National Radio Astronomy Observatory Users Committee
2015 Report

August 12, 2015

Executive Summary

This document reports on the discussions, findings, and recommendations of the Users Committee following its annual meeting at NRAO/Green Bank (Green Bank, WV) on 2015 May 20–22. We highlight here the most important conclusions or findings of the Committee.

- CASA continues to be a source of much frustration among users, yet there are also indications that it may increasingly be treated as a strategic asset for NRAO. If so, there is an expectation that performance and user experience would improve. The CASA users survey and the recommendations of the CASA Users Committee are both welcome steps, and a second users survey should be conducted in approximately one year.

- Jansky Fellowships should be preserved as a prestigious radio astronomy post-doctoral fellowship, with no "functional" responsibilities and retaining the option of being resident at a non-NRAO site. Options should be explored to ensure close connections to NRAO, such a designated NRAO mentor and regular visits to an NRAO site. The UC also supports the goal of reducing or eliminating "functional" post-docs. All too often, their functional duties have expanded to crowd out their research activities, with subsequent career implications.

- The User Committee structure itself needs more integration between the regular UC and the ANASAC as a standing sub-committee. The face-to-face meeting reflected this divide: most of the ANASAC members attended the UC meeting but the reverse was far from true.

- The UC thanks NRAO for reinstating both page charge support and Student Observing Support for the North American telescopes, particularly in light of continuing budgetary challenges.

- There has been significant progress at the ALMA Observatory in the past year, but the UC identified two themes of concerns. The first is limited resources and lack of clear priorities, leading to situations such as most of the new capabilities being labeled "high" priority due partly to lack of resources/time available to demonstrate capabilities. The second theme is transparency with the community—a crucial component for increasing the ALMA user base. Examples of areas for which more clarity would be helpful include the reasoning behind prioritization for the capabilities for Cycle 4, the usability of the Archive, and stale data. In many cases, these are not new examples.

- The UC supports the removal of the hybrid configurations from the JVLA but stresses that their removal must be highlighted in upcoming calls for proposals and strategies for achieving comparable surface brightness must be described clearly.

- Presentations at the meeting were shorter, allowing for more useful time for discussion. There should be a continued effort to ensure that formal presentations do not occupy more than approximately half of the scheduled time, to ensure that issues can be explored sufficiently.

- The UC finds that confusion remains within the user community regarding the importance of the sessions specified in the Proposal Submission Tool to the allocations decided by the Telescope Allocation Committee. This continuing confusion suggests that the underlying concept of sessions needs to be rethought, particularly in light of potential changes to the Proposal Submission Tool.

1 Background

The Users Committee (UC) is a scientific advisory group to the National Radio Astronomy Observatory (NRAO) that provides input on matters relating to NRAO's interfaces to its user community, NRAO's interactions with the larger astronomical community, and NRAO's scientific productivity. This document reports on the discussions, findings, and recommendations of the UC following its annual face-to-face meeting at NRAO/Green Bank (Green Bank, WV) on 2015 May 20–22. The UC has 18 members, of whom 16 attended at least some portion of the meeting.

A welcome change for this year's meeting, relative to last year's meeting, was that presentations on the second two days were shorter and often more focused on user-related issues. Among other benefits, these shorter presentations allowed for more time to discuss topics between the UC and NRAO staff, to ensure that issues were understood and potential solutions explored.

As a result of discussions and presentations at the face-to-face meeting, the UC established two *ad hoc* subcommittees designed to explore items further. These subcommittees are charged with discussing specific items, possibly to present that full UC with a set of potential recommendations. The two subcommittees are Time Domain Science and Large and Legacy Projects.

Finally, the next few UC meetings will likely require either changes to the format or additional time for discussion. The current schedule for the re-competition of the cooperative agreement for the management and operation of the NRAO is that the selection of the managing organization will occur before the next face-to-face UC meeting. Regardless of the outcome of this re-competition, the UC notes that the selection will affect users and the astronomical community for the next decade.

In order to hear reports from the subcommittees, obtain feedback from NRAO on the UC report, assess progress against recommendations from the report, and discuss other topics as they arise, the UC will be attempting to hold more frequenttelecons. The current goal is to hold a telecon once per quarter.[1]

2 User Committee Structure

This year represents the second year of the UC's new structure, in which the ALMA North American Science Advisory Committee (ANASAC) forms a standing subcommittee under the UC. The ANASAC met on the first day (May 20) of the three-day UC meeting.

The initial vision was that the ANASAC be composed of the North American ALMA Science Advisory Committee (ASAC) members, plus a Taiwanese representative. Any "ALMA-interested" members of the UC would be welcome to attend the ANASAC subcommittee meeting and provide input. The attendance at the ANASAC meeting revealed that much more integration is needed, as only one non-ANASAC member (the current UC chair) attended the ANASAC day. In the future, NRAO, the UC Chair, and the ANASAC Chair should coordinate the meetings to foster increased interest and attendance at the ANASAC subcommittee meeting from UC members, with the goal of having more UC members attend all three days of the ANASAC+UC meeting.

The ANASAC strongly recommends that the ANASAC contains members in addition to the ASAC+Taiwan representative. The view of the ANASAC as ASAC+Taiwan is not viable, as it is necessary to ramp up future NA ASAC members so that they understand the history and politics of the project. Non-ASAC members are needed so that they can participate in the ALMA discussions and become potential ASAC members in the future.

[1] At this writing, the first such quarterly telecon is scheduled for August 27.

Compared to when the ANASAC was a stand-alone committee, the current format (one full day) is a much abridged version. The schedule was packed full of presentations, leaving little room for discussion. The agenda is clearly still in a state of flux, and future presentations will need to evolve to convey the essential information while retaining flexibility for discussion.

The ANASAC will be changing its makeup over the next year or two as turnover of committee members leads to a decreased total number of members, which would be roughly six in a steady state situation. Historically, there have been members who have served multiple three year terms, which has provided working memory of issues which have arisen in the recent past. The ANASAC encourages NRAO to continue this practice for a small number of members, but be cognizant in also broadening the community invited to become members. The pool of future potential ANASAC members should grow as the pool of North American ALMA users grows.

3 Facilities

3.1 ALMA Construction

The ANASAC congratulates NRAO on the official closeout of ALMA construction on 2015 June 30. The completion of antenna pads and site power infrastructure over the past year was a key accomplishment that enabled the successful long baseline campaign.

