NGSLR Safety Handbook

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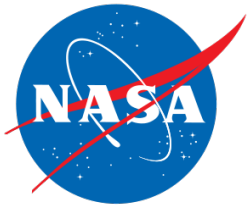
NASA-NGSLR-Safety

NGSLR
Safety Handbook

NGSLR SAFETY PLAN

NASA - GODDARD SPACE FLIGHT CENTER - CODE 694



February 2015

GODDARD GEOPHYSICAL AND ASTRONOMICAL OBSERVATORY

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TABLE OF CONTENTS

1 INTRODUCTION

NASA's Next Generation Satellite Laser Ranging (NGSLR) station is the prototype for NASA's Satellite Laser Ranging (SLR) systems which will be deployed around the world in the coming decade. The NGSLR system will be an autonomous, photon-counting SLR station with an expected absolute range accuracy of better than one centimeter and a normal point (time-averaged) range precision better than one millimeter. The system provides continuous (weather permitting), 24 hour tracking coverage to an existing constellation of approximately two dozen artificial satellites equipped with passive retroreflector arrays, using pulsed, 532 nm, class IV laser systems. Current details on the approved laser systems can be found in the Appendix 1 of this document.

This safety plan addresses the potential hazards to emitted laser radiation, which can occur both inside and outside the shelter. Hazards within the shelter are mitigated through posted warning signs, activated warning lights, procedural controls, personal protective equipment (PPE), laser curtains, beam blocking systems, interlock controls, pre-configured laser control settings, and other controls discussed in this document. Since the NGSLR is a satellite tracking system, laser hazards exist outside the shelter to personnel on the shelter roof and to passing aircraft. Potential exposure to personnel outside the system is mitigated through the use of posted warning signs, access control, procedural controls, a stairwell interlock, beam attenuation/blocking devices, and a radar based aircraft detection system.

1.1 SYSTEM LOCATION

NGSLR is located at the Goddard Geophysical and Astronomical Observatory (GGAO), a secure off-campus location which limits access to the system. Only authorized personnel are allowed inside the shelter, with the shelter remaining locked when it is unoccupied.

Site address:

Removed (jlfm)

1.2 APPLICABLE DOCUMENTS

ANSI Z136.1-2007	American National Standard for Safe Use of Lasers
ANSI Z136.6-2005	American National Standard for Safe User of Lasers Outdoors
GPR 1860.2C NASA / GSFC	Laser Radiation Protection

2 SAFETY HAZARDS

2.1 LASER HAZARDS

The NGSLR poses indoor and outdoor laser exposure hazards to personnel. Potential laser hazards inside the system include eye, skin and fire hazards, though the primary concern is the laser beam and its potential damage to the eyes. External to the system, skin and fire hazards are no longer a concern, but visual hazards remain. These hazards can be temporary, such as glare and flash blindness, or can result in physical damage to the eye itself.

The design of NGSLR requires both vertical and horizontal beam orientations which result in some portion of the beam path inside the shelter to be open and exposed. To minimize personnel exposure to an open beam, the laser table has been isolated in the Laser Operations Area (Figure 6-4). The curtain surrounding this area must be kept closed during operation in order to prevent accidental exposure.

2.1.1 INDOOR LASER HAZARDS

2.1.1.1 Eye Hazards

The laser can pose a serious visual hazard if proper precautions are not observed. Proper eye protection will be worn when the user is within the Laser Operations Area/Nominal Hazard Zone (Figure 6-4) during the operation of the laser. This hazard can originate from viewing the beam directly, or via specular/diffuse reflections.

2.1.1.2 Skin Hazards

The laser can pose a skin hazard if proper precautions are not observed, with the arms, hands, and head as the portions of the body most likely to be inadvertently exposed to the laser beam. At all times personnel are to avoid direct contact with the laser energy by any part of the body or clothing. Even though the heat from the laser beam may cause a flinch reaction before damage occurs, adequate precautions should be taken to avoid contact with the high energy beam.

In order to protect users from laser skin hazards, only *authorized* development personnel will perform optical bench adjustments as described in the NGSLR System Alignment, Focus and Maintenance Manual. All adjustments to the optical bench must be made at a lower power setting, known as alignment power. These authorized personnel are not to perform alignment procedures or any other optical bench adjustments under full power operation. To mitigate skin hazards, all adjustments to the system during alignment should be performed by reaching in from above in order to clear the beam path. In addition, authorized personnel should pay special attention to loose or drooping clothing when reaching over the Optical Bench.

2.1.1.3 Fire Hazards

The laser beam in the system can create a hazard by burning or damaging materials during short term exposure. Ensure that these materials, which include paper, cardboard, clothing, and plastic, do not enter the beam path and that the laser has been properly aligned to reduce stray reflections.

2.1.1.4 Personal Protective Equipment (PPE)

Eye Hazard PPE

Protective eyewear that meets ANSI Z136 standards for the lasers used in the system are supplied in the NGSLR shelter for use by personnel when entering the NHZ. Eye protection will be worn within the NHZ whenever the laser is operational. See the table below to select the appropriate eyewear for each laser and power level.

Northrop Grumman (50 mJ setting)	*>5.6 OD*	*(Setting used for LRO Operations)*
Northrop Grumman (0.1 mJ setting)	*>3.0 OD*	*(Setting used for LRO Alignment)*
Photonics Industries (1.0 mJ setting)	*>4.7 OD*	*(Setting used for SLR Operations)*
Photonics Industries (0.02 mJ setting)	*>3.0 OD*	*(Setting used for SLR Alignment)*

2.1.2 OUTDOOR LASER HAZARDS

2.1.2.1 Eye Hazards

Laser hazards also exist outside the shelter during satellite laser ranging operations as laser energy is emitted from the telescope. Affected areas are the shelter roof, inside the dome, and aircraft in the vicinity.

As a safety precaution, personnel are not allowed on top of the shelter (which includes inside the dome) during laser operations. A chain and warning sign physically block the stair access to the shelter roof, and a set of footpads installed on the stair access will disable laser transmission should anyone attempt to access this area during operations. The only exception to this rule is for Certified Development personnel when confirming the centering of the beam in the telescope. This is a two person process at minimum, and is described in detail in the NGSLR System Alignment, Focus and Maintenance Manual. Proper eye protection will be worn at all times during this procedure as defined in the manual.

Any visual hazards posed to passing aircraft are mitigated through the use of a radar based detection system, known as the LHRS. This system is directly connected to the laser interlock, which blocks the beam and disables the laser fire command should an aircraft enter a 3 degree cone of RF energy surrounding the emitted beam. In addition, the FAA has issued a letter of non-objection to laser operations at GGAO and maintains a Notice to Airmen (NOTAM) informing pilots of laser operations in the area.

2.1.2.2 Personal Protective Equipment (PPE)

Eye Hazard PPE

Protective eyewear that meets ANSI Z136 standards for the lasers used in the system are supplied in the NGSLR shelter for use by personnel when verifying the centering of the beam on the telescope output window (from the top of the NGSLR shelter). Eye protection will be worn within this restricted area whenever the laser is operational. See the table below to select the appropriate eyewear for each laser and power level.

Northrop Grumman (50 mJ max)	*>2.4 OD*	*(Setting used for LRO Operations)*
Northrop Grumman (0.1 mJ setting)	*none required*	*(Setting used for LRO Alignment)*
Photonics Industries (1.0 mJ setting)	*>1.2 OD*	*(Setting used for SLR Operations)*
Photonics Industries (0.02 mJ setting)	*none required*	*(Setting used for SLR Alignment)*

2.2 ELECTRICAL HAZARDS

Instrumentation and equipment in the NGSLR shelter have no electrical hazard other than the standard 120V / 20A service that runs these devices. Employees are not permitted to work on the power supply when alone; there is always a two-person rule in effect. Where possible the power supply is locked out and reduced to a zero energy state.

2.3 RADIO FREQUENCY HAZARDS

The NGSLR system utilizes a radar system to perform aircraft avoidance. The RF energy of this system is tested on an annual basis and is consistently below IEEE exposure limits. Personnel are prohibited from being on the radar tower while the LHRS is in operations mode, due to possible exposure to elevated levels of microwave radiation.

Only qualified radar technicians are allowed on the tower to perform maintenance and are to follow the manufacturer's standard safety procedures. Personnel on any adjacent structure should be a minimum of 10 feet away from the radiating antenna in order to minimize exposure to RF energy. Though this distance is a minimum safe distance, needless exposure to all RF radiation should be avoided whenever possible.

See the NGSLR Safety Manual for details on the NGSLR Lockout / Tagout procedure used during maintenance of laser, electrical and RF devices.

3 SAFETY CONTROLS

3.1 INSPECTION

The NGSLR system has been inspected by the laser custodian and the Radiation Protection Office (RPO) in order to verify that the project has established adequate safety and control measures as outlined in this document. All lasers used in NGSLR meet all ANSI safety requirements. Any additional lasers added via an approved addendum to the Non-Ionizing Radiation Safety Committee (NIRSC) will require a safety compliance check performed by the NGSLR laser custodian.

3.2 LASER HAZARD WARNINGS, LABELS AND CONTROL MEASURES

A variety of warnings and control measures have been put into place to ensure the safe operation of the NGSLR system. These items are listed in the order personnel would encounter them as they approach the system, ending with the control measures inside the NGSLR shelter. See the following page for the figures.

1. The entrance to the site is secure and can only be accessed via keycard entry (Figure 3-1).
2. A large (5'x4') laser warning sign has been posted by the entrance to the site, notifying personnel of potential laser hazards (Figure 3-2).
3. Outdoor laser warning signs have been posted on the outside of the NGSLR shelter, indicating the class and type of lasers in use (Figure 3-3).
4. The shelter is locked when it is unoccupied, with only select personnel allowed a key (Figure 3-3).
5. The stairway access to the roof deck has been cordoned off with a chain and controlled access notice during operations (Figure 3-4).
6. Access to the Laser Operations Area (NHZ) is clearly marked with a lighted laser warning sign, which is active when either laser is energized (Figure 3-5).
7. Standard laser warning signs have been posted just outside the Laser Operations Area (NHZ) *[see Appendix 3 for locations]* indicating the class and type of laser in use, and the filtration wavelength and OD value of the protective eyewear required for that laser (Figure 3-6).
8. NGSLR has a floor to ceiling, beam blocking curtain that stands between the door and the NHZ to prevent accidental exposure to occupants in the control area and to anyone who enters the shelter unexpectedly. This curtain is to remain closed whenever the laser is in operation (Figure 3-7).
9. All laser equipment is clearly marked with a label, indicating the maximum potential output and class of laser. All Class IV lasers have a Radiation Protection Office (RPO) inventory sticker that displays the RSC docket number (Figure 3-8).

Figure 3-1: Controlled access to GGAO via keycard entry

Figure 3-2: Site Entrance Laser Warning Sign

Figure 3-3: Locking handle and posted warning signs on entrance door

Figure 3-4: Notice on stairway access to roof

Figure 3-5: Lighted laser warning sign posted at the entrance

Figure 3-6: PI Laser Warning Sign

Figure 3-7: Beam blocking curtain inside the shelter

Figure 3-8: Example equipment labels

3.3 SAFETY FEATURES

3.3.1 SAFETY FEATURES OF THE LASER SYSTEMS

Both laser systems meet ANSI safety requirements for safe laser operation, which include these features:

1. **Protective Housing**: The laser is in a sealed aluminum housing which cannot be opened except by disassembly.
2. **Key Control**: The laser is key-switch operated; if the key is removed, the laser cannot be energized.
3. **Activation Warning System**: The laser emits an audible or visible signal when in operation.
4. **Automated Shutter Mechanism:** When activated, the shutter prevents beam transmission. This is an internal device that prevents emission of the beam from the COTS laser system.

3.3.2 SAFETY FEATURES OF THE NGSLR SYSTEM

1. **IO Chassis**: The IO Chassis incorporates a laser interlock device that works with the LHRS and other devices to prevent exposure to laser radiation when a set of pre-determined safety conditions is detected. If necessary, the operator can manually disable the laser using the disable button on the front panel of the IO Chassis or the Remote Box at the operator's console.
    a. If a safety condition is triggered during operation of the Photonics Industries laser, the IO Chassis disables the laser fire command, and moves the SLR beam block and SLR ND Insert Filter into place.
    b. If a safety condition is triggered during operation of the Northrop Grumman laser, the IO Chassis moves the LRO beam block and LRO ND Insert Filter into place.
2. **Automated Beam Block Mechanism:** When activated, the beam block device physically prevents beam transmission by placing a beam stop directly in the path of the transmitted laser, which appropriately terminates the beam to limit scatter.
3. **ND Insert Filter:** When either laser is operated below 20 degrees from the horizon, (normally during calibration operations), a beam attenuating filter is automatically inserted into the beam path to decrease the transmitted laser energy to eye safe levels.
4. **Stairway access sensors**: A series of sensors have been placed on the stairway access to the roof deck to detect attempted access to the roof of the shelter during operations. Activation of these sensors triggers a safety condition on the IO Chassis.
5. **Outdoor Laser Control**: The LHRS, a radar based aircraft detection system, terminates the laser beam when an aircraft is detected within a ~3 degree cone around the transmitted beam.

3.4 SAFETY REQUIREMENTS FOR OPERATION

Warning: Either laser can pose a serious visual hazard if proper precautions are not observed. You must follow the below precautions to ensure safe operation. Failure to follow these requirements can result in severe eye damage to anyone exposed to the beam.

