Technology and Enabling Capabilities

Panel Summary by
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I. Fixed Landers & Communication— Summary

- 3 main concepts for delivery platforms. First two drawn on heritage, last is low cost, high risk
  - Proven in Prior Mission (Phoenix, MER): reduce development cost, focus on payload development
  - Dragon commercial platform : potential for lower cost delivery of large payload; possible interest from human exploration?; technology hurdles, in particular, proof of deep-throttling, supersonic retro propulsion, science accomodation.
  - "Piggybacking"/ Multiple small landers: low cost permits higher risk, redundancy, multiple surface data points, e.g. related to weather/climate, greater community/student involvement; better to fly these than ballast!
- Recurring theme of drill or mini-corer for sampling subsurface ice/soil to address science objectives. Drills prototyped and tested.
- Only communication presentation was laser comm: would greatly enhance science data volumes, advancements made, still needs to address technological challenges for Mars
- Science interest in modern climate/life and processes and enabling technologies, complementary to and/or precursors to MSR
  - Ice exploration: ages, processes, habitability , with multiple possible approaches, e.g. roving across layers in the polar cap or coring at near-polar latitudes
  - In-situ life detection in the near subsurface
  - weather stations either stand-alone or piggybacked

II. Mobile Surface Spacecraft and Navigation—Summary

- Complexity or simplicity can both achieve autonomy in mobility
  - "thinking rover" with on-board target selection, terrain relative navigation vs. "survey mode" design of free-moving tumbleweeds
- Small is beautiful: emphasis on creative mass-lowering capabilities
  - Mini rovers, cold-capable rovers
- Major advances in access to previously unaccessible/challenging terrains (cliffs, lava tubes) using novel systems
  - Variety of methods: six legs/wheels, gripping rovers, tethered rovers, hopping
- Most technologies are being validated/have been demonstrated by testing in analog environments
- The Canadian Space Agency is testing multiple potential contributions (instruments, samplers, rovers)
- Utilizing a MER-based rover, high-level science capabilities possible on Mars surface at the 2018 reference landing sites, including organics detection and in-situ age dating

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- Validating small tech demo system, ala Pathfinder, or ISRU for a hopper?

III. Aerial Platforms & Investigations–Summary

- Variability in maturity of design
  - A few balloon and deployed airplane/drones are currently relatively mature with mid to high TRL and have been proposed and/or gone through Phase A.
  - More advanced options (e.g., vertical landing and takeoff systems, entomopters, *in situ* CO2 'gas hoppers' and aerocoasters) have unique access capabilities and may be options for longer term Mars pathway needs
- Mission design exerts strong control over time aloft/mission duration
- Can be on the lower end of mission and subsystem cost ranges
- Fill unique niche for coverage and access: birds-eye view good for study of regional phenomena (between global scale orbiter and local lander) and some areas presently inaccessible to current EDL systems
  - Science enabled: atmospheric gas composition, structure, winds; surface remote sensing (radar, GPR, higher spatial res. surface imaging, composition)
  - New spatial scale of vision/perspective for exploration
  - Possible synergy with MSR and human missions, i.e. balloon for near real-time assessment of local winds before launch
- Some aerial systems can be subsystems deployed from larger missions; others could be co-manifested with other missions

IV. Sample Caching, Handling, Acquisition –Summary

- A number of well-tested concepts for drilling and/or caching
  - Two coring concepts for MSR (10mm diameter x ~50-80mm)
  - Previewable within cached bits and/or encapsulated within cachable tubes
- Deeper drills to access subsurface, including ices
  - Geared toward in-situ analysis with wet chemistry; could also cache a sample
- Relatively small platforms enable these activities
  - Phoenix: meter to few meter drill
  - MER: sample acquisition and caching + science payload
- Characterization needed and instruments under development for sampling and sub-sampling, e.g.,
  - In-situ, non-destructive organics (incl. deep UV)
  - In-situ, non-destructive mineralogy (e.g. spectroscopy, next-gen. XRD)
  - “scratch and sniff” for analysis of presence of trace organics prior to triage
  - Precision subsampling of core systems under developments
- Avoiding contamination
  - Encapsulation in tubes at drilling
  - Air gaps
  - Bioshielding
- Development/interest in microfluidics systems for in-situ wet chem.
- CubeSat-like architecture for Mars orbit-to-Earth orbit transfer of sample

V. Return Architectures Strategies, Vehicles–Summary

- MAVs
  - Functional technology is not new; application to Mars environment pose challenges
  - Challenges: Mars surface temperature change, stage separation, achieving orbit, packaging
  - Need for Earth (and Mars?) demonstrations of feasibility
- Solar-electric-propulsion tugs and on-orbit staging were presented as long-term options for greater mass or delta-V interplanetary transport capabilities
- Heavy launch capabilities (SLS) first tests in 2017, are robotic mission uses later?
- Earth-return capsule: initial findings/status presented for in inverted spherical cone and no parachute design
- Architecture option #1: Upper atmosphere, dust sample return, no rendezvous-Earth-return
  - mature (proposed to Discovery)
- Architecture option #2a: MER+MAV and #2b: Phoenix lander+MAV (both w/ and w/o no rendezvous Earth-return)
  - Variable levels of maturity
  - Regolith (upper 10 cm depth), rock chip, atmosphere sample
- Architecture option #3a: caching MER, part 1 of multi-step architecture and #3b precursor exploring rovers
  - Returns rock cores collected in stratigraphic context
- Discussion of pushback on planetary protection driving requirements for all types of samples and related potential mission impacts

Themes - A number of concepts make use of heritage-based platforms that are plausible

- Spread between the 5 sessions were a number of presentations (~7 or 8) using or referencing a MER class platform for missions, primarily sample acquisition and interrogation missions:
  - A number of those presentations on the readiness of core-based sample acquisition and caching systems intended specifically for MER class rover missions.
  - Several instrument presentations focus on either sample triage, enabling selection, aiming for fitting on MER platform
  - Two non-sample-return based MER based rover missions on Ice sample acquisition, MSR precursor is situ life detection suites, age dating, polar science
  - MER based or MER class rover missions that could cache samples or do science/Strategic Knowledge Gaps/pre-MSR science appear to be possible ‘nearer’ term. Modifications or updates probably needed for MER class EDL and rover were noted
  - One carries MAV for sample return

- Approximately ten presentations reference Phoenix based fixed lander missions:
  - A number were on deep drilling (1-3m) into ice or soil and MSR precursor science, also related to atmospheric measurements
  - A number focused on varying degrees of MSR with atmosphere, regolith, rock chip samples
  - Some carry MAVS, less mature
  - Fixed lander mission approaches and technologies discussed can do some pre MSR science and Strategic Knowledge Gaps and can obtain and analyze or cache samples.

- Multiple Aerial drone or balloon missions:
  - Pre MSR science for atmosphere and surface regional studies

- Longer term :
  - Extreme terrain mobility and other ‘mobility’ solutions could be available for mid to later pathways if science, human mission related knowledge gaps needs or human orbit or surface operations would benefit.
  - There are innovative ideas – for example - Dragon based EDL and fixed landers could provide science platforms and mature potential subsystems for human missions, but they may need work.
  - MAV technologies a risk for most sample return scenarios of any cost range.