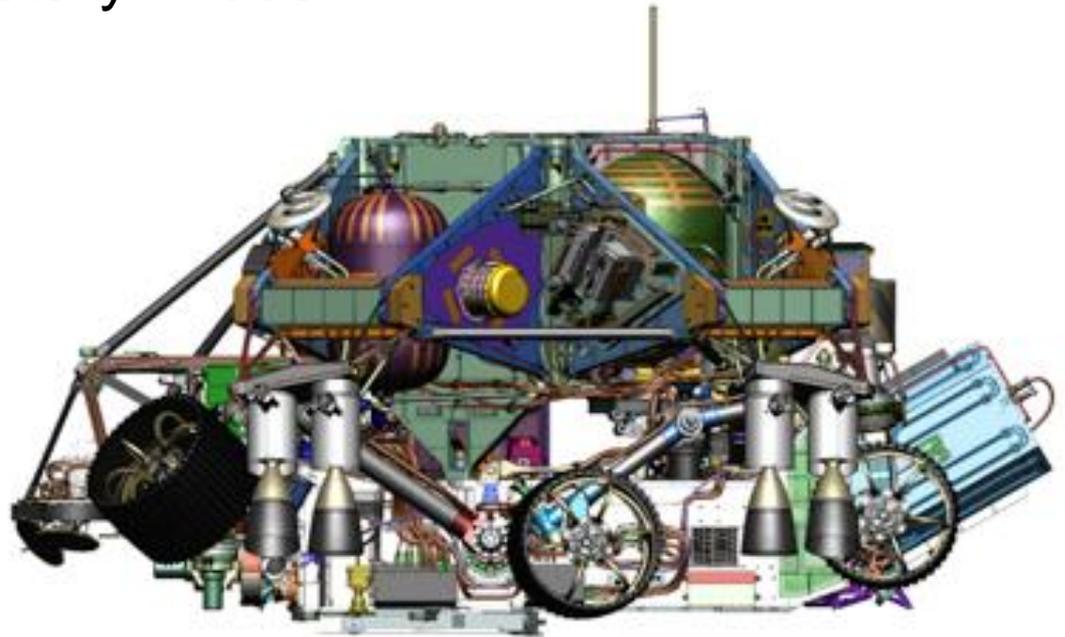


# Mars 2020 Entry, Descent, and Landing Update

## 15<sup>th</sup> International Planetary Probe Workshop

Boulder, CO  
June 2018

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





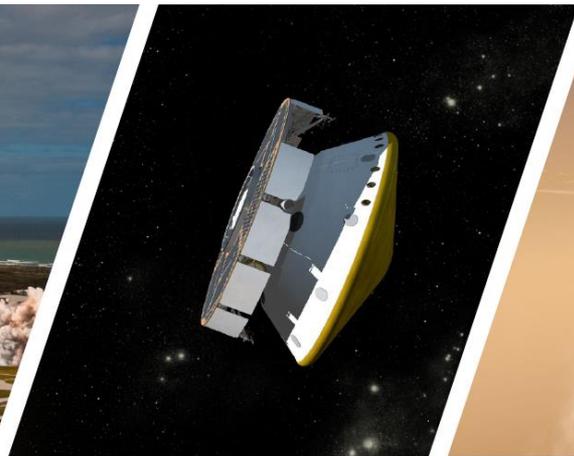
# Mars 2020 Mission Overview

2018 • IPPW 15



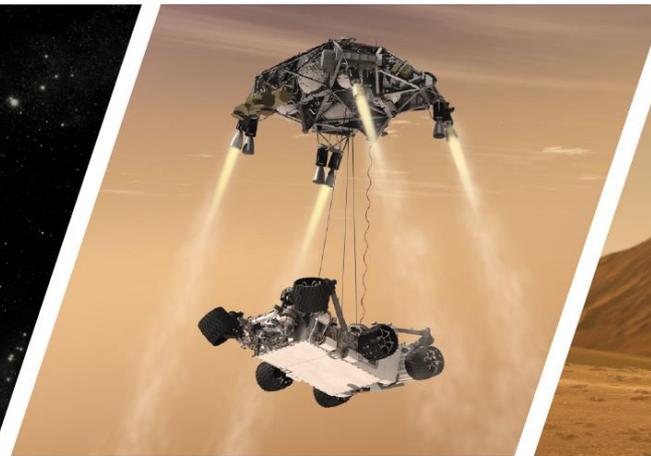
## LAUNCH

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



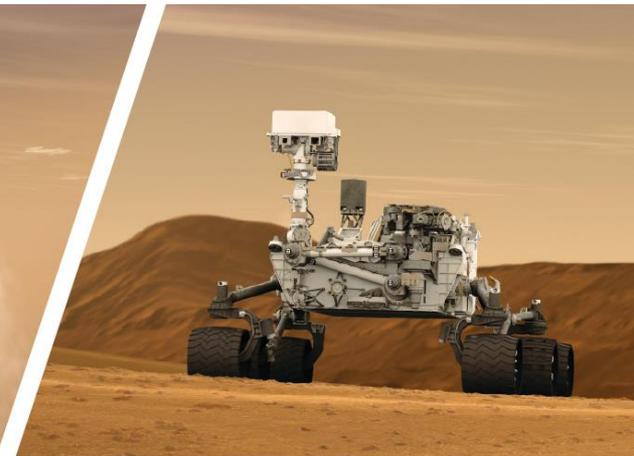
## CRUISE/APPROACH

- ~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,  $\leq -0.5$  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



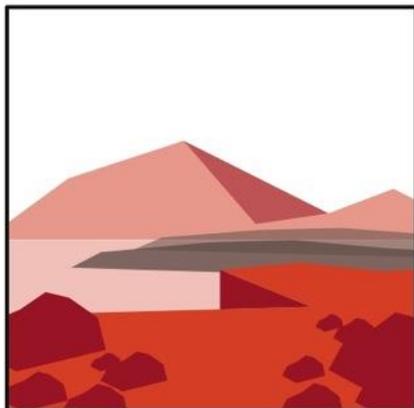
## Understanding the Possibilities for Life on Mars

