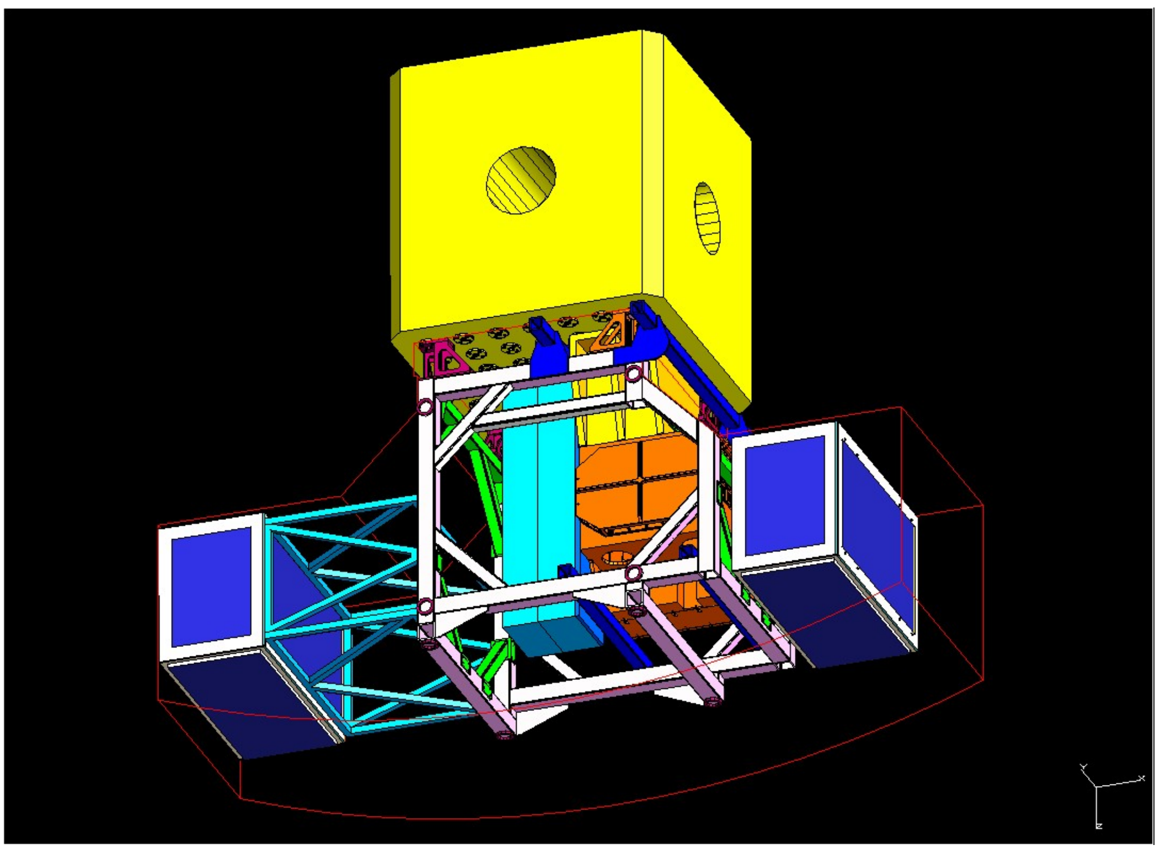
GEMINI

NEAR INFRARED CORONAGRAPHIC IMAGER

(NICI)

SERVICE AND CALIBRATION MANUAL

REVISION 0.20 (PRELIMINARY)
12/08/04



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Revision History

Revision	Author	Summary of revisions	Date
0.20	Mike Thompson	Prepared for Preliminary 80% Release. See v0.12 for issues.	12/08/04

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1 Introduction

This is the Service and Calibration Manual for the Gemini Near Infrared Coronagraphic Imager (NICI). This manual is to serve as a tutorial for qualified maintenance personnel unfamiliar with NICI. It is meant to provide the proper procedures for all aspects of the instrument's servicing procedures, re-alignment, and calibration.

This first revision is an effort to capture the structure of the manual.

2 Safety

This section covers general procedures required when working on the instrument for safety of personnel and equipment concerning issues of cleanliness, safety, etc. This section is not a comprehensive laboratory manual or tutorial. It is meant to provide a summary of safety procedures for work to be carried out by personnel with proper training and adequate experience. It is assumed that telescope personnel are familiar with the safety concerns and procedures for handling and maintenance of telescope instruments.

2.1 Recommended Training

This section provides a list of recommended training that instrument handling and maintenance personnel should have in order to safely work with NICI. This list may not be comprehensive; it is just a general guideline.

- General Awareness Hazardous Material Training
- Specific Hazardous Material Training in Liquid Cryogens
- Specific Hazardous Material Training in Compressed Gases
- Transportation of Compressed Gases
- Handling of Heavy Loads

2.2 Mechanical Handling Precautions

This section provides an overview of the precautions that must be observed when handling NICI.

2.2.1 Tipping hazard

NICI is very heavy, tall and narrow in one dimension. The center of gravity as required is 1 meter from the top making NICI top heavy. When handling and moving NICI great care must be taken to prevent the instrument from tipping over. Personnel must avoid the area around the instrument when it is being moved. When ever possible NICI must be left connected to an overhead crane until secured.

2.2.2 Sweeping when Rotating

When the instrument is rotated the electronics cabinets sweep an area that might be occupied by personnel or equipment such as a ladder. Procedures must not allow the instrument rotator to operate when personnel or equipment are present in the sweep area.

2.2.3 Falling Tool Hazard

When working on NICI tools must be inventoried to make sure no tools are left behind. No personnel may be under the instrument whenever the telescope is moving or the instrument is rotating. Personnel must wear a hard hat when working around the instrument.

2.2.4 NICI Handling Braces

When NICI is removed from the telescope temporary braces are used to connect the cryostat and AO bench to the handling frame. When on the telescope these braces are removed. It is important that these braces always be properly installed before removing the instrument from the telescope.

2.2.5 Using Lift Points

When NICI is to be lifted, spreader bars or similar equipment must be utilized so that lifting forces are not at an angle from the axis of the lift points. That is to say lifting straps should be perpendicular to level ground when lifting NICI. See the diagram below for a graphical explanation.

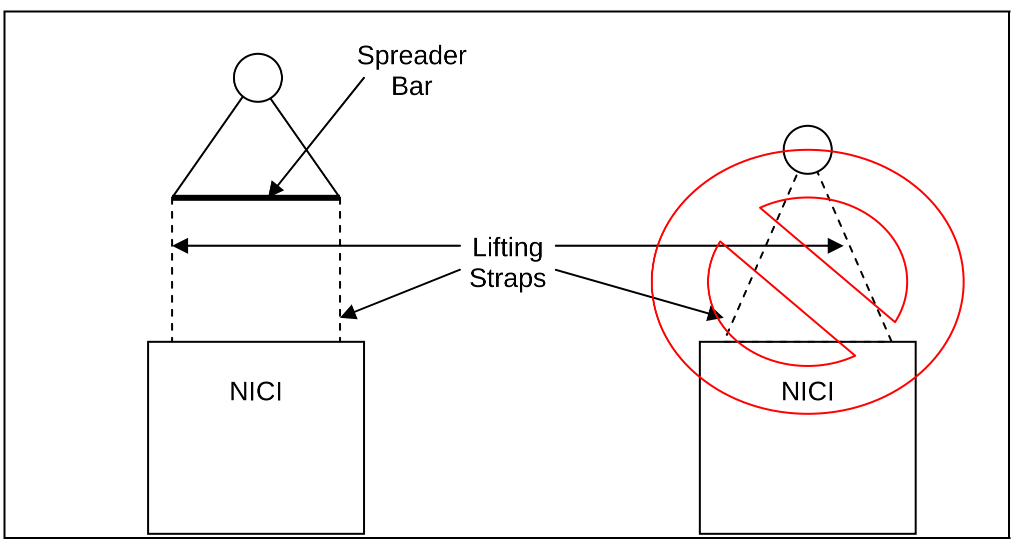

Figure 1 Using a Spreader Bar for Lifting

2.3 Cryogenic System Precautions

2.3.1 Cryogen handling
NICI is a cryogenic instrument. Liquid Cryogens represent a burn hazard and a suffocation hazard. Personnel working with the instrument must receive training in the handling and use of liquid cryogens.

2.3.2 Nitrogen suffocation hazard
During cool-down NICI will consume more than 100 liters of liquid nitrogen. When the liquid nitrogen is consumed it becomes nitrogen gas at a ratio of about 700:1. This nitrogen gas can displace the oxygen in the air reducing the partial pressure of oxygen, creating a suffocation hazard. Boil-off gasses must be vented to outside the building and an oxygen partial pressure alarm must be in place in the room that is used for the cool-down.

2.3.3 Disconnecting Cold Head
The two cold heads must never be disconnected while cold. As the gasses inside the cold head warm up they expand greatly and must vent back to the compressor. If disconnected the expanding gasses will create dangerously high pressures in the cold head

2.3.4 Ice Plug in Pre-charge Neck
After the initial cool-down the instrument will operate with no boil-off in the in the pre-charge can. With no boil-off the pre-charge can will cryo-pump material into the can. Eventually material will close off the neck tube causing an ice plug. If enough material were frozen in the can before the neck closed off and the instrument is rapidly warmed, high-pressure gas can cause the pre-charge can to burst explosively.

NICI must always be operated with the pre-charge can external cover in place that has a check valve to prevent ice plugs. The neck tubes must always be checked for ice plugs before any warm up procedure is started. Ice plugs must be cleared before the instrument is warmed up.

2.4 Compressed Gas

This section provides an overview of the safety issues associated with the compressed gas that the instrument uses.

2.4.1 Compressed gas

NICI is a closed cycle cooler cooled instrument and uses compressed helium. Although it does not contain enough gas to be much hazard, it could cause a suffocation hazard if released in a confined area. The maintenance equipment for the closed cycle cooler compressor uses compressed helium tanks which are classified a Hazardous Material. All personnel involved with the operation of NICI must have Hazardous Materials training for Compressed Gasses.

2.4.2 Compressed Gas Transportation

Compressed Helium gas is a DOT classified Hazardous Material. The amount of helium used in the cold head and lines is low enough to be exempt as of this writing. Before transporting NICI a certified Hazardous Materials employee must verify that all Hazardous Materials procedures are correctly followed

2.5 Electrical System Precautions

This section provides an overview of the precautions that must be taken with the electrical system of NICI.

2.5.1 Electrical shock hazard

NICI is an electronic instrument and uses AC and DC power in most of the subsystems. No access covers may be removed while power is applied to NICI. No grounds may be modified on the instrument.

The AO system has high voltage signals between plus and minus 400 volts. These voltages are used to drive the deformable mirror and are present at the deformable mirror, its cable, and the AO controller crate. These high voltage cables must be kept in good repair. Great care must be taken when troubleshooting this hardware. These voltages can be lethal in some circumstances.

2.5.2 High current on APDs

The Avalanche Photodiode power supply is a high current 5 volt supply. This power is bussed to the APD assembly. Shorts on this power buss can cause arcing, substantial amounts of heat and fire hazard. Tools and components must be handled carefully in the APD assembly. The APD Enclosure should not be opened or worked on any time power is applied to the APDs.

2.5.3 Cabling

To prevent shock all cables must be connected to their proper receptacles whenever the instrument is to be powered on. Any damaged or frayed cables must be replaced before any power is applied to the instrument.

2.6 Vacuum Precautions

Don't break seals that are subject to vacuum. Don't open the instrument when the cryo-pressure is less than atmospheric pressure.

2.7 Areas of Risk to the instrument

2.7.1 Vacuum leaks

Before cooling the instrument it must be leak checked. Every time the vacuum jacket is opened the cryostat must be leak checked. Small leaks may not be noticed but the closed cycle coolers will cryo-pump substantial material and keep the vacuum adequate. This cryo-pumped material will be released rapidly upon warm-up of the instrument and can cause high pressures in the cryostat. Careful leak checking will avoid this problem

2.7.2 Optical Surfaces

Some of the exposed optical elements are made of Calcium Fluoride which is easily scratched and must only be cleaned by a qualified optical technician. Most of the exposed mirrors will be coated with over-coated silver. Silver is more reactive than aluminum and care must be taken with the handling and cleaning of these mirrors.

2.7.3 Cleanliness, Dust, and Optics

NICI is a coronagraphic imager and is very sensitive to scattered light caused by dust on the optics. Care must be taken to keep the optics as clean as possible. Any time that the vacuum jacket, cryostat, or mechanism box is to be opened, great care must be taken to avoid dust or debris entering the enclosures. Optical elements should never be handled without wearing clean gloves appropriate for the optics.

2.7.4 Arrays

Some of the voltages to the arrays are programmable. **It is absolutely critical that VDET be set to a more positive voltage than VDDUC or the array can be critically damaged**.

2.7.5 APDs

The APDs or Avalanche Photodiodes are very sensitive optical detectors that are housed in a module with a fiber input and TE cooler. There are 85 of them in NICI at a cost of about $1800 each for a total of about $150,000. These detectors can be damaged in two ways.

APD exposure to bright lights when energized can damage the detector. When slewing the telescope, the user must execute a software command to set the Tip/Tilt Steering Mirror and Pupil Mask Wheel to protect the APDs from exposure to bright sources.

In normal operating mode the APD photon counts must be kept below 2 megacounts/second or 1000 photon counts per nominal 2KHz AO cycle. The counts displayed on the Adaptive Optics' User Interface are displayed for the duration of the variable loop frequency.

When the AO system is not energized or in use, the user must configure the AO system's WFS filter wheel to an opaque position.

The supply voltage of the APDs must not exceed 5.5 volts. The power supply voltage will be set to an appropriate level by MKIR when NICI is shipped. Gemini personnel should not change this voltage setting and must not raise the supply voltage above 5.5 volts.

2.7.6 Static Discharge

The two infrared detectors are also high value components with a value of about $500,000. Static discharge can destroy these detectors. The detectors mounts, array cables and parts of the cryostat electronics have direct connections to the array. Grounding straps to a proper ground is mandatory before any work on the electronics systems is performed. The APDs and most of the NICI electronics are also static sensitive and grounding straps must be used when ever any cables are connected or disconnected and when electronics boards are inserted or removed.

3 Instrument Description

NICI is a cryogenic 1 - 5 µm dual-channel coronagraphic imager with on-instrument adaptive optics. NICI implements coronagraphic, spider, pupil imager, and focal plane mask options common to both science channels. Each science channel has a dedicate filter wheel for selecting specific spectrums for each channel.

The description in this section is meant to describe the instrument for service and calibration purposes. A more thorough functional description can be found in the User Manual.

3.1 Major Assemblies Description

The major subsystems in NICI are physically located in several major assemblies. These are the Rack1 Instrument Control electronics thermal enclosure, Rack2 AO Control electronics thermal enclosure, the AO Assembly (also known as the AO Bench), the AO APD Enclosure, and Cryostat. These assemblies are depicted in a block diagram in Figure 2 and as a CAD drawing in Figure 3.

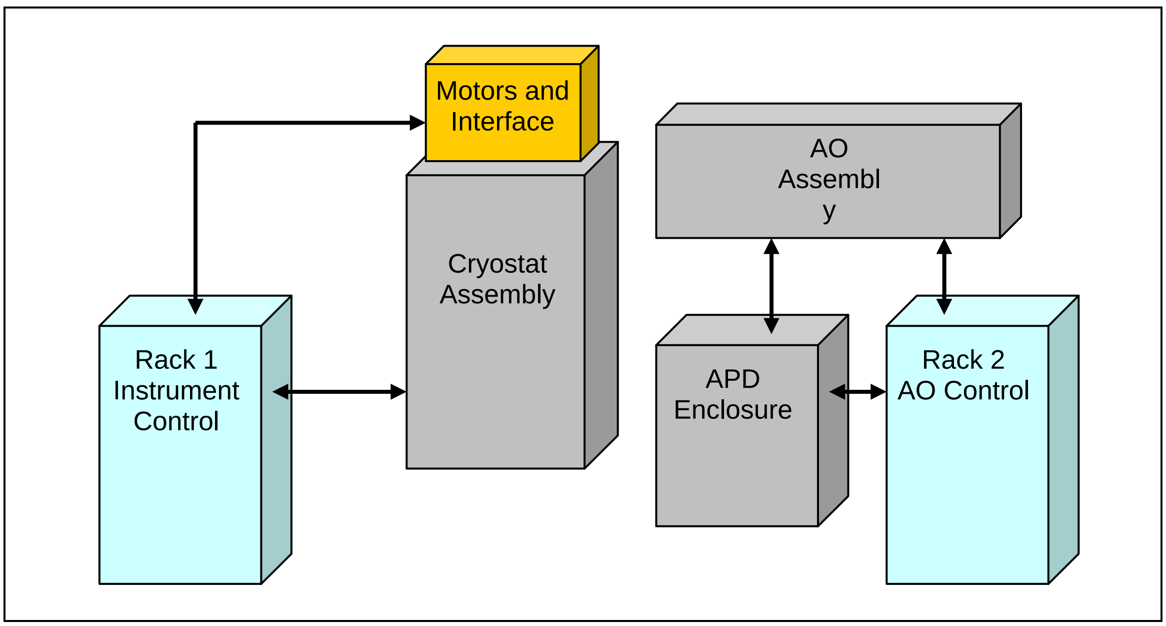

Figure 2 Block Diagram of Major NICI Assemblies

The CAD drawing shows the additional assemblies of the instrument support frame and the mechanism box which houses several filter wheels.

