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Automotive Architectures in ADAS and Automated Driving

Paul Zoratti
Xilinx
Director: Automotive Solutions & System Architects

January 2021

Xilinx Adapt: Automotive

Day 2 – Automotive Architectures in ADAS and AD

January 13, 2021

Xilinx Adaptability – Past, Present, and Future Roles in ADAS/AD	7:00 AM – 7:30 AM
Xilinx Products, Solutions, and Technology for ADAS/AD	7:30 AM – 8:15 AM
Strategy Analytics: Unpacking the Domain Controller – What Should be Inside, and Why?	8:15 AM – 8:45 AM
Autonomous Mobility Everywhere with Pony.ai	8:45 AM – 9:15 AM
Wrap-up	9:15 AM – 9:30 AM

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Xilinx Adaptability – Past, Present, and Future Roles in ADAS/AD

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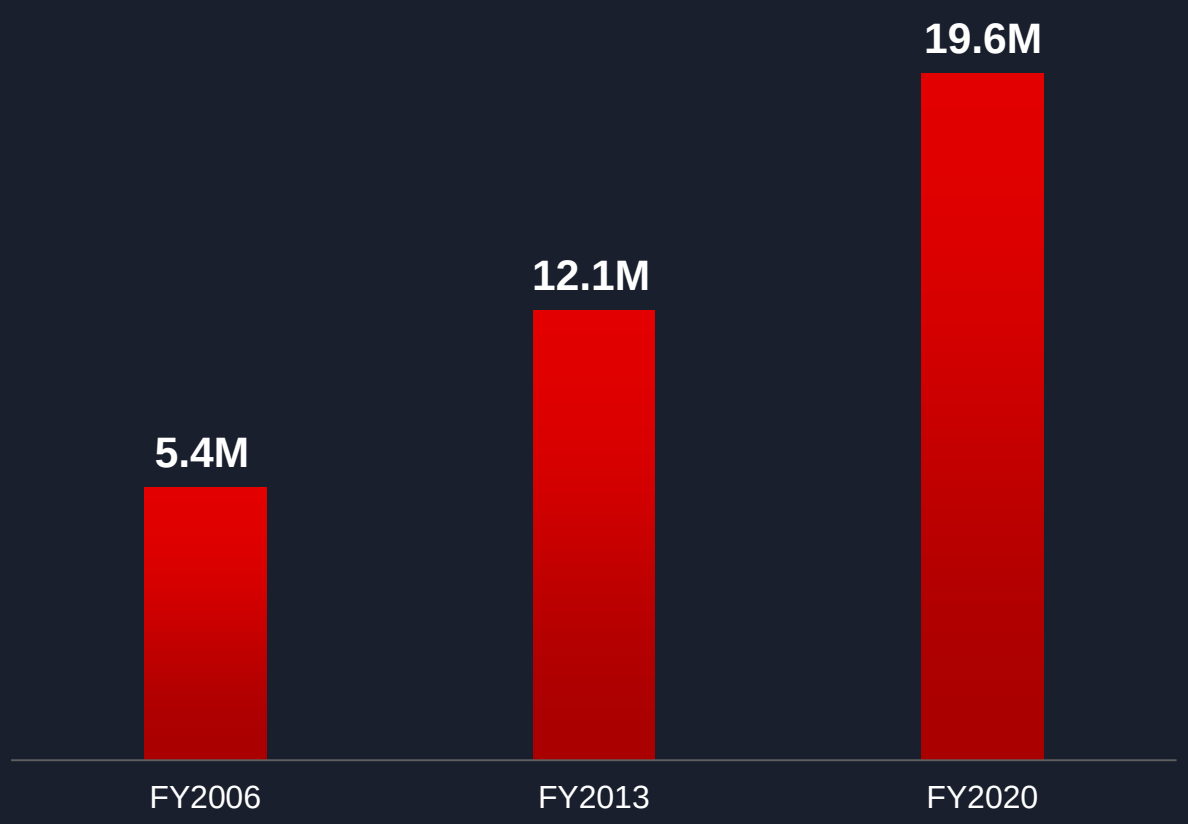
Xilinx Steady Growth in Automotive Applications

Unit Shipments



Consistent Growth

- Double digit unit shipment growth over **15** years
- More than **190M** devices shipped
- More than **75M** devices shipped into ADAS

Tier-1s

Continental, MAGNA, veoneer, ZF, HITACHI, Neusoft REACH

OEMs

BYD, SUBARU, DAIMLER, WELTMEISTER 威马汽车

Startups

Baidu 百度 | apollo, pony.ai, OUSTER, robosense 速腾聚创, MINIEYE

Note: Only showing publicly-announced customer collaborations

Production deployments with our 28nm and 16nm families to fuel continued growth

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Xilinx Automotive Focus Applications

Electrification

Electrification will provide new opportunities in Motor Control, charging systems, etc. Xilinx can leverage existing industrial motor control heritage to address these applications

In Cabin Driver Experience

IVI and DI are converging. Larger, non-standard, innovative display technologies require unique controllers. HMI trends like Heads-Up Displays (HUD), Augmented Reality, e-Mirror, Driver/Occupant Monitoring and Gesture Recognition are changing the way the way humans interact with the vehicle. Secure Vehicle to Infrastructure/Vehicle (V2X) communications are required.

Advanced Driver Assistance Systems (ADAS)

