Optical Engineering

OpticalEngineering.SPIEDigitalLibrary.org

Free-Space Laser Communication

Hamid Hemmati

SPIE.

Hamid Hemmati, “Free-Space Laser Communication,” *Opt. Eng.* **55**(11), 111601 (2016), doi: 10.1117/1.OE.55.11.111601.

Free-Space Laser Communication

Hamid Hemmati
Facebook, Inc.
1 Hacker Way
Menlo Park, California 94025
E-mail: hemmati@fb.com

Free-space optical (laser) communication has now transcended the technology maturation phase to the point of terrestrial and Earth-orbiting satellite links now being deployed operationally. The multitude of successful technology demonstrations since 1995 have led to the understanding that free-space laser communications can be reliably operated in certain short-range to long-range backhaul communications. It is a powerful tool in the telecom technology tool box, and by no means a technology that makes previous telecom technologies obsolete.

The primary benefit of laser communication arises from the narrow beam divergence of the laser, as related to its multi-THz frequencies. These benefits can be applied to substantially increase communications capacity by delivering one-to-three orders of magnitude higher data rate for approximately the same mass and power consumption of conventional long-range telecom links. Typical transmit/receive (telescope) aperture diameters are a fraction of those of antennas for lower-frequency communications systems.

Currently, the unregulated optical spectrum provides another major benefit over highly-to-lightly regulated radio frequency (RF), microwave, and millimeter-wave frequencies. Building-to-building free-space optical links are now commonplace worldwide. The European Space Agency (ESA) is now making operational use of the commercially available transceivers from Tesat Spacecom in low-earth-orbit to high-earth-orbit links. Sub-Gbps links have been demonstrated from the moon orbit, and deep-space laser communications technology demonstrations have been planned by both NASA and ESA. Underwater optical communication is also gaining in popularity. Remarkably, traditional government funding for laser communications research has been substantially augmented by the high-technology entities who seek to apply this technology to providing connectivity to the remaining 3 billion or so population of the world who have either no access or very poor access to the Internet.

This special section of *Optical Engineering* comprises fourteen papers that cover developments in different aspects of optical communications technology, providing insight into current areas of research. The fourteen papers (out of twenty-two submitted) fall into four general categories: components, channel characterization, architecture/modeling/analysis, and satellite links.

Components papers include: inertial-based multiloop control of fast-steering mirrors, by Tian et al.; impact-ionization-engineered avalanche photodiode arrays, by Ferraro et al.; space qualification of a 1550-nm high-power fiber-laser transmitter, by Gupta et al.; and two-dimensional beam steering using a thermo-optic silicon photonic optical phased array, by Rabinovich et al.

Channel characterization papers include: scintillation recording and playback in free-space optical links, by Rabinovich et al.; cross-beam scintillation in underwater medium, by Baykal; investigation of adaptive optics performance from propagation channel characterization with a small optical transponder, by Petit et al.; and average symbol error rate MQAM in generalized atmospheric turbulence and misalignment errors, by Sharma.

The architecture and simulation papers include: joint relay selection and link scheduling in a cooperative free-space optical system, by Tan et al.; demonstration of a variable-data-rate free-space optical communication architecture using efficient coherent techniques, by Geisler et al., and performance analysis of multiple-input multiple-output free-space optical systems with partially coherent Gaussian beams and finite-sized detectors, by Gökçe et al.

The satellite link papers include: a nanosatellite optical downlink experiment, by Clements et al.; planning constraints of low-grazing-altitude GEO-LEO laser links based on in-orbit data, by Sterr et al.; and coherent receiver design based on digital signal processing in optical high-speed intersatellite links with M-phase-shift keying, by Schaefer et al.

Hamid Hemmati, PhD, is the director of engineering for telecom infrastructure at Facebook, Inc. Prior to that he was with the Jet Propulsion Laboratory (JPL), California Institute of Technology for 28 years as principal member of staff and the supervisor of the optical communications group. Previous to joining JPL in 1986, he was a researcher at NASA's Goddard Space Flight Center and at NIST. He has published over 200 journal and conference papers and nine patents. He is the editor and author of two books: *Deep Space Optical Communications* and *Near-Earth Laser Communications*, and author of five other book chapters. In 2011 he received NASA's Exceptional Service Medal. He has also received 3 NASA Space Act Board Awards, and 36 NASA certificates of appreciation. He is a Fellow member of The Optical Society and SPIE. His research interests are in providing global Internet connectivity, and greatly advancing laser and millimeter-wave communications technologies for terrestrial, airborne, and spacecraft applications.