Next Mars Orbiter (NeMO) Mission Concept Overview

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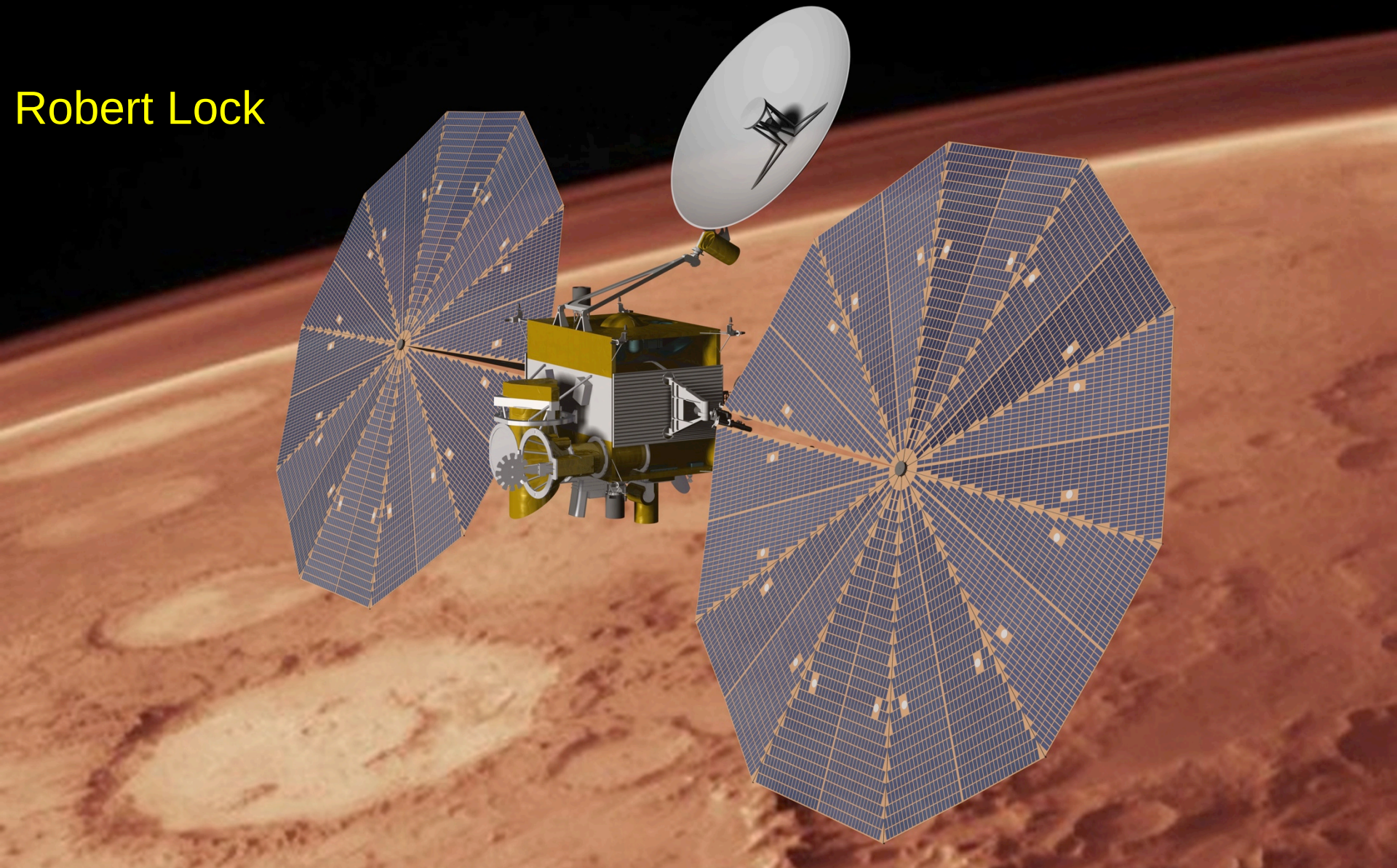
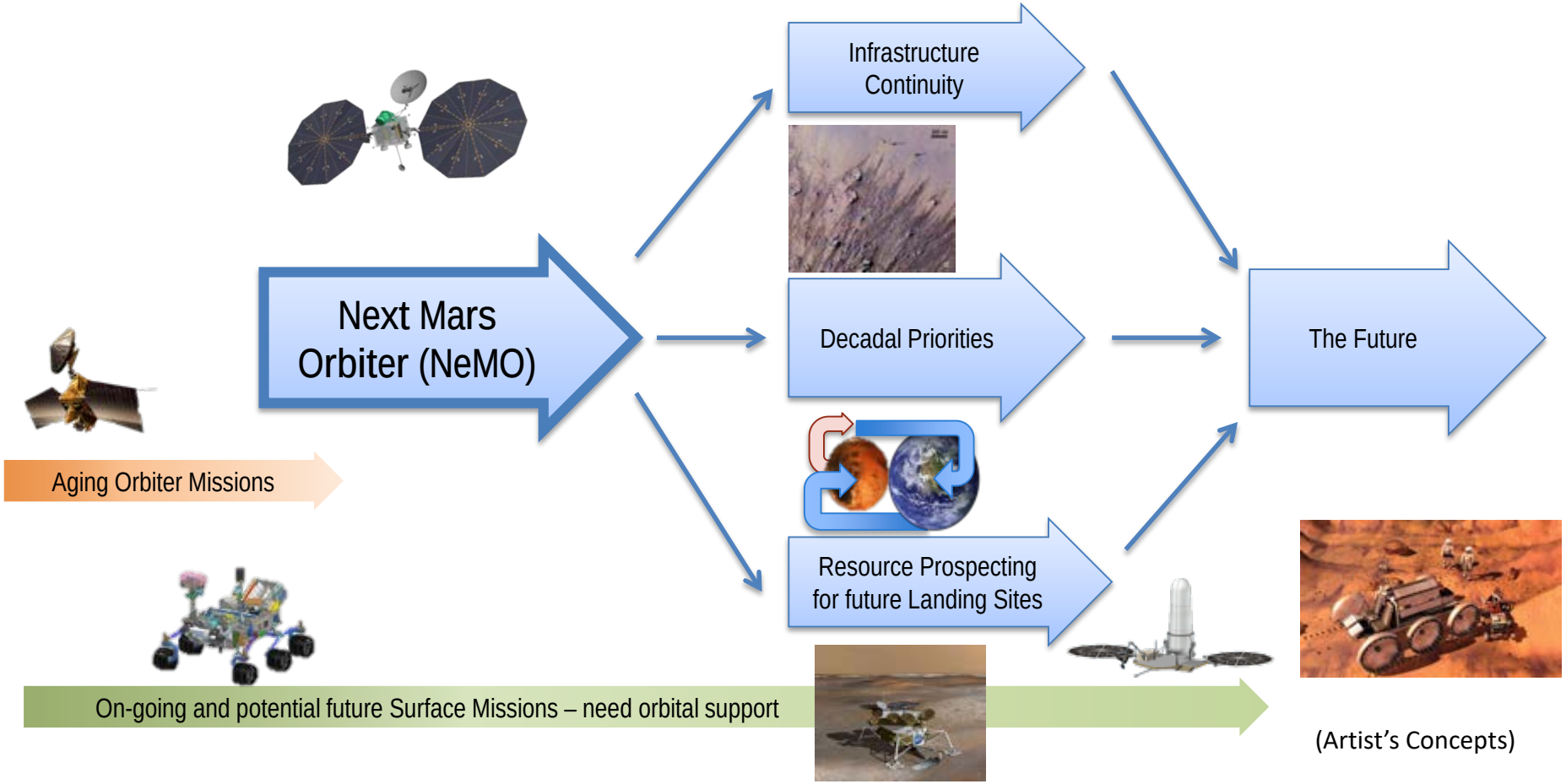