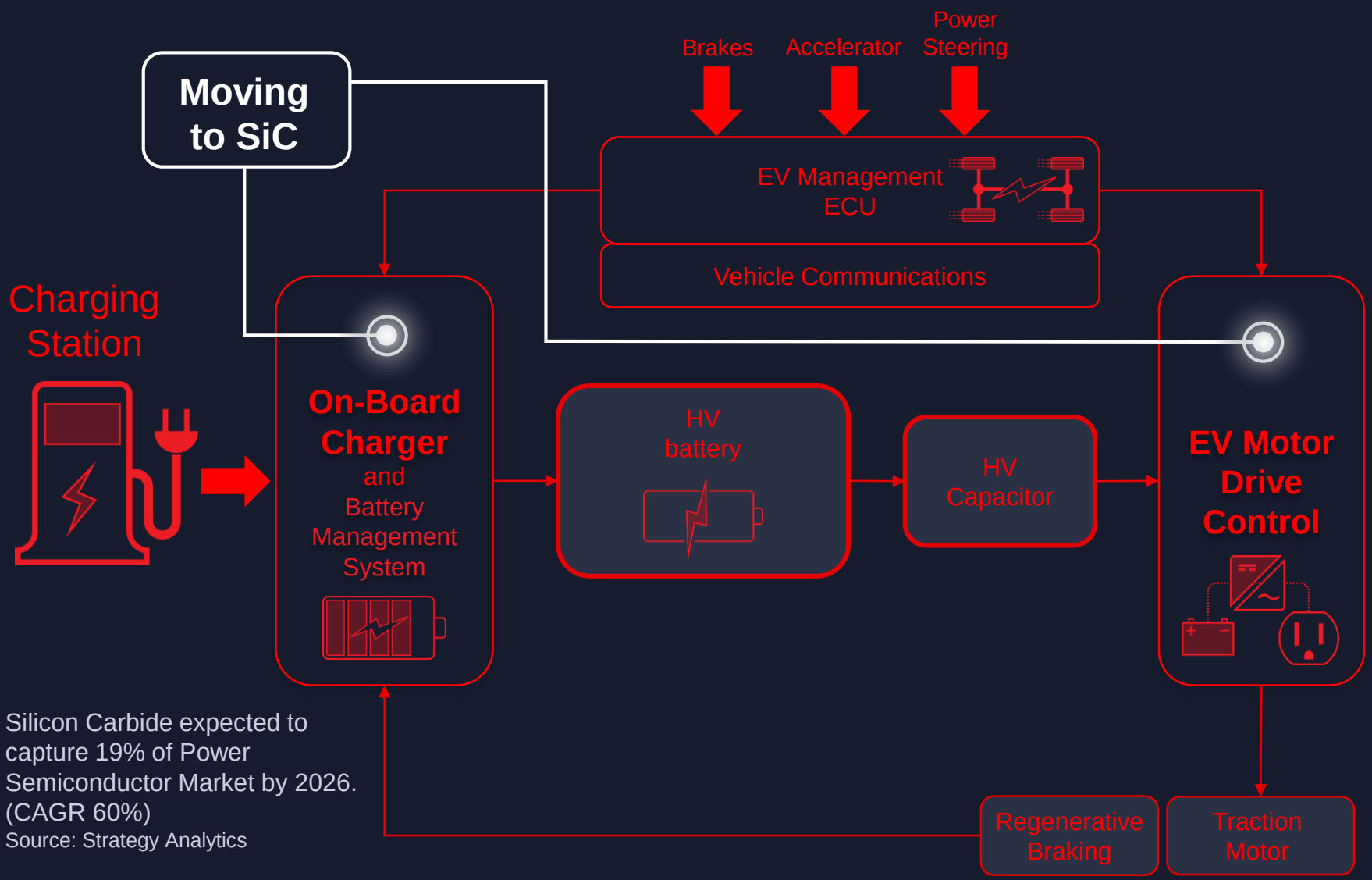
Primarily driven by regional NCAP initiatives pushing collision avoidance, pedestrian, bicycle/motorcycle, vehicle, sign detection and tracking features.

View enhancement systems, like 360 surround view, incorporating more object detection/classification.

Automated / Autonomous Driving (AD)

Next decade of growth as the market drives adoption of conditional automated driving features up through full autonomous vehicles. Includes key new technologies such as Deep Learning paired with traditional Discriminatory Object Detection.

Xilinx Automotive in Vehicle Electrification



Silicon Carbide expected to capture 19% of Power Semiconductor Market by 2026. (CAGR 60%)
Source: Strategy Analytics

Why Xilinx?

SiC
100kHz+ Control Loops

Unparalleled efficiency with custom sophisticated control loops implemented in Programmable Logic for *ultrafast* control

Model Based Algorithms

Adaptable loops can be optimized at individual IO level for precise tuning control via on-chip model-based algorithms

AI
Predictive Maintenance

Scalable ML / AI processing engines for motor aging & predictive maintenance neural networks that feed algorithms for truly adaptable temporal efficiency optimization

Any-to-any Connectivity

Future-proof designs with programmable IO enabling adaptation to changing system connectivity means

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Xilinx Automotive Electrification – Ecosystem Partners

MathWorks®

- Lithium battery models
- Motor Control Library
- Reference Designs
- Xilinx Optimized Toolbox
  - Model Composer

NATIONAL INSTRUMENTS™

- LabView for FPGA
- Motor Control Library
- Power Electronic Drive board

QDESYS
S/W for Embedded Systems

- SIC Reference Platform
- Motor Control IP Library
- Development Tools Suite

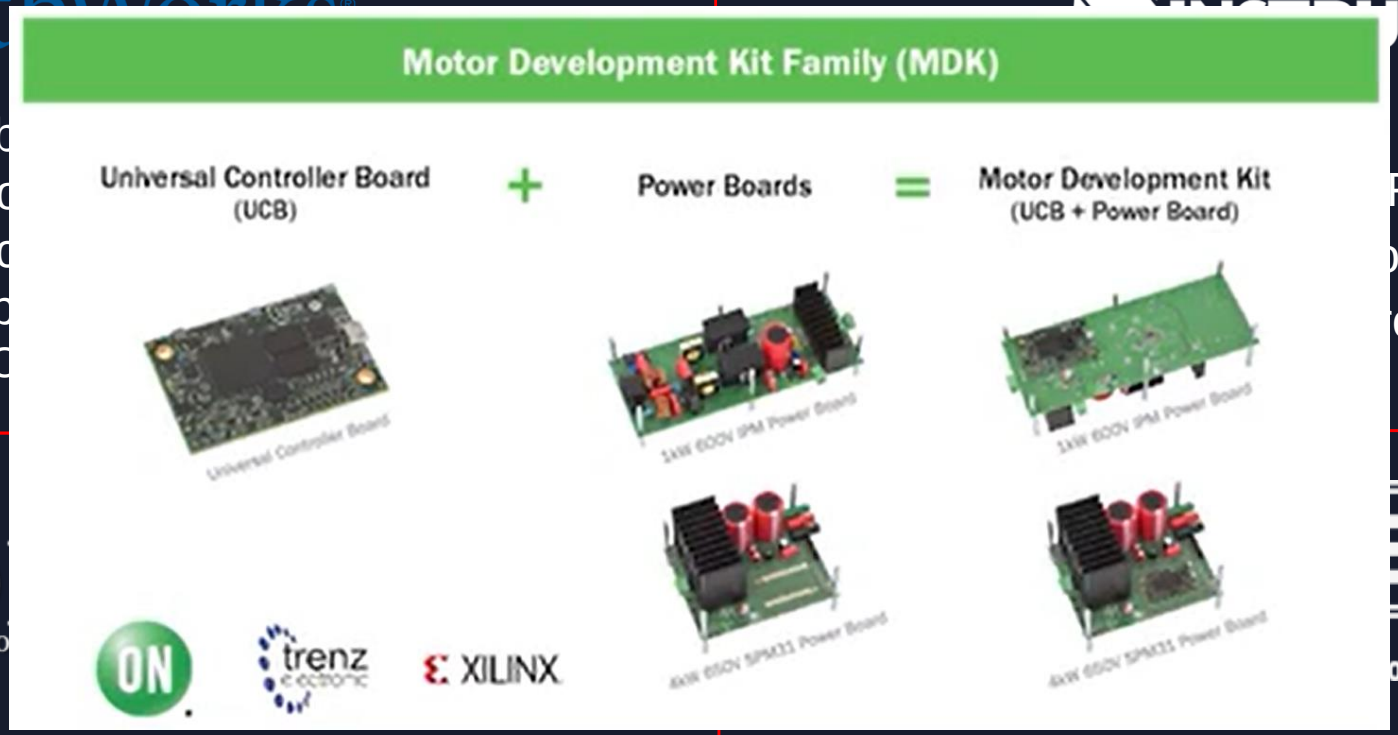
C-PED
CENTER FOR POWER ELECTRONICS AND DRIVES

