S32 Radar Processor, Product Revolution

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Automotive Microcontrollers & Processors

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NXP | CONNECTS

Agenda

- Introduction: Autonomy & Radar

- Automotive RADAR: The Basics

- Adoption through Enablement

- NXP Radar Leadership

- Redundancy & complimentary sensors

- Q&A

1.3 MILLION

Road traffic deaths occur every year

HIT BY A VEHICLE TRAVELING AT:

22 m/h

9 OUT OF 10 PEDESTRIANS SURVIVE*

HIT BY A VEHICLE TRAVELING AT:

31 m/h

5 OUT OF 10 PEDESTRIANS SURVIVE

HIT BY A VEHICLE TRAVELING AT:

44 m/h

ONLY **1 OUT OF 10** PEDESTRIANS SURVIVES

OUT OF ALL ACCIDENTS GLOBALLY, **90%** are caused by **HUMAN ERROR**

Source: Seattle's Vision Zero Plan/Documents/Departments/beSuperSafe/VisionZeroPlan, ASIRT.ORG

Enabling Self-driving Cars

Better senses than the human driver.

Automation of driving decisions.

SENSE

THINK

ACT

Architecting the Car of the Future

More than a brain on four wheels.
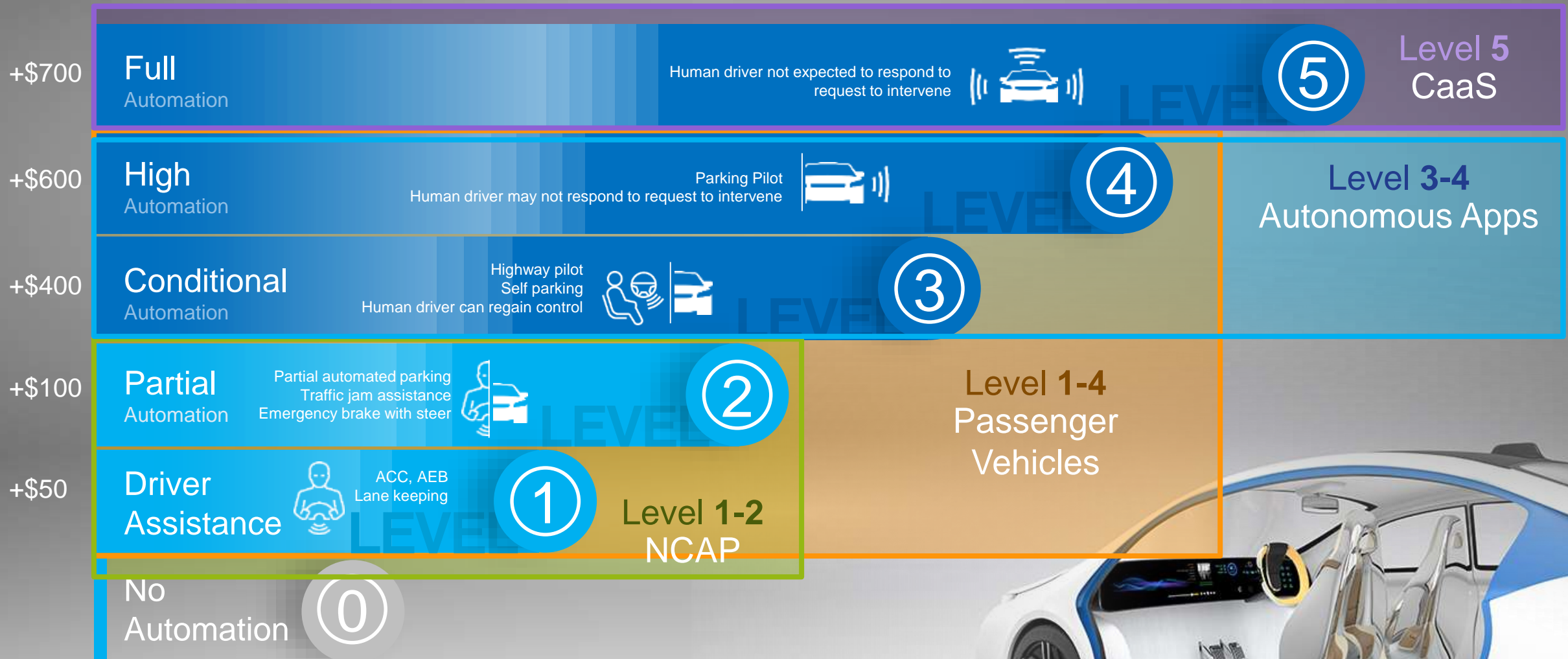The core of safe and secure mobility.

SENSE   **THINK**   **ACT**

LEVERAGING

Leadership in processing, security and mobile

Higher Levels of Automation: Higher Computation, Storage & Sensors

+$700	**Full** Automation — Human driver not expected to respond to request to intervene — ⑤ — Level **5** CaaS
+$600	**High** Automation — Parking Pilot — Human driver may not respond to request to intervene — ④
	Level **3-4** Autonomous Apps
+$400	**Conditional** Automation — Highway pilot, Self parking, Human driver can regain control — ③
+$100	**Partial** Automation — Partial automated parking, Traffic jam assistance, Emergency brake with steer — ②
	Level **1-4** Passenger Vehicles
+$50	**Driver Assistance** — ACC, AEB, Lane keeping — ① — Level **1-2** NCAP
	No Automation — ⓪

Semi Content per Car increase (TAM) vs Level 0
Source: Strategy Analytics; IHS; Evercore; ABI Research; NXP

Higher Levels of Automation: Higher Computation, Storage & Sensors
Typical Vehicle Architecture

		U-sonic	Radar	Imager	S.S. Lidar	V2X Cloud	Conv SIG. Proc/ML & / DL	Storage
5	Level	8-12	6-12	8-12	1-3	Yes	**AI** >200k DMIPS, >50 TOPS	?
4	Level	8-12	6-12	8-12	1-3	Yes	**AI** 200k DMIPS, 50 TOPS	4TB
3	Level	8-12	4-8	3-8	0-1	Yes	**AI** 60k DMIPS, 5-10 TOPS	GBs
2	Level	8-12	3-5	1-3	no		20k DMIPS, 1 TOPS	
1	Level	4-8	0-3	0-1	no		<10k DMIPS	

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New Car Assessment Program (NCAP): <u>Safety</u> Features

- AEB Pedestrians
- AEB Cyclists
- AEB Urban
- Emergency Lane Keeping
- Lane Keep Assist

