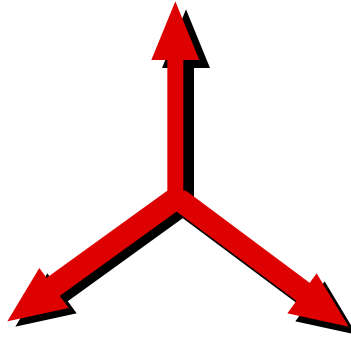


# EXPANDED VERY LARGE ARRAY



## Antenna Monitor & Control Subsystem Preliminary Requirements Specification

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## 1 Introduction

"The VLA Expansion Project will combine modern technologies with the sound design of the existing VLA to produce a tenfold increase in scientific capabilities."

The VLA is being upgraded to modernize its existing 20+ year old equipment and ultimately increase its already excellent capabilities. The project is divided into two phases. Phase I will retrofit the existing 27 VLA antennas with new digital electronics, new wideband receiver systems and a modernized on-line control system. A new correlator with greatly increased performance characteristics will be incorporated as well as a fiber-optic data transmission link between it and the antennas. Phase II of the expansion will add eight new antennas located throughout the state of New Mexico and will interface to the existing inner continental US VLBA antennas.

### 1.1 Purpose of this Document

The purpose of this document is to specify preliminary requirements for the 'modernized on-line control system' portion of the VLA Expansion project. These requirements specify precisely *what* is required of the control system in terms of meeting scientific goals and engineering and operational objectives.

### 1.2 Scope of this Document

The online control system of the EVLA is separated into two areas; control of the array of antennas and control of the system's correlator. This document pertains to the antenna control system which is formally called the EVLA Antenna Monitor and Control Subsystem (AMCS).

The AMCS is responsible for the direct, 'online' operation of the EVLA antennas. It is the software system that interfaces with the antenna hardware on one end and with the Operational Interface system on the other.

The requirements in this document pertain to the AMCS and its interaction with these external systems.

### 1.3 Definitions, Acronyms and Abbreviations used Throughout this Document

AMCS	Antenna Monitor and Control Subsystem. The component of the EVLA responsible for operating the array of antennas.
ASG	Array Support Group. A subgroup of the Computing Division of NRAO Socorro's Array Operations Center. The ASG is responsible for the development and maintenance of the VLA, VLBA and EVLA software systems.
CMCS	Correlator Monitor and Control Subsystem. The component of the EVLA responsible for operating the correlator.
Class	A term used in Object Oriented Design to define a virtual object. All behavior of the virtual object is wholly contained within the class definition of that object. All data and the functions that manipulate that data to specify the object's behavior are defined within the class. Classes are not executed in code, they are simply definitions from which objects are created. .
CMP	Control & Monitor Processor. A VME based single-board processor (MVME162-412) running VxWorks real-time OS that will be used during the transition phase to control and monitor the old style VLA antennas in conjunction with the new EVLA antennas. The purpose of this is to allow all the antennas of the array to be kept in operation during the years it will take to convert them all into EVLA type antennas. The CMP is also known as the Interim Control and Monitor Processor (ICMP).
Correlator Backend	The output side of the correlator. The ASG is responsible for the computing system that will process, in real-time the data produced by the correlator.
COTS	Commercial Off The Shelf (store-bought hardware).
DMA	Direct Memory Access. The ability of an I/O interface to get and put data directly into and out of the memory used by a processor without requiring use of the processor itself.

EVLA	Expanded VLA.
Hybrid Array	During the several-year transition phase where individual VLA antennas are converted to EVLA types, the system will have to be operational with both types of antennas. It is called the Hybrid Array and will remain as such until the last VLA antenna is upgraded.
IAT	International Atomic Time. The Systeme International (SI) second is defined as the duration of 9,192,631,770 cycles of radiation corresponding to the transition between two hyperfine levels of the ground state of cesium 133. IAT is the International Atomic Time scale, a statistical time scale based on a large number of atomic clocks.
ICMP	See CMP.
msec	Milliseconds.
$\mu$ sec	Microseconds.
NMA	New Mexico Array.
Object	A term used in Object Oriented Design to designate an instance of a class. An object is an actual segment of program code that provides the behavior defined by the class of which it is an instance.
Operational Interface	The name given to the EVLA subsystem responsible for the human and programmatic operation of the EVLA to perform science.
SLC	Serial Line Controller. The NRAO built device that collects monitor data from, and sends command data to, the old-style VLA antenna array. The SLC resides between the CMP and the antenna array.
Subarray	A disjoint collection of antennas that operate independently of the other antennas in the system .
UT	Universal Time. Universal Time (UT) is time based on the mean solar day. UT0 is the rotational time of a particular place of observation. It is observed as the diurnal motion of stars or extraterrestrial radio sources.

