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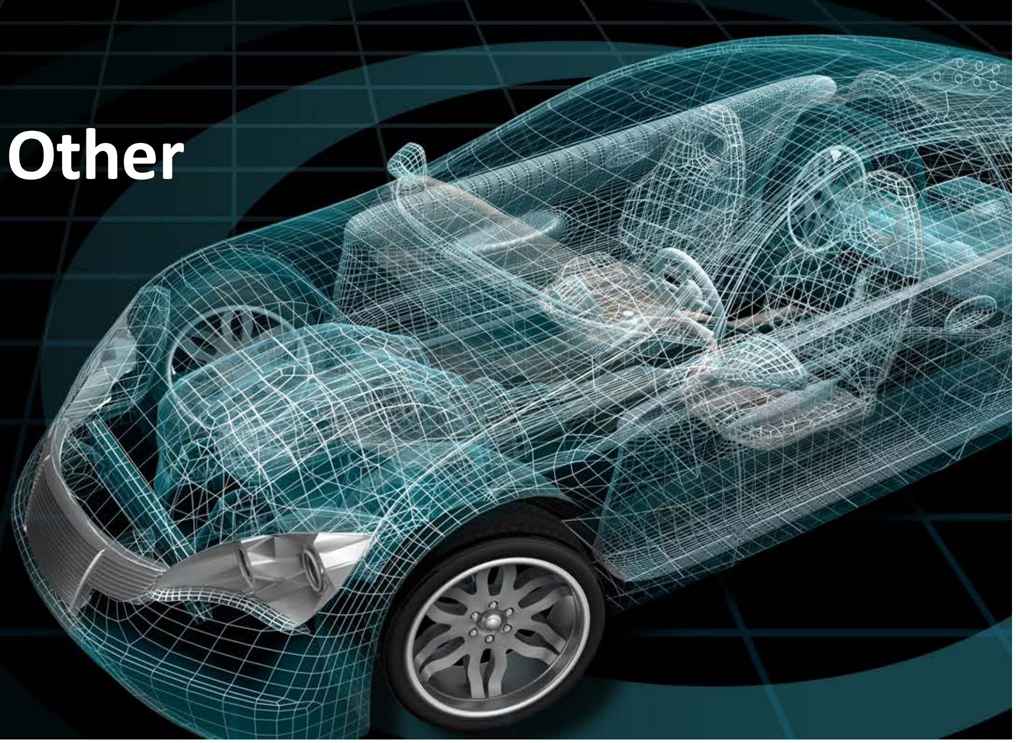
IF IT'S NOT MIPI, IT'S NOT MOBILE

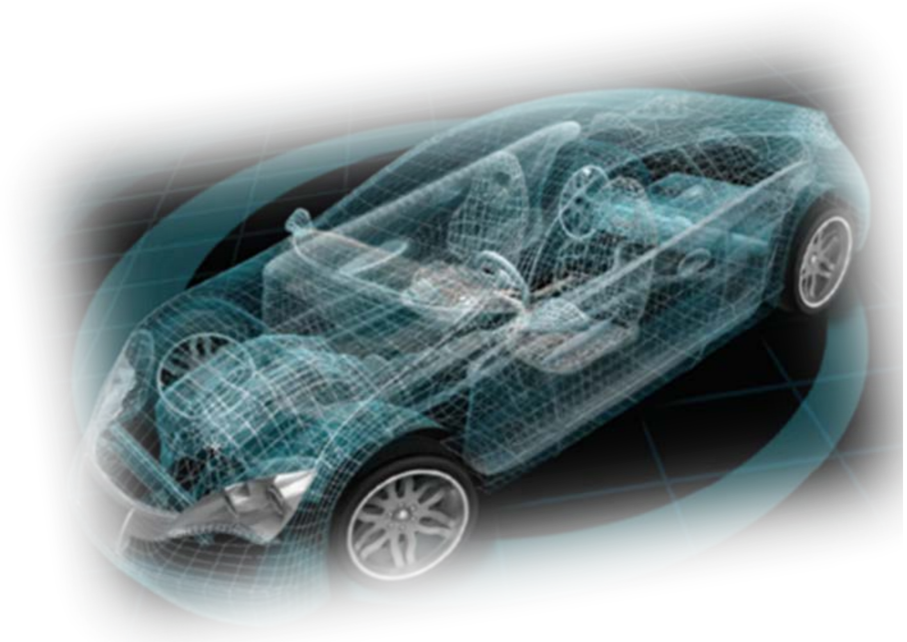
Advancing In-Vehicle Connectivity for ADAS and Other Automotive Applications



Matt Ronning
MIPI Automotive Working Group Chair, Sony

Raj Kumar Nagpal
MIPI A-PHY Subgroup Lead, Synopsys

Presentation Outline



About MIPI Alliance
Peter Lefkin
MIPI Alliance Managing Director

Industry Need
Matt Ronning
MIPI Automotive Working Group Chair

An Overview of MIPI A-PHY
Raj Kumar Nagpal
MIPI A-PHY Subgroup Lead

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About MIPI Alliance

Peter Lefkin
MIPI Alliance Managing Director

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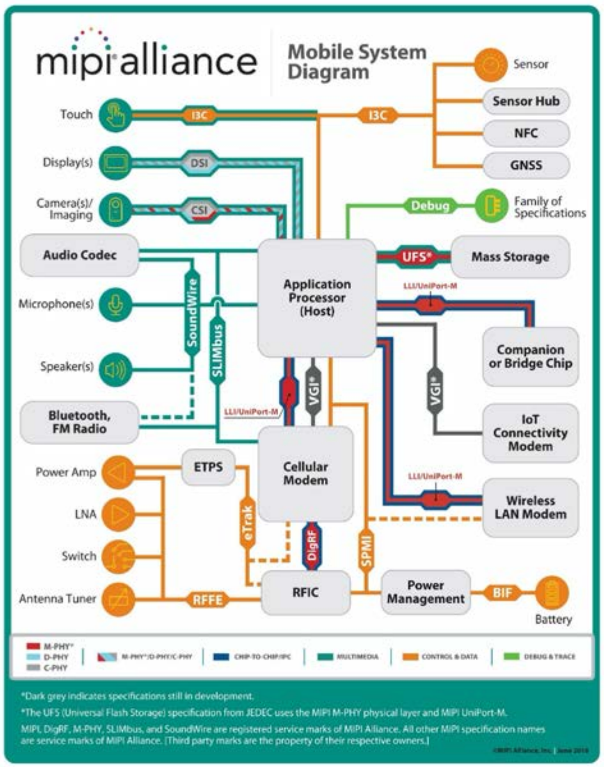
MIPI ALLIANCE FORMED TO STANDARDIZE CAMERA AND DISPLAY INTERFACES

