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| **Radiocommunication Study Groups** |  |
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| Annex 9 to Working Party 5A Chairman’s Report |
| PRELIMINARY DRAFT NEW REPORT ITU-R M.[RLAN REQ-PAR] |
| Technical characteristics and operational requirements of WAS/RLAN in the 5 GHz frequency range |

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Related documents

|  |  |
| --- | --- |
| Recommendation ITU-R [M.1450](http://www.itu.int/rec/R-REC-M.1450/en) | Characteristics of broadband radio local area networks |
| Recommendation ITU-R [M.1454](https://www.itu.int/rec/R-REC-M.1454/en) | e.i.r.p. density limit and operational restrictions for RLANS or other wireless access transmitters in order to ensure the protection of feeder links of non-geostationary systems in the mobile-satellite service in the frequency band 5 150-5 250 MHz |
| Recommendation ITU-R [M.1739](http://www.itu.int/rec/R-REC-M.1739/en) | 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 |
| Recommendation ITU-R [M.1651](https://www.itu.int/rec/R-REC-M.1651/en) | A method for assessing the required spectrum for broadband nomadic wireless access systems including radio local area networks using the 5 GHz band |
| Recommendation ITU-R [M.1652](http://www.itu.int/rec/R-REC-M.1652/en) | Dynamic frequency selection in wireless access systems including radio local area networks for the purpose of protecting the radiodetermination service in the 5 GHz band |
| Recommendation ITU‑R [M.1653](http://www.itu.int/rec/R-REC-M.1653/en) | Operational and deployment requirements for wireless access systems including radio local area networks in the mobile service to facilitate sharing between these systems and systems in the Earth exploration-satellite service (active) and the space research service (active) in the band 5 470-5 570 MHz within the 5 460-5 725 MHz range |
| Recommendation ITU-R [M.1801](http://www.itu.int/rec/R-REC-M.1801/en) | Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz |
| Recommendation ITU-R [F.1763](http://www.itu.int/rec/R-REC-F.1763/en) | Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz |
| Recommendation ITU-R [SM.328](http://www.itu.int/rec/R-REC-SM.328/en)  | Spectra and bandwidth of emissions |
| Recommendation ITU-R [SM.329](http://www.itu.int/rec/R-REC-SM.329/en) | Unwanted emissions in the spurious domain |
| Recommendation ITU-R [SM.1539](http://www.itu.int/rec/R-REC-SM.1539/en) | Variation of the boundary between the out-of-band and spurious domains required for the application of Recommendations ITU-R SM.1541 and ITU-R SM.329 |
| Recommendation ITU-R [SM.1540](http://www.itu.int/rec/R-REC-SM.1540/en) | Unwanted emissions in the out-of-band domain falling into adjacent allocated bands |
| Recommendation ITU-R [P.452](https://www.itu.int/rec/R-REC-P.452/en) | Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz  |
| Recommendation ITU-R [P.528](https://www.itu.int/rec/R-REC-P.528/en) | **Propagation curves for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands** |
| Recommendation ITU-R [P.619](https://www.itu.int/rec/R-REC-P.619/en) | Propagation data required for the evaluation of interference between stations in space and those on the surface of the Earth |
| Recommendation ITU-R [P.2108](https://www.itu.int/rec/R-REC-P.2108/en) | Prediction of Clutter Loss |
| Recommendation ITU-R [P.2109](https://www.itu.int/rec/R-REC-P.2109/en) | Prediction of Building Entry Loss |
| Report ITU-R [P.2402](https://www.itu.int/pub/R-REP-P.2402-2017) | A method to predict the statistics of clutter loss for earth-space and aeronautical paths |
| Report ITU-R M.[AGGREGATE RLAN MEASUREMENTS] | Use of aggregate RLAN measurements from airborne and terrestrial platforms to support studies under WRC‑19 agenda item 1.16 |
| ETSI EN 301 893 | 5 GHz RLAN; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU |
| IEEE 802.11a | IEEE Standard for Telecommunications and Information Exchange Between Systems - LAN/MAN Specific Requirements – Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: High Speed Physical Layer in the 5 GHz band |
| IEEE 802.11n | IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC)and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput |
| IEEE 802.11ac | IEEE Standard for Information technology –Telecommunications and information exchange between systems—Local and metropolitan area networks –Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications – Amendment 4: Enhancements for Very High Throughput for Operation in Bands below 6 GHz |
| IEEE 802.11ax | IEEE Draft Standard for Information Technology – Telecommunications and Information Exchange Between Systems Local and Metropolitan Area Networks – Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment Enhancements for High Efficiency WLAN |
| 3GPP TS-36.101 | 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception |
| 3GPP TR-36.819 | 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Coordinated multi-point operation for LTE physical layer aspects |
| CEPT Report 17 | Report from CEPT to the European Commission in response to the Mandate to: identify the conditions relating to the harmonised introduction in the European Union of radio applications based on ultra-wideband (UWB) technology |
| CEPT Report 64 | Report B from CEPT to the European Commission in response to the Mandate “To study and identify harmonised compatibility and sharing conditions for Wireless Access Systems including Radio Local Area Networks in the bands 5 350-5 470 MHz and 5 725‑5 925 MHz ('WAS/RLAN extension bands') for the provision of wireless broadband services” |

# 1 Introduction

This Report provides technical characteristics and operational requirements of wireless access systems including radio local area networks (WAS/RLAN) in the 5 150 MHz to 5 925 MHz frequency range.

