ECC Report 244

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

Approved 29 January 2016

0 EXECUTIVE SUMMARY

This Report contains compatibility studies related to WAS/RLANs in the 5725-5925 MHz band. These have been triggered by the EC Mandate on 5 GHz [1] and by the activities on WRC-15 Agenda Item 1.1.

The current status of the various sharing and compatibility studies is summarised hereafter:

Compatibility between RLAN and ITS in the bands 5855-5875 MHz (non-safety ITS), 5875-5905 MHz (safety-related ITS) and 5905-5925 MHz (ITS extension band)

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances if compatibility is dependent upon protection to an I/N level of -6 dB. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated to improve the compatibility between individual RLAN devices and ITS. These studies have focussed on a “listen-before-talk” process, where the potential interferer tries to detect whether a channel is busy before transmitting a data packet.

Two possible approaches are under study:

- Generic Energy Detection without any consideration of the interferer and victim signal frames: Under the assumptions considered, preliminary studies show that in the case of an energy detection threshold of -90dBm/10MHz for a RLAN system operating with 23 dBm/20MHz, an ITS device with 23dBm/10MHz is not reliably to be detected. Further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation.
- Combination of energy detection and carrier sensing, such as one of the Clear Channel Assessment (CCA) modes defined in the 802.11 standard [27]. Further study is required to assess the applicability to ITS of the interference avoidance techniques currently employed in 5 GHz RLAN systems.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered and may be an issue for further work.

Compatibility between RLAN and road tolling in the band 5795-5815 MHz

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances if compatibility is dependent upon protection to an I/N level of -6 dB. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated and the following approaches have been suggested to enable the coexistence between RLAN and road-tolling:

- Implementation in RLAN of a detection mechanism to detect road tolling applications based on energy detection. Under the assumptions considered preliminary analysis indicated that for a RLAN system operating with 23 dBm/20MHz a detection threshold of the order of -100 dBm/500kHz and for a RLAN system with 23 dBm/160MHz a detection threshold of the order of -90 dBm/500kHz would be required for a reliable detection of road tolling. Further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation.
- Transmission from the road tolling applications of predefined signals (beacons) which indicate that the used channels are busy, similar to one of the mitigation techniques used to facilitate ITS and Road Tolling adjacent channel co-existence.
- Ensure coexistence with the road tolling systems through the detection of ITS. This is based on the assumption that there will always be ITS systems in the close vicinity of road-tolling road-side units. Under this approach, once ITS have been detected by RLAN under the conditions described in section 2, the road tolling frequency band 5795-5805 MHz / 5805-5815 MHz will also be considered as occupied and thus, not available for RLAN use.

- Use of a geolocation database approach. The geolocation database should hold actual information from static and, due to construction sites, temporary tolling installations. The implementation of such a platform, its access and, its maintenance should be addressed. In addition, the role and responsibilities or the stakeholders have to be clearly defined.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered.

Further work is required to assess these approaches.

Compatibility between RLAN and public transport automation systems in the 5.915-5.935 GHz band

Preliminary calculations have been performed. They would need to be reviewed in the light of the recent developments in ETSI towards a new SRDoc applicable to these systems.

Compatibility between RLAN and FSS (Earth to space) in the bands 5725-5850 MHz and 5850-5925 MHz

The studies have focused on the assessment of the interference from RLAN into FSS and follow a two-step approach:

- **Step 1** is described in section 8.1.2: This step calculates the maximum number of active, on-tune, RLAN transmitters that can be accommodated by the satellite receiver under consideration (see Table 11) (considering the satellite footprint) whilst satisfying the FSS protection criteria described in section 3.2.2.
- **Step 2** is described in section 8.1.3: This step delivers the number of active, on-tune, RLAN transmitters using a deployment model. The Step 2 outputs can be compared with the Step 1 values in order to assess the potential for sharing. In theory, if the Step 2 values are less than or equal to the Step 1 values, then the results suggest that sharing is possible; else if the Step 2 values are greater than the Step 1 values, sharing is not possible.

Concerning step 1, results have been obtained considering 2 different values of building attenuation for indoor use (12 and 17 dB), two values of antenna discrimination (0 and 4 dB), and an approach to service and geographic apportionment of the FSS protection criteria of $\Delta T/T=6\%$.

Further modelling takes account of clutter loss and polarisation mismatch loss on the Earth to space interference path.

The different factors used in step 2 are subject to some uncertainties because of the difficulties involved when deriving values for these factors and in particular when making predictions for 2025. Therefore it was agreed to preform sensitivity analyses, taking into account ranges of values for some of these factors.

Calculations and results are presented in this report but, although providing some relevant results, it is at this stage too early to draw definite conclusions.

Conclusions on the potential for RLAN–FSS sharing will be developed in the Part 2 Report, taking into account additional considerations, such as:

- Antenna discrimination for outdoor RLANs;
- Further studies on polarisation mismatch;
- Studies supporting Stage 8 of FSS Step 2 (see section 8.1.3.4);
- 5 GHz Spectrum Factor (Stage 5 of FSS Step 2);
- Control / monitoring on the long term aggregate effect of RLAN interference into FSS as RLAN deployment increases and investigation of what can be done in a scenario where the interference threshold is reached;
- Further studies on apportionment of the FSS protection criteria.

Some potential mitigation techniques may need to be considered and their impact on the potential sharing between RLAN and FSS should be assessed. Among others, the following potential mitigation techniques could be addressed:

- RLAN Access Points deployed only indoor;
- Additional power limitation for RLAN.

There is a need for studies on the feasibility and practicability on the potential mitigation techniques.

There has been no study on the interference from FSS into RLAN.

Compatibility between RLAN and BFWA (FS) in the band 5725-5875 MHz

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated. Preliminary analysis on detection mechanisms relying on energy detection indicated that a detection threshold of the order of -90 to -95 dBm/20 MHz would be required either on the RLAN side or on the BFWA side. Further consideration is required, including on the feasibility of such detection thresholds.

Due to the similarity between RLAN and BFWA systems using TDD technology, it is also envisaged that more specific coexistence mechanisms may be relevant. This requires further work.

The above considerations on sensing procedures may not apply to FDD BFWA systems.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered and may be an issue for further work.

Compatibility between RLAN and the Amateur (5725-5850 MHz) and Amateur satellite (space to Earth, 5830-5850 MHz) services.

Detail studies have not been performed so far. However some preliminary consideration of the three main categories of radio amateur usage (narrowband, data and amateur satellite) for both directions has been made that may provide guidance for future work (along with ECC Report 206 [26]). This includes an initial identification of relevant mitigation techniques.

Whilst some scenarios and directions may require further study, it has already been found that compatibility is achieved between Amateur Satellite downlink transmissions and RLAN receivers

Compatibility between RLAN and Broadband Direct air to ground communications (BDA2GC) in the frequency range 5855-5875 MHz

A series of compatibility analyses between RLAN and DA2GC have been presented. Studies were performed in respect of the two proposed BDA2GC systems described in ETSI TR 101 599 [24] and ETSI TR 103 108 [25] and were based on commonly agreed assumptions regarding RLAN parameters, distribution densities and activity factors.

Co-channel interference analyses were performed considering the RLANs both as victims and as interferers. The scenarios included consideration of interference to/from DA2GC Aircraft Stations and Ground Stations.

Compatibility is clearly achieved in all scenarios when considering indoor RLANs. For some scenarios involving outdoor RLANs, worst-case Minimum Coupling Loss calculations show that some exceedances of the RLAN or DA2GC receiver protection criteria could potentially occur. However, compatibility is achieved, when taking into account a number of well-defined ameliorating factors such as separation distances, density of active co-frequency RLAN devices, clutter loss, use of power control and antenna discrimination.

It is observed that the outdoor rural RLAN scenarios are the most demanding but the probability of their occurrence is small.

It should be noted that the studies in this section assumed free space loss propagation conditions with clutter loss according to Recommendation ITU-R P.452 [19]. The clutter loss has been used for the studies between DA2GC GS and RLAN for all scenarios including the rural environment with about 15 dB clutter loss. Under worst case conditions, there could be line of sight between victim and interferer without any clutter, especially in rural environments, which would increase the separation distances. However, the probability is expected to be low.

Compatibility between RLAN and Wireless Industrial Applications (WIA) in the band 5725-5875 MHz

The MCL calculations lead to significant separation distances, in particular in the cases where both systems operate without wall or building separation.

Nevertheless, compatibility can be achieved through a coordination procedure within factory premises where WIA are deployed, taking into account that:

- It is expected that the operation of wireless devices (including WIA and RLAN) within the industrial premises would be controlled by the factory management;
- Frequency separation can be applied considering that frequencies outside the 5725-5875 MHz band are available for RLAN;
- The sharing scenarios addressed in this section may benefit from the implementation in WIA of mitigation techniques as described in ECC Report 206 [26]. For example, a detect-and-avoid mechanism is required in WIA for the compatibility between WIA and BFWA.

Issues for further work:

This Report is mainly based on RLAN characteristics derived from 802.11ac [27]. Other RLAN technologies like LAA-LTE are currently under consideration.

Although all RLAN technologies will have to comply with the same harmonised standard and spectrum regulations (i.e. both systems are expected to share certain characteristics), the assumptions regarding user density, indoor/outdoor usage, amount of traffic etc. may be different for LAA-LTE [41] or any other RLAN technologies and deployments compared to the current assumptions used in this report.

Studies of possible impact of LAA-LTE or any other RLAN technologies and deployments, other than the studies carried out so far with RLAN based on 802.11ac, have not been assessed yet. It is intended that studies of such an impact are to be conducted in the subsequent report.

Further studies are also needed for:

- Compatibility between RLAN and non-specific Short range devices in the band 5725-5875 MHz;
- Compatibility between RLAN and the Amateur (5725-5850 MHz) and Amateur Satellite (Space to Earth, 5830-5850 MHz) services;
- Adjacent band compatibility between RLAN on one hand and the FS and FSS above 5925 MHz, on the other hand.
- Compatibility between RLAN and FS operated in band 5725-5925 MHz.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

Abbreviation	Explanation
3GPP	Third Generation Partnership Project
AP	Access Point
AS	Aircraft Station
BDA2GC	Broadband Direct-Air-to-Ground Communications
BFWA	Broadband Fixed Wireless Access
BPSK	Binary Phase-Shift Keying
CCA	Clear Channel Assessment
CEPT	European Conference of Postal and Telecommunications Administrations
C/I	Carrier to Interference ratio
C/N	Carrier to Noise ratio
CS	Carrier Sensing
DFS	Dynamic Frequency Selection
DSRC	Dedicated short-range communications
DSSS	Direct-Sequence Spread Spectrum
dT/T	Allowable relative noise increase (ΔT/T)
EC	European Commission
ECC	Electronic Communications Committee
ED	Energy Detection
e.i.r.p.	Equivalent isotropic radiated power
EN	European Standard
ETSI	European Telecommunications Standards Institute
EU	European Union
FHSS	Frequency Hopping Spread Spectrum
FS	Fixed Service
FSS	Fixed Satellite Service
GMES	Global Monitoring for Environment and Security
GS	Ground Station
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent transportation system
LAA	License Assisted Access
LBT	Listen Before Talk
LEO	Low Earth Orbit

Abbreviation	Explanation
LTE	Long Term Evolution
MCL	Minimum Coupling Loss
OBU	On-Board Units
OFDM	Orthogonal Frequency Division Multiplex
P2MP	Point-To-Multi-Point communication
P2P	Point-To-Point
POD	Probability Of Detection
QAM	Quadrature Amplitude Modulation
R2V	Road to vehicle (downlink)
RLAN	Radio Local Area Network
RSU	Road ‘side Units
RTTT	Road Transport and Traffic Telematics
Rx	Receiver
s-E	Space-to-Earth
SRD	Short Range Device
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TPC	Transmitter Power Control
TTT	Transport and Traffic Telematics
Tx	Transmitter
UE	User Equipment
V2R	Vehicle to Road (uplink)
WAS	Wireless Access Systems
WIA	Wireless Industrial Applications
WRC	World Radiocommunication Conference

1 INTRODUCTION

This Report contains compatibility studies related to WAS/RLANs in the 5725-5925 MHz band. These have been triggered by the EC Mandate on 5 GHz [1] and by the activities on WRC-15 Agenda Item 1.1.

The compatibility between WAS/RLAN and the following systems will be considered in this report:

- Transportation systems, i.e. safety-related ITS systems in the band 5875-5905 MHz, ITS in the extension band 5905-5925 MHz and non-safety ITS in the band 5855-5875 , road-tolling applications (TTT/DSRC) in the bands 5795-5805 and 5805-5815 MHz and other transportation systems used within CEPT for public transport automation (like subways) in the band 5915-5925 MHz;
- FSS (Earth to space) in the band 5725-5925 MHz;
- BFWA (FS) in the band 5725-5875 MHz;
- Amateur (5725-5850 MHz) and Amateur Satellite (Space to Earth, 5830-5850 MHz) services;
- Other potential future use of the 5725-5925 MHz band:
  - Broadband Direct air to ground communications (BDA2GC) in the frequency range 5855-5875 MHz;
  - Wireless Industrial Applications (WIA) in the band 5725-5875 MHz.

For each compatibility scenario, both directions of interference should be considered.

The following studies are not considered in this report:

- Compatibility between RLAN and non-specific Short range devices in the band 5725-5875 MHz;
- Compatibility between RLAN and the Amateur (5725-5850 MHz) and Amateur Satellite (Space to Earth, 5830-5850 MHz) services;
- Adjacent band compatibility between RLAN on one hand and the FS and FSS above 5925 MHz, on the other hand;
- The compatibility study between RLANs in the 5725-5925 MHz band and the Radiolocation Service is not addressed in this Report.

2 OVERVIEW OF RADIO LOCAL AREA NETWORKS IN THE 5 GHZ RANGE

2.1 CURRENT REGULATIONS IN THE 5150-5350 MHZ AND 5470-5725 MHZ

ECC/DEC/(04)08 [2] addresses the designation of the frequency bands 5150-5350 MHz and 5470-5725 MHz for the implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs). These frequency bands have been allocated to the mobile service except aeronautical mobile service on a primary basis in all three regions by World Radiocommunication Conference 2003 (WRC-03), taking into account the need to protect primary services in these frequency bands. Furthermore WRC-03 adopted Resolution 229 [3] on "Use of the bands 5150-5250 MHz, 5250-5350 MHz and 5470-5725 MHz by the mobile service for the implementation of Wireless Access Systems including Radio Local Area Networks".

The results of detailed compatibility studies within CEPT taking into account the existing radio services can be found in ERC Report 67 (February 1999) [4] and ERC Report 72 (May 1999) [5]. The outcome of these studies were also considered in the development of European telecommunication standard ETSI EN 301 893 [6]. As a consequence of these studies, the following bands were identified for use by RLANs under prescribed conditions:

- 5150-5350 MHz
  Only indoor use, mean e.i.r.p.[1] limited to 200 mW, and use of dynamic frequency selection (DFS) as well as transmitter power control (TPC) are required above 5 250 MHz;
- 5470-5725 MHz
  Indoor as well as outdoor use allowed, mean e.i.r.p.[1] limited to 1 W, use of dynamic frequency selection (DFS) and transmitter power control (TPC) required.

These regulations have been implemented into EU regulations through the EC Decision 2005/513/EC complemented by EC Decision 2007/90/EC [7].

2.2 PROPOSAL FOR ADDITIONAL SPECTRUM FOR RLANS IN THE 5 GHZ RANGE

A substantial share of internet traffic in Western Europe is accessed over Wi-Fi and this share is anticipated to grow to ~ 60% of total internet traffic by 2017.

In 2012 the European Commission announced its intention to consider the designation of additional harmonised licence-exempt spectrum for RLAN services at 5 GHz through a revision of Decision 2005/513/EC as amended by Decision 2007/90/EC [7].

In addition, the RSPP requires Member States, in cooperation with the Commission to take all steps necessary to ensure that sufficient spectrum for coverage and capacity purposes is available for all citizens by 2020.

From a technology point of view, the IEEE 802.11ac [27] Wi-Fi standard can support these objectives for capacity, speed and quality, but its true potential will only be realised with the availability of wide spectrum channels (80 or 160 MHz). The likely availability of such wider channels will depend on the availability of more spectrum and therefore opening a contiguous band from 5150 MHz to 5925 MHz for WAS/RLAN use is under study. The proposed additional spectrum would roughly double capacity and support higher speeds in contended environments involving shared use.

[1] The "mean e.i.r.p." refers to the e.i.r.p. during the transmission burst which corresponds to the highest power, if power control is implemented.

Another technology currently under development which is intended to operate in 5 GHz spectrum is License Assisted Access of LTE (LAA-LTE or LAA). LAA is a 3GPP LTE feature that was under study during the development of this ECC Report. LTE Release 13 became available at the end of 2015 and specifies the LAA feature for the existing RLAN bands below 5725 MHz. LAA-LTE will offer the possibility of offloading capacity by using the same LTE air interface technology and network for licensed and unlicensed spectrum. LAA will also meet the coverage and capacity objectives defined in European directive. It is also worth noticing that LAA will fulfil all regulatory requirements applied to RLAN systems in 5GHz spectrum in accordance with the ETSI harmonised standard.

This is in line with the European Commission mandate to CEPT [1] issued in 2013 and which tasks the CEPT to

1 study and identify harmonised compatibility and sharing scenarios for WAS/RLANs to operate on a shared basis in an uninterrupted band from 5150 MHz to 5925 MHz under the condition that

   a) appropriate protection of EU priority applications, in particular the planned introduction of GMES in the band 5350-5450 MHz and the use of safety-related ITS applications in the frequency band 5875-5905 MHz, is ensured and

   b) coexistence of WAS/RLAN with other current civil and/or military radio systems to which the bands 5350-5470 MHz and 5725-5925 MHz and adjacent bands have already been assigned or designated is safeguarded;

2 develop appropriate compatibility and sharing conditions to ensure a long-term spectrum access resource for WAS/RLANs to operate on the basis of a general authorisation as an essential wireless broadband infrastructure in the internal market; and

3 to review and/or reconfirm the compatibility and sharing conditions developed under task 2 for the Final report after WRC-15 taking utmost account of the possibility of international harmonisation.

The present report has been developed as part of the work to be done by the CEPT in response to the EC mandate.

2.3 CHARACTERISTICS OF RLANS IN THE BAND 5725-5925 MHz

New RLAN systems based on IEEE 802.11ac [27] will be considered in this report, whose will be able to use 80 MHz and/or 160 MHz channels. This compares to the 20 MHz or 40 MHz channels supported by IEEE 802.11n devices which are typically used today. As shown in the below figure, the wider RF bandwidths supported by the IEEE 802.11ac standard require large blocks of contiguous spectrum.

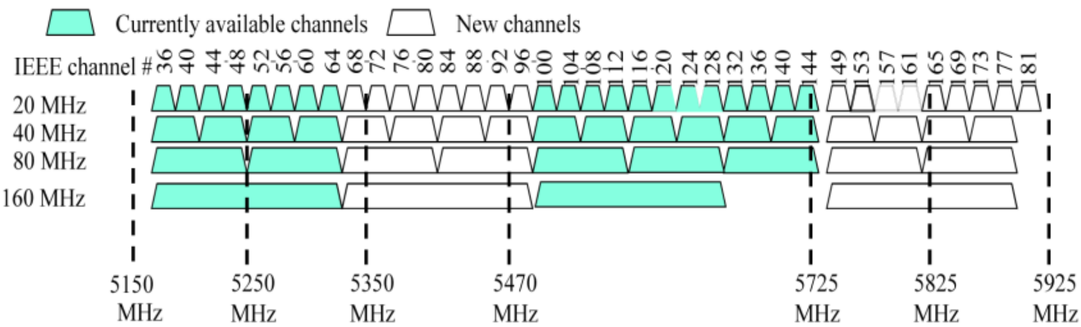


Figure 1: Overview 5 GHz Channels

Envisaged RLAN deployments in the 5725-5925 MHz band include low-power indoor Wi-Fi type networks and higher power outdoor Wireless Internet Service Provider type devices.

For sharing and compatibility studies, RLAN parameters should be similar to those under consideration for the band 5350-5470 MHz as well as some higher power, point-to-point, and point-to-area devices.

Notice that the channelization considered in this report only refers to IEEE 802.11ac [27]. However, LAA-LTE Rel-13 will use the same minimum channel bandwidth of 20MHz and the same channelization considered by IEEE 802.11ac. It is important to notice that EU spectrum regulations do not mandate any particular channelization or minimum bandwidth. Channelization requirements for RLAN in the extension bands are expected to be available in the future.

2.3.1 Basic RLAN characteristics

Table 1: Basic RLAN transmitter characteristics in the band 5725-5925 MHz

	RLAN 1 Omni-Indoor	RLAN 2 Omni Outdoor	RLAN 3 Directional Outdoor
Maximum Transmit Power (e.i.r.p. - dBm)	23	30	30
Bandwidth (MHz)	20/40/80/160	20/40/80/160	20/40/80/160
Maximum Transmit Power Density (e.i.r.p. - dBm/MHz)	10/7/4/1	10/7/4/1	10/7/4/1
Typical AP Antenna Type	Omni (azimuth) See Table 4, Table 5 and Table 6 Type 1 and 2	Omni (azimuth) See Table 6 , Type 1 and 2	Directional, See Table 6, Type 3 and 4
AP Antenna directivity gain (dBi)	0-6	6-7	12/18

The figure below provides the spectrum mask for RLAN as function of the nominal channel bandwidth, typically 20, 40, 80 or 160 MHz

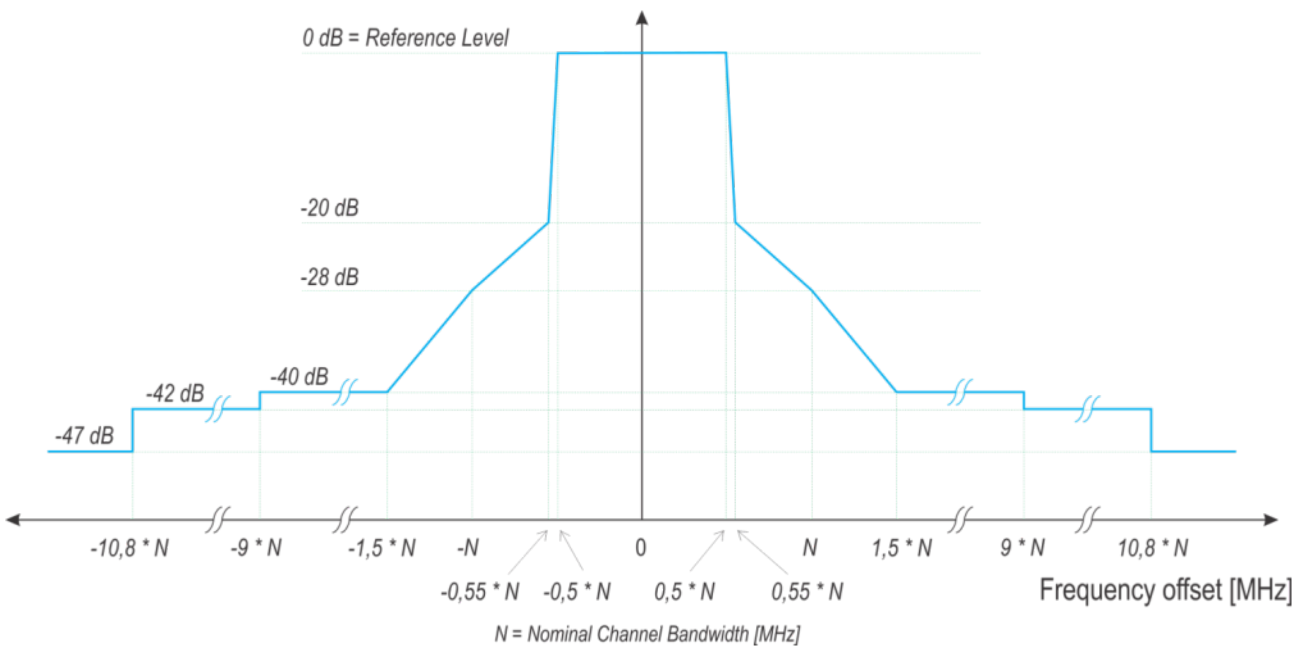


Figure 2: Spectrum mask for RLAN

The assumed average channel bandwidths distribution of RLAN devices is given in the following table.

Table 2: RLAN channel bandwidth distribution

Channel bandwidth	20 MHz	40 MHz	80 MHz	160 MHz
RLAN Device Percentage	10 %	25 %	50 %	15 %

The next table provides RLAN receiver parameters for the purpose of compatibility studies with RLAN as a victim.

Table 3: Basic RLAN receiver characteristics in the band 5725-5925 MHz

System parameter	Value			
Bandwidth (MHz)	20	40	80	160
kTB dBm / bandwidth	-101	-98	-95	-92
Typical Noise figure dB	4			
Noise Power (dBm / bandwidth)	-97	-94	-91	-88
Typical Sensitivity for MCS0, BPSK (½ coding rate) (dBm)	-92	-89	-86	-83
C/N for MCS0, BPSK (½ coding rate) (dB)	5			
I/N (dB) (note 1)	-6			
C/I (dB)	11 for I/N -6 dB; 5 for I/N 0 dB			
Maximum antenna gain at the RLAN Access Point (dBi)	See Table 5 and Table 6			
Maximum antenna gain at the RLAN user device (dBi)	See Table 4			

Note 1: As per ITU-R Recommendation M.1739 [8], the I/N ratio at the WAS/RLAN receiver should not exceed –6 dB, assuring that degradation to a WAS/RLAN receiver's sensitivity will not exceed approximately 1.0 dB. Whilst it is designed to address interference from multiple sources, this criterion is also considered in this Report for single-entry analysis.

2.3.2 RLAN antenna pattern

The characteristics in Table 4 are representative of an average antenna for all User Equipment within a population of RLAN devices. User Equipment can be defined as mobile or portable devices such as smart phones, tablets, notebooks, wireless scanners etc.

Table 4: RLAN User Equipment antenna (mobile/portable device)

#	Type	Gain (dBi)	Antenna height above ground (m)
1	Omni-directional Antenna	1.3	1 to1.5
NOTE: This value is the averaged value obtained from a survey on RLAN UE antennas. For simplicity, this antenna is assumed to be isotropic.			

The antenna pattern in Table 5 is considered as a representative average antenna pattern for indoor access points within the RLAN population. The table specifies the gains available at elevation angles; the antenna pattern is omni-directional in azimuth.

Table 5: Example of Indoor RLAN Access Point Omni-directional (azimuth) Antenna - Elevation Pattern

Elevation angle θ (Degrees)	Gain (dBi)
$45 < \theta \leq 90$	-4
$35 < \theta \leq 45$	0
$0 < \theta \leq 35$	3
$-15 < \theta \leq 0$	-1
$-30 < \theta \leq -15$	-4
$-60 < \theta \leq -30$	-9
$-90 < \theta \leq -60$	-8

The elevation angles in Table 5 are defined from the viewpoint of the RLAN Access Point when mounted to the ceiling. Positive elevation angles are towards the ground and negative elevation angles are towards the sky (typically, the RLAN AP is installed for optimal coverage). The pattern is normalised to 3 dBi gain on boresight.

Table 6 sets out the characteristics of RLAN antennas used on fixed indoor or outdoor equipment such as Access Points, Bridges, P2P or P2MP installations. The corresponding antenna patterns are provided in Figure 3 to Figure 6 below.

Table 6: Typical Fixed indoor and outdoor RLAN antenna (access points, bridges, P2P and P2MP)

#	Type	Gain (dBi)	Indoor / Outdoor	Antenna pattern	Antenna Height (m)
1	Omnidirectional Antenna	6	Indoor & Outdoor	Figure 3	6 to 28,5
2	Directional Antenna (sector)	6	Indoor & Outdoor	Figure 4	
3	Directional Antenna	12	Outdoor	Figure 5	
4	Directional Antenna (sector)	17	Outdoor	Figure 6	

NOTE: The (Highly) directional links are often installed on top of buildings

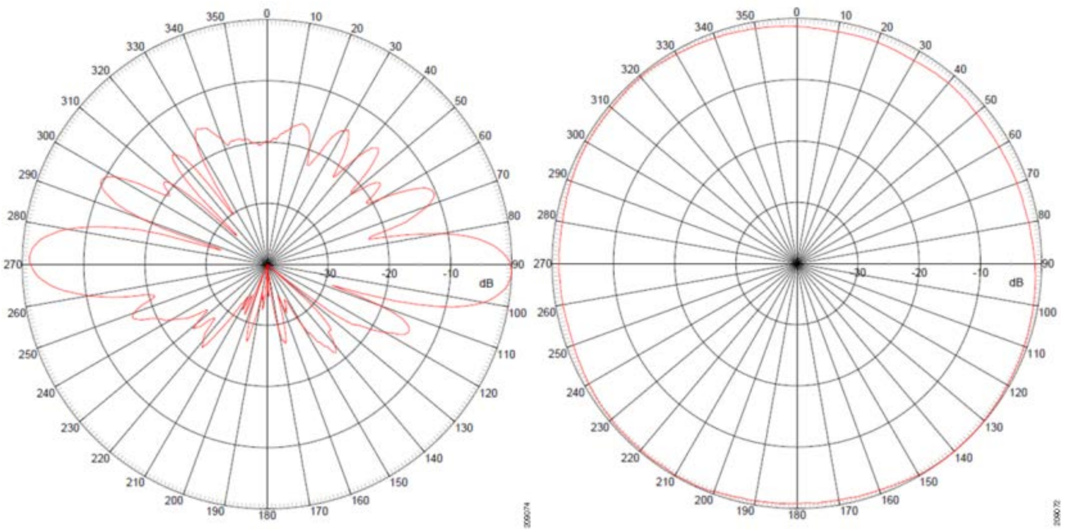


Figure 3: RLAN 6 dBi Omni – Elevation (left) and Azimuth (right) Radiation Patterns

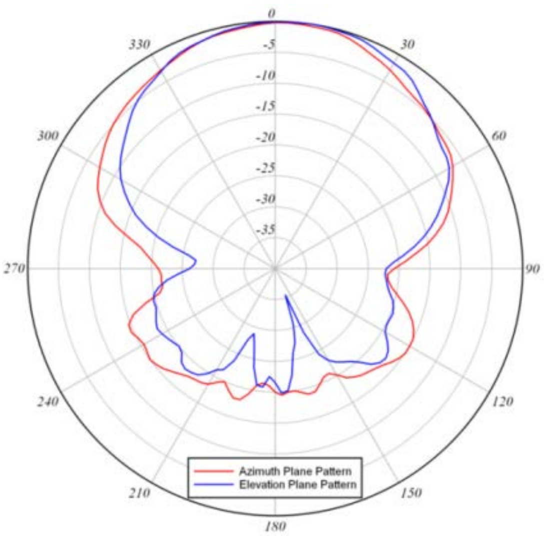


Figure 4: RLAN 6 dBi Directional – Elevation (blue) and Azimuth (red) Radiation Patterns

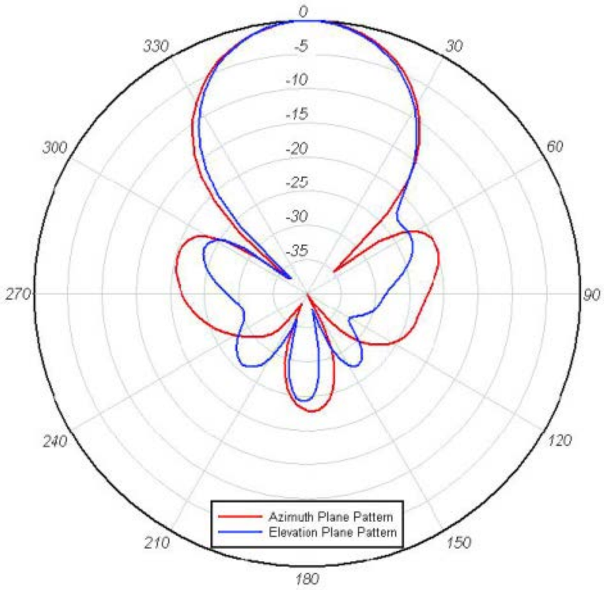


Figure 5: RLAN 12 dBi Directional – Elevation (blue) and Azimuth (red) Radiation Patterns

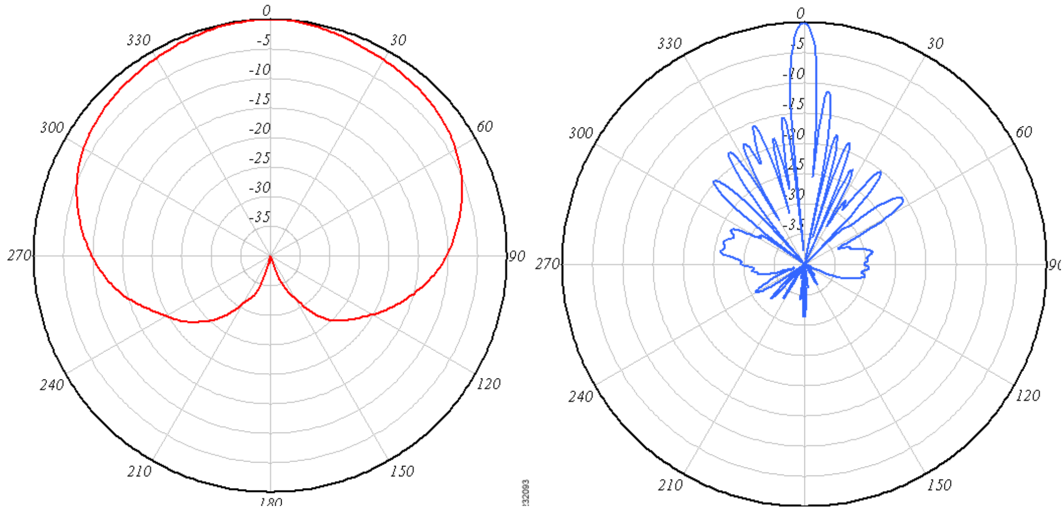


Figure 6: RLAN 17 dBi Sector Antenna – Elevation (blue) and Azimuth (red) Radiation Patterns

2.3.2.1 *RLAN APs antenna pattern measurements*

A measurement campaign (see [46]) was carried out to measure 7 different RLAN APs operating in the 5 GHz band (3 consumer and 4 enterprise 802.11ac Aps [27]). This measurement presented the radiation pattern of all access points from 0° to 360° in azimuth and from −90° to +90° in elevation.

RLAN equipment can broadly be categorised in consumer, enterprise, and industrial equipment. The consumer segment is by far the biggest of the three, accounting for more than 85% of unit shipments[2].

2 2009 status, based on market reports from IMS Research, ABI Research, iSupply, and Plum Consulting

In order to obtain representative results it was decided to characterise state-of-the art IEEE 802.11 ac [27] consumer and enterprise equipment.

The following IEEE 802.11 ac devices were measured:

Table 7: Measured RLAN APs

Consumer	Enterprise
Linksys EA6500	Ubiquiti UAP-AC
Asus RT-AC66U	Aruba APIN0225
Netgear R6300	Zyxel NWA 1123-AC
	Cisco Aircap 37021-E-K9

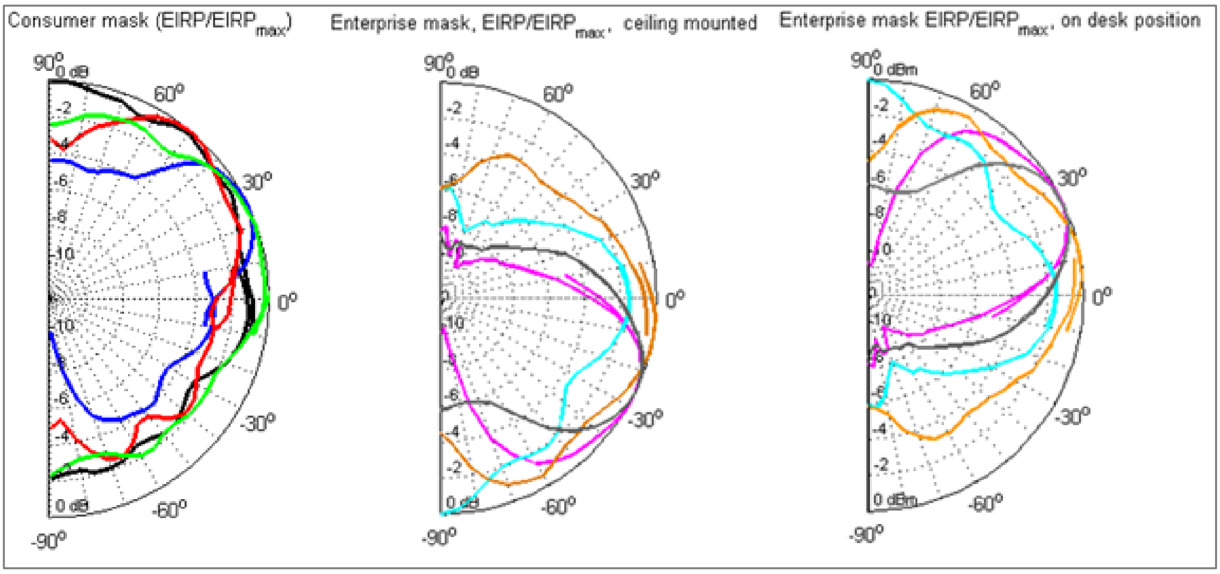


Figure 7: Consumer and Enterprise Antenna patterns

Consumer Access Points measured showed relatively low directivities and similar average e.i.r.p. with respect to elevation angles. In the majority of cases the maximum e.i.r.p. was observed at elevations between 20° and 75°.

Enterprise APs present higher directivities than the consumer ones. Consequently, the emission pattern depends strongly on how the AP is positioned (i.e. ceiling mounted or desk position).

2.3.3 RLAN power distribution

Table 8: RLAN power distribution

Tx power e.i.r.p.	1W (directional)	1 W (omni)	200mW (omni)	80mW (omni)	50mW (omni)	25mW (omni)	all
indoor	0%	0%	18%	25.6%	14.2%	36.9%	94.7%
outdoor	0.10%	0.20%	0.95%	1.35%	0.75%	1.95%	5.3%

The RLAN power distribution presented here leads to a 5.3 % use of outdoor devices. Sensitivity analysis may be performed with other outdoor use ratio to assess the impact of this parameter on the compatibility studies.

2.3.4 RLAN deployment and density of active devices

Two options were considered in CEPT Report 57 [42] (see section A3.1.7) :

Option A: From 0.0008 to 0.008 active devices per 20 MHz channel per inhabitant (based on 3% to 30% activity factor) applied to any population size”.

Option B: 4837 active devices per 20 MHz channel or 9871 active devices per 100 MHz channel per 5.25 million inhabitants as derived from the deployment figures provided in the table below.

Section 8 provides a detailed analysis on RLAN deployment and density of active devices used fort the compatibility studies with FSS.

3 OTHER APPLICATIONS IN THE BAND 5725 MHz-5925 MHz

Table 9: Allocation / Identification of spectrum according to ERC Report 25 [9]

Frequency range	European Common Allocation	ECC/ERC harmonisation measures	Application	European Footnotes	Standard	Notes
5725-5830 MHz	FIXED-SATELLITE (E/S) RADIOLOCATION Amateur Mobile 5.150 EU2 EU22		Amateur		EN 301 783	
		ECC/REC/(06)04	BFWA		EN 302 502	Within the band 5725-5875 MHz
			Defence systems			Tactical and weapon system radars
			ISM			Within the band 5725-5875 MHz
		ERC/REC 70-03	Non-Specific SRD		EN 300 440	Within the band 5725-5875 MHz
		ERC/REC 70-03	Radiodetermination applications			Within the band 4500-7000 MHz for TLPR application
		ERC/REC 70-03	RTTT		EN 300 674	Within the band 5795-5805 MHz. RTTT in the band 5805-5815 MHz on a national basis
			Weather Radars			Ground based and airborne
5830-5850 MHz	FIXED-SATELLITE (E/S) RADIOLOCATION Amateur		Amateur Satellite (S/E)	EU23		Within the band 5830-5850 MHz
		ECC/REC/(06)04	BFWA		EN 302 502	Within the band 5725-

Frequency range	European Common Allocation	ECC/ERC harmonisation measures	Application	European Footnotes	Standard	Notes
	Amateur Satellite (S/E) Mobile 5.150 EU2 EU22					5875 MHz
			Defence systems			Tactical and weapon system radars
			ISM			Within the band 5725-5875 MHz
		ERC/REC 70-03	Non-Specifics SRDs		EN 300 440	Within the band 5725-5875 MHz
		ERC/REC 70-03	Radiodetermination applications		EN 302 372	Within the band 4500-7000 MHz for TLPR application
			Weather radars			Ground based and airborne
5850-5925 MHz	FIXED FIXED-SATELLITE (E/S) MOBILE 5.250	ECC/REC/(06)04	BFWA		EN 302 502	Within the band 5725-5875 MHz
			FSS		EN 301 443	Priority for civil networks
			ISM			Within the band 5725-5875 MHz
		ECC/DEC/(08)01 ECC/REC/(08)01	ITS		EN 302 571	Within the band 5875-5925 MHz. Within the band 5855-5875 MHz
		ERC/REC 70-03	Non-Specific SRDs		EN 300 440	Within the band 5725-5875 MHz
		ERC/REC 70-03	Radiodetermination applications		EN 302 372	Within the band 4500-7000 MHz for TLPR application

Figure 8 below is an overview of the systems/services being considered in the compatibility studies with respect to Wireless Access Services / RLAN in the band 5725-5925 MHz:

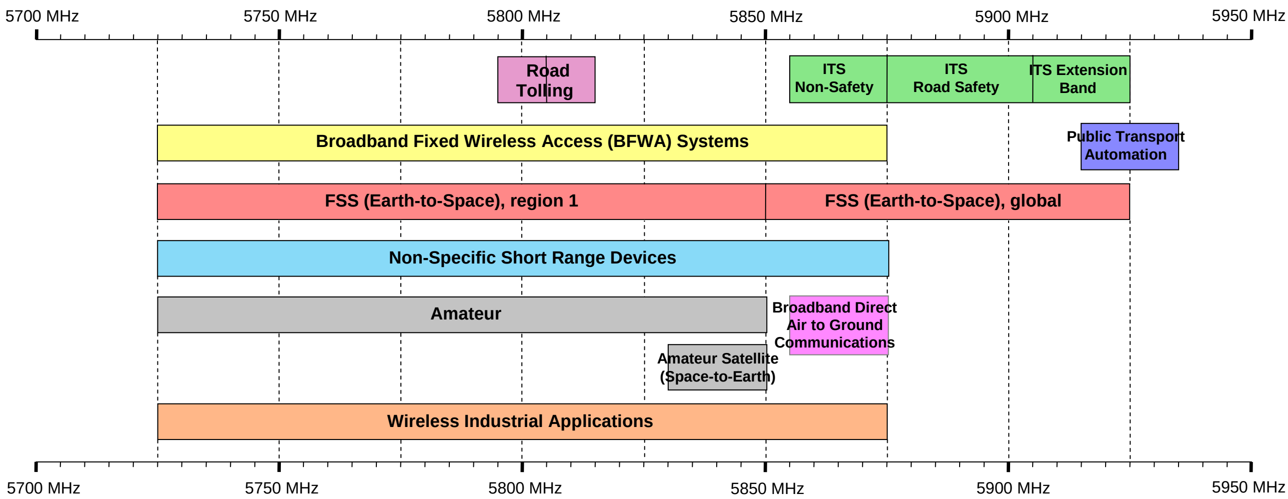


Figure 8: Overview of systems/services considered in the Report within the band 5725-5925 MHz

3.1 TRANSPORTATION SYSTEMS

This Report considers the following transportation applications operating in the 5.8 GHz range:

- Intelligent transportation systems (ITS) in the bands 5875-5905, 5905-5925 and 5855-5875 MHz;
- Road-tolling applications in the band 5795-5915 MHz (also named as CEN-DSRC in Europe)
- Public transport automation systems used at a national level in the 5.915-5.935 GHz band.

Note: DSRC (Dedicated Short Range Communication) is differently used in Europe and the US:

- Europe: CEN-DSRC is used for road tolling systems in the band 5795-5815 MHz, ITS refers to transportation systems in the band 5855-5925 MHz
- US: DSRC refers to transportation systems in the band 5855-5925 MHz; road tolling in the band 5795-5815 MHz is not available.

ETSI TC ITS evaluated interference effects presented in TR 102 960 [34] and developed mitigation methods to avoid interference from ITS into road tolling described in TS 102 792 [35].

3.1.1 Intelligent transportation systems (ITS) in the bands 5875-5905, 5905-5925 and 5855-5875 MHz

3.1.1.1 *Regulations applicable to ITS*

The conditions of use of ITS in the band 5855-5925 MHz have been split into three sub-bands in which different regulations and status apply:

- 5875-5905 MHz: this band is designated through EC Decision 2008/671/EC [10] and ECC/DEC/(08)01 [11] for ITS safety-related applications.
- 5905-5925 MHz: this band is identified in ECC/DEC/(08)01 as potential extension band for ITS.
- 5855-5875 MHz: the band is recommended to be made available for ITS non-safety related applications through ECC/REC/(08)01 [12].

3.1.1.2 *ITS General description*

Radiocommunication systems in the 5 GHz range can today offer communications with a high data rate, ranges up to 1 000 m, low weather-dependence, and global compatibility and interoperability for ITS communication.

The connectivity required by the applications can be summarised as:

1 Inter-Vehicles Communications (IVC) (this includes multi-hop routing involving several vehicles):
- Linear (e.g. for convoys of vehicles);
- Vehicle cluster covering several lanes (e.g. for lane management, overtaking assist).

2 Vehicle to Roadside (uplink) V2R and Roadside to Vehicle R2V (downlink):
- One vehicle to beacon;
- Beacon to one vehicle;
- Beacon to many vehicles (broadcast, short range and long range);
- Beacon to selected vehicles.

3 Cluster of vehicles communication, including to roadside beacon.

This is further described in ECC Report 101 [13].

3.1.1.3 *ITS Technical characteristics*

ITS technical characteristics are provided in ANNEX 1:.

3.1.2 Road-tolling applications in the band 5795-5815 MHz

ECC/DEC/(02)01 has identified the frequencies for RTTT applications in the band 5.795-5.815 GHz, ECC/DEC(02)01 has been withdrawn by ECC/DEC(12)04 [14].

The frequency bands 5795-5805 MHz is identified in ERC/REC 70-03 [15], Annex 5, for TTT, with possible extension to 5815 MHz. The band 5795-5805 MHz is for use by initial road-to-vehicle systems, in particular road toll systems, with an additional sub-band, 5805-5815 MHz, to be used on a national basis to meet the requirements of multi-lane road junctions.

The regulatory parameters (maximum power levels) for TTT are given in Annex 5 of ERC/REC 70-03. The road tolling systems parameters used in this Report are taken from the EN 300 674 [16] developed by ETSI and the EN12253 [17] developed by CENELEC. It should be noted that the EN 300 674 deals with both Road Side Units (RSU) and On-Board Units (OBU) and is divided in two parts, the part 1 providing general characteristics and test methods, the part 2 containing the essential requirements under article 3.2 of the R&TTE Directive.

The characteristics, including the protection criteria, of the road toll systems are summarised in ANNEX 2:.

3.1.3 Systems for public transport automation in the 5.915-5.935 GHz band

The systems allow data exchange between the fixed railway infrastructure and wagons (moving or stationing). Table 10 summarises the parameters of the system.

Table 10: Summary of characteristics of the public transport automation systems in the 5.915-5.935 GHz band

Parameter:	Value
Frequency band:	5915-5935 MHz
Channel bandwidth:	5 MHz
Channel spacing:	fn = 5915 – 2,5 + 5 n MHz, 1 ≤ n ≤ 4 (n integer)
Antenna Infrastructure (case A)	17 dBi (15°-20° aperture)
Antenna Infrastructure (case B)	19 dBi (15°-20° aperture)
Antenna Wagon	17 dBi horn type
C/I adjacent channel	50 dB
Max theoric Power at TX output	24 dBm +- 1 dB
Max e.i.r.p. for regulatory considerations	29.5 dBm
Modulation	DPSK
Receiver noise figure	5 dB

The figure below summarises the spectrum emission mask of the system.

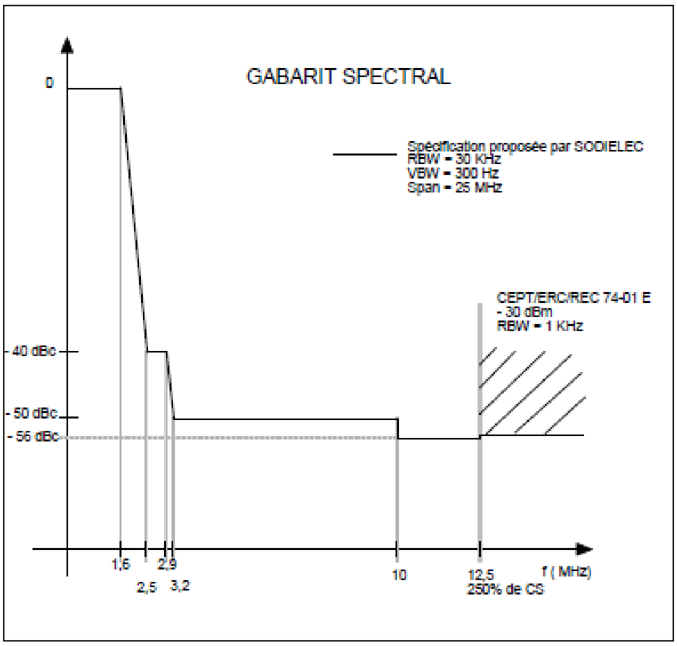


Figure 9: Spectrum emission mask of the public transport automation systems

3.2 FSS (EARTH TO SPACE) IN THE BAND 5725-5925 MHz

3.2.1 FSS technical characteristics and deployments

FSS deployments use the whole band 5725-5925 MHz and it is used by transmitting earth stations in the Earth-to-space direction operating only to satellites in geostationary orbits. In the 125 MHz portion of the band up to 5850 MHz, this is a Region 1 allocation only (i.e. only Europe, Africa, and some of the northernmost countries in Asia). Above 5850 MHz the band is part of the heavily utilised FSS global uplink band and most of the currently operating satellites (INTELSAT & SES for instance) have receive transponders in this upper portion of the band.

The following table provides details of the selection of satellites that have been taken as representative of those requiring protection in the visible portion of the geostationary orbit from Europe. In these frequency bands, the satellite beams cover very large areas of the Earth (using global, hemispherical, zonal or regional beams) as can be seen by the satellite footprint coverage plots in Annex 6 of ECC Report 068 [18].

Table 11: Sample Satellite Data for the band 5725-5875MHz

Satellite	Sub-satellite longitude	Part of Frequency range 5725-5875 MHz used	Satellite Maximum Receive Gain Gsat(dBi)	Space Station Receiving System Noise Temperature Tsat (Kelvin)
A	5o West	Whole band	34	773
B	14o West	Whole band	26.5	1200
C	31.5o West	> 5850 MHz	32.8	700
D	3o East	Whole band	34	773
E	18o West	>5850MHz	32.8	700
F	53o East	Whole band	26.5	1200
G	59.5o East	Whole band	34	1200
H	66o East	>5850 MHz	34.7	700
I	359o East	>5850 MHz	32.8	700
J	40.5o West	>5850 MHz	38.5 (Note 1)	700
K	22o West	>5850 MHz	38.5 (Note 1)	700
L	20 o West	>5850 MHz	38.5 (Note 1)	700
M	50. 5o East	>5850 MHz	38.5 (Note 1)	700
N	57o East	>5850 MHz	38.5 (Note 1)	700

Note 1: for satellites from J to N, the 38.5 dBi value corresponds to beam for continental coverage. For the same satellites, hemispheric and global beams have 32.5 and 28.5 dBi antenna gain values respectively.

Typical FSS parameters developed by the ITU are provided in Table below.

Table 12: Typical FSS parameters in the 6 GHz band

Parameter	Typical value
Range of operating frequencies	5 850-6 700 MHz
Antenna diameters (m)	1.2, 1.8, 2.4, 3.0, 4.5, 8, 16, 32
Antenna reference pattern	Recommendation ITU-R S.465
Range of emission bandwidths	40 kHz - 72 MHz
Receiving space system figure of merit	+5 ↔ -10 dB/K (The database of Recommendation ITU-R S.1328 provides one example with Gsat= 24.8 dBi and Ts= 400 K, corresponding to a G/T of -1.2 dB/K
Earth station deployment	All regions, in all locations (rural, semi-urban, urban)
Earth station e.i.r.p. density towards the horizon	In accordance with RR No. 21.8 and Recommendation ITU-R S.524-9
Minimum earth station antenna elevation angle, h, (degrees)	5, 15 and 40

3.2.2 Protection criteria of FSS systems in the bands 3400-4200, 4500-4800 and 5850-6700 MHz

The criterion adopted for the protection of the FSS is that, on any satellite system, the RLAN emissions should not cause an increase of the equivalent temperature greater that x% of the noise temperature of the satellite receiver in clear sky conditions without interference, i.e. $\Delta T/T \leq x\%$.

In the first instance values for x=6% (generally applicable for sharing in the case of two co-primary services, e.g. the FSS and the MS as co-primary services without service apportionment) and x=1% (generally applicable to interference from a non-primary service into FSS, or to interference from several co-primary services, e.g. the MS and FS, into FSS) are utilised.

Apportionment of interference allowance

To apportion these FSS protection criteria among the potential sources of interference, an apportionment scheme has been considered where interference from RLANs is limited to half of the dT/T= 6% criterion i.e. the dT/T objective is reduced to a value of 3% . In addition, geographic apportionment is applied; dependent on the satellite's coverage, this can have no effect on the dT/T objective or can reduce this to 1.5%. or 1%. Some further explanation of the service and geographic apportionments used for these calculations are given in Section 8.

3.3 BROADBAND FIXED WIRELESS ACCESS (BFWA) SYSTEMS

ECC Report 101 [13] indicated that Broadband Fixed Wireless Access (BFWA) is used for wireless systems that provide local connectivity for a variety of applications and using a variety of architectures, including combinations of access as well as interconnection. ECC Report 068 [18] depicts the different architectures of BFWA and provides the relevant information on these different kinds of networks including technical parameters to ensure compatibility with other systems. The following section provides the main parameters for two BFWA architectures, Point to Multipoint (P-MP) and Mesh.

The 5.725-5.875 GHz band should be able to provide sufficient spectrum for commercial BFWA operations, even though exclusive frequency allocations and channel co-ordination is not envisaged in this band.

The technical parameters of the BFWA systems described below represent an example of real deployment. A P-MP system with a Central Station (sector antenna 120°) and a Terminal Station (direction antenna, 22dBi) was assumed to be representative for the majority of BFWA systems

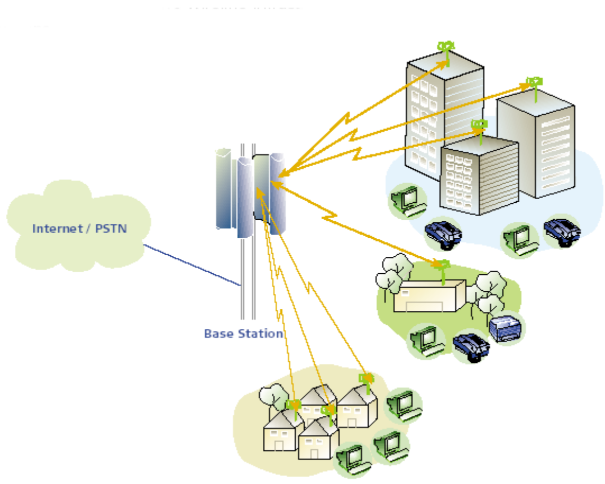


Figure 10: Typical BFWA P-MP deployment scenario (from ECC Report 68 [18])

The technical parameters of the BFWA system used in this study can be found in the following table.

Table 13: BFWA system parameters

Parameter	BFWA P-MP
Topology	Receiver Sectored Central Station (CS) Transmitter Terminal Stations (TS)
Channel bandwidth	20 MHz
Duplex/ Access scheme	TDD/TDMA
Max Tx power dBm TS (conducted)	14 dBm
Max e.i.r.p.	36 dBm
Max Power density spectral (dBm/MHz) e.i.r.p.	23 dBm/MHz
Adaptive power control dB	12 dB
Antenna CS (Rx antenna-> Victim Link Receiver)	16 dBi, sector antenna 120°, 4° down tilt. See Figure 11.
Antenna height CS	30 m
Antenna TS (Tx antenna-> Victim Link Transmitter)	22 dBi (see Figure 12 below)
Antenna height TS	10 m
Receiver sensitivity 64-QAM	-68 dBm

Parameter	BFWA P-MP
Fading Margin	10 dB
Minimum wanted power at TS and BS (Sensitivity – fade margin)	-58 dBm
Protection ratio 64 QAM	C/(I+N) 24 dB C/N=C/I=27 dB
I/N	0 dB
Receiver Noise floor	-95 dBm
Link lenght	Typical 1 km

The following figures provide an overview of the BFWA antenna pattern.

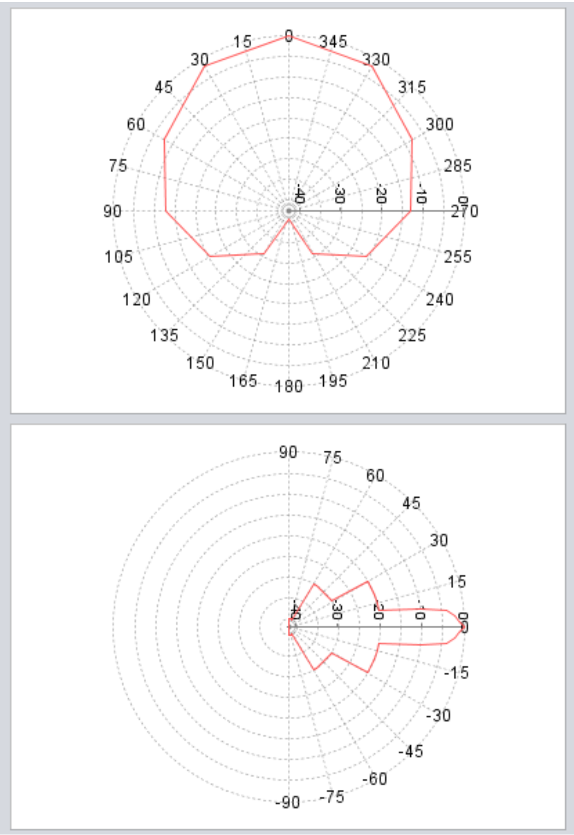


Figure 11: Horizontal and Vertical Pattern of BFWA CS Rx

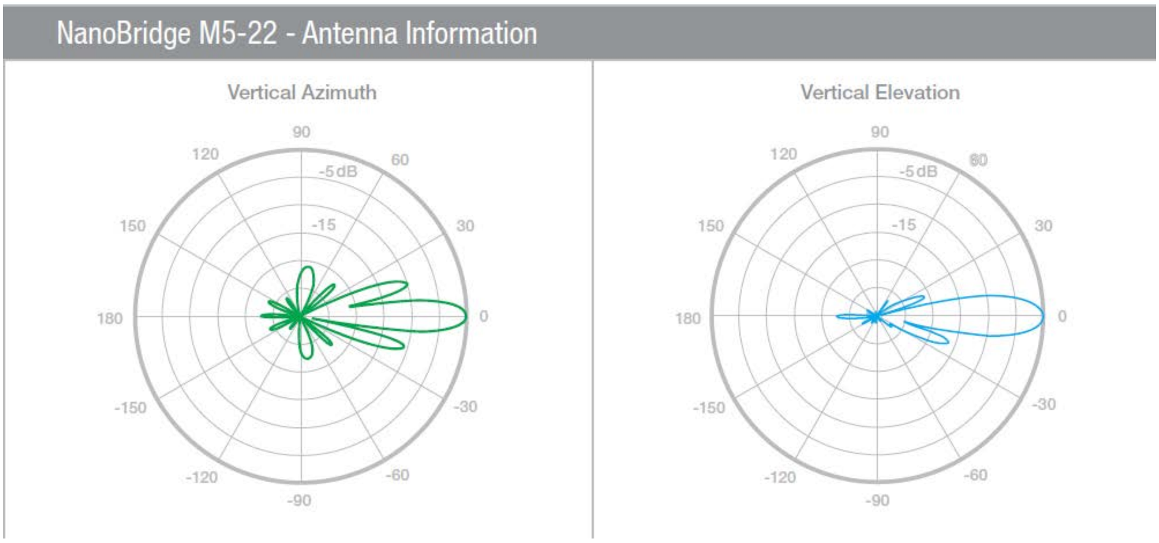


Figure 12: Horizontal and Vertical Pattern of BFWA Ts

3.4 NON-SPECIFIC SHORT RANGE DEVICES IN THE BAND 5725-5875 MHz

The frequency band 5725 MHz to 5875 MHz is designated for non-specific SRDs as per ERC/REC 70-03 [15], Annex 1, and the Decision 2006/771/EC [20] with no duty cycle restriction and a transmit power of 25 mW e.i.r.p.

This use should comply with the technical characteristics as shown below.

Table 14: Technical characteristics of SRD

Frequency Band	Power	Antenna	Channel Spacing	Duty Cycle (%)
5725-5875 MHz	25 mW e.i.r.p	Integral (no external antenna socket) or dedicated	No channel spacing - the whole stated frequency band may be used	No duty cycle restriction

In addition to these regulatory technical characteristics, assumptions on some parameters had to be made in order to carry out compatibility studies. Three kinds of SRD were considered for the interference assessment (see the following table) as in previous CEPT studies (see for example ECC Report 101 [13]). Updated system parameters and examples of real existing equipment were not available at the time this report has been created.

Table 15: SRD parameters

Parameter	SRD I	SRD II	SRD III	Comments
Typical bandwidth BW (MHz)	0.25 MHz	20 MHz	8 MHz	Note 1, Note 2.
TX Power, dBm e.i.r.p.	+14	+14	+14	
Ant. Gain, dBi	2 to 20	2 to 24	2	
Ant. Polarisation	Circular	Circular	Vertical	
Receiver sensitivity, dBm	-110	-91	-84	
Protection criterion, dB	I/N=0dB	C/I=8dB	C/I=20dB	

Parameter	SRD I	SRD II	SRD III	Comments
FkTB	-105 dBm/MHz	N/A	N/A	
Max OoB RX interference, dBm	-35	-35	-35	E.g. limit for Rx blocking
Duty cycle : %	Up to 100%	Up to 100%	100%	
RX wake-up time (if applicable)	1 sec	1 sec	N/A	For battery operated equipment
Note 1: The given bandwidths are for non-spread spectrum modulation. Note 2: For spread spectrum modulation (FHSS, DSSS and other types) the bandwidth can be up to 100 MHz				

3.5 AMATEUR (5725-5850 MHz) AND AMATEUR SATELLITE (SPACE TO EARTH, 5830-5850 MHz) SERVICES

The amateur and amateur-satellite (s-E) services have harmonised allocations in all three ITU Regions in the frequency range 5725-5850 MHz with secondary status as follows:

Table 16: Allocations for Amateur Services

Frequency	Service
5725-5830 MHz	Amateur
5830-5850 MHz	Amateur Amateur Satellite (space-to-Earth)

The operational characteristics of amateur stations and amateur-satellite stations vary significantly. However based on the IARU Region-1 VHF Managers Handbook [21] they can be categorised as:

- Weak signal reception of Narrowband Terrestrial and EME (Moonbounce) operation in the sub-band 5760-5762 MHz, including propagation beacons.
- Data and multimedia systems (point to-point links and area repeaters) in other parts of the band. This use is currently growing with projects such as Hamnet data links systems based on 802.xx technology (see http://hamnetdb.net/ for details).
- Low-power satellite downlinks within 5830-5850 MHz (typically from LEO Cubesat satellites).

3.5.1 Characteristics for the Amateur Service

Recommendation ITU-R M.1732-1 [22] provides characteristics of stations operating in the amateur service for use in sharing studies:

Table 17: Examples of Amateur Service characteristics in the band 5725-5850 MHz

Parameter	CW-Morse, EME	SSB Voice	FM Voice	Digital Voice and Multimedia
Transmitter Power(1) (dBW)	3 – 20 (typically: 13)	3 – 20 (typically: 13)	3 – 20 (typically: 10)	1-10 (typically: 6)

Parameter	CW-Morse, EME	SSB Voice	FM Voice	Digital Voice and Multimedia
Transmitter Feeder Loss (dB)	1 – 2 (typically: 1)	0 – 10 (typically: 1)	0 – 10 (typically: 1)	1 – 6 (typically: 1)
Antenna gain (dBi)	0 – 40 (typically: 33)	0 – 40 (typically: 33)	0 – 40 (typically: 33)	0 – 30 (typically: 27)
Typical e.i.r.p.(dBW)	1 – 45 (typically: 45)	1 – 45 (typically: 45)	1 – 45 (typically: 42)	10 – 40 (typically: 32)
Antenna polarisation	Horizontal, Vertical	Horizontal, Vertical	Horizontal, Vertical	Horizontal, Vertical
Receiver IF bandwidth (kHz)	0.4	2.7	9 15	2.7, 6, 16, 130, 10500
Receiver Noise Figure(2) (dB)	1 – 7 (typically: 1)	1 – 7 (typically: 1)	1 – 3 (typically: 2)	2

(1) Maximum powers are determined by each administration.
(2) Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

In order to simplify studies[3], it is assumed a typical terrestrial CW/SSB amateur station uses a 0.9 m (33 dBi) dish directional antenna, 13 dBW (20 Watt transmitter), and has a 1 dB NF receiver optimised for the 5760-5762 MHz band. The receiver LNA is assumed to be at the antenna feed point, so feeder losses for the receiver situation can be ignored (i.e. assumed to be 0dB).

3.5.2 Characteristics for the Amateur-Satellite Service

In the 5GHz bands the Amateur Satellite service has two distinct ITU secondary allocations:

- 5650-5670 MHz Earth-to-Space only (i.e. for uplinks);
- 5830-5850 MHz space-to-Earth only (i.e. for downlinks).

In this Report, consideration is limited to the space-to-Earth allocation in the 5830-5850 MHz band.

Recommendation ITU-R M.1732-1 [22] provides characteristics of stations operating in the amateur-satellite service for use in sharing studies:

Table 18: Characteristics of Amateur-Satellite systems in the space-to-Earth direction

Parameter	CW-Morse	SSB, FM, Digital Voice, Data
Transmitter Power (1) (dBW)	10	10
Transmitter Feeder Loss (dB)	0.2 – 1	0.2 – 1
Transmitting antenna gain (dBi).	0 – 6	0

[3] In Recommendation IT U-R M.1732-1 [22], the specific 5.7GHz band is combined with other amateur bands. Therefore some adjustments have been made in order to be more representative of 5.7GHz equipment

Parameter	CW-Morse	SSB, FM, Digital Voice, Data
Typical e.i.r.p.(dBW)	0 – 15	9 – 15
Antenna polarisation	Horizontal, Vertical, LHCP, RHCP	Horizontal, Vertical, LHCP, RHCP
Receiver IF bandwidth (kHz)	0.4	2.7, 16, 50, 100
Receiver Noise Figure (2) (dB)	1 – 3 (typically: 1)	1 – 3 (typically: 2)

(1) Maximum powers are determined by each administration.
(2) Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

Most current amateur satellites are typically nano or picosats (also called ‘cubesats’) that occupy slightly elliptical Sun-Synchronous low earth orbits (LEO) of 600-800km altitude. These smaller satellites have relatively low power and antenna gain.

As geostationary systems are generally not in use, it may be noted that for CW systems, therefore, a practical issue arises due to LEO Doppler shift that requires slightly wider Rx rf bandwidth. Therefore, many amateurs would in practice stick to a single 2.4 kHz BW using the SSB-Voice system. Therefore, for the purpose of this report, only the SSB-Voice case is considered in the sharing studies.

For sharing studies 0 dBW Transmit Power, 0.5 dB feeder loss and 3 dB antenna gain for a patch antenna are assumed for the satellite; and the amateur receiving ground station is assumed to be similar to the Amateur Service.

It should be noted that most amateur satellite downlinks are coordinated and harmonised in a sub-band at 5840-5842 MHz.

3.6 BROADBAND DIRECT AIR TO GROUND COMMUNICATIONS (BDA2GC) IN THE FREQUENCY RANGE 5855-5875 MHz

The technical parameters of the DA2GC systems described in ECC Report 210 [23] were used as a basis for the calculations, considering the two following potential BDA2GC systems:

- Section 4.2 of ECC Report 210 describes the technical parameters of the DA2GC system according to ETSI TR 101 599 [24].
- Section 4.3 of ECC Report 210 describes the technical parameters of the DA2GC system according to ETSI TR 103 108 [25].

A summary of the essential technical parameters for use in the compatibility studies considered in this current report can be found in ANNEX 3:

3.7 WIRELESS INDUSTRIAL APPLICATIONS IN THE BAND 5725-5875 MHz

Detailed information on WIA can be found in ECC Report 206 [26]. The following table provides technical parameters of WIA for use in sharing studies.

