



ADAS High Bandwidth Imaging Implementation Strategies

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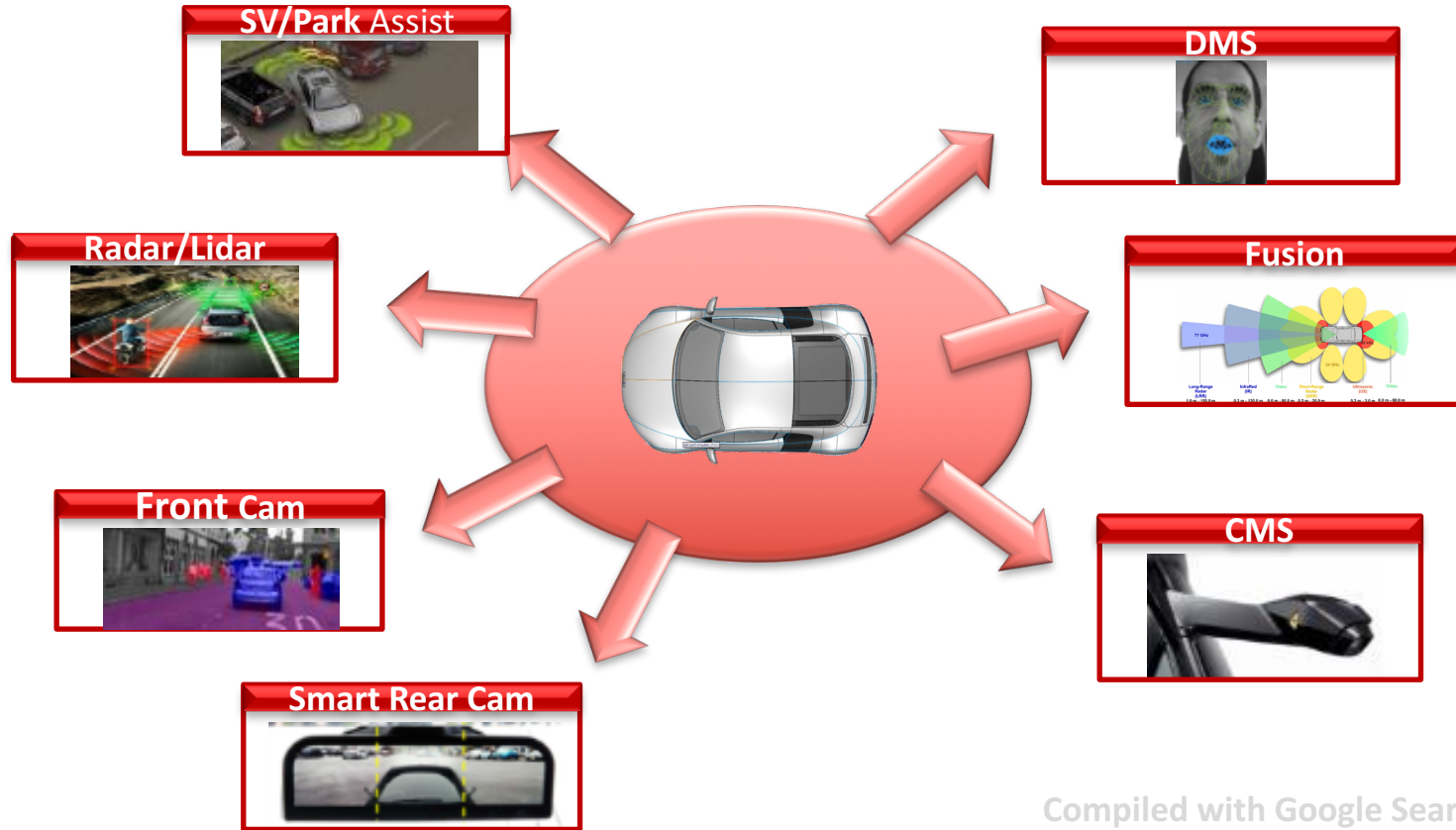
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Automotive Imaging Applications



