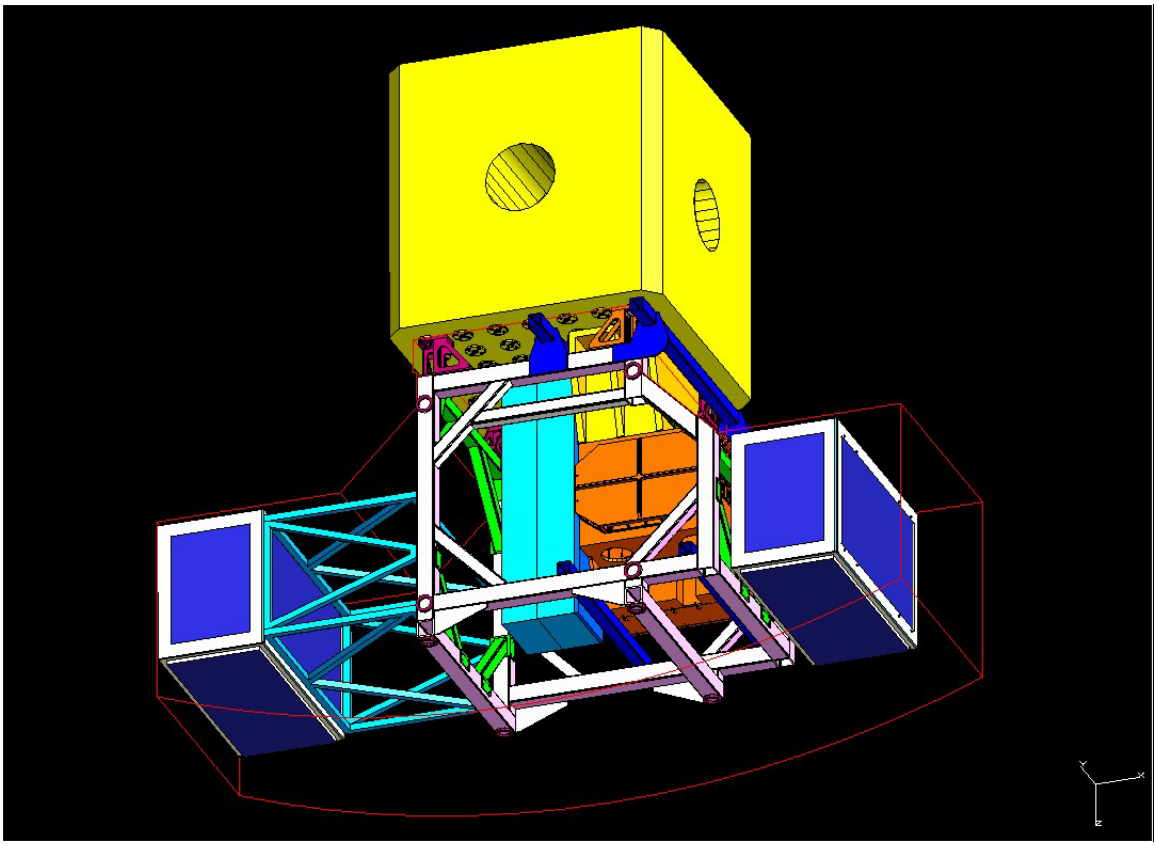
SDN 1013 NICI Safety Review Documentation



Douglas Toomey
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1.0 Introduction

This document will summarize the aspects of the NICI instrument that could represent a hazard to personnel or the instrument. It will begin with the Safety requirements for the design process and then detail NICI specific hazards for Installation, Normal Operations, Maintenance and Repairs and Transportation.

1.1 NICI Safety Policy

Safety has utmost priority in the design and operation of NICI. All staff involved in the NICI design and construction must place the highest priority on the safety of those that will use NICI. If at any time there is the possibility of risk to safety it should be brought immediately to the attention of the Project Manager. NICI must comply with all relevant notified Site Safety Requirements applicable to Mauna Kea and Cerro Pachon and conform to good, safe engineering practices.

1.2 Applicable Safety Documents

Gemini Project Safety Program PG-PM-G00009
Gemini Instrument Site Safety Policy for Mauna Kea & Cerro Pachon
OSHA Regs PART 1910
- Subpart F, 1910.66 to 68
- Subpart G 1910.94 to 98
- Subpart M 1910.166 to 169
- Subpart S, 1910.301 to 399

1.3 Applicable Gemini Instrument Documents

ICD 1.1.13/1.9 Interlock System to Science Instruments
ICD 1.9/2,7 Science Instruments to Facility Handling Equipment
ICD 1.9/3.6 Science Instruments to System Services ICD
ICD 1.9/2.7 Science Instruments to Thermal Enclosures
ICD-G0013 Gemini Environmental Requirements
ICD-G0015 Gemini Facility Handling Equipment and Procedures

1.4 Recommended Training

General Awareness Hazardous Material Training
Specific Hazardous Material training in Liquid Cryogens
Specific Hazardous Material training in Compressed Gases
Transportation of Compressed Gas

1.5 NICI Safety Officers

Until Final Acceptance Douglas Toomey will be the NICI Safety Officer. After acceptance IGPO will appoint a successor safety officer.

