Optical Communications Telescope Laboratory (OCTL)

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Purpose

- Facilitate discussions on defining types of operations (i.e. remote, unattended, automated, autonomous)

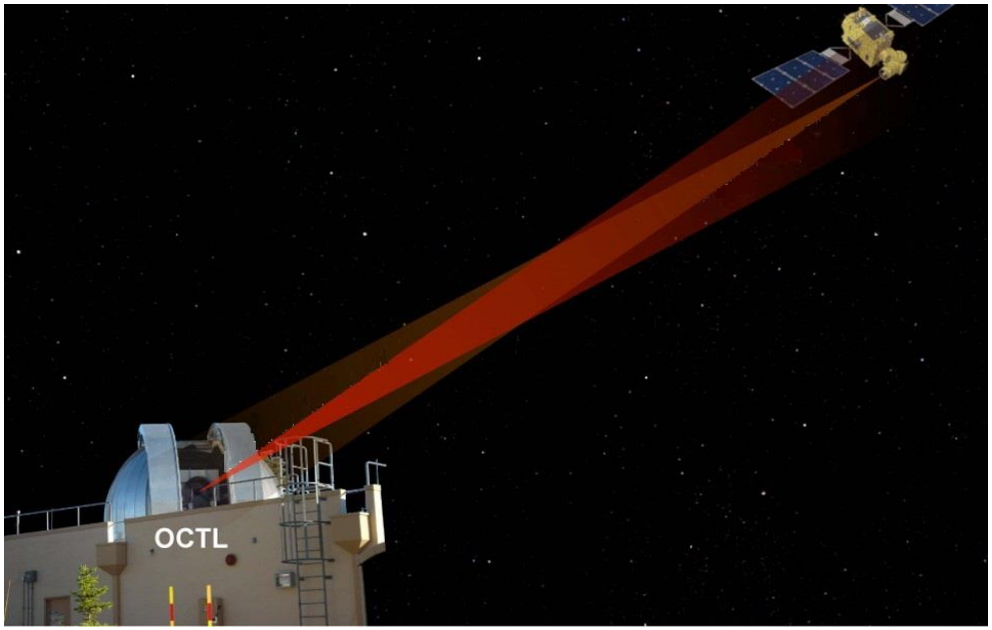
- Applications such as Satellite Laser Ranging and Optical Communications
  - Expanding number of ground stations
  - Potential sites may be remote or isolated locations
  - Potential round the clock operations
  - Potential synchronized multiple ground station operations

- Bottom Line: Project $$$ Savings
  - Operators are expensive and have physical limitations
  - Travel expenses to remote locations

Agenda

1. OCTL Overview
2. LAser Safety System at OCTL (LASSO)
3. Laser Communications Relay Demonstration (LCRD)
4. General discussion on types of operations

Optical Communications Link



- Offers high data rates with compact, lightweight, and reduced power systems when compared to RF
- Links are at near-IR wavelengths
- Typical space to ground link requires an uplink beacon for stable spacecraft pointing throughout downlink pass