- Junction / Cross Traffic Assist
- Auto Emergency Steering
- Reverse AEB
- AEB Pedestrians (low light)
- AEB Cyclists (low light)
- Driver Monitor

- Auto Emergency Steering
- AEB Head on
- Evasive Steering and AEB
- Child Presence Detection

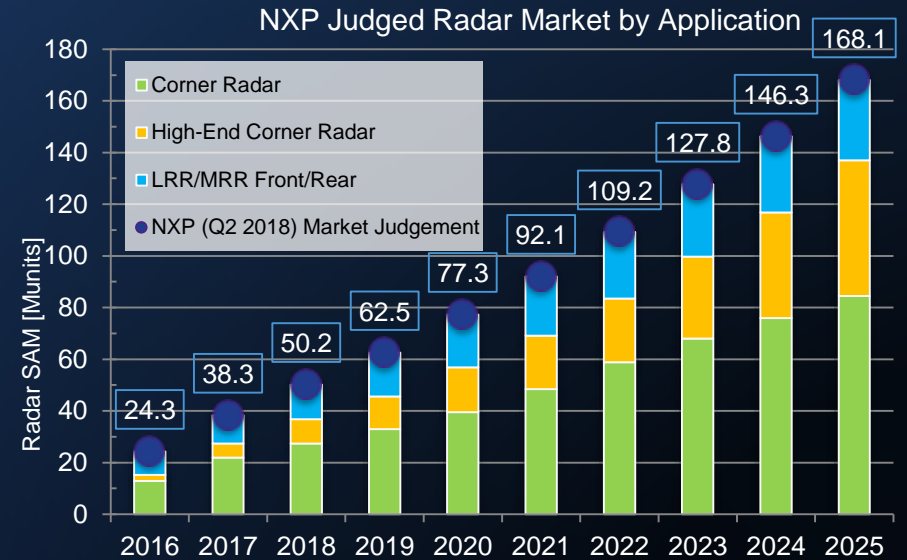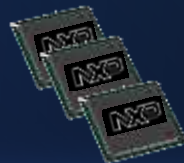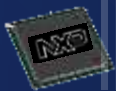# Market Trends: Spurring Radar Growth

1 NCAP Safety
More cars with radar

2 Corner Radar
More sensors per car

Front Cross Traffic Alert (FCA)
Rear Cross Traffic Alert (RCA)
Lane Change Assist (LCA)
Adaptive Cruise Control (ACC)
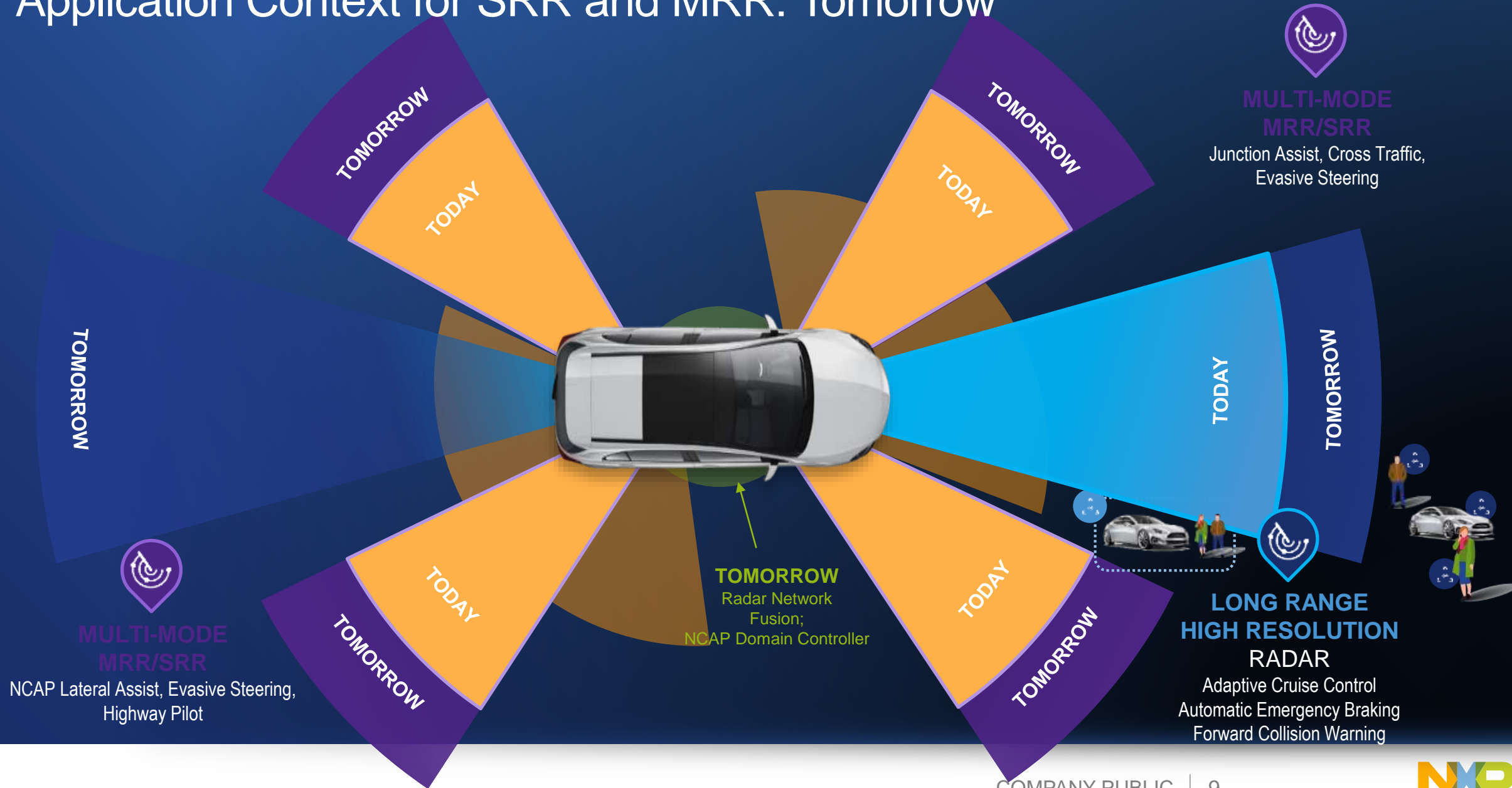Automatic Emergency Brake (AEB)
Blind Spot Detection (BSD)

