# Vision Overview: Using S32V for Mass-Market Applications

Philip Pesses

Automotive Distribution Marketer

Kushal Shah

Automotive Applications Engineer

August 2019 | Session #AMF-AUT-T3808

SECURE CONNECTIONS FOR A SMARTER WORLD

Company Public – NXP, the NXP logo, and NXP secure connections for a smarter world are trademarks of NXP B.V. All other product or service names are the property of their respective owners. © 2019 NXP B.V.

# Agenda

- S32V Family Overview
- S32V Enablement
- Embedded Deep Learning

# Goal of this Class

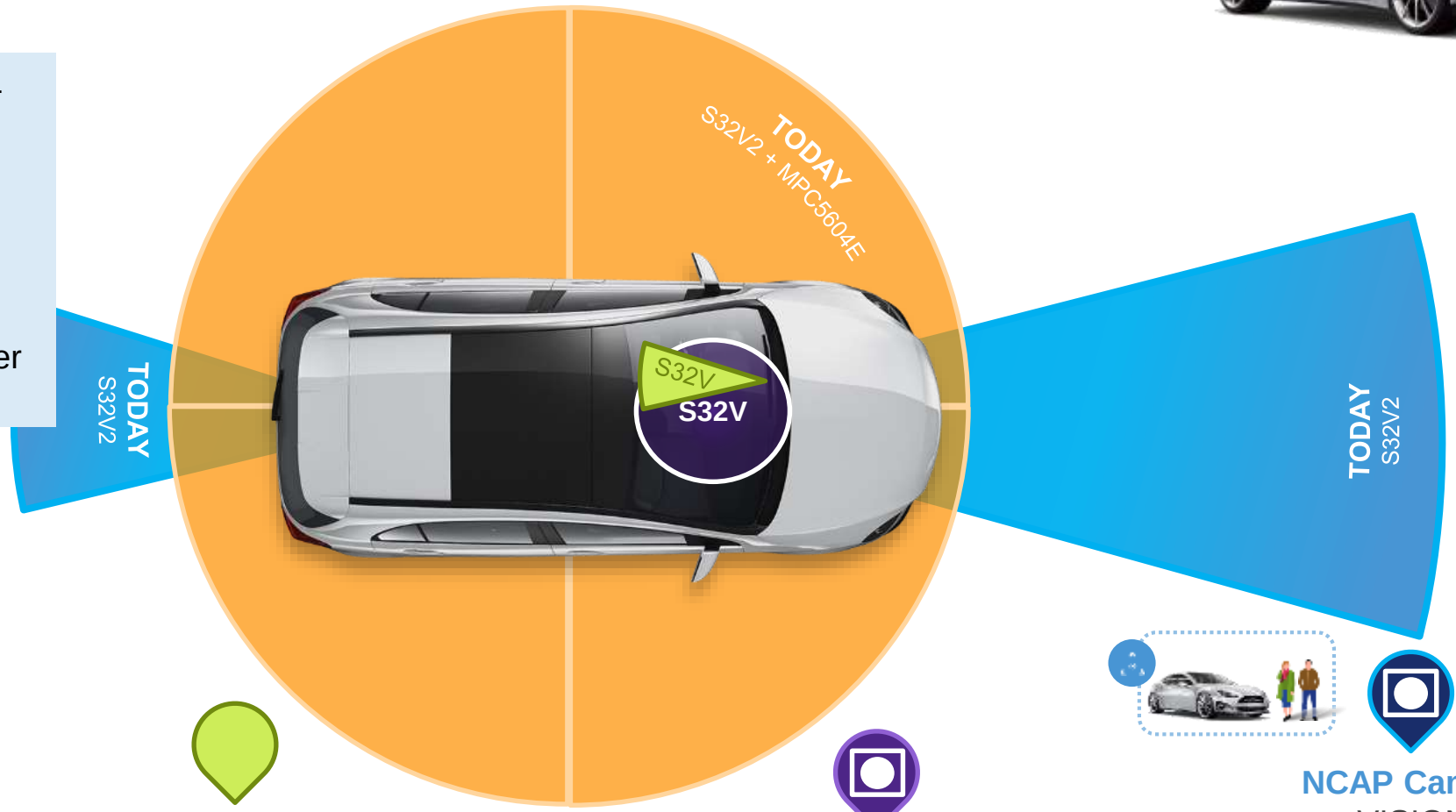
- Prerequisite:
  - I assume you have basic experience with Convolutional Neural Network

- At the end of the class you should:
  - Be aware of NXP hardware accelerator for Automotive Deep learning
  - Understand key challenge when porting from PC to low power embedded
  - Be aware of NXP enablement for Neural Network

# S32V Family Overview

# S32V Family Use Cases

- S32V is automotive ASIL B/C microprocessor
- Embedded / low power Vision accelerator
- Available for production today (PPAP in December 2017)




