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Kelvin Xu
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啟用MIPI相機應用包含汽車ADAS

Enabling MIPI Camera Applications Including Automotive ADAS

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MIPI Specifications in New Applications

Automotive, IoT / Wearables, Virtual / Augmented Reality

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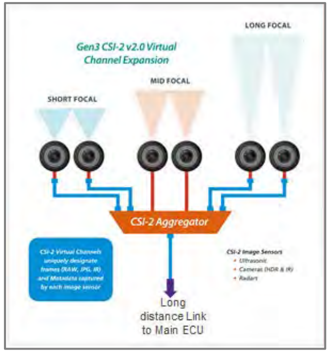
Camera Market Trends

- Higher refresh rates for HDR image quality
- Electronic eyes in consumer, IoT, surveillance
- AI imaging multiple image sensors in devices
- Always on sentinel camera use case
- Myriad of automotive image sensors
- Long reach cameras in IoT



Embedded Display Market Trends

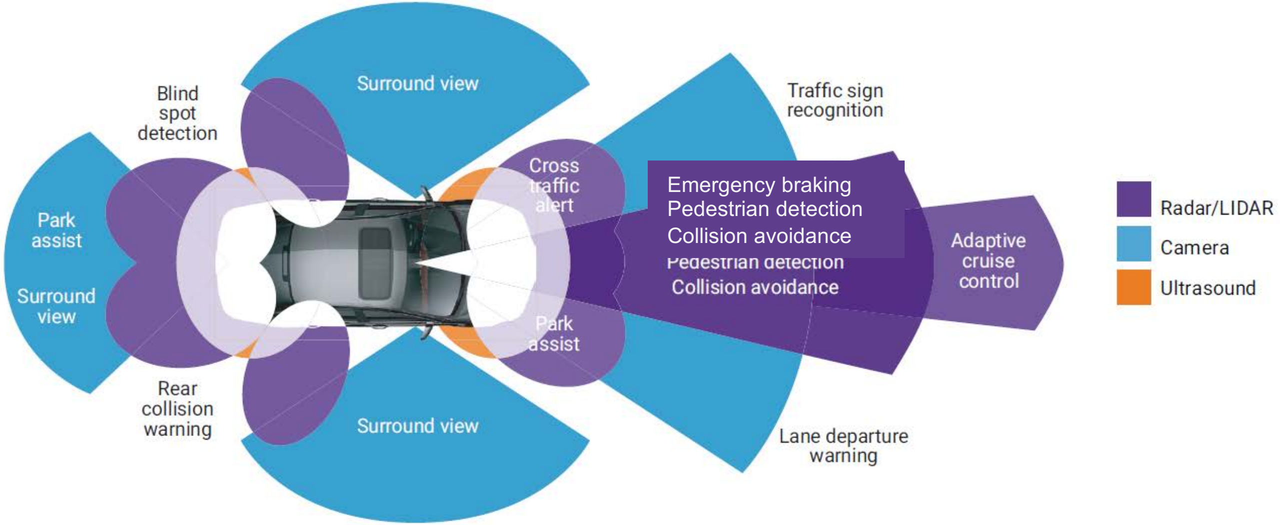
- Higher resolutions: 4K 5.5” in mass market
- Mobile display innovation: folding displays
- Higher refresh rates, AR/VR 120Hz
- Future technologies drive bigger display sizes and higher resolutions
- Displays in automotive and industrial




