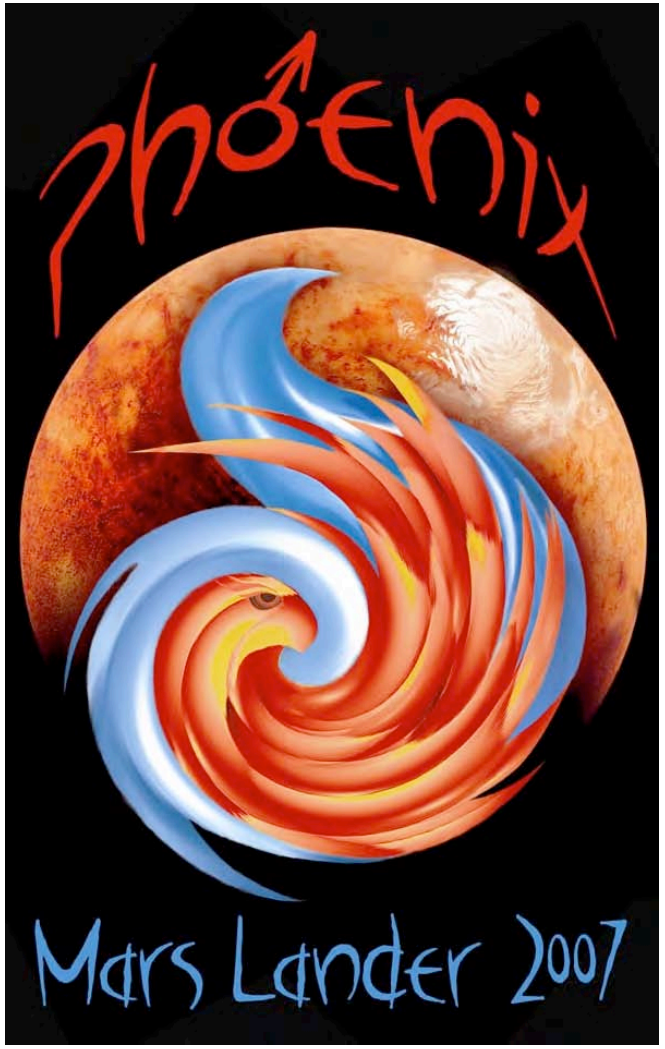


Mission Geometry

Phoenix Launch Window

- Three weeks
- Aug. 3rd – Aug. 24th 2007

Cruise Duration

- 10 months

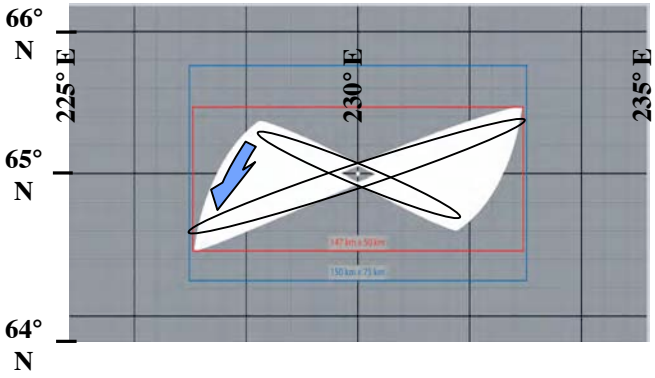
Mars Arrival

- 2 Days
- May 25th, June 5th 2008

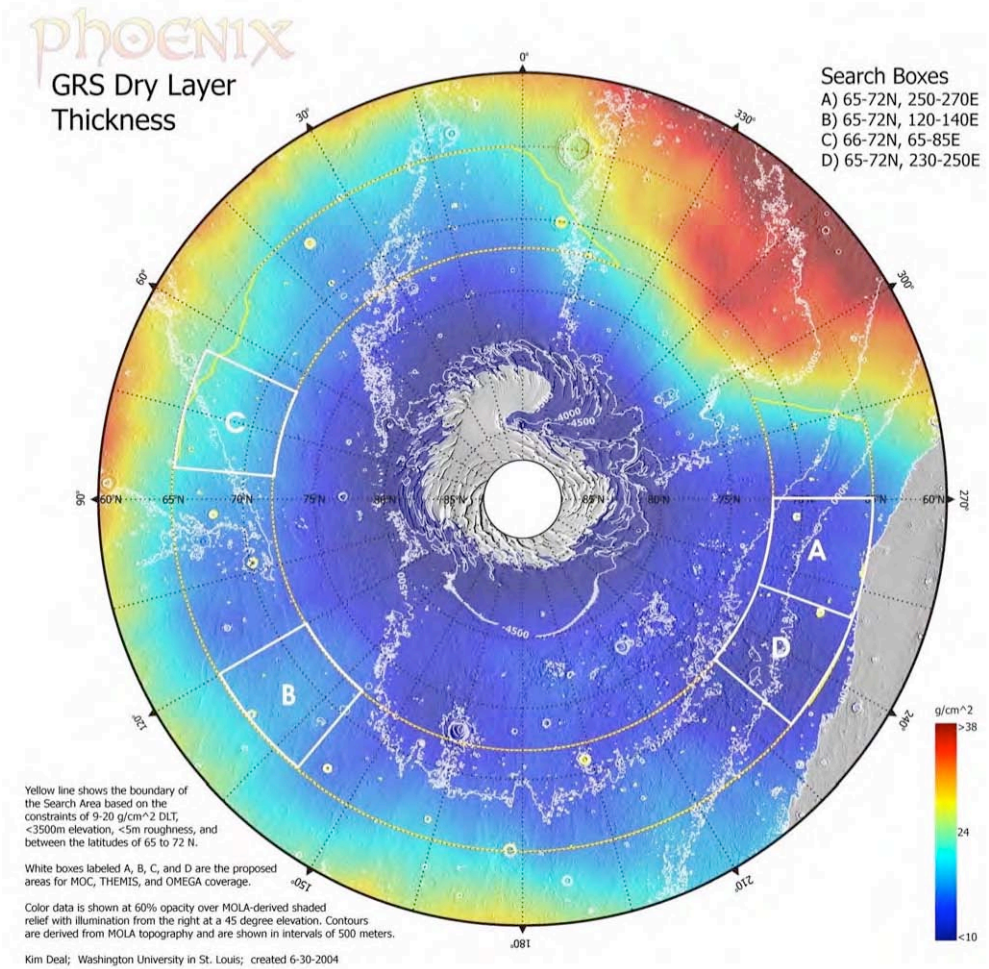
Arrival Characteristics

	MER	Mars 2001	Phoenix
Entry Velocity	5.5 km/s	6.9 km/s	5.6 - 5.9 km/s
Entry Mass	830 kg	529 kg	603kg
Landing Region	15°S - 15°N	15°S - 15°N	65°N - 72°N
Landing Site Elevation	-1.3 km	2.5 km	-3.5 km
Arrival LTST	13:00 - 14:00	9:30 - 10:50	14:00 - 17:30

