PSD Technology Planning

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Technology Planning within the NASA PSD

Goal: to provide upcoming planetary science missions, as prioritized in the Decadal Survey, with the technologies required to successfully implement them (preferably, at lower cost and higher efficiency).

- Near term
- Far Term
- Competed (i.e. multi-mission technologies)
- Assigned (or core) missions.

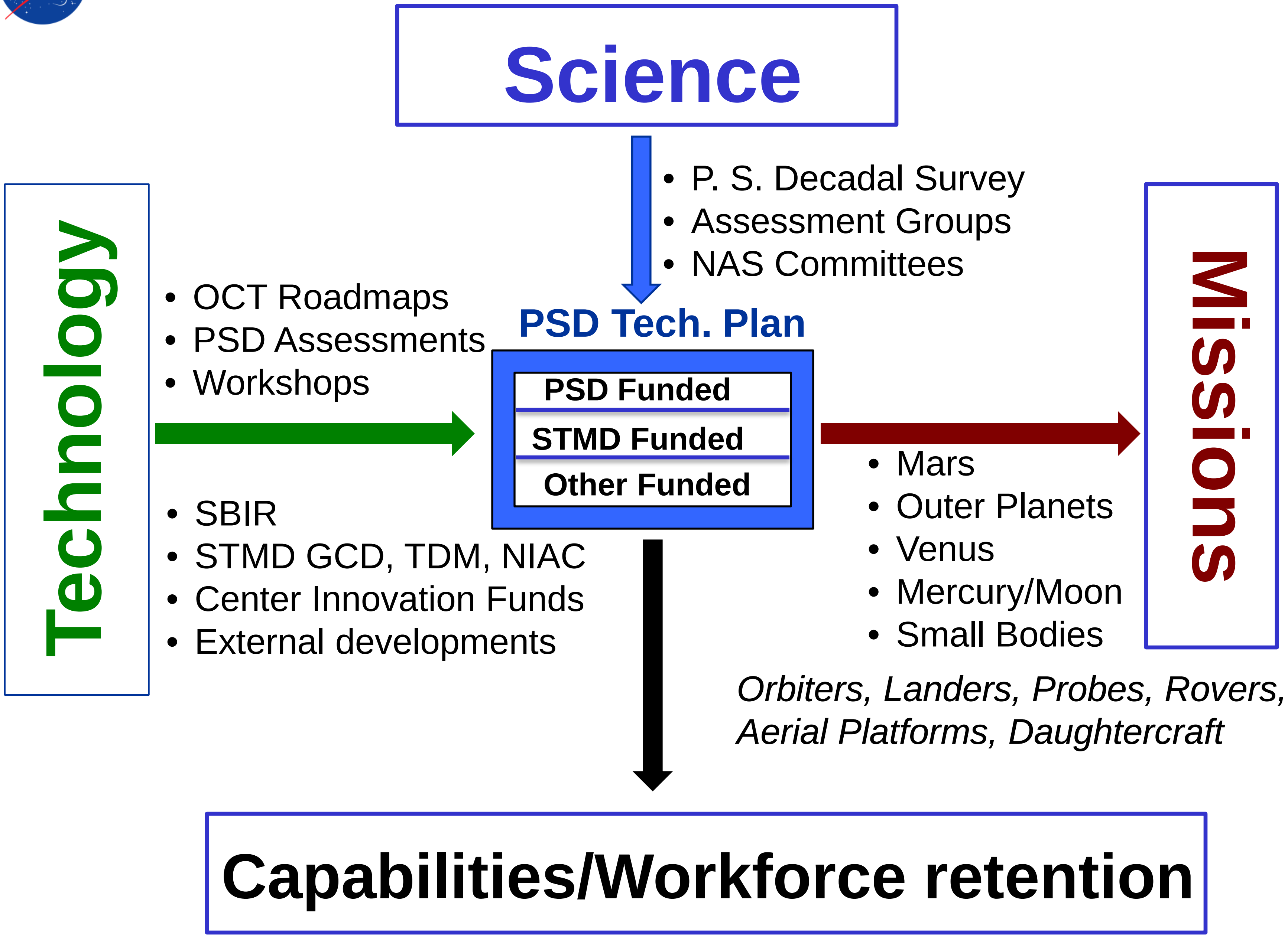
- Planetary Science Decadal Survey (DS) recommended 6-8% of budget to be spent on technology (2011)
- Planetary Science Technology Review (PSTR) panel recommended 8% of budget to be spent on technology (2011)
- STMD not in existence when either the DS or the PSTR made their recommendation. OCT just being formed and roadmaps initiated.
- PSD now responding to recommendations and also evaluating and working with STMD to define and fund needed mission technologies
  - in the process of evaluating current technology developments (throughout the agency and industry) and planning future investments

