NASA'S JOURNEY TO

MARS

Selecting a Landing Site for Humans on Mars

Space Resources Roundtable

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NASA/Richard (Rick) M. Davis

Selecting a Landing Site for Humans on Mars

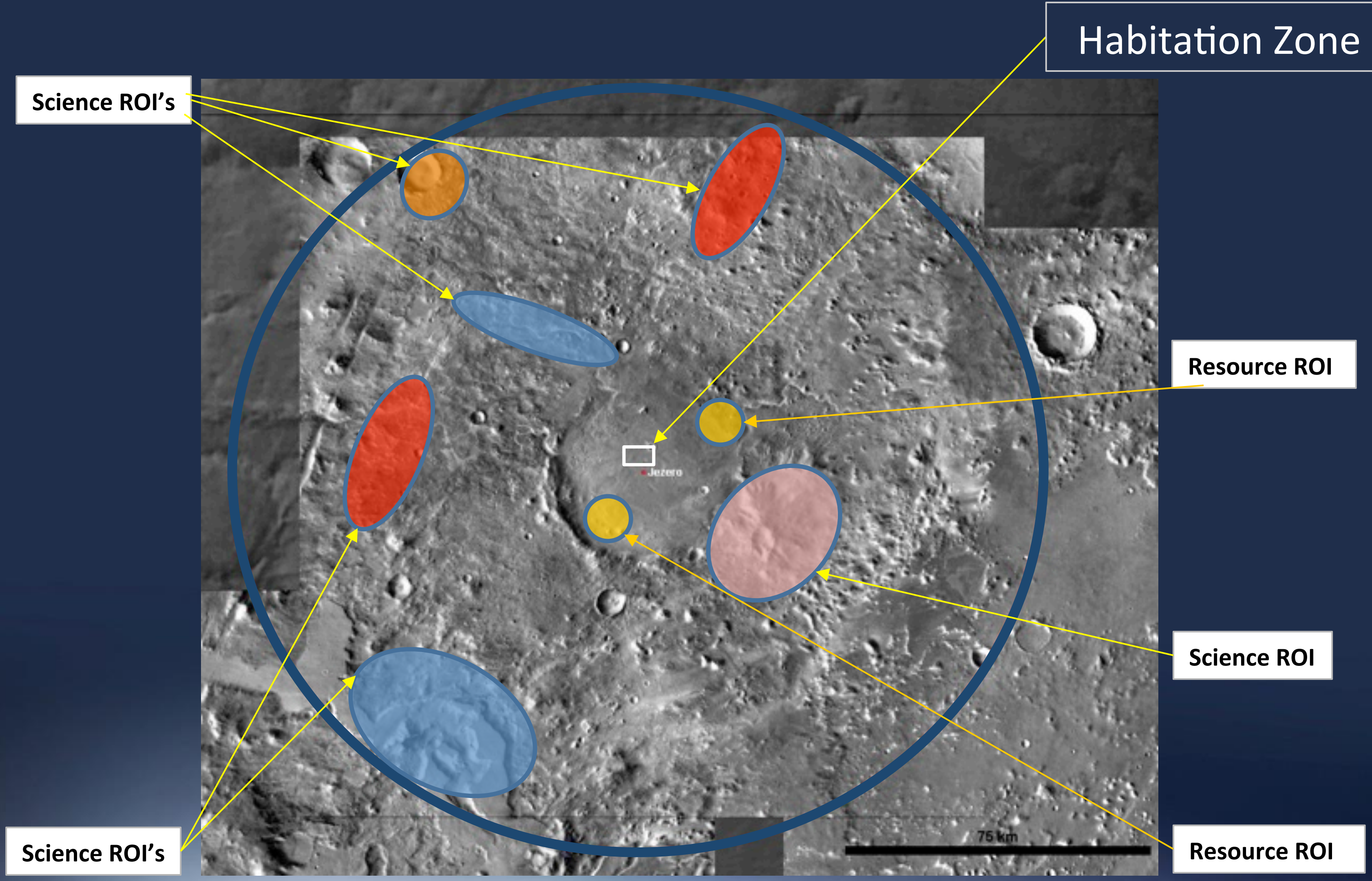
Sending humans to Mars is a top NASA priority and the Agency believes that such missions will significantly expand the amount of science which can be accomplished on the planet. If carefully planned and executed, the Agency sees a natural and symbiotic interdependency between robotic and human missions to Mars.