**Surround View**
VISION
3D Segmentation
Highway Autopilot Assist
Park Assist
Pedestrian Detection

**Driver Monitor**
Camera
3D Positioning
Driver Alertness
Driver Awareness

**Sensor Fusion**
Camera / RADAR
Safe Decision Making



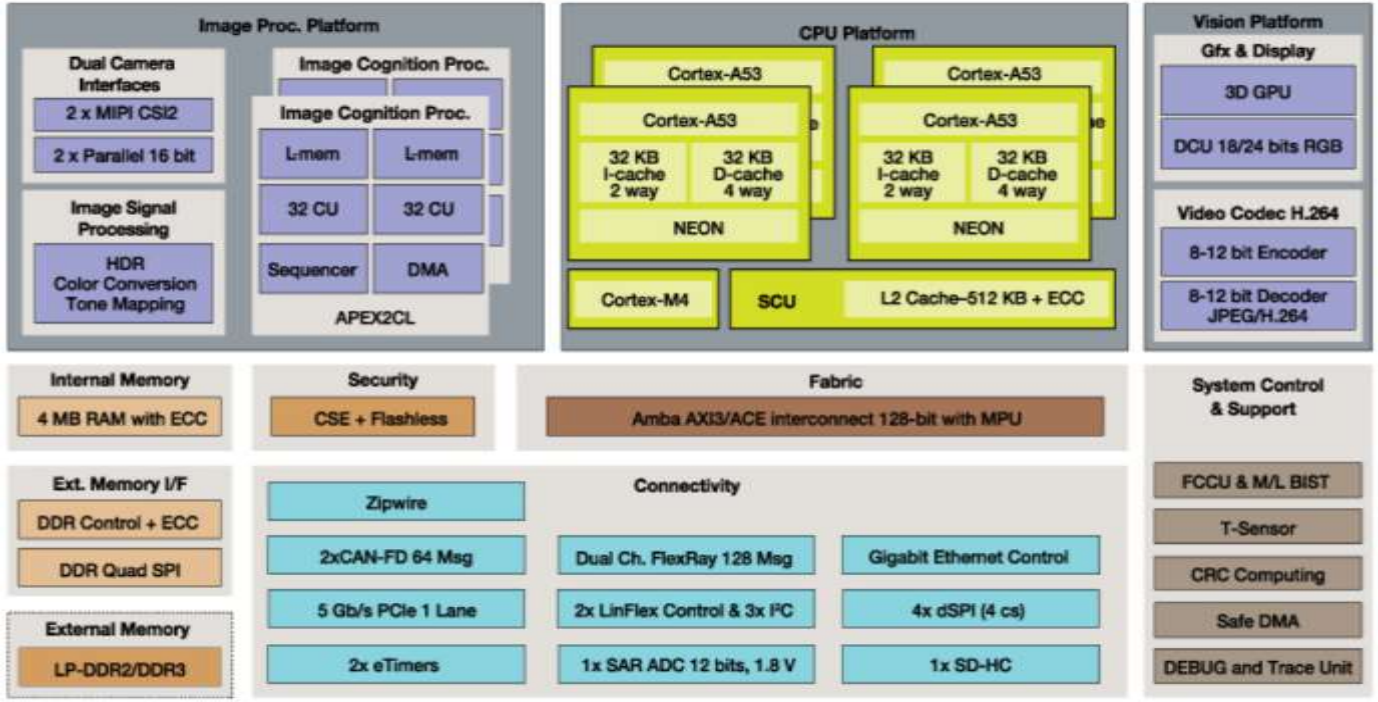
**NCAP Camera**
VISION
Pedestrian Detection, Lateral Tracking
Automatic Emergency Braking
Collision Avoidance
Rear View

SRP: ~$30-35

# S32V234 – In Production Now

## Highlights

- High Performance Processing: Up to Quad core ARM A53 800-1GHz Safe Clusters @ ~10K DMIPS
- Vision Acceleration: Dual APEX-2 image cognition processor cores enabled by OpenCV
- Automotive Safety: Developed according to ISO 26262 standard to reach ASIL C for sensor fusion
- Security Enabled: HIS-SHE compliant Crypto Service Engine (CSE) optimized for flash less devices




## Processing Power

- CPU1-4: ARM Cortex-A53 @1GHz, L1/L2 cache with ECC & Neon
- CPU5: Cortex -M4 for IO control with I/D Cache and ECC
- ICP: 2 x APEX2 CL (MIMD APU-64 CU each) at 400MHz
- 3D-GPU: GC3000 from Vivante (4 Shader)
- DDR3/LPDDR2 at 533MHz (2 x 32bit)
- Image Signal Processing (ISP)
- Image Cognition Processing with 2 x APEX2
- h.264 Codec and MJPEG decoder

## Serial Interfaces

- 1 PCIe controller
- 1 FlexRay (Dual Channel)
- 1 Zipwire
- 1 Gibabit Ethernet
- 2 x MIPI CSI2 - 4 lanes 6Gb/s
- 2 ISO CAN–FD, 4 x SPI, 2 x LinFLEX and 4 x Timer

## Security and Safety

- Crypto Service Engine (CSE3)
- ASIL B capable SoC (Safe Assure™) with LBIST and MBIST self-testing
- Voltage/Temp monitoring
- End to End complete ECC memory
- SW core self testing, Safe DMA and CRC processing

## Temperature and Support

- -40°C to 125°C (junction) AEC-Q100 Grade 2
- 15 year product longevity support

# S32V Value Drivers

**Object Detection** | **Power Savings** | **Safety**

### QUAD 1GHz A53 Cores

- ~10k DMIPS
- 800MHz option
- Dual core option

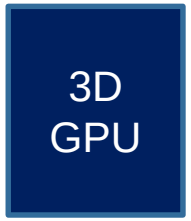
### DUAL APEX Vision Accelerators

- APEXCV support
- CNN Deep learning
- ID and Class.
- APEX graph tool

### M4 Core for Functional Safety

- ASIL-B Safety
- ISO26262 and IEC61508
- AutoSAR MCAL
- AutoSAR OS
- Sensor Fusion

