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| **Radiocommunication Study Groups** |  |
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| Source: Document 5A/TEMP/235 | **Annex 21 to****Document 5A/650** |
| **20 November 2017** |
| **English only** |
| Annex 21 to Working Party 5A Chairman’s Report |
| WORKING DOCUMENT TOWARDS A 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 ITU-R Recommendations and Reports

|  |  |
| --- | --- |
| 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.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.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 |
| Report ITU-R [M.2034](http://www.itu.int/pub/R-REP-M.2034) | Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz |
| Report ITU-R [M.2115](http://www.itu.int/pub/R-REP-M.2115) | Testing procedures for implementation of dynamic frequency selection |
| Report ITU-R [F.2086](http://www.itu.int/pub/R-REP-F.2086) | Technical and operational characteristics and applications of broadband wireless access in the fixed service |

Summary of related ITU-R Recommendations and Reports are contained in Annex 1 to this Report.

# 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

*1 that, for the purposes of conducting compatibility studies with respect to services or applications from which WAS/RLAN systems are entitled, according to their status, to be protected, the protection criteria for WAS/RLAN systems operating in the mobile service in accordance with Resolution 229 (WRC‑03) should be as follows:*

*– 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 as described in Annex 1 (Rec. ITU-R M.1739).*

### 2.2.1 E.I.R.P. requirements

*[Editor’s note: The US proposed to delete this section. France proposed to add a table.]*

a) Current situation in existing bands

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.

Resolution **229 (Rev.WRC-12)** resolves

*“2 that in the band 5 150-5 250 MHz, stations in the mobile service shall be restricted to indoor use with a maximum mean e.i.r.p.[[1]](#footnote-2)1 of 200 mW and a maximum mean e.i.r.p. density of 10 mW/MHz in any 1 MHz band or equivalently 0.25 mW/25 kHz in any 25 kHz band;*

*3 that administrations may monitor whether the aggregate pfd levels given in Recommendation ITU‑R S.1426[[2]](#footnote-3)2 have been, or will be exceeded in the future, in order to enable a future competent conference to take appropriate action;*

*4 that in the band 5 250-5 350 MHz, stations in the mobile service shall be limited to a maximum mean e.i.r.p. of 200 mW and a maximum mean e.i.r.p. density of 10 mW/MHz in any 1 MHz band. Administrations are requested to take appropriate measures that will result in the predominant number of stations in the mobile service being operated in an indoor environment. Furthermore, stations in the mobile service that are permitted to be used either indoors or outdoors may operate up to a maximum mean e.i.r.p. of 1 W and a maximum mean e.i.r.p. density of 50 mW/MHz in any 1 MHz band, and, when operating above a mean e.i.r.p. of 200 mW, these stations shall comply with the following e.i.r.p. elevation angle mask where θ is the angle above the local horizontal plane (of the Earth):*

 *−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;*

*6 that in the band 5 470-5 725 MHz, stations in the mobile service shall be restricted to a maximum transmitter power of 250 mW[[3]](#footnote-4)3 with a maximum mean e.i.r.p. of 1 W and a maximum mean e.i.r.p. density of 50 mW/MHz in any 1 MHz band;”*

Recommendation ITU-R M.1454 *recommends*

“**1** that administrations should ensure that the mean e.i.r.p. density limit of RLAN or other wireless access transmitter devices operating in the band 5 150-5 250 MHz should be no greater than 10 mW in any 1 MHz (or equivalently 0.04 mW in any 4 kHz) per transmitter (see Notes 1, 2 and 3)

NOTE 1 – Annex 1 contains a methodology and parameters that have been used in sharing studies.

NOTE 2 – For a particular type of RLAN standard (i.e. HIPERLAN type 1) the e.i.r.p. density limit in recommends 1 should apply only in payload transmission. Its overall e.i.r.p. should be limited to 200 µW per device. The provisional date of validity of this Note is until 1 January 2003.

NOTE 3 – For RLAN carriers with less than 1 MHz bandwidth, the e.i.r.p. density should not exceed 0.01 µW/Hz over the carrier bandwidth.”

