ASECAP

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5 GHz RLAN studies, TTT---
Impact on road tolling infrastructure

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ECC Report

Compatibility studies related to RLANs in the 5725-5925 MHz band

SE24-M74 Meeting **M74_04R0_SE24**

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Status:	**For consideration**
Subject:	**5 GHz RLAN studies, TTT**

Summary:

This document presents compatibility analyses for the 5 GHz RLAN on TTT at 5.9 GHz.

Proposal:

SE24 is invited to review these analyses and include the results in the 5 GHz RLAN report.

Background:

5 GHz RLAN studies.

1 Considerations for coexistence between 5 GHz RLAN systems and TTT systems

1.1 Introduction

SE24 have initiated studies on the potential coexistence of 5GHz RLAN and ITS systems. This report presents results from the first initial studies with TTT systems as victims of interference. The studies are based on MCL calculations.

In this report realistic worst-case scenarios that reflect the effect of interference in victim receivers were analyzed. Even if the probability is low for a 5 GHz RLAN transmitter to be placed close to a TTT system, there must be a guarantee that the TTT systems work properly. In road toll-based TTT systems, thousands of vehicles pass by the toll gate every hour and each vehicle needs to complete a successful transaction using the TTT system.

SE24 decided to start with interference analysis from the new proposed 5 GHz RLAN systems to other existing radio services. Studies with 5 GHz RLAN systems as victims will be carried out later.

The initial studies are focus on in-band interference. Further studies will also be necessary to study out-of-band scenarios including unwanted emissions and blocking.

Only the TTT uplink has been studied as a victim. This is assumed to be the worst case for in-band interference. However, potential interference effects by 5 GHz RLAN on the TTT downlink must also be investigated.

In Italy a special version of TTT is used, defined in ETSI ES 200 674-1 V2.4.1 (2013-05). Interference effects of 5 GHz RLAN on this type of TTT system has not been considered yet, and will also need to be included in future analyses.

In this study we began studies on single interferer scenarios. In subsequent studies, we will be also considering aggregation effects from the presence of multiple interferers.

Antenna parameters for 5 GHz RLAN system with directional antennas and output 33 dBm e.i.r.p are yet not available. Therefore these particular studies are postponed until the antenna parameters information is available.

The MCL studies were made in two steps. Initially the needed separation distance was determined. Because the results showed very long separation distances, the maximum allowed, transmitted output power for the most demanding scenarios was calculated in a second step.

No study on the probability of interference due to duty cycles has been done so far. However the calculated minimum distance can be used as an input parameter for those studies, if they are required.

1.2 General technical parameters

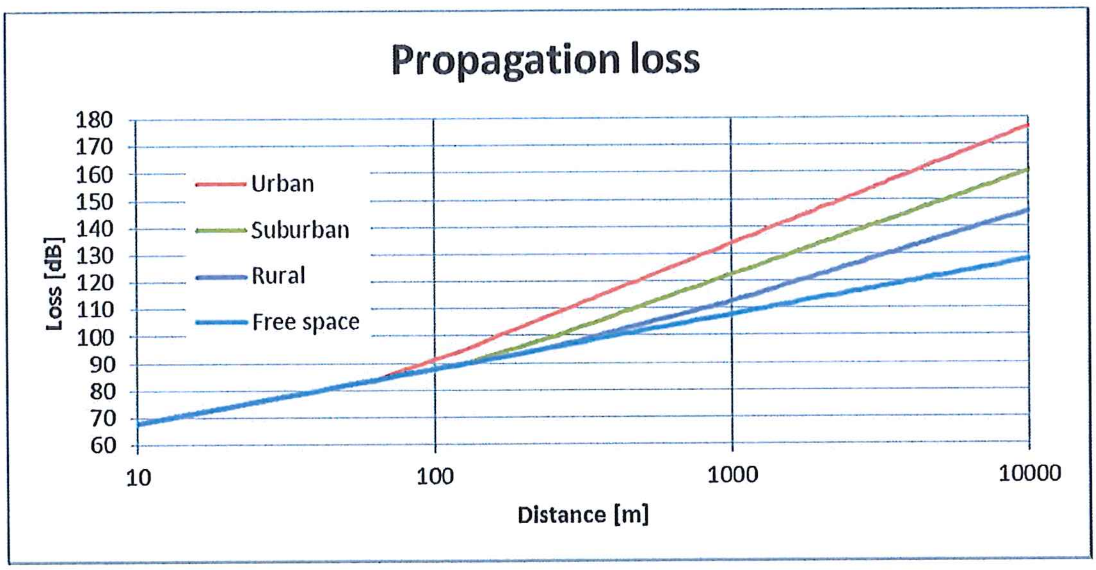
SE24 agreed to the following technical parameters:

Propagation models were taken from the ECC 206 and ECC 210 reports.
A model with two breakpoints as follows:

$$\begin{cases} 20\log\left(\frac{\lambda}{4\pi d}\right) & d \le d_0 \\ 20\log\left(\frac{\lambda}{4\pi d_0}\right) - 10n_0 log\left(\frac{d}{d_0}\right) & d_0 \le d \le d_1 \\ 20\log\left(\frac{\lambda}{4\pi d_0}\right) - 10n_0 log\left(\frac{d_1}{d_0}\right) - 10n_1 log\left(\frac{d}{d_1}\right) & d > d_1 \end{cases}$$

The values of the breakpoints and pathloss factors depend on the environment and are given in the following table.

	Urban	Suburban	Rural	ETSI TR 102- 492
Breakpoint distance d_0 (m)	64	128	256	15
Pathloss factor n_0 beyond the first break point	3.8	3.3	2.8	2.7
Breakpoint distance d_1 (m)	128	256	1024	1024
Pathloss factor n_1 beyond the first break point	4.3	3.8	3.3	2.7



The figure above describes attenuation of the different propagation models.

Loss because of walls with horizontal plane radio communications

10 dB

1.3 Technical parameters of 5 GHz RLAN systems

SE24 agreed to the following technical parameters for 5 GHz RLAN systems:

Frequency range

5150 - 5925 MHz

Bandwidths

20, 40, 80 or 160 MHz

Maximum output power dBm e.i.r.p.

33 dBm with directional antennas

23 dBm with omnidirectional antennas

Antenna polarization

Linear vertical

Antenna height

0,5 to 28,5m (minimum height changed from 1,5 to 0,5 m because of handheld devices)

In this report it is assumed that both RLAN access point to device communication and peer to peer communication are present.

1.4 Technical parameters of TTT systems

Parameters were extracted from [source?].

Frequency range

5795 - 5815 MHz

Channel bandwidth

5 MHz

Receiver bandwidth

500 kHz uplink (road side unit)

200 - 1400 MHz downlink (on board unit)

Receiver sensitivity

-104 dBm receiver uplink (road side unit)

-60 dBm receiver downlink (on board unit)

Antenna gain

13 dBi left circular (10 dBi vert. lin.) antenna uplink (road side unit)

8 dBi left circular (5 dBi vert. lin.) antenna downlink (on board unit)

Antenna side lobe road side difference in antenna gain between main lobe and horizontal direction

-15 dB

Antenna polarization
left circular

Antenna height

2 – 8 m	uplink receiver (road side unit)
1 – 3 m	downlink receiver (on board unit)

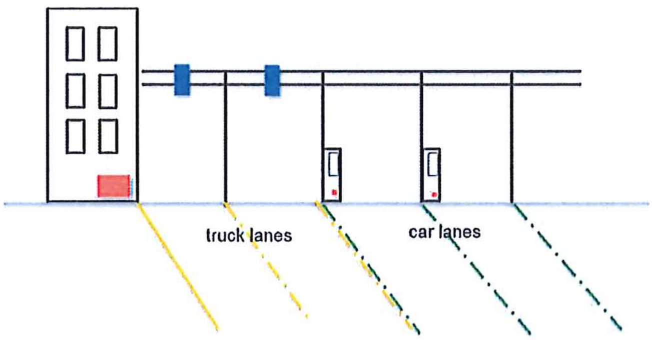
Co-channel C/I (dB)
6 dB

With TTT in Italy, according to ETSI ES 200674, some parameters are different.

1.5 Simulated scenarios

The following scenarios describe realistic, worst-case conditions for TTT as a victim with maximum received interference power.

