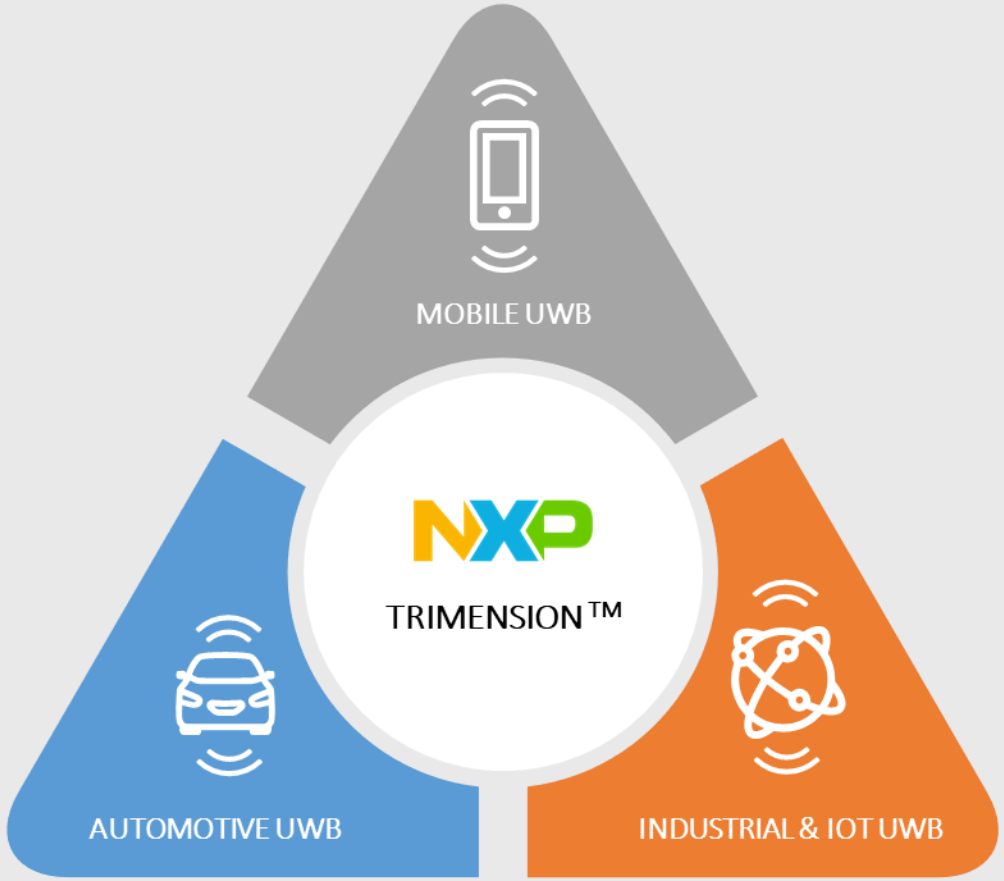
# Combining UWB Ranging and Radar Capabilities for Advanced IoT Applications

**Tony Chen**

November 2024




# Agenda

- UWB Technology Fundamentals
- NXP's UWB Portfolio
  - ✓ SR250 UWB Sensing (Radar)
- UWB ranging and radar use cases
- NXP's UWB Value Proposition

# Only One Thing to Remember Today

WHEN SENSING + EXACT POSITION IS REQUIRED

NXP's UWB IS DESIRED

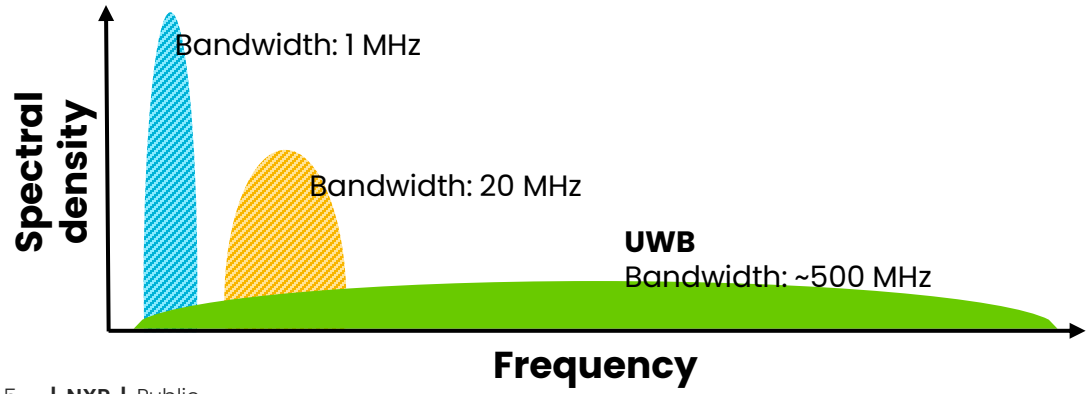
01

# UWB Technology Fundamentals

# Ultra-Wideband (UWB) Basics

## UWB physical layer (PHY)

- Defined in IEEE 802.15.4 / IEEE 802.15.4z
- Bandwidth of ~500 MHz (~2ns pulses)
- Reduced power spectral density (typ. -41.3dBm/MHz)
- NXP UWB band utilization (acc. IEEE 802.15.4)
  - Ch. 5: 6489.6 MHz (499.2 MHz)
  - Ch. 6: 6988.8 MHz (499.2 MHz)
  - Ch. 8: 7488.0 MHz (499.2 MHz)
  - Ch. 9: 7987.2 MHz (499.2 MHz)
  - Ch. 10: 8486.4 MHz (499.2 MHz)
  - Ch. 12: 8985.6 MHz (499.2 MHz)




