11. OPERATIONS AND MANAGEMENT - SOFTWARE

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Revision history

2001-July-18: Initial version 1.0 by Tim Cornwell

2003-August-25: Version 1.1 by Gustaaf van Moorsel

2004-November-10: Version 1.2 by Gustaaf van Moorsel

11.1 Summary

Originally planned to be part of the NRAO-wide End-to-End project (e2e) of the Data Management Division, following the September 2003 reorganization e2e deliverables for the EVLA (see 0 for an overview) have become the responsibility of the EVLA project itself. The overall EVLA software design, presented in June 2004, adheres to the NRAO Observatory Model in which subsystems shared by all NRAO telescopes are separated from those that are instrument-specific.

11.2 Overview of Deliverables

For the EVLA, the software to be delivered must be able to handle:

1. Proposal Preparation, Submission and Handling
2. Observation Preparation
3. Observation Scheduling
4. Data Archive
5. Image Pipeline
6. Data Post-processing

These are to be treated as a whole, so that information flows through the above steps without loss due to e.g. format changes, omissions, etc. In addition, each of these deliverables must interact closely and seamlessly with the Monitor & Control (M&C)

effort which is covered in Chapter 10. For some deliverables, such as Proposal Preparation, interaction with M&C will be modest; for others, such as Observation Scheduling and Data Archiving, interaction will be frequent and intense. A more detailed description of each of these deliverables is given in Section 0.

11.3 Requirements

During 2002 and much of 2003 a number of e2e requirement documents was written. Each document contains the requirements on the e2e software from a particular point of view, e.g. Scientific, Operations, etc. The currently available list of requirement documents is:

- Operations
- Engineering
- Scientific
- Real-time
- Post-processing

Each requirement is given a priority and a timescale for completion. The EVLA Software Systems Requirements Specification document (reference 7) summarizes and re-orders these requirements according to e.g. external interface, functional, and performance requirements.

11.4 Description of Deliverables

The six main categories of e2e deliverables are described in more detail below. In the following, we report on their current status, general priority, and timeline. A number of further e2e tasks, which have substantial overlap with M&C and do not clearly belong in any of the main categories, is listed in Section 0.

All these deliverables are described in much more detail in the EVLA high-level software design document (ref 8).

11.4.1 Proposal Preparation, Submission, and Handling

The proposal submission software allows scientists to submit proposals to the EVLA, ensuring that the information necessary to the review of the proposal is included and, as much as possible, is correct. An observer will use the proposal submission software to construct, verify, and submit a proposal for the EVLA. This may be done collaboratively with other scientists at other locations

It does not require detailed descriptions of the observations, nor does it have capabilities for detailed planning of observations (both responsibilities of the Observation Preparation software). However, in many cases, it will be possible to derive a workable description of the observation from the information in the proposal alone. This description may then require substantial subsequent modifications.

Work on an NRAO-wide proposal system has been underway for some time. It is our intention that this proposal tool will be used for all current and future NRAO telescopes. Most of the user inputs are independent of the instrument observations are proposed for: all instrument-dependent inputs are concentrated in one input page. Adding support for a new instrument then means modifying only that one page. At this point most of the effort is focused on a working proposal tool for the GBT; adding support for the VLA and VLBA is planned for 2005, and for the EVLA after that. The underlying architecture of the NRAO proposal tool has been agreed upon with the ALMA IPT responsible for developing an ALMA equivalent, leaving the possibility for code sharing wide open.

11.4.2 Observation Preparation

The observation preparation software allows description of observations to be made with the EVLA, and is a natural successor to existing tools such as observe and JObserve. The key innovations over the existing software will be:

1. It will provide a sufficiently high level description of the observation that the pipeline can derive suitable processing heuristics. Alternatively, the Observation Preparation software will contain instructions to the pipeline.
2. Eventually, it will be able to drive observation planning software

The output of the Observation Preparation Software will be Observing Blocks, which form the input to the Scheduling Software. The core of each block consists of a Jython observing script which communicates directly with the antenna control computer.

11.4.3 Observation Scheduling

The Observation Scheduling Software allows NRAO telescope operators to schedule a telescope from Observation Descriptions in the form of scheduling blocks created by the Observation Preparation software. Telescope operations staff will receive these scheduling blocks and feed them to a queue for subsequent observation. This queue may be dynamically scheduled or fixed order. The Observation Scheduling Software is not controllable by an observer but the current queue may be viewed by anyone.

