EaPeReg
Eastern Partnership Regulators for Electronic Communications

RRT

Harmonization of Frequency Bands within CEPT and Globally

- **Spectrum Experts Working Group (SEWG)**
- 29 November, 2021

dr. Mindaugas Žilinskas,

Topics for discussion

- 1. Harmonization of 5G Pioneer bands:
- 2. Issues with ITU CS Art.48
- 3. WRC-23 agenda item 1.2: IMT (/ Wi-Fi) in 6 GHz.
- 4. Wi-Fi (2,4GHz; 5GHz; 6 GHz), ITS.
- 5. Harmonization for Satellites systems: in 14.00-14.5 GHz; 27.5-30 GHz frequency band (e.g. Space X, One Web…);
- 6. WRC-23 Agenda item 9 on RR art. 21.5.

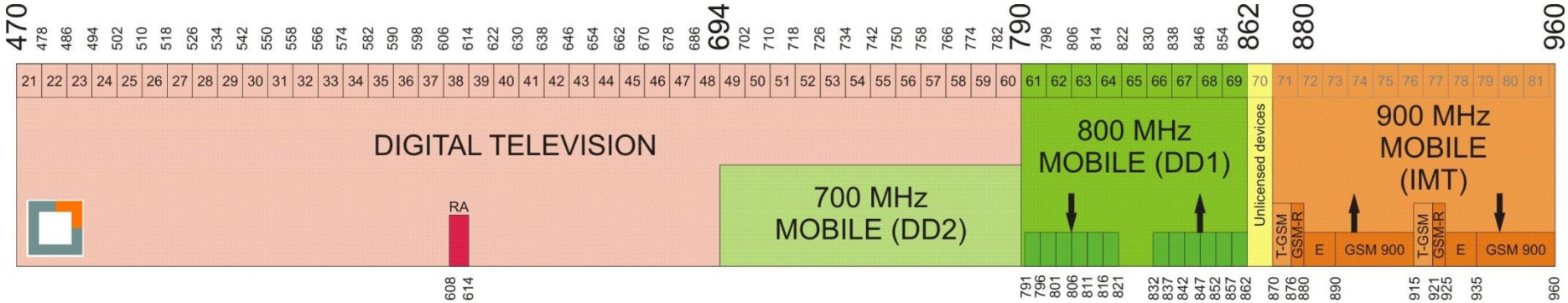
Pioneer bands for 5G in Europe

Radio Spectrum Policy group. Strategic roadmap towards 5G for Europe 2016 (RSPG16-032)

Opinion on spectrum related aspects for next generation wireless systems (5G)

1. 3.4-3.8 GHz primary band before 2020.
2. Harmonized below 1 GHz, particularly 700 MHz for nationwide and indoor coverage.
3. The RSPG recommends the 24.25-27.5 GHz as a pioneer band for 5G above 24 GHz and that: sufficiently large portion (e.g. 1 GHz) of the 26 GHz band made available (locally) in response to market demand by 2020;
4. The band 40.5-43.5 GHz is a viable option for 5G in the longer term.

Pioneer frequency band 700 MHz (694-790 MHz)



DEC. (EU) 2017/899 of the European Parliament and of the Council of 17 May **2017** on the use of the 470-790 MHz frequency band in the Union : **by 30 June 2020** ±2 years for MFCN.

2014 September Lamy Report: until **2030** broadcasting in UHF band Review – **2025**

Protection of incumbent primary services (ARNS, Broadcasting)

ITU regulation since WRC-2015

- **694-790**
- MOBILE except aeronautical
- mobile 5.312A **5.317A**
- BROADCASTING
- 5.300 5.312
- **5.317A …** in Region 1 and 790-960 MHz in Regions 1 and 3 which are allocated to the mobile service on a primary basis are identified for use by administrations wishing to implement International Mobile Telecommunications (IMT) – see Resolutions **224 (Rev.WRC-19)**, **760 (Rev.WRC-19)** and **749 (Rev.WRC-19)**, where applicable… (WRC-19).

