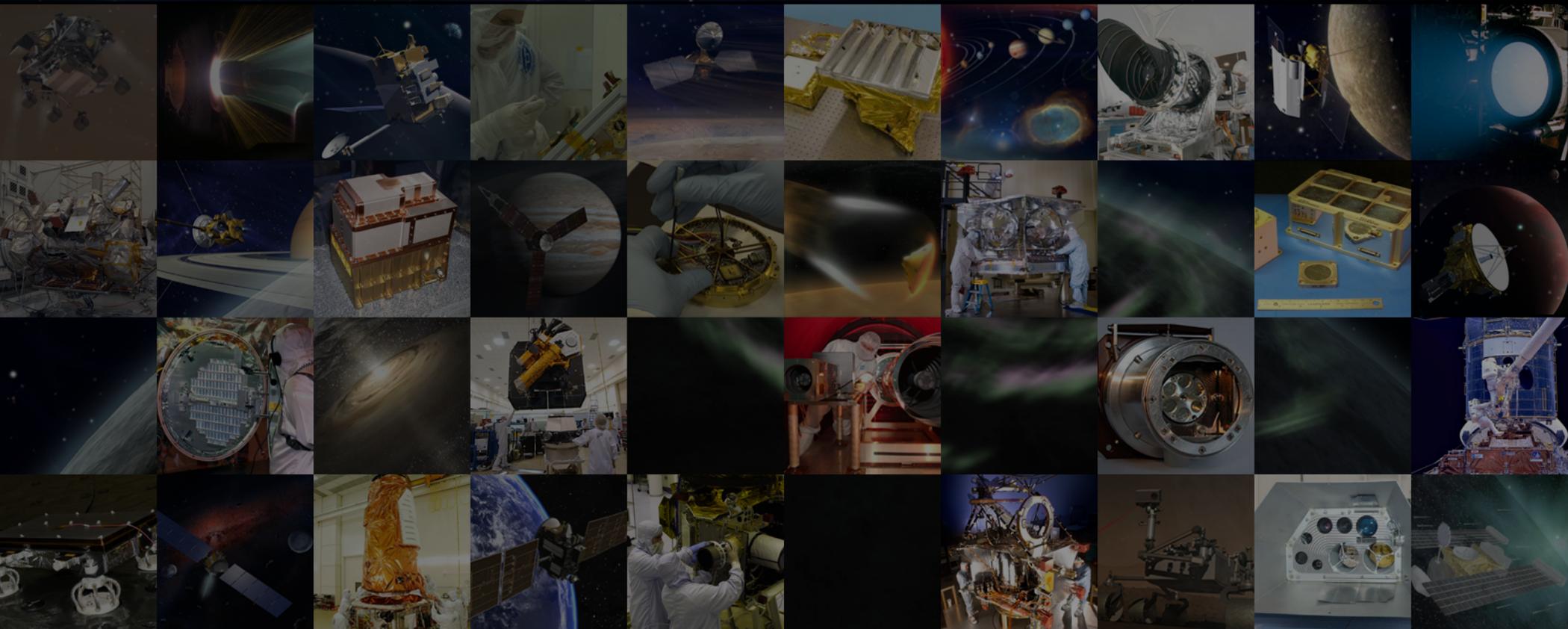




# The Planetary Science Technology Review Panel Final Report Summary



# Outline

- Panel Purpose
- Overall Summary
- Team
- Activities and Planned Products
- Assessment Approach and Methodology
- Major Issues and Observations
- Major Recommendations
- High-level Metrics
- What Next

# Purpose

- The primary purpose of the Planetary Science Technology Review (PSTR) panel and its advisors was to:
  - Assist the Planetary Science Division (PSD) of NASA Headquarters in developing a coordinated and integrated technology development plan that will better utilize technology resources
- The panel recommends process, policy, and structure changes
  - Helps answer the “How” questions
- The panel relied on the Planetary Decadal Survey to identify what technologies PSD should invest in
- The panel coordinated with the PSS SR&T review team

The full charter of PSTR can be viewed online <http://spaceflight systems.grc.nasa.gov/PlanetaryScience/>

# Overall Summary

- Performed an assessment of current PSD technology development processes
- Identified 17 major issues/observations
- Developed 11 major recommendations for PSD to consider to improve their technology development processes/policies
- Engaged the science, technology and mission communities throughout the process
- Generated a final report and summary presentation
- Supporting PSD as requested to implement recommendations
- More information and many documents can be found at <http://spaceflightsystems.grc.nasa.gov/PlanetaryScience/>

