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MIPI Automotive and A-PHY^{SM} Update

Matt Ronning
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MIPI ALLIANCE DEVELOPERS CONFERENCE

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18 OCTOBER 2019

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Presentation Agenda

MIPI in Automotive

Matt Ronning

MIPI Automotive Working Group Chair

An Overview of MIPI A-PHY

Raj Kumar Nagpal

MIPI A-PHY Subgroup Chair

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MIPI in Automotive

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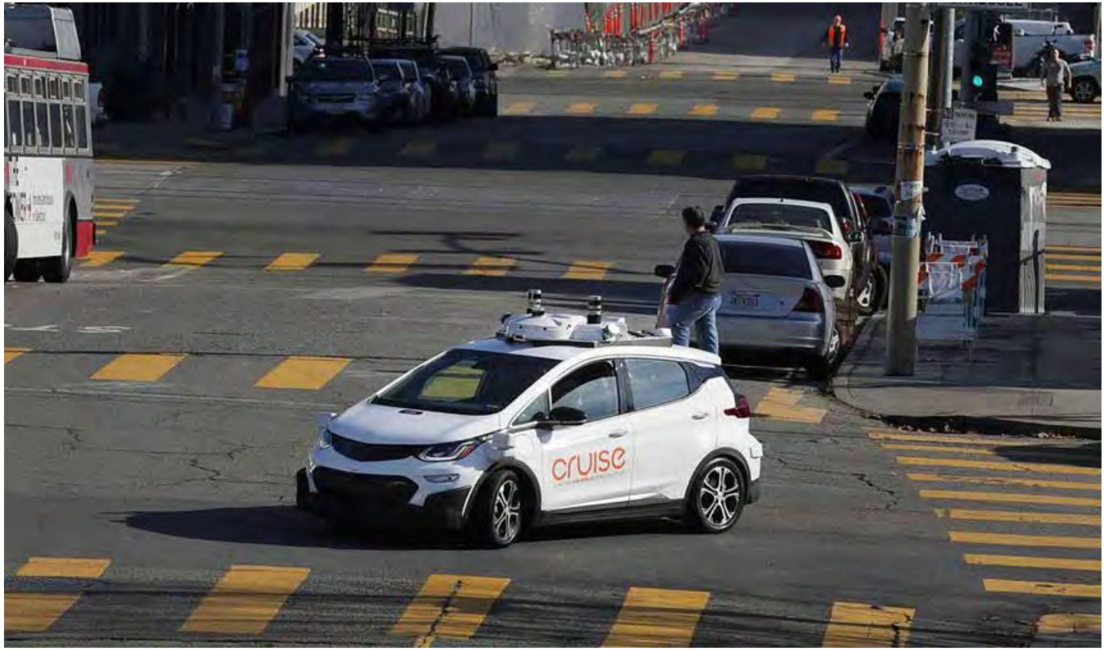
Auto Industry Transformation



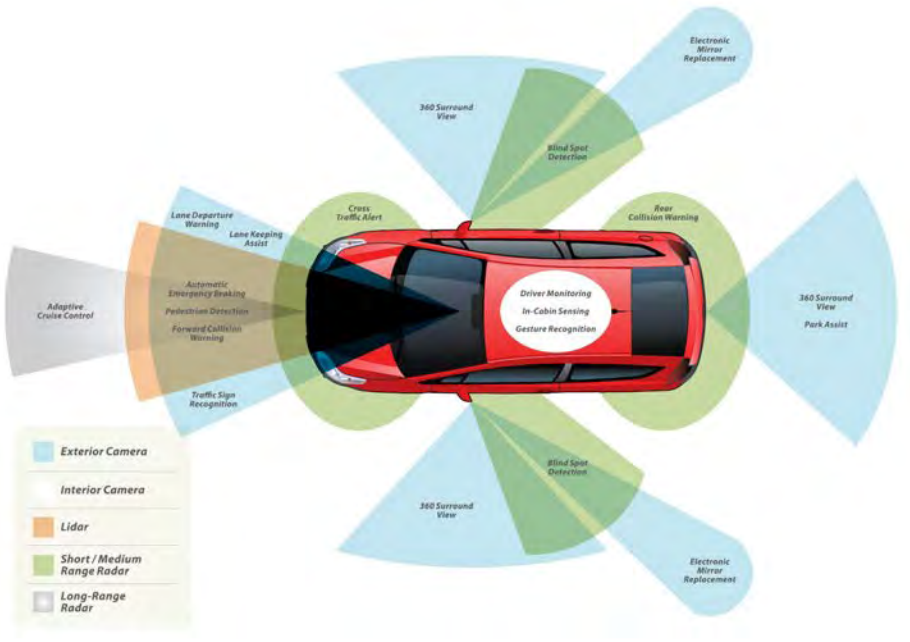
Honda and GM Partner to Develop Mass Produced, Driverless Cars
Source: October 4, 2018, Automotive News

