NASA Perspectives on future exploration science at Mars

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Briefing to: **Virtual MEPAG**

Jim Watzin

NASA's Senior Advisor for Agency Architectures and Mission Alignment

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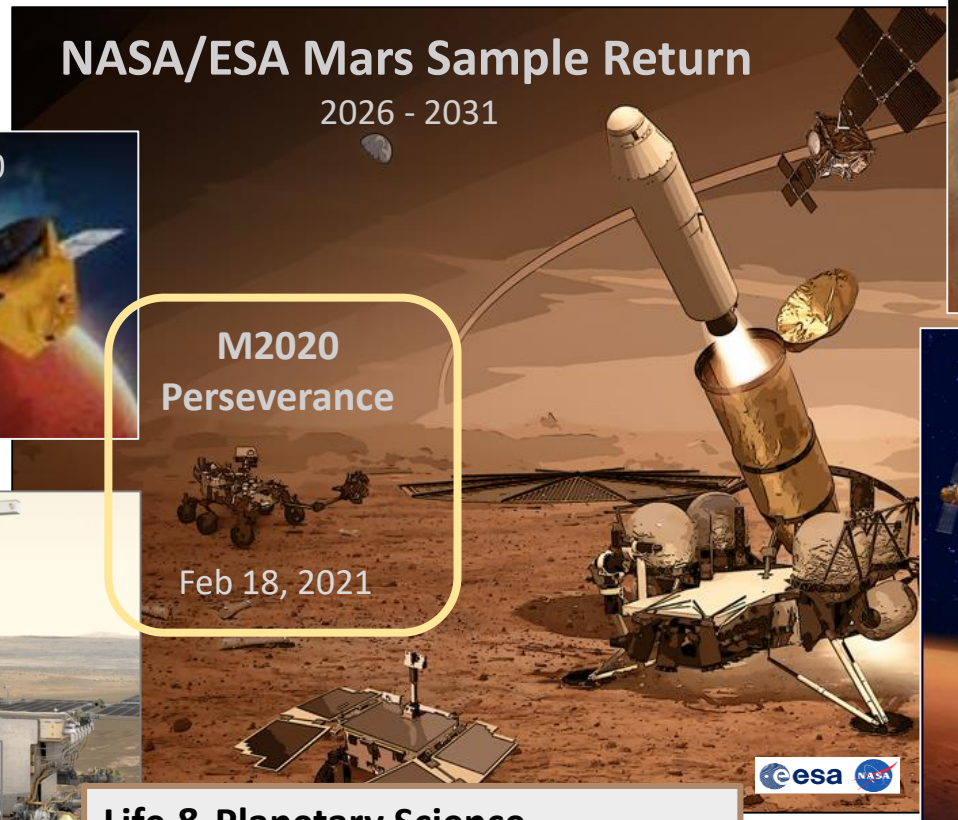
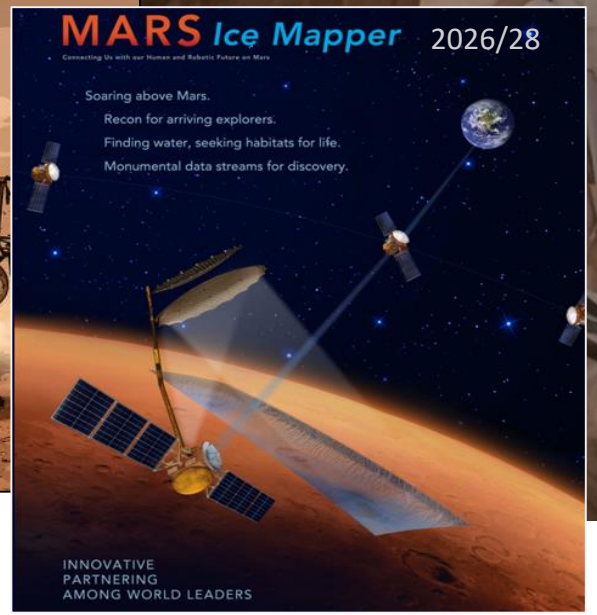
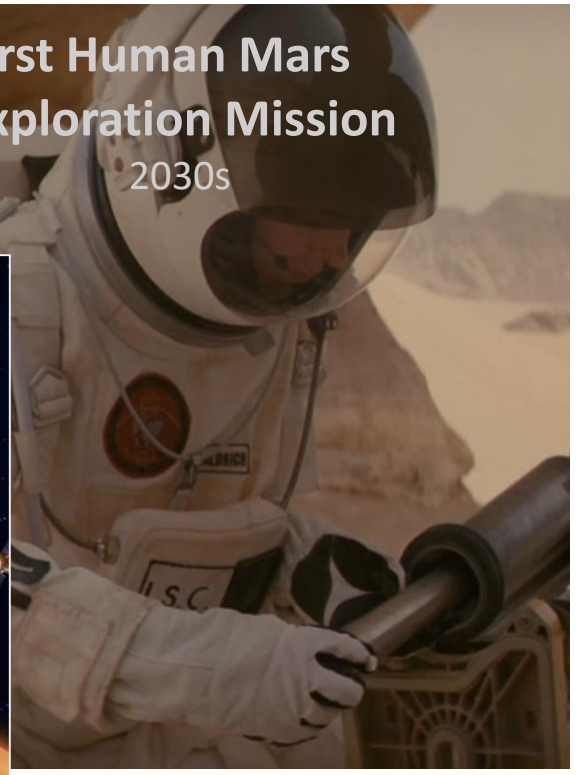
2020s - *a Decade Rich in US Scientific Endeavors at Mars*