Work on telescope scheduling software had already been ongoing as part of the Data Management e2e project, and it is expected that EVLA scheduling software will be able to benefit from these efforts. As with other e2e deliverables, we intend to coordinate with ALMA efforts in this area.

11.4.4 Data Archive

The archive system allows interactions with the archive, including submission, querying, distribution requests, *etc.*

A telescope control system may submit data to be archived, or a request for some archived data. A scientist may submit a query to a catalog or a specific distribution request.

The archive will have to contain scientific (visibility) data, calibration data, and monitor data. The Scientific Requirements state a Dec 2007 beta version delivery for visibility and calibration data, but archival of engineering/monitor is needed much earlier. At this time we are already successfully archiving monitor data from the EVLA test antennas. Tools to search and view the contents of this database are in place.

11.4.5 Image Pipeline

The Pipeline system allows submission, monitoring, and interaction with a pipeline reduction system in AIPS++.

A pipeline may run in a variety of contexts:

- In a user's desktop machine,
- In a user's personal network,

- In a dedicated telescope-based network,
- In a Grid.

It is important that the pipeline run the same software as that used for interactive data reduction, in this case AIPS++. The pipeline is split conceptually into *mechanism* and *heuristics.* The pipeline heuristics are rules to help in the processing of observations on the pipeline. They are driven by the data itself, pipeline processing parameters, and meta-data. EVLA specific heuristics will have to be developed.

As with the Post-processing software (see below), most pipeline related development has been focused on ALMA. After this time the EVLA project will be in a position to benefit from the experience gained by ALMA, and start developing its own version, applying its own requirements as set forth in the various requirements documents.

11.4.6 Post-processing Software

Post-processing software will be delivered by the AIPS++ Integrated Product Team (IPT) of the Interferometry Software Division (ISD). Until the middle of 2004, the effort was focused on ALMA acceptance testing in July 2004, with no attention to EVLA-specific applications. ALMA acceptance testing concentrated on three main aspects: robustness, speed, and completeness. The fact that AIPS++ passed the test in all these three areas is expected to benefit the EVLA as much as ALMA. The EVLA will require significant instrument-specific application development which is of lesser importance and interest to ALMA. These areas include:

- Wide field imaging
- Wide band imaging
- RFI

In the fall of 2004 one FTE in the AIPS++ group was reassigned to EVLA specific applications; we expect to add additional manpower in the beginning of 2005.

11.4.7 Intersections with Monitor and Control

There are a number of places where Monitor and Control and e2e intersect. Such software elements are hard to categorize as either e2e or M&C. It is in addressing these issues that a structure stimulating closer contact between e2e and M&C can be particularly effective. In other cases, the M&C system may impose a much earlier completion date than the one given in the current requirements documents. A current list of issues:

- Control Scripting Language. This is an important element of the e2e Observation Preparation Software, but has become the M&C group's responsibility. This issue needed to be settled during the past year since it is needed for pointing the test antenna. Eventually, Jython (Java-Python) was selected.
- Wrapper for the CALC program. CALC is used to provide the interferometer model to the correlator; it was implemented during 2003/2004 in time for pointing the test antenna.
- Real-time Calibrator Analysis Tool (RTCAT). RTCAT accepts the visibility data for calibrators as input and provides complex antenna gains as output. It will be required in a number of important observing modes, such as reference pointing, auto-phasing for VLBI, data quality displays, and determination of focus parameters. If we wish to retire the Modcomps in Q1 or Q2 2005, then a subset of the full RTCAT functionality as specified in the EVLA e2e Science Software Requirements document will be needed by Q3 2004 or early Q4 2004. The next date after Q3 2004 is the need to support the prototype correlator, which is scheduled to arrive in Q1/Q2 2006. RTCAT must function as a real-time or very near real-time element. Since it may be impossible to obtain current visibility data from the archive quickly enough, a fast path for getting data to RTCAT and the results from RTCAT to the EVLA M&C system may be needed.
- Visibility Data Archive. According to the Scientific Requirements this is needed by Q2 2007. Other drivers call for an earlier delivery date: Retiring the Modcomps (implies archiving the output of the current correlator), capturing the output of the prototype correlator (Q2 2006), and archiving the output of the first functional fraction of the WIDAR correlator (Q3 2007).
- Quick-look pipeline tool. One requirement of the EVLA e2e Science Software Requirements document states "The time-lag between when data is collected by the real-time system and when it is available to the Quick-Look Pipeline Tool should be less than 30 seconds. This may guide a decision on whether data is all archived first, and then retrieved from the archive into the Tool, or fed directly from the real-time system into it". This requirement may force us to abandon the

simple model that visibility data goes only to the archive and that all needs for visibility data are satisfied by the archive.

