IEEE 802.3
Call For Interest

Automotive Optical Multi Gig
July 2019

Consensus presentation

Carlos Pardo

Objective of this meeting

- To measure the interest of starting a new study group to address:
  - Multi gigabit optical PHYs for Automotive applications

- In this meeting, we don’t need to:
  - Choose any technical solution
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose any one solution
  - Create PAR or five criteria
  - Create a standard or specification

- Anyone on the room may speak & vote

- RESPECT… give it, get it

Agenda

- Market Drivers
- Technical Feasibility
- Market potential
- Why now?
- Q&A Panel
- Straw Polls

Panelists

Carlos Pardo, KDPOF

Hideki Goto, Toyota Motor
Takumi Nomura, Honda

Bob Grow, RMG Consulting

Supporters by affiliation

OEMs
- Hideki Goto - TMC
- Takashi Yasuda - TMC
- Doarte Goncalves - PSA
- Samuel Sigfridsson - Volvo Cars
- Jerker Fors - Volvo Cars
- Michael Kaindl - BMW
- Natalie A. Wienckowski - GM
- Josetxo Villanueva - Renault
- Takumi Nomura - Honda
- John Leslie - Jaguar Land Rover
- Syreeta Bath - Jaguar Land Rover
- Sanaz Mortazavi - VW
- Klemens Brückner - Audi

Automotive component suppliers (TIER-1 / TIER-2)
- Dr. Übbing - Leoni
- Daniel Wiesmayer - Dräxlmaier
- Christopher Müller - Valeo
- Mitsuhiko Mizuno - Denso
- Allan Zhu - Huawei Technologies
- Xuehuan Wang - Huawei Technologies
- Xu Yu - Huawei Technologies
- Zhangxingxin - Huawei Technologies
- Shoji Kawashima - Bosch Corporation
- Helge Zinner - Continental
- Tomoo Takahara - Fujitsu
- Hideki Isono - Fujitsu
- Yoshinori Fukuba - Toshiba Corp.

- Thomas Lichtenegger - Broadcom
- Martin Miller - Microchip
- Tim Baggett - Microchip
- Taiji Kondo - Megachip
- Kenichi Okajima - Hamamatsu Photonics
- Takayuki Shimizu - Hamamatsu Photonics
- Masaya Kato - Hamamatsu Photonics
- Kazuhiro Kurata - AIOCore
- Claude Gauthier - NXP
- Alexander Tan - NXP
- Gerrit den Besten - NXP
- Carlos Pardo - KDPOF

- Masato Shiino - Furukawa Electric
- Masayuki Iwase - Furukawa Electric
- Takashi Fukuoka - Sumitomo Electric
- Hayato Yuki - Sumitomo Electric
- Kazuya Takayama - Nitto Denko
- Tadashi Takahashi - Nitto Denko
- Andreas Engel - TE
- Richard Orosz - Yazaki
- Ulrich Keymann - Yazaki
- Steven E. Swanson - Corning
- John S Abbott - Corning
- Alexander Umnov - Corning
- Mabud Choudhury - OFS
- Yoshihiro Niihara - Fujikura Ltd
- Kiyotsugu Oban- Fujikura Ltd
- Hidenari Hirase - AGC Inc.

Other
- Tomohiro Kikuta - Adamant Namiki
- Yasuhiro Hyakutake - Adamant Namiki
- Satoshi Takahashi - POF Promotion
- Bob Grow - RMG Consulting
- Manabu Kagami - Nitech
- Kazuhiko Ishibe - Anritsu
- Oki Sugihara - Utsunomiya University
- Takeo Masuda - Oitda

Market Drivers
Automotive Ethernet

- The automotive industry has decided to go into Ethernet

- Several 802.3 standards published or in preparation
  - 10 Mb/s (P802.3cg Task Force)
  - 100 Mb/s (100BASE-T1)
  - 1000 Mb/s (1000BASE-T1, 1000BASE-RH)
  - 2.5 , 5 & 10 Gb/s (P802.3ch Task Force)
  - Beyond 10 Gb/s (Study group)

- Industry associations are supporting the development of Ethernet for the automotive industry:
  - OPEN Alliance
  - JASPAR
  - NAV Alliance

- Complementary standardization bodies are specifying “missing parts” for automotive Ethernet: Connectors, cables, interfaces, W&S, etc
  - ISO 21111 within ISO - TC 22 - SC31 & SC32

Market Drivers
Automotive Optical Ethernet

- 1000BASE-RH is being used by several OEMs worldwide due to its intrinsic advantages:
  - Galvanic isolation
  - Superior EMC performance. Easy engineering
  - Weight

- Optical and copper Ethernet are complementary, even in the same car

- First car in the market with 1000BASE-RH will be in 2020.

Hideki Goto, Chairman of **JASPAR**'s Next Generation High-Speed Network Working Group and Group Manager at **Toyota** stated:

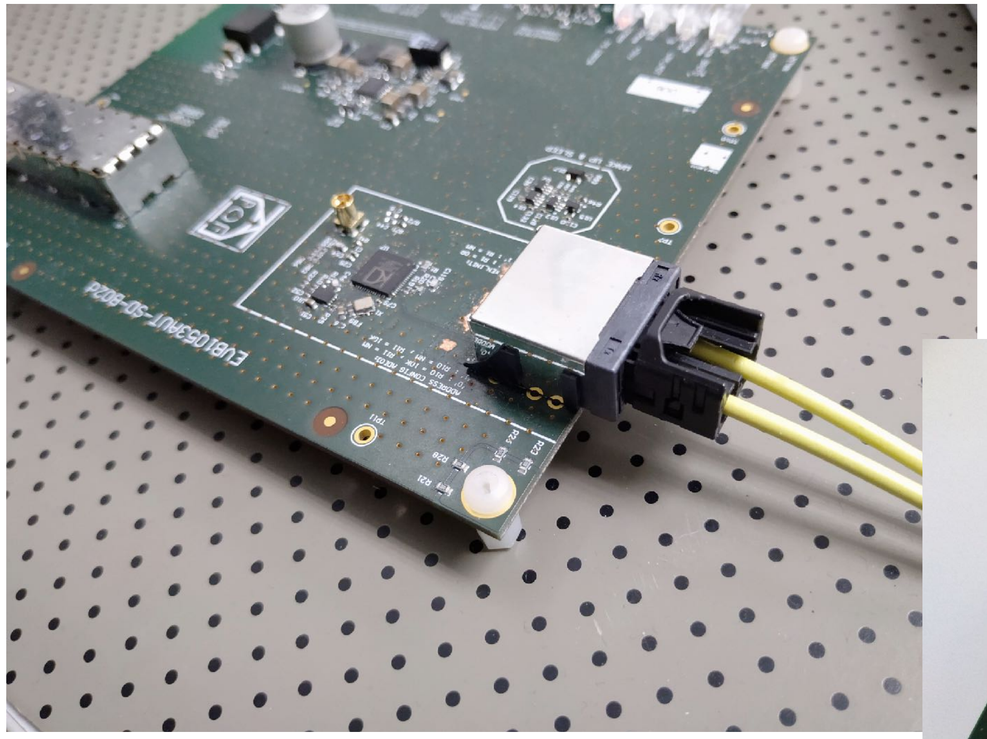
"… optical network solution greatly improves the speed of automotive networks and moves beyond obsolete, lagging networking protocols. Optical Ethernet technology is ideal for future in-vehicle network infrastructure, since it provides a radiation-free harness, and thus meets prerequisites concerning electromagnetic compatibility (EMC). Higher speeds are achieved by wider use of the electromagnetic spectrum, which forces OEMs to impose more and more stringent emissions limits on electronic components."

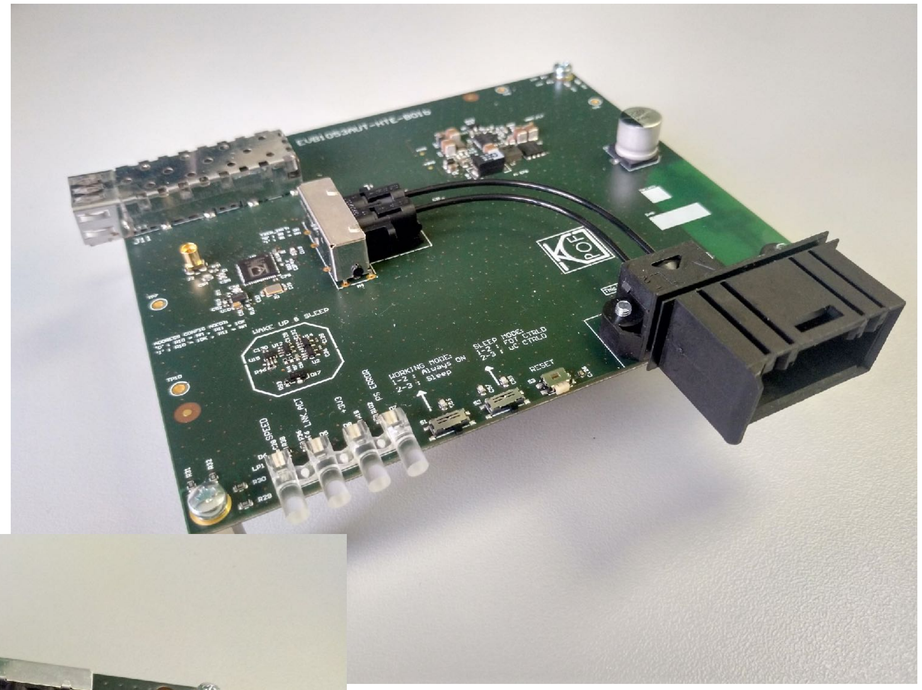
Martin Hiller, Volvo Cars

" … m*any factors come into play here, such as costs, the degree of maturity of the components and so on. Ethernet via fiber optics is definitely of interest. …*"

Automotive Optical Ethernet Connector

- How does it look like ?

