NXP AUTOMOTIVE RADAR

PL ADAS

MARCH 2023

SECURE CONNECTIONS
FOR A SMARTER WORLD

AGENDA

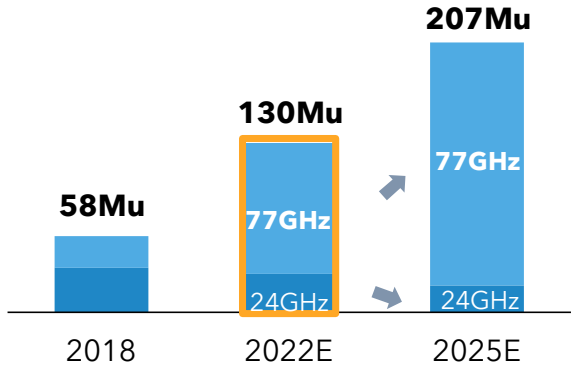
- Automotive Radar market trend
- Radar Roadmap
- Smart TRX 1-chip Radar Family
- 4D Imaging Radar
- ADAS Sensor Bridges
- Advanced Radar Algorithms
- Distributed Coherent Radar

MORE THAN 15 YEARS OF NXP AUTOMOTIVE RADAR EXPERIENCE INVESTMENT

NXP EXTENDS #1 MARKET SHARE POSITION IN 2022

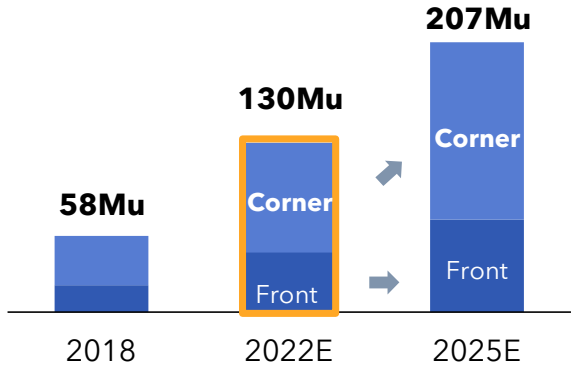
Automotive Radar Market[1]

24 vs. 77 GHz split



The 24GHz to 77GHz transition and corner radar acceleration are key to growth

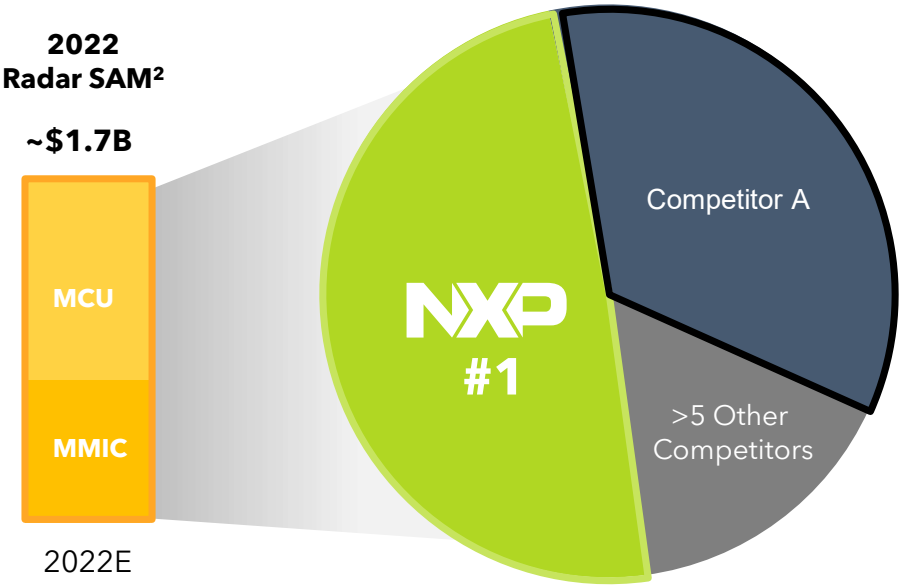
Sensor segment split



Market Share 2022[2]

2022 Radar SAM[2]

~$1.7B



NXP is the market share leader in 2022,
for Automotive Radar overall
as well as for MMIC & MCU categories

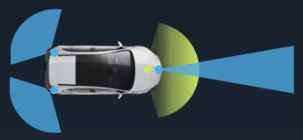
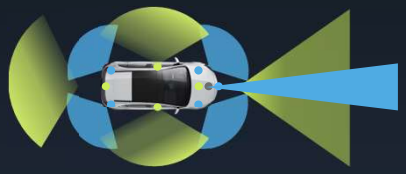
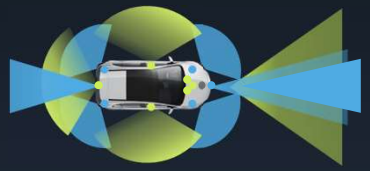
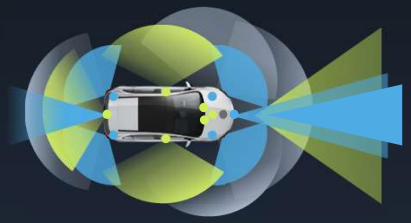
1. Yole Développement
2. Yole Développement, Automotive Radar 2022 MMIC & Radar MCU market shares

ADAS AND AUTONOMOUS DRIVING MARKET TRENDS

NCAP & COMFORT FUNCTIONS DRIVE STRONG L1-3 GROWTH – FULL AUTONOMY DELAYED

NXP 4D Imaging Radar

NXP Radar

LEVEL 1	LEVEL 2	LEVEL 2+ / L3	LEVEL 4 TO 5
Driver Assistance	Partial Automation	Conditional Automation	High/Full Automation
			
~25% of cars '30	**~18%** of cars '30	**~43%** of cars '30	**4%** of cars '30
RADAR 1-3	RADAR 3-5	RADAR 5+	RADAR 6-10
CAMERA 1-2	CAMERA ≥4	CAMERA 6-8	CAMERA 6-8
LIDAR 0	LIDAR 0	LIDAR 0-1	LIDAR 1-3

Vehicle ownership: trending towards higher automation

>90% of vehicles produced in 2030 fall into levels 1-3

Mobility as a service

Opportunity to replace LIDAR using Imaging Radar

1. Yole Développement, NXP estimates

RADAR IS EVOLVING TOWARDS PRECISE MAPPING OF ENVIRONMENT

	Key measurement	Environmental limitations
RADAR	Speed, distance, angle ✓	Insignificant ✓
CAMERA	Object, pattern, color ✓	Rain, fog, night, sun ✗
LIDAR	Angle, distance ✓	Rain, snow ✗

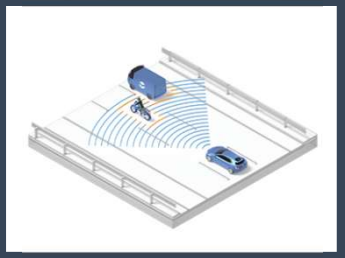
Three generations of 77GHz RFCMOS Radar

Investment Focus

RADAR TECHNOLOGY

Detecting a car

4D sensing: Precise map of the environment



Extended detection range
Detect objects at >300m, lost cargo scenario

Ultra-compact sensor
30% reduction vs. previous generation

Environmental mapping
Detect, classify VRUs & pass-through clearances

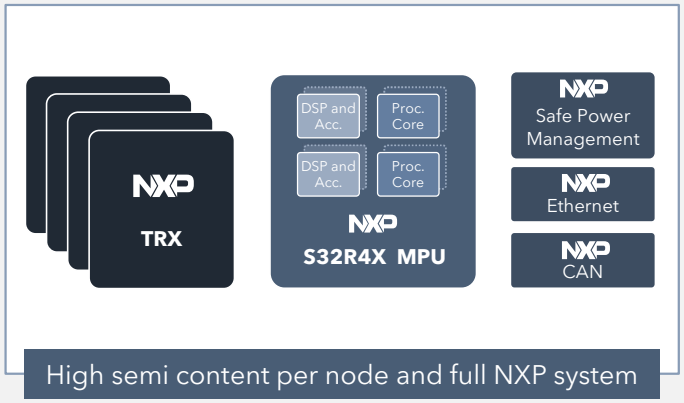
BOOSTING PERFORMANCE WITH HIGH RESOLUTION 3-IN-1 RADAR FOR L2+ AUTOMATION

IMAGING RADAR 77 GHZ
Highest resolution and performance

LONG-RANGE RADAR 77 GHZ
Front and rear higher performance

CORNER RADAR 77 GHZ
Multiple small modules

NXP 4D IMAGING RADAR



High semi content per node and full NXP system

Maximum awareness: concurrent 3-in-1 sensing

Simultaneous multi-mode scan: wide, mid and far in 4 dimensions

Concurrent use of transmitters plus adv. coding and algorithms

Maximum efficiency for <1° resolution

192 virtual channels and 12x efficiency gain

Smart and lean design vs. ordinary antenna count scaling

ENABLING MASS ADOPTION OF L2+

NXP 4D IMAGING RADAR IS READY TO HIT THE ROAD

3-IN-1 SENSING LIVE VEHICLE DEMO

Short- & mid-range sensing in busy urban setting

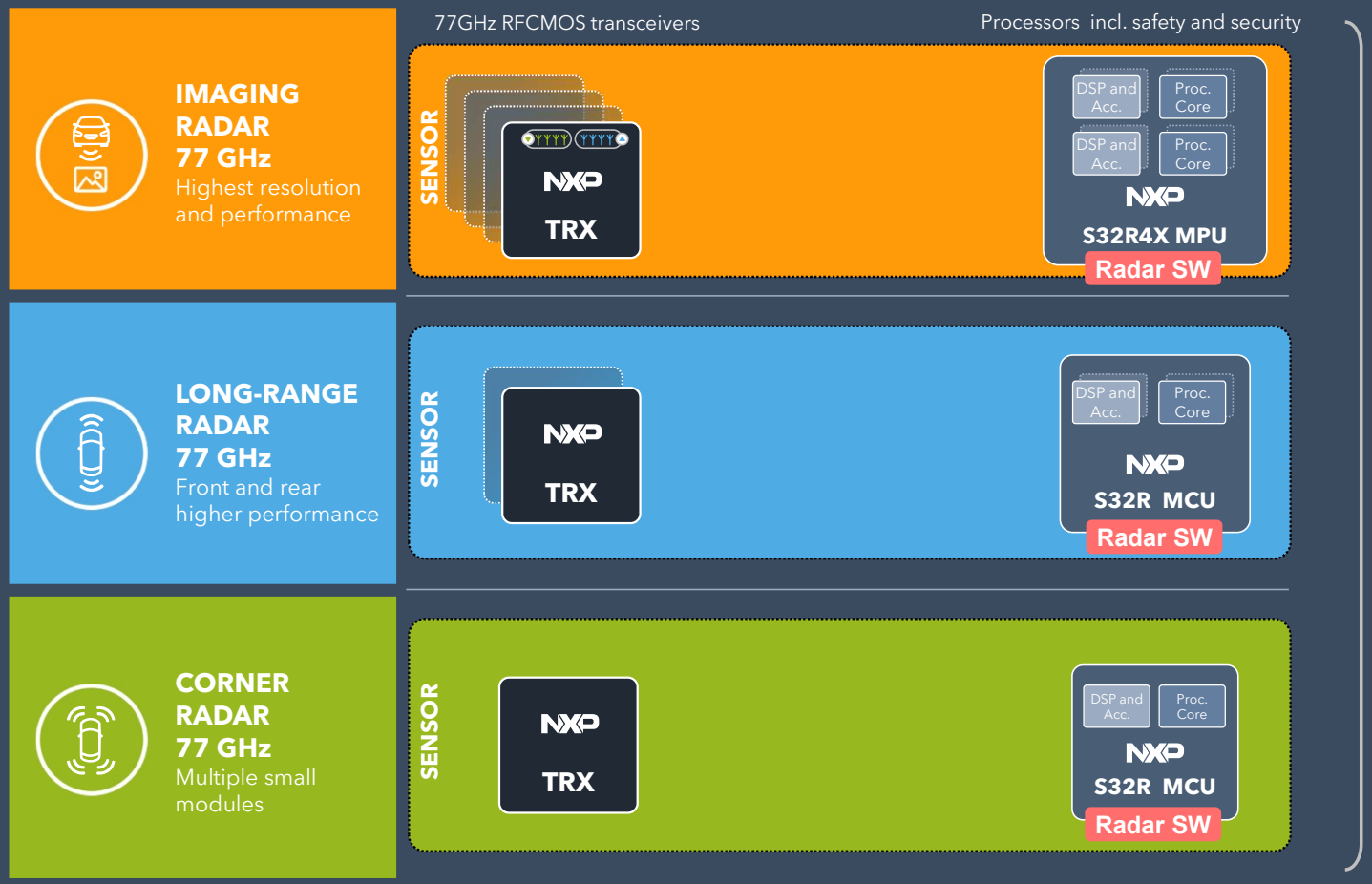
Mid- & long-range sensing in highway scenario

Advanced elevation sensing

NXP COMMON AUTOMOTIVE RADAR PLATFORM TO DATE

TAILORED SOLUTIONS FOR CORNER, FRONT & IMAGING RADAR

AUTO RADAR PRODUCT FAMILY



RADAR TECHNOLOGY LEADERSHIP

Leading edge technology nodes

16nm MCUs and 40nm RFCMOS TRX in production

State of the art 77 GHz RFCMOS performance

First to ramp RFCMOS to volume production

2nd Gen RFCMOS already already fully release

Unique Radar architecture and algorithms

Accelerators for 64x performance vs. standard cores

Minimal power dissipation and footprint

Proprietary Radar algorithms for performance boost

INTRODUCING 28NM SAF85XX 1-CHIP RADAR

DELIVERING 2X RF PERFORMANCE STEP-UP AND 30% SMALLER SENSOR SIZE

AUTO RADAR PRODUCT FAMILY

IMAGING RADAR 77 GHz
Highest resolution and performance

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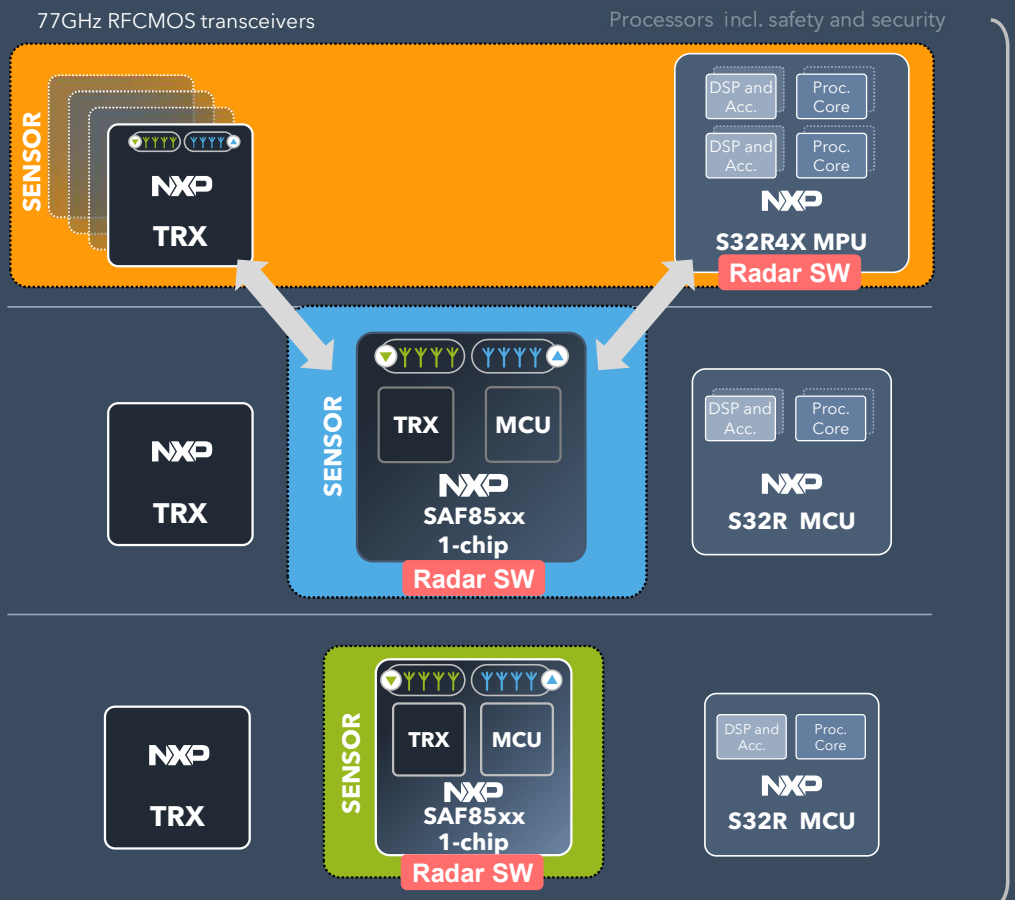
CORNER RADAR 77 GHz
Multiple small modules



RADAR TECHNOLOGY LEADERSHIP

Significant performance step-up

1-chip in 28nm RFCMOS achieves 2x RF performance

Multi-core processor cluster delivers 1.5x compute

Enables advanced 4D sensing

Elevation measurement for 360-degree Radar cocoon

Extended reach for corner (200m+) and front (300m+)

Accurate VRU detection, separation & classification

Seamless scalability

Common architecture from 1-chip corner Radar through high-performance cascade Imaging Radar chipsets