3 Autonomous Driving
More radar ICs per sensor

NXP Judged Radar Market by Application

- ▇ Corner Radar
- ▇ High-End Corner Radar
- ▇ LRR/MRR Front/Rear
- ● NXP (Q2 2018) Market Judgement

Radar SAM [Munits]

Year	Value
2016	24.3
2017	38.3
2018	50.2
2019	62.5
2020	77.3
2021	92.1
2022	109.2
2023	127.8
2024	146.3
2025	168.1

NXP Radar Shipments > 120 Mu

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Application Context for SRR and MRR: Tomorrow

MULTI-MODE MRR/SRR
Junction Assist, Cross Traffic, Evasive Steering

TOMORROW
TODAY
TOMORROW

TOMORROW
TODAY
TOMORROW

TOMORROW
Radar Network Fusion;
NCAP Domain Controller

LONG RANGE HIGH RESOLUTION RADAR
Adaptive Cruise Control
Automatic Emergency Braking
Forward Collision Warning

MULTI-MODE MRR/SRR
NCAP Lateral Assist, Evasive Steering, Highway Pilot

Automotive RADAR
The Basics

RADAR Basics

RADAR (Radio Angle Detection And Ranging)

- ## What is a radar?

  - Transmit a radio signal toward a possible target
  - Some of the radio signal energy that hits the target will return
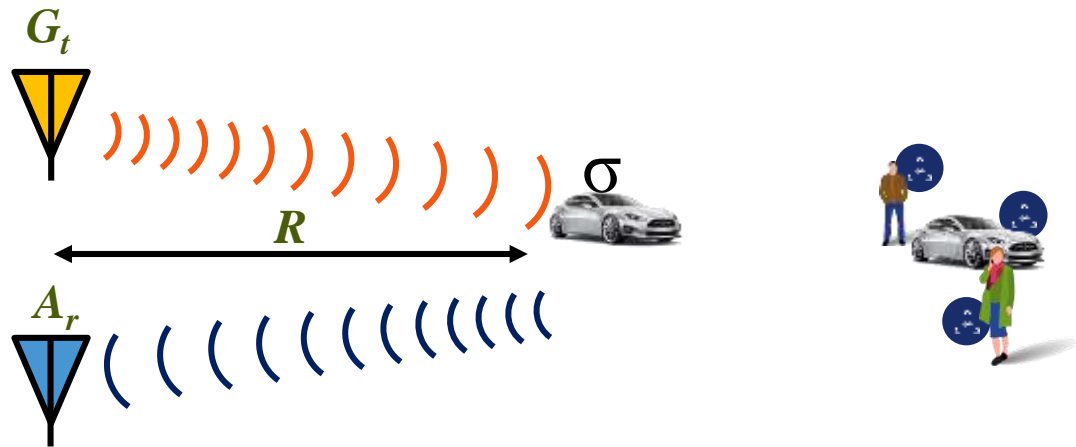
  - Receive the return signal
  - The time delay between the transmitted signal and the received signal gives target range information

RADAR Basics

RADAR (Radio Angle Detection And Ranging)

- For a target 100 meters away, the time delay is doubled because the signal must travel 100 meters to the target and return 100 meters
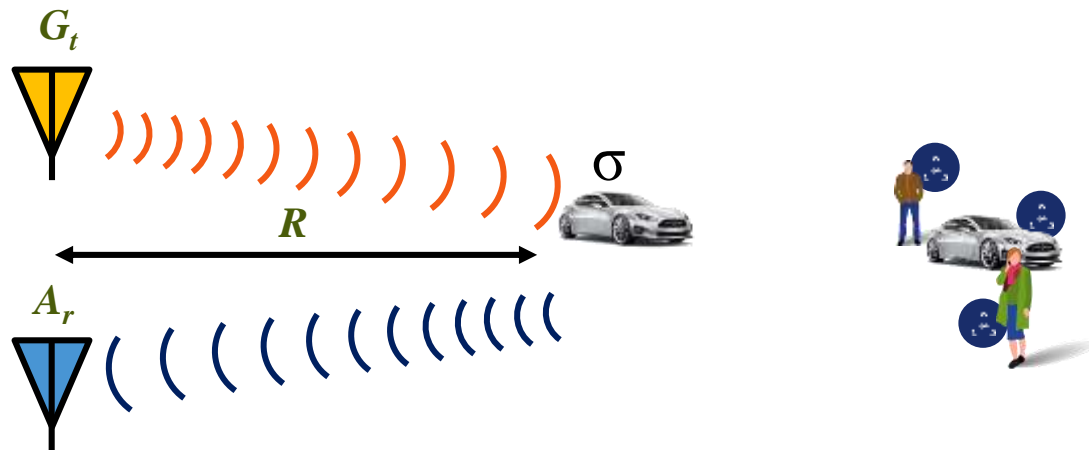
  – Target at 100 meters => 666 nanosecond travel time

- The term commonly used is "radio signal" and can take many forms
  – Pulsed
  – Continuous wave

Automotive RADAR Technology

Industry Standardizations & Regulations…

- Measurement Concept – FMCW (Frequency Modulated Continuous Wave)
- Carrier Frequency
    - 24 GHz
    - 77 GHz

TREND ➡

24 GHz   **77 GHz**

Volume

Model Year
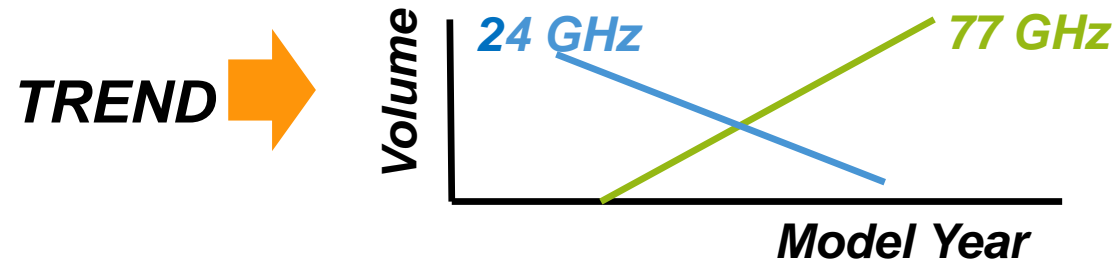
- RF Power – milliwatts to 10s of milliwatts
- Antennas – Patch antennas on "PCB" *(printed circuit board)*
- Electronic Components
    - Two IC packages or One IC package for primary functionality
    - Plus support components (power supply, communications, EMC, etc.)
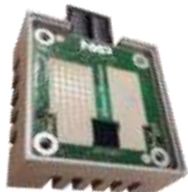
Automotive RADAR Technology

