

RSSI level measurements on the RLAN 5 GHz (5150-5350 MHz)

LPI C2C communication implementation in RLAN 6 GHz (5945-6425 MHz)

DPSAI / DCS - ANFR

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ECC Decision (20)01

on the harmonized use of the frequency band 5945-6425 MHz for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN)

Table 1: Low Power Indoor (LPI) WAS/RLAN devices

Parameter	Technical conditions
Permissible operation	Restricted to indoor use only (including trains where metal coated windows (note 1) are fitted and aircraft) Outdoor use (including in road vehicles) is not permitted.
Category of device	An LPI access point or bridge that is supplied power from a wired connection, has an integrated antenna (note 3) and is not battery powered. An LPI client device is a device that is connected to an LPI access point or another LPI client device and may or may not be battery powered.
Frequency band	5945-6425 MHz
Channel access and occupation rules	An adequate spectrum sharing mechanism shall be implemented.
Maximum mean e.i.r.p. for in-band emissions (note 2)	23 dBm
Maximum mean e.i.r.p. density for in-band emissions (note 2)	10 dBm/MHz
Maximum mean e.i.r.p. density for out-of-band emissions below 5935 MHz (note 2)	-22 dBm/MHz
Note 1: Or similar structures made of material with comparable attenuation characteristics. Note 2: The "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. Note 3: Or a distributed antenna system installed inside a train or an aircraft.	

- LPI category – 200mW e.i.r.p.
- Indoor only

Client to Client (C2C) implementation proposed by industry in the harmonised standard EN 303 687 RLAN 6 GHz

- To enable the C2C communication the RLAN PLI clients need to decode an enabling signal of greater or equal to -93 dBm/MHz received from an LPI AP
- The enabling signal should be decoded in an elapsed time of 4s

The implementation proposed by industry is sensible because it will determine the **enforcement of the operation of LPI C2C in indoor environment.**

Protection of services in band:

- FSS (Fixed Satellite Service)
- FS (Fixed Service)

Measurement campaign carried out by ANFR

Some measurements were carried out by industry and academy to determine this level of the Enabling Signal in deployments in United States, particularly in some University Campus. See: <https://arxiv.org/pdf/2307.00235.pdf> ; [link](#).

However, the density of deployment in Universities Campus is very different from the density of deployment expected for this band in European cities (e.g. the number of Access Points deployed by geographical area, the dimension of the streets).

In order to have a realistic deployment in terms of the density for the RLAN 6 GHz (5945-6425 MHz) in some European cities, ANFR carried out some measurement campaigns of RLAN 5 GHz (indoor) in Paris to have an approximation on the RSSI levels detected by a Client device in outdoor environment.

Measurement campaign carried out by ANFR

OBJECTIVE:

- Measure the RSSI levels of RLAN AP operating in the 5150-5350 MHz band (indoor) received by a device in movement in outdoor environment (walking measurement) in some residential areas in Paris.
- Calculate the Cumulative Distribution Function (CDF) to find the probability of the levels of the RSSI received by the tools used for the measurement.

Measurement campaign carried out by ANFR

ENVIRONMENT AND GEOGRAPHICAL AREAS:

Measures were made in three districts of Paris characterized by being residential areas with the aim to have an example of realistic deployment in European cities, in terms of the density of deployment.

- XII District - Aligre
- XIV District - Alésia
- XVI District - Passy



Measurements tools

Tools	Model / Software	Information
Tablet (Hardware)	Surface PRO9	Windows 11 Professionnel Intel (R) Wi-Fi 6E AX211 160MHz
Scan software	Wi-Fi Analyzer	Acrylic Suite

Tablet Surface PRO9 and Acrylic WiFi Analyzer

- Information provided by this tool includes multiple metrics as Bandwidth, Retries, Speed, RSSI level and other detailed information about WiFi devices as the ISSD and MAC Address.
- This software counts with a graphical interface showing in real time the behavior of the WiFi devices detected and allows to keep a .html file with the behavior of the RSSI level detected vs time.
- The collection of network data is made in format .pcap (packets) file and .csv file (data collected at the last time the WiFi device was seen by the tablet). A .kml file can be generated having as source the .pcap file to have a graphical interface on the geographical area where the measurements were made.



RSSI is related to the beacons sent in the lower channel width of 20MHz.

