



Laser Safety System at OCTL Laser (LASSO)

Briefing to Interagency Operations
Advisory Group (IOAG) Optical Link
Study Group (OLSG)
5-26-2011



Outline



- **Problem Statement**
- **Regulatory Agencies Requirements**
 - **Federal Aviation Administration**
 - **Laser Clearing House**
- **JPL Laser Safety Tiers**
- **History of Safe Laser Beam Transmission from TMF**
- **Planned Experiments**



Problem Statement

- Laser beam propagation through navigable air and near-Earth space can put the flying public and space assets at risk
- Laser beam propagation is regulated by the Federal Aviation Administration (FAA) and by the U.S. Space Command Laser Clearing House (LCH)
- The FAA regulates laser propagation through navigable airspace (airplanes, etc.)
- LCH regulates laser propagation into near-Earth space (LEO, GEO, HEO, etc.) over US territories



FAA Requirements



- No aircraft unless they are specifically a part of the experiment are to be illuminated with lasers
- Transmitting station must deploy outside observers to look for aircraft at risk of transiting the laser beam
 - Observers must have capacity to effect termination of laser transmission if an aircraft is seen to be at risk of intercepting beam



LCH Requirements

- Lasers are to be registered with LCH
 - Points of contact with telephone and email
- Beam propagation details required for registration are specification of laser
 - Wavelength
 - Average output power
 - Modulation
 - CW
 - Pulsed
 - Pulse width, pulse repetition frequency, Instantaneous single pulse power



Required LCH Beam Propagation Parameters cont'd



- Beam width
- Beam type (Gaussian or top hat)
- Beam quality
- Beam size at primary aperture
- Number of beams propagated
- Identification of targets and tracks
 - Supported by written permission from target owners
- Maximum/minimum elevation of beam pointing system



LCH Predictive Avoidance



- Based on parameters LCH may require implementation of predictive avoidance (PA)
 - Times and durations that laser transmission is approved for the targets
 - Outages may range from seconds to minutes
- LCH may also issue a waiver, permitting unrestricted beam propagation
 - Typically obtained when propagating low power, wide divergence, cw beams



Tier 1 Safety System

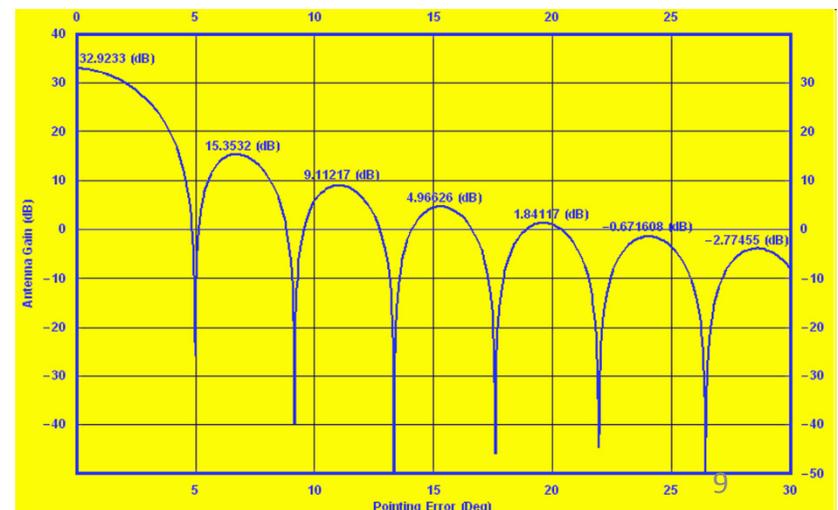
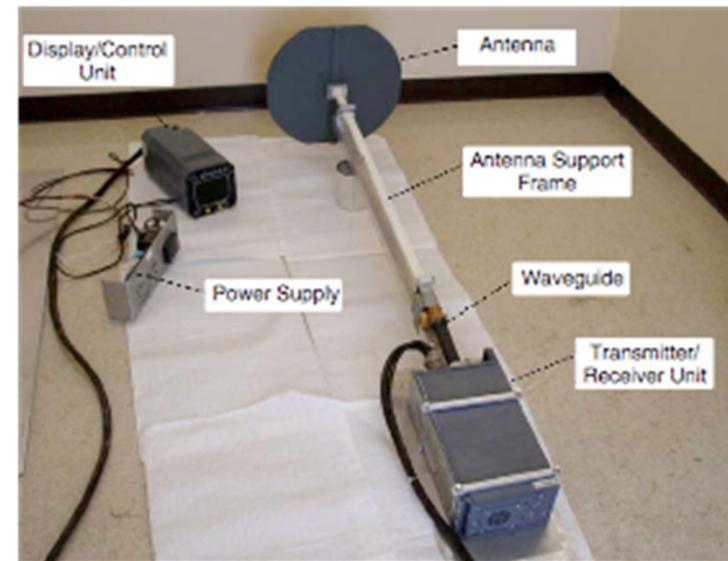
- Tier-1 sensors are Raytheon Control IR 2000B barium strontium titanate (BST) focal plane 320 x 240 pixel arrays
- A combination of wide and narrow field of views allows system to detect close fast moving aircraft or slow small aircraft out to a range of 3.3-km
 - Wide field
 - F/1.0 18-mm germanium lens for a 46 °x 35°
 - Narrow field sensor
 - F/1.0 75-mm germanium lens to generate a 12 °x 9° field
- S/W differences camera scenes to identify moving aircraft and sends command to shutter laser when object is seen to be at risk
 - When telescope is slewing to track LEO satellite or target aircraft slew information is transmitted to Tier-1 computer system to offset background by angular rate
 - Aircraft moving against background are identified and risk evaluated based on relative velocity of aircraft and telescope



