Strategies to Support Safe Laser Beam Transmissions from Unattended Facilities

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Presentation to G-10 Committee

Outline

- Presentation objective
- Technology Driver, Challenge, Optical comm
- Problem Statement
- FAA Policy & Significance
  - Operational Requirements
  - Looking Forward
- Planned NASA Missions
- History of Safe Laser Transmission from TMF
  - Proposed Approach for Unattended Laser Beam Propagation
  - LASSO Test bed
- Summary

Presentation Objective

- To apprise community of future proliferation of optical ground stations
  - Meets future need for secure high bandwidth links to deep space probes, near- Earth spacecraft and aircraft
- Obtain committee's guidance on meeting the need to support unattended operations from remote ground stations
- Provide information and technical guidance to support future lasercomm needs and ensure correct policies are implemented

Technology Drivers & Challenges

Technology Driver

- Novel strategies will enable launch of small specialized satellites that can generate large volumes of data from advanced imaging instruments
- Optical communications offers high bandwidth links and enables data returns at unprecedented rates from small airborne and space borne platforms

The Challenge

- Cloud cover impacts the availability of ground station for optical downlink
  - Preferred ground station locations are on mountain tops to mitigate effect of signal fades

Overcoming the Challenge

- Timely return of data requires ground stations be dispersed in sites with uncorrelated weather patterns
- Universities with small transceivers can collaborate to retrieve data and return it to owner via internet

Problem Statement

- Operational scenarios to support high bandwidth data return from aircraft and spacecraft call for laser uplink beacons from the ground to maintain stable pointing of downlink to ground receiver proliferation of ground stations to mitigate effects of cloud cover
- High power uplink laser beam propagation through navigable air and near-Earth space can put space assets and the flying public at risk
  - U.S. Space Command Laser Clearing House (LCH) regulates laser beam propagation from US territories into near-Earth space and has an established procedure to ensure safe laser propagation from DoD facilities into near-Earth
  - Federal Aviation Administration FAA regulates laser beam transmission through navigable air space

Constraints on beam propagation impact link availability and impact the deployment of remote, unattended ground stations

FAA Policy and Its Significance

Policy

- FAA policy is that no aircraft are to be illuminated by laser beam irrespective of NOHD unless they are specifically a part of the experiment

Significance

- FAA policy will serve as a guide for international policy on laser beam propagation through navigable air space
- JPL/NASA /ESA meeting May 16, 2011 at TMF
  - <u>Europe will look at US policy to develop its own policy for safe laser beam propagation</u>

