
Jet Propulsion Laboratory
California Institute of Technology
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Conceptual Studies for the Next Mars Orbiter (NeMO) Industry Day

May 2, 2016

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Robert Lock, Systems Engineering
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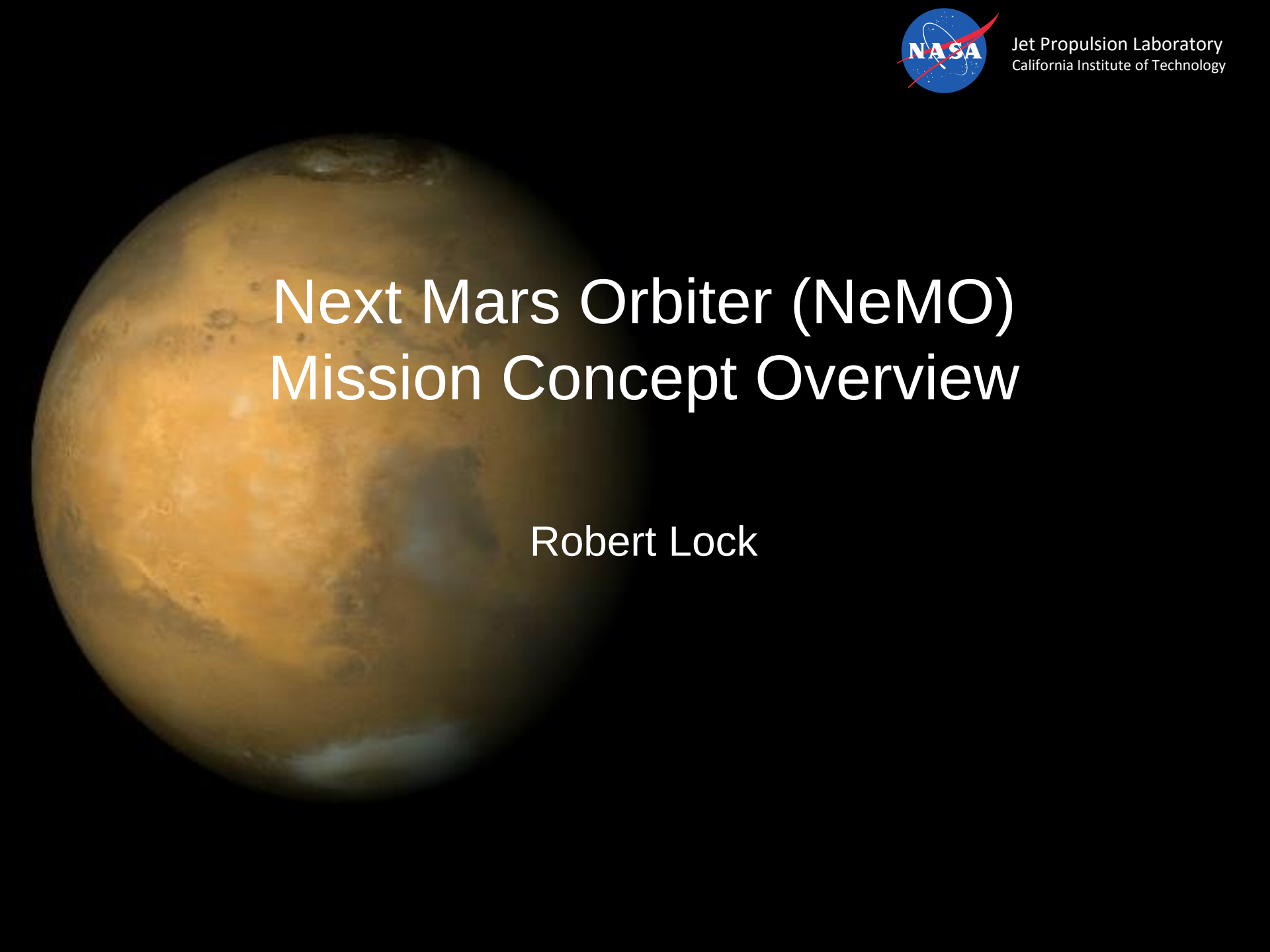
Industry Day Ground Rules