PSD Adopted Methodology

The following key questions are being considered:

1. Portfolio diversification
   - Where we currently are making investments vs. where we want to be making them
2. What technologies are missing from the portfolio?
3. What and how much will PSD and others provide for technology development?
4. What are the longer term (5/10 yr) mission needs and the technology priorities to satisfy them?
5. How do maintain current capabilities – need to determine what we exercise and at what frequency.
6. Who do we partner with to augment the funding required to develop PSD technology?
   - STMD, HEOMD, AF, DARPA, etc.

Schematic of PSD Technology Plan



Science

- P. S. Decadal Survey
- Assessment Groups
- NAS Committees

Technology

- OCT Roadmaps
- PSD Assessments
- Workshops

- SBIR
- STMD GCD, TDM, NIAC
- Center Innovation Funds
- External developments

PSD Tech. Plan

PSD Funded

STMD Funded

Other Funded

Missions

- Mars
- Outer Planets
- Venus
- Mercury/Moon
- Small Bodies

Orbiters, Landers, Probes, Rovers, Aerial Platforms, Daughtercraft

Capabilities/Workforce retention

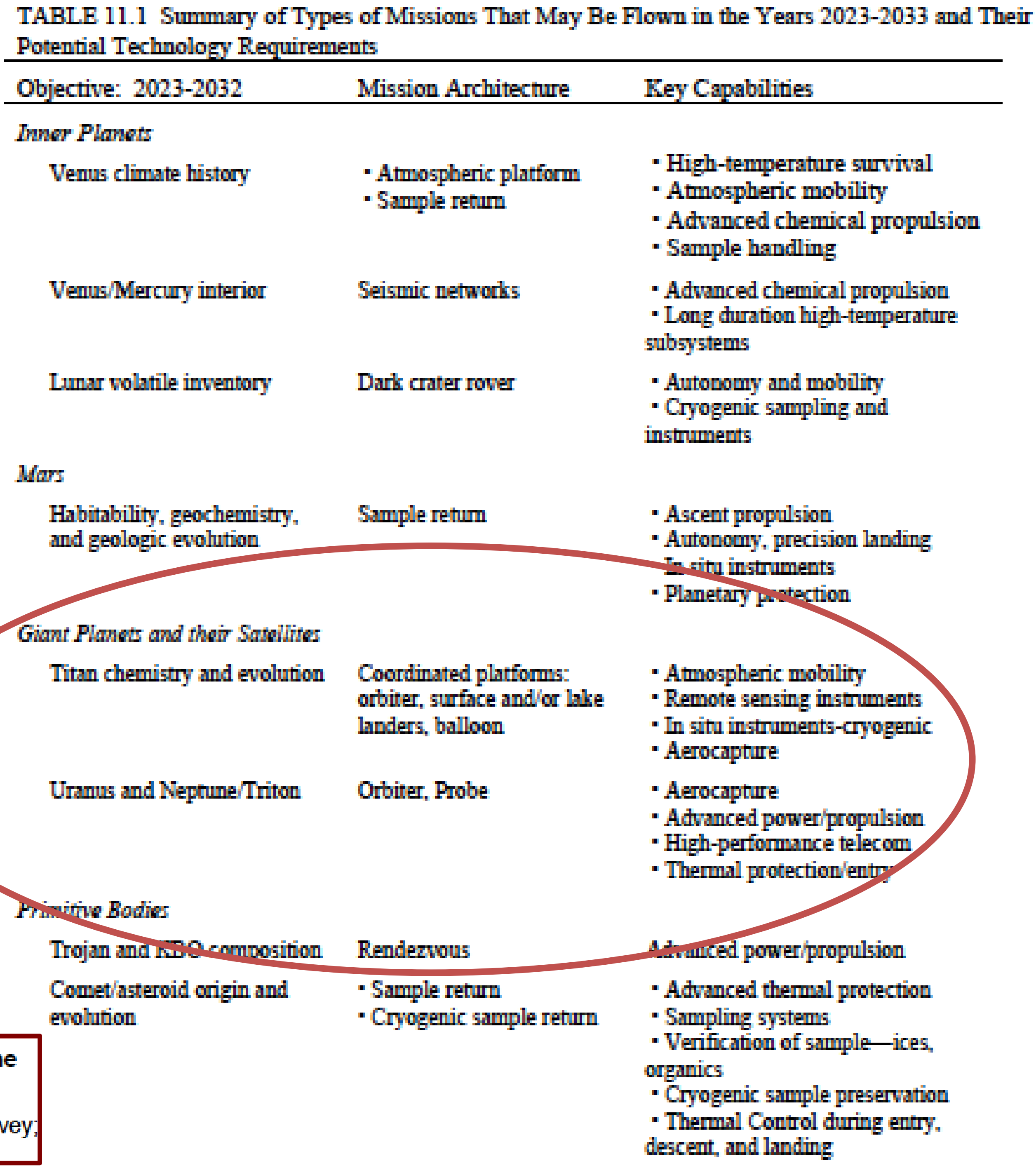


TABLE 11.1 Summary of Types of Missions That May Be Flown in the Years 2023-2033 and Their Potential Technology Requirements

