Mars Exploration Program

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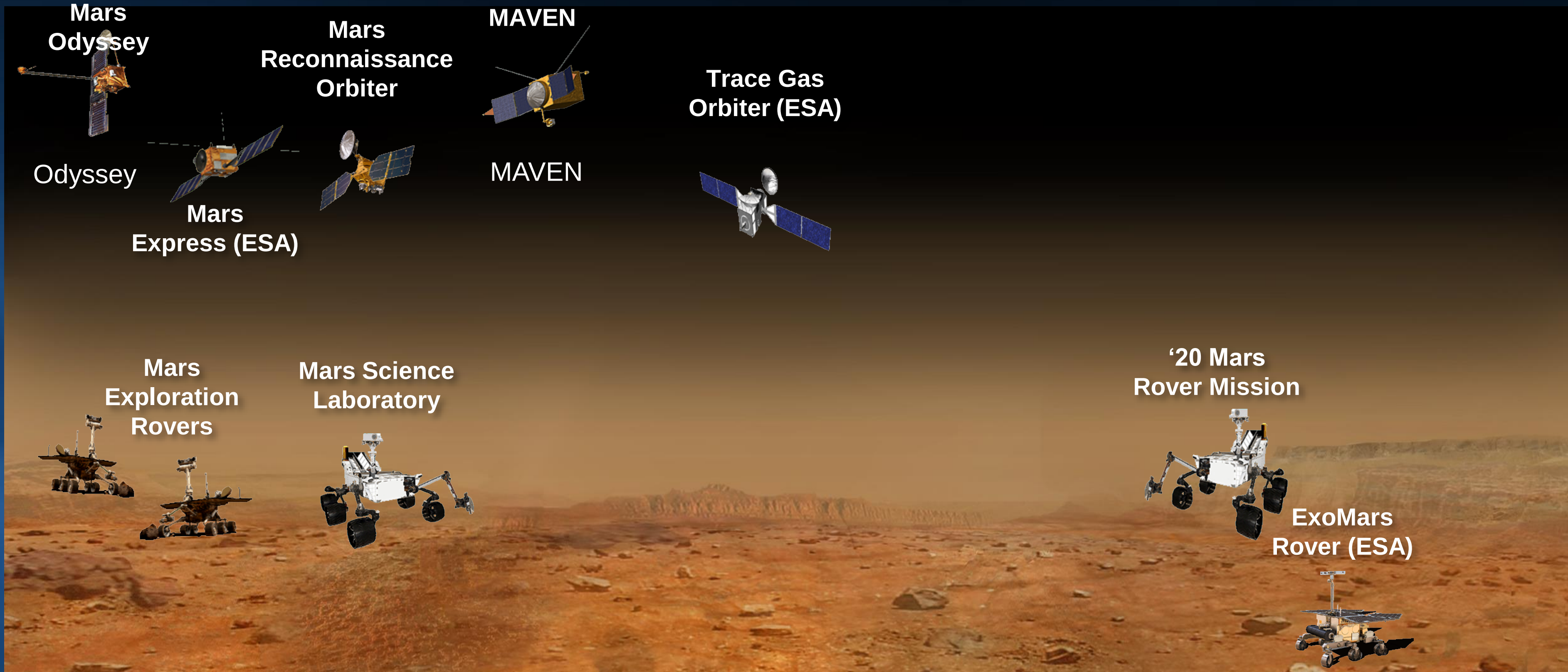
Mars Exploration Program Science Goals

Mars Exploration Program Missions

2001 - 2015 | 2016 | 2018 | 2020 | Future Mars Missions

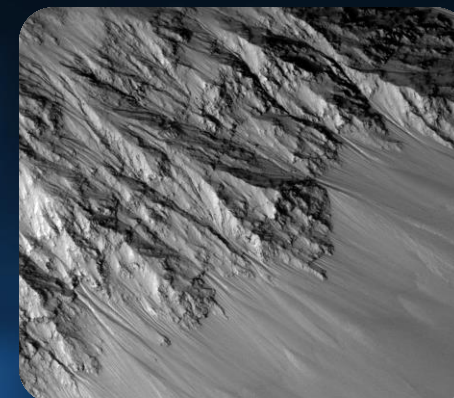


Mars Exploration Program Highlights

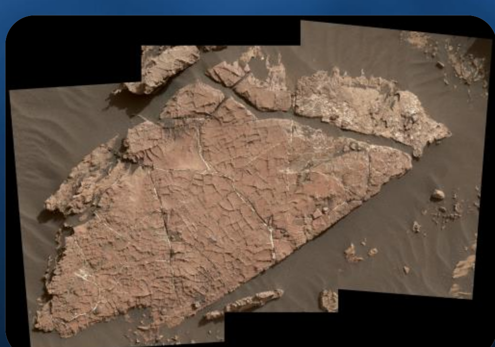
Opportunity: Journey to Perseverance Valley

MRO: >50,000 orbits Completed Global 6m Resolution Imagery

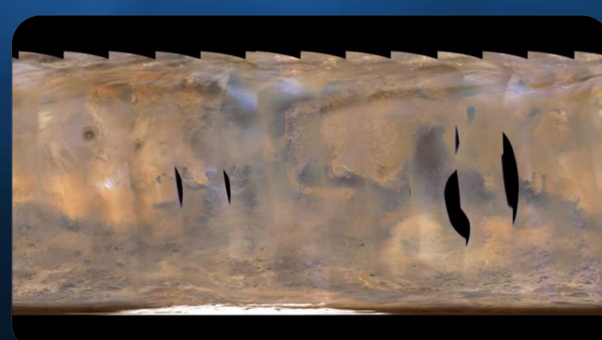
MRO: Continuing Observations of Recurring Slope Lineae



