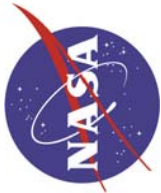




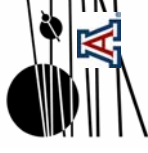
Overview of the Phoenix Entry, Descent and Landing System

Rob Grover
Jet Propulsion Lab



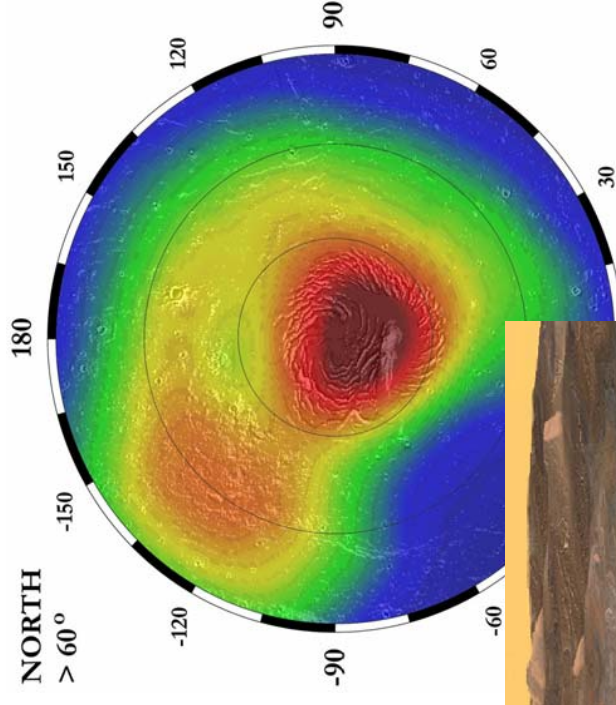


Phoenix Mission Goals



Rebirth of the Mars 2001 Lander

- Study the history of water in Mars' arctic region.
- Search for habitable zones in Mars' arctic.
- Develop a robotic system to explore Mars.



2nd IPPW

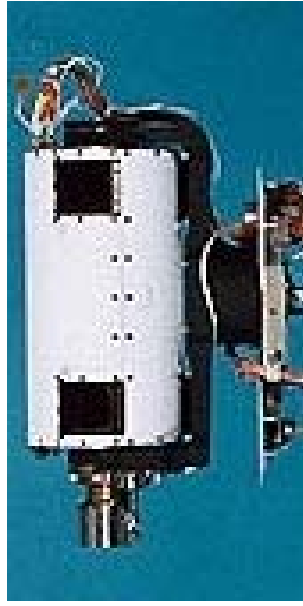
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RG 2



Phoenix Payload



Surface Stereo Imager (SSI)
University of Arizona

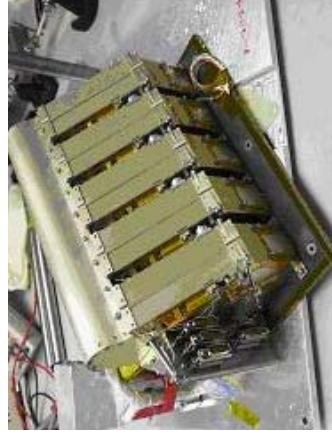


Robotic Arm (RA)

JPL

**Microscopy, Electrochemistry
& Conductivity Analyzer
(MECA)**

JPL



**Thermal Evolved Gas
Analyzer (TEGA)**

University of Arizona



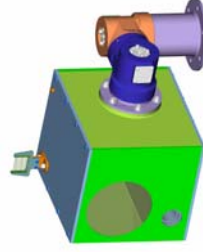
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Robotic Arm Camera (RAC)

