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Deliverable

D8b.2

System parameters for automotive environment applications

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Abstract

This document specifies the system parameters for the EUWB automotive environment applications, as described in the deliverable D8b.1.

Keywords

Automotive, Location Tracking, Intrusion, UWB, Antennas

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Abbreviations

EUWB	CoExisting Short Range Radio by Advanced Ultra-WideBand Radio Technology
BER	Bit error rate
ECU	Electronic Control Unit
AOA	Angle of arrival
TDOA	Time delay of arrival
RCS	Radar Cross Section

1 Executive summary

Based on the applications scenarios for automotive applications, as given in the deliverable D8b.1 [3], system parameters and antenna requirements are specified.

2 Introduction

Three different application classes have been identified the deliverable D8b.1 [3]:

- Data transmission
- Location tracking
- Intrusion detection

The functionality for each of these application classes is based on a distinct type of UWB hardware. The following sections describe the system parameters required to fulfil the application scenarios, without divulging further into the specifics of the hardware needed.

Additionally, antenna requirements for each application scenario and placement options are described.

3 Data transmission

Within the scope of this project, data transmission is limited to the communication of a sensor or remote control unit to a central electronic control unit (ECU). The ECU typically is located within the engine compartment or in the dashboard of the passenger cabin.

Three different application scenarios have been identified in the application scenario document [3]:

a) Communication inside the passenger compartment.
The ECU is typically located in the dashboard. However, the antennas need to be placed in a way to accommodate the propagation channel. The channel can vary with passenger position or passenger cabin loading.

b) Engine compartment communication.
The antennas will typically be integrated with the ECU or the wirelessly connected sensor node. Several node locations (up to 5) within the engine compartment close to the metallic structures can operate simultaneously. Time variance of the channel is expected to occur when the motor is running. Apart from the motor vibrations, moving parts inside the engine compartment are the cooler fan and the power train.

c) Outside of the car, positioned at wheels or axle.
This is used to measure physical values like temperature or pressure while driving. The sensor is typically located at places with increased shielding from the engine compartment.

The required data rate, latency and bit error rate (BER) is given in Table 1:

Table 1: Data transmission parameters for the different scenario classes

Scenario class	**Data rate**	**latency**	**BER** [1]
a)	125 kbps	50ms	CAN: 1e-9
b)	500 kbps	5ms	CAN: 1e-9
c)[2]	250 kbps	2ms	CAN: 1e-9

1 This is the BER for the existing wired solution CAN bus. CAN bus latency best case 47us (however not guaranteed)

2 This scenario is not within the scope of EUWB and is included for information only

4 Location Tracking

For location tracking, operation inside and outside of the car can be differentiated. For in-car operation, the location needs to be update more often and the accuracy requirements are higher, compared to the outside tracking functionality. The required accuracy is derived from the requirement to discriminate between inside and outside of the car enclosure and detection on which seat the tag is located.

For location tracking outside of the car, the basic functionality is to detect an approaching person and to unlock the car when the person is in close proximity.

Table 2 list the important system parameters for location tracking:

Table 2: Location tracking parameters

Parameter	Value	Comment
Discovery time	100 ms	"Wake-up time": time until active tag is detected (without tracking during this state)
Tracking update time inside	50 ms	Time for updating the position at the inside of the car
Tracking update time outside	250 ms	Time for updating the position at the outside of the car
Accuracy inside	+/- 10 cm	
Accuracy outside	+/- 20 cm	
Range outside	<=2 m	
Accuracy discrimination inside/outside	+/- 2.5 cm	
Number of tags	10	Number of tags the system has to be able to locate concurrently

The location tracking has to be capable of coping with changing passenger numbers or loads on the passenger seats. Also, the tag must be tracked even when positioned in the legroom.

From previous investigations, it was found that because of the high multi-path channel environment inside a car, distance information (e.g. TDOA) is not enough for tracking, when using four receiver nodes. Only with additional angular information (e.g. AOA), the valid tracking information could be identified.

5 Intrusion detection

For this application, it is crucial to discriminate between the inside and outside of the car, as this is the main functionality of the sensor. In order to achieve the minimal number of sensor nodes (or antennas), distance and angle measurement are necessary.

Table 3: Intrusion detection parameters

Parameter	Value	Comment
Detection time	250 ms	
Angle range	0..180°	
Angular resolution	10°	
Distance range	0..3 m	Maximum distance inside between sensor and screen
Accuracy discrimination inside/outside	+/- 10 cm	
Sensitivity	0,001 m^2	Minimum radar cross section (RCS) detectable

6 Antennas

6.1 Passenger Cabin

Potential antenna positions for cabin passenger applications are shown in the following figures. The mounting position shown in Figure 1 uses the rear view mirror and the canopy.