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

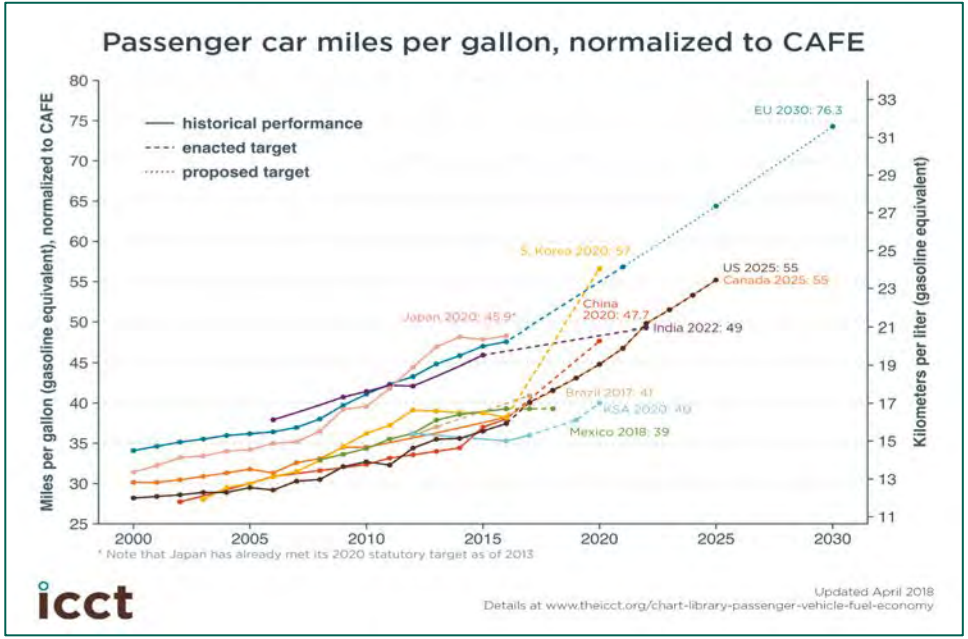
Surround sensors for driver assistance



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

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.

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:

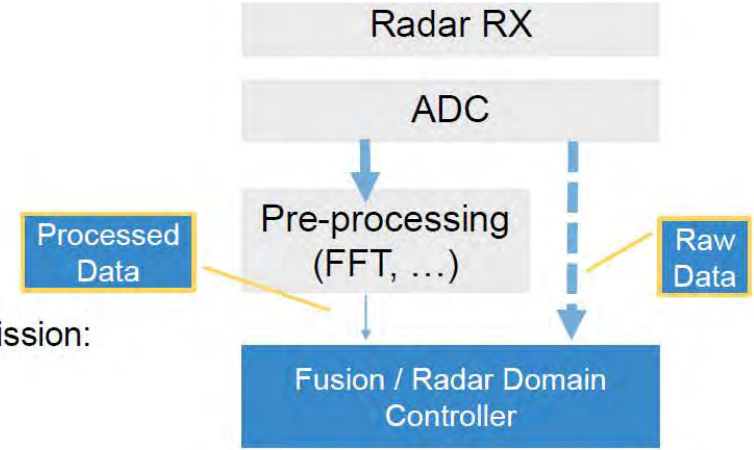
- Up to RAW16, 2MP 2 max exposure channel @ 60fps
- Up to RAW24, 2MP, 1 max exposure channel @ 60 fps