	<p>UT1 is computed by correcting UT0 for the effect of polar motion on the longitude of the observing site. It varies from uniformity because of the irregularities in the Earth's rotation.</p>
UTC	<p>Coordinated Universal Time. Time maintained by the 'atomic second' but adjusted by whole seconds (Leap Seconds) to keep within 0.9 seconds of UT1. Because of the Leap Seconds, UTC differs from IAT by an integral number of whole seconds.</p>
VLA	<p>Very Large Array. A 'Y' shaped array of 27 radio telescopes located in New Mexico, USA.</p>
VLA-LST	<p>VLA Local Sidereal Time. Sidereal time is based on the hour angle of the vernal equinox. VLA LST is sidereal time based on the VLA's meridian.</p>
VLBA	<p>Very Long Baseline Array. An array of 10 radio telescopes located in the northern hemisphere at points ranging from Hawaii, USA to St. Croix, Virgin Islands.</p>

## 1.4 References

EVLA Memo No. 15; "Scientific Requirements for the EVLA Real-Time System", September 26, 2000; John Benson and Frazer Owen, NRAO.

EVLA Project Book, Chapter 9, "EVLA Monitor and Control System", October 16, 2001, Wayne Koski, George Peck, William Sahr.

"EVLA Architecture and Design Snapshot #1", March 26, 2001, Bill Sahr.

"The VLA Expansion Project System Requirements", March 2, 2001, Bill Sahr, Steve Blachman.

ANSI/IEEE Std 830-1998, "IEEE Recommended Practice for Software Requirements Specification", 25 June 1998, IEEE Computer Society.

## 1.5 Overview

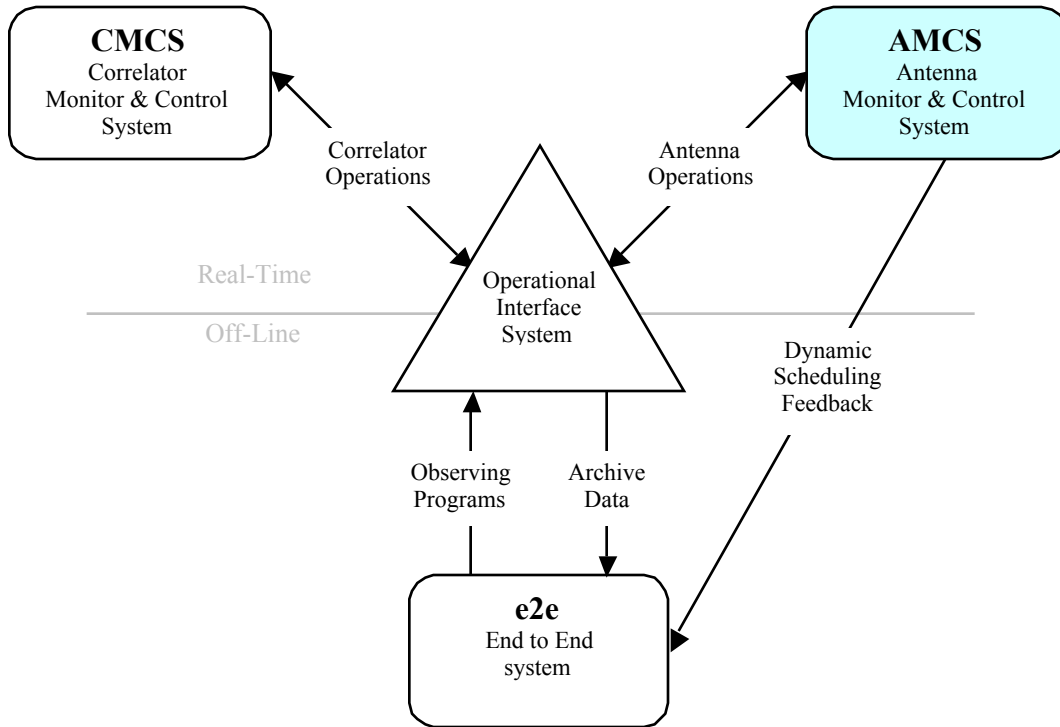
The remainder of this document contains a more detailed description of the AMCS as well as the requirements necessary to design and build the system. Section 2 provides a general description of the AMCS. This description is to acquaint the reader with the system so as to better understand the requirements presented later and should not be interpreted as requirements themselves. Section 3 presents the actual requirements of the AMCS.



