Mars 2020 Project Update

Planetary Science Subcommittee (PSS)
Committee on Astrobiology and Planetary Science (CAPS)

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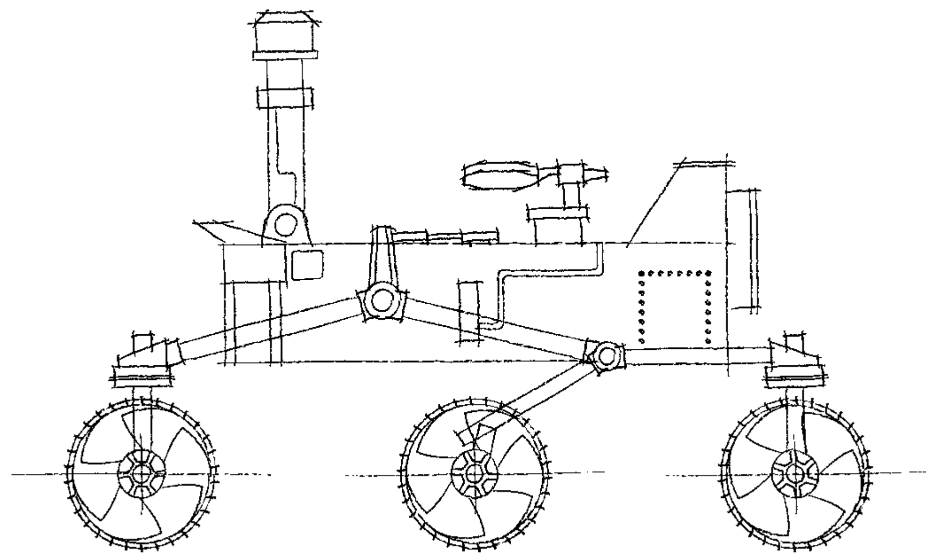


Mars 2020 Project

Introduction

- Mars 2020 mission is responsive to recommendations by the Planetary Science Decadal Survey
  - Addresses top priority science and caches samples for possible future return
  - Descopes cost and delays next large mission (~$3.5B in 2018 to ~$2B in 2020)

- Mission Development History
  - Mars Exploration Program (MEP) restructuring following Mars Program Planning Group (MPPG) effort March-Sept 2012 to define robotic architectures that support science and exploration requirements in an integrated strategy
  - Agency concluded a MSL-derived rover mission in 2020 would be feasible and should be the next strategic mission to Mars
  - Agency/OMB approval Oct/Nov 2012
  - SMD AA announced in Dec 2012 that NASA would send a rover to Mars in 2020

- Mars 2020 addresses the highest priority science
  - Leverages MSL design, residual hardware, and experienced team
  - Builds on MSL/Curiosity results by investigating a landing site for possible bio-signature preservation in full geologic context
  - Provides opportunities for HEOMD and STMD contribution
  - Provides opportunities for international collaboration
  - Provides cached samples for possible return

Mars 2020 Mission Objectives

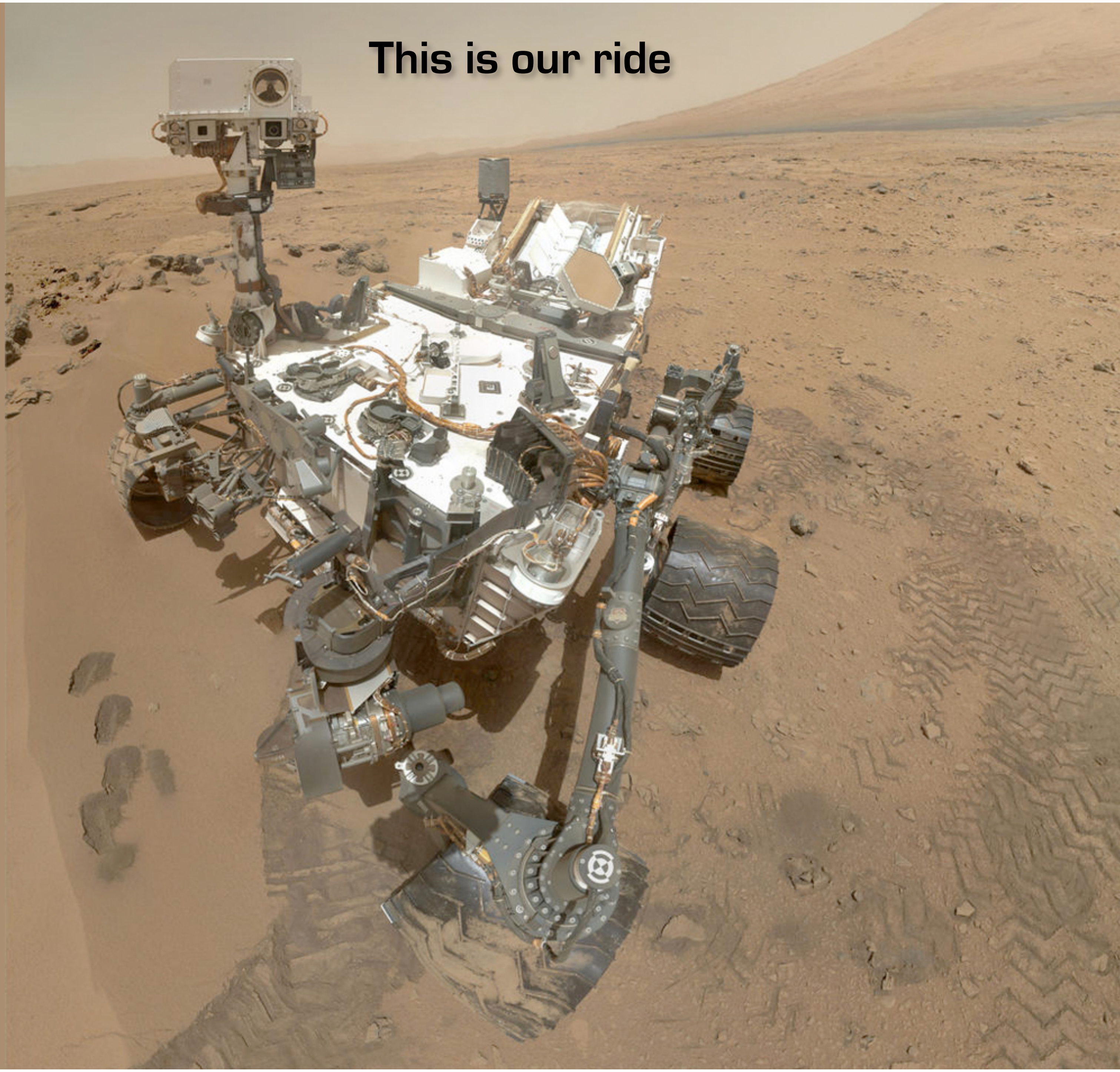
A. Geologic History
Carry out an integrated set of spatially-coordinated measurements to fully characterize the geology of the landing site, including contact science

