Wireless connectivity in automotive

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My first car

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My first car

Wireless optical transmitters

Some of the functions left to the user
- Detection → radar
- Decision → artificial intelligence
- Actuation → steer by wire

Stereo wireless optical receivers

Decision making (brain) and actuators (body)

Wireless in automotive

- Wireless technology has (always) been present in automotive
  - Safety: communications and sensing
  - Entertainment: communications

- The car is not an isolated player
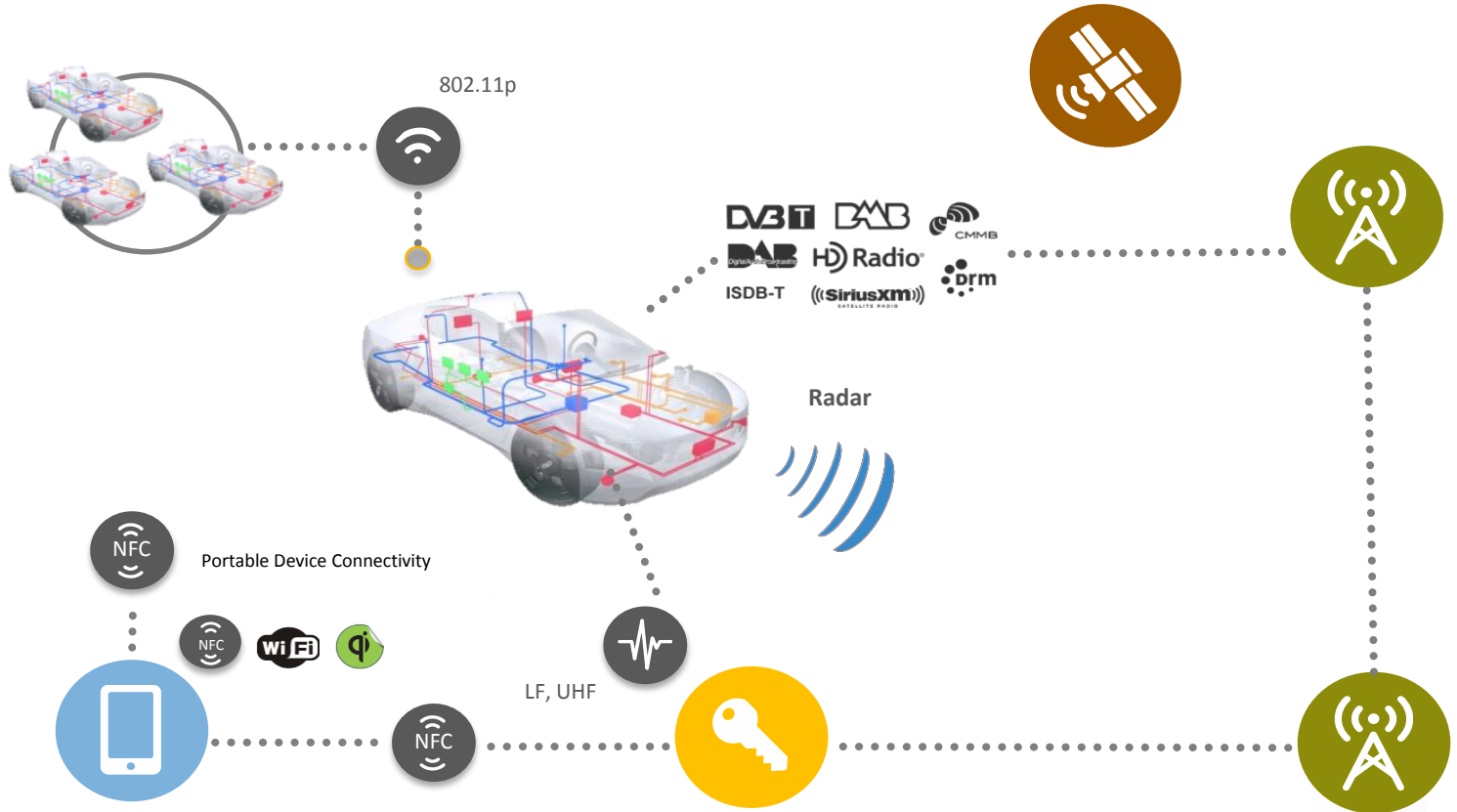 - Cooperative rather than autonomous