RESOLUTION 224 (REV.WRC-19)

Frequency bands for the terrestrial component of International Mobile Telecommunications below 1 GHz

- **resolves:**
- 3 that administrations should take into account the need to **protect existing and future broadcasting stations**, both analogue and digital, except analogue in the GE06 planning area, in the frequency band 470-806/862 MHz, **as well as other primary terrestrial services**;
- 4. that administrations planning to implement IMT in the frequency bands mentioned in *resolves* 2 **shall effect coordination, as required, with all neighbouring administrations prior to implementation**;

RESOLUTION 760 (REV.WRC-19)

Provisions relating to the use of the frequency band 694-790 MHz in Region 1 by the mobile, except aeronautical mobile, service and by other services

- *resolves*
- 1 that use of the frequency band 694-790 MHz in Region 1 by the mobile, except aeronautical mobile, service is subject to agreement obtained under **No. 9.21 with respect to ARNS**
- in countries listed in No. **5.312**, in which regard the criteria for identifying affected administrations
- under No. **9.21** for the mobile service with respect to the ARNS in the frequency band 694-790 MHz
- are set out in the Annex to this Resolution;

ANNEX TO **RESOLUTION 749** (REV.WRC-19)

Criteria for identifying potentially affected administrations with respect to the aeronautical radionavigation service in countries listed in No. 5.312

2 Other cases

ARNS station	System type code	Coordination distances for MS receiving base stations (km)	Coordination distances for MS transmitting base stations (km)
RSBN	AA8	50	125/175*
RLS 2 (Type 1) (aircraft receiver)	BD	410	432
RLS 2 (Type 1) (ground receiver)	BA	50	250/275*
RLS 2 (Type 2) (aircraft receiver)	BC	150	432
RLS 2 (Type 2) (ground receiver)	AA2	50/75*	300/325*
RLS 1 (Types 1 and 2) (ground receiver)	AB	125/175*	400/450*
Other types of ARNS terrestrial station	Not applicable	125/175*	400/450*
Other types of ARNS airborne station	Not applicable	410	432

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

ARNS protection (800 MHz & 700 MHz)

