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

How Use of DSI-2 and Video Compression is Essential for Next-Generation Digital Cockpits

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Product Manager, Hardent

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Agenda

- MIPI DSI-2 overview and latest updates
- Use of video compression to solve the display bandwidth challenge in cars
- Meeting Functional Safety (FuSa) requirements when using video compression

MIPI DSI-2

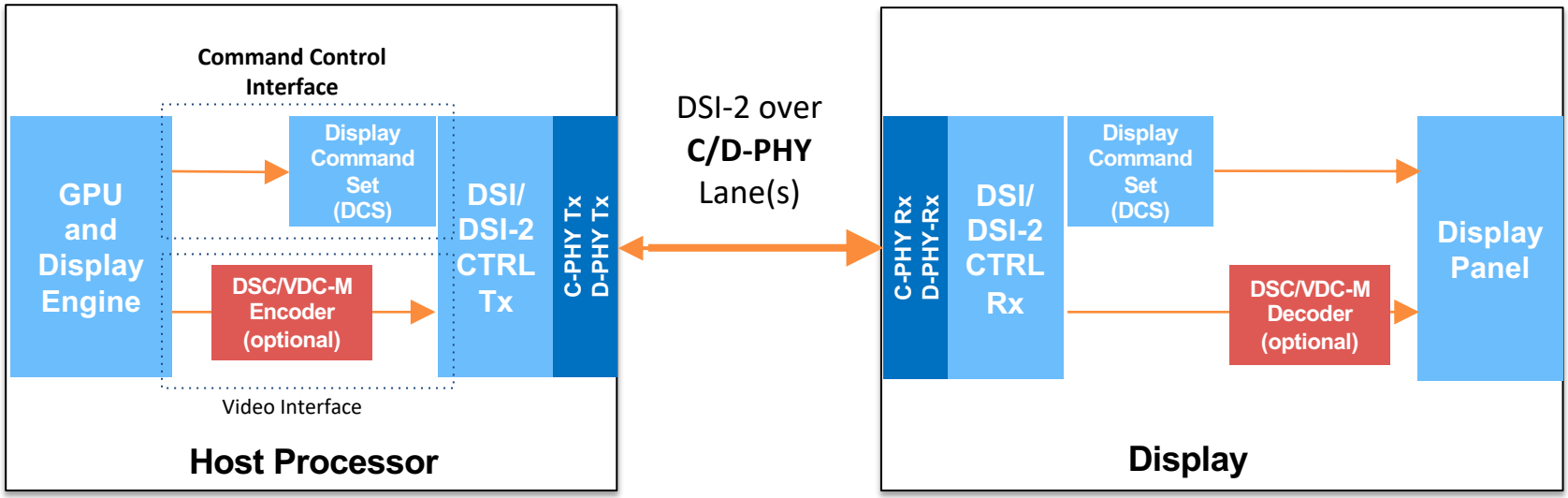
Overview

MIPI Display Ecosystem Virtues

- DSI and DSI-2 serialize two-way data transfer
- Three high-speed transmission modes
  - Real-time video “pixel clock” timing
  - Faster-than-real-time burst video timing
  - Command mode data transfer, similar to writing to an addressable memory
- In-band, half-duplex, for control data reads and writes
- Low-power (LP) and ultra-low power sleep (ULPS) modes
- **Video compression option by standard visually lossless codecs**
  - VESA DSC and VDC-M

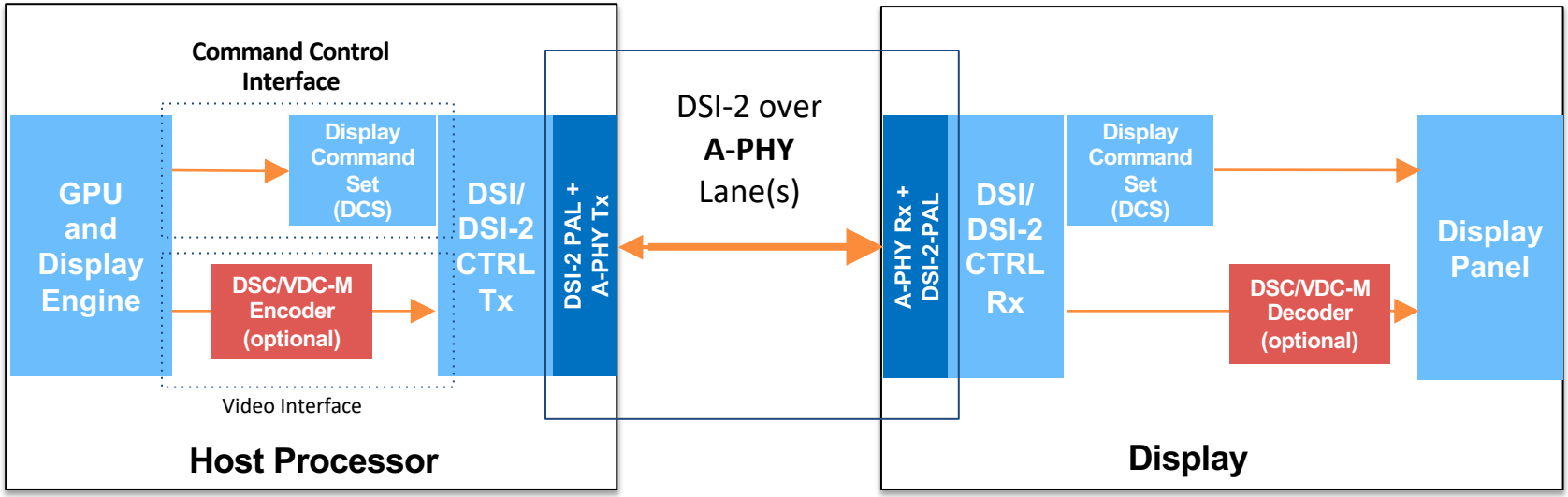
The world’s simplest, yet most effective standard display interface

