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EVLA Array Operations Software Requirements

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Contents

Introduction

Purpose

The primary goal of this document is to provide a complete and accurate list of requirements for the software tools needed by EVLA array operations to fulfill its mission. Array operations is tasked with operating the EVLA in a manner that supports the scientific work of the EVLA, ensures the safety of the equipment and people working on the equipment, and assists technical groups in maintaining peak instrumental performance. Array operators, as well as engineers, technicians, software developers, scientists and other authorized users must have a means to interact with all EVLA equipment and system parameters necessary to acquire and process the astronomical and test data produced by the EVLA. This equipment includes any modules at or associated with the EVLA antennas with monitor and control points, equipment and output associated with the correlator, modules associated with the weather station, with timing, with the Atmospheric phase interferomter, the water vapor radiometers and equipment used to measure RFI. For simplicity, the software tools to do this will be grouped and referred to as the EVLA Operational Interface. The interface is assumed to be a graphical user interface (GUI).

The primary audience of this document includes, but is not limited to, project leaders, the designers and developers of the system and the end user. The document may also be of interest to EVLA project scientists and engineers or as a reference for individuals involved in similar projects with similar requirements.

Functions

The following lists the general functions the Operational Interface will provide:

- The ability to monitor the status and overall health of the array, antenna components, and the correlator. The Operational Interface will supply the array operators and other users with high-level and low-level monitoring abilities. High-level displays will provide information on the overall health of the array whereas the low-level displays will give detailed information on specific components within the system. The displays will be composed of textual and graphical components and use color and audible alerts to inform the user of unexpected events and conditions. The number and exact types of displays are unknown at this time.
- The ability to control certain aspects of an antenna, subarray, the entire array, and the correlator. Displays within the Operational Interface will allow authorized users to control all or parts of the array. Control functionality will be built into the displays using GUI components (sliders, buttons, combo boxes, etc.) that accept keyboard or mouse input from the user. The number and exact types of control displays to be created is unknown at this time.
- The ability to create and manage a variety of reports, including the operator notes pertaining to particular observations (observing log). The Operational Interface will provide a tool that enables authorized users to create and send messages to a message log, presumably a database. This will replace and expand on the functions currently provided by the observing log that is generated by the array operators using Microsoft Excel.
- The ability to view and manage users' system access and privileges. This is required for security purposes.
- The ability to view and manage observing schedules and scheduling blocks provided by e2e. The Operational Interface will allow the operator to interact with e2e tools for the purpose of managing the observations and performing tests. The operator will be able to use the e2e tools for scheduling or to use a manual mode of inserting antenna and array control files. The Operational Interface requires access to scheduling information and will need an API to the e2e project scheduling routines.
- The ability to manage system files and parameters. The Interface will provide a means for operators to update system parameters, such as pointing, delays, baselines, and to maintain a history of parameter changes.

Priorities

Each requirement within the document consists of a description, a priority and a timescale. The description specifies a function or characteristic the software must exhibit and must have a single interpretation. The priorities specify the importance of the requirement and are defined as follows:

1 = essential

2 = important

3 = desirable, but not critical

Priority 1 items must be designed and built into the software. Priority 2 items should be present, though there may have to be sacrifices in performance or availability may be delayed. The software should fulfill all Priority 1 and 90% or more of Priority 2 requirements. Priority 3 items should be considered for upgrades or development. Inclusion of Priority 2 and 3 items will also be based on time and budget constraints.

The timescale of deployment is matched to the EVLA Phase I Project schedule (see the *EVLA Project Book*). The timescale phases are:

A transition phase (2004 Q2)

B prototype correlator (2005 Q4)

C shared-risk Science operations (2007 Q2)

D full science operations, completion of EVLA Phase I (2010 Q2)

E "eventually" sometime after completion (ongoing)

Overview

The remainder of this document contains a more detailed description of the Operational Interface as well as the requirements necessary to design and build it.

Sections 1 to 6 detail the requirements of the Operational Interface and represent the core of this document. They contain both the functional requirements which define functions that the system must perform, and non-functional requirements which describe the manner in which the functions will be performed.

Overall Description

Functional Requirements

Remote Observing The primary goal of the Operational Interface software is to provide the array operators with the tools to safely, effectively and reliably monitor and control the array. In meeting this goal the system designers must also build into the system a secondary goal that allows access to the system independent of location.

There are several reasons for remote observing:

- Observers can monitor the progress of their observing program and make or request changes during their observation to increase the quality of data.
- Hardware and software engineers will have the ability to access the system from remote locations during working and non-working hours to do first-order problem solving.
- In the future, operators may be stationed at the AOC in Socorro.

The ability to remotely observe does not imply that the software must be Web-based and that it run within the confines of, or is launched from, a browser. It only suggests that the software be accessible via the internet and that it provide the same functionality (or subset thereof), remotely, as the user interface software used by the array operator.

At times, it may be necessary for the array operator to have some form of communications link with a remote observer other than telephone and/or email. A simple solution would be to create a "chat" program that allows the operator and observer to exchange messages in near real-time.

Some Details

The capabilities of the Operational Interface will depend in large part on the design for the Monitor and Control system. The EVLA Monitor and Control system will be designed and implemented as a distributed system. Computers in the system may be of different types and operating systems and will communicate with one another over a network.

Client Station A client station is defined as a user's computer that allows interaction with the Operational Interface. Its primary responsibility is to run the Operational Interface and will do this either as a standalone program that executes on the client station or through a browser. The type and operating system of each client station will likely vary, as will the location. Client stations can be located at the VLA Control Building, the AOC, or any Web-accessible location. (See Appendix C, Prototypical operator's workstation.)

Operations Server The Operational Interface will communicate directly with the operations server. The server will have the responsibility of transmitting data acquired from the core M&C real-time system to the outlying client stations. It will also receive commands issued from authorized client stations and forward those commands to the core real-time system.

