Mars Sample Return Pre-Project

MSR Timeline and Concept of Operations

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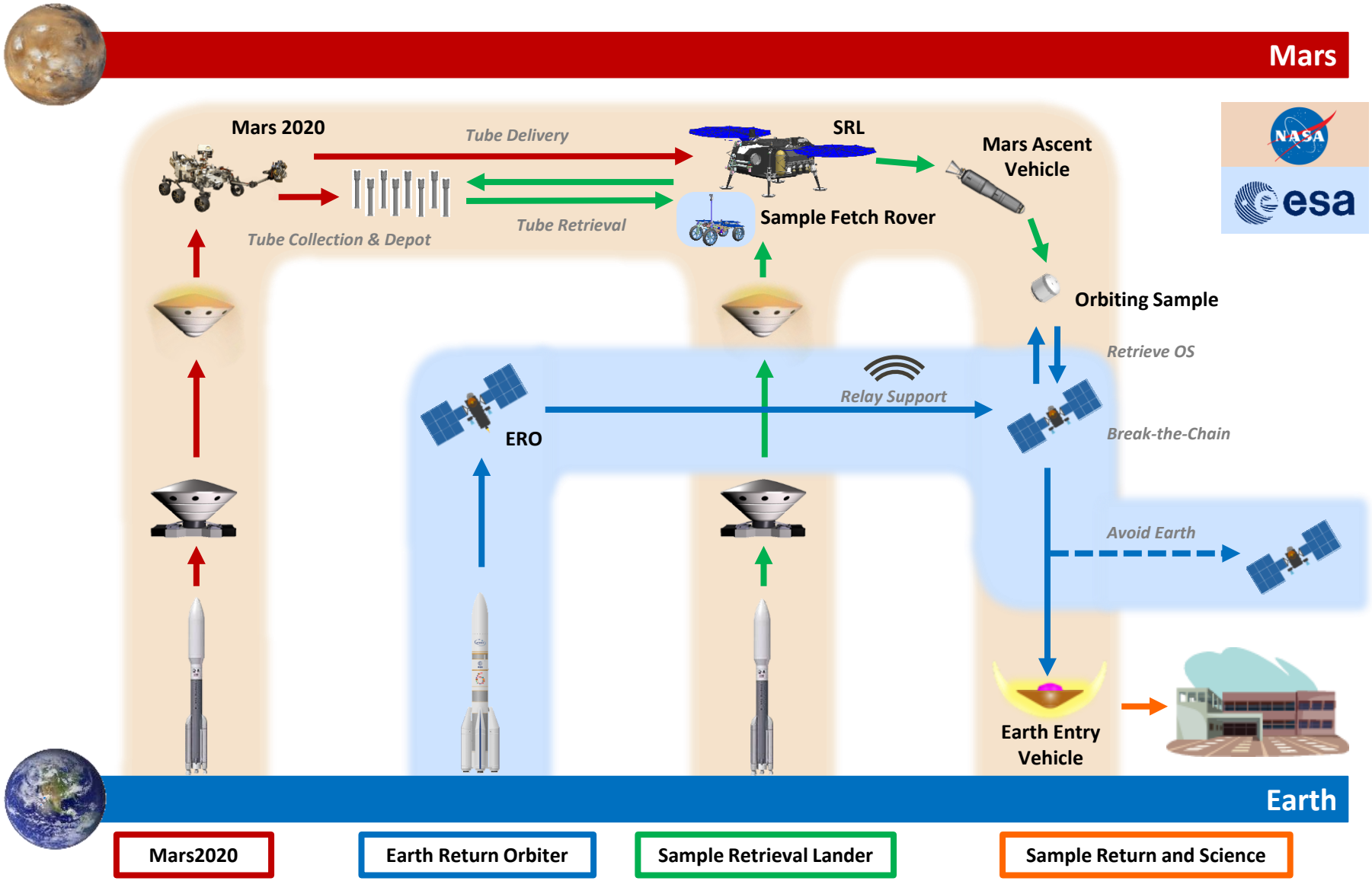
Briefing to MEPAG
April 15, 2020

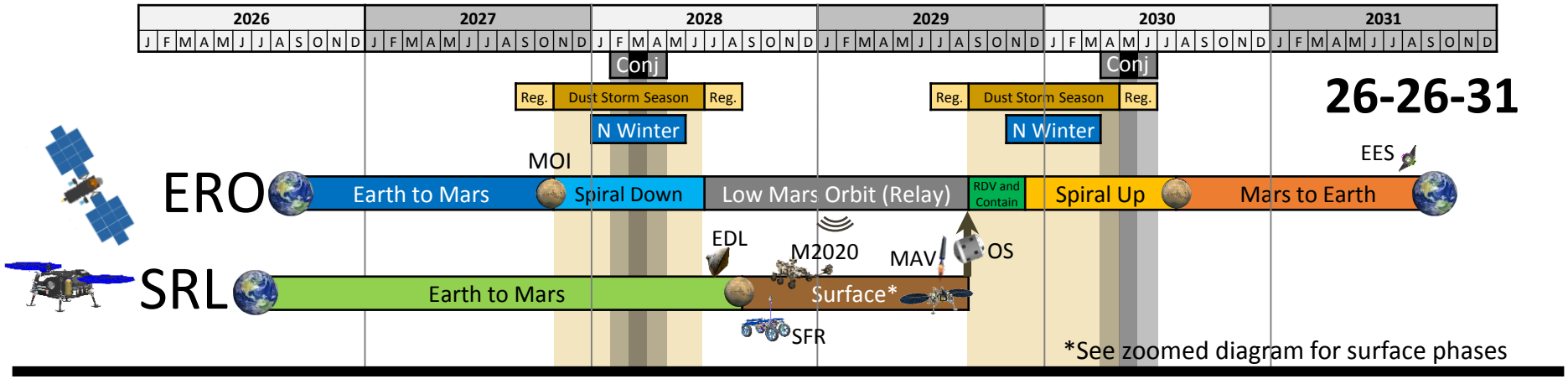
This document has been reviewed and determined not to contain export controlled technical information.

MSR Overview



Campaign Timeline Overview

*Illustrates an example scenario



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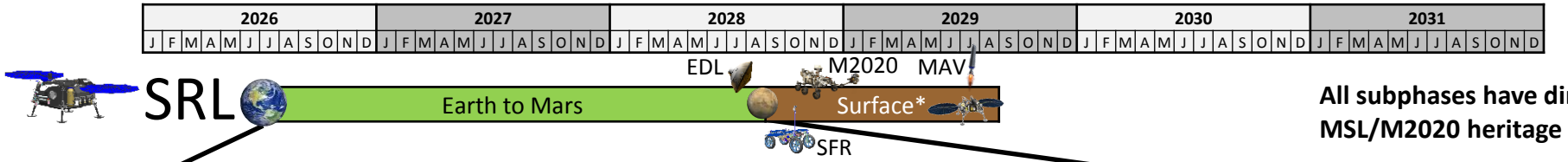
SRL Launches in 2026

