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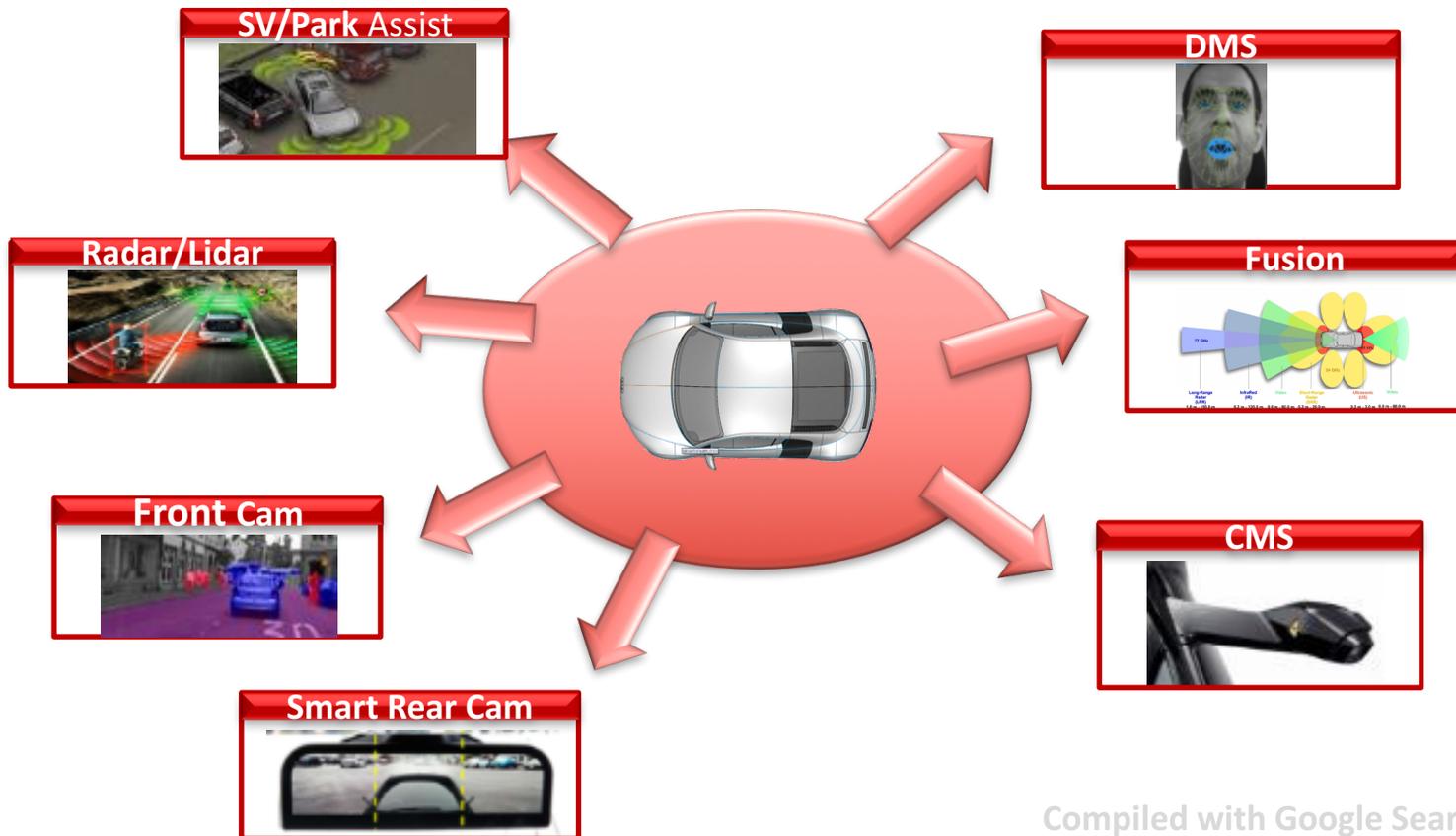
## **ADAS High Bandwidth Imaging Implementation Strategies**

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# Automotive Imaging Applications



