Fiber Optic Transceivers Status
ESA Fiber Optic Workshop

December 2015

Chuck Tabbert

VP Sales & Marketing

Ultra Communications

(505) 823-1293

ctabbert@ultracomm-inc.com

www.ultracomm-inc.com

Briefing Available Upon Request

Agenda

- Introductions
- Overview
- Status
  - AVFOP Conference Summary
- Advanced Technology Developments
- Summary

ULTRA
COMMUNICATIONS

Introductions / Overview

Chuck Tabbert

Thanks Customers & Sponsors !!

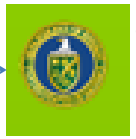
- Thanks to Sponsors & Customers support since 2006!

- Parallel Optics Feasibility
- Board to Board Optical Interconnect

- Transceiver Qualification
- Embedded Fault Diagnostics (OTDR)
- Connectors – RVCON & MT Saver
- DWDM Avionic Transmitter

- Photonics Manufacturing
- RF Photonics (VCSEL)
- URELSOC
- Avionic Fiber Sensing
- Built-In-Test Conops
- Advanced Transceiver Performance

- Chip Scale Packaging of FO Transceiver



- High Density CSP Integration

- Extreme Temperature Performance of FO Transceiver

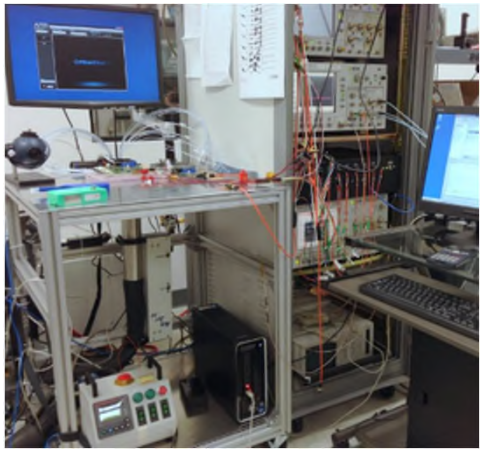
- Single Photon Detector for KQD

- Customers are mainly aerospace

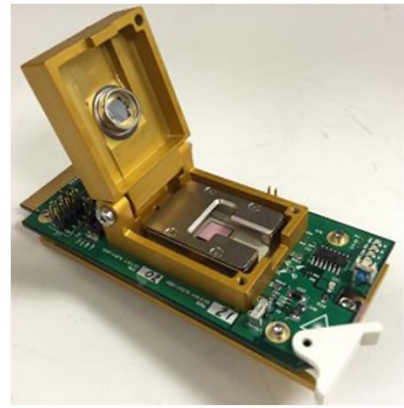
Ultra Communications Overview

- 2006 Spin-out of Peregrine Semiconductor
  - 18 employees (nine dedicated to manufacturing and quality system)
  - $4.2M revenue 2015 (Real Products & R&D)
- Fiber optic communications for harsh environments
  - Fiber optic component packaging and circuit design
    - Built-in-test (including OTDR)
    - Wide temperature operation & survival
  - Primarily R&D (Gov't and Customers)
  - Low rate **production** (50-75 units / month) today
- Business Sectors
  - Aerospace & Military: Avionics, Ships, Space
  - Embedded computing – Data Center, Automobiles
  - Fiber Sensing Market
  - Single Photon Detection for Quantum Key Distribution (QKD) networks

Finetech Fineplacer
(0.5 micron accuracy)

