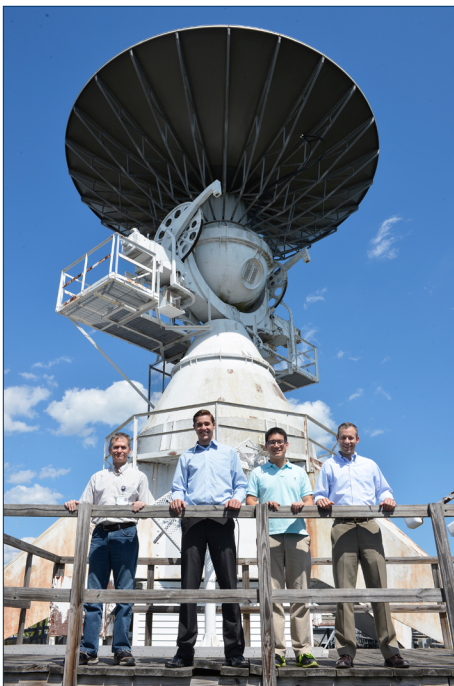




COMMUNICATION SYSTEMS

Students Partner with Laboratory Staff to Modernize LES-9 Satellite Communications



Laboratory staff and summer research students in front of the satellite dish on the roof of B-Building.

As Laboratory staff enter the West Atrium, the morning light catches a familiar object suspended from the ceiling and illuminates it in its fullness of silver and gold. Draped in the original material used on its orbiting counterpart, a satellite model built by Minuteman Technical High School students and Laboratory staff hangs reminiscent of one of the Laboratory's first pioneering inventions, the Lincoln Experimental Satellite (LES) family. Launched on 14 March 1976, LES-9 is the last in a series of three-axis stabilized satellites built by the Laboratory that are powered by a radioisotope thermoelectric generator (RTG). Continuing this legacy, Albert P. Richard, John R. Pineau, John J. Kangas, Warren K. Hutchinson, and Dr. Thomas C. Royster IV, Advanced Satcom Systems and Operations, Group 64, are transitioning the satellite to the digital age. Summer Research Program participants Jonathan Oakley, Clemson University, and Alan Dong, Georgia Institute of Technology, have collaborated with staff to develop the next chapter of the satellite's life. Both students worked towards transitioning the satellite's original analog communication devices to digital platforms using a software radio platform.

Approaching its 40th year in operation, LES-9 continues processing telemetry and exercising the command link. A technological feat of its time, the satellite featured communication at a data rate of 75 bits/s teletype to 2400 bits/s vocoded voice, along with computer data exchanging at a rate of 19200 bits/s. The experimental communications satellite was developed for the U.S. Air Force and designed to operate in coplanar, circular, inclined, and geosynchronous orbits. Royster recalled the insights gained from work on the satellite, "LES-9 demonstrated critical technologies that set the stage for current military secure antijam military satellite communications systems." The LES Operations Center (LESOC) remains preserved

in a second-floor B-Building room. Inside, a 1950s-era clock whispers of an exciting time for some of the Laboratory's first visionaries. LESOC's conservation illustrates the Laboratory's decades-long commitment to reliable space communications. The ultra high-frequency (UHF) antennas and the recognizable dish on the roof of B-Building, combined with LESOC's analog hardware, serve as the original paths of connectivity with LES-9.

Given the age of the analog hardware, certain obstacles arose that the team had to address. The satellite communicates via links and terminals connecting from the Earth's surface. Currently, these terminals are in contact with the satellite's UHF transponder in a low-power and low-bandwidth configuration. "In some cases, the components on these paths have been in service for over a decade," Royster said. This has caused a weaker downlink signal, affecting communications with the satellite. In order to address this issue, Dong and Oakley focused on developing a software radio platform. The platform is built to function using C++ programming running on a standard desktop computer. Through the platform, the digital transmit signal converts to an analog signal to communicate with the satellite. The satellite then returns its signal to the antenna on the roof of B-Building, and the platform converts it to digital samples.

Initially, Dong and Oakley assessed the functionality of LES-9's analog hardware by debugging existing transmit and receive paths. Oakley explained, "The debugging process was long and required considerable attention to detail—since the problem was multidisciplinary, it required a team effort to understand and fix the problems." Several hardware components had to be switched and tested in various configurations while maximizing signal quality. Oakley experimented with various types of communications waveforms on software radio platforms. The summer's research has brought the team closer to eliminating use of the aging analog hardware and transitioning all LES-9 communications to the software radio platform.



Student Alan Dong explains how the antenna is used to communicate with the LES-9 satellite.

Moving forward, the team hopes to extend the software radio project to a software radio Independent Activities Period (IAP) course designed by the Communication Systems, Division 6, staff. The team will work with the Beaver Works center to test how signals connect between the UHF terminal and software radios on campus. Royster added that the summer research students have shown the benefit of the project in an educational setting and uncovered possibilities. “The work this summer has shown that communication over LES-9 with software radios is possible, and we have gained experience with helping the students design and implement a transmitter and receiver,” said Royster. Ultimately, immersing summer research students in the project offered a clear benefit to both parties. Royster explained “the students bring a lot of excitement and feel an urgency to get their project to work. This spreads to Laboratory staff who may be called on to help in their areas of expertise and who become invested as well.”