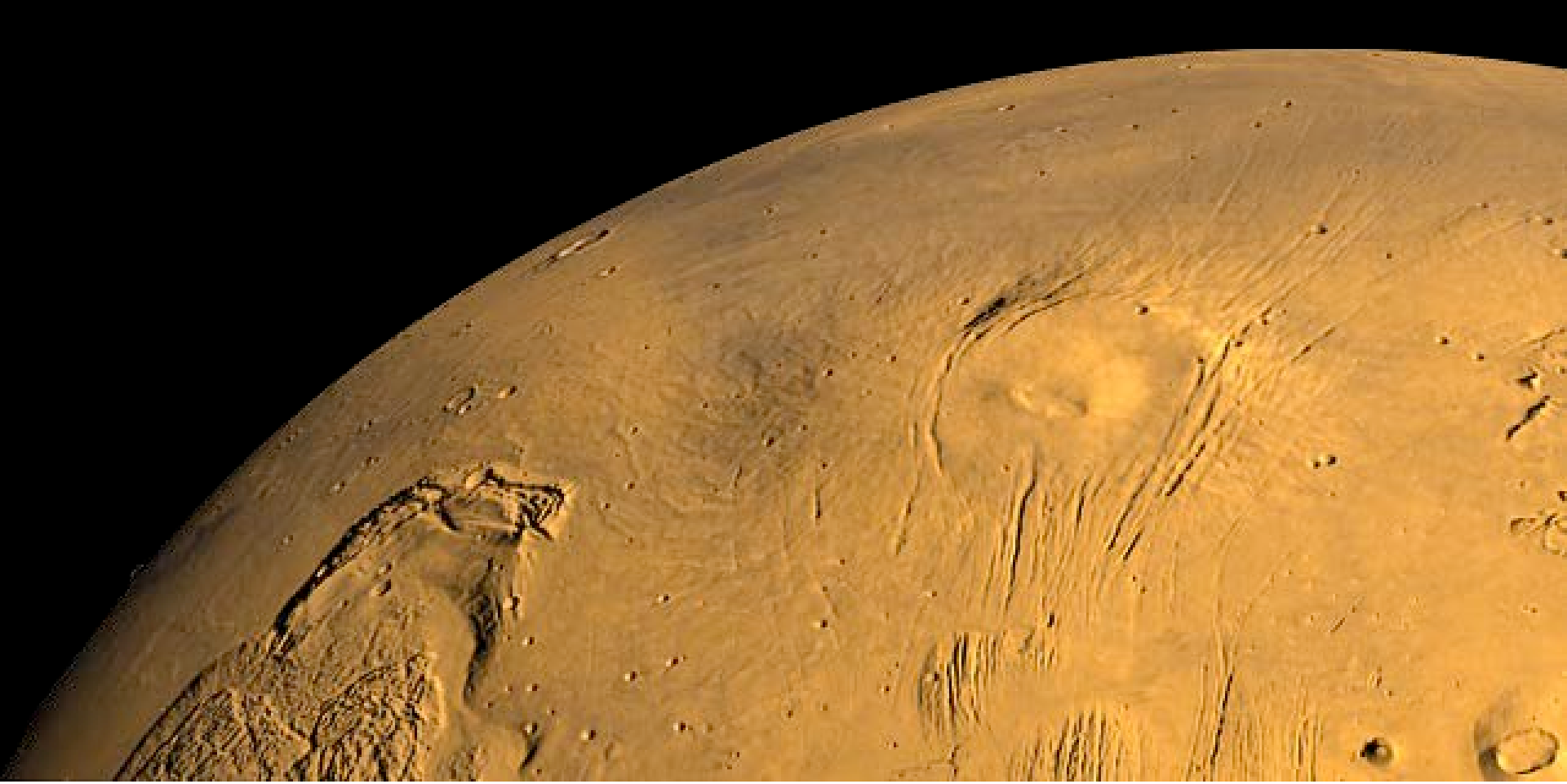


Roving on Mars: The NASA Mars Exploration Program and Future Missions

Joseph Parrish
Deputy Manager, Mars Program Formulation Office
Manager, Mars Technology Development
25 May 2016

Jet Propulsion Laboratory
California Institute of Technology

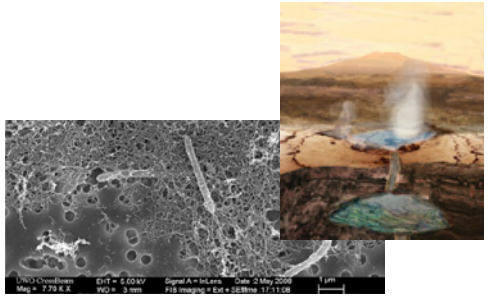
© 2016 California Institute of Technology. Government sponsorship acknowledged.

