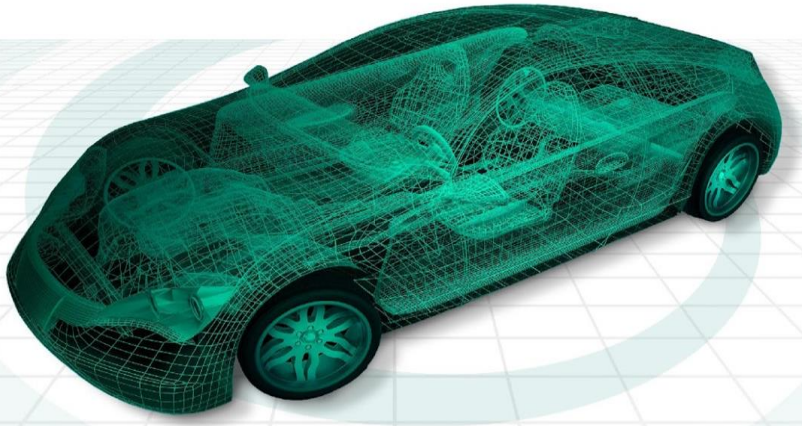
mipi alliance

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

MIPI Automotive SerDes Solutions (MASS):

A Standardized Framework for Creating Functionally Safe and Secure Automotive Sensor Systems



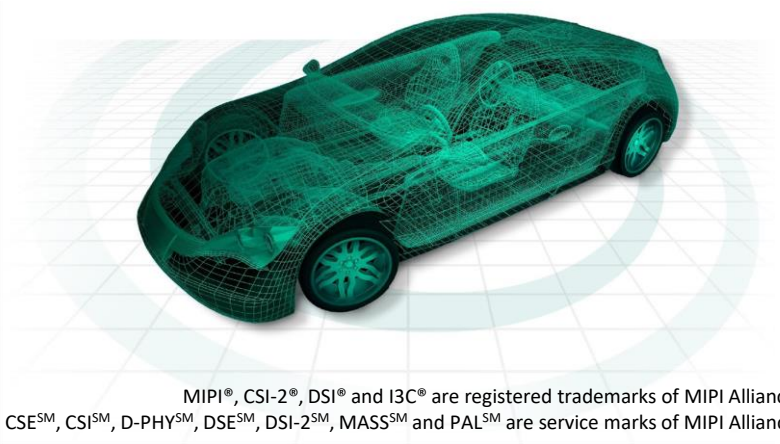
Ariel Lasry
MIPI A-PHY Working Group Vice Chair
Qualcomm CDMA Technologies GmbH

13 October 2021

AUTOMOTIVE SerDes CONFERENCE

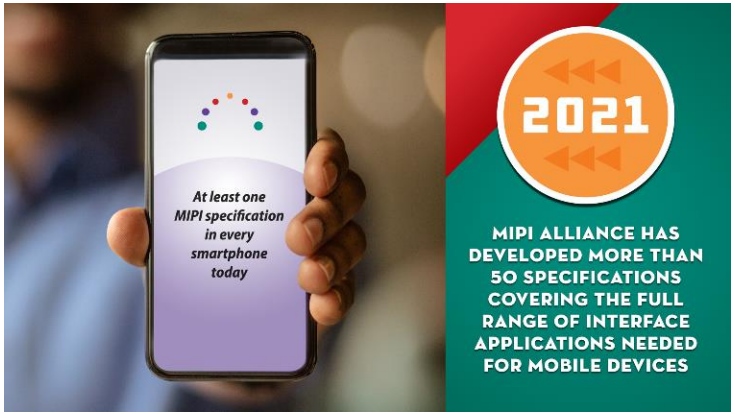
Agenda

- About MIPI Alliance
- Overview of MIPI A-PHY
- MIPI Automotive SerDes Solutions (MASS) Overview
- MASS End-to-End Protection
- MASS Security
- Summary
- Q&A

