新形势下毫米波雷达的发展趋势分析

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PUBLIC

SECURE CONNECTIONS FOR A SMARTER WORLD

Outline
概要

- Automotive Radar definition and application
  毫米波雷达的定义与应用
- Regulations and market demand analysis
  法律法规与市场需求分析
- Application trend in next generation
  毫米波雷达的发展趋势

01

Definition and applications
定义与应用

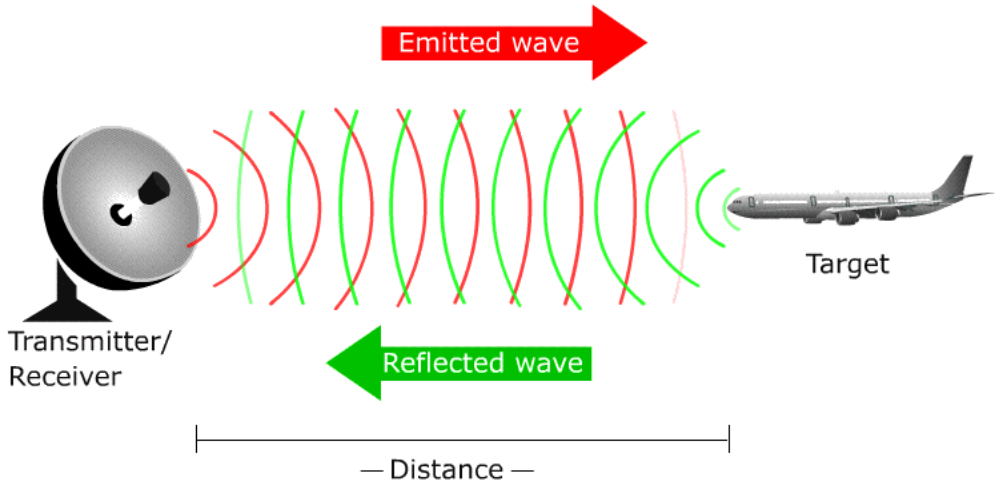
What's RADAR: Radio Detection And Ranging
雷达：无线电探测和测距

Radar is an object-detection system that uses radio waves to determine the range, angle and velocity of objects.
雷达利用无线电波来探测物体的距离，角度和速度

A radar system consists of:

- A transmitter producing electromagnetic waves 发射机发射无线电波
- A receiver receiving return waves of object(s) 接收机接收物理反射回波
- A processor processing signal to determine properties of the object(s). 处理器处理信号以获得物体的信息

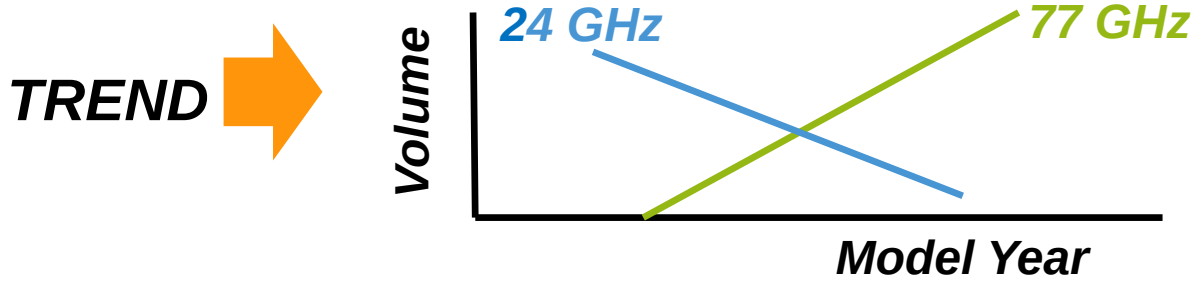
	Radar	Ultrasonic	Camera	Lidar
Method 探测方法	Radio wave 无线电	Mechanical wave 机械波	Vision 视觉	Laser 激光
Distance 作用距离	Long 长	Short 短	Medium 中	Long 长
Night 夜晚工作	Good 好	Good 好	Bad 差	Good 好
Rain & Fog 雨雾天气	Good 好	Affected 受影响	Bad 差	Bad 差
Classification 目标识别分类	Bad 差	Bad 差	Good 好	Medium 中
Cost 成本	Medium 中	Cheap 便宜	Medium 中	Expensive 贵



Automotive RADAR Technology

Industry standardizations & regulations…

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

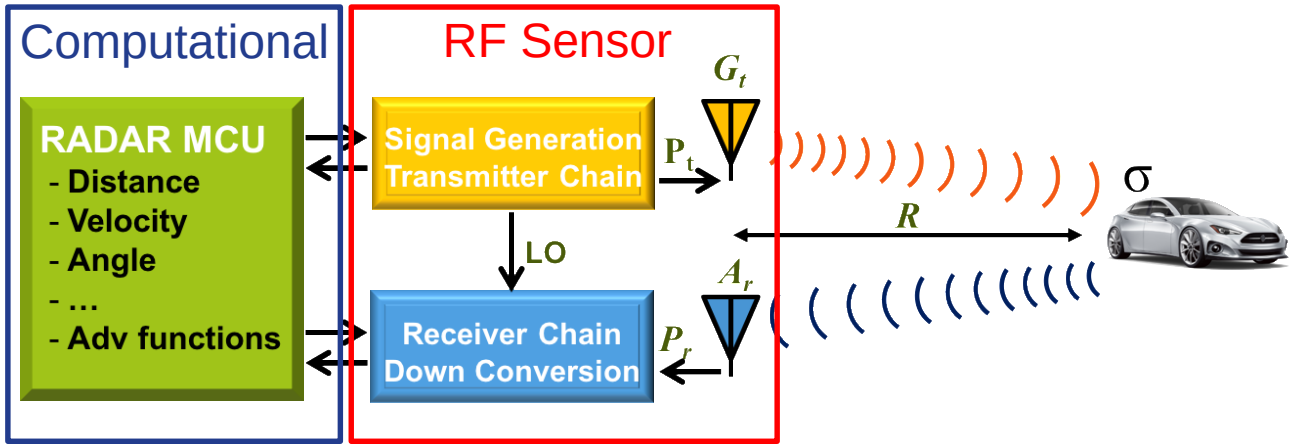


- Antennas – Patch antennas on “PCB” *(printed circuit board)*
- Electronic Components
  - Two IC packages or One IC package for primary functionality
  - Plus support components (power supply, communications, EMC, etc.)

