The National Center for Atmospheric Research (NCAR) is the premier institution in the United States for providing research on all aspects of weather and climate of importance to the nation. The damage in the US from extreme weather and climate has greatly increased in recent years to become a considerable drain on the overall economy, with costs of any one of the many such occurrences readily exceeding billions of dollars, e.g. the current Texas drought. Reduction of these costs requires better understanding of the processes involved and consequent improved capabilities to project their future occurrences. The development of more accurate prediction capabilities, advancement of world-leading numerical models and world-class computational and observational facilities, facilitation of the transfer of scientific applications and technology to meet societal needs, and development of the next generation workforce are the achievements and continuing contributions NCAR with its 76 university partners.

INTRODUCTION:

The Scientific Programs Evaluation Committee (SPEC) is charged by the Members of the University Corporation for Atmospheric Research (UCAR) to evaluate the quality of NCAR and other programs. In fulfilling that role, the SPEC convened with the NCAR Advisory Committee on 16-17 August 2011 in Boulder, Colorado to 1) review the NCAR science programs based on an assessment of NCAR progress on the scientific goals and objectives articulated in the most recent (28 August 2009) NCAR Strategic Plan and 2) assess the progress made on the proposed activities in the 2007 UCAR proposal to manage NCAR. Prior to the meeting in Boulder, the committees were provided with very detailed reports that were prepared by the individual NCAR laboratories/observatory (Computational Information Systems Laboratory (CISL), Earth Observing Laboratory (EOL), High Altitude Observatory (HAO), NCAR Earth System Laboratory (NESL) and Research Applications Laboratory (RAL)) for the NSF science reviews conducted in spring 2011 by unit specific Site Visit Teams (SVTs), the reports of each laboratory/observatory prepared by the SVTs, and responses by NCAR management to the SVTs’ reports. The committees were also provided the current NCAR Strategic Plan, the 2007 UCAR proposal to manage NCAR and other pertinent documents. Stephen Nelson, program director at NSF for the NCAR/Facilities section of the Division of Atmospheric and Geospace Sciences participated via video conferencing for the entire meeting. Michael Morgan, Bernard Grant, and Sarah Ruth at NSF participated during the first morning of the meeting.
At the meeting, UCAR management presented the progress made on the UCAR proposal to manage NCAR. NCAR management presented the findings of the individual NSF science reviews of the laboratories and observatory conducted in spring 2011 and their responses to the reviews. Following the presentations SPEC and the NCAR Advisory Committee met in executive session and drafted additional questions for UCAR and NCAR management.

**EVALUATION:**

The committees were impressed with the thorough documentation of the NCAR laboratories and the thoughtful reports of the SVTs reviewing the laboratories/observatory. The format used was used by the SVTs included NSF's two criteria for evaluation, intellectual merit and broader impacts, and concluded with a summary of strengths, weaknesses, opportunities, significant achievement and recommendations.

Having read the reports, reviews, proposal, and the NACR Strategic Plan before the meeting with the specific charge and report questions in mind, SPEC and the NCAR Advisory Committee members were prepared to openly discuss the questions asked and request clarification of material in the documents and presentations.

Here we address the specific questions asked of SPEC including associated observations, questions and suggestions.

**What are the most important results from the NSF science reviews (e.g., common themes, appropriate center-wide activities, scientific productivity, consistency with the goals stated in the Cooperative Agreement, etc.)?**

All the individual NSF science reviews of the laboratories/observatory consistently emphasized the overall excellent scientific quality of the research and productivity of the scientists and staff. The reviews affirmed that NCAR’s primary research activities remain consistent with the goals in the UCAR Cooperative Agreement with NSF to manage NCAR and with NCAR’s Strategic Plan.

NCAR underwent a significant reorganization in 2004, combining some divisions and creating interdisciplinary and complementary institutes, with the purpose of facilitating multidisciplinary research between the divisions and with universities. There have been modifications made to the reorganization as NCAR strives to find the best model for reaching its goals and aspirations. Future opportunities and challenges will likely lead to more permutations. Leadership has changed in the intervening years at NCAR and NSF. A new UCAR president will be in place by the beginning of 2012. UCAR and NCAR have handled the management changes admirably. Challenges remain in fostering multidisciplinary collaborations particularly in these fiscally constrained times.
Two issues cutting across all the programs are challenges with demographics in the scientific ranks and the diversity of the scientific staff.

