Terrain Safety Assessment Process for MSL

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MSL EDL Terrain Interaction Overview

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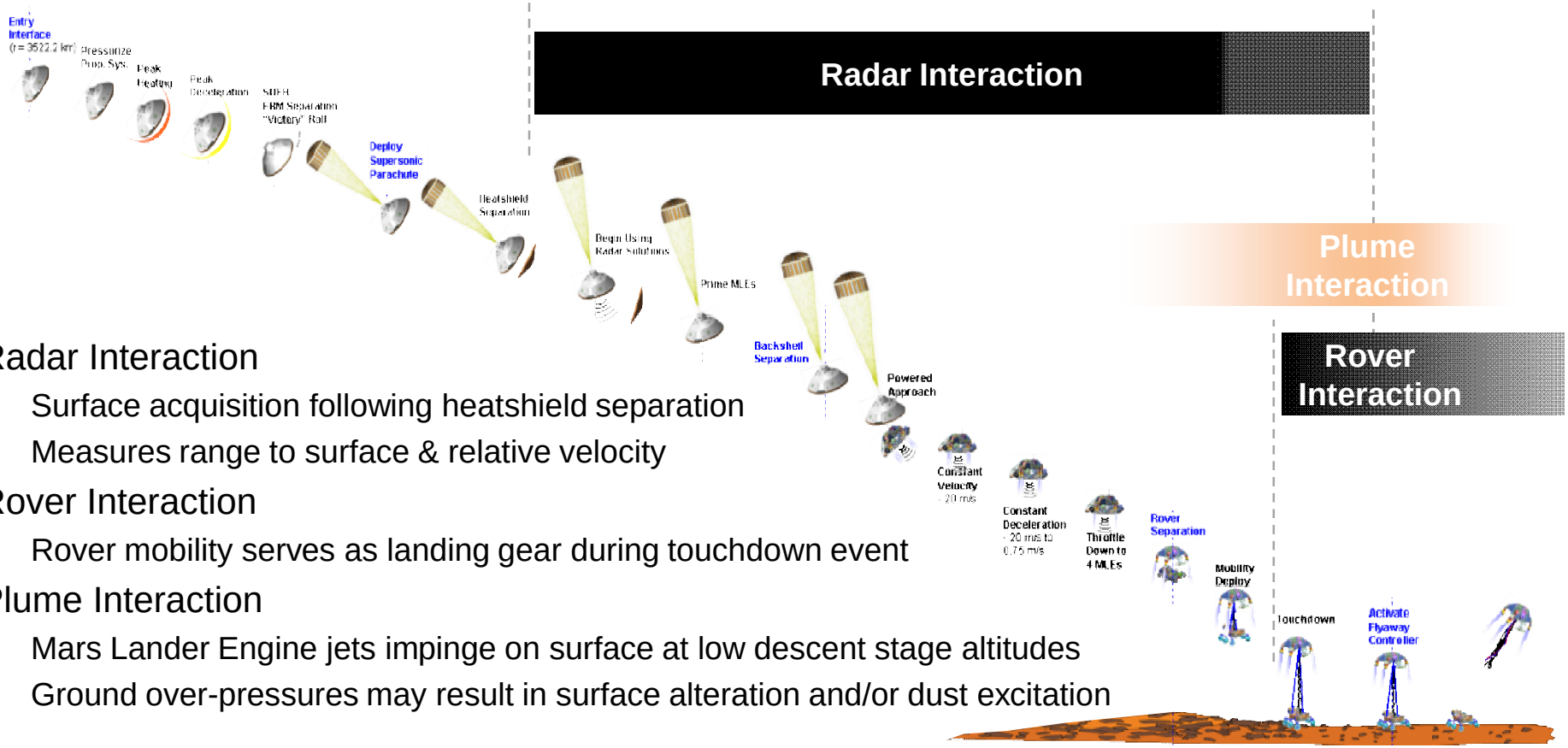
No Surface Interaction

Critical EDL terrain interactions occur via three distinct mechanisms

Radar Interaction

Plume Interaction

Rover Interaction



Radar Interaction

- Surface acquisition following heatshield separation
- Measures range to surface & relative velocity

Rover Interaction

- Rover mobility serves as landing gear during touchdown event

Plume Interaction

- Mars Lander Engine jets impinge on surface at low descent stage altitudes
- Ground over-pressures may result in surface alteration and/or dust excitation

