Mars Exploration Program

Program Status – March 9, 2020
Presented to Planetary Advisory Committee at NASA HQ

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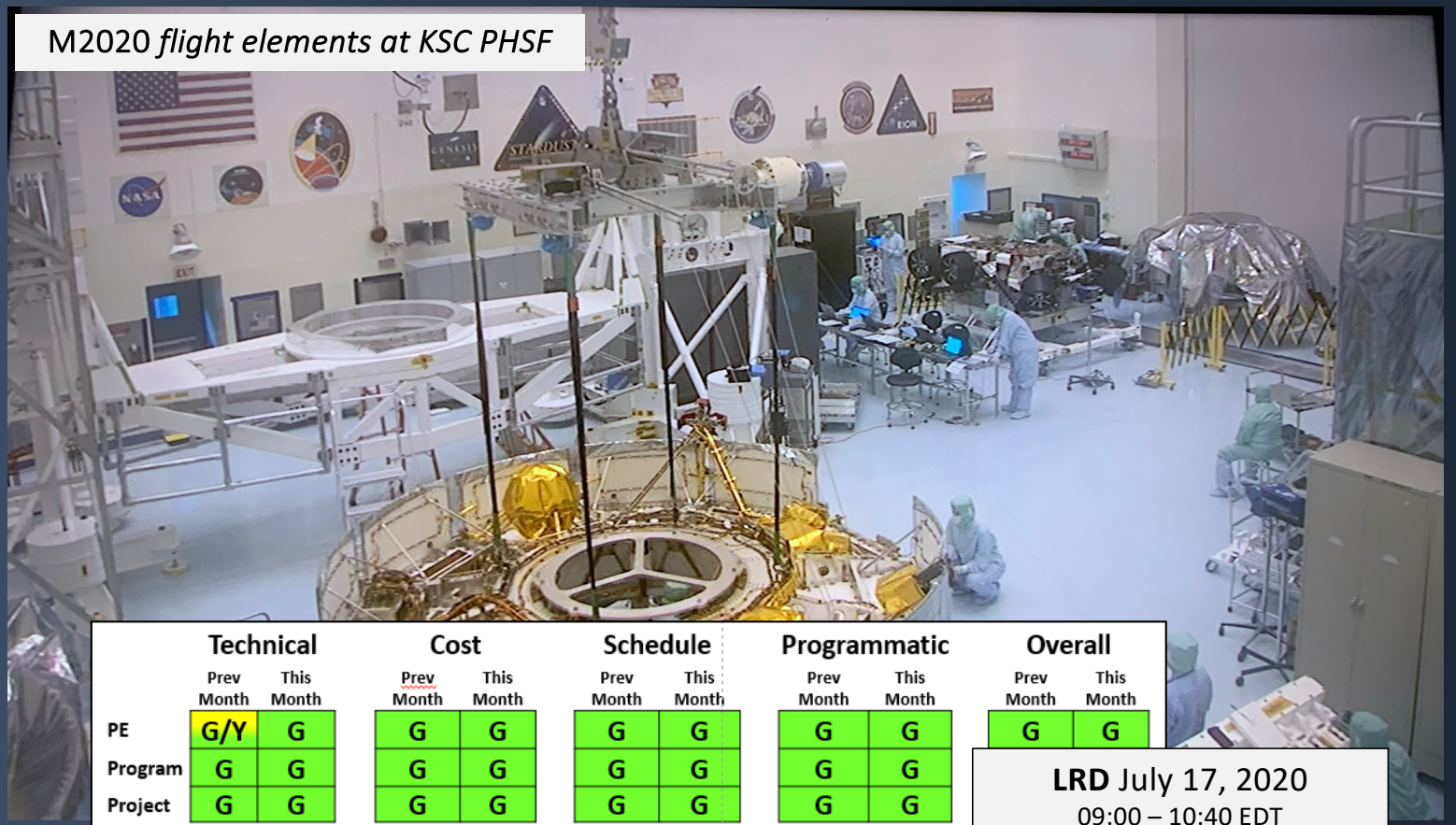
MEP Introduction

