Technology for NASA's Planetary Science Vision 2050. Notes from the Feb 2017 Workshop

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1. Abstract

NASA's Planetary Science Division (PSD) initiated and sponsored a very successful community Workshop held from Feb. 27 to Mar. 1, 2017 at NASA Headquarters. The purpose of the Workshop was to develop a vision of planetary science research and exploration for the next three decades until 2050. This abstract summarizes some of the salient technology needs discussed during the three-day workshop and at a technology panel on the final day. It is not meant to be a final report on technology to achieve the science vision for 2050.

2. Introduction

The V2050 Workshop was intended to envision where planetary science would be in 2050. The program of oral and poster presentations was organized around the following five major themes:

- LIFE
- ORIGINS
- WORKINGS
- DEFENSE AND RESOURCES
- POLICY, PATHWAYS, TECHNIQUES AND CAPABILITIES (PTC).

There were also synopsis presentations for each theme at the end of the Workshop. On the technology side we have taken note of the many technical needs identified either during science presentations, Q&A sessions, or during the final technology panel discussion. We present here a preliminary summary of the main technology challenges to be addressed in order to realize PSD's V2050 science objectives. Many of the technologies needed will probably take more than a decade or more of development to mature.

3. V2050 Technology

3.1 Instrumentation for LIFE, ORIGINS,WORKINGS, Planetary Defense and Resources, and PTC. We list here a few high-level aspects of instrumentation that will need to be developed for V2050:

- Biosignature detection at the nanoscale; non-DNA specific/agnostic sample retrieval and life detection approaches; automated microfluidic systems; advanced spectrometers; penetrator science packages (including asteroids as targets); *in-situ* coring; advanced cryogenic sample return including targets in the outer solar system; immersive virtual reality for sample selection/collection; etc.
- Advanced remote sensing: significantly better spatial and spectral resolution, improved models, high definition camera; sustainable (staffing and funding) advanced Earth-based laboratory analysis tools; etc.

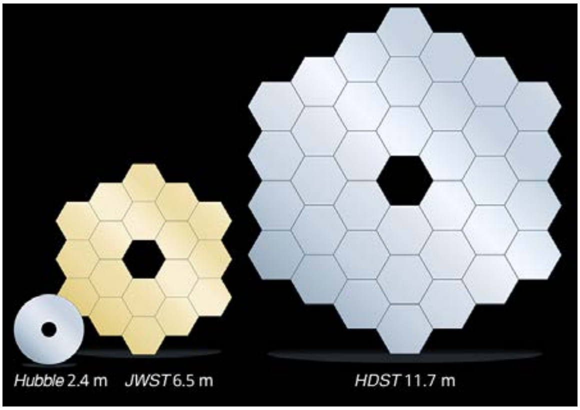

Fig 1: Such next generation large observatories as the High Definition Space Telescope (HDST) would be instrumental for investigation of exoplanets as well our own solar system in the decades ahead. Even bigger clusters of these could be assembled in space for dual astrophysics and planetary science applications. *Courtesy C. Godfrey (STScI)*

3.2 Platforms and architectures. We list here a few high-level platforms and architectures needs discussed during the V2050 Workshop:

- Solar-system-wide infrastructure for navigation and communication; multi-target mission architectures; large space-based observatories (Fig. 1), including in-space, self-assembly of extraordinary structures;
- Modular/standard spacecraft with standard interfaces/volumes for customized instruments to reduce cost of mission and access to space; smallsats, cubesats, chip sats/femtosats; mother-daughter spacecraft; swarm spacecraft systems for distributed multi-point measurement and long-term monitoring; "sciencecrafts".

3.3 Flight system technology. We list here a few high-level needs mentioned during V2050:

- Compact Radioisotope Thermoelectric Generators; surface power systems; energy storage (all-temperature); advanced power for outer solar system bodies (KBO); aerial mobility.
- Upgraded/advanced DSN and beyond; advanced *in situ* resource utilization (ISRU) methods – water, fuel, building material; mobile submersibles for distant oceans; autonomous operations for landing and hazard avoidance; fully autonomous spacecraft; ubiquitous intelligence in machines; advanced computing (including on-board data mining); scalable robotic systems: lander/rover access, mobility and robustness; reconfigurable systems to handle unexpected environments.

3. 4 Advanced propulsion/transportation

- Propulsion technology to get to the outer planets (robotic as well as human missions); radioisotope electric propulsion; photonic propulsion.
- Technology to access new and challenging terrains of interest – surface transportation.

3.5 Technology for extreme environments – high level needs:

- High- and low-temperature tolerant systems; high radiation tolerance; high temperature electronics; advanced manufacturing (3D printing); technology for highly corrosive environment.

4. Synergy with Human Exploration (HEOMD)/ Commercial Space.

- In-space assembly of large structures will require working hand-in-hand with human space program.
- Human-aided sample retrieval/return; ISRU;
- Orion crew vehicle use as relay for surface activity (rover, robots, avatars); the Moon as technology tested for human-aided science elsewhere in the solar system

5. Common threads

A number of ideas proposed highlight common threads. One is that all means of exploration should be integrated together. Another one being that budget (and political) constraints should be considered and that a balanced and prioritized program will still be needed. A few other suggested ideas are listed below:

- Diversity of workforce is very important (such as gender, age, race etc.)
- Collaboration between: the various disciplines of planetary science; engineering and science; Planetary Science, Heliophysics, Astrophysics, Earth Science, and Human Exploration; public/crowd-sourcing/open innovation; planetary, industry and commercial space developers.
- Current planetary atmospheric models need to be advanced to cover global climate system models. models that merge datasets from sample analysis, experimentation, and remote-sensing/ telescopic/ robotic observations will be needed

6. Summary and Conclusions

The above is a preliminary summary of the technology discussion at the V2050 Workshop. A report is expected to be finalized soon. In addition to the Planetary Decadal Survey, a number of other roadmapping activities are being developed or have already been completed, and will need to be taken into consideration to have a more complete vision for the planetary science in 2050.

Acknowledgements

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