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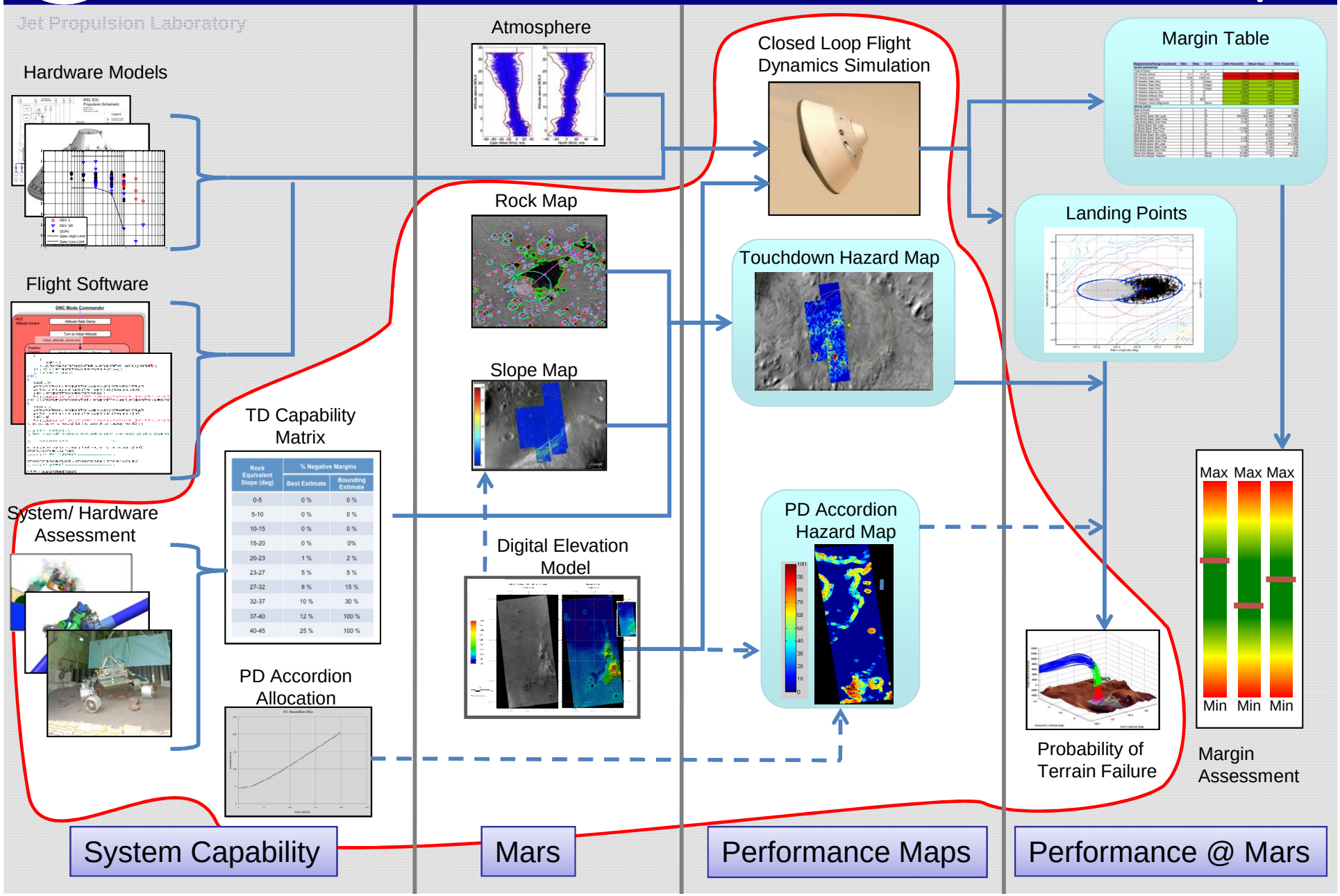

Rock Equivalent Slope (deg)	% Negative Margins	
	Best Estimate	Bounding Estimate
0-5	0 %	0 %
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23-27	5 %	5 %
27-32	8 %	15 %
32-37	10 %	30 %
37-40	12 %	100 %
40-45	25 %	100 %

