A report requested by the Mars Exploration Program Analysis Group

Recipe for Success: Research and Technology Programs as Key Ingredients of the Mars Exploration Program

Final Report of the Supporting Research and Technology Science Analysis Group (SRT SAG)

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

This report documents the work of the Supporting Research and Technology Science Analysis Group (SRT SAG), which was tasked with evaluating current NASA research and technology programs for relevance, importance, and effectiveness with respect to Mars Exploration Program (MEP) and Planetary Science Division (PSD) objectives. The SAG also identified missing, but essential, programs and/or infrastructure.

Key conclusions, in priority order, include:

1) Healthy technology development programs are required for making progress towards new, cutting-edge instruments and technologies for planetary exploration, and ensuring that there is a pool of sufficiently well developed hardware for flight missions; however, these programs currently are insufficiently funded and are not effective in supporting MEP and PSD goals and objectives;

2) Research and analysis programs are the primary means of enabling new discoveries that guide the goals and objectives of the MEP and ensuring that flight data are examined to their fullest extent, but programs critical to achieving MEP research objectives (e.g., Planetary Geology and Geophysics, Exobiology/Evolutionary Biology, Mars Fundamental Research, Mars Data Analysis) are seeing flat or negative growth;

3) The proposal review process takes too long from the time a proposal is submitted until the Principal Investigator is informed of the outcome;

4) There is currently insufficient funding for the development of sample handling and analysis infrastructure that would be critical to a Mars Sample Return mission, and which requires a substantial lead-time to implement.

We offer the following prioritized list of suggestions for improving the SR&T programs:

1) The PSD should establish an adequately funded instrument development program (or series of programs) that take instruments from concept to readiness for proposal for flight; funding levels and the pace of solicitations need to be consistent in order to enable and support a long-term strategy for technology advancement.

2) The PSD should ensure that research and analysis programs supporting fundamental research and data analysis efforts that are highly relevant to the MEP (in particular, the Planetary Geology and Geophysics, Exobiology/Evolutionary Biology, Mars Fundamental Research, and Mars Data Analysis programs) receive increased financial support from NASA;

3) The amount of time it takes for proposals to navigate the review process and for a notification to be made to the proposer needs to be reduced to a period on the order of six months; meeting this goal means finding new efficiencies, such as instituting a pre-proposal or tiered proposal review approach that does not require investigators to submit, or panels to review, a full proposal at the outset of the process;

4) A program should be instituted (or a current program modified in scope) to support work related to Mars sample return acquisition, handling, curation, and analysis and

foster the development of new approaches and laboratory infrastructure required for this specialized sample set of the future.

2. INTRODUCTION

2.1 Background

The National Research Council's report, "An Enabling Foundation for NASA's Earth and Space Science Missions" (http://www.nap.edu/ known as the "Fisk report") recommended a review of the research and analysis activities that contribute to NASA's Planetary Science Division goals and how the activities might be improved. In response to this recommendation, in September 2010, the Planetary Sciences Subcommittee (PSS) of the NASA Advisory Council initiated a study of the Supporting Research and Technology (SR&T) and related activities to assess program relevance and effectiveness, and to suggest possible improvements in program management. The reason for this is that supporting SR&T activities are critical in enabling the strategic goals of the PSD to be met. It is anticipated that the study results would lead to recommendations to the PSD Director through the NAC Science Committee in late summer 2011. The PSS has encouraged an analysis of the issues from the PSD Analysis Groups, including the Mars Exploration Program Analysis Group (MEPAG), which initiated the Supporting Research and Technology Science Analysis Group (SRT SAG) to provide this input.

2.2 SRT SAG Charter

The charter of the SRT SAG (Appendix A) is to support the PSS by providing a Mars-specific perspective on SR&T programs at NASA. To this end, the SAG considered the following:

- Which current science related research and technology activities are essential in meeting Mars Program objectives? Which current science related research and technology programs are less effective in meeting Mars Program or PSD objectives?
- Are there research programs that appear to be missing currently, but that are essential in meeting Mars Program research objectives?
- Is there missing infrastructure that is needed to support Mars Program research objectives?

The SAG also was tasked with prioritizing SR&T programs and needs, as well as offering specific, realistic metrics to evaluate programs and activities in the PSS Study.

The membership of the MRR-SAG is listed on page 2. Team members were selected by the MEPAG Executive Committee to represent a diversity of scientific expertise within the Mars Program, including atmospheric science, astrobiology, surface science, meteoritics, and spacecraft mission experience. To inform its discussions, the SAG solicited, collected, and organized input from the MEPAG membership to identify, and solicit advice on, key elements of the PSD SR&T portfolio, as well as any missing elements. The SAG sought this input via a short survey solicited through the MEPAG mailing list, posted on the MEPAG website, and described at a town hall meeting at the Fall Meeting of the American Geophysical Union (December 15, 2010). Approximately 30 individuals responded to the SRT SAG request for feedback. The questions asked of the community follow closely the questions in the SRT SAG charter, and additionally solicit information on proposal review and administration:

- Which current science-related research and technology programs (e.g., MDAP, PIDDP, PGG) are essential in meeting Mars Program objectives?