## NXP UWB attributes (overview)

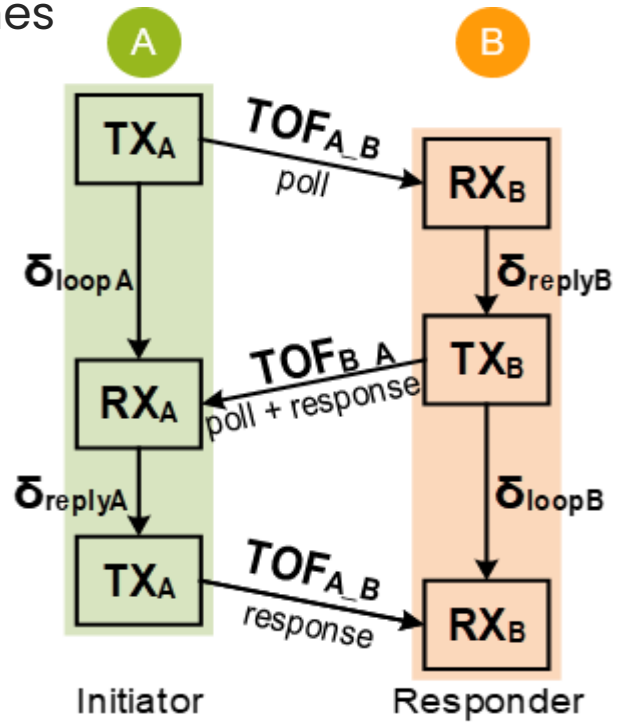
| | |
|---|---|
| **Accuracy** | +/- 10 cm distance<br>+/- 3° of angle |
| **Robustness** | Strong multipath resilience |
| **Range** | >70 meters in LOS<br>30-50 meters in real environments |
| **Security** | Secure ranging due to time-of-flight (ToF) measurements and PHY level security in 802.15.4z |
| **Latency** | Ranging (1-to-n) in <<10ms |
| **Radar** | Sub-Centimeter Motion Detection |

# UWB Ranging Technology Basics – DS TWR and Angle of Arrival (AoA)

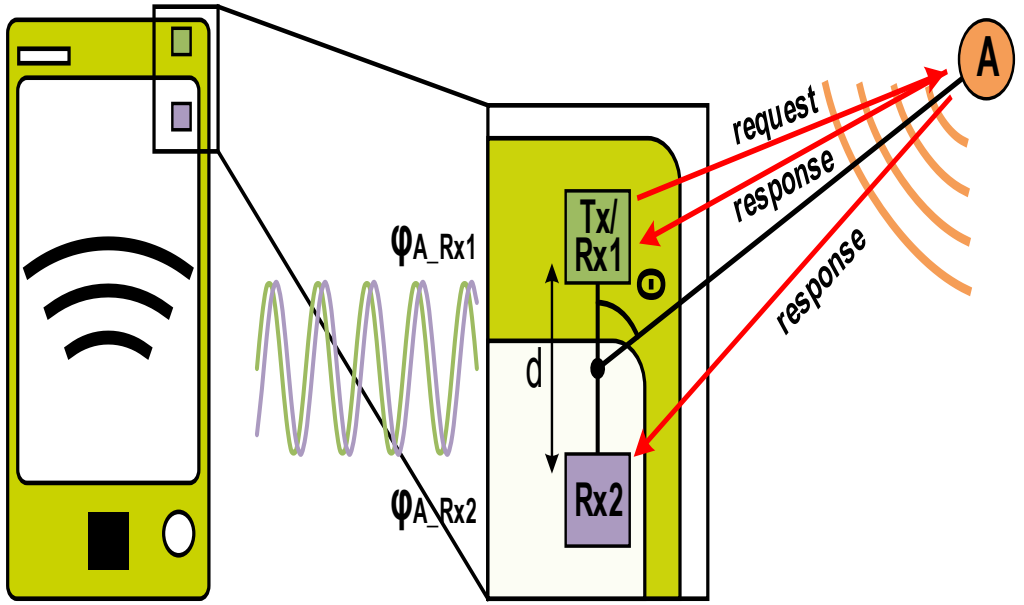
- **DS-TWR,** wo SS-TWR are performed, Each device can calculate the **ToF**
- Then

$$ToF_{A\_B} = \frac{\delta_{loopA} \times \delta_{loopB} - \delta_{replyA} \times \delta_{replyB}}{\delta_{loopA} + \delta_{loopB} + \delta_{replyA} + \delta_{replyB}}$$

- Clock difference in the two devices are compensated but more energy is required due to 3 frames

