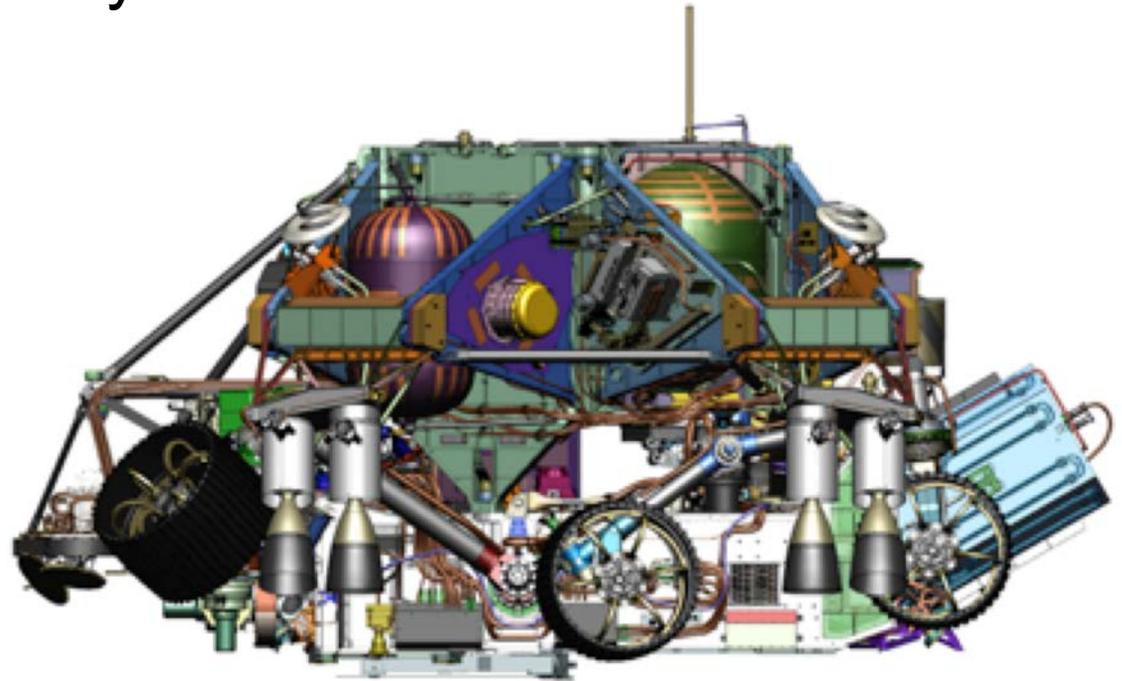


Mars 2020 Entry, Descent, and Landing Update

15th International Planetary Probe Workshop

Boulder, CO
June 2018

Erisa Stille, Paul Brugarolas,
Allen Chen, Richard Otero,
Aaron Stehura, Gregorio Villar





Mars 2020 Mission Overview

2018 • IPPW 15



LAUNCH

- Atlas V 541 Rocket
- Period: Jul-Aug 2020

CRUISE/APPROACH

- ~7 month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL System: guided entry, powered descent, and sky crane
- Augmented by **range trigger**: 16 x 14 km landing ellipse
- Augmented by **TRN**: enables safe landing at a greater number of scientifically valuable sites
- Access to landing sites $\pm 30^\circ$ latitude, ≤ -0.5 km elevation
- Deliver a 1050 kg rover

SURFACE MISSION

- Prime mission of 1.5 Mars years
- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

Mars 2020 Objectives



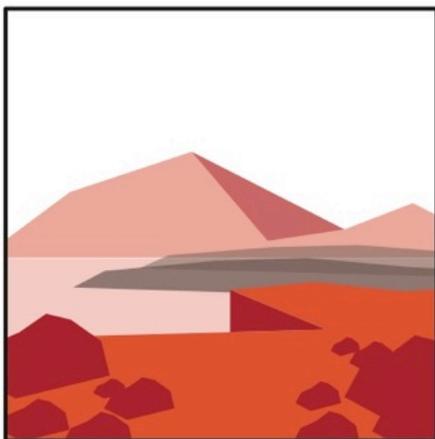
Understanding the Possibilities for Life on Mars