Critical Terrain Data Sets

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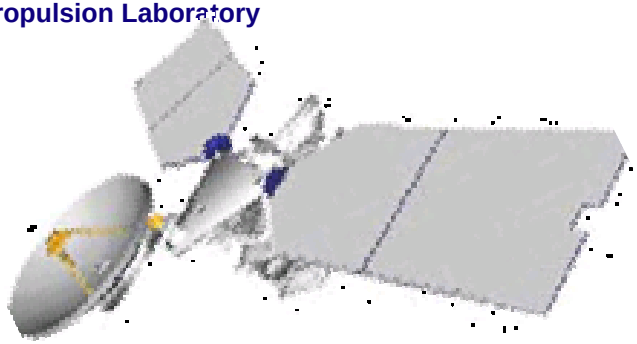
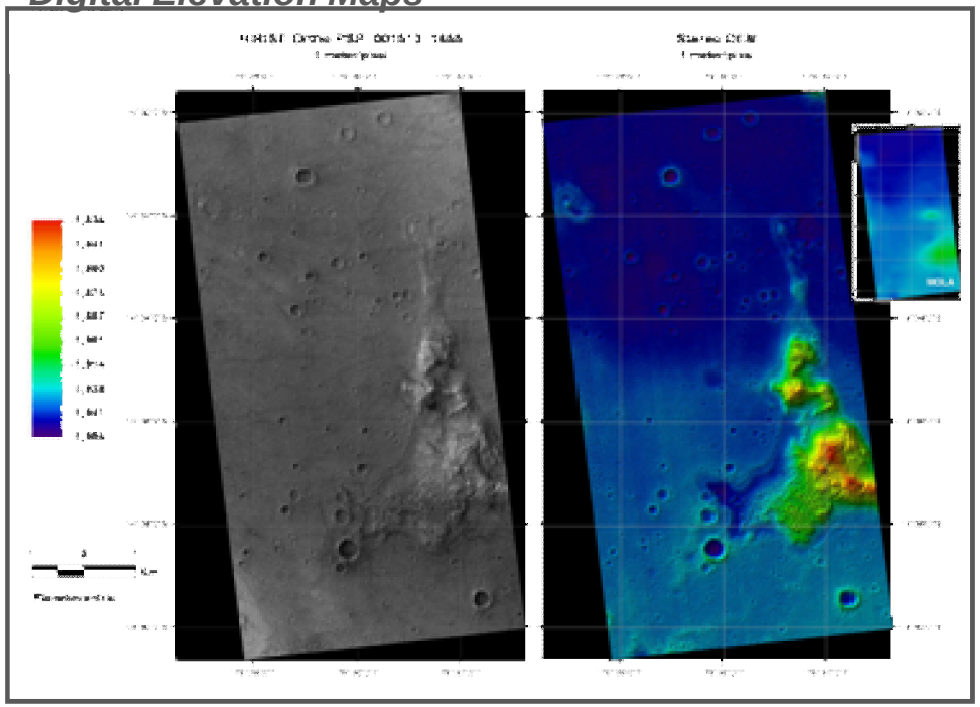
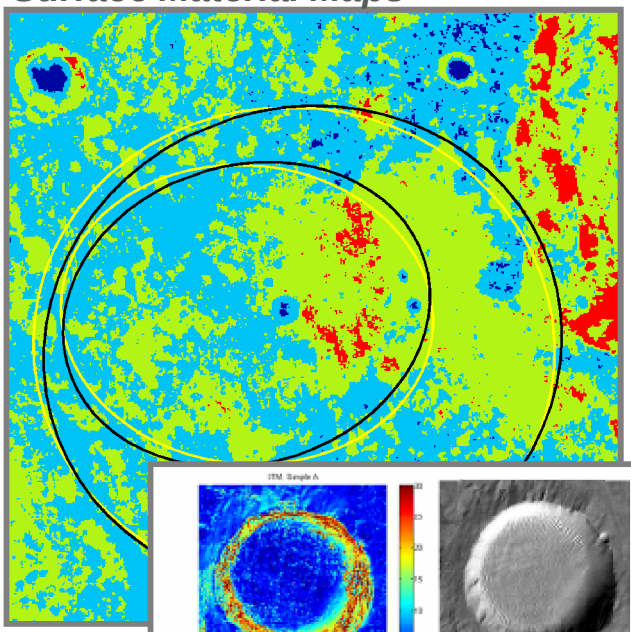
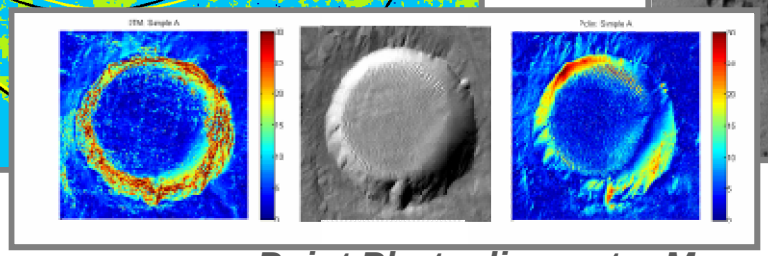


