National Aeronautics and Space Administration

EXPLORE

MARS EXPLORATION PROGRAM

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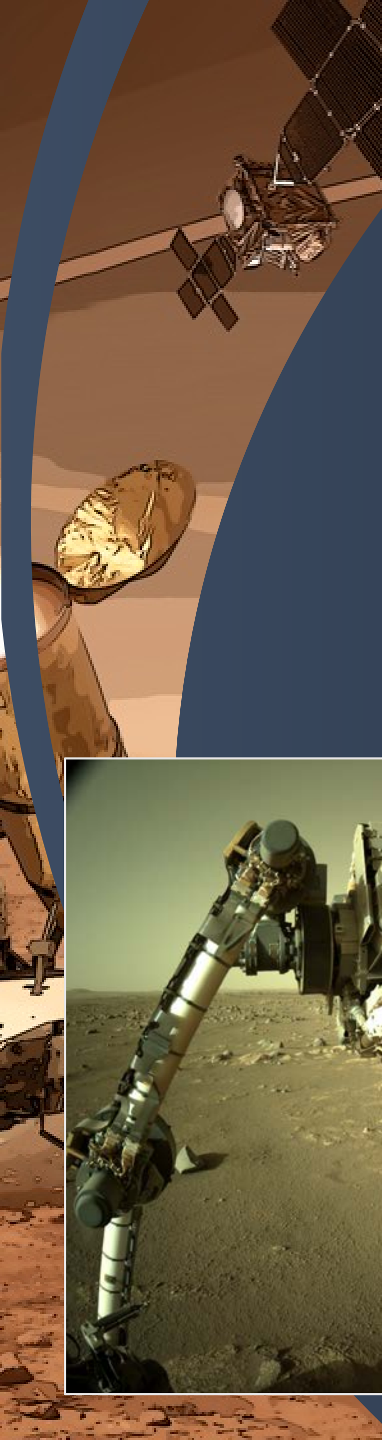
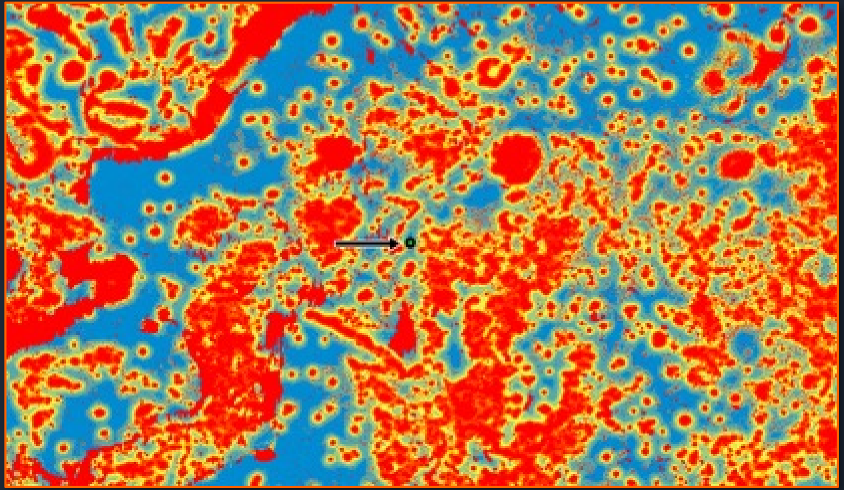
NASA HQ

Presentation to the National Academy of Sciences
Committee on Planetary Protection

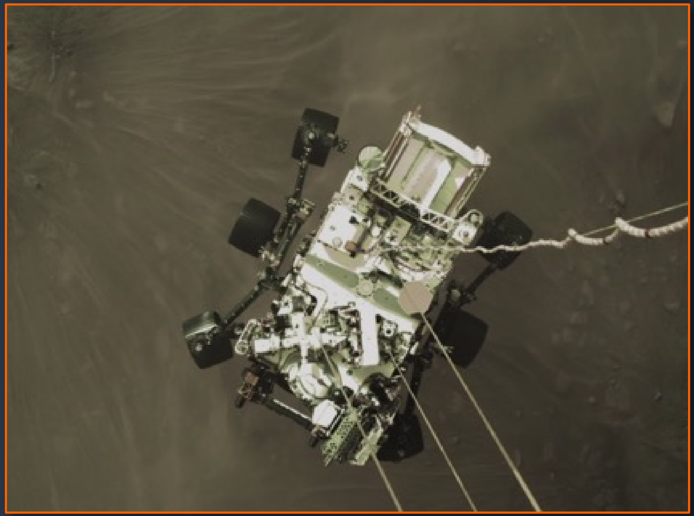
April 5, 2021



Mars Exploration Status Highlights



- Mars 2020 / Perseverance rover successfully conducted Entry, Decent, and Landing (EDL) on February 18, 2021
  - ➢ Perseverance landed in a safe location in Jezero Crater, just 1.7km southwest of the planned target
  - ➢ Initial surface operations are proceeding nominally
  - ➢ Early images have been spectacular