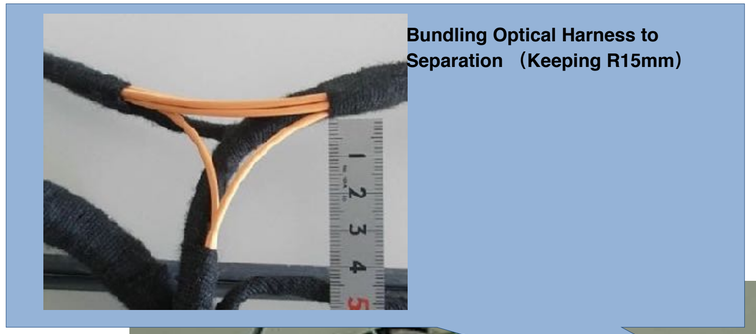




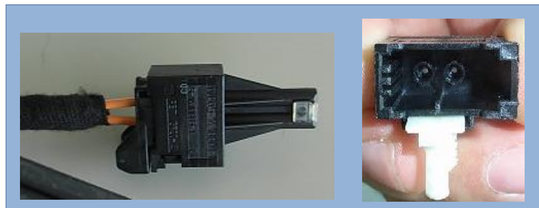
Automotive Optical Ethernet Harness

- How is installed ?

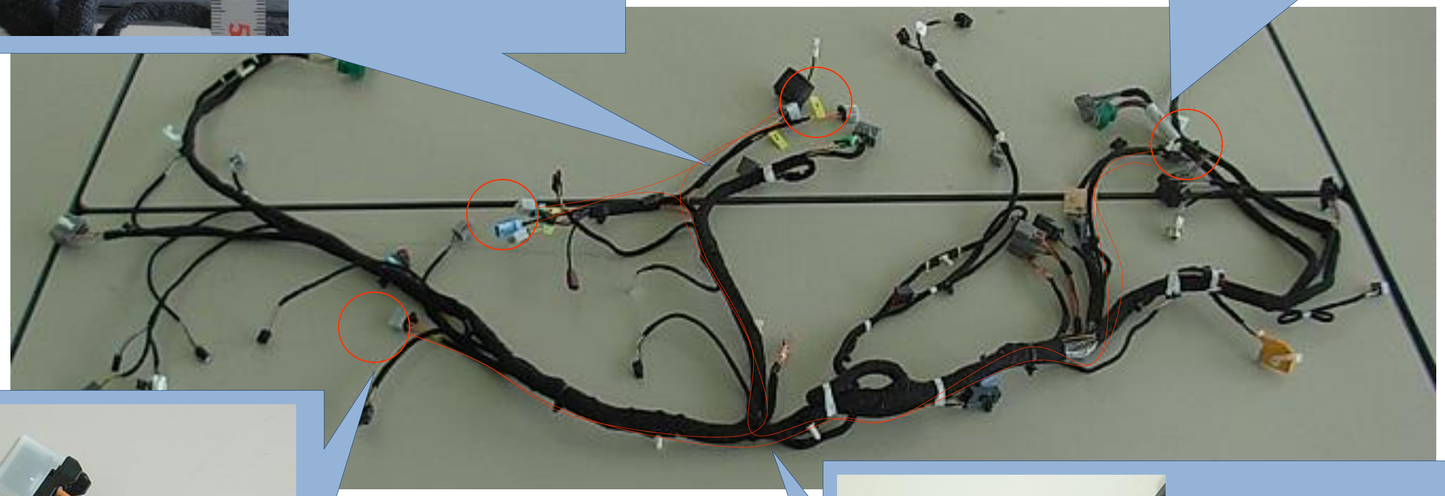
Instrument Panel W/H



Bundling Optical Harness to Separation （Keeping R15mm）



Loopback (for Diagnostics) Connector with Clamp



Dust Protection Cap to all Connector Ends

○Optical Connector End
—Routing

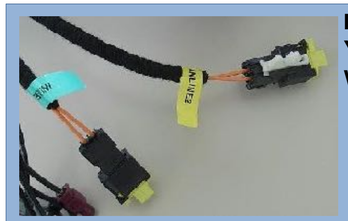
Bundling Optical Harness to Copper Binding

Seamless integration of POF with W/H at manufacturing and installation

Automotive Optical Ethernet Harness

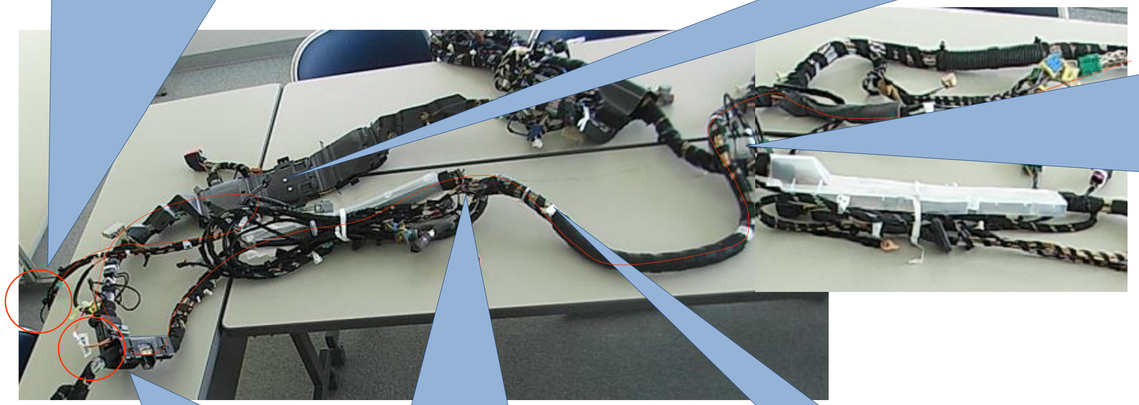
- How is installed ?

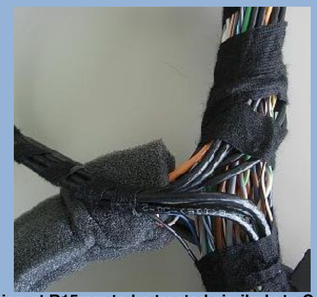
Floor W/H



Inline Connector
Yellow：Dust Protection Cap
White：Clamp

No Protection for Optical Fiber inside Protector





Separation at R15mm to be treated similarly to Copper Cable

Fixing Inline Connector to Protector

Protector Exit ; Similarly treated to Copper Cable

Winding and Clamping similarly to Copper Cable

Seamless integration of POF with W/H at manufacturing and installation

Natalie, GM Poll

Surveys – OEM Responses

Cable Types – Should different speeds use the same cable or is it okay if they're different?

- 68.75% of respondents said it is okay to use different cables for different speeds

Is it okay to use optical cable?

- 50% of respondents said they would consider using optical cable

Maximum operating temperature

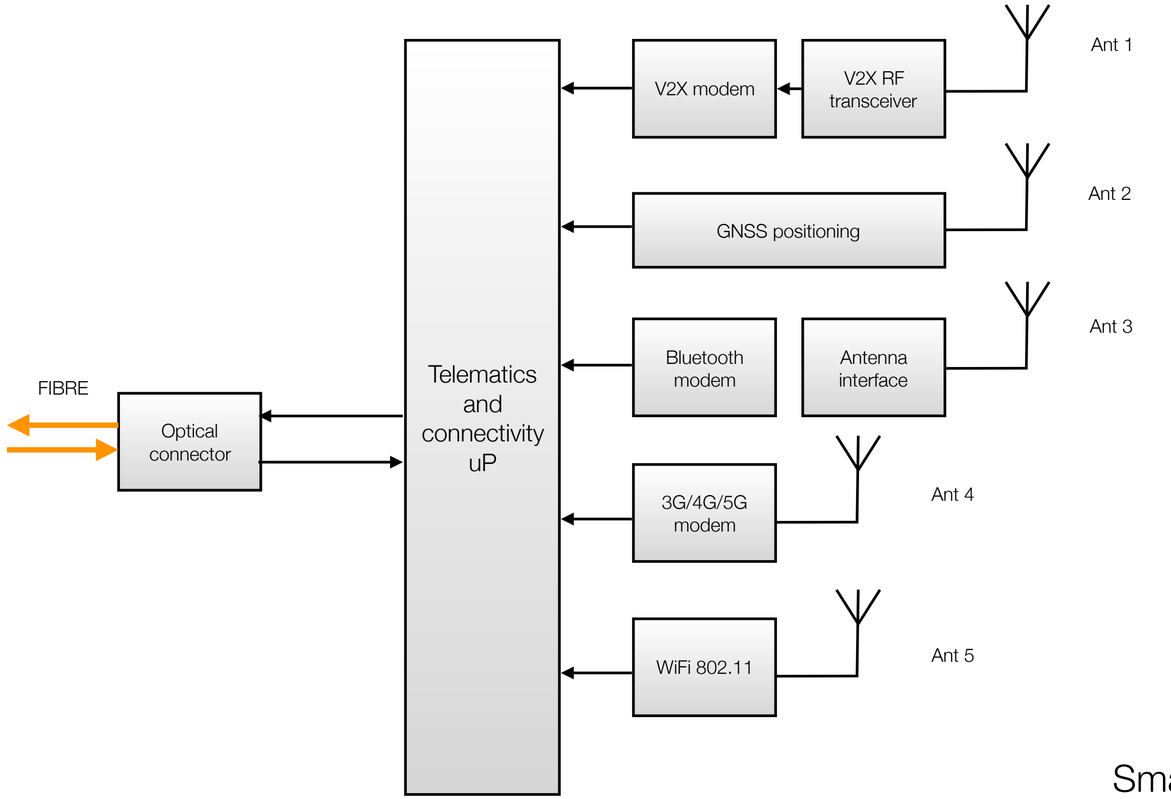
- 62.5% need 105 C for most or all speeds
- 18.75% need more than 105 C for some or all speeds
- 18.75% say 85 C is sufficient for all speeds