Goals of the Human Landing Sites Study

- Identify landing sites for human surface exploration of Mars.
  - These landing sites provide access to Exploration Zones (EZs) which are regions on Mars that contain multiple sites of scientific interest as well as satisfying engineering and human constraints for human exploration
  - Leverage Mars Reconnaissance Orbiter (MRO) data collection capabilities to acquire data of potential prioritized human Mars landing sites within the exploration zones
  - Establish a database of high science interest sites, which can easily be updated as we learn more about Mars and what is needed to support humans on the planet
  - Inform future reconnaissance needs at Mars—orbital and landed missions

This effort is a joint Human Exploration and Operations Mission Directorate (HEOMD) / Science Mission Directorate (SMD) study

Exploration Zone Layout



ROI = Regions of Interest

Field Station Analog-McMurdo, Antarctica

Emplacement

British National Antarctic Expedition 1902
R.F. Scott's "winter quarters hut" - Used for both local scientific research and as a logistical base for traverses inland.

Permanent occupation - 1955
Naval Air Facility McMurdo - Part of "Operation Deep Freeze" to support the International Geophysical Year; included a collection of semi-permanent structures (e.g., tents, Jamesway huts).

Consolidation

McMurdo Station Today
Antarctica's largest community and a functional, modern-day science station, including a harbour, three airfields (two seasonal), a heliport, and more than 100 permanent buildings