Two warranty items will remain after construction closeout. The first of these, quality control issues with the four Front End Handling Vehicles, should be resolved fairly easily. The second item is the temperature-dependent astigmatism of the Vertex antennas. It is not clear just how serious this problem is—the ANASAC has never been presented, for example, with a table of typical Band 9 aperture efficiencies for the three antenna types. However, a plan has now been approved to outfit two of the Vertex antennas with a network of thermistors and to monitor their surfaces with astroholography over a range of environmental conditions. This investigation should be complete by the end of 2015, and corrective action is expected to be finished by the end of 2016. The ANASAC requests updates on this effort at subsequent telecons/meetings.

3.2 ALMA Operations & Development

This last year has been a busy one for the ALMA Observatory, and much progress has been realized. Initial science results are exciting, observations with ALMA are in high demand, and the Observatory appears to be doing an adequate job at correcting some of the issues that had plagued earlier cycles. The ANASAC is cautiously optimistic that issues such as increasing observing efficiency and reducing time from observation to PIs receiving data are being resolved. That said, there were recurring themes in various presentations. The first of these is resources—from the pipeline presentation where the NAASC had an almost factor of two increase in data reduction effort over what had been planned in the ALMA2010 budget, to the Archive where lack of resources is slowing development, to the EOC where most of the new capabilities are labeled "high" priority due to lack of resources rather than technological risks to demonstrate capabilities. On all these fronts, there is movement in the right direction, but the ANASAC is concerned that, without major realistic prioritization and making allowances for contingencies, any new effort will remain superficial rather than substantive. The NRAO has always been remarkable in its ability to manage projects with less than optimum resources.

The second theme is transparency with the community. The ANASAC would like to impress upon NRAO that this is a crucial component of increasing the ALMA user base. The reasoning behind prioritization for the capabilities for Cycle 4, and the lack of explanation for why some more

things could not apparently be included, such as total power continuum, was not apparent. Items such as the project tracker, Archive usability, duplication tracking, and stale data are examples of user-facing components for ALMA yet issues remain with all. These are not new issues but they are important ones. We request status updates on the progress of these issues at subsequent meetings.

The ANASAC and the ASAC have a series of specific charges:

ANASAC Charge #1 Scientific outcomes and impact from Cycles 0, 1, and 2. Is North America doing well–what are the challenges?

An impressive percentage (81%) of the Cycle 0 projects for North America have resulted in a published refereed paper, and the number of publications is growing steadily. This publication record undoubtedly reflects the high quality of ALMA data and the enthusiasm of the community to analyze their results. The publication rates for Cycles 1 and 2 are predictably lower due to the delays in obtaining the data in those cycles and delivering them to PIs. These differences in publication rates emphasize the high priority that must be given to validate and deliver data quickly to investigators.

The ANASAC recommends that the NAASC monitor the number of archival publications closely, and, if growth in the number of publications is not seen in the near future, the NAASC should assess why that is the case. The number of archival papers is steady in time,[2] whereas an increasing number of archival publications would be expected as the Archive increases in size. (Is the format of the archival data useful? Is the Archive interface conducive for archival research?)

ANASAC Charge #2 Assess the status of Cycle 1 and 2 observations and progress made towards Cycle 3. For Cycle 2, are the data meeting user expectations, modulo the best efforts approach to early science? Are the data being released to the PIs in a timely fashion?

Delivered Cycle 1 and 2 observations have resulted in spectacular images and cutting edge science. The delivery rate has, however, been very slow (average about 3 months, but some data sets have taken up to 5 months to be delivered following completion of observations), which has resulted in considerable frustration among the PIs and a reduced publication rate. This slow release of data seems to have two causes:

1. Data sets required manual processing prior to the deployment of the pipeline, which was not implemented until 2014 October. Even though a majority of data sets can now be calibrated by the pipeline, almost all pipeline-calibrated data sets still require human intervention and the number of expert data analysts/scientists/astronomers at the NAASC is too small to meet this demand.
2. Following calibration, the level of imaging work done at the NAASC varies substantially between different people, with some spending considerable time on producing almost science-ready images to PIs.

The ANASAC recommends that continuing to automate the pipeline such that it can handle the vast majority of data sets without human intervention should have the highest priority and only verification images should be delivered for the rest of Cycles 1 and 2. The ANASAC requests an update on progress at the next telecon. The ANASAC was pleased to see a plan to address some of the most common issues that require human intervention during pipeline calibration, as getting data into the hands of the proposer quickly is a clear method to maximize the science output from ALMA. Further, a set of standards for image delivery to

[2] Slide 17 in A. Wootten's presentation

PIs would aid both PIs and NAASC staff in knowing what to expect. Delivering science-ready images to PIs is a commendable long-term goal, but not with the current backlog.

A second concern is the delivery of stale data to PIs, i.e., data sets that cannot be completed within a reasonable time frame due to issues such as configuration schedules. Delivering the few data sets that are affected by such considerations should happen on the shortest possible timescale. In the future, with configurations scheduled, datasets should be able to be identified as stale quickly, and the partial data should be given to PIs. This same concern (PIs being able to evaluate data prior to completion of all scheduling blocks in an observation unit set) is also applicable once large programs are underway, as it allows PIs to optimize the initial observing strategy.

ANASAC Charge #3 The third Call for ALMA Development Studies/NA is under way. Please comment on the process, which was lengthened this cycle and accompanied by specific suggestions ("ALMA2030") developed by ASAC.
The ANASAC is encouraged by the prompt adoption of the ALMA2030 document by NRAO to guide the development process in the recent call for Studies, as it may increase the unified impetus of development across the different regions. Both NRAO and the NA representatives to the ALMA Board should remain consistent in this approach, as well as continuously encouraging the other regions to pursue it.

The ANASAC recommends including among the referees for Development Studies not only experts in hardware and software but also astronomy experts, who will bring the science user perspective into the process. The ANASAC also finds that lengthening of the process, as well as the clear time separation between Study and Project calls (brought about this time by programmatic considerations), will likely benefit the process. Finally, the ANASAC thanks A. Wootten for providing the ANASAC with the current pool of referees, and hope that the response to his request for additional names was adequate.

The ANASAC reiterates the importance of having open communication between NRAO and the ANASAC with respect to the selection of Studies and Projects, as regional choices need to be defended at the ASAC and JAO Development Steering Committee levels. The ANASAC also reiterates the importance of widely advertising these proposal opportunities beyond the NRAO newsletter to reach the wider community.