### Graphic Processing Unit (GPU)




- GC3000 3D GPU
- 4 shader
- Supports OpenCL, OpenVG,OpenGL
- Offload MPUs for graphic/HMI support
- Machine learning

### Low Power Envelope 2-10W

- Low power option
- <7W non GPU with passive heatsink
- GPU enabled option <10W

### Encryption Security (CSE)

- 128bit encryption
- SHE compliant
- Secure Boot
- Trust zone

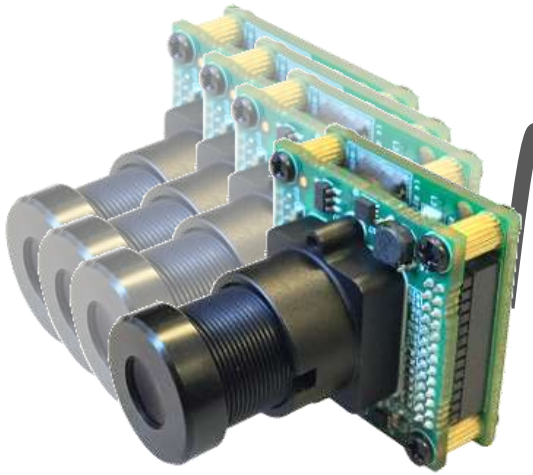
### On-chip Image Signal Processor (ISP)

- Reduce camera BOM for SVM
- ISP graph tool

# What is S32V?

Automotive ASIL Vision Processor Family

**S32V Processing Pipeline**



**ISP**
- ✓ HDR
- ✓ De-mosaic
- ✓ Bayer pattern

**APEX**
- ✓ Filters
- ✓ Kernels
- ✓ Classifiers
- ✓ CNN

**A53's / Neon**
- ✓ Transformation
- ✓ Extraction
- ✓ ASILB - D Decision Making

**3D-GPU**

- Multiple Automotive Vision Applications
- Scalable Software Ecosystem
- Partnerships (Tier 1, Tier 2)