B. Astrobiology
Find and characterize ancient habitable environments, identify rocks with the highest chance of preserving signs of ancient Martian life if it were present, and within those environments, seek the signs of past life

C. Select, Collect and Store Samples
Place rigorously documented and selected samples in a returnable sample cache for possible future return to Earth

D. Facilitate future human exploration by helping fill in Strategic Knowledge Gaps, such as assessing local natural resources or potential hazards for future human explorers.

This is our ride



Mission Concept

LAUNCH
- MSL class/capability launch vehicle
- Period: Jul/Aug 2020

CRUISE/APPROACH
- 7.5 month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING
- MSL EDL system: guided entry and powered descent/Sky Crane
- 25x20km landing ellipse
- Access to landing sites ±30° latitude, ≤0.5 km elevation
- ~950 kg rover

SURFACE MISSION
- Prime mission of one Mars year
- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

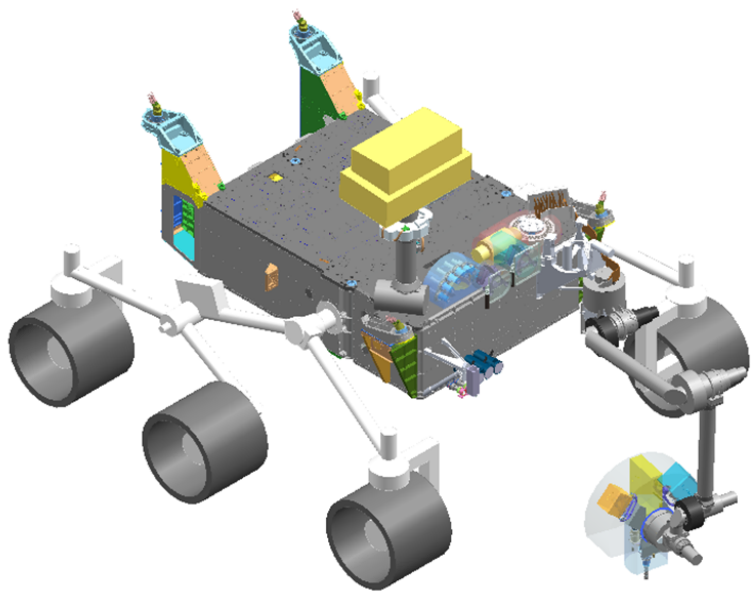
http://mars.jpl.nasa.gov/mars2020/

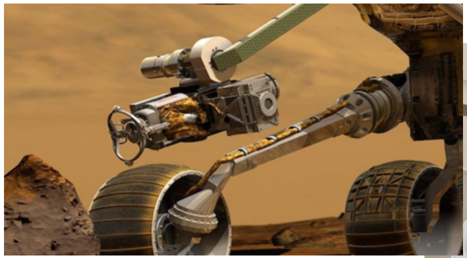
Spacecraft Design Approach

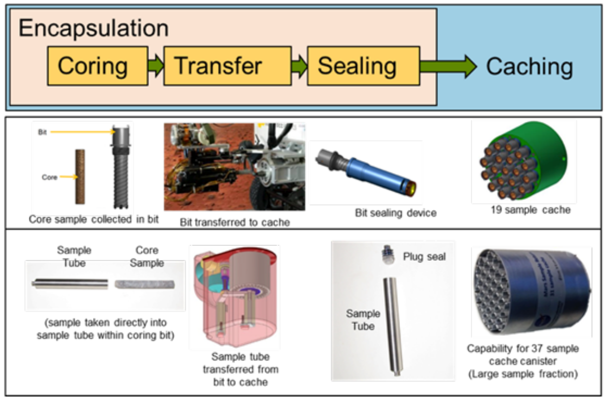
- Leverage successful Curiosity rover and delivery system design, residual hardware, and experienced team.
- Mission concept is predicated on this “high heritage” approach. More than 90% of the spacecraft (by mass) has requirements identical to those for the Curiosity mission.
- ~$200M of residual hardware exists: flight spares, engineering units, electronic parts, testbeds, and support equipment.
- Project has confirmed its ability to buy the same parts and equipment from the top ~25 Curiosity mission vendors.