MIPI Specifications Leveraged Beyond Mobile

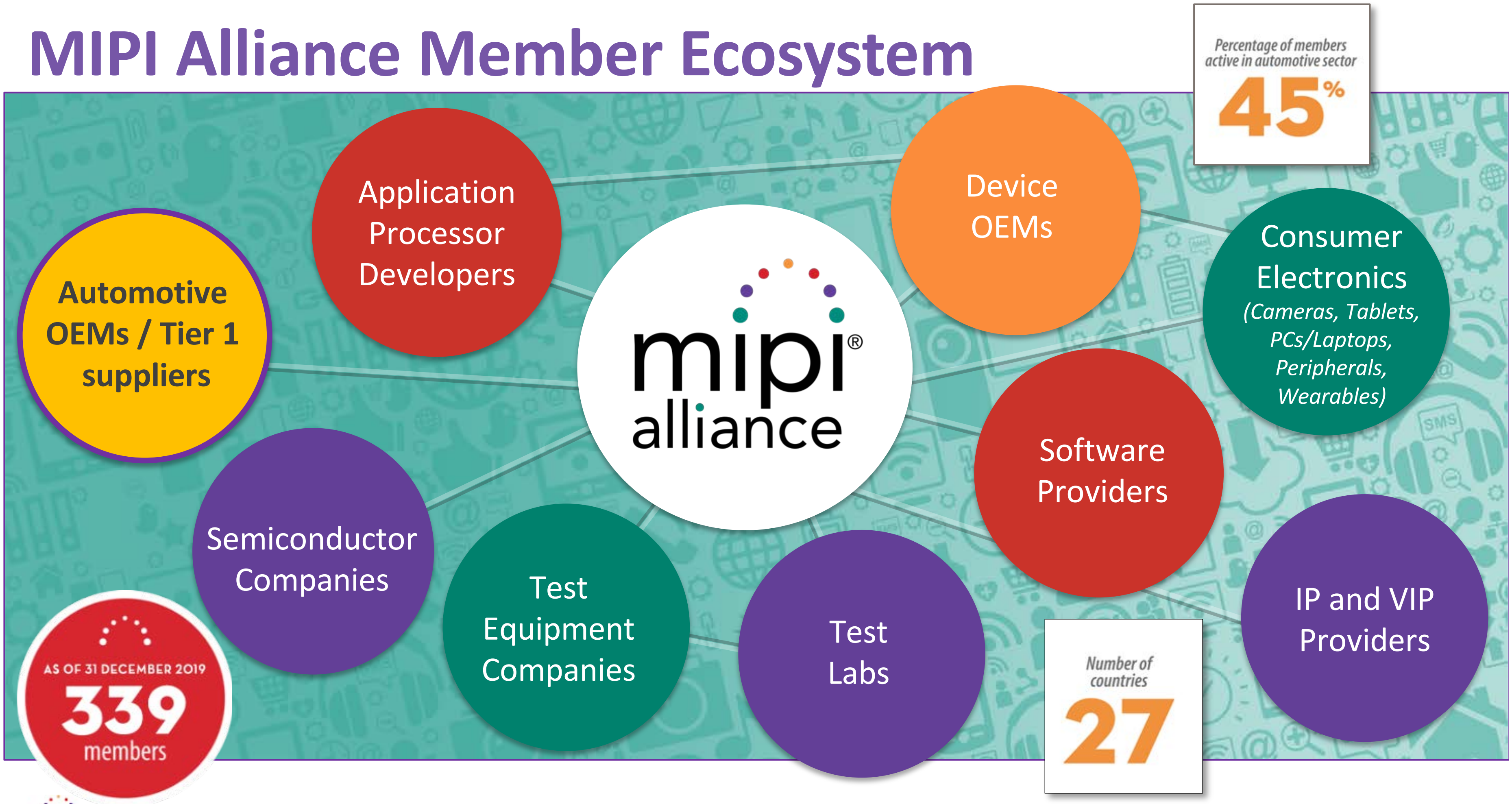


Number of current specifications

48

Fundamentally, usage rights are granted to members royalty free for implementation of MIPI specifications from all MIPI members

MIPI Alliance Member Ecosystem



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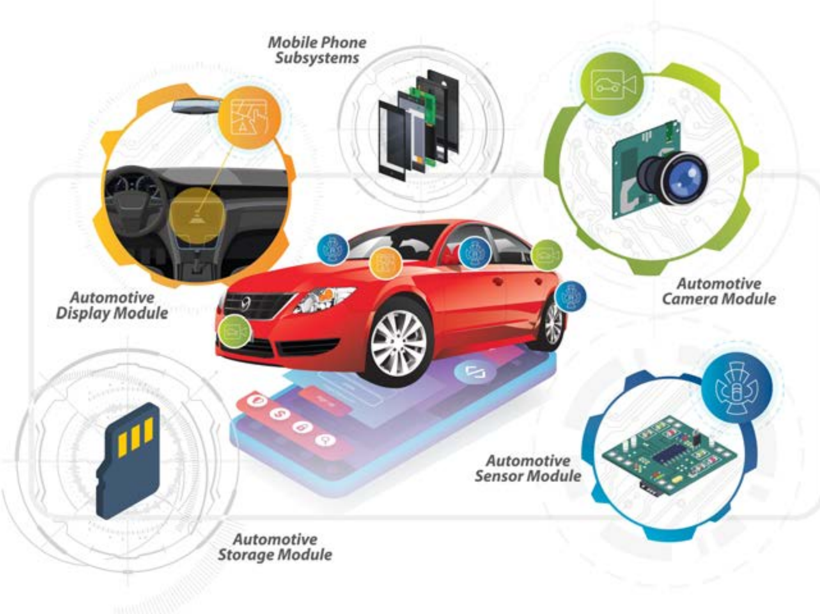
MIPI in Automotive



Cameras, displays, audio, sensors, storage, RFFE for 5G, WiFi, Bluetooth

MIPI SPECIFICATIONS IN AUTOMOTIVE TODAY

CSI-2
Camera Serial Interface protocol
Protocol for cameras, lidar, radar sensors

DSI-2
Display Serial Interface protocol
Protocol for smartphone, IOT and automotive displays

C-PHY
3-phase physical layer for CSI-2 & DSI-2
Short-reach physical layer for cameras and displays

D-PHY
Differential physical layer for CSI-2 & DSI-2
Short-reach physical layer for cameras and displays

I3C
Control and data bus protocol and interface
Sensor and general purpose data and control interface within a module

RFFE
RF control protocol
Front end control within a wireless module

SoundWire & SWI3S
Digital audio and control interface
Audio interface within a module

UniPro for JEDEC UFS
Data transport protocol for UFS over M-PHY
Transport protocol for UFS storage

M-PHY for JEDEC UFS
Differential physical layer for UFS storage
Short-reach physical transport for UFS storage

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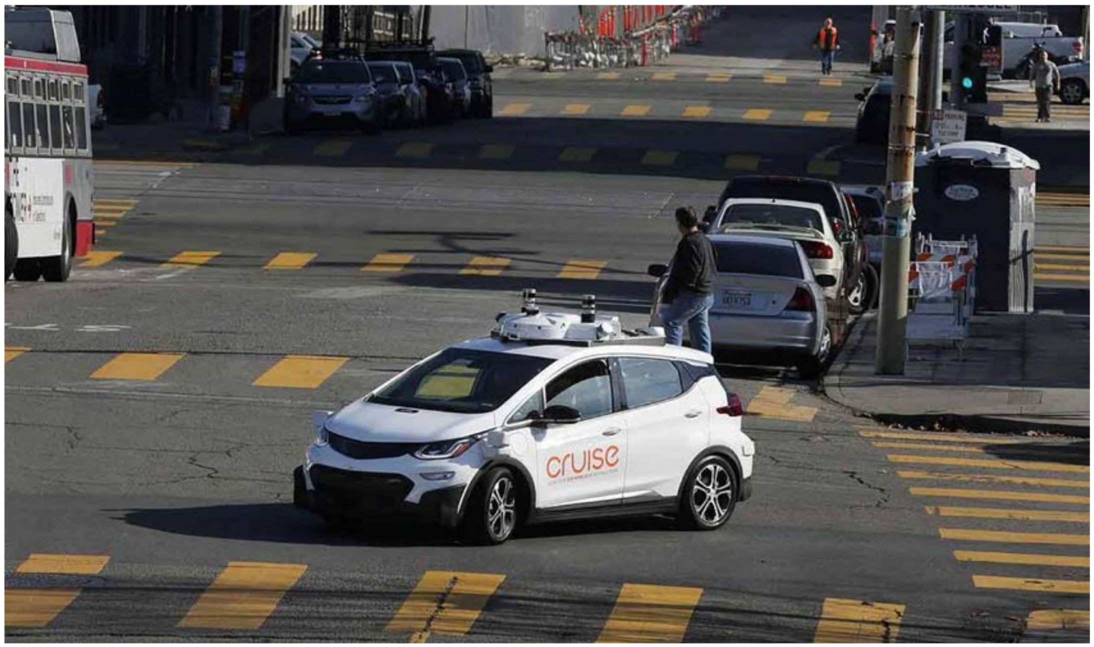
Industry Need