Basic Functional Blocks

The radar have two major functional blocks:

- RF Sensor (the RF "Front End")
  - Antennas
  - Signal creation and transmission
  - Signal reception and signal conditioning
  - Analog to digital sampling

- Computational (RADAR MCU)
  - Convert sampled signal into frequency information
  - Identify "targets"
  - Calculate 1) distance, 2) relative radial velocity and 3) angle of target
  - Advanced functions like classification & tracking
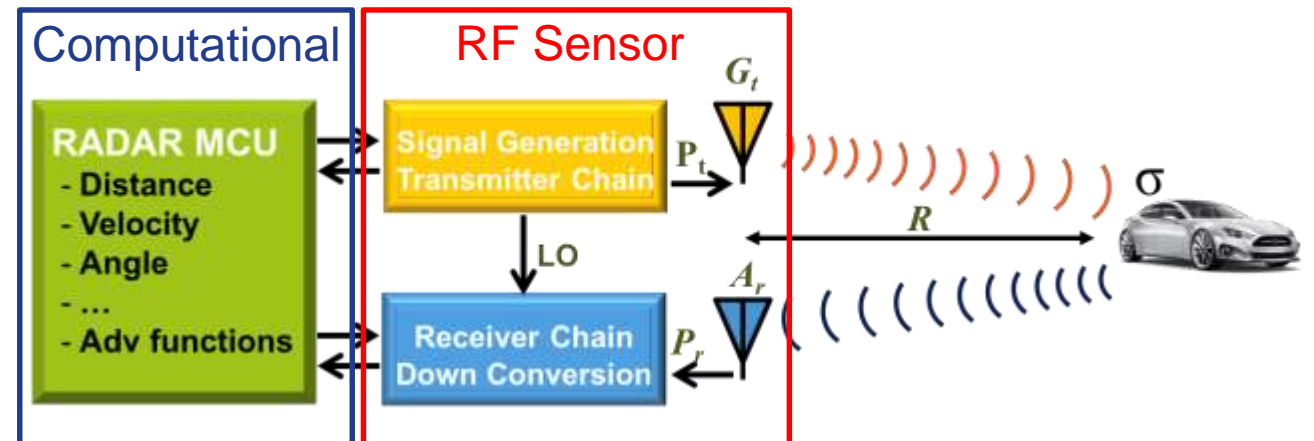
- In Vision, higher resolution is relatively straight-forward
  - Make smaller pixels & more of them

- In RADAR it is more complicated and not that simplified
  - RADAR is an active sensor
  - 4-dimensional attributes (Elevation, Range, Doppler & Angular resolution

- Single dimension optimizations can lead to trade-offs in others
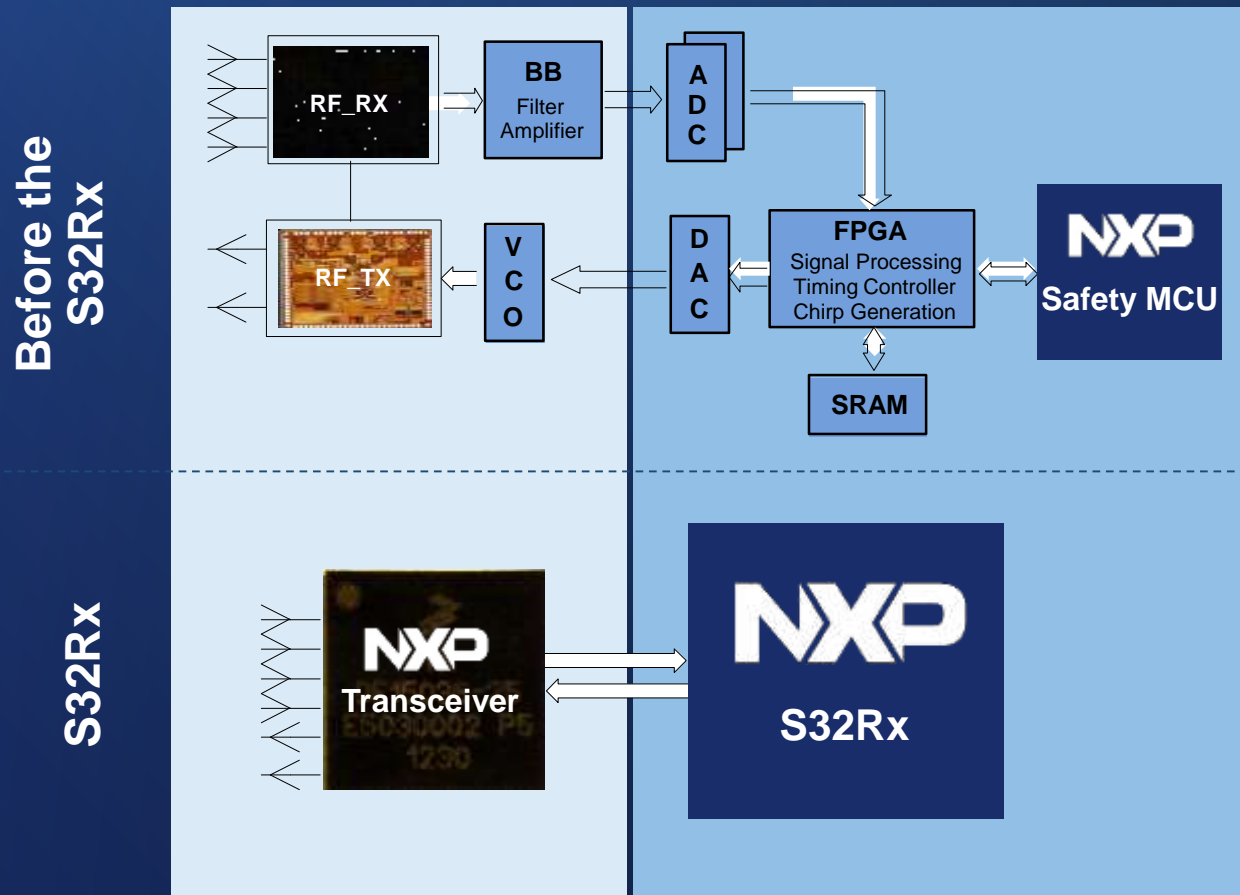
Parameters of Interest

RADAR (Radio Angle Detection And Ranging)

- Range
  - Maximum Detection Range
  - Range Resolution
- Velocity/Doppler
  - Maximum Detection Velocity
  - Velocity Resolution
- Angular/Azimuth
  - Angle Resolution
- Elevation