Program Context

Next Mars Orbiter (NeMO)

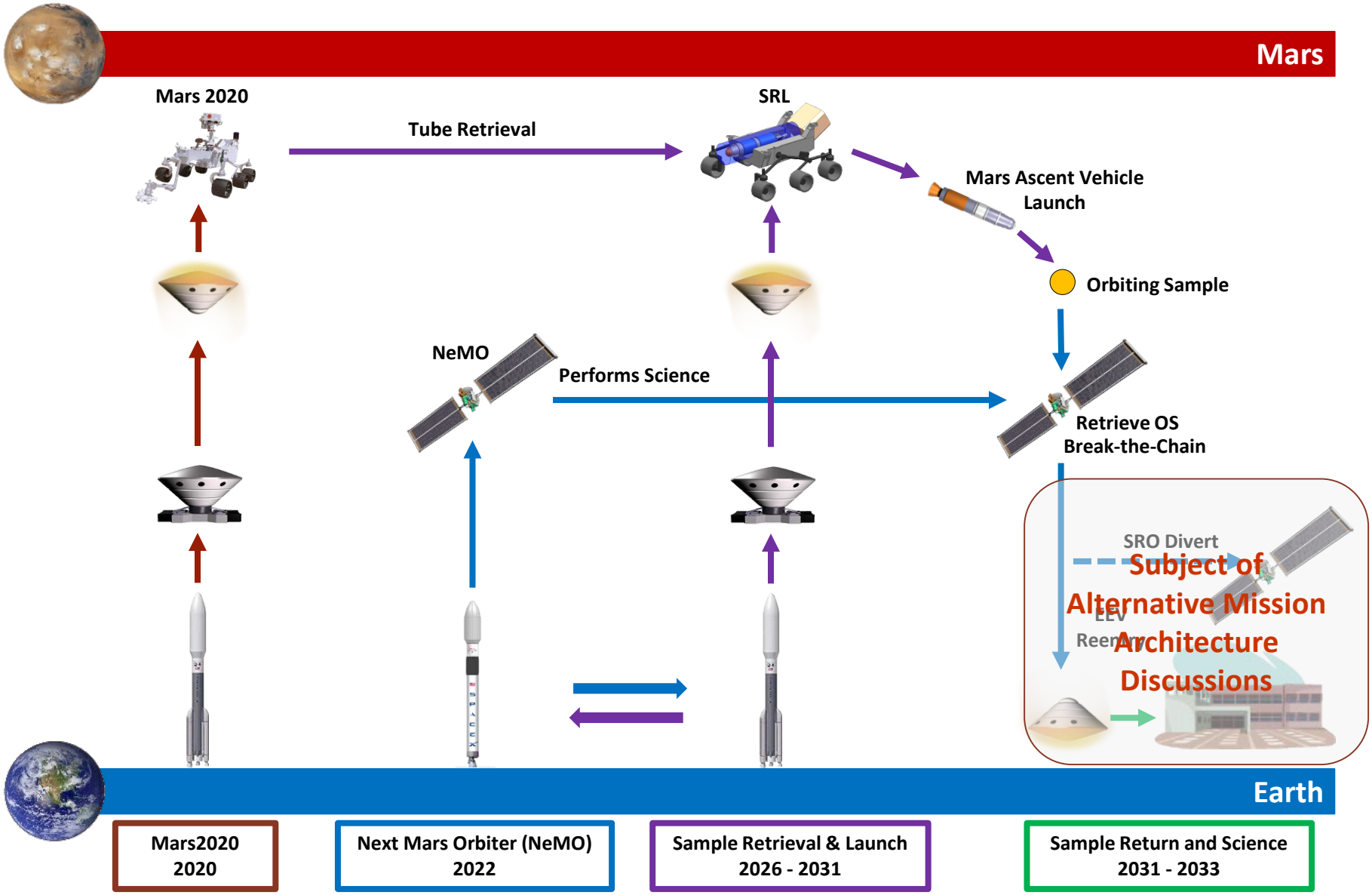
Capability to Enable Future Pathways



(Artist's Concepts)

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

Mars Sample Return Concept



The Next Mars Orbiter (NeMO)

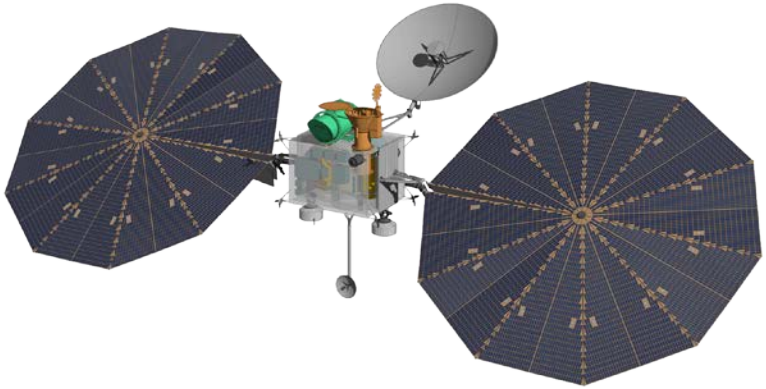
- The Next Mars Orbiter would be capable of continuing and extending the existing infrastructure, and refreshing the critical capabilities necessary to continue exploration of the Mars system and support future mission needs.