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

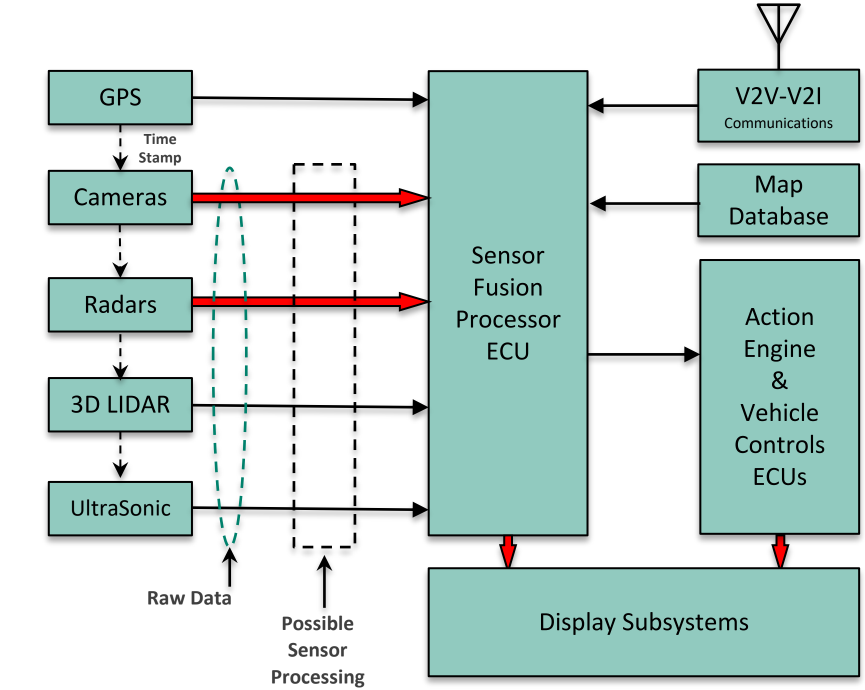
→ Required channel bandwidth for raw data transmission:
  - Min 0.96Gbps
  - Typical 2.40Gbps
  - Max 5.12Gbps



			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

Autonomous Driving System



Highest data rate asymmetrical interfaces include those for camera, radar and display

CENTRAL CHALLENGE:

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

Data Rates

For 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:

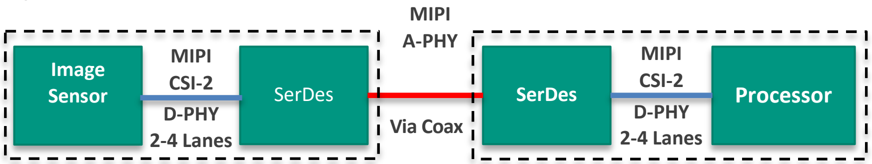
- Four "typical" 4-RX-channel (50MS/sec, 12b res)
- Two "max" 4-RX-channel (80MS/sec, 16b res)

For display subsystems, 16Gbps link could support:

