AN ENABLING FOUNDATION FOR NASA'S EARTH AND SPACE SCIENCE MISSIONS

Committee on the Role and Scope of Mission-enabling Activities in NASA's Space and Earth Science Missions

Space Studies Board
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Study Charge

- **Identify appropriate roles for mission-enabling activities and metrics for assessing their effectiveness.**
- **Evaluate how, from a strategic perspective, decisions should be made about**
  - **balance between mission-related and mission-enabling elements of the overall program, as well as**
  - **balance between various elements within the mission-enabling component.**

Among the topics to be considered are the following:

- Roles and objectives of mission-enabling activities in NASA as a mission-oriented agency;
- Necessary characteristics of an effective program of mission-enabling activities, including metrics by which effectiveness can be evaluated;
- Principles and metrics for determining the appropriate balance of investments between mission-enabling activities and space flight missions so as to best support the Agency's overall strategic objectives;
- Principles and metrics for determining the appropriate allocation of effort and resources between various mission-enabling program components, including scientific infrastructure (e.g., airplanes, computing) that enables R&A activity;
- The role and proper fraction of support that should be devoted to "innovative" (high risk, high payoff) research, and whether this might vary between science areas;
- The extent to which current R&A programs support cross-disciplinary and interdisciplinary science, especially across the divisions within NASA's Science Mission Directorate;
- The role of R&A programs in training the next generation of Earth and space scientists who will contribute to NASA's programs in the future; and
- Relevant benchmarks from industry or other public or private institutions where similar mission versus mission-enabling portfolio allocation assessments are made.

Committee Roster

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Definition of "Mission-enabling Activities"

The committee defines mission-enabling activities as those SMD activities that are not dedicated to a single specific spaceflight mission but that provide a broad enabling foundation for NASA's scientific spaceflight projects.

The principal purposes of mission-enabling activities are to provide

- A knowledge base that allows NASA and the scientific community to explore new frontiers in research and to identify, define, and design cost-effective space and Earth science missions required to address the strategic goals of the agency;
- A wide range of technologies that enable NASA and the scientific community to equip and conduct spaceflight missions to pursue the agency's scientific goals; and
- A robust, experienced technical workforce to plan, develop, conduct, and utilize the scientific missions.

NASA's principal programs to accomplish these purposes are as follows:

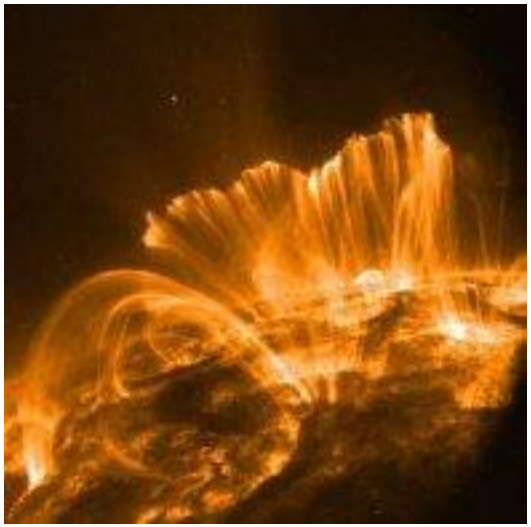
- Research projects (especially via the research and analysis grants programs) and special research facilities (including suborbital flight payloads and operations, ground-based telescopes and dedicated laboratories, and high-end computer systems and data archives);
- Development of advanced sensors, research instruments, and spaceflight mission system technologies;
- General data analysis (including archival data studies and synthesis of new and/or long-term data sets from multiple spaceflight missions); and
- Earth science applications (including research to apply NASA Earth science results to fields such as agriculture, ecology, and public health and safety).

Comparative Statistical Data for SMD Science Division Mission-enabling Programs

	Astrophysics	Heliospheric Physics	Planetary Science	Earth Science	SMD Total
Total budget ($M, FY ’09)	**1,206**	**592**	**1,326**	**1,380**	**4,503**
Total mission-enabling $M	**127**	**77**	**312**	**556**	**1,072**
Total mission-enabling (%)	**10**	**13**	**24**	**40**	**24**
Total proposals (’08)	**824**	**407**	**1,115**	**1,338**	**4,039**
Acceptance rate (%, ‘08)	**36**	**29**	**28**	**31**	**31**
NESSF grad student awds	**8**	**4**	**17**	**51**	**79**
Program officers	**11**	**9**	**23**	**31**	**78**

Case Study: Mission-enabling Activities Advance Study of the Solar Corona

- **Theory: In the 1980s Eugene Parker postulates that magnetic energy should be explosively released at the interfaces between the misaligned field lines at the sun's surface to create "nanoflares."**
- **New instrument development was needed to test the theory, and the new technology has revolutionizes our understanding of coronal structure and dynamics. It becomes standard on currently operating and upcoming solar missions.**
- **Laboratory measurements provide basic atomic data that permits interpretation of new spaceflight measurements.**
- **Ever improving space and ground-based observations have motivated a new round of theoretical investigations to understand the details of how magnetic field footpoint motions at the surface lead to magnetic reconnection and nanoflares in the solar atmosphere.**
- **New numerical simulations show that the spatial and temporal dependence of the energy release can have a fundamental influence on the resulting loop dynamics and structure, and help explain certain mysteries in the space mission observations.**