New Requirements for Automotive Market

ISO 26262 Functional Safety Compliance and ASIL Certification

Electronics failure can have hazardous impact



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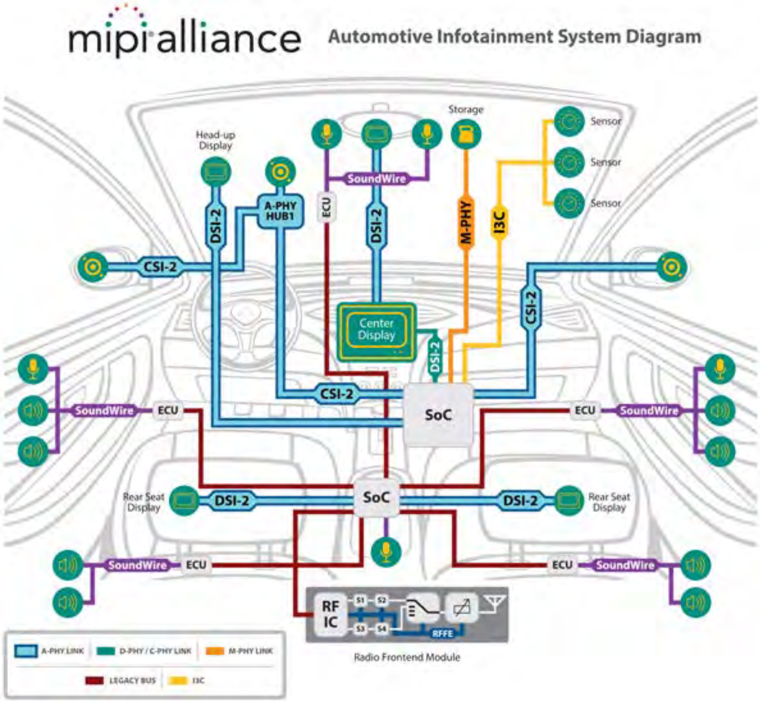
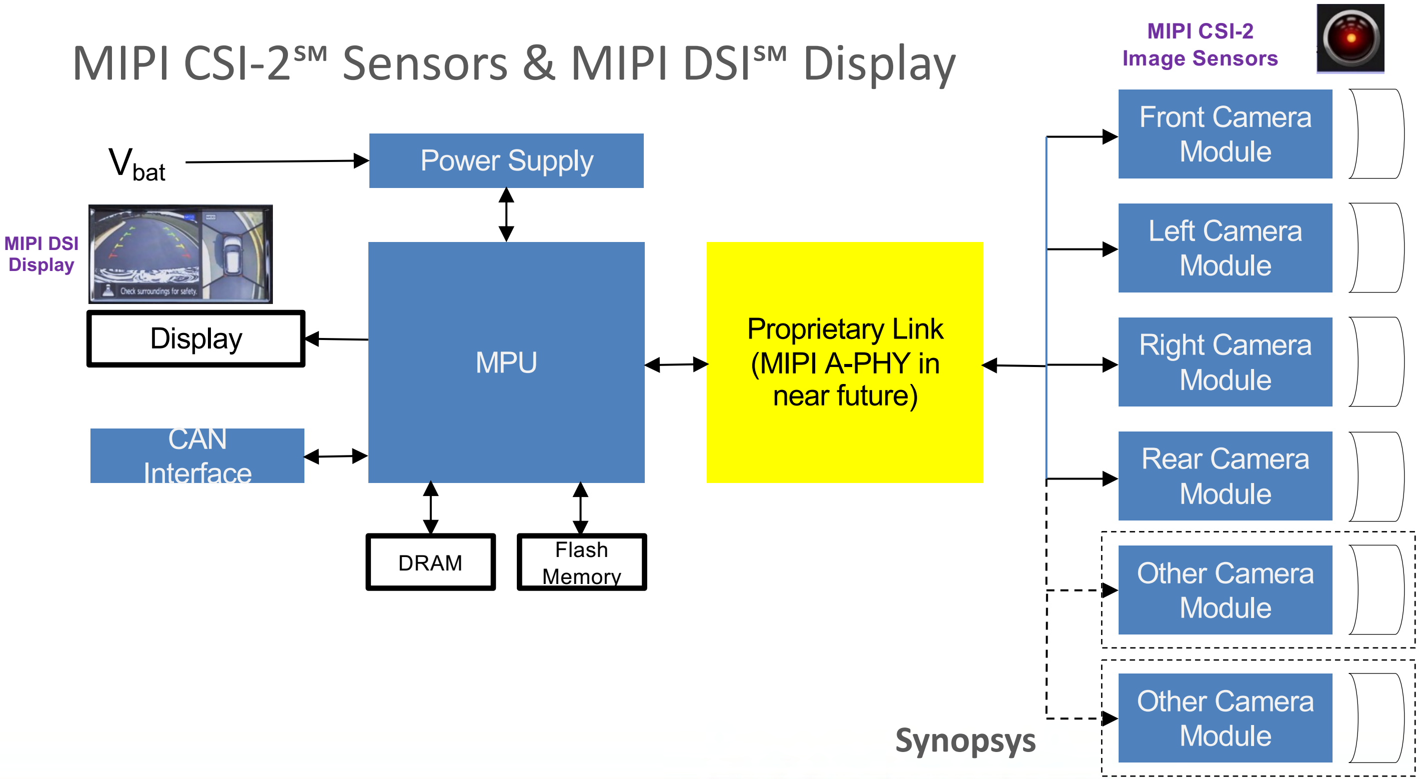
MIPI Specifications for Automotive Applications



Example of MIPI In Automotive

MIPI CSI-2℠ Sensors & MIPI DSI℠ Display



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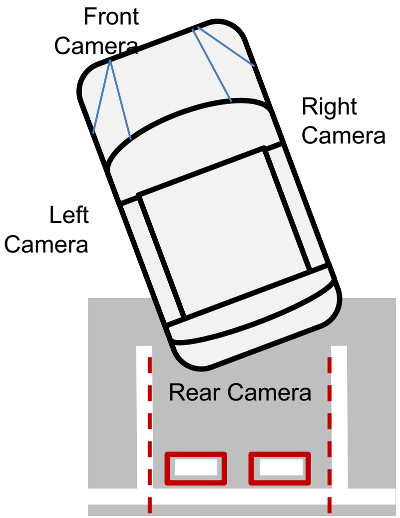
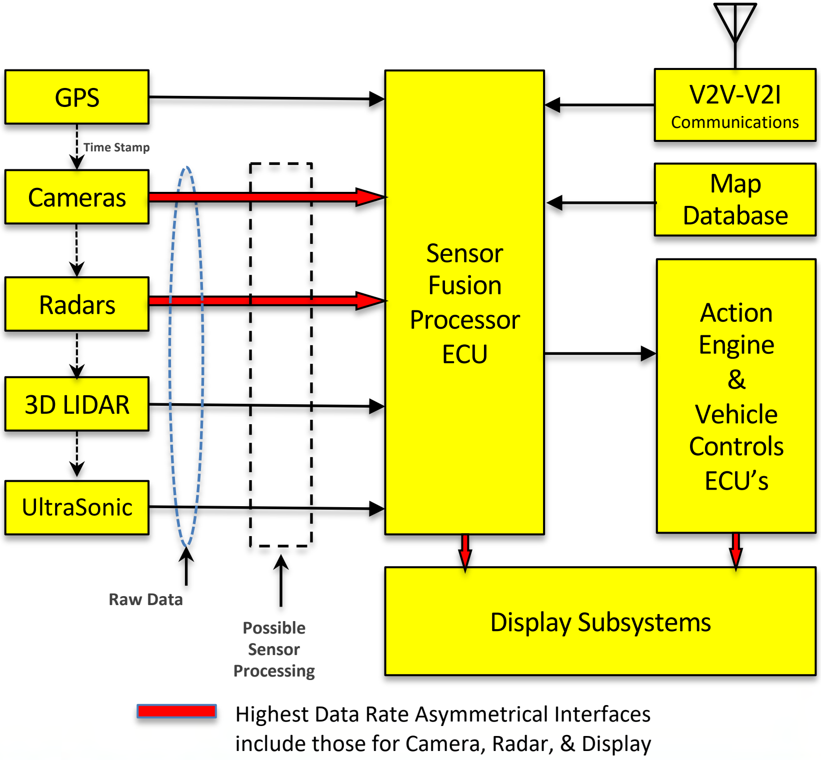


