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| **Doc. PTD(17)34 ANNEX VI - 05** |
| WORKING DOCUMENT in support of CEPT Brief on WRC-19 agenda item 1.16  |
| Sharing and compatibility studies of WAS/RLAN in the 5 GHz frequency range |

*[****Editor’s note****: This document is intended as a placeholder for the various sharing studies in response to WRC-19 agenda item 1.16. As such, the structure of the document should be seen as a guidance for input contributions to the next meeting of CPT PTD but it may evolve depending on future input contributions.]*

# 1 Introduction

This Report includes the sharing and compatibility studies of WAS/RLAN in the 5 GHz frequency range. The primary purpose of the report is to provide background information for the development of CEPT Brief on Agenda item 1.16 and the related ECP.

It is intended to represent the response to *invites ITU-R* *c)*, *d)*, *e)* and *f)* of Resolution **239 (WRC‑15)** under WRC-19 agenda item 1.16.

# 2 Scope of the sharing and compatibility of WAS/RLAN with other services in the 5 GHz range.

The World Radiocommunications Conference 2015 decided on the draft agenda for the upcoming World Radiocommunications Conference scheduled for 2019. Among other items, WRC-19 agenda item 1.16 addresses the need of studies on regulatory actions and additional spectrum allocations to be mobile service, including radio local area networks (WAS/RLAN). Indeed, WRC-19 agenda item 1.16 reads:

 *1.16 to consider issues related to wireless access systems, including radio local area networks (WAS/RLAN), in the frequency bands between 5 150 MHz and 5 925 MHz, and take the appropriate regulatory actions, including additional spectrum allocations to the mobile service, in accordance with Resolution****239 (WRC‑15).***

The related Resolution **239 (WRC‑15)** to the WRC-19 agenda item 1.16 deals with studies concerning Wireless Access Systems including radio local area networks in the frequency bands between 5 150 MHz and 5 925 MHz. The Resolution invites ITU-R to conduct and complete the following in time for WRC‑19:

a) to study WAS/RLAN technical characteristics and operational requirements in the 5 GHz frequency range;

b) to conduct studies with a view to identify potential WAS/RLAN mitigation techniques to facilitate sharing with incumbent systems in the frequency bands 5 150-5 350 MHz, 5 350-5 470 MHz, 5 725-5 850 MHz and 5 850-5 925 MHz, while ensuring the protection of incumbent services including their current and planned use;

c) to performsharing 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;

d) to conduct further sharing and compatibility studies between WAS/RLAN applications and incumbent services addressing:

i) whether any additional mitigation techniques in the frequency band 5 350‑5 470 MHz beyond those analysed in the studies referred to in recognizing a) would provide coexistence between WAS/RLAN systems and EESS (active) and SRS (active) systems;

ii) whether any mitigation techniques in the frequency band 5 350-5 470 MHz would provide compatibility between WAS/RLAN systems and radio determination systems;

iii) whether the results of studies under points i) and ii) would enable an allocation of the frequency band 5 350-5 470 MHz to the mobile service with a view to accommodating WAS/RLAN use;

e) to also conduct detailed sharing and compatibility studies, including mitigation techniques, between WAS/RLAN and incumbent services in the frequency band 5 725‑5 850 MHz with a view to enabling a mobile service allocation to accommodate WAS/RLAN use;

f) to also conduct detailed sharing and compatibility studies, including mitigation techniques, between WAS/RLAN and incumbent services in the frequency band 5 850‑5 925 MHz with a view to accommodating WAS/RLAN use under the existing primary mobile service allocation while not imposing any additional constraints on the existing services,

# 3 Overall view of allocations in the 5 GHz range

## 3.1 View of allocations in the 5 GHz range worldwide

| **Allocation to services** | **Expected studies** |
| --- | --- |
| **Region 1** | **Region 2** | **Region 3** |
| **5** **150-5** **250** FIXED-SATELLITE (Earth-to-space) 5.447A MOBILE except aeronautical mobile 5.446A 5.446B AERONAUTICAL RADIONAVIGATION 5.446 5.446C 5.447 5.447B 5.447C | Coexistence between WAS/RLAN outdoor operations and FSS (feederlinks for non-GSO) and Aeronautical Radionavigation |
| **5** **250-5** **255** EARTH EXPLORATION-SATELLITE (active) MOBILE except aeronautical mobile 5.446A 5.447F RADIOLOCATION SPACE RESEARCH 5.447D 5.447E 5.448 5.448A | Coexistence between WAS/RLAN outdoor operations and EESS (active), Radiolocation and SRS (active) |
| **5 255-5** **350** EARTH EXPLORATION-SATELLITE (active) MOBILE except aeronautical mobile 5.446A 5.447F RADIOLOCATION SPACE RESEARCH (active) 5.447E 5.448 5.448A |
| **5** **350-5** **460** EARTH EXPLORATION-SATELLITE (active) 5.448B RADIOLOCATION 5.448D AERONAUTICAL RADIONAVIGATION 5.449 SPACE RESEARCH (active) 5.448C | Further sharing and compatibility studies between WAS/RLAN applications and incumbent services addressing whether additional mitigation techniques would provide coexistence between WAS/RLAN systems and EESS (active), radio determination and SRS (active) systems (see *invites ITU-R d)* of Res. 239) |
| **5** **460-5** **470** EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION 5.448D RADIONAVIGATION 5.449 SPACE RESEARCH (active) 5.448B |
| **5** **725-5** **830**FIXED-SATELLITE(Earth-to-space)RADIOLOCATIONAmateur | **5** **725-5** **830** RADIOLOCATION Amateur | Coexistence between WAS/RLAN and FSS and Radiolocation |
| 5.150 5.451 5.453 5.455 5.456 |  5.150 5.453 5.455 |
| **5** **830-5** **850**FIXED-SATELLITE(Earth-to-space)RADIOLOCATIONAmateurAmateur-satellite (space-to-Earth) | **5** **830-5** **850** RADIOLOCATION Amateur Amateur-satellite (space-to-Earth) |
| 5.150 5.451 5.453 5.455 5.456 |  5.150 5.453 5.455 |
| **5** **850-5** **925**FIXEDFIXED-SATELLITE(Earth-to-space)MOBILE | **5** **850-5** **925**FIXEDFIXED-SATELLITE(Earth-to-space)MOBILEAmateurRadiolocation | **5** **850-5** **925**FIXEDFIXED-SATELLITE (Earth-to-space)MOBILERadiolocation | Coexistence between WAS/RLAN under the current MS allocation and FS and FSS.  |
| 5.150 | 5.150 | 5.150 |