- Launching as early as 2022, the primary objectives would be:
  - Support increased bandwidth communications
  - Continue high-resolution surface reconnaissance
  - Provide significant orbital flexibility for long term support of future missions

- Additional potential objectives under consideration:
  - Accommodate potential compelling investigations
  - Validate challenging technologies for advanced communications
  - Orbital support for potential Sample Return

Mission Concept Overview

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

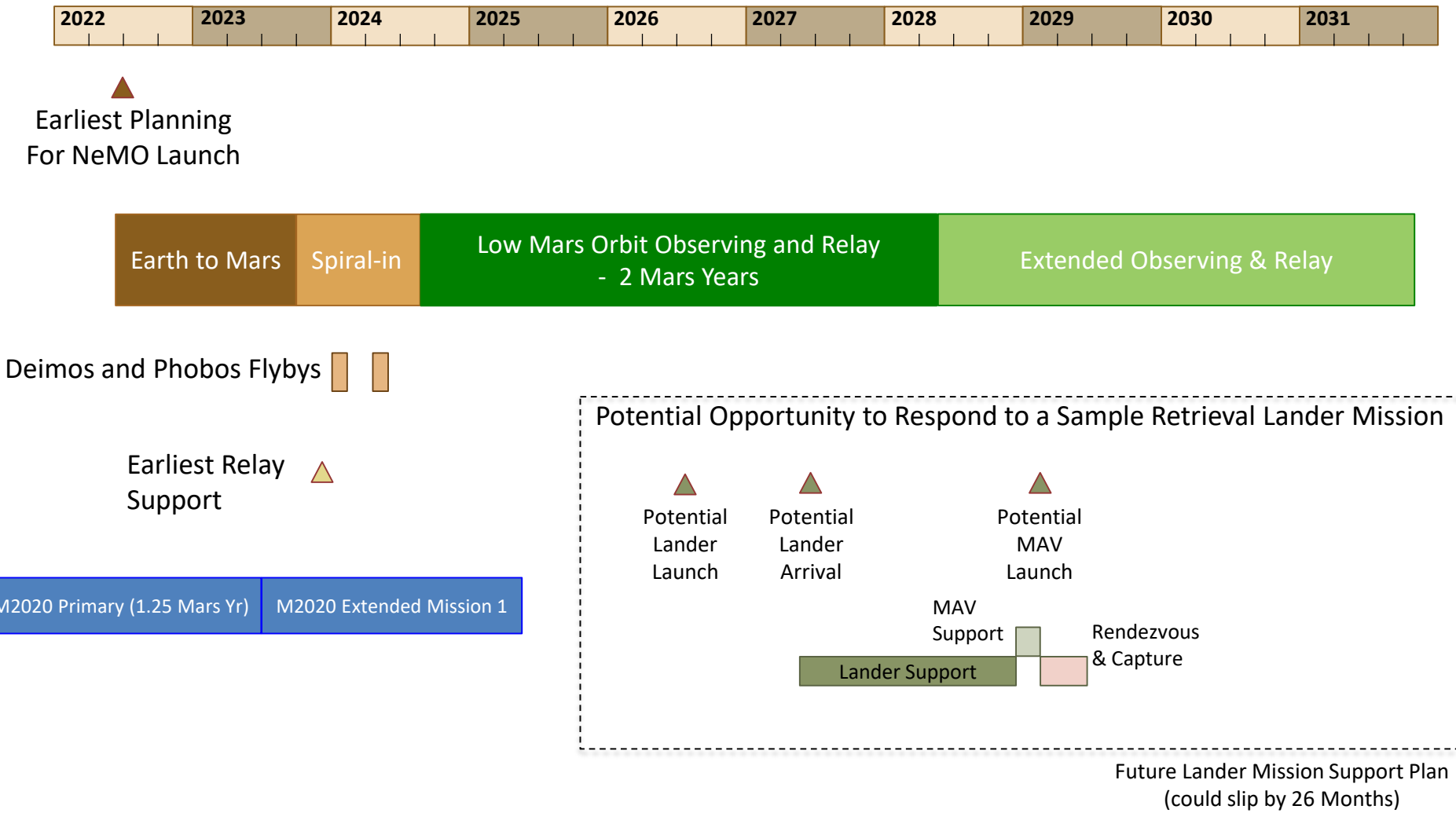
Falcon-9 or Atlas V-411

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)