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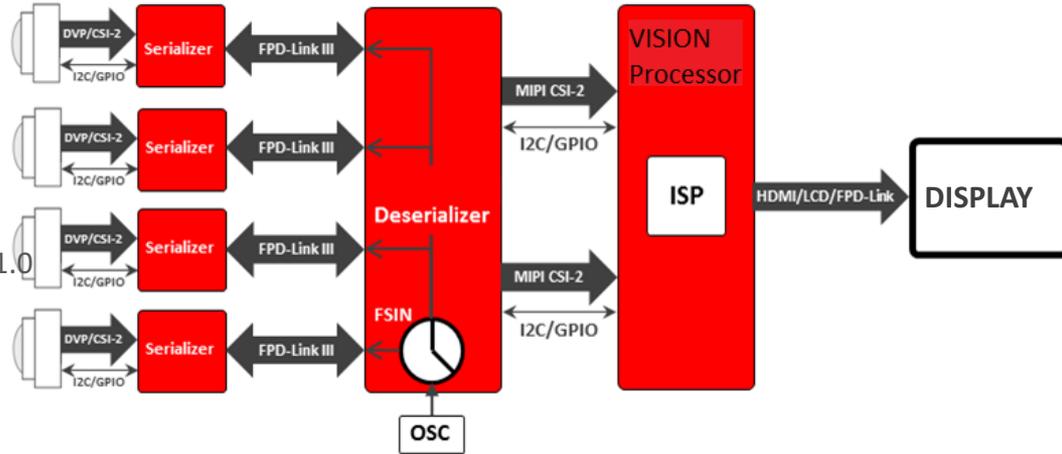
# Challenges

- **High Bandwidth Requirements**
  - Faster frame rate
  - Higher sensor resolution
  - High dynamic range (multiple exposures per pixel)
- **Multi-Camera Systems**
  - Numerous image/video formats
  - Single processor to process video inputs from all cameras
  - Need to distinguish amongst video streams
  - Multi-modal fusion
- **SoC Design Constraints**
  - Package: Minimal pin count
  - Routing: Signal integrity
  - Lower cable usage
- **Automotive Quality & Safety**
  - Need to maintain signal integrity for interface distance > 20 ft

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# Example Solutions

- **FPD Link Deserializer**
  - Quad hub chip
  - Each camera connected through FPD-Link cable
  - VC tag for individual camera streams
  - Mux 4 cameras into a single CSI-2<sup>SM</sup> stream
- **Vision Processor**
  - Rx module fully compliant with MIPI CSI-2<sup>SM</sup> spec 1.0
    - Future: 32 Virtual Channels
  - Up to 6.0 Gbps throughput
  - HW support to parse CSI-2<sup>SM</sup> streams
  - High speed, multi channel image processor
  - Vision accelerators: HW IPs + Programmable Core