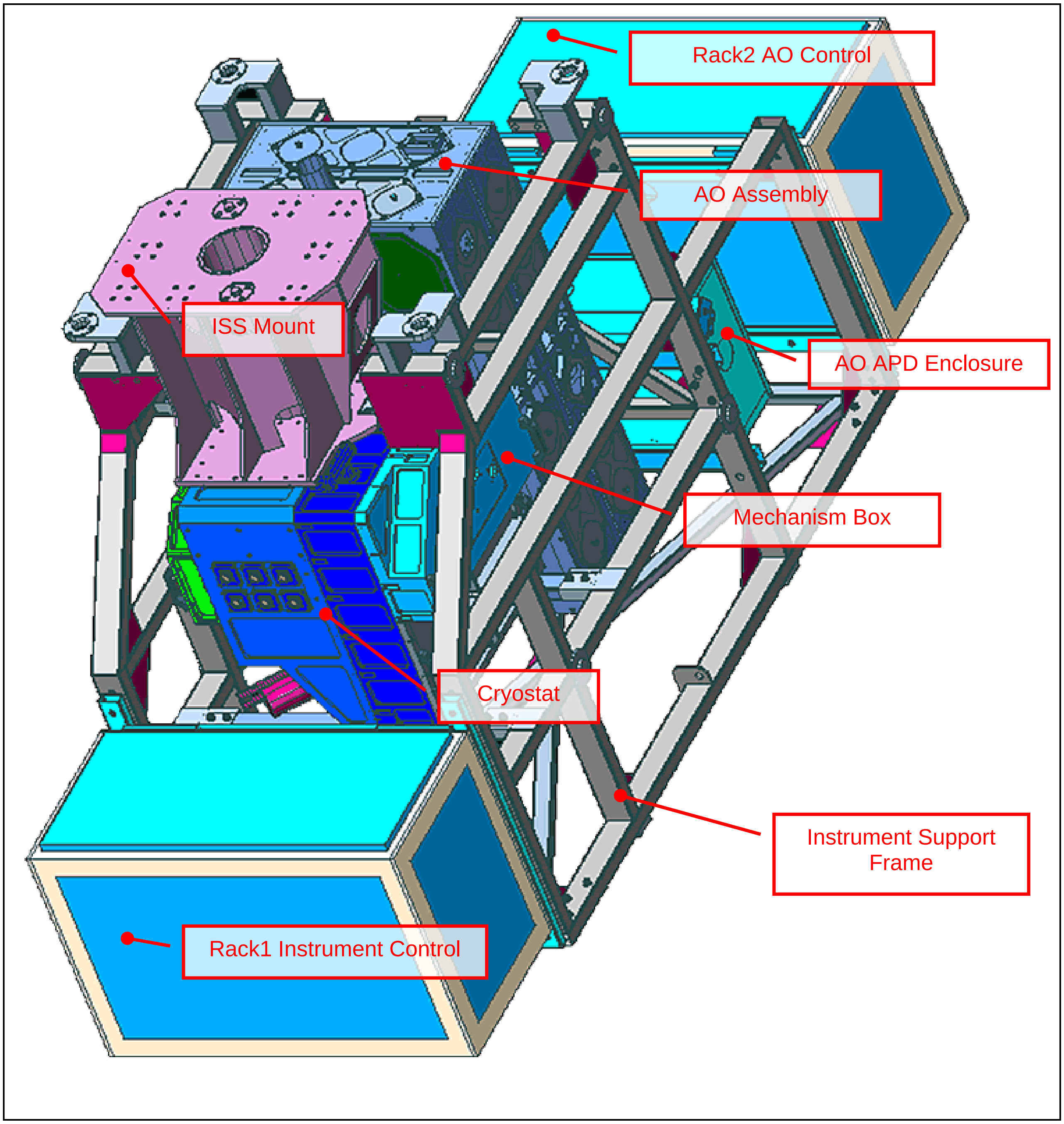

Figure 3 CAD Drawing of the NICI Instrument, Major Assemblies

3.2 Optics and Cameras Description

This section provides an overview of the optics and science cameras in the NICI instrument.

3.2.1 Light Paths Overview

This section provides an overview of the light paths through the AO and science portions of NICI. A diagram of the paths is provided in Figure 4.

NICI takes light from the telescope focus and relays it onto a deformable mirror (DM) where atmospheric phase errors are corrected. Light is then relayed onto the first instrument focal plane where one of several coronagraphic masks can be selected. There is a dichroic in the AO Relay that strips off the visible wavelength light and sends it through the AO Bench to the Wavefront Sensor (WFS). The reflected science beam enters the Dewar and is collimated. An image of the pupil is formed downstream of the collimator. At the re-imaged pupil, the collimated beam is masked by a choice of pupil masks, applying a variety of coronagraphic strategies.

The masked, collimated beam is then split into two beams by a number of different strategies at the cameras' dichroic wheel. Each of these beams is sent to an essentially identical camera. Each channel has its own selectable filter wheel to further define the beam properties. Each of the two beams is then re-imaged onto a detector. In one channel an extra, selectable optic allows imaging of the pupil for diagnostic purposes.

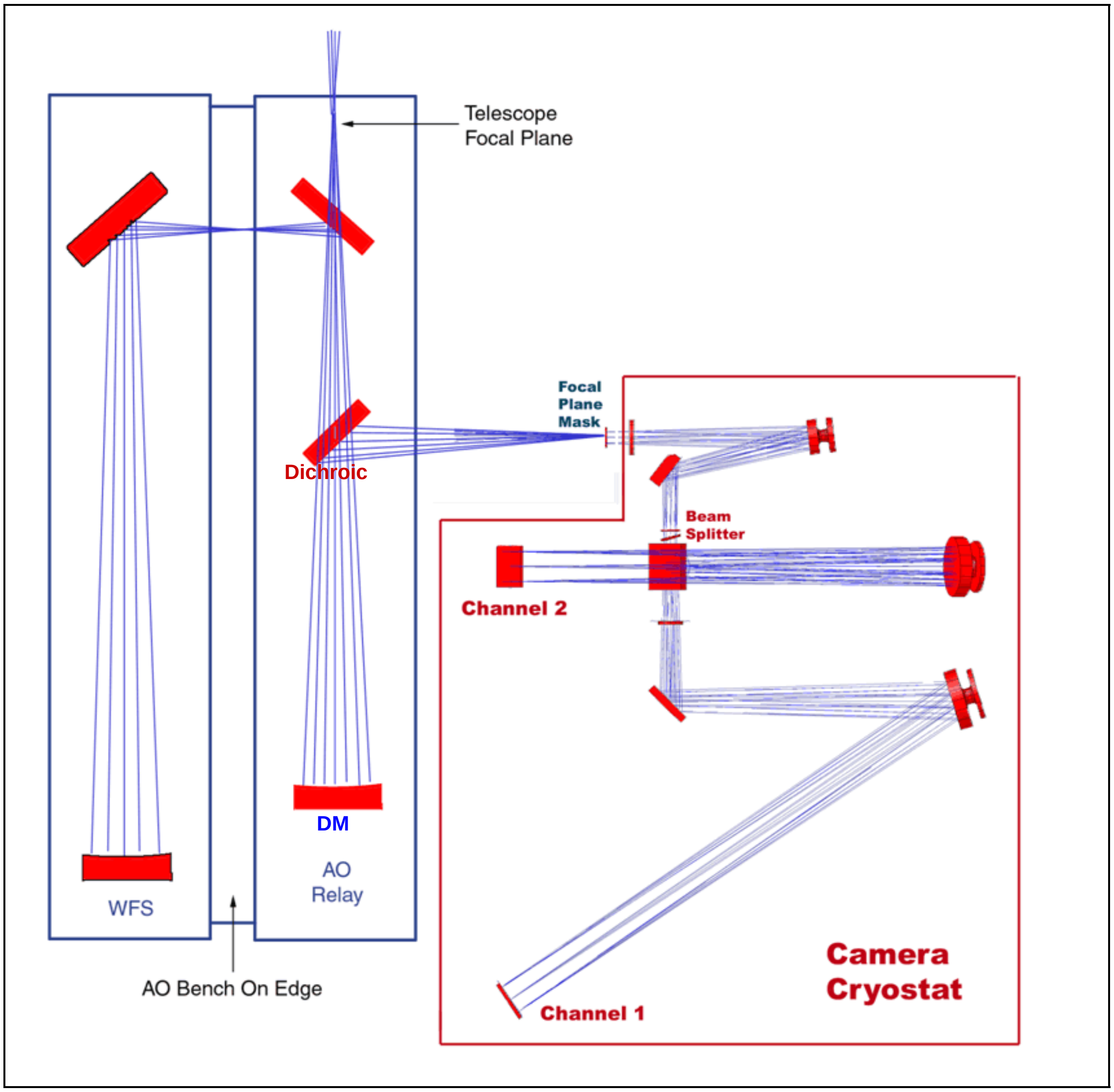

Figure 4 Optical Schematic of NICI AO and Science Light Paths

3.2.2 Adaptive Optics Description

NICI's AO Relay optical layout is illustrated in Figure 5 and WFS optical layout is illustrated in Figure 6. The first instrument subsystem, the Adaptive Optics (AO) relay, images the telescope focal plane (TFP) on to the first instrument focal plane (IFP1). It consists of a pair of off-axis parabolic mirrors (OAPs), an 85 element deformable mirror (DM), a visible transmitting/IR reflecting dichroic and one flat fold mirror. The first OAP images the telescope entrance pupil onto the first instrument pupil plane (IPP1) where the DM is located. The DM reduces atmospheric phase errors based on phase information generated in the AO wave front sensor (WFS). Following the DM, a second OAP relays a corrected, real image of the telescope focal plane to the first instrument focal plane (IFP1) located just above the window of the cryostat. The visible wavelength light is separated by the dichroic and sent to the WFS off a fold mirror. The infrared light is reflected out of the plane of the paper to the cryostat. The AO portion of NICI has a 5 arcsecond field of view.

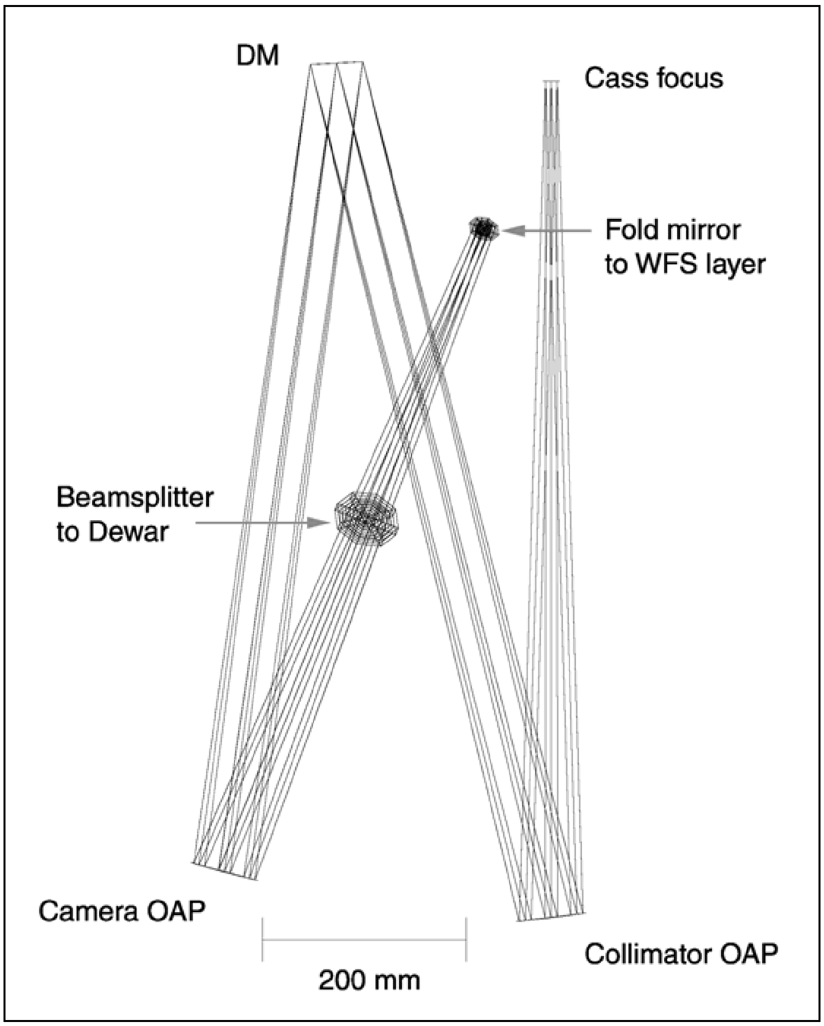

Figure 5 NICI Adaptive Optics Relay Optical Layout

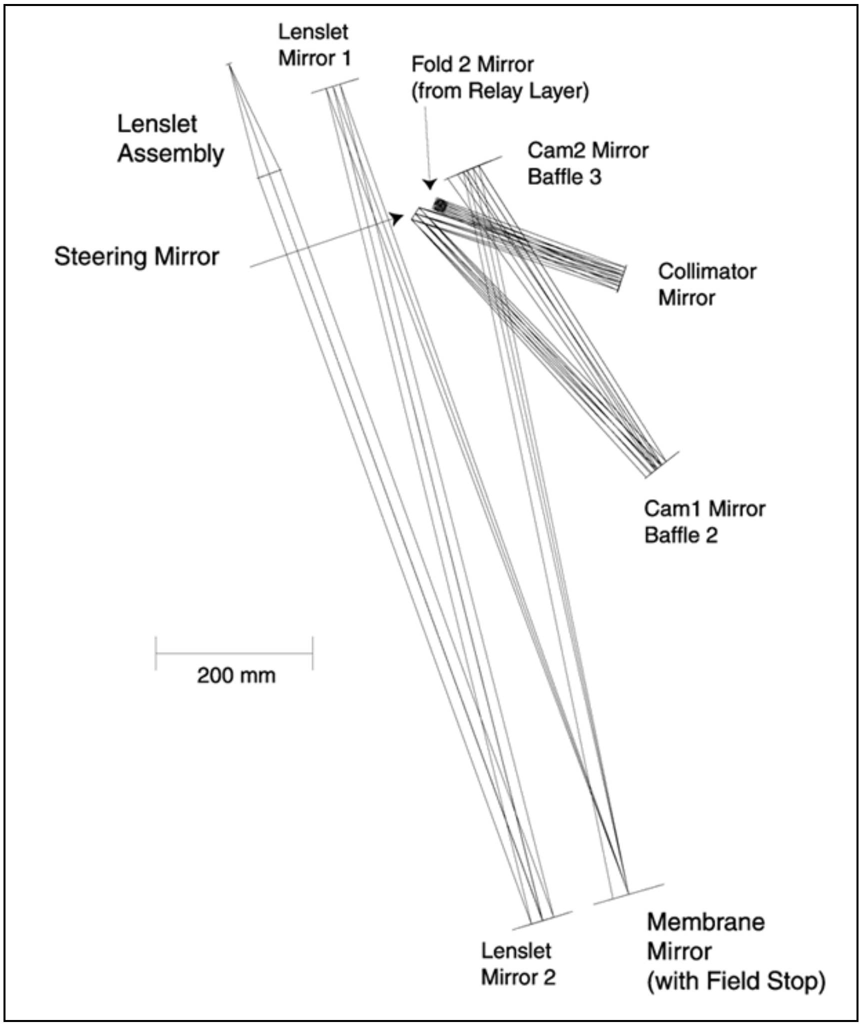

Figure 6 NICI Adaptive Optics Wavefront Sensor Optical Layout

3.2.3 Infrared Cameras Description

This section provides a description of the two cameras' optical layout which is illustrated in Figure 7.

