ECC REPORT 113

Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

COMPATIBILITY STUDIES AROUND 63 GHz BETWEEN INTELLIGENT TRANSPORT SYSTEMS (ITS) AND OTHER SYSTEMS

Budapest, September 2007
Revised Hvar, May 2009

0 EXECUTIVE SUMMARY

In response to a request from ETSI to confirm system parameters for Intelligent Transport Systems (ITS) around 63 GHz, compatibility studies were conducted within WG SE. It was decided to conduct compatibility studies between ITS at 63-64 GHz and the following services/systems:

1) Inter Satellite Service;
2) Fixed Service operating above 64 GHz;
3) Radiolocation service operating in the frequency range 63-64 GHz;
4) proposed Multiple Gigabit Wireless Systems (MGWS)[1].

The following table provides a summary of the results given in this report:

<table>
<tr><th>Services and applications</th><th>Subsection of report</th><th>ITS as interferer</th><th>ITS as victim</th></tr>
<tr><td>Fixed Service</td><td>3.2</td><td>If the unwanted emissions from ITS are limited to -29dBm in the first 200 MHz of the FS band no problem expected</td><td>ITS need to implement mitigation techniques such as a guard band in their operating band in order to reduce the impact of the unwanted emissions from FS system close to 64 GHz.</td></tr>
<tr><td>Radiolocation</td><td>3.3</td><td colspan="2">No NATO usage was reported, however one administration reported that they are using this band for radiodetermination systems.
To be considered on a national basis in countries where radiolocation systems are operated (in particular to calculate the separation distances).</td></tr>
<tr><td rowspan="2">MGWS/ FS co-frequency</td><td rowspan="2">3.4 / Annex D</td><td>MGWS-FLANE vs. ITS-RSU: measures may need to be implemented to reduce the separation distances (e.g. light licensing or co-ordination).
MGWS-WPAN/WLAN
• indoor no problem
• outdoor MGWS-WPAN/WLAN was not studied.</td><td>MGWS-WPAN/WLAN equipment:
• indoor no problem
• outdoor not compatible
noting that compatibility may be achieved if CPE implement mitigation techniques such as Detect And Avoid).

MGWS-FLANE vs. ITS-RSU: measures may need to be implemented to reduce the separation distances (e.g. light licensing or co-ordination).</td></tr>
<tr><td colspan="2">It has to be noted that the coordination between FS and the ITS IVU is unlikely to be feasible.</td></tr>
<tr><td>ISS</td><td>3.5</td><td>No problem expected</td><td>No problem expected</td></tr>
</table>

It has to be noted that the conclusions reached in this report are also applicable to Radiolocation systems and ISS operating in the adjacent band below 63 GHz. In addition, there is no known use of Mobile systems in the adjacent band below 63 GHz.

[1] According to ECC/REC(09)01, it should be considered that FLANE systems are technically equal to any Point to Point application and are considered to be part of the Fixed Service.

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List of Abbreviations

Abbreviation	Explanation
AP	Access Point
CEPT	European Conference of Postal and Telecommunications Administrations
CPE	Customer Premises Equipment (mobile, nomadic)
ECA	European Common frequency Allocations table (ref. ERC Report 25)
ETSI	European Telecommunications Standards Institute
FLANE	Fixed Local Area Network Extension
FS	Fixed Service
ISS	Inter Satellite Service
ITS	Intelligent Transport System
IVC	Inter Vehicle Communication
IVU	In-Vehicle Unit
LBT	Listen Before Talk/Transmit
MCL	Minimum Coupling Loss
MGWS	Multiple Gigabit Wireless System
R2V	Roadside to Vehicle
RSU	Road Side Unit
RTTT	Road Transport and Traffic Telematics
V2V	Vehicle to Vehicle
WIGWAM	Wireless Gigabit With Advanced Multimedia

Compatibility studies around 63 GHz between Intelligent Transport Systems (ITS) and other systems

1 INTRODUCTION

This report was developed by WG SE in order to consider the compatibility between Intelligent Transport System (ITS) operating in the frequency range 63-64 GHz and other systems/services, as follows:

1) Inter Satellite Service (ISS);
2) Fixed Service (FS) operating above 64 GHz;
2) Radiolocation service (RLS) operating in the frequency range 63-64 GHz;
3) proposed Multiple Gigabit Wireless Systems (MGWS) operating from 57 to 66 GHz.

2 DESCRIPTION OF ITS AT 63-64 GHz

The development of ITS, based on Vehicle to Vehicle (V2V) communication and Roadside to Vehicle (R2V) communication, is seen as the best way to proceed in terms of achieving improvements both in the efficiency of the transport systems and in the safety of all road users.

ITS increase the “time horizon” for drivers to be provided with reliable information about his/her driving environment, the other vehicles and all other road users, enabling improved driving conditions leading to better safety and more efficient and comfortable mobility. Such systems also offer increased information about the vehicles, their location and the road conditions in the whole road network to the road operators and infrastructure owners, allowing optimised and safer use of the capacity of the available road network, and better response to incidents and hazards.

The use of frequencies in the 60 GHz range permits the development of wide-band, high data rate systems. In turn, this relieves system designers of a major constraint and enables flexibility in the realisation of systems that can meet the expectations of all stakeholders. Both, high data rates and multiple applications become possible. The short wavelengths also confer flexibility in the design of antennas, enabling the use of many forms, from simple horns to complex dielectric structures. A range of beam sizes and shapes become possible ensuring that the desired properties are achievable in discrete or conformal physical arrangements. Even lane-limited systems are possible.

The frequency band is close to a peak in the oxygen absorption, permitting these devices to re-use spectrum in short distances, again increasing the implementation choices. The typical path length for a 60 GHz system with maximum power levels of 40 dBm is approximately 300 m. The typical number of users therefore within communication range of any individual roadside unit would be no more than 100, assuming traffic jam conditions (considered worst case).

The use of five communication channels ensures continuous communications along a road without causing interference between each short path link.

For V2V communications the system high bandwidth inherently provides the necessary low latency for use in time critical safety applications. The closer the vehicle to another, the shorter is the time for intervention, requiring virtually instant communications.

The capacity of the ITS network is provided by the use of high data rates and short path links. The network will use IP6 internet connection and each IP packet header created by an application contains the priority of that packet.

Communications links expected to be implemented in this band include both R2V(forward and reverse) and V2V. This band is not expected to include anti-collision radars, which may be deployed in higher frequencies (i.e. 76-77 GHz).

Consideration on protection from other services that may be deployed within the 63-64 GHz spectrum is necessary to protect the ITS short range R2V and V2V communications. Therefore, it is expected that a certain level of protection will be afforded to ITS.

2.1 Current Regulation for ITS within CEPT at 63-64 GHz

The need for Road Traffic and Transport Telematics (RTTT) data links and a suitable frequency assignment has been recognised for several years. ERC Report 3 dealing with Harmonisation of Frequency Bands to be designated for Road Transport Information Systems [1] provided initial considerations on the bands for RTTT (ITS) systems.

As a result of some EC-funded work in the early 1990’s, which investigated frequency and design options, CEPT recommended the band 63-64 GHz for future V2V and (in a later amendment) R2V communications (see ECC/DEC/(02)01 [2]). The current regulations permitting RTTT (ITS) devices are given in ERC/REC 70-03 Annex 5 [3].

2.2 Overview of ITS at 63-64 GHz

ITS and RTTT systems will depend for their implementation on a variety of communications and sensing systems. Most of these systems can be supported by appropriate use of the band 63 to 64 GHz.

The functionality required of a millimetric, high data rate communication system for next-generation transport telematics is that it should support V2V and R2V in a dynamic traffic environment, in a range of weather conditions, and with communication ranges extending to several hundred metres. It must be capable of providing broadcast, point-to-point and vehicle cluster connectivity.

The communications traffic will be distributed over a wide area of a country, with a user density dependent on the scenario.. For example in the urban environment, there may be up to 330 vehicles per sq km (see ECC Report 23 [4]).

The 63-64 GHz band communication system is an example of a system that has the capability of meeting a wide range of the communications data link requirements, through its scope for a high data rate, time-division and/or channelised architecture.

The anticipated roll-out is through installation of Road Side Units (RSU) on existing roadside infrastructures. These, in turn, provide services which will increase in number and complexity to vehicles equipped with an In-Vehicle Unit (IVU). As more vehicles are equipped with IVU, so the number and value of services will grow.

It is planned that RSU will be placed at regular intervals along all inter-urban trunk routes, at strategic locations (junctions, services etc) on more minor roads, and at locations of opportunity (e.g. sides of buildings, lamp posts, traffic signs) in urban areas.

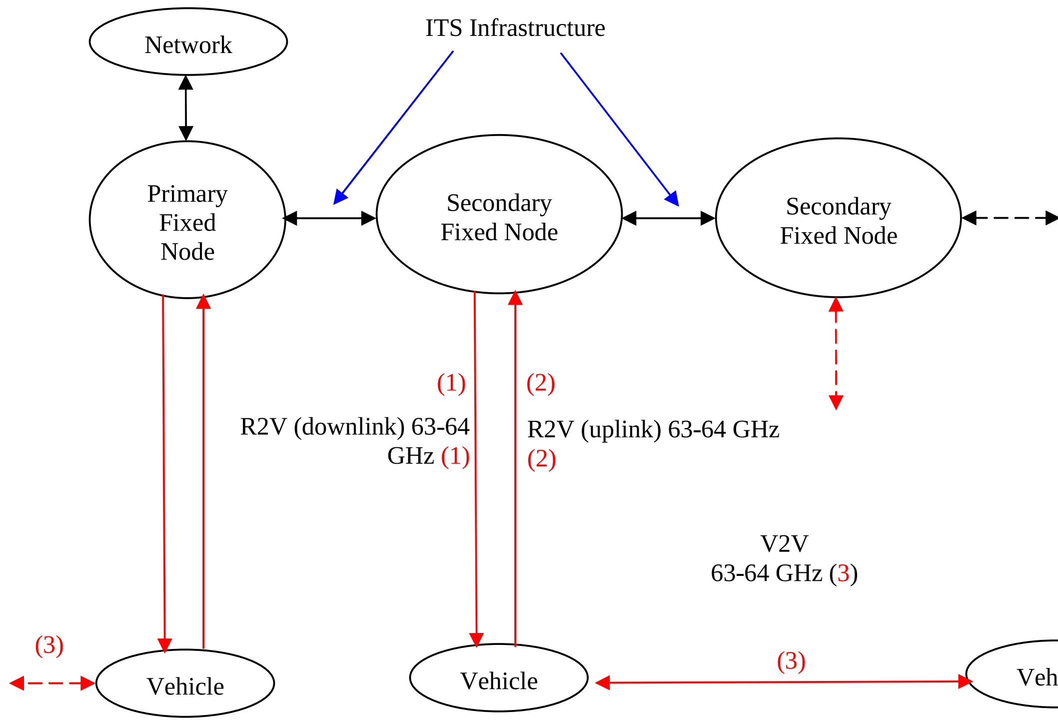
IVU will eventually be fitted to all new vehicles (domestic and commercial), and retro-fitted on an operator/owner-demand basis to a proportion of existing vehicles.