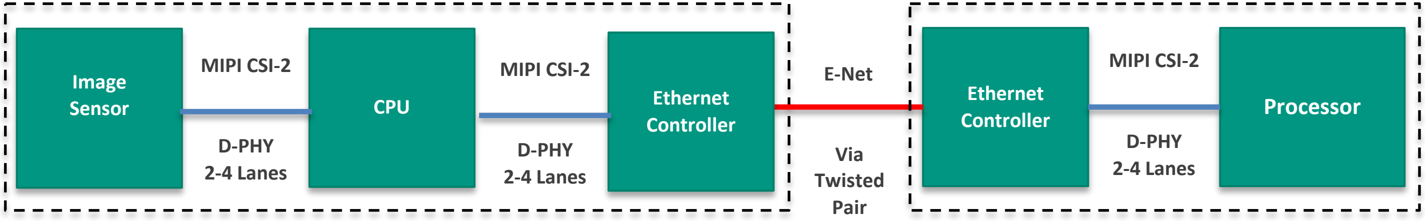
- Ultra-HD 3840x2160 24-bits/pixel RGB 4:4:4 60 Hz

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℠, MIPI CSI-2℠, MIPI DSI-2℠ currently short range – board-level interface for automotive

AUTOMOTIVE REQUIREMENTS

Reliability | Zero Defects | Uninterrupted Supply | Security | Safety

Technology – Process & Packaging → **Design** – DFM, DFT → **Validation** – Qualification, Characterization → **Production** – Testing → **Support** – Supply Chain, FA, FQE

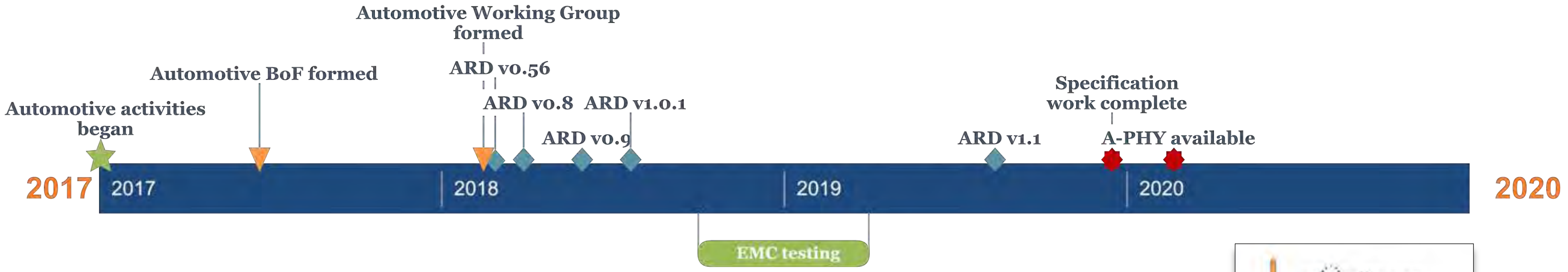
STANDARDS

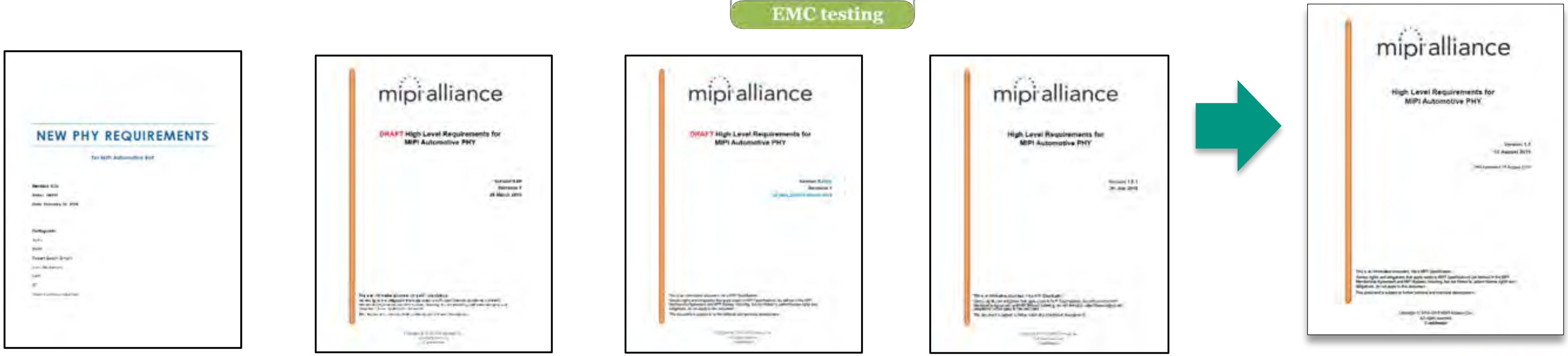
ISO 26262 | AEC-Q100 | TS16949 | MISRA-C* | Others