- Are there research/technology programs or infrastructure that appear to be missing currently, but that are essential in meeting Mars Program objectives?
- Do you feel that non-Mars-specific R&A programs are maintaining a consistent attitude towards Mars-related research?
- What method(s), if any, do you feel would lead to greater efficiency in the grant submission, review, and award process?
- For grant programs that offer longer duration awards, please comment on whether or not you take advantage of this option and why.

The remainder of this report addresses the tasks of the SAG in six major sections: ranking of current SR&T program relevance to MEP/PSD goals and objectives (section 3.1), essential programs and infrastructure (section 3.2), missing programs and infrastructure (section 3.3), ways to improve the proposal evaluation process (section 3.4), issues surrounding extended-length (>3 years) grants (section 3.5), and other topics not addressed by the above categories (section 3.6). Statements regarding levels of funding are based on funding levels projected in the last several (~5) years of ROSES solicitations. Suggestions of the SAG, where they are offered, are accompanied by text describing the rationale behind the suggestion. In sections having more than one suggestion, the suggestions are presented in priority order. Implementation of any or all of the suggestions regarding current or potential future programs should endeavor to be consistent with the recommendations of the forthcoming National Research Council's Planetary Science Decadal Survey.

The SAG recognizes that in the current economic climate, NASA, the Science Mission Directorate, and the PSD are unlikely to receive substantial budgetary increases in coming years. However, funding to support needed programs and infrastructure could be obtained through the re-programming of existing budgets, which may require difficult choices in soliciting and managing SRT programs and flight projects. It was not within the scope of the SAG's charter (nor were there resources available) to quantify what constitutes "adequate" funding of programs, or from where resources might be acquired to augment funding levels of extant programs/infrastructure or provide funds for new ones.

3. NASA SR&T PROGRAMS FROM A MARS EXPLORATION PERSPECTIVE

3.1. Evaluation of ROSES Program Elements for Relevance and Importance to PSD and MEP Objectives

The SRT SAG members compiled a list of programs from the 2010 ROSES NRA that could be considered potentially relevant to the MEP. The group then assessed the programs as having high, moderate, or low relevance to MEP goals as they are currently solicited, referring to the MEPAG Goals document [*MEPAG*, 2010] as necessary. Changes to these programs could alter these rankings. Table 1 shows the SAG's ranking of the programs, in descending order of relevance (unordered within each relevance category). Additional details, where deemed important, are discussed in subsequent sections.

Table 1. SRT SAG ranking of Mars-relevant ROSES 2010 programs.

Program	Current Relevance to MEP Goals	Notes
C.12 Mars Data Analysis	high	--
C.13 Mars Fundamental Research	high	Success rates low compared to similar programs

Program	Current Relevance to MEP Goals	Notes
C.14 Mars Instrument Development Project	high	An important mid-TRL program; not consistently solicited
C.15 Mars Technology Project	high	--
C.21 In-Space Propulsion: Mars Ascent Vehicle	high	--
C.2 Cosmochemistry	high	Not Mars-specific, but Mars has received ~28% of the funding over the last 5 years
C.4 Planetary Geology and Geophysics	high	Not Mars-specific, but Mars has received ~20% of the funding over the last 5 years (primarily mapping in last 2 years); budget has experienced ~$2M reduction over last 5 years
C.6 Planetary Atmospheres	high	Not Mars-specific, complements MDAP; ~10-20% of funding is for Mars-related research
C.16 Planetary Instrument Definition and Development	high	Not Mars-specific, but ~70% funds Mars-related technology; success rates low
C.17 Astrobiology: Exobiology and Evolutionary Biology	high	Not Mars-specific, but focuses on habitability, biosignatures, etc. that are highly relevant to Mars research/exploration; program funds reduced substantially in 2005
C.18 Planetary Protection Research	high	Mars a major focus - would become increasingly important if MEP pursues Mars Sample Return (MSR)
C.19 Astrobiology Science and Technology for Instrument Development	high	Only program for development of instrumentation addressing MEPAG Goal 1; irregularly solicited since 2004; program funds reduced substantially in 2005; success rates low
C.20 Astrobiology Science and Technology for Exploring Planets	high	Only program for field testing concepts addressing MEPAG Goal 1; irregularly solicited since 2004; program funds reduced substantially in 2005
C.23 Planetary Major Equipment	high	--
C.26 Mars Science Laboratory Participating Scientist Program	high	Not a recurring solicitation
C.5 Planetary Astronomy	moderate	Mars not explicitly mentioned, but not excluded
C.22 Fellowships for Early Career Researchers	moderate	Could reward and encourage young scientists, but limited direct impact on MEP goals
C.24 Moon and Mars Analogue Missions Activities	moderate	Small program to fund specific field testing activities; follow-on to PIDDP, ASTID, etc.
C.3 Laboratory Analysis of Returned Samples	low	Formerly SRLIDAP; only Genesis and Stardust analyses are eligible, but something similar is important to MSR
B.3 Heliophysics Research: Geospace Science	low	Primarily plasma physics (magnetospheres, not atmospheres)

