Report of the BERAC

ARM Facility Review Panel

Prepared by a Subcommittee of
The Biological and Environmental Research Advisory Committee

May 2007

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Introduction

A panel was convened to assess the effectiveness of the combined stationary and mobile Atmospheric Radiation Measurement (ARM) facilities as a national scientific user facility. As described in the charge to BERAC (Appendix A), the panel was specifically asked to:

- Assess how well the ARM facility is serving the needs of members of the open scientific user community, that is, users who are not funded by the ARM Research or ARM Infrastructure

- Assess what factors are driving the costs of operating the ARM facility and the trends in those costs over the last 5 years

- Assess whether the critical recommendations from the review in 2005 have been adequately implemented

Members of the panel are listed in Appendix B, with two members from a previous review that was conducted in 2005 and two members from the user community who are not funded by the ARM program. We met on February 5, 2007, and heard presentations on the operation of the facilities from the management team: Jimmy Voyles, Doug Sisterson, and Steve Klein (see agenda in Appendix C). In the following sections, we document our findings in each of the above areas.

ARM as a user facility

The ARM program is composed of two parts: ARM Research, which supports research projects, and ARM Infrastructure, which supports the ARM sites and associated services. In 2004, the ARM sites were officially designated a national scientific user facility, the ARM Climate Research Facility (ACRF). Requests for use of the ACRF are peer reviewed. A review panel, the ACRF Science Board, has been established to review proposals for large campaigns and ARM Mobile Facility (AMF) deployments. The proposal process for requesting a field campaign at the user facility can be found on the ACRF web site at http://www.armgov/acrf.fc.stm. By broadly advertising its facilities to the worldwide community, ACRF has improved the quality of the proposals received and their appropriateness to climate research.

In its role as a user facility, the ACRF does not fund research, but provides instrumentation, data, and expertise that enable scientists to carry out experiments to improve understanding of climate change. The facility resources include a climate-relevant (several-year) data compilation and support of special campaigns designed to address specific scientific questions. These campaigns may require additional facility support and/or measurements. This additional support may be as simple as site preparation for an instrument evaluation study but may require the provision of additional

instrumentation, both ground-based and airborne. The ACRF provides these requested facility capabilities.

The ACRF measurement capabilities provide uniquely valuable resources for the global community doing climate research. Through its instrumentation, support of field programs, and data archives, the ACRF provides quantitative scientific data that are used to improve the representation of physical processes in climate models. In particular, the facility has provided measurement capabilities that are critical for addressing several key sources of uncertainty in the climate models. For example, the observations provided by the facility have made a major contribution to the improvement of the modeling of clouds and moist processes, especially the interactions of clouds with aerosols. The measurements of the ACRF have also allowed improvements on another major question: how to model convective precipitation.

Thus, perhaps the most important contribution of ACRF to the external community is providing input for the major climate modeling issues that are being investigated by scientists worldwide and whose successes are summarized periodically through the Intergovernmental Panel on Climate Change (IPCC).

A more direct contribution is the successful encouragement of non-ARM funded PIs to utilize the ACRF measurement resources. This is particularly striking in the usage of the ARM Mobile Facility (AMF) where three out of the past four users have been non-ARM funded, including, in 2006, a PI from the United Kingdom. Another measure of the use of the facility by non-ARM funded researchers is the number of proposals received and accepted from the general community - 60 percent of the approved proposals came from non-ARM funded researchers. This is a remarkable use rate that shows that the facility is doing a good job of marketing itself beyond just the ARM community itself. Though we did not specifically receive statistics on the number of scientific publications that use ACRF data by non-ARM funded researchers, this might be a metric that could more specifically address the quality of the research that is supported by the ACRF and which is carried out by non-ARM funded researchers.

There are currently 1500 ACRF users; 63 percent of these are not funded by ARM. Of these users, 931 are users of the archive, 69 percent of which are non-ARM funded. This last metric probably underestimates the real data user population since one user may pull data for a group of investigators.

