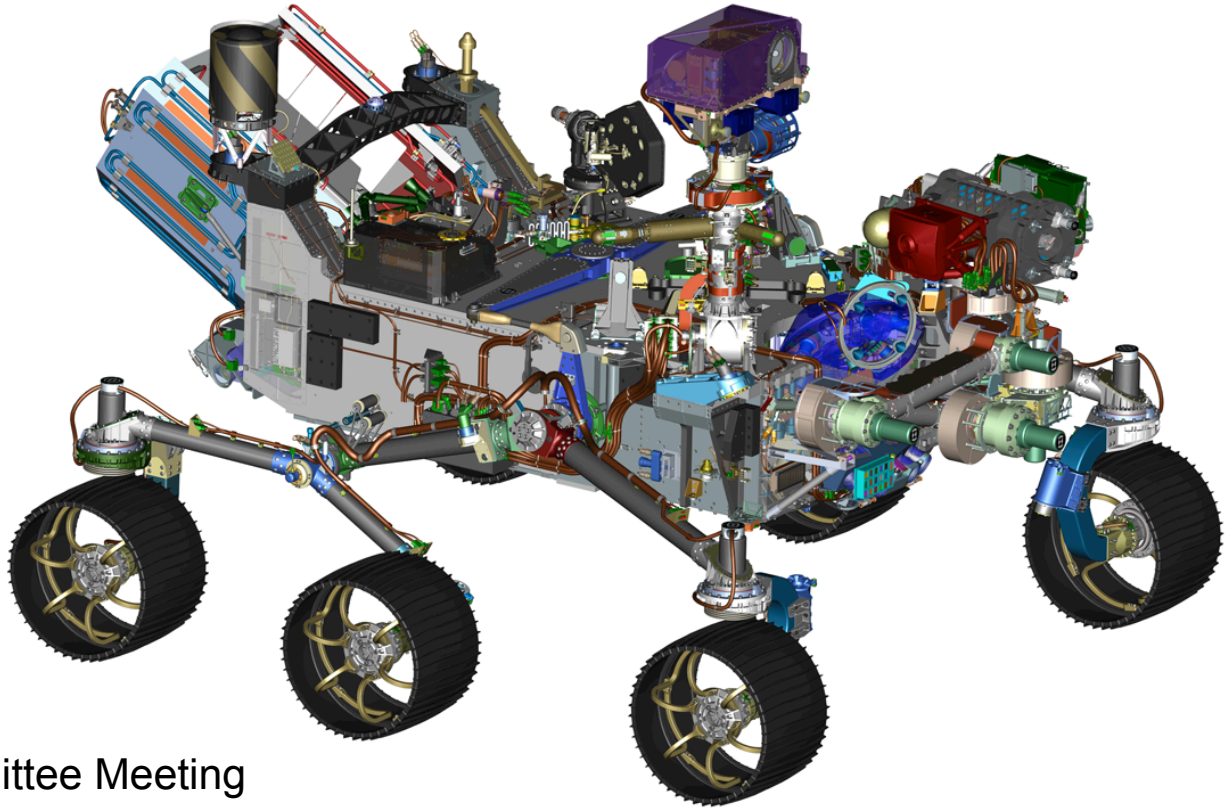
Mars 2020 Status Update

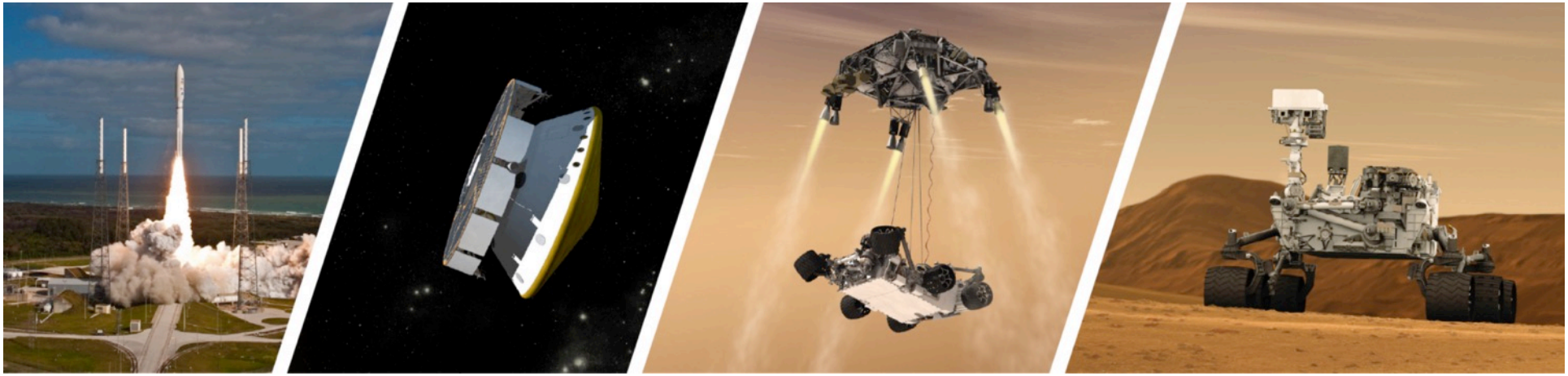
George Tahu
Program Executive

Ken Farley
Project Scientist



Planetary Science Subcommittee Meeting
September 29, 2016

Mission Overview



LAUNCH

- Atlas V 541 vehicle
- Launch Readiness Date: July 2020
- Launch window: July/August 2020