3.4.1 GENERAL OPERATION REQUIREMENTS

1. A certified operator ***must*** be present for operations at NGSLR.
2. A certified laser user ***must*** be present, be certified in the laser to be used and is the only person that can operate the laser.
3. The operator ***must*** verify that the safety chain (and sign) on the stairs is in place, blocking access to the roof. Personnel are not allowed to be on top of the shelter when the laser is operational. The only exception is for authorized development personnel with appropriate PPE protection as described in the NGSLR System Alignment, Focus and Maintenance Manual.
4. The shelter door ***must*** be shut and the laser curtain must remain closed when the laser is operated.
5. The operator ***must*** contact the FAA NCRCC at least 2 hours prior to the first pass of the week to notify them of weekly operations, upon commencement of the first pass for the week, and upon conclusion of the last pass of the week.
6. Because the laser is ***not*** eye safe during SLR or LRO operations, the aircraft avoidance radar (LHRS) ***must*** be used (on and engaged) in this mode.
7. The aircraft avoidance radar is configured to automatically block the laser. If needed, the operator has the ability to manually disable the laser at the operator console using the laser *Disable* button on the Remote Box.
8. The system requires operator intervention to re-enable the laser after the system has been disabled, whether by an aircraft detect or other situation.
9. The operator will ensure that the LHRS Verification Tests are performed regularly.
    a. Weekly Test: At the beginning of weekly operations, and prior to satellite laser ranging operations, the proper operation of the LHRS will be verified using a subset of the LHRS and IOC Verification Procedure found in the NGSLR Safety Manual (NASA-NGSLR-OPS-Safety). Completion of the weekly LHRS Verification Test will be documented and retained in the station NGSLR Safety Logbook (NASA-NGSLR-OPS-Safety-LOG).
    b. Quarterly Test / Verification after Repair: The entire LHRS and IOC Verification Procedure will be completed on a quarterly basis. Completion will be documented in the logbook, as well as by sending a scanned copy of the checklist to the SLR lead and the laser custodian.
10. Operations personnel are prohibited from being on the radar tower while the LHRS is in operation, due to possible exposure to elevated levels of microwave radiation. Only qualified radar technicians are allowed on the tower to perform maintenance and are to follow the manufacturer's standard safety procedures.

3.4.2 PERSONNEL REQUIREMENTS

1. Entrance to the Nominal Hazard Zone (NHZ) during operation of the laser will be limited to authorized personnel (See Figures 6-2 and 6-3 for locations of NHZ).
2. Only personnel who are authorized by the Non-Ionizing Radiation Safety Committee (NIRSC) and are appropriately trained will operate the laser. See Appendix 2 for a list of Certified Laser Users.
3. Each authorized laser user listed in Appendix 2 shall initial next to their docket number. This signifies that they have read and understand the laser safety plan in effect for laser operation.
4. Additions and deletions to Appendix 2 will be documented by submitting an addendum to the RPO for approval. The addendum shall include a new Appendix 2 listing of laser users.

3.4.3 LASER SAFETY REQUIREMENTS

1. The black laser safety curtains ***must*** be pulled completely closed at all times when the laser is firing in order to prevent accidental laser exposure to personnel.
2. Precautions will be taken to reduce all stray specular reflections. Specular reflections should be avoided wherever possible by removing or covering reflective surfaces around the laser. This includes removing tools and mounting hardware left on the optical bench.
3. The laser is never considered eyesafe on the laser table, regardless of the power level.
4. The laser will be terminated using beam stops at the end of its useful beam path.
5. Personnel in the Laser Operations Area / Nominal Hazard Zone will wear appropriate eye protection.
6. Keys will be removed from the laser control panel after use and secured.

3.4.3.1 Safety Requirements for Laser Alignment

The majority of laser related eye injuries occur during alignment procedures. Due to this, safety is especially important when performing this task. All authorized development personnel are required to follow these safety requirements during alignment operations:

1. Reduce the power of the transmitted beam during the alignment process as described in the NGSLR System Alignment, Focus and Maintenance Manual.
2. Precautions will be taken to assure that personnel do not look directly into the beam.
3. Precautions will be taken to assure that the laser is not pointed at specular reflecting surfaces.

Alignment procedures are described in detail in the NGSLR System Alignment, Focus and Maintenance Manual, located in the NGSLR shelter.

3.4.4 MAINTENANCE REQUIREMENTS

If maintenance is performed on any of the laser safety systems, the following processes must be complied with to ensure that all safety features are properly returned to operational status. Laser safety system include devices listed in the section on Safety Features (Section 3.3).

- NGSLR Safety System Troubleshooting Tag-Out Procedure *(for select equipment)*
- LHRS/IOC Verification Procedure for NGSLR
- LHRS/IOC Verification Procedure for LRO

4 EMERGENCY PROCEDURES

If a hazardous condition is detected that is caused by equipment in the system, immediately stop operations, and if necessary, perform an emergency power down of the equipment. If powering down does not fix the problem, call the GSFC Emergency Console Operator by dialing 911 or (301) 286-9111 (cell phone).

4.1 INJURY/IMMINENT DANGER TO PERSONNEL

If someone has been injured and/or there are personnel in imminent danger, immediately warn all affected personnel and evacuate to a safe area. Once all personnel are in a safe area, call the GSFC Emergency Console Operator by dialing 911 or (301) 286-9111 (cell phone). Some typical conditions that require notification of the GSFC Emergency Console Operations include:

- Serious injury to personnel
- Detection of flame, smoke, or other evidence of fire
- The spill of a highly toxic chemical
- Attempted access by unauthorized personnel

4.2 LASER HAZARD EVENT

Any of the following constitutes a Laser Hazard Event:

- If the operator perceives that an aircraft has entered the 2° inscribed circle on the telescope camera monitor without the system causing a laser disable.
- If the aircraft is "lit" by the laser
- If personnel are inadvertently exposed to an unsafe level of laser energy

In the event of a laser hazard event the operator shall:

1. ***Immediately STOP operations!***
2. ***Power down the laser!***
3. Notify NASA SLR lead and the Laser Custodian
4. Impound the following:
    a. Station hardware
    b. System software
    c. Operator's log book
    d. Pass data for the laser
    e. Current operating procedures used by the operations and engineering staff
    f. Any other items identified by the NASA SLR lead or Laser Custodian
5. The NASA SLR lead will notify the Government project office
6. The operator is ***not to continue*** operations until given concurrence by the NASA SLR Lead.

NOTE: Laser Hazard Events and Close Calls are to be reported in accordance with GPR 1860.2C, Laser Radiation Protection and GPR 8621.1, Reporting of Mishaps, Incidents, and Close Calls.

IF YOU ENCOUNTER A LASER HAZARD EVENT, CEASE OPERATIONS AND CONTACT THE NASA SLR LEAD AND THE NGSLR LASER CUSTODIAN IMMEDIATELY! SEE THE EMERGENCY CONTACT LIST POSTED IN THE SHELTER FOR DETAILS.

5 CERTIFICATION AND TRAINING

To assure the safe operation of NGSLR, personnel will be trained and certified before being authorized to operate the laser, perform optical alignments or conduct tracking operations. All certifications are subject to the approval of the SLR Lead. There are separate certifications for the operation of the Photonics Industries Laser, the Northrop Grumman Laser, alignment of system optics, and the operation of the tracking station. In addition, all users will follow the administrative, procedural, training and experience requirements listed in the GSFC 1860.2C as applicable. This process verifies that each operator is knowledgeable in the subject matter, understands the risks involved, and the precautions and regulations that apply to safe operation of the NGSLR system.

5.1 LASER USER CERTIFICATION

The Laser User certification authorizes an individual to operate a particular laser system within NGSLR. Please note that it does not authorize the user to perform optical bench alignment or operate the NGSLR system itself. In order to obtain the NGSLR Laser User certification, personnel must successfully complete the below training regimen, receive approval from the NIRSC for the operation of Class IV lasers, and receive approval by the SLR lead for certification. This approval process indicates that the user understands the requirements listed in the NGSLR Safety Plan, the operation of the laser system, the hazards involved, the use of the laser safety systems, and that the user has achieved certification by the GSFC NIRSC.

5.1.1 TRAINING REQUIRED BY THE NGSLR/LRO PROGRAM

Certified Laser User training provides information on the following topics:

- The roles and responsibilities of a Certified Laser User
- FAA requirements
- Coverage of SLR safety devices and operating procedures, including emergency contacts
- Operation of the Laser System
- IOC and LHRS functionality verification
- Lockout-Tagout troubleshooting procedures

This process includes training and review of the following documents and course material:

- *NGSLR General Overview*
- *NASA SATERN COURSE* - Laser Safety (OCC-003-07)
- *Goddard Laser Safety Refresher Training*
- *NGSLR FAA Letter of Non-Objection*
- *NGSLR Safety Manual*
    - *NGSLR Safety Plan (this document)*
    - *LHRS / IOC Operational Verification Test for 2 kHz Laser Operations †*
    - *LHRS / IOC Operational Verification Test for LRO Laser Operations ‡*
    - *NGSLR Lockout-Tagout Procedure*
- *NGSLR Operations Manual (Sections 2.4, 2.5, & 6) †*
- *LRO Operations Manual (Sections 2.1, 3, & 5) ‡*

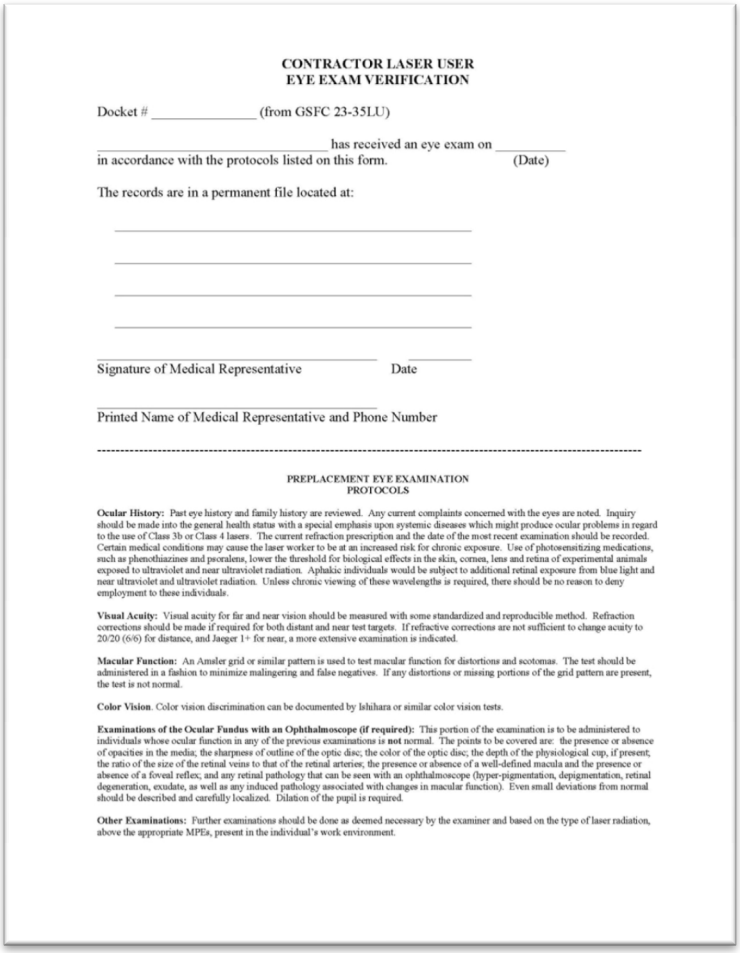
† SLR Operations only ‡ LRO Operations only

Once the above is complete, the *laser user in training* can begin to accrue experience on the system, but only under the supervision of a Certified Laser User. This includes a minimum of 4 hours of training in NGSLR SLR or LRO operations, depending on the certification sought.

5.1.2 NIRSC CERTIFICATION

Personnel seeking NIRSC approval for the use of a specific class of laser must follow the guidelines listed in GPR 1860.2C (or the latest version of this document) and submit the completed GSFC 23-35LU form in order to obtain authorization. Completion of the 23-35LU is a declaration by an individual that they have met the level of safety training, laser operations training, and hands on experience as required by the 1860.2C. A further requirement for laser user certification is that the individual must provide proof of an eye examination meeting the requirements as prescribed by the 23-35LU (Figure 5-1). Only personnel who are authorized by the GSFC Non-Ionizing Radiation Safety Committee (NIRSC) and appropriately trained will operate the laser. Finally, for the individual to use a particular laser, an approved 23-6L, Laser Radiation Source Approval, must list the laser user and the associated laser user certificate number.

For laser users without prior training or experience, the Laser Custodian shall arrange for training / hands-on-experience as required, and will send a memorandum to amend the users GSFC 23-35LU form to document the training provided.



CONTRACTOR LASER USER
EYE EXAM VERIFICATION

Docket # _____ (from GSFC 23-35LU)

_____ has received an eye exam on _____
in accordance with the protocols listed on this form. (Date)

The records are in a permanent file located at:

_____

_____

_____

_____

_____ _____
Signature of Medical Representative Date

_____
Printed Name of Medical Representative and Phone Number

PREPLACEMENT EYE EXAMINATION PROTOCOLS

Ocular History: Past eye history and family history are reviewed. Any current complaints concerned with the eyes are noted. Inquiry should be made into the general health status with a special emphasis upon systemic diseases which might produce ocular problems in regard to the use of Class 3b or Class 4 lasers. The current refraction prescription and the date of the most recent examination should be recorded. Certain medical conditions may cause the laser worker to be at an increased risk for chronic exposure. Use of photosensitizing medications, such as phenothiazines and psoralens, lower the threshold for biological effects in the skin, cornea, lens and retina of experimental animals exposed to ultraviolet and near ultraviolet radiation. Aphakic individuals would be subject to additional retinal exposure from blue light and near ultraviolet and ultraviolet radiation. Unless chronic viewing of these wavelengths is required, there should be no reason to deny employment to these individuals.

Visual Acuity: Visual acuity for far and near vision should be measured with some standardized and reproducible method. Refraction corrections should be made if required for both distant and near test targets. If refractive corrections are not sufficient to change acuity to 20/20 (6/6) for distance, and Jaeger 1+ for near, a more extensive examination is indicated.

Macular Function: An Amsler grid or similar pattern is used to test macular function for distortions and scotomas. The test should be administered in a fashion to minimize malingering and false negatives. If any distortions or missing portions of the grid pattern are present, the test is not normal.

Color Vision. Color vision discrimination can be documented by Ishihara or similar color vision tests.

Examinations of the Ocular Fundus with an Ophthalmoscope (if required): This portion of the examination is to be administered to individuals whose ocular function in any of the previous examinations is **not** normal. The points to be covered are: the presence or absence of opacities in the media; the sharpness of outline of the optic disc; the color of the optic disc; the depth of the physiological cup, if present; the ratio of the size of the retinal veins to that of the retinal arteries; the presence or absence of a well-defined macula and the presence or absence of a foveal reflex; and any retinal pathology that can be seen with an ophthalmoscope (hyper-pigmentation, depigmentation, retinal degeneration, exudate, as well as any induced pathology associated with changes in macular function). Even small deviations from normal should be described and carefully localized. Dilation of the pupil is required.