**2 Overall Description of the AMCS**

**2.1 AMCS Perspective**

The AMCS is one subsystem of the whole EVLA System as shown below. It is responsible for the direct control of the antennas and associated hardware.



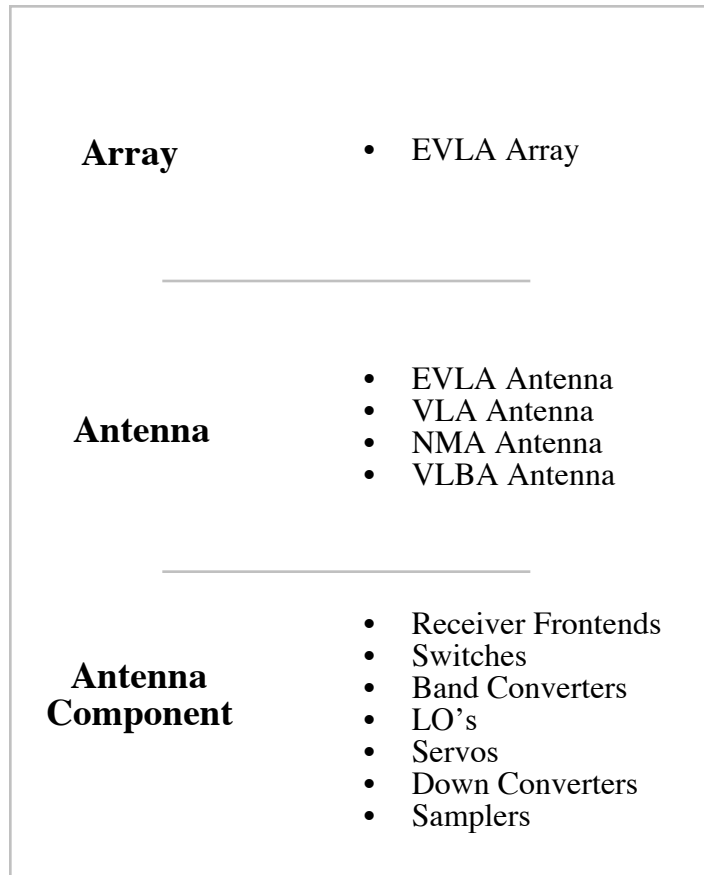
The AMCS interfaces to the rest of the EVLA system as follows:

- *Hardware.* It communicates with hardware sending commands and receiving monitor data to and from the various components that make up the antenna array and support systems such as the EVLA antennas, the interim interface to the old VLA antennas, the weather station and the Atmospheric Phase Interferometer.
- *Operations.* It communicates with the Operational Interface System where it can receive both programmed observation control (through control scripts originating from e2e) and interactive observation control from the Operational Interface's interactive observing mode.

- *e2e*. AMCS's interface to the e2e system is one-way only, from the AMCS to e2e. The information passed is current weather and atmospheric phase interferometer data which e2e can use for dynamic scheduling of subsequent observe programs.

## 2.2 Functional Description of the AMCS

The functionality of the AMCS can be thought of in terms of the 'real world' objects that are the components of the EVLA antenna hardware. Each of these objects is a process that represents the essence of its component to the rest of the system. These objects are 'arranged' in a hierarchical system consisting of three layers.



*Array Layer.* The Array is the top layer of AMCS processes. It represents several antennas operating together on a single observation. There can be more than one array in the system in which case each is called a subarray.

*Antenna Layer.* The Antenna layer represents the antennas that make up the array. The EVLA AMCS must accommodate a variety of antennas starting at the beginning during the transition from the VLA type of antenna to the new EVLA type. This transition will take several years to complete but the system must operate during that time. It is the job of the Antenna Object to provide a common antenna interface to each of the various antennas that may someday be operated from within the EVLA system.

*Antenna Subcomponent Layer.* This is the lowest layer of the system and represents the individual hardware components that combine to form an antenna. This is the layer where the software actually meets the hardware. The sub component objects will hide the internal 'workings' of the hardware they represent and instead present the component's 'front panel' to the rest of the system.

### **2.3 Physical Description of the AMCS**

The AMCS will consist of many processors distributed throughout the system. These processors are the physical medium that contains the component objects described above.

The processors comprising the lowest layer of the hierarchy described above are the so called Module Interface Boards (MIB). MIBs are special purpose computers designed to be built into, and interface with, the antenna hardware. As such, the MIBs will provide the physical interface between the AMCS software and hardware. Software will operate inside the MIB to communicate directly with the antenna hardware.

Other, more general purpose, type computers will house the higher layer Antenna and Array processes.