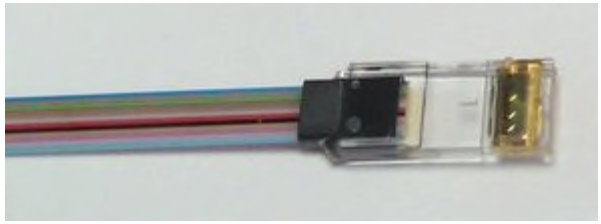


Transceiver Test Station with unique Optical Power Monitoring During Burn-In

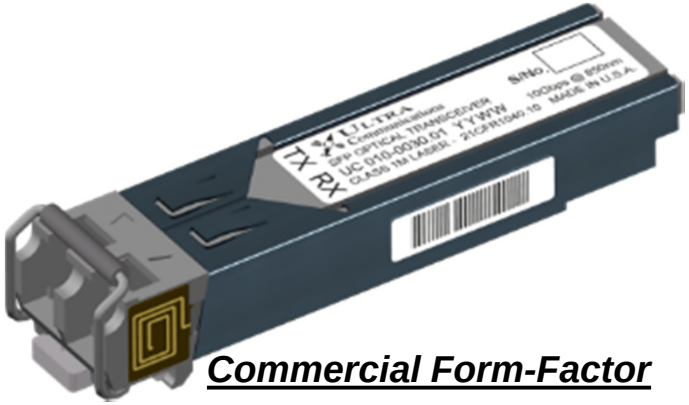


Ultra Comm Roadmap – Size, Data Rate & Functionality

RVCON™ Fiber Connector



SFP+ with integrated OTDR

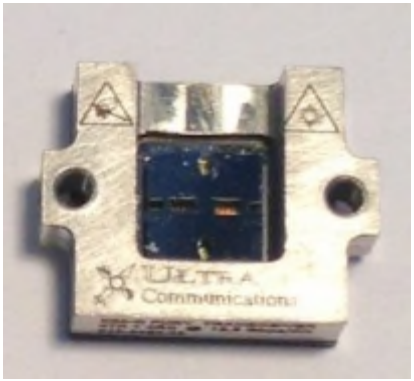


Commercial Form-Factor

JSF 4x4 @ 2.5Gbps/ch

25 mm

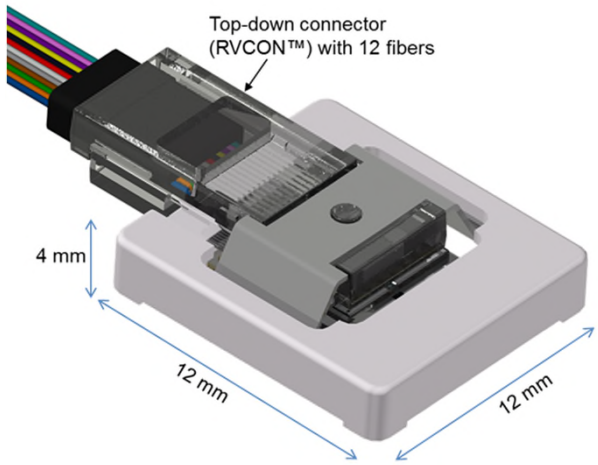
QFN 4x4 @ 10Gbps/ch



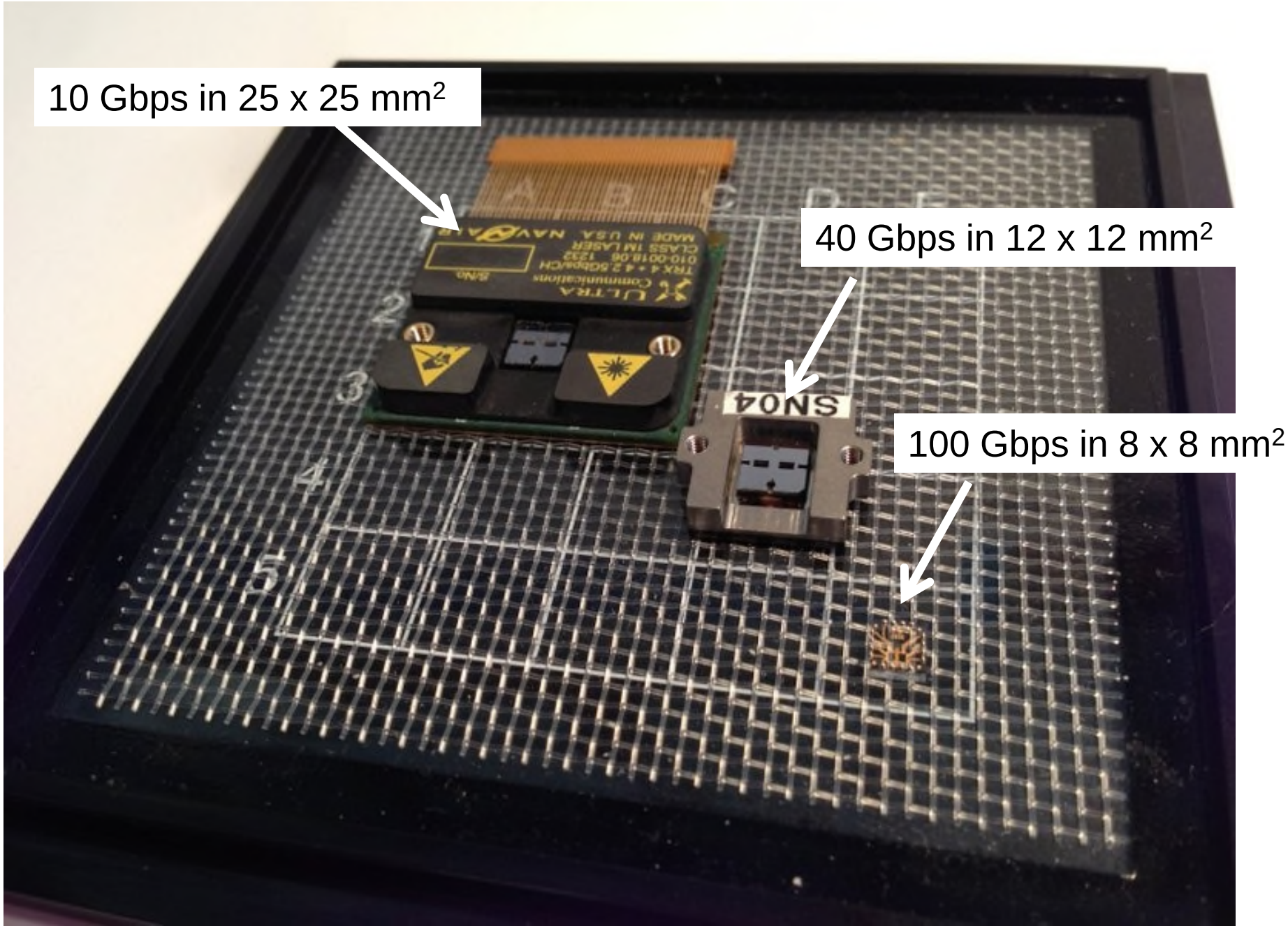
12 mm

(OTDR capability in development)