**NCAP Camera**
VISION

**Sensor Fusion**
VISION / RADAR

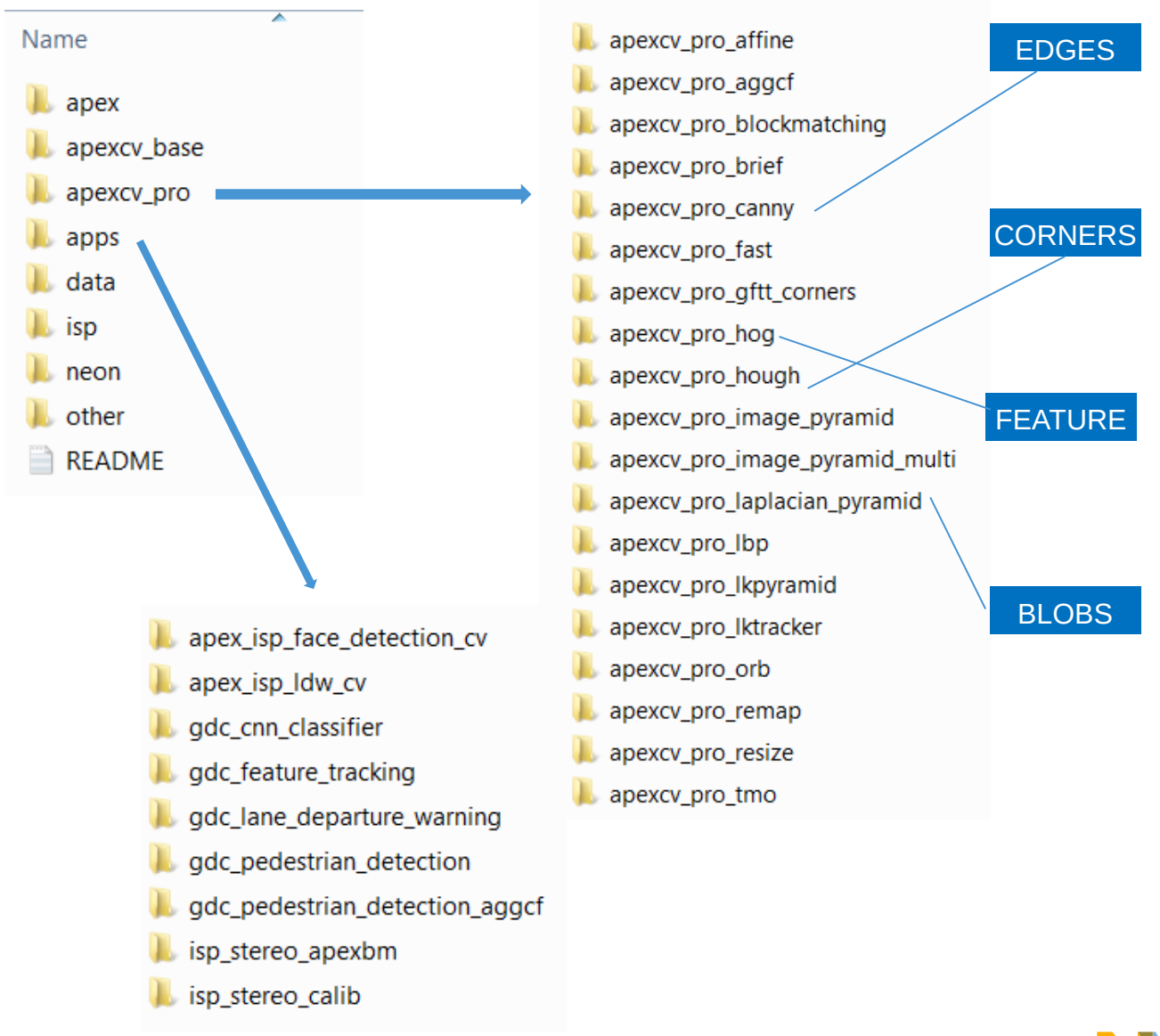
**Surround View**
VISION

**Driver Monitor**
VISION

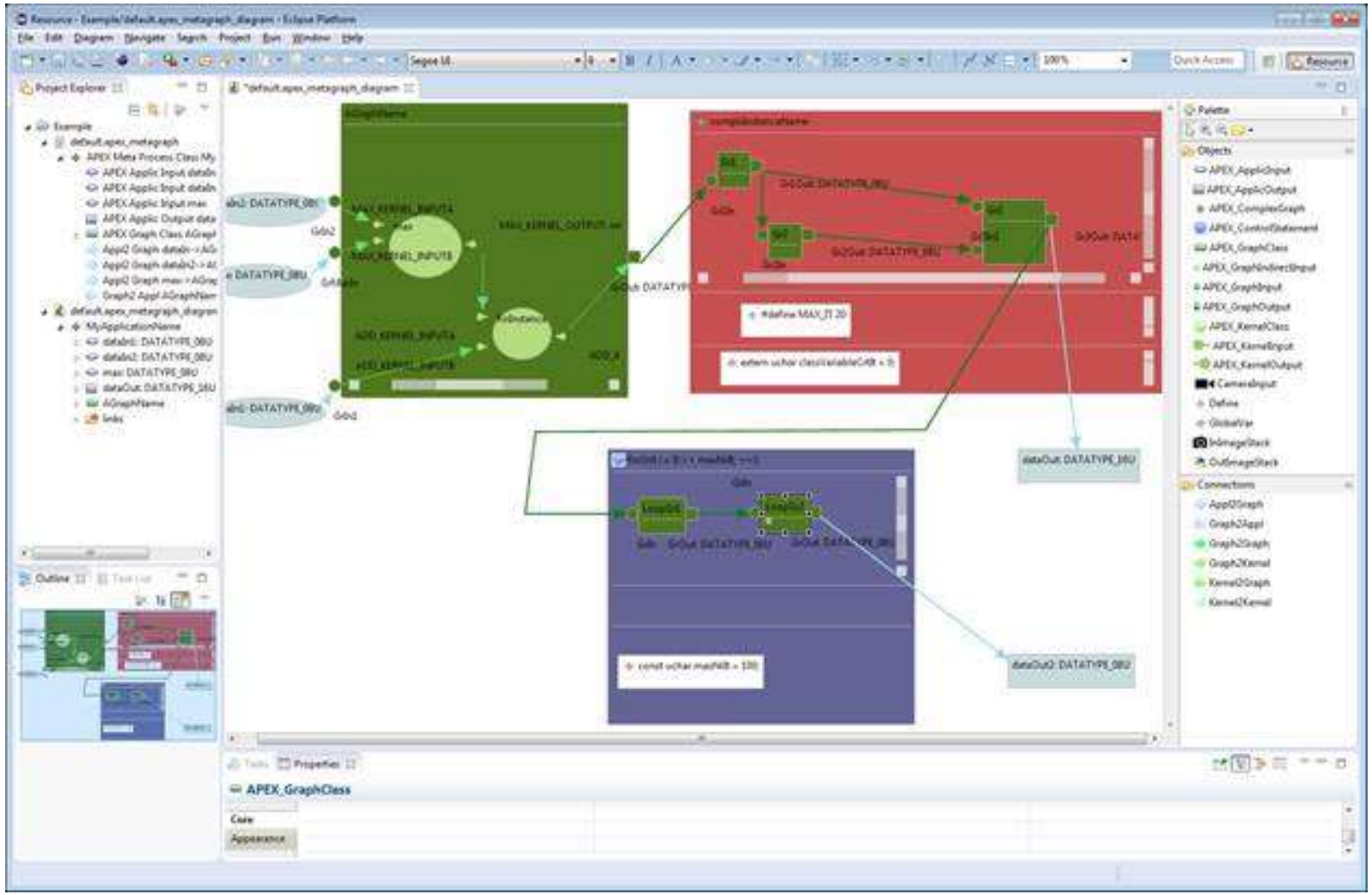
# Enablement

# Vision SDK

- APEX-CV Libraries
  - APEX-CV
  - APEX-native
  - APU programming and ACF support
  - APEX emulation support
- ISP Libraries
  - With MIPI-CSI2, VIU, H264 encoder/decoder and JPEG decoder support
- IO Drivers
  - DCU, camera, i2c, uart, qspi
- 3rd Party SW Support
  - OpenCV, pthread, ffmpeg etc
- Latest Linux BSP Image
- Demos
- Documents