Automotive RADAR Rapid Adoption Through Enablement

S32R – Highly Integrated & Revolutionary

Before the S32Rx

- RF_RX → BB Filter Amplifier → A D C
- RF_TX ← VCO ← D A C
- FPGA: Signal Processing, Timing Controller, Chirp Generation
- NXP Safety MCU
- SRAM

S32Rx

- NXP Transceiver → NXP S32Rx

NXP 77 GHz Chipset replaces

- Bare Die RF solutions with a RF Chipset based on RCP package technology
- Discrete Filter Components and Amplifiers

S32Rx Product Family replaces

- 8 ADC
- 1 DAC
- 1 FPGA
- External SRAM
- General purpose MCU

NXP enables

- Significant PCB area saving
- Reduced assembly cost
- Increased PCB quality

Proliferation of Radar Sensors

Performance

- Robust performance under all conditions

- Miniaturization / cost effectiveness

- Improved Perception: height, imaging, classification

- High 360° detection performance of static and dynamic targets

Tools & Support

- Efficient simulation tooling

- 3D construction combined with simulation

- Support for sensor validation & virtual validation

Features

- Standardized Interface (Measurement, Debugging & Vehicle Connectivity)

- High data rate interconnectivity to record and replay sensor data

- Testing capability at all processing stages – from antenna to object data

NXP Core Values to Solve the Current Challenges of the Market

Computation Performance
Lead the heterogeneous compute performance with purpose built processors, optimized for power

Safety
No compromise on safety. Progression from ASIL to enhanced dependability and fail operational modes support

Ease of Use
Based on OPEN standards, portable and relocatable

Modularity Scalability
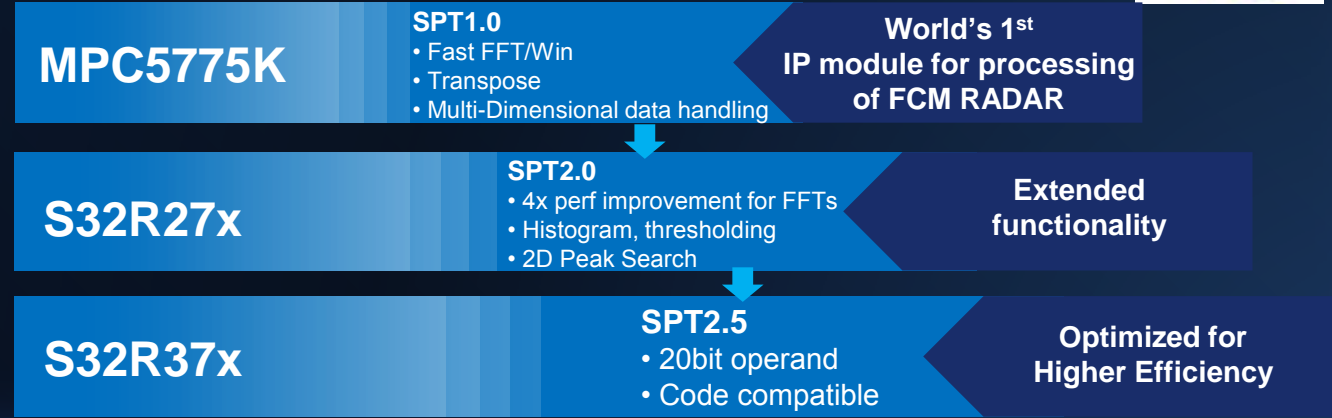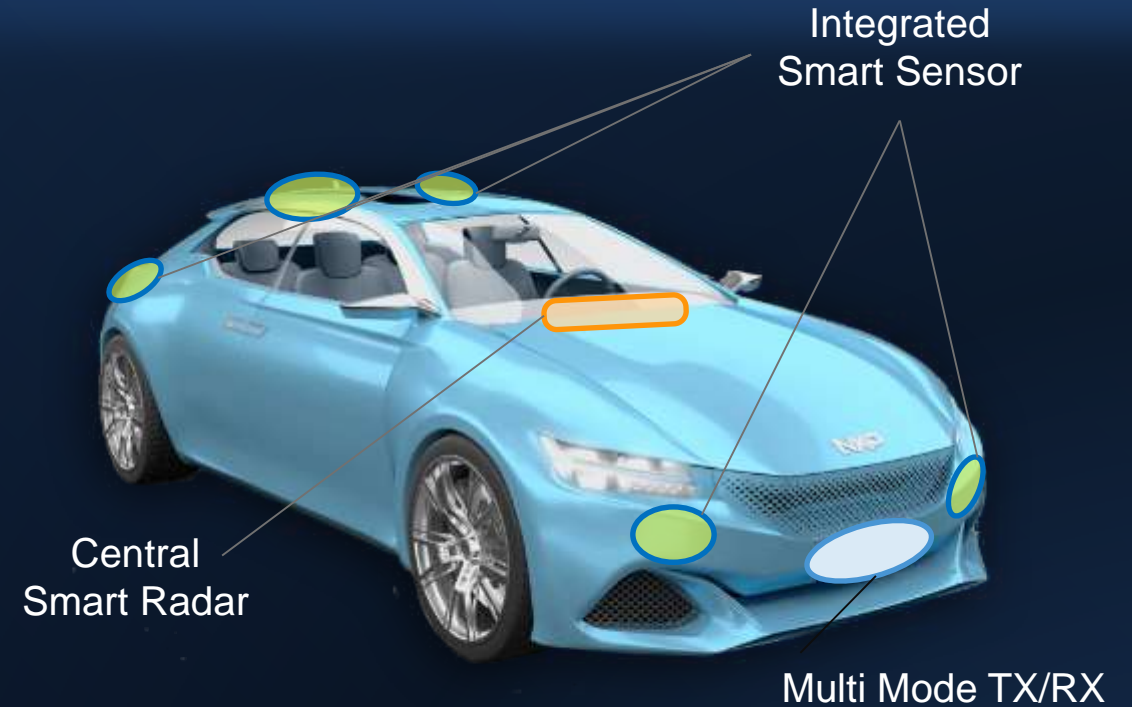Built on 'clear functionally separated extensible' entities

#1 Radar Processor Provider

Scalable, highly integrated, safe and secure family driving the digitalization of radar and sensor data fusion.