- All participants will be on mute, therefore no participant will be heard on the audio connection
- Send questions using the Chatbox within the WebEx meeting window (bottom right) and address them ONLY to the Host, Mika Matsumoto not ‘Everyone’
- Responses to questions may be provided during this teleconference or at a later time by email. Some questions may not be addressed. If a question is addressed, both the question and response will be provided to all participants and/or interested bidders

Industry Day Agenda

- Next Mars Orbiter (NeMO) Mission Concept Overview
- Introduction and Overview of the RFP
- Questions and Answers



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Next Mars Orbiter (NeMO) Mission Concept Overview

Robert Lock

Next Mars Orbiter (NeMO)

NASAWATCH.COM

Capability to Enable Future Pathways

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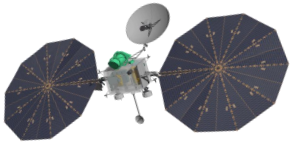
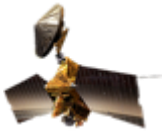
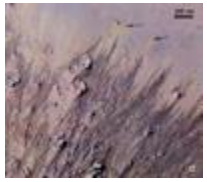




Aging Orbiter Missions

Next Mars Orbiter (NeMO)

Infrastructure Continuity



Decadal Priorities

Resource Prospecting for future Landing Sites

The Future

On-going and potential future Surface Missions – need orbital support

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

Introduction to the NeMO Mission Concept

- The NASA Mars Exploration Program is seeking to update its aging orbital infrastructure with an orbiter, to be launched in the early 2020s

- This Next Mars Orbiter will be capable of continuing and extending that infrastructure and refreshing the critical capabilities necessary to continue exploration of the Mars system and support future mission needs.

- The orbiter would:
  - Support increased bandwidth communications
  - Continue high resolution surface reconnaissance
  - Provide significant orbital flexibility for long term support of future missions
  - *Accommodate potential compelling investigations
  - *Validate challenging technologies for advanced communications
  - *Orbital Support for potential Sample Return

* Potential Objectives under consideration

Next Mars Orbiter (NeMO) Concept Overview

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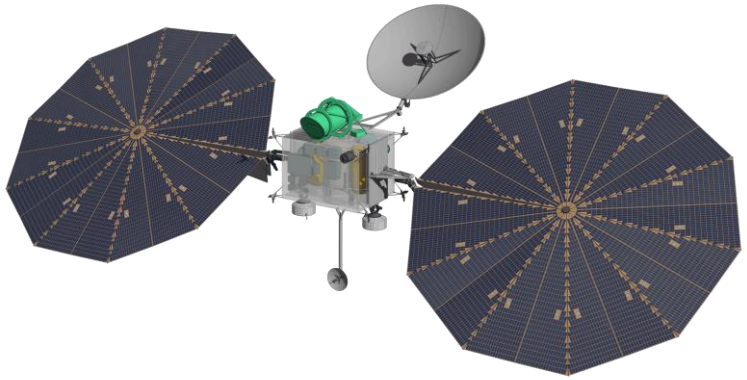

Objectives

- 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)
- Potential for additional observational instruments to be contributed by international partners
- Potential for Rendezvous and Capture payload