# Team

- Panel members were:

- Peter Hughes, NASA GSFC
- Tibor Kremic (chair), NASA GRC
- Brad Perry, NASA HQ
- James Singleton, AFRL

- Advisors were:

- Pat Beauchamp, JPL,
- John Clarke, Boston University
- Ralph Lorenz, APL

- NASA HQ POC was:

- Gordon Johnston

- Technical Support by:

- Waldo Rodriguez, NASA LaRC
- Linda Nero, NASA GRC

# PSTR Activities and Products

- There were three phases to the PSTR charter
  - Assessment of current content and performance
  - Formulation of ideas, recommendations, and high-level metrics
  - Reporting and Communicating
- Products were
  - Interim report for the assessment phase
  - A final report discussing the work for all three phases
  - Notional Roadmaps were de-scoped from Charter

# Assessment Phase Summary

- The primary objective of the assessment phase was to understand current content, missing content, and to identify issues/barriers and what was working well
- A second objective was to look for best practices and possible lessons that could be applied to PSD from other organizations within and outside NASA

# Assessment Methodology

- Held briefings with HQ Program Executives and Officers to understand current content and solicit observations
- Held briefings (mostly via teleconference) between the panel and selected or recommended technology development stakeholders. Looked for patterns of issues from differing views. Contacted representatives from all stakeholders
  - HQ PE/PO
  - Technologists
  - Scientists
  - Government
  - Flight Missions
  - Industry
  - Academia

# Briefing List

Date		Topic	HQ PE/PO	Flight Programs					Technology Management				Technology Tasks/Projects					
				Flagship	Discovery	New Frontiers	Mars	Other	Industry	NASA	Gov	University	Instruments	Bench Marking	Other	Comm / DSN	Notes & Comments	
1/26/2010	ARMD		x					x										
1/26/2010	AMMOS		x															
1/26/2010	ESTO									x				x	x	x		
1/26/2010	PSD Overview/Management Suborbital Investigations under Planetary Astronomy		x						x					x				
1/26/2010	Planetary Protection		x													x		
1/26/2010	AIST		x							x				x	x	x		
1/26/2010	ASTID/ASTED		x							x				x		x		
1/27/2010	Technology Investments																Budget overview	
1/27/2010	ESMD								x						x			
1/27/2010	ISP/Mars		x							x				x		x		
1/27/2010	PIDDIP		x											x				
1/27/2010	Lunar Lander		x							x						x		
1/27/2010	Outer Planets		x	x												x		
1/27/2010	Samples, Curation, Planetary Major Equip.		x							x						x	Facility and ground systems	
1/27/2010	RPS		x													x		
2/25/2010	New Millennium Program								x	JPL					x	x		
3/11/2010	Aerocapture/EDL									x						x	Agency EDL activities	
4/8/2010	Mars Technology Program									JPL				x	x	x	Tech program with multi-	
4/22/2010	MSL			x						JPL				x	x	x		
4/15/2010	Flight Missions														x		Broad experience and lessons learned	
4/29/2010	GSFC Instruments									x				x			Broad experience and lessons learned	
5/6/2010	SAM			x						x				x				
5/6/2010	MESSENGER					x								x		x		
5/11/2010	Decadal white papers								x	x			x					
5/12/2010	AFRL																	
5/11/2010	Dawn																	
5/11/2010	ESMD technology update & gnrl lessons learned Explorers & Helio Program Insights									x					x		Many new activities initiated ETDD	
5/11/2010	NASA SOMD communication plans and insight		x							x						x	Similar issues as PSD to development	
5/11/2010	NASA Chief Technology Office gnrl lessons learned Technology management lessons learned									x			x				CTO impacts to technology development	
5/11/2010	Technology management lessons learned												x					
5/12/2010	New Frontiers/Discover/Lunar Quest Program Insights															x	Lunar program has technology development. Other programs impacts	
5/12/2010	SBIR/STTR process and options		x														Low TRL	
5/20/2010	Technology development at APL								x	APL								
5/20/2010	Scientist view of NMP																	
5/20/2010	SMD POC to OCT role		x														Interfaces to OCT	
5/27/2010	LASP (Academic views / Suborbital roles)													x			x	
5/27/2010	Academic views /Technology																Spacecraft subsystem technology	
6/10/2010	Technology management								x					x				
6/10/2010	New Horizons								x	APL				x				
6/17/2010	Honeybee Robotics									x							x	
6/17/2010	Aerospace Corp									x						x	Small business experience	
written input	UC Berkley																	
				Special Topics														
1/20/2011	JPL/TRL									JPL							x	ESTO TRL tool
1/27/2011	JPL/Databases									JPL							x	Databases of the past
written input	TRL tool									JPL							x	NMP TRL 'handshake' process
3/15/2011	Tech dev. /Decadal survey																x	Recomm/decadal survey
6/16/2011	System Engineering & Infusion									JPL							x	Recomm/decadal survey

