REPORT OF THE 2009 NRAO EVLA ADVISORY PANEL
2009/03/19,20

PANEL MEMBERS

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CHARGE

The Panel was charged by the NRAO Director to assess the:

- Overall progress in the EVLA construction project in terms of schedule, budget and scope, including
  - progress in hardware development & deliverables;
  - progress in outfitting & commissioning of EVLA antennas;
  - the management of budget, contingency funds, and contingency options;
  - progress in meeting the overall project plan.

- The science commissioning plan of EVLA, including the Early Science plan, and comment on
  - the key goals and activities of Science Commissioning;
  - the science-driven priority of the goals and key activities;
  - the schedule of the activities.

- Planning for integrated One Observatory Science Operations that includes the EVLA
  - Scope of the integrated User Support;
  - Areas of special emphasis from the users' point of view

Contents

1 Executive summary

1.1 Introduction

The 2009 EVLA Advisory Panel meeting was held in Socorro on March 19 and 20 and was attended by twelve Panel members (of which one on telephone). Just prior to the meeting, NRAO provided access to either final or mature drafts of the material to be presented at the review.

The Panel would like to thank the NRAO Director, EVLA Project Scientist, Project Manager and the staff for their efforts in preparing and presenting material, and for being so helpful and forthcoming in our discussions during the meeting.

1.2 Response to the 2007 report

NRAO was responsive to the 2007 Panel recommendations and we commend the team for the seriousness with which they responded.

1.3 Main conclusions

The committee was very impressed with the excellent progress achieved by the project. The EVLA will be a transformational instrument. The project should now develop a high-impact science vision, to take full advantage of these transformational capabilities. The committee understands this has been difficult so far due to the pressure of the immediate project concerns. As a first step towards maximizing the scientific potential of the instrument, the committee strongly encourages AOC to carry out high-impact observatory based demonstration science, in conjunction with the NSF. This will advertise the capabilities of the EVLA and further engage the community.

The committee wants to commend especially the Project Manager Mark McKinnon who has done a great job in keeping the project within time, budget and performance; Project Scientist Rick Perley, who has been key in getting the EVLA to work; and the Correlator Project Scientist Michael Rupen who has carried out an impressive and thorough test program of the WIDAR Correlator.

The committee is concerned that some developments that are considered crucial for the EVLA (CASA, some components of SSS, OSO) are beyond the control of the project. The committee encourages the project to clearly indicate expected/required deliverables from these “external” developments, thus integrating them in the EVLA project plan. This has been done successfully for the correlator. The committee urges NRAO to present future meetings of the committee with a more detailed vision of the reach, goals and implications of the OSO plan.

In the present phase, continuity from development into early science and regular operations is essential. This includes continuity in staffing and expertise, informing and engaging the community and ensuring a vibrant scientific community at the AOC.

1.4 Overview of recommendations

1. Further integrate “external” developments (CASA, SSS, OSO) in the EVLA project plan, as has been done for the correlator, including a list of (a) risks, resources, critical interfaces and (b) areas where responsibilities are unclear.
2. Develop a science driven plan for the distribution and processing of data, taking into account the balance between local processing and centralized (super-)computing.
3. Given the importance of user acceptance of the SSS tools, aim at vigorous interaction with end-users and continue working towards external deadlines (in particular making new EVLA modes available through the new tools).
4. Take explicit action on user acceptance of CASA, e.g. integrate in synthesis schools and by facilitating tutorials to interested groups and institutions.
5. Explicitly prioritize specific EVLA requirements and integrate these in the CASA planning, and couple the CASA planning more closely and explicitly with EVLA planning.
6. Secure continuity of CASA key personnel during commissioning and early science.
7. Ensure algorithms developed within the Algorithm R&D are translated into CASA pipelines in a structured way, allowing for proper verification.
8. Make supported configurations and caveats explicit in calls for proposal.
9. Establish a science based long-term observing and archiving plan taking into account the potential benefits of later scientific use.
10. NRAO needs to maintain and grow a vibrant scientific community at Socorro for the EVLA, for the project to be successful and productive.

2 Management and Project Progress

The committee was very impressed by the excellent progress achieved by the project. There is a strong and dedicated team, with a wide range of expertise in management, science, hardware and software development.

2.1 Management

The adopted project management approach is robust and adequate for the size and scope of the project. Project work packages have clear deliverables and milestones in the schedule are unambiguous. Progress tracking is transparent and consistently carried out in those areas that are under direct control of the project.

