Technical White Paper

November 20, 2014

Fog Laser Field Test

Introduction

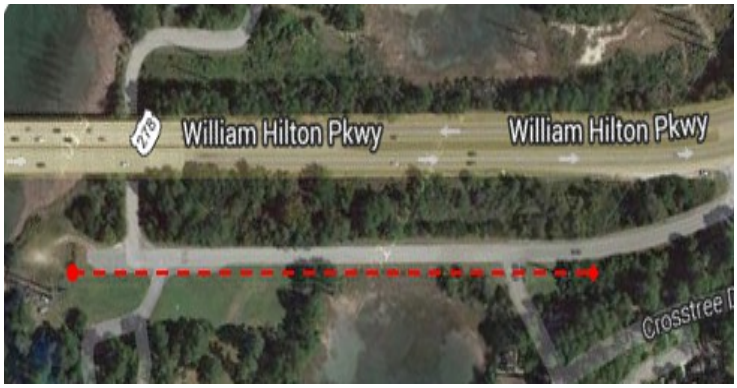
The idea to use light for Free Space Optical (FSO) Communications is as old as the telephone. Since the creation of the laser, various military and commercial organizations have built products using laser light to efficiently transfer information with marginal levels of success.[1]

Fog Optics has gone to great lengths to analyze the history and current competitive landscape of FSO. According to Optics.org, the FSO industry is stagnant at $30M in revenues per year[2]. Reliability issues created by fog are consistently cited by industry experts as the reason the technology is not a standard in data communication networks. If FSO technology could deliver the reliability of RF and Fiber, FSO manufacturers stand to capitalize on significant growth opportunities including the lucrative $5B/year telecom equipment backhaul industry.[3,4,5]

Fog Optics understands one thing better than any other group in the world: how to address reliability in adverse atmospheric conditions including fog. This paper will highlight the test results of Fog Optics' proprietary and patent-protected Fog Laser product. This new technology enables FSO products to become a reliable high-speed backhaul solution without the need for redundant RF systems.

Field Test Conditions

Over the course of more than 50 successful field tests, Fog Optics obtained data consistently proving the reliability of our patented technologies. The most valuable data set is from November 3rd, 2012, taken at a private location on Hilton Head Island between the local commercial airport (airport: HHH) and Marine Corps Air Station at Beaufort. Both locations and the National Weather Service (NWS) reported extreme fog conditions during the test.



The Hilton Head Test Area

1A full history and overview of FSO is available on Wikipedia at: http://en.wikipedia.org/wiki/Free-space_optical_communication

2 http://optics.org/news/4/1/3?goback=.gde_56568_member_201749977

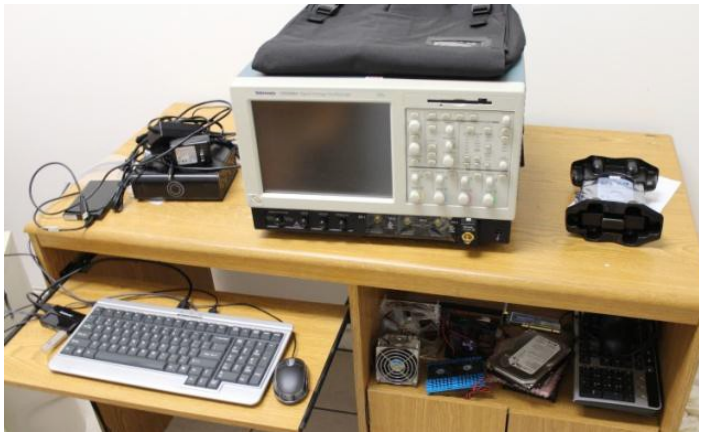
3 2012 Market Size: infonetics.com/pr/2012/2Q12-Microwave-Equipment-Market-Highlights.asp

4 I. Kim et al., "Caracteristicas de propagacion atmosferica para los FSO comerciales" in Optical Wireless Communications IV, SPIE Vol. 4530 (2001) p. 84