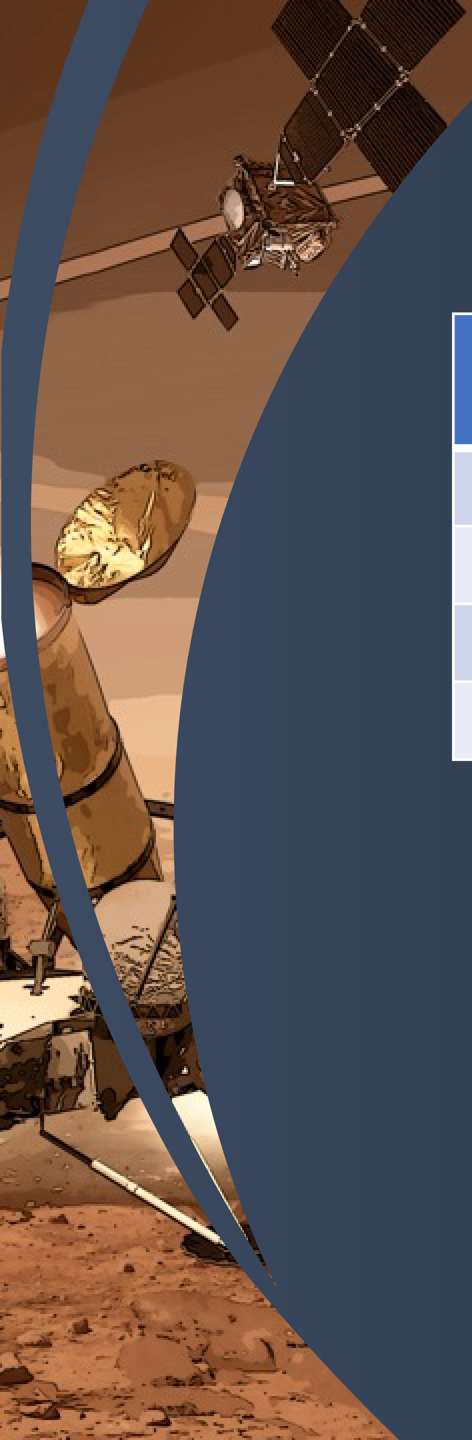


- Ingenuity Helicopter first flight no earlier than April 11

Other Updates

- InSight made a final attempt on January 9 to penetrate further with the Heat Flow and Physical Properties Package (HP^3) mole. Efforts to continue have ended because the team was unable to gain the friction needed to dig. InSight will spend its extended mission listening for more marsquakes. To help obtain the clearest signal, the team plans to bury the cable running between the lander and seismometer. More science to come.
- 2019 and 2020 Senior Review letters have been sent to MSL, MRO, MAVEN, Odyssey, Mars Express, and InSight
- Ongoing NASA missions are healthy, productive, and funded through FY21
  - Odyssey: Providing most of the relay support for InSight
  - MRO: Supported Mars 2020 EDL
  - Curiosity: Achieved 3,000 sols on Mars
  - MAVEN: Exciting science ahead during solar cycle 25; supported Mars 2020 EDL
  - ExoMars/TGO (ESA): Provides ~50% of relay data for Curiosity/InSight/Mars 2020; supported Mars 2020 EDL

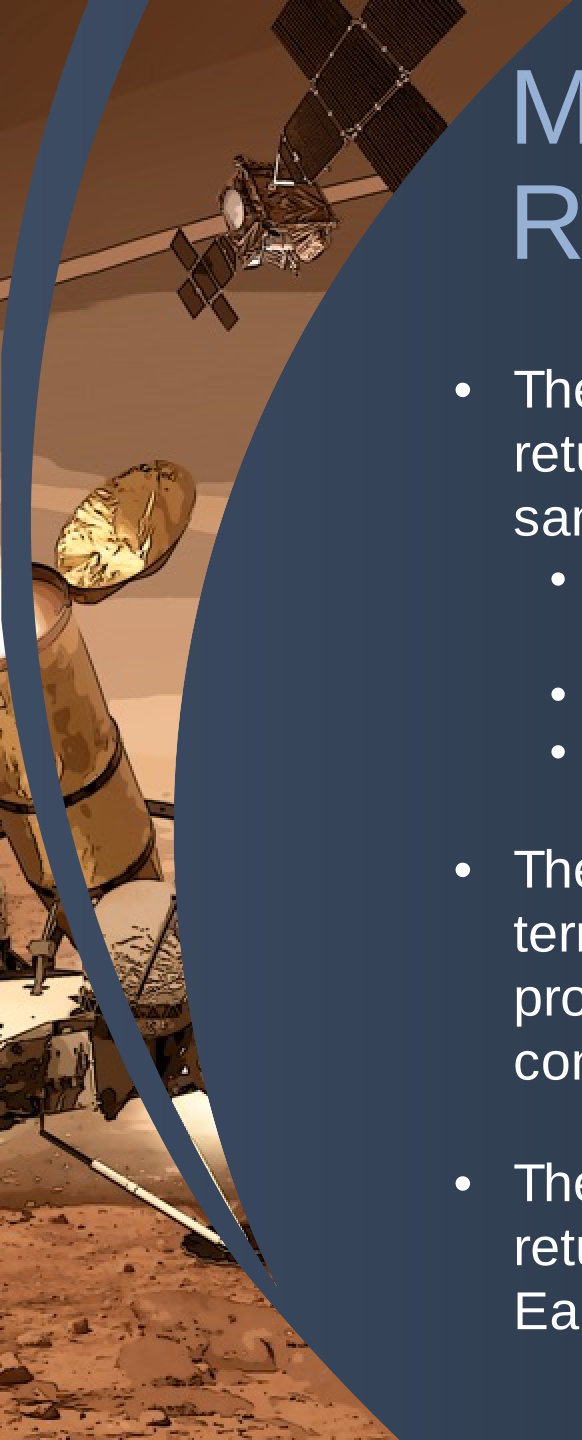
Mars 2020 Planetary Protection Sampling Totals and Cleanliness Results



