



Optical Multigig Automotive Ethernet

CFI Consensus building
NEA AdHoc

March 2019 - Vancouver

Carlos Pardo

cpardo_nea_01d_0319

OEM use cases

- Feedback from several individuals in OEMs:
 - Doarte Gonzalves - PSA
 - Magnus Eek - Volvo
 - Natalie A Wienckowski - GM
 - Michael Kaindl - BMW
 - Dr Rüdiger Roppel - Porsche
 - Mashita Yoshihisa - Jasper:
Toyota, Nissan, Honda, Mazda, Suzuki MC, Isuzu, Subaru, ...

Multi-Gigabit use case 1

Use case name: Smart antenna

Model year intro date: Q1/FY25

Use case description: Antenna hub which aggregates signals from GNSS, 5G, RF and GPS and sends it the head unit

Max. Bitrate: 2.5 Gbps

Key issues to take into account:

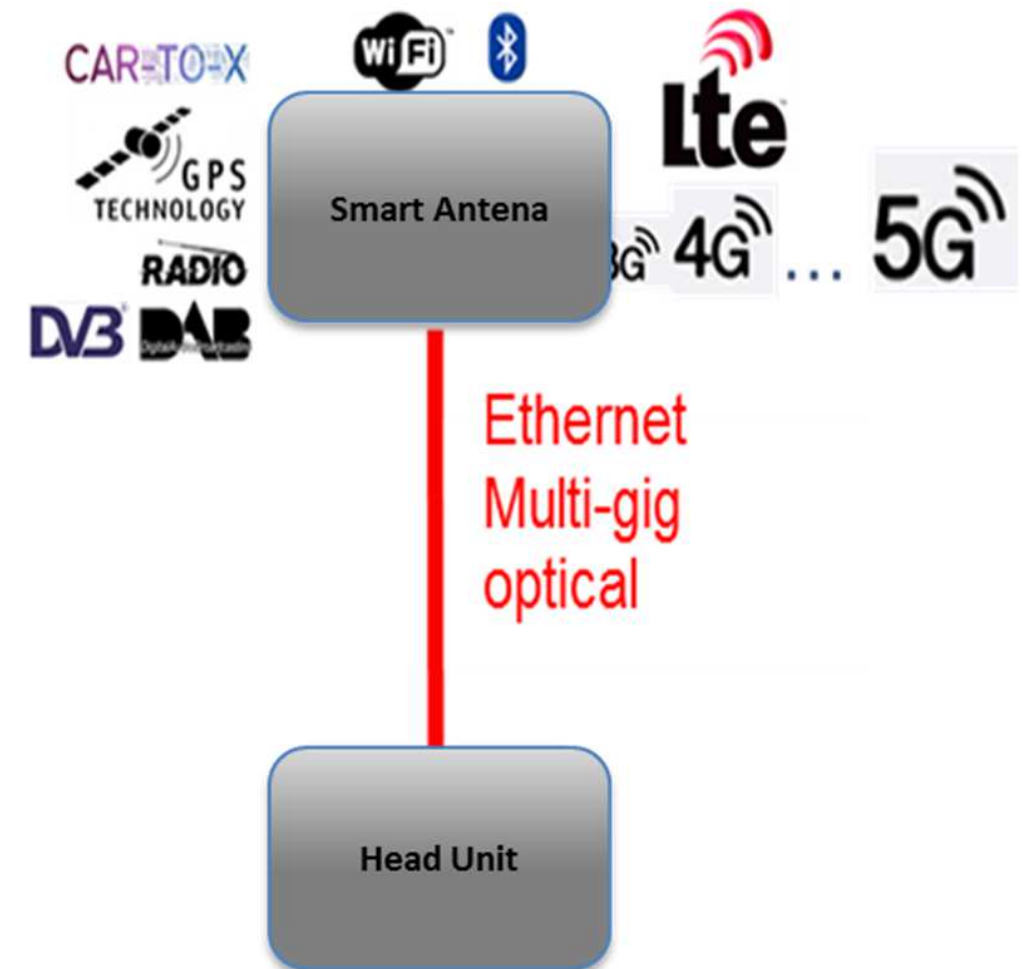
Radiation self coupling of transmission line into antenna

Low profile

Non conductive ceiling

High temperature profile (105°C)

Maximum latency 5 us



Source: Doarte Gonzalves
PSA

Multi-Gigabit use case 2



Use case name: Multi-domain Backbone

Model year intro date: Q1/FY25

Use case description:

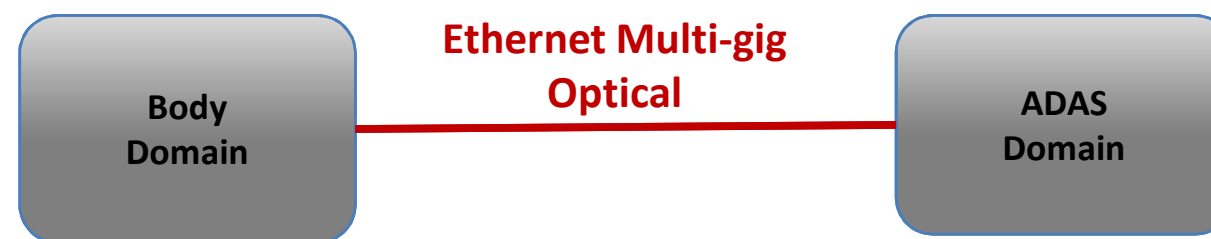
Aggregation of main Ethernet communication over backbone link between main Ethernet ECU's

Max. Bitrate: 5 / 10 Gbps

Key issues to take into account:

High temperature profile (105°C)

Latency, ...



Source: Doarte Gonzalves
PSA

Multi-Gigabit use case 3



Use case name: SENSORS (Cameras, Lidars,...)

Model year intro date: Q1/FY25

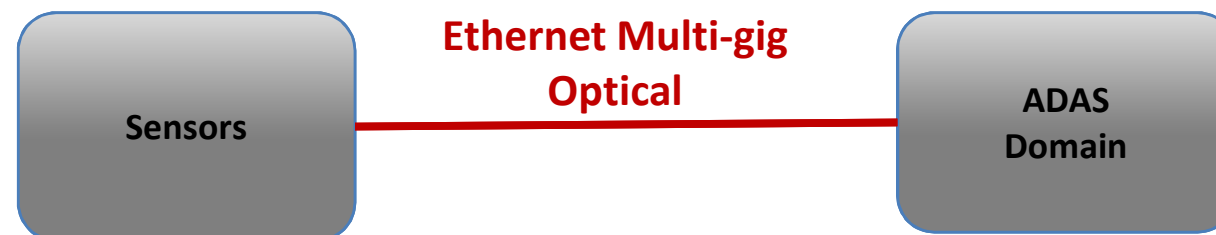
Use case description: Aggregates high definition signals from sensors (video without compression)

Max. Bitrate: 2.5 / 5 Gbps

Key issues to take into account:

High temperature profile (105°C)

Low latency



Source: Doarte Gonzalves
PSA

Multi-Gigabit use case 4

Use case name: Display

Model year intro date: Q1/FY25

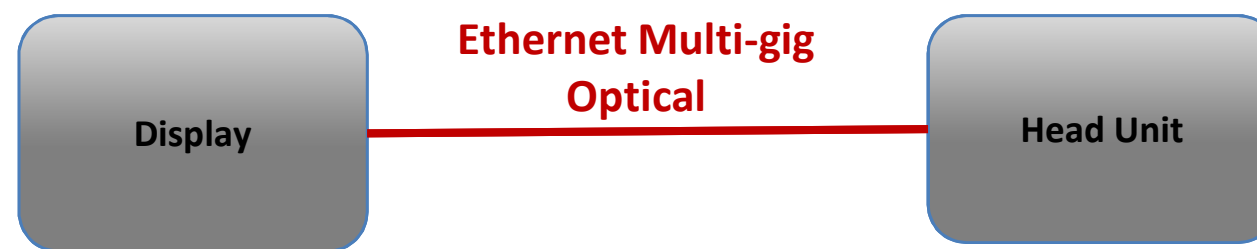
Use case description: Aggregates high definition signals from video source to Screen

Max. Bitrate: 2.5 / 5 Gbps

Key issues to take into account:

High temperature profile (105°C)

Latency, ...



Source: Doarte Gonzalves
PSA

Multi-Gigabit use case 5G Connectivity

Use case name: 5G Connectivity / Smart antenna

Model year intro date: TBD

Use case description: Antenna hub which aggregates signals from GNSS, 5G, RF and GPS and sends it to the head unit

Max. Bitrate: 2.5 Gbps

Key issues to take into account:

- Radiation self coupling of transmission line into antenna

- Low profile

- Non conductive ceiling

- High temperature profile (105°C)

- Maximum latency 5 us



Source: Magnus Eek
Volvo

Multi-Gigabit use case Magnetic Immunity communication

Use case name: Electro Magnetic Immunity communication

Model year intro date: TBD

Use case description: Communication for high Electro Magnetic Immunity for AD Fall back minimum risk condition (Intentional EMI for Safe Stop, Thunder)



Source: Magnus Eek
Volvo

Multi-Gigabit use case Back bone

Use case name: Back bone

Model year intro date: TBD

Use case description: Communication between Core System ECUs

Max. Bitrate: 10 Gbps

Key issues to take into account: Position in car both engine and passenger compartment.