The ANASAC recommends that NRAO work closely with PIs to ensure smooth integration of new capabilities resulting from Development Projects into the ALMA Observatory, where appropriate. Doing so will encourage new and innovative proposals for enhanced ALMA capabilities. Integration may be less of an issue for post-observation analysis software or algorithms, but it is essential for system software or hardware upgrades, for which acquiring test and commissioning time can be difficult. As more Projects are approved and move towards the deployment phase, it will be important for NRAO to facilitate the process of making sure new ALMA capabilities can be utilized. Unnecessary delay in access to new capabilities may dissuade ALMA-NA expert technical groups from committing to ALMA Development work.

ANASAC Standing Charge #1 To assist ASAC in presenting a North American view with respect to ASAC.
With the evolution of the ANASAC into a sub-committee of the Users Committee, the internal organization of the ANASAC has changed somewhat. Currently there is a North American ASAC vice-chair, as well as an ANASAC chair. The committee decided that these should be

two different people so as not to overburden the ANASAC chair when the ASAC vice-chair assumes the ASAC chair.

ANASAC Standing Charge #2 To lead community outreach through leadership of workshops—Plans for next NAASC-sponsored workshop—Plans for community workshops, tutorials, etc. The ANASAC did not explicitly discuss the next NAASC-sponsored workshop at the face-to-face meeting (but should begin discussing appropriate topics). There was discussion about community outreach and workshops. The NRAO Community Days which occurred prior to the Cycle 3 deadline were effective in exposing more astronomers to millimeter/sub-millimeter–wavelength astronomy with ALMA. The NAASC has been very pro-active in this respect over the last several years, and this work is paying dividends in stimulating interest in proposing for ALMA observations. The ANASAC commends the NAASC for heeding the call for additional student training, and inserting an interferometry summer school adjacent to the single dish summer school happening this summer in Green Bank.

ANASAC Standing Charge #3 To provide a mechanism for widening ALMA's base within the community and feedback to the NAASC on community perception of ALMA.
A. Wootten reported that PIs proposing for ALMA come from a broad swath of the astronomy community, not just the radio-millimeter-submillimeter (RMS) segments. It is reassuring that ALMA is attracting interest from the wider astronomical community. The RMS community does appear to have a slight advantage in being successful PIs.

Self-identifications as to previous experience might be useful in this regard; the ANASAC understand that some ALMA partners are uncomfortable with this approach, but believes that this is the best avenue to track how well the Observatory is capturing new interest in the community. Science outreach is also key in making sure that the entire community feels that they can make use of this facility.

The user surveys are an excellent mechanism for identifying topics of deep concern to ALMA proposers. Although previous surveys have indicated that users are generally satisfied with helpdesk and scheduling block generation, there is a worrisome negative trend in the former category (helpdesk) over the first 3 cycles.

The ANASAC recommends that multiple means are used to communicate broadly to the community the new developments regarding NAASC cluster access: via NRAO e-News as well as targeted notices to current and future ALMA observers. The ANASAC applauds this new access being provided to the NAASC cluster, allowing astronomers outside the NAASC to use it for computing, analogous to what is done in Socorro for JVLA datasets.

The ANASAC requests updates on the following topics at the next face-to-face meeting: (i) the Cycle 3 proposal selection statistics, (ii) the status of training and preparation activities, (iii) the level of user satisfaction in helpdesk response and scheduling block generation from the user survey, and (iv) the community use of the NAASC cluster.

ANASAC Standing Charge #4 Evaluation of Proposal Process: Cycle 3
The May face-to-face meeting occurred less than a month after the deadline for Cycle 3 proposal submissions, and a user survey is underway to assess opinions. The ANASAC congratulates the NAASC and the Observatory for a record number of proposal submissions, at 1582 unique proposals. The positive trend of increasing numbers of proposal submissions from Cycle 1 to 3 shows that there is high interest and demand for ALMA observations. Going forward with this assumption of increasing numbers of proposals, the ANASAC argues

that a balance between increasing the level of triage and increasing the number of proposal assessors should be struck.

The ANASAC was heartened that recent operations results showing projections for Cycle 3 indicate a high likelihood of success in carrying out approved observations, but also remembers the recent saga regarding optimistic projections for Observatory efficiency and completion fractions for Cycles 1 and 2, which changed dramatically due to unforeseen weather and other sources of downtime. The recent history of average number of antennas available shows that the numbers needed for Cycle 3 are achievable, as is the recently demonstrated observing efficiency.

The ANASAC requests a status update at the next face-to-face meeting regarding further efforts to maintain and increase the observing efficiency at levels that imply a high completion fraction for Cycle 3 and onward.

3.3 Jansky Very Large Array

The Jansky Very Large Array has transitioned from commissioning to operations, and it continues to serve as one of the premier telescopes on the planet. The UC commends the NRAO staff on their continuing efforts to advance the science capabilities, with recent examples including the replacement of poor-performing 3-bit samplers, the new 4-band feeds, time domain capabilities, and pulsar observing modes. The UC specifically notes the new VLITE system, not only as a new capability but as an example of community engagement and collaboration.

The UC was asked specifically about the removal of hybrid array configurations (BnA, CnB, and DnC), and the UC supports their removal. Hybrid configurations were described as being often difficult to schedule, with relatively lower ranked proposals being observed to ensure that the array does not sit idle at LSTs with lower proposal pressure. The UC also noted that a slight majority of the NRAO Telescope Allocation Committee supported removing the hybrid configurations. NRAO staff (C. Chandler) also demonstrated that the equivalent hybrid u-v coverage can be accomplished with acceptably small overhead by combining primary array configurations. The UC leaves the timing of hybrid configuration elimination to NRAO,[3] but we stress that detailed and clear guidance should be given to users on how to maintain approximately constant brightness temperature sensitivity at all declinations.

NRAO provided data to suggest that both the number of proposals to and number of publications from the JVLA has been declining from 2011 to 2014. The UC thanks NRAO for providing these data. It shares NRAO's concern that this decline could be a worrisome trend and considers the user survey to be a positive step toward determining the origin of this problem. There are potentially multiple causes for this decline in publication, but the results of this survey do indicate that 70% of respondents are still actively working on their data. With the added complexity of the VLA data (as compared to legacy VLA data), the UC suggests that reduction and analysis are likely to be more time consuming, leading to (temporarily) decreased publication rates as the VLA user community ramps up to a steady state of proficiency and productivity. However, the results of that survey also suggest that a significant factor may be difficulties in processing data using CASA (§4.1). As most users will have many ongoing projects, there is a risk that long data reduction timescales may mean that users switch their interest to "easier" data sets. Improving the data pipeline and CASA are areas that are likely to have the most immediate returns in improving community interest in and productivity with the VLA.

[3]Since the original draft of this report, the Semester 2016A Call for Proposals has been released with the announcement that hybrid configurations will be removed in the future.