CSP 4x4 @ 25Gbps/ch



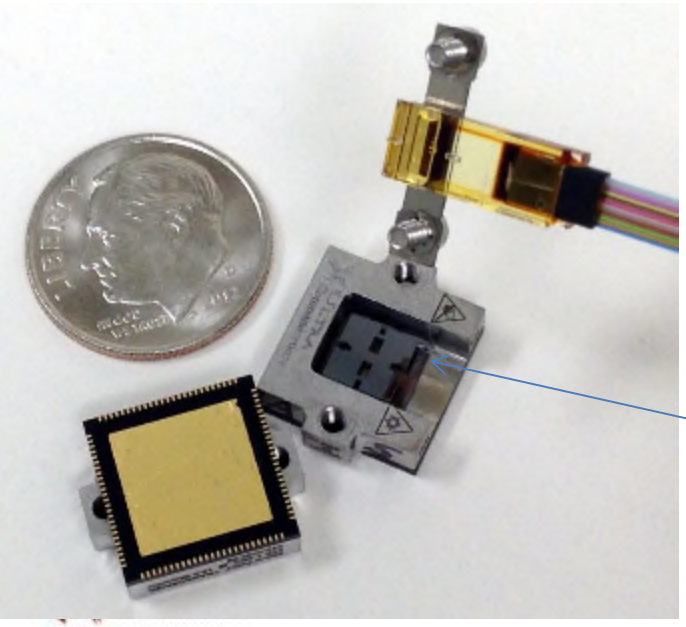
Transceiver Roadmap

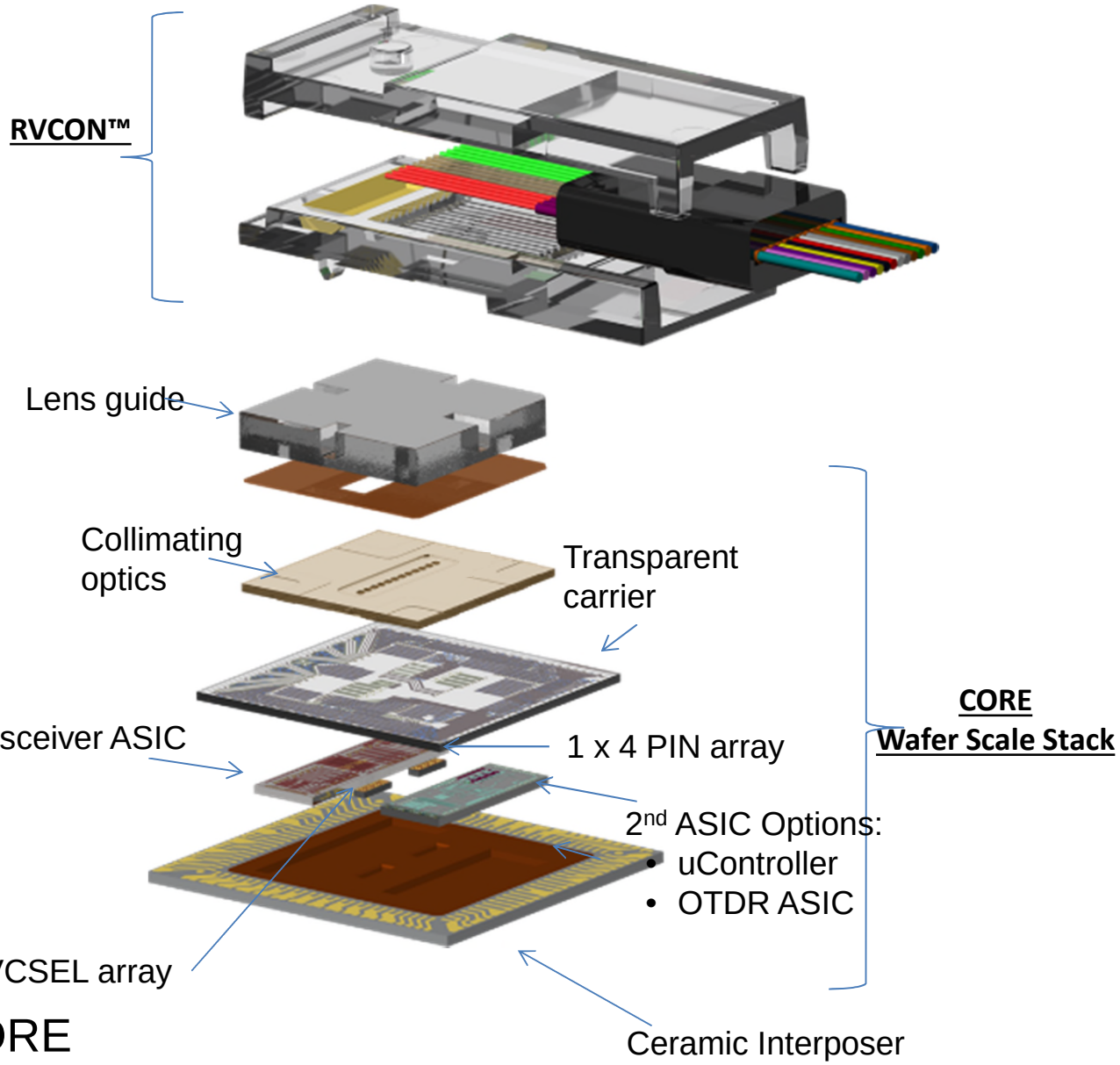


Flip-Chip Transceiver Construction

- Stack of flip-chip bonded wafer-processed materials
  - Advanced submicron flip-chip bonder
  - 10 flip-chip bonding steps

- Rugged Vertical Connector (RVCON™)
  - Ribbon fiber connector
  - <0.5dB loss from laser to end of pigtail over temp -120C to 180C





ULTRA
COMMUNICATIONS

Status

Transceiver Status

- Baselined configuration in fabrication for qualification testing to both avionic and space requirements
  - Both markets are requiring MIL-PRF 38534 Class L testing
    - Element Evaluation - in evaluation at customers
    - Module Screening (Group A)
    - Qualification (Group B,C,D Testing)
  - Avionic Qual Testing to began October 2015
  - Space Qual Testing to begin January 2016
    - **X80-Q baselined into 7 space programs worldwide**
  - Core is common to both packaging configurations
    - JSF
    - X80-Q
- Recent Customer Space Environmental Testing
  - Shock/vibration / Thermal Vacuum – Space Qualification Testing Completed
  - Radiation – Space Qualification Radiation Testing (TID, Proton & SEE) Completed
  - **Summary Data available upon request with Test Conditions!!**
- Quality Systems Installation
  - Full time Quality Engineer hired and have concluded initial customer audits
  - Activity to continue through qualification phase. **Plan to certify to MIL-PRF-38534 Class L**
- Worldwide demand outpacing supply
  - Capacity expansion being finalized for mid 2016 implementation ramping to full rate production
  - In preparation, new hires in operations, multiple shifts
  - Rigorous “fab sizing” for 2016 & 2017 – Need Customer Expectations

ULTRA
COMMUNICATIONS

AVFOP 2015
Santa Barbara, CA
Nov 2015

AVFOP Summary

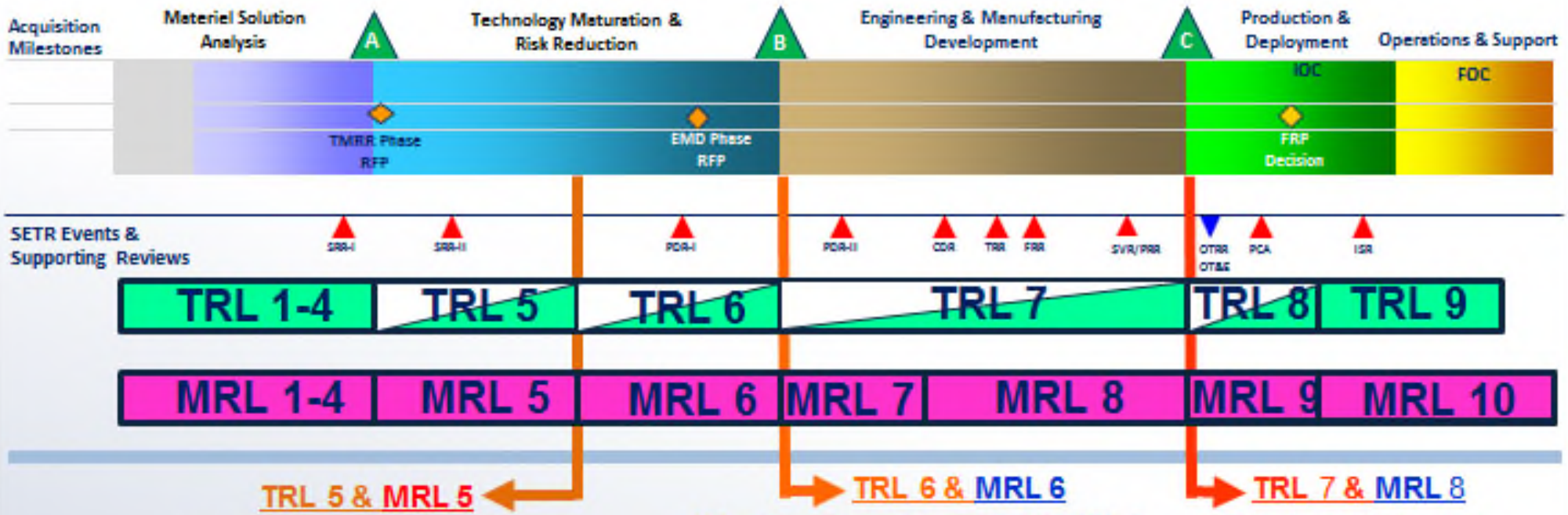
IEEE photonics Society | AVIONICS AND VEHICLE FIBER-OPTICS AND PHOTONICS CONFERENCE | IEEE

