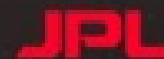


Mars Reconnaissance Orbiter



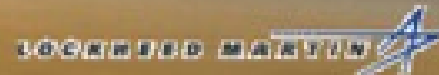
Mars
Reconnaissance
Orbiter

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California Institute of Technology



CL#20-1738



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MRO Mission Objectives for FY21-26

MRO Science Mission Objectives for FY21-26

- Complete Extended Mission 5 (EM5) in FY21-22
 - Pursue 16 science investigations in 4 goal areas (next slide)
 1. Ancient Mars: Environmental Transitions & Habitability
 2. Amazonian Ices and Climate
 3. Modern Mars Surface: Changes and Implications
 4. Modern Mars Climate: Atmospheric and Polar Processes
 - Conduct an Approved Extended Mission 6 (EM6) in FY23-25
 - Similar Science areas as in EM5; focus on change detection



MRO Program Support Objectives for FY21-26

- Provide high-volume relay for surface platforms:
 - MSL & InSight (ongoing), Mars 2020 (≥ 2021), ExoMars Rover/Surface Platform (RSP) (≥ 2023), Sample Retrieval Lander (SRL ≥ 2026)
- Characterize & certify landing sites for future Mars landers (SRL & as directed by NASA)
- Cover mission critical events at Mars:
 - Mars 2020 EDL in 2021
 - Others as requested (e.g., RSP~2023, SRL>2026)
- Provide environment data needed for mission design and operations.
 - Daily global weather maps and atmospheric profiles for ≥ 3 Mars yrs; dust storm frequencies

Payload

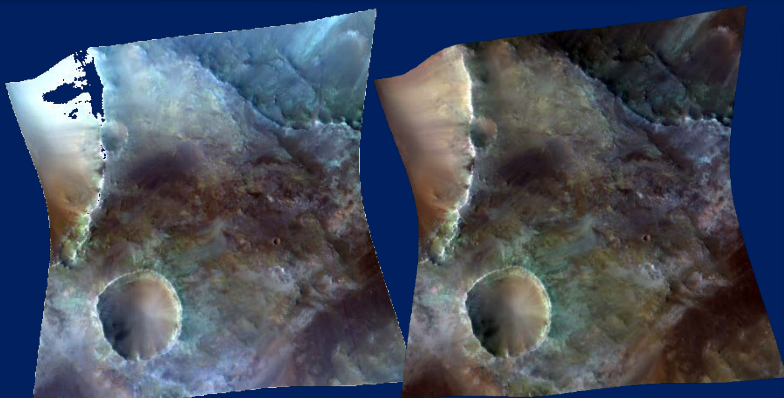
- 6 Instruments in 4 observing modes:
 - Ultra-high-resolution targeting
 - High resolution survey
 - Subsurface radar profiling
 - Daily, global atmospheric coverage
- Electra UHF Relay system
- Budget: Gravity/Radio Science and CRISM phased out in EM5?

MRO is a dual-purpose mission for the Mars Exploration Program with both Program Support & Science Objectives in a 5th Extended Mission.

Mars Reconnaissance Orbiter Highlights

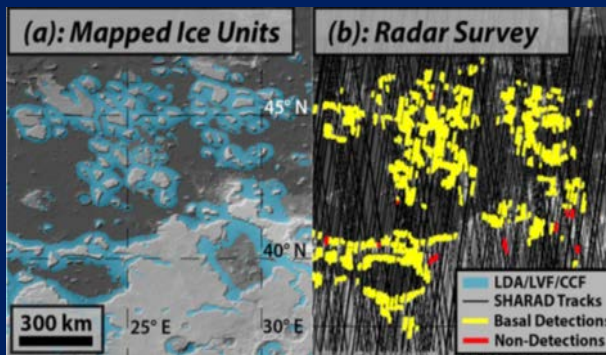
- **2019 Extended Mission 4 Science Highlights:**
 - Focused on modern change, climate, planetary evolution, habitability and potential for life
 - Detected exposed ice cliffs, further mapped shallow ice detection
 - Detected exposed locales with different stages of low/high temperature mineral alteration
 - Observed new surface changes, including after the PEDE
 - MRO data (SHARAD, CTX, HiRISE) formed the basis for mapping of subsurface ice as a resource
 - *Received an “Excellent” by 2019 PMSR on the MRO EM5 Proposal*
- **2020 Extended Mission 5 Science Highlights:**
 - Observed surface changes in Mars year following PEDE; e.g., many more RSLs
 - Started higher resolution seasonal Thermal Ice Mapping campaign to reveal shallow ice
 - Atmospheric monitoring revealed “nominal” aphelion seasonal activity following 2018 PEDE, although an interesting dust event large enough to affect the middle atmosphere did occur
 - Identified targets for HiRISE imaging of areas with interesting signatures in CRISM IR data
 - Progressing on VNIR 100 m/pixel map and on improved Map Tile 200 m/pixel products
 - Adding radar coverage of potential subsurface ice deposits
- **Continued programmatic support functions:**
 - Relay, landed mission support, environmental data
 - Completed extended imaging of Jezero Crater and nearby environs for M2020 & SRL
 - Completed coverage of ExoMars RSP (2021) landing ellipse
 - Relay primarily for MSL; occasional relay for InSight; development & test for M2020 relay
 - Dust storm watch for InSight and MAVEN missions and MSL science