50%
radar modules use
NXP radar technology in 2016

S32R

#1 in Radar Processing Integration & Performance Per Watt

Integrated Smart Sensor

Central Smart Radar

Multi Mode TX/RX

MPC5775K	**SPT1.0** • Fast FFT/Win • Transpose • Multi-Dimensional data handling	**World's 1st** **IP module for processing** **of FCM RADAR**
S32R27x	**SPT2.0** • 4x perf improvement for FFTs • Histogram, thresholding • 2D Peak Search	**Extended** **functionality**
S32R37x	**SPT2.5** • 20bit operand • Code compatible	**Optimized for** **Higher Efficiency**

Automotive RADAR
A Market Leadership Position

NXP Radar System Solution Leader

Complete portfolio of Radar Processors, RF Transceivers, PMIC, & Network ICs

- **Market Leadership – the Proven Partner Today**

  - 11 years leadership in radar

  - >50% market share* for NXP 77 GHz Radar Products

  - Includes MCU, Transceivers, PMIC / SBCs and Networking PHYs

- **A Focus on the future – the Partner for Tomorrow**

  - One-stop shop for complete radar sensor portfolio

  - Scalable from entry level to premium car segments

  - Covers corner radar and high performance imaging radar

  - Driving continuous innovation

  - 91+ patents granted and 72+ patents pending

*NXP Estimates

Bare Die to Chipsets

Blackbird

Osprey

MPC5675K   MPC5775K
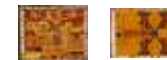
MPC5xxxK

MR2001

A Complete Radar Solution - Integrated Transceivers + Radar Processors

MR3003   TEF810X
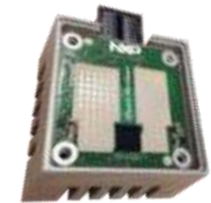
Network ICs

S32Rx Product Family

Safety PMICs

S32R2x   S32R3x

S32R27/37 Value Proposition

Highlights

Computation Cores - Dual Power Architecture e200z7 32-bit CPU compatible to MPC5775K and S32R27

Optimized RADAR Signal Processing Acceleration to maximize performance/watt

Scalable Family of Solutions - Pin compatible with S32R37

Automotive Safety - Designed for ASIL-D applications

Security Enabled - Embedded cryptographic security engine

2 x Dual Power® architecture e200z cores

2x e200z7 32-bit CPU (240 MHz), 2x Power Architecture® e200z4 32-bit CPU (120 MHz) with checker core

System Memory

Up to 2 MB Flash and up to 1.5 MB SRAM for radar app. storage, message buffering and radar stream handling

RADAR I/F & Processing

MIPI-CSI2 (4 data lanes), ΣΔ-ADC (4x 12-bit, 10 MSps) and DAC (10 MSps), Signal Processing Toolbox SPT 2.0

Functional Safety and Security

2x e200z7 & 2xe200z4 (lock-step), ISO 26262 up to ASIL D, Cryptographic Services Engine (CSE2), ECC, BIST, MPU, Voltage & Clock Monitoring

Connectivity

3 FlexCAN incl. 2x CAN-FD (Flexible Data Rate) with enhanced payload and data rate, Ethernet, FlexRay™, Zipwire to connect to a radar ASIC, 2 SAR-ADCs, 2x SPI, 2xI2C, LINFlexD
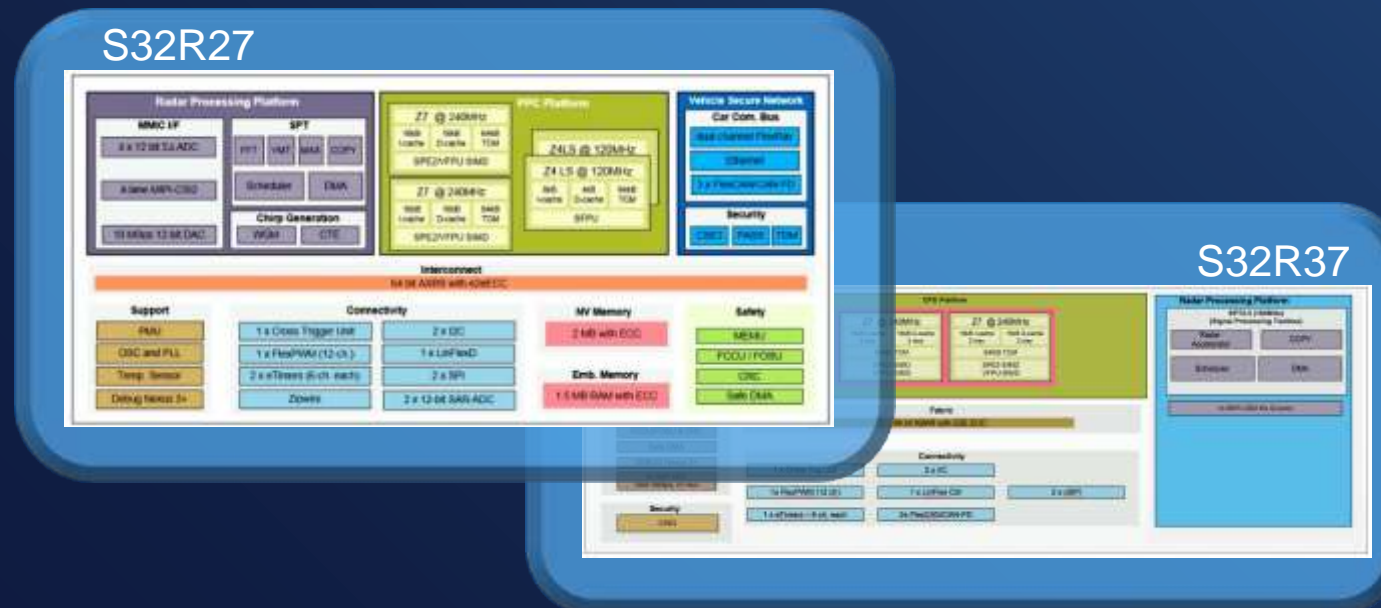
Broadening Ecosystem

Software

✓ AUTOSAR safety MCAL and non-AUTOSAR MCAL

✓ S32 Design Studio IDE support with 3rd party plug-in support

✓ Compiler support by WindRiver, GreenHills

✓ Debugger support by Lauterbach, P&E, iSystems

✓ Automotive grade Radar Software Development Kit

✓ Model based design in MATLAB™ for radar accelerator

✓ RDK-S32R274 Automotive Radar Reference Platform

✓ Hardware and software tools compatible with S32R37 microcontroller

Easy prototype

✓ Processor Expert based configuration
✓ Documented Source code and examples
✓ Eclipse or other IDEs
✓ Middleware stacks + FreeRTOS operating system

