

1. How much funding should be allocated to R&A in 2023 and how should it grow over time?

MVS:

I would like to see \$500M allocated to R&A as clearly defined by the Decadal Survey, including a list of program elements that satisfy that definition (at the level I did in the budget sheets submitted to the steering committee) and noting those program elements that do not. I would then like to see it grow at 1.5% over inflation (I used the NASA inflation tables) in subsequent years. I was giving some thought to how this might be implemented, which I go over below (which does not include growth for the purpose of the exercise).

By my calculation in the spreadsheet of PSD budget numbers acquired under FOIA and submitted to the steering committee, the current R&A budget, under the definition proposed to the Decadal Survey, comes in at \$150M for 2020. This could be bumped up a bit by NASA providing additional detail like that portion of the NEOO budget that funds SSO, but I expect the result would not be a wildly higher number. \$150M corresponds to \$50M for each of Year 1, 2, and 3 of all awards (a fair number of assumptions here, but it is a start). Ultimately, \$500M would correspond to \$167M/year when 3 years of \$167M in new awards are being paid. So, if one were to add \$117M of additional funds to existing programs each year for three years, you would get:

2023	2024	2025
\$150M	\$150M	\$150M (Current R&A)
\$117M	\$234M	\$351M (additional funding to R&A programs)
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\$267M	\$384M	\$501M (close enough)

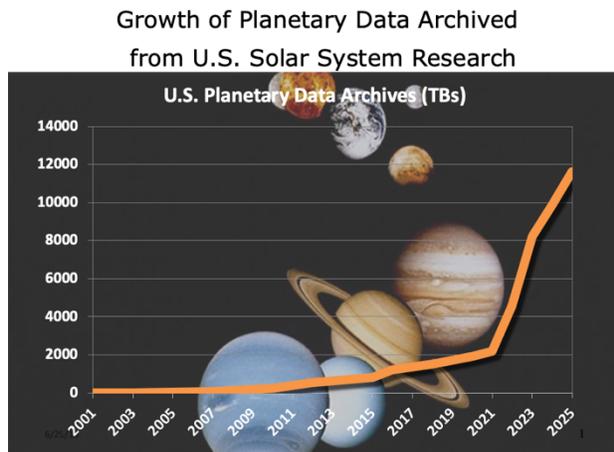
\$233M \$116M \$0M (difference from target budget of \$500M/year starting '23)

Much damage is being done to our community with the exceptionally low selection rates of recent years. I am concerned that we are losing capabilities and talent in a variety of disciplines from which we may not recover any time soon. One way of stemming that damage and stabilize things while new funding and more sustainable selection rates take effect at the new net funding level (which would take a few years of calls) would be to use the bolus of funds identified above (\$233M in 2023 and \$116M in 2024) to do a couple of things:

- (1) Invest in infrastructure supporting R&A research by increasing Planetary Major Equipment awards for this purpose perhaps to \$20M/year for two years.
- (2) Use the balance of the funds for 3-year R&A block grants to institutions on the basis of the number of unique PIs that have submitted proposals to R&A programs over the previous three years. All three years of these awards would be allotted to the year of the award. This would mitigate the some of the accumulated impact of low selection rates and make sure that we do not lose more people before they have an opportunity to propose to the more appropriately budgeted programs. Proposals could even be submitted in 2022, since initial awards would be made in 2023 and accrued to that year.

2. Do we know if research data acquired from missions is growing faster than the research data can be analyzed by the science community? If so, do we have some idea of how fast the gap is growing and what increase in R&A funding is required to level this out?

MVS: Absolutely. Higher bit-rate communication, more storage, and more capable instruments have been swamping our abilities to analyze all of it since MRO, in my opinion. Rates have increased over the past decade, and data holdings are expected to explode even more - starting right now. See the plot below. Not only do we need to greatly increase our investment in R&A, this also needs to include investment in tools to query and analyze such vast amounts of data (wouldn't it be nice to draw a circle around a feature in a HiRISE image and say "now find me every feature of comparable scale in every image of the Martian surface"). By my calculations (provided to the committee with all supporting data), spending on R&A has actually declined since 2011, contrary to the recommendation of the last Decadal Survey.



