Title: Science Instrument Interface Requirements for the WIYN 3.5 Meter Telescope

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.1 General editing to correct syntax and spelling.

.2 Section 4.3: Toolkit provided for accessing EDS archives.

.3 Section 7.2: Specify guide mechanisms for SIs.

1. Scope

The purpose of this document is to define the requirements for the interface between the WIYN control system and science instruments (SIs). Interface specifications will be contained in an interface control document (ICD).

The scope of this document includes the hardware and software being developed for the WIYN project by the University of Wisconsin Controls Group that comprise the Science Instrument interface including (a) system configuration, (b) network protocols, (c) message transport layer, (d) commands, (e) telemetry, (f) image processor interface, and (g) timing signals.

2. Configuration

The primary science instrument interface to the control system is through the Observatory LAN. In the current design, the Observatory LAN has three legs: (a) Telescope Controls, (b) Engineering Data System, and (c) Science Instruments. The SI subLAN supports (a) instrument controllers, (b) data reduction and archiving workstations, (c) scientist workstations, (d) shared disks and (e) printers. The ports and cabling for these instruments will be provided as part of the control system. Providing the instruments is the responsibility of instrument developers. Figure 1 shows the system configuration.

A bridge/router separates the local SI traffic from traffic on the two other subLANs. Messages from SIs to the rest of the observatory control system pass through the bridge/router. The operation of the bridge/router is transparent to software running in the connected peripherals. The bridge/router also connects the Observatory LAN to the Kitt Peak Mountain LAN and provides a gate to the Internet.

Science instruments may have subnets of their own for instrument control and data storage. No requirements are specified in this document for subnets, instrument cabling or the internal design of instrument controllers. Instrument developers must coordinate their controller design with the WIYN Observatory to ensure that the location, cabling, communications links, etc., can be accommodated.

The real time control of telescope motions is carried out by 68000 based single board VME-bus computers (SBCs) running VXWORKS attached to the Telescope Controls leg of the Observatory LAN. A software router (NB. need a different name to distinguish between this and hardware bridge/router) controls the transmission of commands and telemetry between the real-time controllers and workstations, Engineering Data System, SIs, etc.. Except as otherwise provided in this document, there is no provision for connecting SIs directly to the real-time systems without going through the software router.

SIs attached to the Instrument Adapter (IA) at the WIYN port will use the acquisition and guide system provided with the IA to track the telescope. Instruments that provide guide information independent of the IA will be able to do so by (a) sending guide commands to the control system, (b) sending guide signals through a hand controller port, or (b) providing a video signal to the Instrument Adapter System (IAS) image processor as described below. Examples of instances for which this may be necessary are guiding off a spectrograph slit and SIs attached to the other ports.

