February 18, 2016

Dr. Jonathan Rall
Planetary Science R&A Lead
Planetary Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546

Reference: 2015-16 Review of currently funded SMD Planetary Facilities

Dear Dr. Rall

Please find below the review of the four currently funded SMD Planetary Facilities, with Summary Findings and Comments to NASA. Also appended are the Reports of the individual facility reviews that took place in October and November of last year.

I hope that this review will be of use as you seek to redefine planetary facilities support within the Planetary Science portfolio. I am happy to provide amplification on the report, as desired.

Sincerely yours,

Stephen Mackwell, PhD
Director, Lunar and Planetary Institute

USRA
3600 BAY AREA BOULEVARD ◆ HOUSTON, TEXAS 77058-1113
281.486.2159 ◆ mackwell@lpi.usra.edu ◆ www.lpi.usra.edu

February 18, 2016

Review of currently funded SMD Planetary Facilities

Stephen J. Mackwell, USRA-LPI – Panel Chair

Overview

The Planetary Science Division (PSD) within NASA's Science Mission Directorate (SMD) currently provides funding for staffing and infrastructure of four facilities that perform technical and scientific activities for members of the Planetary Science community. These facilities include:

- Reflectance Experiment Laboratory (RELAB) at Brown University in Providence, RI
- Planetary Aeolian Laboratory (PAL) at NASA Ames Research Center in Mountain View, CA
- Ames Vertical Gun Range (AVGR) at NASA Ames Research Center in Mountain View, CA
- Glenn Extreme Environments Rig (GEER) at NASA Glenn Research Center in Cleveland, OH

Reviews of each facility were performed in early FY2016 at the NRESS Facility in Arlington, VA. Each review was conducted by a specialist Review Panel, led by a Group Chief. Also present were the Panel Chair (Dr. Stephen Mackwell), the NASA lead for the facilities review (Ms. Doris Daou) and representatives of the appropriate NASA disciplinary fields. The structure of the reviews was essentially the same, with a presentation by the Facility leadership, followed by questions and answers from the panels, closed discussion among the panel membership, and follow-up questions and answers with the Facility leadership. The Panels were provided with criteria and objectives for this review, which focused on assessing lessons learned and best practices in support of the Facilities. They were charged with writing a report with Strengths and Weaknesses, Findings and Comments to the Facilities leadership and to NASA, all of which are appended at the end of this document. In addition, the Panels were specifically instructed not to make findings or any comments regarding funding.

Panel Reviews

Details of the four Review Panels are provided below, and in more detail in the appended review panel reports:

Planetary Aeolian Facility (PAL)

- Panel Review - October 12, 2015
- Dr. Ralph Lorenz (Johns Hopkins University – Applied Physics Laboratory) – Group Chief
- Dr. Lynn Neakrase (New Mexico State University) - Panelist

- Dr. Laura Kerber (Jet Propulsion Laboratory) - Panelist
- Dr. Stephen Mackwell (Lunar and Planetary Institute) – Panel Chair

Reflectance Experiment Laboratory (RELAB)

- Panel Review – October 14, 2015
- Dr. Vicky Hamilton (Southwest Research Institute) – Group Chief
- Dr. Jeff Johnson (Johns Hopkins University – Applied Physics Laboratory) - Panelist
- Dr. Paul Lucey (University of Hawaii) - Panelist
- Ms. Elizabeth Fisher (University of Hawaii - student) – Executive Secretary
- Dr. Stephen Mackwell (Lunar and Planetary Institute) – Panel Chair

Glenn Extreme Environments Rig (GEER)

- Panel Review – November 16, 2015
- Dr. Natasha Johnson (NASA Goddard Space Flight Center) – Group Chief
- Dr. Sushil Atreya (University of Michigan) – Panelist
- Dr. Allan Treiman (Lunar and Planetary Institute) - Panelist
- Dr. Stephen Mackwell (Lunar and Planetary Institute) – Panel Chair

Ames Vertical Gun Range (AVGR)

- Panel Review – November 16, 2015
- Dr. Kevin Housen (Boeing Corporation) – Group Chief
- Dr. Fred Hörz (Jacobs Engineering) – Panelist
- Dr. Dan Durda (SwRI-Boulder) – Panelist
- Dr. Stephen Mackwell (Lunar and Planetary Institute) – Panel Chair

Summary Findings

While the individual Panel Reports document many strengths and weaknesses that are specific to the facility under review, many of the findings pertain more generally and can be grouped into specific areas for consideration of all Planetary Science Facilities.

1. User Community – all of the reviewed facilities have both in-house and external individuals and groups that make use of the facility. Nonetheless, several of the facilities are dominated by in-house researchers and past students of in-house researchers. The narrow user base is partly a product of the finite size of the appropriate discipline but also results from poor dissemination of information on the nature and availability of the facility.

2. Uniqueness of Facility – the existing facilities all possess capabilities that, at some level, are not replicated elsewhere in the country but provide critical functionality for future scientific and mission activities. In several cases, creation of new facilities, should the existing ones be closed, would present significant financial challenges. This is especially true for existing facilities that leverage other local infrastructure and shared personnel.