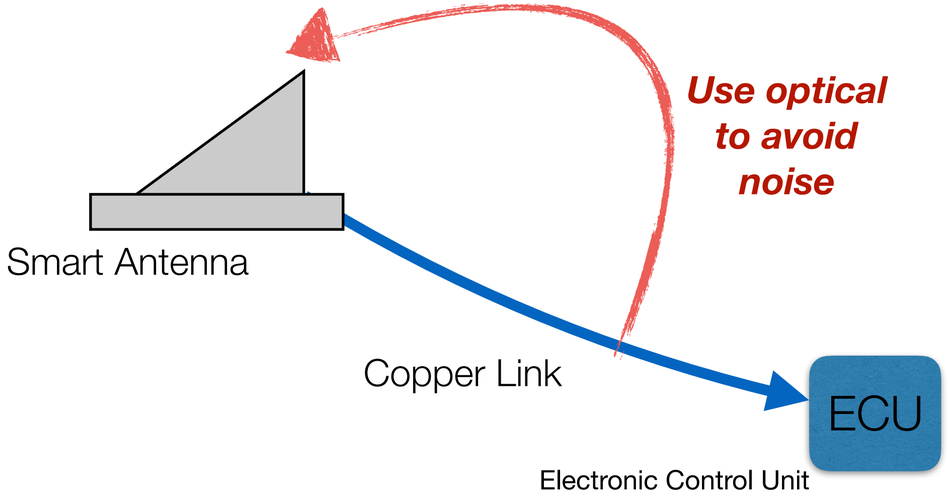
Minimum operating temperature

- 100% agree that -40 C is sufficient
- -55 C is required for storage

Use cases - Why optical?

- Smart Antenna

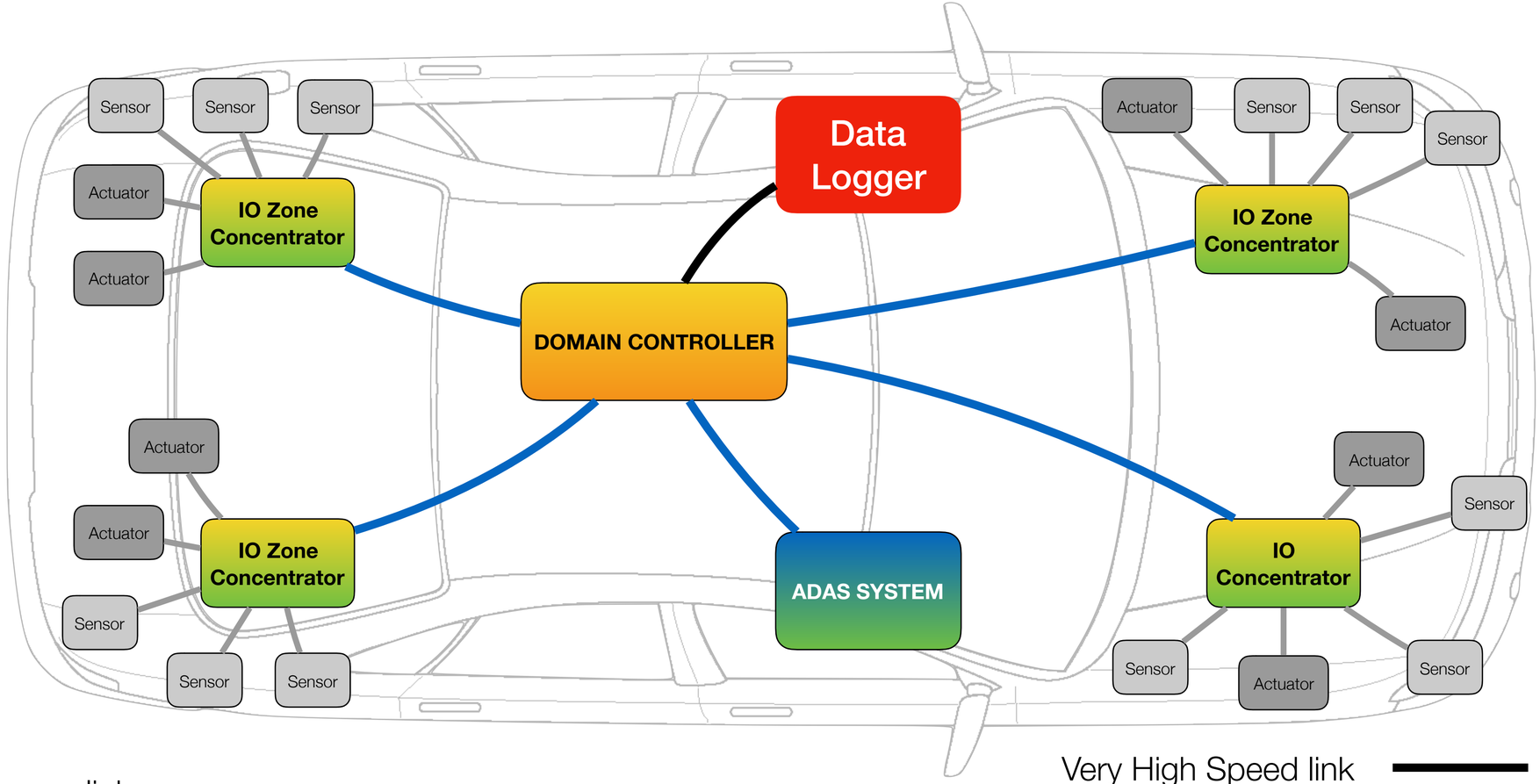




Any small radiation from the copper link will reduce the reception dynamic range of the antennas

Use cases - Why optical?

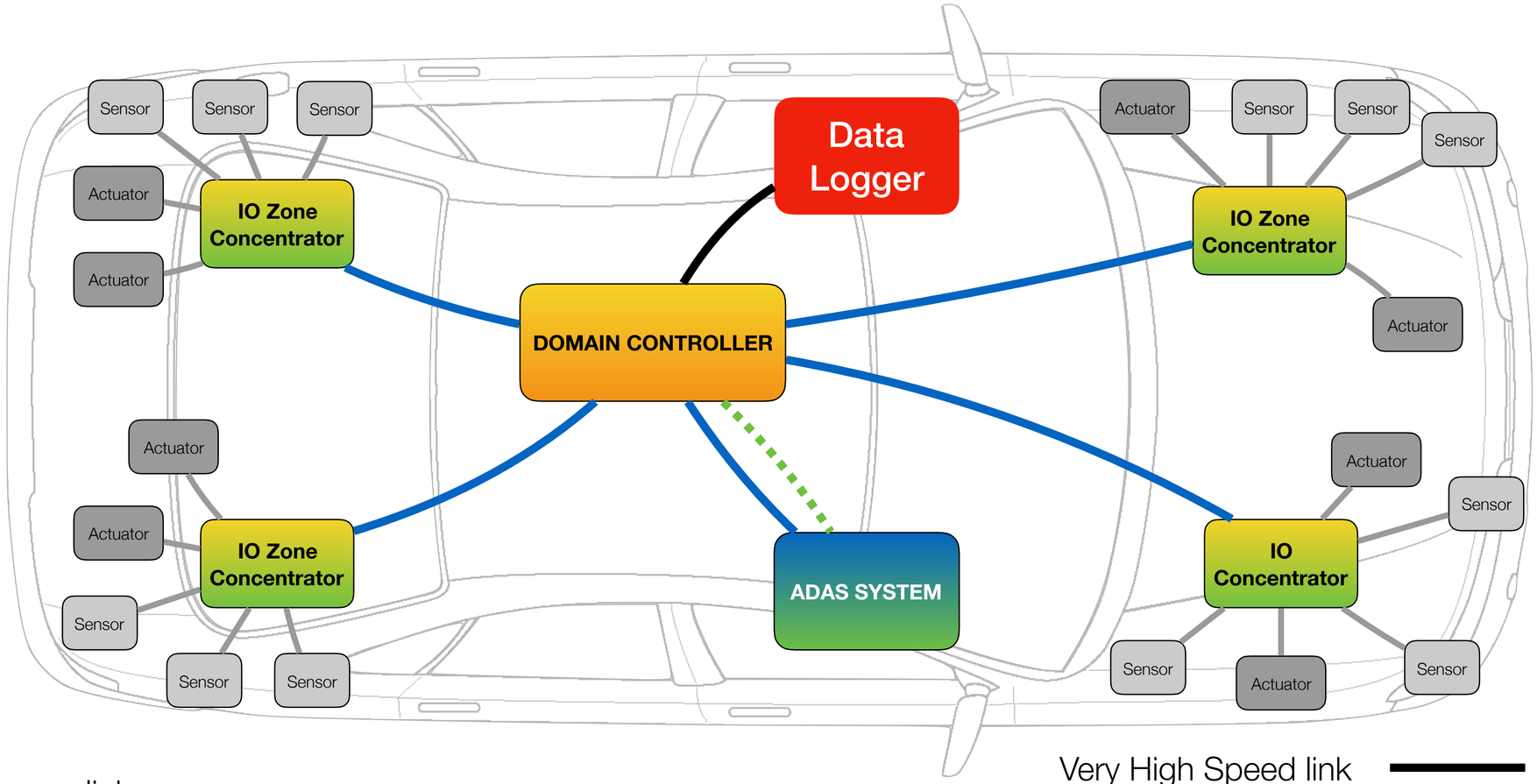
- Zone based network architecture requires long high speed links



ASIL=Automotive Safety Integrity Level
ADAS=Advanced Driver Assistance System

Use cases - Why optical?