Sampling System

- New development with potential for some MSL inheritance
- Will support arm-mounted in-situ instruments selected per AO
- Provide abrading / brushing for contact and remote sensing payloads
- Enable core acquisition and caching

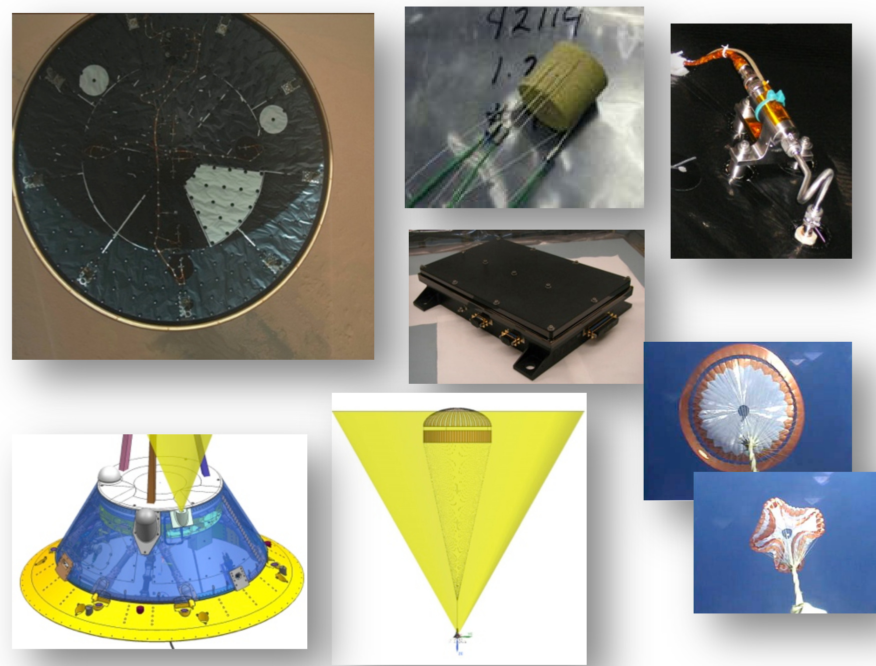


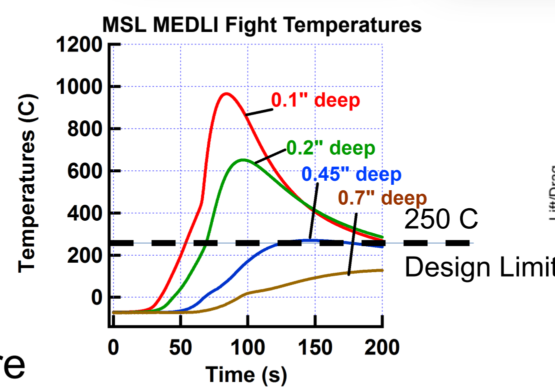


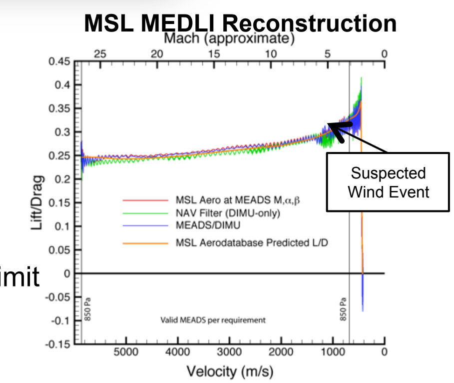


MEDLI for Mars 2020

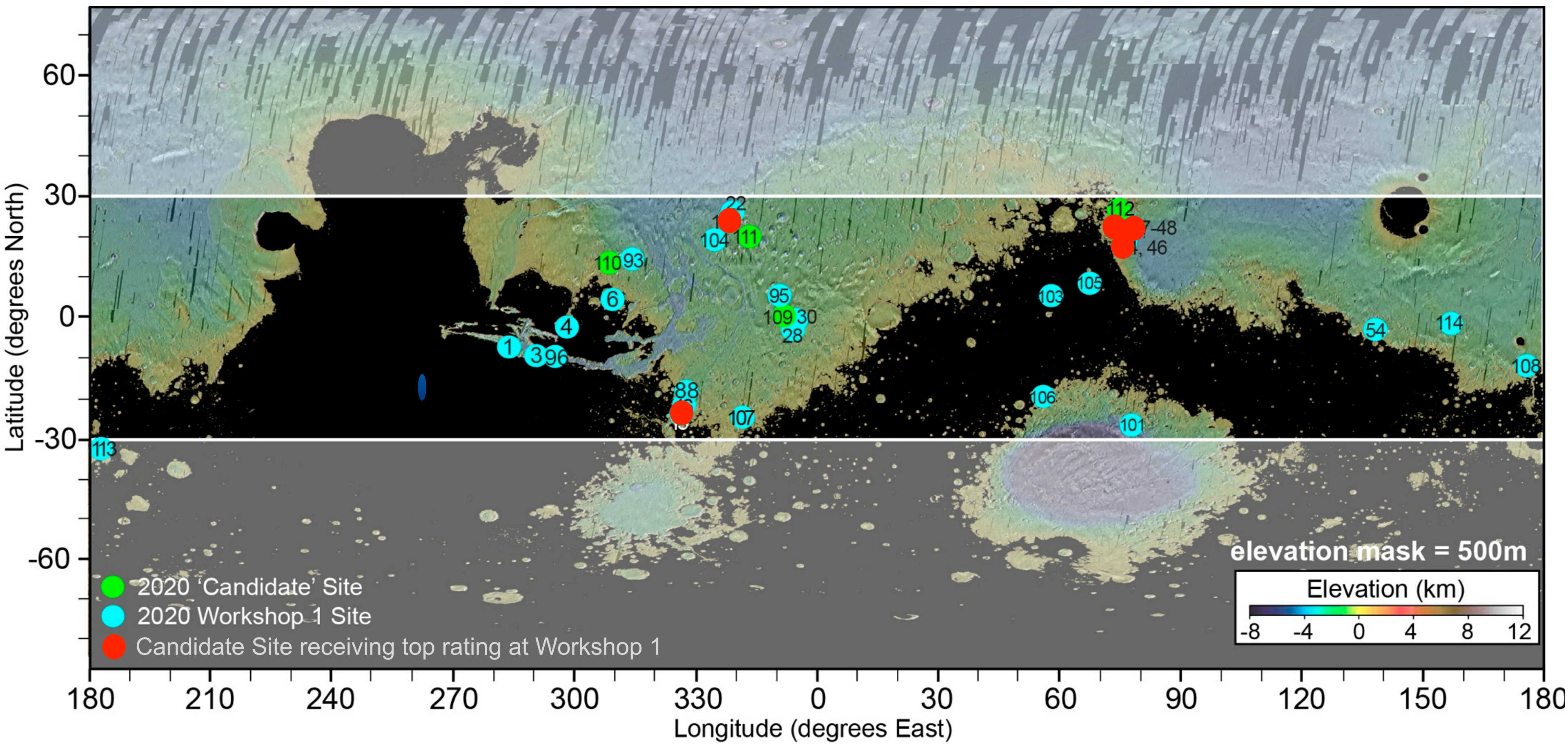
- SMD, HEOMD, and STMD have reached an agreement to co-fund MEDLI
  - HEOMD/STMD jointly fund development
  - SMD funds accommodation, mission operations, and post-flight analysis
- Inter-center effort involving LaRC, ARC and JPL
  - Similar to MSL, MEDLI specific MOUs will define teaming relationships
- Agreement on MEDLI 2.2 Option
  - Re-fly the successful MSL aerodynamics and aerothermal instrumentation
  - Additional sensors (e.g., backshell, supersonic pressure, heat flux)
- Potential enhancements to be evaluated for benefit and cost impacts during Phase A, defined by System Requirements Review:
  - Add a parachute uplook camera to capture parachute inflation and aerodynamics







Current 2020 Candidate Landing Sites



It is possible that the most promising science may be at a site that requires EDL enhancements (e.g., Range Trigger and/or Terrain Relative Navigation) for successful landing. This potential cost of enhancements, when known, will be weighed against the science gained from a more challenging landing site.

Significant Events

- 6-7 Aug 2013 - Mission Concept Review
- 12 Nov 2013 - Agency PMC/KDP-A Gate (Phase A start)
- 15 Jan 2014 - AO proposals received
- 18 Feb 2014 - Acquisition Strategy Meeting
- 25 Mar 2014 - MEDLI Baseline decision
- 14 May 2014 - 1st Landing Site Workshop