Digital Elevation Maps

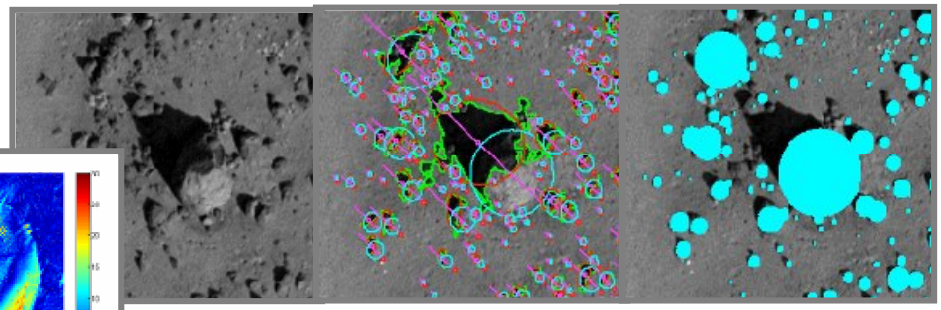


Surface Material Maps





Point Photoclinometry Maps



Rock Maps

HiRISE Coverage at Candidate Landing Sites

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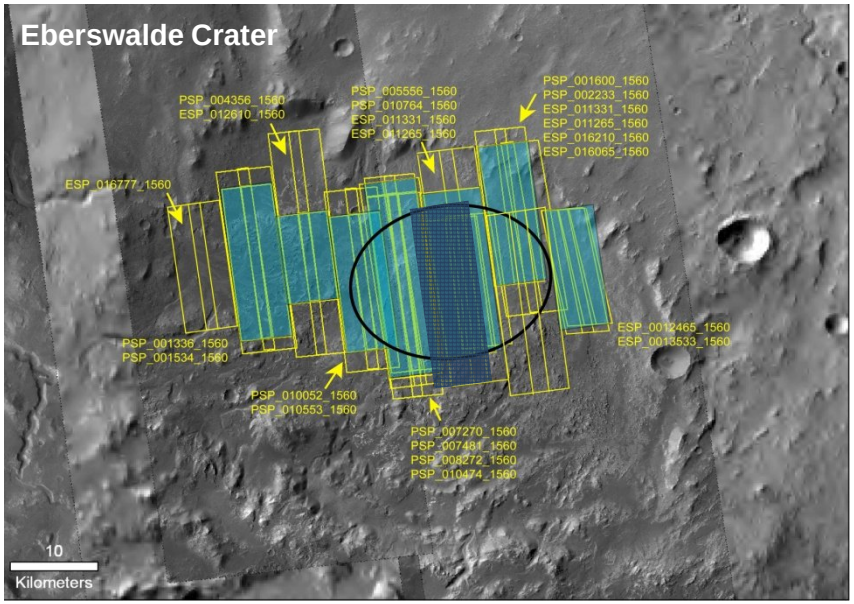