## 3.1 View of allocations in the 5 GHz range within CEPT

Editors Note : To insert European Common Allocation Table

# 4 Assumptions on technical and operational elements for the sharing and compatibility of WAS/RLAN with other services

## 4.1 Technical and operational characteristics of the WAS/RLAN operating in the 5 GHz ranges

***Editor’s note****: Relevant inputs ECC Report 244 and CPG-PTD(16)02. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.2 Technical and operational characteristics of FSS links used for MSS feeder links in the 5 150-5 250 MHz

## 4.3 Technical and operational characteristics of the Aeronautical Radionavigation service operating in the 5 150-5 250 MHz and 5 350-5 460 MHz

***Editor’s note****: Relevant inputs ECC Report 244 and CPG-PTD (16)02,12. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.4 Technical and operational characteristics of the Earth Exploration Satellite service operating in the frequency ranges 5 250-5 570 MHz

***Editor’s note****: Relevant inputs CPG-PTD (16)02,16. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.6 Technical and operational characteristics of the Radionavigation service operating in the 5 460-5 470 MHz

***Editor’s note****: Relevant inputs CPG-PTD (16)02,06,12. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.7 Technical and operational characteristics of the Radiolocation service operating in the 5 250-5 470/5 725-5 850 MHz

***Editor’s note****: Relevant inputs CPG-PTD (16)02,06,12. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.8 Technical and operational characteristics of the Fixed service operating in the 5 850-5 925 MHz

***Editor’s note****: Relevant inputs ECC Report 244 and CPG-PTD (16)02. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.9 Technical and operational characteristics of the Fixed Satellite service operating in the 5 725-5 850 MHz (for Region 1) and 5 850‑5 925 MHz

***Editor’s note****: Relevant inputs ECC Report 244 and CPG-PTD (16)02. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 4.10 Technical and operational characteristics of the ITS applications operating in the 5 855-5 925 MHz

**4.11 Applications contained in ECA Table (ERC Report 25)**

# 5 Sharing studies per frequency range and per service

## 5.1 Sharing and compatibility of MSS feeder links versus WAS/RLAN in the 5 150‑5 250 MHz

***Editor’s note****:* Text to be developed

## 5.2 Sharing and compatibility of radiodetermination radars (Radiolocation, aeronautical radionavigation and radionavigation) versus WAS/RLAN in the 5 250‑5 350, 5 350‑5 470 and 5 725-5 850 MHz bands

**5.2.1 Sharing between radiodetermination and WAS/RLANS in the band 5250-5350 MHz**

Document [CPG-PTD(17)09](http://cept.org/Documents/cpg-pt-d/34044/ptd-17-09_impact-assessment-of-outdoor-rlan-operation-in-the-band-5250-5350-mhz) addresses impact assessment of outdoor WAS/RLAN systems operation with power characteristics similar to those specified in Resolution 229 (Rev. WRC-12) section resolves 4 in the frequency band 5250-5350 MHz into radars.

For a range of different scenarios, the results show that in case of using the outdoor WAS/RLAN systems the required protection distance would increase significantly compared with that for indoor WAS/RLAN systems.

The obtained results show that operation of outdoors WAS/RLAN systems in the frequency band 5250-5350 MHz would require development of effective measures of reducing interference caused by them to operation of air-borne and ground-based radars. Without relevant interference mitigation techniques decision on usage feasibility for the considered outdoor WAS/RLAN systems in the frequency band indicated could not be made.

The effect of DFS as a mitigation technique has not been taken into account in this study.

**5.2.2 Sharing between radiodetermination and WAS/RLANS in the bands 5 350‑5 470 and 5 725-5 850 MHz**

**5.2.2.1 Initial sharing studies**

- Relevant studies have been carried out within CEPT during the period 2013-2016. They are reported in [CEPT Report 57](http://www.erodocdb.dk/Docs/doc98/official/Word/CEPTREP057.DOCX) and confirmed in [CEPT Report 64](http://www.erodocdb.dk/Docs/doc98/official/Word/CEPTREP064.DOCX) . Studies have indicated that RLAN can harmfully interfere with radars if appropriate mitigation techniques are not implemented. It will be required to demonstrate that coexistence between RLANs and radars not previously covered by ITU-R Recommendation M.1638 can be achieved. Therefore future sharing and compatibility studies will have to concentrate on ensuring that any proposed mitigation techniques, particularly the enhancement of the DFS mechanism can protect the operation of these types of radar systems mentioned above. Discussions on new radar test signals for the possible inclusion in an appropriate European harmonised standard have been initiated. Future studies should also include a process to evaluate the operational effect of the mitigation techniques on both RLANs and radars not previously covered by ITU-R Recommendation M.1638 within the 5GHz band.

