Progress Towards Reliable Free-Space Optical Networks


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13 July 2017

Distribution A (approved for Public Release, Distribution Unlimited – DISTAR Case 18266/24008)
FOENEX Program Objectives

**Primary Goal:** Demonstrate a four-node hybrid Lasercomm/RF airborne mesh network which provides high availability, high bandwidth, end-to-end connectivity.

**Goals:**
1. Provide dispersed warfighters a GIG connected tactical network communications backbone
2. Enable Lasercomm bandwidth comms w/RF network availability
3. Enable reliable, on the move, at the halt and airborne communications

**Technical Challenges:**
1. Acquisition, Pointing and Tracking of hybrid communications terminal from air to air and air to ground
2. Extremely high network availability
3. Real time transition between Lasercomm and RF operation

**Air-to-Air Cross-links**
Lasercomm/RF TRL 6 Prototype
Goal: > 200 km Node Separation

**Demonstrated:** 212 km Node Separation

Lasercomm: 10 Gb/s data rate
RF: > 112 Mb/s info rate

**Air-to-Ground / Ground-to-Air Links**
Lasercomm/RF TRL 6 Prototype

**Demonstrated:** 130 km Slant Range

Lasercomm: 10 Gb/s data rate
RF: @ > 185 Mb/s info rate
FOENEX Hardware Configuration

Network router/retransmission system (XIA)

10 Gbps Optical Modem, Optical Automatic Gain Control System (OAGC), Forward Error Correction (FEC)

XIA to RF modem Interface adapter
RF Modem
Oscillator Switch Box (OSB)
RF Electronics

User
Inertial Navigation Unit
XFusion Interface Assembly
Link Interface Assembly
Microwave Modem Assembly
Oscillator Switch Box
RF Equipment Group
System Safety Interlocks
Line-of-Sight Antenna
OMNI Antenna

RF
Networking
Navigation
Optical
Data Collection

Network Time Protocol
Optical FEC
Optical Modem
High Power Optical EDFA
FSO Gimbal
Optical Aperture
Optical PAT Controller
Beacon
WFOV Camera
Data Recording

Free Space Optical (FSO) Terminal

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ORCA/FOENEX Network Stack Capabilities

- Capabilities of the FOENEX Network stack
  - Network discovery, formation/reformation through real-time network control (discovery subsystem and Inter-Platform Communications Manager (IPCM))
  - Hybrid link management and control
  - Link outage mitigation through predictive link outage, Layer 2 re-transmission for handling scintillation effects, deeper queues for 2-3 second cloud blockages and replay of data for 5 second outages
  - Mobility management to dampen the effects of mobility on standard Internet protocols (IPCM Adaptation Layer (IAL))
  - Integrated Diffserv QoS for priority and internal and external ORCA network users, traffic management and flow control

Focus of initial experiments was link layer retransmission performance

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Example Experimental Results [183 km/ 5xHV5/7 (85%)]

- Field-measured OAGC response – OAGC output (POF) vs power from FSO terminal (PIF), OTM system
- 18 May 2009, 01:52 UTC, aircraft range ~ 183 km
- Fielded system had 2 dB higher gain at low PIF than the system measured in the lab - caused by minor system upgrade prior to field test

- 05/18/2009 01:52:59 UTC
- Power from FSO Terminal (PIF) vs Optical Power (dBm)
- OAGC Output (POF) vs Power from FSO Terminal (PIF)

- ORCA Field Test POF vs PIF - 18 May 2009, 01:52:29 UTC
- Lab Measured POF vs PIF – 23 Jan 2009
Example FOENX Experimental Results at ~20xHV5/7

Fremont Peak at 1 PM local time, 8 June 2011

Network Rerouting and Retransmission Needed to Mitigate 20xHV5/7 (>99%) Turbulence