MIPI Display Overview



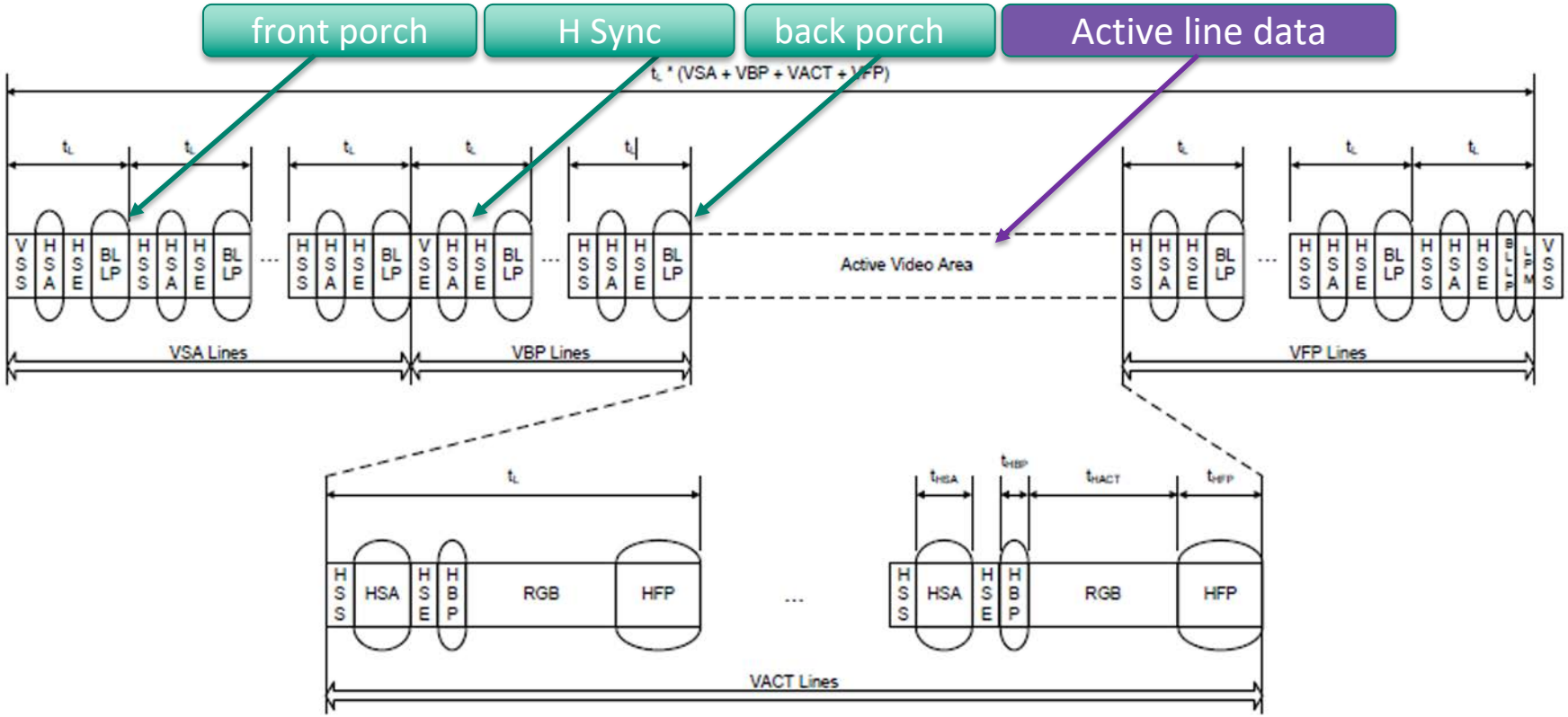
Simplest **Video Mode Only** Host and Display Architecture

