Recent Upgrades to the Optical Communications Telescope Laboratory

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JPL recently procured a 1-m telescope for research and development (R&D) of deep-space optical communications strategies. The telescope's coudé focus design allows precise pointing of high-power laser beams to deep-space probes. As an R&D laboratory, the Optical Communications Telescope Laboratory (OCTL) will act as lead in a variety of areas of free-space communications, such as developing strategies for safe laser-beam propagation through the atmosphere and the challenges associated with daytime operations when pointed at small Sun angles. We have recently made modifications to support high-power operation from the OCTL and to ensure safe laser-beam propagation and daytime operations.

I. Introduction

The Optical Communications Telescope Laboratory (OCTL) telescope was delivered and installed in December of 2003. Since that time, the telescope system has undergone numerous tests in order to assess its performance. Since the facility will be used as a ground-based free-air laser communications terminal during daytime as well as nighttime, many additional upgrades have been incorporated for safe and reliable operation. These upgrades are as follows:

(1) Installation of a radar system to the telescope to avoid aircraft during laser propagation

(2) Installation of a long-wave infrared (LWIR) camera for tracking aircraft flying in low-to-three-mile altitudes during laser propagation

(3) Installation of a Sun shield to protect dome drive electronics during daytime operation

(4) Installation of an outdoor shed for a laser chiller system away from the facility

(5) Installation of four video cameras at various points for remote monitoring

Each of the above-mentioned topics is described in the following sections.

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[1] Communications Architectures and Research Section.

[2] Communications Ground Systems Section.

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II. Radar System Installation

The radar is one element in the integrated safety system. It is a Primus 4000 model manufactured by Honeywell Corporation [1]. It was used previously for aircraft detection in JPL's 1995 Ground/Orbiter Lasercomm Demonstration (GOLD) [2]. The system consists of a transmit/receive unit that is integrated with the antenna, and a control and display unit. A 28-V, 7-A power supply powers the system. Figure 1 shows the radar system with the display and the transmit/receive units interfaced by means of a cable.

The radar system is used as one of the laser safety tiers [1] to track planes and send a trigger signal to the safety system. Hence, it was decided to install the transmit/receive unit on the telescope. To preserve static and dynamic balancing, the unit has been installed at the lower side of the telescope by means of an adaptor block. To improve mechanical stability, the waveguide and antenna have been clamped to a rigid plate (Fig. 2).

The radar display unit is integrated with the laser safety control box and installed on a rack in the control room. The display–transmit/receive interface cable consists of two sections. The first section is a 22-meter-long multi-coax–multi-conductor cable that connects to the power supply and display unit from one end and is routed through cable trays through the coudé room to a bulkhead connector on the other end (Fig. 3).

The remaining length of the cable to the transmit/receive unit is routed internally from the bulkhead connector through a cable guide inside the telescope and terminates at a 55-pin connector for the unit. Great care was taken to meet the radar manufacturer's requirements for shielding and grounding at this point. After installation of the radar system, extra balancing weights were added to proper locations on the telescope for static balancing. The telescope system then was operated to verify the balancing and smooth operation. Prior to power-up, checks for continuity and shorts were made throughout the entire length. Once powered up, the telescope was pointed at a far-field target, and hits were verified from the display unit.

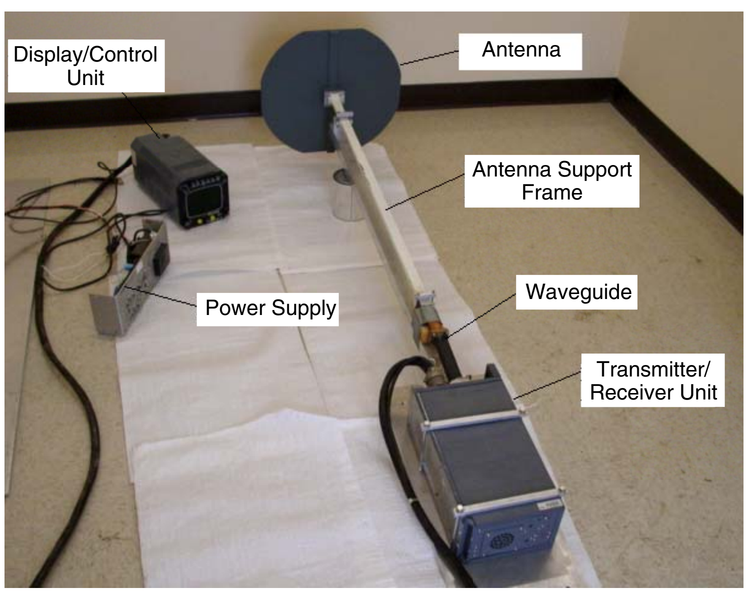

Fig. 1. Radar system.