Contents

- Introduction

- Wireless in automotive: an NXP view
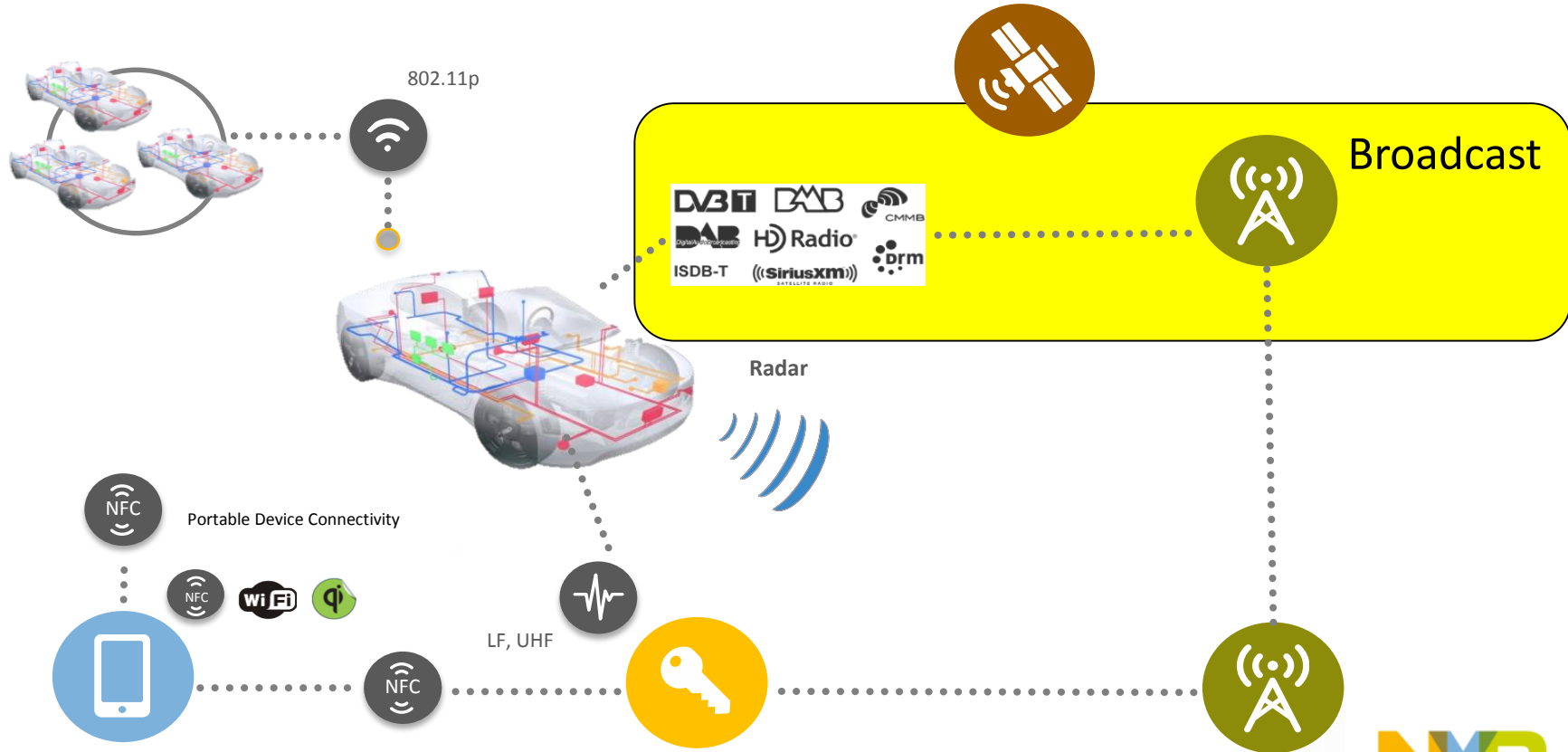 - Broadcast
  - V2x
  - Radar

- Vision and conclusions

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Wireless in automotive: where NXP plays today

802.11p

DVB-T DMB CMMB
DAB HD Radio DRM
ISDB-T SiriusXM SATELLITE RADIO

Radar

NFC

Portable Device Connectivity

NFC WiFi Qi

NFC

LF, UHF

NXP

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Broadcast

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Broadcast reception: innovation

- Mature technology, but still room for differentiating the end-user experience
  - Increased coverage

- Technical challenge
 - Achieve the target BER in tough conditions: SNR and multipath

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Compression of Log Likelihood Ratio

Problem statement: support a distributed architecture with low cost and high performance

Distributed reception

- **70% compression at 0.2dB performance loss**
- Distributed reception at low link bandwidth
- Separately quantizing channel and signal information
- Low in VDSP MIPS and no significant latency
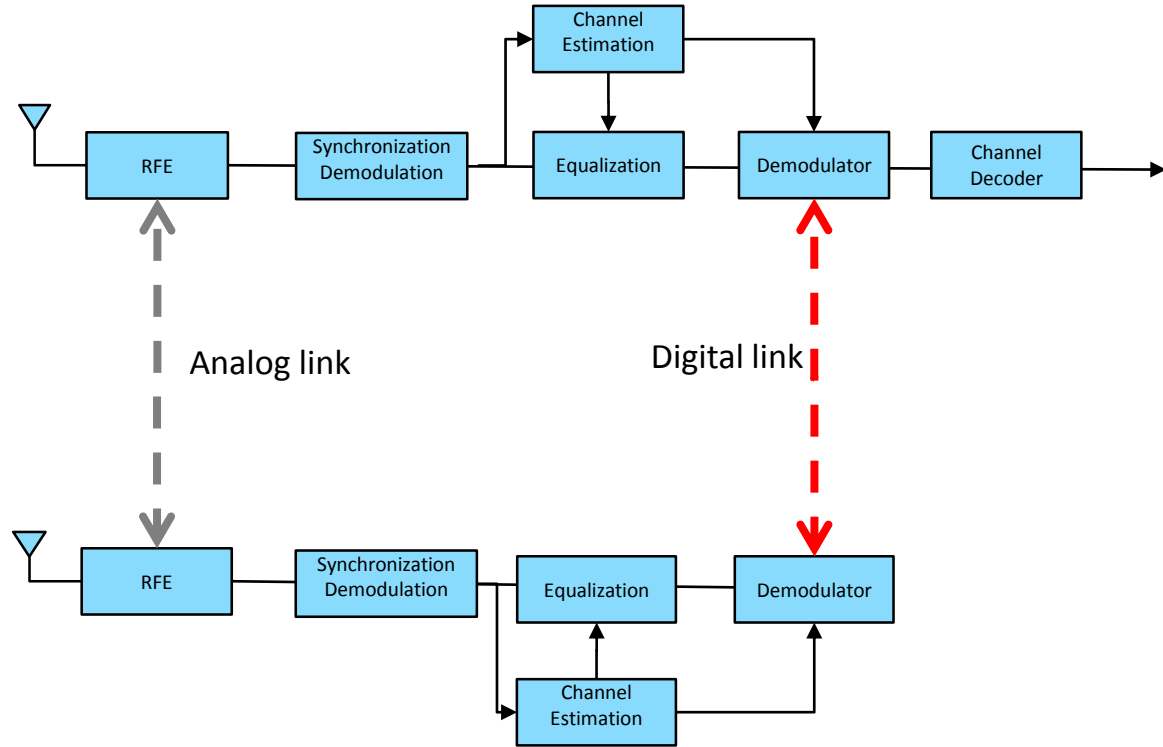
Compression of Log Likelihood Ratio