EXTENDING THE COMMON AUTOMOTIVE RADAR PLATFORM

DELIVERING OPTIMUM PARTITIONING FOR TODAY'S & TOMORROW'S OEM ARCHITECTURES

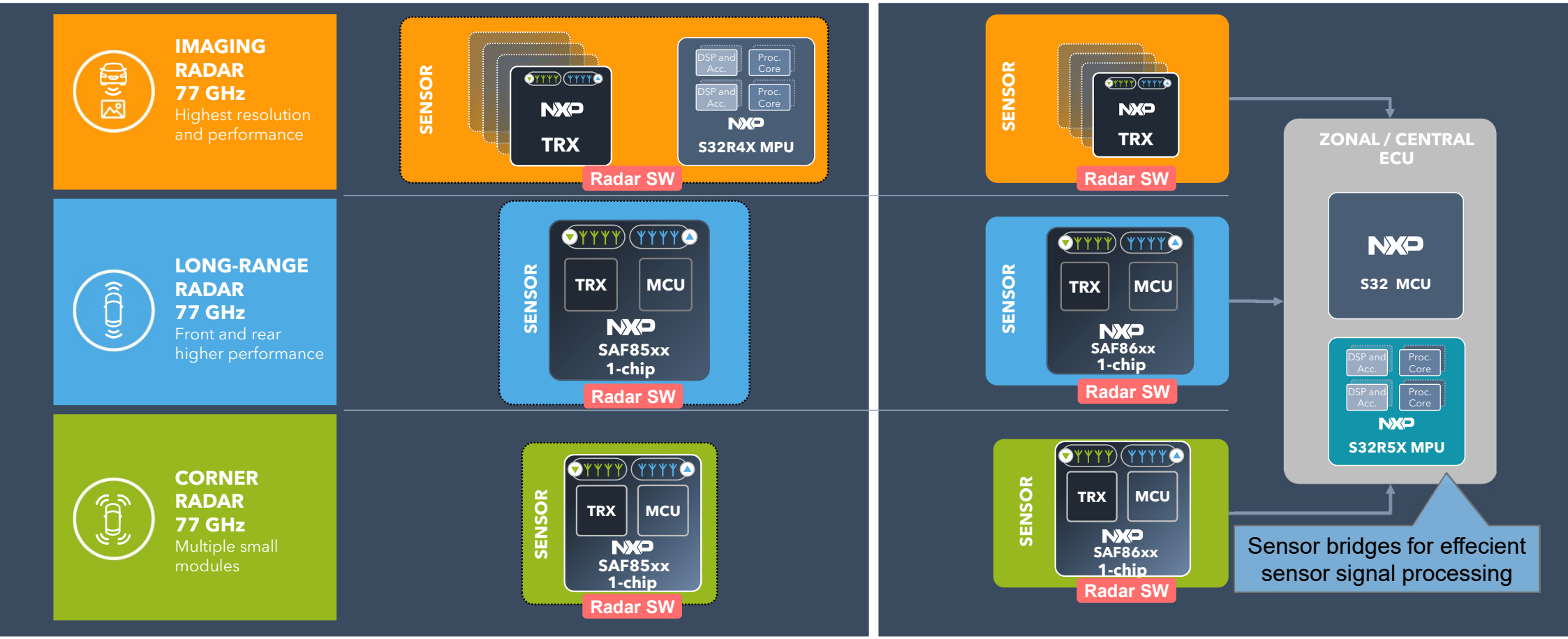
NXP AUTO RADAR PRODUCT FAMILY

Scalable radar chipsets for classical **edge sensors**

Scalable radar chipsets for streaming sensors

Edge ADAS processing

Zonal / central ADAS processing



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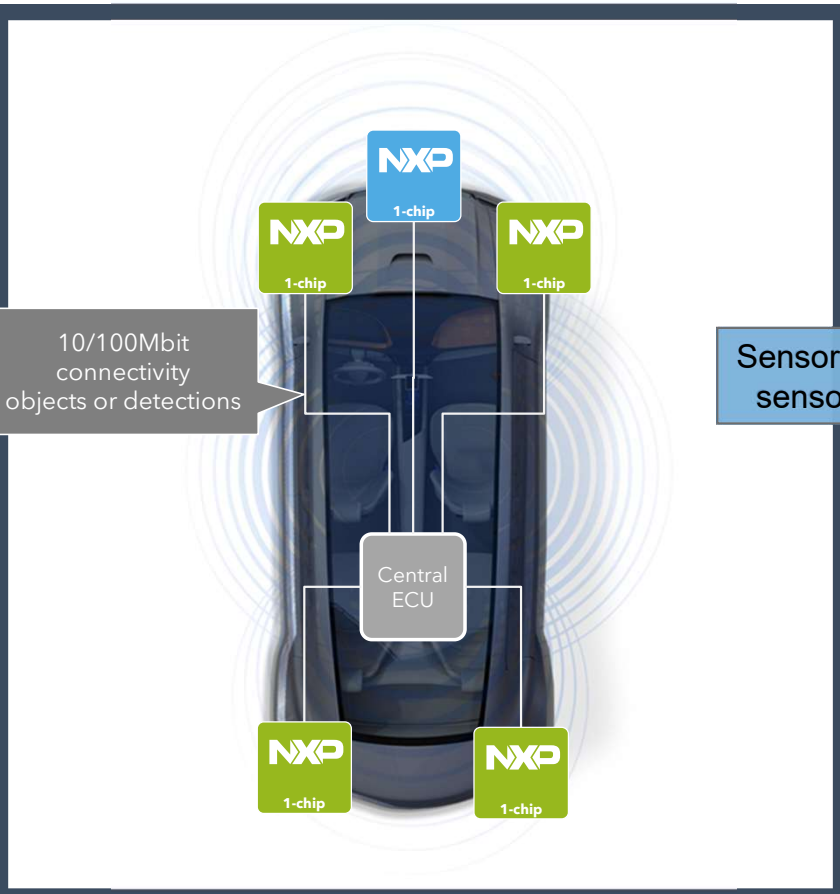
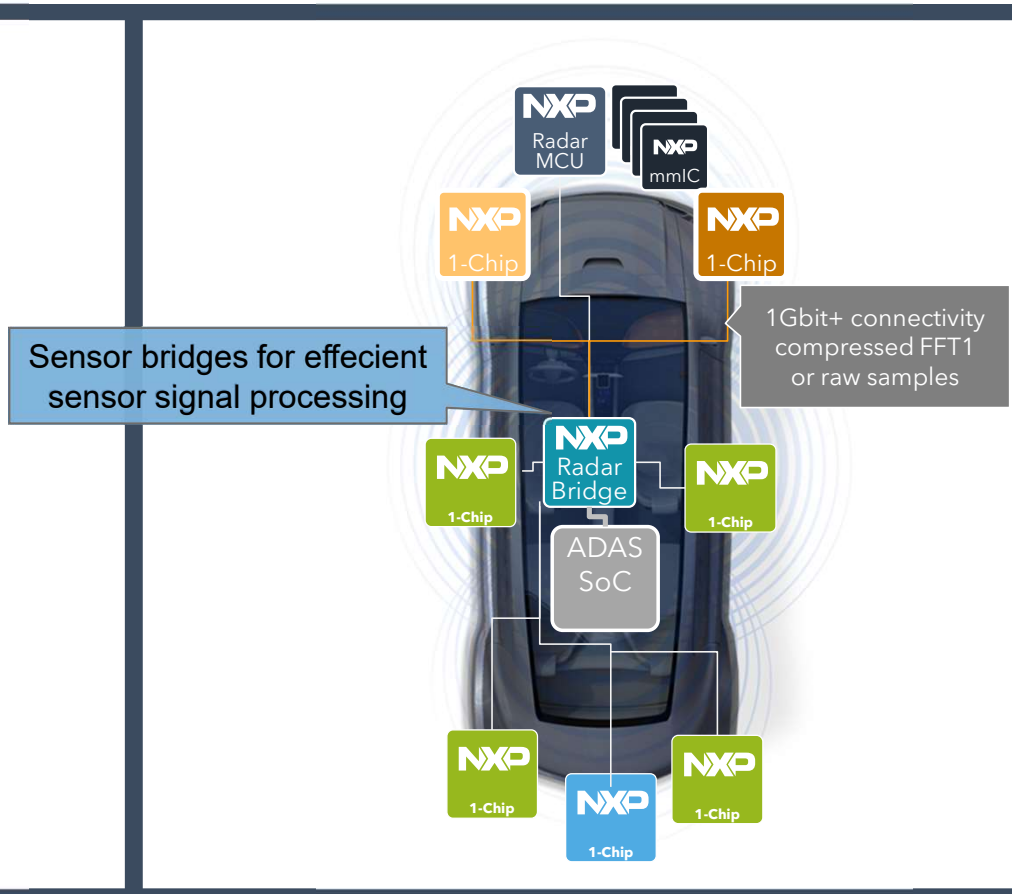




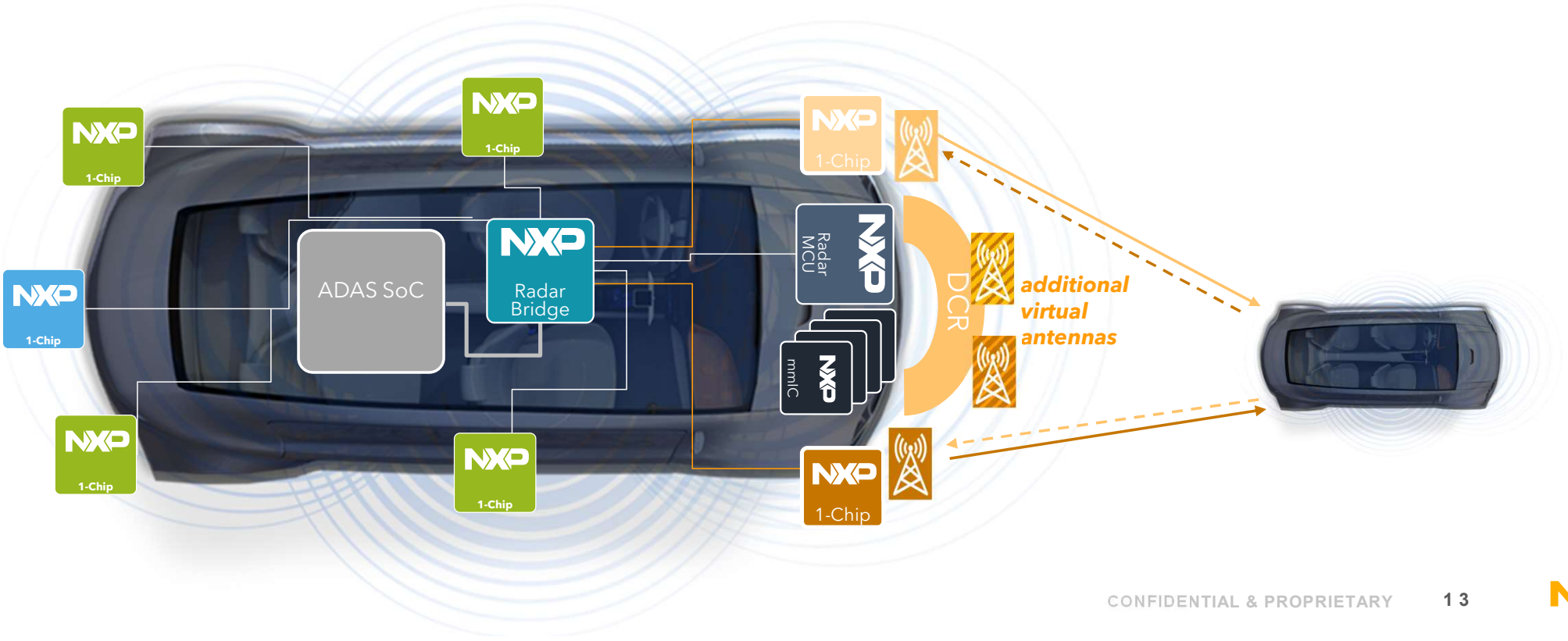
RADAR BRIDGE & DISTRIBUTED COHERENT RADAR
EFFICIENT SENSOR SIGNAL PROCESSING & ADVANCED SYSTEM LEVEL FEATURES

Radar Bridge: integrating value & efficient multi-sensor fusion

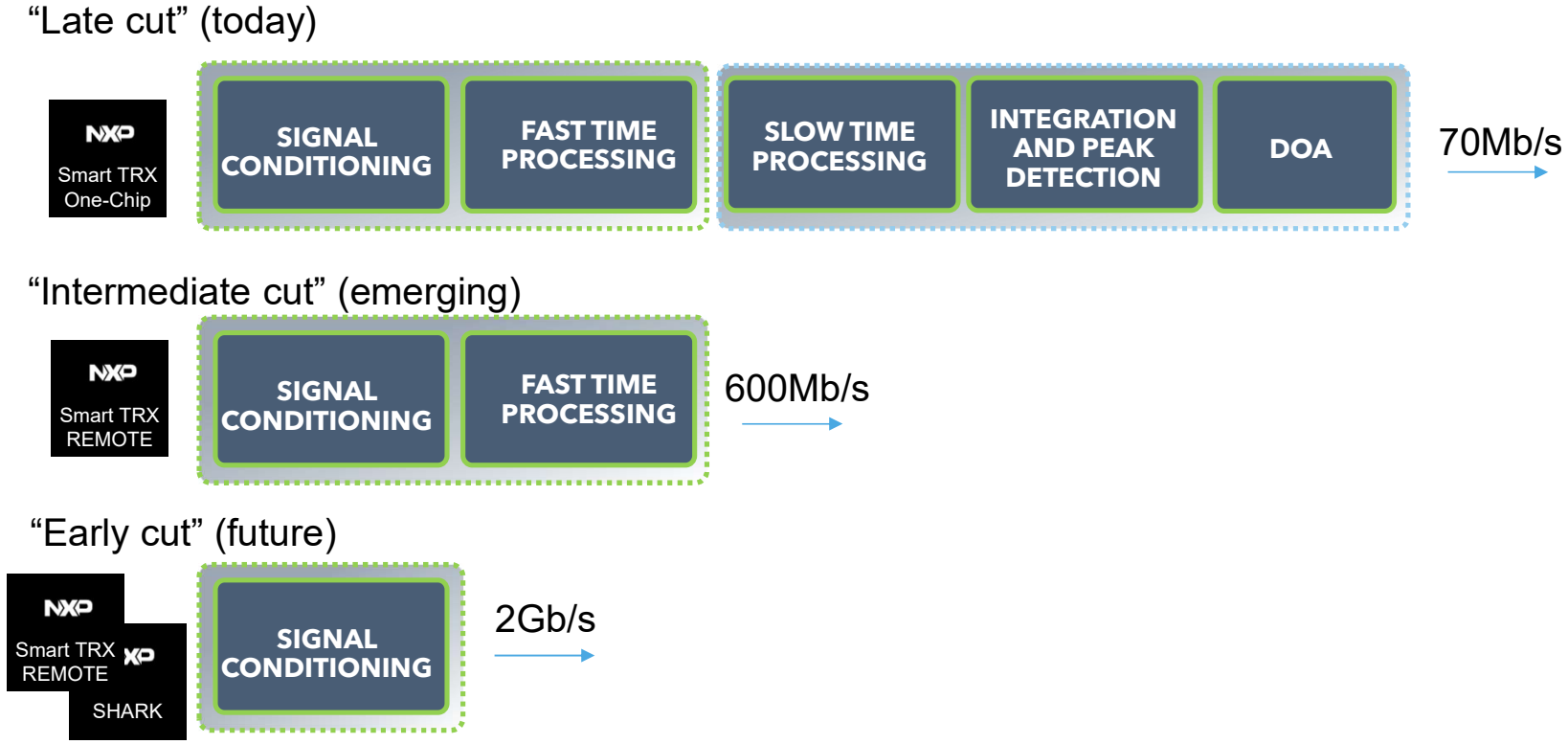
- Radar edge pre-processing → **fusion in Bridge** post processing
- **Solving SoC challenge**: efficient radar processing & interfaces

Distributed Coherent Radar (DCR): add virtual sensors & performance

- **Doubling antennas** virtually by precise synchronization of two sensors
- Add virtual sensors or replace physical ones, gain **up to 2x performance**

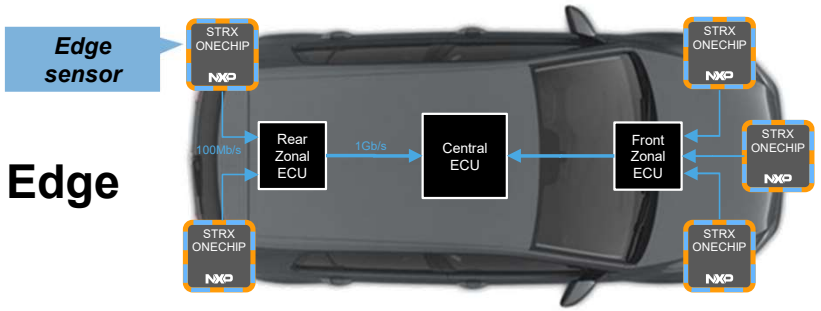


FUTURE RADAR SIGNAL PROCESSING CHAIN ARCHITECTURAL DECISIONS
SMART TRX FAMILY SUPPORTS MULTIPLE OPTIONS WITH SEAMLESS TRANSITION



NXP RADAR SOLUTIONS SERVE ADAS ARCHITECTURE EVOLUTION
FLEXIBLE SUPPORT FOR MULTIPLE TRANSITION SCENARIOS

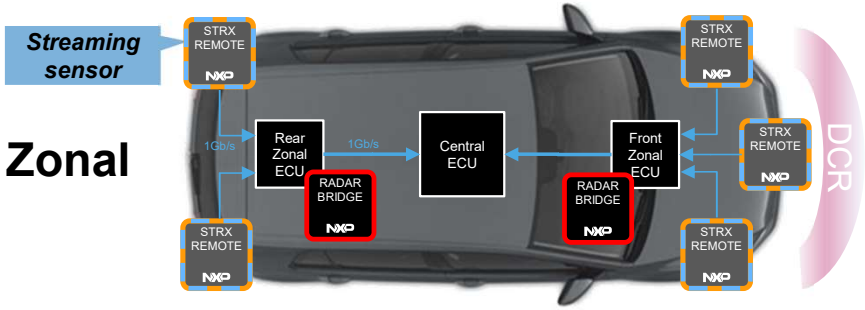
Edge



Classical edge-based ADAS architecture:

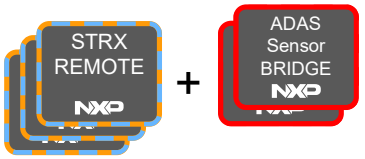
- NXP STRX One-chip delivers up to tracked object list
- Delivers state-of-the-art sensor performance & integration level
- Established functional safety concept
- No Radar specific knowledge & control in central ECU required

Zonal

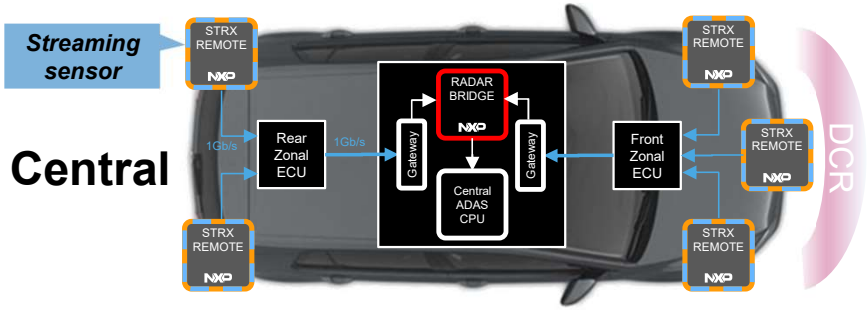


Zonal ADAS architecture: System cost sweet spot & sensor head synergy through ADAS Bridge

- NXP STRX Remote delivers up to FFT1
- NXP ADAS Sensor Bridge in zones for Radar post-processing, enables use of new sensor heads with classical domain ECU
- Supports innovative distributed coherent Radar (DCR) with up to 50% more performance in range and angular resolution
- No Radar specific knowledge & control in central ECU required

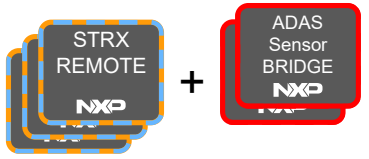


Central



Central ADAS Architecture: Potential SoC off-loading by ADAS Bridge

- NXP STRX Remote delivers up to FFT1 output data
- Zonal ECU only for data aggregation (no ADAS processing)
- NXP ADAS Sensor Bridge in central to process all Radar specific data
- No Radar specific knowledge & control in central ECU required



RADAR ROADMAP

NXP AUTO RADAR TODAY: 6 GENERATIONS OF AUTOMOTIVE RADAR CHIPSETS

RADAR MMICS, MCUS, 1-CHIP SOCS & IN-VEHICLE NETWORKING AND PMICS

Gen 1 — 2011
Industry First Fast Modulation TX
BLACKBIRD
Qorivva MPC56xxx

Gen 2 — 2013
Bare Die Chipset Industry First Production 77 GHz PLL
OSPREY
Qorivva MPC56xxx

Gen 3 — 2015
Scalable 77GHz Chipset
SPIRIT
S32R
S32Rxx

Gen 4 — 2018
Highly Integrated Transceivers
EAGLE
DOLPHIN
S32R Ultra
S32R27

Gen 5 — 2020
High Performance Radar
Barracuda
S32R Ultra2
S32R29

Gen 6 — 2022
Scalable & Imaging Radar Platform
STRX Family
SHARK
One-Chip
S32R Multi Family
S32Rxx

RICH PORTFOLIO OF NXP ADAS SENSOR SOLUTIONS

ONE PLATFORM SERVING STANDARD CORNER TO IMAGING RADAR & **NEW ARCHITECTURES**

OEM SOP	Now	2022	2024 .. 26	2028+

Extended Radar **SW & system** offering

- Radar SW
- Front Radar (cascaded)
- Corner Radar (cascaded)
- Front Radar
- Corner Radar
- ADAS Sensor Bridge

Premium Radar SDK R1.0

Premium Radar SDK R2.0

One common Radar platform architecture: **Easy scaling & optimization** for use cases

Future proof process nodes (16/28nm) for **supply assurance**, economies-of-scale & **differentiating performance** (mmW & proc.)

FULL SCALABILITY

SW Re-Use

RRM MCU (S32R43)

RRM16 MCU (S32R45)

SHARK

RRM4 MCU (S32R41)

STRX 1-Chip

STRX REMOTE

RRU MCU (S32R27)

Dolphin

RRU-2 MCU (S32R29)

Barracuda

Industry-first 16nm Radar MCU

Gen2 RFCMOS Radar MMIC

Vision Processor (S32V)

Camera Processor (i.MIX)

Radar Bridge (S32R51)

ADAS Bridge (S32R52)

Imaging Radar Next-Gen

IMR27

IMR TRX

S32R6x MCU

Smart TRX Next-Gen Evolution

STRX EVO 1-Chip

STRX EVO REMOTE

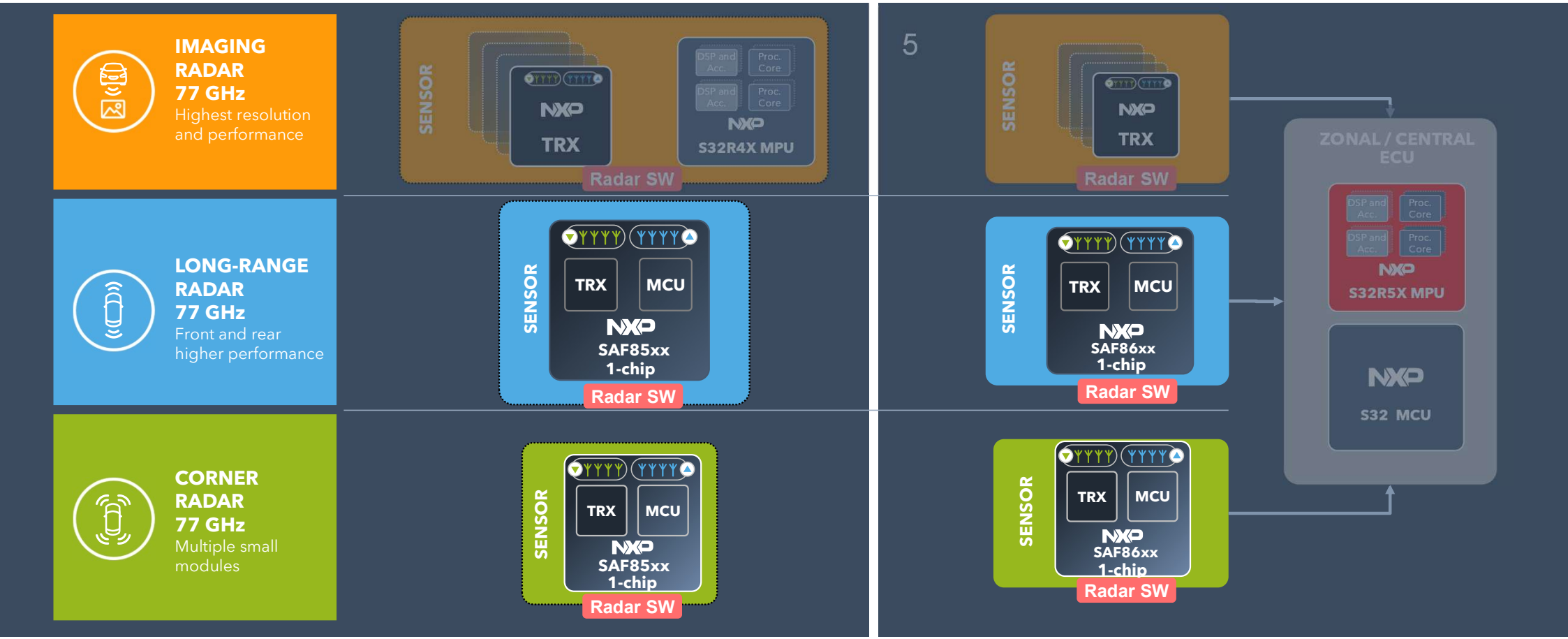
ADAS **system optimization** for zonal / centralized architectures