Recommendation ITU‑R M.1653 recommends

“**1** that to facilitate sharing with EESS (active) and SRS (active) in the band 5 470‑5 570 MHz, as described in Annex 1, either the operational and technical restrictions given in *recommends* 2, where WAS is limited to a maximum e.i.r.p. of 1 W, or those given in *recommends* 3, where WAS is limited to a maximum transmitter power of 250 mW and other WAS configurations with spectral masks versus elevations angle, should be applied to WAS including RLANs;

**2** that WAS including RLANs, operating either indoors or outdoors, in the band 5 470‑5 570 MHz as described in Annexes 2 and 3, should:

a) be limited to 1 W maximum mean e.i.r.p. and 17 dBm/MHz maximum mean e.i.r.p. spectral density per transmitter (Note 1);

b) employ TPC to give an aggregate power reduction of at least 3 dB. If transmitter power control is not implemented, then the power limitation given above should be reduced by 3dB;

c) employ DFS operating across the 5 470‑5 725 MHz band designed to provide near uniform loading of the available channels.

NOTE 1 − The interference criteria of spaceborne active sensors in the EESS (active) are provided by Recommendation ITU-R SA.1166. Further studies are required to confirm the suitability of these limitations in *recommends* 2 to comply with the requirements of Recommendation ITU-R SA.1166.

**3**that WAS including RLANs operating either indoors or outdoors in the band 5 470‑5 570 MHz, as described in Annexes 2 and 4, should be subject to the following conditions:

a) a maximum transmitter power of 250 mW (24 dBm) or 11 + 10 log *B* (dBm) per transmitter, whichever power is less (*B* is the 99% power bandwidth (MHz));

b) a maximum e.i.r.p. should not exceed 1 W (0 dBW) or −13 + 10 log *B* (dBW) per transmitter, whichever power is less;

c) the e.i.r.p. spectral density of the emission of a WAS including RLANs base station transmitter operating outdoor in the band 5 470‑5 570 MHz should not exceed the following values for the elevation angle θ above the local horizontal plane (of the Earth):

–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 θ > 45°”.

The e.i.r.p values to be used for studies in response to Resolution **239 (WRC-15)** are contained in Section 3.1 with their probability distributions.

### 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, and in some administrations in the ISM band or parts of it 5 725-5 875 MHz[[4]](#footnote-5).

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)** WAS/RLAN 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) of stations are limited in the mobile service that are permitted to be used either indoors or outdoors in the band 5 250-5 350 MHz (see 2.2.1).

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 including RLAN base station transmitter operating outdoor in the band 5 470-5 570 MHz (see 2.2.1).

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;*

The use of RLAN inside vehicles is growing, and the band 5 850-5 925 MHz has been designated by some administrations for technologies in support of intelligent transportation systems (ITS). Studies are currently being conducted to examine the potential operation of systems in this band under the auspice of providing roadside-to-vehicle and vehicle-to-roadside communications. In addition, Machine-to-Machine (M2M) communications will arise because of the low costs of components. Such applications may focus on the needs of the agricultural and mining industries that are heavily reliant on control of machinery and sensing platforms. Other users of the 5 GHz bands will include: medical devices, Device-to-Device (D2D) communications, Business-to-Business (B2B) communications, and the Internet of Things (IoT) with applications including smart grids, smart homes, smart cities, and industrial IoT (IIoT).

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 including 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 [working document towards a preliminary draft new Report ITU-R [RLAN Mitigation]] and 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[[5]](#footnote-6): IEEE 802.11a, IEEE 802.11n, and IEEE 802.11ac. A fourth RLAN standard (i.e. IEEE 802.11ax) is currently under development.

The following Figure 1 describes a baseline channelization scheme, assuming that this will follow the current channelization between 5 150-5 350 MHz and 5 470-5 725 MHz bands, for applications as described in Recommendation ITU-R M.1450, considering the existing allocated frequency bands and possible future bands[[6]](#footnote-7). Notice that RLAN technologies consider a minimum channel bandwidth of 20 MHz and the same channelization. Moreover, it is worth noticing that any particular channelization or channel bandwidth are not mandated in the regulations. Figure 1 includes channels in bands being considered for further studies.

Additionally, Figure 1 shows that channelization scheme for Wi-Fi considering channel bandwidth of 40 MHz, 80 MHz and 160 MHz.

Figure 1

Baseline Channelization Scheme







Figure 1 includes frequency bands not allocated to the mobile service for further 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[[7]](#footnote-8).

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

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Standard | ETSI EN 301 893 | IEEE 802.11a | IEEE 802.11n  | IEEE802.11ac | IEEE802.11ax |
| Channel Bandwidth  | [5, 20MHz] | 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)] | 37(20 MHz each) | 37(20 MHz each)18(40 MHz each) | 37 (20-MHz each)18 (40-MHz each)9 (80-MHz each)4 (160-MHz each) | 37 (20-MHz each)18 (40-MHz each)9 (80-MHz each)4 (160-MHz each) |
| Sub-Carrier Spacing |  | 312.5 kHz | 312.5 kHz | 312.5 kHz |

|  |
| --- |
| 78.125 kHz |

 |

[Editor’s note: Characteristics for ETS EN 301 893 needs to be reviewed.]