DAB time deinterleaver memory reduction

- 20% deinterleaver memory reduction at no performance cost
- Use non-uniform quantization (saturation at reliable levels).
  - Max/min values and low magnitude LLRs should be disturbed less
  - 1 bit saving wrt conventional uniform quantization approaches.
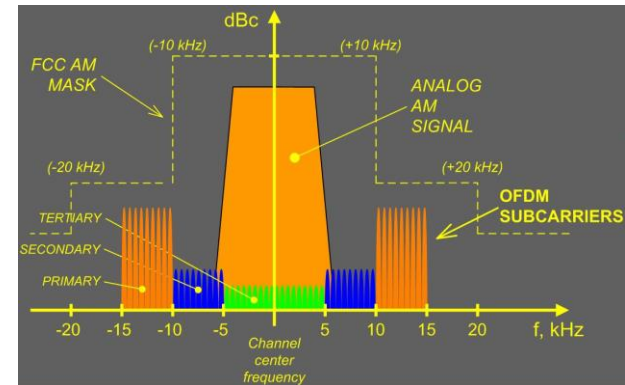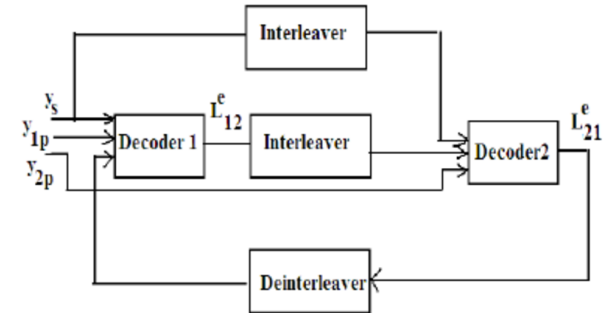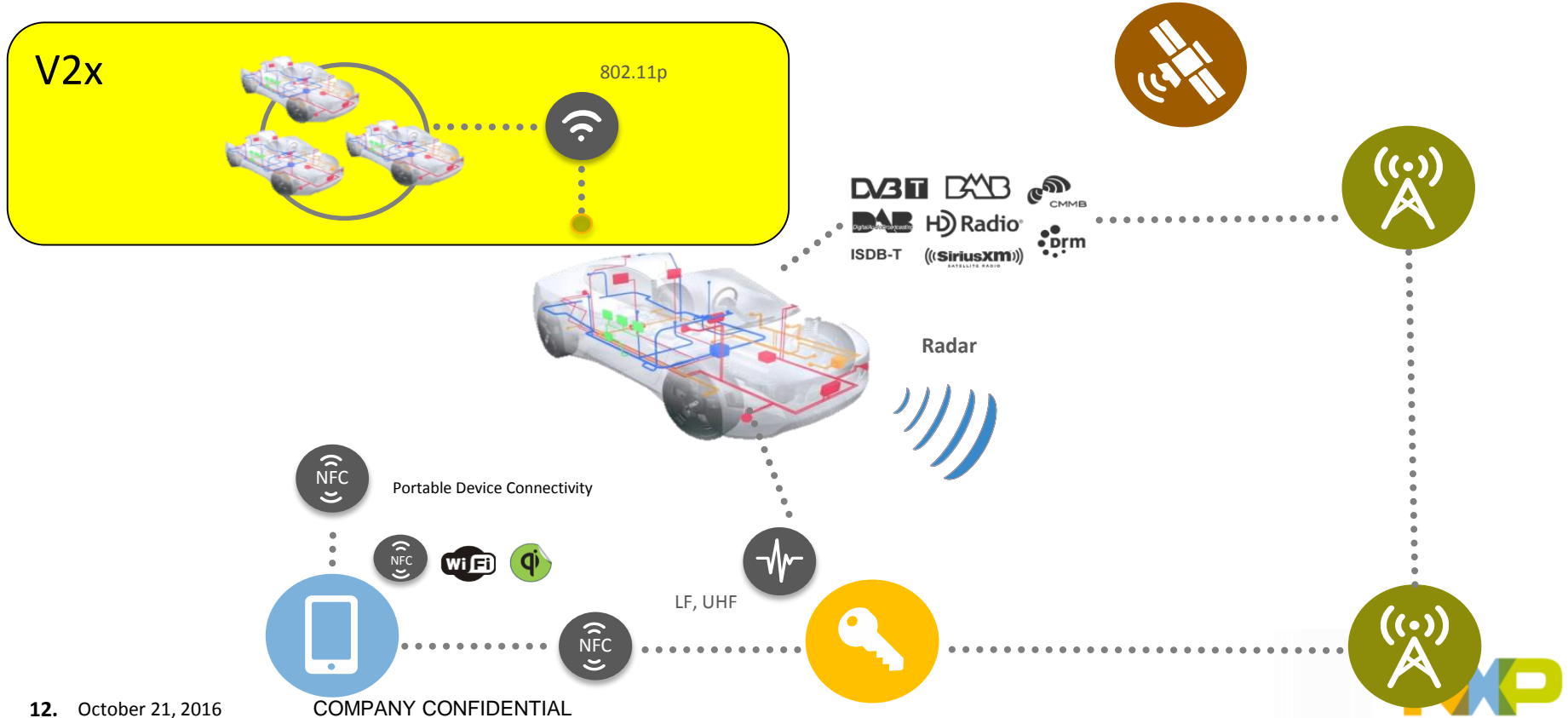 - Simple LUT based conversion
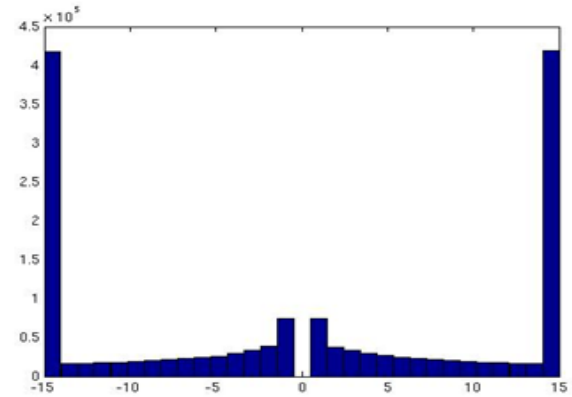
TU-6 channel
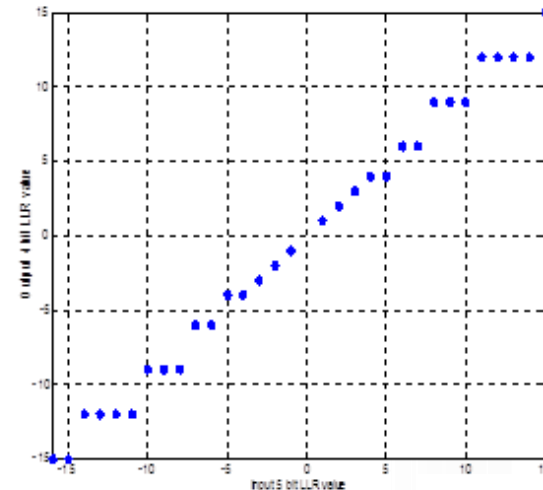
Broadcast reception: next innovation steps