Panelists

- Customer Perspective: Mark Beranek - NAVAIR, Pax River, MD
- Prime Contractor Perspective: Chad Noddings - Boeing Space, El Segundo, CA
- SM Lasers & Components: Dan Renner - Freedom Photonics, Santa Barbara, CA
- MM Lasers: Chris Wiggins - Sumitomo, Albuquerque, NM
- Packaging: Chuck Tabbert - Ultra Communications, Vista, CA
- Cables: Amaresh Mahapatra - Linden Photonics, Westford, MA
- Connectors: Greg Noll - Glenair, Glendale, CA
- Reliability Calculations Rich Wisniewski - Quanterion Solutions, Utica, NY

AVFOP Summary (2)

NAVAIR View of TRLs and MRLs



TRL 5 & MRL 5

TRL 5 & MRL 5 achieved during Technology Maturation & Risk Reduction

- Representative Component
- Representative Packaging
- Environmental Performance Ver &Val
- Environment Stress Screening Ver &Val
- Life Performance Ver &Val
- Prototype materials, tooling, test equipment, personnel skills demo'd in a production relevant environment
- Manufacturing technology development efforts initiated/ongoing
- Producibility assessments and cost modeling ongoing

TRL 6 & MRL 6

Milestone B requires TRL 6 & MRL 6

- No more S&T / R&D Required
- Some Device Reliability Testing Complete
- Some Packaging Durability Testing Complete
- System Level Demo Complete
- Production Capability Demonstrated
- Manufacturing Cost Estimate Completed

TRL 7 & MRL 8

Milestone C requires TRL 7 & MRL 8 (Production Decision)

- Packaged Component Qualification Complete (packaged component built using production equipment, personnel and processes)
- Manufacturing Pilot Line Operational and Ready for Low Rate Production

AVFOP Summary – SAE AIR 6318

SAE AS-3 AIR 6318
Task Group Current Focus

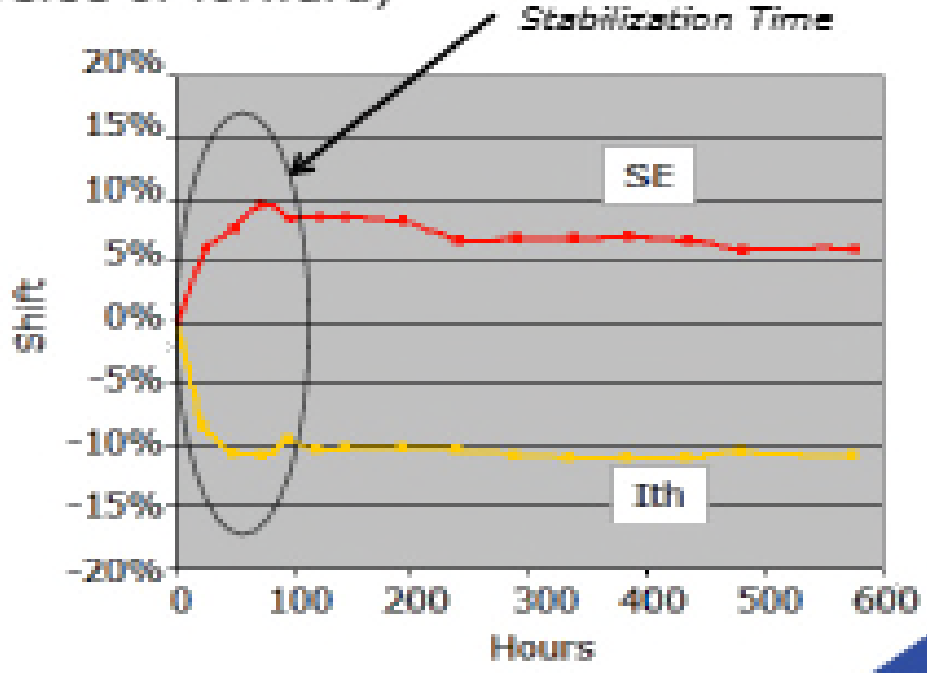
Aerospace Photonics Technology Readiness Advancement and Insertion via Verification and Validation of Active Photonic Device Reliability and Packaging Durability

- **Presents an approach for nominal verification, validation and environmental testing consistent with Technology Readiness Level 6**
- **Defines pre-qualification steps that builds confidence during the development phase with a small number of units and tests.**

Elimination of Manufacturing Defects

- Device testing (Wafer level testing & Burn-in)
  - Device parameter stabilization rather than light-bulb effectiveness
- Visual inspection (process defects, mishandling)
  - Scratches, metalization step coverage defects, debris
- Reverse voltage-current (Vrb) measurements
  - Detection of EOS events (ESD reverse or forward)