## 2.4 Out-of-Band emissions

[Editor’s note: there is a proposal to delete this section in the next meeting].

The following terms are defined in the ITU-R RR: out-of-band (OoB) emission (RR **1.144**), spurious emission (RR **1.145**), unwanted emissions (RR **1.146**), assigned frequency band (RR **1.147**), assigned frequency (RR **1.148**), necessary bandwidth (RR **1.152**), and occupied bandwidth (RR **1.153**).

In analyzing the applicable 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. Refer to the list of “Related Recommendations and Reports” in this document for more details. 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. The IEEE 802.11ac masks have a 160 MHz channelization scheme that can be either contiguous (Fig. 3d) or non-contiguous “80+80 MHz” (Fig. 3e). In the non-contiguous case, the spectrum mask has two parts, each with a base bandwidth of 80 MHz. However, if the parts are adjacent (i.e., the parts have interconnecting frequencies) then the mask obeys the bottom mask shown in Fig. 3e. Otherwise, if no frequency is shared between the two parts in the non-contiguous case, then each part obeys the top mask in Fig. 3e.

Figure 1a (Source Rec. ITU-R M.1450-5)

OFDM transmit spectrum mask for 802.11a, 11g, 11j, and HiSWANa systems



Figure 1B (Source Rec. ITU-R M.1450-5)

Transmit spectrum mask for EN 301 893



FIGURE 2b (Source Rec. ITU-R M.1450-5)

Transmit spectral mask for a 20 MHz 802.11n transmission in 5 GHz band and
transmit spectral mask for 802.11ac



NOTE – For 802.11n, the maximum of –40 dBr and –53 dBm/MHz at 30 MHz frequency offset and above. For 802.11ac, the transmit spectrum shall not exceed the maximum of the transmit spectral mask and –53 dBm/MHz at any frequency offset.

FIGURE 3b (Source Rec. ITU-R M.1450-5)

Transmit spectral mask for a 40 MHz 802.11n channel in 5 GHz band and
transmit spectral mask for 802.11ac



NOTE – For 802.11n, maximum of –40 dBr and –56 dBm/MHz at 60 MHz frequency offset and above. For 802.11ac, the transmit spectrum shall not exceed the maximum of the transmit spectral mask and –56 dBm/MHz at any frequency offset.

FIGURE 3c (Source Rec. ITU-R M.1450-5)

Transmit spectral mask for an 80 MHz 802.11ac channel



NOTE – The transmit spectrum shall not exceed the maximum of the transmit spectral mask and
–59 dBm/MHz at any frequency offset.

FIGURE 3d (Source Rec. ITU-R M.1450-5)

Transmit spectral mask for a 160 MHz 802.11ac channel



NOTE – The transmit spectrum shall not exceed the maximum of the transmit spectral mask and
–59 dBm/MHz at any frequency offset.

FIGURE 3e (Source Rec. ITU-R M.1450-5)

Transmit spectral mask for a 80+80 MHz 802.11ac channel



NOTE – The transmit spectrum shall not exceed the maximum of the transmit spectral mask and
–59 dBm/MHz at any frequency offset.

NOTE – dBr in the above figures is the spectral density relative to the maximum spectral power density of the transmitted signal.

# 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.]

WAS/RLAN technical characteristics in the 5 GHz frequency bands are based on ETSI EN 301 893 and IEEE standards[[8]](#footnote-9): IEEE 802.11a, IEEE 802.11n, IEEE 802.11ac, and IEEE 802.11ax (currently under development). Table y

Characteristics including technical parameters associated with broadband RLAN standards