Automotive RADAR Technology

Basic Functional Blocks

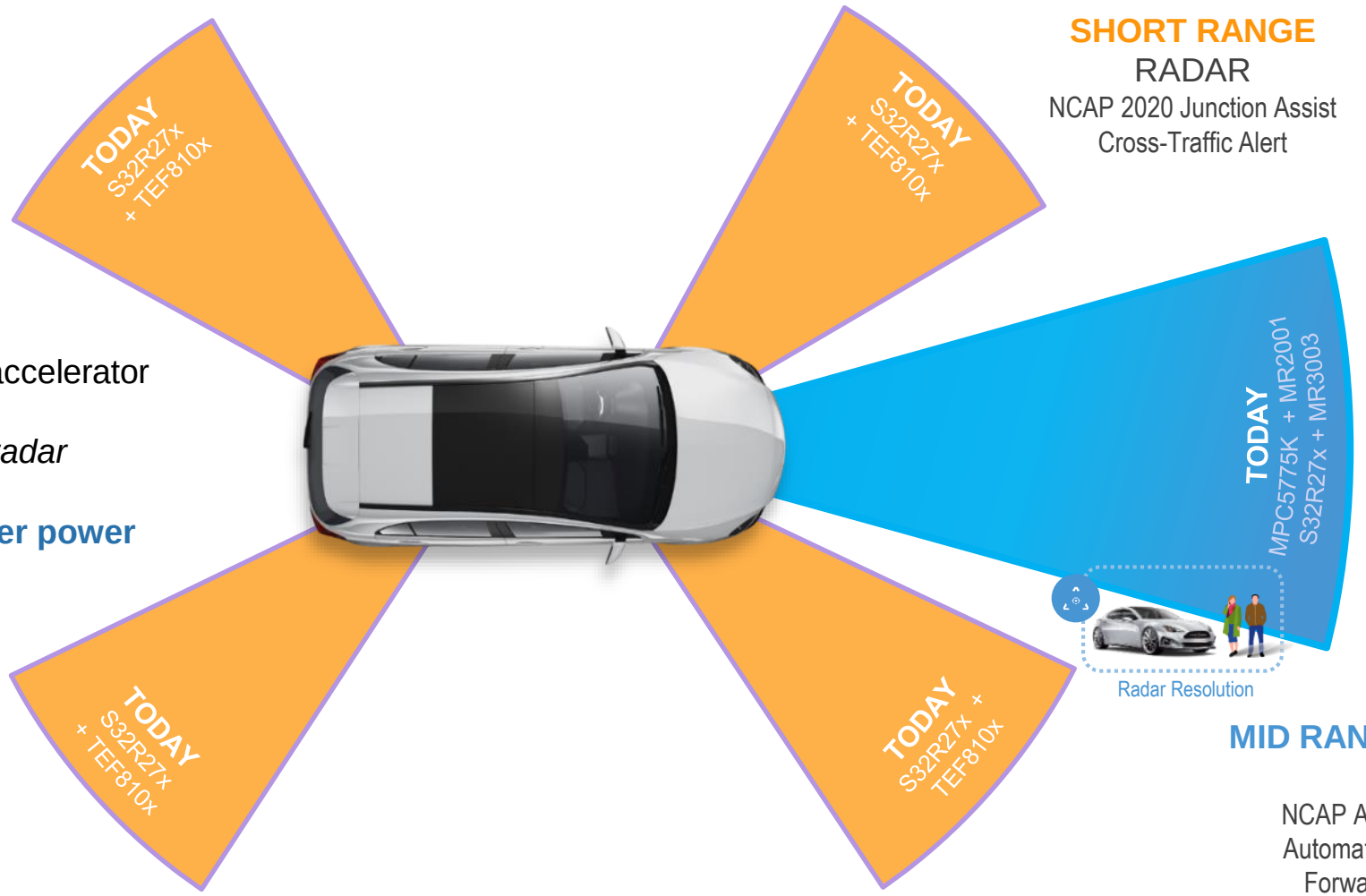
- The radar have two major functional blocks:
  - RF Sensor (the RF “Front End”)
    - Antennas
    - Signal creation and transmission
    - Signal reception and signal conditioning
    - Analog to digital sampling



  - 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

Application Context for SRR and MRR: **Today**

- **First** Radar signal processing accelerator (SPT)
- *S32R* **first** *dedicated MCU for radar processing*
- *Market leading* **performance per power**



SHORT RANGE
RADAR
NCAP 2020 Junction Assist
Cross-Traffic Alert

SHORT RANGE
RADAR
NCAP Lateral Assist

MID RANGE/LONG RANGE
RADAR
NCAP Adaptive Cruise Control
Automatic Emergency Braking
Forward Collision Warning

02

Regulations and demand
法律法规与市场需求

Regulations

- **EU:**
  - **Official Journal of the European Union L325 欧盟公报**
  - **ACEA (The European Automobile Manufacturers' Association) 欧洲汽车制造协会**
  - **Euro NCAP**

- **GC PV:**
  - **《中国新车评价规程》2018 C-NCAP**
    - Implementation 2018/7/1
    - 15pts (ESC 4 pts, AEB-V 8 pts, AEB-P 3pts) in ADAS box
    - ADAS is a must for 5 stars from 2019
  - **《C-NCAP管理规则(2018年版)修订版》征求意见稿**
    - LDW, BSD C2C, SAS are newly added systems for review.
    - Up to 2 pts can be obtained for three systems.

- **GC CV:**
  - **《营运客车安全技术条件》JT/T 1094-2016**
    - Implementation 2018/5/1
    - AEBS, LDW & FCW mandatory for carriers > 9 meters
    - ~500k vehicles / year
  - **《营运货车安全技术条件 第1部分：载货汽车》JT/T 1178.1**
    - Implementation 2020/Q3
    - AEBS, LDW & FCW mandatory for N3 vehicles (> 12 tons)
    - ~4M vehicles / year
  - **《营运货车安全技术条件 第2部分：牵引车辆与挂车》JT/T 1178.2**
    - Implementation 2020/Q3
    - LDW & FCW mandatory for carriers (> 12 tons)
    - AEBS mandatory for carriers maximum speed (> 80km/h)

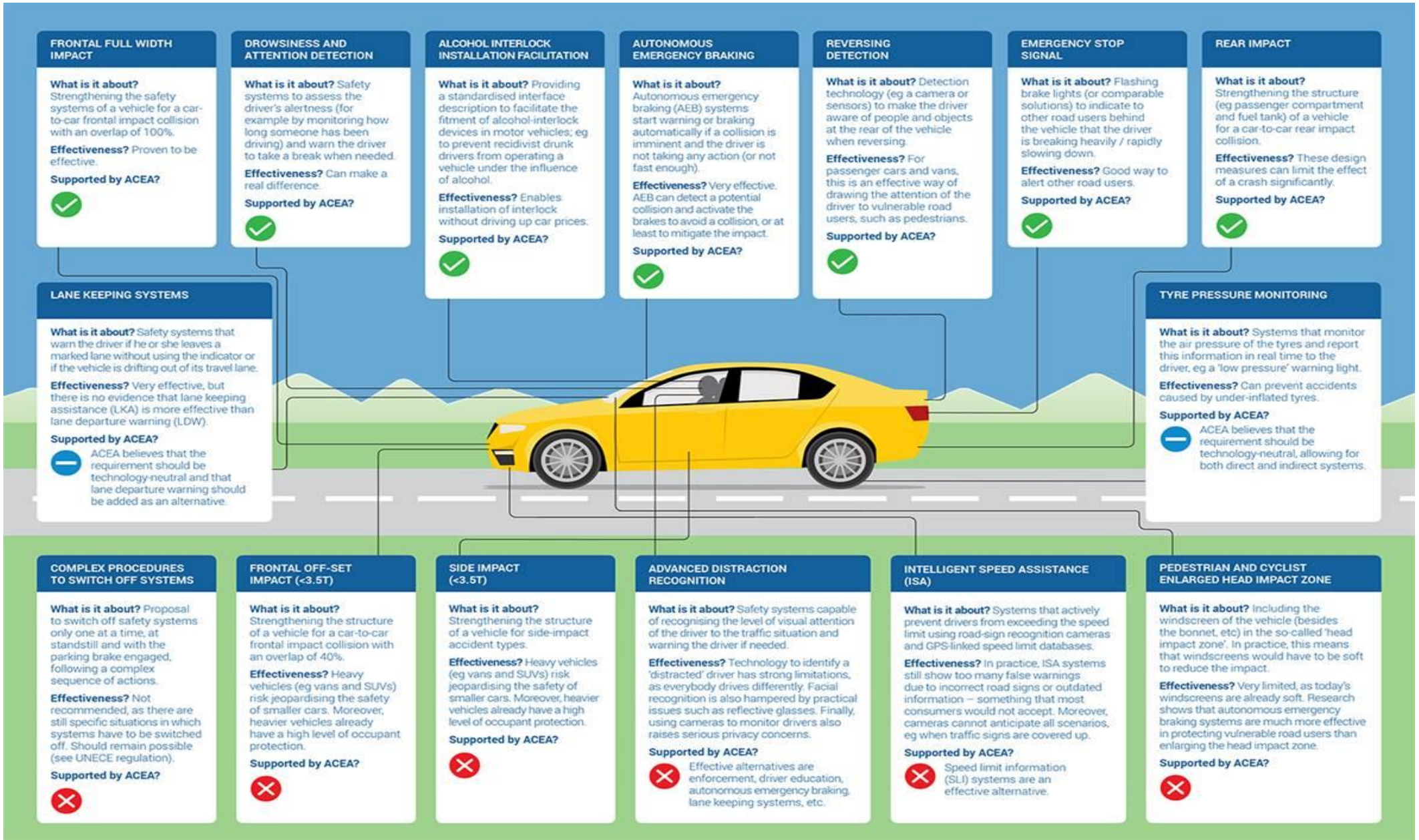
Official Journal of the European Union L325 Intro