APQP support	Qualification acc. to AECQ100	Drift Analysis	Characterization	PPAP	Test insertions & test coverage	Memory ECC testing	Zero defect screen strategy	High voltage stress and/or burn-in	PFMEA	Process Controls
Manufacturing margin / Cpk	Sub-Supplier & Subcontractor	Supply security	Quality Management system / cert. acc. TS16949	VDA audit support (VDA 6.3)	product maturity	FA & 8D support	Commitment to confirmed ppm target	Traceability	Record retention	MAT Label
PCN handling	product life-cycle [illegible] ment	EOL handling & [illegible]	FMEA	Supply Agree- [illegible] CSR	Automotive [illegible] design support	EMC-ECU design [illegible] component certification	ISO26262 related [illegible]	Automotive Software [illegible] ent	pro-active quality [illegible] process	Material compliance & declaration

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

MIPI Automotive Timeline





v0.56
Feb. 26, 2018

v0.8
March 28, 2018

v0.9
May 30, 2018

v1.0.1
July 21, 2018

v1.1
August 14, 2019

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

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

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MIPI A-PHY Subgroup Chair

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What is A-PHY?

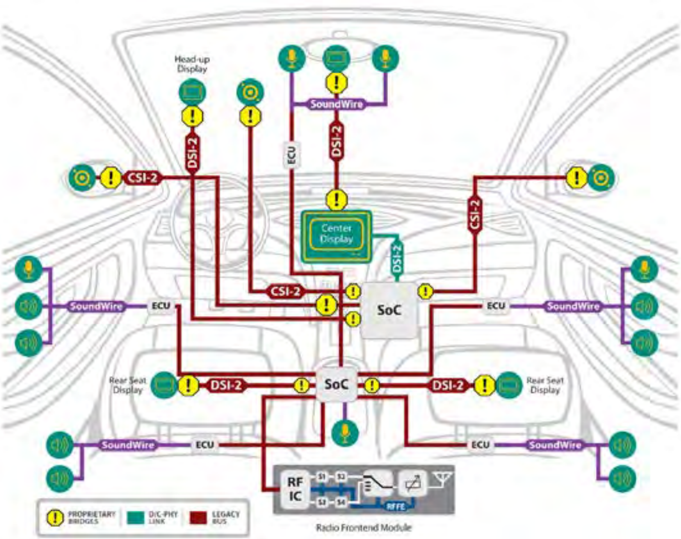
MIPI A-PHY is a physical layer specification targeted for advanced driver-assistance systems (ADAS) and autonomous driving systems (ADS) and other surround sensor applications in automotive (e.g., for displays, cameras), but also for other longer-reach applications such as IoT and industrial.

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 speeds of 2-16 Gbps, with a roadmap to 24, 48 Gbps and beyond (e.g., 100 Gbps).

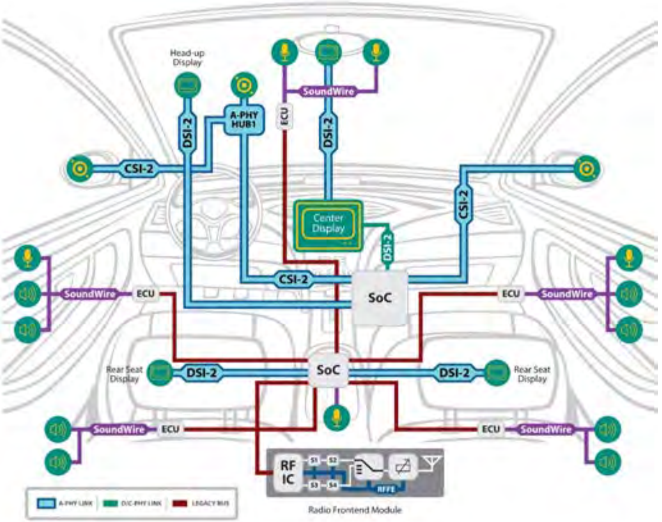
MIPI A-PHY: Solving the Long-Reach Challenge

