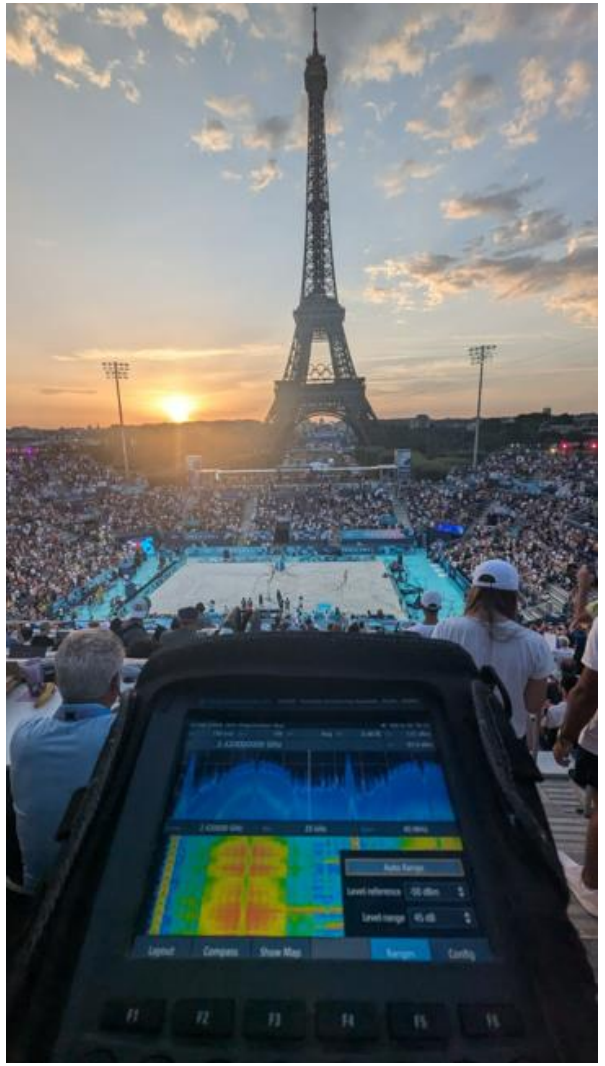
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

ANFR
AGENCE NATIONALE DES FRÉQUENCES

Spectrum lessons from the Paris Olympic and Paralympic Games

Wireless Innovation Forum (hosted by Shure, London)



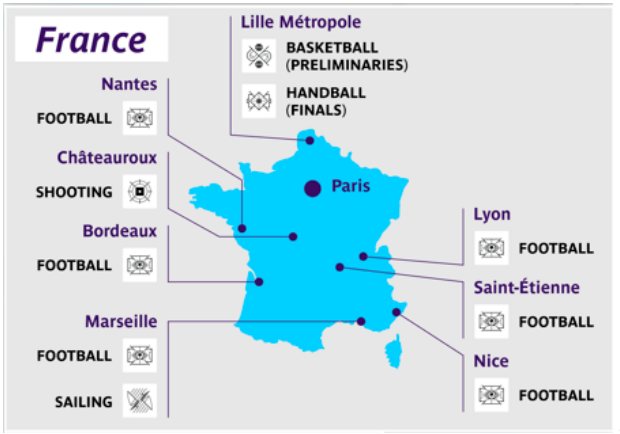
Thursday 31st October 2024

Spectrum Management Plan

The **bands** made available for Paris 2024 were presented in the **Spectrum Management Plan (SMP)** guide.
=> Resulting from an iterative process steered by ANFR with representatives of governmental bodies / independent authorities involved in national spectrum management and with Paris 2024

RÉPUBLIQUE FRANÇAISE
Liberté Égalité Fraternité
ANFR
AGENCE NATIONALE DES FRÉQUENCES

Timelines:
- Frequency plan :
  - Start September 2021
  - Approved June 2022
- Spectrum Management Plan (SMP)
  - Version 1 - July 2022
  - Version 2 - March 2023



For audio PMSE:

- The 35 MHz band: 32-39 MHz
- The VHF band: 174-230 MHz,
- The UHF band: 470-698 MHz,
- The 700 band: 736-753 MHz,
- The 800 band: 821-832 MHz,
- The 1200 band: 1240-1260 MHz,
- The 1300 band: 1375-1400 MHz,

For video PMSE: Ground to ground, Air to ground and Ground to air links

- 1300- 1350 MHz,1427-1518 MHz,1525-1559 MHz
- 1613.8-1660 MHz, 1675-1705 MHz, 1785-1805 MHz
- 1980-2110 MHz, 2170-2500 MHz
- 2570-2620 MHz,
- 2700-2900 MHz,
- 3400-3490 MHz
- 3800-3900 MHz, 4000-4200 MHz
- 4400-4990 MHz, 5091-5150 MHz, 5850-5875 MHz
- 6425-7250 MHz, 7750-7900 MHz

For PMR, several subbands within:

- The VHF band: 68.4625…173,5 MHz
- The UHF band: 403.5 … 470 MHz

https://olympics.com/en/paris-2024/information/spectrum-management-plan-for-the-olympic-and-paralympic-games

Coordination constraints & effective availability (1)

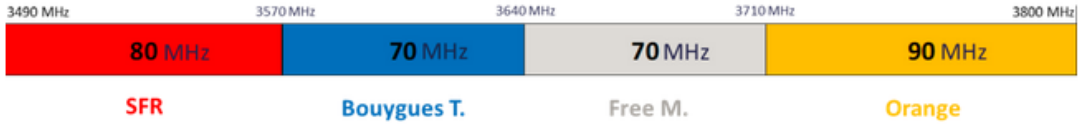
RÉPUBLIQUE FRANÇAISE
Liberté Égalité Fraternité