Other Examinations: Further examinations should be done as deemed necessary by the examiner and based on the type of laser radiation, above the appropriate MPEs, present in the individual's work environment.

Figure 5-1: Example Contractor Laser User Eye Exam Verification Form

5.2 NGSLR OPTICS ALIGNMENT CERTIFICATION

Personnel **must** attain certification in order to perform any of the system optical alignments including system focus and/or maintenance procedures. It can only be held by a user who is certified in *both* laser systems, has completed the below training regimen and has been cleared by the SLR lead for adjustment of the system.

This process includes training and review of the following documents:

- *NGSLR System Alignment, Focus and Maintenance Manual*
- *Photonics Industries – Model RGL-1064/532 Series Laser - Installation and Operation Manual*
- *Northrop Grumman – NASA Laser User*
- *Northrop Grumman – User Manual e-Drive Laser Diode Driver and Laser System Controller*

5.3 CERTIFIED OPERATORS

Operators are certified by the SLR lead to be able to run NGSLR or LRO operations safely and efficiently. Acquiring this certification does not authorize the holder to run the laser, but only authorizes the holder to run the supporting hardware and software. The SLR lead will determine when the trained individual is ready to run the system and perform unsupervised tracking.

Certified Operator Training provides information on the following topics:

- The roles and responsibilities of a Certified Operator
- FAA requirements
- Coverage of SLR safety devices and operating procedures, including emergency contacts
- Operation of the NGSLR System
- IOC and LHRS functionality verification
- Lockout-Tagout troubleshooting procedures

This process includes training and review of the following documents:

- *NGSLR General Overview*
- *NGSLR Safety Manual*
    - *NGSLR Safety Plan (this document)*
    - *LHRS / IOC Verification Procedure for 2KHz Laser Operations †*
    - *LHRS / IOC Operational Verification Test for LRO Laser Operations ‡*
    - *NGSLR Lockout-Tagout Procedure*
- *NGSLR FAA Letter of Non-Objection*
- *NGSLR Operations Manual †*
- *LRO Operations Manual ‡*
- *NGSLR Quick Reference Guide †*
- *NGSLR RAT Training Manual †*

Once the above is complete, the *operator in training* can begin to accrue experience on the system, under the supervision of a qualified operator. This includes:

Operating experience:

Minimum of 24 hours of training in NGSLR SLR operations
Minimum of 24 hours of training in LRO operations
Minimum 40 hours of supervised system operations

† SLR Operations only ‡ LRO Operations only

5.4 REFRESHER TRAINING

Refresher training will be completed every three years for Certified Laser Users, Certified Operators and Certified Development personnel as described below.

5.4.1 CERTIFIED LASER USERS

All *Certified Laser Users* will complete refresher training every three years and include:

- The roles and responsibilities of a Certified Laser User
- Coverage of SLR safety devices and operating procedures, including emergency contacts
- Operation of the Laser System
- IOC and LHRS functionality verification
- Lockout-Tagout troubleshooting procedure
- Any other changes to the documentation, operating procedures or requirements

This process includes training and review of the following documents and course material:

- *NASA SATERN COURSE* - Laser Safety (OCC-003-07)
- *Goddard Laser Safety Refresher Training*
- *NGSLR Safety Manual*
    - *NGSLR Safety Plan (this document)*
    - *LHRS / IOC Verification Procedure for 2KHz Laser Operations†*
    - *LHRS / IOC Operational Verification Test for LRO Laser Operations‡*
    - *NGSLR Lockout-Tagout Procedure*

5.4.2 NGSLR OPTICS ALIGNMENT CERTIFICATION

Refresher training for all personnel authorized to perform system optical alignments, system focus and/or maintenance procedures shall be conducted at least every three years. The training will include the documents and course material outlined in Section 5.4.1, Certified Laser Users, and the following:

This process includes review of the safety sections of the following documents:

- *NGSLR System Alignment, Focus and Maintenance Manual*
- *Photonics Industries – Model RGL-1064/532 Series Laser - Installation and Operation Manual*
- *Northrop Grumman – NASA Laser User*
- *Northrop Grumman – User Manual e-Drive Laser Diode Driver and Laser System Controller*

† SLR Operations only ‡ LRO Operations only

5.4.3 CERTIFIED OPERATORS

Refresher training for all *Certified Operators* shall be conducted at least every three years and include:

- The roles and responsibilities of a Certified Operator
- Coverage of SLR safety devices and operating procedures, including emergency contacts
- IOC and LHRS functionality verification
- Lockout-Tagout troubleshooting procedure
- Any other changes to the documentation, operating procedures or requirements

This process includes training and review of the following documents:

- *NGSLR Safety Manual*
    - *NGSLR Safety Plan (this document)*
    - *LHRS / IOC Verification Procedure for 2KHz Laser Operations†*
    - *LHRS / IOC Operational Verification Test for LRO Laser Operations‡*
    - *NGSLR Lockout-Tagout Procedure*

† SLR Operations only ‡ LRO Operations only

6 OPERATIONS AND ALIGNMENT PROCEDURES

All operations and alignment procedures are posted for use at the NGSLR operator's console.

These include:

- Operations Procedures for the Photonics Industries laser in the *NGSLR Operations Manual*
- Operations Procedures for the Northrop Grumman laser in the *LRO Operations Manual*
- Alignment procedures for both lasers in the *NGSLR System Alignment, Focus and Maintenance Manual*

6.1 LASER SAFETY PROCEDURES DURING OPERATIONS

The procedures in Section 6.1 have been incorporated into the above manuals, and are listed here to illustrate the required laser safety guidelines that must be followed any time the laser is used. These are not inclusive to operation and must be used as described in the above manuals.

1. The operator must verify that the safety chain and access control sign on the stairs are in place, blocking access to the roof of the NGSLR shelter.
2. Close the front door to the NGLSR shelter.
3. Turn on the laser safety warning sign.
4. Retrieve laser operating key.
5. Issue laser safety goggles as required to meet or exceed the required OD for the laser that is to be used. This level is listed on the laser warning signs for each laser.
6. Verify that all personnel within the NHZ are capable of halting laser operation.
7. Verify that all personnel within the NHZ are wearing the issued laser safety goggles.
8. Issue a verbal warning to all personnel within the room that laser operation is about to begin.
9. Begin laser operation in accordance with standard operations/alignment procedures as described in the above manuals. Halt laser operation if unprotected personnel enter the NHZ. Notify the SLR Program Lead, Laser Custodian, and the RPO if personnel exposure occurred (known as a Laser Hazard Event).
10. At the completion of laser operation, turn off the laser and issue a verbal all clear. Return the laser safety goggles and laser operation key to the storage location and turn off the laser warning light.

6.2 LASER SAFETY PROCEDURES DURING ALIGNMENT/MAINTENANCE

This process can be found in the *NGSLR System Alignment, Focus and Maintenance Manual*. Please refer to this document for a detailed explanation of alignment/focus/maintenance procedures and their safety considerations.

APPENDIX 1 – LIST OF APPROVED LASERS FOR NGSLR

Approved Lasers as of April 2013

Laser Specifications					Optical PPE (OD)			Skin PPE
Manufacturer, Model Number and Docket number	**Class**	**Pulsed**	**CW**	**Output**	**532 nm**	**1064 nm**	**Other**	**Applicable Protocols**
Photonics Industries RGL-532-2.5 23-28L Docket 13-087a	IV	Yes	-	2 kHz 50 ps (FWHM) 1 mJ/pulse (tracking)	>4.7	-	-	Follow skin safety requirements as listed in Section 2.1.1.2.
Photonics Industries RGL-532-2.5 23-28L Docket 13-087b	IIIB	Yes	-	2 kHz 50 ps (FWHM) 20 µJ/pulse (alignment)	>3.0	-	-	Follow skin safety requirements as listed in Section 2.1.1.2.
Northrop Grumman 23-28L Docket 07-0203	IV	Yes	-	28 Hz 5.5 ns 50 mJ pulse (max)	>5.6	-	-	Follow skin safety requirements as listed in Section 2.1.1.2.

Note to reader: *Additions and deletions will be documented by sending an addendum to the Non-Ionizing Radiation Safety Committee (NIRSC) for approval. The addendum shall include a copy of the new updated Appendix 1 listing of lasers.*

APPENDIX 2 – LIST OF APPROVED LASER USERS FOR NGSLR

Laser Users for the Photonics Industries Laser				*SLR Operations*
Name	**Employer**	**Code**	**Phone Number**	**Certificate Number**
		694		
		694		
		694		
		694		
		694		
		694		
		694		
		694		

*Laser Custodian

Laser Users for the Northrop Grumman Laser				*LRO Operations*
Name	**Employer**	**Code**	**Phone Number**	**Certificate Number**
		694		
		694		
		694		
		694		
		694		
		694		

*Laser Custodian

APPENDIX 3 – LIST OF APPROVED OPERATORS FOR NGSLR

This list removed (jlfm).

APPENDIX 4 – LIST OF APPROVED ALIGNMENT PERSONNEL

This list removed (jlfm).

