NRAO Users Committee Report 2012

18 July 2012

Contents

1 Executive Summary

The NRAO continues to do a fantastic job operating world-class facilities, especially during this time of serious budget uncertainties. The User's Committee (UC) expresses its gratitude to the entire NRAO staff for their efforts. In this report, we present comments and suggestions on a wide range of topics discussed at the 2012 UC face-to-face meeting. Throughout, we emphasize two goals that were raised repeatedly as essential priorities: **maximizing the science** and **growing the user base**. With the substantial capital expenditures on radio astronomy facilities over the past decade, it is more necessary than ever to ensure a healthy and vibrant user community over the long term, in order to realize the incredible scientific potential of all of the NRAO facilities. Here we summarize several important take-away points from our report:

- We again reiterate that the double-jeopardy situation imposed by completely independent and separate awards of observing time and NSF grant funding remains a significant obstacle to maximizing the science from NRAO facilities. We urge NRAO, with NSF, to obtain a more complete, evidence-based, understanding of the problem, and to continue efforts to forge workable solutions.

- We strongly advocate protecting funding for the NRAO Student Observing Support program, a seemingly easy target for budget cuts, both to enhance scientific output and to continue to grow the user community.

- We encourage the inclusion of several non-NRAO CASA users on the CASA science advisory panel, to continue to priortize the functionality of CASA for routine JVLA and ALMA processing, and for NRAO to seek solutions to software needs from other scientific fields where appropriate.

- We applaud efforts to create and improve learning tools for new radio astronomers, such as the recent Webinar, and strongly encourage the development of even more basic resources to introduce radio techniques to the broader astronomical community.

- We recommend the establishment of clearer EPO procedures and lines of communication for NRAO program PIs to develop notable scientific results for public release.

- We suggest that the NAASC should prepare for, and encourage, frequent visits by NA ALMA users, many of whom will require a significant level of support.

- We are concerned by lingering technical issues with the JVLA Observation Preparation Tool (OPT), especially considering its role as an early point of contact for novice users.

- We are concerned that budget constraints and deferred maintenance have reduced the observing efficiency of the GBT, and this may start a negative feedback loop that could put at risk its long term viability.

- We applaud the successful efforts to raise external funds for VLBA upgrades and operations, and we recommend proactive efforts to develop a scientific and technical roadmap for the future of VLBI.

- We are concerned that CDL efforts that are dependent on the availability of MMIC HEMT amplifiers from JPL are in jeopardy given the uncertain funding situation for this program. We urge NRAO to engage in conversations with JPL and university groups to develop a coordinated approach to securing the MMIC supply.

In addition, we note several items that would be appropriate for discussion at an interim UC telecon at mid-year:

- CASA prioritization and implementation plans for better user input, along with refinement of strategies to handle large data sets. Following the JVLA Aug. 1 deadline and ALMA Cycle 1 deadline, observing programs will be approved that will amass much more data than before.

- Improvements to the NRAO archive to enable use by a broader user community, recognizing the limited resources available.

- A brief report on the time allocation process and plans, with the experience of Aug. 1 deadline included.

- An update on the JVLA 3-bit samplers and any remaining issues from the JVLA construction project.

2 Observatory Science Operations (OSO)

2.1 User Support Services

The issue of user grants to help to support research with ground-based radio telescopes remains a critically important issue for the community. The present system of double-jeopardy with respect to awards of observing time and NSF grant funding is only exacerbated by the advent of the exciting new scientific capabilities provided by new and upgraded NRAO facilities. For example, the double jeopardy of a $\sim$ 15% success rate for ALMA Cycle 0 proposals followed by the $\sim$ 15% success rate for NSF AST grant funding makes it extremely difficult for the typical ALMA user to financially support their research program. The prospects for supporting the most ambitious, large programs appear especially dim. We once again request that efforts be made to find creative ways to enable funding based on the successful award of observing time on NRAO telescopes. This could start with ALMA, with the highest priority science, and potentially be extended to other NSF funded ground-based telescopes, optical and radio.

NRAO has a successful, albeit very limited, program for providing funds for Student Observing Support. This program is one of the best and most cost-effective ways to enhance scientific output and to expand the user base of NRAO telescopes. With most NSF funded university radio observatories now closed or offering little community access (with the significant exception of the remaining NSF URO facilities, pending the health of their funding) NRAO is the de facto main training ground for radio astronomy in the USA. With the low success rate entrenched in the NSF AST grants program, the Student Observing

Support program facilitates the modest levels of funding needed to realize the scientific return from the best proposals for NRAO observing time. The two goals of (1) expanding the radio astronomer users community, (2) allocating funds to achieve the highest priority radio astronomy science, are unified in the Student Observing Support program. At a minimum, the UC strongly recommends that this program be protected from budget cuts, or run the risk of a long-term decline without reaping the benefits of the enormous new investments in NRAO telescopes. Indeed, the UC recommends that efforts be made to expand this program, recognizing the constraints of the current difficult fiscal climate.