Correlator development seems well managed and on-track now, even while not being under direct control of the project. The committee is concerned that some major developments (CASA, components of SSS, OSO) are beyond the direct control of the project. This raises the risk of misalignment and decoupling, if milestones and deliverables are insufficiently aligned with the EVLA planning. The committee expects that CASA will be thoroughly tested during EVLA commissioning to confirm that EVLA science requirements are met.

1. The committee recommends a further integration of the "external" developments into the EVLA project plan, as has been done for the correlator, including a list of:
   a. Risks, resources, critical interfaces
   b. Areas where responsibilities are unclear

This will make potential problem areas visible and explicit, and will allow management to take further action if needed.

The committee strongly agrees with the PM that the success of the project is tied to continued support of both project and operations funding. With the construction project working towards completion, it has to be realized that continuity in staffing and expertise is essential for the scientific success of the EVLA. The project and observatory management established the base staffing levels for EVLA technical operations. It is crucial that this plan provides for retaining mission-critical personnel in long term.

2.2 Budget and contingency

The financial health of the project is good. The project employs the contingency as percentage of cost to complete as an indicator of financial risk. This indicator shows healthy status and development. The project currently is not considering any descope options. The committee agrees that this is not necessary given the status. No plans for using the contingency funding to speed up delivery are being considered. The committee encourages the project to consider such options when opportunities arise.

2.3 Risk management

The risk management plan seems well established and applied rigorously. The risk registry is evaluated and updated at six months intervals, which is certainly adequate for the current phase of the project. The risk register contains no showstoppers. The high-speed samplers and the selection of the X-band OMT are currently on the critical path, and receive adequate attention. The project signals a "marching army" issue in management, but this seems well under control. The committee concludes that the project sets the right priorities with an appropriate sense of urgency.

2.4 Schedule

The project is well on schedule. The committee commends the project for presenting the schedule also in a science-oriented way in the growth of the new capabilities of the EVLA:

- C band totally new without OMT
- K and Q band totally new
- Adding Ka band receivers

The Ka Band adds a completely new frequency capability to the array. It was very good to hear that several exploratory proposals have been accepted for this band.

Risks in correlator delivery schedule have been significantly reduced. First science with WIDAR should be possible in 2010Q1. Mid-2010 half of the high-speed samples should be in place, which will add wideband capabilities to the EVLA.

Twenty antennas have been converted to EVLA antennas, accounting for 71.4% of the total antenna hours used in observations. The committee commends the project on the reliable and predictable conversion and integration process. Antenna conversions are scheduled for completion in 2010Q3, receiver installation is scheduled for completion in 2012Q4. Both seem entirely realistic. There is good coordination with NRAO Central Development Labs for the delivery of the LNAs. Schedule and control is secured since two full-time technicians at CDL are paid from the EVLA project.

2.5 Lifetime cost

The project keeps 10% spares on most components. For WIDAR, 10% spare boards and 10% spare ASICs and FPGAs are kept. A detailed analysis is being made of components becoming obsolete on short notice, and measures will be taken to ensure availability. Correlator testing has a strong focus on lifetime issues, aiming at a 25Y lifetime of the system. The committee encourages the project to continue analysis and testing towards lifetime issues and cost in order to minimize surprises during operations.

3 Hardware development

The committee was impressed by the consistent and steady progress made in the hardware development and integration.

The committee highly commends the project on the progress made on the OMT development, which was a major concern in 2007. Guided by the established roadmap, the team has resolved most of the design and production issues now.

Adequate measures have been implemented for maintenance tracking. The project indicated that in retrospect, more budget should have been reserved for testing at the start. This has been sufficiently addressed in the course of the project.

3.1 Remaining concerns

There are three remaining concerns.

- Phase stability seems still not fully understood. A software change fixed a large part of the excessive phase changes with antenna elevation. The problem is to a large extent understood and calibratable. The committee nevertheless encourages the project to keep studying this issue. It would be somewhat unsatisfactory that the phase stability of the EVLA would remain poorer than that of the VLA.

- The High-Speed sampler (3-bit, 4Gsps) still has an issue with the serial-to-parallel converter on the sampler board. The issue is receiving adequate attention. The solution being currently worked has sufficient potential, and alternative (though less attractive) solutions exist. The committee encourages the project to further study temperature coefficients in the module.

- The decision for X-band OMT is still open. The project is working towards a well-founded decision between the planar and turnstile junction. It is important that producibility is being improved for both options. The low risk path seems to have higher cost, also operationally. However, this option might still turn out to be best from a science perspective, where stability is critical. The committee encourages the project to take into account the science capabilities and the potential long term advantages of adding additional cooling capabilities.