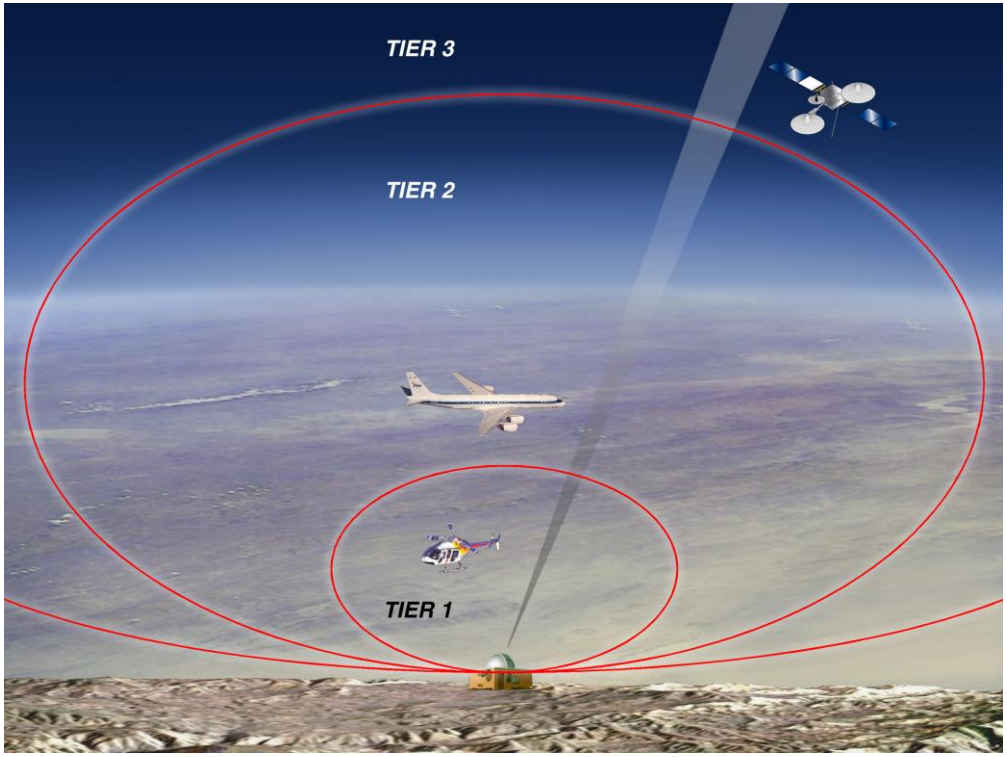
OCTL - Overview

JPL Table Mountain Facility (TMF)
Latitude: 34° 23’ 53.4” N
Longitude: 242° 10’ 04.2” E
Altitude: 2285 m

- R&D facility to advance optical communication development and strategies, and serve as a model for future ground stations
- 1-m coudé focus optical telescope with Az/El mount, first light 2004
- Designed for day and night operations
- Airspace is at the intersection of several major airport flightpaths
  - Los Angeles (LAX)
  - Ontario (ONT)
  - Burbank (BUR)
  - Edwards AFB

OCTL Outdoor Laser Safety
Heritage 3-Tier Strategy

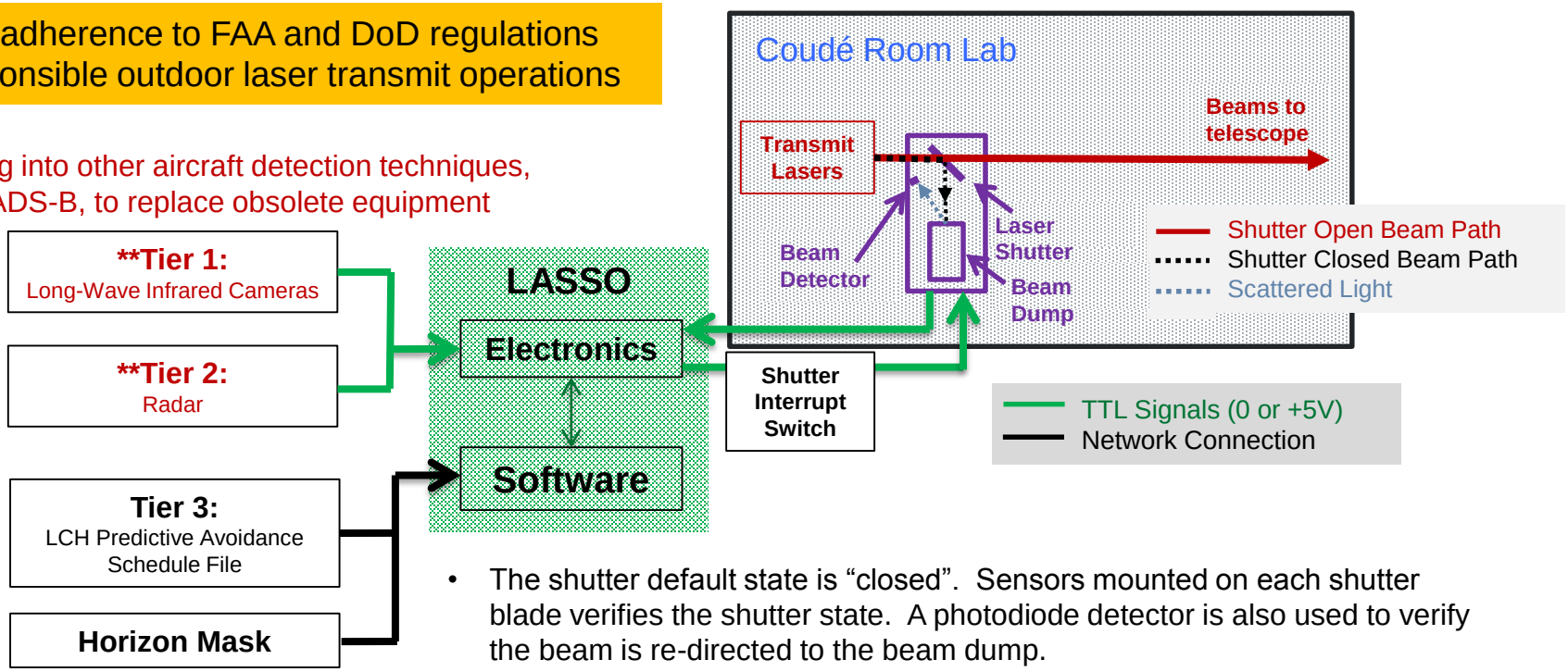
- Tier 1
  - FAA controlled region ranging from dome out to 3.4km
- Tier 2
  - FAA controlled ellipsoidal region ranging to 20km @ zenith and 58km @ 20° elevation
- Tier 3
  - Laser Clearinghouse (STRATCOM) region extends from near-Earth to the ranges of geo-stationary and high elliptical orbiting satellites



