Eric Ianson
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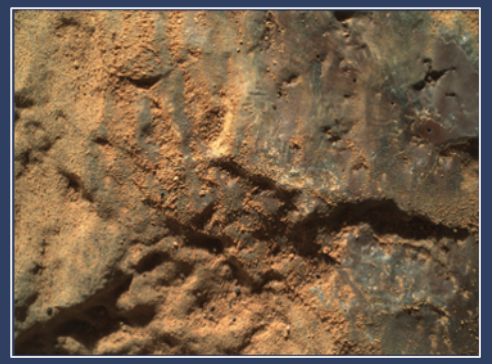
Michael Meyer
Lead Mars Scientist

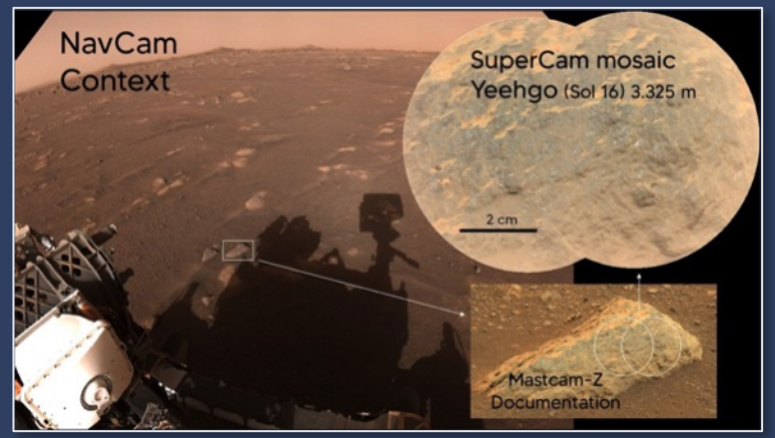
Mars Exploration Program Presentation to PAC
June 14, 2021

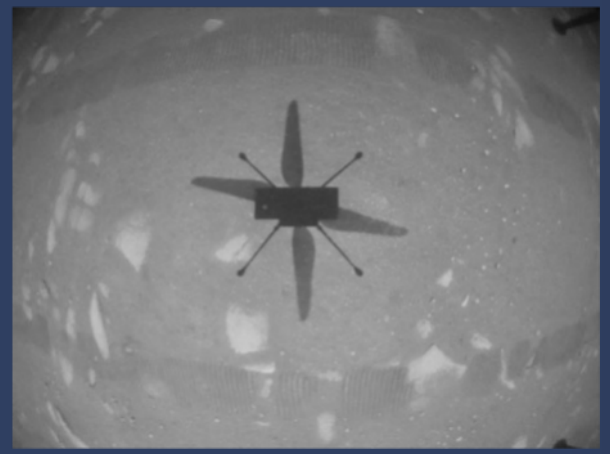
Mars Exploration Status Highlights

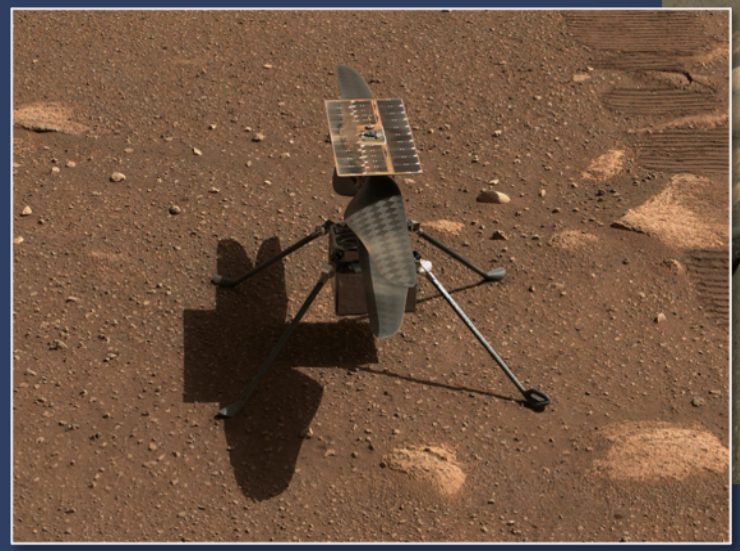
- Perseverance rover and Ingenuity helicopter are healthy and stable on the surface of Mars.
- Commissioning is complete; Perseverance is headed South on our first science campaign
- 100 days (sols) milestone at Jezero Crater as of June 1
  - Tested all cameras and instruments
  - Returned over 75,000 images
  - Deployed Ingenuity and completed technology demonstration phase
  - Recorded first sounds of Mars
  - Extracted oxygen from the atmosphere