Falcon-9 or
Atlas V-411

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

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

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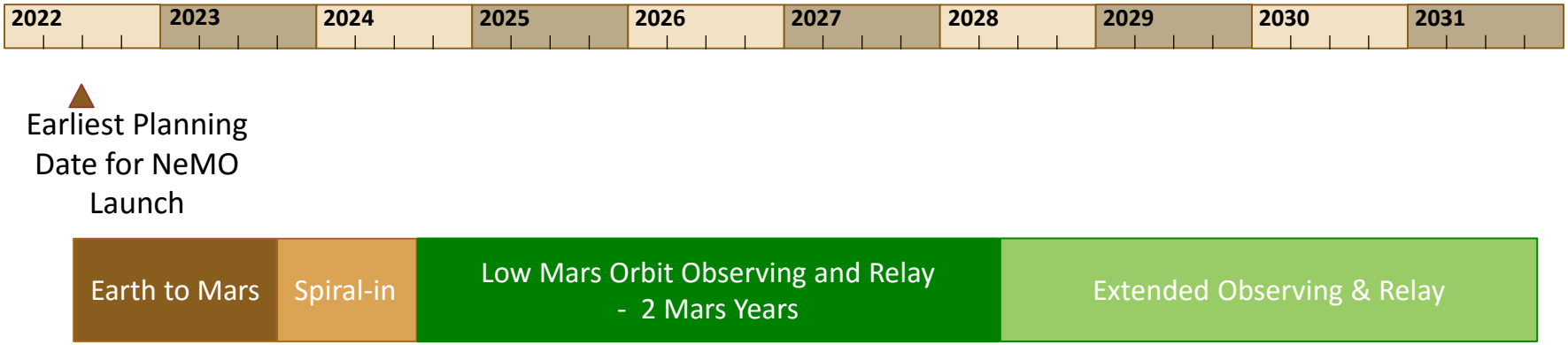
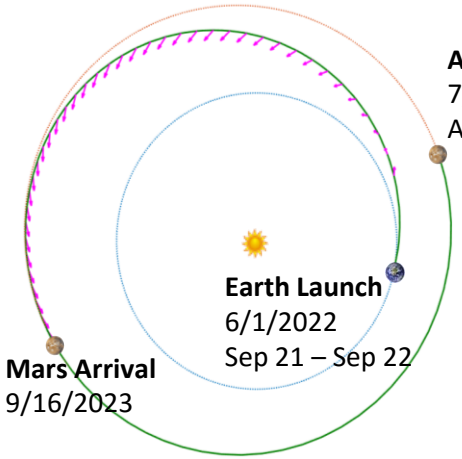


Mission Design Concept

Outbound (Earth-Mars) SEP Cruise

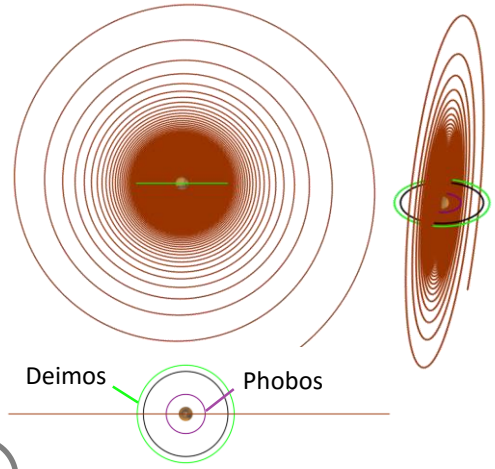


Arrive Low Mars Orbit
7/25/2024
Altitude: 320km

Operations

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

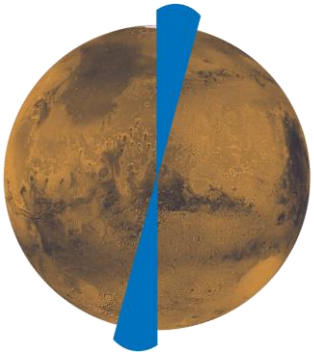
Mars Spirals



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

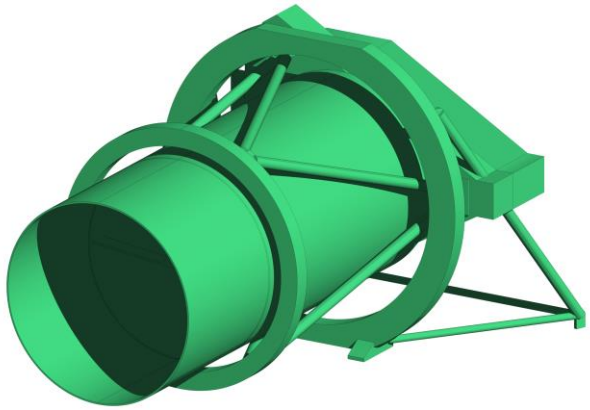
Imaging and Relay Orbit

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)

