NASA: PAC

Review of NASA's Planetary Science Division's Restructured Research and Analysis Programs

Steve Mackwell

February 21, 2018

Charge to the Committee

The Space Studies Board will convene an ad hoc committee to examine the program elements of NASA's Planetary Science Division (PSD) Research and Analysis (R&A) programs, as they currently exist following restructuring, for their consistency with past advice from the Academies. In conducting its review, the committee will address the following questions:

1. *Are the PSD R&A program elements appropriately linked to, and do they encompass the range and scope of activities needed to support the NASA Strategic Objectives for Planetary Science and the Planetary Science Division Science Goals, as articulated in the 2014 NASA Science Plan?*
2. *Are the PSD R&A program elements appropriately structured to develop the broad base of knowledge and broad range of activities needed both to enable new spaceflight missions and to interpret and maximize the scientific return from existing missions?*

In conducting its task, the committee will:

- *Not examine the PSD R&A programs as they were prior to the restructuring;*
- *Conduct its review in the context of current budgetary realities that have differed from projections assumed prior to the release of the most recent planetary science decadal survey; and*
- *Not comment on the strategic science goals and objectives of PSD, SMD, or NASA.*

Committee Membership*

Joe Alexander	NASA (ret.)/NRC
Mike A'Hearn	U. Maryland
Joe Burns	Cornell
Rick Carlson**	Carnegie
Nobu Shimizu (consultant)	WHOI
Larry Esposito	U. Colorado / LASP
Scott Hubbard	Stanford
Torrence Johnson	JPL
Peter Kelemen	Columbia U.
Makenzie Lystrup	Ball Aerospace
Steve Mackwell (Chair)	USRA
Juan Perez-Mercader	Harvard
John Rummel	McGill U.
David Smith	NRC
Charlie Harris	NRC
Dionna Williams	NRC

** Committee members could not be current recipients of NASA PSD R&A funding*
*** Only participated in first meeting – conflict of interest identified*

Meetings:

National Academies, Washington, DC: May 12-13, 2016
Keck Center, Washington, DC: August 16-18, 2016
Woods Hole, MA: September 21-23, 2016

We heard from:

Background:

NASA HQ: charge to the study and current status of R&A

Len Fisk: Academies *"An Enabling Foundation for NASA's Earth and Space Science Missions"*

Mark Sykes: Planetary Science Subcommittee's Greeley-Sykes Report

Community perceptions:

AG chairs: LEAG, SBAG, OPAG, CAPTEM, MEPAG, MAPSIT, VEXAG, PSS

NASA Science Center Leads: Ames, Goddard, Marshall, JPL, JSC

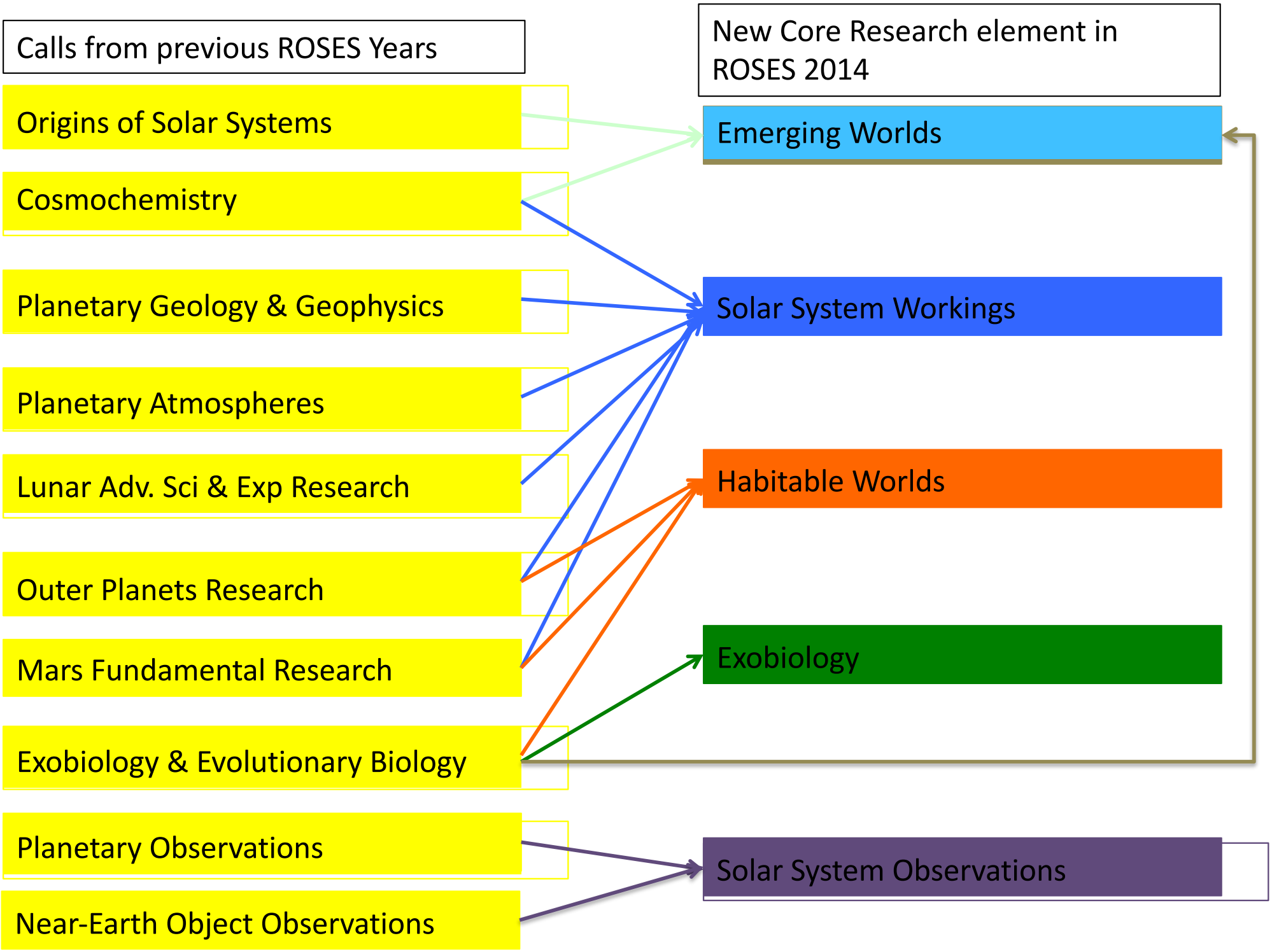
PSD R&A Program Elements*

2014 Reorganization of Planetary R&A

- Predominantly to Core Research; Core Technology had been previously reorganized; data analysis programs change as needed
- First announced in ROSES 2014
- First funded award used FY15 funds (around 30% of $FY15 funded under new program; 66% of $FY16)

Core Research	Strategic	Focused
Emerging Worlds	PDART (data archiving, tools)	LDAP (lunar data analysis)
Solar System Workings	PSTAR (analogues)	CDAP (Cassini data analysis)
Habitable Worlds	Exoplanets (joint with Astro)	
Exobiology	DDAP	
Solar System Observations	NFDAP	
Core Technology	***LARS – Laboratory Analysis of Returned Samples***	
MatISSE	MDAP	
PICASSO	Planetary Protection	
Planetary Major Equipment		

* *Program elements per 2016 ROSES*


Calls from previous ROSES Years
New Core Research element in ROSES 2014
Origins of Solar Systems
Cosmochemistry
Planetary Geology & Geophysics
Planetary Atmospheres
Lunar Adv. Sci & Exp Research
Outer Planets Research
Mars Fundamental Research
Exobiology & Evolutionary Biology
Planetary Observations
Near-Earth Object Observations
Emerging Worlds
Solar System Workings
Habitable Worlds
Exobiology
Solar System Observations

Answering the questions

In order to answer the 2 questions we needed to understand how PSD has implemented the new program in order to address:

- Whether the implementation strategy has been optimized under the new program structure to support linkage of R&A supported activities to NASA Strategic Objectives for Planetary Science and the PSD Science Goals;
- How strategic funding decisions are made both within and between R&A program elements; and
- How issues of balance are dealt with under the more encompassing program elements - the challenges have changed
  - Balance includes: target bodies, sub-disciplines, interdisciplinary versus disciplinary research, risk/payoff level, innovative versus routine activities, PI career level, diversity, etc.
  - Balance is needed both within R&A program elements and between program elements

Process Recommendations

With respect to the procedures followed by PSD in the implementation of the current program, the committee recommends the following:

***Recommendation 2-1*:** In conducting scientific peer reviews of research proposals, NASA PSD should recruit several (at least two or three) external (mail) reviewers well in advance of panel reviews. These reviews are critical to a fair and effective proposal evaluation process, particularly when the review panels have a more interdisciplinary character. The panel chair and group chiefs, if recruited early, can take the lead in identification of appropriate external reviewers.

Recommendation 2-2: NASA PSD should expeditiously complete establishment of the process for reconsideration of proposal selection decisions, develop and implement a formal mechanism to track debriefing and reconsideration requests across program elements, and inform the community about the process. The statistics collected in this way can provide the planetary science community with greater confidence that NASA has appropriate checks and balances in the selection process.