Overview

- **Mars Science and Mission Context**
- **Near-Term (2020's) Mars Mission Needs**
  - **Next Mars Orbiter (NeMO) Concept**
  - **Sample Return Lander (SRL) Concept**
- **Longer-Term Mars Mission Needs**
- **Summary**

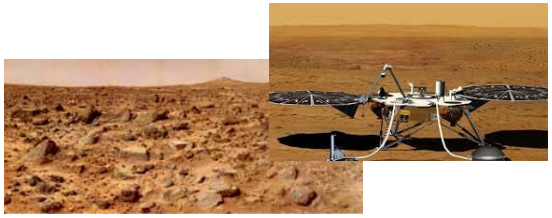
Mars Science Strategy

- **Goal I: Determine If Life Ever Arose On Mars**
  - Objective A: Characterize past habitability and search for evidence of ancient life
  - Objective B: Characterize present habitability and search for evidence of extant life
  - Objective C: Determine how the long-term evolution of Mars affected the physical and chemical environment critical to habitability and the possible emergence of life

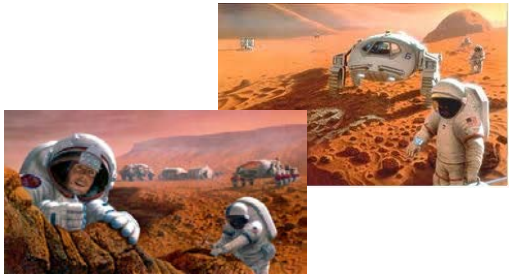


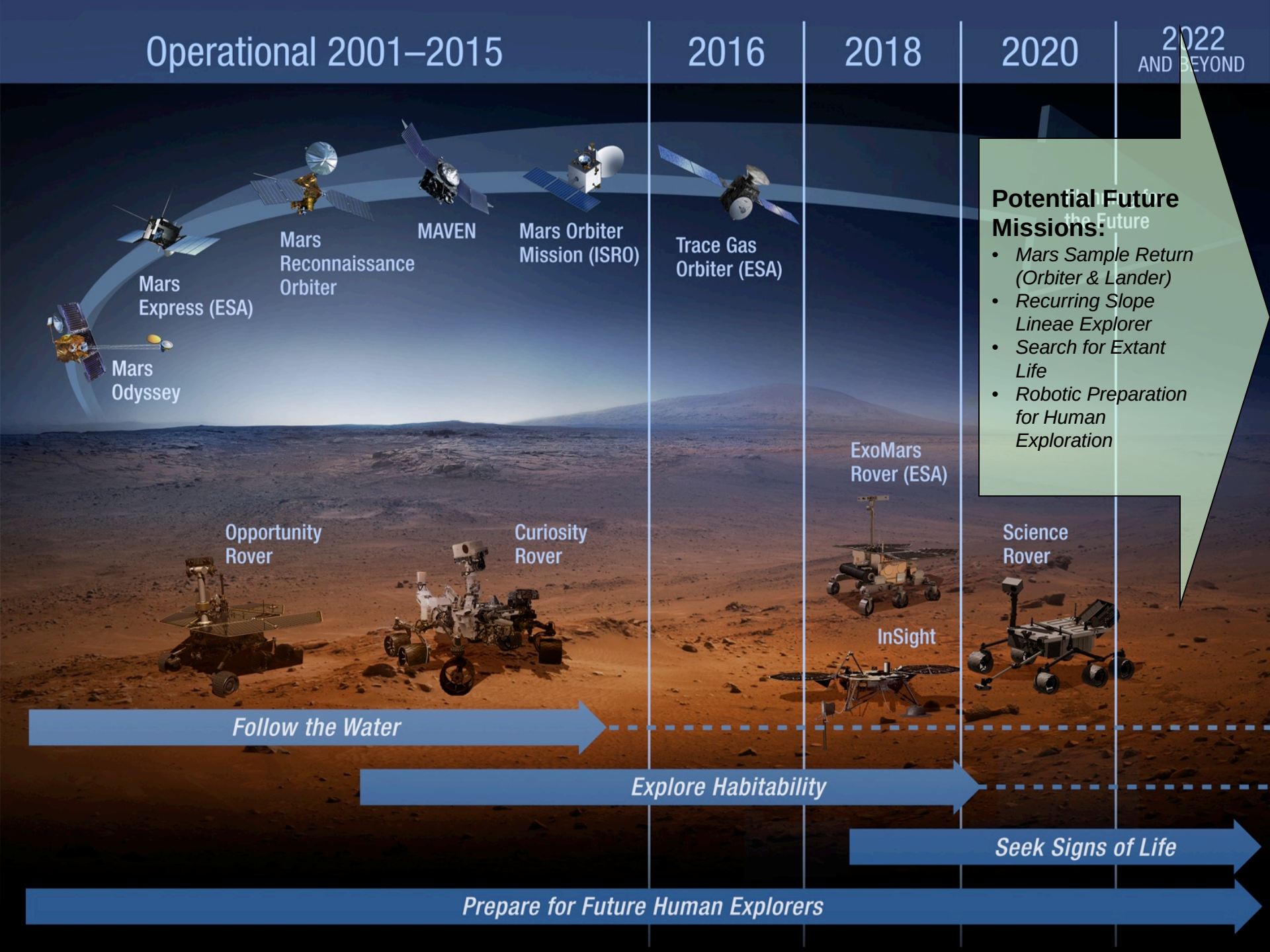
- **Goal II: Understanding The Processes And History Of Climate On Mars**
  - Objective A.: Characterize Mars' Atmosphere, Present Climate, and Climate Processes Under Current Orbital Configuration
  - Objective B.: Characterize Mars' Recent Climate and Climate Processes Under Different Orbital Configurations
  - Objective C.: Characterize Mars' Ancient Climate and Climate Processes

- **Goal III: Determine The Evolution Of The Surface And Interior Of Mars**
  - Objective A.: Determine the nature and evolution of the geologic processes that have created and modified the Martian crust
  - Objective B.: Characterize the structure, composition, dynamics, and evolution of Mars' interior
  - Objective C.: Understand the origin, evolution, composition and structure of Phobos and Deimos.