It is expected that full roll-out will require a decade, but that installations will start in 2008/09 with early adopters (vehicles) and points of need (roadside) providing a realistic and useful service within 24-36 months.

It is important that the use of the ITS is available both for official (i.e. safety, public information and road management) and for commercial purposes, so that viable business cases can be established. The commercial use is critical in providing a payload that "enables" the capital expenditure and thus allowing the ITS to be adopted on a larger scale.

The connectivity required by the application types can be summarized as follows:

- V2V:
  - Vehicle cluster covering several lanes (e.g. lane management, overtaking assist, police instructions to vehicle in-front/behind);
  - Linear (e.g. convoy control);
  - Vehicle cluster including opposite direction (e.g. warnings to vehicle in opposite direction of travel, accident and event warning propagating backward).
- R2V (uplink and downlink):
  - One vehicle to beacon (e.g. alerts from private vehicles to highway control on accident, conditions);
  - Beacon to one vehicle (e.g. highway and traffic management and tolling);
  - Beacon to many vehicles (e.g. broadcast, safety, weather and traffic status messaging, disaster and emergency warning and control);
  - Beacon to selected vehicles (multicast, download of maps and route guidance).
- Safety, weather and traffic status messaging. It should be understood that all links are intended as bi-directional, both at an application level, and for Forward Error Correction and data block re-send requests. Also, each message type can be present in clusters of vehicles, with Medium Access Control (MAC).



Note: only the links identified by a number (also in red) are covered by this report

Figure 1: Possible Architecture of ITS network

Lists of applications for V2V and R2V have been investigated by various projects and groups, and the number of possible applications is very high, typically 100. Table 1 gives a list of general application groups that provide the description of individual applications.

	Application	**Description**
1	Automatic Fee Collection (AFC) Access	Charges for use of roads at point of use / allows access to controlled area.
2	Traffic Information	Sends data to car advising of traffic congestion, poor visibility ahead.
3	Route Guidance	Advises driver on traffic flow problems ahead and alternative routes.
4	Traffic monitoring	Gathers information for traffic management.
5	Parking Management	Enables driver to check ahead on availability of parking and to pre-book.
6	Freight and Fleet Management	Efficient management of freight and fleet. For example, locates vehicles and transmits nature of cargo to save time at border controls.
7	In car internet / PC mobile office	Provides an internet style access of telematic data
8	Co-operative Driving	Alerts driver to other vehicles braking, changing lane etc.
9	Platoons / Road trains	Organizes a number of vehicles into convoys.
10	Emergency warning	Alerts driver to sudden manoeuvres or failures of nearby vehicles.
11	Intelligent Intersection Control	Alerts driver to other vehicles at intersections.
12	Feed from radio station	Local, national or international radio stations stream live (only with Node backhaul) or pre-recorded (content on Node) via Nodes.
13	Stolen Vehicle Alarm, tracking and recovery	Unauthorised movement of vehicle (or boat) is detected and authorities alerted. Vehicle is then tracked for recovery.

Table 1: General application groups of ITS at 63-64 GHz

2.3 Technical description of ITS

ETSI TR 102 400 [5] provides technical details for ITS in the frequency range 63-64 GHz. Table 2 provides a summary of ITS characteristics.

Parameter	Values/Characteristics
Frequency	63-64 GHz
e.i.r.p.	40 dBm
Antenna gain Roadside Unit	23 dBi (1)
Antenna Vehicle	(3) 21dBi (V2V) / (2) 14dBi (V2R)
Sidelobe attenuation	20dB
Range	typically up to 300 m
Channel-spacing Total	192 MHz to 1 GHz
Bandwidth	120 MHz (127 MHz when pilot is activated – see Annex B)
Data rate	40-240 Mbit/s
Modulation	QAM… FSK
Noise Factor	8dB
Sensitivity	-86 dBm (Note)
C/I	6dB

Table 2: ITS characteristics

Note: This value is the noise floor of the system. For operational sensitivity the minimum SNR will vary dependant upon the modulation scheme in use.

2.4 Emission levels for ITS

The maximum e.i.r.p. of ITS transmitter should not exceed 40 dBm in one channel.

It has to be noted that no emissions mask is available in the ETSI TR 102 400 [5]. However, based on the received information (see Annex B), the level of -29 dBm in 200 MHz was considered in section 3.2 for the unwanted emissions of ITS system.

3 COMPATIBILITY BETWEEN ITS AND OTHER SERVICES/SYSTEMS

Table 4 depicts the European frequency allocations for the frequency range between 62-65 GHz.

ECA	**Utilisation**	**ECC / ERC Document**	**Note**
62 - 63 GHz INTER-SATELLITE MOBILE 5.558 RADIOLOCATION 5.559 EU2	Broadband mobile systems Short range non civil radiolocation	ECC/REC/(05)02	For connection to IBCN paired with 65-66 GHz
63 - 64 GHz INTER-SATELLITE MOBILE 5.558 RADIOLOCATION 5.559	RTTT Short range non civil radiolocation	ECC/DEC/(02)01 ERC/REC 70-03	Road Transport and Traffic Telematic Vehicle to road/vehicle to vehicle
64 - 65 GHz FIXED INTER-SATELLITE MOBILE except Aeronautical Mobile 5.547 5.556	High density fixed links	ECC/REC/(05)02	

Table 4: Frequency Allocations (ECA) [6]

Based on the list of services provided in Table 4, it was decided to conduct compatibility studies between ITS at 63-64 GHz and the following services/systems:

1) ISS;
2) FS operating above 64 GHz;
3) RLS operating in the frequency range 63-64 GHz;
4) and the newly proposed MGWS applications.

3.1 Methodology

3.1.1 Propagation model

Signal attenuation on the path is calculated by adding to the free space attenuation the gaseous absorption as described in Recommendation ITU-R P.676 [7].

In case of earth-to-earth paths the attenuation is assumed to be:

Attenuation at 64 GHz= 7 (gaseous absorption at 64 GHz) x d + 32.4 + 20 x log (64 000) + 20 x log (d)

where d (km) is the distance between the two considered systems.

At 63 GHz, the attenuation resulting from the oxygen is around 10 dB/km (see Annex A).

In case of earth-to-space paths the attenuation includes the gaseous absorption resulting from the atmosphere (about 50 dB – see Annex A).

In addition:

- Attenuation by car: window loss (a minimum value of 10dB is assumed);
- Oxygen absorption in the zenith direction are provided in Annex A;
- The attenuation due to indoor-to-outdoor penetration is assumed to be 15dB.

3.1.2 Calculation of the minimum separation distances

The Minimum Coupling Loss (MCL) method is used to determine the minimum separation distances between the Victim and the Interferer [8]. The required protection range is estimated in two steps. Firstly, a required propagation loss or attenuation is estimated within a link budget. Then, the minimum separation distances are calculated using the assumptions on the propagation model as described in section 3.1.1.

In the case where victim protection is evaluated using I/N criterion, the required propagation loss A_{tt} is given by the following equation:

$$S = \left[\frac{I}{N}\right]_{dB} = T_x + G_{Interferer} + G_{Victim} - A_{tt} - N$$
$$\Rightarrow A_{tt} = -S + T_x + G_{Interferer} + G_{Victim} - N \qquad (1)$$
$$\Rightarrow A_{tt} = T_x + G_{Interferer} - I_{\max}$$

where:

- $S=[I/N]_{dB}$ is the protection criterion (e.g. -6dB)
- T_x is the power of the interfering system in dBm
- $G_{Interferer}$ is the interferer antenna gain in dBi in the direction of the victim
- G_{Victim} is the receiver antenna gain in dBi in the direction of the interferer
- N is the received noise on the victim in dBm
- I_{max} is the maximum acceptable level of interference in dBm

In the case where victim protection is evaluated using C/I criterion, the required propagation loss A_{tt} is given by the following equation:

$$S = \left[\frac{C}{I}\right]_{dB} = C - T_x - G_{Interferer} - G_{Victim} + A_{tt}$$
$$\Rightarrow A_{tt} = S - C + G_{Victim} + T_x + G_{Interferer} \qquad (2)$$
$$\Rightarrow A_{tt} = T_x + G_{Interferer} - I_{\max}$$

where:

- $S=[C/I]_{dB}$ is the protection criterion (e.g. 6dB)
- T_x is the power of the interfering system in dBm
- $G_{Interferer}$ is the interferer antenna gain in dBi in the direction of the victim
- G_{Victim} is the receiver antenna gain in dBi in the direction of the interferer
- I_{max} is the maximum acceptable level of interference in dBm

In the case of the victim and the interferer operating in adjacent bands, the T_x will account for the amount of unwanted emissions falling into the receiver bandwidth.

3.2 Compatibility between ITS and the Fixed Service

The general parameters of the FS system are provided in EN 302 217-3 [9].

It has to be noted that the bandwidth of FS systems in the band 64-66 GHz may be flexible, i.e. the channels could be as wide as 2 GHz, and therefore no guard band should be considered in the study.

Table 5 provides some of the FS characteristics, which were used for the compatibility analysis.

K (Boltzmann)	1.38×10^{-23} (J/K)	-229 dBJ/K
T (Temperature)	300 K	25 dBK
B (Bandwidth)	120 MHz	81 dBHz
F (Receiver noise figure)	6.3	8 dB
I/N (interference to noise ratio)	1/100	-20 dB
Antenna gain		38 dBi
Antenna sidelobe level	Sidelobes are 25 dB below main beam	-25 dB
I (acceptable interference power dBm) at the antenna input due to the side lobe of the FS		-148 dBW (-118 dBm) *see below*

Table 5: Characteristics of FS systems

The provisional acceptable level of interference power can be calculated from the figures given in the table:

Acceptable Interference power = -229+25+81+8-20 = -135dBW (-105dBm) *(3)*

However, in order to calculate the level of interference imposed on the Fixed Service by the ITS, it is necessary to include the geometry and antenna gains of the systems involved. The more realistic case scenario is when a mobile ITS unit transmits directly into the sidelobe of the FS antenna. Considering the FS antenna gain in the side lobes, the received interference power becomes:

Acceptable received interference power = -105 -38 +25 = -118 dBm *(4)*

3.2.1 Impact of ITS on FS

Based on the information received by the study (see Annex B), it was assumed that the level of unwanted emissions from ITS falling into the FS bandwidth shall not exceed -29 dBm e.i.r.p. in the first 200 MHz of the FS band.

3.2.1.1 Main lobe ITS – Side lobe FS Case

The required attenuation (ITS main lobe – Fixed Service side lobe case) is 89 dB (-118dBm - –29dBm).