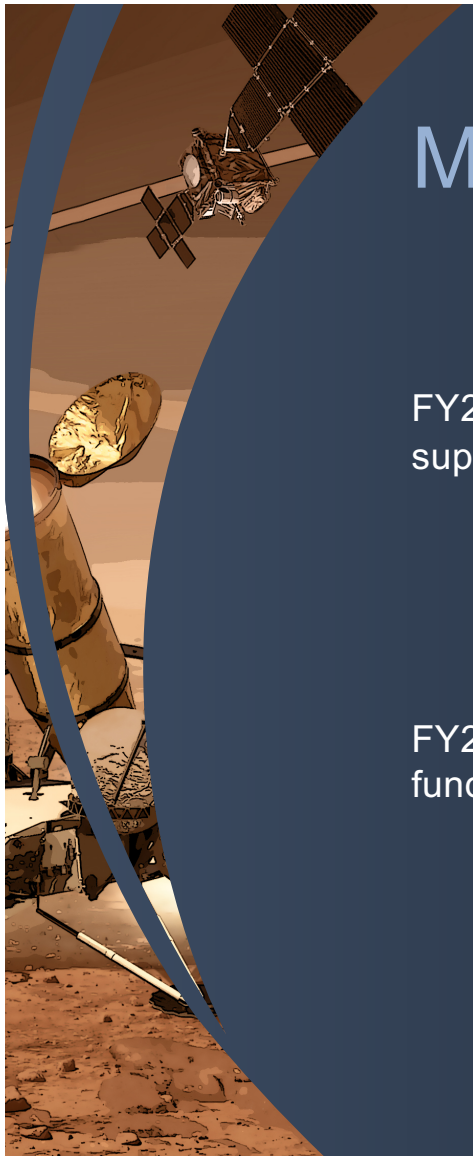
MEP is a healthy and productive program,
making good progress on current obligations,
collaborating with our international partners,
actively working towards humanity's first roundtrip to another planet,
and supporting NASA's M2M planning.

M2020 Status



	Technical		Cost		Schedule		Programmatic		Overall	
	Prev Month	This Month	Prev Month	This Month	Prev Month	This Month	Prev Month	This Month	Prev Month	This Month
PE	G/Y	G	G	G	G	G	G	G	G	G
Program	G	G	G	G	G	G	G	G		
Project	G	G	G	G	G	G	G	G		

LRD July 17, 2020
09:00 – 10:40 EDT



MEP Budget Status

FY20 Budget Appropriation, though favorably marked, was significantly over-stressed supporting problem resolution in multiple areas on M2020

- Required austerity measures across the entire portfolio, except R&A
- MEX support ending mid-FY20 (scored poorly in Senior Review)
- M2020 cost has stabilized and mission is on-track for July 17, 2020 LRD
  - Flight systems shipped to KSC (Feb 2020)

FY21 President's Budget Request is overall very favorable for the MEP, but available funding for extended mission longevity is limited

- Funded two new mission initiatives
- Odyssey at risk of close-out in FY21
- MSL operations reduced in FY21

New MEP Initiatives

President's FY21 Budget Request supports essential Mars precursors

"The Budget also funds the robotic exploration of Mars, in cooperation with international partners, as a precursor to human exploration. In addition to performing cutting-edge scientific investigations, a new Mars Ice Mapper mission would provide data for potential landing sites, and a Mars Sample Return mission would demonstrate the ability to launch from Mars' surface."

- ❑ **Mars Ice Mapper** - searching for habitable environments and accessible ISRU resources
  - Joint NASA/CSA exploration initiative
  - Near surface, shallow (<10m) subsurface ice deposits in the mid-latitudes
  - Detection and mapping to prepare for exploration in the 2030s
    - Characterize quality/purity and distribution
    - Characterization of the overburden (civil engineering)
  - Implementation assumes a major international & commercial partnership
  - 5 year development cycle - 2026 LRD

- ❑ **Mars Sample Return** - humanity's 1st roundtrip to another planet
  - Returning samples from an ancient habitable zone
  - NASA/ESA partnership
  - 6 year development cycle - 2026 LRD (2031 return)

Exploration Ice Mapper: Objectives

EXPLORATION OBJECTIVES

- ❑ Ground Ice as a Resource
  - Is there water ice is contained within the first 10m of the Martian surface?
  - What are the spatial extents of the deposits?
- ❑ Landing Site Geotechnical Properties
  - How rough are the surface and shallow subsurface?
  - How compact are the potential landing sites?

SCIENCE OBJECTIVES (NOTIONAL)

- ❑ Distribution & Origin of Ice Reservoirs
  - Quantify extent and volume of water ice in non-polar regions
- ❑ Dynamic Surface Processes on Mars
  - Establish role of liquid water in Recurring Slope Lineae
- ❑ Geological Evidence for Environmental Transitions
  - Evaluate fine-scale morphology in ancient terrains ("dust removal")

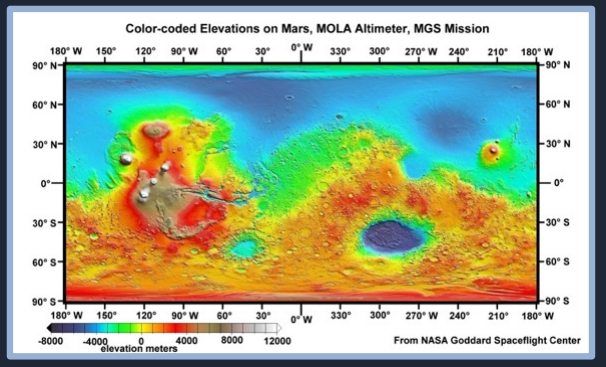
Exploration Ice Mapper: Approach

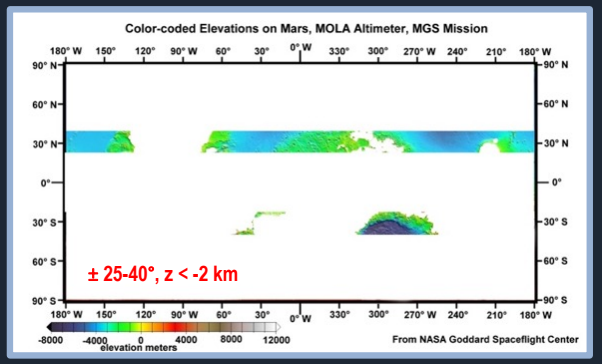
"RECONNAISSANCE ZONE"

