3GPP TSG-RAN Meeting #80
La Jolla, USA, June 11th – June 14th, 2018

RP-181117

Minimum requirement of 2Rx antennas for permanently mounted UE in vehicles for NR

Volkswagen Infotainment

Introduction

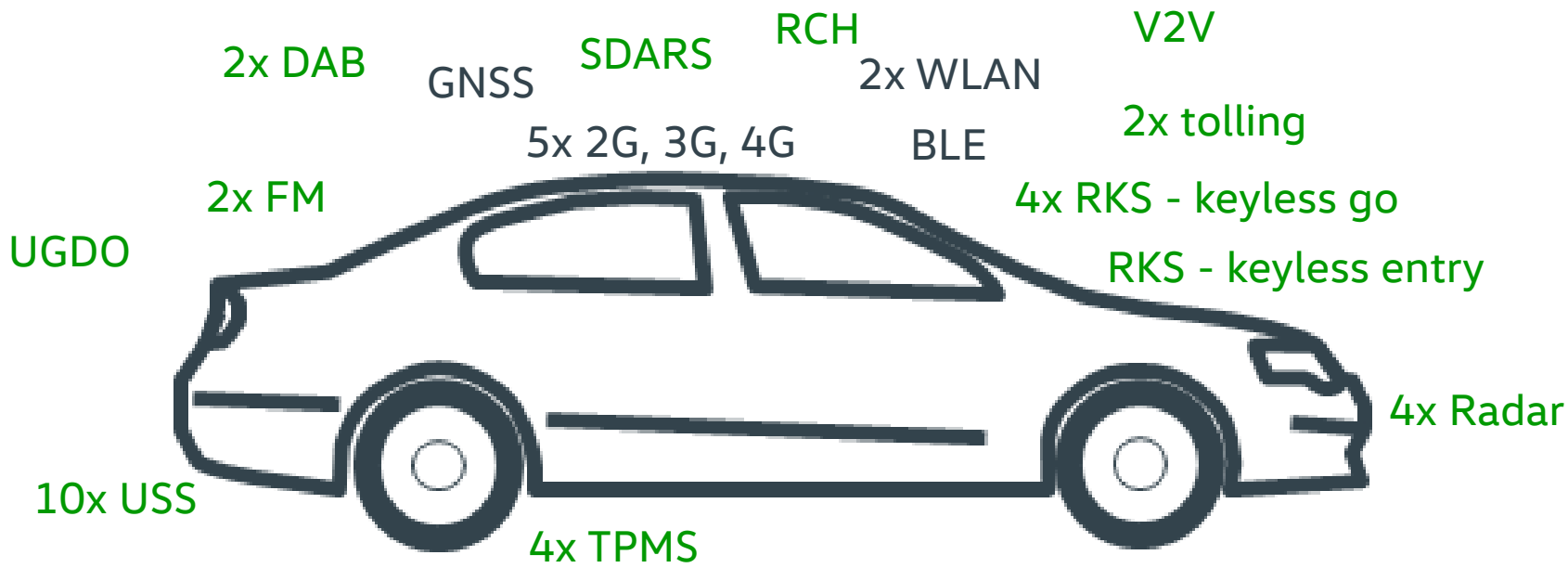
- RAN #78 endorsed the 4Rx antenna mandate for NR UE (RP-172788).
- This requires UE supporting the NR bands n7, n38, n41, n77, n78 and n79 to be equipped with 4Rx antennas.
- As a consequence TS 38.101 demands 4Rx antennas for these band in the “Reference sensitivity power level” requirements.

- The automotive industry understands the reasons to require 4Rx antennas for handhelds but the rationale to mandate 4Rx antennas also for permanently mounted UE in vehicle is not comprehensible:
  - The performance of vehicular mounted antennas differs from handheld antennas.
  - The mounting of antennas on vehicles underlies much more restrictions than handhelds have.
  - Compared to handhelds the implementation of connectivity systems consist of separate antenna modules, cables and communication units.

Radio technologies of current car models

(depending on feature list; incl. max amount of antennas)

More than 15 different technologies require antennas
-> Antenna mounting space is valuable



Technologies special to automotive industry

RCH: remote controlled heating

UGDO: universal garage door opener

TPMS: tire pressure monitoring

USS: ultrasonic sensors

RKS: remote keyless system

Restrictions of car mounted antennas

Extended reliability requirements:

- Operating range -40°C to 105°C
- Rapid changes of temperature
- Waterproofness
  -> Each additional opening in chassis needs to be avoided.
- UV resistance
- long-term durability >15 years

Complexity of car mounted antennas

Special conditions to be met:

- Automotive production requires antennas to be realized as a separate module.
  -> Modules need to be equipped with automotive graded RF components and connectors
  -> Adds design, assembly and reliability complexity.
- Antenna radiation should not direct into the vehicle.
  -> Antennas need to be mounted on the outer shell of the vehicle.
- Chassis made of metal require antennas to be mounted outside of the body sheet to get an almost omni-directional pattern.
  -> Mainly monopole antennas can be used with a dominant vertical polarization.
- Design constraints of brands and for certain models require antennas not to be seen
  -> Alternative antenna concepts need to be used which require more space and are less effective.
  -> Adds complexity because of limited mounting space.