89 (dB) = 7 x d (km) + 32.4 + 20 x log (64 000) + 20 x log (d (km)) *(5)*

The resulting minimum separation distance is about 10 m.

3.2.1.2 Side lobe ITS – Side lobe FS Case

The rejection between the main lobe of the ITS and the side lobe is 20 dB, this gives:

69 (dB) = 7 x d (km) + 32.4 + 20 x log (64 000) + 20 x log (d (km)) *(6)*

The resulting minimum separation distance is about 1 m.

3.2.1.3 Main lobe ITS – Main lobe FS Case

The required attenuation (ITS main lobe – Fixed Service side lobe case) is 89 dB (-118dBm - –29dBm) + 38 dB (maximum antenna gain).

127 (dB) = 7 x d (km) + 32.4 + 20 x log (64 000) + 20 x log (d (km)) *(7)*

The resulting minimum separation distance is about 450 m. It has to be noted that the case main beam to main beam is extremely unlikely to occur.

3.2.2 Impact of FS on ITS

3.2.2.1 Level of unwanted emissions falling into the ITS bandwidth

According to ETSI EN 302 217-3 [9], "the EIRP spectral density falling outside of the band 64 GHz to 66 GHz shall not exceed -20 dBW/MHz", for 120 MHz this corresponds to:

$$-20 \text{ dBW/MHz} + 30 \text{ dB} + 21 \text{ dB} = 31\text{dBm in } 120 \text{ MHz} \qquad (8)$$

for the unwanted emissions of FS systems.

3.2.2.2 Main lobe FS - Side Lobe of ITS Road site

The following assumptions are considered:

- Only the R2V link should be considered
- FS e.i.r.p. in 120 MHz in the adjacent ITS band: + 31 dBm in 120 MHz
- ITS Victim's antenna Gmax: 23 dBi (side lobe rejection 20dB) circular

The power received by the ITS receiver is then:

$$31 \text{ dBm} – A_{tt} = \text{Imax} = \text{Sensitivity} – \text{C/I} – \text{antenna gain (ITS side lobe)} = -86\text{dBm} – (+6\text{dB}) – (23 -20) = -95 \text{ dBm} \qquad (9)$$

$$A_{tt} = 126 \text{ (dB)} = 7 \times d \text{ (km)} + 32.4 + 20 \times \log (64\,000) + 20 \times \log (d \text{ (km)}) \qquad (10)$$

The resulting minimum separation distance to meet the ITS protection criterion is in the order of 500 m.

3.2.2.3 Side Lobe of FS - Main lobe of ITS car

The following assumptions are considered:

- FS e.i.r.p. in the ITS band: 31 dBm in 120 MHz
- FS antenna Gmax: 38 dBi (25 dB rejection in the side lobe)
- ITS victim antenna Gmax: 21 dBi (main beam) circular

The power received by the ITS receiver results in:

$$31 \text{ dBm} – A_{tt} -25 \text{ dB (rejection in the FS side lobe)} = 15 \text{ dBm} – A_{tt} = \text{Imax} = \text{Sensitivity} – \text{C/I} – \text{antenna gain (ITS main lobe)} = -86\text{dBm} – (+6\text{dB}) – 21 \text{ dB} = - 113 \text{ dBm} \qquad (11)$$

$$A_{tt} = 119 \text{ (dB)} = 7 \times d \text{ (km)} + 32.4 + 20 \times \log (64\,000) + 20 \times \log (d \text{ (km)}) \qquad (12)$$

The resulting minimum separation distance to meet the ITS protection criterion is in the order of 275 m.

In the co-located case, it is expected that the antenna discrimination will provide enough isolation and therefore no interference is expected.

3.2.2.4 Main Lobe of FS - Main lobe of ITS car

The following assumptions are considered:

- FS e.i.r.p. in the ITS band: 31 dBm in 120 MHz
- FS antenna Gmax: 38 dBi
- ITS victim antenna Gmax: 21 dBi (main beam) circular

The power received by the ITS receiver follows:

$$31 – A_{tt} = \text{Imax} = \text{Sensitivity} – \text{C/I} – \text{antenna gain (ITS main lobe)} = -86\text{dBm} – (+6\text{dB}) – 21 \text{ dB} = - 113 \text{ dBm} \qquad (15)$$

$$A_{tt} = 144 \text{ (dB)} = 7 \times d \text{ (km)} + 32.4 + 20 \times \log (64\,000) + 20 \times \log (d \text{ (km)}) \qquad (16)$$

The resulting minimum separation distance to meet the ITS protection criterion is in the order of 1.6 km.

Again, it has to be noted that the case main beam to main beam is extremely unlikely to occur.

3.2.3 Conclusions on compatibility between ITS and FS operating in 64-66 GHz

The minimum separation distances required to protect FS from ITS are short due to the assumed unwanted emissions from ITS not exceeding -29 dBm in the first 200 MHz of the frequency range 64-66 GHz.

The minimum separation distances to protect ITS from the unwanted emissions of the FS systems are between 300 m and 550 m. ITS may need to implement mitigation techniques such as guard band in order to reduce separation distances.
In addition, the characteristics and location of the FS links may be known in some countries (e.g. by light licencing or coordination process), therefore it may be feasible to arrange the necessary mitigation techniques to significantly reduce the mutual interference possibility.

3.3 Compatibility between ITS and Radiolocation Systems

NATO did not report any use of radiolocation systems in this band however one nation reported use of radiolocation systems in this band.

In the absence of further information on the characteristics of radars in this frequency range, the list of assumptions given in Table 5 is considered for the characteristics of RLS systems operating in the band 63-64 GHz.

K	1.38 x 10^-23 (J/K)	-229 dBJ/K
T	300 K	25 dBK
B	100 MHz	80 dBHz
F	4	6dB
I/N	¼	-6dB
I (dBm)		-94 dBm
e.i.r.p. of radar		40 dBW
Antenna main beam		38 dBi
Antenna side lobe		10dBi

Table 6: Characteristics of RLS in 63-64 GHz

The separation distances may need to be calculated on a national basis using real characteristics of the radar (antenna gain and noise figure) and the approach provided in section 3.3.1 and 3.3.2. The direct main beam to main beam coupling of the radar and ITS is highly unlikely and therefore is not considered in the following calculations.

The calculations are conducted at 64 GHz where the oxygen absorption is lower in order to provide worst case results. At 63 GHz the oxygen absorption will be around 5 dB higher (see Annex A).

3.3.1 Impact of ITS on Radiolocation Systems

The separation distance is calculated for main lobe ITS to RLS assuming the antenna gain in the side lobe of the radar is 10 dBi.
The maximum ITS e.i.r.p. is 40 dBm, the power received the RLS follows:

$$40\text{ dBm} - A_{tt} = \text{Imax} = -94\text{ dBm} - \text{antenna gain (RLS side lobe)} = -104\text{ dBm} \quad (12)$$

Therefore, using the set of assumptions given in previous section – Table 5, the required attenuation is equal to 144 dB.

Assuming that the gaseous absorption is equal to 5dB/km and the free space attenuation, the required attenuation is achieved for:

$$144\ (dB) = 7 \times d + 32.4 + 20 \times \log(64\,000) + 20 \times \log(d) \qquad (13)$$

i.e. a minimum separation distance in the order of 1.6 km.

3.3.2 Impact of Radiolocation Systems on ITS

Assuming that the RLS e.i.r.p. is 70 dBm, and that the ITS is located in the side lobes of the radar (rejection of 28 dB), the power received by the ITS system follows:

$$42\ dBm - A_{tt} = Imax = Sensitivity - C/I - antenna\ gain\ (ITS\ main\ lobe) = -86dBm - (+6dB) - 14\ dB = -110\ dBm \qquad (14)$$

$$A_{tt} = 148\ (dB) = 7 \times d\ (km) + 32.4 + 20 \times \log(64\,000) + 20 \times \log(d\ (km)) \qquad (15)$$

The separation distance to meet the ITS protection criterion is in the order of 1.95 km.

3.4 Compatibility between ITS and MGWS

3.4.1 Overview of MGWS

MGWS are subdivided into 3 main applications: 2 nomadic applications (WPAN, WLAN) and one fixed application (FLANE).

Wireless Local Area Network (WLAN): radiocommunications used in short range, line-of-sight and non-line-of-sight circumstances. Total range and performance will vary depending on the environment, but full WLAN performance is typically expected at ranges of 10 to 100 meters. The access point is mounted indoor covering an office space with a CPE typically also used indoor.

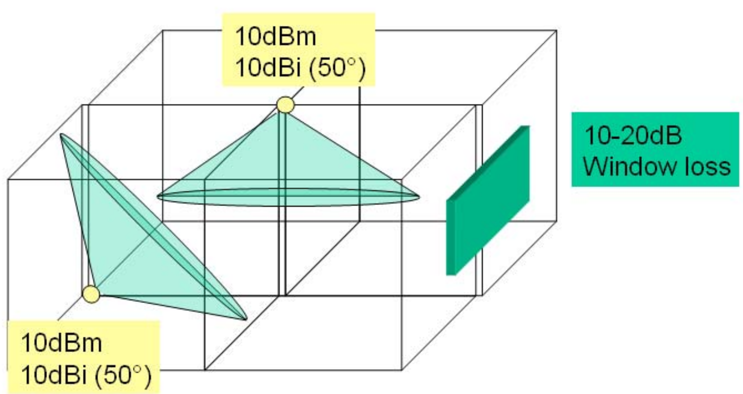


Figure 2: Laptop - WLAN scenario indoor

Wireless Personal Area Network (WPAN): radiocommunications used in line-of-sight or near-line-of-sight circumstances. Total range and performance will vary depending on the environment, but full WPAN performance is typically expected at ranges of less than 10 meters or within a single room in an indoor environment. Typical application is equipment to equipment (Laptop – Projector).

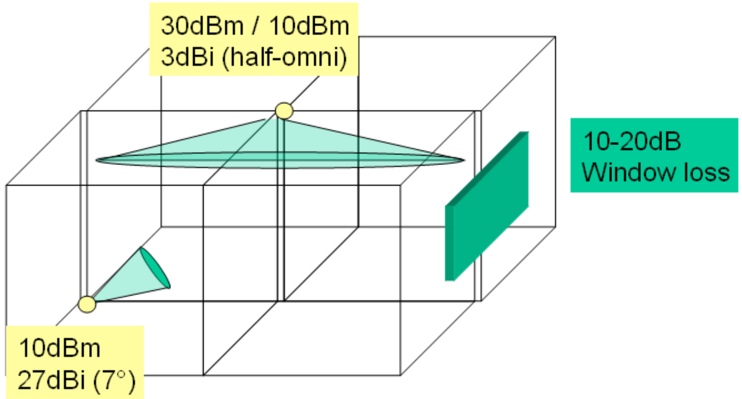


Figure 3: Laptop – Beamer / WPAN scenario indoor

Fixed Local Area Network Extention (FLANE): radiocommunications used in line-of-sight circumstances. Total range and performance will vary depending on the environment, but full FLANE performance is typically expected at ranges of 10-800 meters. The typical application is LAN extension where cable is not appropriate. Environment is between buildings on a campus outdoor situation.