Data collected and its treatment

- **.csv file :**
- The interesting data collected for these measures with the .csv is shown as:

SSID	#	MAC Address	RSSI	SNR	Channel	Band	Width	802.11	First seen	Last seen	Latitude	Longitude
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This information is treated with excel to obtain the CDF (Cumulative Distribution Function) of the RSSI AP levels for the AP operating in the band 5150-5350 MHz where they are allowed to operate in indoor environment. Every RLAN AP detected by the tablet is registered with the parameters read by this device during the last seen.

Every RLAN AP detected is registered in this file, then the number of entries gives the number of AP operating in the geographical area.

Data collected and its treatment

- **.pcap file:**

This file contains traffic packets detected by Acrylic WiFi Analyzer during the time of scanning, that is why the number of samples is much higher than the number of samples recorded in .csv files.

This file is treated initially with WireShark software to extract the interesting information for these measurements (e.g. RSSI level, Central Frequency) and converted to a .csv file to be treated and analyzed with excel. A Cumulative Distribution Function is obtained from the treatment of this data.

It is important to highlight that the .pcap file register any packet received in 2.4 GHz, 5 GHz and 6 GHz band, it means that the button filters do not have impact on the .pcap file, all packets are recorded.

Data collected and its treatment

- .html file:



Data collected and its treatment

- **.kml file:**

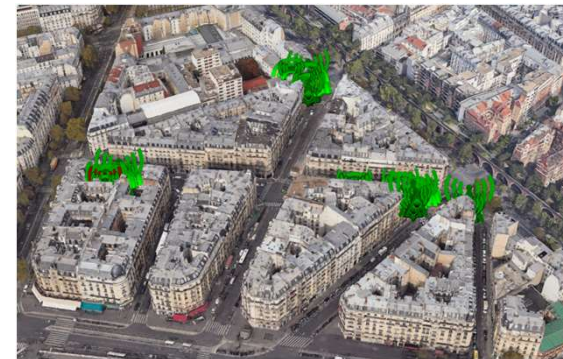
This file allows to present in a visual mode the places where the measurements were made and gets some information from the AP placed in the graphics (e.g. ISSD, MAC Address, others). These files can be read in Google earth software to get the information in a graphical way.



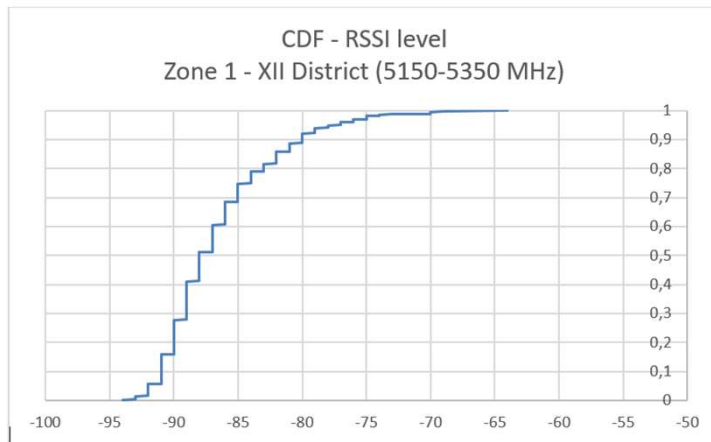
Outcomes

XII District - Aligre

XII District	Distance (km)	Time (minutes)	Number of AP in 5150-5350 MHz band (.csv file)	Packets received in 5150-5350 MHz band (.pcap file)	CDF
Zone 1	1,08	43	548	55495	The median of both .csv (number of AP) and .pcap (packets) data is shown between -88dBm to -87dBm
Zone 2	1,94	27	945	59813	
Zone 3	1,6	15	757	48717	

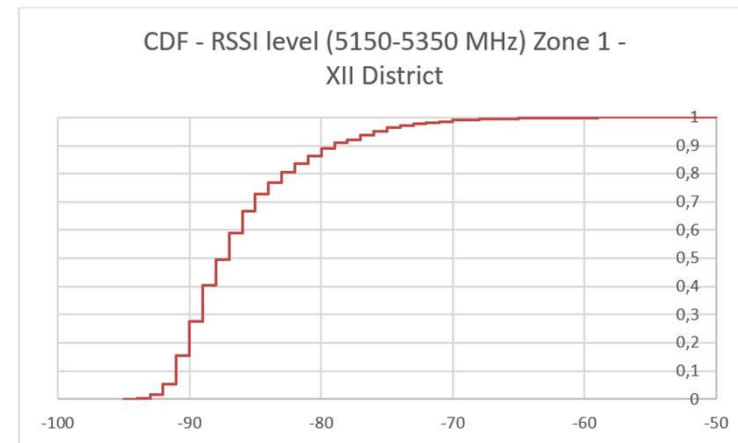


Outcomes



.cvs file

50% of the emissions detected have a level upper than -88dBm
10% of the emissions detected have a level upper than -79dBm