MIPI Automotive Display Overview



Simplest **Video Mode Only** Host and Display Architecture

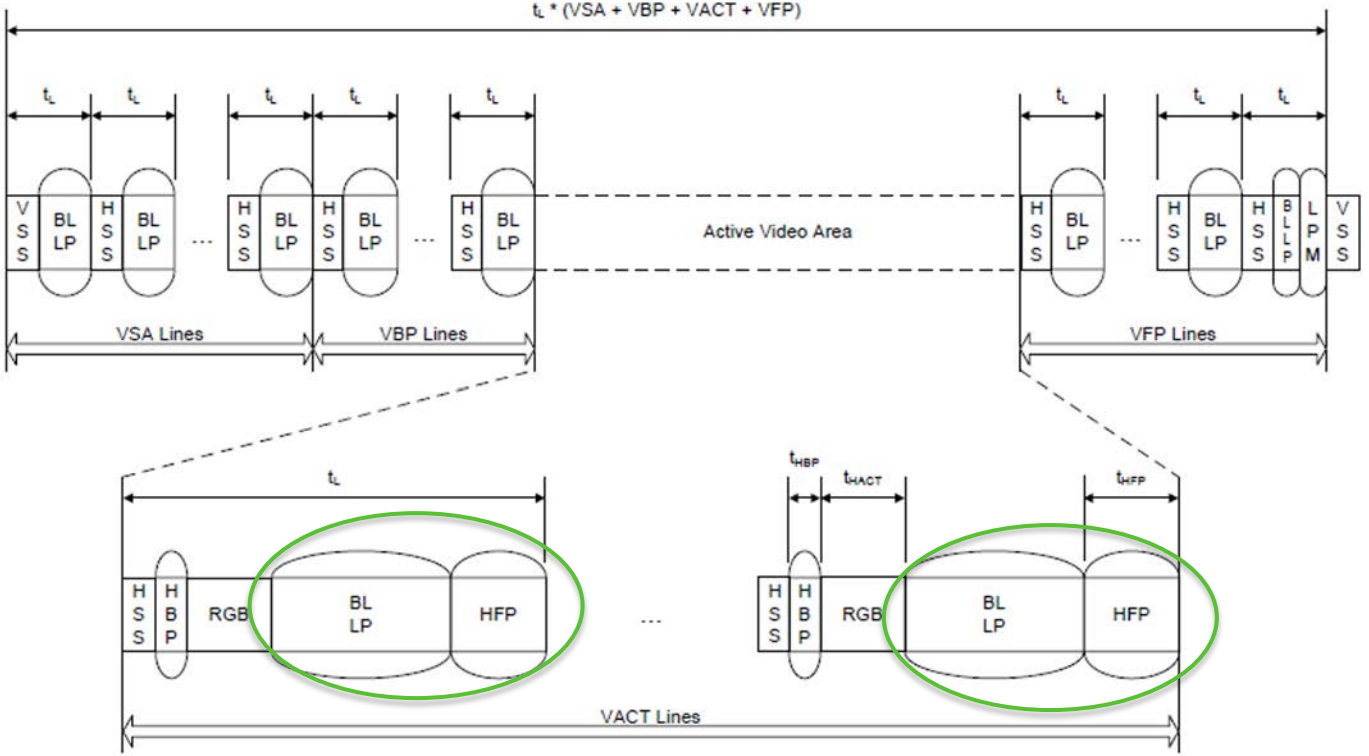
Transmission Mode: Real-time video mode



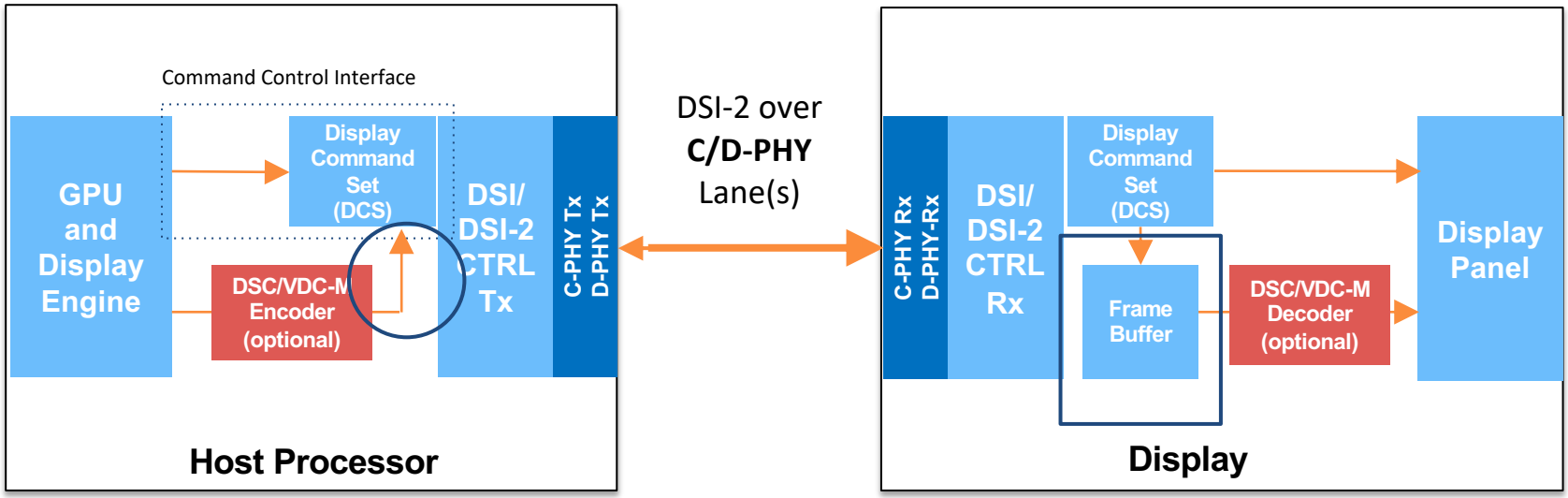
Each symbol replicates a portion of video timing

Transmission Mode: Burst mode

→ Extra nap time for the processor

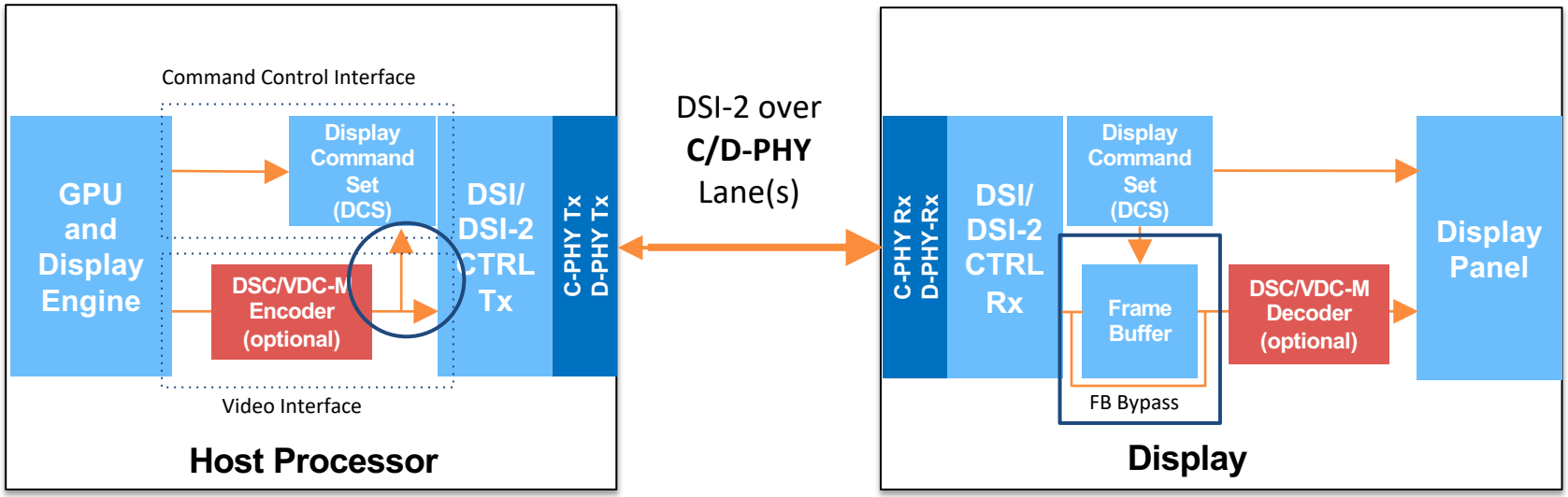


Transmission Mode: Command Mode



Full Command Mode Host and Display Architecture

Mixed Architecture for Multiple Transmission Modes



Mixed Command Mode / Video Mode Host and Display Architecture

Latest Updates in DSI-2 Version 2.0

- **Video-to-command mode** enables displays to seamlessly transition from highly immersive video modes to power-saving command modes.
- **Adaptive refresh panel (ARP)** lowers the processor and interface refresh rate for displays capable of long image retention time. Saving power without requiring a frame buffer.
- **Latest VESA® Display Stream Compression (VESA DSC) and VESA Display Compression-M (VDC-M) codecs** lower power consumption and potentially saves pins between the host and display.

Display Bandwidth Challenge in Cars

Video compression as a solution

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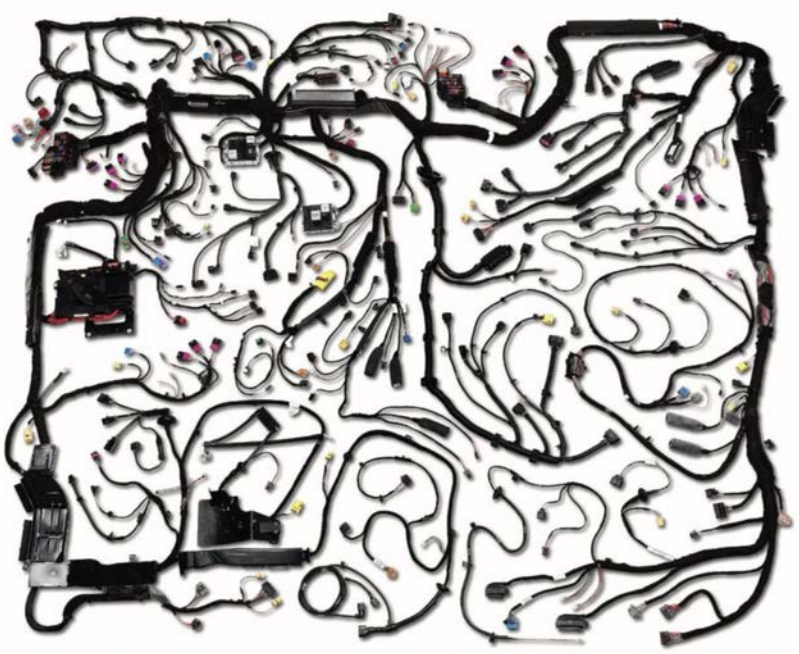
Modern Automotive Cockpit Displays