3. External Interface – current facilities generally do poorly in communicating facility capability, availability and mechanisms for access. They also do not provide adequate indications of the importance and successes of the facility in support of NASA science and missions. In particular, web sites are generally poorly designed and lack critical information, such as a facilities manual, information on how to apply for access, publications resulting from use of the facility, roles in mission activities and technology development, and highlights of recent research. The facilities also generally lack a visible presence at appropriate meetings and conferences, and do not run workshops or training events for potential new users.

4. Management – in general, management of the facilities is provided at minimal cost to the facility budget, allowing only modest time commitment from management personnel. Such a model can result in management by staff that has appropriate administration skills but neither the scientific nor technical knowledge/background appropriate to the facility. This deficiency can hamper reach into the broader user community, result in sub-optimal maintenance of web-based outreach tools and reduce effectiveness of review of user proposals.

5. External Advisory Boards – external advisory boards populated by members of the scientific or technical community knowledgeable about the facility, its operation and requirements have not generally been used by the existing facilities. Such groups can provide review of user proposals for access (although there is a real concern about conflicts of interest as the user communities are often quite small), as well as review requirements for infrastructure maintenance and potential upgrades. They are also able to provide support and advice for facility management in outreach activities.

6. Internal Infrastructure – onsite personnel that are highly knowledgeable about the instrumental and experimental capabilities of the facility is critical for support of external users. In a number of cases, existing facilities have staff members with unique knowledge and skills but no mitigation strategy should that person no longer be available. As Planetary Facilities are generally fairly narrowly focused and operate on modest budgets, potential loss of critical technical personnel is a serious concern.

7. Maintenance and Upgrades – several of the facilities under review are imbedded in organizations that use, provide maintenance, and upgrade existing infrastructure at no or minimal cost to the PSD Facility. In these cases, maintenance and operations staff does not necessarily require full support.

8. Financial Considerations – there is no standardized approach to financial operation of the existing facilities. While this partially reflects the diversity of users from both within and outside the planetary sciences, the extent to which planetary science users pay for facility access, infrastructure and personnel costs from their own grants has not been well-defined.

Comments to NASA

Based on these summary findings, we identified a series of lessons learned resulting in a list of best practices to improve the performance of existing facilities and provide a blueprint for future facilities.

1. User Community – existing and new facilities must demonstrate a broad user base that has a clear interest in using the facility beyond in-house scientists and technologists. Each Facility must also endeavor to assess its community's needs and provide a plan on how to support them.

2. Uniqueness of Facility – while a facility does not necessarily need to be unique within the US, facility leadership must provide justification for and demonstrate why facility support is needed relative to hourly user fees (paid from research grants), as are used for many analytical instruments.

3. External Interface – all facilities should have a strategy to provide potential users and others with information about the facility. In particular, a web presence is necessary that provides potential users with information on facility resources, how to propose for access, and the conditions attached to usage. The web site should also document and archive facility usage and productivity. If appropriate, facilities should also run training workshops at the facility or associated with major meetings to inform potential users of the resource and facilitate access for new users. Presentations during and coordination of facilities related sessions at appropriate major meetings are also an effective way to communicate the existence and capabilities of the facility.

4. Management – management of the facility must be engaged in the scientific and technological aspects of the facility, and preferably be a user of the facility. They must also be prepared and able to commit the time and energy needed to manage the facility and its interface with the external community of current and potential users.

5. Advisory Boards – advisory boards or committees composed of a modest number of senior members of the user community can provide support and advice to facility management on allocation of resources, potential upgrades, and management of the user/community interface. Such a board would meet periodically (quarterly or every 6 months), in person or virtually. The roles for the advisory board membership are likely to vary between facilities.

6. Internal Infrastructure – all facilities should have a succession plan for all key personnel, especially including critical technical support staff.

7. Maintenance and Upgrades – where possible, facilities should leverage non-planetary science usage of the facility and personnel to increase efficiency and minimize dead-time.

8. Financial Considerations – facilities should seek an optimal model for operations that potentially includes user fees for facility access paid from user grants.

Panel Review of PAL Facility, NASA Ames

Venue:
October 12, 2015
9:00 am – 3:00 pm
NRESS Facility, Arlington, VA

Panel Members:
Ralph Lorenz (JHU-APL) – Group Chief
Lynn Neakrase (New Mexico State University)
Laura Kerber (JPL)
Stephen Mackwell (LPI) – Panel Chair

NASA SMD PSD Representatives:
Doris Daou
Jonathan Rall
Sarah Noble

Facility Representatives:
Dave Williams (ASU) – PAL PI
Ken Smith (ASU) PAL Operator - resident at NASA Ames)
Devon Burr (U. Tennessee) – PAL user
Nathan Bridges (JHU-APL) – PAL user
Rob Sullivan (Cornell) – PAL user; participated by telecon