High temperature profile (125°C)



Source: Magnus Eek
Volvo

Multi-Gigabit use case

Uncompressed camera

Use case name: Uncompressed camera data

Model year intro date: TBD

Use case description: Raw data from camera to processing unit.

Max. Bitrate: 10 Gbps

Key issues to take into account:



Source: Magnus Eek
Volvo

Multi Gig optical use cases

- **Camera, Display, Sensors** connection (Serializer function!)
 - Asymmetric function needed.
 - Download up to 10Gbit, uni directional;
 - Upload: Low Speed (10...100MB) Status/ Control
- **Backbone** – point to point 2...10 ECU
 - Required for Autonomous Driving Level 3 and beyond
 - Bandwidth from 2.5 Gbps to very high speeds
- **Data cloud in the car** (as one potential solution)
 - A central data storage system, where the data available for usage when needed/requested by the processor.
 - Also, we should use higher level of SW-Design & abstraction, in order to achieve flexible structures, and reduce amount of information to be stored

Source: email from **Dr Michael Kaindl**
BMW

Multi Gig optical use cases

- **Camera connection**
 - TODAY
 - Download stream 1GB, up to 6 Gbps ; upload stream 100 Mbps is enough
 - Future
 - Asymmetric function (only) needed. Download up to 10 Gbps, upload 10/100 Mbps
- **Autonomous driving**
 - Camera/radar sensors applications
 - Serial (one direction) link is required. Download stream up to 10 Gbps. No upload
 - Display:
 - We need the asymmetric mode:
 - High speed: Image Data, uni directional
 - Low Speed (10...100 Mbps) Status/ Control
 - Backbone – point to point 2...8 ECU units
 - In redundancy configuration. Optical & Copper.
 - Bandwidth 10 Gbps and beyond

**Source: email from Dr Rüdiger Roppel
Porsche**

GENERAL MOTORS

I am interested in investigating the suitability of optical Ethernet for Automotive applications faster than 10 Gb/s, e.g. environment, manufacturability, serviceability, etc.

I expect that as speeds increase, optical may have an advantage in some or all of EMC, power, weight.

Source: email from Natalie Wienckowski
General Motors

Industry activity status

- **Jaspar:** Japanese automotive industry association (<https://www.jaspar.jp/en/>)



- **Vision**

- Lead the automotive industry by promulgating and encouraging the broad-based adoption of new ideas and technologies.

- **Mission**

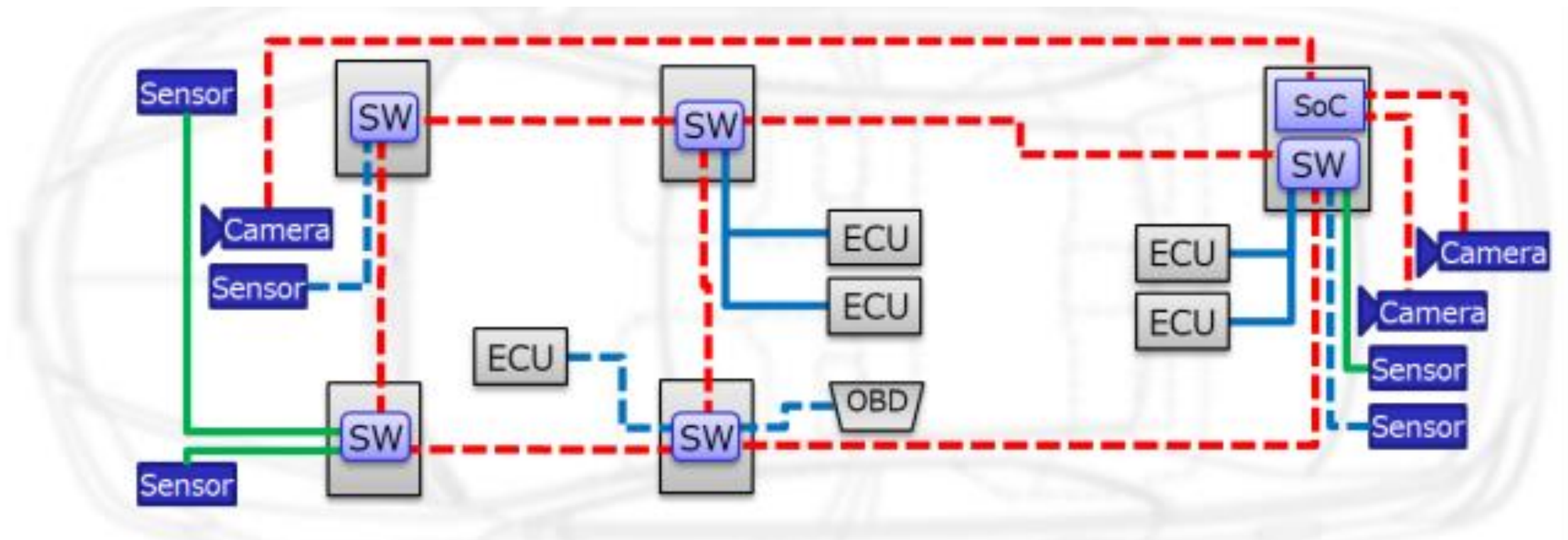
- Identify the common issues to be faced in the future by the automotive electronics sector.
- Undertake standardization initiatives aimed at resolving identified issues.