# Major Issues / Observations

- Observations/Issues were grouped into four categories
  - Strategic - Issues that relate to an overall Planetary technology strategy
  - Process/Structure – Issues that relate to technology program processes and supporting institutional structures
  - Resource - Issues that relate to resources made available for technology development activities
  - Culture/Communication – Issues that relate to the cultures and communication among space projects teams, the supporting technologists, their respective institutions, and external stakeholders

# List of Major Observations and Issues

<b>Issue Number</b>	<b>Observation/Issue</b>
<b>Strategy</b>	
S-1	No overall strategy or accountable manager
S-2	No clear path for technology maturation from TRL 0-9
S-3	Limited engagement of other NASA OCT, ESMD, and ESD technologists
S-4	Technology should be perceived as more than just hardware development
S-5	Efforts by external stakeholders are not worked into PSD strategy
<b>Process/Structure</b>	
P-1	Programs are not consistent and do not have clearly defined processes
P-2	Technology managers are overloaded and often oversee flight projects
P-3	Inconsistent and inaccurate TRL and heritage assessments
P-4	Limited processes that encourage interaction between stakeholders
<b>Resources</b>	
R-1	Technology budgets are unpredictable
R-2	Technology budgets are insufficient
R-3	Inadequate leveraging of others' investments
<b>Culture/Communication</b>	
C-1	Technology investments have not yielded all the benefits they could have
C-2	Inadequate communication (in & out)
C-3	Projects are too risk averse to new technology
C-4	Tenuous commitment by top management
C-5	Need to better sustain capabilities

# Major Observations of Current Programs

## Strategic

\*S-1) There is no comprehensive technology development strategy and no accountable owner to set priorities and increase performance and coordination

S-2) There is no clear path for technologies through the existing programs to mature from TRL-0 to TRL-9. Specifically, there is an issue with funding at mid-TRLs (valley of death) and there are limited mechanisms within PSD for sub-orbital test flights or technology demonstration missions

\* S-1 is the top priority issue in the strategy category, S-2 is the second priority in the category and so on

# Major Observations of Current Programs

## Strategic

S-3) PSD does not adequately engage the OCT, ESD, ESMD, and others as appropriate to ensure coordination and effective leveraging of plans and activities

S-4) Technology is more than just hardware. Technologies that address integration, ease of use, testing capability, and system level issues are not adequately considered.

S-5) PSD strategy does not adequately factor in the technology development efforts and plans of universities and other external organizations

# Major Observations of Current Programs

## Process/Structure

- P-1) The technology related decision making, planning, implementing, and review processes are not well defined and often inconsistent among programs
- P-2) Technology management is scattered across busy headquarters program executives and officers that also have other competing responsibilities
- P-3) The heritage and TRL assessment are inconsistent and inaccurate
- P-4) There are limited processes that encourage strong and early interactions between technologists, missions, and scientists

# Major Observations of Current Programs

## Resources

R-1) Technology budgets are unstable and unpredictable. This makes technology maturation, as well as sustaining skills and capability, challenging and adds risk to overall mission success

R-2) Previously identified technology priorities have not been adequately funded to make progress

- » E.g. the gap to infusion, extreme environments, planetary protection, sample return, and others
- » 2008 CASSE report (solar system decadal mid-term)

R-3) There is inadequate leveraging of technology investments made by other NASA technology programs, agencies, the SBIR/STTR programs, and others

# Major Observations of Current Programs

## Culture / Communication

C-1) Technology investments do not yielded the benefits they could have

- » Better documentation and accessibility to technology is critical to ensure broader use and to maximize investment potential
- » There is no easy way to comprehensively search and learn about technologies PSD is developing, or has made available

C-2) There is inadequate communication and interaction among all stakeholders (scientists, technologists, mission teams, other SMD divisions like the Earth Science Divisions, Centers,...). This negatively impacts technology planning, development, and infusion

# Major Observations of Current Programs

## Culture / Communication

C-3) Projects are too risk averse to new technologies

C-4) Tenuous top-level sustained commitment for technology

C-5) Technology capability and heritage is lost during gaps in flights or lapses in funding for technology programs