	Quantity of Samples Collected for Mars 2020
Swabs	13,042
Wipes	3,521
Air Samples	318
Genetic Samples	1122

Spacecraft Encapsulation into the Fairing

	Requirement	Mars 2020	Mars 2020 Margin
Landed Total (Spores)	**3.00E+05**	**3.86E+04**	**87%**
Landed Density (Spores/m^2)	**300**	**23**	**92.3%**
Accountable Surface Area	**-**	**4512**	**-**
Total[spore]	**5.00E+05**	**3.73E+05**	**25.4%**



Mars 2020 Level 1 Cleanliness Requirements on Returned Samples

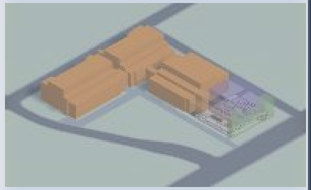
- The Mars 2020 landed system shall be capable of encapsulating samples for return such that the organic contamination levels in each sample in the returned sample set are less than:
    - Any Tier 1 compound (organic compounds deemed as essential analytes for mission success): 1 ppb
    - Any Tier 2 compound (organic compounds not categorized as Tier 1): 10 ppb
    - Total Organic Carbon: 10 ppb Baseline, 40 ppb Threshold

- The project shall identify, quantify, document, and archive potential pre-launch terrestrial contamination sources, both organic compounds and organisms, and provide mechanisms to support characterization of round-trip terrestrial contamination.

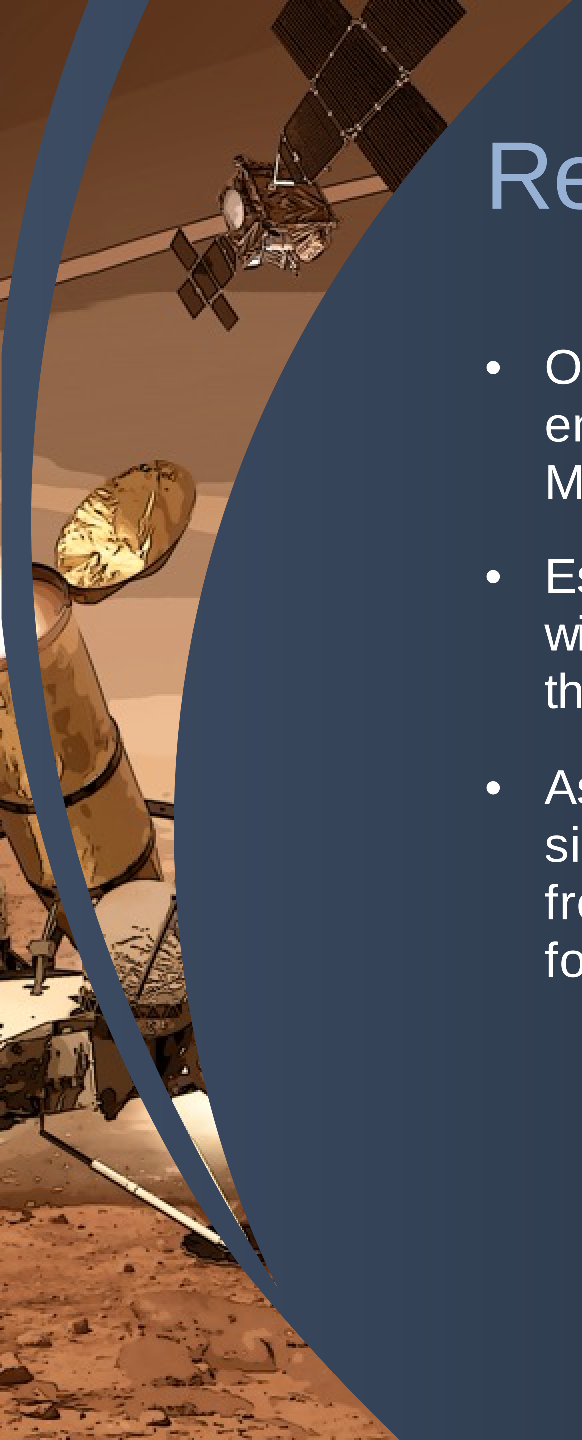
- The Mars 2020 landed system shall be capable of encapsulating samples for return such that each sample in the returned sample set has less than 1 viable Earth-sourced organism.

Mars Sample Return Campaign

Mars Sample Return Program

1	2	3	4
			
Sample Caching Rover (Mars 2020) Operations	**Sample Retrieval Lander**	**Earth Return Orbiter**	**Mars Returned Sample Handling**
• *Sample acquisition/caching* • *Sample (subset) delivery*	• *Fetch Rover* • *Orbiting Sample (OS) container* • *Mars Ascent Vehicle*	• *Capture/Containment System* • *Earth Return Vehicle*	• *Sample Receiving Facility* • *Curation* • *Sample science investigations*
"Initiates the Campaign"	*"New Element"*	*"New Element"*	*"New Element"*
			Ground Element *to be reviewed at a future date*

- 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 Sample Receiving Facility (SRF)
- The MEP Program manages Mars 2020 Phase E operations & will be the home of the future SRF Project



Relationship of the MEP and MSR Programs

- Over multiple decades, the success of the Mars Exploration Program (MEP) has enabled ground-breaking science and built the engineering and science foundation for Mars Sample Return (MSR).
- Establishing the MSR program as a separate implementation organization conforms with the 2019 NASA policy that Agency flagship missions are directly accountable to the responsible Mission Directorate Associate Administrator (AA).
- As the campaign to return samples from Mars is a highly challenging effort with a significant international partnership with ESA, the creation of an MSR program distinct from MEP provides for a focused approach to mission implementation and objectives for both programs.
  - ➢ MSR is tasked with retrieving and returning collected samples safely to Earth.
  - ➢ MEP continues to manage and organize the scientific exploration of Mars, including:
    - Operation of the Perseverance Rover (the “first leg” of the MSR campaign),
    - The future project to establish the sample receiving/curation facility, and
    - Curation of the samples returned to Earth by MSR.