This Report is intended to represent the response to *invites ITU-R a)* of Resolution**239 (WRC-15)** and to serve, as appropriate, as a basis for sharing and compatibility studies and consideration of mitigation techniques under WRC-19 agenda item 1.16.

A number of these characteristics provided in this Report have been derived considering results and related analysis of measurements performed at 2.4 GHz as described in Report ITU-R M.[AGGREGATE RLAN MEASUREMENTS].

WRC‑03 allocated the bands 5 150-5 350 MHz and 5 470-5 725 MHz on a primary basis to the mobile service for the implementation of WAS/RLAN in accordance with Resolution **229 (WRC‑03)**, which is revised as Resolution **229 (Rev.WRC-12)** in WRC-12. Some administrations permit WAS/RLAN devices to operate in the bands 5 150-5 350 MHz, and 5 470‑5 725 MHz on a non‑interference basis as a secondary service. Some administrations also allow WAS/RLAN operations in the ISM band 5 725-5 875 MHz or in parts of it (e.g., 5 725-5 850 MHz).

Resolution **229 (Rev.WRC-12)** “Use of the bands 5 150-5 250 MHz, 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” applies throughout this Report for basis of studies.

The WAS/RLAN characteristics are described in Recommendation ITU-R M.1450. Other information on WAS/RLAN is contained in Recommendations ITU-R M.1652, ITU-R M.1739, ITU-R M.1801, and ITU-R F.1763.

# 2 WAS/RLAN requirements

## 2.1 Spectrum requirements

Recommendation ITU-R M.1651 gives a general description of RLANs, the deployment scenarios, an overview of the method for estimating the required spectrum as well as an example calculation in the 5 GHz band in its Annex 1.

WAS/RLAN spectrum requirements were addressed during the 2012-2015 study period in relevant ITU-R groups under WRC-15 agenda item 1.1 and are duly considered in *recognising b)* of Resolution **239 (WRC-15)**.

As such, the present Report is not aimed as reconsidering the spectrum requirements.

## 2.2 Operational requirements

WAS/RLAN operational requirements have to be considered in the frequency bands between 5 150 MHz and 5 925 MHz in accordance with Resolution **239 (WRC-15)**.

According to RR No. **5.447F** and **5.450A**, stations in the mobile service (WAS/RLAN) in the band 5 250-5 350 and 5 470-5 725 MHz, shall not claim protection from incumbent services. Some administrations offer protection for WAS/RLAN stations. For the latter case, Recommendation ITU-R M.1739 may be applied.

### 2.2.1 e.i.r.p. requirements

Current e.i.r.p. limits are provided in Resolution **229 (Rev.WRC-12)** and some ITU-R Recommendations refer to e.i.r.p. values, such as Recommendation ITU-R M.1454 and ITU‑R M.1653, for certain deployment and usage scenarios. If these deployments and usage scenarios change, then different e.i.r.p. limits may need to be considered for the sub-band.

### 2.2.2 Outdoor /indoor usage

WAS/RLAN may operate outdoors in the following frequency bands: 5 250-5 350 MHz, 5 470‑5 725 MHz, (subject to the conditions specified in Resolution **229 (Rev.WRC-12))** and in some administrations in the ISM band or parts of it 5 725-5 875 MHz[[1]](#footnote-1).

In accordance with *resolves* 2of Resolution **229 (Rev. WRC-12)** WAS/RLAN use in the band 5 150‑5 250 MHz is restricted to indoor use only (see 2.2.1).

In accordance with *resolves* 4 of Resolution **229 (Rev.WRC-12)** stations operating in the mobile service either indoors or outdoors in the band 5 250-5 350 MHz are limited to maximum mean e.i.r.p., maximum mean e.i.r.p. density, ande.i.r.p. spectral density above the local horizontal plane (of the Earth).

Recommendation ITU‑R M.1653 *recommends* 3 limits the e.i.r.p. spectral density above the local horizontal plane (of the Earth) of the emission of a WAS/RLAN base station transmitter operating outdoor in the band 5 470-5 570 MHz.

Resolution **239 (WRC-15)** *invites c)* invites ITU-R to conduct and complete the following in time for WRC-19:

 *c) to perform sharing and compatibility studies between WAS/RLAN applications and incumbent services in the frequency band 5 150-5 350 MHz with the possibility of enabling outdoor WAS/RLAN operations including possible associated conditions;*

Outdoor operation of WAS/RLAN in the 5 GHz range is limited to the bands of 5 250-5 350 MHz and 5 470-5 725 MHz and required to implement DFS. As a result, WAS/RLAN operation in outdoor environment may be terminated for certain duration when DFS detects radar signal. For this reason, it is necessary to consider whether outdoor usage of RLAN systems without DFS should be increased in the bands free from radar operation.

Demand for WAS/RLAN is increased and so it is necessary to consider possibility of wider channels in order to support this demand as stated in Resolution **239 (WRC-15)**. In addition, this demand is in both indoor and outdoor environments. Taking this into account, it should also be considered whether outdoor usage of WAS/RLAN systems should be increased for sub-bands in which DFS is currently not required. In addition, the bands 5 150-5 250 MHz and 5 250-5 350 MHz are consecutive sub-bands and the consistent conditions may be preferred. However, outdoor operation of WAS/RLAN is currently allowed only in the 5 250-5 350 MHz band with certain conditions. Therefore it is necessary to consider whether the restrictions for the outdoor usage in the 5 150‑5 250 MHz band should be eased.