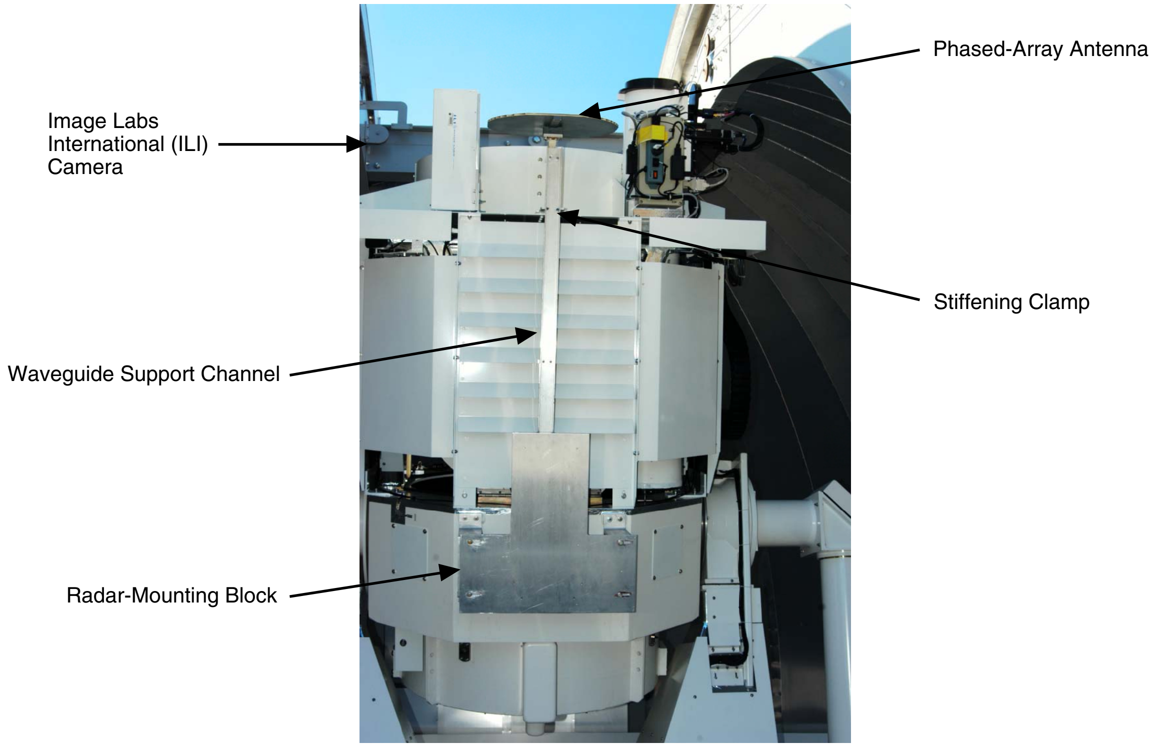

Fig. 2. Radar-mounting scheme on the telescope.

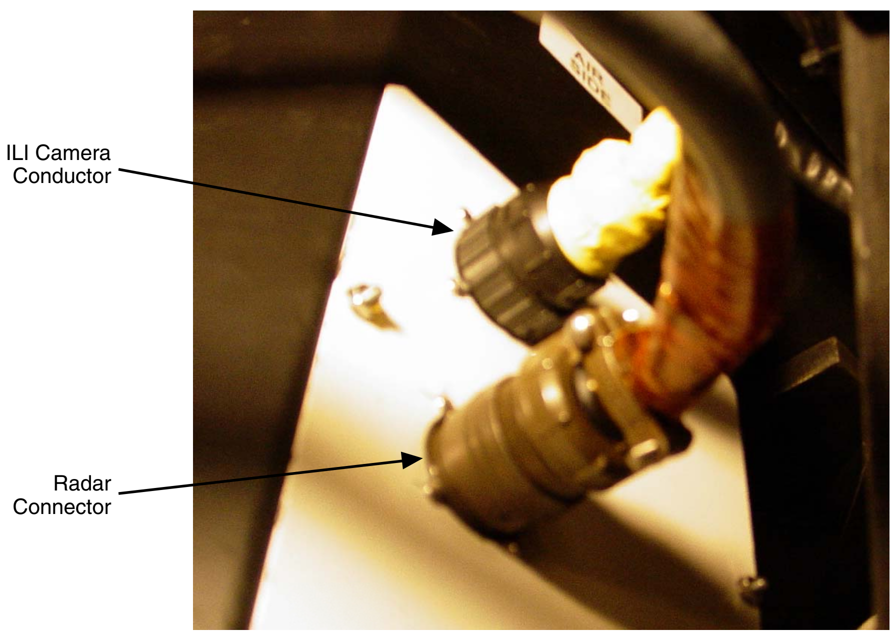

Fig. 3. Bulkhead connectors at the telescope tray.