Compiled with Google Search Images

Challenges

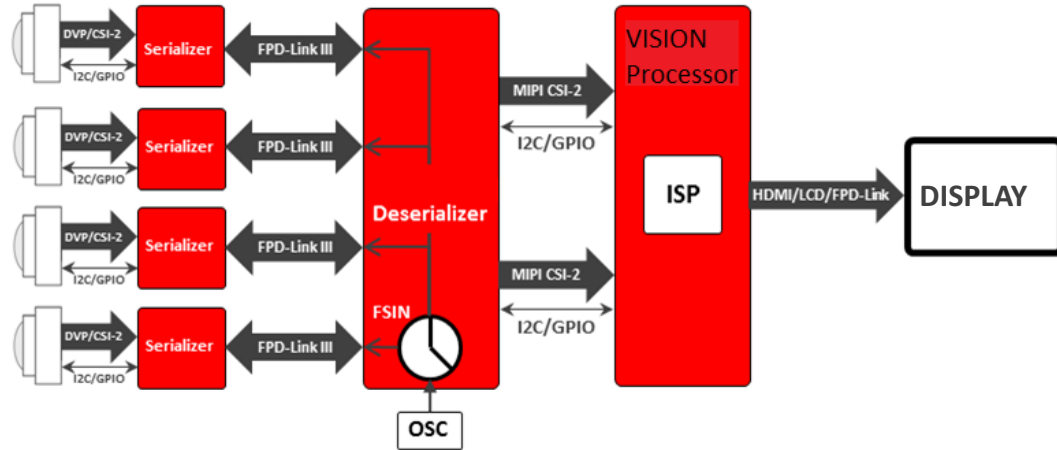
- **High Bandwidth Requirements**
 - Faster frame rate
 - Higher sensor resolution
 - High dynamic range (multiple exposures per pixel)
- **Multi-Camera Systems**
 - Numerous image/video formats
 - Single processor to process video inputs from all cameras
 - Need to distinguish amongst video streams
 - 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-2SM stream

- **Vision Processor**
 - Rx module fully compliant with MIPI CSI-2SM spec 1.0
 - Future: 32 Virtual Channels
 - Up to 6.0 Gbps throughput
 - HW support to parse CSI-2SM streams
 - High speed, multi channel image processor
 - Vision accelerators: HW IPs + Programmable Core