Program	Current Relevance to MEP Goals	Notes
E.4 Opportunities in Education and Public Outreach for Earth and Space Science	low	Pool of awardees does not overlap significantly with research community; not a likely source of funding for Mars community
E.5 Supplemental Outreach Awards for ROSES Investigators	low	Small awards for E/PO related to selected grant; low relevance to achievement of MEPAG goals, but nonetheless important to MEP
E.6 Supplemental Education Awards for ROSES Investigators	low	Small awards for E/PO related to selected grant; low relevance to achievement of MEPAG goals, but nonetheless important to MEP
E.3 Origins of Solar Systems	low	Mars not explicitly excluded, but program goals are primarily related to planetary systems

3.2. Essential Existing Ingredients in SR&T Programs and Infrastructure

Existing programs and infrastructure fall into two general categories, described below: research and analysis (R&A) programs and technology programs. Both strengths and minor weaknesses of these programs are described here and contribute to the prioritized suggestions below. Major weaknesses have been identified with technology programs and are addressed in detail in section 3.3.

Not surprisingly, the overwhelming consensus among community respondents and the SAG membership was that the Mars Fundamental Research Program (MFRP) and Mars Data Analysis Program (MDAP) are lynchpin R&A programs for the MEP, funding a range of theoretical and cross-disciplinary research, field and lab studies, modeling and extended analyses of existing data. These programs define critical hypotheses for future research that can be tested by future flight missions. Although the SAG does not have access to the information needed to fully evaluate the effectiveness of any of the SR&T programs in meeting MEP and PSD objectives, MFRP and MDAP are perceived by the community as being effective in doing so. A particularly important role of MDAP is the contribution the program makes to landing site characterization and analysis. As current orbital assets age, and without replacements for surface characterization on the horizon, it is very important that this program support studies that can lead to the recognition that additional data are required from our current assets. Of concern, however, is the delicate balance investigators must maintain in proposals to these programs to ensure that there is not too much fundamental research in an MDAP proposal and/or too much data analysis in an MFRP proposal. It is difficult to fully integrate field analogue studies, lab experiments, computer modeling, and/or flight data analysis under a single proposal/grant. Furthermore, funding levels appear to have remained stagnant over the last several years (per the ROSES solicitations) during a period where flight missions are producing large volumes of data that are not being fully exploited, and more missions are on the horizon (MSL, MAVEN, TGO, and possibly MAX-C/ExoMars). The cost of keeping funding levels on at least an inflation-adjusted trend is small relative to the benefits reaped in terms of the advances that can be made in data analysis and fundamental research.

The Mars Fundamental Research and Mars Data Analysis programs are not replacements for Mars-related funding in the broader planetary science programs. Important programs that regularly support vital scientific research important to the Mars community include Astrobiology (e.g., the NASA Astrobiology Institute and the Exobiology and Evolutionary Biology (Exo/Evo) program), Planetary Atmos-

pheres (PATM), Cosmochemistry, and Planetary Geology and Geophysics (PGG). None of these programs focus on Mars specifically, but have proven to be essential sources of funding for basic Mars research, and in some cases (e.g., astrobiology) have obviously strong linkages to Mars. These programs also offer a critical opportunity for comparative studies between Mars and Earth, Mars and Venus, Mars and the Moon, and Mars, its moons, and other planetary bodies. Although generally effective in enabling Mars-focused research, the levels of support for Mars research in non-Mars-specific programs varies over time, and may be attributable to factors such as available funding, programmatic considerations, proposal quality, and/or appropriate expertise on review panels to evaluate Mars-focused proposals.