- Background
  - EU has updated the type approval requirements for motor vehicles and this has been formally published as **legislation** in the EU Journal. Safety systems relevant for radar starts in 2022 and is listed in the general safety regulation document published in EU Journal
- Impact
  - Best case scenario:
    - From 2024 all cars and trucks would have **1** front radar sensor for AEB, **2** rear corner radar sensors for Lane keep assist(accident prevention), **1** rear near range radar for reverse AEB: **4 units per car**.
    - From 2026 all cars and trucks would have **1** front radar for AEB, **2** front corner radars for pedestrian/cyclist detection, **2** rear corner radar sensor for Lane Keep assist and **1** rear near range radar for reverse AEB: **6 units per car**
  - This might open up more opportunities for the future and potentially could lead to similar regulations in GC
- Sensors
  - The EU regulation does not mandate any specific technology to fulfill the technical requirements.
- Link: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2019:325:FULL&from=EN

Official Journal of the European Union L325 Summary

Systems	Details
Advanced emergency braking for light-duty vehicles	Mandatory road deployment from 7th July 2024 (Mandatory for Vehicle approval from 6th July 2022) for all cars and trucks
Advanced Emergency Braking Systems Pedestrian/Cyclist	Mandatory road deployment from 7th July 2026 (Mandatory for Vehicle approval from 7th July 2024) for all cars and trucks
Blind Spot information system focusing on pedestrian/cyclist	Mandatory road deployment from 7th July 2024 (Mandatory for Vehicle approval from 6th July 2022) for large cars(>9seats)/trucks above 3.5tonnes
Reversing detection	Mandatory road deployment from 7th July 2024 (Mandatory for Vehicle approval from 6th July 2022) for all cars and trucks
Lane Departure Warning Systems	Mandatory road deployment from 6th July 2022 for large cars/large trucks
Emergency lane keeping system	Mandatory road deployment from 7th July 2024 (Mandatory for Vehicle approval from 6th July 2022) FOR light CARS/light TRUCKS

ACEA's Comments



Market Trends: Spurring Radar Growth

Autonomous Driving
Higher Resolution

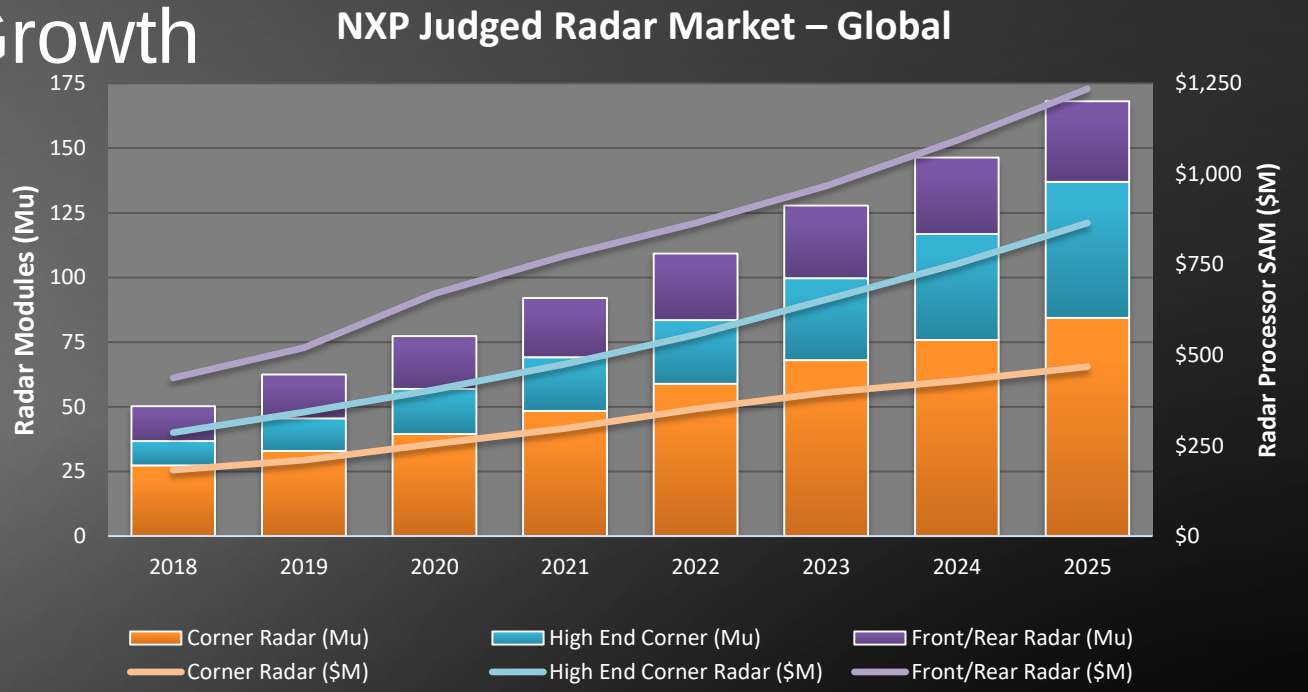
Highway Pilot (L3)
Garage & Park Pilot (L3)
Highway Pilot 2.0 (L4)

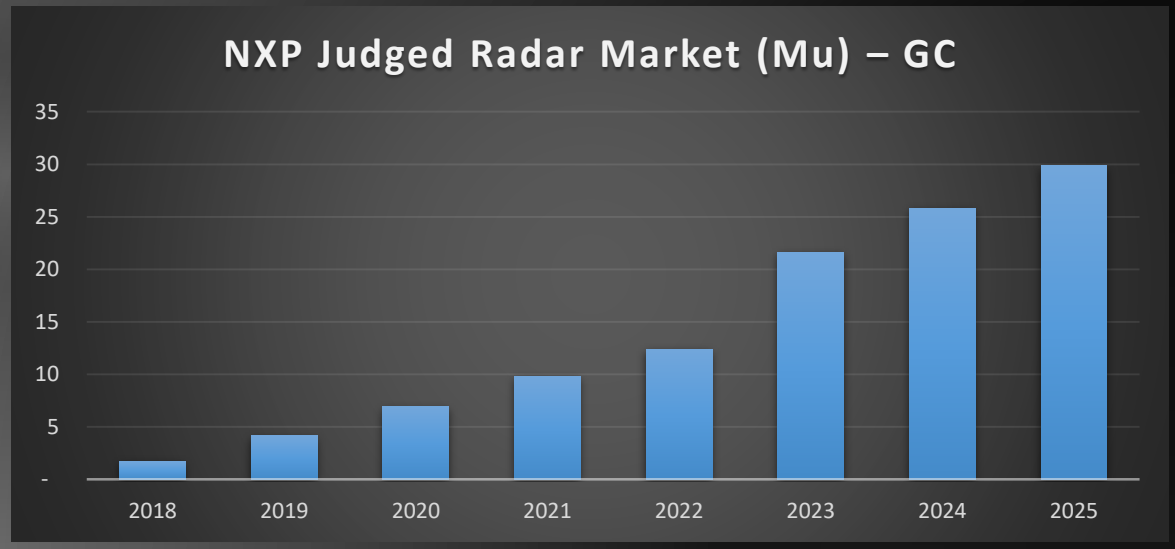
Comfort Features
More sensors per car

Traffic Jam Assist (TJA)
Lane Change Assist (LCA)

NCAP Safety
More cars with radar

Adaptive Cruise Control (ACC)
Automatic Emergency Brake (AEB)
Blind Spot Detection (BSD)