CRUISE/APPROACH

- ~7 month cruise
- Arrive Feb 2021

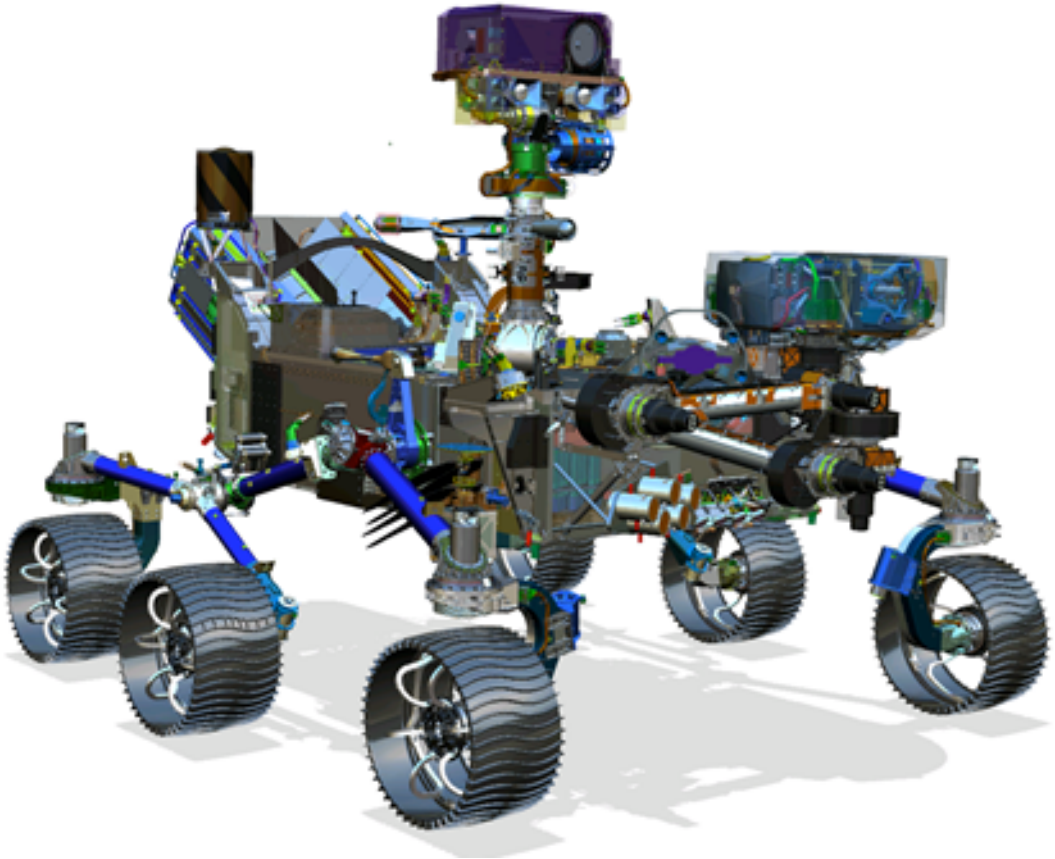
ENTRY, DESCENT & LANDING

- MSL EDL system (+ Range Trigger and Terrain Relative Navigation): guided entry and powered descent/Sky Crane
- 16 x 14 km landing ellipse (range trigger baselined)
- Access to landing sites ±30° latitude, ≤ -0.5 km elevation
- Curiosity-class Rover

SURFACE MISSION

- 20 km traverse distance capability
- Enhanced surface productivity
- Qualified to 1.5 Martian year lifetime
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