- Exploration objectives focus on regions where human landing sites may be possible
  - Equatorward of 40° for solar conditions
  - Poleward of 25° to maximize possibility of locating ground ice
  - Elevation < - 2km from MOLA datum for EDL considerations
- Science objectives – planet wide characterization

KEY OUTPUTS

- Exploration: "Critical Data Products"
  - CDP-1: Reconnaissance Zone Shallow Subsurface Ice Map
  - CDP-2: Reconnaissance Zone Surface & Shallow Subsurface Physical Properties Map
- Science: "High Priority Investigations"
  - HPI-1: Martian Ice Reserves & Surface Morphologies
  - HPI-2: Radar Imaging of Recurring Slope Lineae
  - HPI-3: Ancient Mars Channel 'Excavation'





Substantial Progress Advancing MSR

Critical inflection point for MSR - transition from study to implementation

- Completed Campaign Reference Architecture Peer Review (Jan 22-23, 2020)
  - Marked the beginning of the charge to Formulation
    - Campaign Concept Review (June, FY20)
    - KDP-A (August, FY20)

Chosen late FY26 LRDs

- Earliest technically/programmatically viable date
  - First of two opportunities prior to mid-2030s
- Sample returned to Earth in 2031

1/2 day session on MSR at MEPAG Spring meeting

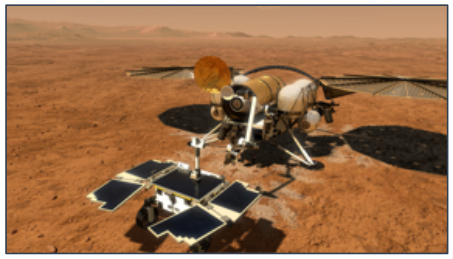
- Arlington, VA (April 15, 2020)

MSR Campaign Mission Elements

M2020 Rover

(July, 2020)

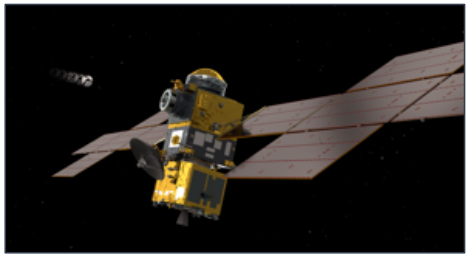
- **Land** in Jezero Crater
- **Explore** and **characterize**
- **Collect** samples for future return. **Retain** some samples for delivery to SRL. **Deposit** some samples on Martian surface for retrieval by the SFR
- **Deliver** retained samples to SRL for transfer to OS



Sample Retrieval Lander

(July, 2026)

- **Land** in the proximity of Jezero Crater
- **Deploy** ESA-supplied **SFR** to **retrieve samples** cached by Mars 2020 at one or more depots, and **receive samples delivered** by M2020
- **Transfer** samples to **OS** onboard **MAV**
- **Launch MAV** to place **OS** in **stable Low-Mars Orbit**



Earth Return Orbiter

(October, 2026)

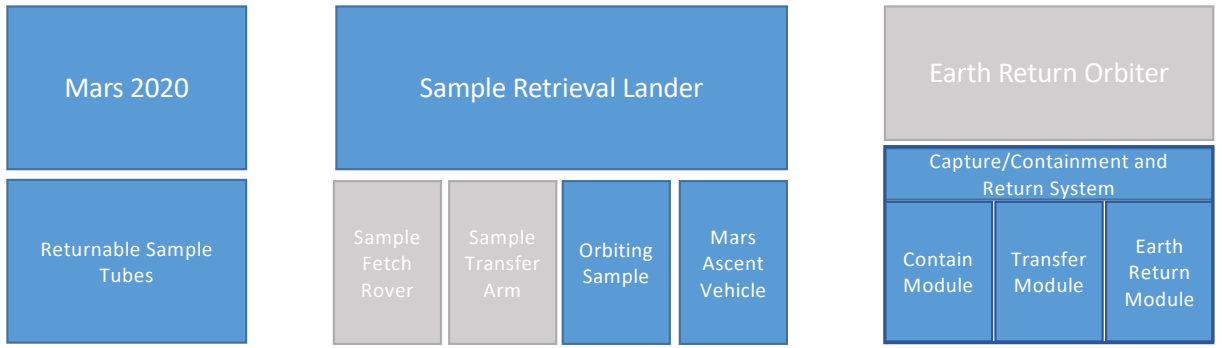
- **Deliver** NASA-supplied **CCRS** payload to Mars orbit
  - **Satisfy Planetary Protection requirements** for returned samples
- **Provide UHF relay** support to SRL EDL and surface mission (SFR, M2020, and MAV)
- **Capture OS** in low-Mars Orbit
- **Contain** the captured OS
- **Return to Earth** and **deliver the EEV** on trajectory to UTTR landing

