ASSESSMENT OF THE NASA PLANETARY SCIENCE DIVISION'S MISSION ENABLING ACTIVITIES

(The Planetary Science Subcommittee's "Greeley-Sykes" Report)

Mark V. Sykes
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May 12, 2016

PSS Working Group for the Assessment

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Ron Greeley (ASU), Co-Chair
Jim Bell (ASU)
Julie Castillo-Rogez (JPL)
Thomas Cravens (U. Kansas)
John Grant (Smithsonian)
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Sarah Noble (NASA GSFC/HQ)
Jonathan Rall (NASA HQ)
Dawn Sumner (UC Davis)
Meenakshi Wadhwa (ASU)
Jim Green (NASA HQ, ex officio)

Tasks

1.Identify those mission-enabling, research and analysis activities (the activities) that are required to support the strategic goals of the NASA SMD Planetary Division;

1.Map these activities onto existing PSD program elements and identify activities that overlap multiple elements and activities unsupported by any element;

1.Provide recommendations to PSD regarding the application of “active portfolio management” to meet its strategic goals.

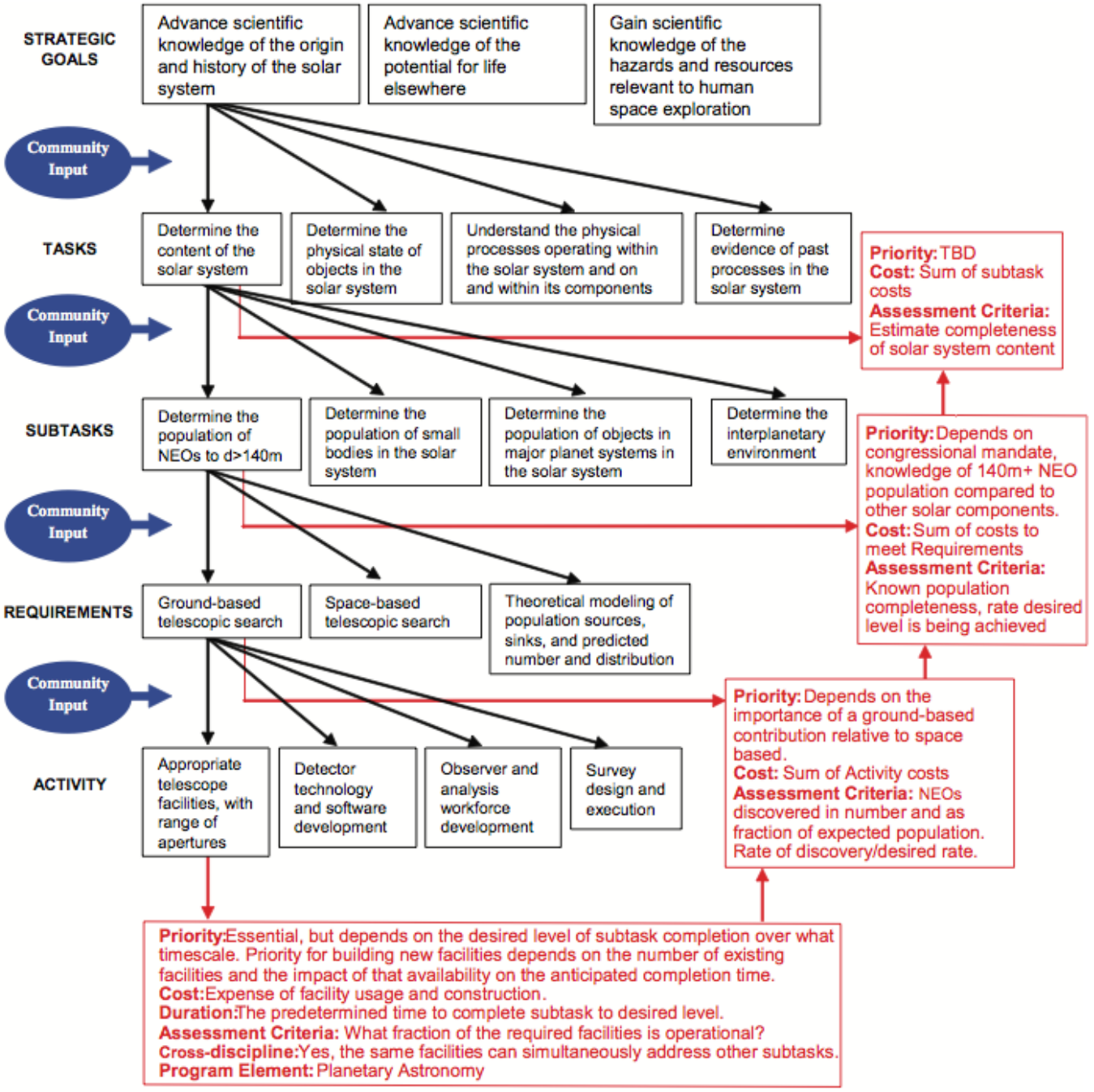

FIGURE C.1 Sample Science Mission Directorate Planetary Science Division traceability matrix (thread).

NASA's goal in planetary science (2010):

Ascertain the content, origin, and history of the Solar System, and the potential for life elsewhere.