Locations of ground ARNS stations in 700 MHz band

Interference scenario between IMT and ARNS

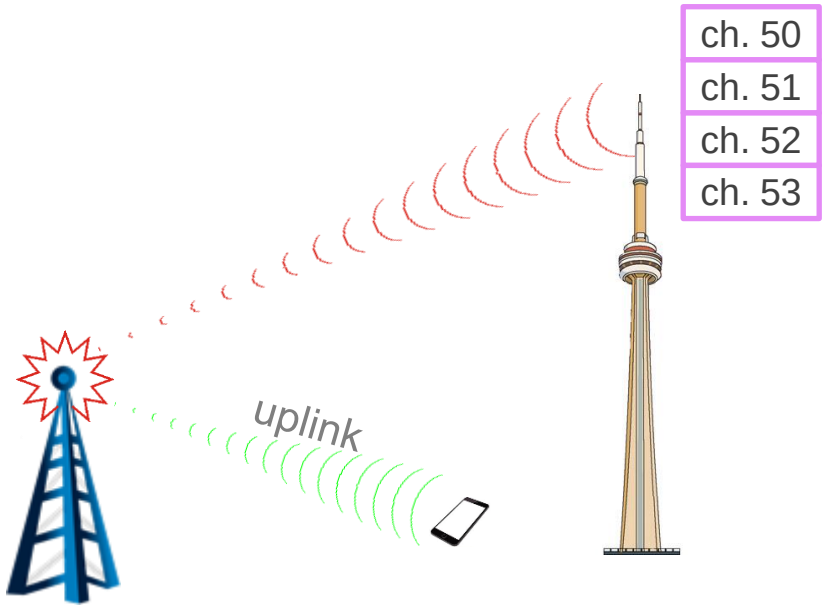
ITURR 5.317A, Res. 760

694-790 MHz

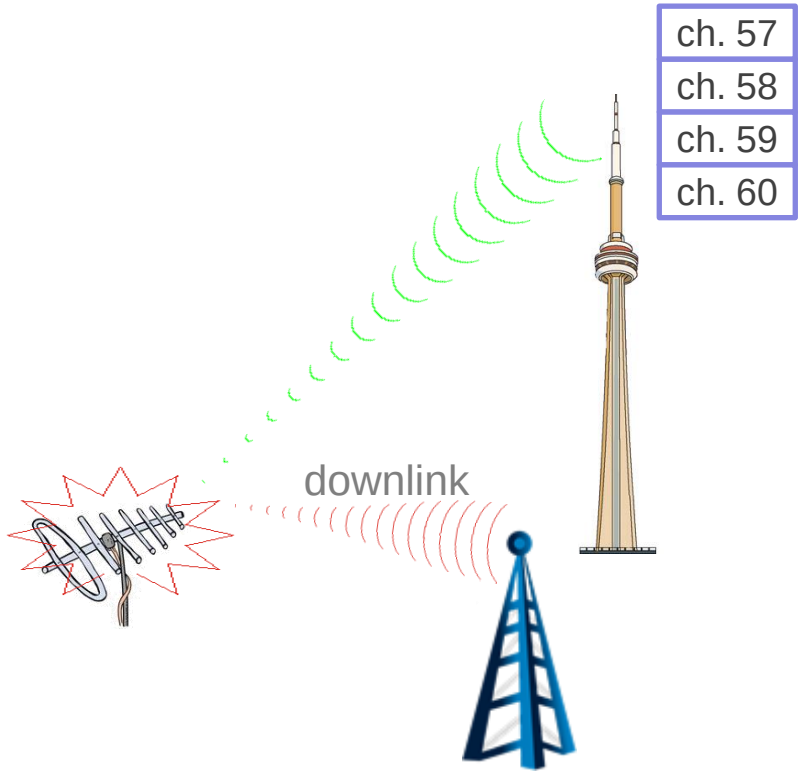
RR 5.312 and RR 9.21

LTE and TV interference scenarios

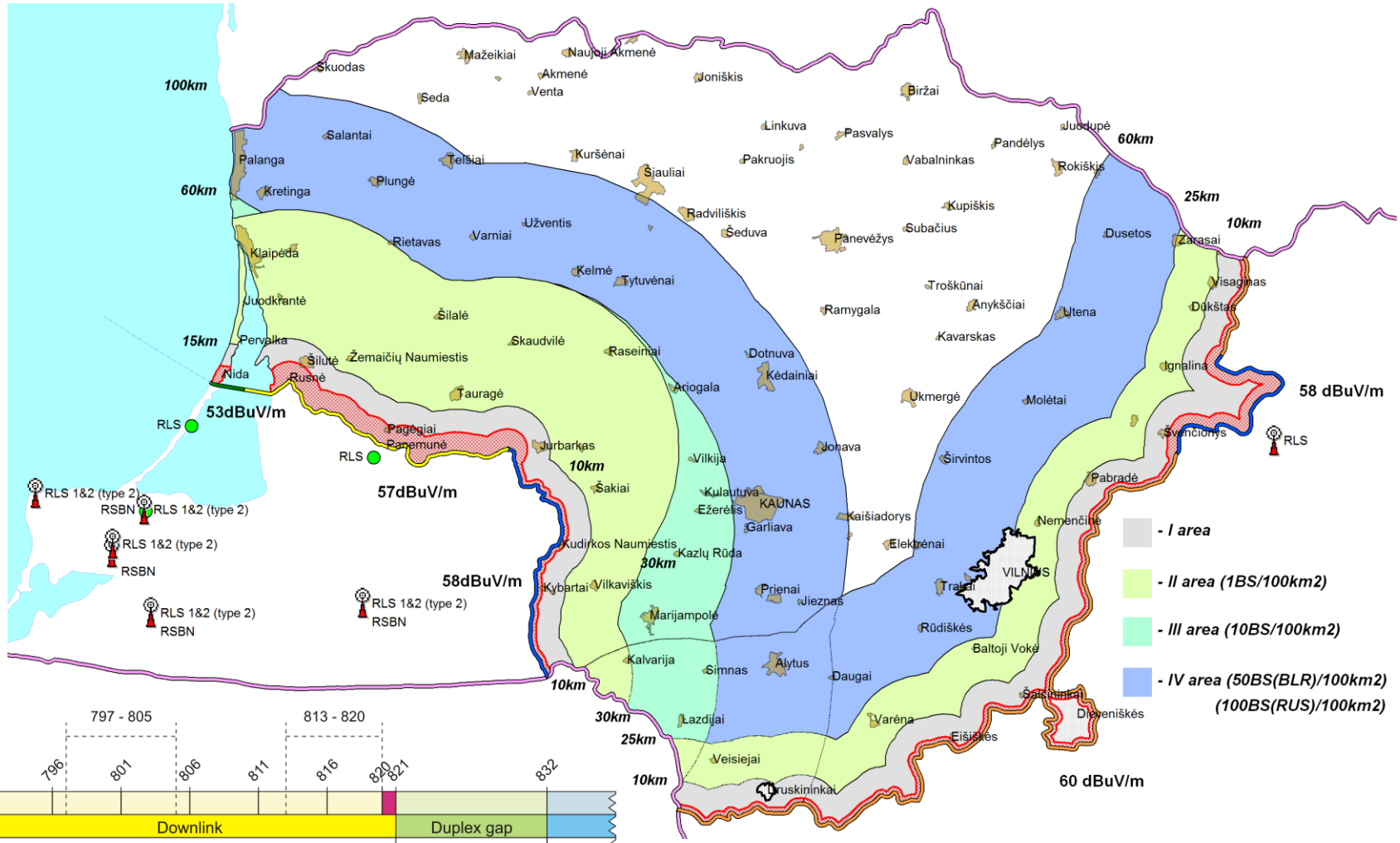
Reception of a base station interfered



Reception of TV interfered



Practical cases: Bilateral coordination (800 MHz)



Q2-2 end of migration

current situation

completed
2017
2018
2019
2020
2021
2022
no date

F* - Republic of North Macedonia

