FTF 2016
TECHNOLOGY FORUM

RADAR INNOVATIONS BY NXP

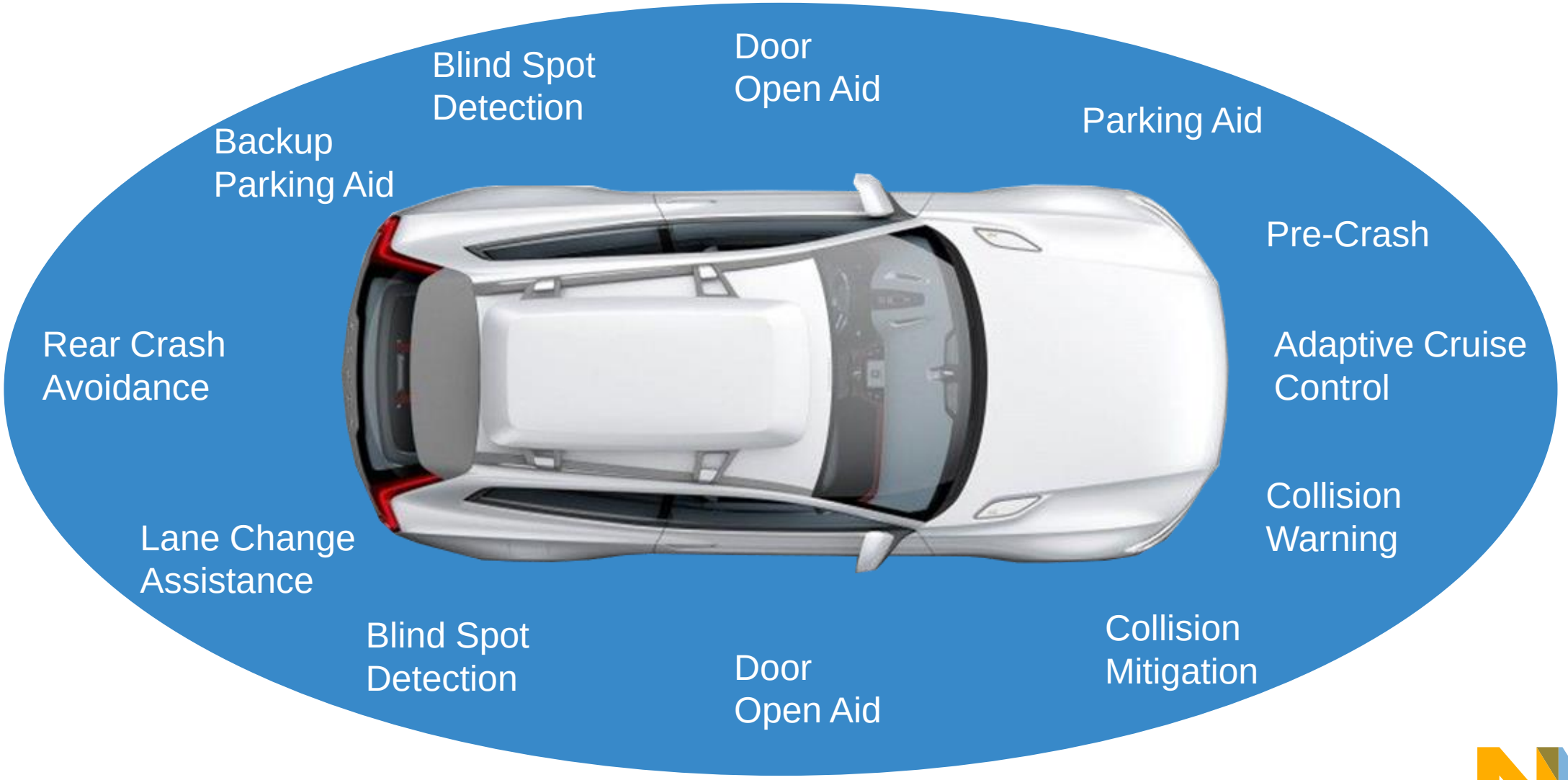
FTF-AUT-N1772

RALF REUTER
FELLOW, WW RADAR SYSTEM & APPS MANAGER
FTF-AUT-N1772
MAY 18, 2016

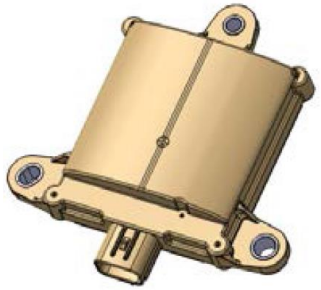
AGENDA

- Introduction
- Radar Transceiver And Radar MCU
- Radar Quo Vadis
- Cocoon Radar
- CMOS vs. BiCMOS
- Evaluation Kits & Demos

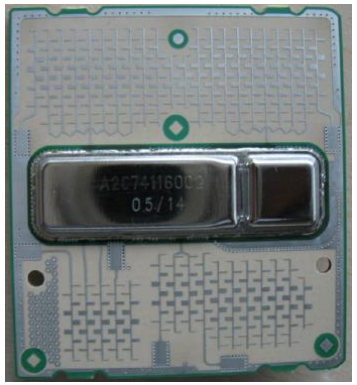
The Vision of Radar People



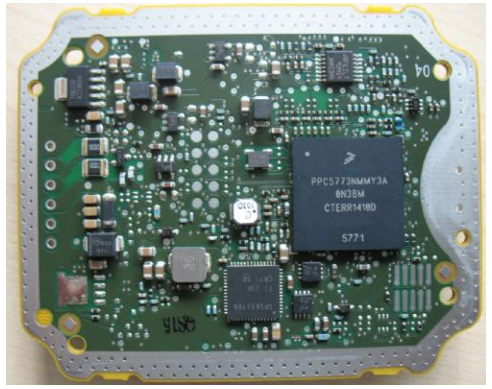
NXP Leadership in Radar ICs



Distance measurement: 0.25 – 250 m
0.25 – 70 m
Accuracy for dis. measurements: +/- 0.2m
speed measurement: -400 – 200 kph
FoV azimuth: -9° - +9° far range
-75° . + 75° near range
FoV elevation: 14°
Angle measurement accuracy: +/-2° (30°)
power consumption: 6 W



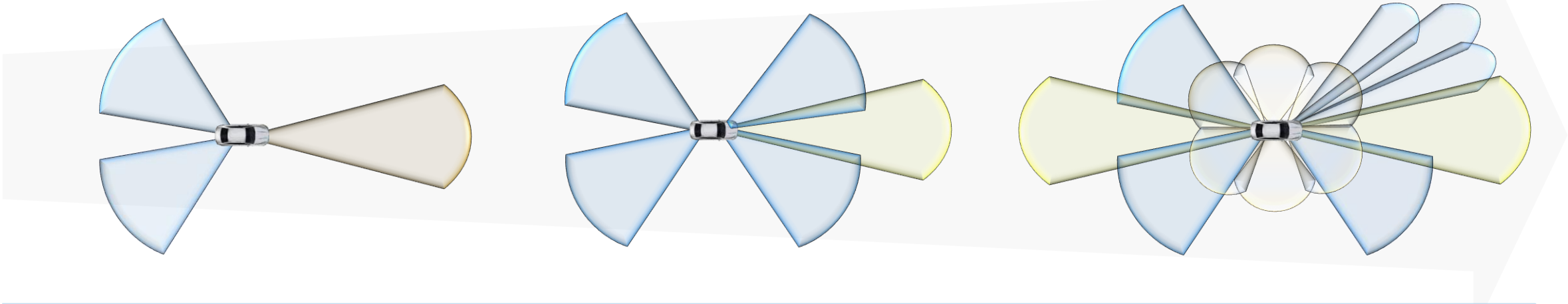
NXP MR2001
Scalable radar transceiver chipset with antenna arrangement



NXP
MPC577xK
Radar processor board

- 11 years of leadership on MMIC+MCU
- Fully scalable platform for channels, performance, software, and safety
- Patents 76 granted, over 100+ disclosures
- Over 100+ R&D engineers active in radar across NXP including Millimeter Wave Center in Munich and design centers throughout the world
- Owned RF processes and fabs with full production test capability at 77 GHz
- Differentiating IP
  - Signal Processing Toolbox developed in cooperation with Continental
  - First integrated ΣΔ ADC for radar
  - High linearity Millimeter Wave VCO+PLL
  - Advanced programmable chirp generator
  - Introduced MIPI-CSI2 standard into the radar system

Revolution in Radar Bandwidth, Processing, and Fusion



Evolving from Sensing to Perception: Dramatic Increases in Integration + Performance per Power + Reliability

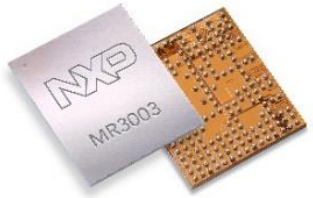
Assist	*Co-Pilot*	*Automated*
• NCAP 2016: Radar Modules • Active safety for AEB, ACC • Passive safety with FCW, BSD • Automotive Safety (ASIL B) and Security • Object Detection in module-as-ECU • **Stand-Alone Modules with CAN**	• Active Steering, Emergency Braking, Self Park, Highway auto-pilot, Platooning • Automotive Safety with Security • Direct interaction with navigation system and V2X • RFCMOS integration • ***CAN-FD and Ethernet Network***	• Fully automated Vehicle & Fail-over operational System • Software Defined Radar for flexible modulation and adaptive radar • Digital modulation control • Radar Fusion Acceleration • **"Radar Network Architecture"**

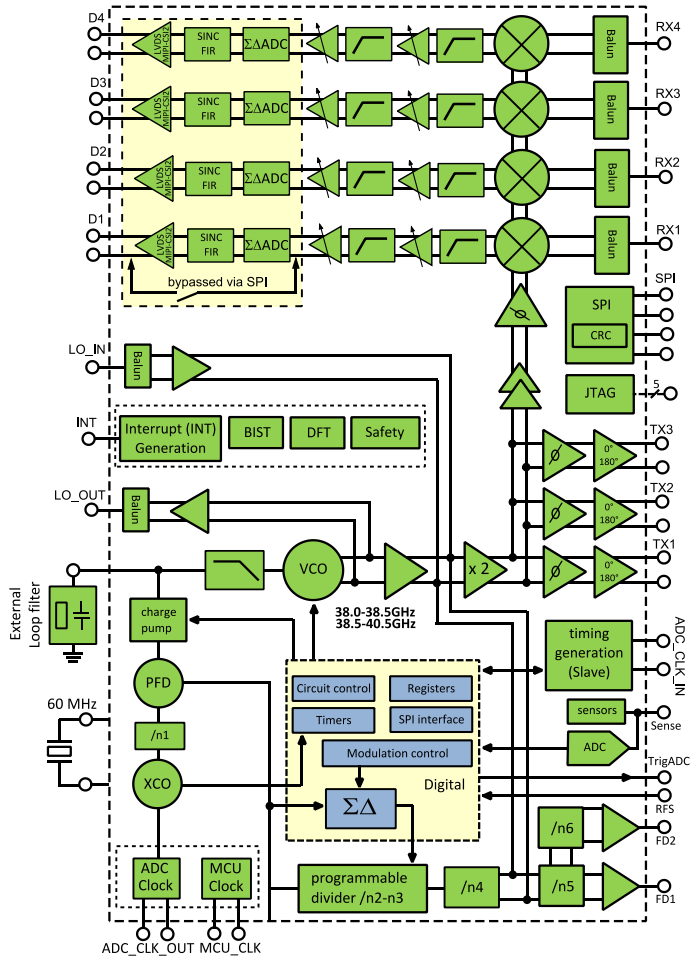
76-81 GHZ TRANSCEIVER

Eagle: MR3003 Car Radar IC:

BiCMOS Car Radar Transceiver for 76-81 GHz

- Applications
  - Mid Range: Emergency Braking
  - Long Range Radar: ACC
- Features
  - Fully integrated BiCMOS Radar Frontend for 76-81 GHz
  - 3 TX (w/ BPSK), 4 RX Channels
  - Optimized for Fast Chirp Modulation
  - Support for 2 GHz bandwidth
  - High Output Power
  - Automotive Temperature Range
  - Support cascading of 4 x MR3003
  - MIPI CSI-2 Interface
  - ISO26262 compliant development - ASIL Level B
- Benefits
  - Low Power: 2.2W (1Tx 50%, 4 Rx 60%, BiST 10%)
  - Few external components, Easy Integration
  - High Range Resolution <8cm

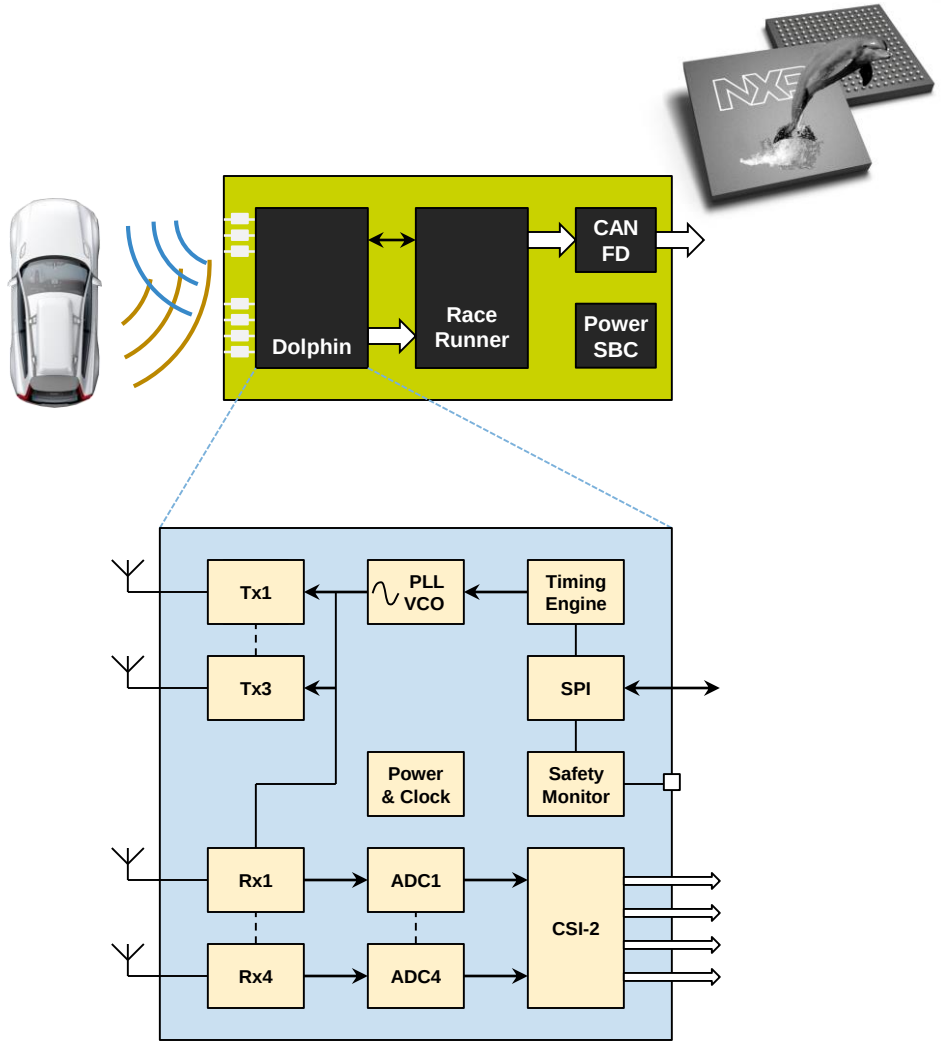




Dolphin: TEF8102/4 Car Radar IC

RFCMOS Car Radar Transceiver for 76-81 GHz

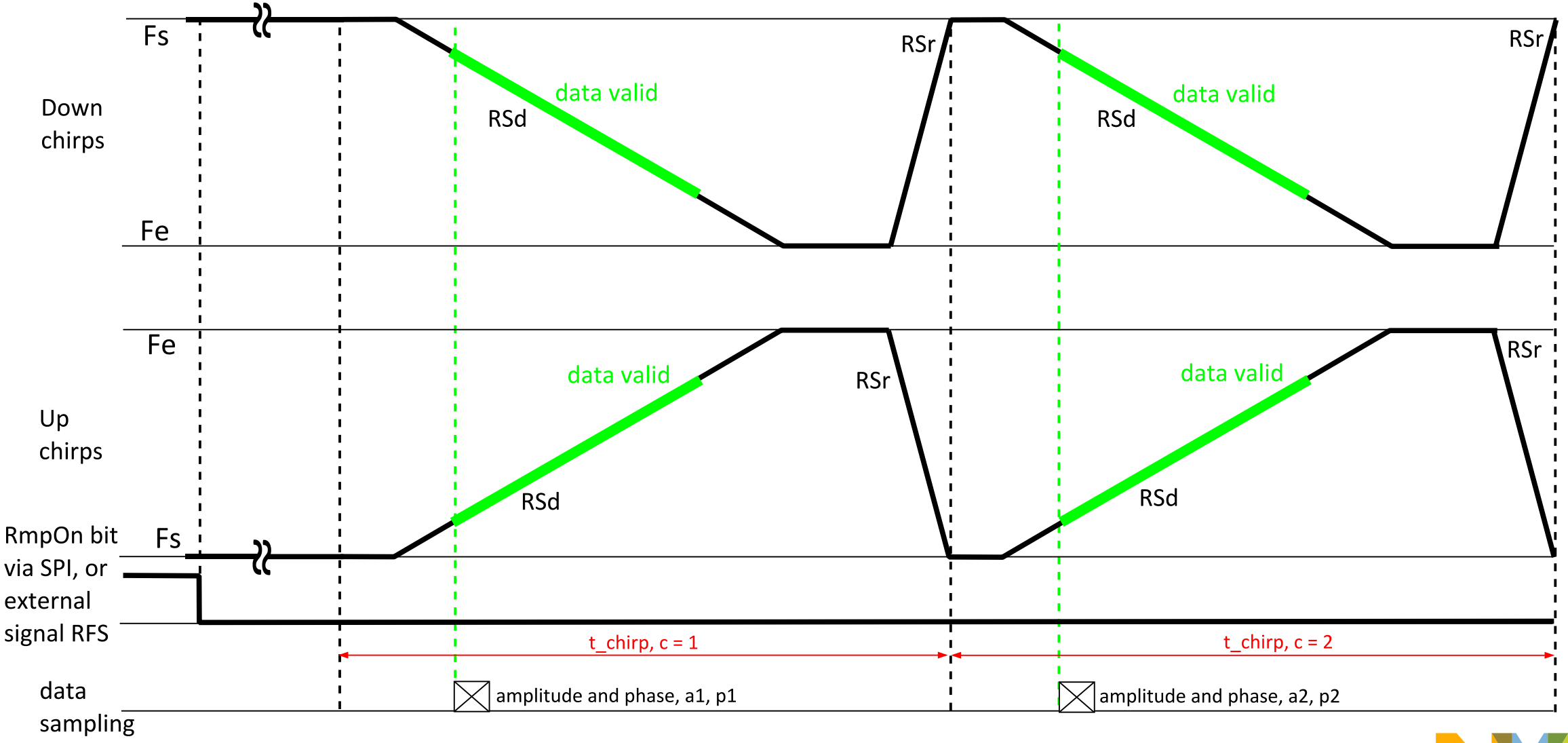
- Mid, Short and Near Range Radar
  - Autonomous Emergency Braking
  - Cross Traffic Alert / Braking
  - Blind Spot Detection, Lane Change Assist, Parking Aid
  - State-of-the-art 40nm CMOS
- High Integration Level
  - Programmable Fast Chirping, up to 2 GHz
  - Integrated IF filtering
  - TEF8102: 3Tx (w/ BPSK) and 4Rx, to support Multi-Mode Radar
  - TEF8104: 2Tx (w/ BPSK) and 4Rx, optimized for lower cost
  - High Performance ADCs (SFDR >= 63 dB, signal > -27 dBFS)
- Integration Benefits
  - Low Cost, Size, Weight, and Power
  - Ease of Application (on PCB)
  - Self-monitoring: Functional Safety
  - Ease of Control (by MCU)
- Performance Benefits
  - Low Noise and High Linearity, for excellent sensitivity and robustness against interference