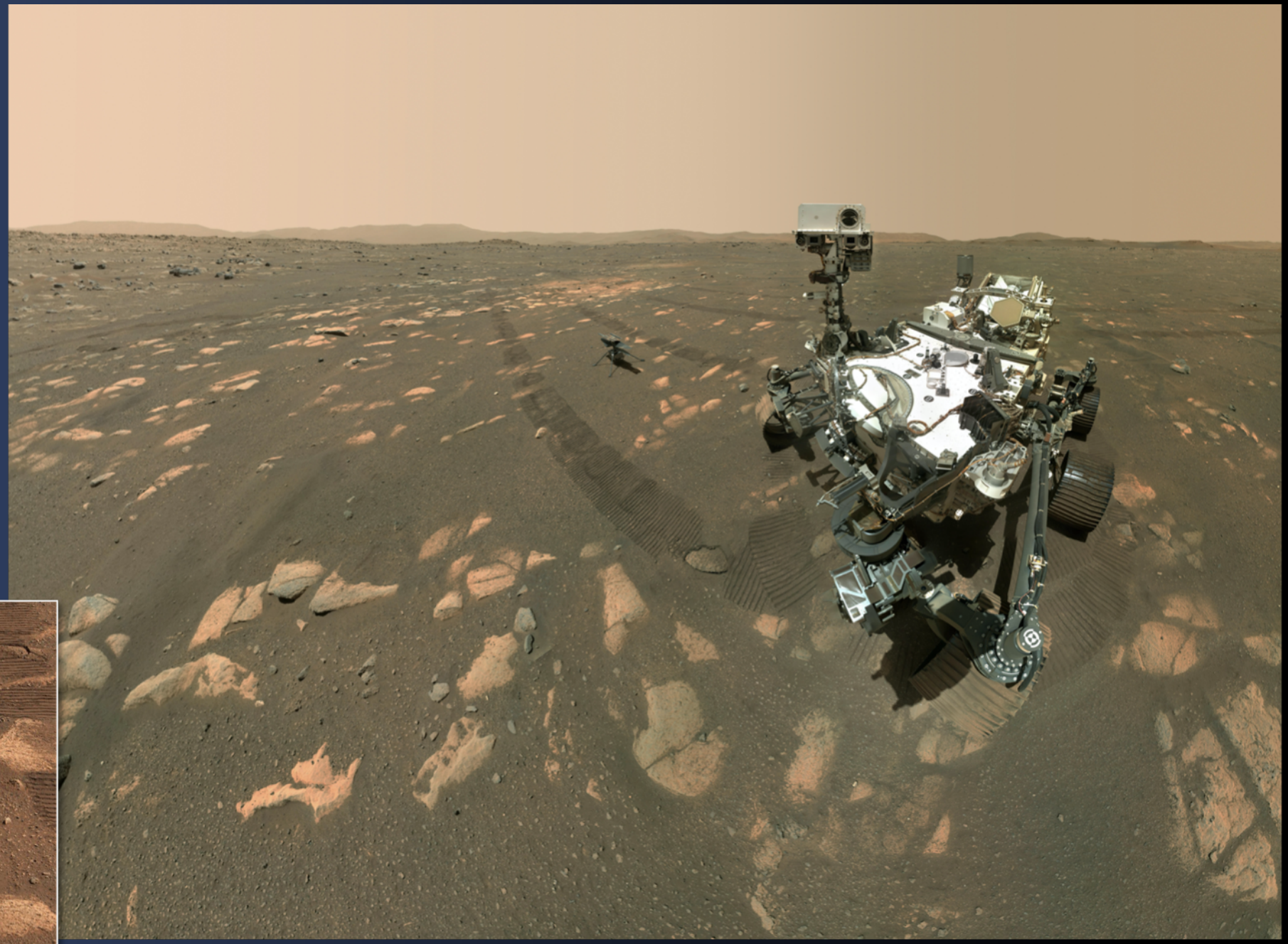


WATSON focus test







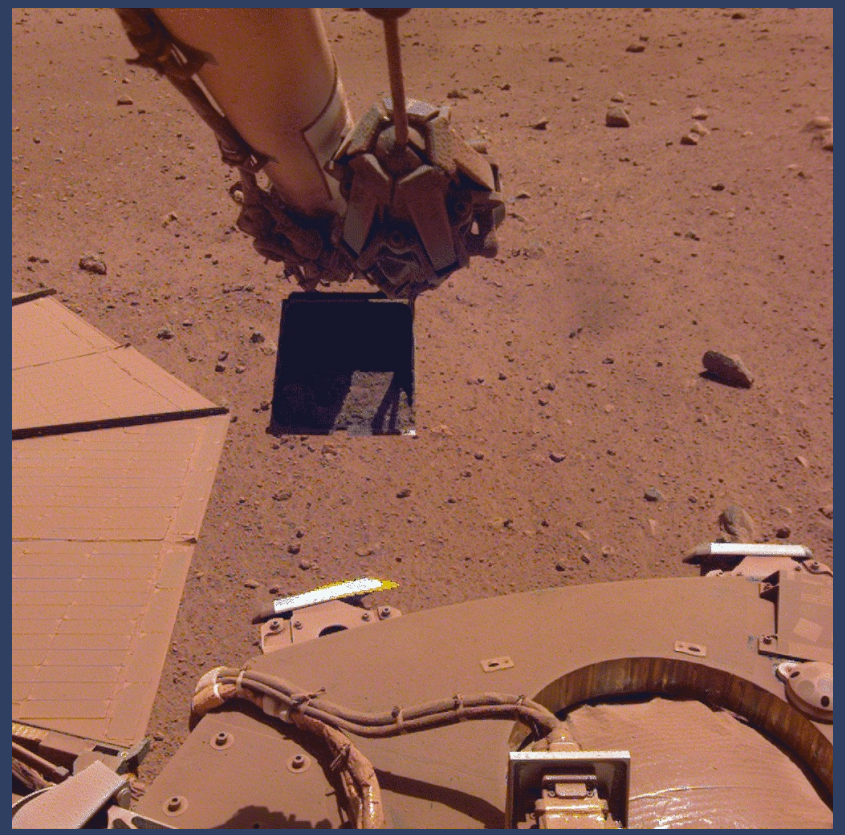


Other Updates

- Dr. Fuk Li retired from JPL as the Mars Exploration Program Manager in April 2021; Mr. Joe Parrish was named by JPL as the new MEP Program Manager
- InSight power generation continues to decay due to buildup of Martian dust on the solar arrays; soil-drop saltation test yielded positive increasing power generation by 30 kwh/sol
- Ongoing NASA missions are healthy, productive, and funded through FY21
  - Odyssey: > 20 years since launch, and still going strong
  - MRO: Decision made to keep MRO in the 15:10 crossing time orbit
  - MSL: Approaching/in the “sulfate unit” identified from orbit
  - MAVEN: Exciting science ahead during solar cycle 25; Supported Mars 2020 EDL
  - ExoMars/TGO (ESA): Provides ~50% of relay data from landed assets
- MEPAG virtual Meeting to be held June 21
- NASA/ESA MSR Science Planning Group-2 been meeting regularly meeting since June 2020
  - Reported out to NASA and ESA HQ on May 27
  - Final documents to be completed by end of June
- Mars Data Analysis Program
  - ROSES 2020: selected 31 of 96 Step 2 proposals submitted this year
  - FINESST proposal selections to be announced soon

InSight Power Boost

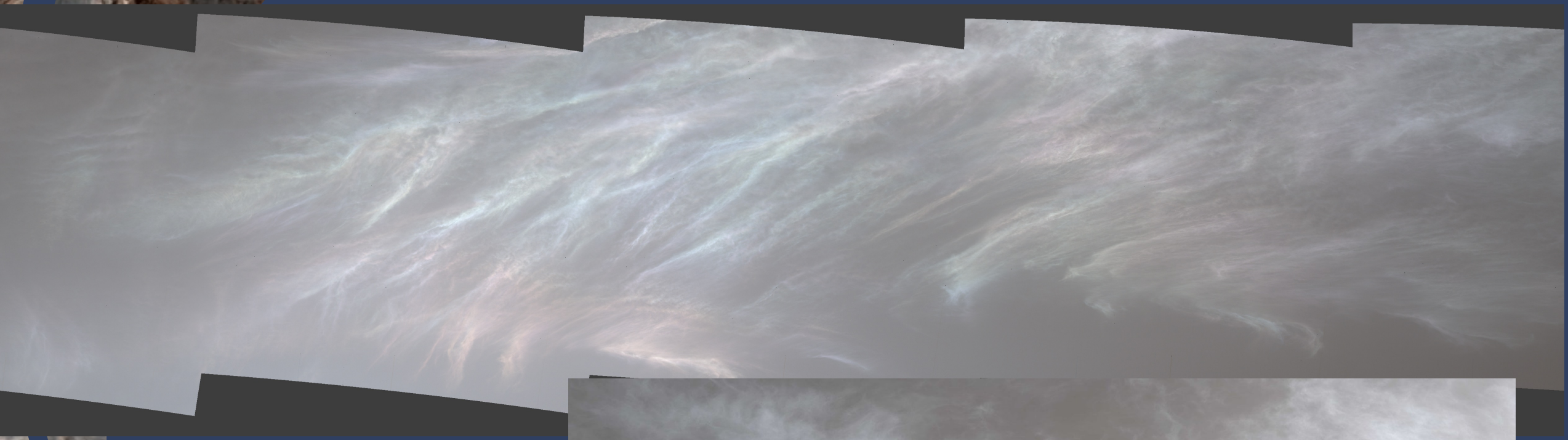
Saltation from sand sprinkled on solar panel removed dust, increasing output by 30 Watt-hours/sol