ERO launches in 2026

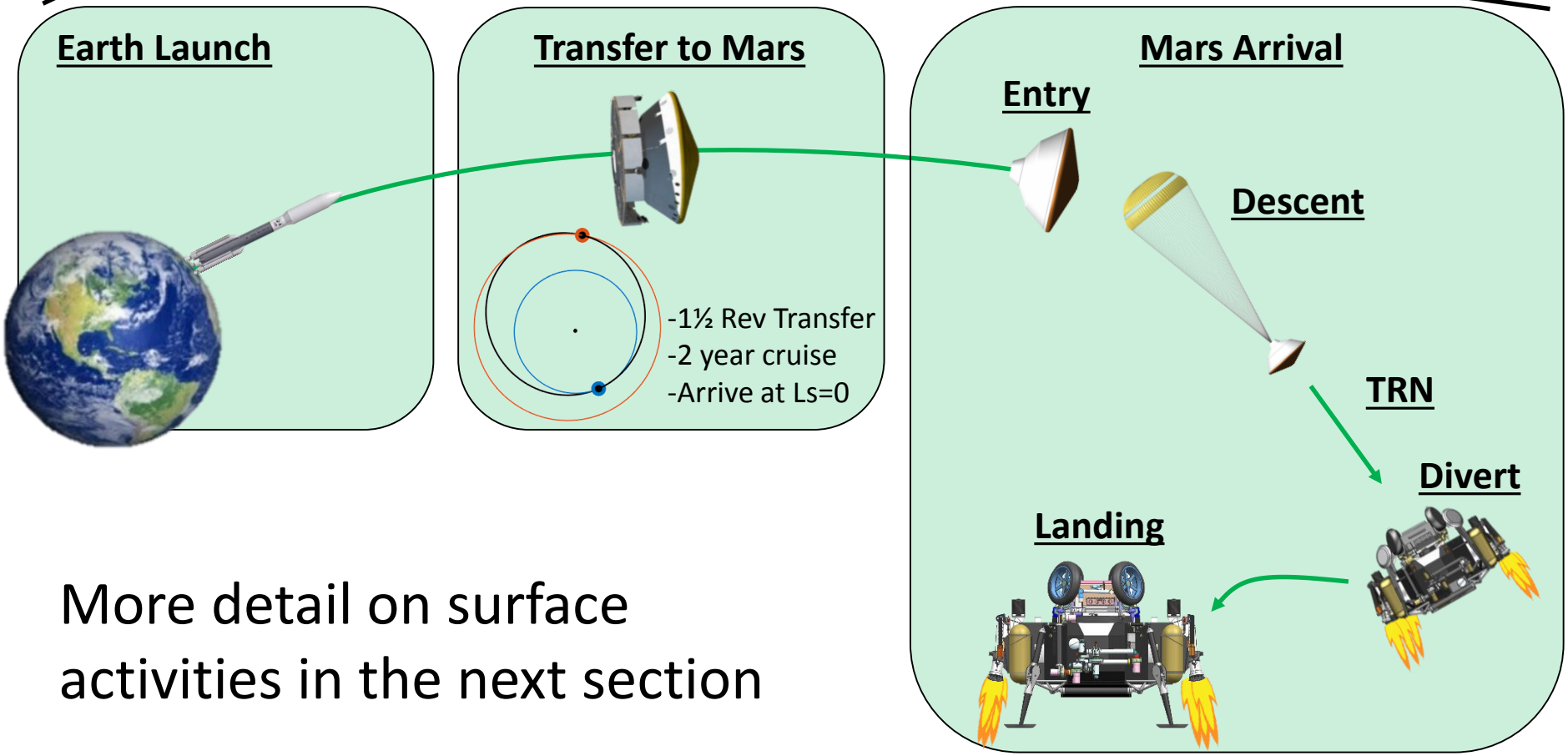
Samples are returned in 2031

- SRL avoids winter and global dust storm season, enabling all-solar SRL/SFR
- SRL EDL occurs in a favorable season, maximizing landed mass
- ERO can provide all relay services needed for MSR (SRL, SFR, M2020, MAV)
- SRL and ERO fit on available launch vehicles and trajectories are feasible

SRL Cruise and EDL

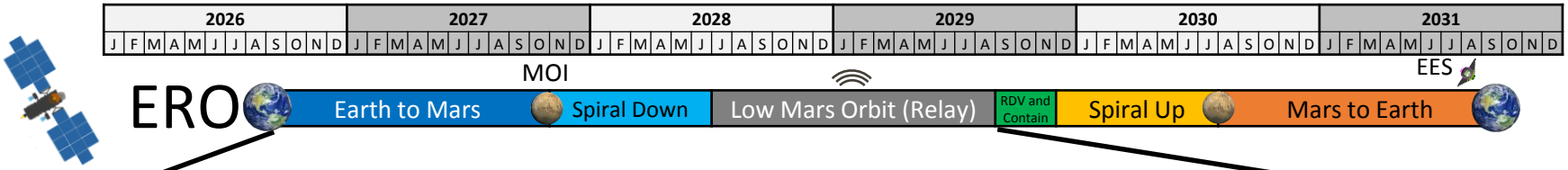


All subphases have direct MSL/M2020 heritage



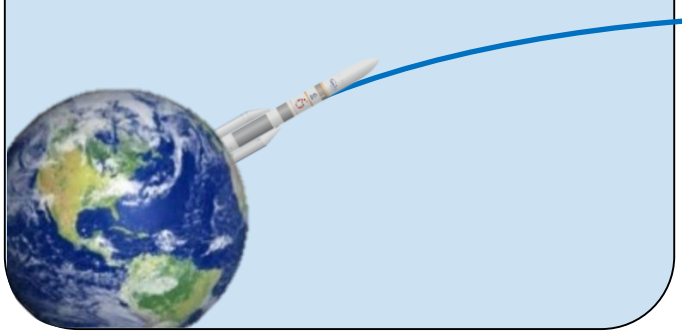
More detail on surface activities in the next section

ERO Cruise and Mars Operations



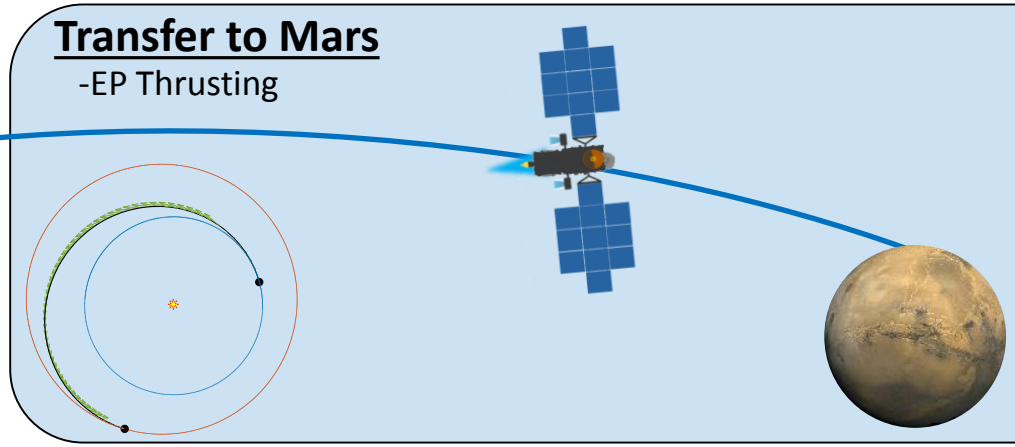
Launch from Earth

-Ariane 6.4



Transfer to Mars

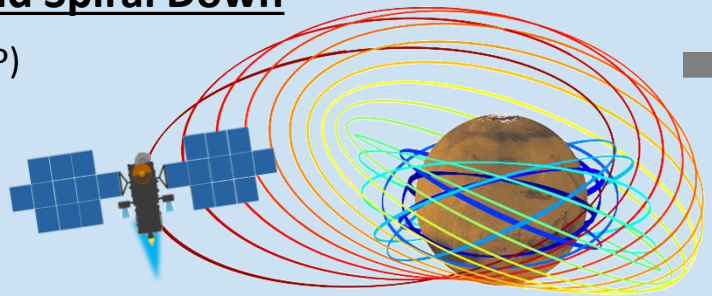
-EP Thrusting



Capture at Mars and Spiral Down

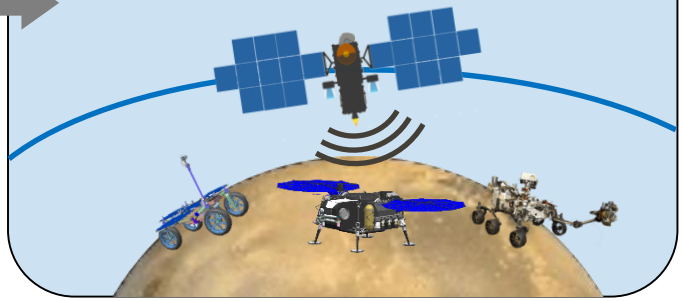
-Mars Orbit Insertion (CP)
-Drop CP stage
-Spiral to LMO (EP)