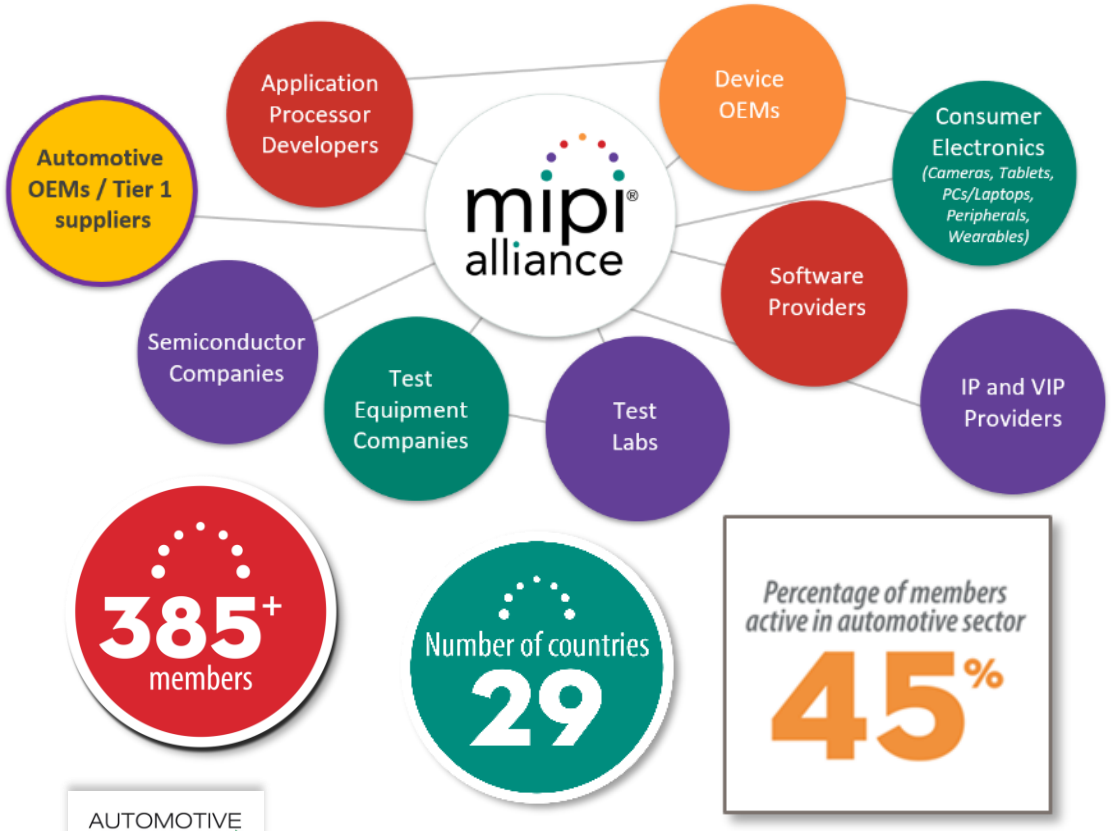


About MIPI Alliance

About MIPI Alliance



TODAY'S MIPI MEMBER ECOSYSTEM



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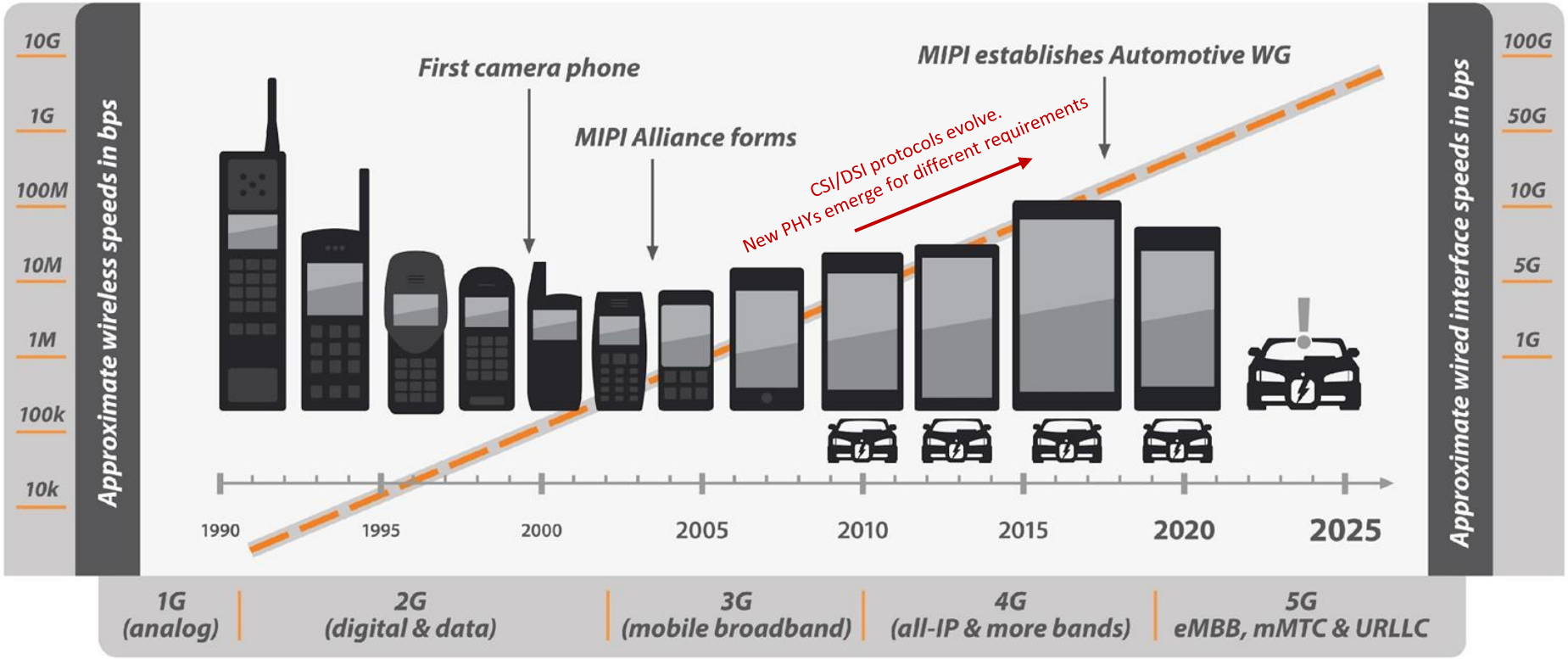
MIPI Alliance Members in Automotive

Partial listing – not all companies represented

MIPI and the Mobile Gs . . . Including Automotive



MIPI in Automotive

Cameras, displays, audio, sensors, storage, RFFE for 5G, Wi-Fi, Bluetooth, NFC

Reuse & extend well-proven protocols == reduced NRE/cost

Intra-box usage has been limited due to lack of native long-reach PHY

SPECIFICATIONS IN AUTOMOTIVE TODAY

Most MIPI interfaces are implemented as "*short reach*" (~15 to ~30cm+)

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

D-PHY SerDes
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

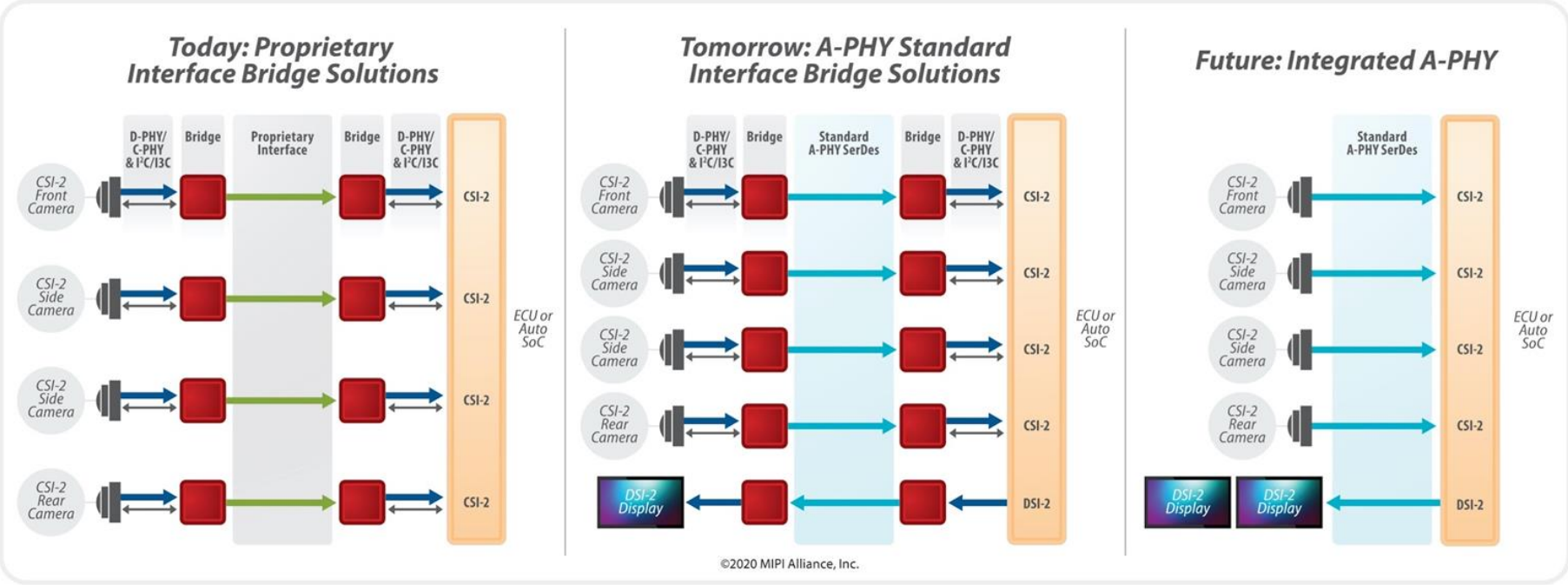
UniPro for JEDEC UFS
Data transport protocol for UFS over M-PHY
Transport protocol for UFS storage

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

A-PHY SerDes
***Long-reach** (up to 15m) asymmetrical physical layer (released Sep 2020)*

About MIPI A-PHY

MIPI A-PHY Overview



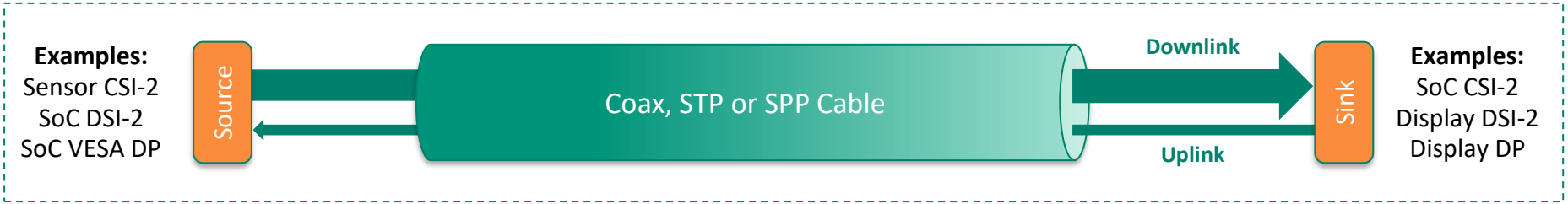
Lower cost through standardization and economies of scale