Table 19: Summary of characteristics of the WIA aystems

Parameter	Indoor	Outdoor
max e.i.r.p.	400 mW (26 dBm)	400 mW (26 dBm)
Receiver sensitivity	WIA-1: -84 dBm in 1 MHz WIA-2: -90 dBm in 3 MHz WIA-3: -88 dBm in 20 MHz	WIA-2: -90 dBm in 3 MHz WIA-3: -88 dBm in 20 MHz
Channel bandwidth	WIA-1: 1 MHz WIA-2: 3 MHz WIA-3:20 MHz	WIA-2: 3 MHz WIA-3: 20 MHz
Antenna	see Figure 13	see Figure 13
Antenna Gain	5 dBi	5 dBi
Antenna height (m)	0.5 m to 10 m	0.5 m to 50 m
Protection criteria (co-channel)	6 dB	6 dB

Antenna:

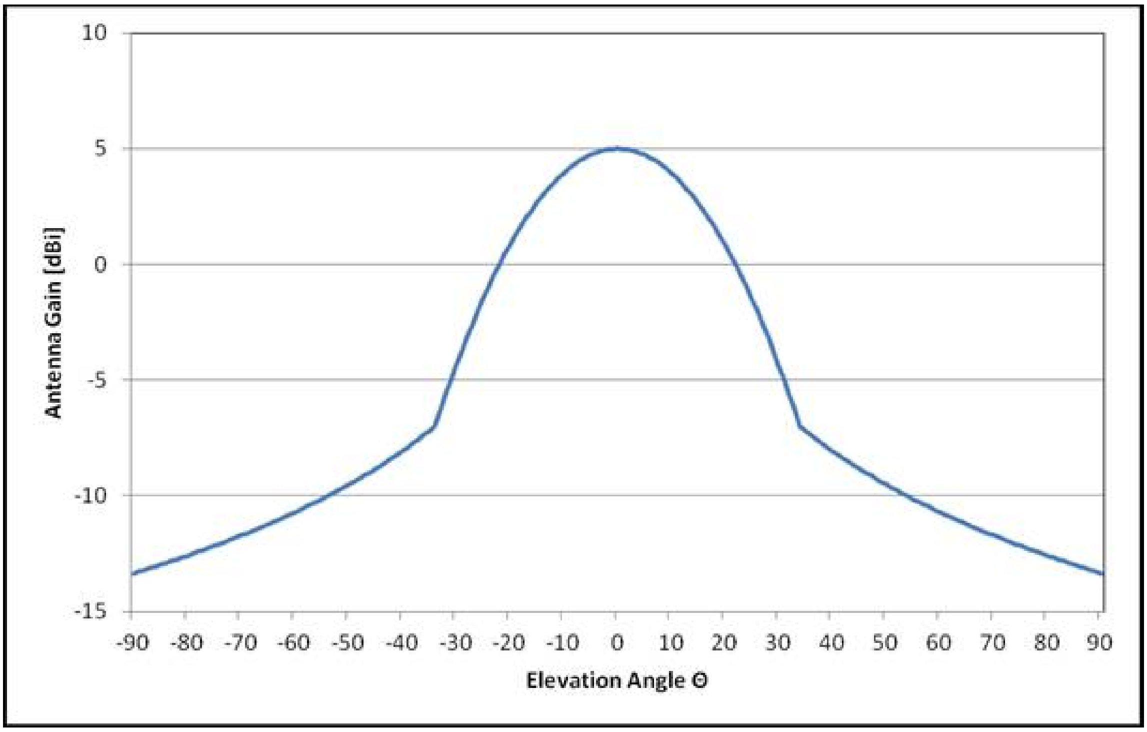


Figure 13: WIA Antenna pattern

4 METHODOLOGY AND APPROACH COMMON TO ALL COMPATIBILITY STUDIES

4.1 METHODOLOGY

For the compatibility studies provided in this Report, the following approach is taken for the compatibility with terrestrial systems:

- As an initial step, perform MCL calculations for potentially worst case scenarios between RLAN and other systems.
- As a second step, analyse potential mitigation techniques, define sharing conditions or conduct statistical simulations.

For the compatibility with FSS, see the details in section 8.1.

4.2 PROPAGATION MODEL

4.2.1 Terrestrial compatibility scenarios

The following propagation model[4] with two breakpoints is used for MCL calculations with terrestrial systems such as ITS, TTT and other transportation systems, Wireless Industrial Applications and BFWA:

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

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

Table 20: Description of the propagation model considered for MCL calculations

	Urban	Suburban	Rural
Breakpoint distance d0 (m)	64	128	256
Pathloss factor n0 beyond the first break point	3.8	3.3	2.8
Breakpoint distance d1 (m)	128	256	1024
Pathloss factor n1 beyond the first break point	4.3	3.8	3.3

[4] This propagation model was first introduced and specified in ECC Report 68.[18]

The figure below describes attenuation of the different propagation models.

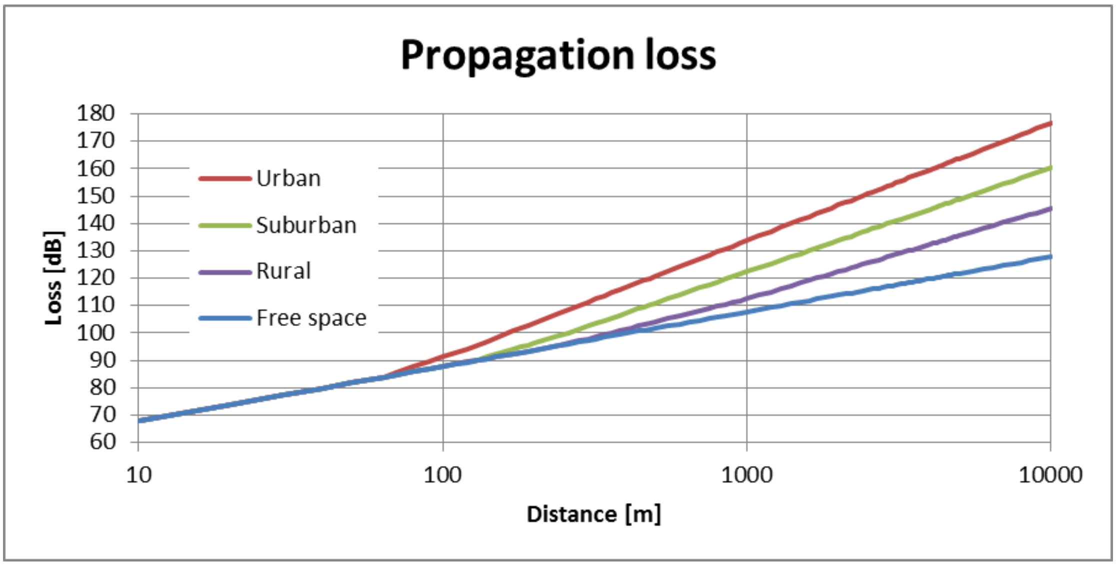


Figure 14: Attenuation of the propagation model used in the MCL calculations

4.2.2 Propagation model RLAN-FSS

For the compatibility studies between RLAN and FSS, free-space loss is used for the generic calculations. Consideration of clutter attenuation as derived from Recommendation ITU-R P.452 [19] is performed as part of the sensitivity analysis.

It is considered that for a geostationary orbit, the variation in length of the slant path from the earth to the satellite are negligible with respect to variation in other parameters, therefore a fixed value of 199.8 dB was retained for the path loss for all simulations, which is the free space loss for 38000 km. Rain and atmospheric absorption were neglected.

4.2.3 Propagation model RLAN-DA2GC

For the compatibility studies between RLAN and BDA2GC, the free-space loss model plus clutter attenuation derived from Recommendation ITU-R P.452 was used.

Table 21: clutter attenuation used for compatibility studies between RLAN and BDA2GC

Clutter (ground-cover) category	Nominal height, ha (m)	Nominal distance Dk (km)	RLAN user defined height		UE any		Macro rural		Macro suburban		Macro urban		Small cell outdoor / micro urban		Small cell indoor / micro urban	
			h = 2 (m)	θmax (o)	h = 1.5(m)	θmax (o)	h = 30(m)	θmax (o)	h = 25(m)	θmax (o)	h = 20(m)	θmax (o)	h = 6 (m)	θmax (o)	h = 3 (m)	θmax (o)
High crop fields. Parkland Irregularly spaced sparse trees. Orchard (regularly spaced). Sparse houses	4	0.1	14.8 dB	1.1 dB	17.3 dB	1.4	-0.3 dB	-14.6								
Suburban	9	0.025	19.5dB	15.6	19.6	16.7			-0.3 dB	-32.6						
Dense suburban	12	0.02	19.7dB	26.6	19.7	27.7			-0.3 dB	-33.0						
Urban	20	0.02	19.7dB	42.0	19.7	42.8					-0.1dB	0.0	19.4dB	35.0	19.7dB	40.4
Dense urban	25	0.02	19.7dB	49.0	19.7	49.6					1.9dB	14.0	19.6 dB	43.5	19.7 dB	47.7
High-rise urban	35	0.02	19.7dB	58.8	19.7	59.2					12.8dB	36.9	19.7 dB	55.4	19.7 dB	58.0
Source of this table: Rec ITU-R P.452-14			dBs of clutter loss calculated using equations (47) and (47a) of Recommendation ITU-R P.452-14													
			Maximum elevation angle of clutter, θmax, calculated using atan ((ha - h)/ dk).													

4.3 BUILDING ATTENUATION

There have been many studies performed over the last 10-15 years considering building attenuation applicable for the 5 GHz range. Many different values for building attenuation (generally between 10 and 20 dB) have been used in these studies depending upon the type of building under consideration, the environment, the sharing scenarios…

In this Report, the following values are assumed:

- 15 dB for short range terrestrial scenarios, i.e compatibility studies with ITS, road tolling, transportation systems, WIA.
- 17 dB for the studies with BDA2GC.
- For the studies on FSS, two values are considered, 12 and 17 dB for the indoor to outdoor attenuation.
- For the specific scenario considering RLAN on-board a vehicle in the ITS section (section 5.1), a value of 20 dB is assumed for the indoor to outdoor attenuation brought by the vehicle.

5 COMPATIBILITY BETWEEN RLAN AND ITS IN THE BANDS 5855-5875 MHz, 5875-5905 MHz AND 5905-5925 MHz

5.1 MINIMUM COUPLING LOSS CALCULATIONS

5.1.1 Description of scenarios

The following scenarios describe realistic, worst-case conditions applicable to both directions of interference between ITS and RLAN. In all cases the inter-vehicular communication is based on the ITS-G5 standard and a broad range of application from safety related to general applications are deployed in the relevant ITS frequency bands. The presented interference scenarios are independent of the applications deployed and the utilised ITS frequency band. The differentiation between the different application and bands will be done in the MCL calculations by using different protection criteria:

- Safety related band (5875MHz - 5905MHz);
- Non Safety related band (5855MHz - 5875MHz);
- Extension band (5905MHz - 5925MHz).

Scenario A1: Indoor RLAN

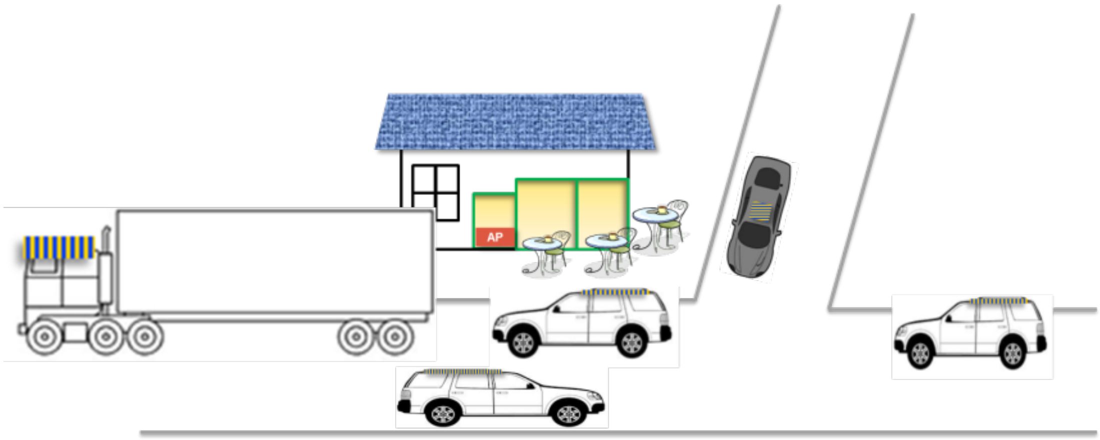


Figure 15: Scenario A1 – ITS vs indoor RLAN

The 5 GHz RLAN device is placed inside a building at street level. Under this scenario, the minimum distance between the 5 GHz RLAN antenna and the ITS antenna, placed on the roof of a vehicle, can be approximately a few meters.

Scenario A2: Outdoor RLAN

This is the same scenario as A1 but where the 5 GHz RLAN device is situated outside. Under this scenario, the minimum distance between the 5 GHz RLAN antenna and the ITS antenna placed on the roof of a vehicle can be approximately a few meters.

Scenario B1: In-car RLAN with external ITS antenna

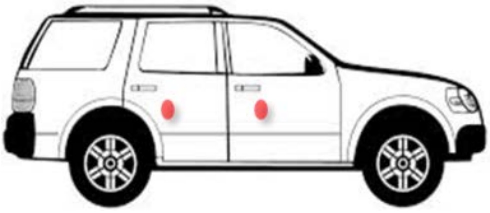


Figure 16: Scenario B1 and B2 – In-car RLAN with ITS internal or external antenna

One or more 5 GHz RLAN devices are situated inside the vehicle. ITS antenna is installed on the roof of the vehicle. There can be a distance of around 1 m between the interferer and the victim. The attenuation between the ITS antenna and the 5 GHz RLAN antenna is highly variable, dependent on antenna positions, antenna performance, glass or metal on the vehicle roof etc. In this study, it was assumed 20 dB extra attenuation in addition to the ordinary path loss.

Scenario B2: In-car RLAN with in-car ITS Antenna

This is the same scenario as B1 but with the ITS antenna integrated inside the vehicle passenger compartment. There can be a distance of 1 m between the interferer and the victim.

Scenario C: Portable outdoor RLAN devices

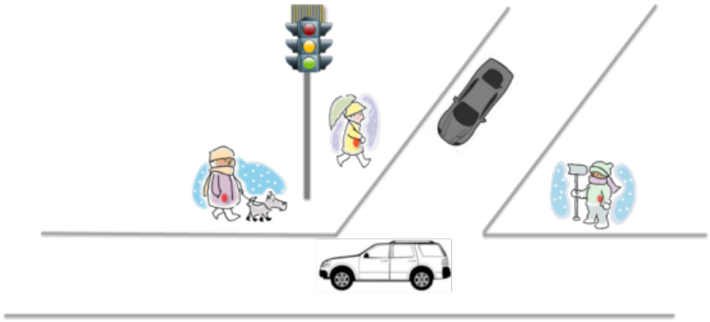


Figure 17: Scenario C: portable out-door RLAN - ITS

The ITS radio is mounted on the road side such as on a traffic light. One or several 5 GHz RLAN devices are in close proximity. In this example, pedestrians carrying smart phones are waiting under a traffic light to cross the street.

5.1.2 Results of MCL calculations for interference from RLAN into ITS in the band 5855-5925 MHz

For the scenarios described above, MCL calculations are performed to derive separation distances using the propagation model described in section 4.2.1.

Table 22: MCL calculations for interference from RLAN into ITS – separation distances

Parameters	Unit	Scenario A1 Urban	Scenario A2 Urban	Scenario B1 Urban	Scenario B2 Urban	Scenario C Urban
Emission part: RLAN (20 MHz)						
Bandwidth	MHz	20	20	20	20	20
TX out (e.i.r.p.)	dBm	23	30	23	23	30

Parameters	Unit	Scenario A1 Urban	Scenario A2 Urban	Scenario B1 Urban	Scenario B2 Urban	Scenario C Urban
Effect of TPC	dB	0	0	15	15	0
Wall loss	dB	15	0	20	0	0
Antenna Gain (0 because of e.i.r.p.)	dBi	0	0	0	0	0
Net Tx density of power e.i.r.p.	dBm/MHz	-5	17	-25	-5	17
Reception part: ITS						
Receiver bandwidth	MHz	10	10	10	10	10
Noise power	dBm	-100	-100	-100	-100	-100
Antenna gain	dBi	4	4	4	4	4
Noise power per MHz at antenna input	dBm/MHz	-114	-114	-114	-114	-114
Protection Criterion I/N	dB	-6	-6	-6	-6	-6
Allowable interfering power level 'I' at the receiver antenna input	dBm/MHz	-120	-120	-120	-120	-120
Main lobe RLAN - Main lobe ITS						
Sidelobe attenuation	dB	0	0	0	0	0
Required Attenuation	dB	115	137	95	120	137
Separation distance RLAN → ITS	m	367	1191	125	479	1191

5.1.3 Results of MCL calculations for interference from ITS into RLAN in the band 5855-5925 MHz

Using the interference scenarios described in section 5.1.1, we set out the results of a Minimum Coupling Loss analysis where ITS is the interferer and RLAN is the victim.

For each scenario, the table sets out the minimum separation required between the ITS interferer and the RLAN victim in order that the required attenuation is resolved.

Table 23: MCL calculations for interference from ITS into RLAN – separation distances

Parameters	Unit	Scenario A1 Urban	Scenario A2 Urban	Scenario B1 Urban	Scenario B2 Urban	Scenario C Urban
Emission part: ITS						
Bandwidth	MHz	10	10	10	10	10
TX e.i.r.p.	dBm	33	33	33	33	33

Parameters	Unit	Scenario A1 Urban	Scenario A2 Urban	Scenario B1 Urban	Scenario B2 Urban	Scenario C Urban
Indoor-outdoor attenuation	dB	15	0	20	0	0
Total net power e.i.r.p.	dBm	18	33	13	33	33
Reception part: RLAN						
Receiver bandwidth	MHz	20	20	20	20	20
Noise power	dBm	-97	-97	-97	-97	-97
Antenna gain	dBi	6	6	1.3	1.3	1.3
Protection Criterion I/N	dB	-6	-6	-6	-6	-6
Interference threshold at antenna	dBm	-109	-109	-104.3	-104.3	-104.3
Required attenuation	dB	127	142	117.3	137.3	137.3
Required separation distance	M	697	1558	415	1211	1211

5.1.4 Summary - Analysis – need for further studies

Table 24: summary results, MCL calculations for interference from RLAN into ITS – separation distances

Scenario	Urban	Suburban	Rural
Scenario A1 – RLAN indoor	367 m	641 m	1193 m
Scenario A2 – RLAN outdoor	1191 m	2430 m	5539 m
Scenario B1 – RLAN in-car, ITS external	125 m	182 m	229 m
Scenario B2 – RLAN in-car, ITS internal	479 m	867 m	1691 m
Scenario C – portable outdoor RLAN	1191 m	2430 m	5539 m

Table 25: summary results, MCL calculations for interference from ITS into RLAN– separation distances

	Urban	Suburban	Rural
Scenario A1 – RLAN indoor	694 m	1326 m	2761 m
Scenario A2 – RLAN outdoor	1558 m	3292 m	7864 m
Scenario B1 – RLAN in-car, ITS external	415 m	737 m	1403 m
Scenario B2 – RLAN in-car, ITS internal	1211 m	2477 m	5666 m
Scenario C – portable outdoor RLAN	1211 m	2477 m	5666 m

Depending on the scenario, the studies showed required minimum separation distances from 415 m up to 1558 m in urban scenarios (from 1.4 km to 7.8 km in rural scenarios) between 5GHz RLAN devices with 20 MHz bandwidth and ITS systems. For RLAN with higher channel bandwidths the distances are expected to be slightly smaller, but this will not solve the issue.

For the scenario where RLAN is used on-board a vehicle equipped with ITS, the coexistence is not feasible in a co-channel case, thus requiring mitigation techniques.

In order to achieve feasible sharing conditions, there is a need for further studies, on the development of additional scenarios and on mitigation techniques to improve the compatibility between RLAN and ITS.

5.2 MITIGATION TECHNIQUES TO ENABLE COEXISTENCE OF RLAN AND ITS

Considerations on mitigation techniques for the coexistence between RLAN and ITS have focused on “listen-before-talk” process, where the potential interferer tries to detect whether a channel is busy before transmitting a data packet.

Two processes are under investigation for the detection mechanisms:

- Energy Detection (ED): based on whether any energy is present above a certain threshold, regardless of the form of the signal;
- Carrier Sensing (CS): tries to match the received signal with known training (preamble) signal signatures.

While CS is primarily designed to avoid interference between devices using the same technology, ED can avoid interference regardless of the technologies used for the systems.

This section describes the studies looking at possible technical requirements to enable the coexistence of RLAN and ITS based on two possible approaches:

- Generic Energy Detection without any consideration of the interferer and victim signal frames;
- Combination of energy detection and carrier sensing, such as one of the Clear Channel Assessment (CCA) modes defined in 802.11 standard [27].

5.2.1 Generic requirements related to Energy Detection for the coexistence between RLAN and ITS

The key requirement under this approach is to determine the detection threshold, which is the signal level above which the channel is considered as busy. This is done using the generic approach outlined in ANNEX 5:.

Using the simplified approach outlined in Annex A5.1, the threshold values for RLAN as interferer and ITS as a victim are determined in the following table.

Table 26: Detection threshold, RLAN as interferer sensing an ITS victim, simplified approach

RLAN is sensing ITS							
			VICTIM : ITS				
			BW2/MHz	10	10	10	10
			Pwt dBm/BW2	**23**	**23**	**33**	**33**
			NF dB	4	4	4	4
			N dBm/BW2	-100	-100	-100	-100
			Margin dB	**0**	**10**	**0**	**10**
			INR dB	**-6**	**-6**	**-6**	**-6**
Interferer : RLAN	**BW1/MHz**	**Pit dBm/BW1**	**Pit dBm/BW2**	**Pthr dBm/BW2**			
	20	23	**19.99**	-102.99	-92.99	-92.99	-82.99
	40	23	**16.98**	-99.98	-89.98	-89.98	-79.98
	80	23	**13.97**	-96.97	-86.97	-86.97	-76.97
	160	23	**10.96**	-93.96	-83.86	-83.96	-73.96
			N RLAN/BW2	-100.00			

The results show that for ITS as victim working with 23 dBm in 10 MHz and is working at its sensitivity, the LBT threshold values for RLAN to detect ITS would be between -94 dBm and -103 dBm in 10 MHz dependent on the RLAN bandwidth; this is for the 20 MHz RLAN bandwidth 3 dB below the noise floor of the receiver (N=-100 dBm in 10 MHz). For ITS working with 33 dBm in 10 MHz the threshold would be 10 dB higher as above. If ITS is working with a certain margin above its sensitivity, then the threshold could be increased accordingly. It has to be noted that the above results are derived with 23 and 33 dBm e.i.r.p.; for lower ITS Tx power values (e.g. -10 dBm as indicated in Annex 1, Figure 41) the threshold values would be correspondingly lower (e.g. for -10 dBm ITS Tx power 33 dB lower as the 23 dBm results above).

Then the threshold values for ITS as interferer are determined in the following table.

Table 27: Detection threshold, ITS as interferer sensing a RLAN victim, simplified approach

ITS is sensing RLAN					
	VICTIM : RLAN				
	BW2/MHz	20	20	20	20
	Pwt dBm/BW2	**23**	**23**	**23**	**23**
	NF dB	4	4	4	4
	N dBm/BW2	-96.99	-96.99	-87.96	-87.96
	Margin dB	**0**	**10**	**0**	**10**

ITS is sensing RLAN							
			INR dB	**-6**	**-6**	**-6**	**-6**
Interferer : ITS	**BW1/MHz**	**Pit dBm/BW1**	**Pit dBm/BW2**	**Pthr dBm/BW2**			
	10	23	**23.00**	-106.00	-96.00	-96.99	-86.00
	10	33	**33.00**	-116.00	-106.00	-106.00	-96.00
			N road tolling/BW2	-96.99			

The results show that for RLAN as victim working with 23 dBm in 20 to 160 MHz and is working at its sensitivity, the LBT threshold values for ITS to detect RLAN would be between -96 dBm in 160 MHz and -106 dBm in 20 MHz; this is for the 20 MHz RLAN bandwidth 9 dB below the noise floor of the ITS receiver (N=-97 dBm in 20 MHz). For ITS working with 33 dBm in 10 MHz the threshold would be 10 dB lower as above. If RLAN is working with a certain margin above its sensitivity, then the threshold could be increase accordingly.

The above considerations are neglecting any hidden node effects. This will be analysed now in more detail according to the more general procedure from Annex 5.2.

First the relevant distances are calculated (see below two figures for LOS and exponent 3 based on the following assumptions:

- Victim system: ITS, 23 dBm e.i.r.p., 0 dBi, 10 MHz, INR -6 dB, SNRlimit 8 dB;
- Interferer RLAN 23 dBm e.i.r.p., 0 dBi, Pthr=-90dBm/10 MHz.

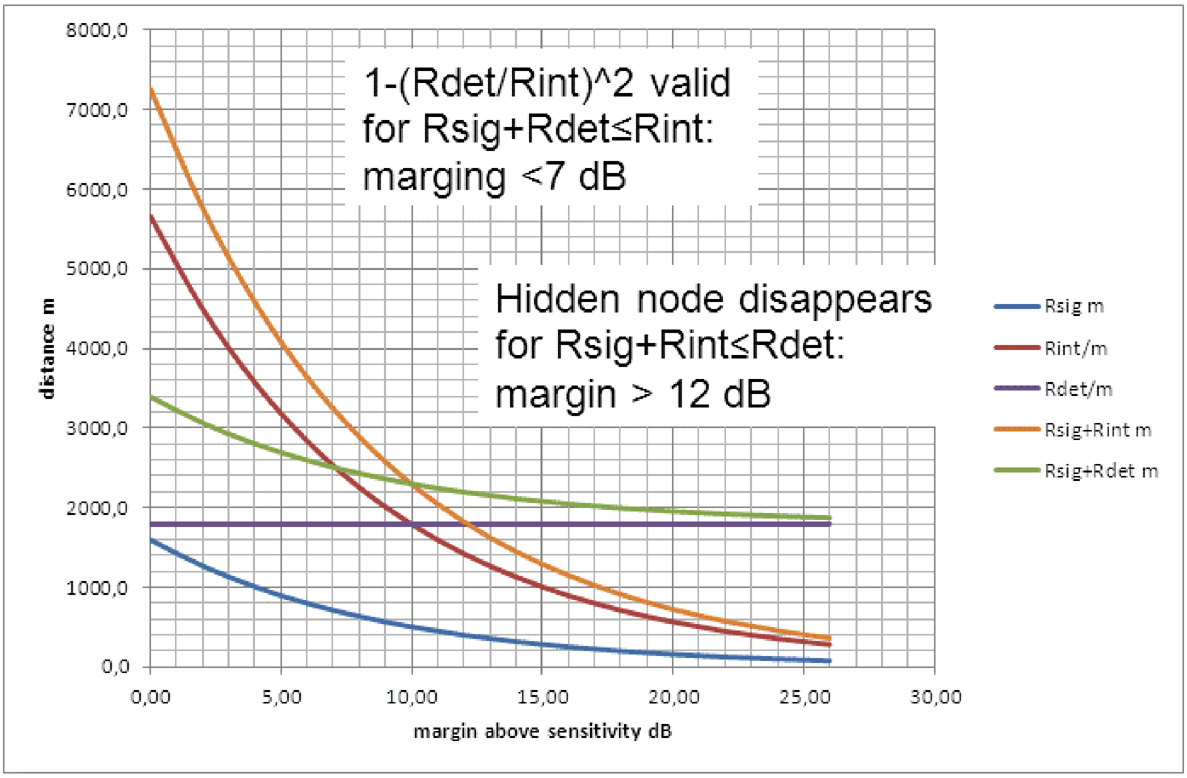


Figure 18: Distances for LOS conditions (exp.2)

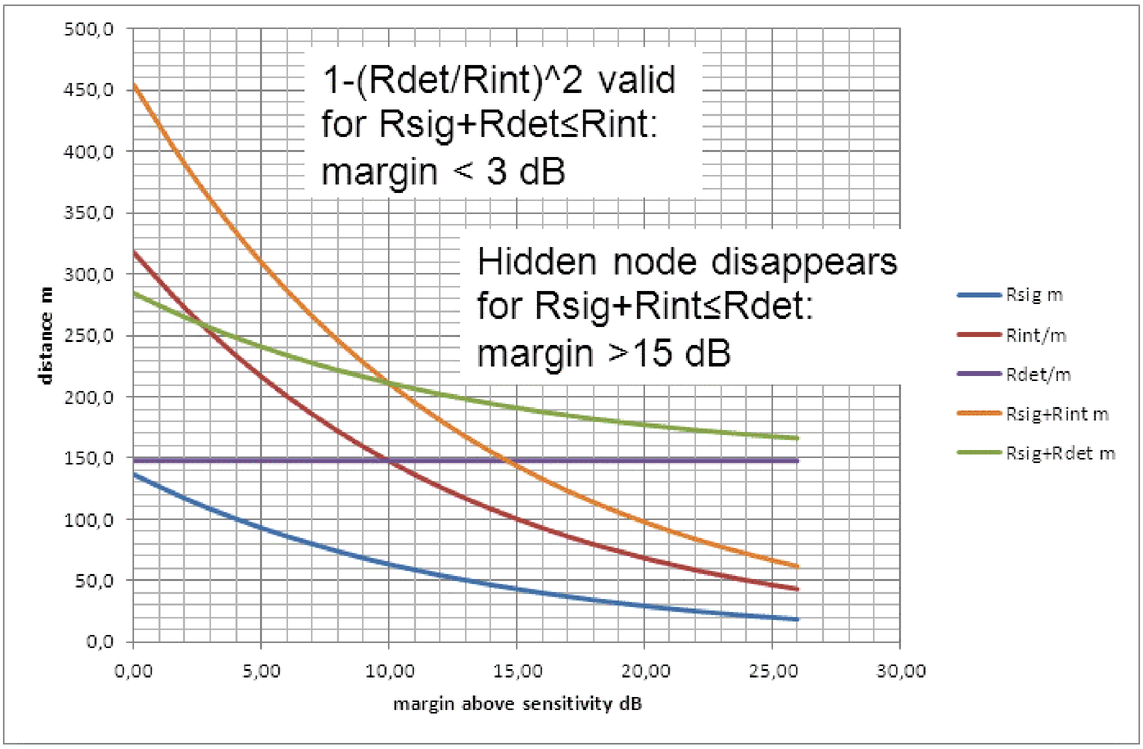


Figure 19: Distances for non LOS conditions (exp.3)

The following figures show the hidden node portion for the ITS as victim (the solid line is only valid until Rsig+Rdet=Rint; after that point the dotted line is valid, which is the linear interpolation between Rsig+Rdet=Rint and Rsig+Rint=Rdet):

- Figure 20 for an INR of -6dB and a threshold of -90 dBm in 10 MHz;
- Figure 21 for an INR of 0 dB and a threshold of -90 dBm in 10 MHz;
- Figure 22 for an INR of -6dB and a threshold of -100 dBm in 10 MHz.

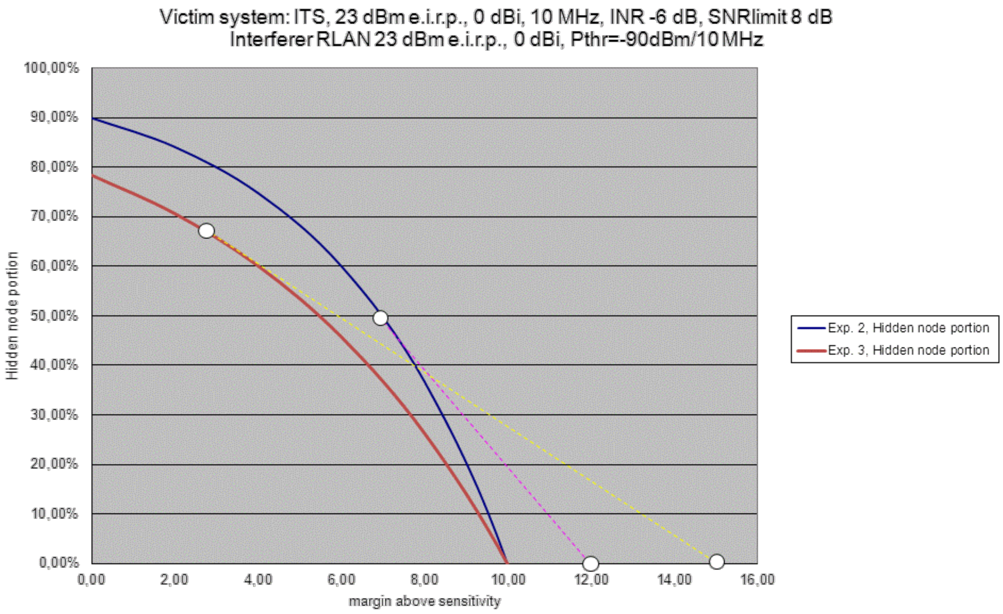


Figure 20: Hidden node probability for ITS as victim as function of the margin above sensitivity at the ITS receiver and the propagation condition

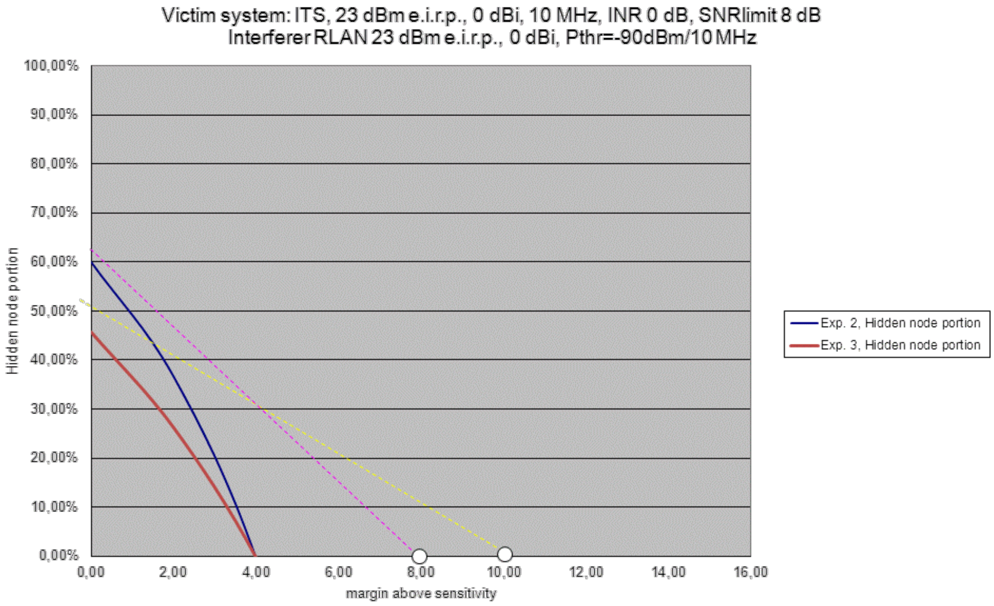


Figure 21: Hidden node probability for ITS as victim as function of the margin above sensitivity at the ITS receiver and the propagation condition

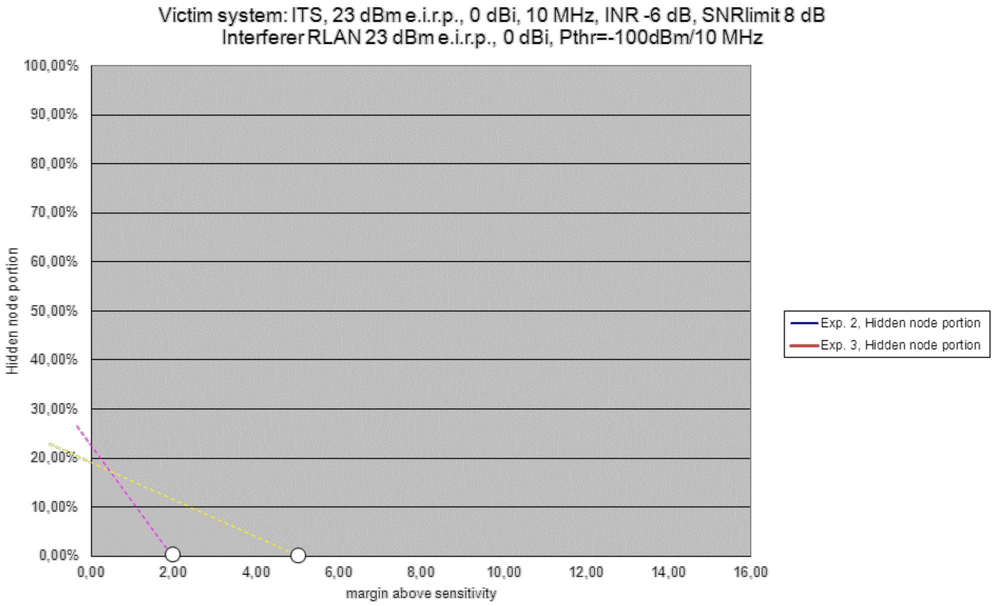


Figure 22: Hidden node probability for ITS as victim as function of the margin above sensitivity at the ITS receiver and the propagation condition

The below table summarises the results.

Table 28: Summary hidden node ratio

I/N criterion	LBT threshold in 10 MHz	0 dB margin	6 dB margin	12 dB margin
-6 dB	-90 dBm	80-90 %	50-60 %	0-20 %
0 dB	-90 dBm	40-60 %	10-20 %	0 %
-6 dB	-100 dBm	20%	0 %	0%

Under the assumptions considered, this study shows that in the case of an energy detection threshold of -90dBm/10MHz for a RLAN system operating with 23 dBm/20MHz, an ITS device with 23dBm/10MHz is not reliably to be detected. A threshold of -90 dBm in 10 MHz would result in a 10 dB degradation to the ITS system. In other words, in order to avoid a high hidden node ratio with a threshold of -90 dBm, a 10 dB margin is needed for a protection criteria I/N of -6 dB.Further consideration may be required on the feasibility of detection thresholds of the order of -90 dBm/10 MHz and on their impact on the RLAN operation, together with the definition of the relevant protection criteria for ITS, since low values of threshold are likely to trigger false detections.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) are not considered in this section and maybe an issue for further work.

5.2.2 Clear Channel Assessment in IEEE 802.11 - requirements for the coexistence between RLAN and ITS

A fundamental principle employed in the IEEE 802.11 (“Wi-Fi”) standard is that of Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). Simply put this is a “listen-before-talk” process, where the 802.11 system tries to detect whether a channel is busy before transmitting a data packet. This process, often referred to as Clear Channel Assessment (CCA), uses Carrier Sensing (CS) and Energy Detection (ED) to detect whether a channel is transitioning from idle to busy (see IEEE 802.11-2012 [27] paragraph 18.3.10.6).

CS tries to match the received signal with known training (preamble) signal signatures of other 802.11 devices. ED detects whether any energy is present above a certain threshold, regardless of the form of the signal. If the medium is determined to be busy, either by CS or ED, then the device must wait (defer) for a period of time called the back off. CCA has proven to be a very effective method for medium sharing, particularly for lightly loaded Wi-Fi networks.

RLAN devices can use channels with 20, 40, 80 or 160 MHz bandwidths (as defined in the 802.11ac specification). In order to use channels wider than 20 MHz CCA must be performed across a wider frequency range. To achieve this, the 802.11ac specification defines several CCA channels; a Primary channel and one or more Secondary CCA channels. For example if an RLAN device is to operate in an 80 MHz it must perform CCA in the Primary (20 MHz) channel as well as 3 adjacent 20 MHz Secondary channels.

The developments in 2014 of the P802.11ac [27] specification define detection levels for CS and ED in the Primary and Secondary channels as shown in Table 29.

Table 29: P802.11ac CCA detection levels (2014)

	CS detection level (dBm)	ED detection level (dBm within 20 MHz)
Primary CCA Channel	-82	-62
Secondary CCA Channel	-72	-62

As can be seen in Table 29, there is a significant difference between detection levels using CS and ED. In the Primary Channel, there is a 20dB difference between detection thresholds. Put in terms of range, if a device is operating in free space (1/R2 path loss) then a preamble can be detected using CS at ten times the distance that energy can be detected using ED. Therefore CS of the preambles offers far better protection against interference than ED.

Studies are ongoing, in particular in IEEE and ETSI, on interference avoidance techniques currently employed in 5 GHz RLAN systems and their applicability to ITS. This might be an issue that requires further work.

Applicability of CCA to ITS

ITS adopted the 802.11p Physical layer (PHY) specification. This has preamble structure in common with other members of the 802.11 OFDM family. Hence CS of the 802.11p preamble should be possible.

However, the following issues need to be resolved in order to achieve this:

1 Neither 802.11n nor 802.11ac are capable of performing CCA on a 10MHz channel; both use a minimum channel bandwidth of 20MHz. For the purpose of ITS detection, a 10MHz CCA mode would have to be added. This would be for the purpose of carrier sensing OFDM frames using a 10MHz channel width, like ITS, and would not require adding a 10 MHz transmit option for the 802.11n or 802.11ac PHY.

2 The 802.11ac specification requires CS to detect frames with received power at or above -82dBm, a threshold that would drop 3 dB to -85 dBm in a 10 MHz channel. But, fielded ITS systems have been demonstrated to successfully decode frames received below -90dBm. In this case, a ITS system would detect another ITS signal at almost twice the distance that a minimum conforming Wi-Fi system would detect ITS. This difference in detection range could lead to scenarios in which a Wi-Fi signal would interfere with a ITS system’s ability to receive ITS frames. For this reason, it is imperative that a Wi-Fi system should have CCA sensitivity levels which are good enough to provide a similar level of protection to that provided by other co-channel ITS devices. It should be noted that the effects of this mitigation has not been assessed as yet for providing adequate protection to safety ITS applications. It is likely that in order to confirm this that there will need to be some simulations, field trials or plug fests to test and or qualify these types of capabilities in RLANs.

3 The reciprocal problem also exists, i.e. ITS systems use CCA to sense other ITS transmissions, but are not capable of detecting the preamble of wider bandwidth Wi-Fi signals. So it is likely that ITS systems could interfere with co-channel WiFi users.

4 The concept of CCA is to assess whether the medium is busy to allow a method for gaining access to the channel. Modern 802.11 systems employ methods to try to give some types of packet traffic a priority over others (e.g., EDCA). ITS traffic would need to have a higher priority identified for its traffic in the case where WiFi services have similar bandwidths and operate co-channel with ITS (e.g. does 802.11j preamble look any different to 802.11p?).

5 The detection of ITS should consider the sensitivity and dynamic conditions of ITS, i.e. a highly dynamic environment, including effects from moving signal sources on the transmitted and received signals.

6 How do systems with mitigation techniques not based on preamble detection meet the requirements needed to protect ITS systems and how do we specify these requirements?

5.2.3 Summary

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances if compatibility is dependent upon protection to an I/N level of -6 dB. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated to improve the compatibility between individual RLAN devices and ITS. These studies have focussed on “listen-before-talk” process, where the potential interferer tries to detect whether a channel is busy before transmitting a data packet.

Two possible approaches are under study:

- Generic Energy Detection without any consideration of the interferer and victim signal frames: Under the assumptions considered, preliminary studies show that in the case of an energy detection threshold of -90dBm/10MHz for a RLAN system operating with 23 dBm/20MHz, an ITS device with 23dBm/10MHz is not reliably to be detected. Further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation.
- Combination of energy detection and carrier sensing, such as one of the Clear Channel Assessment (CCA) modes defined in 802.11 standard [27]. Further study is required to assess the applicability to ITS of the interference avoidance techniques currently employed in 5 GHz RLAN systems.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered and may be an issue for further work.

6 COMPATIBILITY BETWEEN RLAN AND ROAD TOLLING IN THE BAND 5795-5815 MHZ

6.1 MINIMUM COUPLING LOSS CALCULATIONS

6.1.1 Description of scenarios

The following scenarios describe realistic, worst-case scenarios applicable to both directions of interference between road tolling and RLANs.

Scenario A1: Indoor RLAN

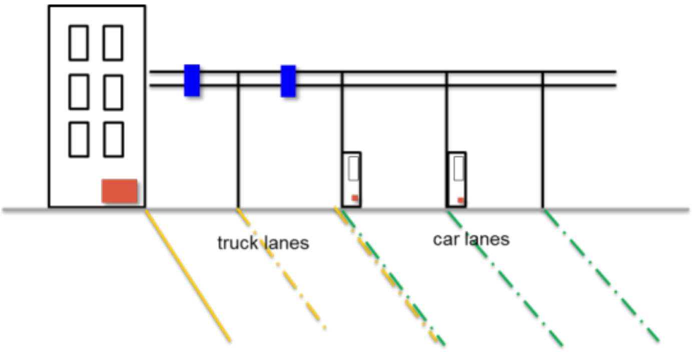


Figure 23: Scenario A1 –road tolling

The 5 GHz RLAN device is situated close to the road tolling system. The figure above shows an example with a multilane road toll. The 5 GHz RLAN transmitter appears in red and the tolling road-side units are shown in blue. In this scenario it is assumed that the 5 GHz RLAN device, access point or the device is close to the road tolling communication zone, but situated inside a building. Under this scenario, the minimum distance between the 5 GHz RLAN transmitter and the tolling road side receiver antenna can be around a few meters.

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. Buildings close to the streets not being owned or controlled by the tolling operator are considered. In this building, RLAN devices could be operated without any influence by the tolling operator.

Scenario A2: outdoor RLAN

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

Scenario B: RLAN on-board a vehicle

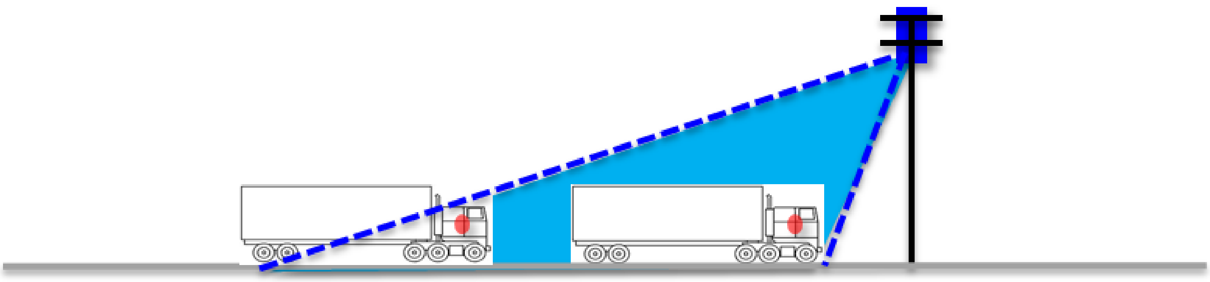


Figure 24: Scenario B – road tolling

Here the 5 GHz RLAN transmitters are found inside the vehicle. If the RLAN device is transmitting within the road tolling communication zone, its transmission would radiate through the vehicle window interfering directly with uplink communications to the tolling 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.

6.1.2 Results of MCL calculations for interference from RLAN into road tolling

For the scenarios A1, A2 and B described above, MCL calculations are performed to derive separation distances using the propagation model described in section 4.2.

Table 30: MCL calculations for interference from RLAN into road tolling – separation distances

Parameters	Unit	Scenario A1 Urban	Scenario A2 Urban	Scenario B Urban
Emission part: RLAN (20 MHz)				
Bandwidth	MHz	20	20	20
Tx out (e.i.r.p.)	dBm	23	30	23
Effect of TPC	dB	0	0	15
Wall loss	dB	15	0	3
Antenna Gain (0 because of e.i.r.p.)	dBi	0	0	0
Net Tx density of power e.i.r.p.	**dBm/MHz**	**-5**	**17**	**-8**
Reception part: road tolling				
Receiver bandwidth	MHz	0.5	0.5	0.5
Noise power	dBm	-115	-115	-115
Antenna gain (includes 3 dB polarisation discrimination)	dBi	10	10	10
Noise power per MHz at antenna input	**dBm/MHz**	**-122**	**-122**	**-122**
Protection Criterion I/N	dB	-6	-6	-6
Allowable interfering power level 'I' at the receiver antenna input	**dBm/MHz**	**-128**	**-128**	**-128**
Main lobe RLAN - Side lobe tolling				
Sidelobe attenuation	dB	15	15	15 / 0
Required Attenuation	**dB**	**108**	**130**	**105 / 120**
Separation distance RLAN → tolling	**m**	**252**	**819**	**215 / 479 (Note)**

Note: For scenario B, as shown in Figure 24, the main beam coupling case is theoretically possible. However, considering the required separation distances, the RLAN transmitter will indeed not be in the Road Tolling main lobe.

6.1.3 Results of MCL calculations for interference from road tolling into RLAN

Using the interference scenarios described in section 6.1.1, we set out the results of a Minimum Coupling Loss analysis where road tolling is the interferer and RLAN is the victim.

For each scenario, the table sets out the minimum separation required between the road tolling interferer and the RLAN victim in order that the required attenuation is resolved.

Table 31: MCL calculations for interference from road tolling into RLAN – separation distances

Parameters	Unit	Scenario A1 Urban	Scenario A2, Urban	Scenario B Urban
Emission part: road tolling				
Bandwidth	MHz	1	1	1
TX e.i.r.p.	dBm	33	33	33
Indoor-outdoor attenuation	dB	15	0	3
Sidelobe attenuation	dB	15	15	15/0
Net Tx power e.i.r.p.	**dBm**	**3**	**18**	**0/15**
Reception part: RLAN				
Receiver bandwidth	MHz	20	20	20
Noise power	dBm	-97	-97	-97
Antenna gain	dBi	6	6	1.3
Polarisation discrimination	dB	3	3	3
Protection Criterion I/N	dB	-6	-6	-6
Interference threshold	dBm	-106	-106	-101.3
Required attenuation	**dB**	**109**	**124**	**131.3 / 116.3**
Required separation distance	**m**	**266**	**594**	**878 / 393 (Note)**

Note: For scenario B, as shown in Figure 24, the mainbeam coupling case is theoretically possible. However, considering the required separation distances, the RLAN transmitter will indeed not be in the Road Tolling main lobe.

6.1.4 Summary - Analysis

Table 32: summary results, MCL calculations for interference from RLAN into road tolling – separation distances

Scenario	Urban	Suburban	Rural
Scenario A1 – RLAN indoor	252 m	419 m	690 m
Scenario A2 – RLAN outdoor	819 m	1590 m	3399 m
Scenario B– RLAN in-car	215 m	349 m	539 m

Table 33: summary results, MCL calculations for interference from road tolling into RLAN– separation distances

	Urban	Suburban	Rural
Scenario A1 – RLAN indoor	266 m	446 m	750 m
Scenario A2 – RLAN outdoor	594 m	1106 m	2240 m
Scenario B– RLAN in-car	393 m	694 m	1309 m

Depending on the scenario, the studies showed required, minimum separation distances from 215 m up to 819 m in urban environment (from 539 m to 3399 m in rural environment) between 5 GHz RLAN devices with 20 MHz bandwidth and road tolling systems. For RLAN with higher channel bandwidths the distances are expected to be slightly smaller, but this will not solve the issue.

In order to achieve feasible sharing conditions, there is a need for further studies, on the development of additional scenarios and on mitigation techniques to ensure the compatibility between RLAN and road tolling.

6.2 MITIGATION TECHNIQUES TO ENABLE COEXISTENCE OF RLAN AND ROAD TOLLING

The following approaches have been suggested to enable the coexistence between RLAN and road-tolling:

- Implementation in RLAN of a detection mechanism to detect road tolling applications – energy detection. The approach detailed in ANNEX 5: can be applied for the determination of the detection threshold.
- Transmission from the road tolling applications of predefined signals (beacons) which indicate that the used channels are busy, similar to one of the mitigation techniques used to facilitate ITS and Road Tolling adjacent channel co-existence.
- Ensure the coexistence with road tolling systems through the detection of ITS. This is based on the assumption that there will always be ITS systems in the close vicinity of road-tolling road-side units. Under this approach, once ITS have been detected by RLAN under the conditions described in section 5.2, the road tolling frequency band 5795-5805/5805-5815 MHz will also be considered as occupied and thus, not available for RLAN use.
- Use of geolocation database approach. The road tolling roadside units are generally fixed with a determined location. Information can be stored in a database and mechanisms may be developed so that this information may be used by RLAN to avoid interference.

Studies are ongoing, in particular in ETSI, on road tolling. This might be an issue that requires further work.

6.2.1 Energy Detection – requirements for the coexistence between RLAN and road tolling

The below considerations are based on the simplified approach in A5.1, where a formula is given to derive the threshold value for a LBT system.

First the threshold values for RLAN as interferer are determined in the following table for an equal road tolling antenna gain on Rx and Tx side.

Table 34: Detection threshold, RLAN as interferer sensing road tolling victim, simplified approach (equal road tolling Rx and Tx antenna gain)

RLAN is sensing road tolling

			Victim: road tolling				
			BW2/MHz	0.5	0.5	0.5	0.5
			Pwt dBm/BW2	23	23	33	33
			NF dB	2.00	2.00	2.00	2.00
			N dBm/BW2	-115.01	-115.01	-115.01	-115.01
			margin dB	0.00	10.00	0.00	10.00
			INR dB	-6.00	-6.00	-6.00	-6.00
Interferer: RLAN	**BW1/MHz**	**Pit dBm/BW1**	**Pit dBm/BW2**	**Pthr dBm/BW2**			
	20	23	6.98	-104.99	-94.99	-94.99	-84.99
	40	23	3.97	-101.98	-91.98	-91.98	-81.98
	80	23	0.96	-98.97	-88.97	-88.97	-78.97
	160	23	-2.05	-95.96	-85.96	-85.96	-75.96

The threshold values for RLAN as interferer for different road tolling antenna gain on Rx and Tx side are given in the following table.

Table 35: Detection threshold, RLAN as interferer sensing road tolling victim, simplified approach (different road tolling Rx and Tx antenna gain)

			RLAN is sensing road tolling (different Tx and Rx gain)				
			Victim: road tolling				
			BW2/MHz	0.5	0.5	0.5	0.5
			Pwt dBm/BW2	23	23	33	33
			Tx gain- Rx gain dB (Gwt-Gvr)	-10	-10	-10	-10
			Rx gain dBi	2.00	2.00	2.00	2.00
			N dBm/BW2	-115.01	-115.01	-115.01	-115.01
			margin dB	0.00	10.00	0.00	10.00
			INR dB	-6.00	-6.00	-6.00	-6.00
Interferer: RLAN	**BW1/MHz**	**Pit dBm/BW1**	**Pit dBm/BW2**	**Pthr dBm/BW2**			
	20	23	6.98	-114.99	-104.99	-104.99	-94.99
	40	23	3.97	-111.98	-101.98	-101.98	-91.98
	80	23	0.96	-108.97	-98.97	-98.97	-88.97
	160	23	-2.05	-105.96	-95.96	-95.96	-85.96

The results show that for road tolling as victim working with 33 dBm in 10 MHz and is working at its sensitivity, the LBT threshold values for RLAN to detect road tolling would be between -86 dBm and -95 dBm in 0.5 MHz dependent on the RLAN bandwidth; this is for the 20 MHz RLAN bandwidth 18 dB above the noise floor of the receiver (N=-113 dBm in 0.5 MHz). For road tolling working with Tx power of 23 dBm (because of the antenna gain of the RSU of about 10 dBi) the threshold would be 10 dB lower as above but still more than 8 dB above the noise floor. If road tolling is working with a certain margin above its sensitivity, then the threshold could be increase accordingly. The above results are given under the assumption of equal road tolling antenna gain on Rx and Tx side. For the case that the Tx antenna gain would be x dB lower than the Rx antenna gain of the road tolling station, then the above threshold values would be x dB lower (e.g. with 5dB lower Tx antenna gain compared to the Tx gain, the threshold values would be 5 dB lower).

Due to the RFID like nature of Road Tolling with the RSU as a kind of reader, hidden nodes are not expected to be a problem.

Further consideration is required on the feasibility of detection thresholds of the order of -100 dBm/500kHz and on their impact on the RLAN operation, together with the definition of the relevant protection criteria for road tolling, since low values of threshold are likely to trigger false detections.

Then the threshold values for road tolling as interferer are determined in the following table.

Table 36: Detection threshold, road tolling as interferer sensing a RLAN victim, simplified approach

Road tolling is sensing RLAN

			Victim: RLAN				
			BW2/MHz	20	20	160	160
			Pwt dBm/BW2	23	23	23	23
			NF dB	4.00	4.00	4.00	4.00
			N dBm/BW2	-96.99	-96.99	-87.96	-87.96
			margin dB	0.00	10.00	0.00	10.00
			INR dB	-6.00	-6.00	-6.00	-6.00
Interferer: road tolling	**BW1/MHz**	**Pit dBm/BW1**	**Pit dBm/BW2**	**Pthr dBm/BW2**			
	1	23	19.99	-118.00	-108.00	-108.00	-98.00
	1	33	29.99	-128.00	-118.00	-118.00	-108.00

The results show that for RLAN as victim working with 23 dBm in 20 to 160 MHz and is working at its sensitivity, the LBT threshold values for road tolling to detect RLAN would be well below the noise floor of the receiver (more than 10 dB). If RLAN is working with a certain margin above its sensitivity, then the threshold could be increase accordingly.

It appears not feasible for road tolling to detect RLAN.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) are not considered in this section and maybe an issue for further work.

6.2.2 Transmission from the road tolling applications of predefined signals (beacons)

The concept foresees that a predefined signal (e.g. from a roadside road tolling station) transmits a trigger to the RLAN equipment to apply sensing mitigation techniques, similar to one of the mitigation techniques used to facilitate ITS and Road Tolling adjacent channel co-existence.

This approach should take into account that:

- Additional installations are needed to apply this procedure;
- The RLAN equipment should be capable of recognising beacons from these Road Tolling stations and applying appropriate mitigation procedures;
- A reprogramming of the RLAN chip (switching on/off RLAN / DSRC mitigation techniques) must be disabled. This would prevent users of tuning their equipment.

6.2.3 Ensure coexistence with the road tolling systems through the detection of ITS

Under this approach, the road-tolling frequencies will be declared unavailable for RLAN whenever ITS transmitters are detected (see section 5.2).

This approach is based on the assumption, that an ITS system implementation is assuring the co-existence of 3rd party applications namely among RLAN and 5.8 GHz road-tolling applications. This means that this approach requires that an ITS system, is always in the vicinity of a 5.8 GHz road-tolling application, whatever the penetration rate of ITS is. It is not predictable to which extent ITS stations will be on the road (or in vehicles) to assure an uninterrupted road-tolling operation. The effectiveness of this solution is highly dependent upon the penetration rate of ITS in vehicles unless ITS beacons were installed at the tolling stations.

6.2.4 Use of geolocation database approach – requirements for the coexistence between RLAN and road tolling

The usage of a geolocation database would need a central registry. This central registry must hold an updated inventory of all databases in Europe which holds information on road sections and the appropriate 5.8 GHz road-tolling implementations. The geolocation database should hold actual information from static and, due to construction sites, temporal tolling installations. From a technical point of view, this includes any 5.8 GHz road-tolling application which needs protection, including in time information about 5.8 GHz mobile enforcement installations.

The implementation of such a platform, its access, its maintenance should be addressed. In addition, the role and responsibilities or the stakeholders have to be clearly defined.

The RLAN equipment on the other hand must have access to the inventory of 5.8 GHz implementations according to its actual position by retrieving information from the geolocation data base. This will allow the RLAN equipment to start mitigation procedures if being close to a 5.8 GHz road-tolling implementation.

6.2.5 Summary

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances if compatibility is dependent upon protection to an I/N level of -6 dB. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated and the following approaches have been suggested to enable the coexistence between RLAN and road-tolling:

- Implementation in RLAN of a detection mechanism to detect road tolling applications based on energy detection. Under the assumptions considered preliminary analysis indicated that for a RLAN system operating with 23 dBm/20MHz a detection threshold of the order of -100 dBm/500kHz and for a RLAN system with 23 dBm/160MHz a detection threshold of the order of -90 dBm/500kHz would be required for a reliable detection of road tolling. Further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation transmission from the road tolling applications of predefined signals (beacons) which indicate that the used channels are busy, similar to one of the mitigation techniques used to facilitate ITS and Road Tolling adjacent channel co-existence.

- Ensure coexistence with the road tolling systems through the detection of ITS. This is based on the assumption that there will always be ITS systems in the close vicinity of road-tolling road-side units. Under this approach, once ITS have been detected by RLAN under the conditions described in section 2, the road tolling frequency band 5795-5805/5805-5815 MHz will also be considered as occupied and thus, not available for RLAN use.
- Use of geolocation database approach. The geolocation database should hold actual information from static and, due to construction sites, temporal tolling installations. The implementation of such a platform, its access, its maintenance should be addressed. In addition, the role and responsibilities or the stakeholders have to be clearly defined.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered.

Further work is required to assess these approaches.

7 COMPATIBILITY BETWEEN RLAN AND PUBLIC TRANSPORT AUTOMATION SYSTEMS IN THE 5.915-5.935 GHz BAND

7.1 MINIMUM COUPLING LOSS CALCULATIONS

7.1.1 Interference from RLAN into public transport automation systems in the 5.915-5.935 GHz band

The following table shows the MCL worst case calculations when RLAN is assumed to be outdoor in an urban environment:

Table 37: MCL calculations- outdoor RLANs into public transport automation systems

OUTDOOR	Parameter	Unit	Dir Lan vs Vagon	Dir Lan vs Infra	Omni vs Vagon	Omni vs Infra
VICTIM RX	RX bandwidth	MHz	5	5	5	5
	Noise Figure	dB	5	5	5	5
	RX temp.	K	290	290	290	290
	Noise level	dBm	-102	-102	-102	-102
	RX antenna gain	dBi	17	19	17	19
	Target I/N	dB	-6	-6	-6	-6
	Max P int	dBm	-108	-108	-108	-108
INTERFERING TX	RLAN e.i.r.p.	dBm	30	30	30	30
	RLAN bandwidth	MHz	20	20	20	20
MCL	Wall loss	dB	0	0	0	0
	Polarisation missmatch	dB	3	3	3	3
	Required coupling loss	dB	146	148	146	148
	Required separation distance (3 slope model, urban)	M	656	705	656	705

The following table shows the MCL worst case calculations when RLAN is assumed to be indoor in an urban environment:

Table 38: MCL calculations- indoor RLANs into public transport automation systems

INDOOR	Parameter	Unit	Omni vs Vagon	Omni vs Infra
VICTIM Rx	Rx bandwidth	MHz	5	5
	Noise Figure	dB	5	5
	Rx temp.	K	290	290

INDOOR	Parameter	Unit	Omni vs Vagon	Omni vs Infra
	Noise level	dBm	-102	-102
	Rx antenna gain	dBi	17	19
	Target I/N	dB	-6	-6
	Max P int	dBm	-108	-108
INTERFERING Tx	RLAN e.i.r.p.	dBm	23	23
	RLAN bandwidth	MHz	20	20
MCL	Wall loss	dB	15	15
	Polarisation missmatch	dB	3	3
	Required coupling loss	dB	124	126
	Required separation distance (free space)	M	293	315

The results indicate MCL worst case separation distances of hundreds of meters, it is therefore necessary to conduct more detailed studies.

7.1.2 Adjacent channel interference from RLAN into public transport automation systems

In this section we consider the adjacent-channel operation of RLANs and public transport automation systems.

The RLAN transmitter mask is provided in Figure 2. As it can be seen from Figure 2, 0.55N (where N is nominal channel bandwidth) is the value, outside the nominal channel, where the emission has fallen by at least 20 dB. With N = 20, 40, 80 and 160 MHz, it means that, to for the emission mask to fall by 20 dB from its maximum, it will take, respectively, 1, 2, 4 and 8 MHz.

Table 39 shows the ACLR derived from Figure 2, with respect to the co-channel case, for a PTAS channel of 5 MHz adjacent to the RLAN channel (starting at 0.5N in Figure 2).

Table 39: adjacent channel attenuation

RLAN bandwidth	Attenuation
20 MHz	13 dB
40 MHz	10 dB
80 MHz	7.5 dB
160 MHz	4.8 dB

Note: between 0.5*N and 0.55*N (N is the RLAN nominal channel bandwidth) the mask drops from 0 to -20 dB and this overlaps with the 5 MHz railway channel; for adjacent band studies.

Table 40 below shows the MCL calculation for the adjacent channel case for a 20 MHz RLAN:

Table 40: MCL calculations- indoor RLANs into public transport automation systems – adjacent channel case

OUTDOOR	Parameter	Unit	Dir Lan vs Vagon	Dir Lan vs Infra	Omni vs Vagon	Omni vs Infra
VICTIM Rx	Rx bandwidth	MHz	5	5	5	5
	Noise Figure	dB	5	5	5	5
	Rx temp.	K	290	290	290	290
	Noise level	dBm	-102	-102	-102	-102
	Rx antenna gain	dBi	17	19	17	19
	Target I/N	dB	-6	-6	-6	-6
	Max P int	dBm	-108	-108	-108	-108
INTERFERING Tx	RLAN e.i.r.p.	dBm	30	30	30	30
	RLAN bandwidth	MHz	20	20	20	20
	RLAN e.i.r.p/MHz	MHz	17	17	17	17
	ACLR	dB	13	13	13	13
	Equivalent e.i.r.p into victim Rx BW	dBm	4	4	4	4
	Polarisation missmatch	dB	3	3	3	3
	Required coupling loss	dB	126	128	126	128
	Required separation distance	M	316	340	316	340

As it can be seen, this preliminary assessment (only considering 1W e.i.r.p for outdoor RLAN) indicates a distance of 340 meters in worst case conditions.

7.1.3 Interference from public transport automation systems into RLAN in the 5.915-5.935 GHz band

In this section, we present the results of a MCL analysis in Table 41 where a Public Transport Automation System is the interferer and RLAN is the victim.

For each scenario, the table sets out the minimum separation required between the Public Transport Automation System interferer and the RLAN victim in order that the required attenuation is resolved.

Table 41: MCL calculations- public transport automation systems into RLANs

Public Transport INTERFERER	Units	Scenario 1 (outdoor RLAN) Urban	Scenario 2 (indoor RLAN) urban
Bandwidth	MHz	5	5
e.i.r.p.	dBm	29.5	29.5
Building attenuation (wall)	dB	0	15
RLAN VICTIM			
Bandwidth	MHz	20	20
Noise Power	dBm	-97	-97
Antenna gain	dBi	6	6
Polarisation discrimination	dB	3	3
I/N	dB	-6	-6
Interference threshold	dBm	-106	-106
Required attenuation	dB	135.5	120.5
Required separation distance	**m**	**1092**	**489**

For these scenarios, we have assumed that an RLAN Access Point is involved in the interference problem.

The results show that minimum separation distances in the range 489 m to 1092 m are required in order that RLAN receivers are protected from harmful interference in a shared environment.

7.2 SUMMARY

Regarding the interference from RLAN into public transport automation systems in the 5.915-5.935 GHz band, the results of MCL calculations indicate worst case separation distances of hundreds of meters, it is therefore necessary to conduct more detailed studies.

Regarding the adjacent channel interference from RLAN into public transport automation systems, a preliminary assessment indicates a distance of 340 meters in worst case conditions.

Regarding the interference from public transport automation systems into RLAN in the 5.915-5.935 GHz band, results show that minimum separation distances in the range 489 m to 1092 m are required in order that RLAN receivers are protected from harmful interference in a shared environment.

In order to further investigate the impact of RLANs on the operation of public transport automation systems, three scenarios were identified (see section 13).

It should be noted that future urban rail systems could be considered as part of ITS.

8 COMPATIBILITY BETWEEN RLAN AND FSS (EARTH TO SPACE) IN THE BAND 5725 - 5925 MHZ

8.1 INTERFERENCE FROM RLAN INTO FSS (EARTH TO SPACE) IN THE BAND 5725 - 5925 MHz

8.1.1 Methodology

A methodology similar to the one used in ECC Report 206 [26] is used for the purpose of sharing and compatibility studies between RLAN and the FSS in the range 5725-5925 MHz.

The methodology follows a 2-step approach as outlined below:

- **Step 1** is described in section 8.1.2: This step calculates the maximum number of active, on-tune, RLAN transmitters that can be accommodated by the satellite receiver under consideration (see Table 11) (considering the satellite footprint) whilst satisfying the FSS protection criteria described in section 3.2.2.
- The criterion adopted for the protection of the FSS is that, on any satellite system, the RLAN emissions should not cause an increase of the equivalent temperature greater that x% of the noise temperature of the satellite receiver in clear sky conditions without interference, i.e. $\Delta T/T \leq x\%$. Some initial calculations and results are provided for x=6% (generally applicable for sharing in the case of two co-primary services, e.g. the FSS and the MS as co-primary services without service apportionment) and x=1% (generally applicable to interference from a non-primary service into FSS, or to interference from several co-primary services into FSS such as FS and MS). Further results are presented, taking account of a service and geographic apportionment scheme applied to the dT/T =6% criterion and further modelling considerations.
- Interference apportionment between various potential sources of interference into FSS can be addressed through the choice of the protection criterion. For example, for sharing between FSS and at least two other co-primary services such as FS and MS, the portion of interference allowed to the MS can be derived by apportioning the total x%. See section 8.1.2.2 for more elements and analysis on geographic and service apportionment.
- The propagation model is described in section 4.2.
- **Step 2** is described in section 8.1.3: This step delivers the number of active, on-tune, RLAN transmitters using a deployment model. The Step 2 outputs can be compared with the Step 1 values in order to assess the potential for sharing. In theory, if the Step 2 values are less than or equal to the Step 1 values, then the results suggest that sharing is possible; else if the Step 2 values are greater than the Step 1 values, sharing is not possible.

8.1.2 Step 1: Calculations for the maximum number of active RLAN transmitters within the FSS footprint

This section presents the calculations for the maximum number of active on-tune RLANs that can be accommodated by a victim satellite receiver considering a range of protection criteria.

8.1.2.1 *Generic calculations*

The following parameters are considered in the calculations:

- RLAN e.i.r.p. distribution and channel bandwidth distribution as provided in section 2.3 and reproduced below.

Table 42: RLAN power distribution

Tx power e.i.r.p.	1W (directional)	1 W (omni)	200mW (omni)	80mW (omni)	50mW (omni)	25mW (omni)	all
indoor	0%	0%	18%	25.6%	14.2%	36.9%	94.7%
outdoor	0.10%	0.20%	0.95%	1.35%	0.75%	1.95%	5.3%

Table 43: RLAN channel bandwidth distribution and bandwidth correction values

Channel bandwidth	20 MHz	40 MHz	80 MHz	160 MHz
RLAN Device Percentage	10 %	25 %	50 %	15 %
Average bandwidth correction ratio	0.7	0.5	0.5	0.25

- RLAN antenna discrimination towards space: calculations are performned using two values: 0 dBi and 4 dBi.
- Building (indoor to outdoor) attenuation, calculations are performed using two values: 12 dB and 17 dB.

The basic calculation method is illustrated in the table below. Assuming a free space path loss of 199.8 dB, the number of RLAN devices are increased until ΔT/T = 6 (or 1)% exactly.

Table 44: Example calculation for the maximum number of RLANs

EIRP + indoor-outdoor distributions						
EIRP (mW)	1000	200	80	50	25	Total
indoor (%)	0%	18%	25.60%	14.20%	36.90%	94.7%
outdoor (%)	0.30%	0.95%	1.35%	0.75%	1.95%	5.3%
Bandwidth distribution						
Bandwidth (MHz)	20	40	80	160		
Distribution (%)	10.00%	25.00%	50.00%	15.00%		
Bandwidth correction						
RLAN Bandwidth (MHz)	20	40	80	160		
Average bandwidth correction factor (ratio)	0.7	0.5	0.5	0.25		
Calculations						
Building loss (dB)	17					
RLANs	606000	606				
Aggregate EIRP (mainbeam) (mW)	5026862					
Transponder bandwidth (MHz)	40					
Aggregate EIRP (bandwidth correction) (mW)	2425461					
Aggregate EIRP (bandwidth correction) dBW	33.85					
RLAN antenna discrimination (dB)	4					
Free Space Path Loss (dB)	199.8					
Satellite antenna gain (dBi)	34					
Aggregate interference incident to satellite (dBW)	-135.95					
Satellite receiver Noise Temp. (K)	773					
Boltzmann's Constant (dBW/K/Hz)	-228.6					
Equiv. interfering Temp. (K)	46.00					
ΔT/T (%)	**6.0**					

Based on this example calculation, Table 45 and Table 46 provide some initial results for the maximum number of RLANs that can be accommodated by the satellite receiver whilst satisfying a dT/T of 6% and 1%, respectively, taking into account two values of antenna discrimination (0 dB and 4 dB) and two values of building loss (12 dB and 17 dB).