Mars 2020 Rover Concept



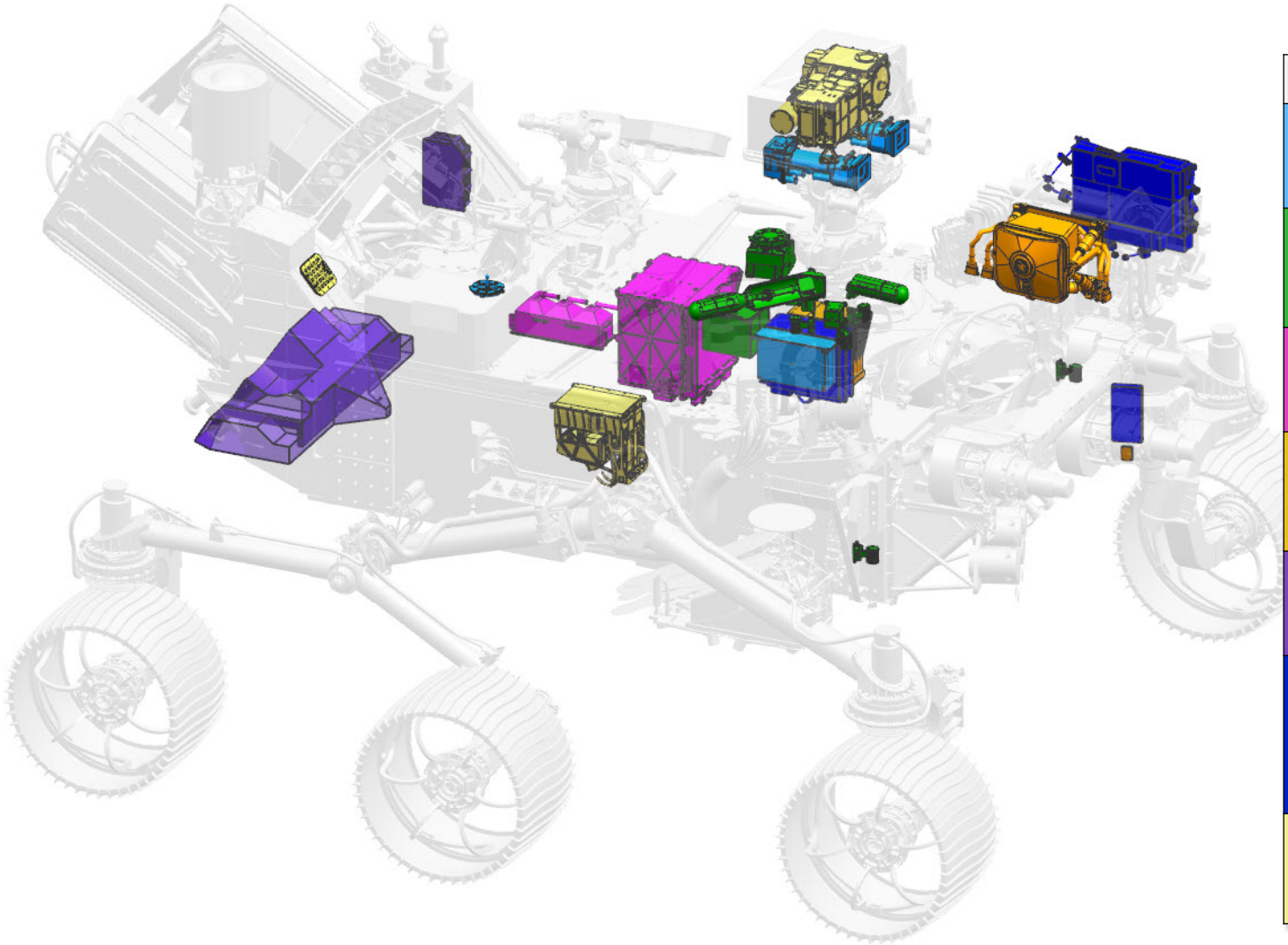
Stays the Same as MSL

- Avionics
- Power
- GN&C
- Telecom
- Thermal
- Mobility (for the most part; see below)

Changed

- New Science Instrument Suite
- New Sampling Caching System
- New Terrain Relative Navigation (TRN)
- New (gaseous) Dust Removal Tool (gDRT)
- Modified Chassis
- Modified Rover Harness
- Modified Surface Flight Software
- Modified Rover Motor Controller
- Modified Wheels
- Modified select mobility components (to support wheel and/or Rover mass changes)

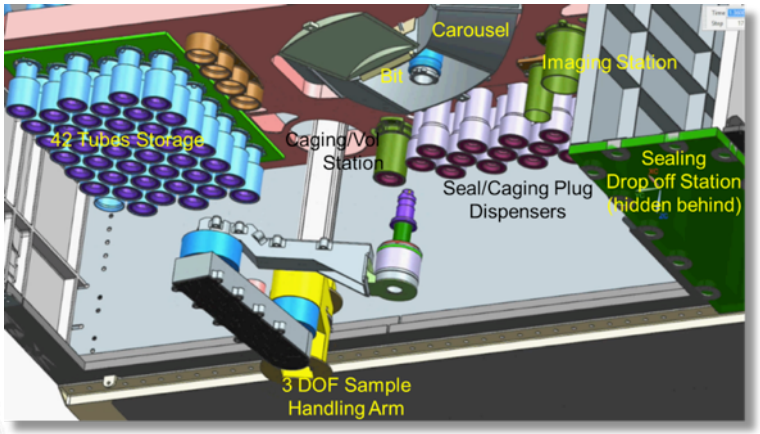
Mars 2020 Payload Family Picture



Instrument Key
Mastcam-Z Stereo Imager
MEDA Mars Environmental Measurement
MOXIE In-Situ Oxygen Production
PIXL Microfocus X-ray fluorescence spectrometer
RIMFAX Ground Penetrating Radar
SHERLOC Fluorescence and Raman spectrometer and Visible context imaging
SuperCam LIBS, Raman, VisIR spectroscopy Remote micro-imager

Sampling & Caching Subsystem

Caching Assembly



Bit Carousel
(part of ACA)

Adaptive Caching Assembly (ACA)
(internal to Rover)

Robotic Arm

Turret (Robotic Arm End Effector)
- Coring drill
- SHERLOC / WATSON Instrument
- PIXL Instrument