Lower cost/eBOM through integration

ECU: Electronic Control Unit **SoC:** System On Chip

MIPI A-PHY – Automotive Long-Reach PHY

The first industry-standard *long-reach* asymmetric SerDes physical layer specification targeted for ADAS/ADS surround sensor applications and infotainment display applications



A-PHY v1.0 offers:

- Direct coupling to native CSI-2/DSI-2/DP-eDP protocols
- High performance of up to 16 Gbps over 10-15m
- High noise immunity, ultra low PER (< 10^{-19})
- Supports bridge-based and endpoint integration
- Support for automotive coax and STP channels
- Power over cable

NEW A-PHY v1.1 Enhancements:

- Increased support for lower cost legacy cables
- Double uplink data rate
- Star quad cable support, enabling dual downlink operation

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PER: Packet Error Rate
STP: Shielded Twisted Pair
SPP: Shielded Parallel Pair

ADAS: Advanced Driver Assistance System
ADS: Autonomous Driving System
SoC: System On Chip

MIPI A-PHY Activity

MIPI ALLIANCE NEWS

A-PHY v1.0 adopted as IEEE 2977-2021 *(June 2021)*

MIPI A-PHY ADOPTED AS IEEE STANDARD

Milestone expands access to automotive SerDes specification

mipi alliance IEEE SA STANDARDS ASSOCIATION

WHAT'S NEXT:

A-PHY v1.1 development complete and will also be submitted to IEEE adoption process

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MIPI Automotive SerDes Solutions (MASS)

Overview

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MIPI Automotive SerDes Solutions (MASS) in the Car

Electronic Control Unit (ECU)

- Advanced driver assistance system (ADAS) based on sensor feeds
- Produces display feeds

Sensors

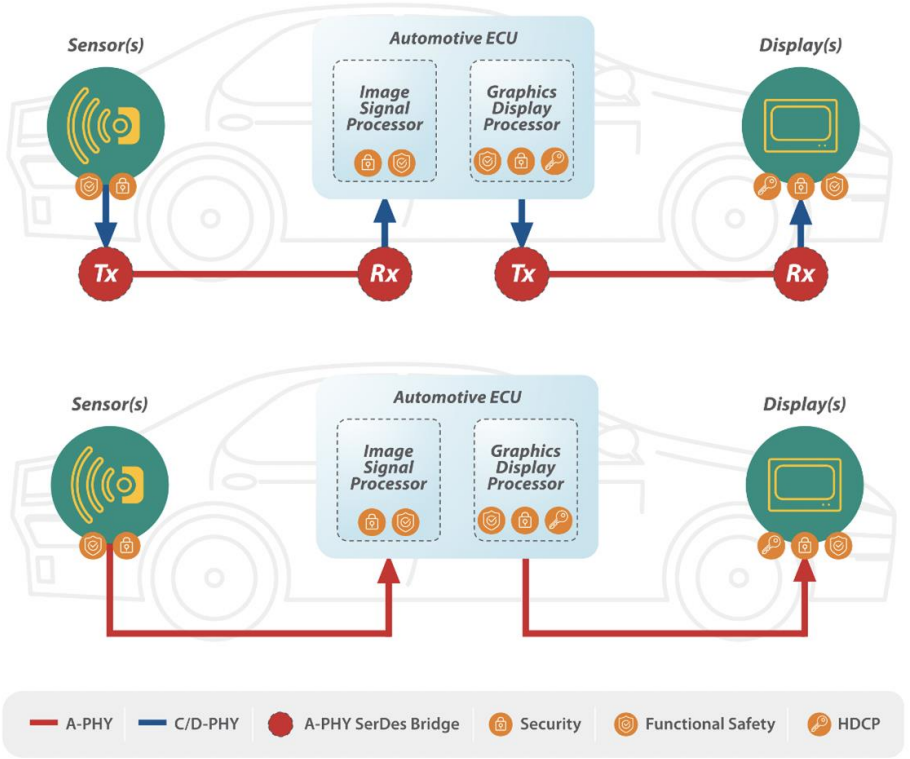
- Camera
- Lidar

Displays

- Dashboard
- Console
- Side view mirrors
- Entertainment

(Optional) A-PHY Bridges

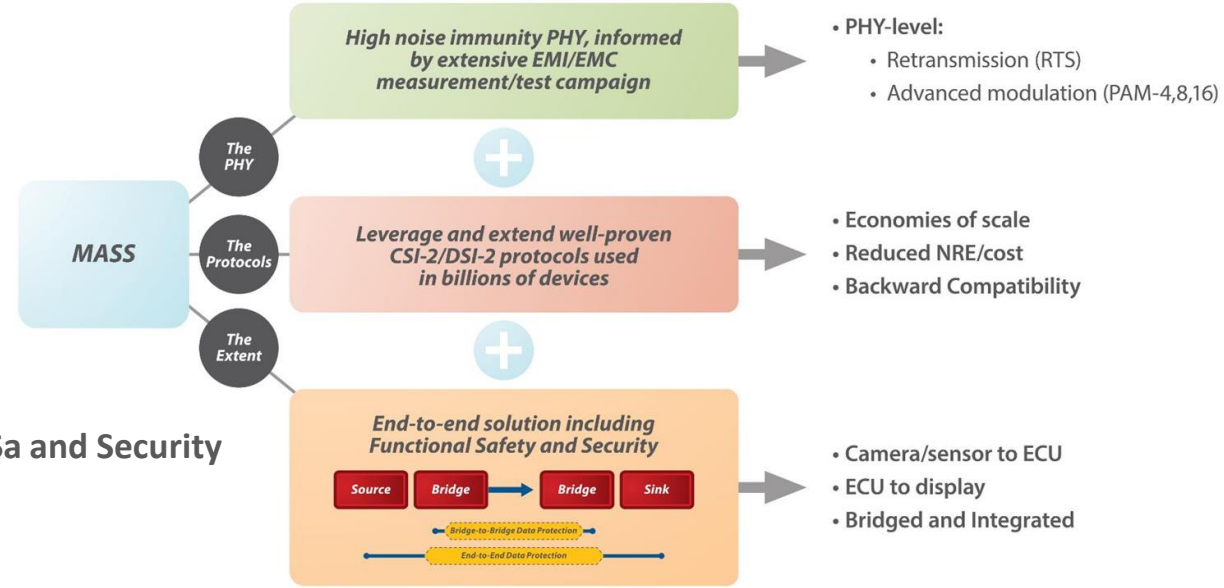
- Translates between short-range MIPI C-PHY / D-PHY & long-range MIPI A-PHY



MASS – Guiding Principles

A collection of MIPI specifications advancing camera and display solutions for automotive:

- **A-PHY**
  - Long reach PHY (15m)
  - v1.0: 2-16 Gbps (Coax, SDP)
  - v1.1: up to 32Gbps (STQ)
- **PAL: Protocol Adaptation Layers**
  - MIPI CSI-2, DSI-2 and I3C
  - VESA eDP/DP
  - Ethernet, I2C, GPIO
- **Service Extensions for End-to-End FuSa and Security**
  - CSE: Camera Service Extensions
  - DSE: Display Service Extensions
  - MIPI Security Specification