The review materials discussed several examples of satellite data validation campaigns supported by the ACRF. This is an essential scientific service provided to NASA and NOAA and is an important interagency contribution to climate change science not easily found elsewhere. The science infrastructure provided by the ACRF enables these validation activities to be performed far more cost effectively than otherwise possible, while also contributing directly to the ARM mission. The scope of satellite validation activities in the National Polar-orbiting Operational Environmental Satellite System (NPOESS) era will increase significantly from the present load, and ACRF Management

should engage NASA and NOAA in strategic planning for these activities to ensure that the appropriate resources are in place when needed.

We found the ACRF web pages to be of high quality and designed to reach out to the non-ARM community in terms of describing activities and opportunities. Extensive documentation of the program is provided there. It appears to be relatively easy to locate within the archives the documented data sets of interest to any particular individual.

The committee believes that a wider solicitation and encouragement of the external science community to make more extensive use of the ACRF resources and to make these resources yet more useful to scientists initially unfamiliar with the ACRF should continue to be a major focus of the ACRF. We suggest that appropriate new initiatives (if resources can be found) would be to:

- Initiate programs to train new scientists (advanced graduate students and beginning post-docs) in the use of the ACRF, and in particular, provide them, to the extent possible, first hand experience with the measurements made by the ACRF
- Initiate a process of outside review of the documentation of data provided for the archive to better establish what difficulties may be encountered in the use of the documentation that may not have been anticipated by its authors

Cost Effectiveness of the ARM facility: Metrics

The ACRF Management presented numerous metrics from which the program effectiveness may be evaluated. There was a consensus among the Review Panel that these metrics fall into two basic categories: those that evaluate cost effectiveness and those that evaluate scientific excellence. The Panel concluded that the cost effectiveness metrics are useful for quantifying the investment benefit to DOE and OMB. The Panel also felt that no single cost effectiveness metric captures the full scientific impact of the ACRF on the national and international research community.

Here we summarize the key metrics presented by the ACRF Management.

Cost/Product. The ACRF Management proposed Cost/Product as the chief measure of cost effectiveness with a long-term target value of $100 ± 15% per data product file produced, based on the actual trend reported over the 1994-2006 period. The Panel concurred that this is a reasonable metric given the following assumptions:

- Product is understood to include only the highest level processed science data products
- The raw data and subsequent levels of processed data are archived but are not included in this metric

The Panel suggests Cost/Product replace the “Cost/File” metric presented in the review materials since this captures more accurately the scientific content of the data.

Leveraged Science Costs. The review included several discussions of campaigns and AMF deployments that leverage the ACRF/DOE investment with funding from other agencies or partners. These leveraged costs were not quantified in the review materials, but the Panel consensus was that they would provide DOE with a valuable metric for the broader impact of the ACRF. The Panel recommends that the ACRF contributions and total costs of major campaigns and AMF deployments be presented to demonstrate ACRF cost effectiveness.

Uptime (percentage) or **Number of Instrument Operation Hours**. This cost effectiveness metric was discussed during the review, but apparently has little value to cost accountants. Nonetheless, many members of the Panel were impressed with the 98+% uptime value of the ACRF. This is a valuable metric for scientific data systems since gaps in data streams are significant and need to be monitored as a measure of overall site/instrument operational performance. This metric should be retained.

Number of Publications Citing ARM or ARM Data. This is a key scientific excellence metric. During 2002-2006 there were 883 peer-reviewed journal articles published in American Geophysical Society, American Meteorological Society, and Royal Meteorological Society journals, an average of ~180 papers/year that used or based their research on ACRF data. Of these, only 306 articles acknowledged funding by ARM. The actual number of papers may exceed the number presented at the review since the literature search was not across all potential journals. A sub-category of this metric would be tracking the number of Intergovernmental Panel on Climate Change (IPCC) Assessment citations that rely on ACRF data. The ARM 2006 Annual Report provides comprehensive coverage of this metric.

A recommendation from the 2005 Panel Review suggested that ACRF develop a standard acknowledgment statement that all data users provide in publications. The request to have all ACRF data users include such a statement is reasonable and would greatly increase the accuracy of tracking relevant publications. It is not clear that the ACRF Management has implemented this recommendation in a systematic manner.

