EVLA Project Book, Chapter 13

Transition Plan

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Summary

13.1 Introduction

The current version of this chapter consists of two parts. The first part (13.2) consists of a revision of the requirements for operation during the transition phase. The second part (13.3) is the summary of the major events in our current draft of the full transition plan.

13.2 Transition Requirements

A primary requirement of the implementation of the EVLA is that the current VLA continues observing and producing forefront science during the long period of construction and phasing in of the EVLA. This requirement has been specified by NRAO Users and Visiting Committees. Although it is expected that there will be some periods when the amount of observing time is reduced, and the average number of antennas available may be less than for the nominal VLA, these periods should be minimized in order that scientific observers reap the maximum benefit from the VLA during the period between 2002 and 2010.

Here, we summarize the scientific and operational requirements for the transition from the VLA to the EVLA, as well as the plans for the transition of a few key subsystems. This section emphasizes the requirements rather than going into great detail on the transition plan for individual subsystems. More details on both the designs and the transition plans for several subsystems can be found in earlier chapters of this Project Book.

13.2.1 Scientific & Operational Requirements

We can define a series of scientific and operational requirements that will enable the VLA to maximize its scientific return while antennas, electronics, computing, and correlator are being brought up to the standards described in the Phase I proposal and in earlier chapters. These requirements have evolved via negotiation among the various divisions of the project and the scientific staff, and are stated succinctly in the succeeding subsections.

13.2.2 Scientific Availability

13.2.2.1 Stand-alone Observing

In 2001 the VLA performed scientific observing for an average of about 77% of the hours in a year. We require that the fraction of time that the array is available for scientific observing be maintained at 60% or greater throughout the transition period, averaged over periods on the order of six months to a year. A period of substantial or complete shutdown lasting not longer than three months would be acceptable, though not desirable. If it is found that a greater degree of VLA down-time during the transition period could reduce significantly the cost and/or timescale for completion of the EVLA, NRAO will solicit recommendations from its advisory committees, including the EVLA External Advisory Committee, about the proper course of action.

13.2.2.2 VLBI Observing

The VLA shall remain capable of participating in scientific VLBI observations, either as a phased array or with a single antenna, with capabilities similar to those available in 2001. If necessary, it is permissible for this capability to be removed for a maximum of two observing trimesters, or approximately eight months.

13.2.2.3 Pie Town Link Observing

Scientific observing with the VLA using the fiber optic link to the Pie Town VLBA antenna has been supported through 2006. Continued use of the Pie Town link after 2006 will be subject to future negotiation and planning.

13.2.3 Antenna and Array Availability

In the text below, "VLA antennas" refers to antennas with the existing IF/LO system communicating through the waveguide. "EVLA antennas" refers to antennas with the new IF/LO system communicating through fiber optics. An "available" antenna is defined as one that supports the full range of capabilities necessary for scientific observing, including monitor/control (M/C), round-trip phase correction, fringe rotation, the full range of delay settings, and normal VLA observing modes such as reference pointing, rapid frequency selection, and fast position switching. There is an important complication in that the EVLA antennas will still have a mix of old and new front-ends for a limited period, so the new IF/LO system must be compatible with both types of front end.

13.2.3.1 General Availability

For a number of years, the VLA operated with a "3-antenna rule," whereby loss of more than three antennas from the array of 27 antennas either for test purposes or because of "broken" antennas is unacceptable. Loss of more than three antennas during a scientific observing program constitutes sufficient cause for an after-hours callout of personnel to fix misbehaving antennas. During the EVLA construction, it is possible that subarrays of three or four antennas may be used for tests, while individual antennas also may be undergoing extensive checkout. Therefore, the 3-antenna rule may be relaxed to a 5-antenna rule; i.e., no more than five antennas may be missing during a normal scientific observing run.