Wafer-level testing

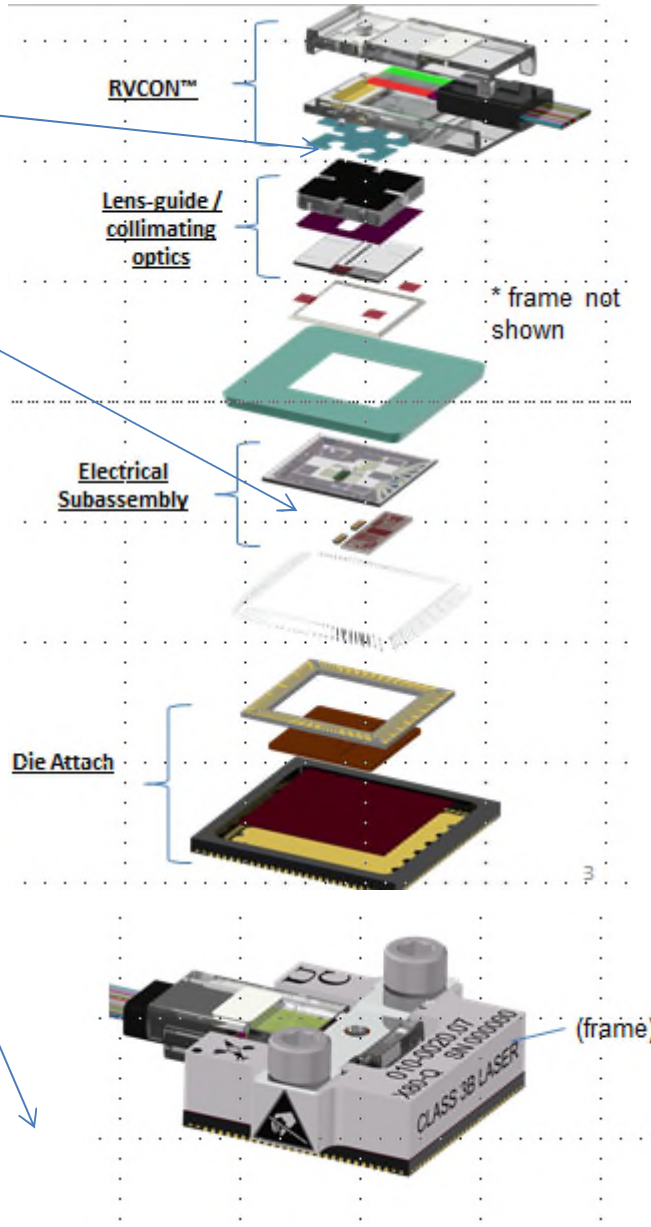


Package Reliability Metrics – Transceiver Manufacturer Perspective

- Package reliability centers around the stability / reliability of the package interfaces:
  - Connector to Transceiver Interface
  - Active Devices to Carrier Interfaces
  - Transceiver package to PCB bonding
  - OE Component Health Post Assembly

- Summary: The most telling acceleration tests to date has been rapid, long duration, thermal cycling and Highly Accelerated Stress Test (HAST) for humidity testing

- **Briefing Available Upon Request**



ULTRA
COMMUNICATIONS

Advanced Technology Developments

Technology Programs Overview

- Ultra Comm also performs advanced research thru Small Business Innovative Research (SBIR) contracts through multi-year phased programs

Technology Programs Overview					
Technology Program	**Program Phase**	**Customer**	**Objective**	**Status**	**End Date**
MT Saver	Phase II Option	NAVAIR	Develop an MT interface protection that can be temporarily and permanently installed	Completed temporary solution, in production at this time. Awaiting funding decision on permanent solution and qualification	Jan-15
OTDR Instrument	Phase II Option	NAVAIR	Develop a high dynamic range OTDR solution pluggable into existing commercial test hardware	Completed breadboard, awaiting Phase III funding decision	Mar-15
High Speed MMF transceiver	Phase II	AFRL	Demonstrate 10G data links over avionic fiber cables	Complete	Jul-15
28G/Channel CSP	Phase II	DOE	Develop a 100G MMF transceiver 4x4 in CSP	Materials on Order	Oct-15
URELSOC	Phase II	AFRL	Develop a Universal Reliability System-On-Chip test solution for mulitple semiconductor technologies	IC taped out, awaiting silicon from fab	Aug-15
Transceiver PEM Qual	Phase II.5	NAVAIR	Qualify PEM transceiver for avionic applications	PEM modules in build and complete environmental testing Q1-2016	Dec-15
10G CSP	Phase IIE	Army	Develop 40G MMF transceiver 4x4 CSP	Awaiting mounting clip mechanism prototypes	Nov-15
10G SFP+ OTDR	Phase II	NAVSEA	Develop OTDR enabled 10G/Channel transceiver in SFP+ form factor	Protos expected Jan 2016	Jan-16
RF Phtonic Receiver	NA	Customer	Develop a RF photonic receiver assembly for radar array	Mid 2016 start	Jul-16
Avionic Repeater	Phase II	NAVAIR	Develop a OTDR enabled pluggable test card for avionic backplane test	Completed base program, awaiting option funding	Dec-15
Quantum Crypto	Phase I	DMEA	Optical receiver for high speed QKD	Approach & Market assessment with component characterization	Nov-15
BIT CONOPS	Phase 1	AFRL	Create firmware that enables OTDR use by customer	Just underway	Apr-16
FO Temp Sensor	Phase II	AFRL	Develop unique temp sensor with OTDR interogator for avionic engine monitoring	Awaiting Phase II funding decision	Dec-16

ULTRA
COMMUNICATIONS

MT Saver

MT Saver

TECHNOLOGY DESCRIPTION

Film protector for MT connectors

- Seals the gap in connectors
- Protects the fiber end-faces
- Low optical loss (0.08 dB)
- Fully operational optical connector w/ film in place
- Removable

MT connector (w/ 12 fibers)


F-35 CP Module (courtesy LMCO)

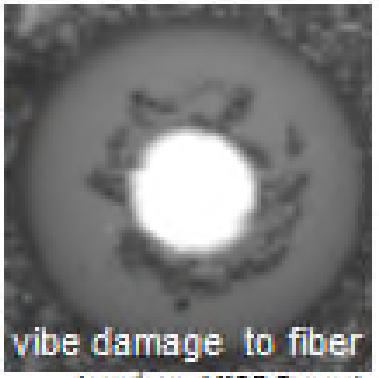
MT fiber connectors (6)

CUSTOMER NEED & REQUIREMENT

Fiber pigtails are prone to damage during assembly and flight, creating maintenance expense and reduced weapons availability

Affordability Issues This Tech Solves

- Vibration Failure: MT Savers are *currently in use* for sub assembly production to eliminate damage in vibe (affecting 50% of units – see photo - MT Saver are removed after vibe).
- Contamination During Flight: MT Savers seal the optical pathways
- Fiber Damage During Assembly: Protection thru production / assembly.


vibe damage to fiber

(courtesy LMCO-Owego)

Program Goal

- Expand for light-use and throughout production. Eliminate vibe-damage, and seal fiber within connectors
- Issues/Hurdles: Environmental tests are a new, but low risk