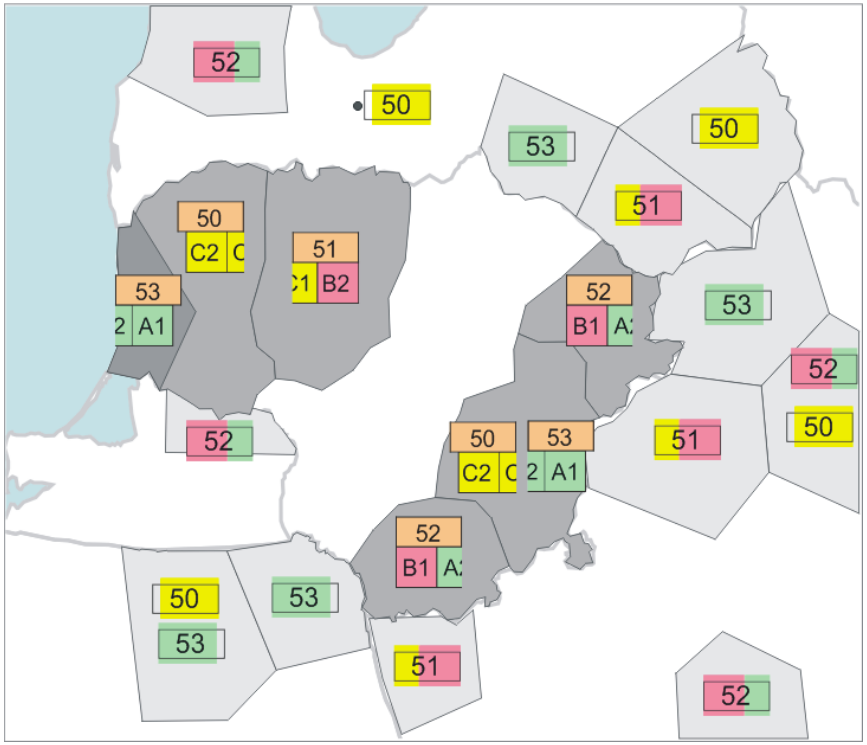
Cross-border Coordination of frequencies for 5G , according Rec 15(01) for 700 MHz band:

*The **758-788** MHz band may be used for MFCN FDD systems downlink without coordination if the mean field strength of each cell produced by the base station does not exceed the value of **59 dBµV/m/5** MHz at a height of 3 m above ground level **at the borderline** between concerned countries and a value of **41 dBµV/m/**5 MHz at a height of 3 m above ground level at a distance of **6 km** inside the neighbouring country.*

