Dynamically Reconfigurable Optical-Wireless Backhaul/Fronthaul with Cognitive Control Plane for Small Cells and Cloud-RANs

D6.1 Contribution to ETSI and CEPT on mm-Wave regulatory issues

This project has received funding from the European Union's Framework Programme Horizon 2020 for research, technological development and demonstration

Advanced 5G Network Infrastructure for the Future Internet

Project Start Date: July 1st, 2015 Duration: 36 months

H2020-ICT-2014-2 671551 July 1st, 2016 – Version 1.0

Project co-funded by the European Commission

Under the H2020 programme

Dissemination Level: Public

Grant Agreement Number:	671551
Project Name:	Dynamically Reconfigurable Optical-Wireless Back-haul/Fronthaul with Cognitive Control Plane for Small Cells and Cloud-RANs
Project Acronym:	5G-XHaul
Document Number:	D6.1
Document Title:	Contribution to ETSI and CEPT on mm-Wave regulatory issues
Version:	1.0
Delivery Date:	March 31st, 2017 (April 11th, 2017)
Responsible:	**BWT**
Editor(s):	Mark Barrett (**BWT**)
Authors:	Mark Barrett (**BWT**)
Keywords:	mmWave, 60 GHz
Status:	Draft
Dissemination Level	Public
Project URL:	http://www.5g-xhaul-project.eu/

Table of Contents

List of Figures

List of Tables

Executive Summary

The 5G-XHaul project proposes a flexible transport infrastructure built on a converged optical and wireless network solution supported by a flexible and scalable control plane. This infrastructure will be able to jointly support backhaul (BH) and fronthaul (FH) functionalities required to cope with the future challenges imposed by fifth generation (5G) Radio Access Networks (RANs).

This deliverable describes ongoing discussions with the relevant regulatory authorities in respect of the regulations relating to the use of 57-66 GHz millimetre wave band for the 5G-XHaul system. The current status of regulations for wireless transmissions in the millimetre wave band of interest to deployment of the 5G-XHaul system is presented as summarised below:

- **USA: FCC Part 15.255** specifies +40 dBmi EIRP (max +27 dBm power) with extension to 82 dBmi minus 2 dB for every dB that the antenna gain is less than 51 dBi
- **Europe: CEPT** : Unlicensed operation for indoor and outdoor operation subject to CEPT ECC/REC(09)01 limitations of maximum EIRP +55 dBm, minimum antenna gain +30 dBi and ,maximum transmitter output power of +10 dBm.
- **Europe: ETSI EN 302 217** for Fixed Wireless (Back Haul) specifies gain (>30 dBi) & (<+10 dBm) power separately > not optimum for phased array operation.
- **Europe: ETSI EN 302 567** for Wireless Access(WLAN) specifies EIRP +40 dBmi > similar to FCC Part 15.255 up to +40 dBmi – *applicable for 5G and wireless access in EU?*

The separation of antenna gain and transmit power for operation in European markets is an impediment to the use of cost effective 'beamsteering' technology based on the use of phased array antenna and transceiver technology being developed for mass market 'WiGig' applications in the 57-66 GHz frequency band.

Therefore, a key objective is to achieve full alignment between the regulations applicable for operation in outdoor conditions between the US market under FCC Part 15.255 rules and European market under relaxed ETSI and CEPT rules –thus resolving the contradiction between EN 302 217 and EN 302 567 for operation in the 57-66 GHz band. This would maximise the commercial opportunity for deployment of flexible wireless infrastructure in alignment with the vision of the 5G-XHaul project.

Further steps will be taken by members of the 5G-XHaul project to continue lobbying for the rules to be changes – notably through CEPT SE19 group as the next step.

1 Introduction

5G mobile networks are expected to offer considerable enhancements such as peak data rates, area capacity, IoT support, etc., ensuring end-to-end latency. To achieve these improvements, traditional Radio Access Networks (RANs) will evolve to alternative solutions, such as C-RAN, requiring increased transport bandwidth, strict latency and synchronization constraints.