2019 NASA *(internal)* Summer Study

Strategy for Preparing for Human Exploration Identified **Ice** as a Focusing Requirement

NASA considered *"What grand science questions could be addressed with the power of humans and machines at Mars?"* - something worthy of the endeavor?

Advancing NASA's *"Follow the Water"* strategy was a natural extension

- ***Search for Life*** identified as key theme
  - Including the Evolution of Mars Climate
  - Evolved to exploring Martian ice reserves
- Also informs future ISRU planning

With **Ice** as a **focusing requirement** for the 1st exploration surface mission planning, characterization became an early need

- **Return of Ice Core samples** has been given to the study teams as a key requirement for the first crewed surface mission
- **Mars Ice Mapper (MIM)** mission was identified as an **essential precursor**

Select Findings & Recommendations

From NASA's 2019 Planetary Protection Independent Review Board

- **NASA's current policies for robotic Mars missions appear to be unachievable for human missions**
    - Regarding the return of humans and equipment from Mars, NASA should invest in developing more informed, backward contamination planetary protection criteria
        - Assess the acceptability of the multi-month return trajectory as a planetary protection quarantine and evaluation period
- **NASA's planetary protection policies and implementation procedures should be reassessed and updated** from Viking-era technologies
    - Planetary protection policy should move beyond exclusive adherence to spore counts and encourage the use of proven modern techniques
    - Allow novel approaches, such as crediting for time spent in the harsh space environment or on harsh planetary surfaces
- **Further study and experiments would be needed to address whether or not terrestrial biota have been able to survive on Mars, replicate, or be transported** beyond the constrained locations where these spacecraft landed or crashed on the surface of Mars

The full report can be found at:
https://www.nasa.gov/sites/default/files/atoms/files/planetary_protection_board_report_20191018.pdf

Potentially Needed Recon Thrusts

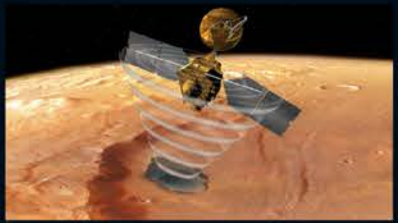
From the International Mars Exploration Working Group

Confirm the mechanical properties of the regolith/dust

- abrasiveness, oxidizing potential, particle size etc. -

- how it will interact with surface systems (suits, rovers, habitats)
- potential human health hazards (toxicity, respiratory, potential extant life)

WATER RECONNAISSANCE



 Identify Near-surface Ice

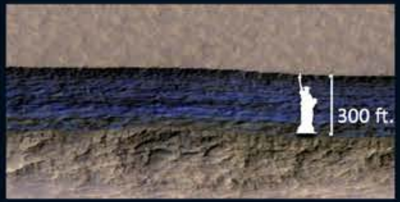
 Assess Potential of Hydrated Minerals

 Groundtruthing

SPECIAL REGIONS DRILL

 Search for Life

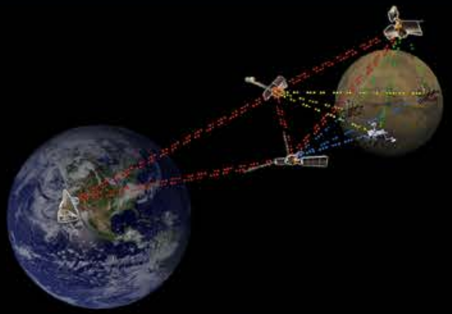
 Characterize the Water
- for ISRU
- for human use



- Ease of Access -

Next-gen High-Res Imaging
(Visual, IR, Radar)

- Target 80% Planetary Coverage
- Compactness of Surface
- Support Change Detection
- Rock Count/Terrain Roughness
- Slope