- **Members**

- 12 OEMs (Toyota, Nissan, Honda, Mazda, Suzuki MC, Isuzu, Subaru, ...)
- 43 Suppliers
- 78 Software/Tool vendors
- 27 Semiconductor/Component vendors
- 25 Others (Trading companies, Universities,...)

Use of optical or copper multi-gig

Information provided by Jaspar



- 10Mbps (10BASE-T1S)
- - - 100Mbps (100BASE-T1/TX)
- 1Gbps (1000BASE-T1/RH)
- - - 2.5, 5, 10Gbps

- Source:
Mashita(真下 喜久) Yoshihisa
Jaspar

Use cases

	2.5 Gbps	5 Gbps	10 Gbps	25 Gbps	50 Gbps	Unidirectional
Backbone	✓	✓	✓			
Smart Antenna	✓					
Cameras, Sensors	✓	✓	✓			✓
Display	✓	✓				✓
Future				✓	✓	

Target SOP date: 2025

**Is there critical mass in the industry to
provide very high speed optical links for
Automotive ?**

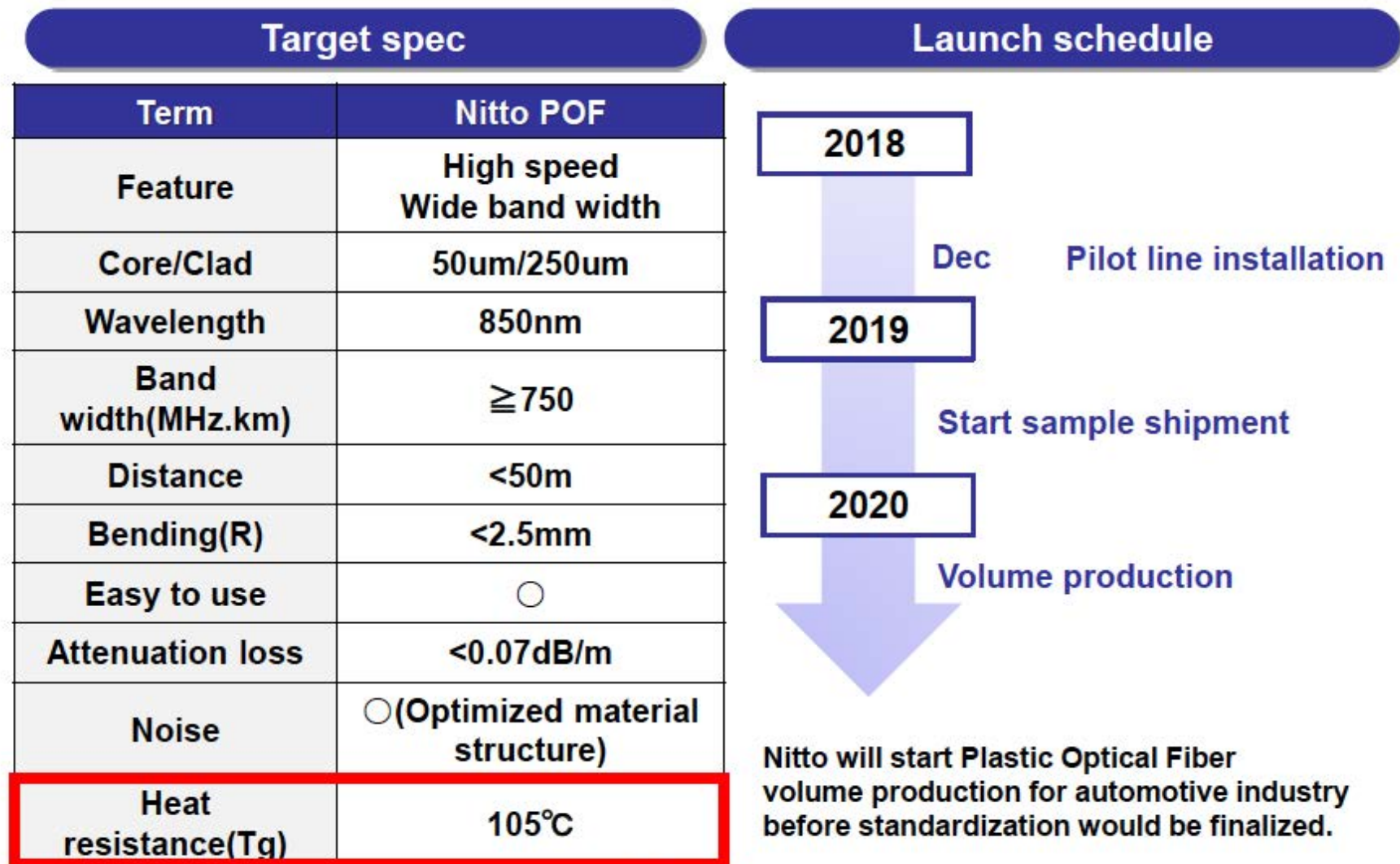
Is there critical mass in the industry to provide very high speed optical links for Automotive ?