Matt Ronning
MIPI Automotive Working Group Chair

Auto Industry Transformation

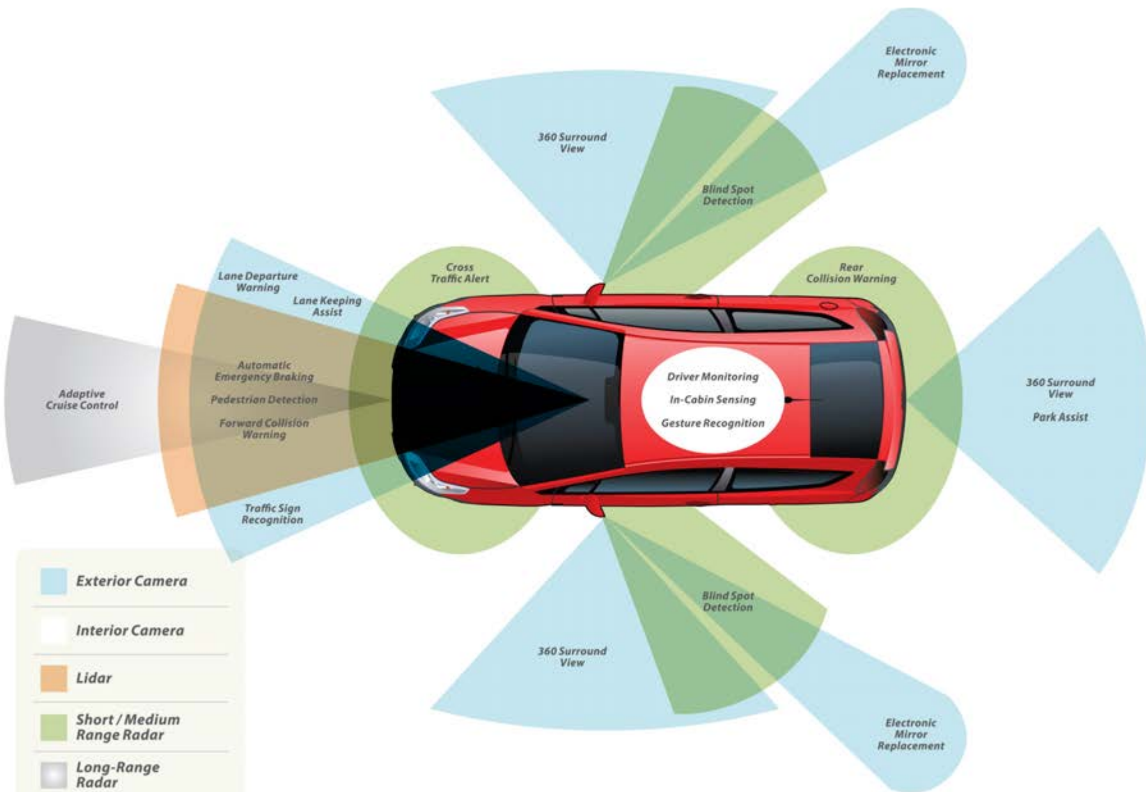


Honda and GM Partner to Develop Mass Produced, Driverless Cars
Source: October 4, 2018, Automotive News

Huge changes in the industry:

- Worldwide new car assessment program (government safety regulations such as FCWS, AEBS, RVS, LDWS, etc.)
- Aggressive fuel economy regulations
- Electrification of cars
- New OEMs, new business models, new alliances
- Autonomous driving systems
- Car connectivity

NCAP Regulations Driving Sensors & Display Adoption



Source: Jabil, Inc

- Worldwide NCAP ADAS standards driving adoption of multiple high data rate “surround sensors”
- Displays for driver viewing of assistance imaging and information also required

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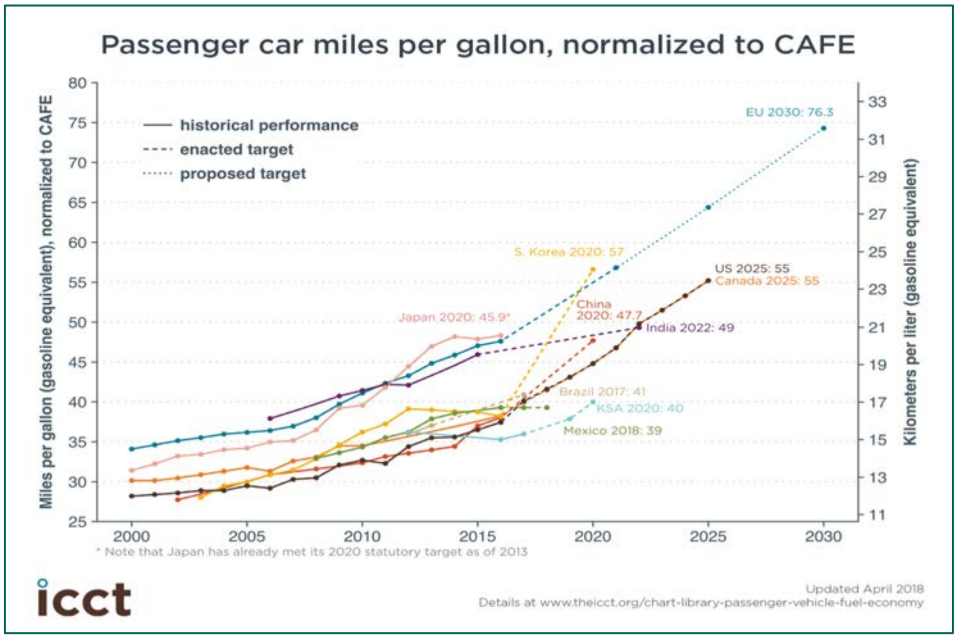
Fuel Economy a Market Force



Source: International Council for Clean Transportation, 2018 Updates

- Fuel economy regulations drive auto tech: Mild hybrids, mirror replacement cameras (MRC), etc.
- MRCs weigh less and reduce side-mirror drag 2%~7%, resulting in improved fuel economy (with improved safety, too)
- Japan/EU regulatory approval for mirrorless cars as of 2016, U.S. approval pending
- Japan new vehicle 2023 projections:*
  - Digital rear-view mirrors: 29%
  - Digital side-view mirrors: 12%

* Source: Ichikoh

"Today's average car burns a full tank of fuel every year, just by transporting its mirrors."

\- Brad Duncan, Sr. Director, Exa Corp.

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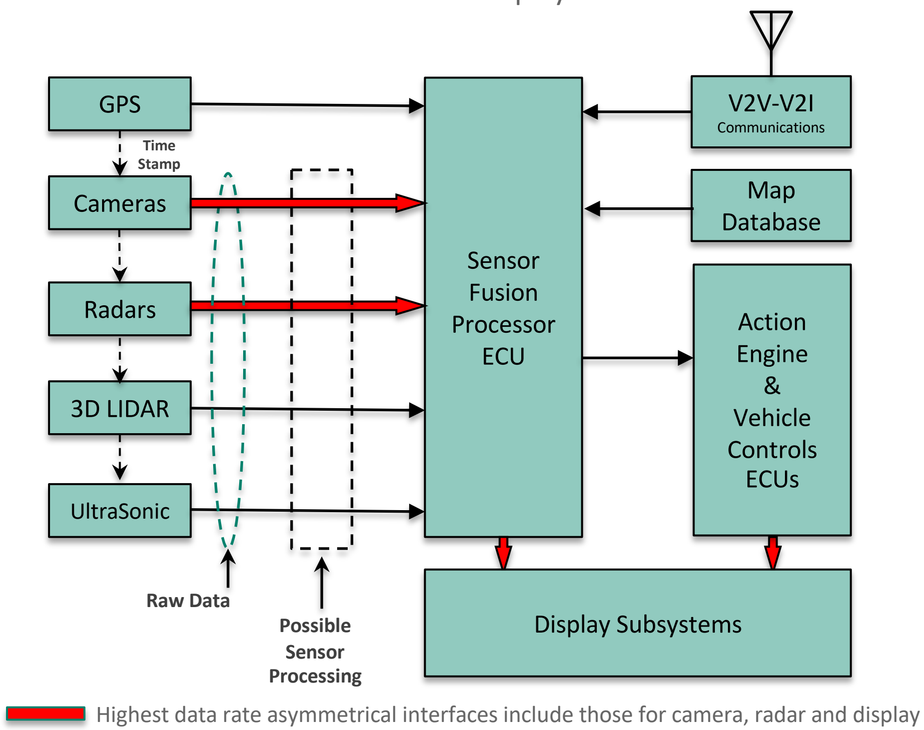
Autonomous Driving System/Architecture