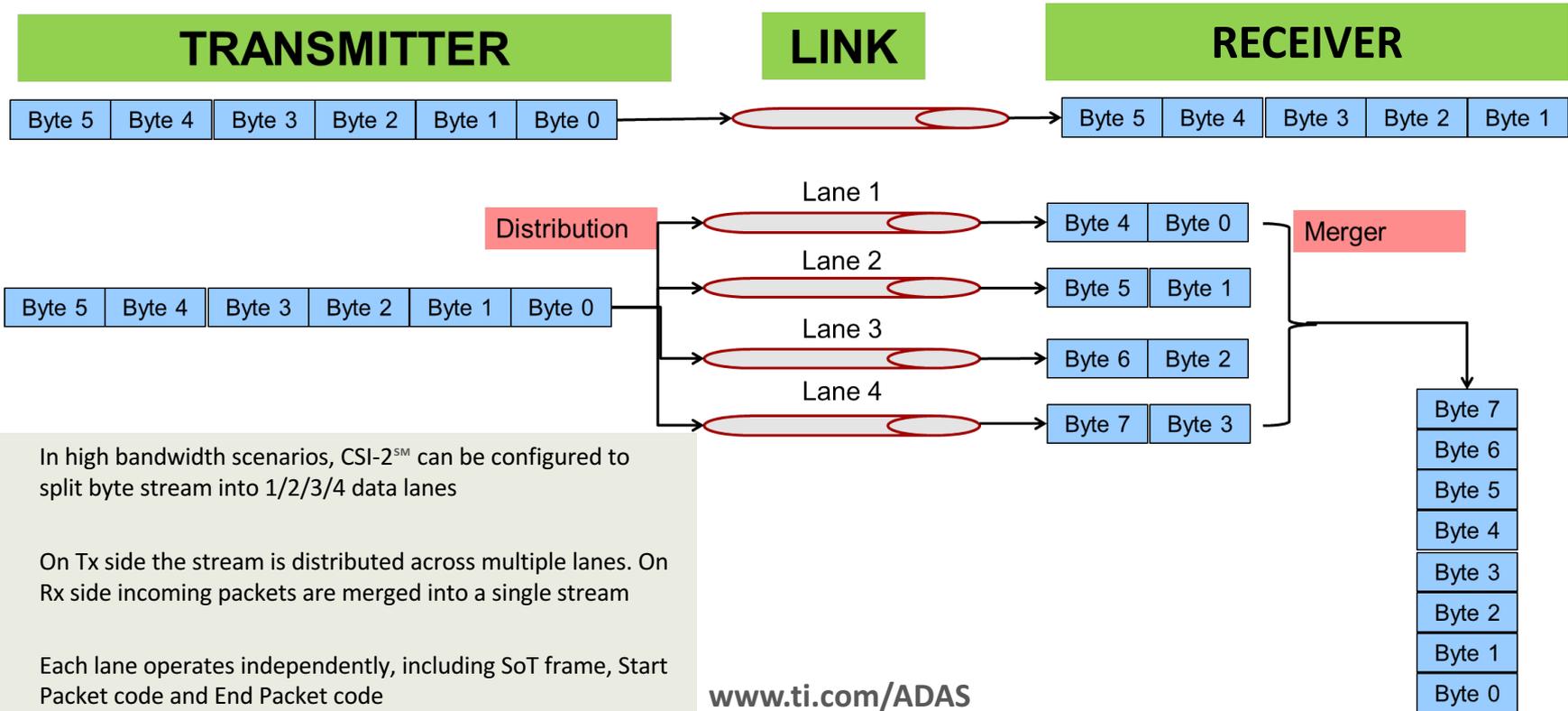


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# Why MIPI CSI-2<sup>SM</sup> in Automotive

- Low power
  - High speed transfers
  - Low pin count
    - Flexibility in choosing 1/2/3/4 lane(s)
  - Standardized vs Proprietary protocols
    - Easy to interface a wide range of transmitters and receivers
  - Virtual channels
    - Allows connections of multiple devices to the same bus
- Error detection and recovery
    - Sync codes
    - ECC codes
    - 16-bits CRC Checksum
  - Safety
    - Safety related meta-data along with pixel data

