SGSLR

Space Geodesy Satellite Laser Ranging

Safety/Security Concerns when Automating SLR Systems

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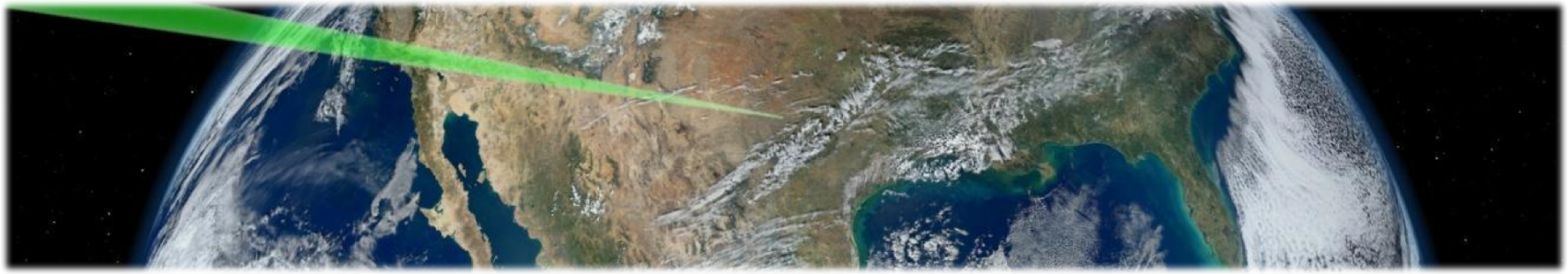
Abstract



Safety/Security Concerns when Automating SLR Systems

This presentation focuses on the identification, analysis and assessment of safety and security issues necessary to achieving automation of SLR systems. The focus will be on SGSLR but will be relevant to any SLR system. Areas of consideration include automation regulatory analysis, hazard analysis, situation knowledge and action, supporting safety systems, hazard reporting, IT Security, and overall site assessment. The presentation will discuss what is needed during design, implementation and verification of the system.

Safety Overview

- **Can we automate safety issues and system integrity issues?**
- Identify the entity or entities that provide the concurrence on non-objection to the automated operation of hazardous outdoor laser operations through the governed airspace.
  - Host Country
    - High level government (Federal/National)
    - Local level Government (State/Region)
      - Requirements of these entities
        - Currently exist or do they need to be created
        - Unattended/automated outdoor laser operations explicitly allowed or are they inferred
  - Organization (Science) sponsoring the outdoor laser operations
    - Safety requirements
    - Procedures for acquiring concurrence
    - Safety plan and implementation
    - Safety plan implementation verification
  - International Requirements if in another country
  - Which requirements take priority (most stringent in each category)
  - Periodic renewal

SGSLR Laser Safety Plan

- Requirements/Standards Used Include:
  - NASA Procedural Requirements (NPR 8715.3)
  - Goddard Procedural Requirement (GPR: 1860.2)
  - Federal Aviation Administration (FAA: AC70-1)
  - American National Standards Institution (ANSI - Multiple)
  - Society of Automotive Engineers (SAE: 3 including AS6029A)

Perform Full System Hazard Analysis

- Indoor laser safety analysis
  - Laser room access
  - Operations area access
  - Building access
- Outdoor laser safety analysis
  - Laser transmitter access
  - Aided viewing
  - Airspace identification
  - Identifying users of the airspace (planes, helicopters, balloons, Gliders, Parachutists, etc.
- Indoor and Outdoor safety analysis must take into account
  - Operations
  - Maintenance
  - General Public access
  - Effects on, or by, close proximity projects/offices/etc.