Max Plank Aeronomie



Meteorological Package with scanning LIDAR

Canadian Space Agency



**Mars Descent Imager
(MARDI)**

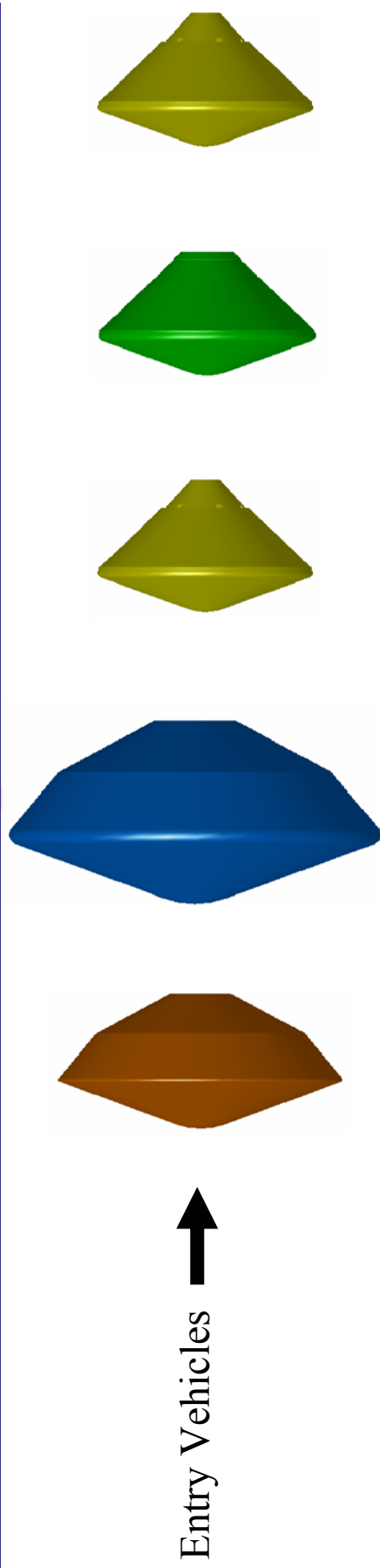
MSSS



RG 3



Aeroshell/Entry Comparison



	Viking I, II	MSL	'01 Lander	MPF/MER	Phoenix
Diameter, m	3.505 4.5, 4.42	4.572 5.2 to 6.8	2.65 6.5	2.65 7.6/5.5	2.65 5.7
Rel. Entry Velocity, km/s	-17.6	-15.63 to -13.68	-12	-13.8/-11.5	-12.5
Entry Mass, kg	930	2400	588	585/840	602
$m/(C_D A)$, kg/m ²	63.7	94	62.9	62.3/89.8	69.3
X_{CG}/D reference	0.221	0.27, TBD	0.25	0.27/0.26	0.25
Nominal α , deg	-11.1	-11	-3.5	0	-3.5
Nominal L/D	0.18	0.18	0.06	0	0.06