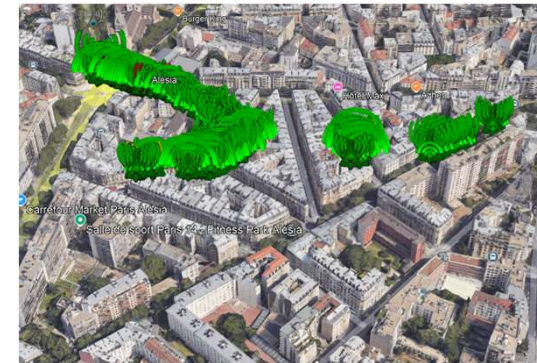
.pcap file

50% of the emissions detected have a level upper than -87dBm
10% of the emissions detected have a level upper than -79dBm

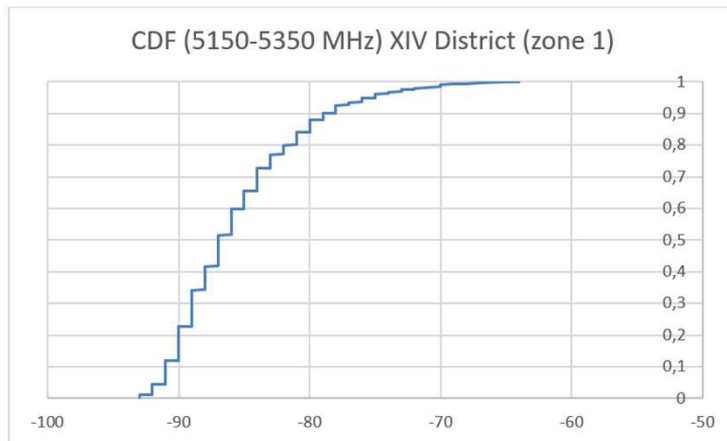
Outcomes

XIV District - Alésia

XIV District	Distance (km)	Time (minutes)	Number of AP in 5150-5350 MHz band (.csv file)	Packets received in 5150-5350 MHz band (.pcap file)	CDF
Zone 1	4,61	41	674	43572	The median of both .csv (number of AP) and .pcap (packets) data is shown between -88dBm to -87dBm
Zone 2	4,41	42	1036	63112	

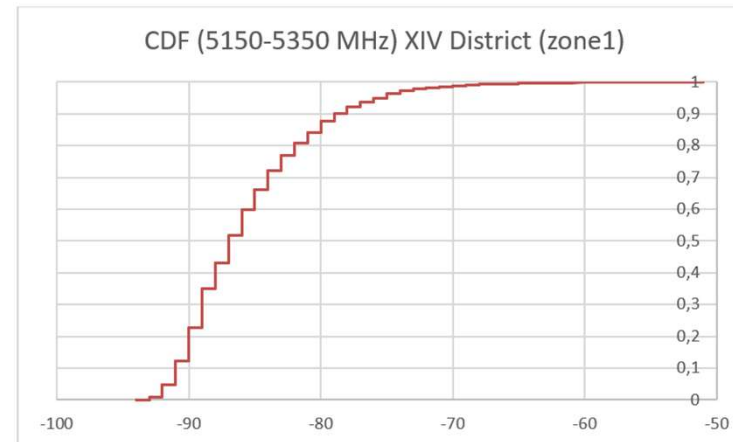


Outcomes



.cvs file

50% of the emissions detected have a level upper than -87dBm
10% of the emissions detected have a level upper than -78dBm



.pcap file

50% of the emissions detected have a level upper than -87dBm
10% of the emissions detected have a level upper than -78dBm