Objectives:

•Inventory Solar System objects and identify the processes active in and among them
•Understand how the Sun's family of planets, satellites, and minor bodies originated and evolved
•Understand the processes that determine the history and future of habitability of environments on Mars and other Solar System bodies
•Understand the origin and evolution of Earth life and the biosphere to determine if there is or ever has been life elsewhere in the universe
•Identify and characterize small bodies and the properties of planetary environments that pose a threat to terrestrial life or exploration or provide potentially exploitable resources

NASA's strategic objective in planetary science (2014):

Ascertain the content, origin, and evolution of the Solar System and the potential for life elsewhere.

Fundamental Science Questions:

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

Science Goals:

•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 threats to Earth, or offer resources for human exploration

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Not a problem. PSD funds a wide range of programs that we assume span all activities needed to support its strategic objectives. We just need to map the programs to the objectives.

Table 1. NASA Planetary Science Division mission-enabling activities.

Basic research
- Astrobiology-Exobiology & Evolutionary Biology
- Cosmochemistry
- NASA Astrobiology Institute
- NASA Lunar Science Institute
- Origins of Solar Systems
- Planetary Astronomy
- Planetary Atmospheres
- Planetary Geology and Geophysics

Target-focused research
- Lunar Advanced Science Exploration Research
- Mars Fundamental Research
- Near-Earth Object Observations
- Outer Planets Research
- Planetary Protection Research

Mission data analysis
- Cassini Data Analysis
- Jupiter Data Analysis*
- Laboratory Analysis of Returned Samples
- Mars Data Analysis
- Planetary Mission Data Analysis

Technology development
- Astrobiology Science & Technology Instrument Development‡
- Astrobiology Science & Technology for Exploring Planets‡
- In Space Propulsion**‡
- Moon and Mars Analog Missions Activities
- Mars Instrument Development*‡
- Planetary Instrument Definition and Development

Recruiting and training the next generation
- Education and Public Outreach Supplements
- Fellowships for Early Career Researchers
- NASA Earth and Space Science Fellowships
- NASA Postdoctoral Program

Supporting infrastructure activities
- Curation (samples)
- Infrared Telescope Facility (IRTF, Hawaii)
- Lunar and Planetary Institute (LPI)
- Mars Climate Modeling Center (proposed)
- NASA Advanced Supercomputing
- National Astronomy & Ionosphere Center/Arecibo
- Planetary Radar System
- Planetary Aeolian Laboratory (PAL, ARC)
- Planetary Cartography (USGS, Flagstaff)
- Planetary Data System (PDS)
- Planetary Major Equipment
- Reflectance Experiment Laboratory (RELAB, Brown U.)
- Regional Planetary Image Facilities (RPIF)
- Venus Chamber (GSFC)
- Vertical Gun Range (AVGR, Ames)