The Infrared beam, or science beam, is reflected off of the dichroic in the AO Relay, normal to the AO bench towards the IR Camera. The IR Camera is a re-imager with about a factor of 2.5 magnification with a dichroic split, two filters wheels and two detectors that will give simultaneous images at two wavelengths. The focal plane re-imaged by the AO Relay falls a couple of centimeters in front of the Camera/cryostat window. At this focal plane position is located a wheel with 8 coronagraphic masks. These are apodized masks on a calcium fluoride substrate. The Camera optics consist of a simple all-reflective two off-axis parabola design with two fold mirrors to isolate the pupil re-imaged by the first parabola. With the exception of the pupil imaging lens all of the mechanisms are located at or near the pupil plane between the two fold mirrors. The first mechanism is a spider mask that will reduce the spider flares in the final image plane. This mask must be rotated as the instrument rotator de-rotates the image. This is followed by the pupil plane mask wheel with a selection of 8 undersized pupil plane masks. The next mechanism is the dichroic wheel that provides a selection of 15 beam splitting options. Following the dichroic are two identical channels each with a 22 element filter wheel and a parabola to image onto the 1024x1024 1-5 micron Aladdin style array.

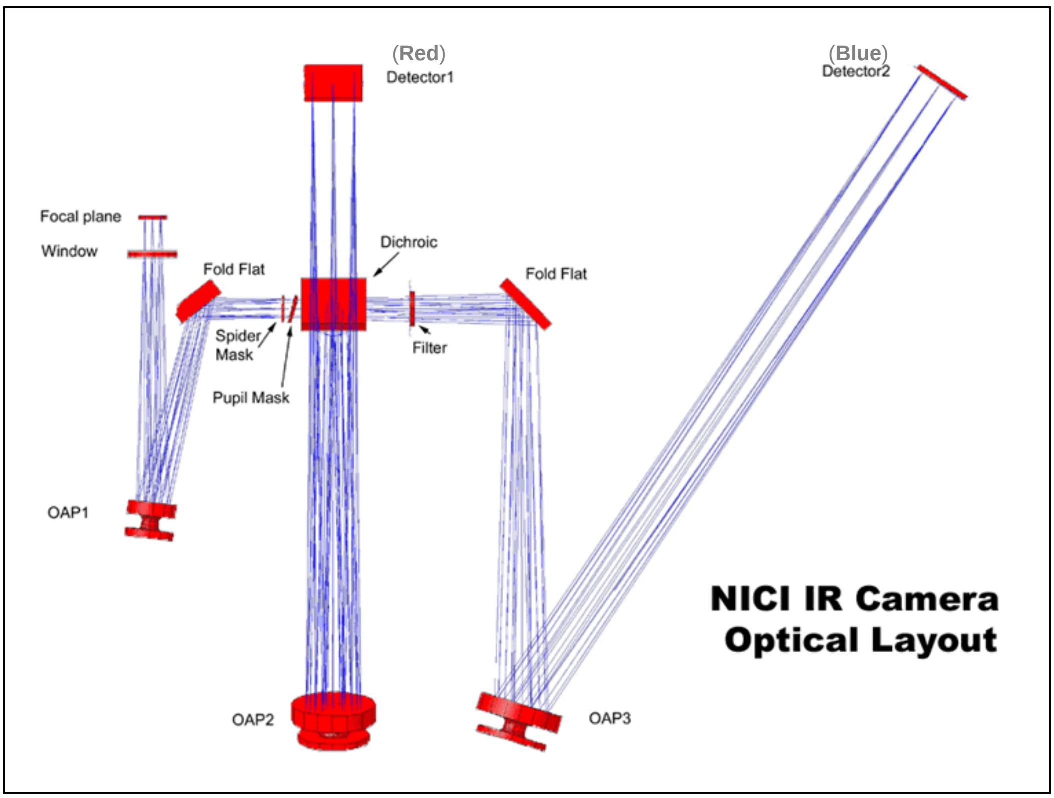

Figure 7 IR Camera Optical Layout

3.3 Coordinate System Description

Describe how the coordinates in the IC and AO systems relate to telescope coordinates.

3.4 Electronics Description

The electronics subsystem in NICI is housed in the Rack1 Instrument Control and Rack2 AO Control thermal electronics enclosures. This section provides a description of the electronics in these two enclosures.

3.4.1 Instrument Control Rack Description

NICI's instrument control electronics are housed in a standard Gemini Thermal Electronics Enclosure. These electronics are responsible for array control, mechanism control, thermal conditioning of the cryostat, and image acquisition. A block diagram of the IC electronics is provided in Figure 8.

The Instrument Control Server is the prime controller for the entire instrument. It receives commands from the Gemini instrument sequencer and orchestrates the actions of the IC and AO electronics. The IC server drives the Array Controller, Pixel Servers, provides instructions for data handling to the instrument, and provides serial control over the mechanisms and temperature control subsystem.

The Array Controller is responsible for array control, clocking, and readout. The Array Controller is powered with a dedicated Array Power Supply which also powers the arrays through the Array Controller. Array clocking control is provided by digital clock signals converted to analog levels in the Array Controller and fed to the arrays in the Cryostat. The resulting analog array readout data are amplified and converted to digital pixel data by the Array Controller. The digital pixel data is fed from the Array Controller to the Red (CH1) and Blue (CH2) Pixel Servers over high speed fiber optic links. The Pixel Servers are server class multi-processor PC based computers. The Pixel Servers assemble the pixel data into frames and prepare the frames for passing to the DHS or local storage.

Mechanism control is driven from the IC Server over the internal IC Rack LAN to a terminal server. Serial lines from the terminal are fed to a Mechanism Control box. The Mechanism Control box bundles power and the serial control lines into one cable for the IC mechanisms and two separate mechanism control lines to the two AO Fiber Calibration Source translator and ND Filter Wheel mechanisms. A Junction Box mounted on the Vacuum Jacket breaks out the 7 IC Mechanism control lines and drives the mechanisms.

The IC Server also provides serial control over the Temperature Control subsystem via the internal LAN and terminal server. Two temperature controllers, one for each array, are used to maintain detector temperatures. A temperature monitor provides information about the health of the cooling system in the cryostat to the IC Server.

All of the electronics in the IC Rack are powered through a remote power control module, the Ethernet Power Control. The Ethernet Power Control is accessed through telnet.

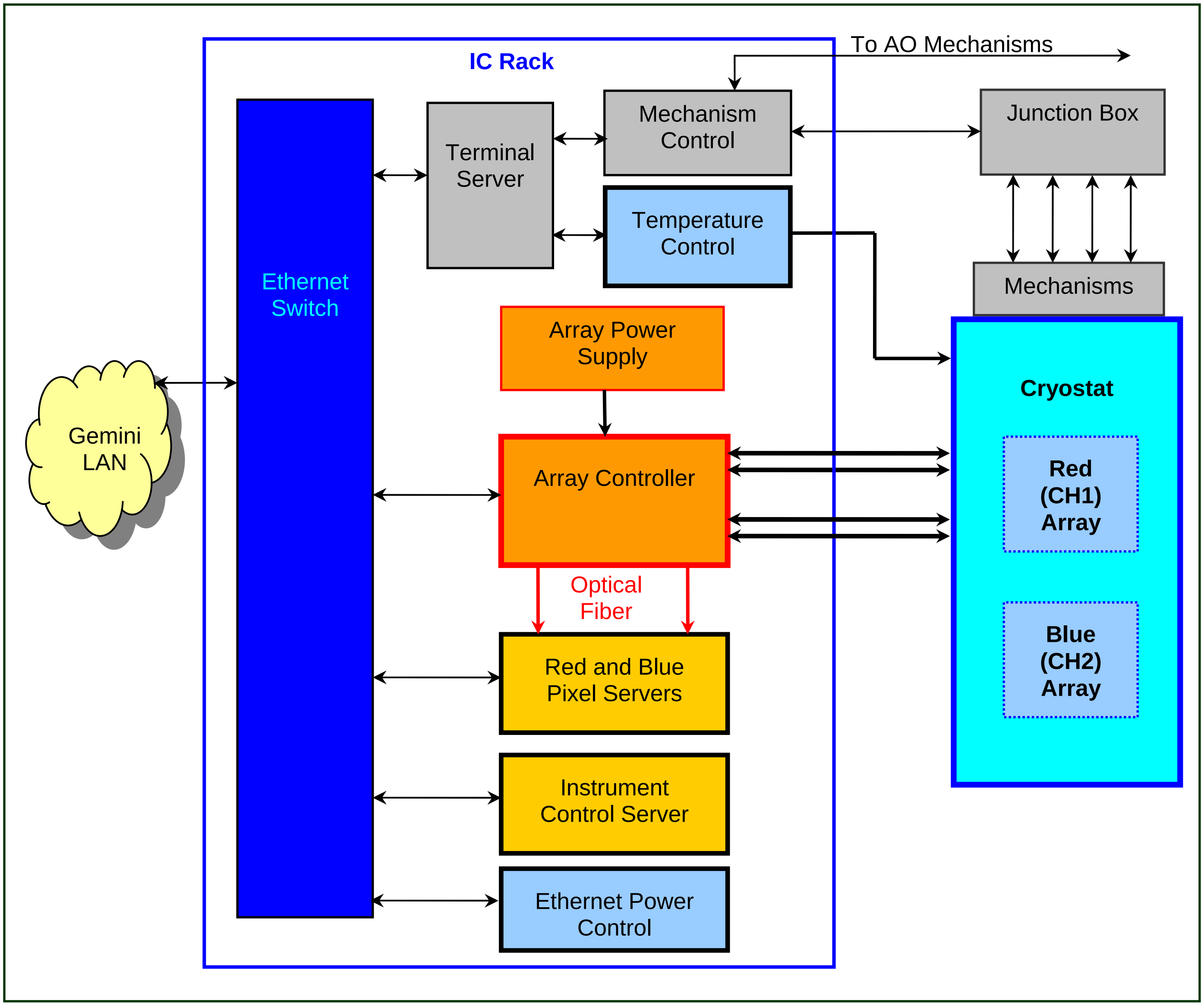

Figure 8 Block Diagram of Instrument Control Rack Electronics

3.4.1.1 Overview of Rack1 Instrument Control Electronics Components

The Instrument Control, Rack1, portion of NICI is contains several subsystems. The subsystems often encompass several subassemblies. Listed below are the subsystems and the subassemblies they contain. There are 2 interfaces to assemblies associated with Rack2, the AO Assembly.

- Dual Array Control
  - Array Control Chassis
  - Pixel Servers (Red and Blue)
  - Array Power Supply Subsystem
- Instrument Controller (server)
- Temperature Control
  - Temperature Controllers (Red and Blue)
  - Temperature Monitor
- Mechanism Control
  - Terminal Server
  - Mechanism Utility Box
  - JBOX (mounted on the cryostat)
  - Motors (mounted on the Cryostat)

Additionally there are two subassemblies that support the general operation of Rack1, the Ethernet Power Control module and the Ethernet Switch. The Ethernet Power Control modules permit remote control of power and rebooting of Rack1 components.

Port #	Component	Notes
1		
2		
3		
4		
5		
6		
7		
8		

Figure 9 Table of Ethernet Power Control Module 1 Port Assignments

Port #	Component	Notes
1		
2		
3		
4		
5		
6		
7		
8		

Figure 10 Table of Ethernet Power Control Module 2 Port Assignments

3.4.1.2 Low Level Descriptions of Rack1 Components

A suite of documents is included with the Service and Calibration Manual to provide detailed low level descriptions of the electronics components in Rack1. The following hierarchical list presents the addendums to this manual.

- SDN3001 **Electronics System Document**: The top-level description of NICI's electronics system.
    - SDN3006 **Instrument Control Rack1**: A high level description of Rack1 electronics.
        - SDN3002 NICI **Temperature Control**: A description of the temperature control subsystem.
        - SDN3003 NICI **Dual Array Controller**: A description of the array control subsystem which is responsible for array configuration, readout, and image capture.
            - 700-111-01 8/16 **CLKBIAS** Channel Clock/Bias Driver Board: Describes the Array Control electronics board that drives clocks and bias voltages to the arrays.
            - 700-158-01 **PREAMP8** 8 Channel Differential Input, Array Optimized Low Noise Preamplifier Board: Describes the Array Control electronics board that pre-amplifies the array outputs before they are digitized by the ADC8.
            - 700-155-01 **ADC8** 8 Channel 2 MHz 16 bit Analog to Digital Converter Board: A description of the Array Control electronics board that digitizes the array outputs.
            - 700-200-01 **FCRYO2** Fiber Interface Subassembly: A description of the Array Control electronics board that provides a fiber interface to the Pixel Servers and hosts array clocking generation hardware.
    - SDN3004 NICI **Mechanism Control Subsystem**: A description of the mechanism control subsystem.
        - NICI **Mechanism Utility Box Specification**: A description of the utility box, or UBox, which houses mechanism control components and concentrates power and control signals to the mechanisms mounted on the cryostat.
        - NICI **JBox Specification**: Describes the Junction Box mounted on the cryostat which fans out the power and control signals from the JBox to the mechanisms mounted on the cryostat.
        - **Hall Effect Sensor Preamplifier**: Describes the electronics board in the JBox which interfaces with the Hall Effect Sensors on the mechanisms.
- **Mechanical Drawings**: See the Preliminary 80% Release Package at
    - http://mkir.com/library/nici80per/

3.4.1.3 Rack1 System Cabling

This section specifies the external cabling associated with Rack1 Instrument Control.

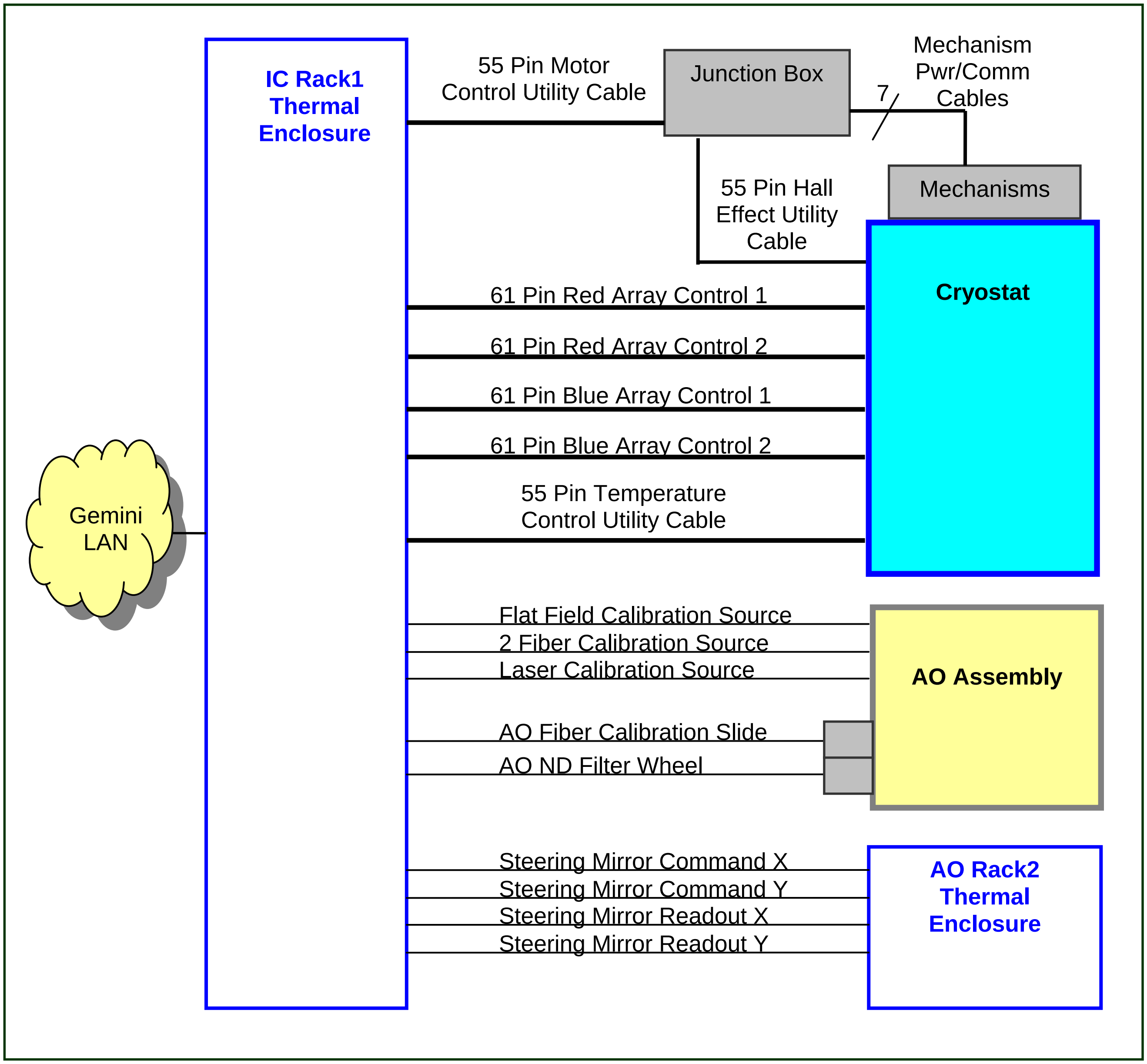

Figure 11 Rack1 Instrument Control System Cabling Block Diagram

3.4.1.4 Rack1 Internal Component Layout

This section specifies the layout of the components mounted in the Rack1 Instrument Control thermal enclosure. Slots are numbered for each U of usable vertical rack space starting from the top of the standard Gemini thermal electronics enclosure. Components can be mounted from the front side or the rear side of the enclosure. The rear side of the enclosure is considered to be the side with the instrument connection breakout panel (patch panel).