Enabling Even Bolder Ventures in the Future







Life & Planetary Science

- In-situ analysis
- Return first samples from Mars
- Humanity's first roundtrip mission to another planet
- Climate & weather studies

"Exploration Precursor"

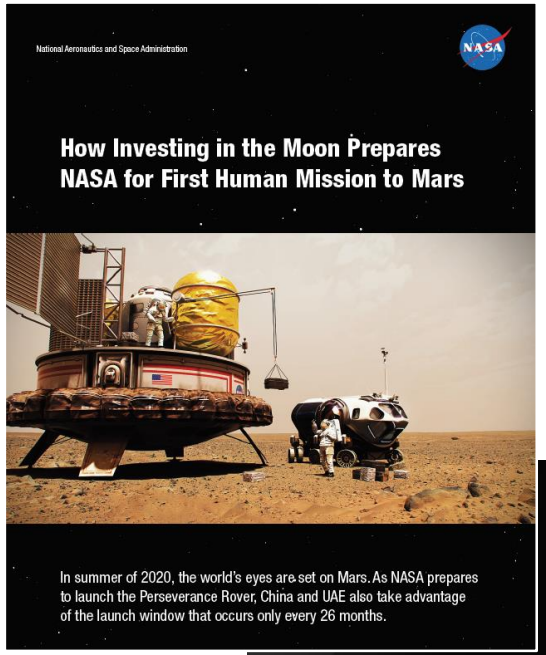
- Produce Maps of Accessible subsurface Ice

Life & Climate Science, Planning for ISRU

- Return Ice Cores

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 machine 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**
- To define a starting point, **NASA Chief Scientist leading** a short scoping study: "*What constitutes a scientifically rich set of ice cores?* "

By focusing on a high priority core science objective, we position the campaign to return Nobel-class science commensurate with the significant expenditure, effort and risk required to make it happen

Mars Ice Mapper (MIM) Fundamentals

Ground Rules

- **M2M/H2M Precursor Mission:** Directed SMD mission in direct support of Agency-level Moon-to-Mars strategy
- **Requirement:** Map and characterize accessible (top 5-10m) subsurface ice and its overburden, in mid-low latitudes, to support planning for first human surface mission in 2030s
- **Secondary Goal:** Extend survey planet-wide to maximize science potential (time & data allowing)
- **Implementation Approach:** Like all exploration endeavors, will be a highly partnered collaboration with international, and potentially commercial, partnerships. Opportunity for experimenting with commercial comm at Mars.
  - CSA contributed radar to be the **anchor** payload – a capable and versatile instrument
  - NASA to serve as mission system architect & coordinator, measurement team member, LV provider, comm provider
- **Schedule:** Prime mission complete by 2030 to inform exploration planning