Each computer in the system will be networked to the rest of the system via Ethernet on fiber optic cable.

### **2.4 System Development Constraints**

A large portion of how the AMCS is engineered is impacted by two important factors:

*Ethernet Fieldbus.* Unlike past systems which use simple memory mapped I/O over a dedicated fieldbus, the various hardware modules of the AMCS will be controlled and monitored over Ethernet using IP under standard protocols such as UDP and TCP. IP communications will require:

- packetizing higher level data which will in turn require more 'intelligence' at the hardware end to interpret the data and convert it to bit-levels,
- a more sophisticated operating system in the MIB capable of supporting Ethernet and the associated protocols.

*RFI Concerns.* Since processors will be located within the antennas themselves, it is extremely important that they be designed to be as 'RF quiet' as possible severely limiting the choice of hardware that can be used to build the MIB. The greatest impact is that the MIB processor must have memory resident on the same core as the processor itself (to eliminate data transfers over an external bus). Most processors that meet this requirement have relatively small amounts of memory. This memory constraint will determine the operating system and programming languages used for the MIB software.

Since one factor (Ethernet) requires more sophisticated MIB hardware while the other (RFI) mandates the opposite, the difficulty in balancing the two is realized.

**3 Preliminary Requirements of the EVLA Antenna Monitor and Control System.**

The following section provides the requirements of the software portions of the EVLA AMCS. The requirements are 'high-level' in nature and describe the AMCS as a whole. As development progresses, more detailed analysis and design of individual system components will be made.

The requirements are presented in table form with a requirement identifier, a reference and the requirement itself comprising the columns. The reference field will only be used if the requirement can be traced to an external source such as those specified by the scientific community or the e2e system.

As a rule, each requirement will contain one, and only one *shall* statement followed by additional amplifying information if needed. The amplifying information is not to be considered a requirement.

*All requirements specified here are Priority 0.* This document is a requirements specification whose purpose is to specify precisely how the system is to perform. The design of the system will be based completely on the goal of satisfying each and every one of these requirements and cannot proceed to completion if inclusion of any single requirement is in doubt. The reader can therefore assume that each requirement listed in this document is indeed a requirement.

**3.1 External interface requirements**

**3.1.1 Interface Requirements of the AMCS by the Operational Interface System.**

The Operational Interface System is responsible for providing the interface between the AMCS and the humans and programs that operate the EVLA System. This section specifies what is required of the AMCS by the Operational Interface System.

3.1.1.1	EVLA Memo 15, 3.1.3	<b>Monitor and Control Data.</b> <i>The AMCS shall provide monitor data to and receive control data from the Operational Interface System for Interactive Observing.</i>
3.1.1.2	EVLA Memo 15, 3.1.3	<b>Online Image Data.</b> <i>The AMCS shall provide required data and imaging control parameters to the on-line imaging pipeline to support interactive observing.</i>
3.1.1.3	EVLA Memo 15, 3.2.3	<b>Timestamped Data.</b> <i>The AMCS shall accommodate interactive control and display data in either or both UTC and VLA LST time.</i>

**3.1.2 Interface Requirements of the Online Operations System by the AMCS.**

This section specifies what must be provided by the Operational Interface System in order for the AMCS to meet its own performance and constraint requirements of the scientific community.

<p><b>3.1.2.1</b></p>		<p><b>Technician Screens.</b> <i>The Operational Interface System shall support low-level technician's type monitor and control screens for every device, giving access to every monitor and control point of that device.</i></p> <p>Every processor based device in the AMCS system will need low-level access by the technicians for initial development and subsequent maintenance.</p>
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**3.1.3 Interface Requirements of the AMCS by the e2e System.**

The e2e system is responsible for providing the observing schedules that determine how the antennas are operated to perform a particular observation. One capability of e2e, called Dynamic Scheduling, generates subsequent observe control scripts based on current system conditions as feedback from the AMCS to e2e. This section specifies what must be provided to the e2e system by the AMCS.