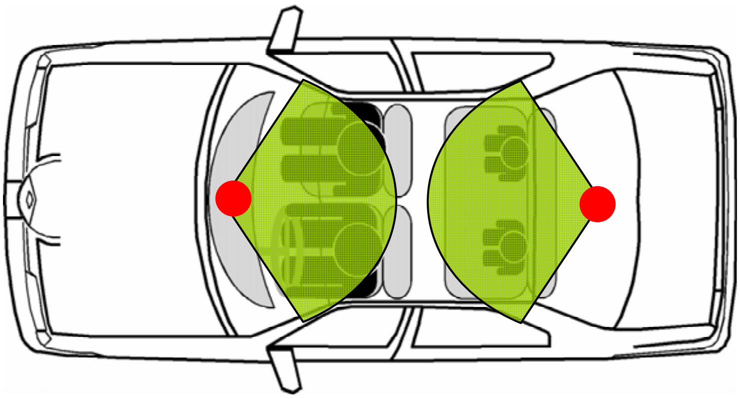

Figure 1: Antenna mounted in front and back

In Figure 2, the antenna is mounted centrally in the canopy and covers the whole hemisphere below.

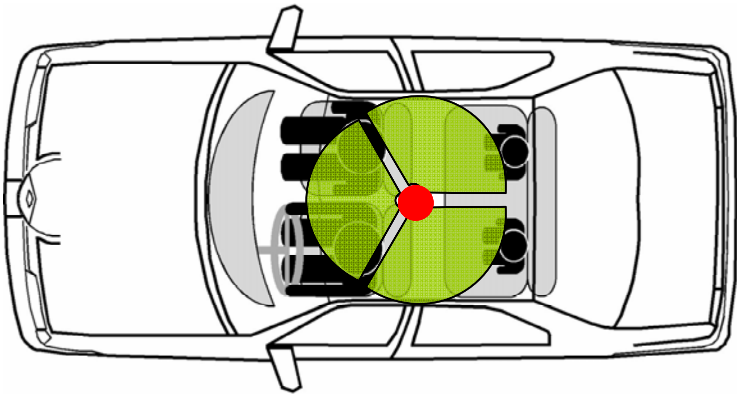

Figure 2: Antenna mounted in the canopy

Figure 3 shows the antennas mounted at the side pillars of the car. By using 6 antennas a overlapping coverage of the interior can be achieved.

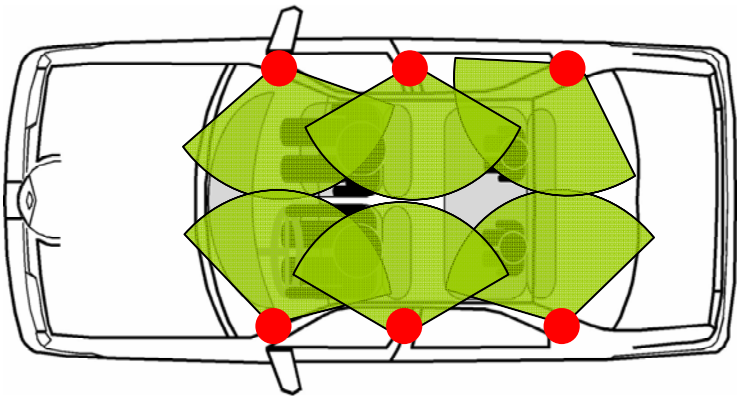

Figure 3: Antenna position in A, B and C pillars for passenger cabin applications

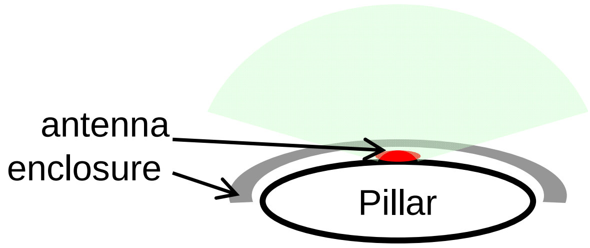

Figure 4: Antenna mounting at pillar

The antennas can be mounted between the steel pillar and the plastic enclosure, as shown in Figure 4.