The probability distributions of outdoor/indoor usages of WAS/RLAN to be used for studies in response to Resolution **239 (WRC-15)** are contained in section 3.1 of this Report.

### 2.2.3 Other requirements

As noted in the sections above, Resolution **229 (Rev.WRC-12)** applies to the operation of RLANs in the 5 GHz band. More specifically, the application of mitigation techniques such as the use of emission masks, transmitter power control (TPC), dynamic frequency selection (DFS), and indoor operation are being used to facilitate sharing WAS/RLANs with incumbent services. These mitigation measures must be used in the design and deployment of RLANs in the applicable ranges within the 5 150-5 925 MHz band.

Further details on the implementation of mitigation techniques in the bands 5 150-5 925 MHz are found in Recommendation ITU-R M.1652-1.

## 2.3 Channel plans

Recommendation ITU-R M.1450 includes channel bandwidths and channel spacing associated with RLAN standards. Additional information on RLAN standards (e.g. IEEE and ETSI) can be obtained as given in Annex 1 to Recommendation ITU-R M.1450.

Channel plans for RLANs in the 5 GHz frequency bands are based on ETSI EN 301 893, and IEEE standards[[2]](#footnote-2): IEEE 802.11a, IEEE 802.11n, and IEEE 802.11ac. A fourth RLAN standard (i.e. IEEE 802.11ax) is currently under development.

Figure 1A illustrates the RLAN channelization schemes based on existing IEEE standards for the frequency bands 5 150-5 350 MHz and 5 470-5 725 MHz that are globally available and for the band 5 725-5 850[[3]](#footnote-3) MHz which is available only in some countries. For the frequency bands 5 350‑5 470 MHz and 5 850-5 925 MHz, no channelization scheme is available. However, for the purposes of studies, bandwidth configurations of 20 MHz, 40 MHz, 80 MHz and 160 MHz are considered, as appropriate and as shown in Figures 1B and 1C.

It is worth noting that any particular channelization or channel bandwidths are not mandated in the regulations.

The 3rd Generation Partnership Project (3GPP) has developed LTE standards for unlicensed use of the frequency band 5 150-5 925 MHz[[4]](#footnote-4).

FIGURE 1A

Channelization schemes based on existing technical standards



FIGURE 1B

Channel plan proposed by industry for use in the studies



FIGURE 1C

Channel plan proposed by industry for use in the studies



ETSI EN 301 893 channelization:

– Channel bandwidth: 20 MHz and alternatively 5 MHz

– Allowed channels:

 5 160 + (*g* × 20) MHz;

 where, 0 ≤ *g* ≤ 9 or 16 ≤ *g* ≤ 27 and g shall be an integer

IEEE 802.11a channelization:

– Channel bandwidth: 20 MHz

– Allowed channels:

 (36 to 64): 5 170 MHz to 5 330 MHz – RLAN

 (149 to 161): 5 735 MHz to 5 815 MHz – ISM band.

IEEE 802.11n channelization:

– Channel bandwidth: 20 MHz and 40 MHz combinations

– Allowed channels:

 (36 to 64): 5 170 MHz to 5 330 MHz – RLAN,

 (100 to 140): 5 490 MHz to 5 710 MHz – RLAN,

 (149 to 165): 5 735 MHz to 5 835 MHz – ISM band[[5]](#footnote-5).

IEEE 802.11ac/ax channelization:

– Channel bandwidth: 20 MHz, 40 MHz, 80 MHz and 160 MHz combinations

– Allowed channels:

 (36 to 64): 5 170 MHz to 5 330 MHz – RLAN,

 (100 to 140): 5 490 MHz to 5 710 MHz – RLAN,

 (149 to 165): 5 735 MHz to 5 835 MHz – ISM band.

Table 1

Existing channel plans for ETSI EN 301 893, and IEEE 802.11a/n/ac/ax.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Standard | ETSI EN 301 893 | IEEE802.11a | IEEE802.11n | IEEE802.11ac | IEEE802.11ax |
| Channel Bandwidth  | 5, 20 MHz | 20 MHz | 20, 40 MHz | 20, 40, 80, 80+80,160 MHz | 20, 40, 80, 80+80,160 MHz |
| Number of Channels in 5 150–5 925 MHz | 32(20 MHz each)944 | 29(20 MHz each) | 29(20 MHz each)14(40 MHz each) | 29 (20-MHz each)14 (40-MHz each)7 (80-MHz each)3 (160-MHz each) | 29 (20-MHz each)14 (40-MHz each)7 (80-MHz each)3 (160-MHz each) |
| Sub-Carrier Spacing |  | 312.5 kHz | 312.5 kHz | 312.5 kHz |

|  |
| --- |
| 78.125 kHz |

 |

Table 1A

Channel plans presented by industry for study under Resolution 239

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Standard | ETSI EN 301 893 | IEEE 802.11a | IEEE 802.11n  | IEEE802.11ac | IEEE802.11ax |
| Channel Bandwidth  | 5, 20 MHz | 20 MHz | 20, 40 MHz | 20, 40, 80, 80+80,160 MHz | 20, 40, 80, 80+80,160 MHz |
| Number of Channels in 5 150–5 925 MHz | 22(20 MHz each)944 | 12(20 MHz each) | 24(20 MHz each)12(40 MHz each) | 24 (20-MHz each)12 (40-MHz each)6 (80-MHz each)3 (160-MHz each) | 24 (20-MHz each)12 (40-MHz each)6 (80-MHz each)3 (160-MHz each) |
| Sub-Carrier Spacing |  | 312.5 kHz | 312.5 kHz | 312.5 kHz | 78.125 kHz |