The UC also encourages NRAO to explore increasing the time that pipeline data products are available from two weeks to one month. Some UC members thought that the current two week window may be an impediment to rapid publication if users are unable to retrieve the data within that window. However, this effort should not detract from the more pressing issues with CASA and the data reduction pipeline.

Finally, NRAO staff asked for feedback regarding the current practice toward discharging B priority sessions. This topic is considered in the discussion of telescope time allocation (§5.1).

3.4 VLBA, HSA, and VLBI

The UC was disappointed that no science results from the VLBA were shown, believing it to be a powerful telescope, particularly for astrometry. The UC also noted the low staffing levels at the VLBA and commends the NRAO for being able to keep the telescope running with so a small staff. The issue of succession planning on the departure of key staff is likely to become ever more critical.

The UC commends the NRAO for a number of significant developments in millimeter-wave VLBI recently. In all cases, though, full capability has not been realized, and continued efforts are necessary. In many cases, the work either requires or could usefully be undertaken in collaboration with the user community and would be a means of ensuring continued vitality of the VLBI community. Examples of areas in which there could be continued NRAO-university collaboration to develop new capabilities include the phasing of ALMA and higher data rates from VLBI systems.

3.5 GBT

The UC commends the GBT staff for continuing to operate a world-class telescope in a challenging and uncertain environment. Even in this environment, the GBT has been the focus of many community engagement and collaboration efforts, which may be even more important as a means of generating support.

The UC was pleased to hear that initiatives to generate external support for the GBT are beginning to bear fruit. Both scientifically-motivated examples (the North American Nanohertz Observatory for Gravitational Waves, West Virginia Univ.) and commercial examples were provided. Nonetheless, a shortfall appears to remain with respect to the NSF target of 50% of the GBT operations budget coming from outside sources. Ongoing efforts to identify new partners are of utmost importance.[4]

The UC recommends that NRAO aggressively promote high frequency capabilities in the community in order to expand the high frequency user base. The new instrumentation initiatives, including VEGAS, ARGUS, and Mustang1.5, provide significantly enhanced capabilities for the GBT, particularly in the high frequency regime, and have been developed in collaboration with the larger user community. High frequency science at the GBT is complementary to ALMA and fills an unique niche. The UC does, however, note that the high frequency community has apparently not yet produced ideas for funding directions.

The GBT will be the host of two meetings this year designed, in part, to expand the supporting user community.[5] The UC recommends that, for these workshops, the desired outcomes, such as white papers or discussions on new funding avenues, be communicated clearly to the community.

[4] During the writing of this report, the Breakthrough Prize Foundation announced a new effort in the Search for Extraterrestial Intelligence that will provide significant support toward GBT operations.

[5] "The Future of Planetary Radio Astronomy with Single-dish Telescopes Workshop," 2015 June 09–10, and "High Frequency Science Workshop," 2015 September 21–23

The UC recommends that NRAO put in place a detailed plan for alerting observers to future hardware problems and strive to maintain a more open dialog with users. This plan should also include language for how to deal with affected proposals, including what to do about proposals that need their deadline extended to meet their science goals. The recommendation is motivated by the recent experience with the VEGA spectrometer. Communication with the user community regarding the bank-to-bank intensity issues with VEGAS was poor. It seems that most observers did not know that VEGAS was having issues until those issues were almost resolved and much of the data were taken. Although best observing practices could have minimized the magnitude of the problems in their data, observers were not told that those best practices were especially important to follow. This lack of communication could have amplified uncertainty regarding the GBT at a time when community support is incredibly important for developing funding opportunities.

4 Data Management & Software

The NRAO Data Management & Software Department has many critical, user-facing components. In some cases, these components may be the *only* interaction that non-traditional users will have with NRAO. Over the past years, the UC has identified a number of components for which seemingly modest changes would yield significant improvements to the user experience. In response to various questions about these potential improvements, wildly different estimates of the level of effort required to implement these changes have been provided. Leaving aside the issue of whether staff has existed to implement any changes, we are concerned that the difficulties in maintaining and updating software speak to a larger issue. If user-oriented software is developed in concert with users, there is less risk that complex changes will be required. Further, given experiences in software development in many fields, it is not clear that adequate attention is being given to future development maintenance—it should be possible to update user interfaces without requiring a full recoding of a software package and there should be an assumption that the individual(s) who develops a tool may not be with NRAO in the future.

4.1 CASA

CASA has become the primary tool to analyze interferometric data from the NRAO-supported ALMA and Jansky VLA, as well as data from many external observatories. This is, in itself, a great achievement for which the UC commends the NRAO CASA team. Further, in the discussion at the UC meeting, it became clear that CASA is increasingly perceived within NRAO as a strategic asset, particularly looking 5–7 years into the future. If so, there is an expectation that performance and user experience would improve.

While the UC was initially skeptical of the value of creating a separate CASA Users Committee, that committee seems to function well. The CASA Users Committee compiled a detailed report with a clear set of user-driven priorities and CASA development recommendations. The UC endorses these priorities and recommendations and looks forward to their implementations.

At this meeting, the UC was pleased to note that there seems to an increasing awareness among the NRAO CASA team that their CASA experience and the experience of the typical user are different and that these differences need to be taken into account when evaluating CASA functionalities and establishing priorities. The UC applauds the development and execution of the CASA user survey and appreciates that this Committee was given a chance to contribute to its content.

The UC recommends that the CASA user survey be studied in detail to evaluate further how the "typical" user experiences CASA capabilities and functionality, and what their priorities are

going forward. The UC further recommends

1. Implement the recommendations laid out by the CASA Users Committee in their report.
2. Continue the ongoing interaction with the users community to facilitate user-driven, need-based CASA development.
3. Carry out a second CASA survey in about one year to evaluate the perceived improvement of the newer CASA versions.

4.2 Archive

A comprehensive and accessible Archive is key to maximize the scientific return of all NRAO facilities. It is also key to maximize the user base, as the Archive is a potential gateway for new users looking to complement data acquired at different wavelengths. The ALMA and NRAO Archives have great promise to become leading astrophysical data resources. Indeed, the combination of rich data sets, often containing plenty of "bonus" spectral lines, and the planned JVLA all-sky survey should make the Archives very attractive for data mining. Because the ALMA Archive is an ESO deliverable, the UC continues to focus recommendations on the NRAO Archive, but looks forward to better integration of the Archives in the future.