Recent MRO Science Highlights



Prior Processing

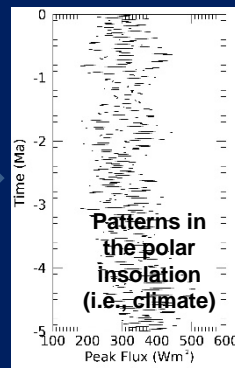
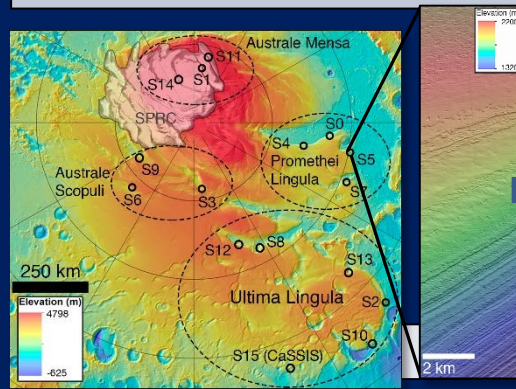
New MTRDR Processing



Icy Reservoirs => Climate Change => Ice Ages

Amazonian Ices, Volcanism & Climate

Subsurface Water Ice Mapping (SWIM) In mid-latitudes

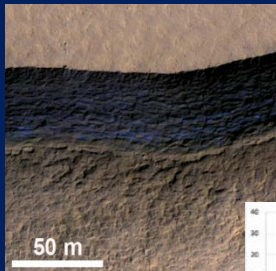


Polar Changes In Recent Geological Times

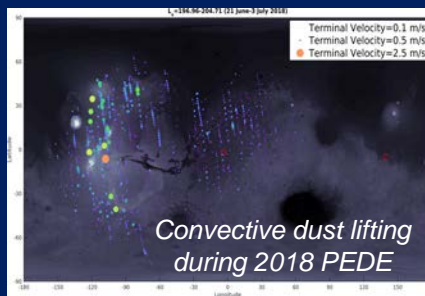
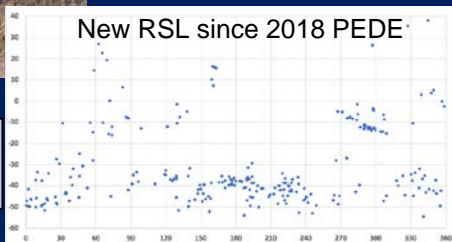
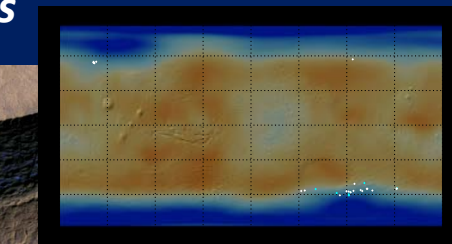
Early Mars, Transitional Environments & habitability