CENTRAL CHALLENGE:

Transport raw image sensor and/or radar data to fusion processor, and processor/other generated data to the displays



Data Rates

For camera/image sensors, 10Gbps link could support:

- RAW16 10MP 1 max exposure channel @ 60fps
- RAW 16 2MP 4 max exposure channel @ 60fps

For radar, 12.5Gbps link could support:

- Four "typical" 4-RX-channel (50MS/sec, 12b res)
- Two "max" 4-RX-channel (80MS/sec, 16b res)

For display subsystems, 16Gbps link could support:

- Ultra-HD 3840x2160 24-bits/pixel RGB 4:4:4 60 Hz

Automotive Image Sensors

Source: MIPI AsG BoF Meetings

Format	Hres (pixels)	Vres (pixels)	Res (Mpixels)	Fps	8 bit	10 bit	12 bit	14 bit	16 bit	20 bit	24 bit (*)
1MP/720P	1280	720	0.92	30	0.22	0.28	0.33	0.39	0.44	0.55	0.66
1MP/720P	1280	720	0.92	60	0.44	0.55	0.66	0.77	0.88	1.11	1.33
2MP/1080P	1920	1080	2.07	30	0.50	0.62	0.75	0.87	1.00	1.24	1.49
2MP/1080P	1920	1080	2.07	60	x2/x4 1.00	1.24	1.49	1.74	1.99	x1 2.49	2.99
4MP	2592	1458	3.78	30	0.91	1.13	1.36	1.59	1.81	2.27	2.72
4MP	2592	1458	3.78	60	1.81	2.27	2.72	3.17	3.63	4.53	5.44
4K Ultra HD	3840	2160	8.29	30	1.99	2.49	2.99	3.48	3.98	4.98	5.97
4K Ultra HD	3840	2160	8.29	60	3.98	4.98	5.97	6.97	7.96	9.95	11.94
10MP	4096	2304	9.44	30	x2 2.26	2.83	3.40	3.96	4.53	x1 5.66	6.79
10MP	4096	2304	9.44	60	x1 4.53	5.66	6.79	7.93	9.06	11.32	13.59

- ≤12 Gbps
- ≤10 Gbps
- ≤ 5 Gbps
- ≤ 2.5 Gbps

Link with 10Gbps could support:

- Up to RAW16, 10MP 1 max exposure channel @ 60fps; 10MP 2 max exposure channel @ 30fps; 2MP 4 max exposure channel @ 60fps
- Up to RAW24, 10MP, 1 max exposure channel @ 30 fps

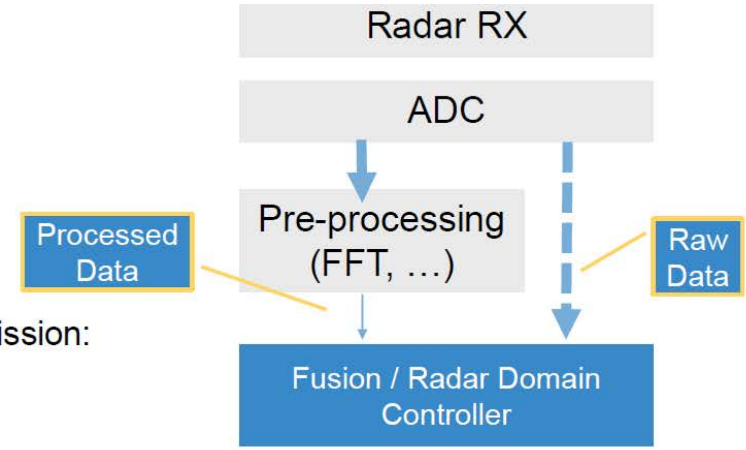
Link with 5Gbps could support:

- Up to RAW16, 2MP 2 max exposure channel @ 60fps
- Up to RAW24, 2MP, 1 max exposure channel @ 60 fps

Automotive Radar

- Data rate per RX channel ADC:
  - Min 20MS/s, 12b resolution
  - Typical 50MS/s, 12b resolution
  - Max 80MS/s, 16b resolution
- Today: clusters of 4 channel transceiver

→ Required channel bandwidth for raw data transmission:
  - Min 0.96Gbps
  - Typical 2.40Gbps
  - Max 5.12Gbps

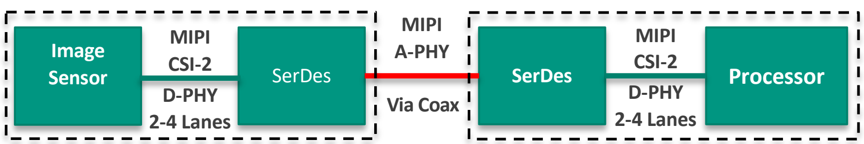


			Datarate in Gbps				
assumption by 2022+	**Samplerate [MS/s]**	**Resolution [bit]**	**1ch**	**2ch**	**4ch**	**8ch**	**16ch**
min	20	12	0.2	0.5	1.0	1.9	3.8
typ	50	12	0.6	1.2	2.4	4.8	9.6
max	80	16	1.3	2.6	5.1	10.2	20.5

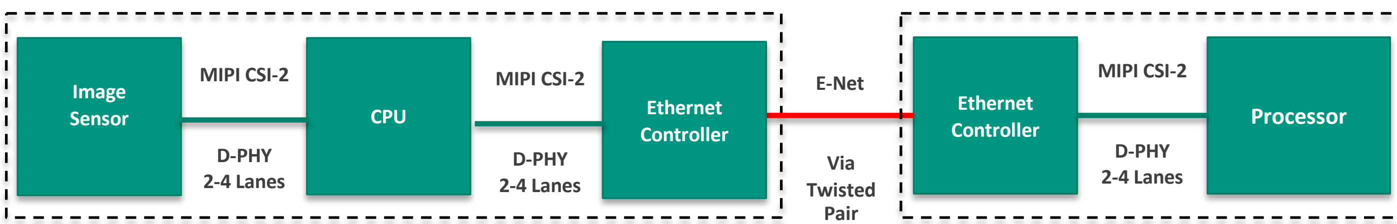
Source: MIPI AsG BoF Meetings

Why MIPI A-PHY for Automotive?