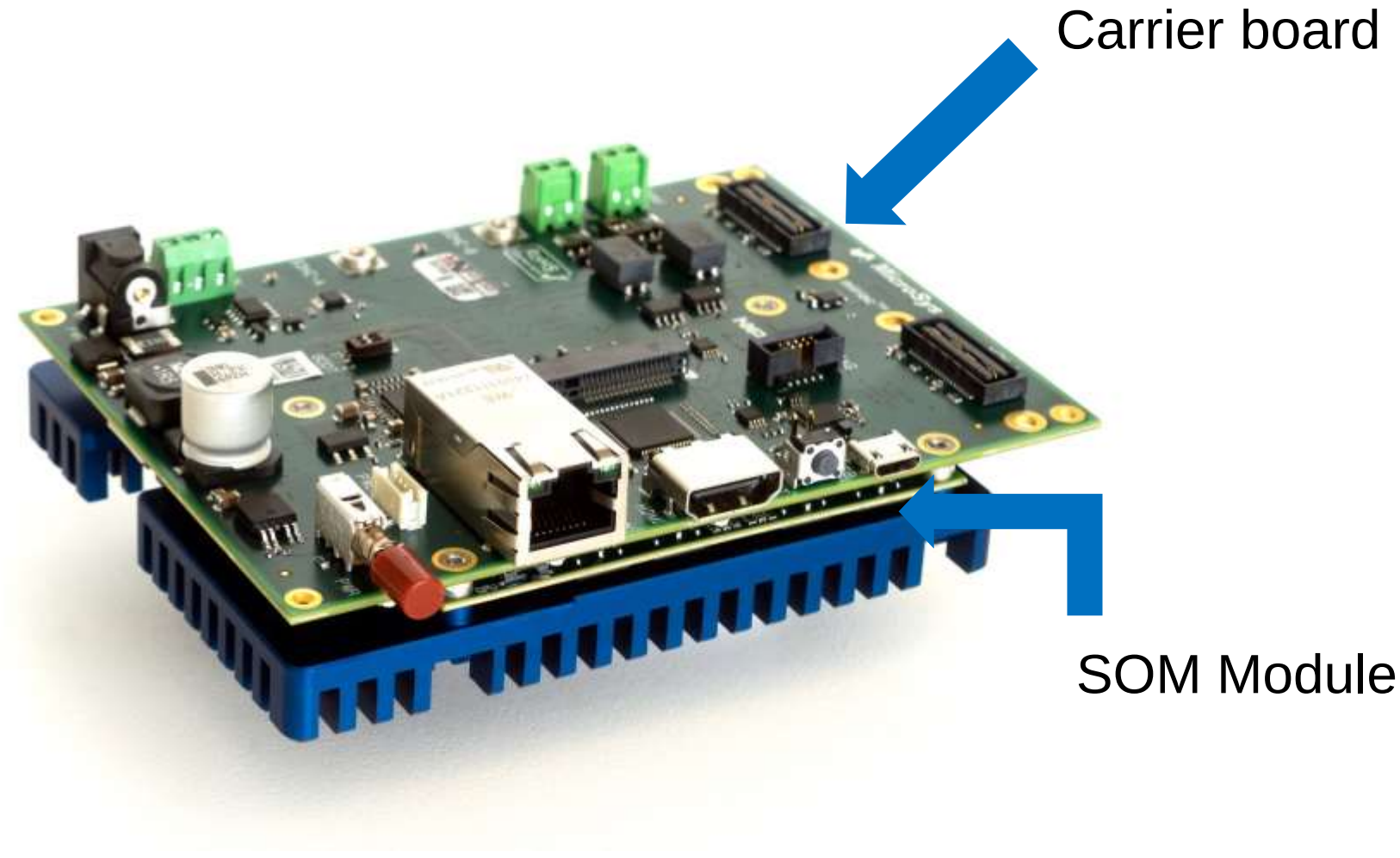


# Visual Graph Tool



# SBC-S32V234 Vision Platform… Only $649

2 x MIPI interfaces
1 x HDMI interface
Gbit Ethernet
PCIe
2 x CAN port
LIN port
USB to Serial port
JTAG



# S32V234 Compatible Cameras & Deserializer

## Supported Cameras

**S32V-SONYCAM**

**OV10640CSP-S32V**

**MXOV10635-S32V**

- MIPI camera

*** OV9716 MIPI / VIU**

- supports Maxim SerDes adapter

*** AR140**

- supports TI SerDes

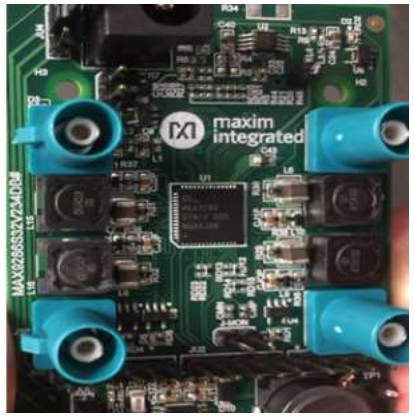
** Software available outside VSDK*

## Serdes Boards

**MAX9286S32V234**

**MAX9286S32V234DB#**

- Adapter supports 4 LVDS cameras



**TI UB964**

- Adapter supports 4 OV10640 or AR140 cameras

# S32V234 Vision Demos

## Demo Description

- The S32V234 Vision demo contains 3 pre-compiled projects which demonstrate the following demos using e-IQ™Auto software:

1. **Quad-camera Surround View Monitoring Demo**
   - Captures and stitches 4 x 1MP cameras together for 360° awareness using software from TES (3rd party)
2. **Image Classifier Demo**
   - CNN algorithm to classify images from trained dataset using Squeezenet and new e-IQ™-Auto software for APEX
3. **Object Detection Demo**
   - CNN vision algorithm detects trained image types such as vehicles, pedestrians, traffic lights and signs using and new e-IQ™-Auto software for APEX