Agenda for Review:
9:00 – 9:30 am – preparatory panel discussion
9:30 - 11:00 am - presentation with questions for clarification
11:00 am - 12:00 noon - Q&A
12:30 noon - 2:00 pm - deliberation and additional Q&A
2:00 – 3:00 pm – panel discussion and began draft of report

Background:
The Planetary Aeolian Laboratory (PAL) is a facility used for conducting experiments in aeolian processes (windblown particles) under conditions representative of planetary atmospheres, namely Titan, Venus and Mars. The PAL is located at NASA Ames Research Center (ARC) in Moffett Field, California. It consists of a large, 30-m tall chamber that can be brought down to low pressures by riding along with adjacent ARC steam plant activities. Inside the chamber are

two wind tunnels: (1) the Mars Surface Wind Tunnel (MARSWIT) and (2) Titan Wind Tunnel (TWT). The PAL is administered by Arizona State University (ASU) and supported by a full-time ASU technician based at ARC. Additional facilities at The Ronald Greeley Center for Planetary Studies at the ASU Main campus in Tempe, AZ include an ambient pressure/temperature wind tunnel (ASUWIT) and a vortex (dust devil) generator (ASUVG) which can be taken to ARC to operate at Mars conditions. While the ASU facilities enhance and complement the facilities available at the PAL, they are not funded by NASA but are maintained (at ASU's discretion) using ASU funding. The PAL was originally established in the 1970s by the late Ron Greeley, with ongoing support from the NASA Planetary Geology and Geophysics (PG&G) program

Strengths:

1. The panel noted the efficient and responsive direction of the facility by the PI Dave Williams, who inherited PAL operations with the death of the original PI, Prof. Ron Greeley in 2011. The efficient on-site operations run by Ken Smith were especially recognized by the panel.
2. The panel noted that the PAL facility addresses scientific questions that cannot be tackled elsewhere. Some relevant European Mars wind tunnels exist in Aarhus, Denmark and Oxford, UK (although only the former handles dust/sand), but neither has the very large Mars pressure operating volume available at PAL. Many NASA and other vacuum chambers can simulate Mars pressure, but are not 'dirty' – i.e. handling particulate materials would degrade their usual operations. The capability of the large PAL to be evacuated to Mars pressure is a special consequence of its relationship with the ARC steam plant (whose primary function is to support arcjet testing of spacecraft thermal protection): for this reason, a new facility with PAL-like capabilities would be significantly more costly to operate. Several Titan simulation facilities also exist (e.g. U. Arkansas and JPL) but cannot provide wind generation and measurement.
3. A number of PAL activities and capabilities are directly relevant to past and ongoing NASA planetary missions, as well as those under development. This uniquely large facility is very flexible in its applications, able to simulate e.g. rock erosion processes, sand deposition and excavation on or around rovers, etc.
4. The PAL has seen significantly improved efforts recently to reach out to the planetary community to solicit wider utilization and to document/archive prior work in a form accessible/searchable on the Planetary Data System, PDS (the latter efforts supported by R&A funding, under the Planetary Data Archiving, Restoration, and Tools (PDART) program).
5. The generation of a User Guidebook has been a tremendous step forward, providing an accessible resource to prospective users. However, there is a need for clarification in the Guidebook on how budget provisions for the PAL should be handled in R&A proposals.

Weaknesses:

1. The user community of the PAL facility, and especially of the recently refurbished Titan Wind Tunnel, is very small so far. It must be noted in this connection that in practical terms, research users must first obtain funding, typically from NASA's Research and Analysis programs such as SSW, in order to use the PAL. Thus, low selection rates in R&A programs may restrict the number of projects using PAL. The cost of wind tunnel hours (now that all PIs are non-PG&G) can make wind tunnel proposals less competitive. Furthermore, a vicious circle may emerge wherein R&A proposals from new prospective users may be seen as risky if the proposers have no experience with the facility, and thus prospective users do not get the funding to acquire such experience. We discuss a possible mitigation in the 'findings' section of this report.
2. While the facility is able to offer unique experimental capabilities (the ability to handle particulate material or liquids – both anathema to typical environmental test chambers – together with wind flow and Mars or Titan pressure, and an exceptionally large Mars pressure volume) it must be conceded that the facility does not fully replicate planetary conditions – only room temperature operations are possible, Venus pressures and temperatures cannot be attained, and of course gravity cannot be matched. In much of the work by the original PI Ronald Greeley, it was claimed that the gravity similarity could be matched by using low density materials (e.g. ground walnut shells instead of silica sand): more recent understanding of the distinction between impact threshold and fluid threshold, particularly with respect to Mars, calls this approach somewhat into question. Nonetheless, the parameter range accessible with the facility (two orders of magnitude down in pressure in MARSWIT, and one order of magnitude up in TWT) is a significant and unique capability for understanding the fundamentals of fluid-surface interactions.
3. While the PAL operator indicated that working arrangements on the ground at Ames had been entirely satisfactory, with all needs being met, the panel noted a limited transparency into the Ames support of the facility. The budget information provided to the panel indicated a significant attribution of Ames FTEs to the facility without detailed justification. The general lack of engagement of Ames management in facility operation, or of Ames scientific personnel in PAL experiments, was noted with some concern.