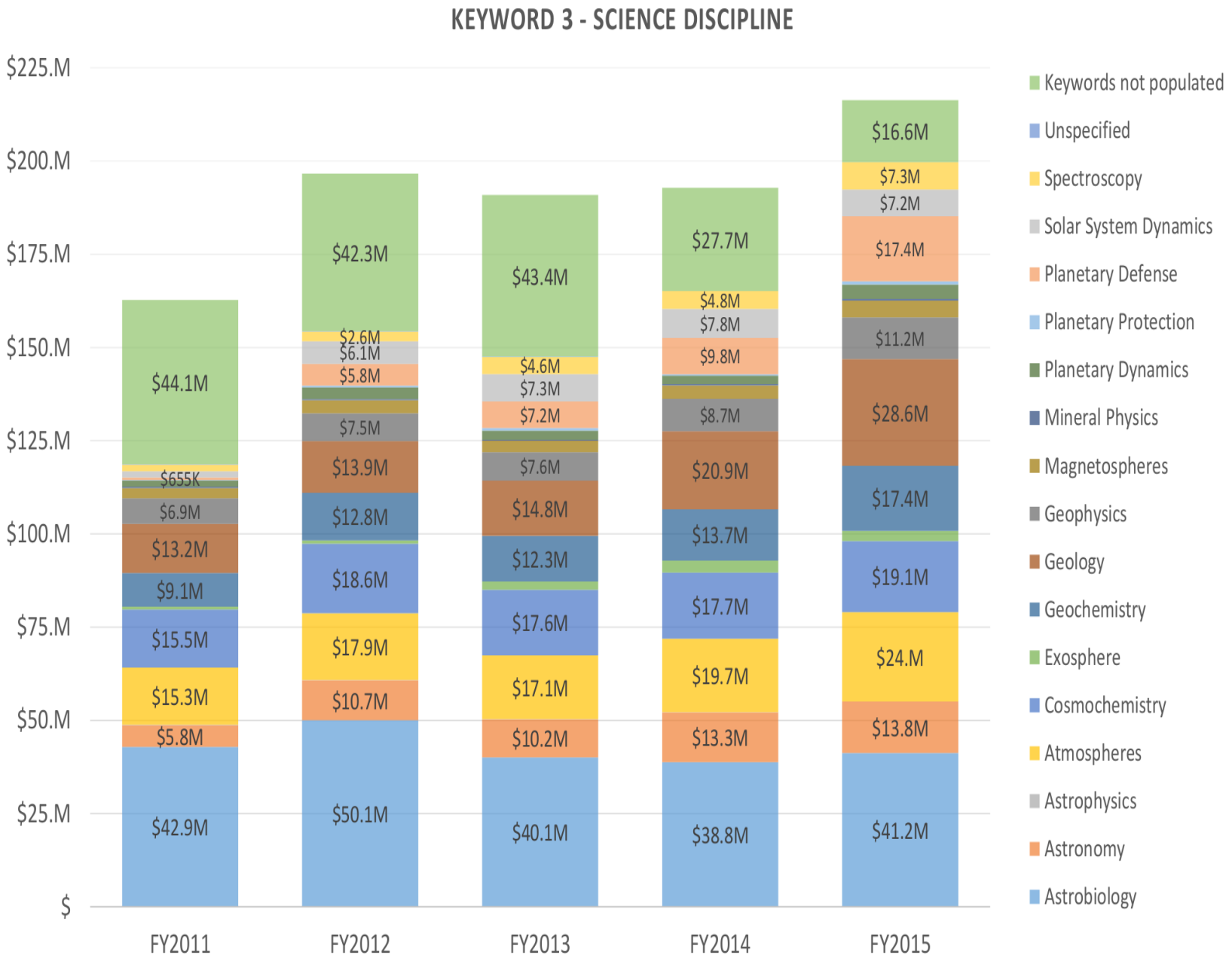
Question 1:

Are the PSD R&A program elements appropriately linked to, and do they encompass the range and scope of activities needed to support the NASA Strategic Objectives for Planetary Science and the Planetary Science Division Science Goals, as articulated in the 2014 NASA Science Plan?

How the Core Research Programs were designed by PSD

The five new core programs are aligned with PSD's goals/objectives.

Explore and observe the objects in the solar system to understand how they formed and evolve	Emerging Worlds
Advance the understanding of how the chemical and physical processes in our solar system operate, interact and evolve	Solar System Workings
Explore and find locations where life could have existed or could exist today	Habitable Worlds
Improve our understanding of the origin and evolution of life on Earth to guide our search for life elsewhere	Exobiology
Identify and characterize objects in the solar system that pose a threat to Earth or offer resources forhuman exploration	Solar System Observations



Note that FY2014 was fully in the previous program structure, while only about 30% of funding for FY2015 was under the new program element structure

Question 1: General Conclusions

Question 1: *Are the PSD R&A program elements appropriately linked to, and do they encompass the range and scope of activities needed to support the NASA Strategic Objectives for Planetary Science and the Planetary Science Division Science Goals, as articulated in the 2014 NASA Science Plan?*