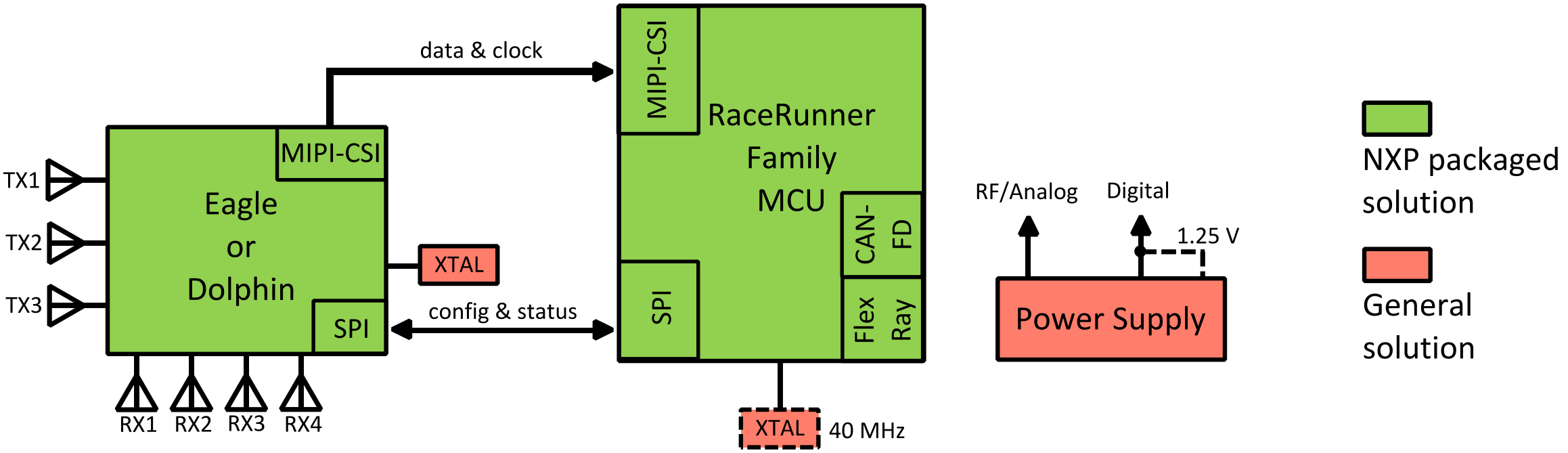
Dolphin

Digital Out, Low Power, Highly Integrated

Basic FMCW Modulation Shape



Simplified System RF-Frontend / MCU Connection

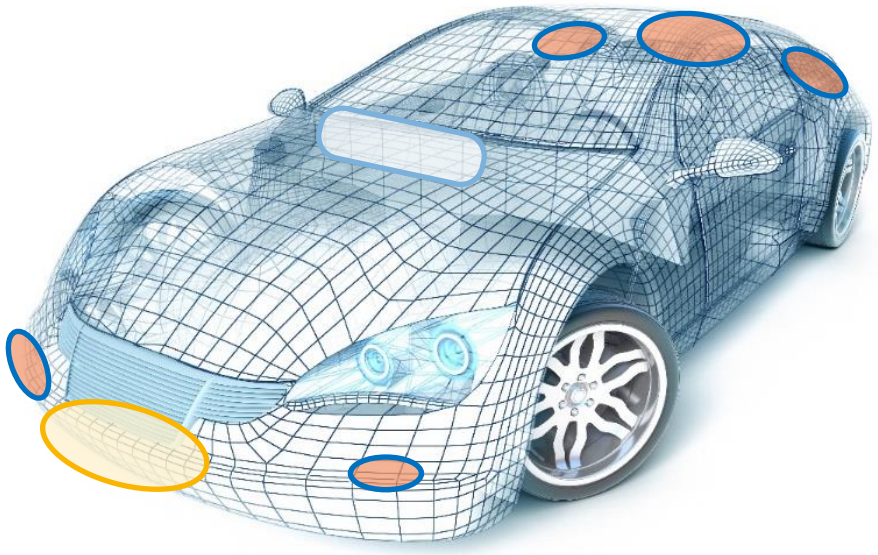


#1 in Radar Processing: Integration and Performance Per Power

Central Smart Radar Fusion

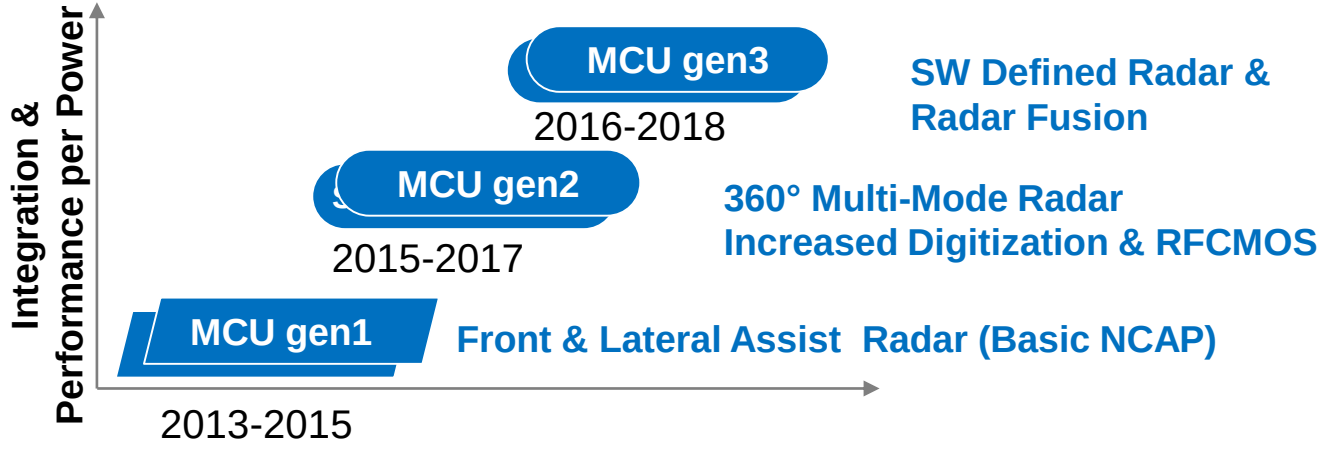
High Resolution Long Range Multi-mode

Multi-mode Integrated Corner radar



- **Four generations** of **Digitalization** ➡ **Smart** integration
- **Simplified** Radar Processing ➡ SW Defined Radar
- Highest **Safety & Security** ➡ ASIL-D and SHE assured
- **Scalable** ➡ **Nano-radar** to **Hi-Perf LRR**

One SW Platform from Smart Sensors to Fusion Unit



Sense	Process	Detect	Track	Cluster
SiGe to RFCMOS 24GHz to 76-81GHz	Signal Processing Toolbox Advanced Safe Processing	High Perf. Cores App Management	ASIL-D Island Secured Actuation	Digitally Modulated Radar Fusion Post-Processing

Value Creation through Full Digitalization ⇒ From Sensing to Clustering, Digitally Programmable Modulation, Safe, Secure and Reliable