Mars 2020 Mission Objectives

- **Conduct Rigorous *In Situ* Science**

  A. **<u>Geologic Context and History</u>** Carry out an integrated set of context, contact, and spatially-coordinated measurements to characterize the geology of the landing site

  B. **<u>In Situ Astrobiology</u>** 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**

  C. **<u>Sample Return</u>** Assemble rigorously documented and returnable cached samples for possible return to Earth

  D. **<u>Human Exploration</u>** Facilitate future human exploration by making significant progress towards filling major strategic knowledge gaps and…

  <u>Technology</u> …demonstrate technology required for future Mars exploration

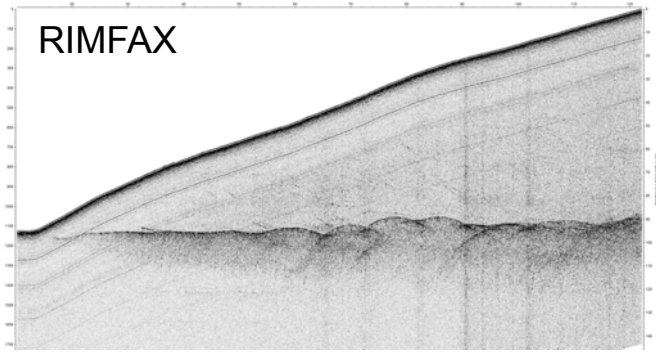
- **Execute Within Current Financial Realities**

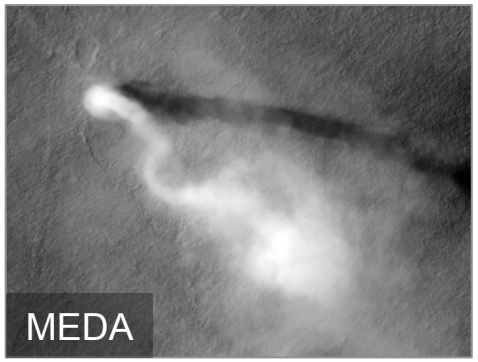
  – Utilize MSL-heritage design and a moderate instrument suite to stay within the resource constraints specified by NASA

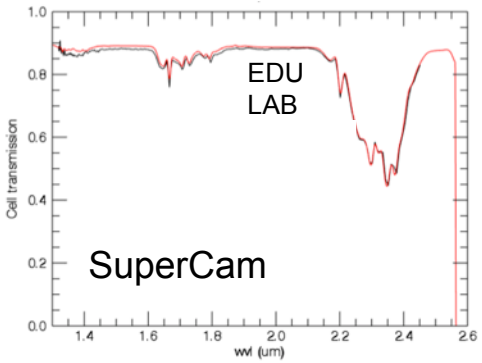
These are a thoroughly integrated set of objectives to support Agency's Journey to Mars

Scientific Exploration Model

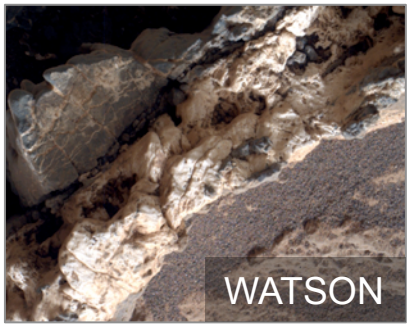
Develop the geologic and astrobiologic context of an ancient martian environment using observations made at a range of spatial scales, culminating in a search for potential biosignatures. Use the emerging model of deposition and alteration to guide the collection of samples that maximize opportunities to understand Mars as a planetary system and determine whether it was once inhabited.