Do they align well?
YES
Did any subdiscipline or target body/group get lost in the reorganization?
NOT THAT WE CAN SEE; there is no clear evidence of any substantial change in distribution of funds by discipline or target body
Do the new program elements and associated processes encompass the range and scope of activities needed…?
Interdisciplinary science, and high-risk/high-payoff research do not necessarily review well. There are some advantages to the new program, but there is still work to do.
What about program balance (distribution of funding across sub-disciplines within a program element, and across program elements)?
Seems to be working, but needs to be watched and evaluated periodically
Transparency between NASA and the science community?
Clearly needs work, despite PSD efforts

Mapping to Goals Recommendations

With respect to how effectively the current R&A program elements align with PSD science goals, and whether specific research areas or sub-disciplinary groups that are critical to NASA's mission are not supported appropriately in the current program, the committee made the following recommendations:

Finding: The new R&A structure is properly aligned with scientific priorities of the decadal survey and Planetary Science Division's 2014 science goals and is consistent with the recommendations of the 2009 National Research Council report *An Enabling Foundation for NASA's Earth and Space Science Missions*.

Recommendation 3-1: An appropriate mechanism is needed to ensure that high risk/high-payoff technology and research activities can receive appropriate consideration during the review process.

Recommendation 3-2: A formal assessment by NASA of how well the program structure and funding are aligned with Planetary Science Division's Science Goals should be conducted at least every 5 years.

Question 2:

Are the PSD R&A program elements appropriately structured to develop the broad base of knowledge and broad range of activities needed both to enable new spaceflight missions and to interpret and maximize the scientific return from existing missions?

Question 2: General Conclusions

Question 2: Are the PSD R&A program elements appropriately structured to develop the broad base of knowledge and broad range of activities needed both to enable new spaceflight missions and to interpret and maximize the scientific return from existing missions?

Is the current program structured to prepare for future missions?
In general yes, though science involving surveys of planetary objects in preparation for future missions does not usually fare well in review.
Is the current program optimal for scientific return from past and current missions?
In general, yes.
Are the current technology programs sufficient to prepare for future missions?
Likely greater priority is needed to these programs.
Is there a timeline problem? (R&A – 3 years, missions – 6+ years, sample return – 10+ years)
There is a concern about maintenance of facilities and expertise from R&A funding on mission timelines. Long lead times are needed for receiving and curation of returned samples (cryogenic / astrobiological samples)

Mapping to Missions Recommendations

With respect to whether the current R&A program adequately supports existing missions and prepares the way for future missions, the committee recommended the following:

Finding: In general, the structure of the program elements will allow NASA PSD to prepare for future spaceflight missions and to maximize science value from existing missions. While there is room for improvement, no recommended mission concept identified in the planetary science decadal survey remains out of reach.

Finding: In addition to scientific research, PSD's planetary R&A supports the development of technology and instrumentation that enables future mission investigations. The variety of current technology and instrument programs is intended to address the breadth of technology development needs for the planetary sciences. However, future technically challenging missions recommended in the 2011 planetary science decadal survey justify enhanced priority for appropriate technology development.

Finding: NASA has not demonstrated that its PSD R&A programs can enable future spacecraft missions that will return samples of biological interest from Mars or cryogenic samples from icy bodies and receive, curate, and analyze them on Earth.

***Recommendation 4-1*:** NASA should support the development of the capability to return astrobiological and cryogenic samples to Earth and the appropriate containment, curation and characterization facilities consistent with Planetary Science Division Science Goals and planetary protection requirements.

Mapping to Missions Recommendations ctd

Finding: R&A technology investments needed for future missions, as identified in the 2011 planetary science decadal survey, require innovative approaches that may be high-risk/high-payoff and are less likely to be supported under the existing program.

Finding: The reliance of PIs on R&A awards (normally offered every 3 years) alone to sustain the critical scientific and technical expertise and infrastructure needed for current and future planned missions can be a challenge. This issue is a particular concern for sample-return missions where laboratory analytical techniques and expertise may need to be sustained so that they remain available when samples are finally returned.

***Recommendation 4-2*:** In making funding decisions for the various R&A program elements, NASA should consider the need to sustain critical scientific/technical expertise and instrumental/facilities capabilities required for scientific return on future missions, as defined in the planetary science decadal survey.

Overarching Comments

The reorganization has largely achieved the intended plan to improve linkage of PSD's R&A program to NASA's strategic objectives for planetary science and PSD goals, as well as to current and future missions.

Nonetheless, diligence is needed to ensure maintenance of programmatic balance and optimal distribution of scarce resources.