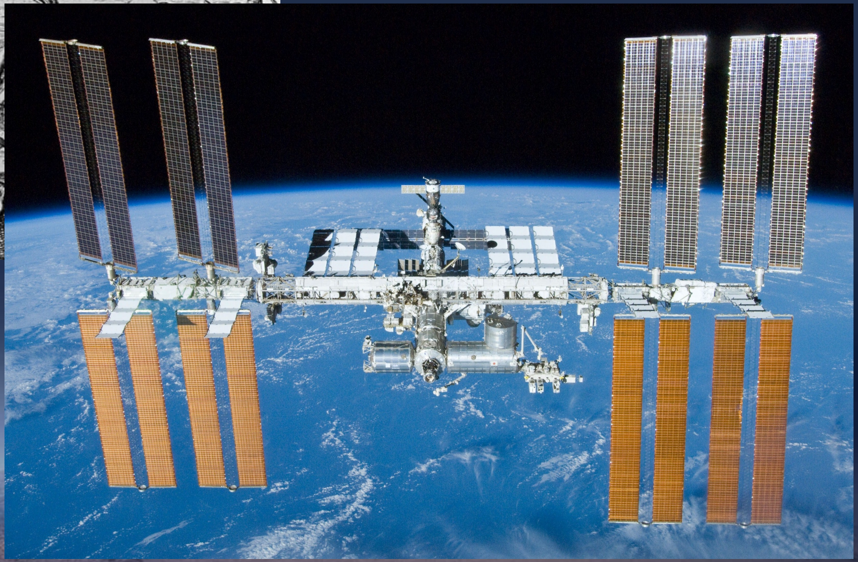
Utilization

Permanent Settlement Analogy

Jamestown (USA), 1607

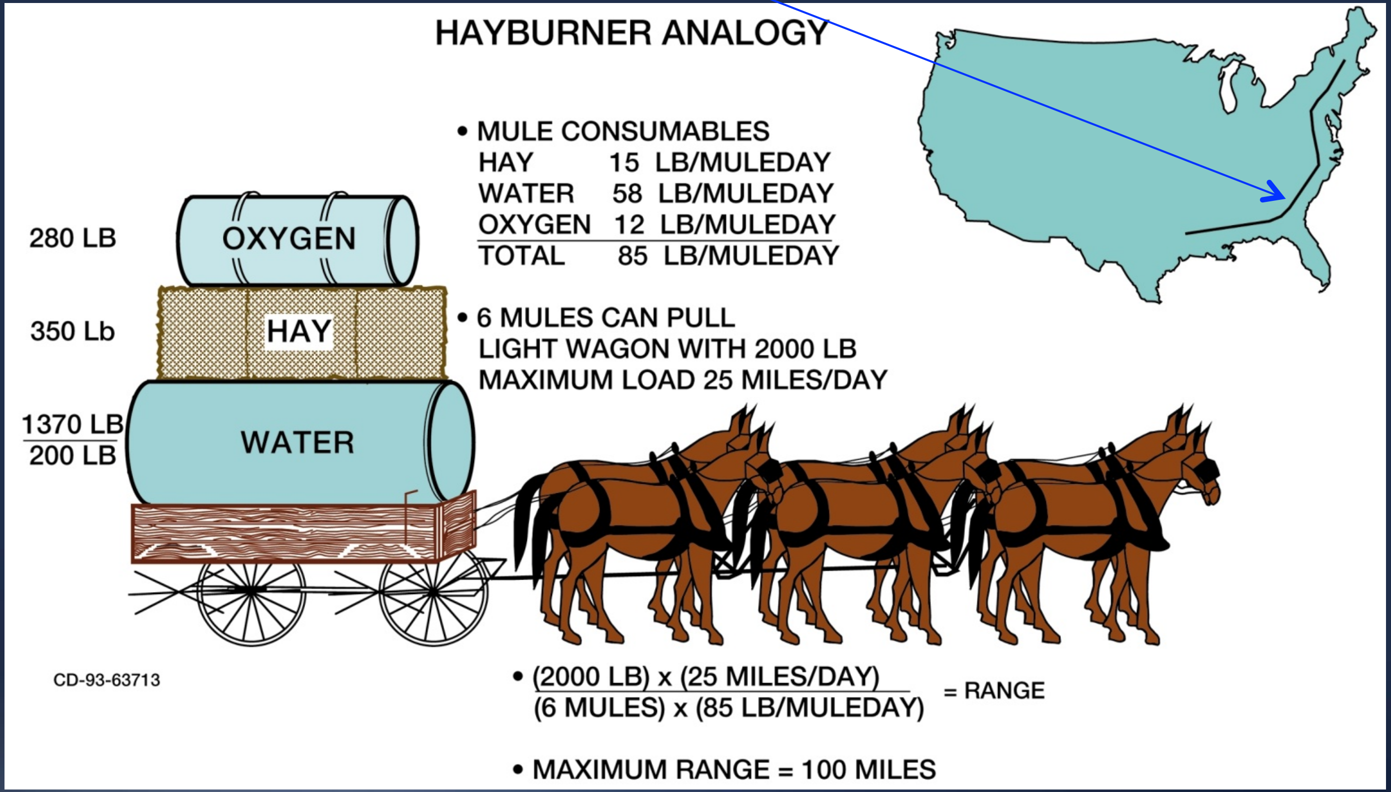
Quebec City (Canada), 1608

International Space Station, 2001



Pioneering Analogy: Settling the West

We wouldn't have gotten far if we couldn't use the local resources



Water for fuel, consumption and farming will be a critical resource on Mars. Priority and amount of water needed are being studied by NASA. These studies are informing what may be needed in a future reconnaissance satellite (as being studied by NEXt Orbiter Science Analysis Group (NEX SAG))