2.0 Safety Related Design Requirements

2.1 Mechanical Safety Design Requirements

The following sections list the design requirements for NICI from a safety perspective.

2.1.1 Structural Integrity

Finite element analysis will be used to verify the NICI components and structures meet a factor of four-safety factor in terms of element failure. The Vacuum Jacket will be analyzed to verify that it also has a factor of 2-safety factor at sea level. Deviations from this requirement must be reported at the PCR and CDR.

NICI must survive the fastest slews and rotations without exceeding any safety limit.

Welding method will be TIG, continuous, full penetration welds.

2.1.2 Fasteners

Fasteners must be of suitable size to support the weights being fastened allowing at least a factor of 2-safety factor. Torque requirements should be listed in the assembly procedure. Hole depth and thread choice should allow for the full strength of the fastener.

2.1.3 Materials

Specific alloys and tempering should be listed on the fabrication drawing and verification of material accuracy should be requested from the sub-contractors.

2.1.4 Coatings

NICI will be situated in a nearly outdoor environment and subject to corrosion that could weaken welds and structural members. Structural members should be coated or painted to prevent corrosion.

2.1.5 Lifting points

NICI will be lifted and handled using an overhead crane and straps that connect to NICI via lifting eyes. Each lifting eye should be capable of supporting the full weight of NICI. While handling NICI may undergo a 10g load which the lifting eyes must be capable of handling.

2.1.6 Mass and Center of Gravity

NICI must comply with ICD 1.9 Science Instruments in terms of weight and center of gravity. It is important to meet the specifications for weight and C.G. in order for the

instrument handling equipment to operate properly and safely. Additional weights will be used to trim the C.G. position. These weights must be installed before the instrument is handled.

2.1.7 Sharp Edges

External edges on NICI should be specified chamfered, or bull nose to reduce the cutting hazard to those handling the instrument.

2.1.8 Mechanisms

Mechanisms must be designed with safety in mind. Spaces that could pinch fingers, hands or arms should be avoided. Mechanisms that could injure personnel should be labeled as a pinching hazard.

2.1.9 Compressed Gas

All fittings and lines for the closed cycle cooler compressed gas supply and return must be rated for the pressures involved and leak checked.

2.2 Electrical Safety Design Requirements

2.2.1 Electronic Shock

NICI has 115 VAC and 440 DC voltages present. Custom equipment must use good safe engineering and construction practices to minimize shock risk.

Warning labels should be visible in areas where voltage is exposed. The areas with exposed 400 DC voltages should be labeled “High Voltage”.

An Interlock should be equipped on the high voltage cable to the DM so that the high voltage is switched off when the cable is disconnected.

An easily accessible master power switch should be installed in each electronics rack.

2.2.2 Cabling

All connectors and cables must be rated for the voltages used and be of robust design so as not to fail in use.

A method will be devised such that the cabling is not loose to catch on people or equipment.

2.2.3 Overcurrent Protection

All power supplies must have overcurrent protection or current limiting circuitry.

Equipment must have circuit breakers or be plugged into a power strip equipped with a circuit breaker.

2.2.4 Interlock Protection

There will be an interlock in the high voltage cable to turn off the high voltage output when the cable is disconnected.

There will be a switch at the instrument that will connect to the Gemini Interlock System. When this switch thrown the interlock will be triggered and the software will not allow any commands to move mechanisms.

2.2.5 Grounding

All housings and cabinets must be connected to ground to avoid shock hazard.

The System Grounding will be implemented according to the Grounding Plan.

2.2.6 Component Rating

Components must be rated with the final environment in mind as specified in ICD-G0013 Gemini Environmental Requirements. When ever possible off the shelf equipment should be rated for this environment. In the case that the vendor does not guarantee performance in the Gemini Environment range then products will be chosen that have been proven to work in Mauna Kea.

2.2.7 Static

Many components in NICI including the ~$600K detectors can be damaged by static discharge. Clearly identified strap grounding locations will be provided in each cabinet.

Use of the static strap will be called out in the troubleshooting documentation when it is required.

3.0 Operational Safety Issues

NICI is a large, heavy, complex instrument and there are some issues that must be understood in order to operate Many of the safety issues are common to all Gemini instruments and some are unique to NICI. These sections will identify the safety issues that might be encountered during the normal operation of the instrument.

3.1 Safety Warnings

The following are specific Safety Issues that must be understood before any operation with NICI begins.

Review of Manuals – Manuals will be supplied with NICI covering the custom and off the shelf hardware that comprises NICI. Instrument handling personnel should review all supplied manuals for both custom and off the shelf hardware before operating the equipment.