MIPI A-PHY℠ – Standard Connectivity To/From ECU

Asymmetric, high speed, low latency, low power, 'safety critical' links, spec available end/2019



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MIPI Camera Serial Interface (CSI-2) Specification

De-facto standard interface used in car sensors

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MIPI CSI-2 Evolution

- From mobile platform to imaging and vision

Mobile

Human vision

Imaging

Aggregator possibilities increased
Beyond human vision

Vision

Longer reach
In-band control signaling

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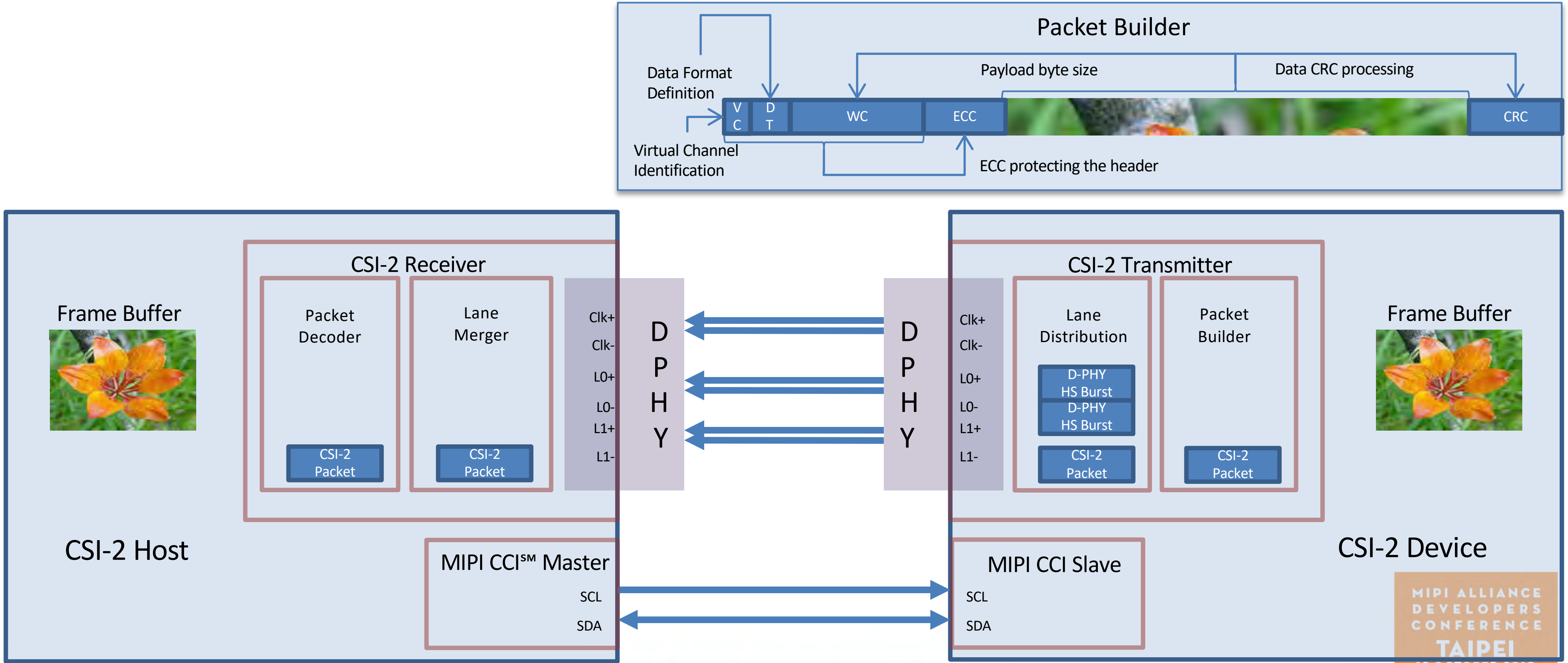
MIPI CSI-2 Versions