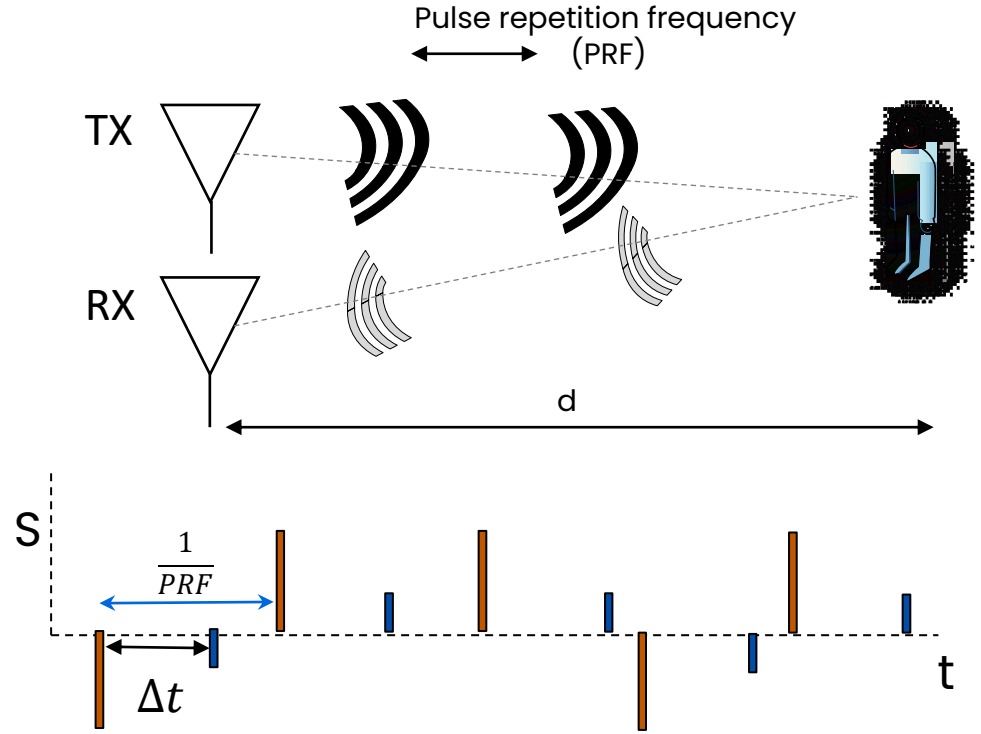


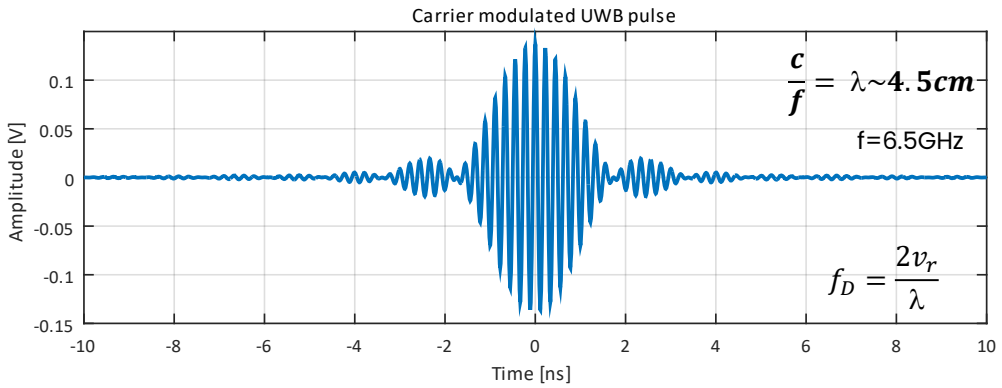

- **Angle of Arrival (AoA)** is based on **Phase Difference of Arrival (PDoA)** method.
- **PDOA** calculation is done during response of TWR using the phase difference (**Δφ**) between two antennas of received signals.



# Working Principle of Pulse Doppler Radar

- Transmit sequence of modulated pulses
- Computation of Channel Impulse Response (CIR) from reflected signal
- Absolute location of target is known by measuring round trip time of flight (ToF) of the pulses (propagation time)
- Large movements of target (and hence radial velocity) can be detected with multiple consecutive measurements.
- Movements (sub-mm) smaller than spatial resolution detected by observing phase change (Doppler effect) in reflected carrier signal between multiple measurements



# UWB Radar Working Principle – Doppler Processing

Channel Impulse Responses (CIR) are gathered

Range to detected objects is determined by time of flight (CIR Taps)

Recording multiple CIRs and performing an FFT over it gives the velocity information (Doppler effect → frequency shift)

Range resolution →

#CIR Index

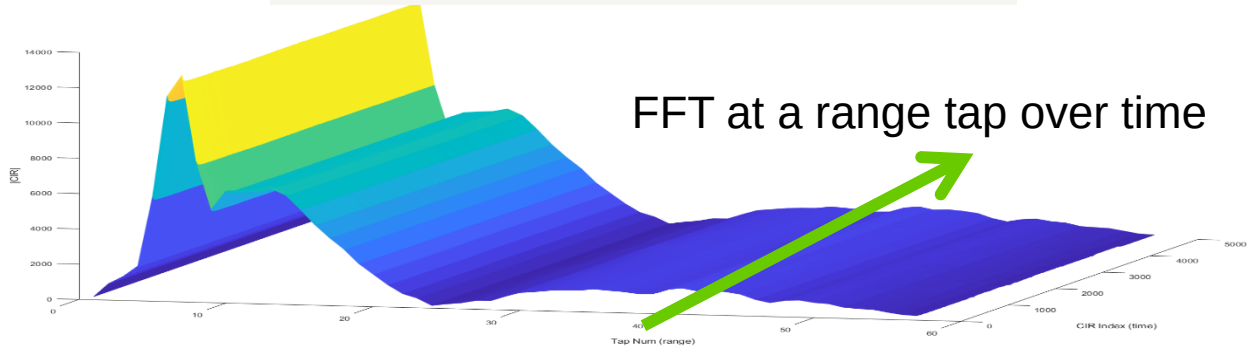
← Velocity resolution

CIR#1 [Tap1, Tap 2.. Tap n]
CIR #2 [Tap1, Tap 2.. Tap n]
.
.
.
.
.
.
.
CIR #m [Tap1, Tap 2.. Tap n]

**CIR_TAPS**

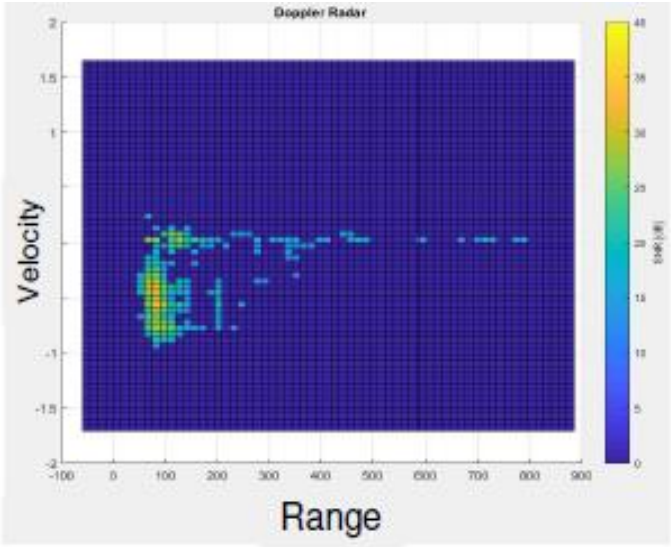
CIR magnitude over time

|CIR|




FFT at a range tap over time

FFT



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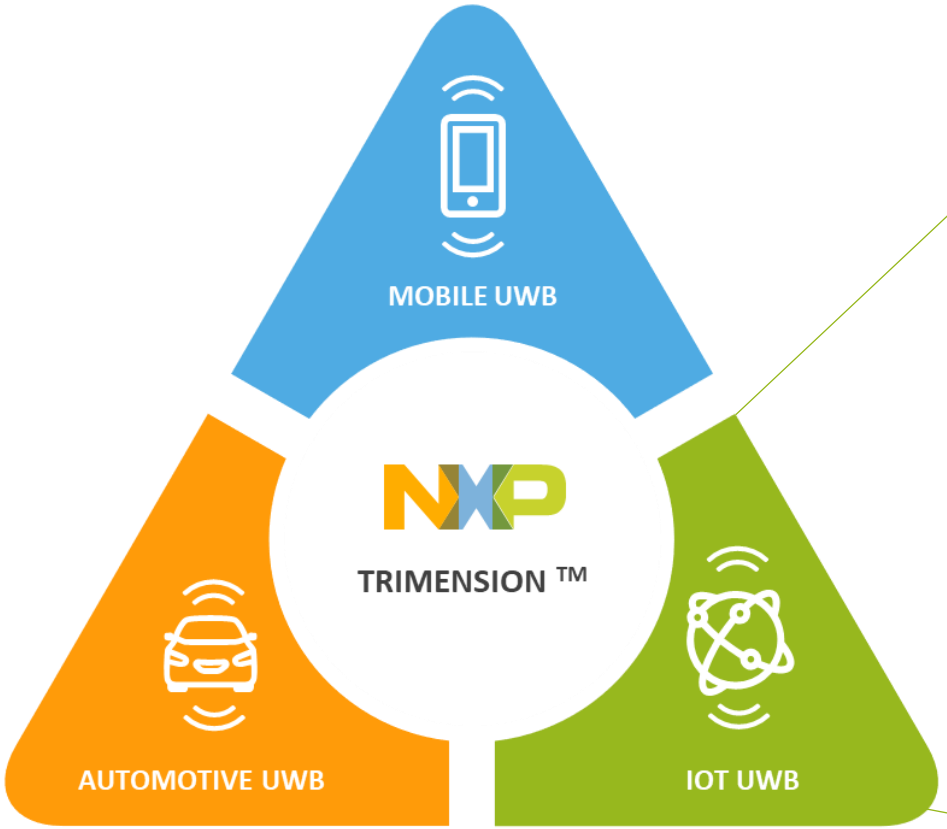
# NXP’s UWB Portfolio