Ancient Microbial Life

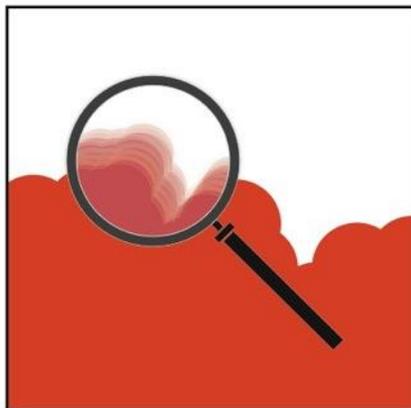


Human Life

**OBJECTIVE A:  
Habitability**



**OBJECTIVE B:  
Biosignatures**



**OBJECTIVE C:  
Sample Caching**



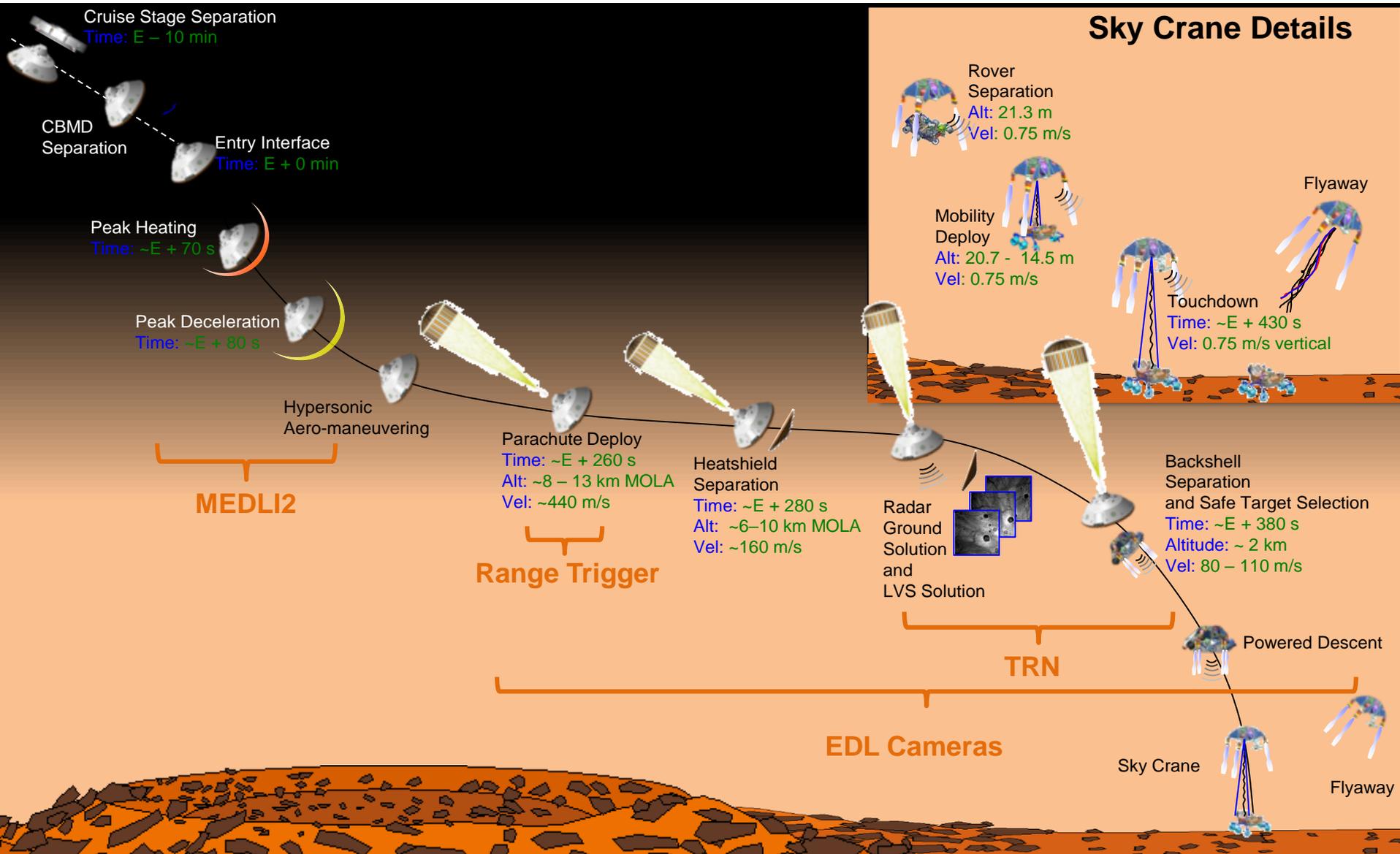
**OBJECTIVE D:  
Prepare for Humans**





# EDL Timeline

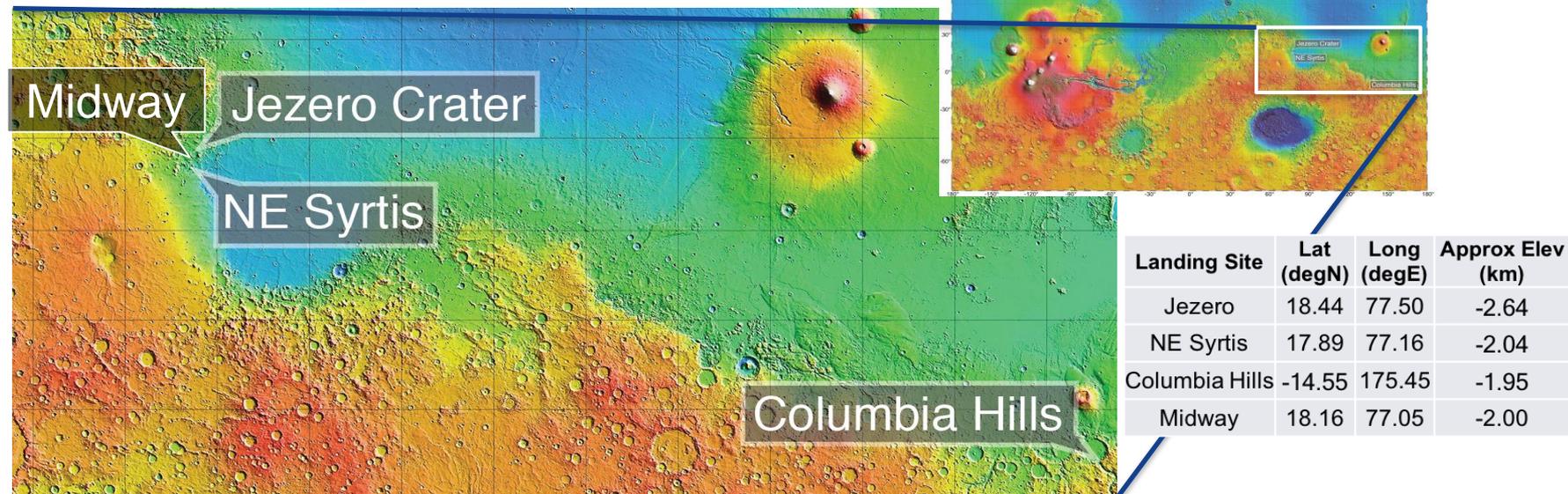
2018 • IPPW 15



# Landing Site Selection

2018 • IPPW 15

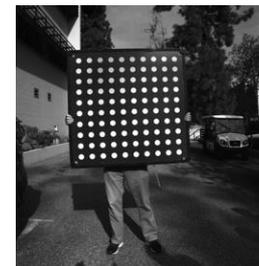
- A fourth candidate site, Midway, has been added for evaluation by the engineering and science teams