Curiosity: >5 years since landing



MAVEN Tracks Back-to-back Regional Storms



Mars 2020 Landing Site Finalists

Summary of ~2 decades of Program achievements

Key science findings

- Presence of liquid water on ancient Mars
- Evidence of habitable environment on ancient Mars
- Subsurface ice and validation
- Measurement of atmospheric loss points to much thicker ancient atmosphere
- Long-lived missions show climate trends and changing phenomena on Mars today

Engineering and science capabilities

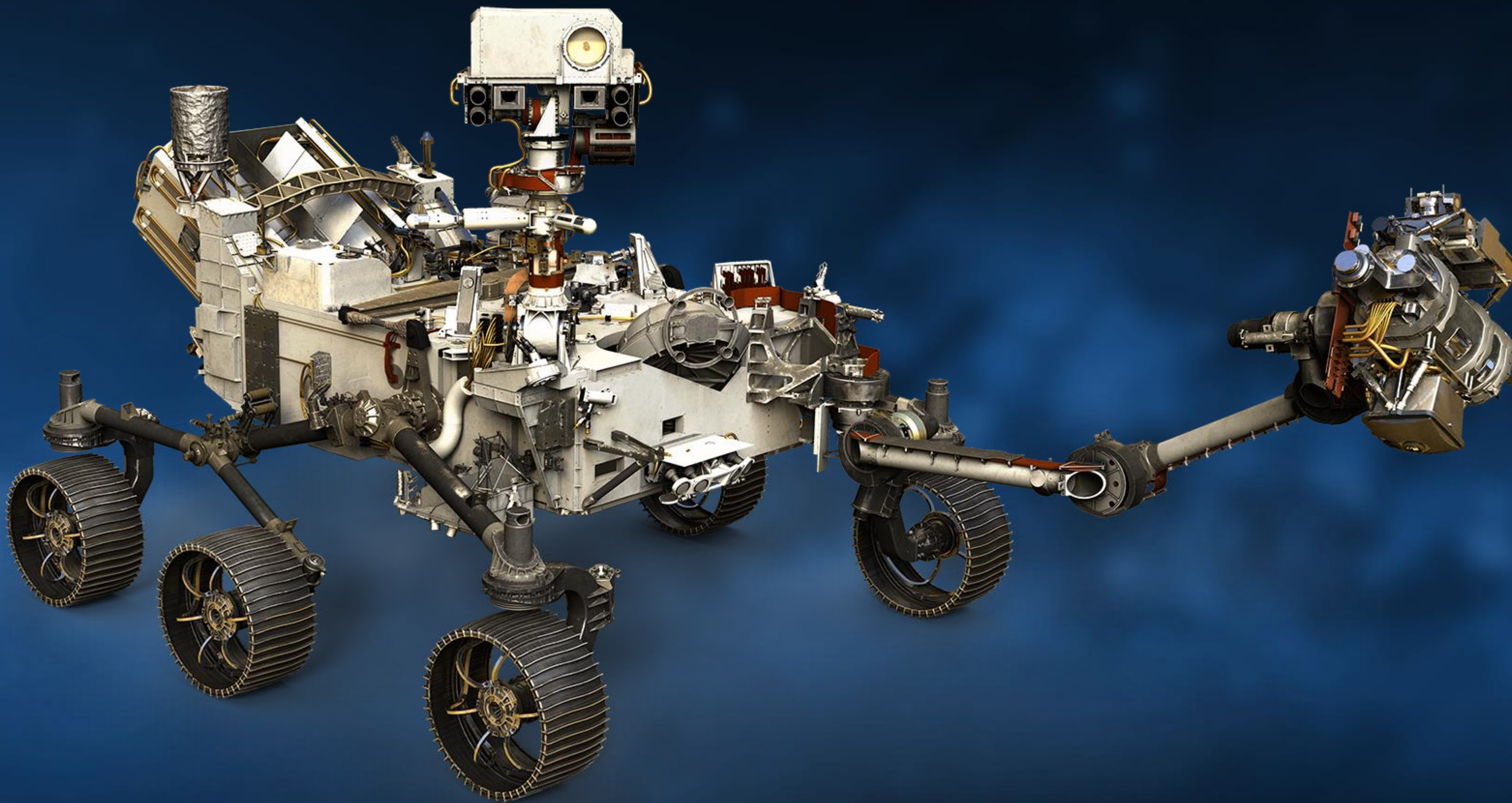
- Rover evolved from Sojourner (~ 11 kg) to Curiosity (~900 kg)
- Ability to land safely with improving landing accuracy
- Orbital and surface operation know-how enabled driving a Marathon distance on Mars
- Global mapping @ 6m/pixel; even higher resolution local mapping @ 0.3 m/pixel resolution
- High data volume returned via telecom network from orbit, with orbital relay 10-100 times better than direct-to-earth
- Capability for sample acquisition and *in situ* sample analysis

Inspiration of people worldwide

- Mars rover landings followed worldwide
  - “Seven minutes of terror” video transformed an engineering operation into a human message
- Strong following on social media
- Public fascination with missions, rover operations and science findings