# MIPI CSI-2<sup>SM</sup> Lane Scalability

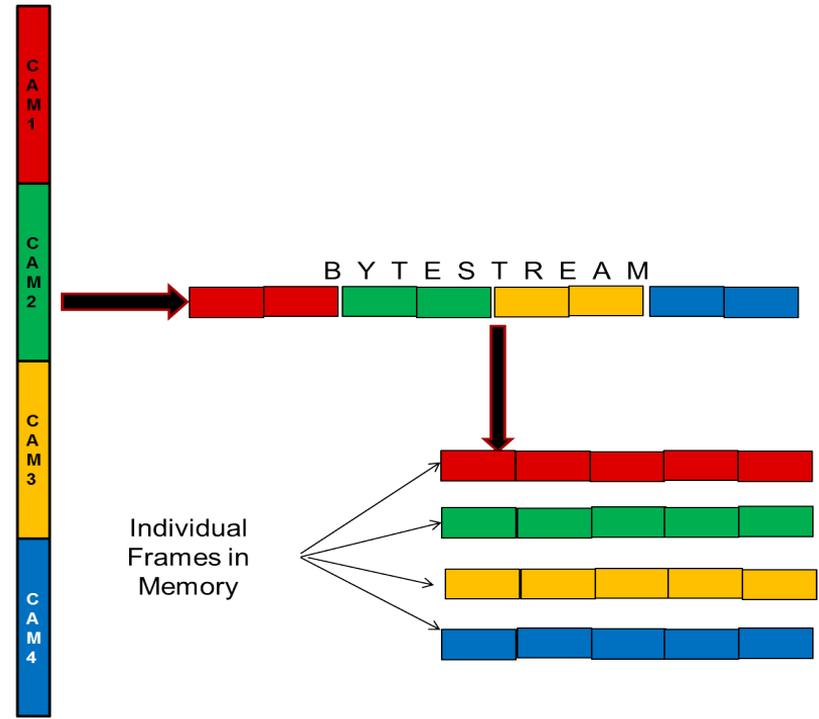


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- In high bandwidth scenarios, CSI-2<sup>SM</sup> can be configured to split byte stream into 1/2/3/4 data lanes
- On Tx side the stream is distributed across multiple lanes. On Rx side incoming packets are merged into a single stream
- Each lane operates independently, including SoT frame, Start Packet code and End Packet code

# Virtual Channels and Data Types

- Each CSI-2<sup>SM</sup> packet has a “Data Identifier” field, which specifies the payload Data Type (DT) and Virtual Channel (VC) number it carries
- Different data types from different sources can be merged into a single stream
- CSI-2<sup>SM</sup> Rx uses DT and VC fields to distinguish amongst different packets and process them accordingly
- Examples:
  - Pixel data vs embedded data
  - Data from different cameras multiplexed into a single CSI-2<sup>SM</sup> stream
  - Multi-exposure WDR where L/M/S pixels are coming in a single stream.



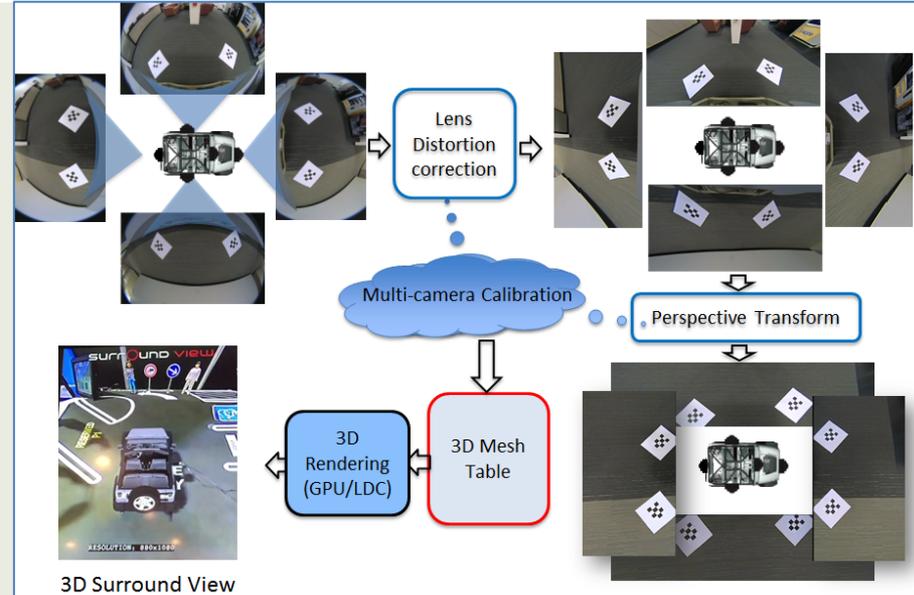
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# Example – Surround View

- 4x Full HD Cameras – Throughput requirement > 3 Gbps
- Each camera sends a high resolution RAW stream at a high frame rate
- Surround View Application (SRV)
  - 4:1 Deserializer Hub (DS90UB96x)
    - Synchronizes video inputs across multiple cameras
    - Aggregates camera streams from four sides of the vehicle
    - Tags each camera stream with unique VC and meta data
    - Multiplexes into a single stream
    - Sends over CSI-2™ interface to the host processor

## Host Processor (TDAx)

- Receives the incoming stream
- Parses each packet, identifies the camera stream based on VC
- Obtains 4 independent video stream in separate buffer queues
- Applies complex SRV image processing algorithms



