Keck Adaptive Optics Note 836

Near-Infrared Tip-Tilt Sensor Camera to Keck Adaptive Optics Interface Control Document

P. Wizinowich, R. Smith

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Document Revision History

Revision Number	Revision Date	Summary of Changes	Author
1.0	11/15/2010	SDR Version	Peter Wizinowich

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1. Introduction

This Interface Control Document (ICD) is written in support of the NSF ATI-funded near-infrared (NIR) tip-tilt sensor (TTS) project. The purpose of this document is to document the interfaces between the NIR TTS camera to be built at Caltech and the remainder of the NIR TTS system including the existing Keck AO system. The remainder of the NIR TTS system includes 4 additional subsystems: the opto-mechanical system, the real-time control system, the controls system and the operations software. A block diagram showing all 5 subsystems and their key components is provided in Figure 1. The overall system requirements and the functional requirements for each of the 5 subsystems can be found in the System Design Manual (SDM); these requirements are not repeated here.

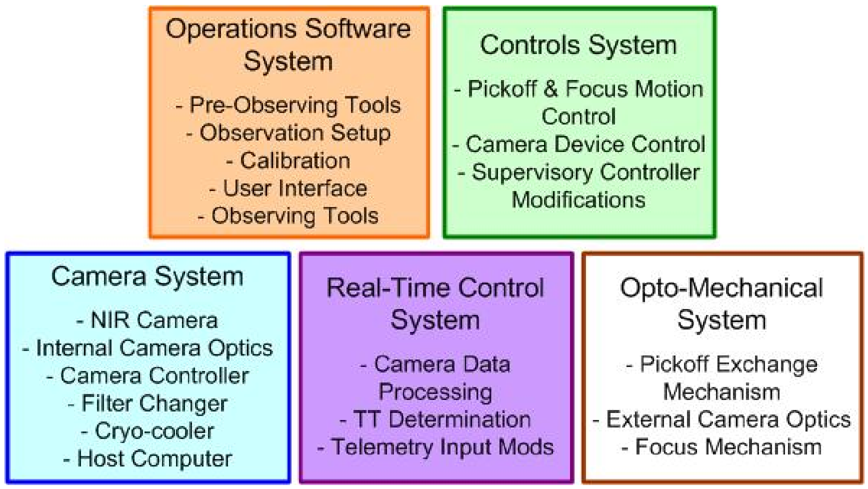

Figure 1: Major subsystems of the NIR TTS and their key components

The NIR TTS camera (i.e. the camera system in Figure 1) is defined as the cryogenic dewar enclosing the NIR detector and all items in this dewar, including optics and motion control, as well as the closed cycle refrigeration system, that keeps the dewar cold, the camera housekeeping and readout electronics and the camera's host computer.

2. Interfaces to the Opto-mechanical System

2.1 Optical Interface

The camera will be located in an f/13.66 beam at the science output of the AO system (f/13.66 is the 149.583 m focal length of the telescope divided by the 10.949 m diameter circumscribed circle enclosing the primary mirror). The telescope pupil will be located 19.948 m in front of the focal plane. The opto-mechanical system will include the part of the camera optics, if any, outside of the camera dewar. The 120" diameter field of view that the camera optics must transmit corresponds to 87 mm at the AO focal plane that feeds the NIR TTS.

2.2 Mechanical Interface

The camera shall mount to a WMKO provided interface plate with a TBD interface bolt pattern. The position of the detector and the camera's optical axis with respect to this interface bolt pattern, and the tolerances on these positions, are defined in a TBD interface control drawing. (Note that the optical axis is located 305 mm above the AO bench and there must be sufficient space under the dewar to accommodate a focus stage).

The maximum allowable envelope for the camera is shown in the TBD interface control drawing.

3. Interfaces to the Real-time Control System

An interface must be provided between the camera readout electronics and the Microgate real-time control system to provide the high speed data needed to compute tip and tilt. This interface is defined in the Microgate statement of work (KAON 824).

4. Interfaces to the Controls and Operations Software Systems

4.1 Device Control and Monitoring Interface

See section 5 for details of control methods, interfaces and signal type.

