NRAO Users Committee Report

July 5, 2013

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1 Executive Summary

The NRAO Users Committee (UC) met on May 1-2, 2013 at the NRAO Headquarters in Charlottesville to discuss the current scientific, technical, operational and development status of the observatory. The Committee appreciates the hospitality of the NRAO team and their efforts in preparing presentations and the resulting discussions. The observatory is at the frontier of radio astronomy and will be for the foreseeable future. In this difficult budgetary time the observatory continues to provide a great service to the community and does an excellent job in operating world-class facilities. This report provides a summary of our discussions and includes some specific recommendations and concerns.

The UC acknowledges a very difficult situation resulting from the declining budget and understands that significant cuts are unavoidable. While it is obviously beyond the purview of this committee to define where such cuts should be made, we have tried to highlight those areas that we feel are essential to the continued and successful scientific support expected for a world class observatory in an effort to help inform some of the difficult choices that need to be made in the coming months.

We include here a summary of the key points related in this report, not necessarily ordered by priority:

- ALMA construction continues apace and results from Cycle 0 have been spectacular. However, the UC expresses concern regarding the schedule slippage for Cycle 1 and hopes to hear an updated status on associated technical issues, as well as an update on the high frequency performance of the Vertex antennas, at the 6 month telecon.

- Archival data represents a crucial resource towards the maximal scientific return from all NRAO facilities. The UC commends efforts to begin an update of the NRAO Archive, both to make it more modern and to take advantage of code developed for the ALMA archives. The UC recommends a unified approach to this update, resulting in a similar user experience when accessing the ALMA archive as other NRAO facilities. Throttling data rates for ALMA and the VLA will have particularly significant impact on the future science return from the archive and, if essential, should be approached in a fashion tailored to minimize this impact.

- The UC congratulates NRAO for the delivery of an excellent new facility in the Jansky VLA, both on time and under budget, and urges the NRAO to complete commissioning of remaining capabilities (e.g. low frequency systems, OTF mapping) in a timely fashion to allow its full capabilities to be exploited.

- It is clear that staff morale has suffered during this period of budgetary contraction and staff reduction. Key to maintaining staff morale is ensuring that sufficient time and resources are available to scientific staff to make use of the facilities that they have helped develop, construct and maintain. The UC recommends that devoted time for independent research by NRAO staff, often making use of the facilities they have helped build and operate, remains a high priority.

- The UC strongly supports the NRAO efforts to seek partners for GBT and VLBA. This activity should be one of NRAO's highest priorities. Both instruments provide unique

capabilities to the community and partnerships may be the only option for keeping them operational. The UC encourages NRAO to coordinate meetings of potential supporters.

- The UC is impressed and very appreciative of the work that the Green Bank director and staff have done to keep the facility operating at a high level despite severe budgetary and personnel pressures. The UC recommends to actively publicize the new capabilities and science discoveries with GBT and its connection to high rated facilities. In particular the highest profile science involves searching for and timing radio pulsars. The GBT is one of the foundational telescopes for the North American Nanohertz Observatory for Gravitational Waves, and its loss would impede, if not entirely cripple, U.S. participation in gravitational wave studies via pulsar timing.

- The motivation for a CASA Users Committee (CUC) and its relationship to the CASA Scientific Steering Committee (CSSC) was not presented clearly. An assessment of the need for such a committee vis-á-vis duplication of effort and efficient use of time, with a clear set of goals or charge should be developed before populating such a committee. The direct involvement of a representative member of the NRAO Users Committee and the ALMA Science Advisory Committee in the CSSC may be a simpler and more expeditious means to achieve the same goals.

- The UC commends the NRAO's efforts to offer pipelined data to the community and feedback to date suggests this pipeline is performing well. Ensuring that the pipeline can deliver calibrated data for all standard observing modes is deemed higher priority by the UC than, for example, developing the capability to offer final science-ready image data products in the near future. Similarly, while the UC highly appreciates efforts in development of data analysis software, the high level data analysis tools not directly related to the calibration of data products and pipeline processing should have a lower priority at this time.

- The UC highly values the investment in future generations of radio astronomers and prioritizes programs supporting Jansky Fellows, pre-docs, Summer Schools and Data Reduction workshops.

- The Resident Shared Risk Observing (RSRO) program offers an excellent means for the NRAO to leverage expertise from the community while simultaneously developing an experienced user base. The UC welcomes the reduced restrictions on RSRO residency and the program should be continued/expanded where possible.

- The UC strongly supports continuing efforts in increasing the STEM programs and ensuring that they reach diverse student population.

- The UC recognizes the importance of the CDL's programs and technology transfers, and strongly supports the focused CDL's activities based on established priorities. The UC endorses the engagement of this office with programs such as the NSF SBIR program. However, it is unlikely that there will be major US investment in SKA in the near term and this should be factored into future planning of CDL's program.

- The committee applauds efforts by CDL to reach out the community and has suggested some possible mechanisms to enhance this outreach. This includes using local seminar series to bring in speakers whose interests may benefit from access to CDL expertise, holding workshops, if resources permit, to ignite community development of new projects and "going on the road" perhaps by contributing to booths at scientific or technical conferences.

2 Facilities

2.1 ALMA

2.1.1 ALMA Construction:

Progress on ALMA construction and commissioning over the past year continues to be impressive. Major construction achievements include 55 antennas at the high site, acceptance of the full ALMA correlator, and delivery of the 27 NA frontends. Major milestones for the user community have been the delivery of spectacular Cycle 0 science data, the conference highlighting first science results from ALMA, access to SV data leading to publications, and the March 2013 ALMA inauguration. The response to the Cycle 1 Call for Proposal has been even more overwhelming than for Cycle 0, underlining the transformational potential of ALMA and the broad awareness in the community. The efforts of the NRAO and JAO staffs in the continued progress and near-completion of the full ALMA and the Cycle 0 data processing are greatly appreciated by the community.

Despite these successes, challenges to the completion of NA ALMA construction and ALMA operations remain. The slow start of Cycle 1 science observations and the delay of the Cycle 2 Call for Proposals are reminders of the difficulty of realizing reliable and efficient operations during ongoing construction, with attendant hardware and software problems.

- The thermal deformation in the Vertex antennas is troubling as it limits the high frequency performance. The UC looks forward to hearing results of the analysis and mitigation of these deformations at the 6 month telecon.