The UC recommends that the modernization of the Archive be given high priority—the delays along the way are unfortunate considering the importance of the Archive. The UC requests a status updates at future telecons and face-to-face meetings on the completion of internal testing and the new interface. The increasing data volumes and complexity of data sets from ALMA, Jansky VLA, VLBA, and GBT entails that there is a great need for a more modern archive compared to the one currently employed by NRAO. The UC acknowledges and commends the continuing efforts that have gone into re-designing and building the new NRAO Archive.

Additional specific recommendations are the following.

Look and Feel The UC supports a unified "look and feel" of the NRAO and ALMA Archives, but not at the cost of functionality. In its current implementation, the ALMA Archive is less intuitive (e.g., mismatches between archive listings and download options) and is less powerful in its querying and data download options than the NRAO Archive. It also appears to be more fragile. While it is good to exploit the work that has already gone into the ALMA Archive development, the UC recommends that any import of ALMA interface features is critically evaluated, taking into account existing criticism of the ALMA Archive from the community.

Data Mining Tools The UC commends NRAO's efforts to work with the community to provide efficient data mining tools such as the ADMIT project and recommends continued investment in developing these tools. A set of efficient data mining tools will be a key resource to optimize the science that can be extracted from the Archive, especially from a multi-wavelength/multi-messenger perspective.

Observing Block Design and Data Processing Capabilities The UC continues to support efforts to increase and optimize data processing, transfer, and storage capabilities to avoid any scientifically crippling reduction of data rates or storage in future cycles. This is especially crucial in light of the download statistics shown at the meeting. The UC recommends to provide clearer guidelines (perhaps including "common examples") to successful proposers to maximize the Archival data value. Archival data that can be (re-)processed by the pipeline

will have more general utility, but scientific value and potential for serendipity should not be compromised for processability with current pipeline versions when designing observations.

Data rates The UC recommends that download statistics are taken into account in discussions of acceptable "standard" data rates in the next proposal calls. When issuing recommendations to proposers, care should be taken to not discourage serendipitous line surveys.

Archive Acknowledgment To increase the visibility of (and to obtain a measure of) the NRAO Archive as a tool in the community, the UC recommends to require a brief but specific acknowledgment of the data archive in publications where appropriate.

4.3 Proposal Submission Tool (PST) and Observation Preparation Tool (OPT)

The PST and OPT are a critical component of NRAO's interface to the user community, second in importance only to the Archive for scientific users. The UC has identified a long list of "pain points" in these tools in past reports but also understands that a severe staffing shortage in this area (4 vacancies) has prevented NRAO from addressing these issues to date. As these staff vacancies are filled and work begins on updating the PST and OPT, the UC reminds NRAO of the feedback provided in previous years.

Further, while the PST and OPT both have their flaws, the planned or on-going approach appears to be a complete "refactor" of these tools. The UC is concerned that a complete re-engineering of these important user-facing tools may not result in any improvement in user experience for a considerable duration. At the 2014 UC meeting, it appeared that the decision had already been made to proceed with a complete restructuring. Nonetheless, the UC requests a more clearly articulated and quantitative description of the trade-offs between simply making changes to the current code, a complete rewrite of the code, and immediate changes of the most "painful" aspects of these tools coupled with a lower level re-engineering effort.

A useful vision for the PST and OPT would also be helpful. Ideally, the VLA and ALMA—the two currently most powerful interfometers in the world—would use a common tool. Doing so might also allow MeerKAT, perhaps even the SKA, to adopt a common tool. An analogy to infrared observatories may serve useful: SPOT was a good tool for *Spitzer*, later largely adopted by Herschel and SOFIA. Consequently, users did not have to learn an entirely new tool for these observatories.

Short of a complete re-engineering, two specific improvements could be made to these tools:

- The UC recommends adding a box to the technical justification section in the PST in order to allow proposers to provide a separate technical justification if joint observations with another facility (*Swift*, *HST*, *Chandra*) are proposed. Currently, the technical justification for these facilities must be included in the four pages of the proposal scientific justification.

- Phased array capabilities have been implemented at the VLA, allowing a new range of observations. However, the OPT support for these modes is limited and is non-existent for pulsar phased-array modes. Especially with the reduction in open observing time that is likely to happen at the GBT, some users might begin to request VLA time. NRAO should consider making pulsar phased-array observations user-schedulable as opposed to a black-belt insider-only capability. Given limited resources, this would be a lower priority than general usability issues, but it should not fall off NRAO's to-do list.

Finally, the UC recommends that, if a complete re-engineering of the PST or OPT is to be undertaken, the linkage between the sessions proposed and the sessions scheduled should be made

much stronger and more clear. The topic of proposals and sessions is discussed in more depth later (§5.1), but there is a continuing confusion in the user community (and at times even among NRAO staff!) regarding the distinction between proposals (or projects) and sessions (and resources and sources in a session) and a lack of appreciation for the importance of sessions in the scheduling of the telescopes.

4.4 User Computing

The UC continues to appreciate the guidance offered by NRAO on the selection of workstations, servers, and clusters needed to run CASA. The detailed information provided on the CASA Hardware Recommendations page is a big help to those who are setting up their own system to process VLA or ALMA data with CASA.

For users who do not want to set up their own system or who have only occasional need to process data in CASA, remote access to the computer clusters at the VLA and the NAASC may well be the preferred solution. While this remote access is a useful capability for the user community, the UC has two concerns.

- There appears to be an assumption that users quickly analyze and move their data, which is often not possible for larger efforts, for which data are received over extended periods of time (but need to be imaged together). The UC is aware of instances in which users have been requested to remove data in the midst of a project.

- It is not clear that ALMA users are being made aware of the opportunity for remote computer access. The DMS presentation noted that external use of NRAO computing resources is very popular at the VLA (300 users/year), but much less used at the NAASC (25 users/year). The VLA web page[6] has a lengthy description of how to obtain a temporary computer account, request resources, etc., whereas the ALMA/NAASC web page discusses only the option of traveling to Charlottesville for help with data reduction.

The UC recommends that NRAO anticipate the need to spend significant effort explaining, "How to process your data in the cloud," as well as in identifying potential funding models. Porting CASA to external computing facilities, such as Amazon/AWS and XSEDE, can provide extra computing resources in case the NRAO systems become overburdened. Although the UC considers this approach to be a good strategy, the average user may need some help to start using these cloud computing services. If users are not guided in how to process data in the cloud, this porting of CASA may very well be a wasted effort.

While monitor and control software for ALMA, the VLA, and the GBT seem to be adequately supported, the UC is concerned that the VLBA is being neglected. The DMS presentation noted that the VLBA is running on obsolescent hardware, with old software and limited support.