Ancient Microbial Life

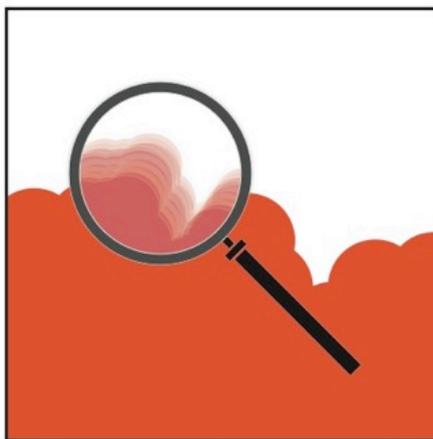


Human Life

OBJECTIVE A:
Habitability



OBJECTIVE B:
Biosignatures



OBJECTIVE C:
Sample Caching



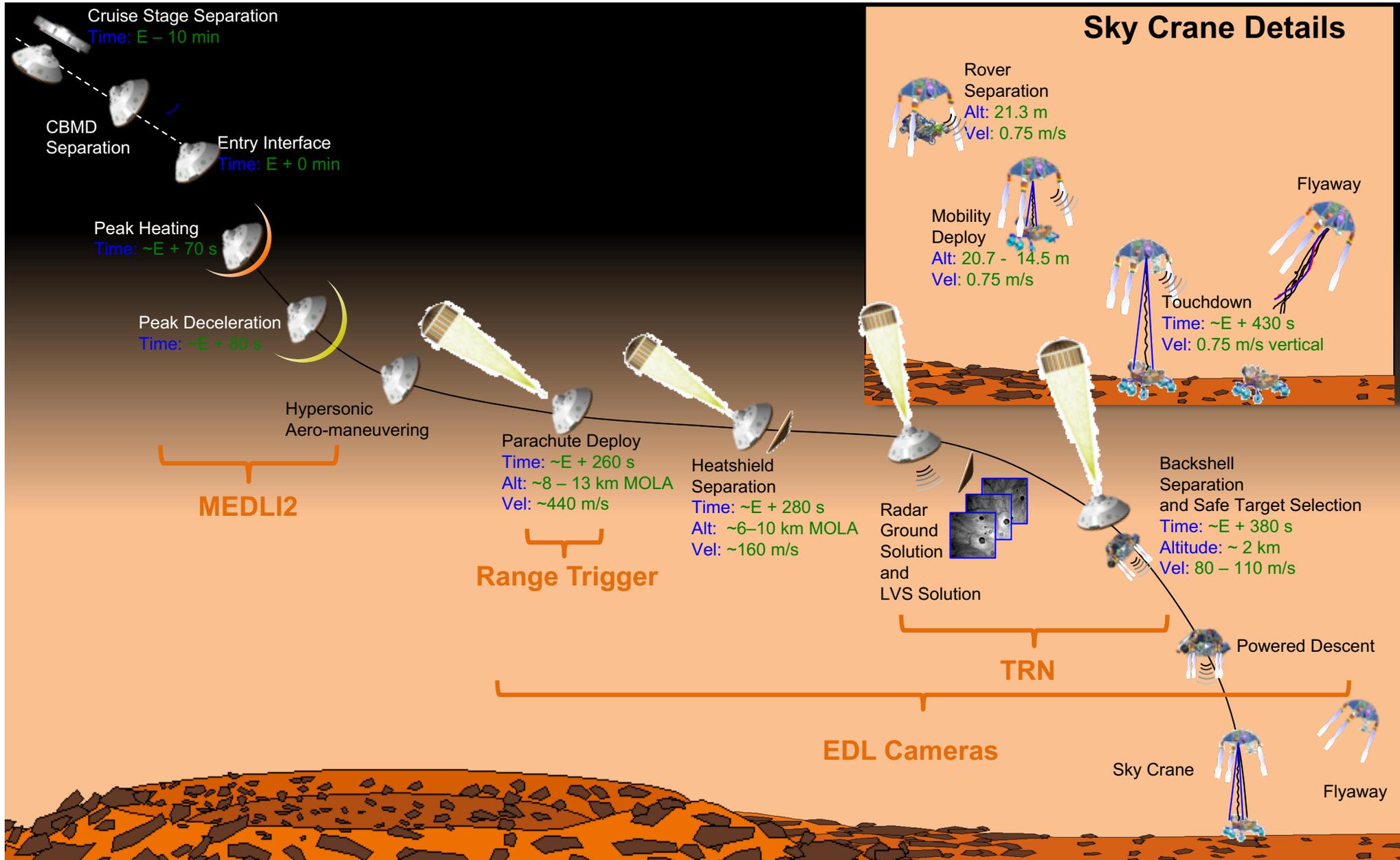
OBJECTIVE D:
Prepare for Humans





EDL Timeline

2018 • IPPW 15

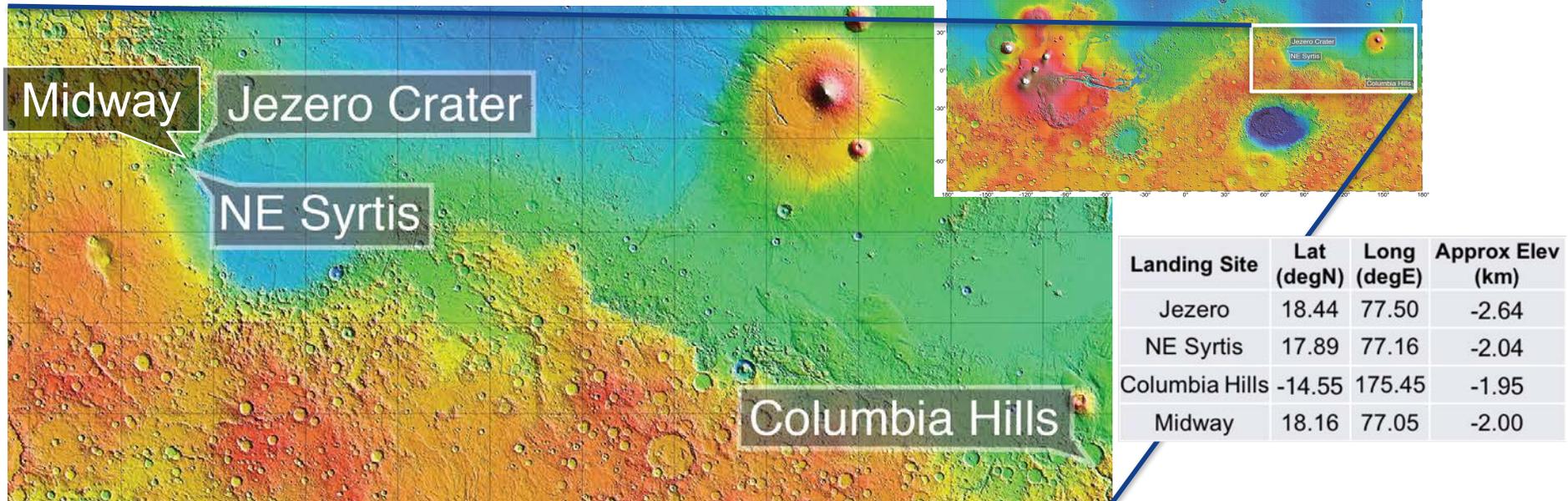




Landing Site Selection

2018 • IPPW 15

- A fourth candidate site, Midway, has been added for evaluation by the engineering and science teams
- Terrain and Atmosphere reviews completed in the past year; several improvements to rock identification have been incorporated
- EDL is currently evaluating landing site safety in support of the 4th landing site workshop this Fall, with final site selection expected in early 2019 by NASA HQ
- All sites are expected to have acceptable risk