Objective: 2023-2032	Mission Architecture	Key Capabilities
Inner Planets		
Venus climate history	· Atmospheric platform · Sample return	· High-temperature survival · Atmospheric mobility · Advanced chemical propulsion · Sample handling
Venus/Mercury interior	Seismic networks	· Advanced chemical propulsion · Long duration high-temperature subsystems
Lunar volatile inventory	Dark crater rover	· Autonomy and mobility · Cryogenic sampling and instruments
Mars		
Habitability, geochemistry, and geologic evolution	Sample return	· Ascent propulsion · Autonomy, precision landing · In situ instruments · Planetary protection
Giant Planets and their Satellites		
Titan chemistry and evolution	Coordinated platforms: orbiter, surface and/or lake landers, balloon	· Atmospheric mobility · Remote sensing instruments · In situ instruments-cryogenic · Aerocapture
Uranus and Neptune/Triton	Orbiter, Probe	· Aerocapture · Advanced power/propulsion · High-performance telecom · Thermal protection/entry
Primitive Bodies		
Trojan and KBO composition	Rendezvous	Advanced power/propulsion
Comet/asteroid origin and evolution	· Sample return · Cryogenic sample return	· Advanced thermal protection · Sampling systems · Verification of sample—ices, organics · Cryogenic sample preservation · Thermal Control during entry, descent, and landing