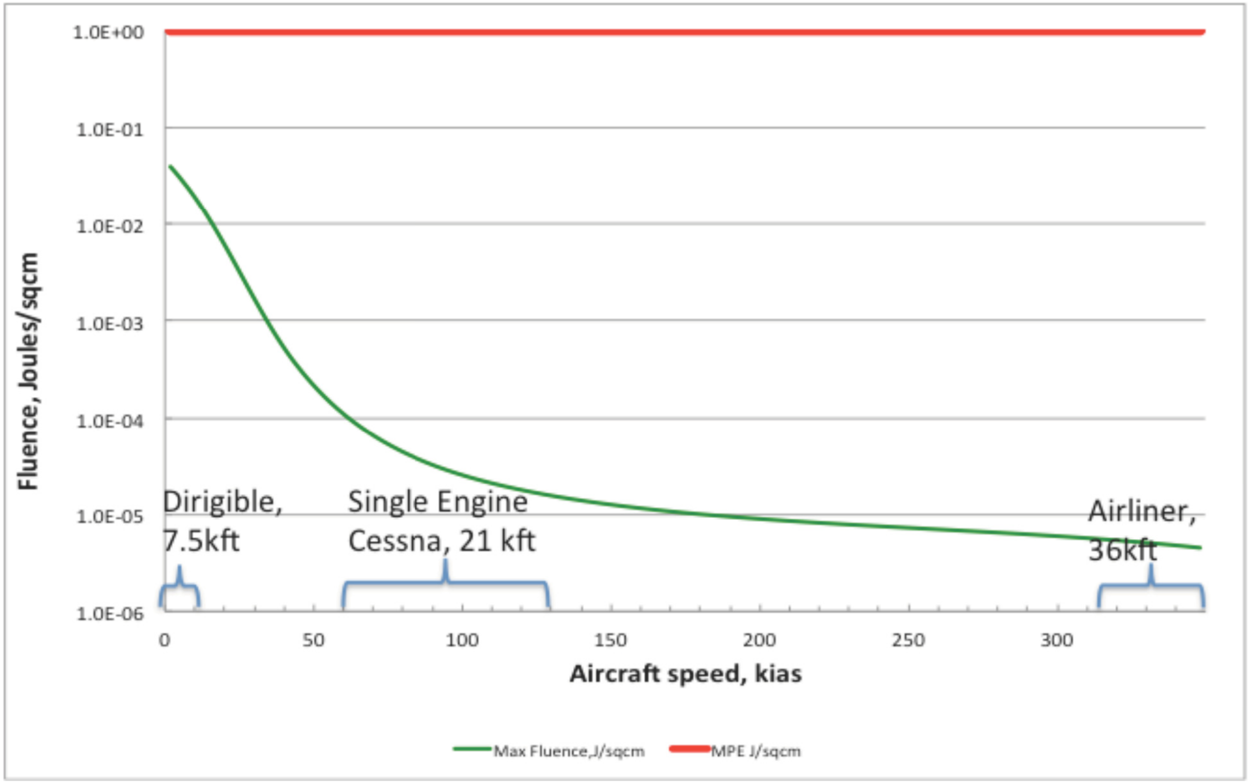
FAA Operational Requirements

- 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

Outside observers looking for backscatter from laser uplink is not an effective means of identifying aircraft at risk when propagating IR beams

Near-IR NOHD analysis considers 10 second exposure and does not take into account moving aircraft which reduces exposure time to laser radiation and results in lower fluence levels

Uplink Fluence vs. Aircraft Speed



- Laser beacon uplink to lunar satellite
  - 1567-nm lunar uplink transmission
  - Exposure levels are below maximum permissible exposure limit even for craft at 2 knots

Looking Forward

Request FAA to support

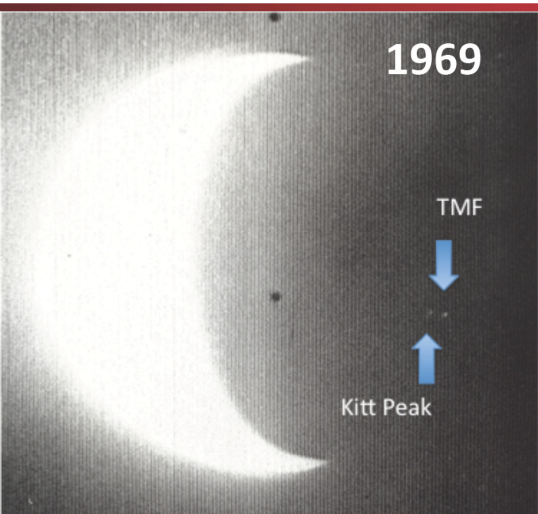
- Adoption of a safety system that supports unattended operation from remote ground stations
  - System that automatically detects and shutters laser beam when aircraft is at risk of intercepting laser beam
- Establishment of a policy that realistically reflects safety risk posed by the laser transmission
  - Development of requirements that consider the effects of aircraft motion on NOHD calculations