TRN Development Status

2018 • IPPW 15

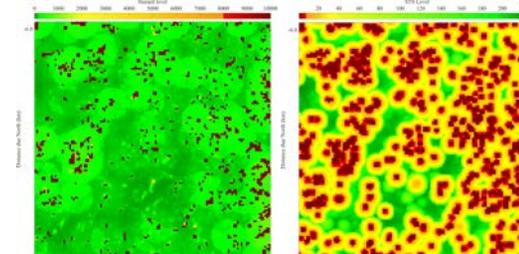
- Terrain Relative Navigation (TRN), Vision Compute Element (VCE), and VCE SW design reviews are complete
- Design has matured and hardware and software deliveries are in progress
 - VCE engineering dev units (EDU) delivered; EM and FM builds are in progress; LVS Camera (LCAM) EM1 delivered
 - Box-level software design is ongoing and expected to be part of 2019 field test
 - System-level software design is finalized and being tested
- Monte Carlo simulations have exercised the TRN capability using a Safe Targets Map (STM) and generated successful landing metrics based on the hazard map
- Full SW testing and delivery to ATLO happening Fall 2018
 - ATLO testing in Jan 2019
 - Field testing in Feb 2019



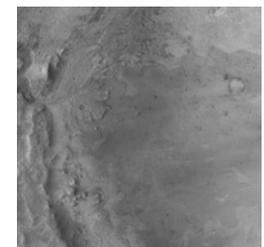
LCAM EM1
calibration image



VCE EDU4 FPGA Card



Jezero site: hazard map vs. STM

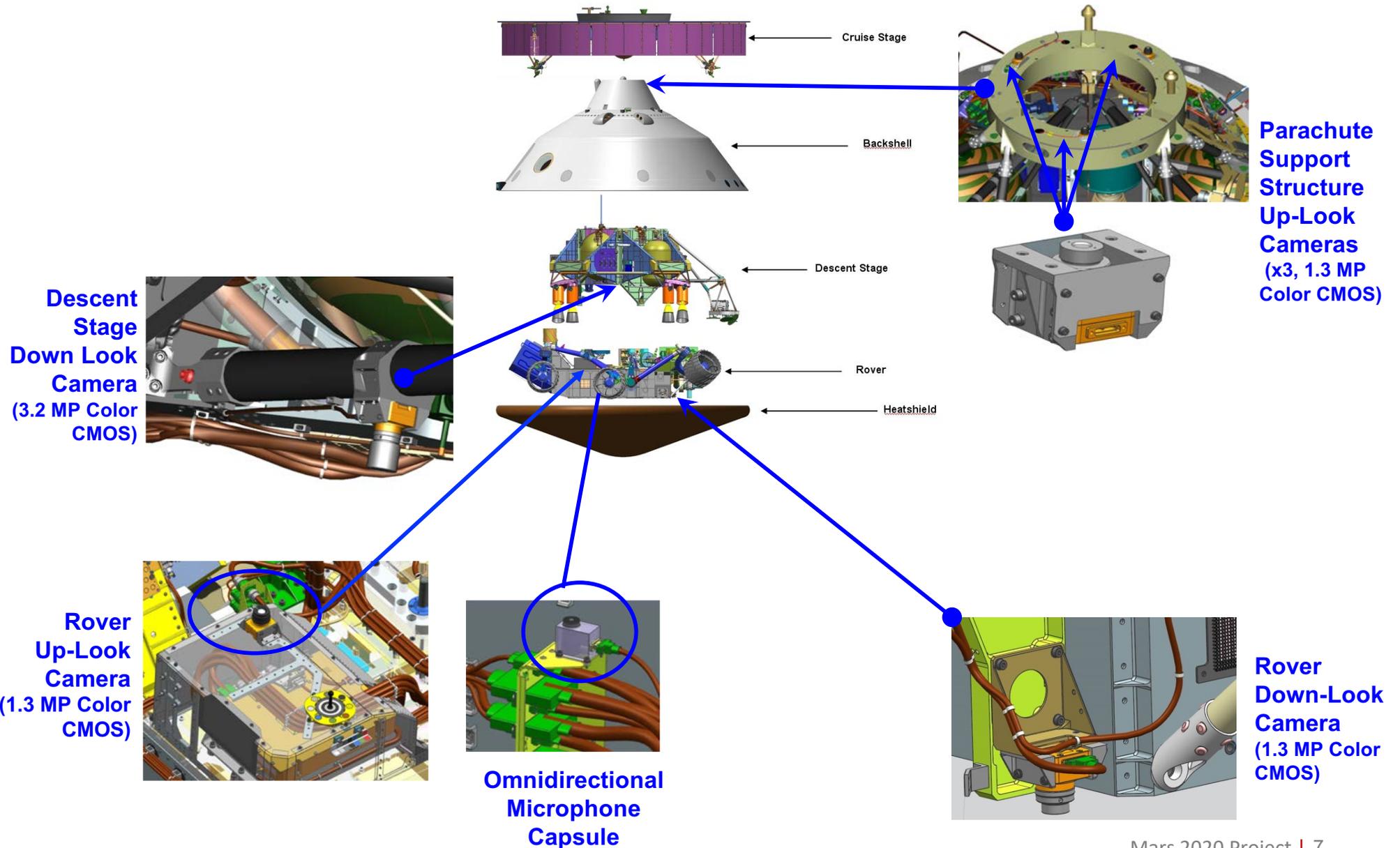


Jezero Mosaic,
example of onboard
appearance map for
TRN