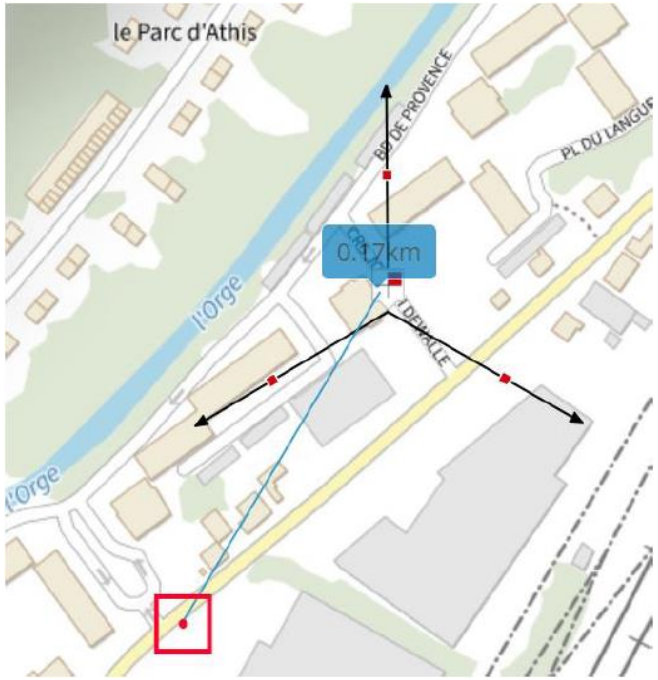
ANFR
AGENCE NATIONALE DES FRÉQUENCES

❑ Coordination with **radars**: 1240-1260 MHz, 1300-1350 MHz, 2.7-2.9 GHz

- **1240-1260 MHz** (**Audio**): measurements at Bordeaux stadium for coexistence with civil aviation radars
  (& protection of EGNOS RIMS station at Paris observatory receiving L2 GPS (1227,6 MHz))
- **1300-1350 MHz** (Cameras): several radars visible within 400 km radius around Paris, only 1300-1310 MHz channel could avoid co-frequency interference for reception @ 8000 m
  (& coexistence with radio astronomy in in 1330-1350 MHz: see Annex A)
  => Available in SMP for **G2G**, **A2G** & **G2A** links: used during Paris 2024 only for **G2G** links
- **2.7-2.9 GHz** (Cameras): measurements near Paris Orly airport => avoidance of radar channels / adjacent channels depending on the venue, use only for **G2G** links

❑ Wireless cameras adjacent to **MNO's downlink bands** (BS tx): location of wireless camera receiver in proximity to Base Station should be avoided
=> Impact to channels adjacent to 2110-2170 MHz, 2620-2690 MHz, 3490-3800 MHz
=> Measurements performed in **3400-3490 MHz** show poor video reception quality within 3440-3490 MHz, even if the camera is close to the receiver (no filtering of 5G BS emissions in accordance with 3GPP standard)





Measurements in **3400-3490 MHz**: SFR base station located at 170 m from the receiver (red square), with a clear line of sight

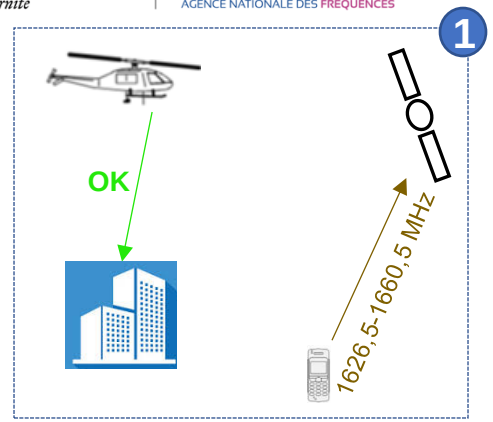
❑ Wireless cameras in **1427-1518 MHz** (**L band**) : studied for **G2A**↑ links with **fixed wings** @ 8000 m
=> Cross-border issues assessed taking into account Mobile SDL assignment process in Belgium, Germany, UK & Italy
=> Band finally selected in SMP for **A2G**↓ links (assigned to helicopter tx @ 500 m)

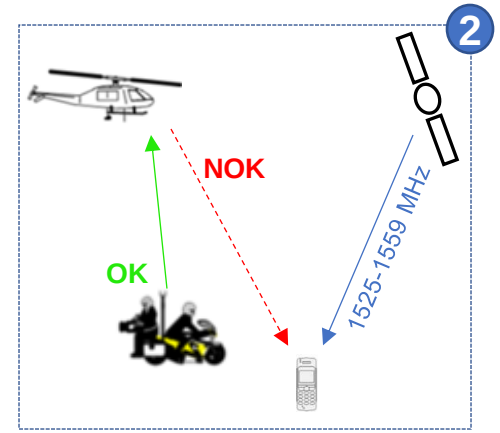
Coordination constraints & effective availability (2)

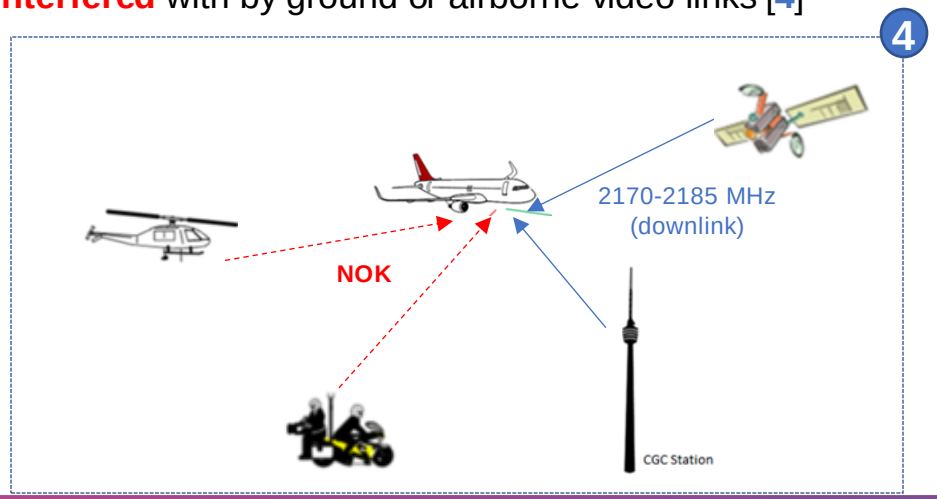
- Coordination with **receiving Earth stations**: meteorology (1675-1705 MHz), space operation (2025-2110 MHz), fixed satellite (3800-4200 MHz)