Surface Changes and Implications

Icy Scarps

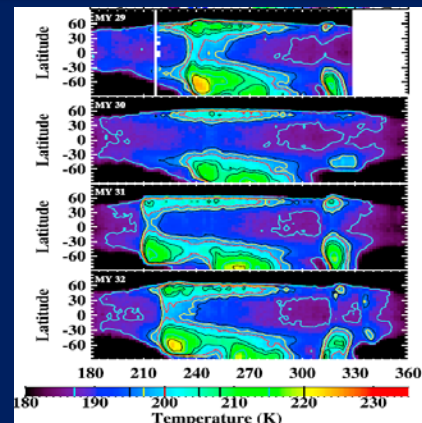


Active Processes

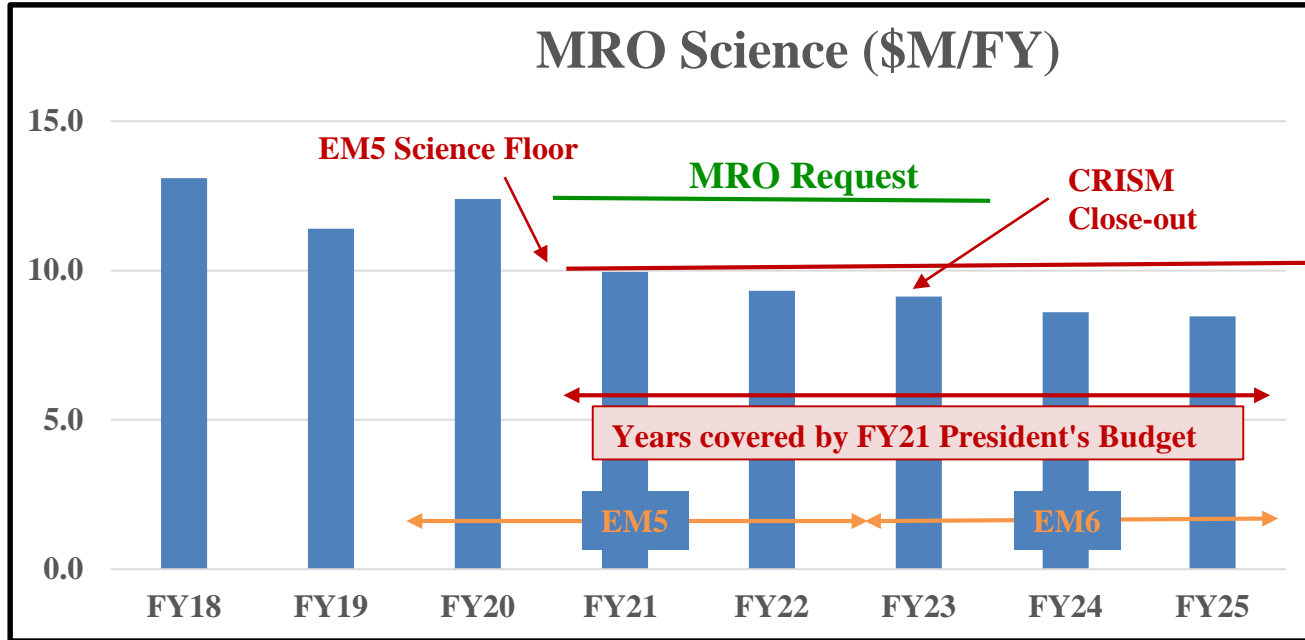


Atmospheric Processes

Regional Dust Storm development in different MYrs



MRO Science Under the FY21 President's Budget



This guideline budget (in blue), if implemented, requires MRO to take the following actions:

- **FY21: Take a \$2.5M reduction across all science investigations**
 - Close out Gravity/Radio Science in FY21
 - Reduce targeted imaging observations by ~50%; radar observations by ~30%
 - Not fund analytic work by Co-I's, posing threat to quality check of data (e.g., late discovery of processing errors)
 - Reduce or eliminate special data products; work on new products stops except for CRISM MTRDRs
 - Discontinue coordinated observations with TGO, MAVEN, InSight, MSL or don't started with M2020
 - Significant reconfiguration of MOS to respond to science team reductions (e.g., single team-led integrated target list)
- **FY22: Begin CRISM close-out**
 - Finish delivery of rectified VNIR/IR Map Tile RDR & complete VNIR 100m/pixel observational survey
- **FY23: Close CRISM out:** CRISM delivers VNIR 100 m/pixel Map Tiles; writes final report in close-out.