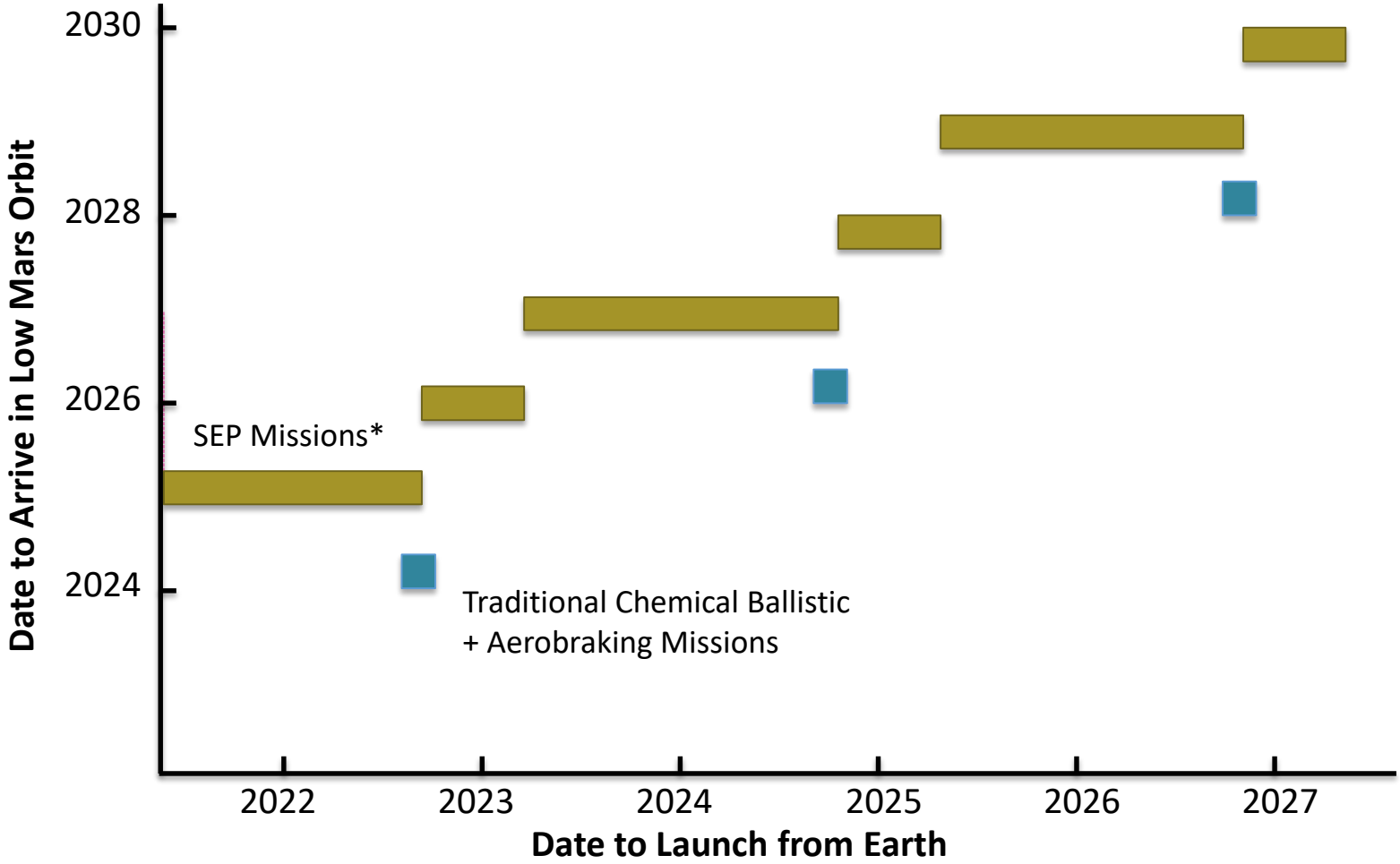
Mission Phase	Start Date
Launch	Jul 2022
Mars Capture Spiral	Sep 2023
Low Orbit Science	Jul 2024
Extended Mission Start	Apr 2028

Notional Mission Timeline



Launch and Arrival Date Opportunities

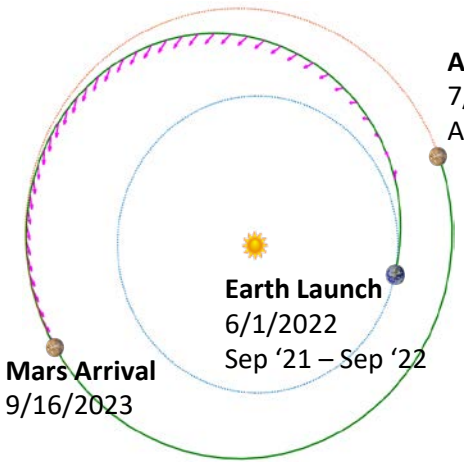
Launch/Arrival Dates for NeMO using Solar Electric Propulsion



* Performance depends on Launch Vehicle and SEP technology selected.
This example is for a large payload NeMO mission using Falcon-9, 7 kW gridded-ion thrusters and 20kW Solar Arrays.

Mission Design Concept

Outbound (Earth-Mars) SEP Cruise

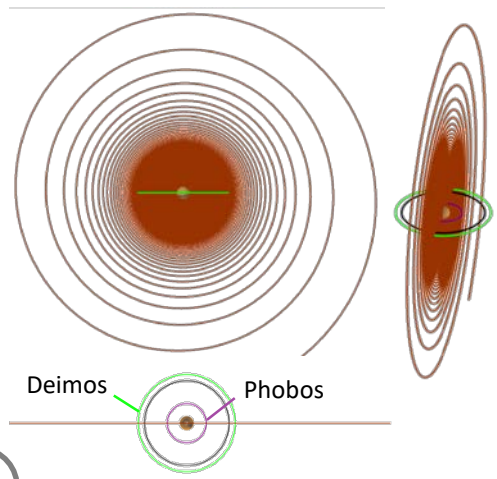


Arrive Low Mars Orbit
7/25/2024
Altitude: 320km

Operations

- Continuous thrusting for long periods
- Communicate while thrusting
- Update thrusting once/month
- No payload activities from checkout to arrival

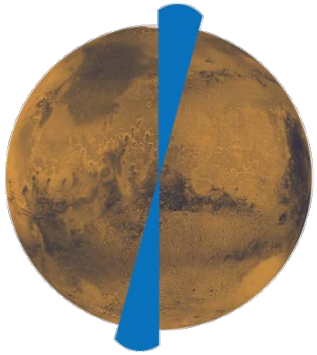
Mars Spirals



Capture Spiral Operations:

- Near-continuous thrusting
- Allow payload activities (checkouts, cals, infrequent observations)
- Opportunistic Deimos and Phobos flyby observations
- Long range relay support

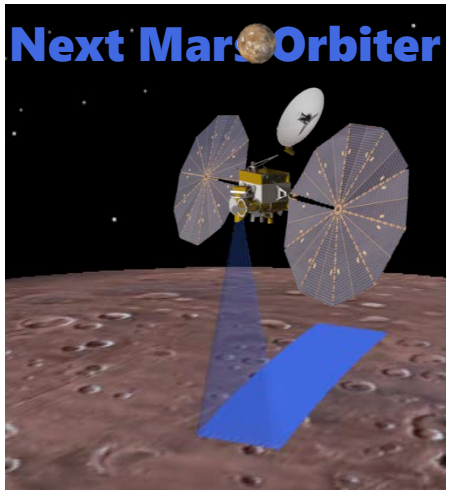
Imaging and Relay Orbit



Low Mars Orbit Extended Mission

- Similar orbit and observing/relay activities (320 km)
- Large ΔV for orbit maneuvers
  - ✧ Large plane changes
  - ✧ Adjustments to orbit for repeat timing
  - ✧ Access to multiple latitudes and altitudes to optimize relay contacts
  - ✧ Modify orbits for future missions