Client/Server Communication The communications protocol between the client and the server are unknown at this time. It will likely be an RPC-like communications middleware specification, for example, CORBA, RMI, XML-RPC, SOAP, etc.

Display Framework A display framework serves two purposes: 1) it forces structure on a display, and 2) it provides a mechanism for integrating the display into the Operational Interface.

Each display will be required to follow a predefined set of rules, thus creating a high-level of common behavior inherent in each display. Once this common behavior has been achieved, the framework can manage each display through this high-level interface.

After a display has been created, the integration of the display into the framework should be a simple process. Two approaches should be offered. The first would allow the user to manually import a display into the Operational Interface. This approach would assist the development and testing of displays and would be used most often by the display developers. The second approach would allow the display to be added to a package of displays that would be recognized at runtime by the Operational Interface. This would be the standard method of integrating displays into the Operational Interface during deployment.

User Characteristics

NRAO Staff

Array Operators: The array operators are responsible for the overall success and safety of all observations and will be the primary users of the Operational Interface. They require monitor and control capabilities of both the array and the correlator and be able to perform their duties from either the VLA Control Building or the AOC. The majority of requirements contained in this document directly reflect his/her needs and duties.

Engineers: Engineers are responsible for the design, development and testing of the mechanical and electrical

components within the system. They require the ability to inspect/control individual system components both remotely and at the antenna during working and non-working hours.

Technicians: Technicians are responsible for the day-to-day monitoring and maintenance of the mechanical and electrical components within the system and are usually the first to be notified in the event of a non-working or malfunctioning component. As with the engineers, technicians require the ability to inspect/control individual system components both remotely and at the antenna during working and non-working hours.

NRAO Scientists: Scientists are granted time on the array to conduct scientific investigations or tests. Their primary interest lies in the scientific data obtained by the instrument. They require remote access to both monitor data and visibility data to assess the progress to help make decisions during an observation. Scientists may or may not require control capabilities.

Programmers: Programmers are responsible for creating the software that drives the system. They must have access (with control capabilities) to the system, both locally and remotely, for testing and troubleshooting during working and non-working hours.

Non-NRAO Staff

Scientists: Non-NRAO scientists will not have any control capabilities.

Web User: Web users are those individuals that are part of the general public. They will have the ability to monitor the system and will not have any control capabilities.

Constraints

Criticality of the Application The Operational Interface is one of many critical components of the EVLA M&C System. Without it, the operators will not have the ability to monitor or control the array, thus jeopardizing the success of the observation and safety of the telescope.

Portability The Operational Interface must be highly portable, as it will run on several different client machines all running disparate operating systems.

Safety and Security Considerations The Operational Interface must be safe and secure. It should never put equipment or personnel at risk and never allow unauthorized users access to control functions of the array.

Interfaces to Other Applications The Operational Interface must work in conjunction with the software developed by the e2e project. In particular, an interface to the e2e scheduling routines must be provided.

Assumptions

Several assumptions have been made about the functionality of the Operational Interface and the way in which it will be implemented.

- The astronomer will in general only interact with e2e software.
- It is expected that the Monitor & Control system will provide e2e with all the information required by the astronomer.
- All user interaction with the EVLA shall be through GUIs with only a few exceptions (e.g., the ability to type Control Scripts directly into the realtime system when observing in manual mode).
- It is expected that there will be close and frequent collaboration between the e2e programmers and the EVLA SSR committee members during software development (on a much shorter scale than the 9 month formal development cycle for e2e).
- The Operational Interface will be able to cooperate or work in tandem with GUIs developed by the e2e group.

- The Operational Interface will not directly interface with hardware, as it will be separated from the hardware by many layers of software.
- The Operational Interface will be developed so that it can easily be expanded to include the control of NMA antennas in an identical manner as EVLA antennas.

1 Operational Interface System Administration Requirements

1.1 Installation and Upgrades

An installation and upgrade mechanism must exist so that users have access to the latest version of the software. The user's role and level of involvement in the installation and upgrade process must be determined early in the design phase as it will affect both the design of the product and the technologies used.

Several options exist for distributing the software, each requiring various levels of user involvement. A Web-based solution may provide the user with the latest software features without the user having to install anything, whereas, a more active user role would be assumed if the user has to navigate to a web site, download the software bundle and install it. If the user will be required to partake in any aspect of the installation process, the software should be designed such that the process of upgrading is automated as much as possible and it should guide the user through the entire installation/upgrade of the product.

1.1-R1 The system shall inform the user that a new version is available.

Priority: 1 Timescale: A

1.1-R2 The system shall inform the user whether the new version is required or recommended.

Priority: 1 Timescale: A

1.1-R3 During the installation process, the system shall allow the user to cancel or delay the installation/update.

Priority: 1 Timescale: A

1.1-R4 The system shall automatically download and install the new software.

Priority: 1 Timescale: A

1.2 System Login

All users will be required to log on to the system. Before a user can interact with the system he/she must first supply his/her system identification information (e.g., username and password) to the system. Using this information, the system will authenticate the user and either grant or deny the user access to the system. Each session will have a unique ID associated with it, as an aid to distinguish mutiple logins from the same user.

1.2-R1 Each user must login to the system.

Priority: 1 Timescale: A

1.2-R2 Each user must have a unique identifier and password to gain access to the system.

Priority: 1 Timescale: A

1.2-R3 The system shall not echo password characters.

Priority: 1 Timescale: A

1.2-R4 The user shall have the ability to discontinue or cancel a login attempt at any time during the login process.

Priority: 1 Timescale: A

1.2-R5 After (TBD) unsuccessful login attempts the system shall (TBD).

Priority: 2 Timescale: A

1.2-R6 The system shall log, at a minimum, the following login and end of session information to a persistent store (db or file):

1.2-R6.1 the time the session was established and ended

Priority: 2 Timescale: A

1.2-R6.2 the user identifier
Priority: 2 Timescale: A
1.2-R6.3 the status of the login attempt (login only)
Priority: 2 Timescale: A
1.2-R6.4 the session ID
Priority: 2 Timescale: A
1.2-R6.5 the cause of session termination (user, administrator, error, etc.)
Priority: 2 Timescale: A

1.3 User Management

This subsection defines the requirements needed to control and manage the users of the system as well as a user's access to the system. The use of the term administrator below refers to the array operator.

