Mars Sample Return: Introduction

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Presented to (virtual) MEPAG Spring Meeting

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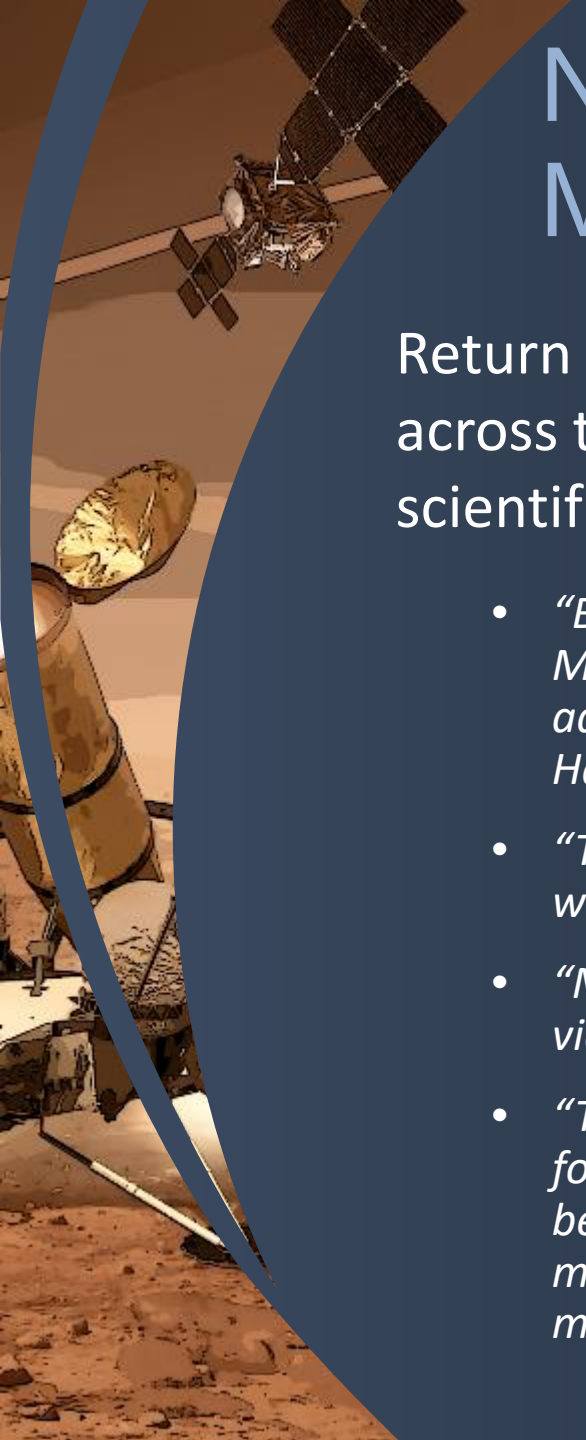
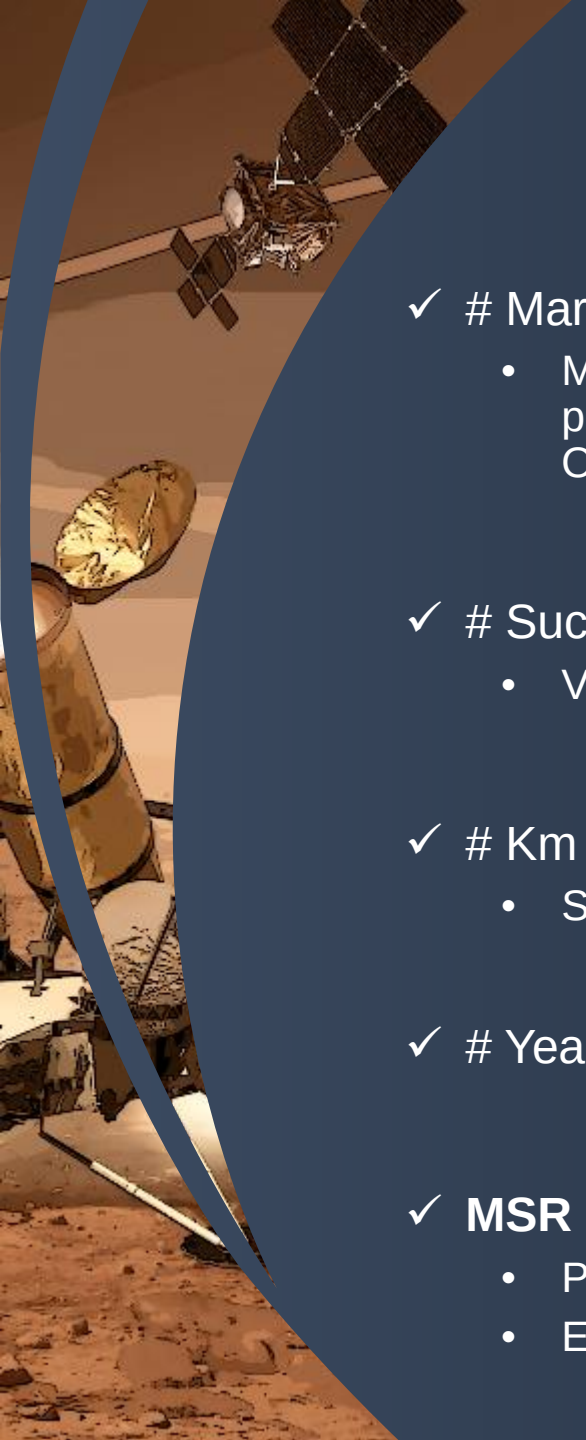