Table 45: Initial results for Max number of RLANs for dT/T = 6%

dT/T = 6%				
Antenna discrimination (dB)	0	4	0	4
Building loss (dB)	17	17	12	12
A	242000	606000	175000	440000
B	2106000	5290000	1528000	3837000
C	288000	724000	209000	525000
D	242000	606000	175000	440000
E	288000	724000	209000	525000
F	2106000	5290000	1528000	3837000
G	375000	941000	272000	683000
H	186000	468000	135000	339000
I	288000	724000	209000	525000
J (Gain=38.5)	78000	195000	57000	142000
J (Gain=32.5)	309000	776000	224000	563000
J (Gain=28.5)	776000	1947000	563000	1413000
K (Gain=38.5)	78000	195000	57000	142000
K (Gain=32.5)	309000	776000	224000	563000
K (Gain=28.5)	776000	1947000	563000	1413000
L (Gain=38.5)	78000	195000	57000	142000
L (Gain=32.5)	309000	776000	224000	563000
L (Gain=28.5)	776000	1947000	563000	1413000
M (Gain=38.5)	78000	195000	57000	142000
M (Gain=32.5)	309000	776000	224000	563000
M (Gain=28.5)	776000	1947000	563000	1413000
N (Gain=38.5)	78000	195000	57000	142000
N (Gain=32.5)	309000	776000	224000	563000
N (Gain=28.5)	776000	1947000	563000	1413000

Table 46: Initial results for Max number of RLANs for dT/T = 1%

dT/T = 1%				
Antenna discrimination (dB)	0	4	0	4
Building loss (dB)	17	17	12	12
A	39000	97000	28000	71000
B	337000	845000	244000	613000
C	46000	116000	34000	84000
D	39000	97000	28000	71000
E	46000	116000	34000	84000
F	337000	845000	244000	613000
G	60000	151000	44000	109000
H	30000	75000	22000	55000
I	46000	116000	34000	84000
J (Gain=38.5)	13000	32000	9000	23000
J (Gain=32.5)	50000	124000	36000	90000
J (Gain=28.5)	124000	311000	90000	226000
K (Gain=38.5)	13000	32000	9000	23000
K (Gain=32.5)	50000	124000	36000	90000
K (Gain=28.5)	124000	311000	90000	226000
L (Gain=38.5)	13000	32000	9000	23000
L (Gain=32.5)	50000	124000	36000	90000
L (Gain=28.5)	124000	311000	90000	226000
M (Gain=38.5)	13000	32000	9000	23000
M (Gain=32.5)	50000	124000	36000	90000
M (Gain=28.5)	124000	311000	90000	226000
N (Gain=38.5)	13000	32000	9000	23000
N (Gain=32.5)	50000	124000	36000	90000
N (Gain=28.5)	124000	311000	90000	226000

8.1.2.2 *Service and geographic apportionment*

It should be noted that the case of dT/T of 6% (Table 45) does not take account of service and geographic apportionment. Table 46 takes account of a service and geographic apportionment in a general manner (considering a dT/T of 1%). In this section more detailed service and geographic apportionment schemes are presented taking into account characteristics of the different satellites considered.

The following Figure 25 shows examples of satellite coverage corresponding to satellites J and K.

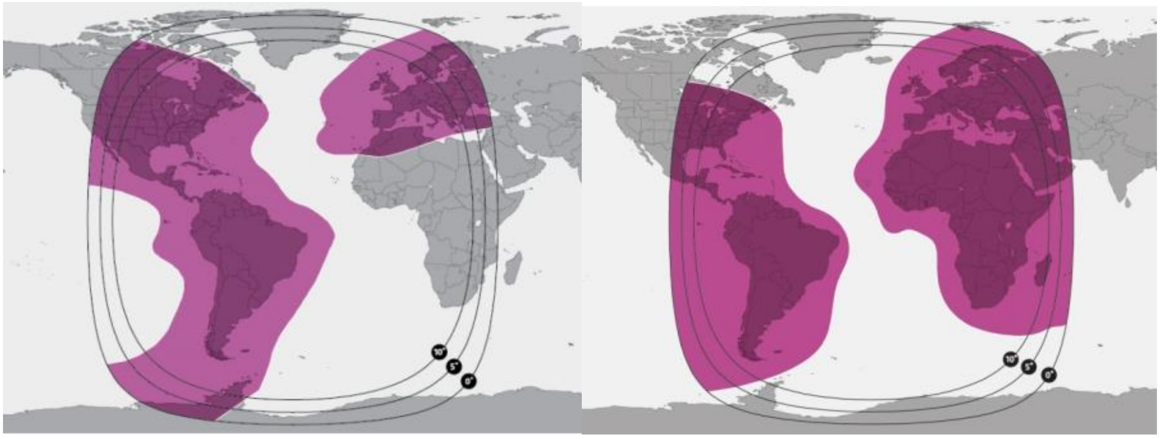


Figure 25: Examples of satellite coverage for satellites J and K

The beam covering Europe corresponds to a continental coverage with 38.5 dBi antenna whereas the hemispheric beam (in this case covering Americas) represents an antenna gain of 32.5 dBi and the global beam (with full coverage above 5° elevation) represents an antenna gain of 28.5 dBi.

The apportionment of the FSS interference criteria (ΔT/T 6%) differs when considering these three cases and a simple approach covering both service and geographic apportionment is presented here:

- Overall, the ΔT/T = 6% can be apportioned between RLAN and other services and applications present in the same band (e.g. FS, BFWA, WIA, DA2GC, etc). It is therefore proposed to allocate a ΔT/T = 3% for RLAN 5 GHz (service apportionment).
- **For continental coverage (38.5 dBi)**: the beam covers Europe and only RLAN in Europe are considered. The FSS protection criteria is set at **ΔT/T = 3% (service apportionment only).**
- **For hemispheric coverage (32.5 dBi)**: the beam covers Europe as well as the Middle-East and the whole of Africa (Europe plus one other geographical region). Therefore the interference is apportioned between these two regions. Thus **ΔT/T = 1.5 %** (taking account of service and geographic apportionment).
- **For global coverage (28.5 dBi)**: the beam covers the visible surface of the Earth from the satellite. Thus **ΔT/T = 1 %** (taking account of service and geographic apportionment).

Making a distinction between the band 5725-5850 MHz and 5850-5925 MHz (see relevant satellites in Table 14), the logic for the service and geographic apportionments specified here are described below:

- **Band 5725-5850 MHz**
  - Service apportionment

In the band 5725-5850 MHz, there are primary allocations to the Radiolocation service and the FSS. In addition, in some countries of Region 1 there are primary allocations to the FS and/or the MS (depending on the country considered).

Considering the wide coverage of the FSS satellites, two services (Radiolocation on one hand, FS or MS on the other hand) will always be present within the FSS coverage, even if locally these services are not deployed within the same geographical area.

There is no situation whereby the FSS would share the band with MS/RLAN only. There would be in any case more than one service/application in the band apart from the FSS, as the Radiolocation service is already in the band.

Therefore, to take into account the service apportionment in the band 5725-5850 MHz as described in section 3.2.2, the FSS protection criteria is set at ΔT/T = 3%.

- Geographic apportionment

FSS satellite networks considered in Table 11 (i.e. FSS satellites covering Europe in 5725-5850 MHz) have geographic footprints wider than Europe, but limited to ITU-R Region 1 (the FSS allocation being limited to ITU-R Region 1). These FSS satellite networks generally cover Europe, Africa and Middle-East and can be considered as presenting **hemispheric coverages**.

There is no information available on deployment of RLANs in regions other than Europe, but one has to take into account the potential deployment of RLANs in these other regions. A simple approach is to consider that these FSS satellite networks cover two wide geographical zones, one of them being Europe and the other Africa/Middle-East.

To take into account the geographic apportionment in the band 5725-5850 MHz as described in section 3.2.2, the FSS protection criteria of ΔT/T is divided by two.

If the ΔT/T is 3% as a result of the service apportionment, then to take into account both service and geographic apportionment the **FSS protection criteria of ΔT/T is 1.5%.**

- **Band 5850-5925 MHz**
  - Service apportionment

In the band 5850-5925 MHz, there are primary allocations to the FS, the MS and the FSS.

Considering the wide coverage of the FSS satellites, two services (FS, MS) will always be present within the FSS coverage, even if locally the FS and MS are not deployed within the same geographical area.

There is no situation whereby the FSS would share the band with MS/RLAN only. There would be in any case more than one service/application in the band apart from the FSS, as the FS/BWA is already in the band.

Therefore, to take into account the service apportionment in the band 5850-5925 MHz as described in section 3.2.2, the FSS protection criteria is a ΔT/T of 3%.

- Geographic apportionment

FSS satellite networks considered in Table 11 (i.e. FSS satellites covering Europe in 5850-5925 MHz) have geographic footprints wider than Europe.

These FSS satellite networks generally cover:

- Europe, Africa/Middle-East and parts of America; or
- Europe, Africa/Middle-East and parts of Asia.

These satellites usually present the 3 different types of coverage, continental, hemispheric and global.

There is no information available on the deployment of RLANs in regions other than Europe, but one has to take into account the potential deployment of RLANs in these other regions. A simple approach is to consider that these FSS satellite networks cover three wide geographical zones, one of them being Europe.

If the ΔT/T is 3% as a result of the service apportionment, then to take into account both service and geographic apportionment the FSS protection criteria is:

- ΔT/T of 3 % for continental coverage (mainly antenna gain of 38.5 dBi);
- ΔT/T of 1.5 % for hemispheric coverage (mainly antenna gain of 32.5 dBi);
- ΔT/T of 1 % for global coverage (mainly antenna gain of 28.5 dBi).

Table 47: Summary of protection criteria apportionment

		Band 5725-5850 MHz		Band 5850-5925 MHz	
Satellite	Frequency range	Type of Beam (coverage)	dT/T (%)	Type of Beam (coverage)	dT/T (%)
A	Whole band	Hemispheric	1.5%	Hemispheric	1.5%
B	Whole band	Hemispheric	1.5%	Global	1%
C	> 5850 MHz	N/A	N/A	Hemispheric	1.5%
D	Whole band	Hemispheric	1.5%	Hemispheric	1.5%
E	>5850MHz	N/A	N/A	Hemispheric	1.5%
F	Whole band	Hemispheric	1.5%	Global	1%
G	Whole band	Hemispheric	1.5%	Hemispheric	1.5%
H	>5850 MHz	N/A	N/A	Hemispheric	1.5%
I	>5850 MHz	N/A	N/A	Hemispheric	1.5%
J (Gain=38.5)	>5850 MHz	N/A	N/A	Continental	3.0%
J (Gain=32.5)	>5850 MHz	N/A	N/A	Hemispheric	1.5%
J (Gain=28.5)	>5850 MHz	N/A	N/A	Global	1%
K (Gain=38.5)	>5850 MHz	N/A	N/A	Continental	3.0%
K (Gain=32.5)	>5850 MHz	N/A	N/A	Hemispheric	1.5%
K (Gain=28.5)	>5850 MHz	N/A	N/A	Global	1%
L (Gain=38.5)	>5850 MHz	N/A	N/A	Continental	3.0%
L (Gain=32.5)	>5850 MHz	N/A	N/A	Hemispheric	1.5%
L (Gain=28.5)	>5850 MHz	N/A	N/A	Global	1%
M (Gain=38.5)	>5850 MHz	N/A	N/A	Continental	3.0%
M (Gain=32.5)	>5850 MHz	N/A	N/A	Hemispheric	1.5%
M (Gain=28.5)	>5850 MHz	N/A	N/A	Global	1%
N (Gain=38.5)	>5850 MHz	N/A	N/A	Continental	3.0%
N (Gain=32.5)	>5850 MHz	N/A	N/A	Hemispheric	1.5%
N (Gain=28.5)	>5850 MHz	N/A	N/A	Global	1%

Table 47 summarises this particular approach to service and geographic apportionment. Further studies may be required.

Maximum number of RLAN after FSS protection criteria apportionment

Taking into account the apportionment scheme summarised in Table 47 above and the initial calculations in Table 45 for dT/T= 6%, the following Table 48 and Table 49 provide the maximum number of on-tune, active, RLANs for the bands 5725-5850 MHz and 5850-5925 MHz respectively.

Table 48: 5725-5850 MHz band (apportionment scheme applied)

Band 5725-5850 MHz				
Antenna discrimination (dB)	0	4	0	4
Building loss (dB)	17	17	12	12
A	60500	151500	43750	110000
B	526500	1322500	382000	959250
D	60500	151500	43750	110000
F	526500	1322500	382000	959250
G	93750	235250	68000	170750

Table 49: 5850-5925 MHz band (apportionment scheme applied)

Band 5850-5925 MHz				
Antenna discrimination (dB)	0	4	0	4
Building loss (dB)	17	17	12	12
A	60500	151500	43750	110000
B	351000	881667	254667	639500
C	72000	181000	52250	131250
D	60500	151500	43750	110000
E	72000	181000	52250	131250
F	351000	881667	254667	639500
G	93750	235250	68000	170750
H	46500	117000	33750	84750
I	72000	181000	52250	131250
J (Gain=38.5)	39000	97500	28500	71000
J (Gain=32.5)	77250	194000	56000	140750

Band 5850-5925 MHz				
J (Gain=28.5)	129333	324500	93833	235500
K (Gain=38.5)	39000	97500	28500	71000
K (Gain=32.5)	77250	194000	56000	140750
K (Gain=28.5)	129333	324500	93833	235500
L (Gain=38.5)	39000	97500	28500	71000
L (Gain=32.5)	77250	194000	56000	140750
L (Gain=28.5)	129333	324500	93833	235500
M (Gain=38.5)	39000	97500	28500	71000
M (Gain=32.5)	77250	194000	56000	140750
M (Gain=28.5)	129333	324500	93833	235500
N (Gain=38.5)	39000	97500	28500	71000
N (Gain=32.5)	77250	194000	56000	140750
N (Gain=28.5)	129333	324500	93833	235500

8.1.2.3 *Further modelling considerations*

The results in Table 48 and Table 49 are considered to be a useful reference point for calculating the maximum number of on-tune, active, RLANs that can be accommodated by the various satellite receivers taking into account the ΔT/T objectives and the apportionment scheme summarised in Table 47. However, there are other well-established factors that should be taken into account when modelling interference on the Earth to space interference paths and in order to achieve a more realistic model, some further modelling has been performed accounting for clutter loss and polarisation mismatch loss.

Clutter loss

Detailed calculations of the impact of clutter loss on the Earth to space interference path are given in A6.2. They are based on the method for the calculation of clutter loss on interference paths as set out in Recommendation ITU-R P.452-15 [19].

Depending upon the satellite under consideration, consideration of the clutter loss leads to a percentage increase in the RLAN population in the range 50.34% to 130.16%, as detailed in Table 50 below.

Table 50: Impact of clutter loss

Satellite	Increase in the RLAN population when clutter is modelled (%)
A	51.43
B	77.58
C	80.14
D	51.43

Satellite	Increase in the RLAN population when clutter is modelled (%)
E	78.08
F	105.98
G	118.95
H	130.16
I	50.34
J	80.14
K	78.08
L	78.08
M	105.98
N	118.95

Polarisation Mismatch Loss

Rationale for values considered for the polarisation mismatch loss and detailed calculations of its impact are given in A6.3. These calculations are based on two values of polarisation mismatch loss, 3 dB and 1.5 dB, applied to those outdoor RLANs that are not exposed to clutter loss.

For all satellites, consideration of polarisation mismatch of 3dB leads to a percentage increase in the RLAN population of 42% when 12 dB building attenuation is used and 70% when 17 dB building attenuation is used.

When considering a polarisation mismatch loss of 1.5 dB, the increase in the RLAN population is 21% when 12 dB building attenuation is used and 31% when 17 dB building attenuation is used

Maximum number of RLANs after further modelling

Taking into account clutter loss and polarisation mismatch loss and the results given in Table 48 and Table 49 (which adjust the results for dT/T = 6% using the approach to service and geographic apportionment summarised in table 47), the following Table 51 and Table 52 give the maximum number of on-tune, active, RLANs for the bands 5725-5850 MHz and 5850-5925 MHz respectively.

Table 51: Maximum number of on-tune RLAN for the 5725-5850 MHz band for Step 1 (apportionment scheme applied)

Band 5725-5850 MHz	With clutter loss and no polarisation mismatch				With clutter loss and polarisation mismatch			
Antenna discrimination (dB)	0	4	0	4	0	4	0	4
Building loss (dB)	17	17	12	12	17	17	12	12
A	91615	229416	66251	166573	155746	390008	94076	236534

Band 5725-5850 MHz	With clutter loss and no polarisation mismatch				With clutter loss and polarisation mismatch			
B	934959	2348496	678356	1703436	1589430	3992442	963265	2418879
D	91615	229416	66251	166573	155746	390008	94076	236534
F	1084485	2724086	786844	1975863	1843624	4630945	1117318	2805726
G	205266	515080	148886	373857	348952	875636	211418	530877

Table 52: Maximum number of on-tune RLAN for the 5850-5925 MHz band for Step 1 (apportionment scheme applied)

Band 5850-5925 MHz	With clutter loss and no polarisation mismatch				With clutter loss and polarisation mismatch			
Antenna discrimination (dB)	0	4	0	4	0	4	0	4
Building loss (dB)	17	17	12	12	17	17	12	12
A	91615	229416	66251	166573	155746	390008	94076	236534
B	623306	1565664	452237	1135624	1059620	2661628	642177	1612586
C	129701	326053	94123	236434	220491	554291	133655	335736
D	91615	229416	66251	166573	155746	390008	94076	236534
E	128218	322325	93047	233730	217970	547952	132126	331897
F	722990	1816057	524562	1317242	1229083	3087297	744879	1870484
G	205266	515080	148886	373857	348952	875636	211418	530877
H	107024	269287	77679	195061	181941	457788	110304	276986
I	108245	272115	78553	197321	184016	462596	111545	280196
J (Gain=38.5)	70255	175637	51340	127899	119433	298582	72903	181617
J (Gain=32.5)	139158	349472	100878	253547	236569	594102	143247	360037
J (Gain=28.5)	232981	584554	169031	424230	396068	993742	240025	602406
K (Gain=38.5)	69451	173628	50753	126437	118067	295168	72069	179540
K (Gain=32.5)	137567	345475	99725	250648	233864	587308	141609	355920
K (Gain=28.5)	230317	577870	167098	419378	391539	982378	237280	595517
L (Gain=38.5)	69451	173628	50753	126437	118067	295168	72069	179540
L (Gain=32.5)	137567	345475	99725	250648	233864	587308	141609	355920
L (Gain=28.5)	230317	577870	167098	419378	391539	982378	237280	595517
M (Gain=38.5)	80332	200831	58704	146246	136565	341412	83360	207669

Band 5850-5925 MHz	With clutter loss and no polarisation mismatch				With clutter loss and polarisation mismatch			
M (Gain=32.5)	159120	399601	115349	289917	270503	679322	163795	411682
M (Gain=28.5)	266401	668405	193278	485083	452881	1136289	274455	688818
N (Gain=38.5)	85391	213476	62401	155455	145164	362910	88609	220745
N (Gain=32.5)	169139	424763	122612	308172	287536	722097	174109	437604
N (Gain=28.5)	283175	710493	205448	515627	481398	1207838	291736	732191

8.1.3 Step 2: RLAN deployment model

Step 1, described in section 8.1.2, provides calculations for the maximum number of active on-tune RLANs that can be accommodated by a victim satellite receiver based on a range of FSS protection criteria; initial results and results based on more advanced modelling and the apportionment scheme summarised in Table 47 are presented. For Step 1, the RLAN deployment is considered over all European countries/areas.

Step 2, presented in this section, aims to develop an RLAN deployment model for Europe with an objective to calculate the number of on-tune RLANs over this area in 2025. In theory, if the value delivered by Step 2 is less than or equal to that obtained in Step 1, this suggests that sharing is feasible.

Although it is obvious that both RLAN Access Points (APs) and terminals present interference potential to incumbent services, this section assumes that APs and terminals are not transmitting simultaneously. The calculation of the number of on-tune RLANs can thus be simplified by calculating the number of on-tune RLAN APs using the following methodology.

This methodology consists of 8 stages:

Stages 1 to 3 aim at defining the expected total number of RLAN APs over Europe.

Stages 4 to 7 are considering RLAN operational parameters to derive the expected total number of on-tune, active, RLANs over Europe.

Stage 8 aims to apply an upper bound on channel re-use.

8.1.3.1 *Elements related to stages 1 to 3*

Stage 1: Define RLAN deployment environments and obtain relevant statistics

The aim is to define RLAN deployment environments and obtain statistics for the set of countries/areas considered (e.g. number of households, number of enterprise establishments).

Stage 2: Assign the statistics obtained in Stage 1 to urban, suburban and rural environments

The aim is to assign the statistics obtained in Stage 1 to urban, suburban and rural environments. This will be more realistic than averaging the RLAN APs over the entire European area. A realistic AP density in urban areas, in particular, allows for a practical investigation of the planning constraints (stage 8).

Stage 3: Apply Market penetration factors in different environments

These factors describe RLAN penetration into the different environments e.g. residential, enterprise and the number of APs per household/enterprise.

Stages 1 to 3 calculations

Detailed statistics and elements related to stages 1 to 3 are provided in [44] and [45] using a deployment model for the projected 2025 RLAN deployment in the whole of Europe and/or the EU-28.

Taking into account these elements and the large number of assumptions, it was agreed that some probable scenarios for the situation in 2025 are those defined in Table 53 below, based on the following assumptions from [44] and [45]:

- Household "high" scenario with 90% penetration for EU-28 and 85% for the whole of Europe and medium projected growth of 10.4%.
- 2 RLAN APs per household >120 sqm (scenario A, corresponding to 1.22 AP average) or 2 RLAN APs per household >100 sqm (scenario B, corresponding to 1.35 AP average).
- Enterprise "medium" scenario.
- 10 Million non-residential hotspots.
- 5% Add-on to cover all other type of usage, such as transport, industrial, mobile wifi, etc.

Table 53: Predictions of number of RLAN APs for 2025

Europe	**2025**	
	Scen. A	**Scen. B**
Area [km^2]	10 009 403	10 009 403
Population	701 083 818	701 083 818
Number of households	320 019 982	320 019 982
Average household RLAN penetration	85%	85%
Number of RLAN households	273 425 558	273 425 558
Average number of RLAN APs per household	1.22	1.35
Total number of residential RLAN APs	**334 672 883**	**369 124 504**
Number of enterprises	31 199 415	31 199 415
Number of enterprises with less than 10 employed persons	*25 700 784*	*25 700 784*
Number of enterprises with 10 and more employed persons	*5 498 631*	*5 498 631*
Number of employed persons	303 939 945	303 939 945
Enterprises with less than 10 employed persons	*79 684 915*	*79 684 915*
Eterprises with 10 and more employed persons	*224 255 029*	*224 255 029*
Average enterprise RLAN penetration	67%	67%
Enterprises with 0-4 employed persons	*49%*	*49%*
Enterprises with 5-10 employed persons	*89%*	*89%*
Enterprises with 10 and more employed persons	*77%*	*77%*
Number of RLAN APs per company (<10 employed persons)	1	1
Number of employed persons per RLAN AP (companies ≥10 employed persons)	9	9
Total number of enterprise RLAN APs	**30 005 636**	**30 005 636**
Total number of RLAN Aps (household and enterprise)	**364 678 519**	**399 130 139**
RLAN density [APs per km^2]	36	40
Share of residential APs	91.8%	92.5%
Share of enterprise APs	8.2%	7.5%
Additional elements		
Public access (hotspots)	10 000 000	10 000 000
Other usages (transport, industrial, mobile wifi, ...) (Add-on 5%)	18 733 926	20 456 507
Total number of RLAN APs	**393 412 445**	**429 586 646**

On this basis, it was agreed that taking a value of 400 Million RLAN APs across Europe will provide a representative value to address the following stages 4 to 7.

However, there is a certain level of uncertainty and, in order to reflect this, it was agreed to consider a range from 300 Million to 500 Million RLAN APs in Europe.

8.1.3.2 *Elements related to stages 4 to 7*

Stage 4: Apply Busy Hour Factor

This Factor gives the percentage of RLAN APs involved in Busy Hour Activity. A range of values is appropriate.

In Stage 3 an estimate of the actual number of APs is given. Stage 4 applies a factor to the output of Stage 3 to obtain the number and density of APs involved in busy hour in urban, suburban and rural environments.

The deployment model should be worst-case i.e. it should aim to model peak RLAN activity rather than average RLAN activity.

ITU-R work (JTG 4-5-6-7) on RLAN at 5 GHz considered an average value (over the population in urban, suburban and rural areas) of 62.7% for the busy hour factor, assumed to be dominated by the corporate usage.

Some consideration was given to the development of a refined Busy Hour model. While the Busy Hour factor is different for enterprise and residential environments no evidence could be found that this is the case for urban, suburban and rural areas. The fact that the satellite footprint covers different time zones has also been considered (for further details see Figure 25).Nevertheless, some further work might be required to refine the busy hour factor model, for instance by taking into account the non-uniform distribution of traffic over the RLAN population.

It was agreed to consider figures of 50%, 62.7% and 70% for the busy hour factor.

Stage 5: Apply 5 GHz Spectrum Factor

This Factor gives the percentage of RLAN activity at 5 GHz (rather than at 2.4 GHz or 60 GHz). This factor is applied in order to obtain the number and density of APs operating at 5GHz in urban, suburban and rural environments during Busy Hour.

It should be noted that there will be RLAN activity at 2.4 GHz and 60 GHz and, since the frequency range under consideration is at 5 GHz only, some RLAN activity during peak periods can be discounted.

A figure of 80% was originally proposed by the RLAN industry based on an optimistic model of corporate Busy Hour where 5 GHz dominates.

In addition, ITU-R work (JTG 4-5-6-7) on RLAN at 5 GHz considered values for the market factor for different environments:

- 80% for urban;
- 80% for suburban;
  and
- 50% for rural.

These values represent an average figure (over the population in urban, suburban and rural areas) of 74% for the 5 GHz spectrum factor.

Further considerations have led to values of 50% and 97% being exercised. The rationales for these values are described below:

- **Rationale for a 5 GHz Spectrum Factor of 97%:**

RLAN has, at this time, 80 MHz of spectrum available in 2.4 GHz and could have potentially 775 MHz of spectrum including the expansion bands in the 5 GHz frequency range. Therefore, considering these two frequency bands but neglecting 60 GHz, about 90% of the spectrum available would be in the 5 GHz range.

Furthermore, the requirement for additional 5 GHz spectrum is mainly based on the need for high throughputs and hence 80 and 160 MHz channels that are only available at 5 GHz, as shown on the RLAN channel bandwidth distribution currently agreed. This distribution depicts a figure of 65 % of use of such 80 MHz and 160 MHz bandwidths that cannot be accommodated in the 2.4 GHz band. In addition, the available number of 20 MHz channels is 3 (not overlapping) in the 2.4 GHz band whereas it is 37 in the extended 5 GHz band showing therefore a share of 8% at 2.4 GHz and 92% at 5 GHz for the small channels (20 or 40 MHz), i.e. 35% of the channel use. Taking into account the fact that the other 65% of the channel use (80 and 160 MHz) will only be accommodated at 5 GHz, this gives an overall share of channel use of 3 % (8% x 35%) at 2.4 GHz and 97% (92% x 35% + 65%) at 5 GHz.

- **Rationale for a 5 GHz Spectrum Factor of 50%:**

Estimations for the current market deployment of 2.4/5 GHz spectrum were made based upon single (2.4GHz only) and dual-band (2.4/5GHz) Wi-Fi products that were shipped (by the overall connectivity market leader) across multiple segments in 2014. By multiplying the “Percentage of single band versus dual band per segment” by the “Percentage of Total products shipped per segment” the percentage of dual-band devices shipped overall was determined. Based upon the above the percentage of 5GHz enabled dual band products shipping across all Wi-Fi segments is approximately 57%. This does not take into account any split in spectrum usage for the dual band devices and the 57% value calculated was therefore an overestimation of the 5GHz spectrum factor as it assumes that all dual band devices are operating in 5GHz mode only.

Over the coming years although the RLAN industry expects to see a move to an increase in dual-band devices compared to single band devices it is also expected to see a penetration of up to 50% for 60GHz devices. It was therefore suggested that a 5GHz spectrum factor of 50% would be a reasonable estimation for current and longer term.

However, consideration of the 60 GHz band use could have an impact on the total number of APs in Europe as calculated under stage 1 to 3 above and would hence require further study.

It is understood that RLAN usage in the different frequency ranges in 2025 is difficult to predict and it was therefore agreed to consider figures of 50%, 74% and 97% for the 5 GHz spectrum factor.

Stage 6: Apply RF Activity Factor

This Factor gives the percentage of time that a RLAN is transmitting. When applied, this factor provides the number and density of active APs operating at 5 GHz during Busy Hour in urban, suburban and rural environments.

ITU-R M.1651 sets out a method and example calculations that can be used as inputs to a calculation for the RF activity factor. For example: in the home environment, an RLAN accessing VHiMM for the entire Busy Hour has an individual Activity Factor (related to this VHiMM service only) of 12%.

It is agreed that a range of 3 to 30% is relevant for this factor. Within this range, it is also proposed to consider an activity factor of 10% corresponding to the figure proposed in JTG by the RLAN industry for rural deployment.

Sources: See section 2.3.4 and CEPT Report 57 [42] (see section A3.1.7). This range covers JTG options A and B. The values of 3% and 30%.

Stage 7: Calculate the number of on-tune RLAN APs per 40 MHz

This stage provides the number and density of active, on-tune, APs operating at 5 GHz during Busy Hour, incident to a 40 MHz victim receiver bandwidth sourced from all (urban, suburban and rural) environments.

As described in ANNEX 7:, this factor depends on the relative positioning of the 40 MHz victim receiver bandwidth on the RLAN channelization scheme, the total number of RLAN channels (for each bandwidth) and the RLAN bandwidth distribution. Stage 7 should be considered together with any bandwidth corrections made during Step 1 (see section 8.1.2).

As shown in ANNEX 7:, there are 2 options to calculate this factor that differ in their outputs (and in where bandwidth correction factors are applied):

- Option 1: delivers the total number of on-tune, active RLANs overlapping in frequency with the 40 MHz FSS receiver. Bandwidth correction factors are considered in Step 1;
- Option 2: delivers the equivalent number of on-tune, active, 40 MHz interferers incident to the 40 MHz FSS receiver. Here the bandwidth correction factor is considered in Step 2.

Outputs from Step 1 are easily adjusted but since the bandwidth correction factor is already considered in Step 1 (see section 8.1.2), Option 1 is considered the simplest to implement in this study.

This leads to a factor of 12.9% of the total number of RLANs in the 5 GHz range overlapping the 40 MHz FSS receiver bandwidth (see detailed calculations in ANNEX 7:).

Stages 4 to 7 calculations

The following table provides the aggregate factor from stages 4 to 7, for the 27 different cases resulting from the range of figures for Stage 4 (busy hour factor, 3 figures), stage 5 (spectrum factor, 3 figures) and stage 6 (activity factor, 3 figures).

Table 54: Aggregate factors 4 to 7

	Stage 4	Stage 5	Stage 6	Stage 7	Aggregate
	Busy hour population	5 GHZ factor	Activity factor	40 MHz FSS	Stage 4 to 7
Case 1	50%	50%	3%	12.9%	0.0010
Case 2	50%	50%	10%	12.9%	0.0032
Case 3	50%	50%	30%	12.9%	0.0097
Case 4	50%	74%	3%	12.9%	0.0014
Case 5	50%	74%	10%	12.9%	0.0048
Case 6	50%	74%	30%	12.9%	0.0143
Case 7	50%	97%	3%	12.9%	0.0019
Case 8	50%	97%	10%	12.9%	0.0063
Case 9	50%	97%	30%	12.9%	0.0188
Case 10	62.70%	50%	3%	12.9%	0.0012
Case 11	62.70%	50%	10%	12.9%	0.0040
Case 12	62.70%	50%	30%	12.9%	0.0121
Case 13	62.70%	74%	3%	12.9%	0.0018

	Stage 4	Stage 5	Stage 6	Stage 7	Aggregate
Case 14	62.70%	74%	10%	12.9%	0.0060
Case 15	62.70%	74%	30%	12.9%	0.0179
Case 16	62.70%	97%	3%	12.9%	0.0024
Case 17	62.70%	97%	10%	12.9%	0.0078
Case 18	62.70%	97%	30%	12.9%	0.0235
Case 19	70%	50%	3%	12.9%	0.0014
Case 20	70%	50%	10%	12.9%	0.0045
Case 21	70%	50%	30%	12.9%	0.0135
Case 22	70%	74%	3%	12.9%	0.0020
Case 23	70%	74%	10%	12.9%	0.0067
Case 24	70%	74%	30%	12.9%	0.0200
Case 25	70%	97%	3%	12.9%	0.0026
Case 26	70%	97%	10%	12.9%	0.0088
Case 27	70%	97%	30%	12.9%	0.0263

8.1.3.3 *Overall application of stages 1 to 7*

Taking into account the above elements in sections 8.1.3.1 and 8.1.3.2, final results of calculations in this study are summarised in Table 55 below.

Table 55 : Number of on-tune RLAN APs per 40 MHz

	Aggregate Stages 4 to 7 (see section 8.1.3.2)	Total number of on-tune RLAN in Europe (for 300 Million APs)	Total number of on-tune RLAN in Europe (for 400 Million APs)	Total number of on-tune RLAN in Europe (for 500 Million APs)
Case 1	0.0010	290118	386824	483530
Case 2	0.0032	967061	1289414	1611768
Case 3	0.0097	2901182	3868243	4835304
Case 4	0.0014	429375	572500	715625
Case 5	0.0048	1431250	1908333	2385417
Case 6	0.0143	4293750	5725000	7156250
Case 7	0.0019	562829	750439	938049
Case 8	0.0063	1876098	2501464	3126830
Case 9	0.0188	5628294	7504392	9380490
Case 10	0.0012	363808	485078	606347

	Aggregate Stages 4 to 7 (see section 8.1.3.2)	Total number of on-tune RLAN in Europe (for 300 Million APs)	Total number of on-tune RLAN in Europe (for 400 Million APs)	Total number of on-tune RLAN in Europe (for 500 Million APs)
Case 11	0.0040	1212694	1616926	2021157
Case 12	0.0121	3638083	4850777	6063471
Case 13	0.0018	538436	717915	897394
Case 14	0.0060	1794788	2393050	2991313
Case 15	0.0179	5384363	7179150	8973938
Case 16	0.0024	705788	941051	1176313
Case 17	0.0078	2352627	3136836	3921045
Case 18	0.0235	7057881	9410507	11763134
Case 19	0.0014	406166	541554	676943
Case 20	0.0045	1353885	1805180	2256475
Case 21	0.0135	4061655	5415541	6769426
Case 22	0.0020	601125	801500	1001875
Case 23	0.0067	2003750	2671667	3339583
Case 24	0.0200	6011250	8015000	10018750
Case 25	0.0026	787961	1050615	1313269
Case 26	0.0088	2626537	3502050	4377562
Case 27	0.0263	7879611	10506149	13132686

Comparison of these values with that obtained in Step 1 are provided in ANNEX 8: for the above 27 cases and all satellites, taking into account 400 Million APs.

Compared to these results for 400 Million APs, the case of 300 Million and 500 Million AP can be extrapolated with a factor -1.25 dB and +0.97 dB, respectively, as shown in ANNEX 8:.

In order to summarise these results, it was agreed to present the results for 3 specific scenarios, as described in the Table 56 below:

Table 56: Scenarios for FSS summary analysis

Scenario	Number of AP	Busy hour factor	Spectrum factor	RF activity factor	Total number of on-tune RLAN in Europe
“Optimistic” scenario (Case 1 above)	300 M	50 %	50 %	3 %	290118
“Medium” scenario (Case 14 above)	400 M	62.7 %	74 %	10 %	2393050
“Pessimistic”	500 M	70 %	97 %	30 %	13132686

Scenario	Number of AP	Busy hour factor	Spectrum factor	RF activity factor	Total number of on-tune RLAN in Europe
scenario (Case 27 above)					

Also, the different FSS satellites have been split in 5 different groups as in Table 57, considering similarities in interference potential, taking into account their main characteristics (e.g. max antenna gain, receiving system noise, orbital position, etc…)

Table 57: FSS groups for FSS summary analysis

FSS Group	Satellites	Main characteritics	Remarks
FSS Group 1	B F	Typical 26.5 dBi antenna gain	Global beams
FSS Group 2	G N (Gain=28.5) M (Gain=28.5) J (Gain=28.5) K (Gain=28.5) L (Gain=28.5)	Typical 28.5 dBi antenna gain	Global beams (Satellite G presents a max antenna gain of 34 dBi but a higher system noise and a far east orbital position)
FSS Group 3	C E N (Gain=32.5) M (Gain=32.5) J (Gain=32.5) K (Gain=32.5) L (Gain=32.5)	Around 32.5 dBi antenna gain	Hemispherical beams
FSS Group 4	A D H I	Around 34 dBi antenna gain	Hemispherical beams
FSS Group 5	N (Gain=38.5) M (Gain=38.5) J (Gain=38.5) K (Gain=38.5) L (Gain=38.5)	38.5 dBi antenna gain	Continental beams

On this basis, the FSS analysis can be summarised as given in Table 58 below, based on results taking into account clutter losses and polarisation mismatch with a 3 dB figure. If a figure of 1.5 dB is considered for the polarisation mismatch, the results would be modified by 0.7 dB (for the cases related to 12 dB building loss) and 1.13 dB (for the cases related to 17 dB building loss). For further details, see sections 8.1.2.3 and A6.3. As an example, the excess interference would be increased by these values.

Table 58 : Summary of FSS analysis

Scenario	Antenna discr. (dB)	Building loss (dB)	Band 5725-5850 MHz	Band 5850 5925-MHz
"Optimistic" scenario (Case 1 above)	4	17	FSS protection criteria satisfied for all FSS groups 1, 2 and 4 (margin ranges 1.3 to 12 dB)	FSS protection criteria satisfied for all FSS groups 1, 2, 3, 4 and 5 (margin ranges 0.1 to 10.3 dB)
	4	12	FSS protection criteria satisfied for FSS groups 1 and 2 (margin ranges 2.6 to 9.9 dB). FSS protection criteria exceeded for other FSS group 4 (exceeding of 0.9 dB)	FSS protection criteria satisfied for FSS groups 1 2 and 3 (margin ranges 0.6 to 8.1 dB). FSS protection criteria exceeded for other FSS groups 4 and 5 (exceeding ranges 0.2 to 2.1 dB)
	0	17	FSS protection criteria satisfied for FSS groups 1 and 2 (margin ranges 0.8 to 8 dB): FSS protection criteria exceeded for other FSS group 4 (exceeding of 2.7 dB)	FSS protection criteria satisfied for FSS groups 1 and 2 (margin ranges 0.8 to 6.3 dB). FSS protection criteria exceeded for other FSS groups 3, 4 and 5 (exceeding ranges 0 to 3.9 dB)
	0	12	FSS protection criteria satisfied for FSS group 1 (margin ranges 5.2 to 5.9 dB). FSS protection criteria exceeded for other FSS groups 2 and 4 (exceeding ranges 1.4 to 4.9 dB)	FSS protection criteria satisfied for FSS groups 1 (margin ranges 0 to 4.1 dB) and Satellite N (28.5 dBi) with a margin of 0 dB. FSS protection criteria exceeded for other FSS groups 2 (except satellite N), 3, 4 and 5 (exceeding ranges 0.2 to 6 dB)
"Medium" scenario (Case 14 above)	4	17	FSS protection criteria satisfied for FSS group 1 (margin ranges 2.2 to 2.9 dB). FSS protection criteria exceeded for other FSS groups 2 and 4 (exceeding ranges 4.4 to 7.9 dB)	FSS protection criteria satisfied for FSS group 1 (margin ranges 0.5 to 1.1 dB). FSS protection criteria exceeded for other FSS groups 2, 3, 4 and 5 (exceeding ranges 3 to 9.1 dB)
	4	12	FSS protection criteria satisfied for FSS group 1 (margin ranges 0 to 0.7 dB). FSS protection criteria exceeded for other FSS groups 2 and 4 (exceeding ranges 6.5 to 10.1 dB)	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 1.1 to 11.2 dB)
	0	17	FSS protection criteria exceeded for all FSS groups 1, 2 and 4 (exceeding ranges 1.1 to 11.9 dB)	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 2.9 to 13.1 dB)
	0	12	FSS protection criteria exceeded for all FSS groups 1, 2 and 4 (exceeding ranges 3.3 to 14.1 dB)	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 5.1 to 15.2 dB)

Scenario	Antenna discr. (dB)	Building loss (dB)	Band 5725-5850 MHz	Band 5850 5925-MHz
"Pessimistic" scenario (Case 27 above)	4	17	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 4.5 to 15.3 dB)	FSS protection criteria exceeded for all FSS groups 1, 2 and 4 (exceeding ranges 6.3 to 16.5 dB)
	4	12	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 6.7 to 17.4 dB)	FSS protection criteria exceeded for all FSS groups 1, 2 and 4 (exceeding ranges 8.4 to 18.6 dB)
	0	17	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 8.5 to 19.2 dB)	FSS protection criteria exceeded for all FSS groups 1, 2 and 4 (exceeding ranges 10.3 to 20.4 dB)
	0	12	FSS protection criteria exceeded for all FSS groups 1, 2, 3, 4 and 5 (exceeding ranges 10.7 to 21.4 dB)	FSS protection criteria exceeded for all FSS groups 1, 2 and 4 (exceeding ranges 12.4 to 22.6 dB)

It is important to understand that the potential for RLAN–FSS sharing (Step 2 in particular) is based on some assumptions that may still need further study and, although providing some relevant results, it is at this stage too early to draw any definite conclusions with regard to the potential for RLAN and FSS to share at 5 GHz.

8.1.3.4 *Stage 8: Apply upper bound on channel re-use.*

The demographic statistics show that in the European Union (EU28) approximately 50% of the population and households (see [37], [38], [39], [40], [44] and [45]) are situated in less than 2% of the total land mass. This stage focusses on applying an upper bound to the number of co-channel RLANs using a practical planning method (i.e. applying a minimum re-use distance between co-frequency RLANs).

This method uses maximum channel re-use factors for active APs per km2 to derive an upper bound in densely populated areas.

This stage provides an adjustment to the results of Stage 7 by introducing an upper bound on the maximum density per km2 of RLAN APs in highly populated urban areas (e.g. London, UK).

The principle of this Stage 8 is agreed but it is recognised as not being trivial to calculate and quite time consuming. In addition, considering the quite large FSS footprint and since it may only apply to high densely population area, its potential advantage needs to be demonstrated.

At the time where this report was finalised, no studies were provided for Stage 8.

8.1.4 Summary – analysis of results

The studies have focused on the assessment of the interference from RLAN into FSS and follow a two-step approach:

- **Step 1** is described in section 8.1.2: This step calculates the maximum number of active, on-tune, RLAN transmitters that can be accommodated by the satellite receiver under consideration (see Table 11) (considering the satellite footprint) whilst satisfying the FSS protection criteria described in section 3.2.2.
- **Step 2** is described in section 8.1.3: This step delivers the number of active, on-tune, RLAN transmitters using a deployment model. The Step 2 outputs can be compared with the Step 1 values in order to assess the potential for sharing. In theory, if the Step 2 values are less than or equal to the Step 1

values, then the results suggest that sharing is possible; else if the Step 2 values are greater than the Step 1 values, sharing is not possible.

Concerning step 1, results have been obtained considering 2 different values of building attenuation for indoor use (12 and 17 dB), two values of antenna discrimination (0 and 4 dB), and an approach to service and geographic apportionment of the FSS protection criteria of $\Delta T/T=6\%$.

Further modelling takes account of clutter loss and polarisation mismatch loss on the Earth to space interference path.

The different factors used in step 2 are subject to some uncertainties because of the difficulties involved when deriving values for these factors and in particular when making predictions for 2025. Therefore it was agreed to preform sensitivity analyses, taking into account ranges of values for some of these factors.

Calculations and results are presented in this report but, although providing some relevant results, it is at this stage too early to draw definite conclusions.

Conclusions on the potential for RLAN–FSS sharing will be developed in the Part 2 Report, taking into account additional considerations, such as:

- Antenna discrimination for outdoor RLANs;
- Further studies on polarisation mismatch;
- Studies supporting Stage 8 of FSS Step 2 (see section 8.1.3.4);
- 5 GHz Spectrum Factor (Stage 5 of FSS Step 2);
- Control / monitoring on the long term aggregate effect of RLAN interference into FSS as RLAN deployment increases and investigation of what can be done in a scenario where the interference threshold is reached;
- Further studies on apportionment of the FSS protection criteria.

8.1.4.1 *Potential mitigation techniques*

Some potential mitigation techniques may need to be considered and their impact on the potential sharing between RLAN and FSS should be assessed. Among others, the following potential mitigation techniques could be addressed:

- RLAN Access Points deployed only indoor;
- Additional power limitation for RLAN.

There is a need for studies on the feasibility and practicability on the potential mitigation techniques.

8.2 INTERFERENCE FROM FSS (EARTH TO SPACE) INTO RLAN IN THE BAND 5725-5925 MHz

Further work is needed to assess the potential impact from FSS (Earth to Space) into RLAN in the band 5725-5925 MHz, if appropriate.

9 COMPATIBILITY BETWEEN RLAN AND BFWA (FS) IN THE BAND 5725 - 5875 MHz

9.1 MINIMUM COUPLING LOSS CALCULATIONS

9.1.1 Results for Interference from RLAN into BFWA (FS) in the band 5725-5875 MHz

The following parameter settings were used in the below MCL calculations:

- Propagation model from section 4.2.1;
- RLAN indoor (17dB wall loss) and outdoor (0dB wall loss);
- RLAN Tx power 23 dBm with 20, 40, 80 and 160 MHz bandwidth;
- RLAN antenna 0 dBi and 7 dBi;
- BFWA reception antenna gain 0dBi (sidelobe), 16 dBi (CS) and 22 dBi (TS);
- Other BFWA parameters from section 3.3.

Table 59: MCL calculations with RLAN as interferer and BFWA as victim

					urban path loss model	suburban path loss model	rural path loss model	urban path loss model	suburban path loss model	rural path loss model
		f/GHz			5,8	5,8	5,8	5,8	5,8	5,8
		do m			64	128	256	64	128	256
		no			3,8	3,3	2,8	3,8	3,3	2,8
		d1 m			128	256	1028	128	256	1028
		n1			4,3	3,8	3,3	4,3	3,8	3,3
		Wall loss dB			**0**	**0**	**0**	**17**	**17**	**17**
		other mitigation factors dB			0	0	0	0	0	0
	Victim	Sensitivity S dBm/BW2			-68	-68	-68	-68	-68	-68
		magin dB			10	10	10	10	10	10
	Victim	C/I dB			27	27	27	27	27	27
	Victim	Imax dBm/BW2			-85	-85	-85	-85	-85	-85
	Victim	BW2 MHz			20	20	20	20	20	20

						separation distances (m) RLAN			separation distances (m) RLAN indoor		
	Tx Interf dBm/BW1	**BW1 MHz**	**Tx Interf dBm/BW2**	**Gs Interferer dBi**	**Ge Victim dBi**	**urban path loss model**	**suburban path loss model**	**rural path loss model**	**urban path loss model**	**suburban path loss model**	**rural path loss model**
BFWA mainbeam 22 dBi	23	20	23,00	7,00	22,00	1191,93	2431,96	5548,32	479,62	868,14	1694,38
	23	40	19,99	7,00	22,00	1014,48	2026,46	4497,18	408,22	723,39	1373,37
	23	80	16,98	7,00	22,00	863,45	1688,57	3645,18	347,45	602,77	1113,19
	23	160	13,97	7,00	22,00	734,90	1407,03	2954,59	295,72	502,27	881,52
BFWA mainbeam 16 dBi	23	20	23,00	7,00	16,00	864,40	1690,68	3650,42	347,83	603,52	1114,79
	23	40	19,99	7,00	16,00	735,71	1408,78	2958,84	296,05	502,89	883,01
	23	80	16,98	7,00	16,00	626,18	1173,88	2398,28	251,97	419,04	689,38
	23	160	13,97	7,00	16,00	532,96	978,15	1943,93	214,46	349,17	538,20
BFWA mainbeam 16dBi	23	20	23,00	0,00	16,00	594,19	1106,25	2239,87	239,10	394,90	636,03
	23	40	19,99	0,00	16,00	505,73	921,79	1815,52	203,50	329,05	496,55
	23	80	16,98	0,00	16,00	430,44	768,10	1471,57	173,21	274,19	387,66
	23	160	13,97	0,00	16,00	366,36	640,02	1192,77	147,42	224,56	302,65
BFWA sidelobe	23	20	23,00	7,00	0,00	366,96	641,22	1195,35	147,66	225,05	303,42
	23	40	19,99	7,00	0,00	312,33	534,31	958,70	125,38	182,41	229,65
	23	80	16,98	7,00	0,00	265,83	445,22	748,46	104,47	147,85	162,38
	23	160	13,97	7,00	0,00	226,26	370,98	584,33	87,05	114,82	114,82
BFWA sidelobe	23	20	23,00	0,00	0,00	252,25	419,56	690,54	98,45	138,09	145,07
	23	40	19,99	0,00	0,00	214,70	349,61	539,11	82,04	102,58	102,58
	23	80	16,98	0,00	0,00	182,73	291,31	420,89	68,36	72,53	72,53
	23	160	13,97	0,00	0,00	155,53	240,79	328,59	51,29	51,29	51,29

The required separation distances are summarised in the below Table.

Table 60: Separation distances with RLAN as interferer and BFWA as victim

	RLAN indoor	RLAN outdoor
BFWA sidelobe	50-300m (urban 50-90 m)	150-1200m (urban 150-370m)
BFWA mainbeam	150-1700m (urban 150-480m)	370-5500m (urban 370-1200m)

9.1.2 Results for Interference from BFWA (FS) into RLAN in the band 5725 - 5875 MHz

The following parameter settings were used in the below MCL calculations:

- Propagation model from section 4.2.1;
- RLAN indoor (17dB wall loss) and outdoor (0dB wall loss);
- RLAN Rx with 20 MHz bandwidth;
- RLAN Rx antenna 0 dBi;
- BFWA Tx antenna gain 0dBi (sidelobe), 16 dBi (CS) and 22 dBi (TS);
- Other RLAN parameters from section 2.3.

Table 61: MCL calculations with BFWA as interferer and RLAN as victim

		urban path loss model	suburban path loss model	rural path loss model	urban path loss model	suburban path loss model	rural path loss model	urban path loss model	suburban path loss model	rural path loss model
	f/GHz	5,8	5,8	5,8	5,8	5,8	5,8	5,8	5,8	5,8
	do m	64	128	256	64	128	256	64	128	256
	no	3,8	3,3	2,8	3,8	3,3	2,8	3,8	3,3	2,8
	d1 m	128	256	1028	128	256	1028	128	256	1028
	n1	4,3	3,8	3,3	4,3	3,8	3,3	4,3	3,8	3,3
	Wall loss dB	**0**	**0**	**0**	**17**	**17**	**17**	**17**	**17**	**17**
	other mitigation factors dB	0	0	0	0	0	0	0	0	0
Victim	Sensitivity S dBm/BW2	-65	-65	-65	-65	-65	-65	-65	-65	-65
	magin dB	0	0	0	0	0	0	10	10	10
Victim	C/I dB	28	28	28	28	28	28	28	28	28
Victim	Imax dBm/BW2	-93	-93	-93	-93	-93	-93	-83	-83	-83
Victim	BW2 MHz	20	20	20	20	20	20	20	20	20

						separation distances (m) RLAN outdoor			**separation distances (m) RLAN indoor**			**separation distances (m) RLAN indoor (10dB margin)**		
	Tx Interf dBm/BW1	**BW1 MHz**	**Tx Interf dBm/BW2**	**Gs Interferer dBi**	**Ge Victim dBi**	**urban path loss model**	**suburban path loss model**	**rural path loss model**	**urban path loss model**	**suburban path loss model**	**rural path loss model**	**urban path loss model**	**suburban path loss model**	**rural path loss model**
	14	20	14,00	22,00	0,00	776,61	1497,72	3174,95	312,50	534,64	959,51	182,93	291,68	421,60
BFWA	14	20	14,00	16,00	0,00	563,21	1041,20	2088,91	226,63	371,68	585,82	132,67	195,74	257,41
	14	20	14,00	0,00	0,00	239,10	394,90	636,03	92,66	128,78	129,29	40,89	40,89	40,89

The required separation distances are summarised in the below Table.

Table 62: Separation distances with BFWA as interferer and RLAN as victim

	RLAN indoor	RLAN outdoor
BFWA sidelobe	40-120 m (urban 40-90 m)	230-590 m (urban 230 m)
BFWA mainbeam	130-900 m (urban 130-300 m)	500-3000 m (urban 500-750 m)

9.2 FURTHER STUDIES – MITIGATION TECHNIQUES

9.2.1 Sensing procedure LBT

The below considerations are based on the simplified approach in Annex 5.1, where a formula is given to derive the threshold value for a LBT system.

First the threshold values for RLAN as interferer are determined in the following table.

Table 63: Detection threshold, RLAN as interferer sensing a BFWA victim, simplified approach

<table>
<tr><th colspan="8">RLAN is sensing BFWA</th></tr>
<tr><td colspan="3" rowspan="7"></td><td>VICTIM : BFWA</td><td colspan="4"></td></tr>
<tr><td>BW2/MHz</td><td>10</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>Pwt dBm/BW2</td><td>14</td><td>14</td><td>20</td><td>20</td></tr>
<tr><td>NF dB</td><td>6</td><td>6</td><td>6</td><td>6</td></tr>
<tr><td>N dBm/BW2</td><td>-94.99</td><td>-94.99</td><td>-94.99</td><td>-94.99</td></tr>
<tr><td>Margin dB</td><td>0</td><td>10</td><td>0</td><td>10</td></tr>
<tr><td>INR dB</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="5">Interferer : RLAN</td><td>BW1/MHz</td><td>Pit dBm/BW1</td><td>Pit dBm/BW2</td><td colspan="4">Pthr dBm/BW2</td></tr>
<tr><td>20</td><td>23</td><td>23.00</td><td>-103.99</td><td>-93.99</td><td>-97.99</td><td>-87.99</td></tr>
<tr><td>40</td><td>23</td><td>19.99</td><td>-100.98</td><td>-90.98</td><td>-94.98</td><td>-84.98</td></tr>
<tr><td>80</td><td>23</td><td>16.98</td><td>-97.97</td><td>-87.97</td><td>-91.97</td><td>-81.97</td></tr>
<tr><td>160</td><td>23</td><td>13.97</td><td>-94.96</td><td>-84.96</td><td>-88.96</td><td>-79.96</td></tr>
<tr><td colspan="3"></td><td>N RLAN/BW2</td><td>-96.99</td><td colspan="3"></td></tr>
</table>

The results show that for the BFWA link has a Tx power of 14 dBm and is working at its sensitivity the LBT threshold values would be very low around and below the noise floor of the receiver (-97 dBm in 20 MHz bandwidth). For BFWA with 20 dBm the threshold would be 6 dB higher. Feasible threshold values above the noise floor are only possible if the BFWA link would be working with a certain margin above its sensitivity (e.g. a threshold with -85 dBm in 20 MHz with the 160 MHz RLAN interferer and 10 dB margin).

Then the threshold values for BFWA as interferer are determined in the following table.

Table 64: Detection threshold, BFWA as interferer sensing a RLAN victim, simplified approach

<table>
<tr><th colspan="8">BFWA is sensing RLAN</th></tr>
<tr><td colspan="3" rowspan="4"></td><td>VICTIM : RLAN</td><td colspan="4"></td></tr>
<tr><td>BW2/MHz</td><td>20</td><td>20</td><td>160</td><td>160</td></tr>
<tr><td>Pwt dBm/BW2</td><td>23</td><td>23</td><td>23</td><td>23</td></tr>
<tr><td>NF dB</td><td>4</td><td>4</td><td>4</td><td>4</td></tr>
</table>

BFWA is sensing RLAN							
			N dBm/BW2	-96.99	-96.99	-87.96	-87.96
			Margin dB	**0**	**10**	**0**	**10**
			INR dB	**0**	**0**	**0**	**0**
Interferer : BFWA	**BW1/MHz**	**Pit dBm/BW1**	**Pit dBm/BW2**	**Pthr dBm/BW2**			
	20	14	**14**	-94.99	-84.99	-88.99	-78.99
	20	20	**20**	-100.99	-90.99	-94.99	-84.99
			N BFWA/BW2	-94.99			

The results show that for RLAN as victim working with 23 dBm in 20 to 160 MHz and is working at its sensitivity, the LBT threshold values for BFWA to detect RLAN would be between -89 and -101 dBm in 20 MHz. If RLAN is working with a certain margin above its sensitivity, then the threshold could be increase accordingly. Feasible threshold values above the noise floor are only possible if the RLAN link would be working with a certain margin above its sensitivity (e.g. a threshold with -85 dBm in 20 MHz with the 20 MHz RLAN interferer and 10 dB margin).

The above considerations are neglecting any hidden node effects. This will be analysed now in more detail according to the more general procedure from Annex 5.2.

First the relevant distances are calculated (see below two figures for LOS and exponent 3 based on the following assumptions:

- Victim system: BFWA, 20 dBm, Rx 22 dBi, 20 MHz, INR 0 dB, SNR limit 27 dB;
- Interferer RLAN 23 dBm e.i.r.p., 0 dBi, Pthr=-90dBm/10 MHz.

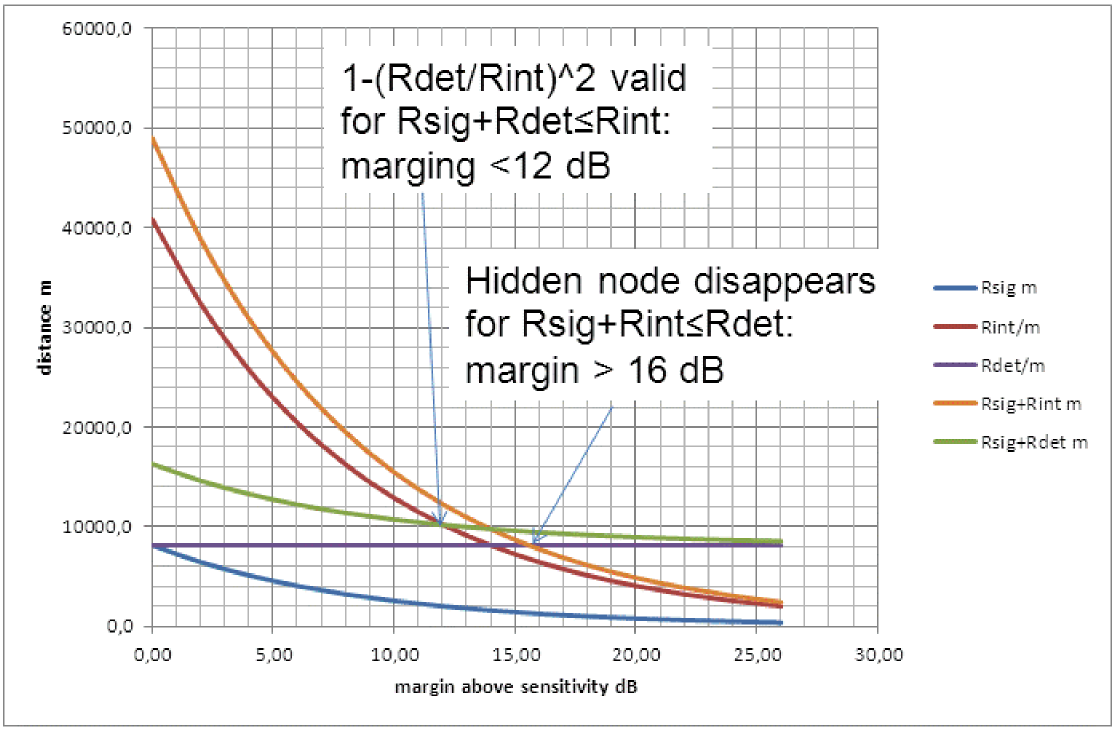


Figure 26: Distances for LOS conditions (exp.2)

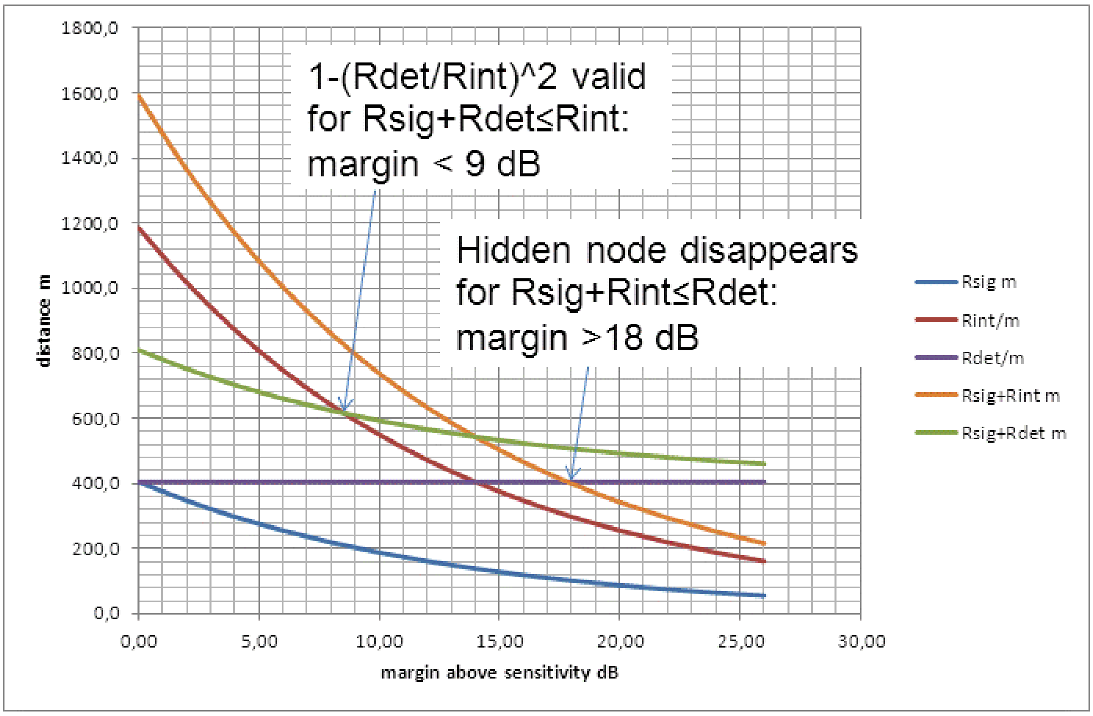


Figure 27: Distances for non LOS conditions (exp.3)

The following figures show the hidden node portion for the BFWA as victim (the solid line is only valid until Rsig+Rdet=Rint; after that point the dotted line is valid, which is the linear interpolation between Rsig+Rdet=Rint and Rsig+Rint=Rdet):

- Figure 28 for an Tx power of 20dBm, Gs 16 dBi, Ge 22 dBi and a threshold of -90 dBm in 10 MHz;
- Figure 29 for an Tx power of 14dBm, Gs 22 dBi, Ge 16 dBi and a threshold of -90 dBm in 10 MHz;
- Figure 30 for an Tx power of 14dBm, Gs 22 dBi, Ge 16 dBi and a threshold of -95 dBm in 10 MHz.

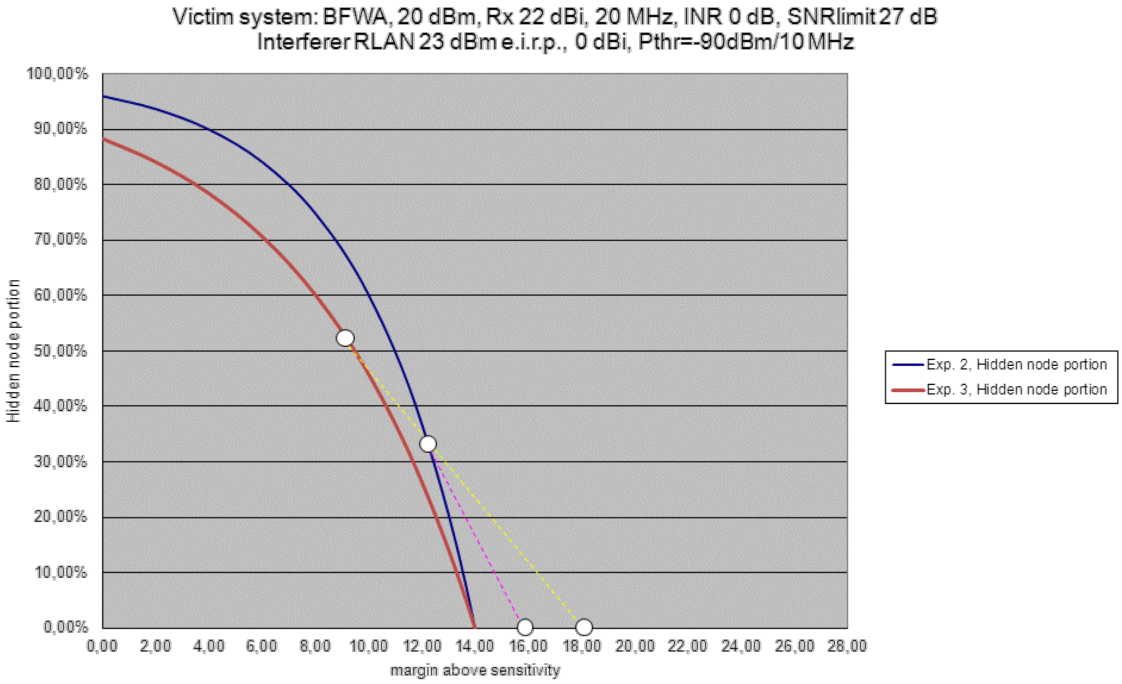


Figure 28: Hidden node probability for BFWA as victim as function of the margin above sensitivity at the BFWA receiver and the propagation condition

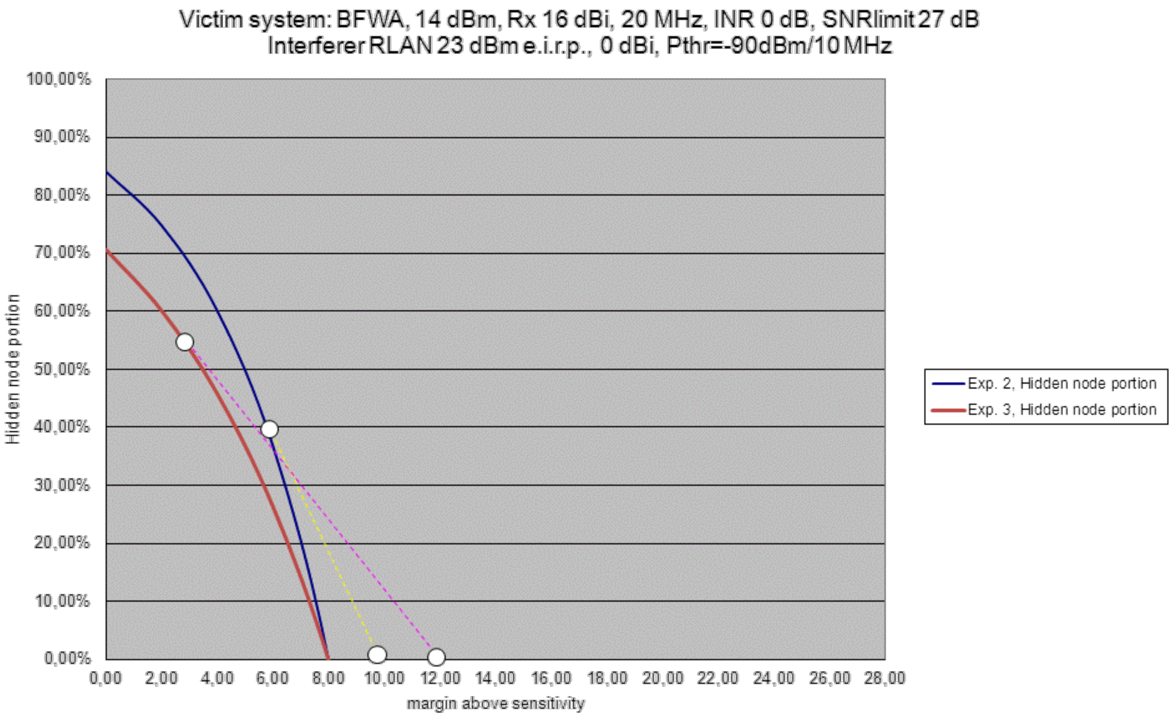


Figure 29: Hidden node probability for BFWA as victim as function of the margin above sensitivity at the BFWA receiver and the propagation condition

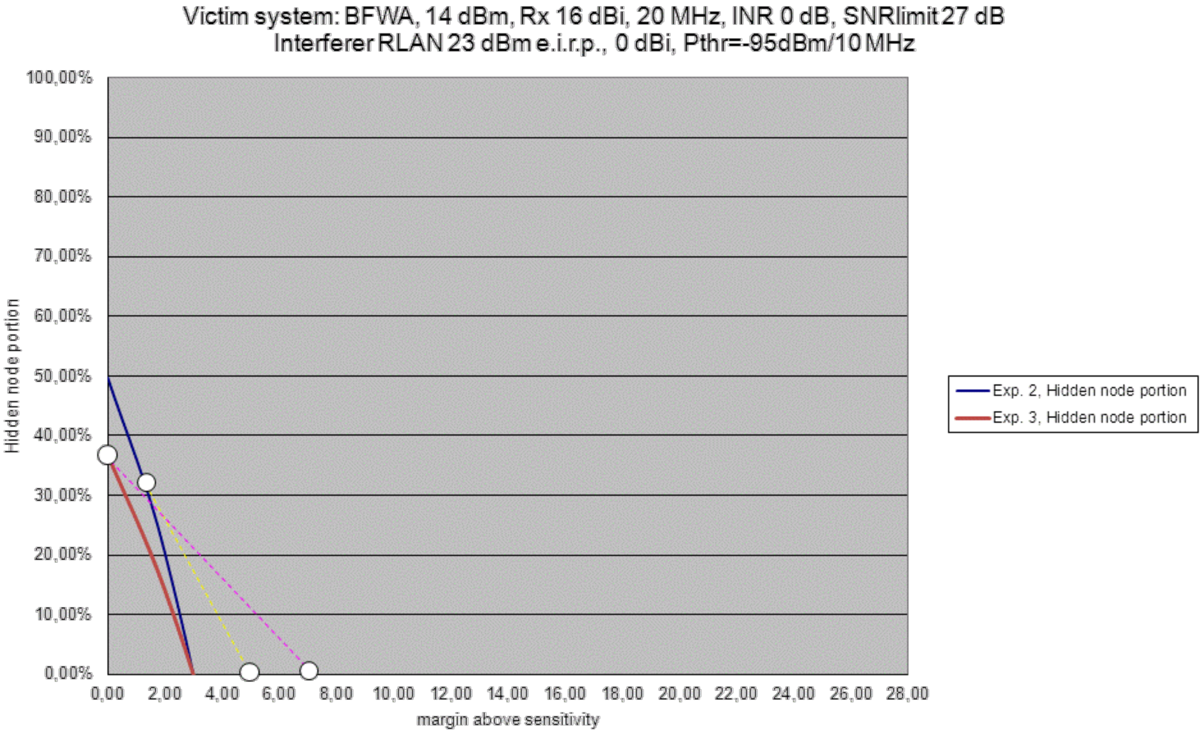


Figure 30: Hidden node probability for BFWA as victim as function of the margin above sensitivity at the BFWA receiver and the propagation condition

The below table summarises the results.