- Safe backbone with redundant links will be needed for ASIL-D architectures.



ASIL-D Safety architecture
ASIL-D = ASIL-B + ASIL-B

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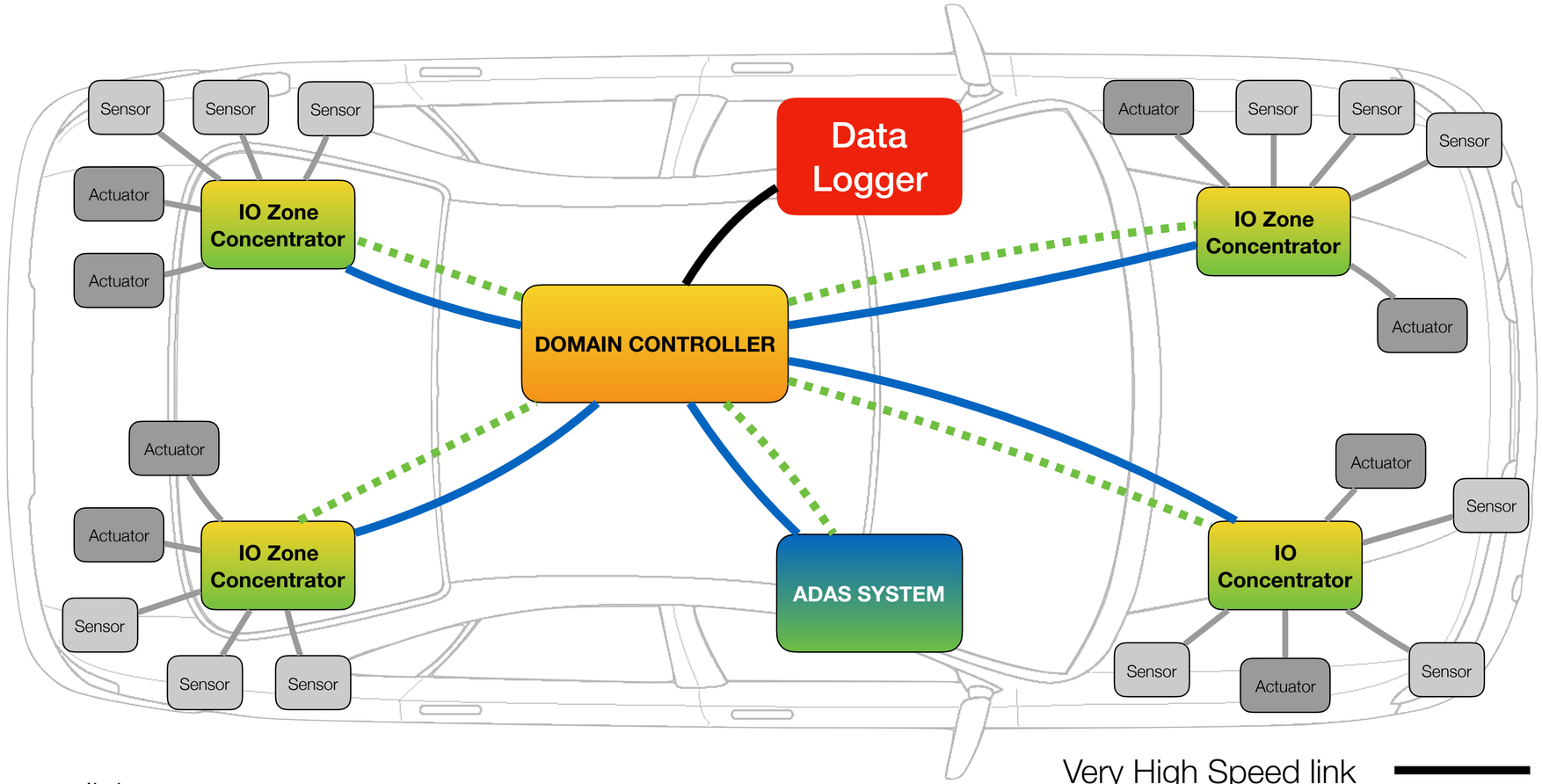

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ASIL-D = ASIL-B + ASIL-B

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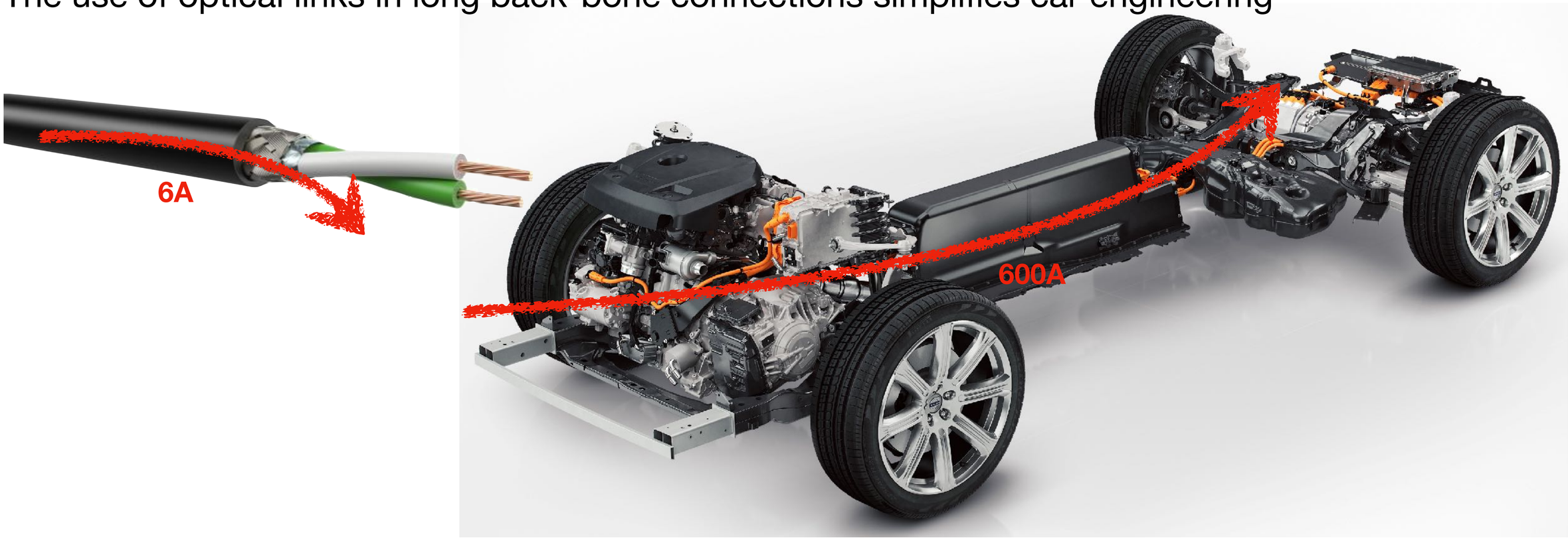
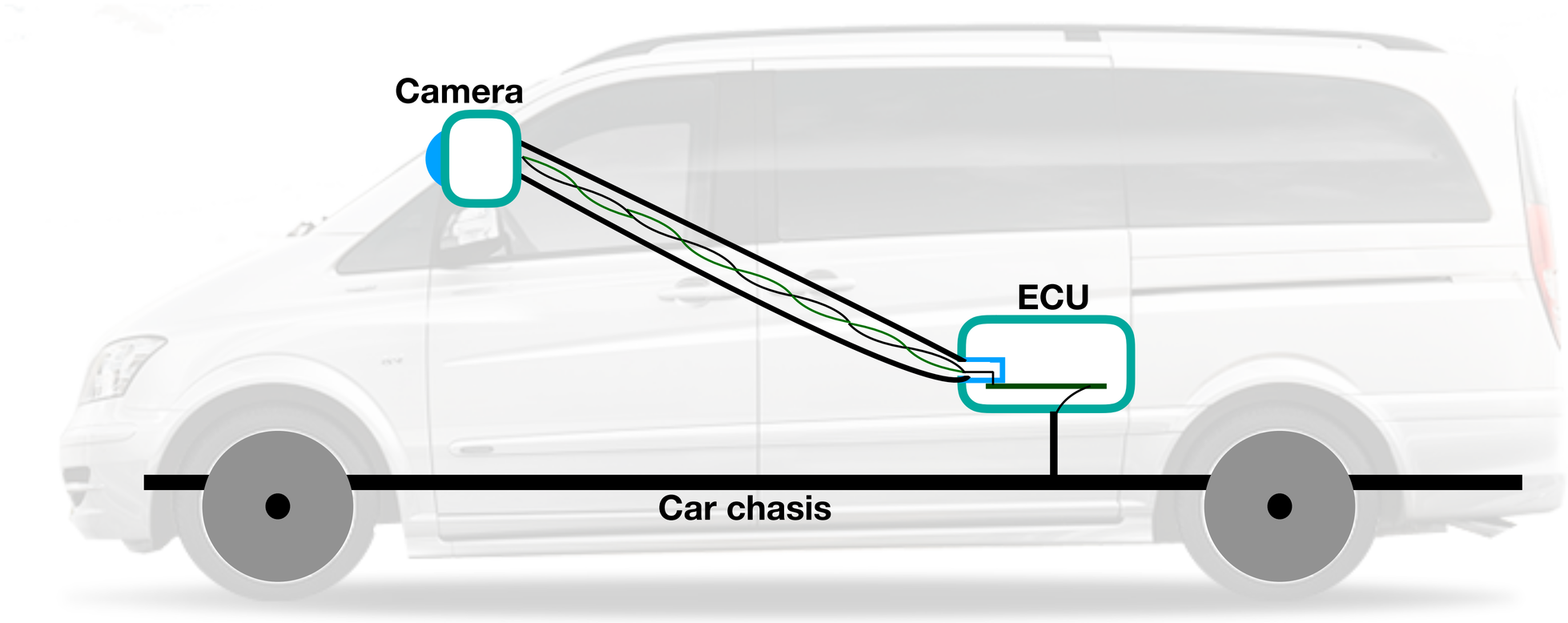
Use cases - Why optical?

