Virtual Research Presentation Conference

SHIELD: A Small, High Impact Energy Landing Device for Low-Cost Access to the Martian Surface

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Program: Strategic Initiative

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Assigned Presentation #RPC-160

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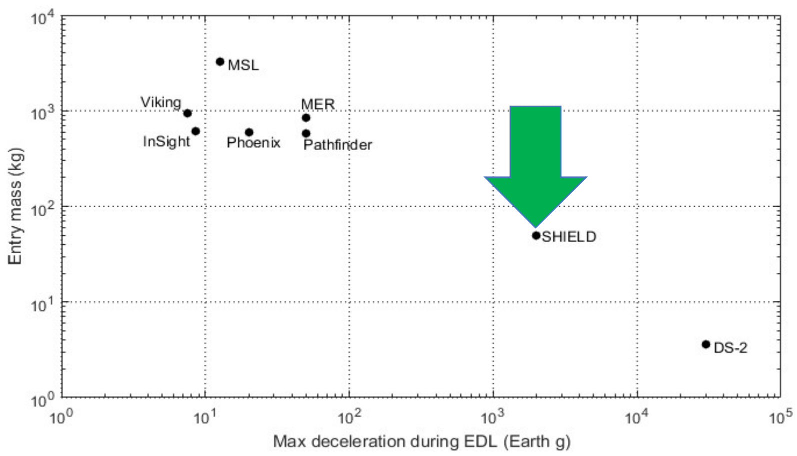
Introduction

The goal of the Small, High Impact Energy Landing Device (SHIELD) concept is to deliver science payloads to the surface of Mars at low-cost and high frequency. The missions thus enabled could range from single small landers to multiple landers carried as supplemental “piggyback” landers on larger missions. Size and cost reduction achieved by eliminating some conventional Entry/Descent/Landing system hardware:

- No backshell
- No parachute
- No ground detection RADAR
- No airbags or propulsive landing system



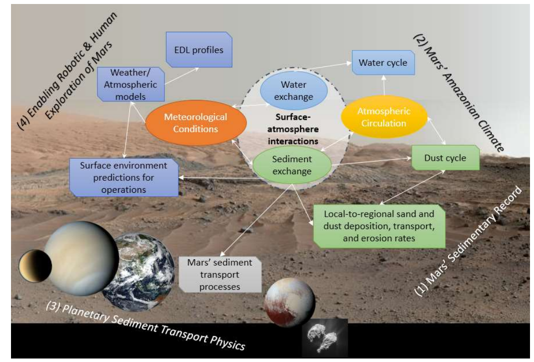
Problem Description

- There is a need within the Mars science community to deliver low-cost (<$50M) landers to the surface of Mars. Satisfying this need will enable a broad suite of potential missions that can complement “flagship class” Mars missions such as Mars Sample Return. The goal of this effort is to develop a new entry/descent/landing (EDL) technology compatible with mission concepts that could investigate a range of Mars science goals including Life, Climate, Geology, and Preparing for Human Exploration.
- The current state of the art for Mars Entry/Descent/Landing (EDL) technology is to use a heatshield and backshell during entry, parachutes during descent, and either a propulsion system or propulsion and airbag systems during landing. These technologies have worked successfully for Mars landers with entry masses ranging from 600 kg to 3300 kg, however the complexity of these individual systems makes them difficult to adapt to low-cost landers.
- SHIELD simplifies the EDL architecture to reduce size and cost. SHIELD has no backshell and no parachute system. Instead, SHIELD relies on a low ballistic coefficient and the Impact Deceleration Mechanism to limit landing decelerations to ≤ 2000 g.
- The SHIELD concept is a candidate for incorporation into a range of future mission concepts, offering a cost-effective technique for deploying small science payloads to the Martian surface. For example, one or more SHIELD vehicles could be deployed in a stand-alone low-cost competed mission, with mission costs far below the Discovery cap. Alternatively, several SHIELD entry vehicles could be deployed from a global remote sensing orbiter, providing ground-truth measurements to complement and validate the orbiter’s global measurements.