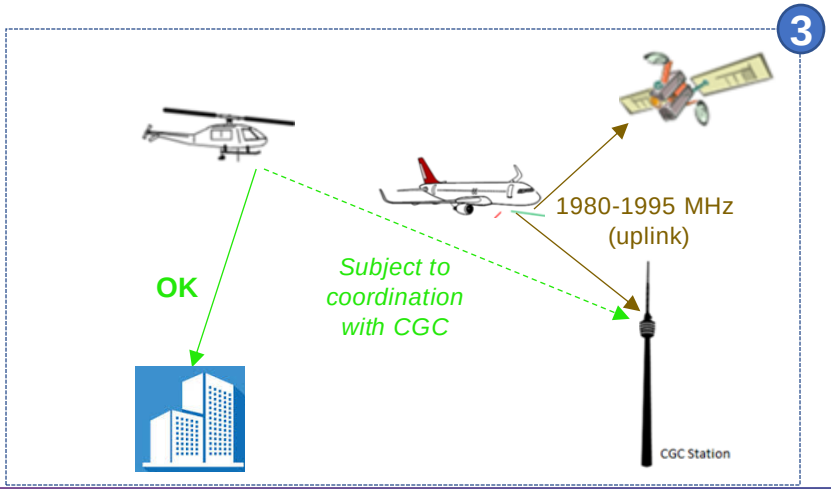
- Coordination with MSS in 1525-1559 MHz (↓), 1613.8-1660 MHz (↑↓), 1980-2010 MHz (↑) & 2170-2200 MHz (↓): **coexistence with mobile airborne video links supported by selecting G2A↑ & A2G↓ directions that is reverse to the MSS uplink↑ / downlink↓ directions**

  - Airborne video transmission (**A2G↓**) in **MSS uplink** band (↑) cannot interfere with MSS ground terminals… & has reduced gain towards receiving space station [1]
  - Airborne video reception (**G2A↑**) in **MSS downlink** band (↓) is not interfered with by terminals… [2]
  - Limited risk of interference between Cameras on the ground and MSS terminals outside venues
  - MSS 2 GHz / Inmarsat aeronautical services supported by Complementary Ground Component (CGC) systems
    - Uplink (↑) aircraft terminals transmitting in 1980-1995 MHz : possible need for **coordination** with Inmarsat CGC [3]
    - Downlink (↓) aircraft terminals receiving in 2170-2185 MHz could be **interfered** with by ground or airborne video links [4]









Frequency assignments

Olympic Games

16 762 frequencies have been authorised for competition venues, opening and closing ceremonies including:

Services	# frequencies
audio PMSE	10 657
video PMSE	621
PMR	3 128

Paralympic Games

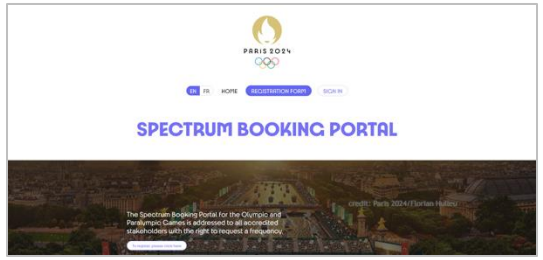
6 200 frequencies have been authorised for competition venues, opening and closing ceremonies including:

Services	# frequencies
audio PMSE	3455
video PMSE	204
PMR	1778

NB: the number of licences per frequency bands is detailed for audio/video PMSE in Annex A

Assignment process : a multi-stage approach

All the stakeholders had the opportunity to request frequencies through the Paris 2024 **Spectrum Booking Portal (SBP)**

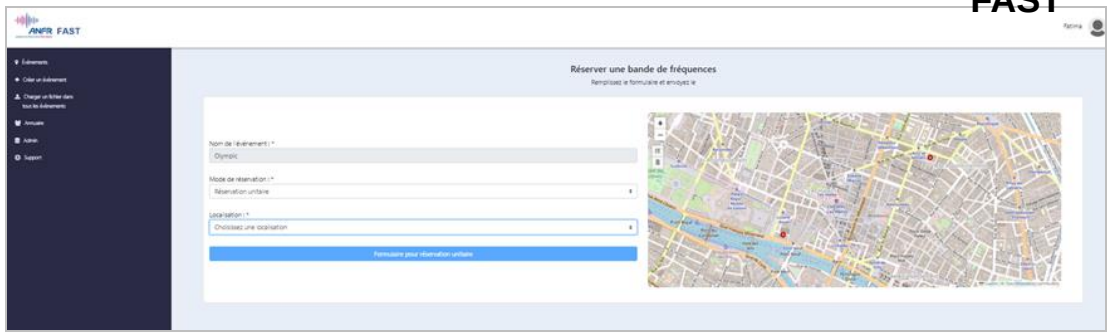


Timelines:
- Spectrum Booking Portal (SBP) made available February 2023
- First detailed frequency assignment plan consolidated July 2023

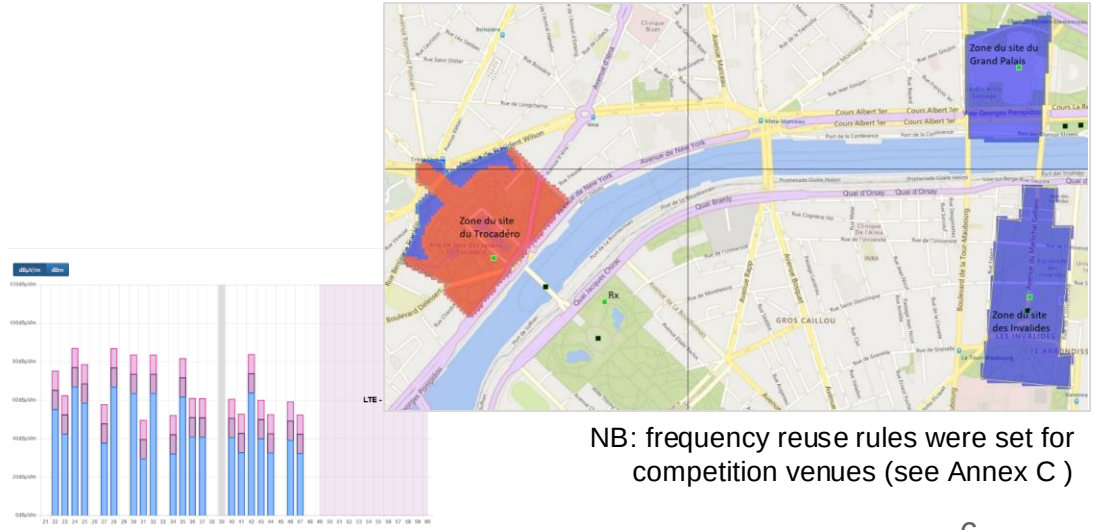
The ANFR has automated the assignment of the frequencies for PMR, audio and video PMSE services, with the support of its internal tool (FAST):