The demographics of the ladder-track scientists show a high percentage of individuals theoretically approaching retirement. With no defined “retirement age”, increased longevity, and a struggling economy, scientists are working longer. This skews the age distribution to the older end in the scientific ranks. UCAR infused general fund monies about seven years ago to fund 20+ new ladder-track scientists. This effort helped balance the age distribution, however, adding ladder-track scientists with only a few years of hard money support has resulted in a situation where there are more salary commitments to the scientists III and IV than the NCAR budget can support with base funds (workforce report). Clearly this is an unsustainable situation.

NCAR has played a critical role in developing careers of young professionals in the atmospheric science and related fields, as well as in enhancing the diversity of our profession. This important contribution of NCAR has been recognized and appreciated by the university and the broader atmospheric science community for years. Appropriately, these programs have received strong, continuing support, even in the face of budget cuts.

NCAR has made great strides in the number of women progressing through the ladder-track ranks and in management roles. The geosciences are among the least diverse fields with respect to underrepresented groups. NCAR and the UCAR university community have a pronounced lack of students and professionally from underrepresented group at all levels. UCAR has diligently worked to increase the number of professional from underrepresented groups through the Significant Opportunities in Atmospheric Research and Science (SOARS) program. SOARS began 14 years ago recruiting undergraduate students from diverse populations and providing research opportunities at the national center. In 2010 the High School Internship and Research Opportunity (HIRO) program began with targeting students at a younger age. Students in both programs are guided in research and mentored by NCAR scientists. Seventeen SOARS students have earned their doctorate and are working in universities, national laboratories and business. The diversity goals set by UCAR and NCAR will take many years to achieve.

We recommend UCAR clearly document through individual personal examples and quantification using collective data the achievement of their diversity efforts and professional development programs to date, e.g. discoveries, publications, citations, subsequent careers, etc.

A significant achievement for NCAR and the scientific community is the advancement in supercomputing at the new supercomputer center being built in Wyoming. Building the partnerships to form a new and critical center outside of the Boulder region required concerted efforts among several individuals and groups at
UCAR, NCAR and NSF. The facility is nearly complete. Acquisition of the computer is in the next few months. New challenges will arise with having this campus and staff a couple hours drive from Boulder. NCAR’s other unique contributions are community models and facilities, and the management, stewardship and distribution of data for the community.

An issue with any national center such as NCAR is whether the center enhances research in the academic community or competes with that community for scarce resources. With regard to capital-intensive facilities such as research aircraft and radars, NCAR has a long history of enhancing atmospheric research at its partner UCAR universities by developing and maintaining facilities that are available for deployment with the approval by NSF of projects proposed by academic researchers. NCAR’s role in this regard is unique in the world. In other areas, such as model development and laboratory-based research, there has been in the past some anxiety on the part of university scientists that NCAR scientists were in direct competition with university researchers. In recent years, however, that anxiety has clearly been diminishing due to a combination of factors that include UCAR and NCAR management efforts and the evolving nature of atmospheric science research. UCAR and NCAR management, with input from the UCAR President’s Advisory Committee on University Relations (PACUR), have stressed the need for university-NCAR partnerships on proposals to NSF. PACUR reviews of NSF proposals from NCAR in recent years have shown that these partnerships are the norm. However, as the number of NSF proposals from both NCAR/university partnerships and university-only investigators increase, the fraction of total proposals that are funded must inevitably decrease. Development of complex models such as Community Earth System Model (CESM), and the Weather Research and Forecasting (WRF) model clearly require extensive university/NCAR partnerships with NCAR serving as facilitator, but in other areas of research, the increased number of proposals competing for limited resources causes concern in the university community. The question that then arises is whether NCAR’s imperatives should be prioritized to focus primarily on areas where NCAR/university partnerships are most essential for advancement of atmospheric science. This issue must be addressed as UCAR and NCAR go forward.