Budget Status

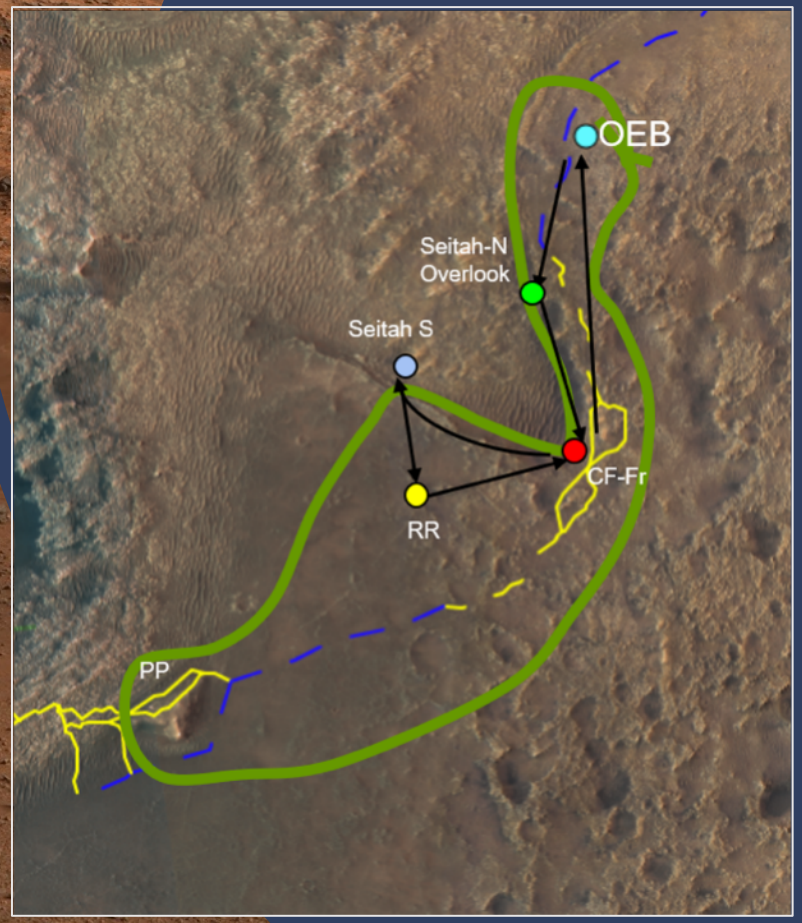
- FY22 President's Budget Request supports a robust Mars Exploration Program, including:
  - Perseverance's science & sample caching campaign on the surface of Mars
  - Continued operation of existing missions, including planning for extended missions
  - International Mars Ice Mapper identified as a separate "project" in the budget
  - Funding to support the delay to the ExoMars/Rosalind Franklin mission
  - Mars fundamental research & analysis
  - Support for existing and future international partnerships
  - Planning for the receiving and curation of returned samples
- Mars Sample Return identified as a separate "project" in the budget

Noctilucent Clouds



Perseverance "Green Zone" Science Campaign

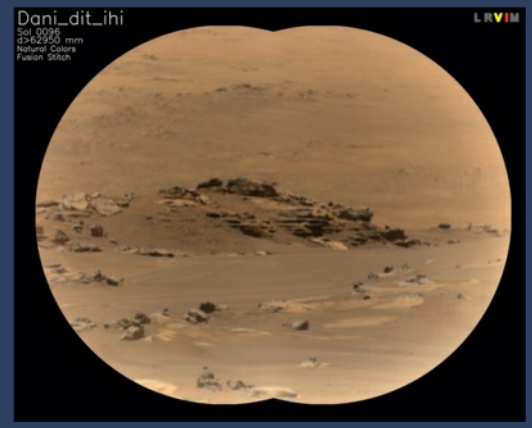
- First segment of 3 Earth-year Jezero phase of Mars 2020 mission: crater floor exploration
  - Other two segments are *delta* and *marginal/crater rim*
- Collect ~ 4 samples (plus duplicates) and a witness blank
- After campaign, fast traverse to Jezero delta (arrive approximately Spring 2022)