Details about the exact rules for general availability during particular time periods will be established as construction proceeds and observations with mixed arrays evolve. In general, it is desirable that VLA outages for EVLA testing should take place during less desirable observing periods, such as daytime and/or bad weather, and away from “popular” Local Sidereal Times (e.g., when the Galactic Center is up). It is also permissible to create a new class of contingency observations (e.g., surveys, monitoring experiments, and observations of strong isolated point sources), where astronomers are granted observing time that can be used during tests, with the understanding that more than five antennas may be missing. The “adjacent antenna” rule, whereby the antennas adjacent to the North arm gap in C are designated as “critical antennas,” may be relaxed.

13.2.3.2 EVLA Antennas

Installation of new systems on VLA antennas will continue through 2010. During this period, it is required that the EVLA antennas be capable of scientific operation in conjunction with the "old" VLA. Thus there must be the capability to operate these new antennas with an available monitor/control (M/C) system (either "new" or "old") and to feed their data into the old (or the new, depending on final delivery schedule) correlator in such a way that the identity of an antenna as "VLA" or "EVLA" is transparent to the end scientific user.

13.2.3.3 VLA Antennas

VLA antennas must be operable by either the old or the new M/C system, with an equivalent range of monitor points and information to that which was available to the on-duty telescope operator before the transition.

13.2.4 Array Operations and Documentation

13.2.4.1 Routine Operations

During the transition period, the VLA, including both VLA and EVLA antennas, must be operable routinely by a single telescope operator, for a full range of normal VLA functions. This includes (but is not limited to) such activities as array calibration (e.g., delay, pointing, and baseline runs), holography, and all significant scientific observing modes of the VLA. Control and data output from ancillary equipment such as the Atmospheric Phase Interferometer, water vapor radiometers, ionospheric monitors, weather stations and other such devices must have at least the same availability as before the transition began. At times it may be necessary to have one operator controlling routine operations and a second operator controlling EVLA tests.

13.2.4.2 EVLA Tests

Computer-controlled tests that make use of the operable M/C system and operational VLA capabilities shall be carried out by the on-duty telescope operator. Special tests of EVLA systems will, in general, require the active participation of EVLA software and/or electronics personnel.

13.2.4.3 EVLA Documentation

The Array Operations Division shall be supplied with sufficient documentation and training so that they can operate VLA and EVLA antennas simultaneously for scientific observing, with fractional downtimes consistent with those achieved in 2001. This downtime refers to unscheduled downtime of antennas or the array, and is not to be confused with the fractional availability discussed previously.

13.2.5 Data Management and Data Analysis

13.2.5.1 Scheduling

Scientific users of the EVLA must continue to be able to create schedule files routinely for the EVLA when it contains both VLA and EVLA antennas, and a mix of VLA and EVLA receivers. Telescope parameters, available frequency ranges, and similar evolving items must be kept up to date in the software, with appropriate selections available and warnings issued about available resources. Requirements on dynamic scheduling are not yet determined.

13.2.5.2 Data Calibration

VLA antennas will continue to operate with their 19.2-Hz calibration-switching cycle. Comparable amplitude calibration information shall be supplied on-line for both types of antennas, implying that the EVLA antennas must be able to “mimic” the performance of a VLA antenna with regard to items such as noise-diode switching, Walsh functions, and fringe rotation. The Monitor/Control system must be capable of applying this information correctly from an array with mixed types of antennas.

13.2.5.3 Data Archive

The data archive shall be capable of coping with data sets that are combinations of VLA and EVLA antennas, and shall include all appropriate ancillary information to decipher the antenna properties necessary to analysis of data that are retrieved from the archive at some (considerably) later date.

13.2.6 VLA Infrastructure

EVLA activities during the transition period shall be coordinated with activities required to maintain the VLA infrastructure (e.g., track repairs and antenna painting). Systems such as the waveguide shall be maintained as required, to support scientific observing and equipment health.

13.2.7 Personnel Safety
Current VLA requirements for personnel safety (e.g., use of hard-hats and other personal protective equipment) shall be maintained during the transition period.

13.2.8 EVLA Test Antennas
There is a general desire to have two EVLA test antennas. This is subject to the "5-antenna rule" discussed above in Section 13.2.3.1. If the EVLA Project decides that three or more test antennas are needed, the 5-antenna rule and related parts of the transition plan will be opened up for further discussion.