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# Example – Surround View

## What is Surround View?

### Description:

- 360 degree Bird's Eye View using multiple cameras

### Key Care Abouts for Surround View:

- **Safety**
  - Gives more visibility around the vehicle
- **Convenience**
  - Enables features such as park assist
- **Autonomy**
  - Enables autonomous functions like self parking



## What are the options for Surround View?

### Surround View Configurations:

#### 4 Cameras

#### 2D



#### 3D

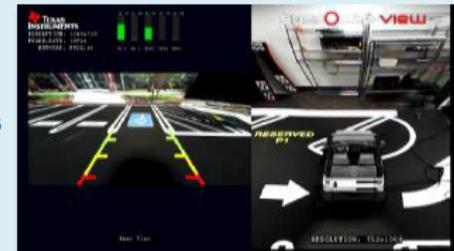


#### ADAS Features

- Park Assist
- Self Parking
- Obstacle Detection

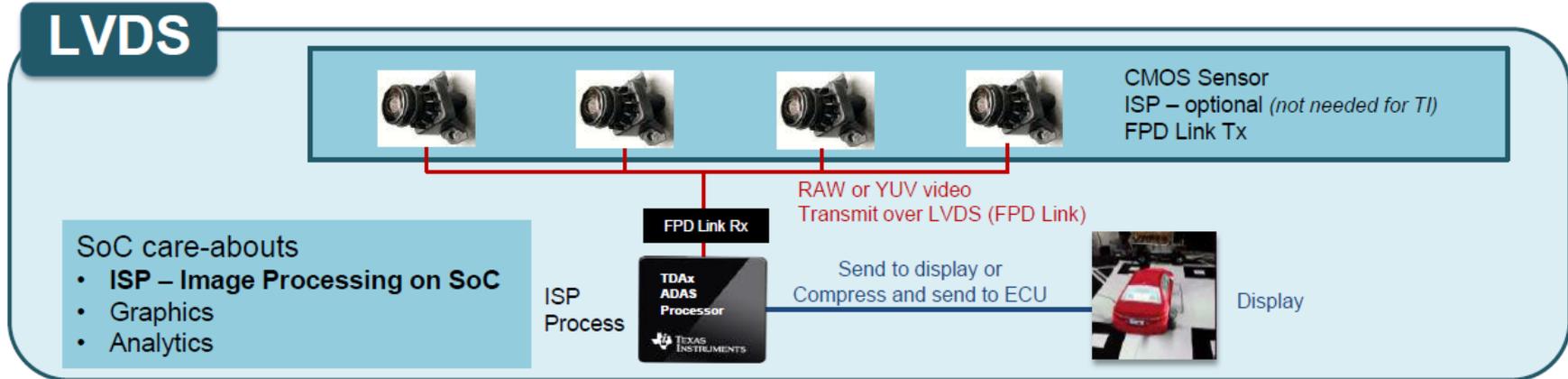
### Variations:

- Additional Cameras
  - Hitch
  - Truck Bed



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# Surround View Configuration