1.3-R1 The administrator shall have the ability to create and add a new user to the system.

Priority: 1 Timescale: B

1.3-R2 The administrator shall have the ability to remove a user from the system.

Priority: 1 Timescale: B

1.3-R3 The administrator shall have the ability to edit a user's system access properties.

Priority: 1 Timescale: B

1.3-R4 The administrator shall have the ability to block all commands sent to the array by all users or selectively by user. (All users will remain logged into the system and will not be allowed to issue commands to any part of the array until the command block is released. The administrator will still have the ability to issue commands to the array.)

Priority: 1 Timescale: B

1.3-R5 The administrator shall have the ability to block all access to the system for all users or selectively by user. (All blocked users with active sessions will automatically be logged off.)

Priority: 1 Timescale: B

1.4 Online Help

A help facility should be incorporated into the design of the software system from the start and it should allow the array operator to find the information he/she seeks quickly and accurately. At a minimum, it should include a table of contents, an index, full-text search and context sensitive help.

1.4-R1 The system shall provide an online help facility with the following features:

1.4-R1.1 table of contents
Priority: 2 Timescale: A
1.4-R1.2 index
Priority: 2 Timescale: A
1.4-R1.3 full-text search
Priority: 2 Timescale: A
1.4-R1.4 The online help facility shall provide context sensitive help.
Priority: 3 Timescale: A

1.5 Documentation

1.5-R1 The system shall provide the following online documentation for all tools associated with the system:

1.5-R1.1 user manual
Priority: 1 Timescale: A

1.6 Printing

Users of the system will need the ability to capture and print screens.

1.6-R1 The user shall have the ability to capture and print any display.
Priority: 1 Timescale: A

1.7 Communications Requirements

At times, it may be necessary for the array operator to have some form of communications link with a remote observer other than telephone and/or email. A simple solution would be to create a "chat" program that allows the operator and observer to exchange messages in near real-time.

1.7-R1 The software shall be accessible via the internet (downloadable, running within a browser, or launched from a browser, etc).
Priority: 1 Timescale: C

1.7-R2 A request for data or commands submitted by the operator or from an operator's station shall take precedence over requests and submissions by non-operators.
Priority: 1 Timescale: C

1.7-R3 A remote user with authorized privileges shall have the ability to communicate with the operator using a simple messaging system (chat tool).
Priority: 2 Timescale: C

2 Software System Attributes (Non-Functional Requirements)

2.1 Reliability

The following requirements describe the expected reliability of the Operational Interface.

2.1-R1 The Operational Interface shall have a Mean Time Between Failures (MTBF) of no less than 7 days.[1]
Priority: 1 Timescale: C

2.2 Availability

The following requirements indicate the expected availability of the Operational Interface.

2.2-R1 The system shall be available 99.5%[2] of the time.
Priority: 1 Timescale: C

[1] A Mean Time To Repair (MTTR) is not supplied, as it is operationally defined and highly variable.
[2] This works out to the system being unavailable a total of 48 hours over a year's time.

2.3 Security

The software system needs a robust security mechanism in place so that unauthorized users are not allowed access to parts of the system that may compromise the success of an observation, cause damage to an antenna or jeopardize the safety of personnel in or around an antenna.

This mechanism must be built into the system from the start. An attempt to add security to the system after the fact would likely prove to be a costly and difficult task.

All users of the system must be uniquely identified. This could be done by using a username and associated password scheme that would authenticate and authorize the user access to the system and, if applicable, grant the user access to restricted or controlled parts of the system. If a user cannot be identified, he/she will be given "anonymous" access with read-only capabilities. In order to monitor all past access to the system, all attempts to access the system must be logged.

Users will be separated into two groups, those we trust and those we do not. Trusted users will have privileged access to the system, namely control capabilities, whereas the non-trusted users will only have monitoring capabilities.

2.3-R1 All users of the system shall login using some form of unique identification (e.g., username and password)

Priority: 1 Timescale: A

2.3-R2 A default user identifier shall exist that allows anonymous, read-only access to the system (e.g., "guest")

Priority: 1 Timescale: A

2.3-R3 All login attempts shall be done so in a secure manner (e.g., encrypted passwords)

Priority: 1 Timescale: A

2.3-R4 A system administrator shall have unrestricted access to all aspects of the system.

Priority: 1 Timescale: A

2.3-R5 Each user shall either be trusted or not trusted.

Priority: 1 Timescale: A

2.4 Maintainability

The following requirements increase the maintainability of the Operational Interface software.

2.4-R1 All source code and development related documents shall be controlled under a version control system (e.g., CVS, RCS or SCCS).

Priority: 1 Timescale: A

2.4-R2 All source code shall adhere to an agreed upon and well-defined set of coding standards for each development language used.

Priority: 1 Timescale: A

2.4-R3 A standard naming convention for classes, variables and packages shall be agreed upon and adhered to.

Priority: 1 Timescale: A

2.5 Portability

2.5.1 Hardware

The manufacturer and type of workstations to be used by the array operators and other authorized users to monitor and control the array are unknown. In the interest of minimizing the cost of these computers and without unnecessarily limiting the available hardware options — now and in the future — the software must be reasonably platform independent so it will run on a variety of machines with minimal impact to the software. This would allow a change in the underlying hardware without requiring a significant rewrite of the software. It would only require changes to a configuration file or to a small layer of the software system.

2.5.1-R1 The system shall be compatible with commodity PCs.

Priority: 1 Timescale: A

2.5.1-R2 The system shall be compatible with Sun Microsystems workstations.

Priority: 2 Timescale: A

2.5.1-R3 The system shall be compatible with Macintosh computers.