A key issue in any wireless system concerns the regulatory and standards regimes under which such systems are permitted to operate. The objectives of these regulations and standards may include:

1. Specifying transmit power, spurious and antenna gain to provide fair use of the allocated spectrum to allow re-use by as many users as possible as well as specifying safe limits for operation.
2. Protect out of band users from interference from intermodulation and other out of band emissions from the band of interest.
3. Specify detailed air interface PHY and MAC protocol to ensure compatibility of equipment development by multiple vendors.

In addition, both licensed (for example 4G-LTE) and unlicensed (for example Wi-Fi) spectrum allocations can be considered. Typical regulatory and standards bodies involved in this process include the following:

- Regulatory Authorities: National government agencies such as FCC (USA), OFCOM (UK) and supra-national bodies such as the CEPT.
- Standardisation organisations: IEEE (eg for Wi-Fi 802.11xx) and ETSI for 3GPP and microwave / millimetre wave technical specifications.
- Industry organisations: Wi-Fi Alliance for promotion of interoperability of Wi-Fi, 3GPP for LTE ad 5G standards.

A key objective of the 5G-XHaul project is the exploitation of the license free band available in Europe from 57-64 GHz and in the USA from 57- 71 GHz. This is because these bands are being targeted by the wireless semiconductor industry for the development of cost effective integrated radio and baseband modems which, if leveraged correctly, has the ability to deliver very flexible solutions for gigabit wireless access and backhaul equipment. The document therefore considers the difference in regulatory regimes – notably in that between the USA from the FCC and in Europe within ETSI and CEPT. As will be seen the document recommends alignment between these two regimes in order to allow maximum commercial leverage of this technology in the worldwide market.

The author is aware of other 5G millimetre wave bands being discussed for licensed operation at 28 GHz (Asia and USA), 26 GHz (Europe) and 39 GHz (USA). However, a discussion on the regulations for these bands is outside of the scope of this document.

This document is organised as follows:

- Brief review of existing standards and regulations impacting operation in 57-64/71 GHz.
- Application review of equipment operating in the above frequency band.
- Commentary on current standards and recommendations.
- List of relevant deliverables aimed at influencing European regulations.
- Conclusions and next steps.

2 Regulatory Emission Limitations for 57-71 GHz

The upper part of V-Band (i.e. 57 to 66 GHz) is generally intended by majority of administrations for "un-planned/uncoordinated" deployment. Therefore, for sake of maintaining a fair and efficient use of the band, most regulations imply limitation in the emission levels and, often, in antenna gain.

In CEPT area the reference, ECC/REC(09)01 , indicate the following limitations apply:

- Maximum EIRP +55 dBm
- Minimum antenna gain +30 dBi
- Maximum transmitter output power +10 dBm

According to this recommendation the combination of 57-64 GHz with 64-66 GHz channel planning under ECC/REC(05)02) is also possible.

In the USA the FCC regulations Part15.255 adopts a methodology of limiting the maximum EIRP as function of antenna gain (G) with the formula:

EIRP (dBmi) = EIRPmax (dBm) – 2*(Gmax-G) (dBi),

where EIRP and G are the values for the product under test, while EIRPmax and Gmax are stated by the FCC. For V-band, Part 15.255 thus states:

- EIRPmax = +82 dBmi
- Gmax = +51 dBi

In addition, FCC Rule Part 15.255 states that for indoor equipment the average EIRP power of any emission shall not exceed 40 dBmi and the peak EIRP power of any emission shall not exceed 43 dBmi. FCC has also clarified that outdoor equipment can comply with both statements – this one or the limiting the maximum EIRP as function of antenna gain as here above reported - whichever provides the higher EIRP limit. This implies that, given the EIRP limitation and the maximum PTX, the minimum antenna gain in FCC area becomes 13 dBi and that antenna gain of < 30 dBi allow compliance with the +40 dBmi EIRP general limit. However, it is important to note that the maximum conducted power possible under FCC Part15.255 is +27 dBm (0.5W) which is specified for safety limits.