## Demo Booking

- Contact: Philip Pesses at philip.pesses@nxp.com
- Available for reservations now

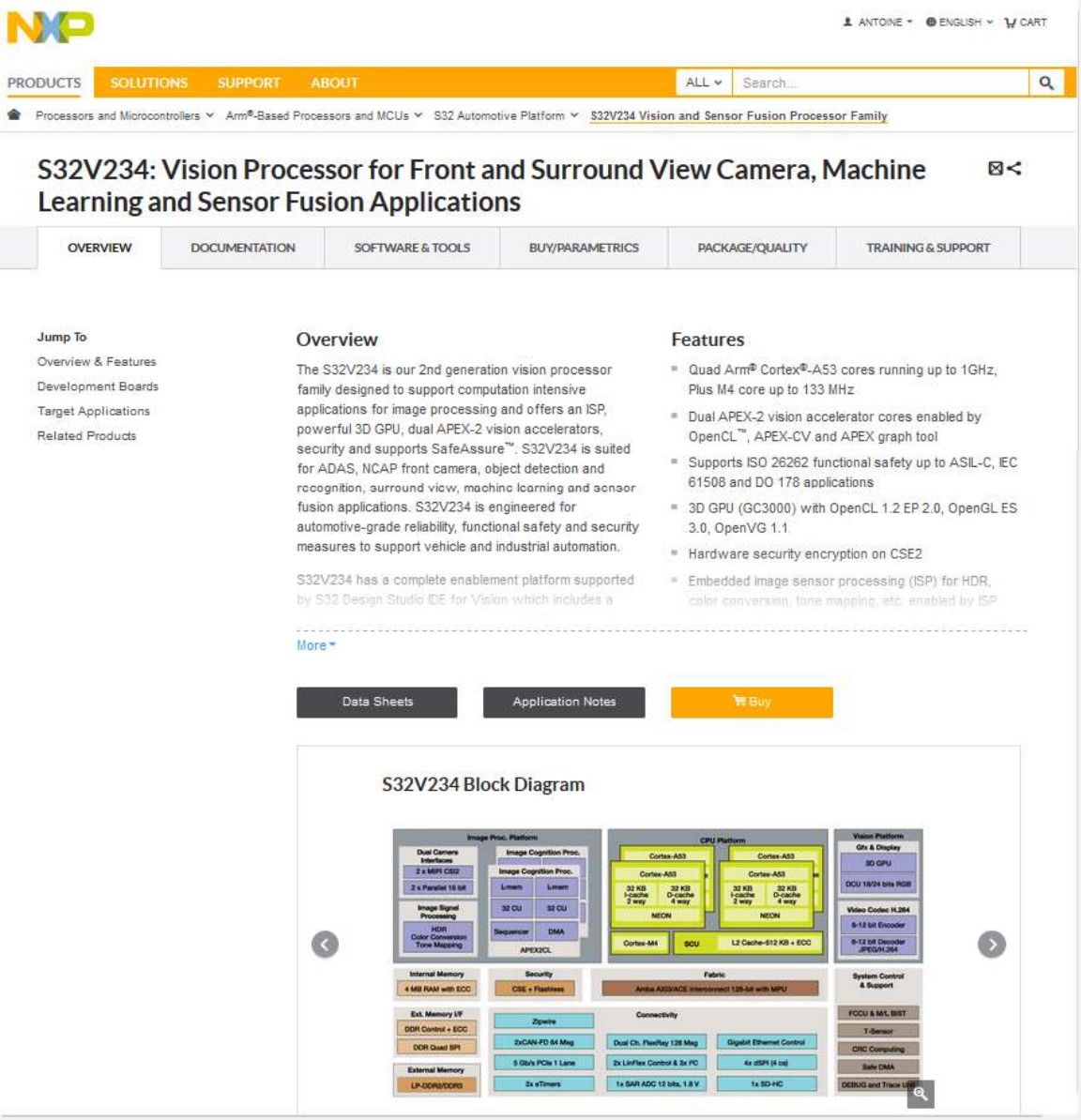
S32V234 Vision Processing Demos

# Ecosystem Overview

Use our SBC-S32V234 Quick Start Guide (QSG) to Get Started

| | | | | |
|---|---|---|---|---|
| SoC | A53 Application Cores | ISP<br>APEX<br>CODECS | GPU | M4 Realtime Core |
| SW | OSs<br>Linux BSP, QNX | Vision SDK | Vivante SDK for GPU | AUTOSAR<br>OS & MCAL<br>SDK, FreeRTOS & Drivers |
| Tools | Yocto Project | S32DS for Vision IDE (+ ISP/APEX Graph tools) | AIR | EB Tresos Studio |
| HW | Low Cost EVB<br>**SBC-S32V234**<br> | Camera Modules<br>**S32V-SONYCAM**<br> <br>**MXOV10635-S32V**<br> <br>**OV10640CSP-S32V**<br> <br>**AR140**<br> <br>**OV9716** | SerDes Modules<br>**MAX9286S32V234**<br>Deserializer<br> <br>**TI UB964**<br>Deserializer<br> | |
| Partners | Extensive partnerships with specialist companies providing - ISP software, surround view applications, AI-ML solution, hardware design and more | | | |

*Software under development and will be available in Q3/Q4 2018. Contact NXP for more information.