- 6 June 2014 - Draft Environmental Impact Statement (EIS) released
- 31 July 2014 - Instrument investigations selection announced
- 26-28 August - First Project Science Group (PSG) meeting
- Oct 28-29, 2014 - System Requirements Review / Mission Definition Review
- Dec'14/Jan'15* - Key Decision Point - B (Phase B start)
- Dec'14/Jan'15 - Final EIS publication

* Pending AO selection subsequent reviews/contracting dates and accommodation study schedule being assessed.

Science Definition, Announcement of Opportunity (AO), & Investigation Selection

Mars 2020 Science Definition Team (SDT) Findings

The SDT envisions a 2020 Mars Rover mission that would:

- **Conduct Rigorous *In Situ* Science**
  - **Geologic Context and History** Carry out an integrated set of sophisticated context, contact, and spatially-coordinated measurements to characterize the geology of the landing site
  - ***In Situ* Astrobiology** Using the geologic context as a foundation, find and characterize ancient habitable environments, identify rocks with the highest chance of preserving signs of ancient Martian life if it were present, and within those environments, seek the signs of life
- **Enable the Future**
  - **Sample Return** Place rigorously documented and selected samples in a returnable sample cache as the most scientifically, technically, and economically compelling method of demonstrating significant technical progress toward Mars sample return
  - **Human Exploration** Conduct a Mars-surface critical ISRU demonstration to prepare for eventual human exploration of Mars
  - **Technology** Demonstrate technology required for future Mars exploration
- **Respect Current Financial Realities**
  - Utilize MSL-heritage design and a moderate instrument suite to stay within the resource constraints specified by NASA