In Europe from ETSI we see that there are two regulations as follows:

- ETSI EN 302 217-3 specifically for fixed wireless equipment which follows the CEPT recommendation ECC/REC(09)01 mentioned above.
- ETSI EN ETSI EN 302 567 V1.2.1 (2012-01) aimed at Broadband Wireless Access networks in which a simple EIRP limit for indoor and outdoor applications of +40 dBmi is specified – similar to the FCC limit from Part15.255.

Therefore, it appears that there is a contradiction between these two ETSI standards and, moreover, the CEPT regulation in relation to allowed transmitter power and antenna gain. The difference is stated as being in the use of 'Fixed' installations for EN 302 217 and 'Temporary' installations for EN 302 567. However, these are rather ill defined terms and therefore subject to interpretation by the equipment vendor or wireless service provider.

To further clarify (?) this issue, the responsible group for fixed wireless regulations in the CEPT – SE 19 – has contributed the following further restrictions on the use of un-licensed band in the 57-66 GHz region as follows[1] [1] (see Figure 1):

[1] CEPT ECC Recommendation 70-03 updated 2017

ANNEX 3: WIDEBAND DATA TRANSMISSION SYSTEMS

Scope of Annex

This annex covers frequency bands and regulatory as well as informative parameters recommended for Wideband Data Transmission Systems and Wireless Access Systems including Radio Local Area Networks (WAS/RLANs) within the bands 2400-2483.5 MHz and for Multiple-Gigabit WAS/RLAN Systems within the band 57-66 GHz.

Table 3: Regulatory parameters

Frequency Band		Power / Magnetic Field	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	ECC/ERC Deliverable	Notes
a	2400-2483.5 MHz	100 mW e.i.r.p.	Adequate spectrum sharing mechanism (e.g. Listen-before-Talk, Detect-And-Avoid) shall be implemented by the equipment	Not specified		For wide band modulations other than FHSS, the maximum e.i.r.p. density is limited to 10 mW/MHz
b	57-66 GHz	40 dBm mean e.i.r.p.. This refers to the highest power level of the transmitter power control range during the transmission burst if transmitter power control is implemented	Adequate spectrum sharing mechanism (e.g. Listen-before-Talk, Detect-And-Avoid) shall be implemented by the equipment	Not specified		Fixed outdoor installations are not allowed. The maximum mean e.i.r.p density is limited to 13 dBm/MHz. Point-to-point links of the Fixed Service are regulated by ECC/REC/(05)02 and ECC/REC/(09)01

Additional Information

Figure 1: Table extract from CEPT ECC 70-03 concerning operation in 57-66 GHz band.

As can be seen, this also specifies the use of ‘Listen before Talk’ mechanisms for transmission in the 57-66 GHz – without specifying the precise protocol for such mechanisms.

In summary, a comparison of the regulations applicable in the USA and Europe reveals a significant difference as follows:

- **USA** : Unlicensed operation for indoor and outdoor applications up to +40 dBmi with no limit on minimum antenna gain and extended EIRP up to +82 dBmi subject to maximum antenna gain of 51 dBi. *Note that the FCC has in mind extended operation of gigabit rate unlicensed ‘high volume’ services such as those based on IEEE 802.11ad ‘WiGig’ and therefore wishes to take a light touch to operation in these frequency bands.*
- **Europe** : Unlicensed operation for indoor and outdoor operation subject to CEPT ECC/REC(09)01 limitations of maximum EIRP +55 dBm, minimum antenna gain +30 dBi and ,maximum transmitter output power of +10 dBm. Further complications between difference ETSI specifications EN 302 217 and EN 302 567.
  Note that regulations in Europe for operation in this band is driven by the deployment of fixed wireless p2p equipment in small volumes for outdoor telecommunication links applications.