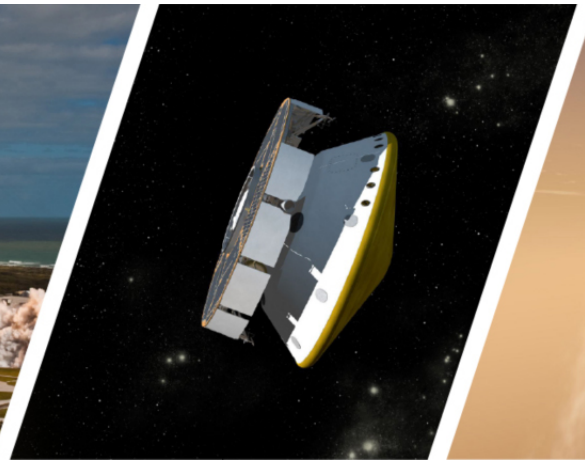


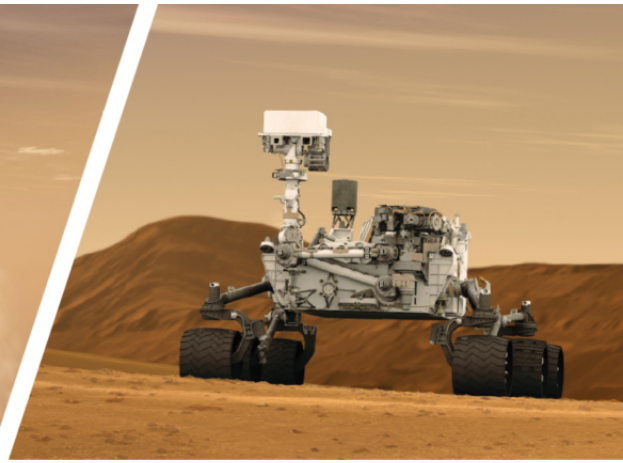
- **Goal IV: Prepare For Human Exploration**
  - Objective A: Obtain knowledge of Mars sufficient to design and implement a human mission with acceptable cost, risk and performance




Operational 2001–2015
2016
2018
2020
2022
AND BEYOND
Mars Odyssey
Mars Express (ESA)
Mars Reconnaissance Orbiter
MAVEN
Mars Orbiter Mission (ISRO)
Trace Gas Orbiter (ESA)
Opportunity Rover
Curiosity Rover
ExoMars Rover (ESA)
InSight
Science Rover
Potential Future Missions:
Mars Sample Return (Orbiter & Lander)
Recurring Slope Lineae Explorer
Search for Extant Life
Robotic Preparation for Human Exploration
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Mars 2020 Mission Overview





LAUNCH

- MSL Class/Capability LV
- Period: Jul/Aug 2020

CRUISE/APPROACH

- 7.5 month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL system (Range Trigger and TRN baselined): 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

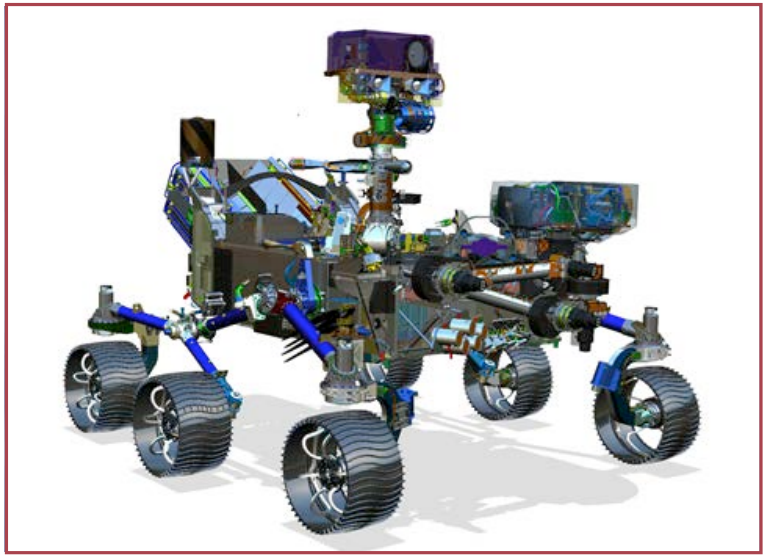
SURFACE MISSION

- 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 Project Overview

Salient Features

- *High heritage MSL design*
- *Modifications only as necessary to accommodate new payload and Sampling / Caching System (SCS)*