Electrical shock hazard – NICI is an electronic instrument and uses AC and DC power in most of the subsystems. Voltages up to 400 volts are present in the Adaptive Optics controller and Relay. No access covers should be removed while power is applied to NICI. No grounds should 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 should be kept in good repair. Great care must be taken when troubleshooting this hardware. These voltages can be lethal in some circumstances such as when hands are wet.

High current on APDs – The Avalanche Photodiode power supply is a high current 5 volt supply. This power is bussed through the APD assembly. Shorts on this power buss can cause arcing, substantial amounts of heat and fire hazard. Tools must be handled carefully in the APD assembly.

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 are working on the instrument.

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 should avoid the area around the instrument when it is being moved. When ever possible NICI should be left connected to an overhead crane until secured

Cryogen handling – NICI is a cryogenic instrument. Those involved with NICI should receive training in the handling and use of liquid cryogens. Liquid Cryogens represent a burn hazard and a suffocation hazard.

Nitrogen suffocation hazard – During cooldown 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 should be in place in the room that is used for the cooldown.

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

Ice plug in precharge neck – After the initial cooldown the instrument will operate with no boil off in the in the precharge can. With no boil-off the precharge can will cryopump 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 precharge can to burst explosively. NICI should always be operated with the precharge can external cover in place that has a check valve to prevent ice plugs. The neck tubes should always be checked for ice plugs before any warm up procedure is started. Ice plugs must be cleared before the instrument is warmed up.

Compressed gas - NICI is a closed cycle cooler cooled instrument and uses compressed helium. Although it self does not contain enough gas to be much hazard, it could cause a suffocation hazard if all 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 should have Hazardous Materials training for Compressed Gasses.

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 Hax Mat employee should verify that all Haz Mat procedures are correctly followed

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.

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

Cabling – To prevent shock all cables should be connected whenever the instrument is to be powered on. Any damaged or frayed cables should be replaced before power is applied.

4.0 Areas of Risk to the instrument

Vacuum leaks – Before cooling the instrument it should be leak checked. Every time the vacuum jacket is opened the cryostat should be leak checked. Small leaks may not be noticed but the closed cycle coolers will cryopump substantial material and keep the vacuum adequate. This cryopumped 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

Optical Surfaces – Some of the exposed optical elements with be made of Calcium Flouride which is easily scratched and should only be cleaned by a qualified optical technician. Most of the exposed mirrors will be coated with overcoated silver. Silver is more reactive than aluminum and care should be taken with the handling and cleaning of these mirrors.

Dust – NICI is a coronagrapic imager and is very sensitive to scattered light caused by dust on the optics. Care should be taken to keep the optics as clean as possible.

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. Exposure to bright lights when energized and possibly when not energized can damage the detector. More importantly turning off the APD power when light is on the detector can destroy the detector. Using the AO software the count rate must be checked before the APD power is turned off.

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 cables are made or broken and boards removed.

5.0 Safety Checklists

The following are checklists to remind instrument handlers of the issues for each phase of handling the instrument

Handling	**Reviewed by**
Review of Manuals	
Sweeping when Rotating	
Tipping hazard	
NICI Handling braces.	
Falling Tool Hazard	

Set up and Installation	**Reviewed by**
Review of Manuals	
Electrical shock hazard	
Sweeping when Rotating	
Tipping hazard	
Cryogen handling.	
Nitrogen suffocation hazard	
Compressed gas	
NICI Handling braces.	
Falling Tool Hazard	
Cabling	

Normal Operations	**Reviewed by**
Review of Manuals	
Electrical shock hazard	
High current on APDs	
Sweeping when Rotating	
Disconnecting Cold Head	
Ice plug in precharge neck	
Compressed gas	
Falling Tool Hazard	
Cabling	

Power down	**Reviewed by**
Review of Manuals	
Electrical shock hazard	
High current on APDs	
Disconnecting Cold Head	
Ice plug in precharge neck	
Compressed gas	

Warm-up	**Reviewed by**
Review of Manuals	
Disconnecting Cold Head	
Ice plug in precharge neck	
Compressed gas	

Maintenance and Repair Operations	**Reviewed by**
Review of Manuals	
Electrical shock hazard	
High current on APDs	
Sweeping when Rotating	
Cryogen handling.	
Nitrogen suffocation hazard	
Disconnecting Cold Head	
Ice plug in precharge neck	
Compressed gas	
Compressed Gas Transportation	
NICI Handling braces.	
Falling Tool Hazard	
Cabling	

6.0 Troubleshooting Cautions

Hazard from moving mechanisms – NICI has numerous translating and rotating mechanisms. In some places fingers can be pinched by these mechanisms if they were to move while being maintained.

Interlock switch – Whenever work is going to be done at the instrument location the interlock switch must be set to prevent the control system from moving any mechanisms related to the instrument.

7.0 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 Material employee should verify that all Hazardous Material procedures are correctly followed.