Next-gen Communications

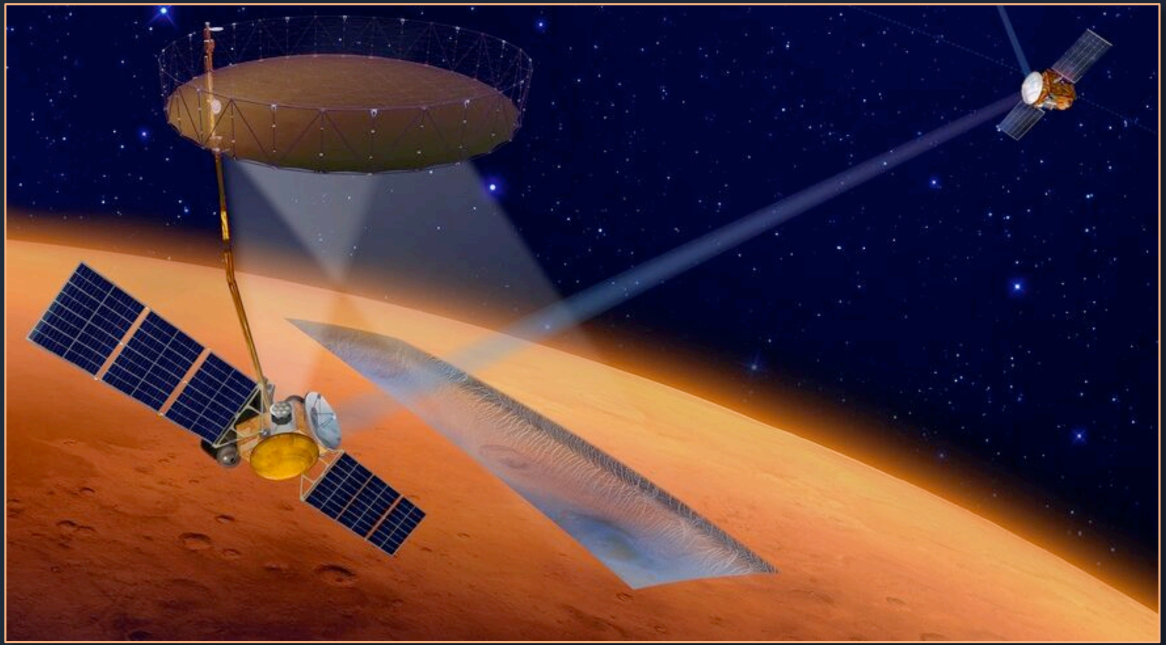
- Increased Data Rate
- Support Small Missions
- Support Change Detection
- Greater Access to Surface Assets (Data & Communications)

Next-gen Weather
(Orbital & Surface)

- Density Profiles (EDL)
- Winds Aloft
- Potential Microbial Transport

Mars Ice Mapper

- Near-surface ice (top 10m) is a critical element of the human exploration of Mars
  - Rich in science potential
  - In situ resource for human exploration
  - Potential driver for human landing site selection
- Planning for human exploration requires knowledge about the location, character, and extent of accessible ice beforehand

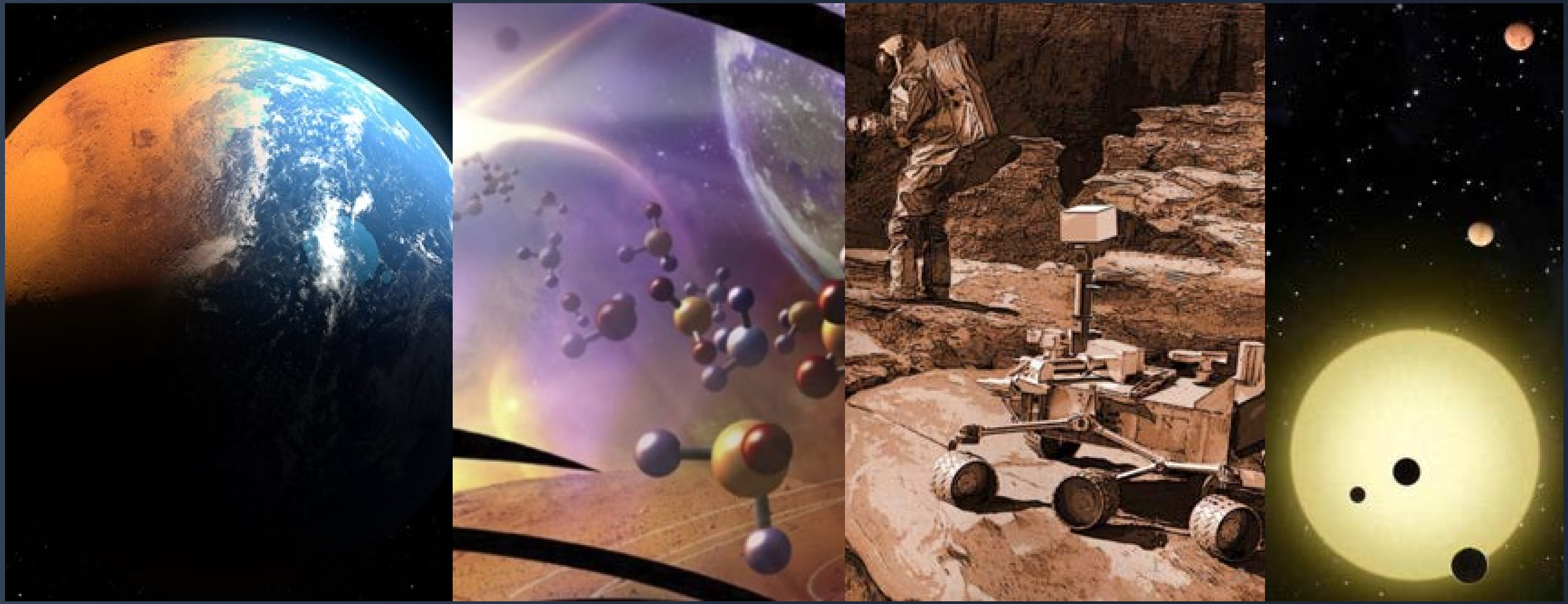


- Emerging multilateral partnership is beginning to plan for the mission (launch as early as 2026), and studying next-gen communications needs that could provide robustness for Mars Sample Return and critical infrastructure for all future Mars missions
  - NASA, ASI, CSA, JAXA recently signed Statement of Intent