MASS – Solution Elements

Comprising PHY, Protocols and Extent for a flexible system solution

Robust Long-Reach PHY (PER 10^{-19})

- MTBF of 1 error over the full vehicle life-time
- Asymmetric high-speed link with fixed low latency ~6µs @G5
- High speed downlink and aggregation to support **multiple** 4K cameras and displays

Application-level End-to-End Functional Safety

Application-level End-to-End Security

- End to end protection covering various topologies
- Flexible coverage: per frame, per ROI, per message, compression ON/OFF

- CRC for error detection
- Frame loss detection
- Time-out Monitoring
- BIST
- Faults injection
- Authentication
- Data integrity
- Encryption
- HDCP for display

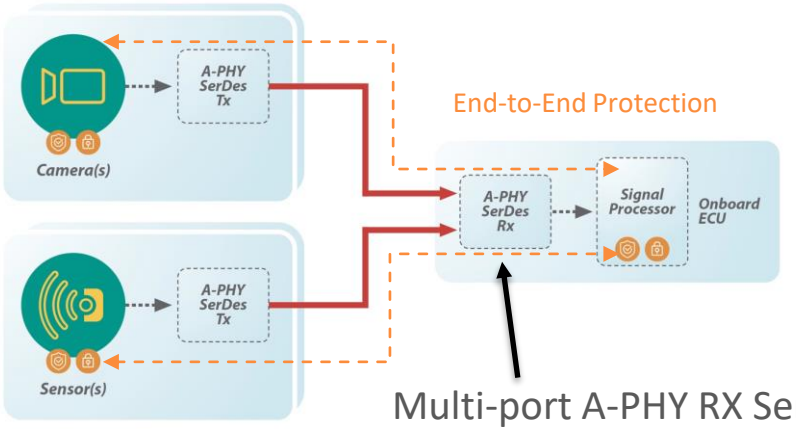
Deep system level consideration for native interfaces and the legacy ecosystem

- Heterogeneous display protocols:
  - DSI-2, eDP/DP
- Different source/sink configs
  - C-PHY, D-PHY, # Lanes, I2C, I3C
  - Integrated A-PHY or bridged A-PHY

PER: Packet Error Rate **BIST:** Built In Self Test
ROI: Region Of Interest **MTBF:** Mean-Time Between Failure

MASS – Examples for Supported Topologies

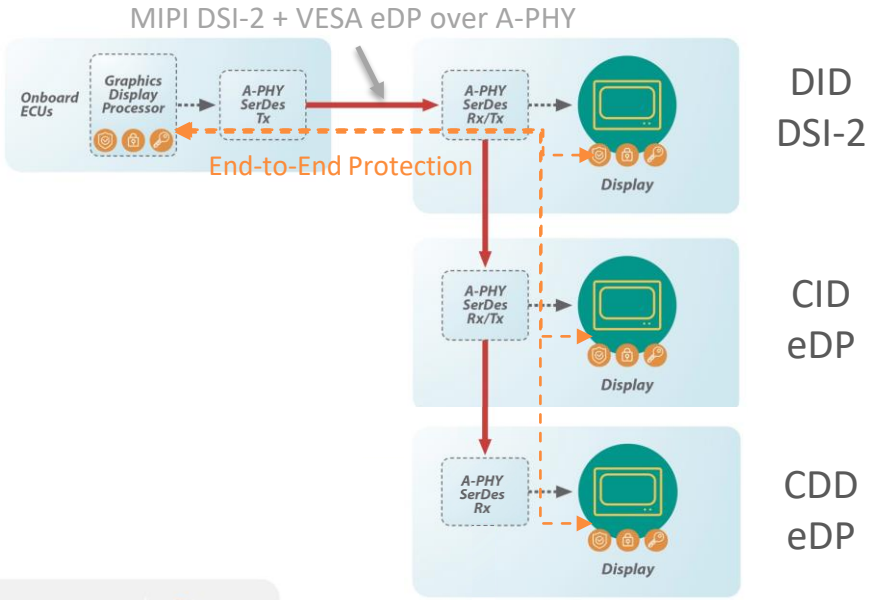
Cameras and Sensors Aggregation



MIPI CSI-2 Sensors

Multi-port A-PHY RX SerDes with CSI-2 Aggregator

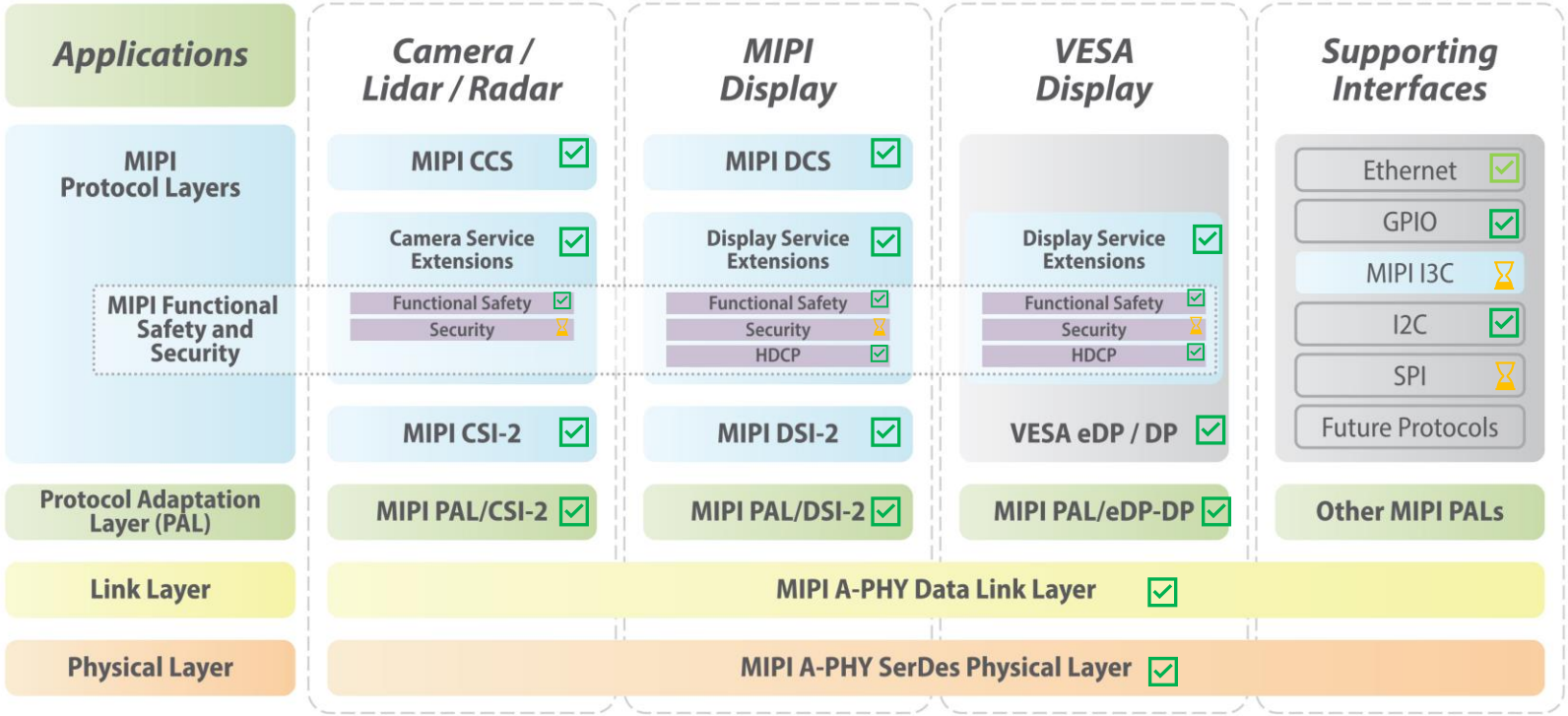
Daisy Chaining of Heterogeneous Displays



