Extending Science – NASA's Space Science Mission Extensions and the Senior Review Process

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Committee on NASA Science Mission Extensions

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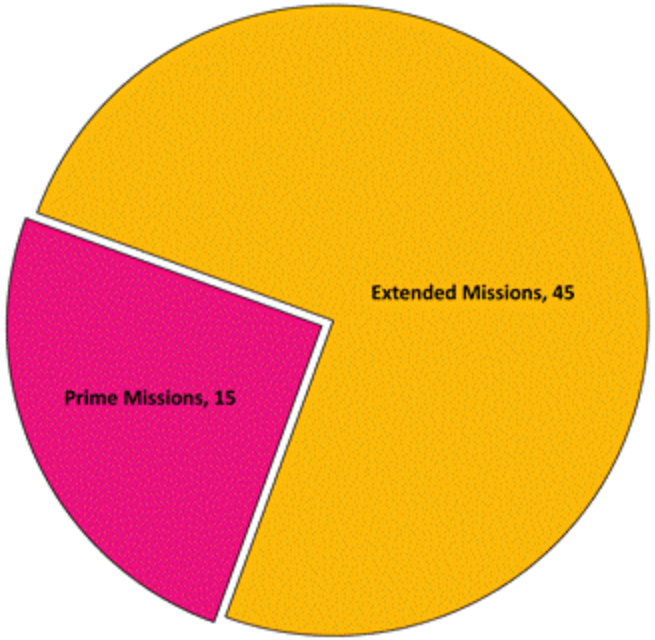
Extended Mission Science is Productive and Valuable

- **Voyagers in operation nearly 40 years, over three decades beyond prime missions, now at edge of the heliosphere**
- **Together with Hubble, the Spitzer Space Telescope identified very distant galaxy GNz-11, finding that star formation proceeds much more rapidly than previously known in early universe**
- **The Aqua Earth-observing spacecraft showed that the melting of the Greenland ice sheet in 2012 was the most extensive surface melting measured to date**
- **The STEREO spacecraft obtained the first 360 degree images of the sun**
- **The Mars Exploration Rovers Spirit and Opportunity identified habitable hydrothermal environments on Mars**
- **The Lunar Reconnaissance Orbiter identified thin layers of water ice in the permanently shadowed polar regions**

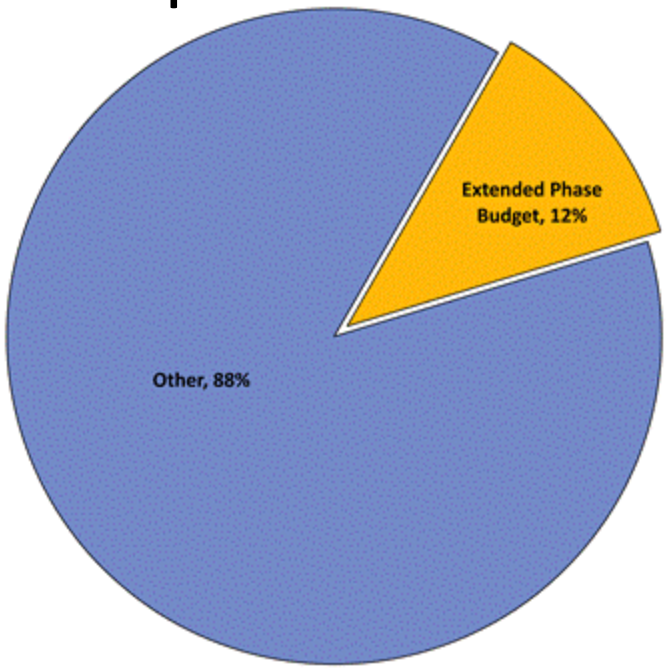
Extended Mission Science is a Bargain

Approximately three quarters of the NASA science missions currently flying are in extended phase, but represent only ~12% of the Science Mission Directorate's FY16 budget

Active space science missions



SMD budget, including extended phase missions



Bottom Line:

- **Many extended science missions have made important discoveries via new destinations, observation types or targets, and/or data analysis methods**
- **Continuous coverage, long-baseline data sets, and statistically significant observations of infrequent events require continuity of measurement over years or decades and are best provided through missions in extended phase**
- **NASA's extended missions commonly achieve science objectives identified by the decadal surveys while providing unique insights for determining priorities and approaches for future exploration**

Based upon its assessment, the committee concluded that extended phase science missions are a vital part of NASA's overall science effort