MRO Science Investigations under Requested Budget

- MRO EM5 covers 3 years (FY20-22): **Keys to Understanding Mars**
- 16 EM5 Investigations addressed 4 Science Goals spanning all Mars epochs

<p>Goal 1: Ancient Mars</p>	<ol style="list-style-type: none"> Determine extent & nature of young aqueous deposits in Valles Marineris; Characterize Ancient Transitional Environments; Search for Hematite/Sulfate Deposits; Complete Data Acquisition/Processing for Selected Outcrops; Rovers & MRO: Characterize Gale & Jezero, InSight & ExoMars Sites; 	<ol style="list-style-type: none"> Test Hypotheses for Active Slope Processes Co-Analysis with InSight; Test Hypotheses about Active Aeolian and Glacial/Periglacial Processes; 	<p>Goal 3 : Active Sfc.</p>
<p>Goal 2: Amazonia Mars</p>	<ol style="list-style-type: none"> Augment Near-surface Ice Inventory; Characterize Amazonian Volcanism; Investigate Polar Radar Highly Reflective Zones, Coordination with MARSIS; 	<ol style="list-style-type: none"> Define the Martian climate and Evaluate Weather in 1.5 New Mars Years; Understand Dust Storm Origin/Evolution and Polar and Surface Responses; Understand CO₂ Ice, Frost, & Snow Trends; Understand Energy and Momentum Transport; Characterize the Structure, Aerosols, and Chemistry of the Middle Atmosphere. 	<p>Goal 4: Modern Atmos.</p>
<ul style="list-style-type: none"> ➤ <i>Instruments and Spacecraft have the needed technical capabilities</i> ➤ <i>They are being used in FY20 to make progress on these investigations</i> ➤ <i>This EM5 proposal was rated excellent by the 2019 Planetary Mission Senior Review</i> 			

MRO Science Investigations under Reduced Guideline

- MRO EM5 covers 3 years (FY20-22): **Keys to Understanding Mars**
- 16 EM5 Investigations addressed 4 Science Goals spanning all Mars epochs

Goal 1: Ancient Mars	1. Determine extent & nature of young aqueous deposits in Valles Marineris;	9. Test Hypotheses for Active Slope Processes	Goal 3 : Active Sfc.
	2. Characterize Ancient Transitional Environments;	10. Co-Analysis with InSight;	
Goal 2: Amazonia Mars	3. Search for Hematite/Sulfate Deposits;	11. Test Hypotheses about Active Aeolian and Glacial/Periglacial Processes;	Goal 4: Modern Atmos.
	4. Complete Data Acquisition/Processing for Selected Outcrops;	12. Define the Martian climate and Evaluate Weather in 1.5 New Mars Years;	
	5. Rovers & MRO: Characterize Gale & Jezero, InSight & ExoMars Sites;	13. Understand Dust Storm Origin/Evolution and Polar and Surface Responses;	
	6. Augment Near-surface Ice Inventory;	14. Understand CO ₂ Ice, Frost, & Snow Trends;	
	7. Characterize Amazonian Volcanism;	15. Understand Energy and Momentum Transport;	
	8. Investigate Polar Radar Highly Reflective Zones, Coordination with MARSIS;	16. Characterize the Structure, Aerosols, and Chemistry of the Middle Atmosphere.	
<ul style="list-style-type: none"> ➤ Of the 16 original EM5 investigations: <ul style="list-style-type: none"> • 4 can be completed (green), 4 cannot be addressed (red), 8 are reduced in scope (yellow) under the guideline budget • Major factors are: Reductions in the number of targets, special products (e.g., DTMs) and the ability to coordinate with other missions 			

MRO Summary

- **MRO spacecraft is healthy – all subsystems operating as required**
 - Full capabilities of the MRO spacecraft being utilized (both relay and science payload).
- **All instruments have the *technical* capabilities needed to achieve the mission science and programmatic objectives proposed under either budget scenario; it's just substantially less under the successive reductions of the guideline budget.**
 - No technical issues with CTX, MARCI; SHARAD dealing with a data framing problem, but workable
 - CRISM restricted to VNIR-only observations (none of the 3 IR coolers can hold low temperature), but is still able to find and aid the characterization of ancient water-related environments.
 - HiRISE detector aging and blurring is mitigated by pre-warming the focal plane and other adjustments. It is still the highest resolution imager in orbit at Mars.
 - MCS azimuth actuator anomalies occasionally occur, but are not persistent. MCS is building on 14 years of globally distributed atmospheric profiles of temperature, dust and ice. MARCI's 14 years of daily global maps extends the MGS MOC WA record to a decade of Mars years.
- **The MRO proposal for FY20-22 (EM5) was judged "excellent" by the Planetary Mission Senior Review**
- **The mission has a seasoned project team, productive science teams, and an experienced industrial partner, all dedicated and ready to go forward.**
- **MRO will do that. The budget requested by the MRO Project will enable the teams to provide the data and the data products that the planetary science community can use to address the compelling questions about Mars and Solar System science.**