As will be seen, the next generation of Wi-Fi ‘WiGig enabled’ chipsets, which are already beginning to enter the market in mass market products such as smartphones, tablets and TVs, include 60 GHz 802.11ad ‘WiGig’ devices and, therefore, on the face of it, not be permitted for operation in outdoor applications in Europe. Clearly this it is not possible in practice to control the use of such devices by the end user.

A further discussion on the implications of these specifications for the deployment of cost effective equipment for flexible backhaul & access applications is considered in the following chapters.

3 Review of Deployed Equipment

According to a survey of fixed point-to-point (p2p) equipment deployments conducted by the ETSI mWT ISG industry working group in September 2015, and based on information provided by Skylight Research, a total of 4M fixed wireless links were deployed worldwide with the ratio of equipment by frequency band as shown below in Figure 2.

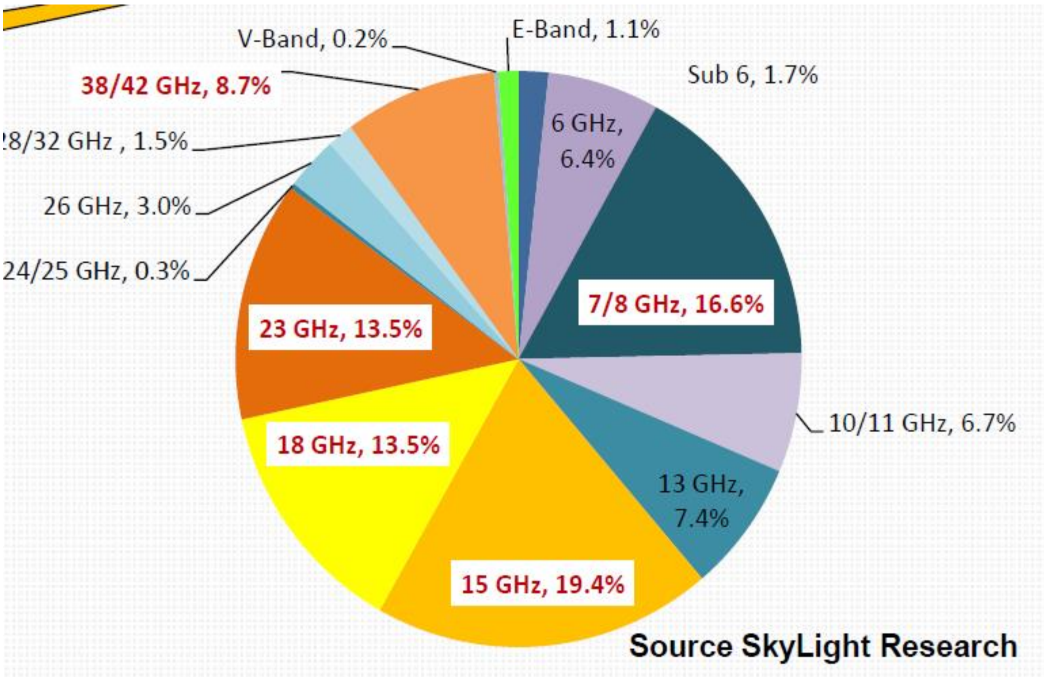

Figure 2: Fixed p2p equipment deployments by frequency.

This shows that only 0.2% of fixed wireless equipment is currently operating in V band (57-66 GHz) – representing just 8,000 p2p links or 16,000 total deployed radios – worldwide! Moreover, the fixed wireless industry is currently moving to higher millimetre frequencies at E and (70/80 GHz), W (94 GHz) and D (140 GHz) bands as they are concerned that emerging wireless products such as WiGig *may* generate some level of interference which will impact the ability to operate fixed p2p connections in V-band. By way of comparison, ABI Research[2] [2] has predicted that 1Billion WiGig devices per annum will ship by Y2021.

Therefore, there is a strong market justification for relaxing the European regulations for operation in V-band as the future trend for fixed p2p equipment is to move to higher millimetre wave frequencies.