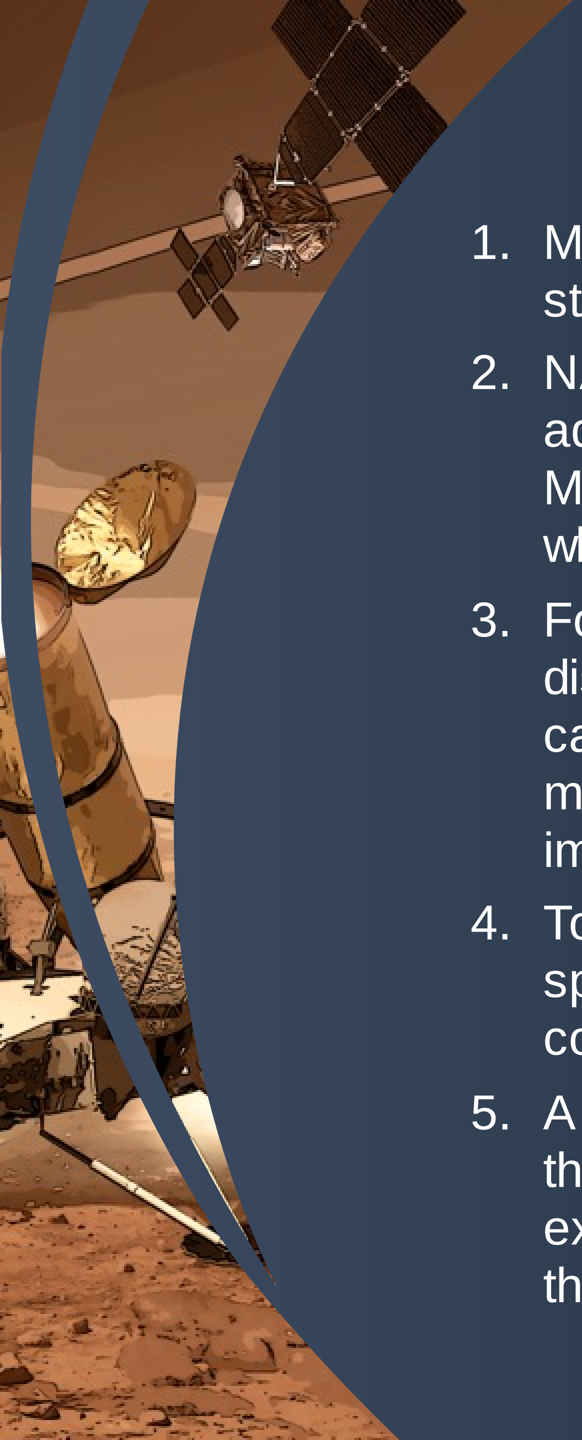
Science Highlights

- Mars Architecture Strategy Working Group (MASWG) report (Nov 2020) proposed program for the scientific exploration of Mars that could be conducted in parallel with, and/or subsequent to, Mars Sample Return.
  https://mepag.jpl.nasa.gov/reports/MASWG%20NASA%20Final%20Report%202020.pdf
- Caching strategy workshop, January 2021
  - Workshop attendance: 255 participants
  - Caching Strategy Steering Committee integrated workshop inputs
  - Report being finalized and agreed-to guidelines will be posted
- NASA/ESA MSR Science Planning Group-2 been meeting regularly. Report in Spring 2021
- Mars missions
  - UAE Hope MOI Feb 9
  - Tianwen-1 MOI Feb 10
  - Perseverance EDL Feb 18
- Deputy Program Scientists
  - Becky McCauley Rench – Curiosity
  - Lindsay Hays – MSR

Mars, The Nearest Habitable World – Defining An Exploration Program



- Reading the Martian record:
  - Potential for life
  - Mars’ habitability and changing climate
  - The first billion years of planetary evolution
  - Using Mars to understand exoplanet evolution
  - Mars as a destination for human exploration



MASWG High-Level Recommendations

1. Mars Sample Return should proceed as currently planned, as it will produce a major step forward in our understanding of Mars, as envisioned by *Visions & Voyages*.
2. NASA should support missions that address fundamental science objectives at Mars in addition to MSR, using the full range of technically viable mission classes. During the MSR era, the emphasis should be on achieving other high-priority science objectives, while developing the needed technologies for going forward.
3. For this next phase of Mars exploration, NASA should retain a programmatically distinct Mars Exploration Program. NASA should institute mission or budget lines that can allow Mars-specific missions, from small spacecraft through New-Frontiers-class missions, to be strategically integrated into a program, with missions chosen and implemented as appropriate for the science to be achieved.
4. To the extent possible, missions and instruments should be openly competed; where specific investigations are desired, objectives can be defined and then opened to competition.
5. A robust Mars exploration program will require affordable access to multiple places on the Martian surface and affordable long-lived orbiters. NASA should invest early to expedite the rapidly evolving small spacecraft technologies and procedures to achieve these capabilities at lower costs than past missions.

Comments on the Planetary Protection Independent Review Board (PPIRB) Specific Findings and Recommendations

Comments on PPIRB Specific Recommendations and Findings

Major Recommendation: PP requirements on missions should be written to define PP intent, rather than detailed implementation methods, thereby allowing projects to select and/or develop implementations most suitable to meet their PP requirements from a systems standpoint.

Comment: Yes, for example: Mars 2020 and the requirements for potential sample return

Comments (continued)

<u>Supporting Finding</u>: For many of NASA's scientifically driven planetary exploration missions to astrobiologically relevant targets, scientific cleanliness requirements often exceed PP bioburden requirements.

<u>Comment</u>: For example: Baseline - 1ppb for specific organic compounds, 10ppb for total organic carbon

Comments (continued)

<u>Supporting Recommendation</u>: For both forward and backward contamination requirements, NASA should continue to allow novel approaches, such as crediting for time spent in the harsh space environment or on harsh planetary surfaces (e.g., UV, radiation, temperature extremes, lack of liquid water). To enable this, NASA should support quantitative laboratory studies of such approaches to demonstrate quantitative PP credits.