NOTE: This layout is subject to flux during implementation. It's probably already outdated.

Slot	Rear Mounted Components	Front Mounted Components	Total Consumed Depth (inches)
1		Instrument Controller: 25.6” D, 1U	25.6*****
2		Mech. Utility Box: 20.96” D, 3U	20.96
3		Mech. Utility Box: 20.96” D, 3U	20.96
4		Mech. Utility Box: 20.96” D, 3U	20.96
5		**2** Temp Controllers: 14.5” D, 2U	14.5
6		**2** Temp Controllers: 14.5” D, 2U	14.5
7		Temperature Monitor: 12.5” D, 2U	12.5
8	Terminal Server: 9.0” D, 1U	Temperature Monitor: 12.5” D, 2U	21.5
9	Ethernet Switch: 9.52” D, 1U		9.52”
10		APS: 26.70” D, 5U	26.7*****
11		APS: 26.70” D, 5U	26.7*****
12		APS: 26.70” D, 5U	26.7*****
13		APS: 26.70” D, 5U	26.7*****
14		APS: 26.70” D, 5U	26.7*****
15	Rotated Array Control Chassis: 12.0” D, 6U		24.0 +
16	Rotated Array Control Chassis: 12.0” D, 6U, Array Cables		24.0 +
17	Rotated Array Control Chassis: 12.0” D, 6U, Array Cables		24.0 +
18	Rotated Array Control Chassis: 12.0” D, 6U		24.0 +
19	Rotated Array Control Chassis: 12.0” D, 6U		24.0 +
20	Rotated Array Control Chassis: 12.0” D, 6U		24.0 +
21		Pixel Server Red: 25.6” D, 1U	25.6*****
22		Pixel Server Blue: 25.6” D, 1U	25.6*****
	Ethernet Power Control (Side mounted in the enclosure outside the rack)		16.73 Wide
	<————————Total Depth 22” (poss. 24”) ————————>		*** Requires custom mounting hardware**

Figure 12 Rack1 Internal Components' Layout

3.4.1.5 Rack1 Mechanical Specifications

- Electronics:
  - IC Rack 1 description (ESD)
    - Mechanical Descriptions
    - Power Dissipation Estimates

3.4.2 Adaptive Optics Control Rack Description

NICI's AO Control electronics are housed in a standard Gemini Thermal Electronics Enclosure. These electronics are responsible for driving the AO portion of NICI. See Figure 13 for a block diagram of the AO Control electronics.

This section provides an overview and some detailed descriptions of the AO Control subsystem. Readers seeking low level details and service and calibration procedures should refer to the Adaptive Optics System User Manual addendum to NICI's Service & Calibration Manual.

The major electronics parts of the AO Control electronics are a Real-Time (RT) Server, a User Interface (UI) Server, High Voltage Amplifier (HVA) Chassis and Counter Chassis, a steering mirror PZT controller, Remote Power Control (RPC) modules, and a terminal server (DIGI Portserver). All of these subsystems reside in the electronics thermal enclosure, except for the UI Server, which is located in the facility. The optical components that are directly controlled by the electronics are the Wavefront Sensor (WFS), the Membrane Mirror (MM), Deformable Mirror (DM), a tip/tilt platform. The Field Steering Mirror (FSM) and Neutral Density Filter Wheel (NDFW) are controlled by the electronics in the IC Rack.

The AO control loop starts with the lenslet array (LLA). Two out of focus images are generated on the LLA by a Membrane Mirror (MM). Photons passed by the lenslet array are converted into TTL pulses by Avalanche Photo Diode modules in the WFS. These pulses flow through 85 coaxial cables from the APD enclosure to the Counter Chassis. Here the pulses are integrated and sent to the RT Server via a fiber optic cable. The RT Server calculates the wavefront errors and the DM and TT platform error signals. These error signals are sent to the HVA Chassis via another fiber optic cable. The HVA chassis converts the error signal into high-voltage signals to drive the DM. Software communicates with the Counter Chassis to generate corrections to the TT platform. The Digi Portserver provides an interface to the Remote Power Control modules and permits monitoring of an APD Temperature Sensor.

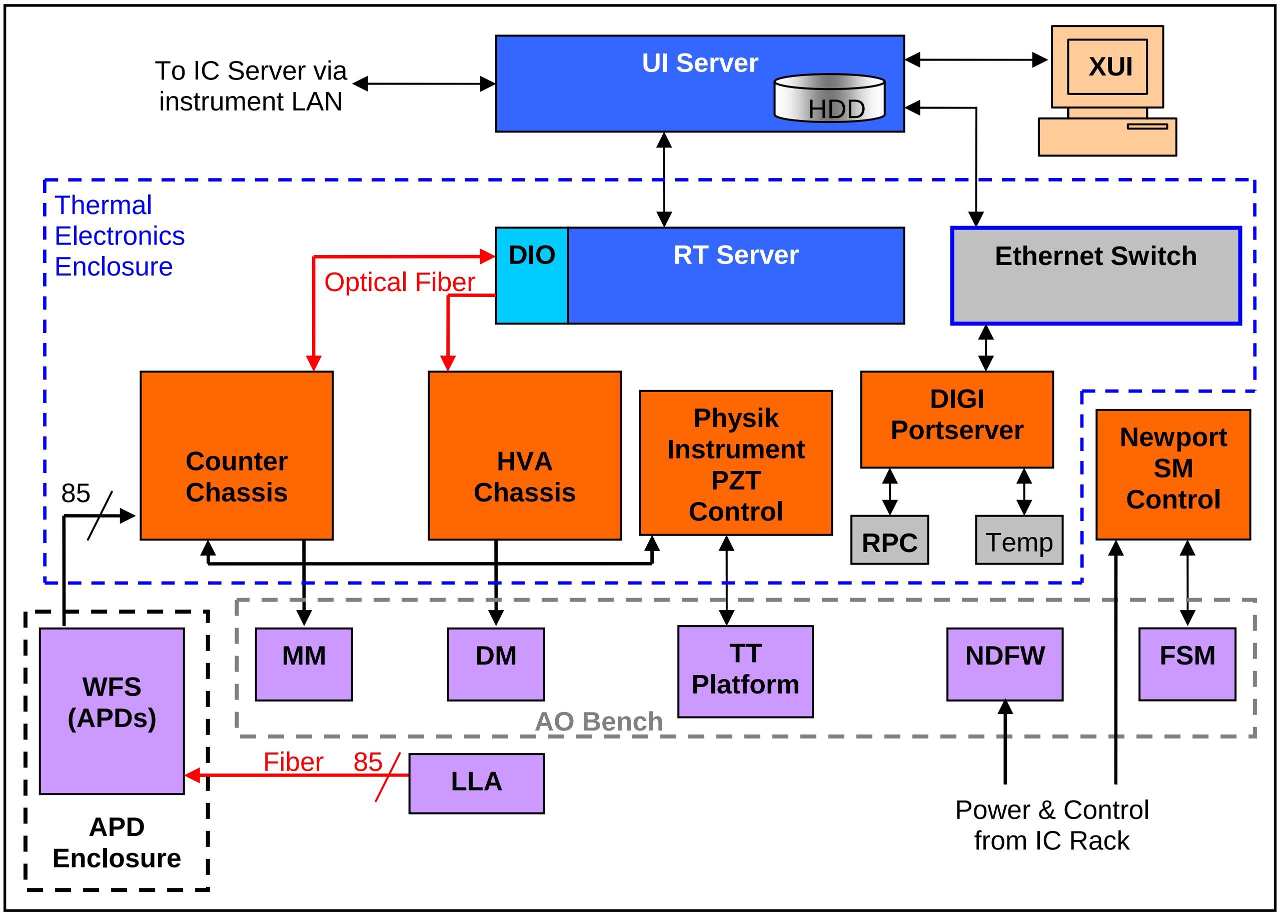

Figure 13 Block Diagram of AO Control Rack Electronics

3.4.2.1 Overview of AO Control Rack Electronics Components

The AO Control Rack portion of NICI contains several sub systems. The subsystems often encompass several subassemblies. This section provides an overview of the AO electronics.

There are 3 major subsystems in H85's electronics, the Servers, Counter Electronics, and High Voltage Electronics. There are also several other components, the Steering Mirror Controller, the Ethernet Switch, the Portserver, and the Remote Power Control modules. See Figure 14 for a graphical depiction of the electronics components.

The Server subsystem encompasses both the RT and UI servers.

The HVA Electronics consists of several components. There is the HVA Chassis populated with a Remote HVA MFB board and HVA Boards. Another component is the High Voltage Power Supply (HVPS) which feeds power to the HVA chassis for driving the DM's actuators.

The Counter Electronics also consist of several components. There is the Counter Chassis populated with a Remote Counter MFB, Counter Boards, and an amplifier for driving the FSM. The APD Power Supply (APD PS) provides power to the APDs in the WFS.

The RT server, HVA, and Counter electronics work in concert at the core of H85's processing and correcting functions. Figure 14 provides a block diagram of the RT Server, HVA Electronics, and Counter Electronics. The User Interface (UI) Server provides the interface to the H85 user and controls the mechanisms.

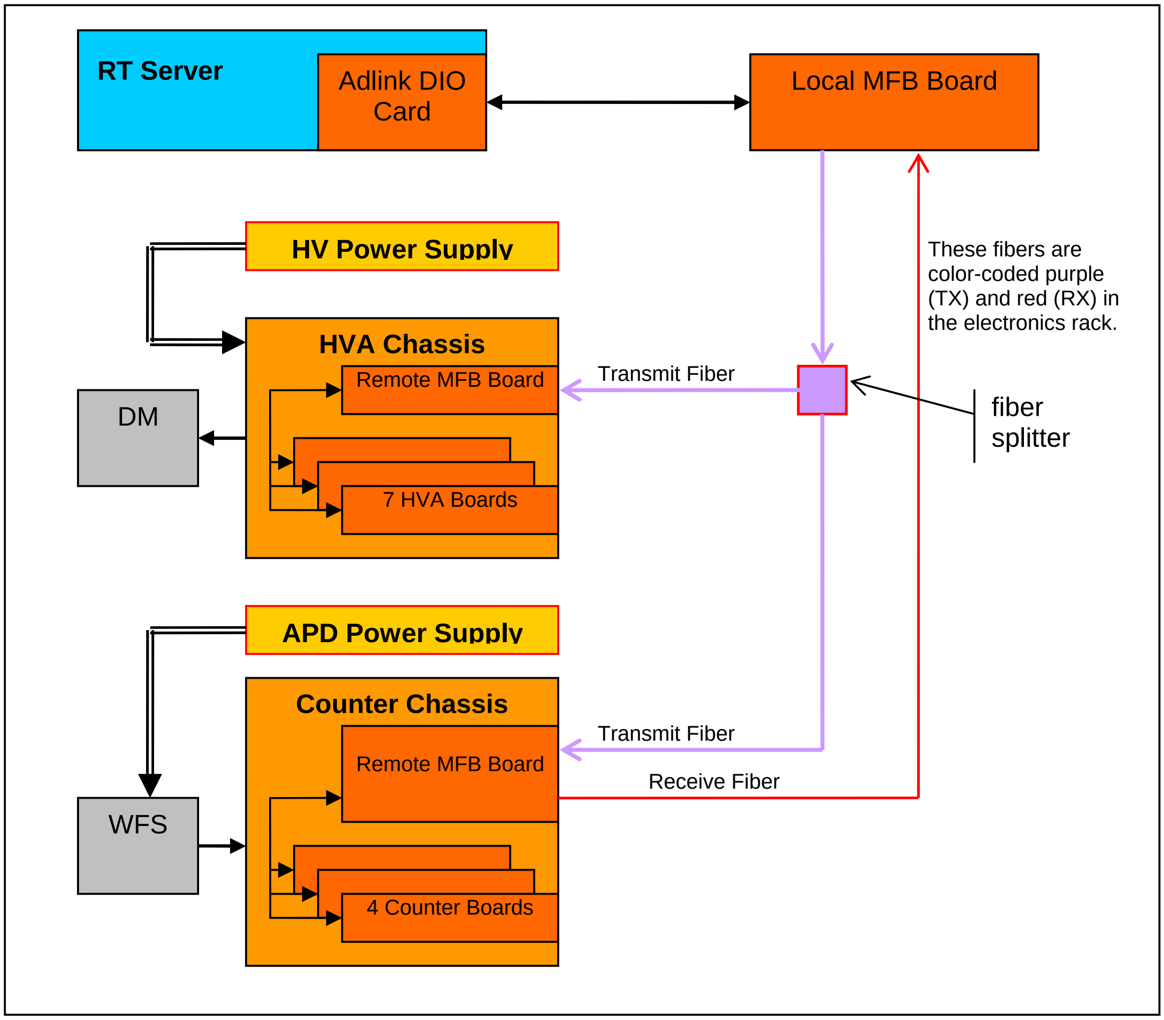

Figure 14 Block Diagram of High Voltage and Counter Electronics AO Components

3.4.2.2 Low Level Descriptions of AO Control Rack Components

The description of the AO Control subsystem is included as an addendum to this document. Please refer to the Adaptive Optics System User Manual which describes the rack's components in detail and provides service and calibration procedures.

3.4.2.3 AO Control Rack System Cabling

This section describes the system level cabling of NICI's AO Control Rack. Connections between assemblies are pictured and defined below. The following cables are the AO Rack's system cables.

- 2 HVA Cables
- 4 APD Power Cables
- Utility Cable
- 85 APD Coax
- 4 FSM Cables
- 85 WFS Fiber
- Fiber Calibration Source Power/Control

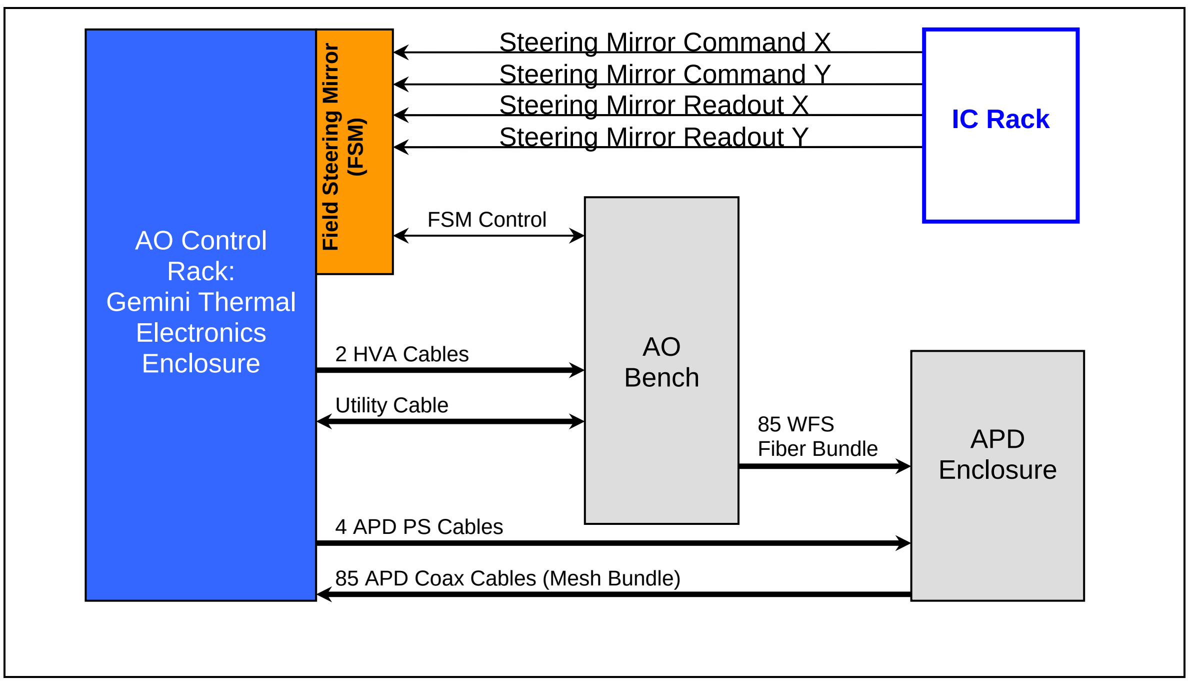

Figure 15 AO Control Rack System Cabling

3.4.2.4 AO Control Rack Internal Component Layout

This section specifies the layout of the components mounted in the AO Control rack. Slots are numbered for each U of usable vertical rack space starting from the top of the standard Gemini thermal electronics enclosure. Components can be mounted from the front side or the rear side of the enclosure. The rear side of the enclosure is considered to be the side with the instrument connection breakout panel (patch panel).

