

# TRENDS IN IN-VEHICLE NETWORKING

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STANDARDS FOR CONNECTED AND AUTONOMOUS TRANSPORTATION



**BMW  
GROUP**

THE NEXT  
100 YEARS



# DIGITIZATION CHANGES CARS INTO MOBILITY.

The car manufacturers are facing a time in which they need to continue to strive in ever fiercer competition while having to embrace the changes induced by a digitized world.

With digitization, data and software are the new currency.



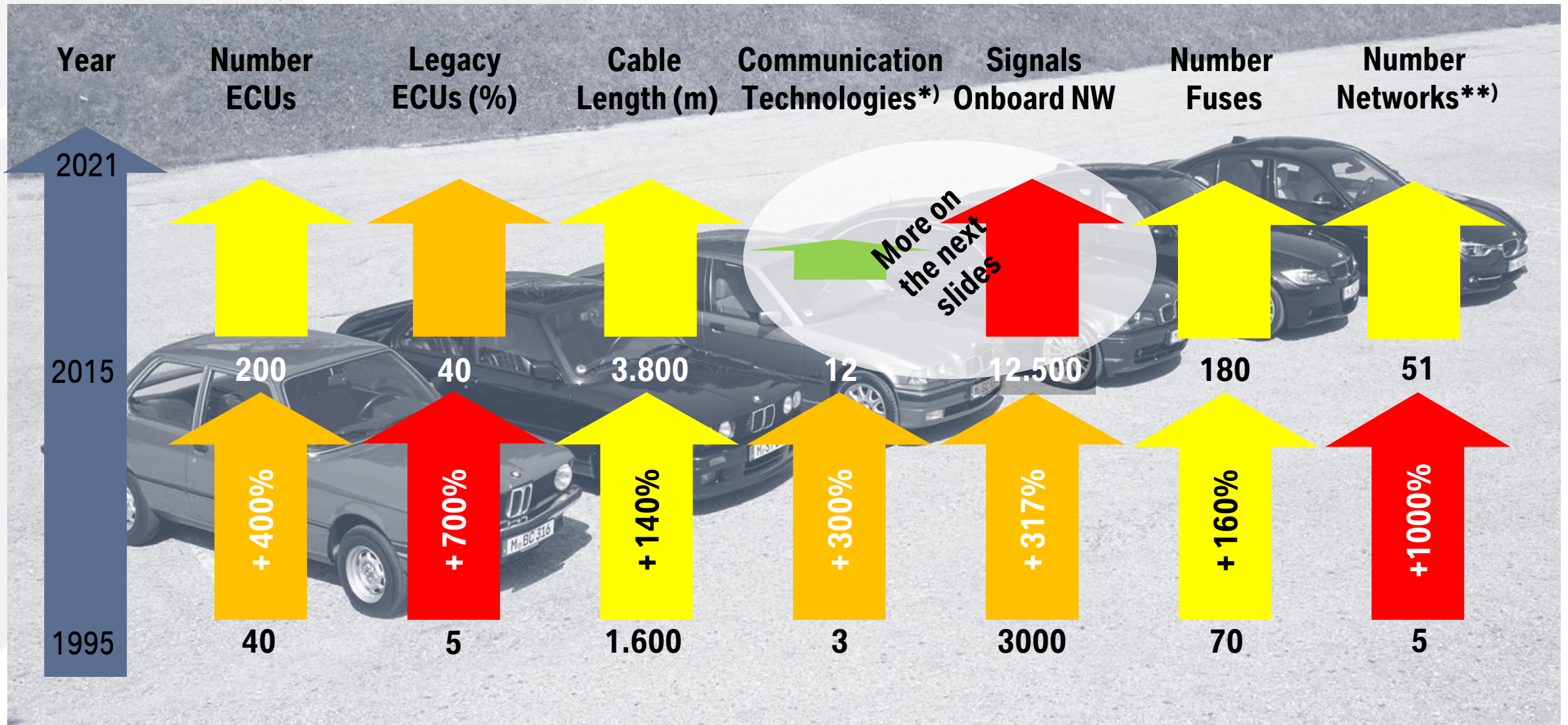
This can change everything. From the way we build cars to the products and services we offer.



It results in new requirements on the infrastructure inside the car: the EE-architecture and also the in-vehicle network.



# ELECTRONICS, SOFTWARE AND COMMUNICATION ARE THE KEY FOR THE DIGITIZATION, CAUSING A COMPLEXITY EXPLOSION INSIDE VEHICLES.