Findings and Comments to Facility Leadership and NASA:

1. Utilization could likely be increased by a factor of ~2 at current staffing levels. Some further increase beyond this could be accommodated by augmenting the technical support to reduce setup/teardown timescales.
2. One approach to increased utilization may be to hold a User Workshop at Ames, which

has on-site conference facilities. The panel noted that such a workshop might provide a useful collaboration opportunity for prospective users. A workshop supporting PAL could be combined with one supporting other facilities – notably the Ames Vertical Gun Range.

3. Greater Ames involvement (possibly even in some aeronautics rather than planetary science applications) might be useful in expanding the user base. Having a research scientist with an active interest in the PAL located at Ames or at a nearby institution could be beneficial for the management of the wind tunnel and improved communication with the rest of Ames. Advertising post-doctoral positions to work in the wind tunnel would be another possible way of both boosting the experienced user base and improving the connection with the broader Ames community.
4. Subject-matter inputs into facility operations (e.g. prioritization of improvements) have so far been handled informally by the PI via past users or the facility operator. To allow greater NASA insight, a small committee of cognizant persons might be appointed by NASA to help reach out to the community, and, when needed, offer advice on prioritization of experiments (in event of oversubscription or PI conflict of interest), and on the justification or prioritization of facility upgrades.
5. A PAL website, where data might be archived (perhaps mirroring relevant PDS archives) as well as summaries of prior experiments, the proposer manual and a list of current/past users might be a useful resource.
6. In tracking future utilization and impact it would be valuable to track publications including conference abstracts as well as citations. These data might be usefully integrated into the resources on a website above.
7. Possible risks to the facility operations include:
    a. Changes in the use of the neighboring steam plant. The current PI has been working with the steam plant to improve the scheduling and duration possible for low pressure runs. This relationship is important for the continued productivity of the facility.
    b. Overturn in staffing. The panel has noted the efficient on-site operations by Ken Smith (above). It is important for this position to be adequately funded to avoid unnecessary overturn.

Additional Comments to NASA:

1. With respect to increasing the user base, our understanding of the experiment pipeline is that it is not presently facility-constrained, but user-limited. The limitations are likely a combination of experimental aptitude/facility familiarity of users and funding support via R&A for such users.
2. The latter restriction (user funding) might be mitigated by improvement in R&A

selection rates overall, or programmatic favoring of proposals using PAL. The panel is not advocating the latter policy, merely noting it as a possible approach.

3. The former restriction (user familiarity) can be addressed by some modest steps by NASA. The resident operator, Ken Smith, indicated an eager willingness to provide familiarization tours of the facility to any interested parties. One approach for NASA to augment the user base might be to offer/compete small 'seed' grants ($5-10K?) specifically to early career scientists to allow prospective proposers to develop new ideas and make a familiarization visit. Documented participation in such a visit might be considered an asset in an R&A proposal.
4. The panel noted that the present 'Administrative PI' arrangement works well – i.e. with the facility PI not having a particular personal interest in the scientific activities of the facility. PIs of specialized facilities can sometimes become gatekeepers—limiting the use of the facility to a small circle of users working directly with the PI. The present arrangement – while possibly counterintuitive - fosters more general community involvement and responsiveness to suggestions and improvements.
5. Some interest was noted by the PAL team in very low-pressure studies (i.e. ~10 microbar) pertinent to possible aeolian processes on Pluto or Triton. There is, however, little obvious synergy for such a capability with the present PAL facility.
6. While historically PAL operations have meshed Ames and ASU facilities, the panel noted a need for a clear separation of these activities today, since they are financially supported through different channels.
7. The means of accounting for costs of facility usage (at Ames or at ASU) in R&A proposals needs to be clarified in e.g. the SSW AO: for example, a subcontract might need to be defined for ASU work, but only a cost item for internal NASA transfer – perhaps the ROSES forms need to have a line wherein such transfers are book-kept – for the Ames facilities.

Panel Review of RELAB Facility, Brown University

Venue:
October 14, 2015
9:00 am – 12:30 pm
NRESS Facility, Arlington, VA

Panel Members:
Vicky Hamilton (SwRI) – Group Chief
Jeff Johnson (JHU-APL)
Paul Lucey (U. Hawaii)
Elizabeth Fisher (U. Hawaii - student) – executive secretary for review
Stephen Mackwell (LPI) – Panel Chair

NASA SMD PSD Representatives:
Doris Daou
Tom Statler
Sarah Noble

Facility Representatives:
Ralph Milliken (Brown University) – RELAB Science Manager
Takahiro Hiroi (Brown University) – RELAB Operator – not present but assisted in preparation of materials for presentation

Agenda for Review:
9:00 - 9:30 am – closed panel discussion of panel purpose
9:30 - 11:00 am – presentation by Dr. Milliken with questions of clarification from the panel
11:00 - 11:30 am - Q&A
11:30 am - 12:00 noon – closed deliberation, followed by brief follow-up questions for presenter
12:00 noon – 12:30 pm - begin draft of report.