(Source: Table 2 of Rec. ITU-R M.1450-5 and IEEE P802.11 TGax Draft D2.0)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Standard | ETSI EN 301 893 | IEEE802.11a | IEEE802.11n | IEEE802.11ac | IEEE802.11ax |
| **Data Rate** | 6, 9, 12, 18, 27, 36 and 54 Mbit/s | 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s | From 6.5 to 288.9 Mbit/s for 20 MHz channel spacingFrom 6 to 600 Mbit/s for 40 MHz channel spacing | From 6.5 to 693.3 Mbit/s for 20 MHz channel spacingFrom 13.5 to 1 600 Mbit/s for 40 MHz channel spacing From 29.3 to 3 466.7 Mbit/s for 80 MHz channel spacingFrom 58.5 to 6 933.3 Mbit/s for 160 MHz and 80+80 MHz channel spacing | From 3.6 to 1 147.1 Mbit/s for 20 MHz channel spacingFrom 7.3 to 2 294.1 Mbit/s for 40 MHz channel spacingFrom 15.3 to 4 803.9 Mbit/s for 80 MHz channel spacingFrom 30.6 to 9 607.8 Mbit/s for 160 MHz and 80+80 MHz channel spacing |
| **Multiuser Transmission** |  | No | No | Downlink Multi-user MIMO: 1 - 4 users | Uplink and Downlink Multiuser MIMO: 2 – 4 usersUplink and Downlink OFDMA: 2 – 74 users |
| **Spatial Streams**  | Tbd | No | 1- 4 | 1-8 | 1-8 |
| **Modulation** | OFDM | OFDM | OFDM | OFDM | OFDM |
| **Data Subcarrier Modulation** | BPSK, QPSK, 16-QAM, 64-QAM | BPSK, QPSK, 16-QAM, 64-QAM |

|  |
| --- |
| BPSK, QPSK, 16-QAM, 64-QAM |

 | BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM | BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024- QAM |
| \* Tx = Transmitter and Rx = Receiver |

Table n

Characteristics including technical parameters associated with broadband RLAN standards

(Source: IEEE 802.11a/n/ac/ax and ETSI EN 301 893)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Standard | ETSI EN 301 893 | IEEE802.11a | IEEE802.11n | IEEE802.11ac | IEEE802.11ax |
| **Coding Scheme\*** | Tbd | BCC (Mandatory), and LDPC (Optional) | BCC (Mandatory), and LDPC(Optional) | BCC (Mandatory), and LDPC (Optional) | BCC (Mandatory), and LDPC (Mandatory) |
| **Symbol Time** | Tbd | 3.2 μs | 3.2 μs | 3.2 μs | 12.8 μs |
| **Cyclic Prefix** | Tbd | 0.8 μs | 0.8 μs | 0.4, 0.8 μs | 0.8. 1.6, 3.2 μs |
| \* BCC = Binary Convolutional Coding, and LDPC = Low Density Parity Check |

WAS/RLAN applications cover a number of different technologies as described in Recommendation ITU-R M.1450-5.

Cable, fibre, and DSL operators are using RLANs to extend connectivity of their wired customers. Broadband traffic is increasingly being delivered via cable or fiber into homes and offices, and then distributed by RLAN to mobile data devices and phones. Cable operators are deploying a large number of private and public RLAN hotspots to create canopies of RLAN coverage in dense urban areas. Cable operators are also installing routers into homes and businesses to act as quasi-public hotspots for other users.

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

### 3.1.1 WiFi type WAS/RLAN e.i.r.p. level distributions

[The e.i.r.p. level distribution for WiFi 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 1A 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 1B.

 Table 1a

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **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 1B

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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% |

The following table 2A depicts the e.i.r.p. level distribution for WiFi type WAS/RLAN in the band 5350-5470 MHz under the assumption that only indoor usage is allowed and a maximum mean e.i.r.p. of 200mW.

Table 2a

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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% |

NOTE to Table 2A RLAN devices are assumed to be indoors only, based on the requirement to help facilitate coexistence. For the purposes of sharing studies, 5% of the devices should be modelled without building attenuation.

Alternatively administrations may choose to carry out a parametric analysis in any range between 2% and 10%.

[Editor’s note: Due to the lack of time, the rest of the document was not discussed at the November 2017 meeting and will be reviewed during the May 2018 meeting. Contributions from input Document 5A/585 will need to be further considered at the next meeting.]

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

*[****Editorial note:*** *The following text from contribution ITU-R 5A/234 represents suggested e.i.r.p. level distributions and should fully be studied in particular outdoor percentages in 5 150-5 250 MHz.] [Editorial comment: This should be deleted since no contribution is received so far.]*

The e.i.r.p level distribution for LAA-LTE described in Table 1b 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) [[9]](#footnote-10).

One may assume, for further studies, that the distribution in Table 1b 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 1b

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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 % |

*[****Editorial note:*** *The above data represents suggested e.i.r.p. level distributions proposed in a specific contribution. This data should fully be studied along in addition to other possible distributions need to be considered.] [Editorial comment: This should be deleted since no contribution is received so far.]*

The following Table 2b 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.