Transition Plan

- MT Savers are used in contractor F-35 production line to enhance yield during vibe test. We will leverage this success to expand across entire line and to fiber backplane assembly
- Installation at contractor ransceiver manufacturers
- Contractor will provide aircraft requirements for MT Saver flight-use testing (i.e., define environment and acceptance testing)

FUNDING / PROGRAM (18 mos $750K Base + 6 mos $250K Option)

Phase	Task	Description
BASE TASKS (18 mos)	Production Development	Develop production, handling, and inspection processes for MT-Savers
	Environmental Testing	Environmental testing to ensure MT Saver is compatible with flight
	Expand Application	Install the MT Saver throughout the avionic supply chain (transceivers, modules)
OPTION (6 mos)	Production Tooling	Tooling for high-rate production and to ease MT Saver installation/removal

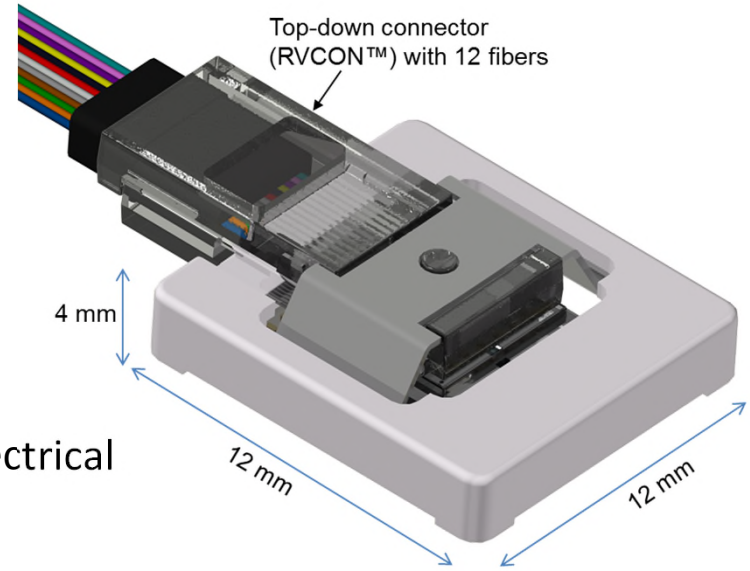
ULTRA COMMUNICATIONS

ULTRA
COMMUNICATIONS

UltraComm Embedded Optical Transceiver Project (LITECHIP™)

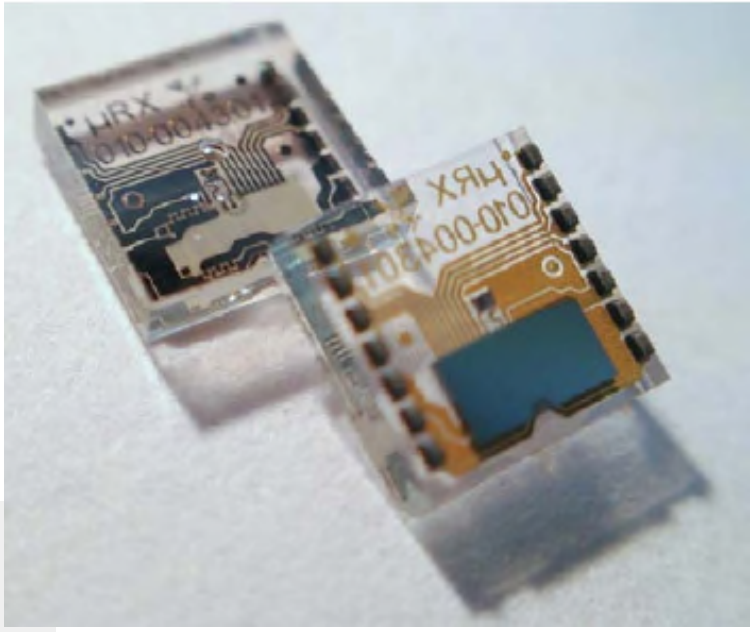
Summary

- Emerging need for embedded optical transceivers
  - On the board near the central processor ASIC
  - Difficultly of electrical routing at 28G and beyond
- UltraComm technology to address this need
  - Chip-scale-packaging and flip-chip assembly
- Value for the customer
  - **Low transceiver cost**
    - minimum BOM and wafer level assembly testing
  - **Ease of use**
    - mass solder assembly onto the customer board (no electrical connector).
  - **Minimum PCB footprint**
    - Electrical I/O density matched to PCB technology (*not* defined by bulky connector).
  - **Performance advantages**
    - Maximal bandwidth (no wire-bonds)
    - Efficient coupling of optical modes into multi-mode fiber
  - **Compatibility with immersion cooling**



Scaling

- Next generation systems are targeting 56 Gbps per channel line rates
- Finisar and VI Systems have demonstrated 56G VCSEL operation over 50 meter fiber links.
- Imperative to control the electrical parasitics inside the package
  - Especially at the ASIC-to-OE device interface.
- ASIC-to-OE interface in the LITECHIP™
  - SOS carrier with excellent dielectric properties
  - lithographically defined traces
  - OE devices are flip-chip bonded (no wire-bonds)
  - CSP -> electrical I/O directly to PCB