MIPI Alliance can provide auto OEMs with a standard I/F vs. current incompatible proprietary LVDS solutions, and enables the use/reuse of billions of instances of MIPI protocols like CSI-2



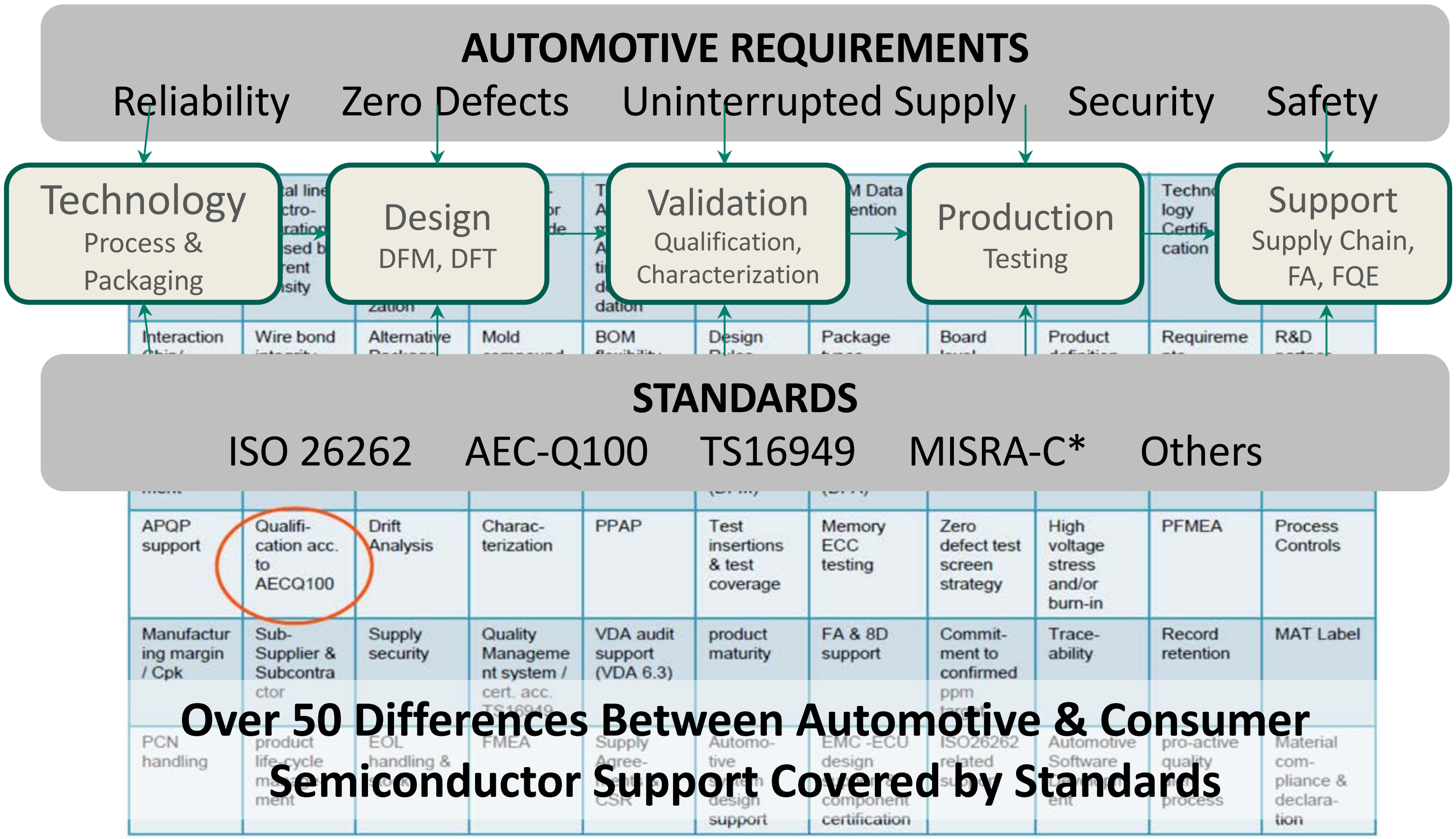
MIPI asymmetric and low complexity automotive I/Fs complementary w/ automotive Ethernet solution:



- High market growth driving MIPI member interest
- Ability to leverage economies of scale from mobile -> automotive
- Physical layer investigations using auto channels (<15m) as targets indicate technically feasible

Cautionary points:

- Migration from consumer to automotive not trivial
- MIPI Alliance not trying to replace existing auto network standards: CAN, LIN, MOST, Auto Ethernet, etc.
- MIPI C-/D-PHY^{SM}, MIPI CSI-2^{SM}, MIPI DSI-2^{SM} currently short range – board-level interface for automotive



Over 50 Differences Between Automotive & Consumer Semiconductor Support Covered by Standards

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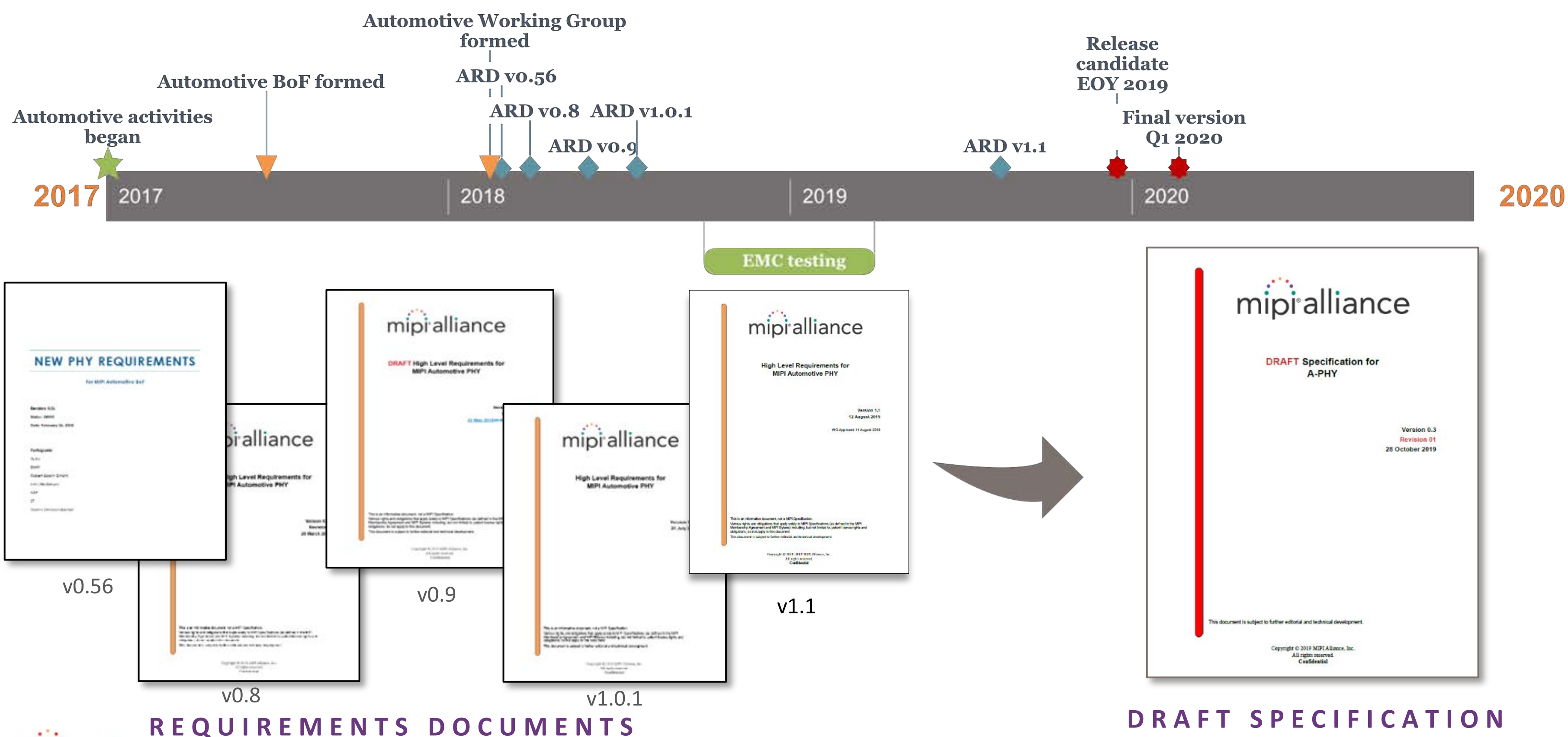
MIPI Automotive Timeline



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EMC Testing Overview

PURPOSE:

To develop the noise and interference requirements in the automotive environment

TARGET EMC TEST:

- Focused on the following immunity and related tests:
  - **ALSE RF Ingress (ISO11452-2)***
  - BCI (ISO11452-4)
  - Transient Immunity (ISO7637-3)
  - Screening Attenuation (IEC62153-4)
- Testing focused on coax rather than STP or SPP, and was performed by Sony, Murata and Shikoku Cable
- Additional interference sources covered by individual company and included the following sources:
  - PCB near end crosstalk (NEXT)
  - Alien crosstalk
  - Car noise

Cooperation with Other Companies

- ***Use of EMC facilities:*** Murata Manufacturing Company, Yokohama tech center
- ***Cable assembly:*** Shikoku Cable, Rosenberger Japan, MD Elektronik
- ***Use of equipment:*** BMW, Valens
- ***Comment and discussion:*** MIPI Automotive WG member companies including BMW, Microchip, NXP, Valens

*Absorber-lined Shielded Enclosure

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Automotive PHY Requirements Overview

Miscellaneous Other Requirements

- Bit Error Rate shall be less than 10^{-12} for both data and control streams
- Latency (Data Link Layer to Data Link Layer) shall be less than 16 µSec
- Design shall support DC power over the data lines with a maximum current limit of 0.5 A
- System shall operate with GND voltage offsets of up to ±1.0 V
- A-PHY shall provide the following modes: Shutdown, Start-Up, Active, Sleep and Safe State
- The A-PHY Data Link Layer shall be agnostic to the higher-level protocols and with an overhead of 20% maximum
- Protocol Adaptation Layer shall support MIPI protocols w/ minimal changes needed
- It shall be possible to aggregate multiple links for increased HS data BW
- A-PHY solution shall support BIST and system diagnostics (eg., link quality)
- A-PHY shall support system designs at the ASIL D level according to ISO26262:2018
- System clock shall be both embedded and asynchronous (i.e., decoupled from data rate clock)
- System cabling shall meet certain IL, RL and coupling requirements
- System operation shall be supported with specified automotive EMC requirements

An Overview of A-PHY

Raj Kumar Nagpal
MIPI A-PHY Subgroup Chair

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What is A-PHY?

MIPI A-PHY is a physical layer specification targeted for advanced driver-assistance systems (ADAS) and autonomous driving systems (ADS) and other surround sensor applications in automotive (e.g., for displays, cameras).

While most MIPI specifications are designed for shorter reaches for use within mobile devices, A-PHY will be capable of reaching up to 15 meters in the demanding automotive environment. A-PHY v1.0 will support up to 16 Gbps, with a roadmap to 24, 48 Gbps and beyond.

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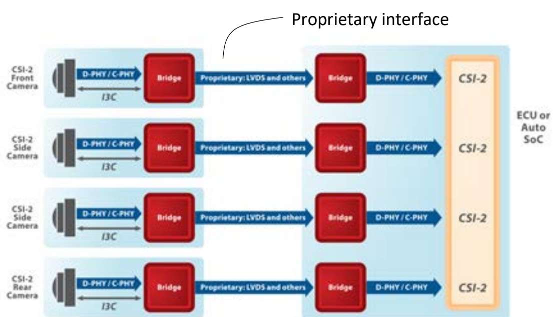
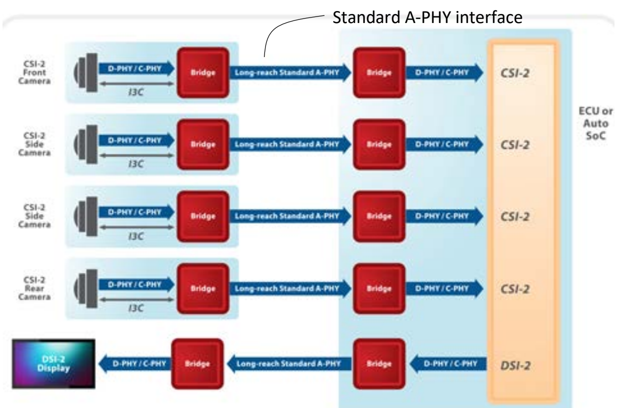
What is MIPI A-PHY?

- MIPI A-PHY is a physical layer specification targeted for ADAS/ADS surround sensor applications in automotive.
- A-PHY v1.0 will provide a 15-meter reach and data rates of 2-16 Gbps, with a roadmap to 24, 48 Gbps and beyond.

TODAY'S PROPRIETARY
INTERFACE BRIDGE SOLUTIONS



TOMORROW A-PHY STANDARD
INTERFACE BRIDGE SOLUTIONS



FUTURE INTEGRATED A-PHY
IN ENDPOINT CAMERAS
(NO BRIDGES: Lower cost, weight, power)

MIPI A-PHY is the ONLY standard interface to support native camera (CSI-2) and display (DSI-2) interfaces for automotive.

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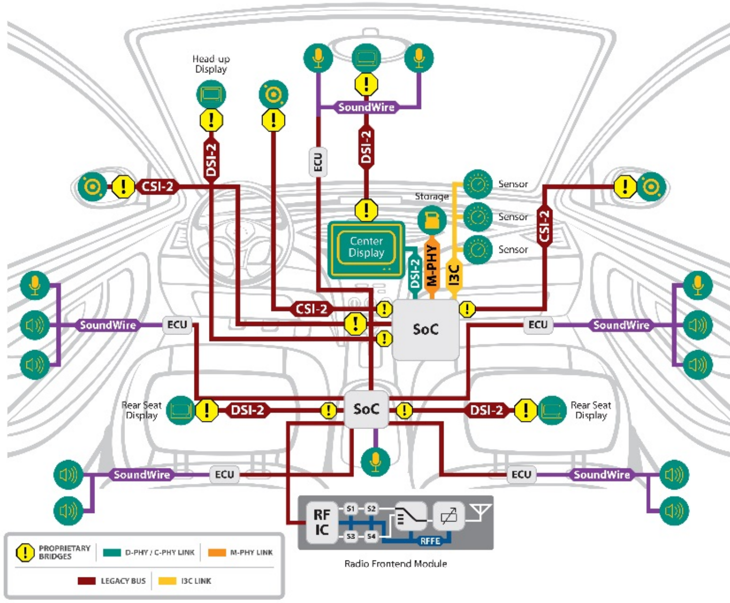
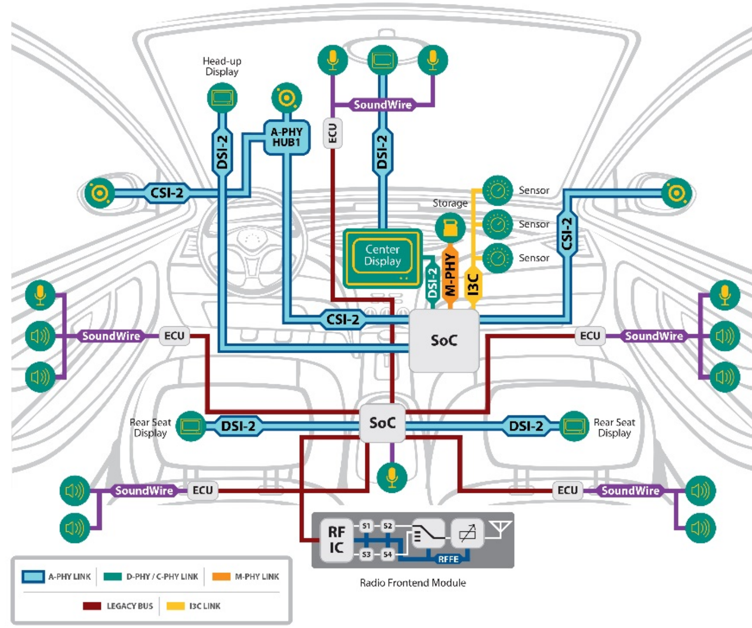
Integrating MIPI A-PHY