The SAG noted particularly troubling funding levels in some important programs to the MEP. Based on budgets listed in the relevant ROSES solicitations, the funding for PGG has dropped from $5M to $3M over the last five years. This reduction in the PGG budget (plus additional losses associated with inflation) has led to a proportional reduction in Mars-specific new starts, with the exception of mapping grants (which have stayed level). The results are that non-mapping geology and geophysics awards have been reduced disproportionately and that the PGG program is losing its effectiveness in addressing MEP objectives. In addition, astrobiology science programs are still recovering from a 30% reduction in funding that occurred between 2005 and 2007. Funding for the astrobiology science programs is being gradually restored, but the NASA Astrobiology Institute has not yet returned to (inflation-adjusted) pre-cut funding levels, and the Exobiology and Evolutionary Biology program has a flat funding trajectory. This situation is problematic because the research supported by these programs shapes the community's understanding of habitability and biosignatures. Vibrant research into habitability and biosignatures would become increasingly important if the MEP evolves to focus on sample return, as is widely expected. This research would strongly influence sample selection, strategies for sample analysis, and planetary protection measures.

Topical workshops funded by R&A programs enable community interaction on a level that goes deeper than typical science conferences allow and permit scientists studying different planetary bodies to engage in discussions about common planetary processes. Participating scientist programs are an essential and highly effective mechanism for increasing and broadening community involvement in flight missions, and help ensure that collected data address a diverse range of scientific questions. However, there is a perception that participating scientist program funds continually are threatened by flight project cost overruns.

For technology development, the Planetary Instrument Definition and Development Program (PIDDP) is critical to the MEP, providing funding for low- to mid-TRL development. When it has been solicited, the Mars Instrument Development Project (MIDP) has provided an important venue to mature Mars-specific instruments to TRL-6. The Astrobiology Science and Technology Instrument Development Program (ASTID) has served a similar, but not as comprehensive, role as MIDP, focusing on astrobiology-related technology. The Astrobiology Science and Technology for Exploring Planets (ASTEP) program is seen as a partner to ASTID and provides the avenue through which astrobiology instrumentation and exploration strategies could be field-tested. These programs are critical to advances in future instrumentation for exploring Mars; at present, they are underfunded, which is a major detriment to the MEP. Problems with technology development in the PSD are addressed in section 3.3.

Suggestion:

- **The PSD should ensure that research and analysis programs supporting fundamental research and data analysis efforts that are highly relevant to the MEP (in particular, the Planetary Geology and Geophysics, Exobiology and Evolutionary Biology, Mars Fundamental Research, and Mars Data Analysis programs) receive adequate financial support from NASA.** In particular, PGG should be returned to the funding levels (adjusted for inflation) at

which it was supported in the beginning of the current 5-year period, and the PGG program manager should ensure that Mars-focused, non-mapping studies do not continue to suffer disproportionate reductions in funding. The PSD should strive to increase funding levels of Exo/Evo, MFRP, and MDAP to obtain the greatest return on investment from past, present, and upcoming Mars missions. Non-Mars-specific programs (e.g., PATM, Cosmochemistry, etc.) should have their funding levels increased at least to match inflation, and they should be monitored to ensure they maintain balance across the solar system (e.g., they do not neglect Mars-focused research simply because of the existence of Mars-specific programs, which do not fill the same role).

3.3. Important Missing Ingredients in SR&T Programs and Infrastructure

Technology development across the PSD has been weakened greatly in recent years due to budget cuts, and lacks a comprehensive approach to shepherding new technologies from low to mid-, or even high TRL. The infrequent solicitation of MIDP (not since 2007) makes it an unstable source of Mars-specific instrument development and forces higher-TRL development into PIDDP. To make matters worse, the non-Mars-specific nature of PIDDP places a heavy burden on that program to sustain any significant Mars technology development, especially for notional Mars sample return timelines. PIDDP also is heavily oversubscribed, with insufficient funds to support all highly ranked proposals. The astrobiology-related programs, ASTID and ASTEP, have not been solicited consistently since 2004 and had their budgets cut severely in 2005; these programs are now just returning to their 2005 funding levels, which means that, adjusting for inflation, they have not yet achieved their pre-budget cut levels of support. The Mars Technology Project is essential to engineering efforts to develop and advance systems such as avionics, entry/decent/landing (EDL) systems, etc., but this program's budget also has been cut from time to time to cover costs elsewhere in the MEP.

The low levels of funding and irregular pace of technology development solicitations preclude a long-term strategy for technology advancement across the PSD; this is a very real hindrance to the Mars program, as it results in the selection of instruments for flight that are inadequately developed, shifting the burden of development to flight projects, which then leads to cost increases and mission delays (with associated, larger cost increases). Problems with instruments and other hardware on the Mars Science Laboratory are an example of this, and the resulting overruns and delays on that project threaten the entire Mars Program and have damaged the MEP's reputation with the planetary science community. A relatively small fiscal investment in instrument development well in advance of the release of the solicitation for MSL instruments could have identified, and possibly helped retire, many risks prior to selection for flight, potentially saving the MSL Project and the MEP tens of millions of dollars. If they persist, current technology funding levels position the MEP to suffer from a continuing lack of sufficiently advanced instrument concepts available for flight, which could again result in selection of underdeveloped instrumentation (and the resultant cost risk to mission definition and development).