The camera must provide a keyword software interface to support monitoring and control. An Ethernet (TBC) interface must be provided to allow this interface.

The allowed control functionality must include power on/off, startup, shutdown, integration time, region of interest control, number of readout samples, start of integration and filter selection. The allowed diagnostics must include health monitoring including internal (dewar) temperature monitoring and (likely) control.

4.2 Acquisition Interface

The camera interface must provide: full frame images for field identification and sub frame images for centroiding needed for pointing adjustments and offsetting. Images are best delivered in binary format directly via an application programming interface (API). FITS images could be used instead however this would add 1 to 2 seconds of overhead per frame.

Camera exposure time and binning control should be available so they can be integrated into the MAGIQ GUI.

It is TBD how time stamps will be applied to FITS images. Option 1: All images will contain UT at which the shutter opened with TBD accuracy, provided by the clock within the TRICK host which is to be slaved to a time server TBD over Ethernet using the Network Time Protocol (NTP). Option 2: Time stamps provided by MAGIQ.

4.3 Electrical Interface

The cabling between the camera and the camera electronics must be at least 1.5 m (TBC) long to allow locating of the electronics off of the AO optics bench. The maximum allowable envelope for the camera electronics is TBD.

Power to the camera will be provided by a TBD interface. An AC power control switch must be provided to support switching of the camera power by commands sent over Ethernet.

The camera host computer must be capable of being mounted in an existing AO electronics rack.

4.4 Coolant Interface

The camera electronics shall be housed in a TBD thermally insulated enclosure, separate from the camera, since the allowable cable lengths are too short to reach the AO electronics room. The camera electronics will be cooled with glycol. The required glycol flow rate shall not exceed TBD.

4.5 Cryogenic Interface

Two compressed gas lines will be run from the Joule Thompson (low vibration) cooler embedded within the camera to a TBD compressor location.

A TBD interface must be provided between the Observatory facilities and the camera's closed cycle refrigerator.

5. Appendix: Control Method/Interface/Signal Type

(from KAON 668 Device Control Architecture)

This section discusses the various signals and types of control that were identified in the section above and how these will be connected to the Ethernet.

5.1 Remote Power Control

The largest classification of control is simple on/off of 120 VAC devices. Remote control of the power to individual devices has proven extremely valuable in the existing AO, Laser and Interferometer systems. Approximately 20 devices requiring this type of control have been identified.

This function will be accomplished primarily through COTS devices. Products by two vendors (Pulizzi and APC) are currently used at the observatory, each with its own benefits.

It will be necessary to create a more customized solution based on solid state relays and digital controls to handle some of the devices, such as the clean-room circulation/HEPA filtering and to integrate emergency stop functionality.

5.2 Camera / Detector Control

Control of the various cameras and detectors used in the system is complicated by the fact that some of the cameras have control interfaces that are part of the data readout interface, as is the case with Camera Link. For these cameras, the control functions will be implemented directly by the RTC, but the RTC is required to make specific control commands available to the NGAO control system for initiation of these functions.

For the other cameras and detectors, the control interface will depend on the specific controllers that are selected. The Sidecar ASIC, which is under consideration for the LOWFS, interfaces to the RTC via USB. This scenario is similar to the cameras with the Camera Link interface where the device is controlled through RTC. A camera controller with an Ethernet interface, or the requirement for a dedicated server, would be an example of a system where the RTC might not be required to implement configuration and diagnostic functionality; the NGAO control system could talk directly to the camera controller (or server).

The control requirements for each camera must be analyzed on a case by case basis once the design is understood.

5.3 Discrete (Digital) Input/Output

Several options exist to implement this requirement. A VME or PCI card could be used in conjunction with a CPU, as is done in the current system. Alternatively, Ethernet (or serial) I/O modules exist (Acromag, B&B and others) that perform the same function without requiring a CPU/Backplane. The use of distributed modules could simplify wiring.

Digital inputs and outputs will be required to control custom on/off devices, provide remote reset capability for equipment and read back the state of equipment.