Slot	Rear Mounted Components	Front Mounted Components	Total Consumed Depth (inches)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
	Ethernet Power Control (Side mounted in the enclosure outside the rack)		16.73 Wide
	<——————————Total Depth 22" (poss. 24") ——————————>		*** Requires custom mounting hardware**

3.4.2.5 AO Control Rack Mechanical Specifications

- AO Rack 2 description
  - Mechanical Descriptions
  - Power Dissipation Estimates

3.5 Cryostat Description

- Cryostat
  - Description and diagrams of the various structures, vacuum jacket, radiation shield, cold structure.
  - Thermal Design:
    - Brief description from SDN2001
    - Diagram from SDN2001 Section 1.0
    - Required Cold structure temperature: 75K max, Section 3.0.
    - Required Detector Temperature: 30 - 35 K, Section 4.0.
    - Required Radiation Shield Temperature: 150K max, Section 5.0.
  - Description of cooling system. (may be covered under thermal design)
  - Description of vacuum system.

3.6 Mechanical/Structural Design Description

NOTE*: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

- Mechanical/Structural Design
    - Description of frame
    - Mass and size
    - Add some of DT's Assembly Pictures
    - Description of how AO bench mounts to ISS and Frame
    - Lifting points
    - Wheels, legs
    - Point to the suite of mechanical drawings.

3.7 Spares List

Possible List

- Electronics - 2 spare boards for each custom electronics board.
    - IC:
        - ADC8 Board
        - FCRYO2 Board
        - Preamp8 Board
    - AO:
        - HVA Board
        - Local MFB Board
        - Remote MFB Board
        - Counter Board
- Cabling
    - 55-pin Utility Cable
    - Mechanism Cable (JBox - Motor)

4 Instrument Preparation and Installation

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

4.1 Vacuum and Cryogenic Procedures

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

4.1.1 Vacuum and Cryogenic Safety

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

4.1.1.1 Vacuum Safety

4.1.1.2 Cryo-cooler Safety

4.1.1.3 Liquid Nitrogen Safety

4.1.2 Evacuation of NICI

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

4.1.2.1 Preparation and Special Equipment

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Covers the auxiliary equipment necessary for pump-down.

4.1.2.2 Evacuation and Backfilling

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

4.1.2.2.1 Pumping on an Existing Vacuum

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

One topic is that an instrument that has been sitting under vacuum warm for a while should be pumped down again to remove any residuals from out-gassing or diffusion prior to cooling down.

4.1.2.2.2 Pumping Down from Ambient Pressure

Covers several cycles of pump-down and N2 backfilling.

4.1.2.2.3 Pumping Down after Disassembly

Follows the procedure for pumping down from ambient pressure and then includes a ??? hour bake-out cycle.

4.1.3 Cryo-cooler Operation

NOTE*: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Covers the installation and removal of helium cryo lines to the "cryo-head" as well as cryo-cooler operation.

4.1.3.1 Connecting Aeroquip Fittings

Does NICI use the same kind of fittings?

4.1.3.2 Cryo-Cooler Start-Up

Includes info on checking for contamination, connecting the input line to pump, return side, and pressure side.

4.1.3.3 Cryo-Cooler Shutdown

4.1.4 Cool-Down Procedure

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Random Info:

- SDN2001 8.1: Cool down time for radiation shield is approximately 36 hours.

4.1.4.1 Cool-Down with Pre-Cool

This section specifies the procedure for cooling down NICI with the pre-cool system.

4.1.4.1.1 Safety

Warnings on Asphyxiation risks, cryogenic liquids, noise hazard, and anything with the cryo-cooler lines.

4.1.4.1.2 Theory of Operation

Overview of pre-cool operation (LN) followed by a backfill with He2 and further cooling with the cryo-cooler alone.

4.1.4.1.3 Preparation

Covers connecting helium lines and vent lines. Some words on insulating lines and protecting electronics from condensation dripping off of the lines. Includes powering on temperature monitor electronics.

4.1.4.1.4 Cryo-Cooler Start-Up

Includes info on qualitative and quantitative assessments on proper cryo-cooler operation.

4.1.4.1.5 Pre-Cool Start

Includes info on adjusting flow rate (so that LN2 evaporation, LN2 dripping from vent line is optimized), LN2 consumption rate, and rate of cooling.

4.1.4.1.6 Pre-Cool Stop

Includes info on minimum pre-cool temperature which indicates when to close the pre-cool LN2 valve.

4.1.4.1.7 Pre-Cool Purge and Backfill

Includes info on connecting dry nitrogen gas source to purge all LN, then purging with He gas, and finishing pre-cool down to about 65K before the cryo-coolers are hooked up.

4.1.4.1.8 Final Cooling with Cryo-Coolers

Basically this just involves leaving the cryo-coolers running and monitoring the temperature.

4.1.4.2 Cool-Down without Pre-Cool

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Describes the procedure for cool-down using the cryo-coolers only.

4.1.4.2.1 Safety

Suggested contents are warnings associated with the cryo-cooler lines.

4.1.4.2.2 Theory of Operation

Describes the stages and copper strap connections.

4.1.4.2.3 Preparation

This section specifies the pressure that must be reached before cool-down is initiated, connecting the high pressure He lines, verifying connections from the cryo-coolers to the instrument, turning on temperature monitoring electronics. Also specifies any backfill (with helium gas) procedure that may be used.

4.1.4.2.4 Cryo-Cooler Start

Contains info on turning on the cryo-coolers manually and verifying cooler heads are operating correctly.

4.1.4.2.5 Cryo-Cooler Cool-Down

Contains info on monitoring pressure in the pre-cool system and topping off. Specifies cool-down time.

4.1.5 NICI Warm-Up Procedures

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

4.1.5.1.1 Safety

Things like "don't remove the cryo window while cold."

4.1.5.1.2 Theory of Operation

Specifies the heat dissipation and limits on warm-up rate. Specifies length of time to warm up. Recommends vacuum pump operation during warm-up.

4.1.5.1.3 Operation

Covers connecting and turning on the turbo pump and monitoring the temperature during warm-up, turning on the warm-up controller, and monitoring warm-up. Also discusses the temperature to warm up to depending on the next step with the instrument (storage or opening for maintenance).

4.1.6 Instrument Pressurization to Atmospheric Pressure

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Possibly this can be wrapped into the next section on back-filling prior to maintenance.

4.1.7 Back-Filling the Instrument Prior to Maintenance

***NOTE**: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Just a little info on the advantages of backfilling with N2.

4.2 Instrument Installation and Removal

Should have some CAD drawings of mounting interface.

4.3 Electronics and Software Start-Up and Shutdown

NOTE*: This section is not required for the initial 80% release of documentation to Gemini. This section will be updated by Gemini during/after commissioning.*

Possibly this section fits better under Section 5 Maintenance and Common Procedures.
This section makes much more sense to devote time to later in the development/release cycle. Specific details on these procedures will be captured as implementation proceeds.

4.3.1 Power Up/Down Thermal Enclosures Procedure

- Establishing Remote Power Control connections. (include AO GUI.)
- Order of component power-up/down
- Verifying nominal operation.

4.3.2 Software Start-Up

- Order of software module initialization and startup.
- Verifying nominal operation.

4.3.3 Electronics and Software Shutdown

- Establishing Remote Power Control connections. An AO GUI is available here.
- Order of component & software module shutdown
- Verifying shutdown.

5 Maintenance and Common Procedures

This section describes procedures that are likely to be performed several times during the life of NICI. Maintenance procedures include cryo-cooler maintenance, evacuation, and window cleaning and replacement and are defined in Section 5.1. Common procedures include filter and mask additions, removal, or changes and are defined in Section 5.2.

5.1 Maintenance Procedures

Maintenance procedures must be performed occasionally for various reasons. The maintenance procedures include the following items.

- Cryo-cooler Maintenance
    - Cryo-cooler purge
    - Cryo-cooler drive replacement
    - Compressor adsorber replacement
- Cryostat window inspection, cleaning and replacement
- Evacuation (described in Section 4.1.2)

5.1.1 Maintenance Intervals

Procedure	Interval
Cryo-cooler Purge	Purge when there is evidence of coolant contamination and after cryo-cooler drive replacement.
Cryo-cooler Drive Replacement	
Compressor Adsorber Replacement	3 Years (For Helix 9600, recommended for CTI 1050.
Cryostat window inspection	Inspect prior to installation on the telescope and after prolonged use.
Cryostat window cleaning	According to inspection prior to installation on the telescope and if contaminated after prolonged use.
Cryostat window replacement	If inspection after cleaning shows any signs of damage (chips, cracks) or stains.
Evacuation	Prior to and during warm-up. Prior to all cool-downs. Described in Section 4.1.2.

5.1.2 Cryo-Cooler Maintenance

(What is the compressor's adsorber replacement interval?)

5.1.2.1 Cryo-head Purge and Decontamination

5.1.2.2 Cryo-head (Drive Unit) Removal

Define procedures for inspection or replacement.

5.1.2.3 Cryo-head (Drive Unit) Installation

5.1.3 Entrance Window Maintenance

5.1.3.1 Entrance Window Inspection

5.1.3.2 Entrance Window Cleaning

Describe procedures for light contamination (dust, lint) and light contamination (smudges fingerprints). What about heavy contamination?

5.1.3.3 Entrance Window Replacement

5.2 Common Procedures

Besides maintenance procedures there are some tasks that will probably be performed occasionally for configuration changes of the instrument. These include adding, changing, or removing filters, masks, and dichroic and beam splitter elements from the mechanisms in or around the cryostat.

The following NICI mechanisms have spare positions which Gemini may populate after taking delivery of the instrument.

- AO Neutral Density Filter Wheel
- Focal Plane Mask Wheel
- Pupil Mask Wheel
- Cryostat Beam Splitter / Dichroic Wheel
- Channel 1 and Channel 2 (Science) Filter Wheels

All of the wheels are accessible through access panels for adding or changing elements without the need to remove the wheels. The procedures for changing the installed elements in these mechanisms are defined in the following sections.

5.2.1 Safety and Precautions

- Disabling mechanisms by turning off power to the mechanisms.
- Pinching hazard.
- Tipping Hazard.
- AO and IC interlocks.
- Dry nitrogen gas asphyxiation warning.
- Handling the filters.
- Warnings on light exposure to APDs or arrays.
- Cleanliness when exposing the interior of the cryostat.

5.2.2 Changing AO Neutral Density Filters

5.2.2.1 Preparation for Changing AO ND Filters

- Power down the instrument. Especially verify that the motor power supply is off.
- Disconnect cables.
- Need to position the wheel so that the desired position is at the access port?

5.2.2.2 Accessing the AO ND Filter Wheel

5.2.2.3 AO ND Filter Installation and Removal

5.2.2.4 Completion

- Closing up the access path.
- Re-connect cables.
- Update software.
- Home the mechanism.

5.2.3 Changing Focal Plane Masks

5.2.3.1 Preparation for Changing Focal Plane Masks

- Power down the instrument. Especially verify that the motor power supply is off.
- Disconnect cables.
- Need to position the wheel so that the desired position is at the access port?

5.2.3.2 Accessing the Focal Plane Mask Wheel

5.2.3.3 Focal Plane Mask Filter Installation and Removal

5.2.3.4 Completion

- Closing up the access path.
- Re-connect cables and hoses.
- Update software.
- Home the mechanism.

5.2.4 Changing Pupil Masks

5.2.4.1 Preparation for Changing Pupil Plane Masks

- Warm-up the instrument. (See Section 4.1.5)
- Backfill with dry nitrogen gas.
- Disconnect cables and hoses.
- Need to position the wheel so that the desired position is at the access port?

5.2.4.2 Accessing the Pupil Plane Mask Wheel

5.2.4.3 Pupil Plane Mask Filter Installation and Removal

5.2.4.4 Completion

- Closing up the access path.
- Dewar purge and evacuation. (See Section 4.1.2)
- Re-connect cables and hoses.
- Cool-down. (See Section 4.1.4)
- Update software.
- Home the mechanism.

5.2.5 Changing Cryostat Beam Splitter / Dichroic Elements

5.2.5.1 Preparation for Changing Beam Splitter / Dichroic Elements

- Warm-up the instrument. (See Section 4.1.5)
- Backfill with dry nitrogen gas.
- Disconnect cables and hoses.
- Need to position the wheel so that the desired position is at the access port?

5.2.5.2 Accessing the Beam Splitter / Dichroic Wheel

5.2.5.3 Beam Splitter / Dichroic Installation and Removal

5.2.5.4 Completion

- Closing up the access path.
- Dewar purge and evacuation. (See Section 4.1.2)
- Re-connect cables and hoses.
- Cool-down. (See Section 4.1.4)
- Update software.
- Home the mechanism.

5.2.6 Changing Channel 1 and Channel 2 (Science) Filters

Channel 1 is also referred to as the Red Channel. Channel 2 is also referred to as the Blue Channel.

5.2.6.1 Preparation for Changing Channel 1 and Channel 2 Filters

- Power down the IC and arrays.
- Warm-up the instrument. (See Section 4.1.5)
- Backfill with dry nitrogen gas.
- Disconnect cables and hoses.
- Need to position the wheel so that the desired position is at the access port?

.

5.2.6.2 Accessing the Channel 1 Filter Wheel

5.2.6.3 Accessing the Channel 2 Filter Wheel

5.2.6.4 Channel 1 Filter Change Completion

- Closing up the access path.
- Dewar purge and evacuation. (See Section 4.1.2)
- Re-connect cables and hoses.
- Cool-down. (See Section 4.1.4)
- Update software.
- Home the mechanism.

5.2.6.5 Channel 2 Filter Change Completion

- Closing up the access path.
- Dewar purge and evacuation. (See Section 4.1.2)
- Re-connect cables and hoses.
- Cool-down. (See Section 4.1.4)
- Update software.
- Home the mechanism.

6 Troubleshooting

6.1 Cooling System Diagnostics

Discuss the temperature at the various sensors and what they indicate.

- Array Temperature Sensors
- CCC 1'st Stage Sensor
- CCC 2'nd Stage Sensor
- Cold Structure Sensor
- Radiation Shield Sensor
- "RAD CCC 1ST" Sensor
- APD Temperature Sensor

6.2 Vacuum Troubleshooting

6.2.1 Vacuum Diagnostic Techniques

This section is a suggestion from the GNIRS example.

- Describes gauges and what pressures at which they're useful.
- Helium leak detector or equivalent.

6.2.2 Ambient Temperature Vacuum Troubleshooting

6.2.2.1 Slow Evacuation

Describes the diagnostics and maintenance for pump-downs that proceed below the normal rate of evacuation.

6.2.2.2 Pressure Rise after Starting Bake-out

This section is a suggestion from the GNIRS example. I'm not sure it makes sense. Basically their section says that if performing a bake-out under vacuum a pressure rise is normal. Otherwise the bake-out procedure is recommended to be carried out when back-filled with dry Nitrogen. Curiously this contradicts their section on Pumping Down after Disassembly.

6.2.3 Cold Vacuum Troubleshooting

This section covers symptoms and solutions for cold vacuum issues with NICI's cryostat assembly and related subsystems.

6.2.3.1 Symptoms

List common symptoms and possible causes.

6.2.3.2 Solution: Emergency Cold Pumping

Covers day-time evacuation during the day while maintaining cryo-cooler operation.

6.2.3.3 Solution: Warming up the Instrument

This section covers warming up the instrument for leak repairs.

6.3 Electronics Troubleshooting

6.3.1 Troubleshooting Motors and Mechanisms

6.3.2 Swapping to Spare IC Electronics Boards

Two spares are provided of each custom electronics board.

- IC ADC8 Board
- IC FCRYO2 Board
- IC PREAMP8 Board
- Warning on VME cards

6.3.3 Swapping to Spare AO Electronics Boards

- AO Counter Board
- AO Remote MFB Board
- AO Local MFB Board
- AO HVA Board
- Warning on VME cards

6.3.4 Changing to Spare Utility Cables

- Mechanism Utility Cable
- Temperature Cable
- Hall-Effect Cable
- AO Utility Cable

6.3.5 Changing to Spare Mechanism Cables

6.3.6 Swapping to a Spare AO APD Module

Occasionally APD modules in the APD enclosure may have to be replaced. This section provides instructions for swapping one of the spare APD modules already installed in the APD enclosure. Generally replacing a module would be done during the day and swapping to a spare module may be done during night-time observation.

Telescope personnel involved in the replacement or spare swapping of APDs should be very cautious about this procedure. There is exposed high voltage inside the APD enclosure. The door of the APD enclosure is quite heavy. It is strongly recommended that the APD enclosure (door hinges) be in a vertical, level position before opening the door as the door could swing open or closed under its own weight. In addition the APDs are very sensitive devices.