- From Mobile to Imaging & Vision to Automotive

CSI-2 Specification	v1.x	v2.x	v3.X	V4.X
vX.0	**29-Nov'05** • First release	**28-Mar'17** • D-PHY 2v1 support • MIPI C-PHY℠ 1v2 support • RAW 16/20 & DPCM 12-10-12 • PPI width extension (up to 32) • LRTE • Scrambling • Extension of Virtual Channel	**10-Sep'19** • D-PHY v2.5 support • C-PHY v2.0 support • RAW24 • EoTp • USL • sROI	**Target: Q4'19** • Always ON Sentinel Controller (AOSC) • Functional Safety (FuSa) • Imaging Security (ISEC) • Multi-Sensor Support • A-PHY 1v0 support (through Link Layer)
vX.1	**09-Nov'10** • MIPI D-PHY℠ 1.0 support	-	-	-
vX.2	**22-Jan'13** • D-PHY 1.0 support	**09-Apr'18** • I3C SDR & HDR_DRR support	-	-
vX.3	**10-Sep'14** • D-PHY 1.2 support	-	-	-

MIPI CSI-2 Over MIPI D-PHY



RAW-16, RAW-20 & RAW-24 Color Depths

- CSI-2 v1.3 color depths are sufficient for Mobile applications, visible to human eye
- RAW-16/-20/-24 color depth bring advanced vision capabilities to Automotive and Industrial applications
  - Improves image capture when the environment changes suddenly and dramatically, for example in a big change in lighting condition
- Enable machines to make decisions from superior quality images
  - An autonomous vehicle, for example, could decipher whether darkness on an image is a harmless shadow or a pothole in the roadway to be avoided

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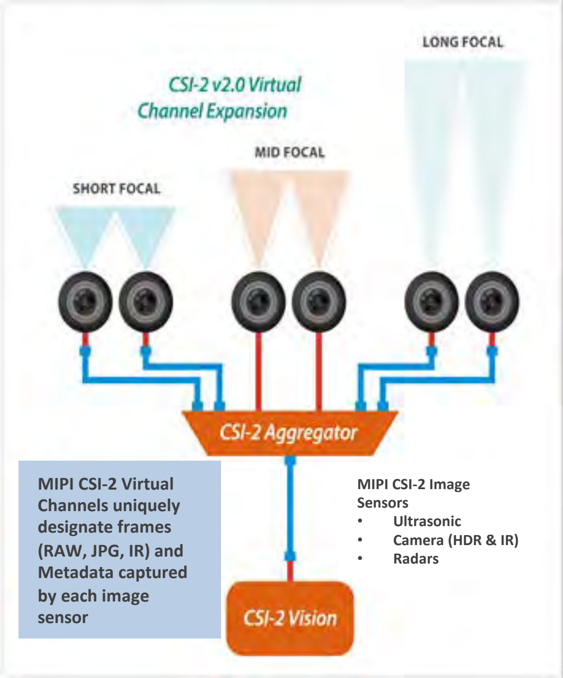
Up to 32 Virtual Channels

- To accommodate the larger number of image sensors and their multiple data types
- To support multi-exposure & multi-range sensor fusion for ADAS



Virtual Channel 0 – Line 0
Virtual Channel 0 – Line 1
Virtual Channel 0 – Line 2
Virtual Channel 0 – Line 3
Virtual Channel 0 – Line 4

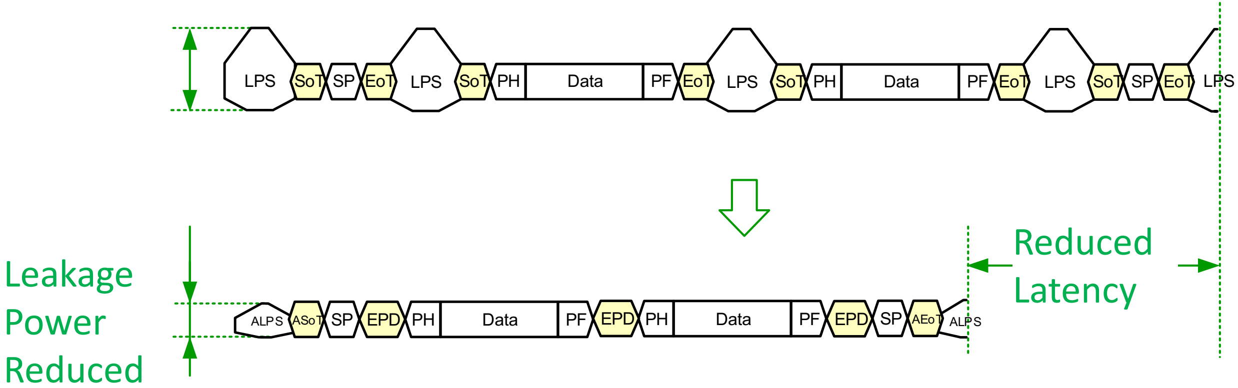
Virtual Channel 0 – Line N

Virtual Channel 1 – Line 0
Virtual Channel 1 – Line 1
Virtual Channel 1 – Line 2
Virtual Channel 1 – Line 3
Virtual Channel 1 – Line 4

Virtual Channel 1 – Line M

Added Latency Reduction & Transport Efficiency (LRTE)

- LRTE reduces frame transport latency & leakage power due to frequent "high speed - low power" transitions
- This enhances image sensor aggregation and multi exposure for real-time perception and decision making applications



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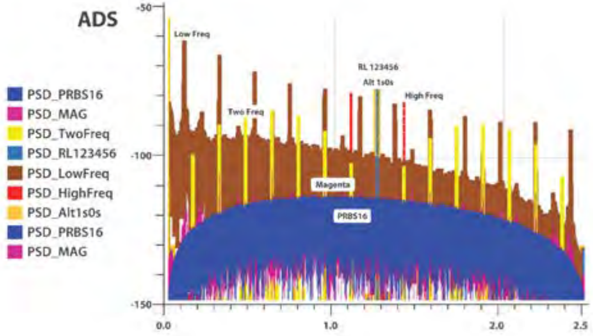
Scrambling and New Compression Scheme