SHIELD Payload Constraints

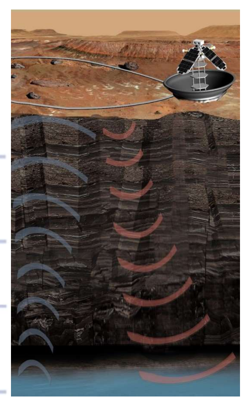
- NTE 10 kg Mass
  - 4 kg avionics + 6 kg instruments
- 2000 g impact acceleration
- Power: 160 W•hr per sol (at 30° N Lat)
  - 380 W•hr batteries capacity
- Data: 19.2 Mbit/sol
  - UHF to assumed orbiter

Planetary Aeolian & Meteorological Investigation (PAMI) *PI: Serina Diniega*

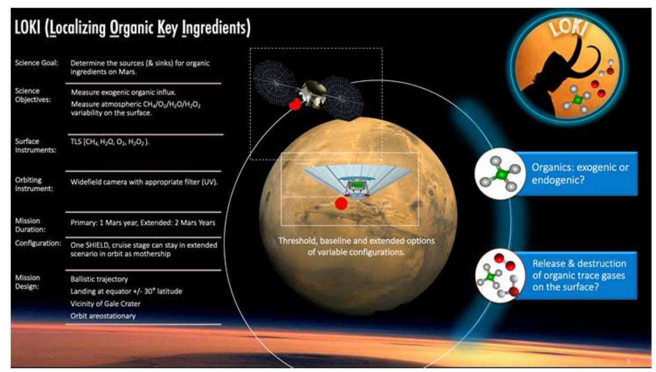


Transmissive H2O Reconnaissance (TH2OR)
PI: Vlada Stamenković

Science Objectives	1. Is there liquid water on Mars today? 2. What's the history of groundwater?
Primary Instrument	TH_2OR TEM Liquid Sounder; 100 m transmit loop=receive loop, detector electronics.
Secondary Instrument	Water vapor sensor, trace gas sensors (1 or 2 channel mini-TLS).
Mission Duration	Primary -10 days, Extended -1 Mars year

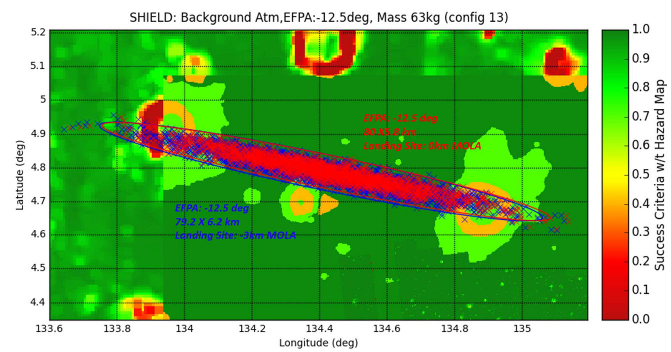


Localizing Organic Key Ingredients (LOKI)
PI: Vlada Stamenković



- Baseline EFPA: -12.5° (±0.21°, 3-σ)
- Entry Vel: 6.46 km/s
- Winds: MKB (Simple Winds)
- Landing ellipse is 80 km x 6 km 3-σ
  - Reduced by 50% for EFPA = -25°