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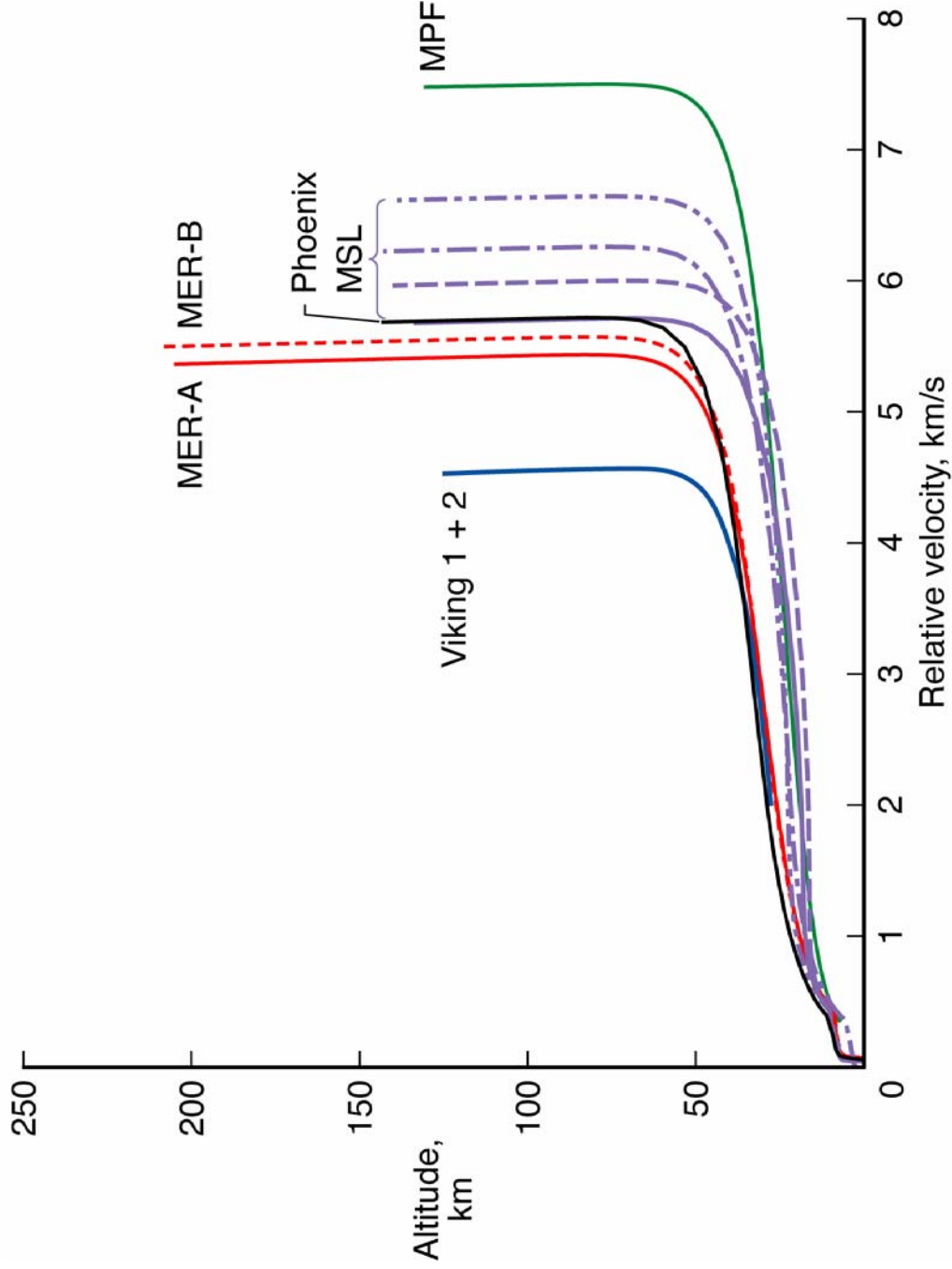


RG 4



Phoenix

Entry Trajectory Comparison



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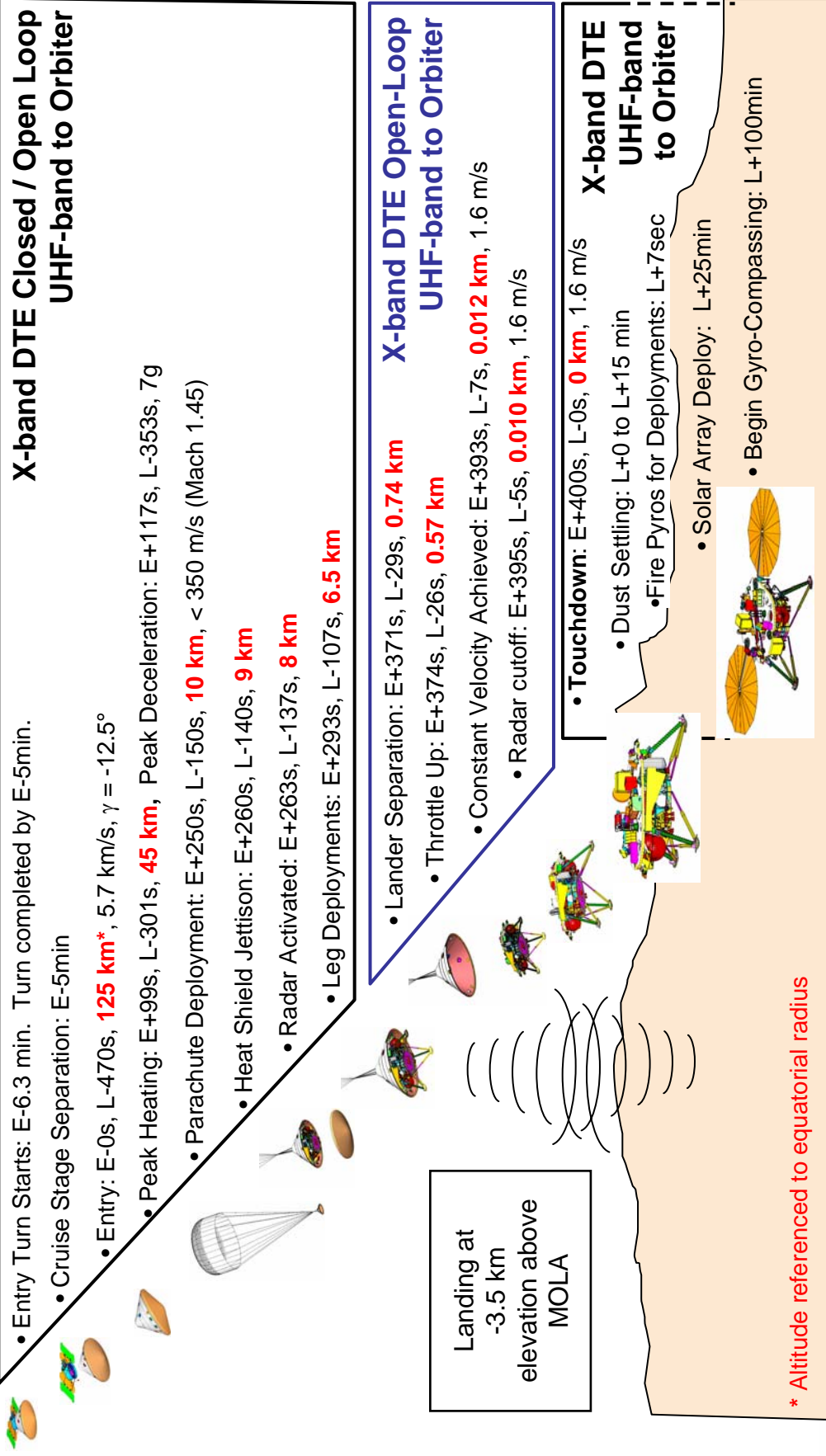
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RG 5