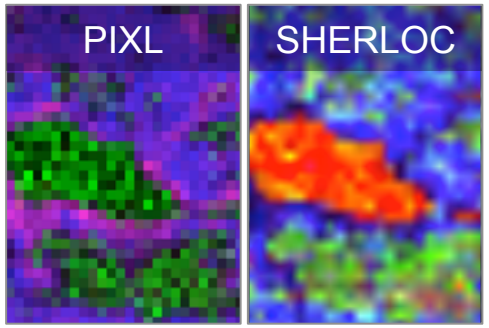




remote chemistry/mineralogy



proximity imaging

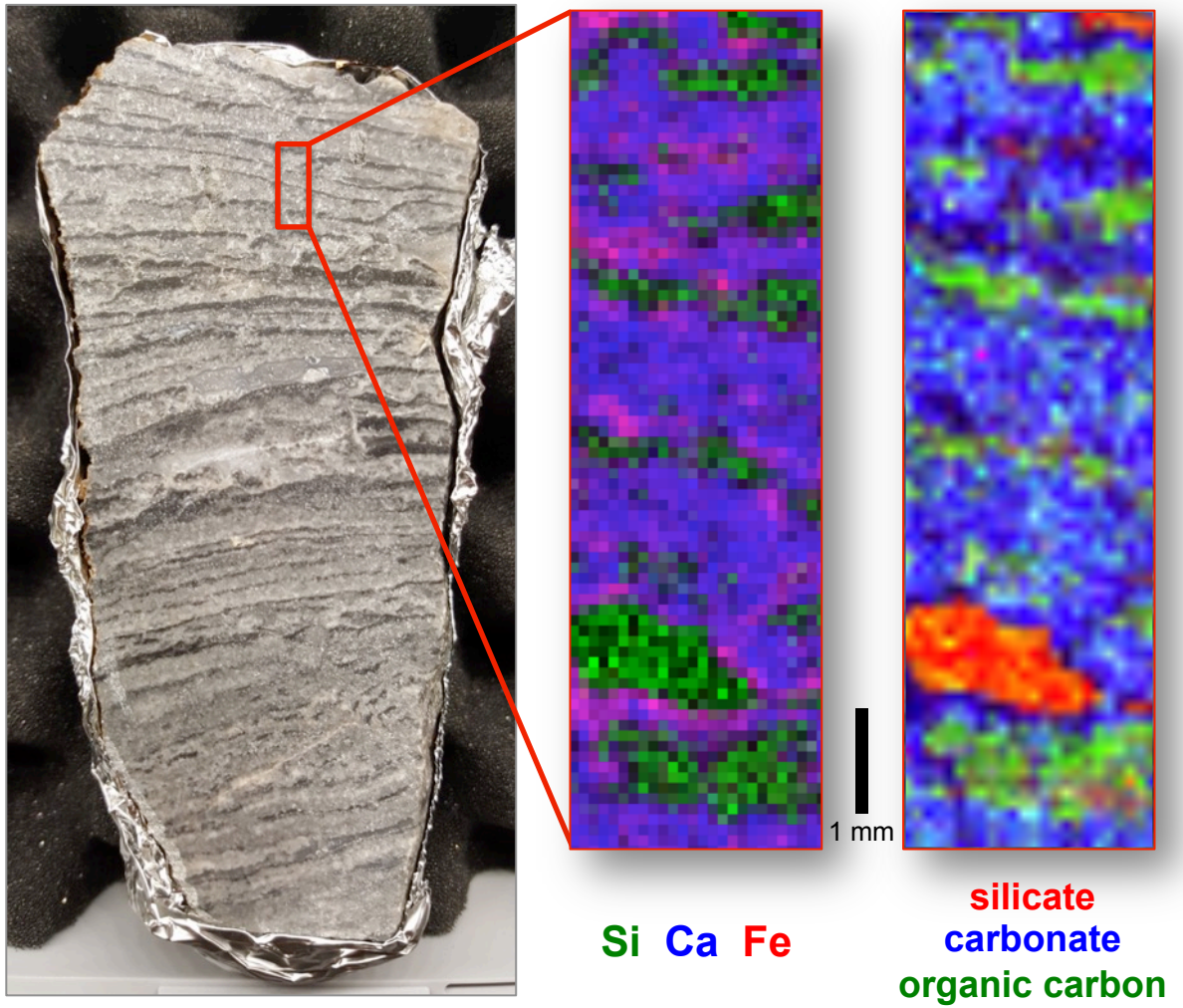


proximity chemical/mineral mapping

sampling and borehole science

Seeking Signs of Ancient Life

3.4 billion year old fossil microbial mat



PIXL

Si Ca Fe

SHERLOC

silicate
carbonate
organic carbon

1 mm

Strelley Pool stromatolites are among the oldest evidence for life on Earth, *equivalent in age to rocks at candidate Mars 2020 landing sites*. Coordinated PIXL and SHERLOC laboratory observations reveal:

- **sub-mm scale chemistry** following visible rock textures
- alternating **silicate** and **carbonate** layers with variable Fe
- **organic carbon** associated with silicate layers

When observed *in a geologic context indicating habitability*, this type of morphologically correlated chemical and mineralogic variation is a **powerful potential biosignature**.