R&A is essential for doing the basic research that needs to be done to understand the data we are accumulating and to engage in the continuing analysis of that data to maximize the continuing return on taxpayer investment in these expensive missions. R&A work is also essential for providing the context within which we define and prioritize our future missions. We are behind the 8 ball in R&A and it is only getting worse with time. I am concerned that things are so bad at this time that we are facing loss of expertise in some disciplines from which we will not soon recover. That is why we are looking at a level of funding of \$500M for R&A *as explicitly defined by the Decadal Survey, which also needs to identify those specific programs within the Planetary Science Division that meets its criteria (and those that do not) to provide clear guidance to the agency.*

At the same time, we need to bolster the science teams on our missions. Such support has been in great decline over the past decade and more. They are on the front lines of data acquisition and have designed the data products to be acquired. They also need to be supported to develop the tools that would enable more efficient and broader analysis of the data to support real time mission planning. These tools should be open-source with interfaces designed to facilitate easy utilization by the non-mission science community for further analysis of the data.

3. Should NASA include mission data analysis in the mission line rather than R&A, as they do in other divisions?

MVS: The question does not appreciate that R&A is not a specific funding line, rather it is a collection of programs scattered across mission and research lines within PSD. So, the Discovery Data Analysis Program is funded under the Discovery mission line, New Frontiers Data Analysis is under the New Frontiers mission line, and the Lunar Data Analysis program is under the Planetary Science Research line! It is these programs in the aggregate that are referred to by the Decadal Survey as the “Research and Analysis programs” (R&A). Some confusion arises because within the Planetary Science Research budget line there is a sub-line called “Planetary Science Research and Analysis” (with the WBS code 811073), but this is not the same as what the Decadal Survey defines as R&A! If we refer to the Decadal R&A programs as “Pink”, there are Pink programs in the mission lines (with examples above) and programs within 811073 that are definitely not pink (e.g., PSD Travel, Planetary Decadal Support, among many others). Because of the value of the Pink programs to our community and to the objectives of solar system exploration, we want to make sure that the sum of their individual budgets are at Decadal-recommended levels. So, there is a little accounting involved in the implementation of such a recommendation, but it is not difficult.

One other comment about mission data analysis programs. Many of them are poorly designed. So, for instance, Discovery Data Analysis has remained pretty flat at around \$3.6M/year since 2014. Data from a new mission like Dawn gets added and analysis is minimized by having to compete with the analysis of many other missions in a zero-sum game.

Every new science mission should have a dedicated data analysis program extending a few years after the end of the mission, in order to attract the most investigative attention (while it is ‘hot’) and, again, maximize the science return from the mission at a level that would not be possible without a focused program. After the individual data analysis program is over, THEN continuing data analysis could still be done in the context of competition among other older missions in a program like Discovery Data Analysis.

4. ISFM is not openly competed. In your view, should it be included in the definition of R&A? If it is justified by e.g. increased service on proposal review, that is not an R&A issue.

MVS: ISFM should absolutely NOT be considered “R&A” in the Decadal Survey precisely for the reason you state. There needs to be civil servant scientists and contractors that are sited at NASA centers for specific strategic purposes. How many civil servants and contractors at NASA centers there should be with what expertise to satisfy what center objectives is not within the scope of the R&A programs or, for that matter, the Decadal Survey. ISFM is a return to the more sensible internal funding model by the agency that was in place under a cross-divisional program 15 or so years ago. With their own separate funding, civil servants should not be competing for R&A funds.

In a 2015 report by the NASA Mission Support Council, it was found that “There is currently no strategic hiring of scientists.” It is not clear what centers need what kinds of scientists in what areas of expertise in order to support what strategic objectives for the agency. It is not clear what work would be more cost-effectively implemented through the use of off-site or temporary on-

site contractors. This would make a great Academy study. My feeling is that the planetary community represents a great national resource that is under-utilized by the agency and I can imagine there are some center scientists that are under-supported and not provided adequate facilities.

5. How do you think NASA can maintain programmatic balance when some programs like lunar or Mars are tied to broader agency goals and thus change, sometimes radically over time?

MVS: We can walk and chew gum at the same time! We need to appreciate that there will always be periods of enhanced focus on some areas for various reasons (for instance, setting up a permanently inhabited facility on the Moon, or suddenly discovering various places where life may have arisen in different areas of the Solar System). We have long term interests in continuing to explore every part of the solar system (and now other solar systems as well) at increasing levels of detail and with increasingly complex and sophisticated science questions in mind. So, we must always maintain a baseline level of open-ended activity supporting our ability to go anywhere and ask the new questions and reorganize what we know as a consequence. R&A is a critical part of our maintaining our broader exploration capabilities.