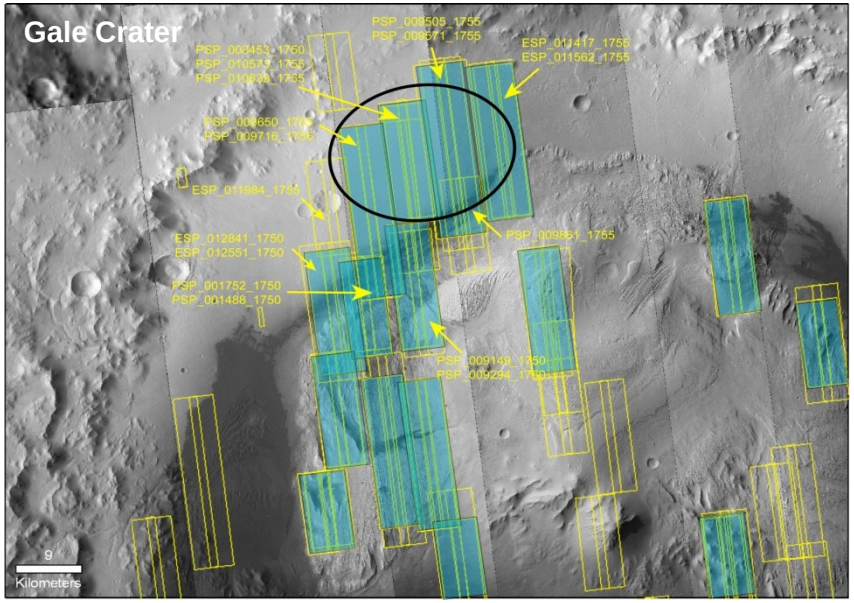

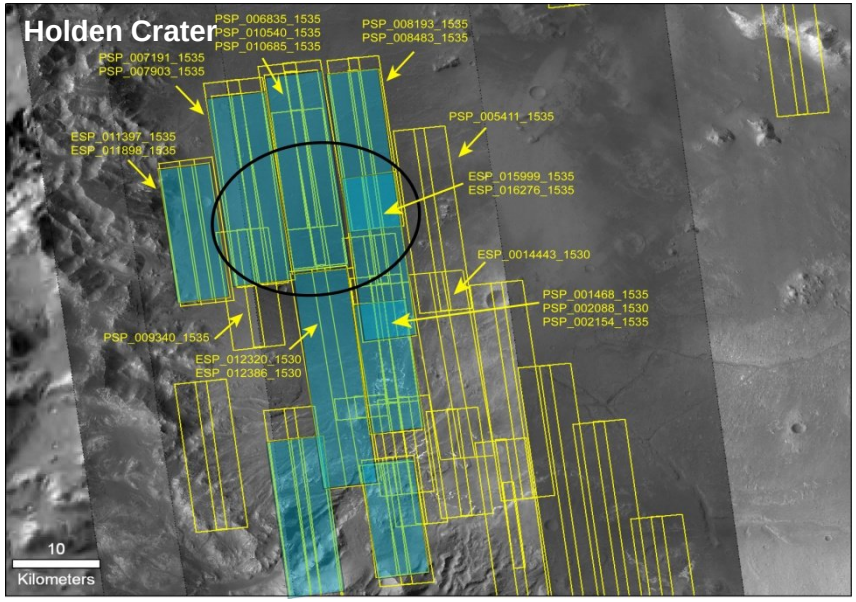

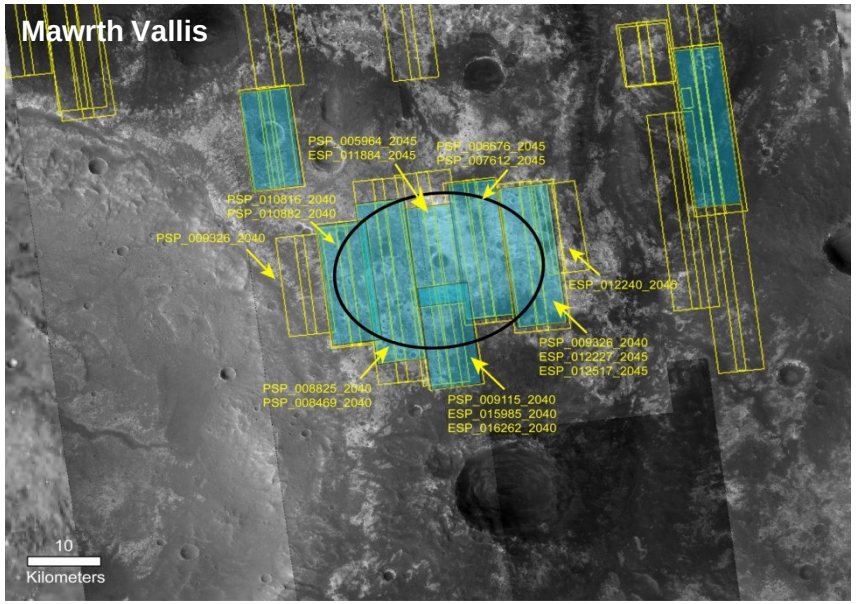

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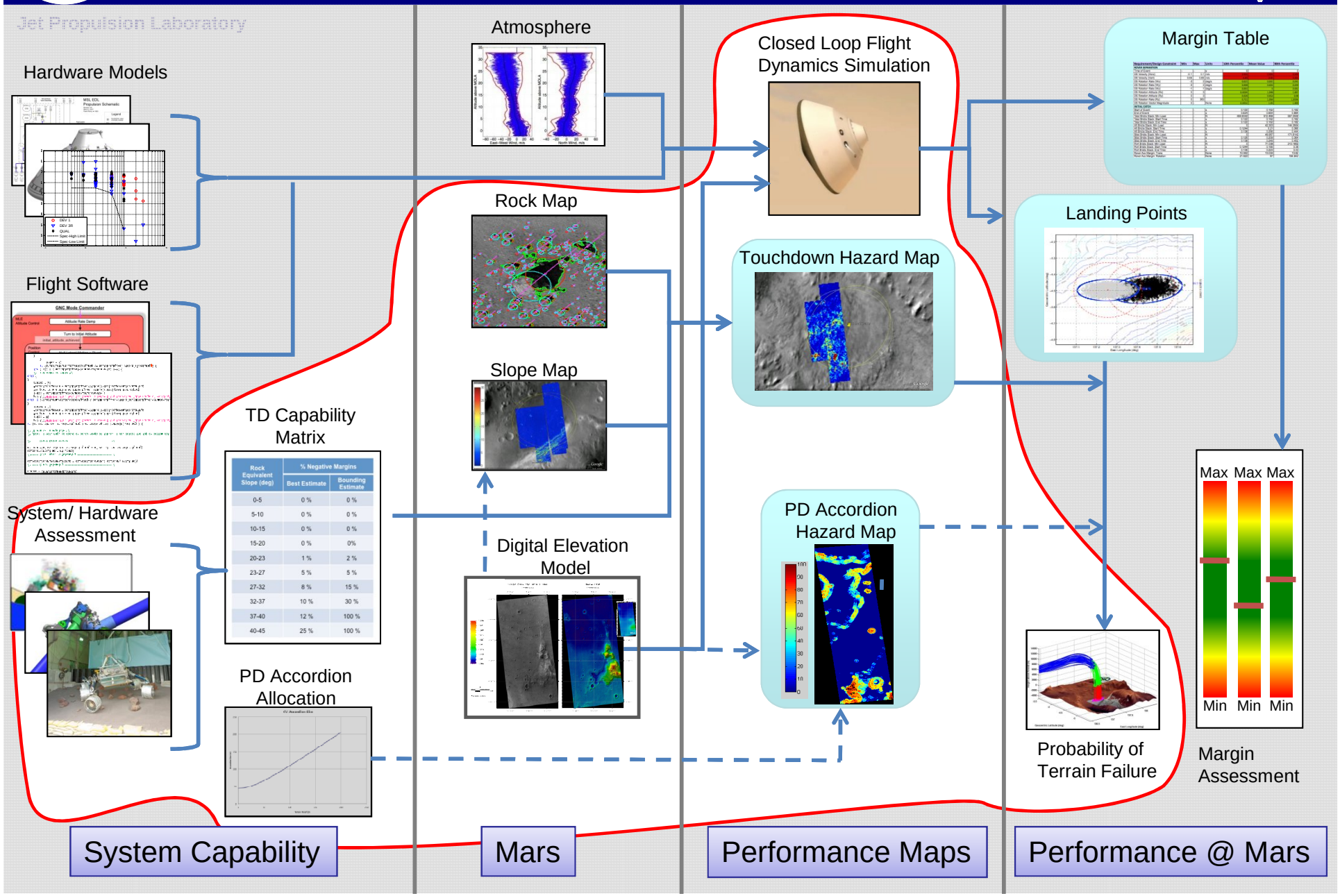