- White Paper
- Reference Design
- Complete Development Kit

Xilinx Automotive Electrification – Ecosystem Partners

- Lithium b
- Motor Co
- Referenc
- Xilinx Op
  - Model C

- FPGA
- l Library
- onic Drive board



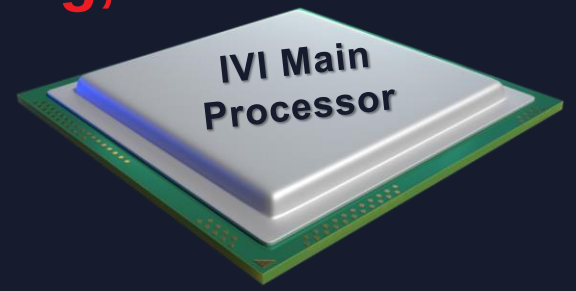
- SIC Reference Platform
- Motor Control IP Library
- Development Tools Suite

- White Paper
- Reference Design
- Complete Development Kit

Xilinx Automotive in the In-Cabin Experience

Infotainment, Driver Information, Driver/Occupant Monitoring, etc.

- **Traditional Infotainment (IVI) and Driver Information (DI)**
  - Adaptable IO extensibility and customizable TCON to drive non-standard innovative displays and interface to new consumer electronics
- **Convergence of IVI/DI & ADAS**
  - Customized accelerators for companion extension of ADAS features (e.g. DMS) without conflicting/interfering with fundamental IVI functions
  - ADAS Sensor South Bridge Connectivity
- **Product Families with IP Portability**
  - Cost effective scalability – only the connectivity and companion processing performance needed - *Stop trying to "thread the needle" with processor IO*
  - OTA SW and HW re-programmability to future proof products and offer security and other performance upgradability
  - Capable of diverse decomposition / redundancy for enhanced system functional safety as ADAS converges with IVI



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Scalable Device Families for Companion Chip Processing Performance and South Bridge Connectivity

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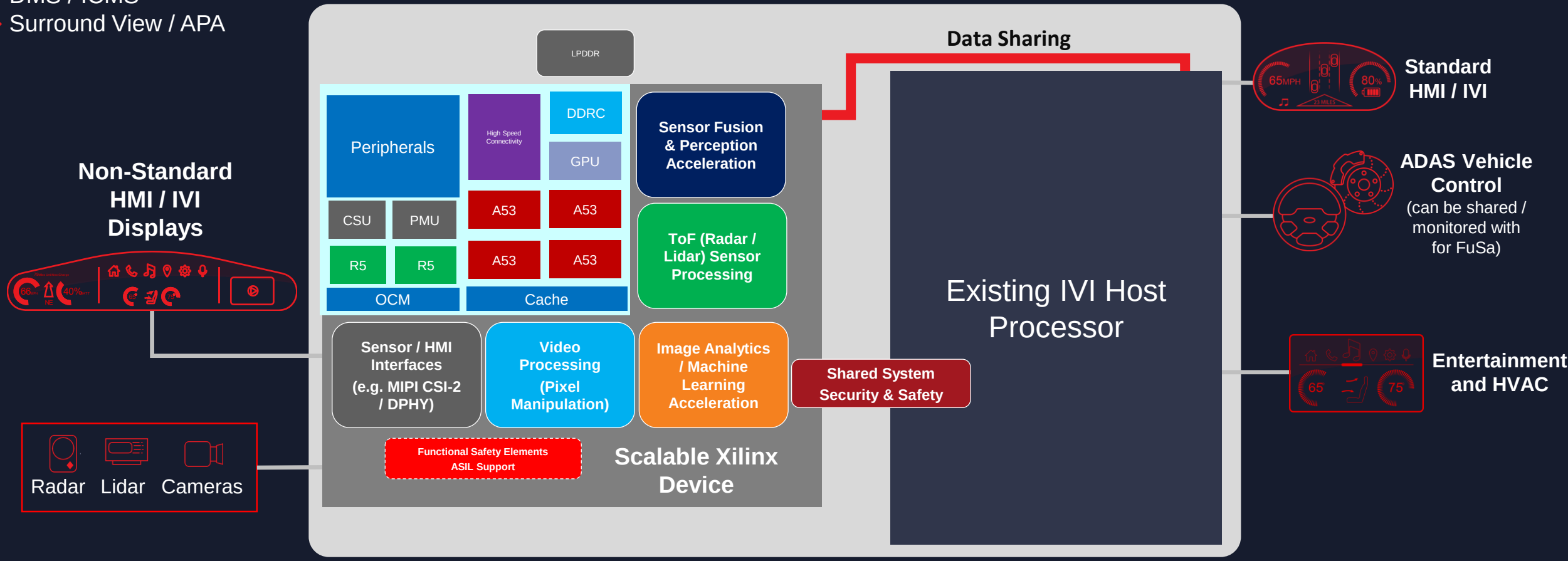
IVI Architectures with Xilinx Adaptable Extension

