

AUTOMOTIVE ETHERNET

The Future for In-Vehicle Networks



Nik Dimitrakopoulos
Automotive Ethernet & Infotainment

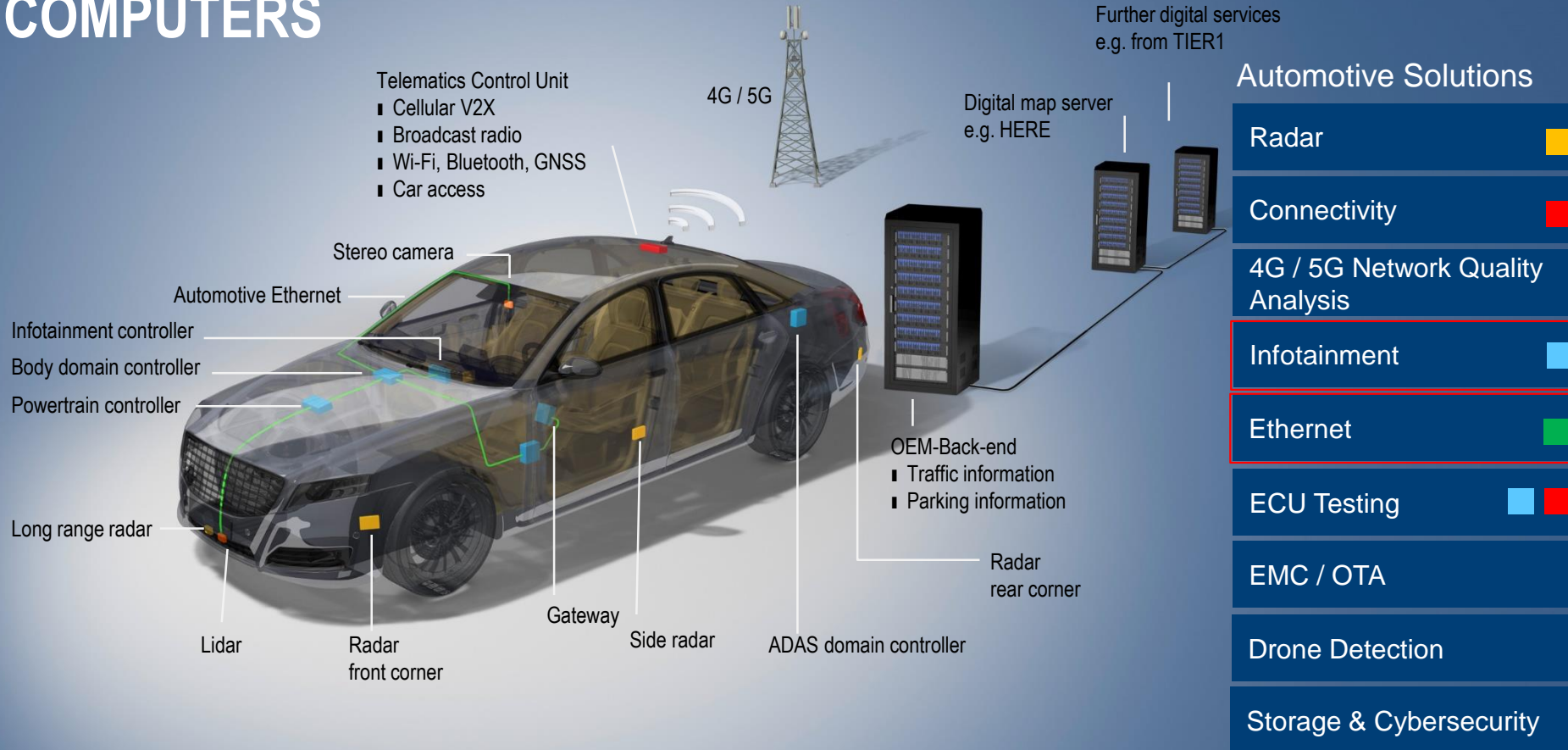


ROHDE & SCHWARZ

Make ideas real



VEHICLE ARCHITECTURE WITH HIGH PERFORMANCE COMPUTERS



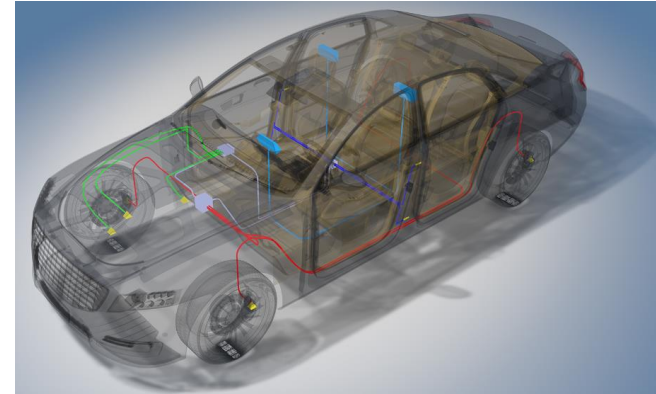
CONTENT

- ▶ Automotive Ethernet
- ▶ 5 years into the future



WHY AUTOMOTIVE ETHERNET ?