- Rising cost of fuel has a significant, non-deterministic impact on the budget that is not readily mitigated.

- The high data rates arising with future ALMA observations have the potential to challenge the current ALMA archive infrastructure. The legacy potential of ALMA observations is generally high because of e.g. serendipitous line surveys and unexpected molecular observations (many lines of sight are expected to present high line densities in all ALMA bands), which will rarely be fully exploited by the PI. In fact, the exceptionally high demand for ALMA data has already been demonstrated by the the large number of publications using ALMA SV data, and a complete archive will be key to attract potential new users and maximize the scientific output from ALMA.

  The UC strongly supports efforts to increase data transfer and storage capabilities to avoid any strangling of data rates or storage in future cycles.

- The UC encourages methods that can boost morale without compromising the NA ALMA mission. In particular, the UC recommends that the individual science time becomes better protected for science staff.

2.1.2 NAASC

The UC welcomes and endorses Phil Jewell as the NAASC Director. His experiences in telescope operations in Tuscon and Green Bank, as Deputy NRAO Director, and his long term involvement in ALMA will enable the NAASC to navigate through the challenging years of early operations. We are pleased to see the filling-out of the NAASC scientific and technical support staff as well as the development of the JAO staff. Both are key components to the success of ALMA in North America. We are pleased to see that the NAASC had already several visitors who were very satisfied with the support provided but also surprised by the limited number of PIs who took advantage of this opportunity. We suggest more announcements of this opportunity be made to the PIs and recommend close monitoring of the process in the coming months as Cycle 1 data is being delivered. The UC is interested to hear about the impact of the webinars and the "remote office hours" to address questions from users and the feedback from users.

The balance of effort at the NAASC between supporting existing PIs and attracting new users is recognized as a critical issue given the available resources. Given the continuing commissioning efforts and high oversubscription rate, ALMA is not yet in a stable operations phase where support of PIs of existing projects is routine. Yet, it is imperative that scientific value be realized in refereed papers, press releases, and conference presentations. If the bottleneck in generating such results is the processing of raw data into a scientific product, then the knowledge base of NAASC must play a role in this step with the emphasis on the calibration steps rather than final imaging. Given the pressures on the staff with current funding issues, it is not evident that the NAASC can take on a *major* effort in attracting and supporting new users. ALMA is a very complex system. The non-radio/mm researchers with innovative applications for ALMA should be encouraged to submit proposals but are also better served by collaborating with an expert. Without such collaborators, such non-radio users will require a significant amount of resources to adequately inform and train. Therefore we suggest to keep the current balance in which support is given to existing PIs for at least another year, especially since one of the most efficient ways to generate new users is to produce fantastic science early on.

Another, comparatively inexpensive route to increase the number of new users may be through making the archives a go-to resource for the astronomy community. In addition to developments of structure and interface, the archives would be a more efficient gateway for new users if it also contained images. These do not necessarily need to be science-ready, and, during commissioning, finishing the calibration pipeline definitely takes precedence over developing an imaging pipeline. Long-term it is, however, important to ensure that ALMA becomes an asset to the astronomy community as a whole and is not perceived as only serving a small sub-community and this will be much easier if the first encounter of a new user with ALMA is in the form of an image or spectral-image cube rather than a visibility data set. The UC also encourages the development of observing templates for future ALMA cycles based on common observing goals, e.g. CO + continuum, to facilitate proposal preparations

for beginners.

To avoid random delays in accessibility to the data and to allow the PI to assess the utility of data flagged as "poor", the UC suggests that raw data be distributed into the ALMA archive immediately for the PI to access. Pipeline-processed products/QA2 can be delivered as an additional component whenever they become available at a later time. This would also leverage more "experienced" users in the community to identify problems and reduce the stress of the staff to shorten the timescale of QA2.

2.1.3 ALMA Development Activities:

The UC endorses continued ALMA development that may enable more capabilities and higher scientific efficiencies. The selected development projects and smaller development studies are appropriate.

- The UC is concerned about potential issues for ALMA operations, mainly the high frequency performance of the Vertex antennas and the operations costs (fuel), and would like to hear an up-date at the 6 month telecon.
- As all ALMA observations are bound to result in rich datasets, high data rates ensuring that this information can indeed be obtained and a good archive seem to be key to attract new users and mitigate the potential frustration arising from the high over-subscription rate. The UC would like to hear an update on the plans for the archive and future data rates at the 6 month telecon.
- Given that ALMA is not yet in a stable operations phase the UC recommends to keep the current balance in giving support to existing PIs for at least another year, as attracting and supporting new users will be a major effort.
- The UC recommends integrated efforts and improved coordination between NA, EU and Japan on ALMA development activities via for example the ALMA wide workshop partnership.

2.2 JVLA

2.2.1 VLA Construction

The UC congratulates NRAO for the delivery of an excellent new facility in the Jansky VLA. Bringing EVLA construction to a close on time and under budget signals the culmination of a very commendable effort by NRAO staff and management. With construction completed, focus has firmly shifted to full science operations while completing commissioning in parallel. Key capabilities yet to be fully commissioned include the P band and 4-band systems, complex correlator recirculation set-ups, short dump times, high data rates, On-the-fly (OTF) interferometric mosaicing, phased array and pulsar modes, sub-arrays and aspects of the 3-bit sampler system. The committee urges the NRAO to ensure that these capabilities are commissioned in a timely fashion to allow the full capabilities of the Jansky VLA to be exploited.

To this end, we are happy to see that the NRAO is continuing the very successful Resident Shared Risk Observing (RSRO) program. The RSRO program offers an excellent means for the NRAO to leverage expertise from the community towards commissioning the Jansky VLA, while simultaneously building expertise among users of the instrument. The UC considers the lessening of certain restrictions, eg. the minimum duration of a RSRO visit, to be worthwhile. The current RSRO page for the VLA [`https://science.nrao.edu/facilities/vla/early-science/rsro`] should be updated to reflect the program's continuation past January 2013 to ensure the community is aware of the opportunity.