Mars 2020 Status

Mars 2020 - Seeking the Signs of Life on Mars



Mars 2020 Mission Objectives

A. Geologic History

Explore the geology of the landing site

B. In Situ Astrobiology

Seek the signs of possible *ancient* Martian life

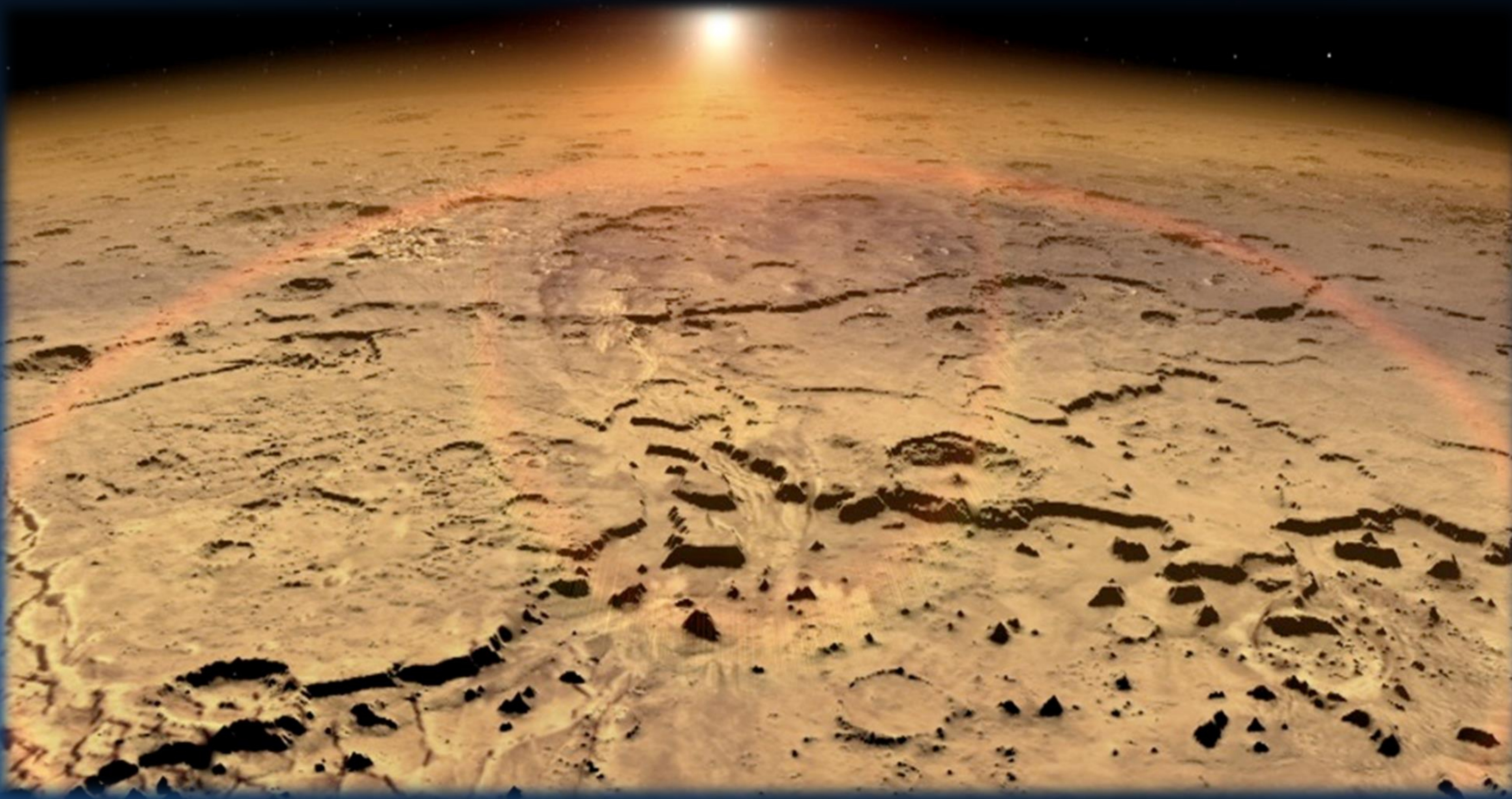
C. Cache samples

Prepare samples for possible future return to Earth

D. Prepare for the future

Demonstrate/test technologies required for human exploration of Mars

Why look for *ancient* life on Mars?