Table 2b

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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 % |

## 3.2 Channel bandwidths distribution

The proposed RLAN device transmitter bandwidth distribution shown in Table 5 needs further studies.

Table 5

Bandwidth distribution

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

## 3.3 Building attenuation

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

## 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.

− The following propagation models are used for interference studies in Recommendation ITU-R M.1652 which describes the mitigation technique (i.e. DFS) for the purpose of protecting the radiodetermination services from WAS/RLANs in 5 GHz band;

– For ground-based radars a random propagation factor was utilized in determining the propagation path loss to each WAS device. A value from 20 to 35 log *D*, where *D* represents distance between a RLAN station and a ground-based radar, was used. In addition, a random building/terrain propagation attenuation was used. A value from 0 to 20 dB was used. A uniform distribution was applied in determining these values.

– For airborne radars, free space loss +17 dB was used.

– For maritime radars, free space loss +0 to 20 dB was used.

– A smooth Earth line-of-sight calculation was utilized. Any WAS devices beyond the line‑of-sight were discounted.

## 3.5 Antenna gain/discrimination

The antenna discrimination figures for compatibility analysis are:

– Omnidirectional in azimuth for all scenarios.

– 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, the following antenna patterns were used in Annex 6 of Recommendation ITU-R M.1652 for conducting aggregate interference studies involving WAS including RLANs and radiodetermination systems in the 5 GHz band;

For omnidirectional (in azimuth orientation),

|  |  |
| --- | --- |
| Elevation angle, ϕ(degrees) | Gain(dBi) |
| 45 < ϕ ≤ 90 |  –4 |
| 35 < ϕ ≤ 45 |  –3 |
|  0 < ϕ ≤ 35 |  0 |
|  –15 < ϕ ≤ 0 |  –1 |
| –30 < ϕ ≤ –15 |  –4 |
| –60 < ϕ ≤ –30 |  –6 |
| –90 < ϕ ≤ –60 |  –5 |

For directional antenna (6 dBi antenna gain),









where:

 *G*(θ) : antenna gain (dBi)

 θ : elevation angle (degrees)

 *k* = 0.5

 *G*0= 6 dBi.

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.

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

The following average RLAN device density is to be used 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]):

0.0265 active devices (Access Point) per inhabitant (see note)

Note : this figure has been obtained with a total population of 701083818 inhabitants, 400000000 RLAN AP, 62.7% Busy hour factor, 74% 5 GHz factor and 10% activity factor (see Report ITU-R M.[AGGREGATE RLAN MEASUREMENTS])

[*Editor’s note: The above density figure are reflective of the European situation and need further confirmation pending finalisation of the assumptions used in Report ITU-R M.[AGGREGATE RLAN MEASUREMENTS]*]

In addition, for each case under study (for aggregate interference to satellite receivers), the following factors are to 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 |

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.

It is noted that these density options are given for 20 and 100 MHz bandwidth victim receiver bandwidth but would have to be scaled, as appropriate for other incumbent services bandwidth.

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 1

Summary of related ITU-R Recommendations and Reports

**Recommendation ITU-R M.1450** “*Characteristics of broadband radio local area networks*”.

This Recommendation provides the characteristics of broadband RLANs including technical parameters, and information on RLAN standards and operational characteristics. Basic characteristics of broadband RLANs and general guidance for their system design are also addressed. This Recommendation provides characteristics of WAS including RLANs that are intended to operate in the 5 GHz frequency range. This Recommendation includes technical parameters associated with RLAN standards including emission masks for EN 301 893, IEEE 802.11a, IEEE 802.11n, and 802.11ac. Basic characteristics of broadband RLANs and general guidance for deployment are addressed in Annex 2 of this Recommendation including operational environment and considerations of interface, interference mitigation techniques under frequency sharing environments, and a table of general technical requirements (e.g.; transmitter output power and antenna gain) applicable in certain administrations and/or regions.

**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*”**.

This Recommendation provides protection criteria for wireless access systems, including radio local area networks (WAS/RLAN), operating in the mobile service in accordance with Resolution 229 (WRC-03), for the purposes of carrying out compatibility studies with services or applications from which WAS/RLAN systems are to be protected.

**Recommendation ITU-R M.1652** “***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***”.

This Recommendation provides requirements of dynamic frequency selection (DFS) as a mitigation technique to be implemented in WAS including RLANs for the purpose of facilitating sharing with the radiodetermination service in the 5 GHz band. Annex 1 specifies the detection, operational and response requirements. Other Annexes address the methodologies and provide information which can be used by administrations when conducting sharing studies between radars and WAS including RLANs.