Imaging and Relay Orbit



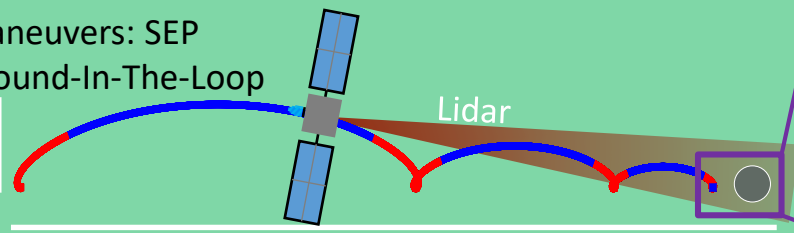
Low Mars Orbit Primary Mission

- 320 km average orbit altitude
- 75° - 93° inclination
- Nadir and ±30° roll observing
- Relay contact activities (landed element contacts, orbiting element contacts)

Rendezvous using a SEP Orbiter

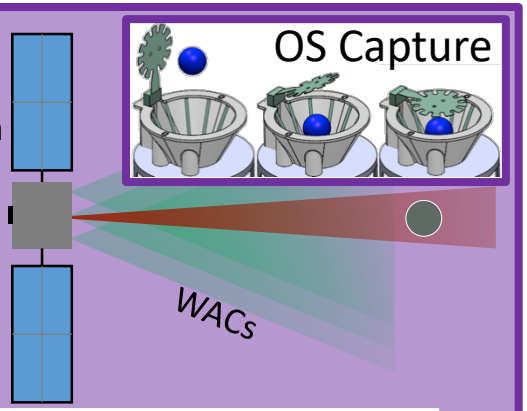
Phase 2: Fine OD and Approach

Sensor: NAC → Lidar
Distance: 10 km → 100 m
Time: 2 weeks
Maneuvers: SEP
Ground-In-The-Loop



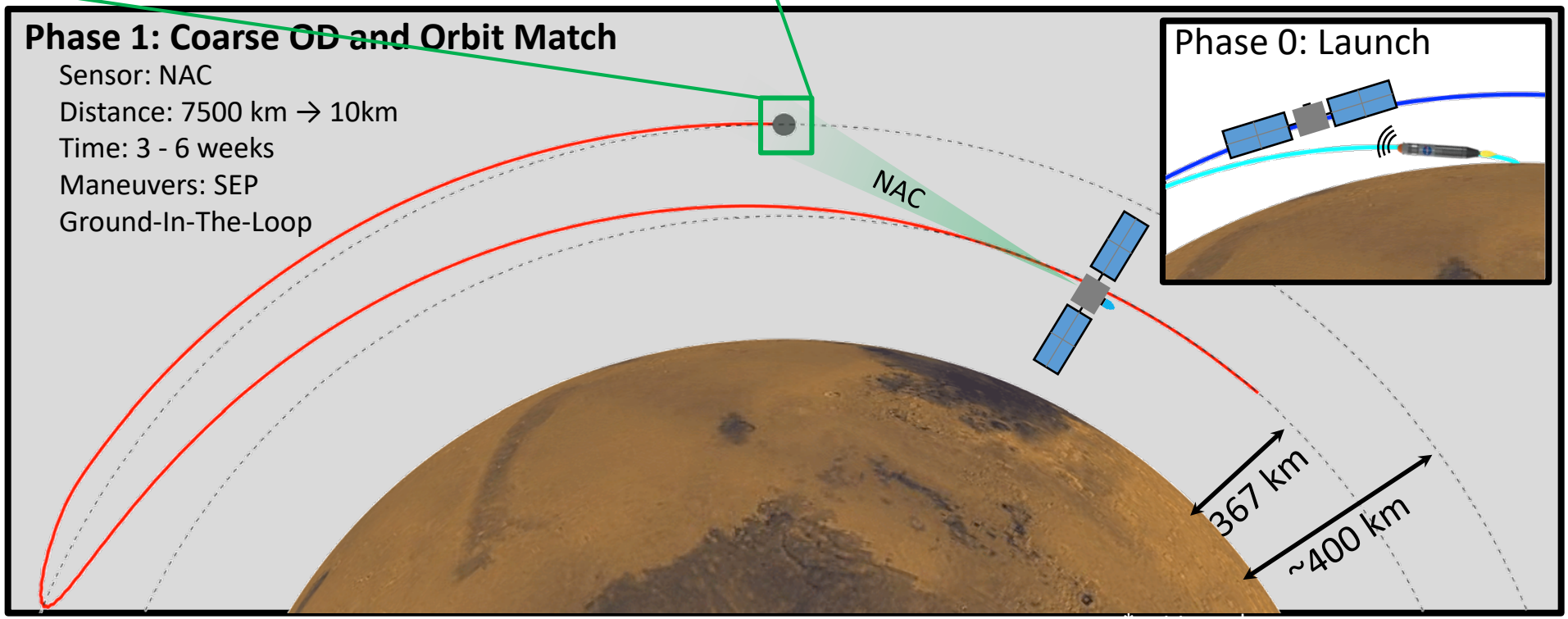
Phase 3: Capture

Sensor: Lidar → WAC
Distance: 100 m → 0 m
Time: 2 hours
Maneuvers: RCS
Autonomous