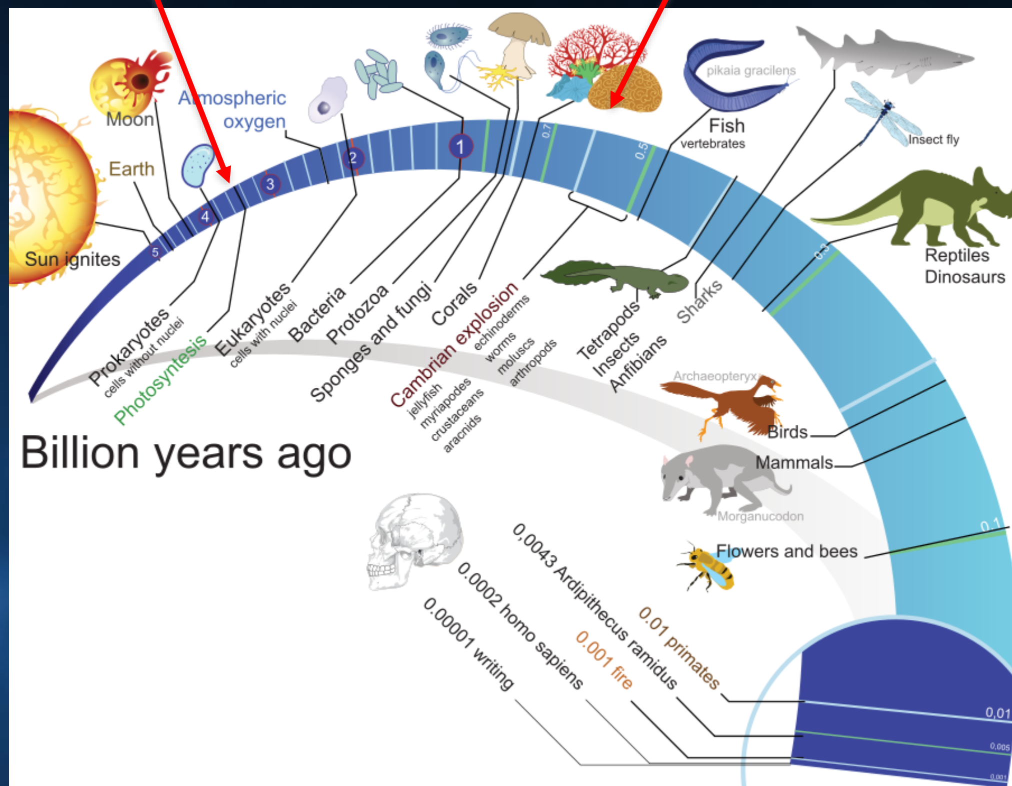


Mars is now cold, dry, and there is almost nowhere to hide from radiation

Mars life, if any, is expected to be microbial…

Mars climate change here

Familiar "fossils"



Mars 2020 Candidate Landing Sites

JEZERO

- Minerologic diversity including clays and carbonates
- Shallow water carbonates?

NE SYRTIS

- Extremely ancient igneous, hydrothermal, and sedimentary environments
- High mineralogic diversity with phyllosilicates, sulfates, carbonates, olivine

COLUMBIA HILLS

- Carbonate, sulfate, and silica-rich outcrops of possible hydrothermal origin. Hesperian volcanics.
- Previously explored by MER