5 Science Support & Research

5.1 Telescope Time Allocation (TTA)

The UC spent considerable time discussing telescope time allocation and the correlation between Science Review Panel scores and Telescope Allocation Committee scheduling priorities. The UC appreciates the efforts of NRAO staff to provide the UC with data from recent TAC meetings and the ongoing efforts to ensure that the community understands how the NRAO telescopes,

[6] `https://science.nrao.edu/facilities/vla/docs/manuals/computing-resources`

particularly the VLA, are scheduled. The UC specifically notes the clear memorandum on the VLA prioritizer,[7] which is linked from the VLA Call for Proposals.

The UC concludes that there is a desirable trend, with sessions from proposals having a higher SRP scores tending to receive higher scheduling priority. However, there are smaller trends within the data that are counter-intuitive, and subsequent discussions with NRAO staff have not been able to clarify the origin of these trends.

The UC concludes that, overall, there is a desirable trend, with sessions from proposals having higher SRP scores tending to receive higher scheduling priority. However, there are smaller trends within the data that are counter-intuitive, and subsequent discussions with NRAO staff have not been able to clarify the origin of these trends. For instance, at some LSTs, it is possible for sessions associated with proposals having an SRP score of 2 to have a higher probability of receiving an A scheduling priority than sessions associated with proposals having an SRP score of 1. Further, there is concern that more sessions ranked in the top decile of SRP scores should be receiving A priority. The situation at low frequency around LST $1^{\rm h}$ is illustrative, as it should be an LST of relatively lower pressure. Only 83% of sessions associated with proposals in the top decile of SRP scores (SRP score 0–1) were awarded A priority, but a full 44% of sessions associated with lower-ranked second decile propsals (SRP score = 1–2) were given A priority, and 37% of sessions associated with even lower-ranked SRP third decile proposals (SRP score = 2–3) were given A priority.

The UC is concerned that these trends reflect two issues. First, the UC has commented in the past on the confusion that can result among proposers about the connections between *sessions*, *sources*, and *resources* within the PST (§4.3). Several UC members confess that they continue to find the connections between these non-intuitive, and it may result in proposers entering incorrect or excessive LSTs for their sessions. An incorrect or excessive range of LSTs could then be further compounded by the prioritizer's practice of spreading time for a session uniformly between the minimum and maximum LST.

Further, the UC has found in previous reports, and continues to find in this one, that the distinction between *projects* (proposals) and *sessions* can be confusing, with NRAO staff at times conflating the two. Users submit proposals for a science project, often times consisting of multiple sessions. The SRPs grade the overall project, but the TAC considers the individual sessions. Many users continue not to appreciate the connection between sessions proposed (in the PST) and the scheduling priorities decided by the TAC. This confusion may be furthered because the prioritizer software often appears as a "black box." The result is that projects with good SRP scores can nonetheless have C priority sessions.

As a minimal first step, the UC recommends that that similar plots of the fraction of sessions awarded the different priorities as a function of LST be shared with the TAC in real time (Figure 1). The objective should be for the highest ranked science to be scheduled on all of the NRAO telescopes. Plots such as the ones presented to the UC would allow the TAC to take a "global" view of their assignments and help ensure that their choices on individual sessions and proposals result in a overall set of scheduling priorities that reflect this goal.

More generally, this continuing confusion suggests that the underlying concept of how sessions are described and handled needs to be reconsidered. If the PST or OPT is to be restructured or re-engineered, it is an opportune time to revisit the manner in which sessions are described and handled.

Finally, in response to a question from NRAO about the completion rate of B priority projects, the UC discussed whether it is preferable to complete a smaller number of projects or provide a fraction of the requested time for a larger number of projects. The current practice is to favor

[7] `http://www.aoc.nrao.edu/~schedsoc/VLAprioritizerMemo.pdf`

Observing allocation (letter grades A or B) by ranked score vs LST

LST-> / score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	10	21	22	23
0	97	96	96	96	97	96	96	96	96	99	99	99	99	99	98	97	97	96	96	97	97	96	96	97
1	82	82	82	85	84	85	82	81	82	84	84	84	83	82	80	69	70	71	71	73	74	84	88	83
2	75	75	72	73	71	71	71	71	72	70	66	66	64	64	64	63	58	62	64	67	71	73	75	75
3	52	51	46	50	49	46	46	40	38	35	32	29	26	26	28	30	33	35	41	44	47	44	47	49
4	39	39	41	39	38	32	31	27	22	21	20	22	22	23	27	30	32	36	38	40	43	39	41	38
5	15	15	19	20	23	22	22	21	20	17	14	10	9	10	13	14	18	20	20	16	18	16	15	16
6	17	13	14	13	12	13	9	8	6	7	7	10	16	17	15	16	18	18	19	24	22	24	19	15
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A&B All Frequencies

0	98	98	98	97	98	98	95	96	96	97	97	97	97	98	98	98	98	98	98	100	98	98	98	98
1	93	94	93	93	92	92	88	87	87	88	87	84	84	80	79	57	57	59	59	60	62	85	92	92
2	70	70	65	68	63	63	65	66	67	62	58	61	59	58	60	61	55	56	59	60	62	66	67	68
3	42	45	39	39	40	32	33	26	40	33	28	22	20	19	25	28	33	35	38	39	42	36	40	41
4	29	29	39	33	31	29	23	21	16	12	9	13	12	9	14	25	29	35	38	40	34	31	31	25
5	12	12	16	16	18	17	18	16	13	12	11	7	7	6	10	12	18	21	21	16	18	15	10	13
6	17	14	15	13	16	11	8	7	5	1	2	2	6	6	9	12	16	18	19	20	16	17	16	16
7	0	1	1	1	3	2	2	2	2	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A&B High Frequencies

0	97	95	96	95	96	96	97	97	97	100	100	100	100	100	98	96	95	94	94	96	95	95	95	97
1	76	76	75	80	79	82	79	79	79	82	83	84	82	83	80	81	82	82	82	85	86	83	85	78
2	79	78	76	77	75	75	75	74	75	73	69	68	67	66	66	64	61	66	69	73	76	78	80	80
3	58	55	51	56	55	55	52	44	38	35	33	31	27	27	29	30	33	35	43	46	50	48	52	54
4	42	42	41	41	41	34	35	29	24	24	23	24	24	27	30	32	33	36	37	39	47	42	44	42
5	17	17	21	24	27	25	25	25	25	19	16	11	11	13	14	16	18	20	19	16	18	17	18	17
6	17	13	13	12	9	14	10	9	7	9	9	12	18	19	17	17	18	18	20	25	24	27	20	15
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A&B Low Frequencies

Figure 1: Illustration of the percentage of sessions scheduled at A or B priority as a function of the SRP score of the parent proposal and the requested LST. This figure shows largely positive trends (sessions associated with higher ranked proposals have a higher probability of receiving an A or B scheduling priority), but it also shows non-intuitive trends (e.g., for the high frequency panel, near $15^{\rm h}$ LST). The UC recommends that such plots be generated at TAC meetings to ensure that the TAC has an ability to take a "global" view of the overall scheduling priorities.

providing some time to a larger number of projects, with the risk that many projects would not receive the full amount of observing time requested originally. The UC did not reach a clear consensus, in part because the implications of any potential change were unclear. Accordingly, the UC requests that the NRAO provide a quantitative assessment of any potential change. Questions to be addressed could include, but need not be limited to, What is the typical or median fraction of B priority sessions that are currently observed in a configuration? How would the current scheduling practices change if the goal was to ensure that 90% (95%, 98%) of all B priority sessions associated with a project were completed once any observing was started for a given project?