## 2.4 Out-of-Band emissions

The following terms are defined in the ITU-R RR: out-of-band (OoB) emission (RR No. **1.144**), spurious emission (RRNo. **1.145**), unwanted emissions (RRNo. **1.146**), assigned frequency band (RR No. **1.147**), assigned frequency (RRNo. **1.148**), necessary bandwidth (RRNo. **1.152**), and occupied bandwidth (RR No. **1.153**).

In analyzing the out-of-band (OoB) emissions applicable to RLANs, it is recommended that Recommendations ITU-R SM.1540, ITU-R SM.329, ITU-R SM.1539, ITU-R SM.328, and Recommendation ITU-R M.1450 be consulted. Recommendations ITU-R M.1450 includes technical parameters associated with RLAN standards including emission masks for ETSI EN 301 893, IEEE 802.11a, IEEE 802.11n, and IEEE 802.11ac.

# 3 WAS/RLAN technical characteristics

The use cases for 5 GHz WAS/RLANs are determined by the regulatory restrictions in each individual band, based on the previous ITU-R studies. The new studies may involve different proposals for studies in each of the sub-band.

## 3.1 e.i.r.p. level distribution

### 3.1.1 Wi-Fi type WAS/RLAN e.i.r.p. level distributions

The e.i.r.p. level distribution for Wi-Fi type WAS/RLAN to be studied for the 5 150‑5 250 MHz, 5 250-5 350 MHz, 5 725-5 850 MHz and 5 850-5 925 MHz bands is consistent and described in Table 2 below following the assumptions that indoor as well as outdoor use is allowed. For sharing studies considering possible 4W operation in the 5 150‑5 250 MHz band, a percentage of the 1W outdoor operation can be modelled at 4W using table 3.

Table 4 is based on the analysis provided in attachment 1 of document 5A/893. The High Power column in Table 4 represents a weighted average e.i.r.p. of devices certified under the 4 watt e.i.r.p. limit by one administration. A survey of devices certified by this Administration, for operation at up to 4 watts e.i.r.p., was conducted. The survey considered the maximum conducted power for each 20, 40, 80 and 160 MHz bandwidths supported by APs. It also considered both correlated and uncorrelated antenna configurations and gains. A weighted average e.i.r.p. was then developed for APs utilizing the channel bandwidth distribution provided in Table 12. The results were averaged across APs for each channel bandwidth supported and a weighted average calculated for indoor and outdoor operation separately.

Table 5 provides a distribution of power levels that described a study area encompassing one Administration, with different regulatory requirements. This allows outdoor e.i.r.p. of up to 4 W, derived from a maximum 1 W conducted power and 6 dBi gain antenna. The last column on the right in the table shows the average conducted power for the weights in each row. The weighted average power of indoor APs is 77 mW. This equates to 19 dBm. This indoor power level is also the same in Table 2 and Table 3.

Table 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Tx power e.i.r.p.  | 1 W (directional) | 1 W (omni) | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (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 3

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tx power e.i.r.p.  | 4 W (directional) | 4 W (omni) | 1 W (directional) | 1 W (omni) | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (omni) | all |
| Indoor | 0% | 0% | 0% | 0% | 18% | 25.6% | 14.2% | 36.9% | 94.7% |
| Outdoor | 0.025% | 0.05% | 0.075% | 0.15% | 0.95% | 1.35% | 0.75% | 1.95% | 5.3% |

TABLE 4

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Type | High Power (APs) | 200 mW (RLAN) | 80 mW (RLAN) | 50 mW (RLAN) | 25 mW (RLAN) | Total % | Wgt Avg e.i.r.p. |
| Indoor e.i.r.p.s  | 29.7 dBm | 23 dBm | 19 dBm | 17 dBm | 14 dBm |  |  |
| 936 mW | 200 mW | 80 mW | 50 mW | 25 mW |  |  |
| Indoor % | 13.5% | 16% | 22.84% | 12.67% | 32.92% | 98.0% | 22.9 dBm |
| Outdoor e.i.r.p.s  | 30.5 dBm | 23 dBm | 19 dBm | 17 dBm | 14 dBm |  |  |
| 1132 mW | 200 mW | 80 mW | 50 mW | 25 mW |  |  |
| Outdoor | 0.175% | 0.35% | 0.49% | 0.27% | 0.71% | 2.00% | 22.3 dBm |

Table 5

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tx power e.i.r.p. | 4W dir. | 4W omni | 1W dir. | 1W omni | 200 mW omni | 80 mW omni | 50 mW omni | 25 mW omni | All | Pavg mW |
| Indoor | 0% | 0% | 0% | 0% | 15.15% | 21.95% | 11.15% | 31.15% | 80.0% | 77 |
| Outdoor | 0% | 3.00% | 0% | 2.85% | 2.00% | 4.05% | 2.25% | 5.85% | 20.0% | 792 |

Further information on WAS/RLAN devices with e.i.r.p.s greater than 200 milliwatts, without including the associated antenna gain, is given in the Annex to this Report.

