MISSION-CRITICAL
INTERCONNECT
SOLUTIONS

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SIGNATURE SERIES

# Ruggedised opto-electronic components for multi-gigabit onboard & inter-satellite optical communications in space

EPIC Meeting on “Photonics at the Final Frontier”
ESA-ESTEC, 14 Sept 2022

**Davinder BASUITA, Business Development Manager, Photonics**

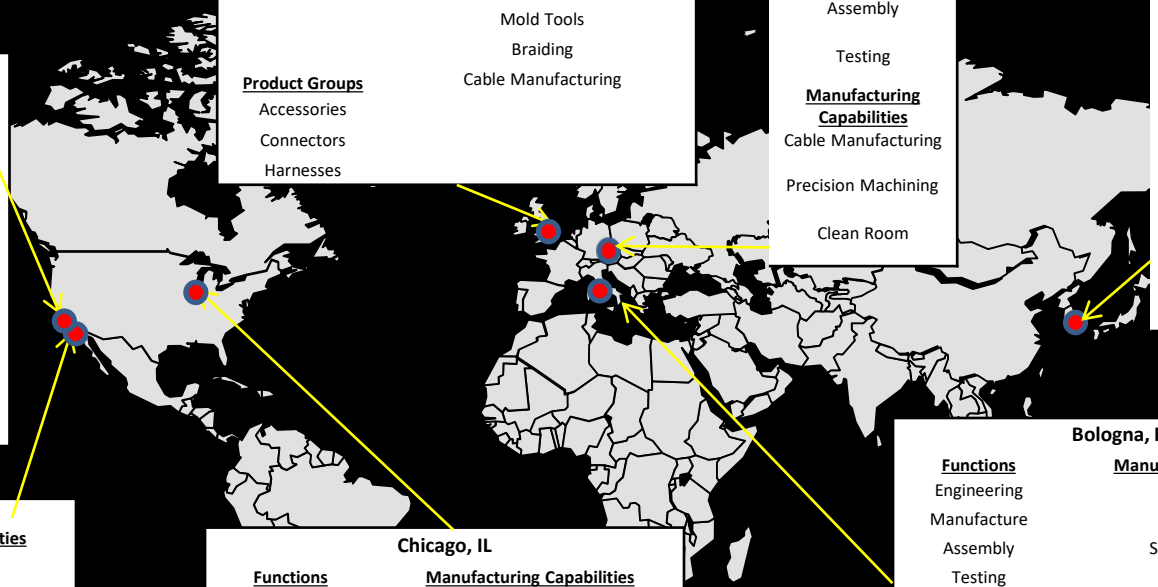
# Glenair Company Overview

## An interconnect industry leader since 1956

- Privately owned
- 2 million square feet factory space world-wide
- Core products: connectors, accessories, wire protection, cable assemblies and optoelectronics / photonics / fibre optics
- Primary markets: military, aerospace, avionics, space, oil / gas and nuclear
- Major focus on new products
- Service-centric business model
- AS9100 Revision D and ISO9000

Glenair UK Headquarters, Mansfield, Notts., UK

# Glenair Company Overview



## Mansfield, England

**Functions**
- Engineering
- Manufacture
- Assembly
- Testing

**Manufacturing Capabilities**
- CNC Lathes
- CNC Mills
- Composite Molding
- Elastomer Molding
- Mold Tools
- Braiding
- Cable Manufacturing

**Product Groups**
- Accessories
- Connectors
- Harnesses

## Salem, Germany

**Functions**
- Engineering
- Manufacture
- Assembly
- Testing

**Manufacturing Capabilities**
- Cable Manufacturing
- Precision Machining
- Clean Room

## Seoul, S. Korea

**Functions**
- Engineering
- Manufacture
- Assembly
- Testing

**Manufacturing Capabilities**
- Cable Manufacturing
- EMP Filters

## Glendale, CA

**Functions**
- Engineering
- Manufacture
- Assembly
- Testing

**Manufacturing Capabilities**
- CNC Lathes
- CNC Mills
- Die Cast Molding
- Composite Molding
- Elastomer Molding
- Mold Tools
- Filter Arrays
- Hermetic Sealing
- Extruded Conduit
- Braiding
- Cable Manufacturing