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THIS IS NOT CORRECT

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Astrobiology-Exobiology & Evolutionary Biology	Moon and Mars Analog Missions Activities
Cosmochemistry	Mars Instrument Development*‡
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NASA Lunar Science Institute	**Recruiting and training the next generation**
Origins of Solar Systems	Education and Public Outreach Supplements
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Planetary Atmospheres	NASA Earth and Space Science Fellowships
Planetary Geology and Geophysics	NASA Postdoctoral Program
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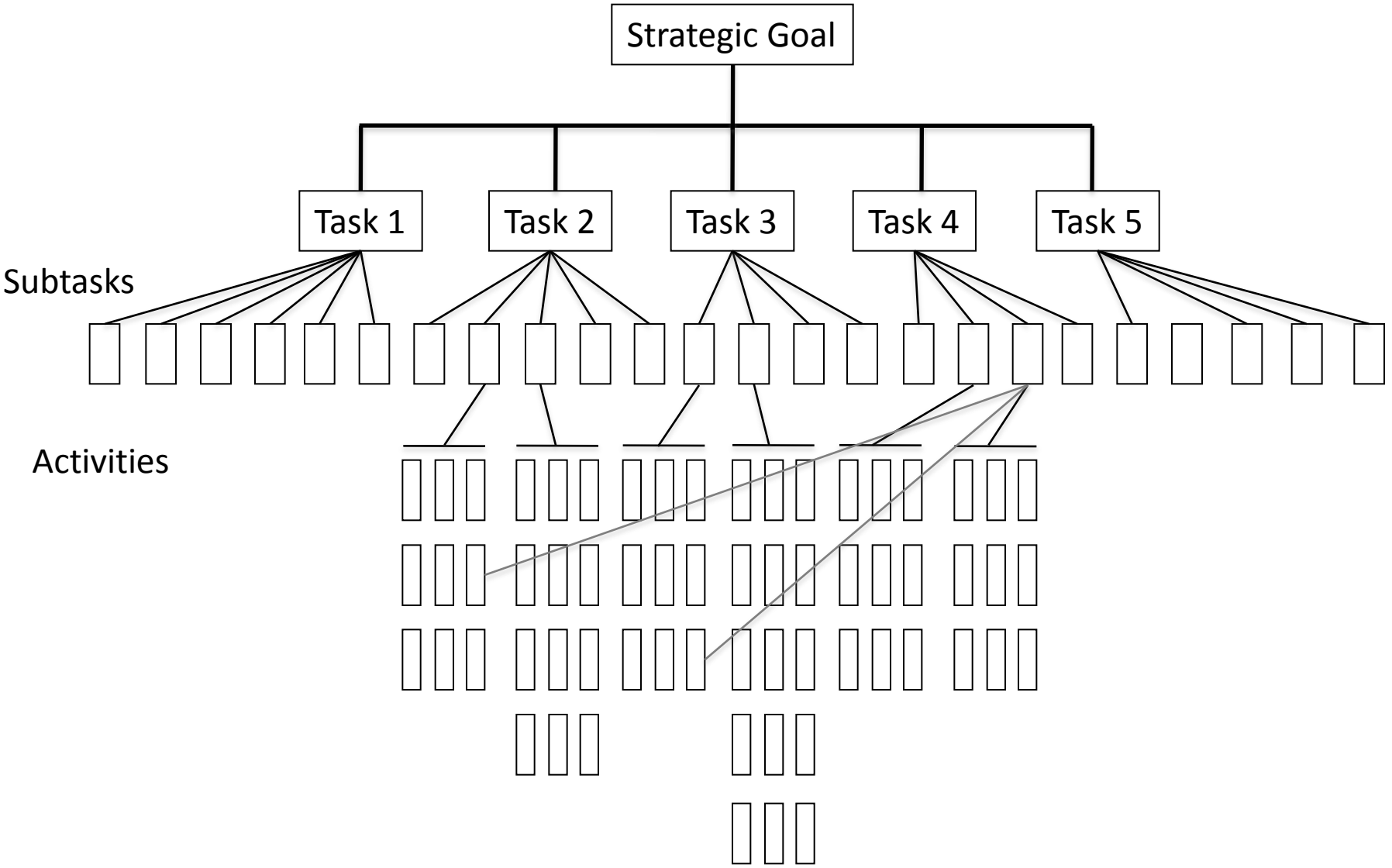
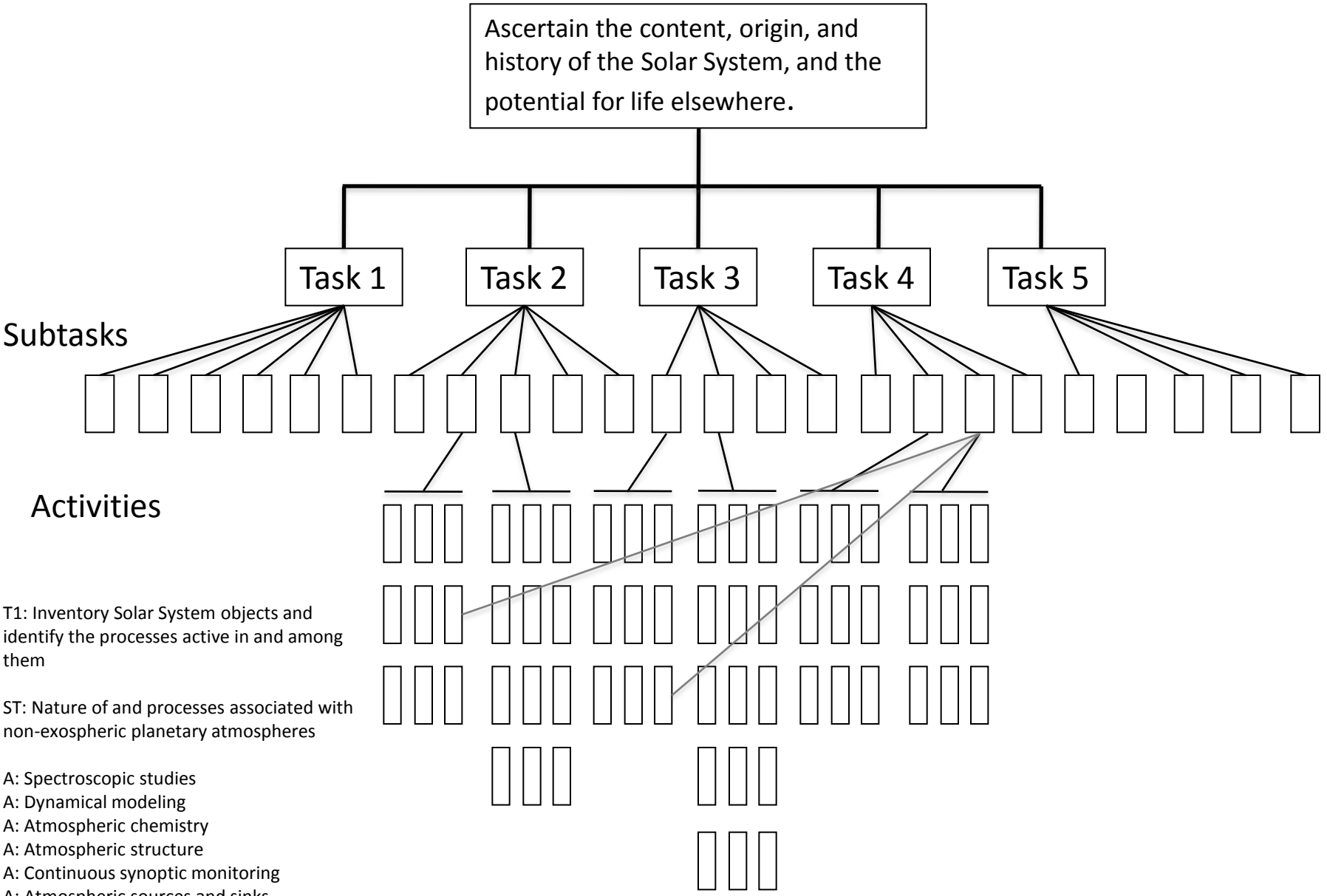
Astrobiology Science & Technology Instrument Development‡	Venus Chamber (GSFC)
Astrobiology Science & Technology for Exploring Planets‡	Vertical Gun Range (AVGR, Ames)