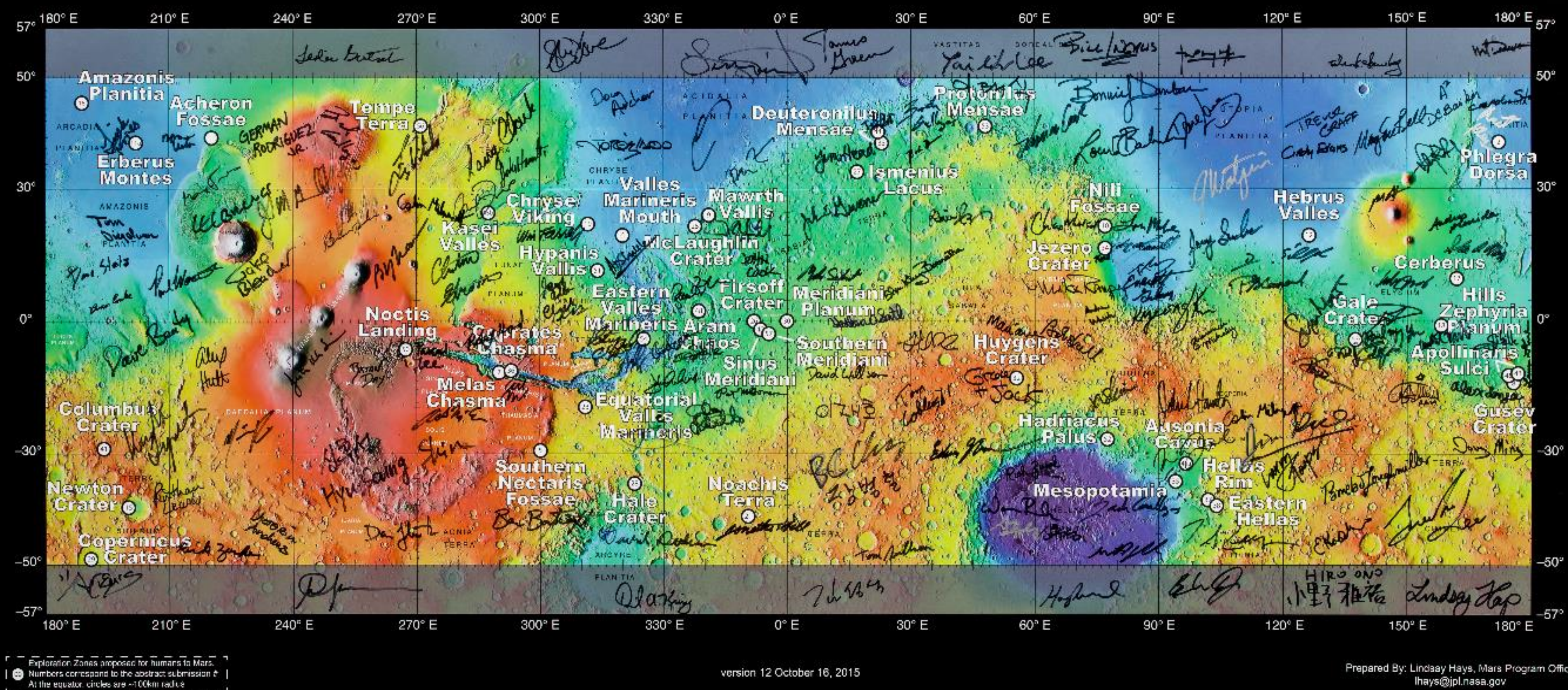
First Mars Human Landing Sites Workshop—Oct 2015

- 45 highly geographically and scientifically diverse EZ proposals
- Strong agreement on the viability of the Exploration Zone approach based on EZ proposals made
- Starting to build an integrated community is a critical result of the workshop
- Strong consensus that more advanced reconnaissance at Mars will eventually be needed to ultimately pick the human landing site / exploration zone

400 participants representing all major disciplines supported the workshop. Representation from multiple countries. Extensive media interest/coverage.