**Product Groups**
- Accessories
- Connectors
- Harnesses
- Conduit Systems

## Anaheim, CA

**Functions**
- Manufacture
- Assembly
- Testing

**Manufacturing Capabilities**
- CNC Lathes
- CNC Mills

**Product Groups**
- Accessories
- Connectors
- Harnesses

## Chicago, IL

**Functions**
- Engineering
- Manufacture
- Assembly
- Testing

**Manufacturing Capabilities**
- CNC Mills
- Composite Molding
- Elastomer Molding
- Mold Tools
- Micro/Nano Contacts

**Product Groups**
- Connectors
- Harnesses

## Bologna, Italy

**Functions**
- Engineering
- Manufacture
- Assembly
- Testing

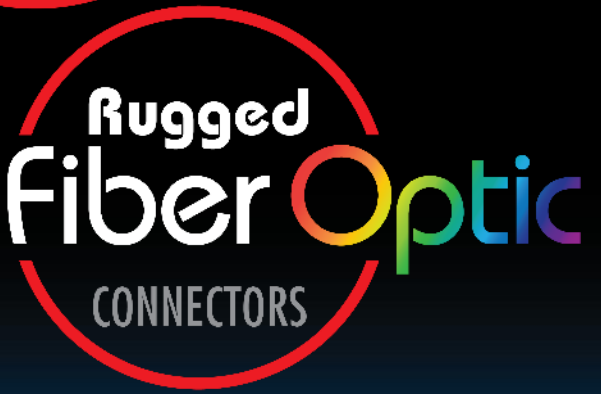
**Manufacturing Capabilities**
- CNC Lathes
- CNC Mills
- Specialty Contacts

**Product Groups**
- Accessories
- Connectors
- Harnessing

# Rugged Aerospace-grade Photonics and Fibre Optics

## Agenda

- Optical transceivers / optoelectronic contacts
- High density parallel optical transmission
- MT ferrule ribbon fibre optical connectors
  - SuperNine and Series 79
- Optical solutions for lasercom terminals
  - ITU grid US SDA compliant optical transceiver
  - Optical amplifiers
  - High power handling optical connectors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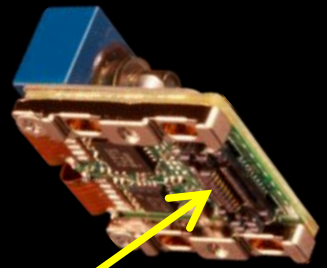
# What makes Glenair optical transceivers rugged?

Commercial SFP Transceiver with LC connector


"GC" Fiber Optic connector support high vibration & shock applications



1. 30Gbps High Speed connector
2. Easy "plug-in" assembly retained with mounting screws
3. Low mass contacts are great for high vibration and shock applications

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# Signature Parallel Optic Solutions

## High bandwidth hermetic parallel optical modules (external micro)

- 4x10G, 4x14G and 4x28G transceiver modules
- 12x10G Tx or Rx modules
- MTP optical connection interface
- SiGe and GaAs optoelectronic ICs
- -40°C to +85°C case operating temp
- Environmental qualification
  - Random Vibration — 46Grms, 2 hours per axis
  - Shock — 650G, 0.9ms, 10 shocks/axis
  - Accel. Aging — 85C, 1000 hours
  - Temp. cycling — 100 cycles, -40C to +85C, operating
  - Thermal shock — 500 cycles, -55C to +125C, non-op
  - Humidity — 10 days, temp cycling, 90% RH
- Radiation test reports available on request

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# Signature Parallel Optic Solutions