Scenario A1



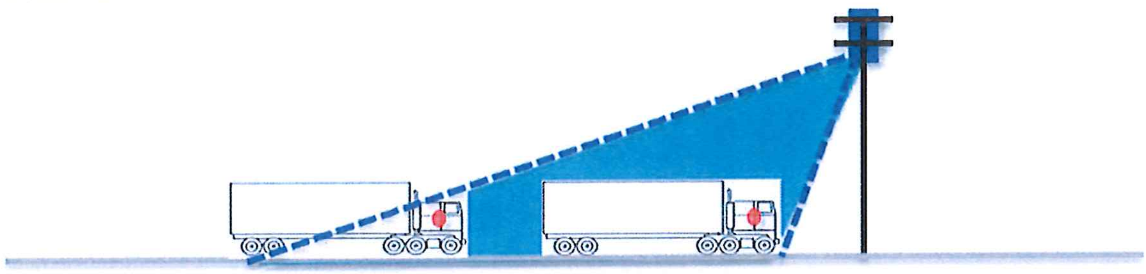
The 5 GHz RLAN transmitter is situated close to the TTT system. The figure above shows an example with a multilane road toll. The 5 GHz RLAN transmitter appears in red and the TTT receivers are shown in blue. In this scenario it is assumed the 5GHz RLAN transmitter, access point or the device, is close to the TTT communication zone, but situated inside a building. The distance between the 5 GHz RLAN transmitter and the TTT road side receiver antenna is assumed to be 4 m or longer.

There are also other possible scenarios, the multilane road toll depicted here is just an example. Other examples could be tolling points within city centres, access point to parking lots, etc.

Scenario A2

This is the same as scenario A1 except that the the RLAN transmitter is situated outside of a building.

Scenario B



Here the 5 GHz RLAN transmitters are found inside the vehicle. If the RLAN device is transmitting within the TTT communication zone, its transmission would radiate through the vehicle window interfering directly with uplink communications to the TTT road side receiver antenna. In the case of a cabriolet or a motor cycle there is no wind screen, which normally reduce transmit power by 3 dB.

1.6 Compatibility between interferer 5GHz RLAN systems and victim TTT, separation distance

1.6.1 Compatibility study scenario A1

Summary: When the 5 GHz RLAN transmitter is placed within a building, below calculations show a required separation distance of up to 425 m between the 5 GHz RLAN transmitter and the victim ITS-vehicle.

Link budget scenario A1		Urban	Suburban	Rural
Emission part: RLAN (20 MHz)				
Bandwidth	MHz	20	20	20
TX out (e.i.r.p.)	dBm	23	23	23
Effect of TPC	dB	0	0	0
Wall loss	dB	10	10	10
Antenna Gain (0 because of e.i.r.p.)	dBi	0	0	0
Net Tx density of power	**dBm/MHz**	**0**	**0**	**0**
Reception part: TTT				
Receiver bandwidth	MHz	0,5	0,5	0,5
Receiver sensitivity	dBm	-104	-104	-104
Antenna gain	dBi	10	10	10
C min per MHz at antenna input	**dBm/MHz**	**-111**	**-111**	**-111**
Protection criterion				
Criterion C/I	dB	6	6	6
Allowable interfering power level 'I' at receiver antenna input	**dBm/MHz**	**-117**	**-117**	**-117**
Main lobe RLAN - Main lobe TTT				
Sidelobe attenuation	dB	15	15	15
Required Attenuation	**dB**	**102**	**102**	**102**
Separation distance RLAN → TTT	m	**185**	**300**	**425**

1.6.2 Compatibility study scenario A2

Summary: When the 5 GHz RLAN transmitter is placed outside, below calculations show a separation distance of up to 970 m between the 5 GHz RLAN transmitter and the victim ITS-vehicle.

Link budget scenario A2		Urban	Suburban	Rural
Emission part: RLAN (20 MHz)				
Bandwidth	MHz	20	20	20
TX out (e.i.r.p.)	dBm	23	23	23
Effect of TPC	dB	0	0	0
Wall loss	dB	0	0	0
Antenna Gain (0 because of e.i.r.p.)	dBi	0	0	0
Net Tx density of power	**dBm/MHz**	**10**	**10**	**10**
Reception part: TTT				
Receiver bandwidth	MHz	0,5	0,5	0,5
Receiver sensitivity	dBm	-104	-104	-104
Antenna gain	dBi	10	10	10
C min per MHz at antenna input	**dBm/MHz**	**-111**	**-111**	**-111**
Protection criterion				
Criterion C/I	dB	6	6	6
Allowable interfering power level 'I' at receiver antenna input	**dBm/MHz**	**-117**	**-117**	**-117**
Main lobe RLAN - Main lobe TTT				
Sidelobe attenuation	dB	15	15	15
Required Attenuation	**dB**	**112**	**112**	**112**
Separation distance RLAN → TTT	**m**	**315**	**540**	**970**

1.6.3 Compatibility study scenario B1

It is not relevant to calculate separation distance within a car when the results show several hundreds of meters .