The 3-bit sampler system remains a point of concern for the committee. The 8 bit samplers are more sensitive, but the wider bandwidth offered through use of the 3-bit samplers allows a deeper continuum sensitivity over the entire band, particularly at K band and higher. However, the benefit of using the 3-bit samplers at C, X and even Ku band is less clear cut, being largely dependent on the resulting impact of additional overheads in scheduling blocks (eg. requantizer scans) and of RFI. The latter is particularly worrisome and remains largely unquantified, with the potential to saturate the limited range of the 3-bit samplers, eg. when geostationary satellites are close to the primary beam. It is clear that the NRAO are aware of the problem (cf. Memo 166) and are restricting use of the 3-bit samplers at Ku band and below to shared risk programs. However, the committee would like to see a clearly defined delineation of the costs/benefits of the use of 3-bit samplers at low bands, with quantitative data on the impact of RFI as a function of frequency and array configuration with data on possible zones of avoidance etc. In many ways, this would be a natural progression from EVLA Memo 166, albeit requiring much additional effort; perhaps the latter might be offered as part of the RSRO program. The result should be a comprehensive and transparent guide on whether and when the 3-bit samplers should be used for standard continuum observing at low bands.

The committee is relieved to see the outstanding issue of the Antenna Control Unit (ACUs) coming to resolution, bringing redundancy to all critical elements of antenna operation. Similarly, we also commend the redirection of the remaining funds in the EVLA construction budget towards outstanding infrastructure and maintenance needs. We hope these conservative actions allow smooth operations of the facility for the foreseeable future.

2.2.2 VLA Operation and Development

The Jansky VLA is an incredible new facility that is working well and producing groundbreaking results. The community is excited about the upgraded array capabilities and the calibration pipeline. The separation of proposal deadlines from Scheduling Block preparation is very helpful to users and telescope operations and development.

The EVLA calibration pipeline is a very positive first step and of great value to both novice and experienced users. We support the current pipeline limitation to calibration and flagging. Although imaging Stokes I continuum is not a hardship for some observing modes, it may be quite demanding for spectral line, polarization, or wide-field/broad-band continuum modes. We also support the 80-20 approach to the pipeline: modes that require extensive pipeline development but are seldom used should not be a priority. The option to run (and modify) pipeline scripts at home institutions is essential for community contribution to the pipeline development.

We are concerned about the data rate in terms of delivery and archiving, the computational resources required to reduce data, and the strain on support staff. In the short term, the EVLA upgrade may be too much of a good thing; the NRAO may need to consider data rate as part of proposal evaluation until computing, transfer, and storage infrastructure catch up to the data rate. The UC recommends that proposers should not be penalized in the time allocation process for proposing a program with high data rates— but they should have to carefully justify why such rates are necessary. Such a justification might be added as an explicit section in VLA proposals.

The Committee has some concern about new capabilities using resources of an already strained staff. Externally-motivated development projects may need to bring significant resources to the observatory in order to be considered because they can have a negative impact on continuing commissioning and routine operations.

Amongst the UC, there was modest interest in re-establishing the Pie Town link, but given the great expense and possible redundancy with new e-MERLIN capabilities, we believe linking the Pie Town dish to the VLA need not be an immediate priority.

The UC heard of tentative plans for a new VLA sky survey to inaugurate the upgraded facility and provide a valuable archive to users. In light of both the NVSS and FIRST, we recognize the potential science return of such a survey, but stress that any such project should be peer-reviewed and community-supported, as it is important to weigh the time required against the opportunity cost to regular science activities. If such a project goes forward, it would be useful to have an NRAO staff member actively involved.

The UC believes a strategy for dealing with commensal observing on the VLA needs to be developed and defined. There have already arisen examples when distinct scientific teams might simultaneously make use of the VLA for very different science goals by taking full advantage of correlator resources. It is unclear how to proceed in these cases, especially as such commensal observing is likely to maximize the data rate coming from the VLA. NRAO should make specific recommendations in this situation. The UC requests a review of some trade-off options for the policy at the 6-month telecon.

The UC would like to reiterate that we strongly discourage penalizing programs which require high data rates during the time allocation process, as long as the high data rates are justified. The UC also believes that NRAO should encourage distinct science teams to work together early in the process of proposing for commensal observing in order to maximize communication and collaboration.

2.3 VLBA Operation and Development

The VLBA is under threat, despite its unique capabilities and its ability to address the science frontier discovery area of special astrometry identified in the *New Worlds, New Horizons* Decadal Survey. We support the NRAO effort to identify partners in order to keep some portion of the observing time public, peer-reviewed, and competitive, as was done in response to the earlier Senior Review recommendation. The VLBA is a world-class unique facility on the cusp of remarkable scientific progress in multiple fields of study, and it would be a genuine loss to U.S. competitiveness and leadership to entirely remove the VLBA from the Nation's telescope portfolio.

The Committee is concerned about the separation of VLBA operations from VLA operations in light of the exclusion of the VLBA from the management re-competition and the NSF divestment order. From a user perspective, we are concerned about the loss of overlapping expertise and science support between the VLA and VLBA.

The new VLBA observing modes and capabilities are a positive improvement, multiplying the steel in place for a small investment. Commissioning of the VLBA+Y27 and VLBA+Y27+GBT arrays is important and laudable, although there have been some unfortunate technical and compatibility problems with both Y27 and the GBT. It is important to address the simultaneous availability of masers at all sites and to stabilize operations generally.

The UC notes that emerging new VLBI sites could add considerably to High Sensitivity Array (HSA) capability at shorter wavelengths ($\leq$ 7mm). At ALMA, there is an ongoing project to enable VLBI operations that should be available in Band 3 (3mm) by 2015, and the Large Millimeter Telescope (LMT) in Mexico is working towards VLBI capability by late 2013 in the 3mm band. These efforts have been undertaken largely through resources assembled by University based groups and represent a large potential gain for the VLBA, which is geographically positioned to optimally leverage the new sites.

We suggest highlighting the opportunity for short scheduling blocks at the VLBA in the next call for proposals; there are many observations that could be done with shorter blocks or fewer than 10 antennas, particularly in the angular resolution niche of a few to 10's of milliarcseconds.

2.4 GBT Operations and Development

The UC is impressed and very appreciative of the work that the Green Bank director and staff have done to keep the facility operating at a high level despite severe budgetary and personnel pressures. The science coming out of the facility has always been at a high level. With new capabilities, we are seeing new discoveries and results. It is unfortunate that the full capabilities of the GBT had not been realized five years ago. If they had, this important and unique asset of US astronomy might have been more appreciated by the astronomical community as a whole and done better in the NSF Portfolio Review. The UC recognizes that the current director of Green Bank and NRAO are working very hard to recover lost ground from the last decade.