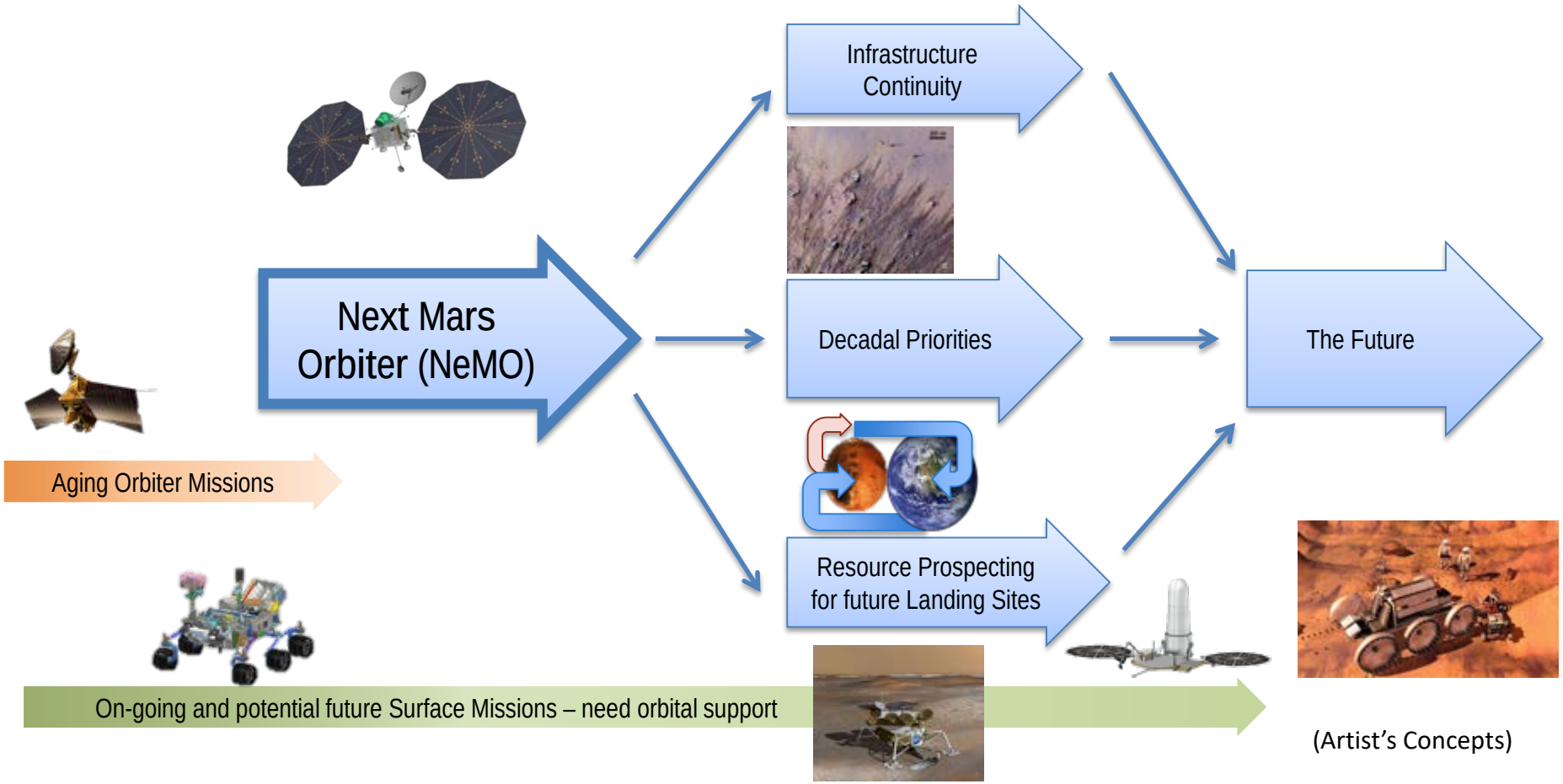


Science

- *Assess past habitability of an astrobiologically relevant ancient environment on Mars*
- *Assess biosignature preservation potential with the environment and search for biosignatures*
- *Assemble cached samples for possible future return to Earth*
- *Provide an opportunity for contributed HEO/STMD participation to advance technologies with potential applications to future human exploration objectives*

