CFI Multi-Gig Automotive Ethernet PHY

Call for Interest at IEEE802.3 Working Group

San Antonio, TX, November 2016 Plenary Meeting

CFI Multi-Gig Automotive Ethernet PHY

CFI Panel Members

- **Chair & Presenter**
  - Steve Carlson (High Speed Design)
- **Supporters and Experts for the Q&A Session**
  - Helge Zinner (Continental)
  - Kirsten Matheus (BMW)
  - Natalie Wienckowski – (General Motors)
  - Thomas Hogenmüller (Bosch)

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Supporters (max. 3 per company)

Automotive Industry Car Makers:

Dongok Kim (Hyundai)
Doug Olliver (Ford)
Hideki Goto (Toyota)
Jim Lawlis (Ford)
Jinhwa Yun (Hyundai)
John Leslie (JLR)
Josetxo Villanueva (Renault)
Juergen Herrle (Audi)
Kirsten Matheus (BMW)
Mike Potts (General Motors)
Natalie Wienckowski (General Motors)
Nishanth Ullas (JLR)
Olaf Krieger (Volkswagen)
Samuel Sigfridsson (Volvo Cars)
Stefan Buntz (Daimler)

Automotive Industry System Suppliers:

Chris Lupini (Delphi)
Christoph Arndt (Continental)
Craig Gunther (Harman International)
Daniel Zebralla (Continental)
Haruka Honda (Denso)
Helge Zinner (Continental)
Larry Matola (Delphi)
Magnus Nigmann (Intedis)
Peter Fellmeth (Vector Informatik GmbH)
Thomas Hogenmüller (Bosch)
Thomas Müller (Rosenberger)
Wes Mir (Delphi)
Yoshifumi Kaku (Denso)

Automotive Industry Components & Tools:

Ali Angha (Spirent)
Bert Bergner (TE Connectivity)
Christian Boiger (b-plus)
Daniel Wiesmayer (DRÄXLMAIER Group)
Eric DiBiaso (TE Connectivity)
Matthias Jaenecke (Yazaki)
Mike Gardner (Molex)
Naoshi Serizawa (Yazaki)
Phillip Brownlee (TDK)
Shigeru Kobayashi (TE Connectivity)
Triess Burkhard (ETAS)
Vimalli Raman (Yazaki Systems Technologies)

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Supporters (max. 3 per company)

Industrial Automation Industry:

Avionics Industry:

Dr. Alexandros Elefsiniotis (Airbus Group)

Semiconductor Industry:

Amir Bar-Niv (Aquantia)
Claude R. Gauthier, Ph.D. (OmniPHY)
Guenter Sporer (NXP) G
Harald Zweck (Infineon)
Henry Muyshondt (Microchip)
Kamal Dalmia (Aquantia)
Mehmet Tazebay (Broadcom)
Mike Jones (Microchip)
Norbert Schuhmann (Fraunhofer IIS)

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CFI Objective

- To gauge the interest in starting a study group developing a

Multi-Gig Automotive Ethernet PHY

- This Meeting will NOT:
  - Fully explore the problem
  - Choose any one solution
  - Debate strengths and weaknesses of solutions
  - Create a PAR or 5 Criteria
  - Create a standard or specification
- Anyone in the room may speak / vote
- Respect … give it, get it

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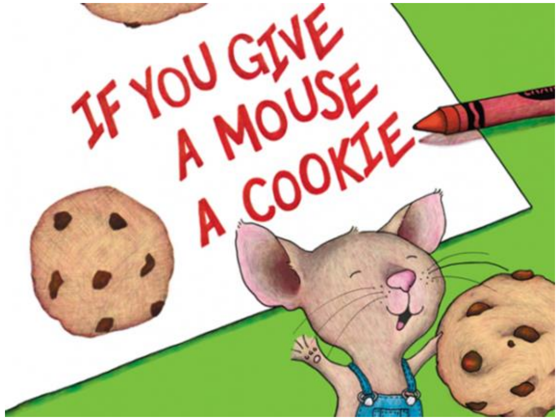

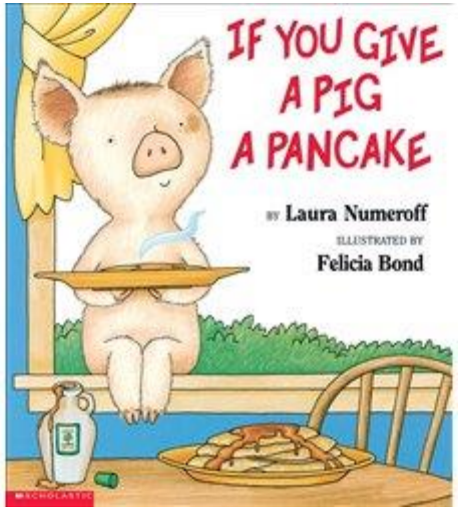

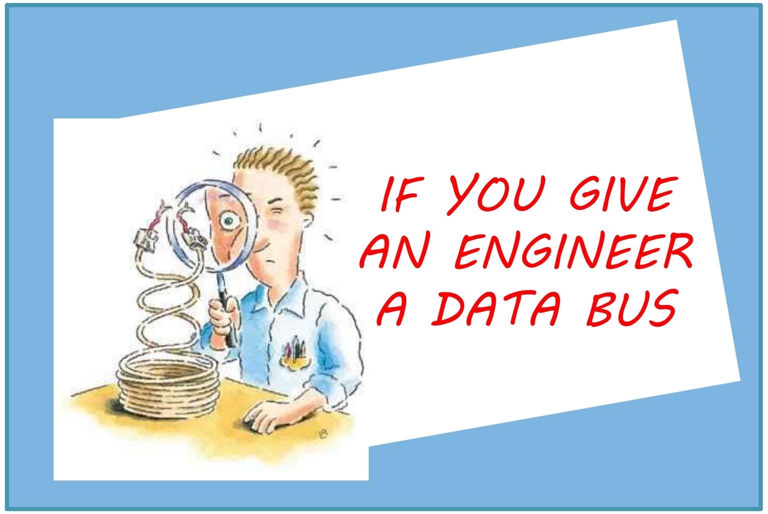

He's going to ask for a glass of milk.

She'll ask for a bottle of syrup.

He'll ask for more bandwidth and faster speeds.