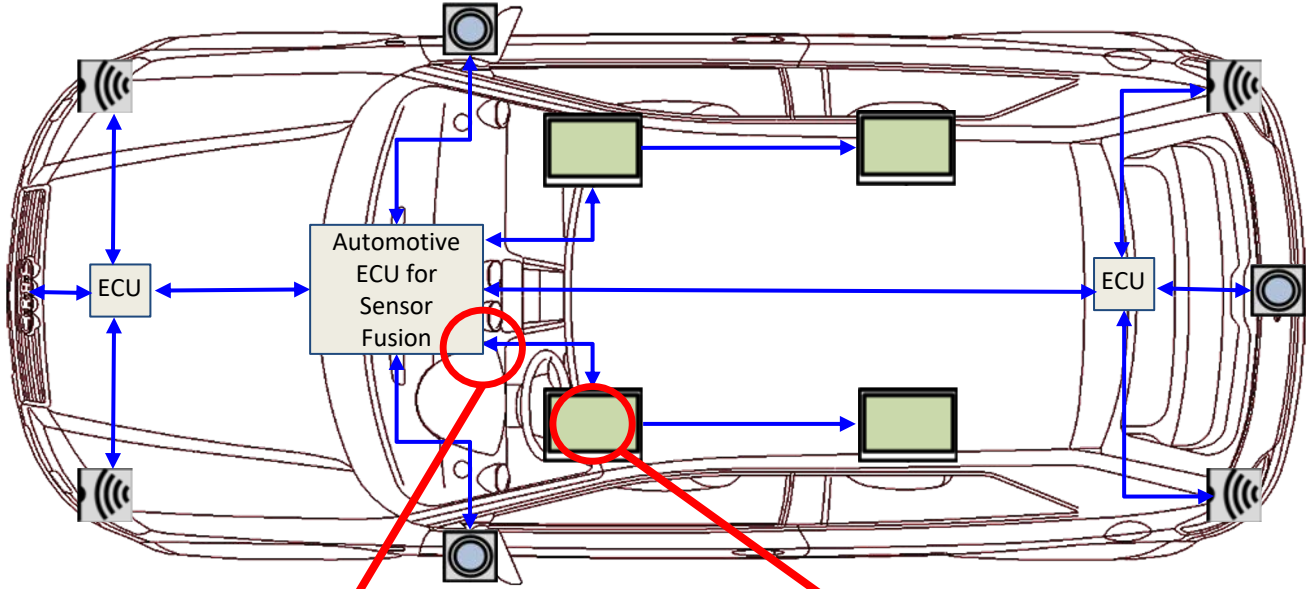
Display Type	Example Size (Inches)	Example Resolution
Left and Right-Side Mirror Displays	7”	1280x800
Driver Instrument Display	12.3”	3840x1440
Center Information Display	12.3”	3840x2160
Extended Co-Driver display	12.3”	3840x2160
Lower Control Display	12.4”	3840x2160

More Displays Yes... But More Cables Is NOT The Solution



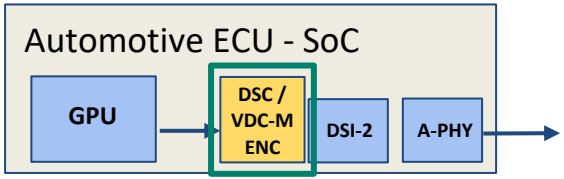
- A car's wiring harness:
  - Represents the **3rd highest cost** component in a car (after the engine and chassis)
  - Comprises **50% of the cost** of labor for the entire car
  - Is a **heavy component** (60kg)
- **Reliability**, **EMI**, and **signal integrity** are major challenges
- For electric-only vehicles, power consumption of video links must be minimized
- FEWER cables reduces many problems!

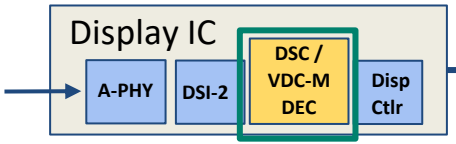
Car Display Systems Using Video Compression



Benefits of using video compression:

- Reduced bandwidth for multiple feeds
- Enhanced image quality (enabling HDR with same bandwidth)
- Savings on expensive cabling
- Lower EMI
- Reduced power





MASS: MIPI Automotive SerDes Solutions

A Vision for End-to-End Systems

CSI-2 Camera Source (Pixels)

CSI-2 Protocol

CCI I²C/I3C or In-Band

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CSI-2 over C-/D-PHY

CSI-2 → A-PHY SerDes Tx

A-PHY → CSI-2 SerDes Rx

CSI-2 over C-/D-PHY

CSI-2 Protocol

Linux Driver

CCI I²C/I3C or In-Band

CCS

CSI-2, DSI-2, eDP/DP Processors

Camera Data Sink (Image Signal Processor)

Display Data Source (Graphics Display Processor)

Linux Driver

DCS

Display Source

Display Source

VESA

VESA Protocol(s) eDP/DP/DSC

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DSI-2 Protocol(s) DSC/VDC-M

eDP/DP

eDP/DP → A-PHY SerDes Tx

DSI-2 over C-/D-PHY

DSI-2 → A-PHY SerDes Tx

A-PHY → eDP/DP SerDes Rx

eDP/DP

VESA

VESA Protocol(s) eDP/DP/DSC

Display Sink (Pixels)

A-PHY → DSI-2 SerDes Rx

DSI-2 over C-/D-PHY

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DSI-2 Protocol(s) DSC/VDC-M

Display Sink (Pixels)

A-PHY

Functional Safety

Security

HDCP

VESA Video Compression Codecs

Video Electronics Standards Association

- 2013: DSC Task Group formed
- 2014: **DSC** released
- 2018: **VDC-M** released

Features	Display Stream Compression (DSC) 1.2b	VESA Display Compression-M (VDC-M) 1.2
Visually lossless compression performance verified by subjective testing		
30 bit color, compression ratio (bits/pixel)	3.75:1 (8 bpp)	5:1 (6 bpp) *& 6:1 (5bpp)*
24 bit color, compression ratio (bits/pixel)	3:1 (8 bpp)	4:1 (6 bpp) *& 6:1 (4bpp)*
IC complexity	Low	Medium
Backwards compatibility	DSC 1.x	VDC-M 1.x
Both encoder and decoder are specified	✓	✓
Normative C language code	✓	✓
Frame-by-frame compression	✓	✓
8, 10, 12 bits per color support	8/10/12/14/16	8/10/12
High Dynamic Range-ready	✓	✓
RGB and YCbCr 4:4:4 native encoding	✓	✓
YCbCr 4:2:0 or 4:2:2 native encoding	✓	✓
Image test database available from VESA	✓	✓
Compliance test guideline and test scripts	✓	✓
Publicly known adopting standards	MIPI DSI-2℠ v2.0, HDMI® 2.1 VESA DP™ 2.0 & eDP 1.4b	MIPI DSI-2 v2.0