Mission Formulation Status

- International partnerships maturing; SOI in signature cycle, MOU by spring/summer 2021
  - CSA – radar provider and measurement team lead
  - JAXA – S/C bus, integration, and mission operations
  - ASI – S/C communication subsystem

Mars Ice Mapper Science Synergy

Though an Agency-directed SMD mission in support of NASA's overall M2M strategy and partnerships, MIM offers significant science synergies and opportunities

Measurement goals and science potential well aligned with past and present studies

- Visions & Voyages Vision for Planetary Science in the Decade 2013-2022
- MEPAG goals/objectives/investigations NEX-SAG Report 2016, White Paper submit to NAS 2020
- CSA (w/NASA) SDT - Mars SAR mission 2017-2018
- ICE-SAG 2019
- Mars Architecture Strategy Working Group Recommendations 2020

Pre-formulation team completing white paper detailing measurement approach

- Peer review in-work; release planned March 2021

Once mission team partnerships are secured (MOU), the intent is to engage broader science community in exploring how to maximize the potential of the mission (within the boundary conditions of budget, partner commitments, timeframe, etc)

- Begin formation of the *"mission measurement team"*

Preparing the Way for Future Exploration

*Science missions **inform**,*
*Precursor activities **prepare** …*

Future planned missions to Mars, such as the NASA collaboration with the Canadian Space Agency called Mars Ice Mapper, will give us more information about the planet and its resources in advance of human missions.

"We've been studying Mars for more than 50 years and maintained a robotic presence there since 1997. With the Perseverance rover, Ice Mapper and the Mars Sample Return missions all on the horizon, we're getting closer to answering questions like whether there was - or is - microbial life on the Red Planet. Sending robots on early missions to study the Martian environment, collect data and test technologies are critical to helping us determine where to best send astronauts to Mars in the future."

Thomas Zurbuchen, NASA Science Mission Directorate Associate Administrator

Scoping Study "ToR" for Characterizing Martian Ice Cores

Task:

The immediate task before us now is to translate the objective of obtaining meaningful Mars ice cores into engineering requirements to provide to the mission designers. ***What constitutes a scientifically rich set of ice cores?***

Recognizing the scope of the mission and the extensive experience of the science community in obtaining and analyzing Earth ice cores:

- Define the key necessary characteristics of Martian ice cores crucial to support NASA's research objectives. Relate those characteristics to anticipated research.
- Describe the minimum attributes required to accomplish mission goals. Provide a range of attributes and requirements from which NASA can make an informed decision on mission scope, considering practical limitations of space flight missions such as technology and time. Provide scientific perspectives and information on activities relating to sample allocation; sample acquisition; ice core processing techniques; infrastructure; and archiving practices.
- Provide examples of how similar ice cores are obtained and preserved by research teams on Earth, with an emphasis on how sites of interest are identified; how cores are taken; how they are preserved for transport; and what, if any, initial assessments are made in the field.

Study Team: Characterizing Martian Ice Cores

Co-Chairs	Institution	Expertise
Mary Albert	Dartmouth	Ice Core Laboratory and storage, Climate adaptation; Arctic engineering; ice cores and climate; glaciology, US ice drilling project
Michelle Koutnik	University of Washington	https://www.ess.washington.edu/people/profile.php?pid=koutnik
Members		
Aaron Johnson	Carnegie Mellon University	Ice-drilling robotics, robomechanics; legged and wheeled mobile robotics, mechanism design, feedback control, computer vision, motion planning, and applications of robotics research to search & rescue, planetary exploration, manufacturing, science, and personal assistance.
TJ Fudge	University of Washington	Climate, glaciers and past climate focusing on Antarctic ice cores, Ice core depth-age scales, glacier sliding, paleo ice flow conditions, glacier mass balance, and snow and firn densification, extreme environments
Ted Schuur	Northern Arizona University	permafrost, SEARCH, Arctic, https://www2.nau.edu/schuurlab-p/research.html
Laurel Childress	Texas A& M	International Ocean Discovery Program, Biogeochemical cycles, with an emphasis on transport, transformation, and burial of organic carbon; active margin sediment export and subduction; tectonic and glacial influences on carbon exhumation; geospatial biochemical patterns; science outreach.
Seth Campbell	University of Maine	Director of Academics & Research for the Juneau Icefield Research Program, Cryosphere basic to applied research with an expertise in applying ground-penetrating radar to near-surface geological and glaciological studies, over 50 field expeditions
Kris Zacny	Honeybee Robotics	https://honeybeerobotics.com/about-us/team/
Michael Sori	Purdue	https://www.eaps.purdue.edu/people/profile/msori.html
Mike Mellon	Cornell	https://research.astro.cornell.edu/michael-mellon
Jack Holt	University of Arizona	https://www.lpl.arizona.edu/faculty/jack-holt
Heidi Smith	Montana State University	http://www.biofilm.montana.edu/people/faculty/smith-heidi.html
John Priscu	Montana State University	https://landresources.montana.edu/directory/faculty/1524489/john-priscu