13.2.9 Electronics Plan

13.2.9.1 EVLA Antennas with VLA Correlator
The signal from an EVLA antenna will be input to the old VLA correlator by taking a wideband digital IF from the EVLA antenna and reconstituting an analog IF using a narrow-band, multi-bit digitizer in the VLA control building.

13.2.9.2 New/Old IF/LO Systems
The IF/LO/FO systems in VLA antennas will be modified in the antenna barn during the period from 2004 through 2010, with approximately four to six antennas modified per year, depending on the funding rate. These antennas will enter the barn as "VLA antennas" and leave the barn as "EVLA antennas" (see definition in Section 13.2.2).

Fringe rotation on the EVLA second LO will have sufficient range and accuracy to provide the fringe-rotation rates required for the old correlator, at the longest baselines and at frequencies up to 50 GHz.

13.2.10 Monitor & Control Plan
A crucial part of the transition plan is the need for the new M/C system to provide sufficient monitor and control capability simultaneously for both VLA and EVLA antennas. A first step in this regard is the complete replacement of the current Modcomps, the correlator controller, and the 9-track tape recording of real-time data. Details are presented in the M/C Chapter.

13.2.11 Correlator Plan
The new WIDAR correlator will be supplied by the DRAO, under funding by the Canadian National Research Council. The general plan is to install the new correlator in the tape/computer/electronics room located immediately to the east of the VLA Control Room. By doing so, it will be possible to run both the old and the new correlators contemporaneously (i.e., the old correlator will not have to be removed in order to install the new correlator). This should enable considerable testing in place, and may prevent a long downtime that would be required if one correlator were to directly replace the other. Note that there is no requirement that the two correlators be fed in parallel (i.e., with data acquired at exactly the same time and split into two simultaneous paths). However, it should be possible to switch between the correlators on a time scale of a few minutes or less, so that comparisons can be made under similar weather conditions. See the Correlator Chapter for detailed schedule for the correlator development and delivery.

13.2.12 Interim Operations Plan
Interim operations for the EVLA will depend critically on the status of the M/C and Data Management developments, as well as any decisions to be made about reduced observing and increased test time. It is expected that considerably more test time (and less scientific observing) will be made available during daylight working hours. In the early years of the EVLA project, this time will be dominated by tests of the new M/C system and the EVLA antennas (including LO/IF/FO capabilities). In the last several years, tests involving the WIDAR correlator are likely to dominate.

13.3 Transition Schedule

13.3.1 Assumptions and Requirements

The transition plan schedule is based first on the hardware milestones. If these milestones slip in time, then the other parts of the transition plan will slip in a corresponding way. Second, the transition plan depends on the availability of the necessary software at the time it is needed. Third, the plan is based on the necessary personnel being available throughout the plan. Fourth, even if the first three requirements are met on time, the plan must be a living document since we continue to learn more details about EVLA, as we build it.

13.3.2 Hardware Milestones

The number of available antennas and the availability of the WIDAR Correlator drive the transition plan. Some key milestones are given below:

- Jan 2007: Seven EVLA antennas/twenty VLA available
- Jul 2007: Prototype WIDAR Correlator on-the-sky testing
- Jan 2008: Thirteen EVLA antennas/fourteen VLA antennas available
- Apr 2008: First part of Final WIDAR Correlator available at the VLA (earliest possible date)
- Jan 2009: Eighteen EVLA antennas/eight VLA available
- Jan 2010: Twenty-four EVLA antennas/two VLA available
- Mar 2010: Full WIDAR Correlator Available
- Jul 2010: Twenty-seven EVLA antennas available
- Oct 2010: Twenty-eight EVLA antenna completed
- Dec 2012: Final EVLA Receiver Installed

It seems prudent to make our plans based on the fastest timescale possible for the hardware. However, we need to remember that any changes in this hardware plan will require changes in the rest of the transition plan.