## Three Versions

- On-board processor version
  - Pros
    - ✓ Plug n play, simple implementation
    - ✓ COTS off the shelf , all feature, functions on-board
  - Cons
    - ✓ Survivability in a radiation environment
- Pin strapped version
  - Pros
    - ✓ Plug n play, simple implementation
    - ✓ High survivability in radiation environment
    - ✓ Works well if signal integrity not challenging (eg next to FPGA or switch IC)
  - Cons
    - ✓ Does not all ability for adjustment to compensate for signal integrity (equalization, pre-emphasis, output level)
    - ✓ I2C status not available
- Externally controlled version
  - Pros
    - ✓ Full advantage of signal integrity enhancements (for high speed signals passing through multiple connectors, long traces)
    - ✓ I2C status information
  - Cons
    - ✓ Need to implement firmware / software control of the transceiver on main board

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# Summary of 4x10G Transceivers

| **050-346**<br>**Quad 10G Transceiver**<br>**Terrestrial Military Grade** | **0500-3048**<br>**Quad 10G Transceiver**<br>**Space Grade** | **0500-3060**<br>**Quad 10G Transceiver**<br>**Full Space Grade** |
|---|---|---|
| Includes Internal Microprocessor<br>Convection or Conduction cooling | Radiation Tolerant<br>External microprocessor or Analog Mode Driver/TIA options<br>Conduction cooling | Radiation Tolerant<br>External microprocessor or Analog Mode Driver/TIA options<br>Conduction cooling |
| Low outgassing, ASTM E595 | Low outgassing, ASTM E595 | Low outgassing, ASTM E595 |
| Non-radiation environments | Radiation effects reports<br>Components same “type” as 0500-3060 but not RLAT | Components qualified by Radiation Lot Assurance Testing (RLAT) |
| Standard PCB components<br>10 micro-inch Au on I/O connector | Standard PCB components<br>10 micro-inch Au on I/O connector | Group C PCB components<br>30 micro-inch Au on I/O connector |
| TRL 9 (Avionics) | TRL 8 (Satellite) | TRL 8 (Satellite) |

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Ref: MIL-PRF-38534L

# Low Profile
# Parallel Fibre Optic Transceivers

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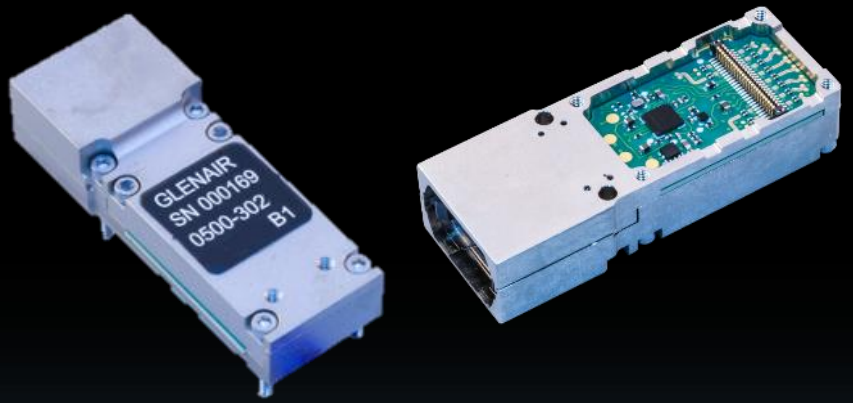
# Low Profile Parallel Fibre Optic Transceivers