Phoenix Butterfly Footprints



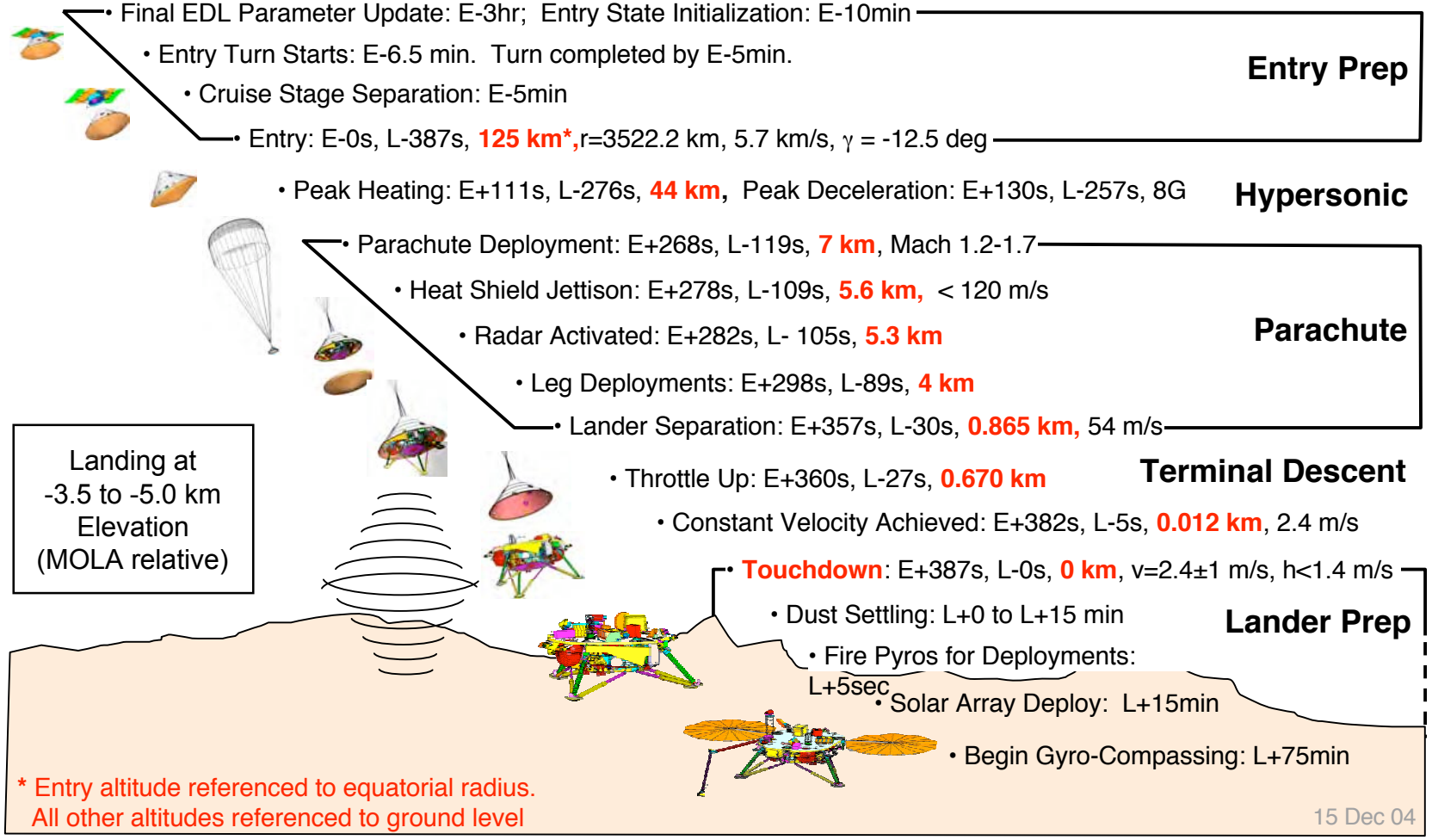
Landing Regions



EDL Reference Scenario

-12.5 EFPA, Ballistic

Communications: UHF-band to Orbiters

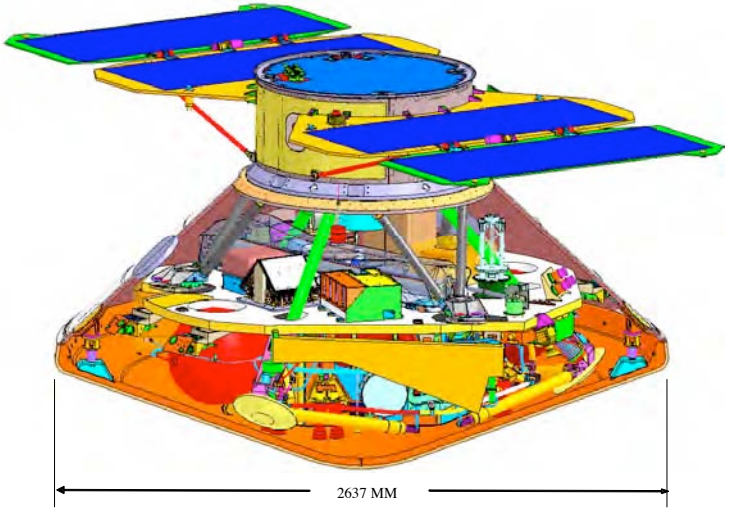


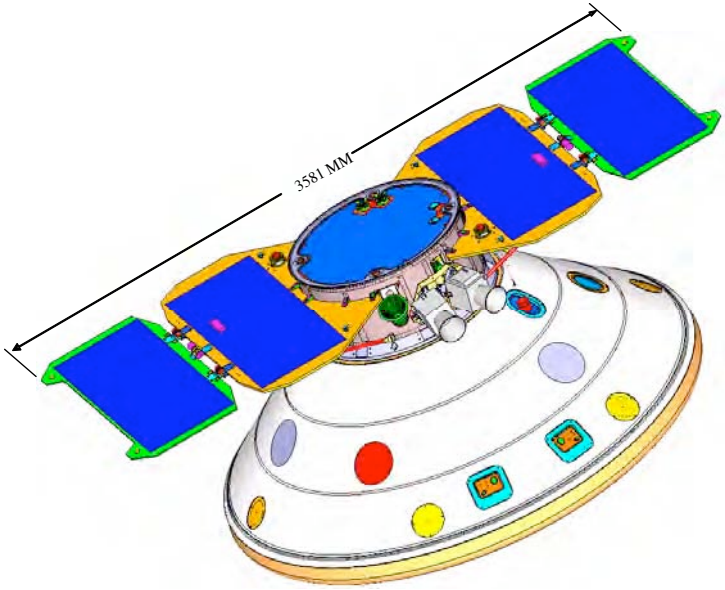
Comparison with Mars Exploration Rover

CHARACTERISTICS	MER	PHOENIX
Entry Mass (kg)	840	600
Relative entry velocity (km/s)	5.5	5.7
Ballistic Coefficient (kg/m^2)	89.8	69.3
Nominal L/D	0	0.06
Parachute System	Viking 1.9-DGB, 14.1 m	Viking DGB, 12.4 m
Entry Attitude Control	Passive spin	Passive Spin
Radar System	Simple altimeter	4-beam Doppler
Terminal Descent Guidance	Open loop for retro fire	3-axis active controller
Retro-Rockets	3 solids	12 Pulse-width modulated
Landing System	Airbag	3 legs
Touchdown requirements	Vv < 14 m/s Vh < 24 m/s	Vv < 3 m/s Vh < 2 m/s