A-PHY | Security | Functional Safety | HDCP

DID: Driver Instrument Display
CID : Central Information Display
CDD: Co-Driver Display

MASS Stack – Current Status



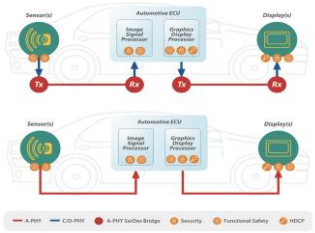
- Specification published
- Completed – in adoption process
- Work in progress

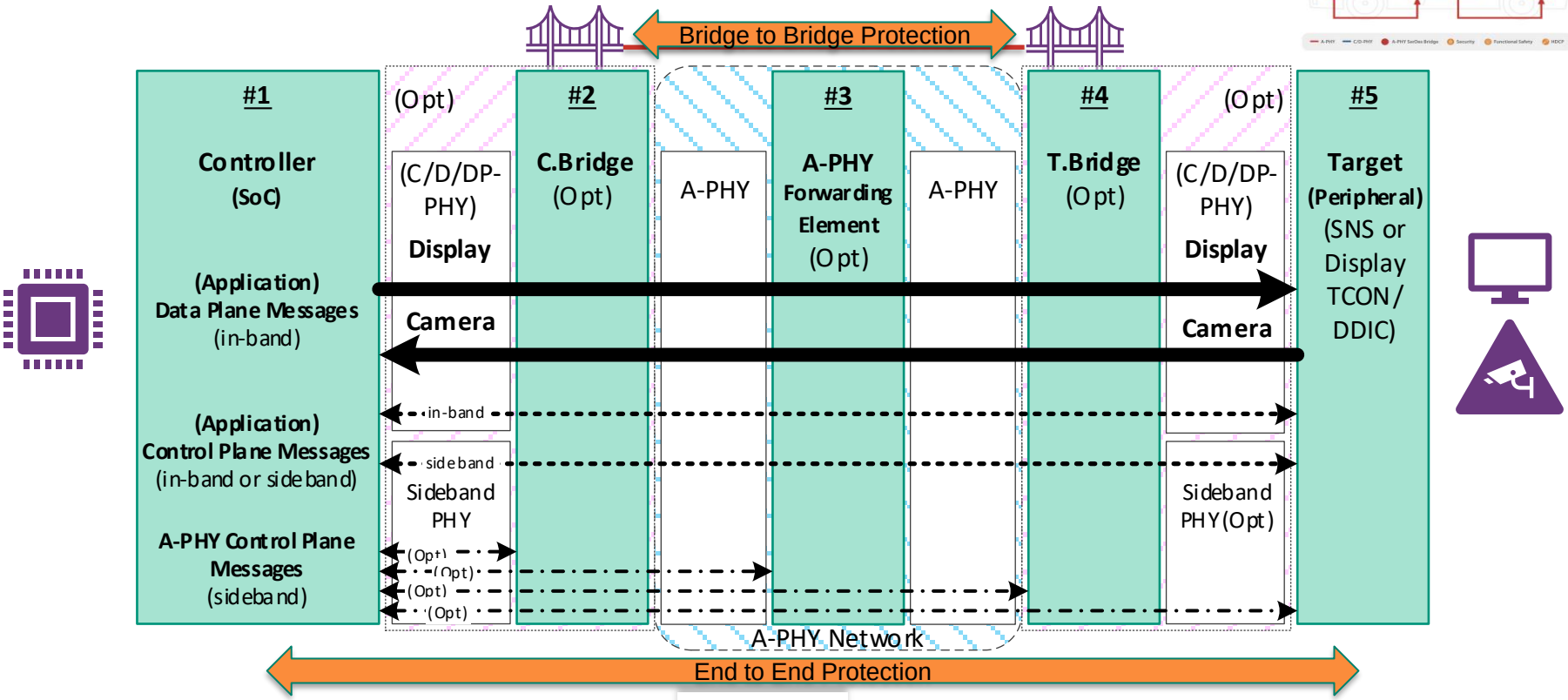
MASS – End to End Protection

Functional Safety and Security

MASS 1-5 Model & MIPI Protocols

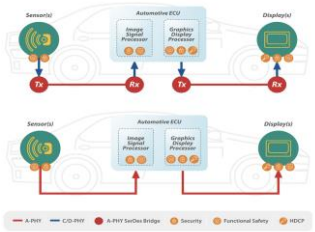
End-to-End Functional Safety and Security Protection