NASA Recognizes the Importance of Mars Sample Return

Return of scientifically selected samples from Mars to address key objectives across the field on Planetary Science has been and remains the highest scientifically endorsed priority by the last two Decadal Surveys

- *“Because of its potential to address essential questions regarding planetary habitability and life, Mars sample return has been a primary goal for Mars exploration for many years. It directly addresses all three of the crosscutting themes …, and it is central to the committee's Planetary Habitability theme “ (Chapter 9)*
- *“The highest priority Flagship mission for the decade 2013-2022 is MAX-C [now, Mars 2020], which will begin the…Mars Sample Return campaign ... "(Chapter 9)*
- *“MAX-C [now, Mars 2020] is the critical first element of Mars sample return and should be viewed primarily in the context of sample return,”... (Chapter 6)*
- *“The [Decadal Survey] committee has therefore taken the unusual step of recommending a plan for the coming decade that also has significant budget implications for one or even two decades beyond. The committee does this intentionally and explicitly, with the realization that important multi-decade efforts like Mars Sample Return can only come about if such recommendations are made and followed”... (Chapter 9)*



Ready for MSR

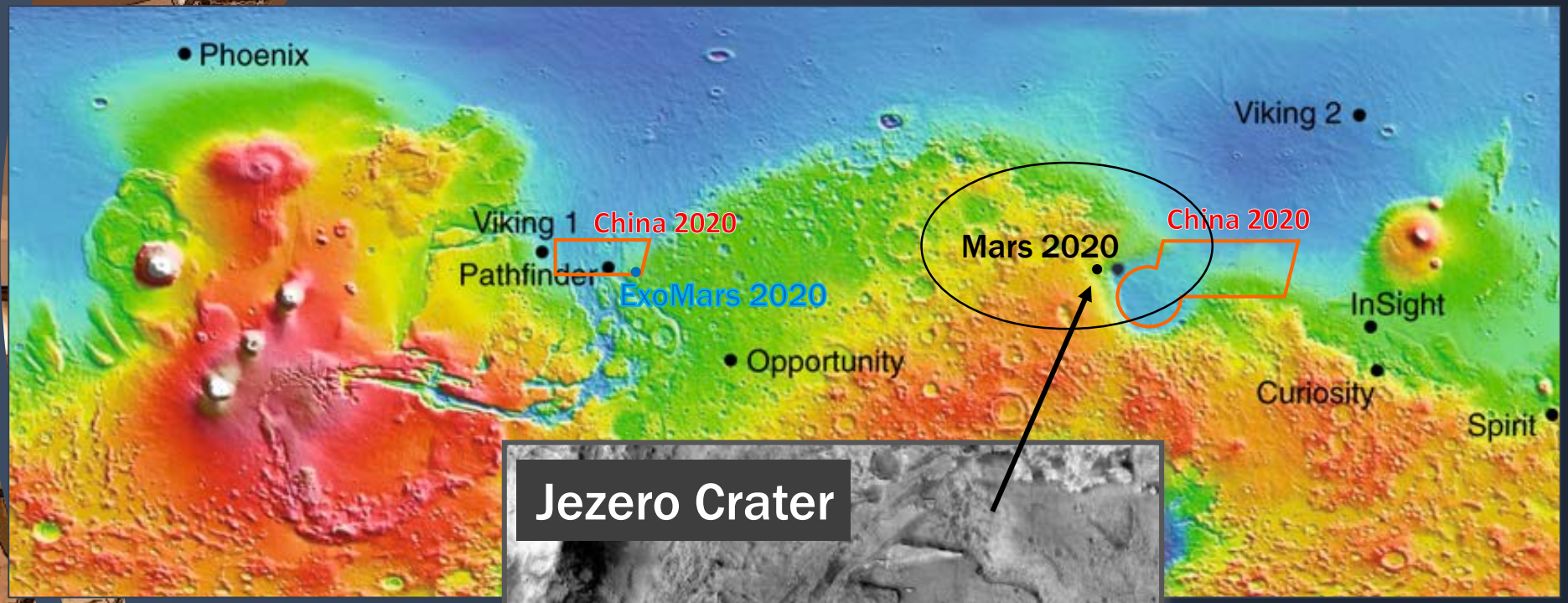
- ✓ # Mars orbits flown by U.S. ***193,560 orbits***
  - Mariner 9: ~700 orbits (deactivated in parking orbit), Viking 1 orbiter: 1485 orbits (deactivated in parking orbit), Viking 2 orbiter: ~700 orbits (deactivated in parking orbit), MGS: 35,885 orbits (lost), Odyssey: ~80,500 orbits (and counting), MRO: 63,418 orbits (and counting), MAVEN: 10,872 orbits
- ✓ # Successful U.S. Mars landings ***8 landings***
  - Viking 1 lander, Viking 2 lander, Pathfinder/Sojourner, Spirit, Opportunity, Phoenix, Curiosity, InSight
- ✓ # Km driven by U.S. Mars rovers ***75 km***
  - Sojourner: 0.104 km, Spirit: 7.73 km, Opportunity: 45.16 km, Curiosity: 22.093 km (and counting)