Background Slides

Meeting 1:

National Academies, Washington, DC
May 12-13, 2016

Presentations

Setting the stage:

James Green	NASA HQ	background to charge to the committee
Jonathan Rall	NASA HQ	status of PSD R&A program
Max Bernstein	NASA HQ	status of other SMD R&A programs
Len Fisk	U. Michigan	report on Academies *"An Enabling Foundation for NASA's Earth and Space Science Missions"*
Mark Sykes	PSI	report on Planetary Science Subcommittee's Greeley-Sykes Report

Community perceptions:

Clive Neal	Notre Dame	LEAG
Nancy Chabot	JHU-APL	SBAG
Alfred McEwen	U. Arizona	OPAG
Andy Westphal	UC Berkeley	CAPTEM
Jeff Johnson	JHU-APL	MEPAG
Jani Radebaugh	Brigham Young	MAPSIT
Bob Grimm	SWRI	VEXAG

Meeting 2:

Keck Center, Washington, DC
August 16-18, 2016

Presentations

Ellen Stofan	NASA HQ	Planetary Science Community Demographics

Center and PSS perceptions:

Colleen Hartman	NASA Goddard	Goddard Planetary Science Perceptions
Eileen Stansbery	NASA JSC	JSC Astromaterials Perceptions
Christophe Sotin	NASA JPL	JPL Planetary Science Perceptions
Janet Luhmann	UC Berkeley	Overarching PSS Perceptions
Jim Spann	NASA MSFC	Marshall Planetary Science Perceptions
Michael Bicay	NASA ARC	Ames Planetary Science Perceptions

Brief AG revisits (by phone):

Alfred McEwen	U. Arizona	OPAG
Tim Swindle	U. Arizona	SBAG

Follow-up questions to NASA:

Michael New	NASA HQ	Keywords and other issues raised by committee

Closed Sessions

Draft outline of report and preparation of a series of Findings and Recommendations

Meeting 3:

Woods Hole, MA

September 21-23, 2016

Presentations

Meagan Thompson NASA HQ Key word analysis

Closed Sessions

Draft text for report:

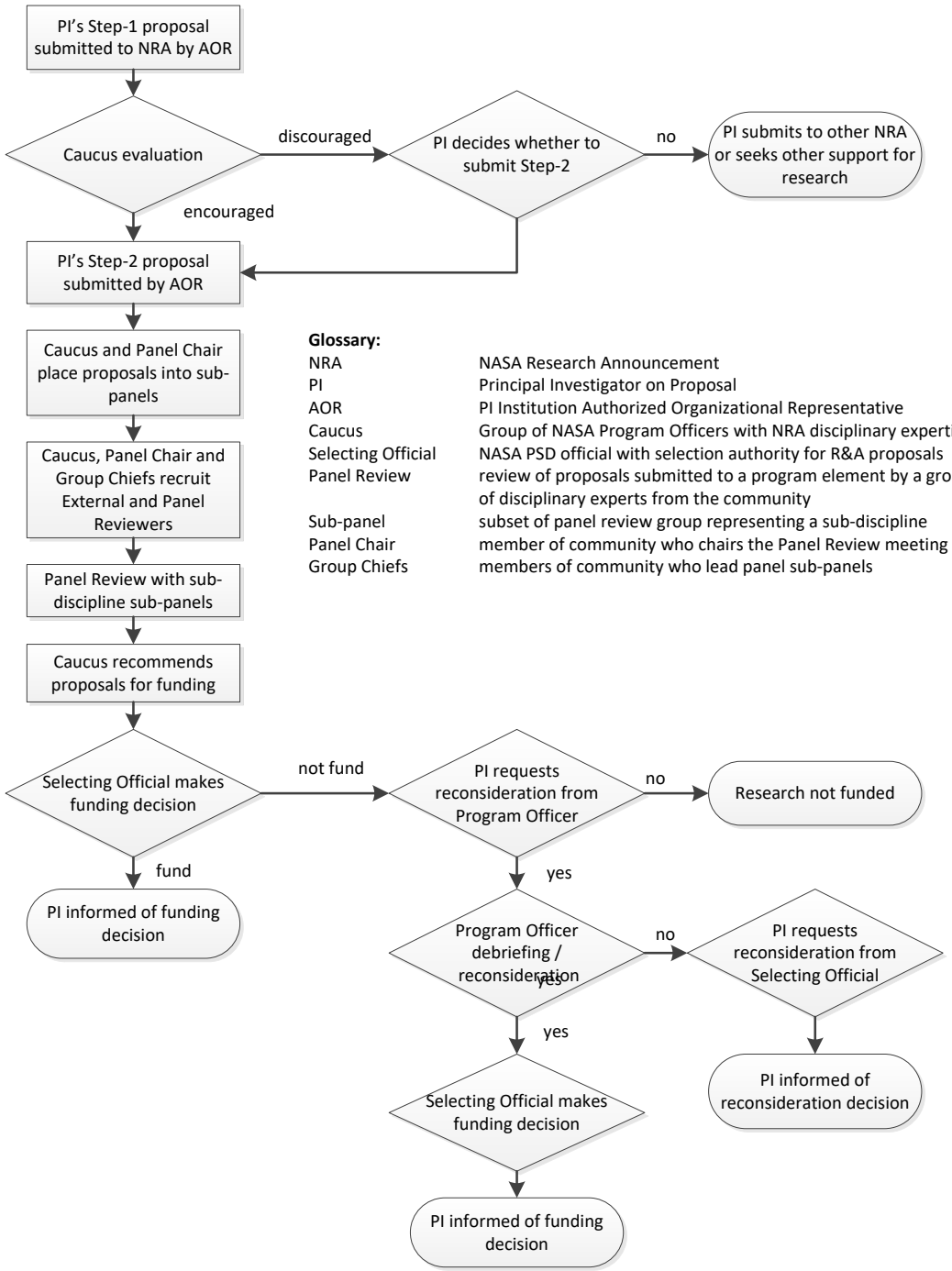
Chapter 1: Introduction

Chapter 2: PSD R&A Review, Recommendation and Reconsideration Processes

Chapter 3: Question 1: Mapping to Science Goals

Chapter 4: Question 2: Mapping to Missions

Cleaning up Findings and Recommendations in Chapters 2-4



Glossary:

NRA	NASA Research Announcement
PI	Principal Investigator on Proposal
AOR	PI Institution Authorized Organizational Representative
Caucus	Group of NASA Program Officers with NRA disciplinary expertise
Selecting Official	NASA PSD official with selection authority for R&A proposals
Panel Review	review of proposals submitted to a program element by a group of disciplinary experts from the community
Sub-panel	subset of panel review group representing a sub-discipline
Panel Chair	member of community who chairs the Panel Review meeting
Group Chiefs	members of community who lead panel sub-panels

Flow chart for NASA PSD processing of proposals submitted to R&A program elements
- a good process if it is followed

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

Cross –cutting themes:

Building new worlds—understanding solar system beginnings

- What were the initial stages, conditions, and processes of solar system formation and the nature of the interstellar matter that was incorporated? Important objects for study: comets, asteroids, Trojans, and Kuiper belt objects.
- How did the giant planets and their satellite systems accrete, and is there evidence that they migrated to new orbital positions? Important objects for study: Enceladus, Europa, Io, Ganymede, Jupiter, Saturn, Uranus, Neptune, Kuiper belt objects, Titan, and rings.
- What governed the accretion, supply of water, chemistry, and internal differentiation of the inner planets and the evolution of their atmospheres, and what roles did bombardment by large projectiles play? Important objects for study: Mars, the Moon, Trojans, Venus, asteroids, and comets.

Planetary habitats—searching for the requirements for life

- What were the primordial sources of organic matter, and where does organic synthesis continue today?
- Important objects for study: comets, asteroids, Trojans, Kuiper belt objects, Enceladus, Europa, Mars, Titan, and uranian satellites.
- Did Mars or Venus host ancient aqueous environments conducive to early life, and is there evidence that life emerged? Important objects for study: Mars and Venus.
- Beyond Earth, are there contemporary habitats elsewhere in the solar system with necessary conditions, organic matter, water, energy, and nutrients to sustain life, and do organisms live there now? Important objects for study: Enceladus, Europa, Mars, and Titan.

Workings of solar systems—revealing planetary processes through time

- How do the giant planets serve as laboratories to understand Earth, the solar system, and extrasolar planetary systems? Important objects for study: Jupiter, Neptune, Saturn, and Uranus.
- What solar system bodies endanger Earth's biosphere, and what mechanisms shield it? Important objects for study: near-Earth objects, the Moon, comets, and Jupiter.
- Can understanding the roles of physics, chemistry, geology, and dynamics in driving planetary atmospheres and climates lead to a better understanding of climate change on Earth? Important objects for study: Mars, Jupiter, Neptune, Saturn, Titan, Uranus, and Venus.
- How have the myriad chemical and physical processes that shaped the solar system operated, interacted, and evolved over time? Important objects for study: all planetary bodies.