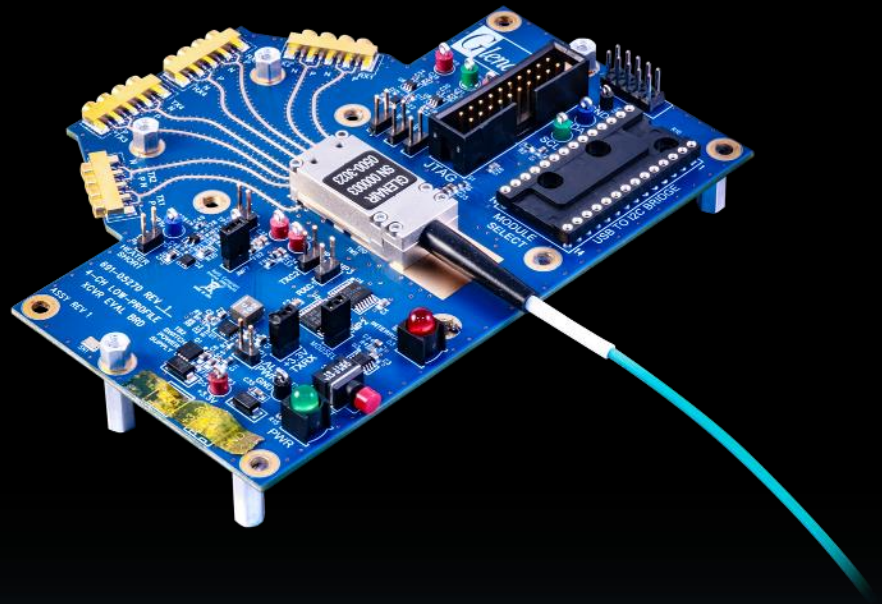
## Key Features

- Three different modules
  - 4Tx / 4Rx (8 fibres) or 12Tx or 12Rx (both 12 fibres)
- Data rates 1,10, 25 and 28Gbps per fibre
- QSFP28+ electrical I/O signal levels with digital diagnostics & control
- Large optical link budget, but still Class 1M eye safe
- MTP optical connector or pigtailed options
- High operating shock & vibration
  - -46Grms / 650g 0.9ms
- -40C to +85C Tcase operating



# Low Profile Parallel Fibre Optic Transceivers

## Evaluation boards for customer testing

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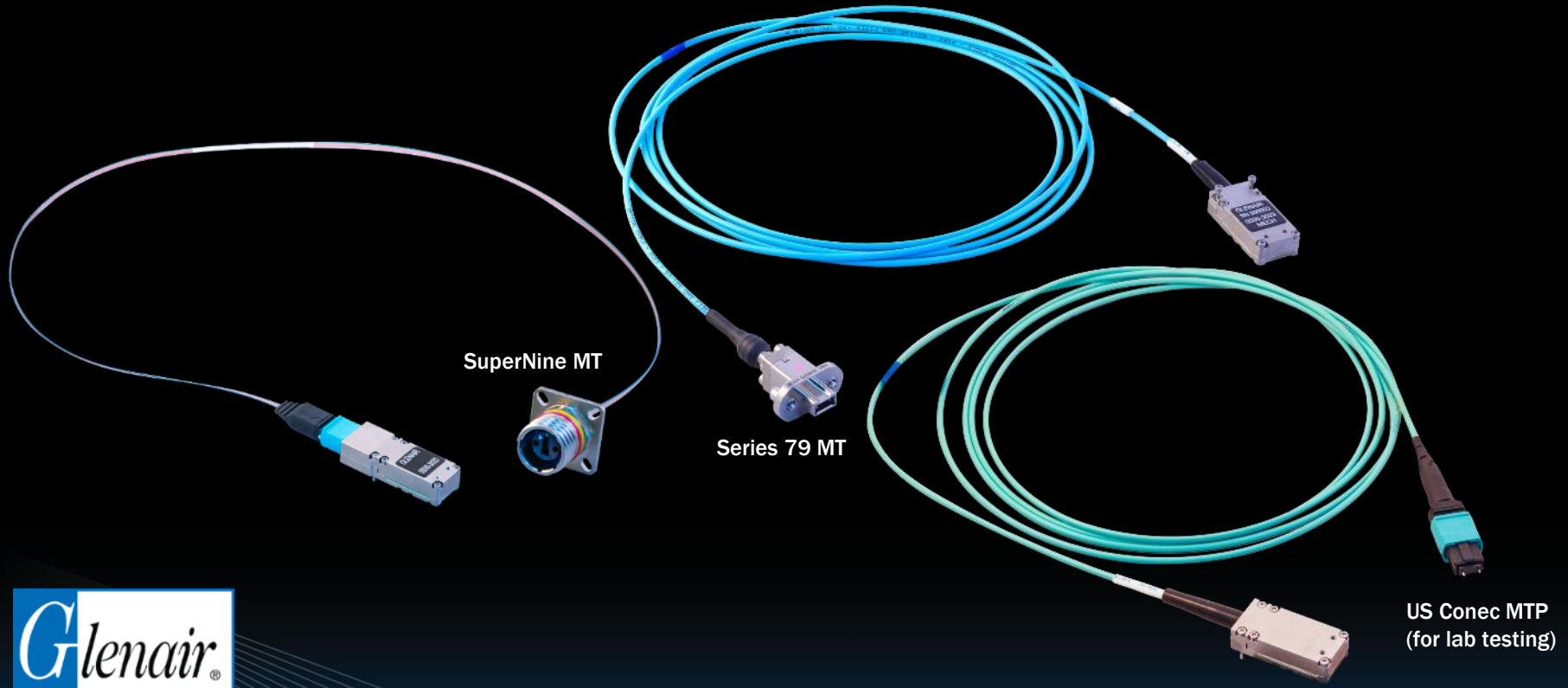
# Low Profile Parallel Fibre Optic Transceivers