LAser Safety System at OCTL (LASSO)

Ensure adherence to FAA and DoD regulations for responsible outdoor laser transmit operations

** Looking into other aircraft detection techniques, such as ADS-B, to replace obsolete equipment



- The shutter default state is “closed”. Sensors mounted on each shutter blade verifies the shutter state. A photodiode detector is also used to verify the beam is re-directed to the beam dump.
- LASSO sends power to the shutter to hold it open allowing the beam to pass when all criteria for safe laser propagation are met.
- Shutter returns to “safe state” blocking the beam when power is cut or subsystem fault is encountered.
- Interrupt switch to override automated shutter and manually block the beam is built-in to the software and a physical switch is also located on the LASSO electronics box

Recent & Future Demos at OCTL

- Recent and current…
  - 2013: Lunar Laser Communications Demonstration (LLCD) – Lunar orbit 400,000 km
  - 2014 to current: Optical PAyload for Lasercomm Science (OPALS) – ISS LEO 370 km
- On the horizon…
  - 2019-2021: Laser Communications Relay Demonstration (LCRD) - GEO
- Future…
  - 2023: Deep Space Optical Communications (DSOC) – Psyche (main belt asteroid)

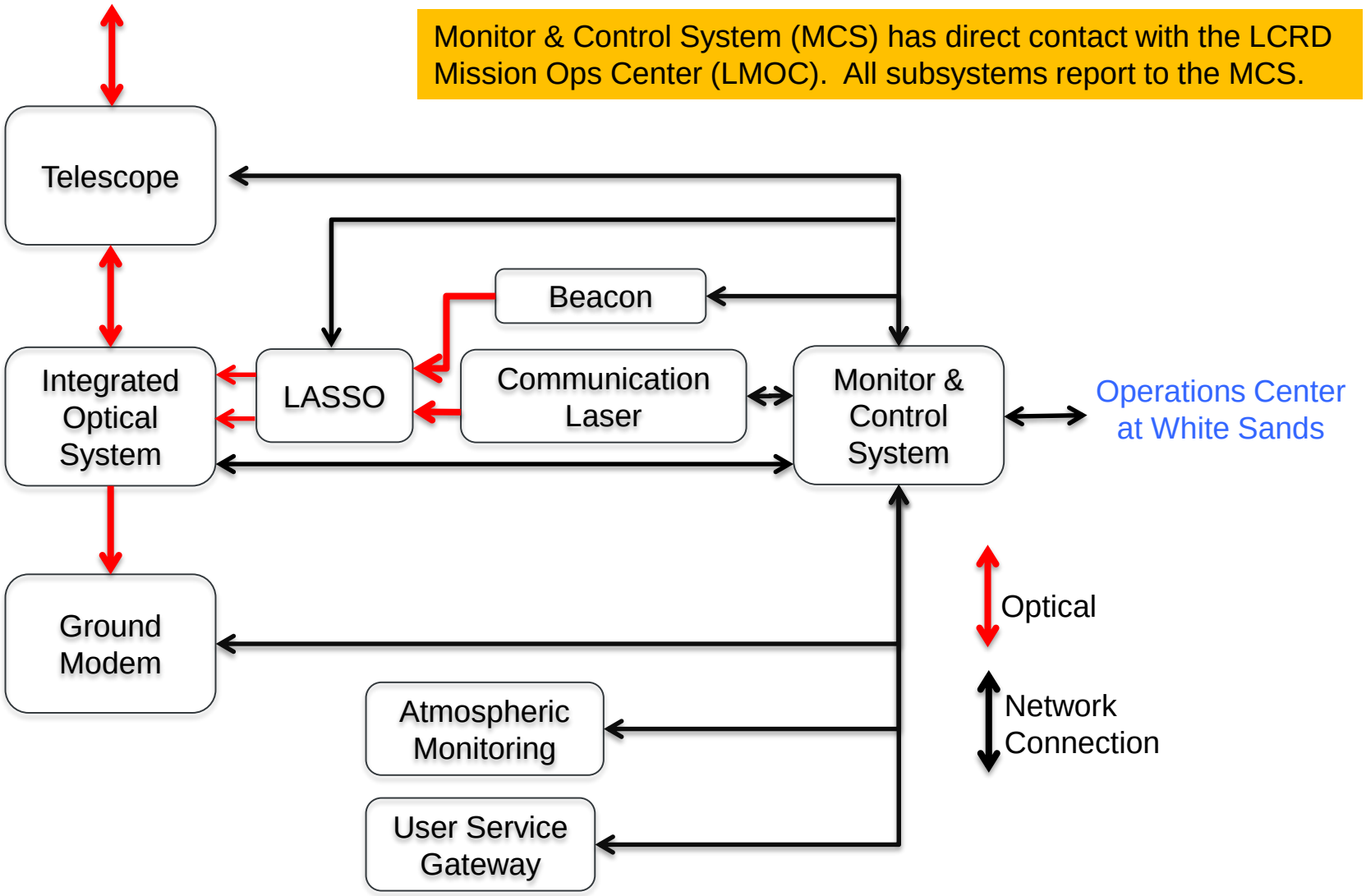
LCRD Overview

Technology Demonstration

- Long-duration optical communications mission (5-year capability)
- USAF Spacecraft Host – 2019 Launch
- Flight Payload
  - Optical payload consists of two space terminals independently articulated
- Two Optical Communications Ground Stations (OGS)
  - OGS-1: Upgrade OCTL at TMF
  - OGS-2: To be built in Hawaii
  - Develop common infrastructure and hardware
- High data rate RF ground station at WSC (White Sands Complex)
- Operations Centers
  - Mission Ops Center (WSC)
  - Partial mission ops center (GSFC)
  - Spacecraft managed by Orbital ATK

LCRD OGS-1 Block Diagram

Monitor & Control System (MCS) has direct contact with the LCRD Mission Ops Center (LMOC). All subsystems report to the MCS.



LCRD Optical Ground Station 1 (LOGS-1) Concept of Operations

Operations:

- 40-hr/week spacecraft link activity
- Automated operations based on schedule files from the LMOC
- At least two operators on duty at the site to monitor system