<u>Comment</u>: Induced Special Regions report

Comments (continued)

<u>Major Recommendation</u>: NASA should reconsider how much of the Martian surface and subsurface could be Category II versus IV by revisiting assumptions and performing new analysis of transport, survival and amplification in order to reassess the risk of survival and propagation of terrestrial biota on Mars.

<u>Comment</u>: The Induced Special Region report found that in general the surface of Mars is inimical to terrestrial life, and more research on transport processes is suggested.

Comments (continued)

<u>Major Recommendation</u>: NASA should consider establishing (i) high priority astrobiology zones, i.e., regions considered to be of high scientific priority for identifying extinct or extant life, and (ii) human exploration zones, i.e., regions where the larger amounts of biological contamination inevitably associated with human exploration missions, as compared to robotic scientific missions, will be acceptable.

<u>Comment</u>: The size of the buffer zone needs to be determined

Comments (continued)

<u>Major Recommendation</u>: NASA's MSR PP approach should take into account the findings of the recent National Academies' Consensus Study Report on sample return from the Martian moons. In particular, the risk of adverse effects Martian material poses to the terrestrial biosphere should be re-evaluated in light of the ongoing, established, natural transport of Martian material to Earth.

<u>Comment</u>: Martian material selected and cached on Mars to be returned to Earth is not the same as martian material blasted onto a martian moon and cached, or blasted back to Earth

Comments (continued)

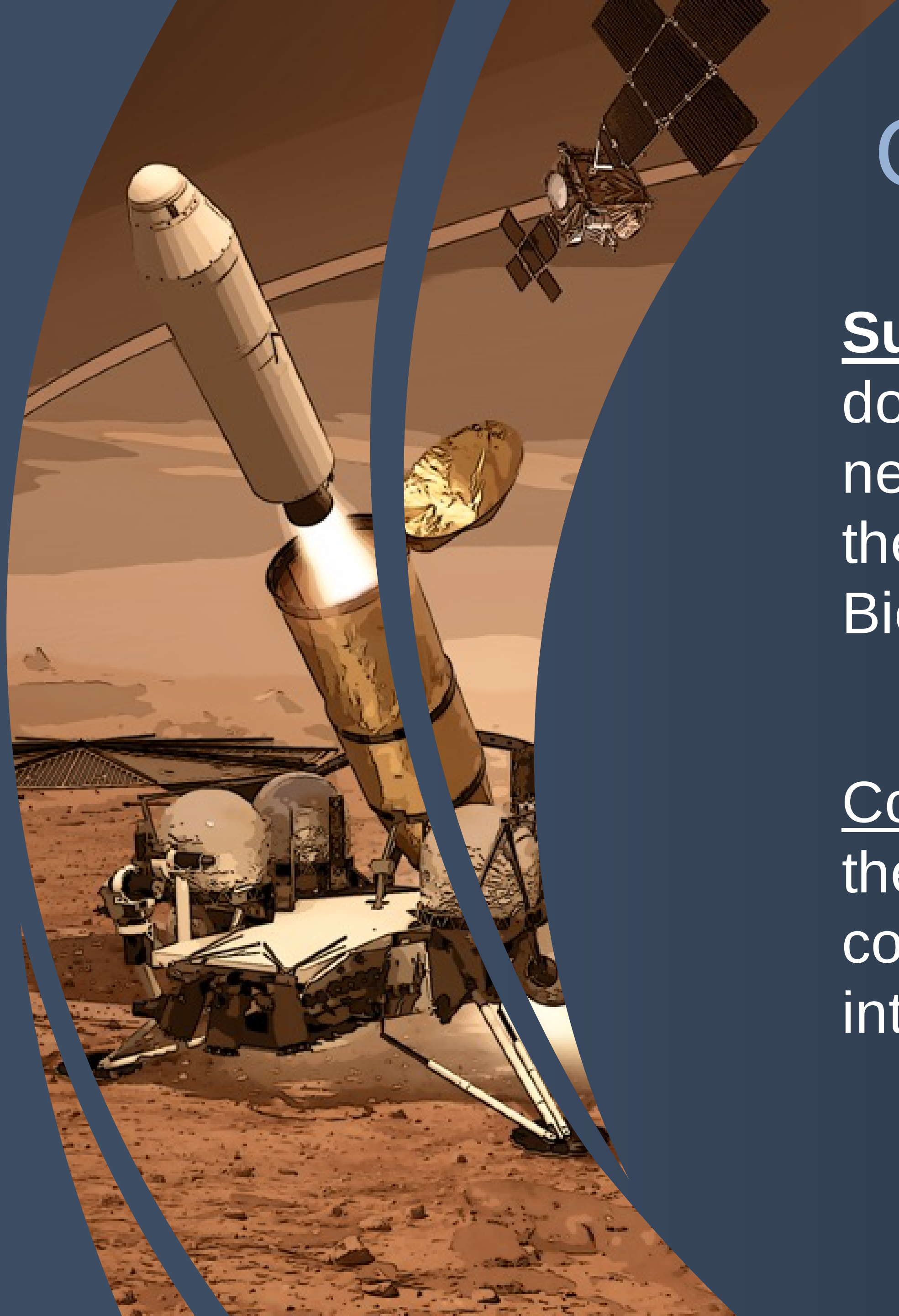
<u>Major Recommendation</u>: Planning for a Mars Sample Receiving Facility (MSRF) should be accelerated, or at least maintained on schedule, and should also be kept as pragmatic and streamlined as possible so that it does not unduly drive the schedule or cost of MSR.