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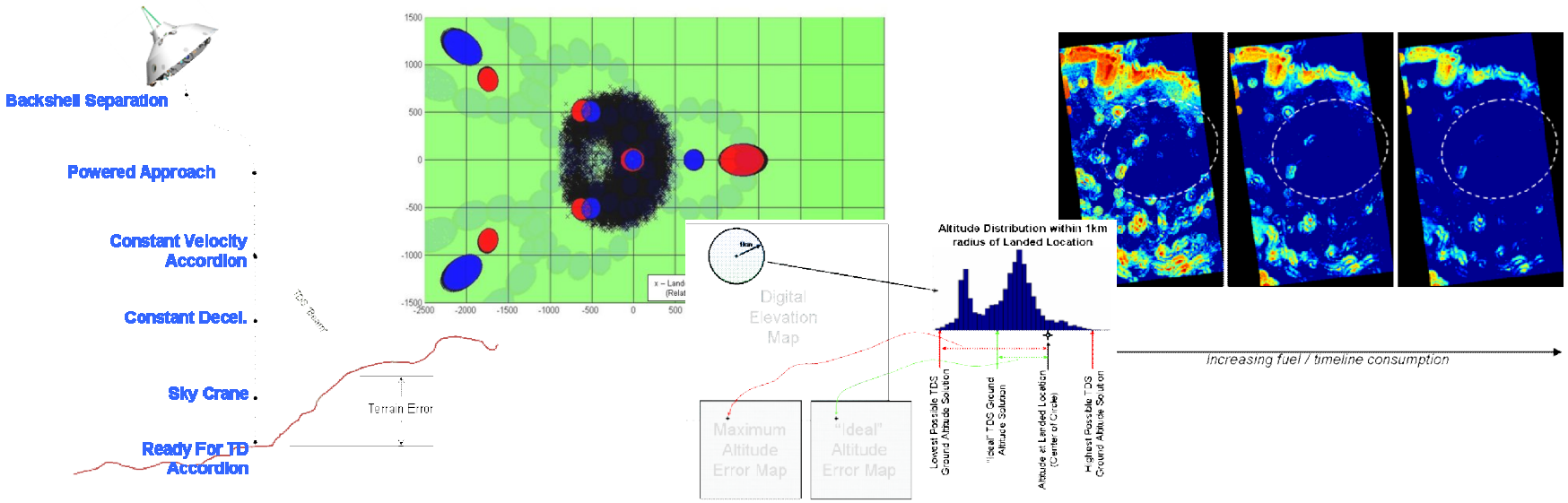
Sizing the Powered Descent Accordion

- The term "*accordion*" refers to a feature of the EDL architecture that accommodates altitude measurement errors prior to the skycrane phase
  - Largest altitude error source is the variability of the terrain itself
  - Terrain relief exceeding system capability threatens fuel/control authority margins
- Accordion failures are assessed in POST monte carlo simulations with detailed radar, flight dynamics, atmosphere, and terrain models
- Risk is bounded, and accordion sized, via bounding approach by querying terrain relief at relevant length scales and constructing hazard maps offline



Accordion Risks are assessed relative to fuel and altitude margins at each site; margins can be traded to increase accordion size and improve terrain tolerance