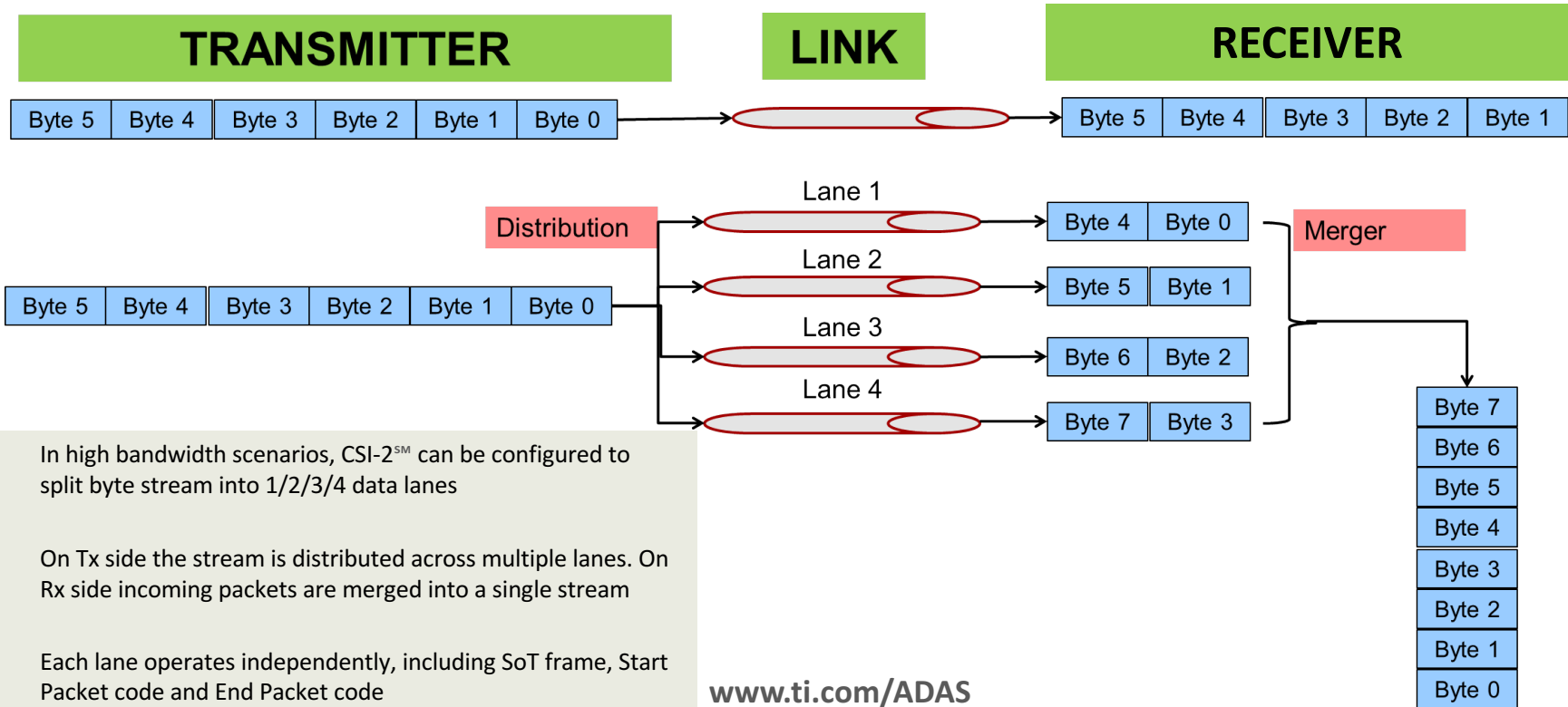


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Why MIPI CSI-2SM in Automotive

- 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-2SM Lane Scalability

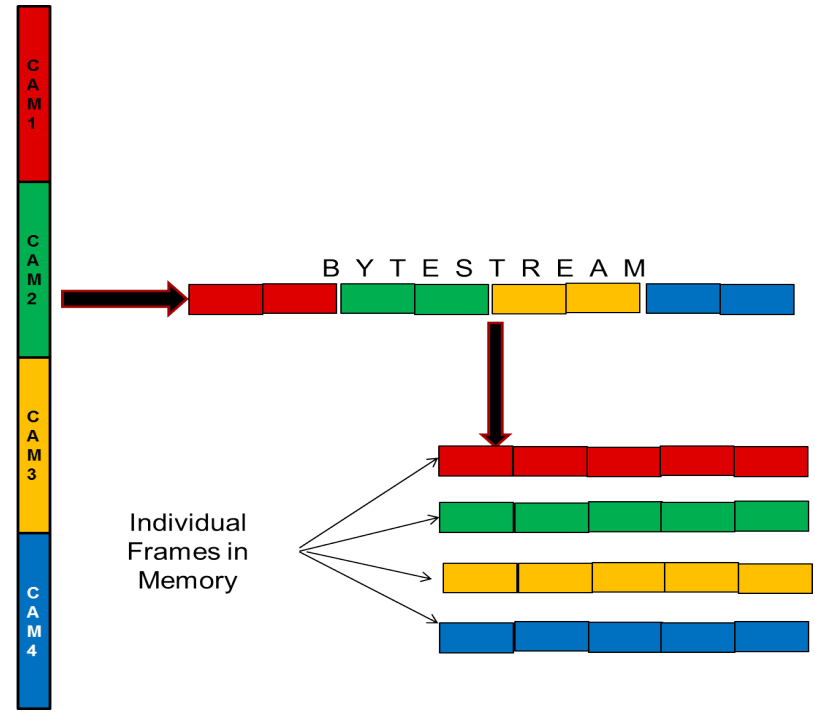


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- In high bandwidth scenarios, CSI-2SM can be configured to split byte stream into 1/2/3/4 data lanes
- On Tx side the stream is distributed across multiple lanes. On Rx side incoming packets are merged into a single stream
- Each lane operates independently,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

Virtual Channels and Data Types

- Each CSI-2SM 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-2SM 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-2SM stream
 - Multi-exposure WDR where L/M/S pixels are coming in a single stream.