# Major Observations of Current Programs

## Culture / Communication

C-3) Projects are too risk averse to new technologies

C-4) Tenuous top-level sustained commitment for technology

C-5) Technology capability and heritage is lost during gaps in flights or lapses in funding for technology programs

# Recommendation Categories and Formulation Methodology

- Solution ideas to the issues were solicited via the PSTR website, comments at various meetings and venues, from the panel and advisors, and a web based survey
- The panel and advisors reviewed the inputs received
- The civil servant panel generated draft recommendations which were fed back to the communities for comment
- The panel reviewed the feedback and generated the final recommendations
- Major Recommendations were grouped into five categories
  - Same categories as issues, but added Management category

# Summary of Major Recommendations

<b>Major Recommendation</b>
<b>Management</b>
MR-1) Establish a dedicated Director position with overall responsibility for PSD technology
MR-2) Establish a small supporting program office
<b>Strategy</b>
MR-3) Develop a comprehensive strategy for PSD technology
MR-4) Strategically allocate resources (guidelines are provided by PSTR)
MR-5) Actively pursue a strategy of leveraging opportunities within and outside NASA
<b>Process</b>
MR-6) Develop a more consistent and accurate TRL assessment process
MR-7) Develop clear, transparent, and consistent decision and review processes
MR-8) Develop a more structured and rigorous process to create interactions between technologists, scientists, and missions
<b>Culture and Communication</b>
MR-9) Develop an overall communication plan and technology database
MR-10) Foster a culture that advocates for and defends technology
<b>Resources</b>
MR-11) Dedicate stable funding at the higher end of the decadal suggested range - 8%

# Recommendations - Management

**MR-1)** Establish a Technology Program Director (TPD) position who reports directly to PSD Director. Consolidate technology management under the TPD as much as practical\*. TPD responsibilities include:

<b>Responsibilities of the Technology Program Director</b>
<b>Strategy /Leadership</b>
Develop and maintain an overall PSD technology strategy with clear priorities
Formulate technology budgets and plans
Develop a strategic technology communication plan and act as POC for PSD technologies
Integrate PSD technology needs and efforts into a coordinated roadmap
Serve as the Program Executive of the supporting program office
Advocate for technology needs and communicate accomplishments and highlights
<b>Implementation</b>
Develop and oversee decision processes for priority setting, gate keeping, and program reviews
Ensure the integrity of the selection processes
Ensure all technologies are either making steady progress toward maturation, being infused, or getting terminated
Ensure that the proper technology related data and status is easily available to the right person, at the right time, and at the level of detail needed.
Oversee the processes that leverage and/or influence stakeholders within, or outside, NASA
Ensure all PSD technology efforts are traceable to PSD science goals

\* In special cases where a *dedicated* program executive and program office already exists it may be more appropriate to keep the existing structure. In that case the TPD can provide higher level guidance and coordination.

