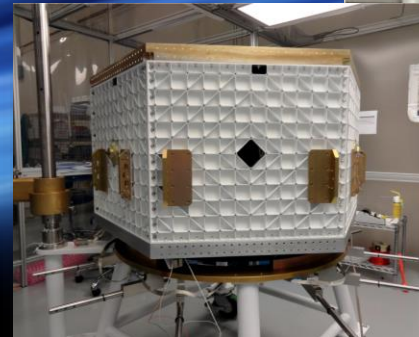


**Implementation
Challenges in Low-SWaP
Free Space Optical
Networks**

**NSF Workshop on Free Space
Optical Networks**

J. McNally and P. Shubert

July 13-14, 2017

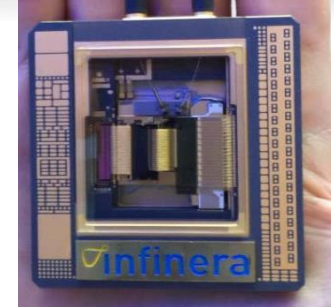


Low-SWaP Free Space Optical Networks

- **Small Size, Weight, & Power (SWaP) are Key to Adoption of Free Space Optical Communications**
 - Aperture Size & Pointing Requirements
 - Photonic Systems: Modulation & Detection
- **High Photon Efficiency Techniques**
 - Pulse Position Modulation (PPM)
 - Photon-Noise Limited Detection
 - Capacity Approaching Error Correction
- **Optical Systems Must Interface with Existing Communications & Networking Infrastructure**

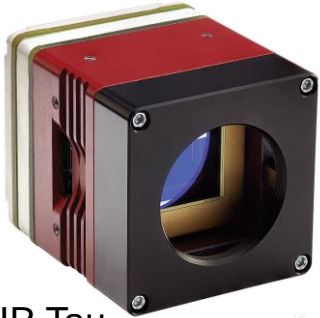
Photonic Integrated Circuits (PIC)

- **Integrated Capability in Low SWaP Package**
 - Modulated Laser Source
 - Pre-Amp & Detection
 - DWDM Add/Drop – PPM/OOK/DPSK
- **NASA Research Projects**
 - Integrated Photonic Modem for LCRD
 - Compact Robust Integrated PPM Laser Transceiver Chip Set
 - Integrated Tapered Active Modulator for High-Efficiency Gbps PPM Laser Transmitter PIC's
- **Tech Transfer to Advance Manufacturing & TRL**
 - Product Standards to Support Optical Networking Protocols
 - Space Qualified & Validated Components

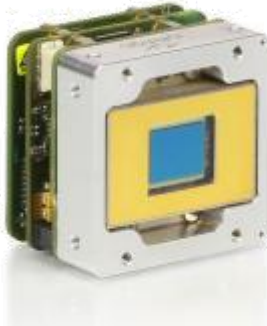


Decreased Size and Weight

SWIR Camera Technology



FLIR Tau



Xenics XSW



UTC Micro-SWIR

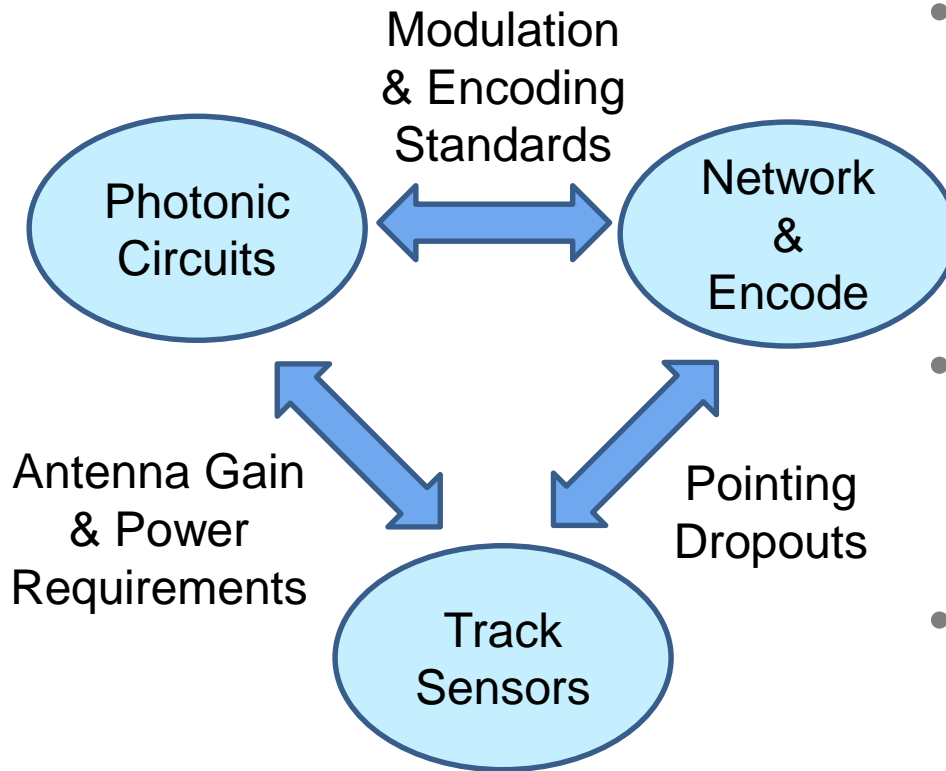
- Compact SWIR Focal Plane Cameras Provide High Performance Tracking at LaserCom Wavelengths
- Sensitivity, FOV, & Accuracy Compared to Quadrant & Position Sensors
- Commercial/MIL Rugged Systems
- Space Qualification
 - Rad Hard ROIC / ASIC
 - Sensor Evaluation

**Improves Optical Tracking Performance
Decreases Signal Loss/Dropouts**

Networking & Interface Standards

- **FSOC Standards Focus on Point-to-Point**
 - Physical & Data Link Layers
 - Optical Channel Fading & Drop-Outs
 - FEC Trades Latency for Reliable Transmission
- **Integration of FSOC into Network Architectures**
 - Latency Resulting from FEC/Interleave
 - Transient FSOC Links
- **FSOC Network Standards to Facilitate Integration**
 - Operate FSOC Network at Transport Layer
 - Cross-Layer Error Detection/Correction/Re-Transmission
 - Data Agnostic Transport Containers

Challenges Linked by Key Trades



- **PIC – Network Trades**
 - Latency vs. Reliability
 - Add/Drop
 - Network Configuration
- **PIC – Tracker Trades**
 - Aperture Size, Transmit Power
- **Track – Network Trades**
 - Dropouts & FEC
 - Network Meshing