Table 65: Summary hidden node ratio

I/N criterion	LBT threshold in 10 MHz	0 dB margin	10 dB margin	15 dB margin
0 dB	-90 dBm	70-96 %	0-60 %	0-20 %
0 dB	-95 dBm	40-50 %	0-20 %	0 %

Assuming a fading margin of 10dB to be generally applicable to BFWA links, then a threshold of -95 dBm in 20 MHz would be sufficient to detect BFWA.

Further consideration may be required on the feasibility of detection thresholds of the order of -95 dBm/20 MHz and on their impact on the RLAN operation, since low values of threshold are likely to trigger false detections.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered and may be an issue for further work.

9.2.2 Coexistence mechanisms

Due to the similarity between RLAN and BFWA systems using TDD technology, it is envisaged that more specific coexistence mechanisms may be relevant. This might be an issue for further work.

9.3 SUMMARY BFWA

The MCL calculations indicate that coexistence between BFWA and RLAN without mitigation techniques is not possible. Worst case analyses show required separation distances between 100 m and 5 km. An indoor restriction for RLAN would help to minimise the problem in both direction, but then still separation distances up to 1 km are needed.

With a LBT approach the coexistence could be achieved under the following conditions:

- BFWA victim: RLAN LBT threshold between -95 dBm within 20MHz and BFWA with 10 dB margin above sensitivity; a margin of 10 dB may be applicable for BFWA real life links, but 20 dB only for some cases.
- RLAN victim: BFWA LBT threshold between -90 dBm within 20MHz and RLAN with 10 dB margin above sensitivity; a margin of 10 dB above sensitivity can’t be ensured for RLAN links, but in real life most links are expected to work with a higher margin.

The feasibility of these detection thresholds still needs to be addressed.

There are BFWA systems in the market compliant with IEEE 802.11 [27] equipment including CSMA features, which is such a sensing feature. Coexistence between RLAN and those BFWA systems might be possible on that basis. Further studies would be needed to verify that assumption.

FWA technologies do not differ from technologies used by RLAN/WAS and therefore the coexistence between BFWA and RLAN/WAS is more an intra-system coexistence issue for which TC BRAN had introduced the Adaptivity requirement in EN 301 893 [6]. The latest version of EN 301 893 is version 1.8.1 which is available for download from the ETSI portal. Adaptivity is contained in clause 4.8.

However, BFWA systems using proprietary systems (FS like systems using FEC and FDD, not using 802.11 standards) are also in the market; the coexistence on CSMA basis is not possible for those systems.

It should also be clear that BFWA systems are already in the market and are operated mostly on license exempt or light licensing basis and administration having normally no information on the location and the parameters of the BFWA systems. Therefore, changes of technical parameters would only be possible in the long-term.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) are not considered in this section and maybe an issue for further work.

10 COMPATIBILITY BETWEEN RLAN AND THE AMATEUR (5725-5850 MHz) AND AMATEUR SATELLITE (SPACE TO EARTH, 5830-5850 MHz) SERVICES

10.1 INTERFERENCE FROM RLAN INTO THE AMATEUR (5725-5850 MHz) AND AMATEUR SATELLITE (SPACE TO EARTH, 5830-5850 MHz) SERVICES

Detailed studies have not been undertaken at this stage. Sections 4.5 and 4.6 of ECC Report 206 [26] may be used as starting point. However the following are some preliminary considerations for the three main categories of radio amateur systems:

- Radio Amateur narrowband stations (typically centred around 5760MHz) feature sensitive receivers and high gain antennas. It is therefore likely that interference from dense RLAN deployments may occur. Detailed studies would need to be developed, although mitigations being considered for other services in Part-2 (such as TPC) may be a significant factor.
- For Radio Amateur data links based on 802.11 technology, the studies on BFWA reported in Section 9 may apply (to be further considered).
- For the reception of Radio Amateur Satellites (which are Space-to-Earth only in the 5830-5850 MHz allocation), the realistic situation is that the RLAN will be not be directly seen by the Radio Amateur stations, since their main beams will be pointing in the direction of sky. The interference from nearby RLANs to the Radio Amateur Station would need to be considered further, but such studies can be based on a rejection of at least 20dB in the antenna side lobes (similar to the scenario in ECC Report 206).

10.2 INTERFERENCE FROM THE AMATEUR (5725-5850 MHz) AND AMATEUR SATELLITE (SPACE TO EARTH, 5830-5850 MHz) SERVICES INTO RLAN

Detailed studies have not been undertaken. However the following may provide some indication for the three main categories of amateur systems:

- Narrowband usage (centered near 5760MHz) might be expected to give significant distances based on MCL calculations if the RLAN was in the main beam of an active Amateur station. This may require further study, for which the following mitigations can also be considered:

  a) Amateur narrowband stations are relatively low density and transmit times;

  b) Frequency separation can be applied considering that frequencies inside and outside the 5725-5875 MHz band are available for RLAN; whilst the amateurs will stay centered on 5760 MHz.
- For Radio Amateur data links based on 802.11 technology, the studies on BFWA reported in Section 9 may apply (to be further considered);
- For Amateur Satellite (s-E), it is unlikely RLANS would see significant power from an amateur satellite downlink (which in any case would not be overhead for long, as they are typically in Low Earth Orbit). Therefore this case is considered to be compatible.

11 COMPATIBILITY BETWEEN RLAN AND BROADBAND DIRECT AIR TO GROUND COMMUNICATIONS (BDA2GC) IN THE FREQUENCY RANGE 5855-5875 MHz

This document presents an assessment of the compatibility of RLAN and BDA2GC with respect to the potential for interference from the DA2GC system into RLANs and vice versa:

- From the DA2GC Aircraft Station (air-to-ground) into RLANs;
- From the DA2GC Ground Station (ground path) into RLANs;
- Into the DA2GC Aircraft Station (ground-to-air) from RLANs;
- Into the DA2GC Ground Station (ground path) from RLANs.

Since two types of systems are envisaged in this band for DA2GC (see section 3.6) with different operational characteristics, this section addresses on one hand the compatibility between RLAN and BDA2GC as described in ETSI TR 103 108 [25] (section 11.1) and on the other hand the compatibility between RLAN and BDA2GC as described in ETSI TR 101 599 [24] (section 11.2).

11.1 COMPATIBILITY BETWEEN RLAN AND BDA2GC SYSTEM AS DESCRIBED IN ETSI TR 103 108

11.1.1 Interference from RLAN into BDA2GC AS (ETSI TR 103 108)

11.1.1.1 *Methodology*

DA2GC will operate when the aircraft altitude is 3 km or more. Therefore the aircraft will see many of the RLAN cells of 30 km radius (as defined in the RLAN deployment model, option B, (see section 2.3.4), as illustrated below:

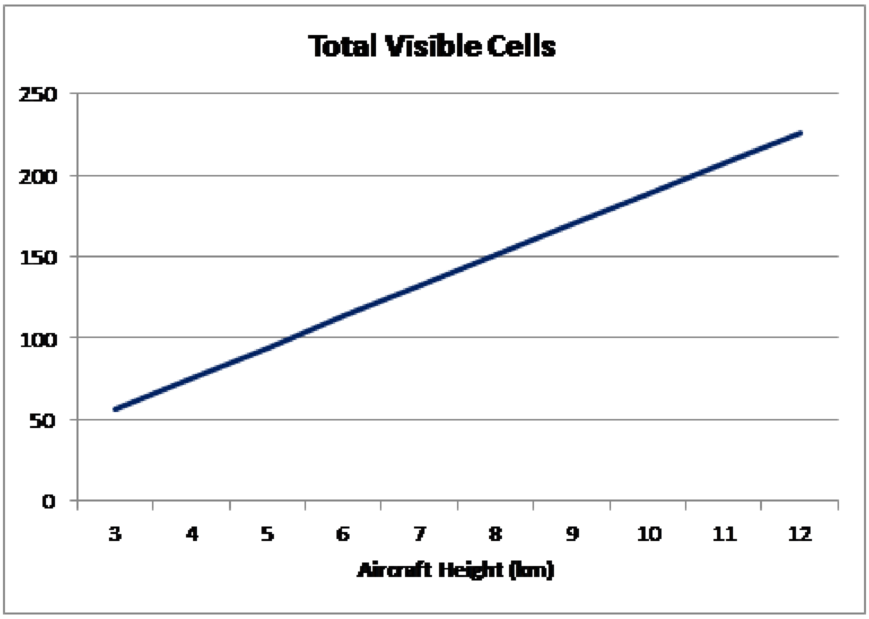


Figure 31 : Visible RLAN Cells (30 km radius each)

It is assumed that the individual cells are clustered as shown below with the aircraft at the centre.

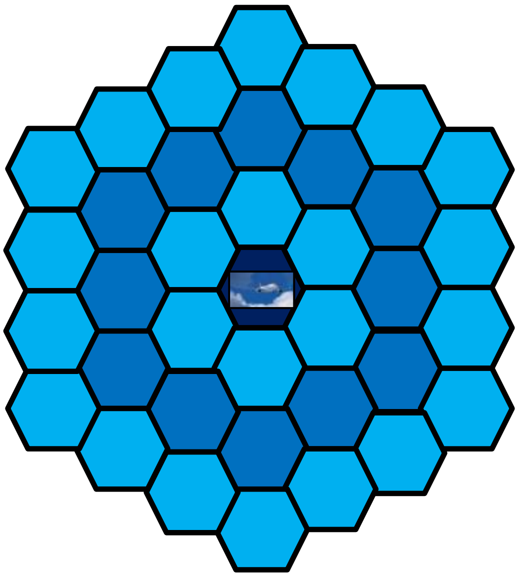


Figure 32: Cell Clusters

For the purposes of compatibility analyses it is necessary to consider aggregate interference rather than single point. The number of RLAN users for each area is defined in terms of:

- Tx e.i.r.p.;
- Indoor/Outdoor scenario;
- Bandwidth.

The RLAN configuration details, including the number of concurrent users, used in the study are provided in ANNEX 4:.

Aggregate Interference for a Single Cell

The aggregate interference transmitted by a single cell is calculated using the distribution of RLAN users in terms of:

- Indoor/Outdoor use;
- Transmitter power;
- Bandwidth;
- Path loss model: Free space loss;
- Clutter attenuation according to elevation angle as defined in Recommendation ITU-R P:452 [19] (see section 4.2.3);
- Wall attenuation for indoor users only.

Aggregate is calculated using the equation:

$$10 * \log10(\sum 10^{\frac{\mathrm{Pwr_{dBm}}}{10}})$$

Equation 1

First the aggregate for each variant of transmission is derived using the equation:

$$\mathrm{Tx} - \mathrm{BF} - \mathrm{Clutter} - \mathrm{Wall} - \mathrm{path\ loss}$$

Equation 2

where:

- Tx : transmitter e.i.r.p. in dBm;
- BF : Bandwidth factor in dB;
- Clutter: Clutter attenuation in dB according to elevation angle (see section 4.2.3);
- Wall : Wall attenuation 17 dB.

When considering the impact of outdoor directional RLAN antennas it has been assumed that 11.1% (beam width 40 degrees) of outdoor RLANs would be pointing, in azimuth, towards the aircraft with a horizontal elevation angle.

Finally the total aggregation, as seen from the cell centre, is calculated for the entire cell taking into account the RLAN antenna patterns.

Aggregate Interference from a Cluster of Cells

This aggregate is calculated using the single cell aggregate interference as the basis. A cluster of visible cells is generated depending on aircraft height and the aggregate interference, taking into account the slant distance between the respective visible cluster and the aircraft, is determined.

11.1.1.2 *Results*

The following figure shows the aggregate interference from all RLAN sources into the DA2GC AS for a range of aircraft altitudes. It is noted that the DA2GC AS will not operate below an altitude of 3 km and 12 km is the highest operational altitude for the aircraft. This aggregate analysis assumes that the RLAN direction antenna beam width is 40 degrees.

Three AS antenna elevation patterns are depicted; namely a fixed gain of 7 dBi, the pattern according to the emission mask specified in ETSI TR 103 108 [25] and an actual measured pattern. It is recognised that the fixed gain scenario is not operationally possible.

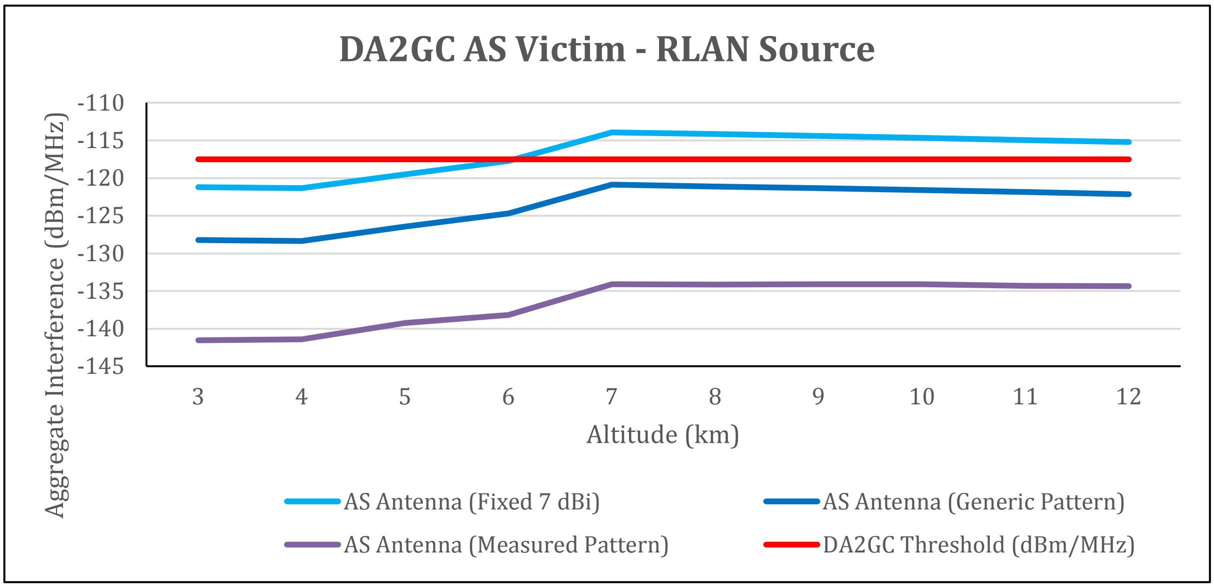


Figure 33: DA2GC AS (ETSI TR 103 108) Victim – RLAN Source

It is noted that if an RLAN outdoor antenna has a vertical boresight pattern then the interference from this single source can exceed the DA2GC threshold. However, this is considered to be an unrealistic scenario.

11.1.2 Interference from BDA2GC AS (TR 103 108) into RLAN

It is noted that the system according to ETSI TR103 108 [25] ensures that only one aircraft in a DA2GC cell will transmit at any given instant. Hence an MCL analysis is appropriate.

First the worst case elevation angle was derived. As shown in the figure below, the minimum loss is given by:

$$\text{Minimum Loss} = \text{Aircraft Antenna Gain} - \text{Free Space Path Loss} + \text{RLAN Antenna Gain}$$

where the antenna gains are a function of elevation angle.

The aircraft is flown at a series of constant levels from 140 km to 0 km ground separation distances from the RLAN victim. It was assumed that there is no ATPC. The elevation angles resulting in the minimum loss were used for the MCL calculations shown in the tables below.

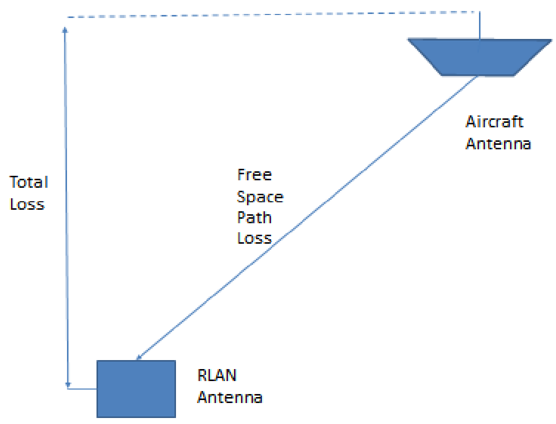


Figure 34: RLAN Victim – Minimum Loss

Table 66: MCL for DA2GC AS (ETSI TR 103 108) Source - RLAN Victim

Parameters	Unit	RLAN AP Indoor	RLAN UE Indoor	RLAN Omni Outdoor	RLAN Directional Outdoor
Worst Case El Angle	deg	14	14	16	12
Emission part: DA2GC AS	AS El Angle for max gain				
Bandwidth	MHz	10	10	10	10
TX power	dBm	36	36	36	36
Feeder Loss	dB	4	4	4	4
Mitigation	dB	0	0	0	0
Antenna Gain	dBi	6.7	6.7	6	6.5

Parameters	Unit	RLAN AP	RLAN UE	RLAN Omni	RLAN
Net Tx density of power	**dBm/MHz**	**28.7**	**28.7**	**28**	**28.5**
Reception part: RLAN					
Receiver bandwidth	MHz	20	20	20	20
Noise power	dBm	-93	-93	-93	-93
Antenna gain	dBi	6	1.3	5.45	12.67
Wall loss	dB	17	17	0	0
Noise Power	dBm/MHz	-106	-106	-106	-106
Protection Criterion I/N	dB	-6	-6	-6	-6
Interference threshold	dBm/MHz	-101	-96	-117	-125
Required attenuation	dB	130	125	145	153
Required separation distance free space loss	km	12.45	7.25	76.37	185.60
Actual separation	km	41.34	41.34	36.28	48.09
Actual Attenuation	dB	140.1	140.1	139.0	141.4
Margin	**dB**	**10.4**	**15.1**	**-6.5**	**-11.7**

Note 1: The elevation angle corresponds to the worst case where the combination of FSL, RLAN antenna gain and AS antenna gain has the maximum interference power.
Note 2: under consideration of the worst case elevation angle and the AS at 10km altitude

For indoor RLAN operation the MCL analysis concludes that compatibility is achieved.

Outdoor RLAN operation, under free space conditions, could be subjected to interference from DA2GC AS that exceeds the interference limit.

However, the following mitigation needs to be taken into account:

- The considered worst case protection objective;
- The probability of outdoor RLAN is low;
- The analysis does not allow for ATPC which will introduce a further 9 dB of attenuation on average;
- The DA2GC AS only transmits for some 1.5 mSec in the 10 mSec frame thereby reducing the impact of any interference.

11.1.3 Interference from RLAN into BDA2GC GS (ETSI TR 103 108)

MCL analyses are presented below for all cases of DA2GC GS (Victim) and RLAN systems (Source). It has been assumed that the antennas are at the same level. This is considered a worst case scenario because the DA2GC GS antenna would normally be sited on the roof of a tall building.

Table 67: RLAN Indoor Source – DA2GC GS Victim

Parameters	Unit	RLAN AP Indoor Urban	RLAN UE Indoor Urban	RLAN AP Indoor Suburban	RLAN UE Indoor Suburban	RLAN AP Indoor Rural	RLAN UE Indoor Rural
Worst Case El Angle	deg	0	0	0	0	0	0
Source: RLAN							
Bandwidth	MHz	20	20	20	20	20	20
Tx e.i.r.p.	dBm	30	30	30	30	30	30
Clutter	dB	19.7	19.7	19.5	19.5	14.8	14.8
Wall loss	dB	17	17	17	17	17	17
Net Tx density of power	**dBm/MHz**	**-19.7**	**-19.7**	**-19.5**	**-19.5**	**-14.8**	**-14.8**
Victim: DA2GC GS							
Receiver bandwidth	MHz	10	10	10	10	10	10
Noise power	dBm	-104.0	-104.0	-104.0	-104.0	-104.0	-104.0
Antenna Down tilt	deg	0	0	0	0	0	0
Antenna gain	dBi	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0
Antenna Feeder Loss	dB	2.0	2.0	2.0	2.0	2.0	2.0
Noise Power	dBm/MHz	-114	-114	-114	-114	-114	-114
Protection Criterion I/N	dB	-6	-6	-6	-6	-6	-6
Interference threshold	dBm/MHz	-107.0	-107.0	-107.0	-107.0	-107.0	-107.0
Required attenuation	dB	87	87	88	88	92	92
Required FSL separation distance (including clutter)	km	0.09	0.09	0.10	0.10	0.17	0.17

Given the relatively high GS antenna position, it is appropriate to consider free space loss with clutter. In this case the separation distances are between 90 m and170 m.

Table 68: RLAN Outdoor Source – DA2GC GS Victim

Parameters	Unit	RLAN AP Oudoor Urban	RLAN UE Outdoor Urban	RLAN AP Outdoor Suburban	RLAN UE Outdoor Suburban	RLAN AP Outdoor Rural	RLAN UE Outdoor Rural
Worst Case El Angle	deg	0	0	0	0	0	0
Source: RLAN							
Bandwidth	MHz	20	20	20	20	20	20
Tx e.i.r.p.	dBm	30	30	30	30	30	30
Clutter	dB	19.7	19.7	19.5	19.5	14.8	14.8
Net Tx density of power	**dBm/MHz**	**-2.7**	**-2.7**	**-2.5**	**-2.5**	**2.2**	**2.2**
Victim: DA2GC GS							
Receiver bandwidth	MHz	10	10	10	10	10	10
Noise power	dBm	-104.0	-104.0	-104.0	-104.0	-104.0	-104.0
Antenna gain	dBi	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0
Antenna Feeder Loss	dB	2.0	2.0	2.0	2.0	2.0	2.0
Noise Power	dBm/MHz	-114	-114	-114	-114	-114	-114
Protection Criterion I/N	dB	-6	-6	-6	-6	-6	-6
Interference threshold	dBm/MHz	-107	-107	-107	-107	-107	-107
Required attenuation	dB	104	104	105	105	109	109
Required separation distance (free space loss and clutter)	km	0.67	0.67	0.69	0.69	1.18	1.18

The preferred siting of DA2GC GS maybe expected to be in urban area, as urban areas provide tall buildings on which the GS may be installed. Also the availability of high capacity internet is easier.

The required separation distances between GS and RLAN outdoor are between 670 m and 1180 m.

Compatibility is assumed to be achieved for indoor RLAN with small separation distances ranging from 90 to 170 metres.

For the low probability outdoor scenarios, separation distances between 700 metres, for the urban case, and 1.2 km for the rural case. However, the following mitigation needs to be taken into account:

- The considered worst case protection objective;
- the majority of DA2GC GS will be located on the roofs of tall buildings in urban regions.

11.1.4 Interference from BDA2GC GS (ETSI TR 103 108) into RLAN

MCL analyses are presented below for all cases of DA2GC GS (Source) and RLAN systems (Victim). It has been assumed that the antennas are at the same level. This is considered a worst case scenario because the DA2GC GS antenna would normally be sited on the roof of a tall building.

Table 69: DA2GC GS Source – RLAN Indoor Victim

Parameters	Unit	RLAN AP Indoor Urban	RLAN UE Indoor Urban	RLAN AP Indoor Suburban	RLAN UE Indoor Suburban	RLAN AP Indoor Rural	RLAN UE Indoor Rural
Worst Case El Angle	deg	0	0	0.0	0.0	0.0	0.0
Source: DA2GC GS							
Bandwidth	MHz	10	10	10	10	10	10
Maximum Tx power	dBm	38	38	38	38	38	38
Feeder Loss	dB	2	2	2	2	2	2
Antenna Gain	dBi	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0
Clutter	dB	19.7	19.7	19.5	19.5	14.8	14.8
Wall loss	dB	17	17	17	17	17	17
Net Tx density of power	**dBm/MHz**	**-21.7**	**-21.7**	**-21.5**	**-21.5**	**-16.8**	**-16.8**
Victim: RLAN							
Receiver bandwidth	MHz	20	20	20	20	20	20
Noise power	dBm	-93	-93	-93	-93	-93	-93
Antenna gain	dBi	6	1.3	6	1.3	6	1.3
Noise Power	dBm/MHz	-106	-106	-106	-106	-106	-106
Protection Criterion I/N	dB	-6	-6	-6	-6	-6	-6
Interference threshold	dBm/MHz	-118	-113	-118	-113	-118	-113
Required attenuation	dB	96	92	97	92	101	97
Required FSL separation distance (plus clutter)	km	0.27	0.16	0.27	0.16	0.47	0.27

The required separation distances between GS and RLAN indoor are between 160 m and 470 m.

Given the considered worst case protection objectives and the small separation distances it may be concluded that compatibility is achieved. It is noted that the preferred location for DA2GC GS is urban on the roof of buildings. Also it is recalled that the density of DA2GC GS is low (about 230 GS for all Europe) so the probability of each of the above scenarios is small.

Table 70: DA2GC GS Source – RLAN Outdoor Victim

Parameters	Unit	RLAN AP Outdoor Urban	RLAN UE Outdoor Urban	RLAN AP Outdoor Suburban	RLAN UE Outdoor Suburban	RLAN AP Outdoor Rural	RLAN UE Outdoor Rural
Worst Case El Angle	deg	0	0	0.0	0.0	0.0	0.0
Source: DA2GC GS							
Bandwidth	MHz	10	10	10	10	10	10
Maximum Tx power	dBm	38	38	38	38	38	38
Feeder Loss	dB	2	2	2	2	2	2
Antenna Gain	dBi	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0
Clutter	dB	19.7	19.7	19.5	19.5	14.8	14.8
Net Tx density of power	**dBm/MHz**	**-4.7**	**-4.7**	**-4.5**	**-4.5**	**0.2**	**0.2**
Victim: RLAN							
Receiver bandwidth	MHz	20	20	20	20	20	20
Noise power	dBm	-93	-93	-93	-93	-93	-93
Antenna gain	dBi	6	18	6	18	6	18
Noise Power	dBm/MHz	-106	-106	-106	-106	-106	-106
Protection Criterion I/N	dB	-6	-6	-6	-6	-6	-6
Interference threshold	dBm/MHz	-118	-130	-118	-130	-118	-130
Required attenuation	dB	113	125	114	126	118	130
Required separation distance	km	0.30	0.60	0.30	0.60	0.40	0.80
Required FSL separation distance (plus clutter)	km	0.20	0.80	0.21	0.82	0.35	1.40

The required separation distances between GS and RLAN outdoor are between 200 m and 1400 m.

Given the considered worst case protection objectives and that the majority of DA2GC GS will be located on the roofs of buildings in urban regions, it may be concluded that the systems are compatible in urban environments for co-channel operation. If necessary, mitigation could be introduced such as additional low angle screening of the DA2GC GS. Also it is recalled that there are only about 230 DA2GC GS expected for Europe so the probability of the above interference scenarios maybe low.

11.1.5 Summary for the compatibility between BDA2GC (ETSI TR 103 108) and RLAN

On the basis of results presented in this document, the following general conclusions can be drawn.

RLAN into DA2GC Aircraft Station

It is concluded that compatibility is ensured for all scenarios with RLAN indoor. It is noted that if an RLAN outdoor antenna has a vertical boresight pattern then the interference from this single source can exceed the DA2GC threshold. However, this is considered to be an unrealistic scenario.

DA2GC Aircraft Station into RLAN

For indoor RLAN operation the MCL analysis concludes that compatibility is achieved.

Outdoor RLAN operation, under free space conditions, could be subjected to interference from DA2GC AS that exceeds the interference limit.

However, the following mitigation needs to be taken into account:
- The considered worst case protection objective;
- The probability of outdoor RLAN is low;
- The analysis does not allow for ATPC which will introduce a further 9 dB of attenuation on average;
- The DA2GC AS only transmits for some 1.5 mSec in the 10 mSec frame thereby reducing the impact of any interference.

For the outdoor scenario an aircraft altitude of 10 km was assumed as it represents an average cruising altitude. Above 10 km the exceedance reduces. Below 7 km the exceedance also reduces because of altitude dependent e.i.r.p. attenuation as described in ECC Report 210 [23]. The worst case is for the aircraft having an altitude of 7 km which results in an interference increase, for both indoor and outdoor scenarios, of +3 dB compared to the 10 km case. The overall conclusions remain the same.

RLAN into DA2GC Ground Station

Compatibility is assumed to be achieved for indoor RLAN with small separation distances ranging from 90 to 170 metres.

For the low probability outdoor scenarios, separation distances between 700 metres, for the urban case, and 1.2 km for the rural case. However, the following mitigation needs to be taken into account:
- The considered worst case protection objective;
- The majority of DA2GC GS will be located on the roofs of tall buildings in urban regions.

DA2GC Ground Station into RLAN

The required separation distances between GS and RLAN indoor are between 160 m and 470 m. For the low probability outdoor scenarios, the required separation distances between GS and RLAN outdoor are between 200 m and 1400 m.

However, the following mitigation needs to be taken into account:
- The considered worst case protection objective;
- The majority of DA2GC GS will be located on the roofs of tall buildings in urban regions.

11.2 COMPATIBILITY BETWEEN RLAN AND BDA2GC SYSTEM AS DESCRIBED IN TR 101 599 [24]

11.2.1 Minimum Coupling Loss analyses

The following sections address each of these potential entries in turn on the basis of Minimum Coupling Loss (MCL) calculations using the information contained in section 2.3 for the RLAN characteristics and in section 3.6 for the DA2GC TR 101 599 [24] characteristics.

Worst case alignments have been assumed. Free space propagation has been assumed on the air-ground path and the two breakpoint propagation model described in section 4.2.1 has been assumed on the ground path.

11.2.1.1 *Determination of the worst case location of an RLAN in respect of interference to/from a DA2GC Aircraft Station*

The surface plots in Figure 35 and Figure 36 below depict the variation in interference level experienced by an RLAN on the ground as the aircraft flies along a straight path which passes directly overhead. The interference level is plotted as a function of distance between the RLAN and the DA2GC Ground Station with which the Aircraft Station is associated and of the aircraft elevation angle as seen from the DA2GC Ground Station.

The vertical axis represents the received signal level (in dBm) and for these examples it falls in the range -100 dBm to -200 dBm (deep null).

The horizontal axis towards the right represents the elevation angle of the aircraft at the DA2GC Ground Station as it traverses its flight path. Note that the scale is from 0 to 180 degrees but the air-ground link is only operational between 5 and 175 degrees.

The horizontal axis towards the rear left represents the distance of the RLAN device from the DA2GC Ground station in a direction towards the aircraft (in km). The aircraft starts transmitting approximately 100 km from the GS (for 10 km altitude) when the elevation angle at the DA2GC GS is 5 degrees. The RLAN device is 80 km from the DA2GC GS such that the angle at the RLAN towards the DA2GC aircraft is approximately 22 degrees.

It can be seen from these plots that the worst case location is where the RLAN is positioned at a point which is some 80 km from the DA2GC Ground Station in the direction towards the aircraft (for 10 km aircraft altitude) and 26 km from the Ground Station (for 3 km altitude).

Once the worst-case location has been determined in this way, due to reciprocity the same location will also be the worst-case in respect of single-entry interference from an RLAN transmitter into the DA2GC Aircraft receiver.

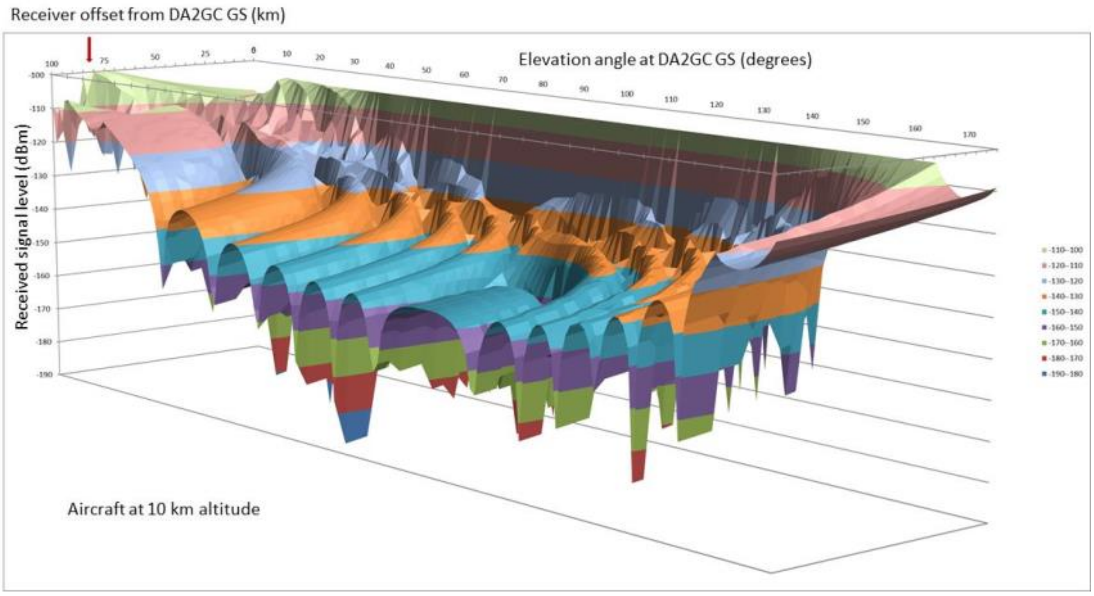


Figure 35: Variation in interference level at RLAN receiver, due to a DA2GC aircraft transmitter at 10km altitude

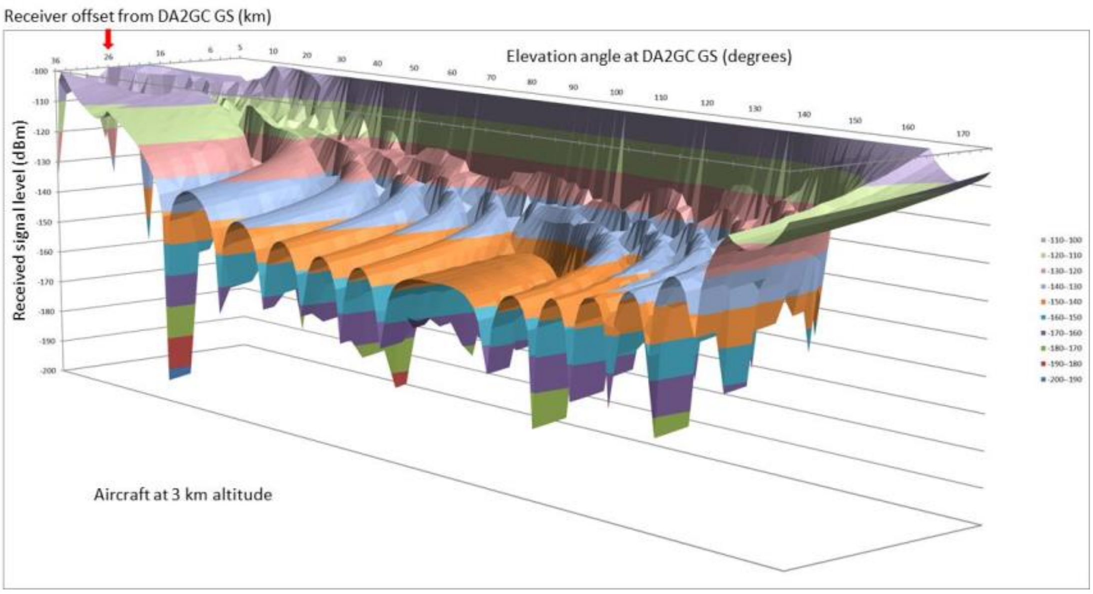


Figure 36: Variation in interference level at RLAN receiver, due to a DA2GC aircraft transmitter at 3km altitude

11.2.1.2 *Interference from RLAN into BDA2GC AS (TR 101 599)*

The potential single entry interference level from an RLAN device into a DA2GC aircraft receiver can be defined as:

I (dBm) = e.i.r.p.$_{RLAN}$ (dBm) – Lp (dB) + G_{AS} (dBi) – L_C (dB) – L_B (dB)

where:

- I (dBm) = Interference level at DA2GC aircraft receiver
- e.i.r.p.$_{RLAN}$ (dBm) = e.i.r.p. of RLAN towards DA2GC aircraft
- Lp (dB) = Path loss (ground to air): Free space loss for worst case location
- G_{AS} (dBi) = Gain of aircraft antenna towards RLAN (derived from Figure 50)

- L_C (dB) (see ANNEX 4:) = Clutter loss at 22 ° elevation angles: urban 19.7 dB / suburban 0 dB / rural 0 dB
- L_B (dB) = Building loss (RLAN outdoor 0dB, RLAN indoor 17 dB)

For an aircraft operating at an altitude of 10 km with an RLAN operating at the worst-case location (see previous section), the interference level received by the DA2GC aircraft is given by the following where this example represents the outdoor rural case (i.e. free space conditions) for a medium power (200 mW) RLAN:

I (dBm) = 23 dBm – 136.22 dB + 15.34 dBi – 0 dB – 0 dB = -97.88 dBm

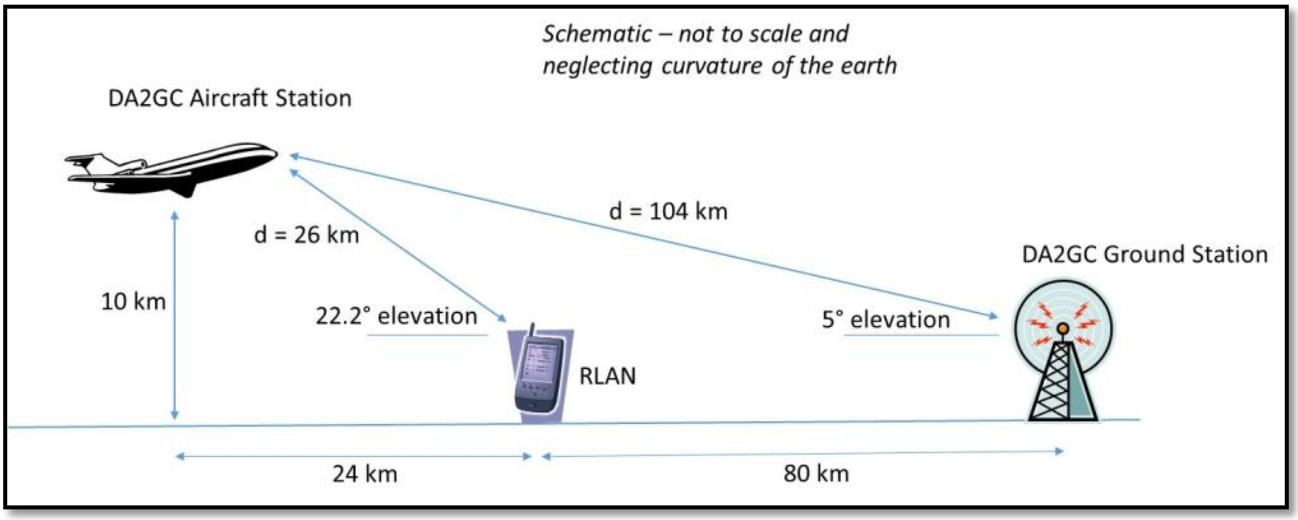


Figure 37: Worst-case geometry for MCL calculation of interference between RLAN and DA2GC AS

The geometry is such that when the DA2GC aircraft starts receiving from the DA2GC Ground Station (where the transmission is emerging at an elevation of 5 degrees) the elevation of the aircraft as seen by the RLAN (which is situated closer to the aircraft) will be higher. Furthermore, while the boresight of the aircraft antenna is directed towards the DA2GC Ground Station, the interference path from the RLAN will be offset from the boresight since the RLAN is situated much closer to the aircraft.

The interference represented in the equation above impinges the aircraft from a ground elevation of 22.2° (line of sight distance about 26 km) as measured at the RLAN and enters through the aircraft antenna main lobe at a point where the off-axis gain is 2.5 dB down on the maximum gain.

For an aircraft operating at an altitude of 3 km with an RLAN operating at the worst-case location, the interference level received by the DA2GC aircraft under the same conditions is given by:

I (dBm) = 23 dBm -125.73 dB + 15.22 dBi – 0 dB – 0 dB = -87.51 dBm

Equation 3

As before, the geometry described above and depicted in Figure 37 also applies here; the only difference being that the aircraft altitude is different and consequently the RLAN worst case location offset is also different. The interference represented in the equation above impinges the aircraft from a ground elevation of 22.4° (line of sight distance about 8 km) as measured at the RLAN and enters the aircraft main lobe 2.6 dB down on the maximum gain.

The results are summarised in Table 71 and Table 72 below.

Table 71: Worst-case interference levels at AS Receiver (aircraft altitude = 10km)

RLAN e.i.r.p.		1 Watt	200 mW	25 mW
Received interference level (dBm in 20MHz))	RLAN Outdoor / Urban	-110.58	-117.58	-126.58
	RLAN Outdoor / Suburban	**-90.88**	**-97.88**	-106.88
	RLAN Outdoor / Rural	**-90.88**	**-97.88**	-106.88
	RLAN Indoor / Urban		-134.58	-143.58
	RLAN Indoor / Suburban		-114.88	-123.88
	RLAN Indoor / Rural		-114.88	-123.88

Table 72: Worst-case interference levels at AS Receiver (aircraft altitude = 3km)

RLAN e.i.r.p		1 Watt	200 mW	25 mW
Received interference level (dBm in 20MHz)	RLAN Outdoor / Urban	**-100.21**	-107.21	-116.21
	RLAN Outdoor / Suburban	**-80.51**	**-87.51**	**-96.51**
	RLAN Outdoor / Rural	**-80.51**	**-87.51**	**-96.51**
	RLAN Indoor / Urban		-124.21	-133.21
	RLAN Indoor / Suburban		-104.51	-113.51
	RLAN Indoor / Rural		-104.51	-113.51

Protection Criterion = -103 dBm in 20 MHz.

The following single entry situations potentially exceed the specified interference criterion:

- For an aircraft at 10 km altitude outdoor 1 W and 200 mW RLANs in suburban and rural environments exceed the criterion: Excess = 12.12 and 5.12 dB,
- For an aircraft at 3 km altitude outdoor RLANs of all power levels in all environments exceed the criterion: Excess = 22.49 to 6.49 dB.

The aggregation of interference from multiple RLANs and the statistical implications are considered in section 11.2.2.1

11.2.1.3 *Interference from BDA2GC AS (TR 101 599) into RLAN*

The potential single entry interference from a DA2GC aircraft transmitter into an RLAN device can be defined as:

$$I\ (\text{dBm}) = \text{e.i.r.p.}_{AS}\ (\text{dBm}) – Lp\ (\text{dB}) + G_{RLAN}\ (\text{dBi}) – L_C\ (\text{dB}) – L_B\ (\text{dB})$$

where:

- I (dBm) = Interference level at RLAN;
- e.i.r.p.$_{AS}$ (dBm) = e.i.r.p. of DA2GC aircraft towards RLAN (Gain derived from Figure 50);
- Lp (dB) = Path loss (air to ground) : Free space loss for worst case location;
- G_{RLAN} (dBi) = Gain of RLAN antenna towards aircraft;
- L_C (dB) = Clutter loss at 22 ° elevation angles: urban 19.7 dB / suburban 0 dB / rural 0 dB (see section 4.2.3);
- L_B (dB) = Building loss (RLAN outdoor 0dB, RLAN indoor 17 dB).

With the RLAN positioned in a worst case location some 80 km from the DA2GC Ground Station in the direction towards the aircraft, the interference level received by the RLAN is given by the following, where this example represents the outdoor rural case (i.e. free space conditions) for a low gain RLAN antenna (6dBi).

$$I\ (\text{dBm}) = (24.32\ \text{dBm} + 15.34\ \text{dBi}) – 136.22\ \text{dB} + 6\ \text{dBi} – 0\ \text{dB} – 0\ \text{dB} = -90.56\ \text{dBm}$$

As with the earlier cases which dealt with the opposite direction of interference, the geometry is such that when the DA2GC aircraft starts transmitting to the DA2GC Ground Station (where it is being received at an elevation of 5 degrees) the elevation of the aircraft as seen by the RLAN (which is situated closer to the aircraft) will be higher. Furthermore, while the boresight of the aircraft antenna is directed towards the DA2GC Ground Station, the interference path to the RLAN will be offset from the boresight since the RLAN is situated much closer to the aircraft. The interference represented in the equation above impinges the RLAN at a ground elevation of 22.2° and comes from the aircraft antenna main lobe 2.5 dB down on its maximum gain.

Table 73: Interference levels at RLAN receiver from DA2GC Aircraft Transmitter

Gain of RLAN antenna towards AS		17 dBi (front)	-7 dBi (rear)	6 dBi	1.3 dBi
Interference level (dBm in 20MHz)	RLAN Outdoor / Urban	**-99.26**	-123.26	-110.26	-114.96
	RLAN Outdoor / Suburban	**-79.56**	-103.56	**-90.56**	**-95.26**
	RLAN Outdoor / Rural	**-79.56**	-103.56	**-90.56**	**-95.26**
	RLAN Indoor / Urban			-127.26	-131.96
	RLAN Indoor / Suburban			-107.56	-112.26
	RLAN Indoor / Rural			-107.56	-112.26

RLAN Protection Criterion = -103 dBm.

Because of power control on the aircraft, results for aircraft operating at 3 km altitude are nearly identical to those for 10 km operations above (less than 0.5 dB variation).

The following situations potentially exceed the specified interference criterion:

- Outdoor high gain RLAN in an urban environment: Excess = 3.74 dB (reduced to this level by clutter);
- Outdoor RLANs of all types in suburban and rural environments: Excess = 23.44 to 7.74 dB (directional to omnidirectional).

The aggregation of interference from multiple aircraft and the statistical implications are considered in section 11.2.2.2.

11.2.1.4 *Interference from RLAN into BDA2GC GS (TR 101 599)*

The potential single entry interference from an outdoor RLAN device into a DA2GC Ground Station can be defined as:

$$I\ (dBm) = e.i.r.p._{RLAN}\ (dBm) - Lp\ (dB) + G_{GS}\ (dBi) - L_C\ (dB) - L_B\ (dB)$$

Equation 4

where:

- I (dBm) = Interference level at DA2GC Ground Station receiver;
- e.i.r.p.RLAN (dBm) = e.i.r.p. of RLAN towards DA2GC Ground Station;
- Lp (dB) = Path loss (ground path): Free space loss;
- G_{GS} (dBi) = Gain of DA2GC Ground Station antenna towards RLAN;
- L_C (dB) = Clutter loss at 22 ° elevation angles: urban 19.7 dB / suburban 19.5 dB / rural 14.8 dB (see section 4.2.3)
- L_B (dB) = Building loss (RLAN outdoor 0dB, RLAN indoor 17 dB)

Consider two cases where the geometry places the RLAN in the DA2GC Ground Station antenna null (G_{GS} = -10 dBi) and where the RLAN is not in the null (G_{GS} = 0 dBi). The above equation can also be restated in terms of the loss required as follows:

$$Loss\ (dB) = e.i.r.p_{.RLAN}\ (dBm) + G_{GS}\ (dBi) - Criterion_{GS}\ (dBm)$$

As an example, the loss required with respect to a medium power RLAN (200 mW) when not in the DA2GC Ground Station null (0dBi) is given by:

$$Loss\ (dB) = 23\ dBm + 0\ dBi - -103\ dBm = 126\ dB$$

The results are summarised in Table 74 and Table 75 below.

Table 74: Required separation distance between DA2GC GS and RLAN - (case when interference path is in the GS antenna null (-10dBi)[5])

RLAN e.i.r.p. (in direction of DA2GC GS)		1 Watt	200 mW	25 mW
Loss required (without indoor-outdoor and clutter losses)		123 dB	116 dB	107 dB
Separation distance (m)	RLAN Outdoor / Urban	595	266	94
	RLAN Outdoor / Suburban	609	272	97
	RLAN Outdoor / Rural	1046	467	166

[5] It should be noted that the separation distances indicated in Table 74 assume that the attenuation due to the DA2GC Ground Station antenna discrimination remains constant as the separation between it and the RLAN decreases. In practice, if the relative height above ground level of the DA2GC Ground Station antenna array and the RLAN remains constant, this will result in increasing negative angles at the Ground Station as the separation distance is reduced. This effect will tend to reduce the benefit of the DA2GC antenna null for separations less than 1km, resulting in slightly larger separation distances (tending towards the out of null values shown in Table 75) than those indicated above.

RLAN e.i.r.p. (in direction of DA2GC GS)		1 Watt	200 mW	25 mW
	RLAN Indoor / Urban		38	13
	RLAN Indoor / Suburban		38	14
	RLAN Indoor / Rural		66	23

Table 75: Required separation distance between DA2GC GS and RLAN - (case when interference path is out of the GS antenna null (0dBi))

RLAN e.i.r.p. (in direction of DA2GC GS)		1 Watt	200 mW	25 mW
Loss required (without indoor-outdoor and clutter losses)		133 dB	126 dB	117 dB
Separation distance (m)	RLAN Outdoor / Urban	1882	841	298
	RLAN Outdoor / Suburban	1926	860	305
	RLAN Outdoor / Rural	3309	1478	524
	RLAN Indoor / Urban		119	42
	RLAN Indoor / Suburban		122	43
	RLAN Indoor / Rural		209	74

Criterion = -103 dBm

The following separation distances are required in order to avoid single entry interference exceeding the specified criterion:

- For outdoor RLAN terminals distances between about 300 to 1000 m are required;
- For indoor RLAN terminals distances between about 40 and 200 metres are required.

The aggregation of interference and the statistical implications are considered in section 11.2.2.3.

11.2.1.5 *Interference from BDA2GC GS (TR 101 599) into RLAN*

The potential single entry interference from a DA2GC Ground Station into an outdoor RLAN device can be defined as:

$$I\ (\text{dBm}) = \text{e.i.r.p}_{.GS}\ (\text{dBm}) - Lp\ (\text{dB}) + G_{RLAN}\ (\text{dBi}) - L_C\ (\text{dB}) - L_B\ (\text{dB})$$

Equation 5

where:

- I (dBm) = Interference level at RLAN;
- e.i.r.p $_{.GS}$ (dBm) = e.i.r.p. of DA2GC Ground Station towards RLAN;
- Lp (dB) = Path loss (ground path): Free space loss G_{RLAN} (dBi) = Gain of RLAN towards DA2GC Ground Station;
- L_C (dB) = Clutter loss at 22 ° elevation angles: urban 19.7 dB / suburban 19.5 dB / rural 14.8 dB (see section 4.2.3);
- L_B (dB) = Building loss (RLAN outdoor 0dB, RLAN indoor 17 dB).

Two cases can be considered where the geometry places the RLAN in the DA2GC Ground Station antenna null (G_{GS} = -10 dBi, e.i.r.p $_{.GS}$ = 14.32 dBm) and where the RLAN is not in the null (G_{GS} = 0 dBi, e.i.r.p.$_{GS}$ = 24.32 dBm). The above equation can also be restated in terms of the loss required:

$$\text{Loss (dB)} = \text{e.i.r.p}_{.GS}\ \text{(dBm)} + G_{RLAN}\ \text{(dBi)} - \text{Criterion}_{RLAN}\ \text{(dBm)}$$

Equation 6

As an example, the loss required for a low gain RLAN antenna when not in the DA2GC Ground Station null is given by:

Loss (dB) = 24.32 dBm + 6 dBi - -103 dBm = 133.32 dB

The results for the required loss and resulting separation distance for differing RLAN locations are summarised in Table 76 and Table 77 below.

Table 76: Required separation distance between DA2GC GS and RLAN - (case when interference path is in the GS antenna null (-10dBi)[6])

RLAN antenna gain in direction of DA2GC GS		17 dBi (front)	-7 dBi (rear)	6 dBi	1.3 dBi
Loss required (without indoor-outdoor and clutter losses)		134.32 dB	110.32 dB	123.32 dB	118.62 dB
Separation distance (m)	Outdoor / Urban	2191	138	618	359
	Outdoor / Suburban	2242	141	632	368
	Outdoor / Rural	**3852**	243	1086	632
	Indoor / Urban			87	51
	Indoor / Suburban			89	52
	Indoor / Rural			153	89

Table 77: Required separation distance between DA2GC GS and RLAN - (case when interference path is out of the GS antenna null (0dBi)

RLAN antenna gain in direction of DA2GC GS		GRLAN = 17 dBi (front)	GRLAN = -7 dBi (rear)	GRLAN = 6 dBi	GRLAN = 1.3 dBi
Loss required (without indoor-outdoor and clutter losses)		144.32 dB	120.32 dB	133.32 dB	128.62 dB
Separation distance (m)	Outdoor / Urban	6929	437	1953	1137
	Outdoor / Suburban	7090	447	1998	1163

[6] It should be noted that the separation distances indicated in Table 76 assume that the attenuation due to the DA2GC Ground Station antenna discrimination remains constant as the separation between it and the RLAN decreases. In practice, if the relative height above ground level of the DA2GC Ground Station antenna array and the RLAN remains constant, this will result in increasing negative angles at the Ground Station as the separation distance is reduced. This effect will tend to reduce the benefit of the DA2GC antenna null for separations less than 1km, resulting in slightly larger separation distances (tending towards the out of null values shown in Table 77) than those indicated above.

RLAN antenna gain in direction of DA2GC GS		GRLAN = 17 dBi (front)	GRLAN = -7 dBi (rear)	GRLAN = 6 dBi	GRLAN = 1.3 dBi
	Outdoor / Rural	12180	769	3433	1998
	Indoor / Urban			276	161
	Indoor / Suburban			282	164
	Indoor / Rural			485	282

The following separation distances are required in order to avoid single entry interference exceeding the specified criterion:

- For outdoor RLAN terminals the directional RLAN terminal requires a separation of up to 3.85 km in rural areas otherwise about 1 km and less (46.6 sq km otherwise 3.14 sq km or less).
- For indoor RLAN terminals distances between about 160 and 500 metres are required (0.08 - 0.785 sq km).

The aggregation of interference and the statistical implications are considered in section 11.2.2.4.

11.2.2 Statistical considerations for the compatibility between RLAN and BDA2GC system as described in ETSI TR 101 599

11.2.2.1 *Interference from RLAN into BDA2GC AS (ETSI TR 101 599 [24])*

The static worst case analysis in section 11.2.1.2 showed that the following single entry situations potentially exceed the specified interference criterion:

- For an aircraft at 10 km altitude outdoor 1 W and 200 mW RLANs in suburban and rural environments exceed the criterion: Excess = 12.12 and 5.12 dB;
- For an aircraft at 3 km altitude outdoor RLANs of all power levels in all environments exceed the criterion: Excess = 22.49 to 6.49 dB.

The aggregation of interference from multiple RLANs and the statistical implications are considered here (details see Annex 4.2).

The RLAN deployment model Option B from section 2.3.4 has been used.

For an aircraft operating at 10 km altitude the exceedance of the AS criterion (12.12 dB noted in the first bullet above) occurs over an angle of ±8° subtended at the aircraft when the aircraft's steerable antenna is pointing vertically downwards (at 8° from nadir the AS antenna pattern provides the 12.12 dB discrimination required). This covers an area of 6.2 sq km (radius = 1.4 km) and the associated minimum interfering path elevation angle at the RLAN is of the order 82° (marginally less than this).

For an aircraft operating at 3 km altitude the exceedance of the AS criterion (22.49 dB noted in the second bullet above) occurs over an angle of ±72° subtended at the aircraft when the aircraft's steerable antenna is pointing vertically downwards (at 72° from nadir the AS antenna pattern provides the 22.49 dB discrimination required). This does include areas with significant nulls in the sidelobes (and therefore no interference) so to a first approximation we will consider a contiguous area defined by ±50°. This covers an area of 40.2 sq km (radius = 3.6 km) and the associated minimum interfering path elevation angle at the RLAN is of the order 40° (marginally less than this).

Using solely the density of 1 Watt 20 MHz outdoor devices employing omnidirectional antennas, and taking account of the areas above, the number of interfering RLANs for different environments is as follows. If the number of RLANs in the designated area is less than 1 then there is a low probability of an RLAN being situated within the area on the ground which could give rise to interference into the DA2GC aircraft station.

Table 78: Number of 1 Watt 20 MHz outdoor devices within area where they could cause interference

	Density of 1W 20 MHz outdoor RLANs (per km²)	No. of RLANs Aircraft at 10 km Area = 6.2 sq km	No. of RLANs Aircraft at 3 km Area = 40.2 sq km
Urban	0.001076	0.00667	0.04326
Suburban	0.0002	0.00124	0.00804
Rural	0.00001081	0.000067	0.0004346

Using the density of all types of outdoor device weighted by power and bandwidth relative to 1 Watt and taking account of the areas above the number of interfering RLANs for different environments is as follows. As before, if the number of RLANs in the designated area is less than 1 then interference has a low probability of exceeding the threshold.

Table 79: Number of equivalent 1 Watt outdoor[7] devices (all powers and bandwidths normalised) within area where normalised 1 Watt equivalent outdoor device could cause interference

	Weighted density of RLANs (per km²)	No. of RLANs Aircraft at 10 km Area = 6.2 sq km	No. of RLANs Aircraft at 3 km Area = 40.2 sq km
Urban	0.0386	0.2393	1.5517
Suburban	0.0072	0.0446	0.2894
Rural	0.0004	0.0025	0.0161

It can be seen that, in the urban case, the number of weighted RLANs is greater than 1. This implies that over urban areas a degree of interference will be experienced although the exceedance is hardly great. However, it should also be noted that the latter normalised device table, where lower power wider bandwidth RLAN transmitters are equated to a smaller number of higher power devices, will overestimate the number of equivalent RLANs interfering with the DA2GC aircraft. This is because RLANs using a lower power and/or wider bandwidth will cause a lower individual exceedance and therefore the area over which they can potentially cause interference is less than that assumed above which has been determined from the worst case exceedance.

The above analysis has considered an aircraft overhead, for the purposes of simplicity, noting that no benefit is obtained from clutter loss because of the high elevation angles at the RLAN. For lower elevation projections of the aircraft beam larger areas are subtended on the ground. The potentially increased community of RLAN interferers implied by this is largely compensated for by increased path loss. Furthermore clutter loss comes into play which, as already noted, has not been included in the calculations above.

This method of calculating the aggregate interference from outdoor RLANs into a DA2GC aircraft indicates a high likelihood of some exceedances (i.e. greater than one) but this reduces to less than one when taking full account of the smaller interference zones that are associated with the lower power / wider bandwidth RLANs. The devices giving the greatest potential problem are the 1 Watt 20 MHz devices and it can be seen from

[7] Indoor devices have been ignored as the 17 dB attenuation reduces the normalised indoor numbers to significantly less than the normalised outdoor numbers.

Table 79above that the numbers of such devices are very small. This suggests that occasionally one of these devices will be in a position to cause interference to a DA2GC aircraft. In these circumstances the nulling capability provided by the DA2GC phased array receives system should eliminate any impact on DA2GC aircraft reception.

11.2.2.2 *Interference from BDA2GC AS (ETSI TR 101 599 [24]) into RLAN*

The static worst case single entry analysis in section 11.2.1.3 showed that the following situations potentially exceed the specified interference criterion:

- Outdoor high gain RLAN in an urban environment: Excess = 3.74 dB (reduced to this level by clutter);
- Outdoor RLANs of all types in suburban and rural environments: Excess = 23.44 to 7.74 dB (directional to omnidirectional).

The aggregation of interference from multiple aircraft and the statistical implications are considered here. Note that as before results for aircraft operating at 3 km altitude are nearly identical to those for 10 km operations because of power control. The results here are for 10 km altitude.

The graph below shows the aggregation of interference from multiple aircraft when an omnidirectional RLAN is placed in a location that experiences the highest level of single entry interference and when the RLAN is co-located with the DA2GC Ground Station. Furthermore, two situations are considered; one where there is no clutter which effectively represents the rural case and the other where there is significant clutter which represents the urban case.

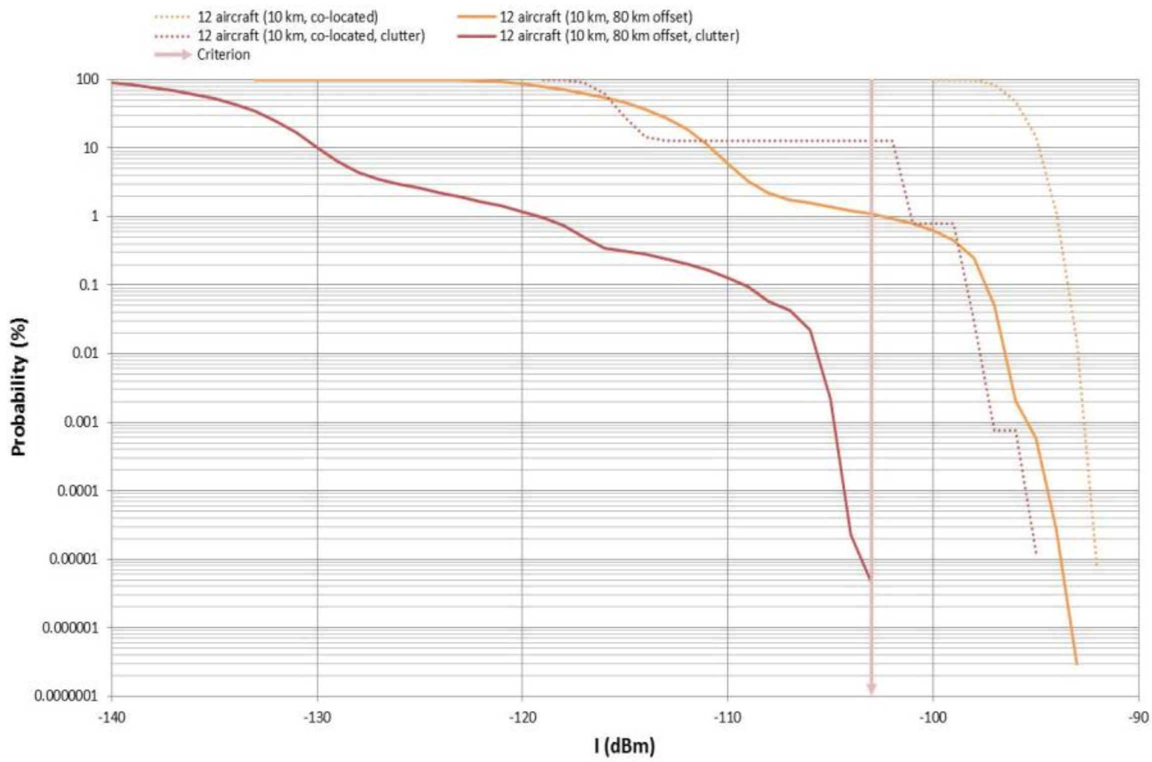


Figure 38: Probability of interference at an RLAN co-located with the DA2GC Ground Station and in the worst case single entry location (80 km offset)

It can be seen from Figure 38 that the exceedance at the 1% level is 2 dB in the urban case (i.e. with clutter) and 9 dB in the rural case (i.e. no clutter) when the RLAN is co-located with the DA2GC Ground Station. When the RLAN is offset from the DA2GC Ground Station these levels reduce significantly. For the location where the RLAN receives the highest level of single entry interference (80 km offset), the aggregate criterion is not exceeded in the urban case and only just exceeded with 1% probability in the rural case. It should further be noted that the number of devices in the rural case is less than 30 and it is likely that a number of these will have sufficient margin so that the impact of DA2GC interference will result in the device operating at a lower modulation state, rather than a complete loss of the link.

11.2.2.3 *Interference from RLAN into BDA2GC GS (TR 101 599 [24])*

The static worst-case analysis in section 11.2.1.4 showed that the following separation distances are required in order to avoid single entry interference exceeding the specified criterion:

- For outdoor RLAN terminals distances between about 1300 to 1000 m are required;
- For indoor RLAN terminals distances between about 40 and 200 metres are required.

A number of statistical elements can be introduced to the assessment including:

- The probability of an active RLAN being within the area of interference around a DA2GC Ground Station;
- The probability of a DA2GC main beam gain (in its azimuthal plane) pointing towards an active RLAN;
- For the high gain RLANs, the probability of the RLAN pointing towards the DA2GC Ground Station.

The numbers of equivalent 1 W RLANS that might adversely affect a DA2GC Ground Station is derived in Table 80. This is effectively an indication of the probability that an RLAN will be in a location that could affect the DA2GC Ground Station assuming the DA2GC Ground Station main azimuthal lobe is pointing at the RLAN.

It can be seen that the numbers are very low which indicates the probability of an RLAN being in a position to interfere with the DA2GC Ground Station is therefore low, even when assuming the maximum azimuthal gain at the Ground Station.

Table 80: RLAN distribution in the vicinity of a DA2GC Ground Station receiver

	Distance (km) for 1 W RLANs (Note 1)	Area (sq km)	Normalised RLAN density (per sq km)	No. of 1 W RLANs
Outdoor / Urban	~1.0	3.14	0.0386	0.121
Outdoor / Suburban	~1.0	3.14	0.0072	0.023
Outdoor / Rural	~1.0	3.14	0.0004	0.0013
Indoor / Urban	0.266 (Note 1)	0.222	0.4103	0.091
Indoor / Suburban	0.272 (Note 1)	0.232	0.0770	0.018
Indoor / Rural	0.467 (Note 1)	0.685	0.0047	0.0032

Note 1: These numbers have been rebased against a 1 Watt transmitter even though 1 Watt transmitters indoors do not exist. This is so normalised density figures can be used.

The DA2GC Ground Station antenna gain statistics along the ground path are represented in the graph below. This relative gain in the horizontal plane (where the gain is dynamic) would generally be applied to the relevant ground path gain in the vertical plane which is static (-10 dBi in null and 0 dBi out of null) in order to get the overall gain in any given direction. However, the position in the null has already been taken into account in deriving the separation distances (and hence areas) in the table above. The implication of the gain statistics below is that the distance / area and hence RLAN numbers that can potentially cause interference as calculated above are based on the maximum azimuthal gain represented by the right hand side of the graph. This part of the graph is associated with a small probability approaching 1% of the time. For the rest of the time there will be a smaller number of RLANs capable of causing interference. This is because the additional discrimination (e.g. 6 dB for 10% of the time) will reduce the area within which RLANs could potentially interfere and hence the absolute number of RLANs from the already small numbers in Table 80 above.

With regard to the high gain directional RLANs there will be a further reduction in potential impact as the e.i.r.p. level remains the same (1 Watt) but there will be a probability as to whether the RLAN is pointing towards the DA2GC Ground Station or not. This aspect has not been explored here.

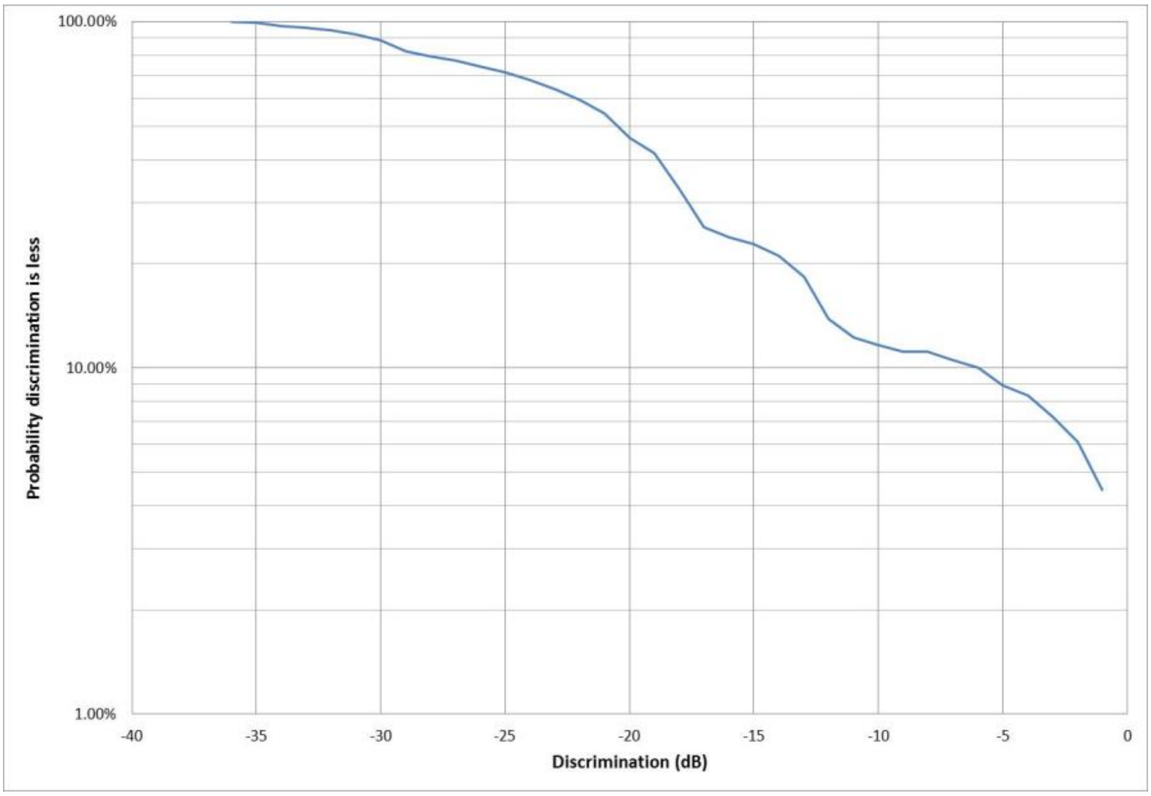


Figure 39: Probability that discrimination in the horizontal plane is less than a given value

It has been shown that even assuming the worst case azimuthal antenna gain the numbers of RLAN devices capable of causing interference to a DA2GC Ground Station is very small which implies a low probability of such interference occurring. Taking account of discrimination that is available in the horizontal plane reduces these numbers even further.