Sample Integrity Requirements

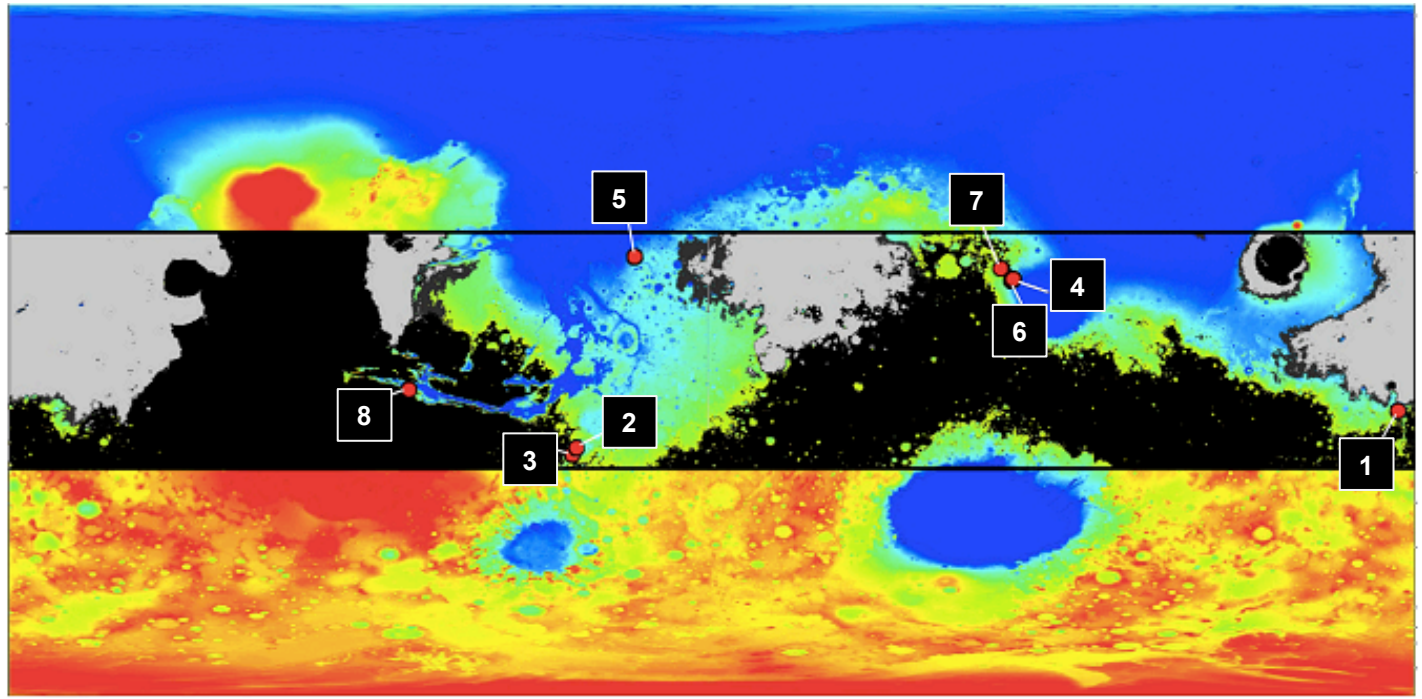
1. Physical characteristics of samples and environments
   - Sample mass, number of samples, fracture limits, environmental requirements
2. Inorganic contaminants
   - Limitations on levels of ~30 elements critical for scientific study of samples
3. Organic contaminants
   - Total organic carbon + critical "Tier 1" list + limit on any single compound
4. Biologic contamination
   a) tightly limit the number of cells per sample
   b) collect thorough genetic inventory and contaminant archive to facilitate recognition of any terrestrial hitchhikers
5. Thorough characterization and archiving of materials which may add inorganic, organic, or biologic contamination to samples
   - Critical information and archive supports potential future missions, and is necessary for the full diversity of investigations likely to be undertaken if samples are returned.

Sample Integrity Requirements

6. Procedural blank program to characterize inorganic, organic, and biologic contamination occurring at and after ATLO (round-trip contamination).
7. Thorough documentation of geology of landing site and drilled sample context
   - critical linkage to the in-situ investigation
   - context-rich samples are of far greater value than “grab” samples

Sample integrity requirements derived through an extensive interaction with the relevant community including the Organic Contamination Panel, the Returned Sample Science Board, and JSC Astromaterial Curation Lab

Where Are We Going?