-Relay support for SRL starts around 1000 km



Low Mars Orbit

-Relay support for SRL/SFR/M2020



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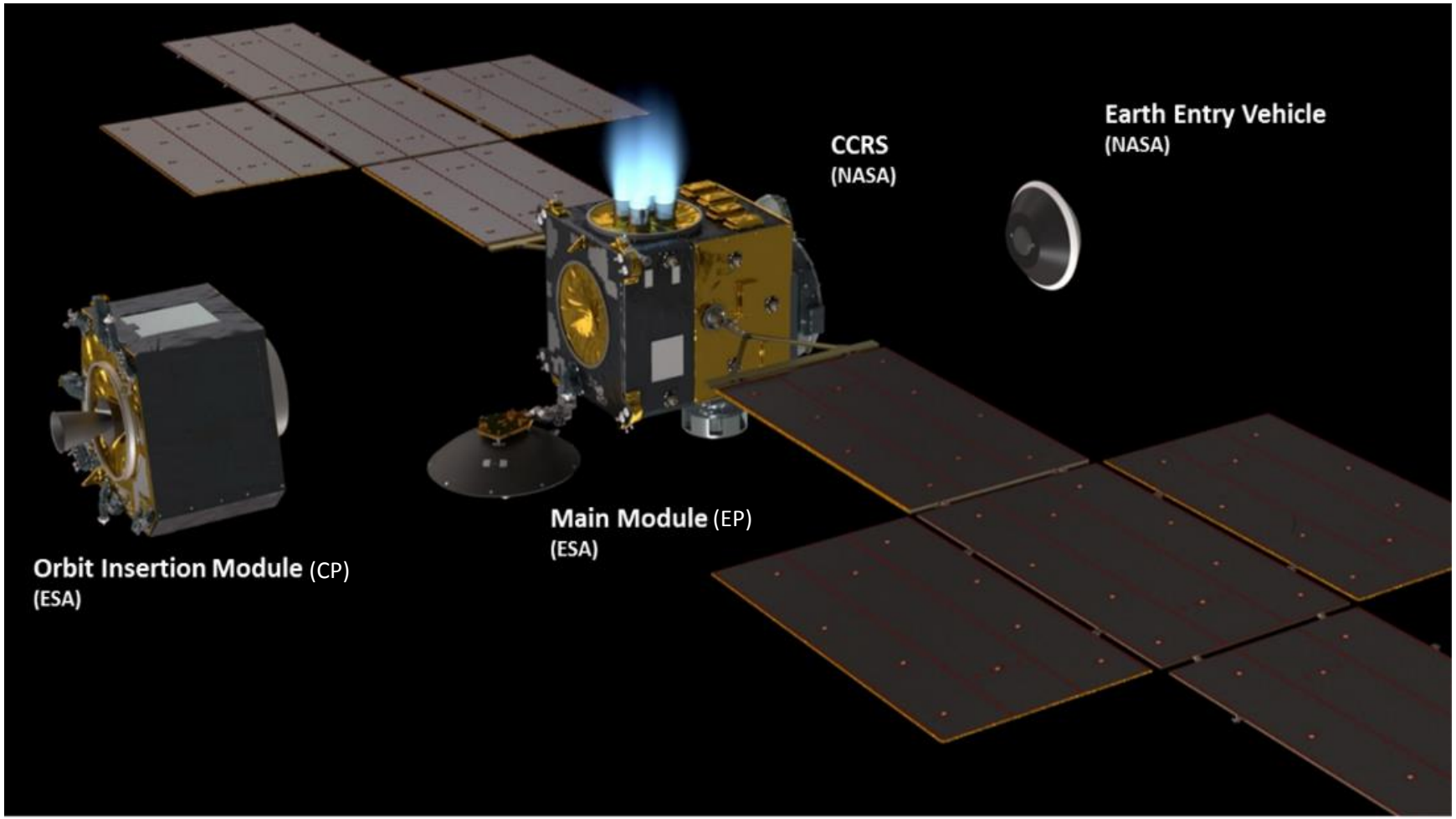
Earth Return Orbiter Contractor Selected: Airbus (Toulouse)



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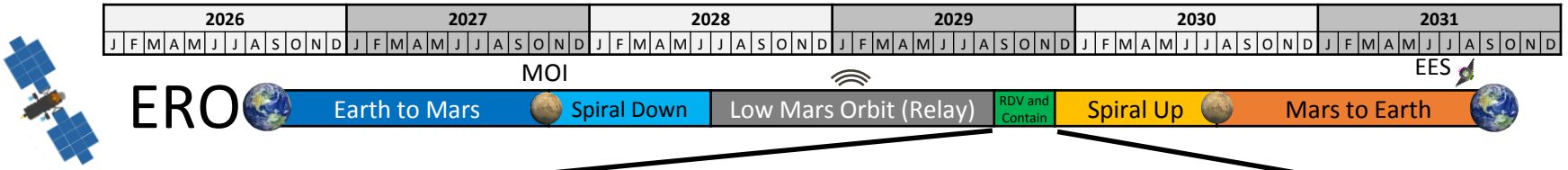
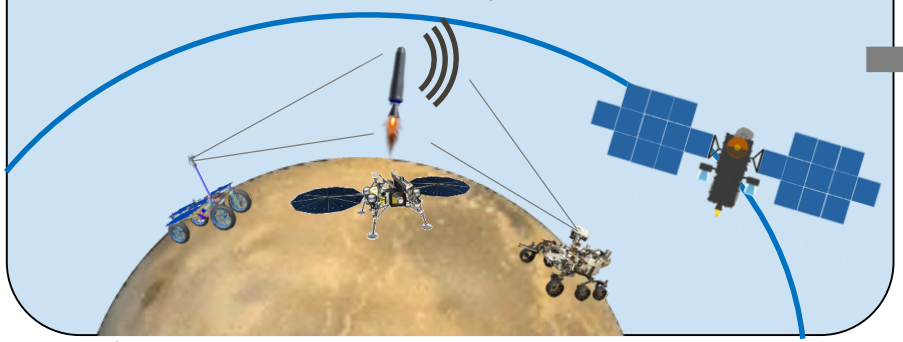
ERO Rendezvous and OS Capture