APPENDIX 5 – LAYOUT OF THE NGSLR SHELTER

GGAO PARTIAL SITE LAYOUT SHOWING NGSLR

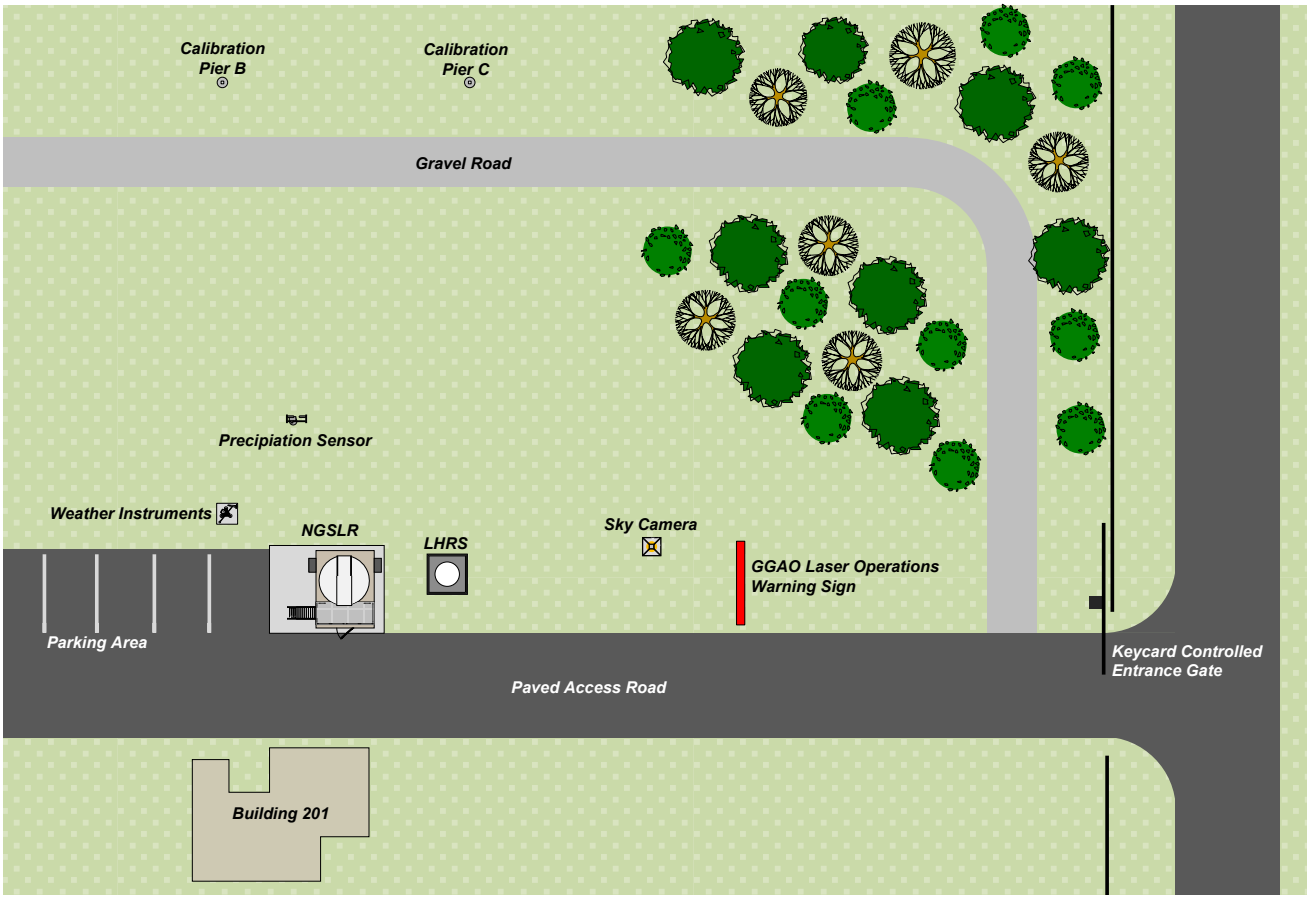


Figure 6-1: Conceptual diagram of the area surrounding NGSLR

OVERHEAD VIEW OF SHELTER AND CONTROLLED ACCESS AREAS

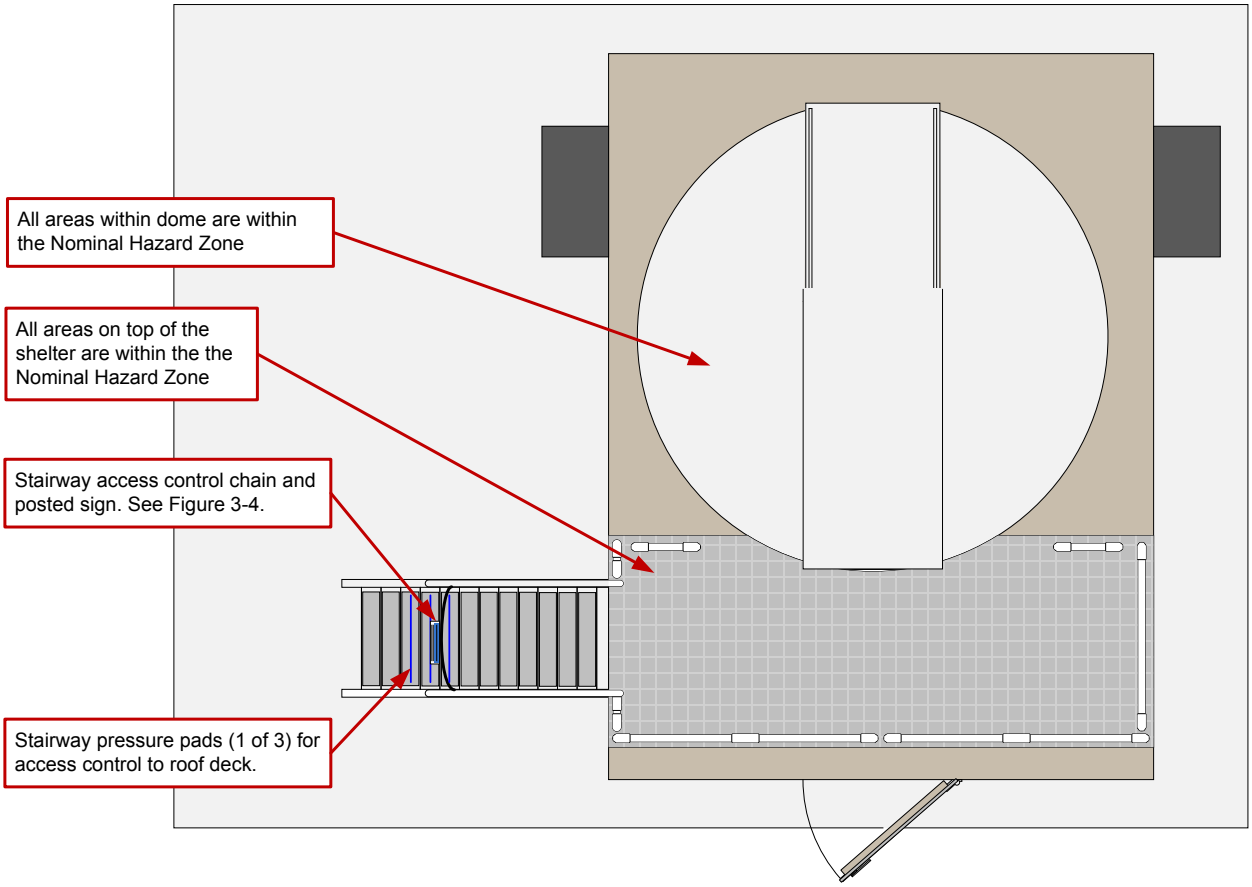


Figure 6-2: Overhead View of Shelter

DETAILED LAYOUT OF EQUIPMENT, CONTROLS, AND POSTED WARNINGS

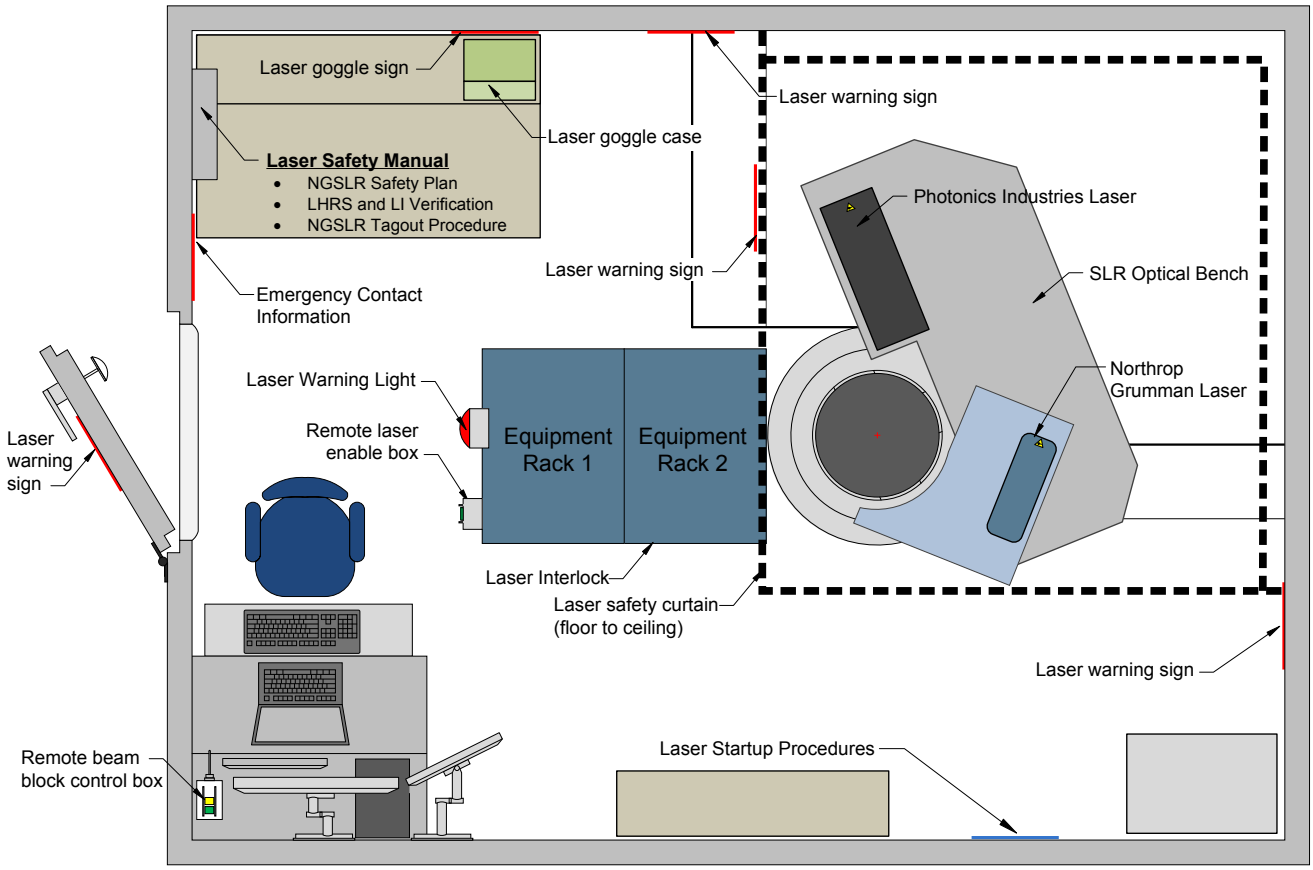


Figure 6-3: Internal Layout of Shelter

THE CONTROL AREA AND THE LASER OPERATIONS AREA

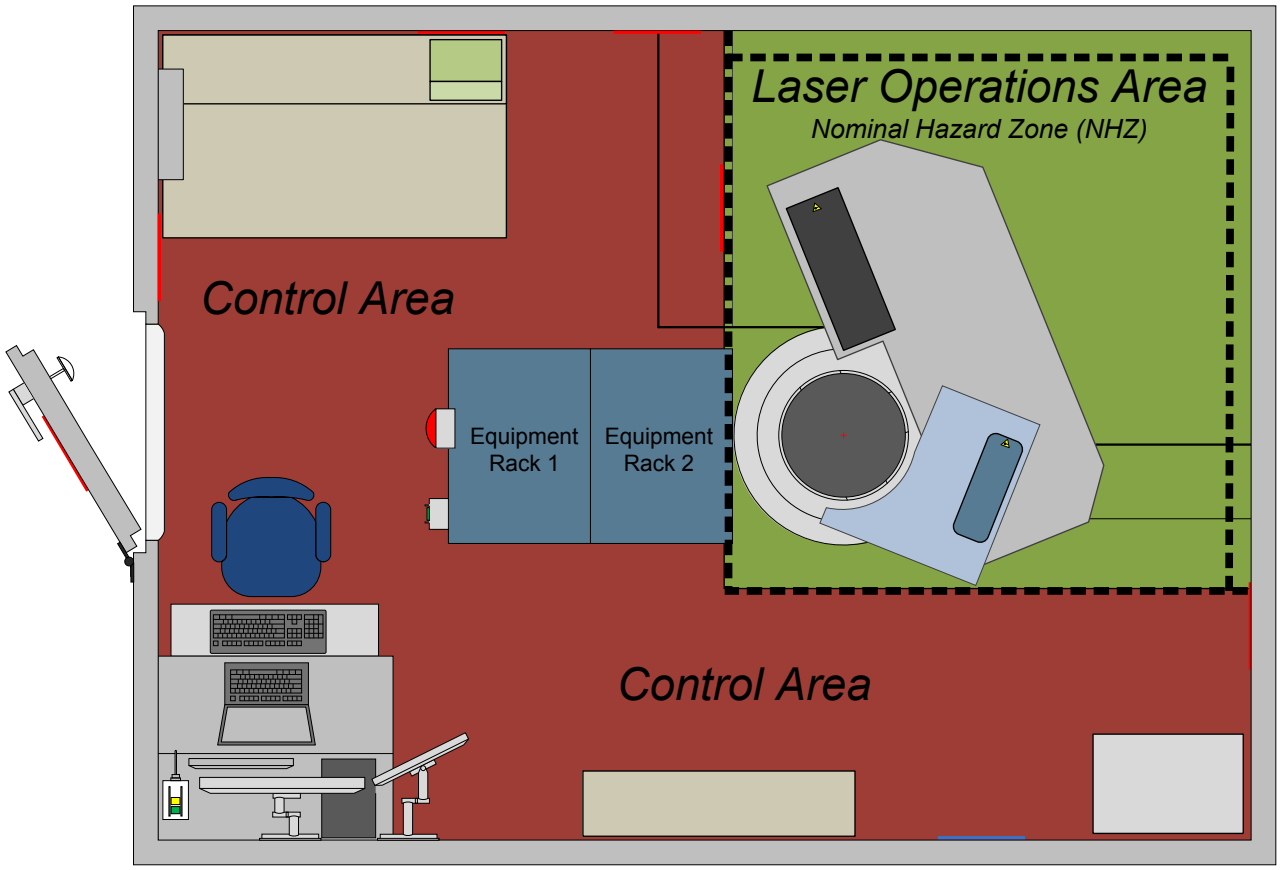


Figure 6-4: Access Areas

Only the Laser Operations Area is considered in the Nominal Hazard Zone (NHZ)

NGSLR EVACUATION PLAN

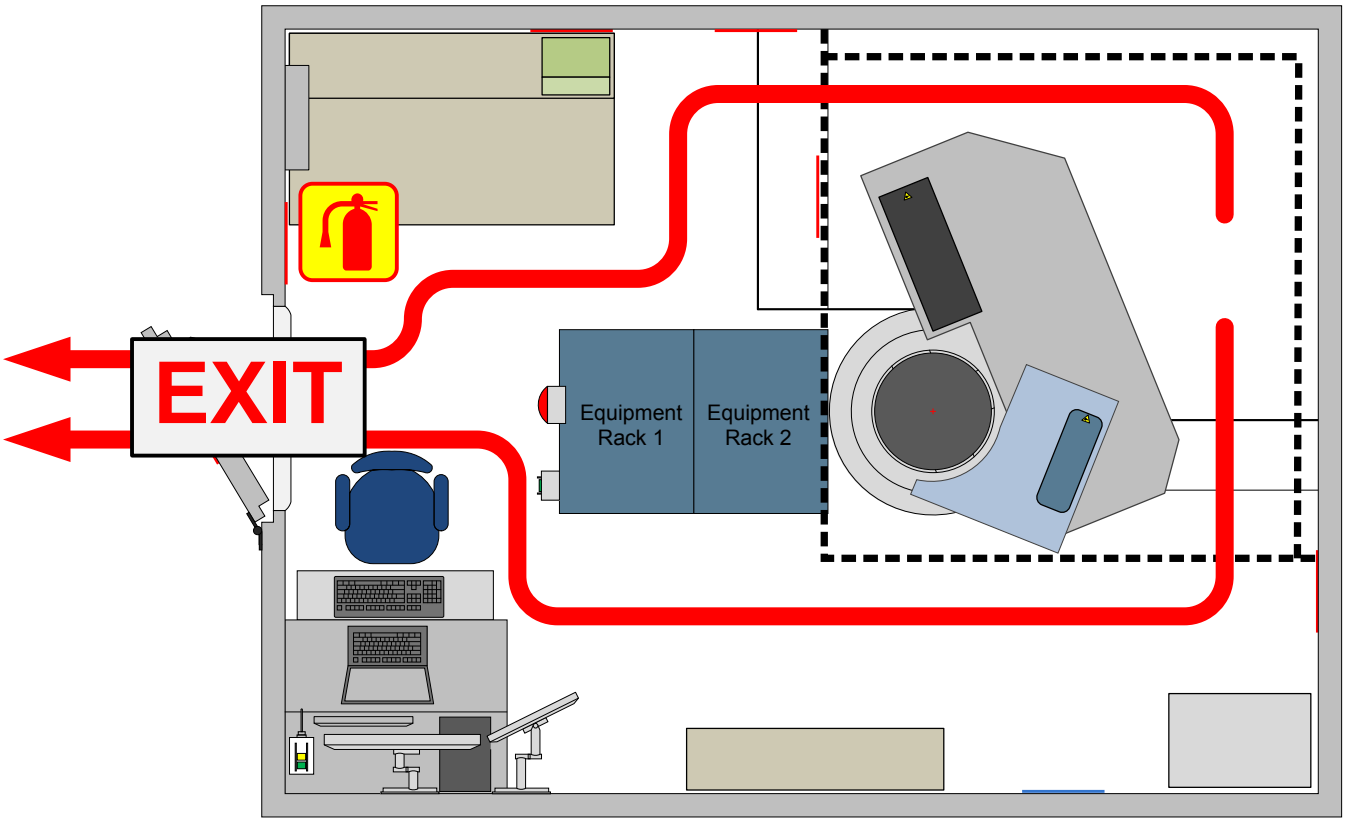
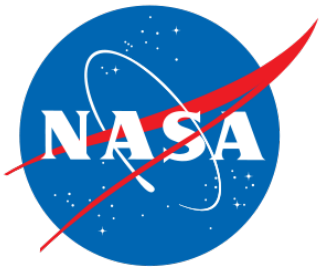


Figure 6-5: Evacuation Plan for NGSLR

LHRS / IOC Verification Procedure for 2 kHz Laser Operations

Version 1.0

June 2013



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Essential Information – *Read this before performing the procedure!*

This LHRS/IOC Verification Procedure allows the operator to verify that the Laser Hazard Reduction System (LHRS) and the IO Chassis (IOC) are working appropriately for the 2KHz laser. These tests should be performed as described below:

Once a week –Complete steps 1 – 10 and 15 of the below procedure, and sign the weekly log.