Table 4: Antenna parameters for passenger cabin coverage

Parameter	**Value**	**Comment**
Beamwidth (elevation)	120°	Coverage of legroom
Beamwidth (azimuth)	120°	
Polarization	vertical	
Frequency range	6-9 GHz	depending on exact hardware used
Input match	< -10 dB	
Size	5 x 10 x 2 cm	width x height x thickness
Feed	single ended	SMA coaxial connector

6.2 Around car

To cover the area directly around the car, an antenna configuration as shown in Figure 5 can be used. Here only the door coverage is relevant. This might be achievable using the same antennas from section 6.1, as the exhibit some backward radiation also.

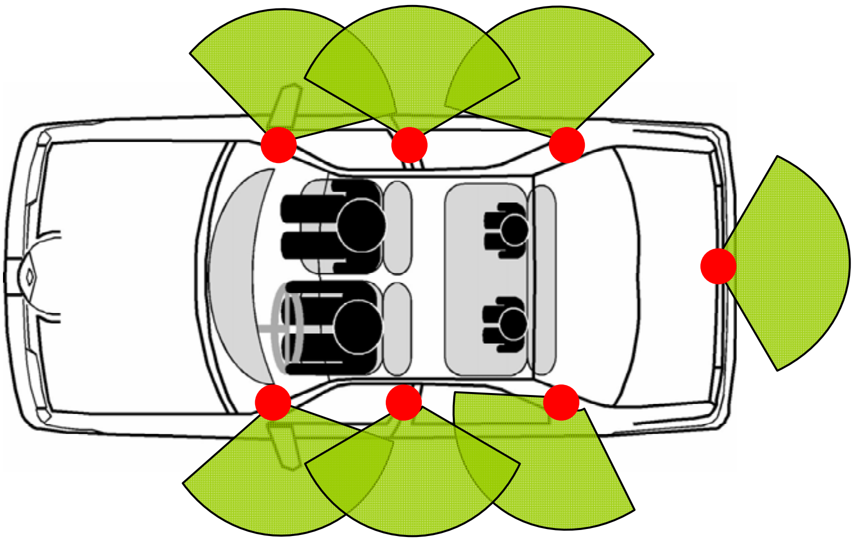

Figure 5: Antenna positions for door coverage

6.3 Engine compartment

For the engine compartment, no separate antenna infrastructure is envisioned. Instead, small omni-directional antennas are mounted directly at the ECU and the sensor units. Depending on the housing of the component, either a standard SMD mounted antenna can be placed inside the unit itself or an external antenna needs to be mounted on the housing. This would require an additional cable and RF connectors, however.

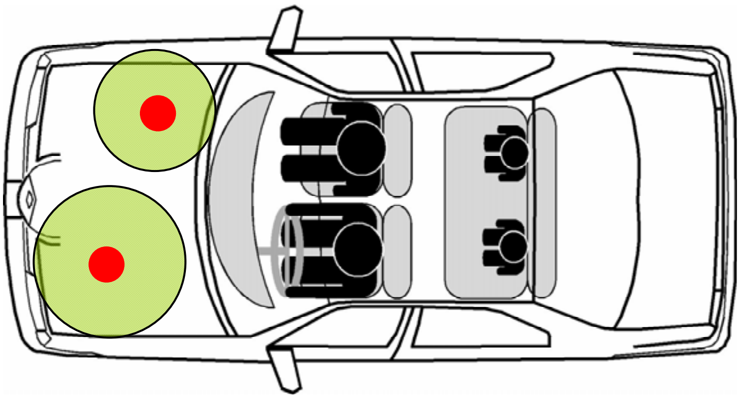

Figure 6: Antennas in the engine compartment

Table 5: Antenna parameters for engine compartment

Parameter	**Value**	**Comment**
Beamwidth (elevation)	90°	
Beamwidth (azimuth)	360°	
Polarization	vertical	
Frequency range	6-9 GHz	depending on exact hardware used
Input match	< -10 dB	
Size	2 x 2 x 2 cm	width x height x thickness
Feed	single ended	SMA coaxial connector

7 Conclusions

References

[1] Zeisberg, S., Schreiber, V.: “EUWB - Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Technology”, ICT Mobile and Wireless Communications Summit, Stockholm, June 2008, accepted for publication
[2] URL of EUWB consortium: http://www.euwb.eu
[3] Application Scenario Description, EUWB Deliverable D8b.1

Acknowledgement

The EUWB consortium would like to acknowledge the support of the European Commission partly funding the EUWB project under Grant Agreement FP7-ICT-215669 [1],[2].