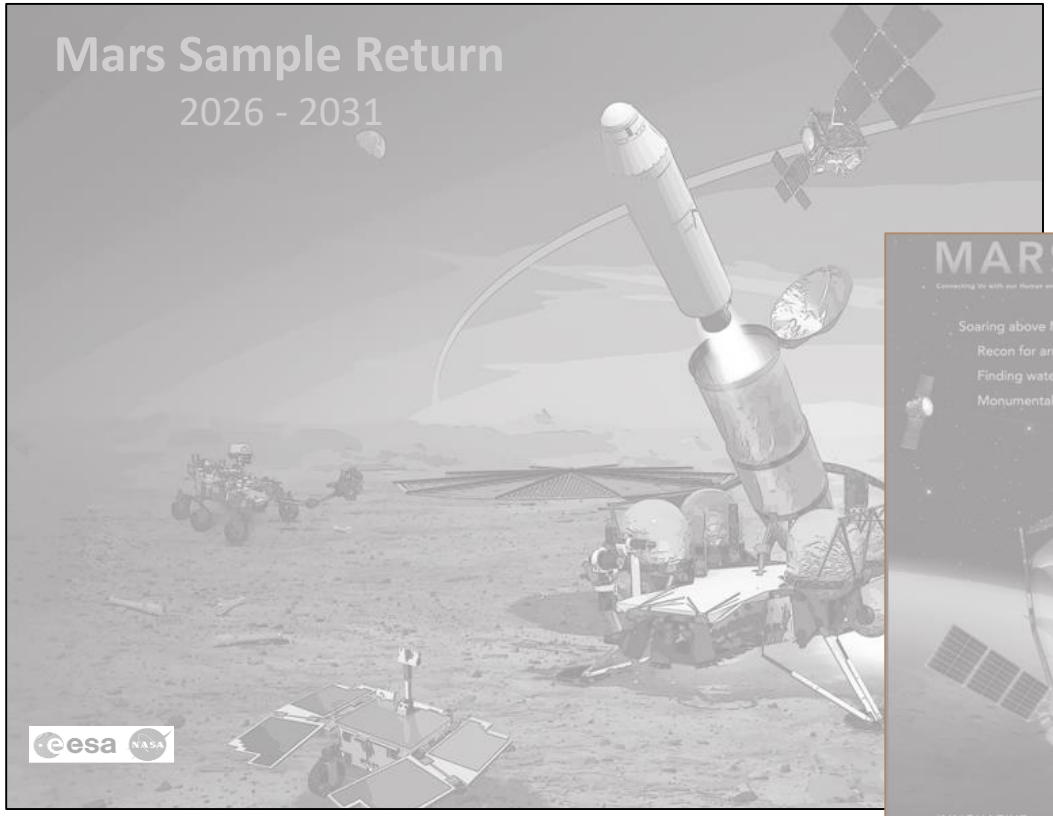
Ex-Officio

Catherine Walker	JPL/NASA OCI/Wood's Hole
Mitch Schulte	NASA Mars Exploration Program / Planetary Science Division