- For a given service (PMR, audio or video PMSE), several clusters of competition's venues were defined in Paris and its suburb
- Each cluster was associated to a pool of frequencies
- Competition venue frequency assignment was exclusive within each cluster according to the rules defined by a global reuse matrix
- Manual management was applied in various cases to accommodate coexistence constraints (e.g. fixed wings, helicopters)

FAST



- The **FAST** configuration (exclusion rules) was inherited from theoretical compatibility studies (with earth stations, radars…) or measurement campaigns (focus done on audio and video PMSE)



NB: frequency reuse rules were set for competition venues (see Annex C)

https://scanfrequences.anfr.fr/

Lessons learned

For audio PMSE:

- Power limitation to 50 mW to reduce IM3,
- Most of the requested channel bandwidths were 200 kHz (few demands at 25 or 50 kHz but in case of issues, 200 kHz BW was assigned),
- ANFR rule was to assign as much as possible the requested channels and to use a random channel spacing with a minimum of 600 kHz for a given stakeholder

- Few requests in the VHF band (DAB+ white space),
- **The UHF band: overloaded,**
- The 700 and 800 bands: the ANFR made a push to use those bands,
- The 1200 band: only used by Japanese company,
- **The 1300 band: no request**

For video PMSE:

- The requested channel bandwidths were mostly 20 MHz and 16 MHz (10 MHz only for motorbikes used for road events),
- Guard band of 3 MHz between channels (at least for A2G and G2A),
- Bands with no demand: > 7750 MHz, 3400-3490 MHz,
- No adjacent band issue with other MNO's band: generally one video PMSE channel used as guard band,
- 4400-4990 & 5091-5150 & 5850-5875 MHz finally used for telemetry systems,
- **2700-2900 MHz: success** (NB: interference cases in Marseille with a fixed 3 GHz radar station and with radars on board ships were addressed)

Others:

- Inefficient filtering of **some DECT equipment** (1880-1900 MHz) used for Intercom: impact of adjacent LTE 1800 band,
- Coexistence issue between **GNSS and 1550 MHz video PMSE** (One 20 MHz channel forbidden),
- Congestion concerns on some SRD license-exempt band: e.g. intercom application for referees @ 868 MHz, DECT…

ANNEXES

A) Spectrum usage by audio/video links
B) Coexistence studies (examples)
C) Frequency reuse rules for competition venues

A- Spectrum usage by audio links

1) Overview :

Band	Frequency band (MHz) CEPT ERC/REC 25-10	Estimated available spectrum in SBP	Number of licences*
30 MHz	32 – 39 MHz	0,45 MHz	73
VHF	55 – 68 MHz	0,9 to 2 MHz	0
	174 – 223 MHz (A2: 174-216 MHz)	Depending on venue	2
	223 – 224.792 MHz	Depending on venue	19
	226 – 230 MHz	4 MHz	0
UHF	470 – 694 MHz (A3: 470-694 MHz)	Depending on venue	12 345
	694 –698 MHz	4 MHz	79
	736 –753 MHz (A4: 733-757.5 MHz)	17 MHz	796
	821 –823 MHz (A5: 821.5-832 MHz)	2 MHz	189
	823 – 826 MHz (A5: 821.5-832 MHz)	3 MHz	13
	826 – 832 MHz (A5: 821.5-832 MHz)	6 MHz	78
1,2 GHz	1240 – 1260 MHz	20 MHz	264
	1350 – 1400 MHz (A7: 1350-1400 MHz)	9 MHz	0
1,5 GHz	1518 – 1525 MHz (A8: 1518-1525 MHz)	7 MHz	0

* 1 frequency used by a **PMSE audio link** requires 1 **licence** for each considered site & event (Olympics games, Paralympics games, Opening/Closing ceremonies)

A- Spectrum usage by video links

1) Overview :

Frequency bands CEPT ERC/REC 25-10	Estimated available spectrum in SBP	Number of "licences" *
1300 – 1350 MHz	From 20 to 50 MHz	9
1427 – 1518 MHz	90 MHz	58
1525 – 1559 MHz	34 MHz	22
1613.8 – 1660 MHz	46.2 MHz	4
1675 – 1705 MHz	30 MHz	2
1785 – 1805 MHz	20 MHz	1
1980 – 2010 MHz	From 15 to 30 MHz	23
2010 – 2025 MHz (C1)	15 MHz	17
2025 – 2110 MHz (C2)	40 MHz	45
2170 – 2200 MHz	15 MHz	10
2200 – 2290 MHz (C3)	40 MHz	68
2290 – 2310 MHz (C3/C4)	20 MHz	25
2310 – 2400 MHz (C4)	30 MHz	33
2400 – 2483.5 MHz (C5)	83.5 MHz	8
2483.5 – 2500 MHz (C5)	16.5 MHz	3
2570 – 2620 MHz	up to 50 MHz	12
2700 – 2900 MHz (C6)	From 90 to 190 MHz	64
3400 – 3490 MHz	From 40 to 90 MHz	7
3800 – 3900 MHz & 4000 – 4200 MHz	From 200 to 300 MHz	0
4400 – 4990 MHz	From 10 to 50 MHz	4
5091 – 5150 MHz	59 MHz	6
5850 – 5875 MHz	25 MHz	3
6425 – 7115 MHz	From 440 to 690 MHz	307
7115 – 7250 MHz (C7)	135 MHz	82
7750 – 7900 MHz (C7)	From 70 to 150 MHz	0

* 1 frequency used by a **video link** requires 1 **licence** for each considered site & event (Olympics games, Paralympics games, Opening/Closing ceremonies)

2) Main bands planned for / used by aerial means :