In addition to that, in the band 5 150-5 250 MHz, it has been proposed to allow a relaxation to an in-car usage with a maximum e.i.r.p. of 40 mW and in-train usage up to 200 mW. An additional vehicle screening attenuation should be considered in that case. The following distribution is to be considered:

TABLE 6

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| RLAN e.i.r.p. level  | 200 mW | 80 mW | 50 mW | 40 mW | 25 mW | All |
| Indoor | 18.25% | 25.95% | 14.39% | 0.00% | 37.41% | 96.00% |
| Outdoor | 0.24% | 0.25% | 0.14% | 0.00% | 0.37% | 1.00% |
| In-vehicle (cars and trains) | 1.50% | 0% | 0% | 1.50% | 0% | 3.00% |

Note that this distribution already takes into account the 1% accidental outdoor usage, not restricted to in-vehicle usage. This 1% can be modulated to other values in order to perform parametric analysis.

The following Table 7 depicts the e.i.r.p. level distribution for Wi-Fi type WAS/RLAN in the band 5350-5470 MHz and 5 725-5 850 MHz under the assumption that 5% of the devices are modelled without building attenuation.

Table 7

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RLAN e.i.r.p. Level | 200 mW(Omni-Directional) | 80 mW(Omni-Directional) | 50 mW(Omni-Directional) | 25 mW(Omni-Directional) |
| RLAN device percentage | 19% | 27% | 15% | 39% |

Alternatively administrations may choose to carry out a parametric analysis in any range between 1% and 10%.

### 3.1.2 LTE type WAS/RLAN e.i.r.p. level distributions

The e.i.r.p. level distribution for LAA-LTE described in Table 8 below follows the assumptions that indoor as well as outdoor use, mean e.i.r.p. limited to 1 W for outdoor, and use of mitigation techniques such as dynamic frequency selection (DFS) and transmit power control (TPC)[[6]](#footnote-6).

One may assume, for further studies, that the distribution in Table 8 below applies to the studies related to the frequency bands 5 150-5 250 MHz, 5 250-5 350 MHz and 5 725‑5 925 MHz.

Table 9 below is a distribution of power levels that described a study area encompassing one Administration, with different regulatory requirements. This allows outdoor e.i.r.p. of up to 4 W, derived from a maximum 1 W conducted power and 6 dBi gain antenna, or 3.16 W with a 5 dBi gain antenna as suggested in section 3.5. The last column on the right in the table shows the average conducted power for the weights in each row. The weighted average power of indoor APs is 58 mW. This indoor power level is also the same in Table 8.

Table 8

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Tx power e.i.r.p.  | 1 W | 200 mW | 140 mW | 100 mW | 50 mW | 13 mW | ≤ 1 mW |
| Indoor RLAN device percentage | 0.00% | 9.55% | 0.96% | 20.58% | 7.96% | 21.50% | 22.95% |
| Outdoor RLAN device percentage | 0.01% | 2.10% | 0.49% | 3.92% | 1.91% | 5.28% | 2.79% |

Table 9

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tx power e.i.r.p. | 3.16 W | 1 W | 200 mW | 140 mW | 100 mW | 50 mW | 13 mW | <=1 mW | All | Pavg mW |
| Indoor | 0% | 0% | 9.55% | 0.96% | 20.58% | 7.96% | 21.50% | 22.95% | 83.50% | 58 |
| Outdoor | 3.00% | 2.85% | 2.00% | 2.00% | 1.85% | 2.25% | 2.55% | 0% | 16.50% | 809 |

Table 9 is a distribution of power levels that is based on initial LTE-LAA deployments in the northern half of Region 2[[7]](#footnote-7) and standards documents.[[8]](#footnote-8) The distribution of indoor and outdoor deployments is based on published industry documents.[[9]](#footnote-9) Regulations of one Administration in this region have permitted outdoor deployment of unlicensed LTE type RLANs since 2014. This allows outdoor power of up to 4 W, derived from a maximum 1 W conducted power and 6 dBi gain antenna, or 3.16 W with a 5 dBi gain antenna as described in section 3.5. The last column on the right in the table shows the average conducted power for the weights in each row. The weighted average power of indoor APs is 58 mW. This indoor power level is also the same in Table 8. The percentages in the table above do not take into account residential small cell counts.

The following Table 11 depicts the e.i.r.p. level distribution for LAA-LTE under the assumption that only indoor usage is allowed, a maximum mean e.i.r.p. of 200 mW, and use of mitigation techniques such as DFS and TPC. One should assume that this e.i.r.p. level distribution is applicable to studies related to the frequency band 5 350-5 470 MHz and 5 725-5 850 MHz.