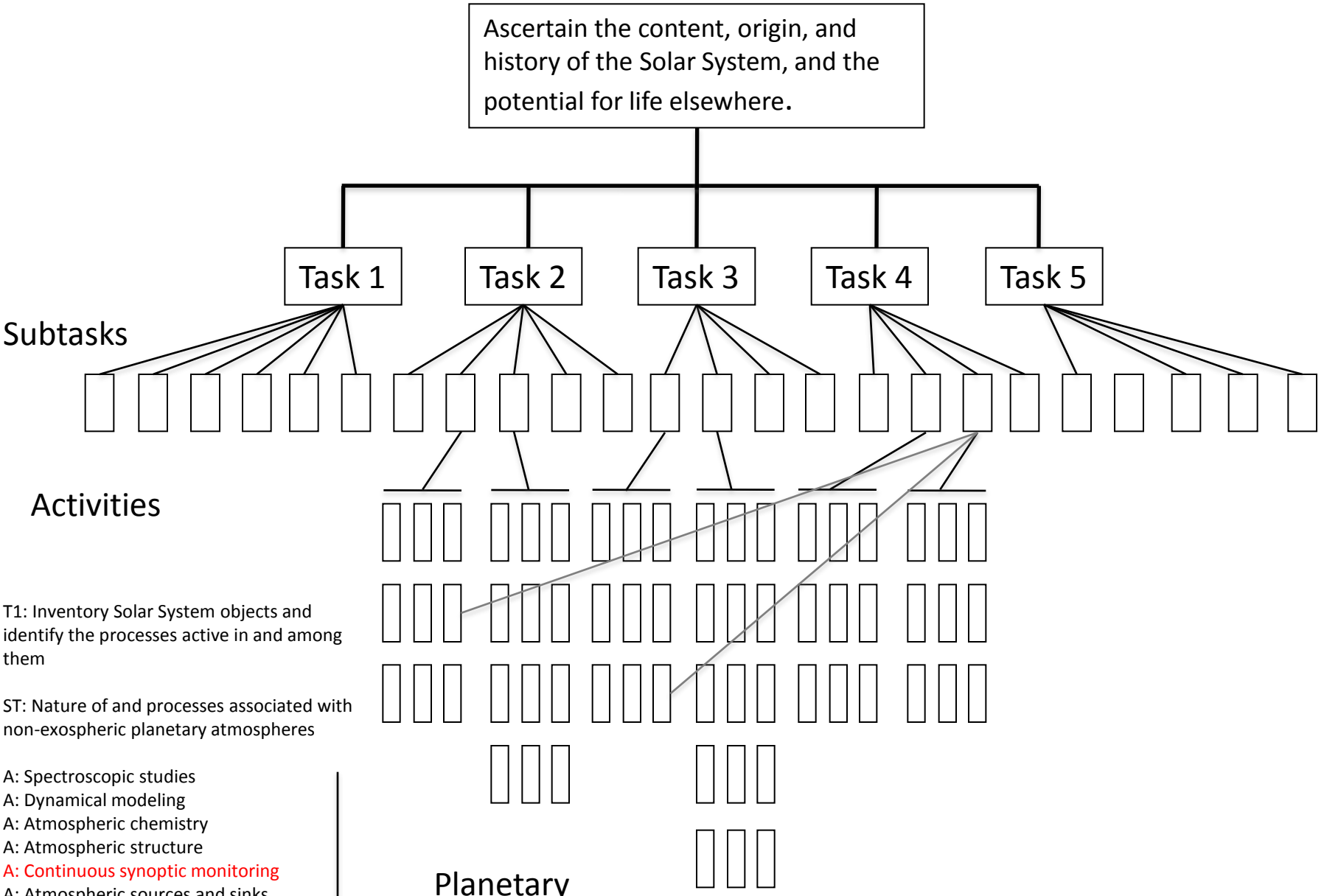

Strategic Goal
Task 1
Task 2
Task 3
Task 4
Task 5
Subtasks
Activities



T1: Inventory Solar System objects and identify the processes active in and among them