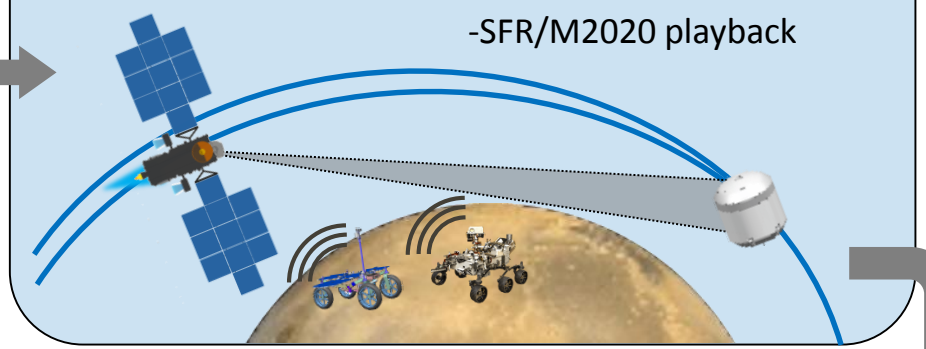
MAV Launch

-ERO receives MAV telemetry
-SFR/M2020 film MAV ascent

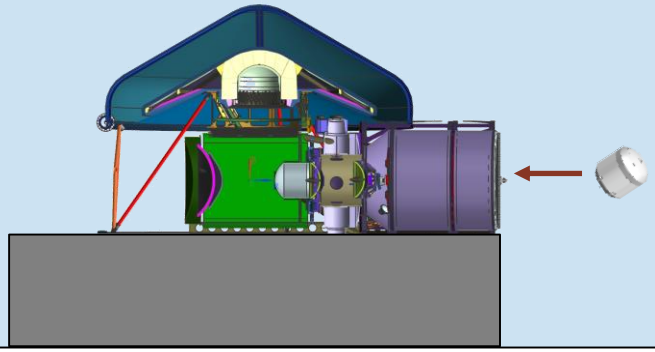


Orbit Matching

-ERO camera acquires OS
-ERO matches OS orbit
-SFR/M2020 playback

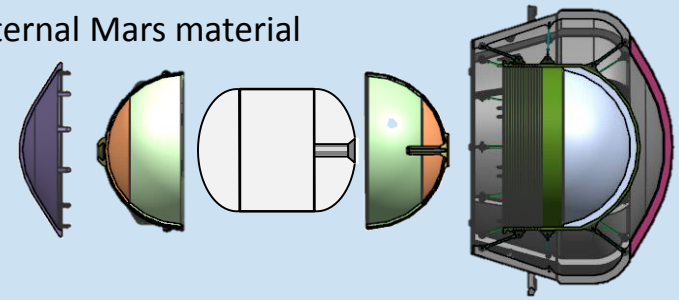


OS Capture

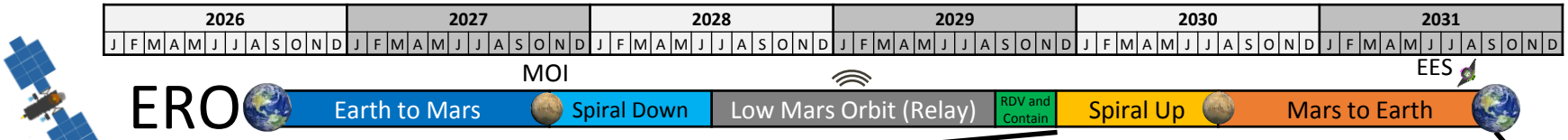


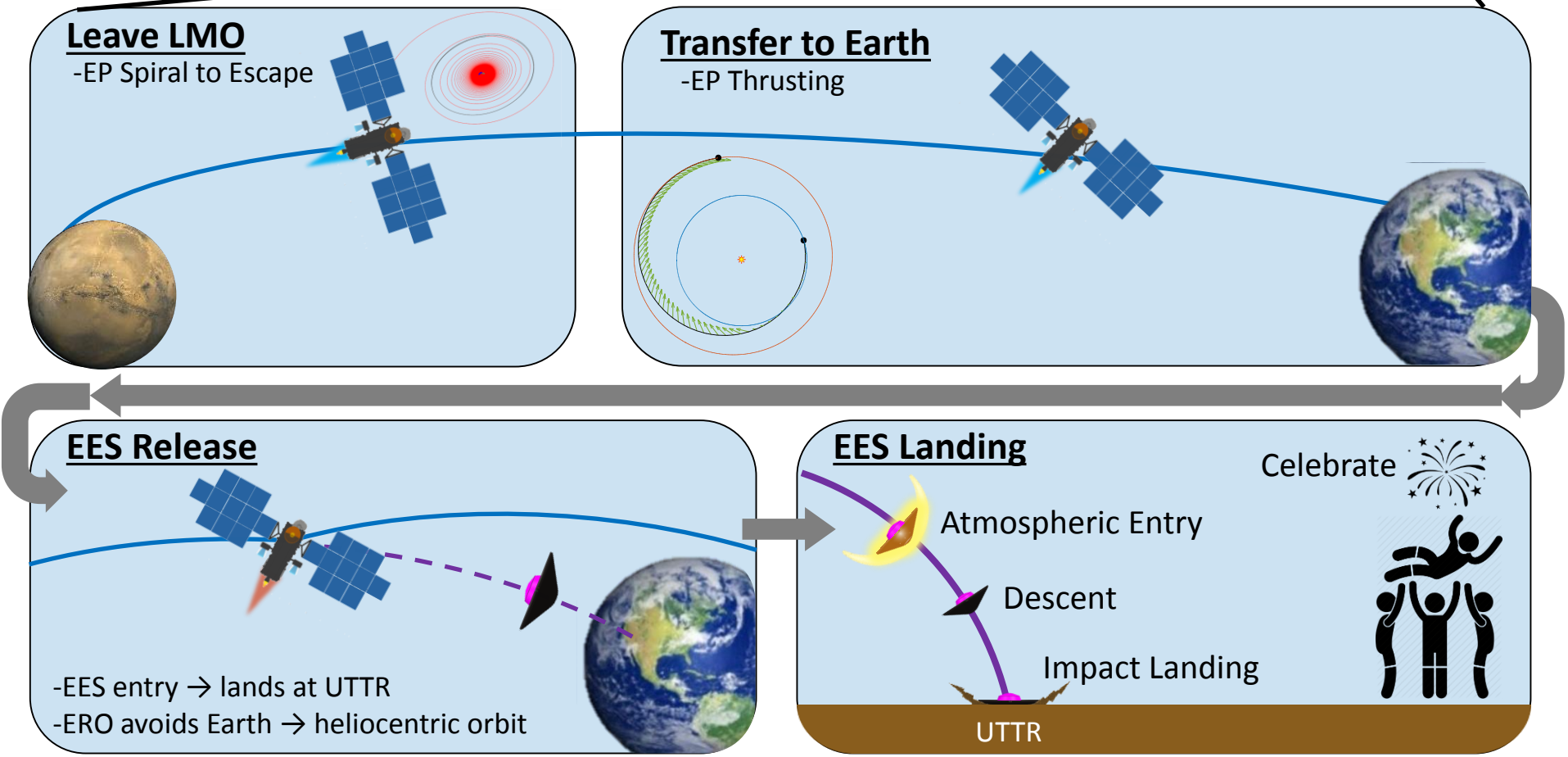
Break-the-Chain

-Sterilize or contain all external Mars material



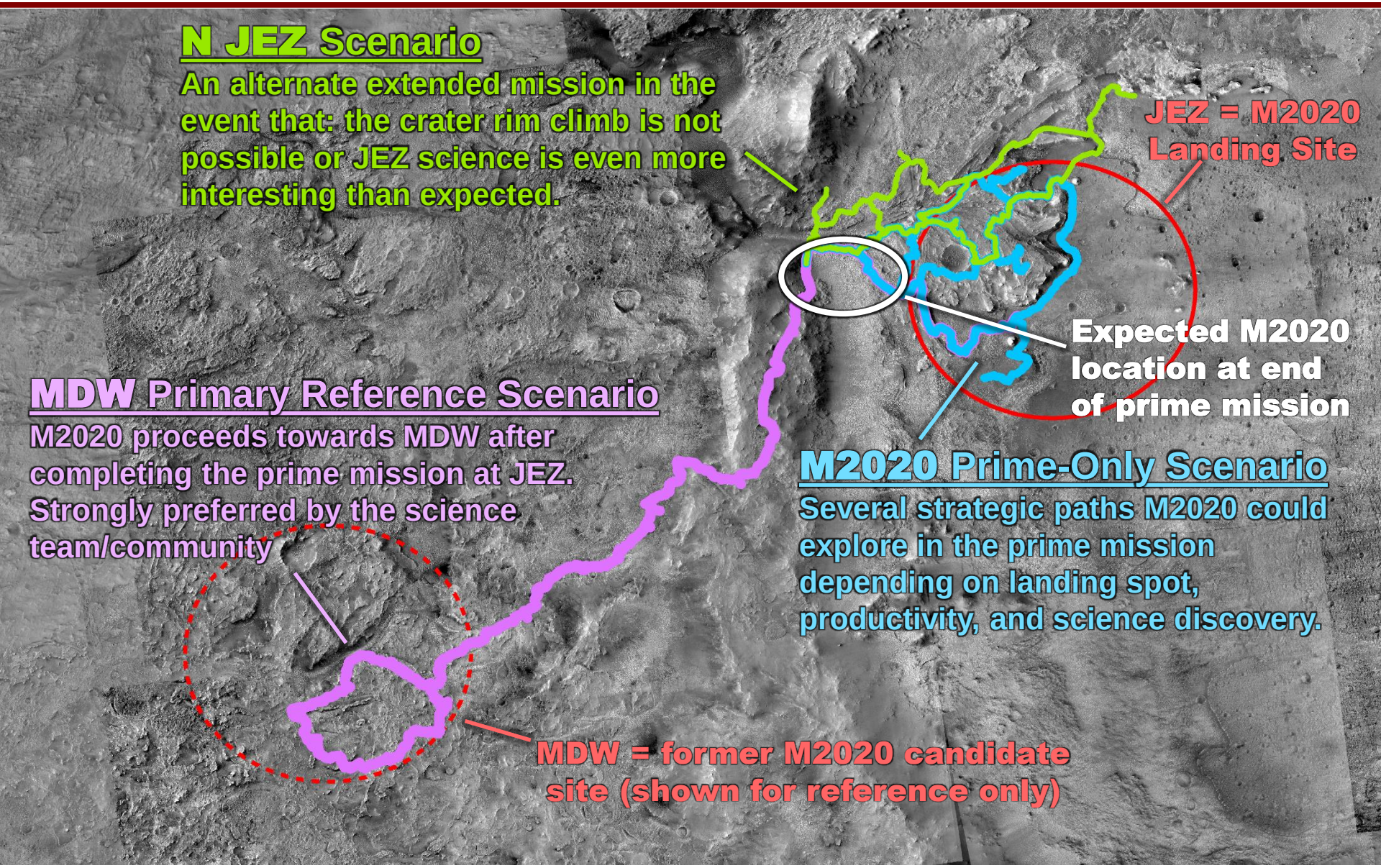
ERO Earth Return and EES Delivery





Surface Mission Activities

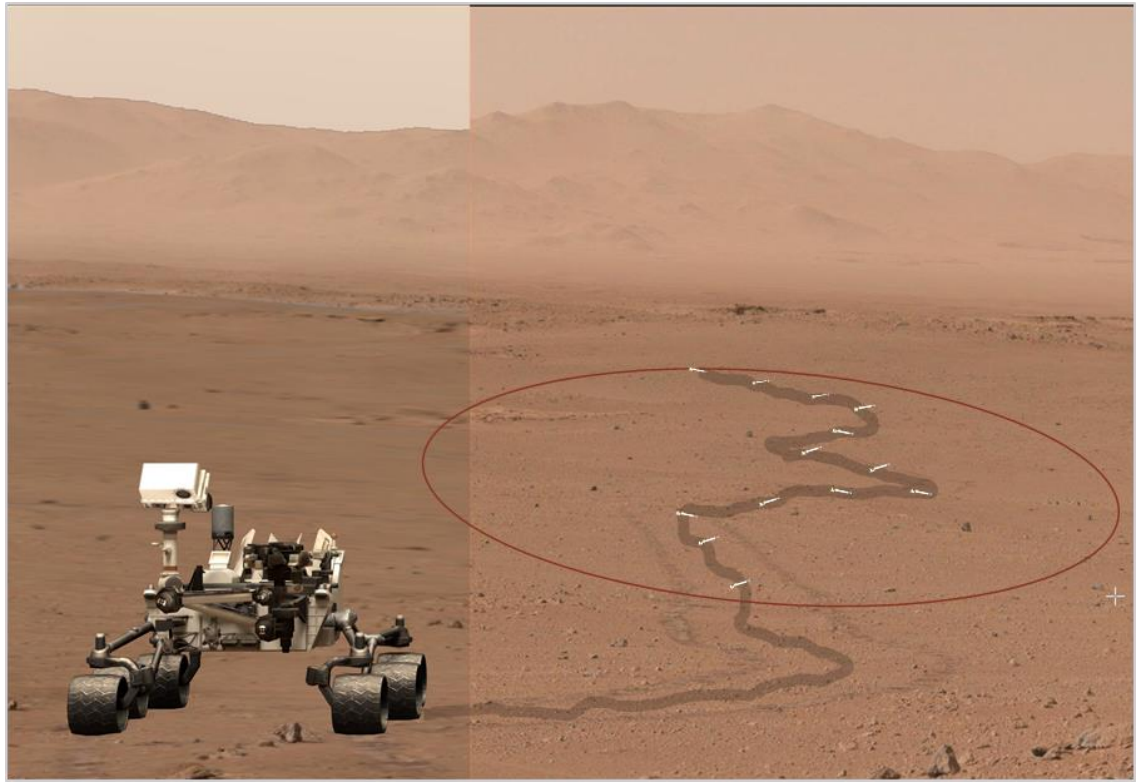
Reference M2020 Scenarios: Three Qualitatively Different Options



What is a Depot?