- Galois Field Scrambling reduces power spectral density (PSD) emissions
  - Minimizes PSD emissions from aggressor components, which are particularly beneficial when placed near sensitive receiver
- New DPCM 12-10-12 compression to further boost image quality
  - Superior SNR using reduced bandwidth PHY
  - Removes more compression artifacts when comparing with MIPI CSI-2 v1.3 compression mode



CSI-2 over D-PHY PSD emission reduction

DPCM 12-8-12 vs DPCM 12-10-12

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Smart Region of Interest (sROI)

- Delivering only data needed when it's needed
- Reduces power consumption, enhances processing speed, solves bandwidth limitation, saving data storage space
- Improves image analysis, inferencing algorithms and making better deductions
  - Enable machines on a factory line to more quickly identify potential defects on a conveyor belt
  - Enable medical devices to recognize anomalies

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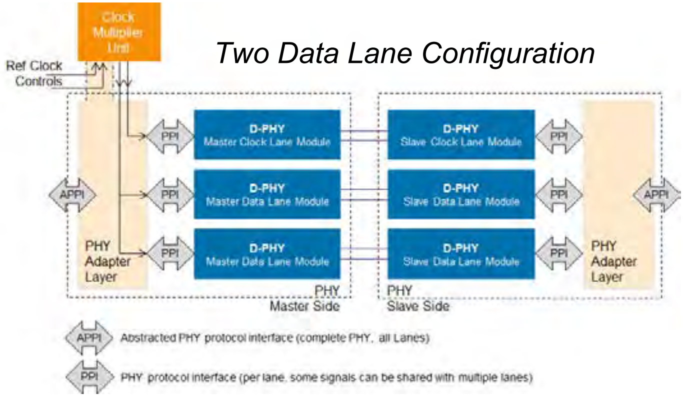
MIPI D-PHY Architecture

The Popular Physical Layer for MIPI CSI-2 and DSI Protocols

- Synchronous Forwarded DDR clock link architecture
- One clock and multiple data lanes configuration
- Static/dynamic de-skew supported through calibration
- Calibration hand-shake not supported
- No encoding overhead
- Low-power and high-speed modes
- Primarily targeting camera and display
- Spread spectrum clocking supported for EMI/EMC considerations
- Large eco-system, proven in billions of phones and cars

Two Data Lane Configuration



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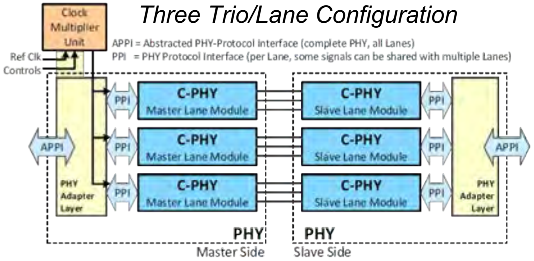
MIPI C-PHY Architecture

Emerging Physical Layer for MIPI CSI-2 and DSI-2 Protocols

- Embedded clock enables assigning lanes
- Bit rate 2.28x the signaling rate, e.g. 1Gsym/s = 2.28Gb/s using encoding
- Multiple trio's configuration to enable higher bandwidth
- Low-power and high-speed modes
- Low EMI/EMC considerations with embedded clock architecture
- Similar to D-PHY
  - LP (Low-Power) Mode is identical, functional definition & electrical specs
  - Common Channel models between the specs
  - PHY-Protocol Interface definition has a lot in-common
  - Similar High-Speed Mode voltage levels
  - A dual-mode C/D-PHY driver or receiver can be built to share the same pins enabling coexistence on same pins with existing D-PHY

Three Trio/Lane Configuration



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Sensors in Autonomous Driving