SMART TRX
GEN3 28NM RFCMOS
1-CHIP RADAR FAMILY

EXTENDING THE COMMON AUTOMOTIVE RADAR PLATFORM

DELIVERING OPTIMUM PARTITIONING FOR TODAY'S & TOMORROW'S OEM ARCHITECTURES

NXP AUTO RADAR PRODUCT FAMILY



NXP INTRODUCES

ADVANCED AUTOMOTIVE RADAR SOC FOR NEXT-GEN ADAS AND AD AUTONOMOUS DRIVING SYSTEMS

Industry-first 28nm RFCMOS radar one-chip

- advanced 4D sensing for safety-critical ADAS use cases
- 30% reduced sensor size vs. previous generation

Gen3 RFCMOS delivers performance step-up

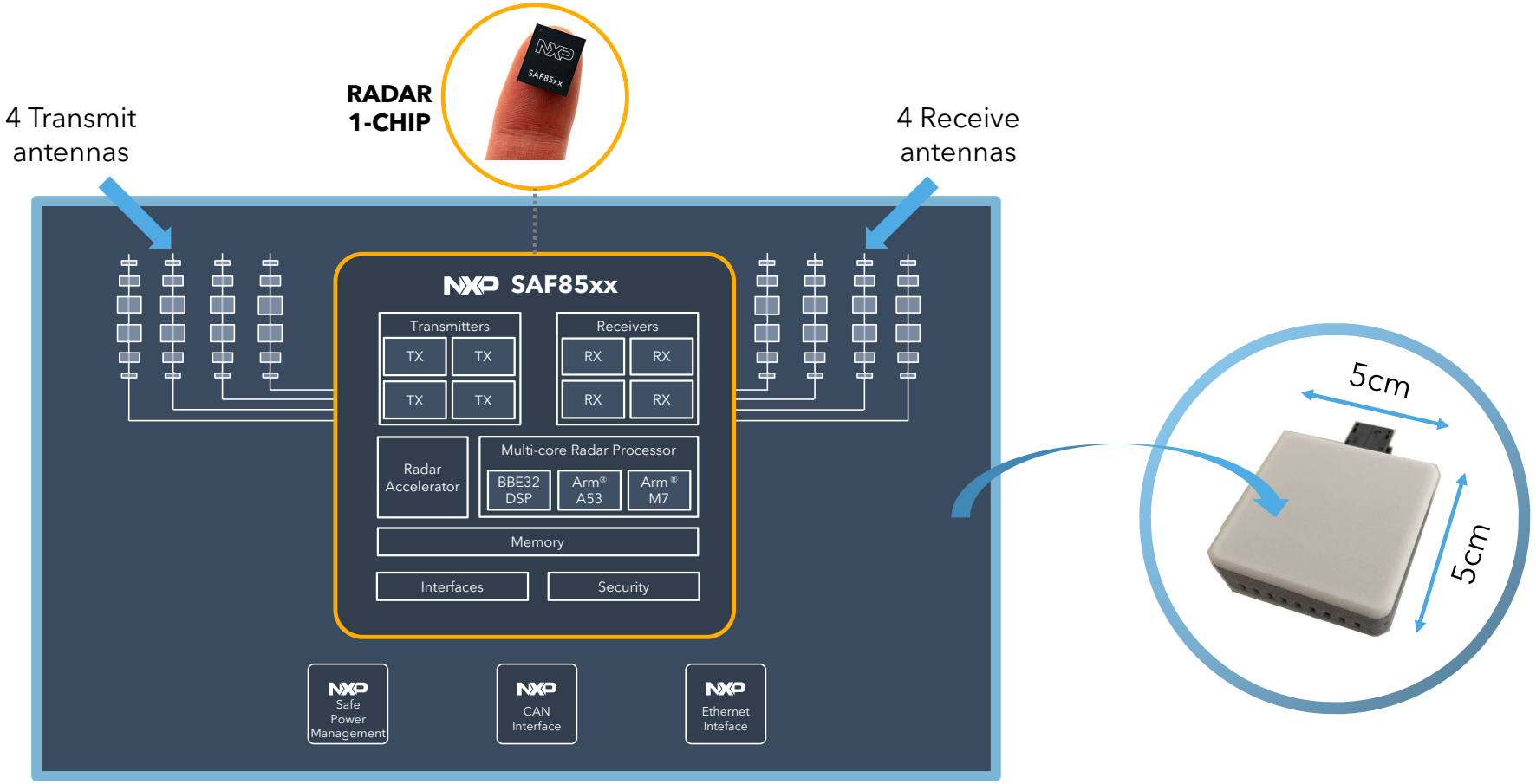
- 2x RF performance step-up vs. previous generation
- 40% compute performance increase vs. previous generation

Scalable platform including advanced radar software

- supports today's & tomorrow's OEM ADAS architectures

NXP 28NM 1-CHIP RADAR INTEGRATION ENABLES MUCH SMALLER SENSORS

30% SIZE SAVINGS VS. PREVIOUS GENERATION



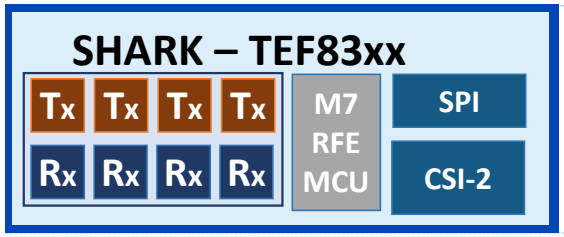
4D RADAR SENSING PROLIFERATION

NXP SAF85XX ADDING **ELEVATION** TO 360-DEGREE RADAR COCOON APPLICATIONS

Adding **elevation as 4th dimension**
to distance, velocity and angle of arrival
enhances Radar based perception & object classification.

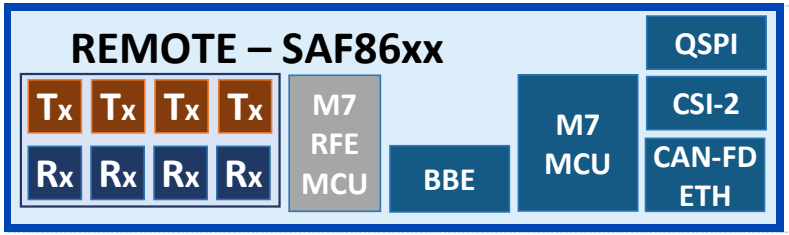
SMART TRX FAMILY COMMON ARCHITECTURE

Application and Benefits



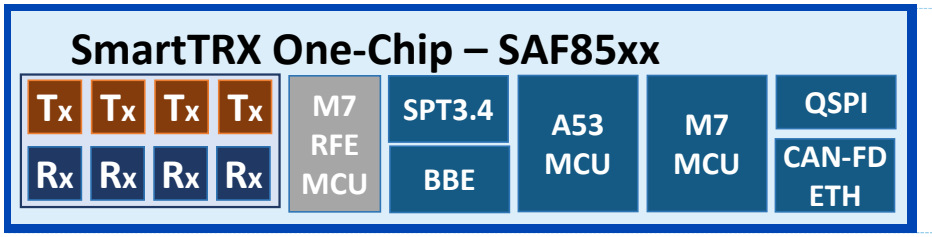
NXP SHARK

- **Barracuda successor**, high performance RF
- **High Resolution Imaging Radar**
- **Long Range Radar**



NXP Smart TRX REMOTE

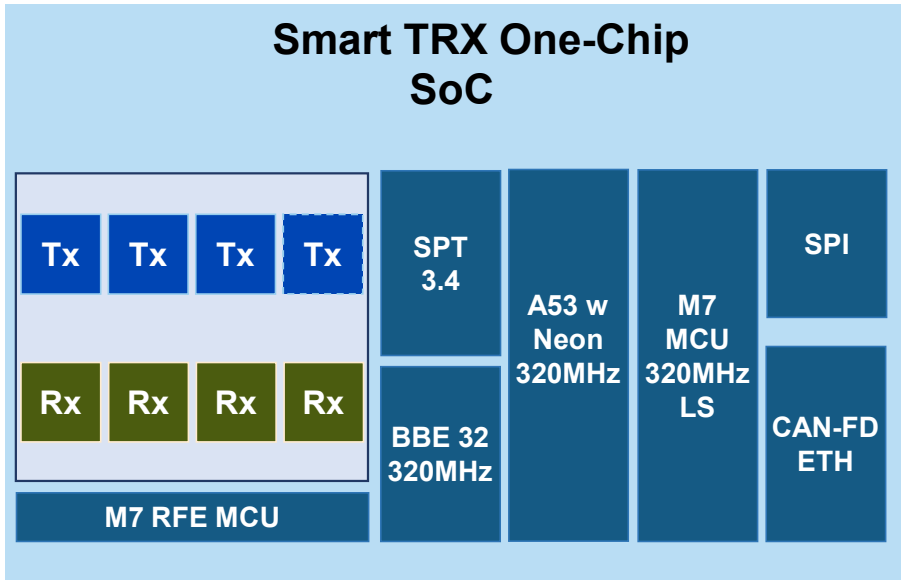
- Optimized for **Remote Sensors** connected to **Zonal / Central data processing** or fusion
- Includes data pre-processing ***(compressed range cube)***



NXP Smart TRX One-Chip

- **One-Chip Radar** for corner, Front radar
- Includes full data processing ***(tracked objects)***
- **Low-Cost Radar** for mainstream usecases

SMART TRX ONE-CHIP
SAF8544



Applications

AEB, ACC, RCTA, FCTA, BSD, LCA, Park Assist

Scalable 3rd Generation 28nm RFCMOS 77GHz Radar One-Chip SoC

Key Features:

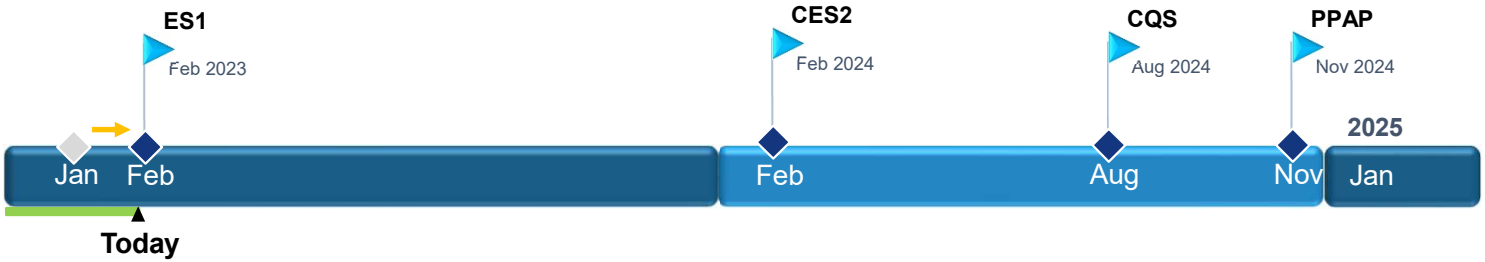
- **Single ended 4 T**ransmit and **4 R**eceive Channels
- **7-bit** Phase Rotator
- **Complex(IQ)** ADC output
- Enhanced RF performance:
  - **Pout ~13dBm (15dBm Typ)**
  - **NF ~12dB (10.5dB)**
- Scalable **Chirp Bandwidth**: up to **4 GHz**
- **IF Bandwidth** up to **20MHz**
- System interfaces: Gb-Ethernet, CAN-FD(2x), QSPI for Flash
- Debug interfaces: AURORA, JTAG, UART
- ISO26262 compliant
  - Product development process - ASIL D
  - Random HW fault Metrics for safety goal - ASIL B
- **HSE-M** security supported with MacSec (SW)
- On-board Radar Processing
  - SPT3.4 with BBE32 320MHz DSP for radar pre-processing
  - A53 with Neon 320MHz processor for post-processing
  - M7 320MHz MCU for control with lock step
- Memory: **4MB SRAM + 1.76MB** Other memories
- Small Footprint:
  - 10.6x11.3mm FcCSP package, 0.5mm pitch
  - 11.95x14mm LIP Package, 0.5mm pitch

All values shown are target values, subject to change. Max. Product configuration shown.

UPDATED SMART TRANSCEIVER SCHEDULE UPDATE

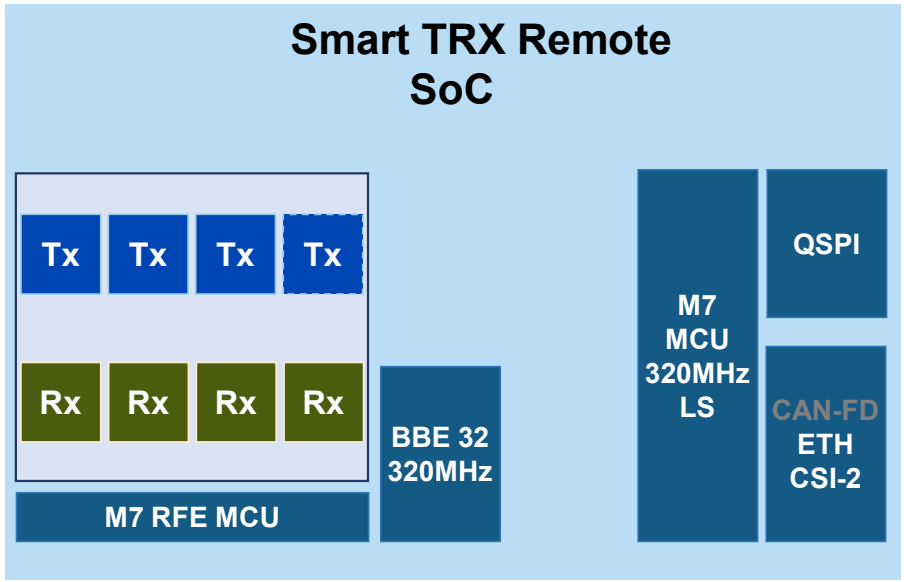
STRX One-Chip FC CSP

STRX One-Chip LIP



Schedule subject to change

SMART TRX REMOTE
SAF8644



Applications

- **Remote Sensorheads with FFT1, Compression**
- **Corner and Front Radar**

Scalable 3rd Generation 28nm RFCMOS 77GHz Radar One-Chip SoC

Key Features:

- **Single ended 4 T**ransmit and **4 R**eceive Channels
- **7-bit** Phase Rotator
- High RF performance: **Pout ~13dBm, NF ~12dB**
- Scalable **Chirp Bandwidth**: up to **4 GHz**
- Supports **Cascading**
- Enhanced **IF Bandwidth: 20 MHz**
- Digital system interfaces
  - **Gbit-Ethernet**
  - **CSI-2 as I/F to SerDes**
  - **CAN_FD**
- ISO26262 compliant
  - Product development process - ASIL D
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- **HSE-M** security supported with MACsec
- Gbit ETH **MACSec** supported
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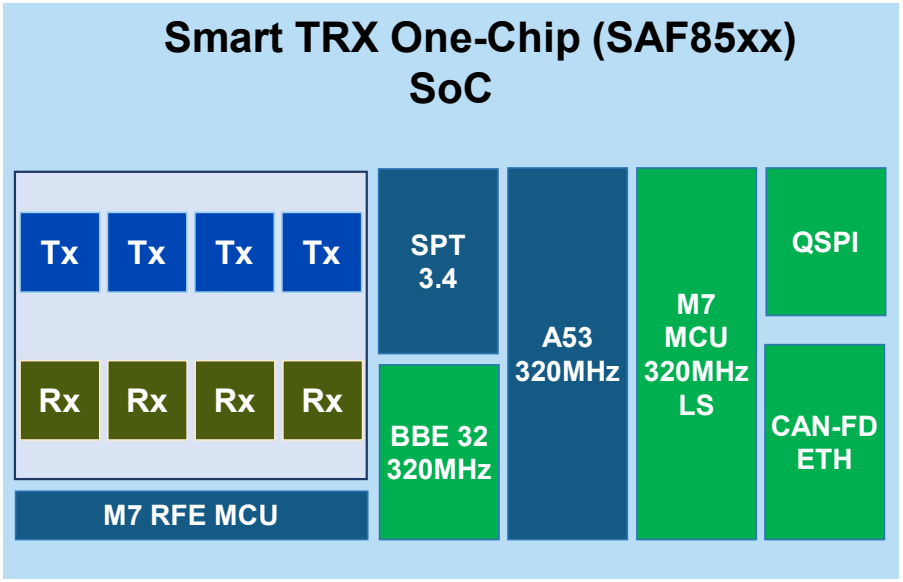
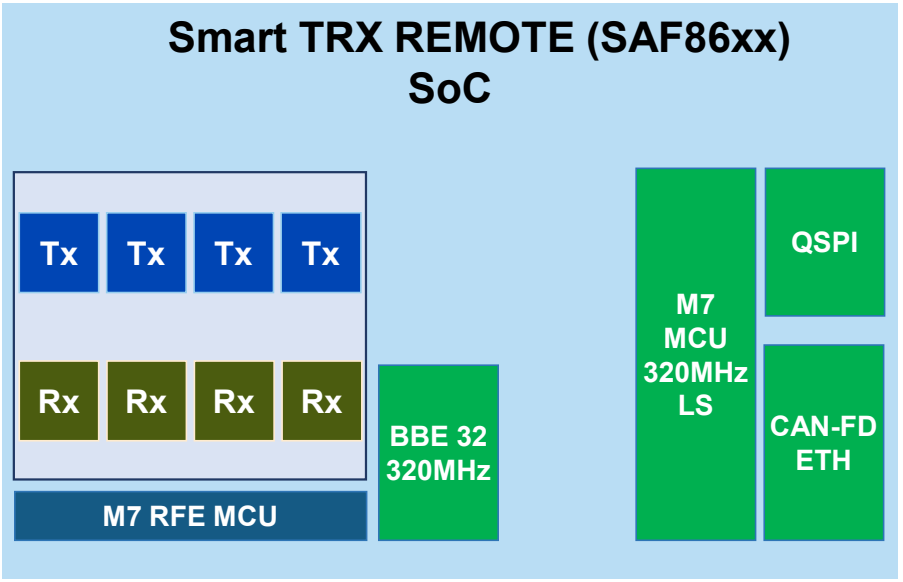
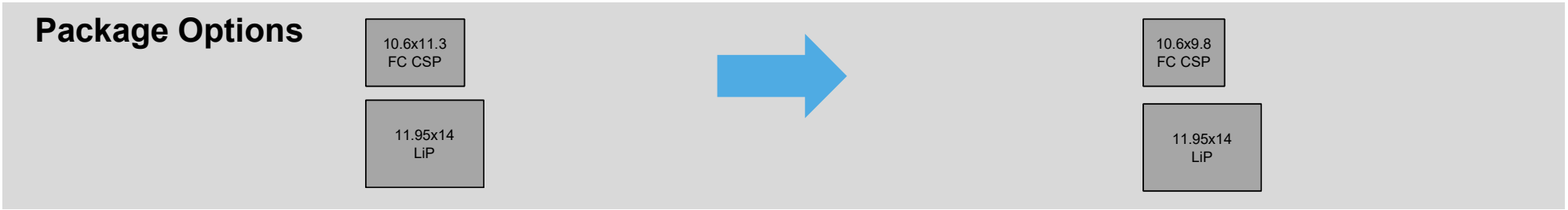
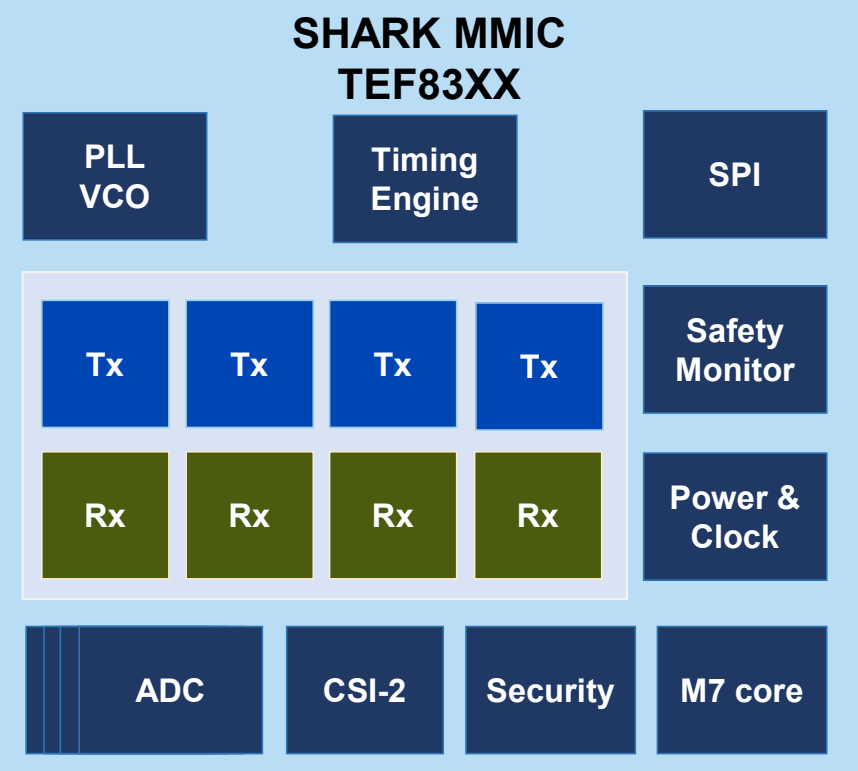
SMART TRX REMOTE
COMPARISON TO SMART TRX REMOTE







SMART TRX MMIC SHARK TEF83XX



Scalable 3rd Generation 28nm RFCMOS 77GHz Radar MMIC

Key Features:

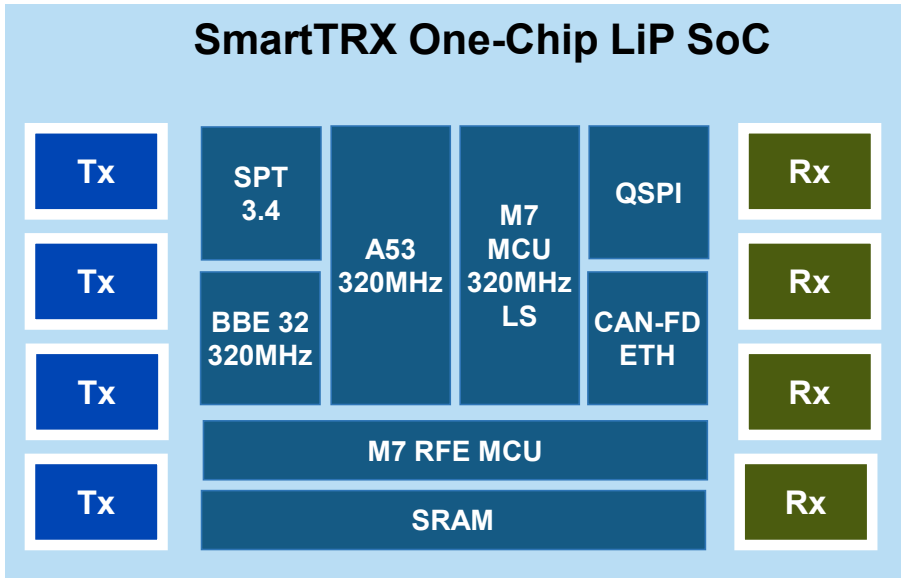
- **4 T**ransmit and **4 R**eceive Channels
- **7-bit** Phase Rotator
- Very high RF performance: **Pout ~13dBm, NF ~12dB**
- Scalable **Chirp Bandwidth**: up to **5 GHz**
- Enhanced **IF Bandwidth: 40 MHz**
- **Cascading** up to 4 devices (1 Leader + 3 Followers)
- Flexible Chirp programming
- ISO26262 compliant: ASIL Level B
- Small footprint: FC-CSP **package** (10.6mmx~8mm)
- Pin compatible 2Tx/4Rx, 4Tx/4Rx devices offered
- ISO26262 compliant: ASIL Level B
- M7 core for agile modulations + calibrations + safety monitor and recovery
- No flash needed. **Boot from MCU**

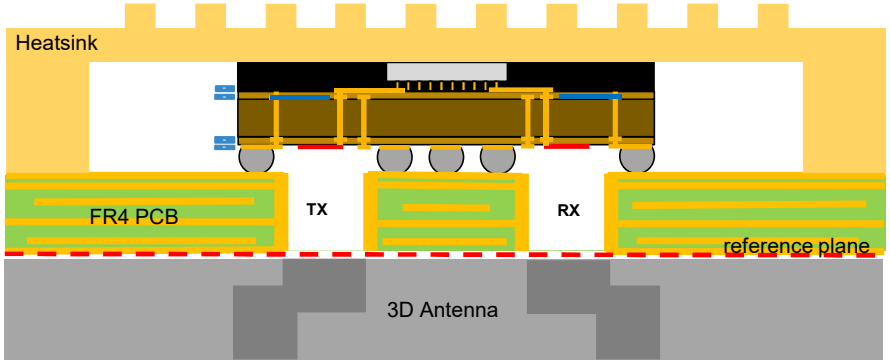
Applications

- **High Performance Front Radar**
- **Imaging Radar**

All values shown are target values, subject to change. Max. Product configuration shown.

