

The Challenge of Multiple Access for Free Space Optics

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The position presented in this document is that of the Author and does not necessarily reflect the position of BAE Systems

Position

Multiple Access technologies dictate the network topologies supportable with Free Space Optics (FSO). Today, FSO largely functions as a point-to-point technology. More must be done in the realm of FSO multiple access technologies if these systems are to fully emulate the networking abilities of RF systems on the battlefield today.

ONR's Tactical Line-of-Sight Optical Network (TALON)

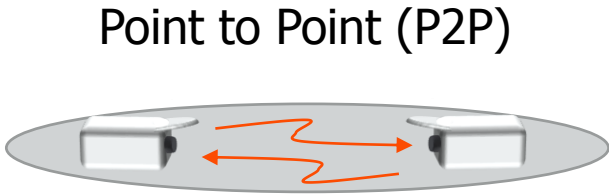


TALON Optical Antenna

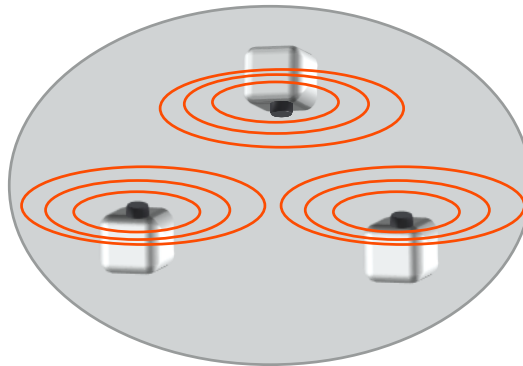


Dr. Linda Thomas and Dr. Christopher Moore, "TALON — Robust Tactical Optical Communications,"
CHIPS, October-December 2014
<http://www.doncio.navy.mil/chips/ArticleDetails.aspx?ID=5550>

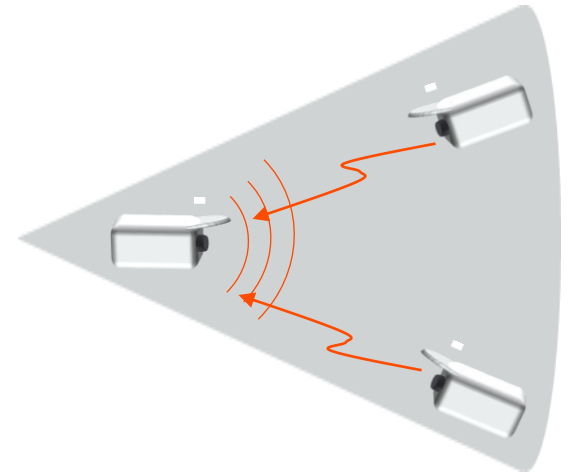
Communications Topologies



Omni-Directional (Omni)

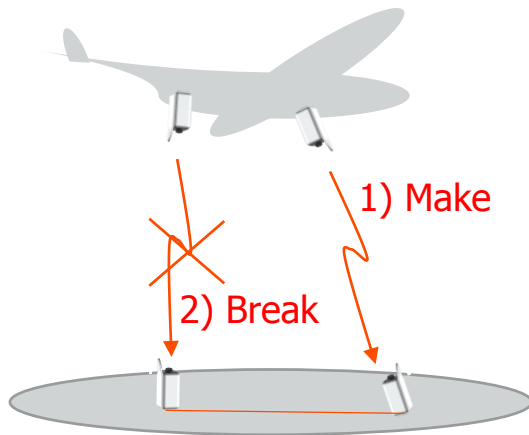


Point to Multi-point (PMP)

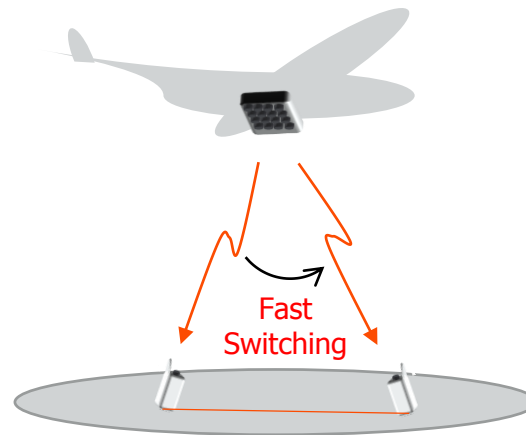


Directional Networking

Link Switching (LSDN)