13.3.3 Science Goals

Based on the accelerated hardware plan in 13.3.2, we can lay out a set of goals for the scientific commissioning and first science with the EVLA.

- Feb 2007: Begin to offer outside users the new frequencies on EVLA antennas with the old correlator
- Jul 2007: Begin Testing of Prototype 4 Station Correlator
- Apr 2008: Begin Science Commissioning
- Jan 2009: Begin Early Science Observing
- Mar 2010: Begin Open “Shared-risk” EVLA Observing

In July 2007, we expect to have the 4-station prototype EVLA Correlator at the VLA. Initially, this system will only have a small fraction of the channels and bandwidth of the final system. It is intended to test the WIDAR concept. However, it can be reconfigured so that we can begin to do test on basic calibration modes. We have no plans to offer this system as a user facility.

Also in early 2007, we expect to offer the user community some new capabilities by using the new EVLA receivers and much larger tuning range with the old VLA correlator. The first bands available will likely be K and Q which will have only small extensions of the currently available turning range on eight EVLA antennas. However during 2007 the situation will improve. By the end of 2007, nine to thirteen EVLA antennas will be available in L(1-2 GHz), C(4-8 GHz), K(18-26.5 GHz), Ka(26.5-40 GHz) and Q(40-50 GHz).

At the end of the first quarter of 2008, the current WIDAR plan is to install the first boards of the final correlator at the VLA. These boards will be from a limited production run, planned to test the WIDAR concept with the final board design. Extensive tests with these boards will take place in Penticton, before they arrive at the VLA site. Such a system will provide 8 GHz of bandwidth (out of 16) for eight antennas and somewhat less bandwidth for sixteen antennas. When this system is installed and working, we plan to begin our serious commissioning efforts. The goals will be to test the hardware, and the post-processing software, and to define and document a limited number of observing modes which could be offered to a broader group of astronomers for initial science. We think this will take at least nine months.

During 2008, we expect to begin using the EVLA antennas extensively with the WIDAR correlator. During the year, the number of available old-style VLA antennas will drop from fourteen to nine. This timeframe may present the opportunity to use the old antennas in novel ways, perhaps for transient searches or other projects requiring a lot of telescope time but not the full array. The practicality of such a VLA-antenna-subarray will depend on the details of the EVLA schedule. Depending on demand, we can also continue to use all the antennas (EVLA+VLA) antennas together with the old correlator. If all goes well, 2008 should be a year of transition from the old VLA to the EVLA.

In early 2009, we hope to begin some very limited, early science observing using the WIDAR correlator. Exactly what this means still needs to be defined in detail. In the very beginning this may mean that our staff will carry out some projects which have been approved by the community and the resulting images placed on the web for general use, as was the case for HDF and the NVSS projects. Another possibility is to involve outside astronomers who are willing to come for extended periods (months?) to Socorro to work with our staff on bringing up the EVLA as a User instrument. As part of this process some limited individual research would be done. Perhaps we would do both of these. The goal would be at the end of this initial period to have developed procedures which would allow the broader community to be able to use EVLA and to get a taste of what the instrument can do.

By January 2009, the number of available old-style VLA antennas will have dropped to eight and by January 2010 to two. Sometime during this period it is likely we will want to stop using the VLA antennas for research, shut down the old correlator and concentrate on EVLA. By early 2010 we should have finished commissioning the WIDAR correlator, although we will still be learning how to use its capabilities effectively. At this time, we hope to begin open, ``shared-risk'' observing. We also need to define exactly what ``shared-risk'' means. At the beginning of this period, it may be necessary for astronomers who have not used EVLA to come to Socorro to learn new techniques. Many astronomers may also not have the computing resources at home to deal with the 1000X increase in data and the new algorithms. We are not sure of the details of this period of early, general operation.

From this stage we hope to transition smoothly into routine operation which we might expect to begin in mid-2010 when we finally get the twenty-seventh EVLA antenna. However, not all the EVLA receivers will be available until the end of 2012. Also number of available WIDAR correlator modes is likely to grow for a few years. Thus, like the early VLA days, we expect new capabilities to continue to appear until at least 2013.