- ✓ # Years exploring Mars ***49 yrs***
- ✓ **MSR Campaign supported by partner agencies**
  - President's FY21 Budget Request supports MSR
  - ESA Council of Ministers approved participation in MSR

(as of 6 Feb 2020)

Maturation of MSR

- Substantial amount of effort expended in FY16-19 in developing the planning and approach for MSR
  - Well established partnership – NASA/ESA
  - Developed a pragmatic, executable architecture
  - Committed to a disciplined approach to adhere to budgetary guidance
    - Keep it simple as possible, use affordability trades to help set capability, no piggy-back science instruments
- Have approached the challenge of providing robust sample protection very seriously
  - Reached outside to diverse spectrum of expertise to help inform our approach
  - Challenging old assumptions and prior studies
  - Architecture ensures multiple layers of protection
- Committed that sample access be open internationally
  - Assessment and analysis of samples will be managed via international governance: currently in early planning

the Stage for Sample Return



~3 Gya paleolake with well preserved deltaic stratigraphy

Searching for fossilized evidence of planetary evolution, climate, and origins of life

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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 push to Formulation

Chosen late FY26 LRDs with Sample returned to Earth in 2031
- Earliest technically/programmatically viable date
- First of two opportunities prior to mid-2030s

Preparing for NASA Campaign Concept Review (CCR) and KDP-A in FY20

ESA prime contractor selected
- Negotiations underway

Early Investments Reduced MSR Risk

- NASA has invested in MSR architecture studies and key technology maturation throughout FY16-19
  - MSR architecture studies (~$25M)
  - MAV technology development: (~$20M)
  - Containment assurance technology development (~$10M)
  - Earth Entry Vehicle (EEV) technology development (~$15M)