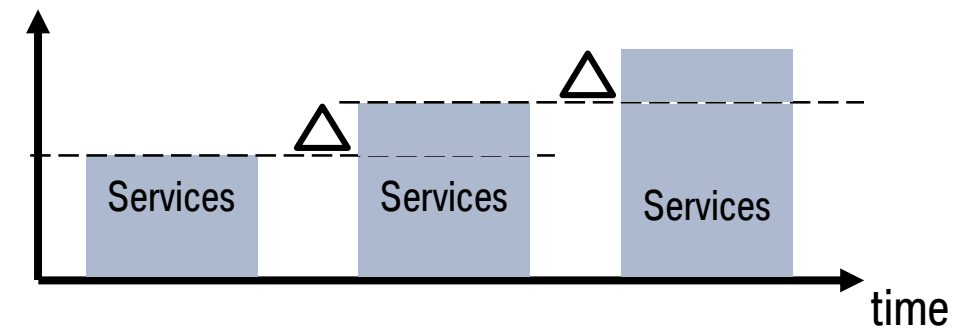
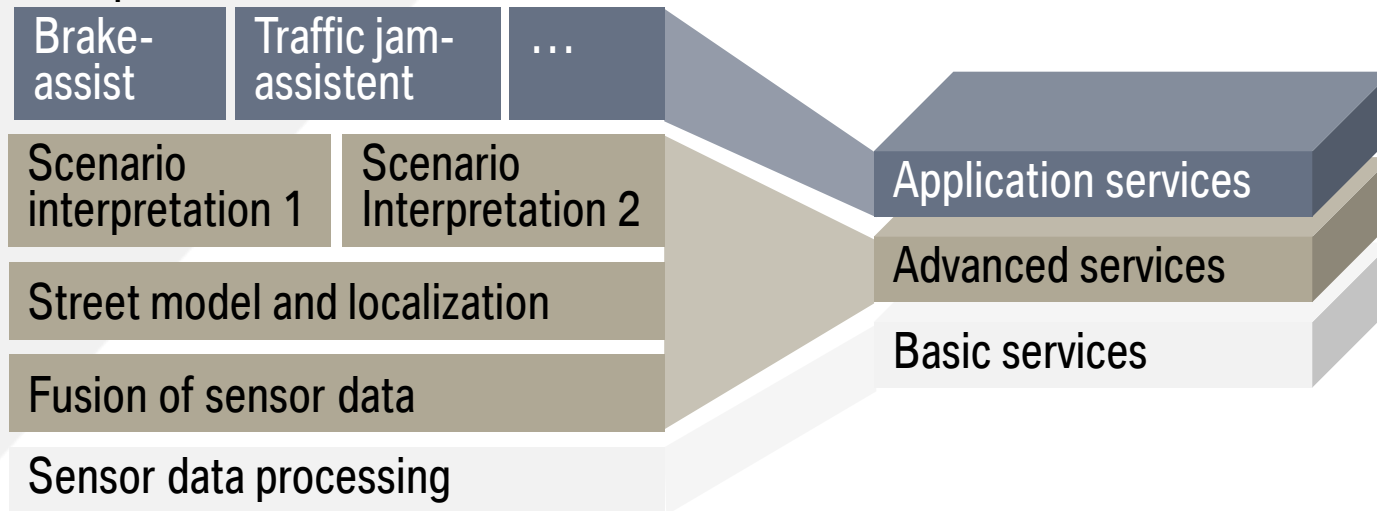
# NEED TO REDUCE COMPLEXITY WHILE SUPPORTING MORE COMPLEX SYSTEMS.

- Shift from signal-based to service based communication
- Focus on Ethernet-based communication.
- Use of standards in the EE-infrastructure.

# A SERVICE-BASED ARCHITECTURE ALLOWS MORE REUSE AND FLEXIBILITY.

- Provides services and transparency in the complete system (across domains).
- Allows handling the complexity, as it supports encapsulation and hierarchies and testing against interfaces.
- The reuse over vehicle generations is significantly simplified.
- But, large change for control loops with stringent timing requirements.

Example:



# SERVICE-ORIENTED ARCHITECTURE (SOA) IS A GAME CHANGER.

- New thinking in terms of the creation of distributed vehicle features.
- Provide the base for a vehicle API used by onboard and off-board apps.
- More efficient allocation of processing resources by concepts of static and dynamic binding during runtime.
- Services as a result of deep machine learning (self optimizing distributed systems).
- Perfect match during the transformation to an all IP vehicle approach.
  