Number of Proposals Received/Number of Proposals Approved. ACRF has received 114 proposals since 2004 and 78 of these (68 percent) were approved. Sixty percent of the approved proposals came from non-ARM funded researchers. This scientific metric indicates the interest in the community for using the ACRF and the high rate at which these requests have been accommodated. The panel felt that this was not an overly high proposal success rate as long as ARCF felt that the scientific merit of all approved proposals justified selection.

The panel felt that these statistics were somewhat misleading since they do not distinguish small instrument deployment approvals from medium-scale instrument development/deployments, field campaigns, or AMF deployments. The Panel recommends some stratification of the proposal reporting based on cost impact.

Separate statistics were presented for proposals to deploy the AMF. Since 2004, four deployments of the AMF have been approved: California (2005), Niger (2006), Germany (2007), and China (2008). The number of proposals for AMF deployment has averaged 6 per year (a 17 percent success rate) and ACRF Management considered virtually all recent proposals "selectable". This indicates an important, unaccommodated need within the scientific community for the AMF's unique measurement capabilities as well as a strong desire within the community to engage the ACRF in these major international activities. The Panel strongly recommends that the ARM Infrastructure receive additional funding to support the development and deployment of a second AMF.

User and Data Use Statistics. ARM currently tracks the demographics of more than 1500 ACRF users. This science metric is broken down by state for U.S. users as well as by country. Nine hundred thirty-one of the users are active archive users. These data use statistics also indicated that the number of non-routine products far exceeds the number of routine products.

The ACRF should proactively solicit feedback from users concerning the quality and ease of use of ACRF products. This feedback can be acquired via the data pull web interface and/or with an automated follow-up email questionnaire to the user.

The Panel strongly recommends that ACRF products be reported with quantified error characteristics for every data point; that is, adding error bars for each data point. The current practice of providing data quality descriptions for the total product diminishes the value of the product, even when detailed references are provided in the metadata.

Cost effectiveness and trends

Previous investments in transforming the ARM sites into a user facility have been tremendously successful. The ACRF is recognized by the national and international science community as a unique asset for the study of clouds, aerosols, and radiation physics as well as for climate change science and the validation of satellite observations. The panel was presented with data that showed that the largest cost factor is for labor associated with maintaining the facilities. The ACRF management team has worked aggressively to keep the cost level in this category flat and even declining over the years. This effort has meant a savings of $6 M compared to what the projected labor costs would have been from 2001 through 2006 by assuming a 3 percent inflation rate. Labor costs growth has been reduced by employing post doctoral researchers and younger Ph.D.'s. These savings were achieved even with the additional staff needed to deploy and operate the ARM Mobile Facility that began in 2004. Other cost savings have resulted through management decisions; two examples follow. Cost savings and a reduction in instrument downtime resulted from training ACRF staff at the Southern Great Plains to assume calibration and instrument repair that was previously done through external contracts. Cost savings in internet services needed for data transfer were also achieved by the introduction of new technologies and more cost effective contractual arrangements.

However, the AMF is enabling a much broader use of the facility. The large number of acceptable proposals noted above that cannot be supported demonstrates that there is a strong desire within the scientific community to engage the ACRF in these major international activities.

The ACRF is approaching a period of optimal productivity. The ARM Infrastructure Management is to be commended for effectively implementing numerous cost reduction measures while simultaneously increasing the number of products delivered to the user community. However, there is a risk that ARM Infrastructure will not be able to sustain continued growth in service to the user community under the current funding profile. The de facto scope of ACRF responsibilities has increased with their support of climate data records, and DOE must recognize that this scope increase requires commensurate resource allocations. The ACRF management must be careful not to compromise data quality and long-term calibration accuracy: scientific excellence, not overall cost, is the highest priority for evaluating the benefit of the ACRF to society. This emphasis on data quality will prove especially important over the next 5-10 years as climate data become a more significant portion of the ACRF product portfolio and the community relies more on the ACRF to provide climate data measurement capabilities.

Implementation of recommendations from prior review (2005)

The energetic efforts of ACRF to adopt the recommendations of the 2005 review are very impressive. The formal process established to address each of the comments and recommendations is to be commended since this process ensures that the independent review results are thoroughly considered, even if not fully acted upon.