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Agenda

- Target Markets
- Why Multi-Gig
- How Many Multi-Gig
- Use Cases
- Why Now?
- Automotive Market Potential
- Q&A
- Straw Polls

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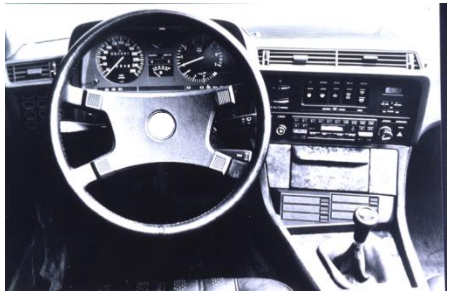
Innovation in Automotive Technology is both Hardware & Software

- **Increasing number of applications**
  - Increasing complexity over time
  - Higher bandwidth requirements
  - Need reliable networks

Electronic Injection
Check engine control
Cruise control
Central locking
…



Gearbox control
Climate control
ASC Anti Slip Control
ABS Anti -lock Brake Sys.
Telephone
Seat heating control
Automatic mirrors

Navigation system
CD-changer
Active Cruise Control
Airbags
Dynamic Stability Control
Roll stabilization
Xenon lighting
Vehicle Assist
Voice input
Emergency call

ACC Stop&Go
Lane departure warning
Blind spot warning
Traffic sign recognition
Night vision
Active headlight system
Parking automation
Efficient dynamics
Hybrid engines
Internet access
Telematics
Online Services
Bluetooth integration
Local Hazard Warning
Personalization
SW Update
Smart Phone Apps
…

1970 1980 1990 > 2010

Adapted from material provided by BMW

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Typical networks used in cars today include:

- **CAN (Controller Area Network) - since 1981**
  - Low-speed serial data bus: 1 – 1000 Kbps
  - Shared medium with CSMA/CR (Collision Resolution)
  - Dominant control bus in all automotive domains
  - Standardized in ISO 11898; Multi-vendor support

- **FlexRay (consortium of automotive companies) - since 2005**
  - 10 Mb/s serial data bus (single or dual channel)
  - Shared medium with TDMA
  - Control bus for high dynamic applications, chassis control, but also designed for future "X-by-Wire" applications
  - Standardized in ISO 10681; Multi-vendor support

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- MOST (Media Oriented Systems Transport) - since 2001
  - Shared ring topology: 25 Mb/s (POF), 50 Mb/s (Cu), 150 Mb/s (POF)
  - Bus system for control and streaming Infotainment data
  - Proprietary solution

- Ethernet (100Mb/s) - since 2008
  - Mainly diagnostics and firmware upgrades during vehicle servicing (typically not used while the car is operating due to EMC limits)
  - Standardized in ISO 13400-3:2011 Road Vehicles – Diagnostic communication over Internet Protocol (DoIP) – Part 3: Wired vehicle interface based on IEEE 802.3
  - 100BASE-T1 – since 2013

- LVDS - since 2002
  - Point-to-point high-speed links (1-4 Gb/s) for cameras and displays
  - Multi-vendor support but typically incompatible with each other

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Target Markets

- **Automotive networking**
  - The dominant driving market for this CFI
  - Increasing bandwidth and interconnecting requirements for in-vehicle control systems
  - Large market volume (i. e., port count)
  - This presentation will focus on this segment

A Multi-Gigabit PHY could be leveraged across other segments including:

- **Avionics networking**
  - The need for weight savings for the cabling infrastructure is even more dominant than in the automotive industry

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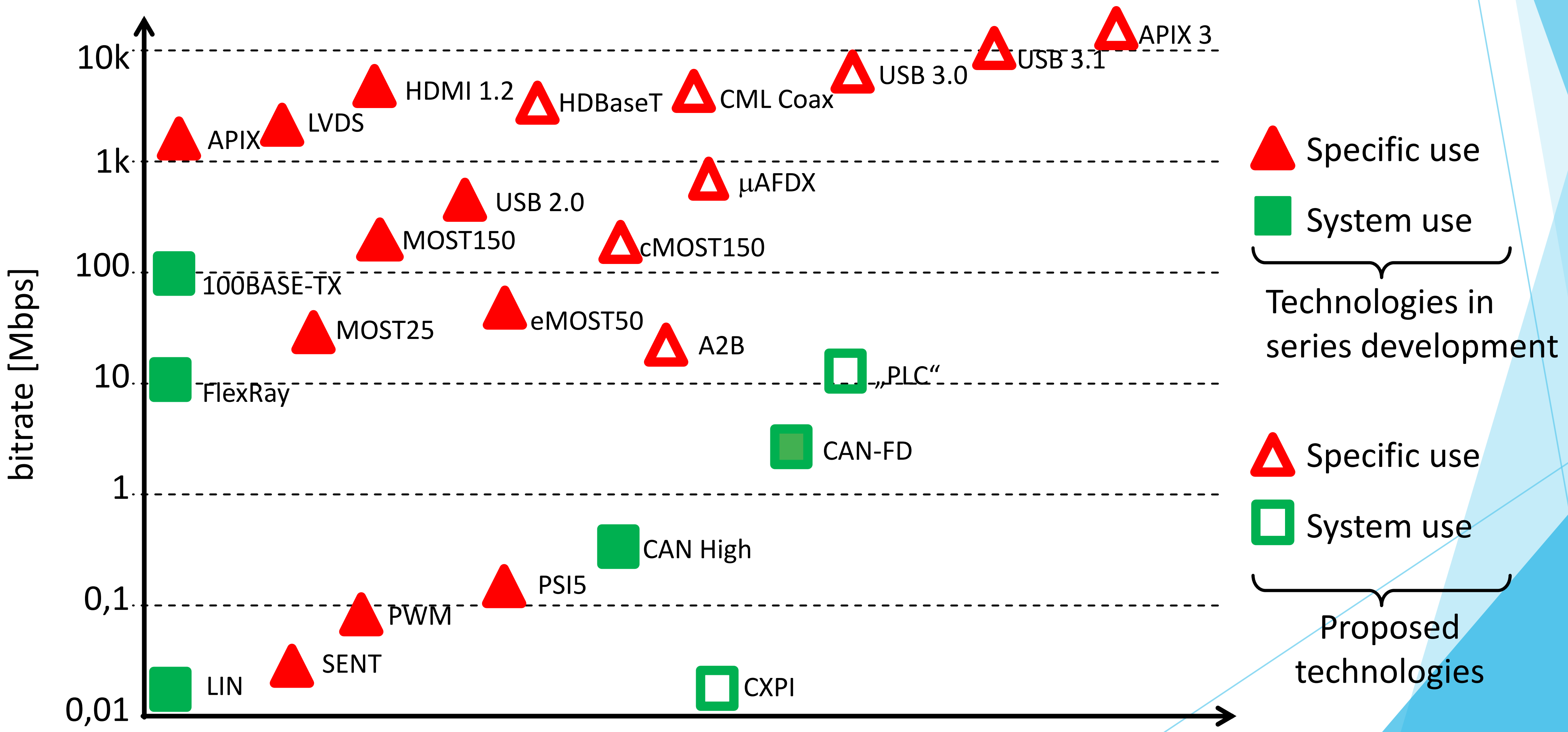
Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