## Full solutions for ribbon fibre connectivity

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# Series 79 MT: Rugged High-Density Fiber Optics

## Single MT ferrule, high-density interconnects in Glenair Signature Series 79 rectangular connectors

- Small form-factor, high-density fiber optic solution for rugged mil-aero applications
- Temperature tolerance from -40°C to +85°C
- Designed for optimal low insertion loss performance in high vibration and shock environments
- Optimized for use with parallel optic transceivers in ribbon or round cable applications

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# Photonic Components for Free Space Optical Laser Communication Terminals

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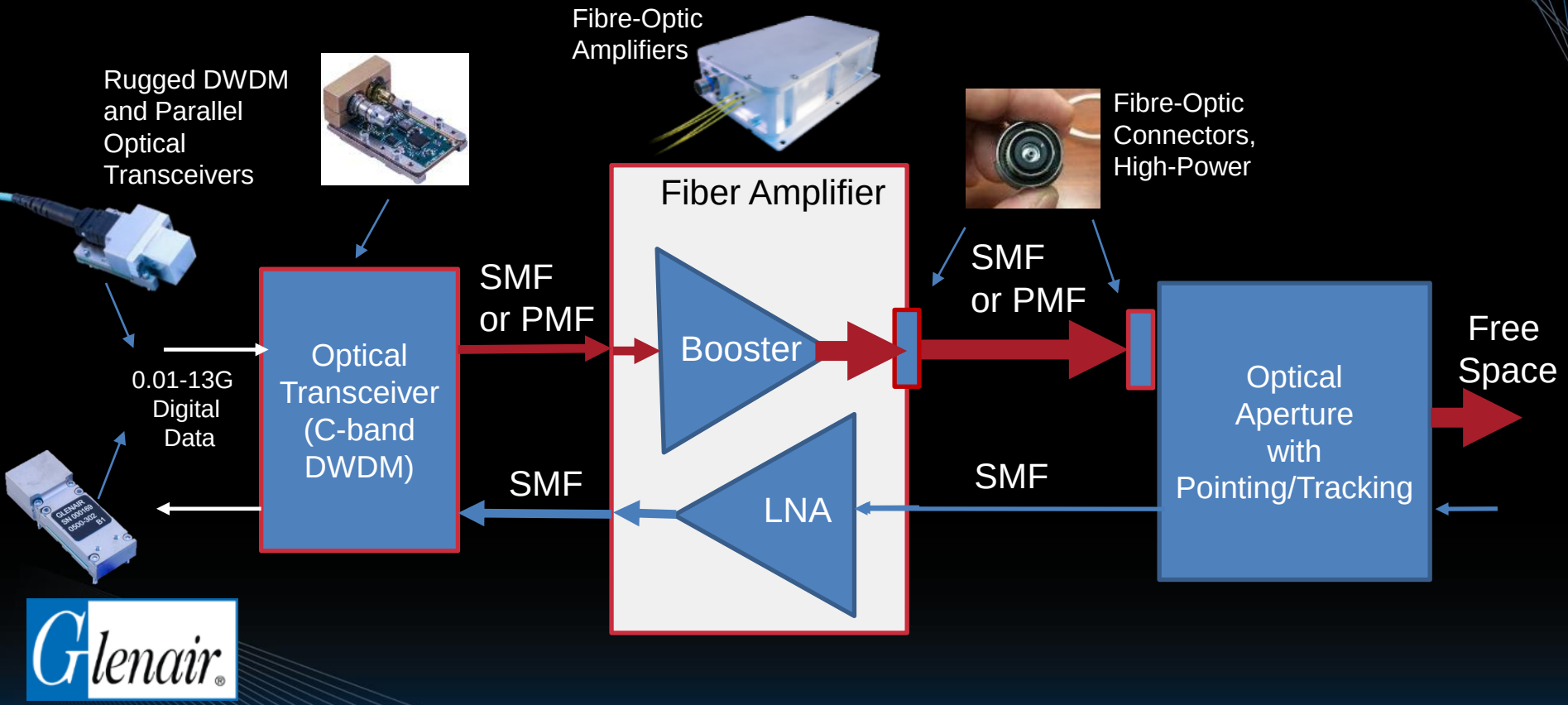
# Free Space Optical (FSO) Lasercom Terminal Block Diagram