3.2 Correlator

After an internal review of the WIDAR management in February 2008, communications on managerial issues were much improved. The new WIDAR PM at DRAO, Sean Dougherty, did an excellent job in leading the project through several important milestones. Major achievements were the first fringes with the WIDAR prototype (August 2008), the successful Production Review (December 2008) and the first fringes with the subset of final WIDAR on Mar 6, 2009. The staged approach adopted by the correlator project has clearly been successful.

With this progress, risks have been significantly reduced in the past period. A clear and detailed production schedule was presented that seems secured but tight. The delivery schedule is such that first all antennas can be connected, after which baseline boards are being added to increase bandwidth. This is in line with the scientific priorities as expressed by SAGE. Production slots have been secured. The committee was surprised to see that delivery of two essential, yet rather standard components is currently on the critical path (due to government procurement rules).

The budget outlook for the correlator project is good. NRC has decided to assume the risk for currency fluctuations and for continued software development (beyond March 2011).

Software development currently seems sufficiently staffed. However, the committee is concerned on the continuity in software support and continued development during early science and operations, and encourages the project to further secure that adequate staffing and expertise remains available, also within NRAO.

The time between hardware delivery and first fringes has been impressively short. Prototype testing demonstrated the benefits of performing early hardware tests. “On the sky” tests were a critical check for hardware problems before entering full production. Even though the correlator is not fully under control of the M&C, most parts of the Virtual Correlator Interface (VCI) have been well tested. The scheme for defining modes for the correlator is not yet fully worked out, but a fall-back exists in capturing expert modes for operational use.

The remaining risk is the system level integration: handling large numbers of boards and scaling all software to system level. Software will be on the crucial path in near future. This is natural and seems well under control.

The committee commends the PMs on the good management communication, NRC on their decision for continued support, and the joint teams on the prototype and WIDAR-0 testing program.

4 Software development

The teams working on software are clearly committed to progress and realized a wide range of components for the EVLA operational software, parts of which have been in operational use now for several years. The software planning aims to ensure that configurations that become available in hardware are adequately supported in software. This is a good approach and should be maintained and further improved.

As a whole, the committee finds it difficult to judge whether targets will be met and feels that more specific planning information and progress evaluation were needed. The availability of reliable software with adequate performance for the commissioning and early science phase cannot be underestimated. The project is therefore encouraged to aim at continued improvement of the software planning and control process, emphasizing focused development, testing with science data, and user involvement. The committee remains in particular concerned on the post-processing software, as there is no fallback here: the existing packages (AIPS) will not be able to process the large data volumes that will be produced by the EVLA.

The development process uses a milestone/planning granularity of three months, which should give the project a good insight in progress, and should allows for sufficient redirection and reprioritization where needed. Configuration control is well in place, including regression tests. There is an active reuse policy, which is a good development. The reuse of ALMA storage technology and the adoption of a common data format with ALMA is a good development. The project is encouraged to continue this policy.

It was stated by the project that the biggest bottleneck is getting the data to the users. It is not yet clear how this influences the decision-making on central supercomputing *versus* local processing.

2. The committee recommends the development of a science driven plan for the distribution and processing of data, taking into account the balance between local processing and centralized computing.

4.1 Monitoring & Control

Monitor and Control software has been in operational use since 2007, when the old Modcom system was switched off. The initial disruption to be expected after such a major change was remarkably limited. The new software has been fully in operation in the complex situation of mixed VLA/EVLA antenna operations. This is a major achievement, and it is important to note that the project never reverted to the old system. M&C development now concentrates on WIDAR support.

4.2 Science Software Systems

The proposal submission tool is in use for all VLA, VLBA and GBT proposals. The Observation Preparation Tool is available, and is the only way to prepare Ka band observations. The committee encourages working towards such system level milestones, since they expose the software to external users ("firetesting"). As the project needs to take user experience into account, the committee is concerned that the present exposure to science users is still limited. Involvement of and acceptance by the broader user community is crucial.

3. Given the importance of user acceptance of the SSS tools, the committee recommends that the project aims at vigorous interaction with end-users and continues working towards "external" deadlines (in particular making new EVLA modes available through the new tools).

The Observation Scheduling Tool is in use, including dynamic scheduling. The committee was pleased to hear that the Archive Access Tool re-uses storage technology from ALMA's Next Generation Archive System, and that a standardized binary data format and science data model is shared with ALMA. The committee encourages the project to consider sharing the Source Catalog and Dynamic Scheduling tools with ALMA.