<u>Comment</u>: That has been the intention of the MSR Science Planning Group and we hope to expand on that work in the coming year

Comments (continued)

<u>Major Recommendation</u>: NASA should begin work with other government agencies to develop a MSR PP public outreach, communications, and engagement plan. Government agencies such as the National Institutes of Health and the Food and Drug Administration have significant experience in crafting public communications policies that could be beneficial to NASA in educating the public about the realities of MSR missions.

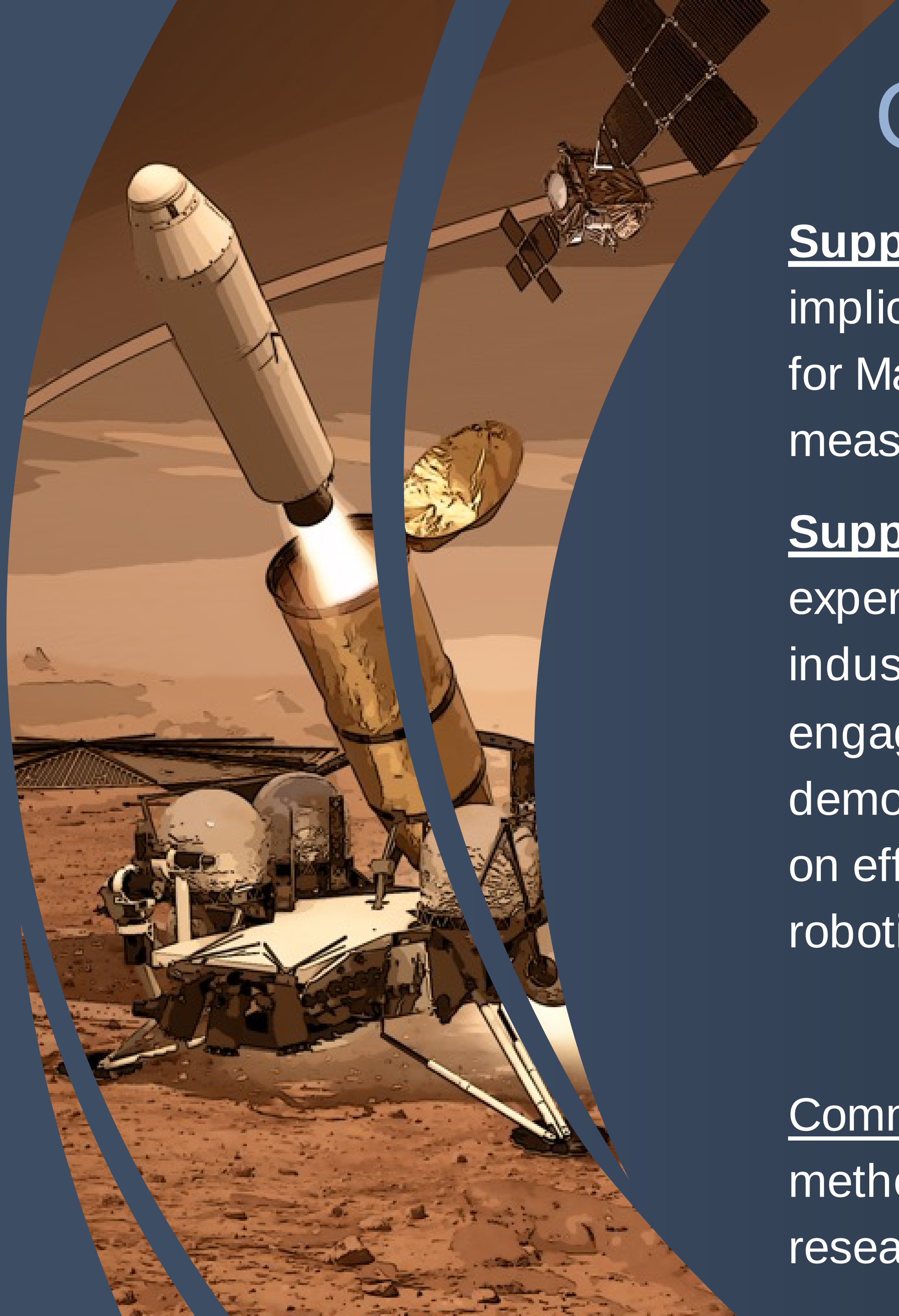
<u>Comment</u>: Good idea



Comments (continued)

<u>Supporting Finding:</u> Significant work is being done to study the MSRF and whether an entirely new facility should be built, and where, or whether the MSRF should be an add-on to an existing Biosafety Level 4 (BSL-4) facility.

<u>Comment</u>: Some consideration has been given in the MSPG #2 workshop – the challenge is potential contamination from existing structures and international access (”owner” of the facility)



Comments (continued)

<u>Supporting Recommendation</u>: NASA should carefully trade the implications of the degree and types of PP sterilization techniques for Mars samples with the implications for various types of science measurements.

<u>Supporting Recommendation</u>: NASA should continue to engage experts from the medical, pharmaceutical, and personal care industries to advise on effective sterilization protocols. Such engagement provides meaningful insights from adjacent fields, demonstrates NASA's due diligence to the public, and offers lessons on effective communication to non-experts regarding safety for both robotic sample return and for future human missions to Mars.

<u>Comment</u>: Heat and gamma-radiation seem to be the leading methods, potentially least damaging to the specific science, but more research is needed.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