This plan assumes that the schedules will be met and the resources made available at the times they are needed. Even then, the job to be done is challenging but it seems possible if all goes well. This plan also requires a lot of resources which are not automatically available. Certainly software development is a key. Right now it appears that we will have only enough software programmers to carry out a minimal version of the plan. We also do not have enough astronomical staff to obtain all the goals we have described here. Starting in 2007 we need a significant increase in scientific staffing to reach our goals. We also need to attract radio astronomers from outside of NRAO to spend significant time as part of the project in 2008/2009 to make the project a success as quickly as we have described here.

13.3.4 Computing Transition Plan

As this version of the transition plan is being written, a comprehensive computing plan for EVLA, including all aspects of post processing, e2e, and the needed computing hardware is still being developed. The internal process to achieve this goal is well underway with very useful, positive discussions taking place at the scientist/programmer level. However, a complete plan still needs to finished and approved by management and our advisory committees.

13.3.4.1 Post-processing

Besides the hardware, the necessary software also needs to be available for the science plan to proceed. The most important thing we need is software and computing hardware which can be used for commissioning the EVLA + WIDAR correlator, starting in 2008. This requires a new imaging algorithm which can handle the wide-band, narrow-field case for continuum. By 2010 we need a wide-band, wide-field algorithm. Right now we have no way to image wide-band data. Without such algorithms we will be unable to take advantage of the increased sensitivity that the EVLA hardware can deliver. There are some good ideas about how to handle the wide-band, narrow-field problem. A simulation has recently been produced using the promising concept. For the wide-band, wide-field problem there are some more general ideas but more work is needed. Wide-band continuum imaging is the most important outstanding problem for EVLA which lacks a well understood technical solution and needs to have top priority.

In 2007, we also need a basic post-processing system which will allow at least the in-house users to begin exercising the WIDAR correlator. In the first half of 2007, we plan to use AIPS to carry out the first tests of the prototype correlator. During the second half of 2007, we plan to develop the software procedures for external calibration of EVLA data which we hope to do in the CASA package. The development work for the wide-field, wide-band imaging is taking place in CASA and so that package will likely be the first place where such imaging is possible. On the other hand, auto-flagging development is currently taking place in AIPS. Given the strengths of the developers working in both packages, it seems wise at this time to keep both paths open. Unlike in the past, both groups are working with one another and algorithms can be developed in one package and then, if desired, ported to the other package. As we move closer to the EVLA commissioning and later to the telescope being available to the entire community, we may pick one or the other package to emphasize. We may also want to combine the two systems under a single framework and user interface so that from the user's point-of-view AIPS and CASA are one package. These ideas are being discussed and developed but for the time being we plan to make use of both packages for EVLA, at least during the transition phase.

13.3.4.2 E2e

In addition to the post-processing, an e2e plan does not exist which clearly fits in to the budget. In this case the problem is having enough personnel. A basic plan has been developed as to how to reach the minimal e2e plan described in the phase I proposal. This requires some additional programmers very soon. As a fall-back, we can operate the EVLA in the same manner as the VLA with some enhancements.

However, there is also a desire to provide services at the level that have been planned for ALMA. This takes significantly more personnel in the ongoing operations budget after 2010, perhaps eight more employees. This requires significant new operating money in excess of the 2000-level budget.

13.3.4.3 Hardware

Besides the software, it seems likely that a computing cluster will be needed to process the large volume of EVLA data, at least in the larger configurations. A large memory may be as important as the multiple processors. This may be needed sometime in 2008 when we start to have the potential to do the science promised by EVLA. There is money in the budget for this but a detailed plan for how and when this money would be spent needs to be developed. Such a computing system may also change the nature of the operation in the AOC.