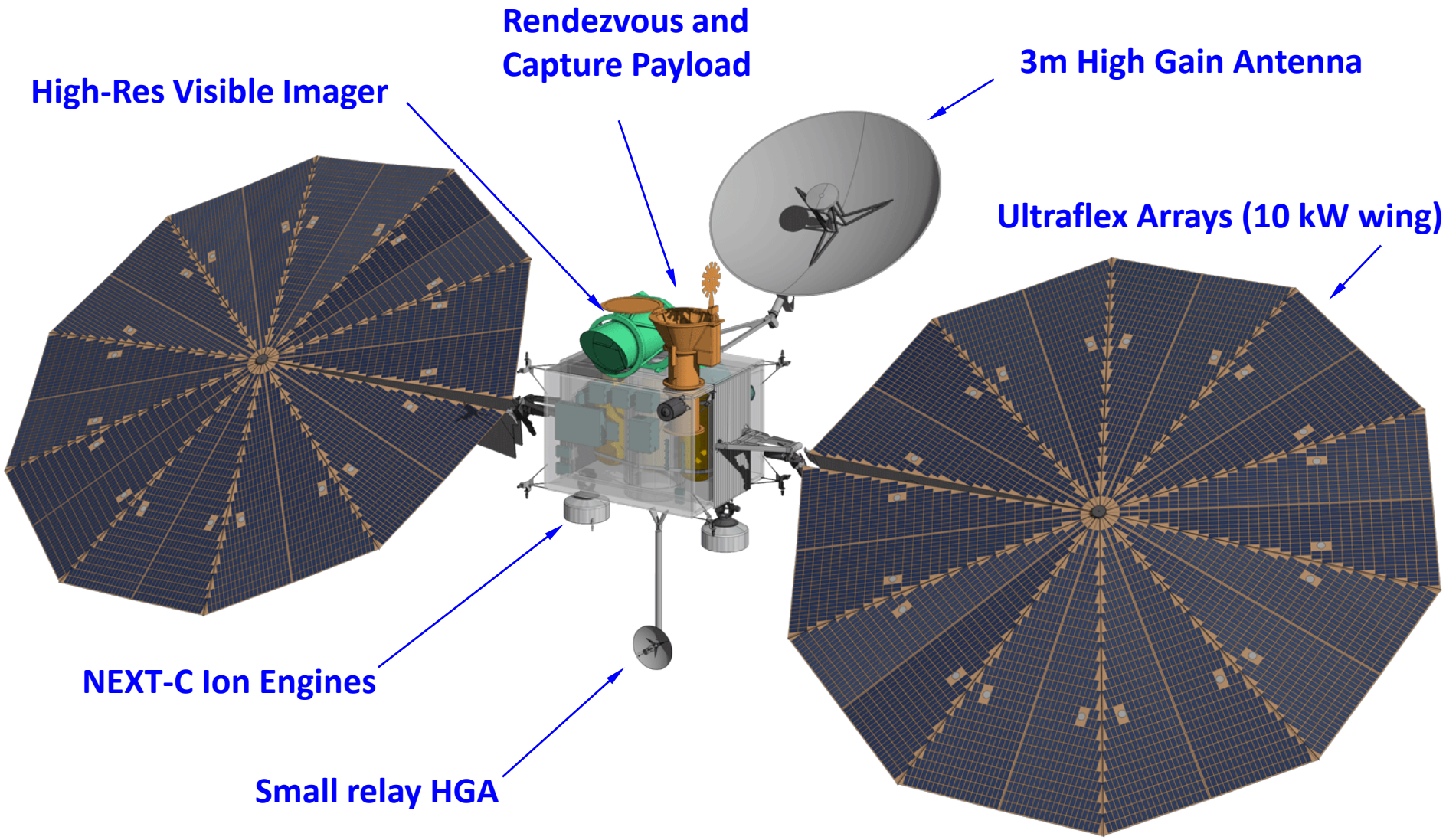


Phase 1: Coarse OD and Orbit Match

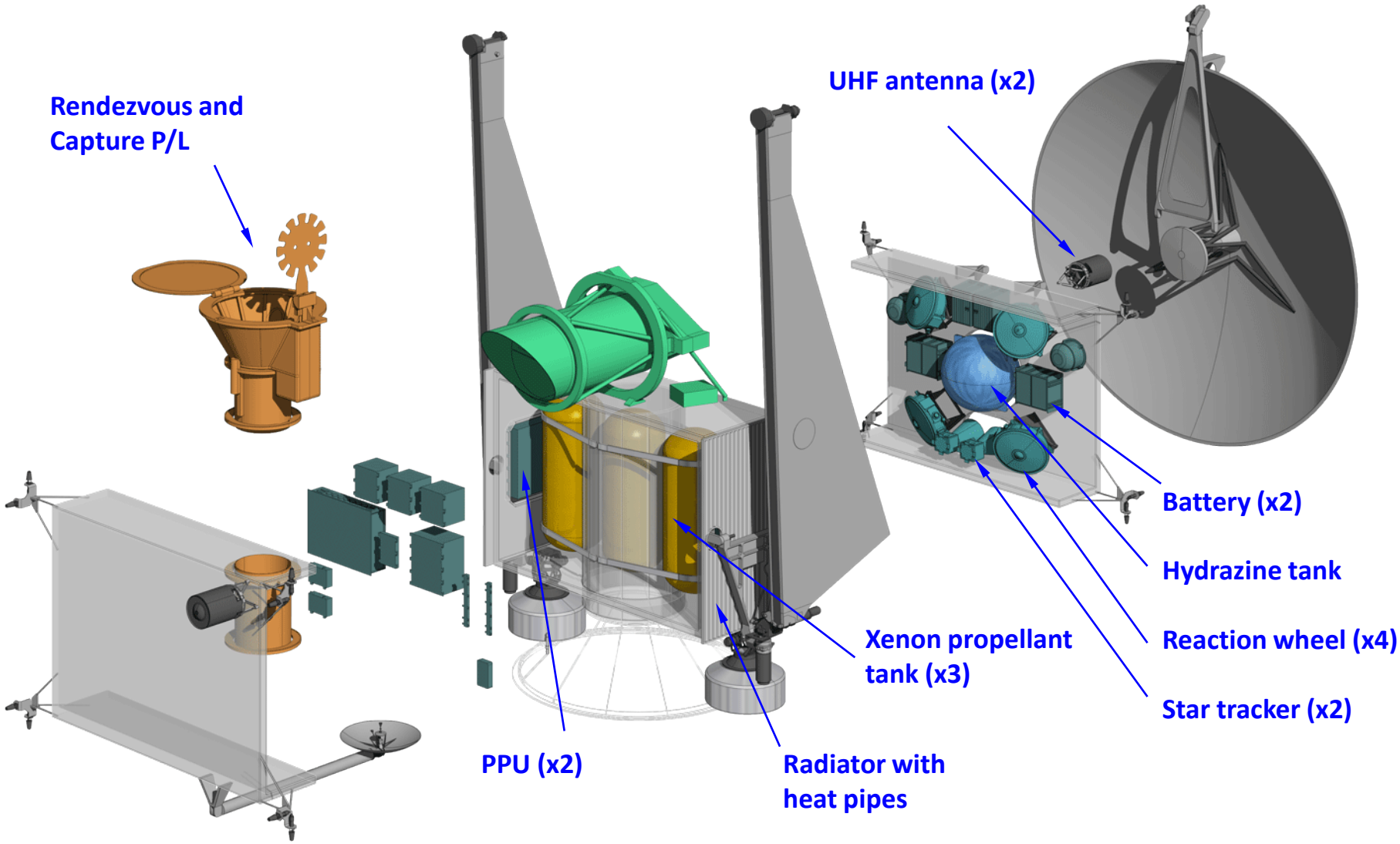
Sensor: NAC
Distance: 7500 km → 10km
Time: 3 - 6 weeks
Maneuvers: SEP
Ground-In-The-Loop