Frequency bands	Directions in SBP	Effective spectrum assignment
1300 – 1350 MHz	G2G / A2G / G2A	
1427 – 1518 MHz	G2G / **A2G**	1x **G2A** channel 6x **A2G** channels @ 500 m Paris & Marseille)
1525 – 1559 MHz	G2G / **G2A**	3x **G2A** channels
1613.8 – 1660 MHz	G2G / **A2G**	1x **A2G** channel @ 500 m
1675 – 1705 MHz	G2G / A2G / G2A	
1785 – 1805 MHz	G2G / A2G / G2A	
1980 – 2010 MHz	G2G / A2G	
2010 – 2025 MHz	G2G / A2G / G2A	
2025 – 2110 MHz	G2G / **A2G**	1x **A2G** channels @ 3000 m (low flying fixed wings)
2170 – 2200 MHz	G2G / G2A	
2200 – 2290 MHz	G2G / A2G / **G2A**	3x **G2A** channels for opening ceremony
2290 – 2310 MHz	G2G / A2G / **G2A**	1x **G2A** channel for opening ceremony 2x **G2A** channels
2310 – 2400 MHz	G2G / **A2G** / **G2A**	3x **A2A** channels @ 300 / 500 m 1x **G2A** channel for opening ceremony
7115 – 7250 MHz	G2G / **A2G**	4x **A2G** channels @ 8000 m
7750 – 7900 MHz	G2G / A2G	

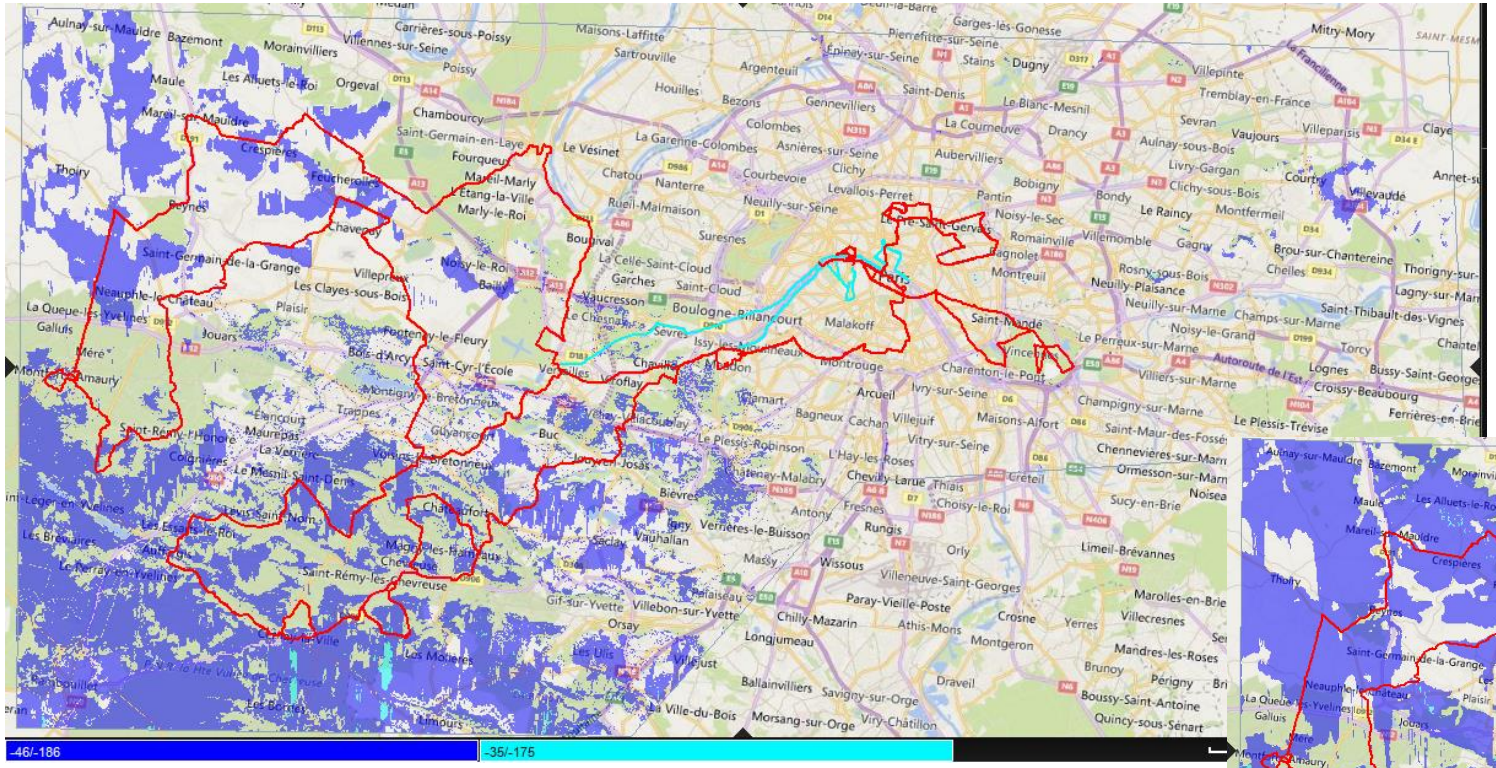


Fig. 1 : no interference zones for a wireless cameras of 24 dBm at **2 m**.