Robust Sample Retrieval Strategy

SFR Fetch

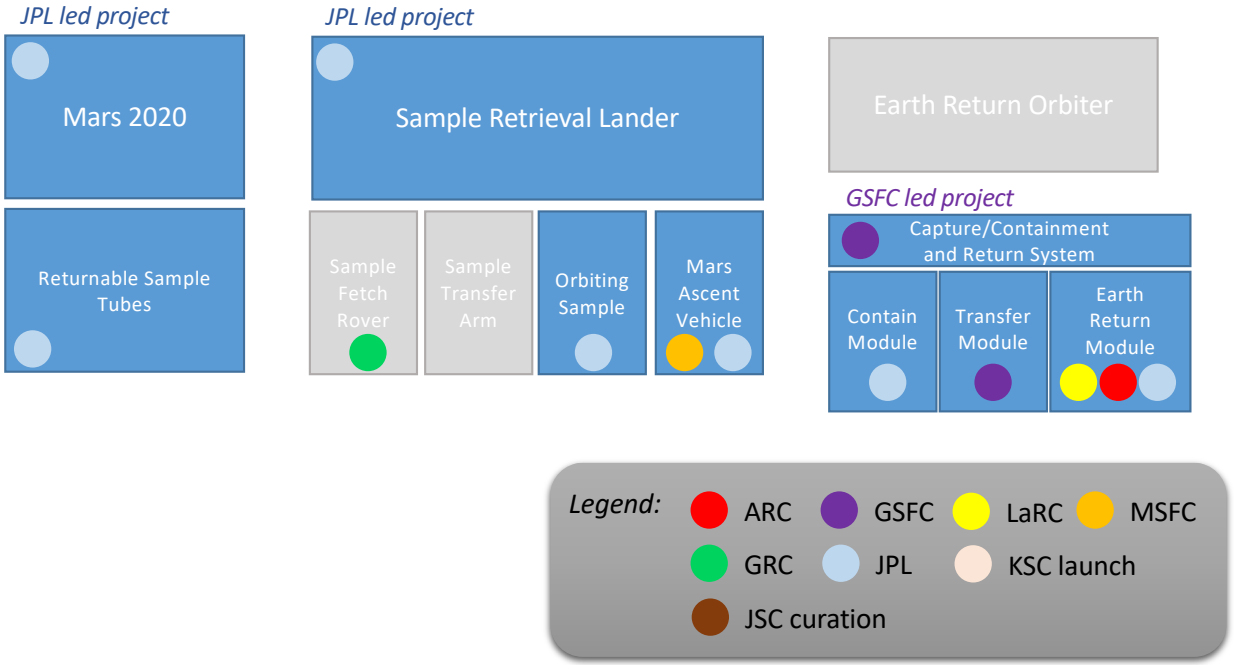
M2020 Delivery

MSR Campaign Elements: Agency Roles Built Upon Capabilities



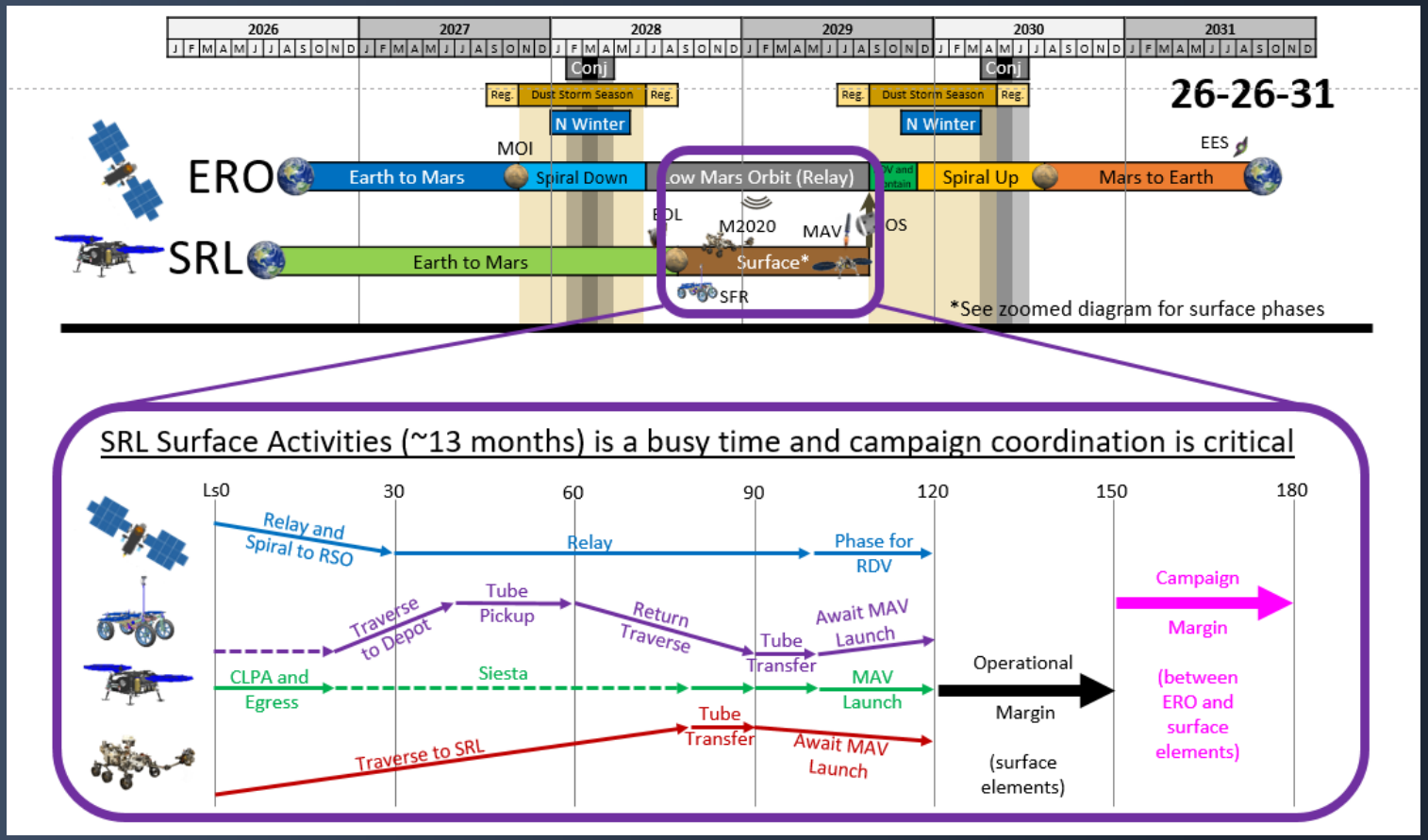
Agency roles chosen to be **strategically aligned with capabilities and