Hazard Analysis - Indoor

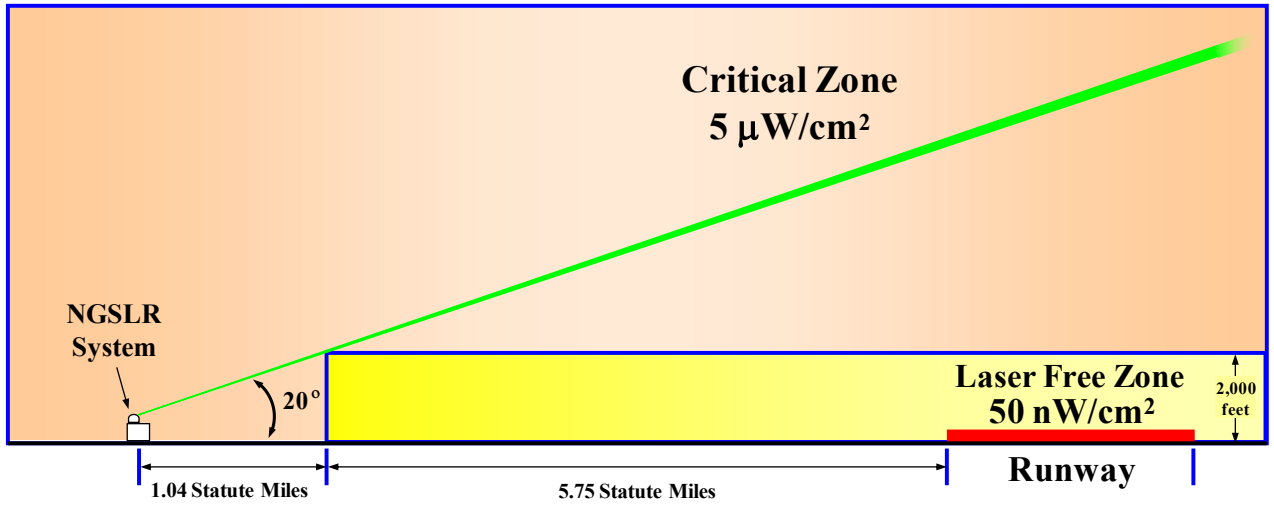
- Perform a comprehensive hazard analysis to identify all hazards associated with the development, implementation, test, operation, and maintenance involving the use of the laser
  - Indoor Laser Hazards
    - Local, state, federal, host nation laser operations requirements
    - Laser parameters and determine
      - Maximum Permissible Energy (MPE)
      - Nominal Ocular Hazard Distance (NOHD)
    - Review the physical layout of the laser room and operations area, identify potential laser hazards and hazard zones
    - Review layout of the optical bench, determine energy densities, identify associated laser hazards
    - Review optical alignment procedures, identify associated laser hazards

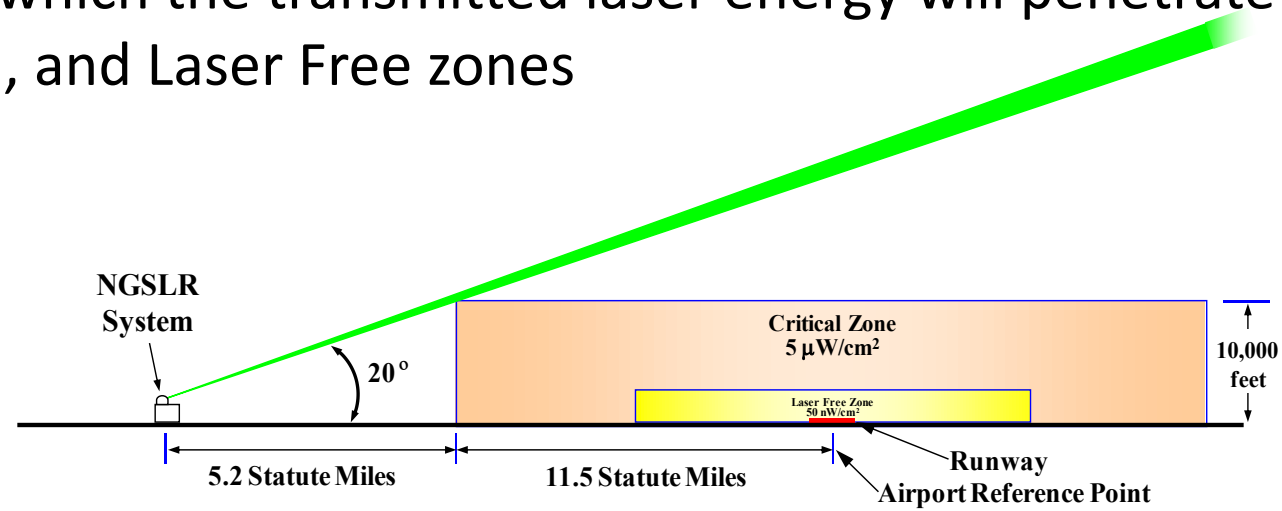
Hazard Analysis - Outdoor

- Identify local, state, federal, and host nation laser operations requirements
- Perform airspace analysis
  - Identify airports within the NOHD, Sensitive, Critical, and Laser Free hazard ranges
  - Determine types of aircraft, aircraft altitudes, and aircraft speeds that are expected to be in the airspace volume
  - Identify annual airport operations
  - Identify nearby operations that use the affected airspace volume
- Identify nearby operations that may be affected by satellite laser ranging activities