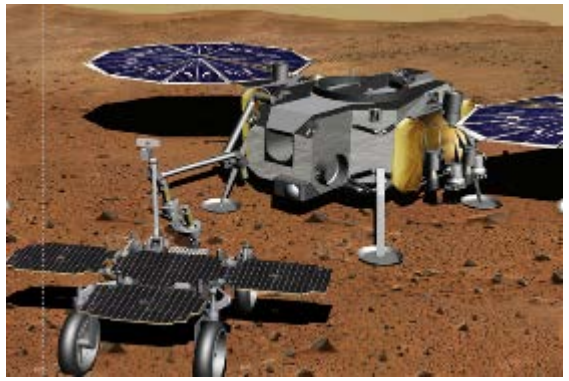
- ESA has made significant investments in MSR mission studies and technologies (since 2017)
  - Mission Studies (~ €9M): Phase A/B1 Industrial system studies on ESA MSR contributions
  - MSR Technologies (~ €19M):
    - Earth Return Orbiter (~ €4M) Propulsion, Rendezvous GNC & Sensors
    - Sample Transfer Arm (~ €2M) Robotic Arm Breadboard
    - Sample Fetch Rover (~ €13M)

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

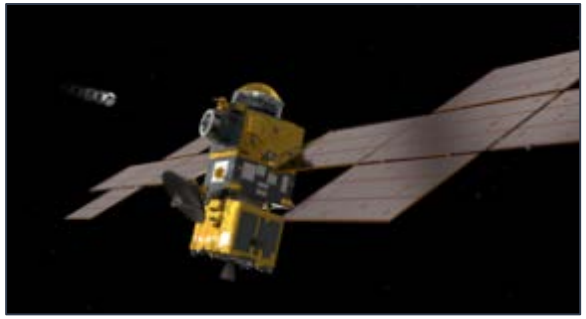
(July, 2026)