ST: Nature of and processes associated with non-exospheric planetary atmospheres

A: Spectroscopic studies
A: Dynamical modeling
A: Atmospheric chemistry
A: Atmospheric structure
A: Continuous synoptic monitoring
A: Atmospheric sources and sinks
A: Impact evolution modeling
A: Electrical processes
A: Plasma interaction studies
A: Laboratory studies of molecular constituents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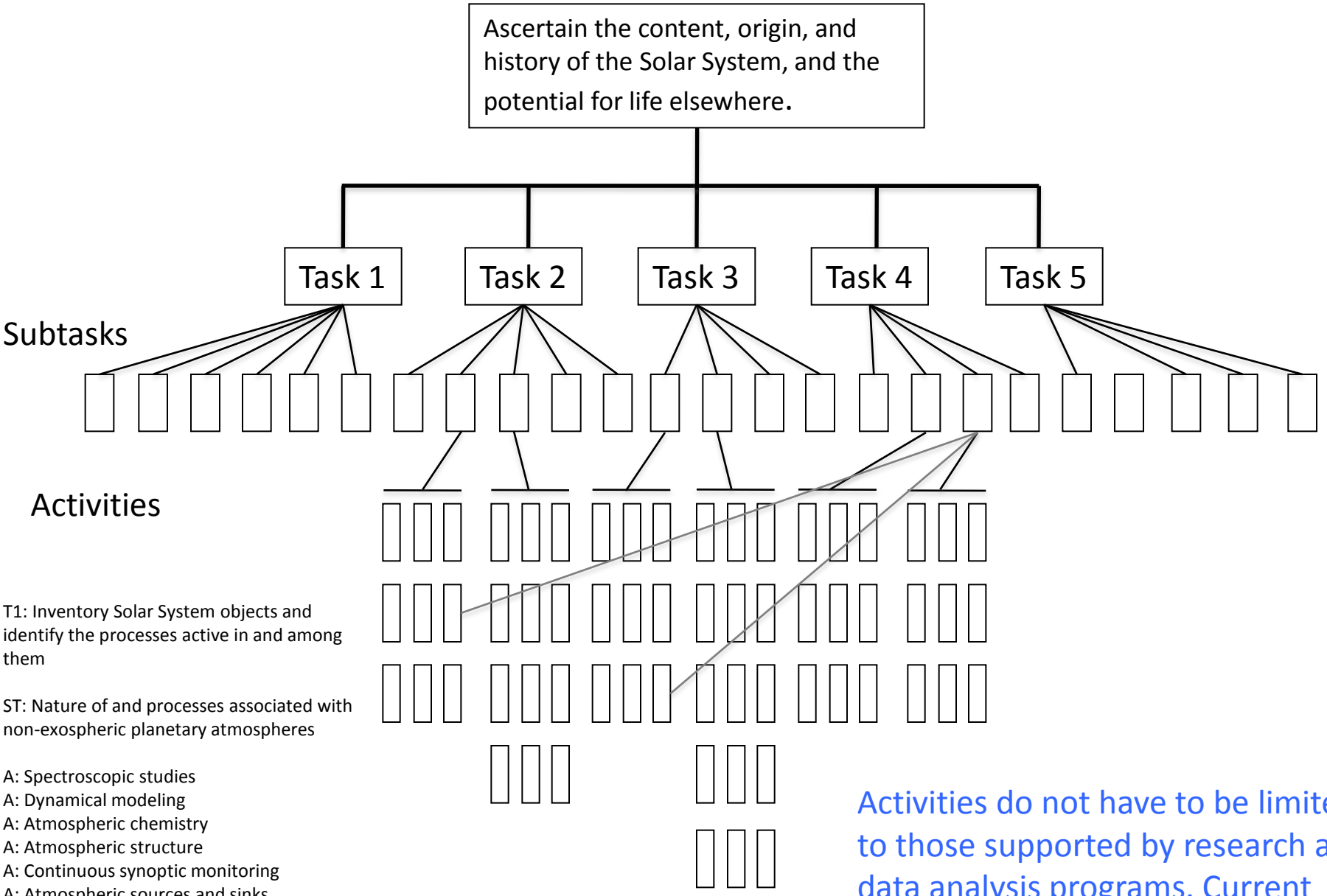
Planetary Atmospheres
May want to break activities further down to be planet-specific.



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A: In-situ sampling
A: High-resolution local climate observations
A: In-situ wind studies

Activities do not have to be limited to those supported by research and data analysis programs. Current and future missions may also be included.

Once all of the activities are identified that are required to support the strategic goals of the NASA SMD Planetary Division (Task 1),