Implementation of camera and display specifications with necessary bridging solutions vs. with A-PHY

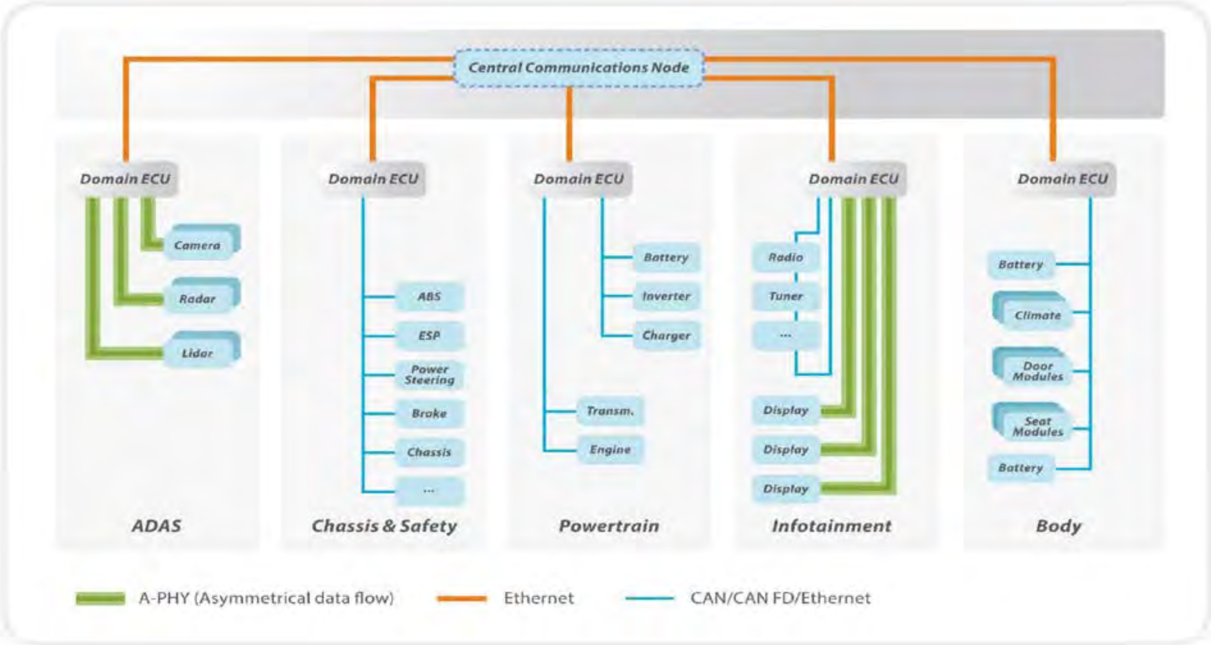
Current implementation with proprietary bridging solutions



