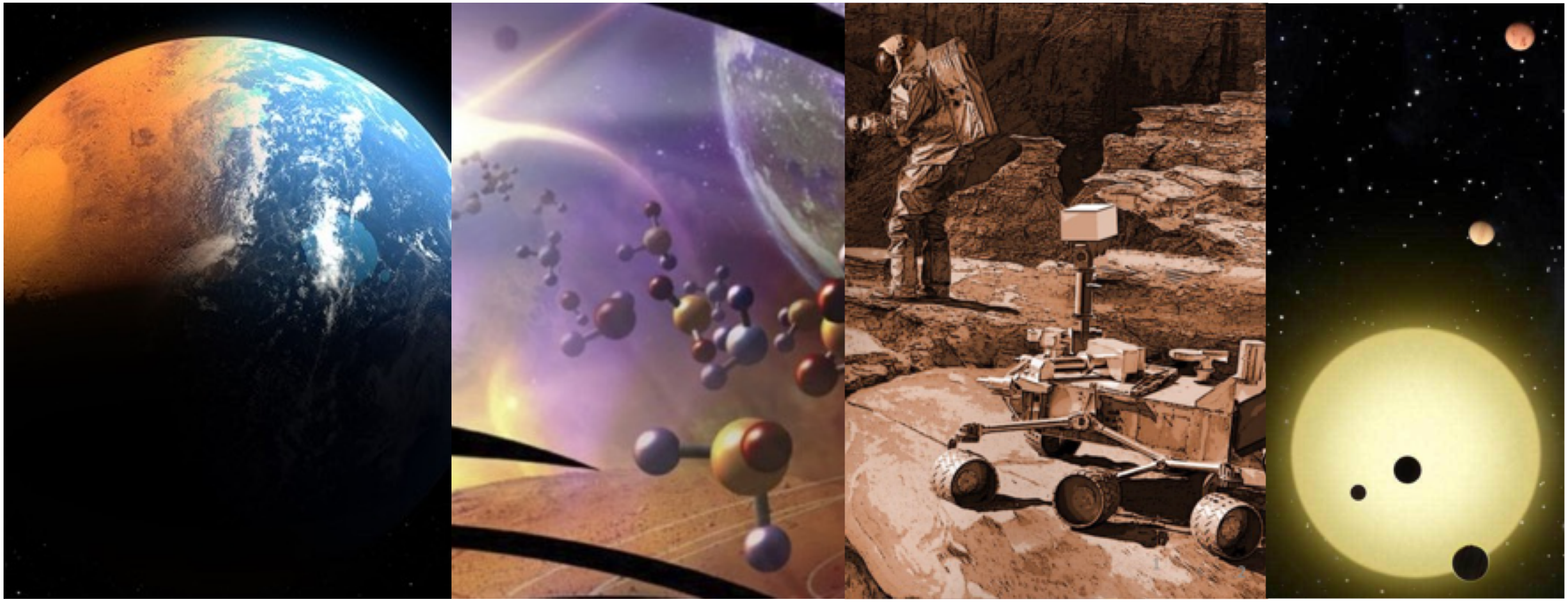
Mars, The Nearest Habitable World –
A Comprehensive Program for Future Mars Exploration
Update



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Bruce Jakosky

(on behalf of a subset of Mars Architectures Strategy Working Group, MASWG)

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Goals of this discussion

- Following MASWG, to examine mission concepts and program beyond or in addition to Mars Sample Return
- To develop concepts of how to revamp the Mars program in a cost-constrained environment

The Mars program has to be science driven

- A Mars program has to involve flight missions, in addition to having technology-development components
- Missions have to be science driven
  - Important science with potential for major breakthroughs – and not just “we’re flying a mission, what science can you do?”
  - The science has to be commensurate with the cost and effort
- Missions can build on each other through effective planning at the program level
- Even if an initial emphasis is on small-spacecraft missions, recognize that many key science objectives will require Discovery-, New-Frontiers-, or Flagship-class missions
- The long-term emphasis has to be on science, but there will be programmatic considerations:
  - Communications relay
  - Technology demonstration
  - Coordination with human program