# Ready to be Used…

- Fully release documentation and enablement available online:
- Specs
- App Notes
- EVB (please email me for schematic)
- Enablement code
  - https://www.nxp.com/products/processors-and-microcontrollers/arm-based-processors-and-mcus/s32-automotive-platform/vision-processor-for-front-and-surround-view-camera-machine-learning-and-sensor-fusion-applications:S32V234?lang_cd=en

# S32V Vision Software Development

Ease of development

S32V Application Partners

S32V SW Partners

S32V APEX-CV

S32V Vision SDK

Apex Core Framework

- ✓ **Fully licensable applications**
  - ✓ **NCAP 2018 / 2020 PDI**
  - ✓ **LKA, AEB …**

Neusoft Automotives

Hella Aglaia

- ✓ **Algorithms**
- ✓ **OS, Tools**
- ✓ **CNN / DNN**

Neusoft Automotives

Green Hills SOFTWARE

QNX SOFTWARE SYSTEMS

…..

- ✓ ~70 kernels and graphs
- ✓ Geometric transformation
- ✓ Feature Descriptors
- ✓ Classifiers
- ✓ Write required kernel(s) or select from pre-existing kernel(s)
- ✓ Construct a graph using desired kernels
- ✓ CNN Inference kernel
- ✓ Demo source code (LDW, Optical Flow, SVM, others)

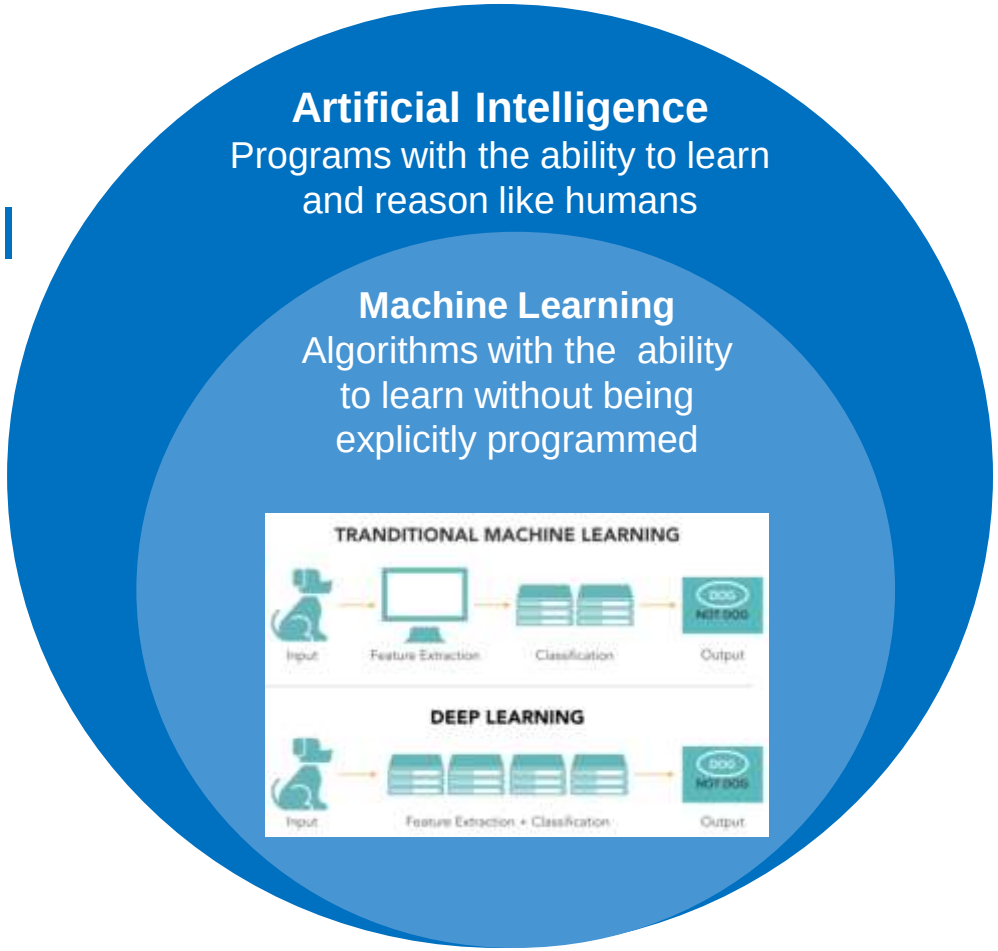
S32V Design Studio For Vision

- ISP Tools
- APEX Tools
- Compiler
- Debugger
- IDE

# EMBEDDED DEEP LEARNING

# Artificial Intelligence – Key Terms

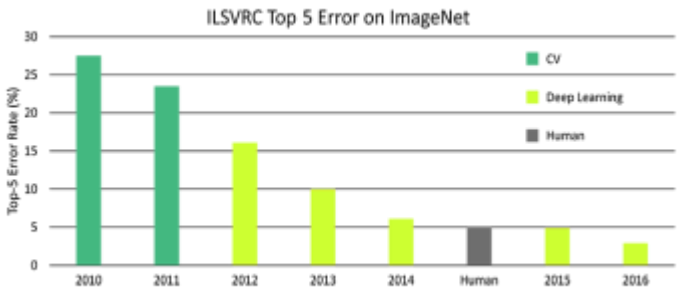
- Machine Learning (ML) is a subset of AI
  - **ML** is more specific than the overall concept of AI
  - **ML** gives computers the ability to learn without being explicitly programmed
- Deep Learning (DL) is a subset of ML
- DL frameworks – many available as open-source software library for dataflow/high performance numerical computation
  - Examples: Tensorflow, Caffe, Pytorch
- Neural Nets
  - A type of DL algorithm
  - CNNs (Convolutional Neural Nets), suited to analyzing images. Typically DL Framework agnostic
  - CNN Examples: MobileNet, ShuffleNet, SqueezeNet, ResNet