We note that although these activities were not emphasized in the presentations to the UC, the highest profile science currently being done at the GBT involves searching for and timing radio pulsars. Individual discoveries such as a two-solar mass neutron stars have great scientific impact, and the discovery of new pulsars by high school students has enormous value from a STEM education / public outreach point of view. Gravitational wave astronomy was identified as one of five science frontier discovery areas in the *New Worlds, New Horizons* Decadal Survey, and timing an array of pulsars was noted as an approach for probing longer wavelength gravitational waves, in unfortunate but clear contradiction to the Portfolio Review. The GBT is one of the foundational telescopes for the North American Nanohertz Observatory for Gravitational Waves, and its loss would impede, if not entirely cripple, U.S. participation in gravitational wave studies via pulsar timing.

Despite the shadow of the Portfolio Review, the GBT has successfully commissioned

the 4 mm receiver and the VEGAS spectrometer. By the fall of 2013 both will be generally available for observations. The UC encourages NRAO to publicize these and all of the Green Bank capabilities to the community. This may take some work, but identifying potential users with the help of current users might be a good first step.

Four exciting new instrument initiatives were presented (ARGUS, MUSTANG1.5, FLAG, and an 800 MHz array). The science goals of these instruments are diverse, but, if they are all commissioned successfully, the result would be a telescope with a formidable mapping speed over a range of frequencies. None of these projects would have been remotely possible without the strong support of the Green Bank staff, and, more broadly, all of these projects represent on-going partnerships between NRAO and the university community. This model is likely to become increasingly important, for both sides, in the forthcoming years. Nonetheless, with the recommendations of the Portfolio Review Committee now to consider, the UC is concerned that substantial efforts, from both the university partners and NRAO, will be wasted unless there is some means by which these instruments can be fielded and conduct some science program (even if perhaps slightly scaled back from an original goal). In the absence of any detailed information about how the Portfolio Review Committee recommendations might be implemented or future operational models for the GBT, the UC recommends that NRAO engage with all of the university partners in these instruments. The goal of such a discussion should be to assess the level of operational support that the university partners could provide, on the assumption that even modest operational support is superior to none. Priorities for continuing support of development activities for these instruments could then be judged according to whether a university partner was willing to provide operational support or not.

Over the next two years, MUSTANG1.5 and ARGUS will come on line. Both instruments will take full advantage of the GBT's highest frequency operations, enormous collecting area, and high resolution. Without aggressive investment and support from NRAO and the Green Bank staff, these types of University-based cooperative instruments could not exist. The UC encourages NRAO to take these instruments as far as they can to make the most of them despite the looming implications of the Portfolio Review.

The Green Bank director asked the UC to comment on the phasing in of new instruments. The integration and commissioning of instruments is recognized by the community as a necessary part of the facility growth. The director should work with the instrument teams to determine a reasonable schedule for commissioning and shared risk observing that can be offered to the community with a single semester as a goal. However, scheduling and calls for proposals warrant a pragmatic approach when working with the community. A reasonable plan might be to state clearly in the call that the coming semester is the first non-shared risk observing being offered. With this in mind, availability and performance specifications are estimates. The community will need to remain flexible.

Green Bank has taken heavy staffing losses over the past five years. While it is remarkable that they have maintained the operations at such a high level, it is also clear that more cuts will do an equally remarkable level of damage to their capability to serve the community. The UC strongly encourages NRAO to support Green Bank at its current level without further cuts at least for the next two years. Furthermore, the UC is encouraged by the positive influence of postdoctoral researchers at the facility. NRAO should continue to encourage postdoctoral researchers to be resident at Green Bank so as to maintain, and to the extent

possible expand, their numbers.

The main challenge over the next year will be to identify partners to help support the GBT. NSF has indicated that they would like to see a plan forming by the fall of 2013. The implication was that they wanted to see the willingness of key members and institutions to partially support operations. Full commitments and MOUs might take longer, but a statement is needed soon. With this in mind, the UC encourages NRAO to coordinate a meeting of potential supporters at an institution such as WVU. In the meantime, the UC would like NRAO to assist in compiling a short list of "power users" who could be contacted by UC members.

3 Data Management & Software

The Data Management & Software Department has the primary responsibility of user-facing software, for all NRAO telescopes, including the NRAO contributions to the North American share of ALMA, with shared responsibility for system software. This department is newly formed (as of 2012 October), thus any efficiencies or improvements from the user perspective have not had an opportunity to appear and be evaluated. The UC is, however, aware of previous efforts (e.g., "end-to-end"). Given the likely continued stress on the NRAO budget, it is imperative that this most recent effort be productive, maintaining or even improving the users' abilities to access and analyze data from NRAO telescopes. We begin with a series of recommendations, presented in an approximate priority order, followed by additional discussion of issues raised during the UC meeting, in approximately the order in which they were presented at that meeting.

- The motivation for a CASA Users Committee (CUC) and its relationship to the CASA Scientific Steering Committee (CSSC) was not presented clearly. An assessment of the need for such a committee vis-á-vis duplication of effort and efficient use of time, with a clear set of goals or charge should be developed before populating such a committee. The direct involvement of a representative member of the NRAO Users Committee and the ALMA Science Advisory Committee in the CSSC may be a simpler and more expeditious means to achieve the same goals.

- To the extent possible, the archives for ALMA and the VLA, VLBA, and GBT should appear seamlessly integrated, even if implemented in different physical systems or architectures. At minimum, the NRAO Archive and the (North American) ALMA Archive should have the same "look-and-feel" and consideration should be given to making selection parameters represent the desired scientific needs as an alternative to technical implementation (e.g., selection by desired angular resolution or by array configuration). Re-use of the maximum amount of the ALMA Archive code base would seem most efficient.

- To the extent possible, the ALMA and VLA data reduction pipelines should have the same "look-and-feel". The on-going effort to identify commonalities between reduction pipelines is both heartening and encouraged.

- Direct access to an NRAO cluster for experienced users while maintaining an approach that allows novice or intermediate-level users to make slight changes to a standard

pipeline and acquire a modified data set will be required as data rates continue to increase.