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# Surround View Solution

## Challenges

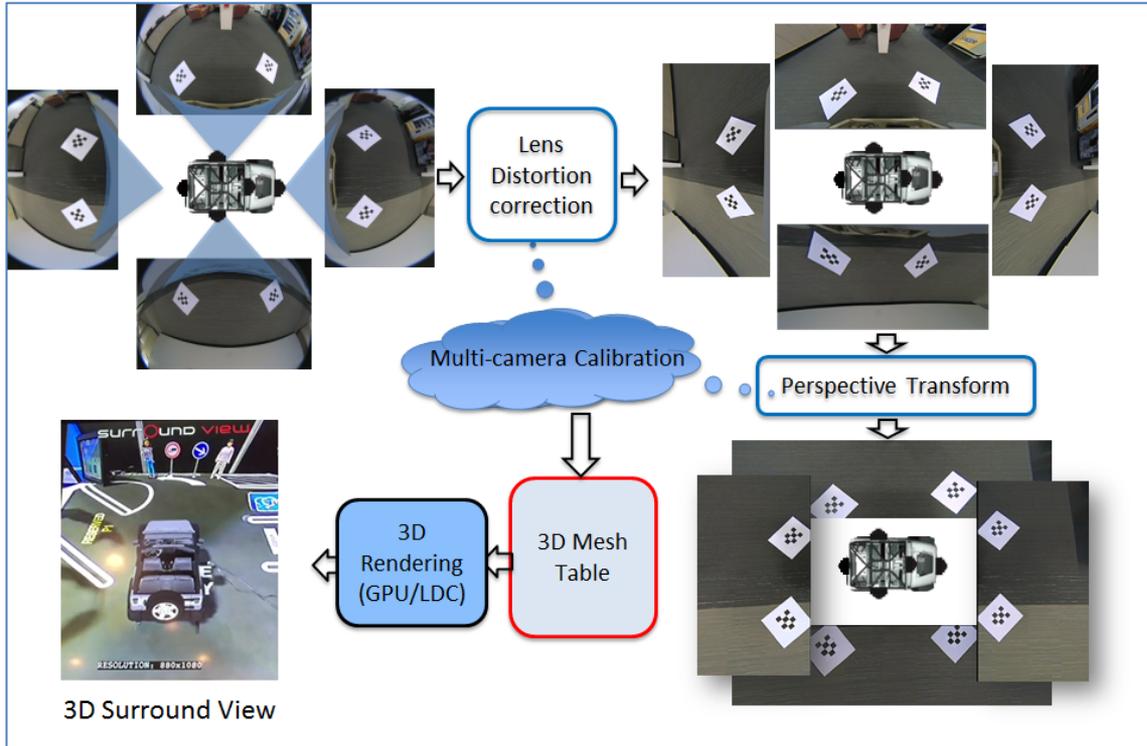
- High Data Rate – Up to 3 Gbps
- High Pin Count – To support multiple cameras
- Long Channel Length – Cameras located far away from the processor
- Sync – All cameras must be synchronized to eliminate motion artifacts

## MIPI CSI-2<sup>SM</sup> to the rescue

- 4-lane interface for High Speed Data Transfer
- Support for Virtual Channels and Data Types
  - Allows multiple camera streams to be muxed into a single CSI-2<sup>SM</sup> stream
  - Processor can identify a CSI-2<sup>SM</sup> packet using VC and DT info
- CSI-2<sup>SM</sup> enabled SerDes chips allow long channel length over FPD Link
  - Act as 4-camera hub
  - Implements sync across all cameras

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# Surround View Flow



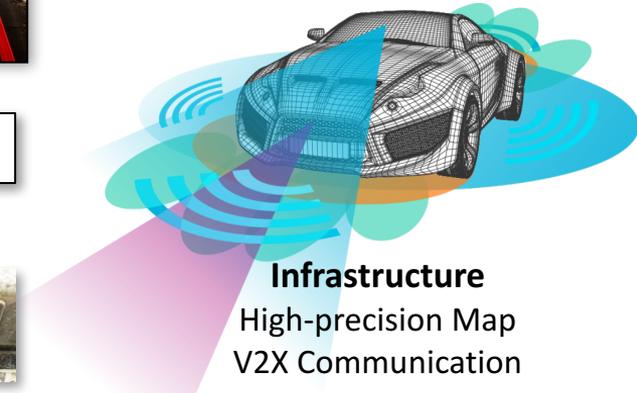
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# Example – Multi-Modal Fusion



**Passive Sensor**  
Camera

**Active Sensor**  
Radar, Lidar, Ultrasound



■ **Mid and Long Range**  
Adaptive Cruise Control,  
Emergency braking, Fully/Highly  
Autonomous Driving

■ **Short Range and Ultra Short Range**  
Blind Spot, Collision Avoidance, Lane Change  
Assist, Pedestrian Detection, Park Assist

■ **Proximity Sensors**  
Occupant Detection, Gesture  
Recognition, Driver Monitoring