[2] https://www.abiresearch.com/press/80211ad-chipset-market-reach-critical-juncture-201/

4 Impact of Regulations on Equipment deployment

As can be seen in other deliverables from the 5G-XHaul project key features of wireless equipment intended for operation in 57-66 GHz bands are as follows:

1. Use of electronic controlled phased array antennas to dynamically direct beams from node to node to create wireless mesh networks.
2. Ability to control the direction and capacity of the beams generated by #1 under software control using SDN methods.
3. Exploit and extend emerging phased array antenna and RF phased array transceiver technologies originally developed for high volume applications like WiGig to create cost effective solutions (€400/node) capable of high volume (M's of units) deployments in dense urban networks.

Chipsets and antenna technologies with sufficient performance for this application are already available from vendors such as SiBeam and SiversIMA and other partners in the 5G-XHaul project are also developing this technology. Key features of such radio technology include:

- Typical active phased array antenna comprising 16 transmitters and 16 receivers.
- Output power of +10 dBm for each transmitter or a maximum combined power of +22 dBmi.
- Phased array antenna of gain +20-24 dBi comprising 16 steerable columns each of ~+11 dBi gain spaced at half wavelength spacing (of 2.5 mm) thus enabling beam steering over at least +/- 45 degrees of azimuth scan range.
- Compact antenna size of 40x30mm for low profile/low environmental impact.
- Total average EIRP, after losses, of +40 dBmi.

However, the equipment described above would not satisfy current European regulations as the transmitter power is too high (+22 dBm compared to a limit of +10 dBm) and the gain is too low (+20 dBi compared to +30 dBi). Compliance with the European (ECC/REC(09)01) rules would require an increase of antenna gain of +10 dB requiring 10x more active columns to meet the regulations – or the use of 10x RF chips each with 16 outputs – for no additional gain in link budget since the transmitter power would also need to be reduced by +12 dB to +10 dBm. Hence the use of cost effective phased array technologies naturally suited to the delivery of dynamic beam steered systems is not cost effective for deployment under current European regulations.

In contrast, current fixed wireless p2p equipment are based on the combination of a single transmitter (<10 dBm) with a simple fixed mechanical high gain parabolic dish antenna (>+30 dBi) and suffer from several limitations for deployment of dynamic wireless mesh networks namely increased size, no dynamic steering ability and increased cost compared to printed devices emerging from the WiGig market.

Therefore, the key objective is to achieve full alignment between the regulations applicable for operation in outdoor conditions between the US market under FCC Part 15.255 rules and European market under relaxed ETSI and CEPT rules –thus resolving the contradiction between EN 302 217 and EN 302 567 for operation in the 57-66 GHz band. This would maximise the commercial opportunity for deployment of flexible wireless infrastructure in alignment with the vision of the 5G-XHaul project.

5 Deliverables to Date

A number of public deliverables and presentations have been made promoting the message that alignment between European and US regulations is necessary to maximise the benefits envisaged by deployment of the 5G-XHaul system concept. A selection of these deliverables are listed below in Table 1.

Table 1: 5G-XHaul contributions to V Band (57-66 GHz) request for regulatory harmonisation.

Description	Organisation	Forum	Date	Comment
Applying 60 GHz WiGig to Backhaul: Update on Recent Developments[3] [3]	Tech-UK, London	UK Spectrum Forum, Cluster 2 mmWave	16th December 2015	
Millimetre Wave Technology for 5G	IET, London	RF & Microwave Engineering	25th January 2017	
mmWave Semiconductor Industry Technologies: Stats and Evolution	ETSI	mWT ISG Industry Working Group	1st July 2016	ETSI White Paper No.15[4] [4]
5G Millimetre Wave FWA 'Wireless is the new Wired?'	Tech-UK, London	Urban Connectivity: The Demand and the Challenges	12th October 2016	
Gigabit Baseband Technology for mmWave Applications	IWPC, San Jose, USA	mmWave Applications and Technology workshop	12th January 2016	IWPC[5] [5]

The regulatory issues related to the impediment to deployment of cost effective electronically steered V band systems were part of the above mentioned presentations.