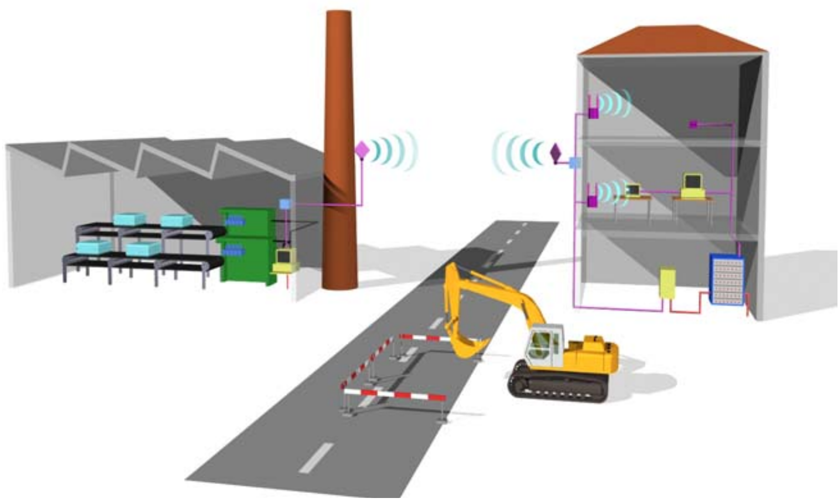


Figure 4: Building to Building / FLANE LAN outdoor extension

3.4.2 Technical description of MGWS

TR 102 555 [10] provides technical characteristics of MGWS. Table 7 provides characteristics extracted from this document to be used for compatibility analysis.

Parameter	**Value/Characteristic**	**Comments**
Maximum radiated power (e.i.r.p.)	+40 dBm (55dBm)	A variety of antennas may be used according to specific applications. (in case FLANE is deployed with max. e.i.r.p of 55dBm please see Annex D)
Antenna aperture/gain	50° / 10dBi 7° / 27dBi 2° / 38dBi	Typical indoor distribution scenario connecting CPE to an access point with very little alignment effort. Both CPE and AP using the same antenna. Scenario study in the project WIGWAM [11]. Indoor distribution system using half omni in combination with high directional CPE antenna. Study carried out by Fraunhofer Institute Typical building to building LAN extension FLANE application [12].
Examples of typical modulation schemes	ASK, FSK, QPSK, OFDM	Modulation schemes currently used by broadband wireless air interfaces
Typical data rates	100Mbps-10 Gbps physical layer	Depending on the channel size and modulation method
Typical Channel Bandwidth	0,15 – 2,5 GHz	Depending on desired data rate
Communication mode	Half Duplex, Full Duplex, broadcast	Duplex and broadcast are believed to be adequate for the applications considered to date.
Typical maximum BER	$<10^{-6}$	Depending on the application
Typical Noise Figure	10 dB	
Noise / Interferer Threshold	10 dB	

Table 7: Technical parameters of MGWS

The following sections provide calculations of the separation distances for the most realistic scenarios. Calculations were conducted at 64 GHz since it was considered as the worst case. The file in Annex C may allow calculating additional scenarios if so needed.

3.4.3 Impact of ITS on MGWS

3.4.3.1 ITS on MGWS (Victim) - Scenario 1 – FLANE as a Victim

This scenario considers the cases were the FLANE is possibly interfered by:

- ITS RSU pointing in the direction of the road (scenario 1-a, see Figure 5), or
- ITS IVU (scenario 1-b, see Figure 6).

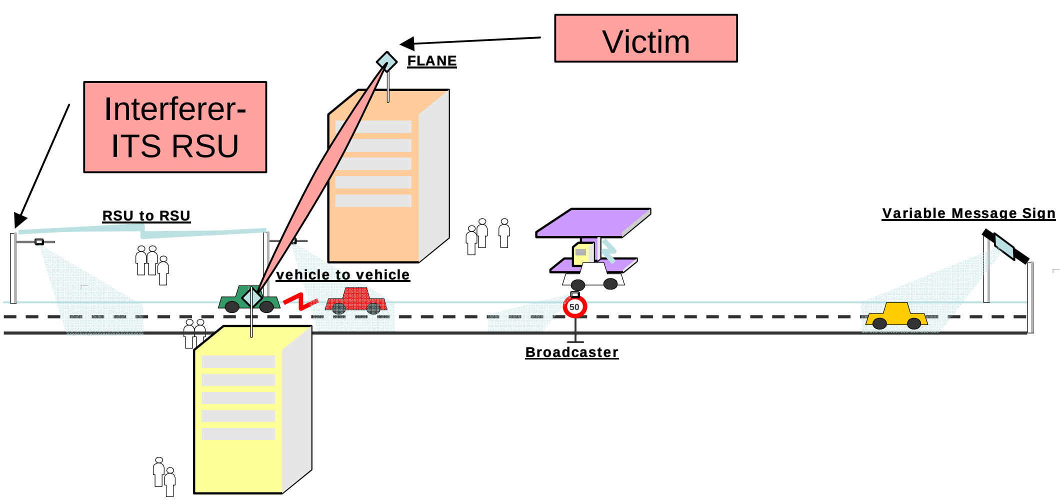


Figure 5: Scenario 1-a – MGWS-FLANE possibly interfered with by an ITS RSU

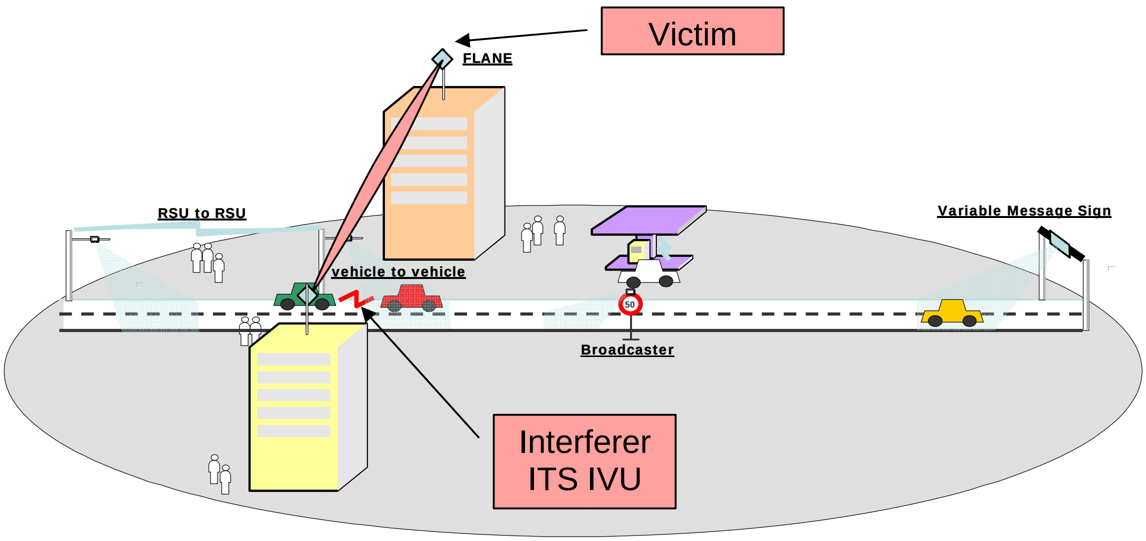


Figure 6: Scenario 1-b – MGWS-FLANE possibly interfered with by an ITS IVU

In this scenario the following assumptions are considered:

ITS:

- e.i.r.p.: 40 dBm (55dBm in Annex D) in a 120 MHz channel bandwidth
- e.i.r.p. in the side lobes: 40 – 20 (rejection in the side lobes) = 20 dBm (for the RSU and IVU)
- Circular polarisation

MGWS-FLANE:

- Bandwidth: 150 MHz
- Building height: 20 m
- Polarisation: slant 45 degree
- Antenna side lobe gain: 8 dBi (G_0=38dBi, value from measured slotted array antenna tilted by -45° taken at an horizontal angle of 5° to the main lobe), 16dBi (G_0=45dBi, value from the Recommendation ITU-R F.699 [13] referenced back to parabolic dishes at 5° to the main lobe) see Annex D.

3.4.3.2 ITS on MGWS (Victim) - Scenario 2 – WLAN/WPAN

This scenario considers the cases were the WLAN/WPAN receiver is located in a building and is possibly interfered by a ITS RSU pointing in the direction of the road (Figure 7).

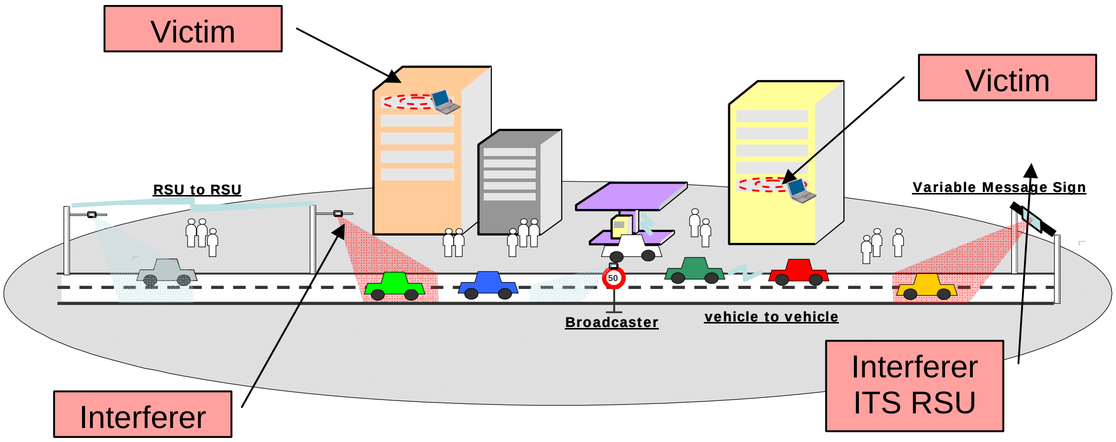


Figure 7: Scenario 2 – MGWS-WLAN/WPAN possibly interfered with by a ITS RSU

In this scenario the following assumptions are considered:

ITS:

- e.i.r.p.: 40dBm
- e.i.r.p. in the side lobes: 40 – 20 (rejection in the side lobes) = 20 dBm (for the RSU)
- Attenuation due to indoor-outdoor penetration: 15dB

MGWS WLAN/WPAN:

- Bandwidth: 350 MHz
- Antenna main lobe gain: 27dBi

3.4.4 Impact of MGWS on ITS

3.4.4.1 MGWS–FLANE on ITS - Scenario 3 –Victim

This scenario considers the cases were the RSU is possibly interfered by a MGWS-FLANE (see Figure 8).