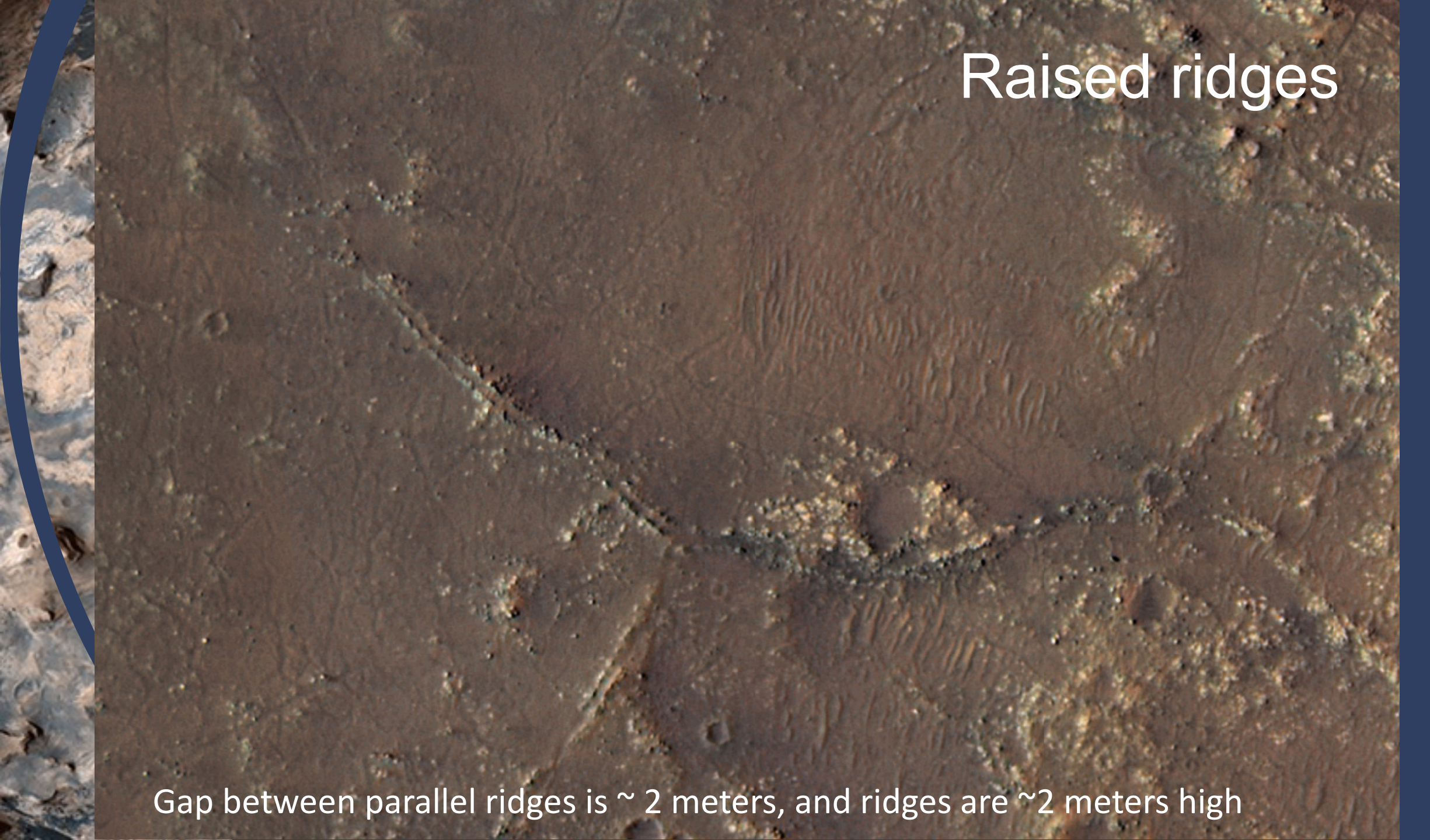
Strategy: an out and back traverse. Head south following black arrow doing imaging and identifying locations for detailed work on return journey. Then fast counter-clockwise traverse from Octavia E. Butler Landing to delta entrance. *Be highly disciplined and focused on sample collection.*

<u>Possible or likely sample sites:</u>

1. Crater Floor – Fractured Rough at red dot
   - heavily cratered unit the rover landed beside and has been studying ever since
2. "Seitah" unit at blue or green dot
   - lacustrine/deltaic sediments (?)
3. Sample of Opportunity
   - mineralized raised ridge (RR)? Pilot Pinnacle (PP) delta remnant?