- During operation, currents up to 600 A move from the front to the back of the car
- This large current generates voltage drops between different ECUs of the car
  These voltages may create up to 6A currents through the shield of data cables

- The use of optical links in long back-bone connections simplifies car engineering

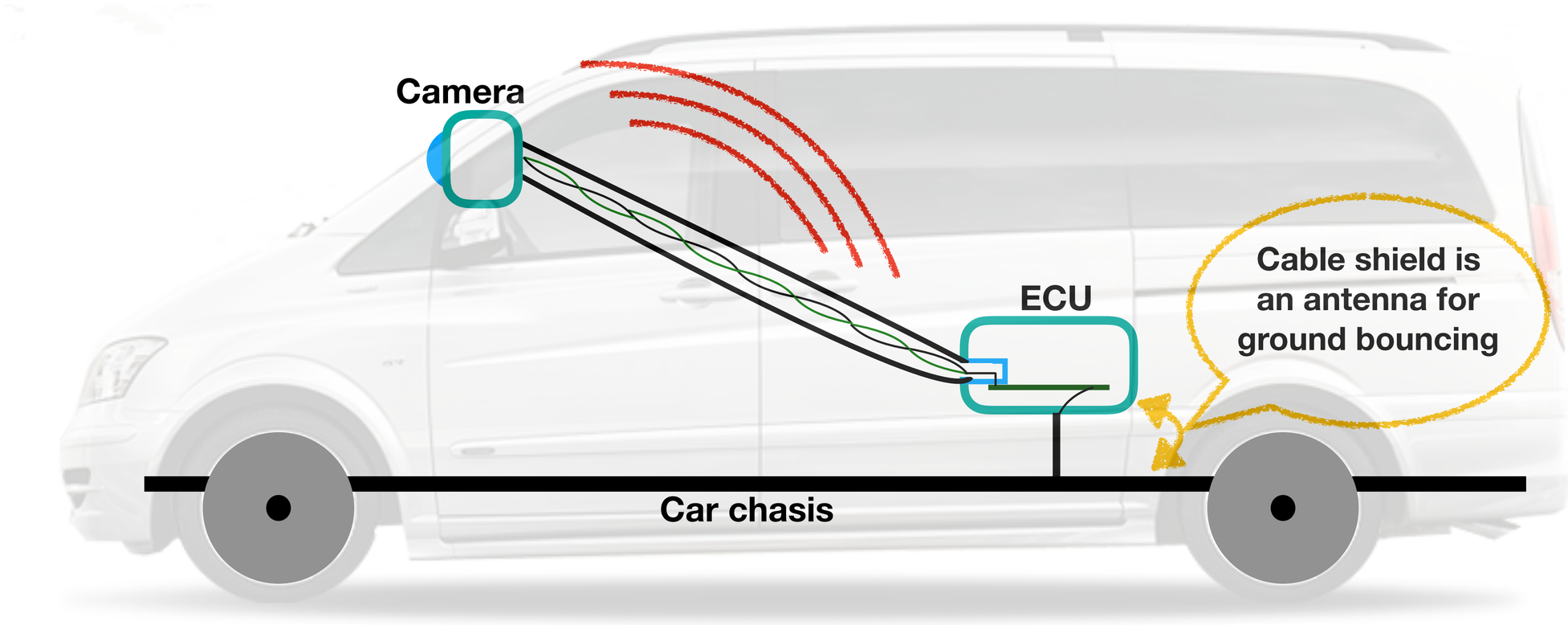


How shielded copper cables radiate?



How shielded copper cables radiate?

- Shield is an antenna for any ground bouncing noise of the ECU (E field)



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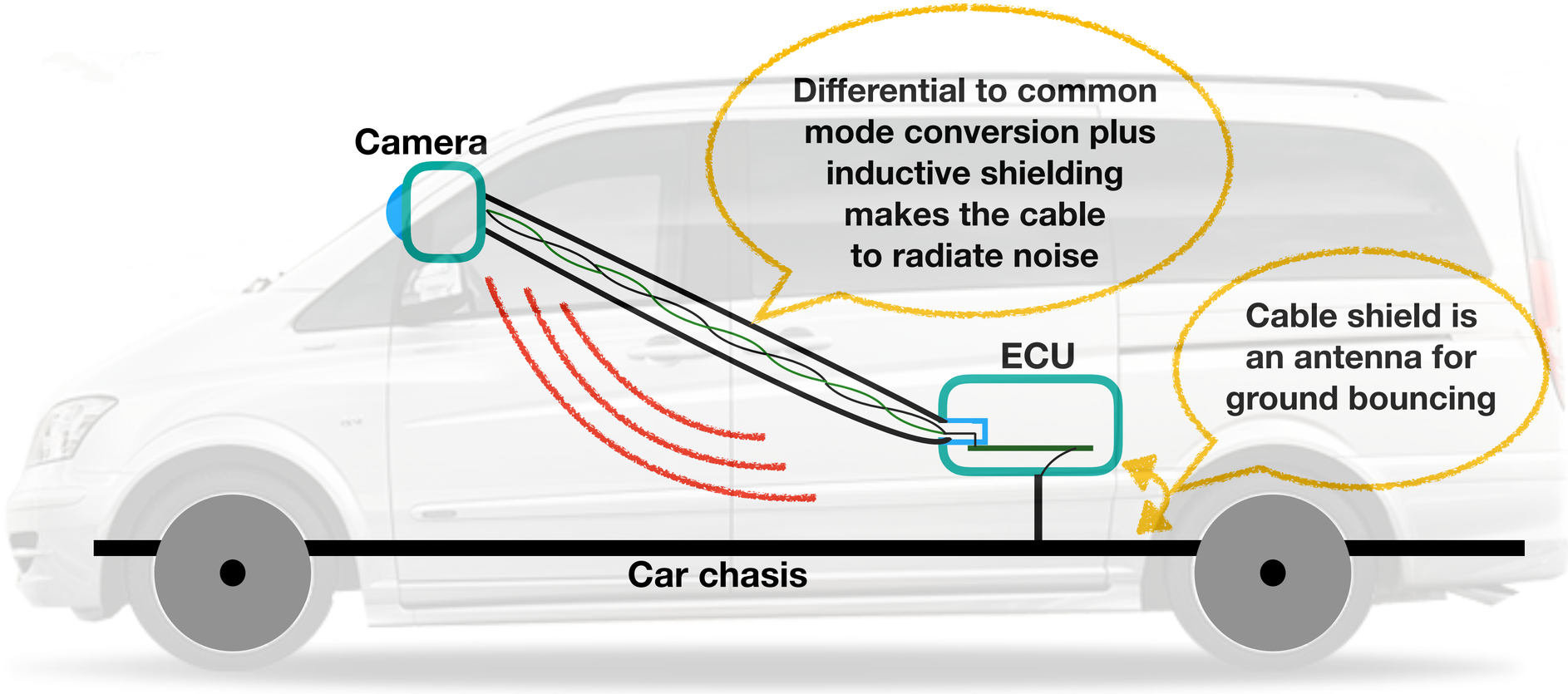