Next Mars Orbiter (NeMO) Concept

Capability to Enable Future Pathways



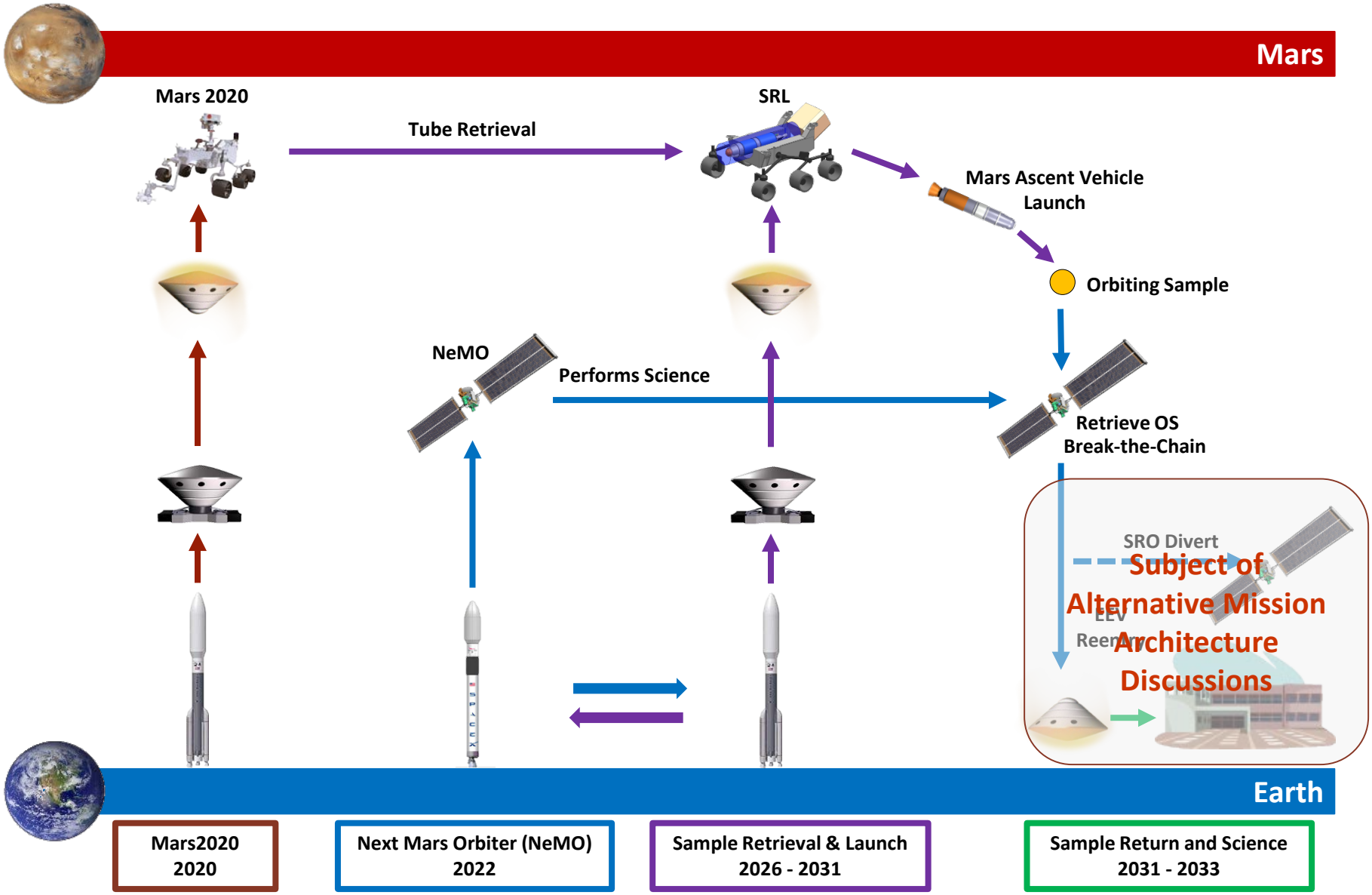
(Artist's Concepts)

Timely Renewal and Enhancement of Infrastructure is needed to Support Future Missions

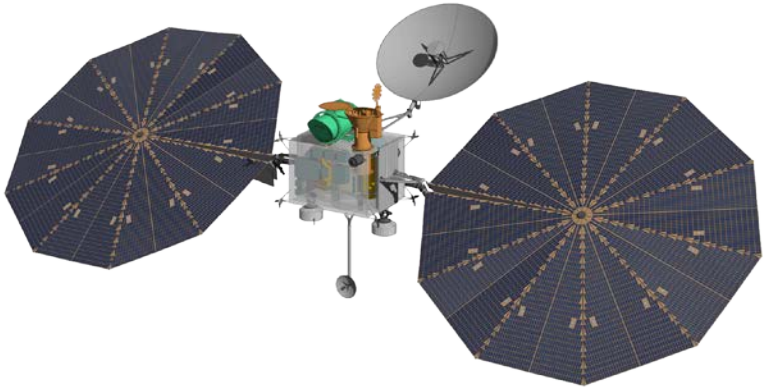
Mars Sample Return Concept Animation

- Note: video file removed because it is breaking the URS file upload system

Mars Sample Return Concept



Next Mars Orbiter (NeMO) Concept Overview



Objectives

- Renew and Update Aging Communications Infrastructure
- Provide Continuity of High Resolution Imaging
- Potential additional objectives for:
  - Orbital Support for Sample Return
  - Remote Sensing

Payload Overview

- High Resolution Imager (30 cm/pixel)
- Rendezvous and Capture payload
- Potential for additional observational instruments to be contributed by international partners

Key Capabilities

- High-rate RF direct-to-earth telecom system
- X-band/UHF relay telecom system
- Advanced solar electric ion propulsion system
- Significant orbital flexibility for long term support of future missions