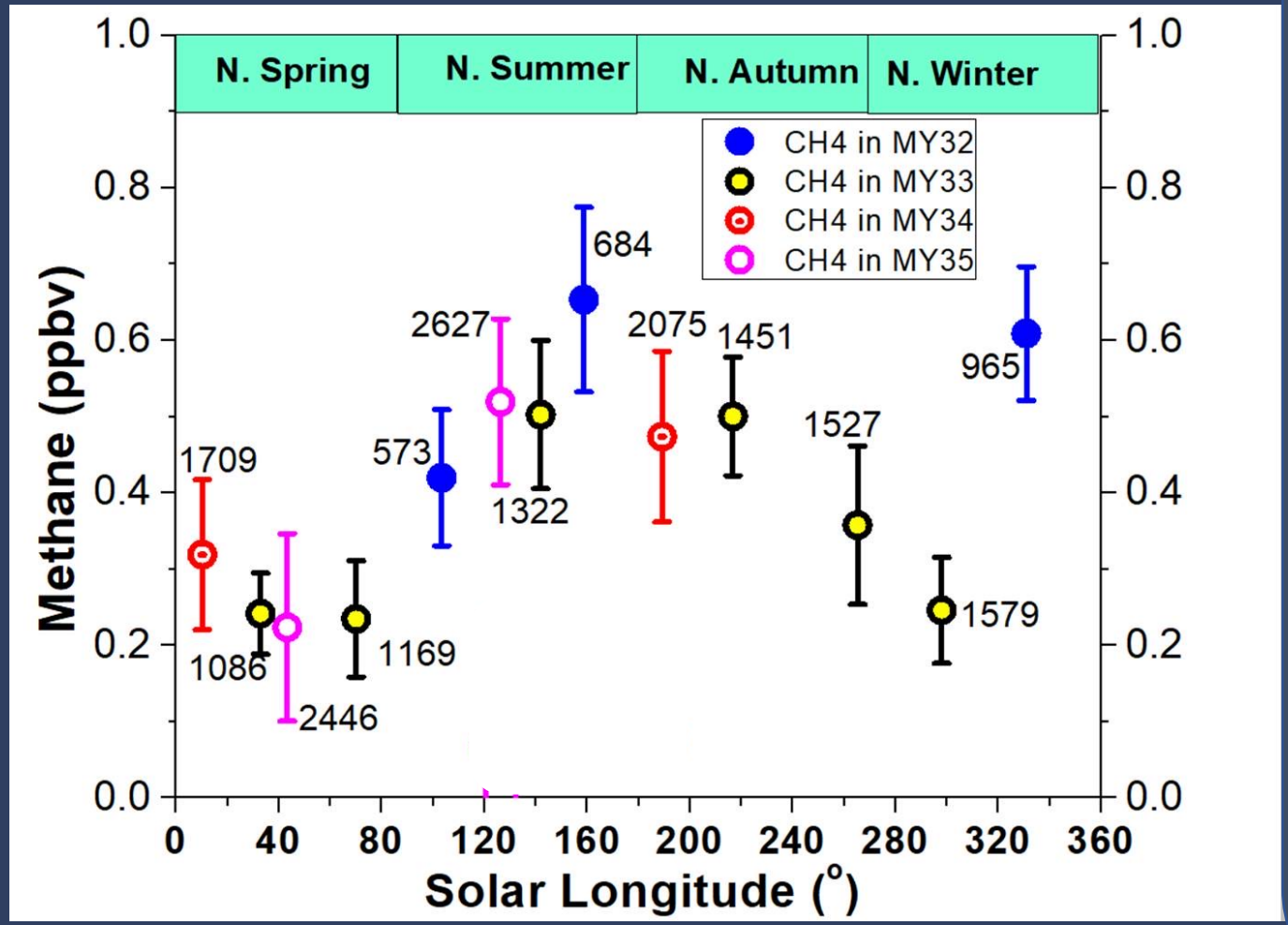


Raised ridges



Gap between parallel ridges is ~ 2 meters, and ridges are ~2 meters high

Methane on Mars

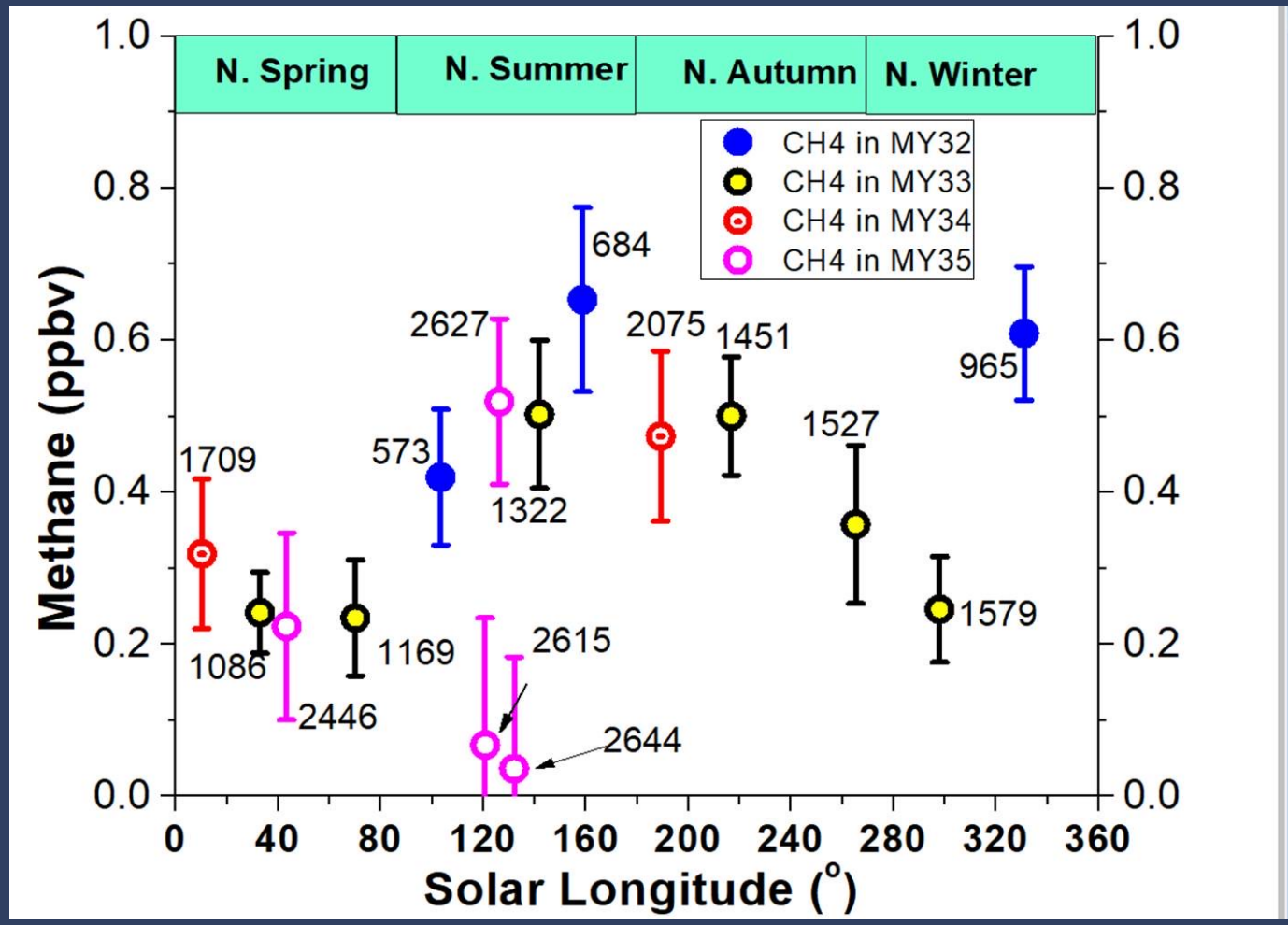


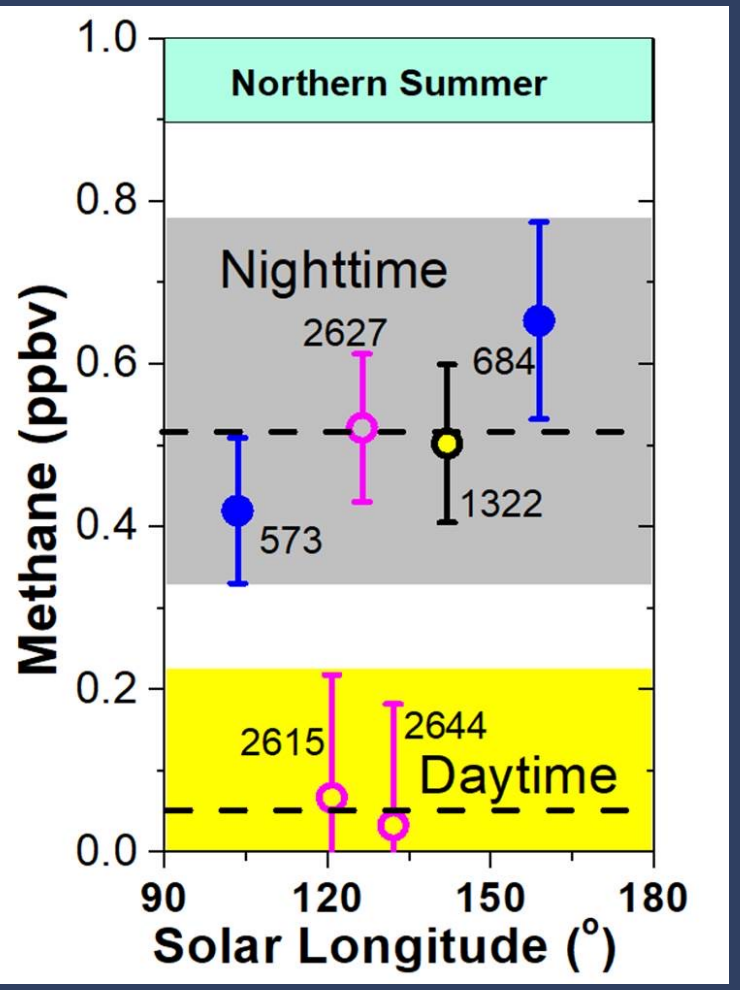
- Nighttime measurements on Mars consistently showed low amount of methane with a seasonal variation,
- But TGO did not see methane from orbit.

What is the cause of this apparent discrepancy?