Recommendations
The Importance of Extended Missions

Recommendation: NASA's Science Mission Directorate (SMD) policy documents should formally articulate the intent to maximize science return by operating spacecraft beyond their prime mission, provided that the spacecraft are capable of producing valuable science data and funding can be identified within the SMD budget. (Chapter 5)

Recommendation: NASA should strongly support a robust portfolio of extended-phase science missions. This support should include advance planning and sufficient funding to optimize the scientific return from continued operation of the missions. (Chapter 2)

Recommendation: If a Senior Review recommends termination of a mission due to funding limitations rather than limited science return, NASA should allow the team to re-propose with an innovative, possibly less scientifically ambitious, approach at reduced operational cost and increased risk. (Chapter 3)

Recommendations
Cadence

Recommendation: NASA should conduct full Senior Reviews of science missions in extended operations on a 3-year cadence. This will require a change in authorizing language, and NASA should request such a change from Congress.

The Earth Science Division conducts annual technical reviews. The other divisions should assess their current technical evaluation processes, which may already be sufficient, in order to ensure that the divisions are fully aware of the projected health of their spacecraft, while keeping these technical reviews moderate in scope and focused on changes since the preceding review. (Chapter 3)

Why a Three-Year Cadence Instead of Two?

- **Currently, proposal teams spend up to six months preparing for a 24-month mission extension. This creates an excessive burden on proposers and impacts ongoing planning and analyzing scientific data.**
- **Volunteer review teams should be easier to recruit over three-year periods as opposed to two.**
- **NASA currently spends considerable time, effort, and money conducting Senior Reviews every two years and will spend less with a three-year cadence.**
- **Spacecraft reliability and science observations can be easily predicted three years out (provided that NASA regularly assesses spacecraft and instrument health, as called for in the recommendation).**

A three-year cadence would ease these burdens, while enabling timely assessment of the quality of the data returned from these missions and their potential for continued productivity.

NASA will get more science, and more value, with a three-year review cadence.

Recommendations
Cadence Flexibility

Recommendation: NASA science divisions should be allowed to conduct reviews out of phase to allow for special circumstances and should have the added flexibility in organizing their reviews to take advantage of unique attributes of each division's approach to science. (Chapter 3)

Recommendations

Range of Objectives for Senior Review Proposals

Recommendation: In order to obtain best value for money, NASA should encourage extended mission proposals to propose any combination of new, ground-breaking, and/or continuity science objectives. (Chapter 3)

Recommendation: NASA should continue to encourage and support extended missions that target new approaches for science and/or for national needs, as well as extended missions that expand their original science objectives and build on discoveries from the prime phase mission. (Chapter 5)

Recommendations
Senior Review Panels (1)

Recommendation: Each of the divisions should ensure that their timelines allocate sufficient time for each stage of the Senior Review process, including a minimum of 6 to 8 weeks from distribution of proposals to the panels until the panel meets with the mission teams. The panels should have at least 4 weeks to review the proposals and to formulate questions for the mission teams, and the mission teams should be allocated at least 2 weeks to generate their responses to the panel questions. (Chapter 3)

Adequate time for the reviews is vital for a thorough review. Expensive and irreplaceable spacecraft are being assessed and the job cannot be rushed or it may be done badly. Review teams are volunteers, not contractors.

Recommendations
Senior Review Panels (2)

Recommendation: NASA's Science Mission Directorate should assemble Senior Review panels that

- **Are comprised primarily of senior scientists knowledgeable about and experienced in mission operations so as to ensure that the operational context of the science being proposed and evaluated is considered in the review (individuals with operations and/or programmatic expertise may also be included as needed)**
- **Are assembled early to avoid or accommodate conflicts of interest, and ensure availability of appropriate expertise**
- **Include some continuity of membership from the preceding Senior Review to reap advantage of corporate memory**
- **Include some early-career members to introduce new and important perspectives and enable them to gain experience for future Senior Reviews**

(Chapter 3)

Recommendations

Senior Review Panels (3)

Recommendation: NASA's Science Mission Directorate division directors should continue to communicate among themselves to identify and incorporate best practices across the divisions into the Senior Review proposal requirements and review processes and procedures. (Chapter 3)

Recommendation: In its guidelines to the proposal teams and the Senior Review panels, NASA should state its intention to solicit feedback from its proposal teams and review panels about the suitability of the proposal content and review process. After obtaining such feedback, NASA should respond and iterate as needed with stakeholders to improve the review process, where possible. (Chapter 3)