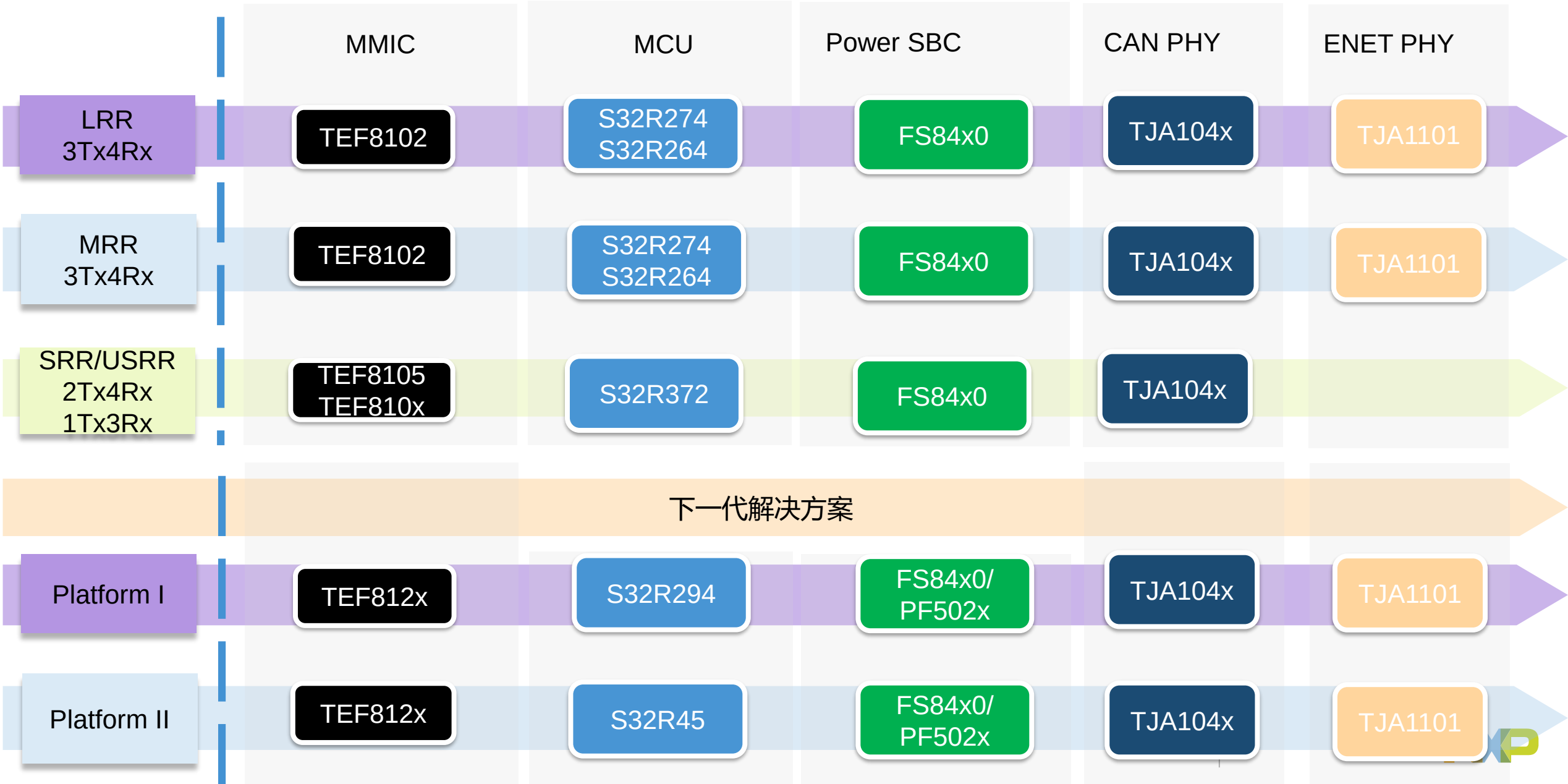




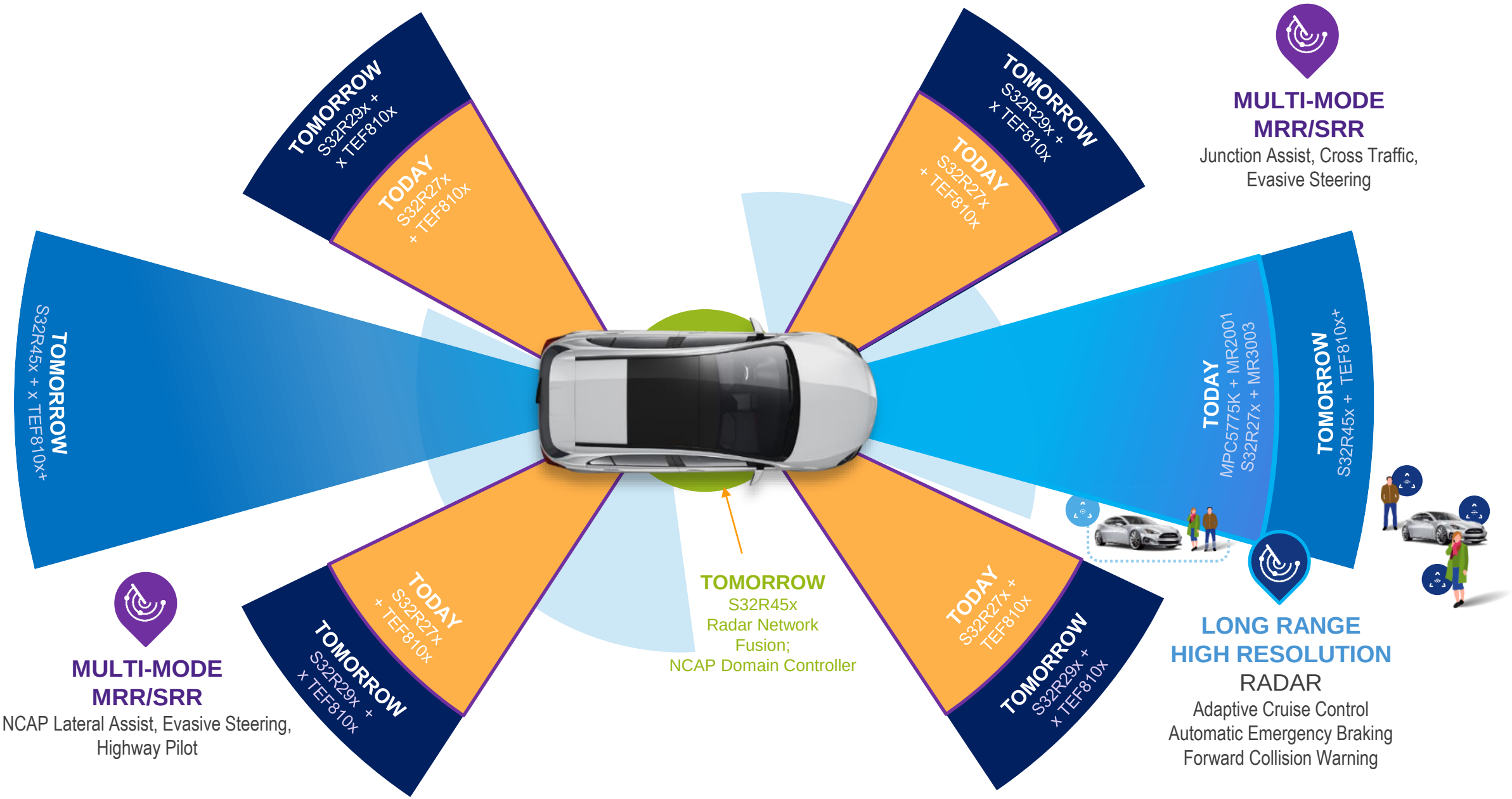
03

Solution and trend
方案与趋势

NXP Provides Full Products Portfolio



APPLICATION CONTEXT FOR SRR AND MRR: TOMORROW



Dolphin One Page

TEF810X 毫米波雷达收发芯片

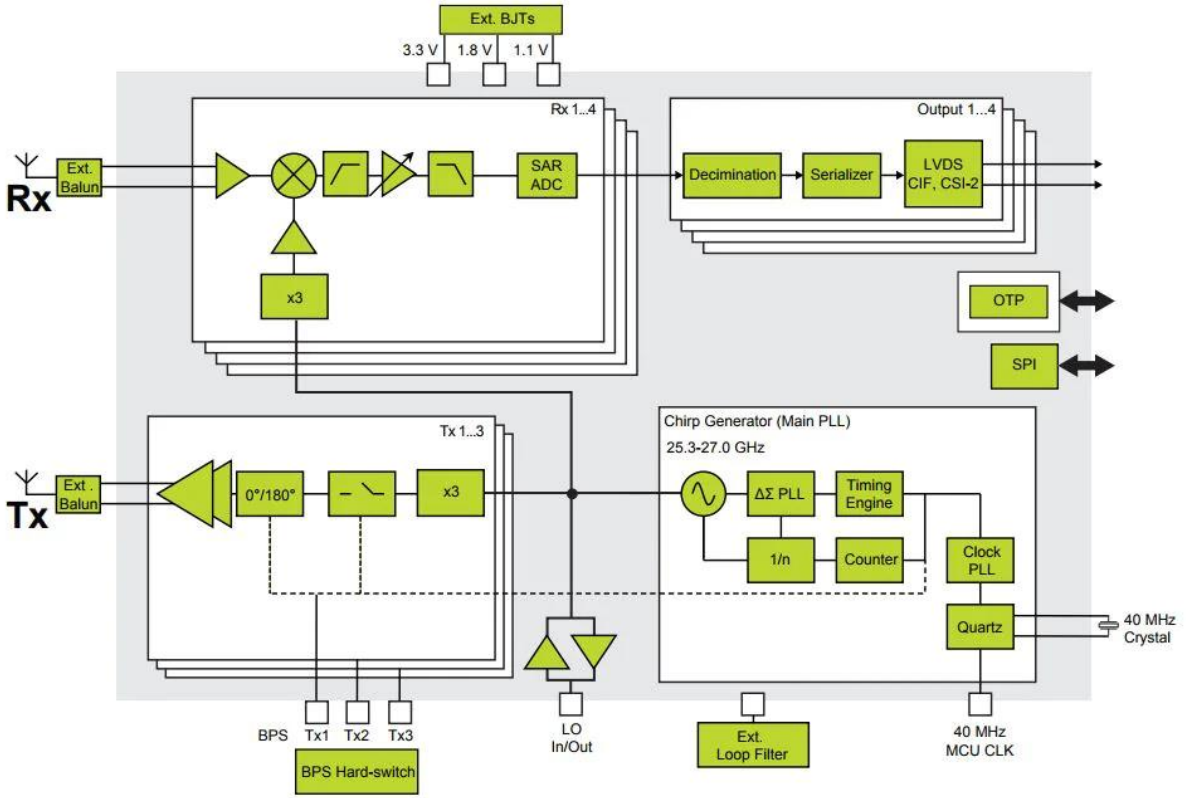
TEF810X 是一款高度集成的汽车FMCW雷达芯片。

支持76-81GHz的工作频段，覆盖了汽车毫米波雷达应用的全频带。收发芯片包含了3路发射，4路接收，ADC内置采样及低噪声VCO。芯片同时内置多种安全监测模块并支持MIPI-CSI和LVDS数据传输接口。

- 基于高度集成的RFCMOS工艺
- 兼容ISO26262， ASIL B 等级
- 优化的快速扫频调制
- 支持汽车级温度范围（-40℃到135℃）
- 高度兼容NXP S32R 系列雷达处理器

通道数	3TX(W/BPSK) & 4RX	级联支持	4 chips for up to 12TX and 16RX with Master Device
频率范围	76-81GHz	封装	155 pin eWLB 7.5x7.5 mm
输出功率	12dBm Typ (76-78 GHz) 11dBm Typ (78-81 GHz)	ADC 采样率	20MS/s
噪声系数	12dBm Typ (76-77 GHz) 13dBm Typ (77-81 GHz)	接口	CSI-2 & LVDS
相位噪声	-90dBc/Hz Typ 0.5GHz chirp (76-77GHz)	温度范围	-40 to 135 ℃ Tj
功耗	1.2W Typical（2TX 50%）	扫频带宽	2GHz

TEF810X BLOCK DIAGRAM



目标应用场景：

- 自适应巡航(ACC)
- 自动紧急刹车控制(AEB)
- 盲点检测(BSD)
- 变道辅助(LCA)
- 停车辅助(PA)
- 后侧横向来车警告(RCTA)
- 前侧横向来车警告(FCTA)
- 后侧碰撞避免(RCA)
- 茧式雷达
- 成像雷达