There are many standard communication links for system usage below 10 Mbps



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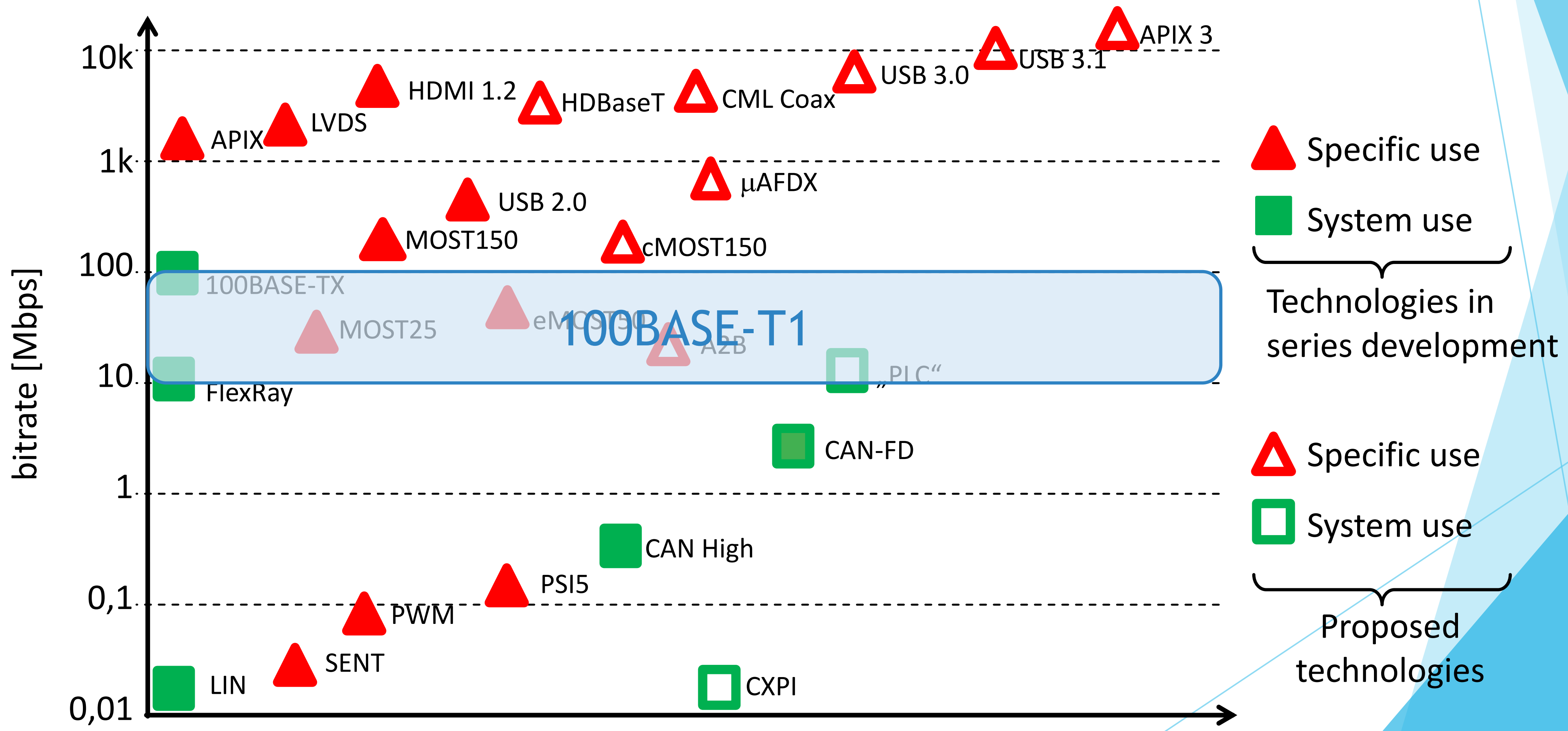
Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

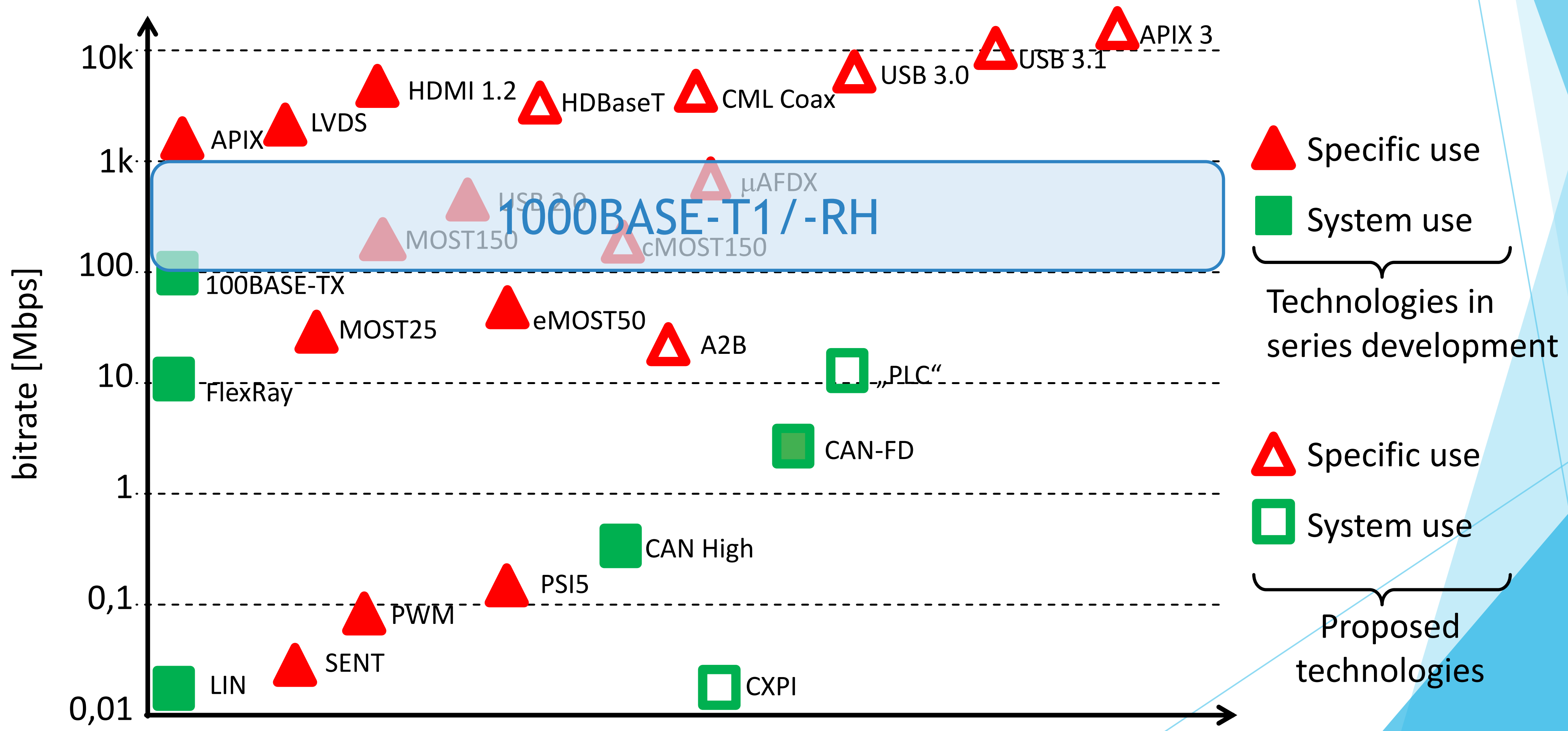
There are few standard communication links for system usage between 10 Mbps and 100 Mbps