Every 3 calendar months – Complete the entire LHRS/IOC Verification Procedure, verifying each step completed in the LHRS/IOC Verification Checklist. Send an email confirmation that this has been completed, along with a copy of the signed checklist to Jan McGarry.

Anytime the LHRS, IOC, or associated hardware systems are repaired – Complete the entire LHRS/IOC Verification Procedure, verifying each step completed in the LHRS/IOC Verification Checklist. Refer to pages 12 - 13 for additional information.

If poor weather conditions (heavy rain, fog, dense clouds, etc.) cause continuous aircraft detects on the LHRS, the verification cannot be performed. The system must be able to successfully clear any aircraft detects in order to check the functionality of the LHRS, IOC and Beam Blocks.

Training

All NGSLR personnel shall be trained every three years on the NGSLR LHRS/IOC Verification Procedure for the 2 kHz Laser.

IF ANY OF THE STEPS WITHIN THIS VERIFICATION PROCEDURE FAILS, DO NOT CONTINUE TRACKING OPERATIONS. IMMEDIATELY CONTACT THE FOLLOWING BY PHONE AND EMAIL:

This list removed (jlfm).

DO NOT CONTINUE OPERATIONS UNTIL GIVEN CONCURRENCE BY EITHER OF THE FOLLOWING:

This list removed (jlfm).

IF YOU ENCOUNTER ANY SAFETY ISSUES, CEASE OPERATIONS AND CONTACT JAN MCGARRY

LHRS / IOC Verification Procedure

Follow the procedure below to verify operation of the Laser Hazard Reduction System (LHRS) and the IO Chassis (IOC).

Warning: ***Do not point the radar to the north to prevent damage to the VLBI 2010 system. The radar must remain between 90° and 270° in azimuth during this procedure!***

NOTE: *The **LRO** block and **LRO ND** insert are not used for 2KHz tracking and will not be addressed in this procedure. The **MCP** and **Camera** Shutters are not addressed in this procedure either.*

1. Bring up system as per normal 2KHz operating procedures. Keep the dome closed and ***DO NOT BRING UP THE LASER***. The ICC, DAM, and RAT software should be running with the LHRS and other peripheral equipment ***ON***.

2. Select **TWO KHz LHRS** from the Schedule Control menu on RAT (Figure 1) and start the POP software.

   POP command line (note the sun avoidance feature is turned off):
   /prod/bin/pop -i -s

   NOTE: *If the mount does not move to the commanded position, the ICC and the Xybion controller must be cycled. Once the mount is in the correct position the POP software must be stopped and restarted before the verification test can continue.*

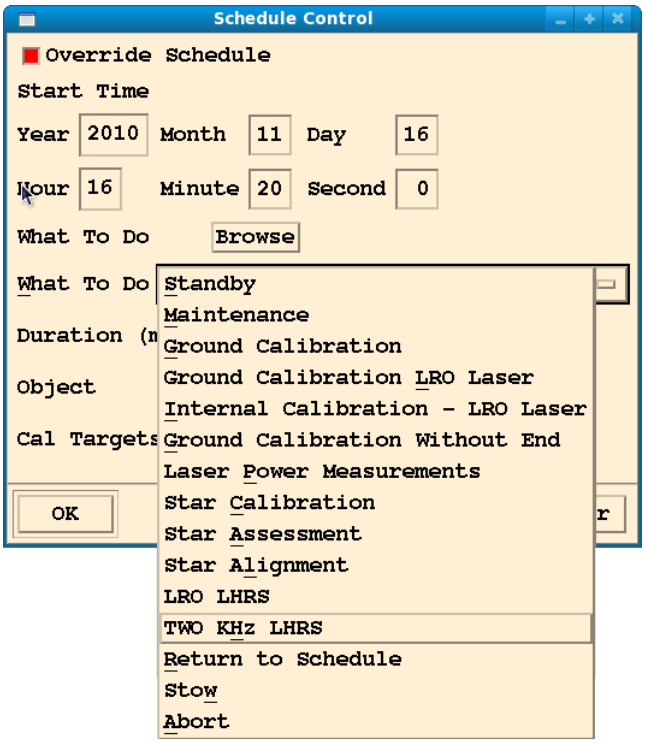


Figure 1: Schedule Control Menu on RAT

3. Verify that the radar is in the manual mode and positioned in the south above 20° (approximately 180° azimuth and 25° elevation) as shown in Figure 2.

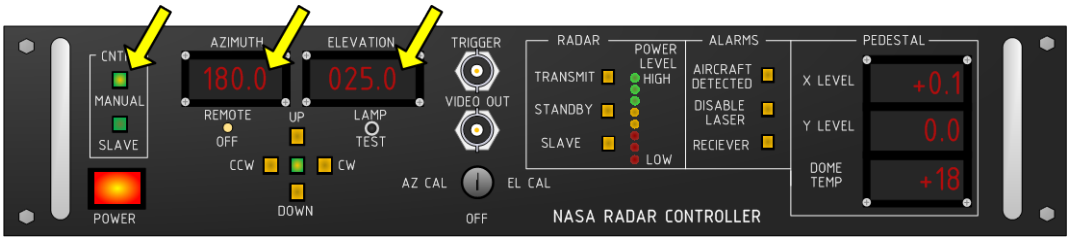


Figure 2: Radar Controller (Local Control Unit) in the manual mode with the correct orientation

NOTE: *If the LHRS is not in the manual mode, the POP software must be stopped and restarted.*

4. Verify that the IOC is correctly configured for the test selected.

   a. Verify that the toggle switch is set to OPERATE (Figure 4).

   b. Verify the IOC display shows that the **2KHZ** laser is selected and the unit is in the **LOCAL** mode (Figure 3).

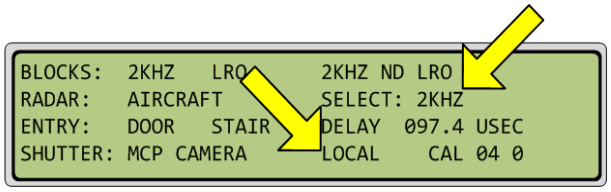


Figure 3: Display of the IOC showing the mode for the verification test

NOTE: *Adjust the contrast (CNTRST) and backlight (BKLT) controls as necessary.*

5. The **Beam Block** LED on the IOC faceplate should light red (Figure 4), and **2KHZ** and **2KHZ ND** should flash on the IOC display (Figure 5).

NOTE: *The flashing text on the IOC display indicates that the **2KHZ*** Beam Block *and **2KHZ ND** Insert are in place.*

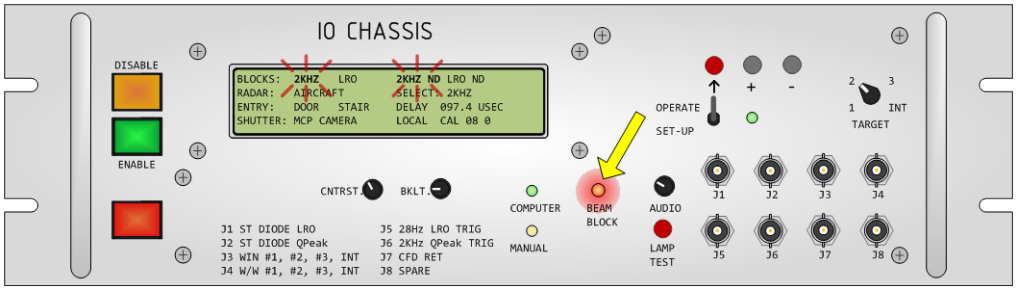


Figure 4: IOC Faceplate showing lit Beam Block LED

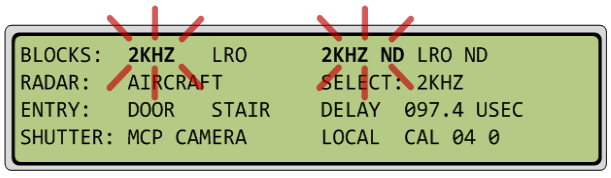


Figure 5: IOC Display showing flashing text indicating that the inserts are in place

6. Verify the configuration of the **2KHZ** Beam Block and **2KHZ ND** Insert (Figure 6).

    a. If necessary, remove the dust cover for the laser table so that the **2KHZ** Beam Block and **2KHZ ND** Inserts are visible.

    b. Verify that the **2KHZ** Beam Block and **2KHZ ND** Insert are in the path of the laser.

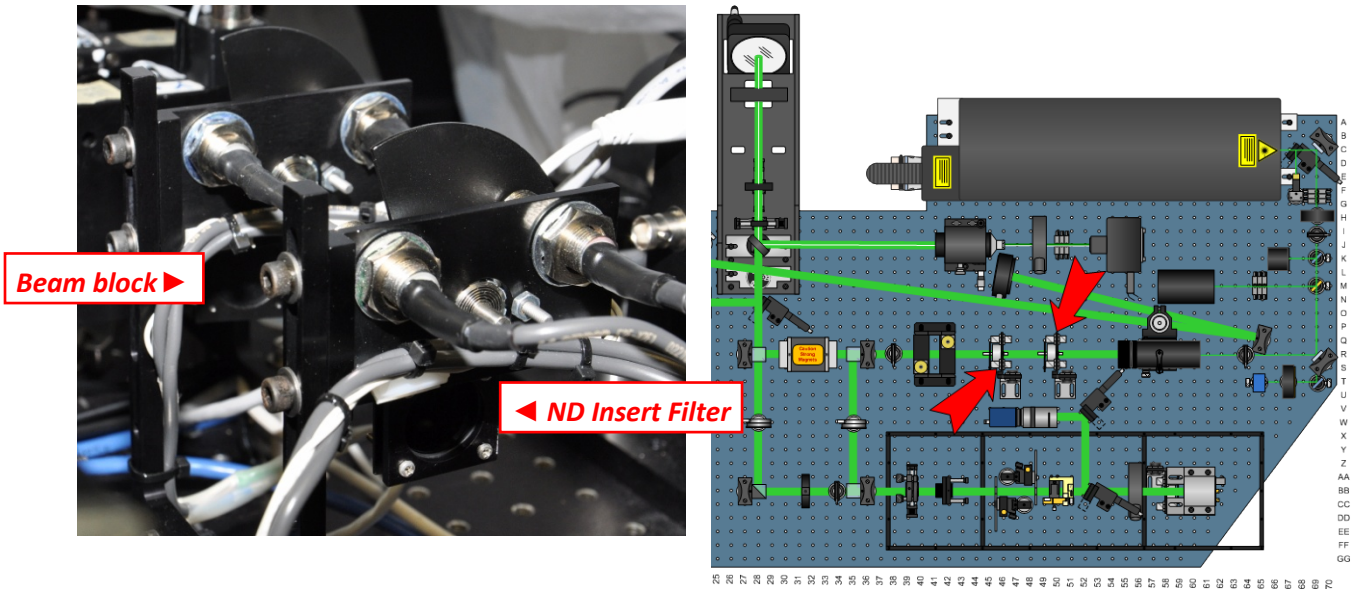


Figure 6: 2KHZ Beam Block and 2KHZ ND Insert

7. Place the Radar Controller (Local Control Unit) in the **Manual Override** Mode.

    a. Press the **Lamp Test** button and at the same time tap the **Jog** button twice. The jog button is the center button between the manual position buttons CW/CCW/Up/Down (Figure 7).

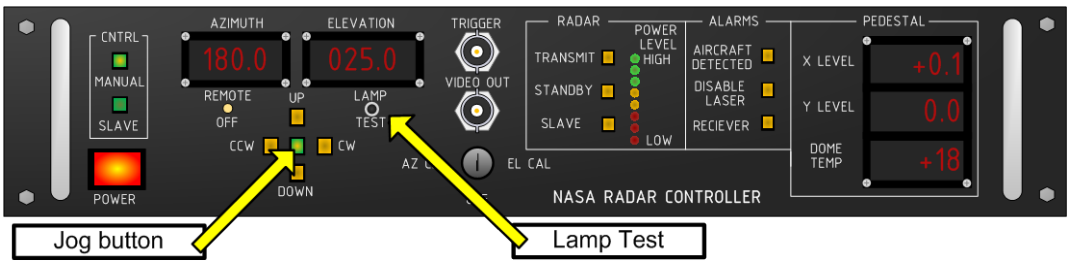


Figure 7: Entering Manual Override mode

    b. Ensure that the green **MANUAL** LED is now flashing at approximately once per second. This indicates that the unit is now in the manual override mode (Figure 8).

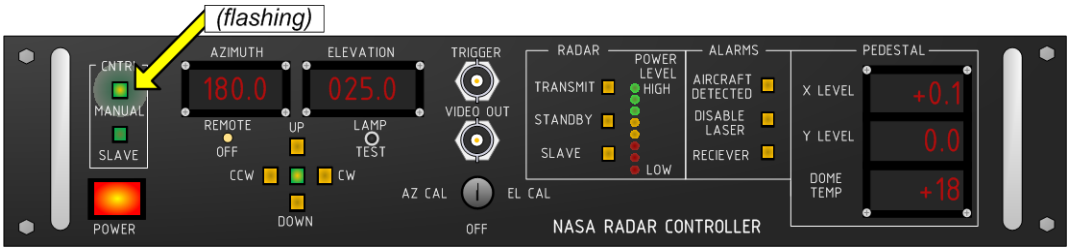


Figure 8: Manual Override indicator flashes during Manual Override mode

8. Enable radar transmission and verify that the appropriate indicators light as listed below.

   a. Press the **Transmit** button on the front panel of the Radar Controller (Figure 9).