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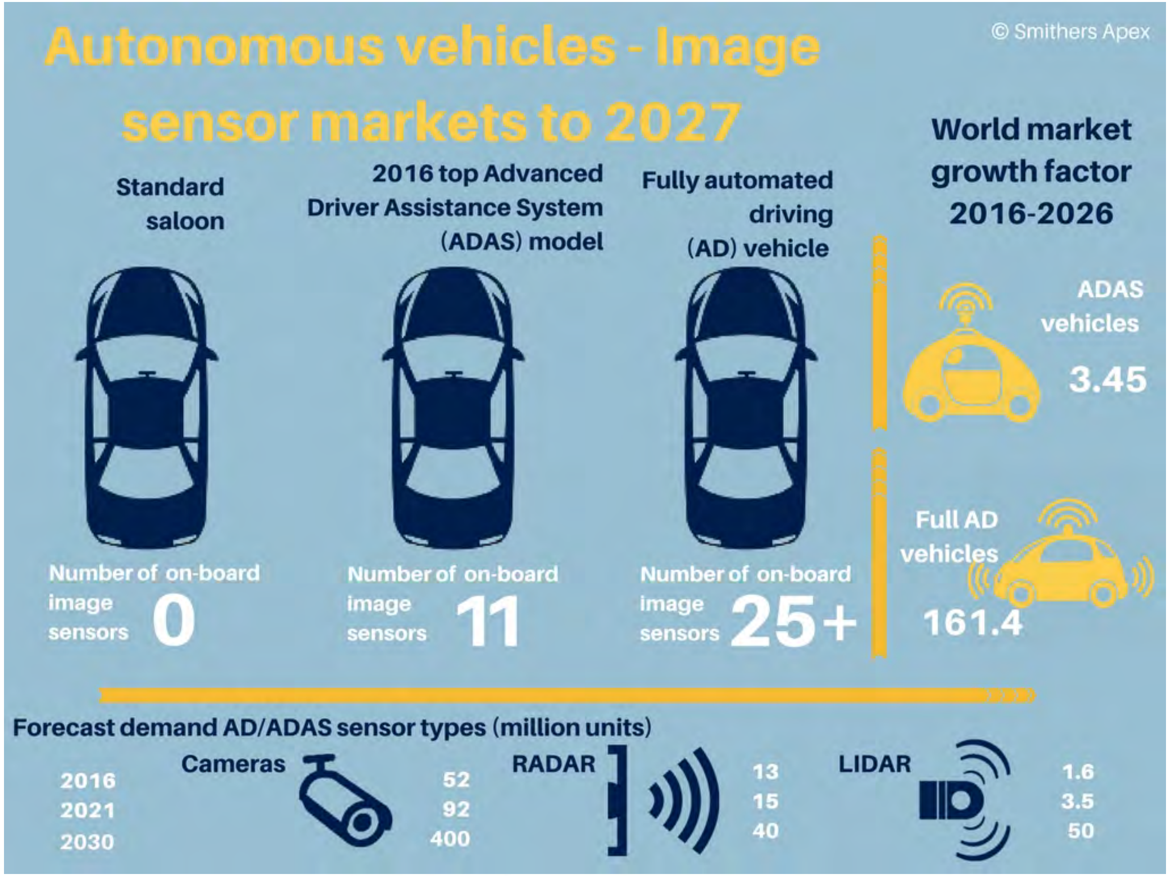
Autonomous vehicles - Image sensor markets to 2027
© Smithers Apex
Standard saloon
2016 top Advanced Driver Assistance System (ADAS) model
Fully automated driving (AD) vehicle
World market growth factor 2016-2026
Number of on-board image sensors 0
Number of on-board image sensors 11
Number of on-board image sensors 25+
ADAS vehicles 3.45
Full AD vehicles 161.4
Forecast demand AD/ADAS sensor types (million units)
Cameras
RADAR
LIDAR
2016 52 13 1.6
2021 92 15 3.5
2030 400 40 50

Overview of Sensor Technologies

	Mono Camera	Stereo Vision Camera	Trifocal Camera	Scanning/LiDAR	3D/ Flash LiDAR
		Triangulation		Time of Flight	
Resolution of Feature Size	Weak	Good, but holes	Medium	Low	Dense Depth Map
Compute Processing	Low	Medium	Medium	High	High
Cost	Low	Low	Medium	Expensive	Medium
Configurability	Fixed	Fixed	Fixed	Flexible	Flexible
Distance Range	Long	Long	Long	Long	Medium
Low Light	Bad	Bad	Bad	Good	Good
Sunlight	Good	Good	Good	Good	Good
Snow, Fog, Rain	Bad	Bad	Bad	Medium	Medium
Accuracy	Medium	Good	Good	Good	Medium
Size	Small	Large		Large	Small

Autonomous Cars Automation Levels

High Growth of Sensors in Cars
Over 20 Sensors Onboard

Today’s Image Sensor

	Level 3	Level 4
Camera Resolution	**2-5MP**	**8MP**
# of cameras	**6-12**	**12 or more**
Smart Camera with AI built-in		✓
Road profile (lane, curb, surface, free space, etc.)	✓	✓
Vehicle detection	✓	✓
Pedestrian detection	✓	✓
Traffic light recognition (RGY, turn light, tail light, etc.)	✓	✓
Traffic sign recognition	✓	✓
Obstacle detection (construction, animal, outliner, etc.)	✓	✓
Driver monitoring	✓	✓
Trifocal and surround based detection	✓	✓
Surround view	✓	✓

Challenges on Current Sensor Technology

- Bandwidth
  - Camera Resolution continues to increase, so as data bandwidth
  - LiDAR needs large data bandwidth
- Distributed networks versus centralized networks
- Real time update (low latency)
- Harsh weather conditions: rain, snow, fog (moisture)
- Redundancy for higher functional safety requirement (ASIL D)

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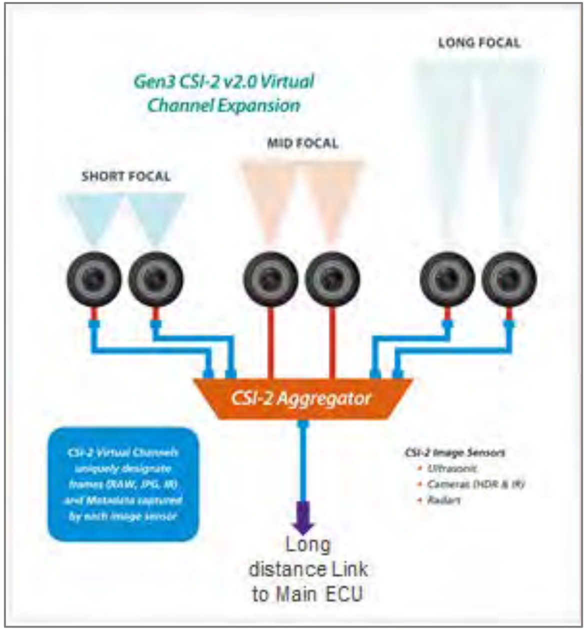
Future Proof MIPI A-PHY to Meet Increased BW