## Space fibre optic transceivers & fibre optic amplifiers

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# Space Fibre Optic Transceivers

## 11.3 Gbps DWDM ITU Grid Transceiver

**Table 1 – Draft OISL Standard**

| Parameter | Threshold | Objective | Notes |
|---|---|---|---|
| A Wavelength: C-band | 1553.33 nm (selectable) | The center frequency of the optical carrier shall be tunable from 193.1 + n×0.1 THz, where n is an integer ranging from -30 to +30 corresponding to wavelengths in vacuum ranging from 1528.77 nm to 1577.03 nm with 100 GHz channel spacing consistent with ITU-T G.694.1 | ITU-T G.694.1<br>100GHz channel<br>N=-1.<br>The intent is for bidders to support two different frequencies in this range separated by at least 15 nm. The specific two wavelengths will be agreed upon between the winning bidders and SDA after award (nominally by PDR). Which wavelength is used for Tx and Rx must be switchable by command on orbit. |
| B Wavelength: C-band | 1536.61 nm (selectable) | | ITU-T G.694.1<br>100GHz channel<br>N=+20 |

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SDA SPACE DEVELOPMENT AGENCY

# Space Development Agency Optical Intersatellite Link (OISL) Standard

Developed by the

**Space Development Agency**

Office of the Under Secretary of Defense,
Research and Engineering (USD(R&E))
3030 Defense Pentagon
Washington, D.C. 20301

Email: OSD.SDA.Outreach@mail.mil

**Date:** 6/4/2020

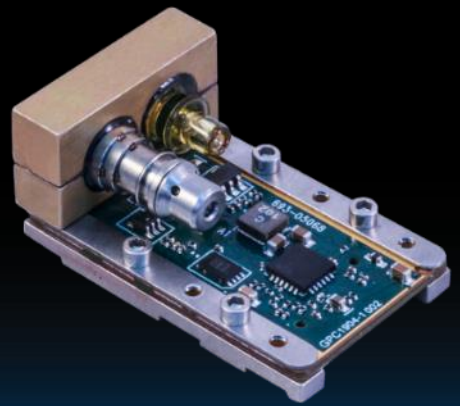
**Document ID:** 9100-0001-01

This document is a draft of a proposed Space Development Agency Standards Document. As such, this document is subject to revision.