Candidate landing sites
in alphabetical order

1. Columbia Hills[+]
2. Eberswalde*
3. Holden[+]
4. Jezero*
5. Mawrth[+]
6. NE Syrtis*
7. Nili Fossae[+]
8. SW Melas*

* TRN enables access
[+] TRN improves science

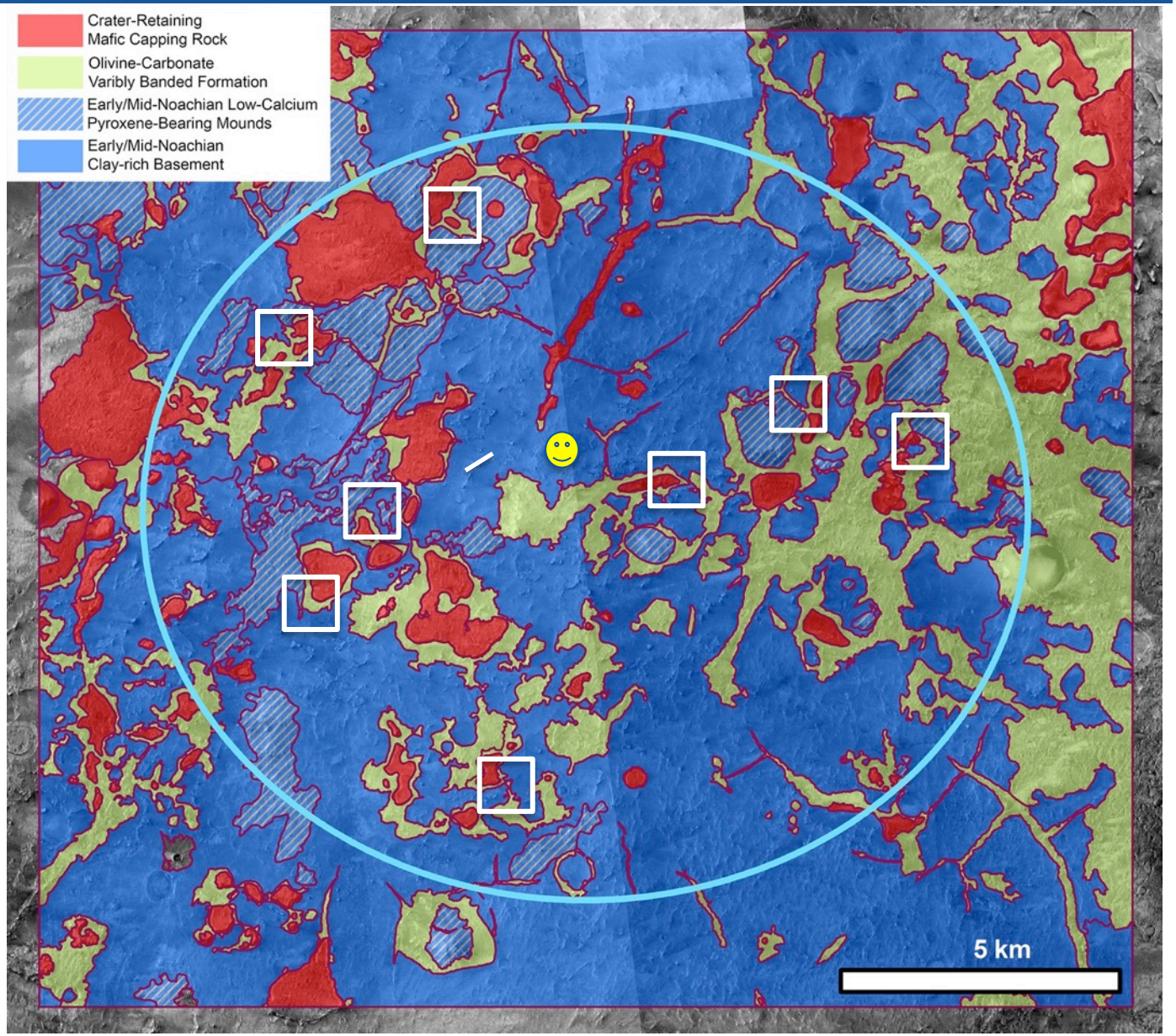
- Eight landing sites are currently under consideration; depositional models range from deltaic/lacustrine to hydrothermal. The selected site must provide *clear opportunities to safely and efficiently explore and sample geologically diverse regions with high potential to preserve signs of* **ancient** *life and planetary evolution*.
- With no mission objective or capability to investigate **extant** life, "special regions" are not under consideration for exploration.

Landing-Site-Specific Studies

- Developing scenarios for exploring Regions of Interest (ROIs) within each proposed landing site
- Collaborative effort with the site proposers to balance landing and traversability constraints with science objectives
- Feeds into Landing Site Workshop #3

Example: Jezero Crater

Note: boxes are approximately 1 km x 1 km and are placed only to illustrate the example, not as suggested ROIs



Returned Sample Science Board (RSSB)

Recent Activities of the RSS Board

1. Analysis of the maximum temperature samples can experience without significant science loss (during drilling and storage).

Answer: 60°C.

2. Analysis of the trade-offs between alternative strategies for assessing contamination in returned samples: drillable substrate vs. witness substrate.

Answer: witness blank strategy is adequate.

3. Analysis of the value of a "caging plug" in the sample tubes to limit sample movement during tube handling post-Mars 2020.

Answer: caging plug adds little/no value and can be removed from design.

Detailed RSS Board reports on these and other topics are available upon request (most have been published and/or presented at scientific conferences)

Redesigned Wheel Tests Ongoing:
Sandy Slope Testing in Mars Yard

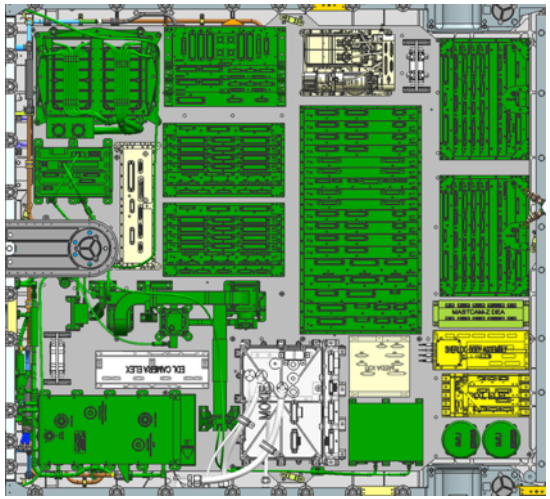
- Scarecrow full vehicle slope climb test campaign #1 completed
- MSL design vs. M2020 candidate designs vs. Mixed Configurations tested @ 13.5deg & 10deg
- All M2020 candidate designs performed as well or better than the all-MSL wheel configuration

Technical Resources

- Project is closely watching Rover mass and turret mass
- Current design fits within available power, energy, volume, power switch, pyro circuits, analog, thermal, sensor, and command/data interfaces, <u>but with no additional scope capacity in many cases</u>