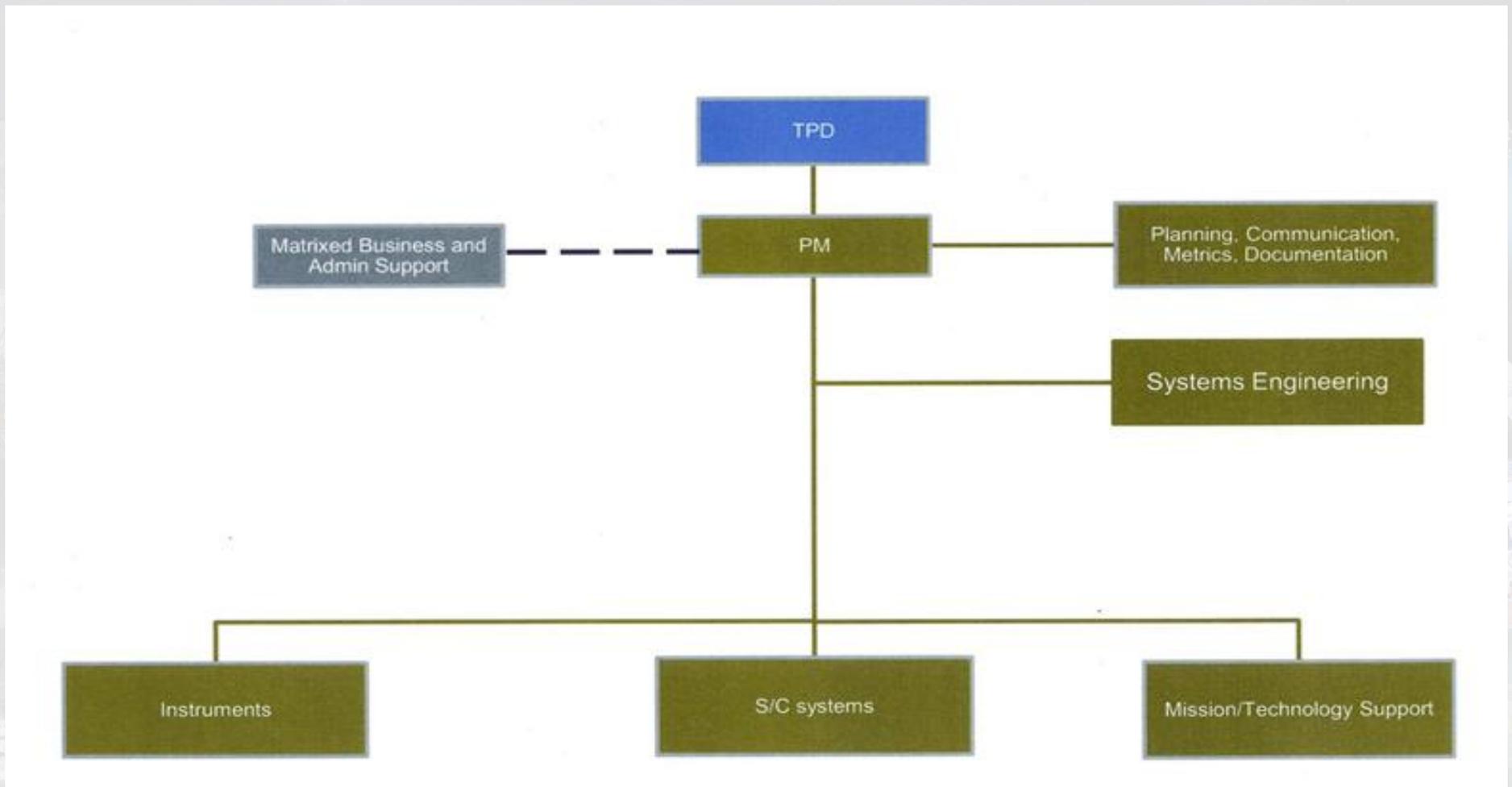
# Recommendations - Management

## MR-2) Establish a small Planetary Technology Program Office to assist the TPD and PSD in implementing and managing technology efforts

- The program office should coordinate the expertise and leadership in the areas of a) instruments, b) spacecraft systems, c) mission / technology support systems, and in d) planning, documenting and communications. Include a strong system engineering position with mission experience
- The program office will assist the TPD in
  - » implementing the overall strategy
  - » developing roadmaps
  - » developing tools for capturing, communicating, and maintaining technology data
  - » implementing reviews and workshops
  - » a host of other duties on behalf of the TPD

# Recommendations - Management

## Notional Program Organization Chart



# Recommendations - Strategy

## MR-3) Develop a comprehensive overall technology strategy

- All the needed elements of a strategy were not developed by the panel, but a simple tool was offered that captures PSD technology in dimensions of maturity and area. The tool can assist PSD in balancing and prioritizing resources and program content

Technology Area	Critical Capabilities/ Facilities, etc	TRL 0-1	TRL 2-3	TRL 4-6	TRL 7+	Recommended Total Percent
Instruments						
Spacecraft Systems						
		System Level Maturity Low to High				
Mission Support						
Planning/ Documentation/ Communication						

- Mission support is inclusive of non-hardware technologies, such as astrodynamics, mission design and planning tools, unique facilities, etc.
- PSD has unique environmental and technology needs and must step up to initiating unique, long-range, and/or high-risk technologies

# Recommendations – Strategy

MR-4) Suggested resource balance/allocation as a percentage of total PSD technology investments

Technology Area	Critical Capabilities/ Facilities, etc	TRL 0-1	TRL 2-3	TRL 4-6	TRL 7+	Recommended Total Percent
Instruments	----	7	8	12	8	35
Spacecraft	-----	5	10	12	8	35
		System Level Maturity Low $\longrightarrow$ High				
Mission Support	5	2	5	8	NA	20
Planning/ Documentation/ Communication	----	2	2	3	3	10

# Other Strategy Recommendations related to technology content and balancing

- Technology decisions need to be guided by missions studies that are tied to decadal survey priorities. These need to be thorough enough to define technology needs, and development requirements for those technologies
  - Ensure technologies are linked to priority missions
  - Leverage the decadal survey studies as applicable