- Interaction between Viterbi and Reed-Solomon decoder

- Iterative decoding with limited resources
  - Compress the I/Q sample?

- Interference management for in-band standards

Wireless in automotive: where NXP plays today
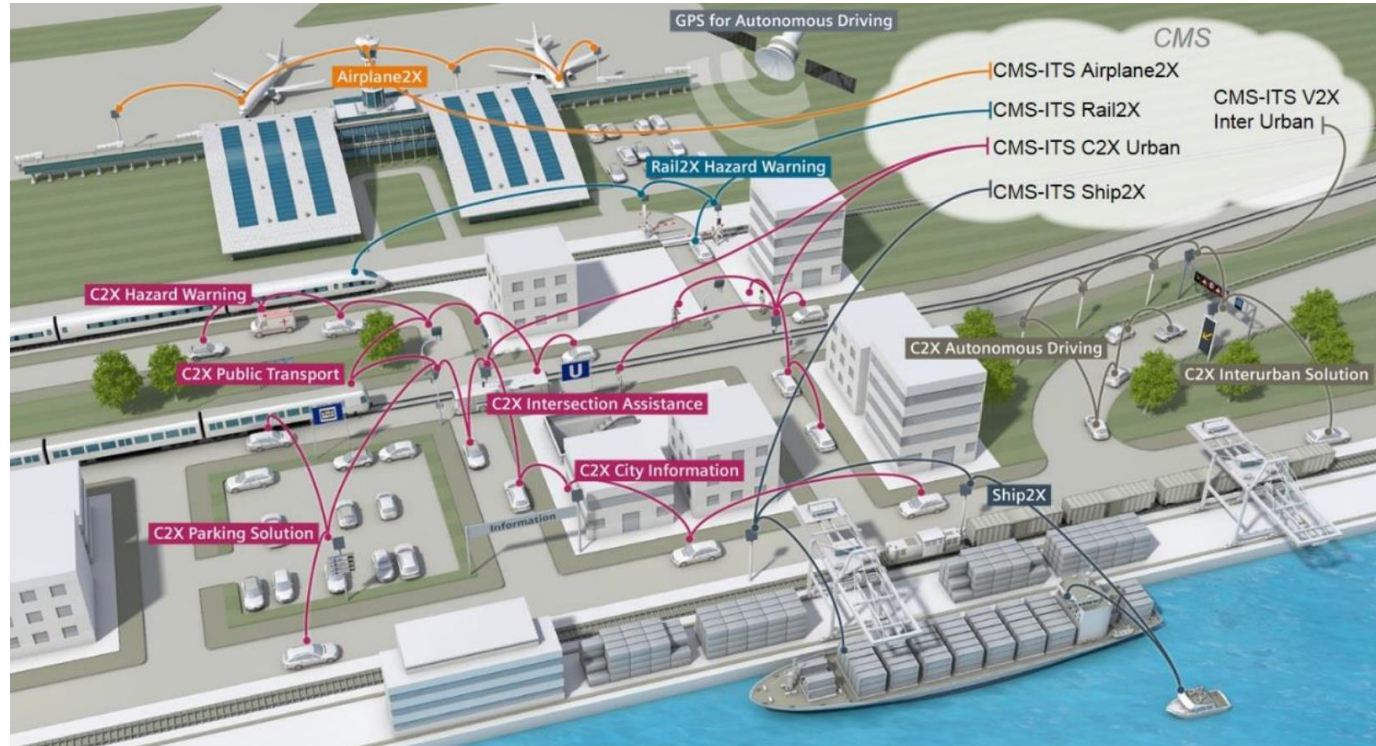