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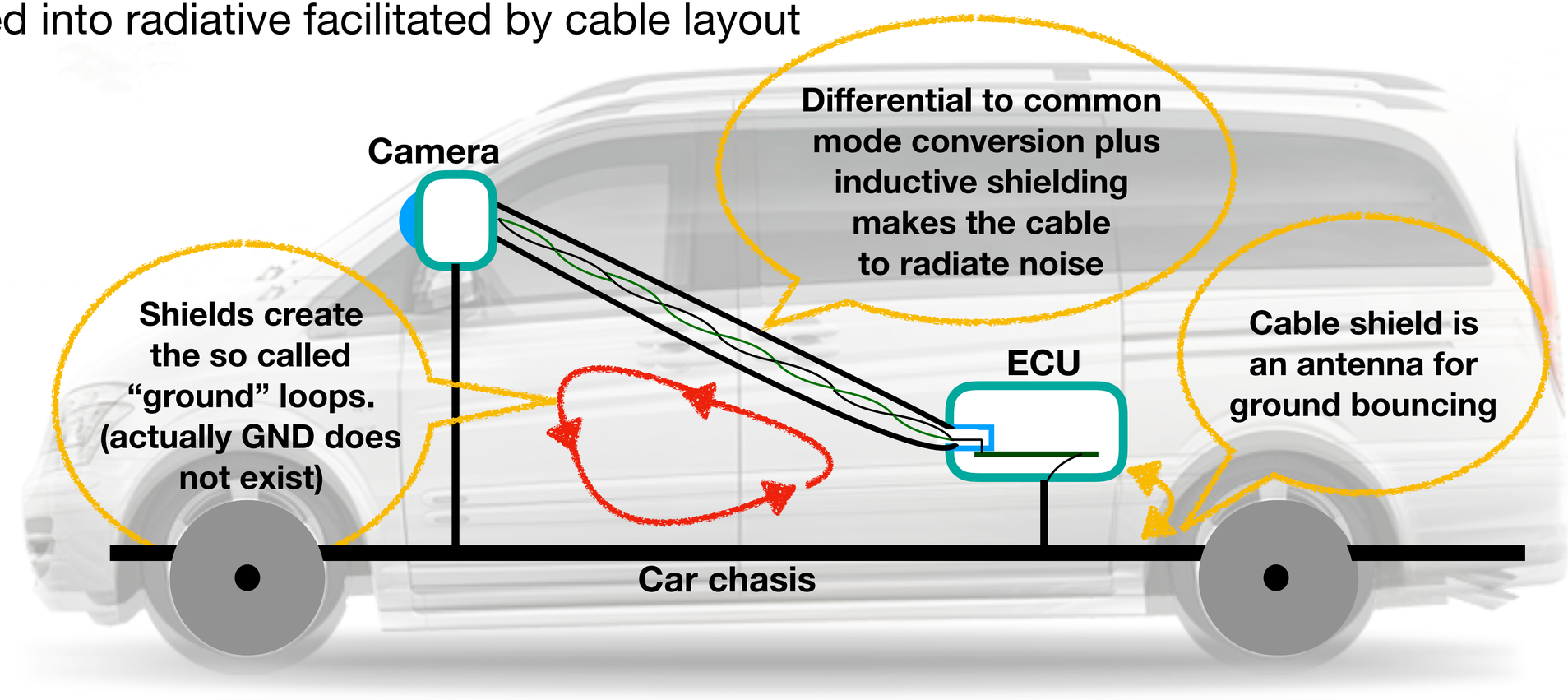

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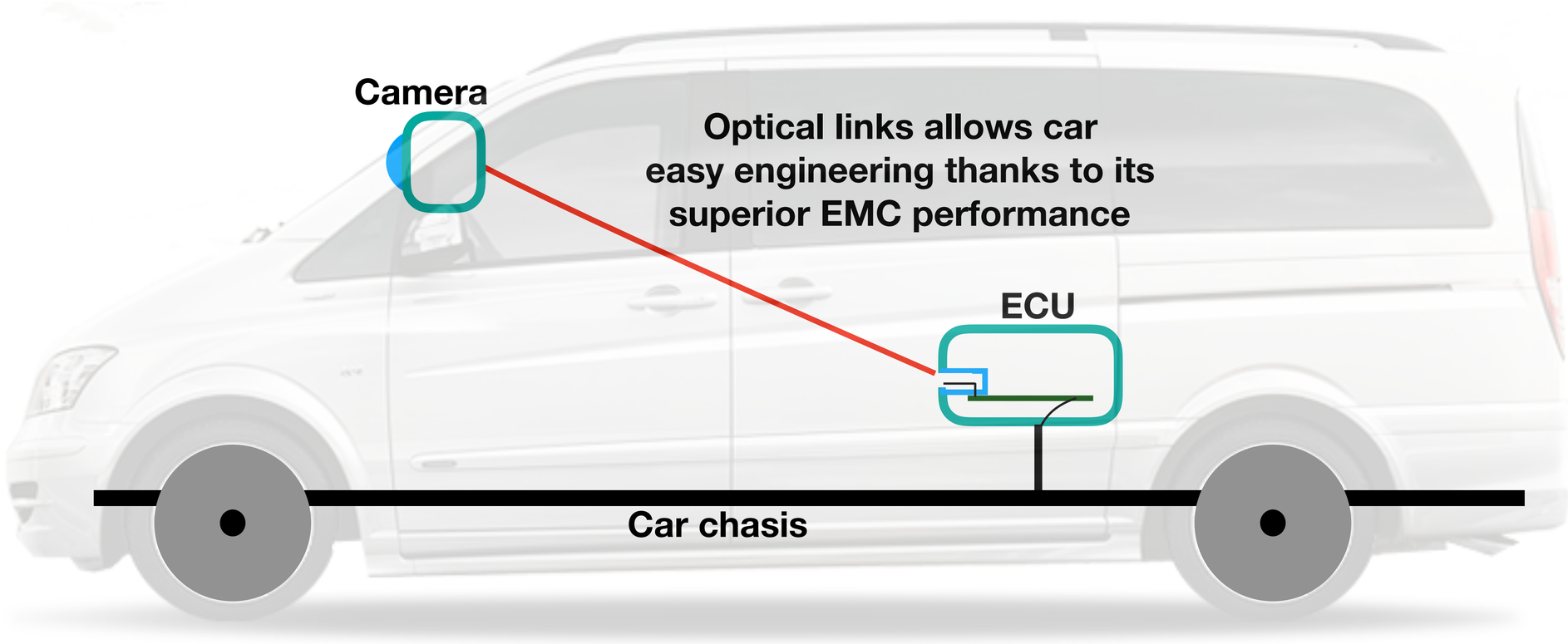

Market Drivers
Optical multi-gig use cases

- Provided by OEMs specialists:

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

Can an Existing Optical Ethernet Types be Used?

- IEEE Std 802.3 already includes the 10GBASE-SR specification that may be considered as starting point to develop multi-gigabit optical solution for automotive applications.
  - However, is it really good enough for automotive applications?

- We need to examine each components in the optical link:
  - Fibers / cables
  - Connectors
  - Light sources
  - Photo Diodes

Automotive Issues for 10GBASE-SR

- 10GBASE-SR was not designed to meet automotive requirements:
  - Automotive temperature range: Tj = -40ºC -> 105ºC/125ºC and more than 15 years of operation with close to 0 ppm failure rate

- 10GBASE-SR has no specified temperature range
  - 10GBASE-SR designed VCSELs don't meet automotive reliability and target temperature range
  - VCSEL current density will need to be reduced to meet automotive requirements
  - VCSEL bandwidth will be reduced due to current density reduction
  - Relative intensity noise will increase due to current density reduction

- Insertion Loss will be increased due to:
  - 4 inline connectors with much higher estimated losses per connector due to:
    - Vibration,
    - Aging,
    - Dust, etc.

- Cost and power consumption restrictions are different

- OAM channel is needed

- System needs to be adaptive to cope with:
  - dynamic changes of temperature
  - large parametric variation with manufacturing processes and temperature
  - low cost

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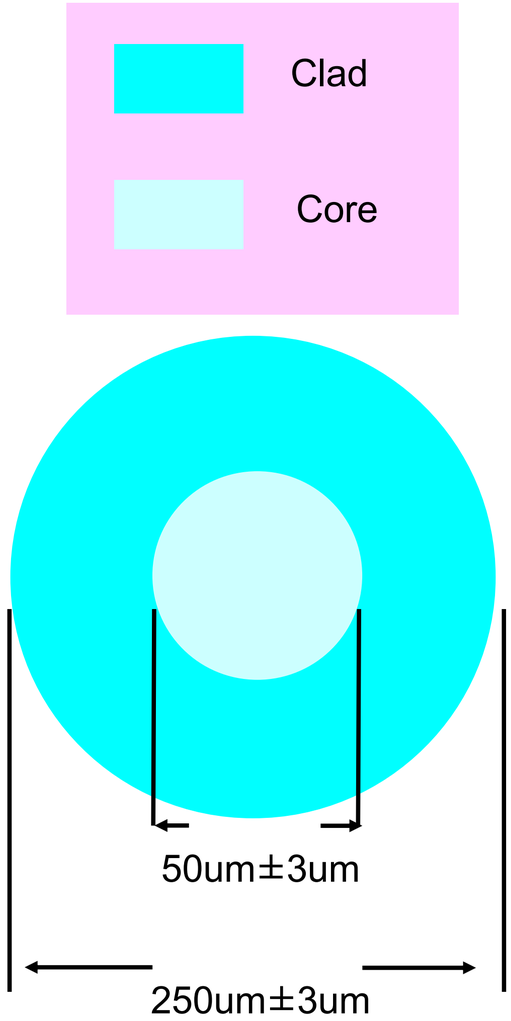
New approach may be required