- ▶ Higher data throughput is required for ADAS like rear view or surround view camera systems
- ▶ Low latency is required for ADAS like for adaptive cruise control etc.
- ▶ Industry standards need to be integrated to save cost: 100BASE-T1 instead of MOST
- ▶ Reuse of TCP/IP in different application (flashing, camera, smart antennas) helps to reduce complexity
- ▶ Ethernet standards like Audio Video-Bridging, Time Sensitive Networks (TSN) enable new applications
- ▶ Unshielded Twisted Pair cabling to save cost



Source: BMW

COMPARISON BETWEEN 100BASE-TX AND 100BASE-T1

100BASE-Tx standard Ethernet



Fast rise time

3 clear levels

100BASE-T1 Automotive Ethernet



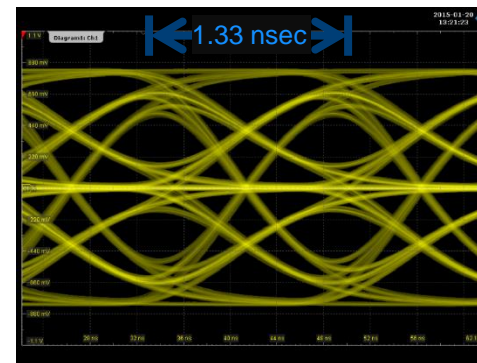
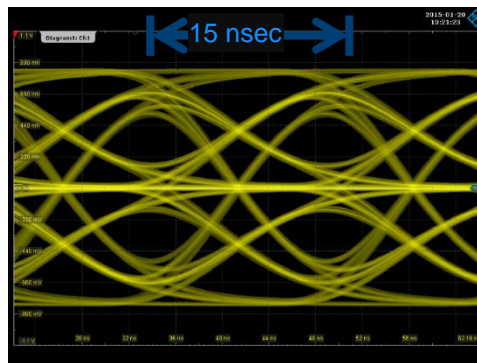
Slower rise time

3 levels not clear

COMPARISON BETWEEN 100BASE-T1 AND 1000BASE-T1

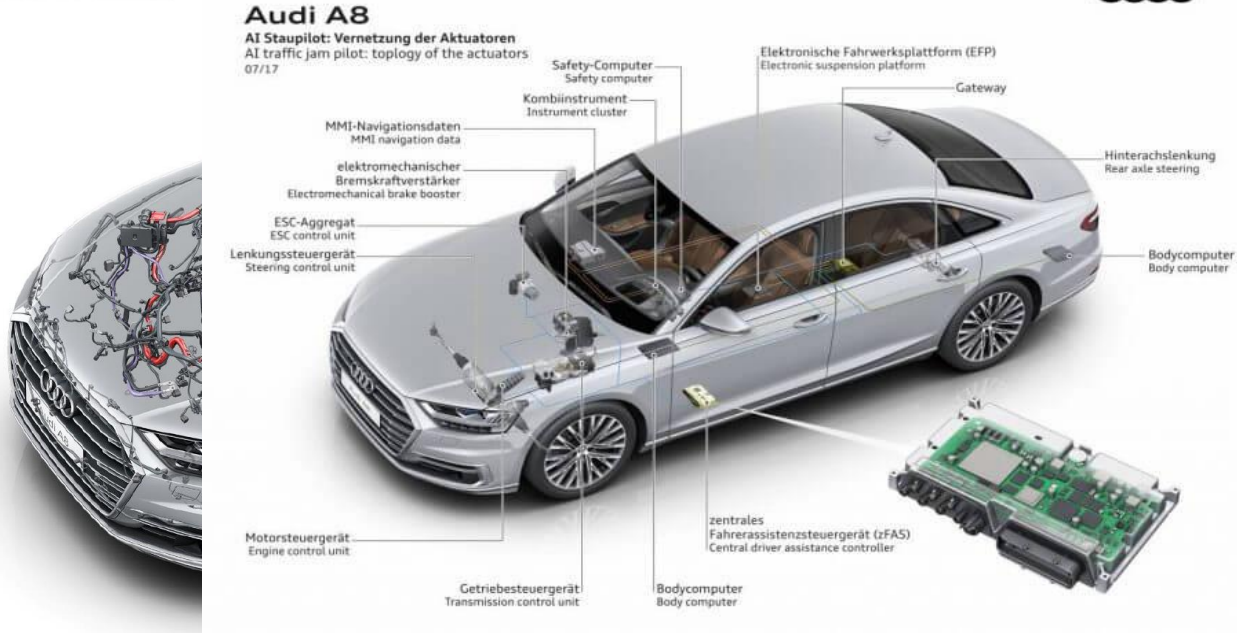
	100BASE-T1	1000BASE-T1
Symbol rate	66.66 MHz	750 MHz
DUT clock	66.66 MHz	125 MHz
Coding	PAM 3	PAM 3
IEEE PHY spec	802.3bp	802.3bw