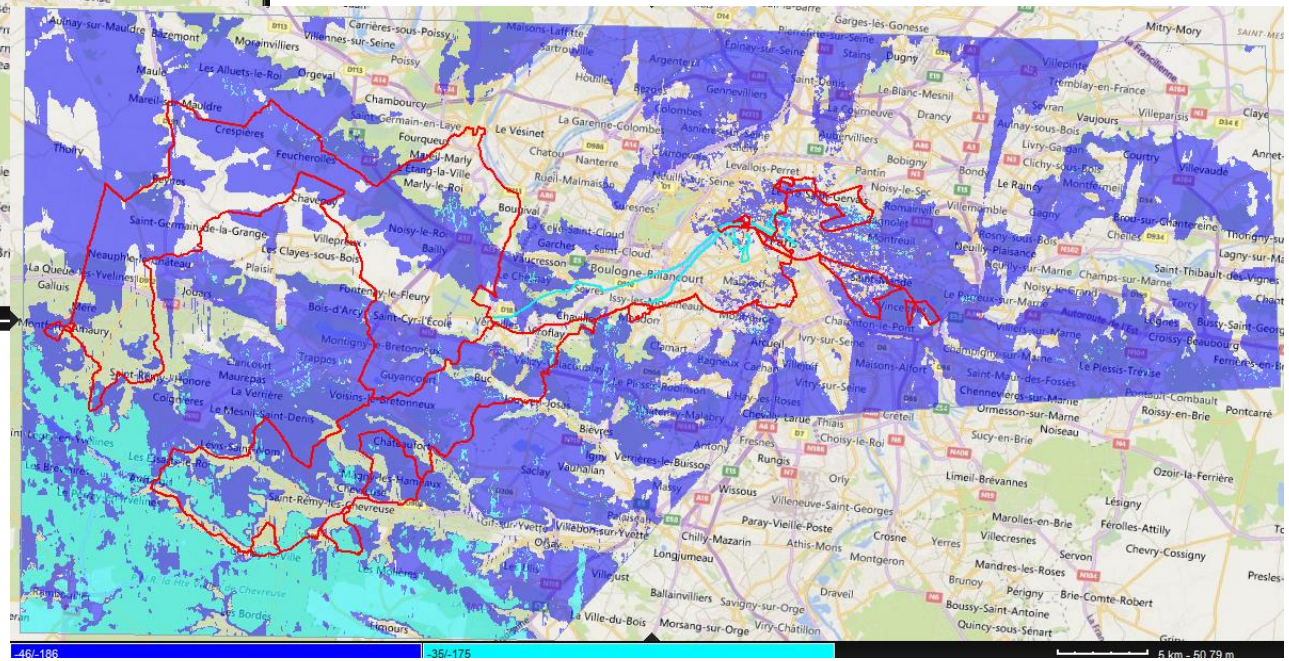
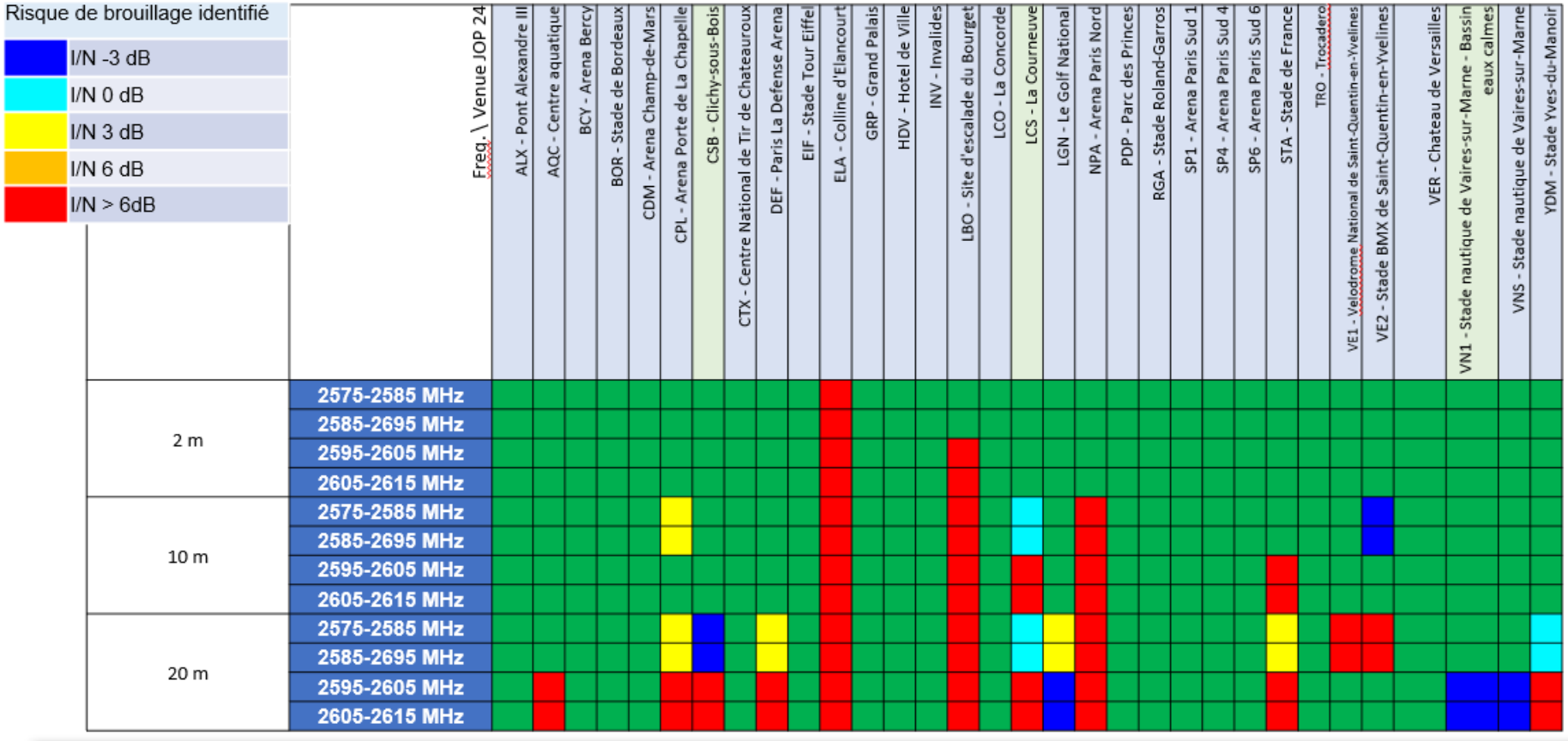


Fig. 2 : Radio astronomy protection threshold exceeded in certain areas of the cycle race for a wireless camera at **20 m**

B- Coexistence studies (example 2)