# Recommendations – Strategy

MR-5) Given the constant pressure on technology resources, PSD should adopt a strategy that aggressively seeks leveraging opportunities within, and outside, to NASA

The next few charts discuss tactics for leveraging

However there is a caution,

- » Realize that additional PSD investments will likely be required beyond what partners will co-fund
- » Leveraging is only a tool to achieve better or more efficient technology develop. If it hinders development efforts in particular cases it should not be utilized

# Recommendations – Leveraging / Collaborating – With NASA

- Implement frequent and routine meetings, meetings timed to impact PPBE or key technology solicitations by other NASA orgs., and coordination discussions with others such as SCAN and OCT
  - Review the technology plans, portfolios, and implementation progress of others to coordinate effective and efficient leveraging
- The TPD is responsible for proactively pursuing collaborations and leverage technology development opportunities with SBIR, ESD, OCT, ESMD, SOMD, DOD, etc. in coordination and compliance with SMD and NASA policies and procedures

# Recommendations – Leveraging / Collaborating - University

- Strengthen university participation by creating opportunities for training future scientists and engineers to address planetary technology priorities
  - Participation can be through consortia, institutes, etc.. Other mechanisms for interaction may include formation of teams focused on solving a specific problem, specialized workshops, sharing of lab facilities, etc.)
- Initiate a workshop, inviting universities, where general PSD needs and opportunities are outlined and attendees have an opportunity to exchange ideas, network, and engage students in projects
- Establish ties with universities to support graduate students for technology development efforts (e.g. use of GSRP for work on technology projects)
  - Timescales for technology awards should be long enough to accommodate needs of graduate students

# Recommendations – Leveraging / Collaborating – Industry & Agencies

- Knowledge of the contacts and synergistic activities of others should be consolidated, documented, and made available to any technology program across PSD and NASA
  - The objective is to better utilize Centers' and other organizations' (e.g. APL, SWRI) relationships and expertise
- External stakeholders (e.g. industry, other domestic and international agencies) should be engaged to address joint needs and create synergistic efforts
- Import technologies into PSD whenever practical

# Other Recommendations – Strategy

- Technology Infusion on future PSD solicitations:
  - Continue, and strengthen, the use of incentives (as was used on recent Discovery and New Frontiers opportunity announcements)
  - Encourage infusing technologies even when an incentive is not offered
    - » Demonstrate tolerance for new technologies (e.g. specify the # of new technologies that can be included in a solicitation to communicate risk tolerance to proposers)
  - Leverage sub-orbital platforms for technology demonstration opportunities

# Recommendations - Process

## MR-6) Develop a more consistent and accurate TRL assessment process and communicate that to the community

- The process needs to be standardized and rigor increased all the while considering the application(s)
  - » Difficult challenge due to the variety of planetary environments and the mission selection processes
- a) Develop a standardized TRL assessment process for PSD technologies, managed at the TPD/program level (leverage new agency TRL standardization initiatives as practicable)
- b) The assessment process should include a simple approach, perhaps leveraging existing tools and/or questionnaires, to assess low TRL levels and evaluate annual maturation progress\*
- c) For critical or maturing technologies, an individualized development plan should be created identifying specific tests/analysis and the test levels to be completed to claim a TRL\*

\* It is expected that all TRL assessments will include interactive discussions between the TPD/program, the technologists, and if available, missions users.

# Recommendations - Process

Assessing TRL for technologies developed for competed missions and yet unknown environments:

- PSD should develop one or more “standard” reference missions that bound representative environments for destination classes. These should be made available to the science and technology communities as pseudo requirements during technology development and testing. Once mission parameters are known delta activities can be undertaken, if needed
  - » The decadal studies may be a good starting point for developing enveloping requirements
- When specific mission requirements are not known, TRL claims will be assessed against the environment set(s) released through the PSD process described above.

# Recommendations - Process

MR-7) Define and implement transparent decision making and review processes across all PSD technology programs, which include

- Discriminating and well-advertised decision factors
- Well-defined planning, review, and selection processes
- Decisions should be clearly traceable to strategic objectives
- Processes should be consistent with 7120.8 and other applicable NASA guidelines
- Benchmarking of successful technology programs

# Recommendations - Process

## Establish a structured review of the overall technology program

- On a regular basis convene an independent performance review board to assess technology program performance
  - » Purpose is to assess and improve implementation performance – not to advise on content or resource balancing
  - » Provide comparative assessments with external SOA in technology management
  - » Board comprised of technologists with broad knowledge, systems engineering experts, technology management experts, scientists, and specialists related to content
  - » Reports to TPD