SMART TRX ONE-CHIP SOC LAUNCHER-IN- PACKAGE SAF85XX LIP

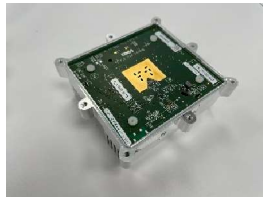




Scalable 3rd Generation 28nm RFCMOS 77GHz Radar One-Chip-LiP SoC

Key Features:

- **4 T**ransmit and **4 R**eceive Channels
- **Downward** Waveguide launchers
- **7-bit** Phase Rotator
- **Complex(IQ)** Receiver
- Very high RF performance: **Pout ~12.5dBm, NF ~12.5dB**
- Scalable **Chirp Bandwidth**: up to **4 GHz**
- Enhanced **IF Bandwidth: 20 MHz**
- Digital system interfaces(Gb-Ethernet and CAN-FD)
- ISO26262 compliant
  - Product development process - ASIL D
  - Random HW fault Metrics for safety goal - ASIL B
- HSE-M security supported
- On-board Radar Processing
  - SPT3.4 with BBE32 320MHz DSP for pre-processing
  - A53 320MHz for post processing
  - M7 320MHz MCU for control with lock step
- Memory: **4MB SRAM + 1.76MB** other memories
- Small Footprint:
  - 11.95x14.00 mm LIP Package,0.5mm solder ball pitch.



Applications Short Range to Long range applications

All values shown are target values, subject to change. Maximum product configuration shown.

4D IMAGING RADAR

EXTENDING THE COMMON AUTOMOTIVE RADAR PLATFORM

DELIVERING OPTIMUM PARTITIONING FOR TODAY'S & TOMORROW'S OEM ARCHITECTURES

AUTO RADAR PRODUCT FAMILY

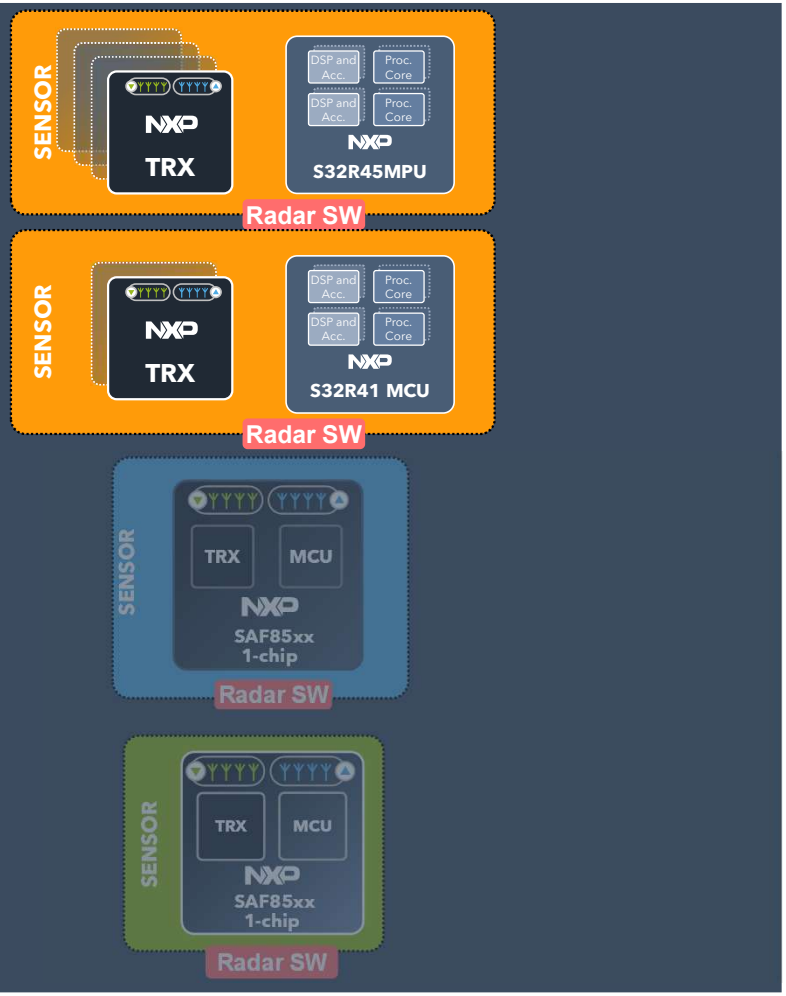
Edge ADAS processing

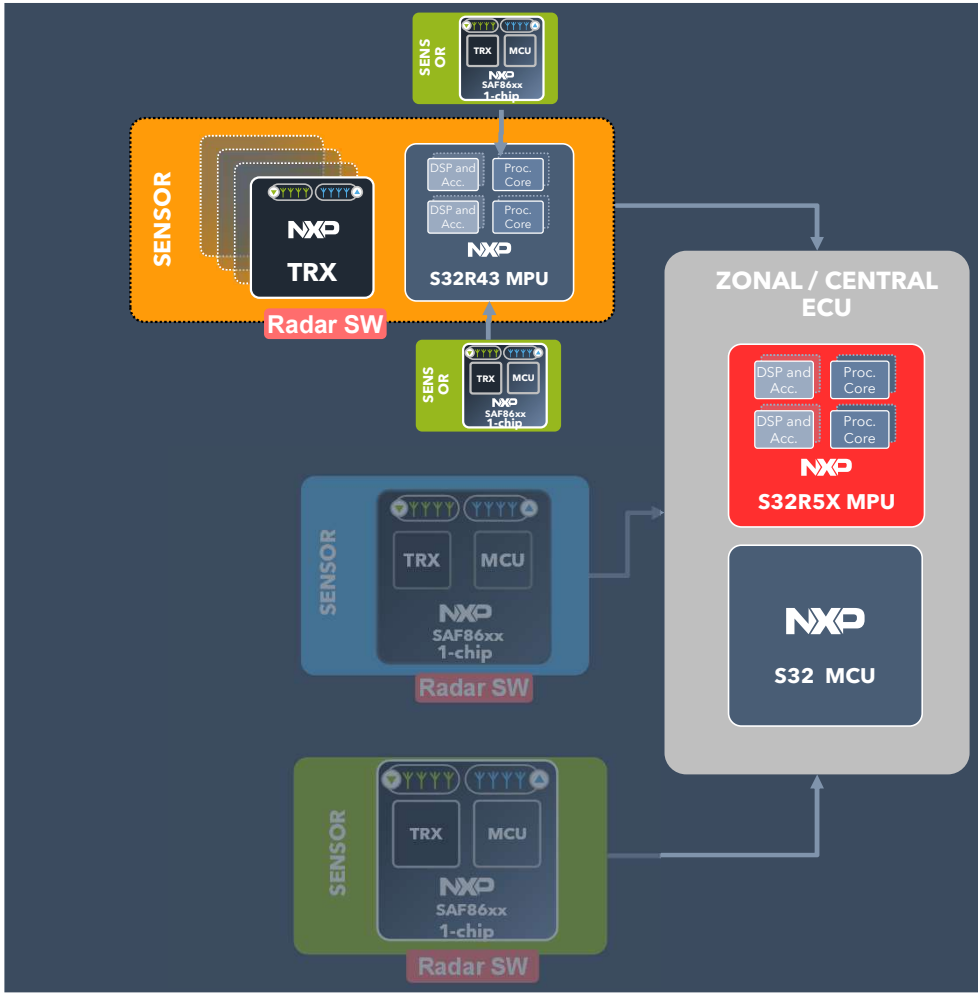
Zonal / central hybrid ADAS processing

IMAGING RADAR 77 GHz
Highest resolution and performance

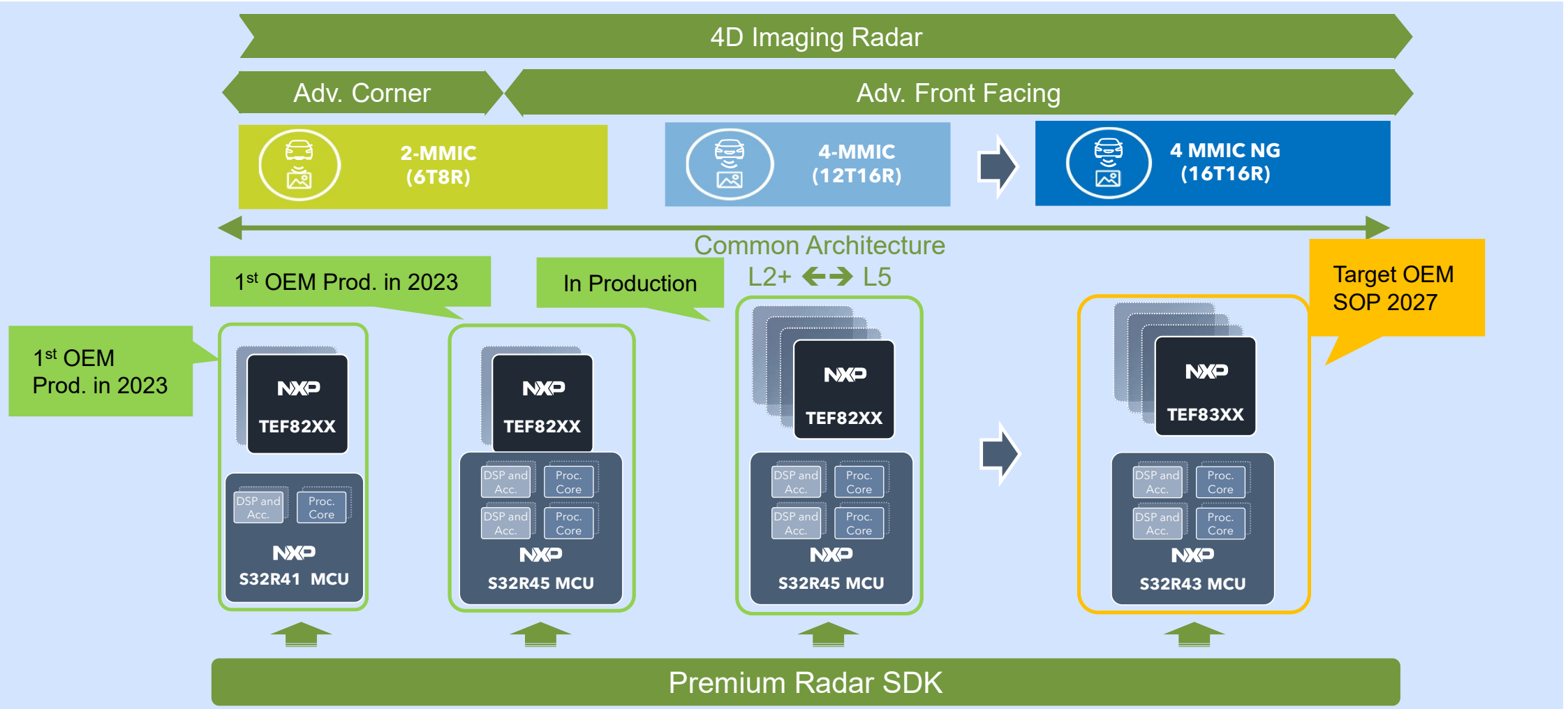
LONG-RANGE RADAR 77 GHz
Front and rear higher performance

CORNER RADAR 77 GHz
Multiple small modules

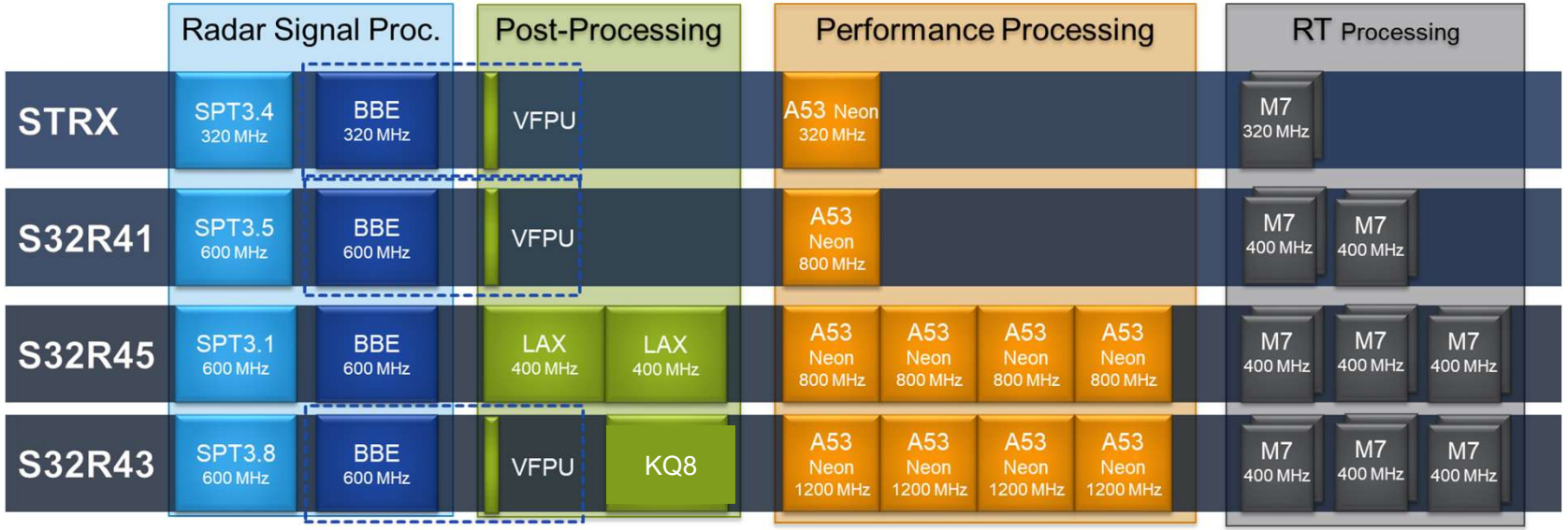




HIGHLY SCALABLE ADVANCED RADAR LINE-UP
ADVANCED CORNER AND FRONT RADARS



S32R PERFORMANCE RADAR MCU FAMILY SCALABILITY



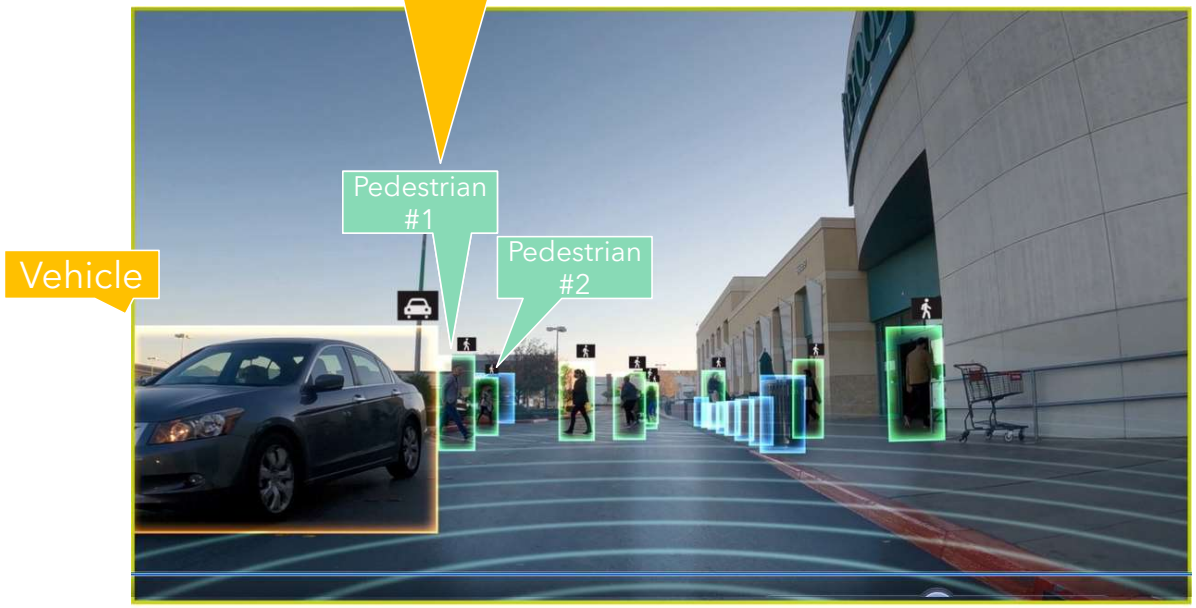
(*)	SPT	CPU			BBE DSP			HW Acc.	Total				SRAM	IC footprint
	MFFT256	DMIPS	GMAC	GFLOP	DMIPS	GMAC	GFLOP	GFLOP	MFFT256	DMIPS	GMAC	GFLOP		
STRX	2.5	768+685	2.56	1.6	592	10.2	5.12	-	2.5	2045	12.8	6.72	4MB	
S32R41	4.69	1920+1712	6.4	4	1110	19.2	9.6	-	4.69	4742	25.6	13.6	8MB	11x11
S32R45	18.75	7680+2568	25.6	14	1110	19.2	-	102.4	18.75	11358	44.8	116.4	8MB (+LPDDR4)	19x19
S32R43 (***)	37.50	11520+2568	38.4	20.4	2220	38.4	19.2	200(**)	37.50	16308	76.8	239.6**	8MB (+LDDR5)	14x14

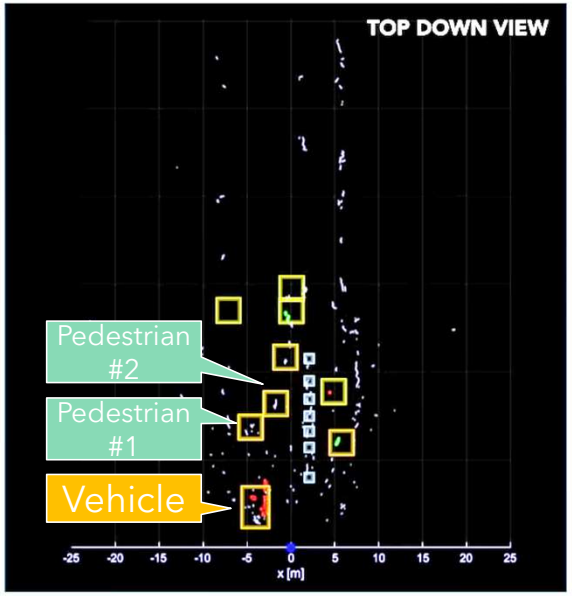
(*) Calculated peak value, not measured
(**) Estimated, IP selection not completed yet
(***) Feature definition not fully finalized, subject to further changes

NXP 4D IMAGING RADAR: SEAMLESS SCALING TO HIGH-RESOLUTION SENSING

ACCURATE DETECTION & SEPARATION OF CLOSELY CO-LOCATED OBJECTS

Fine angular **resolution of < 1 degree** allows **separating vulnerable road users (VRUs)** like pedestrians, bicycle riders or motorcycles **from larger objects** like cars or trucks



