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| **Radiocommunication Study Groups** |  |
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| Source: Document 5A/TEMP/170 | **Annex 27 to** **Document 5A/469-E** |
| **12 June 2017** |
| **English only** |
| Annex 27 to Working Party 5A Chairman’s Report |
| WORKING DOCUMENT TOWARDS A PRELIMINARYDRAFT NEW REPORT ITU-R M.[RLAN REQ-PAR] |
| Technical characteristics and operational requirements of WAS/RLAN in the 5 GHz frequency range |

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 WAS/RLAN in the
5 150 MHz to 5 925 MHz frequency range.

A number of these characteristics 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].

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.

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 wireless access systems (WAS), including radio local area networks (RLANs). Some administrations permit WAS including 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.

The WAS/RLAN characteristics are described in Recommendation ITU R M.1450 “*Characteristics of broadband radio local area networks*”. Other information on WAS including RLANs is contained in Recommendations ITU-R M.1652, ITUR M.1739, ITU-R M.1801, and ITU-R F.1763.

*[****Editor’s note****: The technical and operational parameters contained in this document are based mainly on Wi-Fi usage and discussions associated with the 5 350-5 470 MHz band from the previous study cycle. There will need to be a review of all of these parameters to take account of possible parameters to be used in the other bands under the agenda item and for other types of RLAN technologies (e.g. LTE/LAA etc.)]*

# 2 WAS/RLAN requirements

## 2.1 Spectrum requirements

Recommendation ITU-R M.1651 “A method for assessing the required spectrum for broadband nomadic wireless access systems including radio local area networks using the 5 GHz band” provides a method for assessing the required spectrum for broadband nomadic wireless access (NWA) systems including RLANs. Annex 1 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.

WAS/RLAN spectrum requirements were addressed during previous 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.

*[****Editor’s note****: For reference only, the detailed calculations related to these spectrum requirements can be found in Document 4-5-6-7/137.]*

## 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 5250-5350 and 5475-5725 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).*

*[****Editorial note:*** *The frequency band 5 350-5 470 MHz was proposed for implementing of WAS/RLAN systems. ITU-R Joint Task Group 4-5-6-7 meetings discussed contributions using the RLAN technical characteristics as given in table-1 of Annex 36 to Document 4-5-6-7/715-E. This JTG document includes RLAN parameters and deployment zones (urban, sub-urban, and rural), zone population, activity factor, on-tune distribution of active RLAN devices, distribution of channel bandwidths, indoor/outdoor RLAN power distribution, RLAN device elevation antenna pattern, and antenna heights.*

*It also includes: RLAN systems parameters and deployment (e.i.r.p. level distribution, channel bandwidth (20, 40, 80, and 160 MHz) distribution, building attenuation, and propagation models, antenna patterns and antenna heights), and mitigation techniques including DFS. These two Annexes provide multiple analyses based on various scenarios to address the compatibility between RLAN systems and two incumbent services (EESS (active) and aeronautical airborne radar) in the frequency range 5 350 ‑ 5 470 MHz.]*

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

a) Current situation in existing bands

See Resolution 229 (Rev. WRC-12)

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-1)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-2)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-3)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 the mean 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. It includes the methodology and parameters used in the sharing studies, and it provides recommendations for implementing mitigation techniques to further reduce interference into FSS systems from RLANs.

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°”.

See Resolution **239 (WRC-15)** *invites ITU-R c)*

b) E.i.r.p. requirements over the whole 5 GHz range

c) Consideration of potential e.i.r.p. requirements on a sub-band basis

d) Current equipment conducted power limits.

### 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-4).

Resolution **229 (Rev. WRC-12)** *Resolves 2* restricts WAS/RLAN use in the band 5 150-5 250 MHz to indoor use only (see 2.2.1).

Resolution **229 (Rev. WRC-12)** *Resolves 4* limits 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 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;*

*[****Editor note****: it would be convenient to include references on potential deployment scenarios of RLAN]*

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.