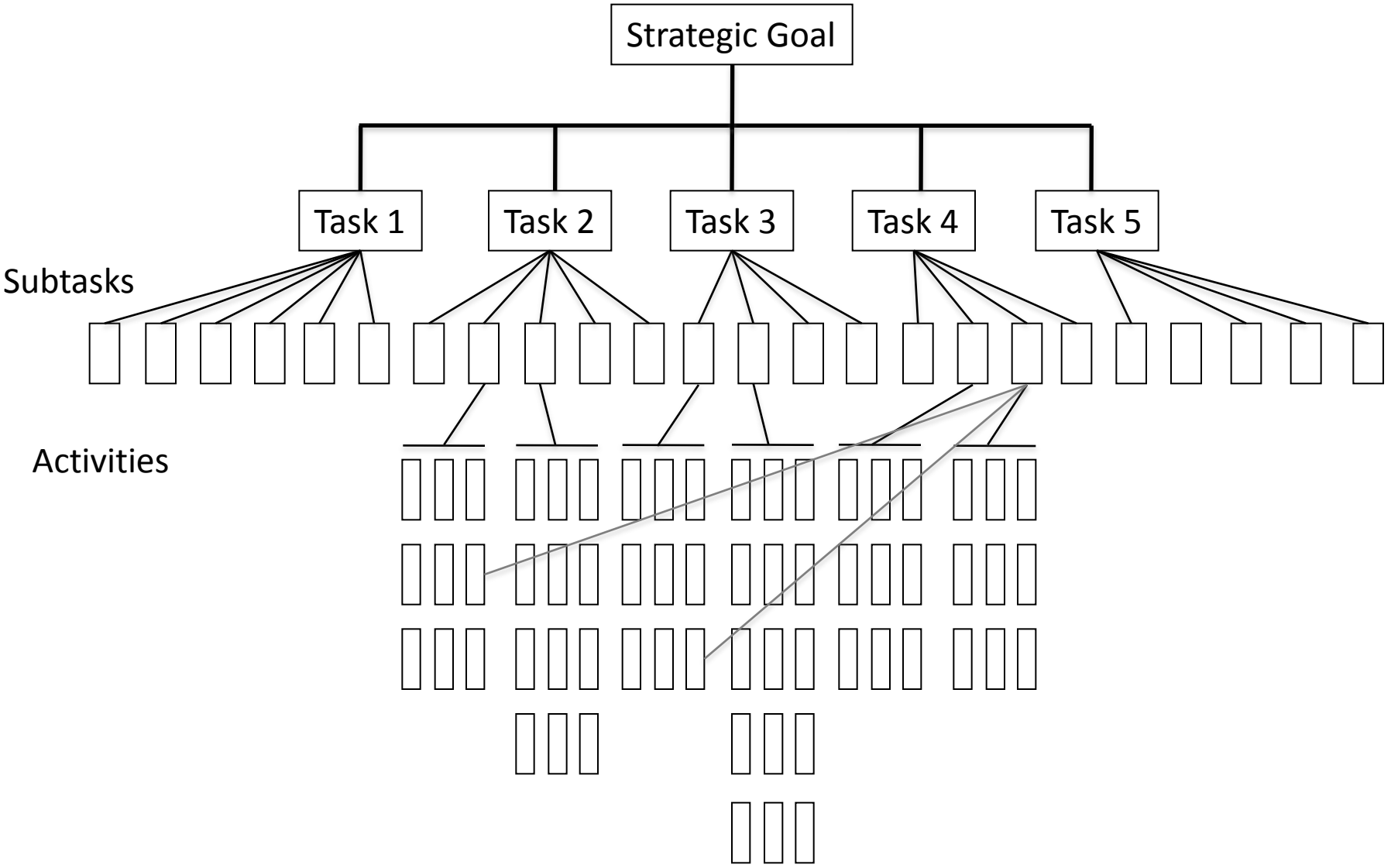
It is then possible to map them onto existing PSD program elements and identify activities that overlap multiple elements and identify activities unsupported by any element (Task 2)

Once an Activity is identified, in the context of the full set of Activities needed to advance a subtask (of a full set of subtasks needed to advance a task, among a full set of tasks needed to advance the strategic goal…), we can now:

- Assign a priority to the activity
- Develop metrics by which activity can be assessed
- Determine an appropriate funding level for the activity (a process)
- Determine the most cost-effective means of managing groups of activities (define programs)
- Iterate

This is the basis for “active portfolio management” needed for PSD to meet its strategic goals. (Task 3)

How do we Flow Down all Necessary Activities from Strategic Goals?

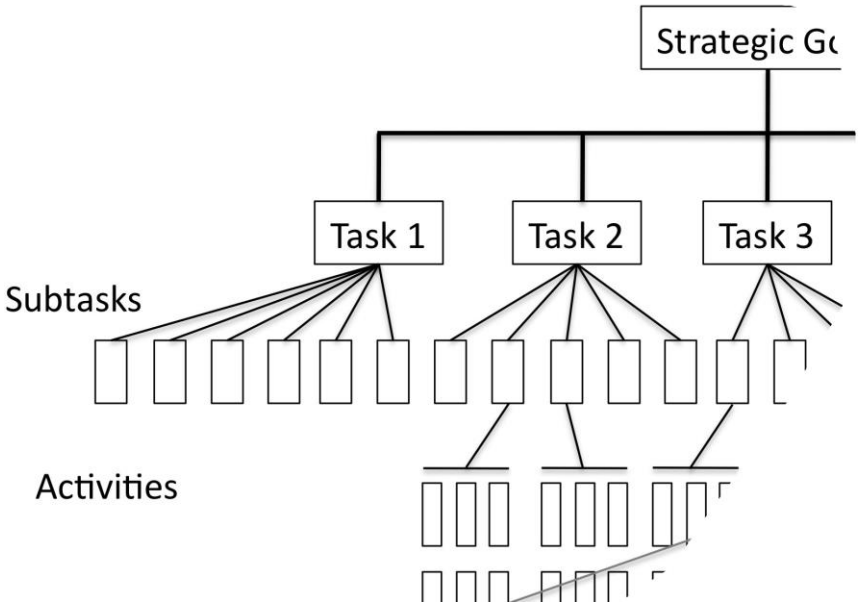


Recommendation: It needs to be recognized that there is more than one NASA planetary science goal (2010) = strategic objective (2014). There are really three separate goals/objectives: science, planetary defense, and support for expanding human space activities for which three separate flowdown efforts should be undertaken.

<u>This is a decadal survey level effort.</u>

A "Steering Committee" might be established to define the tasks and most of the subtasks – all with input and feedback from the planetary community, then iterated.

Unlike the decadal survey process, participation by the planetary science community at all levels and steps is essential for success. This could not be undertaken the NRC.



The planetary community as a whole is required for defining all of the Activities.

NAC Planetary Science Subcommittee

NASA Planetary Supporting Technology and Research Activities Traceability Matrix

UNDER REVIEW - PLEASE SEND YOUR COMMENTS/QUESTIONS TO Mark Sykes

Task: identify all planetary supporting technology and research activities required to support the strategic goals of the planetary division.