V2x

802.11p

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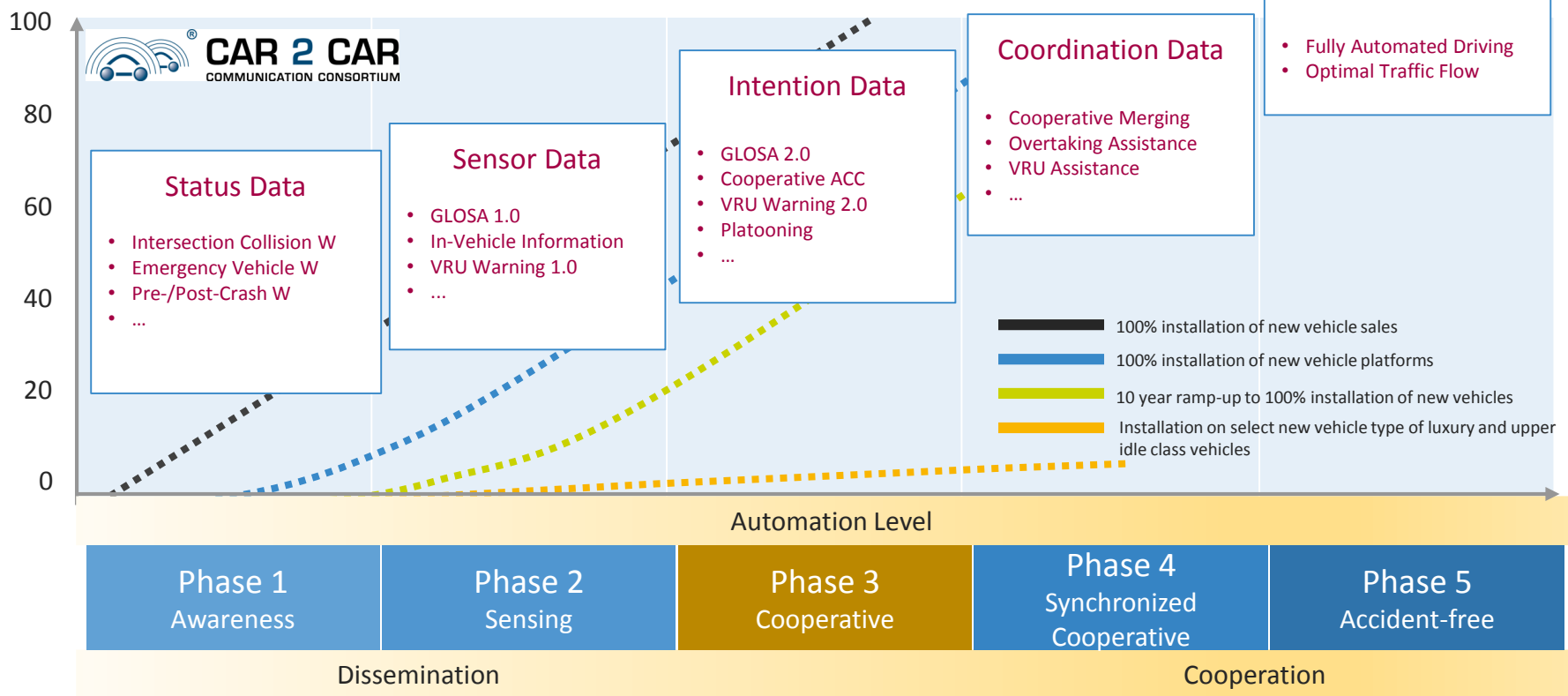October 21, 2016   COMPANY CONFIDENTIAL

Cooperative Intelligent Transport System (C-ITS)

- *Cooperative Intelligent Transport System (C-ITS)*

- *Communicating vehicles and infrastructure*

- *Vehicles can be cars, airplanes, trains and ships*

- *The Central traffic Management System (CMS) manages the C-ITS*

V2X Roadmaps – Applications

Take-over of the driving function
- Fully Automated Driving
- Optimal Traffic Flow

Coordination Data
- Cooperative Merging
- Overtaking Assistance
- VRU Assistance
- …

Intention Data
- GLOSA 2.0
- Cooperative ACC
- VRU Warning 2.0
- Platooning
- …

Sensor Data
- GLOSA 1.0
- In-Vehicle Information
- VRU Warning 1.0
- …

Status Data
- Intersection Collision W
- Emergency Vehicle W
- Pre-/Post-Crash W
- …

CAR 2 CAR
COMMUNICATION CONSORTIUM

100% installation of new vehicle sales
100% installation of new vehicle platforms
10 year ramp-up to 100% installation of new vehicles
Installation on select new vehicle type of luxury and upper idle class vehicles

Automation Level

| Phase 1 Awareness | Phase 2 Sensing | Phase 3 Cooperative | Phase 4 Synchronized Cooperative | Phase 5 Accident-free |

Dissemination   Cooperation

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V2X communications

Extend sensing beyond own vehicle and beyond line of sight

Motorcycle approaching / „do not pass!"

MOTORCYCLE APPROACHING!

Roadworks beyond line-of-sight

ROADWORKS AHEAD!

802.11p required for Safety-critical V2X features

- Providing additional safety data earlier than any other sensor can „see"

- Low latency
- Secure
- Beyond-line-of-sight
- Ad-hoc network
- 7 channels of dedicated licensed spectrum

Platooning / cooperative driving
5m gap @ 80km/h based on 802.11p low latency

JOINING PLATOON

HEAD OF TRUCK PLATOON

Emergency vehicle around corner

EMERGENCY VEHICLE APPROACHING

V2x communications: Innovation

- Mature technology, new market

  - We are very close to start deploying 802.11p for V2x
    - After 10 years of testing and investments, we are ready to save lives!

  - The cellular community is undergoing the 'next-generation' cycle
    - Everybody talks about the next generation: 5G
    - Lots of claims, lots of confusion, little facts
    - Ambition is to cover everything: automotive, low power IoT, …

  We do not want the claims of the cellular community to jeopardize the societal benefit of V2X

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Why 802.11p beats LTE and 5G for V2x. Because …

… 802.11p supports all Vehicle to Vehicle use cases with their unique application requirements: No network and low latency. Cellular technologies don't.

802.11p

- Originally designed for these applications
- Licensed allocated resources
- Ready and validated: 10 years of fields trials
- US mandate is expected soon
- Unique functional safety and security requirements

Cellular technologies: LTE and/or 5G

- Never dealt with these application requirements before
- They do not support them
  - V2x study group in 3GPP
- Niche market with tough requirements
- The will surely be able to, but it will take time

Future of V2X

802.11p and cellular

	802.11p	Cellular		802.11p + Cellular
Operation in absence of network	🟩	🟥		🟩
Support of V2V	🟩	🟥		🟩
Support of safety-critical use cases	🟩	🟥		🟩
Support of multimedia services	🟧	🟩		🟩
Support of V2I/I2V	🟧	🟩		🟩
Network coverage	🟥	🟩		🟩
Advanced PHY	🟥	🟩		🟩

Leverage on

- the gaining momentum of DSRC/802.11p
- the increased interest of the cellular community for DSRC applications