- A depot is a benign patch of terrain ~40m diameter where sample tubes are deposited by M2020 for potential collection and return by MSR
- Tubes are deposited ~5-10m apart to facilitate autonomous localization and acquisition of multiple tubes per sol by SFR

- Depot FAQ:
  - Q: Are tubes placed in a pile?
  - A: Tubes <u>are not</u> placed in a pile
    - ➢ A few meters of separation simplifies the tube pickup problem because each tube is decoupled from the others
  - Q: How does SFR figure out where the tubes are?
  - A: M2020 will collect imagery of the depot generally and each tube after it is dropped
    - ➢ The tubes will not move or become completely buried by dust after M2020 drops them

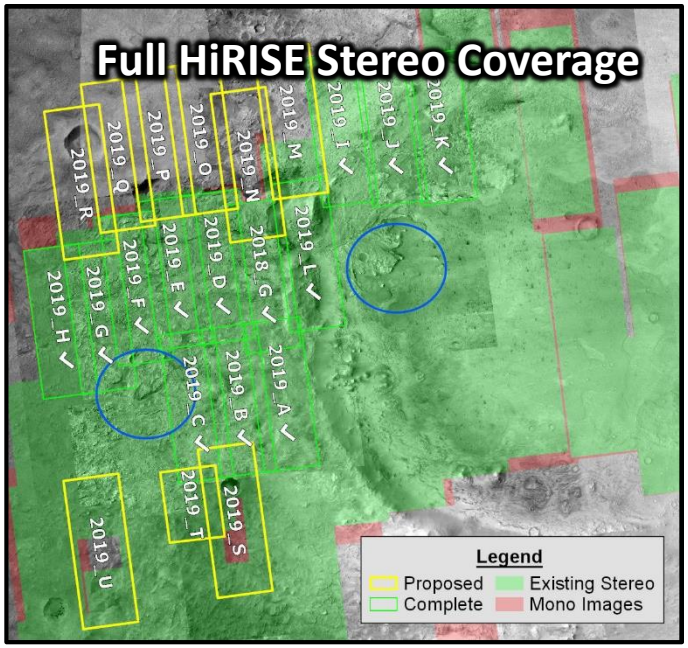


MSR: Differences from Previous Mars Surface Missions

- In-situ science is not the primary objective

- MSR has a required landing site (JZW) and it is already well-characterized
  - Pro: ability to design for a specific site
  - Con: inability to choose an easier site

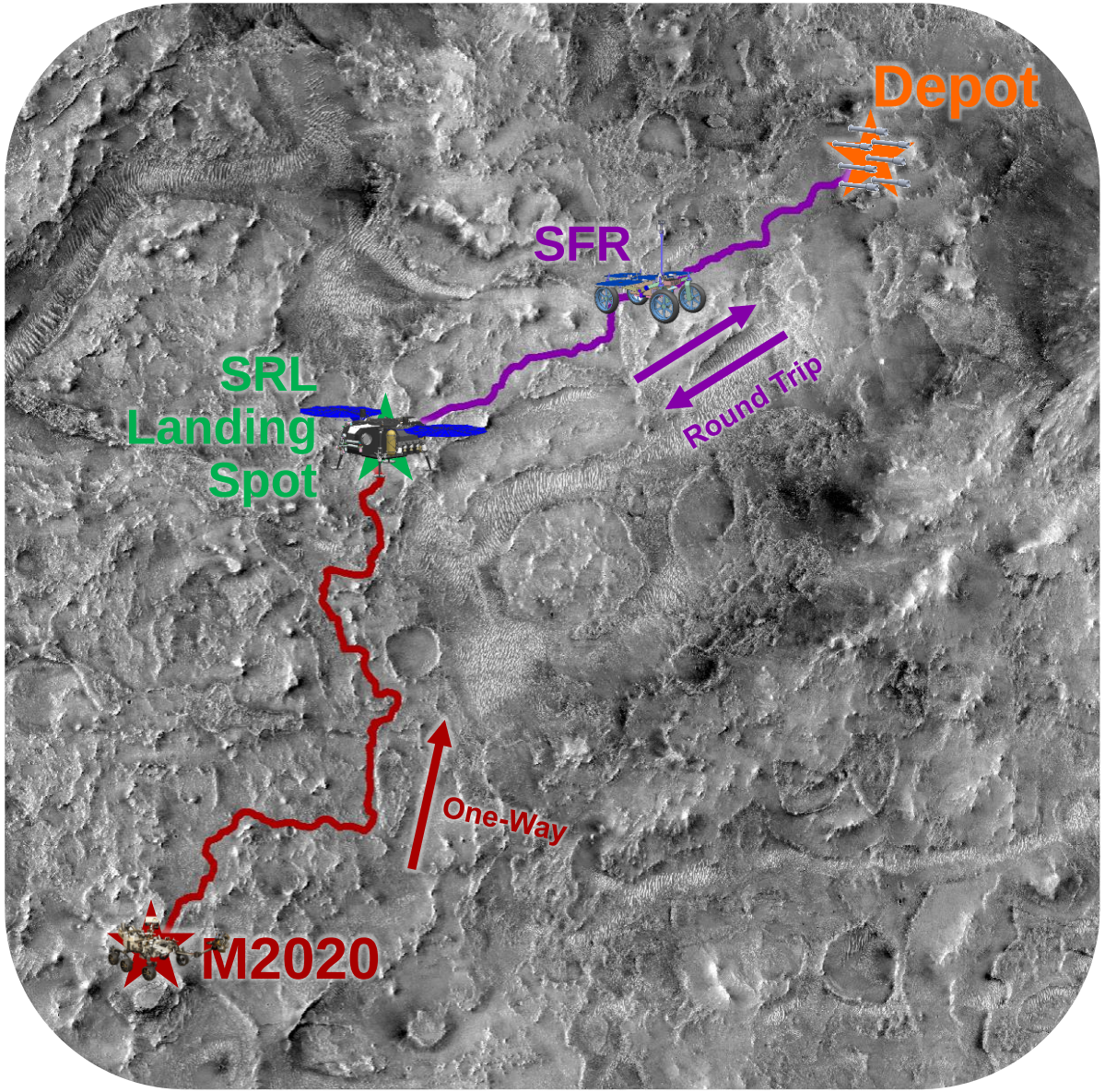
- Binary-ish Mission Success
  - There is limited “partial credit” opportunity - if the MAV is not launched, MSR has failed



- Available timeline is already maxed out:
  - SRL and ERO already optimized for maximum available surface timeline
  - Ls≈0 to Ls≈180 avoids northern winter and dust storm season

- Common conclusion: MSR has a significantly better understanding of its likely surface mission operations than previous missions at this maturity

Two Potential Tube Delivery Vehicles: SFR and M2020



- Using multiple delivery vehicles offers redundancy
- M2020 offloads risk by depoting tubes for SFR retrieval
- M2020 can directly deliver most recent samples to SRL

For planning and discussion purposes only.