Priority: 3 Timescale: C

2.5.1-R4 The system shall be compatible with hand-held computers/calculators.

2.5.2 Operating Systems

Since the software must run on several popular hardware platforms and the goal is to achieve a reasonable level of platform independence, the software must also be capable of running on a number of operating systems supporting that hardware. At a minimum, the software should run on Linux, Solaris and Windows operating systems, all of which are supported by NRAO's staff of system administrators. As with the hardware, a change in operating systems should have minimal impact on the software system.

2.5.2-R1 The system shall be compatible with the Linux Operating System (Red Hat 7.0 or Greater).

Priority: 1 Timescale: A

2.5.2-R2 The system shall be compatible with the Solaris Operating Environment (Solaris 8 or greater).

Priority: 2 Timescale: A

2.5.2-R3 The system shall be compatible with the Microsoft Windows Operating System (NT, 2000, XP or greater).

Priority: 1 Timescale: A

2.5.2-R4 The system shall be compatible with Macintosh (Mac OS X or greater)

Priority: 3 Timescale: C

2.5.2-R5 The operating system shall be compatible with hand held computers.

2.6 Usability

The system's user interface should be intuitive, easy to use and provide an overall positive user experience. It should do what the user expects it to do, inform the user of its current state, and when something goes wrong it should explain the problem in a meaningful context that is understandable by the user and offer guidance toward correcting the problem. It should also conform to a specified set of user interface guidelines to foster consistency between different tools within the application.

An intuitive and easy to use application will undoubtedly decrease the amount of time it currently takes to train an operator. The operator should only be concerned with what they need to do with the tool to perform the task at hand rather than focusing on how to use the tool.

2.6-R1 The system shall adhere to a set of user interface design guidelines.

Priority: 1 Timescale: A

2.6-R2 The system shall allow the user to display multiple windows simultaneously.

Priority: 1 Timescale: D

2.6-R3 Each display shall reflect the level of access and the privileges of the user (security aware).

Priority: 1 Timescale: A

2.6-R4 If the user requests to close a window or exit the system after making uncommitted changes to a screen, the system shall prompt the user to commit or cancel those changes.

Priority: 2 Timescale: C

2.6-R5 The system shall use (TBD) as the default to display time.

Priority: 1 Timescale: A

2.6-R6 Time displays shall always be available in the following standards:

2.6-R6.1 Coordinated Universal Time (UTC)
Priority: 1 Timescale: A

2.6-R6.2 VLA local sidereal time (VLA LST)
Priority: 1 Timescale: A

2.6-R6.3 Local time (MDT or MST, as appropriate)
Priority: 1 Timescale: A

2.6-R7 The user shall have the ability to copy (or cut) text to the system "clipboard" and paste the text to other text-accepting components.

Priority: 2 Timescale: C

2.6-R8 Where applicable, the user shall have the ability to select preferences (color, font, etc.)

Priority: 2 Timescale: C

2.6-R9 In situations that are applicable, the system shall allow for "Undo" and "Redo".[3]

Priority: 3 Timescale: C

2.6-R10 The system shall be internationalized.[4]

Priority: 3 Timescale: E

2.7 Training

The system will facilitate training of new operators with the system by having a feature that simulates the Operational Interface.

2.7-R1 Create simulator of Operational Interface

Priority: 3 Timescale: E

[3] The requirement for undo/redo may or may not be applicable in a real-time control context, but it would be appropriate for the logging and chat tools.

[4] Internationalized applications are easy to tailor to the languages of users in other countries. It also has a desirable side effect of enforcing good coding practices by separating locale specific information from the source code. For example, human readable labels are contained in files that are loaded at runtime. A change in a label does not require a recompile of the source code.

2.8 Display Builder

A display builder would allow developers and end-users to design and create their own displays. The displays can be added to the standard package or imported to the Operational Interface.

2.8-R1 The user shall have the ability to customize their own displays.

Priority: 2 Timescale: C

3 Monitor and Control Interface Requirements

3.1 Performance

The following requirements describe the performance expected from the Operational Interface.

3.1-R1 The system displays shall be capable of, at a minimum, a 1kBaud/sec data refresh rate over a low-bandwidth connection.

Priority: 1 Timescale: A

3.1-R2 The operator stations and technician stations must be capable of much greater refresh rates, not less than 10 per second.

Priority: 1 Timescale: A

3.1-R3 The system shall support a number of concurrent user sessions limited only by system resources.

Priority: 1 Timescale: C

3.2 Warning and Error Messages

Warning and error conditions are meant to alert users of problems in the system that require immediate attention or less serious conditions that, if left unacknowledged, could have the potential to develop into more serious problems. Conditions that warrant warnings or errors include, but are not limited to, loss of communication with a subsystem, device errors, out of range monitor points, invalid device commands, network failures and software errors. The messages should accurately describe the problem and its consequences and provide access to the source (or cause) of the problem as well as a list of possible solutions to the problem.

The system should make every attempt to limit warning and error conditions to only those relevant to the current system activity. All others must be suppressed or ignored. It should not be the responsibility of the array operator to visually weed through a list of faults to determine the actual problem.

During the design process, the system designers will want to investigate fault tree analyzers developed elsewhere, e.g., BIMA and GBT.

3.2-R1 The system shall allow messages to be color-coded based on the type and severity level of the message.

Priority: 1 Timescale: A

3.2-R2 The system shall be able to provide audible alerts for fault conditions based on the type and severity level of the message.

Priority: 2 Timescale: A

3.2-R3 The user shall have the ability to suppress fault conditions for a specified period of time (minutes, hours, days, etc.) or event (source change).