- High bandwidth gears with vision to support 24-48Gb/s+
- Camera aggregation use case
- Flexibility in supporting distributed networks
- High bandwidth display interconnect



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Meeting Automotive Requirements

Key Requirements of Automotive-Grade IP

- Reduce Risk & Accelerate Qualification for Automotive SoCs

Functional Safety	Accelerate ISO 26262 functional safety assessments to help ensure designers reach target ASIL levels
Reliability	Reduce risk & development time for AEC-Q100 qualification of SoCs
Quality	Meet quality levels required for automotive applications

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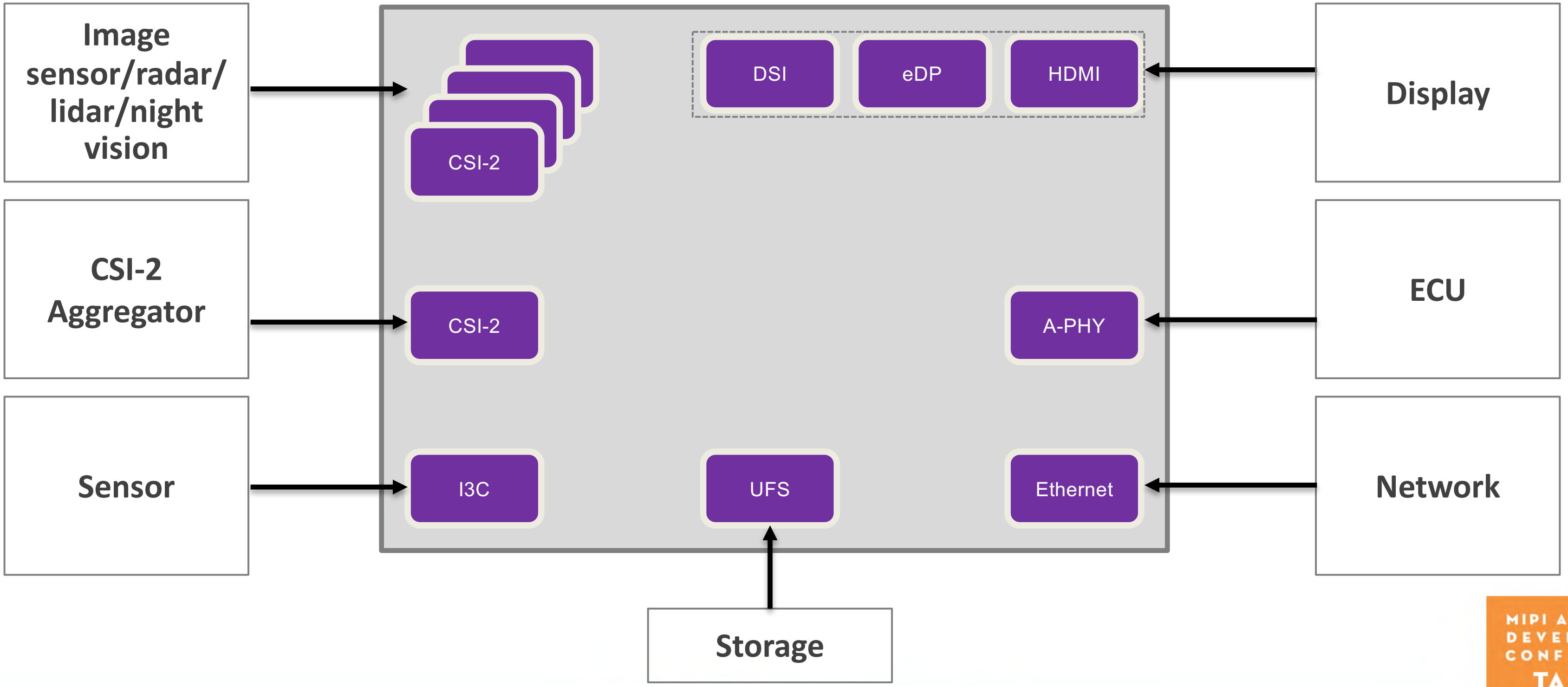
ADAS Domain Controller SoC Architecture



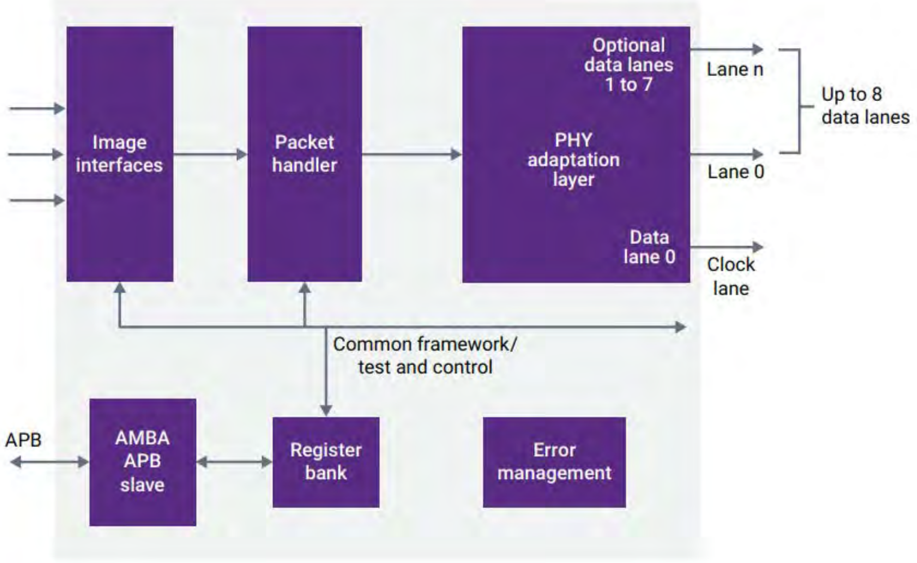
Automotive Safety Features

- DesignWare MIPI CSI-2 Device Controller IP

ASIL B READY

Built-in interrupt injection
Built-in error injection for Memories
Interfaces and RAM protected by Parity
ECC protection on data stored in memory