experience,** and to minimize and balance campaign technical and programmatic risks within anticipated resources

MSR Campaign Center Responsibilities: Key Strategy for Executing Affordably



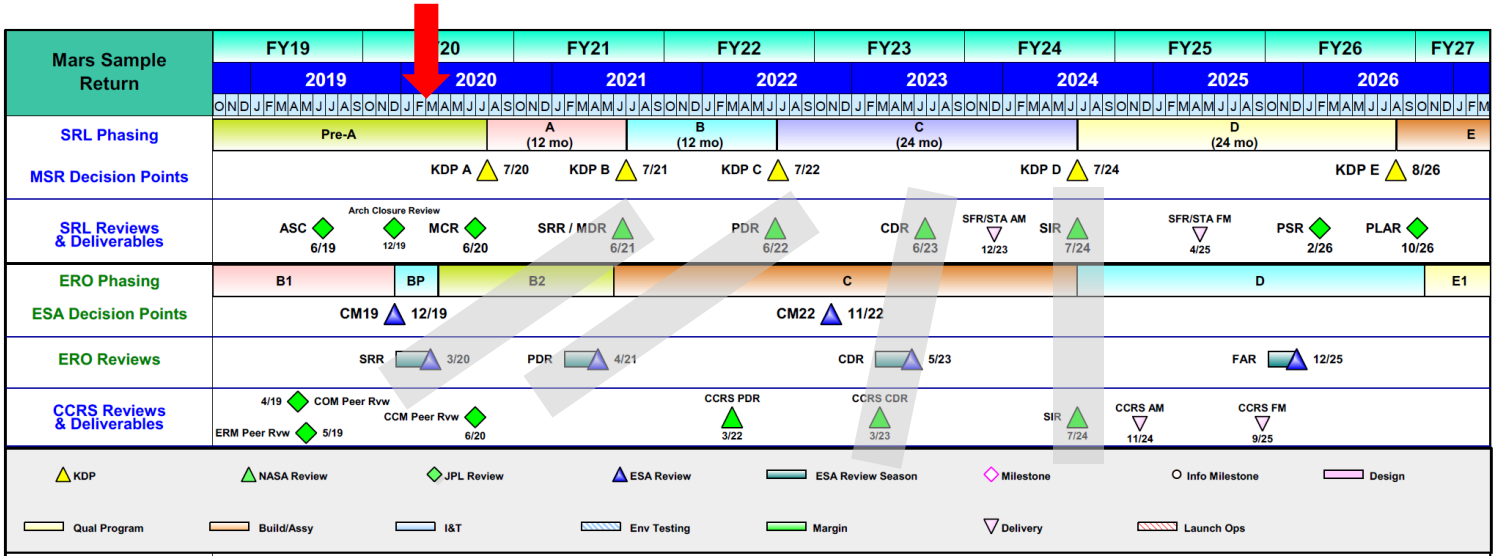
NASA roles **aligned with core competencies and experience**