Going forward, the UC would like to encourage NRAO to track the funding sources that users rely on to analyze data obtained from NRAO telescopes, and when (or if) these data and accompanying results are published in refereed journals. A more complete, evidence-based, understanding of the true nature and scope of the funding issues faced by NRAO users may lead to new and creative ideas for solutions.

2.2 Software and Data Management

2.2.1 CASA

Over the past couple of years, the CASA staff have accomplished the essential goal of developing a software package that can reduce most JVLA and ALMA data streams into science-quality data products. Progress in key areas, such as wide band, wide field imaging has been significant, and work on parallel implementations of key CASA tasks are progressing well. The clear increase in functionality of CASA has been accompanied by a steady growth in its user base; we are pleased to note that NRAO efforts to promote CASA in the community have been significant and effective. On-line tutorials are informative and easy to use, while data reduction workshops and NRAO community days have been accompanied by very positive reports. We applaud NRAO for this effort, and the UC hopes to see this continued through 2013, particularly to support non-expert users.

We note, however, that with the rapid pace of CASA development, the various repositories of information on data processing with CASA (particularly the CASA guides) need to be updated more frequently than is currently the case. An active user forum could help here to reduce the load on NRAO staff. A small initial investment of useful articles in the forums could increase their user base, providing a positive feedback effect by leading to more user-contributed posts.

Furthermore, while the increase in capability offered by the latest iterations of CASA is to be commended, the UC is concerned that some releases may be premature. We note that the latest release of CASA (3.4) still had over 100 unresolved major issues, as logged by the NRAO Bug Tracking System, at the time of release. This can negatively affect the perception of CASA among the community, particularly new users transitioning from AIPS, and everyone might be better served by a more fully tested platform accompanied by a less stringent release schedule, with intermediate versions available for expert users.

The UC recognizes that the primary goal of NRAO staff working on CASA must be to provide the calibration and imaging tools required to generate science-quality data, and to address the unique challenges posed by JVLA and ALMA data. However, it is imperative to keep in sight the long term goal of providing science-ready data to a very broad group of

users via automatic data pipeline processing. As in previous UC reports, we are still concerned with the adequacy of science analysis software treating the images/cubes rather than the visibilities. Should resources allow, some additional effort directed into incorporating existing and well-established algorithms for analysis of image cubes into CASA could significantly improve the scientific yield of JVLA and ALMA data. Specifically, post-imaging software in CASA has not developed much at all since the AIPS package of the 1980s, while image/cube visualization and processing technologies have rapidly advanced in other fields such as medical imaging. We are pleased to learn that new staff will be applied to these issues. NRAO may also want to consider encouraging some software-specific RSROs and to continue to encourage software proposals for ALMA development funding.

We find it encouraging to see that CASA is being used by LOFAR, PAPER, MWA, and even for datacubes coming from optical facilities. However, beyond the JVLA and ALMA, some NRAO-specific facilities functions require further work. For example, the absence of fringe fitting functionality precludes the migration of the VLBI community towards CASA and should be a priority. Inclusion of VLBI functionality in CASA will become important in the future as support for AIPS diminishes.

As CASA development continues, it is important to increase the communication between the developers and the user community on what CASA functionalities that are most urgent to develop. We therefore recommend that several parallel steps be taken to increase the user input on perceived issues with the current version and future directions to prioritize, including a questionnaire to ALMA Cycle 0 PIs and *the inclusion of non-NRAO CASA users on the CASA science advisory panel*. Examples of questions to put to the users are whether increased user-friendliness of calibration pipelines or the development of science image pipelines is more important to produce reliable science results.

2.2.2 Other Computing and Algorithms

The data management group appears to be competently facing the massive data flows and heavy computational burdens with parallelization and improved computational infrastructure within NRAO. The UC is pleased to see a concerted effort to provide the community with multiple tailored solutions to deal with the large data volumes expected for the fully commissioned ALMA and JVLA.

Since a substantial fraction of the user community is dispersed and lacks the computational resources to deal with very large datasets, particularly for large and key projects, it is likely that NRAO resources will be needed to perform substantial data analysis for the NRAO user community. The stated goal of auto processing for most users and the 80/20 breakdown would seem appropriate. The Data Management group deserves considerable credit for establishing pipeline processing plans for all JVLA, ALMA and (soon) GBT data. Communicating the details and a timeline for the proposed data reduction pipeline should be a priority for the near future.

The processing of ALMA and JVLA data will continue to be challenging, especially as the data volume grows larger. The planned high performance cluster dedicated for processing of ALMA data in Charlottesville and JVLA data in Socorro, and the ongoing development of a pipeline with quality assessment, are major steps forward to ensure that all users will be able to fully calibrate their data. For those users that would like to reduce large data sets at

their home institutions, the UC would like to see more detailed hardware recommendations made readily available on the NRAO web pages, as there still seems to be some confusion on these hardware requirements, as opposed to what may be desirable but not necessary. It would also be very beneficial to specify a point of contact for advice on tailored solutions for specific projects.