Recommendations

Effective Practices, Risk Posture, and Communication

Recommendation: NASA should provide open communications and dissemination of information based on actual experience with extended missions so that all missions are aware of and able to draw on prior effective practices and procedures, applying them during development of ground systems and flight procedures, as well as when formulating staffing and budgetary plans for the prime and extended-mission phases. (Chapter 5)

Recommendation: NASA should continue to assess and accept increased risk for extended missions on a case-by-case basis. The headquarters division, center management, and the extended-mission project should discuss risk posture during technical reviews and as part of the extended mission and subsequent Senior Review proposal preparation process and should make all parties fully aware of all cost, risk, and science trade-offs. (Chapter 5)

Recommendations

Funding for Extended Missions (1)

Recommendation: NASA should continue anticipating that missions are likely to be extended and identify funding for extended missions in the longer-term budget projections. (Chapter 5)

Recommendation: NASA should continue to provide resources required to promote a balanced portfolio, including a vibrant program of extended missions. (Chapter 4)

Recommendations
Funding for Extended Missions (2)

Recommendation: Given the demonstrated science return from extended missions, NASA should continue to recognize their scientific importance and, subject to assessments and recommendations from the Senior Reviews, ensure that after the first two Senior Reviews, both operations and science for high-performing missions are funded at roughly constant levels, including adjustments for inflation. (Chapter 5)

Most cost savings are made during the transition from prime to extended phase and during the early extended phase. After that, most efficiencies have been achieved, and costs may even increase due to issues pertaining to an aging spacecraft. Stable funding (including inflation) after the first two Senior Reviews is vital. Further cuts at this point often disproportionately affect science return.

Committee Roster

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Statement of Task

The NRC will appoint an ad hoc committee to conduct an assessment of the scientific value of extended missions in the overall program of NASA's Science Mission Directorate (SMD). The committee's report will provide recommended guidelines for future NASA decision-making about such mission extensions. In conducting this study, the committee could address the following questions:

1. Historically, what have been the scientific benefits of mission extensions? How important are these benefits (for example, benefits that might only accrue during the extended mission phase but not earlier)?

2. What is the current SMD Senior Review process for extending missions--for example, how are reviews chartered and conducted, by whom, and using what criteria? What should be division dependent and what should be uniform across the Directorate?

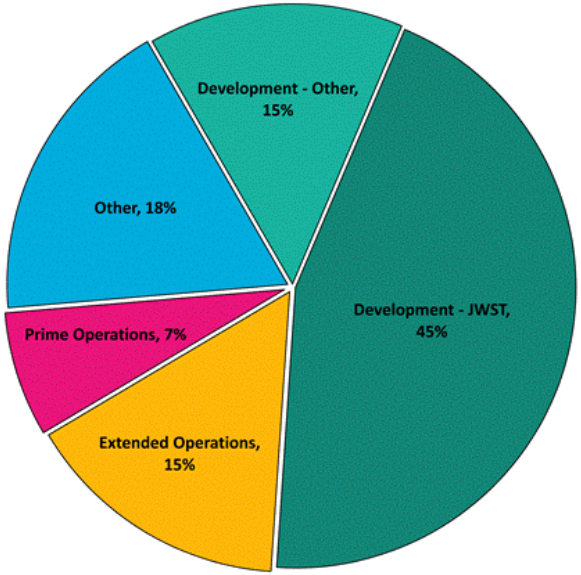
3. The NASA Authorization Act of 2005 requires biennial Senior Reviews for each mission extension. Is this biennial time period optimal for all divisions? Would a longer or shorter time period between reviews be advantageous in some cases?

4. Does the balance currently struck between starting new missions and extending operating missions provide the best science return within NASA's budget? That is, how much of an acceleration of new mission initiation could realistically be achieved by reallocating resources from mission extensions to new programs, compared to the corresponding scientific loss from terminated or diminished mission extensions?