Phoenix EDL Timeline

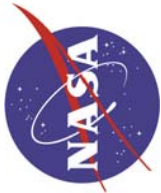


2nd IPPW

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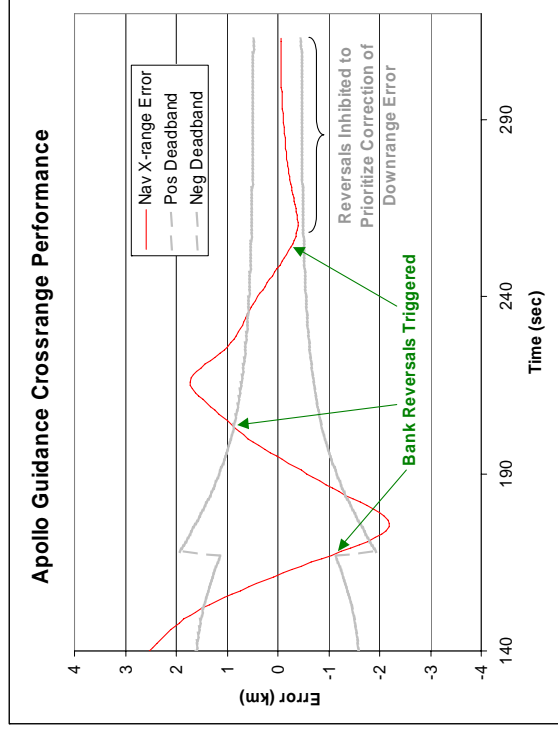
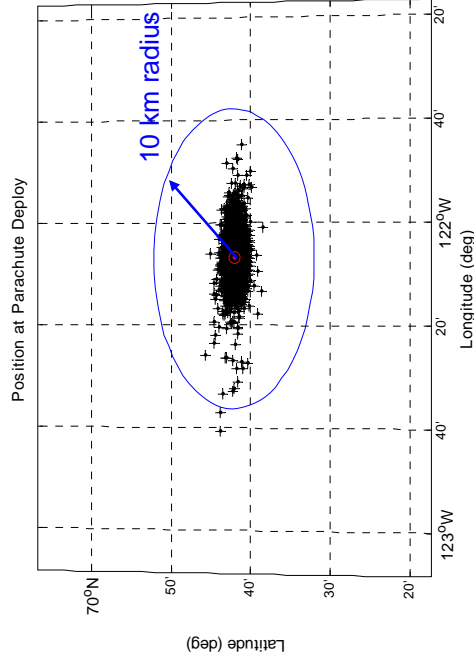
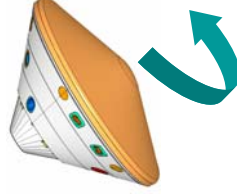


