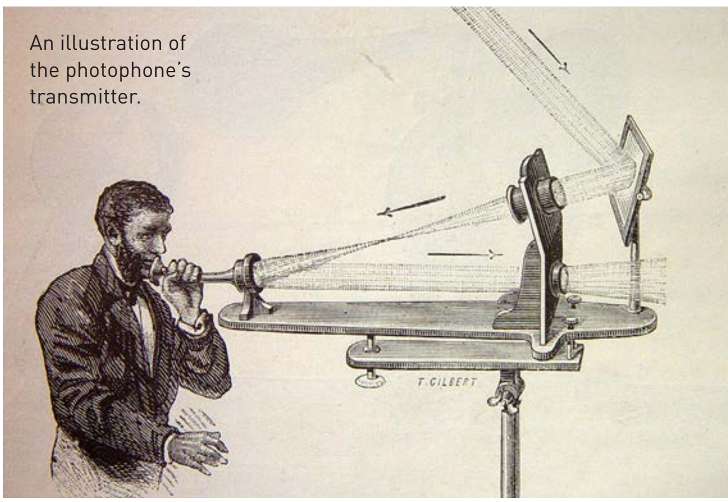
Of Photophones and Lasers

From smoke signals to semaphores, long-distance optical communication has intrigued humans for millennia. But the advent of the laser changed the game.

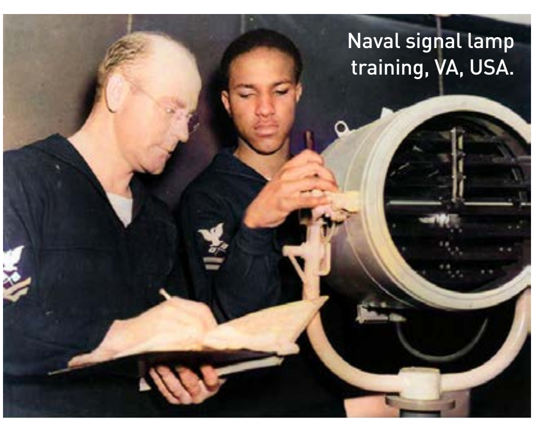


An illustration of the photophone's transmitter.

A. Guillemin/Barcelona Montaner y Simón/Wikimedia Commons

1880: Bell's other telephone

One precursor to modern-day free-space optical communications appeared in 1880, when—four years after the creation of the telephone—Alexander Graham Bell and his assistant Charles Sumner Tainter invented a "photophone" that used modulated sunlight to transmit sound. In one demo, the pair communicated with the device across a distance of more than 200 m. Bell hoped that the device might help in ship-to-ship communication. But it was of limited use in poor weather, and the advent of radio communications put its development on the back burner.



Naval signal lamp training, VA, USA.

US Navy/National Archives

1910s: Wartime signaling

During the world wars, militaries on both sides further experimented with line-of-sight optical communications—a noted example being the German *Lichtsprecher* during World War II, which could reportedly transmit a voice across a 14-km distance. Far more popular, however, were technologies such as the signal lamp. Pioneered by the British Navy in the late 19th century, on the eve of World War I, it transmitted messages using flashing lights. Germans also developed their own version, called the *Blinkgerät*.

NASA

1995: Lasers and space communications

In 1960, announcing his invention of the laser, Theodore Maiman named space communications as an area the laser would transform. While fiber optics dominated on the ground, laser-based free-space communication did indeed make headway in space. In a 1990s joint effort of NASA and the Japanese government, engineers transmitted a laser beam from ground to a satellite and then back, establishing laser communications' viability for spacecraft.

now

An Expanding Vision

As demand for better, faster and more accessible networks continues to increase, scientists are looking at myriad ways to improve free-space optical communication.

Optica Fellow Peter Andrekson.

H. Sandsjö/Chalmers University of Technology

2020: Almost noiseless

While space communication has relied mainly on radio waves, interest in optical communications has grown with the exploding number of satellites and missions and the increasing commercialization of space. Recently, a team in Sweden developed a system that uses an ultrasensitive receiver with a virtually noiseless optical preamplifier. The heightened sensitivity, the team believes, could aid future communications for deep-space missions.

Illustration of a mobile quantum network using drones.

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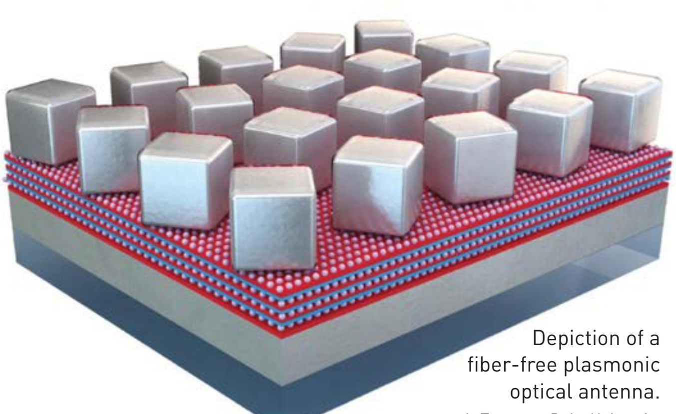
2021: Drones for quantum networks

Quantum encryption promises extraordinarily secure networks. Many experiments in quantum communication have focused on optical fibers or satellite free-space optics—with progress and challenges seen in both. In a different approach, engineers in China used a small laser-generating device and a pair of drones to distribute entanglement between two ground stations 1 km apart—a "mobile" approach to building local quantum networks.



Depiction of a fiber-free plasmonic optical antenna.

A. Traverso, Duke University

2021: Metasurface for wireless internet

Communication with visible and infrared light, while it can in principle carry more information than radio waves, still largely happens via fiber optic cables. To extend the capability of free-space optical alternatives, researchers in the US have developed a centimeter-scale plasmonic metasurface-based detector that demonstrated enhanced speed and efficiency. They hope this metasurface, made of fluorescent dye coupled to nanoscale antennas, can help bring the internet to underserved areas using solar-powered drones.

Clearer future: Atmospheric turbulence is an ongoing problem in free-space optical communication on Earth—a problem that scientists continue to work on, using techniques such as wavefront sensing and adaptive optics. Researchers also are looking at free-space optics on much shorter length scales—such as "LiFi" systems that could use modulated LED light to deliver broadband wireless internet in cafes and other settings.

For a list of references and further resources, go online: **optica-opn.org/then-now/free-space**.

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