- Theory - Micro-seepage of methane could be contained within the collapsed boundary layer at night

Methane on Mars





MSR Science Planning Group –2 (MSPG2)

Initiation

Terms of Reference signed by ESA and NASA in April 2020

Statement of Task

1. Provide inputs for an MSR Science Management Plan
2. Identify technical issues related to potential scientific usefulness of the samples
3. Develop high level requirements for the Sample Receiving Facility to be used for cost estimation and budgeting
4. List key decision points related to the returned samples and represent them on a master timeline

Formation

- Members competitively selected through joint NASA-ESA process
- International team comprised of appointed Coordination team plus 25 members: 12 from Europe, 11 from the United States, one from Canada, one from Japan

MSPG2 Results

1. Science Management Plan

Demonstrated the need for an overarching MSR Campaign Science Program and proposed an implementation approach

2. Technical Issues

Established which sample related activities must be conducted in the containment, either because they are time-sensitive, sterilization-sensitive, or are needed for initial sample characterization

3. Sample Receiving Requirements

Provided technical requirements that would enable the containment laboratory to meet its objectives and accommodate activities that cannot be done in external laboratories

4. Integrated Timeline

The MSR Science Program comprises multiple types of activities - some are tied to the sample return date, while others are tied to the planning and activity of the flight missions, and some must start immediately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MARS SAMPLE RETURN
Jeff Gramling, MSR Program Director
Michael Meyer, Mars Lead Scientist
NASA HQ
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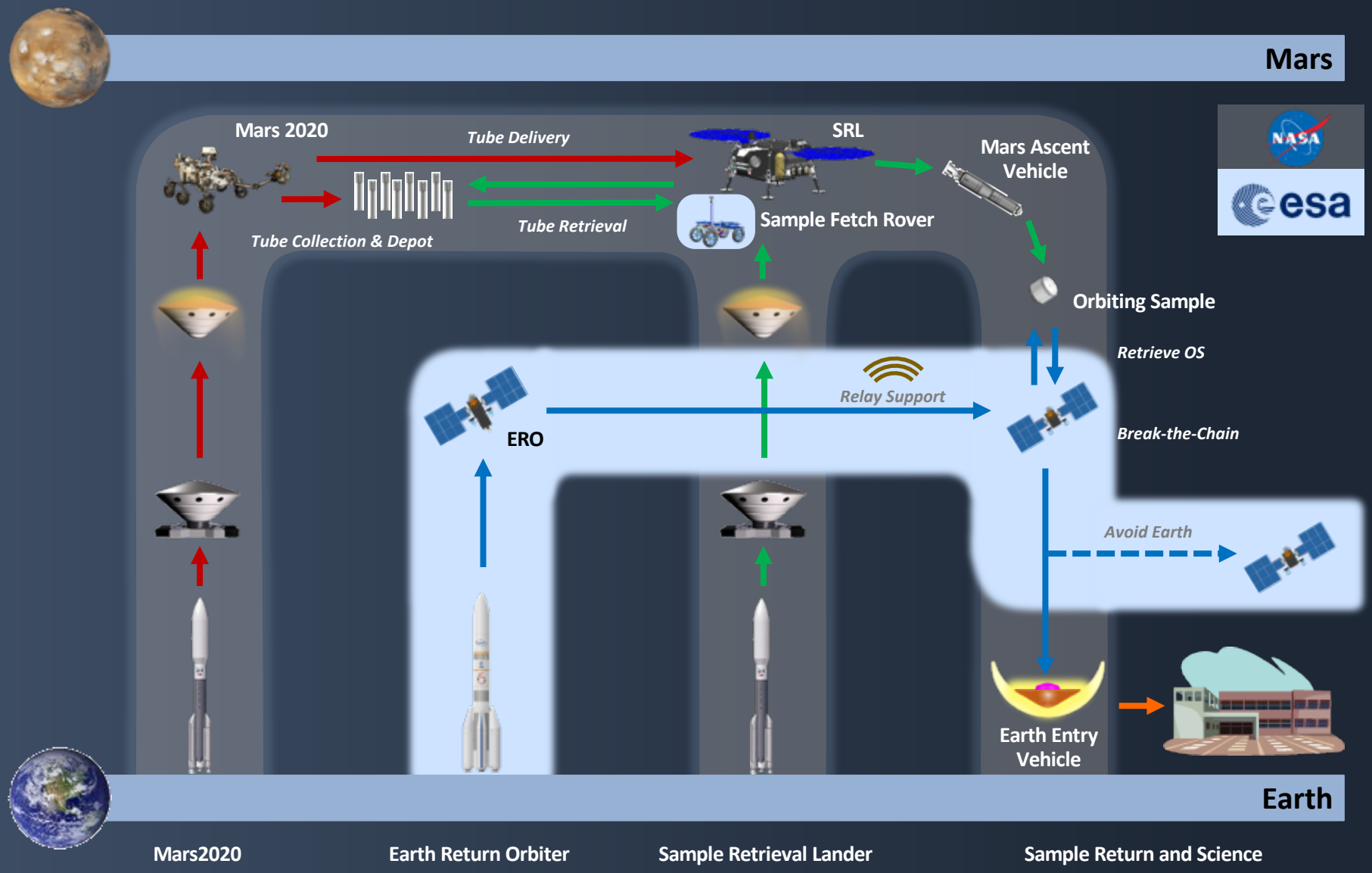
MSR Architecture Overview



Phase A Status

- MSR entered Phase A in December following Independent Review Board and Standing Review Board Review of mission concept and technology plans
- Program has been staffing up
  - Have benefited from staff transitioning from M2020
- Partnership with ESA established
  - Second Joint Steering Board planned for June 17th
  - Review of Proposal for Sample Transfer Arm
- Review Status
  - ESA Earth Return Orbiter (ERO) – PDR 4/15
  - ESA Sample Fetch Rover (SFR) SRR – 4/29
  - Capture, Containment, and Return System (CCRS) SRR – 4/22
- Focusing on developing and refining architecture
  - Ensure alignment with Class A mission requirements
  - Mission Timeline (LRD and Sample Return date)
  - One vs Two landers