# Recommendations - Process

MR-8) Develop a more structured and rigorous process to create early and close interactions between technologists, scientists, and missions

- Accomplish this through a combination of:
  - » Deliberate assignments to study and review teams
  - » Supporting targeted inter-center details
  - » Emphasize this desire in project management documents & handbooks
  - » Increased training, particularly in systems engineering
  - » Encourage scientists to consider a rotation on a mission or technology project team, and technologists to a mission team
- *Several of the communication recommendations will also foster closer interactions*

# Recommendations – Documenting/ Communicating

## MR-9) Develop an overall communication plan and technology database

- Part of that communication plan should be technology (e.g., instruments) or mission-application focused (e.g., MSR, outer planets) workshops featuring PSD technologies where interested parties and stakeholders are invited
- Encourage exchanges and inter-center meetings to raise awareness of capabilities and SOA
- Develop and actively maintain a comprehensive technology database
- Recipients of technology funds must regularly populate technology database with current status and present their work at relevant workshops, and in literature

# Recommendations – Documenting/ Communicating

Technology projects should be funded to, and then required to, document their work in a database. They should also be required to deliver a final report that is comprehensive enough that a potential user can evaluate technology characteristics, readiness, and applicability to the user's needs

- Final reports should be made openly available
  - » If ITAR or confidentiality issues prevent open access, the final report should document open information publically and sensitive information on a secure site for use by NASA or other approved US entities only.
- Projects should document a list of key contributors, their roles and responsibilities, and last known contact information
- The technology database should be structured to also become a portfolio management tool if possible

# Draft Recommendations – Documenting/ Communicating

- A PSD Technology website should be developed and maintained
  - Include all the basic information on all PSD technologies being developed including contact information and links to the other relevant websites
  - Structure the site so a search engine could be used by potential users to locate relevant technologies
- In addition to technologies, important test facilities should also be catalogued and the information made readily available
- Documenting and communicating tools should be tailored to a variety of users
  - Easy search tool for non-technical users and more detailed sections for references and technologists

# Recommendations – Culture Advocacy

## MR-10) Foster a culture of advocating for and defending technology

- PSD leadership should strengthen technology advocacy
  - » Include technology advocacy in PSD leadership's Employee Performance Plans
  - » Influence senior NASA leadership to support technology plans & efforts
- The TPD should advocate technology needs to the PSD division and its' leadership
- Encourage NASA assessment and advisory groups to comment on technology needs, progress, and infusion

# Recommendations – Culture Risk Aversion

- Take active steps to reduce aversion to new technology
  - Improve the TRL assessment processes to better estimate development cost and schedule - this will help provide more confidence in adopting new technologies
  - Continue providing incentives (e.g. ASRG and NEXT on Discovery AO) but also strengthen them so more projects consider adopting new technologies
  - Offer more opportunities to fly new technologies such as tech demos and sub-orbital missions
  - Explore making changes to the mission acquisition approaches; offering a longer and better funded phase A for technology maturation and mission concept refinement

# Recommendations – Resources

MR-11) PSTR fully agrees with the emphasis placed on technology by the Planetary Decadal Survey

- “The committee unequivocally recommends that a substantial program of planetary exploration technology development should be reconstituted and carefully protected against all incursions that would deplete its resources. This program should be consistently funded at approximately 6-8% of the total PSD budget”
- The first priority is to commit to, and defend, a stable budget.

# Recommendations – Resources

We acknowledge the decadal survey's recommendation that 6-8% of the total PSD budget be devoted to technology - However;

- Given the unique nature of PSD missions and the limited number of technology providers / sponsors for those technologies
  - Given the decadal did not include resources for low TRL PSD developments and mission studies
  - Given PSTR recommends a stronger investment in non-hardware technology development elements (e.g. testing and integration technologies, mission planning technologies, etc.)
- 
- **We therefore believe that 8% is needed to adequately fund PSD technology needs**

# Other Recommendations – Resources

- The resources that are book-kept in technology budget lines should not be used for non-technology needs
  - » Artificially reduces efficacy and increases cost perceptions
- *A priori* - Develop a prioritized de-scope plan
  - And a minimum funding floor for key/strategic technologies
- Maintain healthier protected reserves at the division level to avoid raiding technology programs
- Provide funding for up to 4-5 years, as appropriate, for successfully reviewed technology programs and tasks.
- Apply the agency mission reserve policy to higher TRL level technology projects where readiness may impact mission success