Bridging solutions vs. integrated A-PHY

Current implementation with proprietary bridging solutions



Implementation with A-PHY integrated into endpoints (No bridges)



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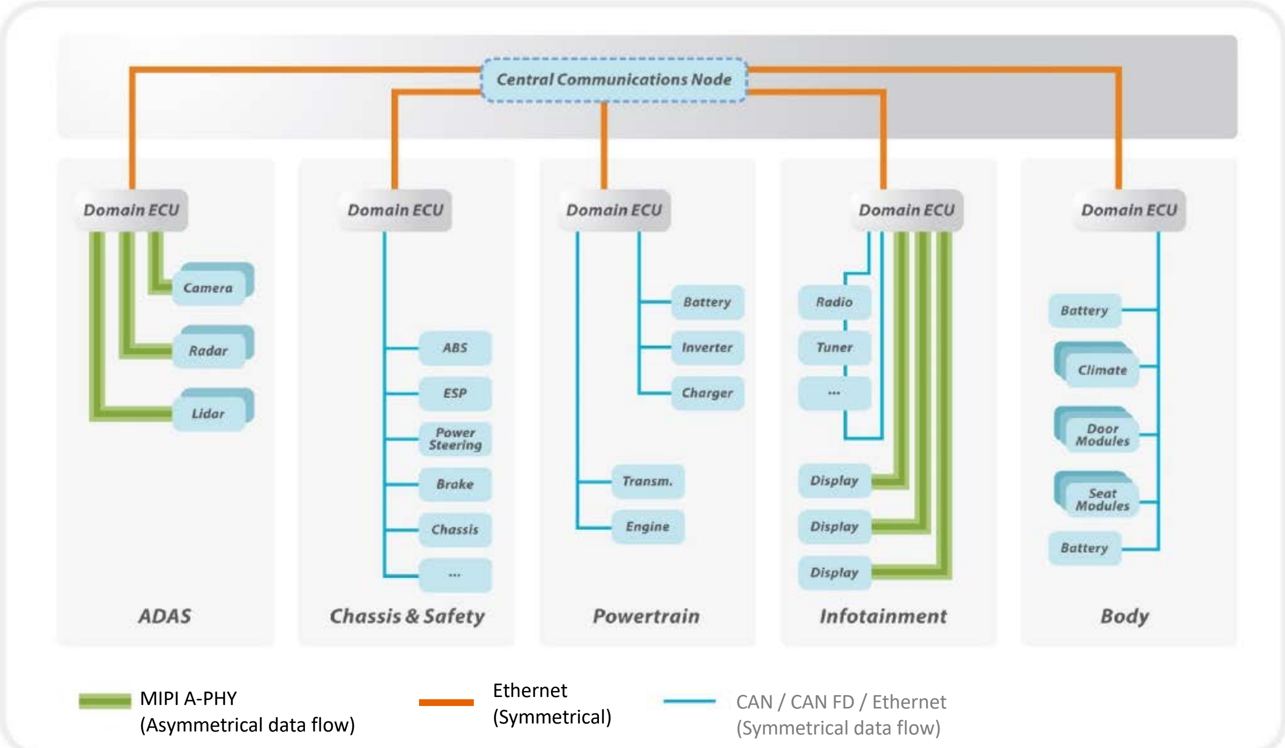
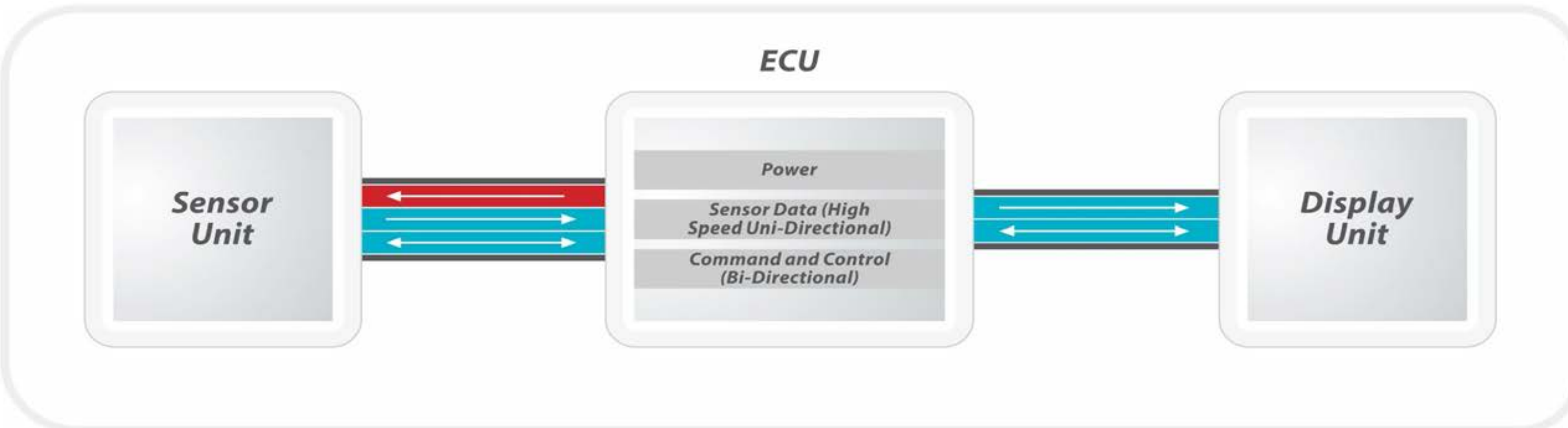
In-Vehicle Networking Architecture

A-PHY/Ethernet Coexistence*: Concurrent use of asymmetric/symmetric data flows/interfaces*



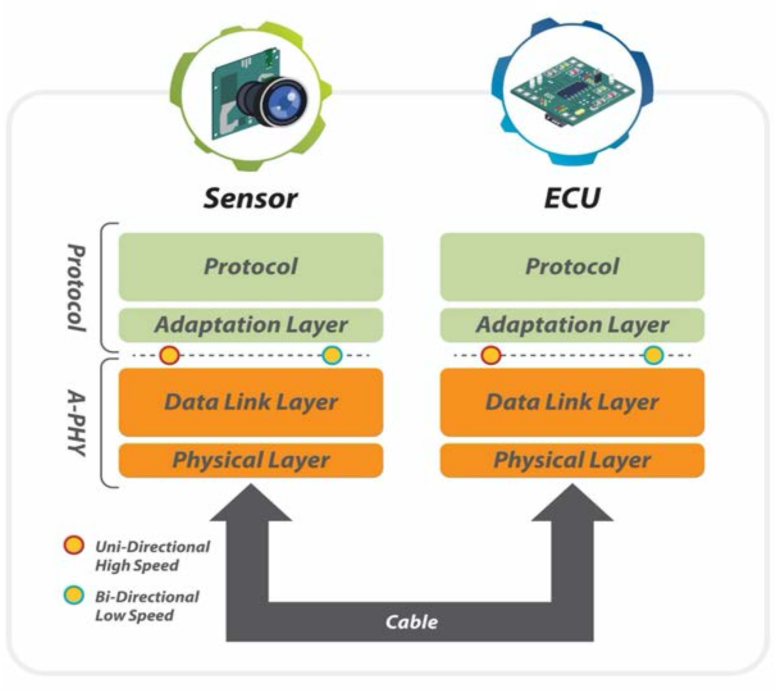
Recognizing that IEEE 802.3ch Ethernet is an emerging network backbone, A-PHY will coexist in many implementations.

A-PHY Data and Power Logical Structure



- Focus is on high throughput data to and from the system CPU over high-speed links with optimal wiring, cost and weight
- The high-speed data, control data and optional power share the same physical wiring

A-PHY High-Level Structure



A-PHY design includes a generic data link layer that will accommodate different protocol adaptation layers (both MIPI and non-MIPI).