In order to process the large A-array datasets, the computing cluster may need to sit next to the archive (or a least one copy of the archive). The most practical configuration is probably that both sit in the AOC. If the real-time processing goals of the EVLA are to be met, this probably requires a wide bandwidth fiber connection between the AOC and the VLA site. The bandwidth could come from a standard commercial fiber rental or a fiber we own or rent and equip with our own electronics. A backup hard disk system would also record a copy of the data at the site in the same format as the final archive. Thus, if a failure occurred in the fiber or if an unusual experiment required a greater data-rate then the site disk copy could be physically transported to the AOC for processing.

In this model, the archive/computing cluster then would be the heart of the EVLA imaging system. In 2008 or 2009, it may be possible to purchase a standard, out-of-the-box cluster computer which will handle the EVLA phase I problem, using parallel processing. However, it may be that the required system will be more like a correlator than a single computer, i.e. one designed with our special purpose needs in mind, possibly with FPGA processors added to the individual CPUs to speed up the most time-consuming steps in the image making. A more detailed hardware plan for EVLA postprocessing needs to be developed.

13.3.5 Operations

13.3.5.1 Telescope Operations

During the transition, operations must change from regular VLA operations in 2006, to Interim operations using both old VLA and new EVLA antennas with the old correlator, to EVLA and/or Interim VLA operations in 2008, to full EVLA operations in 2010. This will require a great deal of interaction between the software and operations personnel.

During 2006-2009, the plan is to continue operations activities at the VLA site as we have done for almost thirty years now. However, in 2010 when the changes have settled down the plan is to move the telescope operators to Socorro, except during a 40 hour work week when the day crews are working at the VLA site. This will require higher bandwidth fiber communications with the site and a backup at the site if those communications should fail. This should allow the number of operators to be reduced somewhat due to having VLA/VLBA/VLBA correlator operations in the same location. It may also be possible to locate more of the computer hardware for VLA Monitor and Control at the AOC, which will make maintenance easier and cheaper. These options will continue to be reviewed as the project progresses.

13.3.5.2 AOC Operations

Besides eventually having EVLA operations in the AOC, the nature of what goes on in the AOC will likely change. For many projects the uv data volume is likely too great to ship to the individual user. The calibration and imaging techniques will also be new and evolving with time. Thus in the early days of the scientific use of the EVLA, the astronomer will probably need to come to the AOC to reduce data or possibly control the processing from a remote site of the Internet. The ultimate goal of EVLA is to be able to process the data into images in a semiautomatic pipeline and then let the astronomer retrieve the images from the archive over the Internet. However, doing this will require a learning process that in the early days will likely need to take place at the AOC.

Thus, in the 2008-2012 time-frame, the AOC may need to become the main processing center for reducing EVLA data to images, either with the astronomer in the loop or automatically depending on the problem and how far in the learning process we have advanced. This means that we need to review how to provide the infrastructure and office space to allow for a significant increase in visitors especially in the 2008-2009 time-frame.

13.3.6 Scientific Staffing

The original concept in the 2000 proposal for EVLA included the contribution of the functional support time from five VLA scientific staff a year to the project. Since EVLA was going to be the main development project for the

AOC, this seemed like a contribution we could afford. This level of contributed scientific staff effort also is an approximate average over the life of the project. In practice, since 2000, the size of the AOC scientific staff working on VLA/EVLA has decreased, due to a number of causes. Up until FY06 we could tolerate the decrease since in the earlier EVLA years, relatively little scientific staff support was essential. In 2006 we have been helped by the delay in the proto-type correlator until 2007. However, this delay and the deferred tasks from earlier years due to lack of astronomical staff now is coming back to bite us. We have a major staffing shortfall for the remaining years of the project. Astronomical staff is needed for hardware testing/commissioning, developing software requirements, advising non-astronomical e2e developers, developing new observing procedures, testing/advising the postprocessing development, documenting EVLA for outside users, and teaching experienced Users how to use EVLA. Given the other ongoing support functions for VLA and EVLA, we are 7-8 people short for 2007 and perhaps 9 in 2008-2010. For some of this work we could use NRAO postdocs if such positions are funded. However, most of the work requires astronomers who are very experienced with the VLA or other such instruments. We clearly need some permanent staff but, we also could use astronomers from outside of NRAO who could come for a year or more to help out.