Easy production

✓ Quality level: SPICE/CMMI compliant (Class B), MISRA 2012 compliant
✓ Automotive-grade quality for low-level drivers code, headers and middleware
✓ Multiple toolchains supported
✓ Consolidates other S32 SW projects: Stacks, Flash drivers, FreeRTOS

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Addressing Market Need

Key Silicon Value

- #1 in Radar manufacturing company

- 4x more radar performance than previous generation

Key Software Value

- Fully utilized integrated radar accelerators

- Software made easy with Auto grade SDK

- Faster development time

SOLUTION

- First Automotive complete solution for developers

- Faster time to market for customers

- Ready to meet NCAP compliance

Addressing Application Needs:

Automatic **E**mergency **B**raking
Adaptive **C**ruise **C**ontrol
Blind **S**pot **D**etection

RDK-S32R274- Reference Platform for Automotive Radar

Key Platform Features

o Targeted at ACC/AEB applications
o Leverages NXP market leading radar processor
o Built on automotive grade radar SDK & HW

*Module housing not shown above

o **NXP/CEI Radar Reference Platform**
  o Complete HW & SW package
  o ASIL-B reference application ready
  o FCC/CE certified design
o **Reference BOM ready for mass market**
  o Radar Front End: TEF8102
  o Radar Processor: S32R27x
o **Availability: Order Today for $3500!**

o **Package Includes:**
  o HW Reference design in production housing
    o NXP RF Front end with Antenna
    o NXP S32R Processor
    o Ethernet enabled output to PC
  o Reference application (app notes & code available)
  o NXP development environment enabling customer optimization

Vehicle Sensor Lineup Redundancy While Also Being Complimentary

Sensor Technologies of the Autonomous Vehicle

RADAR
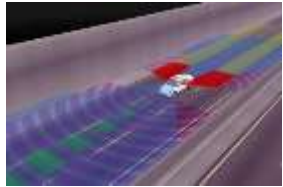
Vision

LiDAR
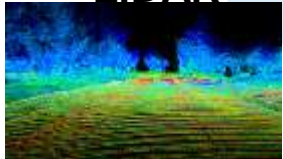
Ultrasonic

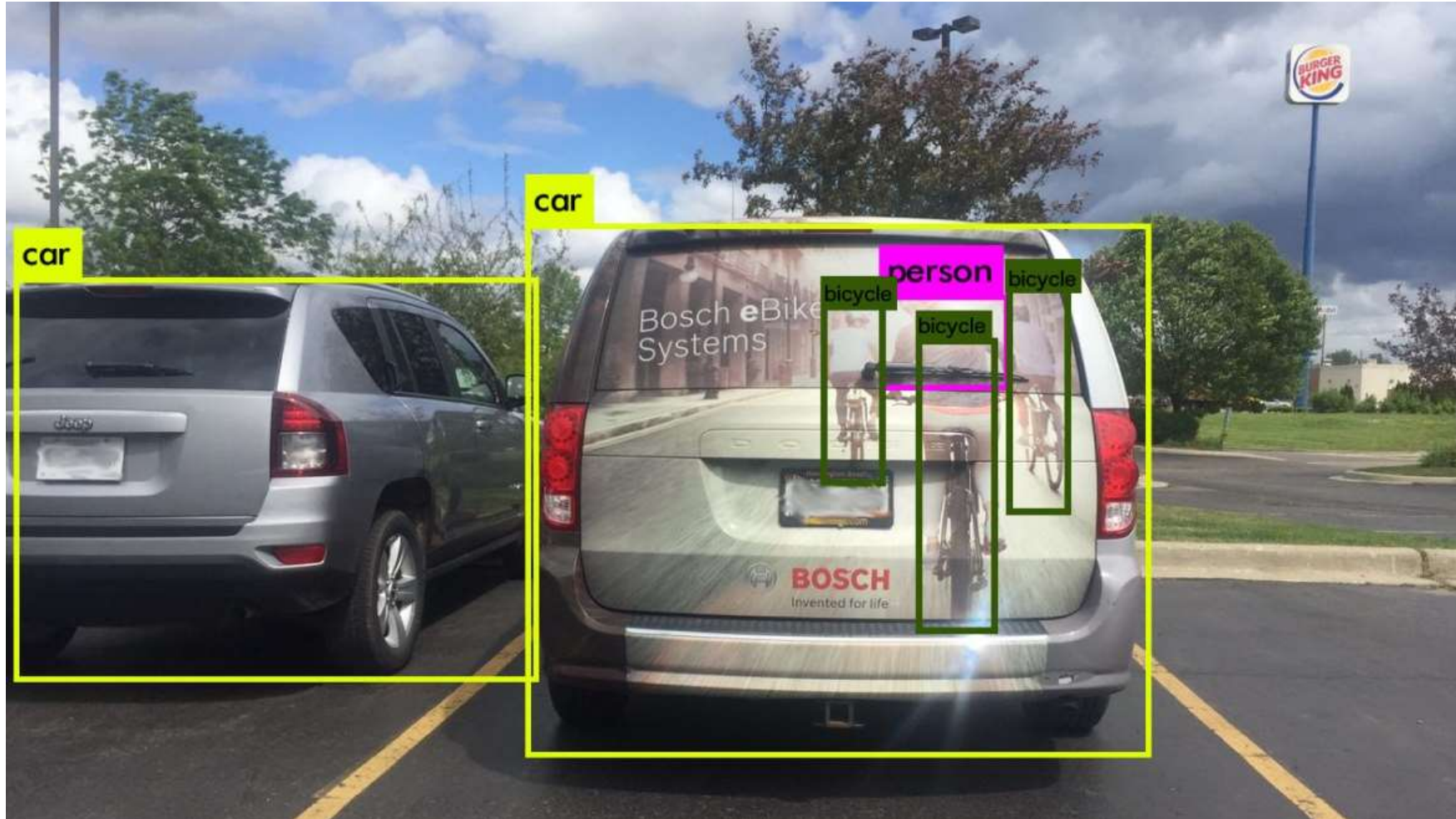A Sensor Package in a L3 Vehicle Today
- 1-3 RADAR's
- 1-5 cameras
- 0-1 Laser/Lidar
- 4-12 Ultrasonic

What will it be in 2020 & beyond?

	All Weather	Classify Objects	Resolution	Industry Adoption
	✓	✓	✗	✓
	✗	✓	✓	✓
	✗	✓	✓	✗
	✓	✗	✗	✓

When Critical Sensors Mislead….