**Recommendation ITU‑R M.1653** “*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* ”.

This Recommendation recommends operational and deployment requirements for wireless access systems including RLANs 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. This Recommendation also includes methodology and parameters used in sharing studies.

**Recommendation ITU-R M.1801** “*Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz*”.

This Recommendation recommends radio interface standards for BWA systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz, some of which may also be used to provide fixed BWA.

**Recommendation ITU-R F.1763** “*Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz*”.

This Recommendation identifies specific radio interface standards which may be utilized for broadband wireless access (BWA)7 systems in the fixed service operating below 66 GHz, addressing profiles for the recommended interoperability standards. It provides references to the standards for interoperability between BWA systems. The interoperability standards referenced in this Recommendation include the following specifications:

– system profiles;

– physical layer parameters, i.e. channelization, modulation scheme, data rates;

– medium access control (MAC) layer messages and header fields.

Recommendation ITU-R F.1763 is not intended to deal with the identification of suitable frequency bands for BWA systems, nor any regulatory issues.

**Recommendation ITU-R SM.328** *“Spectra and bandwidth of emissions”.*

This Recommendation includes considerations of OoB domain and necessary bandwidths (ITU-R SM.328 – Spectra and bandwidth of emissions).

**Recommendation ITU-R SM.329** *“Unwanted emissions in the spurious domain”.*

This Recommendation provides limits for unwanted emissions in the spurious domain, as well as measurement methods of spurious domain emissions

**Recommendation ITU-R SM.1539** *“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”.*

This Recommendation provides provide guidance for determining the boundary between the out-of-band (OoB) and spurious domains in a transmitted radio frequency spectrum.

**Recommendation ITU-R SM.1540** *“Unwanted emissions in the out-of-band domain falling into adjacent allocated bands”.*

This Recommendation provides guidance with regard to unwanted emissions in the out-of-band domain falling into adjacent allocated bands.

**Report ITU-R M.2034** “*Impact of radar detection requirements of dynamic frequency selection on 5 GHz wireless access system receivers*”.

This Report considers how radars operating in the 5 GHz band can be detected by WAS without extreme constraints on the RF front-end design or on the system capacity of the WAS.

**Report ITU-R M.2115** “*Testing procedures for implementation of dynamic frequency selection*”.

This Report consolidates the DFS test methodology used and findings across several administrations, as shown in several annexes. Information is provided on the test methodologies in place in various administrations and/or regional groups to test compliance with DFS requirements. These procedures may be updated over time, and as technology evolves. As a result, web links are provided (in some cases) to the test methodologies themselves, so that the most up-to-date information may be obtained.

**Report ITU-R F.2086** “*Technical and operational characteristics and applications of broadband wireless access in the fixed service*”.

This Report provides technical and operational characteristics and applications of broadband wireless access systems (WAS) in the fixed service. RLAN technology is sometimes used to implement fixed applications, which provide point‑to-multipoint (P-MP) or point-to-point (P-P) links, e.g. between buildings in a campus environment. P-MP systems usually adopt cellular deployment using frequency reuse schemes similar to mobile applications. Technical examples of such schemes are given in Report ITU-R F.2086 (see § 6.6). Point-to-point systems commonly use directional antennas that allow greater distance between devices with a narrow lobe angle. This allows band sharing via channel and spatial reuse with a minimum of interference with other applications.

1. 1 In the context of this Resolution, “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. [↑](#footnote-ref-2)
2. 2 −124 − 20 log10 (*hSAT*/1 414) dB(W/(m2 · 1 MHz)), or equivalently,

 −140 − 20 log10 (*hSAT*/1 414) dB(W/(m2 · 25 kHz)), at the FSS satellite orbit, where *hSAT* is the altitude of the satellite (km). [↑](#footnote-ref-3)
3. 3 Administrations with existing regulations prior to WRC‑03 may exercise some flexibility in determining transmitter power limits. [↑](#footnote-ref-4)
4. 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-5)
5. 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-6)
6. 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-7)
7. The definition of ISM applications is specified in RR No **1.15**. [↑](#footnote-ref-8)
8. ETSI standards available at <http://pda.etsi.org/pda/queryform.asp> and IEEE at <http://standards.ieee.org/about/get/802/802.11.html>. [↑](#footnote-ref-9)
9. 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-10)