RADAR
QUO VADIS

Future Sensors Development

Higher Angular Resolution

More Tx/Rx,

code MIMO

Very compact size

Small, single PCB sensors

Interference suppression

Spectrum spreading, mitigation proc., impr. Rx

Lower Power

next gen TRX/MCU technology, specific SBCs

5D Scanning

Azimuth+Elevation

Connected sensors & central processing

RADAR cocoon, Stereo RADAR

Flex FOV and Multi-mode

Next Gen Sensors

Scalable sensor concepts

One design –many applications

Source: Delphi.com

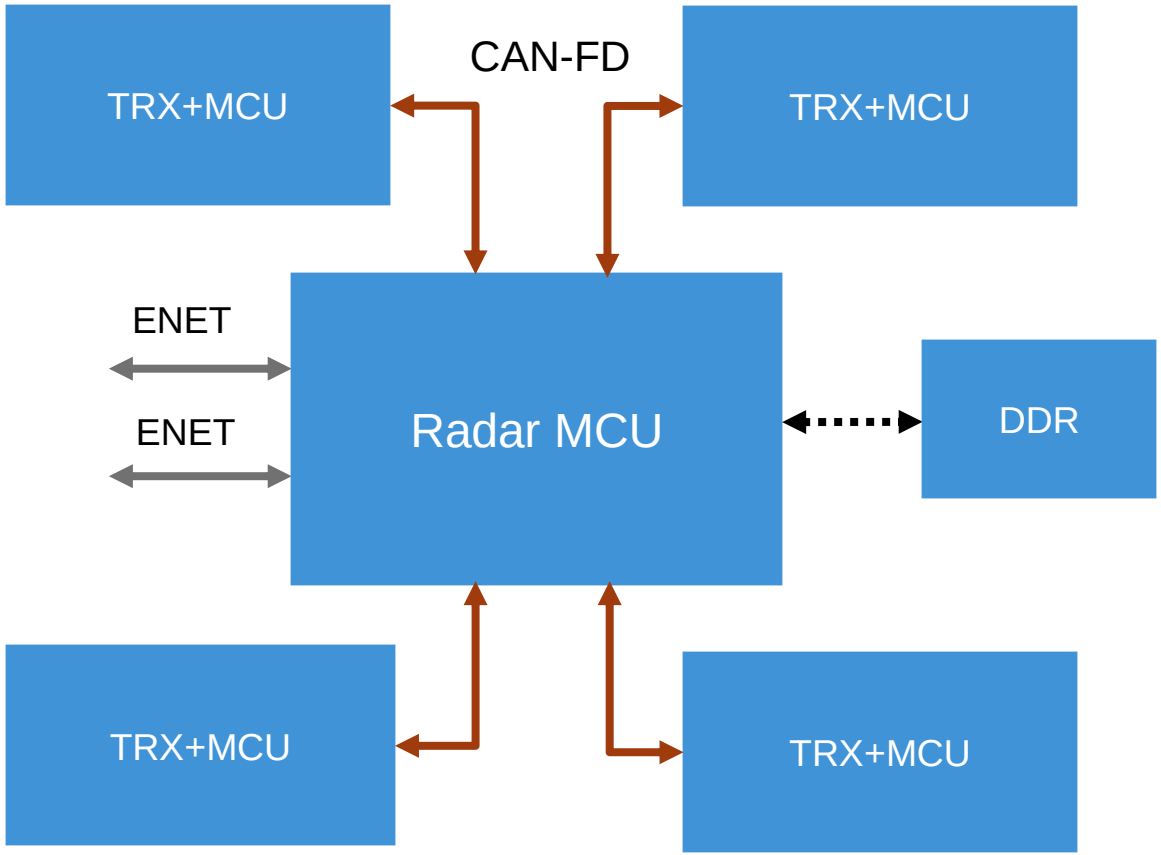
Source: Conti-online.com

Source: http://products.bosch-mobility-solutions.com/

One Device – Scalable Applications for Autonomous Driving

RADAR Cocoon

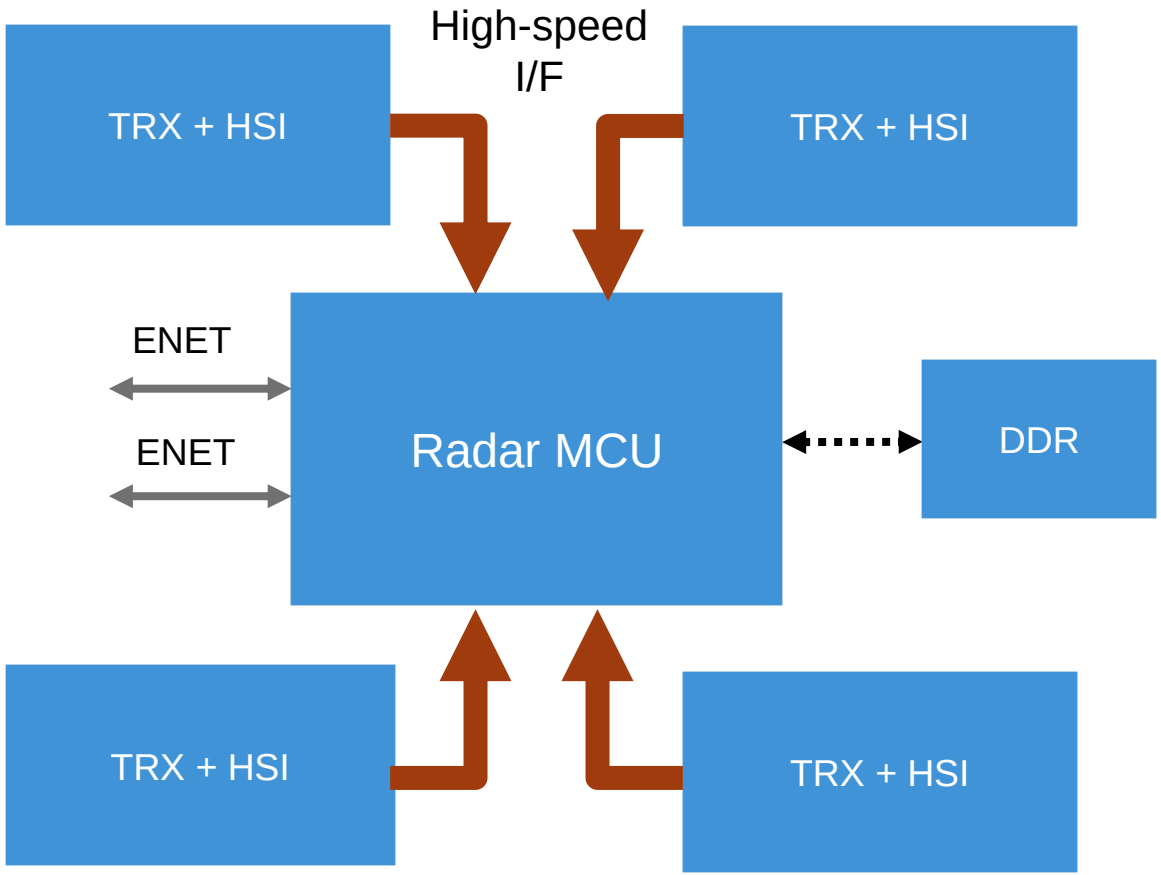
- Local: sensing and processing up to clusters
- Central: fusion of clusters to objects, tracking, grid mapping
- Enables very power-efficient sensors and maximizes compute performance



One Device – Scalable Applications for Autonomous Driving

Distributed Sensor

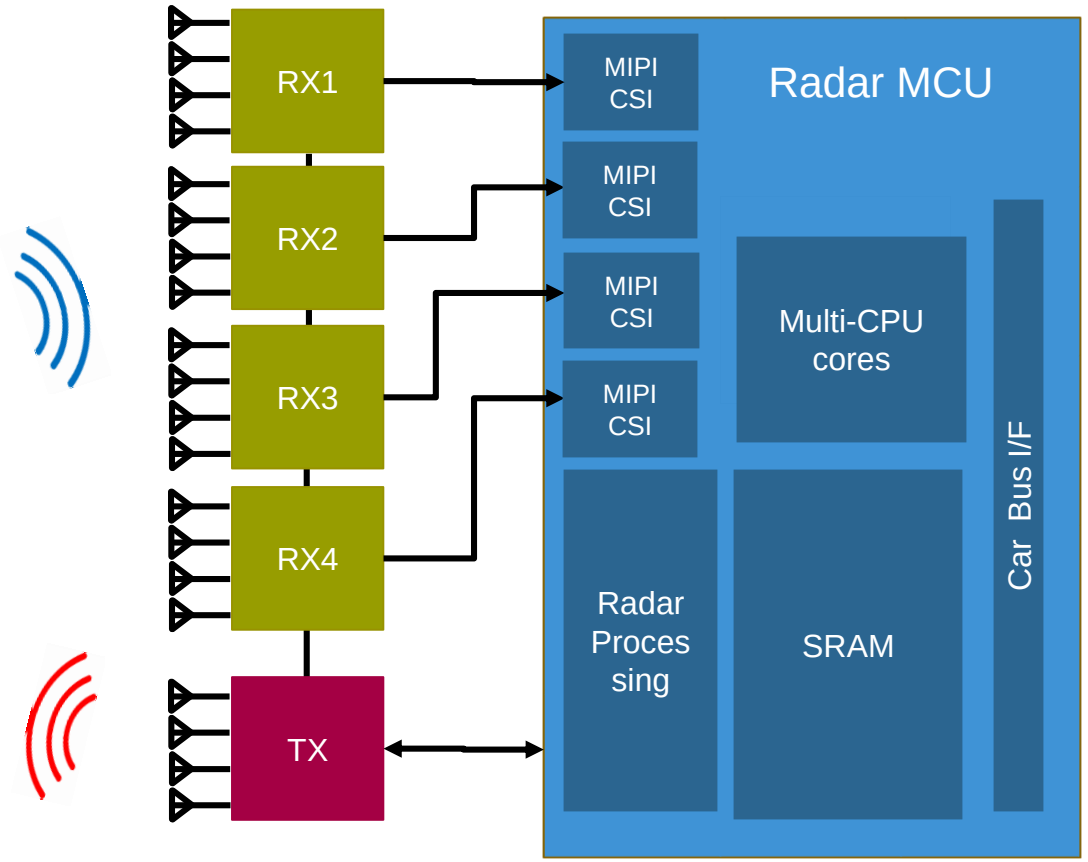
- Local: sensing
- Central: processing and fusion of clusters to objects, tracking and grid mapping
- Enables sensor combination (also non-RADAR)



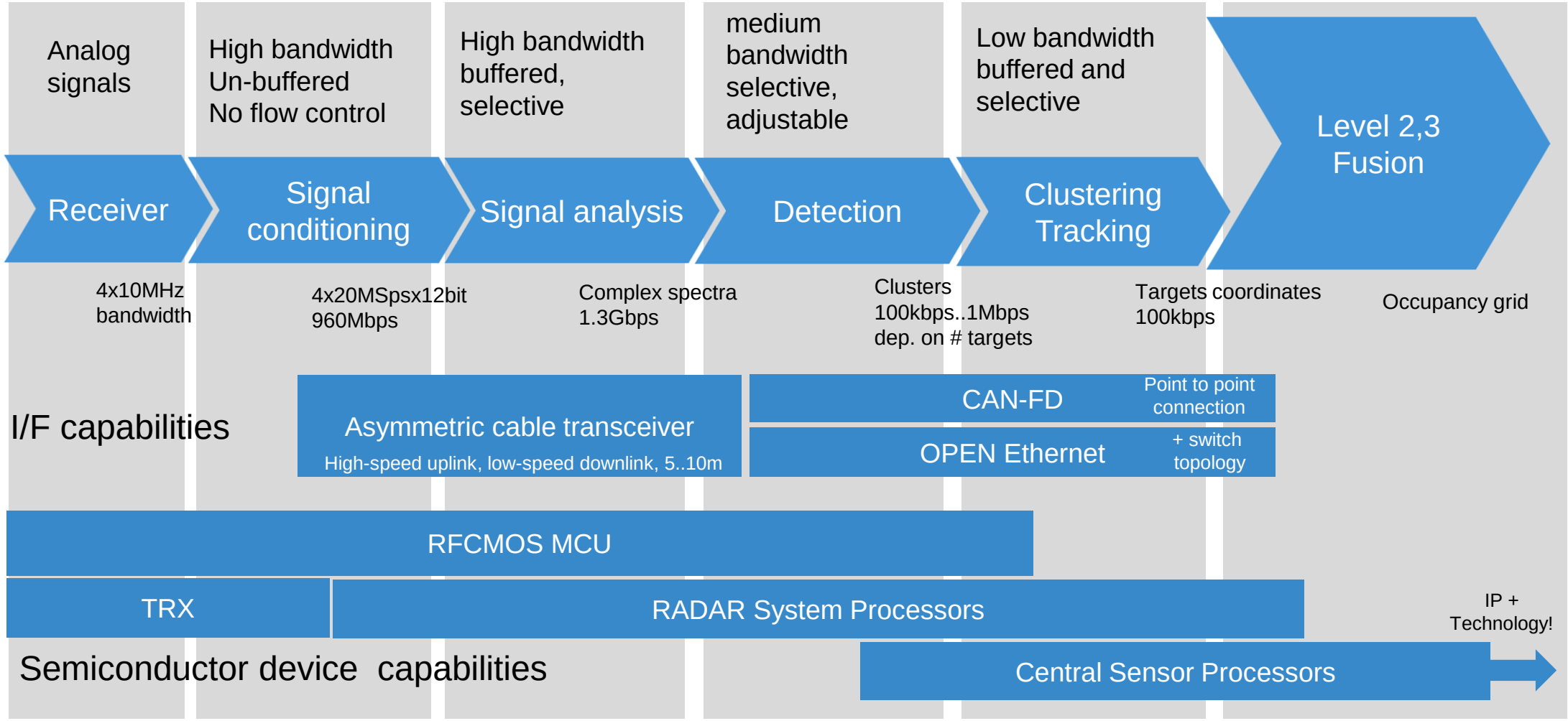
One Device – Scalable Applications for Autonomous Driving

High Performance Sensor

- Increased resolution (range, doppler, azimuth, elevation)
- Processing up to object list
- Decision making (brake/steer)

