**Keck Adaptive Optics Note XXX**

**Near-Infrared Tip-Tilt Sensor System:**

**Pre-Ship Review Report**

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**DRAFT Version 0.14 (outline only)**

# Introduction

The purpose of this KAON is to summarize and assess the completeness and readiness of the Near-InfraRed (NIR) Tip-Tilt Sensor (TTS) opto-mechanical system for delivery to WM Keck Observatory in preparation of its subsequent summit installation.

The Acceptance, Integration, Test and Commissioning plan (KAON 855, section 2.1) states that each NIR TTS subsystem shall include the deliverable of

”An acceptance review document including:

* Compliance matrix for function requirements
* Compliance matrix for interface requirements
* Compliance matrix for system requirements
* Documentation to support the requirements and interface compliance”

This document constitutes this deliverable for the Caltech deliverable components of the Camera subsystem consisting of the following *excluding the Filter Changer* component which is provided by WKMO:



# Report Organization

We choose to organize this document according to broad areas of requirements compliance as follows:

Section 3 System Description Summary [*Rich]*

Section 4 Optical and Mechanical Performance [*Jason / Rich]*

Section 5 Thermal Performance *[Roger / Hector]*

Section 6 Electronics Performance [*Roger]*

Section 7 Detector Performance *[Dave / John]*

Section 8 Software Performance *[Dave / John]*

Section 9 Shipping Readiness [*Hector*]

We include the formal compliance matrices as Appendices to this document and reference their corresponding technical subsection for each of cross-referencing.

The following items are not ready for shipment to WMKO, accompanied by a suggested course of action to bring each to shipment readiness:

* *Pre-ship Exception #1: [status and proposed plan]*
* *Pre-ship Exception #2 [ status and proposed plan]*

# System Description Summary [*Rich]*

For reference, the mechanical configuration of the NIR TTS is shown in Figure 1.

*Add high-level description of key elements of this Figure.*



Figure 1: NIR TTS Mechanical Overview (from KAON 890)

For additional detail pertaining to the opto-mechanical design details of the NIR TTS see KAON 892 Optical Design and KAON 890 Camera Opto-Mechanical Design, which have been updated to accurately reflect the as-built system design (*XXX confirm this*).

Table 1: XXX *Insert table above*

# Optical and Mechanical Performance [*Jason / Rich]*

*[XXX Add possible introduction to key issues discovered / resolved / or remaining relevant to the readiness of the NIR TTS].*

# Functional Compliance

The following critical dimensions were verified to ensure that the NIR TTS camera would not interfere mechanically or optically when installed on the AO bench:

* *Requirement #XXX*

Measured Performance:

* + *We measured…*

Suggested Actions: *None*

# Interface Compliance

# System Compliance

# As-built Documentation

KAON 890 Camera Opto-Mechanical Design contains detail on the as-built mechanical design of the NIR TTS Camera. KAON 892 contains detail on the as-built optical design.

# Thermal Performance *[Roger / Hector]*

*[XXX Add possible introduction to key issues discovered / resolved / or remaining relevant to the readiness of the NIR TTS]*

# Functional Compliance

Measurements were made in the lab to determine compliance with the following thermal functional requirements calling for experimental verification:

* *Requirement #XXX*

Measured Performance:

* + *We measured…*

Suggested Actions: *None*

# Interface Compliance

# System Compliance

# As-built Documentation

KAON 902 contains detail on the as-built thermal design. KAON XXX contains detail on the Assembly and Alignment procedures including the thermal connections internal to the NIR TTS cryostat.

# Electronics Performance [*Roger]*

*[XXX Add possible introduction to key issues discovered / resolved / or remaining relevant to the readiness of the NIR TTS]*

# Functional Compliance

# Interface Compliance

# System Compliance

# As-built Documentation

KAON 888 contains detail on the as-built electronics design. KAON XXX contains detail on the Assembly and Alignment procedures including the electronics connections internal and external to the NIR TTS cryostat.

# Detector Performance *[Dave / John]*

*[XXX Add possible introduction to key issues discovered / resolved / or remaining relevant to the readiness of the NIR TTS]*

# Functional Compliance

Measurements were made in the lab to determine compliance with the following detector functional requirements calling for experimental verification:

* *Requirement #XXX*

Measured Performance:

* + *We measured…*

Suggested Actions: *None*

# Interface Compliance

The detector server interfaces to the detector controller as follows: The timing board, inside the ARC chassis is connected via two fiber-optic fibers to a ARC PCI interface board, plugged into the PCI bus of a Sun Fire V240 server. The software interface consists of three-letter (24-bit) commands that are exchanged between the PCI board and the timing board. Basic commands are defined by ARC. Custom commands have been defined by the Caltech team. Pixel data are transmitted from the timing board to the PCI interface which writes the data to DMA memory, where the server access the data for FITS file creation.

The interface between the detector controller and the real-time computer (RTC) is also fiber optic, running from a second channel on the timing board to the RTC. The software protocol is defined and discussed in KAON 875 – Detector Readout Scheme and Link Protocol Description.

Control of the detector is achieved from other parts of the AO system over Ethernet to the Sun Fire V240 through keywords and Channel Access using the Keck Tasking Library (KTL) software interface.