Coexistence with PMR 4G LTE in 2570-2620 MHz

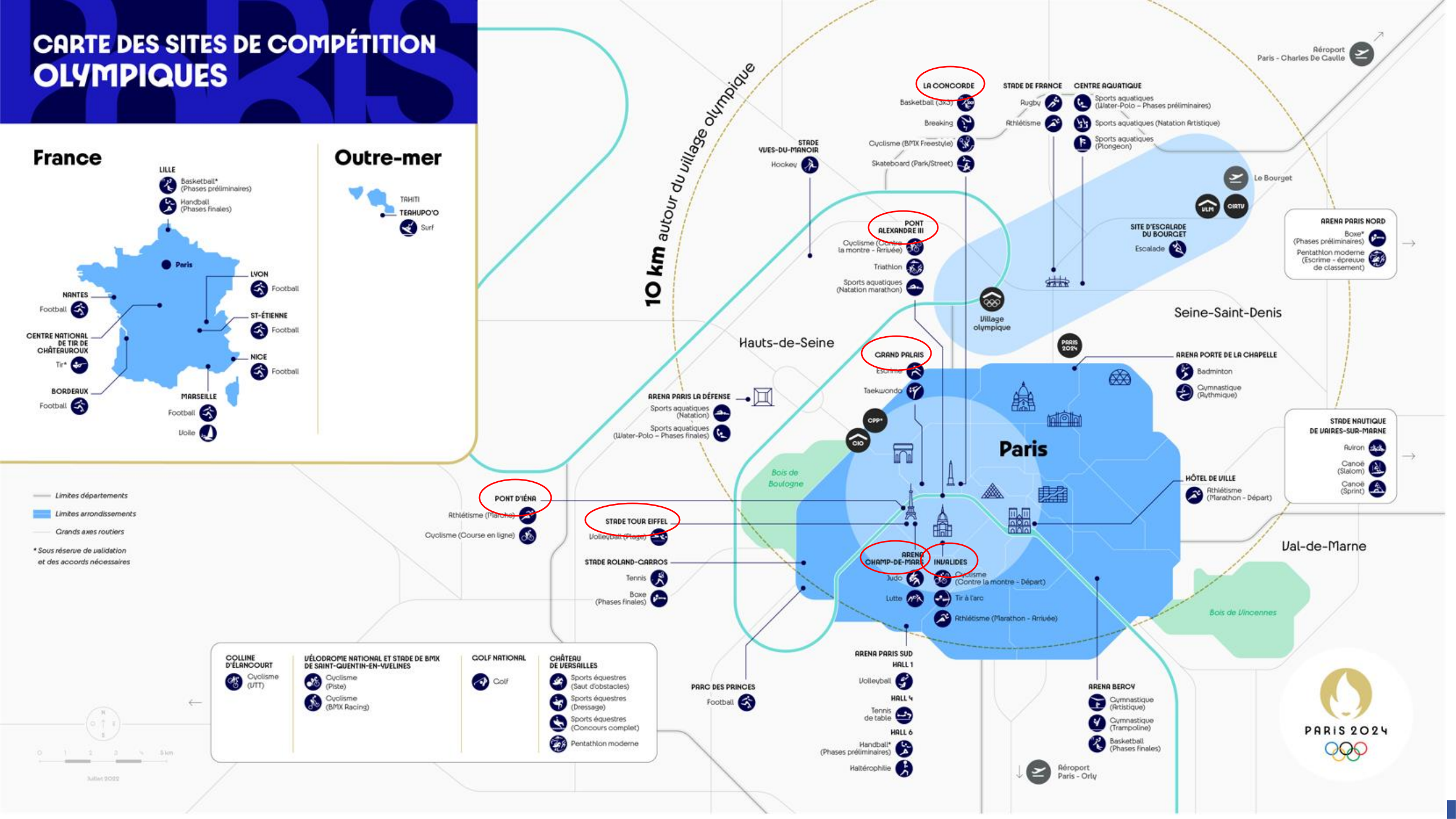


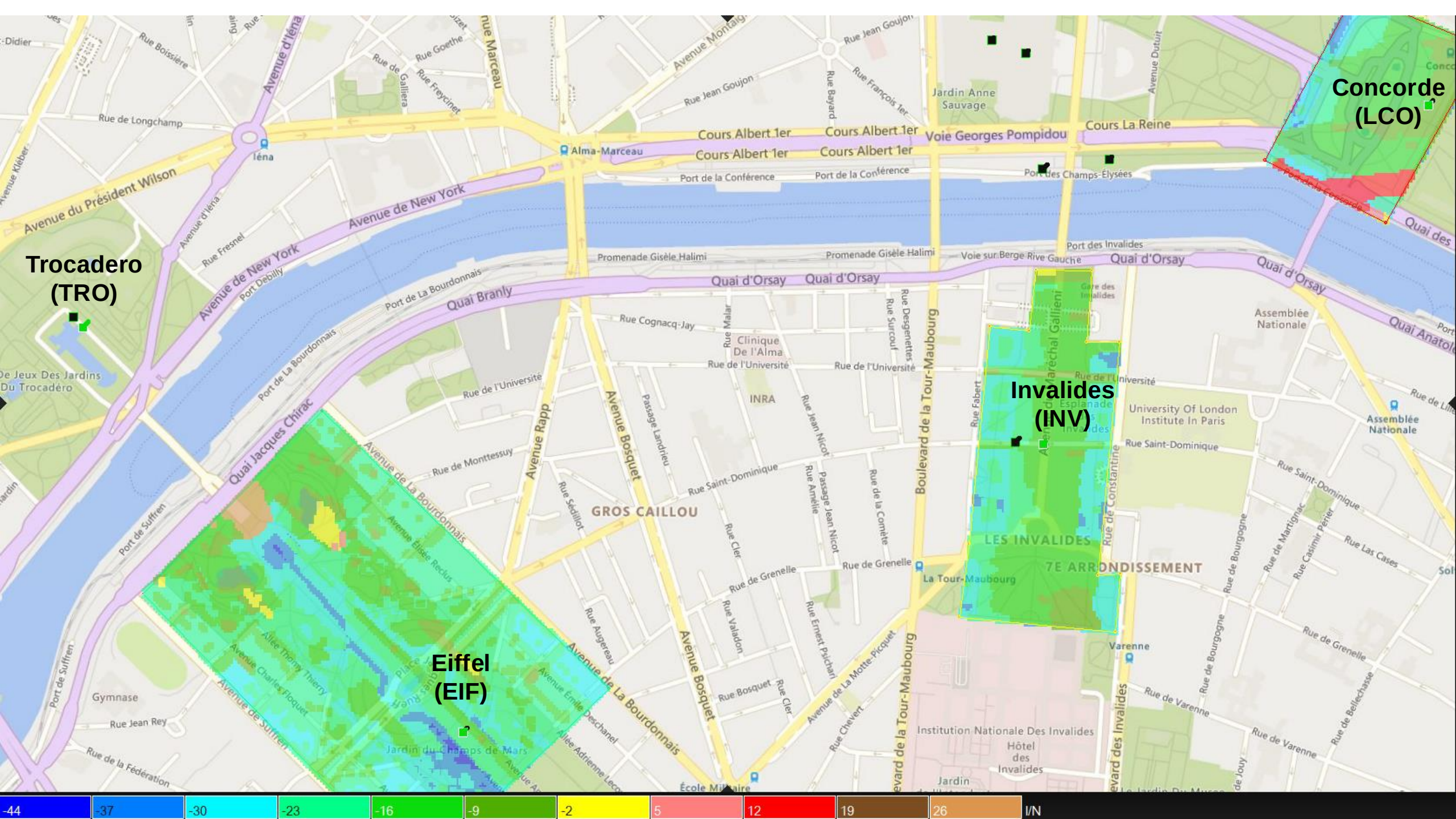
2,6 GHz TDD band : Assessment of spectrum availability depending upon coexistence with LTE private networks authorised in Paris Region