Flight Configuration: Cruise

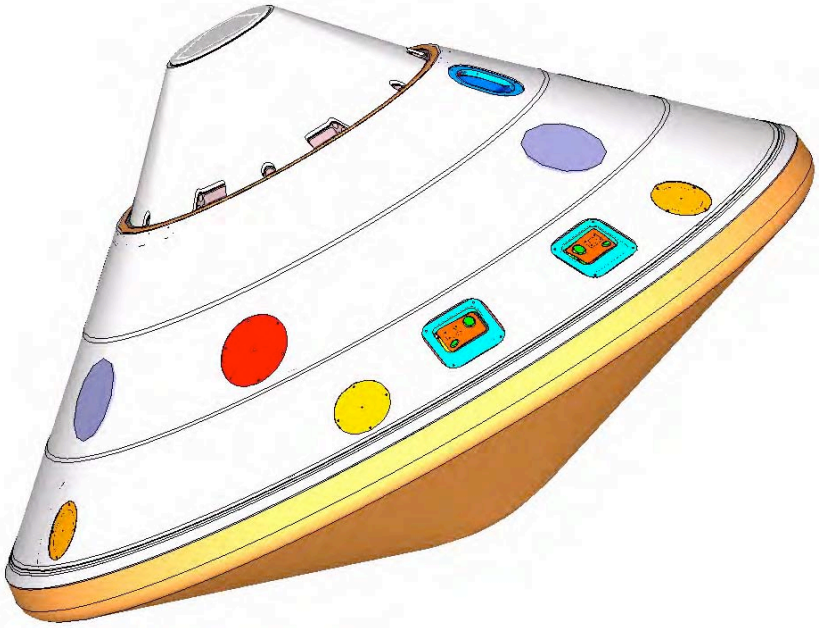
- **Arrays on the Sun - yields maximum battery SOC at C.S. separation (~6% DOD at touchdown)**
- **X-band MGA on Earth - provides DTE communications during approach**
- **8 ACS thrusters – provide 3-axis control and TCM ΔV during approach**
- **Redundant Star Trackers - provide precise and reliable attitude knowledge during approach**



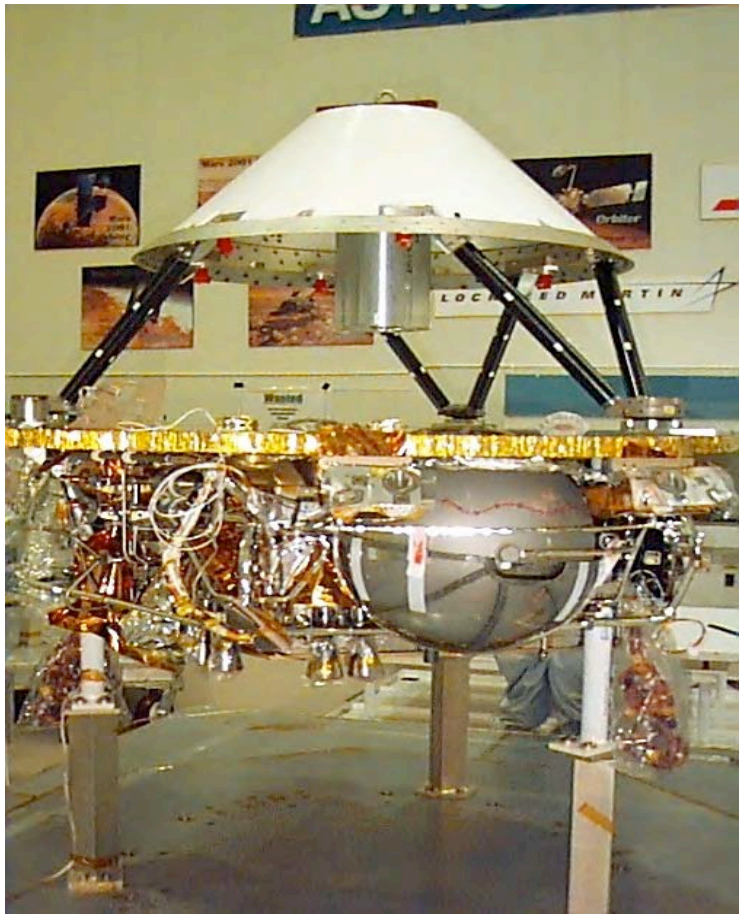


Flight Configuration: Entry

- **Aeroshell diameter 2.65 m**
- **~3° trim AoA, full "lift-up" trajectory w/o guidance**
- **Extensive heritage of from Viking, Pathfinder, and MER**
  - **70° half-cone geometry**
  - **SLA-561V TPS (forebody)**
  - **SLA-561S TPS (aftbody)**
- **Relatively "benign" flight conditions**
  - **~50 W/cm^2 heat flux**
  - **~2900 J/cm^2 heat load**
  - **< 8 g peak deceleration**