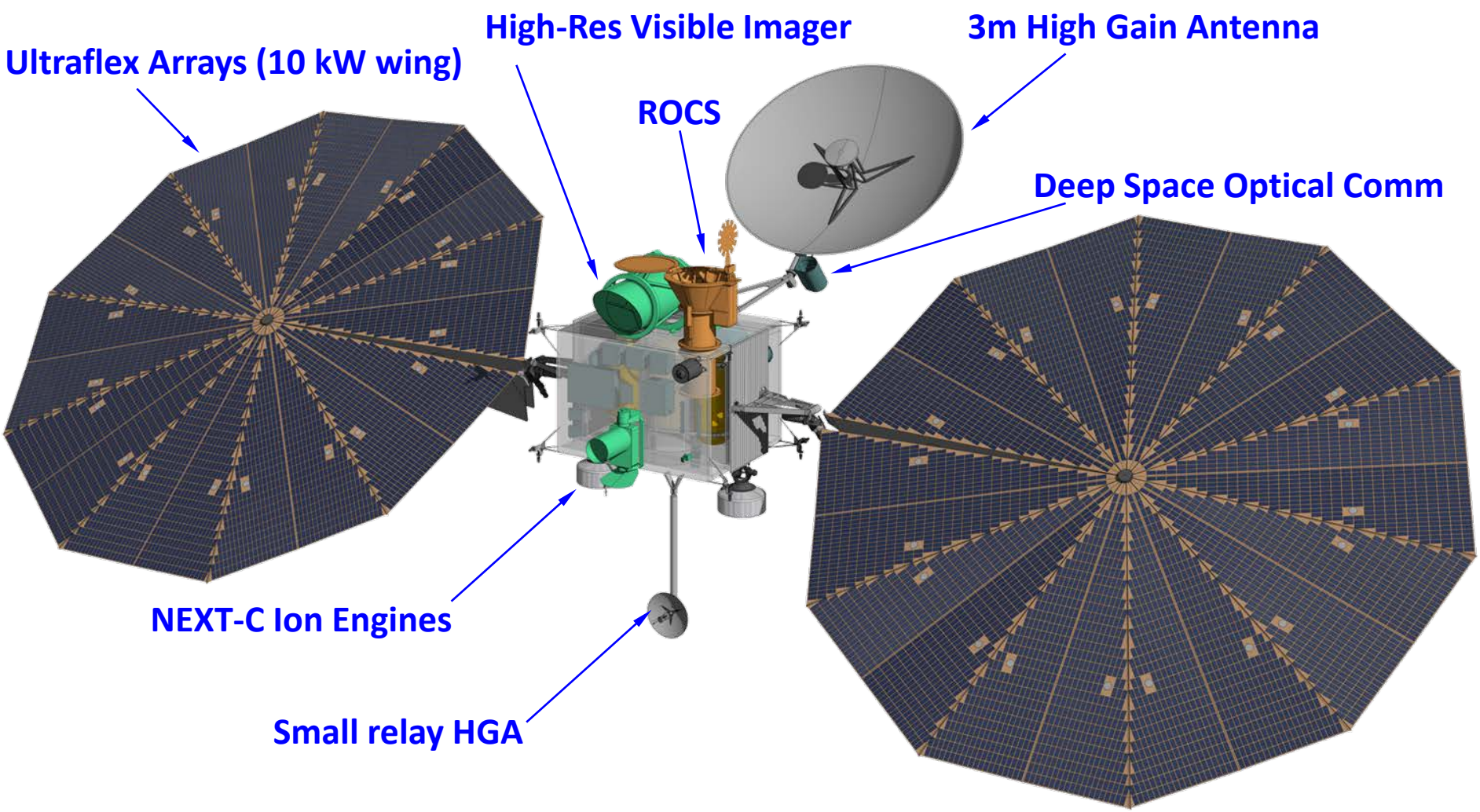
Falcon-9 or
Atlas V-411

Flight System Characteristics

- Moderate Size Spacecraft (6.5 yr life)
- 1250 kg Bus
- 50 kg Payload (High Resolution Imager)
- 600 kg Propellants (~14 km/sec)
- Launch C3 = 15 km^2/s^2
- 20 kW Solar Arrays
- NEXT-C Ion Engines (1 active, 1 spare)

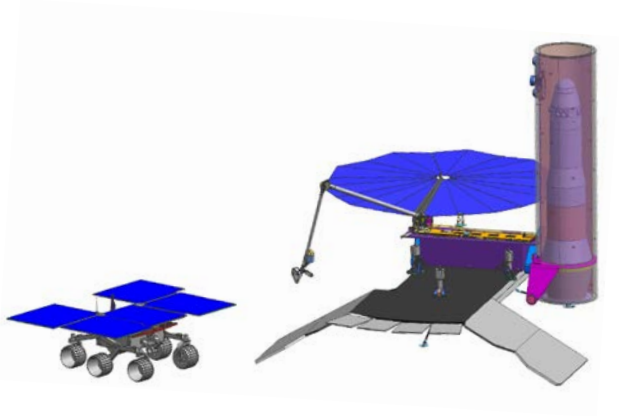
Mission Phase	Start Date
Launch	Jul 2022
Mars Capture Spiral	Sep 2023
Low Orbit Science	Jul 2024
Extended Mission Start	Apr 2028