On a side note, NASA does tend to artificially divide human exploration and science to the detriment of the former. Human enterprises, like the return to the Moon and planning to go to Mars should have science teams in place to apply the science we know and use science to gather the information needed to advance their objectives. PSI scientists are engaged in the Subsurface Water Ice Mapping (SWIM) on Mars to identify where accessible subsurface ice might be found, particularly at lower latitudes, to support a future human presence there (and I enjoy having a PSI SWIM team, with SWIM meets and all that!). I noted during the panel discussion that I was talking with a person in the NASA Space Technology Mission Directorate about potential prizes/challenges that the Directorate might offer for science. My thought was that a science prize might complement a technology prize. For instance, if there is a technology prize for designing a shovel to excavate on the Moon in support of facility construction, there might be a science prize for figuring out how to remotely and/or insitu determine the mechanical properties of potential base site that would be needed to understand shovel requirements. Other directorates need to be making far more use of our scientific knowledge and capabilities (on their dime) than they do at present, if they are serious about doing things like sending people to the Moon or Mars!

6. The call to boldly increase the R&A budget and continually increase each year to achieve a selection rate of >30% is well justified in terms of a robust research program to drive new missions and reap the maximum return from mission investments. My question is, what advice would you provide to NASA within the Decadal framework if the increase in R&A successfully grows the community until selection rates cannot be sustained at a level of >30% even in this increased budget scenario?

MVS: There is only so much that can be predictably controlled absolutely. Decreasing selection rates have a variety of factors including declining funding (primarily impacting

funds for new awards), increase proposals sizes, increasing number of proposals, etc. I think the contributing factors like proposal sizes could be better understood if NASA was more transparent with relevant information. For instance, considering proposal sizes increasing over time, I would ask: Is there a correlation with institution type? Are more students/postdocs being hired? Are the net FTEs of proposal teams (PI+Co-Is) increasing? Is the cost of total subawards increasing? Are average indirect rates increasing? Are average fringe rates increasing? Has there been a change in the distribution of proposal sizes within a program over time? Is there a correlation with decreasing mission science support? Could this be related to NASA (unique among federal agencies) no longer asking reviewers to assess cost reasonableness (therefore people feel writing more expensive proposals are without consequence – e.g., being considered less cost-effective). In the context of this and other information, I would ask the community for their ideas and comments – they are a wonderful resource. Set up a community-based working group that chews on all this in an open forum.

7. R&A is supposed to be protected if PSD funding levels fall, yet it is supposed grow if PSD budgets rise. How do we reconcile this? What is the appropriate metric for a funding level, if there is one? Is it just a fixed fraction of demand from the community?

MVS: My own thought is that having established a new starting level for funding (e.g., \$500M in 2023), that it be allowed to grow 1.5% over inflation each year. However, if the PSD budget fell to the point where R&A would exceed 20% of the budget, I would freeze it until such time as the PSD budget recovered and started growing again. Until such time as we decide to limit our solar system exploration objectives, there will be pressure to increase the resources for PSD.

8. What is your vision for a vital sample analysis program in terms of infrastructure, sustained lab support and support to individual investigators?

MVS: This is not an area of expertise for me and there have been some knowledgeable White Papers written on the subject, but I would say that laboratory work in general is an area that is grossly underfunded by the agency. There is a lot of turn-the-crank, non-sexy measurements of material properties under different conditions that never get funded. These are essential to our interpretation of spacecraft data (and have run into that deficit in some of my own work in the past. There really needs to be a separate program dedicated to making these kinds of measurements that I imagine would also include sample analysis. This could be one (of many) benefit of breaking up Solar System Workings.

9. More R&A funding is always desirable, but in a fixed budget with all money allocated where would you propose to cut to find the additional money?

MVS: I reject the premise, which is negated by the history of the PSD budget. It has grown substantially over time. You ask for the money you need from appropriators. There is no reason to place R&A on a bed of Procrustes. I would absolutely look forward to going to the Hill to advocate for direction to be given to the agency to comply with a Decadal

recommendation for funding R&A as defined by the Survey. If the President did not include it in his budget proposal, I would gladly advocate for Congress to add it. As a community, we have done things like this in the past. Not a problem.

10. How do you reconcile the recommendation that NASA require or give preference to proposals supporting students/post-docs with the fact that many people in the community are not at academic institutions and are already struggling to support themselves in soft money positions?

MVS: You can't and you shouldn't (at least as framed). Such guidance should never be knee-jerk. What is the goal to be achieved? What defines success? What are the short-term and long-term impacts? How should the effort be scaled? And there should be public discussion in advance of implementation.