from Planetary Science Decadal Survey 2011

Vision and Voyages for Planetary Science in the Decade 2013-2022

Committee on the Planetary Science Decadal Survey; National Research Council

From Decadal Survey 2011

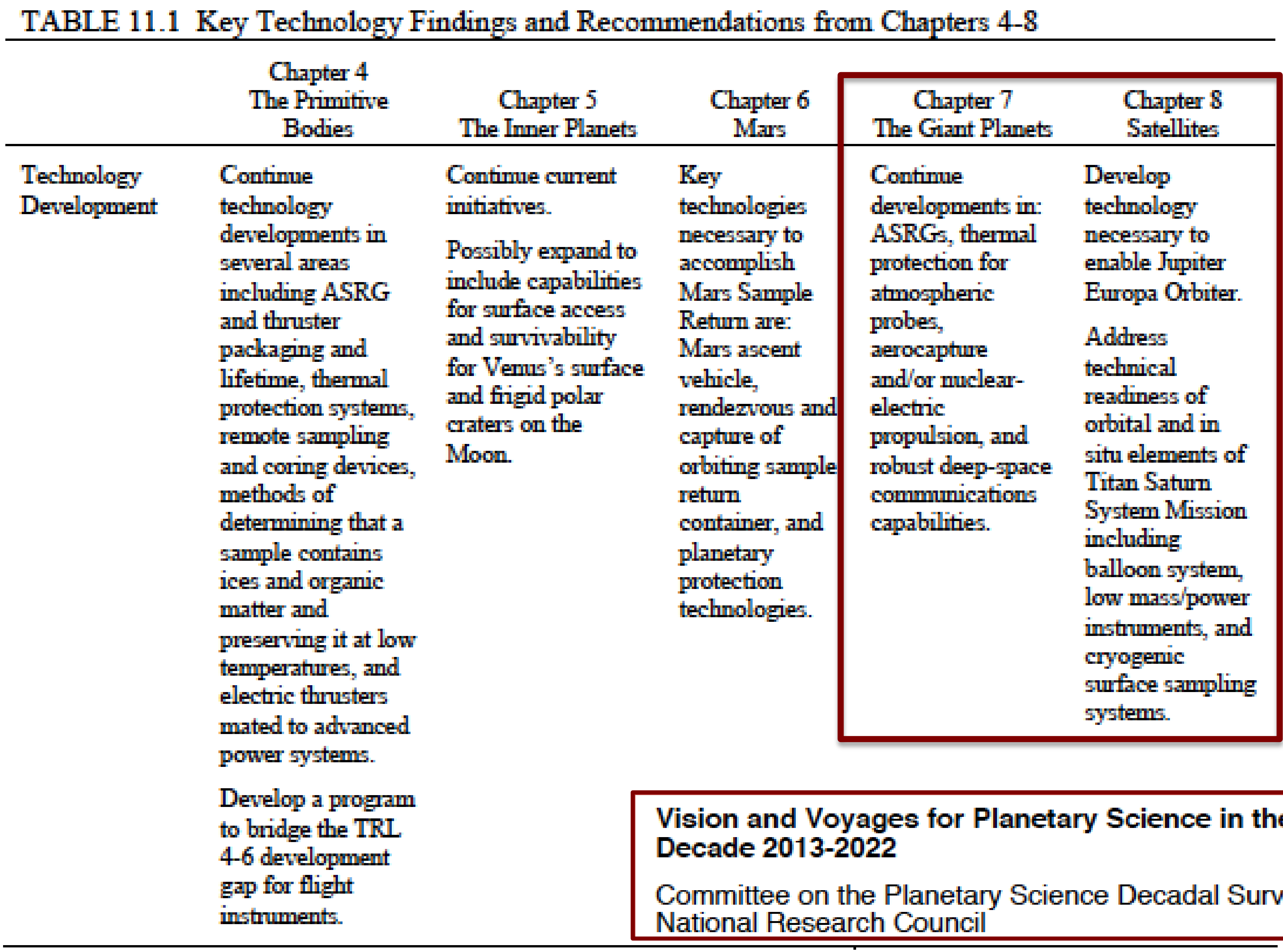


TABLE 11.1 Key Technology Findings and Recommendations from Chapters 4-8

	Chapter 4 The Primitive Bodies	Chapter 5 The Inner Planets	Chapter 6 Mars	Chapter 7 The Giant Planets	Chapter 8 Satellites
Technology Development	Continue technology developments in several areas including ASRG and thruster packaging and lifetime, thermal protection systems, remote sampling and coring devices, methods of determining that a sample contains ices and organic matter and preserving it at low temperatures, and electric thrusters mated to advanced power systems. Develop a program to bridge the TRL 4-6 development gap for flight instruments.	Continue current initiatives. Possibly expand to include capabilities for surface access and survivability for Venus's surface and frigid polar craters on the Moon.	Key technologies necessary to accomplish Mars Sample Return are: Mars ascent vehicle, rendezvous and capture of orbiting sample return container, and planetary protection technologies.	Continue developments in: ASRGs, thermal protection for atmospheric probes, aerocapture and/or nuclear-electric propulsion, and robust deep-space communications capabilities.	Develop technology necessary to enable Jupiter Europa Orbiter. Address technical readiness of orbital and in situ elements of Titan Saturn System Mission including balloon system, low mass/power instruments, and cryogenic surface sampling systems.

Vision and Voyages for Planetary Science in the Decade 2013-2022

Committee on the Planetary Science Decadal Survey; National Research Council

Examples of Current Spacecraft Technologies under development

- PSD
  - Plutonium restart, Stirling conversions and thermo-electric technologies, RPS controllers, insulators and thermal management
- PSD/STMD/HEOMD

Spacecraft Technology	Funding from:
NASA’s Evolutionary Xenon Thruster (NEXT)	PSD
Advanced Solar Arrays	STMD
Deep Space Optical Communications	STMD
Deep Space Atomic Clock	STMD
Heatshield for Extreme Entry Environment Technology	STMD
Aeroentry Data Capture	STMD
Robotic Lander Technology	PSD
Automated Rendezvous and Docking Sensors	HEOMD
Autonomous Landing and Hazard Avoidance Technology	HEOMD
Green Propellant Infusion Mission	STMD

- Joint with AF/STMD
  - Next generation high performance computing.