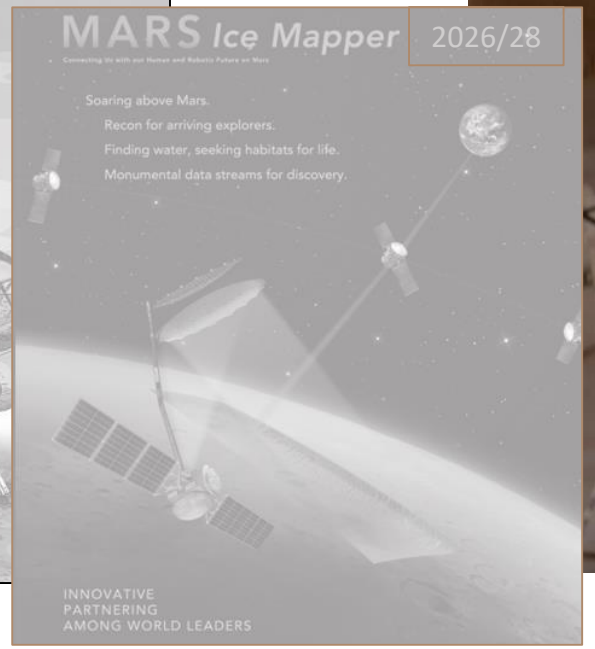
Community *subject-matter-experts* helping inform NASA studies

NASA Robotic and Precursor Missions

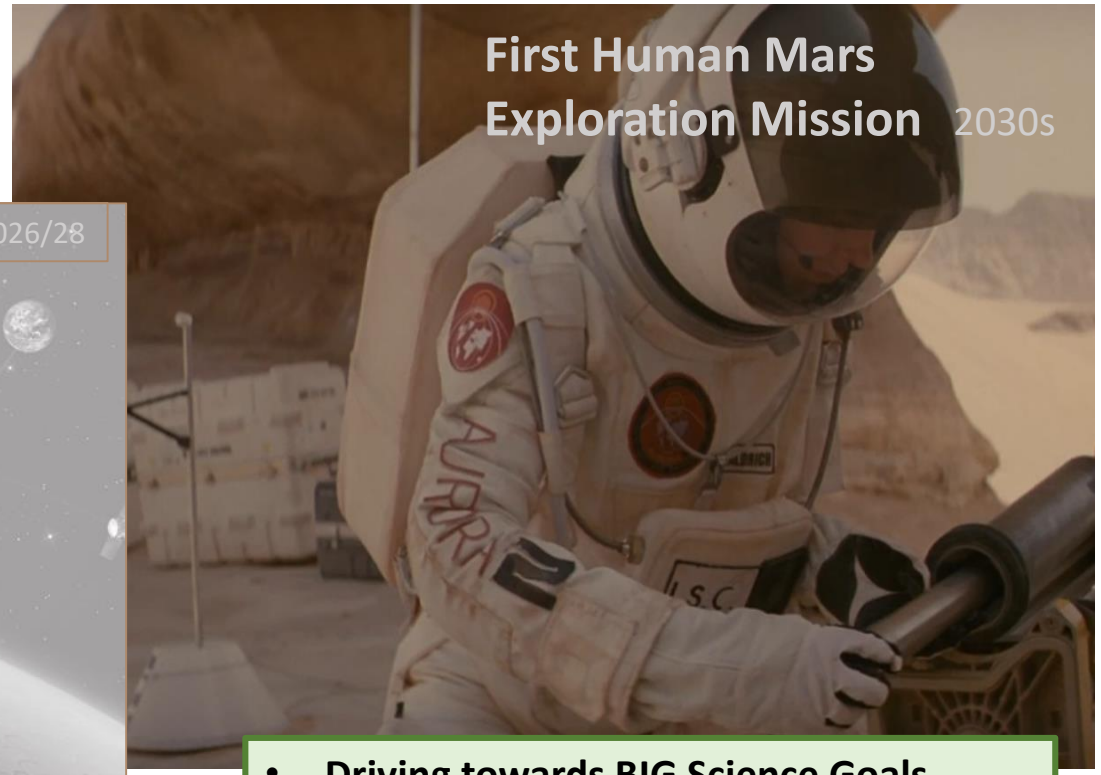
Science Enabling and Shaping Future Exploration of Mars



- 1st Roundtrip to another planet



- Innovative partnerships
- Expanding comm bandwidth



- **Driving towards BIG Science Goals**
- **Managing Long Complex Developments**
  - Different paradigm

Summary

NASA is studying bold and ambitious Mars exploration missions

- NASA is looking for the combination of human and machine at Mars to enable addressing BIG science questions with the 1st surface mission to the Red Planet