Table 10

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tx power e.i.r.p.  | 200 mW | 140 mW | 100 mW | 50 mW | 13 mW | <=1 mW |
| Indoor RLAN device percentage | 11.43% | 1.15% | 24.65% | 9.53% | 25.75% | 27.49% |

### 3.1.3 e.i.r.p. elevation angle mask

For sharing studies, the following regulatory conditions for e.i.r.p. elevation angle mask have been proposed by some countries for the 5 150-5 250 MHz band:

Proposal 1:

When operating above a mean e.i.r.p. of 200 mW, the stations comply with the following e.i.r.p. elevation angle mask where θ is the angle above the local horizontal plane (of the Earth), that is the same as specified for the 5 250-5 350 MHz band in Resolution **229 (Rev.WRC-12)**:

 −13 dB(W/MHz) for 0° ≤ θ < 8°

 −13 − 0.716(θ − 8) dB(W/MHz) for 8° ≤ θ < 40°

 −35.9 − 1.22(θ − 40) dB(W/MHz) for 40° ≤ θ ≤ 45°

 −42 dB(W/MHz) for 45° < θ;

Proposal 2:

The service the maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon shall not exceed 125 mW (21 dBm), in addition, for WAS/RLAN transmitters operating in the 5 150-5 250 MHz band.

## 3.2 Channel bandwidths distribution

The proposed RLAN device transmitter bandwidth distribution shown in Table 11 needs further studies.

LAA-LTE includes a function for Channel Aggregation (CA) to increase the bit rate that is similar in purpose to the increased bandwidths for Wi-Fi. LAA-LTE can assert CA dynamically, and the constituent channels can be within the same band, or in different bands, and they can be contiguous, or non-contiguous. The proposed model for interference therefore simply uses the constituent channels and presumes that they are randomly used according to the traffic load. Wider bandwidth channels are not statically determined. Transmitter power levels for aggregated channels must meet the appropriate regulatory requirements for both transmitted power flux density in watts/Hz, and maximum e.i.r.p., for the region of study.

Table 11

Bandwidth distribution

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RLAN Transmitter Bandwidth | 20 MHz | 40 MHz | 80 MHz | 160 MHz |
| RLAN Device Percentage | 10% | 25% | 50% | 15% |

## 3.3 Building and vehicle attenuation

The building attenuation model in Recommendation ITU-R P.2109 should be used in sharing studies.

The values determined for the German ICE4 long-distance train are substantial attenuation values that are greater than 20 dB and thus similar to those of building attenuation. One of the key reasons for the attenuation values are the metal coated glasses (train windows) used as well as the robust steel structure of the ICE4 carriages. Similar attenuation values can also be assumed for other long-distance trains with a comparable structure.

The insulation and thermal insulation glass windows form a closed surface with high attenuation values in the 5 GHz range. In the areas between the carriage and glass, small increases in the field strengths can be detected when determining the optimal measuring points. Another critical factor in terms of the emission of RLAN signals externally is the location of the antennas within the train. In the ICE4, appropriate positions for the APs have been chosen to ensure that there is no clear line of sight between the external area and the antennas when the doors are opened. This means that only weak and reflected signals can be received in front of the opened doors.

The place at which the largest amount of signals is emitted externally is in the connection between carriages. This is an intercarriage gangway with the lowest attenuation values due to its composition. The emissions here are also weak and caused by reflected signals.

A maximum attenuation of **41.2 dB** and a minimum attenuation of **21.1 dB** were detected over the frequency range in question at the intercarriage gangway, see **Table 12**. These values apply for a train in motion.

The measurements, carried out by using a German ICE4 train, are considered as representative. Hence the results are relevant for long-distance trains in general. It is assumed that the measurement results are not applicable for regional trains, urban rail trains and trams.

Table 12

Attenuation values for high-speed trains

| Attenuation values with regard to the frequency ranges | At the intercarriage gangway with a closed connecting door | At the intercarriage gangway with an open connecting door | On the window | Door open | Door closed |
| --- | --- | --- | --- | --- | --- |
| Minimum value 5.1‑5.4 GHz | 23.38 | **21.13** | 45.90 | 20.00 | 51.08 |
| Maximum value 5.1‑5.4 GHz | 40.67 | **41.25** | 57.65 | 43.87 | 61.96 |
| Average value 5.1‑5.4 GHz | 31.95 | 30.66 | 51.84 | 31.60 | 56.94 |
| Minimum value up to 5.25 GHz | 24.12 | 21.13 | 46.04 | 22.07 | 51.08 |
| Maximum value up to 5.25 GHz | 39.90 | 37.62 | 57.65 | 35.21 | 59.50 |
| Average value up to 5.25 GHz | 32.27 | 29.91 | 51.62 | 28.28 | 55.74 |
| Minimum value from 5.25 GHz | 23.38 | 22.91 | 45.90 | 20.00 | 52.69 |
| Maximum value from 5.25 GHz | 40.67 | 41.25 | 56.14 | 43.87 | 61.96 |
| Average value from 5.25 GHz | 31.69 | 31.22 | 52.00 | 33.39 | 57.74 |

– Attenuation of **cars**:

 It should be noted, that cars with metallized windows provide a mean attenuation of about 15 dB and cars without any metallized windows provide a mean attenuation of about 8 dB. Cars with one window being metallized (front window) provide a mean attenuation of 12 dB. (See CEPT Report 17, Annex 2, Chapter 2.3).