- Astronomer's Status Display.
- Data from the correlator back-end (a M&C effort) will have to be fed in to the science archive (an e2e deliverable). Issues regarding data format will have to be resolved and be in agreement with the Science Data Model (0).

11.5 E2e oversight committee - Standard Models

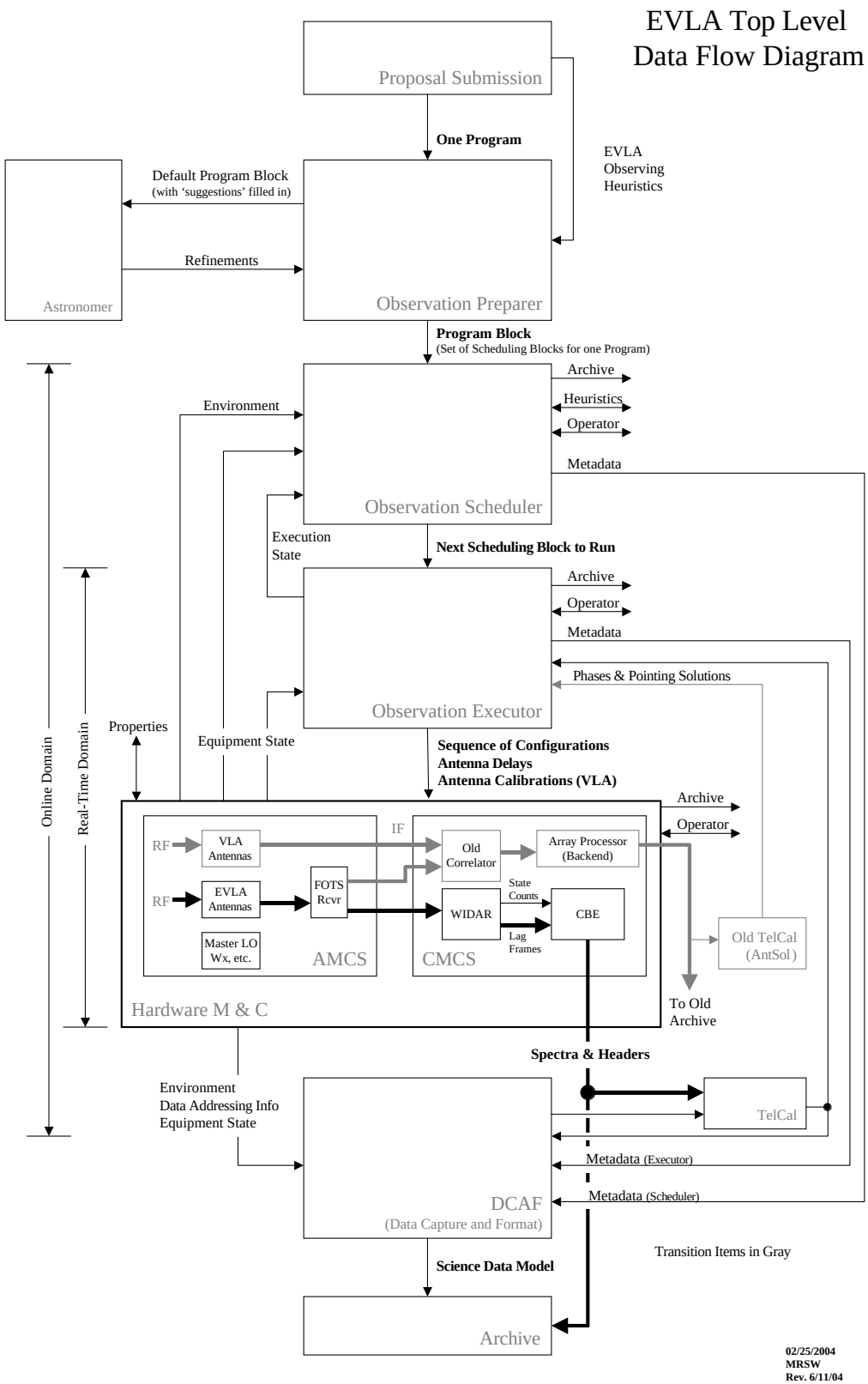
The e2e oversight committee, created in early 2004, and with representation of all NRAO telescopes and projects, has developed a number of standard models all current and future NRAO telescopes need to adhere to if there is any chance of code reuse between these telescopes. These are:

- Observatory Model
- Observing Project Model
- Observing Model
- Science Data Model

11.6 Overall Design

Following the creation of the EVLA computing division in September 2003, an overall design team was formed in December 2003 with the charge to produce an overall design for end-to-end EVLA computing within 6 months. Through a series of intermediate, monthly, reviews with participation by other NRAO projects, the overall design was presented to the e2e oversight committee in June, 2004. The top-level EVLA data-flow diagram is shown in the following diagram, which is fully consistent with the Observatory Model and the Project Model agreed on by the e2e oversight committee.