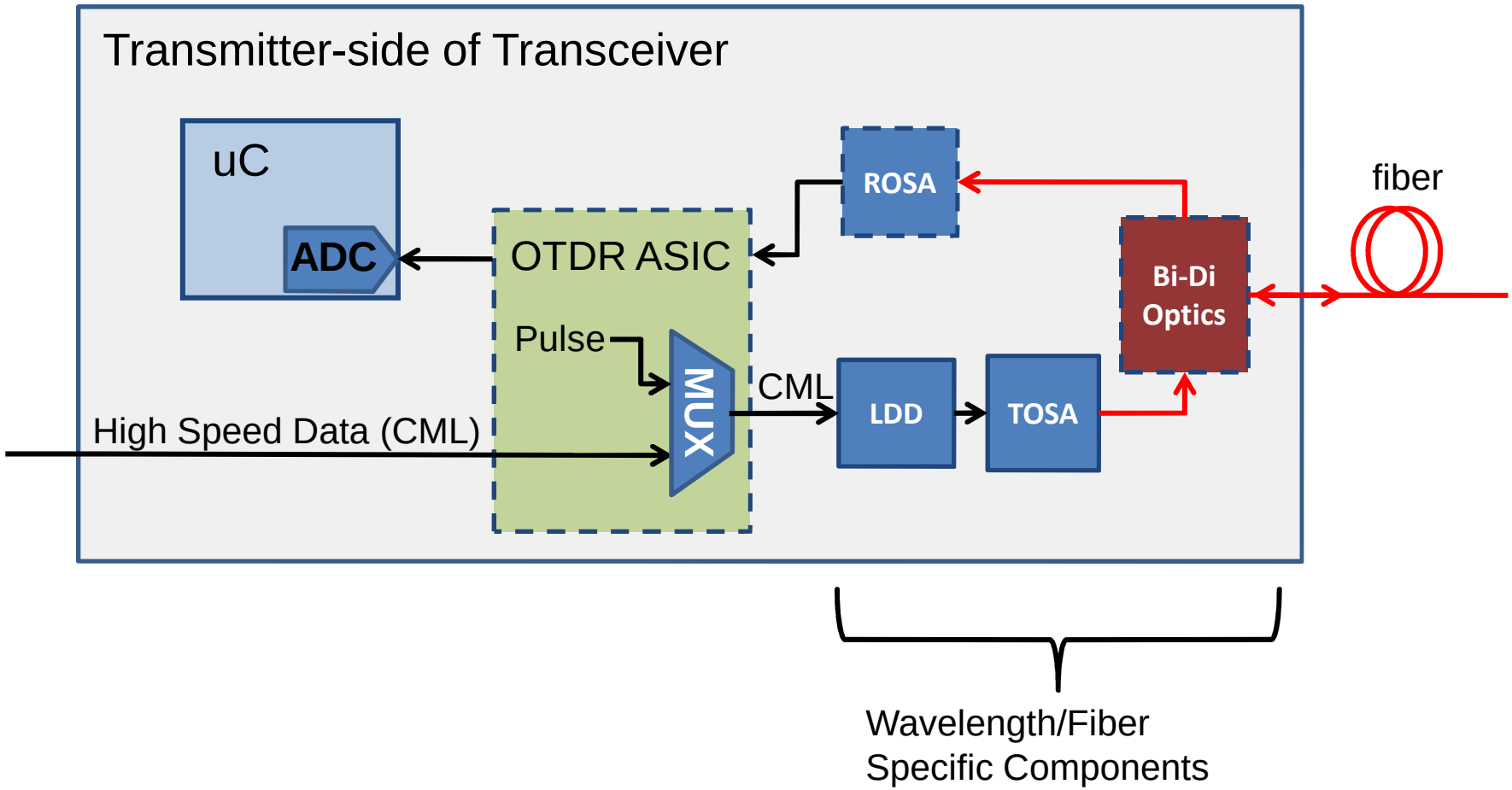
UltraComm dual-metallization process
- both flip-chip bumps (for the OE devices) and copper pillars for the electrical I/O.