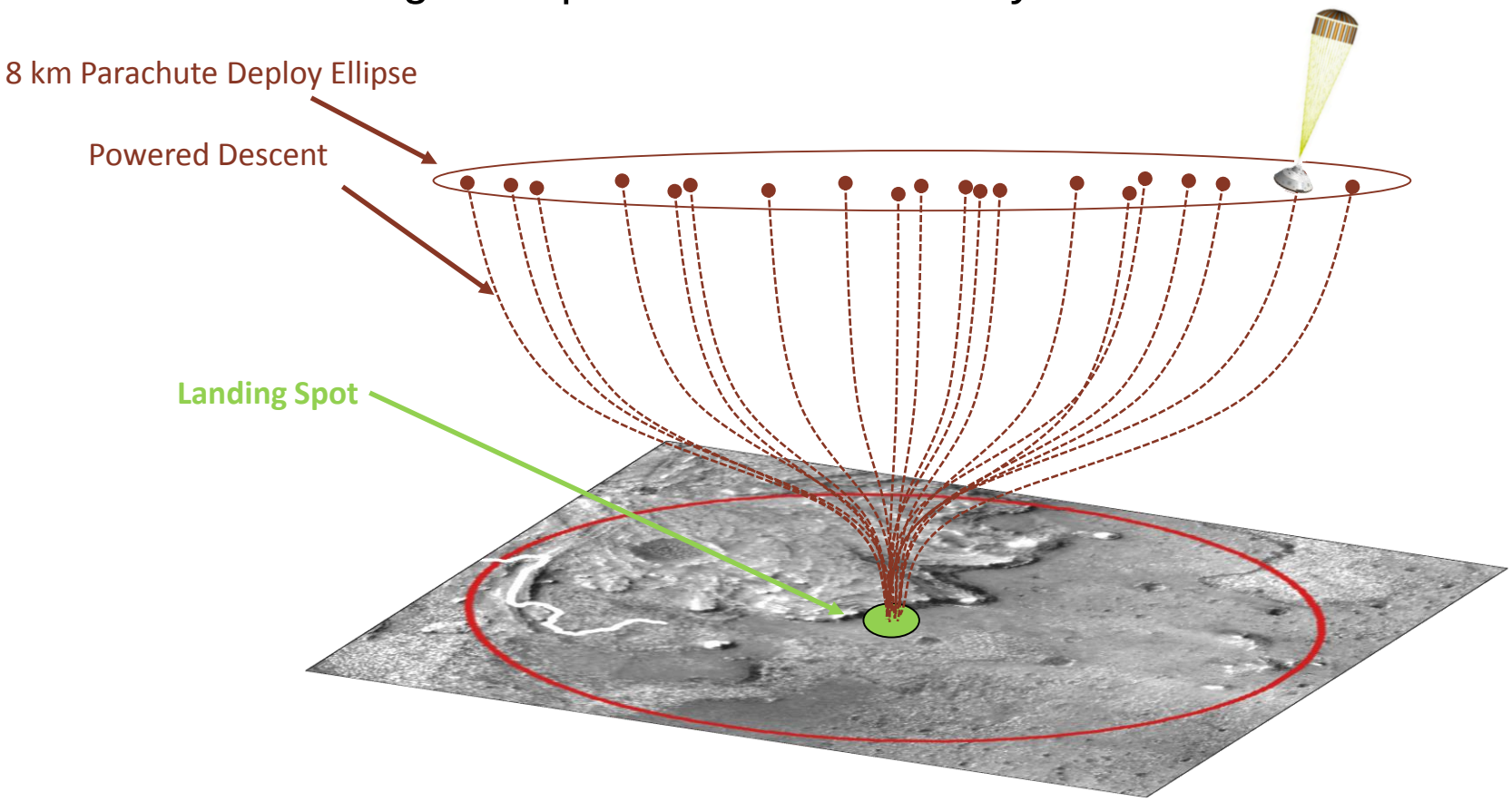
SRL Touchdown

For planning and discussion purposes only.

SRL EDL - Extended Divert

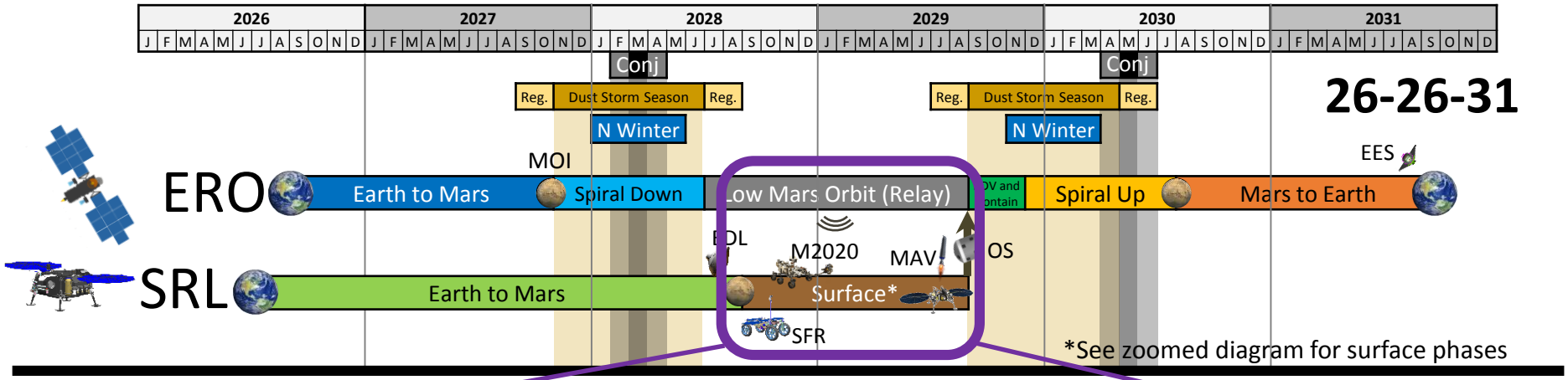
- SRL will carry enough propellant to fly out the backshell separation ellipse and land at a specific spot (~±20m accuracy)