Strengths:

1. The RELAB facility offers the planetary science community a substantial resource in terms of hardware for making a variety of spectral measurements (at no cost to users) that are of high quality and consistent over time.
2. The focus of the facility is visible to near infrared (VNIR) measurements, with the custom bi-directional spectrometer (BDR) being one of the most flexible/capable instruments,

and to the best of the panel's knowledge, offering a unique capability in the planetary sciences. The Nexus 870 FTIR and the Nicolet Continuum microscope offer more conventional, but complementary measurements in terms of spectral range and measurement spot size.

3. The RELAB database contains, and makes available to the community at no cost to users, an extraordinary number of spectral measurements (~25,000 spectra) of terrestrial and planetary samples (~12,000 samples) that exhibit long-term continuity of calibration and quality. This database is a tremendously valuable resource that must remain available to the broader community. The Science Manager's desire to modernize the process of user requests for measurements and allow for (encourage) the submission of ancillary data (e.g., chemistry, mineralogy, images) is strongly supported by the panel.

Weaknesses:

1. The fact that a single individual, RELAB Operator Dr. Hiroi, appears to be the only person capable of both preparing samples in a careful, consistent manner and producing high quality measurements is a significant concern that should be remedied as soon as possible. Should Dr. Hiroi become unavailable to operate the facility for a prolonged period of time, the panel is concerned that the timeliness, consistency, and quality of RELAB measurements could be at risk if there is no documentation of the procedures and there are no other personnel available who have been trained by Dr. Hiroi and can take over for him.
2. The panel has a similar concern related to engineering support, which is essential to maintaining the data continuity that RELAB advertises and has offered to date. If Bill Patterson (RELAB Engineer) becomes unavailable, there does not appear to be a reliable source of support for the highly customized equipment (even if it is comprised largely of commercial hardware).
3. The panel has lingering concerns with the assertion that there are no inter-laboratory calibration/continuity issues because the system is entirely new with respect to the system used in the 1980s and early 1990s.
4. Despite the fact that the RELAB database represents a tremendously valuable resource, the practical utility of the database has long been known to be hindered by an outdated, cumbersome web interface and lack of up-to-date, citable documentation (e.g., the Science Manager is still listed as Carlé Pieters on the website). The current implementation of the database also prevents the RELAB Science Manager from tracking important usage statistics such as who is using the data and how many publications result from or include RELAB data (either author-requested measurements or data downloaded from the archive). Although the RELAB Science Manager has

submitted proposals that, if funded, would lead to an improved database interface and long-term archiving of RELAB data with the PDS (which the panel supports because it allows the RELAB personnel to focus on data collection), the panel remains concerned by the long implementation time (3-4 years) that multi-year proposals imply, and urges the RELAB Science Manager to take intermediate steps that would start to address some of the interface, documentation, and user-tracking issues ahead of the next facility review.

Comments to Facilities Leadership:

1. The staff backup capability does not necessarily require a new hire, but may require an ongoing commitment by the Science Manager and RELAB Operator to ensure that there is always someone (e.g., a postdoc or researcher) in the Department who has had sufficient interaction with Dr. Hiroi (e.g., in the course of their own spectroscopy research) to understand how and why he prepares and measures samples the way he does, and who has been observed by Dr. Hiroi to be capable of reproducing his methods to the degree required to maintain the high standards the facility has worked so hard to establish.
2. The RELAB facility should produce, as soon as possible, a complete set of drawings and master equipment list of the hardware, and full schematics for the data collection system, so that the details of the system can be understood by anyone who may need to step in and help with engineering support. A written plan for replacing (or keeping spares of) key parts would also benefit RELAB in the event of unexpected hardware failures.
3. The panel suggests that the Science Manager consider developing a set of standards encompassing a variety of albedo, texture, and composition (in addition to traditional standard materials such as Spectralon) to show that calibration is indeed continuous over a range of observing conditions, time, and new hardware.
4. Another suggestion by the panel is that the database include some kind of basic quality assessment of the data entered going forward, such that (particularly novice) users do not assume that the user-provided labels for the samples accurately reflect the actual composition of the sample (e.g., an "enstatite" that is really a forsterite, or a "basalt" that is really an andesite). This could be a simple binary flag that indicates whether the composition has been validated by the submitter (e.g., via ancillary analysis) or the RELAB Operator (by inspection of the spectral data), or has not been validated (buyer beware).
5. Because RELAB is intended to support a broad user base there should be regular interactions with that user base, or the facility risks decreasing relevance to the very community it is intended to serve. The panel strongly supports the Science Manager's

suggestion of reconstituting an external advisory committee; this committee should have a clearly defined role and be comprised of a diverse cross-section of scientists who are able to represent the expertise and needs of the RELAB user base. Regular interactions with this advisory committee would ensure that the RELAB Science Manager is tracking usage statistics, is aware of the evolving needs of the user base, and is able to adequately project the allocation of resources for new capabilities and maintenance and modifications/upgrades to existing equipment and the database.