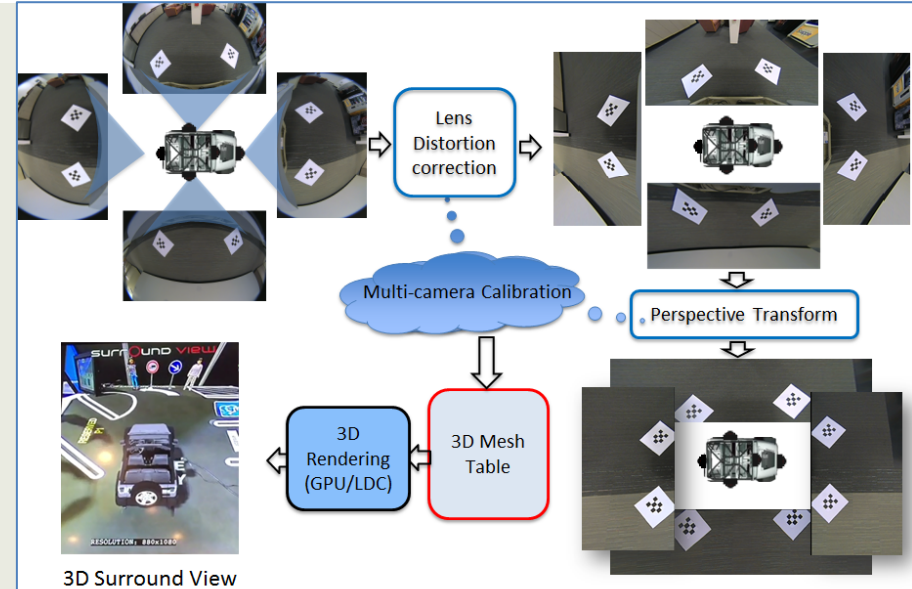
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Example – Surround View

- 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

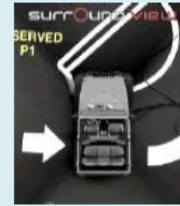


What are the options for Surround View?

Surround View Configurations:

4 Cameras

2D



3D

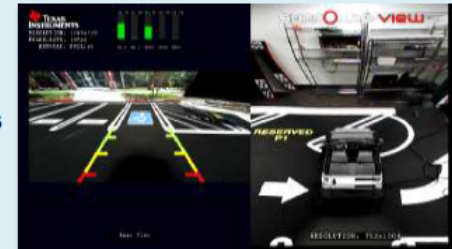


ADAS Features

- Park Assist
- Self Parking
- Obstacle Detection

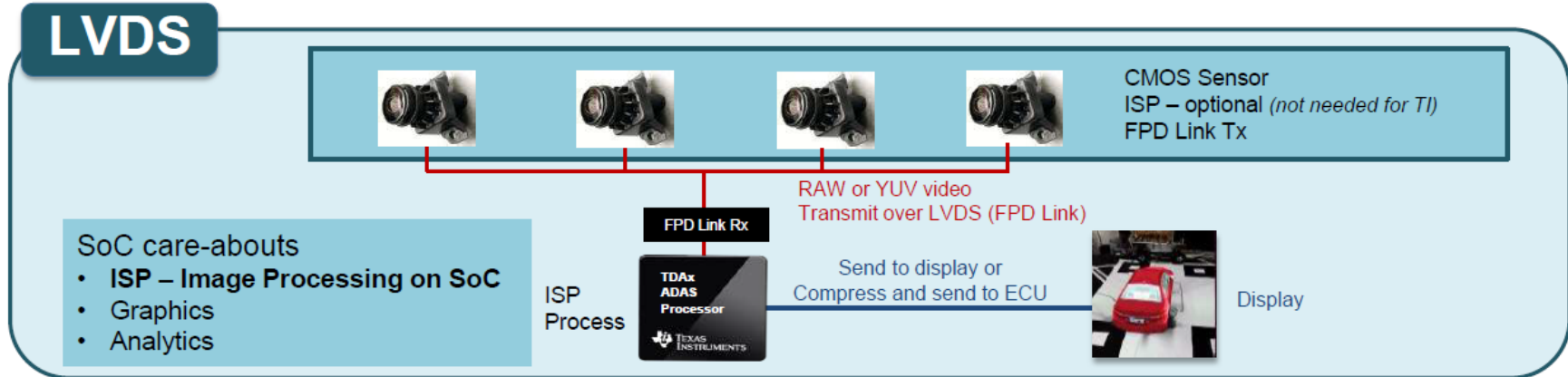
Variations:

- Additional Cameras
 - Hitch
 - Truck Bed



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Surround View Configuration



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Surround View Solution

Challenges

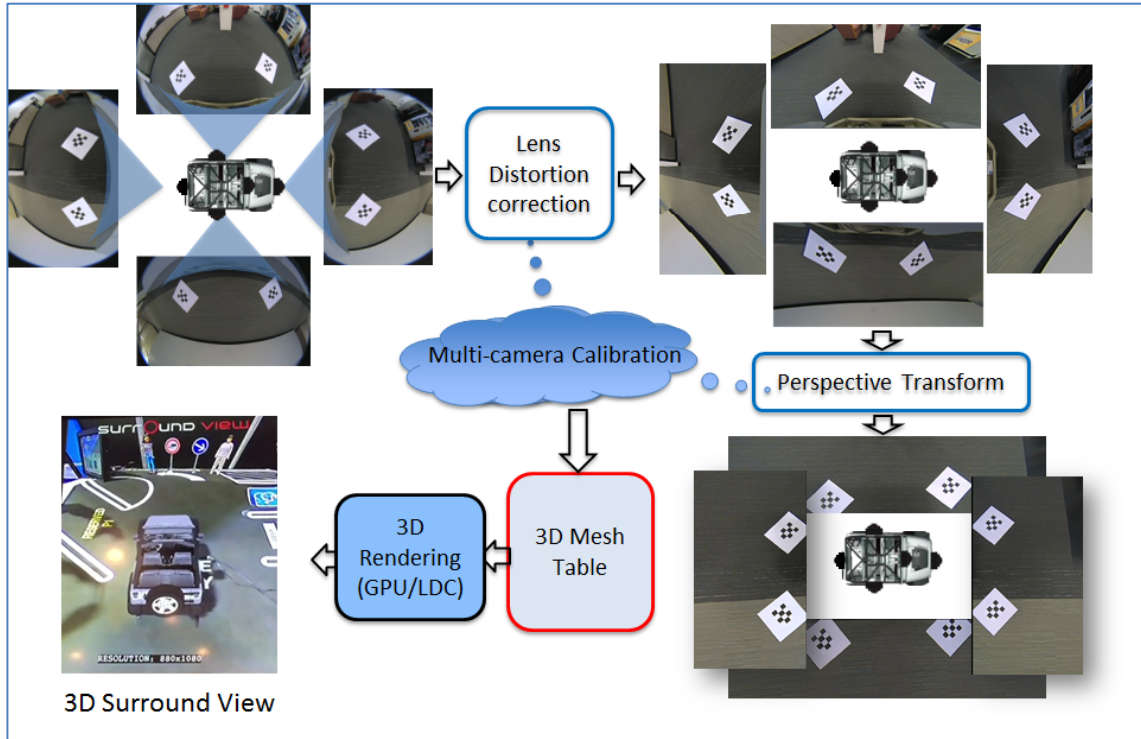
- High Data Rate – Up to 3 Gbps
- High Pin Count – To support multiple cameras
- Long Channel Length – Cameras located far away from the processor
- Sync – All cameras must be synchronized to eliminate motion artifacts

MIPI CSI-2SM 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-2SM stream
 - Processor can identify a CSI-2SM packet using VC and DT info
- CSI-2SM 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