Priority: 3 Timescale: C

3.2-R4 The user shall have the ability to view the fault conditions for the following groups:

3.2-R4.1 a single antenna
Priority: 1 Timescale: B
3.2-R4.2 all antennas
Priority: 1 Timescale: A
3.2-R4.3 a subarray
Priority: 2 Timescale: C
3.2-R4.4 a subsystem (i.e. FE, LO, FRM, etc.)
Priority: 2 Timescale: B
3.2-R4.5 antenna type (i.e. VLA, EVLA, VLBA,NMA)
Priority: 2 Timescale: C

3.2-R5 At a minimum, the system shall provide access to the following fault condition properties:

3.2-R5.1 the date/time of the message
Priority: 1 Timescale: A
3.2-R5.2 origin of the message (computer, subsystem, etc.)
Priority: 1 Timescale: A
3.2-R5.3 the message type (WARNING or ERROR, etc.)
Priority: 1 Timescale: A
3.2-R5.4 the message code
Priority: 1 Timescale: A
3.2-R5.5 a terse description of the problem
Priority: 1 Timescale: A
3.2-R5.6 a severity level
Priority: 1 Timescale: A
3.2-R5.7 a detailed description of the problem
Priority: 2 Timescale: C
3.2-R5.8 a detailed description of possible or likely consequences
Priority: 3 Timescale: E
3.2-R5.9 a detailed description of possible or likely causes
Priority: 2 Timescale: C
3.2-R5.10 a detailed description of corrective actions
Priority: 2 Timescale: C
3.2-R5.11 a link to relevant or helpful documents
Priority: 2 Timescale: C

3.2-R6 The user shall have the ability to redirect warning or error messages to:

3.2-R6.1 the operator (or system) log
Priority: 2 Timescale: C
3.2-R6.2 a printer
Priority: 1 Timescale: C

3.2-R7 The user shall have the ability to retrieve and sort messages by time, message code, type, source (subsystem) and severity level.

Priority: 2 Timescale: C

3.2-R8 The user shall have the ability to create and enter a known solution that addresses a particular error message and submit the solution to a persistent store for future reference.

Priority: 3 Timescale: E

3.3 Monitor Points

A monitor point can be defined as an independent piece of data. Each monitor point should have a unique ID, description, value, units, etc. A user should have access to all the information pertaining to a monitor point.

3.3-R1 The user shall be able to store as a file all monitor points.

Priority: 1 Timescale: B

3.3-R2 The user shall be able to list, plot and print any monitor point over a specified time range.

Priority: 1 Timescale: B

3.3-R3 The user shall be able to view the following monitor point properties:

3.3-R3.1 date/time stamp
Priority: 1 Timescale: A
3.3-R3.2 current value
Priority: 1 Timescale: A
3.3-R3.3 raw units
Priority: 1 Timescale: A
3.3-R3.4 units conversion factor (e.g., 1 volt = 10 degrees celsius)
Priority: 2 Timescale: A
3.3-R3.5 engineering units
Priority: 1 Timescale: A
3.3-R3.6 description (terse and detailed)
Priority: 1 Timescale: A
3.3-R3.7 type (raw, derived, etc.)
Priority: 2 Timescale: A
3.3-R3.8 data type (binary, decimal, hexadecimal, octal, logical, floating point, or integer)
Priority: 2 Timescale: A

3.4 General Data Requirements

The monitor and control displays will allow users to visualize the current state of the system at varying levels of detail as well as provide the required control capabilities. The number and details of the M&C displays to be generated is unknown at this time, however, the data required by the displays can be addressed.

3.4.1 Weather/Environmental Data

3.4.1-R1 All monitor points from weather-related equipment, for the array and for individual antennas, shall be available to the user.

Priority: 1 Timescale: B

3.4.1-R2 The user shall have the ability to submit current weather data to the log.

Priority: 2 Timescale: C

3.4.1-R3 The user shall have the ability to display real-time atmospheric phase interferometer data.

Priority: 1 Timescale: C

3.4.1-R4 The user shall have the ability to display archival atmospheric phase interferometer data for a user-specified time range.

Priority: 1 Timescale: C

3.4.1-R5 The user shall have the ability to display real-time ionospheric data.

Priority: 3 Timescale: E (PP No equipment currently exists)

3.4.1-R6 The user shall have the ability to display archival ionospheric data for a user-specified time range.

Priority: 3 Timescale: E

3.4.1-R7 The following information on RFI shall be available:

3.4.1-R7.1 duty cycle
Priority: 2 Timescale: B

3.4.1-R7.2 average signal received power
Priority: 2 Timescale: B

3.4.1-R7.3 peak signal received power
Priority: 2 Timescale: B

3.4.1-R7.4 origin
Priority: 3 Timescale: E

3.4.1-R7.5 a matrix database that shows the presence of RFI at different thresholds greater than ITU thresholds and in 3dB steps
Priority: 3 Timescale: C

3.4.1-R7.6 provide overlay to identify RFI in each band
Priority: 1 Timescale: B

3.4.2 Monitoring Visibility Data

Users of the Operational Interface must have a means for viewing and assessing array/antenna performance based on the correlator output. This need is currently addressed by the F and D10 displays on the Modcomps. Something comparable for EVLA is required.

3.4.2-R1 The system shall enable the user to view amplitudes and phases for all correlated Stokes parameters for a selected baseline.(i.e. the D10 display

Priority: 1 Timescale: B

3.4.2-R2 The system shall enable to user to view individual antenna gains. (i.e. the F display)

Priority: 1 Timescale: B

3.4.3 Antenna Data

3.4.3-R1 The system shall provide the user with the ability to control the full functionality of all modules on each antenna individually (e.g., ACU,FRM,FE etc.):

Priority: 1 Timescale: A

3.4.3-R2 The following data shall be available for each antenna:

3.4.3-R2.1 antenna number
Priority: 1 Timescale: A

3.4.3-R2.2 antenna address
Priority: 1 Timescale: A

3.4.3-R2.3 station or pad ID
Priority: 1 Timescale: A

3.4.3-R2.4 subarray affiliation
Priority: 2 Timescale: B

3.4.3-R2.5 azimuth and elevation in antenna coordinates
Priority: 1 Timescale: A

3.4.3-R2.6 current source
Priority: 1 Timescale: A
3.4.3-R2.7 RA and DEC of current source
Priority: 1 Timescale: A
3.4.3-R2.8 pointing errors
Priority: 1 Timescale: A
3.4.3-R2.9 weather data (anemometers 1 and 2)
Priority: 1 Timescale: A
3.4.3-R2.10 stop time of a scan
Priority: 2 Timescale: B
3.4.3-R2.11 affiliated project
Priority: 2 Timescale: B
3.4.3-R2.12 observations title (observe files name)
Priority: 2 Timescale: B
3.4.3-R2.13 slew rate (azimuth and elevations)
Priority: 1 Timescale: B

3.4.4 Array and Subarray Data

3.4.4-R1 The following data shall be available for each subarray:

3.4.4-R1.1 affiliated project
Priority: 1 Timescale: B
3.4.4-R1.2 current source
Priority: 1 Timescale: B
3.4.4-R1.3 current position
Priority: 1 Timescale: B
3.4.4-R1.4 antenna(s)
Priority: 1 Timescale: B
3.4.4-R1.5 mode(s)
Priority: 1 Timescale: B

3.4.4-R2 Authorized users shall be able to command the array and subarrays using the full capability of all modules.(e.g. send point, stow, avoidsnow, etc. commands simultaneously to all antennas in the array or subarray)

Priority: 1 Timescale: C

3.4.4-R3 Authorized user shall be able to move antennas from one subarray to another with ease and at will

Priority: 1 Timescale: C

3.4.4-R4 Authorized users shall have access to the functions of the backup safety path in order to set emergency stops, power resets to modules, etc. in order to retain the same functions as the existing Wye Mon.

Priority: 1 Timescale: C

3.5 Plotting

A general-purpose plotting component will be needed. Several of the standard M&C displays will likely contain plots of monitor points relevant to that display and a user must have the ability to plot any monitor points on the fly.

3.5-R1 The user shall be able to generate the following plot types:

3.5-R1.1 scatter plot
Priority: 1 Timescale: B

3.5-R1.2 histogram
Priority: 1 Timescale: B
3.5-R1.3 line plot
Priority: 1 Timescale: B

3.5-R2 The user shall be able to view the plot dynamically (real-time) or statically (offline).

Priority: 1 Timescale: B

3.5-R3 The user shall have the ability to give the plot a title.

Priority: 1 Timescale: B

3.5-R4 The user shall have the ability to define the plot axis labels in the following manner:

3.5-R4.1 user defined character string
Priority: 1 Timescale: B
3.5-R4.2 import predefined labels from a monitor point definition database
Priority: 1 Timescale: B

3.5-R5 The user shall have the ability to specify the number of major and minor tick marks for a plot.

Priority: 1 Timescale: B

3.5-R6 The user shall have the ability to view multiple monitor points on a single axis.

Priority: 1 Timescale: B

3.5-R7 The user shall have the ability to specify whether the major and minor tick marks are:

3.5-R7.1 linear
Priority: 1 Timescale: B
3.5-R7.2 logarithmic
Priority: 1 Timescale: B

3.5-R8 The user shall have the ability to auto-scale plots.

Priority: 1 Timescale: B

3.5-R9 The user shall have the ability to specify the scale of the plot for all axes.

Priority: 1 Timescale: B

3.5-R10 The user shall be able to plot any monitor point in the system.

Priority: 1 Timescale: B

3.5-R11 The user shall be able to plot the same monitor point for all antennas or selected antennas.

Priority: 1 Timescale: B

3.5-R12 The user shall have the ability to infinitely zoom in and out of the plot.

Priority: 1 Timescale: B

3.5-R13 The user shall be able to select various point styles:

3.5-R13.1 none
Priority: 1 Timescale: B
3.5-R13.2 dots
Priority: 1 Timescale: B
3.5-R13.3 points
Priority: 1 Timescale: B
3.5-R13.4 shapes (triangles, squares, circles, etc.)
Priority: 1 Timescale: B

3.5-R14 The user shall be able to show error bars.

Priority: 1 Timescale: B

3.5-R15 The user shall have the ability to view the plot's legend.

Priority: 1 Timescale: B

3.5-R16 The user shall be able to print a hardcopy of the plot.

Priority: 1 Timescale: B

3.5-R17 The system shall identify the following characteristics of a monitor point over a specified time range:

3.5-R17.1 minimum value
Priority: 1 Timescale: B

3.5-R17.2 maximum value
Priority: 1 Timescale: B

3.5-R17.3 average
Priority: 1 Timescale: B

3.5-R17.4 RMS
Priority: 1 Timescale: B

3.5-R18 The user shall have the ability to set maximum and minimum limit markers.

Priority: 1 Timescale: B

4 Log and Report Writing Requirements

VLA operators are required to document a wide range of information. They must log information about antennas and the array concerning an observer's project which is intended to alert the observer to conditions or events that occurred during the project that may have affected the collection or quality of the data. The operators are also required to log antenna visits by technicians, document security checks, and create notes and reminders to each other. The logging tool must be flexible enough to manage all these requirements. Various reports from the logged information can be generated, customized by purpose. At the completion of a project, the observer would be e-mailed a copy of the (time-ordered) log entries relevant to his or her observations. Certain critical events, such as an antenna auto-stowing for high winds, should be logged automatically.

The logging facility should be designed as a distributed tool that can be easily embedded into other applications. There has been discussion that logging tools with similar functionality are needed at other sites for other instruments. The logging facility should thus be designed and developed with this in mind so that the tool is as general purpose as possible with preferential treatment given to the EVLA. It should be built so that it can be expanded easliy to log entries regarding NMA antennas.

4.1 General Logging Requirements

4.1-R1 The system shall save log entries to a persistent store.

Priority: 1 Timescale: B

4.1-R2 The user shall have the ability to query the persistent store (by time range, message, type, program, etc.).

Priority: 1 Timescale: B

4.1-R3 The logging system must be distributed and platform independent.