Implementation with A-PHY integrated into all components



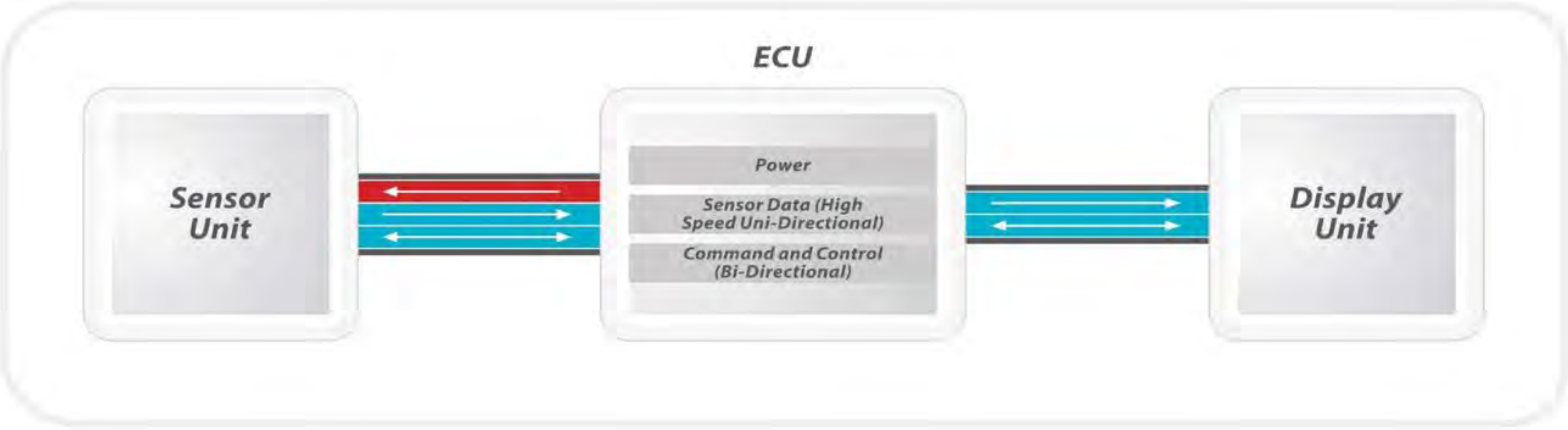
Co-Existence with Ethernet



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

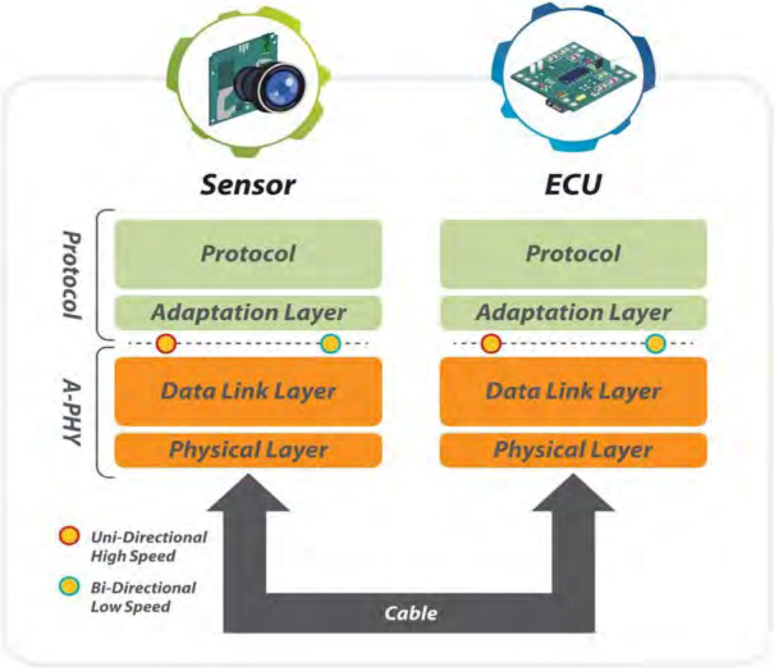
Illustration of concurrent use of asymmetric and symmetric data flows and interfaces

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



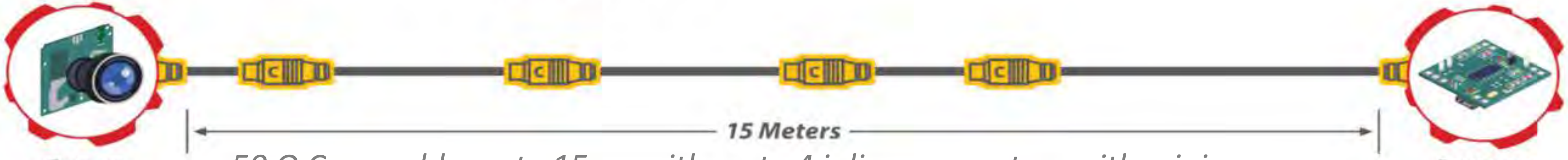
A-PHY design includes a generic data link layer that will accommodate different protocol adaptation layers (both MIPI and non-MIPI)