<p><b>3.1.3.1</b></p>		<p><b>Weather Data.</b> <i>Data from the weather station shall be provided by the AMCS to the e2e system for dynamic scheduling purposes.</i></p>
<p><b>3.1.3.2</b></p>		<p><b>Atmospheric Phase Interferometer Data.</b> <i>Data from the API data shall be provided by the AMCS to the e2e system for dynamic scheduling purposes.</i></p>
<p><b>3.1.3.3</b></p>	<p>EVLA Memo 15, 3.2.3</p>	<p><b>Archived Data Time Tag.</b> <i>Data from the AMCS that is destined to be archived by the e2e system shall be time tagged in UTC only.</i></p> <p>The intent of this requirement is that archived data be stored with only one time convention.</p>
<p><b>3.1.3.5</b></p>	<p>EVLA Memo 15, 3.2.3</p>	<p><b>Dynamic Scheduling Time Tag.</b> <i>AMCS shall accept dynamic scheduling data that is oriented around VLA LST time.</i></p>
<p><b>3.1.3.6</b></p>	<p>EVLA Memo 15, 3.2.3</p>	<p><b>Control Script time.</b> <i>AMCS shall accept control script data based around either or both UTC and VLA LST time.</i></p>

**3.1.4 Interface Requirements of the e2e System by the AMCS.**

This section specifies what must be provided by the e2e in order for the AMCS to meet its own performance and constraint requirements of the scientific community.

<b>3.1.4.1</b>	EVLA Memo 15, 3.2.5	<b>Source Position Precision.</b> <i>e2e shall supply an observing source position to a precision within 10 microarcseconds.</i>
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**3.1.5 Requirements of the AMCS Software to Antenna Hardware Device Interface.**

The Module Interface Board (MIB) has been defined as the physical medium which will interface the antenna hardware components to the monitor and control software. As such, the responsibility of MIB software development will be shared between hardware and software engineering.

This section specifies the requirements for the software to hardware interface.

<b>3.1.5.1</b>		<p><b>No Special Diagnostic Ports.</b> <i>There shall be no special diagnostic ports, located in the antenna, that could provide monitor and control information not available to the rest of the AMCS.</i></p> <p>This is not to preclude test points, indicator lights, panel gauges and etc. that would normally be in and around equipment. It simply means that any monitor and control data conveyed by the MIB must be available to the whole MCS.</p>
<b>3.1.5.2</b>		<p><b>Control Points are Readable.</b> <i>Every control point shall be readable.</i></p> <p>In other words, the last value written to a control point can be read back from it at any time.</p>
<b>3.1.5.3</b>		<p><b>Control Points have Monitor Points.</b> <i>Every control point shall have a corresponding monitor point.</i></p> <p>This means that every point that can be controlled must also be able to be monitored (this is not the same as simply reading the last command sent).</p>
<b>3.1.5.4</b>		<p><b>Monitor Point has Time.</b> <i>Monitor data shall be time stamped.</i></p>

<p><b>3.1.5.5</b></p>	<p><b>Monitor Point Reflects Actual State.</b> <i>Monitor points shall reflect actual state of the device being monitored as opposed to merely an echo of the last command sent.</i></p> <p>This is not requiring that the actual value of a device parameter be available. In some cases this would not be to our best advantage such as with an LO where it is of more value to know simply whether or not it is locked to the commanded reference frequency as opposed to knowing the actual frequency of the LO itself. In that case, a simple lock status would reflect the 'actual state' of the device.</p>
<p><b>3.1.5.6</b></p>	<p><b>Monitor Points not Resettable.</b> <i>Monitor points shall not be resettable (or have its value changed) by software.</i></p> <p>If software can reset or write to a monitor point than that monitor point would no longer reflect the actual state of the hardware.</p> <p>This requirement does not preclude the software from resetting the device itself which would in turn cause the monitor point to be reset by the hardware system.</p>
<p><b>3.1.5.7</b></p>	<p><b>Monitor Points have Indicators of Health.</b> <i>A monitor point shall have an indicator of its health.</i></p> <p>This means that there can be no ambiguity as to whether a monitor value is actually 'zero' or if the device is not present.</p>
<p><b>3.1.5.8</b></p>	<p><b>Fail-Safe Hardware.</b> <i>The hardware shall be responsible for its own safe operation.</i></p> <p>This means that, in the absence of control software, the hardware will resume a safe state. It also means that software cannot command a hardware device into an unsafe state.</p> <p>The idea of this requirement is that the system must not rely on software to be operating properly in order for the hardware to operate in a manner that will not bring harm to human or machine.</p>
<p><b>3.1.5.9</b></p>	<p><b>Tolerance Ranges.</b> <i>Each monitor point shall have a default tolerance range supplied by hardware but able to be overridden by software.</i></p> <p>This means hardware engineering must provide the default limits for each monitor point (where an alert is raised if the value exceeds these limits) but that these default limits can be overridden by software.</p>