NeMO Concept Deployed Configuration



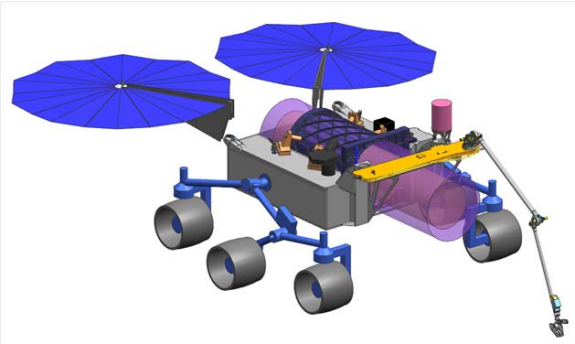
Sample Return Lander Concepts

2011 Decadal Study Concept –
MER-class rover + Fixed platform

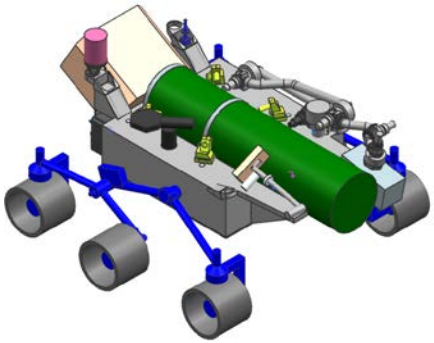


Mobile MAV Concepts –
MSL-class rover

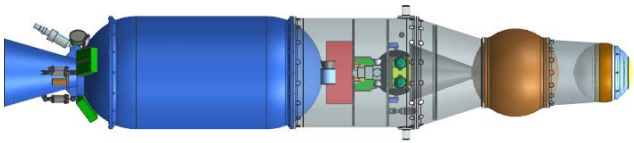
Solar Mobile MAV



RTG Mobile MAV



Example MAV (2-stage Solid, Solid)
Approx 2.7 m length; 280 kg mass

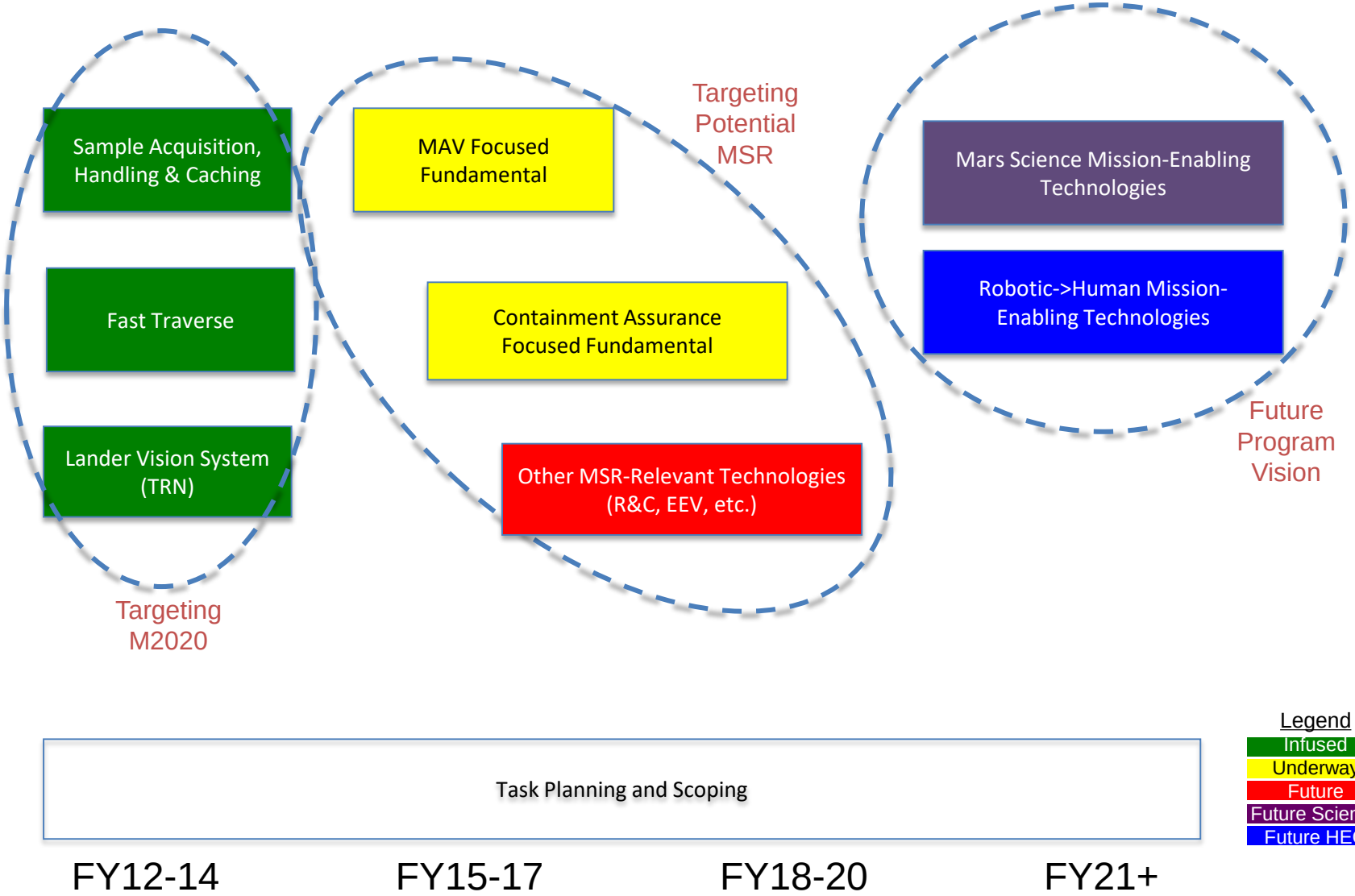


Other propellant options (hybrid, liquid) also under consideration

Design considerations and Drivers:

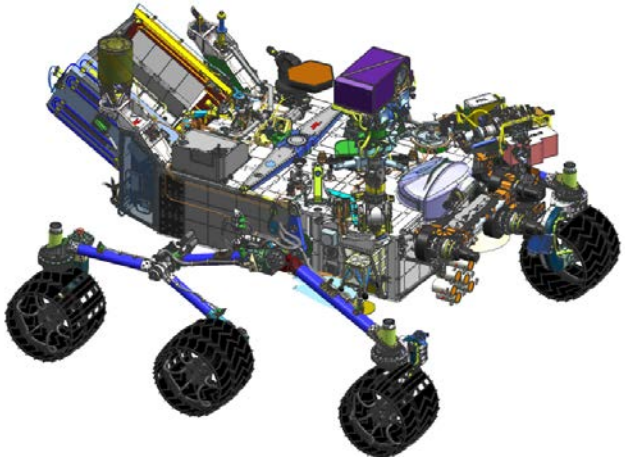
- Traverse distance
- Landing ellipse and hazard avoidance
- Sample Handling and Transfer
- MAV Launch
- Ancillary Objectives