Mars 2020: 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

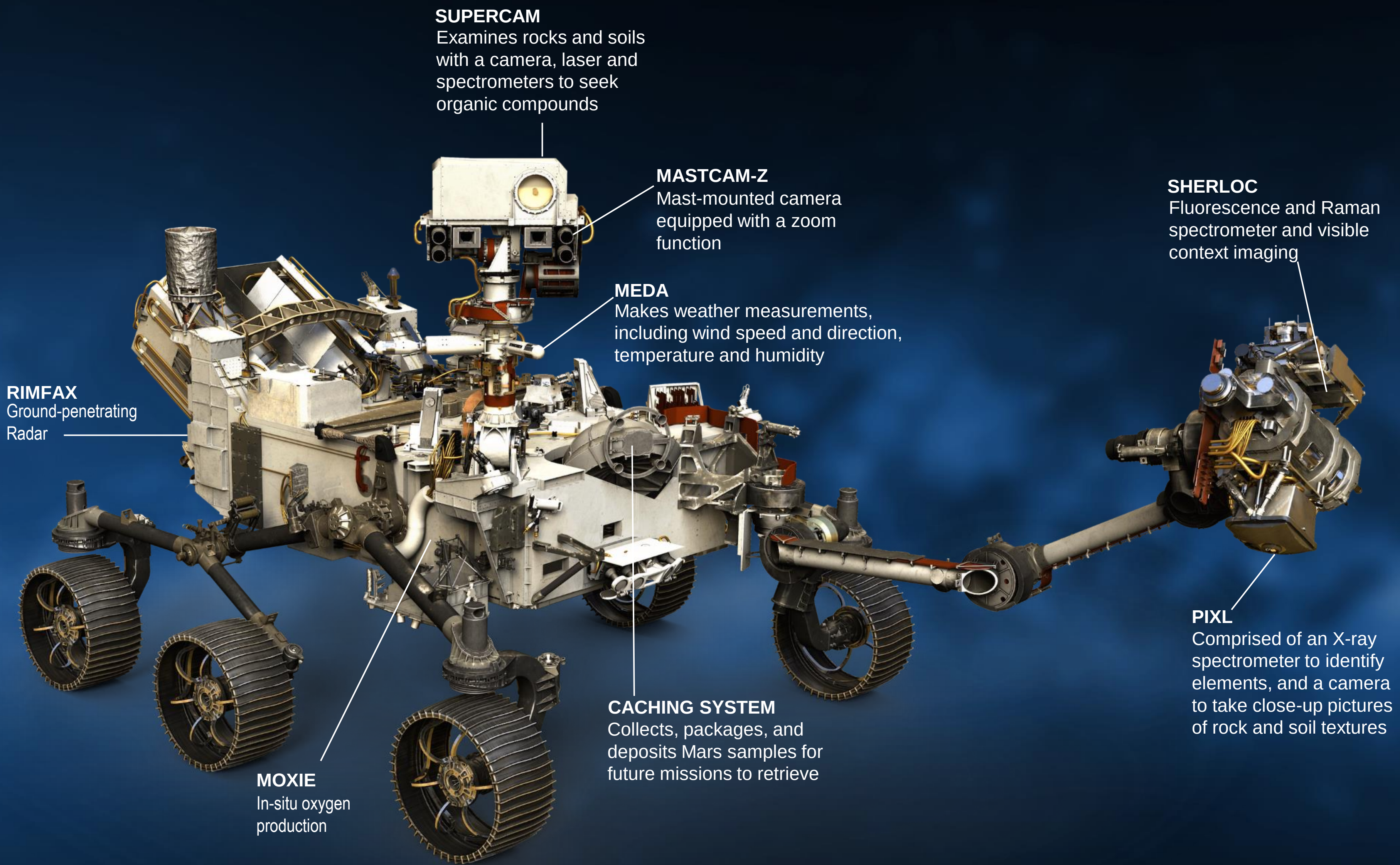
ENTRY, DESCENT & LANDING

- 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 $\pm 30^\circ$ 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 Instruments



Descent Stage Walkdown 1/9/18

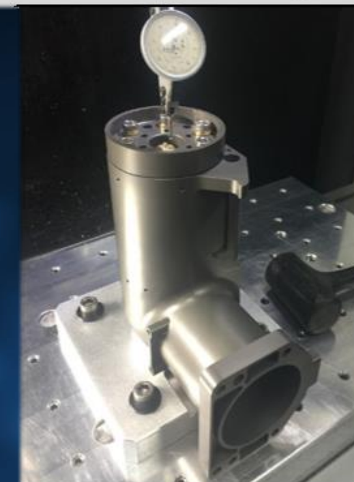
Robotic Arm Highlights

Piece Part Fabrication Continues

Upper Arm Fittings 80% complete

Turret Output Plate and Flexure

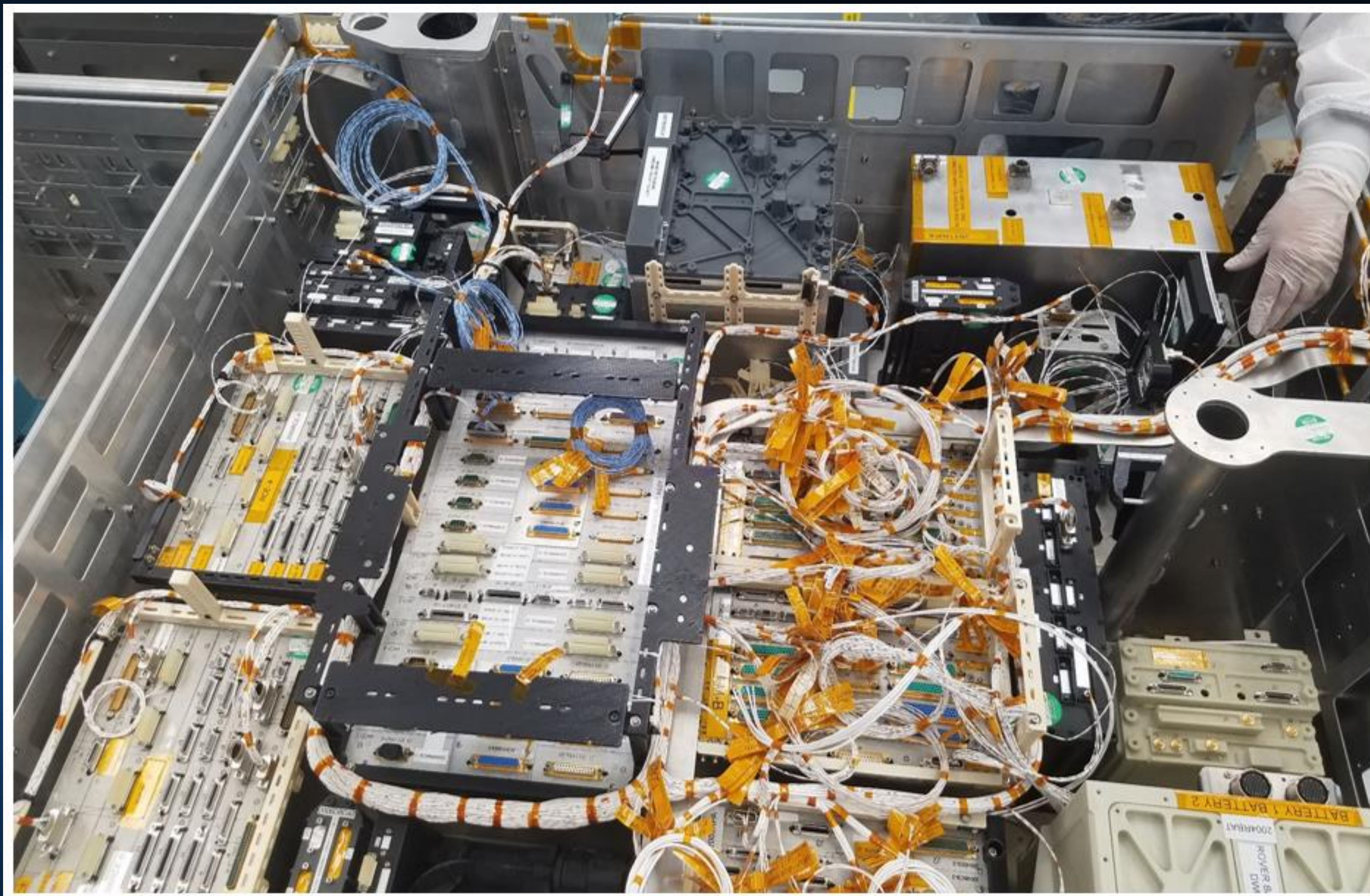
Wrist/turret fitting being match machined to facilitate wrist and turret actuator assembly