RG 6



Hypersonic Phase

- Hypersonic Guidance will be Demonstrated by Using a Modified Version of the Apollo Earth-entry Guidance
 - Terminal Point Range Control with Gain Matrix From Trajectory Perturbations
 - Nominal Vehicle $L/D = 0.06$ ($\text{Alpha} = 3.5 \text{ deg}$)
 - Utilizes Bank Control to Steer to Target at Chute Deploy
 - Operates at 10 Hz



- No Requirement on Guidance Accuracy
- Performance will be Characterized by End-to-End Monte Carlos
- “Break-it” Testing Will Help Define Capability Limits
- Full “Lift Up”/“Lift Down” Does Not Impact Landed Success, Just Accuracy



2nd IPPW

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RG 7

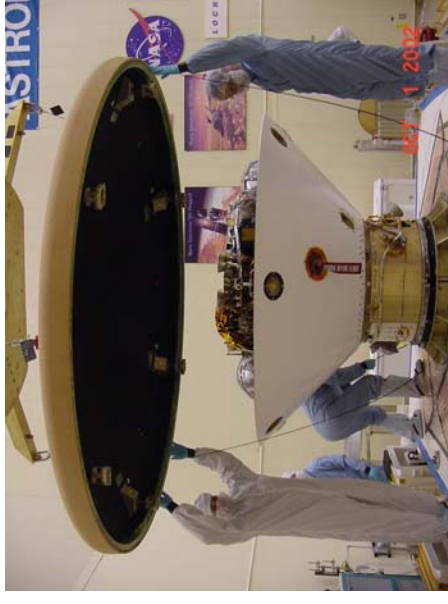


Hypersonic Phase

- Begins with Entry Interface at 125 km Reference Altitude
- Dominated by Entry Heating
- *All Key Parameters Within Mars 2001 Design Envelope*

	<u>Phoenix</u>	<u>Mars '01 Requirement</u>
• Entry Velocity	5.76 kps	~6.5 kps
• Entry Errors, Delivery	0.20 deg	0.27 deg
• Entry Errors, Nav	0.15 deg	0.15 deg
• Max Heating	62 W/cm ²	72 W/cm ²
• Max Loads	9.5 g's	16 g's
• Max Bondline Temp	150 C	250 C

- Exist Hardware: Heatshield / Backshell Structure & TPS
- New Hardware: EDL Antennas & Assoc. TPS



2nd IPPW

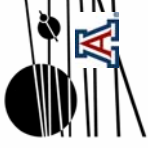
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RG 8



Parachute Phase



Phoenix Parachute

- Viking Design Disc Gap Band (DGB)
- Mars 2001 Parachute: 13.4m Viking disc gap band
- Phoenix Currently 12.4m Viking Disc Gap Band
- Phase Begins with Parachute Mortar Firing
- Mars-01 Deploy Pushed to Viking Limit for Site Performance
- Current Lander Loads Capability Requires a Deploy Below 500 Pa

	<u>Phoenix</u>	<u>Mars '01 Requirement</u>
• Max Deploy Mach	1.7	2.25
• Max Deploy Qbar	485 Pa	1100 Pa