We encourage the Data Management group to consider the broad view from data acquisition through the NRAO archive and access to the world via the Virtual Observatory. It is not clear that the current provision of QA-level images/cubes is not adequate for widespread use. The UC recommends a long term investment in a development of modern data analysis algorithms and numerical techniques. A cutting edge science requires often novel approaches. However, adaptations of new methods from statistics, biostatistics or other fields, require a careful evaluation process. NRAO scientists are experienced and well positioned to make significant steps into the future. The development of new methods will not be quick and will require long term support to succeed.

Overall, the UC recommends a careful review of the current issues and show-stoppers in the data analysis process. As with CASA specifically, we suggest that more direct input from the community will be valuable to set priorities for testing and development.

2.3 Community Support Programs

NRAO continues to offer a wide range of programs for summer students, undergraduate and graduate students, and science visitors. These programs have outsized impact on growing the user community. The summer student program has impressive statistics, with 167 applications for 25 positions this year and most of the students presenting results at an AAS meeting.

The Student Observing Support program provides up to $35K in a year for students working on programs scheduled on NRAO telescopes. At the moment, the procedure for requesting this funding is different between ALMA and JVLA/GBT/VLBA. For ALMA Cycle 0, a notification was provided in the e-mail to PIs of successful proposals that requests can be made to this funding source, while for the other telescopes the request has been part of the initial proposal. Based on the statistics provided, it appears that the ALMA model is more effective. Nearly half of the successful ALMA Cycle 0 PIs requested student support (17/38), while only a very small fraction of proposals for the other telescopes had accompanying requests. The committee recommends that *all* of the NRAO facilities follow the ALMA model by including a statement in the time allocation award notification to tell the PI that Student Observing Support can be requested. That is, the request for funds should be made upon the acceptance of the observing proposal, not on its submission. This process requires an additional step to decide which programs should be funded; the ranked list of proposals from the TAC might be used to help to guide funding award decisions.

We recognize that the $35K cap allows for dispensing these limited funds in the broadest way, but we recommend that NRAO consider relaxing this cap in certain circumstances. First, the cost of one year of student support is simply not under the control of the proposal PI and varies widely across Universities, as some require fees and tuition as well as stipend support. Because the full amount needed for a year of student support can exceed $35K, we suggest that the terms be modified to allow up to a year of student support at the amount

required by the associated University (though typically not to exceed $35K). Second, the funding cap effectively precludes the student resources that may be appropriate for large or key programs. In exceptional cases of high priority science, where the workload can be clearly justified, requests for support for multiple students could be entertained.

The NRAO Community Day Events are an important way to reach potential new users. The NAASC held 23 ALMA CDEs in support of Cycle 0, and these events are now being done jointly for all NRAO telescopes. There were 4 NRAO-wide events and 2 data processing workshops last year. These are widely perceived as very successful and we hope that they continue (and continue to evolve based on participant feedback, such as requests for more hands-on help, a higher level overview of CASA, and easier ways to follow along in walk-throughs).

The UC supports the new and innovative efforts undertaken to reach potential users. NRAO recently tried a webinar (like the Herschel Science Center) in June 2012 with emphasis on proposal presentation this time. Invitations are being issued to host local meetings, which need a minimum of 25 to sign-up, and NRAO is also considering a roadshow of one-day events, a January 2013 proposals special session for ALMA, on-line tutorials, and a remote "office hours" helpdesk signup. The on-line Essential Radio Astronomy course looks excellent and seems to be thorough in covering the basic scientific motivations as well as the details of how radio astronomy works.

In last year's report, the UC pushed for more basic material on interferometry (etc.), and we are pleased to see that recommendation implemented in the form of supplemental material for the webinars. A specific suggestion is that the introductory supplemental material be *much* more basic in order to avoid turning off potential new users. First-time users of NRAO facilities must not be scared away. The UC is concerned that users whose first interaction with NRAO facilities are these lectures may indeed be put off by the high level of the content. The existing material seems more appropriate for the next level of learning, perhaps as preliminary viewing for the summer school. Indeed, we hope that demand for practical education in radio astronomy techniques will become so high that the synthesis summer school in Socorro will have to be held every year. Lastly, it should be more clear to users first coming to an NRAO site where the best place is to get started.

2.4 Archive

NRAO data are important in many multi-wavelength studies and are highly desirable to non-radio astronomers. Easy access to ready-to-use data products is important for the entire astronomical community. The UC advises NRAO to consider carefully the needs of non-radio specialists in the ongoing development of NRAO archives.