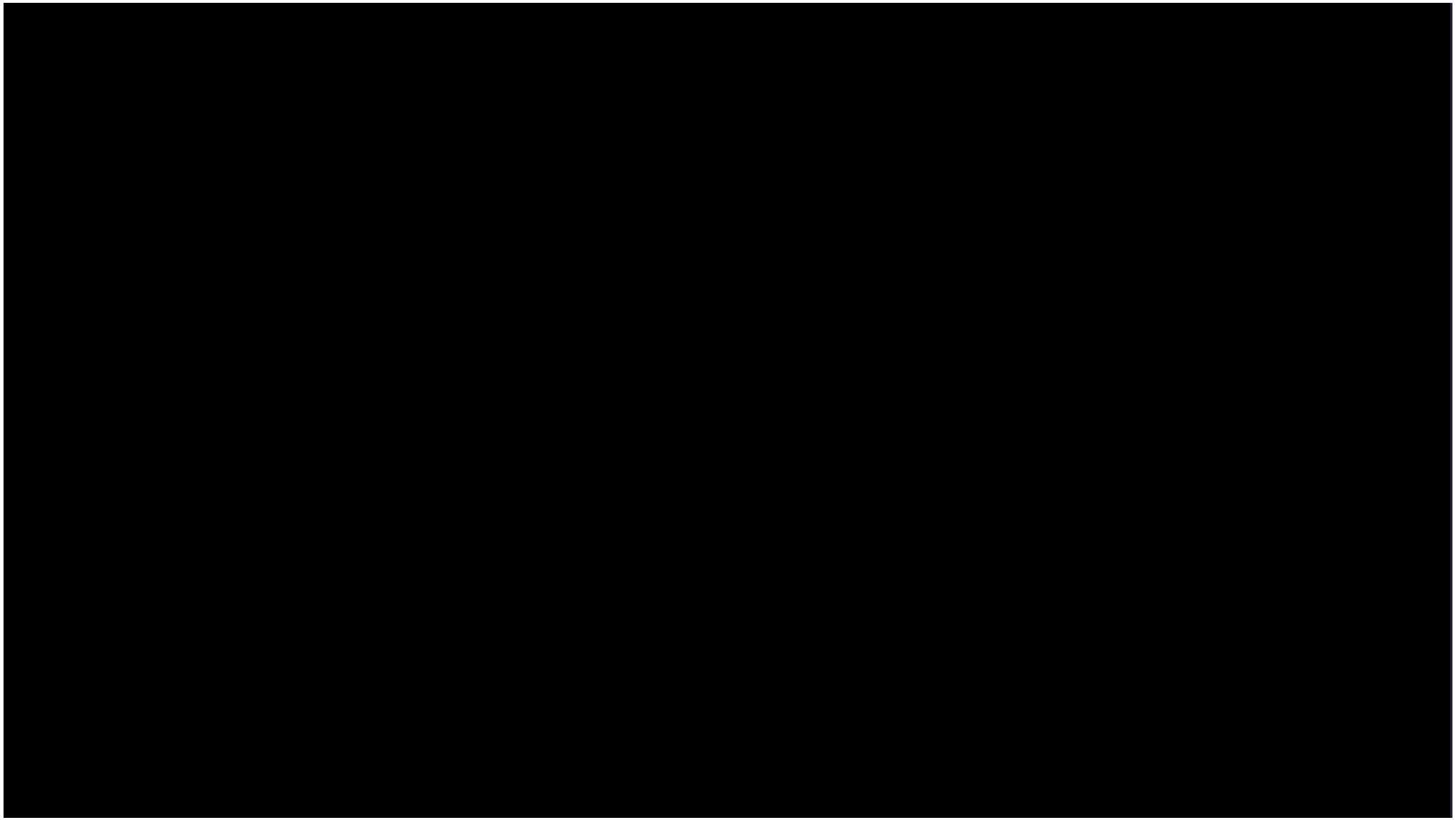
MSR Campaign Timeline



Pre-Phase A Schedule Planning 26/26/31

- With ~ 4 years of pre-phase A investments, plan to formulate and implement the missions with 1 year Phase A, 1 year Phase B and 4 years of Phase C/D
- Agency development cycle utilize different timelines
  - Requires continual coordination to keep cross-deliverables sync'd
  - Managed this well so far





Mars Science

Mars Exploration Program

Two main science activities for MEP

- MSR Science Planning Group (MSPG) in a NASA and ESA partnership
- Mars Architecture Strategy Working group

Science Highlights

- MRO
- MSL

MSR Science Planning Group (MSPG)

MSPG established by NASA and ESA to help develop a stable foundation for international scientific cooperation for the purposes of returning and analyzing samples from Mars. Report completed Nov 2019

Products*

- Workshop - Science in Containment
- Workshop - Contamination Control
- Science Management Framework

Guiding Principles

- Transparency
- Science maximization
- Accessibility/Opportunities for international scientists
- Return on investment for the agency partners
- One return canister: one collection