South Bridge Connectivity
- ADAS Sensor Expansion
- Specialized Display Drive

Feature Acceleration e.g.:
- DMS / ICMS
- Surround View / APA



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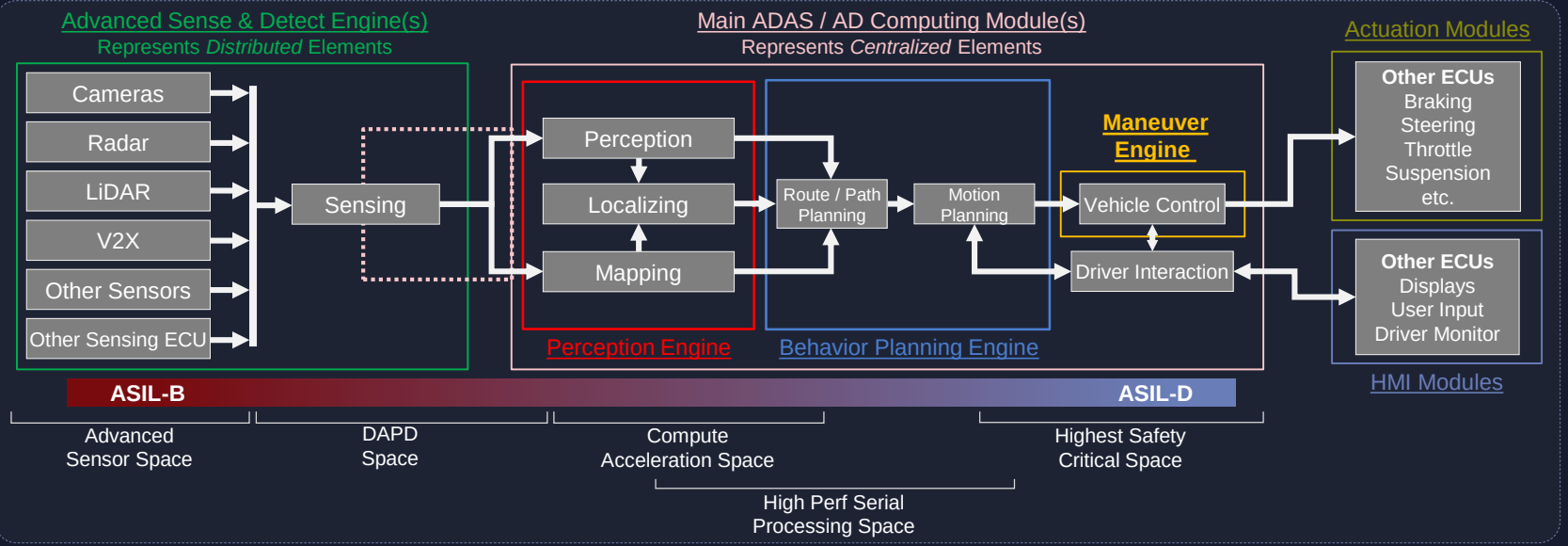
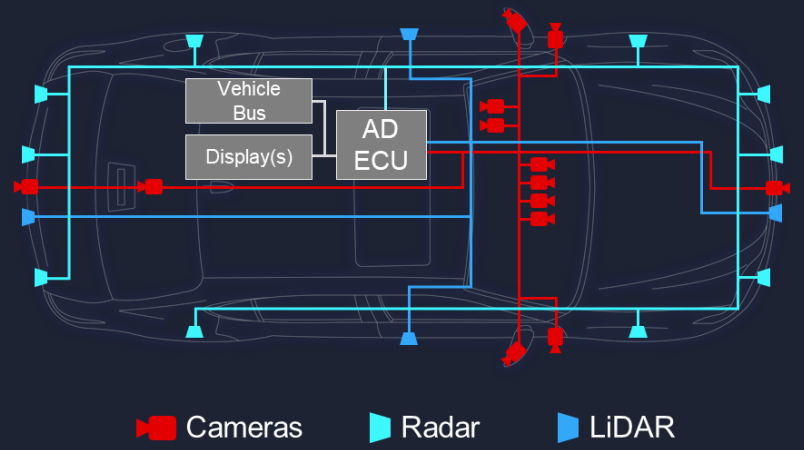
Xilinx Automotive in ADAS / AD *Today*

Complex Interaction of Functional Elements Requiring Heterogeneous Set of Processing Engines

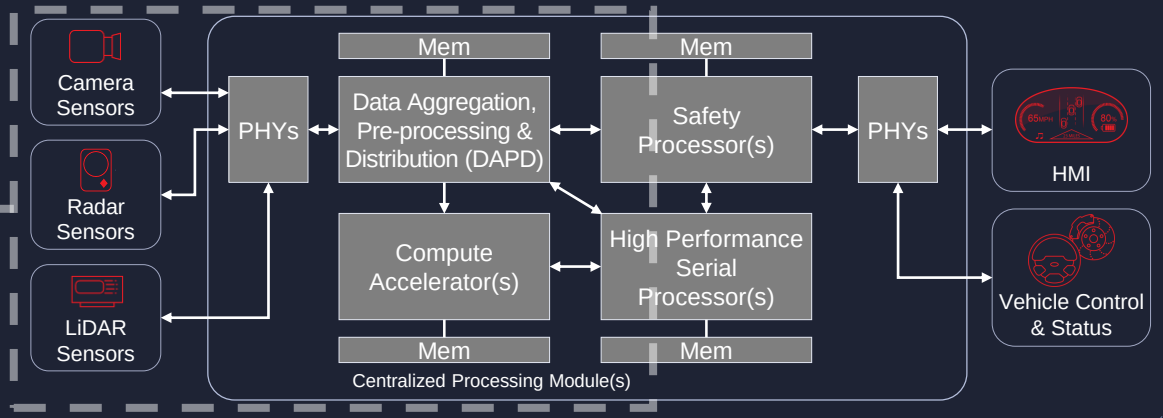


Broadly Varying Sets of Sensor Configurations



Central AD Module Requiring Basic Processing Element "Roles"

- XILINX Primary Areas of Focus:
  - Edge Sensors (e.g. 4D Radar, Lidar)
  - DAPD = Data Aggregation Pre-Processing & Distribution
  - Compute Acceleration (ML, CV, etc.)



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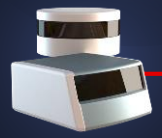
Xilinx Automotive in ADAS & AD *TODAY*