CFI Multi-Gig Automotive Ethernet PHY

Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

There are no standard communication links for system usage between 100 Mbps and 1000 Mbps



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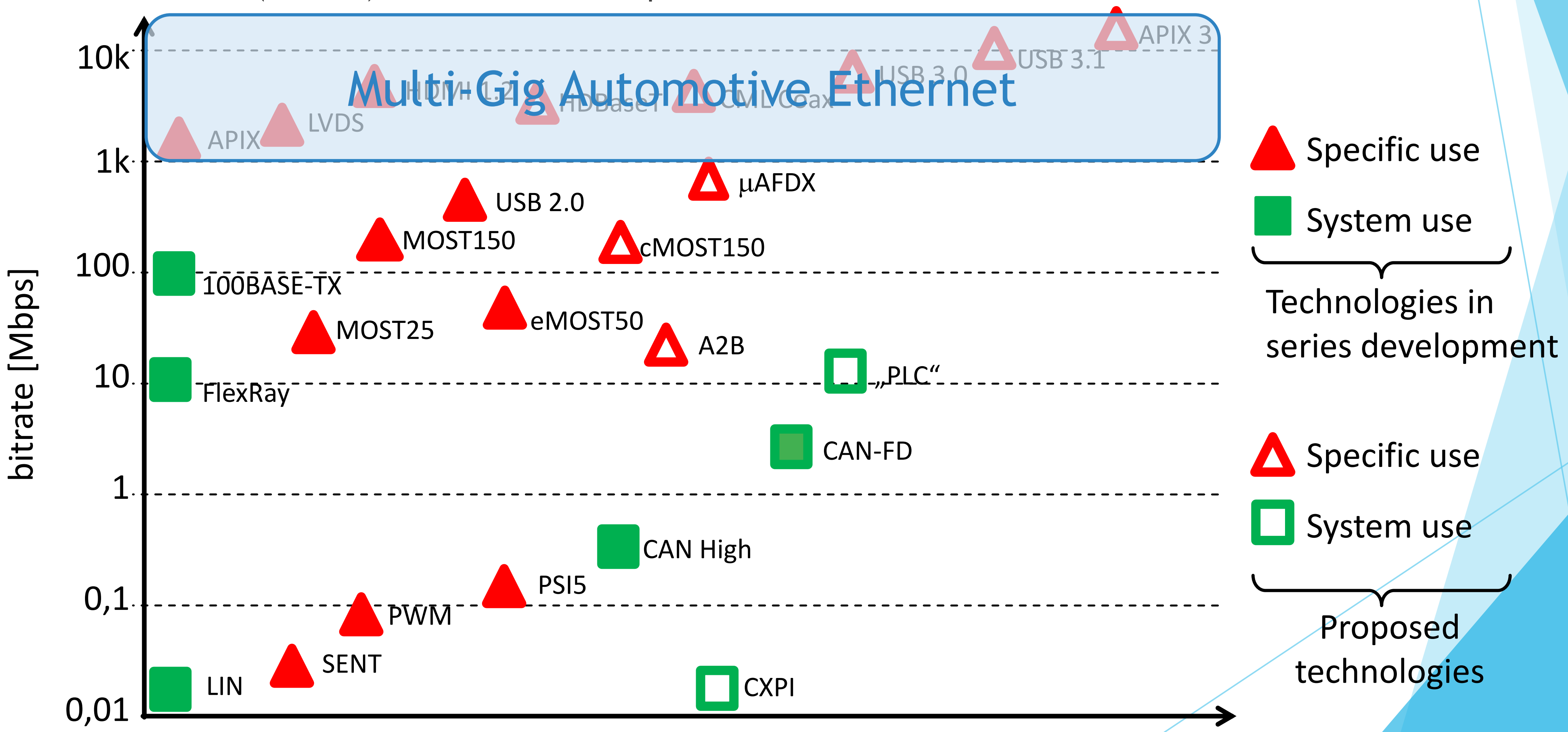
Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