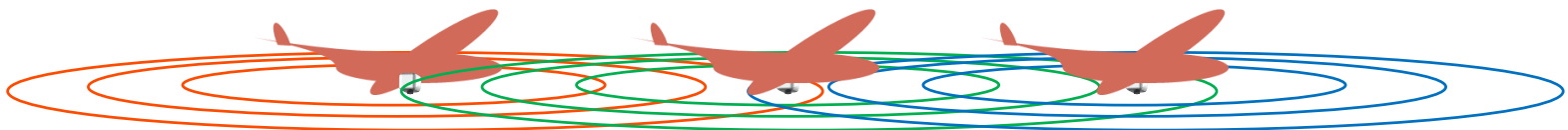
Packet Switching (PSDN)



Omni Concepts

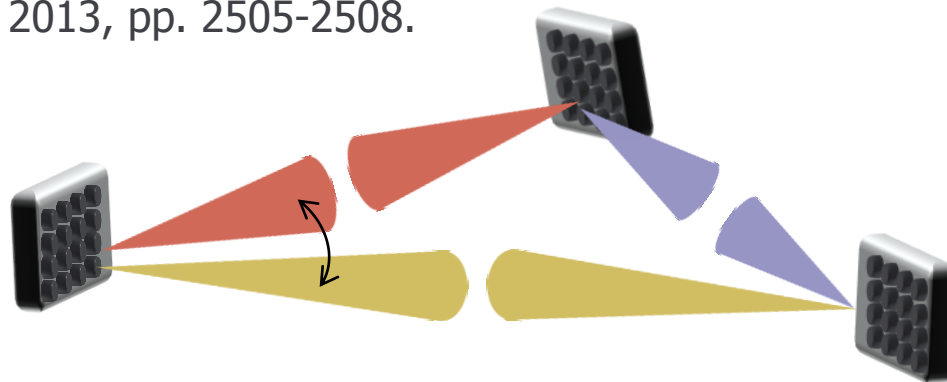
Long Range Omni-FSO propagation with multiple access

- Adjacencies (Indoor Wireless, Vehicular, retroreflectors, UV)
 - UV Communications
 - R. Yuan and J. Ma, "Review of ultraviolet non-line-of-sight communication," in *China Communications*, vol. 13, no. 6, pp. 63-75, June 2016.
 - Visible Light Communications
 - P. H. Pathak, X. Feng, P. Hu and P. Mohapatra, "Visible Light Communication, Networking, and Sensing: A Survey, Potential and Challenges," in *IEEE Communications Surveys & Tutorials*, vol. 17, no. 4, pp. 2047-2077, Fourth quarter 2015.
- IR Communications
 - Kaushal, Hemani; Kaddoum, Georges Free Space Optical Communication: Challenges and Mitigation Techniques, arXiv:1506.04836, 06/2015
 - J. M. Kahn and J. R. Barry, "Wireless infrared communications," in *Proceedings of the IEEE*, vol. 85, no. 2, pp. 265-298, Feb 1997.



PSDN (Optical Adaptive Array) Concepts

- P. F. McManamon *et al.*, "Optical phased array technology," in *Proceedings of the IEEE*, vol. 84, no. 2, pp. 268-298, Feb. 1996.
- J. Kim, M. N. Miskiewicz, S. Serati and M. J. Escuti, "Nonmechanical Laser Beam Steering Based on Polymer Polarization Gratings: Design Optimization and Demonstration," in *Journal of Lightwave Technology*, vol. 33, no. 10, pp. 2068-2077, May15, 15 2015.
- W. J. Miniscalco and S. A. Lane, "Optical Space-Time Division Multiple Access," in *Journal of Lightwave Technology*, vol. 30, no. 11, pp. 1771-1785, June1, 2012.
- N. Premkumar, Y. Xu and B. Lail, "2D infrared phased array leaky-wave antenna," *2016 IEEE International Symposium on Antennas and Propagation (APSURSI)*, Fajardo, 2016, pp. 401-402.
- B. W. Yoo *et al.*, "32×32 Optical phased array with ultra-lightweight high-contrast-grating mirrors," *2013 Transducers & Eurosensors XXVII: The 17th International Conference on Solid-State Sensors, Actuators and Microsystems (TRANSDUCERS & EUROSENSORS XXVII)*, Barcelona, 2013, pp. 2505-2508.



Conclusions

- Free Space Optics is a highly useful technology with many advantages
 - High Capacity
 - Low Probability of Detection / Intercept
 - High Anti-Jam capabilities
- FSO has many challenges that are being worked
 - Largely propagation related
- Current FSO technologies do not support all the networking topologies available with RF systems
 - Particularly Long-range omnidirectional (LR-Omni) and
 - Packet switched directional networks (PSDN)
- Certain DoD RF use cases could be met with FSO resulting in greater spectrum agility if these networking topologies were available for FSO systems

It is recommended that the NSF invest more in LR-Omni and PSDN FSO technologies