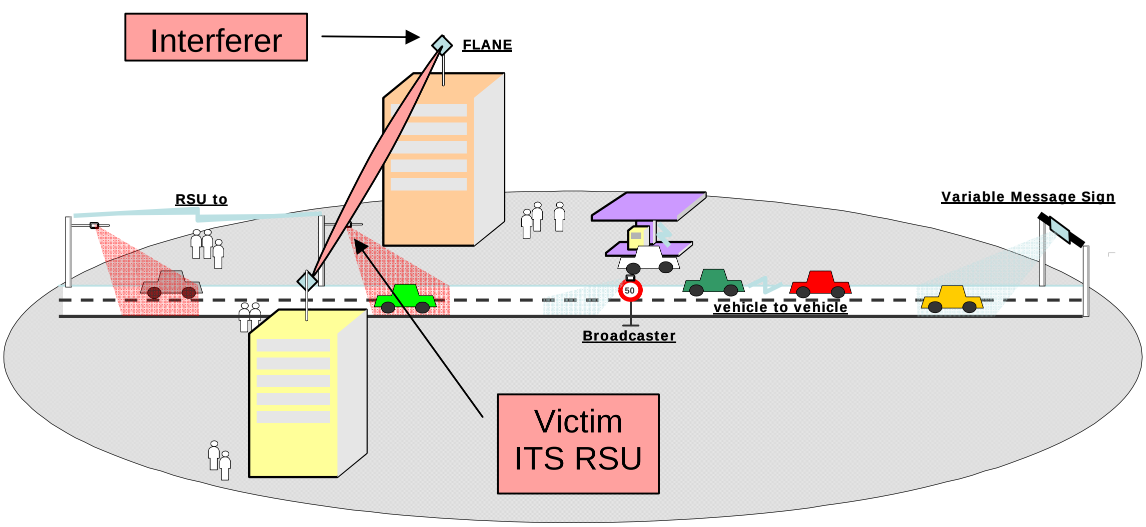


Figure 8: Scenario 3 – ITS RSU possibly interfered with by MGWS-FLANE

In this scenario the following assumptions are considered:

MGWS FLANE:

- Bandwidth: 150 MHz
- e.i.r.p.: 40 dBm, 55dBm see Annex D
- gain in side lobes:
    - case 3 a (see Table 8) (e.i.r.p 40 dBm): 8 dBi (G_0=38dBi, value from measured slotted array antenna tilted by -45° taken at an horizontal angle of 5° to the main lobe)
    - case 3 b (see Table 8) (e.i.r.p 40 dBm): 19.4 dBi (G_0=38dBi, value from RecommendationITU-R F.699 [13] referenced back to parabolic dishes at 5° to the main lobe)
    - and see Annex D (e.i.r.p 55 dBm): 16dBi (G_0=45dBi, value from Recommendation ITU-R F.699 [13] referenced back to parabolic dishes at 5° to the main lobe).
- Building height: 20 m
- Polarisation: slant 45 degree

ITS RSU antenna main lobe gain: 23dBi (Circular polarization)

3.4.4.2 MGWS–WLAN/WPAN on ITS - Scenario 4 –RSU as a Victim

This scenario considers the cases were an ITS RSU is possibly interfered by a MGWS-WLAN/WPAN located in a building (see Figure 9).

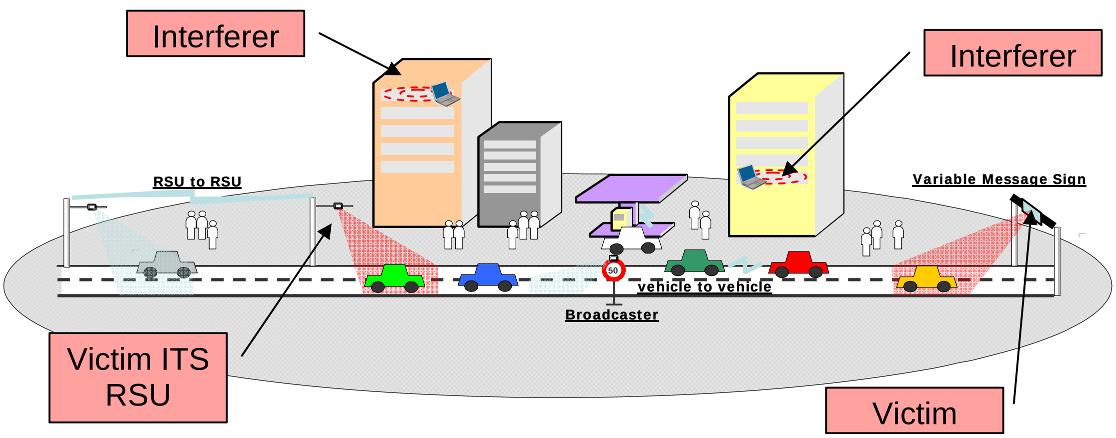


Figure 9: Scenario 4 – ITS RSU possibly interfered with by MGWS-WLAN/WPAN

In this scenario the following assumptions are considered:

MGWS WLAN/WPAN:

- Bandwidth: 350 MHz
- e.i.r.p.: 37 dBm in 350 MHz
- Gain in main lobe: 27 dBi
- Attenuation due to indoor-outdoor penetration: 15dB

ITS RSU antenna side lobe gain: 23 dBi – 20 dBi = 3dBi

3.4.4.3 MGWS–WLAN/WPAN on ITS - Scenario 5 – RSU as a Victim – WLAN/WPAN located within a car

This scenario considers the cases were ITS RSU is possibly interfered by a MGWS-WLAN/WPAN equipment located within a car (see Figure 10).

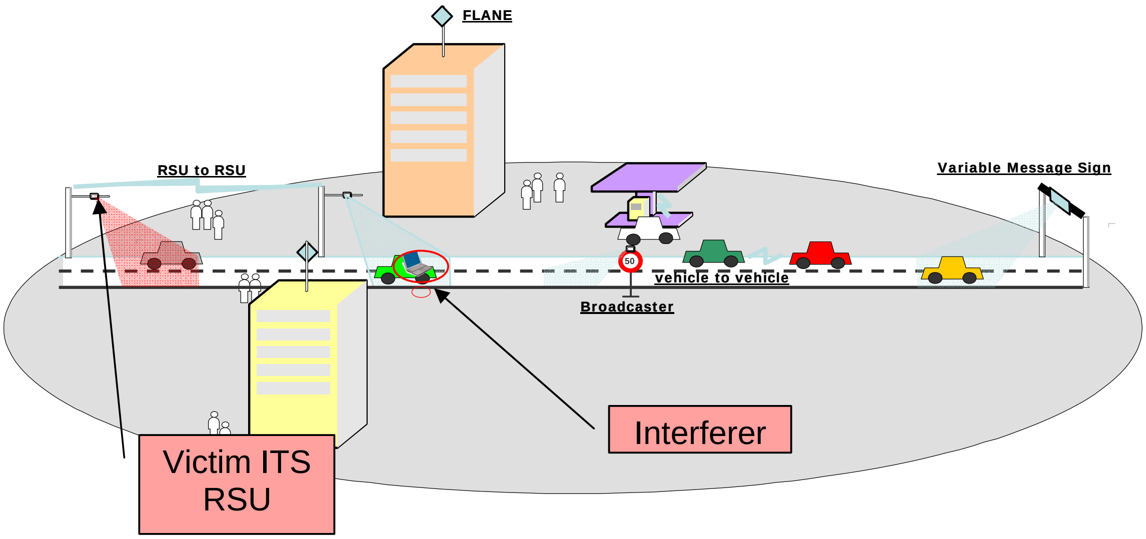


Figure 10: Scenario 5 – ITS RSU possibly interfered with by MGWS-WLAN/WPAN located within a car

In this scenario the following assumptions are considered:

MGWS WLAN/WPAN:

- Bandwidth: 350 MHz
- e.i.r.p.: 37 dBm
- Gain in main lobes: 27 dBi
- Attenuation due to car (window) penetration: 10dB

ITS RSU antenna main lobe gain: 23 dBi.

3.4.4.4 MGWS–WLAN/WPAN on ITS - Scenario 6 – IVU as a Victim – WLAN/WPAN located within another car

This scenario considers the cases were ITS IVU is possibly interfered by a MGWS-WLAN/WPAN located within another car (see Figure 11).

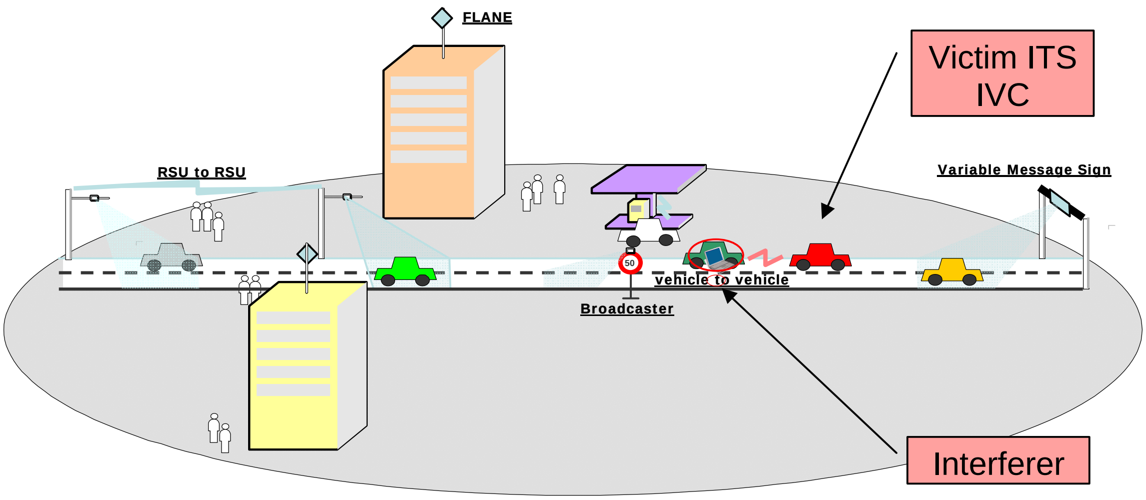


Figure 11: Scenario 6 – ITS IVU possibly interfered with by MGWS-WLAN/WPAN located within another car

In this scenario the following assumptions are considered:

MGWS WLAN/WPAN:

- Bandwidth: 350 MHz
- e.i.r.p.: 37 dBm
- Gain in main lobes: 27 dBi
- Attenuation due to car (window) penetration: 10dB

ITS:

- ITS IVU antenna main lobe gain: 21 dBi.

3.4.5 Conclusions on compatibility between ITS and MGWS

The following Table 8 provides results of calculations of the minimum separation distances for various scenarios. The resulting minimum separation distances resulting from the FLANE MGWS EIRP increase from 40dBm to 55dBm is presented in file “ITS-63GHz_ECC Rep 113_rev_2009” and Annex D.