*With regard to NCAR’s contributions to the nation, is a cost-benefit analysis needed?*

With heightened attention on the federal debt, considerable cutbacks in federal funding of research are possible in the coming years. While it is generally understood that R&D is critical for a thriving economy, government agencies that support research will come under increasing pressure to justify and make clear the value of their sponsored research. Given this situation, the economic impact to the United States of weather extremes and climate change, the potential for improved predictions to mitigate those impacts, and the critical role that NCAR plays in improving the accuracy of predictions, the time is right for NCAR/UCAR to undertake a cost-benefit analysis of its operations. Considerable data exist for an analysis of
not only the benefits from incremental improvements in weather and climate prediction, but also the positive impact of NCAR facilities and community weather and climate models on research in the atmospheric sciences. It is expected that a strong case can be made for continuing support of a national center based on objective measures of the value of NCAR’s activities.

Do any of the individual science reviews have implications for NCAR as a whole?

Each of the individual science reviews recommended increasing the amount of NSF core support to that specific laboratory/observatory. Obviously that scenario is not possible with flat budgets. NCAR was originally founded to

“Attack the fundamental problems of the atmosphere on a scale commensurate with their global nature.
Aggregate the large-scale research facilities necessary for such an attack.
Provide a coordinated, interdisciplinary approach to these problems on a scale not possible in individual university departments.
Preserve the natural alliance between research and education, without unbalancing university departments.”

its current mission

“To understand the behavior of the atmosphere and related physical, biological, and social systems
To support, enhance, and extend the capabilities of the university community and the broader scientific community, nationally and internationally
To foster the transfer of knowledge and technology for the betterment of life on Earth”

reflects the advancement in the science and technology with time.

NCAR management is currently and will continue to be faced with difficult budgetary and staffing decisions. Salary commitments to senior scientists in laboratories/observatories exceeding the core NSF budget necessitates increasing amounts of soft funding support and tapping other resources for new initiatives in their “frontier” areas. Maintaining a proper balance is essential. NCAR should also consider retirement incentives for its senior scientists that are beneficial to the organization as a whole.

Augmentation and protection of the Advanced Study Program (ASP) aids both NCAR and the science community through postdoctoral opportunities at NCAR and in supporting interaction of NCAR scientists and university colleagues through the Faculty Fellowship program.

Model development at NCAR is one of its signature achievements, culminating in the CESM, the WRF model, and the Whole Atmosphere Community Climate Model (WACCM). Future models require collaborations with multiple groups to provide
critical pieces of the code. It will be fruitful to reduce duplication of effort where appropriate, and increase collaboration in model development across NCAR.

**Are NCAR’s planned responses to the science reviews appropriate?**

NCAR’s responses to the science reviews appropriately address the concerns and recommendations made. All reviews note the increasing demand on the NSF core funding. NCAR’s management will need to be skillful in balancing strategic frontier initiatives with core responsibilities to the community. Another general concern was insufficient progress in recruitment of underrepresented minorities. NCAR has strong programs attempting to address this issue across the community NCAR serves, rather than within NCAR alone. These diversity programs are reaching a level of maturity for their results to begin to be seen in the workforce.

A significant weakness identified is the large shrinkage in NCAR’s capabilities to do in situ chemical measurements. To address this concern, NCAR will reorganize their atmospheric chemistry activities to be a single facility, guided by planning with the community, making sure they do not duplicate university activities and provide data through a single portal. However, staffing concerns remain.

NCAR needs to protect the core modeling activities while finding ways to limit the direct demands on staff from user support. Model develop activities need to be coordinated across NCAR to avoid duplication of effort.

**Do the science reviews warrant changes to NCAR’s Strategic Plan? Should NCAR modify its imperatives and frontiers?**

NCAR’s strategic goals, priorities and objectives are laid out in the NCAR Strategic Plan that is revised every five years. The document also provides the framework for future program development and as such should be considered dynamic rather than static. The reviews do not suggest any significant changes to the Strategic Plan; indeed much of the high praise in the reviews concerns accomplishment of those goals. At the same time, there are examples of NCAR’s nimbleness in recognizing new frontiers and opportunities as they arise and successfully pursuing those new developments. An example is in the many unanticipated versions of the WRF model, including a version that links health to weather. Adjustment to changing frontiers is a great strength of NCAR that should continue to be an important part of strategic planning.