11. Can the panel discuss: What is the right number of 100% soft money researchers in Planetary Science? Should this continue to grow yearly and at what rate? Should a community model that encourages more mixed funding positions in planetary science -- industry appt+R&A, community college appt+R&A, R2 university appt+R&A -- be promulgated in our community to help mitigate proposal pressure? Or is it better to have a dedicated and growing cadre of fully planetary science R&A-supported scientists?

MVS: Hah! I was a 100% soft-money scientist at the University of Arizona for 17 years until becoming a CEO, after which my science (still soft-money) slowly ramped down over 15 years as PSI grew! There have never been enough hard-money positions at Universities to accommodate our growing field. Our field has been relentlessly growing because our exploration of the solar system has expanded enormously over decades. The scientists needed to support that enterprise long ago outstripped the ability (or interest) of Universities (or NASA centers) to accommodate it! I had it easy, though in comparison with our colleagues today struggling with ridiculously low selection rates and diminished support for science both in R&A and missions. However, a number of friends of mine in the 90s were unable to get grants funded and found other careers. For me that inspired a backup plan: I went to law school and was admitted to the Arizona Bar and Federal District Court – just in case.

In general, I think it is best for people to have diversity of funding – particularly mission support in addition to R&A funding. Of course, with diminished mission science support that becomes tough (and needs to be fixed).

Our missions are SCIENCE missions and I think there needs to be a rethinking of how they are selected and supported in terms of science. More than anything else, NASA (as a bureaucratic organization) wants to be able to say that a mission (or any activity for that matter) is 100% successful. As a consequence, we focus on defining Level 1 requirements, by which success is measured, that are as minimal as possible. Now defining Level 1 requirements are fine, as a threshold, but in proposing and considering missions we should

also be thinking of what is most that might be returned from a mission? That maximal potential return should be a significant factor in the selection of any mission, and there should be metrics about the success in realizing those returns in addition to unexpected returns. We should feel good about a 40% return on the visionary stuff. We also need to staff mission science teams and provide the support that enables our achieving that return on investment. Even then, science would be a small fraction of the mission cost!

And if I may go on in a similar theme (rant) - I have chaired or otherwise served on most of the senior review panels of the last two cycles for extended missions. The starting point is some guideline budget from HQ that comes up with out of the sky with no support (at least support that is conveyed to the reviewers). It is usually a “modest” cut from the current budget, say 10%. That does not sound too bad until you take into consideration that the major part of the budget is operations, and that usually cannot be reduced. So, a 10% mission budget cut may translate to a 50% cut in science. Then, with few exceptions, I am impressed by the imaginative and valuable science that is proposed for what is, in the grand scheme of things, a marginal expense. The bureaucratic justification of there being is a similarly a limited pie and a zero-sum game afoot is a false premise similar to what has been stated during the panel discussion about R&A. Instead of celebrating them, these missions seem to be considered some kind of an embarrassment, because they are still alive. I was thrilled by the compelling case made for the continuation of Mars Exploration Rover, which was entering its 11th year of a 90-day mission, and for what New Horizons could achieve after Pluto. I was very impressed with the cases for extending Lunar Reconnaissance Orbiter and the Mars Science Laboratory. I have also seen cases in which the new science proposed did not justify the cost of continuation. The lesson is that we do not wring our hands over missions that do not want to die. We ask appropriators for the programs we want and advocate for it. As a consequence, there will also be more mission opportunities and mission funding to diversity the funding base for our community (and, frankly, the diversity of our community!).

12. Would you advocate for a funding guideline for missions as a % of the cost? If so, what would that % be?

MVS: No. I think the current nominal mix and cadence of mission sizes is appropriate (1 flagship every 10 years, 1 New Frontiers missions every 5 years, and I would love to see a Discovery mission every 2 years). Sometimes this can be disrupted by Congressional preferences, but instead of disruption, we should be pushing for necessary funding IN ADDITION to funding for our baseline programs. The Administration and NASA officials also need to value the baseline mission.

Now sometimes there just is not enough money to cover priorities for a baseline mission cadence. The last Decadal (V&V) made a recommendation for this situation, which I think is the most important recommendation of the Survey:

“If cuts to the program are necessary, the committee recommends that the first approach should be descoping or delaying Flagship missions. Changes to the New Frontiers or Discovery programs should be considered only if adjustments to Flagship missions cannot solve the problem. And high priority should be placed on preserving funding for research and analysis programs and for technology development.”

I hope a similar finding is made this year and that it is placed in the Executive Summary!

13. We have heard suggestions for targeting an increased proposal selection rate vs. targeting a total funding level for R&A. Could you comment on these different strategies and what you see as strengths and weaknesses of each?