- Terrain and Atmosphere reviews completed in the past year; several improvements to rock identification have been incorporated
- EDL is currently evaluating landing site safety in support of the 4th 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

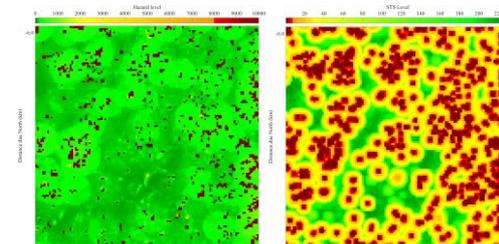
- Terrain Relative Navigation (TRN), Vision Compute Element (VCE), and VCE SW design reviews are complete
- Design has matured and hardware and software deliveries are in progress
  - VCE engineering dev units (EDU) delivered; EM and FM builds are in progress; LVS Camera (LCAM) EM1 delivered
  - Box-level 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



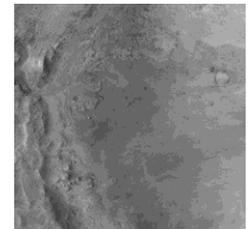
LCAM EM1  
calibration image



VCE EDU4 FPGA Card



Jezero site: hazard map vs. STM

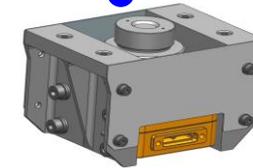
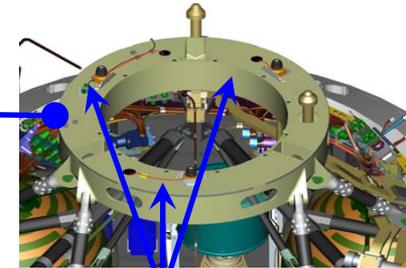
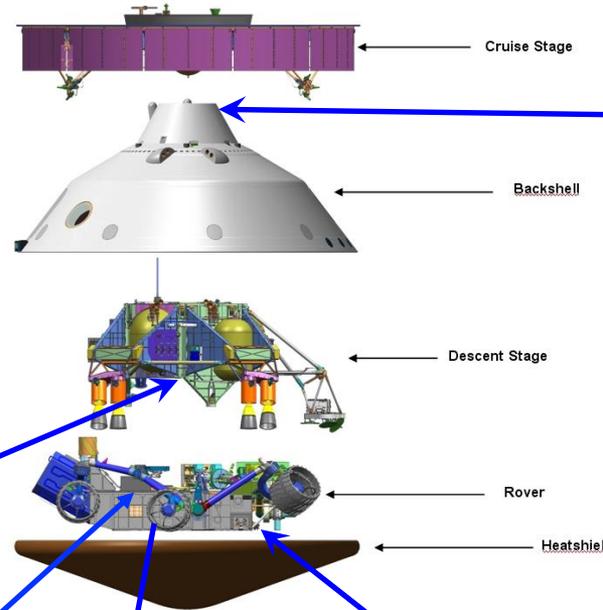


Jezero Mosaic,  
example of onboard  
appearance map for  
TRN

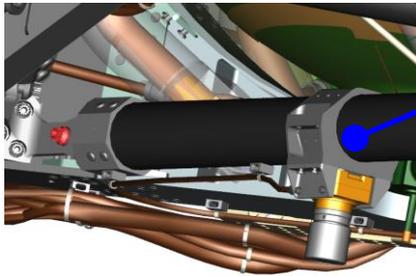


# EDL Camera Overview

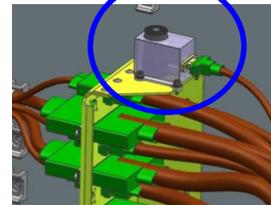
2018 • IPPW 15



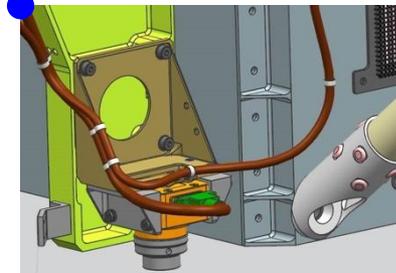
Descent Stage Down Look Camera (3.2 MP Color CMOS)