OSI	TCP/IP
7 Application	Applications: FTP, HTTP, SMTP...)
6 Presentation	
5 Session	
4 Transport	TCP
3 Network	IP
2 Data Link	Network Access
1 Physical	100/1000BASE-T1



EXAMPLE AUDI A8

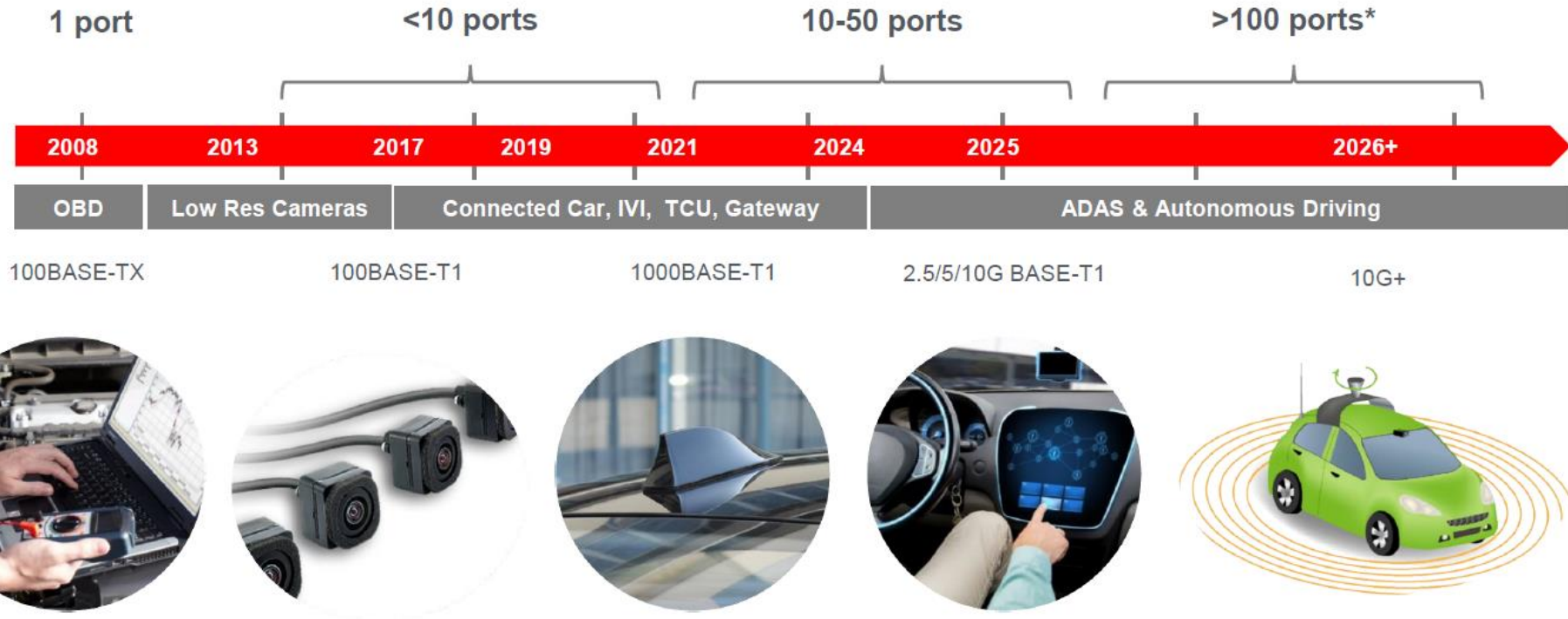
Overview



- ▶ 48 V +12 V network
- ▶ ADAS controller zFAS with 70W
- ▶ 2.3 km cable
- ▶ 54 kg
- ▶ 3000 contacts
- ▶ 9 relays
- ▶ 380 fuses

Source: Audi, Boardnetz Congress 2018

Trends in Automotive Ethernet



*average Ethernet ports per vehicle
** Photo courtesy of Marvell Technology Group

AUTOMOTIVE ETHERNET IS EVERYWHERE



Radar

Ensuring radar performance from development to production

Radar sensor to ADAS controller moves to 100/1000BASE-T1
Sensor fusion will use 10GBASE-T1



Connectivity

Testing conformance and performance of eCall, V2X, LTE-V, WLAN and Bluetooth®

Smart antennas have 1000BASE-T1



Bus systems

Debugging of bus systems such as automotive Ethernet and CAN-FD

Backbone 100/1000BASE-T1



Infotainment

Validating multimedia, audio, antenna and navigation equipment

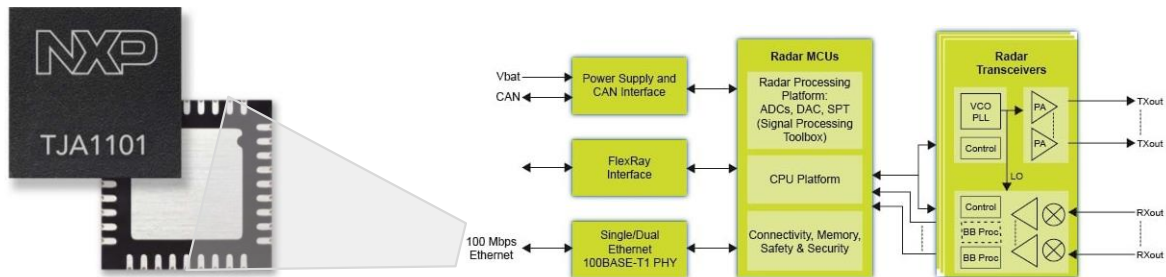
Connection to display, antenna etc based on 100/1000BASE-T1- AVB etc.