- The NRAO commitment to allow users to discover data (other images, catalogs) through the VO directly within the CASA Viewer and to provide VO access to pipeline image products in the Archive is welcomed and encouraged. For now, NRAO could usefully limit any additional VO activities to ensuring that CASA and the VAO Python toolkit can inter-operate.

3.1 Specific Topics

3.1.1 CASA

The CASA software suite was recently comprehensively reviewed, and UC largely agrees with the review recommendations. We note that a primary focus on EVLA and ALMA data reduction seems inevitable, as dictated by funding, but approve of the plan to propose development of a full VLA data reduction suite to the ALMA development fund, and to explore other fallback options if needed. As long as CASA lacks complete coverage of interferometric data reduction capabilities (eg. fringe fitting), there will be a continued need for the maintenance of AIPS and thus the duplication of software development efforts.

Further, the committee approved of actions taken to address concerns previously raised regarding the premature release of major CASA versions. More stringent testing of monthly releases of "stable" versions of CASA should lead to more fully developed major releases on 6 month cycles and preclude long-standing unpatched issues. The decision to update documentation together with monthly stable releases is also worthwhile, although versioning of documentation should be specific and prominent, e.g., the described calibration recipe has been tested with the current release, especially given that CASA guides will remain on a 6 month cycle.

The usage of CASA by outside groups (e.g., MWA, LWA, or LOFAR) tests various assumptions in the code and has the potential to expose significant issues before they affect EVLA and ALMA users. As such, the committee felt that NRAO should continue to devote some small fraction of time (as resources permit) to supporting non-NRAO/non-ALMA users of CASA. Enhanced usage of the CASA forum should be encouraged: for example, the automated acknowledgment email to every Helpdesk query could include a pointer to the forum (*Did you try looking for similar issues here?*) and every resolved Helpdesk query thread could be posted to the forum so that it is archived and searchable.

One specific concern of the committee was the need for a CASA Users Committee. A specific recommendation for a separate CASA Users Committee was not presented as part of the summary of the CASA review, and its membership would appear to be somewhat duplicative of existing committees (e.g., this committee, ALMA ASAC). Further, given constrained budgets, alternate models for obtaining more rapid feedback should be explored, rather than a face-to-face meeting.

The Users Committee was also interested in the statistics of CASA uptake and usage within NRAO ("dogfooding"), possibly via an informal survey. What missing capabilities (besides inertia) are holding CASA back from universal adoption within NRAO?

3.1.2 NRAO Archive

Given the multi-decade lifetime of NRAO telescopes, the NRAO Archive represents a source of rich scientific value for the community. The NRAO Archive is also a common gateway for the wider astronomy community (*Does my newly discovered object have a radio counterpart?*). Finally, with a likely change in the operational model of both the GBT and the VLBA, the archives may become potentially the only means of access to data from these telescopes for members of the community. For these reasons, we commend the effort to begin an update of the NRAO Archive for NRAO telescopes, both to make it more modern and to take advantage of code developed for the ALMA archives. From a user perspective, several design aspects should be considered. First and foremost, there are likely to be many scientific questions that can be addressed only by a combination of both ALMA and other NRAO telescopes (most likely the VLA, but also notably the GBT). For that reason, making the (North American) ALMA and NRAO Archives appear to be seamlessly integrated will likely ease users' abilities to access data, and potentially benefit NRAO by enabling savings in code re-use and increase usage of its data.

With the goal of making ALMA, and NRAO telescopes in general, more accessible to the larger astronomical community, the Archive should enable searching for data with a focus on users' needs as an alternative to technical implementation. As specific examples, if there are multiple descriptions or units for a quantity, allow for the user to enter any - wavelengths (in meters, centimeters, or millimeters) or frequency (in Hz, MHz, GHz, or THz) are equivalent descriptions of a photon. Allow users to search for regions in the sky using a variety of coordinate systems (B1950 equatorial, J2000 equatorial, J2050 equatorial, Galactic, Supergalactic, even ecliptic, if feasible), expressed in a variety of formats (sexagesimal or decimal degrees). Allow users to search for quantities of scientific interest (e.g., angular resolution) in addition to specific technical implementation details (e.g., array configuration). Finally, providing a means to access the Archive in a scripted fashion would be welcomed. Conducting statistical analyzes of a population of sources can be conducted by stacking or co-adding observations of different sources, even if emission is not detected from any individual source (e.g., w*hat's the average 1.4 GHz emission from brown dwarfs?*). Being able to provide a list of sources or easily query the Archive from a script would ease the use of the Archive for these kinds of studies.

3.1.3 ALMA and VLA pipelines

The pipelines for ALMA and the VLA are likely to be important to attract new users to these facilities as well as to provide initial feedback to expert users on the likely avenues for most effort in improving their data. Several UC members have used the VLA pipeline, in some cases even providing feedback on it, and we regard it as a significant effort and believe that it is already providing dividends. We look forward to the release of the ALMA pipeline. Similar in spirit to our recommendations for the NRAO Archive, to the extent possible, the ALMA and VLA pipelines should have the same "look-and-feel", and the on-going identification of commonalities between ALMA and VLA data reduction is an important step in this regard.

3.2 Virtual Observatory

The Virtual Observatory is an initiative to make astronomical data discoverable and accessible world wide, under the international auspices of the International Virtual Observatory Alliance (IVOA). The U.S. Virtual Astronomical Observatory (VAO) leads efforts within the U.S., and NRAO is a member of the VAO. Notably absent from many VO databases is much radio data, in part because existing VO standards often do not describe radio wavelength data adequately. NRAO is in a position to help change this situation, it has the opportunity to do so in the context of a VAO initiative, and the NRAO commitment to take fundamental steps in this direction is welcomed.

From a scientific perspective, it is often required to compare and contrast radio emission with emission from other wavelengths'. Doing so can take many forms, an overlay of a catalog from another wavelength on a user's image, overlay of image contours from another wavelength on a user's image, or a combination of images from different wavelengths (a pseudo-RGB image, with the red channel from radio, the green channel from optical, and the blue channel from X-ray). It is now possible in many other astronomical image viewers to query and access remote data, then display those data with the user' image. The NRAO commitment to ensure that this capability is also possible in the CASA viewer is welcomed.

More generally, the VO provides a means to enable data from multiple archives to be discovered and accessed. In general, radio astronomical data is only poorly represented in the VO. The VAO, and the IVOA, are in the process of developing standards for describing multi-dimensional data, such as naturally produced by radio astronomical interferometers. Once again, NRAO's commitment to with these entities to develop and implement these standards, providing the leadership to ensure that radio astronomical data are more widely accessible, is welcomed.