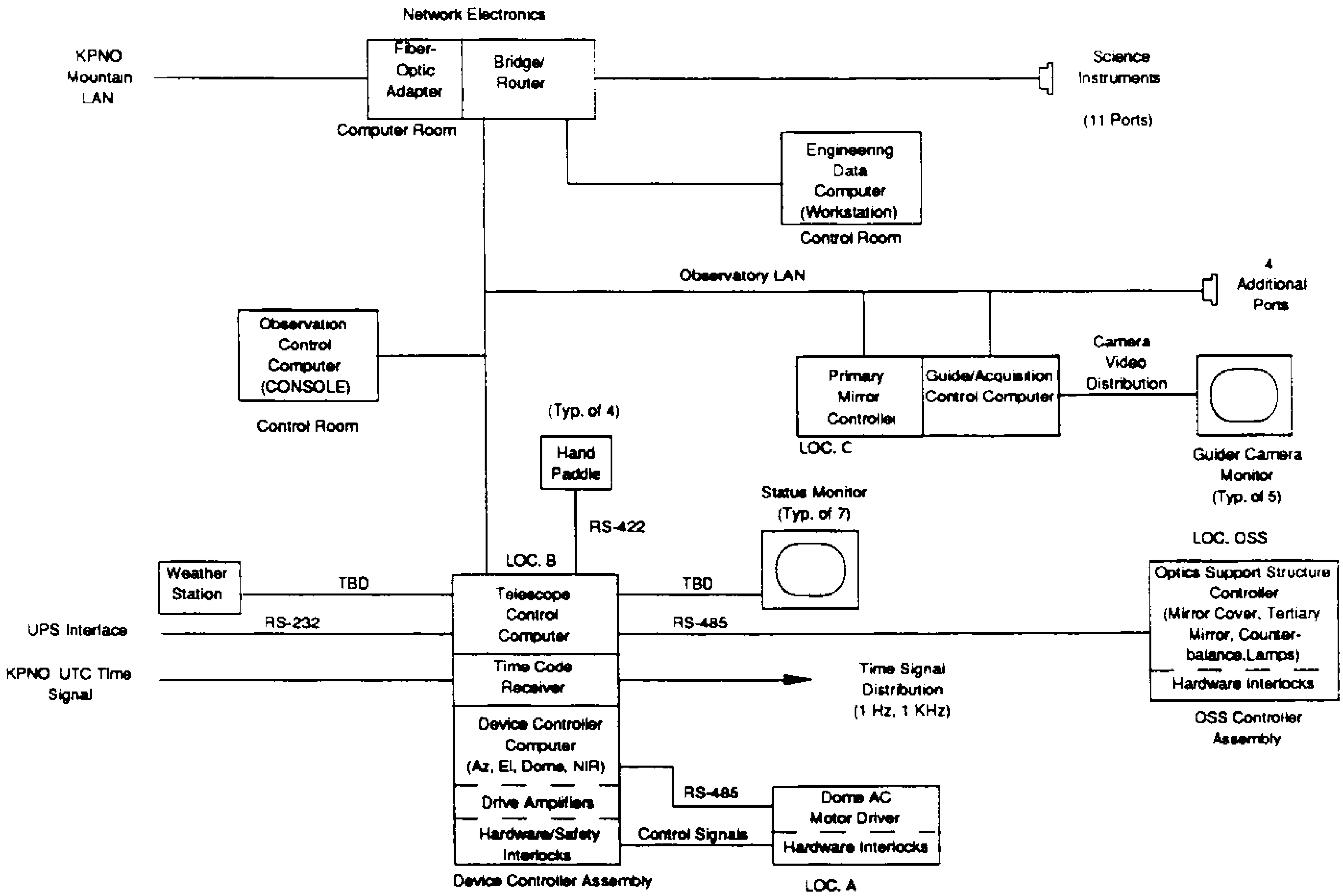

Figure 1. WIYN Control System Block Diagram

3. Observatory LAN

The Observatory LAN is a resource that is shared between the telescope controls, science instruments, and workstations. The LAN consists of three legs as described under "Configuration". Access to the NOAO network and Internet is provided through a connection to the Mountain LAN.

The Observatory LAN backbone uses thick-wire 10base5 Ethernet and TCP/IP. Twisted-pair 10baseT extensions of the LAN will be implemented in locations where wiring access is limited.

Instrument developers planning to use the network need to submit an estimate of the bandwidth and timing requirements for their instrument before finalizing the design. Advance approval is required from the Observatory to assure adequate resources will be available.

3.1 Science Instrument subLAN

SIs will attach to the Science Instrument leg of the Observatory LAN. These will include (a) instrument controllers, (b) data reduction workstations, (c) shared peripherals such as disks, tape drives, and printers, and (d) scientist workstations. Ports will be provided in the following locations:

a. Spectrograph laboratory (1)

b. Computer room (3)

c. Instrument shop (1)

d. Enclosure second floor (1)

e. Control room (3)

f. Scientist's office (1)

g. Observing floor (1)

3.2 Telescope Control subLAN

The real-time controllers for the telescope and dome will be attached to the Telescope Control leg of the Observatory LAN. The Observation Control Computer (OCC) will also be connected to this leg. The SIs will interact with the real-time controllers by passing messages through router software running on the OCC. The exceptions to this rule are (a) video input from the SIs to the image processor, (b) guide/acquisition frames from the image processor, and (c) time signals from the WWV time base to the SIs as described below.

3.3 Engineering Data subLAN

Engineering data is defined in Section 5. The engineering data archiver will be connected to the Engineering Data leg of the Observatory LAN. SIs will be able to access archives using standard UNIX network tools (rlogin, telnet, ftp, etc.).

3.4 Kitt Peak Mountain LAN

SIs will connect to the Kitt Peak Mountain LAN through the bridge/router and Whisperlan® fiberoptic link. The Mountain LAN will provide T1 service to the Tucson NOAO LAN and Internet.

The Mountain LAN and T1 link to the downtown NOAO network are shared with the other telescopes and observatories on Kitt Peak. Use restrictions may be imposed at various points in the net if demand exceeds the capacity of the system.

4. Network Protocols

The high level control subsystems including the SIs will communicate over thick-wire (10base5) Ethernet using the TCP/IP protocols. Telemetry between the SIs and the real-time controls is based on a client/server model in which commands and data are encapsulated in messages that are passed between processes using software socket connections. All telemetry passes through the software router. The messages are encoded in a machine and network independent format and are not restricted to connections on the local networks. Message formats are described in the Message Handler Manual available from the project.

The format for passing guide/acquisition and wavefront sensor images is to be determined (TBD).

The guiding philosophy of the top level control system design is that information is exchanged as telemetry over the network rather than being embedded in rlogin or xwindow sessions. Software running locally at the control sites to processes the telemetry and runs terminal sessions and displays. This reduces the network traffic and transmission delays for remote clients but does require that each node be a workstation. The hardwired display providing telescope/dome position and status at the observatory is the exception.