Complementary Sensors in the Autonomous Vehicle

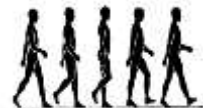Could High Resolution Radar be the perfect complement to Vision?

Radar

Vision

What if we could solve the "Resolution problem" in current Radar Applications?
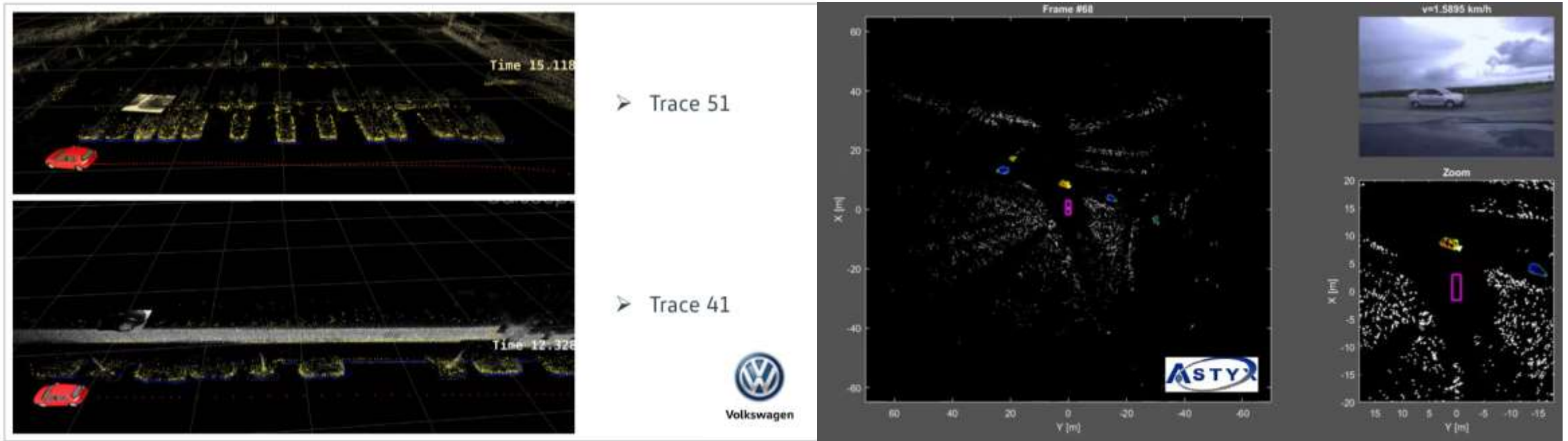
Mapping
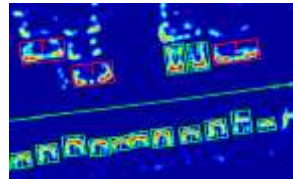
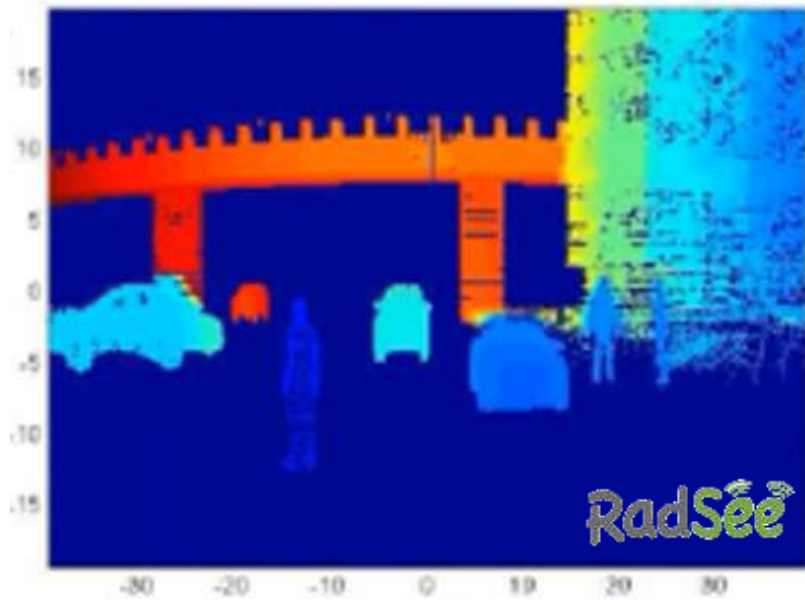Classification
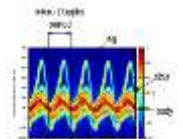
High Resolution RADAR

Vision

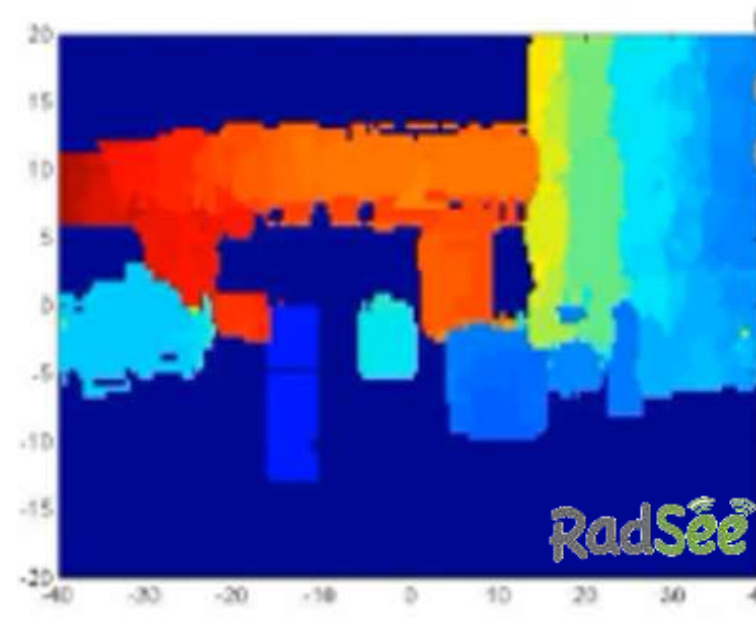# Advanced Radar Techniques: Imaging

- Higher Resolution 77GHz Radar – enabling mapping

Advanced Radar vs. Lidar

Lidar

High Resolution Radar

- High Resolution Radar ('Imaging Radar')
  - Claims as low as 1.2° of angular resolution

SAFE AND SECURE MOBILITY
AT THE HEART OF AUTONOMOUS DRIVING

SECURE CONNECTIONS
FOR A SMARTER WORLD