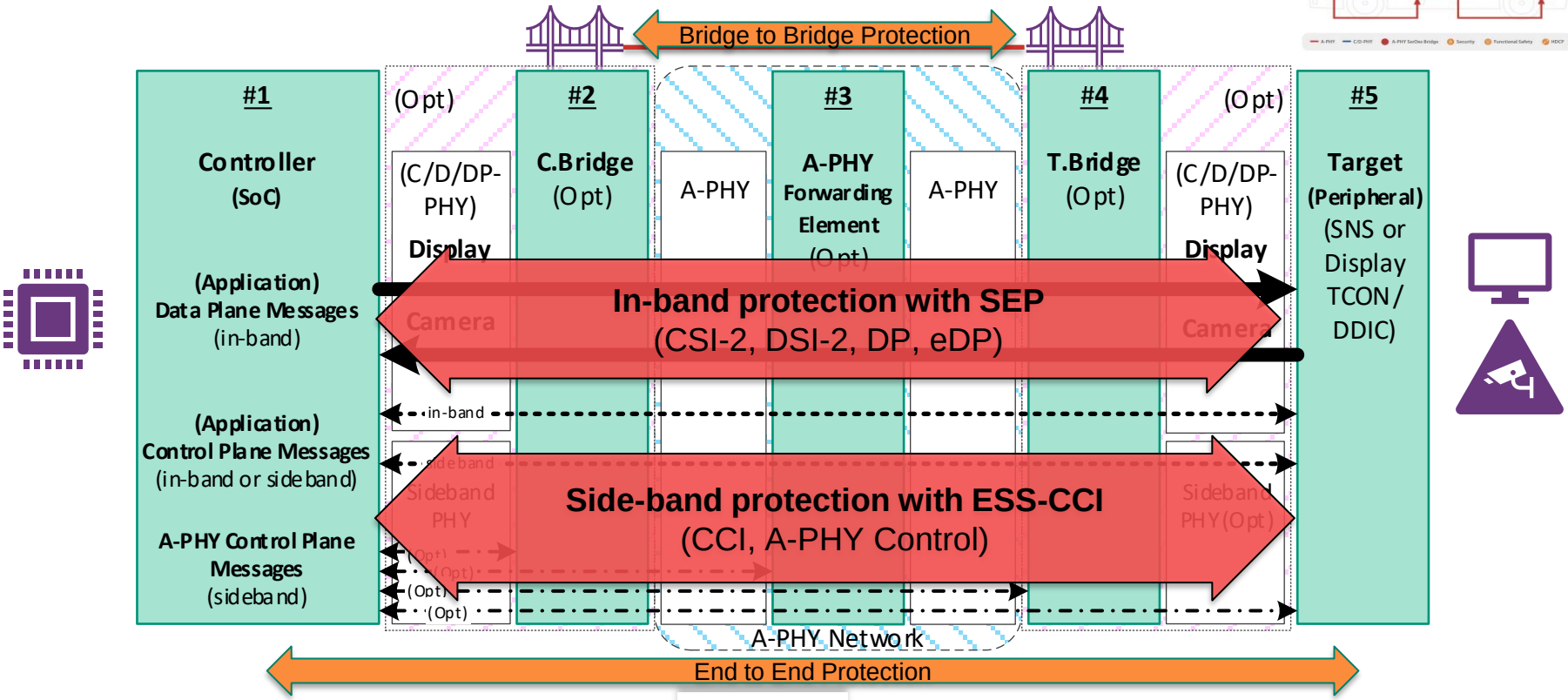




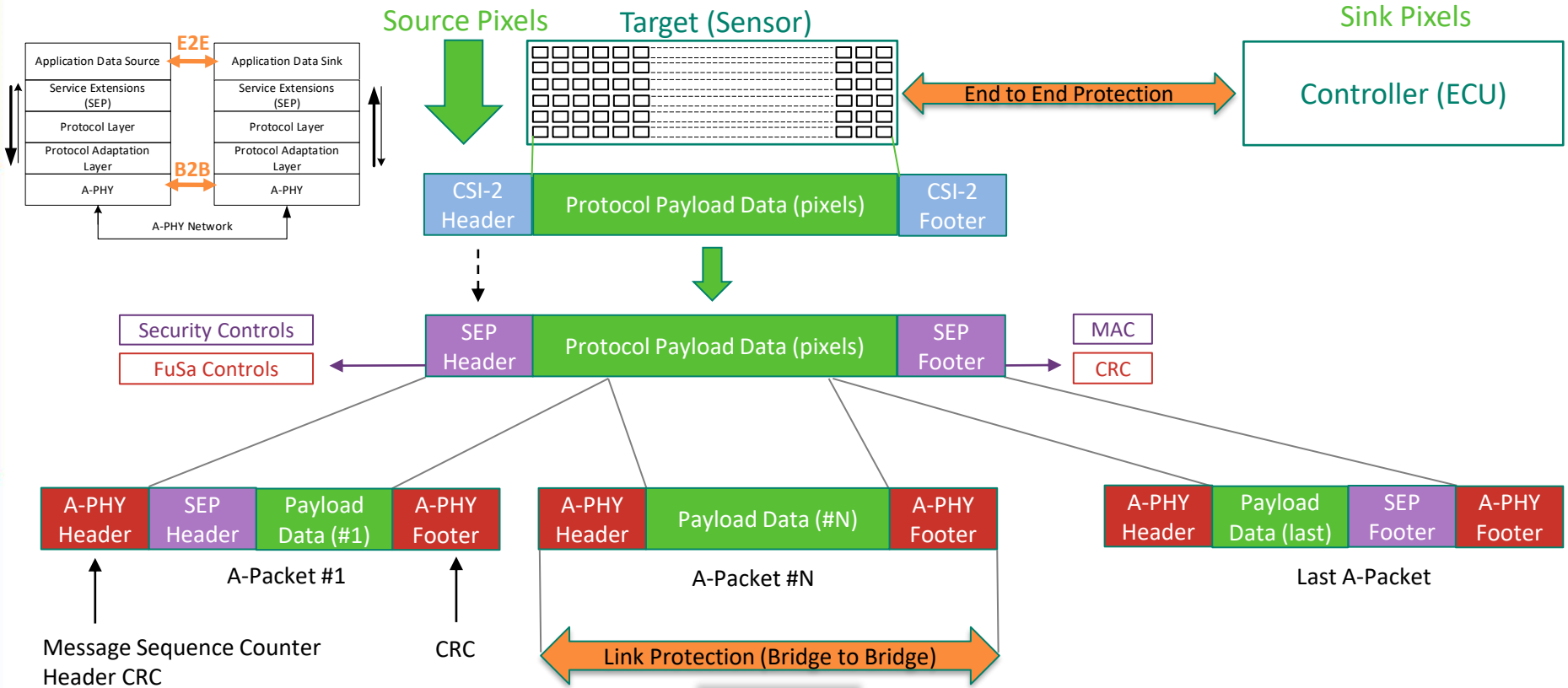
MASS 1-5 Model & MIPI Protocols

End-to-End Functional Safety and Security Protection





Service Extension Packets (SEP) for End-to-End Protection



E2E: End-to-End; **B2B**: Bridge to Bridge
MAC: Message Authentication Code
CRC: Cyclic Redundancy Check

ISO26262-5 Annex D – Communications Bus


INTERNATIONAL STANDARD

ISO 26262-5

Second edition 2018-12

Road vehicles — Functional safety —

Part 5:
Product development at the hardware level

Véhicules routiers — Sécurité fonctionnelle —
Partie 5: Développement du produit au niveau du matériel

Reference number
ISO 26262-5:2018(E)

© ISO 2018

Annex D – Communication bus safety mechanisms:

- One-bit hardware redundancy
- Multi-bit hardware redundancy
- Read back of sent message
- Complete hardware redundancy
- Inspection using test patterns
- Transmission redundancy
- Information redundancy
- Frame counter
- Timeout monitoring
- Combination of information redundancy, frame counter and timeout monitoring

Functional Safety – A-PHY

- **A-Packets provide**
  - CRC-32 for each packet providing a Hamming Distance > 3 – detecting communication failure (bad payload)
  - Message Sequence Counter – detecting packet loss / duplication
  - Timeout Monitoring – detecting potential loss of communication
  - Header CRC – header protection
  - BIST

Functional Safety – Service Extensions (CSE/DSE)

- **Flexible End-to-End Functional Safety and Security framework with SEP**
  - Packet based: per SEP
  - Frame based: per Video Frame
  - Regions of Interest: per ROI
  - With compression enabled/disabled

- **Example of FuSa Elements used**
  - CRCs with Hamming distance > 3
    - SEP Header CRC + SEP Footer CRC
    - ROIs, Compression Slices / Columns etc.
  - Message Sequence Counter
  - Timeout monitoring
  - Test pattern generators (solid colors, color bar, tiles etc.)
  - Faults injection – checking error detection mechanisms