Lack of e2e manpower devoted to the EVLA, and the overriding priority of concluding phase 1 of the transition plan forced us to postpone the next logical step, detailed subsystem design, until after the conclusion of this phase 1 in early 2005.


EVLA Top Level
Data Flow Diagram
Proposal Submission
One Program
EVLA
Observing
Heuristics
Default Program Block
(with 'suggestions' filled in)
Refinements
Astronomer
Observation Preparer
Program Block
(Set of Scheduling Blocks for one Program)
Archive
Heuristics
Operator
Environment
Metadata
Observation Scheduler
Execution
State
Next Scheduling Block to Run
Archive
Operator
Metadata
Phases & Pointing Solutions
Observation Executor
Properties
Equipment State
Sequence of Configurations
Antenna Delays
Antenna Calibrations (VLA)
Online Domain
Real-Time Domain
Archive
Operator
IF
RF
VLA
Antennas
RF
EVLA
Antennas
FOTS
Rcvr
Master LO
Wx, etc.
AMCS
Old
Correlator
Array Processor
(Backend)
State
Counts
WIDAR
CBE
Lag
Frames
CMCS
Old TelCal
(AntSol)
To Old
Archive
Hardware M & C
Spectra & Headers
Environment
Data Addressing Info
Equipment State
TelCal
Metadata (Executor)
Metadata (Scheduler)
DCAF
(Data Capture and Format)
Transition Items in Gray
Science Data Model
Archive
02/25/2004
MRSW
Rev. 6/11/04

11.7 Timeline

The due date for the various subsystems is determined by the timeline of hardware availability. The following table lists the major subsystems and the target dates for completion of the various intermediate releases. One of these targets, producing a first release for the monitor data archive, has already been met.

subsystem	first release	beta release	final release	driver	date
proposal tool	Aug-06	Aug-07	Mar-08	shared-risk science	Mar-08
observation preparation	Dec-06	Mar-08	Mar-09	full science observing	Mar-09
scheduling	Dec-07	Mar-09	Dec-11	full science observing	Mar-09
monitor data archive	Mar-04	Jun-05	Dec-05	multiple antennas available	Mar-04
science data archive	Dec-05	Mar-08	Mar-09	shared-risk science	Mar-08
pipeline	Mar-08	Mar-09	Dec-11	end of construction	Dec-11

11.8 Personnel Resources

Most staff in the e2e group of the EVLA computing division is assigned to more general tasks which date back to their membership of the data management division. As a result, the Division currently (November 2004) has only 1.5 FTE available to work on EVLA-specific e2e issues. This 1.5 FTE is currently devoted to certain aspects of phase 1 of the transition plan and further development of the monitor data archive. It is our intention to gradually reduce non-EVLA work to the extent that we will have 3 FTE's available in 2006 and beyond.

This is still insufficient to complete all priority 1 items and most priority 2 items in the EVLA requirements documents. A requirements study conducted earlier this year concluded that at least 6 FTE's are needed each year for the duration of the project to deliver basic e2e capabilities. This study assumed the code would be shared with ALMA wherever possible.

11.9 References

1. EVLA Array Operations Software Requirements
   (http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/array-sw-rqmts.pdf)
2. EVLA Engineering Software Requirements
   (http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/engr_requirements_2003aug06.pdf)
3. EVLA e2e Science Software Requirements
   (http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/evla_requirements_15apr03.pdf)
4. EVLA Real-time Software Requirements (*reference still to be added*)
5. EVLA Post-processing Software Requirements (DRAFT)
   (http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/evla_offline.pdf)
6. e2e Project Book (http://www.nrao.edu/e2e/documents/e2eprojectbook.doc)
7. EVLA Systems Requirements Specification
   (http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/evla_srs_1.pdf)
8. EVLA High Level Software Design
   (http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/swdesign_1.0.pdf)