- Enables landing at a specific site scouted by Mars 2020 ahead of time

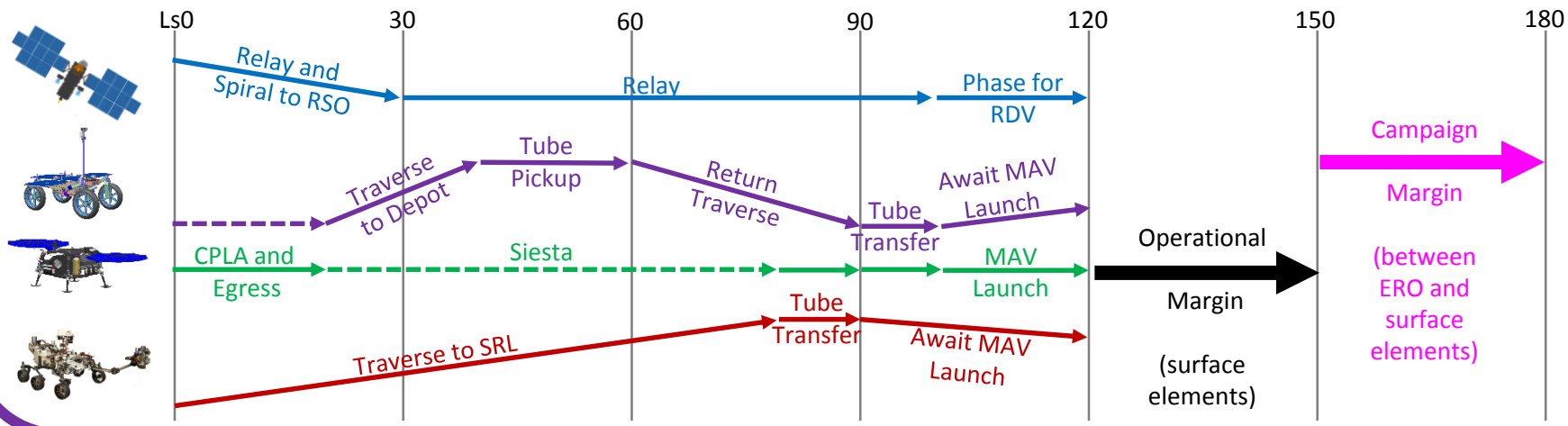


Campaign Timeline Overview

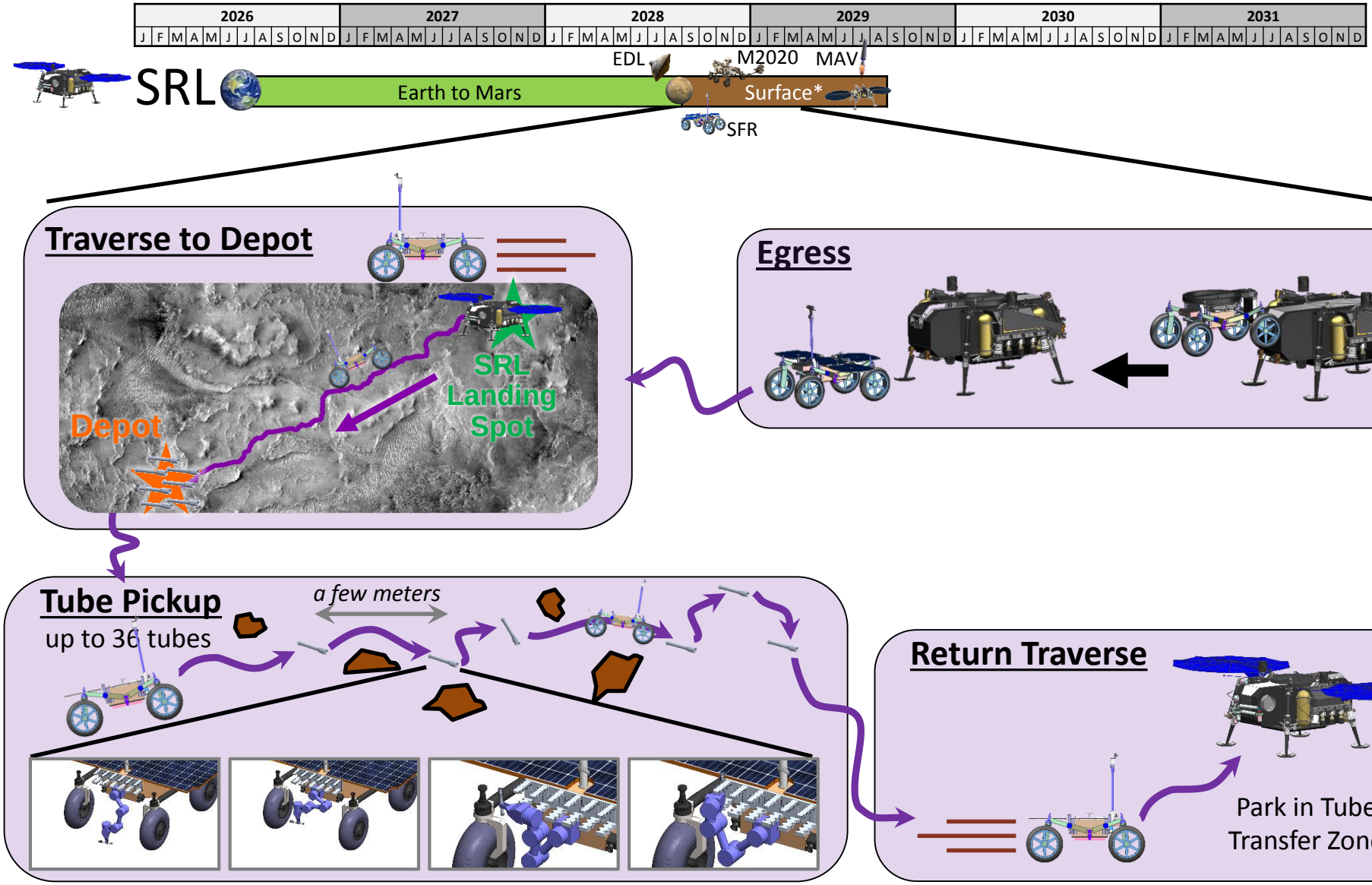
*Illustrates an example scenario



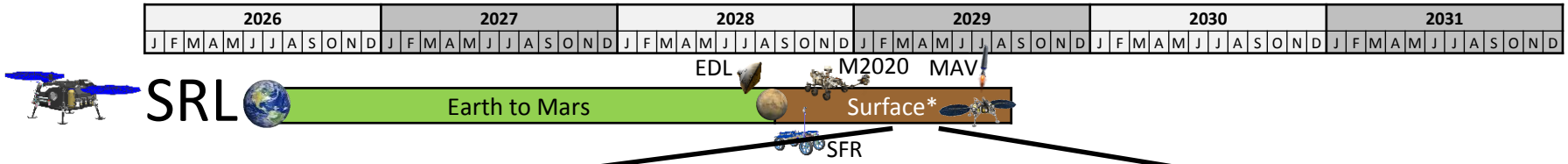
SRL Surface Activities (~13 months) is a busy time and campaign coordination is critical



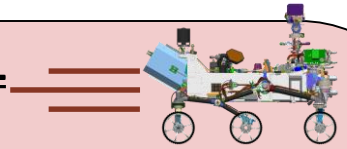
SFR Operations

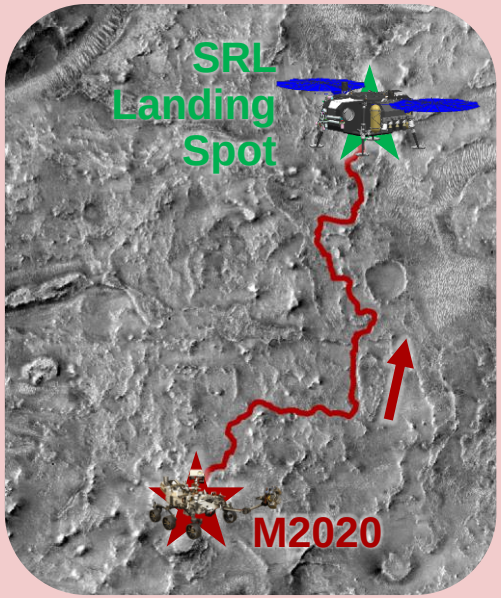


M2020 Operations



Traverse to SRL

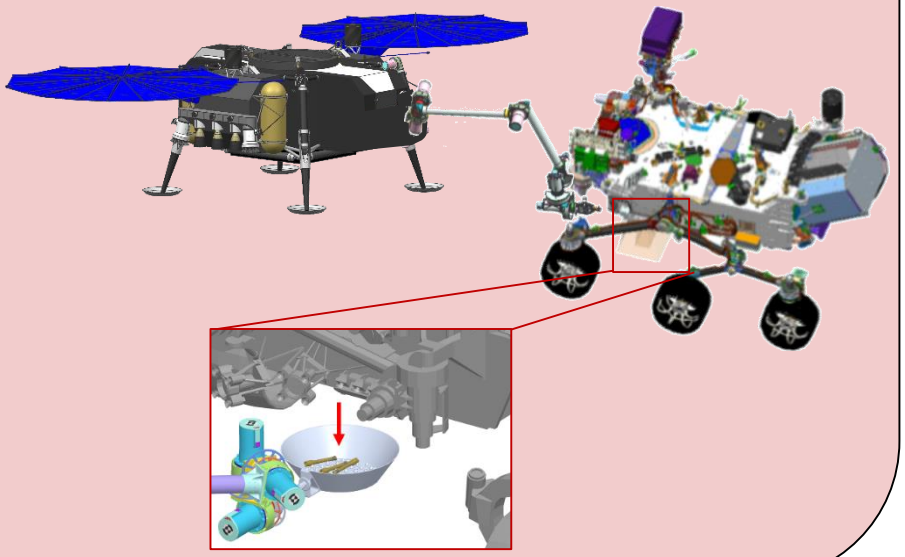




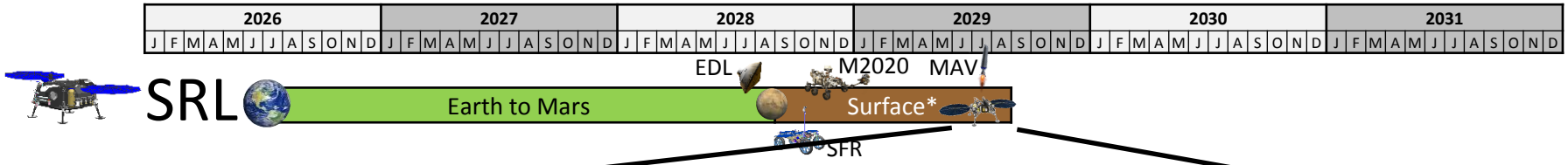
(example scenario only)

Transfer Tubes from M2020

- -M2020 drops tubes into tray
- -Tray placed on lander
- -Tubes picked up from tray
- -Tubes loaded into OS

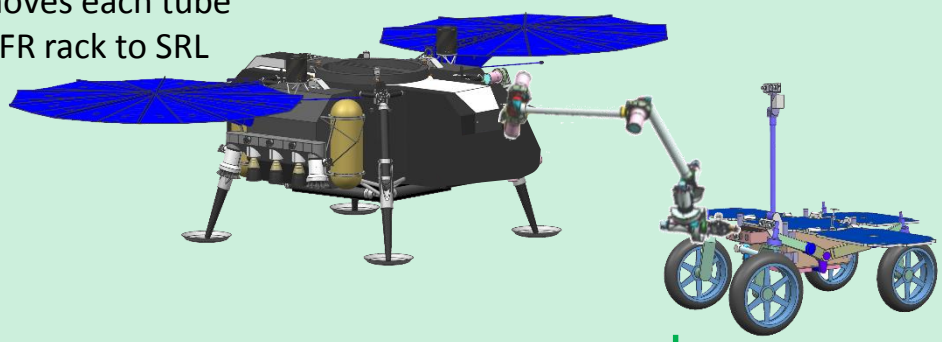


OS Loading and MAV Preparation

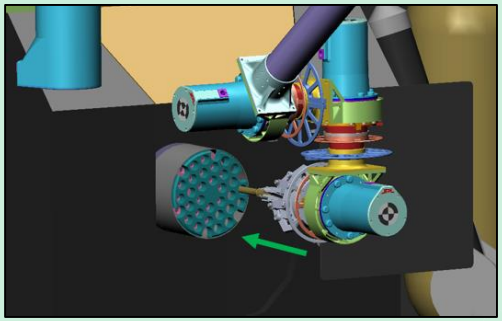


Transfer Tubes from SFR

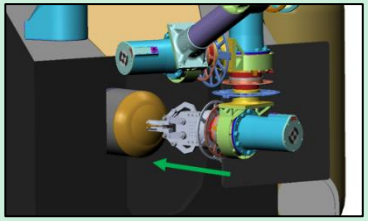
-STA moves each tube from SFR rack to SRL