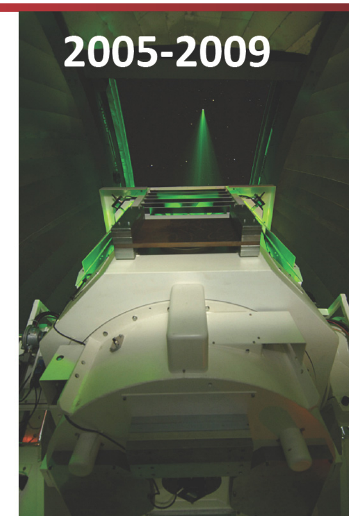
Proposed Near-term NASA Experiments

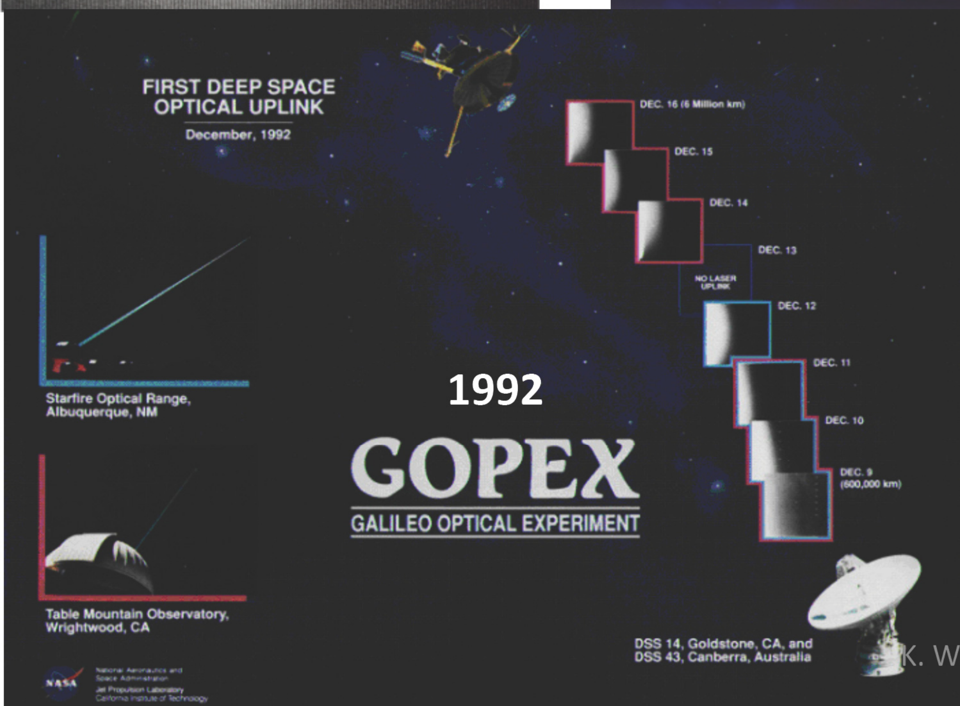
Future lasercomm missions will be impacted by policy

- Loss of uplink beacon signal will S/C to reacquire beacon
  - Process can last from seconds to minutes
- 2012
  - 1064-nm, 523-nm laser transmission experiments from TMF
- 2013
  - 1568-nm uplink to LADEE spacecraft from Hawaii & TMF
  - 976-nm uplink to ISS

Laser beam Transmission From TMF







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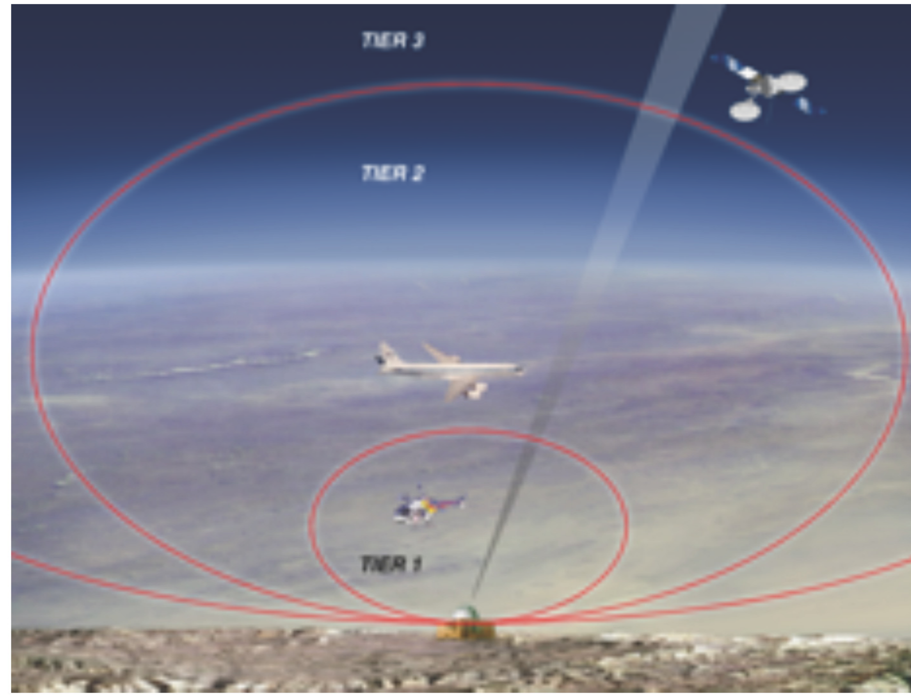
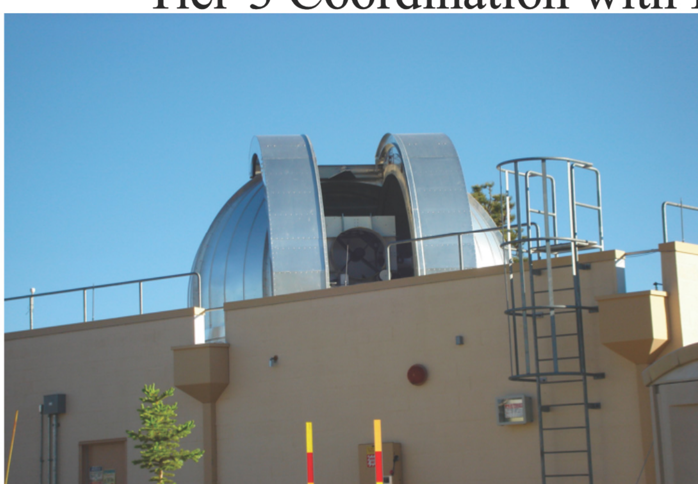
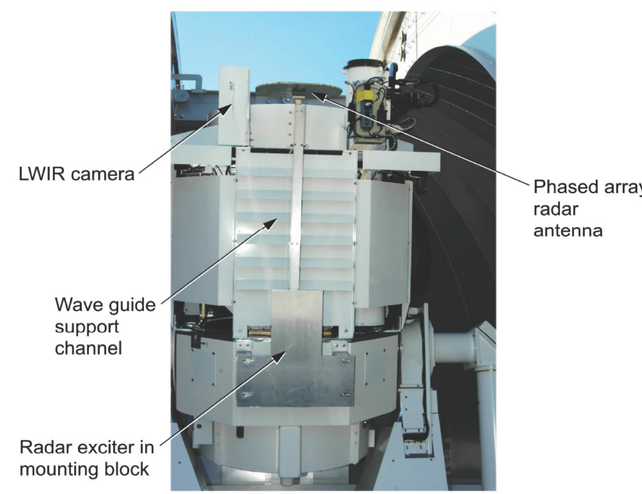
LASSO

