Reagan Test Site Optics Modernization Program

Upgrades to the optical systems combine state-of-the-art commercial focal plane technologies with a wide-area, network-centric, open-system design to allow distributed system command and control while achieving record-high metric accuracy.

From intercontinental ballistic missile developmental testing in the late 1960s to hypersonic glide-vehicle testing in the 2010s, the suite of tracking and staring optical sensors at the U.S. Army Reagan Test Site (RTS) on the Kwajalein Atoll, Marshall Islands, has made critical contributions to Department of Defense (DoD) missile defense and space control programs. By the early 2000s, the DoD and industry clients seeking test support from the RTS systems were demanding advanced capabilities, such as new high-speed, high-resolution camera technology. Concurrently, the failure rates and the costs of operating and sustaining the RTS optical systems had increased. Corroded telescope optics, outdated focal planes, and obsolete computer equipment all contributed to the deteriorating system capability and to the degradation or loss of data on important flight tests. By 2007, the optical suite's performance and capabilities had declined to a point at which it became vital for the Army to undertake a modernization program if the site were to retain its preeminence in optical tracking and imaging. In 2015, MIT Lincoln Laboratory, under Army sponsorship, successfully completed an eight-year, $20 million program to upgrade the RTS optical suite.

The optical systems used by the Reagan Test Site are geographically dispersed around the six islands as shown in this map of the Kwajalein Atoll. The older film cameras in the optical systems were replaced with high-resolution digital cameras. With their wide variety of cameras and lenses, the five Super RADOTs (Recording Automatic Digital Optical Trackers) are the most capable systems in the suite. All the systems can be controlled by personnel at the Optics Remote Operations Center located in Huntsville, Alabama.
For the RTS Optics Modernization Program (ROMP), Lincoln Laboratory engineers integrated many technologies into a complex “system of systems” that enables remote, distributed command-and-control mission operations from Huntsville, Alabama. To achieve robust remote operation of an unattended field site, the ROMP team first had to make substantial infrastructure upgrades: installing remote software-switchable power relays, programmable astromodes, fail-safe rain sensors that activate automatic dome closure, and control room instrumentation and video systems that provide remote monitoring of system health and status. In addition to implementing these infrastructure advancements, the ROMP team successfully developed and delivered sustainable new technology upgrades to servo control systems, digital focal planes, high-speed data recording systems, lenses and telescopes, scripted and automated sensor control systems, and an automatic encrypted security lockdown architecture to support classified operations on Kwajalein’s uninhabited outer islands.

**Design Approach**

Use of off-the-shelf x86 computers and established industry standards, such as the Camera Link communication protocol, enabled the engineers to develop a low-cost, sustainable command, control, and data-acquisition hardware architecture. The sensors’ design leveraged advanced commercial focal plane arrays and new off-the-shelf programmable cameras that have larger-format imagers with increased pixel densities, better sensitivity, increased dynamic range, and higher imaging rates.

ROMP was the pilot project for the Laboratory’s Real-time Open Systems Architecture (ROSA II), a distributed computing technology developed with line funding from the Laboratory’s Technology Office. The design of the ROSA II optics software components was based upon a careful functional decomposition of the Super RADOT (Recording Automatic Digital Optical Tracker) systems. Each software component is written to “publish” key data messages to the network while also “subscribing” to data messages it needs from the network. Generally, a ROSA II optical system’s computer is configured to run a set of closely related components, and the number of required computers scales as needed to compose the complete distributed system architecture. System operations could thus be composed by using a highly configurable and scalable approach that can employ any number of computer systems distributed across a local or wide-area network.

The new ROMP sensors operate in the visible, mid-wave infrared (MWIR), and long-wave infrared (LWIR) bands. The main tracking mount sensor is Vision Research’s Phantom v341 camera integrated with the tracking mount’s 24-inch Perkin-Elmer telescope. The Phantom camera was selected as the workhorse metric measurement system because of its high-speed and high-resolution capabilities. This main sensor is the backbone of the modernized systems’ metric tracking and imaging capability. Since being fielded in summer 2013, this sensor has enabled 30% longer data collection spans than attained by the former system while consistently generating metric data more than twice as accurate as data previously captured. Each tracking optics system is also outfitted with a zoom and pan wide-field-of-view situational awareness sensor; a true-color, high-resolution, and long-focal-length secondary metric sensor; and MWIR and LWIR infrared cameras behind new and refurbished 16-inch and 20-inch aperture infrared telescopes.

**Challenges**

The field upgrade of twin optics sites at the uninhabited outer island of Legan was particularly challenging because the classified systems and networks could not be operated on Legan until a secure solution was devised and approved. Lincoln Laboratory personnel responded with a rapid, focused effort to design a novel security architecture involving physical security, intrusion detection, encrypted computer systems, and remotely zeroized cryptographic networks. This architecture, which was designed, built, fielded, and operationally accepted in less than a year, provided a first-of-its-kind automatic, remote secure lockdown encryption solution. Other significant challenges that arose during system integration and initial sensor operations included the validation of precise image timing and the design and implementation of new digital focal plane calibration techniques. Advanced calibration algorithms and analysis tool enhancements were critical to the detection and correction of data artifacts (i.e., timing errors) that arose from the distributed systems’ timing and data-acquisition architecture.

**Future Directions**

The technologies developed for ROMP are being utilized in follow-on efforts at RTS but also can be applied to other projects. For example, representatives from several test ranges and the sponsor for a newly proposed U.S. Army optical asset have expressed significant interest in the open-systems distributed software technologies and in the remotely operated command-and-control paradigm developed for ROMP. Under the DoD’s Central Test and Evaluation Investment Program, the Optical Radar Calibration Adjunct (ORCA) rapid development project is reusing ROMP technology to integrate an optical star tracker with the AN/MPS-36–class radars at RTS in order to use star truth data to model metric bias of the radar antenna. The ORCA initiative will greatly enhance AN/MPS-36 metric accuracy while avoiding the need for the DoD to invest in the launch of a new beacon-equipped metric calibration satellite into orbit. Going forward, Lincoln Laboratory will continue innovative technology improvements for RTS, including the recently announced modernization of the Ground-Based Radar Prototype.