The JVLA and ALMA archives of pipeline processed data have the potential to act as an easy entry point for potential new users that are interested in combining other wavelength data with radio data via, e.g., simple overlays. This would require some additional information from the pipeline processing, i.e. quality of the calibration. A dedicated guide on the usage of the pipeline produced images ranging from ready to use images or need for extra processing, i.e. cleaning, would be very useful. Another option might be to ingest final (i.e., published) images/data cubes from the PI with the relevant publication listed (similar to the NED approach).

The UC would like to remain informed about the status and future plans for the NRAO data archive, including a description of the archival process, types of archive data products and a user interface for accessing the data (for PI and the other users). The UC would also like to see the current statistics concerning archival data downloads and usage.

2.5 Time Allocation

A new time allocation system was adopted for 2011B, and this new system, which is more transparent and more akin to the process used by the NASA great observatories, is already broadly accepted by the user community. The UC has heard few complaints about the new process. We reiterate two specific recommendations from last year's UC report that we believe still require attention: (1) We recommend that instead of having each panel review different science categories that the panels be divided into four broad science categories with two parallel panels covering each topic (like HST and ALMA); this reduces the bias in favor of proposals from reviewers on a panel. (2) The UC recommends that NRAO explore adding language to the call for proposals that encourages high-risk/high-return science proposals, perhaps reserving time (like Spitzer) for a small number of these programs that have the potential to provide very high impact science but are either technically difficult to implement or just have a low or undefined probability of getting a positive result. An additional recommendation is to look into ways to speed up the proposal evaluation process that is currently taking 4 months, which is long compared to other major observatories (ESO takes less than 3 months, IRAM about 2 months).

The UC recognizes the NRAO efforts to distribute details of the TAC review to the community. An email announcement with the proposal results is sent to the PI and all the co-I's, which contains comments from SRC and TAC, plus the score and a number of approved hours. In addition, the NRAO web page now contains the information about 2012B cycle statistics. The UC notes that all of the NRAO facilities have a healthy oversubscription rate.

While the UC was provided with a brief discussion of the new TAC in the OSO report, the 2012 UC meeting did not include a presentation on TAC issues. This may be reasonable given the relatively smooth functioning, but the UC would like to hear about NRAO self-evaluation at the next UC meeting (or at an interim telecon).

3 Directorate-level Programs

3.1 Communications

In the view of the UC, NRAO communication to the science community is highly effective. The current efforts concentrate on meetings such as AAS, AAAS, IAU, and the high-performance computing conference, with SPIE and AGU considered as future possibilities. Other approaches include eNews, announcements, brochures, and an annual report. NRAO participated in the National User Facilities Organization with displays in Washington for Congress. The web site for scientists is starting a welcome redesign. The lack of extensive commentary here by the UC should be interpreted as a sign of our satisfaction with these

efforts, e.g., the format/distribution of eNews is good (much better than the AAS newsletter, which requires downloading). If specific UC feedback is needed/desired for the web format, we welcome NRAO to use the committee as a focus group by sending a specific solicitation for UC commentary between meetings. One specific suggestion is to make sure that science.nrao.edu prominently features a link telling potential new radio astronomers where learning resources can be found.

3.2 Education and Public Outreach

The NRAO Education and Public Outreach program concentrates on news/outreach and STEM Education. The UC commends NRAO for its wide range of EPO activities, particularly given the limited staffing resources at its disposal. In STEM Education, programs include the Pulsar Collaboratory, GB overnight educational field trips, and the West Virginia Governor's School student program. An emphasis has been on increasing diversity, an effort supported by the UC last year. The Spanish-language sessions at the Charlottesville Astronomy Festival are laudable. Many activities encompass the news/outreach program, including a new Public Website Design that is highly visual, app-like, and database-driven, improvements at the Visitors Centers, public release images from VLA, and online virtual tours of VLA and ALMA (with GB next). An HD broadcast documentary on ALMA was produced and is being marketed. The UC was a bit skeptical about selling this documentary, but we are pleased to know there are interested parties. Public events include the USA Science and Engineering Festival, ALMA Early Science results publicity, media visits, and social media.

One area where improvements could be made is in the communication of the most exciting new science results to the general public. The UC recommends the establishment of a better-defined line of communication for NRAO program PIs to report exciting upcoming results, to ensure that opportunities are not missed. A section on the website devoted to this process would be a good starting point, as would a dedicated PIO. That person could make specific efforts to follow up on all designated Key Science Projects once their observations have been completed, with a view to drafting press releases on the most interesting new results. We also encourage NRAO to be more proactive by sending standardized e-mail to all ALMA/JVLA/GBT PIs, informing them of the existence of NRAO PR resources in case they discover something press-worthy, and through the identification of interesting projects during the proposal reviewing process. This burden should not rest entirely on the EPO staff. To further encourage the incorporation of NRAO results in research and public talks, we recommend that the ALMA and NRAO websites expand their multimedia sections to include attractive renderings of key science results as well as accessible telescope information slides at different levels of detail.