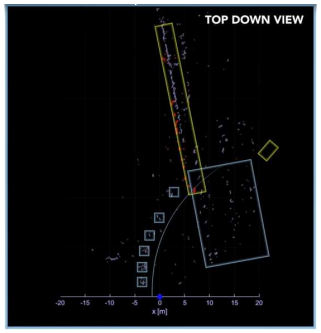


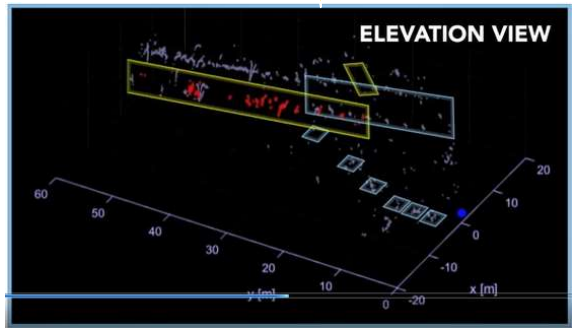
NXP 4D IMAGING RADAR: SEAMLESS SCALING TO HIGH-RESOLUTION SENSING

COMBINING HIGH RESOLUTION WITH ADVANCED ELEVATION SENSING

Fine angular **resolution of < 1 degree** in horizontal plane

Advanced **4D elevation sensing** in vertical plane



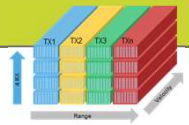


NXP 4D IMAGING RADAR DIFFERENCE

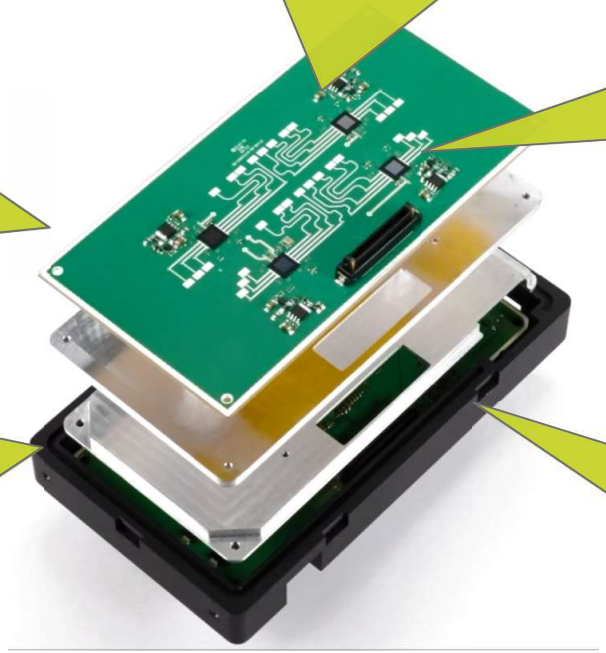
TOTAL SOLUTION APPROACH DELIVERS LEADING EDGE PERFORMANCE & EFFICIENCY

Purpose-made
Radar acceleration:
64x Arm® A53 equivalent

Advanced MIMO
wave-forms



Gen2 RFCMOS:
2x link RF budget



3-in-1 sensor
antenna design

Super-resolution
radar algorithms

NXP-BASED IMAGING RADAR SENSORS READY TODAY

NXP IMAGING RADAR HITS THE ROAD

Ref-design orderable H2 2023

A-Sample

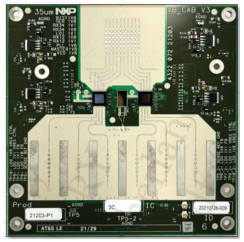
340m achieved

	Parameters	Solution Partner 1	Solution Partner 2
RANGE	Min / Max	0.5m/300m	0.63/300m
	Resolution	0.55m/2.5m (LR/SR)	0.63m
VELOCITY	Min / Max	-400~200kmh	-255~255kmh
	Resolution	0.16m/s	0.069m/s
ANGLE	Azimuth FOV	+/-48°	+/-55°
	Azimuth Separation LR	1° (target 0.5°)	0.9° (target 0.6°)
	Elevation FOV	±5° (target ±9°)	±9°
	Elevation Separation LR	2°	2°
System	Output	Point cloud	Point cloud
	Update Rate	20 FPS	20 FPS
	Power consumption	Typ. 15W	Typ. 15W
	Dimensions	13.6x11.6x4.5cm	12.7x12.2x3.2cm

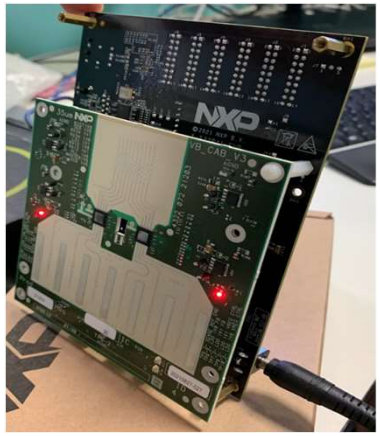
AVAILABLE TODAY:
S32R41 + DUAL TEF82XX DEVELOPMENT PLATFORM

- Development platform designed for quick and easy radar development based on S32R41 EVB and Dual-TEF82xx CAB
- Example software provided integrating NXP software (RSDK, RTD, IPCF, SAF, etc.)
- Documentation and Software available online: S32R41 & TEF82xx

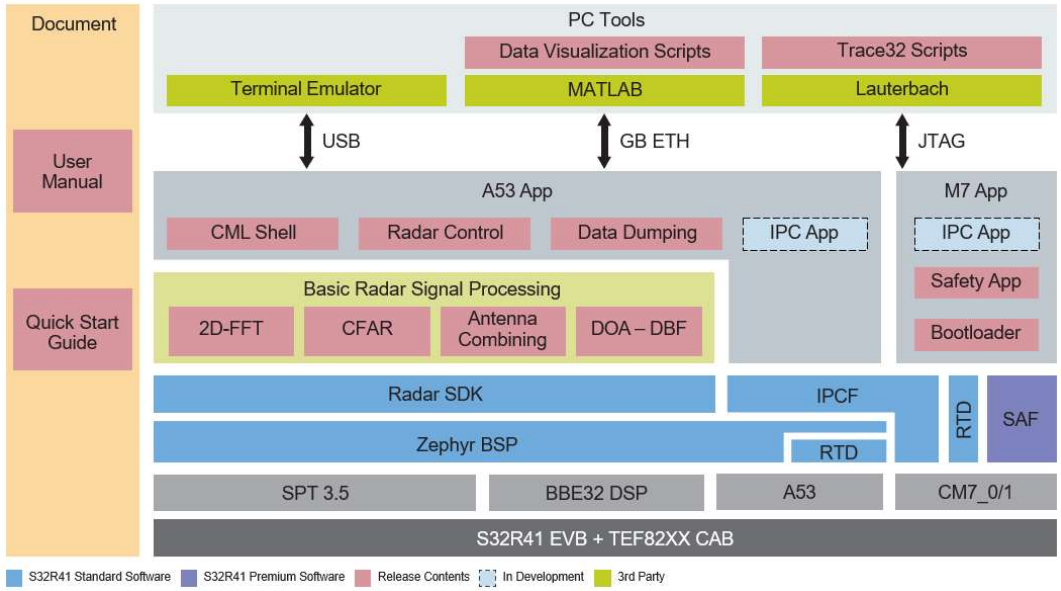
S32R41-EVB



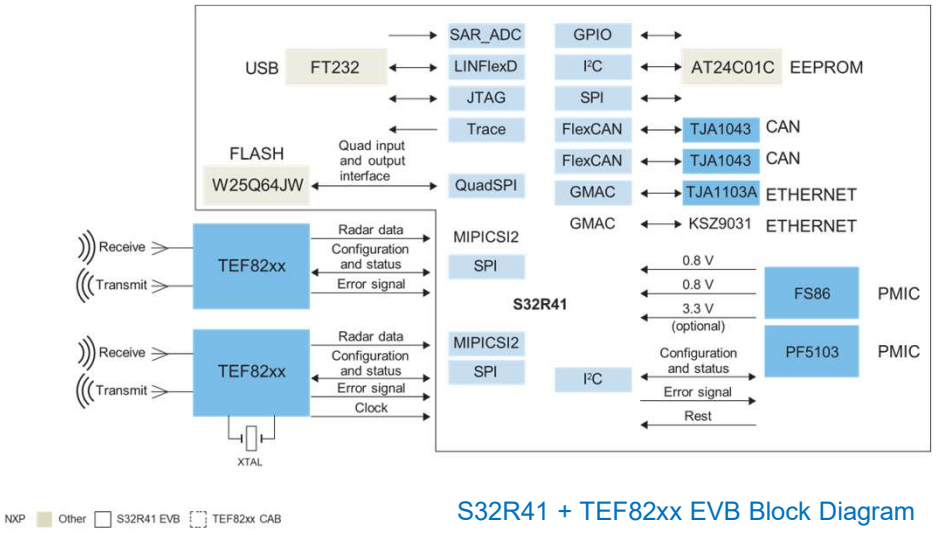
TEF82xx CAB



Stacked view



S32R41 + TEF82xx Development Platform SW Block Diagram



S32R41 + TEF82xx EVB Block Diagram

AVAILABLE TODAY: NOVTECH™ RENAN™ BOARD (R45 + QUAD TEF82XX)
FULL IMAGING RADAR SOFTWARE DEVELOPMENT PLATFORM

Highlights

Full NXP Imaging Radar Chipset	➔	✓ 4x TEF8232 ✓ S32R45 ✓ NXP Auto-PMIC ✓ TJA1103 (10/100Mb, 1G in Q4/23)
Many Connection Options	➔	✓ Dedicated 1Gb & 2.5Gb PHY ✓ PCIe 2xM.2 (NVMe) ✓ 2x CAN TJA1462
Flexible Debug and Storage	➔	✓ JTAG & Aurora ✓ DDR4 ISSI 8Gb ✓ QSPI NOR Flash Q/O up to 2Gb ISSI ✓ SD Card Slot
Maximum GPIO adaptability with CPLD	➔	➢ All SPI and GPIO between S32R45 and TEF8232s routed through CPLD ➢ Reconfigurable to mimic own design

NXP Imaging Radar Chipset

NovTech – designed

NXP-reviewed
NXP also internally uses this board

Full enablement package

Board // Schematics // GERBER Files // BSP // User Guides
Direct Support by NovTech, or NXP*

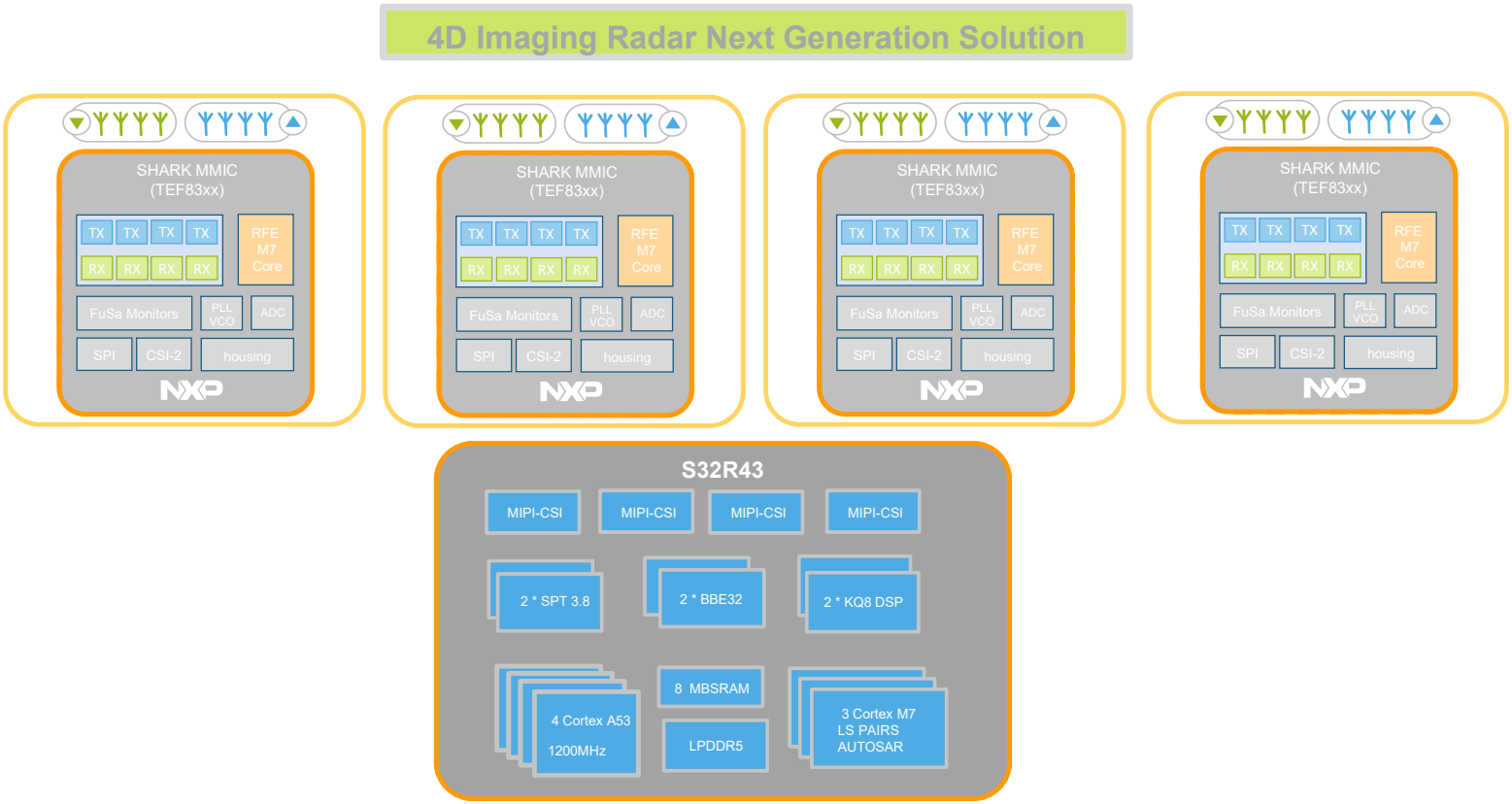
Customizable and Flexible

Software open and modifiable, Usable with RSDK
Hardware changes, on request (NovTech)
Flexibility through Networking BoM & CPLD

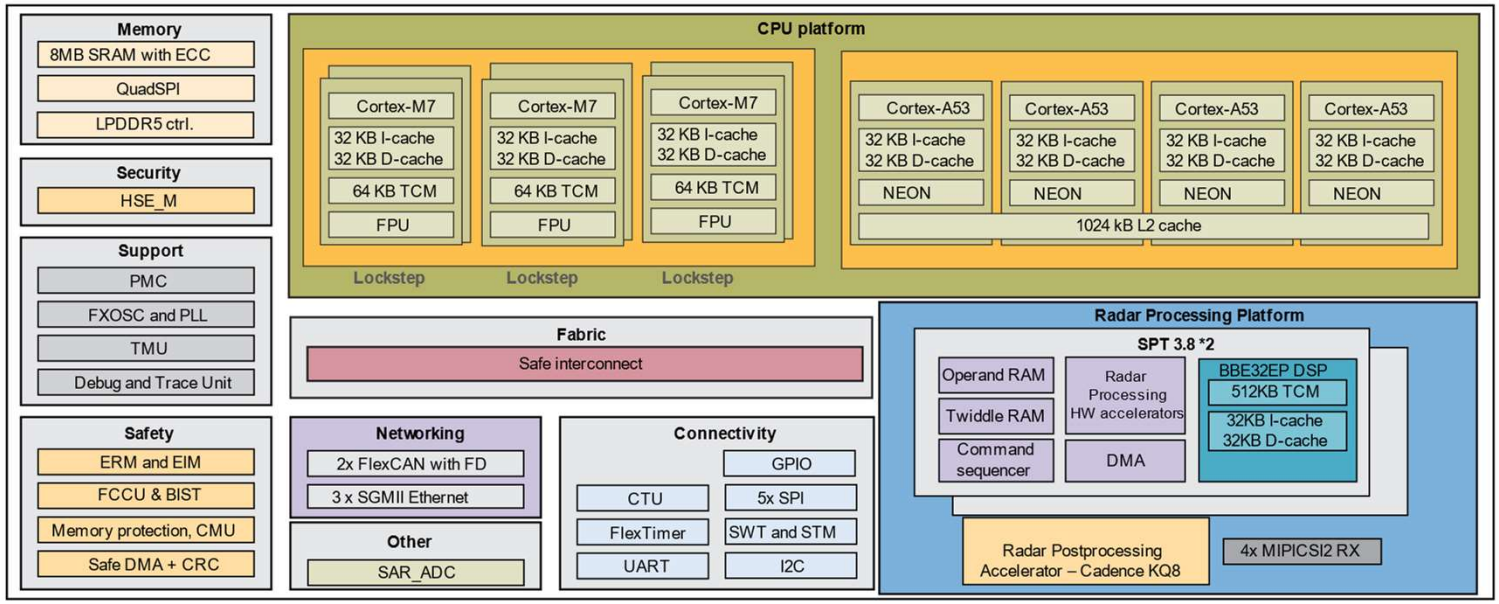
Sold directly through NovTech and Dist.

Please contact Yossi Har-Nov: yossi@novtech.com
5,900$ per board --- Available from 03.2023

NEXT GENERATION IMAGING RADAR SOLUTION –S32R43 AND TEF83XX



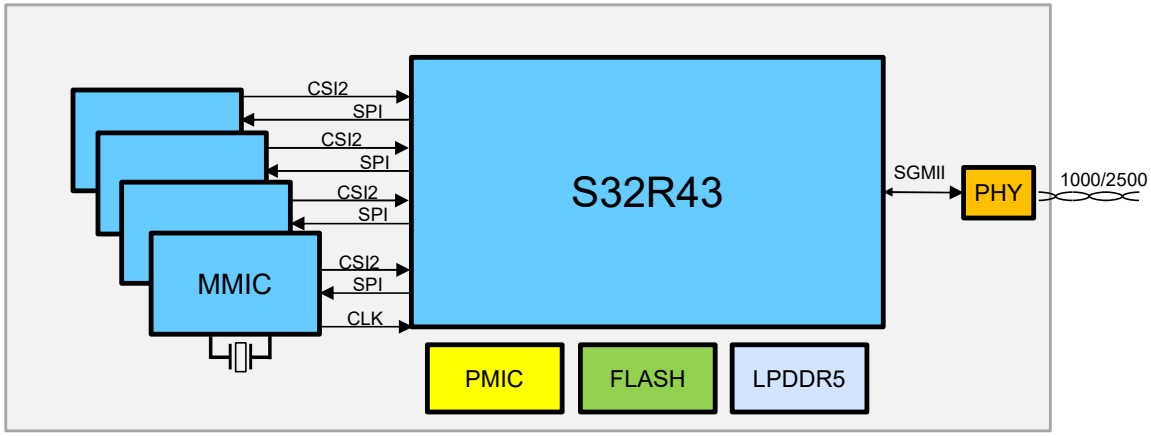
S32R43 IMAGING RADAR PROCESSOR ARCHITECTURE



KEY FEATURES

- 4x Cortex-A53 @ 1200 MHz, (non-LS)
- 3x Cortex-M7 lock-step pairs @400 MHz
- Dual SPT 3.8 @ 600MHz (16way complex, four threads)
- Dual BBE32 DSP @ 600MHz (with integrated DSP-VFPU)
- Radar Postprocessing: Cadence KQ8 * 2
- 8 MB SRAM with ECC
- External LPDDR5 Supported
- 4x MIPI CSI-2 RX
- 3x Ethernet (SGMII, 1 / 2.5Gbit/s), MACSEC support
- 2x FlexCAN with FD
- GMAC MACsec implementation
- HSE Security module - Edge Lock 500
- -40 ºC to 150 °C (Tj) AEC-Q100 Grade-1
- ~500-ball FC_CSP, 0.50mm ball pitch
- 0.8V and 1.8V supply voltages, (optional: 3.3 V can be used on a few I/O pins)
- Safety architecture, ASIL D (systematic), ASIL B (metrics)
- Compliant with ISO/SAE 21434 "Road vehicles — Cybersecurity engineering
- High SW compatibility to SAF85xx and S32R4x devices
- System solution with TEF83xx or SAF86xx and other NXP components