RADAR + AUTOMOTIVE ETHERNET



Features

- ▶ Automotive Qualified
- ▶ IEEE 100BASE-T1 compliant PHY transceiver
- ▶ OPEN Alliance TC-10 compliant sleep / wake up
- ▶ ISO26262 ASIL-A
- ▶ Optimized for Automotive Usecases
- ▶ Advanced Diagnostic Features
- ▶ HVQFN36 (6mm x 6mm)



Source: NXP



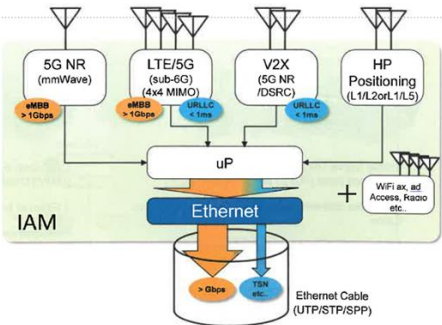
ARS4-A 77GHz
Long & Short Range Radar

Vehicle Interface		
Vehicle interface	CAN, Flexray, Ethernet	A host wake-up or unworkable CAN transceiver module
Power consumption	typ. 7 W	Power supply of 12 V on KL 15 (ignition), without optional DSP. 0.6A at 12VDC

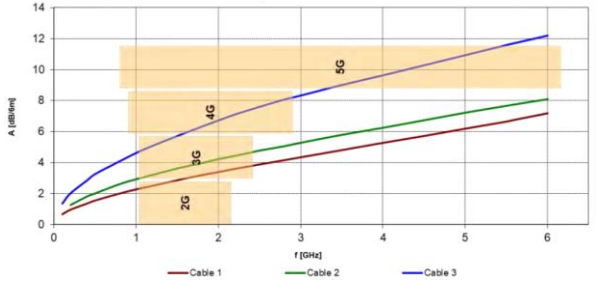
Source: Continental

TELEMATICS + AUTOMOTIVE ETHERNET

Multimedia Gateway with active antenna and various RF functions



Cables (6 meters): Standard and Low Loss



Source: Max Mueschenborn – Continental AG

WHY MULTIGIG ETHERNET?

Important to know:

- ▶ Some automotive 4G LTE modems implemented in the TCU can operate at 300-400 Mbps