11.2.2.4 *Interference from BDA2GC GS (ETSI TR 101 599 [24]) into RLAN*

The static worst case analysis in section 11.2.1.5 showed that the following separation distances are required in order to avoid single entry interference exceeding the specified criterion:

- For outdoor RLAN terminals the directional RLAN terminal requires a separation of up to 3.85 km in rural areas otherwise about 1 km and less (46.6 sq km otherwise 3.14 sq km or less);
- For indoor RLAN terminals distances between about 160 and 500 metres are required (0.08 – 0.785 sq km).

A number of statistical elements can be introduced to the assessment including:

- The variation in power used by the DA2GC Ground Station while it is supporting multiple aircraft with power control being used on each connection;
- The probability of an RLAN being within the area of interference around a DA2GC Ground Station;
- For the high gain RLANs, the probability of the RLAN pointing towards the DA2GC Ground Station.

The DA2GC Ground Station e.i.r.p. statistics along the ground path (assuming the zero degree elevation null is applied) are represented in the graph below. The worst case e.i.r.p. along the ground path in the null amounts to 24.32 dBm – 10 dBi = 14.32 dBm for a single aircraft (from the single entry analysis earlier in this document).

The graph below represents the aggregate e.i.r.p. when a DA2GC Ground Station is supporting 12 aircraft. As explained in ECC Report 210 [23], this is the maximum number of aircraft which can be simultaneously supported by a single Ground Station and hence represents another worst-case assumption. It can be seen that even when supporting 12 aircraft the aggregate level only exceeds the single entry level with 0.025% probability.

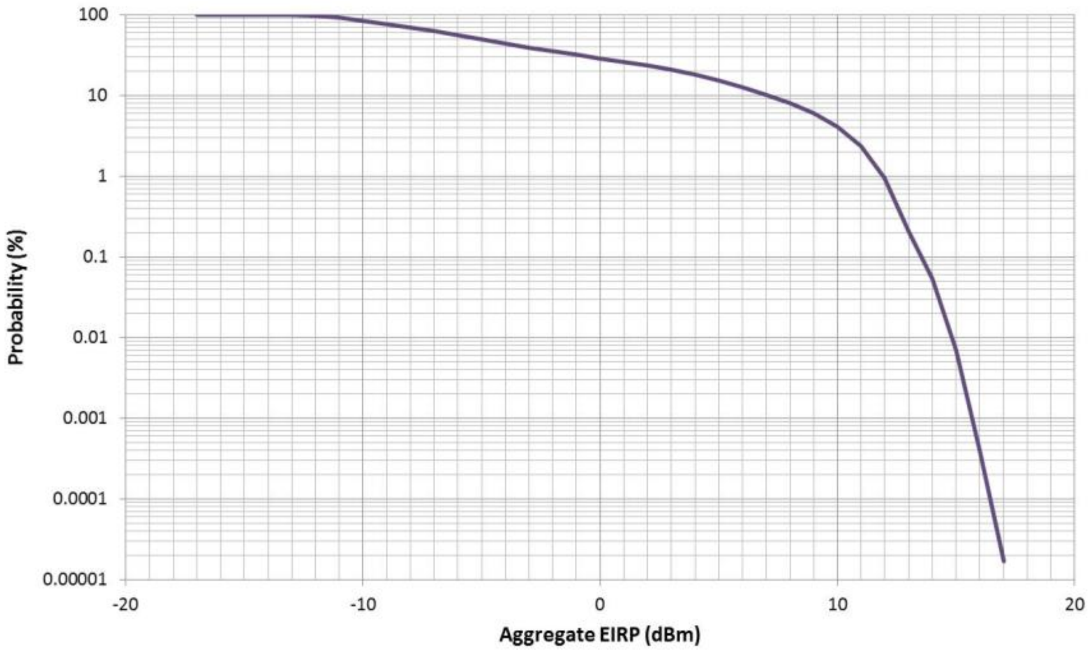


Figure 40: Aggregate e.i.r.p. (in any azimuth direction) produced by a DA2GC GS supporting 12 aircrafts

This result can then be viewed in conjunction with the probability of a 6 dBi RLAN being located within the immediate area as given in Table 81.

Table 81: RLAN distribution in the vicinity of a DA2GC Ground Station transmitter

	Distance (km)	Area (sq km)	RLAN density (per sq km)	No. of RLANs
Outdoor / Urban	~1.0	3.14	1.1584	3.637
Outdoor / Suburban	~1.0	3.14	0.2173	0.682
Outdoor / Rural	~1.0	3.14	0.0131	0.041
Indoor / Urban	0.276	0.239	20.6988	4.947
Indoor / Suburban	0.282	0.250	3.8827	0.971
Indoor / Rural	0.485	0.739	0.2340	0.173

It can be seen from the figures above that the number of RLANs likely to be affected in the vicinity of a DA2GC Ground Station transmitter is less than one for all but two of the considered environments. Even in those cases, as can be seen from Figure 40, the probability of receiving interference is of the order 0.025% so the impact of DA2GC Ground Station transmissions can be regarded as insignificant.

11.2.3 Summary for the compatibility between BDA2GC (ETSI TR 101 599 [24]) and RLAN

On the basis of results presented in this document, the following general conclusions can be drawn.

RLAN into DA2GC Aircraft

The worst-case MCL analysis indicates that outdoor RLAN operation would result in interference levels into DA2GC aircraft receivers exceeding the criterion in several cases up to 23 dB.

Positive margins exist in all cases when considering indoor RLAN operation.

Calculations of the aggregate interference from outdoor RLANs into a DA2GC aircraft indicate a high likelihood of some exceedances (i.e. greater than one) but this reduces to less than one when taking full account of the smaller interference zones that are associated with the lower power / wider bandwidth RLANs.

The devices giving the greatest potential problem are the outdoor 1 Watt 20 MHz devices but the numbers of these devices are very small. This suggests that occasionally one of these devices will be in a position to cause interference to a DA2GC aircraft. Even in such cases, the nulling and interference cancellation capability provided by the DA2GC phased array receive system should eliminate any impact on DA2GC aircraft reception.

DA2GC Aircraft into RLAN

RLANs located indoors would benefit from additional indoor-outdoor attenuation which results in more than enough margin to absorb the aggregation effects, and even more so when clutter loss is taken into account.

It can therefore be concluded that indoor RLAN operation would not be affected by DA2GC aircraft transmissions.

Outdoor directional RLAN operation, under free space conditions, could be subjected to interference from DA2GC in exceedance of the interference limits (up to 23 dB) with respect to a single aircraft and there is in this case an insignificant increase when considering aggregation from multiple aircraft).

For lower gain RLANs, the single entry interference is significantly lower and may in some cases exceed the interference limits. In addition, the aggregation effect due to multiple aircraft takes the total potential interference over the limit by nearly 7 dB.

However, when examining the probabilities associated with such interference events, the following points emerge:

- The probability to have an interference power less than the protection objective is 12 % in the urban case (i.e. with clutter) and 100% in the rural case (i.e. no clutter) when the RLAN is co-located with the DA2GC Ground Station.
- When the RLAN is offset from the DA2GC Ground Station these probability values reduce significantly. For the location where the RLAN receives the highest level of single entry interference (80 km offset), this value is reduced to 1% in the rural case and to 0.00001% in the urban case.
- It should further be noted that the number of devices in the rural RLAN case is less than 30 and it is likely that a number of these will have sufficient margin so that the impact of DA2GC interference will result in the RLAN device operating at a lower modulation state rather than a complete loss of the link.

RLAN into DA2GC Ground Station

When considering worst-case alignments, and in the absence of any mitigation, protection of a DA2GC Ground Station from high power high gain RLAN interference would require a separation of between 0.5 and 1 km if the RLAN were to be operating outdoors in rural areas. For an RLAN operating indoors, this distance would reduce to just over 200 metres, with even shorter distances in urban and suburban environments.

It has been shown that, even assuming the worst case azimuthal antenna gain, the numbers of RLAN devices capable of causing interference to a DA2GC Ground Station is very small which implies a low probability of such interference occurring. Taking account of the discrimination that is available in the horizontal plane reduces these numbers even further.

DA2GC Ground Station into RLAN

When considering worst-case alignments, in order to avoid unacceptable interference into high gain devices, RLANs operated outdoors would need to be more than 3.8 km from a DA2GC Ground Station in rural areas.

Restricting RLAN operation to indoor use only would reduce this worst-case distance to approximately 500 m in rural areas (noting that the geometry reduces the impact of the null) and even shorter distances in urban and suburban environments.

The number of RLANs likely to be affected in the vicinity of a DA2GC Ground Station transmitter is small for all but two of the considered environments, namely indoor and outdoor urban. Even in those cases the probability of receiving interference is very low (of the order 0.025%) so the impact of DA2GC Ground Station transmissions can be regarded as insignificant.

11.3 CONCLUSION ON THE COMPATIBILITY BETWEEN RLAN AND BDA2GC

A series of compatibility analyses between RLAN and DA2GC have been presented. Studies were performed in respect of the two proposed BDA2GC systems described in ETSI TR 101 599 [24] and ETSI TR 103 108 [25] and were based on common agreed assumptions regarding RLAN parameters, distribution densities and activity factors.

Co-channel interference analyses were performed considering the RLANs both as victims and as interferers. The scenarios included consideration of interference to/from DA2GC Aircraft Stations and Ground Stations.

Compatibility is clearly achieved in all scenarios when considering indoor RLANs. For some scenarios involving outdoor RLANs, worst-case Minimum Coupling Loss calculations show that some exceedances of the RLAN or DA2GC receiver protection criteria could potentially occur. However, compatibility is achieved, when taking into account a number of identified ameliorating factors such as separation distances, density of active co-frequency RLAN devices, clutter loss, use of power control and antenna discrimination.

It is observed that the outdoor rural RLAN scenarios are the most demanding but the probability of their occurrence is small.

It should be noted that the studies in this section assumed free space loss propagation conditions with clutter loss according to Recommendation ITU-R P.452 [19]. The clutter loss has been used for the studies between DA2GC GS and RLAN for all scenarios including the rural environment with about 15 dB clutter loss. Under worst case conditions line of sight conditions without any clutter could happen especially in rural environments, which would increase the separation distances. However, the probability is expected to be low.

12 COMPATIBILITY BETWEEN RLAN AND WIRELESS INDUSTRIAL APPLICATIONS (WIA) IN THE BAND 5725-5875 MHz

12.1 MINIMUM COUPLING LOSS CALCULATIONS

12.1.1 Description of scenarios for MCL calculations

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

Scenario 1: Indoor RLAN devices

Most RLAN transmitters are placed indoor with a maximum transmit power of 200 mW. The following scenarios are applicable for indoor RLAN devices.

Scenario 1-1 - an indoor RLAN access point (AP) is the interferer and an indoor wireless system for WIA is the victim. Both devices are placed in the same factory area.

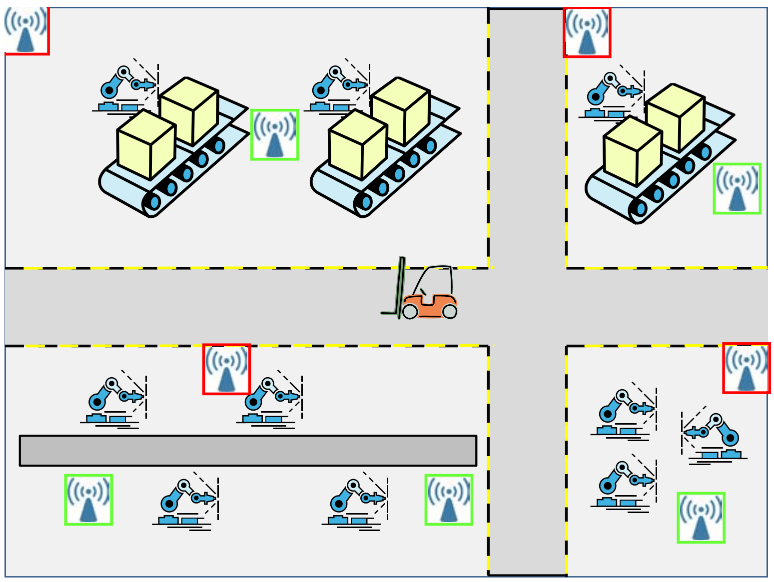


Figure 41: Scenario 1-1: RLAN Access Point in a factory floor

Scenario 1-2 WIA and RLAN located indoor and separated by a wall: an indoor RLAN access point (AP) is the interferer and an indoor WIA in an adjacent factory hall or an outdoor WIA is the victim.

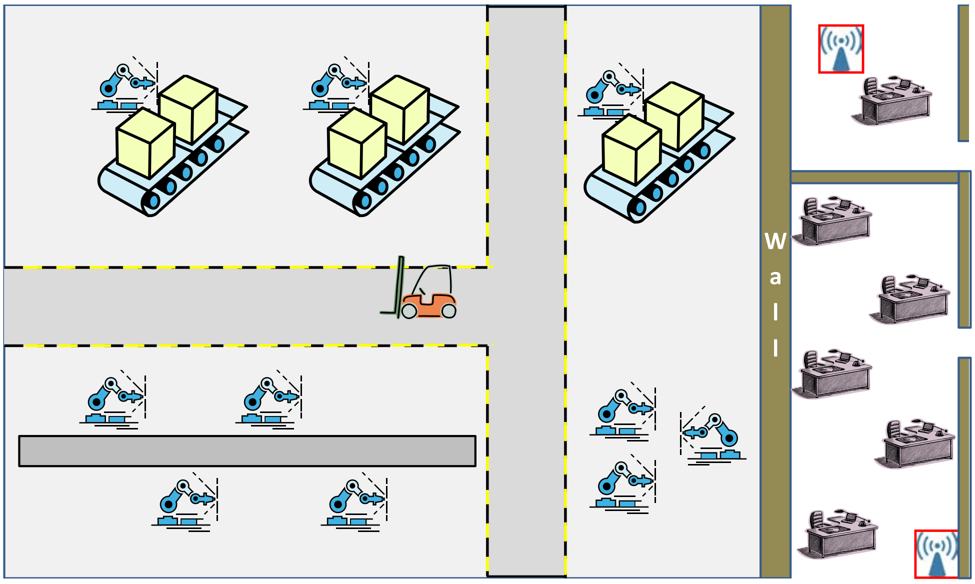


Figure 42: Scenario 1-2: RLAN Access Point and Clients in the adjacent office to WIA

Scenario 2 – Outdoor RLAN devices:

The minority of RLAN devices are placed outdoor with a maximum transmit power of 1 W. The following scenarios are applicable for outdoor RLAN devices.

- Scenario 2-1 - The outdoor RLAN access point (AP) is the interferer and an indoor wireless system for WIA is the victim, a wall loss of 15 dB must consider.
- Scenario 2-2 - The outdoor RLAN access point (AP) is the interferer and an outdoor wireless system for WIA is the victim.

All above described scenarios are applicable for the contrary case, where the wireless system for WIA is the interferer and the RLAN Access Point is the victim.

12.1.2 Results of MCL calculations - Interference from RLAN into WIA in the band 5725-5875 MHz

The separation distance values for the above described scenarios are depicted in for the indoor RLAN interferer in Table 82 and in Table 83 for the outdoor RLAN interferer. These MCL calculations consider only the expected worst case conditions with co-channel and main beam.

Table 82: Separation distance for victim WIA and interferer indoor RLAN

Scenario	1-1			1-2		
WIA System	1	2	3	1	2	3
RLAN: 20 MHz	215 m	296 m	266 m	93 m	133 m	118 m
RLAN: 40 MHz	183 m	252 m	226 m	77 m	111 m	98 m
RLAN: 80 MHz	156 m	214 m	193 m	64 m	92 m	82 m
RLAN: 160 MHz	132 m	183 m	164 m	46 m	77 m	68 m

The scenarios with indoor RLAN interferer require a minimum separation distance between 132 m and 296 m for the case that the victim and interferer are sharing the same environment. If the victim (WIA) and interferer (RLAN) are separated by a wall a minimum separation distance between 46 m and 133 m are required.

Table 83: Separation distance for victim WIA and interferer outdoor RLAN

Scenario	2-1			2-2		
WIA System	1	2	3	1	2	3
RLAN: 20 MHz	93 m	133 m	118 m	350 m	503 m	445 m
RLAN: 40 MHz	77 m	111 m	98 m	291 m	419 m	371 m
RLAN: 80 MHz	64 m	92 m	82 m	241 m	349 m	309 m
RLAN: 160 MHz	46 m	77 m	68 m	195 m	291 m	258 m

The scenarios with outdoor RLAN interferer and an indoor WIA victim require a minimum separation distance between 46 m and 133 m. The scenarios with outdoor RLAN interferer and an outdoor WIA victim require a minimum separation distance between 195 m and 503 m.

The MCL calculations with co-channel considerations lead to significant distances in the following cases:

- the interferer and the victim are both indoor;
- the interferer and the victim are both outdoor.

12.1.3 Interference from WIA into RLAN in the band 5725-5875 MHz

The parameters for MCL calculation are summarised in Table 84, where WIA is the interferer and RLAN is the victim. The bandwidth of wireless systems for WIA has no effect on the results, because the RLAN (victim) bandwidth is equal or greater than the WIA (interferer) bandwidth.

Table 84: Parameters for each of the scenarios

Scenario	1-1	1-2	2-1	2-2	3-1	3-2
Environment	Urban	Urban	Suburban	Suburban	Rural	Rural
WIA e.i.r.p.	26 dBm					
WIA Bandwidth	1/3/20 MHz					
Additional losses	None	15 dB	None	15 dB	None	15 dB
RLAN Gain	6 dBi					
RLAN Bandwidth	20/40/80/160 MHz					
RLAN Noise Power (dBm)	-97/-94/-91/-88					
I/N	-6 dB					

The separation distance values for the above described scenarios are depicted in Table 85. These MCL calculations consider only the worst case conditions with co-channel and main beam.

Table 85: Separation distance for victim RLAN and interferer WIA

Scenario	1-1	1-2	2-1	2-2
RLAN: 20 MHz	868 m	387 m	387 m	1691 m
RLAN: 40 MHz	763 m	330 m	330 m	1410 m
RLAN: 80 MHz	627 m	281 m	281 m	1127 m
RLAN: 160 MHz	534 m	239 m	239 m	980 m

If the interferer WIA and victim RLAN are separated by a wall a minimum separation distance between 239 m and 387 m are required. The separation distance between 534 m and 868 m are required for the case that the devices (interferer and victim) are shared the same indoor environment. A separation distance between 980 m and 1691 m are required by a worst case scenario, where the interferer and victim are placed outdoor. The MCL calculations with co-channel considerations lead to significant separation distances.

12.2 ANALYSIS

The MCL calculations lead to significant separation distances, in particular in the cases where both systems operate without wall or building separation.

Nevertheless, compatibility can be achieved through a coordination procedure within factory premises where WIA are deployed, taking into account that:

- It is expected that the operation of wireless devices (including WIA and RLAN) within the industrial premises would be controlled by the factory management;
- Frequency separation can be applied considering that frequencies outside the 5725-5875 MHz band are available for RLAN;
- The sharing scenarios addressed in this section may benefit from the implementation in WIA of mitigation techniques as described in ECC Report 206 [26]. For example, a detect-and-avoid mechanism is required in WIA for the compatibility between WIA and BFWA.

13 ANALYSIS OF THE STUDIES - AREAS FOR FURTHER WORK

This section provides a non-exclusive list of elements to be studied in the subsequent report. These elements include inter alia the completion of studies which have not been finalised, the assessment of mitigation techniques and further improvements to studies presented in this report.

13.1 TRANSPORTATION SYSTEMS

13.1.1 Intelligent transportation systems (ITS) in the bands 5875-5905, 5905-5925 and 5855-5875 MHz

- In MCL calculations, analyse the actual effects of a protection corresponding to I/N level of -6 dB being reached due to intermittent interference.
- Continue the study of mitigation techniques to enable the coexistence between RLAN and ITS including the following two possible approaches:
  - Generic Energy Detection without any consideration of the interferer and victim signal frames: further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation;
  - Combination of energy detection and carrier sensing, such as one of the Clear Channel Assessment (CCA) modes defined in the 802.11 standard: further study is required to assess the applicability to ITS of the interference avoidance techniques currently employed in 5 GHz RLAN systems.
- Further consideration to time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment.

13.1.2 Road-tolling applications in the band 5795-5815 MHz

- In MCL calculations, analyse the actual effects of a protection corresponding to I/N level of -6 dB being reached due to intermittent interference.
- Continue the study of mitigation techniques to enable the coexistence between RLAN and road-tolling including the following possible approaches:
  - Implementation in RLAN of a detection mechanism to detect road tolling applications based on energy detection: further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation;
  - Transmission from the road tolling applications of predefined signals (beacons) which indicate that the used channels are busy: further consideration is needed;
  - Detection of ITS: further consideration is needed for this mitigation technique in order to ensure coexistence with the road tolling systems;
  - Use of a geolocation database approach: define the type of information that it should contain, assess its implementation, access and maintenance. Define the role and responsibilities of stakeholders.
- Further consideration to time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment.

13.1.3 Systems for public transport automation in the 5.915-5.935 GHz band

In order to further investigate the impact of RLANs on the operation of public transport automation systems, the following scenarios were identified:

- Scenario A (inside and outside subway tunnels) a passenger, on board a train, is using his mobile phone as a wireless access to bridge his PC to the MFCN. In this configuration the mobile phone transmits over wifi at 5.8 GHz, to the PC of the passenger. This scenario has already been identified as a real interference scenario, in other bands, for communications on board of trains. The situation is particularly prone to interference, considering that attenuation from inside the train to outside it, where the antenna of the automation systems is located, is estimated to be around 20 dB only.

- Scenario B (outside subway tunnels): a RLAN access point (i.e. at a fixed location) is installed in proximity of the fixed infrastructure antenna of the public transport automation system.
- Scenario C (outside subway tunnels r): a train moves, on a rail in an open area. The rail is surrounded by buildings, where RLANs are operated.

Further work is therefore needed to further investigate these or other scenarios.

13.2 FSS (EARTH TO SPACE) IN THE BAND 5725 - 5925 MHz

Conclusions on the potential for RLAN–FSS sharing will be developed in the Part 2 Report, taking into account additional considerations, such as:

- Antenna discrimination for outdoor RLANs;
- Further studies on polarisation mismatch;
- Studies supporting Stage 8 of FSS Step 2 (see section 8.1.3.4);
- 5 GHz Spectrum Factor (Stage 5 of FSS Step 2);
- Control / monitoring on the long term aggregate effect of RLAN interference into FSS as RLAN deployment increases and investigation of what can be done in a scenario where the interference threshold is reached;
- Further studies on apportionment of the FSS protection criteria.

Some potential mitigation techniques may need to be considered and their impact on the potential sharing between RLAN and FSS should be assessed. Among others, the following potential mitigation techniques could be addressed:

- RLAN Access Points deployed only indoor;
- Additional power limitation for RLAN.

There is a need for studies on the feasibility and practicability on the potential mitigation techniques.

13.3 ADJACENT BAND COMPATIBILITY BETWEEN RLAN AND THE FSS ABOVE 5925 MHz

Studies are needed in order to assess the adjacent band compatibility between RLAN and the FSS above 5925 MHz.

13.4 ADJACENT BAND COMPATIBILITY BETWEEN RLAN AND THE FS ABOVE 5925 MHz

Studies are needed in order to assess the adjacent band compatibility between RLAN and the FS above 5925 MHz.

13.5 BROADBAND FIXED WIRELESS ACCESS (BFWA) SYSTEMS

- In MCL calculations, analyse the actual effects of a protection corresponding to I/N level of -6 dB being reached due to intermittent interference.
- Continue the study of mitigation techniques to enable the coexistence between RLAN and BFWA, such as:
  - Further investigation of detection mechanisms relying on energy detection, including their feasibility;
  - Further work in order to investigate more specific coexistence mechanisms between RLAN and BFWA systems using TDD technology, noting that these sensing procedures may not apply to FDD BFWA systems.
- Further consideration to time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment.

13.6 NON-SPECIFIC SHORT RANGE DEVICES IN THE BAND 5725-5875 MHZ :

Further studies are needed in order to assess the compatibility between RLAN and short range devices in the band 5725-5875 MHz.

13.6.1 Interference from RLAN into non-specific Short Range Devices in the band 5725-5875 MHz

It should be noted that SRDs operating in 5.8 GHz band can use large bandwidths with no duty cycle restrictions at with a max e.i.r.p. of 25 mW e.i.r.p. In addition there are no requirements for SRDs to employ mitigation techniques to help intra and/or inter band sharing. Evidence suggests that the usage of these SRDs is widespread in the 5.8 GHz band for applications such as outdoor/indoor alarm-security microwave sensors, outdoor/indoor security wireless CCTV cameras and professional/consumer use of video cameras.

13.6.2 Interference from non-specific Short Range Devices into RLAN in the band 5725-5875 MHz

Studies are needed in order to assess the interference from non-specific short range devices into RLAN in the band 5725-5875 MHz.

13.7 AMATEUR (5725-5850 MHZ) AND AMATEUR SATELLITE (SPACE TO EARTH, 5830-5850 MHZ) SERVICES

Detail studies have not been performed so far. However some preliminary consideration of the three main categories of radio amateur usage (narrowband, data and amateur satellite) for both directions has been made, which may provide guidance for future work (along with ECC Report 206 [26]). This includes an initial identification of relevant mitigation techniques.

Whilst some scenarios and directions may require further study, it has already been found that compatibility is achieved between Amateur Satellite downlink transmissions and RLAN receivers.

13.8 INTERFERENCE FROM ISM DEVICES INTO RLAN

This band is designated for the use of Industrial Scientific and Medical devices according to the ITU-R regulations. Therefore the impact of these devices into RLAN needs to be taken into account.

13.9 OTHER AREAS FOR FURTHER WORK

This Report is mainly based on RLAN characteristics derived from 802.11ac. Other RLAN technologies like LAA-LTE are currently under consideration.

Although all RLAN technologies will have to comply with the same harmonized standard and spectrum regulations (i.e. both systems are expected to share certain characteristics), the assumptions regarding user density, indoor/outdoor usage, amount of traffic etc. may be different for LAA-LTE [41] or any other RLAN technologies and deployments compared to the current assumptions used in this report.

Studies of possible impact of LAA-LTE or any other RLAN technologies and deployments, other than the studies carried out so far with RLAN based on 802.11ac, have not been assessed yet. It is intended that studies of such an impact are to be conducted in the subsequent report.

14 CONCLUSIONS

This ECC Report contains compatibility studies related to WAS/RLANs in the 5725-5925 MHz band. These have been triggered by the EC Mandate on 5 GHz [1] and by the activities on WRC-15 Agenda Item 1.1.

The current status of the various sharing and compatibility studies is summarised hereafter:

Compatibility between RLAN and ITS in the bands 5855-5875 MHz (non-safety ITS), 5875-5905 MHz (safety-related ITS) and 5905-5925 MHz (ITS extension band)

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances if compatibility is dependent upon protection to an I/N level of -6 dB. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated to improve the compatibility between individual RLAN devices and ITS. These studies have focussed on a “listen-before-talk” process, where the potential interferer tries to detect whether a channel is busy before transmitting a data packet.

Two possible approaches are under study:

- Generic Energy Detection without any consideration of the interferer and victim signal frames: Under the assumptions considered, preliminary studies show that in the case of an energy detection threshold of -90dBm/10MHz for a RLAN system operating with 23 dBm/20MHz, an ITS device with 23dBm/10MHz is not reliably to be detected. Further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation.
- Combination of energy detection and carrier sensing, such as one of the Clear Channel Assessment (CCA) modes defined in the 802.11 standard. Further study is required to assess the applicability to ITS of the interference avoidance techniques currently employed in 5 GHz RLAN systems.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered and may be an issue for further work.

Compatibility between RLAN and road tolling in the band 5795-5815 MHz

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances if compatibility is dependent upon protection to an I/N level of -6 dB. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated and the following approaches have been suggested to enable the coexistence between RLAN and road-tolling:

- Implementation in RLAN of a detection mechanism to detect road tolling applications based on energy detection. Under the assumptions considered preliminary analysis indicated that for a RLAN system operating with 23 dBm/20MHz a detection threshold of the order of -100 dBm/500kHz and for a RLAN system with 23 dBm/160MHz a detection threshold of the order of -90 dBm/500kHz would be required for a reliable detection of road tolling. Further consideration is required, including on the feasibility of such a detection threshold and its impact on the RLAN operation.
- Transmission from the road tolling applications of predefined signals (beacons) which indicate that the used channels are busy, similar to one of the mitigation techniques used to facilitate ITS and Road Tolling adjacent channel co-existence
- Ensure coexistence with the road tolling systems through the detection of ITS. This is based on the assumption that there will always be ITS systems in the close vicinity of road-tolling road-side units. Under this approach, once ITS have been detected by RLAN under the conditions described in section 2, the road tolling frequency band 5795-5805/5805-5815 MHz will also be considered as occupied and thus, not available for RLAN use.

- Use of a geolocation database approach. The geolocation database should hold actual information from static and, due to construction sites, temporary tolling installations. The implementation of such a platform, its access and, its maintenance should be addressed. In addition, the role and responsibilities or the stakeholders have to be clearly defined.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered.

Further work is required to assess these approaches.

Compatibility between RLAN and public transport automation systems in the 5.915-5.935 GHz band

Preliminary calculations have been performed. They would need to be reviewed in the light of the recent developments in ETSI towards a new SRDoc applicable to these systems.

Compatibility between RLAN and FSS (Earth to space) in the bands 5725-5850 and 5850-5925 MHz

The studies have focused on the assessment of the interference from RLAN into FSS and follow a two-step approach:

- **Step 1** is described in section 8.1.2: This step calculates the maximum number of active, on-tune, RLAN transmitters that can be accommodated by the satellite receiver under consideration (see Table 11) (considering the satellite footprint) whilst satisfying the FSS protection criteria described in section 3.2.2.
- **Step 2** is described in section 8.1.3: This step delivers the number of active, on-tune, RLAN transmitters using a deployment model. The Step 2 outputs can be compared with the Step 1 values in order to assess the potential for sharing. In theory, if the Step 2 values are less than or equal to the Step 1 values, then the results suggest that sharing is possible; else if the Step 2 values are greater than the Step 1 values, sharing is not possible.

Concerning step 1, results have been obtained considering 2 different values of building attenuation for indoor use (12 and 17 dB), two values of antenna discrimination (0 and 4 dB), and an approach to service and geographic apportionment of the FSS protection criteria of $\Delta T/T=6\%$.

Further modelling takes account of clutter loss and polarisation mismatch loss on the Earth to space interference path.

The different factors used in step 2 are subject to some uncertainties because of the difficulties involved when deriving values for these factors and in particular when making predictions for 2025. Therefore it was agreed to preform sensitivity analyses, taking into account ranges of values for some of these factors.

Calculations and results are presented in this report but, although providing some relevant results, it is at this stage too early to draw definite conclusions.

Conclusions on the potential for RLAN–FSS sharing will be developed in the Part 2 Report, taking into account additional considerations, such as:

- Antenna discrimination for outdoor RLANs;
- Further studies on polarisation mismatch;
- Studies supporting Stage 8 of FSS Step 2 (see section 8.1.3.4);
- 5 GHz Spectrum Factor (Stage 5 of FSS Step 2);
- Control / monitoring on the long term aggregate effect of RLAN interference into FSS as RLAN deployment increases and investigation of what can be done in a scenario where the interference threshold is reached;
- Further studies on apportionment of the FSS protection criteria.

Some potential mitigation techniques may need to be considered and their impact on the potential sharing between RLAN and FSS should be assessed. Among others, the following potential mitigation techniques could be addressed:

- RLAN Access Points deployed only indoor;
- Additional power limitation for RLAN.

There is a need for studies on the feasibility and practicability on the potential mitigation techniques.

There has been no study on the interference from FSS into RLAN.

Compatibility between RLAN and BFWA (FS) in the band 5725-5875 MHz

MCL calculations for both directions of interference have been performed and showed the need for significant separation distances. No studies have been conducted to analyse the actual effects of this I/N level being reached due to intermittent interference.

As a result, work on mitigation techniques has been initiated. Preliminary analysis on detection mechanisms relying on energy detection indicated that a detection threshold of the order of -90 to -95 dBm/20 MHz would be required either on the RLAN side or on the BFWA side. Further consideration is required, including on the feasibility of such detection thresholds.

Due to the similarity between RLAN and BFWA systems using TDD technology, it is also envisaged that more specific coexistence mechanisms may be relevant. This requires further work.

The above considerations on sensing procedures may not apply to FDD BFWA systems.

It has to be noted that time domain effects in regard to sensing procedures (e.g. listening time, dead time) or the effect of RLAN network deployments on POD (Probability Of Detection) and the associated aggregate interference environment have not yet been considered and may be an issue for further work.

Compatibility between RLAN and the Amateur (5725-5850 MHz) and Amateur satellite (space to Earth, 5830-5850 MHz) services.

Detail studies have not been performed so far. However some preliminary consideration of the three main categories of radio amateur usage (narrowband, data and amateur satellite) for both directions has been made that may provide guidance for future work (along with ECC Report 206 [26]. This includes an initial identification of relevant mitigation techniques.

Whilst some scenarios and directions may require further study, it has already been found that compatibility is achieved between Amateur Satellite downlink transmissions and RLAN receivers

Compatibility between RLAN and Broadband Direct air to ground communications (BDA2GC) in the frequency range 5855-5875 MHz

A series of compatibility analyses between RLAN and DA2GC have been presented. Studies were performed in respect of the two proposed BDA2GC systems described in ETSI TR 101 599 [24] and ETSI TR 103 108 [25] and were based on commonly agreed assumptions regarding RLAN parameters, distribution densities and activity factors.

Co-channel interference analyses were performed considering the RLANs both as victims and as interferers. The scenarios included consideration of interference to/from DA2GC Aircraft Stations and Ground Stations.

Compatibility is clearly achieved in all scenarios when considering indoor RLANs. For some scenarios involving outdoor RLANs, worst-case Minimum Coupling Loss calculations show that some exceedances of the RLAN or DA2GC receiver protection criteria could potentially occur. However, compatibility is achieved, when taking into account a number of well-defined ameliorating factors such as separation distances, density of active co-frequency RLAN devices, clutter loss, use of power control and antenna discrimination.

It is observed that the outdoor rural RLAN scenarios are the most demanding but the probability of their occurrence is small.

It should be noted that the studies in this section assumed free space loss propagation conditions with clutter loss according to Recommendation ITU-R P.452 [19]. The clutter loss has been used for the studies between DA2GC GS and RLAN for all scenarios including the rural environment with about 15 dB clutter loss. Under worst case conditions, there could be line of sight between victim and interferer without any clutter, especially in rural environments, which would increase the separation distances. However, the probability is expected to be low.

Compatibility between RLAN and Wireless Industrial Applications (WIA) in the band 5725-5875 MHz

The MCL calculations lead to significant separation distances, in particular in the cases where both systems operate without wall or building separation.

Nevertheless, compatibility can be achieved through a coordination procedure within factory premises where WIA are deployed, taking into account that:

- It is expected that the operation of wireless devices (including WIA and RLAN) within the industrial premises would be controlled by the factory management;
- Frequency separation can be applied considering that frequencies outside the 5725-5875 MHz band are available for RLAN;
- The sharing scenarios addressed in this section may benefit from the implementation in WIA of mitigation techniques as described in ECC Report 206 [26]. For example, a detect-and-avoid mechanism is required in WIA for the compatibility between WIA and BFWA.

Issues for further work:

This Report is mainly based on RLAN characteristics derived from 802.11ac. Other RLAN technologies like LAA-LTE are currently under consideration.

Although all RLAN technologies will have to comply with the same harmonised standard and spectrum regulations (i.e. both systems are expected to share certain characteristics), the assumptions regarding user density, indoor/outdoor usage, amount of traffic etc. may be different for LAA-LTE [41] or any other RLAN technologies and deployments compared to the current assumptions used in this report.

Studies of possible impact of LAA-LTE or any other RLAN technologies and deployments, other than the studies carried out so far with RLAN based on 802.11ac, have not been assessed yet. It is intended that studies of such an impact are to be conducted in the subsequent report.

Further studies are also needed for:

- Compatibility between RLAN and non-specific Short range devices in the band 5725-5875 MHz;
- Compatibility between RLAN and the Amateur (5725-5850 MHz) and Amateur Satellite (Space to Earth, 5830-5850 MHz) services;
- Adjacent band compatibility between RLAN on one hand and the FS and FSS above 5925 MHz, on the other hand.

ANNEX 1: ITS TECHNICAL CHARACTERISTICS

Table 86: System parameter of ITS

Parameter	Value	Comments
Frequency stability	10 ppm	According to ETSI EN 302 571 V1.2.2 (2011-10)
Maximum radiated power (e.i.r.p.)	Channel 5860, 5910 and 5920MHz: 0 dBm, -10 dBm/MHz. Channel 5870 and 5890 MHz: 23 dBm, 13 dBm/MHz. Channel 5880 and 5900 MHz: 33 dBm, 23 dBm/MHz	According to ETSI EN 302 571 V1.2.2 (2011-10) and ETSI EN 302 663 V1.3.1 (2012-06) There are no equipment classes anymore. There are different power limits for different channels with highest allowed power for the most critical channels. See Figure 43
Antenna beam shape/gain	For RSU and OBU use antenna model ITU-R F.1336-3 with parameters G0 5 dB, k 1.2, max gain in +10 deg elevation	See Figure 44 and Equation 7. In ECC Report 101 there were 2 possible antennas, one very directional and one omnidirectional ITU-R F.1336-1. However ITS systems development shows that the omnidirectional will be the dominant type and therefore only this should be used in these compatibility studies. There is a new version of model ITU-R F.1336-3 which should be used. Both versions 1 and 3 results in exactly the same antenna performance with these parameter settings
Polarisation	Vertical linear	The antenna performance is not described in ETSI ITS however the vertical linear polarisation is dominant
Modulation scheme	BPSK QPSK 16QAM 64QAM	According to ETSI EN 302 571 V1.2.1 (2013-09) and ETSI EN 302 663 V1.2.1 (2013-07)
Data rates	3/4.5 /6/9/12/18 /24/27 Mbit/s Mandatory: 3/6/12 Mbit/s	According to ETSI EN 302 571 V1.2.1 (2013-09) and ETSI EN 302 663 V1.2.1 (2013-07)
Channel Bandwidth	10 MHz	According to ETSI EN 302 571 V1.2.1 (2013-09) and ETSI EN 302 663 V1.2.1 (2013-07)
Communication mode	Half-duplex, broadcast	Half-duplex and broadcast are believed to be adequate for the applications considered to date
Receiver noise power	-100 dBm	Typical performance, same value is used with the RLAN technology
Receiver sensitivity	-92dBm/MHz	Based on -82 dBm for a bandwidth of 10 MHz. ETSI EN 302 571 V1.2.1 (2013-09) specifies minimum required sensitivity
Protection criterion	I/N=-6 dB	The three ITS-G5A channels (5880, 5890 and 5900 MHz) are decided by the European Commission to be used for road safety communication and therefore additional care should be given for the protection of these channels

Communication channels will be open for the applications within the respective usage category (either road safety related or not, i.e. used for traffic management).

The required power levels (e.i.r.p.) range from 3 dBm to 33 dBm to achieve communication distances of up to 1000 m.

To avoid collisions of radio messages in areas with a lot of vehicles, a mechanism DCC (dynamic congestion control) in ITS radios will when necessary reduce the output power and the available time to transmit.

There is a mechanism in ITS radios which will reduce the output power or available time to transmit when the radios are close to 5.8 GHz RTTT road tolling stations.

Unwanted emission levels are given by to ETSI EN 302 571 V1.2.2 (2011-10) [28] for the out of band domain and SM.329 [29] and ERC/REC 74-01 [30] for the spurious domain.

Table 87: Transmitter unwanted emission limits inside the 5 GHz ITS bands (e.i.r.p.)

Power spectral density at the carrier center fc (dBm/MHz)	±4,5 MHz Offset (dBm/MHz)	±5,0 MHz Offset (dBm/MHz)	±5,5 MHz Offset (dBm/MHz)	±10 MHz Offset (dBm/MHz)	±15 MHz Offset (dBm/MHz)
23	23	-3	-9	-17	-27
The limits are reduced by 10 dB for the 5870 and 5890 channels and by 33 dB for 5860, 5910 and 5920 channels.					

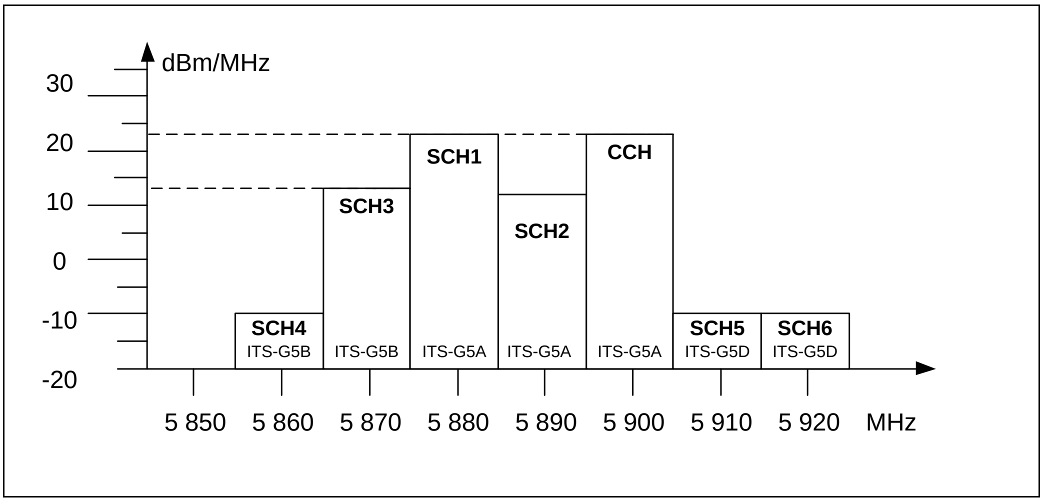


Figure 43: Maximum limit of mean spectral power density for each channel type in ITS-G5A, ITS-G5B, and ITS-G5D

Table 88: Minimum required receiver sensitivity; receivers will have up to 10 dB better sensitivity

Modulation	Coding rate	Minimum sensitivity (dBm)
BPSK	1/2	–85
BPSK	3/4	–84
QPSK	1/2	–82
QPSK	3/4	–80
16-QAM	1/2	–77
16-QAM	3/4	–73
64-QAM	2/3	–69
64-QAM	3/4	–68

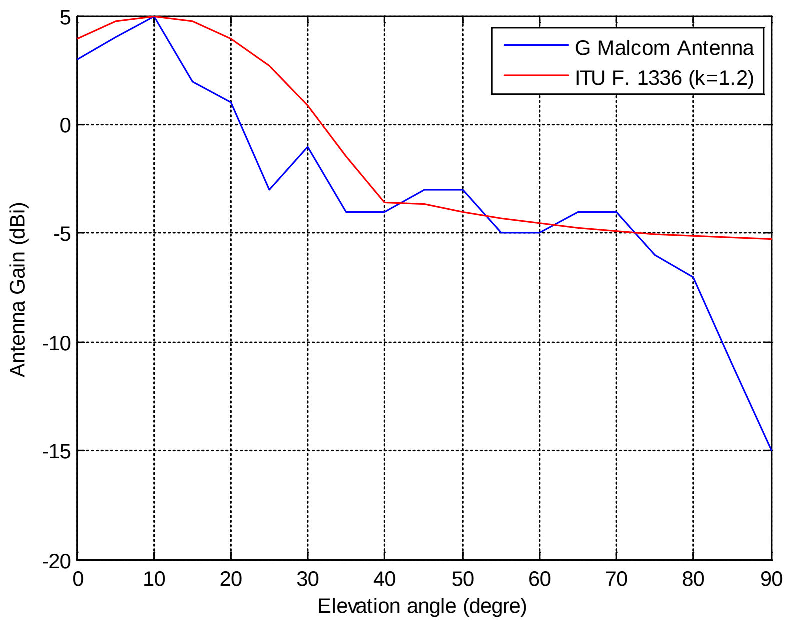


Figure 44: OBU and RSU antenna pattern

$$G(\theta) = \begin{cases} G_0 - 12\left(\dfrac{\theta}{\theta_3}\right)^2 & \text{for} \quad 0 \leq |\theta| < \theta_4 \\ G_0 - 12 + 10\log(k+1) & \text{for} \quad \theta_4 \leq |\theta| < \theta_3 \\ G_0 - 12 + 10\log\left[\left(\dfrac{|\theta|}{\theta_3}\right)^{-1.5} + k\right] & \text{for} \quad \theta_3 \leq |\theta| \leq 90° \end{cases} \quad (1a)$$

with:

$$\theta_3 = 107.6 \times 10^{-0.1 G_0} \tag{1b}$$

$$\theta_4 = \theta_3 \sqrt{1 - \frac{1}{1.2} \log(k+1)} \tag{1c}$$

where:

G(θ) : gain relative to an isotropic antenna (dBi)

G0 : the maximum gain in the azimuth plane (dBi)

θ : elevation angle relative to the angle of the maximum gain (degrees) (–90°≤ θ ≤ 90°)

θ3 : the 3 dB beamwidth in the elevation plane (degrees)

k: parameter which accounts for increased side-lobe levels above what would be expected for an antenna with improved side-lobe performance

Equation 7: Antenna model ITU-R F.1336-3 [31]**; use G0 5 dB, k=1.2, max gain in +10 deg elevation**

Regarding coexistence studies where these systems are potentially victims of interference from other systems, representative receivers have been used as follows:

In the case of ITS the RSU is considered to point towards the ground from an elevated position whereas the OBU uses an aerial that is omnidirectional in the horizontal plane and has some directivity in the vertical plane. The most susceptible of these is the vehicular unit.

ANNEX 2: ROAD-TOLLING TECHNICAL PARAMETERS

The regulatory parameters (maximum power levels) for road-tolling systems are given in Annex 5 of ERC/REC 70-03 [15]. The parameters used in this Report are taken from the EN 300 674 [16] developed by ETSI and the EN 12253 [17] developed by CENELEC. It should be noted that the EN 300 674 deals with both Road Side Units (RSU) and On-Board Units (OBU) and is divided in two parts, the part 1 providing general characteristics and test methods, the part 2 containing the essential requirements under article 3.2 of the R&TTE Directive .

Table 89: Summary of characteristics of the road-tolling systems

	Road Side Units	On Board Units
Frequency range (MHz)	5795 and 5815	
e.i.r.p.	2 W (33 dBm) standard for -35° ≤ θ ≤ 35° 18 dBm for θ > 35° 8 W (39 dBm) optional	Maximum re-radiated sub-carrier e.i.r.p.: -24 dBm (Medium data rate) -14 dBm (High data rate)
Antenna gain	10 – 20 dB (assumed front-to-back ratio of 15 dB)	1 – 10 dB (assumed front-to-back ratio of 5 dB)
Transmitter Bandwidth	1 MHz	500 kHz
Receiver bandwidth	500 kHz	200 MHz – 1.4 GHz (not used)
Polarisation	left circular	left circular
Receiver sensitivity (at the receiver input)	-104 dBm (BPSK)	-60 dBm
Receiver noise power (at the receiver input)	-115 dBm	
Co-channel C/N (dB)	6 for 2-PSK, 9 for 4-PSK, 12 for 8-PSK	Not defined
I/N (dB)	-6	

The following figure depicts the road-tolling frequency utilisation for 1.5 MHz sub-carrier frequency, according the EN 300 674 [16]. The location of downlink channels from RSU to OBU and the location of uplink channels from OBU to RSU become visible.

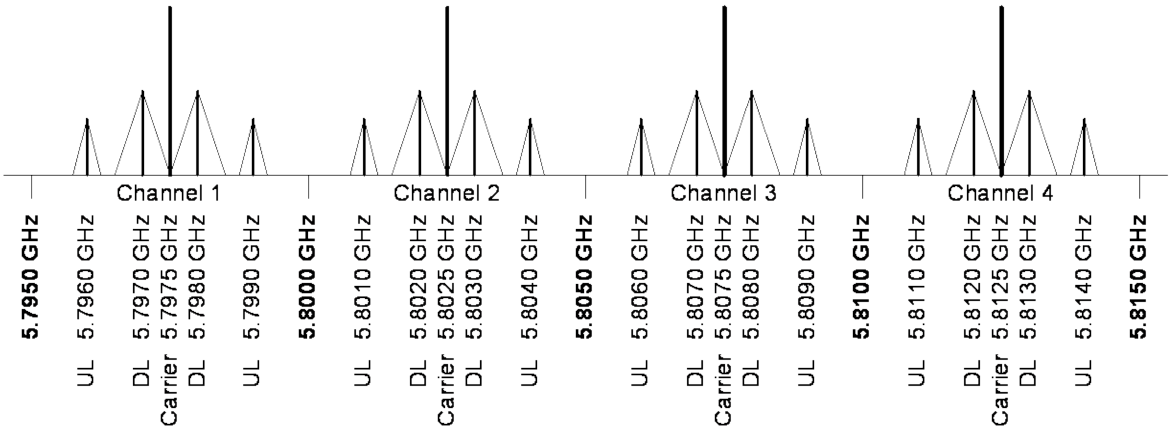


Figure 45: road-tolling systems frequency utilisation for 1.5 MHz sub-carrier frequency, according the ETSI EN 300 674

The transmit power limits of road-tolling downlink, uplink and out of band emissions are depicted in the following Figure.

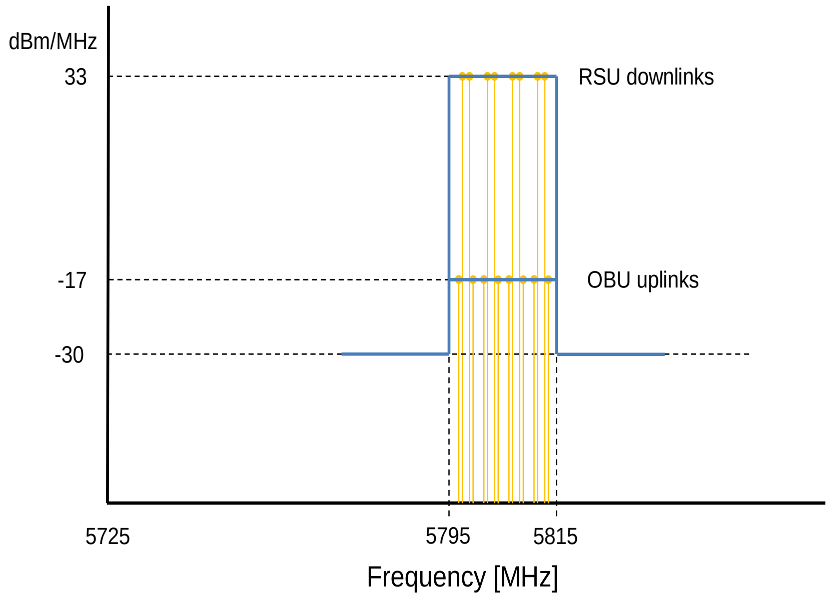


Figure 46: e.i.r.p. limits of road-tolling

Characteristics of the road-tolling antennas in RSU (Road Side Unit) and OBU (On Board Unit):

- Main lobe to communication zone (see Fig. 45), gain RX antennas;
  - RSU: 13 dBi left circular (10 dBi vert. lin.) (RX antenna uplink (OBU to RSU);
  - OBU: 8 dBi left circular (5 dBi vert. lin.) (RX antenna downlink (RSU to OBU).

- Antenna side lobe suppression in horizontal plane (RSU to/from interferer) see Figure 47: (Figures given are the difference in gain between main lobe and horizontal direction);
  - -15 dB: RX antenna uplink (Interferer to RSU);
  - -25 dB: TX antenna downlink (RSU to Interferer).

- Antenna polarisation;
  - Left-circular.

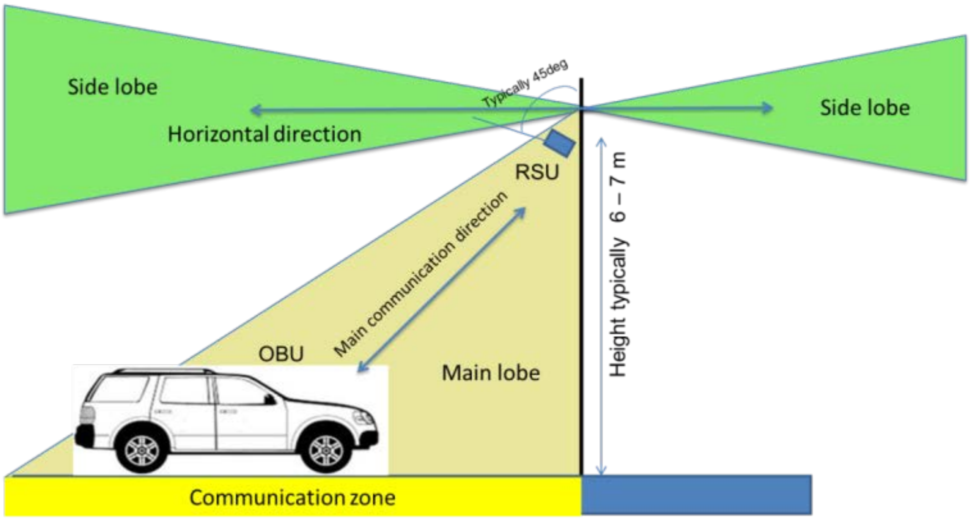


Figure 47: antenna configuration for road-tolling

In Italy a special version of TTT is used, defined in ETSI ES 200 674-1 V2.4.1 (2013-05) [32]. Interference effects of 5 GHz RLAN on this type of TTT system has not been considered yet, and may also need to be included in future analyses.

ANNEX 3: TECHNICAL CHARACTERISTICS OF BROADBAND DIRECT AIR TO GROUND COMMUNICATIONS (BDA2GC) SYSTEMS

The technical parameters of the DA2GC systems described in ECC Report 210 [23] were used as a basis for the calculations, considering the two following potential BDA2GC systems:

- Section 4.2 of ECC Report 210 describes the technical parameters of the DA2GC system according to ETSI TR 101 599 [24].
- Section 4.3 of ECC Report 210 describes the technical parameters of the DA2GC system according to ETSI TR 103 108 [25].

A3.1 DA2GC SYSTEM ACCORDING TO ETSI TR 101 599

A detailed description of the beamforming DA2GC system (ETSI TR 101 599) can be found in ECC Report 210. The following tables and figures provide the essential technical parameters for use in the compatibility studies considered in this current report.

Table 90: DA2GC Transmitter characteristics (GS and AS, ETSI TR 101 599 [24])

Parameter	Unit	Value GS	Value AS
Channel bandwidth	MHz	20	20
Transmitter maximum output power	dBm	24.3	28
Max. antenna gain	dBi	23 (Antenna array)	17
Transmitter maximum e.i.r.p. (Note)	dBm/MHz	32 (boresight)	32
Antenna height	m	20 (nominal)	3000-10000

Note: calculations in the Report also take into account, when relevant, the use of power control. See ECC Report 210 for details.

Table 91: Receiver characteristics (GS and AS, ETSI TR 101 599 [24])

Parameter	Unit	Value
Bandwidth	MHz	20 MHz
Receiver sensitivity	dBm	-87
Thermal Noise level (290K)	dBm/MHz	-110
Receiver noise figure	dB	4.0
Receiver thermal noise level	dBm	-97
Interference protection ratio (I/N)	dB	-6
Interference protection level	dBm	-103
Interference protection level	dBm/MHz	-116

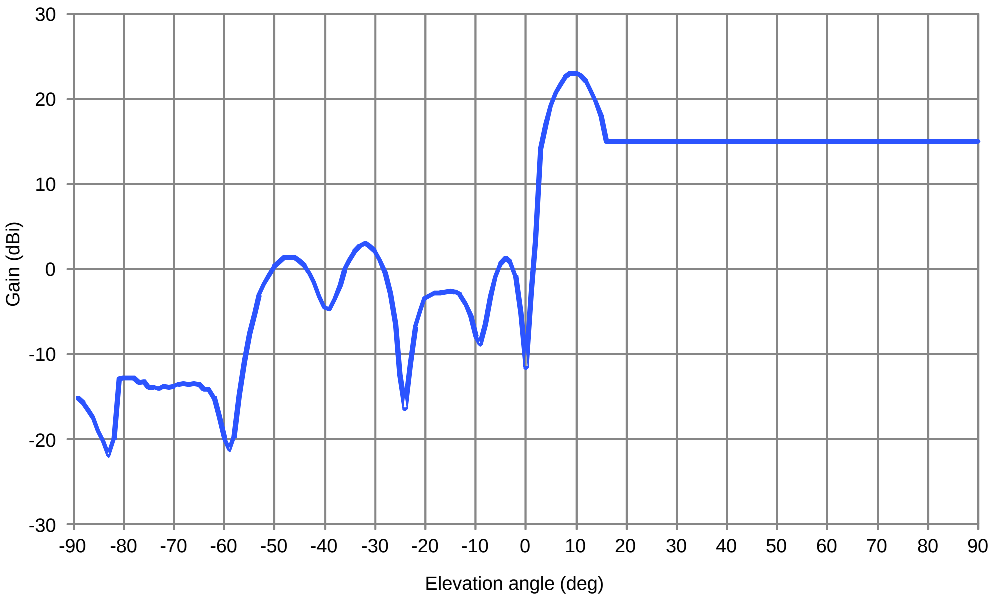


Figure 48: Ground Station antenna elevation pattern (ETSI TR 101 599 [24])

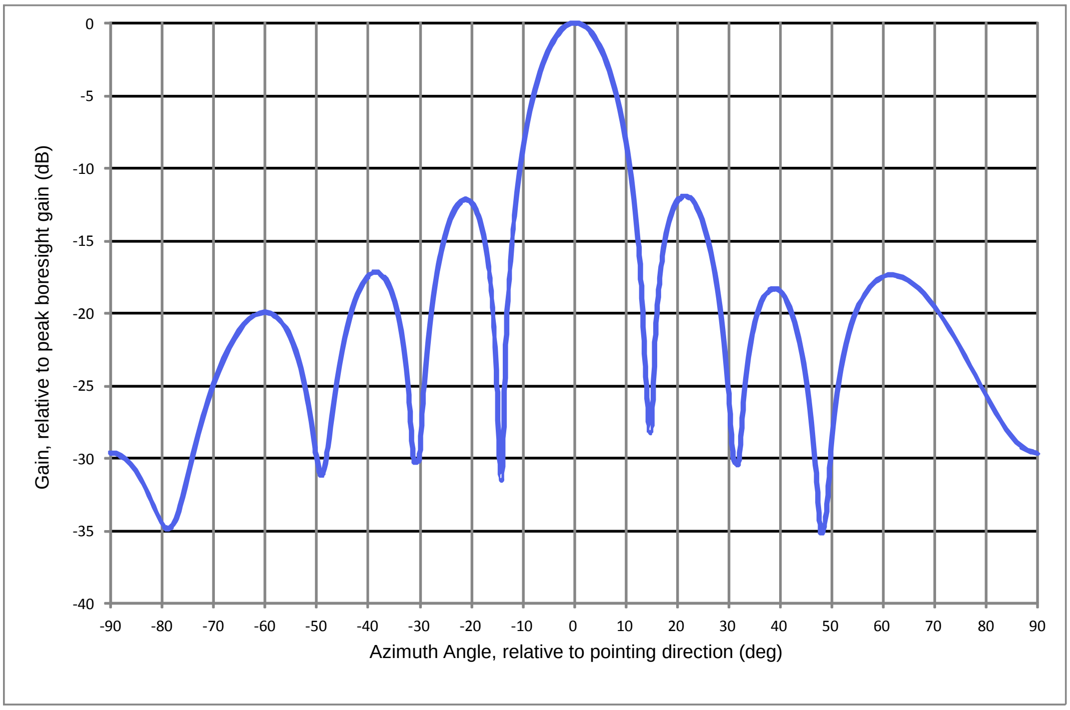


Figure 49: Ground Station antenna azimuth pattern (ETSI TR 101 599)

The Ground Station antenna has a fixed beamforming pattern in the vertical plane, but is designed to use dynamic beamforming in azimuth so that aircraft can be tracked during flight. The resulting ground station antenna gain in any given pointing direction is the sum of the relevant elevation and azimuth gains shown in Figure 48 and Figure 49 respectively.

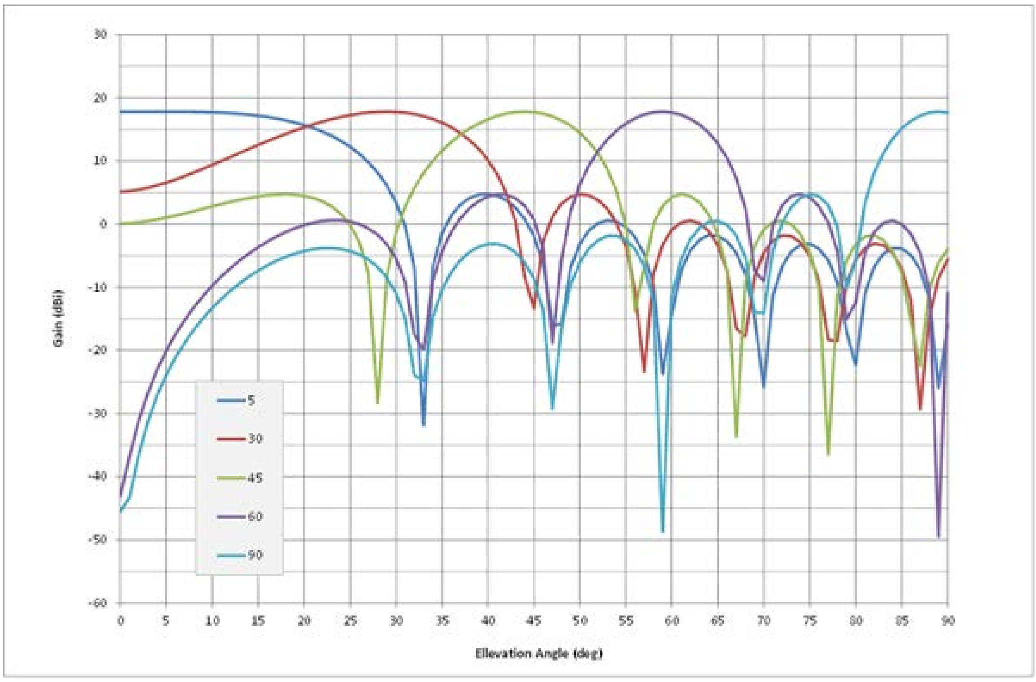


Figure 50: Aircraft Station antenna elevation patterns (ETSI TR 101 599 [24])

The beam produced by the aircraft antenna array is steered in both azimuth and elevation so that the main lobe tracks the ground station as the aircraft traverses its flight path. Figure 50 contains just a sample of the aircraft antenna elevation patterns for selected beam pointing directions.

Note that, in the above plots, an elevation angle of 0 degrees represents the horizon pointing direction and 90 degrees is straight down. Each pointing direction is represented by a different coloured plot.

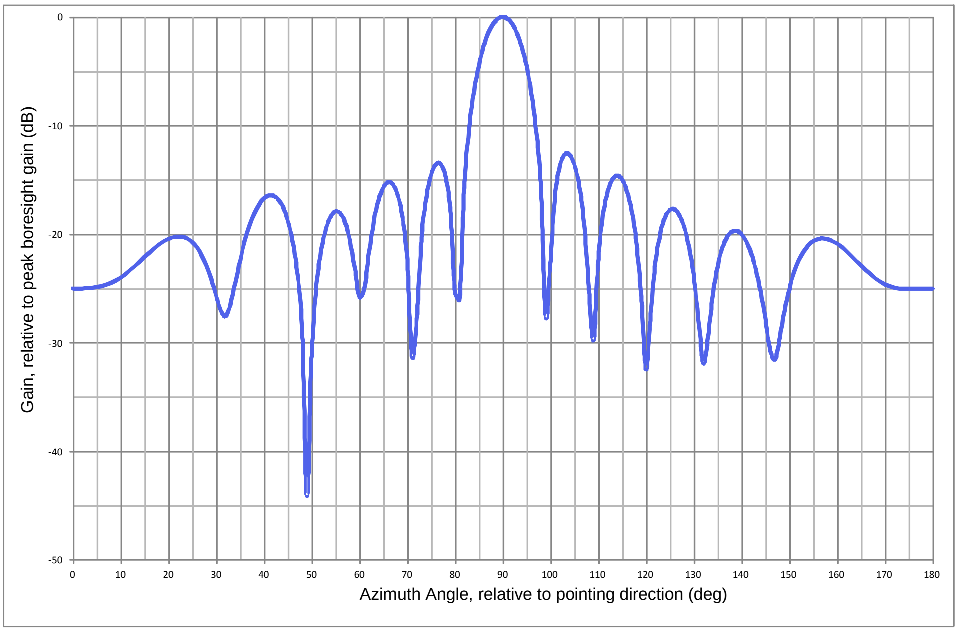


Figure 51: Aircraft Station antenna azimuth pattern (ETSI TR 101 599)

The resulting aircraft station antenna gain for any given pointing direction is the sum of the relevant elevation and azimuth gains shown in Figure 50 and Figure 51 respectively.

A3.2 DA2GC SYSTEM ACCORDING TO ETSI TR 103 108

Detailed information can be found in ECC Report 210 [23]. The following tables provide technical parameters of DA2GC (ETSI TR 103 108 [25]) for use in sharing studies.

Table 92: DA2GC Transmitter characteristics (ETSI TR 103 108)

Parameter	Unit	Value GS	Value AS
Channel bandwidth	MHz	5 or 10	
Transmitter maximum output power	dBm	38 (10 MHz channel) 35 (5 MHz channel)	36 (10 MHz channel) 33 (5 MHz channel)
Transmitter feeder loss	dB	2	4
Max. antenna gain	dBi	15 (Sector Antenna) 24 (Directional Antenna , Note 1)	7
Transmitter maximum e.i.r.p	dBm/MHz	41 (Sector Antenna) 50 (Directional Antenna)	29
Antenna up-tilt (GS – Sector Antenna)	deg.	6 (Sector Antenna) 3 (Directional Antenna)	
GS antenna height	m	10 – 50 (Note 2)	
Estimated number of stations across Europe		230	

Note 1: The directional antenna will only be used where maximum range is required. This will be mainly over sea. To protect any systems located near the coast, the main beam shall not illuminate any landfall within 4 km. The directional antenna may be used in remote areas, such as desert regions, subject to agreement by the regulatory administration(s).

Note 2: The preferred ground station antenna location is on the roof of a tall building resulting in a height of 50 metres or more. However remote locations could result in lower antenna heights.

Table 93: Receiver characteristics (ETSI TR 103 108)

Parameter	Unit	Value
Bandwidth	MHz	5 or 10
Thermal noise power density	dBm/MHz	-114
Thermal Noise floor	dBm	-107 (5 MHz channel) -104 (10 MHz channel)
Receiver noise figure	dB	2.5
Receiver thermal noise level	dBm	-104.5 (5 MHz channel) -101.5 (10 MHz channel)
Interference protection ratio (I/N)	dB	-6
Interference protection level	dBm	-110.5 (5 MHz channel) -107.5 (10 MHz channel)
Interference protection level	dBm/MHz	-117.5
Receiver adjacent channel selectivity (ACS)	dB	36 (5 MHz channel) 33 (10 MHz channel)

Table 94: DA2GC Antenna Parameters (ETSI TR 103 108 [25])

Parameter	Unit	Value
Max antenna gain (AS)	dBi	7
Max antenna gain (GS Omni)	dBi	7
GS omni antenna up-tilt	degrees	15
Max antenna gain (GS Sector) (Note 1)	dBi	15
GS sector antenna up-tilt	degrees	6
Max antenna gain (GS Directional)	dBi	24
GS directional antenna up-tilt	degrees	3

Note 1: It is expected that the sector antenna case for GS will be the predominant one.

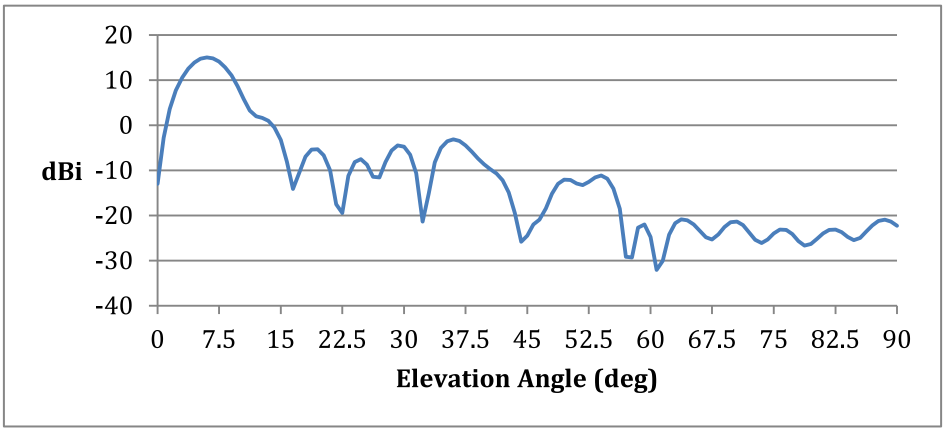


Figure 52: Ground Station Elevation Pattern for Sector Antenna (ETSI TR 103 108)

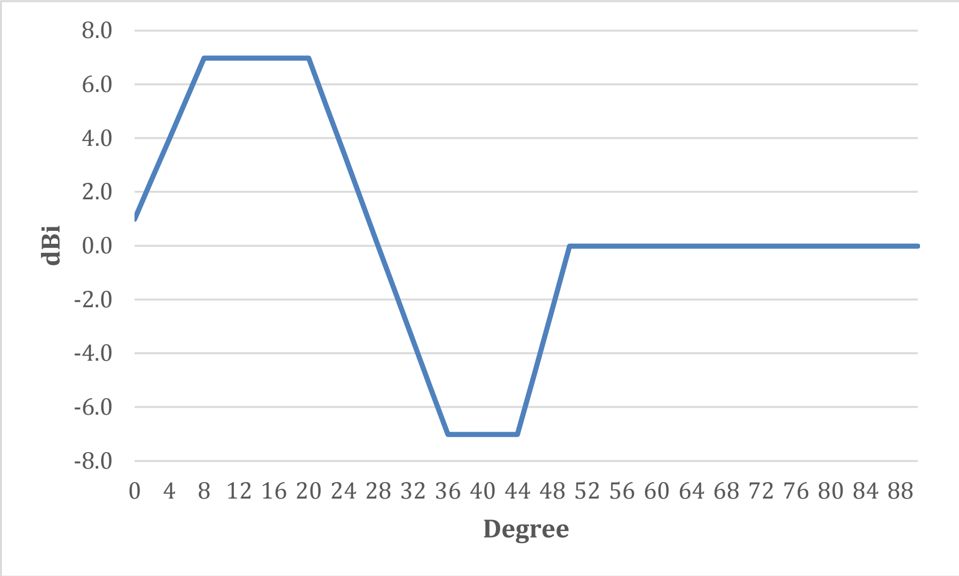


Figure 53: Aircraft Station Antenna Elevation Pattern (ETSI TR 103 108)

ANNEX 4: AGGREGATED CALCULATIONS FOR DA2GC SYSTEMS

A4.1 DA2GC ACCORDING TO ETSI TR 103 308 [25]

The first step was to calculate the maximum number of co-channel active RLANS based on information given in section 11. The result is shown in the table below:

Table 95: Number of Co-channel Active RLANS

Active device density per bandwidth	Active RLANs per Bandwidth	Available No of channels	Active device density/km^2 Urban, per BW	Active device density/km^2 Suburban per BW	Active device density/km^2 Rural, per BW	Actual Number Co-channel (Urban)	Actual Number Co-channel (Suburban)	Actual Number Co-channel (Rural)
20 MHz systems	0.1	37	19.93	3.74	0.23	42.31	63.57	13.34
40 MHz	0.25	18	49.83	9.36	0.58	217.44	326.67	68.54
80 MHz	0.5	9	99.67	18.72	1.16	869.75	1306.67	274.17
160 MHz	0.15	4	29.90	5.61	0.35	587.08	882.00	185.06
Areas			78.54	628.32	2120.58	1716.58	2578.90	541.11
Total Active RLANS	4836.59							

Next the number of the different active RLAN categories (in terms of Indoor/Outdoor, e.i.r.p. and Bandwidth) was calculated. These numbers were then used to calculate the aggregate power contribution for each category.