- Additional studies were recently performed in document [CPG-PTD(16)12](http://cept.org/Documents/cpg-pt-d/32292/ptd-16-12_sharing-between-rlan-and-radars-in-the-frequency-bands-5350-5470-mhz-and-5725-5850-mhz). Results of compatibility estimation in the frequency bands 5350-5460 MHz, 5460-5470 MHz and 5725-5850 MHz show that development of additional interference mitigation techniques is required to provide compatibility of RLAN with radiodetermination radars operating in the specified frequency bands. Usage of RLAN with 160 MHz bandwidth and also usage of indoor RLAN cannot considered as the effective interference mitigation technique providing sharing of RLAN with the radiodetermination radars especially in case of multiple interferences caused by RLAN networks.

- Further studies were provided in document [CPG-PTD(16)31](http://cept.org/Documents/cpg-pt-d/34082/ptd-17-31_initial-risk-assessment-of-rlan-vs-radar-sharing-in-58-ghz-for-agenda-item-116), which compare the possible level of interference from RLAN into radars in the band 5725 – 5850 MHz with the impact from other applications already operating within the band. The results of these studies show that, if you assume the same sharing scenarios and limit the RLANs maximum EIRP and corresponding PSD/MHz to those in the regulations in the other 5GHz bands, then RLANs, even operating without DFS, can constitute less of an impact in terms of interference than some SRDs which would be legal under today’s EC and ECC spectrum deliverables (EC Decision 2006/771/EC and ECC Recommendation 70-03) for SRD/TTT use in the band.

**5.2.2.2 Considerations on DFS**

***Editor’s note****:* Text to be developed

**5.2.2.3 Compatibility with frequency hopping radars**

Document [CPG PTD(17)23](http://cept.org/Documents/cpg-pt-d/34074/ptd-17-23_test-signals-for-frequency-hopping-radars) proposes a set of test signals which are representative of FH radars waveforms and characteristics. The proposed test signals are to be used for the validation of the efficiency of the new proposed DFS techniques.

The following table depicts the test signals that should be implemented to assess the design of any new enhanced DFS dedicated to protect FH radars within the bands 5350 – 5470 MHz and 5725 – 5850 MHz.

Table 1: Frequency Hopping DFS test signals

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Frequency hopping radar type(Note1) | Pulse Width (µsec) | Pulse Repetition Interval (pri) (µsec) | # Number of pulses per frequency hop | Burst length (ms)(Note 2) | Trial length (ms) | Pulse modulation(Note 3) | Minimum detection probability with 30% channel load(Note 4) |
| 1 | 1 | 200 (=5kHz) | 4 | 0.8 | 480 | none | Pd>80% |
| 1 | 20 | 333 (=3kHz) | 3 | 1 | 600 | none | Pd>80% |
| 1 | 30 | 500 (=2kHz) | 2 | 1  | 600 | none | Pd>80% |
| 2 | 3 | 333 (=3kHz) | 1 to 9 | #  | 120 | chirp | Pd>80% |
| 2 | 10 | 500 (=2kHz) | 1 to 9 | #  | 120 | chirp | Pd>80% |
| 2 | 15 | 1000 (=1kHz) | 1 to 9 | #  | 120 | chirp | Pd>80% |
| Note 1: Radar type 1: 475 possible frequencies (step 1 MHz) within the range 5250 – 5850 MHz, Radar type 2: 120 possible frequencies (step 5 MHz) within the range 5250 – 5850 MHz (Note 5).A frequency is selected randomly from a group of 600 (or 120 for radar type 2) integer frequencies ranging from 5250 – 5850 MHz, using a ‘use without re-use’ scheme. Frequency test signal changes after each burst.Note 2: For radars type 2, a burst is randomly composed of 1 to 9 pulses (n), then burst length (or hop length) = n x pri.Note 3 : The modulation to be used for radar type 2 is a chirp modulation with a ± 2,5 MHz frequency deviation which is described below. Note 4: The proposal includes that a minimum of 30 trials per set be run with a minimum probability of detection calculated by  . For RLAN ChS=10MHz, Pd>70%; for ChS = 20MHz, Pd>80%.Note 5 : Although these frequency hopping radar test signals hop over the entire range from 5250 – 5850 MHz, detection of these signals is only required when operating within the 5350 – 5470 MHz and the 5725 to 5850 MHz. |

**5.2.2.4 Compatibility with meteorological radars in the band 5 350-5 470 MHz**

Document [CPG PTD(16)06](http://cept.org/Documents/cpg-pt-d/32109/ptd-16-06_ai-116-dfs-requirements-for-sharing-with-meteorological-radars) addresses the DFS requirements for sharing with meteorological radars.

As meteorological radars operating in the frequency band 5 350-5 470 MHz present similar characteristics (e.g. transmit power, EIRP, wave forms, pulse width, scanning strategies, …) than those operating in the band 5 600-5 650 MHz, their protection could therefore be ensured by applying a DFS mitigation technique as specified for the 5 600-5 650 MHz frequency band according to Table 2 and Table 3.