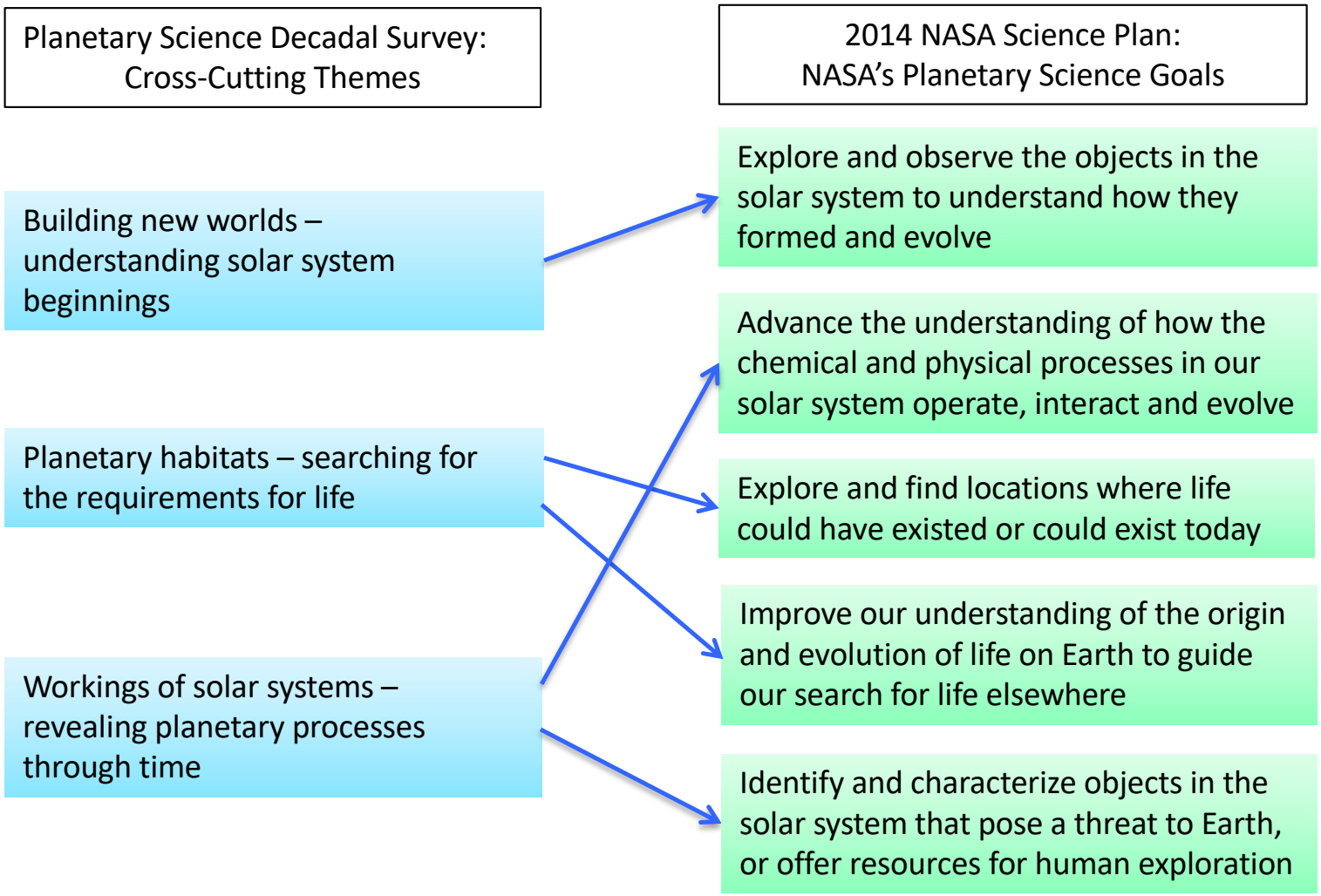
NASA's 2014 Science Plan

Planetary Science Questions:

1. How did our solar system form and evolve?
2. Is there life beyond Earth?
3. What are the hazards to life on Earth?

Planetary Science Goals 2014 (with 2010 Science Plan questions in parentheses)

1. Explore and observe the objects in the solar system to understand how they formed and evolve *(How did the Sun's family of planets, satellites, and minor bodies form and evolve?)*
2. Advance the understanding of how the chemical and physical processes in our solar system operate, interact and evolve *(How do the chemical and physical processes active in our solar system operate, interact and evolve?)*
3. Explore and find locations where life could have existed or could exist today *(What are the characteristics of the solar system that lead to habitable environments?)*
4. Improve our understanding of the origin and evolution of life on Earth to guide our search for life elsewhere *(How did life originate and evolve here on Earth and can that guide our search for life elsewhere?)*
5. Identify and characterize objects in the solar system that pose threats to Earth, or offer resources for human exploration *(What are the characteristics of planetary objects and environments that pose threats to, or offer potential resources for, human as we expand our presence into the solar system?)*