LINK BUDGET	Value	Units	**I v V**	**ITS RSU - FLANE**	**ITS IVU - FLANE**	**ITS RSU – WLAN/WPAN**	**FLANE- ITS RSU**	**FLANE- ITS RSU**	**WLAN/WPAN indoor – ITS RSU**	**WLAN/WPAN (in car)- ITS RSU**	**WLAN/WPAN (in car)– ITS IVU**
Emission part											
Bandwidth		MHz		120	120	120	150	150	325	325	325
Tx Antenna gain		dBi		14	21	14	38	38	27	27	27
Tx Power		dBm		26	19	26	2	2	10	10	10
Tx out, eirp		dBm		40	40	40	40	40	37	37	37
Tx Out eirp per MHz		dBm/MHz		19	19	19	18	18	12	12	12
effect of TPC (dB)		dB		0	0	0	0	0	0	0	0
Sidelobe rejection		dB		20	20	20	30	18.6	0	0	0
Interferer Effective Gain Gt				-6	1	-6	8	19.4	27	27	27
Net Tx Out power towards the victim		dBm		20	20	20	10	21.4	37	37	37
Net Tx Out power towards the victim		dBm/MHz		-1	-1	-1	-12	0	12	12	12
Reception part:											
Receiver bandwidth		MHz		150	150	325	120	120	120	120	120
Receiver sensitivity		dBm					-86	-86	-86	-86	-86
Antenna gain		dBi		38	38	27	23	23	23	23	21
Sidelobe rejection		dB		30	30	0	0	0	20	0	0
Interferer Effective Gain Gt				8	8	27	23	23	3	23	21
C min at antenna input		dBm					**-109**	**-109**	**-89**	**-109**	**-107**
C min per MHz at antenna input		dBm/MHz					**-130**	**-130**	**-110**	**-130**	**-128**
Thermal noise floor	-174	dBm/Hz		-174	-174	-174					
Receiver noise figure		dB		10	10	10					
Receiver noise level 'N' at antenna input		dBm		**-90**	**-90**	**-106**					
Receiver noise level per MHz 'N' at antenna input		dBm/MHz		**-112**	**-112**	**-131**					
Protection criterion											
Criterion C/I	6	dB					6	6	6	6	6
Criterion I/N	-10	dB		-10	-10	-10					

Allowable Interfering power level 'I' at receiver antenna input		dBm		**-100**	**-100**	**-116**	**-115**	**-115**	**-95**	**-115**	**-113**
Allowable Interfering power level per MHz 'I' at receiver antenna input		dBm/MHz		**-122**	**-122**	**-141**	**-136**	**-136**	**-116**	**-136**	**-134**
Propagation model											
Bandwidth correction factor		dB		**0**	**0**	**0**	**-1**	**-1**	**-4**	**-4**	**-4**
MCL		dB		120	120	136	124	135	128	148	146
Polarisation Loss min.			H/V/C/45°	3	3	0	3	3	0	0	0
Window Barrier Loss	15	dB		0	0	15	0	0	15	10	10
Free Space Loss L_s		dB		117	117	121	121	132	113	138	136
Oxygen induced Loss	7	dB/km									
Frequency (GHz)	64.00	GHz									
SITUATION (Emission/Reception)				SL-SL	SL-SL	SL-ML	SL-ML	ML-SL	ML-SL	ML-ML	ML-ML
Separation distance (m)				**227**	**227**	**320**	**325**	**815**	**144**	**1704**	**1512**
Case				1a	1b	2	3a	3b	4	5	6

Table 8: ITS-MGWS separation distances

Table 9 provides an overview of MGWS applications and Table 10 provides a summary of the calculated separation distances.

Application	**Typical operation distance**	**Mobility**	**Position and Place**	**Remarks**
WPAN	10 m	Nomadic	Not predictable	WPAN could be in any nomadic or mobile device
WLAN	100 m	Indoor Fixed	Not predictable indoor	Access Point fixed CPE nomadic indoor
FLANE	1000 m	Outdoor Fixed	Predictable	Both stations fixed

Table 9: Overview of MGWS applications

ITS	MGWS		
	FLANE	WPAN/WLAN (indoor)	WPAN/WLAN (outdoor)
Interferer	230	320	Not studied
Victim	815	145	1700

Table 10: Minimum separation distances for 40dBm e.i.r.p (for 55dBm e.i.r.p. see Annex D)

WPAN/WLAN equipment

WLAN equipment is typically implemented in an Access Point / CPE scenario indoor. Considering the separation distances and the interference probability, it is concluded that the operation of indoor WPAN/WLAN will not impact ITS.

However, since the separation distances are large in the WPAN outdoor case, the following mitigation techniques should be considered:

- no transmissions of nomadic and mobile systems in the frequency band 63-64 GHz should be allowed, or
- Detect And Avoid (DAA) feature, in order to detect ITS and avoid collisions of MGWS and ITS transmissions.

FLANE

FLANE position is fixed and predictable. The separation distances are in the order of 100 m and the FLANE system works with a small antenna opening angle (below 2 degrees) minimizing the probability of interference. In order to protect ITS from possible interference resulting from FLANE operating in the band 63-64GHz and deployed in the same areas, there may be a need to introduce additional mitigation techniques (e.g. light licensing or co-ordination process).

3.5 Compatibility between ITS and ISS

Due to the attenuation between the earth and the ISS (50dB oxygen absorption + 185 dB of Free Space loss for 700 km satellite altitude), no compatibility issue is expected.

4 CONCLUSIONS

Table 11 provides an overview of the results of compatibility studies.

<table>
<tr><th>Services and applications</th><th>Subsection of report</th><th>ITS as interferer</th><th>ITS as victim</th></tr>
<tr><td>Fixed Service</td><td>3.2</td><td>If the unwanted emissions from ITS are limited to -29dBm in the first 200 MHz of the FS band no problem expected</td><td>ITS needs to implement mitigation techniques such as a guard band in their operating band in order to reduce the impact of the unwanted emissions from FS system close to 64 GHz.</td></tr>
<tr><td>Radiolocation</td><td>3.3</td><td colspan="2">No NATO usage was reported however one administration reported that they are using this band for radiodetermination systems.
To be considered on a national basis in countries where radiolocation systems are operated (in particular to calculate the separation distances).</td></tr>
<tr><td rowspan="2">MGWS / FS co-frequency</td><td rowspan="2">3.4 / Annex D</td><td>MGWS-FLANE[2] vs. ITS-RSU: measures may need to be implemented to reduce the separation distances (e.g. light licensing or co-ordination)

MGWS-WPAN/WLAN:
• indoor no problem
• outdoor MGWS-WPAN/WLAN was not studied.</td><td>MGWS-WPAN/WLAN equipment:
• indoor no problem
• outdoor not compatible
noting that compatibility may be achieved if CPE implement mitigation techniques such as Detect And Avoid feature.

MGWS-FLANE[2] vs. ITS-RSU: measures may need to be implemented to reduce the separation distances (e.g. light licensing or co-ordination).</td></tr>
<tr><td colspan="2">It has to be noted that the coordination between FS and the ITS IVU is unlikely to be feasible.</td></tr>
<tr><td>ISS</td><td>3.5</td><td>No problem expected</td><td>No problem expected</td></tr>
</table>

Table 11: Conclusions of the compatibility studies

It has to be noted that the conclusions given in Table 11 are also applicable to the Radiolocation systems and ISS operating in adjacent band below 63 GHz. In addition, there is no known use of Mobile systems in the adjacent band below 63 GHz.

[2] According to ECC/REC(09)01, it should be considered that FLANE systems are technically equal to any Point to Point application and are considered to be part of the Fixed Service.