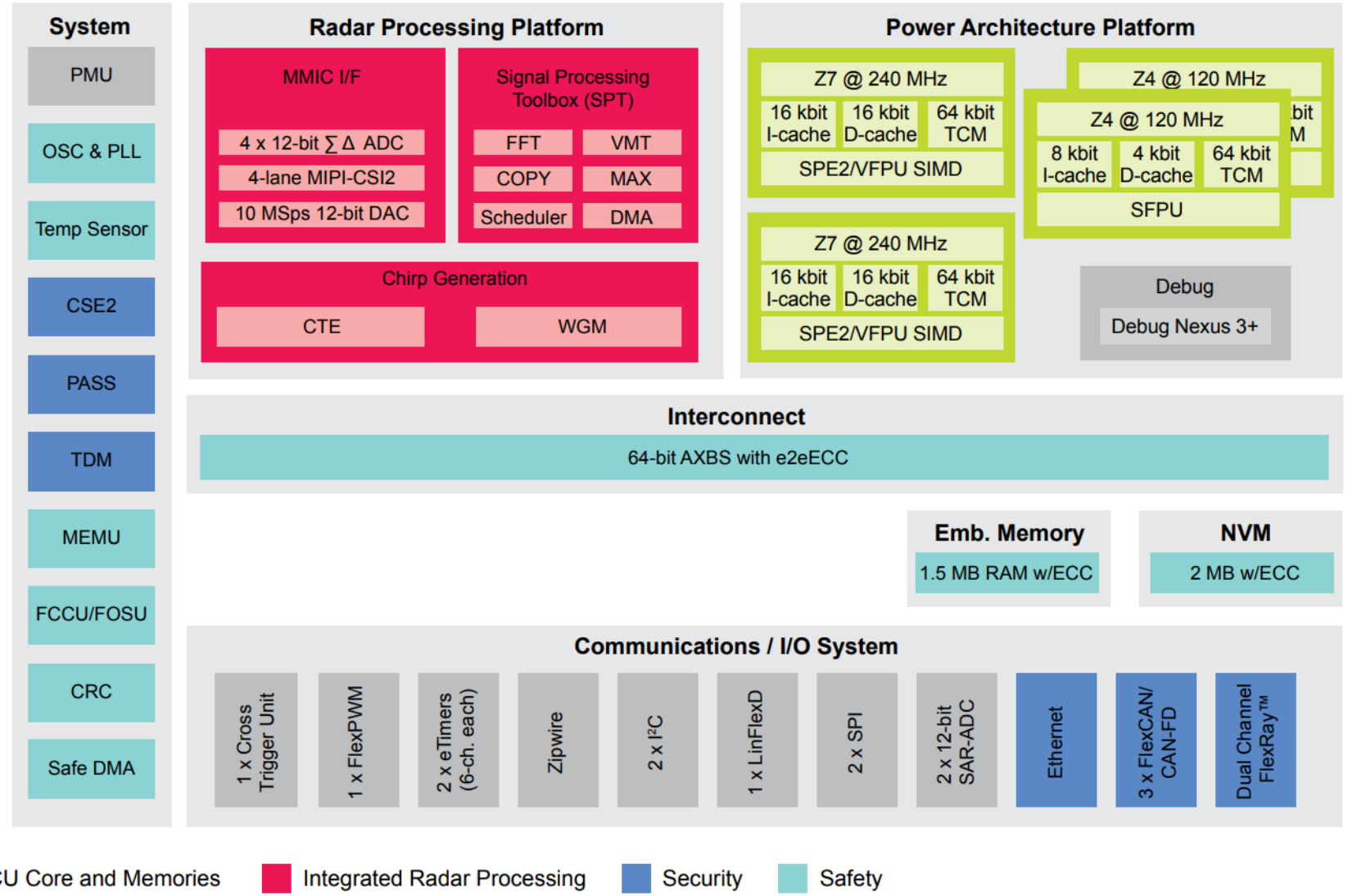
S32Rx One Page

S32R274 毫米波雷达处理器
基于Power PC架构的MCU，可用于汽车及工业应用

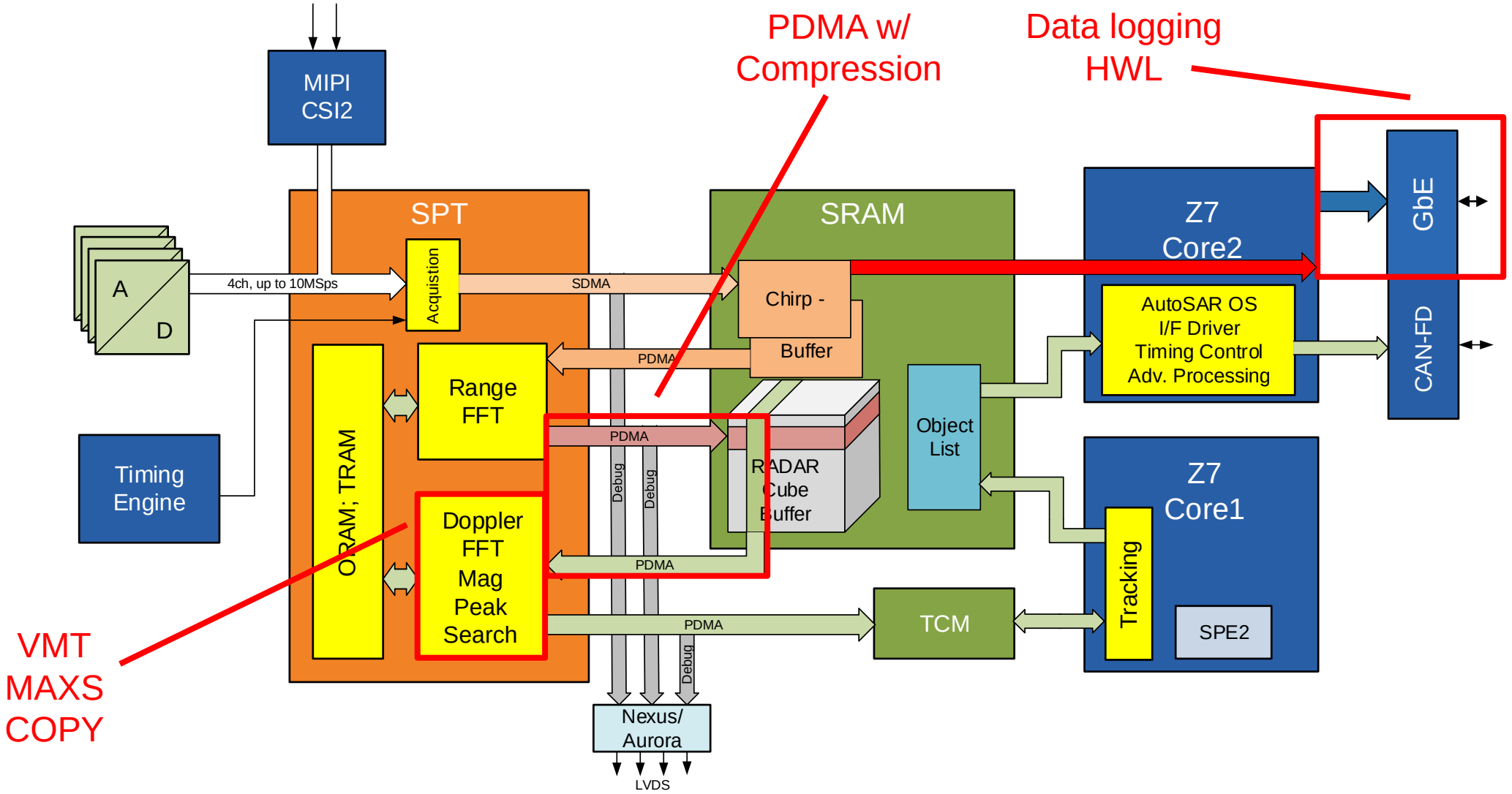
特性：
1. 两个高性能处理PowerPC e200z7 32位内核
2. 一个安全处理PowerPC e200z4 32位锁步内核
3. 专用雷达信号处理硬件加速器SPT 2.0
4. 支持到ASIL-D功能安全应用
5. 支持信息安全服务的硬件引擎CSE2

相关支持工具：
1. AUTOSAR sMCAL
2. S32 Design Studio IDE, 支持第三方插件，编译器，调试器。
3. 编译器支持WindRiver和GreenHills
4. 调试器支持Lauterbach, P&E, iSystems
5. SPT 2.0图形编辑工具和Radar SDK
6. 集成在S32DS IDE中的底层驱动SDK
7. 基于Matlab的SPT2.0开发工具

应用场景：
• 汽车毫米波雷达应用
1.支持中短距雷达应用，例如变道辅助LCA，盲点检测BSD等
2.支持长距雷达应用，例如自适应巡航ACC，自动紧急制动AEB等
• 非汽车雷达应用
1. 安防监控
2. 智能家居，手势识别等
3. 工业自动化，例如位置检测等



SPT Algorithm Example 雷达信号加速器算法样例



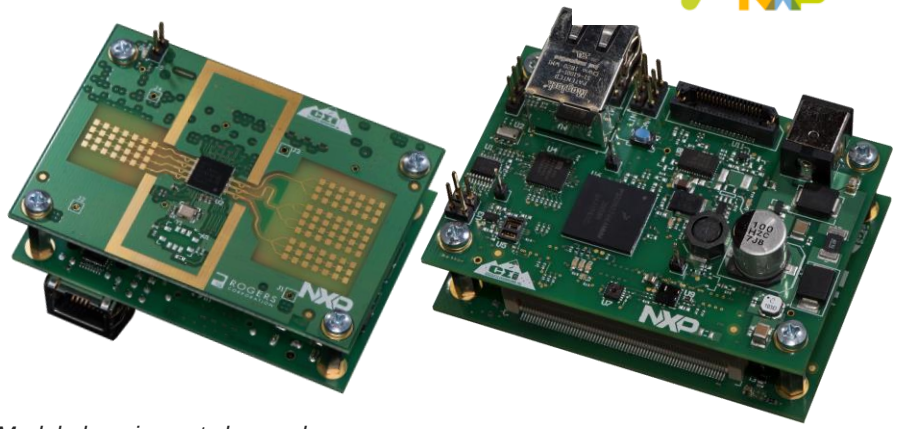
RDK-S32R274 – Reference Platform for Automotive Radar

RADAR SIGNAL PROCESSING TOOLBOX

NXP

Key Platform Features:

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



**Module housing not shown above*

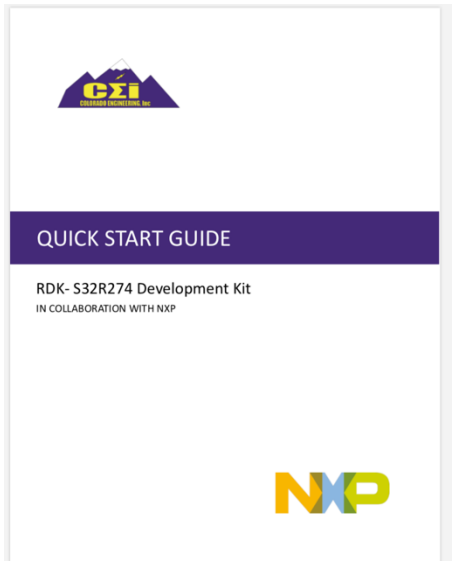
- NXP/CEI Radar Reference Platform
  - Complete HW & SW package
  - ASIL-B reference application ready
  - FCC/CE certified design
- Reference BOM ready for mass market
  - Radar Front End: TEF8102
  - Radar Processor: S32R27x
- Availability: Order Today for $3500!

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

CEI COLORADO ENGINEERING, Inc.

NXP

RDK-S32R27: Out of the Box Experience



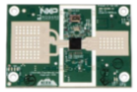
Overview

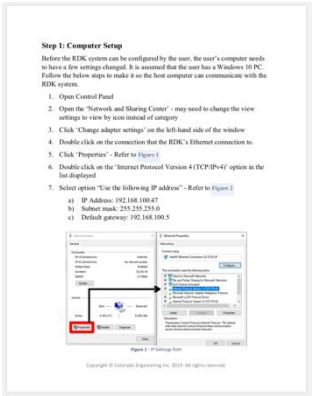
This quick start guide provides the necessary information to get the RDK system powered on and functional using the chirp configuration GUI.