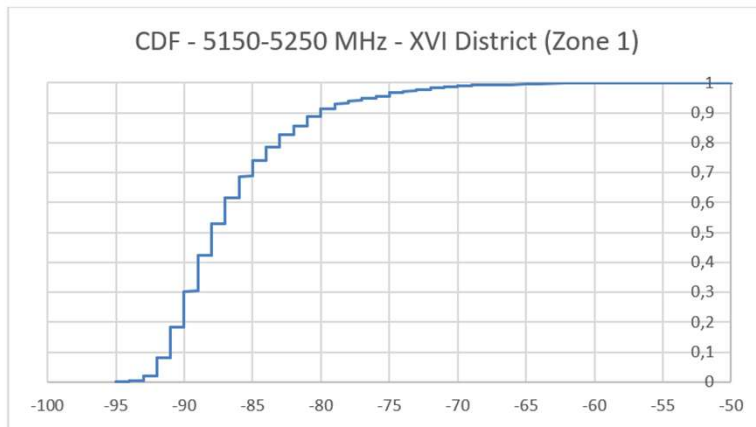
Outcomes

XVI District - Passy

XVI District	Distance (km)	Time (minutes)	Number of AP in 5150-5350 MHz band (.csv file)	Packets received in 5150-5350 MHz band (.pcap file)	CDF
Zone 1	4,61	45	1122	68993	The median of both .csv (number of AP) and .pcap (packets) data is shown between -88dBm to -87dBm
Zone 2	3,46	37	847	54774	

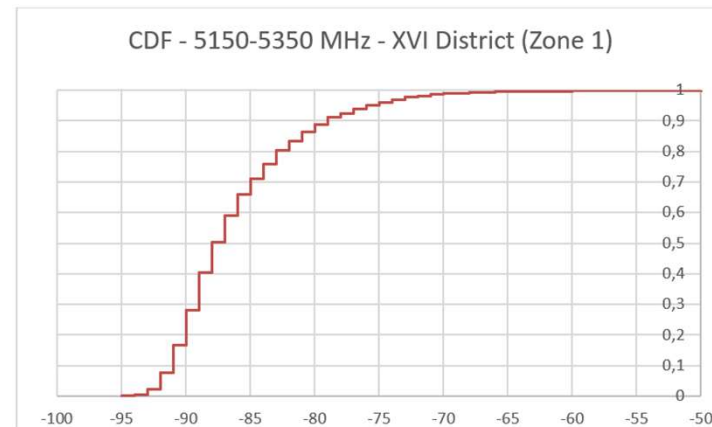


Outcomes



.cvs file

50% of the emissions detected have a level upper than -88dBm
10% of the emissions detected have a level upper than -80dBm



.pcap file

50% of the emissions detected have a level upper than -88dBm
10% of the emissions detected have a level upper than -79dBm

Conclusions

- The current density of deployment of RLAN in the 5 GHz band in Paris, particularly in the residential areas is representative of a realistic scenario of deployment expected for the RLAN 6 GHz band (5945-6425 MHz). The walking measurements carried out in this campaign show that a high number of AP operating indoor could be detected by a Client device in outdoor environment.
- **At least 10% of the RSSI levels are detected in outdoor environment at levels higher than -80dBm/20MHz emitted by Access Points operating in 5150-5350 MHz (indoor band).**
- 10% of RSSI level of signal received by any Client device in a high densified outdoor environment is still a very high percentage of probability for the C2C communication between LPI devices considering that regulatory framework sets out an operation indoor only for the 6 GHz band.

Conclusions

- The percentage of RSSI levels detected can be bigger than the 10% shown by the statistics because the level of RSSI registered by the tool is the last seen value. In some cases, the last seen value is the worst one because the tool was moving away from the AP.
- In high densified scenarios as the residential areas in European cities, implementation of indoor operation regulation in the RLAN 6 GHz band (5945-6425 MHz) for C2C communication cannot be based on an enabling signal at a level of -93 dBm/MHz due to the high number of indoor AP exhibiting a significant signal level outside buildings.
- **The protection of the services operating in-band (FSS and FH) will be impacted by the impossibility of enforcing the indoor only use condition for the C2C LPI in ECC/DEC/(20)01 RLAN 6GHz.**

Food for thought

- Which could be the suitable level for the enabling signal to have more certainty on the enforcement of the only indoor use for the C2C LPI communication? Through:
 - other measurement campaigns
 - further analysis of available data
- It could be suitable to add another condition to the implementation? Example:
 - both LPI Client devices should receive the enabling signal from the same RLAN network to enable the C2C communication

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