ANNEX A: OXYGEN ATTENUATION IN 60 GHz RANGE

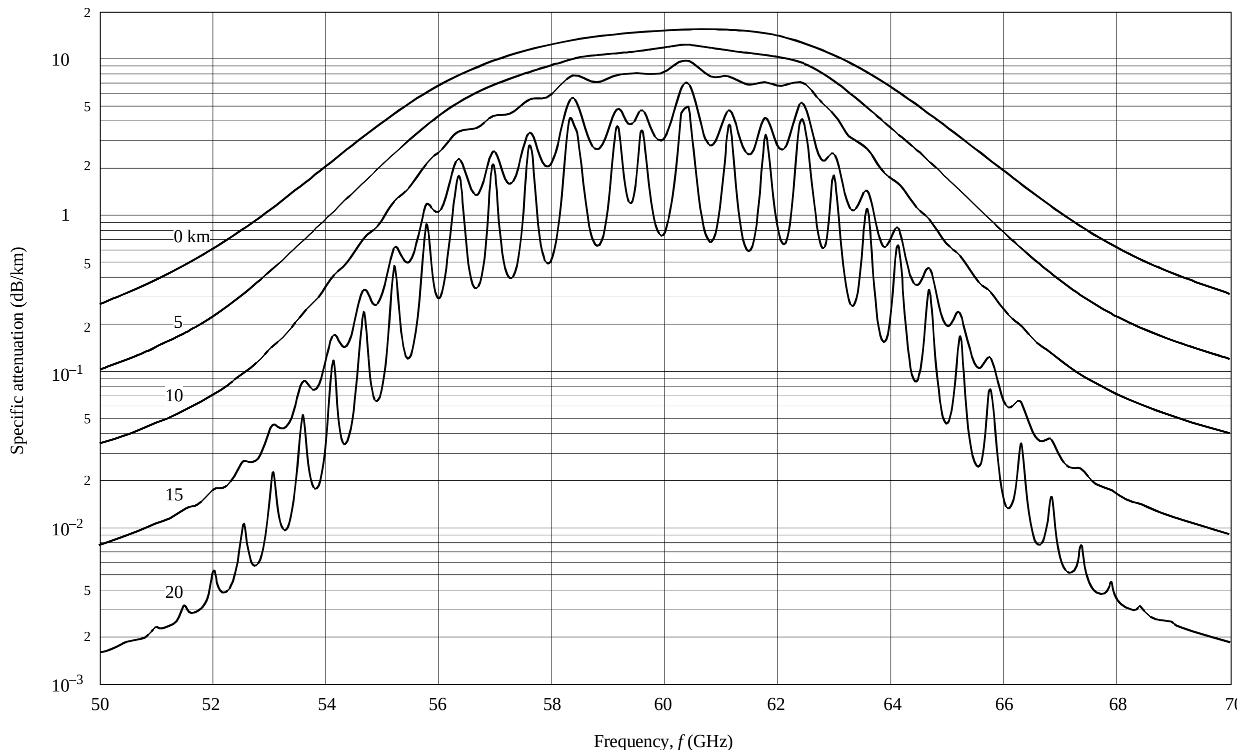


Figure A.1: Oxygen Attenuation (dB/km) – Path Land - Recommendation ITU-R P.676

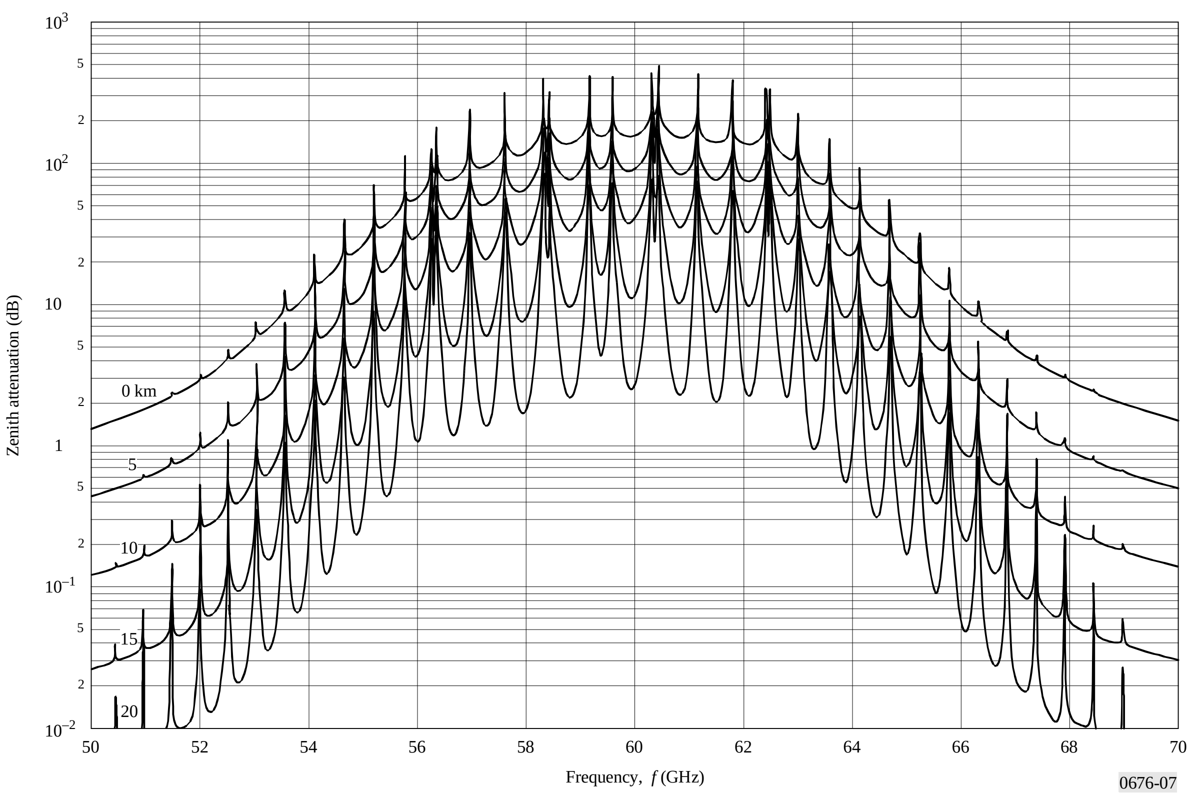


Figure A.2: Zenith Oxygen Attenuation (dB) – Recommendation ITU-R P.676

ANNEX B: CHARACTERISTICS OF ITS AT 63-64 GHz

	63-64GHz R2V and V2V	
Total Tx Power at antenna feed	<+18 dBm Peak	
Bandwidth including OOB	165 MHz	
Channel Spacing	192 MHz	
Channel Bandwidth	120 MHz / 127 MHz (pilot activated)	
Rx noise figure	<8 dB	
Modulation and channelisation	BPSK, 4QAM 4 single carriers at 20 MBaud	
Single carrier centre spacing	~28 MHz (see Figure B.1 and Note 1)	)

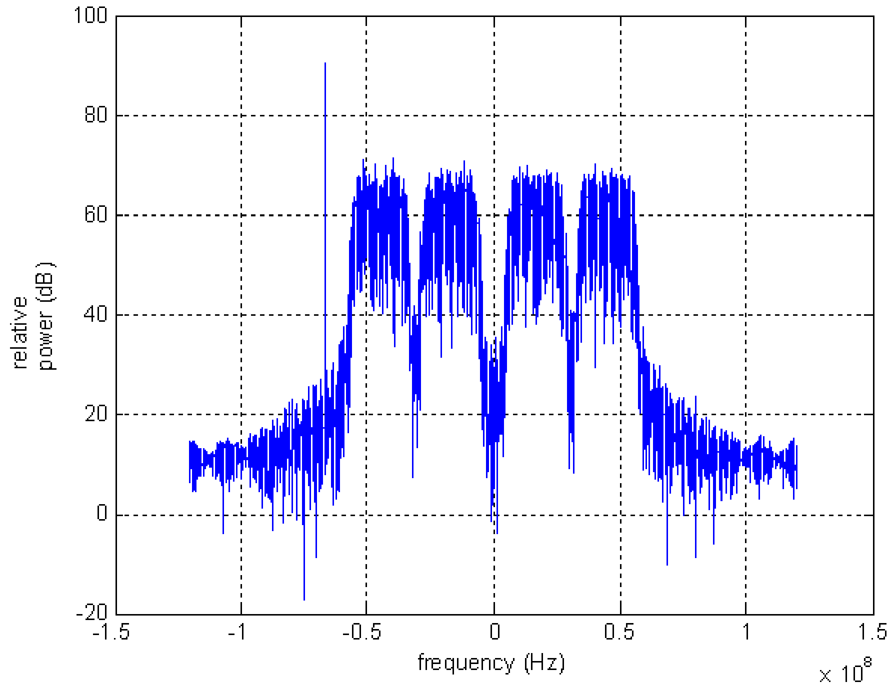


Figure B.1: Baseband power spectrum of an RF ITS channel

Note 1: By taking the centre frequencies of the pilot signal and the 4 IF channels, and centring the spectrum about DC, one would get the following arrangement of pilot and IF channels (the pilot tone and the IF channels have the same spectral density):

- *Pilot signal* *-67 MHz;*
- *IF channel 1* *-45 MHz;*
- *IF channel 2* *-17 MHz;*
- *IF channel 3* *17 MHz;*
- *IF channel 4* *45 MHz.*

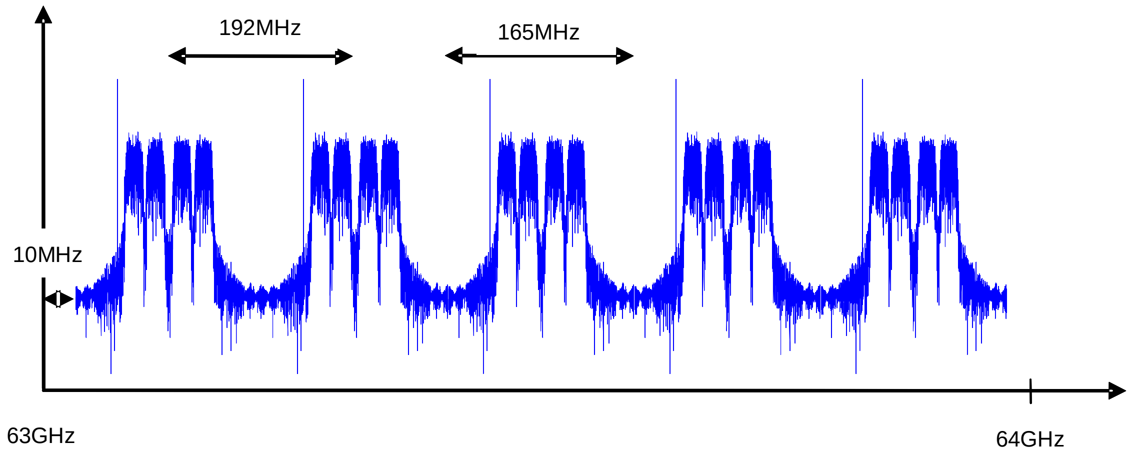


Figure B.2: ITS channels

ANNEX C: FILE FOR CALCULATION

The calculation sheet may be used in order to calculate separation distances taking into account the appropriate assumptions which should be inserted in the “green cells”.

The calculation sheet is in a zip file together with the report an can be found on the Office document database

(Zip file includes. Doc and Annex C: Calculation separation distance parameter)

ANNEX D: MGWS FLANE WITH 55dBm EIRP

D.1 Technical description of MGWS (see section 3.4.2. for e.i.r.p at 40 dBm)

The technical description of the MGWS are the same as for section 3.4.2., except for the e.i.r.p which has increased from 40 dBm to 55 dBm and the consequent antenna characteristics used.

It is important to note that the study made for an e.i.r.p. of 40 dBm considered manufacturer data originated from a slotted array antenna tilted by -45° with a value taken in an horizontal angle of 5° to the main lobe, since this is representing the worst case (in real live unrealistic). Pointing an antenna 5° away from the min lobe does not represent common sense experience but it was decided to get the real worst case.

In the process of updating the study with an e.i.r.p of 55 dBm, it was however recognized that the manufacturer antenna values where not official data available publicly and therefore it was agreed to use Recommendation ITU-R F.699 standard levels referenced back to parabolic dishes which are far worst in the side lobe behaviour. The 5° deviation from the main lobe to characterize the effective gain which a victim would be seeing was considered.

The table below summarises the difference between the measured slotted antenna and the theoretical parabolic antenna at 5° and for two antenna nominal gains. When comparing the 5° performance of the measured slotted array antenna and using the theoretical ITU parabolic dish antenna values the gain is actually increasing, which physically is impossible.

e.i.r.p (dBm)		Measured slotted array antenna tilted by -45° gain (dBi)	Rec. ITU F.699 parabolic antenna gain (dBi)
40 dBm	Main lobe (0°)	38	38
	Side lobe (5°)	8	19.4
55 dBm	Main lobe (0°)	45	45
	Side lobe (5°)	6	15.85

Table D1: Summary of the antenna characteristics used in the study for e.i.r.p of 40 dBm and 55 dBm

Table D.2 provides characteristics extracted from section 3.4.2 used to update the compatibility analysis.

Parameter	**Value/Characteristic**	**Comments**
Maximum radiated power (e.i.r.p.)	+55 dBm	A variety of antennas may be used according to specific applications.
Antenna aperture/gain	See table D.1	
Examples of typical modulation schemes	Same as for the 40dBm e.i.r.p study	
Typical data rates	Same as for the 40dBm e.i.r.p study	
Typical Channel Bandwidth	Same as for the 40dBm e.i.r.p study	
Communication mode	Same as for the 40dBm e.i.r.p study	
Typical maximum BER	Same as for the 40dBm e.i.r.p study	
Typical Noise Figure	Same as for the 40dBm e.i.r.p study	
Noise / Interferer Threshold	Same as for the 40dBm e.i.r.p study	

Table D.2: Technical parameters of MGWS for the study at e.i.r.p of 55 dBm

The following sections provide calculations of the separation distances for the most realistic scenarios considering an increase in e.i.r.p from 40dBm to 55 dBm. As for the study made in section 3.4.3 Calculations were conducted at 64 GHz since it was considered as the worst case. The file in Annex C may allow calculating additional scenarios if so needed.