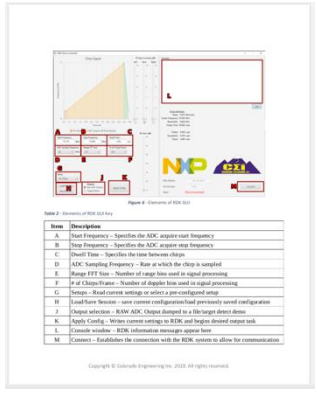
Development Kit Contents

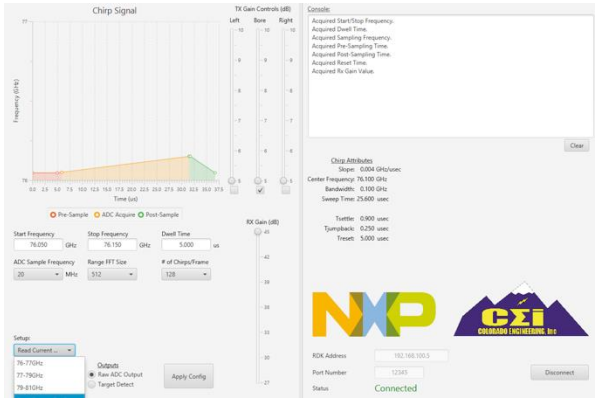
The RDK-S32R274 includes the contents listed in Table 1.

Table 1 - Development Kit Contents

Component	Description	Note
	RDK-S32R274 Enclosure	
	iScan Edge 3 (iScan-P-S32R): Processor Module	Pre-installed in RDK Enclosure
	iScan Prizm 2 (iScan-A-TEF8102): 77GHz Antenna Module	Pre-installed in RDK Enclosure
Cables	Ethernet Cable (14ft), Power Adapter Cable	
AC Adapter	12 Volts - 1.6 Amps	

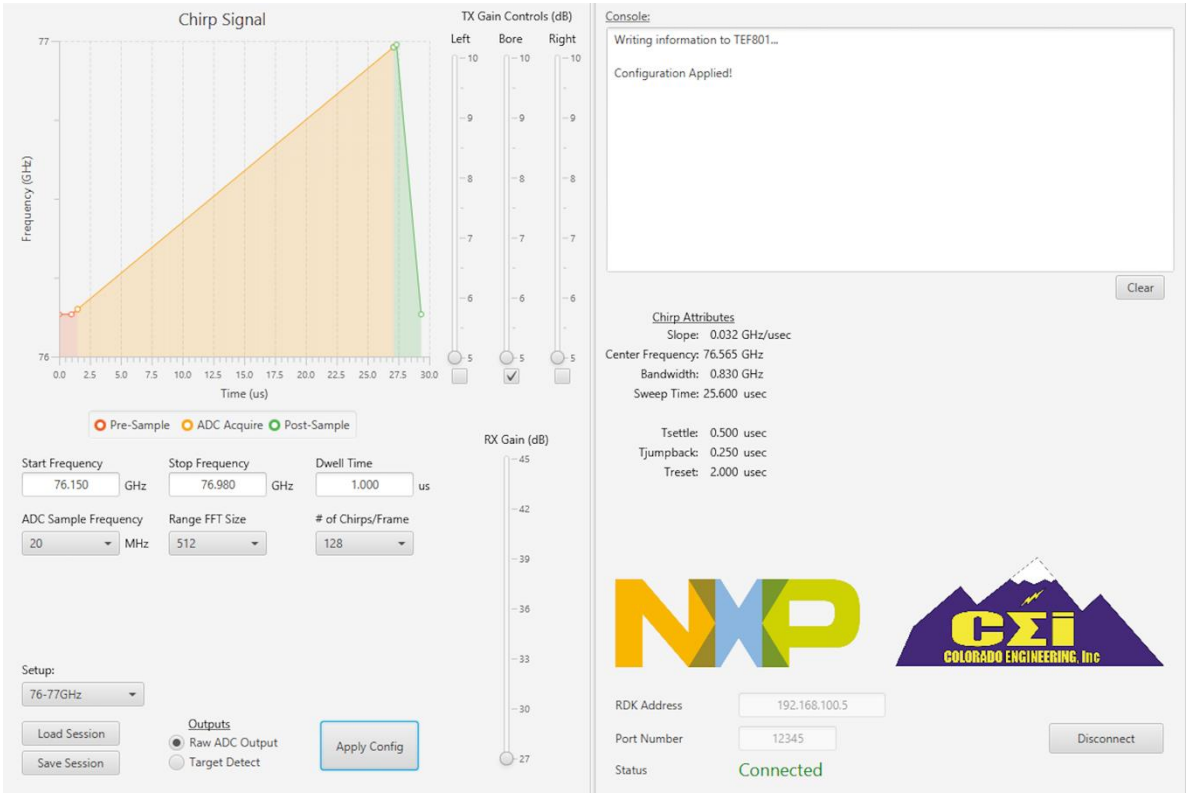




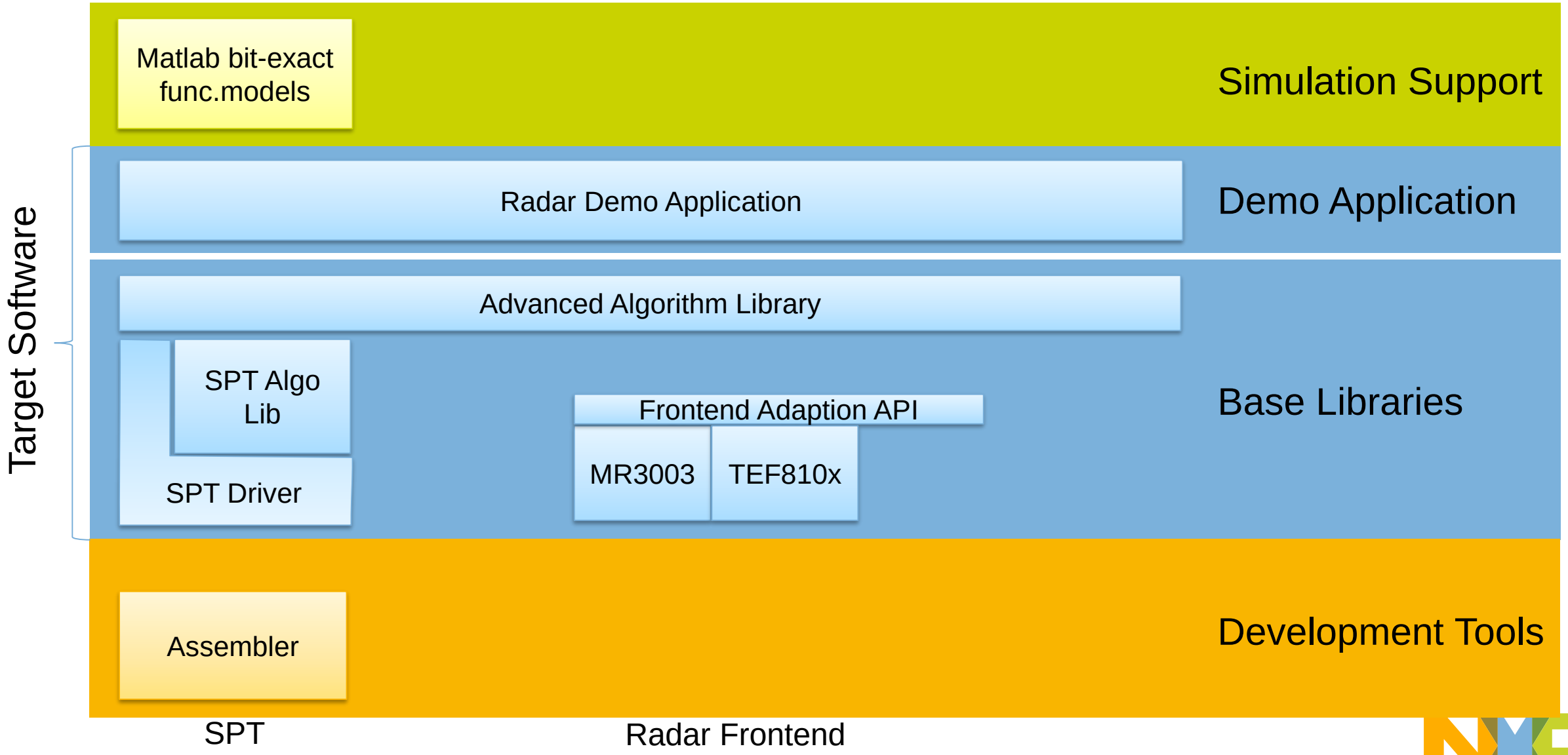


RDK-S32R27: SW & Capabilities

- Sample Applications ready to use
- Raw ADC data output ready
- Graphical Interface enabling development