Image source: Ficosa



----- Is 1000BASE-T1 enough? -----



HUAWEI

■ T-Box 3.0: DA2300 will support 5G speeds up to 1.6Gbps*

*Maximum theoretical download speed

Image source: Huawei Autonomous Vehicles Show Shanghai Sept 2018

C-V2X 芯片
2018.02 巴塞罗那

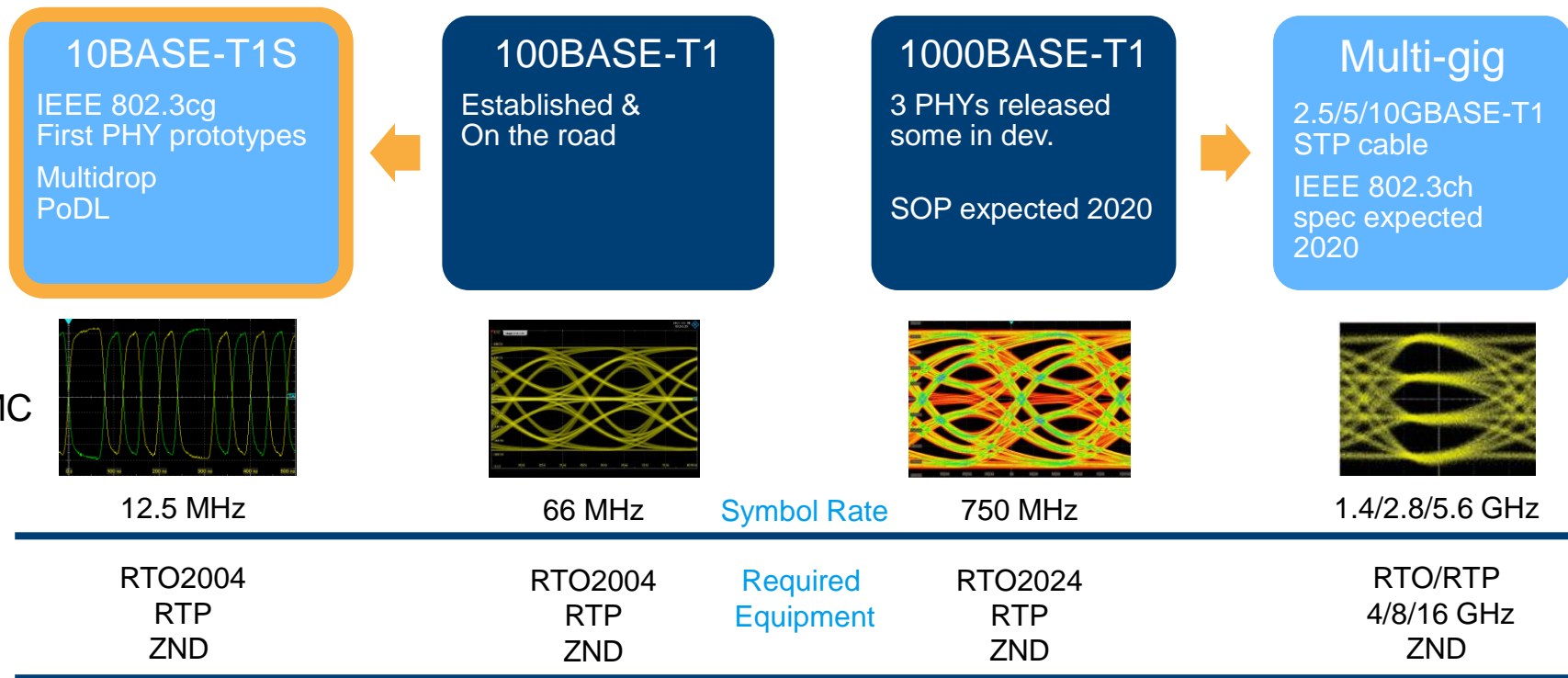
T-Box 3.0
2018.02 C-V2X inside

C-V2X 特性
PC5 + Uu并发
Mode3 + Mode4

MBB 特性
3GPP Rel. 14
下行峰值 1.6Gbps
4CC CA + 4x4 MIMO
2CC CA + 8x8 MIMO
DL 256QAM

- 首款 T-Box 2016年上市, 获众多车企认可
- C-V2X、5G先发优势

FUTURE AUTOMOTIVE ETHERNET STANDARDS



10GBASE-T1: BENEFITS

Sensor Fusion & Rich Data Drive Bandwidth To Multi-Gig

Cameras

Increasing resolution from 720p to 4K and improving dynamic range

= **Multi-Gigabit/s of raw bandwidth**

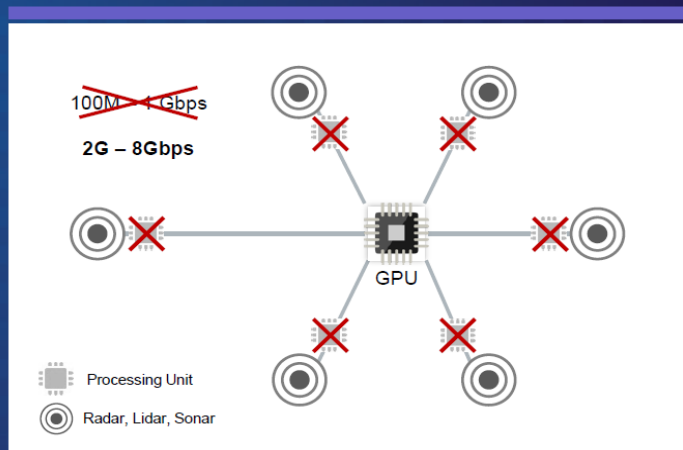
Hres	Vres	Fps	8bit	12bit	16bit	20bit	24bit
1280	720	30	0,22	0,33	0,44	0,55	0,66
1280	1080	30	0,33	0,50	0,66	0,83	1
1280	720	60	0,44	0,66	0,88	1,11	1,33
1920	1080	30	0,50	0,75	1,00	1,24	1,49
1280	1080	60	0,66	1,00	1,33	1,66	1,99
1920	1080	60	1,00	1,49	1,99	2,49	2,99
3840	2160	30	1,99	2,99	3,98	4,98	5,97
3840	2160	60	3,98	5,97	7,96	9,95	11,94

100BASE-T1	1000BASE-T1	Multi-Gig Ethernet 2,5 Gbps	Multi-Gig Ethernet 5 Gbps	Multi-Gig Ethernet 10 Gbps
No Use Case	Available	Speed grades which are currently discussed		