SDT Proposed Measurement Options

From SDT Report

<table>
<tr><th>Objective A
Geology</th><th>Objective B
Biosignatures</th><th>Objective C
Caching</th><th>Objective D
HEO/Tech</th></tr>
<tr><td colspan="3">THRESHOLD</td><td rowspan="2">BASELINE OPTIONS</td></tr>
<tr><td>Measurements/Capabilities</td><td>Measurements/Capabilities</td><td>Measures/Capabilities</td></tr>
<tr><td>•Context Imaging
•Fine-Scale Imaging
•Context Mineralogy
•Fine-Scale Elem Chem
•Fine-scale Mineralogy</td><td>•Context Imaging
•Fine-Scale Imaging
•Context Mineralogy
•Fine-Scale Elem Chem
•Fine-scale Mineralogy
•Reduced/Organic C detection</td><td>•Context Imaging
•Fine-Scale Imaging
•Context Mineralogy
•Fine-Scale Elem Chem
•Fine-scale Mineralogy</td><td rowspan="5">• ISRU Demo
• EDL Data
• EDL Precision & Site Access
• Surface Weather Monitoring
• Biohazards to Astronauts</td></tr>
<tr><td colspan="3">BASELINE OPTIONS
Enhanced-capability instrument(s) in THRESHOLD category OR add one of the following:</td></tr>
<tr><td>•Subsurface Sensing
•Organic C detection</td><td>•2nd method of Organic C Detection</td><td>•Organic C detect</td></tr>
<tr><td colspan="3">ENHANCED OPTIONS
Enhanced-capability instrument(s) in THRESHOLD category AND an additional BASELINE or ENHANCED instrument</td></tr>
<tr><td></td><td>•Molecular Analysis</td><td></td></tr>
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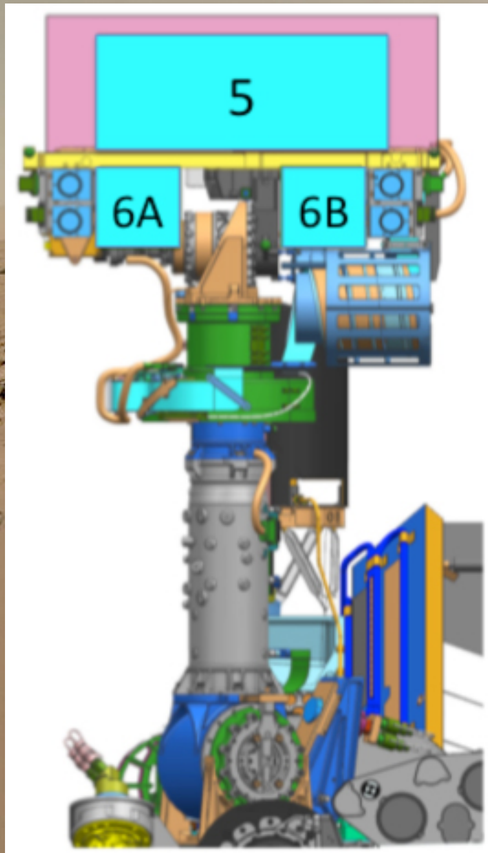
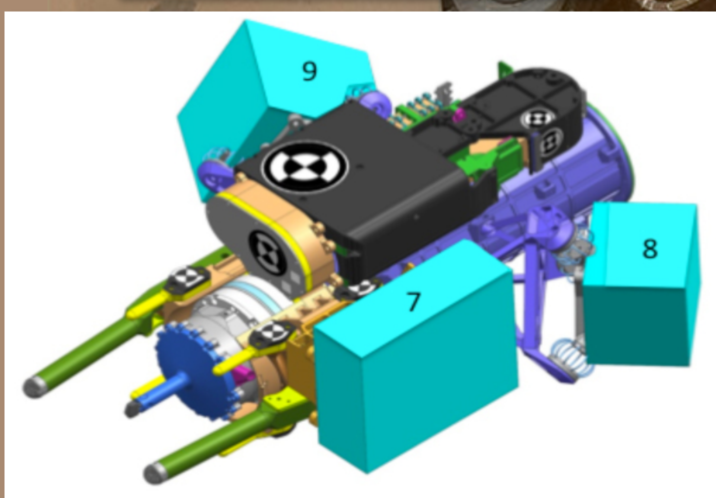
- The measurements required to meet Objectives A – C are nearly identical. Thus, these three objectives are highly integrated and compatible with a common mission.
- Instrument combinations exist that meet budget and measurement requirements
- Arm and mast mounted instruments alone are sufficient to meet the objectives