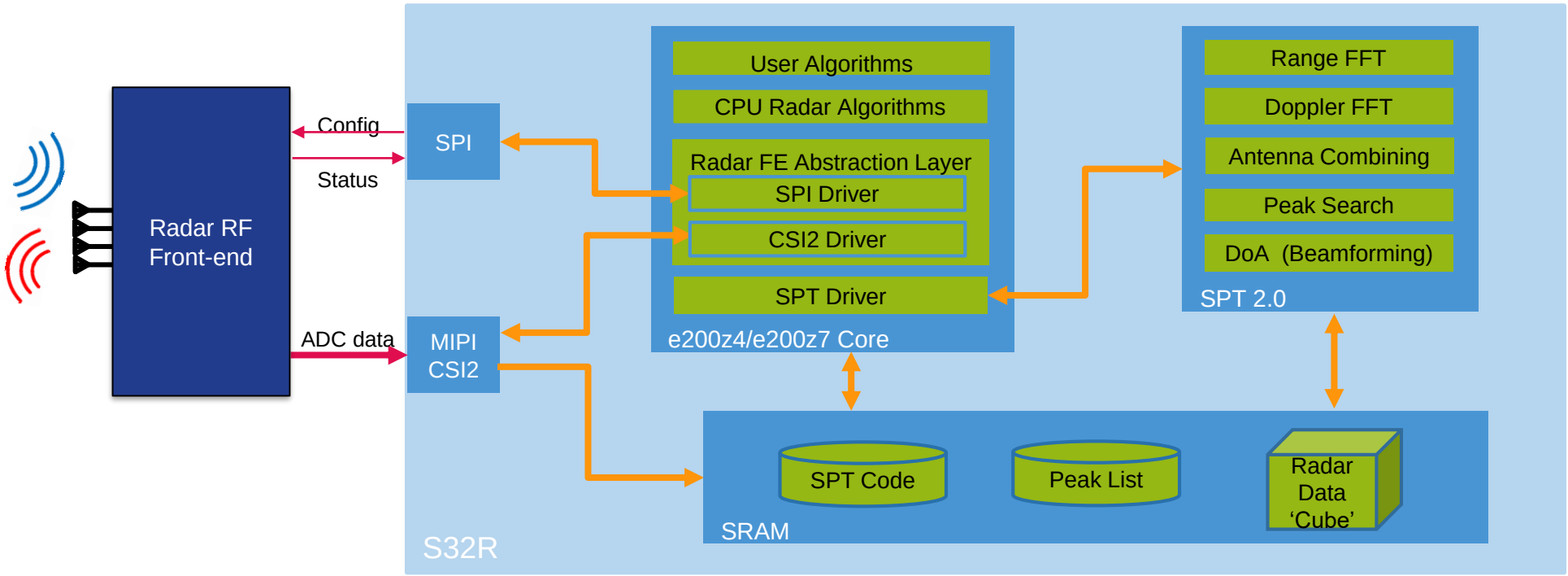


S32R274 Radar SDK



Radar Software Development Kit - RSDK

- Radar SDK provides **basic radar processing algorithms** and **device drivers** for S32R hardware devices.
- **Facilitate radar algorithm development** (using SPT kernels, Matlab models), creation of higher level algorithms (starting from the basic blocks supplied with RSDK)
- **Easy application development** by integrating driver and platform support.



Typical Automotive RADAR Processing

The RADAR MCU

MMIC

High Performance MCU

Rx

Signal conditioning

Signal analysis

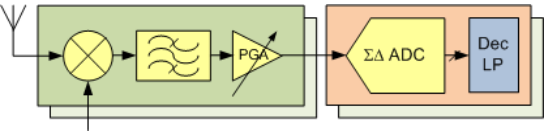
Detection

Tracking

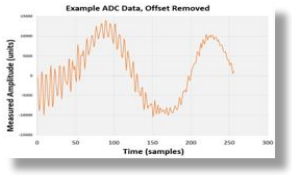
- Antenna
- Mixer

- LNA
- HP/LPF
- AAF
- ADC

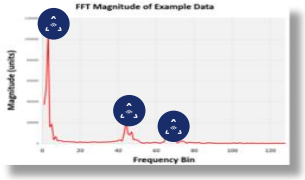
Range FFT → **Doppler FFT** → **MIMO & Beamforming** → **Adv Functions Thresholding (ex CFAR), 3D Interpolation** → **DOA Super Resolution (e.g. MUSIC, ESPRIT)** → **Tracking (e.g. Kalman + Munkres)**



RSDK



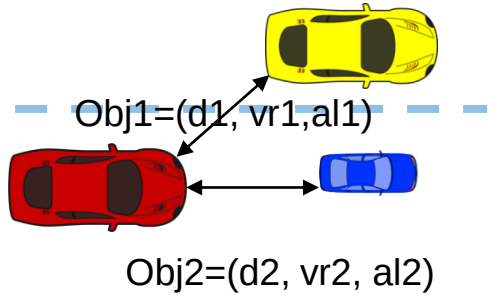
Range FFT



Detection

3 Targets

- **~0.5m**
- **~7.0m**
- **~10.5m**



Comparison of algorithm validation – MATLAB vs target

write SPT kernels

Lab environment

- Deploy the code to target using Lauterbach
- Run kernel
- Collect results from memory of SPT
- Unformat data to be human readable

Non bit-exact model

Corrections

- Write MATLAB model for the SPT kernel
- Validate results from non-exact MATLAB model
- Corrections are needed to match non-exact model results with target results

Validation

Model is validated

Cost:
- MATLAB license
- Lauterbach license
- Development board
- Time spent to validate corrections

RSDK development environment

Use of MATLAB Toolbox in development

SPT Toolbox

write SPT kernels in MATLAB

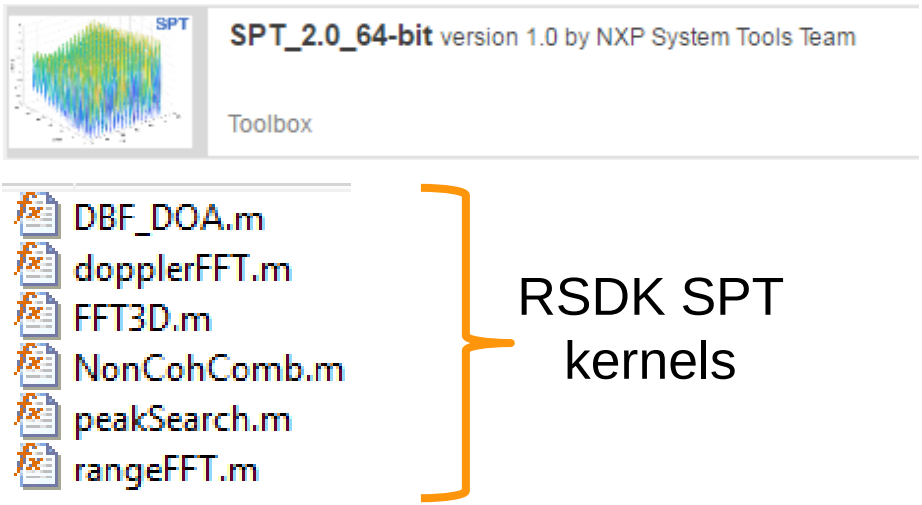
Validation

Model is validated

Cost:
- MATLAB license

MATLAB Environment

- **Support for MATLAB on 32-bit and 64-bit (R2015a, R2016a, R2016b, R2017a, R2017b)**
- **Must install the SPT Toolbox add-on** (see link)
- RSDK Bit-exact kernel scripts are included in release package
  - Each MATLAB '.m' script represents a kernel
  - Scripts dynamically adapt to samples/chirps configuration



- **Advanced users can use the Design Toolbox to <u>design their own SPT kernels in MATLAB</u>**
  - In the simulation environment we can ignore the SPT memory layout demands
  - Once the desired simulation results are achieved the MATLAB script must be translated into SPT code

Links

Radar SDK:

https://www.nxp.com/products/processors-and-microcontrollers/power-architecture/s32r-radar-mcus/s32r-radar-microcontroller-s32r27-automotive-industrial-radar-applications:S32R27?tab=Design_Tools_Tab

or…

1. Go to www.nxp.com
2. Search ‘S32R’ and click the first result
3. Click ‘TOOLS & SOFTWARE’