Example for ROI usage in Driver Information Display

Control Plane End-to-End protection

ESS-CCI: Enhanced Safety and Security – Camera Control Interface

Display: MIPI DSI-2

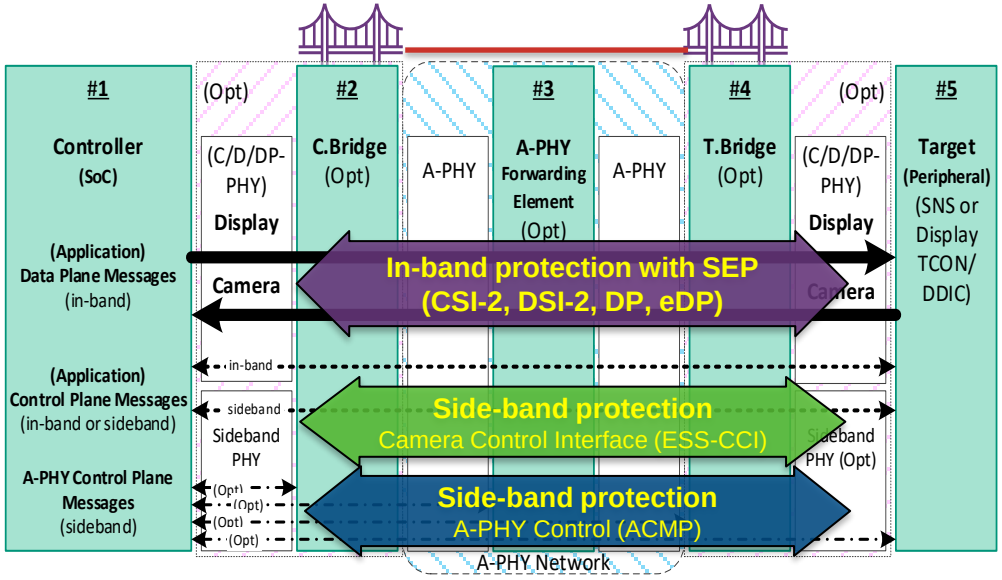
- In-band Control Plane is protected with SEP
- Defined in MIPI DSE Specification

Camara: MIPI CSI-2

- In-band Data Plane is protected with SEP
  - Defined in MIPI CSE Specification
- ESS-CCI for Camera Control Interface
  - I2C-based register access
  - Defined in MIPI CSE Specification

A-PHY Network: MIPI A-PHY

- ACMP for A-PHY Control
  - I2C-based register access
  - Re-use of ESS-CCI Protocol
  - Defined in MIPI A-PHY Specification



CCI: Camera Control Interface
ACMP: A-PHY Control and Management Protocol

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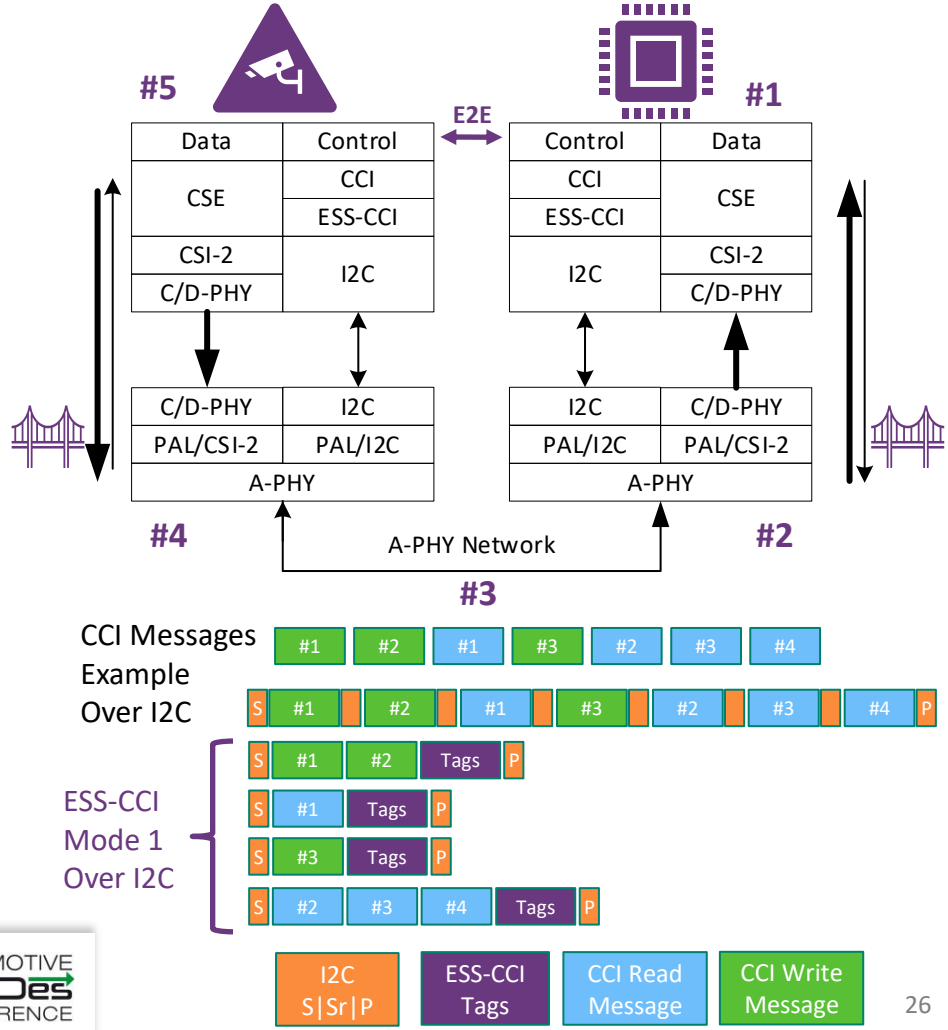
ESS-CCI

- **ESS-CCI provides services to support E2E FuSa and Security**
  - CSE v1.0 : Functional Safety Services
  - CSE v2.0 : Provides FuSa + Security Services
- **CCI Read and Write Messages are extended with ESS-CCI Tags**
  - Message Counters and CRCs
  - Separate Tags for Read and Write messages
  - Tags are used for verification of the CCI messages
- **ESS-CCI Mode 1**
  - ESS-CCI Tags are transmitted along with the CCI Messages
  - Each message can be verified and processed as soon as it is received by the Target or by the Controller
- **ESS-CCI Mode 2**
  - ESS-CCI Tags are accumulated over multiple messages (e.g per Frame)
  - The accumulated Tags are sent as CSI-2 Embedded Data from the Target to the Controller
  - The Controller verifies the ESS-CCI Tags
  - No bandwidth overhead on I2C