Laser-Free & Critical Zone Conditions

- Identify airport Sensitive, Critical, and Laser Free zones
- Identify airports which the transmitted laser energy will penetrate Sensitive, Critical, and Laser Free zones





Hazard Mitigation – Indoor & Outdoor

- Identify local, state, federal, and host nation offices/agencies mitigation requirements
- Identify methods to mitigate all identified indoor laser hazards
  - Hazard elimination, engineering controls, use of safety devices, use of caution and warning devices, implementation of procedures and training, and the use of PPE
- Correlate mitigation methods with all identified indoor laser hazards
  - Hazard elimination, engineering controls, use of safety devices, use of caution and warning devices, implementation of procedures and training, and the use of PPE
  - Identify laser safety subsystem capabilities
  - Implement changes to mitigation methods/subsystems as needed
- Implement and verify mitigation methods/subsystems

Hazard Reporting

- Emergency reporting
- Record keeping
- Time tagging of critical data

Safety Controls (1)

- Safety inherent in design
- Personal Protective Equipment (PPE)
- Automated emergency notification system
- Laser hazard warnings, labels, and control measures
  - Warning signs and labels
  - Video monitoring system
  - Procedures and beam blocks
- Integrated system safety features
  - Area Safety - Doorway Sensors/Stairway Pressure plates
  - Keyed Access to Building and Laser
  - Beam containment barriers
  - Laser Safety Chassis with automated beam block and laser fire (trigger) inhibit signal
- Safety requirements and procedures
  - General Safety Requirements (SGSLR Safety Handbook)
  - Operations Procedures (SGSLR Operations Manual)
  - System Maintenance Procedures (SGSLR Operations Manual)
  - Laser Alignment Procedures (SGSLR Alignment Manual)
  - Emergency Procedures (SGSLR Safety Handbook)

Safety Controls (2)

- Certification and Training
  - Training and Certification Requirements for all users of the system -System Operators, Laser Users and Optical Alignments
  - All users must follow the requirements and procedures listed in system manuals
- Safety Equipment (Laser safety goggles, fall protection, etc.)
- Safety Verification
  - Routine Safety Inspection, periodic testing and communications
- Security Concerns
  - Situational Awareness of System Health and surrounding environment
  - Prevention of Unauthorized Entry – Both Physical and Electronic

System Security

- Physical security assessment
  - Secure compound
  - Building access
  - Laser transmitter access
  - Reaction to Unauthorized access
  - Reaction to authorized access but unauthorized operations
  - Security implementation
    - Redundancy
    - Security levels
- IT Security assessment
  - Internet access
  - Instant termination of laser operations in an emergency
  - System monitor and control
  - Upgrades
  - Unauthorized control

Implementation Phase

- Implement according to all guidelines, requirements and implementation plans developed during design phase.
- Ensure all plans, Hardware, Software, other controls are implemented and documented prior to testing.
- All possible scenarios must be determined, documented, reviewed, tested and verified.
- All possible decision paths for the software must be documented and tested. In an automated system the hardware/software become safety critical.
- Subsystems that can be tested separately should be, but final verification can only be done at the system level in as close to actual usage as possible.

Testing Phase

- Testing and verification should be documented and tested in all operational modes, maintenance modes, diagnostic modes and simulations. Shutdown and power-up should also be part of this.
- Some software testing may require simulation because some paths may not easily be reached.
- Methods to test must be determined that do not harm any humans, or damage any instrumentation, facilities, aircraft, but that allow testing as close as possible to real system use.
- All testing and verification will need to be performed with a human present but only watching (in case something goes wrong). The human will document performance seen, but the final verification will be from analysis performed using the data collected (including video) during testing.

Safety/security for full automation is a major design, documentation and testing effort.