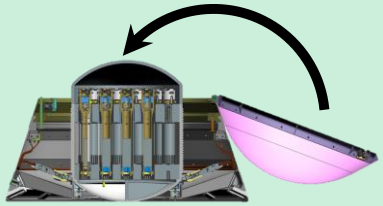
Insert tubes into OS



Prepare for MAV Launch



Assemble OS



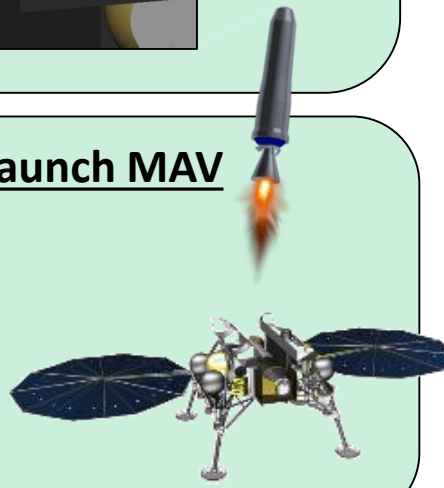
Closeout MAV

GNC Calibrations

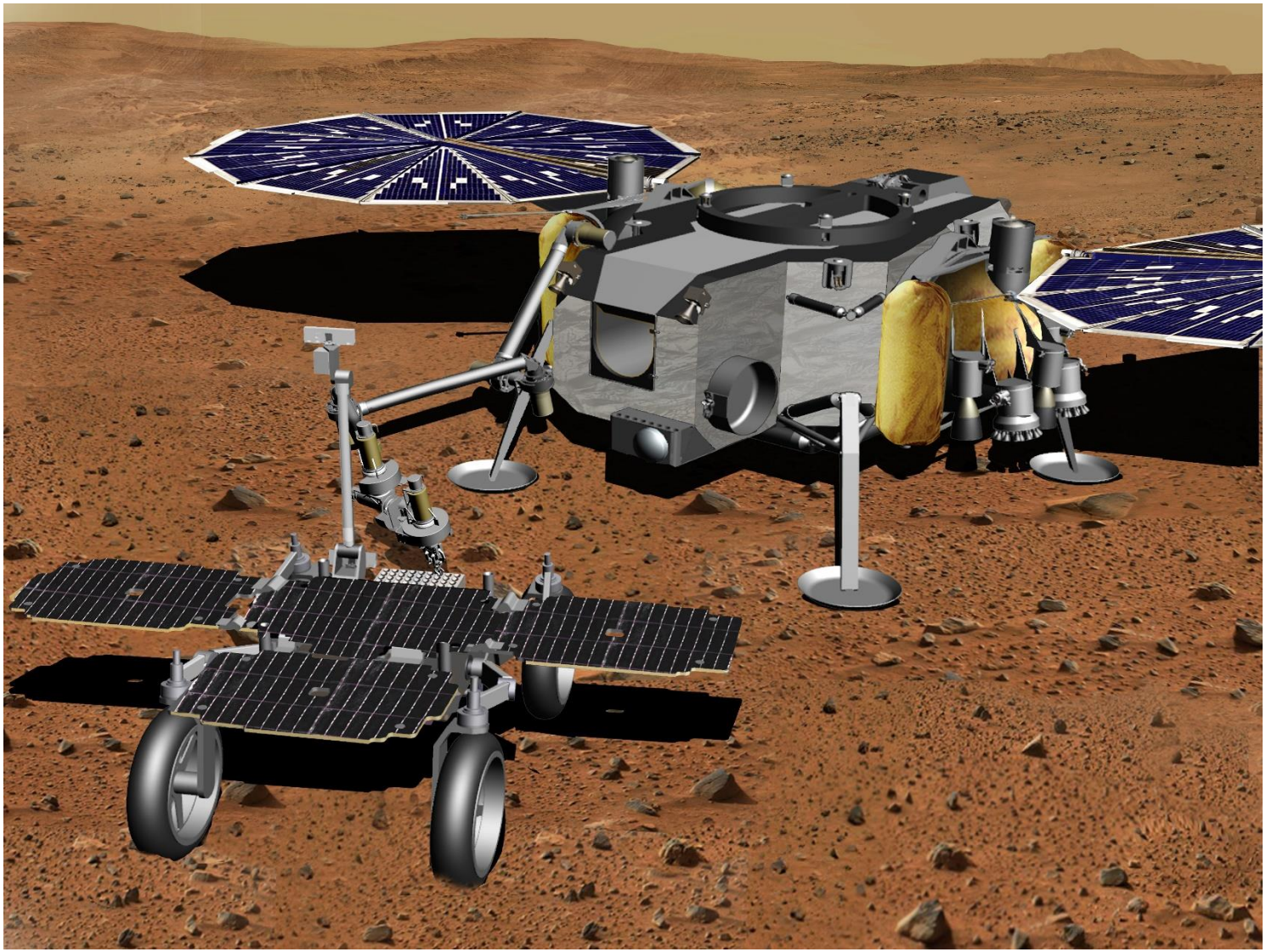
Heat MAV to AFT

Checkout Comm

Launch MAV



Sample Tube Transfer from SFR



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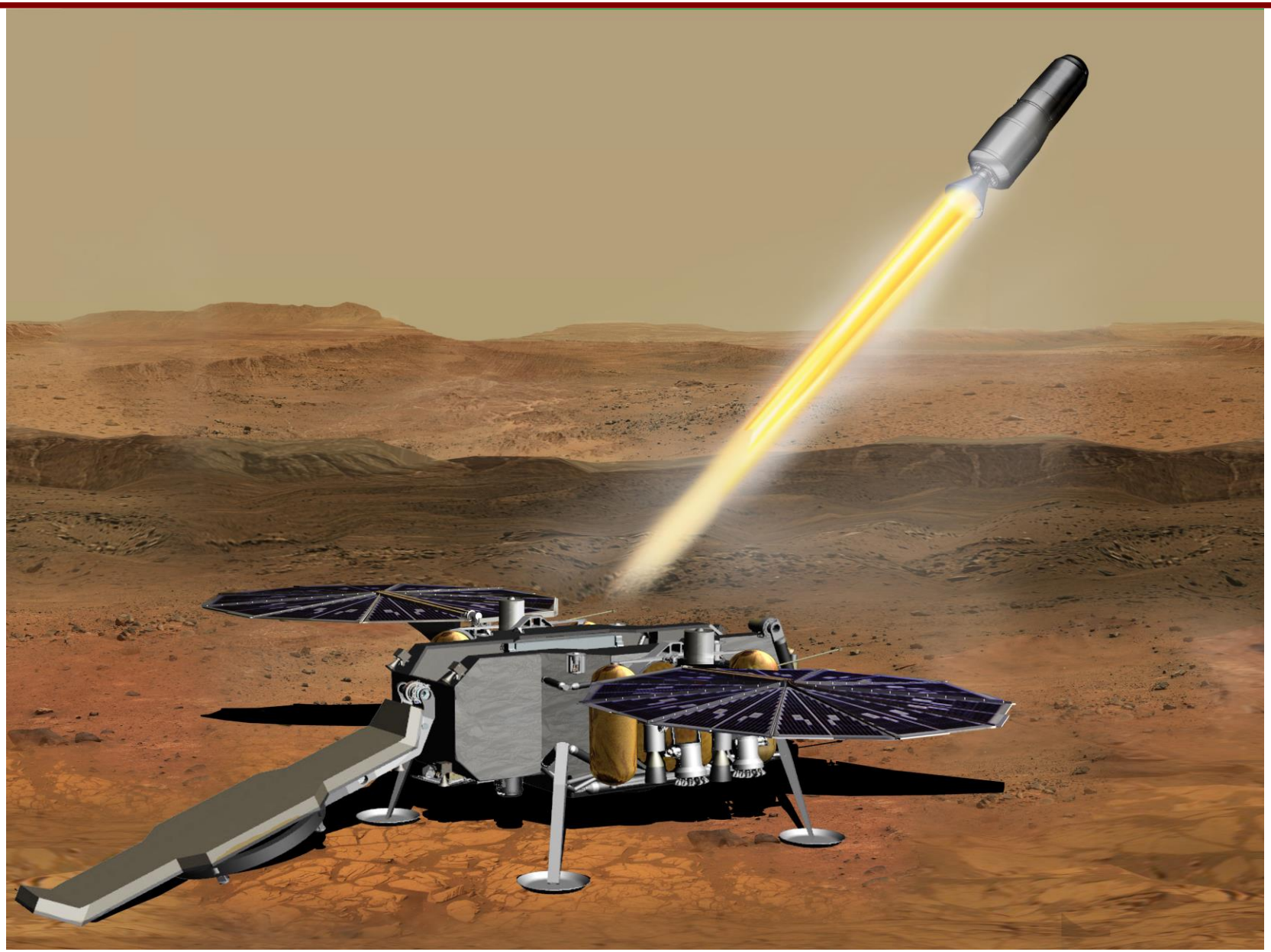
MAV Launch with VECTOR