- High bandwidth Fibres
 - Capable of support automotive requirements: Thermal, Aging, Cost, ...
 - Bending
 - Strength
- Connectors
 - Capable of support automotive requirements: Thermal, Aging, Cost, ...
 - Water / Dust Proof
 - Vibrations
 - Strength
 - Losses
- VCSELs
 - Capable of support automotive requirements: Thermal, Aging, Cost, ...
 - Bandwidth
- Photo Diodes
 - Capable of support automotive requirements: Thermal, Aging, Cost, ...
 - Noise
- Semiconductors
 - Knowhow to develop high speed optical links for Automotive applications

Fibres

- Different suppliers are suggesting different fibres

Nitto Plastic optical fiber target spec & launch schedule

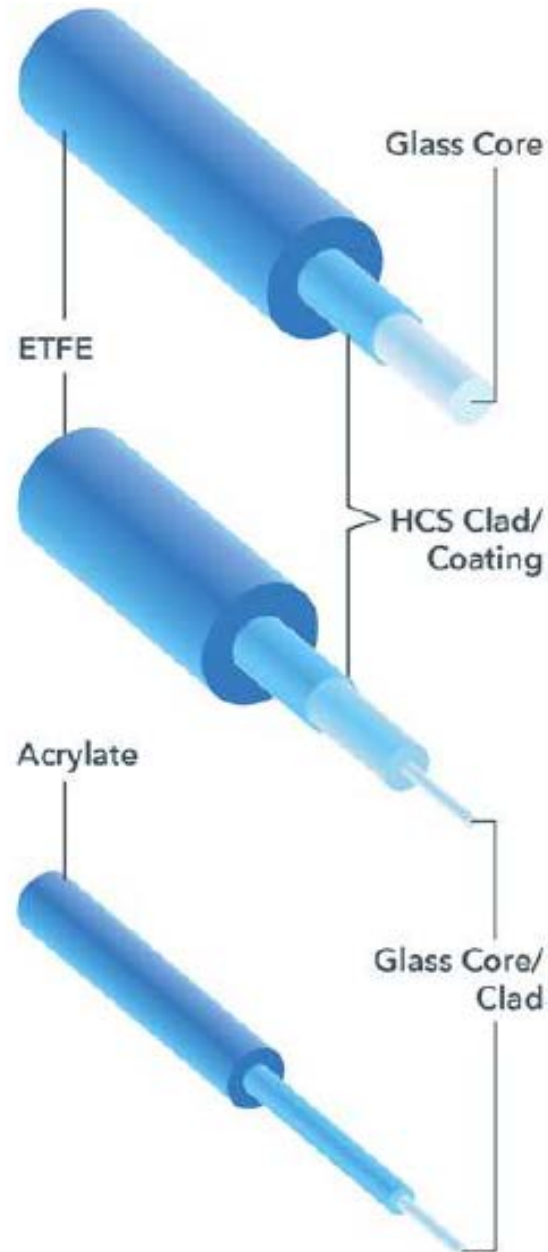


*These will be our target value and would subject to change.