Small spacecraft can play an important role

- In the MASWG report, we defined “small spacecraft” as being in the range of $100-300M for full life-cycle cost
- Missions in this size class have the potential to do outstanding science
- Costs are difficult to estimate, as no small NASA planetary missions have flown yet; real-world estimates of costs:
  - Hope Emirates Mars Mission, cost estimate of $200M LCC released by UAE
  - SIMPLEX ESCAPADE, cost cap of $55M
  - Fitting important science into missions costing less than $100M will be difficult
- We believe that significant opportunities begin to open up at ~$100M cost
- MASWG analysis and knowledge are now a year out of date; small-spacecraft capabilities are evolving quickly
- Requires ride-shares, which are turning out to be problematic once you want to go beyond Earth orbit

Development of infrastructure and technology will be necessary to support small spacecraft

- Low-cost EDL with significant science capability (note – currently being addressed by a KISS workshop/study)
- Low-cost / long-lived orbiters
- Comm. data relay that can be utilized to return data from small spacecraft
- Propulsion, including solar-electric
- Next-generation of compact science instruments
- Group buys on key components (e.g., radios)
- Planetary-protection protocols appropriate for small spacecraft
- Significant tailoring of 7120.5 may be required

Potential role of commercial collaboration

- Would a CLPS-like program work for Mars?
  - NASA would have to ramp up Mars program in order to provide multiple opportunities
  - Guaranteed number of opportunities to support the level of effort required to develop spacecraft?
  - Longer spacecraft lifetimes, greater development effort required compared to CLPS
- Data buys?
  - Would companies be willing to sign up for this level of investment and risk?
  - How to ensure appropriate involvement of science, both in the planning and in the implementation?
- Opportunities for collaboration with commercial entities committed to Mars?
  - Are they going to be going to Mars in a realistic time frame, and could we rely on them?
  - Rideshares versus integration into their spacecraft?

Interface with human exploration program

- There is a need to engage the robotic program now in order to support a human program 15 years from now
- Requires effective interaction/integration between programs, currently being done at an inadequate level
    - MEPAG has addressed "preparation for humans" as one of its goals, but this has been done largely in isolation from human program
    - Requires more or more-formal coordination between Mars and human communities
    - [• Note that there has been interaction in the past (e.g., MSL/RAD, M2020/MOXIE, Clementine), so we're not starting from scratch]
- Areas where robotic program and supporting science can be playing a role now:
    - Astronaut health (radiation, perchlorates/oxidizing agents in dust, etc.)
    - Planetary protection
    - ISRU
    - Science objectives/planning for human missions

Suggested near-term actions

- Any path forward needs to involve interaction with and solicitation of input from the broader community
- Technology workshop
  - How have small-spacecraft capabilities evolved in the last two years, what are the current capabilities, what are expectations for the next several years?
  - Development of instruments suitable for big science on small missions
  - Launch vehicle capabilities – rideshares, small LVs, commercial (i.e., non-NASA) launches
- Science/mission workshop
  - What are realistic costs for science missions that can be carried out by small spacecraft?
  - Do they address important science? Enable more-comprehensive future programs?
  - Where is the lower limit or breakpoint on science versus cost?
- Use results as a lead-in to future development/program, requires and supports existence of a dedicated Mars program

Backup

Participants in MASWG sub-group for this discussion

- Bruce Jakosky (co-chair)
- Rich Zurek (co-chair)
- Wendy Calvin
- Shannon Curry
- Bethany Ehlmann
- Scott Hubbard
- Jack Mustard

Small Spacecraft Concepts Identified In The Mission Arcs In The MASWG Report

Mission Arc 1: Diverse Ancient Environments & Habitability

- Mineral mapping by orbital spectroscopy
- Investigation of multiple sites using pin-point landing, mobility (air, ground).

Mission Arc 2: Subsurface Structure, Composition & Possible Life

- Low-altitude magnetic survey & gravity mapping
- Remote EM sounding and active-source seismic devices; trace gas fluxes

Mission Arc 3: Ice: Geologically Recent Climate Change

- Polar energy balance mission

Mission Arc 4: Atmospheric Processes and Climate Variability

- Multiple, long-lived SSc to achieve global and local time coverage (e.g., areostationary), and long-term records of temperature/pressure, winds, and aerosols & water (columns and profiles).

Full original MASWG report available at:

https://mepag.jpl.nasa.gov/reports.cfm