C - Frequency reuse rules were set for competition venues

- Wireless camera (ground-to-ground) spectral resources are limited (compared to the needs) and frequency reuse is necessary to meet the overall demand
- Frequency reuse is constrained by the proximity of the sites especially for sites in the centre of Paris
- To perform a frequency plan per site for the wireless camera service, frequency reuse rules were identified
  - By frequency band
  - By defining clusters where reuse is prohibited

CARTE DES SITES DE COMPÉTITION OLYMPIQUES




Concorde
(LCO)
Trocadero
(TRO)
Invalides
(INV)
Eiffel
(EIF)
-44
-37
-30
-23
-16
-9
-2
5
12
19
26
I/N

Results, Validation and Decision

Measurement results at Eiffel venue (EIF) in reception

Tx Position	**TRO** – 2m – 100mW		**CDM** – 2m – 250mW (Doors closed)		**INV** – 2m – 250mW		**LCO** – 2m – 250mW	
Frequency	2280 MHz	7080 MHz	2280 MHz	7080 MHz	2280 MHz	7080 MHz	2280 MHz	7080 MHz
Signal level (dBm)	-97	-100	-110	-115	-124	-	-	-118
Video quality	Bad	Bad	Good	Good	Good	Good	Good	Good

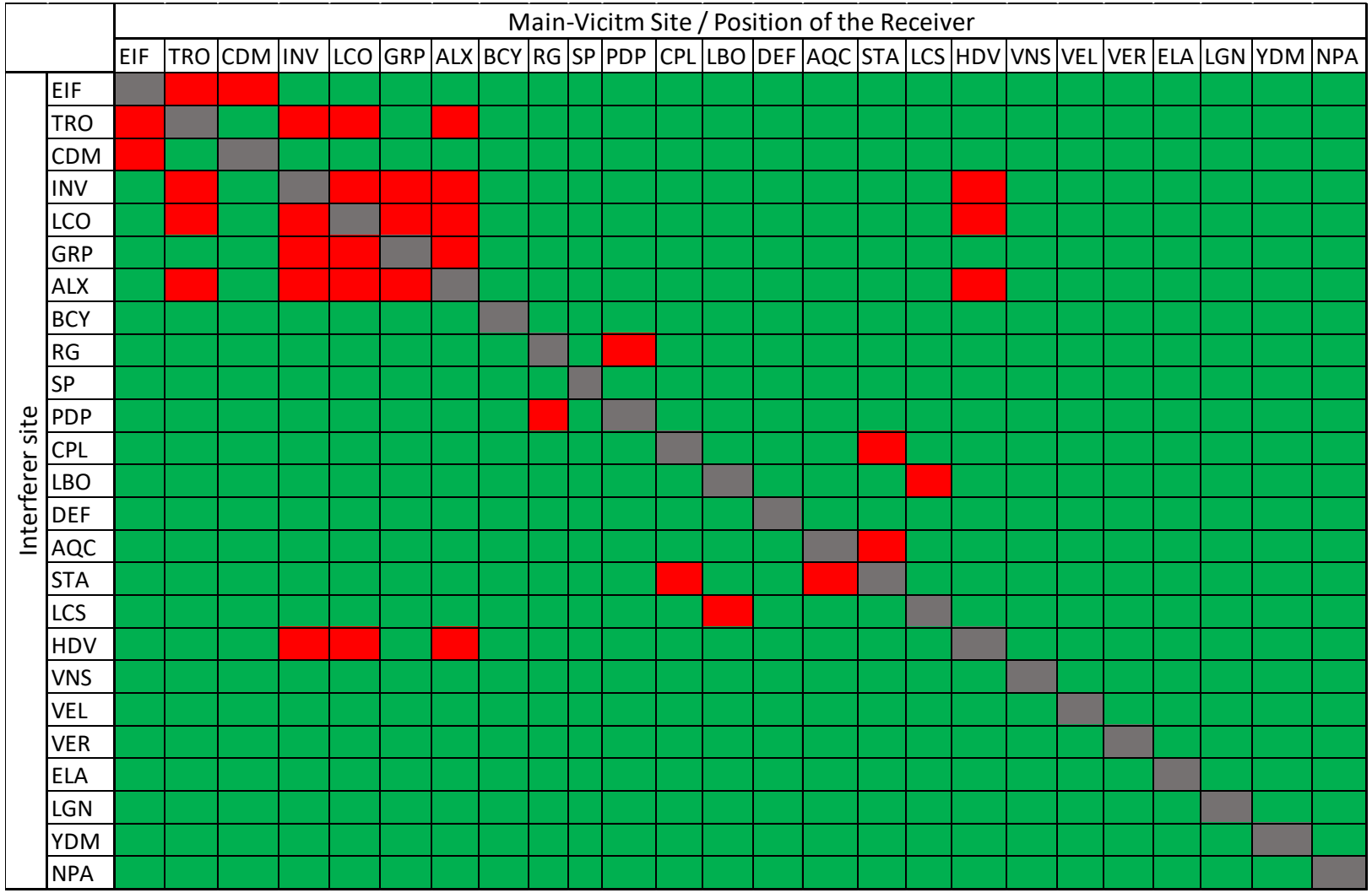
Tx Position	**TRO** – 10m – 100mW		**CDM** – 2m – 250mW (Doors open)*		**INV** – 10m		**LCO** – 10m – 250mW	
Frequency	2280 MHz	7080 MHz	2280 MHz	7080 MHz	2280 MHz	7080 MHz	2280 MHz	7080 MHz
Signal level (dBm)	-98	-105	-	-98	-123	-118	-124	
Video quality	Bad	Bad		Bad	Good	Good	Good	

* Doors should remain closed in front of EIF, otherwise a risk of interference occurs

Frequency Reuse Table (examples)

Frequencies up to 4990 MHz

Decision based on measurement results & simulations



RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

ANFR
AGENCE NATIONALE DES FRÉQUENCES

Agence nationale des fréquences

T. +33 (0)1 45 18 72 72
F. +33 (0)1 45 18 73 00

78, avenue du Général de Gaulle
94707 MAISONS-ALFORT CEDEX

www.anfr.fr

Rejoignez-nous sur

/anfr