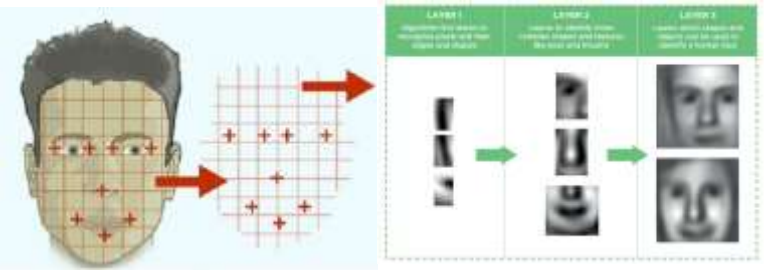


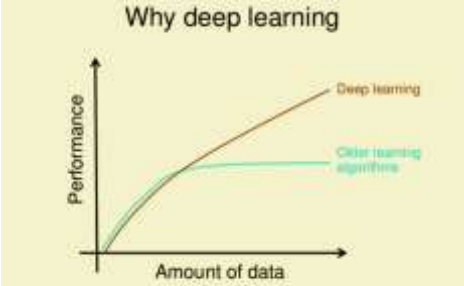

- Traditional Machine Learning
  - Is a subset of ML
  - Not DL
  - Traditional approach used in Computer Vision

# Traditional v Deep Learning

| Attribute | Comparison |
|---|---|
| Accuracy | • DL accuracy surpassed ML in many domains (vision, speech, natural languages)<br>• Breakthrough in 2012 (vision) and reached Human accuracy in 2015 |
| Domain Knowledge | • DL does not require hand crafted features and deep domain knowledge to improve accuracy |
| Data Set | • Larger training data leads to much higher accuracy improvement for DL<br>• Large public dataset available + customer proprietary |



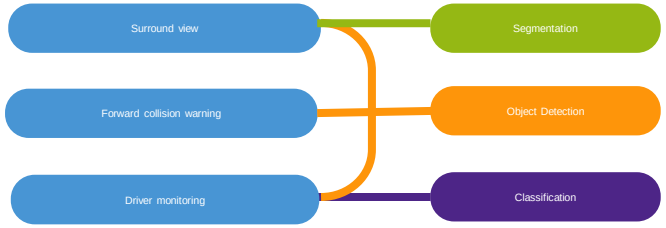






How do data science techniques scale with amount of data?

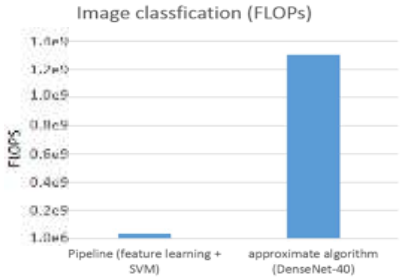
# Traditional v Deep Learning

| Attribute | Comparison |
|---|---|
| Adaptability to other use cases/markets | • Same neural network used in different use cases and markets after re-training |
| Interpretability | • Misclassification can happen with both deep learning and machine learning<br>• Harder to explain in deep learning case |
| Speed of execution | • Deep learning requires more compute power<br>• Research trend: smaller and efficient network with same accuracy (next slide) |



Squirrel identified as sea lion

Dragonfly identified as manhole cover




Takeaway: Deep learning offers path to higher accuracy and advanced features for most markets

## NXP eIQ – Inference Engines & Libraries

eIQ Deployment NN Models

CMSIS-NN | TensorFlow Lite | GLOW | TensorFlow Lite | arm NN | arm COMPUTE LIBRARY | ONNX RUNTIME | TensorFlow Lite | OpenCV | OpenCL | arm NN | arm COMPUTE LIBRARY | eIQ-MLa

## Embedded Compute Engines

| | Cortex-M | | DSP | Cortex-A | | | | GPU | | ML Accelerator |
|---|---|---|---|---|---|---|---|---|---|---|
| i.MX 8QM | * | * | | NOW | Aug '19 | NOW | NOW | Aug '19 | --- |
| i.MX 8QXP | * | * | | NOW | * | * | NOW | Aug '19 | --- |
| i.MX 8M Quad | * | * | | NOW | * | * | NOW | Aug '19 | --- |
| i.MX 8M Mini | * | * (some models) | | NOW | * | * | NOW | --- | --- |
| i.MX 6 and 7 | * (only some models) | --- | | * | * | * | * | * (some models) | --- |
| LS1, LS2, LX2 | --- | * | | * | --- | * | * | --- | --- |
| i.MX RT1050/1060 | NOW | * | | --- | --- | --- | --- | --- | --- |

# Contact and Questions

Philip Pesses

Automotive Distribution Marketing

philip.pesses@nxp.com

Kushal Shah

Automotive Applications

kushal.shah@nxp.com

SECURE CONNECTIONS
FOR A SMARTER WORLD

NXP and the NXP logo are trademarks of NXP B.V. All other product or service names are the property of their respective owners. © 2019 NXP B.V.