Source: Takahashi, Tadashi; Nitto

Fibres

- Different suppliers are suggesting different fibres



Potential Glass Fibers for Automotive

200µm HCS Fiber with ETFE Buffer

Temperature: -65 °C to +125 °C
BW: ≥ 5 MHz-km @ 850 nm per IEC Standard
Attenuation: ≤ 6 dB/km @ 850 nm
Bend Radius: ≥ 16 mm

GI HCS Fiber with ETFE Buffer

Temperature: -65 °C to +125 °C
BW: ≥ 400 MHz-km @ 850 nm (depending on core size)
Attenuation: ≤ 2.8 dB/km @ 850 nm (depending on core size)
Bend Radius: ≥ 16 mm

50/125 Standard GI Fiber

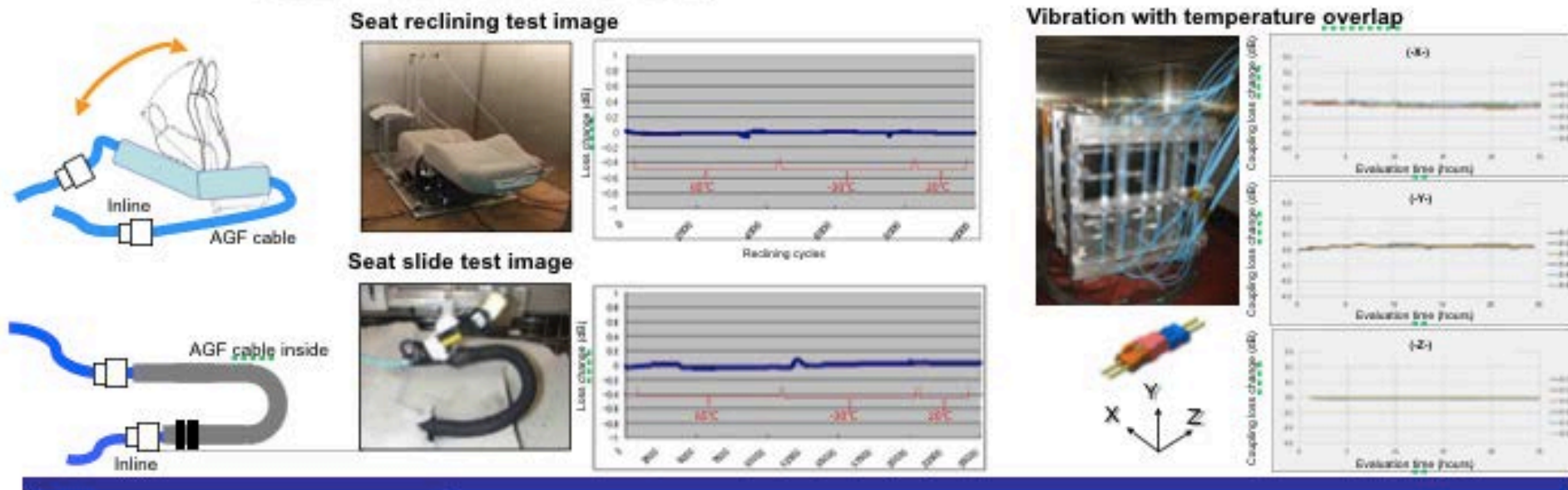
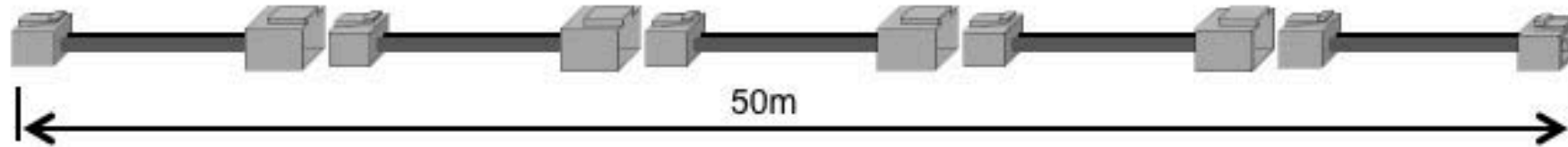
Temperature: -65 °C to +85 °C
BW: ≥ 4700 MHz-km @ 850 nm (depending on type and launch)
Attenuation: ≤ 2.2 dB/km @ 850 nm
Bend Radius: 17 mm



Fibres

- Different suppliers are suggesting different fibres

Even with 10 gigabit or over communication, it is possible to freely arranged with 50m optical harness.