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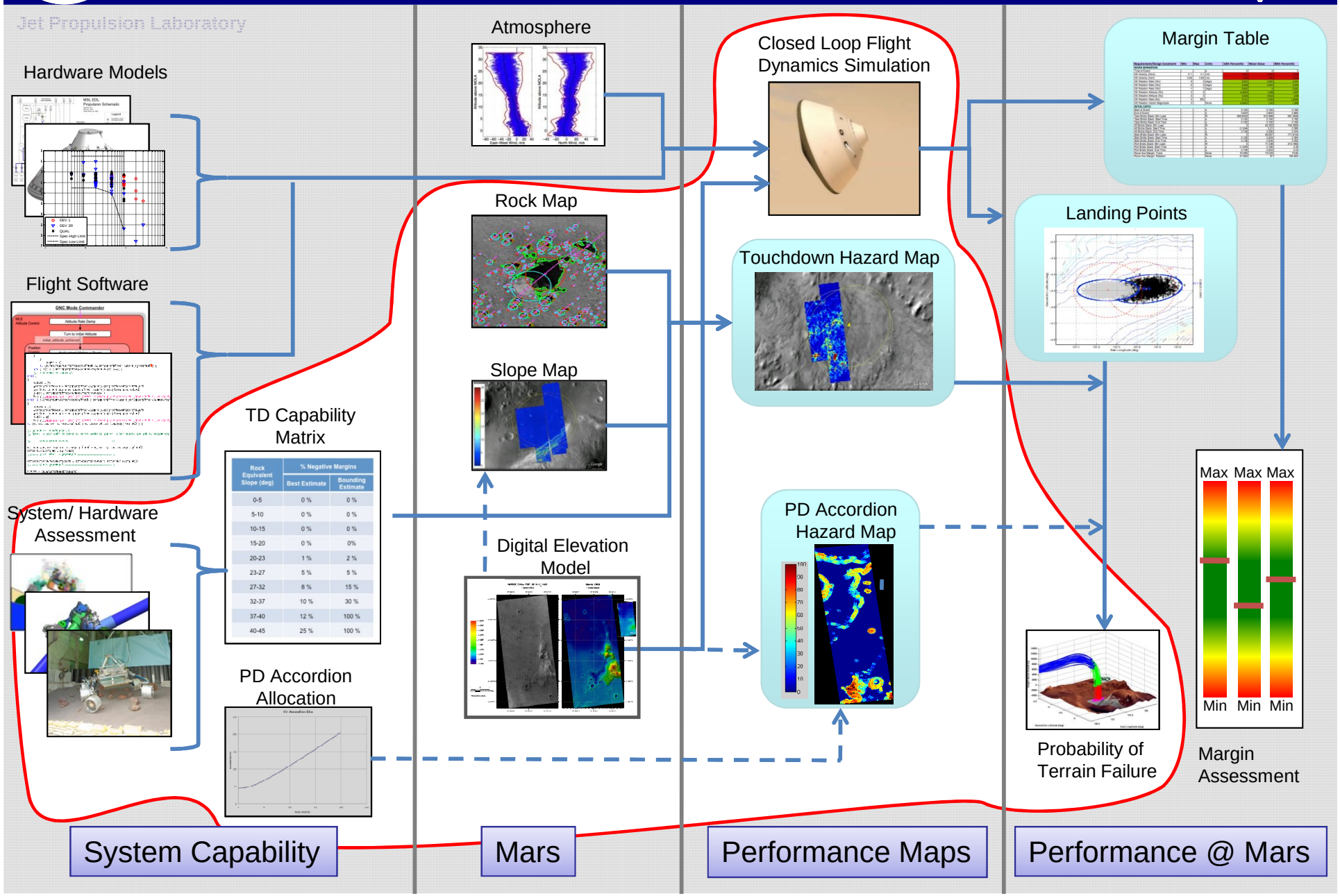

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Rover Capability Matrix

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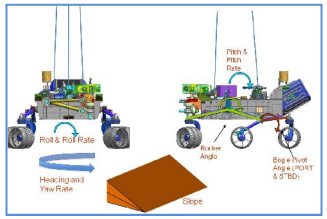
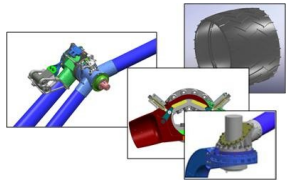
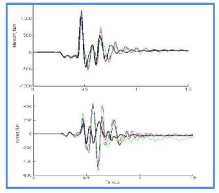
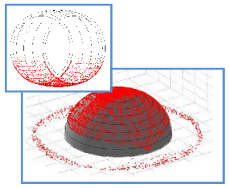
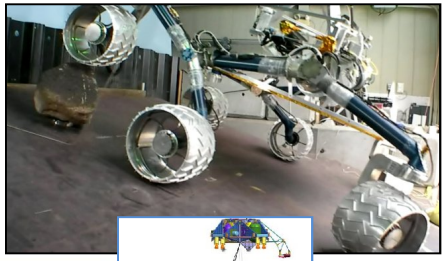
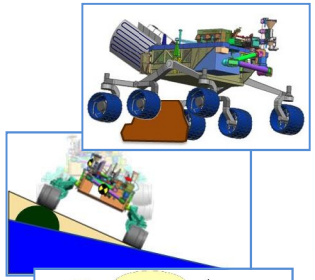