   ***Note**: Once pressed, the transmit indicator light will turn yellow. The unit will take approximately 6-8 seconds to tune.*

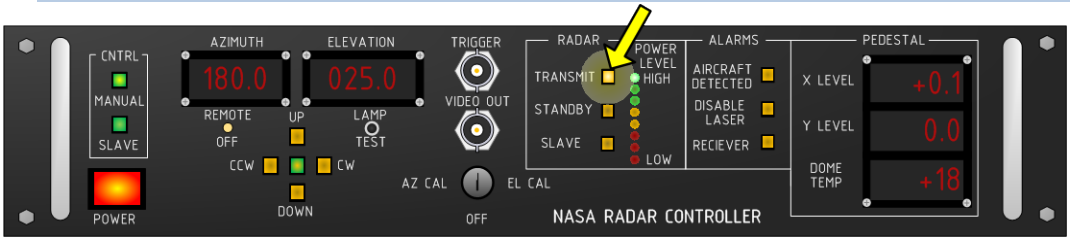


Figure 9: Enabling the radar to transmit

   b. Verify that the **POWER LEVEL** reading is high, as indicated by any of the top 3 green LEDs.

9. Enable the IOC.

   a. Ensure the **LASER CLEAR** button is selected on the Remote Beam Block Control Box (Figure 10). This is located next to the telescope camera monitor at the operator's station.

Figure 10: Remote Beam Block Control Box

   b. Press the green **ENABLE** button on the left hand side of the IOC (Figure 11).

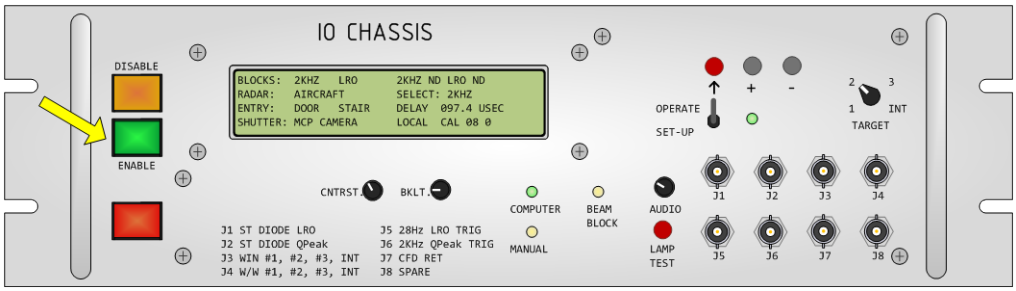


Figure 11: Location of the *ENABLE* button on the IOC

   c. The **Beam Block** LED should turn off (Figure 11) and the ***2KHZ*** Block and ***2KHZ ND*** indicators on the IOC display should no longer flash (Figure 12).

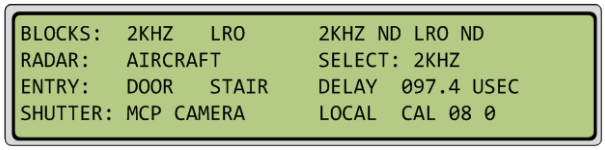


Figure 12: IOC display after the system is set to ENABLE

   d. Verify that the **2KHZ** Beam Block and **2KHZ ND** Insert rotate out of the beam path.

Warning: ***Do not point the radar to the north to prevent damage to the VLBI 2010 system. The radar must remain between 90° and 270° in azimuth during this procedure!***

10. Verify that the IOC operates correctly during an Aircraft Detect.

    a. Using the control buttons on the face of the Radar Controller, manually drive the radar ***CLOCKWISE*** to the ground target at 193.6° AZ, 3.4° EL (±1°).

    b. Ensure that the yellow **AIRCRAFT DETECTED** and the **DISABLE LASER** LEDs light on the front panel of the Radar Controller (Figure 13).

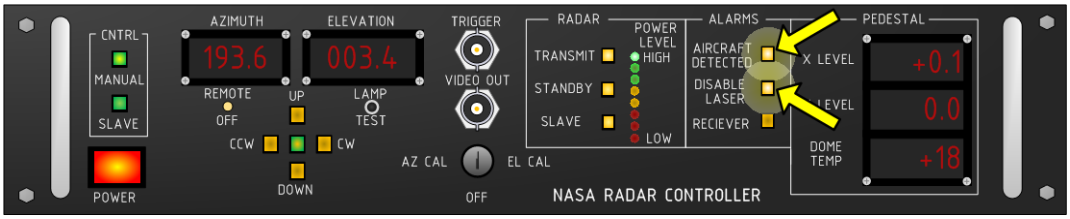


Figure 13: Verify that these LED's are lit on the Radar Controller

    c. The Beam Block LED on the IOC faceplate should turn *ON*, and the **2KHZ** Block, **2KHZ ND** and **AIRCRAFT** indicators on the IOC display should flash (Figure 14).

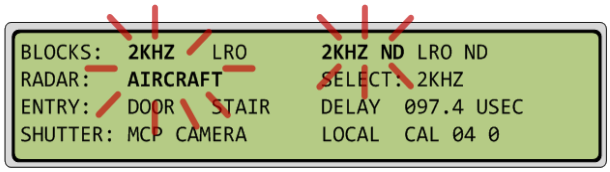


Figure 14: IOC display after an aircraft detect

    d. Verify that the **2KHZ** Beam Block and **2KHZ ND** Insert are physically in the path of the 2KHz laser.

> ***Note:*** *The operation of the devices should be smooth, and they should drop into place without sticking. This action should occur immediately, as described in the previous step.*

    e. Point the radar mount away from the ground target until the **AIRCRAFT DETECTED** and the **DISABLE LASER** lights on the Radar Controller turn off.

11. Re-enable the IOC.

    a. Re-enable the IOC via the front panel **ENABLE** button (Figure 11). As before, the Beam Block LED should turn off, and the **2KHZ** Block, and **2KHZ ND** and **AIRCRAFT** indicators on the IOC display should no longer flash.

    b. Verify that the **2KHZ** Beam Block and **2KHZ ND** Insert are physically out of the path of the 2KHz laser.

12. Verify the function of the Remote Beam Block Control box (Figure 15).

    a. Press the **LASER DISABLE** button on the Remote Beam Block Control box. Ensure that the **2KHZ** Beam Block and **2KHZ ND** Insert drop into the laser beam path.

    b. The Beam Block LED on the IOC faceplate should turn *ON*, and the text for the **2KHZ** Beam Block and **2KHZ ND Insert** should be flashing on the IOC display (Figure 5).

    c. Clear the laser disable on the Remote Beam Block Control box by pressing the green ***LASER CLEAR*** button.

    d. Finally, re-enable the IOC using the green ***ENABLE*** button on the front of the unit (Figure 11). Verify that the **2KHZ** Beam Block and **2KHZ ND** Insert have been taken out of the laser beam path and that the **2KHZ** Block and **2KHZ ND** Insert on the IOC display no longer flash and the Beam Block LED is *OFF*.

Figure 15: Remote Beam Block Control box

13. Verify the operation of the **DISABLE** button on the IOC:

    a. Ensure that the **Beam Block** LED is *OFF* and the **2KHZ** Block and **2KHZ ND** indicators on the IOC display are not flashing.

    b. Press the **DISABLE** button on the front of the IOC. The **Beam Block** LED on the IOC faceplate should turn *ON*, and the **2KHZ** Block and **2KHZ ND** indicators on the IOC display should flash (Figure 5).

    c. Visually verify that the **2KHZ** Beam Block and **2KHZ ND** Insert have moved into the laser beam path.

    d. Re-enable the system using the **ENABLE** button on the Remote Laser Enable Control box (Figure 16), verifying that both blocks have been taken out of the laser beam path. The text for the **2KHZ** block and **2KHZ ND** Insert should no longer flash and the **Beam Block** LED is *OFF* (Figure 12).

Figure 16: The ENABLE button on the Remote Laser Enable Control box

14. Verify the operation of each of the pressure pads on the stairs leading to the telescope/dome.

    a. Step on the first pressure pad

        i. The **Beam Block** LED on the IOC faceplate should turn *ON*, and the **2KHZ** Beam Block, **2KHZ ND** and **STAIR** indicators on the IOC display should flash (Figure 17).

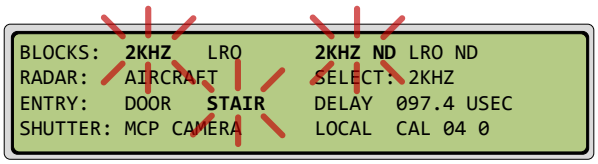


Figure 17: IOC Display when the pressure pad is triggered

Note: *STAIR will only flash as long as someone is physically on the stair.*

ii. Visually verify that the **2KHZ** Beam Block and **2KHZ ND** Insert have moved into the laser beam path.

iii. Re-enable the system, verifying that both blocks have been taken out of the laser beam path. The text for the **2KHZ** Beam Block and **2KHZ ND** Insert should no longer flash and the **Beam Block** LED is *OFF*.

b. Repeat step "a" for the second pressure pad.

c. Repeat step "a" for the third pressure pad.

15. Return the system to the standard configuration.

    a. Type in "**x**" followed by <ENTER> on the POP terminal.

    b. Replace the dust cover for the laser and ensure the laser safety curtain is closed.

16. Complete the appropriate paperwork.

    a. **Weekly Verification** – Sign the weekly log once the appropriate steps have been completed. No additional concurrence is required for operations to continue.

    b. **Quarterly Verification** – Complete the LHRS/IOC Verification Checklist and send to Jan McGarry. Concurrence is not necessary for operations to continue.

    c. **Verification After Repair of LHRS, IOC, or associated Hardware Systems** – Complete the attached checklist. Tracking cannot resume until concurrence has been provided (written or verbal) from Jan McGarry.

Important Reminder!

IF ANY OF THE STEPS WITHIN THIS VERIFICATION PROCEDURE FAILS, DO NOT CONTINUE TRACKING OPERATIONS. IMMEDIATELY CONTACT THE FOLLOWING BY PHONE AND EMAIL:

This list removed (jlfm).

DO NOT CONTINUE OPERATIONS UNTIL GIVEN CONCURRENCE BY EITHER OF THE FOLLOWING:

This list removed (jlfm).

IF YOU ENCOUNTER ANY SAFETY ISSUES, CEASE OPERATIONS AND CONTACT JAN MCGARRY

LHRS/IOC Verification Checklist

Each step of the following LHRS / IOC VERIFICATION CHECKLIST is to be completed. The Test Engineer is to date and initial each step, note the Pass/Fail condition, and provide comments where necessary. The Test Engineer is to then sign and date the document and email it to the NGSLR Engineering lead for signature and concurrence.

OPERATIONS CANNOT BEGIN UNTIL
NASA SLR LEAD PROVIDES CONCURRENCE

The LHRS / IOC VERIFICATION CHECKLIST follows on the next page **>>>**

LHRS / IOC VERIFICATION CHECKLIST – 2KHz Laser

Each item on this checklist pertains to a specific step in the LHRS / IOC procedure. Fill out each item accordingly as each step is performed. The checklist should be filled out quarterly, or anytime the LHRS, IOC or associated hardware systems are repaired.

Items (As described above)	Pass /Fail	Tester	Date	Comments
1. Bring up system as per normal 2KHZ operating procedures. ***DO NOT BRING UP THE LASER!***				
2. Select **TWO KHz Test** from the Schedule Control menu on RAT and start the POP software.				
3. Verify the LHRS is in the **MANUAL** mode at approximately 180° AZ, 25° EL.				
4. Verify the IOC display shows that the **2KHZ** laser is selected and the unit is in the **LOCAL** mode.				
5. Verify the Beam Block **LED** on the IOC is **red**, and the **2KHZ** and **2KHZ ND** indicators are flashing on the display.				
6. Verify the **2KHZ** Beam Block and **2KHZ ND** Insert are in the path of the laser.				
7. Place the LHRS into the **Manual Override** mode.				
8. Enable radar transmission and verify that: **Transmit** LED is yellow **Power Level** reads high, as indicated by any of the top 3 green LEDs				
9. Enable the IOC using the **ENABLE** button on the IOC. Verify that: Beam Block LED is off ***2KHZ*** block and ***2KHZ ND*** indicators are no longer flashing **2KHZ** Beam Block and **2KHZ ND** Insert have rotated out of the beam path				
10. Verify that the IOC operates correctly during an **Aircraft Detect**. Verify that: Yellow **AIRCRAFT DETECTED** and **DISABLE LASER** LEDs light on LHRS Beam Block LED on the IOC is ON (red) **2KHZ Block**, **2KHZ ND** and **Aircraft** are flashing on the IOC **2KHZ** Beam Block and **2KHZ ND** insert are physically in the laser path				
11. Re-enable the IOC.				
12. Verify the function of the **Remote Beam Block Control Box**.				
13. Verify the operation of the **DISABLE** button on the IOC.				
14. Verify the operation of each of the **three pressure pads**.				
15. Return the system to the standard configuration.				
16. Complete the necessary paperwork and obtain concurrence to track if applicable.				

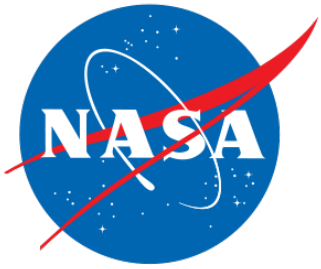
Sign-Off Sheet

Test Engineer: _____ Date: _____

NGSLR Lead: _____ Date: _____

LHRS / IOC Operational Verification Test for LRO Laser Operations

June 2013



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Essential Information – *Read this before performing the procedure!*

This LHRS/IOC Verification Procedure allows the operator to verify that the Laser Hazard Reduction System (LHRS) and the IO Chassis (IOC) are working appropriately for the LRO laser. These tests should be performed as described below:

Once a week –Complete steps 1 – 10 and 15 of the below procedure, and sign the weekly log.

Every 3 calendar months – Complete the entire LHRS/IOC Verification Procedure, verifying each step completed in the LHRS/IOC Verification Checklist. Send an email confirmation that this has been completed, along with a copy of the signed checklist to Jan McGarry.

Anytime the LHRS, IOC, or associated hardware systems are repaired – Complete the entire LHRS/IOC Verification Procedure, verifying each step completed in the LHRS/IOC Verification Checklist. Refer to pages 12 - 13 for additional information.