EDL Camera Overview

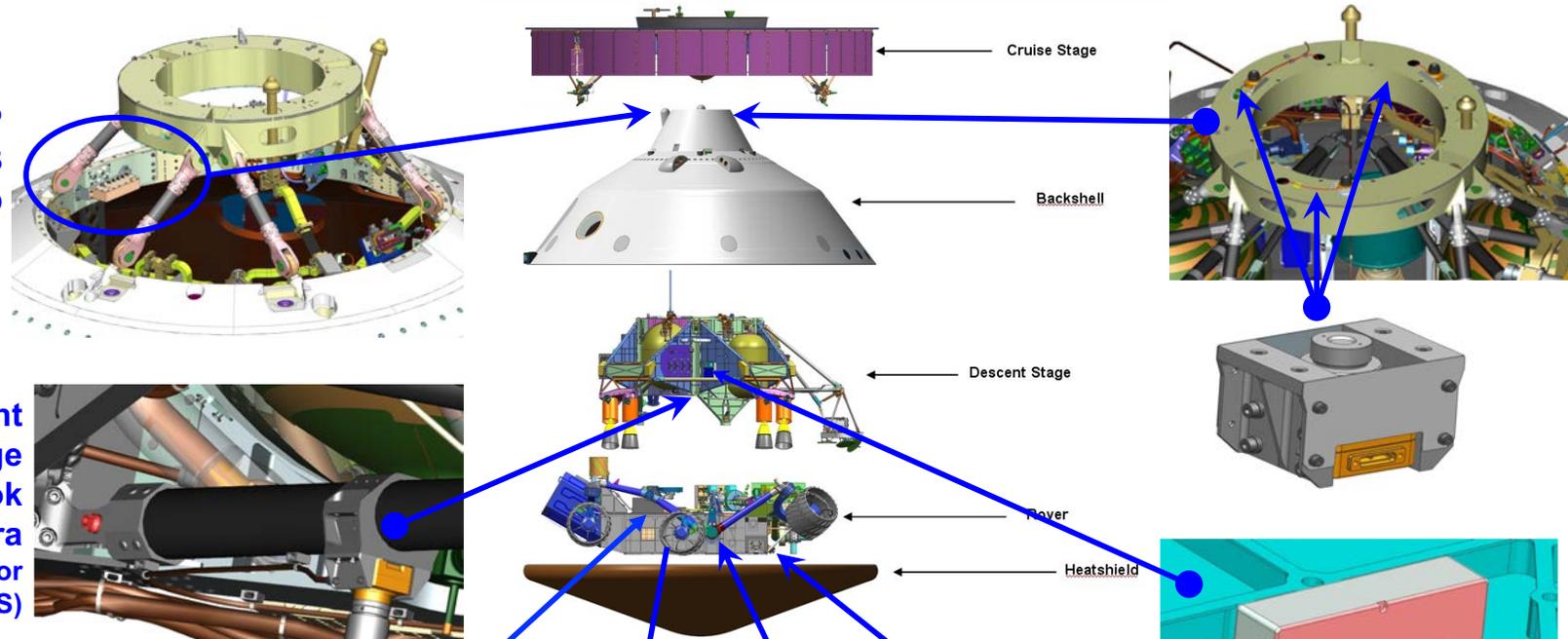
2018 • IPPW 15



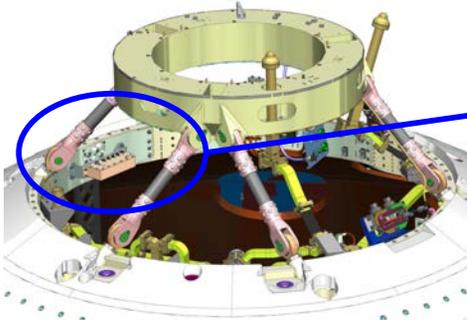


EDL Camera Overview

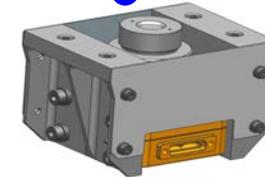
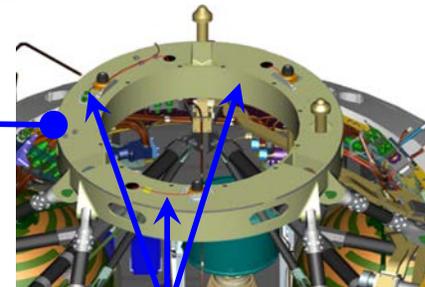
2018 • IPPW 15



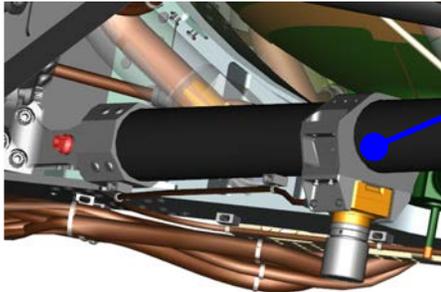
**BIP
USB3
Hub**



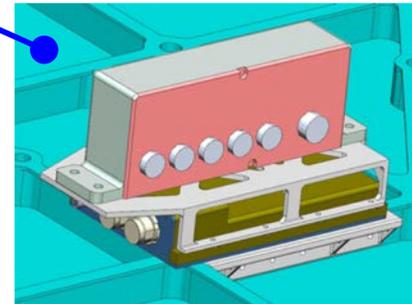
**Parachute
Support
Structure
Up-Look
Cameras
(x3, 1.3 MP
Color CMOS)**



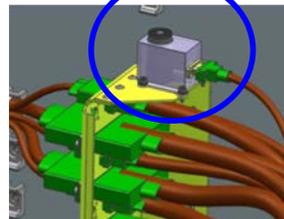
**Descent
Stage
Down Look
Camera
(3.2 MP Color
CMOS)**