Sensor Fusion

Moving processing of data from sensors to a centralized GPU

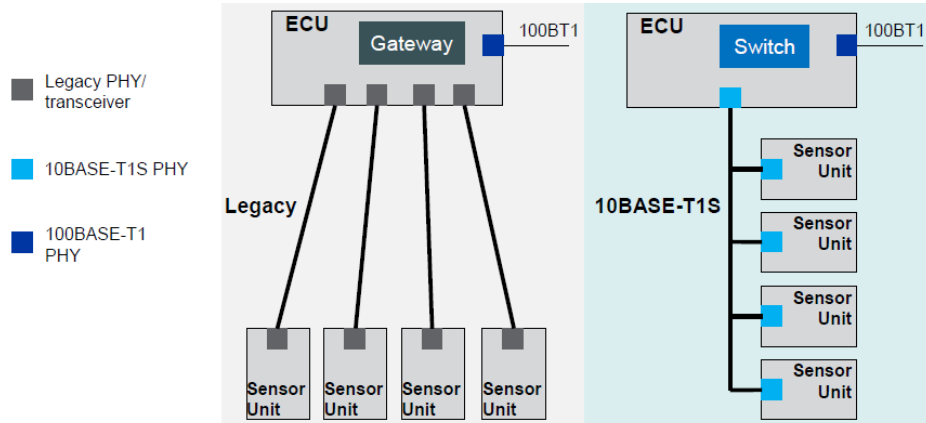
= **Multi-Gigabit/s data over the network**



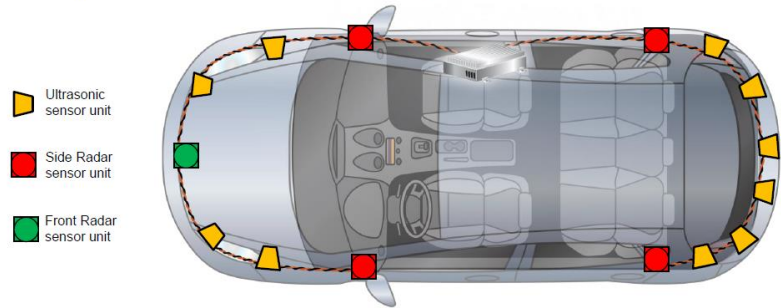
IEEE Automotive Ethernet London: Oct 2018

AQUANTIA
ACCELERATING CONNECTIVITY

10BASE-T1S: BENEFITS



Example: Ultrasonic and Short Range Radar



Benefits of 10BASE-T1S

# PHYs	8	5	Fewer PHYs
# Connectors ECU	4	1	Fewer connectors and less connector space on ECU
Cabling	4 cables	1 bus line	Less cabling, extendability, scalability
Bandwidth	< 10 Mbps	10 Mbps	More bandwidth
Ethernet-based network	no	yes	Seamless integration into overall Ethernet architecture
Gateways	yes	no	Eliminates need to translate messages

Source: Miller, Microchip, Oct 2018

Members

[Promoters](#)[Adopters](#)[Membership](#)

OPEN Alliance SIG Promoter Members

BMW
Daimler AG
Hyundai Motor Company
Realtek Semiconductor Corp.
Robert Bosch GmbH
Volvo Cars

Broadcom Limited
General Motors Co.
Jaguar Land Rover (JLR)
Renault SA
Toyota

Continental
HARMAN
NXP
Renesas
Volkswagen Group

Driven by OEMs

<http://www.opensig.org/>

Tech Committees



TC15 group created for MultiGig Ethernet 2.5/5/10GBase-T1.
TC15 is mainly related to IEEE 802.3ch

Automotive Ethernet ECU Test Specification

1000BASE-T1 Ethernet Channel & Passive Components

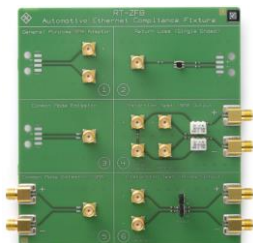
10/100/1000BASE-T1 COMPLIANCE TEST PACKAGE (LAYER 1)



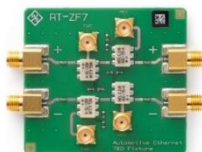
Key Features

- Complete test solution from R&S (PHY)
 - Includes OEM required test cases
 - Future proof solution for Automotive Ethernet
 - UNH-IOL uses RTO + ZNB for all automotive Ethernet tests
 - Dedicated test fixtures made by R&S – OA TC8 compliant!
- Latest add on → 10BASE-T1S (only a software option)

Complete PHY Test Solution including VNA, function generator and test fixtures!