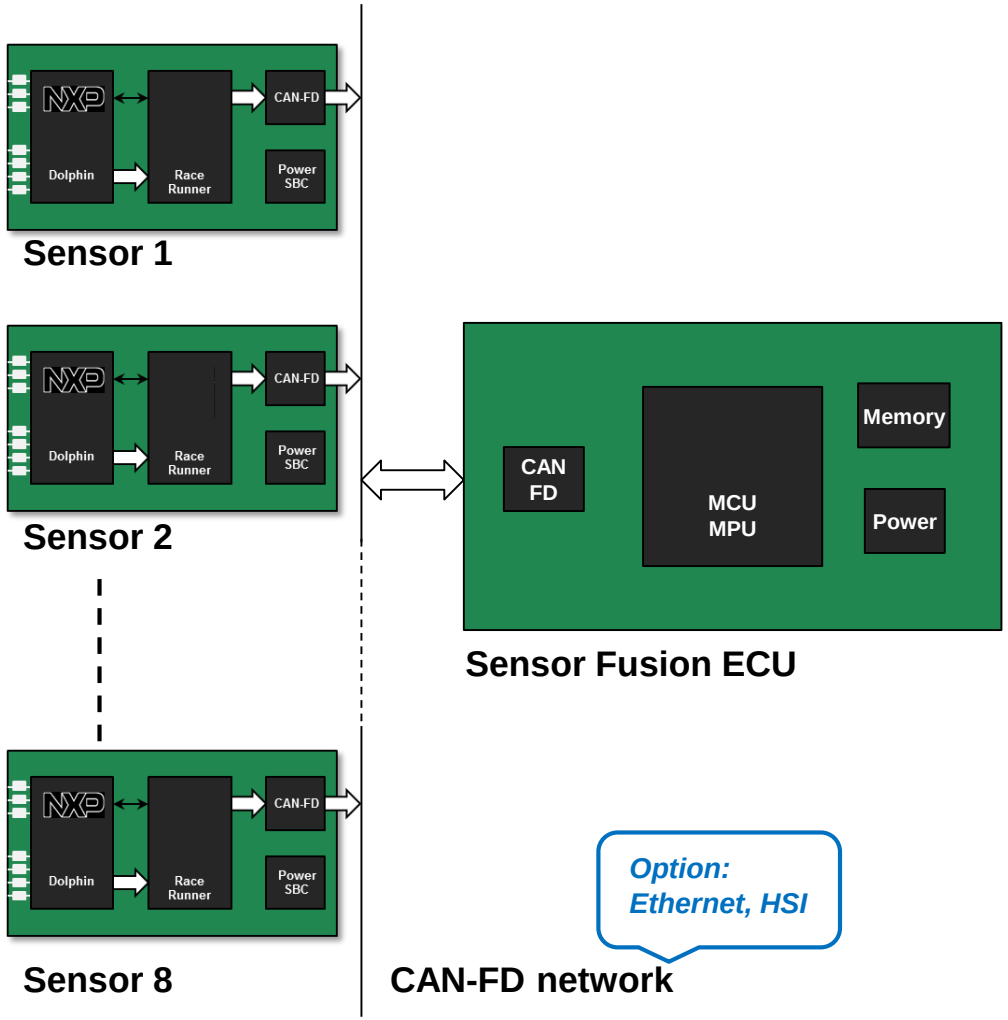


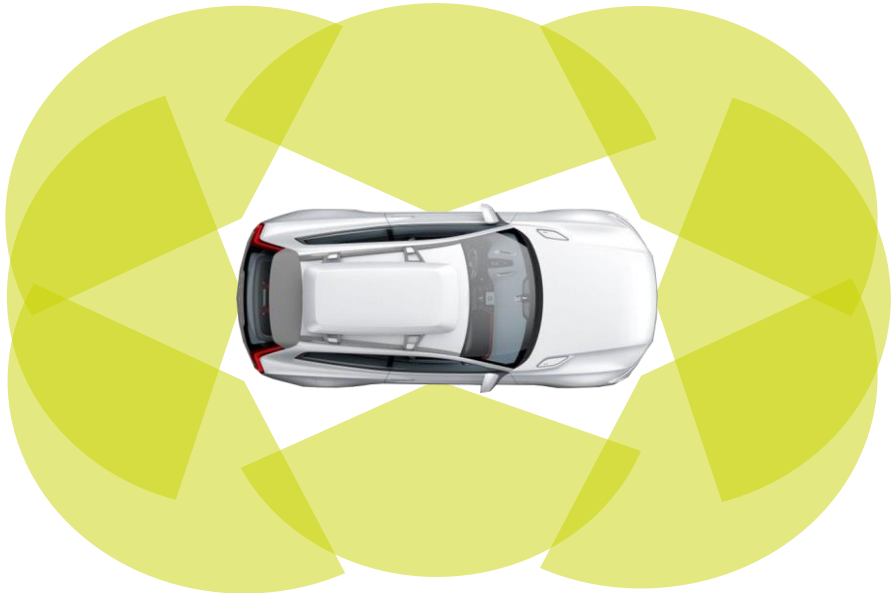
Where to Cut the Processing?



COCOON RADAR

Cocoon Radar in System Context



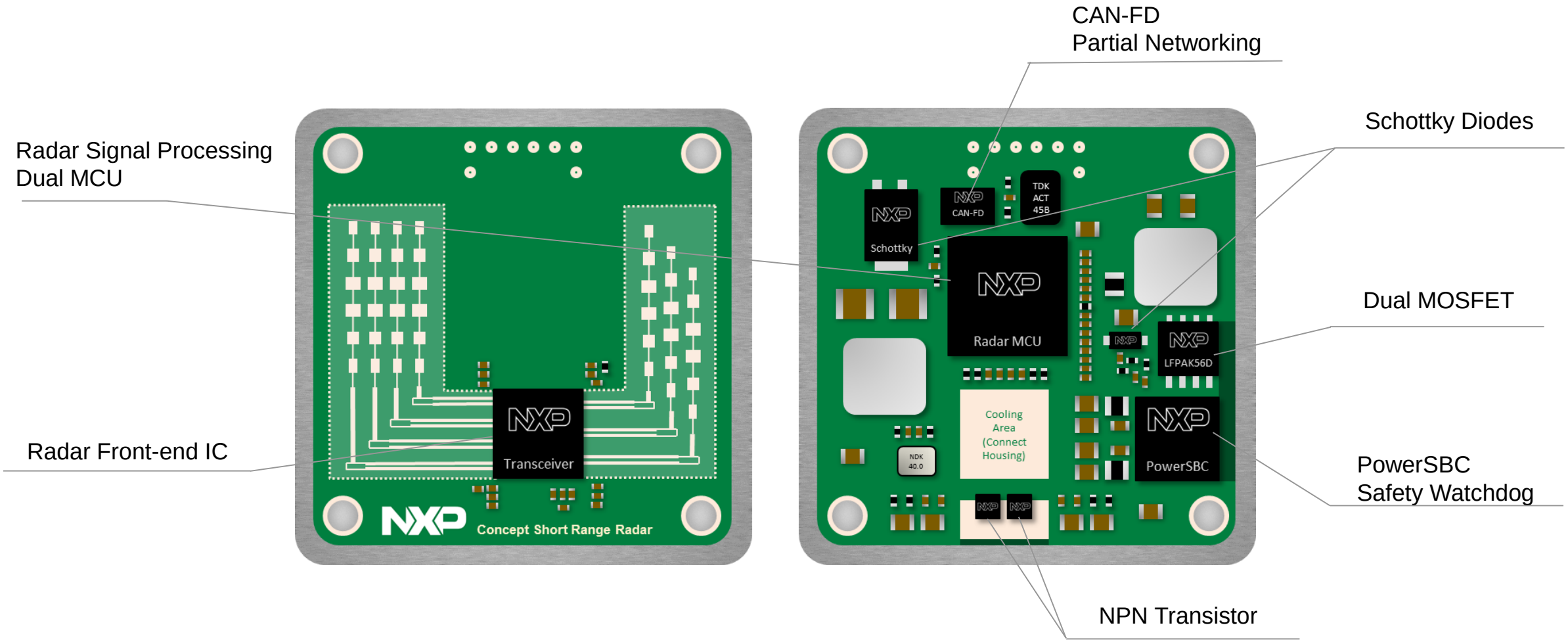


Use Cases

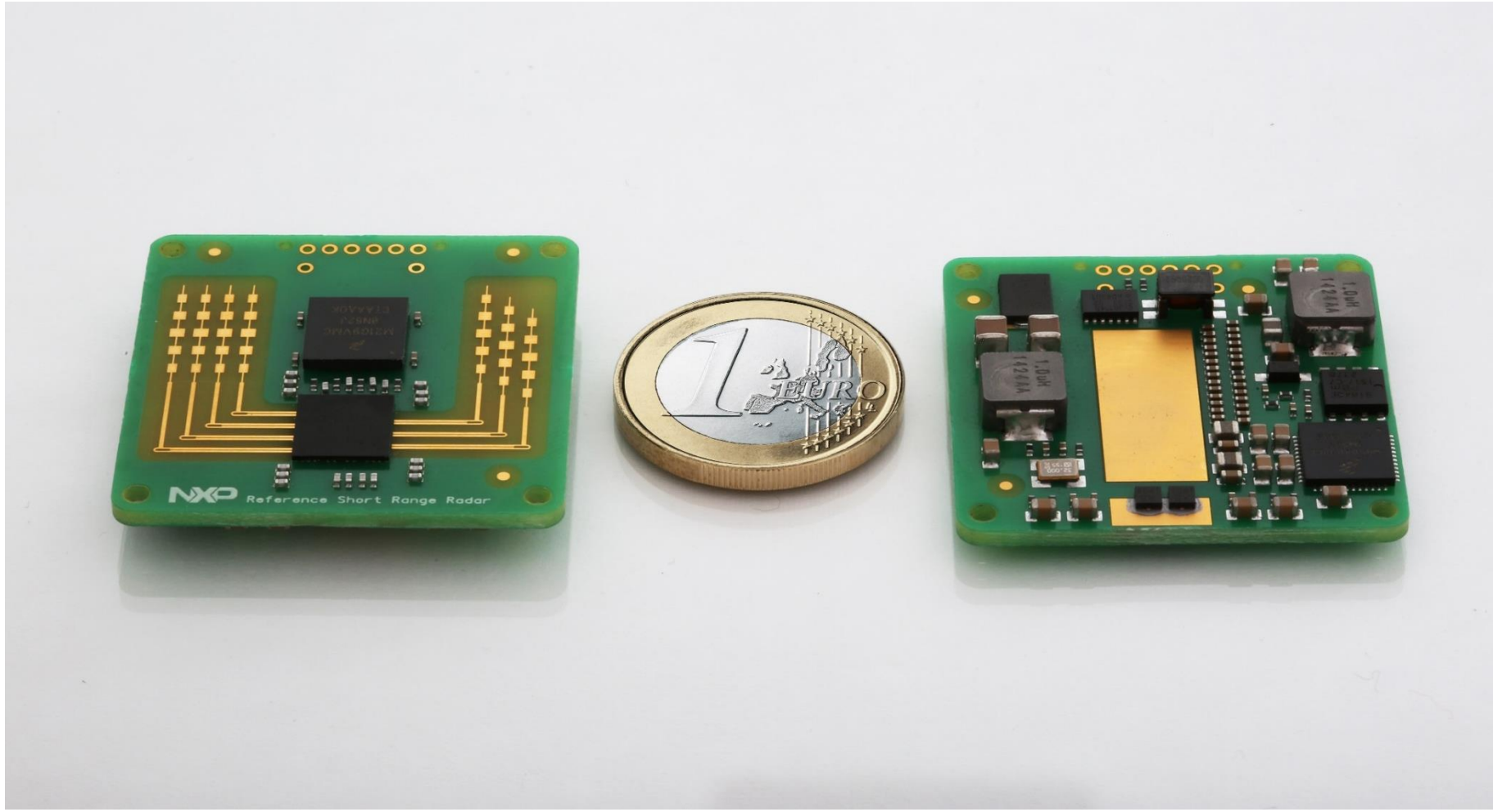
- Parking Distance Control
- Parking Slot Detection
- Blind Spot Monitoring
- Cross Traffic Alert
- Emergency Braking
- Door Open Assist
- Pre-crash Safety
- …