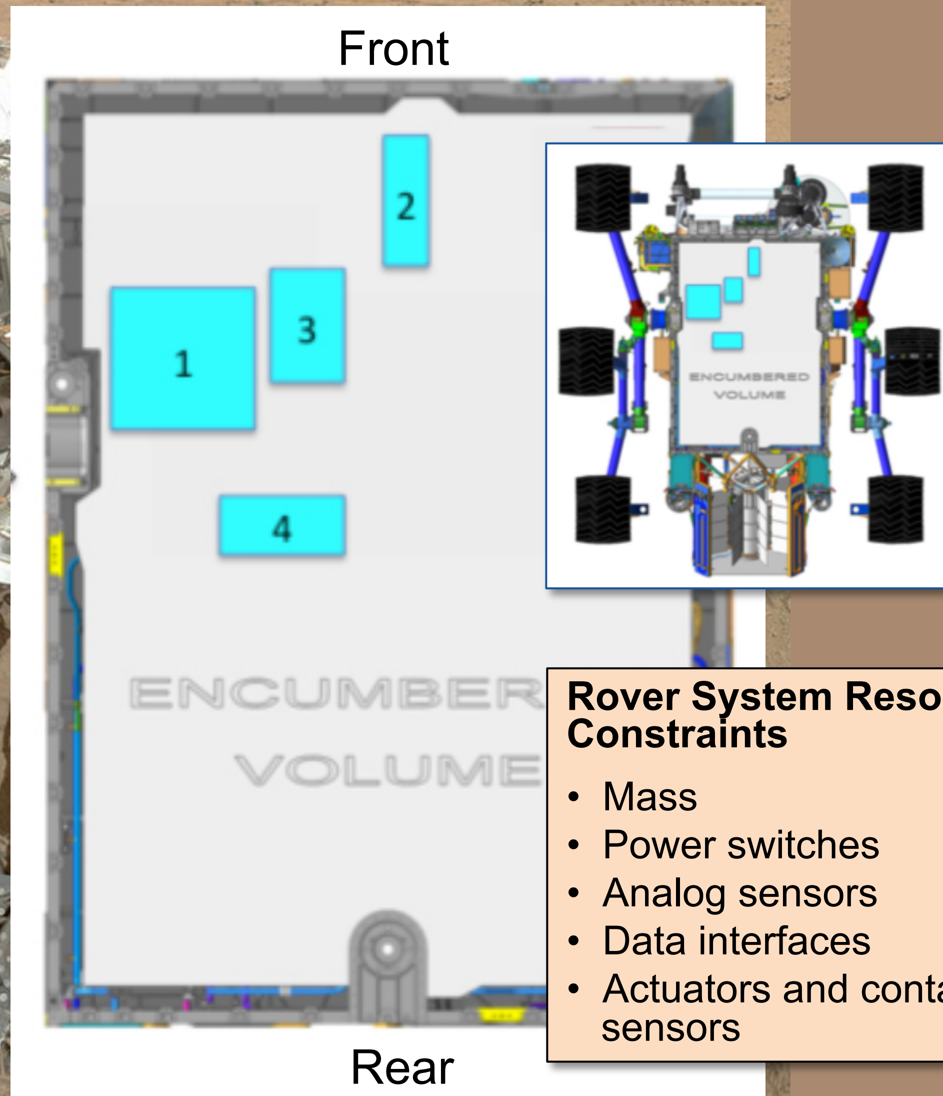
Mars 2020 AO Overview

- Based on standard SMD PI-led mission AO with changes to address unique requirements of instrument investigations.
- Proposals must address Mars 2020 **Proposal Information Package (PIP) that contains descriptions of rover (volume, mass, power, etc. constraints).**
- Proposals shall be for either or both a:
  - Mars instrument science investigation or a
  - Mars exploration technology investigation
- Proposals can address both an instrument science investigation and an exploration technology investigation in a single proposal. [Q&A #66]
- Announced as a one step selection process.
- There is no predetermined cost cap per instrument in this AO; however, the budget resources for all SMD-funded investigations are limited to approximately **$100M RY for Phases A through D** and approximately $60M RY for Phase E. HEOMD and STMD funded exploration technology investigations are limited to approximately **$30M RY for Phases A through E**.
- Proposals that address an exploration technology investigation are permitted to include an advanced technology option that offers a parallel path for advancing promising, lower TRL technologies (Section 5.3.1).

Volumes provided in the Proposal Information Package (PIP)