# System Compliance

# As-built Documentation

KAON 894 describes the extensive inherent detector noise performance evaluation made with the NIR TTS sensor upon receipt in the Caltech Optical Observatories Test Cryostat. The results presented herein supersede those results, however, as they have been obtained with final electronics, mount, and cabling.

NIR TTS control and detector software has been installed in the *XXX* version control system as WKMO observatory. Build procedures have been delivered to WMKO and are available at *XXX*.

# Software Performance *[Dave / John]*

*[XXX Add possible introduction to key issues discovered / resolved / or remaining relevant to the readiness of the NIR TTS]*

*The NIR TTS camera control software consists of three instances of the Keck-developed rpcKey\_server, with Caltech-supplied libraries for control of the detector, the filter wheel and the temperature controller. A fourth instance of the server is run as a global server which acts as a single-point access server for the camera and also communicates with the AO system for real-time updates to the detector server.*

# Functional Compliance

Measurements were made in the lab to determine compliance with the following software functional requirements calling for experimental verification:

* *Requirement #XXX*

Measured Performance:

* + *We measured…*

Suggested Actions: *None*

# Interface Compliance

The interface between the NIR TTS camera software and other software components of the AO system is done through the WMKO-developed KTL keyword interface, over Ethernet. Additionally, real-time updates to certain detector parameters are obtained from the AO Supervisory Control (SC) system via Channel Access using “event functions” defined in the NIR TTS global server. For each detector-server keyword that needs to be modified in real time (I E during pixel streaming through the second-channel fiber) a corresponding AO keyword is defined in the global server keyword configuration file. Each of these keywords is associated with an event function, which matches the AO keyword to the NIR TTS detector keyword. When the global server detects a change in any one of these AO keywords, the corresponding detector keyword is changed also. In this way, real-time updates from the AO SC can be made in the NIR TTS detector server.

Interfaces from the servers to the temperature and filter controllers are done with TCP/IP over Ethernet using the socket library supplied with the rpcKey\_server.

# System Compliance

Measurements were made in the lab to determine compliance with the following software functional requirements calling for experimental verification:

* *Requirement #58, Tab 2, #10, Tab 4, #28 Tab 4, KAON 835.*

Measured Performance:

* + *Measured time to start all servers: 22 seconds. Note that any individual server can be stopped and restarted independently. Individual server starts take about 5 seconds or less. Hardware is not necessary for a server to start but the server will complain frequently in the log file if the hardware is not available.*
	+ *Measured time to initialize the detector server: 3 seconds. If starting in the middle of operations, neither the temperature server nor the filter server should require initialization.*
	+ *Measured time to home the filter wheel: 42 seconds. This is the maximum amount of time, for the wheel to make a complete revolution. Normal times should be substantially less.*
	+ *Measured time for the Sun Fire V240 to reboot: 1 min. 48 seconds.*
	+ *Measured time for the Sun Fire V240 to reboot from a complete power outage: 9 minutes 33 seconds. This lengthy time is because the computer does a number of self-tests before actually booting the operating system. There may be some system settings that could be changed to eliminate or shorten these tests and thus decrease the time to power up.*

Suggested Actions: *Investigate possible ways to shorten the power-up time for the V240.*

* *Requirement #68, Tab 3, KAON 835.*
	+ *No measurements required. All code is archived in the WMKO CVS repository. The camera system can be built by checking out the code and running the appropriate make files.*
	+ *Documentation will be stored and maintained on the appropriate WMKO instrument page.*
* *Requirement #69, Tab 3, KAON 835.*
	+ *No measurement required. For any of the servers, to move from the current release to a previous version requires only the change of a soft link in the released area of the software environment to point to the desired version directory:*
		- *Detector server: $RELDIR/Versions/kss/trick/server/tds/default*
		- *Filter server: $RELDIR/Versions/kss/trick/server/tfs/default*
		- *Temperature server: $RELDIR/Versions/kss/trick/server/ttcs/default*
		- *Global server: $RELDIR/Versions/kss/trick/server/tgs/default*

# As-built Documentation

The Keywords supported by the NIR TTS are described in KAON 857 Keyword Interface Spreadsheet, Tab #4.

Complete, detailed descriptions of the servers can be found in KAON 882, Camera Host Software.

NIR TTS control and detector software has been installed in the *XXX* version control system at WKMO observatory. Build procedures have been delivered to WMKO and are available at *XXX*.

* OM FR-19. Each opto-mechanical stage shall be provided with an appropriate servo motor and encoder to ensure that the positioning requirements can be met.

Requirements…

* + The dichroic exchanger positioning requirement is  1 mm. The focus stage positioning requirement is  0.05 mm (confirmed).

Measured Performance…

* + The positional repeatability of both stages was better than the measurement resolution of a dial indicator with 2.5 μm accuracy when driven under servo control, dramatically exceeding the requirements.

# Shipping Readiness [*Hector*]

The NIR TTS Packing and Shipment plan was distributed on *XXX* to the following persons for review:

* *Reviewer #1*
* *Reviewer #2*
* *…*

We have incorporated feedback from these reviews in version *XXX* of this document. Currently, the state of shipping readiness of the equipment described in Section 3 is summarized in Table 2.

Table 2. Shipping Readiness [*XXX insert table above*]