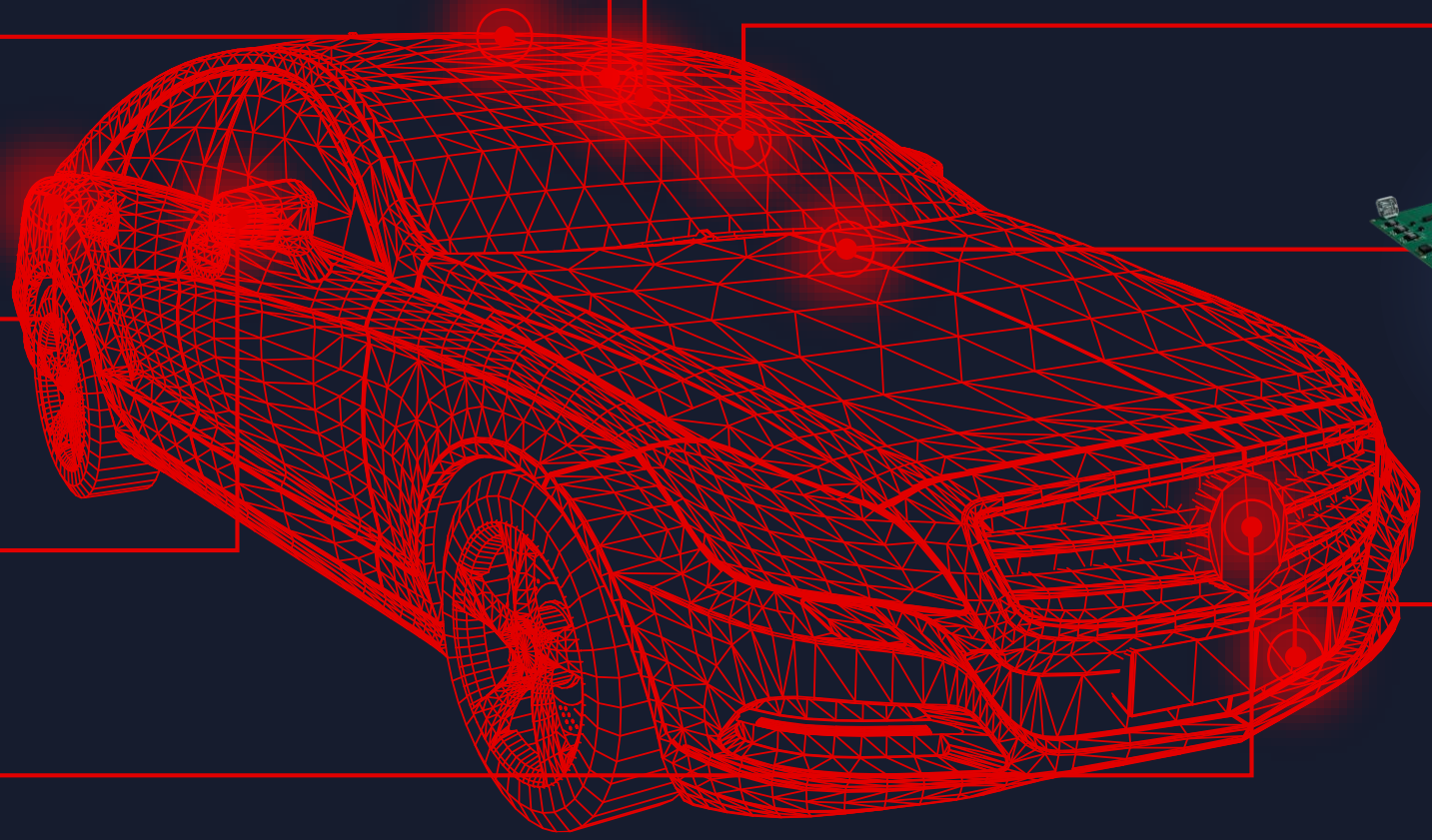
Mirror Enhancement /Replacement

Forward Camera

LiDAR



In-Cabin Monitoring Camera

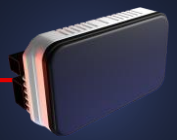


Surround View and Automated Parking

Domain Controller

- Gateway
- Compute Acceleration
- Data Aggregation, Pre-processing, and Distribution (DAPD)

RADAR



Note: Not representing actual vehicle architecture; Sensors are for illustrative purposes

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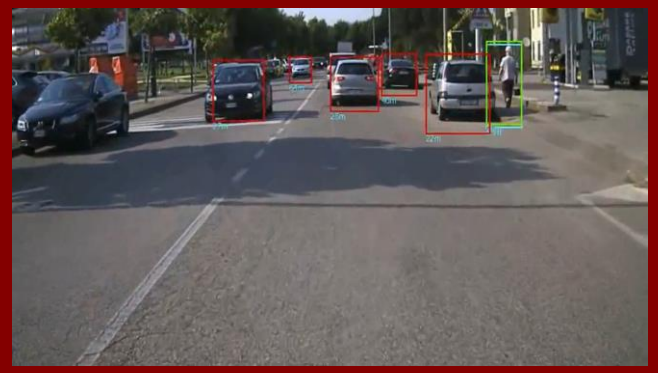
Xilinx Automotive Role in Forward Camera Evolution

Xilinx Deployed in Production Systems for first 3 Generations and targets NCAP2022 with Next Generation of Devices

2008 2010 2012 2014 2016 2018 2020 2022



- **GEN1: Spartan 6**
  - Camera: VGA/WVGA
  - Warning Only, e.g. Lane Departure Warning
  - Xilinx Value
    - Imager Interfacing
    - Image Conditioning and Feature Extraction
- **GEN2: Zynq 7000**
  - Camera: Up to 2 Mpixel
  - Lane Departure Warning, Speed Alert, Collision Mitigation (AEB)
  - Xilinx Value
    - Optimal HW/SW Partitioning
    - Scalability
    - Differentiation
- **GEN 3: Zynq MPSoC**
  - Camera: Up to 4/8 Mpixel
  - Broader Protection (e.g. Pedestrian/Cyclist Protection)
  - Vehicle Convenience Control (e.g. Traffic Jam Assist)
  - Xilinx Value
    - Heterogeneous processors
    - Tightly coupled Application SW and custom HW accelerators
    - Safety Island for FuSa
- **Future: ACAP**
  - Camera: Up to 8/12 Mpixel
  - System Features:
  - Level 2/3 Automation
  - Urban and Highway Scenarios
  - Xilinx Value
    - Higher Data Bandwidth Channels
    - High Performance / Low Power CNN Processing for environment Cognition
    - Advancing FuSa

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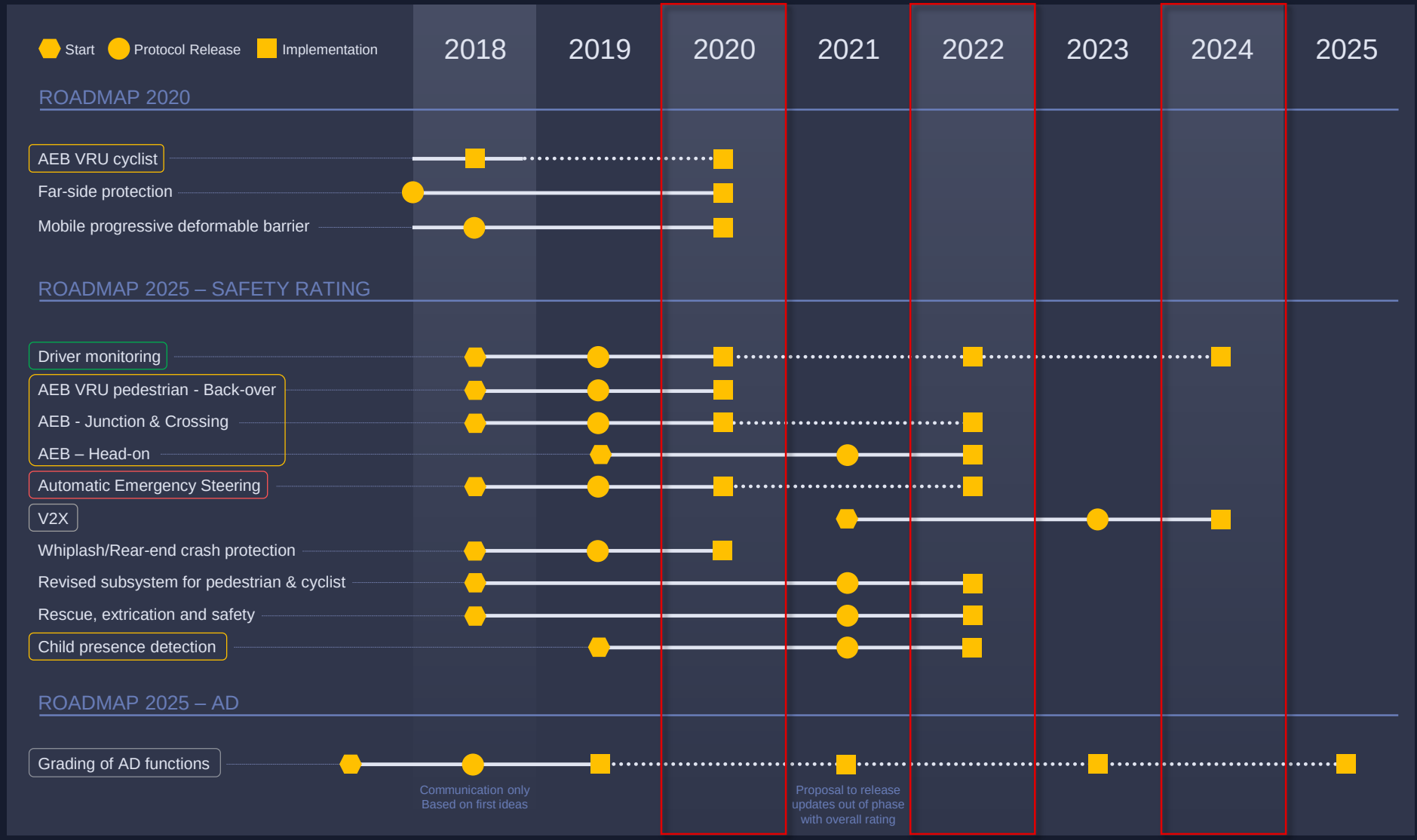
Euro NCAP – Driving Force for Innovation
Roadmap 2020 – 2025