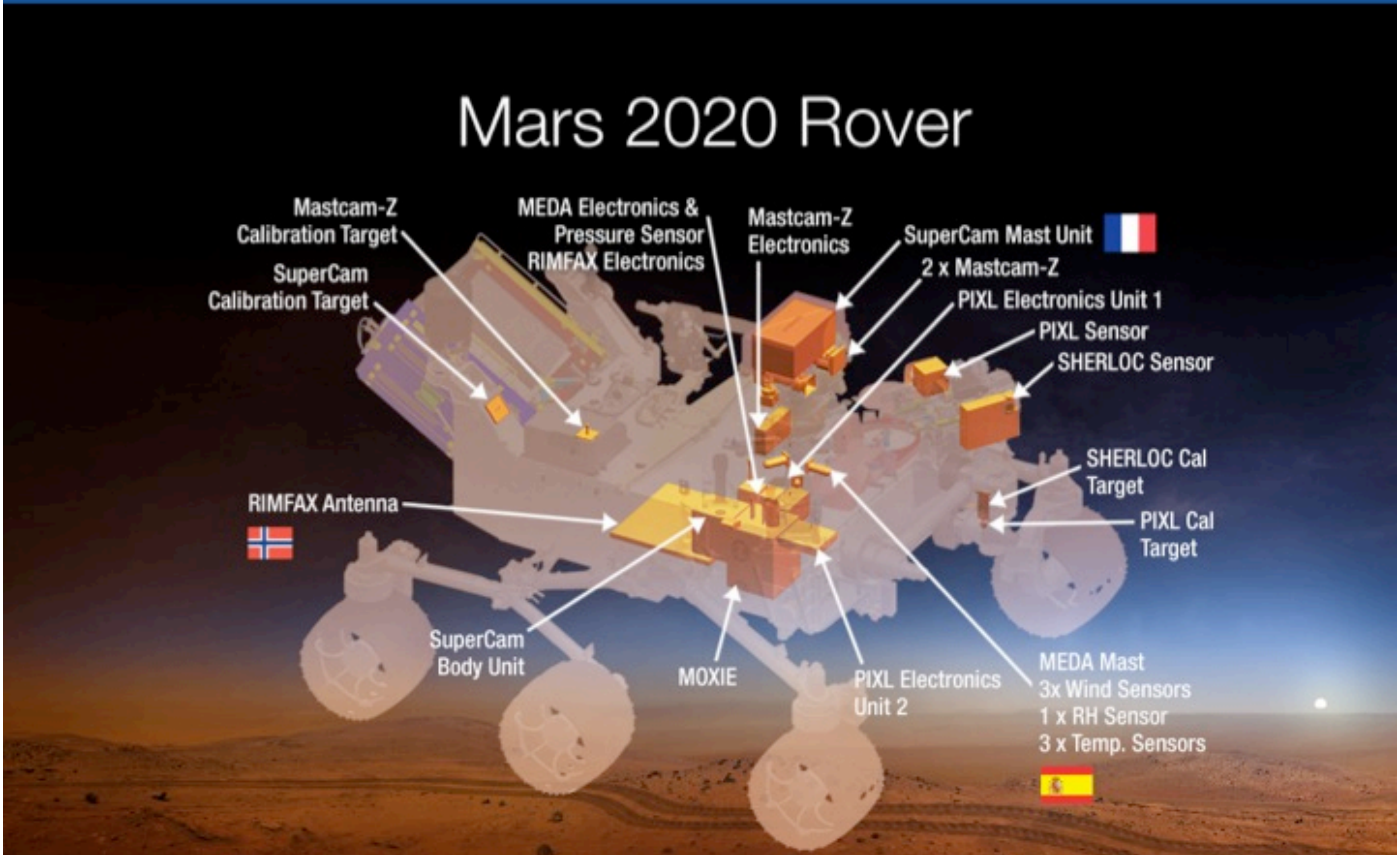




Rover System Resource Constraints

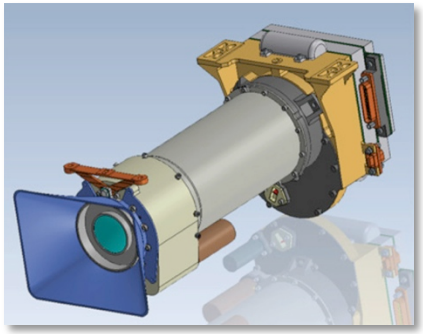
- Mass
- Power switches
- Analog sensors
- Data interfaces
- Actuators and contact sensors

Mars 2020 Selected Payload Suite



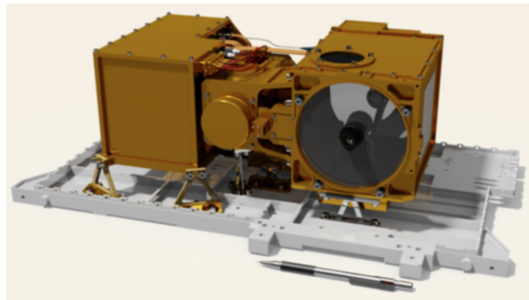
Remote Sensing Mast:
Context Imaging, Mineralogy, Chemistry, Organic Detection

Mastcam-Z

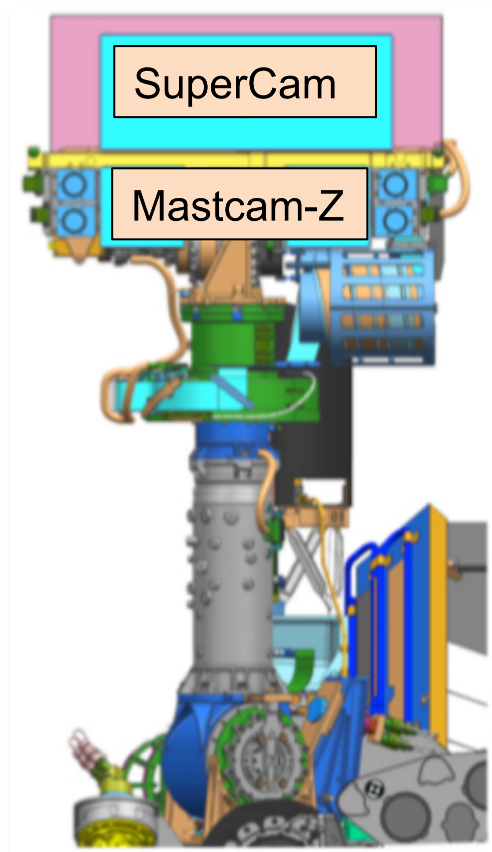


- J. Bell, AZ State Univ.
- Context imagery and mineralogy
- RGB and multispectral VNIR (400-1000 nm) stereo imaging

SuperCam

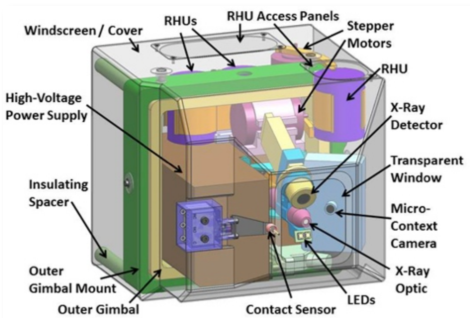


- R. Wiens, Los Alamos NL
- Context mineralogy, fine-scale imagery, mineralogy, and chemistry, organic detection
- RMI - ~25-250 μm/pixel at 1.2 to 12 m distance
- LIBS - 1064 nm laser
- RAMAN - 532 nm laser, 150-4400 cm-1
- VISIR - 0.3-0.9 μm, 1.3-2.6 μm