MVS: They are seen as complementary strategies. Increased funding allows for a higher selection rate (though there are also other factors such as proposal size that may be mitigated to help increase selection rates).

14. We have heard that proposal budgets are increasing steadily, in addition to the increased number of proposals received. Can you comment on your sense of the reason for this?

MVS: Much more information is needed. See my response to 6 regarding proposal budgets. With extremely low selection rates, I would presume there is a tendency to recycle unselected proposals. This is encouraged when you see the same proposal getting widely different scores from one year to the next (suggesting the process is strongly stochastic!). Decreasing mission science support and the end of some major missions like Cassini and Dawn would also increase the numbers of proposals being submitted.

15. This is very NASA-specific discussion. For non-civil servants there are other funding sources - has anyone looked into those and do they have similar recommendations and numbers for NSF and others?

MVS: In straight-up planetary science, NASA is the main game by far (about 98%). NSF Planetary Astronomy has a budget of only \$2-2.5M(?). When I started out in this profession in the very early 80s, I would say that planetary science was dominated by telescope jockeys. Today it is dominated more by geoscientists. So, there are overlapping NSF opportunities in areas of Earth science and terrestrial biology. Earth is a planet too!

16. Are universities over-producing planetary science Ph.D.'s? Should graduate students be required to earn their own NASA or other fellowship (a coarse means of population control, so to speak...) or should writing of graduate students into R&A proposals continue to be encouraged and supported by the R&A budget?

MVS: People have been asking that first question since *I* was in graduate school! Not all planetary science graduate students end up in the profession. Perhaps the DPS has some statistics on that. It used to be that graduate students were relatively cheap labor, but with the inclusion of tuition and other costs, they can often be comparable in cost to a post-doc. That can discourage their inclusion in proposals.

17. Is it feasible to employ a double blind review process when the proposal PIs often request funding to complete studies based on their previous observations. In other words, are all PI truly anonymous?

MVS: The proof will be in the pudding! It will be an interesting experiment. Given the potential for bias with extremely low selection rates, I think the double-blind process should be extended to program officers as well until it is time to weigh other programmatic factors that are objective and documented. Mackwell reported that someone in the chat indicated there might be legal problems with this – which is something I would love to discuss with a NASA attorney to see what the constraints really are and how a more extended execution of double blind review might be facilitated.

18. Do you have process or policy-related recommendations for the PSD R&A program, beyond DAPR that has already been discussed today?

MVS: Absolutely! Imbedded in the answers to previous questions. Something not yet discussed involves the peer review process. At (I believe the last) face-to-face LPSC during R&A Lunch, Jonathan Rall stated that they only had a 20% success rate in getting peer reviewers for R&A proposals. I found this shocking because (as I stated at the time) it was therefore unlikely that reviewers would be expert in the subject areas of the proposals they would be reviewing (perhaps at all). My experience with being asked to review proposals in recent years tends to be an email out of the blue that assumes I will do the review – something I expect many people simply ignore. For decades, I regularly served on review panels and even organized and ran them for some programs. Whenever I was putting together a panel, I would look through the proposals, identify the subject areas and figure out who were experts in those areas. I would call them up directly and when they would tell me they were too busy, I would say that I was busy too and ask what dates would work for them? I never failed to put together a good panel of senior experts (and would always include one or two early career persons so they could learn – and connect with – their more experienced colleagues). Program officers should not be putting out blind email requests. They need to contact people directly and talk with them (or zoom or Facetime, whatever). It is totally doable and would improve the quality and consistency of reviews.

Another recommendation is the need to reorganize the R&A programs, in particular breaking up the very unwieldy Solar System Workings program into five core programs. This is described in a White Paper co-authored (NASA Planetary Research and Analysis: Strategy for Reorganization,

http://surveygizmoreponseuploads.s3.amazonaws.com/fileuploads/623127/5489366/146-68f3e166bfb1bdfdaf311277b03feac0_SykesMarkVb.pdf).

19. Should proposal selection be influenced by the desire to maintain capabilities? If so, how is this implemented fairly?

MVS: Absolutely. Maintaining capabilities is important. This should be clearly articulated and documented in the selection document, however. My main concern is the extent to which desired capabilities are recognizable by program officers (you cannot be an expert on everything). To help with this, I think it would be of value to restore program MOWGs (Management Operation Working Groups), comprised of funded experts in a program to advise the program officer on questions such as this (e.g., a list of capabilities important to the program – not a review of proposals). This allows a program officer, who is not necessarily expert in the area to make a more informed judgement about whether needed capabilities are being maintained by the program.