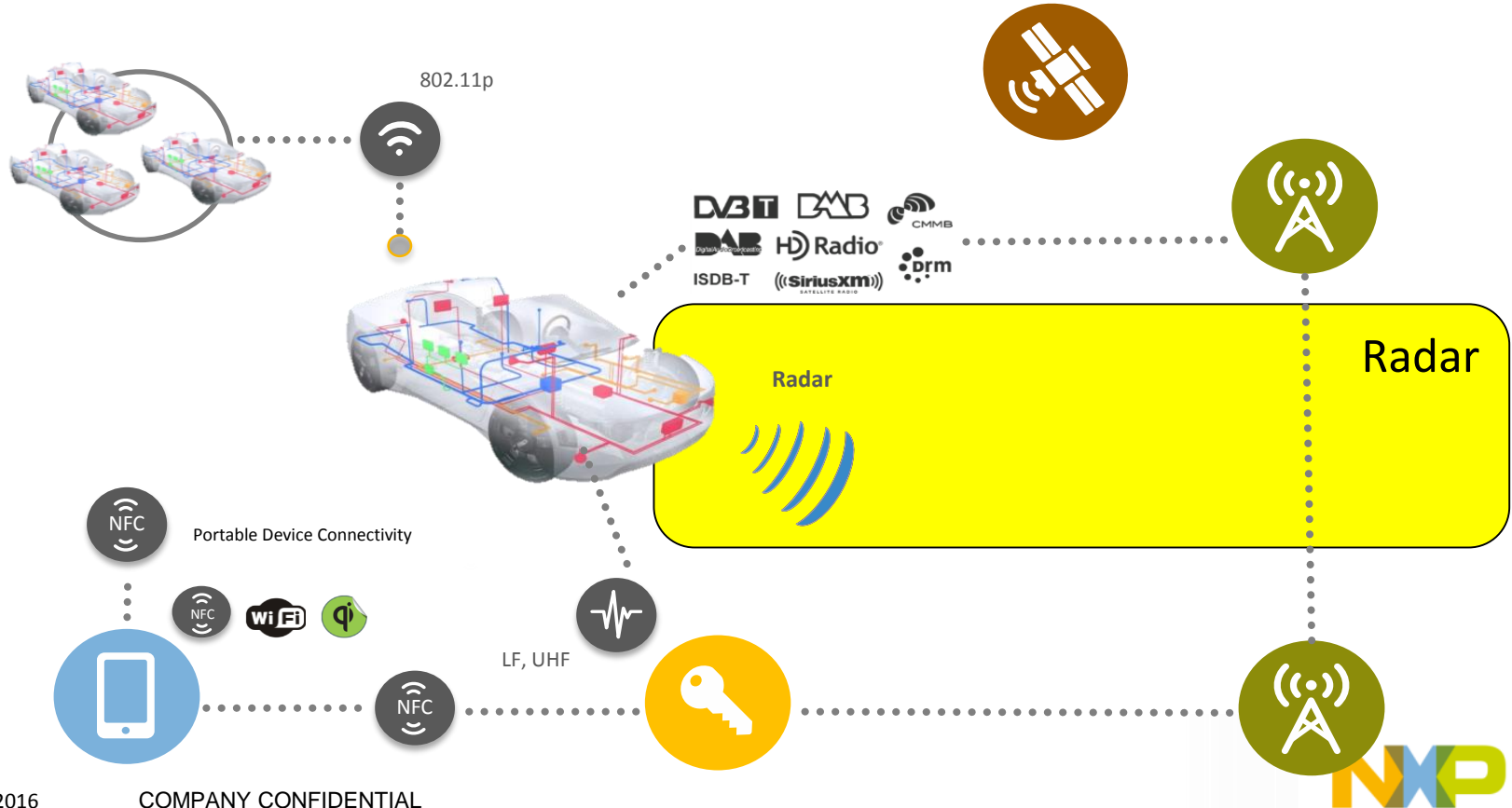to build a sustainable future for V2X by combining the best of 802.11p and cellular (HetVEN)
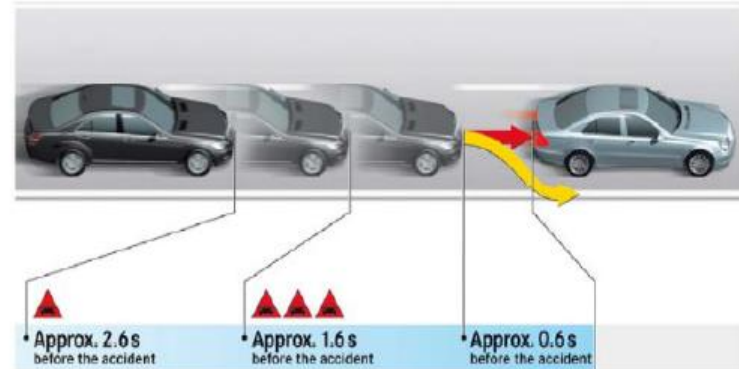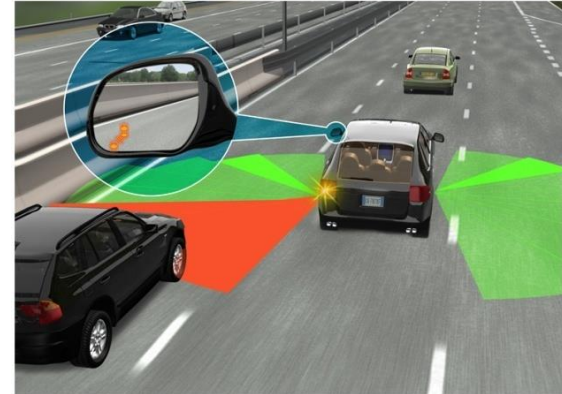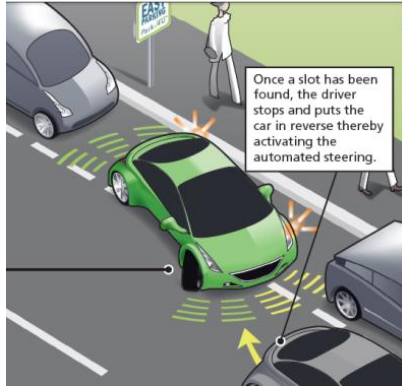
V2x: next innovation steps