4.3 Post-Processing software

It was encouraging to see the increased management support for CASA. The committee strongly endorses the present management set-up with the EVLA and ALMA CASA managers in the same place. The committee strongly agrees with the project management that the search for a replacement of McMullin should continue. The current situation is workable for an interim period, but a full-time CASA PM for the EVLA is necessary given the importance of post-processing software. It was noted that CASA has a much better mix of astronomers and computer scientist now, which is a good development.

It was encouraging to see increased science usage. However, given the importance of science usage, the committee expected to be presented statistics: number of users, number of bug reports, time to fix, open issues. User acceptance is still a major hurdle for CASA.

4. The committee recommends taking explicit action on user acceptance of CASA, e.g. by further integrating CASA usage in the synthesis schools and by facilitating tutorials to interested groups and institutions.

CASA performance is optimized towards large datasets, which is clearly a key requirement for the EVLA. It is important that the CASA planning is well aligned with the new capabilities that will be offered by the EVLA. The committee expects that CASA will be thoroughly tested during EVLA commissioning to confirm that EVLA science requirements are met.

5. The committee recommends explicitly prioritizing specific EVLA requirements and integrating these in the CASA planning, and coupling the CASA planning more closely and explicitly with EVLA planning.

It was good to note that the PM is confident of delivery. Several independent estimations of the required resources up to completion agree. The committee wishes to point out though that it is hard to make such estimates complete and reliable. Continued attention has to be paid to planning and progress. It is to be expected that development and optimization will continue during commissioning and early science.

6. The committee strongly recommends securing continuity of CASA key personnel during commissioning and early science.

4.4 Algorithms for postprocessing

The committee was impressed by the progress in this area. It was good to see a clear focus on the EVLA needs. The activity is well-organized and addresses both the short and longer term needs. The goal for these special algorithms is to deliver them at a pace to match the science schedule on which EVLA hardware capabilities will be delivered to the community

The ultimate goal of the algorithmic research is to ensure full beam, full bandwidth, full Stokes noise limited imaging. The initial goal is to speed up efficiency by developing pipelines that exploit data parallelization, and to get hardware requirements for a processing cluster. It was good to hear that the EVLA project takes the responsibility for the process and purchasing of the computation power needed for Early Science.

New developments in imaging will focus on the integration of the W-term, primary beam corrections, etc, allowing to handle wide(er) fields in full polarization. In addition, better scale-sensitive (multi-scale) deconvolution schemes will be studied. New developments in computing will be studied as well, e.g. OpenMP to exploit multi-CPU/core computers, and robust pipelines for e2e processing.

7. The committee recommends that the project defines procedures and allocates resources to ensure that the transition of algorithms into CASA pipelines does indeed happen, is properly verified, and is coordinated with the commissioning of science capabilities.

5 Commissioning and early science

5.1 Commissioning results

The committee was impressed by the performance demonstrated.

The committee was especially pleased to see that Tsys at the higher frequencies exceeds specifications. The limiting in Aeff seems to be caused by the panels. Cross polarization seems to be well understood; in particular the stability (which is indeed the critical factor here) looks good based on C-Band imaging of NGC7027.

Bandshape measurements show no saturation effects due to RFI, apart from the case of direct pointing at a satellite. The provided headroom is apparently sufficient (but necessary!). The correlator has sufficient linearity and channel separation to allow for post-correlation removal of narrow band RFI. In the plots shown, there was no sign of mixing with noise limited signals between RFI peaks.

5.2 SAGE

There have been two SAGE meetings. The first concentrated on explaining the capabilities of the EVLA, the second meeting resulted in a set of recommendations. These included the engagement of experienced scientists in commissioning and the preference for wide bandwidth over recirculation. The committee commends the project on adapting the correlator growth path according to the SAGE recommendations.

The Committee considers SAGE as an important body for increasing user involvement and commitment, and agrees with management that a formal response to the SAGE is appropriate. Although SAGE's concerns on post-processing software were not explicitly mentioned, these concerns were adequately addressed in the agenda for the advisory panel meeting; we suggest mentioning that in the response to SAGE.

5.3 Early Science

Well-worked out plans for the transition to Science Operations were presented, aiming at delivery in 2013 of support for essential correlator capabilities (continuum: 8 GHz, dual pol, in 64 separately steerable sub-bands, with adjustable frequency resolution) and NRAO data reduction package(s) available to the community which are capable of supporting the analysis of data obtained with the completed EVLA. It is recognized that the success of early science and in particular shared risk observing is closely coupled with the readiness of the software.

The correlator growth path will start with two basic modes at 256 MHz total bandwidth. Then bandwidth will be increased to 2 GHz (2011) and 8 Ghz (2012). Finally the number of channels will be increased by recirculation, flexibility will be increased and special modes will be added.