## SR250 UWB Sensing (Radar)

# NXP TRIMENSION covers UWB portfolio across Automotive, Mobile and IoT





3D UWB Secure Ranging + **UWB Radar**
Consumer, Industrial, Healthcare


2D/3D UWB Secure Ranging
Consumer, Industrial, Healthcare


UWB Ranging
Coin cell battery operated

# SR250 Introduction

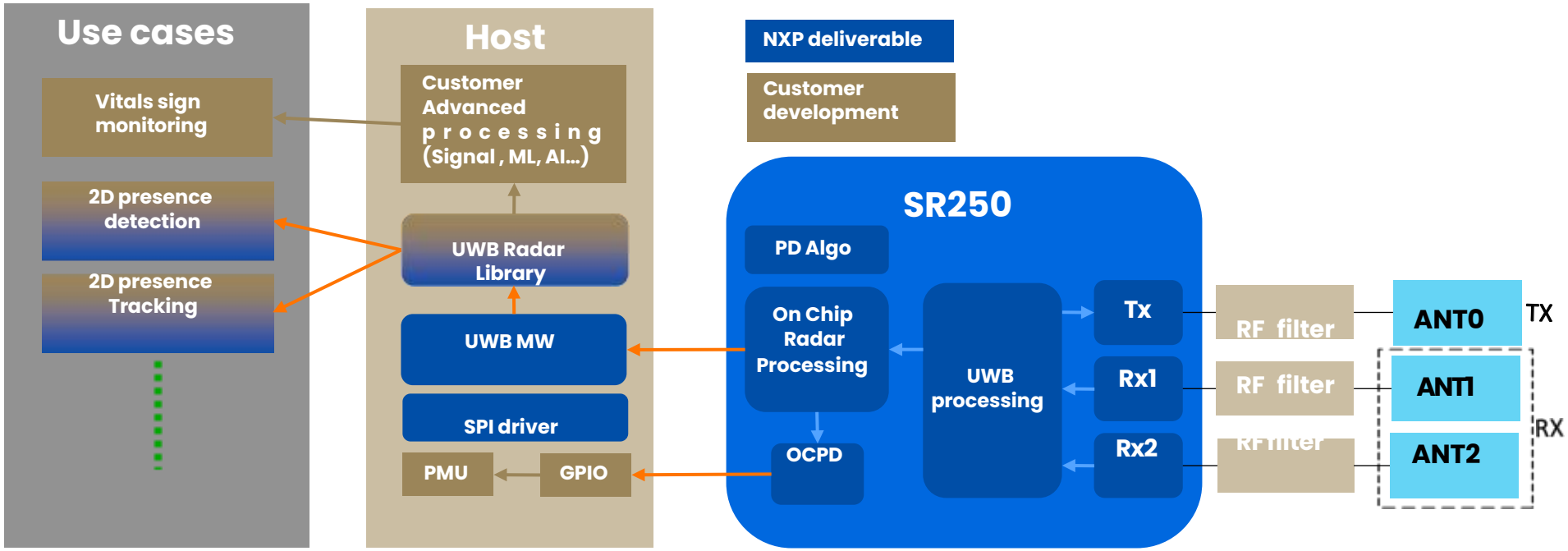
- Trimension SR250 is the industry's first single-chip solution combining on-chip processing with short-range ultra-wideband (UWB) **radar** and secure UWB ranging, enabling new user experiences in autonomous homes and for Industrial IoT.
- It integrates **3 Rx** for single shot 3D AoA support. **No extra RF switches** required.
- It embeds PMU that can be **battery supplied** (3.6V).
- It supports and **advanced Radar processing** algorithm enabling **On Chip Presence Detection** feature.
- Its **2D** pre-processed **CIRs streaming** allows customers developing advanced applications.

## CUSTOMER BENEFITS

1 **MATURE AND PROVEN UWB**
Multiple generations of UWB products covering complete eco-system, with various deployed use cases.

2 **IMPROVED PERFORMANCE**
Higher range, lower power consumption and improved radar performance.

# SR250 radar feature



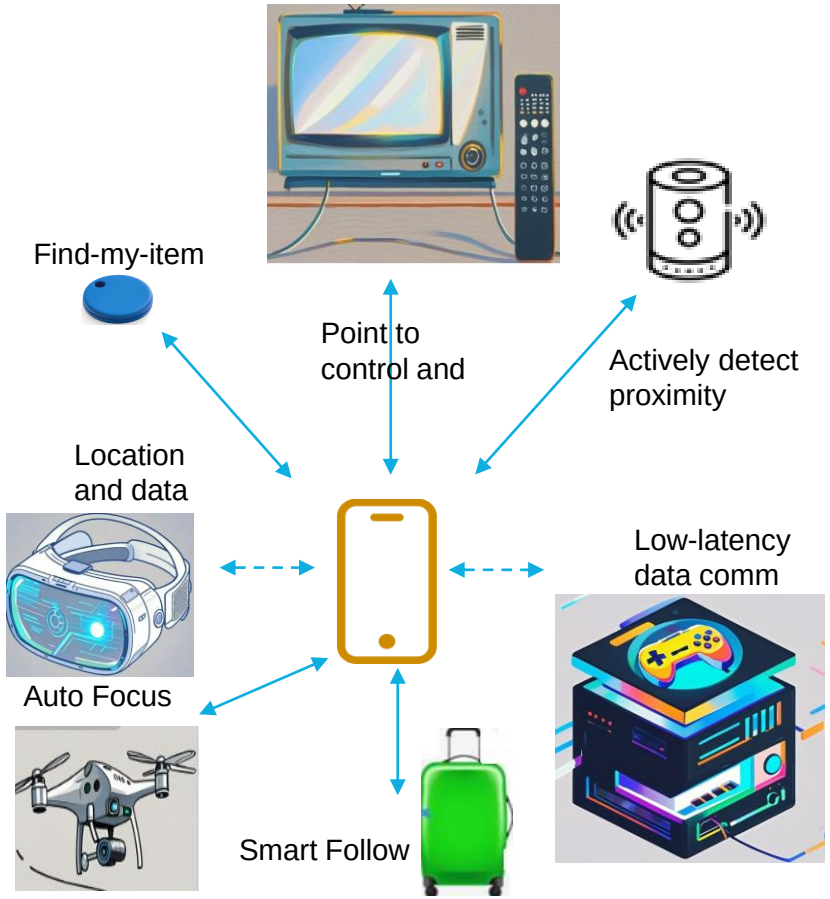

SR250 features Includes an **On Chip Radar processing** providing:

- **OCPD** (**O**n **C**hip **P**resence **D**etection)
  - a **GPIO** signal triggered by the detection of a presence in a defined range
  - An **UCI notification** providing info from Target (distance, Angle...)
- **CIRs** streaming (**C**hannels **I**mpulse **R**esponses)
  - The streaming to the host of the Radar signal response, ready for advanced processing
  - **Off Chip Radar Libraries** are used to develop final use cases.

03

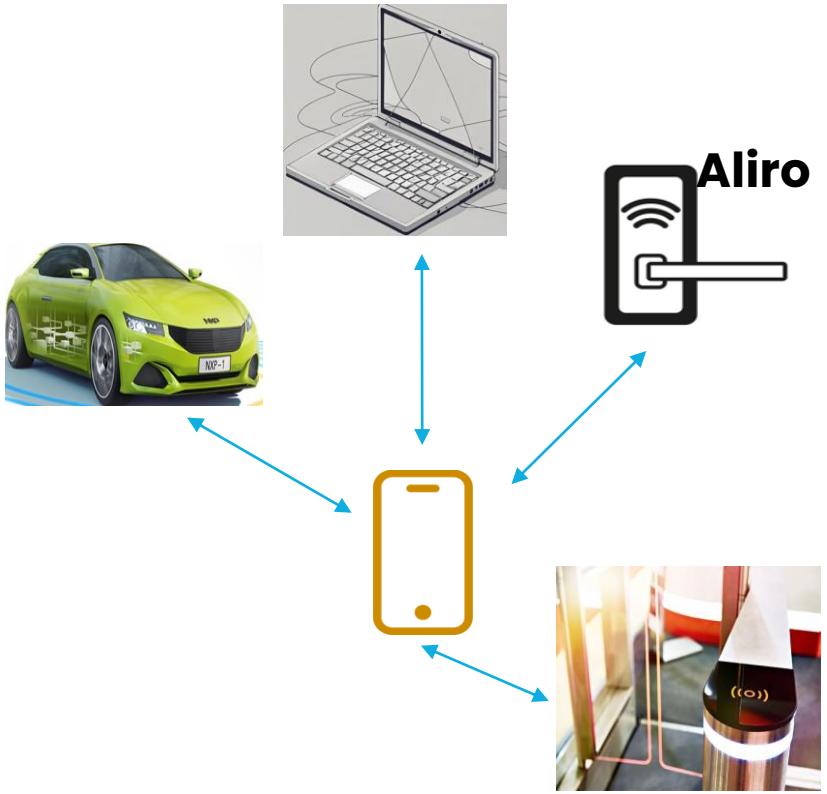
# UWB ranging and radar use cases

# UWB IoT use cases with standards and solutions



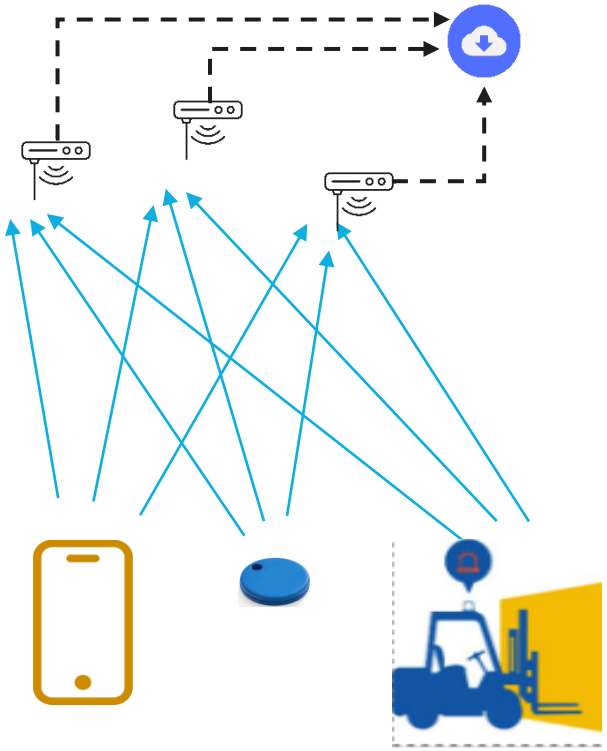

**Device to device interactions**

- Non-secure ranging
- Data communication




**Secure handsfree ranging for access control**

- Physical access
- Logical access



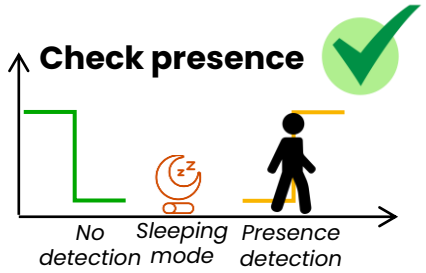
**RTLS: finding a device or tag using infrastructure (consumer & industrial)**

- Indoor parking navigation
- Museum guided experience

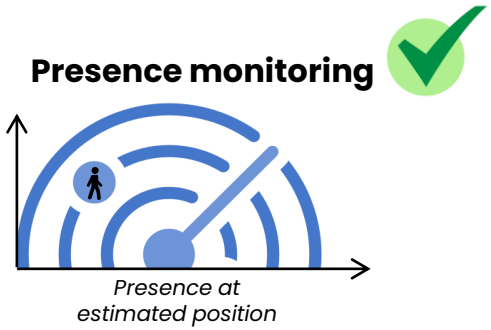
**Multiple UWB use cases can run in parallel in one device**

# UWB Radar for IoT

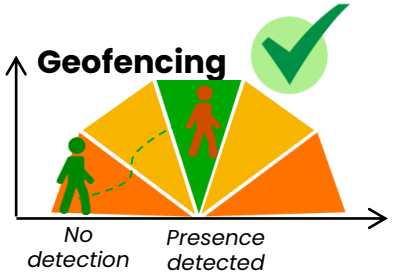
- ✓ System Wake Up based on presence detection (**OCPD**)
  - Device ( Switch ON / OFF; Starting time improvement…)
  - PC Login (Wake – UP computer and switch to UWB authentication for Login)
- ✓ Geofencing for safety
- ✓ Presence detection and tracking
- ✓ Vitals sign monitoring (**Off-chip** PD + AI)




Monitor presence status reported by SR250 OCPD at defined reporting period. Full scale of the Radar

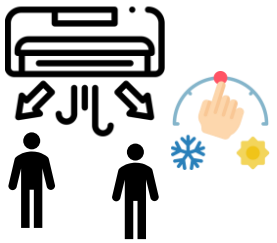



Monitor epicenter Position (X,Y) of the reported presence by SR250 OCPD for a defined zones.