Turret Output shaft caps arrived

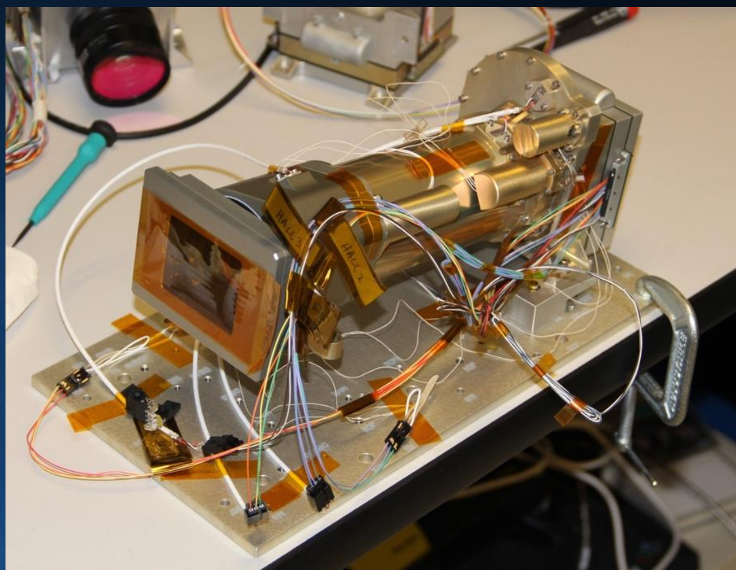
EM Shoulder Bracket 50% complete

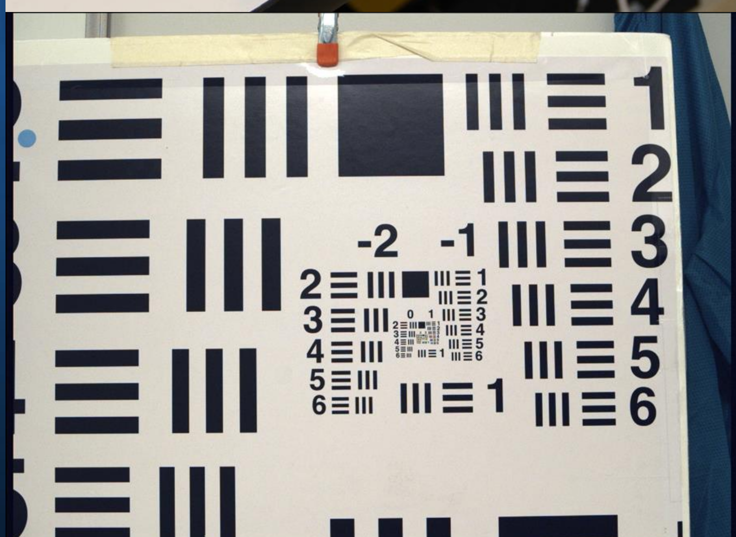
Rover Harness Production



Payload
Mastcam-Z Hardware

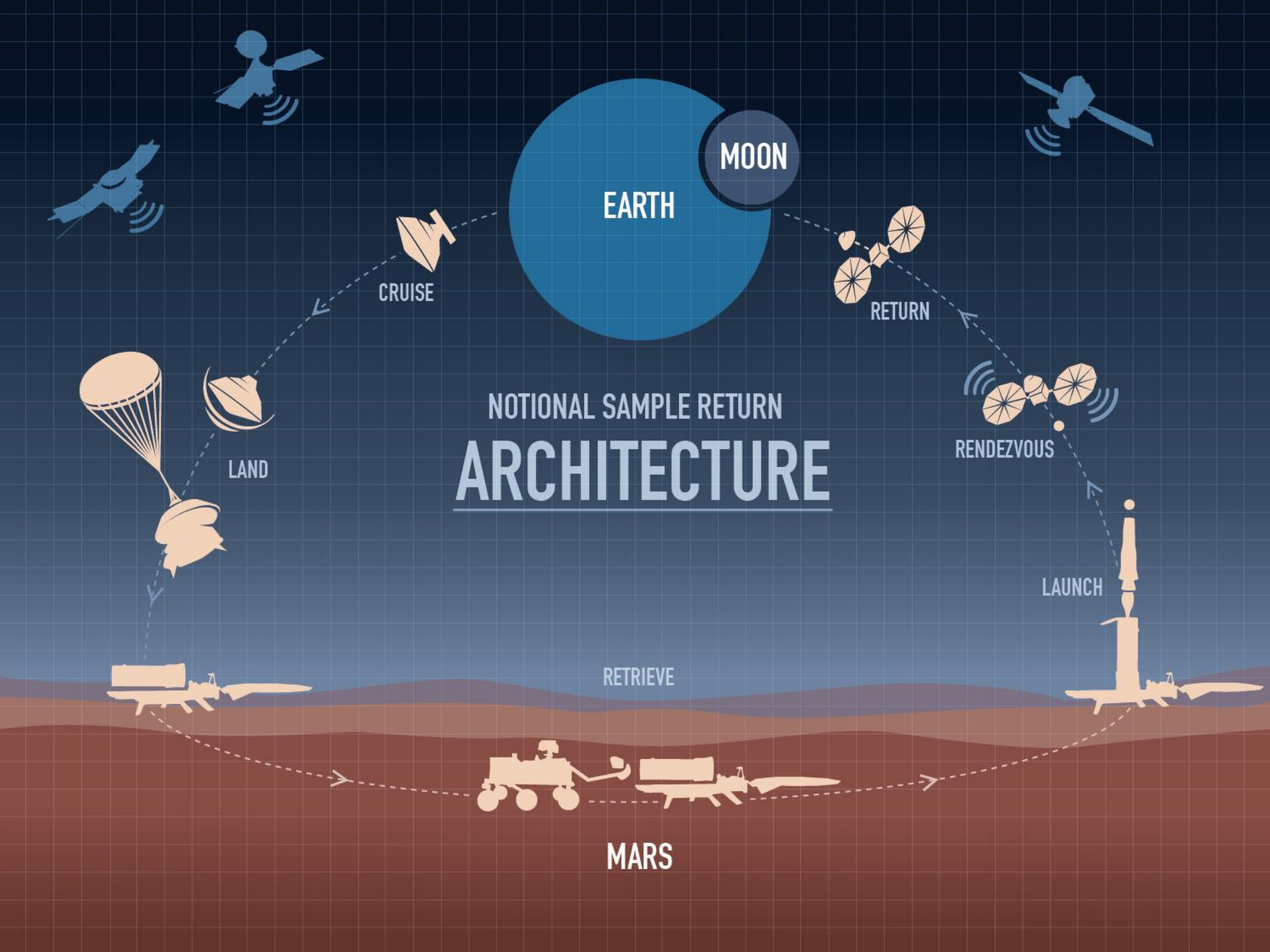
Assembled Mastcam-Z EQM at MSSS
Image date: 23 January, 2018