Lack of support for tackling issues related to sample acquisition, handling, and analysis is another problem identified by the SAG and members of the community, as these capabilities are pre-cursors to successful acquisition and analysis of samples returned from Mars. Planetary protection research to prevent contamination of Mars by spacecraft that drill or collect samples for return to Earth is currently inadequately supported. Samples returned from Mars would need to be handled, subdivided and stored in an analogous way to meteorites and the Apollo lunar samples. However, the required environment of preservation would be different and the total amount of material would be relatively small. Therefore new handling techniques would have to be developed far in advance to enable improved detection accuracy, precision and detection limit, as well as reduce consumption of sample mass and reduce the vulnerability of measurements to terrestrial contamination. Robotic sample handling is likely to be very useful in the handling of samples that have planetary protection requirements and also for samples which must be kept

sterile or at least minimizing additional terrestrial organic contamination during the handling process. Second, scientific studies of returned Martian samples would require new equipment and specialized analytical approaches that could be carried out on very small and precious samples. These techniques must cover a large range of scientific disciplines from studies of crystallization conditions and ages of rocks, to studies of secondary weathering processes at the surface of Mars, to astrobiology and organic geochemistry (life detection). There also is a concern that there is not sufficient training of students in specialized sample return handling methods or in developing specialized analytical approaches. This may be due to Mars sample return being on a longer-term schedule (decade or so) rather than the shorter-term cycles of typical SRT programs.

Members of the Mars community also expressed concern about a lack of sufficient support for development, release, and support of tools for the analysis of large Martian (and other planetary) data sets, as well as barriers to entry for analyzing Mars (and other planetary) data. A wide variety of data analysis tools exist for analyzing Martian data but the tools and data are commonly written and/or stored in a variety of formats that may be incompatible. Directions on how to use tools and/or data may be missing or cryptic. Technology research into developing new ways to analyze or inter-compare data sets has been lacking, although there are some funding sources (e.g., critical data products programs) and successful examples that demonstrate the utility of such tools (e.g., Arizona State University's publicly-available JMARS software). Investigators may develop innovative methods of data analysis in their scientific projects, but there is no consistent funding venue for developing these tools to the point where members of the general community could use them or for continuing to support them after that point, as science programs generally do not fund proposals that contain a significant portion of work effort devoted to model or tool development. We observe that the Advanced Information Systems Research (AISR) Program, which appears in ROSES every year, fills a niche for infrastructure research and software development in support of data analysis, but hasn't been solicited since ROSES 2007.

Suggestions:

- **The PSD should add to or augment the current SR&T portfolio with an adequately funded series of development programs that take planetary instruments and other hardware from concept to flight readiness.** Programs within this series need not be Mars-specific but should aggressively solicit input from the planetary science community as to what technologies/measurement capabilities are most greatly desired for anticipated mission opportunities, and then prioritize these technologies in their solicitations. With regard to technology development, we suggest that the PSD expand financial support for programs that fund low-TRL development, but which currently are underfunded relative to the number of highly-ranked proposals and the need for a diverse suite of instrument concepts to support the MEP and other PSD exploration objectives (e.g., Discovery and New Frontiers missions). Additionally, fiscal support for mid-TRL development needs to be expanded and offered on a regular basis. We suggest that this could be accomplished within a single program addressing instrumentation covering all areas of planetary science, providing multiple years (e.g., three) of funding, and with an average funding level of $1M/year or greater. An expanded field-testing program should be available for mid- and high-TRL instruments. Lastly (but at lowest priority due to its likely cost), a limited, high-TRL program should be available to aid instruments in preparing for flight, up to levels of $5-10M per instrument for particularly complex concepts.

- **A program should be instituted (or a current program modified in scope, e.g., Laboratory Analysis of Returned Samples) to support work related to Mars sample return acquisition, handling, curation, and analysis and foster the development of new approaches required for this specialized sample set of the future.** For the handling and curation development, such work should include (but not necessarily be limited to) robotic sample handling and curation of materi-

al in temperature and humidity environments relevant to the Martian surface (rather than at room temperature in gaseous nitrogen cabinets). This program should focus on improving the community's ability to work with small sample masses (improved detection, accuracy and precision, as well as reduced contamination, and reduced sample consumption) and begin to develop sufficient infrastructure in the form of multiple laboratories that are able to operate at sufficient technical standards to enable them to receive allocations of Martian samples. In a modified version of an extant program, funding allocated Mars-focused work could start at relatively low levels and increase with time.