5.4 Analog Input

As with the digital I/O, a VME or PCI card could be used in conjunction with a CPU, as is done in the current system. Alternatively, Ethernet (or serial) I/O modules exist (Keithley, B&B and others) that perform the same function without requiring a CPU/Backplane. This approach will accommodate both voltage and current type sensors. The use of distributed modules could simplify wiring.

Analog inputs will be required to digitize signals from sensors. Examples are environmental temperature sensors and intensity feedback from the stimulus sources.

5.5 Analog Output

Analog signals can be generated via a peripheral card installed in a VME system or by a stand-alone module connected to the Ethernet. Channel density, speed and latency requirements will probably dictate the type of source.

Analog outputs may be required to modulate the intensity of stimulus source intensity and to ramp the output of high voltage power supplies. This could also be used as the control command for low bandwidth, open loop PZT devices.

5.6 COTS Controllers

A number of off the shelf controllers will be required to provide monitoring/control the environment and instruments. In some cases, a sensor will be connected to an analog input described above. In other cases, controllers such as a Lakeshore temperature controller, Varian ion pump controller, or similar device will be used. These controllers will be fitted with either a serial or Ethernet interface to allow connection to the control system.

5.7 Remote Reset Control

Another functionality that has proven useful is the ability to remotely reset equipment, specifically VME backplanes, without cycling power. The existing design (119-70-00) is a 1U package, based on a digital I/O module with a serial interface, which implements eight optically isolated outputs, each with local/remote capability. The outputs are the emitter and collector of the opto-isolator transistors. Internal configuration can include a pull up resistor and/or grounding the low side of the transistor. The serial to I/O module used in this design is obsolete, so a replacement module will need to be sourced.

5.8 Video

Video encoders (servers) manufactured by Axis communications are currently used at the observatory and can be used for NGAO as well. These simple devices convert an analog video signal to Ethernet, allowing web based viewing/configuration. The Interferometer uses software to processes the network video stream and obtain centroids that are used for automatic beam train alignment.

5.9 RS-232 and USB

The goal is communicate with every controllable device via Ethernet. To accomplish this, some equipment will require a protocol converter. Lantronix terminal servers are currently used for RS-232 and RS-422/485 devices. Lantronix also produces a USB server, should that functionality be required.

5.10 Ethernet

Devices will connect to the Ethernet via a managed switch. Managed switches allow creation of ‘V-LANs’ that help route network traffic and optimize data flow. Currently HP products are used.

5.11 Time Distribution / Synchronization

Two types of synchronization are required for NGAO. First, many of the components will need a precise UTC reference. In addition, the distributed components of the RTC subsystem have an extremely tight internal synchronization requirement. Fortunately, this does not extend to the UTC reference.

Existing observatory infrastructure distributes a GPS time signal via the IRIG-B protocol. Each system requiring a UTC reference makes use of a local VME decoder board. This method is capable of delivering microsecond level accuracies, if care is taken to account for propagation delays in the cabling. Components with relaxed requirements, generally servers and PCs, use the Network Time Protocol (NTP) to synchronize their local clock. It is not clear if this is done at any time other than boot-up, so the initial millisecond level accuracy degrades rapidly. It is also not clear how the local NTP server is synchronized to UTC. [Note: NTP is adequate for the camera system]

There have been investigations into the use of the Precision Time Protocol (PTP, IEEE-1588) within NGAO (and the Telescope Drive Control Upgrade project), as an alternative to IRIG-B, to synchronize distributed equipment to a master clock and Universal Coordinated Time (UTC) as derived from Global Positioning System (GPS) satellites. PTP uses Ethernet messages to determine (and manage) the offset between distributed equipment and a master clock. Synchronization with sub-microsecond accuracies is readily achievable. Adoption of PTP would greatly reduce the amount of IRIG-B hardware at the possible expense of additional network infrastructure. This work is ongoing and a final decision has not been made.

A custom system will need to be engineered to synchronize the RTC components. Precision high frequency oscillators and careful attention to propagation delays will be required. Fiber-optic may be used for signal transport to ease transmission line effects over long distances. It is assumed that this work will be handled by RTC design team, collaborating with Keck engineers to ensure the system can be integrated into the facility.