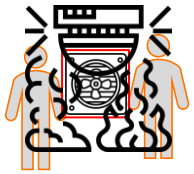


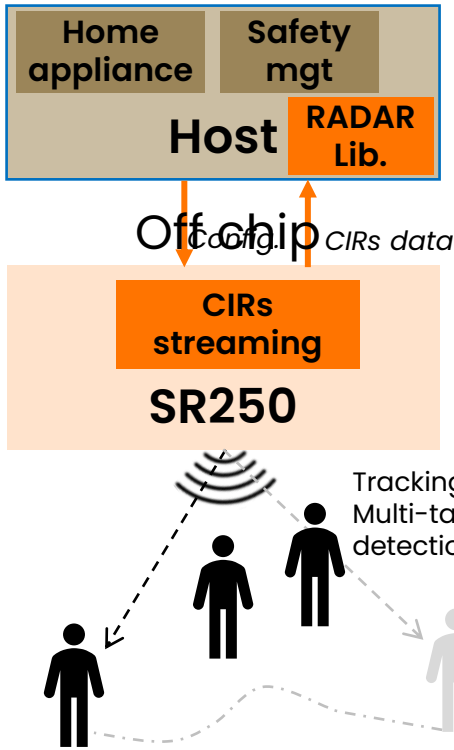

Monitor presence status reported by SR250 OCPD for the defined zone (distance and angle)