<p><b>3.1.5.10</b></p>		<p><b>Device Mapping.</b> <i>AMCS shall support automatic device recognition on the fieldbus/network.</i></p> <p>This means that each device connected to the network/fieldbus will have its identity discovered by the rest of the system automatically.</p> <p>The MIB device IP Addresses will most likely be slot dependent; if this is indeed the case, this requirement would ensure that the Ethernet MAC address of a board in a particular slot will be automatically mapped to the IP address of that slot.</p>
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**3.2 Functional Requirements AMCS Software.**

**3.2.1 Hybrid Array Operation.**

<p><b>3.2.1.1</b></p>	<p>EVLA Memo 15, 3.1.1</p>	<p><b>Support both VLA and EVLA Antennas.</b> <i>The EVLA AMCS system shall support simultaneous operation of the old VLA antenna systems and the EVLA antennas during the transition phase.</i></p> <p>Simultaneous operation means that one operation program will control both antenna types.</p>
<p><b>3.2.1.2</b></p>	<p>EVLA Memo 15, 3.1.1</p>	<p><b>Down Time During Transition.</b> <i>Array down time shall be minimized as much as possible during the transition phase.</i></p>
<p><b>3.2.1.3</b></p>	<p>EVLA Memo 15, 3.1.1</p>	<p><b>Maintain Current Operation for VLA.</b> <i>Operations using the old VLA shall be possible using the current OBSERV/JOBSERVE script files.</i></p> <p>This is to maintain backward compatibility (for the remaining VLA antennas only) with current observing programs while VLA antennas exist during the transition phase.</p>

**3.2.2 Operation.**

<p><b>3.2.2.1</b></p>		<p><b>Programmed Observing.</b> <i>The AMCS shall support programmed (observe control script type) observing.</i></p> <p>This refers to being able to run observe control scripts that will be generated by the e2e system.</p>
<p><b>3.2.2.2</b></p>	<p>EVLA Memo 15, 3.1.3</p>	<p><b>Interactive Observing.</b> <i>The AMCS shall support interactive observing from control and data displays over the Internet.</i></p>

3.2.2.3		<p><b>Dynamic Scheduling.</b> <i>The AMCS shall support dynamic scheduling.</i></p> <p>The e2e will be able to refine observe parameters based on feedback of current conditions by the AMCS. The AMCS must be able to accept newly updated parameters during an observation.</p>
3.2.2.4	<p>EVLA Memo 15, 3.2.6</p>	<p><b>Subarraying.</b> <i>Two levels of subarraying shall be supported by the AMCS:</i></p> <ul style="list-style-type: none"> <li>• <i>where the VLA operations staff will assign antennas to specific observing programs,</i></li> <li>• <i>where the observing programs may freely schedule their antennas into subarrays.</i></li> </ul>

### 3.2.3 Control and Monitor Data.

3.2.3.1		<p><b>Monitoring.</b> <i>Every monitor point in the system shall be available for viewing by the operator.</i></p> <p>This simply means that the operator (not just technicians) will have access to every piece of monitor data generated by the system.</p>
3.2.3.2		<p><b>Logging.</b> <i>Every monitor point shall be able to be logged.</i></p> <p>Able to be logged - not necessarily logged.</p>
3.2.3.3		<p><b>Logging.</b> <i>The operator shall be able to select which monitor points are to be logged and the interval at which they are logged.</i></p>

### 3.2.4 System Operation Quality and Integrity.

3.2.4.1		<p><b>Support BIT.</b> <i>Built In Testing (BIT) shall be supported by AMCS.</i></p> <p>The extent of this is not yet know but may include</p> <ul style="list-style-type: none"> <li>• Periodic confidence tests</li> <li>• Simple health indicators of every device</li> <li>• Watchdog timeouts</li> </ul>
3.2.4.2		<p><b>Alert Reporting.</b> <i>The EVLA shall support an alert reporting system where abnormal conditions are made known to the Operational Interface System.</i></p>