NeMO Deployed Configuration

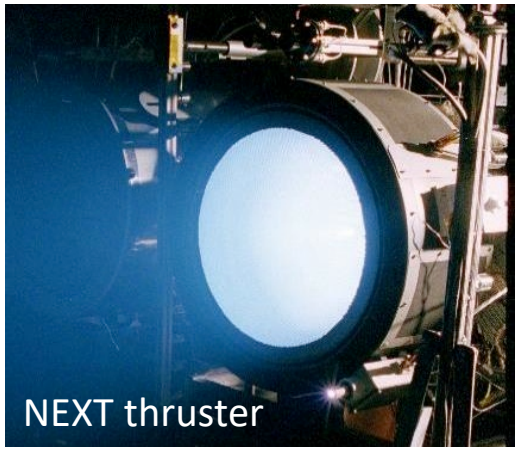


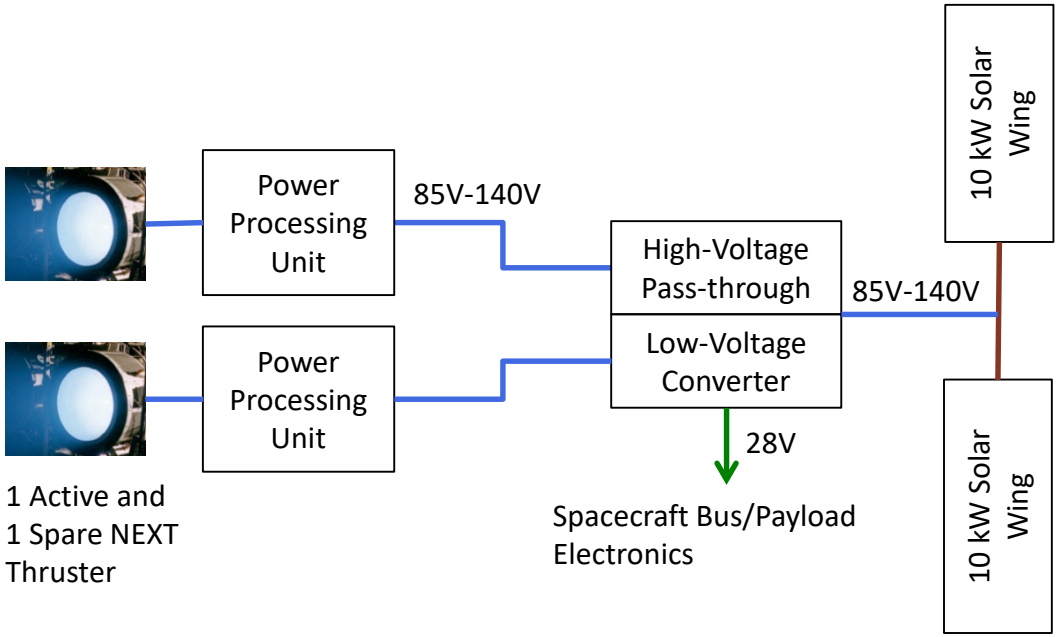
NeMO Configuration
Expanded Diagram



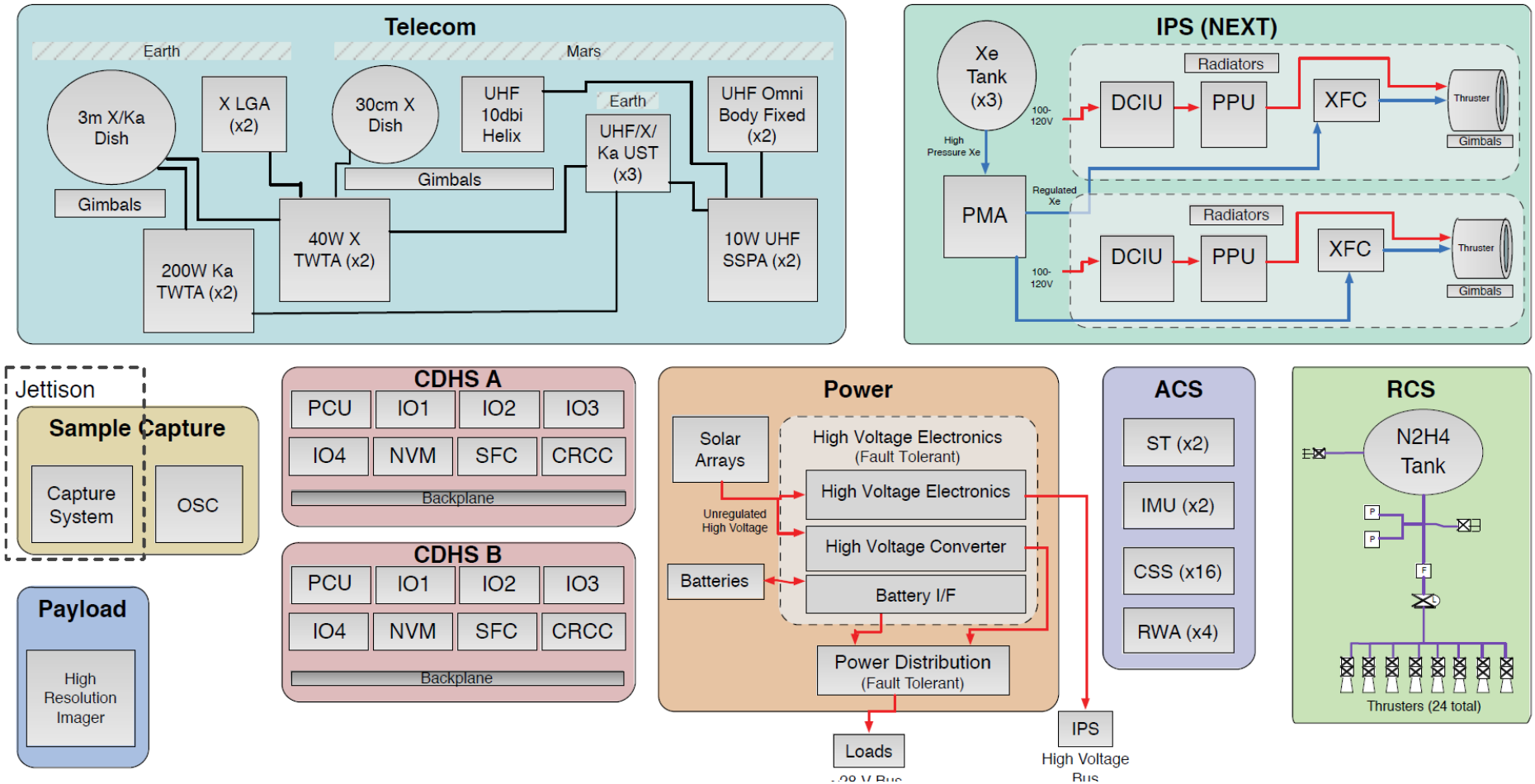
Solar Electric Propulsion

- NeMO has baselined using NASA developed NEXT thrusters
- 600 kg Xenon
- 20 kW (1 AU) Solar Power
- NEXT Characteristics
  - Power: 7.3 kW
  - Thrust: 235 mN
  - Isp: 4150 sec





Spacecraft Block Diagram



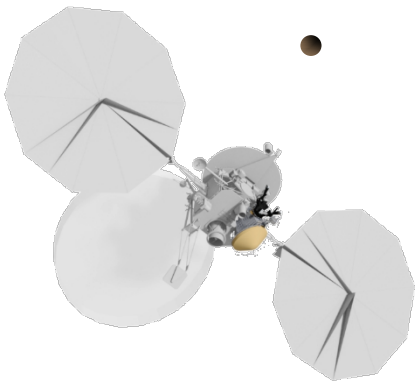
Operations Concept

- Operations concept based on heritage JPL SEP and Mars science missions
  - S/C contractor remote operations
  - Collaborative science operations from home institutions
  - Non-interactive instrument sequencing is independent of other instruments and S/C
- All nominal operations via stored sequences
  - 1 month background sequence duration for engineering events
  - Relay forward link process allows late data uplinks
  - Rendezvous operations use nominal ops up to final few days, autonomous in the final few hours
  - Additional flexible sequencing will be used (within sequences) to manage fine observation time/pointing, relay passes, DSN weather outages, potential rendezvous operations
- DSN Tracking: 2-3 passes per week Cruise tracking, 7 passes per week during Mars operations
  - DSN scheduling will be more dynamic due to Ka-band weather sensitivity
  - 3x more data will flow through the system than MRO with moderate latency requirements
  - Relay and Rendezvous operations require low data latency (~1 min plus one-way light time)
  - ≥ 95% of data return (standard for planetary missions)
- No Critical Events after Launch

Potential Payloads

MSR Rendezvous & OS Capture System (ROCS) Concept Overview

1) Rendezvous

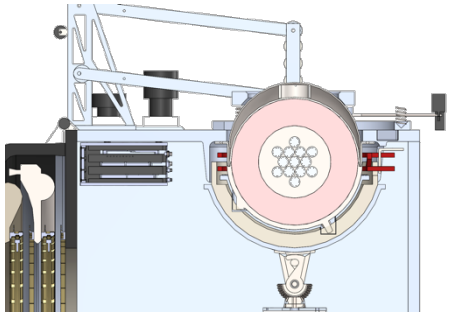


- Acquire OS from 4000km (optical or RF)
- Match orbits using SEP
- Ground-commanded until terminal phase
- Autonomous terminal rendezvous from 100 m

2) Capture

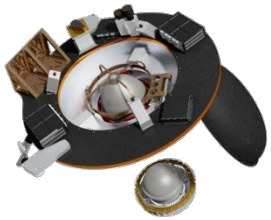
- SC approaches OS at 0-10 cm/sec rate, 0-10 cm accuracy
- OS enters capture volume, trips sensor