The quickest method of replacing a dead APD module is by swapping the fiber and coax connections of the defective module to one of the 5 spare APD modules already installed in the APD Enclosure. It is critical that the APDs be properly powered down before attempting any maintenance.

Materials and Tools Needed:
It may be helpful to bring some small zip ties and a tool for clipping zip ties to the APD enclosure. Also needed is material for insulating BNC and connectors, like shrink wrap and a heat gun. This procedure is estimated to take 20 minutes.

1. Level the APD Enclosure. It is strongly recommended that the APD enclosure (door hinges) be in a vertical, level position before opening the door as the door could swing open or closed under its own weight. When NICI is installed on a side-looking port, this is the case when the telescope is in the zenith position.
2. Identify the number of the defective APD.
3. Pause the AO loop through the XUI Operator Tab.
4. Power down the APD Power Supplies through the XUI Operator Tab's APD Power popup window.
5. Power down the High Voltage Power Supplies through the XUI Operator Tab's AC Power popup window.
6. Verify that the APD Power Supplies are powered down. You may like to open the thermal enclosure's front door to do a visual check. The APD Power Supplies are labeled "Sorensen #1" and Sorensen #2." There should be no illuminated lights on the front panel displays.
7. Open the front panel of the APD Enclosure.
8. Detach the coax cable from the defective APD. APDs are numbered on the side facing the front panel of the APD Enclosure.
9. Remove the power connector from the defective APD.
10. Insulate the power connector from the defective APD to avoid shorts to the power bus bars. Shrink wrap will do nicely. Secure the connector (with a zip tie).
11. Remove the coax cable from the Spare APD.
12. Insulate the spare BNC connector to avoid shorts to the power bus bars. Shrink wrap will do nicely. Secure the spare BNC connector (with a zip tie).
13. Attach the coax cable for the defective channel to the closest spare APD. The APD spares are labeled Spare 1 - Spare 5. Enabling this cable to reach the spare may involve cutting zip ties that secure the cable's routing.
14. Remove the shrink wrap protective covering from the spare power plug near the chosen spare APD.
15. Attach the spare APD power cable to the spare APD.
16. Replace any zip ties that were removed for cable routing to the spare APD.
17. Check that no cables are dangling.
18. Close the APD Enclosure front cover.
19. Open the door of the APD Enclosure. The door is heavy. Be sure to take caution against the door swinging open or closed under its own weight.
20. Detach the fiber cable from the defective APD. APDs are numbered on their back sides.

21. Remove the protective fiber connection cover from the nearest spare APD and install it on the defective APD module's fiber connector.
22. Attach the fiber cable for the defective channel to the closest spare APD.
23. Check that no cables or hoses are dangling.
24. Close the APD door and firmly secure the latches.
25. Power on the High Voltage Power Supplies through the XUI Operator Tab's AC Power popup window.
26. Power on the APD Power Supplies through the XUI Operator Tab's APD Power popup window.

6.3.7 Replacing an AO APD Module

Replacing an APD module is generally a daytime procedure. It is critical that the APDs be properly powered down before attempting any maintenance. This procedure assumes that the instrument has been totally shut down. This procedure is estimated to take 45 minutes. The APDs are mounted with M3 hex screws and will require a 2.5 mm hex wrench to remove and re-install.

1. Level the APD Enclosure. It is strongly recommended that the APD enclosure (door hinges) be in a vertical, level position before opening the door as the door could swing open or closed under its own weight. When NICI is installed on a side-looking port, this is the case when the telescope is in the zenith position.
2. Identify the number of the defective APD.
3. If the AO system is running, pause the AO loop through the XUI Operator Tab.
4. Power down the APD Power Supplies through the XUI Operator Tab's APD Power popup window.
5. Power down the High Voltage Power Supplies through the XUI Operator Tab's AC Power popup window.
6. Verify that the APD Power Supplies are powered down. You may like to open the thermal enclosure's front door to do a visual check. The APD Power Supplies are labeled "Sorensen #1" and Sorensen #2." There should be no illuminated lights on the front panel displays.
7. Verify that the High Voltage Power Supplies are powered down. You may like to open the thermal enclosure's front door to do a visual check. The two HV Power Supplies are labeled "HVDC Sorensen." There should be no illuminated lights on the front panel displays.
8. Open the front panel of the APD Enclosure.
9. Detach the coax cable from the defective APD. APDs are numbered on the side facing the front panel of the APD Enclosure.
10. Detach the power cable from the defective APD. The power cable is connected between the two BNC (coax) connectors.
11. Open the door of the APD Enclosure. The door is heavy. Be sure to take caution against the door swinging open or closed under its own weight.
12. Detach the fiber cable from the defective APD. APDs are numbered on their back sides.
13. From the front panel side of the APD Enclosure, push on the shelf to which the defective APD module is mounted to release the shelf from its locked position. Be careful not to let the shelf swing out quickly.
14. Swing the shelf out being careful not to snag any cables or lines on the front, back, or side of the shelf. Be careful not to crush any lines or cables behind the shelf's hinges.
15. Remove and secure all 8 hex mounting screws from the defective APD with a 2.5 mm hex wrench. These screws are not captive. Don't drop them.
16. Remove the defective APD module.
17. Mount a replacement APD module in place of the defective module. Re-install all 8 hex mounting screws with a 2.5 mm hex wrench.
18. Swing the APD shelf back into its locked position.
19. Attach the fiber cable to the new APD.
20. Close and secure the door of the APD Enclosure.
21. Attach the coax BNC connector to the TTL Output of the new APD module.

22. Insert the power connector for the replaced APD into the new APD module. The power connector is between the two BNC connectors on the APD.
23. Close the APD Enclosure's front cover.

7 Calibration

This section describes the procedures for calibrating the mechanical and control functions of NICI. General operational calibration procedures are defined in the User Manual.

7.1 Mechanism Calibration

7.1.1 Pupil Centering

7.2 Software Configuration

Discusses how to make changes to software lookup tables in response to mechanism configuration changes.

7.3 Temperature Controller Calibration

7.3.1 Setting P-I-D Temperature Controller Terms

Covers setting the P-I-D terms.

7.3.2 Temperature Diode Calibration

8 Major Disassembly and Assembly

8.1 Safety and General Considerations

8.1.1 Safety

Covers heavy components, dewar vacuum, cryogenic temperatures, high voltages, and ESD sensitive devices.

8.1.2 Sub-system Disassembly

Describes which subsystems require only partial disassembly, and which subsystems can be accessed thru access panels.

8.1.3 Assembly Checklist and Ordered Procedures

Breaks the assembly procedure up into specific sections for sub-assemblies and provides a numbered checklist for each step in the subassembly assembly procedure.

8.2 Preparation for Disassembly

8.2.1 Introduction to Disassembly Procedures

Covers the requirements for replacement fasteners, material, cleaning, and lubrication. Estimated time for disassembly and assembly.

8.2.2 Definition of Instrument Orientation

This section defines top, bottom, forward, aft, port and starboard directions for the instrument for reference during assembly and handling procedures.

8.2.3 Handling Fixtures

Defines and pictures fixtures for lifting heavy components, aligning critical components, protecting optical surfaces, and special tools.

8.2.4 Lifting and Handling Equipment

- Define lifting points, labels.
- Illustrates lifting rings.
- Describes the orientations that the instrument can be in when not installed on the telescope.

8.2.5 Orienting the Instrument Vertically

Describe the procedures for rotating the instrument from horizontal to vertical using lifting straps.

8.2.6 Orienting the Instrument Horizontally

Describe the procedures for rotating the instrument from vertical to horizontal using lifting straps.

8.2.7 Instrument Warm-Up
Prior to instrument disassembly the instrument must be warmed up as described in Section 4.1.5.

8.2.8 Instrument Pressurization to Atmospheric Pressure
Prior to instrument disassembly the instrument must be pressurize to atmospheric pressure as described in Section 4.1.6.

8.2.9 Removal of Cabling, Helium Lines, and Glycol Coolant Lines from the Cryostat Assembly and AO Bench
Include grounding concerns.

8.2.10 Removal of Cabling and Glycol Coolant Lines from the IC and AO Control Racks
Include grounding concerns.

8.3 External Structure Removal and Installation

8.3.1 Removing Rack 1 (IC) Thermal Enclosure

Describes the procedures for removing the Thermal Enclosure from the Cryostat instrument support frame.

8.3.2 Removing Rack 2 (AO) Thermal Enclosure

Describes the procedures for removing the Thermal Enclosures and associated extension frames from the Cryostat instrument support frame.

8.3.3 Removal of the Instrument Support Frame

8.4 Cryostat Internal Structure Removal and Installation

8.4.1 Preparing Cryostat for Disassembly in a Clean Room

Covers cleaning the exterior of the cryostat, ensure has been warmed up and purged to atmospheric pressure.

8.4.2 Cryostat Disassembly Procedures in a Clean Room

Define procedures for each internal assembly.

8.5 Cryostat Optics Removal and Installation

8.6 Detector Removal and Installation

8.7 Mechanism Removal and Installation

8.8 AO Bench Internal Structure Removal and Installation

9 Appendix A: Ballast Weight Station Table

A table of ballast weight mounting locations, numbers, and weights.

10 Appendix B: Software Configuration Files

Probably this is **more relevant in the Software Maintenance Manua**l. A list of configuration files and their contents. These are used for things like configuration changes to the initial complement of filters, masks, and dichroics.

11 Appendix C: Optical Specifications

These optical specifications are taken from SDN1007 NICI Optical Performance by John T. Raynor.

The physical dimensions of all delivered optics should be measured to 0.025mm (0.001ins). Focal lengths should be measured to 0.025mm (0.001ins). Vendors should provide reduced interferograms to demonstrate that the optical figure meets the specification and proof should be provided that optical surfaces meet the roughness specification.

Important note: the surface figure errors are SURFACE errors (half the wavefront error). These requirements are derived from document SDN 1008 NICI Optical Figure Requirements.

11.1 Introduction

The optics are separated into three major sections: the relay optics, wavefront sensor (WFS) and cryostat optics.

The relay optics (see Figure 16) relay the telescope focal plane at 1:1 to the front foci of both the wavefront sensor and cryostat. A relay collimator mirror images the telescope pupil onto a high frequency piezoelectric deformable mirror which corrects the wavefront under control of the wavefront sensor. The deformable mirror is an 85-electrode bimorph mirror. A relay camera mirror takes the collimated beam from the deformable mirror and re-images the telescope plane. The re-imaged telescope focal plane is split into optical and infrared foci by a dichroic beamsplitter. Chromatic aberration introduced into the transmitted beam by the dichroic is removed by a compensator plate immediately following the dichroic. The compensator plate is made from the same material (fused silica) and is of the same thickness as the dichroic. The plane of the plate is oriented a right-angle to the dichroic.

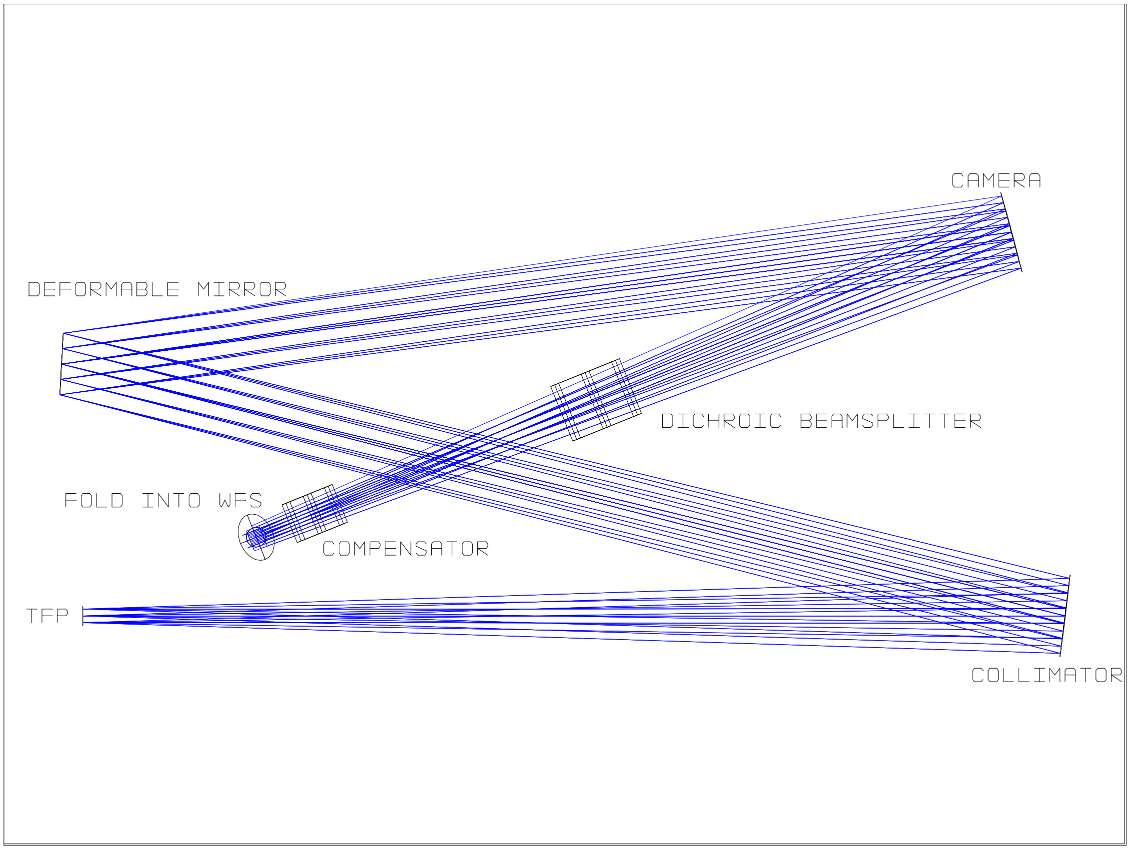

Figure 16 Relay Optics Ray Trace

The f/16 optical beam transmitted by the compensator enters the wavefront sensor (see Figure 17) where it is first folded before coming to a focus at an intermediate telescope focal plane (TFP). Following the TFP the beam is folded and then collimated by a spherical collimator mirror. The collimator forms an image of the telescope secondary mirror on a flat steering mirror (SM). The steering mirror can be articulated to select suitable point sources in the 18.4x18.4 arcsec field of view for wavefront sensing. Two spherical camera mirrors (CAM1 and CAM2) following the steering mirror form a second TFP on a membrane mirror (MM). The membrane mirror is acoustically driven at about 2 kHz to rapidly switch between positive and negative curvatures. When the membrane is flat two lenslet mirrors (LM1 and LM2) which follow it form a pupil image on an 85-element lenslet array. Optical fibers attached to each of the lenslets feeds light into 85 Avalanche Photo-Diodes (APDs). On activating the membrane the pupil image on the lenslet array is sequentially defocused in opposite directions at 2 kHz. The difference of intensity of the two images divided by the sum gives an 'image' of the curvature and slope of the incoming wavefront which can then be corrected by adjusting the deformable mirror in the relay optics.