Other examples of Mission-enabling Activities

Roles	Examples
Theoretical investigations & modeling	**Solar & heliospheric modeling** **Earth Observation System Simulation Experiments** **Solar system evolution modeling** **Modeling of supernova nucleosynthesis**
Acquisition & analysis of supporting data from ground-based facilities, laboratories, aircraft, balloons, & sounding rockets	**Sub-orbital science investigations (e.g. gamma ray astro)** **Earth science ground truth & flight data validation flights** **Ground-based planetary & solar astronomy**
Analysis of space mission data	**Retrospective re-analyses of Viking & IRAS data** **Heliospheric Great Observatory data analyses**
Establishment &/or maintenance of data archive, computational, curatorial, and other ground-based facilities	**Planetary Data System, Earth Observing System Data & Info System, Astrophysics Data systems** **Astromaterials Curation Facility** **ARC & GSFC High-end Computing Systems**
Technology development for space flight missions	**Planetary Instrument Design & Development Program** **Sub-orbital flight technology development & testing (e.g. many astrophysics instruments)**
Development of [external & internal-to-NASA] science & engineering workforce	**Graduate (& undergraduate) student research** **Graduate student fellowships & early career awards** **Hands-on training in sub-orbital flight projects**

Finding 1. The mission-enabling activities in SMD—including support for scientific research and research infrastructure, advanced technology development, and scientific and technical workforce development—are fundamentally important to NASA and to the nation.

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,**
- **Provide the broad knowledge-base that is the context necessary to interpreting data from spaceflight missions and defining new spaceflight missions,**
- **Maximize the scientific return from all spaceflight missions,**
- **Supply a continuous flow of new technical capabilities and scientific understanding from mission-enabling activities into new spaceflight missions, and**
- **Enable the healthy scientific and technical workforce needed to conduct NASA's space and Earth science program.**

OPPORTUNITIES FOR IMPROVEMENT

An effectively structured program would have the following attributes:

- **Mission-enabling activities, and the criteria for establishing their priorities and resource allocations, that are clearly traceable to division mission statements and strategic goals.**
- **Portfolio allocations based on systematic criteria and metrics of program effectiveness.**
- **Continual interaction with and assessment by the science community via a well-structured advisory apparatus.**
- **Transparent budget structure in which all mission-enabling activities are aggregated into visible budget lines so as to facilitate more effective portfolio management decisions and communication about the value and impacts of mission-enabling programs.**
- **Explicit statement of the role of mission-enabling activities in sustaining a capable technical workforce in the overall program strategy.**
- **Adequate staff to devote an appropriate amount of time to the responsibilities of properly managing mission-enabling activities.**

Implementation Principles

- Investment needs will be different across SMD divisions.
- Division-level mission statements should clearly articulate the division's strategic priorities and should provide a rational framework for assessing how the division's portfolio ensures support for the full range of activities.
- Balance between mission-enabling and spaceflight mission portfolios
  - does not mean using a fixed ratio across all programs,
  - does not mean equity, and
  - need not be constant over time.
- Programmatic relationships of mission-enabling activities to spaceflight programs should be clearly communicated so that mission-enabling portfolios can be effectively prioritized and managed.
- Balance within portfolios requires active management. Determining whether investments are appropriately balanced within schedule and budget constraints to achieve the intended near, mid, and far-term goals and objectives requires continuing assessment.
- Budget transparency enhances active management by facilitating analysis, advocacy, and stability.

Template for Performance Metrics

- **A simple statement of what the component of the mission-enabling activity is intended to accomplish and how it supports the strategic or tactical plans of the division.**
- **A statement as to how the component is to accomplish its task.**
- **An evaluation of the success of the activity relative to the stated mission, unexpected benefits, and lessons learned.**
- **A justification for the resource allocation that is being applied to the component vis-à-vis other mission-enabling activities within the division.**

Finding 2. Adoption of an active portfolio management approach is the key to providing an effective program of mission-enabling activities that will satisfy the intent of this committee's first finding and recommendation.

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:

- **Clearly defined science division mission-enabling mission statements, objectives, strategies, and priorities that can be traced back to the overall strategic goals of NASA, SMD, and the division.**
- **Flexibility to accommodate differences in the scientific missions and programmatic options that are most appropriate to the different science discipline divisions.**
- **Clearly articulated relationships between mission-enabling activities and the ensemble of ongoing and future spaceflight missions that they support.**
- **Clear metrics that permit program managers to relate mission-enabling activities to strategic goals, evaluate the effectiveness of mission-enabling activities, and make informed decisions about priorities, programmatic needs, and portfolio balance.**
- **Provisions for integrating support for innovative high-risk/high-payoff research and technology, interdisciplinary research, and scientific and technical workforce development into mission-enabling program strategies.**
- **Active involvement of the scientific community via an open and robust advisory committee process.**
- **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.**

Finding 3. The NASA SMD headquarters staff is not adequately sized to manage mission-enabling activities effectively.

Recommendation 3. NASA should increase the number of scientifically and technically capable program officers so that they can devote an appropriate level of attention to the tasks of actively managing the portfolio of research and technology development that enables a world-class space and Earth science program.

In making this recommendation the committee is convinced that having mission-enabling program managers divide their time between mission-enabling activities and duties related to spaceflight programs is desirable and that management of mission-enabling activities is properly a NASA headquarters, not a NASA field center, function.