Table 2

**DFS parameters of EN 301 893 as defined in V1.4.1 and before, respectively in V1.6.1 and beyond**

*Note 1: The alternative “Off-Channel” CAC process consists of an RLAN operating in another channel that will verify on a non-continuous and statistical basis possible meteorological radar signal detection. This process is based on short-time slots detection periods (down to few ms) over a sufficiently long period of time (several hours)*

*Note 2: The corresponding probability relates to the detection of one single radar burst (18 pulses for the 5 600-5 650 MHz band) over the CAC time period.*

Table 3

**Parameters of radar test signals (Table D.4 from EN 301 893 V1.8.1)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Radar test signal #(see notes 1 to 3) | Pulse width W [µs] | Pulse repetition frequency PRF (PPS) | Number of different PRFs | Pulses per burst for each PRF (PPB)(see note 5) |
| Min | Max | Min | Max |
| 1 | 0.5 | 5 | 200 | 1000 | 1 | 10(see note 6) |
| 2 | 0.5 | 15 | 200 | 1600 | 1 | 15(see note 6) |
| 3 | 0.5 | 15 | 2 300 | 4000 | 1 | 25 |
| 4 | 20 | 30 | 2 000 | 4000 | 1 | 20 |
| 5 | 0.5 | 2 | 300 | 400 | 2/3 | 10(see note 6) |
| 6 | 0.5 | 2 | 400 | 1200 | 2/3 | 15(see note 6) |
| NOTE 1: Radar test signals #1 to #4 are constant PRF based signals. See figure D.1. These radar test signals are intended to simulate also radars using a packet based Staggered PRF. See figure D.2.NOTE 2: Radar test signal 4 is a modulated radar test signal. The modulation to be used is a chirp modulation with a ±2,5MHz frequency deviation which is described below. NOTE 3: Radar test signals #5 and #6 are single pulse based Staggered PRF radar test signals using 2 or 3 different PRF values. For radar test signal 5, the difference between the PRF values chosen shall be between 20 and 50 pps. For radar test signal #6, the difference between the PRF values chosen shall be between 80 and 400 pps. See figure D.3NOTE 4: Apart for the Off-Channel CAC testing, the radar test signals above shall only contain a single burst of pulses. See figure D.1, D.2 and D.3.  For the Off-Channel CAC testing, repetitive bursts shall be used for the total duration of the test. See figure D.4. See also clause 4.7.2.2. NOTE 5: The total number of pulses in a burst is equal to the number of pulses for a single PRF multiplied by the number of different PRFs used. NOTE 6: For the CAC and Off-Channel CAC requirements, the minimum number of pulses (for each PRF) for any of the radar test signals to be detected in the band 5 600 to 5 650 MHz shall be 18. |

## 5.3 Sharing and compatibility of Earth exploration satellite (Active) systems versus WAS/RLAN in the band 5 250-5 570 MHz

The sharing and compatibility studies between WAS/RLAN and EESS (active) systems concern different type of sensors operating in different portions of the 5 250-5 570 MHz band:

* Synthetic aperture radars (SAR) in the 5 350-5 470 MHz band.
* Altimeters covering the whole 5 250-5 570 MHz band.
* Scatterometers with small bandwidths in the 5 250-5 350 MHz band or the 5 350‑5 470 MHz band.

According to Resolution **239 (WRC-15)**, the issues to be addressed in relation to EESS (active) are twofold:

* In the 5 250-5 350 MHz band, to study the possibility of enabling outdoor WAS/RLAN operations including possible associated conditions (see *invites ITU-R c)).* This implies studies with Altimeter and scatterometer sensors.
* In the 5 350-5 470 MHz band, to study whether additional mitigation techniques would provide coexistence between WAS/RLAN systems and EESS (active) (see *invites ITU‑R d))* This implies studies with Altimeter, SAR and scatterometer sensors.

**5.3.1 Sharing between EESS (active) and WAS/RLANS in the band 5250-5350 MHz**

Compatibility studies have been performed using static and dynamic analysis with altimeter (Sentinel-3 Altimeter sensor (SRAL)) and scatteromter (EPS-SG sensor (SCA)) and were presented in CPG/PTD in annexes 1 and 2 of document [**CPG-PTD(16)16**](http://cept.org/Documents/cpg-pt-d/32341/ptd-16-16_agenda-item-116-sharing-studies-between-rlan-and-eess-active-scatterometers-and-altimeters-in-the-5-ghz-range), respectively.

These studies take into account similar assumptions and ranges of RLAN 5 GHz parameters (e.g. antenna gain discrimination, devices densities, outdoor ratio, building attenuation) than those considered for analysis made for SAR sensors in the 5350-5470 MHz band during previous study period. They show that under all scenarios, RLAN deployment in the 5 GHz range (based on the current indoor-only RLAN regulations) would create large interference to altimeters (from -0.6 dB up to 26.6 dB) and scatterometers (from 3.7 dB up to 20.9 dB), once full RLAN deployment levels will be reached.