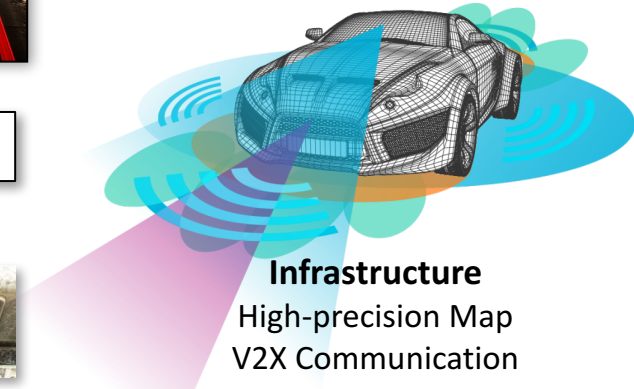
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Example – Multi-Modal Fusion



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

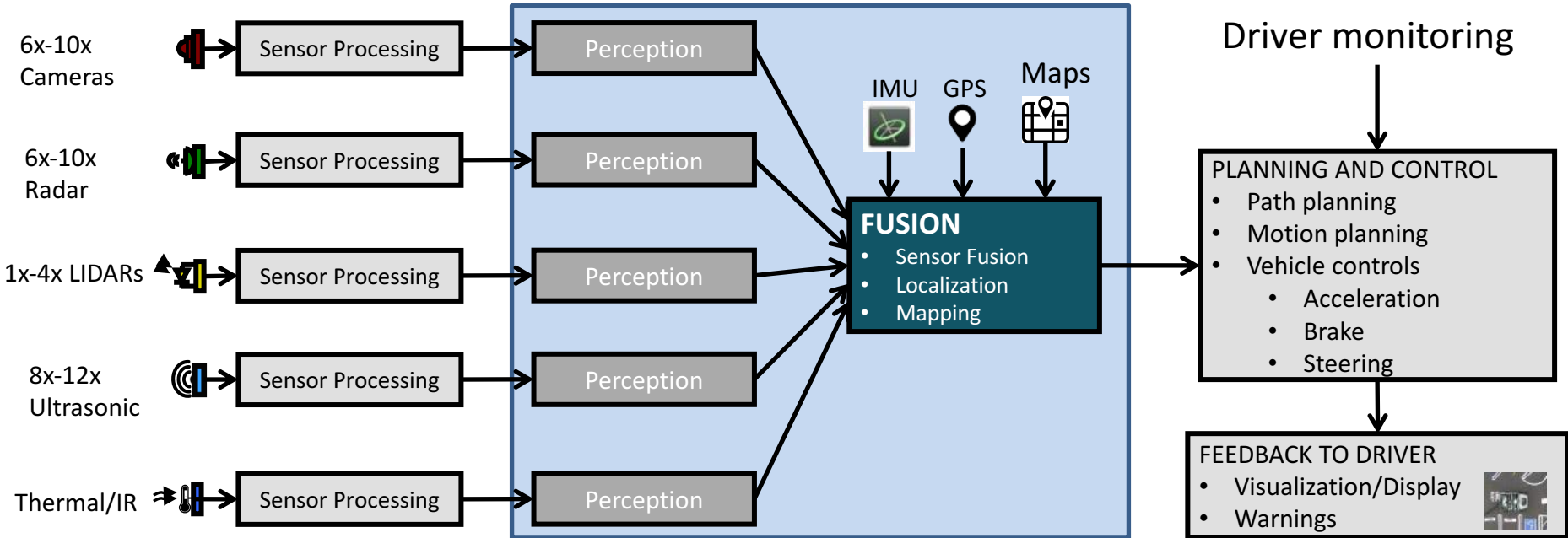
- High Data Rate – 1 Gbps/Camera + 2.4Gbps/Radar
- High PIN Count – To support large number of devices
- Imaging Format Variations – Need a standard protocol for imaging and non imaging devices

MIPI CSI-2SM 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 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-2SM 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-2SM, the trend is expected to continue and gain momentum in the years to come.

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