Source: VESA

MIPI Automotive 6:1 Image Compression Study

1. **MIPI automotive dashboard images**
2. **Selected ISO/IEC 29170-2:2015 Subjective Trials protocol**
   - Optimized for low-impairment compression visual quality analysis
3. **Expert reviewers evaluated images**
4. **Generated report results**
   - All images passed a limited expert review
     - *For automotive applications,* ***VDC-M 6x compression is visually lossless***
   - MIPI whitepaper “Validating the Use of Compression for Automotive Displays”
     - *Download: resources.mipi.org/download-mipi-whitepaper-automotive-display-compression*

VDC-M Visually Lossless Quality Assessment

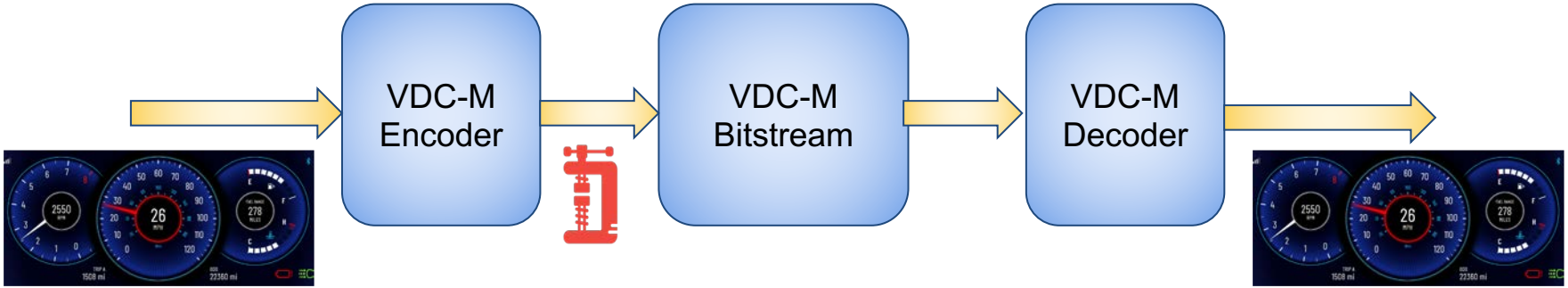
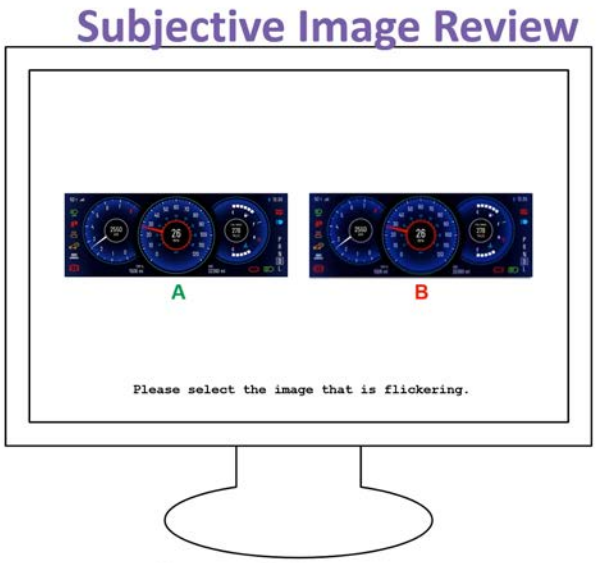


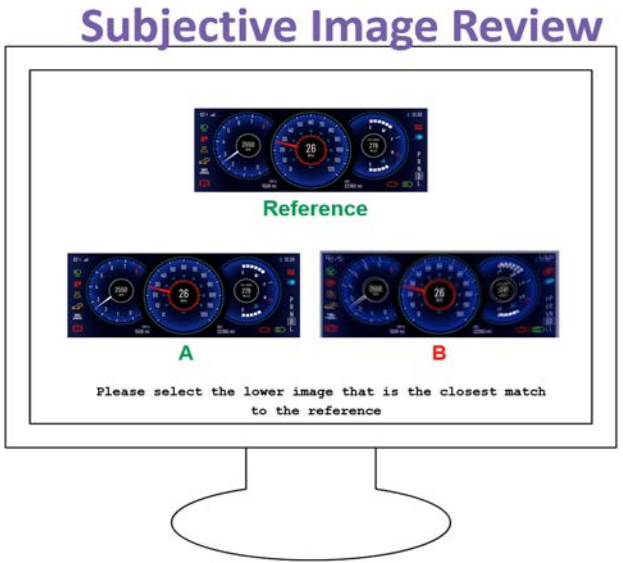
Image A
(Reference)

Image A’
(Compressed)