S32R43 USE CASES – IMAGING RADAR

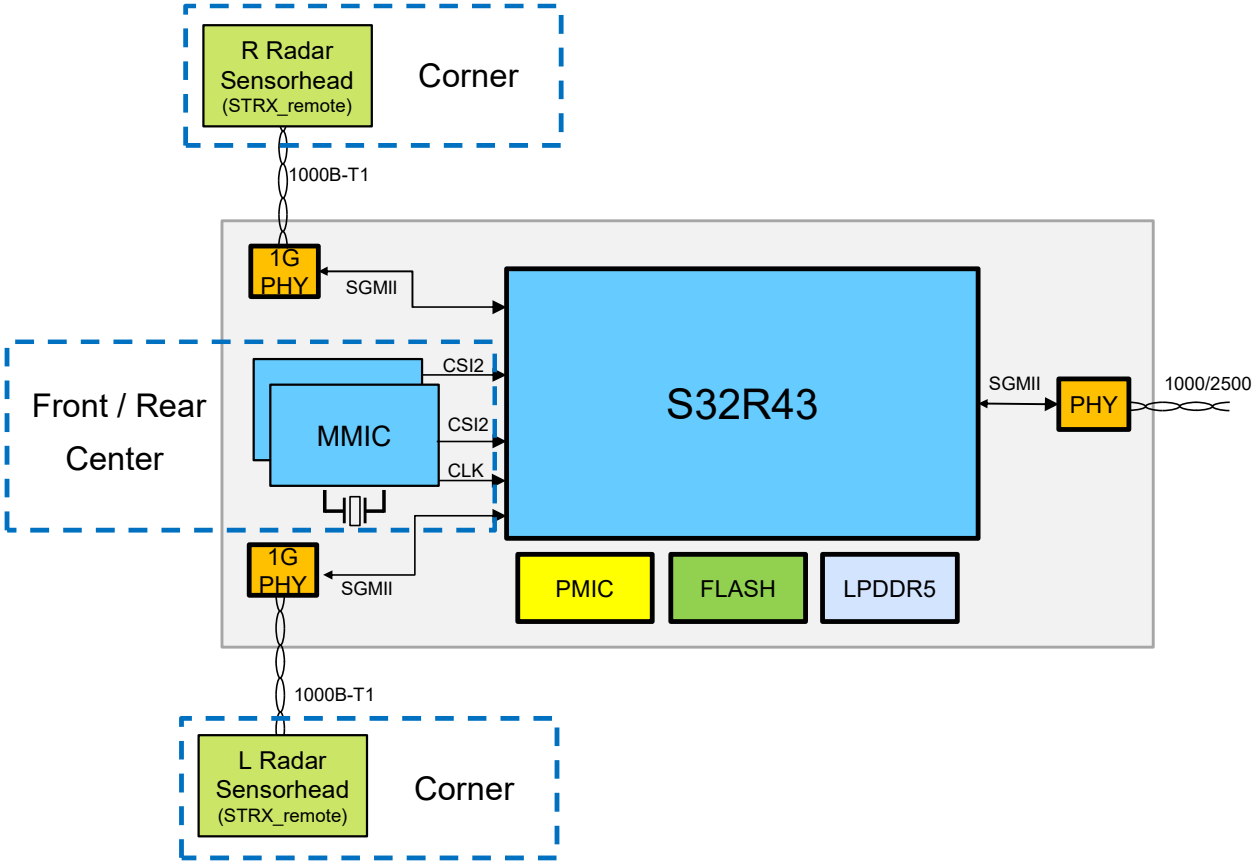


- Imaging Radar MPU **optimized for large-scale adoption**
- **Compatible SW** with NXP's scalable radar platform easing migration from S32R45, S32R41 and STRX
- **Optimized architecture*** supporting current and next generation MMIC's
  - **2x SPT** (MFFT256) capability
  - **50% up A53 frequency** to 1.2 GHz
  - **2x vector floating point processing** to 200 GFLOPS with dedicated post-processing accelerator

* subject to further changes

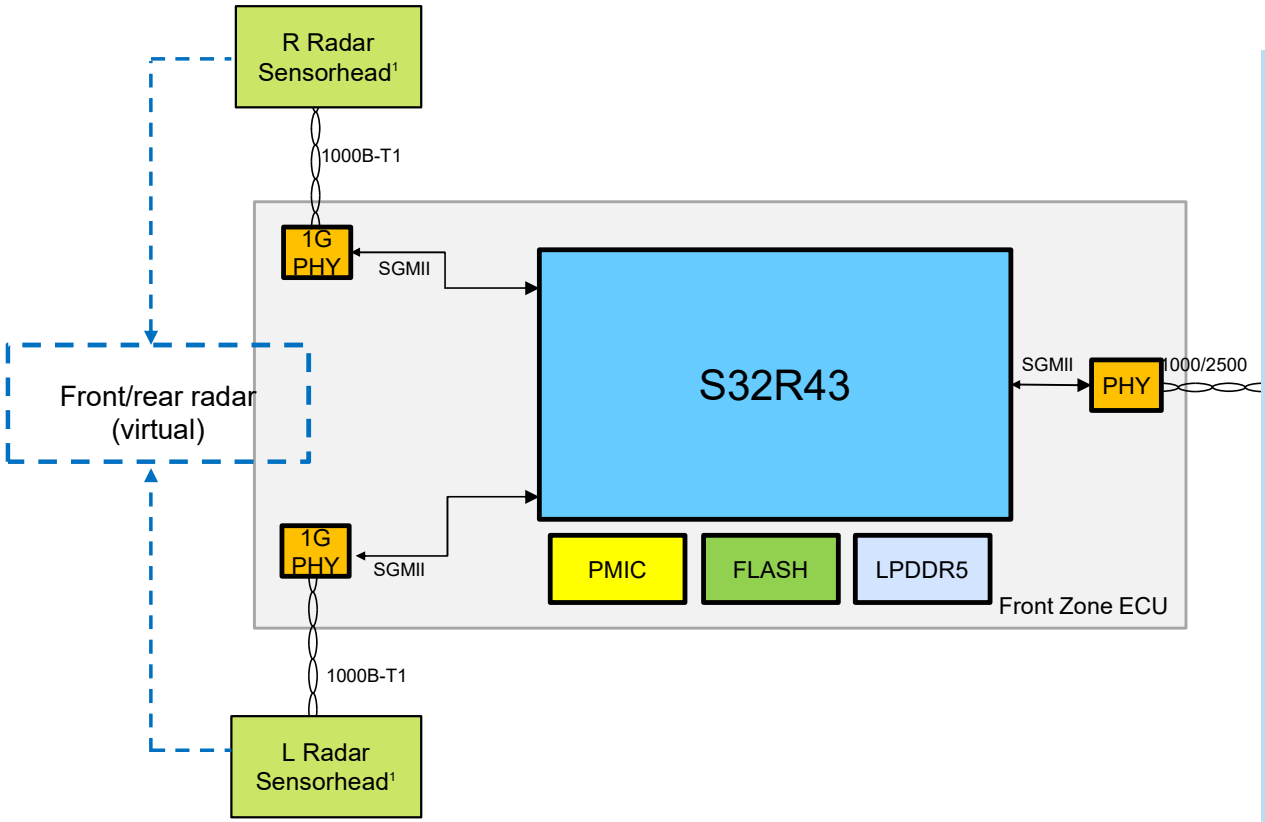
S32R43 USE CASES – MIXED ADVANCED FRONT AND REMOTE CORNER

COMBINED ADVANCED FRONT/REAR AND CORNER SENSOR PROCESSING



- Processing advanced front / rear long-range sensor and two additional corner sensors with one processor

S32R43 USE CASES – DISTRIBUTED COHERENT RADAR



- Two standard corner sensors in synchronized bistatic operation
- Substitute a front/rear radar sensor in the middle
- Benefits:
  - Affordable radar sensor suite
  - Small size & easy integration
  - Higher angular resolution
  - Higher detection probability
  - Tangential velocity (5D Radar)
- Proof of Concept: mid 2023

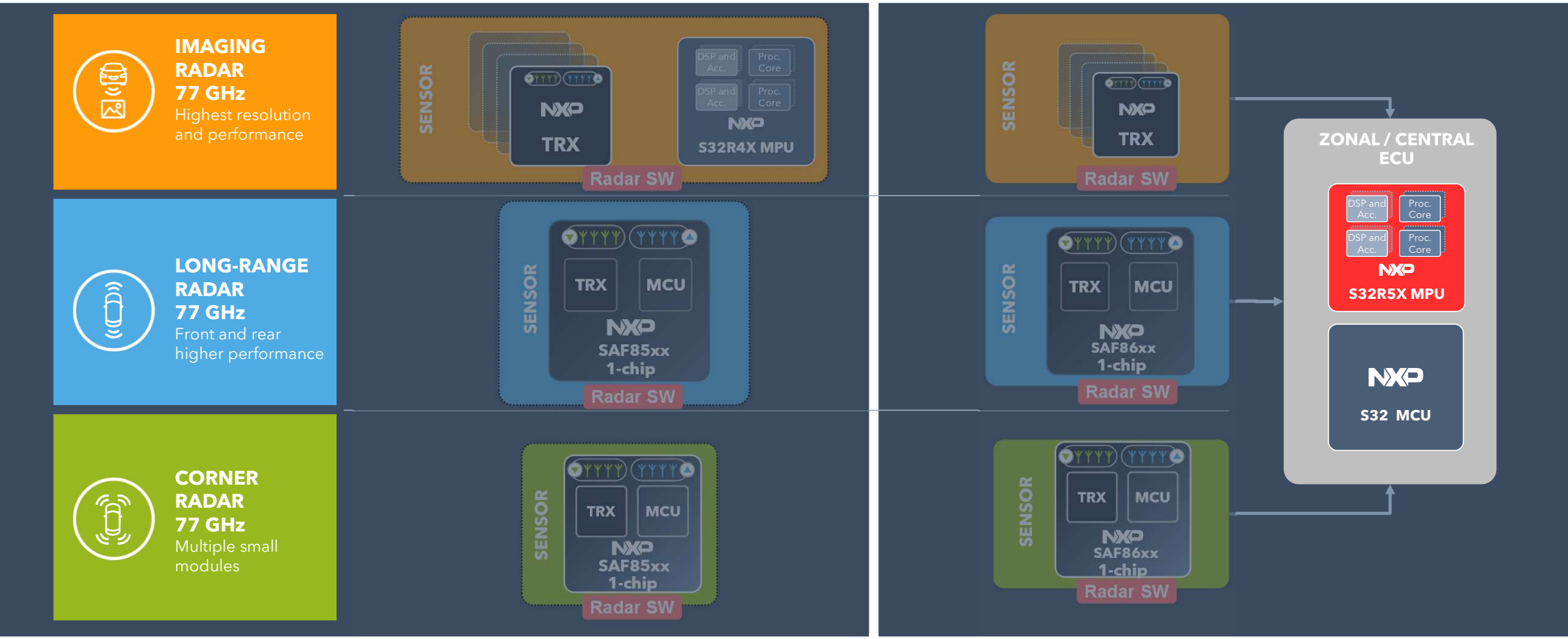
[1] STRX Remote: SAF86xx. [2] TEF82xx.

ADAS SENSOR BRIDGES

EXTENDING THE COMMON AUTOMOTIVE RADAR PLATFORM

SUPPORTING TODAY'S & TOMORROW'S OEM ARCHITECTURES

NXP AUTO RADAR PRODUCT FAMILY



EXTENDING THE COMMON AUTOMOTIVE RADAR PLATFORM

READY TO SUPPORT TODAY'S & TOMORROWS OEM ARCHITECTURES

NXP AUTO RADAR PRODUCT FAMILY

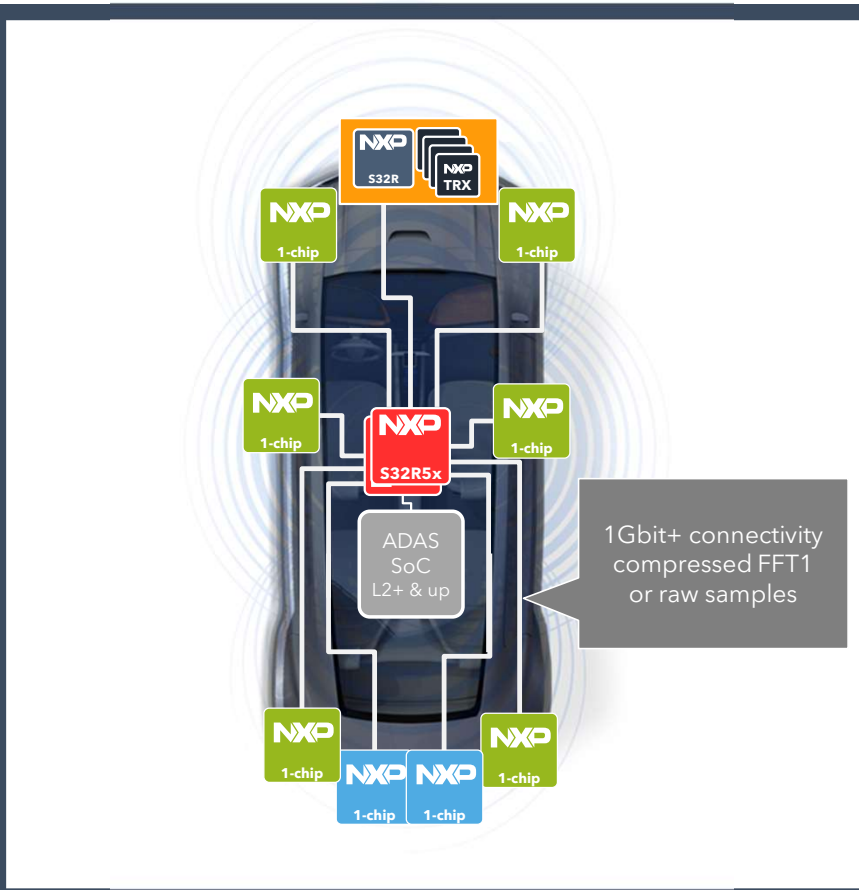
IMAGING RADAR 77 GHz
Highest resolution and performance

LONG-RANGE RADAR 77 GHz
Front and rear higher performance

CORNER RADAR 77 GHz
Multiple small modules

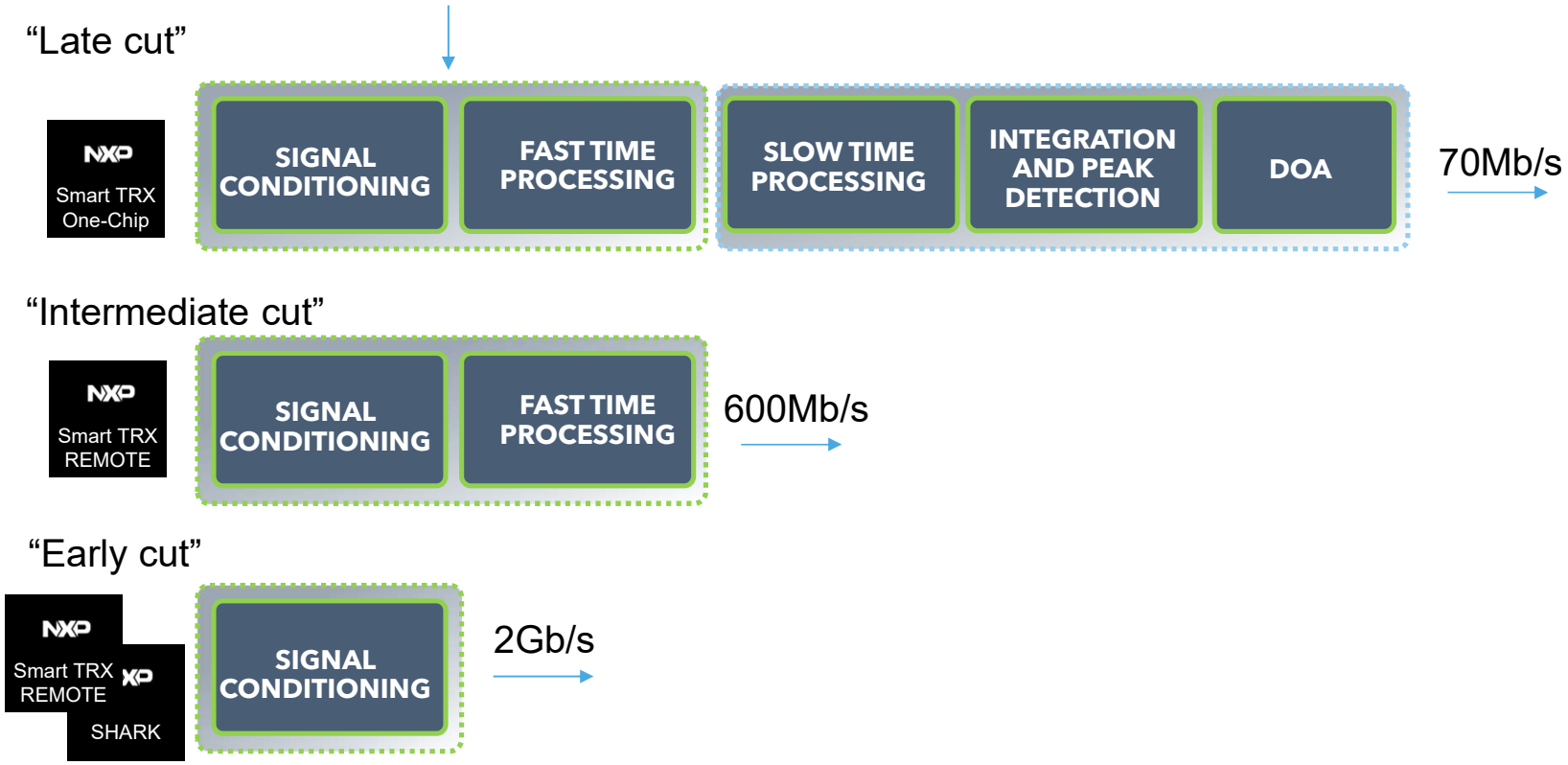
Edge ADAS processing

Zonal / central ADAS processing



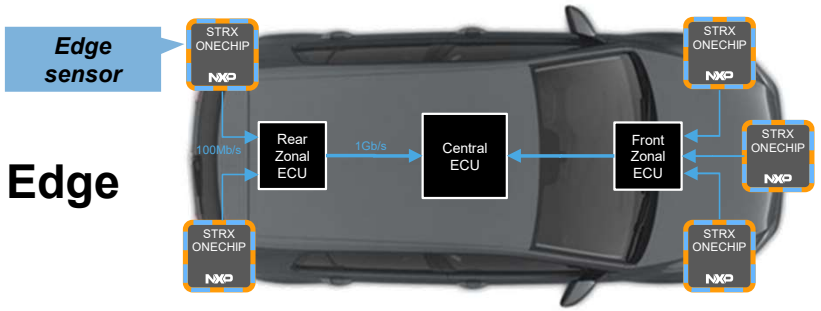
FUTURE RADAR SIGNAL PROCESSING CHAIN ARCHITECTURAL DECISIONS

SMART TRX FAMILY SUPPORTS MULTIPLE OPTIONS WITH SEAMLESS TRANSITION



NXP RADAR SOLUTIONS SERVE ADAS ARCHITECTURE EVOLUTION
FLEXIBLE SUPPORT FOR MULTIPLE TRANSITION SCENARIOS

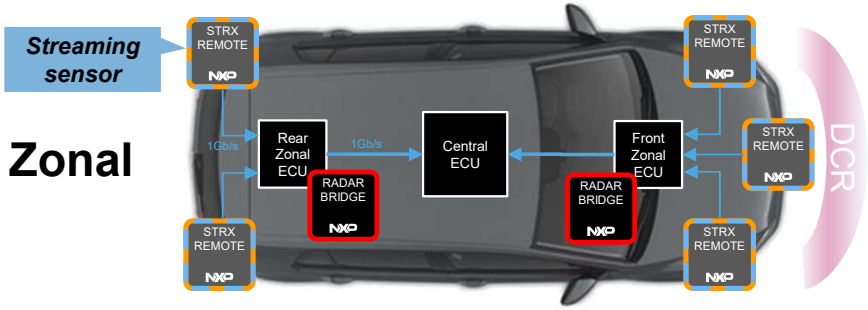
Edge



Classical edge-based ADAS architecture:

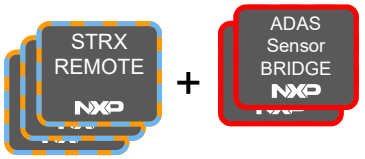
- NXP STRX One-chip delivers up to tracked object list
- Delivers state-of-the-art sensor performance & integration level
- Established functional safety concept
- No Radar specific knowledge & control in central ECU required

Zonal

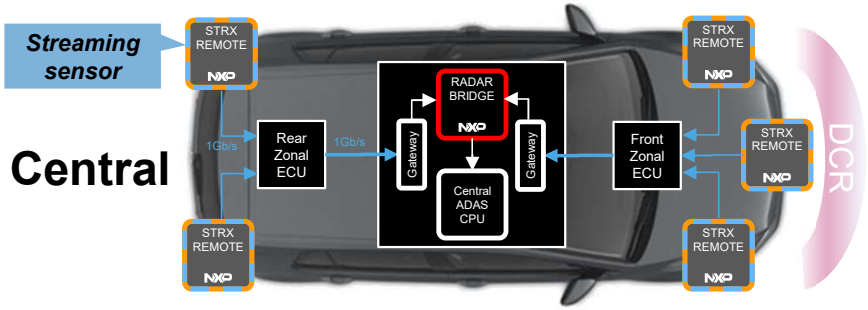


Zonal ADAS architecture: System cost sweet spot & sensor head synergy through ADAS Bridge

- NXP STRX Remote delivers up to FFT1
- NXP ADAS Sensor Bridge in zones for Radar post-processing, enables use of new sensor heads with classical domain ECU
- Supports innovative distributed coherent Radar (DCR) with up to 50% more performance in range and angular resolution
- No Radar specific knowledge & control in central ECU required