- **NASA should ensure that there is funding available to develop and maintain tools for the community that would allow analysis of the large and complex data sets that flight missions acquire.** This includes software, documentation, and training for new users. User-friendly access to data, through PDS or other sources, should be (or continue to be) required and verified by the funding programs. Regular calls for funding to support development and formal release of new data analysis tools for the community should be available; a resurrected AISR (or similar) could fill this gap. A funded program to make software methods and tools available to the community could accompany MDAP and MFRP awards, similar to the manner in which Planetary Major Equipment supports hardware expansion.

3.4. Improving the Proposal Submission/Review Process

There is room for improvement in the proposal submission and review process in terms of the dissemination of information, the speed of the process, and incentives for community participation. The SAG understands that SRT program offices are generally understaffed for the amount of work generated by proposals and grants, and that it is unlikely, especially in the current fiscal climate, that any significant increase in staffing can be expected. Therefore, some improvements may be achieved through alternative approaches reviewing proposals. No respondents to the community survey indicated problems with the proposal solicitation and submission process, and the SAG does not believe there are major problems that require addressing at this time. However, numerous, creative ideas were contributed by members of the Mars community as to how to streamline the proposal review process or incentivize the community to participate; because their concise nature makes it feasible to do so, we list all of them here:

- institute a pre-proposal or tiered proposal review approach that does not require a full proposal at the outset of the process;
- allow PIs and Co-Is to serve on review panels;
- provide a digital system whereby members of the community could indicate (and update) their availability to review during the year, their areas of expertise, and their preferences for programs on whose panels they are willing to serve;
- if feasible, enable review panels to meet via telecon/WebEx for portions of the review process;
- re-institute previous PSD-developed deadlines (relative to proposal submission dates) for holding review panels, giving preliminary indications of selection, and delivering award paperwork to NSSC, and ensure that backup personnel are available so that the absence of a single individual at NASA HQ does not result in the award process coming to a halt;
- ensure that programs tapping a similar segment of the community (e.g., MFRP and MDAP) do not hold review panels in close temporal proximity;
- consolidate some programs with similar or related objectives (i.e., reduce number of reviews required, and reduce opportunities for research being funded in more than one program);
- split large programs into more manageable chunks with more specialized foci;

- increase award amounts and/or durations on a regular basis (e.g., do away with the perception that an investigator cannot ask for more than 20-30% of their time from a single program and /or reduce the number of proposal submissions required to fund an investigator's time);
- vary proposal page requirements depending on the level of effort requested (lesser levels of effort given shorter page limits, which require less time to evaluate);
- allow members of the community to bill NASA for their time spent contributing to the review process;
- minimize the effort required by review panels to evaluate proposal relevance (e.g., by making it a binary outcome);
- identify a legally acceptable means of requiring funded PIs to serve on at least one review panel during the term of their award;
- consider using contracts instead of grants as funding vehicles to ensure that work (hardware and/or scientific research) is completed and delivered in some form;
- ensure that review panels are given consistent direction as to how to evaluate merit, relevance, and cost realism;

Suggestions:

The SAG members believe that although virtually all of the suggestions offered have merit and could be helpful in streamlining the grant review process, some are more amenable to rapid implementation than others, and these are prioritized and described below.

- **Institute a pre-proposal or tiered proposal review approach that does not require a full proposal at the outset of the process.** The large number of programs requiring peer-review is a burden to proposers, reviewers, and program managers. Proposers currently must write full proposals at every opportunity, which takes significant amounts of their time (and their institution's time) and reduces the time available for investigators to conduct their scientific work. Review panels and program managers must fully evaluate every proposal that is submitted, even in cases where proposals are not well aligned with the program goals or are clearly deficient in their methods or objectives. Developing a pre-proposal or tiered proposal review system like those employed by other federal agencies would ease the burden on both proposers and reviewers and program managers by reducing the number of full proposals that must be written and reviewed. For example, NASA could request that all potential proposers to a solicitation submit a 2-3 page pre-proposal that is reviewed (remotely and rapidly) for merit and alignment with high-priority objectives of the programs (stated in the NASA Research Announcement) by the program manager and a small committee of community members; each investigator would receive, in return, a request for a full proposal or a notice declining or discouraging submission of a full proposal. In another example, a tiered proposal review process could request submission of only the scientific and technical management section of the proposal (with the length potentially keyed to the anticipated level of effort), including a work plan and notional budget; only if a proposal is deemed to have sufficient scientific/technical merit and relevance to the program (i.e., it scores Good or better) would the PI would be asked to submit a formal budget and budget justification (saving proposers and their institutions effort as well as saving the review panel time and effort).