6. Keeping the science community informed about the capabilities and offerings of the RELAB facility is a top priority to ensure maximum usage; the suggestion by Dr. Milliken that RELAB offer "get the word out" meetings associated with conferences is one that the panel supports. Such meetings would also help the Science Manager assess interest in the community and avoid the risk that an unexpected uptick in usage could lead to backlogs.

Additional Comments to NASA:

1. If the existence of RELAB means that NASA is relieved of the need to support even one additional laboratory (and likely several), there is a clear benefit to the investment. As such, the facility should be supported.

Summary:

In summary, the RELAB facility remains a valuable resource for the planetary community by producing consistent, high quality spectral data and its continued support by NASA is justified. However, RELAB also continues to suffer from long-term neglect in terms of the poor accessibility of these high-quality data and lack of regular interaction with the user base. Although support is being sought from research and analysis programs to bring the database into the 21st century, the nature of such funding poses a risk that it will be several more years before the database problems are solved and RELAB becomes a fully modern resource for the community.

Panel Review of GEER Facility, NASA Glenn

Venue:
November 16, 2015
9:00 am – 12:00 noon
NRESS Facility, Arlington, VA

Panel Members:
Natasha Johnson (NASA GSFC) – Group Chief
Sushil Atreya (U. Michigan) – could not participate in person but provided questions and input into the report
Allan Treiman (LPI)
Stephen Mackwell (LPI) – Panel Chair

NASA SMD PSD Representatives:
Doris Daou
Sarah Noble

Facility Representatives:
Tibor Kremic (NASA Glenn)
Lori Arnett (NASA Glenn) – GEER Facility Manager
Dan Vento (NASA Glenn) – GEER Project Manager

Agenda for Review:
9:00 - 9:30 am – closed panel discussion of panel purpose
9:30 - 11:00 am – presentation by the Facility Representatives with questions of clarification from the panel
11:00 - 11:30 am - Q&A
11:30 am - 12:00 noon – closed deliberation, followed by follow-up questions for presenters
12:00 noon – 12:30 pm - begin draft of report.

Background:
The Glenn Extreme Environments Rig (GEER) is the newest NASA Planetary Facility. GEER provides a unique capability for NASA science and technology development by simulating environmental conditions for a wide range of planetary atmospheres (temperatures from cryogenic to 500°C, pressure from vacuum to ~90 atmospheres, and complex realistic gas compositions) in a large working volume (approximately 22 cubic feet) for, preferably, long durations (> 30 days). GEER is located at the Glenn Research Center in Cleveland, Ohio; it

passed Operations Readiness Review in March 2015, and is now running experiments in Venus science and in materials technology. The GEER facility, including the pressure/temperature vessel, the gas mixing system, and the control system, was originally designed for a different objective. In the last few years, the facility has been repurposed to its present configuration, and established as a NASA facility.

The focus of GEER, as it is now, is a cylindrical pressure-temperature vessel, with interior dimension of four feet long and three feet in diameter. The vessel is rated for extended duration use to 500°C and ~90 atmospheres total pressure. The vessel is heated internally by Inconel-clad heating elements that are situated across the lower half of the interior cylindrical space. The heating elements and a cylindrical steel latticework structure stand ~2 inches away from the interior wall of the vessel, thereby reducing the working volume to approximately 22 cubic feet. The chamber can be nominally heated at a rate of seven degrees Celsius per hour. The exterior of the vessel is insulated, and is sheathed with sheet metal to reduce convective heat loss and to prevent potential damage from water from the facility's fire suppression system. After an experiment, several days are necessary for the vessel to cool to near-room temperature.

The vessel is pressurized by compressed gas, dominantly carbon dioxide with the final pressure being obtained via heating. The vessel can be 'topped off' with the appropriate gas mixture if a small leak is detected. Over the pressure-temperature range tested for commissioning, the carbon dioxide behaved nearly as an ideal gas, giving confidence that its behavior can be well predicted. A wide range of other gases has been pre-approved for use in the vessel; these gases are mixed before introduction into the vessel. The composition of the gas mix is measured on an aliquot of the gas by Fourier transform infrared (FTIR) spectrometry.

There are two options for access to the vessel interior. Removing the flat main lid of the vessel allows insertion and retrieval of objects or apparatuses as large as the working volume. Removing and replacing the main lid is a major operation. It takes about ten days to open/close the main lid because of torqueing requirements and the number of bolts involved. The bolts are not inconsequential. However, the main method to access the interior of the chamber is through six working access ports: two on the main lid, and four on the back surface. The two larger ports/flanges centered on the front and back have inner working diameters of 3.4 inches. The smaller ports/flanges on the back surface have inner diameters of 2.59 inches. Samples inserted through these ports have typically been elongate trays of multiple samples.

The process for scheduling is a combination of first-come, first-served and priority basis (e.g., mission critical versus mineral/material experiments). The upcoming FY16 year has a full schedule of projects from a variety of parties ranging from commercial, NASA centers, to university-based programs. Note that there is a required scheduled downtime for maintenance and safety checks. As presented, 40 weeks per year are allocated for end users.