Now the e.i.r.p. aggregates for all indoor and all outdoor RLANS in one 30 km radius cluster were calculated as shown in the table below:

Table 96: Aggregate e.i.r.p. for a Cluster

	Total	Unit
Total Aggregate (Indoor)	38.52	dBm/MHz
Total Aggregate (Outdoor)	18.31	dBm/MHz
Total Cell Aggregate	38.56	dBm/MHz

The propagation paths and DA2GC parameters (e.g. aircraft station antenna gain) were now used to aggregate the e.i.r.p. from all visible clusters as a function of aircraft altitude. Free space loss without clutter was assumed but wall attenuation was introduced for the indoor RLANs.

$$\begin{aligned}&\text{Single Cluster Rx Power(Indoor or outdoor for every AS height and every cluster ground range: 0,60,120,180 or 240 km from AS)}\\&= \text{Single Cluster Aggregate (indoor or outdoor)} + \text{Antenna Gain(AS)} - \text{Feeder Loss(AS)} - \text{Height Mitigation(AS)} - \text{FSL}\\&- \text{Clutter} - \text{Buiding Loss(Indoor only)}\end{aligned}$$

Hence for a given Aircraft Station height (e.g. 5 km) there are 10 solutions:

Table 97: Cluster ground range in different environments

Scenario	Range (km)
Indoor	0
Indoor	60
Indoor	120
Indoor	180
Indoor	240
Outdoor	0
Outdoor	60
Outdoor	120
Outdoor	180
Outdoor	240

Finally the single cluster Rx powers for all cases are aggregated to yield the total received interference.

A4.2 DA2GC ACCORDING TO ETSI TR 101 599 [24]

This Annex contains additional parameters used in the compatibility studies between RLAN and BDA2GC in section 11, i.e. about RLAN deployment details based on RLAN cell clusters as described in section 11.1 and about clutter attenuation.

There are a number of types of RLAN in terms of power (25 mW to 1 Watt) and bandwidth (20 MHz to 160 MHz), some 24 combinations.

The DA2GC system operates in a 20 MHz bandwidth.

Corrections have been applied to represent the power falling within the DA2GC bandwidth (Spectral density correction) and RLAN power level (power correction) which allows the numbers and densities of RLAN devices to be weighted by power and bandwidth to represent an equivalent number or density of 1 Watt / 20 MHz RLAN devices.

Table 98: Number of co-channel active RLANs

	Spectral density correction (dB)		Power correction (dB)	Both corrections (dB)	U indoor	S indoor	R indoor	U outdoor	S outdoor	R outdoor	
20 MHz	0	1 W dir	0	0	0.00	0.00	0.00	0.04	0.06	0.01	
20 MHz	0	1 W omni	0	0	0.00	0.00	0.00	0.08	0.13	0.02	
20 MHz	0	200 mW	-7	-7	7.60	11.31	2.06	0.40	0.60	0.11	
20 MHz	0	80 mW	-11	-11	10.81	16.08	2.93	0.57	0.85	0.15	
20 MHz	0	50 mW	-13	-13	6.00	8.92	1.63	0.32	0.47	0.09	
20 MHz	0	25 mW	-16	-16	15.59	23.18	4.23	0.82	1.23	0.22	
40 MHz	-3	1 W dir	0	-3	0.00	0.00	0.00	0.22	0.33	0.07	
40 MHz	-3	1 W omni	0	-3	0.00	0.00	0.00	0.43	0.66	0.14	
40 MHz	-3	200 mW	-7	-10	39.11	59.06	12.72	2.06	3.12	0.67	
40 MHz	-3	80 mW	-11	-14	55.63	84.00	18.10	2.93	4.43	0.95	
40 MHz	-3	50 mW	-13	-16	30.86	46.59	10.04	1.63	2.46	0.53	
40 MHz	-3	25 mW	-16	-19	80.18	121.08	26.08	4.24	6.40	1.38	
80 MHz	-6	1 W dir	0	-6	0.00	0.00	0.00	0.87	1.31	0.28	
80 MHz	-6	1 W omni	0	-6	0.00	0.00	0.00	1.74	2.61	0.57	
80 MHz	-6	200 mW	-7	-13	156.61	234.99	50.89	8.27	12.40	2.69	
80 MHz	-6	80 mW	-11	-17	222.73	334.21	72.38	11.75	17.62	3.82	
80 MHz	-6	50 mW	-13	-19	123.55	185.38	40.15	6.53	9.79	2.12	
80 MHz	-6	25 mW	-16	-22	321.05	481.73	104.33	16.97	25.46	5.51	
160 MHz	-9	1 W dir	0	-9	0.00	0.00	0.00	0.59	0.88	0.16	
160 MHz	-9	1 W omni	0	-9	0.00	0.00	0.00	1.17	1.76	0.32	
160 MHz	-9	200 mW	-7	-16	105.68	158.34	28.63	5.58	8.36	1.51	
160 MHz	-9	80 mW	-11	-20	150.29	225.19	40.72	7.93	11.88	2.15	
160 MHz	-9	50 mW	-13	-22	83.37	124.91	22.58	4.40	6.60	1.19	
160 MHz	-9	25 mW	-16	-25	216.63	324.59	58.69	11.45	17.15	3.10	
					1625.68	2439.57	496.17	90.98	136.53	27.77	
					Number of co-channel active devices						4816.71

		U indoor	S indoor	R indoor	U outdoor	S outdoor	R outdoor	
20 MHz	1 W dir	0.00	0.00	0.00	0.04	0.06	0.01	
20 MHz	1 W omni	0.00	0.00	0.00	0.08	0.13	0.02	
20 MHz	200 mW	1.52	2.26	0.41	0.08	0.12	0.02	
20 MHz	80 mW	0.86	1.28	0.23	0.05	0.07	0.01	
20 MHz	50 mW	0.30	0.45	0.08	0.02	0.02	0.00	
20 MHz	25 mW	0.39	0.58	0.11	0.02	0.03	0.01	
40 MHz	1 W dir	0.00	0.00	0.00	0.11	0.16	0.04	
40 MHz	1 W omni	0.00	0.00	0.00	0.22	0.33	0.07	
40 MHz	200 mW	3.91	5.91	1.27	0.21	0.31	0.07	
40 MHz	80 mW	2.21	3.34	0.72	0.12	0.18	0.04	
40 MHz	50 mW	0.78	1.17	0.25	0.04	0.06	0.01	
40 MHz	25 mW	1.01	1.52	0.33	0.05	0.08	0.02	
80 MHz	1 W dir	0.00	0.00	0.00	0.22	0.33	0.07	
80 MHz	1 W omni	0.00	0.00	0.00	0.44	0.66	0.14	
80 MHz	200 mW	7.85	11.78	2.55	0.41	0.62	0.13	
80 MHz	80 mW	4.44	6.67	1.44	0.23	0.35	0.08	
80 MHz	50 mW	1.56	2.33	0.51	0.08	0.12	0.03	
80 MHz	25 mW	2.03	3.04	0.66	0.11	0.16	0.03	
160 MHz	1 W dir	0.00	0.00	0.00	0.07	0.11	0.02	
160 MHz	1 W omni	0.00	0.00	0.00	0.15	0.22	0.04	
160 MHz	200 mW	2.65	3.98	0.72	0.14	0.21	0.04	
160 MHz	80 mW	1.50	2.25	0.41	0.08	0.12	0.02	
160 MHz	50 mW	0.53	0.79	0.14	0.03	0.04	0.01	
160 MHz	25 mW	0.69	1.03	0.19	0.04	0.05	0.01	
		32.22	48.37	10.02	3.03	4.55	0.94	
		Number weighted by power and bandwidth relative to 1 W						99.14

Note: U-urban, S-suburban, R-rural

Table 99: Density of RLAN devices in DA2CG channels

	Spectral density correction (dB)		Power correction (dB)	Both corrections (dB)	U indoor	S indoor	R indoor	U outdoor	S outdoor	R outdoor
20 MHz	0	1 W dir	0	0	0.0000	0.0000	0.0000	0.0005	0.0001	0.0000
20 MHz	0	1 W omni	0	0	0.0000	0.0000	0.0000	0.0011	0.0002	0.0000
20 MHz	0	200 mW	-7	-7	0.0968	0.0180	0.0010	0.0051	0.0010	0.0001
20 MHz	0	80 mW	-11	-11	0.1377	0.0256	0.0014	0.0073	0.0014	0.0001
20 MHz	0	50 mW	-13	-13	0.0764	0.0142	0.0008	0.0040	0.0008	0.0000
20 MHz	0	25 mW	-16	-16	0.1985	0.0369	0.0020	0.0105	0.0020	0.0001
40 MHz	-3	1 W dir	0	-3	0.0000	0.0000	0.0000	0.0028	0.0005	0.0000
40 MHz	-3	1 W omni	0	-3	0.0000	0.0000	0.0000	0.0055	0.0010	0.0001
40 MHz	-3	200 mW	-7	-10	0.4980	0.0940	0.0060	0.0263	0.0050	0.0003
40 MHz	-3	80 mW	-11	-14	0.7083	0.1337	0.0085	0.0374	0.0071	0.0005
40 MHz	-3	50 mW	-13	-16	0.3929	0.0742	0.0047	0.0208	0.0039	0.0003
40 MHz	-3	25 mW	-16	-19	1.0209	0.1927	0.0123	0.0540	0.0102	0.0007
80 MHz	-6	1 W dir	0	-6	0.0000	0.0000	0.0000	0.0111	0.0021	0.0001
80 MHz	-6	1 W omni	0	-6	0.0000	0.0000	0.0000	0.0222	0.0042	0.0003
80 MHz	-6	200 mW	-7	-13	1.9940	0.3740	0.0240	0.1052	0.0197	0.0013
80 MHz	-6	80 mW	-11	-17	2.8359	0.5319	0.0341	0.1496	0.0281	0.0018
80 MHz	-6	50 mW	-13	-19	1.5730	0.2950	0.0189	0.0831	0.0156	0.0010
80 MHz	-6	25 mW	-16	-22	4.0877	0.7667	0.0492	0.2160	0.0405	0.0026
160 MHz	-9	1 W dir	0	-9	0.0000	0.0000	0.0000	0.0075	0.0014	0.0001
160 MHz	-9	1 W omni	0	-9	0.0000	0.0000	0.0000	0.0150	0.0028	0.0002
160 MHz	-9	200 mW	-7	-16	1.3455	0.2520	0.0135	0.0710	0.0133	0.0007
160 MHz	-9	80 mW	-11	-20	1.9136	0.3584	0.0192	0.1009	0.0189	0.0010
160 MHz	-9	50 mW	-13	-22	1.0615	0.1988	0.0107	0.0561	0.0105	0.0006
160 MHz	-9	25 mW	-16	-25	2.7583	0.5166	0.0277	0.1458	0.0273	0.0015
					20.6988	3.8827	0.2340	1.1584	0.2173	0.0131
					Density of devices in DA2GC channel					

		U indoor	S indoor	R indoor	U outdoor	S outdoor	R outdoor
20 MHz	1 W dir	0.000000	0.000000	0.000000	0.000538	0.000100	0.000005
20 MHz	1 W omni	0.000000	0.000000	0.000000	0.001076	0.000200	0.000011
20 MHz	200 mW	0.019316	0.003591	0.000194	0.001019	0.000190	0.000010
20 MHz	80 mW	0.010937	0.002033	0.000110	0.000577	0.000107	0.000006
20 MHz	50 mW	0.003828	0.000712	0.000038	0.000202	0.000038	0.000002
20 MHz	25 mW	0.004985	0.000927	0.000050	0.000263	0.000049	0.000003
40 MHz	1 W dir	0.000000	0.000000	0.000000	0.001387	0.000262	0.000017
40 MHz	1 W omni	0.000000	0.000000	0.000000	0.002773	0.000523	0.000033
40 MHz	200 mW	0.049800	0.009400	0.000600	0.002628	0.000496	0.000032
40 MHz	80 mW	0.028197	0.005322	0.000340	0.001487	0.000281	0.000018
40 MHz	50 mW	0.009868	0.001863	0.000119	0.000521	0.000098	0.000006
40 MHz	25 mW	0.012852	0.002426	0.000155	0.000679	0.000128	0.000008
80 MHz	1 W dir	0.000000	0.000000	0.000000	0.002783	0.000522	0.000033
80 MHz	1 W omni	0.000000	0.000000	0.000000	0.005565	0.001044	0.000067
80 MHz	200 mW	0.099937	0.018744	0.001203	0.005274	0.000989	0.000063
80 MHz	80 mW	0.056584	0.010613	0.000681	0.002984	0.000560	0.000036
80 MHz	50 mW	0.019803	0.003714	0.000238	0.001046	0.000196	0.000013
80 MHz	25 mW	0.025792	0.004838	0.000310	0.001363	0.000256	0.000016
160 MHz	1 W dir	0.000000	0.000000	0.000000	0.000941	0.000176	0.000009
160 MHz	1 W omni	0.000000	0.000000	0.000000	0.001882	0.000352	0.000019
160 MHz	200 mW	0.033797	0.006330	0.000339	0.001784	0.000334	0.000018
160 MHz	80 mW	0.019136	0.003584	0.000192	0.001009	0.000189	0.000010
160 MHz	50 mW	0.006697	0.001254	0.000067	0.000354	0.000066	0.000004
160 MHz	25 mW	0.008722	0.001634	0.000088	0.000461	0.000086	0.000005
		0.410252	0.076986	0.004725	0.038597	0.007243	0.000444
		Density weighted by power and bandwidth relative to 1 W					

ANNEX 5: REQUIREMENTS FOR A SENSING PROCEDURE

In this section the requirements for an interfering systems (Interfering transmitter IT, transmitting to its wanted receiver WR) to detect a victim system (Wanted transmitter WT transmitting to the victim receiver VR) are analysed. The IT is able to monitor the WT (e.g. pure power detection or preamble detection), which is the basis for the sensing mechanism which is called LBT in this section. It has to be noted that in that section victim link and interfering link are working continuously at the same frequency. Time domain effects in regard to sensing procedures (e.g. listening time, dead time) are not considered in this section.

The following abbreviations and definitions are valid in this section:

- Dimensions: r/m, P/dBm, S/dBm, INR/dB, f/GHz;
- VR Victim receiver;
  - N: Noise floor kTBF of VR;
  - F: Noise figure of VR;
  - S: Signal strength received at the VR from WT (Pwt);
  - SNRmin: minimum signal to noise ratio, or C/Nmin at VR;
  - SNR: signal to noise ratio, or C/N at VR;
  - SIRmin: Signal to interference ratio, or C/I at VR;
  - INR: Interference to noise ratio at VR;
  - WT Wanted transmitter;
  - Pwt Transmit power of WT;
  - Gwt, Gvr, Antenna gain WT/VR;
- IT Interfering Transmitter;
  - Pit Transmit power of IT;
  - Git, Gwr, Antenna gain IT/WR;
  - WR Wanted receiver (Interfering Link);
  - Plbt: LBT power received at WR from WT (Pwt);
  - Pthr: power threshold for the LBT mechanism at IT;
- I: Interfering power at VR;
- n: Path loss exponent n (e.g. n=2 free space loss);
- Rint: radius around VR; inside interference can occur (S-I<SIRmin);
- Rsig: radius around VR; inside the victim link works with S-N<SNRmin;
- Rdet: radius around WT; inside the IT can detect the WT;
- Wall: wall attenuation dB.

The following Figure explains the investigated scenario. Within a radius of Rint around the VR the IT can exceed the protection objective of the VR (e.g. C/I). Within a radius of Rdet around the WT the IT can detect the WT (Threshold is exceeded).

In the light blue area in the following figure LBT is working effectively. The red area is the so called “hidden node”, where the IT is not able to detect the WT.

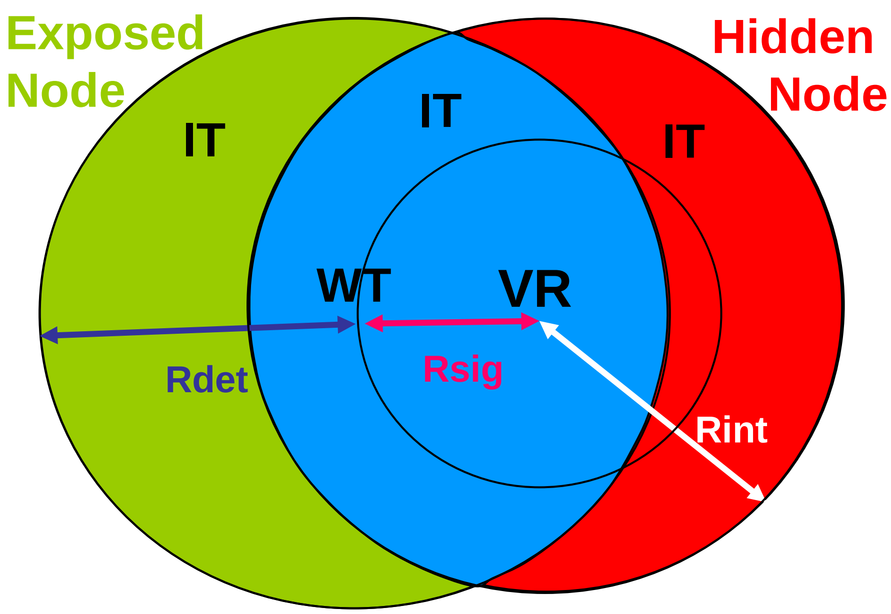


Figure 54: Hidden and exposed nodes

The formulas given hereafter are the basis for the analysis.

Wanted signal strength at the victim receiver:

S (at VR)= N + SNR = Pwt + Gswt +Gevr- PL(Rsig) (1)

The interference power at the victim receiver:

I (at VR)= S - SIRlimit = Pit +Gsit+Gevr-Wall- PL(Rint) (2)

The threshold power at the interfering transmitter:

Pthr (at RLAN)= Pwt +Gswt+Geit-Wall- PL(Rdet) (3)

Path loss model:

PL = 32.5+10*n*log(R/m)+20*log(f/GHz) (4)

(1)+(4) -> 10n*log(Rsig) = Pwt+ Gwt+Gvr -N-SNR-32.5-20logf (5)

(2)+(4) -> 10n*log(Rint) = Pit+ Git+Gvr-Wall-N-SNR+SIRlimit-32.5-20logf (6)

(3)+(4) -> 10n*log(Rdet) = Pwt+ Gwt+Gwr-Wall-Pthr-32.5-20logf (7)

Under the assumption that the antenna gain on Rx and Tx side are equal (Git=Gwr and Gvr=Gwt) the following can be derived:

Relation Rdet/Rint: (7)-(6) -> 10n*log(Rdet/Rint)=Pwt-Pit-Pthr+N+SNR-SIRlimit (8)

with SIRlimit=SNRlimit-INRlimit -> 10n*log(Rdet/Rint)=Pwt-Pit-Pthr+N+SNR-SNRlimit+INR (9)

with SNR-SNRlimit=margin -> 10n*log(Rdet/Rint)=Pwt-Pit-Pthr+N+margin+INR (10)

If the antenna gain is not equal on Rx and Tx on the victim side then the following formula should be used:

10n*log(Rdet/Rint)=Pwt-Pit-Pthr+N+margin+INR +Gwt-Gvr (10a)

The following Annex 5.1 provides a simplified procedure for cases where all involved tranceivers are transmitting and receiving continuously, whereas Annex 5.2 provides a generally applicable procedure.

A5.1 SIMPLIFIED ASSUMPTIONS

Under the assumption that WT, VR, IT and WR are transmitting and receiving continuously, that on victim side the Tx and Rx antenna gain are equal and that Rdet=Rint, the threshold for perfectly detecting the interfering system could be derived using formula (10):

. Pthr=Pwt-Pit+N+margin+INR (11)

It should be clear that any antenna gain and path loss have no impact on the derivation of the threshold value in formula (11), and only the conducted Tx power levels are relevant.

For the case that the Rx and Tx antenna gain on victim side are different, the following formula should be used (derived from 10a):

. Pthr=Pwt-Pit+N+margin+INR+Gwt-Gvr (11a)

The following points are important to highlight the limitations applicable to the above formula:

- The simplified assumption that all transceivers are using the same frequency has been used that means the simplified formula is not applicable to FDD systems (special consideration is given in the BFWA section).
- The assumption that all tranceivers are transmitting and receiving continuously in time is not absolutely correct, also because the involved radio systems mostly using TDD channel access and thus transmitter and receiver are not able to transmit and receive simultaneously. The so called hidden and exposed node problem occurs accordingly. The following Annex 5.2 is considering those effects.

A5.2 DETAILED HIDDEN NODE ANALYSIS FOR THE EXAMPLE OF ITS

The results for Rsig, Rint and Rdet should be calculated with formulas (5) to (7). The below Figures provide those distances for the example of ITS as victim and RLAN as interferer with the path loss exponents 2 (=LOS) and 3. The main parameters are:

- Victim system: ITS, 23 dBm e.i.r.p., 0 dBi, 10 MHz, INR -6 dB, SNRlimit 8 dB;
- Interferer RLAN 23 dBm e.i.r.p., 0 dBi, Pthr=-90dBm/10 MHz.

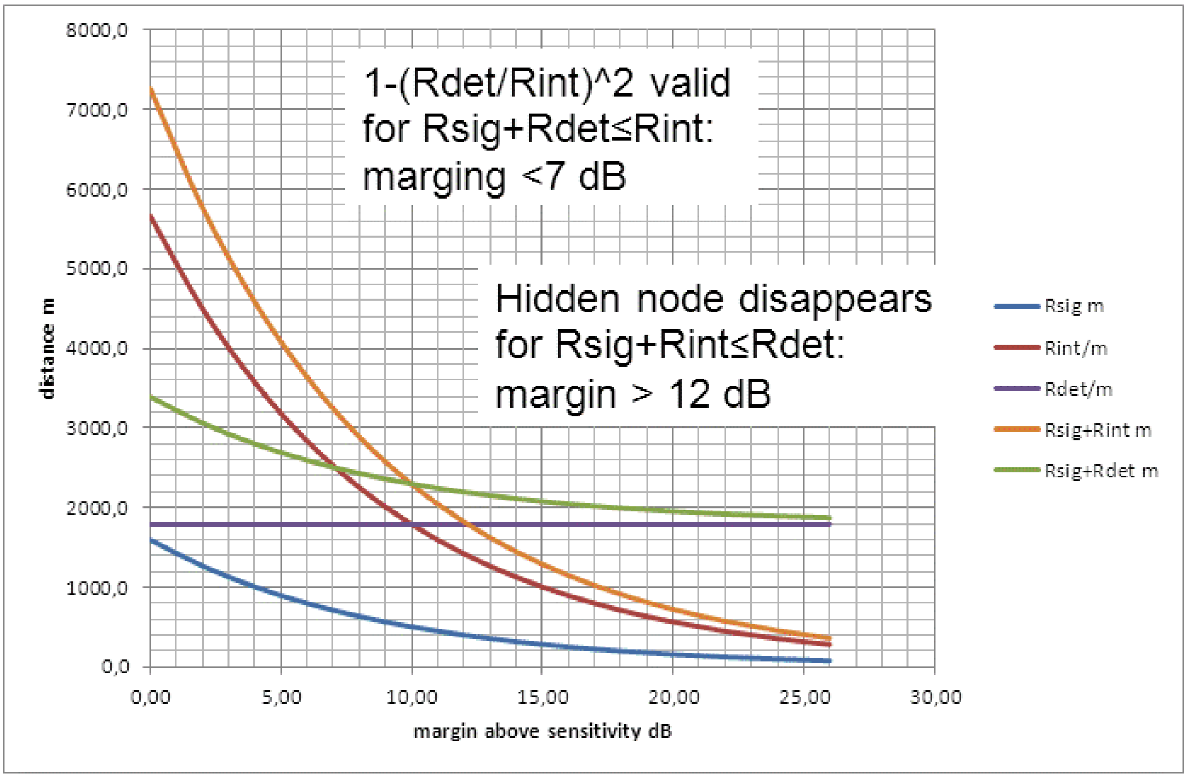


Figure 55: Distances for LOS conditions (exp.2)

Under the assumption Rsig+Rdet≤Rint the hidden node portion can be easily calculated with 1-(Rdet/Rint)^2 using the formula (10), (see below figure).

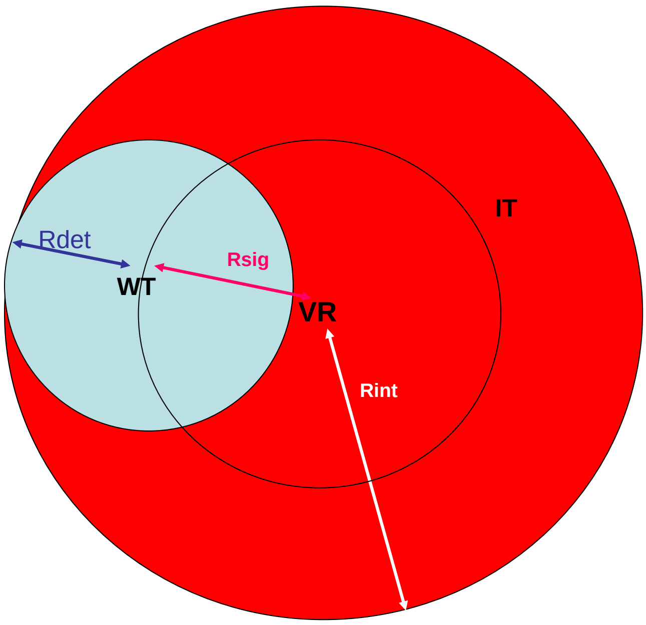


Figure 56: Illustration of the scenario

If the condition Rsig+Rdet ≤Rint is not fulfilled, the situation is more complex. But the following condition can be used to derive the SNR ratio where the hidden nodes are disappearing: Rsig+Rint≤Rdet.

The following figure show the hidden node portion for the ITS example (the solid line is only valid until Rsig+Rdet=Rint; after that point the dotted line is valid, which is the linear intrapolation between Rsig+Rdet=Rint and Rsig+Rint=Rdet).

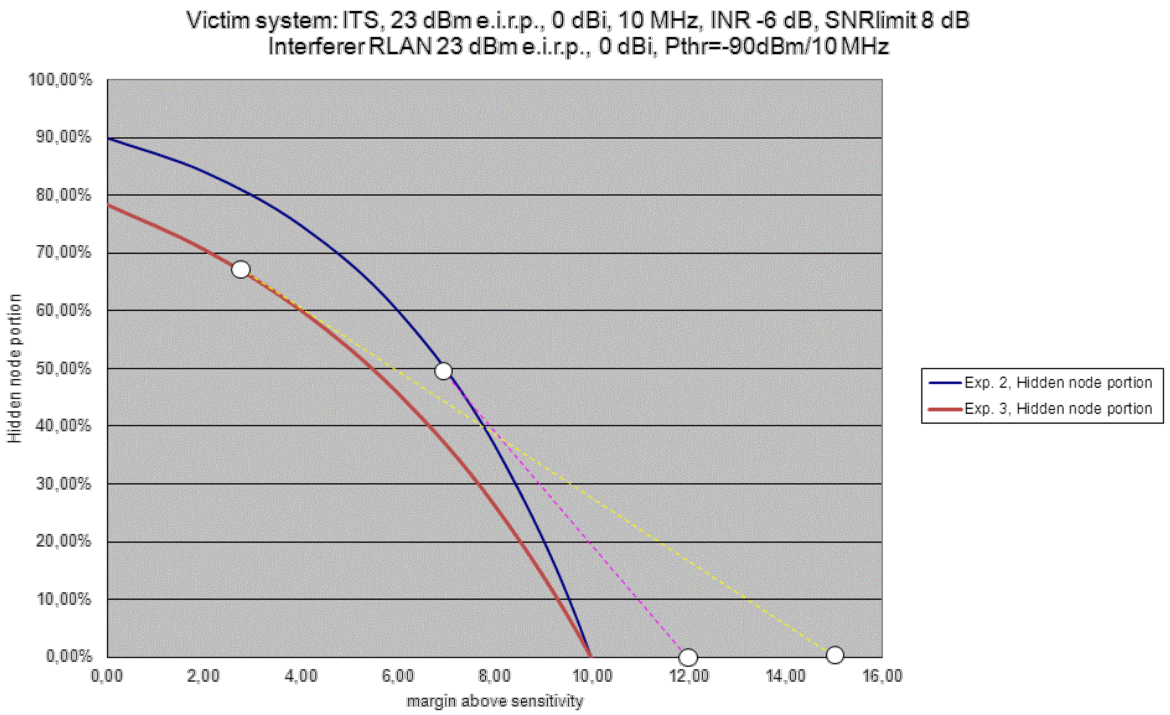
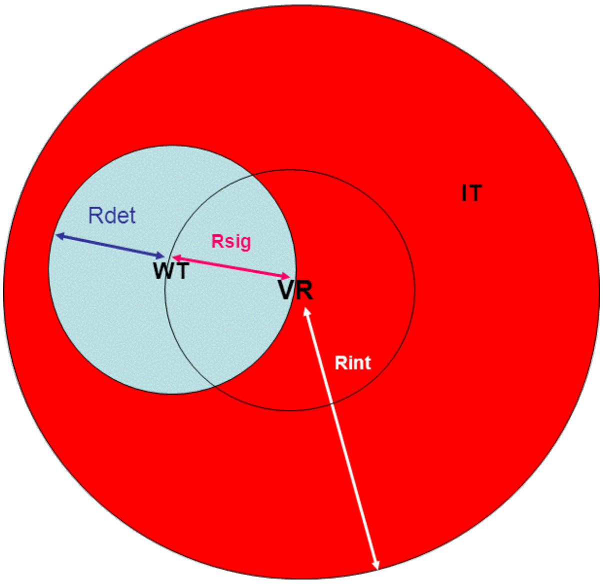


Figure 57: Hidden node probability for ITS as victim as function of the margin above sensitivity at the ITS receiver and the propagation condition

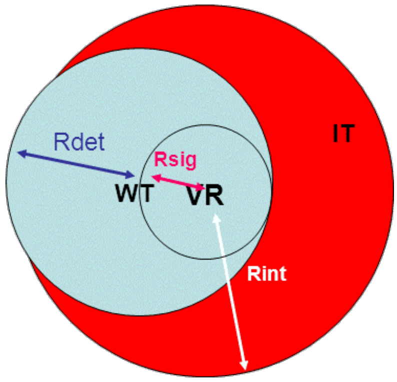
It is important to consider what the changing margin means in a real system context. The wanted signal strength will normally vary according to the distance of the wanted link. If the receiver is close to the transmitter, the signal will be high (=margin high) and the hidden node probability correspondingly low. On the other hand, if VR is far from its serving WT, the margin will be lower and the danger of a hidden node effect increases.

If the victim link distance is held constant, there is a similar effect if WT applies adaptive power control or APC.

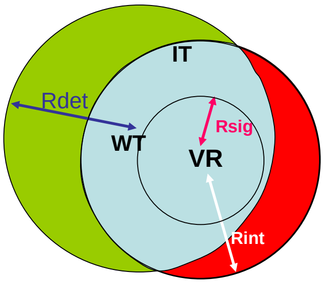
The next figures give an illustration of how the results depend on the margin above sensitivity. In the light blue area LBT is working effectively; the red area is the hidden node and the green area the exposed node. The diagrams show how, as the signal strength increases, there is a shift from hidden nodes to exposed node.



0dB margin,
hidden node 89%, Exposed nodes 0%



5dB margin,
hidden node 50-70%, Exposed nodes <10%



10 dB margin,
hidden node <20%, Exposed nodes >20%

Figure 58: Illustration of the hidden and exposed node

Further details are given in ECC Report 181 [43] (section 3.3 and Annex 1).

ANNEX 6: FURTHER MODELLING CONSIDERATIONS: INTERFERENCE FROM RLAN INTO FSS

This Annex provides the detailed analysis in support for the sensitivity analysis summarised in section 8.1.2.2 and the mitigation techniques described in section 8.1.2.3 for the interference from RLAN into FSS.

A6.1 ANTENNA DISCRIMINATION AT OUTDOOR RLANS (1 W)

We take the same approach here in relation to antenna discrimination at outdoor RLANs operating at 1000 mW.

The e.i.r.p. distribution set out in Table 8 specifies 0.3% of RLAN devices outdoor and radiating at 1000 mW: 0.1% using directional antennas and 0.2% using omni-directional antennas.

Table 6 and the related Figure 3, Figure 4, Figure 5 and Figure 6 set out antenna patterns that are used on outdoor RLANs.

In our calculations, we have used the 12 dBi directional and 6 dBi omni-directional antenna patterns (elevation) in order to determine the average discrimination towards space. We calculate an average of 20.9 dB and 13.1 dB discrimination for the directional and omni-directional antennas respectively using the following approach: For both antennas we draw a radiation pattern envelope around the antenna elevation patterns shown in Figure 3 (6 dBi omni) and Figure 5 (12 dBi directional). Then the antenna discrimination at each angle pointing towards the sky is determined and the average calculated. A worst-case approach is taken when the antenna pattern is asymmetric. Applying these values to the maximum e.i.r.p. of 1000 mW, we obtain e.i.r.p.s on the Earth to space interference path of 49 mW and 8.1 mW.

Some further discussion and analysis is required with regard to the calculation of average antenna discrimination towards space.

This report only considers GSO satellites, i.e. these satellites are located on a specific orbit, which corresponds to a specific “path or curve” in the sky as seen from the European geographical area. The GSO orbit as seen from the European geographical area will predominantly correspond to specific elevation angles of the WIFI antenna pattern. It may be that the calculations are constrained to a specific set of angles.

These reduced values for e.i.r.p. on the Earth to space interference path are used to adjust the e.i.r.p. distribution in our calculations for the maximum number of RLANs that can be accommodated by the satellite receiver.

Using these values in the e.i.r.p. distribution, we obtain the values in Table 100. As with our earlier refinements, we consider this in isolation; all other RLANs are subject to 0 dB discrimination towards space.

Table 100: Results (antenna discrimination)

Satellite	Max number of RLANs with 0 dB discrimination towards space	Max number of RLANs using avg discrimination towards space at outdoor 1000 mW e.i.r.p. RLANs; 0 dB discrimination at all other RLAN devices.	Increase in RLAN population (%)
A	245000	376000	53.47
B	2141000	3288000	53.57
C	292000	449000	53.77
D	245000	376000	53.47
E	292000	449000	53.77
F	2141000	3288000	53.57
G	380000	584000	53.68
H	189000	290000	53.44
I	292000	449000	53.77

A6.2 CONSIDERATION OF CLUTTER LOSS

A method for the calculation of clutter loss on interference paths is set out in Recommendation ITU-R P.452-15 [19]. In our calculations, we make use of equations 57 and 57a and the nominal clutter heights and distances specified in Table 4 of the Recommendation.

From the point of view of the RLAN Access Point (AP) or User Equipment (UE), in order for clutter to be considered on the Earth to space interference path the elevation angle from the RLAN to the satellite under consideration must be equal to or less than the elevation angle to the clutter height. Hence, the first step in our method is to position RLANs at cities across Europe and to calculate elevation angles to the satellites under consideration.

For clarity, we break our calculations down into four parts here.

Part one of the clutter loss calculations

This part is completed in Visualyse software. In this paper, we consider a satellite footprint over Europe. Our approach here is to deploy a RLAN in each country/area identified in the earlier contribution from France M76_25R0_SE24 RLAN @ 5.8 GHz vs FSS. Here, each country/area identified is considered to be under the satellite's footprint. These deployments are specified in Table 101 together with the human populations. We have selected one location per country/area, normally the capital city; then one AP and one UE are deployed at each of these locations. Each of the satellites from Table 102 are deployed and the elevation angle from each RLAN towards each of these satellites is obtained.

Table 101: Locations for RLANs and human populations

Country / Area	Population	RLAN location
Albania	2783000	Tirana
Andorra	75000	Andorra La Vella
Austria	8477000	Vienna
Belgium	11162000	Brussels
Bosnia and herzegovina	3847000	Sarajevo
Channel Islands (UK)	163857	St Peter Port
Croatia	4268000	Zagreb
Czech Republic	10519000	Prague
Estonia	1283000	Tallin
Faroe Islands (Denmark)	48000	Torshavn
France	63702000	Paris
Germany	81840000	Berlin
Gibraltar (UK)	30000	Gibraltar
Greece	10758000	Athens
Italy	61789000	Rome
Kosovo	1826000	Pristina
Liechtenstein	37000	Vaduz

Country / Area	Population	RLAN location
Lithuania	2956000	Vilnius
Luxembourg	542000	Luxembourg City
Macedonia	2066000	Skopje
Malta	419000	Valletta
Monaco	36000	Monaco
Montenegro	620000	Podgorcia
Netherlands	16794000	Lisbon
San Marino	32000	City of San Marino
Serbia	7203000	Belgrade
Slovakia	5413000	Bratislava
Slovenia	2062000	Ljubljana
Spain	46958000	Madrid
Switzerland	8075000	Geneva
Vatican City	800	Vatican City

Table 102: FSS satellites

Satellite	Sub-satellite longitude	Part of Frequency range 5725-5875 MHz used	Satellite Maximum Receive Gain Gsat (dBi)	Space Station Receiving System Noise Temperature Tsat (Kelvin)
A	5o West	Whole band	34	773
B	14o West	Whole band	26.5	1200
C	31.5o West	> 5850 MHz	32.8	700
D	3o East	Whole band	34	773
E	18o West	>5850MHz	32.8	700
F	53o East	Whole band	26.5	1200
G	59.5o East	Whole band	34	1200
H	66o East	>5850 MHz	34.7	700

Part two of the clutter loss calculations

Part two determines whether the RLANs are involved in clutter loss.

According to RLAN deployment density statistics (see [44] and [45]), 50% of households in the EU-28 area are located in densely populated areas, 23% in intermediate urban areas and 27% in thinly populated areas. These three areas are mapped to the urban, suburban and sparse homes clutter environments specified in Recommendation ITU-R P.452-15 [19] .

Using the human population statistics, population is assigned to each country/area and distribute these over the three clutter environments according to the apportionments provided in [44] and [45]. Then having set the height of the APs to 6m and the UEs to 1.25m, the elevation angle at the RLANs towards the clutter height in each environment is calculated.

For each country/area in Table 101 and for each clutter environment, it is determined whether the elevation angles at the RLANs pointing towards the satellite under consideration are equal to or less than the elevation angles when pointing to the top of the clutter. If this is so, it is considered that the human population assigned to this country/location and clutter environment is involved in clutter loss.

Part two delivers the percentage of the RLAN population involved in clutter loss for each clutter environment and each satellite.

Part three of the clutter loss calculations

Using Recommendation ITU-R P.452-15 [19], we calculate the clutter loss (dB) for each environment.

Summary of parts one, two and three of the clutter loss calculations

Parts one, two and three of our calculations deliver the percentage of the RLAN population involved in clutter loss per clutter environment and the actual clutter loss in dB per environment.

Part four of the clutter loss calculations

Finally, the results from parts one, two and three can be used to adjust the e.i.r.p. distribution used in the calculations that determine the maximum number of RLANs which can be accommodated by a satellite receiver.

Results

Table 103 sets out the obtained results. Assuming 0 dB antenna discrimination at all RLAN devices, maximum RLAN populations in the range 189,000 to 2,141,000 are calculated. Assuming 0 dB antenna discrimination and taking account of clutter loss, the populations in the range 371,000 to 4,410,000 with the percentage increase in the RLAN population in the range 50.34% to 130.16% are obtained.

Table 103: Results

Satellite	Max number of RLANs with no clutter loss and 0 dB discrimination towards space	Max number of RLANs with clutter loss and 0 dB discrimination towards space	Increase in the RLAN population when clutter is modelled (%)
A	245000	371000	51.43
B	2141000	3802000	77.58
C	292000	526000	80.14

Satellite	Max number of RLANs with no clutter loss and 0 dB discrimination towards space	Max number of RLANs with clutter loss and 0 dB discrimination towards space	Increase in the RLAN population when clutter is modelled (%)
D	245000	371000	51.43
E	292000	520000	78.08
F	2141000	4410000	105.98
G	380000	832000	118.95
H	189000	435000	130.16
I	292000	439000	50.34

It can be noted that the increase percentage in RLAN population is mostly dependent on the orbital position of the satellite. On this basis, although this percentage was not calculated for satellites J, K, L, M and N in the initial detailed analysis, it is hence possible to derive it using the calculation for a satellite presenting a similar or close orbital position (see Table 104 below).

Table 104: Increase in the RLAN population when clutter is modelled

Satellite	Orbital position	Close to satellite	Increase in the RLAN population when clutter is modelled (%)
J	40.5° West	C	80.14
K	22° West	E	78.08
L	20° West	E	78.08
M	50. 5° East	F	105.98
N	57° East	G	118.95

A6.3 CONSIDERATION OF POLARISATION DISCRIMINATION

Detailed calculations of the impact of polarisation are based on a polarisation mismatch figure that only applies to outdoor RLAN that are not exposed to clutter loss, taking into account the e.i.r.p. distribution. Polarisation mismatch figures of 1.5 dB and 3 dB have been considered.

Detailed calculations of the impact of polarisation are based on a polarisation mismatch figure that is applied to those outdoor RLANs that are not exposed to clutter loss but not to outdoor RLANs exposed to clutter loss or to indoor RLANs; this is because of some uncertainties regarding the involvement of polarisation loss in the building loss and clutter loss inputs. Taking into account the e.i.r.p. distribution, polarisation mismatch figures of 1.5 dB and 3 dB have been considered.

Rationale for a 3 dB Polarisation Mismatch Loss

From the point-of-view of the satellite receiver, it can be assumed that the interfering RLAN device has a random signal polarisation. This assumption encompasses signals sourced from vertically polarised APs in fixed positions as well as APs and UEs that are free to adjust their orientation. We may assume, in general, that the satellite receiver has either a linear or a circular polarisation.

The Polarisation Loss Factor (PLF) is given by:

$$PLF = \cos^2(\phi),$$

where ϕ is the angle between the wanted and unwanted signal vectors at the victim receiver. With circular polarisation the electric field vector rotates but still has a definite polarisation and angle at some instant of time.

If the victim satellite receiver at an instant of time is considered, the antenna (either linearly or circularly polarised) will receive a wanted signal at some definite polarisation and, given the sharing scenario, will also receive a mass of unwanted signals with random polarisation. It is then possible to calculate PLF for each pairing of the wanted signal polarisation with an individual unwanted signal polarisation but, with a mass of interferers involved, a generalized approach is required and taking the average of $\cos^2(\phi)$ over all possible incident angles delivers an average PLF = 0.5 or 3 dB when expressed in decibels.

Rationale for a 1.5 dB Polarisation Mismatch Loss

To determine the polarisation advantage between RLAN and FSS, it is possible to use the values provided in the Radio Regulations in Appendix 8 (section 2.2.3), reproduced hereafter:

Table 105: 1.5 dB Polarisation Mismatch Loss

Network R		Network R’	
Network R	**Network R’**	**Numerical ratio**	**dB**
LHC	RHC	4	6
LHC	L	1.4	1.5
RHC	L	1.4	1.5
LHC	LHC	1	0
RHC	RHC	1	0
L	L	1	0

where:

- LHC: left-hand circular (anti-clockwise);
- RHC: right-hand circular (clockwise);
- L: linear.

For circular versus linear polarisations, the polarisation advantage, recommended by the Radio Regulations, is 1.5 dB.

Polarisation discrimination calculations:

Let p_i denote the ith power of the e.i.r.p. distribution expressed in milliwatts and let a_i represent the ith apportionment of RLANs to p_i expressed as a percentage. Then $p_i.a_i$ gives the average power per RLAN (over the entire RLAN population) due to this pair. The average power per RLAN P_{avg} can be calculated by taking account of all pairs $p_i.a_i$ in the e.i.r.p. distribution. If building loss and polarisation mismatch loss are neglected P_{avg} , expressed in dBm, can be calculated as follows:

$$P_{avg} = 10log\left(\sum_{i=1}^{i=n} P_i a_i\right).$$

Equation 8

However, in order to take account of building loss and polarisation mismatch loss, the approach taken here is elaborated in order to calculate contributions to the average RLAN power from indoor RLANs associated with building loss and, for some, clutter loss, outdoor RLANs associated with Polarisation Mismatch Loss and outdoor RLANs associated with clutter loss only. It should be noted that clutter loss is accounted for in the e.i.r.p. distribution (for both indoor and outdoor RLANs).

Considering building loss L_b, summing l pairs $p_i^{ind} a_i^{ind}$ associated with indoor RLANs, attenuating this sum by L_b , the contribution to average RLAN power from these elements, expressed in milliwatts, is calculated as follows:

$$p_{avg}^{ind} = \sum_{i=1}^{i=l} p_i^{ind} a_i^{ind} \cdot 10^{(-L_b/10)}.$$

Equation 9

Considering polarisation mismatch loss L_{pol}, m pairs $p_i^{out(pol)} a_i^{out(pol)}$ associated with outdoor RLANs exposed to polarisation mismatch loss are summed, attenuating this sum by L_{pol}, and so calculating the contribution to average RLAN power (milliwatts) due to these elements:

$$p_{avg}^{out(pol)} = \sum_{j=1}^{j=m} p_j^{out(pol)} a_j^{out(pol)} \cdot 10^{(-L_{pol}/10)}$$

Equation 10

Summing n pairs $p_k^{out(clut)} a_k^{out(clut)}$, calculating the contribution to average RLAN power (miliwatts) from outdoor RLANs associated with clutter loss (already accounted for in the e.i.r.p. distribution) but not with L_b or L_{pol}:

$$p_{avg}^{out(clut)} = \sum_{k=1}^{k=n} p_k^{out(clut)} a_k^{out(clut)}.$$

Equation 11

Finally with the sum p_{avg}^{ind}, $p_{avg}^{out(pol)}$ and $p_{avg}^{out(clut)}$ in order to obtain the average power per RLAN (taking account of all elements in the e.i.r.p. and indoor-outdoor distributions), expressed in dBm, we obtain the following equation:

$$P_{avg} = 10log\left(p_{avg}^{ind} + p_{avg}^{out(pol)} + p_{avg}^{out(clut)}\right).$$

Equation 12

These calculations are repeated with L_{pol}= 0 dB, obtaining then the gain associated with polarisation mismatch loss:

$$G'_{PML} = P_{avg(L_{pol}=3dB)} - P_{avg(L_{pol}=0dB)}.$$

Equation 13

Taking the Step 1 calculations into account, considering a polarisation mismatch loss of 3 dB results in an increase in the RLAN population of 42% when 12 dB building attenuation is used and 70% when 17 dB building attenuation is used.

Similarly, for a polarisation mismatch loss of 1.5 dB, the increase in the RLAN population is 21% when 12 dB building attenuation is used and 31% when 17 dB building attenuation is used.

ANNEX 7: NUMBER OF ACTIVE, ON-TUNE, APS OPERATING AT 5 GHz DURING BUSY HOUR, INCIDENT TO A 40 MHz VICTIM RECEIVER BANDWIDTH.

Consistently with STEP 1 calculations, the FSS vs RLAN case can be depicted as follows (assuming an example of 10000 RLAN in the whole 5 GHz band):

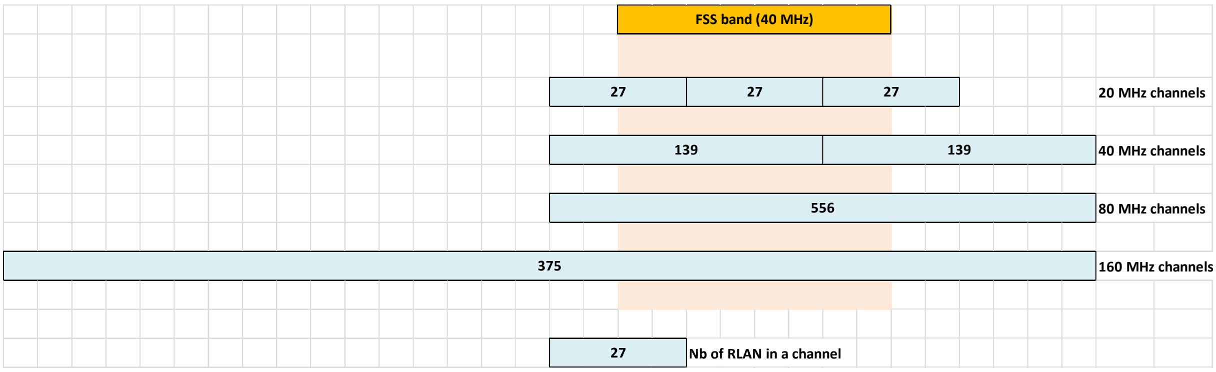


Figure 59: RLAN channels incident to a 40 MHz FSS receiver bandwidth

This corresponds to an FSS band overlapping:

- 3 channels of 20 MHz;
- 2 channels of 40 MHz;
- 1 channel of 80 MHz;
- 1 channel of 160 MHz.

It should be read in conjunction with the following table:

Table 106 : Number of RLAN Aps for different RLAN channels

RLAN Channels	Nb of channels	Percentage of RLAN	Nb of RLAN per bandwidth	Nb of RLAN per channel
20 MHz	37	10%	1000	27
40 MHz	18	25%	2500	139
80 MHz	9	50%	5000	556
160 MHz	4	15%	1500	375
Nb of RLAN in the whole 5 GHz range				10000

The situation therefore represents a total of (3 x 27 + 2 x 139 + 1 x 556 + 1 x 375) = 1290 RLAN overlapping the FSS band.

There are 2 options to handle such situation and consider the effective aggregate e.i.r.p. produced by RLAN within the 40 MHz FSS band:

Option 1: to consider the different bandwidth factors pertaining to the different channels and that will apply to the corresponding RLAN within each channel

Option 2: to normalise the number of RLAN in each channel as an equivalent number of RLAN fully within the FSS band

A7.1 OPTION 1 : STEP BY STEP, WE CAN CONSIDER EACH OF THE RLAN CHANNELS BANDWIDTH:

A7.1.1 For 20 MHz channels:

The first 20 MHz channel overlaps 1/2 the FSS band. We therefore have 27 RLAN with a bandwidth factor of 0.5 (linear).

The second 20 MHz channel overlaps fully the FSS band. We therefore have 27 RLAN without bandwidth factor or a bandwidth factor of 1 (linear).

The third 20 MHz channel overlaps 1/2 the FSS band. We therefore have 27 RLAN with a bandwidth factor of 0.5 (linear).

In summary, we have therefore 81 RLAN using 20 MHz channels with an average bandwidth factor of ((0.5 x 27 + 1 x 27 + 0.5 x 27)/81) = 0.667 (rounded to 0.7 in step1).

A7.1.2 For 40 MHz channels:

The first 40 MHz channel overlaps 3/4 the FSS band. We therefore have 139 RLAN with a bandwidth factor of 0.75 (linear).

The second 40 MHz channel overlaps 1/4 the FSS band. We therefore have 139 RLAN with a bandwidth factor of 0.25 (linear).

In summary, we have therefore 278 RLAN using 40 MHz channels with an average bandwidth factor of ((0.75 x 139 + 0.25 x 139)/278) = 0.5.

A7.1.3 For 80 MHz channel:

The 80 MHz channel overlaps 1/2 the FSS band. We therefore have 556 RLAN with a bandwidth factor of 0.5 (linear).

A7.1.4 For 160 MHz channel:

The 160 MHz channel overlaps 1/4 the FSS band. We therefore have 375 RLAN with a bandwidth factor of 0.25 (linear).

Assuming the 80 mW (19 dBm) average e.i.r.p. per RLAN (based on the e.i.r.p. distribution), one can then calculate the aggregate e.i.r.p. based on the above assumptions:

Table 107 : Option 1. Calculation of the aggregated e.i.r.p

RLAN Channels	Average e.i.r.p. (mW)	Nb of RLAN	Bandwidth factor	Aggregate e.i.r.p. (mW)
20 MHz	80	81	0.667 (1.75 dB)	4322
40 MHz	80	278	0.5 (3 dB)	11120
80 MHz	80	556	0.5 (3 dB)	22240
160 MHz	80	375	0.25 (6 dB)	7500
TOTAL		1290		45182
				46.55 dBm

Note: this represent an average of (46.55 – 10log(1290))=15.45 dBm per RLAN in the FSS band, thus an average (19 – 15.45)=3.55 dB bandwidth factor.

As a summary option 1 lead to 12.9% of the total number of RLAN in the FSS band with an average e.i.r.p. of 15.45 dBm (or an average 3.55 dB bandwidth factor).

A7.2 OPTION 2 : STEP BY STEP, WE CAN CONSIDER EACH OF THE RLAN CHANNELS BANDWIDTH:

A7.2.1 For 20 MHz channels:

The first 20 MHz channel overlaps 1/2 the FSS band. This is therefore equivalent to have 27/2 = 13.5 equivalent RLAN fully in the FSS band.

The second 20 MHz channel overlaps fully the FSS band. This is therefore equivalent to have 27 RLAN fully in the FSS band.

The third 20 MHz channel overlaps 1/2 the FSS band. This is therefore equivalent to have 27/2 = 13.5 equivalent RLAN fully in the FSS band.

In summary, we have therefore an equivalent of (13.5 + 27 + 13.5) = 54 RLAN transmitting fully in the FSS band.

A7.2.2 For 40 MHz channels:

The first 40 MHz channel overlaps 3/4 the FSS band. This is therefore equivalent to have 139x3/4 = 104.25 RLAN fully in the FSS band.

The second 40 MHz channel overlaps 1/4 the FSS band. This is therefore equivalent to have 139x1/4 = 34.75 RLAN fully in the FSS band.

In summary, we have therefore an equivalent of (104.25 + 34.75) = 139 RLAN transmitting fully in the FSS band.

A7.2.3 For 80 MHz channel:

The 80 MHz channel overlaps 1/2 the FSS band. This is therefore equivalent to have 556/2 = 278 RLAN transmitting fully in the FSS band.

A7.2.4 For 160 MHz channel:

The 160 MHz channel overlaps 1/4 the FSS band. This is therefore equivalent to have 375/4 = 93.75 RLAN transmitting fully in the FSS band.

Assuming the 80 mW (19 dBm) average e.i.r.p. per RLAN (based on the e.i.r.p. distribution), one can then calculate the aggregate e.i.r.p. based on the above assumptions:

Table 108: Option 2. Calculation of the aggregated e.i.r.p

RLAN Channels	Average e.i.r.p. (mW)	Nb of RLAN	Bandwidth factor	Aggregate e.i.r.p. (mW)
20 MHz	80	54	1 (0 dB)	4320
40 MHz	80	139	1 (0 dB)	11120
80 MHz	80	278	1 (0 dB)	22240
160 MHz	80	93.75	1 (0 dB)	7500
TOTAL		564.75		45180
				46.55 dBm

As a summary option 2 lead to 5.6% of the total number of RLAN in the FSS band with an average e.i.r.p. of 19 dBm.

A7.3 CONCLUSION

Both options handle the RLAN vs FSS from 2 different angles but lead to a similar end result, i.e. an aggregate e.i.r.p. of 46.55 dBm in the FSS band for the example of 10000 RLAN over the whole 5 GHz band.

ANNEX 8: FSS ANALYSIS : COMPARISON OF STEP 2 AND STEP 1 (FOR THE CASE OF 400 MILLION APS)

A8.1 : STEP 2 CASE 1

Table 109 : Step 2 - Case 1 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	50%	3%	12.9%	386824

Table 110 : Step 2 - Case 1 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***5.1***	229416	***2.3***	66251	***7.7***	166573	***3.7***	155746	***4.0***	390008	0.0	94076	***6.1***	236534	***2.1***
B	1224796	-5.0	2348496	-7.8	678356	-2.4	1703436	-6.4	1589430	-6.1	3992442	-10.1	963265	-4.0	2418879	-8.0
D	120016	***5.1***	300536	***1.1***	80163	***6.8***	201553	***2.8***	155746	***4.0***	390008	0.0	94076	***6.1***	236534	***2.1***
F	1420675	-5.6	3568552	-9.6	952081	-3.9	2390794	-7.9	1843624	-6.8	4630945	-10.8	1117318	-4.6	2805726	-8.6
G	268898	***1.6***	674755	-2.4	180152	***3.3***	452367	-0.7	348952	***0.4***	875636	-3.5	211418	***2.6***	530877	-1.4

Table 111 : Step 2 - Case 1 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***5.1***	300536	***1.1***	80163	***6.8***	201553	***2.8***	155746	***4.0***	390008	0.0	94076	***6.1***	236534	***2.1***
B	816531	-3.2	2051019	-7.2	547207	-1.5	1374105	-5.5	1059620	-4.4	2661628	-8.4	642177	-2.2	1612586	-6.2
C	169908	***3.6***	427130	-0.4	113889	***5.3***	286085	***1.3***	220491	***2.4***	554291	-1.6	133655	***4.6***	335736	***0.6***
D	120016	***5.1***	300536	***1.1***	80163	***6.8***	201553	***2.8***	155746	***4.0***	390008	0.0	94076	***6.1***	236534	***2.1***
E	167965	***3.6***	422245	-0.4	112587	***5.4***	282813	***1.4***	217970	***2.5***	547952	-1.5	132126	***4.7***	331897	***0.7***
F	947117	-3.9	2379035	-7.9	634721	-2.2	1593863	-6.1	1229083	-5.0	3087297	-9.0	744879	-2.8	1870484	-6.8
G	268898	***1.6***	674755	-2.4	180152	***3.3***	452367	-0.7	348952	***0.4***	875636	-3.5	211418	***2.6***	530877	-1.4
H	140202	***4.4***	352766	***0.4***	93992	***6.1***	236023	***2.1***	181941	***3.3***	457788	-0.7	110304	***5.4***	276986	***1.5***
I	141801	***4.4***	356471	***0.4***	95049	***6.1***	238759	***2.1***	184016	***3.2***	462596	-0.8	111545	***5.4***	280196	***1.4***
J (Gain=38.5)	92034	***6.2***	230084	***2.3***	62121	***7.9***	154758	***4.0***	119433	***5.1***	298582	***1.1***	72903	***7.2***	181617	***3.3***
J (Gain=32.5)	182297	***3.3***	457808	-0.7	122063	***5.0***	306792	***1.0***	236569	***2.1***	594102	-1.9	143247	***4.3***	360037	***0.3***
J (Gain=28.5)	305205	***1.0***	765766	-3.0	204528	***2.8***	513318	-1.2	396068	-0.1	993742	-4.1	240025	***2.1***	602406	-1.9
K (Gain=38.5)	90981	***6.3***	227453	***2.3***	61411	***8.0***	152989	***4.0***	118067	***5.2***	295168	***1.2***	72069	***7.3***	179540	***3.3***
K (Gain=32.5)	180213	***3.3***	452573	-0.7	120667	***5.1***	303284	***1.1***	233864	***2.2***	587308	-1.8	141609	***4.4***	355920	***0.4***
K (Gain=28.5)	301715	***1.1***	757009	-2.9	202189	***2.8***	507448	-1.2	391539	-0.1	982378	-4.0	237280	***2.1***	595517	-1.9
L (Gain=38.5)	90981	***6.3***	227453	***2.3***	61411	***8.0***	152989	***4.0***	118067	***5.2***	295168	***1.2***	72069	***7.3***	179540	***3.3***
L (Gain=32.5)	180213	***3.3***	452573	-0.7	120667	***5.1***	303284	***1.1***	233864	***2.2***	587308	-1.8	141609	***4.4***	355920	***0.4***
L (Gain=28.5)	301715	***1.1***	757009	-2.9	202189	***2.8***	507448	-1.2	391539	-0.1	982378	-4.0	237280	***2.1***	595517	-1.9
M (Gain=38.5)	105235	***5.7***	263088	***1.7***	71032	***7.4***	176957	***3.4***	136565	***4.5***	341412	***0.5***	83360	***6.7***	207669	***2.7***
M (Gain=32.5)	208447	***2.7***	523478	-1.3	139572	***4.4***	350799	***0.4***	270503	***1.6***	679322	-2.4	163795	***3.7***	411682	-0.3
M (Gain=28.5)	348985	***0.4***	875611	-3.5	233866	***2.2***	586950	-1.8	452881	-0.7	1136289	-4.7	274455	***1.5***	688818	-2.5
N (Gain=38.5)	111862	***5.4***	279654	***1.4***	75505	***7.1***	188100	***3.1***	145164	***4.3***	362910	***0.3***	88609	***6.4***	220745	***2.4***
N (Gain=32.5)	221572	***2.4***	556440	-1.6	148361	***4.2***	372888	***0.2***	287536	***1.3***	722097	-2.7	174109	***3.5***	437604	-0.5
N (Gain=28.5)	370960	***0.2***	930746	-3.8	248592	***1.9***	623909	-2.1	481398	-0.9	1207838	-4.9	291736	***1.2***	732191	-2.8

Note: Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level of negative margin (in dB).

A8.2 : STEP 2 CASE 2

Table 112 : Step 2 - Case 2 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	50%	10%	12.9%	1289414

Table 113: Step 2 - Case 2 - Calculations for the band 5725-5850 MHz in the band 5725- 5850...