<p><b>3.2.4.3</b></p>		<p><b>Alert Causes.</b> <i>The alert reporting system shall apply, but not be limited, to the following:</i></p> <ul style="list-style-type: none"> <li>• <i>Catastrophic failures,</i></li> <li>• <i>Out or range conditions,</i></li> <li>• <i>Loss of communications with a device or subsystem,</i></li> <li>• <i>Network failures,</i></li> <li>• <i>Software based errors such as math errors, I/O errors, invalid commands to a hardware device.</i></li> </ul>
<p><b>3.2.4.4</b></p>		<p><b>Defined Alerts.</b> <i>The alert reporting system shall define, as a minimum, the following types of alerts:</i></p> <p><i>Failure</i>      A non-working state (a +5 VDC monitor point reads 0 VDC),</p> <p><i>Warning</i>      An out-of-tolerance state (a +5 VDC monitor point reads +4.7 VDC),</p> <p><i>Error</i>          An illegal or undefined state (such as if a hardware device was commanded to a position outside of it operating range).</p>
<p><b>3.2.4.5</b></p>		<p><b>Every Monitor Point can Alert.</b> <i>Every monitor point shall be capable of reporting an alert.</i></p>
<p><b>3.2.4.6</b></p>		<p><b>Alerts Report.</b> <i>Every alert shall, at a minimum, indicate:</i></p> <p><i>Type</i>            i.e. Failure, Warning, Error,</p> <p><i>Description</i>    A message describing the alert.</p> <p><i>Severity</i>        The consequences or impact to the system and or operation.</p> <p><i>Root Cause</i>    The underlying cause of the alert.</p> <p><i>Action</i>          A suggested action that the operator should take. This could mean a corrective action to remove the problem or possibly just a suggestion to call a technician.</p>
<p><b>3.2.4.7</b></p>		<p><b>Meaningful Alerts.</b> <i>The alert reporting system shall be designed so that only messages of a meaningful nature are reported.</i></p> <p>This is rather subjective but is meant to convey the idea that the reporting system should not be 'clogged' with 'noise' of over reporting trivial and meaningless messages. (See VLBA Checker for what is trying to be avoided).</p>

<p><b>3.2.4.8</b></p>		<p><b>Tolerance Ranges.</b> <i>Software shall be able to override the default tolerance range set by the hardware.</i></p> <p>An earlier requirement specified that the hardware system is responsible for setting the default out-of-range values for each monitor point. This requirement allows the operator to override the default settings.</p>
<p><b>3.2.4.9</b></p>		<p><b>Flagging System.</b> <i>The AMCS shall support a data flagging system where observer data received under questionable conditions is flagged for possible corruption.</i></p>
<p><b>3.2.4.10</b></p>	<p>EVLA Memo 15, 3.2.10</p>	<p><b>Flagging Data.</b> <i>Flagging data shall be made available to EVLA Operators and Astronomers.</i></p>
<p><b>3.2.4.11</b></p>	<p>EVLA Memo 15, 3.2.10</p>	<p><b>Flagging Data Generation.</b> <i>Flagging data shall be constructed by the AMCS mainly from monitor data.</i></p>
<p><b>3.2.4.12</b></p>	<p>EVLA Memo 15, 3.2.10</p>	<p><b>Flagging Causes.</b> <i>Data shall be flagged for (but not limited to) the following conditions:</i></p> <p style="padding-left: 40px;"><i>Pointing</i>    When pointing errors exceed a specified threshold,</p> <p style="padding-left: 40px;"><i>Frequency</i>    When local oscillators are not locked,</p> <p style="padding-left: 40px;"><i>Shadowing</i>    When shadowing occurs.</p>
<p><b>3.2.4.13</b></p>	<p>EVLA Memo 15, 3.2.6</p>	<p><b>RFI Detection and Excision.</b> <i>The system shall accommodate the control and monitoring of a separate RFI monitoring radiometer if such a system is built in the future.</i></p> <p>There are no concrete plans yet for an RFI Detection and Excision system but it is agreed that such a system is highly desirable if not needed. This requirement is in place simply to ensure that such a system can be accommodated if it is added.</p>