45 EZ Proposals covering highly diverse regions of Mars

Potential Exploration Zones for Human Missions to the Surface of Mars

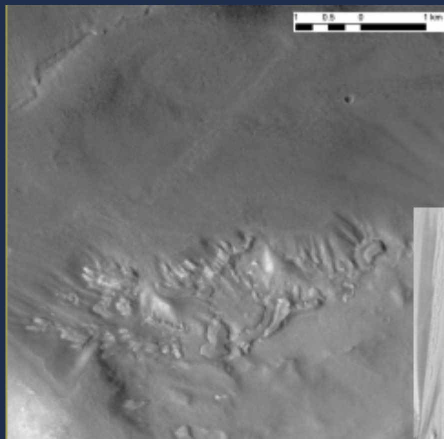


Permanent Research Outpost
Diverse Science and ISRU ROIs
Access to Water

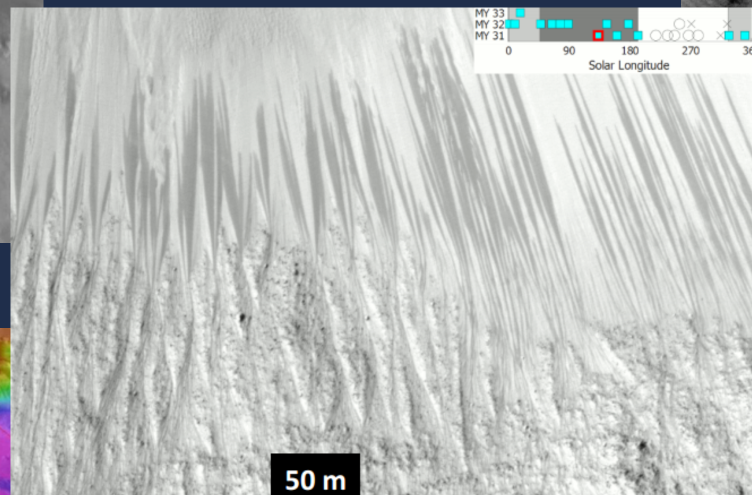
Pinpoint Landings are assumed and required
+/- 50 degrees latitude
+2 miles MOLA altitude

MARS

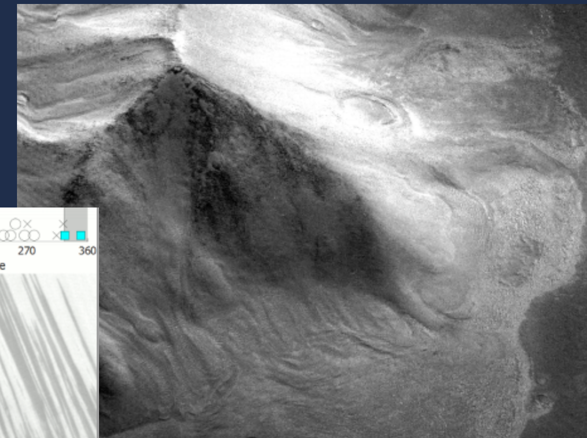
Mars has Several Water Feedstock Options:



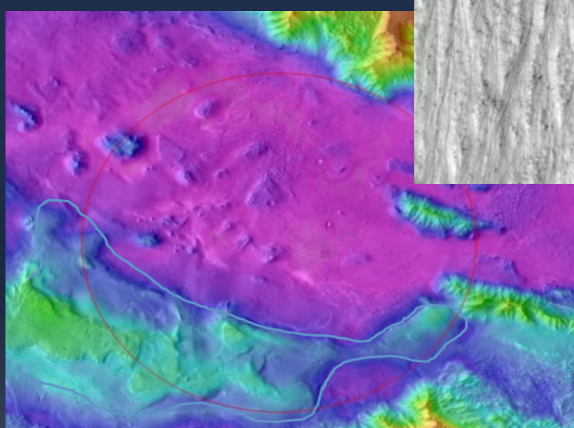
"Sheet" Ice



Recurring Slope Lineae

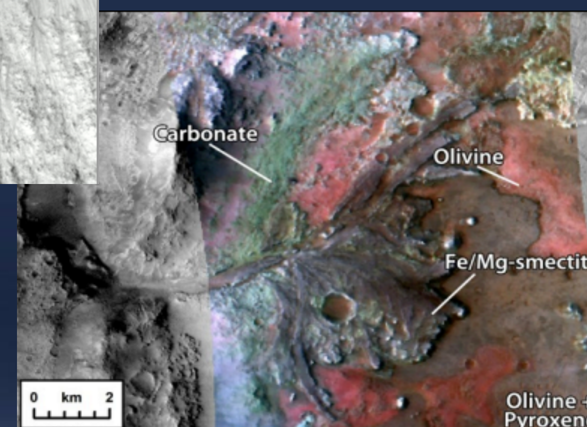


Debris-Covered Glaciers



Poly-hydrated Sulfates

Other Options:
- Hydrated Dunes
- Atmospheric H2O



Other Hydrated Minerals

Many EZs had multiple water feedstock types

Post Workshop Progress

- MRO Imaging opportunity to support the HLS2 effort was initiated
  - We received 72 targets (HiRISE & CRISM)
  - 27 image/data requests have already been acquired

- Evolvable Mars Campaign has initiated a study to consider how the availability of water would modify the human exploration architecture

- HLS2 results fed directly into NEXt Orbiter Science Analysis Group (NEX-SAG) analysis of what is needed in a next generation reconnaissance Orbiter

- Mars Water ISRU Planning (M-WIP)
  - Considered the complexities associated with different water feed stocks
  - Ultimately driving to understand how much mass, power and operational complexity is involved with producing water from each type of feed stock.
  - Learning that the value of water/methane ISRU production is significant
  - We need to use Mars as Mars is…..Not as we want it to be!

Exploring Potential Next Steps

- Prototyping to determine how we actually image and assess the potential for something as large as an EZ

- Multi-Directorate ISRU Production Team to define ISRU production options for each type of water feedstock: mass of production equipment needed at Mars, power levels required as well as operational complexity. Would build on M-WIP results.

  – Building on ISRU Production Team results as well as NEX SAG results, narrow water options down as well as to figure out how we can use our current fleet at Mars to help further with this process

- Final human architecture may be dependent on water resources. Assuming so, then goal would be to down select some water feedstock options and then have more integrated teams propose updated/new EZs based on that down-select

- Next workshop is anticipated to be in April 2017, one and a half years after the first workshop

The Team


Potential Exploration Zones for Human Missions to the Surface of Mars

Backup

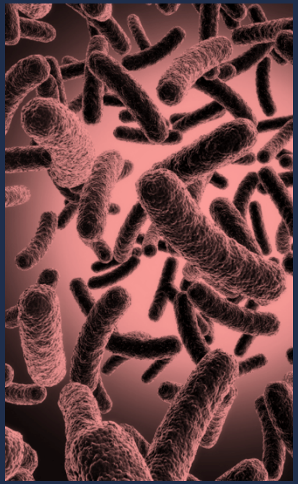
Key Links

- Mars Human Landing Sites Study (HLS2) Website:
  http://www.nasa.gov/journeytomars/mars-exploration-zones

For more information, contact
NASA-Mars-Exploration-Zones@mail.nasa.gov

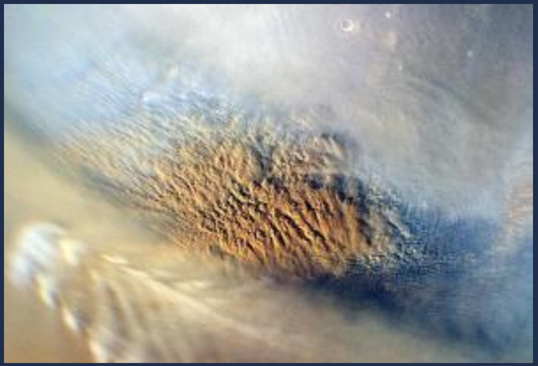
Credit: Page 2 photo of astronaut on Mars is from the movie, The Martian.