Overall, we are impressed by the sheer number of different avenues that are being tested to communicate NRAO science to the public and within the astronomical community. We encourage the NRAO EPO staff to continue to explore different approaches to increase the visibility of radio astronomy in general and NRAO science in particular. Based on NASA successes with short movies and smart phone apps, we recommend that both are considered when developing new material on e.g. ALMA science for the public. Especially app development could be done at low cost if cast in the form of a competition judged

by high-ranking NRAO-associated scientists. Combining the need to support the Pulsar Collaboratory after its funding ends and the desire to delve into "Citizen Science", the UC suggested existing citizen-science efforts like Galaxy Zoo or Einstein@Home as possible new homes for the Pulsar Collaboratory after funding ends.

The JVLA Explorer site should benefit both the public and upcoming summer school participants. One suggestion is that it should also be possible to view the videos more linearly (e.g., maybe in 4 different segments for the different sections).

Following up on last year's report, the UC was encouraged to hear that the fee for Green Bank tours has not caused any problems and that school groups are still free. We would also like to re-emphasize our approval of the idea of "what the telescope is observing now" and encourage NRAO to facilitate the interactions needed between EPO and OSO to make that happen.

4 Facilities

4.1 ALMA

Progress on ALMA construction and commissioning over the past year continues to be impressive, with half the antennas already on-site in Chile and the official call out to the start of the first cycle of science observations. We congratulate everyone involved for these achievements.

Major milestones for the user community have been the Cycle 0 science observations that are currently underway with the first datasets released to the PIs and the stunning press releases showcasing the powerful capabilities of ALMA. The response to the Cycle 0 Call for Proposal numbers have been overwhelming, underlining the transformational potential of ALMA. At the same time, we note that the slow release of Cycle 0 science data to the PIs is a reminder of the difficulty of realizing reliable and efficient operations during ongoing construction, with attendant hardware and software problems. One simple idea that would save everyone work would be to establish several standard setups, e.g. to obtain the best continuum sensitivity in each ALMA band. Proposers will adopt these defaults, and operations will not be faced with as many different spectral setups, so shared calibration among projects becomes more feasible and efficient.

We are pleased to see that the NAASC has been staffed with excellent and ambitious scientists. They have helped the JAO staff with the processing of Cycle 0 science data to deliver a useful, calibrated science product to the users while also gaining an improved understanding of problems and limitations with the hardware and software. This effort enhances their capabilities as ALMA support scientists and should be strongly encouraged. Given the stated concerns and apparent complexities of the data processing, *the NAASC should prepare/expect frequent visits by NA ALMA users, who will require a significant level of support.* We are very interested to hear about the feedback from visitors to the NAASC for the Cycle 0 (and 1) support, as well as outcome and feedback from users from the scheduled webinars and the "remote office hours" to address questions from users. We also urge the NAASC to provide support to astronomers who aim to establish high performance processing capabilities at their home institutions.

The UC looks forward to the hiring of the NAASC AD while also commending the accomplishments and fortitude of Mark McKinnon in his role as NA Project Manager over the last several years.

The UC expects to be able to have more concrete input on ALMA next year once more data has made its way to the users and expects that the ASAC is in a better position at the moment to provide more timely feedback on ALMA-related issues.

4.2 JVLA

We commend the NRAO staff for their successful efforts to bring the JVLA to an on-budget, on-schedule completion in 2012. As highlighted by the ApJL EVLA special issue in 2011, the telescope is already delivering a wide range of fantastic science. The additional features due to be made available (up to 8 GHz of bandwidth per polarization, increase in the maximum number of spectral channels, the phased array and subarray capabilities) will further increase its ground-breaking capabilities.

The ongoing RSRO program has clearly proven to be very successful means of bringing well-motivated scientists to Socorro to contribute in the commissioning of the array as well as providing a means to establish a core user base with a high level of expertise in using the telescope. The program should be continued as the telescope enters full science operations, particularly to test new observing modes that will have become available but not fully tested. It is encouraging to see similar RSRO programs commencing at other NRAO facilities, especially the VLBA.

Completing commissioning of the core capabilities of the array remains a priority for 2012, specifically the installation of 3-bit samplers on all antennas. The unexpectedly high levels of noise associated with these 3-bit samplers has been troublesome and the ongoing investigation into a future long term solution is certainly worthwhile. The UC would be interested in an update on this issue and that of the Antenna Control Units at the interim phone-con.

The Observation Preparation Tool (OPT) remains a point of concern, particularly considering its role as an early point of contact for novice users of the telescope. While the capabilities of the tool clearly have to be expanded to accommodate future observing modes associated with the installation of the 3-bit samplers, as well as modes such as phased array and sub-arrays, this expansion in functionality should not be at the expense of the usability of the tool. The latter has been severely impacted by the inability to update the duration of scheduling blocks in real time—a problem that has persisted since late 2011. The lengthy delays associated with creating large or complicated scheduling blocks also make interactive use of the tool untenable.