There are no standard communication links for system usage above 1000 Mbps

There are many proprietary communication links above 1000 Mbps

A standard link (or links) is needed for this space



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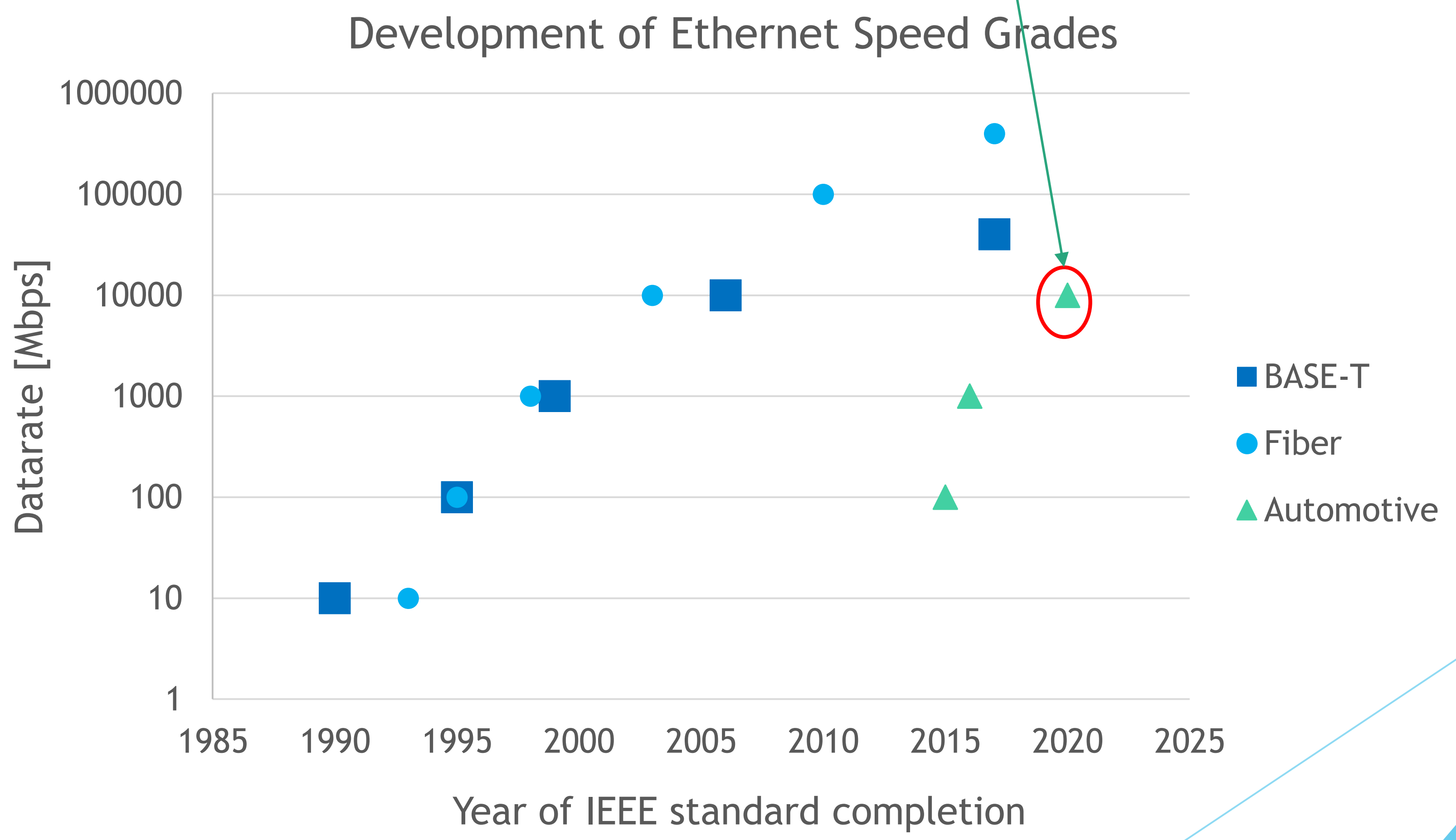
Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

This follows the typical Ethernet PHY development schedule.



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Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

- **Multi-Gig Data Transmission Links in Automotive Today**
  - LVDS / CML
  - APIX
  - USB
  - HDMI
- **Drawbacks of these links**
  - Point-to-point with no automatic relay systems
  - Additional processing power to retransmit
  - Difficult to coordinate timing
  - Proprietary solutions that make adding / changing devices difficult
  - High cable cost (shielding and application specific cables and connectors)

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Why Multi-Gig in Addition to 1000BASE-T1/-RH and 100BASE-T1

- **Use Cases**
  - Sharing camera data
  - 4K and 8K shared display data
  - Connectivity: LTE 4G/5G, transport of 802.11ac
  - Connecting 1000BASE-T1/-RH switches
  - Diagnosis (port mirroring of multiple 1000BASE-T1/-RH links)
- **Scalability within a network**
  - 100BASE-T1 may be sufficient for collision warning
  - 1000BASE-T1/-RH may be sufficient for collision avoidance
  - xGig (Multi-Gig) required for advanced driver assistance
  - Switch with 100M/1000M/xGig capability

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Use Cases

- **Cameras**
  - 4K Cameras at 60 fps – 6 to 8 Gbps
  - Short propagation delay (< 20 ms) doesn’t allow for compression
- **Data Sharing**
  - Aggregation of multiple 1 Gbps links requires xGbps links
- **Displays**
  - 4K/8K displays will start appearing in vehicles
- **Data Recorder**
  - Significant amount of raw data may need to be saved to reconstruct incidents

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How many Multi-Gig

- Automotive applications are very cost sensitive
  - There is always a need for more (speed and/or bandwidth)
  - Long cycle times require ability to upgrade without complete redesign, backward compatibility
  - Don’t want to pay for more than required
  - Prefer designs that allow components to be added on an “as needed” basis

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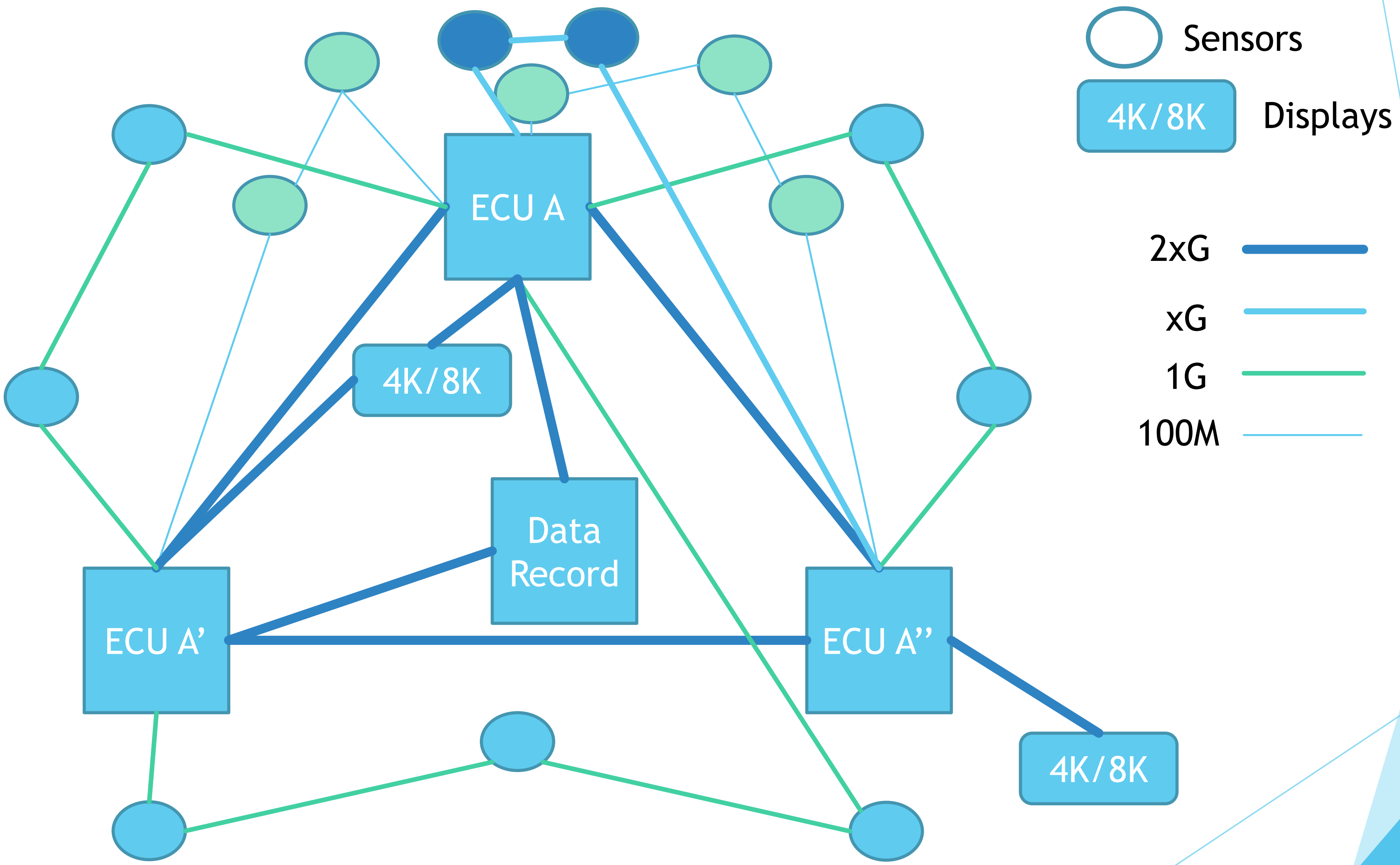