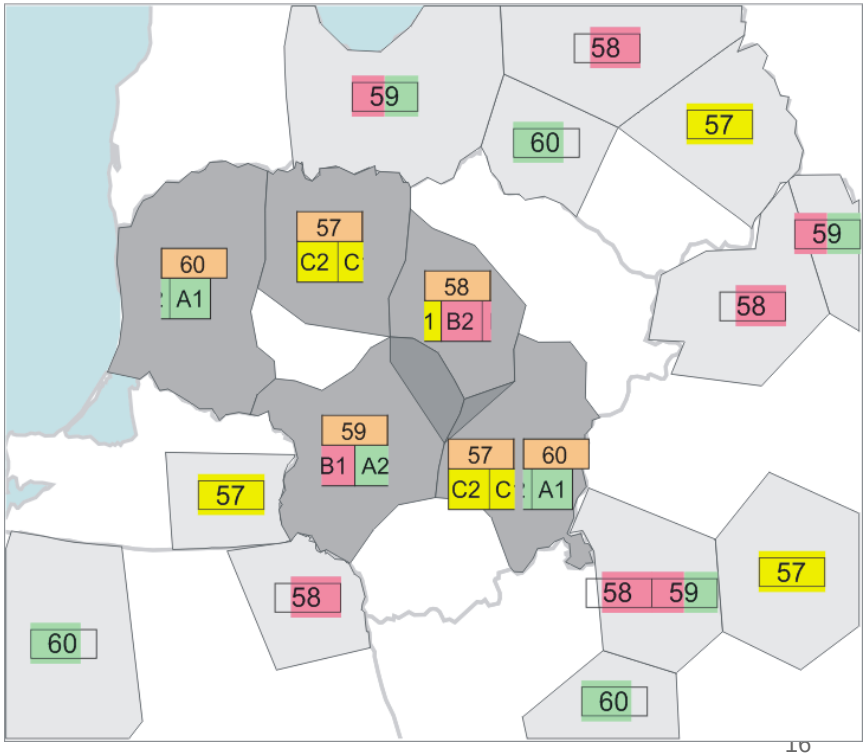
In cases of other frequency block sizes 10 x Log10 (frequency block size/5 MHz) should be added to the field strength values.