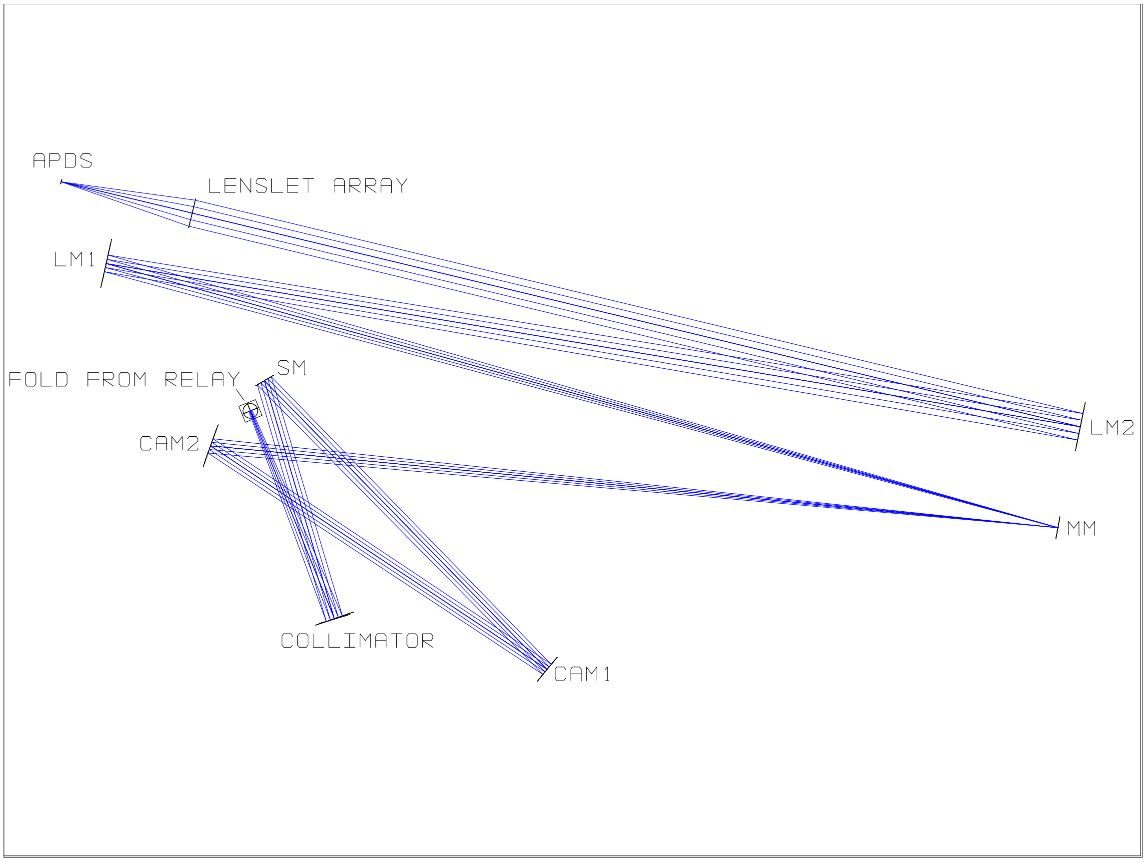

Figure 17 Wavefront Sensor Optics Ray Trace

The f/16 infrared beam reflected by the relay dichroic beamsplitter converges to a focus just in front of the cryostat window. This is the location of the 8-position telescope focal plane mask wheel (see Figure 18). The mask wheel contains a selection of apodized coronagraphic masks and slits deposited on calcium fluoride substrates. The beam then enters the cryostat through a calcium fluoride window where it is collimated by an off-axis parabolic (OAP) aluminum mirror. The collimator forms an image of the telescope secondary mirror on an 8-position pupil wheel which follows a fold mirror. Contained in the pupil wheel are several pupil masks deposited on calcium fluoride substrates. The collimator also forms an image of the telescope spider fractionally in front of the secondary image. A rotatable spider mask is located here. A 15-position dichroic wheel following the cold pupil separates the beam into red (transmitted) and blue (reflected) channels. The dichroics are deposited upon calcium fluoride substrates. In the red channel the collimated beam transmitted by the dichroic passes through a 22-position wheel containing filters and grisms before being folded onto an OAP aluminum camera mirror which re-images the telescope focal plane onto a 1024x1024 InSb detector array at 0.018 arcsec per pixel (f/36, 1:2.25 re-imaging).

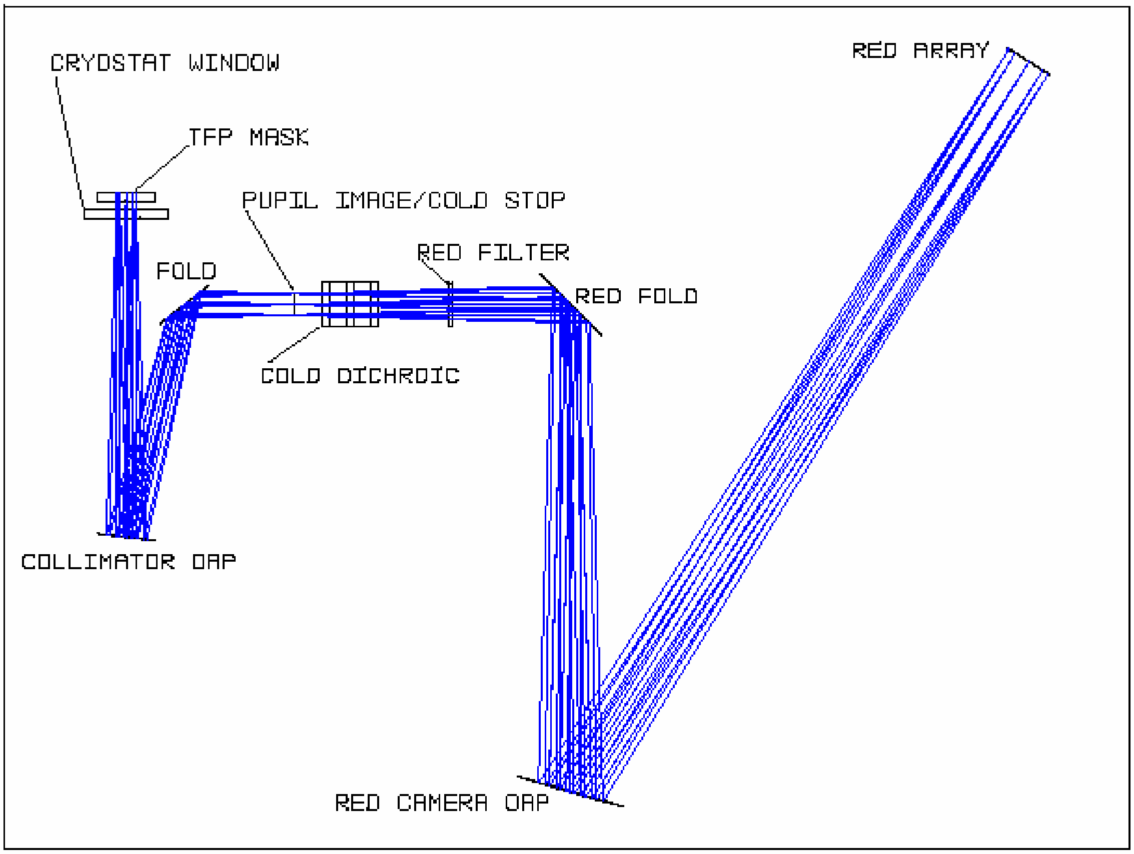

Figure 18 Cryostat Fore-optics + Red (CH1) Channel Ray Trace

In the blue channel (see Figure 19) the collimated beam reflected by the dichroic passes through another wheel containing filters and grisms before being folded onto an OAP aluminum camera mirror which re-images the telescope focal plane onto a second 1024x1024 InSb detector array identically to the red channel.

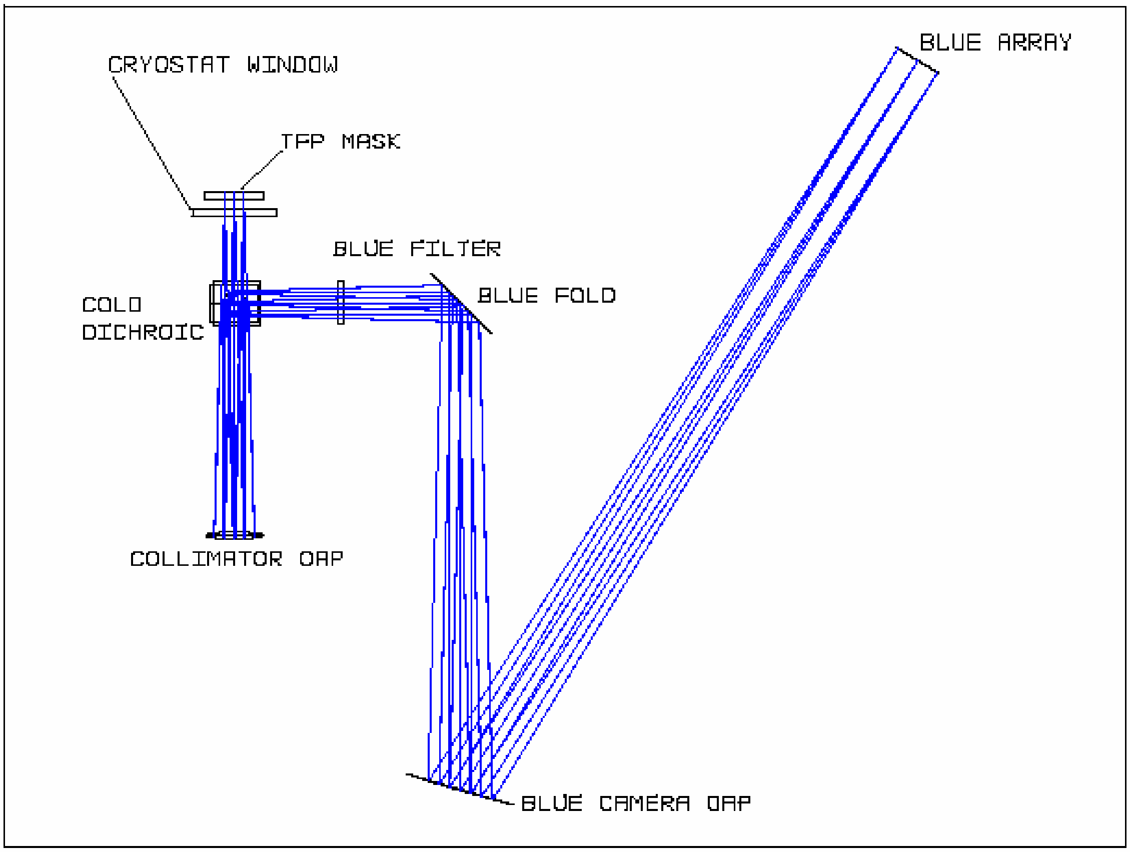

Figure 19 Cryostat Fore-optics + Blue (CH2) Channel Ray Trace

A pupil-viewing lens (see Figure 20) is included in the red channel to image the telescope pupil, pupil and spider masks. The lens is a Barium Fluoride-Calcium Fluoride doublet mounted in a wheel, and which can be rotated into and out of the beam between the camera OAP and the array.

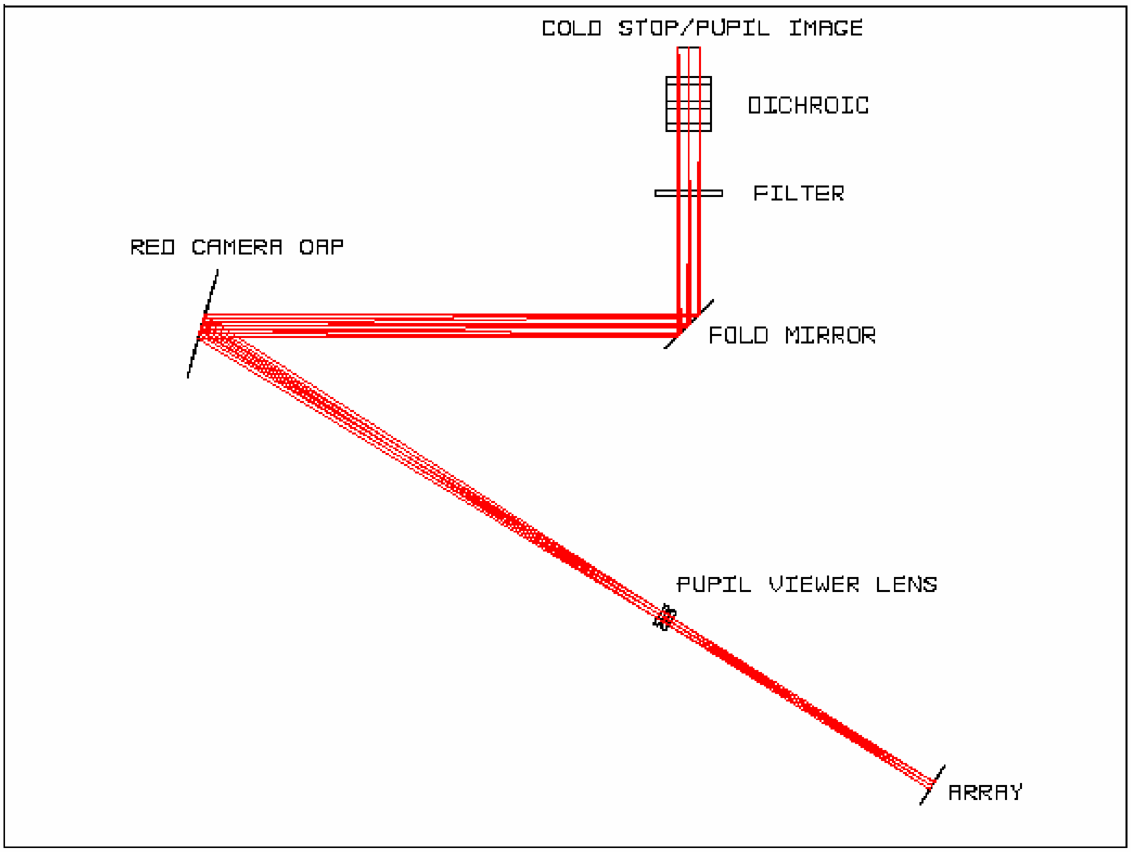

Figure 20 Pupil Viewer Ray Trace

11.2 Relay Optics

11.2.1 Relay Collimator and Camera

The relay collimator and camera OAPs are identical fused silica mirrors. The required focal length tolerance is ±0.5% (±4.1mm) but the fabricated focal length will be measured to a precision of ±0.1mm.

PARAMETER	***VALUE***	***TOLERANCE***
Conic shape	-1.00 (parabola)	±0.005
Substrate	Zerodur	
Working temp	≈275K	
Mirror thickness	14.08mm (diameter/6)	±0.05mm
Focal length	809.1mm, plano-concave	±0.5% (±4.1mm)
Off-axis center distance	200.0mm	±0.3mm
Off-axis center matching		±0.3mm
Physical diameter	84.45mm	+0.00/–0.05mm
Clear aperture diameter	67.56mm	
Beam footprint diameter	50.74mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/30 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/15 over any beam footprint	@0.63μm
Surface RMS 4	λ/13 over clear aperture	@0.63μm
Surface finish	<30 Angstroms RMS	
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.50mm	
Bevel	See drawing	
Coating	Silver overcoated with Thorium Fluoride	
Quantity	2	

11.2.2 Deformable Mirror

The deformable or bimorph mirror is constructed from two thin plates of piezoelectric material separated by an electrical ground plane. The 85-element electrode pattern is deposited upon the backside plate. The plates glued together, forming a sandwich of electrodes. Connections to these electrodes are brought out to the rear piezo plate. An optical surface is constructed on the front plate. When voltage is applied to the backside the bimorph bends.

PARAMETER	***VALUE***	***TOLERANCE***
Shape	Plane-parallel	
Substrate	Piezoelectric stack	
Working temp	≈275K	
Thickness	5.00mm	±0.05mm
Physical diameter	64.65mm	+0.00/-0.02mm
Clear aperture diameter	51.7mm	
Beam footprint diameter	51.7mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/30 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/15 over any beam footprint	@0.63μm
Surface RMS 4	λ/15 over clear aperture diameter	@0.63μm
Front-side, coat	Silver overcoated with Thorium Fluoride	
Back-side coat	None	
Quantity	1	

11.2.3 Relay Dichroic Beamsplitter

The relay dichroic reflects the infrared beam into the cryostat and transmits the optical beam into the wavefront sensor. It is a simple plane-parallel silica substrate with a front-side dichroic coating and a back-side optical anti-reflection coating.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Fused Silica	
Working temp	≈275K	
Thickness	10.00mm	±0.05mm
Physical size	79.02x57.14mm (rect.)	+0.00/–0.05mm
Clear aperture	56.0x40.0mm (rect.)	
Beam footprint diameter	40.0x28.0mm (rect.)	
Surface figure 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface figure 2	λ/41 over any ½ beam footprint	@0.63μm
Surface figure 3	λ/28 over any beam footprint	@0.63μm
Surface figure 4	λ/26 over clear aperture diameter	@0.63μm
Surface finish	<30 Angstroms RMS	
Bevel	Standard	
Front-side dichroic coat	R>90% 1.05-5.5μm, av. 95%	@45 degree
	T>90% 0.4-1.0μm, av. 95%	@45 degree
Back-side BBAR coat	Optimize for 0.4-1.0μm, R<1%	@45 degree

Quantity	1	

11.2.4 Relay Dichroic Beamsplitter Compensator Plate

The compensator plate cancels chromatism introduced by the warm dichroic.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	Plane parallel	wedge ± 3 arcmin
Substrate	Fused Silica	
Working temp	≈275K	
Thickness	10.00mm	±0.05mm
Physical size	54.0x34.0mm (rect.)	+0.00/–0.05mm
Clear aperture	34.0x24.0mm (rect.)	
Beam footprint diameter	18.0x12.0mm (rect.)	
Surface figure 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface figure 2	λ/41 over any ½ beam footprint	@0.63μm
Surface figure 3	λ/28 over any beam footprint	@0.63μm
Surface figure 4	λ/26 over clear aperture diameter	@0.63μm
Surface finish	<30 Angstroms RMS	
Bevel	Standard	
Front-side BBAR coat	Optimize for 0.4-1.0μm, R<1%	@45 degree
Back-side BBAR coat	Optimize for 0.4-1.0μm, R<1%	@45 degree
Quantity	1	

11.3 Wavefront Sensor Optics

11.3.1 WFS Fold #1 Mirror

The first fold mirror is a plane-parallel silica substrates with a broad-band reflection coating applied to the front-side.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Zerodur	
Working temp	≈275K	
Thickness	7.00mm	±0.05mm
Physical diameter	40.0mm	+0.0/-0.05mm
Clear aperture diameter	33.0mm	
Beam footprint diameter	14.0mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/18 Over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	Standard	
Front side coat	Silver overcoated with Thorium Fluoride	

Quantity	1	

11.3.2 WFS Fold #2 Mirror

The second fold mirror is a plane-parallel silica substrates with a broad-band reflection coating applied to the front-side.