The UC was asked specifically about the relative priority of extending NRAO software to implement additional VO capabilities within NRAO software as opposed to enhancing "native" capabilities. A current VAO priority is to develop a python toolkit, in part to allow users to implement VO capabilities within their own scripts. For now, NRAO could usefully limit any additional VO activities to ensuring that CASA and the VAO python toolkit can inter-operate.

3.3 User Computing

The data volumes being produced by NRAO telescopes are rapidly approaching the point at which the current approach of PIs downloading their raw data may not be feasible. It is likely that some amount of initial data processing may be required to bring the data volumes to the point that a PI can access his/her data, and there are scientific use cases for which data processing on NRAO computers is essential (e.g., rapid transient response). Various approaches are being investigated in order to enable this initial processing, and current efforts to provide access to NRAO computing resources are appreciated. At a minimum, NRAO should provide a means by which a user can specify a modest series of changes to the standard processing pipeline, and acquire a modified data set. Direct access to an NRAO cluster would be both welcomed and of considerable use for the more experienced users and essential for certain classes of observations (e.g., transient response).

3.4 Observation Preparation Tool (OPT)

The UC understands that the OPT has been recovered from a third-party vendor. Many members of the UC continue to find the OPT and the Proposal Submission Tool (PST) unintuitive and cumbersome. The UC would welcome the opportunity to work with the development team to provide a more user-friendly structure and interface to both tools. We list specific issues and recommendations in the Appendix.

4 Science, Support & Research

In the past year, the Observatory Science Operations (OSO) functional group has been split up into the newly formed Science Support & Research (SSR) Department and Data Management & Software (DMS) Department. The former includes Telescope Time Allocation (TTA), Science User Support (SUS) and Science & Academic Affairs (SSA), each of which will be discussed in turn.

4.1 Telescope Time Allocation (TTA)

Panel-based review of VLA, VLBA and GBT proposals by the community has entered its third year. The transition from the older format, involving internal review at NRAO, has largely been a smooth one. However, the committee feels that the process should be more transparent to the user. Specifically, the new format of the proposal dispositions gives less detailed feedback from the time allocation committee than the old format, where multiple referees were quoted individually. We understand that the sentiments of individual referees can sometimes seem disjoint and even confusing to proposers, but we regret the loss of this information; every piece of feedback on a proposal has a useful kernel of truth in it. The UC therefore encourages NRAO to include the text of individual referees in the dispositions. NRAO should make it clear to proposers that these are views of individuals, and the synthesized report from the TAC takes precedence. The UC applauds the effort to synthesize the TAC's discussion, and we do not want to see this big-picture feedback lost or over-shadowed.

The committee looks forward to hearing further details on the planned evolution of the Proposal Submission Tool (PST), which involves the separation of the scientific and technical justifications for individual proposals.

The fraction of C-rated proposals that are actually observed is fairly high and may be under-appreciated by observers; observers should be encouraged to submit Scheduling Blocks for C-rated proposals.

4.2 Science User Support (SUS)

The role of SUS is clearly one of enormous priority to the UC and we hope that the planned transitions outlined as part of the ramping up of SUS operations prove to be beneficial to the community. In particular, the UC hopes that the current degree of observer support is maintained through this transition phase and into the future, despite the difficult fiscal challenges facing the NRAO.

The NRAO Helpdesk is the first point of contact for most users that encounter problems in any aspect of operation of NRAO facilities. We hope that NRAO can find resources to adequately staff the Helpdesk. The UC stresses the continued importance of this resource, particularly in light of the move to an integrated Helpdesk under SSR, and would like to see more detailed discussion of the statistics of the Helpdesk in future meetings, in terms of number of tickets, the response time and the time to resolution of tickets, etc.

While the OPT continues to have some issues, the SUS aspect of observation preparation has notably been an area of improvement, with VLA schedule block verification by NRAO staff, for example, typically rapid and often containing useful feedback.

The UC commends the NRAO's efforts to offer pipelined data to the community and feedback to date suggests this pipeline is performing well. Ensuring that the pipeline can deliver calibrated data for all standard observing modes of the VLA is deemed higher priority by the UC than, for example, developing the capability to offer final science-ready image data products in the near future.

The UC commends the NRAO for their continued support of user training programs, eg. via data reduction workshops and the highly successful biennial Synthesis Imaging Workshop. This effort is deemed of high priority to the community, much more so than NRAO-organized science workshops, for example. Similarly, the committee is very pleased with the plan to revise the Synthesis Imaging in Radio Astronomy book and to make it an active online document.

4.3 Science & Academic Affairs (SSA)

The UC encourages the continued support of key programs such as the Jansky Fellowship, which serves as a flagship program for the NRAO and attracts some of the best young radio astronomers, many of which go on to faculty positions in the US and abroad. Similarly, undergraduate (eg. REU) and graduate (eg. Reber fellows) support programs are excellent means by which the NRAO seeds the radio astronomy field. Obviously, not all programs will be sustainable due to lack of funds, and the UC suggests that certain elements of the support program, eg. financial aid for visiting astronomers, are less important than funding key programs (e.g. Jansky, REU).

We encourage the NRAO to continue publication support, as this can be a roadblock for publication of results from NRAO telescopes. However, in this fiscal climate we understand that NRAO may have to make difficult decisions. We would prioritize programs for young scientists, like summer schools, above publication support.

5 Program Management Department

The UC appreciated the informative presentation of the NRAO's complex organization with footprints throughout the world. In these days of reduced budgets, dwindling resources, and increasing documentation requirements, program management of NRAO activities is essential. From a user standpoint, the effective management of NRAO resources is important as it offers transparency, maintains the basic NRAO mission and ensures resources are not overcommitted.

It is understandable that medium to large scale projects require the tools and assistance of the PMO. The UC would like to know if there is a threshold of effort by NRAO staff and the value of that threshold, below which the program management activities are not necessary. For example, if a member of the NRAO research staff is invited to participate in an observing proposal by an external PI that may require a small amount of effort (say 1%), does this require approval and PMO documentation? For such small efforts, this extra layer of institutional approval could be unwieldy such that outside collaborators may be reluctant to add the NRAO staff member to their proposal to the detriment of the staff member and NRAO.