**Descent
Stage
USB3 Hub &
Data
Storage Unit**

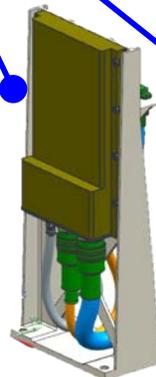


**Rover
Up-Look
Camera
(1.3 MP Color
CMOS)**

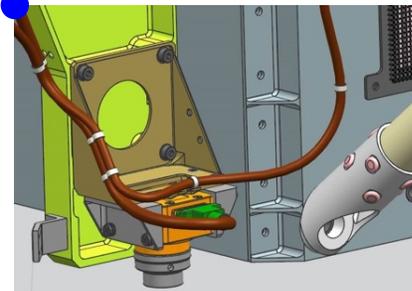


**Omnidirectional
Microphone
Capsule**

**EDL Camera Data
Storage Unit
(Rover Internal)**



**Rover
Down-Look
Camera
(1.3 MP Color
CMOS)**





Mars Helicopter

2018 • IPPW 15

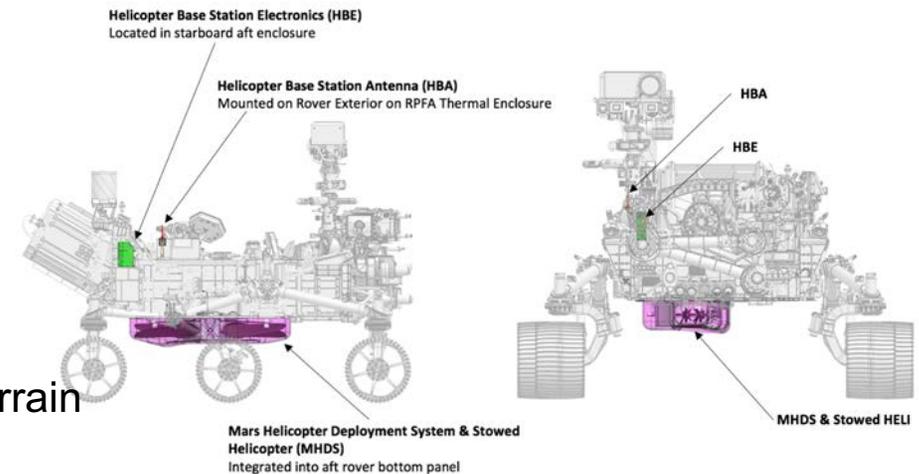
■ Mars Helicopter is now officially part of the Mars 2020 Mission

■ Overview:

- Mass: ~1.8kg
- Approx. 1.1m x 0.25m x 0.02m
- Dual counter-rotating blades (L = 1.21m)
- Solar powered with lithium-ion battery
- B&W camera for nav; color camera for terrain

■ Concept of Operations

- The helicopter will be “dropped off” at a relatively flat location.
 - 5 tech demo flights in 30-sol period of 30-120 sec each
- EDL Impact: due to its location, the helicopter increases the risk due to a rock strike by ~0.5-1%



Credits: NASA/JPL-Caltech

Mars 2020 Project | 9



ATLO Hardware Status

2018 • IPPW 15

- Major hardware integration on the cruise and descent stage is complete (thermal, propulsion) or in progress (e.g. GNC sensor integration)
- First power on occurred in April
- System testing begins February 2019

Descent Stage



CS Propulsion Tanks and Power Dist Module Installed



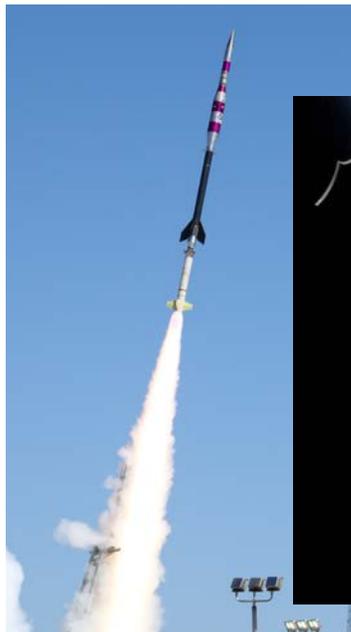
Credits: NASA/JPL-Caltech



Supersonic Parachute Testing Status

2018 • IPPW 15

- Mars 2020 is doing supersonic parachute testing as a risk reduction activity for canopy stresses during the inflation process
- One flight test each of the MSL design and a strengthened Mars 2020 design have been successfully completed
 - 2nd flight was highest load ever survived by a supersonic parachute! (56 klb/ 249 kN)
- A third flight test, 2nd of the strengthened design, at a margined load condition is planned for late July 2018; target load will be even higher than the prior flight