Since altimeters are operating over the whole 5250-5570 MHz band, additional analysis may be required to address different cases of RLAN deployment, in particular taking into account a scenario where no RLAN use would be considered in the 5350-5470 MHz band;

**5.3.2 Sharing between EESS (active) and WAS/RLANS in the band 5 350‑5 470 MHz**

**5.3.2.1 Initial sharing studies**

Sharing and coexistence between RLAN 5 GHz and EESS (active) in the 5 350-5 470 MHz band were studied during the previous study period (in JTG 4-5-6-7) and led to the following conclusion (see CPM Report to the 2015 World Radiocommunication Conference (Document N° 3 of WRC‑15)):

*“Results of sharing studies show that with the RLAN parameters described above, sharing between RLAN and the EESS (active) systems in the 5 350-5 470 MHz frequency band would not be feasible. Sharing may only be feasible if additional RLAN mitigation measures are implemented.”*

One should also highlight the fact that these findings are duly reproduced in *Recognising a)* of Resolution **239 (WRC-15)**.

Similar conclusions were also drawn in CEPT Report 57:

*” When considering the various technical studies in CEPT and ITU-R, concerns have been raised about the feasibility of RLAN usage in the band 5350-5470 MHz, as current studies show that there is a significant enough negative margin to conclude that sharing with EESS (active) is not feasible unless additional sharing/mitigation techniques are identified that can provide the necessary protection to EESS (active).*

These conclusions were developed after intensive studies on sharing and coexistence between RLAN 5 GHz and EESS (active) mainly with EESS (active) SAR systems. These conclusions are summarised in the preliminary draft new Report ITU-R RS.[EESS RLAN 5 GHz] on *“Sharing studies between RLAN and EESS (active) systems in the frequency range 5 350-5 470 MHz”* (see Annex 35 to Document 4-5-6-7/715 (Chairman’s Report)). Taking into account the whole ranges of RLAN 5 GHz parameters (e.g. antenna gain discrimination, devices densities, outdoor ratio, building attenuation) under all scenarios, these studies shows that RLAN deployment in the frequency band 5 350-5 470 MHz would create large interference in the CSAR sensor on board the Sentinel-1 satellite (from 5.8 dB up to 30.4 dB).

**5.3.2.2 Additional sharing studies**

Additional studies have been performed using static and dynamic analysis with altimeter (Sentinel-3 Altimeter sensor (SRAL)) and scatteromter (EPS-SG sensor (SCA)) and were presented in CPG/PTD in annexes 1 and 2 of document [**CPG-PTD(16)16**](http://cept.org/Documents/cpg-pt-d/32341/ptd-16-16_agenda-item-116-sharing-studies-between-rlan-and-eess-active-scatterometers-and-altimeters-in-the-5-ghz-range), respectively.

These studies take into account similar assumptions and ranges of RLAN 5 GHz parameters (e.g. antenna gain discrimination, devices densities, outdoor ratio, building attenuation) than those considered for analysis made for SAR sensors during previous study period. They confirm that, under all scenarios, RLAN deployment in the 5 GHz range would create large interference to altimeters (from -0.6 dB up to 26.6 dB) and scatterometers (from 3.7 dB up to 20.9 dB), hence in the same order of magnitude than for SAR sensors.

All together, these studies confirm the previous findings of JTG 4-5-6-7 and CEPT Report 57 that sharing between RLAN and EESS (active) in the 5350-5470 MHz band may only be feasible if additional RLAN mitigation measures are implemented.

**5.3.2.3 Considerations on additional mitigation techniques**

At the current stage, compared to the situation prior to WRC-15, no new elements have been presented either in ITU-R WP 5A or CPG/PTD on any additional mitigation techniques that could be envisaged to provide co-existence with all types of EESS sensors in the band 5350-5470 MHz.

## 5.4 Sharing and compatibility of Fixed Satellite Service versus WAS/RLAN in the 5 725-5 850 MHz (for Region 1) and 5 850‑5 925 MHz

According to Resolution **239 (WRC-15)**, the issues to be addressed in relation to 5725 – 5925 MHz are the following:

* to also conduct detailed sharing and compatibility studies, including mitigation techniques, between WAS/RLAN and incumbent services in the frequency band 5 725‑5 850 MHz with a view to enabling a mobile service allocation to accommodate WAS/RLAN use;
* to also conduct detailed sharing and compatibility studies, including mitigation techniques, between WAS/RLAN and incumbent services in the frequency band 5 850‑5 925 MHz with a view to accommodating WAS/RLAN use under the existing primary mobile service allocation while not imposing any additional constraints on the existing services,

**5.4.1 Sharing between Fixed Satellite Service (Region 1 allocation only) versus WAS/RLAN in the 5 725-5 850 MHz**

**5.4.1.1 Initial sharing studies**

Initial sharing studies have been carried out in ITU-R and CEPT that are considered relevant for sharing between FSS and WAS/RLAN in the 5 725-5 850 MHz. These initial sharing studies can be seen in the following Reports:

– Report ITU-R S.2367 – Sharing and compatibility between International Mobile Telecommunication systems and fixed-satellite service networks in the 5 850‑6 425 MHz frequency range

– ECC Report 244 – Compatibility studies related to RLANs in the 5 725-5 925 MHz band

In these studies, it can be seen that the FSS use of the band has been the subject of some examination either at the ITU-R and/or the CEPT level:

* Regarding 5850-5925 MHz, WP4A provided (to JTG 4-5-6-7 under WRC-15 AI 1.1) generic FSS characteristics for studies between FSS and IMT for the range 5850-6425 MHz. This is reflected in ITU-R Report S.2367. There should be a need of revising and, as appropriate, update the list of operational satellites (updating also the ITU filings used for sources of information on FSS characteristics). The CEPT studies, as provided in the ECC Report 244, assumed the same parameters and a sample of "representative" FSS satellites covering Europe.
* Regarding 5725-5850 MHz (Region 1 only), studies have not yet been addressed at ITU level, CEPT assumed the same typical characteristics for earth stations and space stations operating in this band, as for 5850-5925 MHz. Most of the satellite filings in this band are operated by one European country.