The initial modes significantly increase the capabilities of the EVLA. The output data rate will be an order of magnitude more than for the current VLA. As mentioned before it is essential that this data rate can adequately processed and transported (see recommendation 2).

The committee strongly endorses a much less defensive stance with respect to early science now taken by management. The project is encouraged to aggressively seek normal operations once configurations are commissioned. Evidently there will be shared risks between 2010 and 2013 for new configurations, but this needs not block "regular" observations for commissioned configurations. The committee understands the concerns of the project with respect to user expectations, but feels these can be handled.

8. The committee recommends making supported configurations and caveats explicit in calls for proposal, thus creating clear expectations towards science users.

The Resident Shared Risk Observing program is fully appropriate, and it is encouraging to see the amount of applications. The committee encourages advertising the RSRO on AAS.

A vast fraction of the science will be done using pre-selected configurations. Therefore robust support for those configurations should be top-priority. The project presented a good growth-path for correlator capabilities. The committee encourages the project to turn these into new pre-selected configurations in close consultation of the user community.

This will enable a more uniform and accessible archive that will maximize scientific yield beyond the original proposals ("maximum greediness mode").

9. The committee recommends establishing a science based long-term observing and archiving plan taking into account the potential benefits of later scientific use.

Of course this should not block users from using novel configurations as dictated by specific scientific needs.

6 Science Operations plan

Preliminary concepts for the integrated observatory model (OSO) were presented to the committee. Aims of OSO are easier access to the NRAO observatories through a uniform interface, an increased operational efficiency by centralizing certain shared functions, and an optimal leveraging of resources also over time. This model has some opportunities, especially in releasing resources for shared software development for ALMA and EVLA.

The committee was relieved to hear that NRAO management is not aiming at a centralized operation of all NRAO telescopes and that professional local observatory staff will maintain the ability to specialize to push the limits of the instruments.

10. The committee strongly recommends NRAO to maintain and grow a vibrant scientific community at Socorro for the EVLA, for the project to be successful and productive.

The committee is concerned that it is currently not clear how OSO relates to earlier initiatives (in particular e2e), and how current users will be involved in the definition and implementation. User involvement, an "outward" rather than an "inward" process, is essential in establishing the concepts of OSO. Experiences of committee members with centralizing models are not at all encouraging. The committee strongly encourages careful planning, in close collaboration with AOC management and staff and with the NRAO user community to secure and advance the success of the EVLA.

The advantages of uniform interfaces should not be overestimated: they can easily lead to a decreased "user experience" if performance is less than with the existing, non-uniform approach. A single interface to the NRAO archives, on the other hand, would be very scientifically beneficial. The recent experience with CASA shows the success of a focused approach *vis a vis* a too generic model.

Additionally, members noted the importance of NRAO continuing to have synthesis workshops in the future. While we thoroughly support the drive of NRAO to simplify interferometric observations for users (of ALMA and EVLA), nevertheless we feel that observers will need some understanding of radio interferometry to make full use of their data and the training of graduate students in radio interferometric principles is a critical role that NRAO provides for the community.

7 Science vision

The EVLA will be a transformational instrument. The committee encourages the project to start developing a high-impact science vision now, to take full advantage of these transformational capabilities. The committee understands this has been difficult so far due to the pressure of the immediate project concerns.

As a first step towards maximizing the scientific potential of the instrument, the committee strongly encourages AOC to carry out high-impact observatory based demonstration science. This will advertise the capabilities of the EVLA and further engage the community. Such observatory based science programs should not be confused with e.g. large surveys, but should be designed to provide high visibility to both the astronomical community and the general public as to the scientific capabilities of the EVLA. We further recommend that these observations be undertaken in collaboration/consultation with the NSF.

The committee advises NRAO in general to provide scientific guidance to the community, both in terms of demonstration science and in keeping/developing a strategic vision beyond PI driven science. We realize this would be a major change in NRAO's practice, where the staff scientists are largely focused on "pushing the envelope" projects. These are also necessary to move the observatory forward, but have by their very nature less focus on maximizing science return. We advise to take both focus points in view: pushing instrument capabilities to the limits, and providing scientific observations and end products of high quality and high fidelity beyond the specific request of a PI. We acknowledge that this bifocal approach will require additional resources to implement. Specifically, NRAO will need to provide oversight of PI based science programs to ensure that observations are carried out in a manner that will benefit both the PI and the larger community. In addition, additional telescope time (charged to NRAO rather than PI) may be necessary to allow for "basic" calibration beyond that required for the PI-based program.