Rover Up-Look Camera (1.3 MP Color CMOS)



Omnidirectional Microphone Capsule

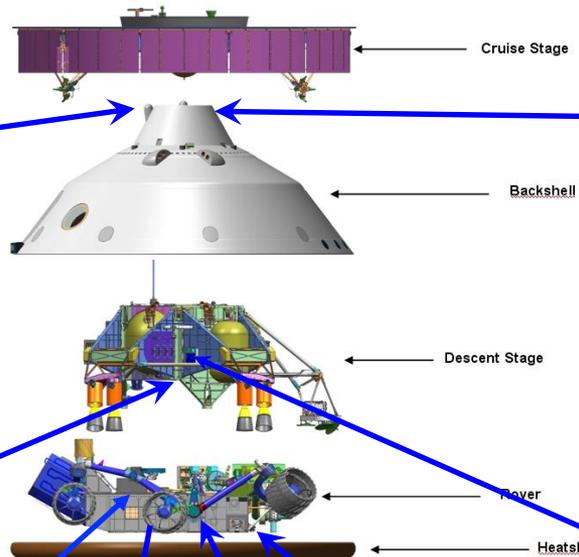


Rover Down-Look Camera (1.3 MP Color CMOS)

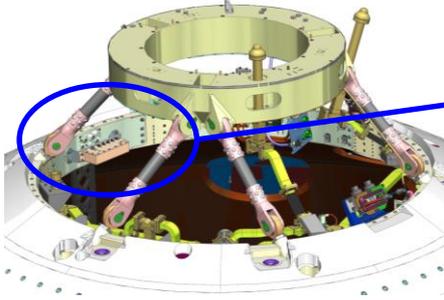


# EDL Camera Overview

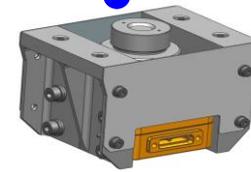
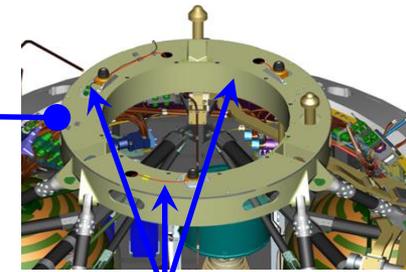
2018 • IPPW 15



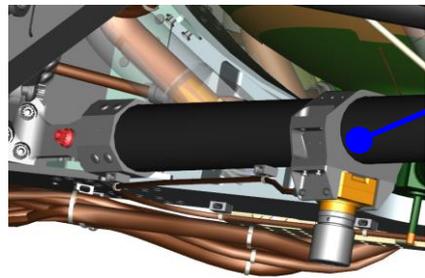
BIP  
USB3  
Hub



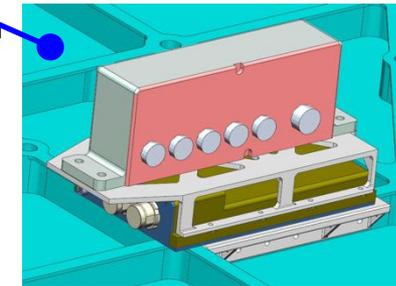
Parachute  
Support  
Structure  
Up-Look  
Cameras  
(x3, 1.3 MP  
Color CMOS)



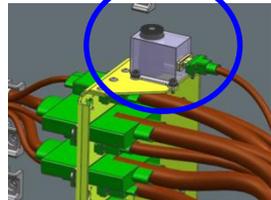
Descent  
Stage  
Down Look  
Camera  
(3.2 MP Color  
CMOS)



Descent  
Stage  
USB3 Hub &  
Data  
Storage Unit

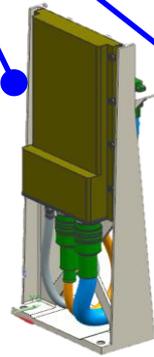


Rover  
Up-Look  
Camera  
(1.3 MP Color  
CMOS)