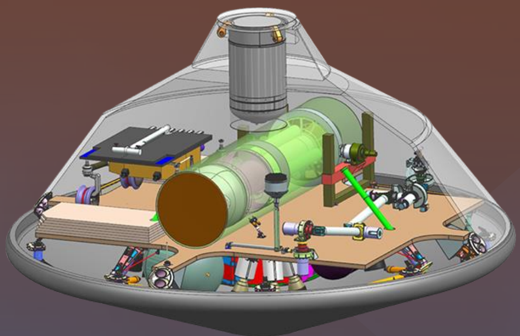

MARS 2020
MISSION OVERVIEW

Mars Sample Return Planning

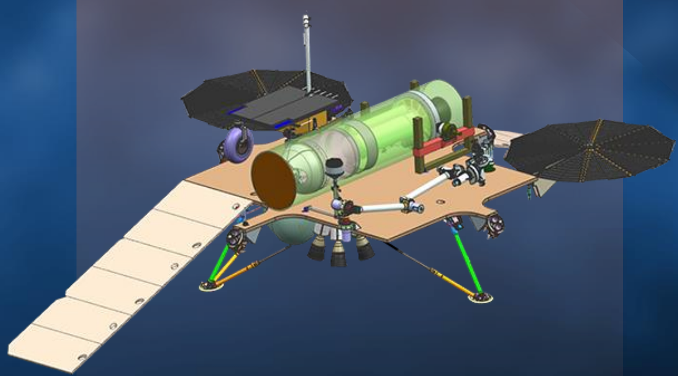

MOON
EARTH
CRUISE
RETURN
NOTIONAL SAMPLE RETURN
ARCHITECTURE
LAND
RENDEZVOUS
LAUNCH
RETRIEVE
MARS

TWO LANDER CONCEPTS

2017 Highly Integrated Concept



Propulsive Platform Lander (PPL) *Concept*
Packaged in MSL 4.5m Aeroshell

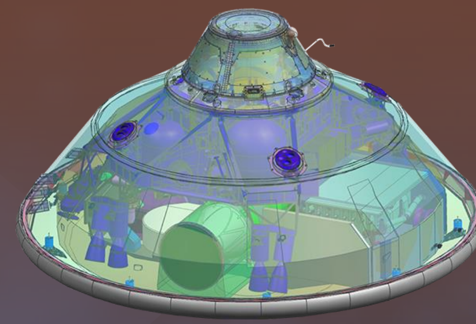


Propulsive Platform Lander
Concept Deployed

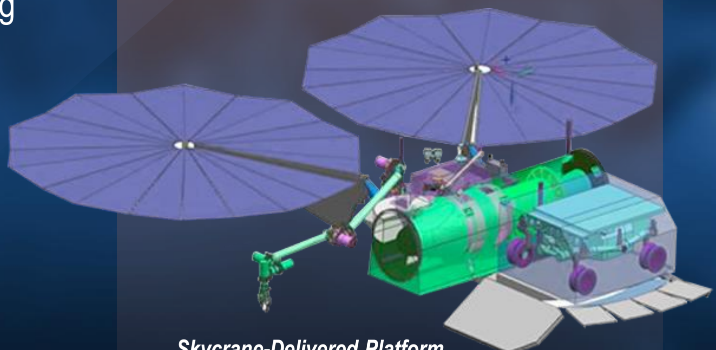
Common Attributes

- Identical cruise and entry architecture
- ~ 10 km landing ellipse
- ~ 900-1000 kg landed useful mass
- Accommodates ~ 600 kg MAV and Fetch Rover