Cocoon Radar

Parking, Blind Spot Detection, Cross Traffic Alert, Emergency Braking



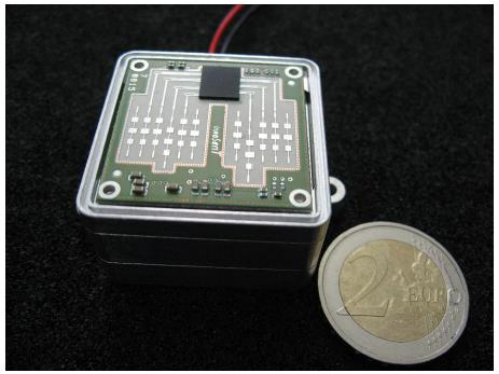
Concept Design

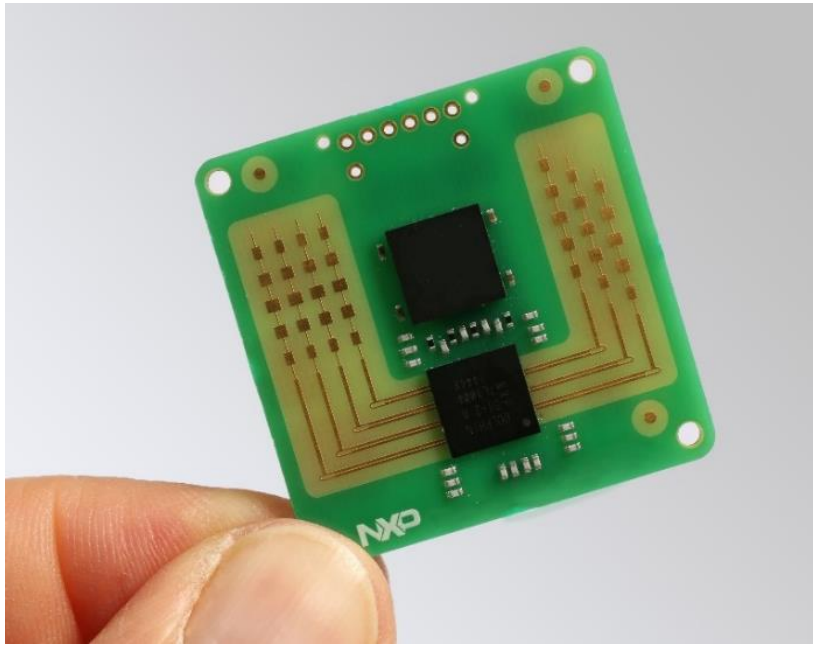


Cocoon Radar

Parking, Blind Spot Detection, Cross Traffic Alert, Emergency Braking

- CMOS is the next big step:
  - Cocoons of radar sensors for 360° surround view
  - Driving radar-based safety from premium into volume market
  - Making ultra-sonic parking sensors obsolete



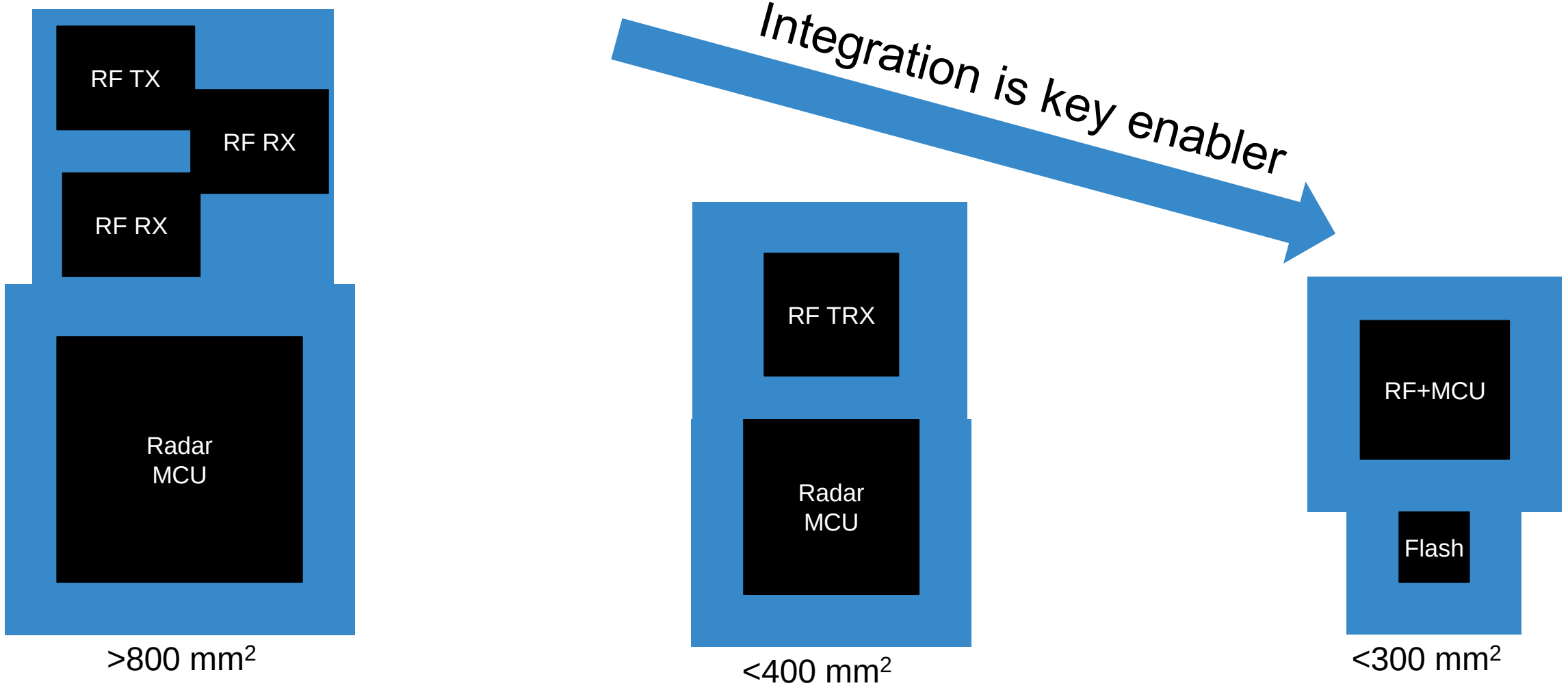


Requirements on Cocoon Radar

Generic requirements for a small SRR sensor

Parameter	Value
Range	0.05…50m @ 10dBsm RCS
Multi-mode	MRR “NCAP” mode ~1GHz chirp BW, SRR Park-Assist 4GHz
Field of View	160°
# Antennae	3 Transmit + 4 Receive
Sensor Size	40 x 40 x 20mm
Temperature Range	-40 to +85°C
Functional Safety	ASIL B
Network	CAN-FD, 2MBps, Partial Networking, Sleep Mode
System cycle	40ms, 1 Tx 50%, 4 Rx 60%, Chirp 60%, BiST 10%
Power Supply	4V - 42V@ Battery Side. Power 4W (average @ max temp)

Footprint Evolution

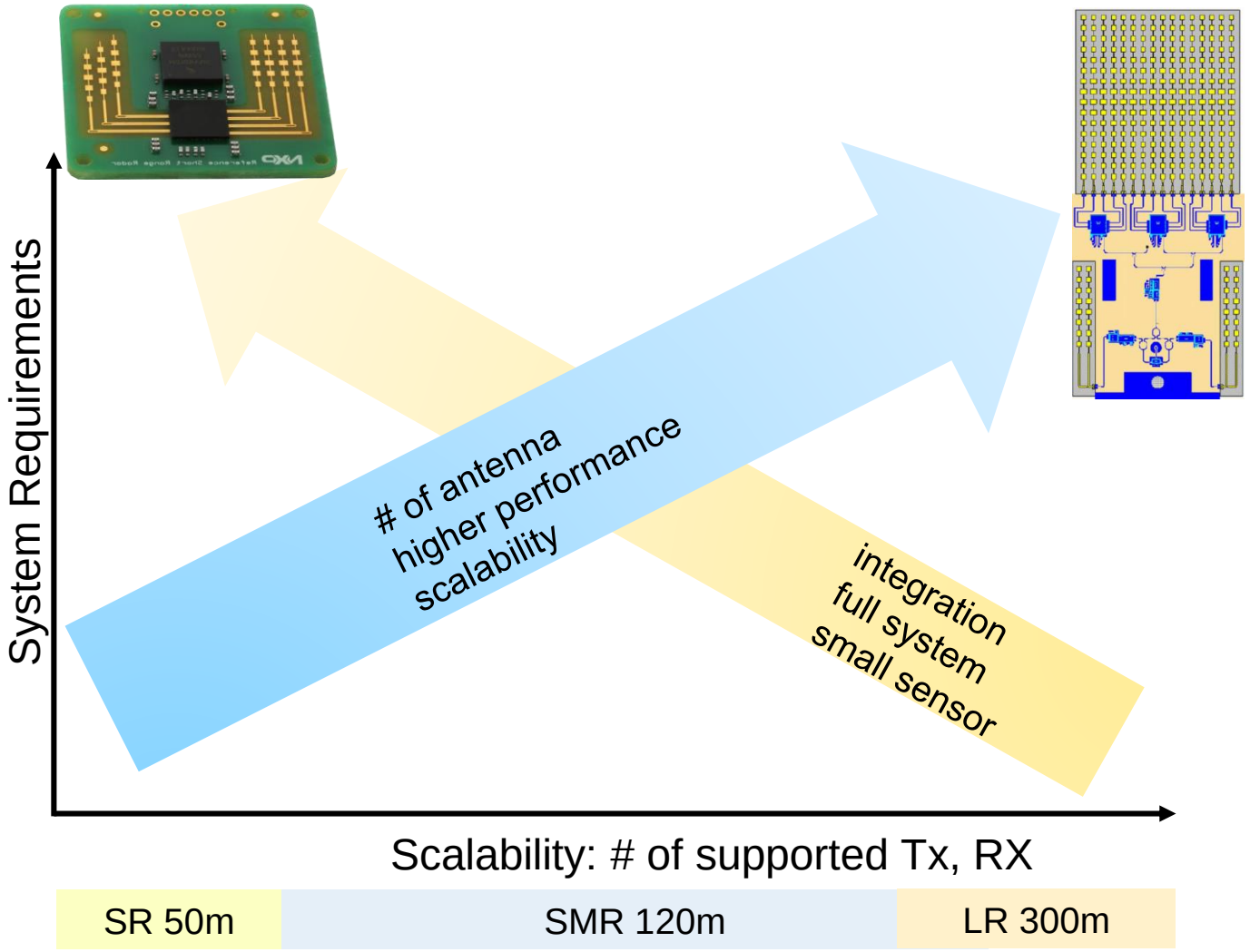


CMOS VS BICMOS

Why CMOS And BiCMOS

Technology Choice:

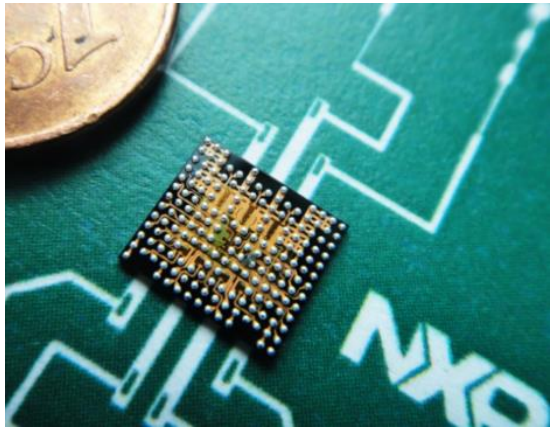
- Integration Level
- Digital Content
- Market scenario
- Analog Content
- Performance

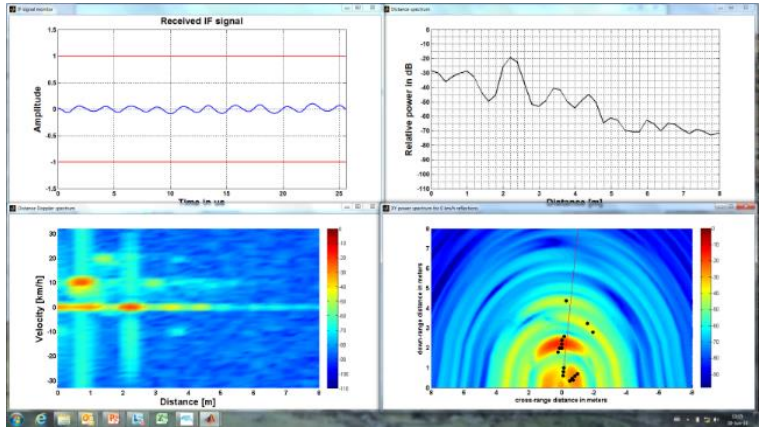


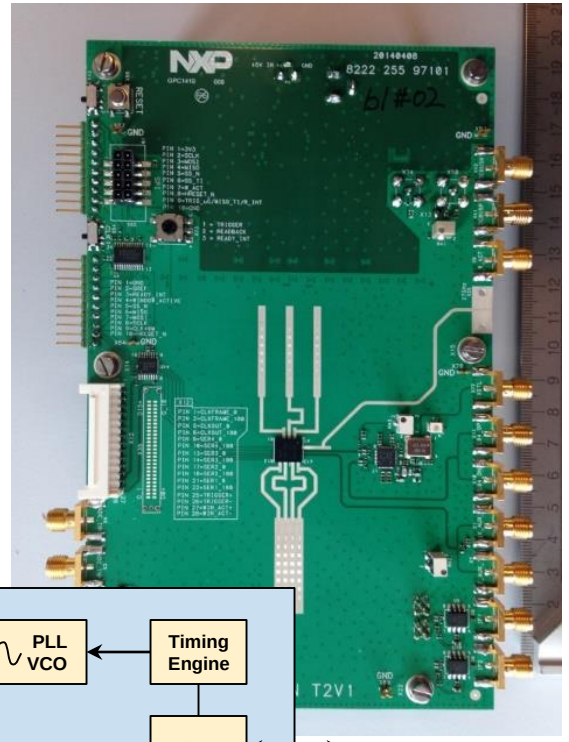
EVALUATION KITS AND RADAR SENSORS

Dolphin Evaluation Kit - Coming

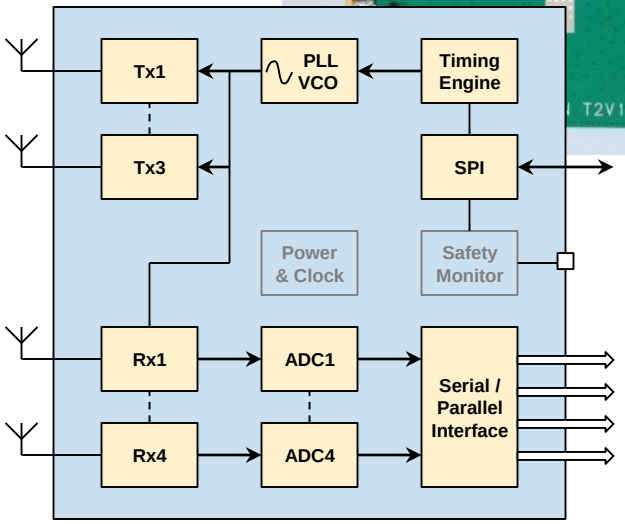
Fully Functional, and fully performing



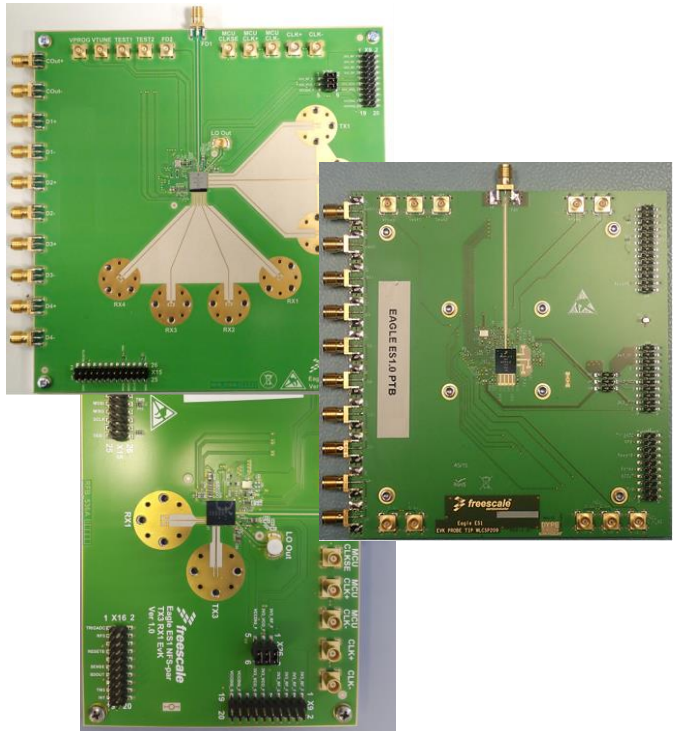




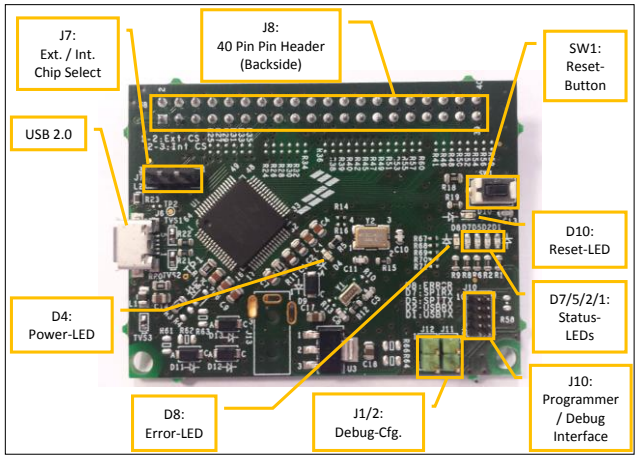
- Test board and samples and software available soon
  - For evaluation by selected customers
- Prototype has full functionality of the final IC
  - Not implemented: power & clock infrastructure and self-testing & self-monitoring
- All functional blocks work, and work together
  - Signal generation ⇨ Tx ⇨ Rx ⇨ ADC ⇨ Serializer
- All spec parameters perform well
  - Close to specification and simulation



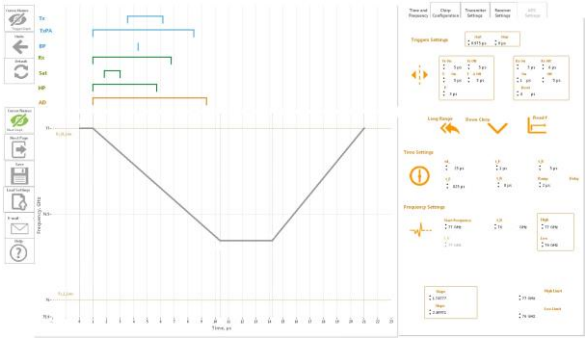
Eagle Evaluation Kit - Overview



SPI



USB



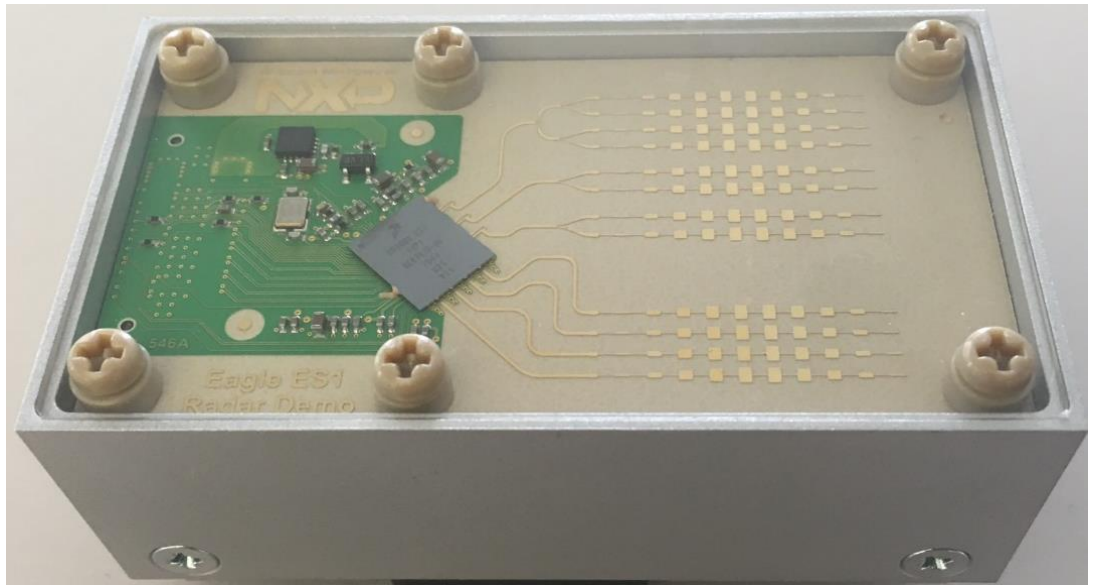
- Various evaluation kits
- pin header for USB to SPI bridge
- no special power supply
- easy to use interfaces
- Today w/ Eagle ES1.x