Redundancy for data acquisition
Redundancy and data sharing for computing platform ECUs (number crunchers)

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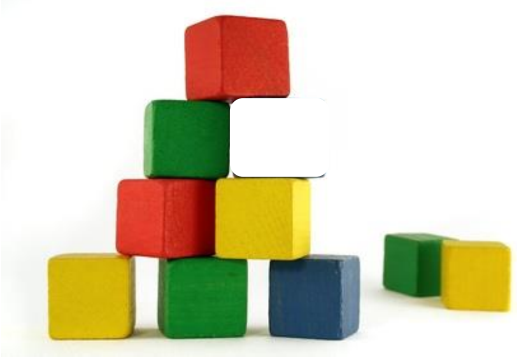
IEEE 802 Automotive Ethernet Eco-System

- IEEE 802.3 for Diagnostics and Flashing
  - S 100BASE-TX
- IEEE 802.3 for In-vehicle communication
  - S 802.3bp 1000BASE-T1 / RTPGE
  - S 802.3br Interspersing Express
  - T 802.3bu PoDL
  - T 802.3bv Gigabit over Plastic Optical Fiber (GEPoF)
  - S 802.3bw 100BASE-T1 / 1TPCE
  - C 10 Mbps for Automotive
  - C Multi-GE for Automotive
- IEEE 802.1 Data Link Layer
  - S Audio Video Bridging
    802.1 BA, 802.1 AS*, 802.1 Qat*, 802.1 Qav
  - T Time Sensitive Networks
    802.1AS-Rev, 802.1CB, 802.1Qcc, 802.1Qci,
    802.1 Qbu, 802.1 Qbv, 802.1 Qca, 802.1Qcr
  - T Security – 802.1AEcg



Something is missing!

I= Idea; C = CFI; T = TaskForce; S = Standard

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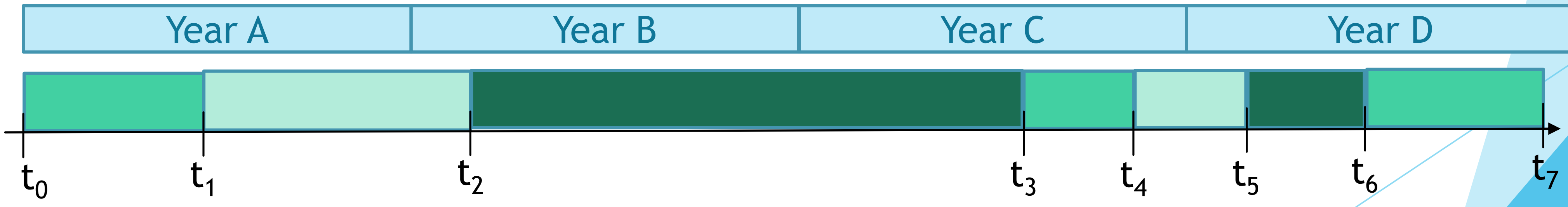
Why Now?
Typical Automotive Ethernet PHY IEEE Timing

- t_0 - Idea for CFI.
- t_1 - CFI approved. Start to work on PAR Components.
- t_2 - PAR approved. Start TF meetings and select technology components.
- t_3 - D1.0 complete. Refine specification.
- t_4 - D2.0 complete. WG ballot begins.
- t_5 - D3.0 complete. Sponsor ballot begins.
- t_6 - Sponsor ballot complete.
- t_7 - Completed specification available.



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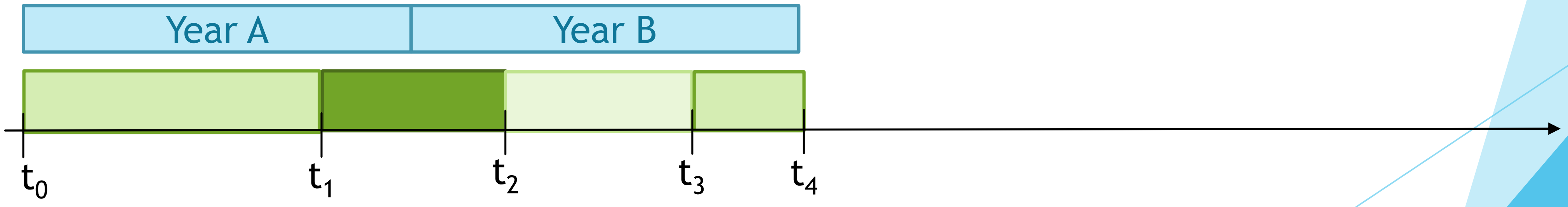
Why Now?

Typical Automotive IC Development Timing

- t_0 - Start new IC design. Most requirements are known.
- t_1 - Early Engineering Samples Available. Functionally Close.
- t_2 - Engineering Samples Available. Expected to be Final Silicon.
- t_3 - Validation (PPAP) Complete.
- t_4 - Released for Production.