Touchdown Conditions: 0km and -3km MOLA

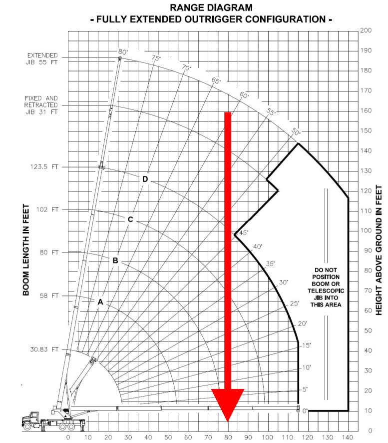


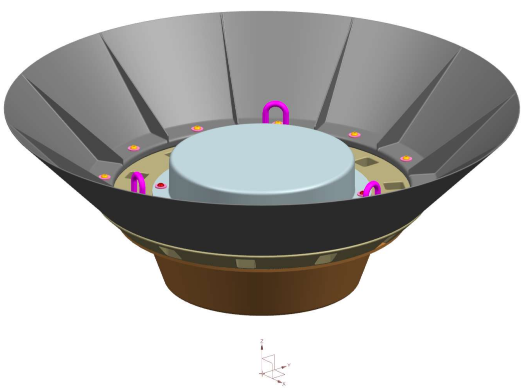
EFPA:	Skirt Deploy Mach range	Vertical impact speed at 0km MOLA	Horizontal impact speed at 0km MOLA	Landing Ellipse at 0km MOLA, Along Track	Landing Ellipse at 0km MOLA, Cross Track
-12.5°	Mach 0.70 – 0.80	56m/s (95%)	15m/s (95%)	82.5km (99%)	5.85km (99%)
-25°	Mach 0.70 – 0.80	46m/s (95%)	13m/s (95%)	40.3km (99%)	2km (99%)

28 kg (62 lb) test article
Drop from roughly 50m (160 feet)
Impact at roughly 25 m/sec (56 mph)
Impact onto steel plate

Data collection:

- High speed imagery
- Onboard accelerometer

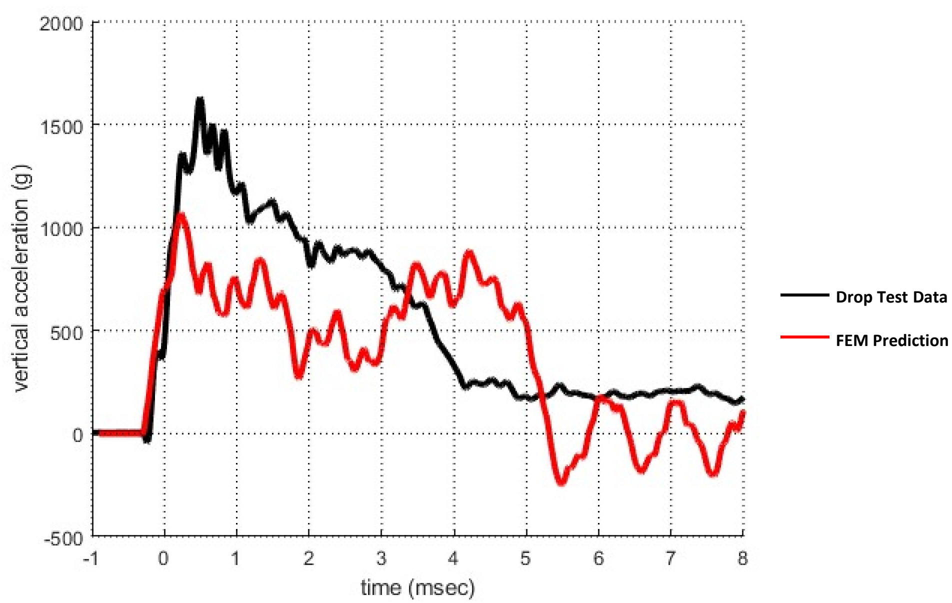




SHIELD
Drop Test
August 27, 2020

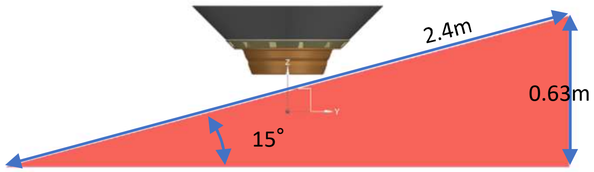
Recorded: 10,000 FPS
Playback: 1,000 FPS

- Note: 500 µsec wide “boxcar” filter applied to both the “raw data” and “raw FEM”
- Measured bounce height was 0.40m (16”), FEM predicted bounce height was 0.36m
- Good overall agreement, but improvements can be made

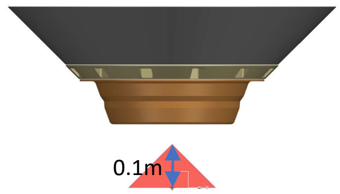


Plans for future FEM and testing in FY21

- Improve IDM performance
  - Reduce peak deceleration
  - Reduce “bounce height” to less than 1 SHIELD radius



- Performance on slope
  - Currently assuming a maximum slope of 15˚
  - What maximum slope should we assume? Slope statistics on Mars?



- Performance on “rock-like” discontinuity
  - Currently assuming a “rock” 0.1m tall at sub-scale (0.4m tall at Mars)
  - What maximum rock height should we assume? Rock size statistics on Mars?