Strengths:

1. The GEER facility has unique experimental capabilities (gas mixture, temperature and pressure) for science and technology tests in a range of planetary atmospheres.
2. The GEER gas mixing system is a major capability.
3. GEER has the potential to serve a wide range of NASA users, including technology and science.
4. GEER allows long-duration tests, at P and T to > 24 days so far.
5. GEER management's plans for augmentation of the facility are appropriate and will add materially to GEER's value to NASA and its community:
    a. A near term objective is to install viewports in the chamber. However, any viewport situated on these flanges would likely be small, with the current estimate of maximum diameter as ~ 2 inches. GEER personnel are currently studying the installation of viewports with possible implementation for the spring of 2016.
    b. It is anticipated to eventually sample and analyze gas from the vessel during experiments. This will allow real-time monitoring of atmosphere changes from chemical reactions with the materials in the vessel; planned instruments could be either Raman spectroscopy and/or gas chromatography mass spectrometry.
    c. GEER management hopes to replace the flat, main lid of the pressure-temperature vessel with a hemispherical lid. This will allow a slightly larger volume, and better mechanical stability.
    d. GEER management intends to install several smaller pressure vessels that could be run in parallel with the main GEER vessel. This improvement would utilize the same gas mixing system, which stands idle during a run and could be used for other vessels. Also, many experiments or tests do not require the large volume of the available vessel, or could benefit by the faster heat-up and cool-down of a smaller vessel.
6. The panel was impressed at operating procedures with regards to human safety and equipment maintenance, as established in the GEER ORR. In particular, we note that: the building that houses GEER is designed for safe disposal of a wide range of potentially toxic gases; that only facility personnel are permitted near GEER while it is operating; and that maintenance and evaluation of corrosion are regularly scheduled (annually).

Weaknesses:

1. It is difficult to find the basic information needed to plan experiments/tests on the GEER website & documents. GEER management should, as quickly as possible, write an "Operating / Experiment Manual" and make it available for all potential users, i.e., a detailed "User's Guide".
2. None of the current ports have viewports, i.e., can allow light into the chamber or imaging of the vessel interior. Nonetheless, the two ports on the main lid are aligned with ports on the back surface, potentially allowing the capability of 'see-through' experiments. There is a plan to remedy this situation.
3. Turnaround time is not fast. For a straightforward experiment transfer, the experiment turn around could potentially be as short as 3 days or as long as a week. It is necessary to wait until the chamber is cool enough to handle. It takes about 2 days to heat and approximately 5 days to cool. Operations need to be efficient in order to make effective use of the chamber.
4. Currently, it is not clear who at GEER to contact regarding scheduling and costs.
5. GEER does not have a dedicated science advisor or an outside science advisory committee to consider importance, prioritization, and scheduling of proposed experiments and tests. In particular, management needs to consider prioritizations for experiments associated with spacecraft mission proposals and with spacecraft development.
6. Needs a plan for an annual review by an independent external board/committee.
7. Requires development of a plan of presentation of GEER capabilities at major national scientific meetings, such as LPSC, DPS, AGU, NASA "AG's, etc. This is essential not just for advertising the capability to the larger planetary community, but also for community "buy-in", which is essential for sustenance and growth of the facility.
8. For certain planetary applications, descent "profile" (e.g. from upper atmosphere to surface of Venus) simulation is important, not just the high P-T. Extending the GEER capability to this would require additional work. As it currently stands, GEER is unable to replicate a realistic descent profile (P-T) for the Venus atmosphere.
9. Currently, GEER does not have a consistent costing structure, especially with respect to experiments that "piggy back" onto primary experiments.

Additional Comments to NASA:

As this review panel was not tasked with specifics in regards to costing, general questions were asked in order to get an idea of what costs might be expected for potential proposers. It is anticipated that each test could potentially cost $15K (i.e., consumables, overhead). However, GEER has been fully operational for less than a year so it is likely that the price will be better refined as more experiments and situations are run and experience is gained. For the upcoming fiscal year, GEER is fully funded so it is not expected that labor will be passed onto the end user. How GEER is funded currently or will be in the future is beyond the scope of this review.

Summary:

GEER provides a long-awaited capability for the high/moderate temperature-pressure regimes. Operation is still a work in progress but clearly there is a pent-up demand for such a facility as demonstrated by the presented schedule for FY16. It is currently operational with ongoing experiments. There is a varied audience for use of the chamber from commercial to NASA sponsored research. Costing needs to be better defined but this will come with experience and time. There is a great deal of potential for this facility if properly managed.