ISO/IEC 29170-2:2015 Subjective Trials Protocol

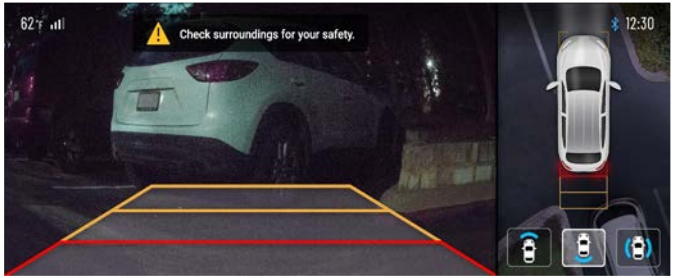


Exaggerated 5 Hz Flicker Image Comparison

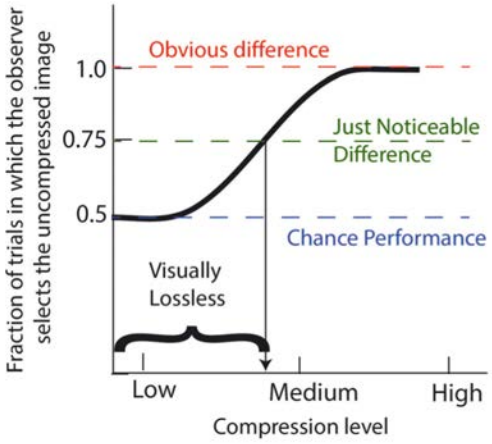


Exaggerated Static Image Comparison

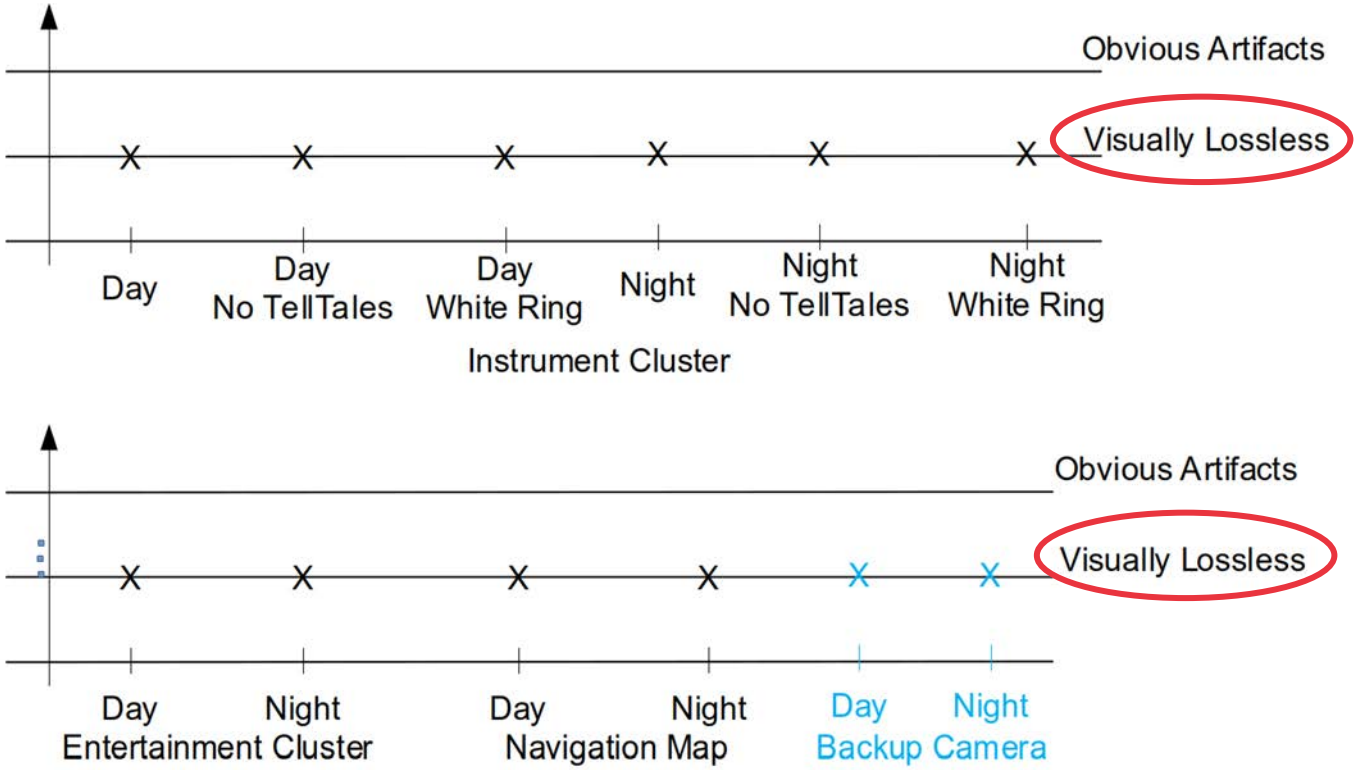
Summary of MIPI Commissioned Test Images



ISO Quality Results Report



Source: Hoffman & Stolitzka, 2015



Automotive Display Bandwidth: Case Study

Display Parameters							Total Bandwidth (Gbps)		MASS
Display Config	Driver Instrument Display (DID) 12"	Centre Information Display (CID) 10.2"	Lower Control Display (CLD) 10.2"	CoDriver Display (CDD) 12"	Left Side Mirror 3.6"	Right Side Mirror 3.6"	Src 30-bit	VDC-M Comp 5bpp (6:1)	Minimum A-PHY Gear Required
1	1280x720	1280x720	None	None	None	None	3.558	0.593	G1
2	1920x720	1920x720	1920x720	None	None	None	8.007	1.335	G1
3	3840x1440	3840x1440	3840x1440	3840x1440	None	None	41.824	6.971	G3
4	3840x2160	3840x2160	3840x2160	3840x2160	640x390	640x390	63.694	10.616	G4
5	5120x2160	3840x2160	3840x2160	5120x2160	640x390	640x390	74.136	12.356	G5
6	5120x2160	7680x2800	3840x2160	5120x2160	None	None	98.89	16.482	G5 2 lanes
7	7680x2800	7680x2800	7680x2800	7680x2800	640x390	640x390	166.558	27.760	G5 2 lanes

Video Compression for Automotive Displays

Is it safe?

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Functional Safety in Display Applications

- Display systems, when involved in ADAS, are required to meet ASIL and ISO 26262 requirements

Safety Critical Information!

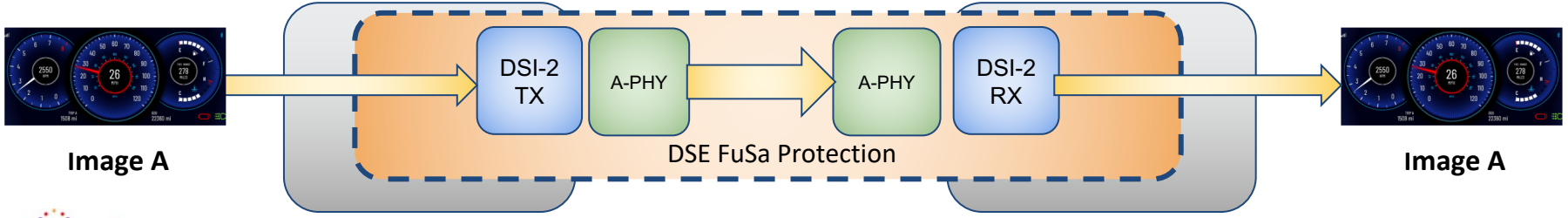
MIPI DSE - Display Service Extensions

MIPI DSE protocol adds Functional Safety (FuSa) features for displays:

- SEP
- Message Counters
- CRCs

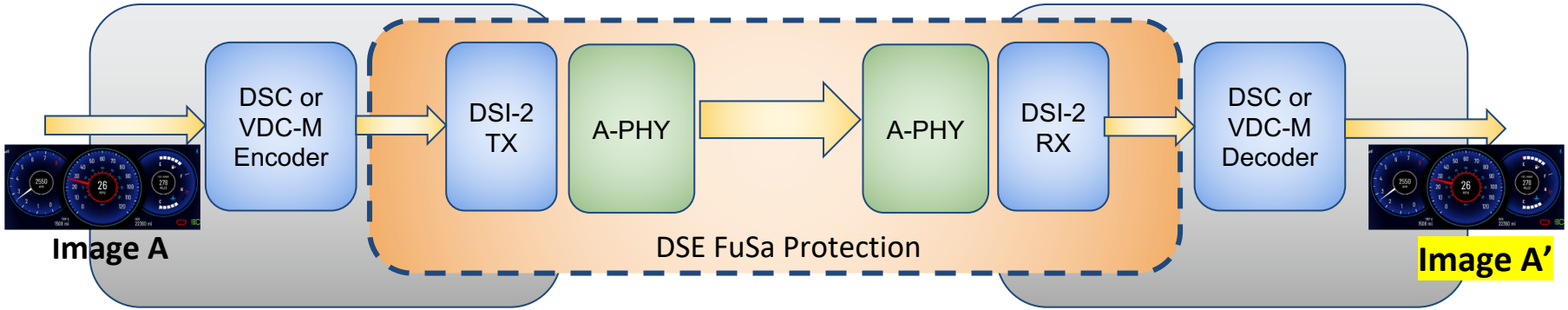
	MIPI Display	VESA Display
Protocol Layers	MIPI DCS	
	MIPI DSE Functional Safety Security* HDCP	MIPI DSE Functional Safety Security* HDCP
	MIPI DSI-2	VESA eDP / DP
Protocol Adaptation Layer (PAL)	MIPI PAL/DSI-2	MIPI PAL/eDP-DP
Link Layer	MIPI A-PHY Link Layer	MIPI A-PHY Link Layer
Physical Layer	MIPI A-PHY Physical Layer	MIPI A-PHY Physical Layer

* To be added in a future release



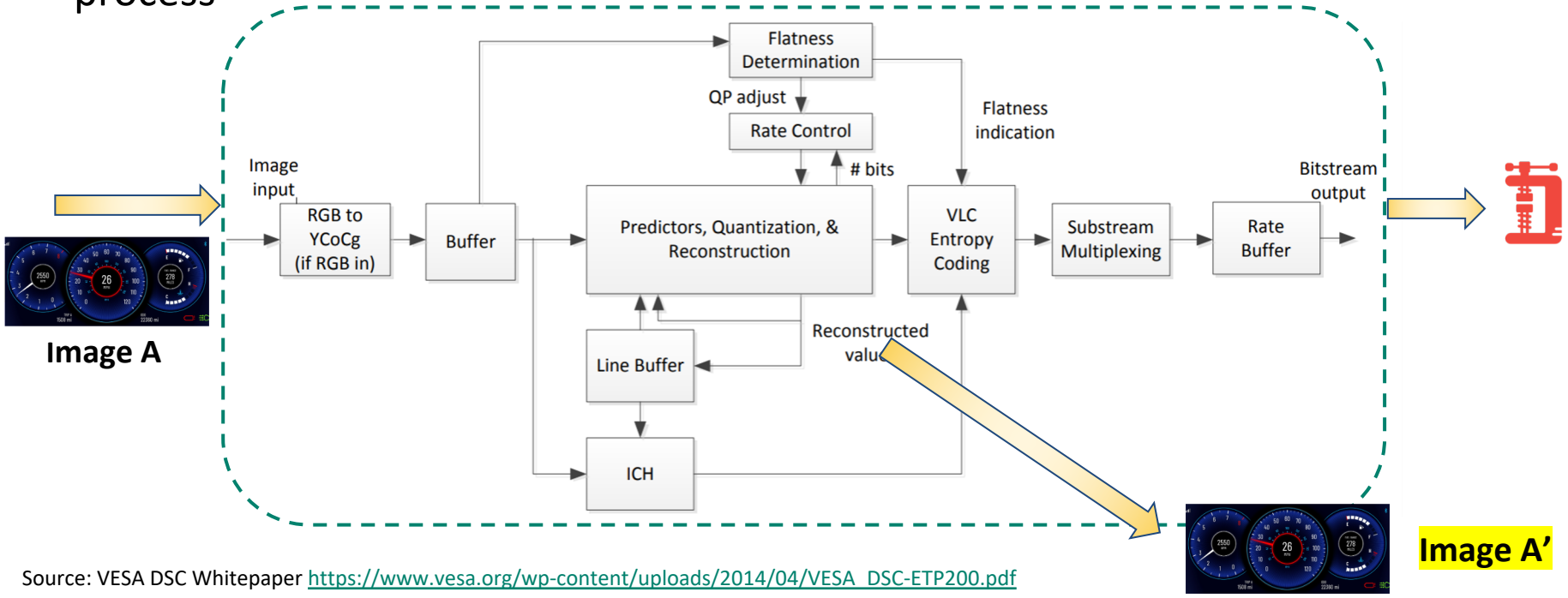
Additional Challenge with Video Compression

- When compression is used, the compressed image payload and DSI-2 packets are protected by DSE FuSa, but not the image content itself
- However…
  - Failures could occur during the encoding or decoding process
  - Even when there is no failure, the decoded image is NOT identical to the original image (it is visually lossless but not bit exact)



FuSa with DSC & VDC-M Video Compression

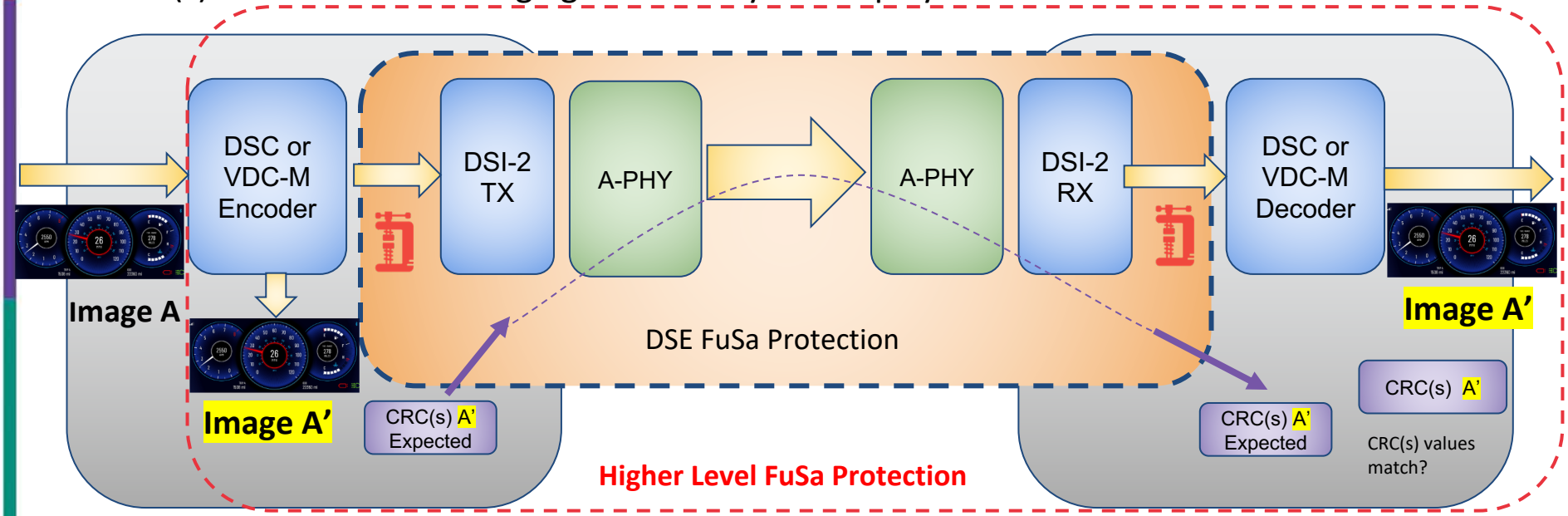
- For DSC and VDC-M, the decoded image is generated during the encoding process