Example use cases:

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

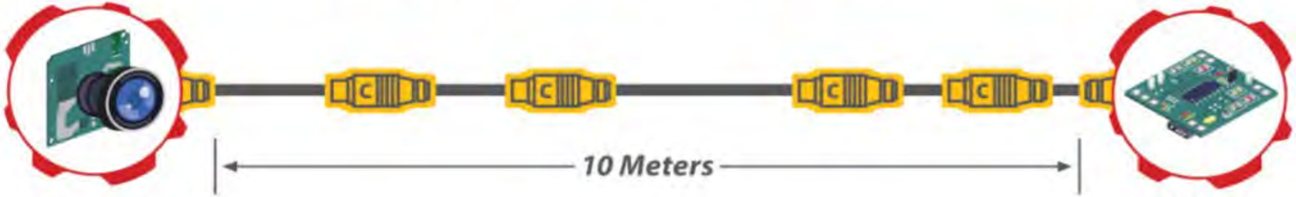
A-PHY Cable Type & Topology

MIPI Automotive Coax Topology “A”

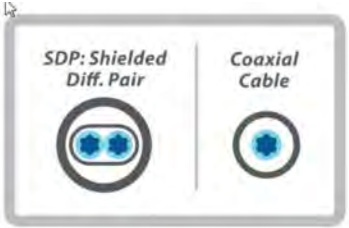


50 Ω Coax cable up to 15 m, with up to 4 inline connectors with minimum segment of 30 cm

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



A-PHY Vision

To address the complete market, A-PHY will:

- Provide options to **suit various design needs**
- Support speeds of **2-16 Gbps**, with a roadmap to **24, 48 Gbps and beyond** (e.g., 100 Gbps)
- Ensure **scalability** to stay ahead of growing bandwidth requirements
- **Serve the** broadest possible spectrum of OEMs, suppliers and vendors

With this design, MIPI Alliance will offer a ***complete solution that addresses all speeds***

A-PHY Profile Overview

Profile 1

- Focused toward lower speed applications
- Intended for lowest cost, low-design-complexity solutions and to speed time to market
- Expected upper speed will be about 8 Gbps at 15 meters
- Based on NRZ-8b10b

Profile 2

- Can be used for all speeds
- Interoperates with Profile 1
- Provides superior EMC performance
- Provides roadmap to higher speeds in future A-PHY revisions
- Based on PAM4/8/16 with PHY-level retransmission scheme (RTS) and narrowband interference cancellation (NBIC)

The two profiles interoperate to ensure ***compatibility, interoperability and system gradual scale-up***

A-PHY Channel Throughput

Forward channel throughput and gear definition

Gear	Raw Data Rate
1	≤ 2 Gbps
2	≤ 4 Gbps
3	≤ 8 Gbps
4	≤ 12Gbps
5	≤ 16 Gbps

Reverse channel, in full duplex with forward channel, will support the following data rates:

- Low speed: **25** Mbps
  (Aimed for camera and sensor products)
- High speed: **125** Mbps
  (Aimed for display and touchscreen products)

A-PHY Key Technical Advantages

- ***Asymmetric-optimized architecture***
  A-PHY is designed from scratch 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.

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. This includes VESA, which is adapting its DisplayPort protocol specification for automotive use. To accommodate these developing specifications, A-PHY includes a generic Data Link Layer that accommodates different protocol adaptation layers, with a plan to support VESA's vehicular DisplayPort protocol.

- ***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.

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ADDITIONAL RESOURCES

More information can be found at:

- 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***

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