Possible fibers

Nitto plastic optical fiber target structure & specification

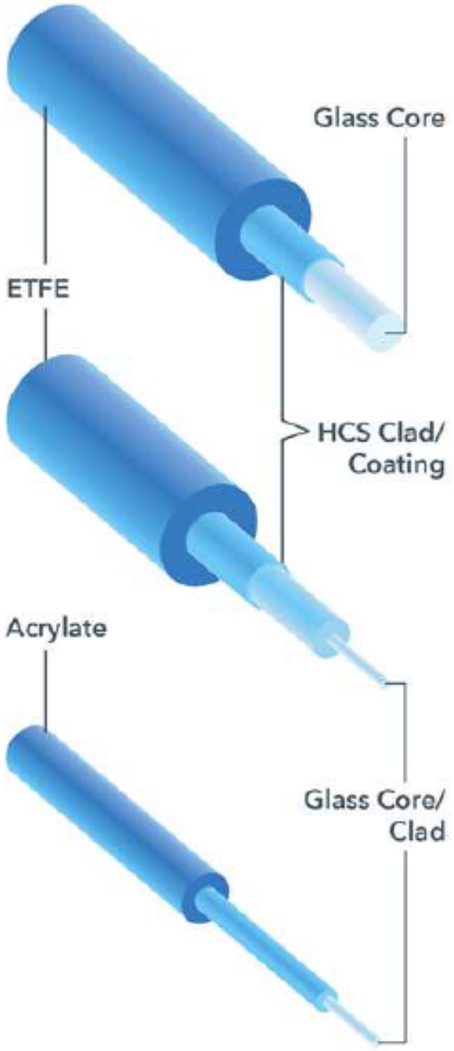
Nitto
Innovation for Customers



Items		Target
Structure	Core size (um)	50 ± 3
	Clad size (um)	250 ± 3
	Eccentricity(um)	≦3
Optical Property	Wavelength	850nm
	Attenuation loss (dB/km)	≦70 @ 850nm
	Band width (GHz)	≧50 @850nm, 15m ≧18 @850nm, 40m
	NA	0.30
	Bending loss (dB)	≦0.5 @ R2.5mm
Reliability	Heat resistance(℃)	105℃
	Increment Attenuation loss after temperature cycle test (dB/km)	< 5 (-55～85℃)
	Increment Attenuation loss after high temperature acceleration test (dB/km)	< 5 (85℃×1000h)

Source: Takahashi, Tadashi; Nitto

Possible fibers



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: ≥ 16mm

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

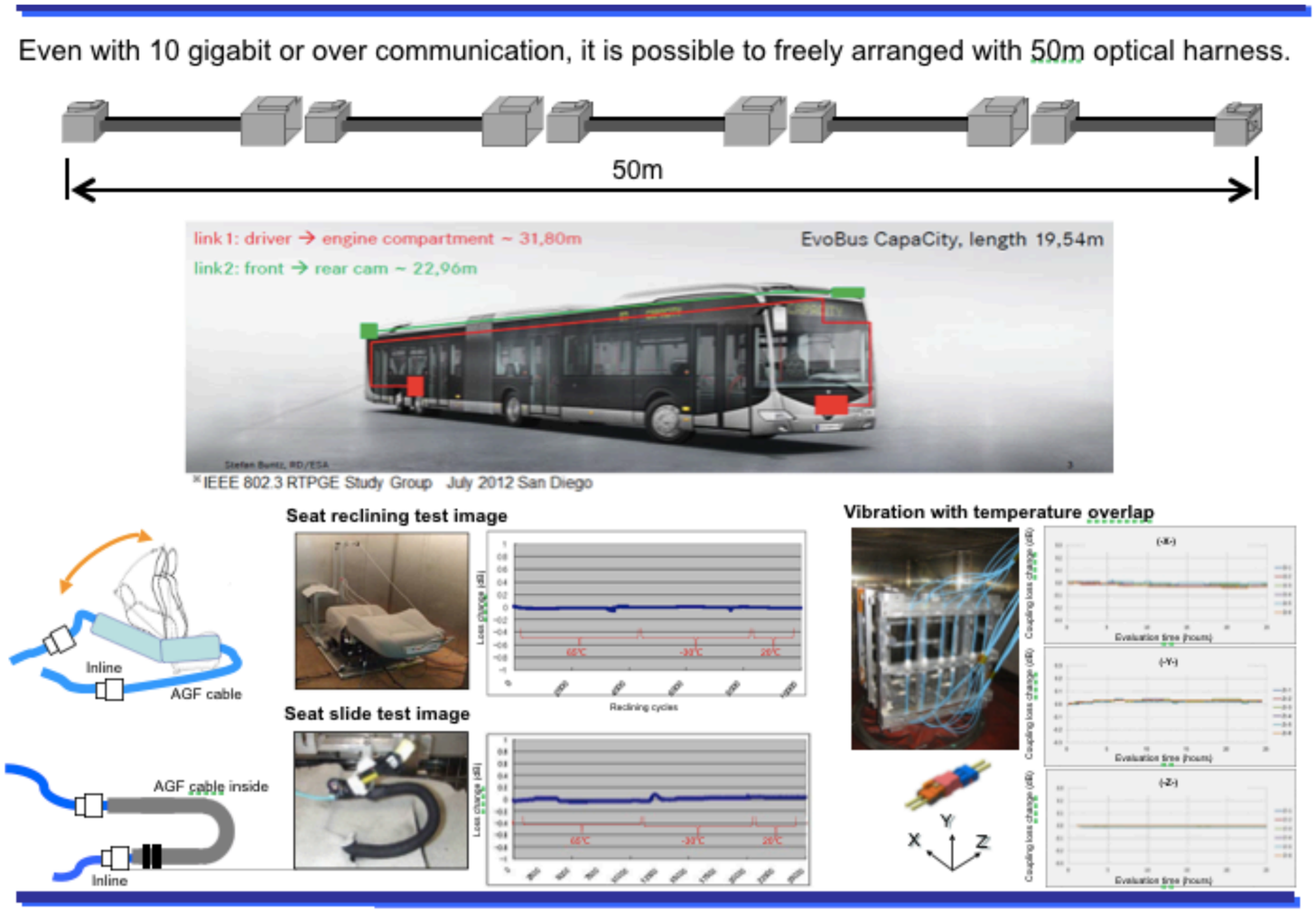
Temperature: -65 °C to +85 °C
BW: ≥ 4700 MHz-km @ 850 nm (depending on type and launch)
Attenuation: ≤ 2.2 dB/km @ 850 nm
Bend Radius: 17 mm

ofs
A Furukawa Company

http://www.ieee802.org/3/NGAUTO/public/jan17/whelan_3NGAUTO_01b_0117.pdf

Fibers for long vehicles

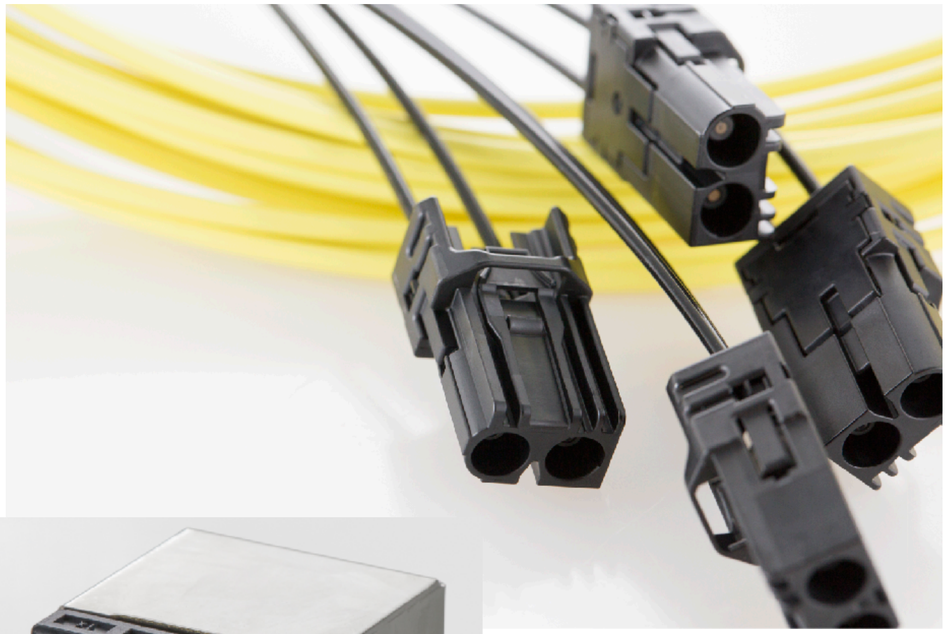
- Automotive Optical Ethernet can support longer link lengths

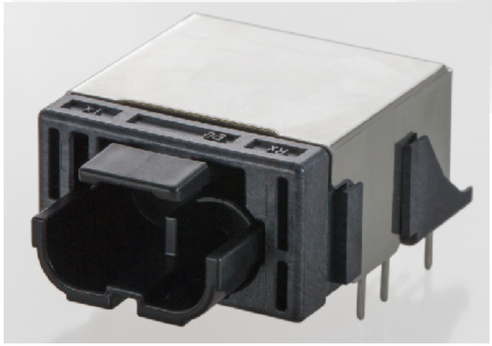


Source: Hayato Yuki, Sumitomo Electric

Connectors

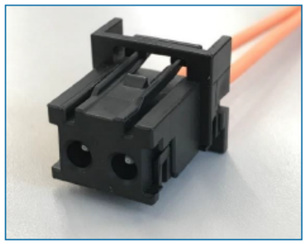
- Connector suppliers are in advanced development of Multi-gig optical ***waterproof*** connectors