# Fusion Solution

## Challenges

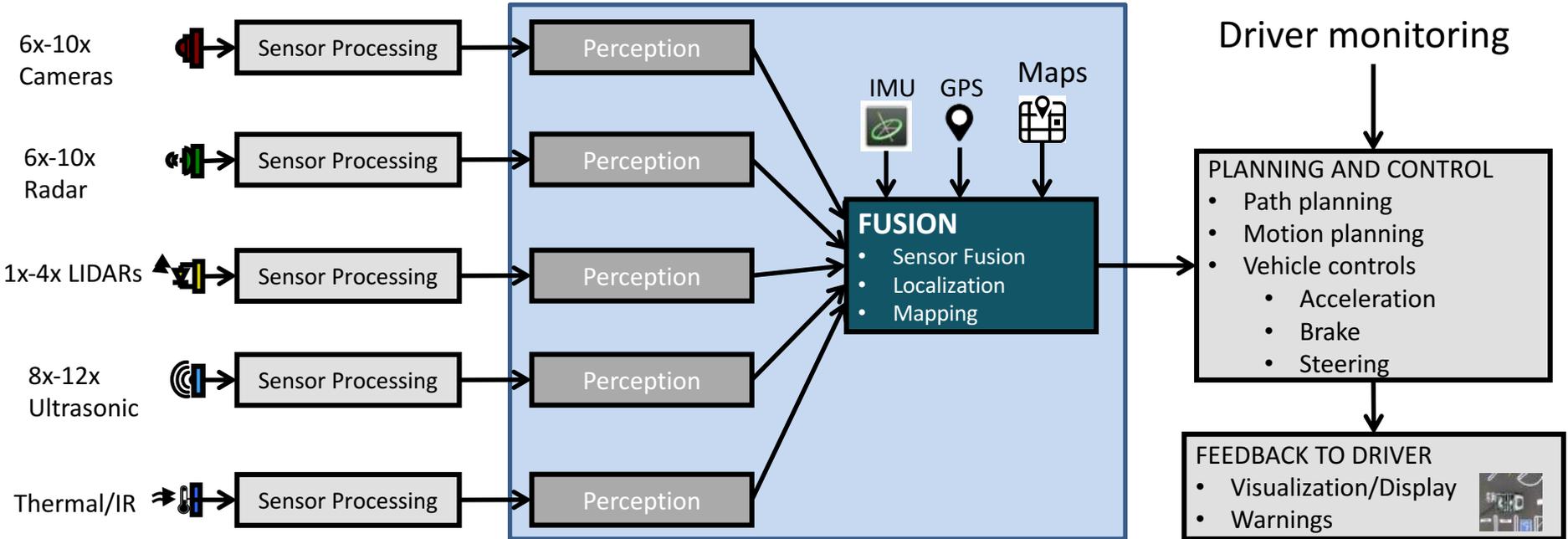
- High Data Rate – 1 Gbps/Camera + 2.4Gbps/Radar
- High PIN Count – To support large number of devices
- Imaging Format Variations – Need a standard protocol for imaging and non imaging devices

## MIPI CSI-2<sup>SM</sup> to the rescue

- 4-Lane interface for High Speed Data Transfer.
- Ability to MUX Camera/Radar/LIDAR
- Processor can identify the source using VC and DT
- CSI-2<sup>SM</sup> specification easily extends to non imaging devices like Radar.
  - No design change needed at the processor Rx interface
  - Serializer and Deserializer chips for FPD link transmission can process Radar stream exactly like camera.

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# Fusion – SLAM (Simultaneous Localization and Mapping)



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# Summary

MIPI CSI-2<sup>SM</sup> is gaining popularity in Automotive industry because of the following benefits

- **High Bandwidth:** Total 6.0 Gbps. Allows 4x 1080p cameras on a single Processor
- **Low pin count:** Scalable from 6 - 12
- **Multi Camera/Multi Modal Architecture:** Efficient use of Virtual Channel and Data Types
- **Quality:** SerDes solutions converts image signal from digital to analog form. FPD link cable transports analog signal over long distance without degradation
- **Safety:** TDAXx processors has advanced capability for error detection, recovery, and embed safety data along with pixel data
- **Future:** 32 virtual channels

With more Image sensors, Radar and other devices adopting CSI-2<sup>SM</sup>, the trend is expected to continue and gain momentum in the years to come.

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