1.6.4 Compatibility study scenario B2

It is not relevant to calculate separation distance within a car when the results show several hundreds of meters.

1.7 Compatibility between interferer 5GHz RLAN systems and victim TTT, maximum output power

1.7.1 Compatibility study scenario A1

Summary: When the 5 GHz RLAN transmitter is placed within a building, calculations show a maximum allowed 5 GHz RLAN transmitter output power of -34 dBm e.i.r.p., which is equivalent with -47 dBm/MHz e.i.r.p.

Link budget scenario A1		Urban
Emission part: RLAN (20 MHz)		
Bandwidth	MHz	20
TX out (e.i.r.p.)	dBm	-34
Effect of TPC	dB	0
Wall loss	dB	10
Antenna Gain (0 because of e.i.r.p.)	dBi	0
Net Tx density of power	**dBm/MHz**	**-57**
Reception part: TTT		
Receiver bandwidth	MHz	0,5
Receiver sensitivity	dBm	-104
Antenna gain	dBi	10
C min per MHz at antenna input	**dBm/MHz**	**-111**
Protection criterion		
Criterion C/I	dB	6
Allowable interfering power level 'I' at receiver antenna input	**dBm/MHz**	**-117**
Main lobe RLAN - Main lobe TTT		
Sidelobe attenuation	dB	0
Required Attenuation	**dB**	**60**
Separation distance RLAN → TTT	**m**	**4**

1.7.2 Compatibility study scenario A2

Summary: When the 5 GHz RLAN transmitter is placed outside, calculations show a maximum allowed 5 GHz RLAN transmitter output power of -44 dBm e.i.r.p., which is equivalent with -57 dBm/MHz e.i.r.p.

Link budget scenario A2		Urban
Emission part: RLAN (20 MHz)		
Bandwidth	MHz	20
TX out (e.i.r.p.)	dBm	-44
Effect of TPC	dB	0
Wall loss	dB	0
Antenna Gain (0 because of e.i.r.p.)	dBi	0
Net Tx density of power	**dBm/MHz**	**-57**
Reception part: TTT		
Receiver bandwidth	MHz	0,5
Receiver sensitivity	dBm	-104
Antenna gain	dBi	10
C min per MHz at antenna input	**dBm/MHz**	**-111**
Protection criterion		
Criterion C/I	dB	6
Allowable interfering power level 'I' at receiver antenna input	**dBm/MHz**	**-117**
Main lobe RLAN - Main lobe TTT		
Sidelobe attenuation	dB	0
Required Attenuation	**dB**	**60**
Separation distance RLAN → TTT	m	**4**

1.7.3 Compatibility study scenario B

Summary: When the 5 GHz RLAN transmitter is placed within a vehicle, calculations show a maximum allowed 5 GHz RLAN transmitter output power of -41 dBm e.i.r.p., which is equivalent with -54 dBm/MHz e.i.r.p.

Link budget scenario B		Urban
Emission part: RLAN (20 MHz)		
Bandwidth	MHz	20
TX out (e.i.r.p.)	dBm	-41
Effect of TPC	dB	0
Vehicle windows	dB	3
Antenna Gain (0 because of e.i.r.p.)	dBi	0
Net Tx density of power	**dBm/MHz**	**-57**
Reception part: TTT		
Receiver bandwidth	MHz	0,5
Receiver sensitivity	dBm	-104
Antenna gain	dBi	10
C min per MHz at antenna input	**dBm/MHz**	**-111**
Protection criterion		
Criterion C/I	dB	6
Allowable interfering power level 'I' at receiver antenna input	**dBm/MHz**	**-117**
Main lobe RLAN - Main lobe TTT		
Sidelobe attenuation	dB	0
Required Attenuation	**dB**	**60**
Separation distance RLAN → TTT	**m**	**4**

1.8 Conclusion

Initial compatibility studies have been performed with a proposed 5 GHz RLAN systems as interferer and with TTT systems as victim. The studies were based on MCL calculations.

This initial study identified a set of realistic, worst-case conditions for interference. Only a limited set of parameters and scenarios were investigated, and we do not know if we have found the most critical scenarios.

Depending on the scenario, the studies showed required, minimum separation distances from 185 m up to 970 m between 5 GHz RLAN devices and TTT systems.

The spectrum sharing with 5 GHz RLAN-devices is in principal possible if the 5 GHz RLAN output power does not exceed the following:

-47 dBm/MHz e.i.r.p. indoor
-57 dBm/MHz e.i.r.p. outside
-54 dBm/MHz e.i.r.p. within a vehicle