Examples of Instrument Technologies under development

- Many being developed under PIDDP, PICASSO and MATISSE
- Some being developed under Discovery funds within PSD

Instrument Technologies
MaSPEx Advanced Mass Spectrometer - H. Waite, SWRI
A Compact Integrated Raman Spectrometer (CIRS) - A. Wang (Wash U)
High-performance in-situ dust analyzer - Z. Sternovsky (Univ Colorado)
Planetary Instrument for Submillimeter-wave Surface and Atmospheric Reconnaissance and Research in Orbit (PISSARRO) - I. Mehdi (JPL)
A simple instrument suite to characterize weathering and habitability of the shallow Martian subsurface (MAHRS) - N. Renno (U Mich)
Ultra Compact Imaging Spectrometer (UCIS) - D. Blaney (JPL)

Outer Planets Assessment Group (OPAG)
White Paper on Technology

- OPAG tracks the needed technologies
- In process of revising Science Goals which will lead to a new Technology Plan
- Improvements in Power, Propulsion and Communication for Outer Planet missions needed as well as lightweight structures

OPAG website:
www.lpi.usra.edu/opag/

OPAG Technology Priorities – tracked and updated

Technologies for Outer Planet Missions:
A Companion to the Outer Planet Assessment Group (OPAG)
Strategic Exploration White Paper

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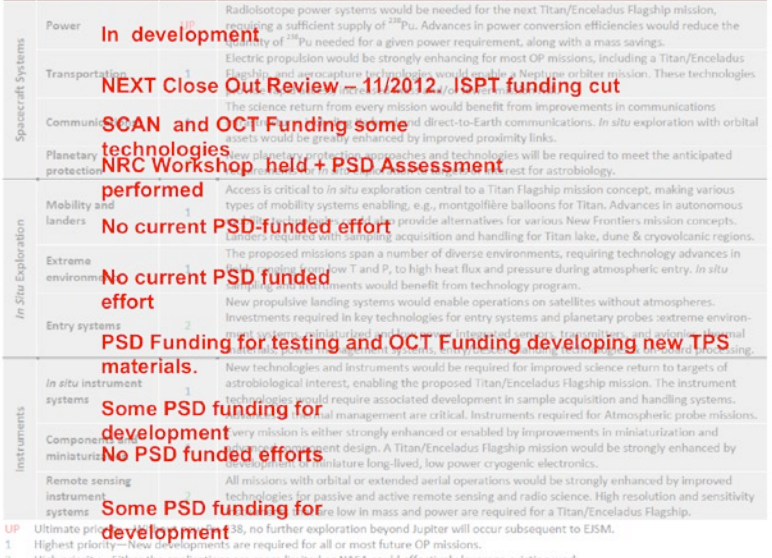

Table 1. Technology Priorities for Outer Planet Exploration.

	Technology	Priority	Comments
Spacecraft Systems	Power	UP	Radioisotope power systems would be needed for the next Titan/Enceladus Flagship mission, requiring a sufficient supply of ^{238}Pu. Advances in power conversion efficiencies would reduce the quantity of ^{238}Pu needed for a given power requirement, along with a mass savings.
	Transportation	1	Electric propulsion would be strongly enhancing for most OP missions, including a Titan/Enceladus Flagship, and aerocapture technologies would enable a Neptune orbiter mission. These technologies [illegible] increase mass and/or lower mission risk.
	Communications	[illegible]	The science return from every mission would benefit from improvements in communications [illegible] and direct-to-Earth communications. *In situ* exploration with orbital assets would be greatly enhanced by improved proximity links.
	Planetary protection	[illegible]	New planetary protection approaches and technologies will be required to meet the anticipated [illegible] requirements for *in situ* exploration to targets of interest for astrobiology.
In Situ Exploration	Mobility and landers	1	Access is critical to *in situ* exploration central to a Titan Flagship mission concept, making various types of mobility systems enabling, e.g., montgolfière balloons for Titan. Advances in autonomous mobility technologies could also provide alternatives for various New Frontiers mission concepts. Landers required with sampling acquisition and handling for Titan lake, dune & cryovolcanic regions.
	Extreme environments	1	The proposed missions span a number of diverse environments, requiring technology advances in fields ranging from low T and P, to high heat flux and pressure during atmospheric entry. *In situ* sampling and instruments would benefit from technology program.
	Entry systems	2	New propulsive landing systems would enable operations on satellites without atmospheres. Investments required in key technologies for entry systems and planetary probes :extreme environment systems, miniaturized and low power integrated sensors, transmitters, and avionics, thermal [illegible] materials, power management systems, entry/descent/landing technologies & on-board processing.
Instruments	*In situ* instrument systems	1	New technologies and instruments would be required for improved science return to targets of astrobiological interest, enabling the proposed Titan/Enceladus Flagship mission. The instrument technologies would require associated development in sample acquisition and handling systems. Advances in thermal management are critical. Instruments required for Atmospheric probe missions.
	Components and miniaturization	[illegible]	Every mission is either strongly enhanced or enabled by improvements in miniaturization and advanced component design. A Titan/Enceladus Flagship mission would be strongly enhanced by development of miniature long-lived, low power cryogenic electronics.
	Remote sensing instrument systems	2	All missions with orbital or extended aerial operations would be strongly enhanced by improved technologies for passive and active remote sensing and radio science. High resolution and sensitivity [illegible] that are low in mass and power are required for a Titan/Enceladus Flagship.