As ECC Report 244 was looking at actual RLAN characteristics and deployments, rather than small cell IMT, CEPT consider these studies to be more indicative of the possible sharing scenarios for RLANs vs FSS in this band.

Analysis of results of the ECC Report 244

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

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

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

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

The different factors used in step 2 are subject to some uncertainties because of the difficulties involved when deriving values for these factors and in particular when making predictions for 2025.

Therefore, it was agreed to perform sensitivity analyses, taking into account ranges of values for some of these factors.

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

Calculations and results are presented in ECC Report 244, and although providing some relevant results, it was considered too early to draw definite conclusions.

From the sensitivity analysis carried out in these studies it highlighted 28 possible cases (Case 1 to Case 27) which also showed results for sub-cases.

For the band 5725 – 5850 MHz the range of results showed for the most optimistic scenario under Case 1 there was up to 12 dB positive margin, and for the most pessimistic scenario under Case 27 there was up to 21.4 dB negative margin

The Report also concluded that additional considerations on the potential for RLAN–FSS sharing are still needed, such as:

* Antenna discrimination for outdoor RLANs;
* Further studies on polarization mismatch;
* Studies supporting Stage 8 of FSS Step 2 which proposed an application of upper bound on channel re-uses were not finalized;
* 5 GHz Spectrum Factor (Stage 5 of FSS Step 2);
* Control / monitoring on the long term aggregate effect of RLAN interference into FSS as RLAN deployment increases and investigation of what can be done in a scenario where the interference threshold is reached;
* Further studies on apportionment of the FSS protection criteria.
* Potential mitigation techniques have to be considered and assessment of their impact on the potential for sharing between RLAN and FSS is required. Their feasibility and practicality are still pending of further study. Among others, the following potential mitigation techniques could be addressed:
	1. - RLAN Access Points deployed only indoor;
	2. - Additional power limitation for RLAN.

Additional studies were also carried out in CEPT after the publication of ECC Report 244 looking at adding LAA-LTE use into the bands studied, compared to ECC Report 244 and they concluded the following:

* Compatibility of a mix LAA and WiFi market share with FSS. Results are roughly the same as for the case of WiFi only.
* Therefore, the impact of adding LAA-LTE use case in 5 GHz bands appears to have minimal effect on the overall results of compatibility and sharing as shown in ECC Report 244.

**5.4.1.2 Additional sharing studies**

Taking account of the studies shown in CEPT Report 57 and ECC Report 244 and additional studies carried out within CEPT, CEPT Report 64 was published in November 2016 and it provides a summary on the results achieved at that point in time and pending activities.

It concluded that it has not been possible to arrive at a consensus regarding suitable inputs for the modelling, and further studies would be required. Further mitigation techniques may also need to be investigated and studied for their impact on RLAN operations and results of studies. One possible way forward to address some of the uncertainties currently seen in the range of results is to carry out some airborne measurements to compare actual RLAN use with the predicted results from the model for defined geographical areas. An example of how to compare real measurements with the results of the model has been presented during the course of the studies.

It also concludes that work is still required on the specification of appropriate mitigation techniques and/or operational compatibility and sharing conditions that would allow WAS/RLANs to be operated in the bands while ensuring relevant protection of the Fixed Satellite Services in these bands.

There have been no studies on the potential interference from FSS earth stations into RLAN.

Document [CPG PTD (17)32](http://cept.org/Documents/cpg-pt-d/34074/ptd-17-23_test-signals-for-frequency-hopping-radars) looks to develop further the results of the previous sharing studies carried out in ITU-R and CEPT using a methodology that makes reference to the studies contained in ECC Report 244, it then takes a 3 step approach to the analysis when looking at an assessment of the interference from RLAN into FSS.

– **Step 1:** This step calculates the maximum number of active, on-tune, RLAN transmitters that can be accommodated by the satellite receivers under consideration in ECC Report 244 whilst satisfying the FSS protection criteria. In addition, as part of this step in order to reduce the large range of results given in ECC Report 244 some decisions were made on the choices available regarding suitable technical parameters. These choices were based on the following principles: evidence based (where suitable evidence was available), realistic, justifiable and not overly conservative.

– **Step 2:** This step delivers a sensitivity analysis of the number of active, on-tune, RLAN transmitters using various different assumptions when looking at possible RLAN deployment models. The Step 2 outputs can be compared with the Step 1 values in order to assess the potential for sharing when inputting the different assumptions. In theory, if the Step 2 values are less than or equal to the Step 1 values, then the results suggest that sharing is possible; else if the Step 2 values are greater than the Step 1 values, sharing is not possible.

– **Step 3:** This step delivers a comparison of the overall results from the measurement campaigns with the range of various results that can be seen from Step 2 and looks to see if the range of the assumptions with their results could be compared with the measurement results with an appropriate margin for error. As part of this work there was also a further analysis of the various assumptions used to build up the 27 different cases that were studied for each satellite that looked at recent evidence collected by Ofcom UK in its recent market reports on current and future broadband usage trends.