5.2 Science User Support (SUS)

The UC applauds NRAO's commitment to student training and outreach via summer programs, undergraduate technical internships, graduate internships, Reber fellowships, and other activities. Over and over again, UC members encounter graduate students or professional colleagues who

first became hooked on radio astronomy as a result of their undergraduate research experiences at NRAO. These programs are also an effective way to boost diversity by engaging women and underrepresented minorities in radio astronomy.

The UC is pleased to hear that the Observatory will offer an introductory interferometry school in addition to the normal single dish summer school in Green Bank this summer, consistent with a recommendation in the 2014 UC report.

It was also commendable to learn that funding for page charges was reinstated in 2015, and that Student Observing Support will be available for VLA, as well as ALMA, projects in FY16. SOS is one of the most effective tools for supporting student training at universities. At the time of the face-to-face meeting, SOS for the VLBA and GBT were not available, but there has been a subsequent announcement that they have been added. The UC commends NRAO for making SOS available for all North American telescopes, particularly in light of the continuing budgetary challenges.

The UC agrees with NRAO's plan to phase out "functional" post-doctoral scholars, those who are expected to spend 50% of their effort on service tasks like imaging ALMA data. It is difficult to preserve 50% science time for these post-doctoral scholars in the face of the Observatory's workload, demoralizing them and impeding their careers. Data analysts will take over the work formerly done by them. The UC assumes that post-doctoral scholars can still be funded, through NRAO or external grants, to work with NRAO scientists on particular projects. The UC notes, however, that the removal of the "functional" post-doctoral scholars may have the unintended consequence of constricting further the number of available radio astronomy post-doctoral positions in the U.S.

The Observatory proposes to "reboot" the Jansky Fellowship program, by requiring a small service component (20% was mentioned), and by eliminating non-resident fellowships. The UC **unanimously opposes these changes**, for the following reasons:

- The Jansky is the most prestigious fellowship in radio astronomy. Requiring a service component will reduce its attractiveness compared to Hubble, Einstein, Sagan, or other prize fellowships, potentially discouraging talented students from entering the field of radio astronomy.

- While the UC is sympathetic to the argument that non-resident Fellows can become detached from NRAO and its mission, the UC is concerned that a strict residency requirement is likely to drive away talented applicants—for example, those whose spouse might not be able to find a job in Socorro.

- Non-resident Fellows provide a means for building stronger relationships between the NRAO and university communities.

- NRAO has not demonstrated the capability to protect the 50% "science time" for "functional" post-doctoral scholars. There is the risk that any service component for Jansky Fellows would slowly increase, crowding out their science time.

The UC recommends that other measures be taken, such as making sure that an NRAO mentor is assigned to each Fellow or requiring regular visits to an NRAO site.

6 Central Development Laboratory

The UC notes the essential role of CDL in ALMA maintenance and upgrade projects. The UC also understand that CDL is the process of recovering from recent staff and budget upheavals in

this area. The UC encourages NRAO to continue to take steps to ensure CDL's ALMA technical activities continue unabated, since these efforts provide clear science benefits for ALMA users.

A past recommendation from the UC has been that CDL increase interaction with the broader community. The motivation behind this recommendation is that much of the development of future capabilities and instruments is centered in academia, Government labs, and non-US institutions. While some examples of interaction were cited this year, the UC continues to encourage CDL to develop comprehensive collaborations to whatever extent possible in order to ensure that NRAO has the opportunity to be fully-engaged as nascent projects originating outside NRAO mature into future user capabilities and instruments.

The UC congratulates CDL on its successful program of technology transfer. While the impact for the user community is not clear, it is assumed that patents and licensing arrangements are useful side-products of CDL's research and not a primary emphasis.

The UC has two recommendations for future briefings. First, the relationship between technical activities at CDL and those of the Socorro and Green Bank operations should be addressed. From the perspective of instrument maintenance/upgrades and capabilities ultimately provided to users, what is the division of responsibilities and to what extent do these groups collaborate? Second, the UC is intrigued by Slide 16 of the CDL presentation (among the backup slides): It would be useful to be apprised in greater detail of current vs. projected allocations of resources to projects, including nascent instrument development projects. The specific goal is to understand the strategy that CDL has for maintaining excellence over the next decade.

7 NRAO Future Initiatives

7.1 VLA Sky Survey (VLASS)

Since the last UC meeting, a proposal for the VLASS was submitted for NRAO (internal) review and a Community Review. In its 2014 report, the UC stressed the VLASS not be treated as a *fait accompli*, but that it undergo a critical review. The UC finds that the level of community engagement and review addresses this Committee's initial concerns. In particular, the Community Review recommended that only the first two epochs of the VLASS proceed initially, with a third epoch subject to demonstration of sufficient progress.

The UC also appreciates NRAO's concern about the effect of the VLASS on the amount of time for PI-led projects during the B configuration. In §3.3, the UC supports the removal of the hybrid configurations, which will help minimize the effects of the VLASS observations. However, the UC is also concerned that executing the VLASS may further stress NRAO resources and staff.

7.2 Spectrum Management

The UC appreciated the update on the status of current and proposed uses radio spectrum and NRAO's continuing efforts to ensure that the radio astronomy service can continue to use the spectrum. These efforts must be continual as the situation is dynamic, with both positive and negative developments in the past year. Last year, there was an initial discussion about potentially new approaches to spectrum management. There was relatively less discussion on this topic this year, but any new approach is likely to require some time to implement and the UC looks forward to continuing this discussion with NRAO, should new approaches be warranted.

7.3 Open Skies

Last year, the Director introduced the concept that NRAO might move away from, or be requested to move away from, its traditional stance of Open Skies. This principle is that proposals are evaluated solely on the basis of scientific merit, without regard to the affiliation of the PI or the proposal team.