Temp. and air flux management based on occupancy



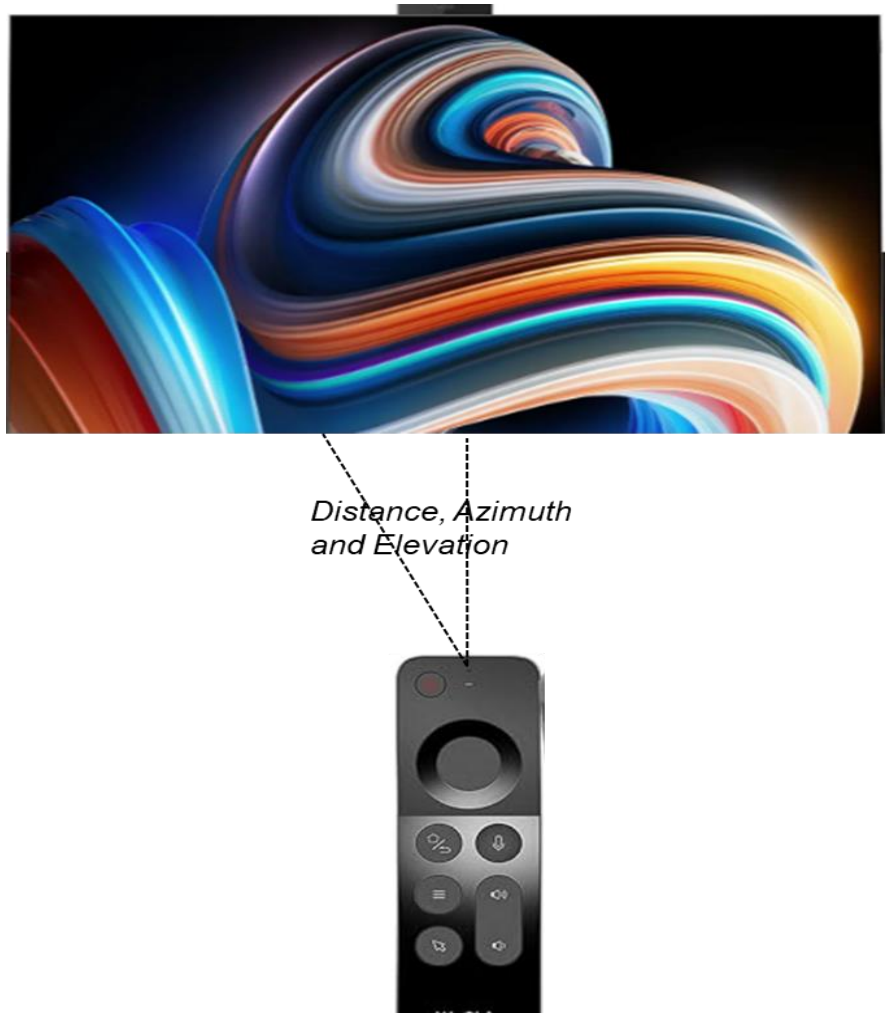
SAFETY: detection of nonvisible person



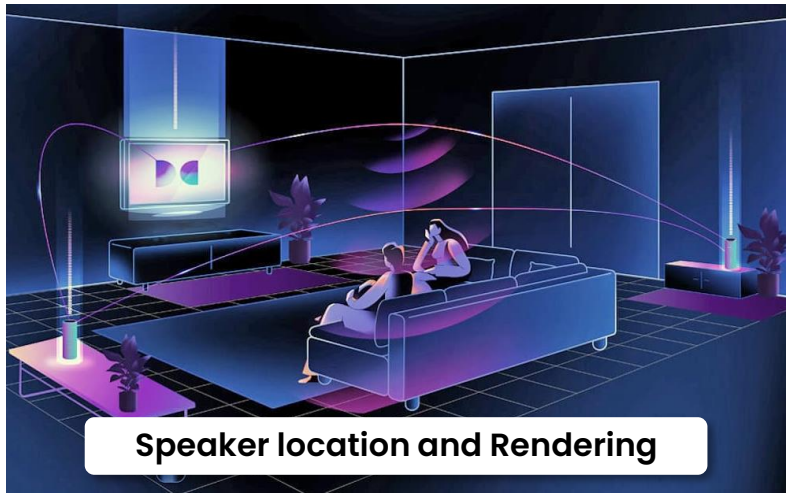



**UWB RADAR is providing the best value when combined with UWB ranging use cases**

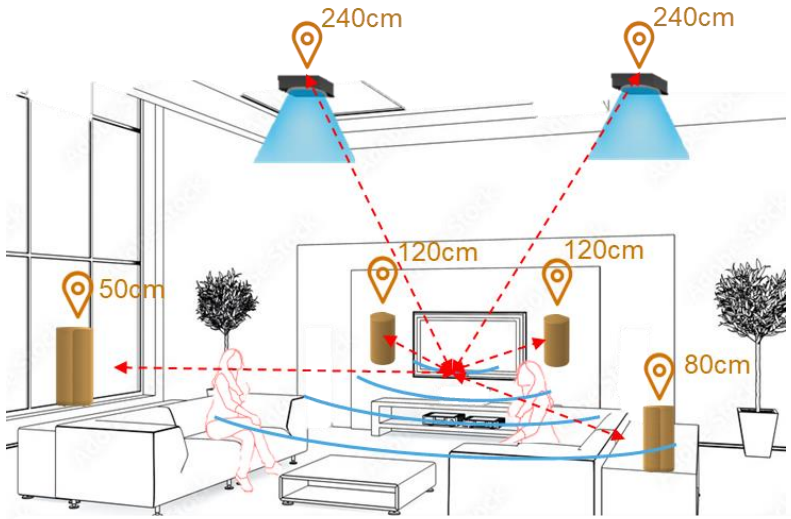
# Combining UWB Ranging and Radar Capabilities for Smart Home




It supports swiping, tapping, dragging and other gestures available on mobile devices, allowing you to conveniently manage content on the big screen.



Speaker location and Rendering




Speaker elevation, angle, displacement
Sweet spot detection

04

# Value Proposition

# Integration of UWB into Automotive, Mobile and IOT – The Market






All major brands have at least one model equipped with UWB

UWB-enabled phones from iPhone 11 onwards

Samsung flagship devices are UWB-enabled since Galaxy Note 20, GS 21,22, 23 Ultra and Z Fold 2, 3, 4

Xiaomi MIX4
Pixel Pro
Vivo x90 Pro
Sharp AQUOS R8, Pro


Airtag


Homepod Mini


Apple Watch


Airpod Pro


Smart Tag 1 and 2


Zigbang Door Lock

Verifone UX700


Beosound A5

BANG & OLUFSEN


Beolab 8

Huawei TV & Remote control

By 2025 ABI Research expects that 1/3 of smartphones shipping will be UWB enabled, resulting to well over **600 million annual shipments**.

# Standards + interoperability for UWB ranging span multiple layers

Car access

CARCONNECTIVITY consortium

Door access

csa

Full use case:

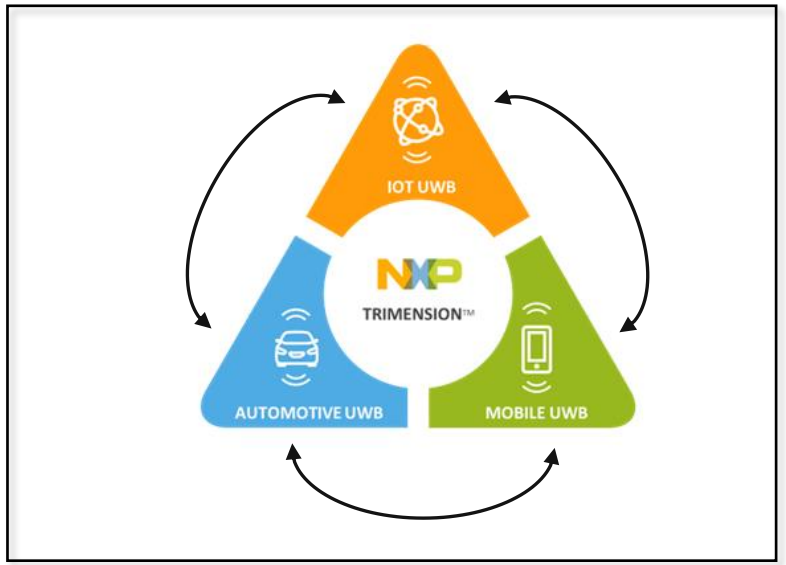
NFC+BLE+UWB+ transaction,...

fira — Higher layer UWB + certification

IEEE — Base technology layer

**Standards**

+




**Product Interoperability**

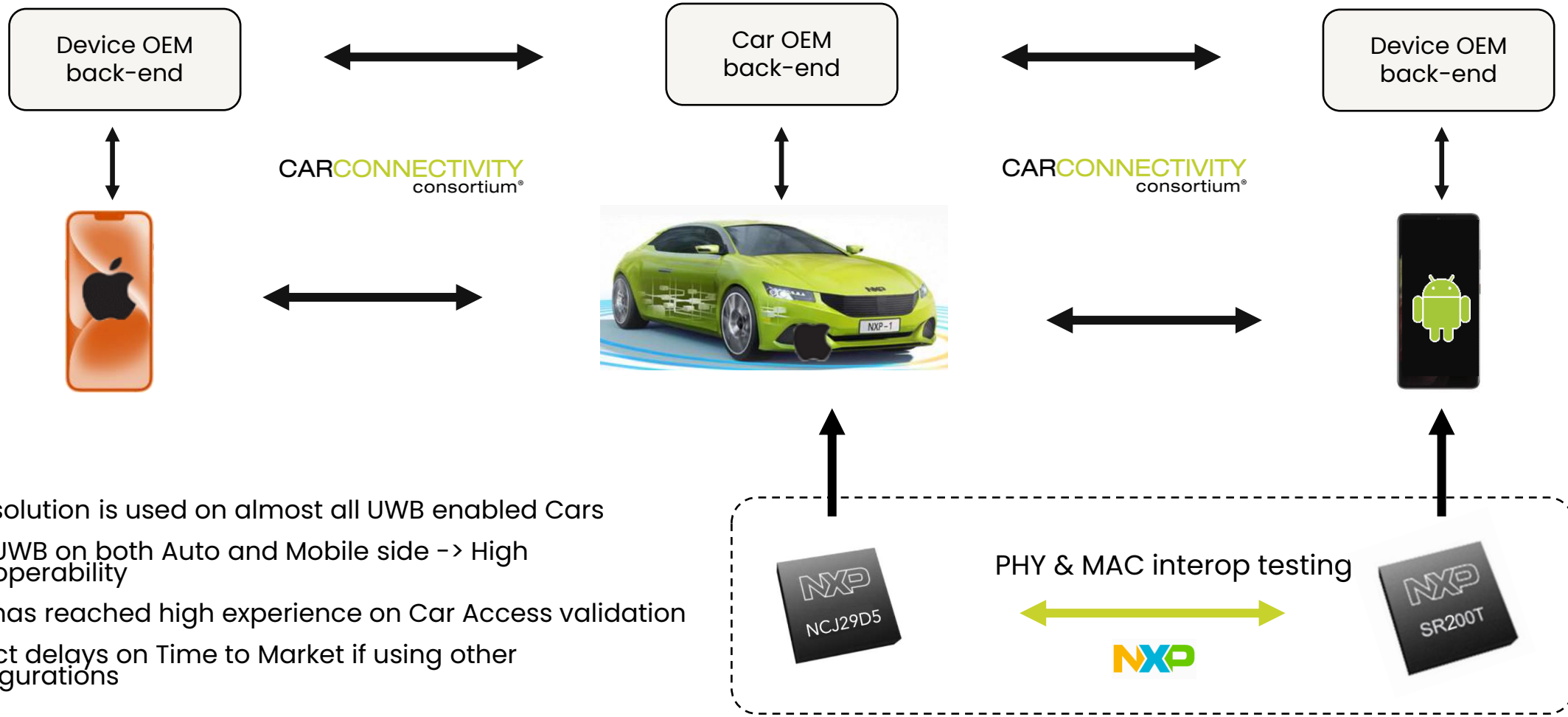
Other than technology providers like NXP, the biggest drivers across standards are Apple, Samsung and Google.