ULTRA
COMMUNICATIONS

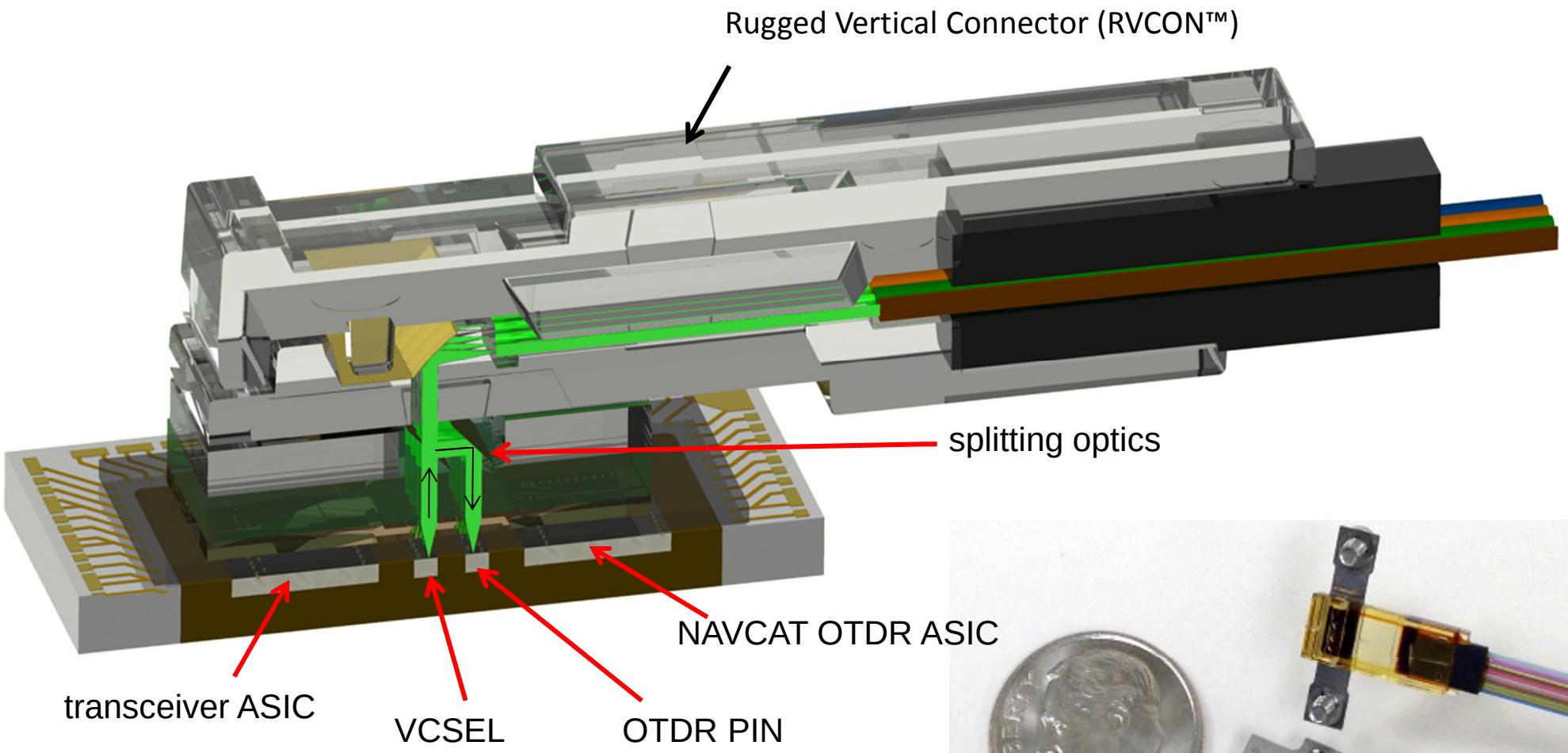
Embedded OTDR Technology

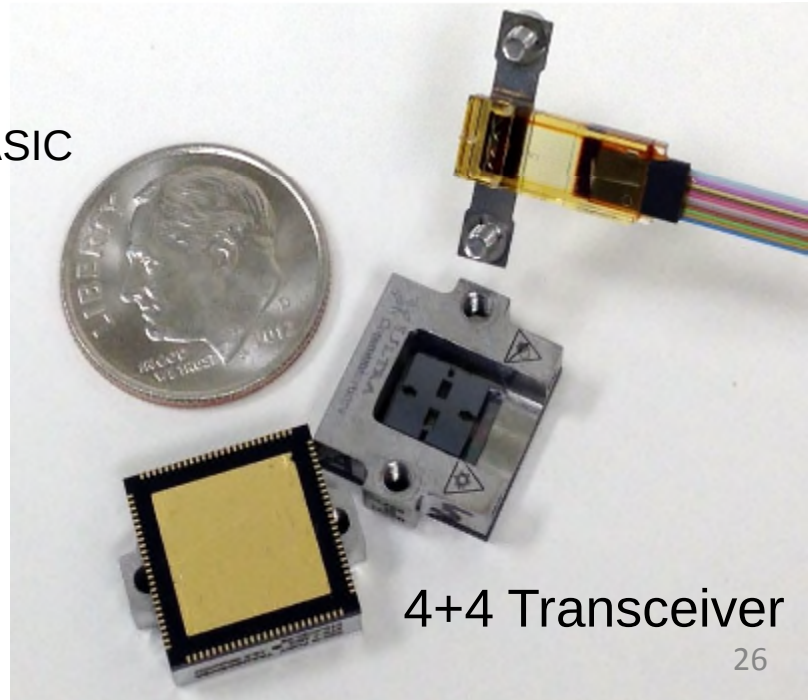
OTDR Application in Transceiver

- OTDR ASIC is compatible with multiple transceiver types
  - Need 10 Gbps technology to achieve 1 cm resolution
  - Add OTDR ASIC, ROSA and bi-directional coupling



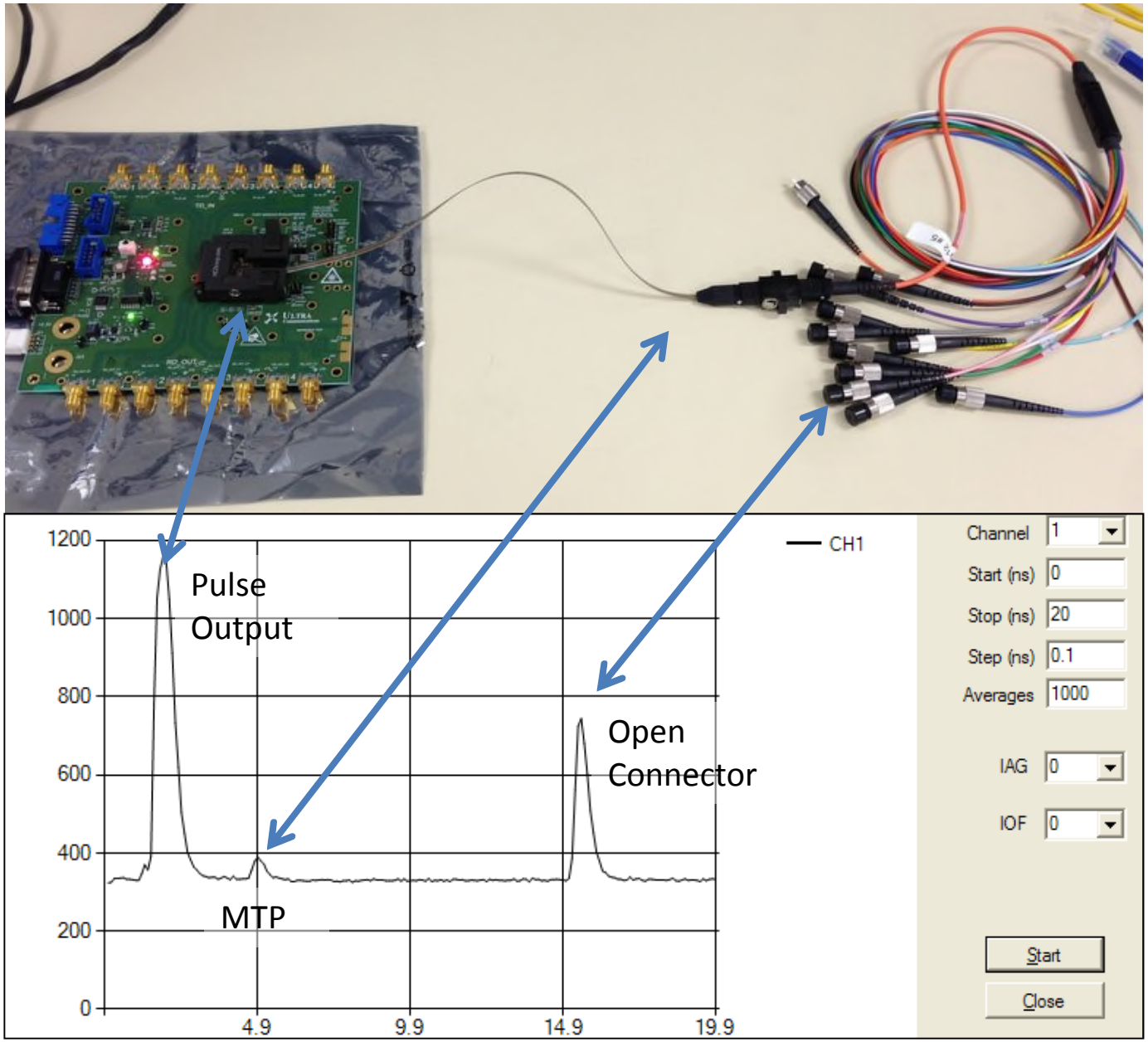
Cross-section of OTDR in Parallel Transceiver





ULTRA COMMUNICATIONS

Built-in-Test ODTR in transceiver



nanoseconds 1 meter =10 ns (round-trip)

ULTRA COMMUNICATIONS

Summary

- Ultra Comm is presently immersed in qualification of fiber optic transceivers for harsh environments
- Ultra Comm is also bringing up audited quality system and planning capacity expansion in 2016
- Ultra Comm's advanced technology development remains strong and an integral part of company's product development efforts