This exercise provides the fundamental justification for funding these activities by NASA. Providing an exhaustive list of these activities will help to identify areas not currently supported and allow for their more efficient management across research programs.

After registration, you are invited to submit the input form for as many times as there are activities you wish to make sure are included.

Sample inputs
View inputs to date
Register for Survey

NASA PSS Community Input Page

Mark's Input

Activity:

PSD Strategic Goal:

Choose one of the following answers

Please choose...

How activity is necessary to support that strategic goal:

Program currently funding this activity:

Choose one of the following answers

Please choose...

What metrics should be used for evaluating the effectiveness of the research activity in supporting the strategic goal:

Comment (optional):

Note: A given activity may support more than one strategic goal, which may then be captured by more than one submission.

Submit

NASA Planetary Research Activities Traceability Matrix

Community Input Page

SAMPLE INPUTS

Activity:
Obtain reflected spectra of all detectable asteroids.

PSD Strategic Goal:
Inventory solar system objects and processes

How the activity is necessary to support the strategic goal:
An inventory that informs the understanding of processes requires an undertanding of the composition of the objects.

Program currently funding this activity:
Planetary Astronomy

What metrics should be used for evaluating the effectiveness of the research activity in supporting the strategic goal:
Percentage of asteroids in different size ranges for which spectra have been obtained at visible and near-infrared wavelengths.

Comment (optional):
None.

Activity:
Synoptic observations of planetary atmospheres.

PSD Strategic Goal:
Inventory solar system objects and processes

How the activity is necessary to support the strategic goal:
Atmospheres are complex systems for which continuous monitoring provides important baseline information in understanding potential processes within them.

Program currently funding this activity:
Planetary Atmospheres

What metrics should be used for evaluating the effectiveness of the research activity in supporting the strategic goal:
For each planet/satellite with an observable atmosphere, the density of diurnal and seasonal sampling using imaging in meaningful bandpasses.

Comment (optional):
None.

UNDER REVIEW - PLEASE SEND YOUR COMMENTS/QUESTIONS TO Mark Sykes

View inputs to date
Main Page

Strategic goal: Understand origin and evolution of life on Earth and potentially elsewhere

Activity: Study the origin, evolution, and distribution of life in the universe.
How activity is necessary: Without a supporting program in astrobiology the proper questions will not be addressed by missions, and the results of those missions will not be understood when they are returned. This is a critical goal with respect to public understanding and future human exploration. It may be the most significant goal that NASA has in ANY program.
Program currently funding: Astrobiology: Exobiology, and Evolutionary Biology
Metrics: Scientific results published in the literature PIs and Co-Is on flight missions Ties to other SMD programs (e.g., Astrophysics)

Activity: Develop instruments capable of making astrobiological measurements on flight missions.
How activity is necessary: Without a specific program to develop astrobiology instruments, the proper questions cannot be addressed by missions, and the results of those missions will not be available to support scientific understanding of the goal. This is a critical goal with respect to public understanding and future human exploration.
Program currently funding: Astrobiology Science and Technology for Instrument Development
Metrics: Excellent instrument proposals to both Planetary Sciences and Astrophysics Divisions. Successful instruments, PIs and Co-Is or Teams on flight missions Scientific results published in the literature

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Activity: A specific program to test and evaluate deployment systems and astrobiologically relevant instruments in the field, prior to flight.
How activity is necessary: Without operational-style tests of concepts in this area, complex flight systems may fail, the proper questions would not be able to be addressed by missions, and the results of those missions will not be available to support scientific understanding of the goal. This is a critical goal with respect to public understanding and future human exploration.
Program currently funding: Astrobiology Science and Technology for Exploring Planets
Metrics: Excellent instrument and mission proposals to the Planetary Sciences Division. Successful systems, instruments, and operations with PIs and Co-Is or Teams on flight missions. Scientific results published in the literature.

Activity: Develop an understanding of the microbes carried by spacecraft, the potential for them to live on other worlds, and the means to remove them from spacecraft without killing the spacecraft and its mission capabilities. An understanding of effective policies and procedures to effectively prevent forward and backward

NAC Planetary Science Subcommittee

UNDER REVIEW - PLEASE SEND YOUR COMMENTS/QUESTIONS TO Mark Sykes

View inputs to date
Main Page

Strategic goal: Inventory solar system objects and processes

Activity: Geological mapping of planetary surfaces.
How activity is necessary: Identification and mapping of geological features creates an important context within which the manifestation of processes are identified and located on a surface, supporting their focused study and interrelationships. This also supports the identification of features associated with the same processes, but in the context of different worlds, supporting the investigation of similarities and differences and their roots in different physical environments.
Program currently funding: Planetary Geology and Geophysics
Metrics: The fraction of surface of each solar system body mapped at different spatial scales. The constancy of funding in terms of net FTEs to ensure that a given level of effort in this area is sustained. An assessment of workforce demographics and whether knowledge is being passed along from experienced to new generations at a level that offers continuity of effort in this area.

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What would it take?

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- Estimate (Sykes)

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What would it take?
-Major General Dick Paul, Ret. (former commander AFRL; member, Fisk Committee)
-~~Estimate~~ Wild guess? (Sykes): With full engagement of the planetary community, 1-2 years, a few hundred K (programming, processing and structuring of input). Consider dividing the resultant matrix among the AGs to oversee maintenance and updates.

Implications for SSB's Review of NASA's Planetary Science Division's Restructured Research and Analysis Program

"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 Objective 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 mission?"