1. AEB requirements will be updated along the way
2. New functions need more performance and may only be achieveable with sensor fusion (camera + x)
3. AEB – Back-over needs either additional camera (similar to FWD cam) or surround view system.

- Driver monitoring will be required, independent of any AD function
- Emergency Steering – most probably will re-use LKA hardware
- V2X – not relevant for now. Uncertainty regarding technical standardization and feature roll-out.
- Child presence detection – will drive additional hardware, may be combined with driver monitoring system
- AD – NCAP will drive acceptance of AD systems in the market but not include in star rating for the forseeable future



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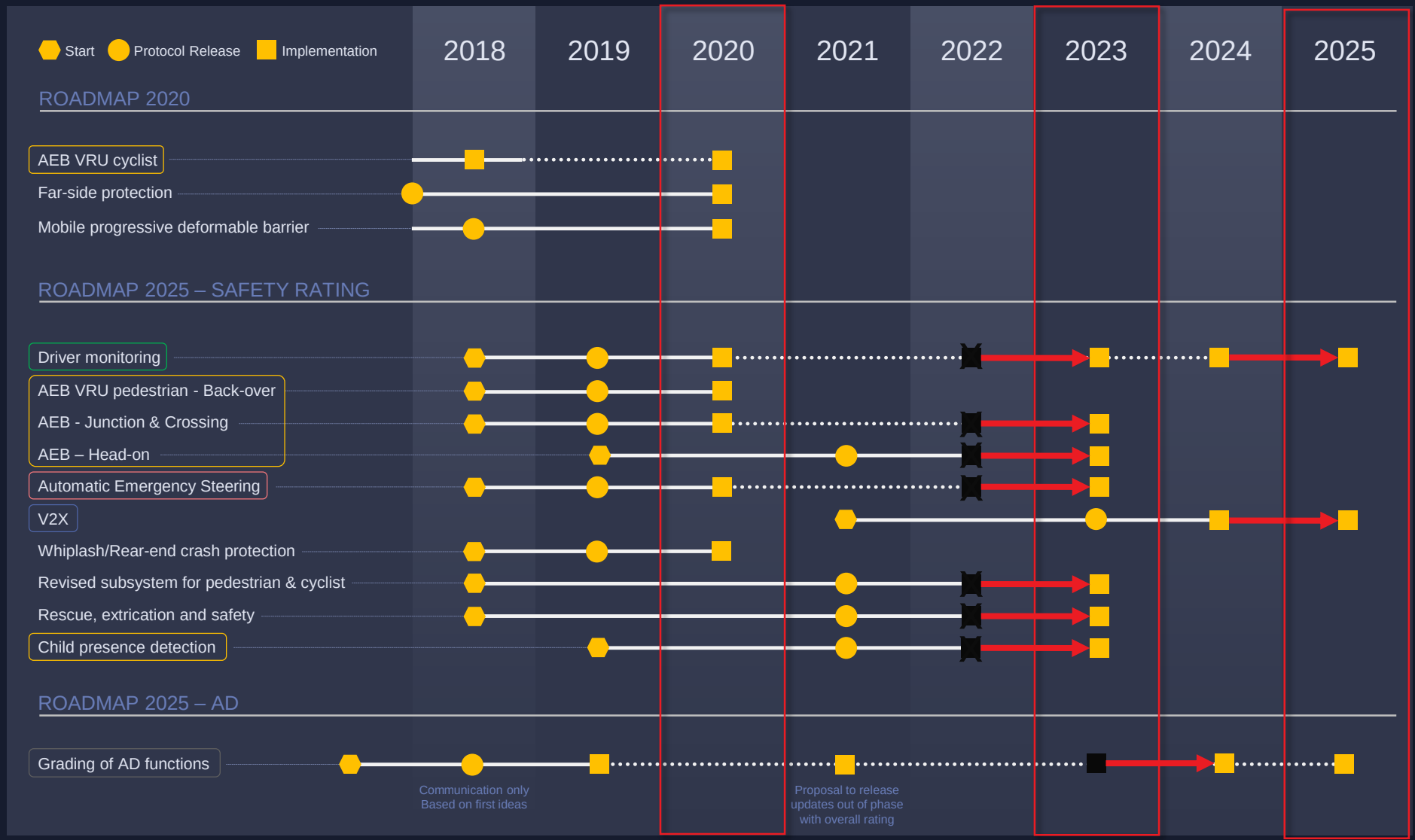