Strawman Instrument

- For study purposes, assume the following straw man instrument list
  - High Resolution Imager
    - Support Reconnaissance for landing site selection and geologic context for science and resource prospecting
      - 6 km image width, ≤ 30 km length, 30 cm/pixel
      - 50 kg mass, 60 W average power, 100 Mb/sec data transfer rate



- Assume:
  - Nadir pointing
  - S/C orientation to align ground-track velocity vector with instrument
  - Dayside operations

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
  - 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 operations require relatively low data latency (~10 minutes plus one-way light time)
  - ≥ 95% of data return (standard for planetary missions)
- No Critical Events after Launch

Telecom Payload Concepts

Deep Space Network (DSN)

X: ~0.01 Mbps

X: ~1 Mbps

Ka: 3-45 Mbps

Orbiter Comm and Relay

DTE Link

RF:
- X-band uplink
- X/Ka-band downlink
  - *X/Ka HGA*
  - *X, Ka TWTAs*

Real-time data pass-through

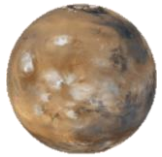
Multiple combinations

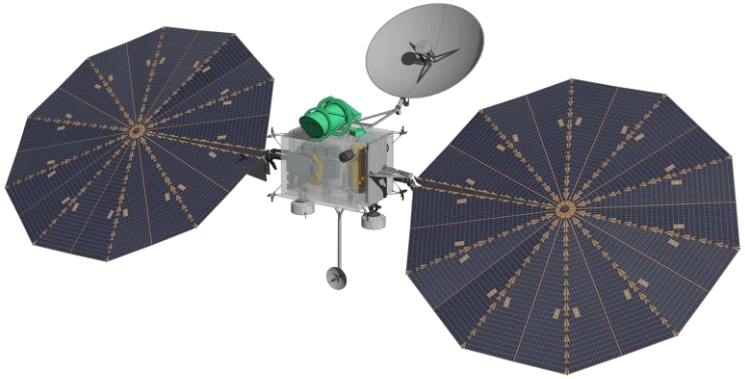
Proximity Link

RF:
- UHF-band fwd/ret
  - *LGA*
  - *MGA*
- X-band fwd/ret
  - *HGA*

UHF: 1 -10 Mbps

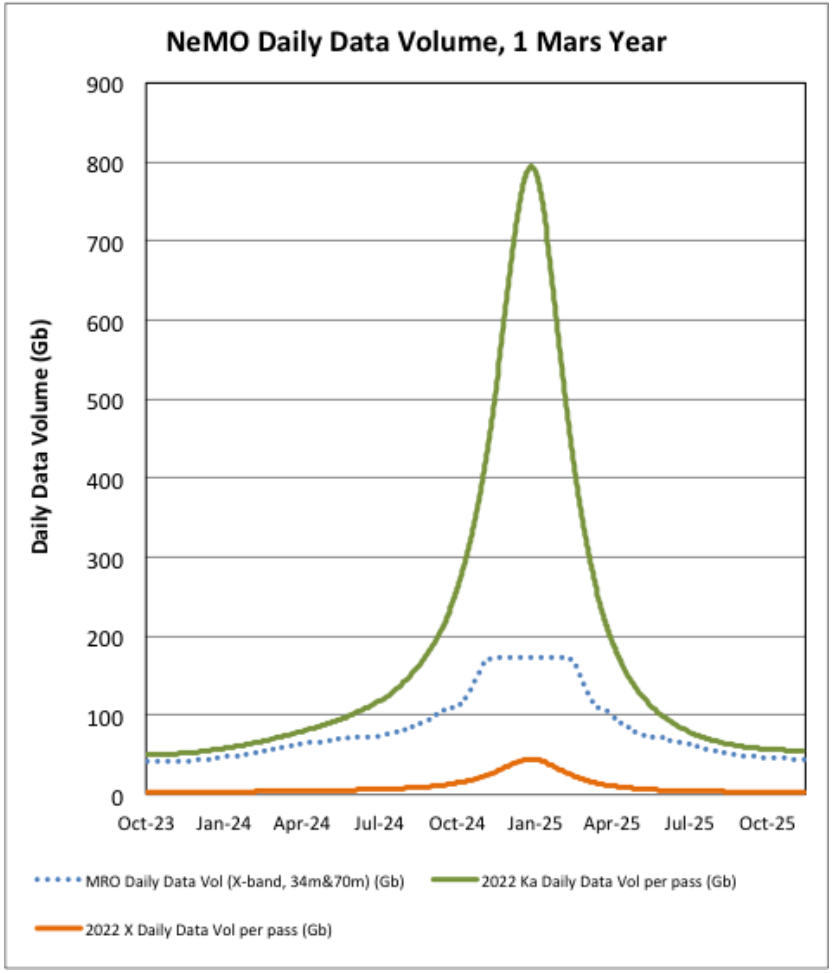
X: 10-100 Mbps

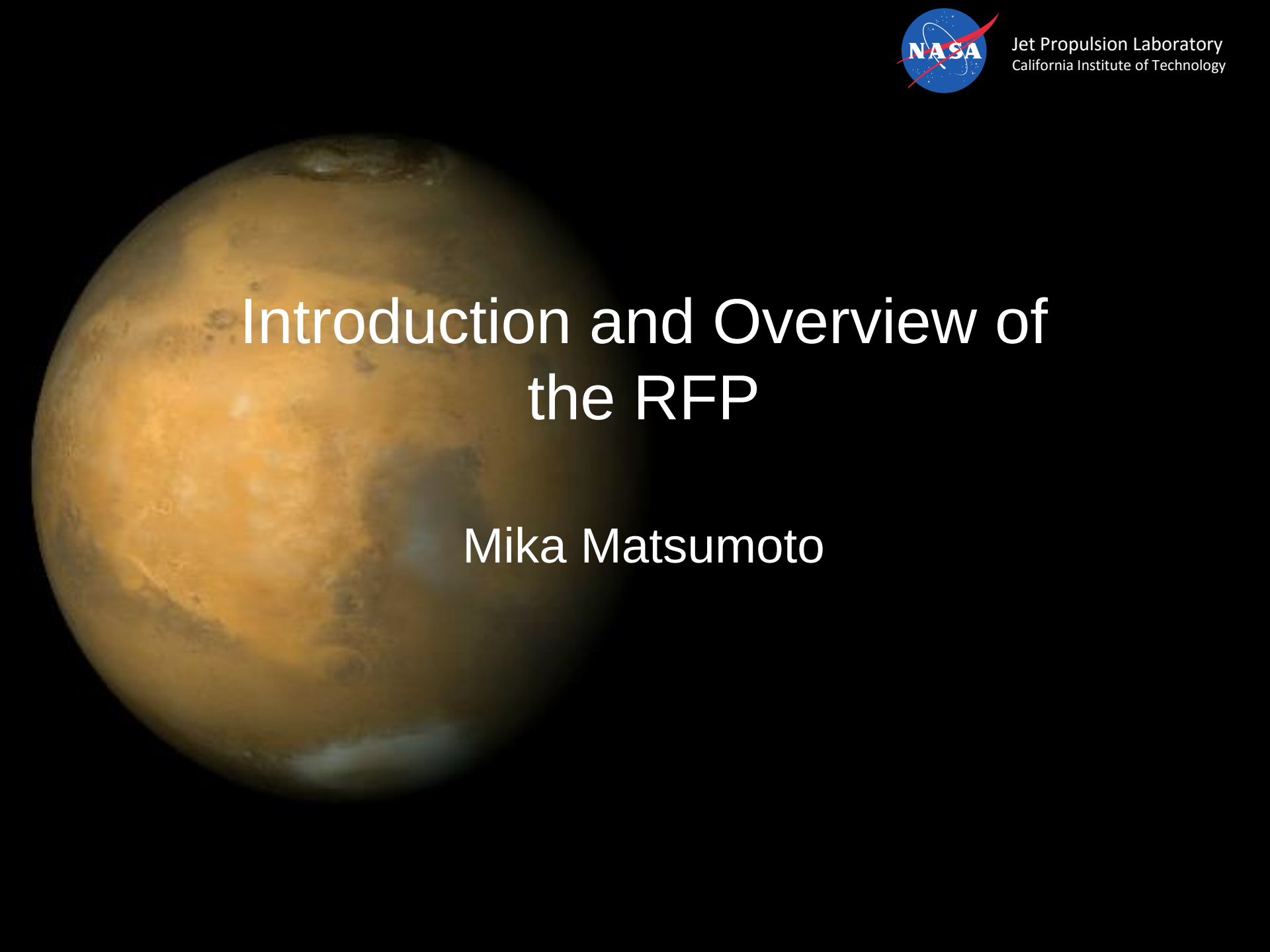




Estimated Mission Data Volume

- Data Volume Assumptions
  - One 34m DSN pass/day
  - Ka-band for high rate telemetry
  - X-band for command and high reliability telemetry