- Three-tiered (LASSO) laser safety system at OCTL (Optical Communications Telescope Laboratory) <u>can support remote unattended operations</u>
  - Tier-1: Long Wave IR wide field cameras
  - Tier-2 X-band radar system bore sighted with telescope
  - Tier-3 Coordination with LCH







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LASSO operator display

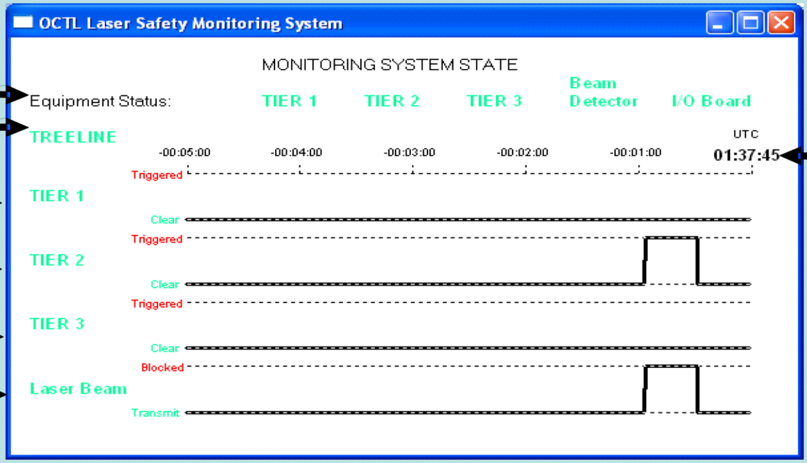
Operator Display

"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

Running clock of current time
- reference for time history plots
- evidence that software is executing



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

Summary

- Proliferation of ground and airborne optical communications terminals will require regulatory agencies to provide guidelines that support safe laser beam transmission from unattended remote locations
- Current requirements to deploy outside observers is ineffective when propagating near-IR beams and does not support future laser beam links
- Future expansion lasercomm technology will require international coordination for safe laser beam propagation from airborne assets and remote unattended ground facilities
- Based on its experience over the past twenty-years, JPL has developed a three-tiered safety system that can support safe laser transmission from unattended facilities
- **FAA can take advantage of this opportunity to guide organizations worldwide in adopting an effective policy that supports safe laser beam transmission through navigable air space from unattended facilities**