**3.3 Performance and Constraint Requirements of the AMCS.**

<p><b>3.3.1</b></p>	<p>EVLA Memo 15, 3.2.6</p>	<p><b>Antenna Position.</b> <i>Antenna position and axis offsets shall be known to a geodetic level of accuracy.</i></p>
<p><b>3.3.2</b></p>	<p>EVLA Memo 15, 3.2.1</p>	<p><b>Hardware Reconfiguration Time.</b> <i>The time it takes for hardware to begin a reconfiguration from when the reconfiguration is scheduled to execute shall not exceed 100 <math>\mu</math>Seconds.</i></p> <p>This does not mean that the hardware must be reconfigured within that time.</p>
<p><b>3.3.3</b></p>	<p>EVLA Memo 15, 3.2.1</p>	<p><b>Frequency Change Rate.</b> <i>The AMCS shall support frequency switching within a receiver's band at the rate of 1 per second.</i></p>
<p><b>3.3.4</b></p>	<p>EVLA Memo 15, 3.2.1</p>	<p><b>Frequency Change Time.</b> <i>The time it takes to complete a frequency change within a receiver's band shall be limited only by the LO settling time.</i></p>
<p><b>3.3.5</b></p>	<p>EVLA Memo 15, 3.2.1</p>	<p><b>Nodding Source Switch Rate.</b> <i>The AMCS shall support 'nodding' source switching at the rate of once per 10 seconds.</i></p>
<p><b>3.3.6</b></p>	<p>EVLA Memo 15, 3.2.1</p>	<p><b>Nodding Source Switch Time.</b> <i>The time it takes to complete a source change shall be limited only by the servo settling time.</i></p>
<p><b>3.3.7</b></p>	<p>EVLA Memo 15, 3.2.7</p>	<p><b>Pointing Update Rate.</b> <i>To keep the antenna pointed to a sub-arcsecond level of accuracy, the pointing servos shall be updated with new azimuth and elevation values at least every 50 milliseconds.</i></p>
<p><b>3.3.8</b></p>	<p>EVLA Memo 15, 3.2.7</p>	<p><b>Focus Correction.</b> <i>Antenna focus shall be corrected in real time.</i></p> <p>This means that focus will be corrected while observing but it does not specify how or when. Current systems correct focus during source change; unless a better mechanism is thought of, the EVLA may update focus at source change time also.</p>
<p><b>3.3.9</b></p>		<p><b>Temperature Compensation for Focus.</b> <i>The AMCS shall accommodate temperature compensation into focus corrections if such a function is incorporated in the future.</i></p> <p>It has not yet been decided if temperature compensation of focus is desired. This requirement is in place to ensure that such a function can be implemented if decided.</p>

**3.4 AMCS Software System Attributes.**

**3.4.1 Availability, Maintainability and Portability.**

The EVLA is being designed for a 20+ year existence; it is imperative that the system be developed with longevity of its components parts in mind. The requirements in this section specify the software attributes needed to ensure this longevity.

<p><b>3.4.1.1</b></p>	<p>EVLA Memo 15, 3.1.2</p>	<p><b>Operational Flexibility.</b> <i>The system shall be designed to minimize software modifications needed to accommodate unforeseen observing requirements that may arise during the lifetime of the EVLA.</i></p>
<p><b>3.4.1.2</b></p>		<p><b>System Growth.</b> <i>Software shall be designed to accommodate system growth or change with minimal impact on the existing system.</i></p> <p>The EVLA will eventually utilize more antennas than the original 27; software design should foresee expansion and avoid hardcoded limits in areas that might see future change.</p>
<p><b>3.4.1.3</b></p>		<p><b>Component Diversity.</b> <i>Software shall accommodate operation of heterogeneous antennas and antenna component hardware under the same operational system.</i></p> <p>The EVLA will eventually be comprised of different antenna types (EVLA antennas, New Mexico Array Antennas, VLBA antennas, etc.). The EVLA AMCS Software must be able to operate these different antennas from a single operational system. The same holds true for the components that make up a single antenna; like antennas may incorporate different models or versions of sub components. The software must accommodate these variances with minimal modifications.</p>
<p><b>3.4.1.4</b></p>		<p><b>Longevity.</b> <i>Software shall be developed using programming languages and tools that are maintainable over the life of the project.</i></p> <p>The life span of the EVLA will be tens of years; care must be taken to ensure that short-term 'fad' languages, OS's and middleware are avoided. COTS software that is embraced by industry today will most likely be directly supported for years or will be provided with migration paths to new technologies as they become available.</p>

<p><b>3.4.1.5</b></p>	<p><b>Maintainability - Change Affects.</b> <i>The software shall be designed so that a change (either hardware or software) at one level requires minimal or no changes at other levels.</i></p> <p>Due to the potential diverse nature of the EVLA hardware it is important that differences or changes at one level do not cause 'trickle-up' affects at other levels that may require extensive changes and regression testing.</p>
<p><b>3.4.1.6</b></p>	<p><b>Maintainability - Documentation.</b> <i>Software shall be documented well enough to support future maintenance by personnel who may not necessarily be the original authors.</i></p> <p>This means (but is not limited to) both high level overall system descriptions and detailed module level descriptions.</p>
<p><b>3.4.1.7</b></p>	<p><b>Software Engineering Tools.</b> <i>Code generation tools (such as compilers) shall meet industry certification.</i></p> <p>This simply requires the use of ANSI certified C/C++ compilers, Sun Certified Java Compilers and Virtual Machines, etc.. Its purpose is to keep the software compatible with industry standards.</p>
<p><b>3.4.1.8</b></p>	<p><b>Programming Style.</b> <i>Programming style shall conform to industry standards for the particular language used.</i></p> <p>The purpose of this requirement is to make the AMCS software 'look' familiar to industry software of the same language which in turn enhances long term maintainability. For example, Java programs should use the commenting style recommended by Sun so that the automated documentation tools operate properly.</p>