- Address known shortcomings of the technology
  - Distributed Congestion Control (w TUe)

- Next generation 11p standard (w TUe and NTU)
  - Match the efficiency of modern communications technologies: shaping gain/Cooperative communications
  - 11p and 5G

- Precise positioning (NTU)
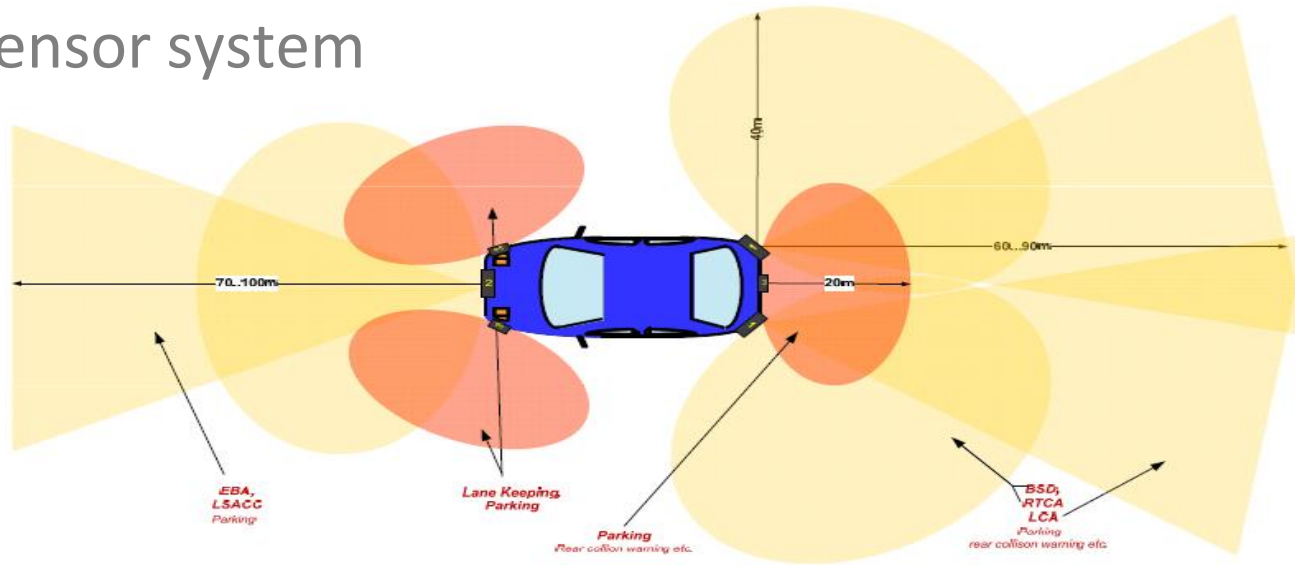
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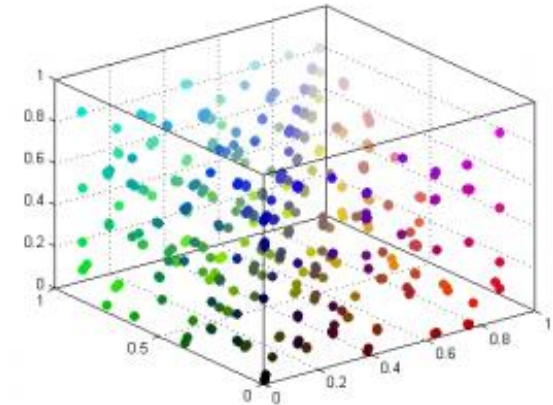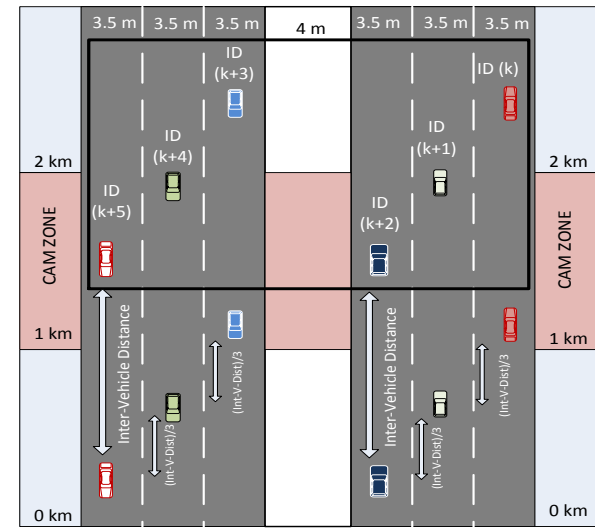
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Automotive radar: safety and comfort

Once a slot has been found, the driver stops and puts the car in reverse thereby activating the automated steering.

- Approx. 2.6 s before the accident
- Approx. 1.6 s before the accident
- Approx. 0.6 s before the accident

Radar Sensor system

- Multiple sensors per car, different field of view, sensor fusion

- Trade-offs in maximum range, resolution and antenna design

- Complementary technologies: Camera, LIDAR, ultra-sonic.