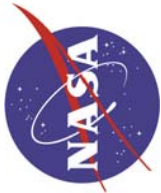


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RG 9



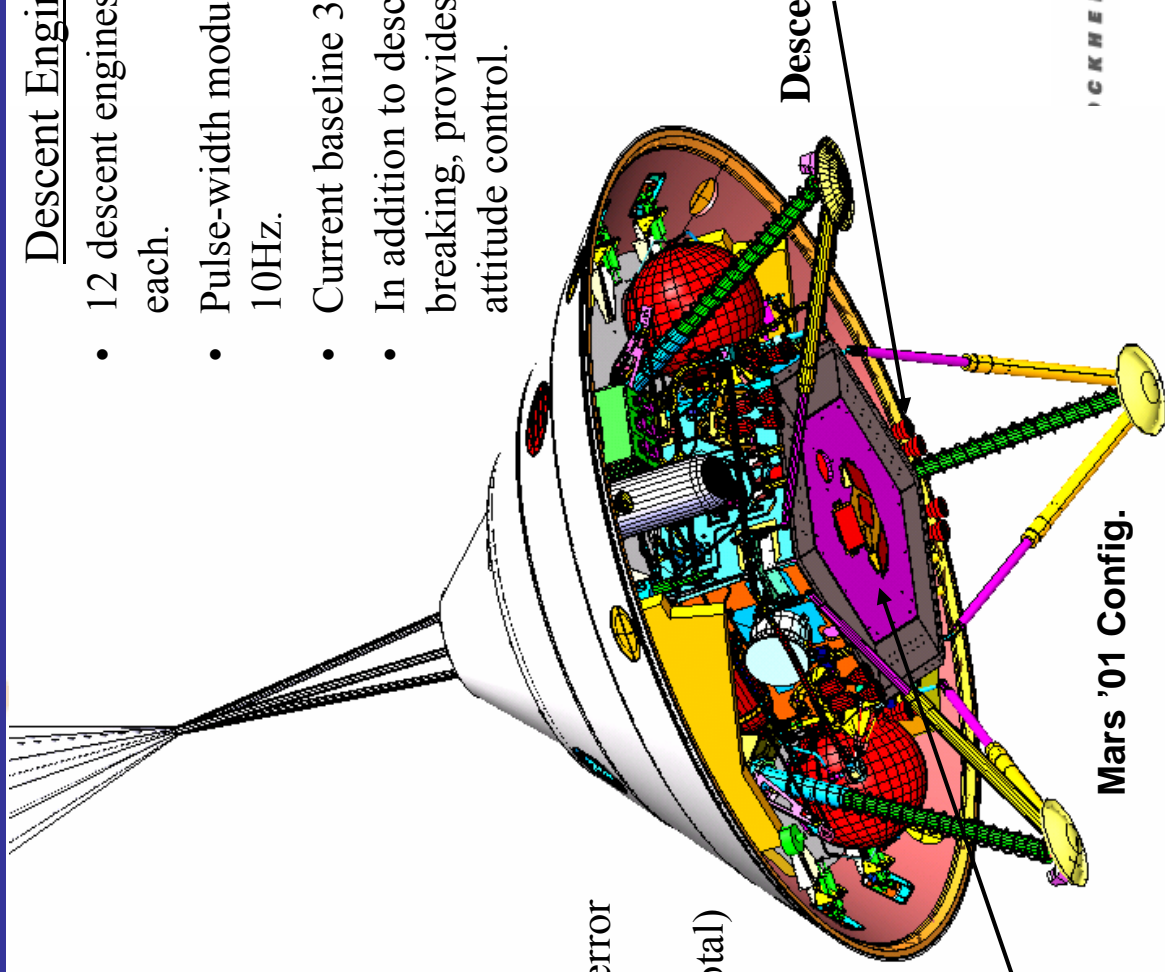
Terminal Descent Phase

Doppler Radar

- Altitude
 - Op. Range: 40-2400 m
 - Error: $\leq 5\%$
- Velocity
 - Op. Range: 40-1400 m
 - Error: $\leq 4\%$ ($> 1\text{m/s}$)
 - Quantization: 0.82 m/s
- Phoenix Upgrade
 - Mitigates horizontal vel. error due to slopes
 - Extra set of antennas (8 total)
 - Alt. Range: 1-3700 m
 - Vel. Range: 10-2150 m
 - Quantization.: 0.40 m/s
 - Same error specs

Descent Engines

- 12 descent engines, $\sim 300\text{N}$ each.
- Pulse-width modulated at 10Hz.
- Current baseline 3 full on.
- In addition to descent breaking, provides 3-axis attitude control.



Descent Engine (12)

Mars '01 Config.