Compliance Test fixture RT-ZF8



Decoding fixture RT-ZF7

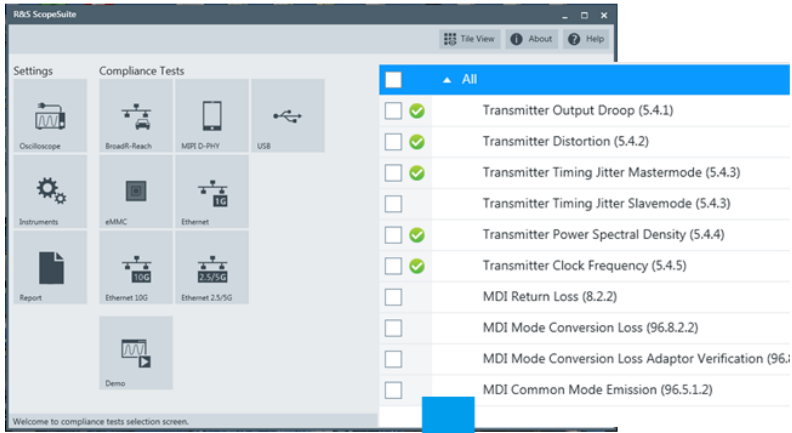


SMA adapter for TD & Compliance RT-ZF7A

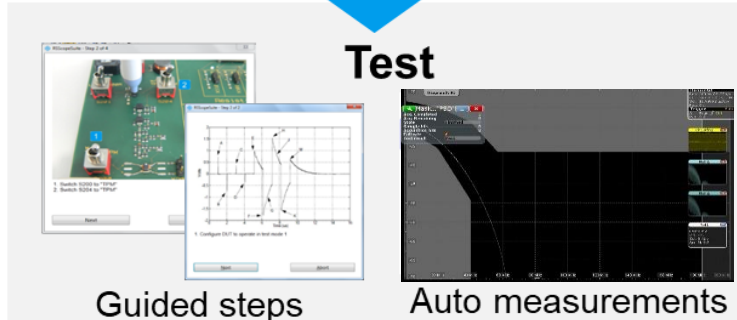


Frequency converter RT-ZF3/6

BUILT-IN COMPLIANCE TEST SOFTWARE



Test



Guided steps

Auto measurements

Pass-Fail results

Test	Description	Run	Result	Detail
<input type="checkbox"/>	Output Droop	1	✓	2/2
<input type="checkbox"/>	Transmitter Distortion No TX_TCLK No Disturber	1	✓	11/11
<input type="checkbox"/>	Transmitter Timing Jitter Mastermode	1	✓	1/1
<input type="checkbox"/>	Power Spectral Density	1	✗	0/1
<input type="checkbox"/>	Power Spectral Density	2	✓	1/1
<input type="checkbox"/>	Transmitter Clock Frequency	1	✓	1/1

Report



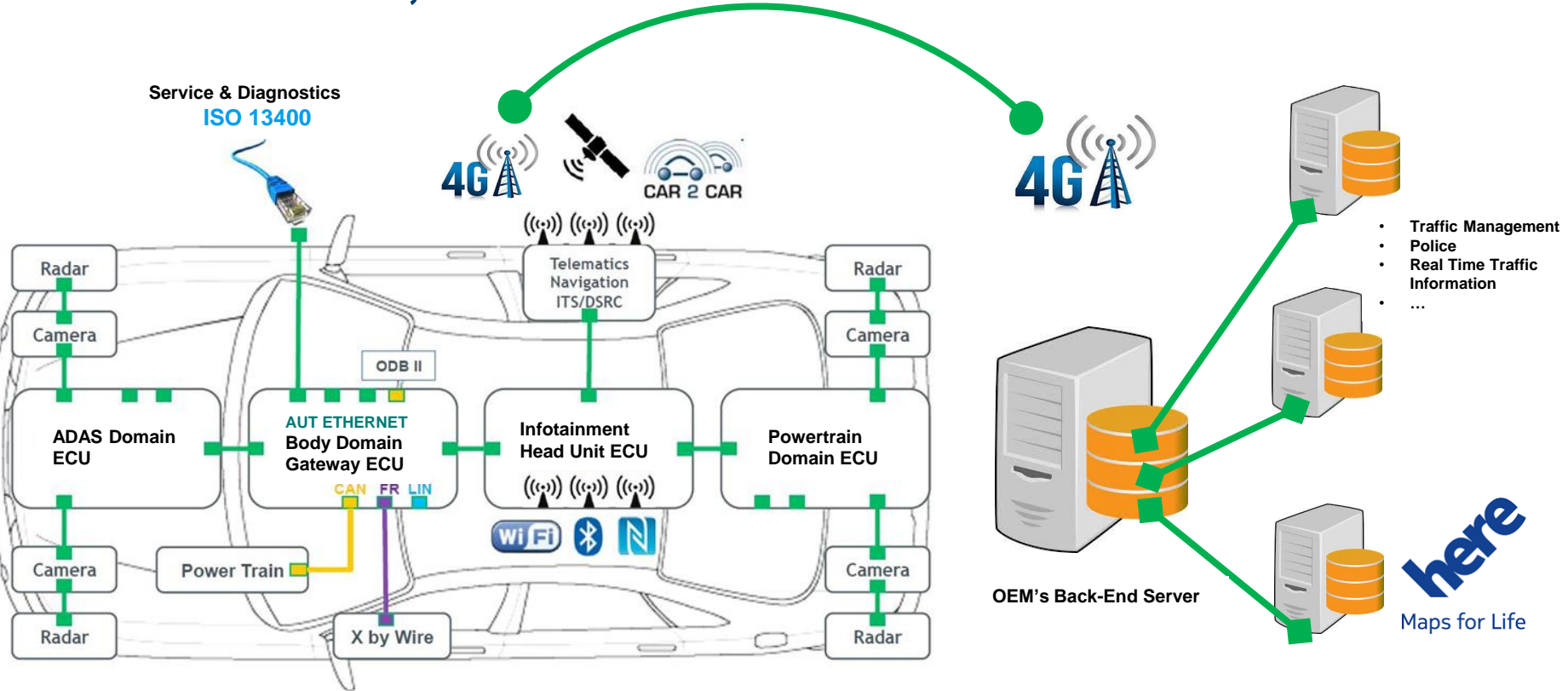
- Screenshot
- Measurement result
- Pass-Fail result
- Test summary