Evolved 2011 Decadal Concept



Skycrane-Delivered Platform Concept
Packaged in MSL 4.5m Aeroshell



Skycrane-Delivered Platform
Concept Deployed

Two concepts that leverage Mars program legacy system capabilities

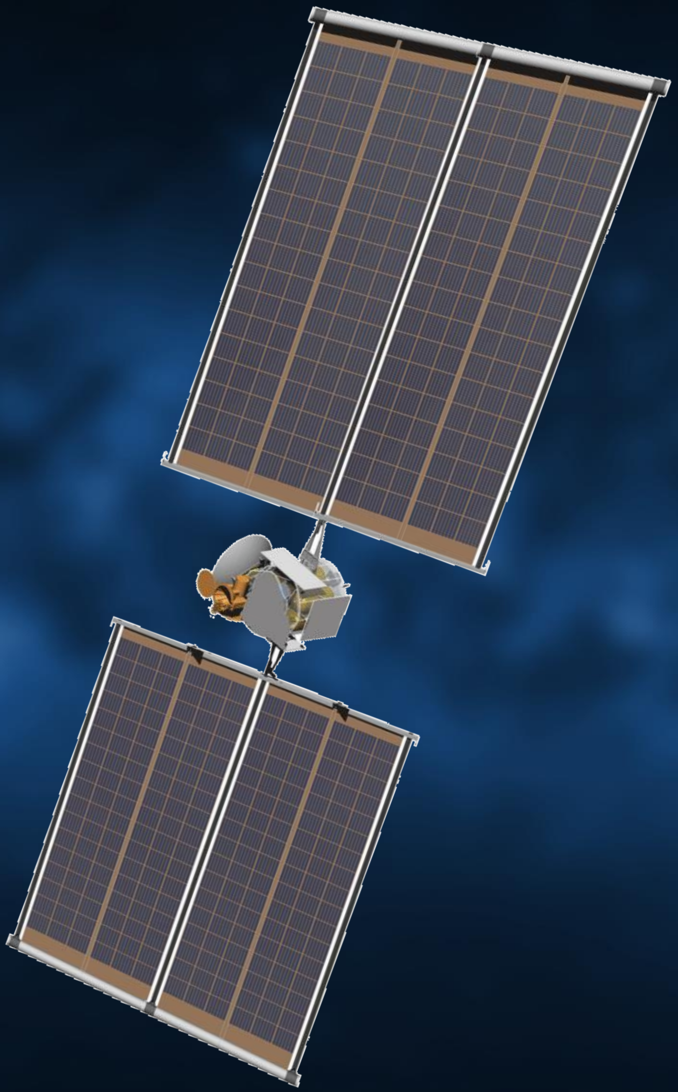
NOTIONAL SAMPLE RETURN ORBITER

Design for Orbital Rendezvous & Fast Sample Return

- Rendezvous & Capture
- Containment and Earth Planetary Protection
- Communication Relay Support for Surface Ops and Critical Events
- Return to Earth, either via
  - Direct return to Earth
  - Deliver to cis-lunar space for human-assisted returns

Implementation Options

- NASA provided
- Partner provided



MAV - TECHNOLOGY MATURATION

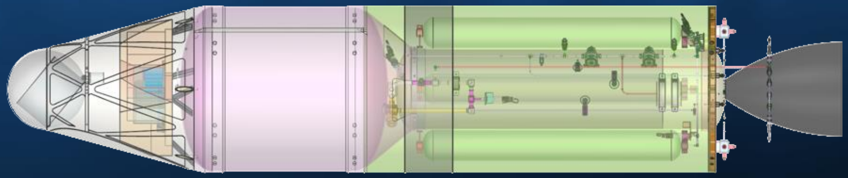
Objective

- Achieve stable orbit @ 18 deg, 350 km circular
- Minimize thermal survival power
- Constrain mass/volume

Technology Maturation Progress

- Pursuing hybrid propulsion SSTO approach
  - Paraffin based fuel has superior cold temperature properties (-90 C)
  - Inert fuel grain and low temp MON3 oxidizer
- Full scale motor test firings in-work

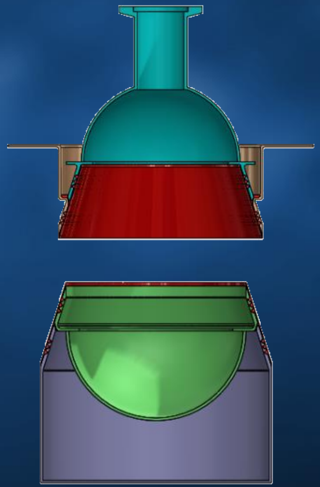
Full-scale hybrid motor test at Whittinghill Aerospace – Feb 2018



Mars Ascent Vehicle (MAV)
~2.4m length/~ 300 kg mass

BIO-CONTAINMENT TECHNOLOGY MATURATION

- Simultaneous Sealing and Sterilization via Brazing
- Cone-within-cone design serves both structural and sealing functions
  - Approach has been validated using 4” bench test induction heater
  - Multiple test items successfully brazed
  - Sealed and separated containers were tested with spectrometer/vacuum/Helium



He leak test

Mars Sample “Returned”:
Mars Meteorite on SHERLOC for Mars 2020