- **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**

Robust Sample Retrieval Strategy

SFR Fetch

M2020 Delivery

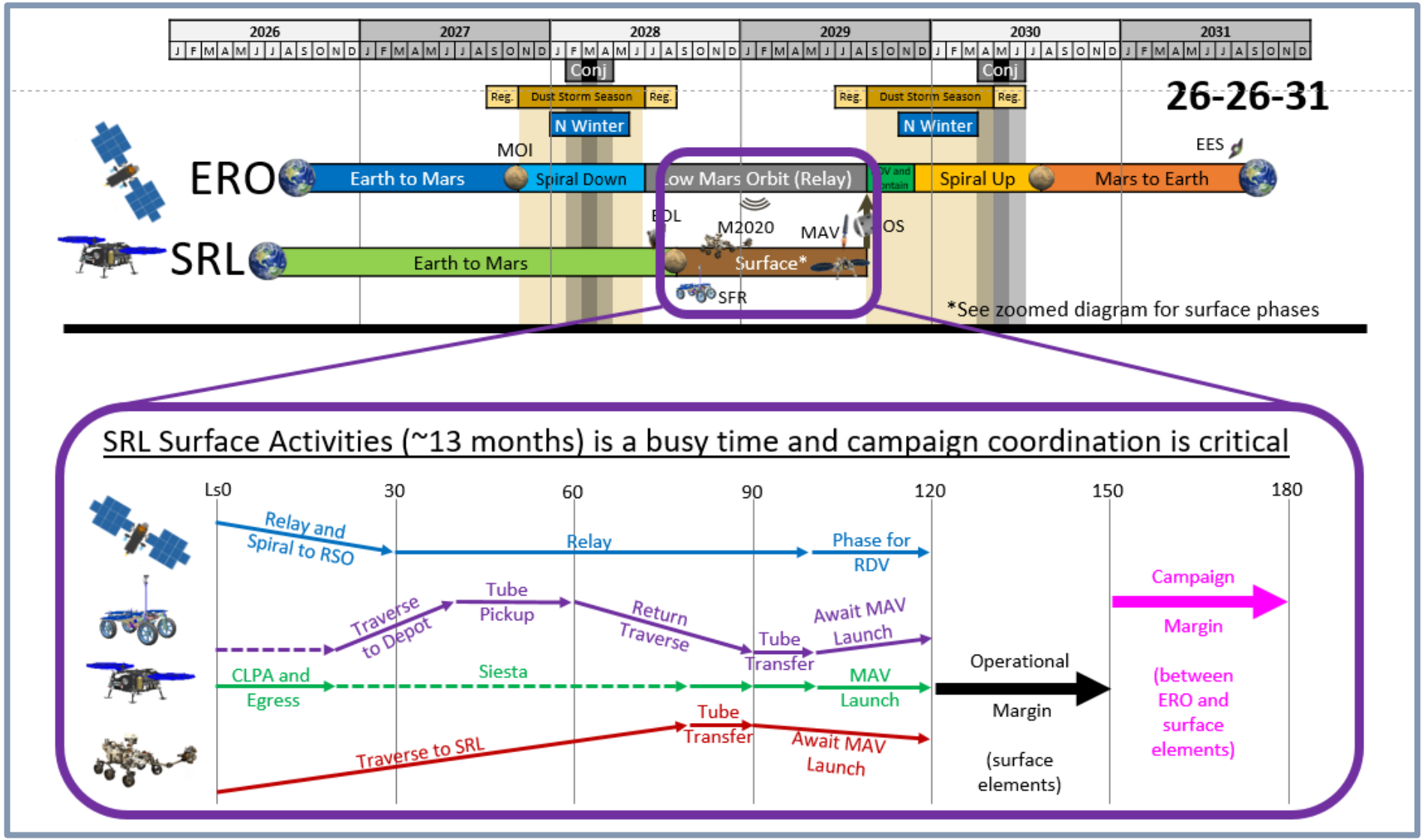


Earth Return Orbiter

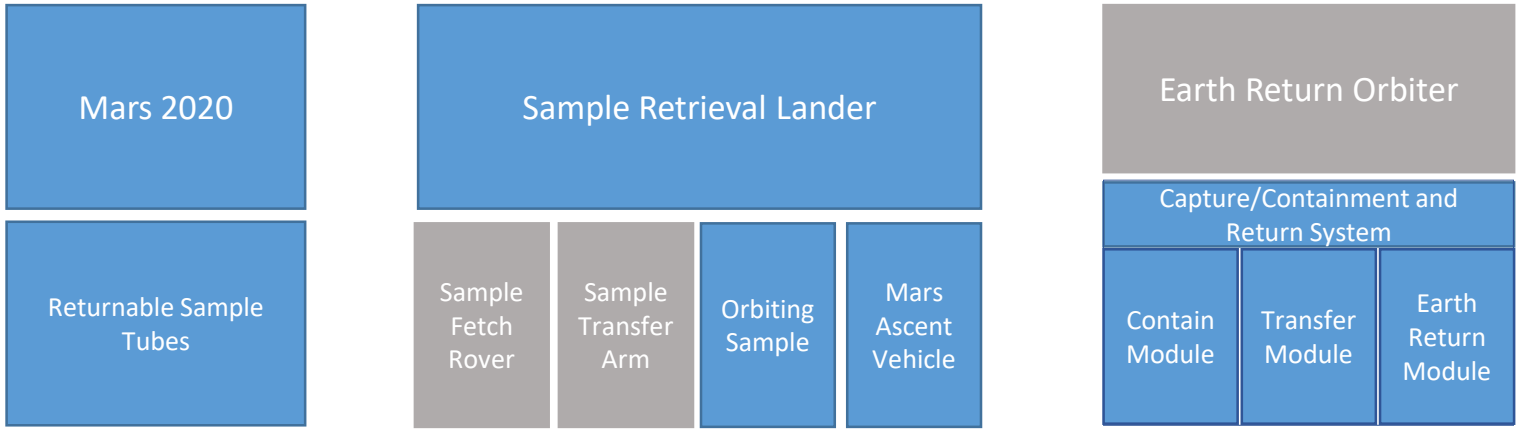
(October, 2026)