Source: Hayato Yuki, Sumitomo Electric

Connectors

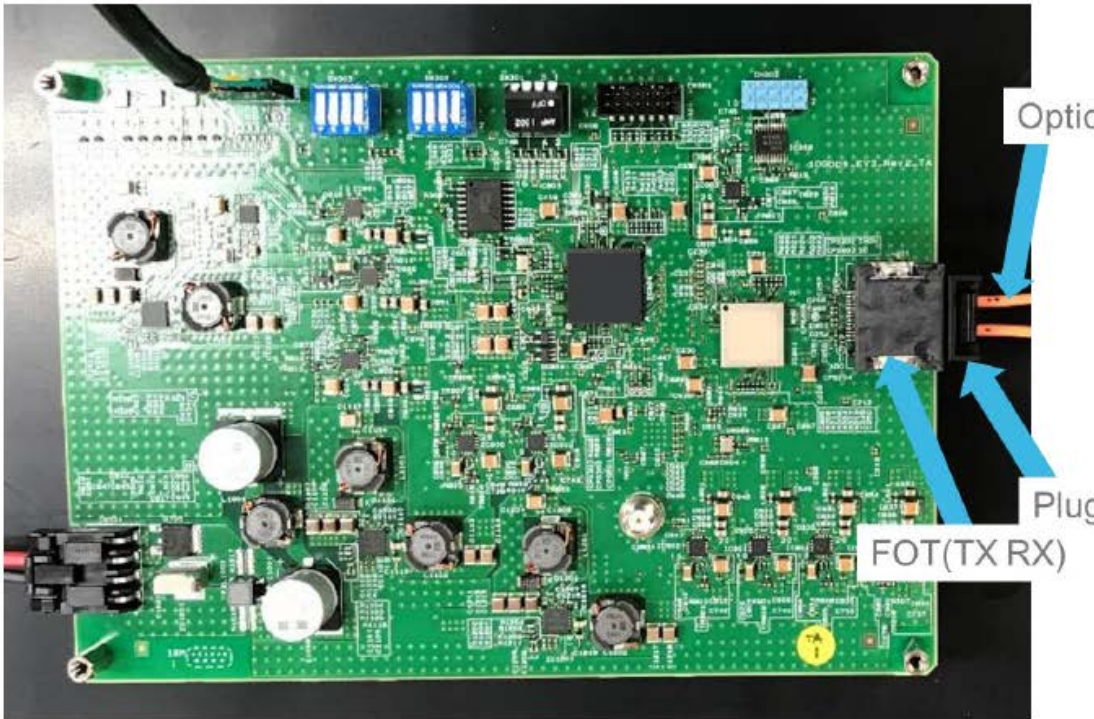
- Connector suppliers are in advanced development of Multi-gig optical connectors



Plug Assy(Silica fibre)



FOT(TX RX)



PHY and devices, VCSEL, PD, TIA and driver for FOT come from consumer market

Source: Shoji Kawashima, TE Connectivity; Tomohiro Kikuta, Adamant Namiki

Source: Ulrich Kleymann, Yazaki



Optical devices

- VCSELs and PD being qualified for Automotive applications
 - Reducing current density of VCSEL
 - Use robust PD architectures