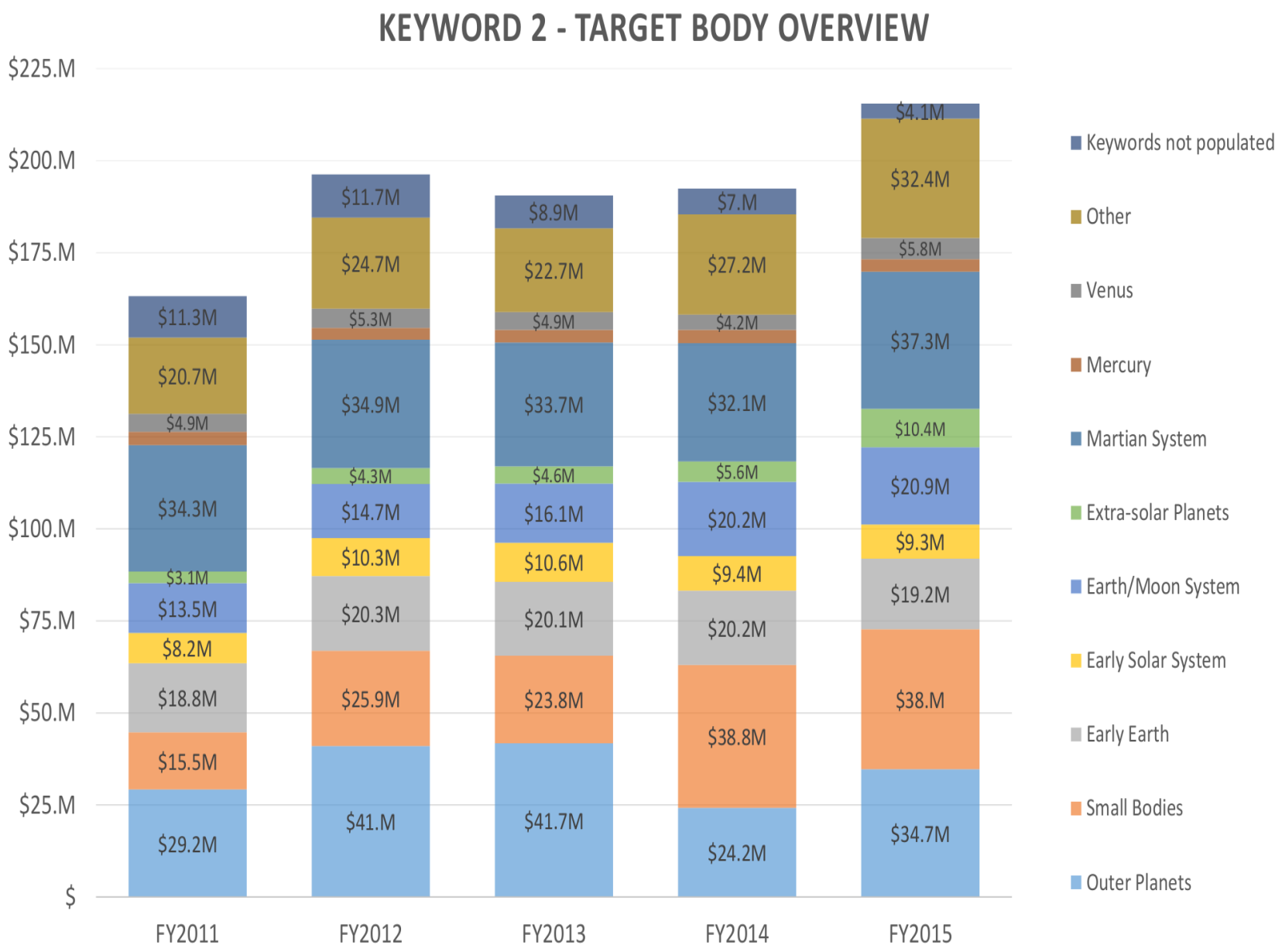

Planetary Science Decadal Survey:
Cross-Cutting Themes
2014 NASA Science Plan:
NASA's Planetary Science Goals
Building new worlds – understanding solar system beginnings
Planetary habitats – searching for the requirements for life
Workings of solar systems – revealing planetary processes through time
Explore and observe the objects in the solar system to understand how they formed and evolve
Advance the understanding of how the chemical and physical processes in our solar system operate, interact and evolve
Explore and find locations where life could have existed or could exist today
Improve our understanding of the origin and evolution of life on Earth to guide our search for life elsewhere
Identify and characterize objects in the solar system that pose a threat to Earth, or offer resources for human exploration

How can we tell if the new program elements fully encompass the needs in NASA's strategic planning documents?

Were any planetary science community groups disenfranchised by reorganization?

PSD program officers assign keywords to each proposal to identify:

1. *Type of task (e.g., sample analysis, theory, experimental, field-based, mission data analysis)*
2. *Target body (e.g., Venus, Jupiter, extra-solar planets, outer planets, and subsets thereof)*
3. *Science discipline (e.g., cosmochemistry, spectroscopy, astrobiology, geophysics)*
4. *Data/sample source (mission or facility) (e.g., Ames vertical gun range, Pioneer Venus, Juno, Mars Odyssey, Curiosity, New Horizons)*



Note that FY2014 was fully in the previous program structure, while only about 30% of funding for FY2015 was under the new program element structure

Mapping to Missions Recommendations ctd
Other findings

Finding: The current R&A program elements are appropriately structured to interpret and maximize the scientific return from existing space missions. In particular, there is sufficient scope and level of support in the current data analysis program elements to enable maximum return on the raw data from the present suite of missions.

***Finding*:** The range of current R&A program elements is broad enough to address the full scope of credible research activities resulting from current and past missions.

Finding: The scope of the current planetary R&A program appears to be sufficient to adequately support scientific research activities that enable future planetary science missions. Nonetheless, it was not possible to determine whether innovative mission concepts are adequately supported.

Finding: The committee has concerns that some activities that are critical components in addressing PSD science goals for future missions, which include long-term synoptic surveys (e.g., NEO, TNO, and KBO surveys), laboratory investigations, and planetary cartography, often receive a lower priority in science merit reviews.