D.2 Impact of ITS on MGWS (see section 3.4.3. for e.i.r.p at 40 dBm)

D.2.1 ITS on MGWS (Victim) - Scenarios 55dBm – FLANE as a Victim (See section 3.4.3.1. for e.i.r.p of 40 dBm)
For this scenario the ITS characteristic are unchanged from the e.i.r.p at 40 dBm study. This scenario considers the cases were the FLANE is possibly interfered by:

- ITS RSU G_0 = 23dBi, G_1: 12dBi pointing in the direction of the road (scenario 1-a, see Figure 5), or
- ITS IVU G_0 = 21dBi, G_1: 14dBi (scenario 1-b, see Figure 6).

In this scenario the following assumptions are considered:
ITS:

- e.i.r.p.: 40 dBm in a 120 MHz channel bandwidth
- e.i.r.p. in the side lobes: 40 – 10 (rejection in the side lobes) = 30 dBm (for the RSU G_0 = 23dBi, G_1: 12dBi and IVU G_0 = 21dBi, G_1: 14dBi) antenna side lobe gain G_1: 14dBi
- Circular polarisation

MGWS-FLANE:

- Bandwidth: 150 MHz
- Max e.i.r.p = 55 dBm
- Building height: 20 m
- Polarisation: slant 45 degree
- Cases :
    - Case 1a is described in section 3.4.3.1 and is identical to 1b (see section 3.4.3.1).
    - Case 1 c: 19 dBi (G0=38dBi, value from ITU-R F.699 at 5° to the main lobe)
    - Case 1 d: 16 dBi (G0=45dBi, value from ITU-R F.699 at 5° to the main lobe)

Separation distances are given in Table D.3.

D.3 Impact of MGWS on ITS (see section 3.4.4. for e.i.r.p at 40 dBm)

D.3.1 MGWS–FLANE on ITS - Scenario 3 –Victim (See section 3.4.4.1 for e.i.r.p of 40 dBm)
For this scenario the ITS characteristic are unchanged from the e.i.r.p at 40 dBm study. This scenario considers the cases were the RSU is possibly interfered by a MGWS-FLANE (see Figure 8).

In this scenario the following assumptions are considered:
MGWS FLANE:

- Bandwidth: 150 MHz
- Max e.i.r.p.: 55 dBm
- Building height: 20 m
- Polarisation: slant 45 degree
- Cases:
    - Case 3a and case 3b are described in section 3.4.4.1
    - Case 3 c (e.i.r.p 55 dBm): 16 dBi (G0=45dBi, value from ITU-R F.699 at 5° to the main lobe and a Tx power of 10 dBm)
    - Case 3d (e.i.r.p 48 dBm): 19 dBi (G0=38dBi, value from ITU-R F.699 at 5° to the main lobe and a Tx power of 10 dBm)

ITS RSU antenna main lobe gain: 23dBi (Circular polarization)

Separation distances are given in Table D.4.

D.4. Conclusions on compatibility between ITS and MGWS FLANE (e.i.r.p = 55dBm)

LINK BUDGET	Value	Units	**I v V**	**ITS RSU - FLANE**	**ITS IVU - FLANE**	**ITS RSU - FLANE**
Emission part						
Bandwidth		MHz		120	120	120
Tx Antenna gain		dBi		14	21	14
Tx Power		dBm		26	19	26
Tx out, e.i.r.p.		dBm		40	40	40
Tx Out e.i.r.p. per MHz		dBm/MHz		19	19	19
effect of TPC (dB)		dB		0	0	0
Sidelobe rejection		dB		20	20	20
Interferer Effective Gain Gt				-6	1	-6
Net Tx Out power towards the victim		dBm		20	20	20
Net Tx Out power towards the victim		dBm/MHz		-1	-1	-1
Reception part:						
Receiver bandwidth		MHz		150	150	150
Receiver sensitivity		dBm				
Antenna gain		dBi		38	38	45
Sidelobe rejection		dB		30	19	29
Interferer Effective Gain Gt				8	19	16
C min at antenna input		dBm				
C min per MHz at antenna input		dBm/MHz				
Thermal noise floor	-174	dBm/Hz		-174	-174	-174
Receiver noise figure		dB		10	10	10
Receiver noise level 'N' at antenna input		dBm		**-90**	**-101**	**-98**
Receiver noise level per MHz 'N' at antenna input		dBm/MHz		**-112**	**-123**	**-120**
Protection criterion						
Criterion C/I	6	dB				
Criterion I/N	-10	dB		-10	-10	-10
Allowable Interfering power level 'I' at receiver antenna input		dBm		**-100**	**-111**	**-108**
Allowable Interfering power level per MHz 'I' at receiver antenna input		dBm/MHz		**-122**	**-133**	**-130**
Propagation model						
Bandwidth correction factor		dB		**0**	**0**	**0**
MCL		dB		120	131	128
Polarisation Loss min.			H/V/C/45°	3	3	0
Window Barrier Loss	15	dB		0	0	15
Free Space Loss L_s		dB		117	128	113
Oxygen induced Loss	7	dB/km				
Frequency (GHz)	64.00	GHz				
SITUATION (Emission/Reception)				SL-SL	SL-SL	SL-ML
Separation distance (m)				**227**	**600**	**152**
Case				1a/1b	1c	1d

Table D.3: ITS – MGWS separation distance (ITS interferer).

LINK BUDGET	Value	Units	I v V	FLANE-ITS RSU	FLANE-ITS RSU	FLANE-ITS RSU	FLANE-ITS RSU
Emission part							
Bandwidth		MHz		150	150	150	150
Tx Antenna gain		dBi		38	38	45	38
Tx Power		dBm		2	2	10	10
Tx out, e.i.r.p.		dBm		40	40	55	48
Tx Out eirp per MHz		dBm/MHz		18	18	33	26
effect of TPC (dB)		dB		0	0	0	0
Sidelobe rejection		dB		30	18.6	29	19
Interferer Effective Gain Gt				8	19.4	16.0	19.0
Net Tx Out power towards the victim		dBm		10	21.4	26	29
Net Tx Out power towards the victim		dBm/MHz		-12	0	4	7
Reception part:							
Receiver bandwidth		MHz		120	120	120	120
Receiver sensitivity		dBm		-86	-86	-86	-86
Antenna gain		dBi		23	23	23	23
Sidelobe rejection		dB		0	0	0	0
Interferer Effective Gain Gt				23	23	23	23
C min at antenna input		dBm		**-109**	**-109**	**-109**	**-109**
C min per MHz at antenna input		dBm/MHz		**-130**	**-130**	**-130**	**-130**
Thermal noise floor	-174	dBm/Hz					
Receiver noise figure		dB					
Receiver noise level 'N' at antenna input		dBm					
Receiver noise level per MHz 'N' at antenna input		dBm/MHz					
Protection criterion							
Criterion C/I	6	dB		6	6	6	6
Criterion I/N	-10	dB					
Allowable Interfering power level '*I*' at receiver antenna input		dBm		**-115**	**-115**	**-115**	**-115**
Allowable Interfering power level per MHz '*I*' at receiver antenna input		dBm/MHz		**-136**	**-136**	**-136**	**-136**
Propagation model							
Bandwidth correction factor		dB		**-1**	**-1**	**-1**	**-1**
MCL		dB		124	135	140	143
Polarisation Loss min.			H/V/C/45°	3	3	3	3
Window Barrier Loss	15	dB		0	0	0	0
Free Space Loss L_s		dB		121	132	137	140
Oxygen induced Loss	7	dB/km					
Frequency (GHz)	64.00	GHz					
SITUATION (Emission/Reception)				SL-ML	ML-SL	SL-ML	SL-ML
Separation distance (m)				**325**	**815**	**1100**	**1310**
Case				3a	3b	3c	3d

Table D.4 ITS – MGWS separation distance (MGWS interferer)

ITS	MGWS		
	FLANE e.i.r.p = 55 dBm	WPAN/WLAN (indoor)	WPAN/WLAN (outdoor)
Interferer	600 (see table 14)	See table 10	Not studied
Victim	1310 (see table 15)	See table 10	See table 10

Table D.5: Minimum separation distances with an e.i.r.p of 55 dBm (See Table 9 for an overview of the MGWS applications)

FLANE 55dBm e.i.r.p.

As explained in the study made with an e.i.r.p of 40 dBm, FLANE position is fixed and predictable. The separation distances are in the order of 1300 m using Recommendation ITU-R F.699, parabolic antenna. In order to protect ITS from possible interference resulting from FLANE operating in the band 63-64GHz and deployed in the same areas, there may be a need to introduce additional mitigation techniques (e.g. light licensing or co-ordination process).

The conclusions given in Table 11 are the same for an e.i.r.p of 40dBm or 55 dBm. The calculated separation distances are larger when considering Recommendation ITU-R F.699 instead of real measured radiation pattern as used in case 1a and case 3a.According to ECC/REC(09)01 [14], it should be considered that FLANE systems are technically equal to any PP application and are considered to be part of the Fixed Service. Therefore the conclusions given in this annex are also applicable to the Fixed Service.

ANNEX E: REFERENCES

[1] ERC Report 3: “Harmonisation of frequency bands to be designated for road Transport Information Systems”

[2] ECC/DEC/(02)01: “On the frequency bands to be designated for the coordinated introduction of Road Transport and Traffic Telematic Systems”

[3] ERC/REC 70-03: "Relating to the use of Short Range Devices (SRD)", Annex 5.

[4] TR 102 400*:* Intelligent Transport Systems (ITS); Road Traffic and Transport Telematics (RTTT); Technical characteristics for communications equipment in the frequency band from 63 GHz to 64 GHz; System Reference Document

[5] ECC Report 23: “Compatibility of automotive collision warning Short Range Radar operating at 24 GHz with FS, EESS and Radio Astronomy”

[6] ERC Report 25: “The European Table of Frequency Allocations and Utilisations covering the frequency range 9 kHz to 275 GHz”

[7] ITU-R Recommendation P.676: “Attenuation by atmospheric gases“

[8] ECC Report 101: “A comparison of the minimum coupling loss method, enhanced minimum coupling loss method, and the Monte-Carlo simulation”

[9] EN 302 217-3 Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas

[10] TR 102 555-3: Technical characteristics of multiple gigabit wireless systems in the 60 GHz range System Reference Document

[11] WIGWAM: System Concept Development for 1 Gbit/s Air Interface http://www.wigwam-project.com

[12] www.hubersuhner.com/sl60

[13] Recommendation ITU-R F.699: Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to about 70 GHz

[14] ECC/REC/(09)01: “Use of the 57-64 GHz frequency band for Point-to-point fixed wireless systems”