Researchers demonstrate high-bandwidth communications capability for ships

August 28 2017, by Paulette Campbell

APL's compact free-space optics system during ship-to-ship testing. Credit: APL

A team of engineers from the Johns Hopkins University Applied Physics Laboratory (APL), in Laurel, Maryland, has successfully demonstrated a high-bandwidth, free-space optical (FSO) communications system between two moving ships, proving operational utility of FSO technology in the maritime environment.

Juan Juarez, the technical lead for the team developing the technology, said APL is the first organization to successfully operate such a high-capacity optical communications capability—up to 10 gigabits per second—on the move, on board ships at sea, and in challenging near-shore environments.

"We demonstrated bandwidths that were several orders of magnitude higher than all current radio frequency [RF] communications capability on Navy vessels, and at longer ranges than previously demonstrated FSO technology for maritime applications," Juarez said. "This is the equivalent to having up to 2,000 users simultaneously watching high-definition video streams across the optical link."

The Lab demonstrated its latest compact form factor system at the 2017 Trident Warrior Exercise, an annual event where sailors try out the newest innovations in naval warfare systems and provide feedback on those systems to commanders and developers.

Staying in Touch

Navy ships typically use RF systems to communicate—but the Navy also looks for alternative means of communication in case, for technical, operational or environmental reasons, radio transmission isn't available. "Naval platforms increasingly need to operate effectively in reduced-RF or emission control conditions while maintaining their tactical advantage and situational awareness," noted Juarez.

Free-space optical communication systems—which make use of wireless transmission to deliver optical data signals at high bit rates—offer a compelling adjunct communications capability to conventional RF and microwave communications by providing secure high data rates outside the conventional RF spectrum.

Commercial FSO systems exist but typically don't address defense needs, Juarez said, "specifically in terms of system mobility, link range, and data rate while operating in the highly scintillated terrestrial environment, especially close to the water." FSO demonstration systems previously built for terrestrial defense applications have been too large, or lacked the mobility, data rates, or ranges to be practical on naval platforms.

Over Land and Sea

APL FSO operators check the monitors on Sea Hunter as a third operator monitors operations. Credit: APL

APL's system overcomes many of these challenges. The first week of testing was ship-to-shore, from the motor vessel (M/V) Merlin off the coast of Naval Base Point Loma, San Diego, to the 3rd Fleet Headquarters parking lot. The team achieved more than 14 hours of link-

up time, including during 4- to 6-foot high seas; 1–2 gigabits of error-free data transport at ranges greater than 25 kilometers; voice communications at greater than 35 kilometers; chat messaging out to 45 kilometers, the maximum available line of sight; and repeatable, semiautomatic reacquisitions over the entire line-of-sight range.

Also during that first week, Vice Adm. Nora Tyson, commander of U.S. 3rd Fleet, visited the land-based testing site and was briefed by the ship-based team over the optical link—the first time a three-star admiral held a video teleconference over an optical link.

"Weather conditions during the two weeks of testing were typical of San Diego's 'June Gloom' and gave the APL team plenty of opportunities to show that our FSO technology can operate even through some levels of fog and haze," Juarez said. "While the fog layer was present, links of over 10 kilometers were achieved, even though visibility at times was reduced to 2–3 kilometers."

During the second week of testing, the second set of hardware was installed onboard the Sea Hunter, an autonomous continuous trail unmanned vessel (ACTUV) developed by the Defense Advanced Research Projects Agency (DARPA) and the Office of Naval Research. The Sea Hunter was temporarily manned by a six-person Space and Naval Warfare Command crew in addition to the APL test team for this demonstration.

Multiple links between the two ships were achieved in 3- to 5-foot swells, over 10 kilometers in range, with ACTUV Sea Hunter going 24 knots and M/V Merlin going 12 knots in a "V" formation that allowed the ships to quickly separate from one another, while maintaining the links at varying speeds and motions.

"Despite seas that had both ships rolling with the swells, the link stayed

solid," Juarez said. The FSO equipment experienced significant sea spray, and the omnipresent San Diego marine layer fog added an additional challenge to the ship-to-ship linkages. Nonetheless, first-time data rates as high as 7.5 gigabits were achieved over a link between two vessels.

Game-Changing Technology

APL's compact, mobile FSO demonstration system is the culmination of more than a decade of Laboratory achievement in the field of free-space optics.

APL led the highly successful DARPA Free Space Optical Experimental Network Experiment (FOENEX) to field-test high-bandwidth communications systems, integrating FSO and radio frequency technology in a mesh airborne network. "After FOENEX we decided to invest in the development of a system to prove that a compact, free-space optics system could operate in the highly challenging naval environment," Juarez said. "As APL proved in Trident Warrior 2017, FSO technology is finally a viable, non-RF communication technology for U.S. Navy platforms."

"The demonstrated performance of APL's laser communications systems opens up various potential applications," said APL's Air and Missile Defense Sector Head Mike White. "We are looking forward to working with sponsors and warfighters to further develop this game-changing technology."

Provided by Johns Hopkins University

ships.html