If poor weather conditions (heavy rain, fog, dense clouds, etc.) cause continuous aircraft detects on the LHRS, the verification cannot be performed. The system must be able to successfully clear any aircraft detects in order to check the functionality of the LHRS, IOC and Beam Blocks.

Training

All NGSLR personnel shall be trained every three years on the NGSLR LHRS/IOC Verification Procedure for the LRO Laser.

IF ANY OF THE STEPS WITHIN THIS VERIFICATION PROCEDURE FAILS, DO NOT CONTINUE TRACKING OPERATIONS. IMMEDIATELY CONTACT THE FOLLOWING BY PHONE AND EMAIL:

This list removed (jlfm).

DO NOT CONTINUE OPERATIONS UNTIL GIVEN CONCURRENCE BY EITHER OF THE FOLLOWING:

This list removed (jlfm).

IF YOU ENCOUNTER ANY SAFETY ISSUES, CEASE OPERATIONS AND CONTACT JAN MCGARRY

LHRS / IOC Verification Procedure

Follow the procedure below to verify operation of the Laser Hazard Reduction System (LHRS) and the IO Chassis (IOC).

Warning: ***Do not point the radar to the north to prevent damage to the VLBI 2010 system. The radar must remain between 90° and 270° in azimuth during this procedure!***

NOTE: *The **2KHZ** block and **2KHZ ND** insert as well as the shutters for the **MCP** and **Camera**, are not used for LRO tracking and will not be addressed in this procedure.*

1. Bring up system as per normal LRO operating procedures. Keep the dome closed and ***DO NOT BRING UP THE LASER***. The ICC, DAM, and RAT software should be running with the LHRS and other peripheral equipment ***ON***.

2. Select **LRO LHRS** from the Schedule Control menu on RAT (Figure 1) and start the POP software.

   POP command line (note the sun avoidance feature is turned off):
   /prod/bin/pop -i -s

   NOTE: *If the mount does not move to the commanded position, the ICC and the Xybion controller must be cycled. Once the mount is in the correct position the POP software must be stopped and restarted before the verification test can continue.*

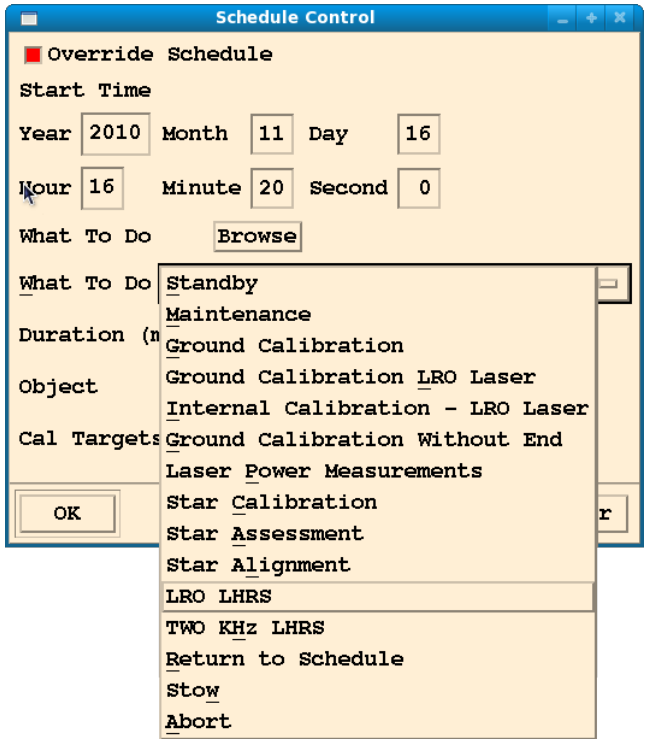


Figure 1: Schedule Control Menu on RAT

3. Verify that the radar is in the manual mode and positioned in the south above 20° (approximately 180° azimuth and 25° elevation) as shown in Figure 2.

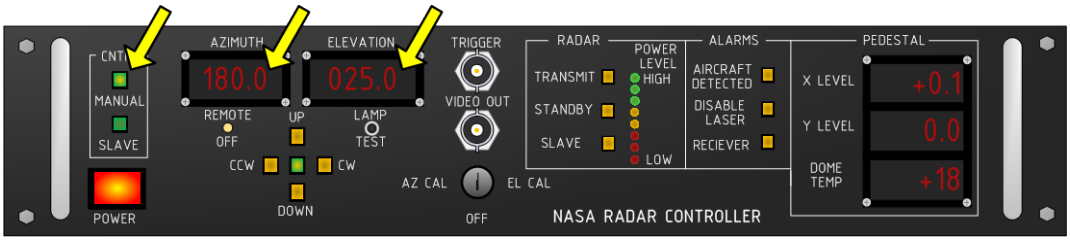


Figure 2: Radar in the manual mode with the correct orientation

NOTE: *If the LHRS is not in the manual mode, the POP software must be stopped and restarted.*

4. Verify that the IOC is correctly configured for the test selected.

   a. Verify that the toggle switch is set to OPERATE (Figure 4).

   b. Verify the IOC display shows that the **LRO** laser is selected and the unit is in the **LOCAL** mode (Figure 3).

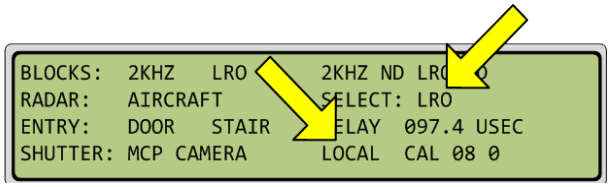


Figure 3: Display of the IOC showing the mode for the verification test

NOTE: *Adjust the contrast (CNTRST) and backlight (BKLT) controls as necessary.*

5. The **Beam Block** LED on the IOC faceplate should light red (Figure 4), and **LRO** and **LRO ND** should flash on the IOC display (Figure 5).

NOTE: *The flashing text on the IOC display indicates that the **LRO** Beam Block and **LRO ND** Insert are in place.*

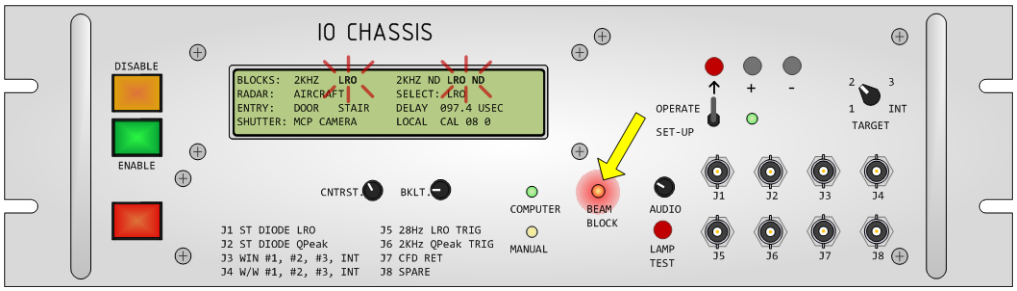


Figure 4: IOC Faceplate showing lit Beam Block LED

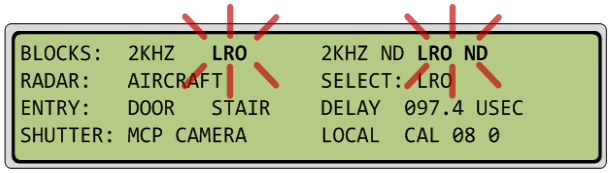


Figure 5: IOC Display showing flashing text indicating that the inserts are in place

6. Verify the configuration of the **LRO** Beam Block and **LRO ND** Insert (Figure 6).

    a. Remove the LRO laser enclosure (cover) so that the **LRO** Beam Block and **LRO ND** Inserts are visible.

    b. Verify that the **LRO** Beam Block and **LRO ND** Insert are in the path of the laser.

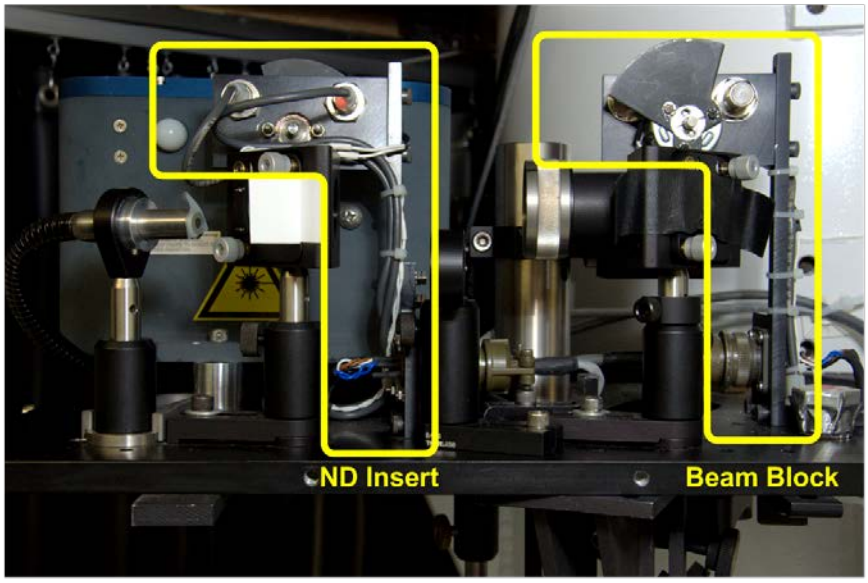


Figure 6: LRO Beam Block and LRO ND Insert

7. Place the Radar Controller (Local Control Unit) in the **Manual Override** Mode.

    a. Press the **Lamp Test** button and at the same time tap the **Jog** button twice. The jog button is the center button between the manual position buttons CW/CCW/Up/Down (Figure 7).

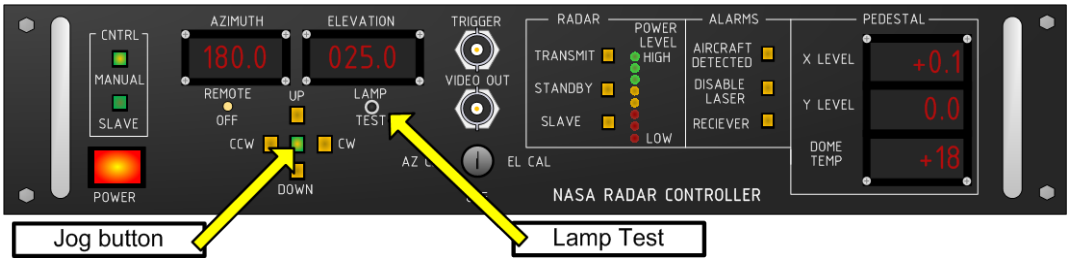


Figure 7: Entering Manual Override mode

    b. Ensure that the green **MANUAL** LED is now flashing at approximately once per second. This indicates that the unit is now in the manual override mode (Figure 8).

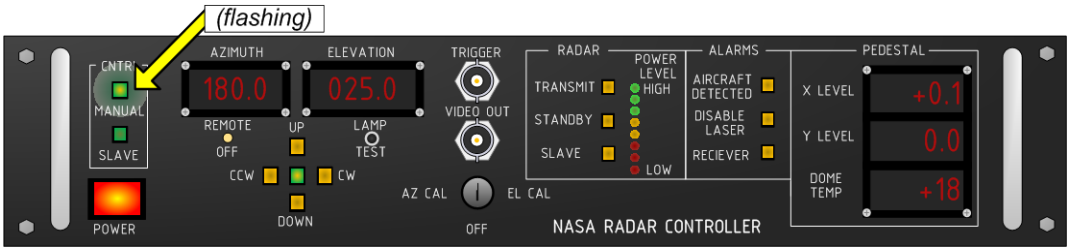


Figure 8: Manual Override indicator flashes during Manual Override mode

8. Enable radar transmission and verify that the appropriate indicators light as listed below.

   a. Press the **Transmit** button on the front panel of the radar Local Control Unit (Figure 9).

   ***Note**: Once pressed, the transmit indicator light will turn yellow. The unit will take approximately 6-8 seconds to tune.*

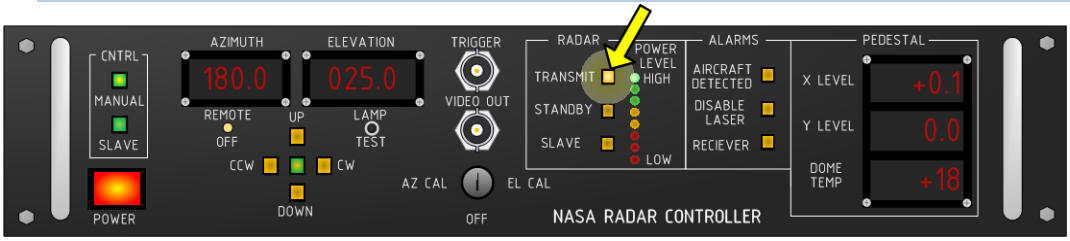


Figure 9: Enabling the radar to transmit

   b. Verify that the **POWER LEVEL** reading is high, as indicated by any of the top 3 green LEDs.

9. Enable the IOC.

   a. Ensure the **LASER CLEAR** button is selected on the Remote Beam Block Control Box (Figure 10). This is located next to the telescope camera monitor at the operator's station.

Figure 10: Remote Beam Block Control Box

   b. Press the green **ENABLE** button on the left hand side of the IOC (Figure 11).

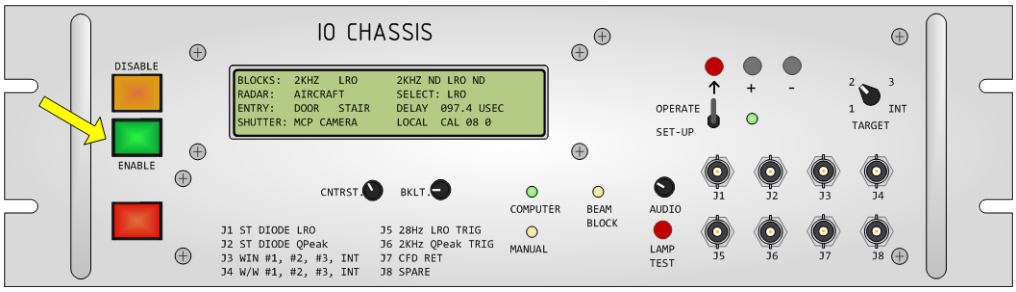


Figure 11: Location of the *ENABLE* button on the IOC

   c. The **Beam Block** LED should turn off (Figure 11) and the ***LRO*** Block and ***LRO ND*** indicators on the IOC display should no longer flash (Figure 12).