4.1 Software Standards

The top level software standards for the WIYN control system are UNIX and C. WIYN will provide instrument developers with C subroutines for interfacing to the Engineering Data System (EDS) and Command and Control System (CCS). These will include procedures for: (a) connecting to the EDS and CCS, (b) message formatting, and (c) miscellaneous utilities.

A command line interpreter will also be available.

4.2 Communication with Real-time System

SIs will communicate with the real-time telescope controls using the message passing protocols described in the Message Handler and Command and Control Manuals. Messages will pass through the router software running on the OCC that will (a) validate access privileges, (b) determine single or multiple recipients, and (c) transmit the message accordingly. Engineering data from the SI to the EDS will also be handled by the router.

4.3 UNIX tools

SIs will have the standard UNIX network tools (rlogin, telnet, ftp, etc.) for communicating over the network with the Engineering Data System and remote workstations.

A toolkit will be provided for accessing EDS archives.

5. Engineering Data System

Engineering data consists of all control system messages not classified as commands or control. Examples of engineering data are positions, velocities, temperatures, voltages, currents, target names, program ID's, etc.. Command and control messages become engineering data after they have been acted upon by the appropriate subsystem. Engineering data allow the operators and processes to monitor the real-time status and performance of the observatory and allow non-real time archival and analysis for trending and troubleshooting. Engineering data will be used by remote stations for generating operator displays.

The EDS is not intended to handle science data but will process engineering data associated with science instruments. Examples of SI engineering data are instrument configuration, exposure start/stop time, detector temperature and so on. Instruments will be both generators and consumers (ie. servers and clients) of engineering data. As an example of the later, FITS headers produced by the instrument controller will include telescope position and time information obtained from the EDS message stream.

Engineering data messages are initiated at the subsystem level. The content and timing of messages are determined by processes running at this level. For example, the Primary Mirror System will broadcast the set temperature of the thermal control system at a rate determined by software running in the Primary Mirror Controller. Likewise, science instruments will generate their own engineering data and send it to the EDS server. The server routes the messages to subscribing clients. These will include other subsystems, science instruments, control stations and the archiver.

The format for engineering data messages is specified in "WIYN Control System: Message Handler Software Programmer's Guide".

6. Command and Control System

Command and control messages have the same format as EDS messages with flags set to distinguish them from engineering data. A command and its arguments are encapsulated together in the same message. Two examples of commands are (a) moving the telescope to a new position and (b) turning on a bank of calibration lamps. Examples of control are (a) requesting position telemetry and (b) inhibiting a motion command.

The Command and Control System (CCS) has a single entry point called the CCS socket server running under the router. Users connect to this server using standard TCP/IP sockets. The server accepts commands and dispatches them to the appropriate subsystem. The CCS sends command messages to the real time subsystems over UNIX socket connections.

SIs will be able to send and receive commands to/from the CCS socket server if they are connected to the LAN and implement this feature in their software. The socket server will validate command permission and transmit the command message to the appropriate subsystem. All system commands are potentially available to the SI using this system.

The format for command and control messages is specified in "WIYN Control System: Command and Control System User's Guide".

7. Image Processor

The image processor is provided as part of the Instrument Adapter System (IAS) at the WIYN port. In addition to providing a mount for instruments, the IAS contains acquisition and guide cameras for tracking the telescope. Video processor hardware and software in the IAS provides field acquisition and tracking using the guide camera images. Spare video inputs will accept video signals from SIs mounted on any port.

7.1 Description

Video signals from the cameras in the Instrument Adapter go to the IAS Image Processor. The image processor (a) captures frames for target acquisition, (b) integrates multiple frames to improve signal-to-noise, (c) displays raw and integrated images, (d) adds cursor and other graphical information to the display, and (d) calculates star centroids to obtain guide errors for tracking the telescope axes. The format for video signals between the cameras and the image processor is RS170.

Additional camera inputs will be provided in the IAS for those science instruments that require some or all of the capabilities of the IAS provided that they are design to use the same hardware and software. Reconfiguration between the IAS and SI cameras will be handled in the IAS software in response to operator commands.

7.2 Guide function

The control system will accept telescope guide signals from SIs in one of three formats: (a) commands messages in IAS compatible format, (b) raw video in IAS compatible format, and (c) hand controller inputs that duplicate the action of the hand control paddles.

7.3 Frame store

Image frames from the IAS will be sent to the SI in TBD format. SIs will initiate the transmission by sending a command to the IAS. Image frames sent from the IAS to the SI are not intended to be used for realtime control of the telescope or instruments.

8. Time Signals

Buffered 1 Hz and 1 kHz signals synchronized to WWV will be distributed throughout the observatory for use by instrument developers. The signals will be carried on separate coaxial cables.

System time is available asynchronously as EDS telemetry over the Observatory LAN.