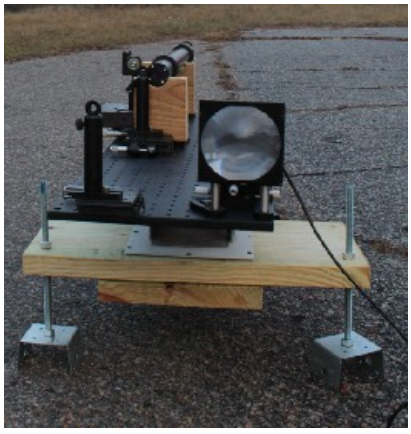
5 http://lightpointe.com/images/LightPointe_White_Paper_What_is_Free_Space_Optics.pdf

Details of the test include:

- The path link was 600 meters to a reflector, and 600 meters back, for a total of 1.2km.
- The prototype Fog Laser system did not use a commercial telescope, did not have a pointing and tracking system, and no error correction coding (ECC) was used for data.
- Due to the losses in the optics, the beam was nominally outputting about 30 mW, which is about 10% of the power of a commercial grade eye-safe FSO laser.
- The visual record at the test site was a total of 80 dB (approximately 20 dB every 300 meters). In conditions like these, standard FSO systems would have completely failed
- The packet data was recorded by a Tektronix TDS 6604 that captured waveform data every 5 seconds



A TDS 6604 Oscilloscope



The Demonstration System

Field Test Results

Review of the test data indicates a reliability of 99.99953% for year-round operation. This number is the multiplied result of the packet field test with the statistical likelihood of a similar event occurring according to the National Weather Service (NWS).

According to the NWS, a 20 dB fog event is the benchmark where visibility functionally drops to zero.[6] Standard FSO technology reliability drops to 0% over 49 dB of cumulative effect – so 20 dB/km over 3km (60 dB total) will shut down all modern FSO units. Using historical visibility data for Airports in the United States, Fog Optics calculated a 80+ dB fog event (the conditions on November 3rd) will occur less than 0.105% of the time.

Except for the November 3rd test, all other Fog Optics field test data show no dropped or false packets (approximately 535 GB of data from over 50 field tests). Fog Optics put the remainder of the year (99.895%) as a 100% up-time.

6 Historic weather data available from: http://www.ncdc.noaa.gov/

The field test data on November 3rd showed 57 possible dropped or false packets out of 12,617 (99.548%) during the extreme fog event. Anyone analyzing the data will find almost all data packets are recoverable with standard ECC. However, because this shorter distance is being used for extrapolation purposes, Fog Optics took the most conservative approach (see components not included in the following section to achieve this Quality of Service) and left the figure at 99.548%. To put this in perspective, Fog Optics's successful 99.548% is in a fog event where traditional commercial grade FSO technology would achieve 0% reliability.

Taking these numbers and using atmospheric data from the NWS, a conservative year-round estimation of availability is 99.9995254%, which Fog Optics has rounded up to 99.99953%. This does not factor in improvements from use of a telescope, pointing and tracking, or ECC. These additions will easily allow the system to achieve the same success over back-haul distances.

Field Test Conclusions

Given the data we have collected, we project that the same quality can be achieved at back-haul distances in dense fog events with the addition of off-the-shelf part that meet Fog Optics specifications, such as commercial grade encoding, a standard low-loss telescope, standard error correction coding (ECC), and a pointing and tracking system.

Note that this extrapolation does not include any adaptive optics, as there is not enough data on that system to properly calculate its effect. This also does not include added benefit from a unique form of ECC the Fog Optics team is developing based on the November 3rd test, for the same reason - there is no real world test data to validate any projections from these newer technologies.

The raw data for the November 3rd field test is 65.5 MB, and can be provided for review. Our additional field tests, 535 GB, are also available for review.

About Fog Optics

Fog Optics is an applied optics company that produces the most effective products for high quality, high bandwidth communications today, and to will continue to achieve the highest communications rates terrestrially and extra terrestrially in the future.

Contact

Solutions@FogOptics.com