III. LWIR Camera System Installation

The LWIR camera system consists of two barium strontium tantalate (BST) focal-plane array (FPA) units packaged together and a control box that interface together by means of a cable (Fig. 4). Each camera is equipped with separate lenses that provide a wide-field and a narrow-field of view.

The control box is mounted in the same rack as the laser safety system and communicates with a personal computer (pc) for control and laser shutter trigger signals. Due to the large field of view of the camera and the possibility of the dome slit getting in the field of view, it was decided to mount the unit at the bottom-front face of the telescope. A 1-cm-thick aluminum plate is used as an interface and is bolted to a support bracket to the telescope input aperture. The interface cable for the system consists of two segments. The first segment connects to the control box at one end and a separate bulkhead connector at the telescope coudé box from the other (Fig. 3). The second segment is routed from the bulkhead connector internally through the telescope cable router to a mating connector for the camera housing. Efforts were made to comply with the manufacturer's requirements for shielding and grounding.

After installation, the telescope was balanced in a similar manner as the radar system and was operated to ensure no transients were present. Prior to power-up, cables were checked for shorts and continuity.

IV. Sun-Shield Installation

During daytime observations, the curved, smooth surfaces of the dome walls act as spherical reflectors of sunlight and focus the beam at the power rails that carry power and control signals for the dome drive. Most dome vendors anodize or paint the interior walls in order to prevent such an effect, but, for the case of the OCTL, no coating was used. This causes the rails, which are plastic, to expand and melt on some occasions. To prevent this from happening, a sun shield was designed and fabricated from aluminum (Fig. 5). A high-temperature, highly reflective paint was used to double coat each segment and was tested for effectiveness prior to installation. The plates were joined together by means of aluminum channels that bolt to the rotating part of the dome bracket at the bottom face and are tapered at the top

Fig. 4. ILI camera system.

Fig. 5. Sun shield for dome power rails.

face. Once bolted at the top face, the shields are oriented at approximately 15 degrees with respect to the horizon, hence, providing a baffling effect against the Sun rays during daytime and reflecting infrared away from the telescope at nighttime.

V. Laser Chiller Outdoor Shed Installation

The Nd:YAG laser system for the satellite tracking produces 12.5-W and 32-W average power at 532 nm and 1064 nm, respectively. The coolant system for the flash lamps and optics is circulated through an internal heat exchanger which, itself, is cooled by an external water chiller manufactured by Affinity Corporation. To minimize thermal infrared (IR) signatures created by convected warm air from the chiller, an outdoor shed was procured and installed approximately 50 feet (16 m) away from the building (Fig. 6). The chiller is housed in the shed with the supply and return water lines routed 3-feet (1 m) underground. Great care has been taken to provide the necessary insulation at the connections over ground. A thermostatically controlled fan heater installed inside the shed provides the required environment to the chiller. The power to the system is provided from a three-phase 208-V outlet installed outside the building.

VI. Video Camera Installation

Safe and efficient operation of the OCTL facility requires knowledge of the weather, personnel, and hardware status. This prompted the procurement of four video cameras from Cohu Instruments—two units were Model 1300 color charge-coupled devices (CCDs) and the other two were Model 2700 monochrome CCDs. From these four, two cameras are equipped with extra sensitivity in the near-IR and, hence, provide operation in dimmer lighting conditions. One of the two is installed in the dome pointed at the telescope. This will allow operators as well as remote users to have a knowledge of the dome and telescope positions and of whether the dome slit is engaged. The other near-IR camera is installed inside the coudé room pointed at the optics tables. This will allow the users to monitor the presence of personnel near the coudé optics, especially when the laser is on. The third camera is mounted in the operations (control) room pointing at the control consoles. This will allow remote users

Fig. 6. Laser chiller outdoor shed.

to monitor the presence of personnel in the room. The fourth camera is encapsulated in a weather-proof housing and mounted at the top of the roof of the OCTL facility. The camera points at the dome in the foreground and the mountains and sky in the background. This will provide valuable information to both operators and remote users as to the weather conditions as well as to the possibility of ice and/or condensate formation on the dome.

Video outputs from all four cameras are processed and displayed by an Adlink frame grabber installed in a pc. The pc has been connected to the internet so that displayed information can be accessed by remote users.

VII. Conclusion

The OCTL facility has been built for both day and night optical communications as well as satellite tracking. With the recent additions and modifications, this task will be accomplished more efficiently and in a safe manner.

Acknowledgments

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References

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