Tier-2 Safety System



- Primus-40 X-band weather system radar
 - 3W average output power
 - 7kW peak power 1-microsec pulse
 - 122Hz repetition rate
 - Minimum detectable signal - 108dBm
- If aircraft is detected system sends trigger to safety system to shutter laser transmission
 - Radar returns from clouds will trigger false alarm.



K. Wilson



Tier-3 Safety



- Process for laser propagation not waived by LCH
 - Submit target list to LCH ~ 6 months ahead of planned operation
 - Specify frequency of operation
 - Coordinate with LCH 7 days ahead of planned operations
 - LCH emails PA periods for laser transmission 24 hours in advance
 - Files are loaded in to safety system computer and automatically generate trigger to shutter transmission during LCH prohibited periods
 - LCH contacts POCs to deny transmission if unanticipated conflict arises
- Tier-3 not invoked for waived laser transmission



Preparing For Operations



- LCH predicts converted from email text to ASCII file and loaded onto LASSO computer
- Mock file generated with PA times advanced to check system operation prior to transmission
- Laser power up and output delivered to beam dump
- Telescope is pointed to mountain peak to check Tier -1 and Tier-2 system responses.
- Tier-3 response in checked against mock PA file



Operator Display

“Equipment Status” row displays operational status of each tier and the I/O board

- Green = Equipment functional
- Red = Equipment not responding

“Treeline” warning

- Green = Pointing above site terrain
- Red = Pointing below site terrain

5 minute time history plot of detection status for each tier

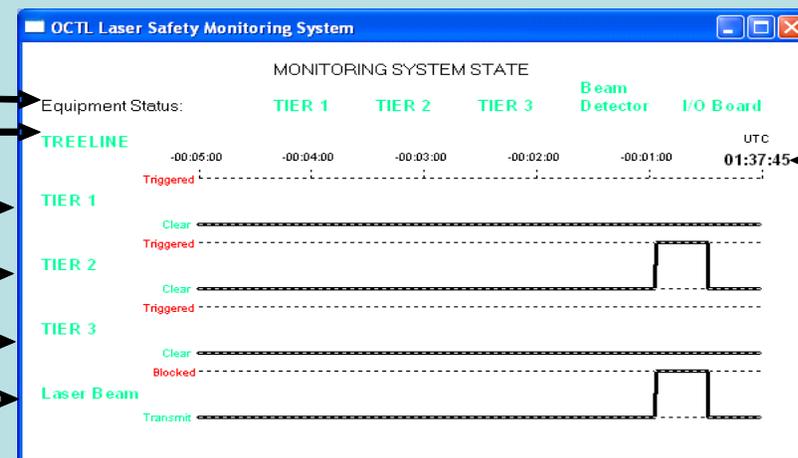
- Tier labels are highlighted according to corresponding detection status
- Green = Safe for laser propagation
- Red = Object Detection

5 minute time history plot of shutter response

- “Laser Beam” label is highlighted according to shutter response
- Green = Verified that shutter commanded to open
- Red = Verified shutter commanded to close

Running clock of current time

- reference for time history plots
- evidence that software is executing





History Of Safe Laser beam Transmission From TMF



- 1992: Galileo Optical Experiment (GOPEX) =>532-nm
 - Nighttime beam propagation
 - JPL worked with FAA to define guidelines for safe atmospheric laser beam propagation.
 - FAA required an outside observer
- 1995 & 1996: GOLD Demonstration=>514.5 nm, 7W
 - Daytime and nighttime beam propagation
 - FAA required outside observer and radar system integrated to the telescope
- 2009 Active satellite tracking=> 532nm
 - Tiers-1,2 and 3 activated with outside observer
- 2009 OTOOLE => 800nm
 - LCH waived transmission
 - Used Tier-1 and Tier -2 safety systems
 - Outside observer alerted operators of aircraft at risk



Planned Experiments



- Track Moon and Mars
 - Record Tier-2 radar outages
 - Request Tier-3 predictive avoidances over extensive 24 hour period
- Develop representative statistics of mission profile