The study results indicate that large numbers of high power, outdoor access points could significantly increase the coexistence risk so it proposes to futher investigate the effect that some simple mitigation techniques would have on the sharing situation (based on the fact that the allocation is for mobile stations) like limiting the maximum power levels to 200mW and limiting the outdoor use of the band (i.e. no fixed outdoor use).

Overall, when looking at the results, this study concludes that sharing may be possible between RLAN and FSS in the 5725 - 5850 MHz band especially if further mitigation techniques are investigated further in order to reduce the negative margins shown in the results for the most pessimistic cases. The study also concluded that when taking account all some of the additional mitigation factors proposed in the study that some further analysis will prove that sharing is feasible even for the more conservative assumptions studied.

Finally, when looking at the overall conclusions on whether sharing would be feasible, this study also looks at the bigger picture regarding the methodology used in ITU-R Recommendation S.1432-1 to derive the sharing criteria for satellite sharing, the low use of the band by the satellite community, the current situation in CEPT regarding other terrestrial use and ISM emmissions in the band and the fact that there is use of Wi-FI in this band elsewhere in the world in regions 2 and 3 where there is no satellite allocation.

**5.4.1.3 Considerations on additional mitigation techniques**

There is a need for studies on the feasibility and practicability on the potential mitigation techniques, to be developed. Some initially suggested techniques are:

* RLAN Access Points deployed only indoor (i.e. no fixed outdoor);
* Additional power limitation for RLAN.

**5.4.2 Sharing between FSS and WAS/RLANS in the band 5 850‑5 925 MHz**

**5.4.2.1 Initial sharing studies**

Initial sharing studies have been carried out in ITU-R and CEPT that are considered relevant for sharing between FSS and WAS/RLAN in the 5 850-5 925 MHz. These initial sharing studies can be seen in the following Reports:

– Report ITU-R S.2367 – Sharing and compatibility between International Mobile Telecommunication systems and fixed-satellite service networks in the 5 850‑6 425 MHz frequency range

– ECC Report 244 – Compatibility studies related to RLANs in the 5 725-5 925 MHz band

In these studies, it can be seen that the FSS use of the band has been the subject of some examination either at the ITU-R and/or the CEPT level:

* Regarding 5850-5925 MHz, WP4A provided (to JTG 4-5-6-7 under WRC-15 AI 1.1) generic FSS characteristics for studies between FSS and IMT for the range 5850-6425 MHz. This is reflected in ITU-R Report S.2367. There should be a need of revising and, as appropriate, update the list of operational satellites (updating also the ITU filings used for sources of information on FSS characteristics). The CEPT studies, as provided in the ECC Report 244, assumed the same parameters and a sample of "representative" FSS satellites covering Europe.
* Regarding 5725-5850 MHz (Region 1 only), studies have not yet been addressed at ITU level, CEPT assumed the same typical characteristics for earth stations and space stations operating in this band, as for 5850-5925 MHz. Most of the satellite filings in this band are operated by one European country.

As ECC Report 244 was looking at actual RLAN characteristics and deployments, rather than small cell IMT, CEPT consider these studies to be more indicative of the possible sharing scenarios for RLANs vs FSS in this band.

Analysis of results of the ECC Report SE244

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

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

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

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

The different factors used in step 2 are subject to some uncertainties because of the difficulties involved when deriving values for these factors and in particular when making predictions for 2025.

Therefore, it was agreed to preform sensitivity analyses, taking into account ranges of values for some of these factors.

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

Calculations and results are presented in ECC Report 244, and although providing some relevant results, it was considered too early to draw definite conclusions.

From the sensitivity analysis carried out in these studies it highlighted 28 possible cases (Case 1 to Case 28) which also showed results for sub-cases that range from conservative figures for RLAN numbers/activity put forward by the satellite industry to less conservative proposals put forward by the RLAN industry.

For the band 5850 – 5925 MHz the range of results showed for the most optimistic scenario under Case 1 there was up to 10.3 dB positive margin, and for the most pessimistic scenario under Case 28 there was up to 22.6 dB negative margin.

The Report also concluded that additional considerations on the potential for RLAN–FSS sharing are still needed, such as:

* Antenna discrimination for outdoor RLANs;
* Further studies on polarization mismatch;
* Studies supporting Stage 8 of FSS Step 2 which proposed an application of upper bound on channel re-uses were not finalized;
* 5 GHz Spectrum Factor (Stage 5 of FSS Step 2);
* Control / monitoring on the long term aggregate effect of RLAN interference into FSS as RLAN deployment increases and investigation of what can be done in a scenario where the interference threshold is reached;
* Further studies on apportionment of the FSS protection criteria.
* Potential mitigation techniques have to be considered and assessment of their impact on the potential for sharing between RLAN and FSS is required. Their feasibility and practicality are still pending of further study. Among others, the following potential mitigation techniques could be addressed:
	1. - RLAN Access Points deployed only indoor;
	2. - Additional power limitation for RLAN.

Additional studies were also carried out in CEPT after the publication of ECC Report 244 looking at adding LAA-LTE use into the bands studied, compared to ECC Report 244 and they concluded the following:

* Compatibility of a mix LAA and WiFi market share with FSS. Results are roughly the same as for the case of WiFi only.
* Therefore, the impact of adding LAA-LTE use case in 5 GHz bands appears to have minimal effect on the overall results of compatibility and sharing as shown in ECC Report 244.

**5.4.2.2 Additional sharing studies**

Taking account of the studies shown in CEPT Report 57 and ECC Report 244 and additional studies carried out within CEPT, CEPT Report 64 was published in November 2016 and it provides a summary on the results achieved at that point in time and pending activities.