- **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

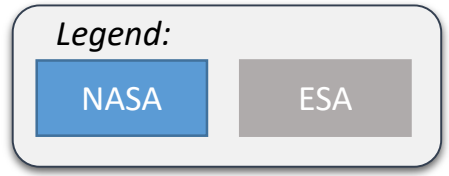
Robust MSR Campaign Timeline



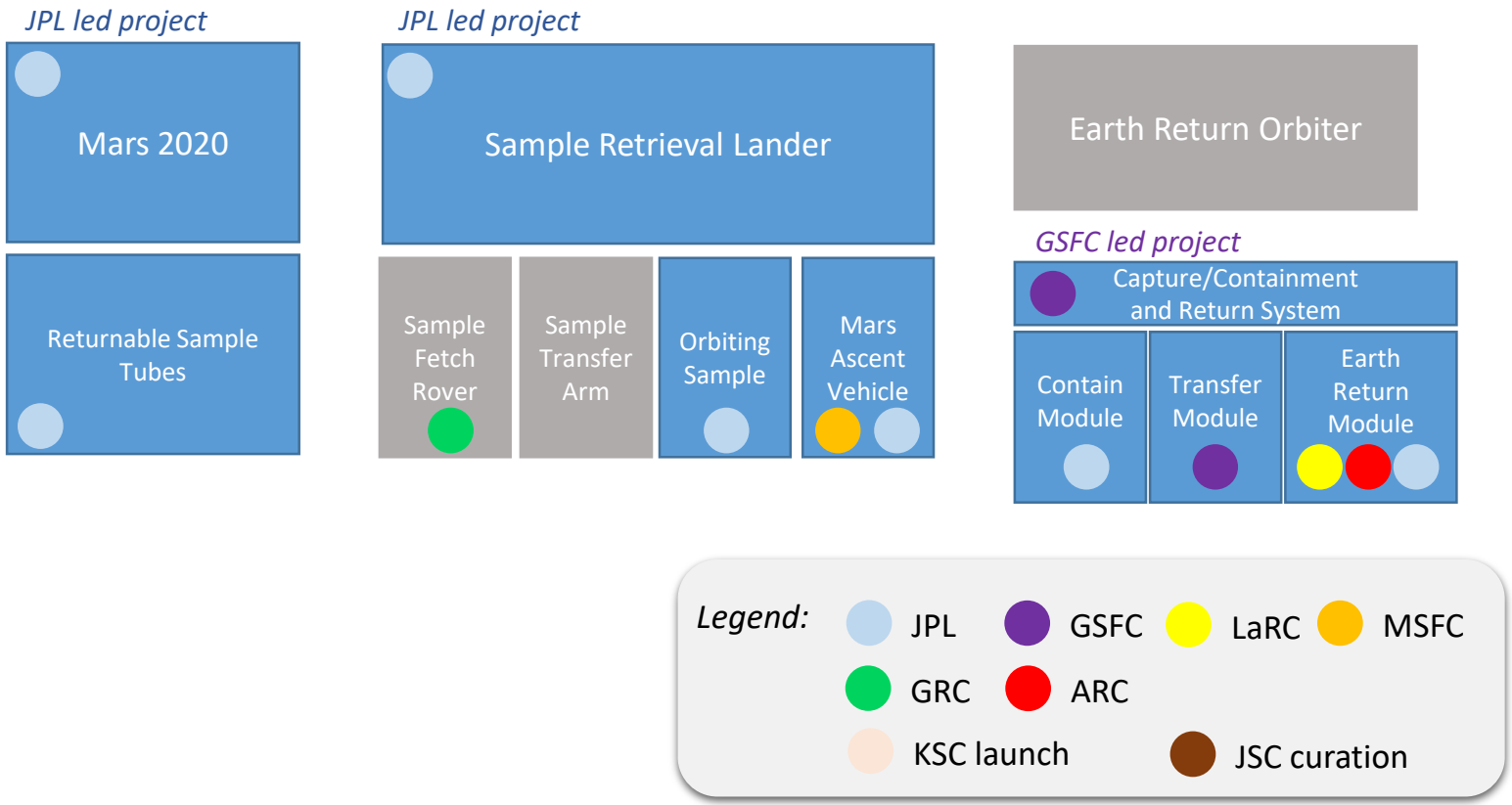
MSR Campaign Elements: Agency Roles Built Upon Capabilities