Further steps are planned in relation to lobbying for the regulations to be harmonised between USA and Europe– notably through representations to the CEPT SE19 group.

[3] https://www.techuk.org/component/techuksecurity/security/download/6870?file=4_BWT_mmW_BH_TechUK_Dec15_Rel.pdf&Itemid=182&return=aHR0cHM6Ly93d3cudGVjaHVrLm9yZy9pbnNpZ2h0cy9tZWV0aW5nLW5vdGVzL2l0ZW0vNjg3MC1tZWV0aW5nLW5vdGVzLWZyb20tdWstc3BmLWNsdXN0ZXItMi1ldmVudC1vbi1tbXdhdmU=

[4] http://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp15_mwt_semiconductor_technology.pdf

[5] www.iwpc.org

6 Conclusions and Next Steps

The current status of regulations for wireless transmissions in the millimetre wave band of interest to deployment of the 5G-XHaul system has been presented as summarised below:

- **USA: FCC Part 15.255** specifies +40 dBmi EIRP (max +27 dBm power) with extension to 82 dBmi minus 2 dB for every dB that the antenna gain is less than 51 dBi.
- **Europe: CEPT** : Unlicensed operation for indoor and outdoor operation subject to CEPT ECC/REC(09)01 limitations of maximum EIRP +55 dBm, minimum antenna gain +30 dBi and ,maximum transmitter output power of +10 dBm.
- **Europe: ETSI EN 302 217** for Fixed Wireless (Backhaul) specifies gain (>30 dBi) & (<+10 dBm) power separately > not optimum for phased array operation.
- **Europe: ETSI EN 302 567** for Wireless Access (WLAN) specifies EIRP +40 dBmi > similar to FCC Part 15.255 up to +40 dBmi – *applicable for 5G and wireless access in EU?*

The separation of antenna gain and transmit power for operation in European markets is an impediment to the use of cost effective 'beam steering' technology based on the use of phased array antenna and transceiver technology being developed for mass market 'WiGig' applications in the 57-66 GHz frequency band.

Therefore, a key objective is to achieve full alignment between the regulations applicable for operation in outdoor conditions between the US market under FCC Part 15.255 rules and European market under relaxed ETSI and CEPT rules –thus resolving the contradiction between EN 302 217 and EN 302 567 for operation in the 57-66 GHz band. This would maximise the commercial opportunity for deployment of flexible wireless infrastructure in alignment with the vision of the 5G-XHaul project.

Further steps will be taken by members of the 5G-XHaul project to continue lobbying for the rules to be changes – notably through CEPT SE19 group as the next step.

7 References

[1] CEPT ECC Recommendation 70-03 updated 2017.

[2] ABI Research comment on WiGig market development. https://www.abiresearch.com/press/80211ad-chipset-market-reach-critical-juncture-201/

[3] Tech UK seminar archive.https://www.techuk.org/component/techuksecurity/security/download/6870?file=4_BWT_mmW_BH_TechUK_Dec15_Rel.pdf&Itemid=182&return=aHR0cHM6Ly93d3cudGVjaHVrLm9yZy9pbnNpZ2h0cy9tZWV0aW5nLW5vdGVzL2l0ZW0vNjg3MC1tZWV0aW5nLW5vdGVzLWZyb20tbWstc3BmLWNsdXN0ZXItMi1ldmVudC1vbi1tbXdhdmU=

[4] ETSI mWT ISG Archive. http://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp15_mwt_semiconductor_technology.pdf

[5] International Wireless Industry Consortium. www.iwpc.org

8 Acronyms

Acronym	Description
3GPP	Third Generation Partnership Project
CEPT	European Conference of Postal and Telecommunications Administrations
ECC	Electronics Communications Committee (part of CEPT)
EIRP	Effective Isotropic Radiated Power (equals the product of transmitter power and antenna gain)
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
p2p	Point-to-Point