6 New Initiatives Office

The UC recognizes the need for NRAO to seek new scientific and technical initiatives in which it can participate and to maintain a long term view of scientific and technical developments – especially in new post-ALMA instruments. Such activities can enhance its mission as these may leverage the current facilities and resources to maximize science output and can engage NRAO in new, innovative, state of the art technologies. The UC applauds the efforts of the NIO in finding partners to operate the VLBA and the injection of money from radio-downlinks to the 140 foot telescope but also recognizes the stated current risks in these respective partnerships. The UC encourages exploration of other partnerships as these serve the interests of NRAO and the community.

7 Central Development Lab

The Central Development Laboratory (CDL) remains a valuable source of expertise both for instrumenting NRAO facilities and also for assisting the broader radio astronomy community to develop cutting edge experiments. The committee was pleased to receive a briefing that clearly laid out the connections between the different programs in CDL and their role in the existing and future programs in which NRAO is involved. Clearly a major role of CDL over the next few years will be to support ALMA development projects such as filling in gaps in the frequency coverage, and supporting the ALMA phasing project. The CDL is also participating in a number of community led initiatives such as PAPER and DARE. This engagement of NRAO in the more targeted style of experiment that will address *New Worlds, New Horizons* science is likely to remain important, particularly in the absence of SKA from US plans. The CDL has addressed some of the concerns and questions raised in last year's UC report, including establishing an improved website and highlighting efforts to increase its interaction with the community.

The CDL report identified potential risks to the program, particularly from budget cuts and loss of personnel. At particular risk is the future of technology developments at low frequencies such as phased array feeds which are driven in large part by requirements for the SKA or GBT both of which have considerable uncertainty associated with them. The UC recognizes the expertise of CDL in this area, but NRAO needs to make some hard choices across the program, and looking at the areas of technology that CDL is invested in could be required. The involvement in PAPER/HERA and in planning with the community for these

low frequency programs is a good thing in this regard and can help to set priorities.

The UC was specifically asked to comment on the following:

- **How can the CDL help the North American Community reengage in SKA?** This can only happen if the SKA is identified as a major priority for the larger astronomical community, something which did not happen in the *New Worlds, New Horizons* Decadal Survey. NRAO should continue to enable community discussion of the full suite of radio astronomical science and tools, including SKA, so that the community can advertise its science and plans well ahead of the next decadal survey. The low frequency workshop is an excellent example of such outreach.

- **Ideas for Tech Transfer?** The UC heard that an observatory-wide technology transfer office was established in 2012, and committee input on ideas for technology transfer were solicited. Committee suggestions include engaging in the NSF SBIR program to create connections with small businesses and by continuing to advertise its capabilities, possibly by establishing NRAO booths at trade shows and IEEE conferences. These suggestions seemed to be aligned with the plans of the office and the committee encourages their implementation.

- **Ideas for more CDL-Community collaboration?** The committee applauds efforts by CDL to reach out the community, and some committee members have had productive discussions with CDL members on several projects in the last year. The committee heard that there are opportunities for students and postdocs to visit and work with CDL and this should continue to be encouraged in order to establish the next generation of instrument builders and innovators in radio astronomy. We suggest that CDL make use of local seminar series to bring in speakers whose interests may benefit from access to CDL expertise, particularly if those speakers have not previously worked with CDL or are just starting to work with CDL. CDL could also investigate holding workshops, if resources permit, to ignite community development of new projects and could consider "going on the road" perhaps by contributing to booths at scientific or technical conferences.

8 Education and Public Outreach

The UC strongly supports the NRAO Education and Public Outreach program concentration on news/outreach and STEM Education and commends the wide range of EPO activities successfully carried out with a very limited staff. The STEM activities continue to be strong. Since the last UC report the geographical diversity and participation in the Pulsar Search Collaboratory and start of Radio Skynet Junior Scholars STEM programs have increased, which is laudable. The UC supports continued efforts in increasing these and other STEM programs and ensuring that they reach a diverse student population.

Many activities encompass the news/outreach program, including a new Public Website Design, improvements at the Visitors Centers, public release images from VLA, and online virtual tours of VLA and ALMA. An HD broadcast documentary on ALMA was produced, and while the UC was a bit skeptical about selling this documentary, we are pleased to know that it has been picked up by some NPR channels. The UC continues to recommend

that the Website remain a focus for EPO, both the public and 'for scientists' sites, since this is the first contact with the observatory for the large majority. Additional material on radio astronomy, telescopes and ongoing science at a range of levels of detail would be very welcome. The UC continues to support plans to make public "what the telescope is observing now," and the expansion of the science news effort. The NRAO staff responses to the 2012 UC report were positive. The usual challenge of limited resources is clear.

Since the last UC report a PIO (Public Information Officer) has been hired, which should enable the establishment of a better-defined line of communication for NRAO program PIs to report exciting upcoming results. The UC continues to recommend the development of a section on the Website devoted to this process and that PIs are proactively contacted to inquire about newsworthy science results (this can for example be done through a standardized email after data delivery). While radio astronomers are less used to writing press releases and taking part in news conferences compared to some of their optical counterparts, the UC is confident that such opportunities would be welcomed by the community and strongly supports the proposals to arrange online chats and "hang-outs," following press releases.

9 UC Management Structure, Membership and Meeting Logistics

The UC voted to approve the Committee Charge document which defines the UC purpose, its structure and the yearly schedule. The term of the 2013 chair, Aneta Siemiginowska, ends in December 2013. For 2014, Gregg Hallinan will serve as chair, Joseph Lazio was elected a deputy chair.

The UC welcomes the new 2013 members. We appreciate an appointment of a pulsar expert this year. We would like to suggest a balance between senior and junior members to be taken into account in future appointments to the UC. Also a consultation about the new membership may help in creating a balanced membership.

10 2013 Charlottesville Meeting Participants

The 2013 meeting of NRAO Users Committee was held on May 1-2 at the NRAO Headquarters in Charlottesville, VA. The following members of the committee were in attendance of the meeting:

Aneta Siemiginowska (chair)
Gregg Hallinan (co-chair)
Shami Chatterjee
Laura Chomiuk
Sarah Church
Jeremy Darling
Mark Devlin
Sheperd Doeleman (via telecon)
Mark Heyer
Joseph Lazio
James Miller-Jones (via telecon)
Karin Öberg
Dominik Riechers(via telecon)
Gordon Richards (via telecon)
Eva Schinnerer
Michael Skrutskie
David J. Thompson (via telecon)

A Appendix

The specific issues and recommendations to the current tools are listed in this section.