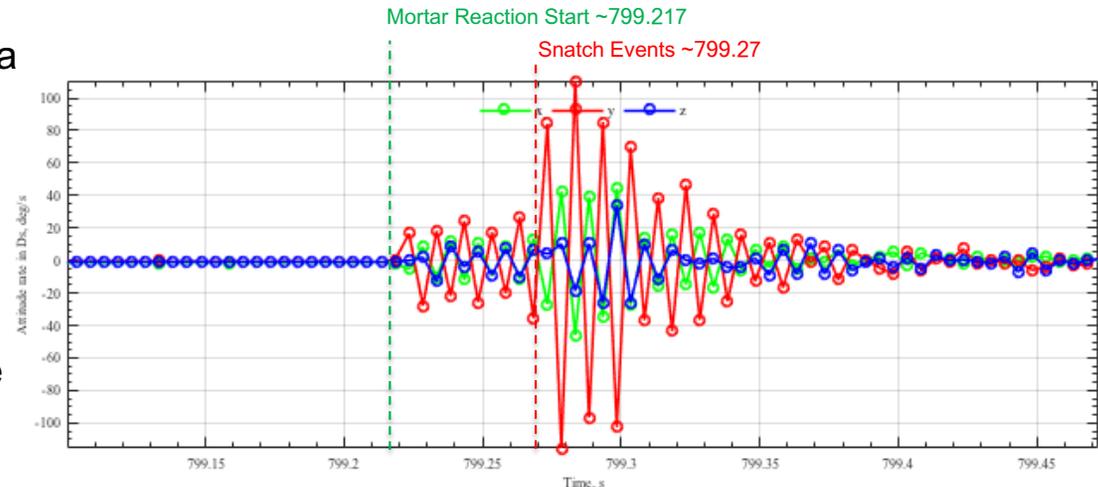


Issues in Work (1/2)

2018 • IPPW 15

■ Parachute Deployment Snatch Forces Disturbance on Descent IMU

- Recent analysis of the MSL flight data revealed an excitation that caused unexpected large rates ($120^\circ/\text{s}$)
- The timing suggests it is likely due to a snatch event associated with the mortar sabot and/or the confluence fitting (hardware connecting the triple bridle to the parachute single riser)



- There are concerns this excitation could cause temporary IMU saturation and/or navigation errors which can lead to large EDL attitude errors and potentially loss of mission
- Mitigations
 - Mechanical design changes are being considered to reduce the magnitude or coupling of the disturbance; these include softer triple bridles, a lighter confluence fitting, adding mass to the descent stage panel where the IMU is mounted, etc.
 - The primary GNC mitigation being considered is enabling a low pass filter in the IMU; there is also the potential to use the Rover IMU (lower quality data, less susceptible to saturation) as a sanity check on the descent IMU.



Issues in Work (2/2)

2018 • IPPW 15

■ Heatshield Static Test Failure

- The flight heatshield developed a circumferential crack during static testing in March
- Root cause is still under investigation while Project is moving to build a replacement heatshield
- Adequate schedule margin exists to build the new heatshield and still meet the Mars 2020 launch opportunity



Summary

2018 • IPPW 15

- Mars 2020 Project development is making good progress and continues to be on track for the 2020 launch opportunity
- Landing Site Selection efforts will likely wrap up this year, leading to a final site selection by NASA HQ in early 2019
- The EDL team continues to work technical issues while supporting hardware deliveries, FSW testing, and the start of activities in ATLO