- 50 – 800 Gb/day
- Data Storage Sizing
  - 1 Tb missed pass volume margin for Ka-band weather losses
  - 2 Tb data storage needed for daily operations and missed pass margin





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Introduction and Overview of the RFP

Mika Matsumoto

Tentative RFP Schedule

- 05/02/2016 – Industry Day
- 05/04/2016 – RFP Released and Posted Online
- 05/25/2016 – Proposal Due Date
- 06/03/2016 – Proposal Evaluation Complete
- 06/08/2016 – Oral Discussions & Fact-Finding Complete
- 06/13/2015 – Source Selection
- 06/23/2016 – Subcontract Award

RFP Highlights

- In order to access the RFP, each proposer must complete a Submission of Company Contact Information form. Bidders may now email Mika Matsumoto at Mika.L.Matsumoto@jpl.nasa.gov to request the form.

- JPL intends to award multiple Fixed-Price Research and Development Conceptual Study Subcontracts in this study phase

- In an effort to maximize the number of concepts achievable within our funding profile, JPL intends to award each study subcontract with a total fixed price of $400,000.00. JPL may reject proposals exceeding $400,000.00 and would like to encourage proposers to propose a study that meets the Specimen Subcontract requirements and offers JPL the maximum benefit for the total price.

- The following RFP information is subject to change.

RFP Highlights Continued

- Any exceptions to either the RFP and/or Specimen Subcontract (including its exhibits), or a declination to provide Cost Instruction-requested rate information, may make your proposal unacceptable for evaluation. ***For each and every exception or declination you must provide a detailed explanation and associated full rationale; place in a special section of your proposal entitled "Exceptions/Declinations."***

- **If a proposer has any exceptions, JPL and each proposer will negotiate in good faith. JPL does not plan to engage in negotiations for a duration in excess of three (3) business days from the date the Subcontracts Manager indicates in writing negotiations have commenced. JPL may at its discretion, discontinue negotiations with the proposer after three (3) business days. If a mutually agreeable resolution is not reached after three (3) business days, this shall be considered a factor in evaluation and may make your proposal unacceptable for award.**

- There will be a 20-page maximum limit for the Technical/Management proposal, including mandatory qualifications

- Proposers are encouraged to submit a completed Attachment A-14 Past Performance 10 working days before the proposal due date

Mandatory Qualifications

Proposers **must** meet the following mandatory qualifications by time of award in order to be considered a qualified source and thereby eligible for award.

- **MQ 1**: Within the last 10 years, the proposer shall have successfully developed and flown a spacecraft with a solar power system of at least 10KW at 1 AU.