Mars Technology Program Architecture



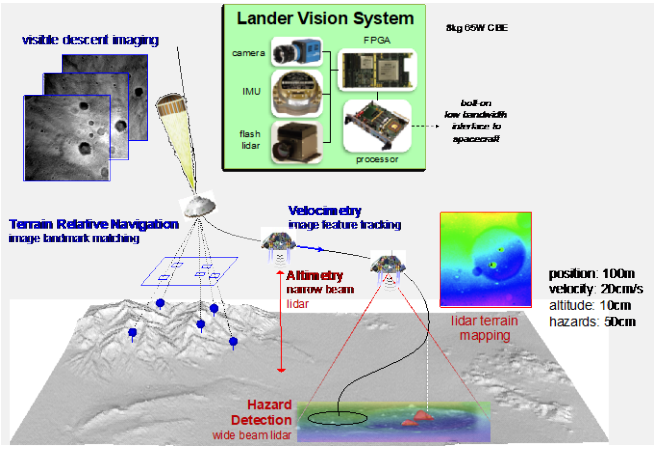
Recent Infusion Successes

Several key technologies have successfully infused to the Mars 2020 Rover mission



Sample Acquisition & Caching

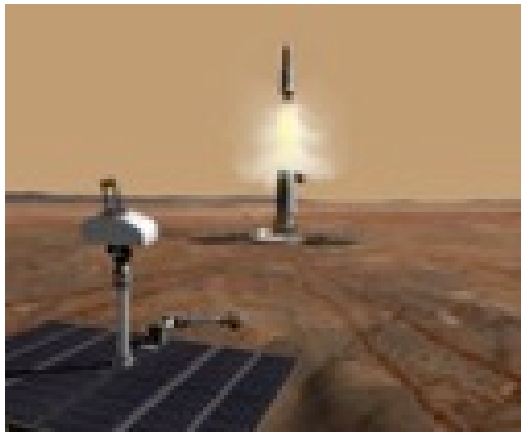
Safe & Fast Traverse



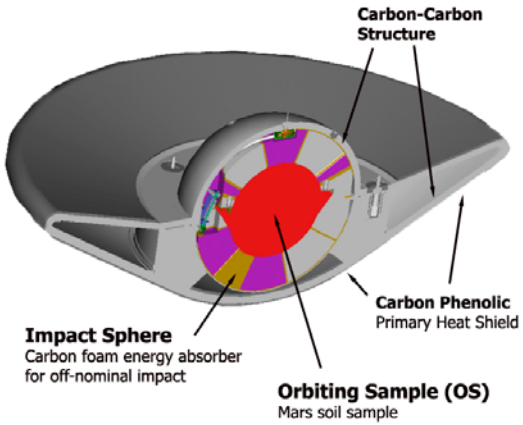
Terrain Relative Navigation

Current Technologies Under Development

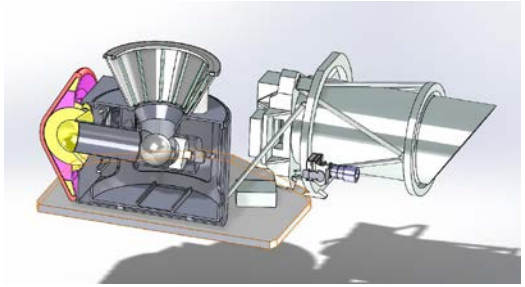
Current portfolio is focused on key technologies for potential Mars Sample Return:



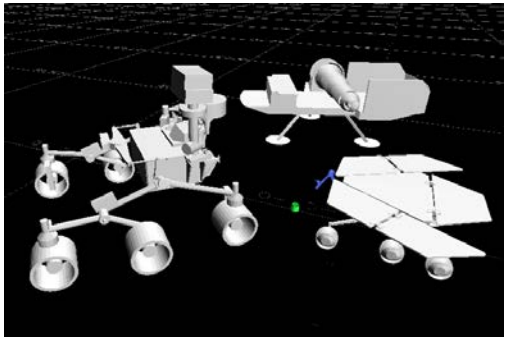
Mars Ascent Vehicle



Break-the-Chain/Containment Assurance



On-Orbit Sample Transfer

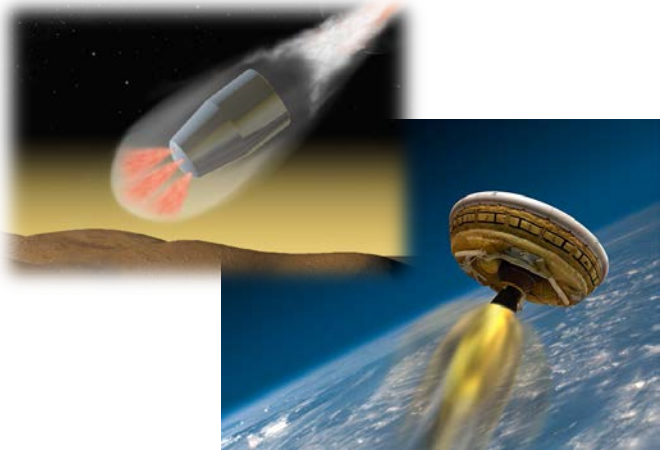


Surface SampleTransfer

New Technology Investment Directions

Longer-term investment areas:

Extreme Terrain Access



Advanced EDL

Aerial Platforms