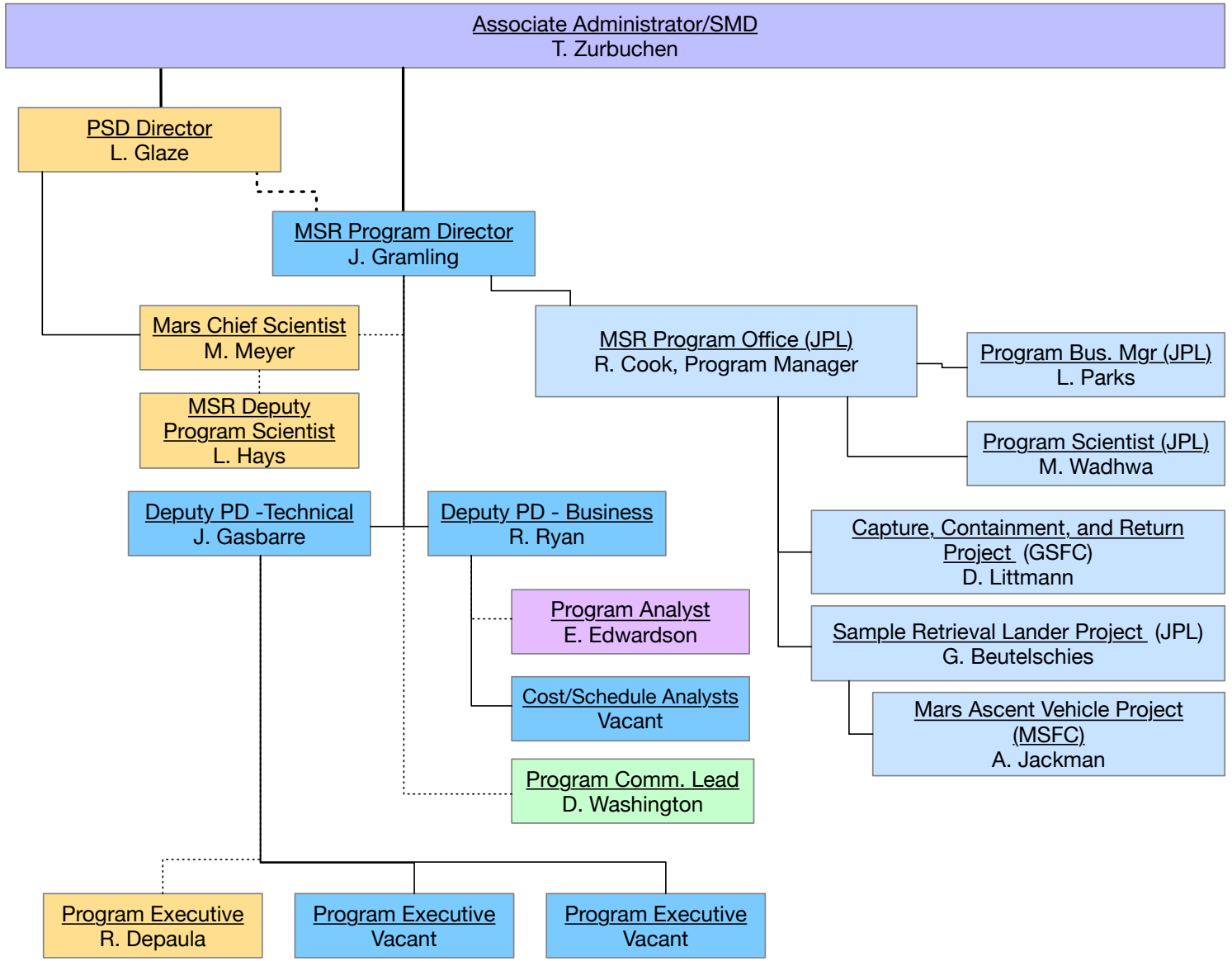
Phase A Status, cont'd

- Agency Delta Acquisition Strategy Meeting, 5/13
  - Consistent with IRB Recommendations, MAV, SRL Cruise Stage, and EEV will be system procurements
- Near Term Strategic Procurements:
  - SRL/EEV Thermal Protection System (TPS) material, Contractor: FMI
  - MAV Solid Rocket Motors, Contractor: Northrup Grumman
  - Aeroshell, Contractor: Lockheed Martin
  - EEV
  - MAV
  - SRL Cruise Stage