It concluded that it has not been possible to arrive at a consensus regarding suitable inputs for the modelling, and further studies would be required. Further mitigation techniques may also need to be investigated and studied for their impact on RLAN operations and results of studies. One possible way forward to address some of the uncertainties currently seen in the range of results is to carry out some airborne measurements to compare actual RLAN use with the predicted results from the model for defined geographical areas. An example of how to compare real measurements with the results of the model has been presented during the course of the studies.

It also concludes that work is still required on the specification of appropriate mitigation techniques and/or operational compatibility and sharing conditions that would allow WAS/RLANs to be operated in the bands while ensuring relevant protection of the Fixed Satellite Services in these bands.

When reviewing the assumptions for future RLAN deployments any further studies will need to take account of the life cycle of current and/or future satellite systems.

There have been no studies on the potential interference from FSS earth stations into RLAN.

**5.4.2.3 Considerations on additional mitigation techniques**

There is a need for studies on the feasibility and practicability on the potential mitigation techniques, to be developed. Some initially suggested techniques are:

* RLAN Access Points deployed only indoor (i.e. no fixed outdoor);
* Additional power limitation for RLAN.

**5.5 Sharing between Intelligent Transport Systems (ITS) and WAS/RLANS in the band 5 850‑5 925 MHz**

**5.5.1 Initial sharing studies**

Results of ECC Report 244 for Compatibility between RLAN and ITS in the bands 5855-5875 MHz (non-safety ITS), 5875-5905 MHz (safety-related ITS) and 5905-5925 MHz (ITS extension band)

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

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

Two possible approaches are under study:

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

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

**5.5.2 Considerations on additional mitigation techniques**

Document [CPG PTD(17)30](http://cept.org/ecc/groups/ecc/cpg/cpg-pt-d/client/meeting-documents/file-history/?fid=34081) looks to develop further the results of the previous sharing studies carried out in CEPT in ECC Report 244. two mitigation techniques are being considered to ensure an interference free operation of ITS applications, Detect and Vacate (D&V) and Detect and Mitigate (D&M). They are described in the ETSI TR 103 319.

The studies within this document look at the influence of these two different mitigation techniques on ITS and proposes first recommendations and conclusions for these two methods. Due to the fact that not all parameters of the mitigation techniques are full defined some assumptions are made in these studies.

D&M and D&V proposals were analysed with simulations and he following results can be observed.

The D&V algorithm likely enables acceptable protection to ITS communications after successful detection of ITS traffic. However, harmful interference to ITS communications may exist prior to the detection, especially in scenarios with heavy RLAN traffic. In some situations, a large number of ITS packets may be lost before ITS traffic is detected by RLAN. Having in mind that a CAM is generated every 5m of driven distance (CAM generation rate max. 10Hz) the values in document [CPG PTD(17)30](http://cept.org/ecc/groups/ecc/cpg/cpg-pt-d/client/meeting-documents/file-history/?fid=34081) (Figure 8) represent 100 m (20 lost messages in the left figure) and 35 m (7 lost messages), respectively. An appropriate amount of gap between consecutive RLAN transmissions (266 µs) is shown to help partly mitigate interference.

Future studies should take into account that future ITS-G5 application use lower transmit power, e.g. pedestrians sending CAM with a lower transmit power and using a lower generation rate to save the user equipment energy.

The D&M algorithm results in harmful interference to ITS communications as D&V does prior to detection of ITS packets. Worse, the algorithm's packet-by-packet sharing technique (D&M) after the detection has been observed to cause significant interference even with limited simulations. In summary, the D&M algorithm fails in all NLOS scenarios that were tested.

From these first results there are possibilities that coexistence of ITS-G5 and IEEE-based RLAN can be reached with D&V mitigation technique. Further studies are necessary to set appropriate parameters like vacate time, detection method (preamble), detection thresholds (energy), extra idle time and channel models for performance definition. The asymmetric detection based on the different detection thresholds for RLAN and ITS-G5 signals could be used as additional mitigation method to solve issues which occurs as described in section 3.1 of document [CPG PTD(17)30](http://cept.org/ecc/groups/ecc/cpg/cpg-pt-d/client/meeting-documents/file-history/?fid=34081).

As a conclusion of this study all possible seven ITS channels should be monitored and vacated in the case of ITS signal detection.

Editors Note: There are further studies and simulations presented in ETSI TR 103 319 which look at these mitigation techniques. These other studies are not reflected in this document at present and CPG PTD invites inputs to its next meeting to reflect the results of these studies.

## 5.6 Sharing and compatibility of Fixed Service versus WAS/RLAN in the 5 850‑5 925 MHz

***Editor’s note****: Relevant inputs ECC Report 244 and CPG-PTD (16)02,18,24. The documents will be considered in detail at the next meeting of CPG PTD and relevant parts will then be inserted into this working document as appropriate.*

## 5.7 Consideration of the cross bands sharing and compatibility issues

## 6 Conclusions of sharing and compatibility studies per frequency range and per service

## 6.1 General considerations

## 6.2 Sharing and compatibility results in the band 5 150-5 350 MHz

## 6.5 Sharing and compatibility results in the band 5 350-5 470 MHz

## 6.6 Sharing and compatibility results in the band 5 725-5 850 MHz

## 6.7 Sharing and compatibility results in the band 5 850-5 925 MHz

## 6.8 Cross bands sharing and compatibility issues