The UC re-iterates in the strongest possible terms its position that Open Skies maximizes the scientific productivity of NRAO telescopes. The Universe does not care about political boundaries, and the skies should belong to all.

Nonetheless, the UC is cognizant that the access policies being adopted by several new and planned observatories (e.g., ALMA, LOFAR, IRAM, SKA) imply that NRAO's Open Skies policy may no longer best serve the U.S. radio astronomy community as a whole, as it leaves NRAO with limited options to negotiate better U.S. access to facilities that do not adopt it. This unfortunate political reality therefore mandates NRAO to reconsider its long-held and visionary policy. Should NRAO move away from Open Skies, it must communicate any proposed changes in a clear, open and timely fashion, well ahead of the implementation of any changes.

7.4 Future Telescopes

The UC listened with interest to the planning activities that are underway in preparation for the next Decadal Survey. Continuing along the path prepared for the 2010 survey, the priority for NRAO is a next-generation VLA (ngVLA) with approximately 10 times the collecting area and resolution of the VLA, and operating up to 3 mm. Science groups were convened over the last year and tasked with identifying science to be done with the array, and the results were presented to the astronomical community at the January AAS meeting, as a first step toward building the support needed to achieve a high priority in the 2020 Decadal Survey. The UC applauds NRAO's proactive stance at setting the goal to build a uniquely powerful new facility that will be at the world-wide technical forefront of radio astronomy.

The UC encourages NRAO to strive for broad and open community engagement on this topic and to follow the science in fully defining the concepts. NRAO has chosen a particular path (ngVLA) early on, an interesting concept that wisely amalgamates centimeter- and millimeter-wavelength interests, but which needs to be sharpened and gain broad community support well beyond the traditional radio astronomy user base to succeed (thus avoiding the fate of the North America Array, which it resembles). It is crucial to demonstrate that the ngVLA provides the best path forward within the national (and international) science priorities, to confront the skeptical critique that this concept mainly represents an approach set by the interests of the centimeter- and millimeter-wavelength interferometry groups that naturally dominate NRAO at present.

The role of NRAO in an open community-wide discussion should be to prompt, enable, organize, and listen. The 2015 December futures meeting[8] is a good step in this direction, though it is not clear whether this meeting is intended to explore the accessible frontiers of radio science or to solidify the ngVLA concept. The UC encourages NRAO to pay attention now to the key issue of establishing the best mechanisms for involving the community and gaining wide acceptance.

A related concern is that the US radio (m/cm/mm/sub-mm) instrumentation community is dwindling outside of NRAO due to limited funding opportunities and the demise of several university-based facilities, and the user community may also be shrinking (or not renewing itself through student involvement). Accordingly, the Director expressed a desire to partner with universities in developing the necessary technology for the "next-big-thing," to maintain community

[8] `https://science.nrao.edu/science/meetings/2015/2020futures`

strength and interest, and the UC strongly endorses that approach.

If NRAO is going to expend significant resources in technology development activities over the next several years with an eye toward 2020, it is the UC's view that NRAO needs to connect those efforts and expenditures to community-identified science goals by partnering with university groups for pathfinder and demonstration instruments in an open and inclusive manner, as well as also partnering with universities to diffuse radio astronomy expertise through the wide astronomical community.

A concern of the UC is that the "work for others" fee-for-service model that is presently employed does not really engage the community or diffuse knowledge beyond NRAO, nor will NRAO benefit the community or science in the near term by hiring engineers to develop technologies without connections to current astrophysical problems. The U.S. community outside NRAO needs to be incorporated early-on in an open manner, and have a strong role in defining, developing, and testing the concepts that will enable the next big development(s).

The UC is excited about the future prospects for NRAO and stands ready to aid in devising the best way to proceed in these discussions. While the ngVLA was discussed, the Director also requested input on the SKA.[9] The UC did not have significant discussions comparing the ngVLA with the SKA.

8 Science Communications and Education & Public Outreach

The UC recommends that NRAO continue its efforts to organize symposia and events at major meetings. The UC is pleased to see a sustained and high profile presence of NRAO in the astronomy community by its activities at the AAS, AAAS, IAU, and similar meetings.

NRAO runs an active and very impressive EPO effort, in breadth, depth, and enthusiasm. A substantial portion of this effort is run from the Green Bank site, and the UC commends the EPO team for maintaining such a high standard in the shadow of the Green Bank divesture. The UC especially commends the EPO team for its efforts to reach out to under-represented and marginalized groups. The UC encourages NRAO to continue to prioritize EPO efforts, and to consider EPO as an integral aspect when new projects are developed. The UC expects that the EPO team will continue to explore new avenues and, where needed, break new ground to reach audiences that may otherwise not be exposed to astronomy research. The UC appreciates that with the current staff it is not possible to develop all digital learning products that are desired. From the UC perspective, the UC continues to recommend prioritizing the development of a "what the telescope is seeing now" Web presence (and possibly an app).

The past year has resulted in a large number (46) press releases of exciting science, essentially 1 per week. The UC recognizes the high quality and impact of this work, especially when considering the small number of communication and EPO staff at NRAO compared to institutions, e.g., ESO and NASA. The UC is somewhat concerned that not all PIs seem to be aware of this resource at the NRAO and encourages the EPO team to be pro-active in contacting PIs with potentially exciting science results (e.g., based on accepted proposal abstracts).

[9] "How important/interesting is SKA to the US community?"

Appendix A 2015 Green Bank Meeting Participants

Joseph Lazio (*Chair*)	JPL/CIT
Laura Chomiuk (*Co-Chair*)	Michigan State Univ.
Loren D. Anderson	West Virginia Univ.
Alberto Bolatto (ANASAC/ASAC)	Univ. Maryland
John Carpenter (ANASAC/ASAC)	Caltech
Shami Chatterjee	Cornell Univ.
Sheperd Doeleman (ANASAC)	MIT/Haystack Obs.
Steven W. Ellingson	Virginia Tech
Rachel Friesen	Univ. Toronto
Shih-Ping Lai (ANASAC)	National Tsing-Hua Univ.
Dan Marrone (ANASAC)	Univ. Arizona; Steward Obs.
Karin Öberg (ANASAC)	Harvard-Smithsonian Center for Astrophysics
Rachel Osten (ANASAC/ASAC)	Space Telescope Science Institute
Dick Plambeck (ANASAC/ASAC)	Univ. California, Berkeley
Dominik Riechers	Cornell Univ.
Douglas Scott (ANASAC/ASAC)	Univ. British Columbia