Hardware Photos

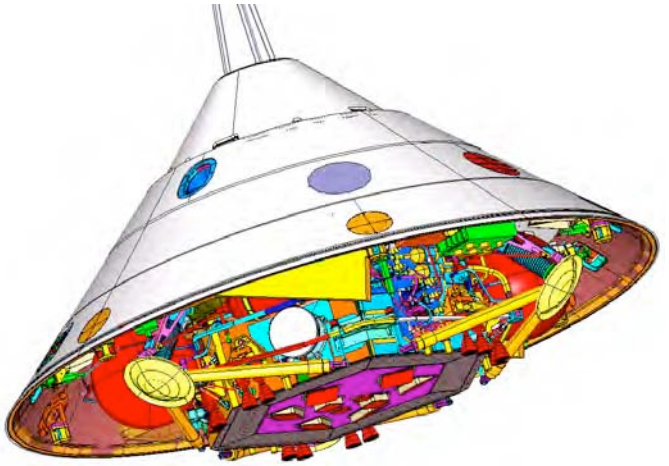


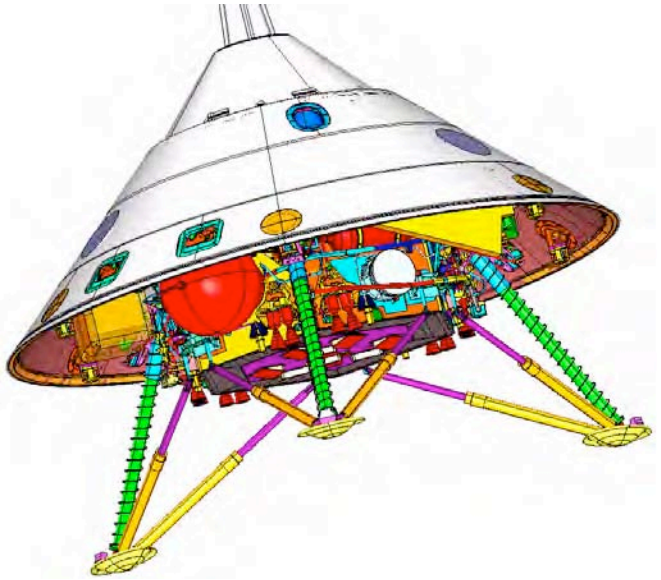
MSP '01 Parachute Cone/Bipod Assembly

MSP '01 Lander Launch Configuration +Z up

Flight Configuration: Parachute Descent

- **Parachute system is 12.4-m DGB scaled down from Viking geometry**
- **Deployment triggered by flight software based on accelerometers ~300 s from entry**
  - **Mach 1.6 (~360 m/s)**
  - **Dynamic pressure 430 N/m^2**
  - **Altitude 10.5 km (MOLA)**
- **Terminal velocity conditions achieved ~490 s from entry**
  - **Velocity ~60 m/s**
  - **Height ~700 m above ground**





Flight Configuration: Terminal Descent

- Final descent slowed by 12 pulse-mode hydrazine thrusters firing at 10 Hz
- Landing radar provides both altimeter and velocity data (via 4-beam Doppler)
- Flight software will guide vehicle along classical gravity-turn “pitch-over” trajectory
- Landing expected ~520 s after entry
  - Impact ~2 m/s
  - Thruster termination based on sensors in landing legs
  - Max. propellant used 35 kg

Summary

- **Project recently confirmed by NASA HQ at funding level of ~$400 M**
- **EDL team working toward CDR at end of September 2005**
- **Major EDL activities underway include:**
  - **Demonstration of propulsion system viability via hot-fire test**
  - **Development of baseline entry trajectory and flight modes**
  - **Development of parachute deployment and terminal descent algorithms**
  - **Preparations for start of arc-jet testing of existing TPS in July 2005**
  - **Preparations for radar field test campaign in November 2005**
  - **Preparations for parachute wind-tunnel strength test in May 2006**
- **Start of ATLO and system test expected summer of 2006**
- **Delivery of vehicle to the Cape April 2007**