Following the 2005 review ACRF management developed a grouping of eight topic areas of recommendations and proceeded to address each. In response to the most urgent needs identified, emphasis was given to improvement of data quality, documentation, and dissemination, along with enhancement of communications to the user community. The user community in particular relies heavily on the ARM web site for initial access to ACRF data and subsequent data interpretation and distribution.

Web Technology, Data Products and Information. The committee notes massive improvement to the ARM web site and organization of the ARM database. This has been a daunting task, given the size of the database, the variety of instruments, the number of sites and facilities, and the intermittent nature of many observing records. The changes address the wide ranging needs of the three main user groups of the database - ARM PIs/WG members, K-12/educational customers, and interdisciplinary scientists. Every area of concern was well addressed, with special emphasis appropriately placed on outreach to the educational and modeling communities. Much progress has been made to make the archive accessible and understandable to new users. The addition of correlative external data, including both satellite and model output, is particularly noteworthy.

There are, however, still a few concerns that should be considered:

- Feedback from external, non-ARM users seems to rely chiefly on problem form submissions. A more pro-active approach should be pursued, including direct contact with data users and those who access the site, but do not download data. Many aspects of an expanded customer follow-up could be automated.

- Data quality, especially error characteristics, are not as well defined and easily found as might be needed by interdisciplinary scientists. The color code for data quality is helpful, but it would be valuable to have a quantitative calibration and accompanying error bars.

- Linking and cross-cutting (as a function of time) of related data sets could still be improved.

- Grouping of data sets, such as suggested data applicable to addressing typical climate research problems/issues, has begun already and should be continued and improved.

The review team concludes that ACRF has made excellent progress toward improving its web technology for making the ARM data archive user-friendly, but these efforts need to continue.

Instrument Systems. There did not seem to be any interest displayed by ACRF (or the 2007 review team) to "Consider revival of the instrument development program." Even though this was a recommendation in 2005, it may not be practical or necessary today. ACRF appears to be doing better in the other area listed for this grouping, "Establish criteria for instrumentation deployment that address the needs of the broader scientific community," especially with the ARM Mobile Facility.

Broader Outreach. This area can never be considered completed, but it is clear that the ACRF is actively pursuing constructive outreach. Continually attracting more users should remain a major goal of the ACRF. It was suggested that other organizations with major user-support missions could be contacted to share ideas about how outreach can be further improved.

The review committee discussed the scheduling of user access, support, and campaign participation. This is a complicated process, since funding is needed before applying, but accepted participation may be required to obtain other agency funding. However, with well advertised procedures and reasonably effective coordination efforts, the process appears to be working and handled well.

A great strength of the ARM program and ACRF is in the world-wide, diverse regional climate measurements being obtained. However, it appears possible that not enough effort has been focused on this important aspect of the overall program. The committee offers two recommendations on this point:

- A limited number (one to three) of ACRF signature data sets should be identified and special attention placed upon providing superior access, format, correlative data, QA, error characteristics and linkages, and prominent depiction of specific global climate research applications.

- More focused attention could be given to applications of the world-wide, regionally diverse, collective data from the ACRF sites to global climate research, with possible direction of DOE/ARM funding toward this specific goal. Multiple-site data applications could be emphasized further. The ARM facilities are in an excellent position to make significant contributions to global climate issues, and research utilizing these facilities should increasingly be of value to ongoing IPCC efforts. DOE management is encouraged to support these efforts. The value of ARM data sites for satellite calibration and in validating parameterizations that are used to upgrade and improve climate models used by the IPCC should not be overlooked.

Communication of ACRF Accomplishments. The importance of ARM and ACRF to international climate science must be communicated through an ongoing effort. The new annual report and newsletters, in addition to the improved web site, appear to be significant improvements to scientific outreach and advertising. The suggestion was made to place the most high-impact product on the cover of the annual report as an example of communicating well by making a good first impression.

Data Quality. Recommendations from the earlier review included "Expand data quality efforts…" and "Establish a review mechanism… of expanded data quality efforts." The first is certainly being done, but it did not seem that there is a way (or a way has not been identified) to track improvements explicitly.

Refined Management/Leadership Approaches. In general, this area appears to have progressed well. ACRF is fairly young and is still developing its approaches and techniques for becoming more effective.