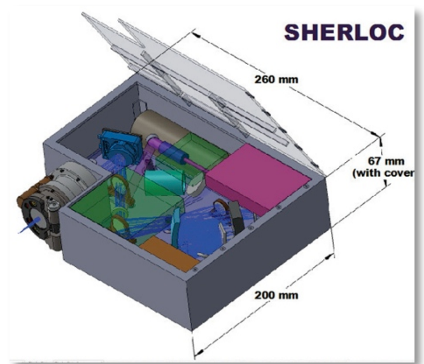
Robotic Arm Turret
Fine-scale Imaging, Mineralogy, Chemistry, Organic Detection

PIXL

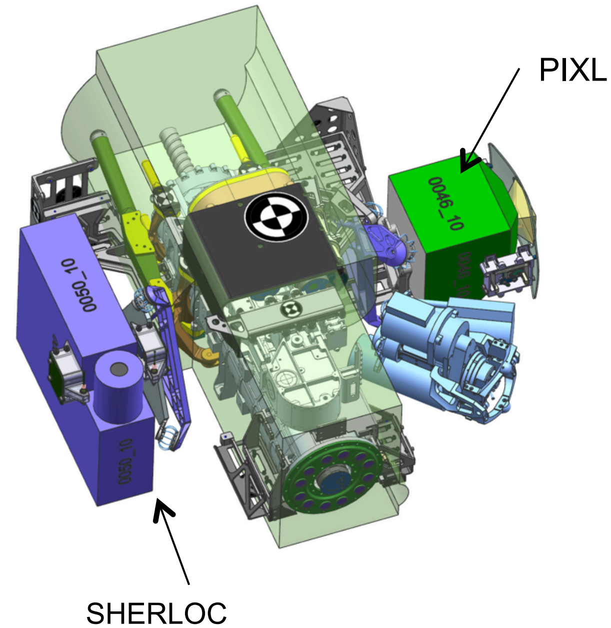


- A. Allwood, JPL
- Fine-scale imagery and chemistry
- 50 µm/pixel microcontext camera
- 100-µm spot, 0-28 keV

SHERLOC

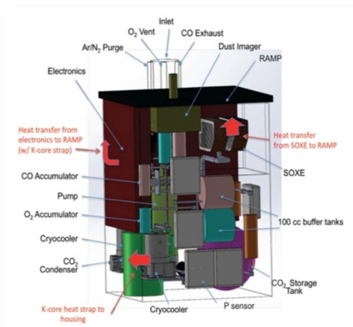


- L. Beagle, JPL
- Fine-scale imagery and mineralogy, organic detection
- Imager - 30 µm/pixel
- Raman - 248.6 nm laser, 252-274 nm, 50 µm spot size
- UV fluorescence - 274-354 nm, 50 µm spot size



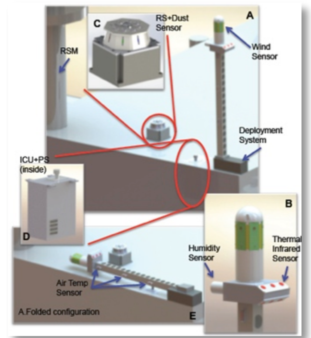
Rover Body
ISRU, Weather/Dust, Subsurface Sensing

MOXIE



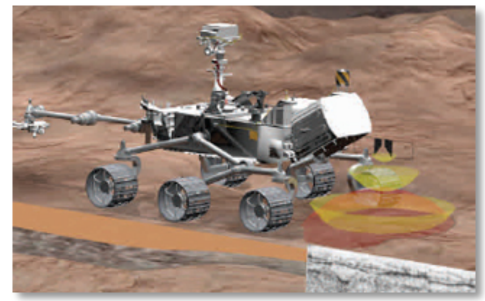
- M. Hecht, MIT
- ISRU
- Solid Oxide Electrolysis for producing O_2

MEDA



- J. Rodriquez-Manfredi, Centro de Astrobiologia (Spain)
- Temp/Pressure/Wind speed/Wind Direction
- Dust Characterization

RIMFAX



- S. Hamran, Forsvarets Forskningsinstitutt (Norway)
- Subsurface Sensing
- Ground penetrating radar for subsurface structure
- 150-1440 MHz
- 10 to 500 m penetration depth

Investigation Suite Functionalities

Functionalities Required	Mars 2020
Context imaging	Mastcam-Z
Context Mineralogy	SuperCam
Elemental Chemistry	PIXL/SuperCam
Fine-scale imaging	SHERLOC/SuperCam
Fine-scale mineralogy	SHERLOC/SuperCam
Organic Detection	
Science support equipment	Includes robotic arm, surface prep tool, coring/sampling drill, cache
Technology payload elements	Includes range trigger (and preserves option for TRN)
Threshold Total (Phase A-D)	**~100M**
Additional Instrument Options	RIMFAX
HEO/STMD contributed payload	MOXIE / MEDA
Baseline Total (Phase A-D)	**~105M (SMD)** **~31M (HEO/STMD)**

SDT Baseline and Threshold Options

A baseline mission would include one or more of the following (not listed in priority order):

- **Superior capabilities (e.g., resolution, range of minerals detected, accuracy) for instruments in the threshold measurements category: "superiority" to be evaluated in the instrument competition**
- **A second organic detection capability complementary to the first one**
- **An instrument that measures subsurface structure or composition**


MARS
#JOURNEYTOMARS