Steps Forward

- Science Management Plan
- Establish a science management structure - an MRSH Council.
  - There are analogous major science management organizations (CERN, IODP)
- Expand on technical issues related to MSR

* https://mepag.jpl.nasa.gov/reports.cfm?expand=mspg

Mars Architecture Strategy Working Group
MASWG Charter

Chair: Bruce Jakosky

The tasks to be addressed are:

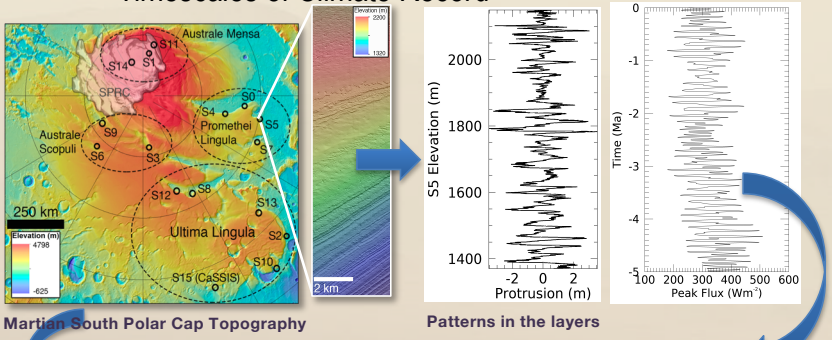
- Determine what could and should be done beyond (i.e., in addition to or after) the Mars Sample Return campaign.
- Survey the compelling science addressable by various classes of missions during the period 2020-2035, building on the science goals outlined in *Vision & Voyages* and updated in the *MEPAG Goals Document*.
- Define mission candidates in various mission classes to guide future MEP planning including, but not necessarily restricted to, missions in the small-spacecraft, Discovery, and New Frontiers categories, which may also be considered by the upcoming Planetary Decadal Survey (2023-2032).
- Define strategic technologies, infrastructure, and partnerships (international and commercial) that can enable compelling science in the specified time horizon, showing their programmatic linkage.

MASWG Schedule and Status

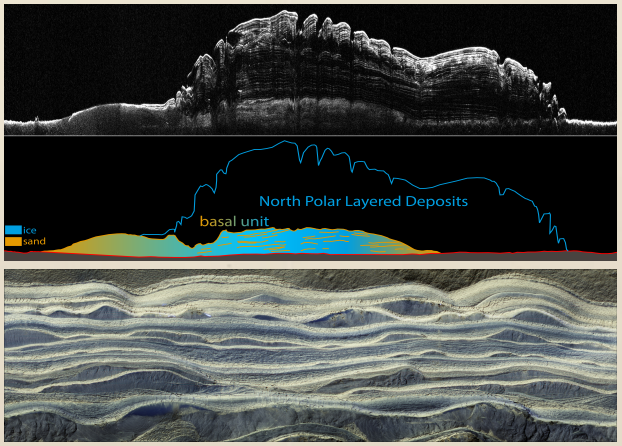
- Schedule
  - Already two meetings in 2020
  - Next meeting 20-22 April 2020
  - PowerPoint preliminary results, expected May/June 2020
  - Full written version of final report, expected August 2020
- Status
  - >50 “One-pagers” on mission concepts were submitted and discussed in detail at January meeting
  - Received briefings on key programmatic, technology, mission, science issues
  - Additional briefings to be conducted by telecon prior to next meeting
- Preliminary report (ppt version) to be released for input and feedback
  - External review by selected members of the Mars community
  - Brief to Mars program at NASA HQ and JPL
  - Brief to MEPAG (with web mechanism to allow written feedback)
- Written results in time for Planetary Decadal Survey Steering Committee

MRO Science Highlights

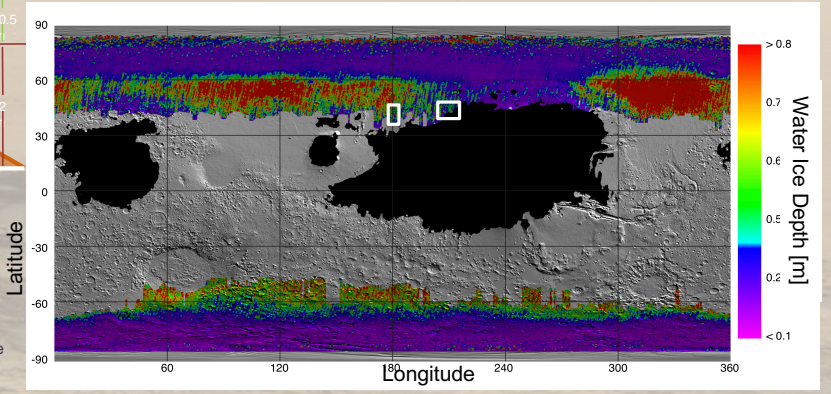
Mars' South Pole Ice Layers Reveal Timescales of Climate Record[1]



Ancient remnants of Mars' northern ice caps revealed by orbital sounding radar[2]