ACRF Management Structure and Performance. An extensive list of recommendations in this area from the previous review appears mostly directed toward internal organization and management. The presentations by ACRF in this review focused mostly on mission and outreach, which the committee considered appropriate; however, this makes it difficult to assess progress toward implementing the recommendations regarding internal organization. The inclusion of non-DOE members on the ACRF Science Board, which is related to outreach, was noted positively. The committee notes that the success of ACRF in its primary mission objectives as a user-oriented facility provides evidence that the internal structure is operating productively.

Conclusions

The ARM Facilities Review Panel found that the facility was, indeed, being effectively used by the broader scientific community. This was demonstrated through the successful number of user requests from the non-ARM funded community that were received and

accepted by the facility. The much-improved web interface aids this use, but a limited training program might be enhance it further, together with an outside review of the archive documentation.

The ACRF Management has worked aggressively to decrease costs of running the ARM facility. A number of metrics can be defined to measure this effectiveness. We recommend the ACRF widen the types of metrics used, to show both the breadth of use of the facility and its effectiveness. It appears that further cost-cutting measures could significantly impair the running of the facility.

ACRF management also aggressively pursued implementation of the 2005 review recommendations. We have made a number of suggestions to further improve the facility and its use by the broader scientific community, but believe that progress has been substantial already in addressing the most important aspects from the 2005 review.

Appendix A

Charge to BERAC

Under Secretary for Science
Washington, DC 20585
October 24, 2006

Dr. Michelle S. Broido
Associate Vice Chancellor for Basic Biomedical Research,
And Director, Office of Research, Health Sciences
University of Pittsburgh
Scaife Hall, Suite 401
3550 Terrace Street
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Dear Dr. Broido:

By this letter, I am charging the Biological and Environmental Research Advisory Committee (BERAC) to convene a panel to assess the effectiveness of the combined stationary and mobile Atmospheric Radiation Measurement (ARM) facilities as a national scientific user facility – The ARM Facility. I am also charging the BERAC to assess the cost effectiveness of operating the ARM facility. The facilities are funded by the BER Climate Change Research Program.

The panel is specifically charged to assess how well the ARM facility is serving the needs of members of the open scientific user community who are not funded by the ARM program. For example, are the stationary and mobile ARM facilities being maintained and operated effectively to serve their needs? What changes, if any, are needed to better serve the needs of outside users? What evidence demonstrates that these facilities are being effectively used by the open scientific user community?

With respect to cost effectiveness of the ARM facility operations, what factors are driving the costs of maintaining and operating the ARM facility and what has been the trend in these factors over the past 5 years? What actions, if any, have been taken to optimize ARM facility operations over the past 5 years and what are the cost savings that have been realized? What are additional actions that could be implemented to optimize ARM facility operations and realize additional cost savings?

The panel is also asked to assess whether critical recommendations from an earlier independent review conducted in 2005 of the operations of the ARM facility have been or are being adequately implemented. The report from the 2005 review of ARM facility operations is accessible at:
http://www.arm.gov/publications/programdocs/doe-er-arm-0502.pdf

Sincerely,

Raymond L. Orbach
Under Secretary for Science

Printed with soy ink on recycled paper

Appendix B
Members of Panel

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Appendix C

Meeting of the ARM Radiation Facilities Review Sub-Committee a

February 5, 2007

8:30 – 9:00	Joyce Penner, Welcome and Introductions
9:00 – 9:15	Jerry Elwood, Introduction and Charge to the Subcommittee
9:15 – 9:45	Jimmy Voyles, ACRF as a User Facility – overview of facility and request process
9:45 – 10:15	Break
10:15 – 11:00	Doug Sisterson, Operations – budget discussion
11:00 – 11:45	Steve Klein, Support to Non-ARM users – summary of scientific use and publications
11:45 – 12:15	Jimmy Voyles, ACRF Response to 2005 review
12:15 - 1:15	Lunch, with roundtable discussion
1:15 – 3:30	Committee closed discussion and writing
3:30 – 4:00	Break
4:00 - 5:00	Committee brief to Jerry Elwood and Wanda Ferrell
5:00	Adjourn