Add to Google Wallet

Add to Apple Wallet

Add to SAMSUNG Wallet

# NXP UWB is a safe solution for car access




- NXP solution is used on almost all UWB enabled Cars
- NXP UWB on both Auto and Mobile side -> High Interoperability
- NXP has reached high experience on Car Access validation
- Expect delays on Time to Market if using other configurations

**NXP UWB is the lowest risk solution to guarantee car access interoperability**

# 恩智浦与深圳通合作推出业界首个基于UWB的轨道交通支付解决方案

2024年10月8日 10:41 AM by 恩智浦 新闻摘要

中国上海——2024年10月8日——恩智浦半导体（NXP Semiconductors N.V.，纳斯达克股票代码：NXPI）今日宣布，深圳市城市交通卡运营服务商"深圳市深圳通有限公司"（下简称深圳通）将采用恩智浦Trimension®产品组合提供基于超宽带技术(UWB)的创新性无感支付过闸产品。Trimension UWB 将实现安全无感支付的便捷体验，即公共交通乘客在通过闸机检票口时，无需停下来刷手机或刷公交卡，只需直接通过就可以完成支付。

深圳通采用恩智浦Trimension UWB 产品组合实现公共交通的无感式支付服务，乘客通过闸机时无需刷手机或公交卡，即可轻松完成出入站

深圳通与深圳云巴一号线运营单位紧密合作，联合手机厂商、TSM服务商等，目前已经在坪山高铁站、中芯国际站成功启动UWB系统商用，预计2024年10月底完成云巴一号线11个站点的全面部署。

## 技术亮点

过去的几年，基于NFC的非接触式票务迅速普及，为乘客提供便捷的"即触即付"解决方案。UWB 技术则代表了非接触式票务的下一代发展——无感式支付，进一步简化和加快入站流程。UWB测距技术可使支付系统通过智能手机自动检测到乘客，即使手机放在口袋或包中，也能无缝完成闸机通过。这一流程进一步改善用户体验，解放了乘客双手的同时还将缩短通过闸机的排队时间。

恩智浦安全嵌入式交易业务副总裁Jerome Legros表示："恩智浦曾率先在中国推出NFC与安全元件相结合的非接触式票务解决方案，现在我们通过UWB实现新的创新。我们与深圳通密切合作，定义并实现了端到端用户体验，涵盖支持UWB的轨道交通闸机和用户的移动设备。通过使用恩智浦的 Trimension UWB 产品，我们为深圳公共交通的乘客创造了真正无缝的用户体验。"

# World's first UWB Transit is Live

BYD Yunba SkyShuttle line in Shenzhen went live in September 2024, making hands-free UWB-based transit a reality.

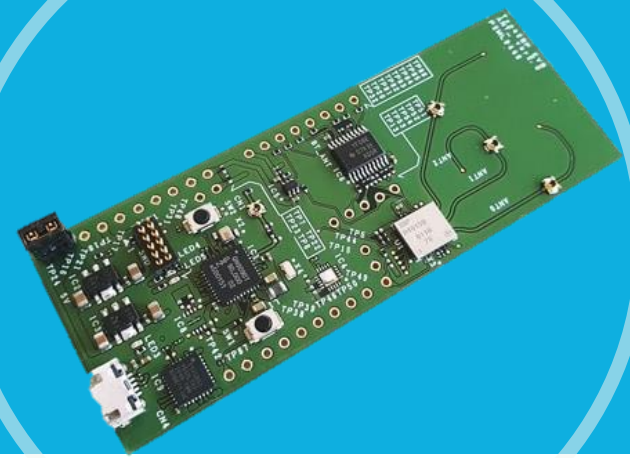
- Press release (in Chinese): https://www.nxp.com.cn/company/about-nxp/newsroom/NB-NXP-SZ-UWB-CN
- Blog post (in English): https://www.nxp.com/company/about-nxp/smarter-world-blog/BL-NXP-COLLABORATES-WITH-SHENZHEN-TONG

# UWB Module value proposition

## WHAT IT TAKES TO INTEGRATE A UWB CHIP ON BOARD?

- Experienced manpower on HW design in 6.5 – 8GHz band
- Simulation tools for PCB and RF simulations
- Tester dedicated for UWB needed (debugging and testing)

**~500K$ Tools Investment + Manpower**



## BENEFITS OF UWB MODULE VS. COB

| | |
|---|---|
| • PCB – 2 Layer vs. 4-6 Layer HD | ➔ Low-cost PCB design |
| • Proven and tested design | ➔ First time right UWB design |
| • Calibration of Power and Xtal | ➔ Shorter production test time |
| • FCC Module cert (on demand) | ➔ Lower certification cost |
| • Form factor agnostic RF design | ➔ Easy reuse of same design in various form factors |

# I’m Here to Help!

**Tony Chen, Sr. UWB Business Development Manager**
tony.chen_5@nxp.com
19121631992

nxp.com

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