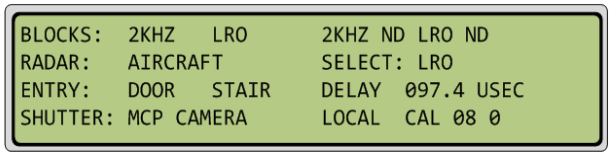


Figure 12: IOC display after the system is set to ENABLE

   d. Verify that the **LRO** Beam Block and **LRO ND** Insert rotate out of the beam path.

Warning: ***Do not point the radar to the north to prevent damage to the VLBI 2010 system. The radar must remain between 90° and 270° in azimuth during this procedure!***

10. Verify that the IOC operates correctly during an Aircraft Detect.

    a. Using the control buttons on the face of the Local Control Unit, manually drive the radar ***CLOCKWISE*** to the ground target at 193.6° AZ, 3.4° EL (±1°).

    b. Ensure that the yellow **Aircraft Detected** and the **Disable Laser** LEDs light on the front panel of the radar Local Control Unit (Figure 13).

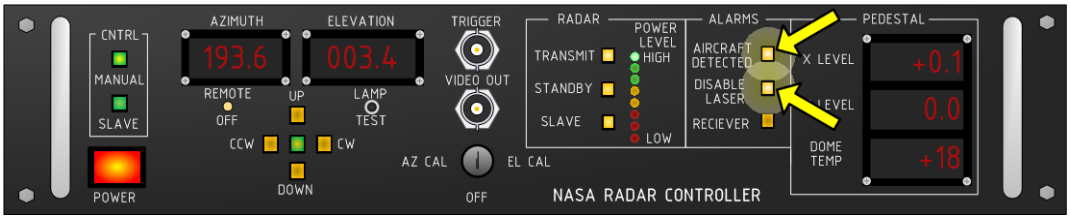


Figure 13: Verify that these LED's are lit on the radar Local Control Unit

    c. The Beam Block LED on the IOC faceplate should turn *ON*, and the **LRO** Block, **LRO ND** and **Aircraft** indicators on the IOC display should flash (Figure 14).

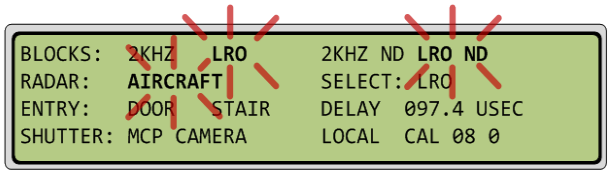


Figure 14: IOC display after an aircraft detect

    d. Verify that the **LRO** Beam Block and **LRO ND** Insert are physically in the path of the LRO laser.

> ***Note:*** *The operation of the devices should be smooth, and they should drop into place without sticking. This action should occur immediately, as described in the previous step.*

    e. Point the radar mount away from the ground target until the **Aircraft Detected** and the **Disable Laser** lights on the Radar Local Control Unit turn off.

11. Re-enable the IOC.

    a. Re-enable the IOC via the front panel **ENABLE** button (Figure 11). As before, the Beam Block LED should turn off, and the **LRO** Block, and **LRO ND** and **Aircraft** indicators on the IOC display should no longer flash.

    b. Verify that the **LRO** Beam Block and **LRO ND** Insert are physically out of the path of the LRO laser.

12. Verify the function of the Remote Beam Block Control box (Figure 15).

    a. Press the **LASER DISABLE** button on the Remote Beam Block Control box. Ensure that the **LRO** Beam Block and **LRO ND** Insert drop into the laser beam path.

    b. The Beam Block LED on the IOC faceplate should turn *ON*, and the text for the **LRO** Beam Block and **LRO ND Insert** should be flashing on the IOC display (Figure 5).

    c. Clear the laser disable on the Remote Beam Block Control box by pressing the green ***LASER CLEAR*** button.

    d. Finally, re-enable the IOC using the green ***ENABLE*** button on the front of the unit (Figure 11). Verify that the **LRO** Beam Block and **LRO ND** Insert have been taken out of the laser beam path and that the **LRO** Block and **LRO ND** Insert on the IOC display no longer flash and the Beam Block LED is *OFF*.

Figure 15: Remote Beam Block Control box

13. Verify the operation of the **DISABLE** button on the IOC:

    a. Ensure that the **Beam Block** LED is *OFF* and the **LRO** Block and **LRO ND** indicators on the IOC display are not flashing.

    b. Press the **DISABLE** button on the front of the IOC. The **Beam Block** LED on the IOC faceplate should turn *ON*, and the **LRO** Block and **LRO ND** indicators on the IOC display should flash (Figure 5).

    c. Visually verify that the **LRO** Beam Block and LRO ND Insert have moved into the laser beam path.

    d. Re-enable the system using the **ENABLE** button on the Remote Laser Enable Control box (Figure 16), verifying that both blocks have been taken out of the laser beam path. The text for the **LRO** block and **LRO ND** Insert should no longer flash and the **Beam Block** LED is *OFF* (Figures 12).

Figure 16: The ENABLE button on the Remote Laser Enable Control box

14. Verify the operation of each of the pressure pads on the stairs leading to the telescope/dome.

    a. Step on the first pressure pad

        i. The **Beam Block** LED on the IOC faceplate should turn *ON*, and the **LRO** Beam Block, **LRO ND** and **Stair** indicators on the IOC display should flash (Figure 17).

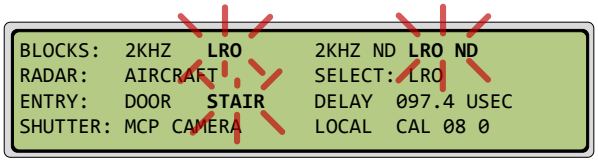


Figure 17: IOC Display when the pressure pad is triggered

Note: *STAIR will only flash as long as someone is physically on the stair.*

ii. Visually verify that the **LRO** Beam Block and **LRO ND** Insert have moved into the laser beam path.

iii. Re-enable the system, verifying that both blocks have been taken out of the laser beam path. The text for the **LRO** Beam Block and **LRO ND** Insert should no longer flash and the **Beam Block** LED is *OFF*.

b. Repeat step "a" for the second pressure pad.

c. Repeat step "a" for the third pressure pad.

15. Return the system to the standard configuration.

a. Type in "**x**" followed by <ENTER> on the POP terminal.

b. Cover the LRO Optical Bench with the LRO laser enclosure (cover).

Important Reminder!

IF ANY OF THE STEPS WITHIN THIS VERIFICATION PROCEDURE FAILS, DO NOT CONTINUE TRACKING OPERATIONS. IMMEDIATELY CONTACT THE FOLLOWING BY PHONE AND EMAIL:

This list removed (jlfm).

DO NOT CONTINUE OPERATIONS UNTIL GIVEN CONCURRANCE BY EITHER OF THE FOLLOWING:

This list removed (jlfm).

IF YOU ENCOUNTER ANY SAFETY ISSUES, CEASE OPERATIONS AND CONTACT JAN MCGARRY

LHRS/IOC Verification Checklist

Each step of the following LHRS / IOC VERIFICATION CHECKLIST is to be completed. The Test Engineer is to date and initial each step, note the Pass/Fail condition, and provide comments where necessary. The Test Engineer is to then sign and date the document and email it to the NGSLR Engineering lead for signature and concurrence.

OPERATIONS CANNOT BEGIN UNTIL
NASA LRO LEAD PROVIDES CONCURRENCE

The LHRS / IOC VERIFICATION CHECKLIST follows on the next page **>>>**

LHRS / IOC VERIFICATION CHECKLIST – LRO Laser

Each item on this checklist pertains to a specific step in the LHRS / IOC procedure. Fill out each item accordingly as each step is performed. The checklist should be filled out quarterly, or anytime the LHRS, IOC or associated hardware systems are repaired.

Items (As described above)	Pass /Fail	Tester	Date	Comments
1. Bring up system as per normal LRO operating procedures. ***DO NOT BRING UP THE LASER!***				
2. Select **LRO LHRS Test** from the Schedule Control menu on RAT and start the POP software.				
3. Verify the LHRS is in the **MANUAL** mode at approximately 180° AZ, 25° EL.				
4. Verify the IOC display shows that the **LRO** laser is selected and the unit is in the **LOCAL** mode.				
5. Verify the Beam Block **LED** on the IOC is **red**, and the **LRO** and **LRO ND** indicators are flashing on the display.				
6. Verify the **LRO** Beam Block and **LRO ND** Insert are in the path of the laser.				
7. Place the LHRS into the **Manual Override** mode.				
8. Enable radar transmission and verify that: **Transmit** LED is yellow **Power Level** reads high, as indicated by any of the top 3 green LEDs				
9. Enable the IOC using the **ENABLE** button on the IOC. Verify that: Beam Block LED is off ***LRO*** block and ***LRO ND*** indicators are no longer flashing **LRO** Beam Block and LRO ND Insert have rotated out of the beam path				
10. Verify that the IOC operates correctly during an **Aircraft Detect**. Verify that: Yellow **Aircraft Detected** and **Disable Laser** LEDs light on LHRS Beam Block LED on the IOC is ON (red) **LRO Block**, **LRO ND** and **Aircraft** are flashing on the IOC The **LRO** Beam Block and **LRO ND** insert are physically in the path of the laser				
11. Re-enable the IOC.				
12. Verify the function of the Remote Beam Block Control Box.				
13. Verify the operation of the **DISABLE** button on the IOC.				
14. Verify the operation of each of the **three pressure pads**.				
15. Return the system to the standard configuration.				

Sign-Off Sheet

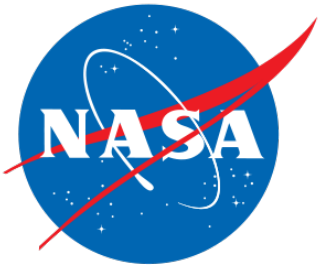
Test Engineer: _____ Date: _____

NGSLR Lead: _____ Date: _____

NGSLR Lockout-Tagout Procedure

Version 4.2

June 2013



Purpose:

The purpose of this procedure is to provide a method for identifying laser safety system components that have been taken out of service or bypassed during troubleshooting activities and to ensure effective communication to NGSLR station personnel.

Scope:

This procedure applies to all troubleshooting activities at the NGSLR station that have the potential to affect laser safety systems including but not limited to:

- Any component of the Laser Hazard Reduction System (LHRS)
- IO Chassis
- Remote Laser Clear/Disable Box
- Remote Enable Box
- Insert filters, beam blocks and their actuators
- Any equipment that could affect the operation of the previously listed safety systems

During service or maintenance operations, Lockout/Tagout shall be utilized

Equipment:

This procedure requires the use of an Administrative Tag. All tags will be alike and have the wording “Notice, Troubleshooting” written in bold letters across the top (Figure 1).

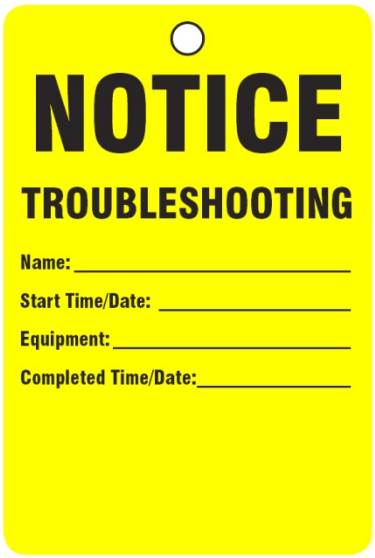


Figure 1 – Administrative Tag

Procedure:

To ensure safety systems are returned to service prior to operation the following steps will be performed:

1. Obtain a hard copy of the NGSLR Lockout-Tagout form. Blank forms are kept in the NGSLR Laser Safety Logbook.
2. Communicate to station personnel that a task is going to be performed that require laser safety systems to be taken out of service or bypassed and tracking operations will cease.
3. Place an administrative tag at the operator console in a conspicuous location, affixed in a manner that the tag cannot be inadvertently removed.
4. Place an administrative tag on/near the safety system component that has been disabled.
5. Upon conclusion of the troubleshooting activities, all safety devices shall be returned to the proper working order.
6. Perform the LHRS & IOC Verification Procedure.
7. Remove tags from equipment.
8. Remove tag from operator console and inform station personnel that safety systems are back on line.
9. After all components are operational, sign and date the NGSLR Lockout-Tagout form indicating that the troubleshooting and verification activities have been completed.
10. Send a copy (hard or soft) of the completed NGSLR Lockout-Tagout Form and the completed LHRS & IOC Verification Check List form to:

    Jan McGarry

11. Keep a copy of the completed NGSLR Lockout- Tagout Form, the LHRS / IOC checklist, and the Administrative tag(s) in the NGSLR Laser Safety Logbook.

Training:

All NGSLR personnel shall be trained on the NGSLR Lockout-Tagout Procedure every three years.

Records:

Completed NGSLR Lockout-Tagout form and the LHRS & IOC Verification Check List form will be maintained as records for at least 3 years.

NGSLR Lockout-Tagout Form

Brief Description of Issue:

_____

_____

_____

_____

System(s) to be Bypassed/Disabled:

☐ **IO Chassis** ☐ **LHRS** ☐ **Beam Block** ☐ **Insert Filter** ☐ **Remote Enable Box**

☐ **Other:** _____

Notification and Tagging:

☐ Notify Station Operators of Work to be Completed
☐ Place Tag at Operator's Console
☐ Place Tag(s) on Equipment Checked or Listed Above

Returning System to Operation:

☐ Returned Safety System Components to Operational Status
☐ Completed LHRS & IOC Verification Check List form
☐ Removed Tags on Equipment
☐ Removed Tag at Operator's Console
☐ Notified Station Operators Work has been Completed and Safety Systems Operational

Signature:

I herby certify that all safety system components have been restored to their normal operational state.

_____

Signature / Date / Phone Number