UP Ultimate priority—Without new Pu-238, no further exploration beyond Jupiter will occur subsequent to EJSM.
1 Highest priority—New developments are required for all or most future OP missions.

In development

NEXT Close Out Review – 11/2012. ISPT funding cut

SCAN and OCT Funding some technologies

NRC Workshop held + PSD Assessment performed

No current PSD-funded effort

No current PSD funded effort

PSD Funding for testing and OCT Funding developing new TPS materials.

Some PSD funding for development

No PSD funded efforts

Some PSD funding for development

Summary

- The PSD is developing a Technology Plan which will be completed during FY15. This plan will:
  - rely on input from the Decadal Survey and the more detailed work of the Assessment Groups
  - integrate the PSD, and pertinent STMD and HEOMD developments into a single coherent plan
  - include Technologies that have been identified outside those bodies and have arisen from assessment reports and workshops
  - ensure that the current technological capabilities are maintained

Posters

1. Hyperdust instrument for the detection and chemical analysis of dust particles in planetary environments and interplanetary space.
   Z. Sternovsky, E. Gruen, M. Horanyi, S. Kempf, K. Maute, F. Postberg,[*] R. Srama[*]
   LASP, University of Colorado, Boulder CO IRS, Stuttgart University, Stuttgart, Germany*

2. The Deep Space Atomic Clock – Advancing Navigation and Science
   Todd Ely, JPL

3. High Performance Spaceflight Computing (HPSC): Flexible Multicore Flight Computing for NASA's Future Space Missions
   Richard Doyle, JPL, Montgomery Goforth, JSC, Michael Lowry, ARC, Wesley Powell, GSFC, Raphael Some, JPL

4. Development of a Conformal Ablative Backshell Thermal Protection System for Outer Planetary Exploration Missions,
   R. Beck, J. Arnold, M. Gasch, M. Stackpoole, E. Venkatapathy

5. Nano-ADEPT: ADEPT For Secondary Payloads,
   B. Smith, A. Cassell and E. Venkatapathy

Posters (continued)

6. Heat Shield for Extreme Entry Environment Technology (HEEET)

   E. Venkatapathy, *D. Ellerby, M. Stackpoole, K. Peterson, P. Gage, M. Gasch, D. Prabhu, M. Blosser, C. Poteet,* A. *Beerman, M. Fowler, R. Chinnapongse and J. Feldman.*

7. Low Mass/Power Avionics Technology for Outer Planet Missions: Wireless and Wired Intra-spacecraft Communications

   K. Bruvold, Y. He, N. Lay, W. Whitaker

8. Low Mass/Power Avionics Technology for Outer Planet Missions: Advanced Power Management and Extreme Environment Electronics

   Y. He, K. Bruvold, W. Whitaker, N. Lay

9. Deep-Space Optical Communications

   Abhijit Biswas, JPL

10. EDL Data Capture Methods

    Michelle Munk. STMD

11. NEXT and HIVHAC

    David Anderson, GRC

Posters (continued)

12. Advanced Solar Arrays

Carolyn Mercer and Thomas W. Kerslake

13. High Efficiency Stirling Generators for Science and Exploration

Lee Mason

14. Precision Resonant Vibratory MEMS Sensors for Navigation and Science.

Karl Yee, Brent Blaes, Bruce Banerdt, Ken Hurst and John Gill

15. An Enhanced MMRTG for Exploration of the Outer Planets,

David Woerner

16. Parametric Analyses of an Advanced RTG

David Woerner, Jean-Pierre Fleurial, William Otting, Tom Hammel

17. The MMRTG: an Update and Primer

David Woerner

18. Ultra-light Propellant Tank

Paul Woodsmansee and Ron Reeve

Posters (Continued)

19. Cryogenic Propulsion for Planetary Science Missions

    Shuvo Mustafi, Lloyd Purves, Dewey Willis, Conor Nixon, and Matt Devine