- **MQ 2**: Within the last 5 years, the proposer shall have successfully developed and flown a spacecraft that operated in deep space (beyond Earth orbit) or geosynchronous orbit (GEO).

- **MQ 3**: The proposer (both the prime contractor and its major lower-tier subcontractors for this effort) shall be a concern incorporated in the United States of America.

Criteria and Factors

Criteria and Factors	Scoring
•T-1 Study Approach Factor 1: Study Implementation Approach Factor 2: Technical Risk Identification and Mitigation Factor 3: Potential Cost Trades and Associated Risk	500
•M-1 Personnel and Schedule Factor 4: Study Personnel Factor 5: Schedule	250
•M-2 Related Experience Factor 6: Related Institutional Experience	250

RFP Cost Instructions

- Partial/Milestone payments will be allowed under this Subcontract

- The anticipated start date for this effort will be June 23, 2016

RFP Attachments

- Group A - Complete and return as part of your quotation/proposal
  - A-1 Acknowledgment (Form JPL 2384-A1)
  - A-14 Past Performance (Form JPL 0358-A14)
  - A-15 Cost Element Breakdown - Long Form (Form JPL 0549-A15)
  - A-21 Supplier Information Request (Form JPL 7255-A21)(Supplier to submit if not in JPL's Supplier Data Base)

- Group B - Are for use in preparing your quotation/proposal
  - B-1 Waiver of Rights to Inventions (Form JPL 62-301-B1)

SOW Background Material

- Key Study Objectives
  - Balance significant NASA budget pressures with flexibility to accomplish mission goals and accommodate international and interagency contributed elements
  - Develop a spacecraft conceptual design (with provided requirements & GFE)
    - Identify cost driving requirements and suggest alternatives to mitigate cost and cost risk
    - Describe use of heritage and production designs

- Main Mission Objectives
  - Telecommunications infrastructure at reasonable cost
  - Provide continuity of high resolution imaging
  - Significant orbital flexibility for long term support of future missions
  - Potential orbital support for sample return
  - Potential opportunities for contributed payloads

Specimen Subcontract SOW Highlights

- Conduct a Kickoff Meeting / SRR including conceptual design elements and fault protection

- Perform the following analysis and planning:
  - Develop a conceptual design of the spacecraft and a compliance matrix, including margin identification
  - Perform / document analyses that demonstrate performance, margin and/or sizing
  - Define the design elements that inherit from the Subcontractor's flight heritage
  - Perform sensitivity studies to assess the additional resources for:
    - A GFE rendezvous and capture payload and up to six additional Mars-viewing science payloads
    - Extending the operational lifetime to 11 years
    - Adding another NEXT-C string or using an alternative thruster technology in place of NEXT (includes use of new trajectory, re-sizing of the solar array, propellant loads, etc.)
  - Develop a technical and implementation risk assessment

- Develop a schedule of the development activities for proposed spacecraft

- Develop a ROM cost estimate for the proposed spacecraft, including identifying any long lead procurements

Specimen Subcontract Deliverables

Item No.	Description	Delivery Date
1	Kickoff Meeting	2 weeks ADOS*
2	Midterm Report I	2 days prior to Midterm Briefing I
3	Midterm Briefing I	8 weeks ADOS
4	Midterm Report II	2 days prior to Midterm Briefing II
5	Midterm Briefing II	12 weeks ADOS
6	Final Report	2 days prior to Final Briefing
7	Final Briefing	17 weeks ADOS
8	Response to Questions and Updated Final Report	18 weeks ADOS

**ADOS – After Date of Subcontract*

Specimen Subcontract Exhibits

- Exhibit I: NeMO Spacecraft Functional Requirements
- Exhibit II: NeMO Government Furnished Equipment Assumptions
- Exhibit III: NeMO Trajectory Description
- Exhibit IV: NeMO Key Milestones Schedule
- Exhibit V: Reference Documents List

Questions and Answers

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jpl.nasa.gov