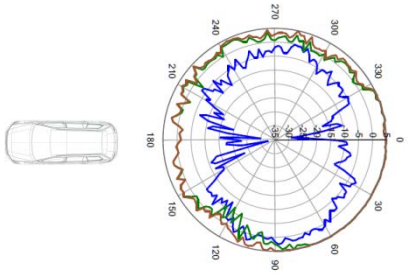
Implementation of connectivity systems in vehicular environments

- Center of connectivity systems is the TCU (Telematics Control Unit, be aware of alternative naming among companies).
- Packaging or regulatory constrains (e.g. eCall) can require the mounting of the TCU inside the vehicle's interior.
- Mounting positions of the TCU inside the interior always require RF cables to connect the antennas mounted at the outer shell.
- RF cables introduce restrictions in the installation in terms of bending and feedthrough.
  -> Can lead to long cable lengths and complexity in cable routing. This implies unbalance antennas systems.
- Sometimes it is required that the system must maintain basic functionality after the event of crashes to ensure emergency calls.
- Due to service separations (car oem services vs. user services) the use of two separate TCU can be required.
  -> This leads to a double amount of antennas that need to be placed.

One example for positioning of cellular antennas

Roof antenna:

Gain:	3 dBi
Cable length:	2 m
Overall gain:	1 dBi

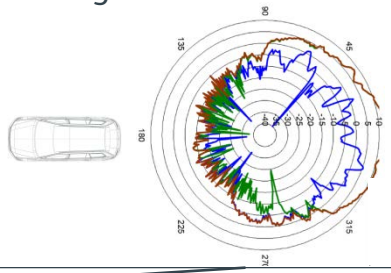


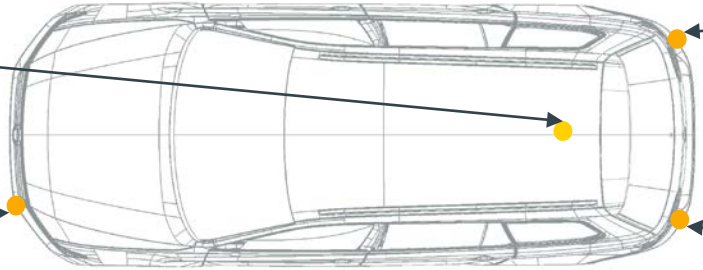
- Frequency: 2500 MHz
- Typical automotive graded RF cable
- Cable lengths apply to mid-sized car

- Polarization: horizontal
  vertikal

Bumper antenna:

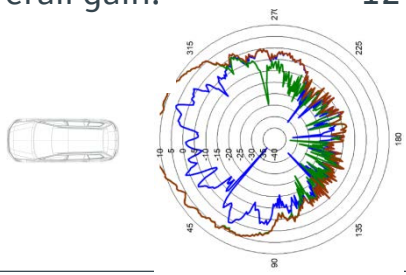
Gain:	-4 dBi
Cable length:	3m
Overall gain:	-7 dBi





Bumper antenna:

Gain:	-4 dBi
Cable length:	8m
Overall gain:	-12 dBi

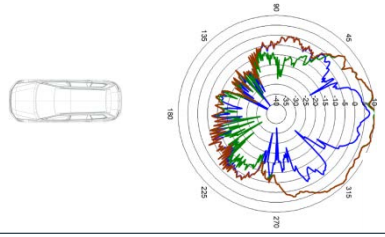


Calculation:

Average gain (in areas relevant for mobile communication)
- Cable loss
= Overall gain

Bumper antenna:

Gain:	-3 dBi
Cable length:	3m
Overall gain:	-6 dBi



Positioning of cellular antennas

NOTE: The positioning of antennas differs from brand to brand, model to model and even from model feature list to model feature list.

- The previous slide shows, that a roof antenna module can give up to 1dBi. This is much better than current handheld antennas can provide.
- Alternative antenna positions generate less omni-directional but more directional radiation patterns.
  -> Unbalanced antennas system: Contribution to MIMO or diversity reception is hard to achieve for some directions.

Coverage and Performance aspects

RAN4 did an analysis of the impact of using 2Rx antennas instead of using 4Rx antennas on the coverage and performance of the 5G system.

To our understanding this analysis always considered antennas of handhelds. Antennas in handhelds can be considered as co-located instead of distributed like in vehicles.

Analysis of antenna performance in handhelds needs to consider human body losses (e.g. head / hands).

> In contrast to this vehicular mounted antennas are not close to human bodies, so body losses don’t apply.

For a coverage analysis a significant amount of indoor handheld usage needs to be considered. This adds propagation losses of the buildings to the link.

> In contrast to this vehicles are dominantly operated outdoor, therefore no building losses apply.

Summary

- We believe that the conclusion to mandate 4Rx antennas for NR UE is based on assumptions that are not applicable to UE permanently mounted in vehicles.
  - Antenna gains, gain imbalance and radiation patterns are different from handhelds
  - Body losses don‘t apply for vehicles
  - Building losses don‘t apply to usage scenarios

- The automotive industry would like to have the freedom to equip 4Rx antennas only when the complexity of implementation in vehicles can be justified by the performance improvements of the overall system.

- 3GPP RAN is kindly asked to allow 2 RX antennas as an option for permanently mounted UE in a vehicle (vehicular UE).

Thank you