### 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

*[****Editorial Note****: Potential cross band issues should be addressed in the working document contained in Annex 27 of Chairman’s Report.]*

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-5): IEEE 802.11a, IEEE 802.11n, and IEEE 802.11ac. [A fourth RLAN standard (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-6)~~. 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:

## *[TBD]*

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-7).

## IEEE 802.11ac[/ax] channelizatin:

* 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  | Tbd | 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 | Tbd | 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 | Tbd | 312.5 kHz | 312.5 kHz | 312.5 kHz |

|  |
| --- |
| [78.125 kHz] |

 |

## 2.4 Out-of-Band emissions

*[****Editor’s note****: this section is aimed at listing OOB emission limits of WAS/RLAN in different 5 GHz range sub-bands (5 150-5 250 MHz, 5 250‑5 350 MHz, 5 350-5 470 MHz, 5 470-5 725 MHz, 5 725-5 850 MHz and 5 850-5 925 MHz bands)]*

*[****Editorial note:*** *Potential cross-band issues are the domain of Annex-27 of WP 5A Chairman’s Report. This section should only list out-of-band (OoB) emission limits in the WAS/RLAN bands.]*

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

WAS/RLAN technical characteristics in the 5 GHz frequency bands are based on ETSI EN 301 893 and IEEE standards[[8]](#footnote-8): 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)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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 | [up to 10 Gbps] |
| **MIMO****TxXRx** |  | No | Downlink4X4 | Downlink8X4 | [Uplink and Downlink8X4] |
| **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

*[****Editorial note:*** *Over the previous study period, only WiFi type applications were considered, leading to the technical characteristics as given in section 3.1 below. Additional and consistent work will be needed to address other technologies and in particular LTE systems.]*

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.

*[****Editor’s note****: see Document 4-5-6-7/715 (Annex 35)]*

## 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 for the 5725-5850 MHz band is described in Table 1A below follows the assumptions that indoor as well as outdoor use is allowed.

*[Editor’s note: Table 1a should be used for sharing studies. The contents, values and distribution may be reviewed at the next WP 5A meeting in the light of new technical elements. Additional option is provided in Table 3a. Use of these tables for the bands 5 150-5 250 MHz, 5 250-
5 350 MHz, and 5 850-5 925 MHz needs to be confirmed.]*

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% |

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.

*[****Editor’s note****:* The suggested numbers in Table 1A need to be further studied.

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%.

Some countries proposed in addition to Table 1A, for sharing studies with a maximum e.i.r.p. of 1W in the 5 150-5 250 MHz band, the following e.i.r.p level distribution for WiFi type WAS/RLAN in Table 3a can be used as an option under the following conditions:

– RLAN devices are assumed to be used indoors and outdoors;

– 15% of the devices are used outdoors;

– The maximum e.i.r.p. level might be 4W (Directional) instead of 1W (Directional) for a wider range of outdoor usage.

This e.i.r.p. distribution may also be considered for the studies regarding the 5 250-5 350 MHz band.

Table 3a

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| RLAN e.i.r.p. Level | 1 W(directional) | 200 mW(omni) | 80 mW(omni) | 50 mW(omni) | 25 mW(omni) | All |
| Indoor | 0% | 16.15% (\*) | 22.95% | 12.75% | 33.15% | 85% |
| Outdoor | 2.85% (\*) | 0% (\*) | 4.05% | 2.25% | 5.85% | 15% |

Note to Table 3a: The percentages of 1W (Outdoor), 200 mW (Indoor) and 200 mW (Outdoor) (\*) may be changed for sharing studies. For each e.i.r.p level (1W/200 mW, 80 mW, 50 mW, 25 mW), the outdoor usage ratio is 15%.

The value of 15% is used in Recommendation ITU-R RS.1632 for the band of 5 250-5 350 MHz. This value should also be applied to the band of 5 150-5 250 MHz.