Key Resources	CBE	Allocation (power system capability)	Margin (%) = (Allocation-CBE) / Allocation	Required Margin (%) at PDR
Launch Energy (Nominal Launch, max %DOD)	31	70	56%	13%
Late Cruise Power (W)	983	1158	15%	13%
EDL Energy (Rover Battery, max %DOD)	2.9	20	86%	13%
Surface Energy Balance – 500WH day (Wh)	1777	2509	29%	17%
Surface High Energy – 1500WH day(Wh)	1777	4116	57%	17%

	Allocation (kg)	CBE (kg)	Uncertainty of CBE (%)	CBE + Unc. (kg)
1.C.3 Landed Mass	**1050**	**914**	**11%**	**1013**
1. Heritage Rover Guts	208	203	2%	208
"Mod" 2. Rover Chassis	204	180	14%	204
"Mod" 3. Rover Mobility	259	248	4%	259
"Mod" 4. RSM Mechanical	37	34	8%	37
"Mod" 5. Rover System Harness	55	46	20%	55
"New" 6. Navcam & Hazcam	8	6.0	25%	7.5
"New" 7. SCS/Caching	68	51	33%	68
"New" 8. SCS/Robotic Arm	78	67	16%	78
"New" 9. SCS/Turret+Corer, etc.	28	24	16%	28
"New" 10. Payload (on Turret)	12	9.2	24%	11
"New" 11. Payload (on RSM)	10	9.2	10%	10
"New" 12. Payload (not on Turret)	37	30	23%	37
"New" 13. TRN (VCE/LCAM)	6	5.4	8%	5.8
14. Balance Mass	10			3
PM unencumbered allocation	29			



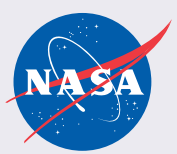
	Allocation (kg)	CBE (kg)	Uncertainty of CBE (%)	PBE = CBE + Unc. (kg)
1 Launch Mass (wet)	4050	3866	4%	4009
1.A Cruise Stage Prop	72	72	-	72
1.B EDL System Prop	401	401	-	401
1.C Launch Mass (dry)	3577	3393	4%	3536
1.C.1 Heritage Cruise Stage (dry)	472	466	1%	472
1.C.2 EDL System (dry)	**2055**	**2014**	**2%**	**2052**
1. Heritage EDL System	1689	1673	1%	1690
Heritage a. Descent Stage	676	670	1%	676
Heritage b. Parachute + Lid	61	60	1%	61
Heritage c. Heatshield	433	428	1%	432
Heritage d. Backshell	520	515	1%	520
"New" 2. MEDLI2	30	22	24%	27
"New" 3. EDLCameras - DS/BS	7	5	20%	6
4. CBM	154	146	5%	154
5. EBM	175	168	4%	175
1.C.3 Landed Rover Mass	**1050**	**914**	**11%**	**1013**

Mars 2020 Status

- Atlas V 541 launch vehicle selection announced August 25.
- Terrain Relative Navigation (TRN) has been added to the baseline mission under a collaboration with STMD. Addition of TRN can augment surface productivity improvements by allowing access to landing sites with Regions of Interest in close proximity.
- Microphone capability has been baselined with the EDL cameras and on SuperCam
- Surface operation productivity improvements have been identified, prioritized, and baselined
  - 1.5 Mars year hardware qualification
  - 5 hour tactical timeline
  - Faster traverse using TRN avionics for image processing and navigation
  - On-board autonomy for traverse planning and remote science productivity
- Helicopter technology demonstration is being considered for addition to the mission
  - Solar powered, with demonstration objective of 5 autonomous flights
  - Mars 2020 Project conducted accommodation study during Phase B
  - Technology development and testbed unit flights ongoing during FY16
  - Decision whether to add this tech demo to the baseline should be made by CDR.
- Costs performance on heritage hardware continues to be on or under plan
- Cost estimates for new developments (i.e., the instrument payload and Sample Caching System) incorporated known cost growth into the baseline and provide acceptable cost and schedule margins —payload and Sample Caching System remain critical path developments
- Project is proceeding with critical design of flight system and payload, along with continued procurements and builds of heritage elements in order to buy down risk.

Project continues to make excellent progress, with plenty of challenging work still ahead. Critical Design Reviews scheduled through Fall/Winter.

Timeline to Critical Design Review



- 2-4 Feb 2016 - Project Preliminary Design Review (PDR)
- Feb 24 2016 - KDP-C JPL Center Management Council
- 30 Mar 2016 - KDP-C SMD Program Management Council
- 27 Apr 2016 - KDP-C Agency Program Management Council
- 27 June 2016 - Phase C Start
- 25 Aug 2016 - Launch Vehicle Selection – Atlas V 541
- 29-30 Aug 2016 - Contamination Control/Planetary Protection Working Group mtg
- 7-9 Sept 2016 - Interagency Nuclear Safety Review Panel Kickoff Meeting
- Sept'16-Feb'17 - Payload and Flight Subsystem Pre-CDR reviews
- 6-8 Feb 2017 - 3rd Landing Site Workshop
- Feb 2017 - Project Critical Design Review (CDR)