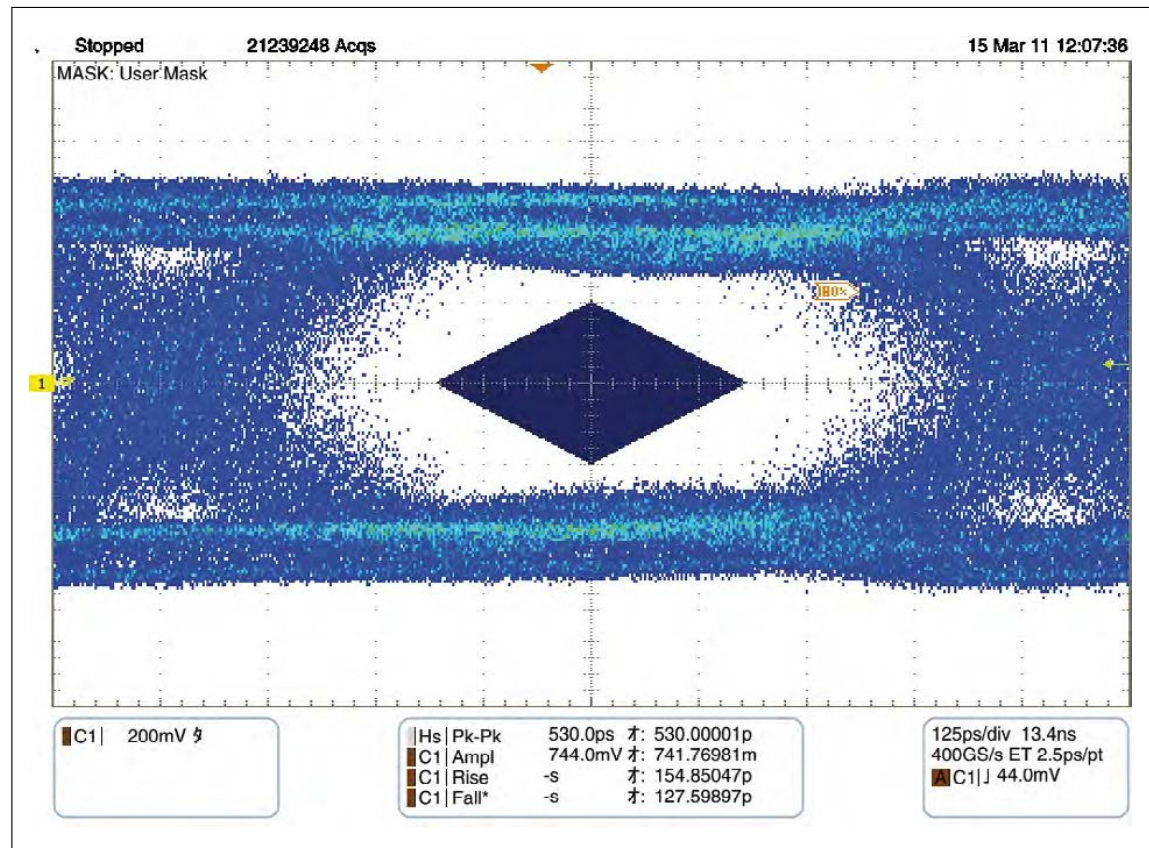


Figure 1. Eye pattern at -20 dBm (850 nm VCSEL), PCF (200 μ m diameter), GaAs PD (200 μ m diameter).

(Source: Hamamatsu Photonics)

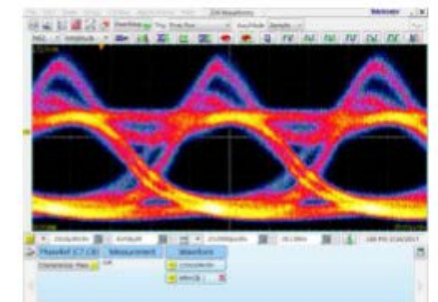
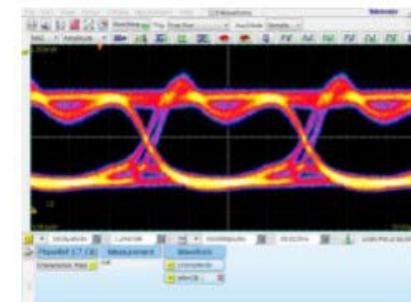
Source: Takayuki Suzuki
Hamamatsu Photonics



Different bit rates and receivers

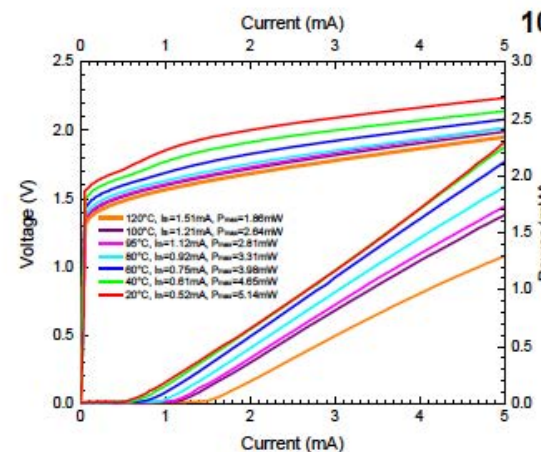
10

30GHz linear receiver
(evaluation of the optical eye)

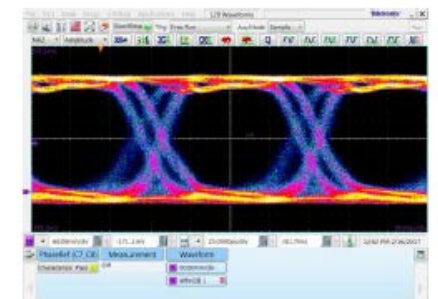


105°C 3 mA Vpp=0.15V 5 Gb/s

10 Gb/s



VIS 40G ROSA
35GHz limiting TIA
(evaluation of electrical eye)



105°C 3 mA Vpp=0.15V 10 Gb/s

→ Reliable electrical eye at 10 Gb/s 3mA 105°C

Semiconductors

- 1000BASE-RH is a successful story implementing advance modulation techniques in automotive optical applications:
 - Linear high speed opto-electronics
 - 16 PAM modulation
 - TH precoding
 - Multilevel coset coding with BCH inner code
 - Advanced equalization and synchronization

CFI proposal

- To create a Study Group for the standardization of an Optical Multi Gig Ethernet Physical Layer in Automotive Applications
 - To be presented during July Plenary in Vienna