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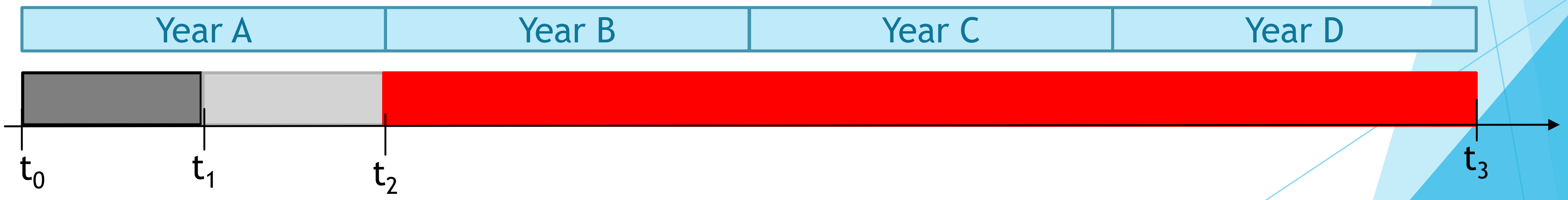
Why Now? - Typical Automotive Architecture Development Timing

- t_0 - Decision to create a new Architecture, n. Determine what functions should be included.
- t_1 - Investigate available technologies. Verify proposed technologies are viable through demonstrations.
- t_2 - Decide on technologies to be included. Kick-off ECU development. Window closed to consider new technologies.
- t_3 - Decision to create next new Architecture, n+1



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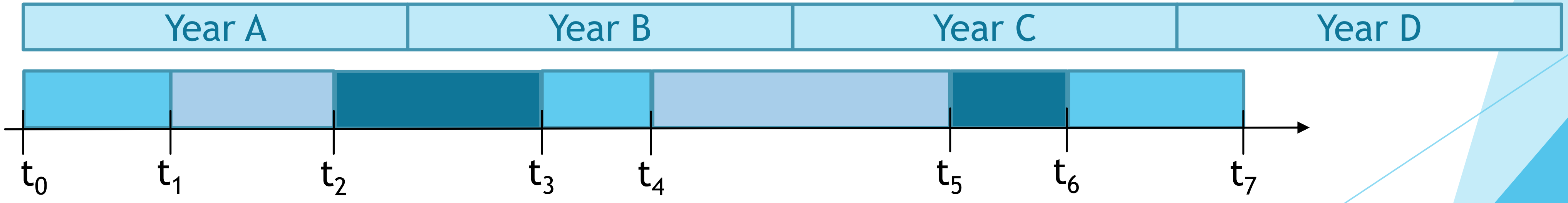
Why Now

Typical Automotive ECU Development Timing

- t_0 - Start of new ECU (RFQ). Expect that at least Early Samples of PHYs are available.
- t_1 - Tier 1 has been selected.
- t_2 - ECU Mule bench delivery with PHY included. Does not have to be production part or package.
- t_3 - Development ECU available to perform validation testing. Production PHY is required; however, supplier PPAP does not have to be complete.
- t_4 - Validation complete on Development ECU.
- t_5 - Production ECU available.
- t_6 - Validation complete on Production ECU.
- t_7 - Start of Vehicle Production (SOP).



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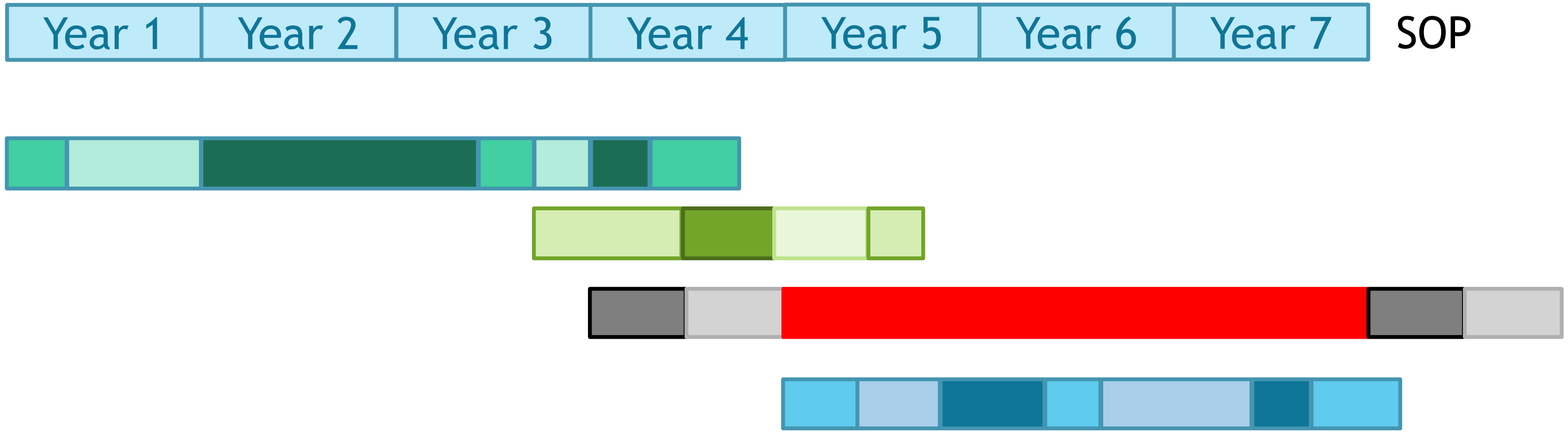
Why Now?

Total Automotive Ethernet PHY Development from Concept to Production

Best Case Scenario

- PHY Development starts with WG ballot
- EES available just in time for new Architecture consideration
- Vehicle production starts just over 7 years from initial idea



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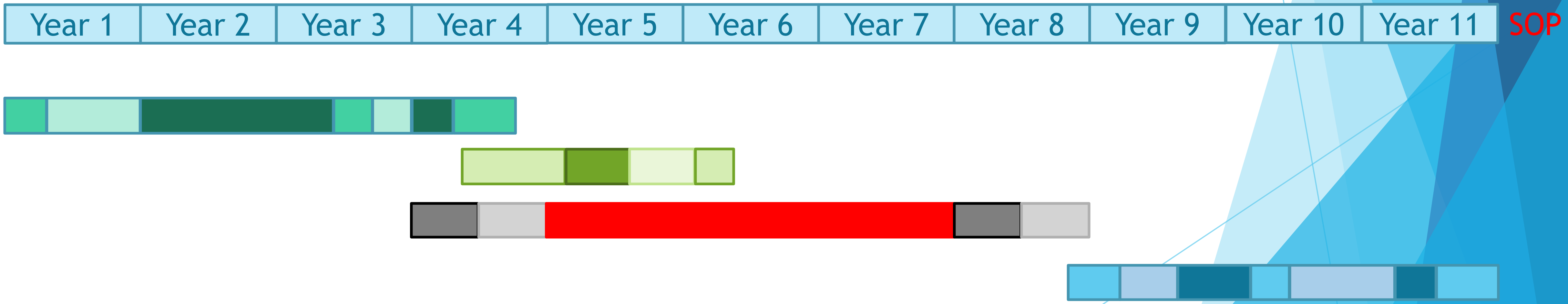
Why Now?