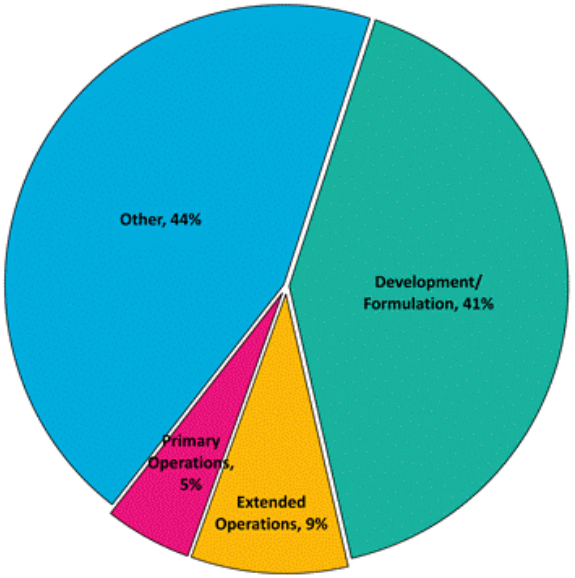
5. Are there innovative cost reduction approaches that could increase the science cost-effectiveness of extended missions? Are there any general principles that might be applied across the board or to all of the missions for an individual science theme or a particular class? Are there alternative mission management approaches (e.g., transfer to an outside technical or educational institution for training or other purposes) that could reduce mission costs during extended operations and continue to serve SMD's science objectives?

John Grunsfeld’s Urban Legends

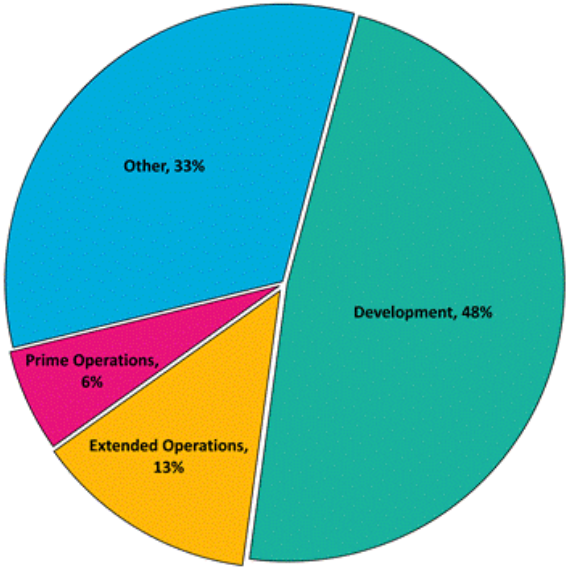
NASA Science Division Budgets FY 2016



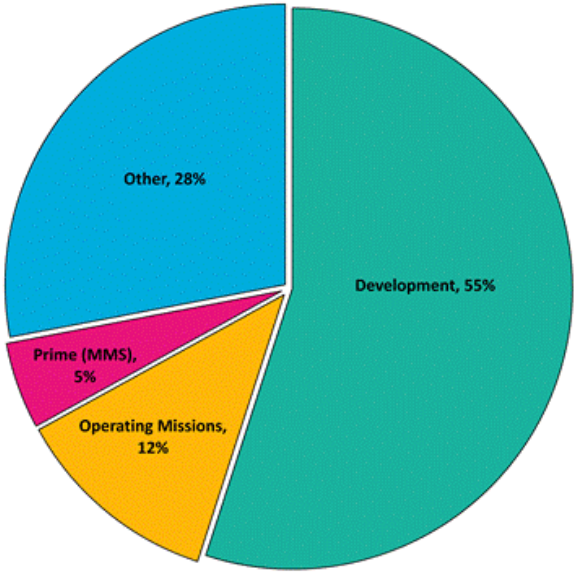
Astrophysics



Earth Science



Planetary



Heliophysics

Urban Myth:

SMD spends most of its budget on extended missions for limited science return

Extended missions are a vital and major part of NASA's overall space science effort

…

… for only ~ 12% of the budget

Urban Myth:

We can't build new missions because of the cost of extended missions

Annual operation costs for all 45 extended missions are roughly equal to one new Discovery class mission per year

Urban Myth: NASA never turns anything off

IUE: terminated 1996
ISEE-3/ICE: ended 1997; recently rebooted by non-NASA group
CGRO: de-orbited June 2000, to avoid potential uncontrolled re-entry
EUVE: decommissioned January 2001
SAMPEX: NASA funding ended June 2004, operated by Bowie State University thereafter until 2012
CHIPS: NASA funding ended 2005; UCB operated until 2008
FAST: NASA funding ended 2005
ERBS: terminated October 2005
Gravity Probe B: funding ended 2008
TRACE: terminated June 2010 after success of SDO
WMAP: ended October 2010 after four extensions
GALEX: terminated February 2011
WISE: terminated February 2011, restarted August 2013 for NEO hunting
RXTE: terminated January 2012
QuickScat: terminated 2015, then restarted following RapidScat issues

Urban Truth:

We have a deliberate and well-documented process for determining when to terminate a mission

Community input is key!