Priority: 1 Timescale: B

4.2 Log Entries

A log entry is any user or system generated message that will be submitted to the operator/system log. Authorized users should have the ability to create and submit log entries as well as modify and delete them.

4.2-R1 An authorized user shall have the ability to create a log entry.

Priority: 1 Timescale: B

4.2-R2 The system shall automatically provide the event timestamp at the moment the entry is created.

Priority: 1 Timescale: B

4.2-R3 An authorized user shall have the ability to select the type of entry (operator note, operator to operator message, antenna visit, observers note, weather, etc.).

Priority: 1 Timescale: B

4.2-R4 An authorized user shall have the ability to edit and/or void a log entry.

Priority: 1 Timescale: B

4.2-R5 An authorized user shall have the ability to delete and/or void a log entry.

Priority: 1 Timescale: B

4.2-R6 An authorized user shall have the ability to save or submit a log entry.

Priority: 1 Timescale: B

4.2-R7 The system shall automatically timestamp the entry on submission.

Priority: 1 Timescale: B

4.2-R8 The system will be able to calculate downtime for an entry.

Priority: 1 Timescale: B

4.3 Reminders

A reminder is simply a mechanism that allows the user to generate a message and have that message displayed at a specified time.[5] *This feature does not necessarily have to be a part the logging system and could easily be promoted to an overall system feature.*

4.3-R1 The user shall have the ability to create a reminder.

Priority: 2 Timescale: C

4.3-R2 The user shall have the ability to specify all properties of the reminder (the trigger time, the message to display, etc.)

Priority: 2 Timescale: C

4.3-R3 The user shall have the ability to edit a reminder.

Priority: 2 Timescale: C

4.3-R4 The user shall have the ability to delete a reminder.

Priority: 2 Timescale: C

4.3-R5 The user shall have the ability to view all scheduled reminders.

Priority: 2 Timescale: C

4.3-R6 The user shall have the ability to specify the frequency of the reminder (once, every hour, daily, monthly, etc.)

Priority: 2 Timescale: C

4.3-R7 The system shall automatically delete all triggered and acknowledged nonrecurring reminders.

Priority: 2 Timescale: C

[5] Most operating systems are equipped with a tool that provides similar functionality. The advantage of having it implemented in the software is to provide the user with a tool that has the same behavior regardless of the operating system.

4.3-R8 The user shall have the ability to enter the reminder trigger time in any of the following time standards:

4.3-R8.1 UTC
Priority: 2 Timescale: C

4.3-R8.2 VLA LST
Priority: 2 Timescale: C

4.3-R8.3 local time
Priority: 2 Timescale: C

4.3-R9 The user shall have the ability to link a reminder to an event (program change, source change, parameter value).

Priority: 3 Timescale: C

4.3-R10 The user shall have the ability to specify the method of notification: popup message (default), beeping, flashing, email.

Priority: 3 Timescale: C

4.3-R11 The user shall have the ability to postpone a reminder.

Priority: 3 Timescale: C

4.4 Scheduled Tasks

A scheduled task is similar in functionality to the reminders, however, rather than displaying a message, a scheduled task would instead launch a script (or executable) at a specified time. This feature could be used to enter weather data on an hourly basis into the operator/system log.[6]

4.4-R1 The user shall have the ability to create a scheduled task.

Priority: 3 Timescale: D

4.4-R2 The user shall have the ability to edit a scheduled task.

Priority: 3 Timescale: D

4.4-R3 The user shall have the ability to delete a scheduled task.

Priority: 3 Timescale: D

4.4-R4 The user shall have the ability to postpone a scheduled task.

Priority: 3 Timescale: D

4.4-R5 The user shall have the ability to view upcoming scheduled tasks.

Priority: 3 Timescale: D

4.5 Customized Log Entries

The ability to create and save text that can be used for multiple log entries. Once created, it should be possible to insert the text easily into a log, e.g., with the click of a button.

4.5-R1 The user shall have the ability to create a macro containing log text.

Priority: 1 Timescale: C

4.5-R2 The user shall have the ability to save a macro.

Priority: 1 Timescale: C

[6] See previous footnote.

4.5-R3 The user shall have the ability to name a macro.

Priority: 1 Timescale: C

4.5-R4 The user shall have the ability to delete a macro.

Priority: 1 Timescale: C

4.5-R5 The user shall have the ability to run a macro.

Priority: 1 Timescale: C

4.5-R6 The user shall have the ability to link a macro to a user interface component (button or menu component) or keyboard shortcut.

Priority: 1 Timescale: C

4.6 Maintenance Database

This feature would allow the user limited access to the maintenance database (MainSaver). Simple queries could be performed so that users could locate maintenance database entries for known problems that are potentially causing or having some impact on an observation. When the user finds the database entry he or she should be able to link that entry to a log entry.

4.6-R1 The system shall have the ability to search the maintenance database.

Priority: 2 Timescale: C

4.6-R2 The system shall have the ability to link maintenance database entries to log entries.

Priority: 2 Timescale: C

4.7 Reporting

The user should have the ability to create a number of reports from the data contained in the log. A standard package of reports should be available to the user and possibly in the future a report-building feature would be added to the system.

4.7-R1 The user shall have the ability to create a report based on specific purposes:

- **4.7-R1.1** Observer's Log.
  Priority: 1 Timescale: C
- **4.7-R1.2** Guard Check-in Log
  Priority: 1 Timescale: C
- **4.7-R1.3** Antenna Visit Log
  Priority: 1 Timescale: C
- **4.7-R1.4** Operator Notes
  Priority: 1 Timescale: C

4.7-R2 The user shall be able to harvest the reports for specific type of information.

- **4.7-R2.1** Downtime calculations by time and by projects
  Priority: 1 Timescale: C
- **4.7-R2.2** Search feature by entry type and by string
  Priority: 1 Timescale: C

4.7-R3 The user shall be able to create a new report.