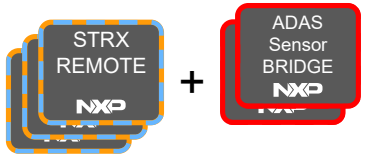


Central



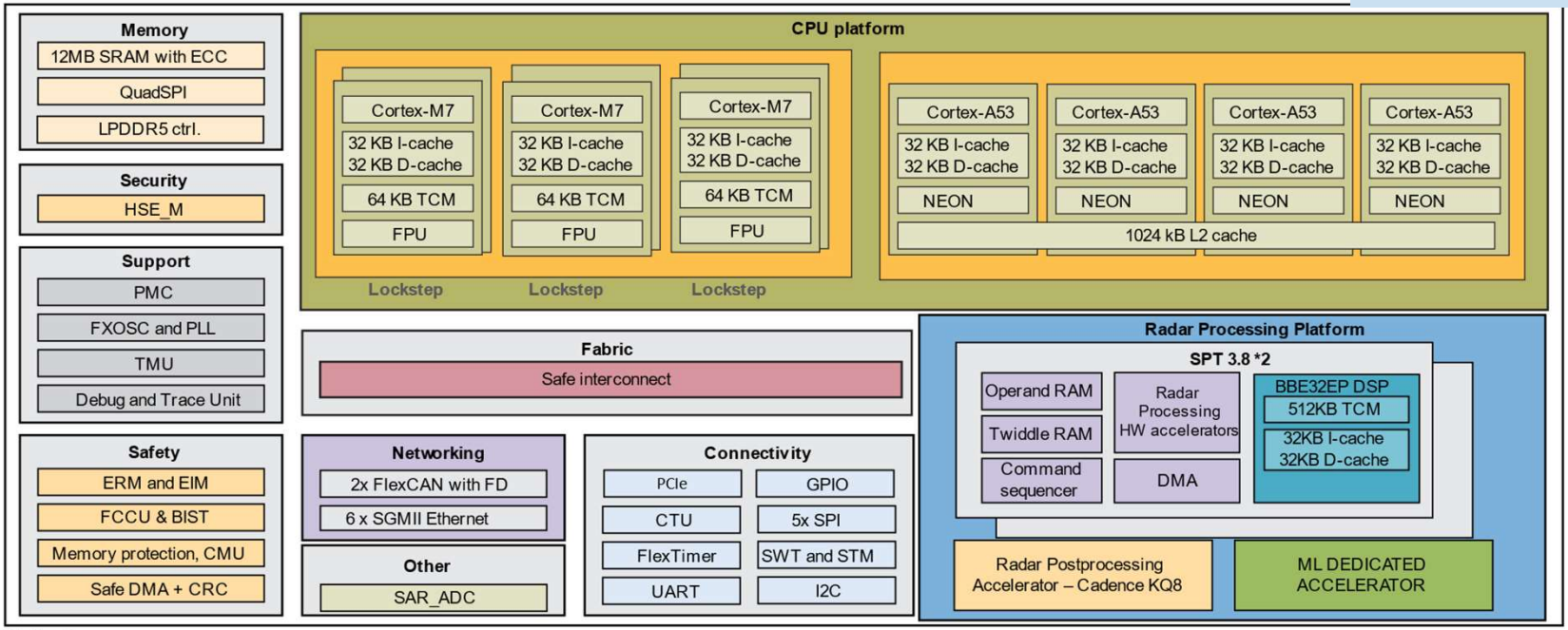
Central ADAS Architecture: Potential SoC off-loading by ADAS Bridge

- NXP STRX Remote delivers up to FFT1 output data
- Zonal ECU only for data aggregation (no ADAS processing)
- NXP ADAS Sensor Bridge in central to process all Radar specific data
- No Radar specific knowledge & control in central ECU required



S32R51 RADAR BRODGE PROCESSOR ARCHITECTURE

PRODUCT IDEA
SPECIFICATION SUBJECT TO CHANGE

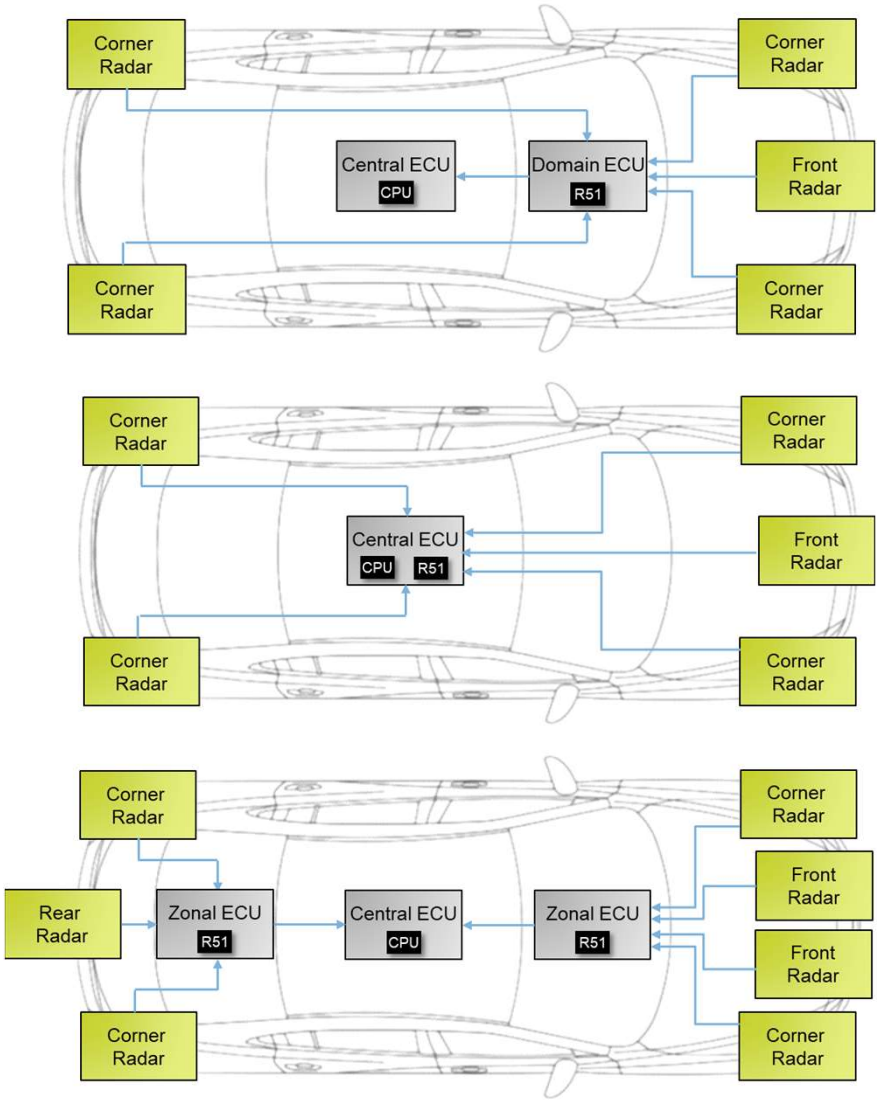


KEY FEATURES

- 4x Cortex-A53 @ 1200 MHz, (non-LS)
- 3x Cortex-M7 lock-step pairs @400 MHz
- Dual SPT 3.8 @ 600MHz (16way complex, four threads)
- Dual BBE32 DSP @ 600MHz (with integrated DSP-VFPU)
- Radar Postprocessing: Cadence KQ8 * 2
- Dedicated ML Accelerator
- 12 MB SRAM with ECC
- External LPDDR5 Supported
- 1x PCIe (2 lanes, Gen2/3)
- 6x Ethernet (SGMII, 1 / 2.5Gbit/s), MACSEC support
- 2x FlexCAN with FD
- GMAC MACsec implementation
- HSE Security module - Edge Lock 500
- -40 ºC to 150 °C (Tj) AEC-Q100 Grade-1
- ~500-ball FC_CSP, 0.50mm ball pitch
- 0.8V and 1.8V supply voltages, (optional: 3.3 V can be used on a few I/O pins)
- Safety architecture, ASIL D (systematic), ASIL B (metrics)
- Compliant with ISO/SAE 21434 "Road vehicles — Cybersecurity engineering
- High SW compatibility to SAF85xx and S32R4x devices
- System solution with TEF83xx or SAF86xx and other NXP components

S32R51 RADAR BRIDGE

- Radar pre-processing and aggregation
  - Offloading the central ADAS processor
  - Offloading the satellite sensors (STRX remote)
  - Connecting up to 5 Radar Sensors
    - 6 Ethernet ports
    - Input: Compressed FFT1 data via 1Gb/s
    - Output: Pointclouds via 2.5Gb/s
  - Software: all radar-specific functions
    - Combining data from various FoV
- Configurations
  - Domain Processor
  - Co-processor in Central ECU
  - Zonal Processor

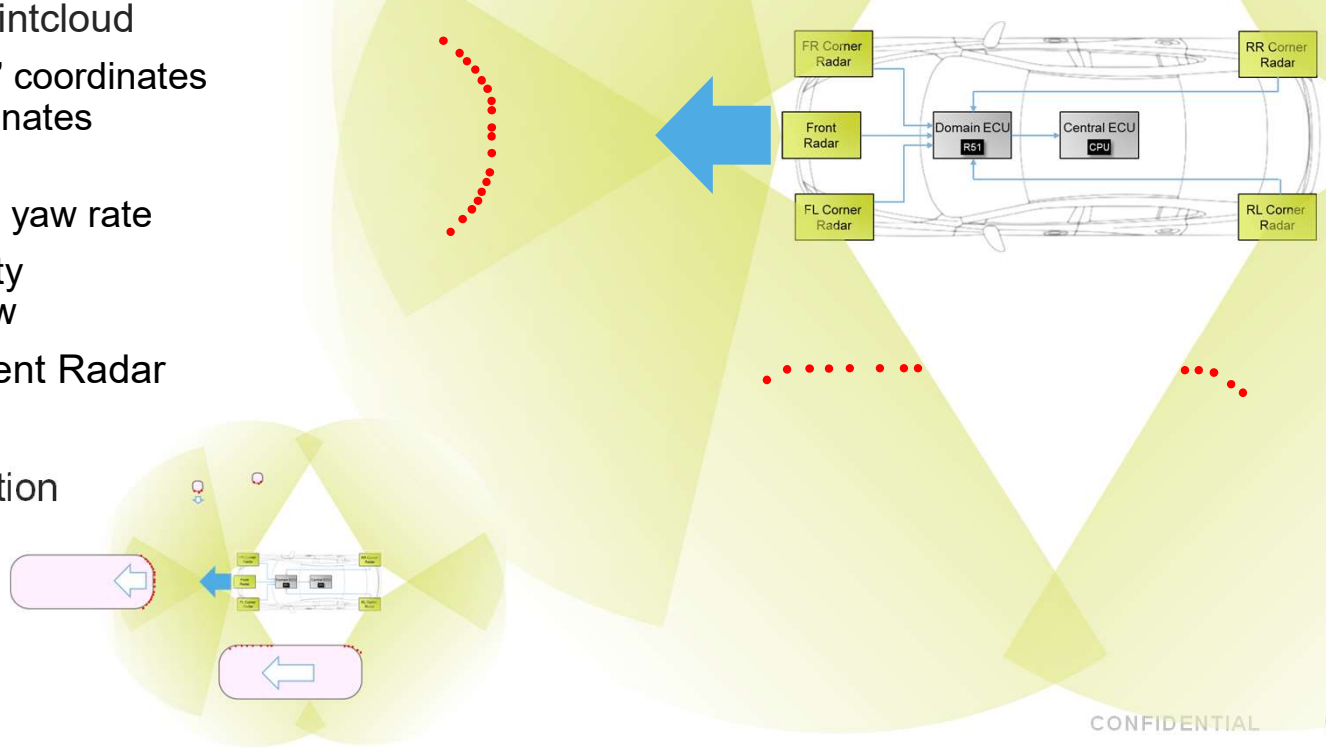


S32R51 RADAR BRIDGE SOFTWARE USE CASE
CREATING, COMBINING AND COMPREHENDING POINTCLOUDS

1. Create 5 Pointclouds
   - Using 5x compressed FFT1 as input via 1Gb/s Ethernet
   - High Quality Pointcloud (high resolution, no interference)

2. Combine into a surround Pointcloud
   - Transforming polar “sensor” coordinates into cartesian “world” coordinates to simplify tracking objects
   - Determining ego speed and yaw rate
   - Measuring tangential velocity in overlapping Fields of View
   - Option: Distributed Coherent Radar

3. Comprehend: Radar perception
   - Object detection
   - Object classification
   - Object tracking



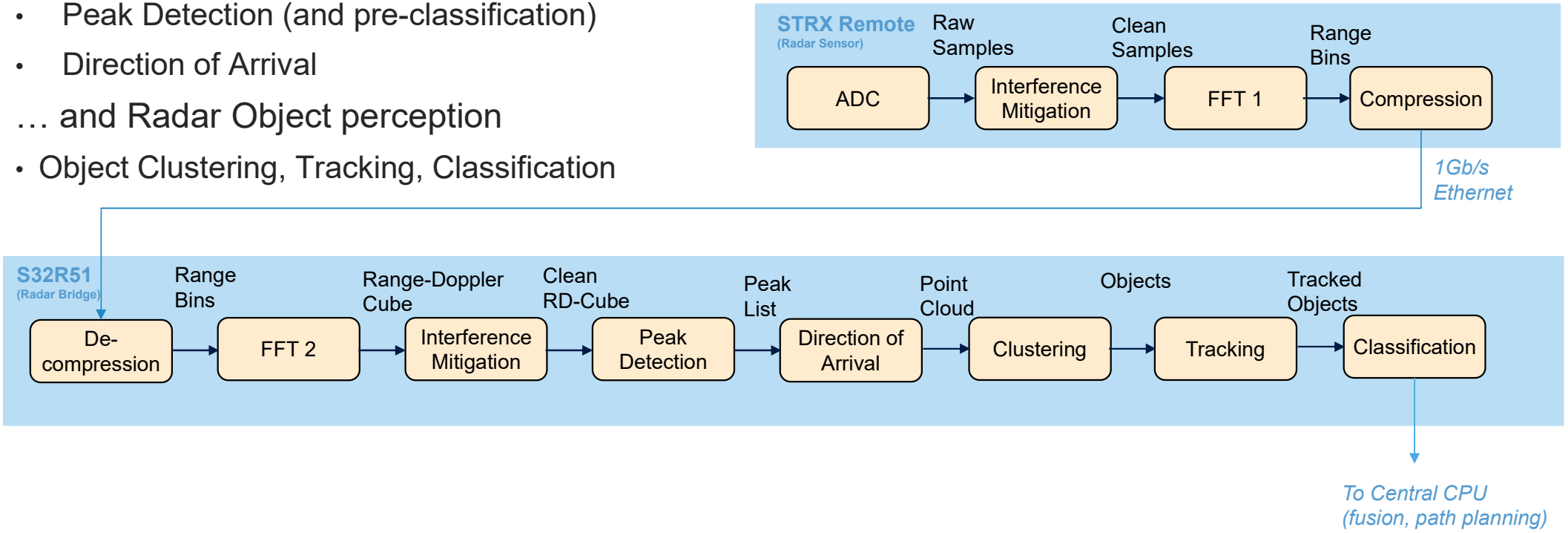
S32R51: MACHINE LEARNING ACCELERATION

Machine Learning efficiently supports a high-quality point cloud…

- Interference Mitigation
- Peak Detection (and pre-classification)
- Direction of Arrival

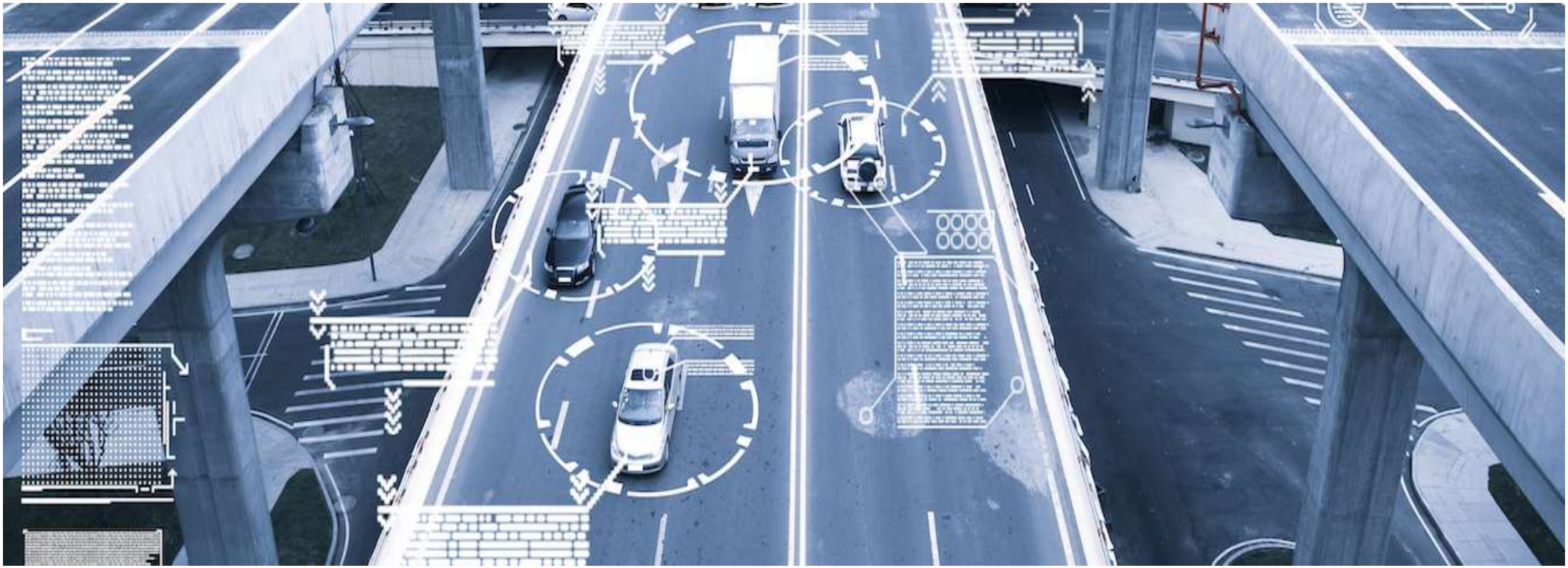
… and Radar Object perception

- Object Clustering, Tracking, Classification



Project Kingston

Radar Bridge PoC



ADAS BRIDGE POC ROADMAP

Radar Bridge PoC – R45 + 2x SJA1110D

Proof of Concept

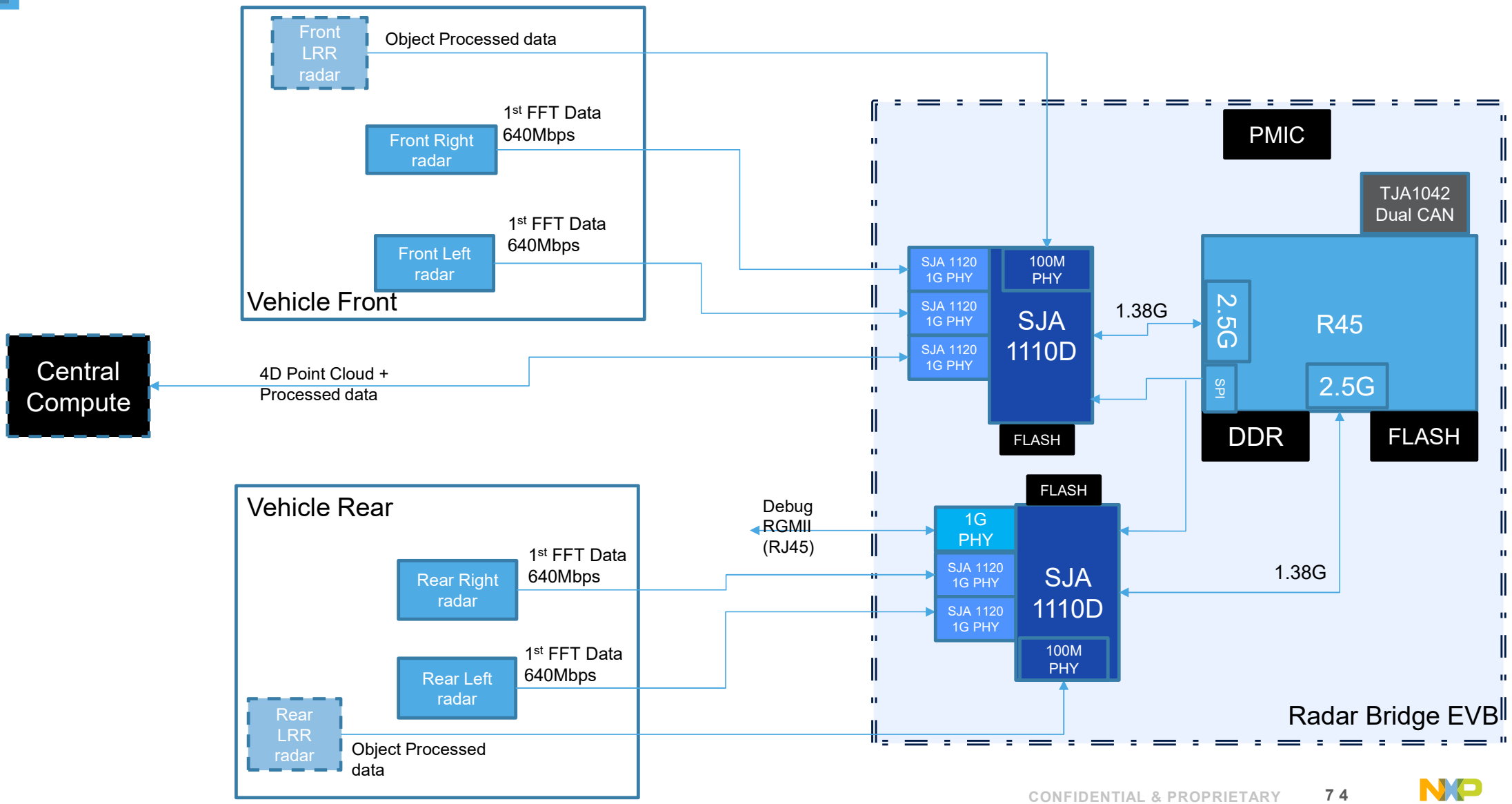
Automotive Quality

ADAS Bridge PoC – R45 + camera ISP

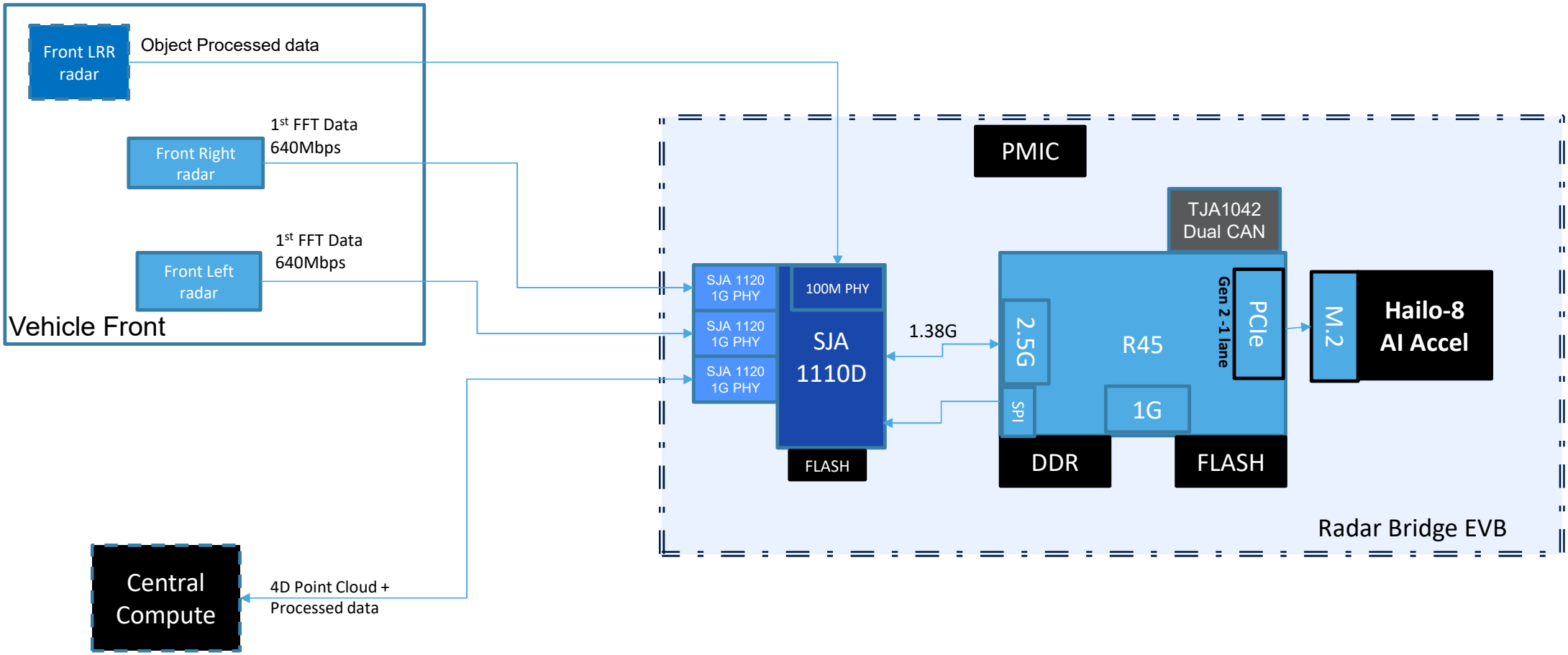
Proof of Concept

Automotive Quality

Radar Bridge PoC – Surround Use Case



Radar Bridge PoC – AI Usecase



PLATFORM SOFTWARE

- A53 Cores – Linux
- M7 Core – Free RTOS
- 2G DDR Memory
- MACSec at PHY level – customer enabled
- UDP or TSN(gPTP) – Still under investigation
- OTA – Still under investigation