*[Japan’s note: The e.i.r.p distribution in Table 3a is based on Annex 35 to Document 4-5-6-7/715. The maximum e.i.r.p. of 200 mW is replaced with 1W for simplicity. This maximum e.i.r.p of 1W is allowed for the band 5 250-5 350 MHz with an elevation attenuation mask as specified in Resolution 229 (Rev. WRC-12).* *The 5 150-5 250 MHz band and the 5 250-5 350 MHz band are consecutive, and similar technical/operational conditions may be applied.]*

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

*[****Editorial note:*** *The following text from contribution ITU-R 5A/234-E represents suggested e.i.r.p. level distributions and should fully be studied in particular outdoor percentages in 5 150-5 250 MHz.]*

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-9).

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.]*

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

*[****Editorial note:*** *The following text is from Attachment 2 to Annex 8 to Document 4-5-6-7/584-E].*

*[****Editorial note:*** *Please consult SG 3 for their advice on building attenuation.]*

The building attenuation model in Draft new Recommendation ITU-R P.[BEL] should be used in sharing studies.

## 3.4 Propagation model for sharing studies

*[****Editorial note:*** *Please consult SG 3 for their advice on propagation loss and clutter loss. Antenna heights in the following table need further studies.]*

*[Editor’s note: Guidance was received from WPs 3K and 3M as shown below, WP 5A is seeking further clarification on applicability of clutter loss in 5 GHz range.]*

− With regard to the propagation model, Working Parties 3K and 3M would like to clarify that 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.

− For including the effects of clutter, Working Party 5A should not use the clutter component of Recommendation ITU-R P.452. Instead, Working Parties 3K and 3M would like to point Working Party 5A to the work being done by Working Parties 3K and 3M on clutter loss put forth in section 3.3 of draft new Recommendation ITU‑R P.[CLUTTER] (see Document [3/51](https://www.itu.int/md/R15-SG03-C-0051/en)(Rev.1)).While the lower limit of the frequency does not include 5 GHz at this time progress is being made to extend this. The current frequency range of applicability of section 3.3 of draft new Recommendation ITU-R P.[CLUTTER] is 10‑100 GHz, however if the deployment scenario is similar to that in section 3.3 of draft new Recommendation ITU‑R P.[CLUTTER] and in draft new Report ITU-R P.[CLUTTER\_REP] (see Document [3/52](https://www.itu.int/md/R15-SG03-C-0052/en)) 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 draft new Recommendation ITU-R P.[CLUTTER] down to 5 GHz would provide more accurate results than Recommendation ITU-R P.452.

## 3.5 Antenna gain/discrimination

The antenna discrimination figures for compatibility analysis with satellite services (i.e. MSS, EESS (active) and FSS) 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

*[****Editor’s Note****: Antenna patterns for compatibility with other services may need to be described.]*

*[****Editor’s Note****: The parameters and general effect of RLANS employing multi-mimo and beamforming technology could be addressed in future studies.]*

## 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 (Acces 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.]

*[Editor’s note: These material above are proposed to replace options D1, D2 and D3. Further discussion is needed.]*

**[Option D1**: 9 365 active devices per 20 MHz channel or 11 279 active devices per 100 MHz channel per 5.25 million inhabitants.

**Option D2**: From 0.000 8 to 0.008 active devices per 20 MHz channel per inhabitant (0.004 to
0.04 per 100 MHz channel) (based on 3% to 30% activity factor) applied to any population size.

**Option D3**: Take into account the EESS interference threshold in order to determine the number of simultaneous RLAN connections which can be tolerated. The RLAN density can then be determined for a given population.]

*[****Editor’s Note****: 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.]*

*[****Editor’s note****: see also Document* [*5A/100*](http://www.itu.int/md/R15-WP5A-C-0100/en) *for busy hour and activity factors]*

Annex 1

Summary of related ITU-R Recommendations and Reports

**Recommendations 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)[[10]](#footnote-10) 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-1)
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-2)
3. 3 Administrations with existing regulations prior to WRC‑03 may exercise some flexibility in determining transmitter power limits. [↑](#footnote-ref-3)
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-4)
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-5)
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-6)
7. The definition of ISM applications is specified in RR No **1.15** [↑](#footnote-ref-7)
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-8)
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-9)
10. [↑](#footnote-ref-10)