Source: VESA DSC Whitepaper https://www.vesa.org/wp-content/uploads/2014/04/VESA_DSC-ETP200.pdf

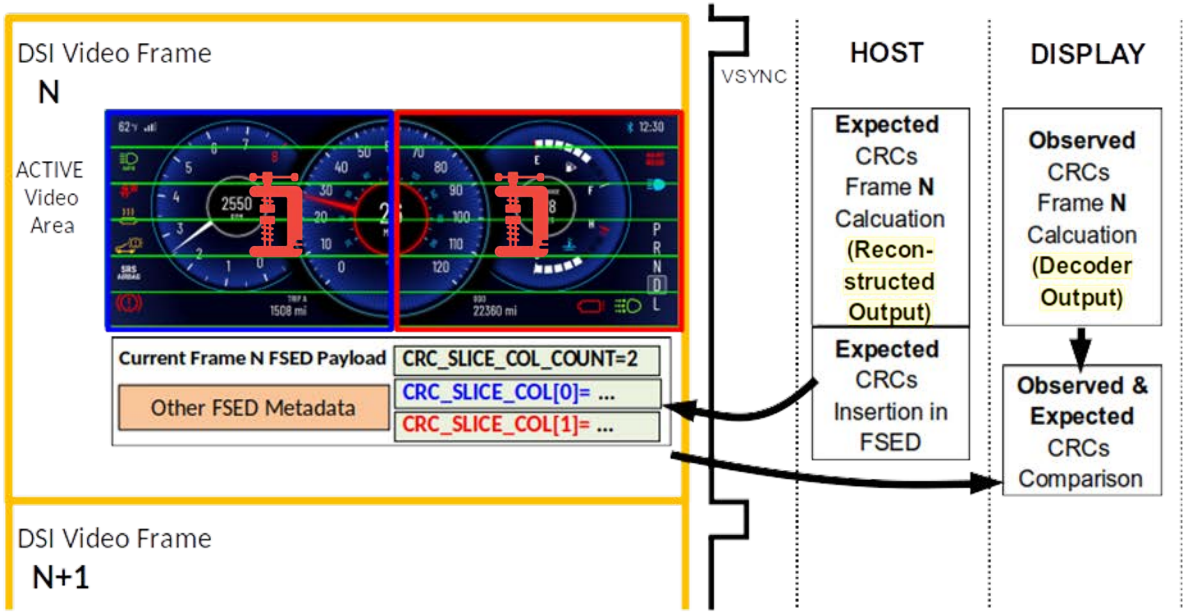
FuSa with DSC & VDC-M Video Compression

- The integrity of the decompressed image in the display can be verified by comparing the CRC(s) of the decoded image generated by the encoder with the CRC(s) of the decoded image generated by the display



MIPI DSE : Support for FuSa Compression CRCs

- Per “Slice Column” Decoded Image CRCs are calculated in both the Host (**Expected**) and the Display (**Observed**)
- **Expected** CRCs inserted in Frame Service Extension Data (FSED)
- Comparison of **Expected** and **Observed** CRCs in the display



FuSa with DSC & VDC-M Video Compression

- **Benefits of the Decoded Image CRC(s) approach:**
  - **End to end protection** that includes compression / decompression
  - Easy to implement, **low area footprint**, removes the need for duplicated logic (a common technique for fault detection)
  - **Very high safety goal violation coverage** for both Single Point Faults (SPF) “Stuck bits” and Transient Faults (TF) “Glitches”, for the whole display subsystem
- With the addition of Decoded Image CRC(s) when DSC or VDC-M compression is used, it becomes possible to meet the safety goals

Conclusions

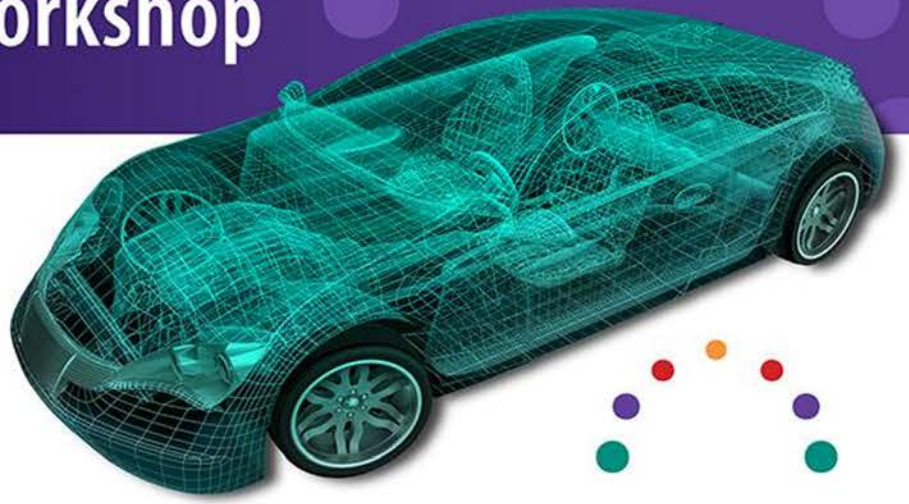
- MASS incorporates DSI-2, a simple, efficient, and low power display protocol offering high scalability and flexibility
- Video compression is essential for meeting the bandwidth requirements of current and future automotive display applications
- VESA DSC & VDC-M offer proven visually lossless performance
- Using video compression for automotive applications offers many benefits and it can be used safely with SerDes solutions

Additional Information

- **MIPI Display Serial Interface**
  - www.mipi.org/specifications/dsi
- **MIPI Display Serial Interface-2**
  - www.mipi.org/specifications/dsi-2
- **MIPI Display Command Set**
  - www.mipi.org/specifications/display-command-set
- **MIPI Display Services Extensions**
  - www.mipi.org/specifications/mipi-dse
- **MIPI Bytes Video: Introduction to the Video Compression Standards Within MIPI DSI-2**
  - www.mipi.org/resources/knowledge-library/videos
- **MIPI Whitepaper: Validating the Use of Compression for Automotive Displays**
  - resources.mipi.org/download-mipi-whitepaper-automotive-display-compression
- **VESA Compression Codecs**
  - vesa.org/vesa-display-compression-codecs

MIPI Automotive Workshop

An in-depth look at the MIPI Automotive SerDes Solutions (MASS) framework



Q&A