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*10.3*	229416	*7.5*	66251	*12.9*	166573	*8.9*	155746	*9.2*	390008	*5.2*	94076	*11.4*	236534	*7.4*
B	1224796	*0.2*	2348496	-2.6	678356	*2.8*	1703436	-1.2	1589430	-0.9	3992442	-4.9	963265	*1.3*	2418879	-2.7
D	120016	*10.3*	300536	*6.3*	80163	*12.1*	201553	*8.1*	155746	*9.2*	390008	*5.2*	94076	*11.4*	236534	*7.4*
F	1420675	-0.4	3568552	-4.4	952081	*1.3*	2390794	-2.7	1843624	-1.6	4630945	-5.6	1117318	*0.6*	2805726	-3.4
G	268898	*6.8*	674755	*2.8*	180152	*8.5*	452367	*4.5*	348952	*5.7*	875636	*1.7*	211418	*7.9*	530877	*3.9*

Table 114 : Step 2 - Case 2 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*10.3*	300536	*6.3*	80163	*12.1*	201553	*8.1*	155746	*9.2*	390008	*5.2*	94076	*11.4*	236534	*7.4*
B	816531	*2.0*	2051019	-2.0	547207	*3.7*	1374105	-0.3	1059620	*0.9*	2661628	-3.1	642177	*3.0*	1612586	-1.0
C	169908	*8.8*	427130	*4.8*	113889	*10.5*	286085	*6.5*	220491	*7.7*	554291	*3.7*	133655	*9.8*	335736	*5.8*
D	120016	*10.3*	300536	*6.3*	80163	*12.1*	201553	*8.1*	155746	*9.2*	390008	*5.2*	94076	*11.4*	236534	*7.4*
E	167965	*8.9*	422245	*4.8*	112587	*10.6*	282813	*6.6*	217970	*7.7*	547952	*3.7*	132126	*9.9*	331897	*5.9*
F	947117	*1.3*	2379035	-2.7	634721	*3.1*	1593863	-0.9	1229083	*0.2*	3087297	-3.8	744879	*2.4*	1870484	-1.6
G	268898	*6.8*	674755	*2.8*	180152	*8.5*	452367	*4.5*	348952	*5.7*	875636	*1.7*	211418	*7.9*	530877	*3.9*
H	140202	*9.6*	352766	*5.6*	93992	*11.4*	236023	*7.4*	181941	*8.5*	457788	*4.5*	110304	*10.7*	276986	*6.7*
I	141801	*9.6*	356471	*5.6*	95049	*11.3*	238759	*7.3*	184016	*8.5*	462596	*4.5*	111545	*10.6*	280196	*6.6*
J (Gain=38.5)	92034	*11.5*	230084	*7.5*	62121	*13.2*	154758	*9.2*	119433	*10.3*	298582	*6.4*	72903	*12.5*	181617	*8.5*
J (Gain=32.5)	182297	*8.5*	457808	*4.5*	122063	*10.2*	306792	*6.2*	236569	*7.4*	594102	*3.4*	143247	*9.5*	360037	*5.5*
J (Gain=28.5)	305205	*6.3*	765766	*2.3*	204528	*8.0*	513318	*4.0*	396068	*5.1*	993742	*1.1*	240025	*7.3*	602406	*3.3*
K (Gain=38.5)	90981	*11.5*	227453	*7.5*	61411	*13.2*	152989	*9.3*	118067	*10.4*	295168	*6.4*	72069	*12.5*	179540	*8.6*
K (Gain=32.5)	180213	*8.5*	452573	*4.5*	120667	*10.3*	303284	*6.3*	233864	*7.4*	587308	*3.4*	141609	*9.6*	355920	*5.6*
K (Gain=28.5)	301715	*6.3*	757009	*2.3*	202189	*8.0*	507448	*4.1*	391539	*5.2*	982378	*1.2*	237280	*7.4*	595517	*3.4*
L (Gain=38.5)	90981	*11.5*	227453	*7.5*	61411	*13.2*	152989	*9.3*	118067	*10.4*	295168	*6.4*	72069	*12.5*	179540	*8.6*
L (Gain=32.5)	180213	*8.5*	452573	*4.5*	120667	*10.3*	303284	*6.3*	233864	*7.4*	587308	*3.4*	141609	*9.6*	355920	*5.6*
L (Gain=28.5)	301715	*6.3*	757009	*2.3*	202189	*8.0*	507448	*4.1*	391539	*5.2*	982378	*1.2*	237280	*7.4*	595517	*3.4*
M (Gain=38.5)	105235	*10.9*	263088	*6.9*	71032	*12.6*	176957	*8.6*	136565	*9.8*	341412	*5.8*	83360	*11.9*	207669	*7.9*
M (Gain=32.5)	208447	*7.9*	523478	*3.9*	139572	*9.7*	350799	*5.7*	270503	*6.8*	679322	*2.8*	163795	*9.0*	411682	*5.0*
M (Gain=28.5)	348985	*5.7*	875611	*1.7*	233866	*7.4*	586950	*3.4*	452881	*4.5*	1136289	*0.5*	274455	*6.7*	688818	*2.7*
N (Gain=38.5)	111862	*10.6*	279654	*6.6*	75505	*12.3*	188100	*8.4*	145164	*9.5*	362910	*5.5*	88609	*11.6*	220745	*7.7*
N (Gain=32.5)	221572	*7.6*	556440	*3.6*	148361	*9.4*	372888	*5.4*	287536	*6.5*	722097	*2.5*	174109	*8.7*	437604	*4.7*
N (Gain=28.5)	370960	*5.4*	930746	*1.4*	248592	*7.1*	623909	*3.2*	481398	*4.3*	1207838	*0.3*	291736	*6.5*	732191	*2.5*

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.3 : STEP 2 CASE 3

Table 115: Step 2 - Case 3 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	50%	30%	12.9%	3868243

Table 116: Step 2 - Case 3 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	15.1	229416	12.3	66251	17.7	166573	13.7	155746	14.0	390008	10.0	94076	16.1	236534	12.1
B	1224796	5.0	2348496	2.2	678356	7.6	1703436	3.6	1589430	3.9	3992442	-0.1	963265	6.0	2418879	2.0
D	120016	15.1	300536	11.1	80163	16.8	201553	12.8	155746	14.0	390008	10.0	94076	16.1	236534	12.1
F	1420675	4.4	3568552	0.4	952081	6.1	2390794	2.1	1843624	3.2	4630945	-0.8	1117318	5.4	2805726	1.4
G	268898	11.6	674755	7.6	180152	13.3	452367	9.3	348952	10.4	875636	6.5	211418	12.6	530877	8.6

Table 117: Step 2 - Case 3 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	15.1	300536	11.1	80163	16.8	201553	12.8	155746	14.0	390008	10.0	94076	16.1	236534	12.1
B	816531	6.8	2051019	2.8	547207	8.5	1374105	4.5	1059620	5.6	2661628	1.6	642177	7.8	1612586	3.8
C	169908	13.6	427130	9.6	113889	15.3	286085	11.3	220491	12.4	554291	8.4	133655	14.6	335736	10.6
D	120016	15.1	300536	11.1	80163	16.8	201553	12.8	155746	14.0	390008	10.0	94076	16.1	236534	12.1
E	167965	13.6	422245	9.6	112587	15.4	282813	11.4	217970	12.5	547952	8.5	132126	14.7	331897	10.7
F	947117	6.1	2379035	2.1	634721	7.8	1593863	3.9	1229083	5.0	3087297	1.0	744879	7.2	1870484	3.2
G	268898	11.6	674755	7.6	180152	13.3	452367	9.3	348952	10.4	875636	6.5	211418	12.6	530877	8.6
H	140202	14.4	352766	10.4	93992	16.1	236023	12.1	181941	13.3	457788	9.3	110304	15.4	276986	11.5
I	141801	14.4	356471	10.4	95049	16.1	238759	12.1	184016	13.2	462596	9.2	111545	15.4	280196	11.4
J (Gain=38.5)	92034	16.2	230084	12.3	62121	17.9	154758	14.0	119433	15.1	298582	11.1	72903	17.2	181617	13.3
J (Gain=32.5)	182297	13.3	457808	9.3	122063	15.0	306792	11.0	236569	12.1	594102	8.1	143247	14.3	360037	10.3
J (Gain=28.5)	305205	11.0	765766	7.0	204528	12.8	513318	8.8	396068	9.9	993742	5.9	240025	12.1	602406	8.1
K (Gain=38.5)	90981	16.3	227453	12.3	61411	18.0	152989	14.0	118067	15.2	295168	11.2	72069	17.3	179540	13.3
K (Gain=32.5)	180213	13.3	452573	9.3	120667	15.1	303284	11.1	233864	12.2	587308	8.2	141609	14.4	355920	10.4
K (Gain=28.5)	301715	11.1	757009	7.1	202189	12.8	507448	8.8	391539	9.9	982378	6.0	237280	12.1	595517	8.1
L (Gain=38.5)	90981	16.3	227453	12.3	61411	18.0	152989	14.0	118067	15.2	295168	11.2	72069	17.3	179540	13.3
L (Gain=32.5)	180213	13.3	452573	9.3	120667	15.1	303284	11.1	233864	12.2	587308	8.2	141609	14.4	355920	10.4
L (Gain=28.5)	301715	11.1	757009	7.1	202189	12.8	507448	8.8	391539	9.9	982378	6.0	237280	12.1	595517	8.1
M (Gain=38.5)	105235	15.7	263088	11.7	71032	17.4	176957	13.4	136565	14.5	341412	10.5	83360	16.7	207669	12.7
M (Gain=32.5)	208447	12.7	523478	8.7	139572	14.4	350799	10.4	270503	11.6	679322	7.6	163795	13.7	411682	9.7
M (Gain=28.5)	348985	10.4	875611	6.5	233866	12.2	586950	8.2	452881	9.3	1136289	5.3	274455	11.5	688818	7.5
N (Gain=38.5)	111862	15.4	279654	11.4	75505	17.1	188100	13.1	145164	14.3	362910	10.3	88609	16.4	220745	12.4
N (Gain=32.5)	221572	12.4	556440	8.4	148361	14.2	372888	10.2	287536	11.3	722097	7.3	174109	13.5	437604	9.5
N (Gain=28.5)	370960	10.2	930746	6.2	248592	11.9	623909	7.9	481398	9.1	1207838	5.1	291736	11.2	732191	7.2

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.4 : STEP 2 CASE 4

Table 118: Step 2 - Case 4 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	74%	3%	12.9%	572500

Table 119: Step 2 - Case 4 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***6.8***	229416	***4.0***	66251	***9.4***	166573	***5.4***	155746	***5.7***	390008	***1.7***	94076	***7.8***	236534	***3.8***
B	1224796	-3.3	2348496	-6.1	678356	-0.7	1703436	-4.7	1589430	-4.4	3992442	-8.4	963265	-2.3	2418879	-6.3
D	120016	***6.8***	300536	***2.8***	80163	***8.5***	201553	***4.5***	155746	***5.7***	390008	***1.7***	94076	***7.8***	236534	***3.8***
F	1420675	-3.9	3568552	-7.9	952081	-2.2	2390794	-6.2	1843624	-5.1	4630945	-9.1	1117318	-2.9	2805726	-6.9
G	268898	***3.3***	674755	-0.7	180152	***5.0***	452367	***1.0***	348952	***2.2***	875636	-1.8	211418	***4.3***	530877	***0.3***

Table 120: Step 2 - Case 4 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***6.8***	300536	***2.8***	80163	***8.5***	201553	***4.5***	155746	***5.7***	390008	***1.7***	94076	***7.8***	236534	***3.8***
B	816531	-1.5	2051019	-5.5	547207	***0.2***	1374105	-3.8	1059620	-2.7	2661628	-6.7	642177	-0.5	1612586	-4.5
C	169908	***5.3***	427130	***1.3***	113889	***7.0***	286085	***3.0***	220491	***4.1***	554291	***0.1***	133655	***6.3***	335736	***2.3***
D	120016	***6.8***	300536	***2.8***	80163	***8.5***	201553	***4.5***	155746	***5.7***	390008	***1.7***	94076	***7.8***	236534	***3.8***
E	167965	***5.3***	422245	***1.3***	112587	***7.1***	282813	***3.1***	217970	***4.2***	547952	***0.2***	132126	***6.4***	331897	***2.4***
F	947117	-2.2	2379035	-6.2	634721	-0.4	1593863	-4.4	1229083	-3.3	3087297	-7.3	744879	-1.1	1870484	-5.1
G	268898	***3.3***	674755	-0.7	180152	***5.0***	452367	***1.0***	348952	***2.2***	875636	-1.8	211418	***4.3***	530877	***0.3***
H	140202	***6.1***	352766	***2.1***	93992	***7.8***	236023	***3.8***	181941	***5.0***	457788	***1.0***	110304	***7.2***	276986	***3.2***
I	141801	***6.1***	356471	***2.1***	95049	***7.8***	238759	***3.8***	184016	***4.9***	462596	***0.9***	111545	***7.1***	280196	***3.1***
J (Gain=38.5)	92034	***7.9***	230084	***4.0***	62121	***9.6***	154758	***5.7***	119433	***6.8***	298582	***2.8***	72903	***9.0***	181617	***5.0***
J (Gain=32.5)	182297	***5.0***	457808	***1.0***	122063	***6.7***	306792	***2.7***	236569	***3.8***	594102	-0.2	143247	***6.0***	360037	***2.0***
J (Gain=28.5)	305205	***2.7***	765766	-1.3	204528	***4.5***	513318	***0.5***	396068	***1.6***	993742	-2.4	240025	***3.8***	602406	-0.2
K (Gain=38.5)	90981	***8.0***	227453	***4.0***	61411	***9.7***	152989	***5.7***	118067	***6.9***	295168	***2.9***	72069	***9.0***	179540	***5.0***
K (Gain=32.5)	180213	***5.0***	452573	***1.0***	120667	***6.8***	303284	***2.8***	233864	***3.9***	587308	-0.1	141609	***6.1***	355920	***2.1***
K (Gain=28.5)	301715	***2.8***	757009	-1.2	202189	***4.5***	507448	***0.5***	391539	***1.7***	982378	-2.3	237280	***3.8***	595517	-0.2
L (Gain=38.5)	90981	***8.0***	227453	***4.0***	61411	***9.7***	152989	***5.7***	118067	***6.9***	295168	***2.9***	72069	***9.0***	179540	***5.0***
L (Gain=32.5)	180213	***5.0***	452573	***1.0***	120667	***6.8***	303284	***2.8***	233864	***3.9***	587308	-0.1	141609	***6.1***	355920	***2.1***
L (Gain=28.5)	301715	***2.8***	757009	-1.2	202189	***4.5***	507448	***0.5***	391539	***1.7***	982378	-2.3	237280	***3.8***	595517	-0.2
M (Gain=38.5)	105235	***7.4***	263088	***3.4***	71032	***9.1***	176957	***5.1***	136565	***6.2***	341412	***2.2***	83360	***8.4***	207669	***4.4***
M (Gain=32.5)	208447	***4.4***	523478	***0.4***	139572	***6.1***	350799	***2.1***	270503	***3.3***	679322	-0.7	163795	***5.4***	411682	***1.4***
M (Gain=28.5)	348985	***2.1***	875611	-1.8	233866	***3.9***	586950	-0.1	452881	***1.0***	1136289	-3.0	274455	***3.2***	688818	-0.8
N (Gain=38.5)	111862	***7.1***	279654	***3.1***	75505	***8.8***	188100	***4.8***	145164	***6.0***	362910	***2.0***	88609	***8.1***	220745	***4.1***
N (Gain=32.5)	221572	***4.1***	556440	***0.1***	148361	***5.9***	372888	***1.9***	287536	***3.0***	722097	-1.0	174109	***5.2***	437604	***1.2***
N (Gain=28.5)	370960	***1.9***	930746	-2.1	248592	***3.6***	623909	-0.4	481398	***0.8***	1207838	-3.2	291736	***2.9***	732191	-1.1

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.5 : STEP 2 CASE 5

Table 121: Step 2 - Case 5 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	74%	10%	12.9%	1908333

Table 122: Step 2 - Case 5 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***12.0***	229416	***9.2***	66251	***14.6***	166573	***10.6***	155746	***10.9***	390008	***6.9***	94076	***13.1***	236534	***9.1***
B	1224796	***1.9***	2348496	-0.9	678356	***4.5***	1703436	***0.5***	1589430	***0.8***	3992442	-3.2	963265	***3.0***	2418879	-1.0
D	120016	***12.0***	300536	***8.0***	80163	***13.8***	201553	***9.8***	155746	***10.9***	390008	***6.9***	94076	***13.1***	236534	***9.1***
F	1420675	***1.3***	3568552	-2.7	952081	***3.0***	2390794	-1.0	1843624	***0.1***	4630945	-3.9	1117318	***2.3***	2805726	-1.7
G	268898	***8.5***	674755	***4.5***	180152	***10.3***	452367	***6.3***	348952	***7.4***	875636	***3.4***	211418	***9.6***	530877	***5.6***

Table 123: Step 2 - Case 5 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***12.0***	300536	***8.0***	80163	***13.8***	201553	***9.8***	155746	***10.9***	390008	***6.9***	94076	***13.1***	236534	***9.1***
B	816531	***3.7***	2051019	-0.3	547207	***5.4***	1374105	***1.4***	1059620	***2.6***	2661628	-1.4	642177	***4.7***	1612586	***0.7***
C	169908	***10.5***	427130	***6.5***	113889	***12.2***	286085	***8.2***	220491	***9.4***	554291	***5.4***	133655	***11.5***	335736	***7.5***
D	120016	***12.0***	300536	***8.0***	80163	***13.8***	201553	***9.8***	155746	***10.9***	390008	***6.9***	94076	***13.1***	236534	***9.1***
E	167965	***10.6***	422245	***6.6***	112587	***12.3***	282813	***8.3***	217970	***9.4***	547952	***5.4***	132126	***11.6***	331897	***7.6***
F	947117	***3.0***	2379035	-1.0	634721	***4.8***	1593863	***0.8***	1229083	***1.9***	3087297	-2.1	744879	***4.1***	1870484	***0.1***
G	268898	***8.5***	674755	***4.5***	180152	***10.3***	452367	***6.3***	348952	***7.4***	875636	***3.4***	211418	***9.6***	530877	***5.6***
H	140202	***11.3***	352766	***7.3***	93992	***13.1***	236023	***9.1***	181941	***10.2***	457788	***6.2***	110304	***12.4***	276986	***8.4***
I	141801	***11.3***	356471	***7.3***	95049	***13.0***	238759	***9.0***	184016	***10.2***	462596	***6.2***	111545	***12.3***	280196	***8.3***
J (Gain=38.5)	92034	***13.2***	230084	***9.2***	62121	***14.9***	154758	***10.9***	119433	***12.0***	298582	***8.1***	72903	***14.2***	181617	***10.2***
J (Gain=32.5)	182297	***10.2***	457808	***6.2***	122063	***11.9***	306792	***7.9***	236569	***9.1***	594102	***5.1***	143247	***11.2***	360037	***7.2***
J (Gain=28.5)	305205	***8.0***	765766	***4.0***	204528	***9.7***	513318	***5.7***	396068	***6.8***	993742	***2.8***	240025	***9.0***	602406	***5.0***
K (Gain=38.5)	90981	***13.2***	227453	***9.2***	61411	***14.9***	152989	***11.0***	118067	***12.1***	295168	***8.1***	72069	***14.2***	179540	***10.3***
K (Gain=32.5)	180213	***10.2***	452573	***6.2***	120667	***12.0***	303284	***8.0***	233864	***9.1***	587308	***5.1***	141609	***11.3***	355920	***7.3***
K (Gain=28.5)	301715	***8.0***	757009	***4.0***	202189	***9.7***	507448	***5.8***	391539	***6.9***	982378	***2.9***	237280	***9.1***	595517	***5.1***
L (Gain=38.5)	90981	***13.2***	227453	***9.2***	61411	***14.9***	152989	***11.0***	118067	***12.1***	295168	***8.1***	72069	***14.2***	179540	***10.3***
L (Gain=32.5)	180213	***10.2***	452573	***6.2***	120667	***12.0***	303284	***8.0***	233864	***9.1***	587308	***5.1***	141609	***11.3***	355920	***7.3***
L (Gain=28.5)	301715	***8.0***	757009	***4.0***	202189	***9.7***	507448	***5.8***	391539	***6.9***	982378	***2.9***	237280	***9.1***	595517	***5.1***
M (Gain=38.5)	105235	***12.6***	263088	***8.6***	71032	***14.3***	176957	***10.3***	136565	***11.5***	341412	***7.5***	83360	***13.6***	207669	***9.6***
M (Gain=32.5)	208447	***9.6***	523478	***5.6***	139572	***11.4***	350799	***7.4***	270503	***8.5***	679322	***4.5***	163795	***10.7***	411682	***6.7***
M (Gain=28.5)	348985	***7.4***	875611	***3.4***	233866	***9.1***	586950	***5.1***	452881	***6.2***	1136289	***2.3***	274455	***8.4***	688818	***4.4***
N (Gain=38.5)	111862	***12.3***	279654	***8.3***	75505	***14.0***	188100	***10.1***	145164	***11.2***	362910	***7.2***	88609	***13.3***	220745	***9.4***
N (Gain=32.5)	221572	***9.4***	556440	***5.4***	148361	***11.1***	372888	***7.1***	287536	***8.2***	722097	***4.2***	174109	***10.4***	437604	***6.4***
N (Gain=28.5)	370960	***7.1***	930746	***3.1***	248592	***8.9***	623909	***4.9***	481398	***6.0***	1207838	***2.0***	291736	***8.2***	732191	***4.2***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.6 : STEP 2 CASE 6

Table 124: Step 2 - Case 6 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	74%	30%	12.9%	5725000

Table 125: Step 2 - Case 6 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*16.8*	229416	*14.0*	66251	*19.4*	166573	*15.4*	155746	*15.7*	390008	*11.7*	94076	*17.8*	236534	*13.8*
B	1224796	*6.7*	2348496	*3.9*	678356	*9.3*	1703436	*5.3*	1589430	*5.6*	3992442	*1.6*	963265	*7.7*	2418879	*3.7*
D	120016	*16.8*	300536	*12.8*	80163	*18.5*	201553	*14.5*	155746	*15.7*	390008	*11.7*	94076	*17.8*	236534	*13.8*
F	1420675	*6.1*	3568552	*2.1*	952081	*7.8*	2390794	*3.8*	1843624	*4.9*	4630945	*0.9*	1117318	*7.1*	2805726	*3.1*
G	268898	*13.3*	674755	*9.3*	180152	*15.0*	452367	*11.0*	348952	*12.2*	875636	*8.2*	211418	*14.3*	530877	*10.3*

Table 126: Step 2 - Case 6 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*16.8*	300536	*12.8*	80163	*18.5*	201553	*14.5*	155746	*15.7*	390008	*11.7*	94076	*17.8*	236534	*13.8*
B	816531	*8.5*	2051019	*4.5*	547207	*10.2*	1374105	*6.2*	1059620	*7.3*	2661628	*3.3*	642177	*9.5*	1612586	*5.5*
C	169908	*15.3*	427130	*11.3*	113889	*17.0*	286085	*13.0*	220491	*14.1*	554291	*10.1*	133655	*16.3*	335736	*12.3*
D	120016	*16.8*	300536	*12.8*	80163	*18.5*	201553	*14.5*	155746	*15.7*	390008	*11.7*	94076	*17.8*	236534	*13.8*
E	167965	*15.3*	422245	*11.3*	112587	*17.1*	282813	*13.1*	217970	*14.2*	547952	*10.2*	132126	*16.4*	331897	*12.4*
F	947117	*7.8*	2379035	*3.8*	634721	*9.6*	1593863	*5.6*	1229083	*6.7*	3087297	*2.7*	744879	*8.9*	1870484	*4.9*
G	268898	*13.3*	674755	*9.3*	180152	*15.0*	452367	*11.0*	348952	*12.2*	875636	*8.2*	211418	*14.3*	530877	*10.3*
H	140202	*16.1*	352766	*12.1*	93992	*17.8*	236023	*13.8*	181941	*15.0*	457788	*11.0*	110304	*17.2*	276986	*13.2*
I	141801	*16.1*	356471	*12.1*	95049	*17.8*	238759	*13.8*	184016	*14.9*	462596	*10.9*	111545	*17.1*	280196	*13.1*
J (Gain=38.5)	92034	*17.9*	230084	*14.0*	62121	*19.6*	154758	*15.7*	119433	*16.8*	298582	*12.8*	72903	*19.0*	181617	*15.0*
J (Gain=32.5)	182297	*15.0*	457808	*11.0*	122063	*16.7*	306792	*12.7*	236569	*13.8*	594102	*9.8*	143247	*16.0*	360037	*12.0*
J (Gain=28.5)	305205	*12.7*	765766	*8.7*	204528	*14.5*	513318	*10.5*	396068	*11.6*	993742	*7.6*	240025	*13.8*	602406	*9.8*
K (Gain=38.5)	90981	*18.0*	227453	*14.0*	61411	*19.7*	152989	*15.7*	118067	*16.9*	295168	*12.9*	72069	*19.0*	179540	*15.0*
K (Gain=32.5)	180213	*15.0*	452573	*11.0*	120667	*16.8*	303284	*12.8*	233864	*13.9*	587308	*9.9*	141609	*16.1*	355920	*12.1*
K (Gain=28.5)	301715	*12.8*	757009	*8.8*	202189	*14.5*	507448	*10.5*	391539	*11.7*	982378	*7.7*	237280	*13.8*	595517	*9.8*
L (Gain=38.5)	90981	*18.0*	227453	*14.0*	61411	*19.7*	152989	*15.7*	118067	*16.9*	295168	*12.9*	72069	*19.0*	179540	*15.0*
L (Gain=32.5)	180213	*15.0*	452573	*11.0*	120667	*16.8*	303284	*12.8*	233864	*13.9*	587308	*9.9*	141609	*16.1*	355920	*12.1*
L (Gain=28.5)	301715	*12.8*	757009	*8.8*	202189	*14.5*	507448	*10.5*	391539	*11.7*	982378	*7.7*	237280	*13.8*	595517	*9.8*
M (Gain=38.5)	105235	*17.4*	263088	*13.4*	71032	*19.1*	176957	*15.1*	136565	*16.2*	341412	*12.2*	83360	*18.4*	207669	*14.4*
M (Gain=32.5)	208447	*14.4*	523478	*10.4*	139572	*16.1*	350799	*12.1*	270503	*13.3*	679322	*9.3*	163795	*15.4*	411682	*11.4*
M (Gain=28.5)	348985	*12.1*	875611	*8.2*	233866	*13.9*	586950	*9.9*	452881	*11.0*	1136289	*7.0*	274455	*13.2*	688818	*9.2*
N (Gain=38.5)	111862	*17.1*	279654	*13.1*	75505	*18.8*	188100	*14.8*	145164	*16.0*	362910	*12.0*	88609	*18.1*	220745	*14.1*
N (Gain=32.5)	221572	*14.1*	556440	*10.1*	148361	*15.9*	372888	*11.9*	287536	*13.0*	722097	*9.0*	174109	*15.2*	437604	*11.2*
N (Gain=28.5)	370960	*11.9*	930746	*7.9*	248592	*13.6*	623909	*9.6*	481398	*10.8*	1207838	*6.8*	291736	*12.9*	732191	*8.9*

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.7 : STEP 2 CASE 7

Table 127: Step 2 - Case 7 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	97%	3%	12.9%	750439

Table 128: Step 2 - Case 7 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***8.0***	229416	***5.1***	66251	***10.5***	166573	***6.5***	155746	***6.8***	390008	***2.8***	94076	***9.0***	236534	***5.0***
B	1224796	-2.1	2348496	-5.0	678356	***0.4***	1703436	-3.6	1589430	-3.3	3992442	-7.3	963265	-1.1	2418879	-5.1
D	120016	***8.0***	300536	***4.0***	80163	***9.7***	201553	***5.7***	155746	***6.8***	390008	***2.8***	94076	***9.0***	236534	***5.0***
F	1420675	-2.8	3568552	-6.8	952081	-1.0	2390794	-5.0	1843624	-3.9	4630945	-7.9	1117318	-1.7	2805726	-5.7
G	268898	***4.5***	674755	***0.5***	180152	***6.2***	452367	***2.2***	348952	***3.3***	875636	-0.7	211418	***5.5***	530877	***1.5***

Table 129: Step 2 - Case 7 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***8.0***	300536	***4.0***	80163	***9.7***	201553	***5.7***	155746	***6.8***	390008	***2.8***	94076	***9.0***	236534	***5.0***
B	816531	-0.4	2051019	-4.4	547207	***1.4***	1374105	-2.6	1059620	-1.5	2661628	-5.5	642177	***0.7***	1612586	-3.3
C	169908	***6.5***	427130	***2.4***	113889	***8.2***	286085	***4.2***	220491	***5.3***	554291	***1.3***	133655	***7.5***	335736	***3.5***
D	120016	***8.0***	300536	***4.0***	80163	***9.7***	201553	***5.7***	155746	***6.8***	390008	***2.8***	94076	***9.0***	236534	***5.0***
E	167965	***6.5***	422245	***2.5***	112587	***8.2***	282813	***4.2***	217970	***5.4***	547952	***1.4***	132126	***7.5***	331897	***3.5***
F	947117	-1.0	2379035	-5.0	634721	***0.7***	1593863	-3.3	1229083	-2.1	3087297	-6.1	744879	***0.0***	1870484	-4.0
G	268898	***4.5***	674755	***0.5***	180152	***6.2***	452367	***2.2***	348952	***3.3***	875636	-0.7	211418	***5.5***	530877	***1.5***
H	140202	***7.3***	352766	***3.3***	93992	***9.0***	236023	***5.0***	181941	***6.2***	457788	***2.1***	110304	***8.3***	276986	***4.3***
I	141801	***7.2***	356471	***3.2***	95049	***9.0***	238759	***5.0***	184016	***6.1***	462596	***2.1***	111545	***8.3***	280196	***4.3***
J (Gain=38.5)	92034	***9.1***	230084	***5.1***	62121	***10.8***	154758	***6.9***	119433	***8.0***	298582	***4.0***	72903	***10.1***	181617	***6.2***
J (Gain=32.5)	182297	***6.1***	457808	***2.1***	122063	***7.9***	306792	***3.9***	236569	***5.0***	594102	***1.0***	143247	***7.2***	360037	***3.2***
J (Gain=28.5)	305205	***3.9***	765766	-0.1	204528	***5.6***	513318	***1.6***	396068	***2.8***	993742	-1.2	240025	***5.0***	602406	***1.0***
K (Gain=38.5)	90981	***9.2***	227453	***5.2***	61411	***10.9***	152989	***6.9***	118067	***8.0***	295168	***4.1***	72069	***10.2***	179540	***6.2***
K (Gain=32.5)	180213	***6.2***	452573	***2.2***	120667	***7.9***	303284	***3.9***	233864	***5.1***	587308	***1.1***	141609	***7.2***	355920	***3.2***
K (Gain=28.5)	301715	***4.0***	757009	0.0	202189	***5.7***	507448	***1.7***	391539	***2.8***	982378	-1.2	237280	***5.0***	595517	***1.0***
L (Gain=38.5)	90981	***9.2***	227453	***5.2***	61411	***10.9***	152989	***6.9***	118067	***8.0***	295168	***4.1***	72069	***10.2***	179540	***6.2***
L (Gain=32.5)	180213	***6.2***	452573	***2.2***	120667	***7.9***	303284	***3.9***	233864	***5.1***	587308	***1.1***	141609	***7.2***	355920	***3.2***
L (Gain=28.5)	301715	***4.0***	757009	0.0	202189	***5.7***	507448	***1.7***	391539	***2.8***	982378	-1.2	237280	***5.0***	595517	***1.0***
M (Gain=38.5)	105235	***8.5***	263088	***4.6***	71032	***10.2***	176957	***6.3***	136565	***7.4***	341412	***3.4***	83360	***9.5***	207669	***5.6***
M (Gain=32.5)	208447	***5.6***	523478	***1.6***	139572	***7.3***	350799	***3.3***	270503	***4.4***	679322	***0.4***	163795	***6.6***	411682	***2.6***
M (Gain=28.5)	348985	***3.3***	875611	-0.7	233866	***5.1***	586950	***1.1***	452881	***2.2***	1136289	-1.8	274455	***4.4***	688818	***0.4***
N (Gain=38.5)	111862	***8.3***	279654	***4.3***	75505	***10.0***	188100	***6.0***	145164	***7.1***	362910	***3.2***	88609	***9.3***	220745	***5.3***
N (Gain=32.5)	221572	***5.3***	556440	***1.3***	148361	***7.0***	372888	***3.0***	287536	***4.2***	722097	***0.2***	174109	***6.3***	437604	***2.3***
N (Gain=28.5)	370960	***3.1***	930746	-0.9	248592	***4.8***	623909	***0.8***	481398	***1.9***	1207838	-2.1	291736	***4.1***	732191	***0.1***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.8 : STEP 2 CASE 8

Table 130: Step 2 - Case 8 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	97%	10%	12.9%	2501464

Table 131: Step 2 - Case 8 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	13.2	229416	10.4	66251	15.8	166573	11.8	155746	12.1	390008	8.1	94076	14.2	236534	10.2
B	1224796	3.1	2348496	0.3	678356	5.7	1703436	1.7	1589430	2.0	3992442	-2.0	963265	4.1	2418879	0.1
D	120016	13.2	300536	9.2	80163	14.9	201553	10.9	155746	12.1	390008	8.1	94076	14.2	236534	10.2
F	1420675	2.5	3568552	-1.5	952081	4.2	2390794	0.2	1843624	1.3	4630945	-2.7	1117318	3.5	2805726	-0.5
G	268898	9.7	674755	5.7	180152	11.4	452367	7.4	348952	8.6	875636	4.6	211418	10.7	530877	6.7

Table 132: Step 2 - Case 8 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	13.2	300536	9.2	80163	14.9	201553	10.9	155746	12.1	390008	8.1	94076	14.2	236534	10.2
B	816531	4.9	2051019	0.9	547207	6.6	1374105	2.6	1059620	3.7	2661628	-0.3	642177	5.9	1612586	1.9
C	169908	11.7	427130	7.7	113889	13.4	286085	9.4	220491	10.5	554291	6.5	133655	12.7	335736	8.7
D	120016	13.2	300536	9.2	80163	14.9	201553	10.9	155746	12.1	390008	8.1	94076	14.2	236534	10.2
E	167965	11.7	422245	7.7	112587	13.5	282813	9.5	217970	10.6	547952	6.6	132126	12.8	331897	8.8
F	947117	4.2	2379035	0.2	634721	6.0	1593863	2.0	1229083	3.1	3087297	-0.9	744879	5.3	1870484	1.3
G	268898	9.7	674755	5.7	180152	11.4	452367	7.4	348952	8.6	875636	4.6	211418	10.7	530877	6.7
H	140202	12.5	352766	8.5	93992	14.3	236023	10.3	181941	11.4	457788	7.4	110304	13.6	276986	9.6
I	141801	12.5	356471	8.5	95049	14.2	238759	10.2	184016	11.3	462596	7.3	111545	13.5	280196	9.5
J (Gain=38.5)	92034	14.3	230084	10.4	62121	16.0	154758	12.1	119433	13.2	298582	9.2	72903	15.4	181617	11.4
J (Gain=32.5)	182297	11.4	457808	7.4	122063	13.1	306792	9.1	236569	10.2	594102	6.2	143247	12.4	360037	8.4
J (Gain=28.5)	305205	9.1	765766	5.1	204528	10.9	513318	6.9	396068	8.0	993742	4.0	240025	10.2	602406	6.2
K (Gain=38.5)	90981	14.4	227453	10.4	61411	16.1	152989	12.1	118067	13.3	295168	9.3	72069	15.4	179540	11.4
K (Gain=32.5)	180213	11.4	452573	7.4	120667	13.2	303284	9.2	233864	10.3	587308	6.3	141609	12.5	355920	8.5
K (Gain=28.5)	301715	9.2	757009	5.2	202189	10.9	507448	6.9	391539	8.1	982378	4.1	237280	10.2	595517	6.2
L (Gain=38.5)	90981	14.4	227453	10.4	61411	16.1	152989	12.1	118067	13.3	295168	9.3	72069	15.4	179540	11.4
L (Gain=32.5)	180213	11.4	452573	7.4	120667	13.2	303284	9.2	233864	10.3	587308	6.3	141609	12.5	355920	8.5
L (Gain=28.5)	301715	9.2	757009	5.2	202189	10.9	507448	6.9	391539	8.1	982378	4.1	237280	10.2	595517	6.2
M (Gain=38.5)	105235	13.8	263088	9.8	71032	15.5	176957	11.5	136565	12.6	341412	8.6	83360	14.8	207669	10.8
M (Gain=32.5)	208447	10.8	523478	6.8	139572	12.5	350799	8.5	270503	9.7	679322	5.7	163795	11.8	411682	7.8
M (Gain=28.5)	348985	8.6	875611	4.6	233866	10.3	586950	6.3	452881	7.4	1136289	3.4	274455	9.6	688818	5.6
N (Gain=38.5)	111862	13.5	279654	9.5	75505	15.2	188100	11.2	145164	12.4	362910	8.4	88609	14.5	220745	10.5
N (Gain=32.5)	221572	10.5	556440	6.5	148361	12.3	372888	8.3	287536	9.4	722097	5.4	174109	11.6	437604	7.6
N (Gain=28.5)	370960	8.3	930746	4.3	248592	10.0	623909	6.0	481398	7.2	1207838	3.2	291736	9.3	732191	5.3

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.9 : STEP 2 CASE 9

Table 133: Step 2 - Case 9 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	50%	97%	30%	12.9%	7504392

Table 134: Step 2 - Case 9 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***18.0***	229416	***15.1***	66251	***20.5***	166573	***16.5***	155746	***16.8***	390008	***12.8***	94076	***19.0***	236534	***15.0***
B	1224796	***7.9***	2348496	***5.0***	678356	***10.4***	1703436	***6.4***	1589430	***6.7***	3992442	***2.7***	963265	***8.9***	2418879	***4.9***
D	120016	***18.0***	300536	***14.0***	80163	***19.7***	201553	***15.7***	155746	***16.8***	390008	***12.8***	94076	***19.0***	236534	***15.0***
F	1420675	***7.2***	3568552	***3.2***	952081	***9.0***	2390794	***5.0***	1843624	***6.1***	4630945	***2.1***	1117318	***8.3***	2805726	***4.3***
G	268898	***14.5***	674755	***10.5***	180152	***16.2***	452367	***12.2***	348952	***13.3***	875636	***9.3***	211418	***15.5***	530877	***11.5***

Table 135: Step 2 - Case 9 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***18.0***	300536	***14.0***	80163	***19.7***	201553	***15.7***	155746	***16.8***	390008	***12.8***	94076	***19.0***	236534	***15.0***
B	816531	***9.6***	2051019	***5.6***	547207	***11.4***	1374105	***7.4***	1059620	***8.5***	2661628	***4.5***	642177	***10.7***	1612586	***6.7***
C	169908	***16.5***	427130	***12.4***	113889	***18.2***	286085	***14.2***	220491	***15.3***	554291	***11.3***	133655	***17.5***	335736	***13.5***
D	120016	***18.0***	300536	***14.0***	80163	***19.7***	201553	***15.7***	155746	***16.8***	390008	***12.8***	94076	***19.0***	236534	***15.0***
E	167965	***16.5***	422245	***12.5***	112587	***18.2***	282813	***14.2***	217970	***15.4***	547952	***11.4***	132126	***17.5***	331897	***13.5***
F	947117	***9.0***	2379035	***5.0***	634721	***10.7***	1593863	***6.7***	1229083	***7.9***	3087297	***3.9***	744879	***10.0***	1870484	***6.0***
G	268898	***14.5***	674755	***10.5***	180152	***16.2***	452367	***12.2***	348952	***13.3***	875636	***9.3***	211418	***15.5***	530877	***11.5***
H	140202	***17.3***	352766	***13.3***	93992	***19.0***	236023	***15.0***	181941	***16.2***	457788	***12.1***	110304	***18.3***	276986	***14.3***
I	141801	***17.2***	356471	***13.2***	95049	***19.0***	238759	***15.0***	184016	***16.1***	462596	***12.1***	111545	***18.3***	280196	***14.3***
J (Gain=38.5)	92034	***19.1***	230084	***15.1***	62121	***20.8***	154758	***16.9***	119433	***18.0***	298582	***14.0***	72903	***20.1***	181617	***16.2***
J (Gain=32.5)	182297	***16.1***	457808	***12.1***	122063	***17.9***	306792	***13.9***	236569	***15.0***	594102	***11.0***	143247	***17.2***	360037	***13.2***
J (Gain=28.5)	305205	***13.9***	765766	***9.9***	204528	***15.6***	513318	***11.6***	396068	***12.8***	993742	***8.8***	240025	***15.0***	602406	***11.0***
K (Gain=38.5)	90981	***19.2***	227453	***15.2***	61411	***20.9***	152989	***16.9***	118067	***18.0***	295168	***14.1***	72069	***20.2***	179540	***16.2***
K (Gain=32.5)	180213	***16.2***	452573	***12.2***	120667	***17.9***	303284	***13.9***	233864	***15.1***	587308	***11.1***	141609	***17.2***	355920	***13.2***
K (Gain=28.5)	301715	***14.0***	757009	***10.0***	202189	***15.7***	507448	***11.7***	391539	***12.8***	982378	***8.8***	237280	***15.0***	595517	***11.0***
L (Gain=38.5)	90981	***19.2***	227453	***15.2***	61411	***20.9***	152989	***16.9***	118067	***18.0***	295168	***14.1***	72069	***20.2***	179540	***16.2***
L (Gain=32.5)	180213	***16.2***	452573	***12.2***	120667	***17.9***	303284	***13.9***	233864	***15.1***	587308	***11.1***	141609	***17.2***	355920	***13.2***
L (Gain=28.5)	301715	***14.0***	757009	***10.0***	202189	***15.7***	507448	***11.7***	391539	***12.8***	982378	***8.8***	237280	***15.0***	595517	***11.0***
M (Gain=38.5)	105235	***18.5***	263088	***14.6***	71032	***20.2***	176957	***16.3***	136565	***17.4***	341412	***13.4***	83360	***19.5***	207669	***15.6***
M (Gain=32.5)	208447	***15.6***	523478	***11.6***	139572	***17.3***	350799	***13.3***	270503	***14.4***	679322	***10.4***	163795	***16.6***	411682	***12.6***
M (Gain=28.5)	348985	***13.3***	875611	***9.3***	233866	***15.1***	586950	***11.1***	452881	***12.2***	1136289	***8.2***	274455	***14.4***	688818	***10.4***
N (Gain=38.5)	111862	***18.3***	279654	***14.3***	75505	***20.0***	188100	***16.0***	145164	***17.1***	362910	***13.2***	88609	***19.3***	220745	***15.3***
N (Gain=32.5)	221572	***15.3***	556440	***11.3***	148361	***17.0***	372888	***13.0***	287536	***14.2***	722097	***10.2***	174109	***16.3***	437604	***12.3***
N (Gain=28.5)	370960	***13.1***	930746	***9.1***	248592	***14.8***	623909	***10.8***	481398	***11.9***	1207838	***7.9***	291736	***14.1***	732191	***10.1***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.10 : STEP 2 CASE 10

Table 136: Step 2 - Case 10 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	50%	3%	12.9%	485078

Table 137: Step 2 - Case 10 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***6.1***	229416	***3.3***	66251	***8.6***	166573	***4.6***	155746	***4.9***	390008	***0.9***	94076	***7.1***	236534	***3.1***
B	1224796	-4.0	2348496	-6.8	678356	-1.5	1703436	-5.5	1589430	-5.2	3992442	-9.2	963265	-3.0	2418879	-7.0
D	120016	***6.1***	300536	***2.1***	80163	***7.8***	201553	***3.8***	155746	***4.9***	390008	***0.9***	94076	***7.1***	236534	***3.1***
F	1420675	-4.7	3568552	-8.7	952081	-2.9	2390794	-6.9	1843624	-5.8	4630945	-9.8	1117318	-3.6	2805726	-7.6
G	268898	***2.6***	674755	-1.4	180152	***4.3***	452367	***0.3***	348952	***1.4***	875636	-2.6	211418	***3.6***	530877	-0.4

Table 138: Step 2 - Case 10 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***6.1***	300536	***2.1***	80163	***7.8***	201553	***3.8***	155746	***4.9***	390008	***0.9***	94076	***7.1***	236534	***3.1***
B	816531	-2.3	2051019	-6.3	547207	-0.5	1374105	-4.5	1059620	-3.4	2661628	-7.4	642177	-1.2	1612586	-5.2
C	169908	***4.6***	427130	***0.6***	113889	***6.3***	286085	***2.3***	220491	***3.4***	554291	-0.6	133655	***5.6***	335736	***1.6***
D	120016	***6.1***	300536	***2.1***	80163	***7.8***	201553	***3.8***	155746	***4.9***	390008	***0.9***	94076	***7.1***	236534	***3.1***
E	167965	***4.6***	422245	***0.6***	112587	***6.3***	282813	***2.3***	217970	***3.5***	547952	-0.5	132126	***5.6***	331897	***1.6***
F	947117	-2.9	2379035	-6.9	634721	-1.2	1593863	-5.2	1229083	-4.0	3087297	-8.0	744879	-1.9	1870484	-5.9
G	268898	***2.6***	674755	-1.4	180152	***4.3***	452367	***0.3***	348952	***1.4***	875636	-2.6	211418	***3.6***	530877	-0.4
H	140202	***5.4***	352766	***1.4***	93992	***7.1***	236023	***3.1***	181941	***4.3***	457788	***0.3***	110304	***6.4***	276986	***2.4***
I	141801	***5.3***	356471	***1.3***	95049	***7.1***	238759	***3.1***	184016	***4.2***	462596	***0.2***	111545	***6.4***	280196	***2.4***
J (Gain=38.5)	92034	***7.2***	230084	***3.2***	62121	***8.9***	154758	***5.0***	119433	***6.1***	298582	***2.1***	72903	***8.2***	181617	***4.3***
J (Gain=32.5)	182297	***4.3***	457808	***0.3***	122063	***6.0***	306792	***2.0***	236569	***3.1***	594102	-0.9	143247	***5.3***	360037	***1.3***
J (Gain=28.5)	305205	***2.0***	765766	-2.0	204528	***3.8***	513318	-0.2	396068	***0.9***	993742	-3.1	240025	***3.1***	602406	-0.9
K (Gain=38.5)	90981	***7.3***	227453	***3.3***	61411	***9.0***	152989	***5.0***	118067	***6.1***	295168	***2.2***	72069	***8.3***	179540	***4.3***
K (Gain=32.5)	180213	***4.3***	452573	***0.3***	120667	***6.0***	303284	***2.0***	233864	***3.2***	587308	-0.8	141609	***5.3***	355920	***1.3***
K (Gain=28.5)	301715	***2.1***	757009	-1.9	202189	***3.8***	507448	-0.2	391539	***0.9***	982378	-3.1	237280	***3.1***	595517	-0.9
L (Gain=38.5)	90981	***7.3***	227453	***3.3***	61411	***9.0***	152989	***5.0***	118067	***6.1***	295168	***2.2***	72069	***8.3***	179540	***4.3***
L (Gain=32.5)	180213	***4.3***	452573	***0.3***	120667	***6.0***	303284	***2.0***	233864	***3.2***	587308	-0.8	141609	***5.3***	355920	***1.3***
L (Gain=28.5)	301715	***2.1***	757009	-1.9	202189	***3.8***	507448	-0.2	391539	***0.9***	982378	-3.1	237280	***3.1***	595517	-0.9
M (Gain=38.5)	105235	***6.6***	263088	***2.7***	71032	***8.3***	176957	***4.4***	136565	***5.5***	341412	***1.5***	83360	***7.6***	207669	***3.7***
M (Gain=32.5)	208447	***3.7***	523478	-0.3	139572	***5.4***	350799	***1.4***	270503	***2.5***	679322	-1.5	163795	***4.7***	411682	***0.7***
M (Gain=28.5)	348985	***1.4***	875611	-2.6	233866	***3.2***	586950	-0.8	452881	***0.3***	1136289	-3.7	274455	***2.5***	688818	-1.5
N (Gain=38.5)	111862	***6.4***	279654	***2.4***	75505	***8.1***	188100	***4.1***	145164	***5.2***	362910	***1.3***	88609	***7.4***	220745	***3.4***
N (Gain=32.5)	221572	***3.4***	556440	-0.6	148361	***5.1***	372888	***1.1***	287536	***2.3***	722097	-1.7	174109	***4.4***	437604	***0.4***
N (Gain=28.5)	370960	***1.2***	930746	-2.8	248592	***2.9***	623909	-1.1	481398	***0.0***	1207838	-4.0	291736	***2.2***	732191	-1.8

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.11 : STEP 2 CASE 11

Table 139: Step 2 - Case 11 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	50%	10%	12.9%	1616926

Table 140: Step 2 - Case 11 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	11.3	229416	8.5	66251	13.9	166573	9.9	155746	10.2	390008	6.2	94076	12.4	236534	8.3
B	1224796	1.2	2348496	-1.6	678356	3.8	1703436	-0.2	1589430	0.1	3992442	-3.9	963265	2.2	2418879	-1.7
D	120016	11.3	300536	7.3	80163	13.0	201553	9.0	155746	10.2	390008	6.2	94076	12.4	236534	8.3
F	1420675	0.6	3568552	-3.4	952081	2.3	2390794	-1.7	1843624	-0.6	4630945	-4.6	1117318	1.6	2805726	-2.4
G	268898	7.8	674755	3.8	180152	9.5	452367	5.5	348952	6.7	875636	2.7	211418	8.8	530877	4.8

Table 141: Step 2 - Case 11 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	11.3	300536	7.3	80163	13.0	201553	9.0	155746	10.2	390008	6.2	94076	12.4	236534	8.3
B	816531	3.0	2051019	-1.0	547207	4.7	1374105	0.7	1059620	1.8	2661628	-2.2	642177	4.0	1612586	0.0
C	169908	9.8	427130	5.8	113889	11.5	286085	7.5	220491	8.7	554291	4.6	133655	10.8	335736	6.8
D	120016	11.3	300536	7.3	80163	13.0	201553	9.0	155746	10.2	390008	6.2	94076	12.4	236534	8.3
E	167965	9.8	422245	5.8	112587	11.6	282813	7.6	217970	8.7	547952	4.7	132126	10.9	331897	6.9
F	947117	2.3	2379035	-1.7	634721	4.1	1593863	0.1	1229083	1.2	3087297	-2.8	744879	3.4	1870484	-0.6
G	268898	7.8	674755	3.8	180152	9.5	452367	5.5	348952	6.7	875636	2.7	211418	8.8	530877	4.8
H	140202	10.6	352766	6.6	93992	12.4	236023	8.4	181941	9.5	457788	5.5	110304	11.7	276986	7.7
I	141801	10.6	356471	6.6	95049	12.3	238759	8.3	184016	9.4	462596	5.4	111545	11.6	280196	7.6
J (Gain=38.5)	92034	12.4	230084	8.5	62121	14.2	154758	10.2	119433	11.3	298582	7.3	72903	13.5	181617	9.5
J (Gain=32.5)	182297	9.5	457808	5.5	122063	11.2	306792	7.2	236569	8.3	594102	4.3	143247	10.5	360037	6.5
J (Gain=28.5)	305205	7.2	765766	3.2	204528	9.0	513318	5.0	396068	6.1	993742	2.1	240025	8.3	602406	4.3
K (Gain=38.5)	90981	12.5	227453	8.5	61411	14.2	152989	10.2	118067	11.4	295168	7.4	72069	13.5	179540	9.5
K (Gain=32.5)	180213	9.5	452573	5.5	120667	11.3	303284	7.3	233864	8.4	587308	4.4	141609	10.6	355920	6.6
K (Gain=28.5)	301715	7.3	757009	3.3	202189	9.0	507448	5.0	391539	6.2	982378	2.2	237280	8.3	595517	4.3
L (Gain=38.5)	90981	12.5	227453	8.5	61411	14.2	152989	10.2	118067	11.4	295168	7.4	72069	13.5	179540	9.5
L (Gain=32.5)	180213	9.5	452573	5.5	120667	11.3	303284	7.3	233864	8.4	587308	4.4	141609	10.6	355920	6.6
L (Gain=28.5)	301715	7.3	757009	3.3	202189	9.0	507448	5.0	391539	6.2	982378	2.2	237280	8.3	595517	4.3
M (Gain=38.5)	105235	11.9	263088	7.9	71032	13.6	176957	9.6	136565	10.7	341412	6.8	83360	12.9	207669	8.9
M (Gain=32.5)	208447	8.9	523478	4.9	139572	10.6	350799	6.6	270503	7.8	679322	3.8	163795	9.9	411682	5.9
M (Gain=28.5)	348985	6.7	875611	2.7	233866	8.4	586950	4.4	452881	5.5	1136289	1.5	274455	7.7	688818	3.7
N (Gain=38.5)	111862	11.6	279654	7.6	75505	13.3	188100	9.3	145164	10.5	362910	6.5	88609	12.6	220745	8.6
N (Gain=32.5)	221572	8.6	556440	4.6	148361	10.4	372888	6.4	287536	7.5	722097	3.5	174109	9.7	437604	5.7
N (Gain=28.5)	370960	6.4	930746	2.4	248592	8.1	623909	4.1	481398	5.3	1207838	1.3	291736	7.4	732191	3.4

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.12 : STEP 2 CASE 12

Table 142: Step 2 - Case 12 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	50%	30%	12.9%	4850777

Table 143: Step 2 - Case 12 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*16.1*	229416	*13.3*	66251	*18.6*	166573	*14.6*	155746	*14.9*	390008	*10.9*	94076	*17.1*	236534	*13.1*
B	1224796	*6.0*	2348496	*3.2*	678356	*8.5*	1703436	*4.5*	1589430	*4.8*	3992442	*0.8*	963265	*7.0*	2418879	*3.0*
D	120016	*16.1*	300536	*12.1*	80163	*17.8*	201553	*13.8*	155746	*14.9*	390008	*10.9*	94076	*17.1*	236534	*13.1*
F	1420675	*5.3*	3568552	*1.3*	952081	*7.1*	2390794	*3.1*	1843624	*4.2*	4630945	*0.2*	1117318	*6.4*	2805726	*2.4*
G	268898	*12.6*	674755	*8.6*	180152	*14.3*	452367	*10.3*	348952	*11.4*	875636	*7.4*	211418	*13.6*	530877	*9.6*

Table 144: Step 2 - Case 12 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*16.1*	300536	*12.1*	80163	*17.8*	201553	*13.8*	155746	*14.9*	390008	*10.9*	94076	*17.1*	236534	*13.1*
B	816531	*7.7*	2051019	*3.7*	547207	*9.5*	1374105	*5.5*	1059620	*6.6*	2661628	*2.6*	642177	*8.8*	1612586	*4.8*
C	169908	*14.6*	427130	*10.6*	113889	*16.3*	286085	*12.3*	220491	*13.4*	554291	*9.4*	133655	*15.6*	335736	*11.6*
D	120016	*16.1*	300536	*12.1*	80163	*17.8*	201553	*13.8*	155746	*14.9*	390008	*10.9*	94076	*17.1*	236534	*13.1*
E	167965	*14.6*	422245	*10.6*	112587	*16.3*	282813	*12.3*	217970	*13.5*	547952	*9.5*	132126	*15.6*	331897	*11.6*
F	947117	*7.1*	2379035	*3.1*	634721	*8.8*	1593863	*4.8*	1229083	*6.0*	3087297	*2.0*	744879	*8.1*	1870484	*4.1*
G	268898	*12.6*	674755	*8.6*	180152	*14.3*	452367	*10.3*	348952	*11.4*	875636	*7.4*	211418	*13.6*	530877	*9.6*
H	140202	*15.4*	352766	*11.4*	93992	*17.1*	236023	*13.1*	181941	*14.3*	457788	*10.3*	110304	*16.4*	276986	*12.4*
I	141801	*15.3*	356471	*11.3*	95049	*17.1*	238759	*13.1*	184016	*14.2*	462596	*10.2*	111545	*16.4*	280196	*12.4*
J (Gain=38.5)	92034	*17.2*	230084	*13.2*	62121	*18.9*	154758	*15.0*	119433	*16.1*	298582	*12.1*	72903	*18.2*	181617	*14.3*
J (Gain=32.5)	182297	*14.3*	457808	*10.3*	122063	*16.0*	306792	*12.0*	236569	*13.1*	594102	*9.1*	143247	*15.3*	360037	*11.3*
J (Gain=28.5)	305205	*12.0*	765766	*8.0*	204528	*13.8*	513318	*9.8*	396068	*10.9*	993742	*6.9*	240025	*13.1*	602406	*9.1*
K (Gain=38.5)	90981	*17.3*	227453	*13.3*	61411	*19.0*	152989	*15.0*	118067	*16.1*	295168	*12.2*	72069	*18.3*	179540	*14.3*
K (Gain=32.5)	180213	*14.3*	452573	*10.3*	120667	*16.0*	303284	*12.0*	233864	*13.2*	587308	*9.2*	141609	*15.3*	355920	*11.3*
K (Gain=28.5)	301715	*12.1*	757009	*8.1*	202189	*13.8*	507448	*9.8*	391539	*10.9*	982378	*6.9*	237280	*13.1*	595517	*9.1*
L (Gain=38.5)	90981	*17.3*	227453	*13.3*	61411	*19.0*	152989	*15.0*	118067	*16.1*	295168	*12.2*	72069	*18.3*	179540	*14.3*
L (Gain=32.5)	180213	*14.3*	452573	*10.3*	120667	*16.0*	303284	*12.0*	233864	*13.2*	587308	*9.2*	141609	*15.3*	355920	*11.3*
L (Gain=28.5)	301715	*12.1*	757009	*8.1*	202189	*13.8*	507448	*9.8*	391539	*10.9*	982378	*6.9*	237280	*13.1*	595517	*9.1*
M (Gain=38.5)	105235	*16.6*	263088	*12.7*	71032	*18.3*	176957	*14.4*	136565	*15.5*	341412	*11.5*	83360	*17.6*	207669	*13.7*
M (Gain=32.5)	208447	*13.7*	523478	*9.7*	139572	*15.4*	350799	*11.4*	270503	*12.5*	679322	*8.5*	163795	*14.7*	411682	*10.7*
M (Gain=28.5)	348985	*11.4*	875611	*7.4*	233866	*13.2*	586950	*9.2*	452881	*10.3*	1136289	*6.3*	274455	*12.5*	688818	*8.5*
N (Gain=38.5)	111862	*16.4*	279654	*12.4*	75505	*18.1*	188100	*14.1*	145164	*15.2*	362910	*11.3*	88609	*17.4*	220745	*13.4*
N (Gain=32.5)	221572	*13.4*	556440	*9.4*	148361	*15.1*	372888	*11.1*	287536	*12.3*	722097	*8.3*	174109	*14.4*	437604	*10.4*
N (Gain=28.5)	370960	*11.2*	930746	*7.2*	248592	*12.9*	623909	*8.9*	481398	*10.0*	1207838	*6.0*	291736	*12.2*	732191	*8.2*

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.13 : STEP 2 CASE 13

Table 145: Step 2 - Case 13 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	74%	3%	12.9%	717915

Table 146: Step 2 - Case 13 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	7.8	229416	5.0	66251	10.3	166573	6.3	155746	6.6	390008	2.6	94076	8.8	236534	4.8
B	1224796	-2.3	2348496	-5.1	678356	0.2	1703436	-3.8	1589430	-3.5	3992442	-7.5	963265	-1.3	2418879	-5.3
D	120016	7.8	300536	3.8	80163	9.5	201553	5.5	155746	6.6	390008	2.6	94076	8.8	236534	4.8
F	1420675	-3.0	3568552	-7.0	952081	-1.2	2390794	-5.2	1843624	-4.1	4630945	-8.1	1117318	-1.9	2805726	-5.9
G	268898	4.3	674755	0.3	180152	6.0	452367	2.0	348952	3.1	875636	-0.9	211418	5.3	530877	1.3

Table 147: Step 2 - Case 13 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	7.8	300536	3.8	80163	9.5	201553	5.5	155746	6.6	390008	2.6	94076	8.8	236534	4.8
B	816531	-0.6	2051019	-4.6	547207	1.2	1374105	-2.8	1059620	-1.7	2661628	-5.7	642177	0.5	1612586	-3.5
C	169908	6.3	427130	2.3	113889	8.0	286085	4.0	220491	5.1	554291	1.1	133655	7.3	335736	3.3
D	120016	7.8	300536	3.8	80163	9.5	201553	5.5	155746	6.6	390008	2.6	94076	8.8	236534	4.8
E	167965	6.3	422245	2.3	112587	8.0	282813	4.0	217970	5.2	547952	1.2	132126	7.4	331897	3.4
F	947117	-1.2	2379035	-5.2	634721	0.5	1593863	-3.5	1229083	-2.3	3087297	-6.3	744879	-0.2	1870484	-4.2
G	268898	4.3	674755	0.3	180152	6.0	452367	2.0	348952	3.1	875636	-0.9	211418	5.3	530877	1.3
H	140202	7.1	352766	3.1	93992	8.8	236023	4.8	181941	6.0	457788	2.0	110304	8.1	276986	4.1
I	141801	7.0	356471	3.0	95049	8.8	238759	4.8	184016	5.9	462596	1.9	111545	8.1	280196	4.1
J (Gain=38.5)	92034	8.9	230084	4.9	62121	10.6	154758	6.7	119433	7.8	298582	3.8	72903	9.9	181617	6.0
J (Gain=32.5)	182297	6.0	457808	2.0	122063	7.7	306792	3.7	236569	4.8	594102	0.8	143247	7.0	360037	3.0
J (Gain=28.5)	305205	3.7	765766	-0.3	204528	5.5	513318	1.5	396068	2.6	993742	-1.4	240025	4.8	602406	0.8
K (Gain=38.5)	90981	9.0	227453	5.0	61411	10.7	152989	6.7	118067	7.8	295168	3.9	72069	10.0	179540	6.0
K (Gain=32.5)	180213	6.0	452573	2.0	120667	7.7	303284	3.7	233864	4.9	587308	0.9	141609	7.0	355920	3.0
K (Gain=28.5)	301715	3.8	757009	-0.2	202189	5.5	507448	1.5	391539	2.6	982378	-1.4	237280	4.8	595517	0.8
L (Gain=38.5)	90981	9.0	227453	5.0	61411	10.7	152989	6.7	118067	7.8	295168	3.9	72069	10.0	179540	6.0
L (Gain=32.5)	180213	6.0	452573	2.0	120667	7.7	303284	3.7	233864	4.9	587308	0.9	141609	7.0	355920	3.0
L (Gain=28.5)	301715	3.8	757009	-0.2	202189	5.5	507448	1.5	391539	2.6	982378	-1.4	237280	4.8	595517	0.8
M (Gain=38.5)	105235	8.3	263088	4.4	71032	10.0	176957	6.1	136565	7.2	341412	3.2	83360	9.4	207669	5.4
M (Gain=32.5)	208447	5.4	523478	1.4	139572	7.1	350799	3.1	270503	4.2	679322	0.2	163795	6.4	411682	2.4
M (Gain=28.5)	348985	3.1	875611	-0.9	233866	4.9	586950	0.9	452881	2.0	1136289	-2.0	274455	4.2	688818	0.2
N (Gain=38.5)	111862	8.1	279654	4.1	75505	9.8	188100	5.8	145164	6.9	362910	3.0	88609	9.1	220745	5.1
N (Gain=32.5)	221572	5.1	556440	1.1	148361	6.8	372888	2.8	287536	4.0	722097	0.0	174109	6.2	437604	2.1
N (Gain=28.5)	370960	2.9	930746	-1.1	248592	4.6	623909	0.6	481398	1.7	1207838	-2.3	291736	3.9	732191	-0.1

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.14 : STEP 2 CASE 14

Table 148: Step 2 - Case 14 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	74%	10%	12.9%	2393050

Table 149: Step 2 - Case 14 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	13.0	229416	10.2	66251	15.6	166573	11.6	155746	11.9	390008	7.9	94076	14.1	236534	10.1
B	1224796	2.9	2348496	0.1	678356	5.5	1703436	1.5	1589430	1.8	3992442	-2.2	963265	4.0	2418879	0.0
D	120016	13.0	300536	9.0	80163	14.7	201553	10.7	155746	11.9	390008	7.9	94076	14.1	236534	10.1
F	1420675	2.3	3568552	-1.7	952081	4.0	2390794	0.0	1843624	1.1	4630945	-2.9	1117318	3.3	2805726	-0.7
G	268898	9.5	674755	5.5	180152	11.2	452367	7.2	348952	8.4	875636	4.4	211418	10.5	530877	6.5

Table 150: Step 2 - Case 14 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	13.0	300536	9.0	80163	14.7	201553	10.7	155746	11.9	390008	7.9	94076	14.1	236534	10.1
B	816531	4.7	2051019	0.7	547207	6.4	1374105	2.4	1059620	3.5	2661628	-0.5	642177	5.7	1612586	1.7
C	169908	11.5	427130	7.5	113889	13.2	286085	9.2	220491	10.4	554291	6.4	133655	12.5	335736	8.5
D	120016	13.0	300536	9.0	80163	14.7	201553	10.7	155746	11.9	390008	7.9	94076	14.1	236534	10.1
E	167965	11.5	422245	7.5	112587	13.3	282813	9.3	217970	10.4	547952	6.4	132126	12.6	331897	8.6
F	947117	4.0	2379035	0.0	634721	5.8	1593863	1.8	1229083	2.9	3087297	-1.1	744879	5.1	1870484	1.1
G	268898	9.5	674755	5.5	180152	11.2	452367	7.2	348952	8.4	875636	4.4	211418	10.5	530877	6.5
H	140202	12.3	352766	8.3	93992	14.1	236023	10.1	181941	11.2	457788	7.2	110304	13.4	276986	9.4
I	141801	12.3	356471	8.3	95049	14.0	238759	10.0	184016	11.1	462596	7.1	111545	13.3	280196	9.3
J (Gain=38.5)	92034	14.2	230084	10.2	62121	15.9	154758	11.9	119433	13.0	298582	9.0	72903	15.2	181617	11.2
J (Gain=32.5)	182297	11.2	457808	7.2	122063	12.9	306792	8.9	236569	10.0	594102	6.1	143247	12.2	360037	8.2
J (Gain=28.5)	305205	8.9	765766	4.9	204528	10.7	513318	6.7	396068	7.8	993742	3.8	240025	10.0	602406	6.0
K (Gain=38.5)	90981	14.2	227453	10.2	61411	15.9	152989	11.9	118067	13.1	295168	9.1	72069	15.2	179540	11.2
K (Gain=32.5)	180213	11.2	452573	7.2	120667	13.0	303284	9.0	233864	10.1	587308	6.1	141609	12.3	355920	8.3
K (Gain=28.5)	301715	9.0	757009	5.0	202189	10.7	507448	6.7	391539	7.9	982378	3.9	237280	10.0	595517	6.0
L (Gain=38.5)	90981	14.2	227453	10.2	61411	15.9	152989	11.9	118067	13.1	295168	9.1	72069	15.2	179540	11.2
L (Gain=32.5)	180213	11.2	452573	7.2	120667	13.0	303284	9.0	233864	10.1	587308	6.1	141609	12.3	355920	8.3
L (Gain=28.5)	301715	9.0	757009	5.0	202189	10.7	507448	6.7	391539	7.9	982378	3.9	237280	10.0	595517	6.0
M (Gain=38.5)	105235	13.6	263088	9.6	71032	15.3	176957	11.3	136565	12.4	341412	8.5	83360	14.6	207669	10.6
M (Gain=32.5)	208447	10.6	523478	6.6	139572	12.3	350799	8.3	270503	9.5	679322	5.5	163795	11.6	411682	7.6
M (Gain=28.5)	348985	8.4	875611	4.4	233866	10.1	586950	6.1	452881	7.2	1136289	3.2	274455	9.4	688818	5.4
N (Gain=38.5)	111862	13.3	279654	9.3	75505	15.0	188100	11.0	145164	12.2	362910	8.2	88609	14.3	220745	10.4
N (Gain=32.5)	221572	10.3	556440	6.3	148361	12.1	372888	8.1	287536	9.2	722097	5.2	174109	11.4	437604	7.4
N (Gain=28.5)	370960	8.1	930746	4.1	248592	9.8	623909	5.8	481398	7.0	1207838	3.0	291736	9.1	732191	5.1

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.15 : STEP 2 CASE 15

Table 151: Step 2 - Case 15 - Factors

Total Nb of AP	Busy hour population	5 GHZ factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	74%	30%	12.9%	7179150

Table 152: Step 2 - Case 15 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***17.8***	229416	***15.0***	66251	***20.3***	166573	***16.3***	155746	***16.6***	390008	***12.6***	94076	***18.8***	236534	***14.8***
B	1224796	***7.7***	2348496	***4.9***	678356	***10.2***	1703436	***6.2***	1589430	***6.5***	3992442	***2.5***	963265	***8.7***	2418879	***4.7***
D	120016	***17.8***	300536	***13.8***	80163	***19.5***	201553	***15.5***	155746	***16.6***	390008	***12.6***	94076	***18.8***	236534	***14.8***
F	1420675	***7.0***	3568552	***3.0***	952081	***8.8***	2390794	***4.8***	1843624	***5.9***	4630945	***1.9***	1117318	***8.1***	2805726	***4.1***
G	268898	***14.3***	674755	***10.3***	180152	***16.0***	452367	***12.0***	348952	***13.1***	875636	***9.1***	211418	***15.3***	530877	***11.3***

Table 153: Step 2 - Case 15 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***17.8***	300536	***13.8***	80163	***19.5***	201553	***15.5***	155746	***16.6***	390008	***12.6***	94076	***18.8***	236534	***14.8***
B	816531	***9.4***	2051019	***5.4***	547207	***11.2***	1374105	***7.2***	1059620	***8.3***	2661628	***4.3***	642177	***10.5***	1612586	***6.5***
C	169908	***16.3***	427130	***12.3***	113889	***18.0***	286085	***14.0***	220491	***15.1***	554291	***11.1***	133655	***17.3***	335736	***13.3***
D	120016	***17.8***	300536	***13.8***	80163	***19.5***	201553	***15.5***	155746	***16.6***	390008	***12.6***	94076	***18.8***	236534	***14.8***
E	167965	***16.3***	422245	***12.3***	112587	***18.0***	282813	***14.0***	217970	***15.2***	547952	***11.2***	132126	***17.4***	331897	***13.4***
F	947117	***8.8***	2379035	***4.8***	634721	***10.5***	1593863	***6.5***	1229083	***7.7***	3087297	***3.7***	744879	***9.8***	1870484	***5.8***
G	268898	***14.3***	674755	***10.3***	180152	***16.0***	452367	***12.0***	348952	***13.1***	875636	***9.1***	211418	***15.3***	530877	***11.3***
H	140202	***17.1***	352766	***13.1***	93992	***18.8***	236023	***14.8***	181941	***16.0***	457788	***12.0***	110304	***18.1***	276986	***14.1***
I	141801	***17.0***	356471	***13.0***	95049	***18.8***	238759	***14.8***	184016	***15.9***	462596	***11.9***	111545	***18.1***	280196	***14.1***
J (Gain=38.5)	92034	***18.9***	230084	***14.9***	62121	***20.6***	154758	***16.7***	119433	***17.8***	298582	***13.8***	72903	***19.9***	181617	***16.0***
J (Gain=32.5)	182297	***16.0***	457808	***12.0***	122063	***17.7***	306792	***13.7***	236569	***14.8***	594102	***10.8***	143247	***17.0***	360037	***13.0***
J (Gain=28.5)	305205	***13.7***	765766	***9.7***	204528	***15.5***	513318	***11.5***	396068	***12.6***	993742	***8.6***	240025	***14.8***	602406	***10.8***
K (Gain=38.5)	90981	***19.0***	227453	***15.0***	61411	***20.7***	152989	***16.7***	118067	***17.8***	295168	***13.9***	72069	***20.0***	179540	***16.0***
K (Gain=32.5)	180213	***16.0***	452573	***12.0***	120667	***17.7***	303284	***13.7***	233864	***14.9***	587308	***10.9***	141609	***17.0***	355920	***13.0***
K (Gain=28.5)	301715	***13.8***	757009	***9.8***	202189	***15.5***	507448	***11.5***	391539	***12.6***	982378	***8.6***	237280	***14.8***	595517	***10.8***
L (Gain=38.5)	90981	***19.0***	227453	***15.0***	61411	***20.7***	152989	***16.7***	118067	***17.8***	295168	***13.9***	72069	***20.0***	179540	***16.0***
L (Gain=32.5)	180213	***16.0***	452573	***12.0***	120667	***17.7***	303284	***13.7***	233864	***14.9***	587308	***10.9***	141609	***17.0***	355920	***13.0***
L (Gain=28.5)	301715	***13.8***	757009	***9.8***	202189	***15.5***	507448	***11.5***	391539	***12.6***	982378	***8.6***	237280	***14.8***	595517	***10.8***
M (Gain=38.5)	105235	***18.3***	263088	***14.4***	71032	***20.0***	176957	***16.1***	136565	***17.2***	341412	***13.2***	83360	***19.4***	207669	***15.4***
M (Gain=32.5)	208447	***15.4***	523478	***11.4***	139572	***17.1***	350799	***13.1***	270503	***14.2***	679322	***10.2***	163795	***16.4***	411682	***12.4***
M (Gain=28.5)	348985	***13.1***	875611	***9.1***	233866	***14.9***	586950	***10.9***	452881	***12.0***	1136289	***8.0***	274455	***14.2***	688818	***10.2***
N (Gain=38.5)	111862	***18.1***	279654	***14.1***	75505	***19.8***	188100	***15.8***	145164	***16.9***	362910	***13.0***	88609	***19.1***	220745	***15.1***
N (Gain=32.5)	221572	***15.1***	556440	***11.1***	148361	***16.8***	372888	***12.8***	287536	***14.0***	722097	***10.0***	174109	***16.2***	437604	***12.1***
N (Gain=28.5)	370960	***12.9***	930746	***8.9***	248592	***14.6***	623909	***10.6***	481398	***11.7***	1207838	***7.7***	291736	***13.9***	732191	***9.9***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.16 : STEP 2 CASE 16

Table 154: Step 2 - Case 16 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	97%	3%	12.9%	941051

Table 155: Step 2 - Case 16 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*8.9*	229416	*6.1*	66251	*11.5*	166573	*7.5*	155746	*7.8*	390008	*3.8*	94076	*10.0*	236534	*6.0*
B	1224796	-1.1	2348496	-4.0	678356	*1.4*	1703436	-2.6	1589430	-2.3	3992442	-6.3	963265	-0.1	2418879	-4.1
D	120016	*8.9*	300536	*5.0*	80163	*10.7*	201553	*6.7*	155746	*7.8*	390008	*3.8*	94076	*10.0*	236534	*6.0*
F	1420675	-1.8	3568552	-5.8	952081	-0.1	2390794	-4.0	1843624	-2.9	4630945	-6.9	1117318	-0.7	2805726	-4.7
G	268898	*5.4*	674755	*1.4*	180152	*7.2*	452367	*3.2*	348952	*4.3*	875636	*0.3*	211418	*6.5*	530877	*2.5*

Table 156: Step 2 - Case 16 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*8.9*	300536	*5.0*	80163	*10.7*	201553	*6.7*	155746	*7.8*	390008	*3.8*	94076	*10.0*	236534	*6.0*
B	816531	*0.6*	2051019	-3.4	547207	*2.4*	1374105	-1.6	1059620	-0.5	2661628	-4.5	642177	*1.7*	1612586	-2.3
C	169908	*7.4*	427130	*3.4*	113889	*9.2*	286085	*5.2*	220491	*6.3*	554291	*2.3*	133655	*8.5*	335736	*4.5*
D	120016	*8.9*	300536	*5.0*	80163	*10.7*	201553	*6.7*	155746	*7.8*	390008	*3.8*	94076	*10.0*	236534	*6.0*
E	167965	*7.5*	422245	*3.5*	112587	*9.2*	282813	*5.2*	217970	*6.4*	547952	*2.3*	132126	*8.5*	331897	*4.5*
F	947117	0.0	2379035	-4.0	634721	*1.7*	1593863	-2.3	1229083	-1.2	3087297	-5.2	744879	*1.0*	1870484	-3.0
G	268898	*5.4*	674755	*1.4*	180152	*7.2*	452367	*3.2*	348952	*4.3*	875636	*0.3*	211418	*6.5*	530877	*2.5*
H	140202	*8.3*	352766	*4.3*	93992	*10.0*	236023	*6.0*	181941	*7.1*	457788	*3.1*	110304	*9.3*	276986	*5.3*
I	141801	*8.2*	356471	*4.2*	95049	*10.0*	238759	*6.0*	184016	*7.1*	462596	*3.1*	111545	*9.3*	280196	*5.3*
J (Gain=38.5)	92034	*10.1*	230084	*6.1*	62121	*11.8*	154758	*7.8*	119433	*9.0*	298582	*5.0*	72903	*11.1*	181617	*7.1*
J (Gain=32.5)	182297	*7.1*	457808	*3.1*	122063	*8.9*	306792	*4.9*	236569	*6.0*	594102	*2.0*	143247	*8.2*	360037	*4.2*
J (Gain=28.5)	305205	*4.9*	765766	*0.9*	204528	*6.6*	513318	*2.6*	396068	*3.8*	993742	-0.2	240025	*5.9*	602406	*1.9*
K (Gain=38.5)	90981	*10.1*	227453	*6.2*	61411	*11.9*	152989	*7.9*	118067	*9.0*	295168	*5.0*	72069	*11.2*	179540	*7.2*
K (Gain=32.5)	180213	*7.2*	452573	*3.2*	120667	*8.9*	303284	*4.9*	233864	*6.0*	587308	*2.0*	141609	*8.2*	355920	*4.2*
K (Gain=28.5)	301715	*4.9*	757009	*0.9*	202189	*6.7*	507448	*2.7*	391539	*3.8*	982378	-0.2	237280	*6.0*	595517	*2.0*
L (Gain=38.5)	90981	*10.1*	227453	*6.2*	61411	*11.9*	152989	*7.9*	118067	*9.0*	295168	*5.0*	72069	*11.2*	179540	*7.2*
L (Gain=32.5)	180213	*7.2*	452573	*3.2*	120667	*8.9*	303284	*4.9*	233864	*6.0*	587308	*2.0*	141609	*8.2*	355920	*4.2*
L (Gain=28.5)	301715	*4.9*	757009	*0.9*	202189	*6.7*	507448	*2.7*	391539	*3.8*	982378	-0.2	237280	*6.0*	595517	*2.0*
M (Gain=38.5)	105235	*9.5*	263088	*5.5*	71032	*11.2*	176957	*7.3*	136565	*8.4*	341412	*4.4*	83360	*10.5*	207669	*6.6*
M (Gain=32.5)	208447	*6.5*	523478	*2.5*	139572	*8.3*	350799	*4.3*	270503	*5.4*	679322	*1.4*	163795	*7.6*	411682	*3.6*
M (Gain=28.5)	348985	*4.3*	875611	*0.3*	233866	*6.0*	586950	*2.1*	452881	*3.2*	1136289	-0.8	274455	*5.4*	688818	*1.4*
N (Gain=38.5)	111862	*9.2*	279654	*5.3*	75505	*11.0*	188100	*7.0*	145164	*8.1*	362910	*4.1*	88609	*10.3*	220745	*6.3*
N (Gain=32.5)	221572	*6.3*	556440	*2.3*	148361	*8.0*	372888	*4.0*	287536	*5.1*	722097	*1.2*	174109	*7.3*	437604	*3.3*
N (Gain=28.5)	370960	*4.0*	930746	*0.0*	248592	*5.8*	623909	*1.8*	481398	*2.9*	1207838	-1.1	291736	*5.1*	732191	*1.1*