Science Objectives



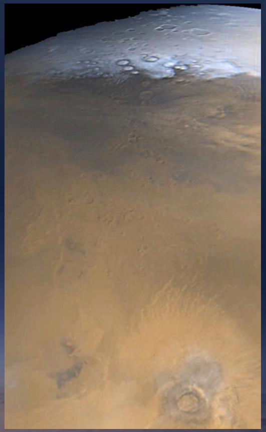
Astrobiology:

- *LIFE*: Search for evidence of past or present life Investigate the exchange and cycling of material between the subsurface, surface and atmosphere.
- *CHEMISTRY*: Investigate the complex chemistry, including mechanisms for organosynthesis, alteration and destruction.



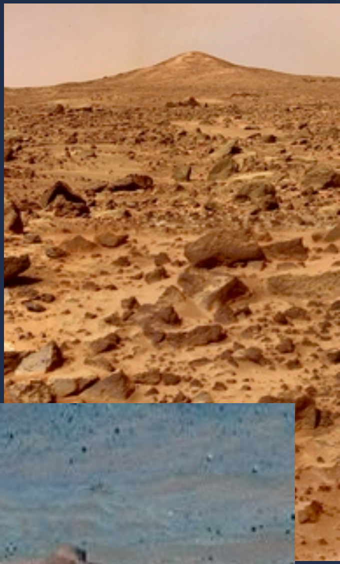
Atmospheric Science:

- *PRESENT CLIMATE & WEATHER*: Quantify the atmospheric state and driving forces of the present atmosphere
  - Characterize the local source and sinks in the dust, water and CO_2 cycles, and the key parameters that
  - Quantify photochemical and electrochemical cycles and potential subsurface trace gas sources
- *PAST CLIMATE*: Constrain past climate states and atmospheric composition, particularly as recorded in trace gases and surface morphology and composition



MARS

Science Objectives (cont.)



<u>Geosciences:</u>

- *GEOLOGY*: Characterize the composition and evolution of surface units and evaluate the diverse geologic processes and paleoenvironments that have affected the martian crust;
- *AGES*: Determine relative and absolute ages of geologic events and units, and relate their ages to major events through martian history.
- *INTERIOR GEOPHYSICS*: Constrain the dynamics, structure, composition and evolution of the martian interior

<u>Cross-Cutting:</u>

- *WATER*: Determine the availability of water, as vapor, ice or in hydrated materials in the near-surface environment
- *HUMAN IMPACTS*: Characterize the impact of humans on the martian environment.
- *RADIATION*: Evaluate variability in the martian radiation environment.

ISRU/Civil Engineering Criteria

- Access to raw material that exhibits the **potential** to (a) be used as feedstock for water-generating In-Situ Resource Utilization (ISRU) processes and (b) yield significant quantities (>100MT) of water. Raw material can be in the form of ice, ice/regolith mix, or hydrated minerals and the top of the raw material deposit should be as close to the surface as possible
- Access to a region where infrastructure can be emplaced or constructed. This region must be less than 5 km from a central landing site and contain flat, stable terrain. The region should exhibit evidence for an abundant source of cobble-sized or smaller rocks and bulk, loose regolith. Natural terrain features that can be adapted for construction purposes (e.g., to enhance habitat radiation protection) are considered beneficial
- Access to raw material that exhibits the **potential** to be used as metal or silicon feedstock for ISRU and construction purposes. Of primary interest are iron, aluminum, and silicon; titanium and magnesium are of secondary interest. Raw material should be as near to the surface as possible and be in a form that can be mined by highly automated systems

Engineering Constraints

- Located between +/- 50 degrees latitude
- Less than +2 km altitude (Mars Orbiter Laser Altimeter (MOLA) reference)
- An area of approximately 25 km^2 within which the terrain is generally level (slopes less than ~10 degrees) and significantly devoid of landing hazards (e.g., large and/or closely concentrated craters, mountainous terrain, broken/jumbled/chaotic terrain, extensive dune fields, etc.)
- Does not contain thick deposits of fine-grained dust (e.g., extremely low thermal inertia and high albedo)