- **Provide a simple, internet-based means for members of the community to indicate (and update) their availability to review proposals during the upcoming year, their areas of expertise, and their preferences for programs on whose panels they are willing to serve**. A major impediment to responding to proposers in a timely manner is the difficulty associated with convening review panels for the large number of programs that exist. Review panels require large numbers of reviewers with relevant expertise many times throughout the year. Finding panelists to populate a review is an essentially random and time-intensive process of calling members of

the community to ask for their help with no knowledge of their past contributions or future schedule availability. A database fronted by a simple calendar and list of questions could be developed and deployed in NSPIRES that would enable members of the community to indicate their schedule availability, areas of expertise, and program review panels on which they feel most competent to serve. Program managers could then quickly search this database for people with the relevant experience, interest, and availability to serve on review panels, thus potentially saving weeks of time, and jump-starting the review process as soon as submissions are received.

- **Allow proposal principal investigators and co-investigators to serve on the review panels of programs to which they have submitted a proposal.** The science community understands that eliminating conflict of interest issues is an important element of a fair evaluation process. However, in recent years, the increased restrictions on the participation of PIs and Co-Is on review panels has significantly reduced the number of people available to participate in the review process. This could result in proposals being reviewed by members of the community who do not necessarily have the expertise needed to provide thorough evaluations, which is a negative impact on the process. There are numerous mechanisms for avoiding conflicts of interest during panel reviews, and these have worked successfully in the past; with the increased number of programs and review panels, NASA needs to find ways to broaden, not restrict, the reviewer pool.

- **On a case-by-case basis, consider providing the option for review panels to meet via telecon/WebEx for portions, or all, of the review process.** A major impediment to scheduling review panels and identifying willing volunteers to serve on them is the requirement that panelists must generally travel for the better part of a week. For faculty members, this could be problematic as it interferes with teaching and exam schedules. For some people, family considerations make travel inconvenient or impossible. With the availability of instant communication via telephone and the Internet (as well as document sharing), there are aspects of the review process that could be accomplished remotely. If some, or all, panel work could be accomplished in advance, it would reduce or eliminate the time required for a final face-to-face meeting of the panelists. Additionally, although review panel budgets are not contained within the PSD budget, shorter travel durations would enable NASA to realize a cost savings.

- **Re-institute previous PSD-developed deadlines (relative to proposal submission dates) for holding review panels, giving preliminary indications of (non-) selection, and delivery of award paperwork to NSSC**. At present, the time between submission of a proposal and receipt of a letter indicating the acceptance or declination of that proposal (along with the consensus review) is on the order of 6 - 12 months, typically at the longer end of that schedule. Although the effort required to complete the review process is high, delays in notification are a significant burden on proposers, especially for those individuals who support themselves largely on grants and already spend a great deal of time writing proposals. Resubmission of proposals to the same or different programs as a result of delays in notification are a waste of proposers', review panels', and program managers' time. In recent years and within the current process, the PSD Director developed a schedule of deadlines that reduced the time to notification and award to something on the order of six months; this resulted in more rapid notifications that were viewed very favorably by the community, but these deadlines appear to have been disregarded recently, so we encourage the PSD to reinstitute them. Introducing other efficiencies to the process, as suggested above, may make it less difficult to meet these deadlines.

3.5. Longer Duration Grants

The SAG asked the community to comment specifically on the topic of longer duration (>3 years) grants and whether investigators are taking advantage of them or not and why. The community is divided as to the usefulness and/or value of such awards.

Many members of the community had favorable comments about the availability of longer duration (>3 years) awards and indicated they had taken advantage of this relatively new possibility. The kinds of arguments used in favor of longer awards were: allows extra time for re-proposing at the end of an award, allows extra time to get things done in general, allows maturing of ideas, good for field work and modeling because these are time intensive studies, good for instrument development because these could be more time consuming than normal research projects, good for graduate student support due to greater funding stability over the timeframe of a Master's or Doctoral degree, and allows proposers to write fewer proposals and focus more time on doing science.

On the other hand, several respondents had negative things to say about the longer duration awards. Some felt that five-year awards are too long and require too much trust in an individual research program. Others felt that it is not necessary to wait three or more years into an award before producing high quality research to warrant another award. Another common complaint was that investigators who had requested longer duration awards (over multiple submissions) but did not get a longer award were left with the feeling that something is blocking the deployment of this concept. Another concern is that five-year awards might introduce inefficiency compared to the traditional shorter awards of 3 years. Lastly, in at least one program, it appears that extended duration awards have been used as a programmatic tool to even out funding loads over time.

Suggestion:

- **For longer duration proposal requests, consider implementing a system that enables extensions to three-year awards.** Requests for extended funding may be reviewed quickly and awarded in cases of well-documented merit and where a project making adequate progress demonstrates that additional time and funds are warranted.

3.6. Additional Topics for Consideration

Topics that do not fit neatly into the categories above also were raised during the SRT SAG's deliberations and through the community survey. These are described here in no particular order as additional topics to consider, without specific suggestions for addressing them.