**Are there other factors, such as emerging scientific opportunities or the likelihood of level or diminished federal funding, that should lead NCAR to change its Strategic Plan?**
NCAR has developed the Annual Budget Review (ABR), a process tied to the Strategic Plan that allows response to emerging scientific opportunities or a diminished budget within a +5% to -10% range. In years of significant decreases, or increases for that matter, program decisions must be accompanied by revised budget allocations. The ABR process also can accommodate pursuit of emerging scientific frontiers that are consistent with the broad goals and objectives of the Strategic Plan. NCAR and UCAR leadership have been using this mechanism for many years and both the reviewers and the committees have confidence that this will continue successfully. The Strategic Plan should always be dynamic enough to cover the year-to-year variability in budget and emerging scientific frontiers. Therefore, short-term adjustments should (and currently do) come through the ABR process and the Strategic Plan is used for long-term adjustments to goals, priorities and objectives. Obviously, longer-term budget trends will have an effect on formulating each new five-year Strategic Plan.

**Has UCAR made progress on the proposed activities in the 2007 UCAR proposal to manage NCAR? What remains to be done?**

The 2007 UCAR proposal to manage NCAR contains three principal components: corporate leadership, administration, and management of human resources.

With respect to specific goals, UCAR has made substantial progress. These are a few highlights of goals where progress has been made.

A top priority in Goal 4.2.1 (*Improve understanding of the atmosphere, the Earth system, and the Sun*) is earth system modeling. The CESM represents a highly successful accomplishment related to this goal. Furthermore, the development of CESM has extensively involved the university community and was released ahead of schedule.

Goal 4.2.2. (*Provide robust, accessible, and innovative information services and tools*) has also met with considerable success. The top priority was to replace NCAR’s aging supercomputer center. With the help of a $300K investment from UCAR, planning was initiated and this effort is well underway. Much of the construction of the facility in Cheyenne is now complete and the successful computer bid will be announced soon. It will be a year or more before the first measures of the impact of the center can be assessed, but this new facility has the potential to greatly enhance modeling of the earth-sun system.

In the area of facilities (Goal 4.2.3 - *Provide world-class ground, airborne, and space-borne observational facilities and services*), the use and evolution of the Gulfstream V aircraft was identified as the top priority. This goal has also been met with great success as the aircraft instrumentation has advanced and unique field campaigns have been undertaken. For example, a pole-to-pole atmospheric chemistry mission aimed at measuring the global distribution of trace gases, HIPPO.
(HIAPER Pole to Pole Observations), heretofore not possible with the previous fleet, has recently been completed.

Goal 4.2.5 (Cultivate a scientifically literate and engaged citizenry and a diverse and creative workforce) has been the target of a number of UCAR/NCAR activities. One objective has been to expand the number and scope of ASP postdoctoral appointments to include engineering, education, computer science, and other relevant disciplines. Data were not provided concerning an expanded scope of ASP post-docs, but it was learned at the SPEC briefing that the ASP program has been augmented and protected in the face of NCAR-wide budget cuts. It is laudable that NCAR has committed resources to this important program despite the challenging budget climate.

Following the presentations by NCAR management the SPEC and NCAR Advisory Board followed up with additional questions to management that we include below.

What process will UCAR/NCAR use for budget allocation with significant to severe cuts in the near future?

The primary mechanism for adjusting to year-to-year changes in budget is the ABR. Scenarios using a range of +5% to -10% in total budget are worked out each year to be able to quickly respond to available funding while adhering to the Strategic Plan. The ABR process has long been in place and has worked well. One type of scenario that is difficult to fully adjust to using the ABR process is budget cuts that are greatly amplified by coming late in a fiscal year. Situations of this type will test the leadership skills of the management. The SPEC has confidence that the UCAR/NCAR leadership will preserve NCAR’s core mission as a national center and its added value to the scientific community when faced with budgetary reductions.

What value does UCAR management bring to the management of NCAR?