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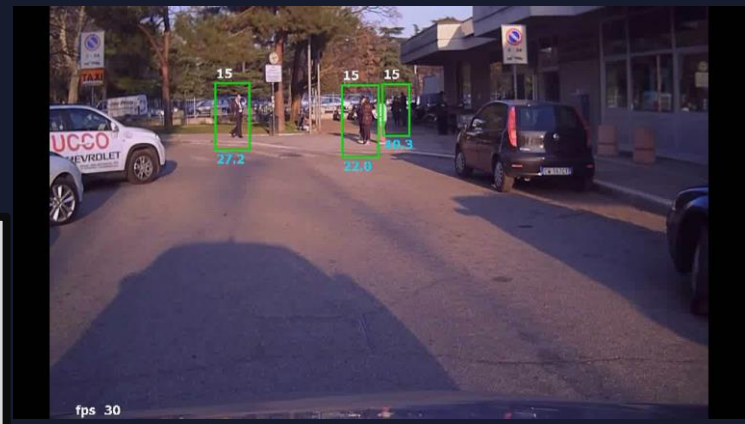
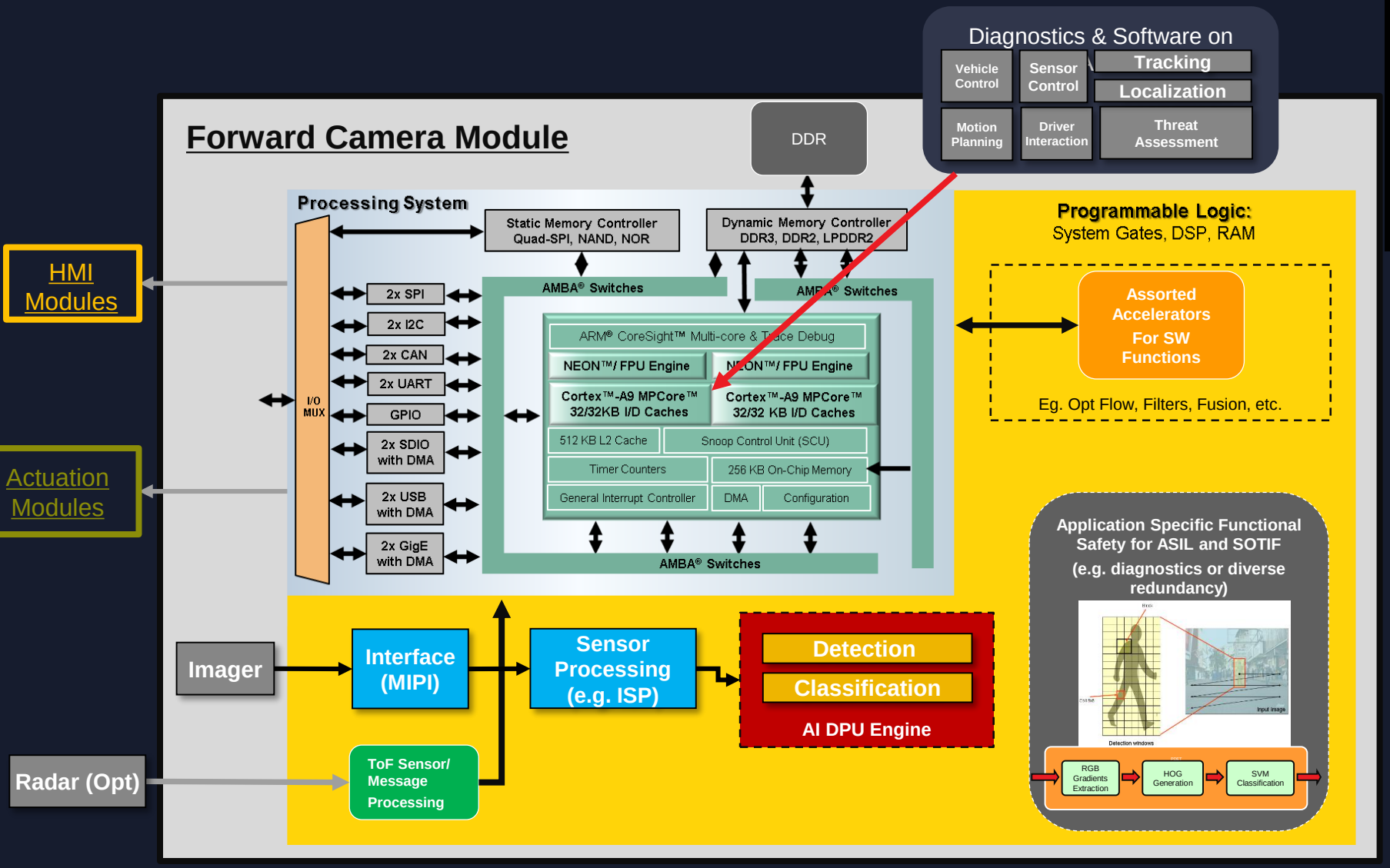
Enabling the Evolution of CV to AI

Traditional CV



Forward Cam AI



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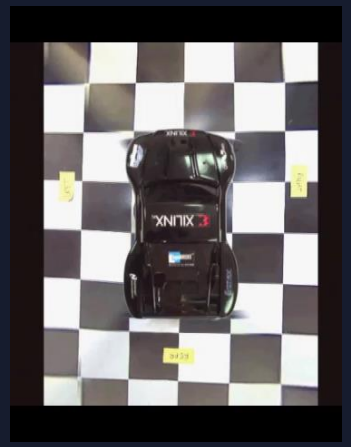
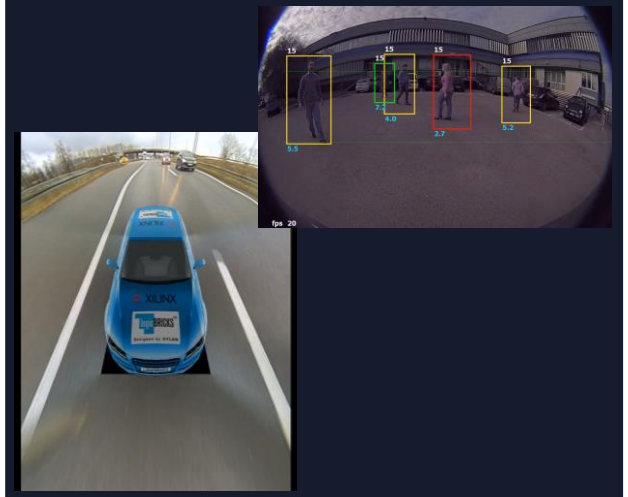
Evolution in Surround View -> Automated Park Assist

Xilinx Deployed in High Volume Production Systems for 3 Generations

2008 2010 2012 2014 2016 2018 2020 2022 2024

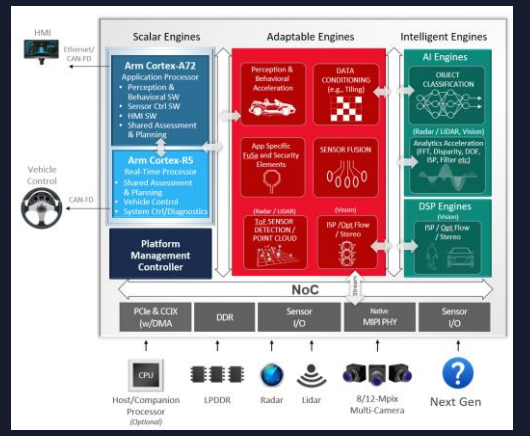


- **GEN1: 2D Bird's Eye View**
- **Spartan 6 FPGA**
  - Video Processing
    - Sensor Interface
    - Pixel Warping/Stitching
  - Graphic Overlay
  - Display Controller
  - VGA to 1 Mpix Imagers