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.17 : STEP 2 CASE 17

Table 157: Step 2 - Case 17 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	97%	10%	12.9%	3136836

Table 158: Step 2 - Case 17 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	14.2	229416	11.4	66251	16.8	166573	12.7	155746	13.0	390008	9.1	94076	15.2	236534	11.2
B	1224796	4.1	2348496	1.3	678356	6.7	1703436	2.7	1589430	3.0	3992442	-1.0	963265	5.1	2418879	1.1
D	120016	14.2	300536	10.2	80163	15.9	201553	11.9	155746	13.0	390008	9.1	94076	15.2	236534	11.2
F	1420675	3.4	3568552	-0.6	952081	5.2	2390794	1.2	1843624	2.3	4630945	-1.7	1117318	4.5	2805726	0.5
G	268898	10.7	674755	6.7	180152	12.4	452367	8.4	348952	9.5	875636	5.5	211418	11.7	530877	7.7

Table 159: Step 2 - Case 17 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	14.2	300536	10.2	80163	15.9	201553	11.9	155746	13.0	390008	9.1	94076	15.2	236534	11.2
B	816531	5.8	2051019	1.8	547207	7.6	1374105	3.6	1059620	4.7	2661628	0.7	642177	6.9	1612586	2.9
C	169908	12.7	427130	8.7	113889	14.4	286085	10.4	220491	11.5	554291	7.5	133655	13.7	335736	9.7
D	120016	14.2	300536	10.2	80163	15.9	201553	11.9	155746	13.0	390008	9.1	94076	15.2	236534	11.2
E	167965	12.7	422245	8.7	112587	14.5	282813	10.4	217970	11.6	547952	7.6	132126	13.8	331897	9.8
F	947117	5.2	2379035	1.2	634721	6.9	1593863	2.9	1229083	4.1	3087297	0.1	744879	6.2	1870484	2.2
G	268898	10.7	674755	6.7	180152	12.4	452367	8.4	348952	9.5	875636	5.5	211418	11.7	530877	7.7
H	140202	13.5	352766	9.5	93992	15.2	236023	11.2	181941	12.4	457788	8.4	110304	14.5	276986	10.5
I	141801	13.4	356471	9.4	95049	15.2	238759	11.2	184016	12.3	462596	8.3	111545	14.5	280196	10.5
J (Gain=38.5)	92034	15.3	230084	11.3	62121	17.0	154758	13.1	119433	14.2	298582	10.2	72903	16.3	181617	12.4
J (Gain=32.5)	182297	12.4	457808	8.4	122063	14.1	306792	10.1	236569	11.2	594102	7.2	143247	13.4	360037	9.4
J (Gain=28.5)	305205	10.1	765766	6.1	204528	11.9	513318	7.9	396068	9.0	993742	5.0	240025	11.2	602406	7.2
K (Gain=38.5)	90981	15.4	227453	11.4	61411	17.1	152989	13.1	118067	14.2	295168	10.3	72069	16.4	179540	12.4
K (Gain=32.5)	180213	12.4	452573	8.4	120667	14.1	303284	10.1	233864	11.3	587308	7.3	141609	13.5	355920	9.5
K (Gain=28.5)	301715	10.2	757009	6.2	202189	11.9	507448	7.9	391539	9.0	982378	5.0	237280	11.2	595517	7.2
L (Gain=38.5)	90981	15.4	227453	11.4	61411	17.1	152989	13.1	118067	14.2	295168	10.3	72069	16.4	179540	12.4
L (Gain=32.5)	180213	12.4	452573	8.4	120667	14.1	303284	10.1	233864	11.3	587308	7.3	141609	13.5	355920	9.5
L (Gain=28.5)	301715	10.2	757009	6.2	202189	11.9	507448	7.9	391539	9.0	982378	5.0	237280	11.2	595517	7.2
M (Gain=38.5)	105235	14.7	263088	10.8	71032	16.5	176957	12.5	136565	13.6	341412	9.6	83360	15.8	207669	11.8
M (Gain=32.5)	208447	11.8	523478	7.8	139572	13.5	350799	9.5	270503	10.6	679322	6.6	163795	12.8	411682	8.8
M (Gain=28.5)	348985	9.5	875611	5.5	233866	11.3	586950	7.3	452881	8.4	1136289	4.4	274455	10.6	688818	6.6
N (Gain=38.5)	111862	14.5	279654	10.5	75505	16.2	188100	12.2	145164	13.3	362910	9.4	88609	15.5	220745	11.5
N (Gain=32.5)	221572	11.5	556440	7.5	148361	13.3	372888	9.2	287536	10.4	722097	6.4	174109	12.6	437604	8.6
N (Gain=28.5)	370960	9.3	930746	5.3	248592	11.0	623909	7.0	481398	8.1	1207838	4.1	291736	10.3	732191	6.3

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.18 : STEP 2 CASE 18

Table 160: Step 2 - Case 18 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	62.7%	97%	30%	12.9%	9410507

Table 161: Step 2 - Case 18 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***18.9***	229416	***16.1***	66251	***21.5***	166573	***17.5***	155746	***17.8***	390008	***13.8***	94076	***20.0***	236534	***16.0***
B	1224796	***8.9***	2348496	***6.0***	678356	***11.4***	1703436	***7.4***	1589430	***7.7***	3992442	***3.7***	963265	***9.9***	2418879	***5.9***
D	120016	***18.9***	300536	***15.0***	80163	***20.7***	201553	***16.7***	155746	***17.8***	390008	***13.8***	94076	***20.0***	236534	***16.0***
F	1420675	***8.2***	3568552	***4.2***	952081	***9.9***	2390794	***6.0***	1843624	***7.1***	4630945	***3.1***	1117318	***9.3***	2805726	***5.3***
G	268898	***15.4***	674755	***11.4***	180152	***17.2***	452367	***13.2***	348952	***14.3***	875636	***10.3***	211418	***16.5***	530877	***12.5***

Table 162: Step 2 - Case 18 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***18.9***	300536	***15.0***	80163	***20.7***	201553	***16.7***	155746	***17.8***	390008	***13.8***	94076	***20.0***	236534	***16.0***
B	816531	***10.6***	2051019	***6.6***	547207	***12.4***	1374105	***8.4***	1059620	***9.5***	2661628	***5.5***	642177	***11.7***	1612586	***7.7***
C	169908	***17.4***	427130	***13.4***	113889	***19.2***	286085	***15.2***	220491	***16.3***	554291	***12.3***	133655	***18.5***	335736	***14.5***
D	120016	***18.9***	300536	***15.0***	80163	***20.7***	201553	***16.7***	155746	***17.8***	390008	***13.8***	94076	***20.0***	236534	***16.0***
E	167965	***17.5***	422245	***13.5***	112587	***19.2***	282813	***15.2***	217970	***16.4***	547952	***12.3***	132126	***18.5***	331897	***14.5***
F	947117	***10.0***	2379035	***6.0***	634721	***11.7***	1593863	***7.7***	1229083	***8.8***	3087297	***4.8***	744879	***11.0***	1870484	***7.0***
G	268898	***15.4***	674755	***11.4***	180152	***17.2***	452367	***13.2***	348952	***14.3***	875636	***10.3***	211418	***16.5***	530877	***12.5***
H	140202	***18.3***	352766	***14.3***	93992	***20.0***	236023	***16.0***	181941	***17.1***	457788	***13.1***	110304	***19.3***	276986	***15.3***
I	141801	***18.2***	356471	***14.2***	95049	***20.0***	238759	***16.0***	184016	***17.1***	462596	***13.1***	111545	***19.3***	280196	***15.3***
J (Gain=38.5)	92034	***20.1***	230084	***16.1***	62121	***21.8***	154758	***17.8***	119433	***19.0***	298582	***15.0***	72903	***21.1***	181617	***17.1***
J (Gain=32.5)	182297	***17.1***	457808	***13.1***	122063	***18.9***	306792	***14.9***	236569	***16.0***	594102	***12.0***	143247	***18.2***	360037	***14.2***
J (Gain=28.5)	305205	***14.9***	765766	***10.9***	204528	***16.6***	513318	***12.6***	396068	***13.8***	993742	***9.8***	240025	***15.9***	602406	***11.9***
K (Gain=38.5)	90981	***20.1***	227453	***16.2***	61411	***21.9***	152989	***17.9***	118067	***19.0***	295168	***15.0***	72069	***21.2***	179540	***17.2***
K (Gain=32.5)	180213	***17.2***	452573	***13.2***	120667	***18.9***	303284	***14.9***	233864	***16.0***	587308	***12.0***	141609	***18.2***	355920	***14.2***
K (Gain=28.5)	301715	***14.9***	757009	***10.9***	202189	***16.7***	507448	***12.7***	391539	***13.8***	982378	***9.8***	237280	***16.0***	595517	***12.0***
L (Gain=38.5)	90981	***20.1***	227453	***16.2***	61411	***21.9***	152989	***17.9***	118067	***19.0***	295168	***15.0***	72069	***21.2***	179540	***17.2***
L (Gain=32.5)	180213	***17.2***	452573	***13.2***	120667	***18.9***	303284	***14.9***	233864	***16.0***	587308	***12.0***	141609	***18.2***	355920	***14.2***
L (Gain=28.5)	301715	***14.9***	757009	***10.9***	202189	***16.7***	507448	***12.7***	391539	***13.8***	982378	***9.8***	237280	***16.0***	595517	***12.0***
M (Gain=38.5)	105235	***19.5***	263088	***15.5***	71032	***21.2***	176957	***17.3***	136565	***18.4***	341412	***14.4***	83360	***20.5***	207669	***16.6***
M (Gain=32.5)	208447	***16.5***	523478	***12.5***	139572	***18.3***	350799	***14.3***	270503	***15.4***	679322	***11.4***	163795	***17.6***	411682	***13.6***
M (Gain=28.5)	348985	***14.3***	875611	***10.3***	233866	***16.0***	586950	***12.1***	452881	***13.2***	1136289	***9.2***	274455	***15.4***	688818	***11.4***
N (Gain=38.5)	111862	***19.2***	279654	***15.3***	75505	***21.0***	188100	***17.0***	145164	***18.1***	362910	***14.1***	88609	***20.3***	220745	***16.3***
N (Gain=32.5)	221572	***16.3***	556440	***12.3***	148361	***18.0***	372888	***14.0***	287536	***15.1***	722097	***11.2***	174109	***17.3***	437604	***13.3***
N (Gain=28.5)	370960	***14.0***	930746	***10.0***	248592	***15.8***	623909	***11.8***	481398	***12.9***	1207838	***8.9***	291736	***15.1***	732191	***11.1***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.19 : STEP 2 CASE 19

Table 163: Step 2 - Case 19 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	50%	3%	12.9%	541554

Table 164: Step 2 - Case 19 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***6.5***	229416	***3.7***	66251	***9.1***	166573	***5.1***	155746	***5.4***	390008	***1.4***	94076	***7.6***	236534	***3.6***
B	1224796	-3.5	2348496	-6.4	678356	-1.0	1703436	-5.0	1589430	-4.7	3992442	-8.7	963265	-2.5	2418879	-6.5
D	120016	***6.5***	300536	***2.6***	80163	***8.3***	201553	***4.3***	155746	***5.4***	390008	***1.4***	94076	***7.6***	236534	***3.6***
F	1420675	-4.2	3568552	-8.2	952081	-2.5	2390794	-6.4	1843624	-5.3	4630945	-9.3	1117318	-3.1	2805726	-7.1
G	268898	***3.0***	674755	-1.0	180152	***4.8***	452367	***0.8***	348952	***1.9***	875636	-2.1	211418	***4.1***	530877	***0.1***

Table 165: Step 2 - Case 19 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***6.5***	300536	***2.6***	80163	***8.3***	201553	***4.3***	155746	***5.4***	390008	***1.4***	94076	***7.6***	236534	***3.6***
B	816531	-1.8	2051019	-5.8	547207	0.0	1374105	-4.0	1059620	-2.9	2661628	-6.9	642177	-0.7	1612586	-4.7
C	169908	***5.0***	427130	***1.0***	113889	***6.8***	286085	***2.8***	220491	***3.9***	554291	-0.1	133655	***6.1***	335736	***2.1***
D	120016	***6.5***	300536	***2.6***	80163	***8.3***	201553	***4.3***	155746	***5.4***	390008	***1.4***	94076	***7.6***	236534	***3.6***
E	167965	***5.1***	422245	***1.1***	112587	***6.8***	282813	***2.8***	217970	***4.0***	547952	-0.1	132126	***6.1***	331897	***2.1***
F	947117	-2.4	2379035	-6.4	634721	-0.7	1593863	-4.7	1229083	-3.6	3087297	-7.6	744879	-1.4	1870484	-5.4
G	268898	***3.0***	674755	-1.0	180152	***4.8***	452367	***0.8***	348952	***1.9***	875636	-2.1	211418	***4.1***	530877	***0.1***
H	140202	***5.9***	352766	***1.9***	93992	***7.6***	236023	***3.6***	181941	***4.7***	457788	***0.7***	110304	***6.9***	276986	***2.9***
I	141801	***5.8***	356471	***1.8***	95049	***7.6***	238759	***3.6***	184016	***4.7***	462596	***0.7***	111545	***6.9***	280196	***2.9***
J (Gain=38.5)	92034	***7.7***	230084	***3.7***	62121	***9.4***	154758	***5.4***	119433	***6.6***	298582	***2.6***	72903	***8.7***	181617	***4.7***
J (Gain=32.5)	182297	***4.7***	457808	***0.7***	122063	***6.5***	306792	***2.5***	236569	***3.6***	594102	-0.4	143247	***5.8***	360037	***1.8***
J (Gain=28.5)	305205	***2.5***	765766	-1.5	204528	***4.2***	513318	***0.2***	396068	***1.4***	993742	-2.6	240025	***3.5***	602406	-0.5
K (Gain=38.5)	90981	***7.7***	227453	***3.8***	61411	***9.5***	152989	***5.5***	118067	***6.6***	295168	***2.6***	72069	***8.8***	179540	***4.8***
K (Gain=32.5)	180213	***4.8***	452573	***0.8***	120667	***6.5***	303284	***2.5***	233864	***3.6***	587308	-0.4	141609	***5.8***	355920	***1.8***
K (Gain=28.5)	301715	***2.5***	757009	-1.5	202189	***4.3***	507448	***0.3***	391539	***1.4***	982378	-2.6	237280	***3.6***	595517	-0.4
L (Gain=38.5)	90981	***7.7***	227453	***3.8***	61411	***9.5***	152989	***5.5***	118067	***6.6***	295168	***2.6***	72069	***8.8***	179540	***4.8***
L (Gain=32.5)	180213	***4.8***	452573	***0.8***	120667	***6.5***	303284	***2.5***	233864	***3.6***	587308	-0.4	141609	***5.8***	355920	***1.8***
L (Gain=28.5)	301715	***2.5***	757009	-1.5	202189	***4.3***	507448	***0.3***	391539	***1.4***	982378	-2.6	237280	***3.6***	595517	-0.4
M (Gain=38.5)	105235	***7.1***	263088	***3.1***	71032	***8.8***	176957	***4.9***	136565	***6.0***	341412	***2.0***	83360	***8.1***	207669	***4.2***
M (Gain=32.5)	208447	***4.1***	523478	***0.1***	139572	***5.9***	350799	***1.9***	270503	***3.0***	679322	-1.0	163795	***5.2***	411682	***1.2***
M (Gain=28.5)	348985	***1.9***	875611	-2.1	233866	***3.6***	586950	-0.3	452881	***0.8***	1136289	-3.2	274455	***3.0***	688818	-1.0
N (Gain=38.5)	111862	***6.8***	279654	***2.9***	75505	***8.6***	188100	***4.6***	145164	***5.7***	362910	***1.7***	88609	***7.9***	220745	***3.9***
N (Gain=32.5)	221572	***3.9***	556440	-0.1	148361	***5.6***	372888	***1.6***	287536	***2.7***	722097	-1.2	174109	***4.9***	437604	***0.9***
N (Gain=28.5)	370960	***1.6***	930746	-2.4	248592	***3.4***	623909	-0.6	481398	***0.5***	1207838	-3.5	291736	***2.7***	732191	-1.3

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.20 : STEP 2 CASE 20

Table 166: Step 2 - Case 20- Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	50%	10%	12.9%	1805180

Table 167: Step 2 - Case 20 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	11.8	229416	9.0	66251	14.4	166573	10.3	155746	10.6	390008	6.7	94076	12.8	236534	8.8
B	1224796	1.7	2348496	-1.1	678356	4.3	1703436	0.3	1589430	0.6	3992442	-3.4	963265	2.7	2418879	-1.3
D	120016	11.8	300536	7.8	80163	13.5	201553	9.5	155746	10.6	390008	6.7	94076	12.8	236534	8.8
F	1420675	1.0	3568552	-3.0	952081	2.8	2390794	-1.2	1843624	-0.1	4630945	-4.1	1117318	2.1	2805726	-1.9
G	268898	8.3	674755	4.3	180152	10.0	452367	6.0	348952	7.1	875636	3.1	211418	9.3	530877	5.3

Table 168: Step 2 - Case 20 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	11.8	300536	7.8	80163	13.5	201553	9.5	155746	10.6	390008	6.7	94076	12.8	236534	8.8
B	816531	3.4	2051019	-0.6	547207	5.2	1374105	1.2	1059620	2.3	2661628	-1.7	642177	4.5	1612586	0.5
C	169908	10.3	427130	6.3	113889	12.0	286085	8.0	220491	9.1	554291	5.1	133655	11.3	335736	7.3
D	120016	11.8	300536	7.8	80163	13.5	201553	9.5	155746	10.6	390008	6.7	94076	12.8	236534	8.8
E	167965	10.3	422245	6.3	112587	12.1	282813	8.1	217970	9.2	547952	5.2	132126	11.4	331897	7.4
F	947117	2.8	2379035	-1.2	634721	4.5	1593863	0.5	1229083	1.7	3087297	-2.3	744879	3.8	1870484	-0.2
G	268898	8.3	674755	4.3	180152	10.0	452367	6.0	348952	7.1	875636	3.1	211418	9.3	530877	5.3
H	140202	11.1	352766	7.1	93992	12.8	236023	8.8	181941	10.0	457788	6.0	110304	12.1	276986	8.1
I	141801	11.0	356471	7.0	95049	12.8	238759	8.8	184016	9.9	462596	5.9	111545	12.1	280196	8.1
J (Gain=38.5)	92034	12.9	230084	8.9	62121	14.6	154758	10.7	119433	11.8	298582	7.8	72903	13.9	181617	10.0
J (Gain=32.5)	182297	10.0	457808	6.0	122063	11.7	306792	7.7	236569	8.8	594102	4.8	143247	11.0	360037	7.0
J (Gain=28.5)	305205	7.7	765766	3.7	204528	9.5	513318	5.5	396068	6.6	993742	2.6	240025	8.8	602406	4.8
K (Gain=38.5)	90981	13.0	227453	9.0	61411	14.7	152989	10.7	118067	11.8	295168	7.9	72069	14.0	179540	10.0
K (Gain=32.5)	180213	10.0	452573	6.0	120667	11.7	303284	7.7	233864	8.9	587308	4.9	141609	11.1	355920	7.1
K (Gain=28.5)	301715	7.8	757009	3.8	202189	9.5	507448	5.5	391539	6.6	982378	2.6	237280	8.8	595517	4.8
L (Gain=38.5)	90981	13.0	227453	9.0	61411	14.7	152989	10.7	118067	11.8	295168	7.9	72069	14.0	179540	10.0
L (Gain=32.5)	180213	10.0	452573	6.0	120667	11.7	303284	7.7	233864	8.9	587308	4.9	141609	11.1	355920	7.1
L (Gain=28.5)	301715	7.8	757009	3.8	202189	9.5	507448	5.5	391539	6.6	982378	2.6	237280	8.8	595517	4.8
M (Gain=38.5)	105235	12.3	263088	8.4	71032	14.1	176957	10.1	136565	11.2	341412	7.2	83360	13.4	207669	9.4
M (Gain=32.5)	208447	9.4	523478	5.4	139572	11.1	350799	7.1	270503	8.2	679322	4.2	163795	10.4	411682	6.4
M (Gain=28.5)	348985	7.1	875611	3.1	233866	8.9	586950	4.9	452881	6.0	1136289	2.0	274455	8.2	688818	4.2
N (Gain=38.5)	111862	12.1	279654	8.1	75505	13.8	188100	9.8	145164	10.9	362910	7.0	88609	13.1	220745	9.1
N (Gain=32.5)	221572	9.1	556440	5.1	148361	10.9	372888	6.8	287536	8.0	722097	4.0	174109	10.2	437604	6.2
N (Gain=28.5)	370960	6.9	930746	2.9	248592	8.6	623909	4.6	481398	5.7	1207838	1.7	291736	7.9	732191	3.9

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.21 : STEP 2 CASE 21

Table 169: Step 2 - Case 21 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	50%	30%	12.9%	5415541

Table 170: Step 2 - Case 21 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***16.5***	229416	***13.7***	66251	***19.1***	166573	***15.1***	155746	***15.4***	390008	***11.4***	94076	***17.6***	236534	***13.6***
B	1224796	***6.5***	2348496	***3.6***	678356	***9.0***	1703436	***5.0***	1589430	***5.3***	3992442	***1.3***	963265	***7.5***	2418879	***3.5***
D	120016	***16.5***	300536	***12.6***	80163	***18.3***	201553	***14.3***	155746	***15.4***	390008	***11.4***	94076	***17.6***	236534	***13.6***
F	1420675	***5.8***	3568552	***1.8***	952081	***7.5***	2390794	***3.6***	1843624	***4.7***	4630945	***0.7***	1117318	***6.9***	2805726	***2.9***
G	268898	***13.0***	674755	***9.0***	180152	***14.8***	452367	***10.8***	348952	***11.9***	875636	***7.9***	211418	***14.1***	530877	***10.1***

Table 171: Step 2 - Case 21 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***16.5***	300536	***12.6***	80163	***18.3***	201553	***14.3***	155746	***15.4***	390008	***11.4***	94076	***17.6***	236534	***13.6***
B	816531	***8.2***	2051019	***4.2***	547207	***10.0***	1374105	***6.0***	1059620	***7.1***	2661628	***3.1***	642177	***9.3***	1612586	***5.3***
C	169908	***15.0***	427130	***11.0***	113889	***16.8***	286085	***12.8***	220491	***13.9***	554291	***9.9***	133655	***16.1***	335736	***12.1***
D	120016	***16.5***	300536	***12.6***	80163	***18.3***	201553	***14.3***	155746	***15.4***	390008	***11.4***	94076	***17.6***	236534	***13.6***
E	167965	***15.1***	422245	***11.1***	112587	***16.8***	282813	***12.8***	217970	***14.0***	547952	***9.9***	132126	***16.1***	331897	***12.1***
F	947117	***7.6***	2379035	***3.6***	634721	***9.3***	1593863	***5.3***	1229083	***6.4***	3087297	***2.4***	744879	***8.6***	1870484	***4.6***
G	268898	***13.0***	674755	***9.0***	180152	***14.8***	452367	***10.8***	348952	***11.9***	875636	***7.9***	211418	***14.1***	530877	***10.1***
H	140202	***15.9***	352766	***11.9***	93992	***17.6***	236023	***13.6***	181941	***14.7***	457788	***10.7***	110304	***16.9***	276986	***12.9***
I	141801	***15.8***	356471	***11.8***	95049	***17.6***	238759	***13.6***	184016	***14.7***	462596	***10.7***	111545	***16.9***	280196	***12.9***
J (Gain=38.5)	92034	***17.7***	230084	***13.7***	62121	***19.4***	154758	***15.4***	119433	***16.6***	298582	***12.6***	72903	***18.7***	181617	***14.7***
J (Gain=32.5)	182297	***14.7***	457808	***10.7***	122063	***16.5***	306792	***12.5***	236569	***13.6***	594102	***9.6***	143247	***15.8***	360037	***11.8***
J (Gain=28.5)	305205	***12.5***	765766	***8.5***	204528	***14.2***	513318	***10.2***	396068	***11.4***	993742	***7.4***	240025	***13.5***	602406	***9.5***
K (Gain=38.5)	90981	***17.7***	227453	***13.8***	61411	***19.5***	152989	***15.5***	118067	***16.6***	295168	***12.6***	72069	***18.8***	179540	***14.8***
K (Gain=32.5)	180213	***14.8***	452573	***10.8***	120667	***16.5***	303284	***12.5***	233864	***13.6***	587308	***9.6***	141609	***15.8***	355920	***11.8***
K (Gain=28.5)	301715	***12.5***	757009	***8.5***	202189	***14.3***	507448	***10.3***	391539	***11.4***	982378	***7.4***	237280	***13.6***	595517	***9.6***
L (Gain=38.5)	90981	***17.7***	227453	***13.8***	61411	***19.5***	152989	***15.5***	118067	***16.6***	295168	***12.6***	72069	***18.8***	179540	***14.8***
L (Gain=32.5)	180213	***14.8***	452573	***10.8***	120667	***16.5***	303284	***12.5***	233864	***13.6***	587308	***9.6***	141609	***15.8***	355920	***11.8***
L (Gain=28.5)	301715	***12.5***	757009	***8.5***	202189	***14.3***	507448	***10.3***	391539	***11.4***	982378	***7.4***	237280	***13.6***	595517	***9.6***
M (Gain=38.5)	105235	***17.1***	263088	***13.1***	71032	***18.8***	176957	***14.9***	136565	***16.0***	341412	***12.0***	83360	***18.1***	207669	***14.2***
M (Gain=32.5)	208447	***14.1***	523478	***10.1***	139572	***15.9***	350799	***11.9***	270503	***13.0***	679322	***9.0***	163795	***15.2***	411682	***11.2***
M (Gain=28.5)	348985	***11.9***	875611	***7.9***	233866	***13.6***	586950	***9.7***	452881	***10.8***	1136289	***6.8***	274455	***13.0***	688818	***9.0***
N (Gain=38.5)	111862	***16.8***	279654	***12.9***	75505	***18.6***	188100	***14.6***	145164	***15.7***	362910	***11.7***	88609	***17.9***	220745	***13.9***
N (Gain=32.5)	221572	***13.9***	556440	***9.9***	148361	***15.6***	372888	***11.6***	287536	***12.7***	722097	***8.8***	174109	***14.9***	437604	***10.9***
N (Gain=28.5)	370960	***11.6***	930746	***7.6***	248592	***13.4***	623909	***9.4***	481398	***10.5***	1207838	***6.5***	291736	***12.7***	732191	***8.7***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.22 : STEP 2 CASE 22

Table 172: Step 2 - Case 22 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	74%	3%	12.9%	801500

Table 173: Step 2 - Case 22 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	8.2	229416	5.4	66251	10.8	166573	6.8	155746	7.1	390008	3.1	94076	9.3	236534	5.3
B	1224796	-1.8	2348496	-4.7	678356	0.7	1703436	-3.3	1589430	-3.0	3992442	-7.0	963265	-0.8	2418879	-4.8
D	120016	8.2	300536	4.3	80163	10.0	201553	6.0	155746	7.1	390008	3.1	94076	9.3	236534	5.3
F	1420675	-2.5	3568552	-6.5	952081	-0.7	2390794	-4.7	1843624	-3.6	4630945	-7.6	1117318	-1.4	2805726	-5.4
G	268898	4.7	674755	0.7	180152	6.5	452367	2.5	348952	3.6	875636	-0.4	211418	5.8	530877	1.8

Table 174: Step 2 - Case 22 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	8.2	300536	4.3	80163	10.0	201553	6.0	155746	7.1	390008	3.1	94076	9.3	236534	5.3
B	816531	-0.1	2051019	-4.1	547207	1.7	1374105	-2.3	1059620	-1.2	2661628	-5.2	642177	1.0	1612586	-3.0
C	169908	6.7	427130	2.7	113889	8.5	286085	4.5	220491	5.6	554291	1.6	133655	7.8	335736	3.8
D	120016	8.2	300536	4.3	80163	10.0	201553	6.0	155746	7.1	390008	3.1	94076	9.3	236534	5.3
E	167965	6.8	422245	2.8	112587	8.5	282813	4.5	217970	5.7	547952	1.7	132126	7.8	331897	3.8
F	947117	-0.7	2379035	-4.7	634721	1.0	1593863	-3.0	1229083	-1.9	3087297	-5.9	744879	0.3	1870484	-3.7
G	268898	4.7	674755	0.7	180152	6.5	452367	2.5	348952	3.6	875636	-0.4	211418	5.8	530877	1.8
H	140202	7.6	352766	3.6	93992	9.3	236023	5.3	181941	6.4	457788	2.4	110304	8.6	276986	4.6
I	141801	7.5	356471	3.5	95049	9.3	238759	5.3	184016	6.4	462596	2.4	111545	8.6	280196	4.6
J (Gain=38.5)	92034	9.4	230084	5.4	62121	11.1	154758	7.1	119433	8.3	298582	4.3	72903	10.4	181617	6.4
J (Gain=32.5)	182297	6.4	457808	2.4	122063	8.2	306792	4.2	236569	5.3	594102	1.3	143247	7.5	360037	3.5
J (Gain=28.5)	305205	4.2	765766	0.2	204528	5.9	513318	1.9	396068	3.1	993742	-0.9	240025	5.2	602406	1.2
K (Gain=38.5)	90981	9.4	227453	5.5	61411	11.2	152989	7.2	118067	8.3	295168	4.3	72069	10.5	179540	6.5
K (Gain=32.5)	180213	6.5	452573	2.5	120667	8.2	303284	4.2	233864	5.3	587308	1.4	141609	7.5	355920	3.5
K (Gain=28.5)	301715	4.2	757009	0.2	202189	6.0	507448	2.0	391539	3.1	982378	-0.9	237280	5.3	595517	1.3
L (Gain=38.5)	90981	9.4	227453	5.5	61411	11.2	152989	7.2	118067	8.3	295168	4.3	72069	10.5	179540	6.5
L (Gain=32.5)	180213	6.5	452573	2.5	120667	8.2	303284	4.2	233864	5.3	587308	1.4	141609	7.5	355920	3.5
L (Gain=28.5)	301715	4.2	757009	0.2	202189	6.0	507448	2.0	391539	3.1	982378	-0.9	237280	5.3	595517	1.3
M (Gain=38.5)	105235	8.8	263088	4.8	71032	10.5	176957	6.6	136565	7.7	341412	3.7	83360	9.8	207669	5.9
M (Gain=32.5)	208447	5.8	523478	1.9	139572	7.6	350799	3.6	270503	4.7	679322	0.7	163795	6.9	411682	2.9
M (Gain=28.5)	348985	3.6	875611	-0.4	233866	5.3	586950	1.4	452881	2.5	1136289	-1.5	274455	4.7	688818	0.7
N (Gain=38.5)	111862	8.6	279654	4.6	75505	10.3	188100	6.3	145164	7.4	362910	3.4	88609	9.6	220745	5.6
N (Gain=32.5)	221572	5.6	556440	1.6	148361	7.3	372888	3.3	287536	4.5	722097	0.5	174109	6.6	437604	2.6
N (Gain=28.5)	370960	3.3	930746	-0.6	248592	5.1	623909	1.1	481398	2.2	1207838	-1.8	291736	4.4	732191	0.4

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.23 : STEP 2 CASE 23

Table 175: Step 2 - Case 23 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	74%	10%	12.9%	2671667

Table 176: Step 2 - Case 23 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	13.5	229416	10.7	66251	16.1	166573	12.1	155746	12.3	390008	8.4	94076	14.5	236534	10.5
B	1224796	3.4	2348496	0.6	678356	6.0	1703436	2.0	1589430	2.3	3992442	-1.7	963265	4.4	2418879	0.4
D	120016	13.5	300536	9.5	80163	15.2	201553	11.2	155746	12.3	390008	8.4	94076	14.5	236534	10.5
F	1420675	2.7	3568552	-1.3	952081	4.5	2390794	0.5	1843624	1.6	4630945	-2.4	1117318	3.8	2805726	-0.2
G	268898	10.0	674755	6.0	180152	11.7	452367	7.7	348952	8.8	875636	4.8	211418	11.0	530877	7.0

Table 177: Step 2 - Case 23 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	13.5	300536	9.5	80163	15.2	201553	11.2	155746	12.3	390008	8.4	94076	14.5	236534	10.5
B	816531	5.1	2051019	1.1	547207	6.9	1374105	2.9	1059620	4.0	2661628	0.0	642177	6.2	1612586	2.2
C	169908	12.0	427130	8.0	113889	13.7	286085	9.7	220491	10.8	554291	6.8	133655	13.0	335736	9.0
D	120016	13.5	300536	9.5	80163	15.2	201553	11.2	155746	12.3	390008	8.4	94076	14.5	236534	10.5
E	167965	12.0	422245	8.0	112587	13.8	282813	9.8	217970	10.9	547952	6.9	132126	13.1	331897	9.1
F	947117	4.5	2379035	0.5	634721	6.2	1593863	2.2	1229083	3.4	3087297	-0.6	744879	5.5	1870484	1.5
G	268898	10.0	674755	6.0	180152	11.7	452367	7.7	348952	8.8	875636	4.8	211418	11.0	530877	7.0
H	140202	12.8	352766	8.8	93992	14.5	236023	10.5	181941	11.7	457788	7.7	110304	13.8	276986	9.8
I	141801	12.8	356471	8.7	95049	14.5	238759	10.5	184016	11.6	462596	7.6	111545	13.8	280196	9.8
J (Gain=38.5)	92034	14.6	230084	10.6	62121	16.3	154758	12.4	119433	13.5	298582	9.5	72903	15.6	181617	11.7
J (Gain=32.5)	182297	11.7	457808	7.7	122063	13.4	306792	9.4	236569	10.5	594102	6.5	143247	12.7	360037	8.7
J (Gain=28.5)	305205	9.4	765766	5.4	204528	11.2	513318	7.2	396068	8.3	993742	4.3	240025	10.5	602406	6.5
K (Gain=38.5)	90981	14.7	227453	10.7	61411	16.4	152989	12.4	118067	13.5	295168	9.6	72069	15.7	179540	11.7
K (Gain=32.5)	180213	11.7	452573	7.7	120667	13.5	303284	9.4	233864	10.6	587308	6.6	141609	12.8	355920	8.8
K (Gain=28.5)	301715	9.5	757009	5.5	202189	11.2	507448	7.2	391539	8.3	982378	4.3	237280	10.5	595517	6.5
L (Gain=38.5)	90981	14.7	227453	10.7	61411	16.4	152989	12.4	118067	13.5	295168	9.6	72069	15.7	179540	11.7
L (Gain=32.5)	180213	11.7	452573	7.7	120667	13.5	303284	9.4	233864	10.6	587308	6.6	141609	12.8	355920	8.8
L (Gain=28.5)	301715	9.5	757009	5.5	202189	11.2	507448	7.2	391539	8.3	982378	4.3	237280	10.5	595517	6.5
M (Gain=38.5)	105235	14.0	263088	10.1	71032	15.8	176957	11.8	136565	12.9	341412	8.9	83360	15.1	207669	11.1
M (Gain=32.5)	208447	11.1	523478	7.1	139572	12.8	350799	8.8	270503	9.9	679322	5.9	163795	12.1	411682	8.1
M (Gain=28.5)	348985	8.8	875611	4.8	233866	10.6	586950	6.6	452881	7.7	1136289	3.7	274455	9.9	688818	5.9
N (Gain=38.5)	111862	13.8	279654	9.8	75505	15.5	188100	11.5	145164	12.6	362910	8.7	88609	14.8	220745	10.8
N (Gain=32.5)	221572	10.8	556440	6.8	148361	12.6	372888	8.6	287536	9.7	722097	5.7	174109	11.9	437604	7.9
N (Gain=28.5)	370960	8.6	930746	4.6	248592	10.3	623909	6.3	481398	7.4	1207838	3.4	291736	9.6	732191	5.6

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.24 : STEP 2 CASE 24

Table 178: Step 2 - Case 24 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	74%	30%	12.9%	8015000

Table 179: Step 2 - Case 24 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***18.2***	229416	***15.4***	66251	***20.8***	166573	***16.8***	155746	***17.1***	390008	***13.1***	94076	***19.3***	236534	***15.3***
B	1224796	***8.2***	2348496	***5.3***	678356	***10.7***	1703436	***6.7***	1589430	***7.0***	3992442	***3.0***	963265	***9.2***	2418879	***5.2***
D	120016	***18.2***	300536	***14.3***	80163	***20.0***	201553	***16.0***	155746	***17.1***	390008	***13.1***	94076	***19.3***	236534	***15.3***
F	1420675	***7.5***	3568552	***3.5***	952081	***9.3***	2390794	***5.3***	1843624	***6.4***	4630945	***2.4***	1117318	***8.6***	2805726	***4.6***
G	268898	***14.7***	674755	***10.7***	180152	***16.5***	452367	***12.5***	348952	***13.6***	875636	***9.6***	211418	***15.8***	530877	***11.8***

Table 180: Step 2 - Case 24 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***18.2***	300536	***14.3***	80163	***20.0***	201553	***16.0***	155746	***17.1***	390008	***13.1***	94076	***19.3***	236534	***15.3***
B	816531	***9.9***	2051019	***5.9***	547207	***11.7***	1374105	***7.7***	1059620	***8.8***	2661628	***4.8***	642177	***11.0***	1612586	***7.0***
C	169908	***16.7***	427130	***12.7***	113889	***18.5***	286085	***14.5***	220491	***15.6***	554291	***11.6***	133655	***17.8***	335736	***13.8***
D	120016	***18.2***	300536	***14.3***	80163	***20.0***	201553	***16.0***	155746	***17.1***	390008	***13.1***	94076	***19.3***	236534	***15.3***
E	167965	***16.8***	422245	***12.8***	112587	***18.5***	282813	***14.5***	217970	***15.7***	547952	***11.7***	132126	***17.8***	331897	***13.8***
F	947117	***9.3***	2379035	***5.3***	634721	***11.0***	1593863	***7.0***	1229083	***8.1***	3087297	***4.1***	744879	***10.3***	1870484	***6.3***
G	268898	***14.7***	674755	***10.7***	180152	***16.5***	452367	***12.5***	348952	***13.6***	875636	***9.6***	211418	***15.8***	530877	***11.8***
H	140202	***17.6***	352766	***13.6***	93992	***19.3***	236023	***15.3***	181941	***16.4***	457788	***12.4***	110304	***18.6***	276986	***14.6***
I	141801	***17.5***	356471	***13.5***	95049	***19.3***	238759	***15.3***	184016	***16.4***	462596	***12.4***	111545	***18.6***	280196	***14.6***
J (Gain=38.5)	92034	***19.4***	230084	***15.4***	62121	***21.1***	154758	***17.1***	119433	***18.3***	298582	***14.3***	72903	***20.4***	181617	***16.4***
J (Gain=32.5)	182297	***16.4***	457808	***12.4***	122063	***18.2***	306792	***14.2***	236569	***15.3***	594102	***11.3***	143247	***17.5***	360037	***13.5***
J (Gain=28.5)	305205	***14.2***	765766	***10.2***	204528	***15.9***	513318	***11.9***	396068	***13.1***	993742	***9.1***	240025	***15.2***	602406	***11.2***
K (Gain=38.5)	90981	***19.4***	227453	***15.5***	61411	***21.2***	152989	***17.2***	118067	***18.3***	295168	***14.3***	72069	***20.5***	179540	***16.5***
K (Gain=32.5)	180213	***16.5***	452573	***12.5***	120667	***18.2***	303284	***14.2***	233864	***15.3***	587308	***11.4***	141609	***17.5***	355920	***13.5***
K (Gain=28.5)	301715	***14.2***	757009	***10.2***	202189	***16.0***	507448	***12.0***	391539	***13.1***	982378	***9.1***	237280	***15.3***	595517	***11.3***
L (Gain=38.5)	90981	***19.4***	227453	***15.5***	61411	***21.2***	152989	***17.2***	118067	***18.3***	295168	***14.3***	72069	***20.5***	179540	***16.5***
L (Gain=32.5)	180213	***16.5***	452573	***12.5***	120667	***18.2***	303284	***14.2***	233864	***15.3***	587308	***11.4***	141609	***17.5***	355920	***13.5***
L (Gain=28.5)	301715	***14.2***	757009	***10.2***	202189	***16.0***	507448	***12.0***	391539	***13.1***	982378	***9.1***	237280	***15.3***	595517	***11.3***
M (Gain=38.5)	105235	***18.8***	263088	***14.8***	71032	***20.5***	176957	***16.6***	136565	***17.7***	341412	***13.7***	83360	***19.8***	207669	***15.9***
M (Gain=32.5)	208447	***15.8***	523478	***11.9***	139572	***17.6***	350799	***13.6***	270503	***14.7***	679322	***10.7***	163795	***16.9***	411682	***12.9***
M (Gain=28.5)	348985	***13.6***	875611	***9.6***	233866	***15.3***	586950	***11.4***	452881	***12.5***	1136289	***8.5***	274455	***14.7***	688818	***10.7***
N (Gain=38.5)	111862	***18.6***	279654	***14.6***	75505	***20.3***	188100	***16.3***	145164	***17.4***	362910	***13.4***	88609	***19.6***	220745	***15.6***
N (Gain=32.5)	221572	***15.6***	556440	***11.6***	148361	***17.3***	372888	***13.3***	287536	***14.5***	722097	***10.5***	174109	***16.6***	437604	***12.6***
N (Gain=28.5)	370960	***13.3***	930746	***9.4***	248592	***15.1***	623909	***11.1***	481398	***12.2***	1207838	***8.2***	291736	***14.4***	732191	***10.4***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.25 : STEP 2 CASE 25

Table 181: Step 2 - Case 25 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	97%	3%	12.9%	1050615

Table 182: Step 2 - Case 25 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	9.4	229416	6.6	66251	12.0	166573	8.0	155746	8.3	390008	4.3	94076	10.5	236534	6.5
B	1224796	-0.7	2348496	-3.5	678356	1.9	1703436	-2.1	1589430	-1.8	3992442	-5.8	963265	0.4	2418879	-3.6
D	120016	9.4	300536	5.4	80163	11.2	201553	7.2	155746	8.3	390008	4.3	94076	10.5	236534	6.5
F	1420675	-1.3	3568552	-5.3	952081	0.4	2390794	-3.6	1843624	-2.4	4630945	-6.4	1117318	-0.3	2805726	-4.3
G	268898	5.9	674755	1.9	180152	7.7	452367	3.7	348952	4.8	875636	0.8	211418	7.0	530877	3.0

Table 183: Step 2 - Case 25 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	9.4	300536	5.4	80163	11.2	201553	7.2	155746	8.3	390008	4.3	94076	10.5	236534	6.5
B	816531	1.1	2051019	-2.9	547207	2.8	1374105	-1.2	1059620	0.0	2661628	-4.0	642177	2.1	1612586	-1.9
C	169908	7.9	427130	3.9	113889	9.6	286085	5.6	220491	6.8	554291	2.8	133655	9.0	335736	5.0
D	120016	9.4	300536	5.4	80163	11.2	201553	7.2	155746	8.3	390008	4.3	94076	10.5	236534	6.5
E	167965	8.0	422245	4.0	112587	9.7	282813	5.7	217970	6.8	547952	2.8	132126	9.0	331897	5.0
F	947117	0.5	2379035	-3.5	634721	2.2	1593863	-1.8	1229083	-0.7	3087297	-4.7	744879	1.5	1870484	-2.5
G	268898	5.9	674755	1.9	180152	7.7	452367	3.7	348952	4.8	875636	0.8	211418	7.0	530877	3.0
H	140202	8.7	352766	4.7	93992	10.5	236023	6.5	181941	7.6	457788	3.6	110304	9.8	276986	5.8
I	141801	8.7	356471	4.7	95049	10.4	238759	6.4	184016	7.6	462596	3.6	111545	9.7	280196	5.7
J (Gain=38.5)	92034	10.6	230084	6.6	62121	12.3	154758	8.3	119433	9.4	298582	5.5	72903	11.6	181617	7.6
J (Gain=32.5)	182297	7.6	457808	3.6	122063	9.3	306792	5.3	236569	6.5	594102	2.5	143247	8.7	360037	4.7
J (Gain=28.5)	305205	5.4	765766	1.4	204528	7.1	513318	3.1	396068	4.2	993742	0.2	240025	6.4	602406	2.4
K (Gain=38.5)	90981	10.6	227453	6.6	61411	12.3	152989	8.4	118067	9.5	295168	5.5	72069	11.6	179540	7.7
K (Gain=32.5)	180213	7.7	452573	3.7	120667	9.4	303284	5.4	233864	6.5	587308	2.5	141609	8.7	355920	4.7
K (Gain=28.5)	301715	5.4	757009	1.4	202189	7.2	507448	3.2	391539	4.3	982378	0.3	237280	6.5	595517	2.5
L (Gain=38.5)	90981	10.6	227453	6.6	61411	12.3	152989	8.4	118067	9.5	295168	5.5	72069	11.6	179540	7.7
L (Gain=32.5)	180213	7.7	452573	3.7	120667	9.4	303284	5.4	233864	6.5	587308	2.5	141609	8.7	355920	4.7
L (Gain=28.5)	301715	5.4	757009	1.4	202189	7.2	507448	3.2	391539	4.3	982378	0.3	237280	6.5	595517	2.5
M (Gain=38.5)	105235	10.0	263088	6.0	71032	11.7	176957	7.7	136565	8.9	341412	4.9	83360	11.0	207669	7.0
M (Gain=32.5)	208447	7.0	523478	3.0	139572	8.8	350799	4.8	270503	5.9	679322	1.9	163795	8.1	411682	4.1
M (Gain=28.5)	348985	4.8	875611	0.8	233866	6.5	586950	2.5	452881	3.7	1136289	-0.3	274455	5.8	688818	1.8
N (Gain=38.5)	111862	9.7	279654	5.7	75505	11.4	188100	7.5	145164	8.6	362910	4.6	88609	10.7	220745	6.8
N (Gain=32.5)	221572	6.8	556440	2.8	148361	8.5	372888	4.5	287536	5.6	722097	1.6	174109	7.8	437604	3.8
N (Gain=28.5)	370960	4.5	930746	0.5	248592	6.3	623909	2.3	481398	3.4	1207838	-0.6	291736	5.6	732191	1.6

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.26 : STEP 2 CASE 26

Table 184: Step 2 - Case 26 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	97%	10%	12.9%	3502050

Table 185: Step 2 - Case 26 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***14.7***	229416	***11.8***	66251	***17.2***	166573	***13.2***	155746	***13.5***	390008	***9.5***	94076	***15.7***	236534	***11.7***
B	1224796	***4.6***	2348496	***1.7***	678356	***7.1***	1703436	***3.1***	1589430	***3.4***	3992442	-0.6	963265	***5.6***	2418879	***1.6***
D	120016	***14.7***	300536	***10.7***	80163	***16.4***	201553	***12.4***	155746	***13.5***	390008	***9.5***	94076	***15.7***	236534	***11.7***
F	1420675	***3.9***	3568552	-0.1	952081	***5.7***	2390794	***1.7***	1843624	***2.8***	4630945	-1.2	1117318	***5.0***	2805726	***1.0***
G	268898	***11.1***	674755	***7.2***	180152	***12.9***	452367	***8.9***	348952	***10.0***	875636	***6.0***	211418	***12.2***	530877	***8.2***

Table 186: Step 2 - Case 26 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	***14.7***	300536	***10.7***	80163	***16.4***	201553	***12.4***	155746	***13.5***	390008	***9.5***	94076	***15.7***	236534	***11.7***
B	816531	***6.3***	2051019	***2.3***	547207	***8.1***	1374105	***4.1***	1059620	***5.2***	2661628	***1.2***	642177	***7.4***	1612586	***3.4***
C	169908	***13.1***	427130	***9.1***	113889	***14.9***	286085	***10.9***	220491	***12.0***	554291	***8.0***	133655	***14.2***	335736	***10.2***
D	120016	***14.7***	300536	***10.7***	80163	***16.4***	201553	***12.4***	155746	***13.5***	390008	***9.5***	94076	***15.7***	236534	***11.7***
E	167965	***13.2***	422245	***9.2***	112587	***14.9***	282813	***10.9***	217970	***12.1***	547952	***8.1***	132126	***14.2***	331897	***10.2***
F	947117	***5.7***	2379035	***1.7***	634721	***7.4***	1593863	***3.4***	1229083	***4.5***	3087297	***0.5***	744879	***6.7***	1870484	***2.7***
G	268898	***11.1***	674755	***7.2***	180152	***12.9***	452367	***8.9***	348952	***10.0***	875636	***6.0***	211418	***12.2***	530877	***8.2***
H	140202	***14.0***	352766	***10.0***	93992	***15.7***	236023	***11.7***	181941	***12.8***	457788	***8.8***	110304	***15.0***	276986	***11.0***
I	141801	***13.9***	356471	***9.9***	95049	***15.7***	238759	***11.7***	184016	***12.8***	462596	***8.8***	111545	***15.0***	280196	***11.0***
J (Gain=38.5)	92034	***15.8***	230084	***11.8***	62121	***17.5***	154758	***13.5***	119433	***14.7***	298582	***10.7***	72903	***16.8***	181617	***12.9***
J (Gain=32.5)	182297	***12.8***	457808	***8.8***	122063	***14.6***	306792	***10.6***	236569	***11.7***	594102	***7.7***	143247	***13.9***	360037	***9.9***
J (Gain=28.5)	305205	***10.6***	765766	***6.6***	204528	***12.3***	513318	***8.3***	396068	***9.5***	993742	***5.5***	240025	***11.6***	602406	***7.6***
K (Gain=38.5)	90981	***15.9***	227453	***11.9***	61411	***17.6***	152989	***13.6***	118067	***14.7***	295168	***10.7***	72069	***16.9***	179540	***12.9***
K (Gain=32.5)	180213	***12.9***	452573	***8.9***	120667	***14.6***	303284	***10.6***	233864	***11.8***	587308	***7.8***	141609	***13.9***	355920	***9.9***
K (Gain=28.5)	301715	***10.6***	757009	***6.7***	202189	***12.4***	507448	***8.4***	391539	***9.5***	982378	***5.5***	237280	***11.7***	595517	***7.7***
L (Gain=38.5)	90981	***15.9***	227453	***11.9***	61411	***17.6***	152989	***13.6***	118067	***14.7***	295168	***10.7***	72069	***16.9***	179540	***12.9***
L (Gain=32.5)	180213	***12.9***	452573	***8.9***	120667	***14.6***	303284	***10.6***	233864	***11.8***	587308	***7.8***	141609	***13.9***	355920	***9.9***
L (Gain=28.5)	301715	***10.6***	757009	***6.7***	202189	***12.4***	507448	***8.4***	391539	***9.5***	982378	***5.5***	237280	***11.7***	595517	***7.7***
M (Gain=38.5)	105235	***15.2***	263088	***11.2***	71032	***16.9***	176957	***13.0***	136565	***14.1***	341412	***10.1***	83360	***16.2***	207669	***12.3***
M (Gain=32.5)	208447	***12.3***	523478	***8.3***	139572	***14.0***	350799	***10.0***	270503	***11.1***	679322	***7.1***	163795	***13.3***	411682	***9.3***
M (Gain=28.5)	348985	***10.0***	875611	***6.0***	233866	***11.8***	586950	***7.8***	452881	***8.9***	1136289	***4.9***	274455	***11.1***	688818	***7.1***
N (Gain=38.5)	111862	***15.0***	279654	***11.0***	75505	***16.7***	188100	***12.7***	145164	***13.8***	362910	***9.8***	88609	***16.0***	220745	***12.0***
N (Gain=32.5)	221572	***12.0***	556440	***8.0***	148361	***13.7***	372888	***9.7***	287536	***10.9***	722097	***6.9***	174109	***13.0***	437604	***9.0***
N (Gain=28.5)	370960	***9.7***	930746	***5.8***	248592	***11.5***	623909	***7.5***	481398	***8.6***	1207838	***4.6***	291736	***10.8***	732191	***6.8***

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

A8.27 : STEP 2 CASE 27

Table 187: Step 2 - Case 27 - Factors

Total Nb of AP	Busy hour population	5 GHz factor	Activity factor	40 MHz FSS	Nb of on-tune RLAN
400000000	70%	97%	30%	12.9%	10506149

Table 188: Step 2 - Case 27 - Calculations for the band 5725-5850 MHz

Band 5725-5850 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*19.4*	229416	*16.6*	66251	*22.0*	166573	*18.0*	155746	*18.3*	390008	*14.3*	94076	*20.5*	236534	*16.5*
B	1224796	*9.3*	2348496	*6.5*	678356	*11.9*	1703436	*7.9*	1589430	*8.2*	3992442	*4.2*	963265	*10.4*	2418879	*6.4*
D	120016	*19.4*	300536	*15.4*	80163	*21.2*	201553	*17.2*	155746	*18.3*	390008	*14.3*	94076	*20.5*	236534	*16.5*
F	1420675	*8.7*	3568552	*4.7*	952081	*10.4*	2390794	*6.4*	1843624	*7.6*	4630945	*3.6*	1117318	*9.7*	2805726	*5.7*
G	268898	*15.9*	674755	*11.9*	180152	*17.7*	452367	*13.7*	348952	*14.8*	875636	*10.8*	211418	*17.0*	530877	*13.0*

Table 189: Step 2 - Case 27 - Calculations for the band 5850-5925 MHz

Band 5850-5925 MHz	With clutter loss and polarisation mismatch (1.5 dB)								With clutter loss and polarisation mismatch (3 dB)							
Antenna discrimination (	0		4		0		4		0		4		0		4	
Building loss (dB)	17		17		12		12		17		17		12		12	
A	120016	*19.4*	300536	*15.4*	80163	*21.2*	201553	*17.2*	155746	*18.3*	390008	*14.3*	94076	*20.5*	236534	*16.5*
B	816531	*11.1*	2051019	*7.1*	547207	*12.8*	1374105	*8.8*	1059620	*10.0*	2661628	*6.0*	642177	*12.1*	1612586	*8.1*
C	169908	*17.9*	427130	*13.9*	113889	*19.6*	286085	*15.6*	220491	*16.8*	554291	*12.8*	133655	*19.0*	335736	*15.0*
D	120016	*19.4*	300536	*15.4*	80163	*21.2*	201553	*17.2*	155746	*18.3*	390008	*14.3*	94076	*20.5*	236534	*16.5*
E	167965	*18.0*	422245	*14.0*	112587	*19.7*	282813	*15.7*	217970	*16.8*	547952	*12.8*	132126	*19.0*	331897	*15.0*
F	947117	*10.5*	2379035	*6.5*	634721	*12.2*	1593863	*8.2*	1229083	*9.3*	3087297	*5.3*	744879	*11.5*	1870484	*7.5*
G	268898	*15.9*	674755	*11.9*	180152	*17.7*	452367	*13.7*	348952	*14.8*	875636	*10.8*	211418	*17.0*	530877	*13.0*
H	140202	*18.7*	352766	*14.7*	93992	*20.5*	236023	*16.5*	181941	*17.6*	457788	*13.6*	110304	*19.8*	276986	*15.8*
I	141801	*18.7*	356471	*14.7*	95049	*20.4*	238759	*16.4*	184016	*17.6*	462596	*13.6*	111545	*19.7*	280196	*15.7*
J (Gain=38.5)	92034	*20.6*	230084	*16.6*	62121	*22.3*	154758	*18.3*	119433	*19.4*	298582	*15.5*	72903	*21.6*	181617	*17.6*
J (Gain=32.5)	182297	*17.6*	457808	*13.6*	122063	*19.3*	306792	*15.3*	236569	*16.5*	594102	*12.5*	143247	*18.7*	360037	*14.7*
J (Gain=28.5)	305205	*15.4*	765766	*11.4*	204528	*17.1*	513318	*13.1*	396068	*14.2*	993742	*10.2*	240025	*16.4*	602406	*12.4*
K (Gain=38.5)	90981	*20.6*	227453	*16.6*	61411	*22.3*	152989	*18.4*	118067	*19.5*	295168	*15.5*	72069	*21.6*	179540	*17.7*
K (Gain=32.5)	180213	*17.7*	452573	*13.7*	120667	*19.4*	303284	*15.4*	233864	*16.5*	587308	*12.5*	141609	*18.7*	355920	*14.7*
K (Gain=28.5)	301715	*15.4*	757009	*11.4*	202189	*17.2*	507448	*13.2*	391539	*14.3*	982378	*10.3*	237280	*16.5*	595517	*12.5*
L (Gain=38.5)	90981	*20.6*	227453	*16.6*	61411	*22.3*	152989	*18.4*	118067	*19.5*	295168	*15.5*	72069	*21.6*	179540	*17.7*
L (Gain=32.5)	180213	*17.7*	452573	*13.7*	120667	*19.4*	303284	*15.4*	233864	*16.5*	587308	*12.5*	141609	*18.7*	355920	*14.7*
L (Gain=28.5)	301715	*15.4*	757009	*11.4*	202189	*17.2*	507448	*13.2*	391539	*14.3*	982378	*10.3*	237280	*16.5*	595517	*12.5*
M (Gain=38.5)	105235	*20.0*	263088	*16.0*	71032	*21.7*	176957	*17.7*	136565	*18.9*	341412	*14.9*	83360	*21.0*	207669	*17.0*
M (Gain=32.5)	208447	*17.0*	523478	*13.0*	139572	*18.8*	350799	*14.8*	270503	*15.9*	679322	*11.9*	163795	*18.1*	411682	*14.1*
M (Gain=28.5)	348985	*14.8*	875611	*10.8*	233866	*16.5*	586950	*12.5*	452881	*13.7*	1136289	*9.7*	274455	*15.8*	688818	*11.8*
N (Gain=38.5)	111862	*19.7*	279654	*15.7*	75505	*21.4*	188100	*17.5*	145164	*18.6*	362910	*14.6*	88609	*20.7*	220745	*16.8*
N (Gain=32.5)	221572	*16.8*	556440	*12.8*	148361	*18.5*	372888	*14.5*	287536	*15.6*	722097	*11.6*	174109	*17.8*	437604	*13.8*
N (Gain=28.5)	370960	*14.5*	930746	*10.5*	248592	*16.3*	623909	*12.3*	481398	*13.4*	1207838	*9.4*	291736	*15.6*	732191	*11.6*

Note : Cells highlighted in red depict a situation where the Nb of on-tune RLAN is higher than the maximum Nb of RLAN acceptable by the FSS and hence a scenario where the FSS protection criterion remains unsatisfied. The second number provides the level o

ANNEX 9: CONSIDERATIONS OF THE BUSY HOUR FACTOR

In classical voice communications, Busy Hour Traffic (BHT) presented the number of hours of call traffic during the busiest hour of operation. In data communications, the busy hour usually is defined as the hour of the day with the highest amount of data traffic. While estimates of busy hour traffic vary it is generally assumed that the busy hour carries in the range of 10%-15% of the daily traffic. Due to the growing popularity of video streaming and the introduction of higher-definition video standards the share of daily traffic carried during the busy hour is expected to grow. For Fixed/Wi-Fi internet traffic it is estimated that the share of the busy hour will increase from about 12% in 2014 to more than 18% in 2025.

More than 80% of the global IP traffic is generated by the consumer/residential segment; businesses account for less than 20%. Considering that about 90% of deployed RLAN APs are located in residential environments it can be concluded that consumer/residential traffic is the dominant component of busy hour RLAN activity.

The daily patterns of residential broadband traffic, Internet traffic (which is dominated by residential traffic), and mobile data traffic are very similar; they typically hit the bottom around 5 a.m. and peak in the evening between 8 and 9 p.m. Enterprise traffic, in contrast, shows two typical peaks, the first one around 11 a.m. and the second, somewhat lower one around 3 p.m. (Figure 60).

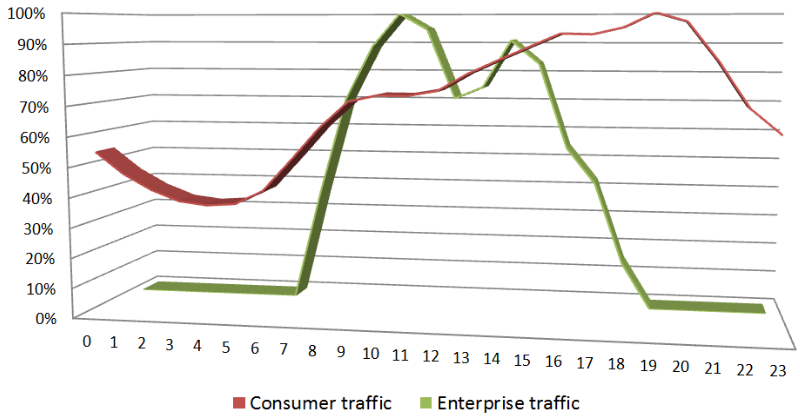


Figure 60: Enterprise and consumer internet hourly traffic (illustrative, normalised graphs)

The Busy Hour Factor (BHF) that was introduced by ITU-R JTG 4-5-6-7 and adopted in this report is applied to the total population within the area of interest in order to determine the number of RLANs available for active transmissions during the busy hour. The reasoning is that even during the busy hour not all deployed 5 GHz RLANs will be actively transmitting. A certain percentage of 5 GHz RLANs will be idle, others will be switched off. Based on the findings of JTG 4-5-6-7, this report considers a BHF range of 50% to 70%, with a median value of 62.7%.

The definition of the BHF Is linked to that of the previously defined activity factor (AF). The upper limit of the AF (30%) represents the case of maximum activity and can therefore be considered a busy hour activity factor (AFBH).

Assuming that RLAN traffic is uniformly distributed over the RLAN population, i.e. each RLAN generates the same amount of traffic, the percentage of active RLANs that transmit during the busy hour will be identical to busy hour share of the daily traffic (SBH). Thus, the relation between the Busy Hour Activity Factor (AFBH), the Busy Hour Share of RLANs (SBH), and the Busy Hour Factor (BHF) can be expressed as follows:

$$SBH = AFBH * BHF$$

For AFBH = 30% and BHF = 62.7% the resulting SBH is 18.8% which is very much in line with the share of Fixed/Wi-Fi busy hour traffic predicted for 2025.

A9.1 GEOGRAPHICAL CONSIDERATIONS

During the discussions about the BHF, it was frequently stated that victim services such as FSS that cover large geographical areas spanning several countries and time zones may experience peaks of RLAN activity caused by an overlap of a residential busy hour in one time zone and a corporate busy hour in another time zone.

As shown above, consumer and enterprise traffic have distinctively different peak times, with several hours in between. Even if nowadays and in the future there may be considerable enterprise traffic generated outside typical office hours (due to data transfer/backup and/or software updates) it can be assumed that a large part of this traffic will remain to be routed over wired networks. Furthermore, the consumer segment accounts for approximately 80% of traffic so that the consumer/residential busy hour can be expected to have the strongest impact.

Consumer/residential traffic is typically highest during the two hours from 7 to 9 p.m. The worst case in terms of interference generated should therefore be the consumer/residential busy hour in the time zone with the highest number of RLANs, i.e. between 8 and 9 p.m. in UTC+1. As close to 90% of European RLANs are located in the three adjacent time zones UTC to UTC+2 it seems appropriate to apply the BHF to the entire residential RLAN population, and not only to a subset of it.

ANNEX 10: LIST OF REFERENCE

[1] EC Mandate to CEPT to study and identify harmonised compatibility and sharing conditions for Wireless Access Systems including Radio Local Area Networks in the bands 5350-5470 MHz and 5725-5925 MHz ('WAS/RLAN extension bands') for the provision of wireless broadband services, September 2013
[2] ECC Decision (04)08: "Harmonised use of 5 GHz for the implementation of WAS/RLANs "
[3] WRC Resolution 229 (WRC-03): "Use of the bands 5 150-5 250, 5 250-5 350 MHz and 5 470-5 725 MHz by the mobile service for the implementation of Wireless Access Systems including Radio Local Area Networks"
[4] ERC Report 67: "Study of the Frequency sharing between HIPERLANs and MSS feeder links in the 5 GHz band"
[5] ERC Report 72: " Compatibility studies related to the possible extension band for HIPERLAN at 5 GHz"
[6] ETSI EN 301 893: " Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive"
[7] EC Decision 2005/513/EC complemented by EC Decision 2007/90/EC
[8] Recommendation ITU-R M.1739: "Protection criteria for wireless access systems, including radio local area networks, operating in the mobile service in accordance with Resolution 229 (WRC-03) in the bands 5 150-5 250 MHz, 5 250-5 350 MHz and 5 470-5 725 MHz"
[9] ERC Report 25: "The European table of frequency allocations and applications in the frequency range 8.3 kHz to 3000 GHz"
[10] EC Decision 2008/671/EC: "Commission Decision of 5 August 2008 on the harmonised use of radio spectrum in the 5875-5905 MHz frequency band for safety related applications of Intelligent Transport Systems (ITS)"
[11] ECC Decision (08)01: " ECC Decision of 14 March 2008 on the harmonised use of the 5875-5925 MHz frequency band for Intelligent Transport Systems (ITS)"
[12] ECC Recommendation (08)01: " Use of the band 5855-5875 MHz for Intelligent Transport Systems"
[13] ECC Report 101: "Compatibility studies in the band 5855– 5925 MHz between Intelligent Transport Systems (ITS) and other systems"
[14] ECC Decision (12)04: " ECC Decision of 2 November 2012 on the withdrawal of ECC Decision (02)01. For national implementation issues related to the withdrawn Decision, check EFIS"
[15] ERC Recommendation 70-03: " Relating to the use of Short Range Devices (SRD)"
[16] ETSI EN 300 674: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band; Part 1: General characteristics and test methods for Road Side Units (RSU) and On-Board Units (OBU)"
[17] CENELEC EN 12253: "" Road transport and traffic telematics - Dedicated short-range communication - Physical layer using microwave at 5.8 GHz"
[18] ECC Report 68: "Compatibility studies in the band 5725-5875 MHz between Fixed Wireless Access (FWA) systems and other systems"
[19] ITU-R Recommendation P.452: "Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz"
[20] EC Decision 2006/771/EC: "Commission Decision of 9 November 2006 on the harmonisation of the radio spectrum for use by short-range devices"
[21] IARU Region-1 VHF Managers Handbook
[22] Recommendation ITU-R M.1732-1: "Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies"
[23] ECC Report 210: "Compatibility/sharing studies related to Broadband Direct-Air-to-Ground Communications (DA2GC) in the frequency bands 5855-5875 MHz, 2400-2483.5 MHz and 3400-3600 MHz"
[24] ETSI TR 101 599: "Electromagnetic compatibility and Radio spectrum matters (ERM) System Reference Document (SRDoc); Broadband Direct-Air-to-Ground Communications System employing beamforming antennas, operating in the 2,4 GHz and 5,8 GHz bands"
[25] ETSI TR 103 108: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc); Broadband Direct-Air-to-Ground Communications System operating in the 5,855 GHz to 5,875 GHz band using 3G technology"
[26] ECC Report 206: "Compatibility studies in the band 5725-5875 MHz between SRD equipment for wireless industrial applications and other systems"
[27] IEEE 802.11-2012: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications"

[28] ETSI EN 302 571 V1.2.2 (2011-10): "Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive"
[29] ITU-R Recommendation SM.329: "Unwanted emissions in the spurious domain"
[30] ERC Recommendation 74-01: "Unwanted Emissions in the Spurious Domain"
[31] ITU-R Recommendation F.1336-3: "Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile service for use in sharing studies in the frequency range from 400 MHz to about 70 GHz"
[32] ETSI ES 200 674-1 V2.4.1 (2013-05): "Technical characteristics and test methods for High Data Rate (HDR) data transmission equipment operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band"
[33] NTIA 5 GHz report, January 2013, "Evaluation of the 5350-5470 MHz and 5850-5925 MHz bands pursuant to section 6406(b) of the middle class tax relief and job creation act of 2012
[34] ETSI TR 102 960: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (RTTT DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range; Evaluation of mitigation methods and techniques"
[35] ETSI TS 102 792: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range"
[36] http://www.statistiques-mondiales.com/union_europeenne.htm
[37] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_hhnhtych&lang=en
[38] https://www.ssb.no/en/befolkning/statistikker/familie/aar/2014-12-12
[39] http://www.bfs.admin.ch/
[40] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bd_9ac_l_form_r2&lang=en
[41] 3GPP TR 36.889: Feasibility Study on Licensed-Assisted Access to Unlicensed Spectrum, http://www.3gpp.org/DynaReport/36889.htm
[42] CEPT Report 57 : "Compatibility and sharing conditions for WAS/RLAN in the bands 5350-5470 MHz and 5725-5925 MHz"
[43] ECC Report 181 on improving spectrum efficiency in SRD bands
[44] JRC study on RLAN deployment and device densities: http://www.cept.org/Documents/se-24/25709/SE24(15)070R0_WI52_number-of-RLAN-JRC
[45] JRC study on in-home RLAN coverage and number of RLAN APs per household: http://www.cept.org/Documents/se-24/25805/SE24(15)089R0_WI52_Further-considerations-on-WLAN-indoor-coverage
[46] JRC measurements of 802.11ac RLAN APs operating in the 5 GHz band: http://www.cept.org/Documents/se-24/24051/SE24(15)042R0_WI52_JRC_5GHZ_RLAN-_measurements