A.1 Proposal Submission Tool (PST) Specific Issues

1) Reordering of authors is painful. The "up/down" options only move an author one step at a time, which can be extremely tedious in long lists of authors. Perhaps a numbering scheme would be better—if an author is moved up by being given a higher ranking, all authors lowers than this new rank drop down one rank.

2) The concept of a "source group" is unintuitive in many situations. Imagine a new observer who has a single target they would like to propose for—let's say M87. The very first thing they do is click on "new source group" and type in M87. Then they do a NED/SIMBAD search for M87, get its information, but when they click 'Save', they get an error:

   "The source name cannot be same as group name. Please try again."

   First, why not? Second, this user is not even making a group of sources, they just have one.

3) This issue of source groups then complicates the issue of sessions. Imagine a case where we have 15 targets—ten we want to observe in B config, and 5 we want to observe in A config. So we put them in two different source groups, according to desired configuration. But when we get to the sessions page, we are confused about how to input the desired observations (say, three 3-hour blocks on each source). We can only select the entire source group, which makes it sound like we want to observe all 10 targets in a single block. Should we say we want 30 sessions, each of 3 hours, for the B-config group? Or should we throw up our hands and say we just want 1 session of 90 hours, because we're confused any way? Or should we go back to 'sources' and place each target in a separate group, and then make one set of sessions per source (this is very time consuming)? We've tried all of these options in the past and we're still not sure which is right. Hence our complaint that sessions are quite unintuitive.

4) Take another example—let's say we do want to observe all ten sources in a source group in a single block. Should the rms noise then be the rms noise per session per source, or the rms noise assuming we just observe one source all session long?

5) It is unclear if the LST range needs to actually be set and taken seriously under sessions. An ominous error message comes up if the LST range is not set: "The LST Range has not been modifed from the default values: '00:00:00' - '24:00:00.' Your session will be assumed to be centered at 12h LST. If that is undesirable, enter appropriate values for the session's LST minimum and LST maximum."

   First, we think this is requiring too much of the observers, to predict their LST ranges before observations are approved. Second, this information is roughly redundant with the 'minimum elevation' request—minimum elevation should be sufficient to give the TAC a sense of when a given target will be up. Thirdly, in the example from point

(3), where we seek to observe multiple targets each in their own block, the setting of an LST range is impractical.

6) Once a session is established, if the user would like to go back and edit the session, there are multiple places to click edit, and only parts of the session are editable at a given time. For example, the user can click 'edit' under the session, or they can click on the source group name and then edit that. Why not just make everything editable if the user selects edit? This would make use of Sessions much easier and faster.

7) Why do velocities, reference frames, and conventions need to be included under sources?

8) The PST gives strong errors if there are unused resources in the proposal. This is confusing to the user, and often a significant inconvenience at submission time—isn't it the sessions that count?

A.2 Observation Preparation Tool (OPT) Specific Issues

The UC also has several suggestions about the Observation Preparation Tool, which are listed in this section.

While performance of the OPT is much improved from a year ago, this software still remains slow and unwieldy. The primary recommendation of the UC is that the OPT be transferred away from a web-based platform. Most "clicks" in the OPT still take 1–5 seconds to register, which makes writing scheduling blocks an extremely tedious process, and can lead to mistakes simply because the observer loses patience. We suspect that running the OPT on one's personal computer, rather than over the web, would speed its performance considerably and provide added flexibility to the observer (enabling them to write scheduling blocks even over a slow internet connection).

The other critical point about the OPT is that an observer should be able to give it a range of LSTs, and it should be able to return to the user for each scan:

–the minimum elevation (and LST time it occurs)
–the maximum elevation (and LST time it occurs)
–the minimum slew time (and LST time it occurs)
–the maximum slew time (and LST time it occurs)

This would cut down on a lot of wasted time spent entering different LST start times at 30m intervals to evaluate the above. During the VLA Ops talk, it was mentioned that a strategy is in development where SBs may be written in terms of "on source" time rather than "duration." This prospect sounds difficult to implement from a queue-observing and scheduling perspective. We believe a simple strategy like the one outlined above would alleviate the majority of tedium associated with the OPT.

Error messages in the OPT are often ambiguous. For example, when it complains about there not being enough time on source or shadowed antennas, it simply gives the name of the scan (and there are often multiple scans with the same name). It would be good to give the scan number too, as listed in the Summary report. The OPT currently notes a very confusing and long ID number in some errors (like shadowing) that does not seem to correspond to anything.

In addition, any messages of import should show up in the Error window above the long list of shadowed antennas. That would include "Project passes validation" and "The scan XX will hit the minimum or maximum elevation at some point", and "there is no time on source for scan XXX." Error messages should be ordered in terms of importance, not chronological order, because the list can often be very long and the user may miss something important.

Calculating a new summary report for a new LST start time remains very slow.

Why when stepping through different LST start times, one has to first enter the start time (involving one set of information transfer over the web, and waiting for the system to think) and then press update (involving more time waiting for the system to think). This seems to be an obvious place where efficiency could be enhanced (updating to happen immediately after entering the new start time).

Switching between "Observation Preparation", "Sources" and "Instrument Configurations" is often slow enough that it discourages the user between readily switching between these modes, which is something the user probably wants to do while designing a scheduling block. One problem is that, if I am editing a scheduling block and switch to "Sources" for a second, and then switch back to the "Observation Preparation" mode, the OPT has closed my scheduling block and I have to go find it and reopen it again. This sounds like a small thing, but an observer might do this small check many times while writing an SB, might get frustrated with the slow process, and might stop double-checking their sources simply due to impatience. We recommend that places be "saved" in the "Observation Preparation", "Sources" and "Instrument Configurations" to encourage more ready switching between them.

It would be very useful if, under Project Details, the date of expiration of the program was listed. The expiration date can often be ambiguous (does the program cover move time? etc.), and currently, the Scheduling Officer must be contacted with such questions.

It would be excellent if a user could "drag" items to change their position in a list (e.g., change the order of scans in a scheduling block). Currently the position of an item is changed one place at a time, slowly, with the up and down arrows.