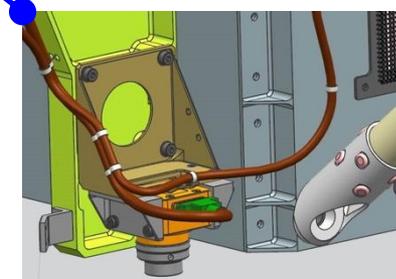


Omnidirectional  
Microphone  
Capsule

EDL Camera Data  
Storage Unit  
(Rover Internal)



Rover  
Down-Look  
Camera  
(1.3 MP Color  
CMOS)



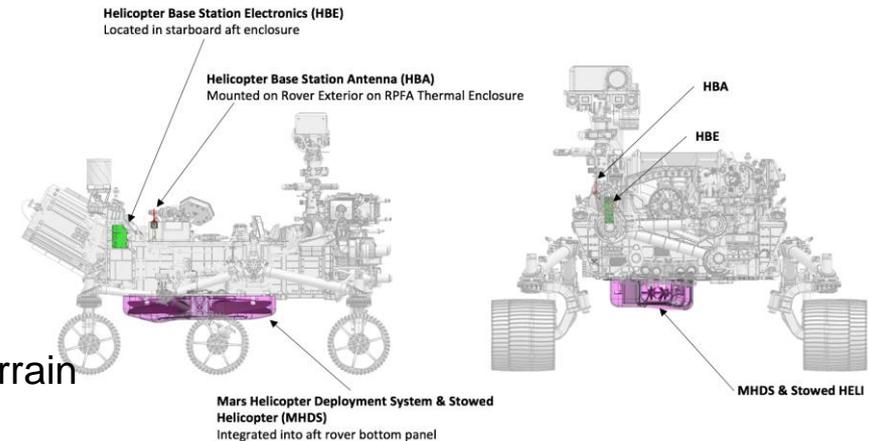
# Mars Helicopter

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%



# 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*

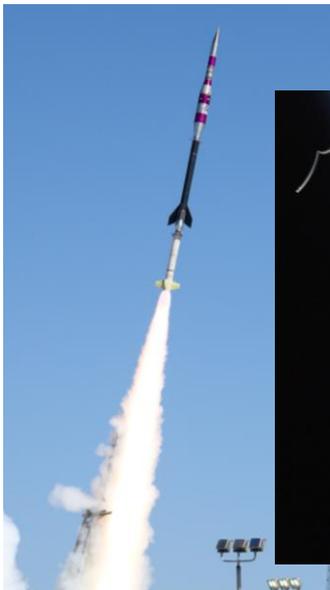


Credits: NASA/JPL-Caltech

# 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
  - 2<sup>nd</sup> flight was highest load ever survived by a supersonic parachute! (56 klbf/ 249 kN)
- A third flight test, 2<sup>nd</sup> 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

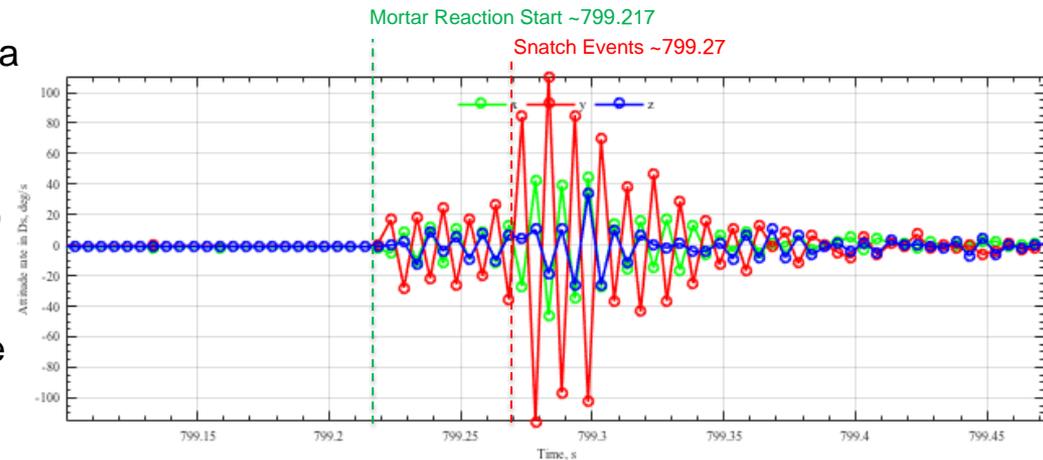


# Issues in Work (1/2)

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