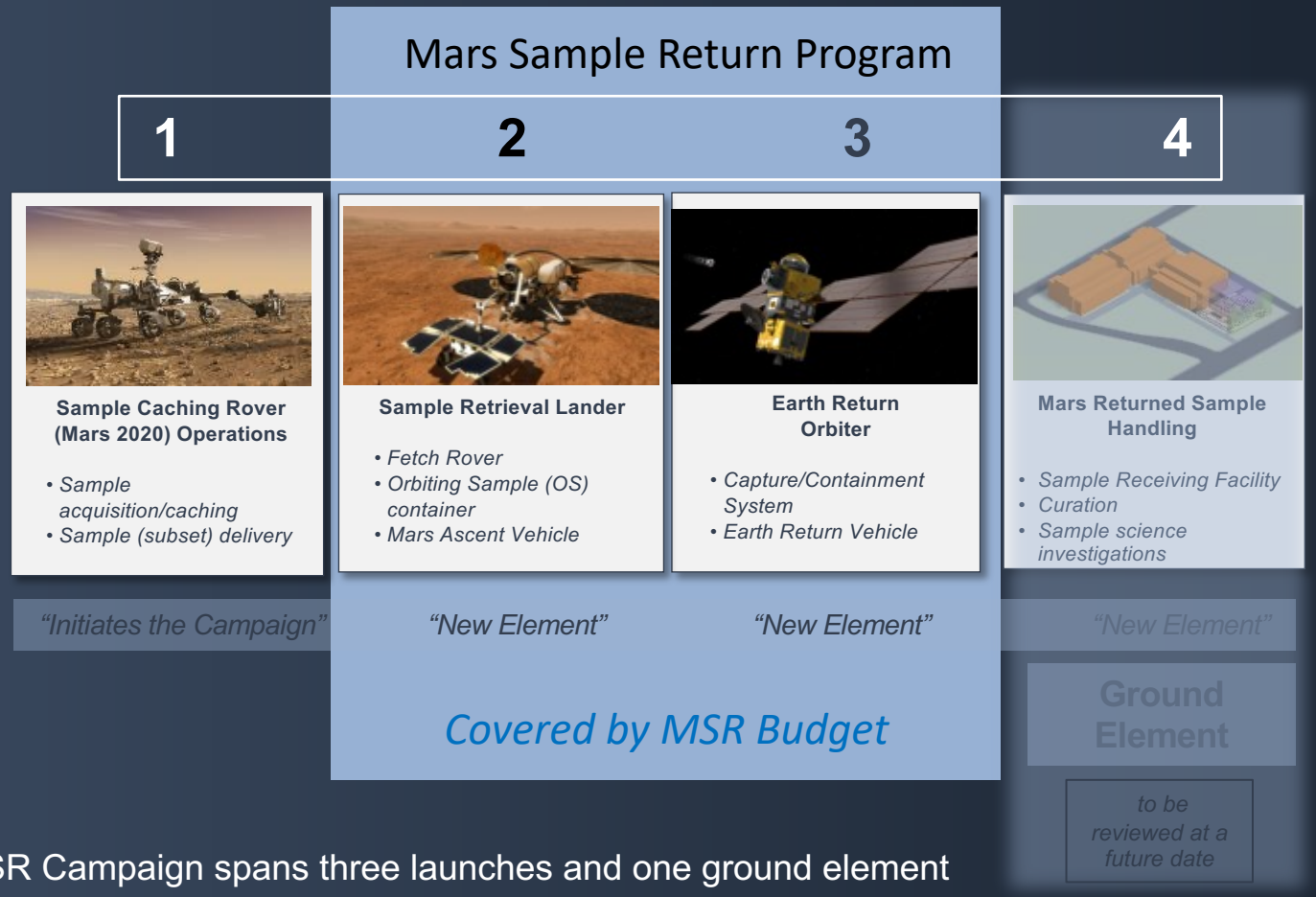
Staffing Updates

- Richard Cook named MSR Program Manager (JPL)
- Joe Gasbarre selected as permanent Deputy Program Director/Technical
- Dewayne Washington joins team as HQ Communications Lead
- Mini Wadhwa joins team as Program Scientist (JPL)
- Guy Beutelschies named SRL Project Manager (JPL)
- Dave Littmann named CCRS Project Manager (GSFC)
- Larisa Parks joins team as Program Business Manager (JPL)
- Randy Blue joins team as Program Mission Assurance Manager (JPL)

Mars Sample Return



MSR Campaign



- The MSR Campaign spans three launches and one ground element
- The MSR Program manages development and operations of elements 2 and 3 above and interfaces to elements 1 and 4; program concludes with recovery/containment of samples for transfer to SRF
- The MEP Program manages M2020 Phase E operations & will be the home of the future SRF Project

MSR Budget Status

President's FY22 Budget request

Budget Authority (in $ millions)	Op Plan FY 2020	Enacted FY 2021	Request FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Total Budget	0.0	246.3	653.2	772.3	800.0	700.0	600.0

- We are pleased that the President's FY22 Budget request funds us at levels consistent with the recent IRB recommendations and the presentations made to the Planetary Science and Astrobiology Decadal Survey
- Program Cost Commitment established at KDP-C, following completion of Phase B

MSR Cost Control

- Cost Control and reduction measures
  - Partnership with ESA reduces cost & risk to both partners
  - Increased use of independent review starting in Pre-Phase A
  - Two independent cost and schedule assessments in Pre-Phase A
  - Standing Review Board (SRB) for the Mission Concept Review prior to entry into Phase A
  - Deputy Director-Business position created at HQ to ensure rigorous cost and schedule management processes are established for the program
  - MSR will be the first SMD program to perform a Joint cost and schedule confidence exercise for KDP-B
  - MSR will perform Integrated Baseline Reviews and Earned Value starting in Phase B
- Descopes
  - The only cost/complexity reducing descope identified has been the draft requirement for a dedicated Atmospheric Sample in the OS, which is being studied in Phase A

Science Involvement in Sample Return

- MSR Program Staff
  - Dr. Meyer, Lead Mars Scientist (HQ)
  - Dr. Hays, Deputy Program Scientist (HQ)
  - Dr. Gerhard Kminek (ESA)
  - Dr. Wadhwa, Program Scientist (JPL)
    - Scientific leadership in the execution of MSR Program activities
    - Responsible for the scientific integrity and overall scientific success of the MSR Campaign
    - Provide a science voice in MSR Program decision making
- Key stakeholders/authors of Level 1 Requirements and Mission Success Criteria
- Agency Standing Review Board scientists for MSR Program
  - Chaired by Dr. Zuber
  - Members include Drs. Grotzinger and Lunine
- Community inputs via working groups (typically with competed membership)
  - Established by the Mars lead scientists at NASA HQ and ESA for targeted activities (such as the Caching Strategy Steering Committee & MSPG2)
- MSR Science Plan being developed jointly with ESA

Summary

- Perseverance is progressing towards initiation of sampling science operations
- Organizational responsibilities and Make/Buy decisions have been aligned consistent with recommendations by the IRB
- Team continues to mature architecture in Phase A
  - Close trades
  - Demonstrate viability on technology and engineering developments
  - Refine cost and schedule estimates with institutional commitments
  - Continue refinement of mission design and planning
- The President's FY'22 budget request funds the program consistent with IRB recommendations
- The program has benefited from addition of experienced staff from M2020 and other missions

Acronyms

- CM: Containment Module
- CCM: Capture and Containment Module
- CCRS: Capture, Containment and Return System
- CONOPS: Concept of Operations
- CP: Chemical Propulsion
- CS: Cruise Stage
- DOF: Degree of Freedom
- EE: End Effector
- EES: Earth Entry System (includes OS)
- EEV: Earth Entry Vehicle
- EP: Electric Propulsion
- ERO: Earth Return Orbiter
- ERM: Earth Return Module
- GNC: Guidance, Navigation and Control
- HEEET: Heatshield for Extreme Entry Environments Technology
- IRD: Interface Requirements Document
- IDRA: Interface Definition and Requirements Agreement
- ITT: Invitation to Tender
- JMIP: Joint Management and Implementation Plan
- LMO: Low Mars Orbit
- LRD: Launch Readiness Date
- LV: Launch Vehicle
- MAPS: Mars Ascent Propulsion System
- MAS: Mars Ascent System
- MAV: Mars Ascent Vehicle
- MPA: MAV Payload Assembly
- MEL: Mass Equipment List
- MEP: Mars Exploration Program
- MMOD: MicroMeteoroid and Orbital Debris
- MRSH: Mars Returned Sample Handling
- MSR: Mars Sample Return
- OS: Orbital Sample
- PICA: Phenolic Infused Carbon Ablator
- PLV: Propulsion Landed Vehicle
- PP: Planetary Protection
- PPO: Planetary Protection Officer
- QPM: Quarterly Progress Meeting
- RSTA: Returned Sample Tube Assembly
- RTA: Robotic Transfer Arm
- SEP: Solar Electric propulsion
- SFR: Sample Fetch Rover
- SRL: Sample Retrieval Lander
- SRF: Sample Receiving Facility
- STA: Sample Transfer Arm
- STS: Sample Transfer System
- SOI: Statement of Intent
- TAA: Technology Assistance Agreement
- TGO: Trace Gas Orbiter
- TM: Transfer Module
- TPS: Thermal Protection System
- TVC: Thrust Vector Control
- TRN: Terrain-Relative Navigation
- VECTOR: Vertical Ejection, Controlled Tip-off Rate launch mechanism
- UTTR: Utah Test and Training Range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