UCAR has been selected by the National Science Foundation to manage NCAR since 1960, a selection that was renewed in 2008 on the basis of a proposal and through a formal competitive selection processes. UCAR’s management of NCAR provides the administrative glue that is required for NCAR to thrive through development of needed infrastructure, e.g., world-class computational center and research and meeting facilities. UCAR also acts to bring academia, government, and industry together to address issues of global importance. In doing so, its has greatly enhanced not only NCAR’s value but also programs of the university community and federal laboratories concerned with weather and climate.

Oversight of NCAR’s research and service activities by the university community, through a range of mechanisms created by UCAR, has been critically important to NCAR’s success over the past 50+ years. This oversight, accomplished by the now
76 member universities via committees, advisory panels, workshops, etc., as well as a board of trustees, provides for checks and balances in NCAR planning and activities. It serves to keep NCAR on a path beneficial and continually relevant to the atmospheric science community. UCAR facilitates the research, community model development, and facility operations within NCAR not only by bringing the university community together in a collaborative and advisory way, but also through a variety of supporting activities: assisting in the development of NCAR strategic plans, providing effective management of NCAR staff, fostering a diverse and productive workforce, creating a stimulating physical working environment, providing NCAR-wide education and outreach coordination, leveraging NCAR’s efforts through the UCAR Community Programs (UCP), as well as others. It is safe to say that UCAR is unique among management structures for national centers of physical sciences.

A recent example of the value of UCAR management to NCAR is the planning and construction of the NCAR-Wyoming Supercomputer Center (NWSC) in Cheyenne during the past few years. UCAR invested $300K to get the planning effort off the ground and, according to CISL leadership, the center could not have been realized without this investment. Although the computer purchase has not yet been announced and some hurdles remain, the NWSC is expected to become a key resource in solving the most challenging problems in weather and climate change.

The successful UCAR management of NCAR over the past 23 years has been accomplished with Rick Anthes at the helm. It is important to point out that a part of this success is the fact that Rick is not only a skillful manager but also a respected scientific leader. UCAR would do well to consider this combination of talents in its hiring decision for the next president of UCAR.

**What is the process for arriving at decisions for balancing the distribution of core NSF funds across the labs?**

NCAR management has the ABR for allocation of core NSF funding where decisions are made in concert with the Strategic Plan. New opportunities, though aligned with the overall NCAR mission, reduce the time and effort that can be devoted to community needs. The community expects increased NCAR services in providing data streams and data sets, community models, education materials, community workshops, and observational facilities. The competing needs at NCAR of finding additional funding for salaries, increasing diversity, and providing community services makes initiating frontier activities impossible without reductions in some areas.

Addressing the frontier areas, e.g.

“Advance modeling and analysis focused on informing climate change adaptation and mitigation and
Conduct and enable studies of water resource availability, vulnerability, and adaptation planning” is the means for NCAR to fulfill its mission and imperatives. The committees recognize the significant challenges and choices with the competing needs, however there is confidence that NCAR management is able to tackle the vexing problems and marshal the human, technological and facility resources needed.

What’s ISPs mission and why was it formed?

The Integrated Science Program (ISP) is a recent addition to the NCAR structure. ISP was formed in 2009 as a “virtual organization” in the NCAR directorate to forge multidisciplinary connections among disparate fields, NCAR divisions, institutes and programs and with universities. ISP is a reformulation of The Institute for Integrative and Multidisciplinary Earth Studies (TIIMES) that was embedded in a NCAR science laboratory.

ISP’s mission is to fund and foster the initiation and early development of multidisciplinary programs that will ultimately be transferred to one of the existing laboratories/observatory. As described to the committees, ISP in unsustainable. Funding for the new initiatives transfers with the emergent program, so there is no “backfill” for funding the new ideas that follow.

NCAR is struggling with how to promote multidisciplinary activity. ISP is another approach to address the need. Much interdisciplinary and multidisciplinary work takes place independent of ISP. If ISP is to become a successful incubator it needs a stable budget carved from existing resources.

IN CONCLUSION:

NCAR is a unique center. It has made fundamental contributions in atmospheric and related sciences. There is every reason to celebrate prior achievements and look forward with confidence to more success in the future.

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