Hardware

- Develop using Auto Grade components
- Customer can go to production with components used in the ECU
- NXP components are available for production

Application Software

- Radar Processing Demo
- Simulation Platform
- Sensor Isolation

Dates

- Engineering Samples May 2023
- Customer Samples Aug 2023

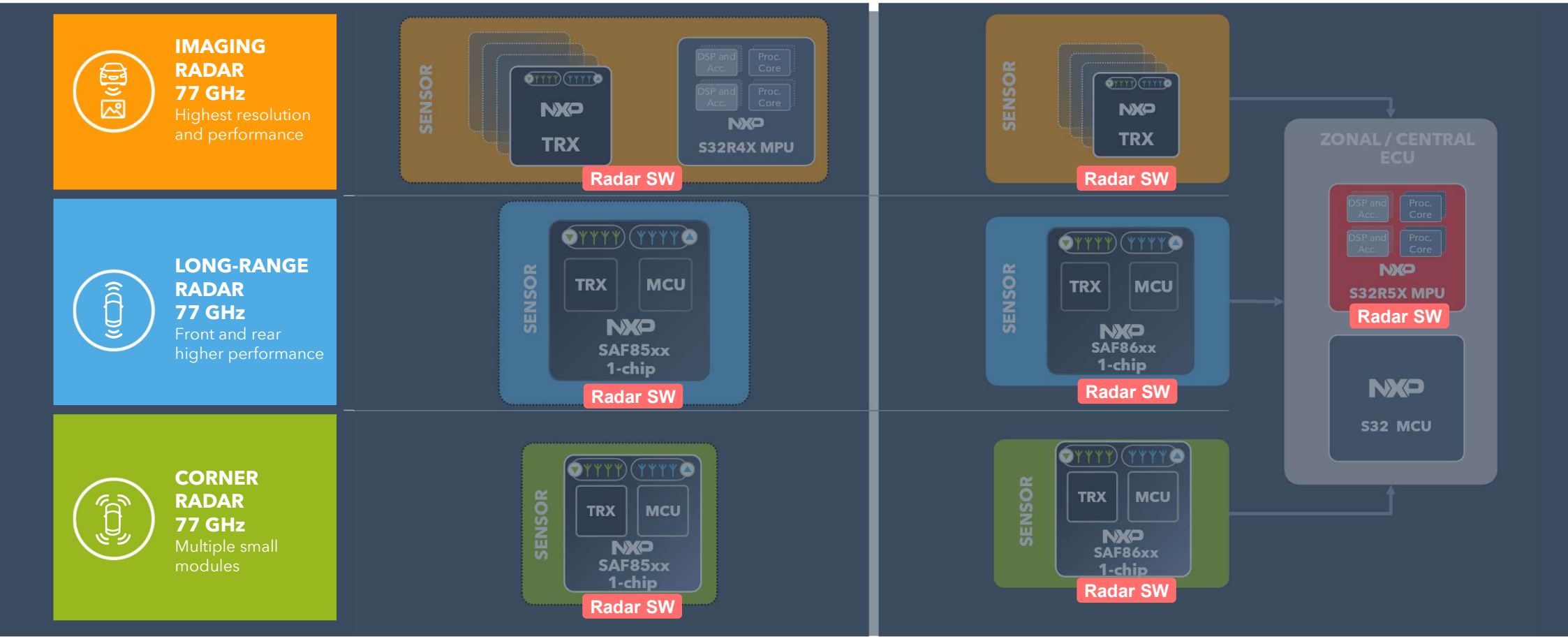
Subject to Change without Notice

PREMIUM RADAR SDK ADVANCED RADAR ALGORITHMS

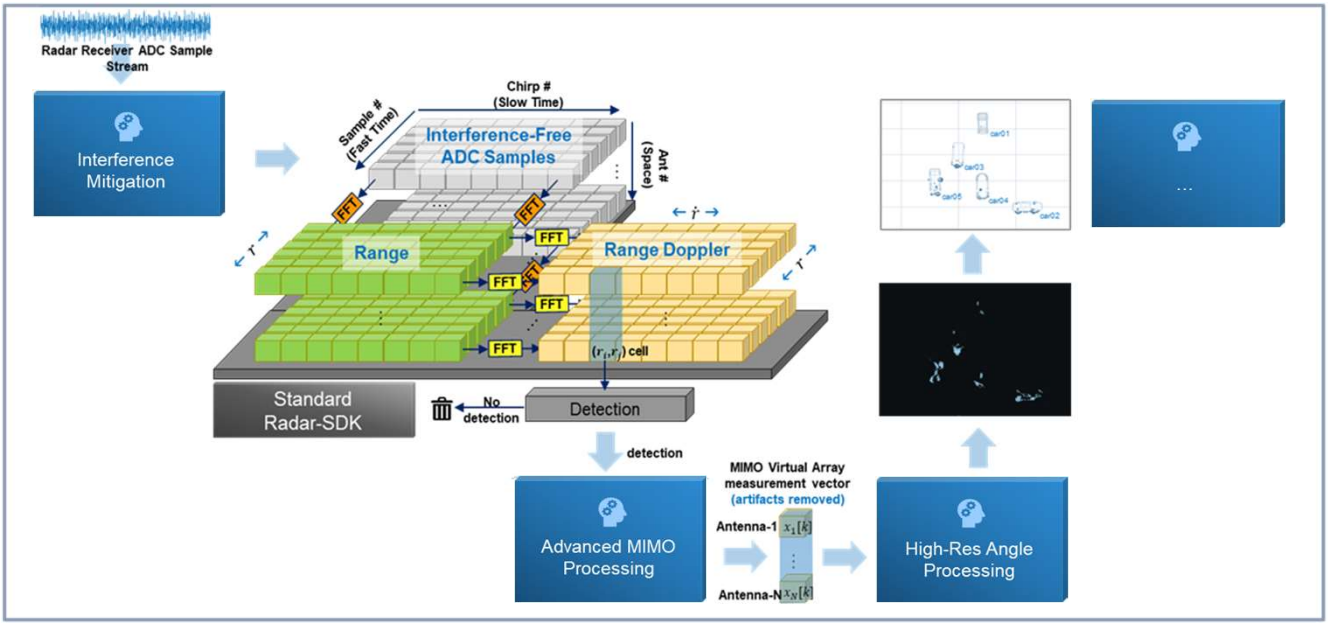
EXTENDING THE COMMON AUTOMOTIVE RADAR PLATFORM

DELIVERING OPTIMUM PARTITIONING FOR TODAY'S & TOMORROW'S OEM ARCHITECTURES

NXP AUTO RADAR PRODUCT FAMILY



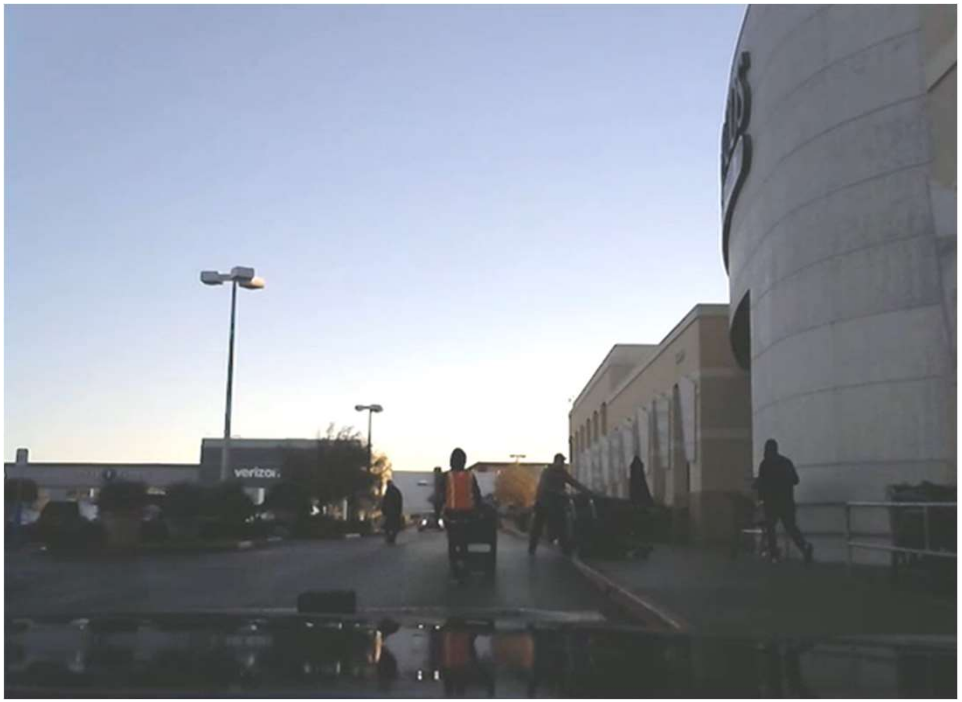
NXP PREMIUM RADAR SDK
ADVANCED RADAR ALGORITHMS ENHANCE SENSOR PERFORMANCE

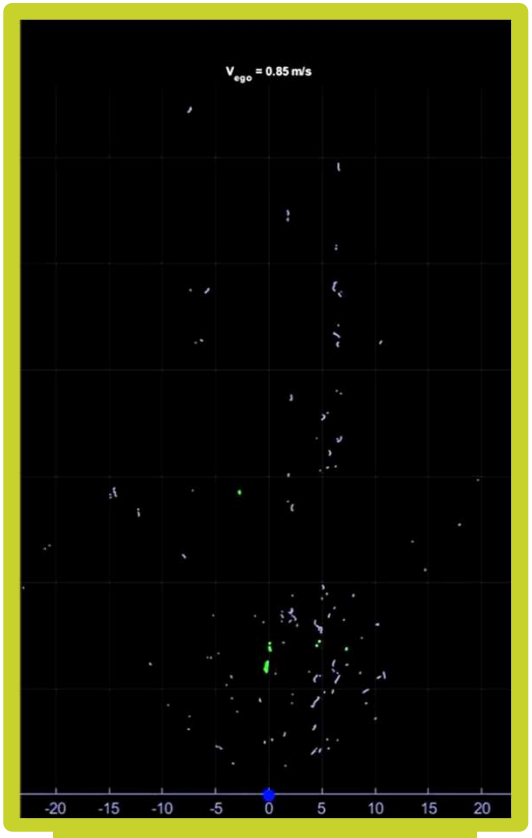


- Differentiating performance
- Solving common challenges
- Optimized implementation
- Customer Modifiable

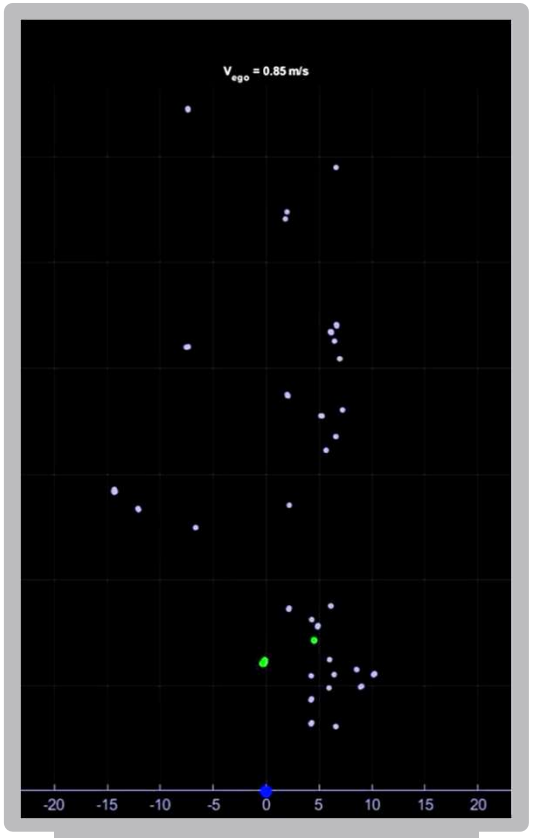
NXP 4D IMAGING RADAR LEVERAGES PROPRIETARY SILICON & SW IP

PREMIUM RSDK ALGORITHMS FOR HIGH-RESOLUTION VS STANDARD PROCESSING





Hi-Res Processing

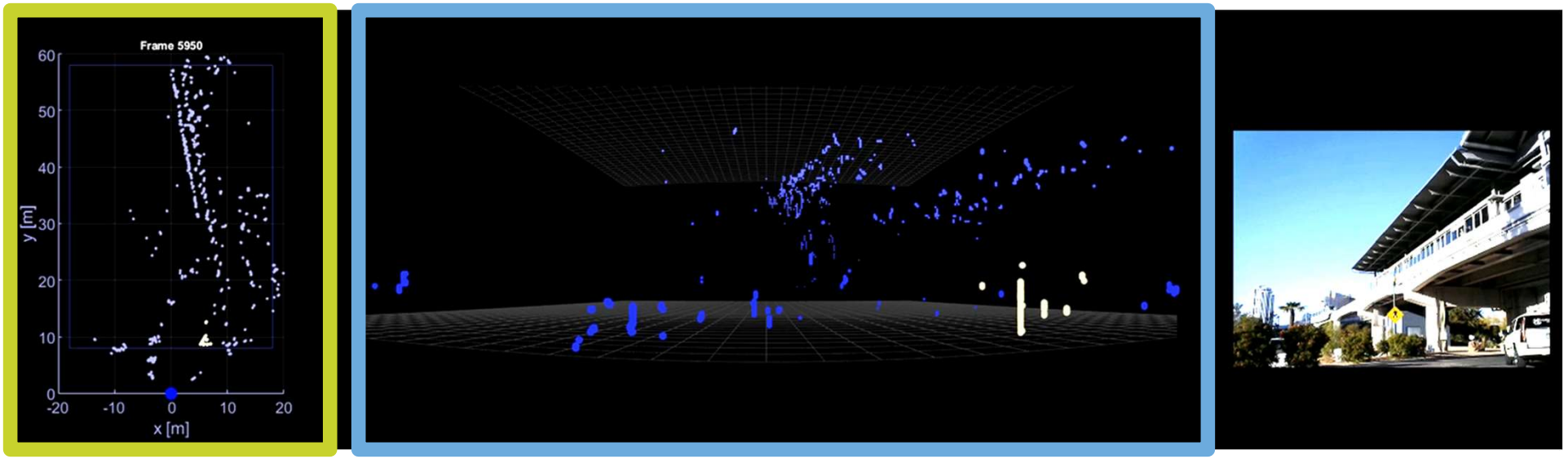


Standard Processing

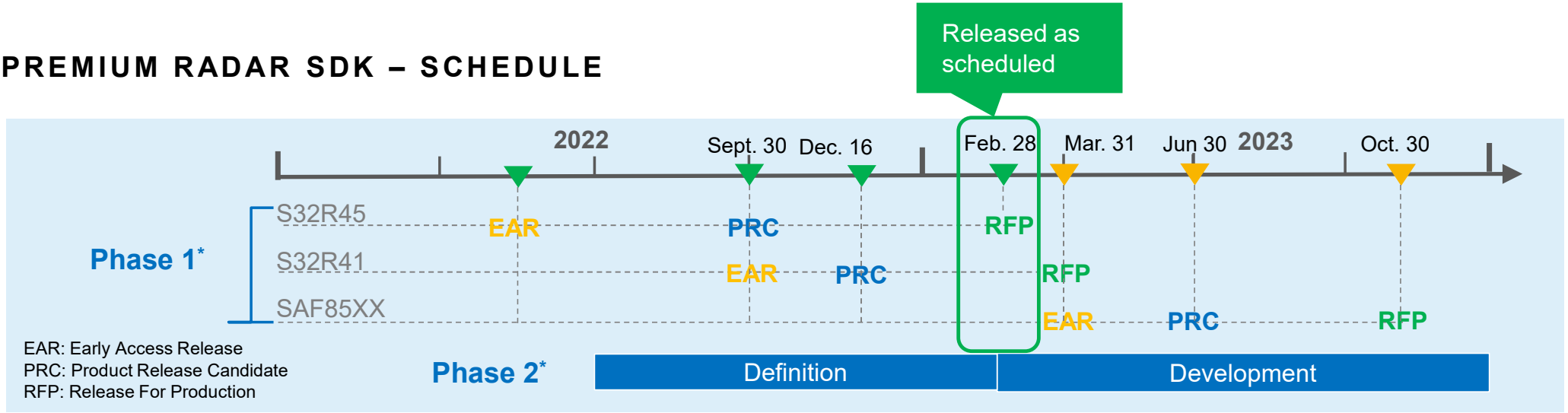
NXP 4D IMAGING RADAR LEVERAGES PROPRIETARY SILICON & SW IP
HIGH RESOLUTION SENSING IN AZIMUTH AND ELEVATION DIMENSIONS

High-resolution azimuth sensing in x-y plane

High-resolution elevation sensing



PREMIUM RADAR SDK – SCHEDULE



* Content and schedule subject to change without further notice

- RFP release for **S32R45** *available NOW!*
- RFP release for **S32R41**: Mar. 2023
- RFP release for **SAF85xx**: Oct. 2023
- **Successful demonstration** @ CES 2022
- **2x** signed customer contracts
- **20+** customer evaluations
- **Release 2** fully defined

Phase 1*	Algorithm	S32R45	S32R41	SAF85xx
Advanced Interference Mitigation	TDAT	SPT	SPT	SPT
	TFDT	SPT	SPT	SPT
Advanced MIMO Processing	CPC DDM	BBE	BBE	BBE
High-Res. Angle Processing	SMP (ULA)	LAX	VFPU	VFPU
	OMP (SA & ULA)	LAX	-	-
	BLRC (SA & ULA)	LAX	VFPU	VFPU
	BSMP (SA & ULA)	LAX, BBE	VFPU	VFPU

PREMIUM RADAR SDK – PHASE 2 ALGORITHMS

	Phase 1	S32R45	S32R41	SAF85xx
Advanced Interference Mitigation	TDAT	✓	✓	✓
	TFAT	✓	✓	✓
Advanced MIMO Waveform	CPC DDM (16TX)	✓	✓	✓
High Res. Angle Processing	SMP	✓	✓	✓
	OMP	✓	-	-
	BSMP	✓	✓	✓
	BLRC	✓	✓	✓
Perception & AI/ML				

+

Phase 2	S32R45	S32R41	SAF85xx
TFCT	✓	tbd	tbd
CPC DDM (12TX)	✓	tbd	tbd
M3	✓	tbd	tbd
CC-LISTA	✓	tbd	tbd
TPoT	✓	tbd	tbd

Adding a new high-dimension for enhanced SINR recovery and false alarm suppression

Enhanced DD MIMO for 12+ Tx simultaneous transmission

Support of arbitrary sparse array geometry & multi-path filtering

Improved point cloud density for enhanced target separation based on hybrid DNN model

Compact 4D point cloud based target classification

SECURE CONNECTIONS
FOR A SMARTER WORLD

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