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Radar Antennas



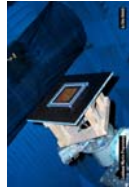
RG 10



EDL Communications

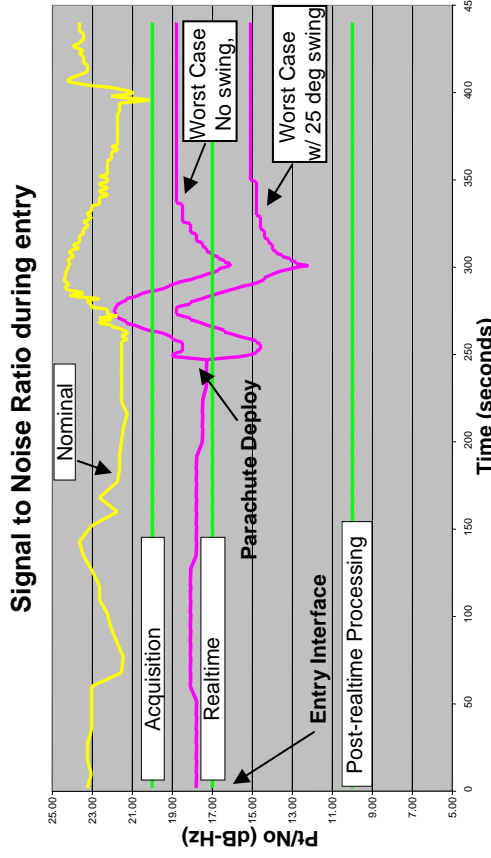
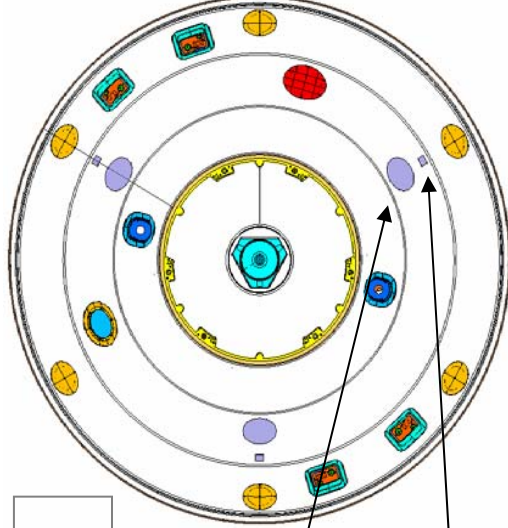
KDR 3.3.5 Telemetry Durations

UHF ANTENNA



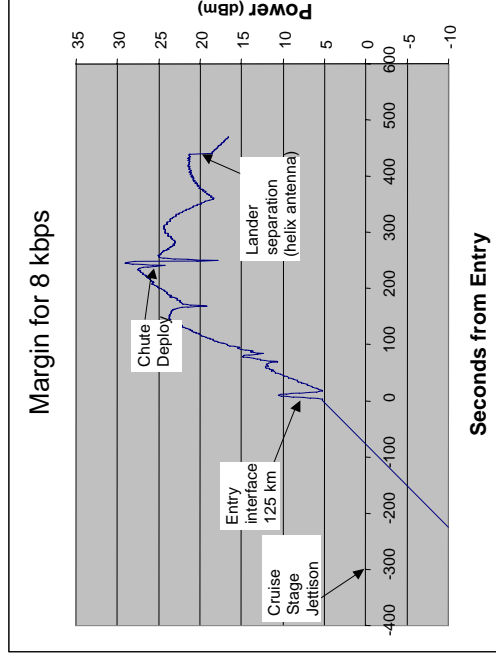
3 PLCS

LGA
3 PLCS



Data Return

- UHF Comm during all of EDL
 - Direct link to Odyssey or MRO
 - 8 Kb/s Data Rate
 - Concern about Plasma blackout in Hypersonic
- X-Band Semaphores during all of EDL
 - Confirmation of Key Events
 - Capability to produce "fault" semaphores
 - Some level of performance data
- Link analyses to be refined as Mission Design matures



2nd IPPW

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RG 11



Phoenix Summary



- Phoenix is a rebirth of the 2001 Lander using the same hardware and many of the same team members.
- Continuation of follow water strategy targeting subsurface ice in the northern polar region.
- First use of hypersonic guidance at Mars.
- Launching in 2007 and landing in 2008, it returns to propulsive soft landing with strong similarity to the Viking landings.



2nd IPPW

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RG 12