 (In some exceptional cases, where the antennas were placed directly behind the car windows pointing through the window outside, there was less attenuation reported (2 dB). It is important to note, that in addition to the screening attenuation there is an absorption loss due to the effect of the human body being close to the UWB antenna in a car. This loss could be as high as 10-20 dB. In particular the use case of entertainment of the back seats contributing mainly to the activity is characterised by having at least 3 passengers in the vehicle.)

## 3.4 Propagation model for sharing studies

− With regard to the propagation model, Recommendation ITU-R P.619 should only be used for earth-to-space paths while Recommendation ITU-R P.452 should be strictly limited to terrestrial propagation paths.

− The appropriate propagation model to be used for sharing studies between airborne platforms and terrestrial stations is Recommendation ITU-R P.528. This Recommendation contains a method for predicting basic transmission loss in the frequency range 125-15 500 MHz for aeronautical and satellite services.

− The sets of median basic transmission loss curves in Recommendation ITU-R P.528 are derived assuming propagation over a smooth spherical earth with a stratified atmosphere. Therefore, terrain diffraction within this recommendation is due to smooth sphere diffraction caused by the bulge of the Earth. Effects due to diffraction by irregular terrain at low elevation angles are not included in these curves.

− Recommendation ITU-R P.528 does not include clutter as an adjustment to its basic transmission loss predictions. Additional loss due to local clutter and or building entry loss may be calculated using Recommendations ITU-R P.2108 and ITU-R P.2109, respectively.

− The current frequency range of applicability of section 3.3 of Recommendation ITU-R P.2108 is 10‑100 GHz, however if the deployment scenario is similar to that in section 3.3 of Recommendation ITU‑R P.2108 and in Report ITU-R P.2402 the model could reasonably be applied to frequencies as low as 5 GHz, but limited to suburban and urban environments, and antenna heights up to 6 metres. It is expected that extending Recommendation ITU-R P.2108 down to 5 GHz would provide more accurate results than Recommendation ITU-R P.452.

− Parameters included in Annex 6 to Recommendation ITU-R M.1652 may be used for sharing studies.

## 3.5 Antenna gain/discrimination

The antenna discrimination figures for compatibility analysis are:

– Generally omnidirectional in azimuth however directional antennas might be employed in some scenarios.

– Reference radiation patterns may be required in situations where information concerning the actual radiation patterns are not available.

– Overall discrimination should take into account both client and AP antennas and is therefore dependent on the percent of time upstream and downstream transmissions take place. This may differ by scenarios considered.

– Discrimination should also take into account the position of the antennas generally the outdoor antennas are pointed with the main beams facing downward while the indoors the main beams will generally face upward.

– In elevation, an average 2 dB antenna discrimination is applied in the direction of the satellite (see note).

Note: To allow for discussion on final results, values of 0 dB and 4 dB could also be considered.

Alternatively, antenna patterns included in Appendix 2 to Annex 6 to Recommendation ITU-R M.1652-1 may be used for sharing studies.

Some WAS/RLANs such as IEEE 802.11n, 802.11ac and 802.11ax employ active antenna systems such as MIMO and beamforming technologies employing precoding at RLAN transmitters. It is expected that effects of MIMO or beamforming technologies result in same aggregated interference to other services given the same e.i.r.p. because the effect of these technologies are applied only to the locations of the RLAN receivers.

The following antenna pattern is defined in 3GPP TR-36.819 for LAA-LTE system simulation purposes. The antenna is defined for low-power pico cells. The pattern is omni-directional in azimuth and selective with vertical elevation as follows.

 $A\_{V}\left(θ\right)=G\_{0} -min\left[12\left(\frac{θ-θ\_{tilt}}{θ\_{3dB}}\right)^{2}, SLA\_{V}\right]$

 3dB = 40 degrees, *SLAV* = 20 dB

 tilt = 0 or -10 degrees *G0* = 5 dBi

## 3.6 WAS/RLAN device density relevant to sharing studies

The following average RLAN device densities are to be considered as simultaneously transmitting within the whole 5 GHz range with the e.i.r.p. distribution as given above. (see Report ITU-R M.[AGGREGATE RLAN MEASUREMENTS]).

In addition, for each case under study (for aggregate interference to satellite receivers), the following factors can be considered:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Case under study | Receiver Bandwidth (MHz) | Overlapping factor | Resulting density (RLAN/inhab.) | Average Bandwidth factor |
| FSS | 40 | 12.9% | 0.0034 | 3.59 dB |
| EESS (SAR) | 100 | 22% | 0.0058 | 1.94 dB |
| EESS (Altimeter) | 320 | 48.9% | 0.0130 | 0.35 dB |
| EESS (scatterometer) | 2 | 11.0% | 0.0029 | 15.89 dB |
| MSS Feeder links | 16.5 | 11.0% | 0.0029 | 6.73 dB |
| MSS aggregate feeder uplink / Wi-Fi  | 80 | 13.2% | 0.0035 | 0.67 dB |
| MSS aggregate feeder uplink / LAA-LTE | 100 | 15.6% | 0.0041 | 0.00 dB |