Example use cases:

- Camera module to ECU
- Camera ECU to ECU
- Lidar, radar
- Display including touch and controls
- A-PHY links over PCB interconnect

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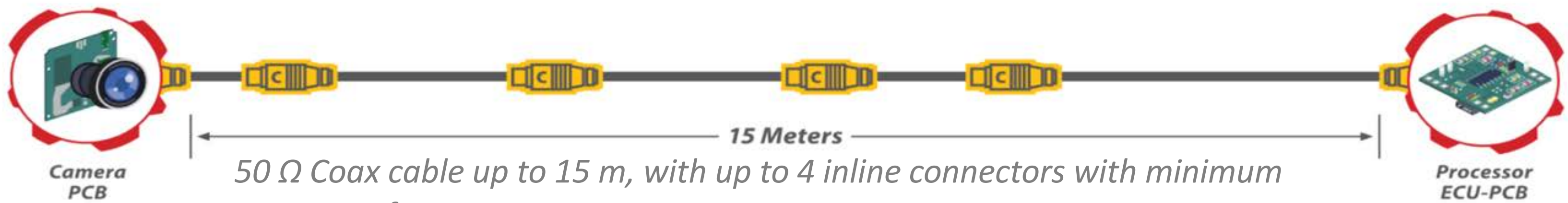
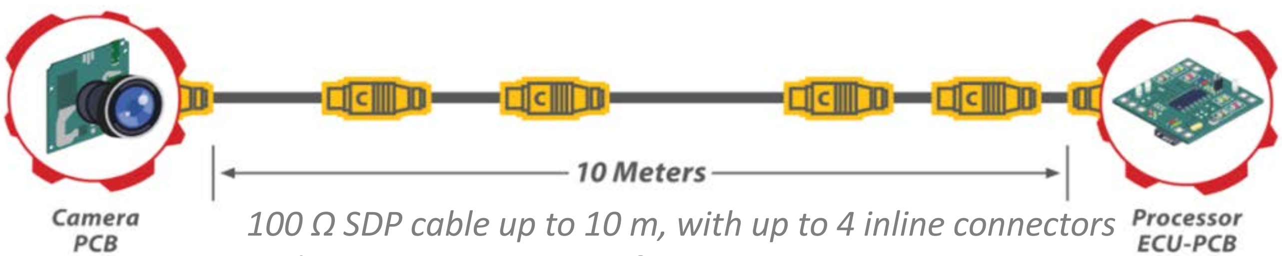
A-PHY Cable Type & Topology

MIPI Automotive Coax Topology "A"

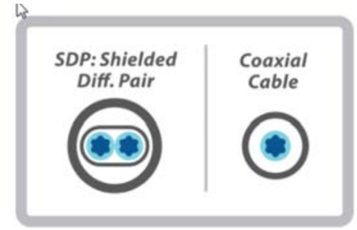


50 Ω Coax cable up to 15 m, with up to 4 inline connectors with minimum segment of 30 cm

MIPI Automotive STP/SPP Topology "B"



100 Ω SDP cable up to 10 m, with up to 4 inline connectors with minimum segment of 30 cm



MIPI Automotive PHY Key Technical Specs

Gear Data Rate	Modulation [One modulation per Gear]	Symbol Rate [GBaud]	Net Application Data Rate [Gbps]
G1 2 Gbps	NRZ-8b/10b	2	1.5
G2 4 Gbps	NRZ-8b/10b	4	3
G3 8 Gbps	PAM4	4	7.2
G4 12 Gbps	PAM8	4	10.8
G5 16 Gbps	PAM16	4	14.4
Uplink, All Gears 100Mbps	NRZ-8b/10b	0.1	0.055 (55Mbps)

MIPI A-PHY v1.0 supports simple lowest-cost implementations using NRZ-8b10b encoding in its lower two speeds gears 1 and 2 supporting speeds of 2 and 4 Gbps, respectively.

These high-performance features support all A-PHY speed gears up to gear 5 at 16 Gbps for v1.0 and has a scalable architecture to address higher speeds going forward. The NBIC and PHY-level retransmission (RTS) ensure maximum reliability/robustness of the A-PHY link.

A-PHY Key Technical Advantages

- ***Optimized asymmetric architecture***
  A-PHY is designed for high-speed asymmetric-only transmission from cameras/sensors to ECU, and ECU to display, while providing concurrent low-speed bidirectional traffic for command and control. The optimized asymmetric architecture allows for design simplification and lower cost than other/symmetric architectures.

- ***Mobile protocol reuse***
  After successful deployment in billions of smartphones and IoT devices, the MIPI protocols are well-proven for direct leverage into automotive.

- ***Hardware-only protocol layers***
  As in mobile applications using C-PHY/D-PHY layering, A-PHY is tightly coupled with the CSI-2/DSI-2 protocol layers, thus essentially operating with hardware-only protocol layers without software intervention. This architecture is contrasted to other interfaces that are designed with more flexibility and utilize software layers to accomplish this flexibility. Protocol with built-in support for functional safety.

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A-PHY Key Technical Advantages

- ***Optimized architecture for wiring, cost and weight***
  By its optimized asymmetric architecture and hardware protocol layering, A-PHY implementations achieve optimized cabling wiring, cost and weight requirements. This is increasingly important as the number of electronic components and their interface cabling increases on the road to autonomy.

- ***Flexible link layer support of other protocols***
  MIPI Alliance expects to work with other organizations leveraging their native protocols into automotive. To accommodate these developing specifications, A-PHY includes a generic Data Link Layer that enables multiple data streams on the same wire and accommodates MIPI approved third-party protocols.

- ***High EMC immunity***
  MIPI has invested significantly to analyze and measure the harsh automotive channel, and has concluded that an architecture based on a Narrowband Interference Canceller (NBIC) and Retransmission system (RTS) provides the most robust performance, particularly for the applications requiring the higher data rates at longer distances.

Concluding Thoughts

- *In-vehicle architecture is* ***rapidly evolving*** *. . .*
- *Increased focus on* ***surround sensor applications*** *for ADAS / autonomous driving . . . Best served by dedicated high-speed asymmetric interfaces from sensors to ECU.*
- *Standardization important for* ***economies of scale, lower cost & greater capabilities****.*
- *The native MIPI protocols (CSI-2, DSI-2, I3C, others, available in billions of devices) with* ***A-PHY deliver enormous benefit*** *to the automotive industry . . . performance, cost, noise immunity, and long-term EBOM reduction via elimination of interface bridges.*
- *The MIPI solution is being developed to* ***meet the broadest spectrum*** *of automotive industry needs . . . with anticipated SOP as early as 2024.*

Additional Resources

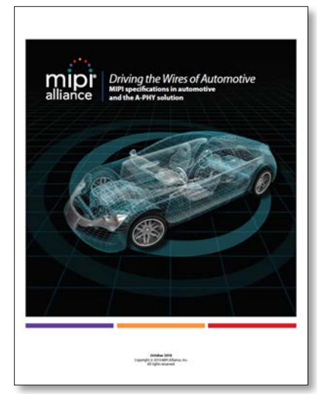
Resources

More information can be found at:

- A Look Under the Hood at MIPI CSI-2 and MIPI DSI-2 in Automotive *(Blog, January 2020)*
- MIPI Alliance Advances Activities for ADAS, ADS and Other Automotive Applications *(Press release, October 2019)*
- Automotive Applications Drive MIPI A-PHY Development *(Blog, May 2019)*
- MIPI Alliance Meets the Needs of Autonomous Driving *(DevCon presentation, October 2018)*
- MIPI Alliance Extends Interface Standards to Support the Automotive Market *(Webinar, April 2018)*
- MIPI Alliance to Advance Autonomous Driving, other Automotive Applications with New Data Interface Specifications at 12-24 Gbps and Beyond *(Press release, August 2018)*
- MIPI Alliance Expands Reach with New Automotive Working Group *(Press release, March 2018)*

Other Resources

- Automotive Working Group page
- A-PHY specification page



Download the new ***MIPI in Automotive white paper***