- Standards are essential for structuring concepts, SW stacks, data exchange and tooling.
- Automotive Ethernet as an in-vehicle networking technology inherently supports SOA.

# AUTOMOTIVE ETHERNET ALLOWS TO REDUCE THE NUMBER OF IVN-TECHNOLOGIES.

– Fewer technologies

- No gateways, no gateway tables, no complex coupling.
- Reduced number of different tools, simpler analysis.

- Ethernet/IP

- Flexible (for many different applications), scalable (in data rates and features).
- Inherently supports a service based architecture.
- State of the art security standards.
- Eco system goes beyond the borders of automotive.
- Unified software architecture possible.
- Inherently supports a zonal architecture (allow one physical network).
- Unified connectivity to the outside world/cloud.



# BECAUSE OF THE STRICT LAYERING NEW SPEED GRADES OR MEDIA INTEGRATE SEAMLESSLY INTO THE NETWORK.

Name	Data rate	Status	Cabling	SOP
<b>100BASE-T1*)</b>	100Mbps	Completed Standard	UTP P2P	2013
<b>1000BASE-T1</b>	1Gbps	Completed Standard	Jacketed UTP P2P or STP	2020
<b>10BASE-T1S</b>	10Mbps	Taskforce at IEEE, complete within 2019	UTP P2P or multidrop	2022 possible
<b>2.5,5,10GBASE-T1</b>	2.5, 5, 10Gbps	Taskforce at IEEE, complete 2020	STP (Coax in discussion)	2024 possible
<b>&gt;10G</b>	25, 50Gbps	Study group at IEEE, NAV Alliance	Open, STP likely	2027 target

Additional features on PHY level are: PoDL, autonegotiation, EEE, wake-up/sleep

Challenges on PHY level: Automotive EMC validation for every speed grade. Patience to wait for the next standard.

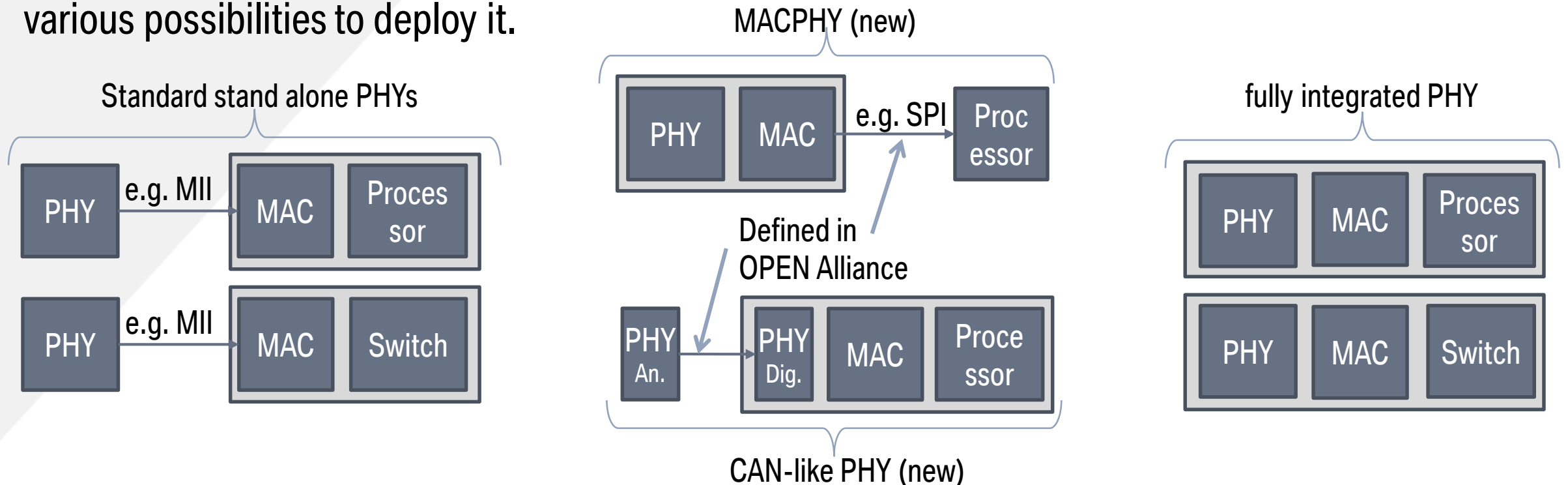
The IEEE TSN standards allow the support of applications with different timing requirements.