- USB to SPI bridge based on Pigeon NXP MCU
- Directly attached to EvK
- Hard- and software developed by NXP sys & apps

- GUI to send excel scripts
- Full GUI to graphically control chip parameter (in development)
- Full GUI to accquire data from measurement equipment (in development)

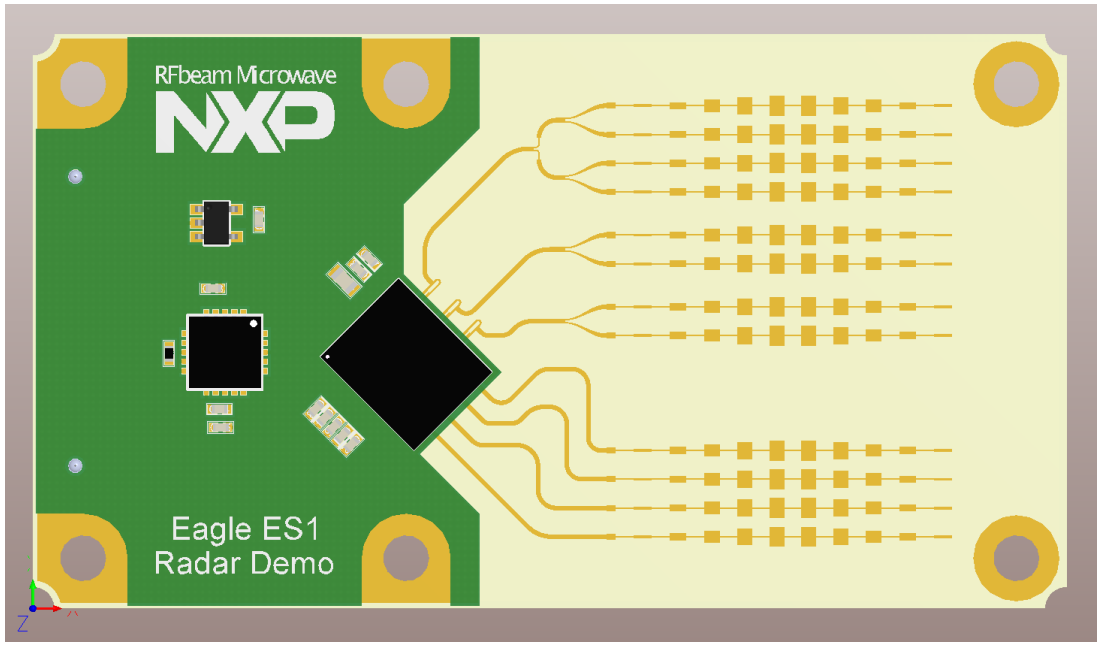
Radar Demo Eagle + Radar MCU

- Eagle ES1 (MR3003) + Radar MCU
- RO3003 on FR4
- 3 Tx and 4 Rx channels
- Mechanical, and thermal design included
- Transparent radom
- 2 board design (RF + MCU)
- Ethernet interface
- Single supply



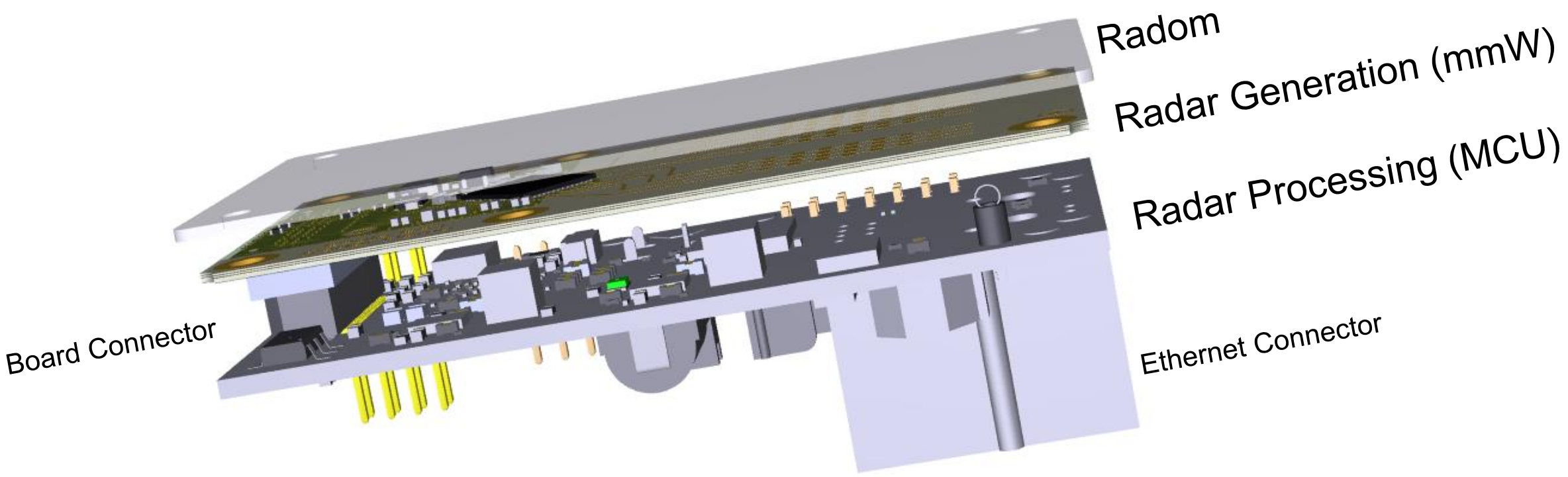
~7.2 cm

~4 cm



- Fully functional sensor
- Software included (Radar processing)
- Graphical Frontend (for Demo purpose)
- Demonstration on FTF2016

Radar Demo Stack



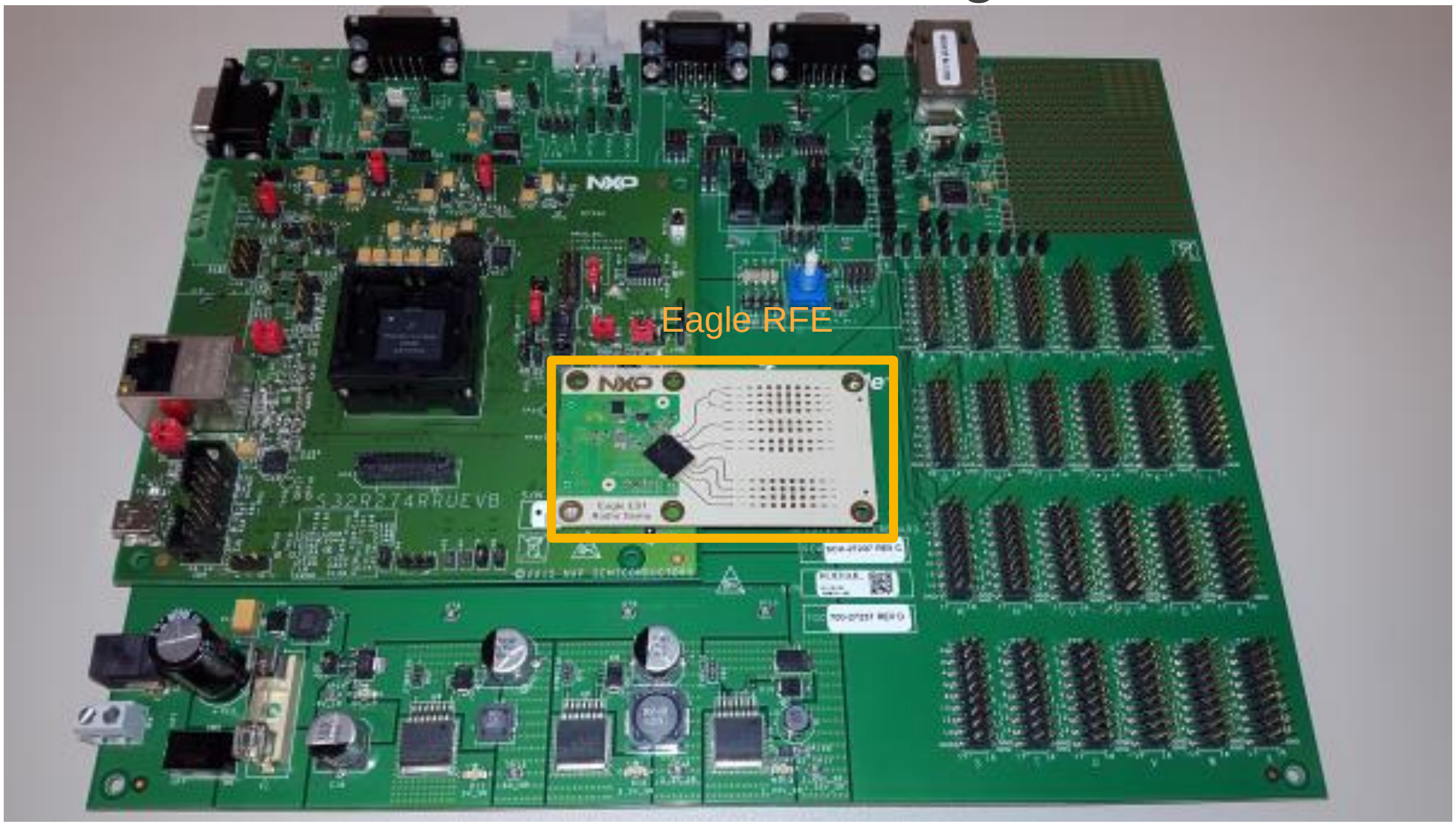
- Two PCB design to achieve flexibility
- mmW board can be combined with full size Radar MCU Evaluation board

Radar Demo Eagle+RaceRunner Family MCU

Top side, radom removed:

Back side, RRU with debug and Ethernet:

Fullsize Radar MCU Evk with Attached Eagle RF Board



SECURE CONNECTIONS
FOR A SMARTER WORLD

ATTRIBUTION STATEMENT