Broadly speaking, research/analysis and technology funding needs to be maintained and even increased if NASA wants to ensure that the United States maintains a capable and vibrant scientific and engineering community that is working on the cutting edge of space science and conducting successful spaceflight missions. If a perception develops that this community is inadequately supported and trained, it may result in a loss of support from the public and the federal government. Because of its high-profile role in solar system exploration, specific attention needs to be paid to the workforce of the Mars science community. Members of the community have noted growing difficulties in attracting and retaining the most talented graduate students because other fields appear to offer greater, more stable opportunities. Workforce issues that face the Mars science community have been described in a white paper submitted to MEPAG [*Beaty et al.*, 2003]. In large part, these issues cascade down from the stagnant R&A funding levels over the past several years, and include: the present need for researchers to win numerous proposals (and submit many more) to support a research career; the loss of highly talented, established investigators and young scientists to fields that offer greater financial stability and job security; an out-of-the-gate disadvantage for young scientists competing against well-established senior scientists for very limited funds

from these R&A programs; and a growing volume of spaceflight data that cannot be fully exploited due to underfunding of R&A programs.

As described in section 3.2, substantial, consistent support for technology programs that fund advanced TRL development efforts across the PSD could go a long way to reducing the increasing tendency for flight projects to bear development costs (potentially resulting in delays with their additional costs) for hardware that is not sufficiently mature. However, increased technology development support is only part of the solution; many cost growth-evaluating bodies have found that there are no incentives for proposers of hardware to be realistic about TRL or costs [c.f., *NRC*, 2010]. In the case of MSL, the tendency of proposers to be overly optimistic about TRL and cost, and NASA review panels and selecting officials to buy into that optimism for the sake of attaining the most conceptually desirable scientific data, has had devastating effects on the MEP. Although the promise of a successful MSL mission is enormous, the technical problems of that mission have resulted in a loss of funds for research and future planetary instrument/technology development, as well as damage to our reputation with the planetary science community. Therefore, although increased financial support of technology programs may enable the community to better prepare for flight mission proposals, it is important to point out that NASA must also bear the burden of not soliciting or selecting proposals for spaceflight hardware that is not sufficiently mature, even if it means that we cannot immediately make the scientific measurements we might want. Additionally, NASA must not shrink from descoping instruments or canceling missions in cases where technical problems are causing significant cost and/or schedule delays. By making difficult, but fiscally responsible, decisions, there is a greater opportunity for NASA missions to stay within budget, and less risk of research and technology funds being used to cover the costs of inadequate initial development of selected flight hardware.

References

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4. APPENDIX A. SRT SAG CHARTER

The NRC Fisk report (2010) "An Enabling Foundation for NASA's Earth and Space Science Missions" (www.nap.edu) recommended a review of the R&A activities that contribute to PSD goals and how the activities might be improved. In response to this recommendation, in September 2010, the NAC Planetary Sciences Subcommittee (PSS) initiated a study of the Supporting Research and Technology (SR&T) and related activities to assess program relevance and effectiveness, and to suggest possible improvements in program management. The reason for this is that supporting Research and Technology (SR&T) activities are critical in enabling the strategic goals of the Planetary Science Division (PSD) to be met. It is anticipated that the study results will lead to recommendations to the PSD Director through the NAC Science Committee in late summer 2011.

As input to this study, the PSS has encouraged an analysis of the issues from the AGs, including MEPAG.

Tasks requested:

Work to support the PSS committee as they refine their questions and needs for information. Make sure that a Mars perspective has been considered. Some initial candidate discussion topics posed by the PSS include:

- Which current science related research and technology activities are essential in meeting Mars Program objectives? Which current science related research and technology programs are less effective in meeting Mars Program or PSD objectives?
- Topics/research programs that appear to be missing currently, but that are essential in meeting Mars Program research objectives
- Infrastructure that is missing but is needed to support Mars Program research objectives
- Prioritize the above.
- Valid specific metrics to evaluate programs and activities in the Study

Timescale – over next 5 years (=length of longest awards).

Solicit, collect and organize inputs from the MEPAG membership; identify strategic issues that MEPAG should address. Solicit advice on those specific issues.

Schedule and Deliverables:

Initiated during September 2010 MEPAG meeting
Collect and organize inputs from MEPAG community in Oct-Dec.
Interim report in PPT format in November to the MEPAG Executive Committee
Be prepared for a short discussion (15 minutes) at the MEPAG townhall meeting at AGU.
Short white paper by end of December

Dave DesMarais, MEPAG Chair (incoming)
Michael Meyer, NASA Senior Scientist for Mars Exploration, NASA HQ
David Beaty, Mars Directorate Chief Scientist
Rich Zurek, Mars Program Chief Scientist

October 21, 2010