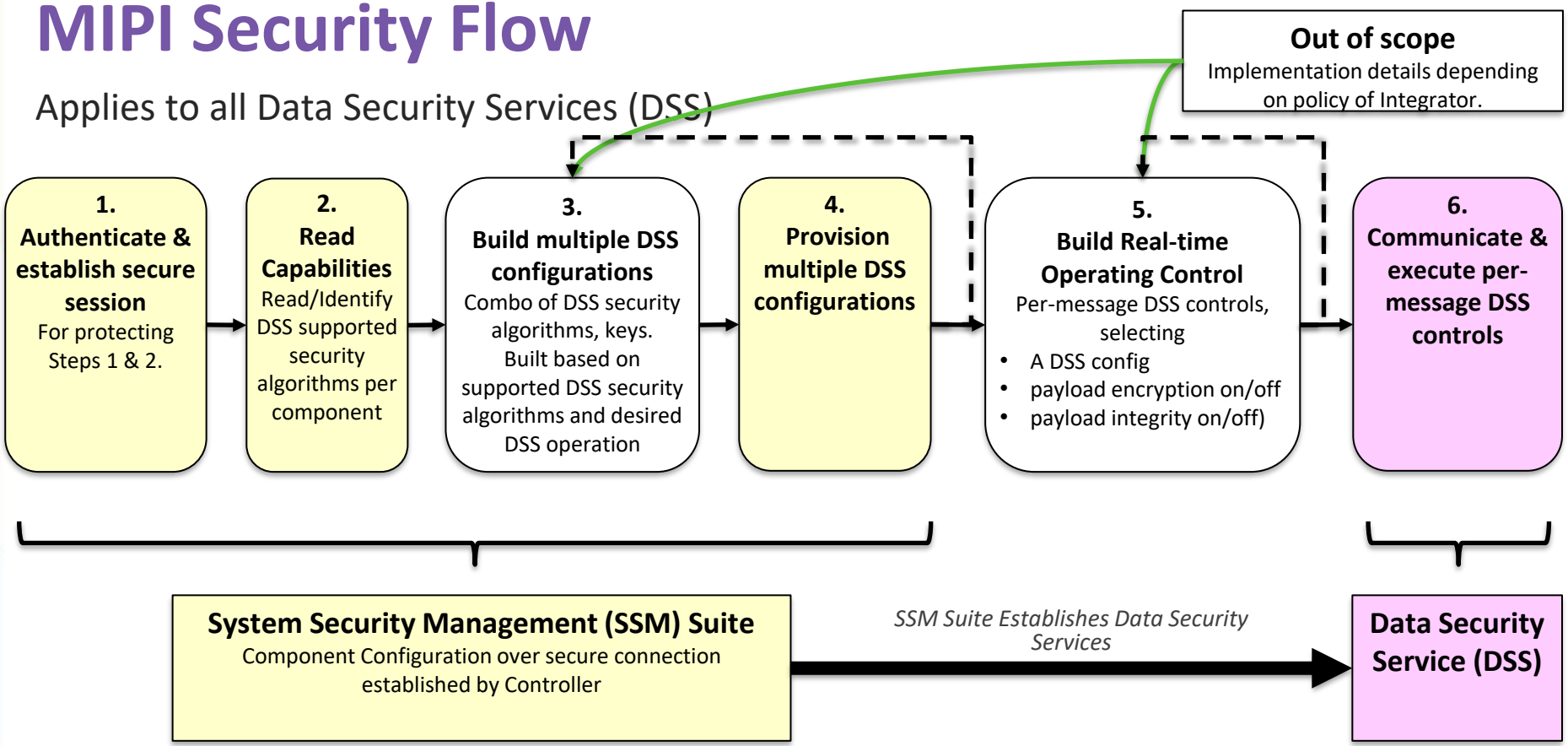
MASS – Security

What are the Data Security Services Protecting?

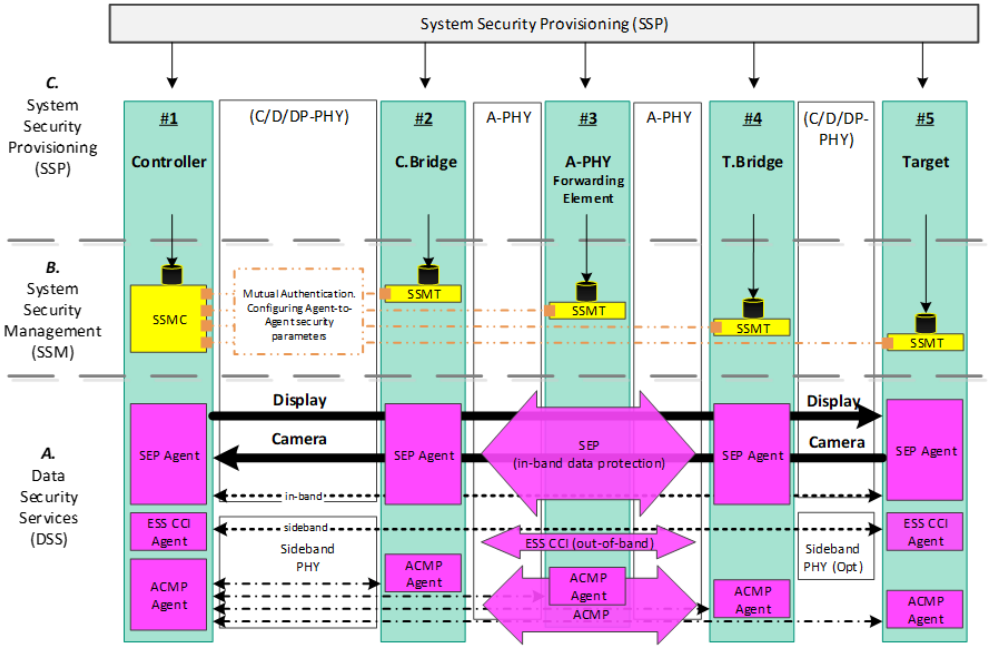
Image Data	Security Considerations
– Integrity of Sensor images	Manipulating ADAS
– Confidentiality of Sensor images	Privacy: location-revealing images
– Integrity of Display images	Incorrect dashboard display
Control Data	
– Integrity of Sensors Capabilities/config	Disable/manipulate sensor
– Integrity of Display Capabilities/config	Disable/manipulate display
– Integrity of A-PHY Capabilities/config	Disrupt A-PHY network
– Confidentiality of all config	Proprietary/sensitive/privacy

MIPI Security Flow

Applies to all Data Security Services (DSS)



MIPI Security Framework



Framework can be applied directly from Controller #1 to Target #5 over any MIPI PHYs

SSMC: System Security Management Controller
SSMT: System Security Management Target
DMTF: Distributed Management Task Force
SPDM: Security Protocol and Data Model

System Security Management (SSM)

- **Between SSMC (#1) and SSMTs (#2,#3,#4,#5)**
- **Authenticate and establishes secure sessions using DMTF's SPDM**
  - DSP0274: Symmetric / Asymmetric mutual authentication
  - DSP0277: Secured Messages to protect MIPI SCAP (encryption and integrity protection)
- **Service Association Configuration Protocol (SACP)**
  - Read Security Capability Registers for DSS
  - Write Security SA Registers for DSS
- **MIPI Security Specification**

Apply Data Security Services (DSS)

- **Flexible DSS**
  - Encryption
  - Integrity Protection via Message Authentication Codes (MAC)
  - Per Message / per Frame / per ROI → Trade-offs
- **SEP Security for MIPI CSI-2, MIPI DSI-2 and VESA eDP/DP**
  - To be specified in next versions of MIPI CSE, MIPI DSE
- **Side band control channel security**
  - ESS-CCI Security for Camera Control
  - Extending ESS-CCI to include DSS in next CSE version
  - ACMP Security for A-PHY Control (re-use of ESS-CCI)

Summary

Summary

- **MASS provides a standardized framework enabling end-to-end FuSa and Security**
  - Addresses both the data and control planes including side-band control
  - Flexible framework to allow tailoring the FuSA and security services for a wide range of use cases and OEM preferences
- **MASS reuses widely adopted MIPI and VESA protocols to address automotive requirements**
- **MIPI has completed the first suite of MASS specifications**
  - A-PHY v1.0 / v1.1, Protocol Adaptation Layers for CSI-2, DSI-2, VESA eDP/DP, I2C, GPIO, Ethernet
  - MIPI DSE and MIPI CSE providing service extensions for FuSa
- **MASS Security Specification is expected in 2022**

Q&A

MIPI Automotive Resources

For automotive developers, system architects and engineering managers who are focused on the design, development, integration and test of next-generation automotive E/E architectures. Will cover:

- **MIPI Automotive SerDes Solutions (MASS)**
- Display and sensor (camera/lidar/radar) stacks
- Functional safety, security and data protection
- **MIPI A-PHY** implementation, system modelling and test.

https://www.mipi.org/events/2021-automotive-workshop

Information on A-PHY can be found at:

- MIPI A-PHY Specification Homepage
- MIPI White Paper: Introduction to MASS

Thank you