- Capture mechanism also orients OS for subsequent operations

3) Break-the-Chain



- Outside of OS is assumed contaminated with Martian material
- Clean/sterilize/ encapsulate to meet PP requirements
- Install clean OS into ruggedized container for return

4) Encapsulated OS Release



- Encapsulated OS may be: (1) released into Mars orbit (courier return), (2) returned to Earth-Moon system, or (3) placed in EEV for direct Earth entry
- Spacecraft releases OS after PP approval

Nex-SAG Table of Themes, Investigations and Representative Instruments

- Summarized NEX-SAG report, November 2015

Mission Concept	Investigations Addressed	Imaging	Very Shallow Radar	NIR Mineral Mapping	Thermal-IR mapper	Wide Angle Camera	Sub-mm Sounder: T,wind, water (v)	Thermal-IR Sounder
Basic Reconnaissance	Certify landing sites (threshold) and characterize new ones (highly desired)							
Ground Ice	Find shallow ground ice and overburden outside poles							
RSL	RSL fine structure & hydration state							
Atmosphere (including Strategic Knowledge Gaps and Reconnaissance)	Winds, temperature & aerosol profiles							
Environmental Transitions	Fine scale composition & morphology in ancient terrain							

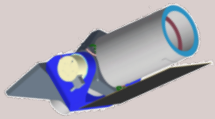
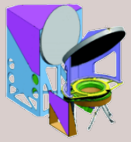
Threshold Instrument – needed for the theme

Strongly enhancing for the theme

Not needed for the theme

Potential Partnership Opportunities

- Observational Payloads

Very Shallow Radar	NIR Mineral Mapping	Thermal-IR mapper	Wide Angle Camera	Sub-mm: T, wind, water	Thermal-IR Sounder
					
Polarimetric SAR	High Resolution Compositional Imager	TIR Mapper	Weather camera	Sub-mm Wave Spectrometer (SWS)	TIR Sounder
Candidate payloads recommended by MEPAG Next Orbiter Science Analysis Group (2015)					

- Rendezvous and Capture Sensors
  - Narrow and wide-angle cameras
  - LIDARs, long-wave infrared (LWIR)

- Small Deployed Payloads
  - Small Satellites or Cubesats
  - Independently operated (e.g., Philae) or coordinated observations (e.g., radio or gravity experiments)