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



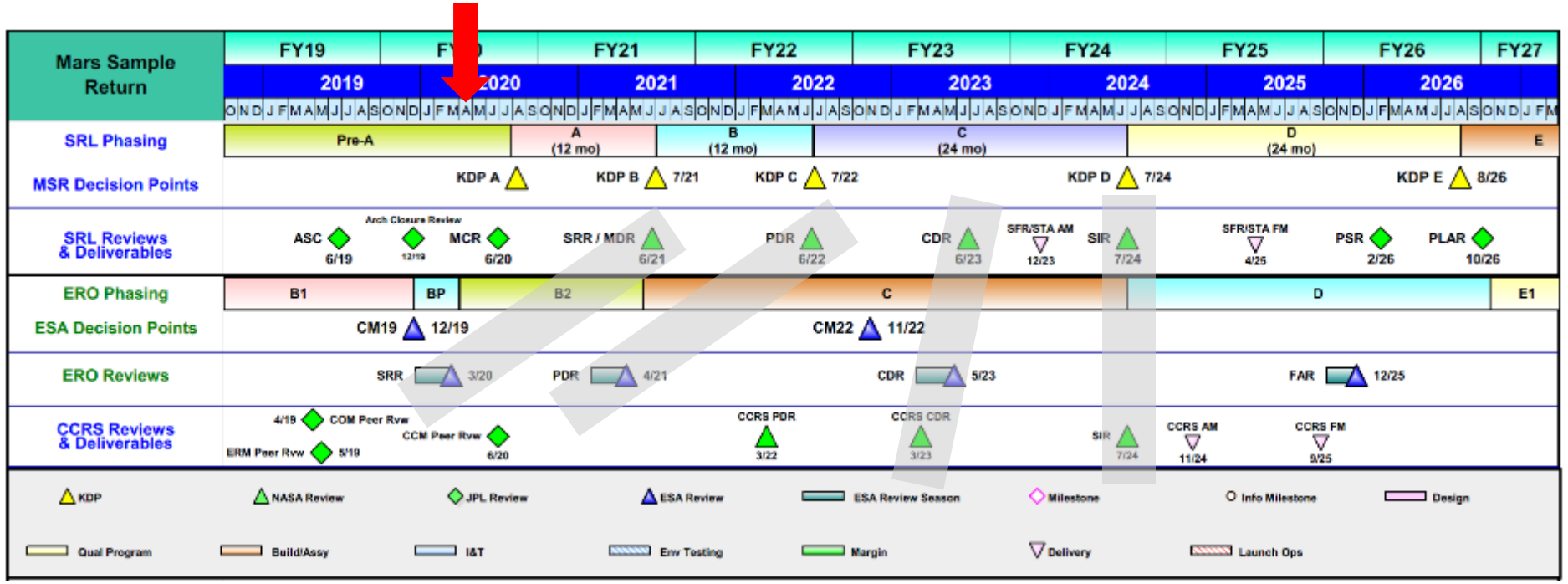
MSR - NASA Center Responsibilities: Key Strategy for Executing Affordably



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

Pre-Phase A Schedule Plan
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 cycles utilize different timelines
  - Requires continual coordination to keep cross-deliverables sync'd
  - Managed this well so far



Video

(WEBMASTER note: link will be added here if this video is posted online)

MSR Summary

- **NASA and ESA are well prepared to proceed with an effective partnership**
  - Have established sound alignment of development capabilities and teaming between the NASA Centers and with ESA and its contractors
  - Institutional approval cycles have been well coordinated
  - Both Agencies working towards 2026 LRD
- **Investments in architecting, trade studies, and technology maturation have positioned NASA to achieve a successful KDP-A in FY20**

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