  - Robust (weather, light)

  - Direct distance and speed measurement

  - Invisible integration

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Data in real life

Reference receiver chain

- Range
- Velocity: A/B measurements
- Angular: Multi antenna support, and super-resolution
- Clustering and ego-motion estimation
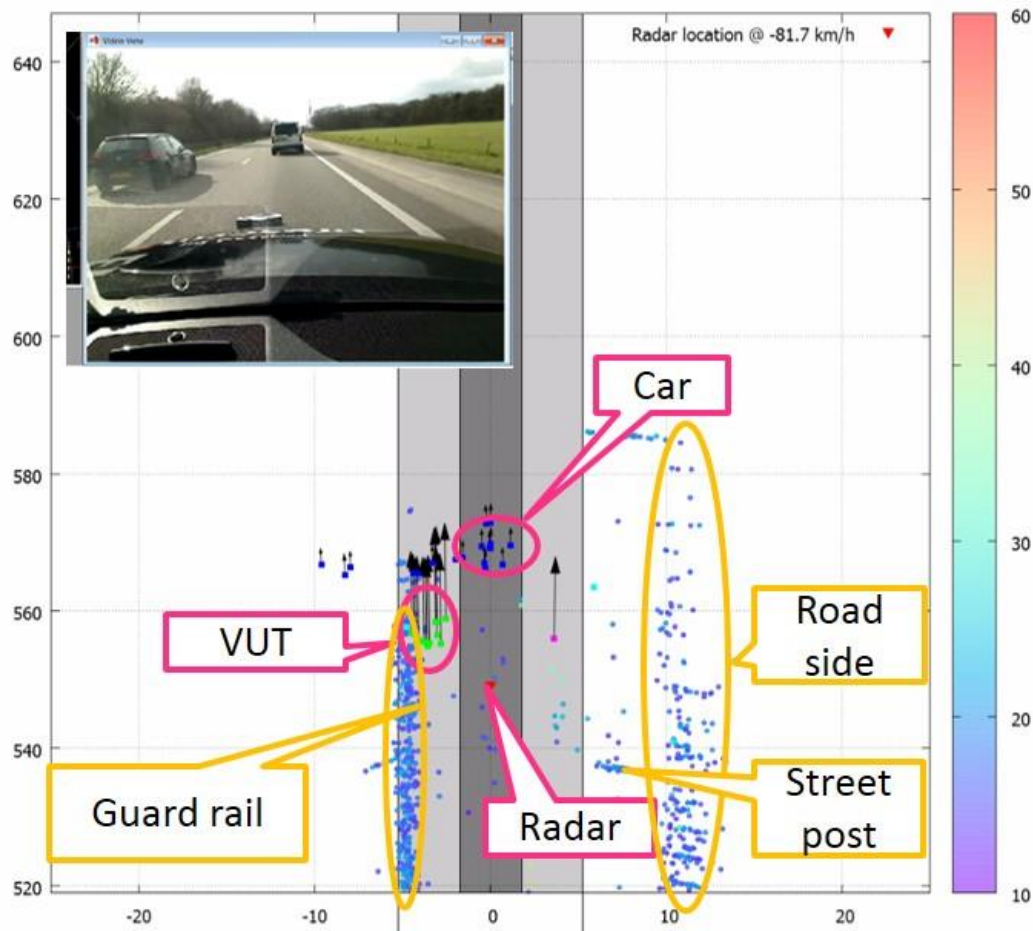
Target list visualization: snapshot

- Split between moving and still standing detections

- Radar position updated according to estimated ego-motion and measurement time

- Road edges clearly visible

- Some errors in
  - DOA estimation
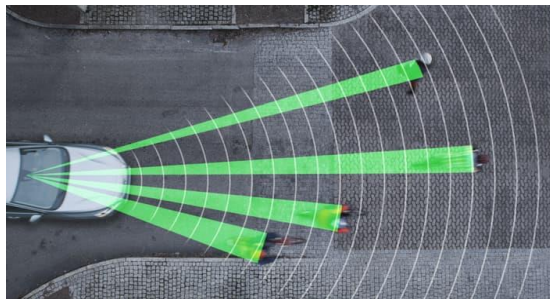 - Velocity ambiguity

Radar signal processing: next steps

The next generation automotive Radar waveforms

- Today: FMCW is the de-facto standard radar waveform
- Tomorrow: ?

High resolution radar

Toward lidar-like performance
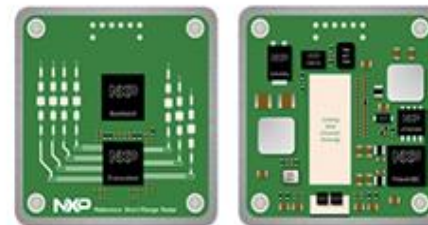
High density radar

Highly integrated, distributed

Cocoon Radar
Parking, Blind Spot Detection, Cross Traffic Alert, Emergency Braking, ...

Increase resolution

- Space, velocity, range

Interference management

- Interference mitigation: MAC protocols (standardization)
- Synchronization over the air of multiple units
- Embed information in the radar waveform

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Wireless connectivity for Automotive

- Societal benefits: "Road to Zero"

- Autonomous cooperative driving
  - Pro-actively share information among actors
    - Data: Sensor (radar) data, vehicle data
    - Technology: V2x, V2x + cellular
  - System view

- Innovation in wireless technology
  - Combine radar and communications (iCAVE)
  - In-band full Duplex
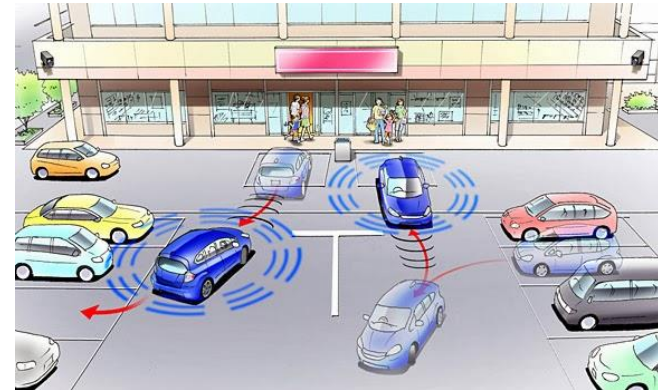
Conclusions

- Wireless vehicle-to-vehicle communications is at the heart of automotive

- Key technical differentiators are extremely important for our business
  - Industry + Academia is a win-win construction
    - Academia: deep theoretical understanding
    - Industry: problem formulation (broadcast, V2x, Radar)

- There's so much exciting work ahead of us!

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