Supports both limits for IEEE an OA

5 YEARS INTO THE FUTURE!



UPCOMING VEHICLE ARCHITECTURE WITH DOMAIN CONTROLLERS, ETHERNET AND BACK-END SERVERS



DOMAIN CONTROLLERS



Image source: NXP

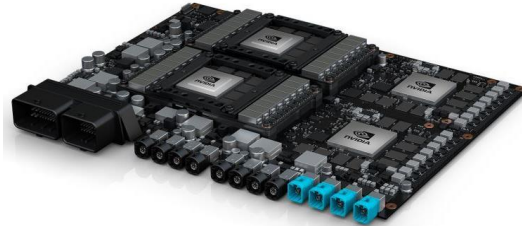


Image source: Nvidia

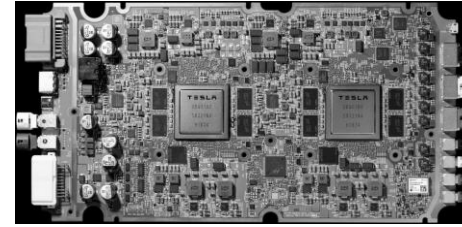


Image source: Tesla



Image source: TTTech

Domain controllers:

- Infotainment
- Powertrain
(engine, brakes, gearbox)
- Body electronics & security
(windows, wipers, car seat etc)
- ADAS



Image source: Veoneer

Mobilye Tech inside Delphi's Multi-Domain Controller

Mobilye will add new software and hardware into Delphi's existing Automated Driving Multi-Domain Controller. Here's a breakdown of what's inside:

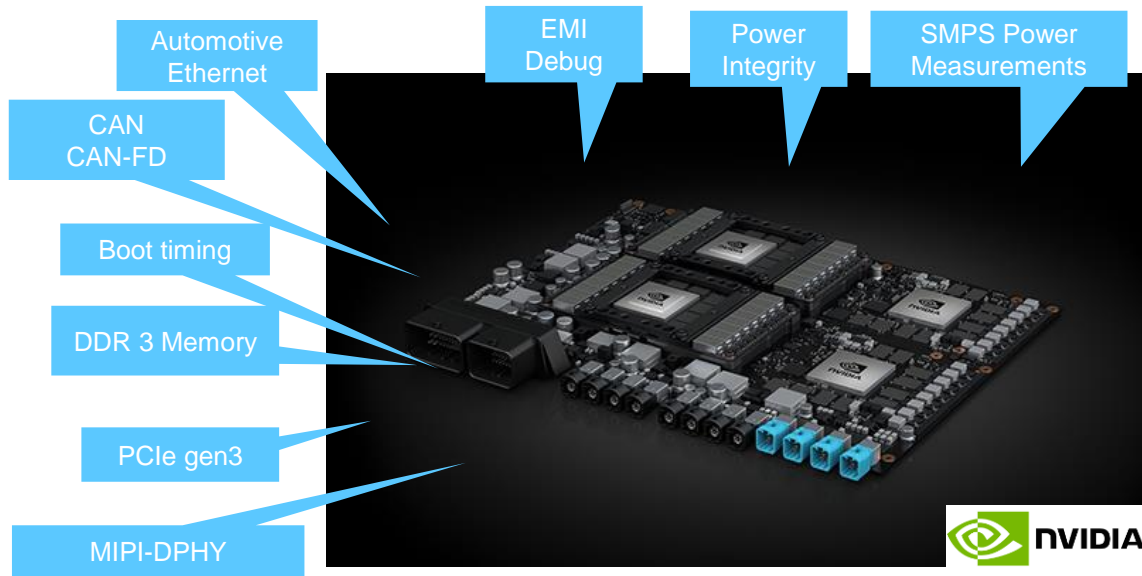


Image source: Delphi



Image source: Continental

WHAT AND HOW TO TEST NEXT GENERATION ECU FOR ADAS




Example Nvidia Pegasus

8-16 CPU cores
+ GPU
5-10 TFLOPS
200-600 W TDP (SMPS)
Liquid cooling

DDR3/4 RAM, 8 GB
FLASH NVMe (PCIe 3), 64 GB
100/1000/10GBASE-T1
CAN-FD



R&S®RTP (16GHz)

A close-up, low-angle shot of a car's front end, focusing on the headlight and hood. The car is dark-colored, possibly black or dark blue, and its surface is highly reflective, showing vibrant, distorted reflections of red and blue light. The background is a blurred, streaked pattern of light and dark colors, suggesting high speed or motion. The overall mood is dynamic and futuristic.

Automotive

TEST IT. TRUST IT.