In terms of making the JVLA more accessible to novice users, the ongoing work into pipelining the data reduction process is invaluable. The large data volumes are likely to preclude many users from both accessing and processing their data and NRAO's initiative to make its own data-processing resources available to users should be made a priority. Given the new capabilities of the JVLA, it would make sense to update the Synthesis Imaging book from the NRAO summer school. NRAO might also consider making recordings of the summer school lectures available on the web—to go with the suite of webinars being broadcast and generally supporting the webinars with additional (introductory) supplementary material.

4.3 GBT

The GBT continues to offer a unique and valuable platform for radio astronomy research to the astronomical community. There are many exciting scientific results emerging from the GBT programs that span a broad range of astrophysics. Concurrently, the GBT seeks to expand its capabilities with the development and deployment of state of the art instrumentation. The observatory has made a modest, but steady, investment in new receivers and spectrometers. In several cases, these instruments have been realized through collaborations with university groups (Versatile GBT Astronomical Spectrometer with WVU and UC Berkeley). The K-band Focal Plan Array, now classed as a user facility instrument, is a welcome addition that should alleviate some of the time pressure on the GBT during the oversubscribed Galactic Center time slots, while also enabling new science that leverages its imaging capability. The dual-beam 4 mm receiver on the GBT serves as an important complement to ALMA to image the more extended distribution of key molecular emission lines in star forming regions not covered by the ALMA primary beam or mosaicking fields or to confirm higher J transitions of CO from high z galaxies. The UC looks forward to seeing results from the upcoming commissioning of the C-band and Ku receivers.

A major concern amoung the UC is the fact that telescope operating efficiency has dropped from 81% to 70%. This decrease can be attributed in part to deferred maintenance but is also a result of the budget cuts sustained by Green Bank last year. The committee is very concerned that further budget cuts will have a dramatic effect on the telescope observing efficiency which would put its long term viability at risk. Specifically, there seems to be a danger of a catch-22 situation whereby the GBT may *appear* to be operating inefficiently as a result of budget cuts, which will lead to the suggestion of even more future budget cuts. Given this difficult fiscal environment, the committee commends the GBT director and staff for continuing to support the community and look towards future directions.

It was reported that the Dynamic Scheduling System (DSS) is now fully implemented. However, the Committee notes that one of its comments from 2011 related to dynamic scheduling has not been addressed: the issue of limited (24 hours) time notice for low frequency observing. The recommendation was to implement a queue-like mode that is in use at the EVLA. The UC recommends that NRAO explore a hybrid Dynamic Schedule where low frequency projects are provided with a larger advance window that can allow researchers to submit queues for all of the possible times. This will require some experimentation. The committee recognizes that implementing this change may be a low priority given budgetary and personnel limitations. However, it would be useful to assess the feasibility of such scheduling.

It is abundantly clear that the GBT is a state-of-the-art, highly competitive and scientifically productive facility. The primary limitation to achieving its full potential is funding for infrastructure maintenance and personnel.

4.4 VLBA

The UC supports and congratulates NRAO management and VLBA staff for guiding the VLBA to relative financial stability through identifying non-NSF funding opportunities. Over the next 5 years, the outlook for continued operations appears good, with one VLBA

staff member describing the facility as *threatened* but no longer *endangered*. Contributions from USNO and multiple international sources are creating a more robust funding portfolio. The committee encourages continued investigation of new funding possibilities, potentially including satellite tracking, although attention will have to be paid to appropriately balance new time commitments with peer reviewed science observations.

With its high angular resolution and well-determined instrumental properties, the VLBA continues to provide unique capabilities for high impact science. Astrometric work, in particular, has gained considerable traction within the broad astronomy community by providing (through parallax) geometric distances across the Galaxy, as well as enabling relative astrometry leading to important work on young stellar objects, binary systems, core-shifts in AGN, and extrasolar planet searches. In parallel, AGN imaging and monitoring projects have established vital links with the Fermi mission and other instruments. The success of the High Sensitivity Upgrade (discussed below) will open up an even broader range of exciting topics with increased opportunities for contact with other wavebands and new areas of investigation.

The UC noted the very large fraction (71%) of observing time now assigned to large/key projects. The UC emphasizes the importance of maintaining a healthy and varied portfolio of smaller scale PI-driven science projects that will increasingly take advantage of the recent VLBA upgrades. It is essential, from the users community viewpoint, that there remains sufficient VLBA observing time to allow highly rated small projects to be carried out. While the science case represented by the key projects is impressive, the future of the VLBA will also depend on the success of new and smaller projects that leverage the collective intellect of the community. The UC would like to see a breakdown of the key projects and publications next year along with a measure of success rates for the smaller proposals.