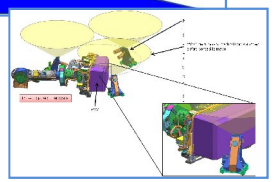


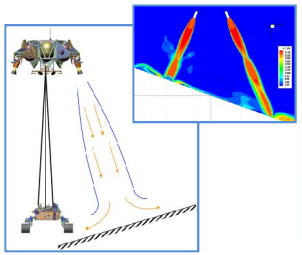




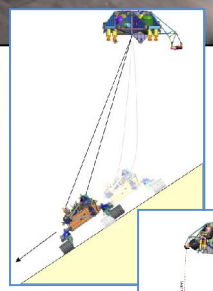


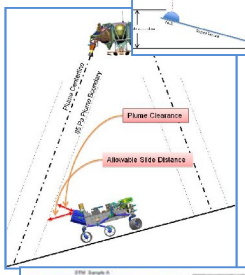


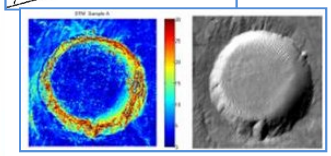




Category	Description
Touchdown Loads	Rover/Mobility margins during touchdown
Touchdown Stability	Rover dynamic stability (tip-over)
Touchdown Trigger Spoofing	Prolonged Rover-DS interaction (retensioning of the bridle) could preclude timely detection of the post-touchdown state and cause the DS to approach too close to the surface
Propellant Usage	Extended touchdown event due to large slope
Loaded Bridle Contact	Tensioned bridles coming into contact with top deck hardware during the touchdown event.
Direct Plume Impingement	Thermal and physical damage caused by direct plume impingement on the rover during the touchdown event
Indirect Plume Impingement	Sandblasting/covering the rover with entrained surface particulates
Telecom / Thermal	Rover left in a state such that basic surface operation functions can be carried out
Trafficability	Rover is left in a state where traverse is possible







Rover Capability Matrix enumerates touchdown failure rates as a function of local rocks and slopes, <u>for all failure modes</u>, in a manner consistent with terrain data resolution

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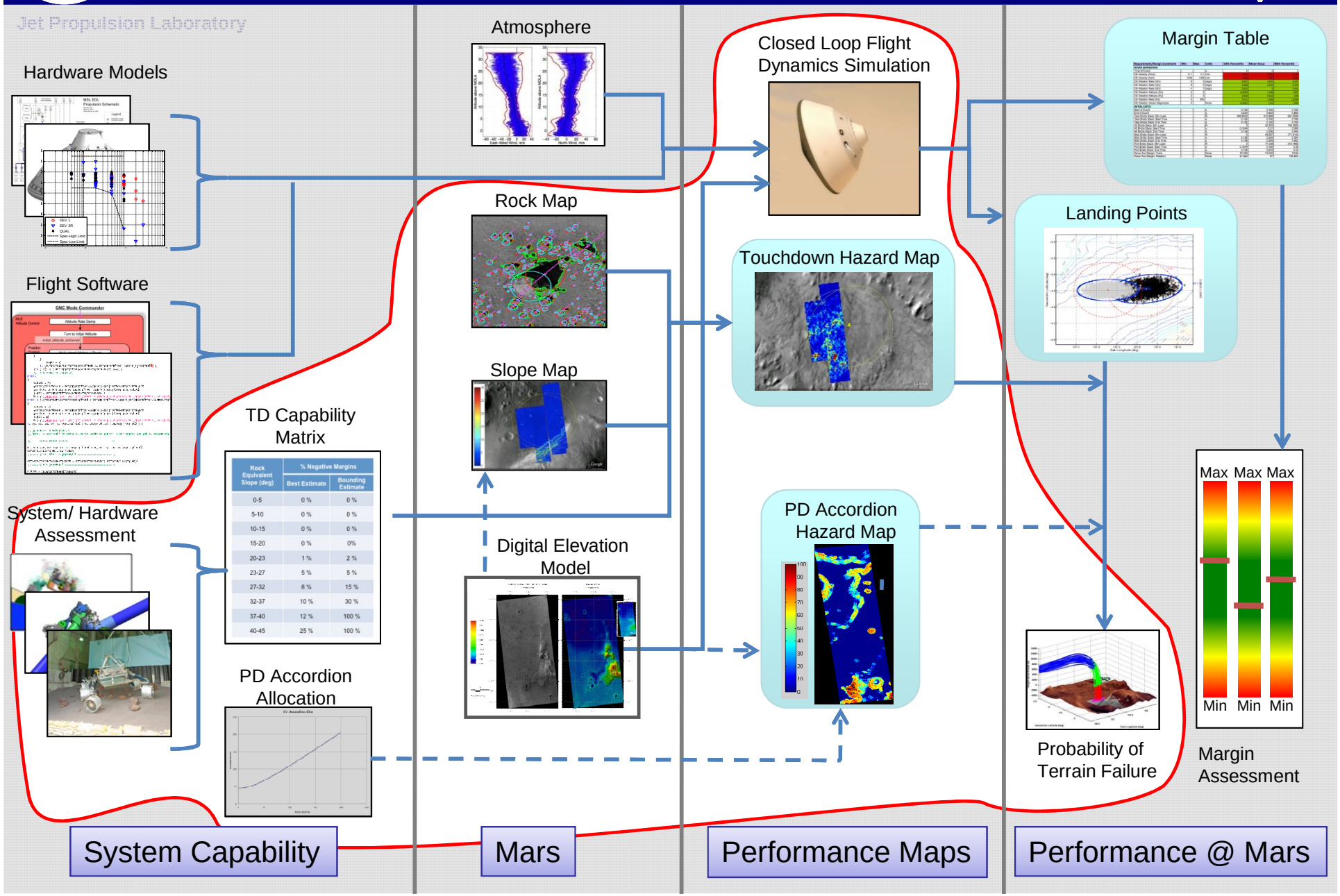

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