Implications for SSB's Review of NASA's Planetary Science Division's Restructured Research and Analysis Program

PSD has never undertaken the flowdown exercise described in the NRC's "An Enabling Foundation for NASA's Space and Earth Science Missions" (NRC 2010) to identify the range and scope of activities needed to support the NASA Strategic Objective for Planetary Science and the Planetary Science Division Science Goals, as articulated in the 2014 NASA Science Plan.

The PSS WG, co-chaired by Sykes and Greeley failed to accomplish this task [for the strategic goal(s) of 2010].

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So What was done in the "Greeley-Sykes Report"?

Greeley-Sykes Report

Define existing program elements as “mission-enabling activities”, describe these program elements (6 pg).

Provide example investigations that advance each of the five 2010 strategic objectives, identifying multiple program elements and facilities that support aspects of the investigations (Appendix 2, 7 pg.) [closer to “activities” that might flow down from strategic objectives]

Mapping program elements and facilities UP to strategic objectives (next).

Respond to the recommendations in NRC 2010.

Findings and recommendations on R&A informed by a PSS survey of the planetary community.

Greeley-Sykes Report

Table 2. Relevance of activities to the PSD science objectives
(●=directly relevant, O=somewhat relevant)

Program element	Objective 1 (objects, processes)	Objective 2 (origin, evolution)	Objective 3 (habitability)	Objective 4 (life: Earth, elsewhere)	Objective 5 (small bodies)
Astrobiology-Exobiology & Evolutionary Biology	O	O	●	●	
Astrobiology Science & Technology Instrument Development	O	O	●	●	
Astrobiology Science & Technology for Exploring Planets	O		●	●	
Cassini Data Analysis	●	●	●	O	O
Cosmochemistry	●	●	O	O	●
Laboratory Analysis of Returned Samples	●	●	O	O	O
Lunar Advanced Science Exploration Research	●	O		●	●
Mars Data Analysis	●	●	●	●	O
Mars Fundamental Research	●	●	●	O	
Mars Instrument Development	●	●	●	●	

This demonstrates that all existing program elements and facilities have at least some relevance to at least one strategic objective and that all strategic objectives are supported to some level (unknown) by existing program elements and facilities. Since the strategic objectives were defined by the PSS, informed by existing programs, the outcome is true by definition.

Greeley-Sykes Report

Responses to NRC (2010) – sparse samples

NRC Recommendation 1: ***NASA should ensure that SMD mission-enabling activities are linked to the strategic goals of the agency and of SMD and that they are structured so as to:***

- ***Encompass the range and scope of activities needed to support those strategic goals***

"One means of identifying these unsupported activities would be to add language to a program element AO that requests whether work proposed, in addition to being relevant to the program, is an activity falling within an area of activities not previously funded that directly support a PSD strategic objective or objectives and to describe how this area of activities supports that objective or objectives..."

This was at least one suggestion of identifying gaps, even though it is not possible for any proposer to know whether work proposed is in an area not previously funded, unless the area is new. PSS WG was too uncertain about what is required for a full-up flowdown exercise per NRC 2010.

Greeley-Sykes Report

Responses to NRC (2010) – sparse samples

NRC Recommendation 2: ***NASA's Science Mission Directorate should develop and implement an approach to actively managing its portfolio of mission-enabling activities. Active portfolio management should include the following elements:***

- ***Transparent budgets that permit program managers to effectively manage mission-enabling activity portfolios and permit other decision makers and the research community to understand the content of mission-enabling activity programs.***

"Work is needed in this area by PSD. The budgets available for new awards for most research and analysis activities are published with the annual call for proposals. Planned total program budgets for a given fiscal year are not made available. Sometime after the end of the fiscal year, final budgets may be posted on the SARA website. Budgets for many of the supporting activities and facilities are not generally accessible."

Budget transparency is still an issue.

Greeley-Sykes Report

PSS Findings (abbreviated)

(1)Budget volatility across PSD SR&T programs degrades the healthy scientific and technical workforce needed to conduct NASA's space and Earth science program. Funding issue.
(2)PSD "mission enabling activities" evolve, but are never reviewed across the board. Senior review every decade?
(3)TRL development issue. Substantial tech development program needed.
(4)Aging flight team. Plan for turnover and augment science teams.
(5)No metrics for determining success of mission-enabling activity.
(6)Community stretched "thin" in preparation and review of proposals. Increase grant size and duration?
(7)Proposal process transparency.
(8)Survey respondents feel 50% (and more) of salary should be OK in proposals.
(9)Quality and usefulness of summary proposal reviews. Standard charges to panels (and publish this?).
(10)Shorter duration selections not explained by PO.
(11)Problems in getting qualified reviewers.
(12)Notifications of review results too late to be useful for next call.
(13)Curation capabilities for future sample missions may not exist.

CONCLUSION

Tasks

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2.Map these activities onto existing PSD program elements and identify activities that overlap multiple elements and activities unsupported by any element;
3.Provide recommendations to PSD regarding the application of “active portfolio management” to meet its strategic goals.

The tasks that motivated the establishment of the PSS WG are still of great value for PSD and should include activities requiring missions to execute. Creating a matrix tracing FROM strategic goals TO those activities necessary to support those goals would be an invaluable tool. It would be maintained to reflect new discoveries and even completion of activities. It would reflect a continuing positive engagement between NASA and the planetary community.