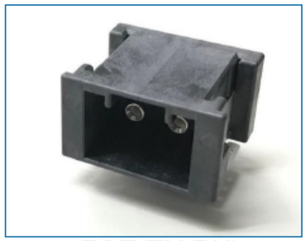


Source: Ulrich Kleymann, Yazaki

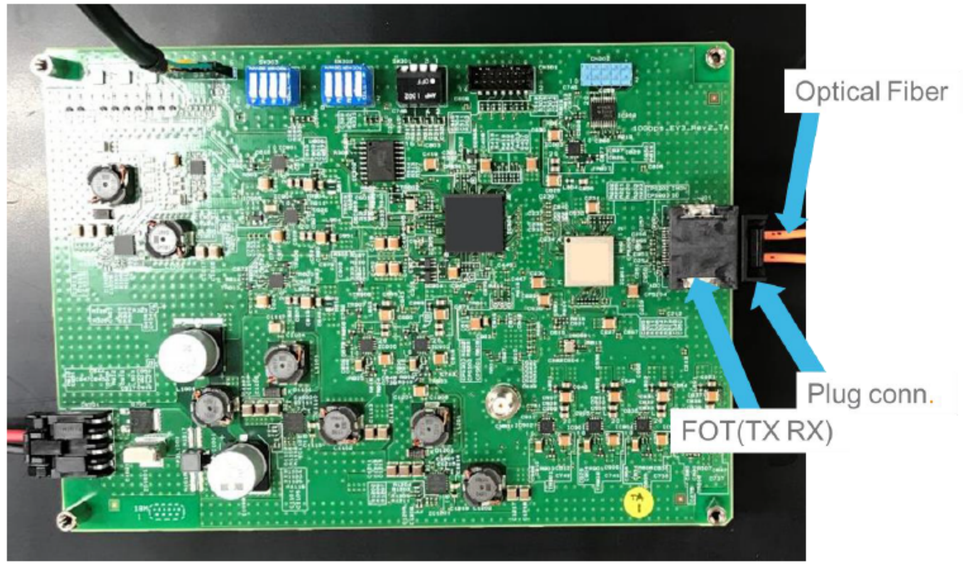
Kojiri criteria and dust covers protects connectors against dust and damage



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

Optical devices

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

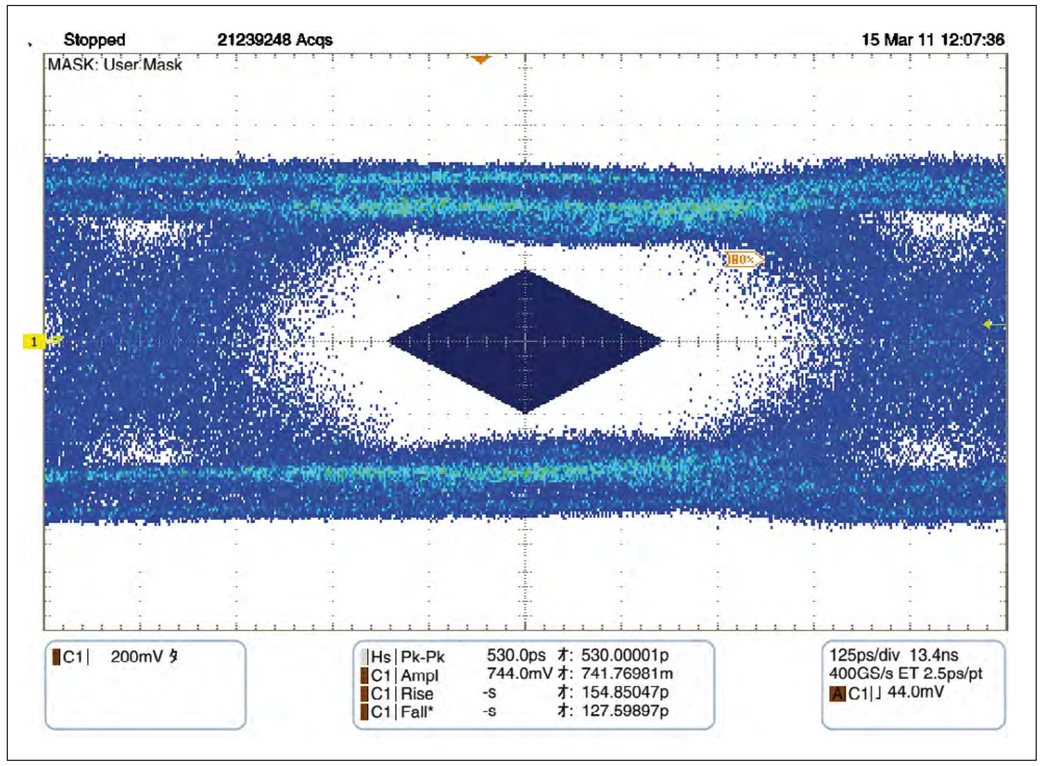


Figure 1. Eye pattern at –20 dBm (850 nm VCSEL), PCF (200 µm diameter), GaAs PD (200 µm diameter).

(Source: Hamamatsu Photonics)

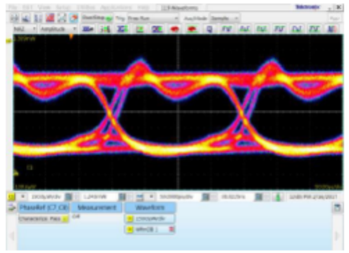
Source: Takayuki Suzuki
Hamamatsu Photonics

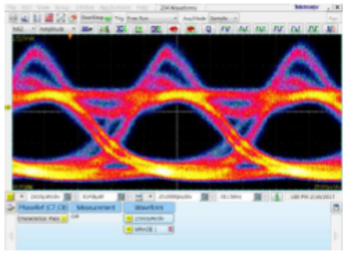
Vertically Integrated Systems

Different bit rates and receivers

10

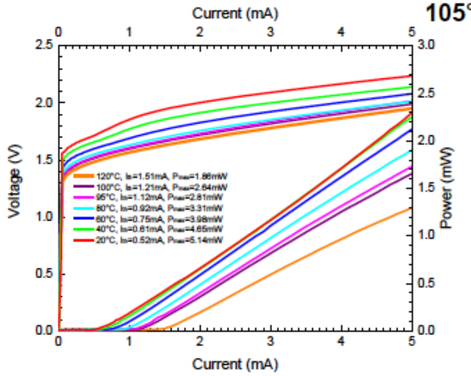
30GHz linear receiver
(evaluation of the optical eye)



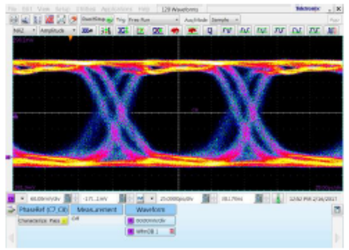


105°C 3 mA Vpp=0.15V 5 Gb/s

10 Gb/s



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



105°C 3 mA Vpp=0.15V 10 Gb/s

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

Presentation for IEEE 802.3 Multi-Gig Automotive Ethernet PHY Study Group *VI Systems GmbH*

http://www.ieee802.org/3/NGAUTO/public/adhoc/Kropp_NGAUTO_0317.pdf

Market potential

- Around 90 M vehicles sold in 2018
  - 70 M cars, 20 M are Commercial Vehicles and Trucks
- Links:
  - By 2030 almost all cars will have at least one back camera high speed link
  - Backbone: 1 to 10 links/car
    - 5 + 5 redundant links for full autonomous cars
  - Smart Antenna: 1 link/car
  - Camera/Sensor: 1 to 10 links/car
  - Displays: 1 to 4 links/car
- Mature market will show the following approximate numbers:
  - 25 M links per year for smart antennas (1/4 of cars with smart antenna)
  - 70 M links per year for backbone (Average 1 link/car)
  - 150 M links per year for cameras and other sensors (Average 2 links/car)
  - 100 M links per year for displays
- Total ports per year can be estimated in 700 M (Average 4 links/car)

- These numbers will overlap with 1 Gb/s links deployment

Why now ?

- Demo cars are using 10GBASE-SR links in anticipation of a multi-gig Automotive Optical Ethernet standard.

- First car with multi-gig optical links is planned for 2025.
  OEMs are requesting a automotive qualified optical solution

- 1000BASE-RH already qualified and in production for 2020

- Industry suppliers are ready to provide automotive qualified components

Straw polls

- Should a study group be formed for “Optical multi-gig PHY for automotive applications”?
  - Y: 65 N: 0 A: 27
  - Room: 104

- I would participate in a “Optical multi-gig PHY for automotive applications” study group
  - Tally: 37

- I believe, my affiliation would support my participation in a “Optical multi-gig PHY for automotive applications” study group
  - Tally: 30

Next steps

- Ask 802.3 at Thursday's closing meeting to form study group

- If approved:
  - Request 802 EC to approve creation of the study group on Friday
  - First study group meeting would be during September 2019 IEEE 802.3 interim meeting