The UC is very pleased with the excellent progress of the High Sensitivity Upgrade program, which now enables 2 Gb/s recording rates through use of the new Mark5C recorders and RDBE digital backends. This reflects a great deal of hard work by the dedicated VLBA staff, signals a very large and cost-effective boost in capability, and the user community is deeply appreciative. The successful demonstration of expected continuum sensitivity improvements at these high bandwidths is reassuring, as is the apparent resolution to the problem of bad disks that has been limiting the duty-cycle of this high data rate mode. Establishment of this wideband capability provides a big boost to many science projects, including astrometry and AGN imaging. The UC is particularly pleased to see that NRAO has executed this upgrade through collaborative work with University based groups (Haystack and UC Berkeley), and with international partners (S. Africa). The committee encourages the VLBA staff to continue with further upgrade enhancements as resources permit, particularly DDC modes in the new backend for spectral line work, VDIF format for inclusion of the phased JVLA, and increasing the aggregate recording rate to 4Gb/s (to take advantage of available front end BW of many receivers).

The UC recommends that 3mm VLBI tests be carried out at the GBT in the near future to enable future HSA and GMVA use of that site. In addition to work on the HSA, the committee encourages NRAO to monitor activity of other Global VLBI networks and look for opportunities for collaborative work that may lead to additional scientific partnerships and possible non-NSF funding.

Adoption of the DiFX software correlator at NRAO has been very successful. The UC is

very pleased to see the prominent role that VLBA staff have assumed in the DiFX community, which ensures that enhancements, bug fixes, and new capability will be rapidly assimilated in VLBA operations. With the adoption of DiFX correlators at other institutes, DiFX work at NRAO is having a very broad impact.

Continued work and near-completion of the C-band upgrade represents a significant new capability for the VLBA. The target key project science is understood to be precision astrometry of high-mass star forming regions, but the UC notes that smaller projects will also want to propose for time on these new receivers.

Following the successful completion of the bandwidth upgrade at the VLBA, the UC was interested in the possibility of trading off bandwidth for time (at least for continuum projects) in order to reduce the oversubscription rate at Galactic Center LSTs.

Lastly, we respond to two specific NRAO queries. First, regarding whether further VLBA pipeline development would be a good use of NRAO resources, one member felt that it would be productive to even just release the pipelines that have already been developed. Second, regarding whether Ku- or Q-band would give the highest science return, one member felt that the Q-band would have the highest potential as it yields higher angular resolution, which is an advantage for study of AGNs and also since SiO maser sources at 43 GHz are the main targets in this band and are associated with evolved stars in the Milky Way as a whole and not just the Galactic plane.

5 Observatory Development and Programs (ODP)

5.1 Coordinated Development Lab, NRAO Technology Center

The UC received a lengthy report detailing the activities of the Coordinated Development Laboratory (CDL) and a separate report describing the activities of the NRAO Technology Center (NTC). The reports describe the engagement of CDL in the development of new or improved technologies that are well-suited to externally led experiments such as PAPER, FASR, and DARE. NRAO is to be applauded for this effort to broaden the scope of its activities by playing a key role in the more targeted style of experiment that will address New Worlds New Horizons (NWNH) science.

That said, it is not yet clear that the potential of CDL to provide a significant national resource for advanced radio science R&D has yet been fully achieved (this applies also to the New Initiatives Office program—see next section). For example, the CDL report lacked a discussion of the synergistic interactions between the various parts of the technology program. It is also not clear how the external community becomes aware of NRAO developments. The public wiki could be a good forum in which to display the latest developments and to provide information to the community on how to tap into these efforts.

Along the same lines, last year's UC report suggested that NRAO consider whether changes to the ODP Development Proposal Program could increase community involvement in these proposals. The NRAO response, that such collaborations are already underway, is true. However, the process by which those projects were selected is unclear to external users. The UC is happy to hear that NRAO is open to new collaborations. However, it still seems like that the program would benefit from some increased interactions with the larger

community, perhaps through some kind of mechanism analogous to the ALMA development program that would solicit ideas from community.

One UC member raised a concern about the CDL Monolithic Millimeter-Wave Integrated Circuit (MMIC) Development Program. The MMIC amplifiers that have been designed by Morgan and Bryerton are manufactured via an arrangement with JPL in a program that is currently funded by a NASA APRA grant that ends in 2012. Since many of the near-term applications for these amplifiers are ground-based rather than space-based, continued NASA funding is by no means guaranteed, especially in the tight funding environment that currently exists. Recent efforts to secure NSF funding or ALMA development funds to continue this program as a national resource for radio astronomy have been unsuccessful. Consequently there is a serious risk to this program on a relatively short timescale. Because NRAO considers MMIC development to be an important part of their program going forward, there must be a coordinated effort with JPL and university users who have been playing a major role in the development of these devices to secure the future of the MMIC development program.

Finally the UC had some thoughts about the format of the reports to this committee. The CDL report was far too long, with a level of detail that was difficult for the large majority of non-technical experts on the committee to follow. The split between the CDL and NTC reports also seemed arbitrary. For instance, amplifier development and production were described separately in the CDL and NTC. A single *brief* report covering both activities would make more sense in the future. It would also be helpful to see more discussion of efforts to coordinate the disparate efforts in the various technology development areas.