# DWDM Optical Transceiver for FSO Lasercom Terminals

## 11.3 Gbps ITU Grid PCB-mount module

- DFB-EAM EML on ITU 100 GHz wavelength grid
- SDA standard compliant
- Thermo-electrically cooled EML, precise 1GHz wavelength control via temp
- PIN-TIA only, or PIN-TIA + limiting amplifier
- Firmware resides in on-board EEPROM or can be loaded from remote processor or EEPROM
- SFP+ I2C addressable and memory map
- -40C to +85C operating temperature range
- Radiation test reports available on request



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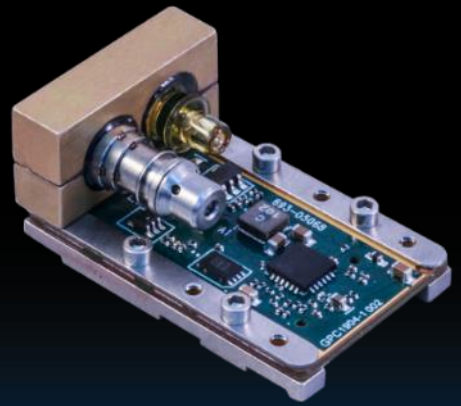
# DWDM Optical Transceiver for FSO Lasercom Terminals

## Unique Features

- Via the I2C comms bus the receiver sensitivity has been improved by >3dB relative to standard COTS competitors (ie SFP+)
  - Adjustable receiver decision-threshold and transmitter zero crossing compensates for optical amplification effects
  - Adjustable optimum power input
  - Tuning wavelength precisely with ASE filter passband
  - Carefully controlling optical power into the receiver input
- This product solves many problems unique to the FSO terminal applications
  - Offering a pilot tone for terminal acquisition
  - Fine-wavelength-tunability to compensate for Doppler-shift due to platform relative motions



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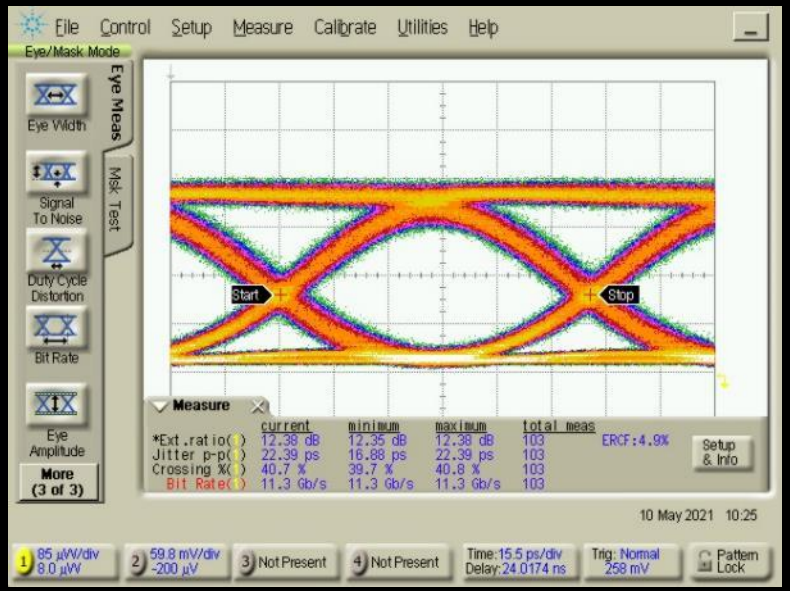
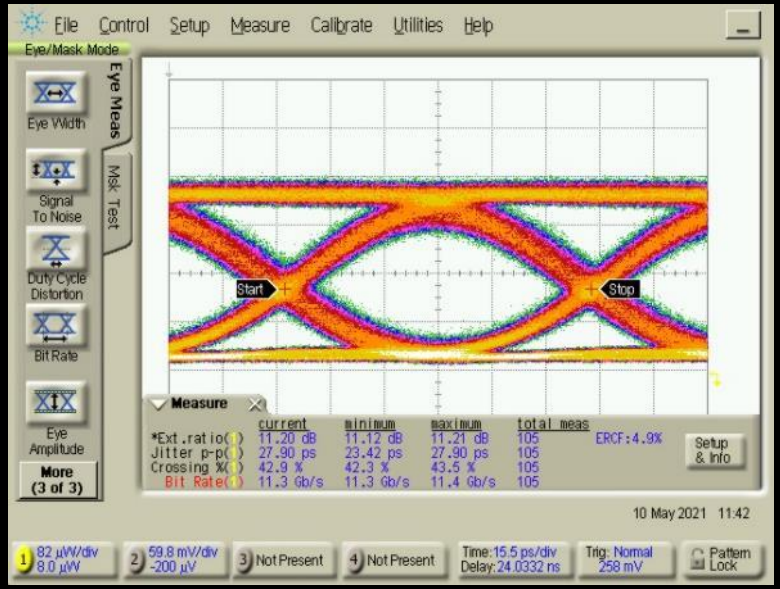
# Transmitter Optical Eye, 40% crossing