Table 13

RLAN densities and factors to be considered in sharing studies

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Receiver Bandwidth (MHz) | Busy hour factor | 5 GHz factor | Activity factor | Chanellization factor | Resulting density (RLAN/inhab.) | Average Bandwidth factor (dB) |
| FSS | Upper case | 40 | 62.70% | 38% | 10% | 12.90% | 0.001753601 | 3.59 |
| Lower case | 40 | 62.70% | 59% | 10% | 12.90% | 0.002722697 | 3.59 |
| EESS (SAR) | Upper case | 100 | 62.70% | 38% | 10% | 22.00% | 0.002990638 | 1.94 |
| Lower case | 100 | 62.70% | 59% | 10% | 22.00% | 0.004643359 | 1.94 |
| EESS (Altimeter) | Upper case | 320 | 62.70% | 38% | 10% | 48.90% | 0.006647373 | 0.35 |
| Lower case | 320 | 62.70% | 59% | 10% | 48.90% | 0.010320921 | 0.35 |
| EESS (scatterometer) | Upper case | 2 | 62.70% | 38% | 10% | 11.00% | 0.001495319 | 15.89 |
| Lower case | 2 | 62.70% | 59% | 10% | 11.00% | 0.00232168 | 15.89 |
| MSS Feeder links\* | Upper case | 16.5 | 62.70% | 38% | 10% | 11.00% | 0.001495319 | 6.73 |
| Lower case | 16.5 | 62.70% | 59% | 10% | 11.00% | 0.00232168 | 6.73 |
| \* This is the FDM feeder link channel bandwidth, the received channel bandwidth is 1.23 MHz and may also be used as long as the KTB bandwidth corresponds. |

Detailed calculations of the overlapping factors and average bandwidth factors are given in the following file.



It should be noted that these factors are given considering deployment of RLAN over the whole 5 GHz range (i.e. 5 150-5 925 MHz). They would have to be recalculated if the RLAN 5 GHz range of frequency was to be changed.

In addition, it is necessary to consider operations in which the number of RLAN devices is limited and controlled. Therefore it should be possible to take into account the interference threshold to ensure protection of the existing systems in order to determine the number of simultaneous RLAN connections which can be tolerated. Accordingly the number or the density of RLANs can be determined for each case of the interference scenario.

ANNEX

The distribution of RLAN transmit powers in Figure 2 is based on an analysis of the database of unlicensed WAS/RLAN device certifications for one administration where outdoor RLANs were authorized.

Figure 2

Distribution of Outdoor Wi-Fi Certified Devices by Power



Analysis of Certified Devices

The analysis of the unlicensed WAS/RLANS certifications was conducted by accessing the unlicensed certification database from an Administration and downloading certification data for all devices capable of operating in 5 150-5 250 MHz.[[10]](#footnote-10) More than 7750 WAS/RLAN devices were certified during this time period. The device characteristics were then manually inspected, and the WAS/RLAN devices capable of outdoor operation were identified. Approximately 492 devices capable of operating outdoors in the frequency band 5 150-5 250 MHz were identified. The WAS/RLAN devices with transmit conducted power greater than 250 mW were then sorted according to the transmit conducted power listed in the certification data. Figure 2 summarizes the number of WAS/RLANS certified for operation in 5 150-5 250 MHz, as a function of maximum transmitted conducted power. The regulations in an administration where outdoor WAS/RLANS have been authorized since March 2014 also permit a 6 dBi gain antenna for devices with conducted power up to 1 Watt. The resulting transmit e.i.r.p. values for the WAS/RLAN devices with conducted power greater than 250 mW is also indicated in Figure 2. The number of outdoor devices certified in 5 150-5 250 MHz operating at transmitted e.i.r.p.s up to 4.0 watts e.i.r.p. is the basis for including WAS/RLAN device power levels in Table 5 in section 3.1.1.

1. The band 5 725-5 875 MHz is designated globally for ISM applications by means of the footnote **5.150** in the allocation table. [↑](#footnote-ref-1)
2. ETSI standards available at <http://pda.etsi.org/pda/queryform.asp>, and IEEE 802.11 standards are available at: <http://standards.ieee.org/about/get/802/802.11.html>. [↑](#footnote-ref-2)
3. In Europe, the frequency band 5 725-5 875 MHz is used for low-power wireless industrial applications (ETSI EN 303 258 is under development). [↑](#footnote-ref-3)
4. 3GPP Standard TS 36.101, available at <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=2411>. [↑](#footnote-ref-4)
5. The definition of ISM applications is specified in RR No **1.15**. [↑](#footnote-ref-5)
6. CEPT Report 64 “To study and identify harmonised compatibility and sharing conditions for Wireless Access Systems including Radio Local Area Networks in the bands 5 350-5 470 MHz and 5 725-5 925 MHz ('WAS/RLAN extension bands') for the provision of wireless broadband services”. [↑](#footnote-ref-6)
7. “Radio Local Area Network (“RLAN”) and Microwave Fixed Service (“FS”) Sharing at 6 GHz,” AT&T, March 16, 2018. <https://ecfsapi.fcc.gov/file/10319087261781/OETMtgMidBand_Final.pdf> [↑](#footnote-ref-7)
8. 3GPP Technical Specification 36.104 v14.1.0. 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E‑UTRA); Base Station (BS) radio transmission and reception (Release 14). [↑](#footnote-ref-8)
9. Small Cell Forum document 050.10.02, *Small cells market status report*, February 2018, <https://scf.io/en/documents/050_-_Small_cells_market_status_report_February_2018.php>. [↑](#footnote-ref-9)
10. The WAS/RLAN certification data was downloaded from <https://fccid.io>. [↑](#footnote-ref-10)