Total Automotive Ethernet PHY Development from Concept to Production

Best Case Scenario

- PHY Development starts with WG ballot — PHY Development is delayed
- EES available just in time for new Architecture consideration — PHY is not available for evaluation
- Vehicle production starts just over 7 years from initial idea — Vehicle production starts 11 years from initial idea



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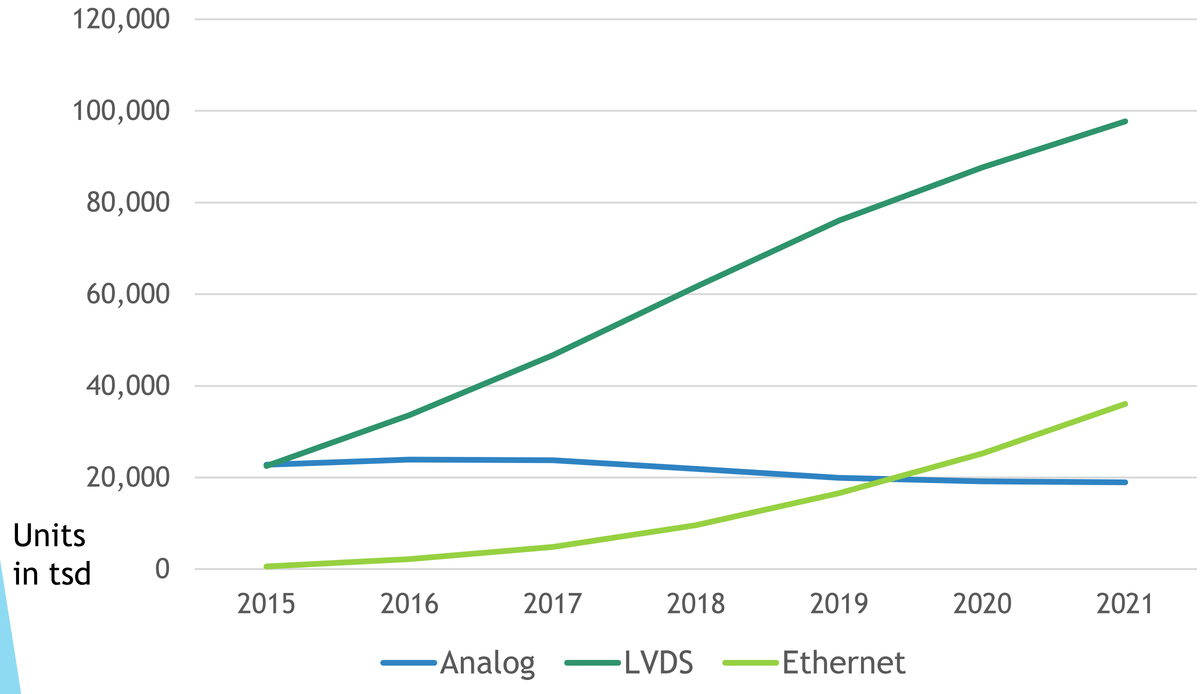
Automotive Market Potential

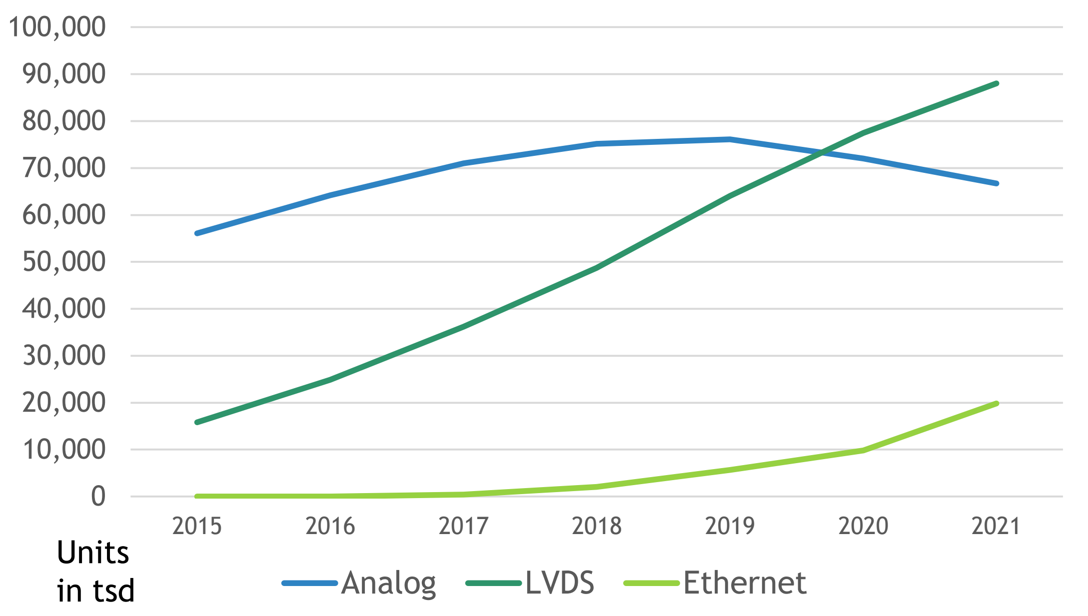
Camera Connectivity Forecast

(Distance Warning, Parking, Blindspot, Nightvision,...)



Display Connectivity Forecast

(Headunit, Seperate, HUD,...)



Data provided by STRATEGY ANALYTICS

CFI Multi-Gig Automotive Ethernet PHY

- Forecast from 100 BASE-T1 CFI

Forecast from 2014 CFI for 1TPCE

- For RTPGE CFI we forecasted 270 million Ethernet ports by 2019/20
- We were wrong, sorry!
- We now assume about 400 million ports

Some numbers

- In 2019 the automotive industry will produce 117 million vehicles
- Up to 35 ports (20 avg.) in premium class vehicles and 20 (8 avg.) in medium class vehicles that have Ethernet

Ethernet increases creativity for new applications

- Ethernet provides an infrastructure for automotive innovations