Panel Review of Ames Vertical Gun Range (AVGR) Facility, NASA Ames

Venue:
November 16, 2015
1:30 – 4:30 pm
NRESS, Arlington, VA

Panel Members:
Kevin Housen (Boeing) – Group Chief (by telecon)
Fred Hörz (Jacobs Engineering)
Dan Durda (SwRI-Boulder)
Stephen Mackwell (LPI) – Panel Chair

NASA SMD PSD Representatives:
Doris Daou
Sarah Noble

Facility Representatives:
John Karcz (NASA Ames – AVGR Science Coordinator)
George Raiche (NASA Ames – Thermophysics Branch Chief)

Agenda for Review:
Prior to the review, a series of questions were submitted to the AVGR Science Coordinator, Dr. John Karcz, and the Thermophysics Branch Chief, Dr. George Raiche. During the roughly 2-hr panel review, Drs. Karcz and Raiche addressed those questions and gave an overview presentation of the AVGR Facility and its capabilities. The questions were broadly directed at:

1. Current objectives, historical accomplishments and impact on planetary science and past and future missions.
2. Facility management plan
3. Unique or distinguishing features of the Facility
4. A quantitative description of usage of the Facility
5. Publications list for research performed using the AVGR
6. Current costs

Following the presentation and questions/answers/discussions with Drs. Karcz and Raiche, the Panel identified a set of Strengths and Weaknesses in the AVGR, and made a series of Findings.

Strengths:

1. The Panel was impressed with the presentation given by the new Science Coordinator,

Dr. Karcz, and viewed him as a competent scientist who has enthusiastically adopted his new position.
2. There is significant (~75%) financial leveraging from NASA Ames. Personnel and equipment are shared among other Ames groups. During "quiet" times, AVGR personnel work in other TSF facilities, so PSD does not bear the full cost of maintaining and operating the AVGR. Planetary Science Research Program funding supports 25% utilization, which is about equal to the average usage over the past 3 years.
3. The technical support staff members on-site are highly qualified, competent, responsive, and are very good at helping experimenters attain their goals. AVGR personnel are cross trained, so they can fill in for each other when needed. The Panel specifically noted recent useful improvements at the Facility that have largely resulted from the initiative of the outstanding crew at the AVGR.
4. The AVGR has unique capabilities (worldwide):
    a. the vertical configuration and variable impact angle of the gun
    b. the capabilities of the gun in terms of projectile size and velocity
    c. the very large vacuum chamber, which can accommodate a variety of experimental hardware
    d. high-quality imaging systems (cameras and associated hardware/software) and IT support. New cameras are paid for by Ames.
5. The AVGR has a long history of supplying high-quality data to understand the various processes involved in impact cratering and collisional disruption of solar system objects.
6. The AVGR stands out among PSD facilities in Education and Public Outreach. It is a highly visible asset that features quite prominently in many television science documentaries, thus providing significant public outreach for NASA and PSD research activities.

Weaknesses:

1. The capabilities of the AVGR, and the fact that impact experiments and associated travel can be covered by the NASA Facilities grant, are perhaps not generally known to the broader planetary sciences community. This has potentially limited the usage of the Facility. The lack of a dedicated web presence seriously limits communication.
2. There is no oversight committee to provide input and recommendations to NASA on new directions and Facility upgrades.
3. Limited personnel could potentially limit the time that can be devoted to overseeing AVGR operations, advertise the AVGR capabilities at scientific meetings, etc. But, given the Panel's very favorable impression of Dr. Karcz, this is viewed a minor weakness that, if necessary, could be remedied by a full-time Science Coordinator, or the assistance of an oversight committee described below.
4. Absence of advisory board or committee composed of a modest number of senior

members of the user community who would provide advice and needed expertise.

Findings:

1. Many of the weaknesses identified in the previous AVGR review (2009) have been adequately addressed.
2. The AVGR facility is in dire need of a web presence. This web site would:
    a. provide current information to potential users on the nature of the facility and available resources
    b. provide an optional venue for presentation of raw data resulting from experiments conducted using the facility
    c. provide a venue to highlight current activities and publications, as well as a venue for novel and topical impact videos and other materials that can be used for public relations and education
    d. include forms that would be used to request use of the facility, simplifying review and ensuring that proposers are aware of the facility protocols
    e. likely be based at Ames
3. The Panel noted that usage of the AVGR is tethered to research funding levels and proposal selection rates, which have declined in recent years. A future decrease in the AVGR usage rate should not be interpreted as an indication of lack of community interest in the facility. Rather, in light of the recent decline in the acceptance rate of impact-related proposals, a better measure of interest would be the number of submitted proposals that would utilize the AVGR.
4. An Oversight Committee could provide more effective management of the AVGR facility. Such a Committee would be composed of a NASA Discipline Scientist and independent members of the planetary science community with a knowledge of and interest in experimental impact work. The purpose of the Committee would be to assist the Science Coordinator in developing effective strategies for communication of AVGR capabilities to other potential users, to assure the Facility is available to a broad cross section of the impact community, and to help identify Facility needs and new capabilities. The Committee would specifically not serve as an additional review gate beyond the current peer review process for PSD research proposals.

Summary:

In summary, the Panel recognizes the importance of the AVGR to NASA PSD R&A Program objectives. Given the Facility's unique nature and the effective cost-shared environment in which it exists, the Panel was very favorably disposed towards maintenance of the AVGR as a NASA Research Facility. The Facility would further benefit from the development of a web presence and an oversight committee to assist the new Science Coordinator.