\*) prev. BroadR-Reach or OPEN Alliance BroadR Reach (OABR)

# 10MBPS AUTOMOTIVE ETHERNET ADDRESSES THE COMMUNICATION WITH LOWER DATA RATES WHICH CURRENTLY REPRESENTS ~93%.

The costs factors generally considered in comparisons are: PHY, CMC, crystal, connectors, cables, sometimes peripherals, sometimes effort in processor, sometimes software (licenses).

In order to have an attractive PHY cost, 10BASE-T1S is developed such that there are (will be) various possibilities to deploy it.



## SUMMARY AND CONCLUSION.

- The car manufacturers are facing a time in which they need to continue to strive in ever fiercer competition while having to embrace the changes induced by a digitized world.
- Service based communication and in-vehicle communication network (IVN) are essential for both efficiency and enabling the future.
- Automotive Ethernet represents the most important trend and offers the chance to simplify the IVN while at the same supporting existing functions, future innovations, service based communication.
- However, to really embrace the future, the automotive industry does not only need standards, it needs a mind change as well.

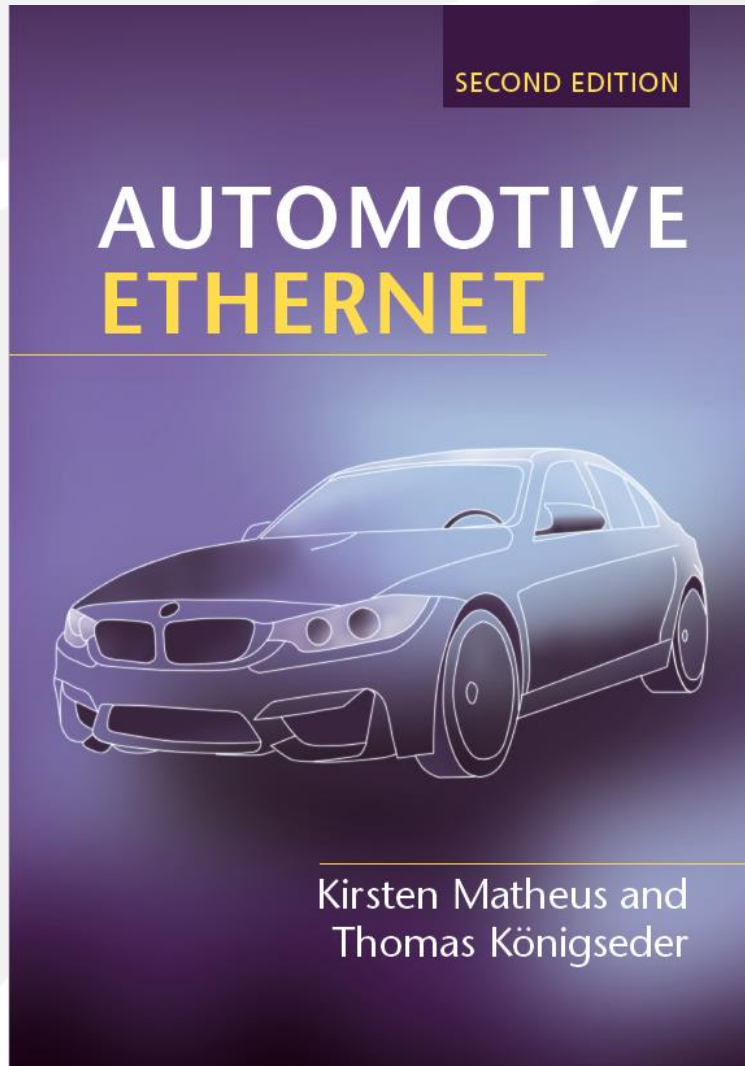
# THANK YOU FOR YOUR ATTENTION



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## MORE INFORMATION ON AUTOMOTIVE ETHERNET CAN BE FOUND IN:



New content includes:

- Detailed explanations of how the 100BASE-T1 PHY and 1000 BASE-T1 PHY technologies actually work.
- A step-by-step description of how the 1000BASE-T1 channel was derived.
- A summary of the content and uses of the new TSN standards.
- A framework for security in Automotive Ethernet.
- Discussion of the interrelation between power supply and Automotive Ethernet communication.