5.2 New Initiatives Office

The UC applauds the efforts of NRAO to apply its expertise and experience to new projects initiated by the outside community, including international partners. Clearly many of these projects address the science goals prioritized by the decadal survey and NRAO can bring much to the table. However the UC reaffirms the comment from last years report, that NRAO needs to pay attention to the *evolution* of these goals, particularly given the extremely tight funding environment that currently exists. The review of progress towards implementation of decadal survey goals that is expected to be carried out by the Committee on Astronomy and Astrophysics (CAA) mid-decade will be of great importance to NRAO's planning process.

Last year, the UC discouraged NRAO from joining the LSST collaboration, as the direct benefits were not clearly articulated. We would like to re-iterate that this seems to be an unnecessary expense, and that such funds would be better utilized in supporting e.g., the Student Observing Support program. It is not that the UC is not in favor of LSST, or of NRAO scientists being deeply involved in LSST. Instead, it is simply that NRAO scientists already have a conduit for participating in LSST, namely by joining a science collaboration. Furthermore, the UC does not see any advantage to NRAO *users* from NRAO's formal membership in the LSST consortium.

The committee was also briefed about some other, non-scientific, challenges facing these new efforts. For instance global partnerships, e.g. SKA, AASIA in ALMA, raise potentially troublesome administrative issues related to export control and ITAR. These issues are not unique to NRAO—some university groups and national labs have encountered similar

problems. The committee recommends that NRAO coordinate their efforts in this area with external groups to increase the efficiency of mitigation efforts, and the ability of the radio astronomy community to influence government policy in these areas.

6 Future Planning by NRAO

As the JVLA upgrade is completed and ALMA construction winds down, the UC encourages NRAO leadership to find ways to encourage staff scientists to make full use of the facilities and their full contractual science time to do their own science. Users will be best served if the staff themselves are active users (especially collaborating with scientists from the external community).

The UC supports efforts by NRAO to convene a new *VLBI Future* committee to develop a scientific and technical roadmap for future VLBI development. Ideally, this will include participation by University groups and international partners, and will be a valuable way to highlight the scientific impact of VLBI and its synergy with other instruments/wavebands. The UC views this activity as an essential part of strategizing for the future of the VLBA.

Although not discussed in detail at the meeting, the UC continues to support joint NRAO/Chandra and NRAO/Fermi proposals as a way to maximize science from the NRAO facilities.

The UC also discussed the impact of the ending of SKA development in the USA on NRAO future plans in this area. Since international partners are pushing ahead with the SKA, NRAO must remain aware of developments.

The suite of unique and versatile NRAO facilities promise to play a key role in addressing fundamental questions in astronomy, including many of those highlighted by the New Worlds, New Horizons decadal report.

7 Outgoing NRAO Director Acknowledgement

The UC offers its earnest congratulations, appreciation, and best wishes to Dr. Fred Lo as he steps down as NRAO Director. Under his successful leadership, NRAO has engaged in two major construction projects in ALMA and EVLA while also realizing the rich, scientific potential of the VLBA and GBT. He has reorganized NRAO into divisions that span across facility boundaries. This effort leverages and consolidates the excellence of the NRAO staff and provides a near-homogeneous interface of NRAO to the user community. These accomplishments have been achieved while facing a difficult funding climate and facility reviews by the community. Dr. Lo has passed onto the next director an NRAO organization that is much leaner, with transformative facilities and a staff eager to take on the challenges of science in the 21st century.

The UC further welcomes incoming Director, Tony Beasley, and looks forward to working with him in the coming years.

8 UC Management Structure, Membership, and Meeting Logistics

The UC proposed a new management structure going forward with an elected chair and a deputy chair who will ascend to the chair for the following year. For 2013, the committee elected Aneta Siemiginowska as chair and Gregg Hallinan as deputy chair.

We would like to suggest the appointment of a pulsar expert to the UC to improve representation of this important and specialized field. We are grateful for the addition of RSRO and Jansky fellow members to the UC this past year, and we encourage their continued participation in future years. Concerning logistics for the 2013 meeting, the outgoing chairs will make suggestions regarding the overall meeting schedule.

9 2012 Socorro Meeting Participants

The 2012 meeting of the NRAO Users Committee was held May 21–22 at the Pete V. Domenici Science Operations Center in Socorro, NM. The following members of the committee were in attendance for the meeting:

Gordon Richards (co-chair)
David Wilner (co-chair)
Ted Bergin
Sarah Church
Jeremy Darling
Mark Devlin
Shep Doeleman
Eric Feigelson (via telecon)
Gregg Hallinan
Mark Heyer
Hiroshi Imai
James Miller-Jones
Karin Öberg
Eva Schinnerer
Aneta Siemiginowska
Michael Skrutskie
David Thompson