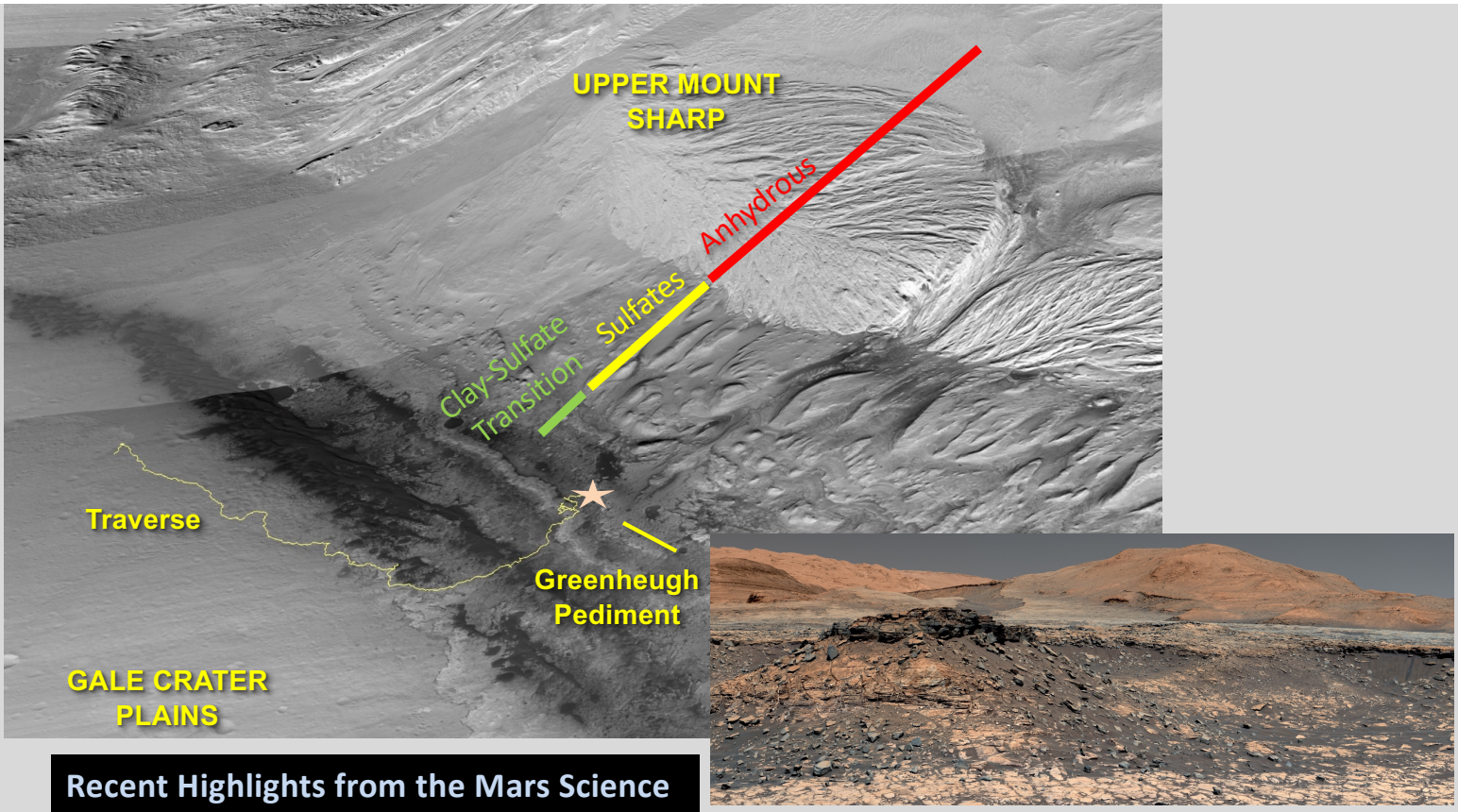
Shallow Water Ice at Mid-Latitudes[3]



1. Nerozzi, S., and Holt, J. W., (2019) Geophysical Research Letters; doi:10.1029/2019GL082114 Ojha, L., Nerozzi, S., Lewis, K. (2019) Geophysical Research Letters; doi:10.1029/2019GL082294

2. Nerozzi, S., and Holt, J. W., (2019) Geophysical Research Letters; doi:10.1029/2019GL082114 Ojha, L., Nerozzi, S., Lewis, K. (2019) Geophysical Research Letters; doi:10.1029/2019GL082294

3.S. Piqueux, J. Buz, C. S. Edwards, J. L. Bandfield, A. Kleinböhl, D. M. Kass, P. O. Hayne, the MCS and THEMIS teams, 2019, Widespread Shallow Water Ice on Mars at High and Mid Latitudes, GRL, doi:XXXXXXXXXXXXX.



Recent Highlights from the Mars Science Laboratory

- Curiosity is nearing the transition from clay-bearing to sulfate-bearing strata on Mount Sharp, potentially marking a major environmental transition in Mars' history and one of the features identified from orbit that resulted in the selection of Gale crater for the mission's landing site