Capabilities:

- 24/7 link up to 2 weeks at a time
- Limited remote access for trouble-shooting

Long-term duration of mission in addition to low NOHD near-IR transmission provides opportunity to develop and test remote/unattended operation strategies as a model for future ground stations

Discussion: Defining Types of Operations

- Remote
  - Trouble-shooting vs. operations
    - Access to trouble-shoot with some operational capability
    - Access to monitor operations
    - Access to control operations
  - On-site vs. off-site
    - Connecting to system from a separate on-site computer (same room or different building but same site)
    - Connecting to system from off-site
    - ➢ If system software is on a server, what is the difference whether logged in from on-site or off-site?
- Unattended
  - Operator(s) off-site
  - Operator(s) on-site but distracted from monitoring system (such as lunch/coffee/bathroom break)
    - ➢ How long can an operator be away from the system before considered "unattended"? >15 minutes? >30 minutes?

Discussion: Defining Types of Systems

- Automation
  - Functions performed by a system without human interaction but an operator oversees control for safe operation
    - Example: LASSO system can self-identify malfunctions and automatically block laser transmission when they occur, but human is still needed to fix problems. LASSO cannot react to LCH unscheduled cease transmissions without system input.

- Autonomous
  - A self-monitoring automated system that does not require an operator for normal operations and safe for all operations
  - ➢ *Does such a system need to include self-correcting capabilities if there is a malfunction? Or just stop operations and recover to a fail-safe state (may require human assistance to re-start operations)?*

Further Discussion

- *Is an "automated" laser safety system satisfactory for remote and/or unattended operations?*
- *Under what circumstances should an "autonomous" system be considered over an "automated" one?*
- *What additional features are needed to upgrade a system from "automated" to "autonomous"?*
- *Is "self-certifying" the safety system acceptable or is additional certification needed for remote and/or unattended operations?*