# Other Recommendations – Sustaining Capabilities

- Minimize loss of capability by maintaining consistent funding in the critical areas.
- Technologies needed for future missions, but not actively worked, should be identified and the reactivation cost/schedule tracked
- PSD should work with Centers and other technology providers to understand and preserve the core capabilities needed to achieve PSD science goals
- Plan that technology developments, improvements, and sustainability may go beyond first flight.
  - E.g. Technology may be used in a different environment and may require additional investment

# High-Level Metrics

- PSTR developed high-level metrics (goals) for the overall technology program. The objective of the high-level metrics is to provide PSD a relatively simple way to assess overall program success
- PSTR did not attempt to create detailed performance metrics or specific metrics for specific technologies
  - » Will be developed by the TPD and supporting program
- Metrics address several areas including Technology Maturation and Infusion, Leveraging, Communicating, and Programmatic

# Summary of High-Level Metrics

Metric/Goal	Metric/Goal
<b>Technology Maturation and Infusion</b>	
G-1a	10-30% of TRL 1-2 technologies make it to TRL 3 (Adjust metrics over time)
G-1b	40-60% TRL 3-4 technologies make it to TRL 6 (adjust over time)
G-1c	Infusion to flight for technologies that achieve TRL 6 should be > 80%
G-2	Develop a maturation schedule for each technology and ensure the technology is making the progress it should. Review on an annual basis
G-3	Each technology should have specific technical requirements and maturation milestones to achieve. Review on an annual basis
<b>Leveraging</b>	
G-4	Attract leveraging support of technologies suitable to PSD and track it as a percentage of total PSD technology investment. Work towards developing a specific goal based on initial experiences
<b>Communication</b>	
G-5	Implement at least one PSD technology focused workshop annually
G-6	All technology development efforts are described in conference proceedings or peer reviewed publications and results are documented in a standard final report
<b>Programmatic</b>	
G-7a	Establish a responsible technology program director (TPD) by end of FY12 and the supporting office/structure by end of FY13
G-7b	Create, document, and communicate an overall technology strategy by middle of FY13
G-7c	Establish a TRL assessment process for PSD technology developments and identify representative environments that can become pseudo requirements for technology development projects by middle of FY13
G-7d	Roadmaps for all technology developments are developed and linked to the overall strategy, the decadal survey, and expected mission needs by end of FY13
G-8	Timely and adequate funds are provided in needed technology developments. The goal is to fund technology efforts at levels needed to achieve desired readiness as identified in the respective technology's roadmap.

# High-Level Metrics – Technology Maturation

- PSD should strive to successfully mature roughly 1 in 4 low TRL technologies to TRL 3 -- to successfully mature roughly 1 in 2 technologies that have reached TRL 3 to TRL 6 -- and successfully infuse at least 4 of 5 technologies that have reached TRL 6
  - These goals define a general “funneling” that is required for a balanced program that includes low-TRL high-payoff efforts yet maintains enough resources for the most promising technologies to be matured to infusion
- Each technology must have specific technical requirements to work toward and a tailored roadmap to guide maturation and assess progress

# High-Level Metrics – Leveraging and Communications

- Establish a goal for how much external funding to leverage for technology development. The goal should be described as a percentage of the overall PSD technology investment
  - PSTR does not have enough information to define a specific percentage at this time. This will be left to the TPD
- The TPD and supporting program should implement a minimum of one technology focused workshop annually. Additional workshops are appropriate for more focused technologies or special topics
- Capture and report **all** technical capabilities and accomplishments. Technology advances should be presented at relevant conferences and in peer reviewed journals. **All** tasks should have a final report.

# High-Level Metrics – Programmatic

- Programmatic metrics are intended to encourage timely implementation of technology program improvements. Whatever variant of the PSTR recommendations are implemented they should be done in a timely manner. The goals are:
  - The TPD function fully implemented by end of FY12
  - Complete development of a comprehensive and detailed technology strategy by mid FY13. Technology roadmaps completed by end of FY13
  - Establish the PSD TRL assessment process by mid FY13
  - Program office function being fully implemented by end of FY13. Some support is needed sooner to develop and communicate the strategy, technology roadmaps, and TRL assessment process

# High-Level Metrics – Programmatic

- Establish funding in accord with Decadal Survey and PSTR recommendations as soon as budget processes allow. Maintain / defend those resources as recommended by the Decadal Survey and PSTR
- The technology strategy and roadmaps must be consistent with the planned budgets

# What Next

- PSTR will continue to share results with the impacted communities
- PSD has begun developing an implementation plan. The next level of detail to the recommendations provided by PSTR