Priority: 2 Timescale: C

5 System File Management Requirements

Operators and others will need to periodically update system parameters unique to individual antennas,such as subreflector positions, pointing parameters and Tcals, to particular pad positions, such as delays and locations, etc. A tool for updating, enabling, documenting and retrieving all system parameters is required. Additionally, operators will need to access the file actually used to perform the observations.

5-R1 The tool shall give the user the ability to edit current parameters.

Priority: 1 Timescale: A

5-R2 The user shall have the ability to control when new parameters are applied (i.e. at scan change, at program change, at a specific time, etc.)

Priority: 1 Timescale: A

5-R3 The tool shall allow the user to store, retrieve and view old versions of a given system parameter

Priority: 1 Timescale: A

5-R4 The system shall provide a method for operators to view and edit observe files.

Priority: 1 Timescale: A

6 Scheduling Requirments

The day-to-day scheduling, either fixed or dynamic, is the responsibility of the e2e project. For a detailed description of scheduling see the e2e Project Book. The Operational Interface, however, must provide the operators with the ability to manipulate individual scans (or scheduling blocks). The operators must also have a means for inserting standard and non-standard test files into the observing system at will. Examples of testing include pointing, delays, baselines, subreflector positioning and fringe checks.

6-R1 The system shall be compatible with the the time frame required in the Science Requirements Document. (See Section 3.2.3 of the Scientific Requirements document.)

Priority: 1 Timescale: B

6-R2 The user shall have the ability to view the individual scans of a project.

Priority: 1 Timescale: B

6-R3 The user shall have the ability to reorder the scans.

Priority: 1 Timescale: B

6-R4 The user shall have the ability to set the end time for a specific source or scan (overriding the end time in the observation script file).

6-R4.1 extend/shorten by a specific time
Priority: 1 Timescale: B

6-R4.2 extend/shorten for a duration
Priority: 1 Timescale: B

6-R4.3 extend for an indefinite period
Priority: 1 Timescale: B

6-R5 At a minimum, the user shall have access to the following scan properties:

6-R5.1 end time (in VLA LST)
Priority: 1 Timescale: B

6-R5.2 source
Priority: 1 Timescale: B

6-R5.3 position
Priority: 1 Timescale: B
6-R5.4 frequency
Priority: 1 Timescale: B
6-R5.5 equipment configuration
Priority: 1 Timescale: B
6-R5.6 subarray affiliation
Priority: 1 Timescale: B
6-R5.7 mode(s)
Priority: 1 Timescale: B
6-R5.8 quality of calibrator
Priority: 1 Timescale: B

6-R6 The user shall have the ability to extend on a source or scan for a specified duration

Priority: 1 Timescale: B

6-R7 The user shall have the a means to over-ride the automatic scheduling process, and manually insert schedule files into the observing system.

Priority: 1 Timescale: B

A Definitions, Acronyms and Abbreviations

A.1 Definitions

Array – A collection of antennas. At times it will be used to indicate a subarray, but will most often refer to the VLA, NMA or VLBA.

Observer – An individual granted time on the array to conduct a scientific investigation or test.

Operator – An individual authorized to issue commands to the array. In most instances, the term operator will refer to the array operator, an NRAO employee whose duty it is oversee the success and safety of an observation.

Operator station – The primary work area of an array operator, consisting of computers, monitors and communications equipment.

Scan – An atomic element of an observation. It defines the source being observed, the duration and the hardware setup.

Administrator – An individual with unrestricted access to all aspects of the system.

Display (or Screen) – A GUI component contained within a frame. A display may be static or non-static and may or may not accept input from the user.

Frame (or Window) – A top level GUI component that contains other GUI components, such as menu bars, tool bars, etc.

A.2 Acronyms

AOC – Array Operations Center

API – Application programming interface

e2e – End-to-end project

GUI – Graphical user interface

M&C – monitor and control

NMA – New Mexico Array

VLA – Very Large Array

EVLA – The VLA Expansion Project

VLBA – Very Long Baseline Array

LST – Local Sidereal Time

UTC – Universal Time Coordinated

RA – Right ascension

RPC – Remote procedure call

WVR – Water Vapor Radiometer

SyRS – System Requirements Specification document

SRS – Software Requirements Specification document

A.3 Abbreviations

Az – azimuth

Dec – declination

El – elevation

B References

(1) ANSI/IEEE Std 830-1998, IEEE Recommended Practice for Software Requirements Specifications

(2) ANSI/IEEE Std 1233-1996, IEEE Guide for Developing System Requirements Specifications

(3) EVLA Memo No. 15, Scientific Requirements for the EVLA Real-Time System, http://www.aoc.nrao.edu/evla/memolist.shtml

(4) EVLA Project Book, http://www.aoc.nrao.edu/evla/pbook.shtml

(5) EVLA System Requirements Specification (SyRS), http://www.aoc.nrao.edu/evla/pbook.shtml

(6) EVLA Software Architecture and Design, http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/index.shtml

(7) The Very Large Array Observing Log (J. Nieri, February 1994)

(8) NRAO Computing Security Policy, http://www.aoc.nrao.edu/evla/techdocs/computer/workdocs/index.shtml

C Prototypical Operator's Workstation

The operator workstation is the computing system designated to run the software used by the array operators to monitor and control the array. The workstation(s) will be located in the control room of the VLA Control Building and possibly the AOC in Socorro.

The number of workstations and/or terminals required is undecided at this time and is somewhat dependent on the working style and personality of the operator. However, at a very minimum, the operator should have two workstations, with at least one of them having multiple monitor capability. One workstation would be used for array monitor and control tasks and the other would be used for logging, email and other non-M&C activities. Also, in the event that one of the systems becomes unusable the working system can be used as a backup system to monitor and control the array.

The specifications provided below are to be used as a guide in selecting such a system and does not target any particular manufacturer or system model.

- 2GHz processor
- 1 GB RAM
- 80–100 GB hard drive
- CD-RW drive
- DVD-ROM drive
- Keyboard and mouse (perhaps wireless)
- $19''$ display (perhaps digital flat panel)