PARAMETER	VALUE	TOLERANCE
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Zerodur	
Working temp	≈275K	
Thickness	5.00mm	±0.05mm
Physical size	27.0x20.0mm (rect.)	+0.0/-0.05mm
Clear aperture diameter	22.0mm	22x16mm ellipse
Beam footprint diameter	6.0mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/15 Over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	Standard	
Front side coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

11.3.3 WFS Collimator Mirror

The collimating mirror is a plano-concave silica substrate with a broad-band reflection coating applied to the concave side.

PARAMETER	VALUE	TOLERANCE
Shape	Plano-concave	
Substrate	Zerodur	
Working temp	≈275K	
Radius, front surface	561.5mm	±0.1% @ 290K
Radius, back surface	infinity (plane)	
Center thickness	8.00mm	±0.05mm
Physical diameter	44.50mm	+0.0/-0.02mm
Clear aperture diameter	35.6mm	
Beam footprint diameter	19.3mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/22 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	See drawing	

Front side, coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

11.3.4 WFS Steering Mirror

The steering mirror is a plane-parallel silica substrate with a broad-band reflection coating applied to the front-side.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Zerodur	
Working temp	≈275K	
Thickness	4.00mm	±0.05mm
Physical diameter	23.00mm	+0.0/-0.05
Clear aperture diameter	18.4mm	
Beam footprint diameter	18.0mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/28 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	Standard	
Front side coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

11.3.5 WFS Camera Mirror 1

The first camera mirror is a plano-convex silica substrate with a broad-band reflection coating applied to the front-side.

PARAMETER	***VALUE***	***TOLERANCE***
Shape	Plano-convex	
Substrate	Zerodur	
Working temp	≈275K	
Radius, front surface	2845mm	±0.1% @ 290K
Radius, back surface	Infinity (plane)	
Center thickness	6.00mm	±0.05mm
Physical diameter	35.0	+0.00/-0.02mm
Clear aperture diameter	24.6mm	set by baffle
Beam footprint diameter	14.6mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/22 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	see drawing	

Front side, coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

11.3.6 WFS Camera Mirror 2

The second camera mirror is a plano-concave silica substrate with a broad-band reflection coating applied to the front-side.

PARAMETER	***VALUE***	***TOLERANCE***
Shape	Plano-concave	
Substrate	Zerodur	
Working temp	≈275K	
Radius, front surface	1584mm	±0.1% @ 290K
Radius, back surface	Infinity (plane)	
Center thickness	8.00mm	±0.05mm
Physical diameter	50.0mm	+0.00/-0.02mm
Clear aperture diameter	39.8mm	set by baffle
Beam footprint diameter	16.9mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/17 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	see drawing	
Front side, coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

11.3.7 WFS Membrane Mirror

The membrane mirror consists of a nitro-cellulose pellicle mirror. The membrane is attached to the end of small acoustic cavity, which when driven at resonance by a high frequency loudspeaker (tweeter), causes the membrane to rapidly switch between positive and negative curvature. The membrane runs at about 2 kHz, at which frequency a minimum radius of about 250mm can be achieved.

PARAMETER	***VALUE***	***TOLERANCE***
Shape	Plane-parallel	
Working temp	≈275K	
Physical diameter	25.0mm	+0.00/-0.02mm
Clear aperture diameter	1.2mm	10 diffraction rings @ 0.8μm
Beam footprint diameter	0.025mm	
Surface RMS 1	λ/43 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/30 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/22 over any beam footprint	@0.63μm
Surface RMS 4	λ/0.9 Over clear aperture diameter	@0.63μm
Front side, coat	Silver overcoated with Thorium Fluoride	

Backside coat	None	
Quantity	1	

11.3.8 WFS Lenslet Mirror 1

The first lenslet mirror is a plano-concave silica substrate with a broad-band reflection coating applied to the concave surface.

PARAMETER	***VALUE***	***TOLERANCE***
Shape	Plano-concave	
Substrate	Zerodur	
Working temp	≈275K	
Radius, front surface	5295mm	±0.1% @ 290K
Radius, back surface	infinity (plane)	
Center thickness	9.00mm	±0.05mm
Physical diameter	60.0mm	+0.00/-0.02mm
Clear aperture diameter	34.0mm	set by baffle
Beam footprint diameter	18.6mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/20 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	see drawing	
Front side, coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

Note, baffle set by unvignetted FOV with membrane mirror curvature -1167mm and one arcsecond of tilt.

11.3.9 WFS Lenslet Mirror 2

The second lenslet mirror is a plano-convex silica substrate with a broad-band reflection coating applied to the convex surface.

PARAMETER	*VALUE*	*TOLERANCE*
Shape	Plano-concave	
Substrate	Zerodur	
Working temp	≈275K	
Radius, front surface	5940mm	±0.1% @ 290K
Radius, back surface	infinity (plane)	
Center thickness	9.00mm	±0.05mm
Physical diameter	60.0mm	+0.00/-0.02mm
Clear aperture diameter	48.0mm	set by baffle
Beam footprint diameter	29.5mm	
Surface RMS 1	λ/56 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/41 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/28 over any beam footprint	@0.63μm
Surface RMS 4	λ/24 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	see drawing	
Front-side, coat	Silver overcoated with Thorium Fluoride	
Quantity	1	

Note: the baffle is set by unvignetted FOV with membrane mirror curvature -1167mm and one arcsecond of tilt.

11.3.10 Lenslet Array

The lenslet array is constructed from 85 individual lenses which have been sectioned and glued together. Individual lenses are 12mm diameter BK7 plano-convex lenses, EFL 24.0mm from Edmund.

PARAMETER	*VALUE*	*TOLERANCE*
Shape	lenslet array, 85 elements	
Substrate	BK7	
Working temp	≈275K	
Physical diameter	?mm	+0.00/-0.02mm
Clear aperture diameter	30.8mm	set by baffle
Beam footprint diameter	30.8mm	
Surface RMS 1	λ/22 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/15 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/11 over any beam footprint	@0.63μm
Surface RMS 4	λ/11 over clear aperture diameter	@0.63μm
Surface RMS over single lens	λ/26?	@0.63μm
BBAR coat range	Edmund VIS-NIR	
BBAR coat av. Refl./surface	<1%	optimize for 0.8μm
Quantity	1	

11.4 Cryostat Optics

11.4.1 Telescope Focal Plane Masks

The masks are applied to front-side of plane-parallel calcium fluoride substrates which have been anti-reflection coating for the infrared.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Calcium Fluoride	
Working temp	≈275K	
Thickness	5.00mm	±0.05mm
Physical diameter	35.00mm	+0.0/-0.05
Clear aperture diameter	11.9mm	11.9x11.9mm (rect.)
Beam footprint diameter	0.013mm	
Surface RMS 1	λ/42 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/30 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/21 over any beam footprint	@0.63μm
Surface RMS 4	λ/0.8 over clear aperture diameter	@0.63μm
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish	<30 Angstroms RMS	
Bevel	standard	
Front surface mask	TBD	
BBAR coat range	1.0-5.5μm	
BBAR coat av. Refl./surface	<2.5%	optimize for 1.65μm
Quantity	8?	

11.4.2 Cryostat Window

The cryostat window is a plane-parallel calcium fluoride substrate which has been anti-reflection coated for the infrared.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Calcium Fluoride	
Working temp	≈275K	
Thickness	5.00mm	±0.05mm
Physical diameter	50.00mm	+0.0/-0.05
Clear aperture diameter	11.9mm	11.9x11.9mm (rect.)
Beam footprint diameter	0.26mm	
Surface RMS 1	λ/42 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/30 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/21 over any beam footprint	@0.63μm
Surface RMS 4	λ/3.0 over clear aperture diameter	@0.63μm
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish	<30 Angstroms RMS	
Bevel	standard	
BBAR coat range	1.0-5.5μm	
BBAR coat av. Refl./surface	<2.5%	optimize for 1.65μm

Quantity	8?	

11.4.3 Cryostat Collimator OAP Mirror

The cryostat collimator is a diamond-turned aluminum mirror. It has a required focal length tolerance is ±0.5% (±1.0mm) but the fabricated focal length will be measured to a precision of ±0.1mm.

PARAMETER	***VALUE***	***TOLERANCE***
Conic shape	-1.00 (parabola)	±0.005
Substrate	Aluminum	
Working temp	≈60K	
Center thickness	5.71mm (diameter/6)	±0.05mm
Focal length	202.5mm, concave	±0.5% (±1.0mm)
Off-axis distance	14.00 degrees	±0.1 degrees
Physical diameter	34.25mm	+0.00/–0.05mm
Clear aperture diameter	28.84mm	
Beam footprint diameter	12.5mm	
Surface RMS 1	λ/45 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/32 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/21 over any beam footprint	@0.63μm
Surface RMS 4	λ/15 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	See drawing	
Coating	SSG electrolytic gold plating	
Quantity	1	

11.4.4 Cryostat Fore-optics Fold Mirror

The fore-optics fold mirror is a plane-parallel silica substrate with a broad-band reflection coating applied to the front side.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Zerodur	
Working temp	≈60K	
Thickness	6.00mm	±0.05mm
Physical size	36.51x28.57mm (rect.)	+0.0/-0.05mm
Clear aperture diameter	26.6mm	27x17mm ellipse
Beam footprint diameter	21.0mm	13x21mm ellipse
Surface RMS 1	λ/66 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/47 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/34 over any beam footprint	@0.63μm
Surface RMS 4	λ/30 over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	standard	
Front-side coat	Gold	

Quantity	1	

11.4.5 Cryostat Spider Wheel
This wheel contains electron discharge machined (EDM) metal apertures to mask the telescope spider.

11.4.6 Cryostat Telescope Pupil Plane Mask Wheel
This wheel contains apodized pupil masks deposited on calcium fluoride substrates which have been anti-reflection coated for the infrared.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	Plane parallel	wedge ± 3 arcmin
Substrate	Calcium Fluoride	
Working temp	≈60K	
Thickness	5.00mm	±0.05mm
Physical diameter	25.00mm	+0.0/-0.05
Clear aperture diameter	13.0mm	
Beam footprint diameter	13.0mm	
Surface RMS 1	λ/66 Over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/47 Over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/34 Over any beam footprint	@0.63μm
Surface RMS 4	λ/34 Over clear aperture diameter	@0.63μm
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish	<30 Angstroms RMS	
Bevel	standard	
Front surface mask	TBD	
BBAR coat range	1.0-5.5μm	
BBAR coat av. Refl./surface	<2.5%	optimize for 1.65μm
Quantity	TBD	

11.4.7 Cryostat Dichroic Wheel

The dichroic wheel contains 15 individually optimized dichroics. Each dichroic is a plane-parallel calcium fluoride substrate with a dichroic coating applied to the front-side and an infrared anti-reflection coating applied to the back-side.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	Calcium Fluoride	
Working temp	≈60K	
Thickness	6.00mm	±0.05mm
Physical size	39.68x26.41mm (rect.)	+0.00/–0.05mm
Clear aperture diameter	21.0mm	21x15mm ellipse
Beam footprint diameter	18.0mm	18x13mm ellipse
Surface RMS 1	λ/66 over any ¼ beam footprint	@0.63µm
Surface RMS 2	λ/47 over any ½ beam footprint	@0.63µm
Surface RMS 3	λ/34 over any beam footprint	@0.63µm
Surface RMS 4	λ/32 over clear aperture diameter	@0.63µm
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish	<30 Angstroms RMS	
Bevel	Standard	
Front side dichroic coat	R>90% TBDµm, av. 95%	@45 degree
	T>90% TBDµm, av. 95%	@45 degree
Backside BBAR coat	R<1%, optimize for TBDµm	@45 degree
Quantity	TBD	

11.4.8 Cryostat Filter Wheel

The filter wheels (one in each channel) contain a selection of filters and grisms.

PARAMETER	***VALUE***	***TOLERANCE***
Surface shape	plane parallel	wedge ± 3 arcmin
Substrate	custom filters	
Working temp	≈60K	
Thickness	<8.00mm (individual)	±0.05mm
Physical size	25.40	+0.00/–0.05mm
Clear aperture diameter	20.0mm	21x15mm ellipse
Beam footprint diameter	13.0mm	18x13mm ellipse
Surface RMS 1	λ/66 over any ¼ beam footprint	@0.63µm
Surface RMS 2	λ/47 over any ½ beam footprint	@0.63µm
Surface RMS 3	λ/34 over any beam footprint	@0.63µm
Surface RMS 4	λ/28 over clear aperture diameter	@0.63µm
Surface finish	<30 Angstroms RMS	
Coat	Filter multi-layer	
Quantity	TBD	

11.4.9 Cryostat Red and Blue Channel Fold Mirrors

These mirrors are plane-parallel silica substrates with broad-band reflection coatings applied to the front-side.

PARAMETER	*VALUE*	*TOLERANCE*
Surface shape	Plane parallel	wedge ± 3 arcmin
Substrate	Zerodur	
Working temp	≈60K	
Thickness	6.00mm	±0.05mm
Physical diameter	50.80mm	+0.0/-0.05mm
Clear aperture diameter	32.94mm	
Beam footprint diameter	19.0mm	
Surface RMS 1	λ/66 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/47 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/34 over any beam footprint	@0.63μm
Surface RMS 4	λ/25 Over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Bevel	standard	
Front-side coat	Gold	
Quantity	2	

11.4.10 Cryostat Camera OAP Mirrors

The red and blue channel camera OAP mirrors are identical diamond-turned aluminum mirrors. The required focal length tolerance is ±0.5% (±2.3mm) but the fabricated focal length will be measured to a precision of ±0.1mm.

PARAMETER	*VALUE*	*TOLERANCE*
Conic shape	-1.00 (parabola)	±0.005
Substrate	Aluminum	
Working temp	≈60K	
Center thickness	10.58mm (diameter/6)	±0.05mm
Focal length	458.3mm, concave	±0.5% (±2.3mm)
Off-axis distance	263.57mm	±0.3mm
Physical diameter	63.50mm	+0.00/–0.05mm
Clear aperture diameter	48.86mm	
Beam footprint diameter	13.1mm	
Surface RMS 1	λ/45 over any ¼ beam footprint	@0.63μm
Surface RMS 2	λ/32 over any ½ beam footprint	@0.63μm
Surface RMS 3	λ/21 over any beam footprint	@0.63μm
Surface RMS 4	λ/11 Over clear aperture diameter	@0.63μm
Backside surface figure	Flat λ/4 with coarse grind	
Sides	Smooth to meet positioning of ±0.05mm	
Surface finish front side	<30 Angstroms RMS	
Coating	SSG electrolytic gold plating	

Quantity	2	

11.4.11 Pupil Viewer Doublet Lens

The pupil viewer doublet lens consists of separated barium fluoride and lithium fluoride lenses. Due to the low refractive index of these materials and high level of flux expected from the pupil, no anti-reflection coatings are needed.

PARAMETER	***LENS 1***	***LENS 2***	***TOLERANCE***
Shape	Bi-convex	Meniscus	
Material	Barium Fluoride	Lithium Fluoride	
Working temp	~60K	~60K	
Radius, front surface	623.4mm	-57.64mm	±0.1% @ 290K
Radius, back surface	-71.98mm	-77.87mm	±0.1% @ 290K
Irregularity	0.5 fringes	0.5 fringes	@ 0.63μm
Center thickness	3.00mm	3.00mm	±0.05mm
De-centration	0.00mm	0.00mm	±0.05mm
Physical diameter	13.00mm	13.00mm	+0.00/-0.02mm
Clear aperture diameter	5mm	5mm	
Beam footprint diameter	5mm	5mm	
Surface finish	60/40	80/50	scratch/dig
Bevel	see drawing	see drawing	
BBAR coat	single layer λ/4	single layer λ/4	@2.2μm, protection coat
Quantity	1	1	

12 Acronyms and Definitions

AO	Adaptive Optics
APD	Avalanche Photo Diode
DHS	Gemini's Data Handling System
DM	Deformable Mirror
HVA	High Voltage Amplifier
IAO	Instrument Adaptive Optics system, NICI's AO.
ND	Neutral Density
NICI	Near Infrared Coronagraphic Imager
OAP	Off-Axis Parabolic mirror
OIWFS	On-Instrument Wavefront Sensor
PWFS	Peripheral Wavefront Sensor
RT	Real Time
SSA	System Support Associate
UI	User Interface, usually referring to the IAO UI Server.
WFS	Wavefront Sensor