- **GEN2: 3D Surround View w/ Object Detection**
- **Zynq 7000 SoC**
  - Selectable 3D Views
  - Image Analytics beyond "view-only" – e.g. Object Alert and Trailer Guidance
  - Park Assistance and Rear Camera Processing
  - Sensor Fusion (ultrasonic)
  - 1 to 2 Mpix Imagers

- **GEN 3: Automated & Valet Parking**
- **Zynq Ultrascale+ MPSoC**
  - Dynamic 3D Views (Flying Camera)
  - Hi Res Graphics Animation
  - ML-based Scene Segmentation and Object Classification
  - Vehicle Control and Low Speed Automated Emergency Braking
  - FuSa Enabled
  - 2 to 4 Mpix Imagers



- **NextGen: Automated Driving/Parking**
- **Versal ACAP**
  - Advanced ML/AI Compute Density
  - Enabling Next Level of Autonomous Control
  - Enhanced FuSa and Security
  - 4 to 8/12 Mpix Imagers

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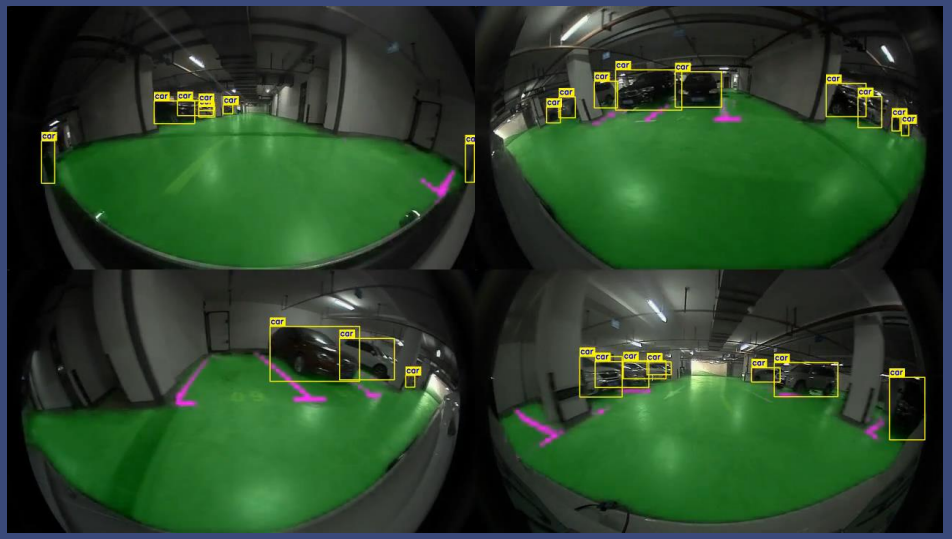
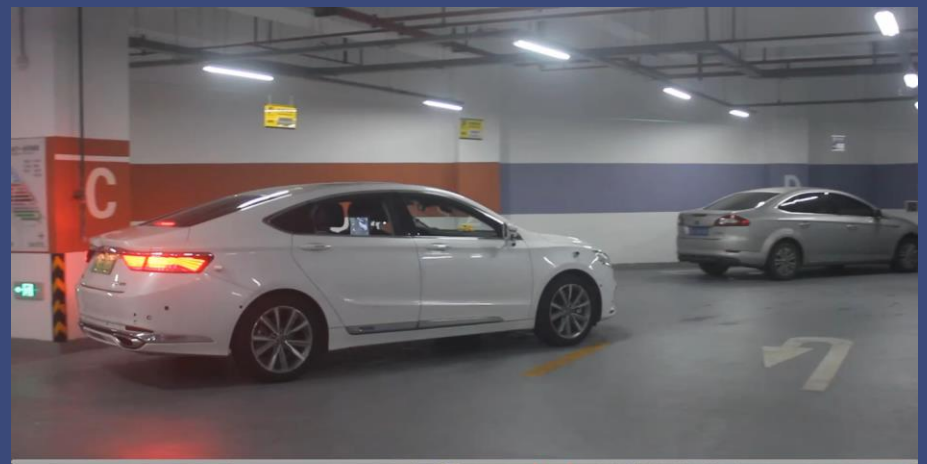
Automated Parking on ZU+

- Multiple customers and partners have adopted Zynq Ultrascale+ devices for their APA systems
- Advantages
  - Adapt to rapidly evolving sensor suites
  - High performance, Low latency DNN solutions
  - Reduce time to market and scalable performance
  - Upgradability to add new features during development cycle
  - Functional Safety
- Solutions available through ecosystem partners





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Xilinx Adaptability – Past, Present, and Future Summary

- **Electrification** – New technology adoption (SiC) and the quest for higher efficiencies requires:
  - Dynamically optimized high complexity/low latency HW-based control loops
  - Innovation in Motor prognosis and status via AI processing

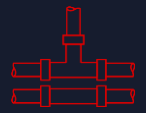
- **In-Cabin Experience** - Convergence of IVI/DI/ADAS driving the need for
  - Adaptable “ADAS South Bridge Connectivity” for sensor and display interfacing innovations
  - Scalable Families of Companion Devices which extend AI/other processing performance to cost-effectively adapt platforms to varying ADAS/AD feature bundles

- **ADAS/Automated Driving** – Xilinx success in multiple generations of high volume product deployments indicates:
  - Key ADAS and AD technology (sensors, algorithms, architectures) and associated innovation continues to emerge/evolve
  - Xilinx product technology advancement (SoC -> MPSoC -> ACAP) is well aligned with industry needs

THE NEED FOR XILINX ADAPTIVE SILICON & SOCs IS CLEAR

Xilinx *Unique* Technology Advantages for ADAS / AD

- Optimal Partitioning Between System Software and Hardware Accelerators
  - Integrated Sensor Data Aggregation, Compute Acceleration, and Scalar Processing



- Independent (Isolated), Simultaneous, and Optimized Processing Pipelines
  - Lowest latency sensor data paths and sensor fusion

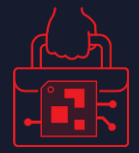
- Power Efficient, High Utilization AI / ML Inference
  - More effective use of TOPs

- Customer-owned (Proprietary) or Xilinx / Partner Licensable IP / Accelerators
  - Market Differentiation / Leadership and Fast Time to Market

- Customizable Interfaces
  - Platform Specific Sensor Configuration IO

- Cost-effective & Scalable Device Families
  - Platform design for BoM scaling to various ADAS / AD Sensor and Feature Bundles

- Unmatched Design Adaptability (processing pipelines, interfaces, etc.)
  - Efficiently address new requirements for “Future Proofed” Platforms



- Unique IP portability
  - IP designs migrate to / from Distributed Sensors to Centralized Modules

- In-field SW and HW upgradability (Unique OTA-HW)
  - Unparalleled ability to update system capabilities / performance

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Thank You