Certification for ISO 26262 Part 5 HW



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Synopsys MIPI IP for Automotive

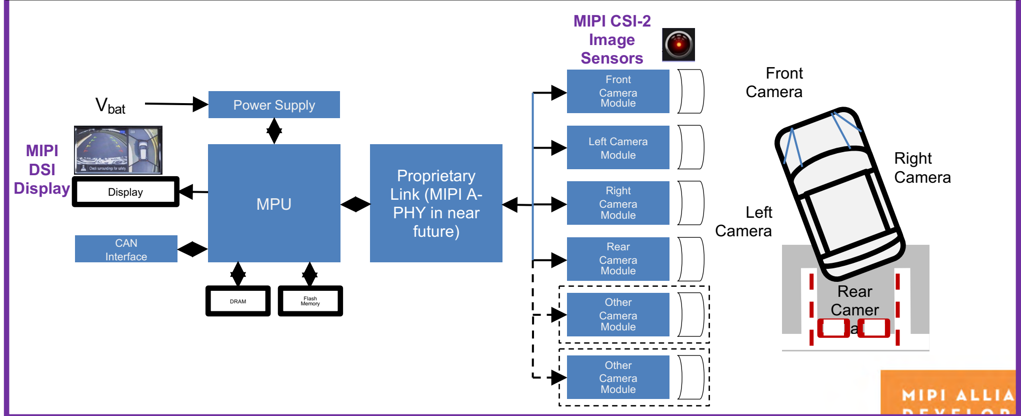
- DesignWare MIPI Controllers & PHYs for Sensors, ADAS, and Infotainment SoCs
- ISO 26262 certified* IP helps accelerate SoC-level qualification & reach target ASILs
- AEC-Q100 designed and tested MIPI IP meets Grade 1 & 2 temperature requirements
- Quality management system meets automotive quality requirements

ISO 26262:2011 CERTIFIED

SGS TÜV SAAR ASIL D READY Functional Safety

- MIPI PHYs
  - Functional Safety ISO 26262 ASIL B*
  - AEC-Q100 Grade1 and Grade2 options
  - Quality DFMEA
- CSI-2 and DSI controllers
  - Functional Safety ISO 26262 ASIL B*
  - Quality DFMEA

Example: Automotive Surround View Using MIPI CSI-2 Image Sensors & DSI Display



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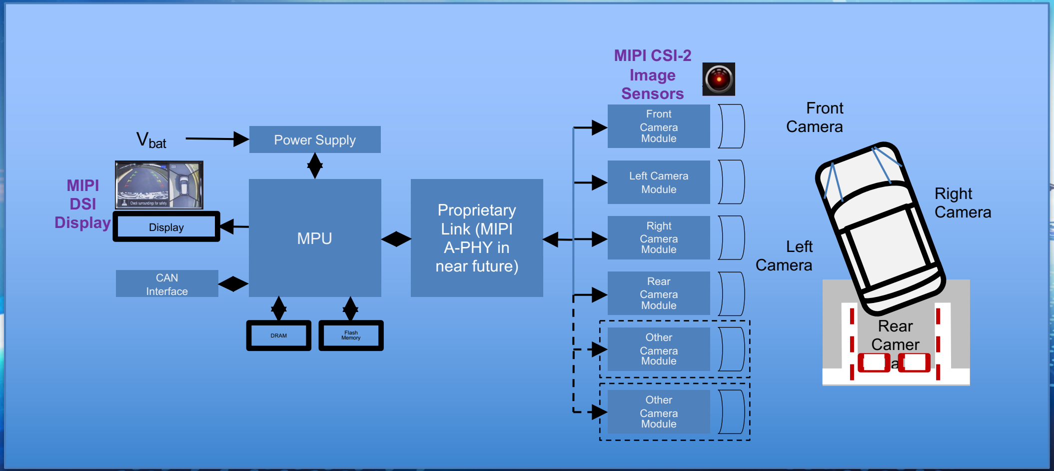
* Certification of IP for ISO 26262 Chapter 5 random HW failures

Hangzhou FABU Tech co. LTD
And Synopsys

FABU Leverages Synopsys' DesignWare MIPI IP to interface with high-definition cameras and displays



DesignWare IP Solutions for Cameras, Displays, Sensors

Single-Vendor Solution, Production-Proven in >1B units, Interoperable eco-system

- Complete end- to-end solution scaling to meet all project needs
- Optimized to deliver best power & area
- Production & interoperability proven to reduce risk
- Lowest integration effort to accelerate time-to-market
- Available silicon-proven MIPI PHYs in mainstream and advanced FinFET processes

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Thank You

ADDITIONAL RESOURCES

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