## Up to 11-13 dB extinction ratio at 11.3 Gbps, -10 to +85C




-10C




+85C

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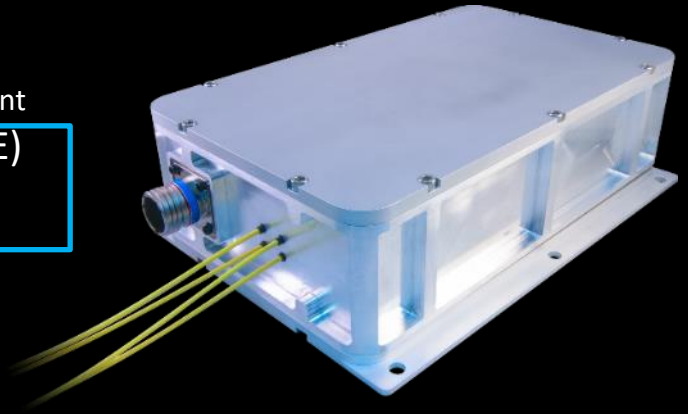
# Fibre Optic Amplifiers for FSO Lasercom Terminals

## Overview

- Erbium-Ytterbium (ErYb) booster amps
  - Output power to 5W
  - 8W and 10W under development
  - Polarisation maintaining fibre versions under development
- Booster amp excellent wall-plug efficiency (WPE)
  - 26W power consumption for 5W output
  - At 5W (37dBm) WPE is 18-20 %, NF <6dB
- Erbium LNAs with ~4 dB noise figures
- Novel conduction-cooled vacuum operation
  - > 1000 hours TVAC testing completed
- Supports two modes
  - Uncooled pumps: -5 to +60C
  - TECs under pumps: -40 to +85C
- COTS components to lower costs
- Low earth orbit radiation tested



Fibre optic amplifier with integrated low noise amplifier (LNA)

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# Fibre Optic Amplifiers for FSO Lasercom Terminals

## Compact version for CubeSats

- Development completed
  - Small form factor 1-2 W booster
  - 10 x 10 x 3.5 (cm)
- Prototypes already under customer evaluation
- Other form-factors / configurations possible


1-2W optical amplifier for CubeSats

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# Eye-Beam Power
# High Power Handling Optical Connector


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# Eye-Beam Power

## Results Achieved

- Proven 20W power capable @ 1064nm wavelength
  - Single-mode, polarization maintaining fibre (PMF)
  - Insertion loss < 0.5 dB (over -40C to +85C operating)
  - Only 6-8ºC contact temperature rise
  - Achieved under 20Grms random vibration with no measurable coupling change
- Proven 5W power capable @ 1550nm wavelength
- Compatible with standard Size 8 cavity for pre-existing MIL/Aero connector systems eg D38999, D-Sub, etc
- Our testing is limited by the equipment we have available


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# Glenair contacts…

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Eric Marcus, BeNeLux Account Manager (emarkus@glenair.de)

## Any questions…?

“Ruggedised opto-electronic components for multi-gigabit onboard & inter-satellite optical communications in space”

A

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