Practical case for 700 MHz band and GE06 Plan

Uplink



Downlink



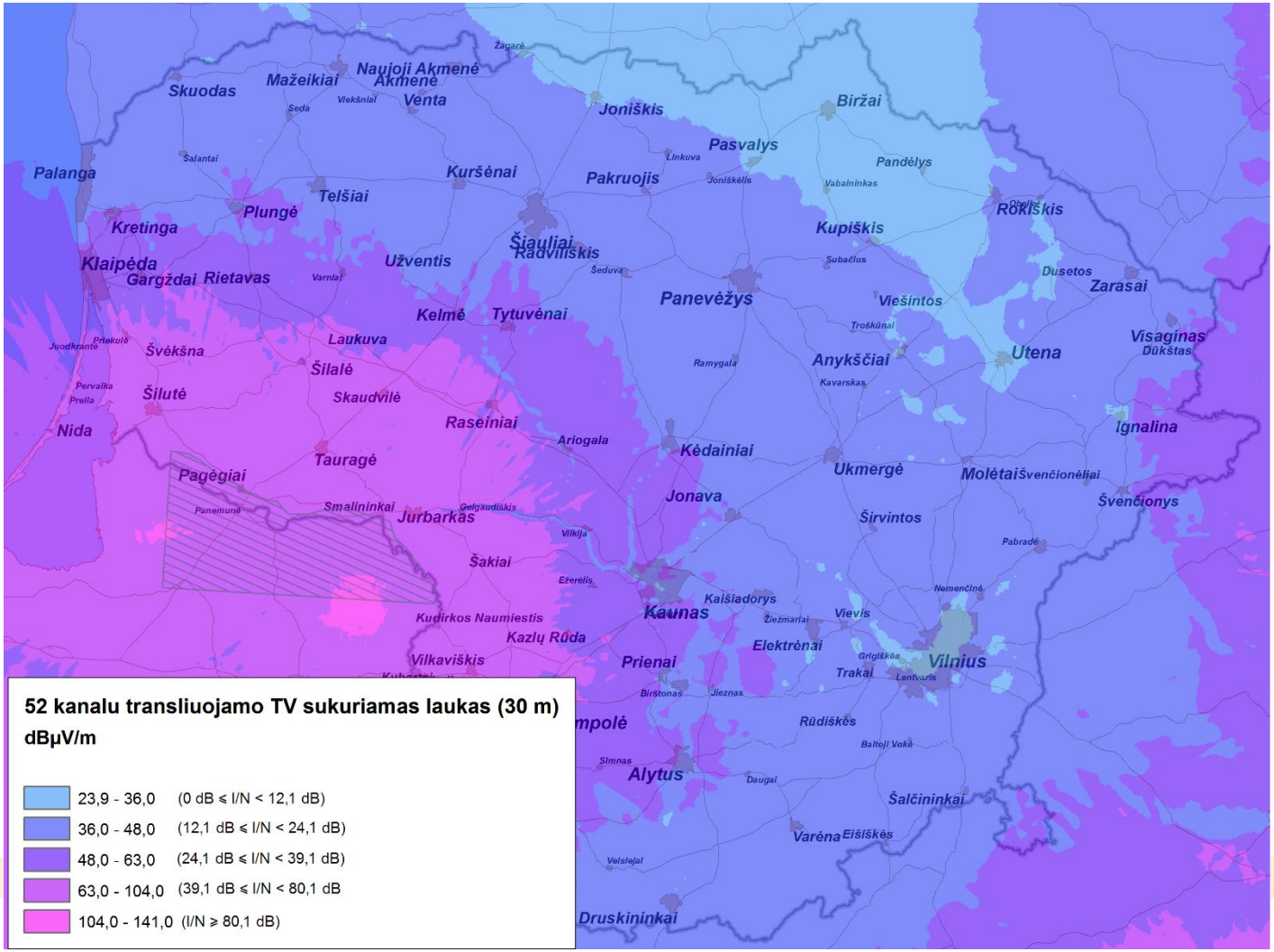
49	50	51	52	53	54	55	56	57	58	59	60
	C2	C1	B2	B1	A2	A1		C2	C1	B2	B1	A2	A1

GE06: ARTICLE 5
Notification of frequency assignments

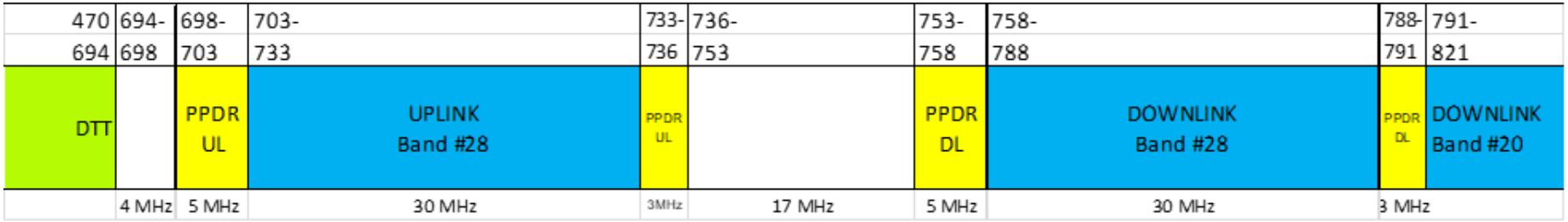
- 5.1.3 A digital entry in the Plan may also be notified with characteristics different from those
- appearing in the Plan, for transmissions in the broadcasting service or in *other primary terrestrial*
- *services* operating in conformity with the *Radio Regulations*, **provided that the peak power density**
- **in any 4 kHz of the above-mentioned notified assignments shall not exceed the spectral power**
- density in the same 4 kHz of the digital entry in the Plan. Such use shall not claim more protection
- than that afforded to the above-mentioned digital entry.

Broadcasting protection/impact

52 channel (RUS & BLR) impact on LTE



PPDR FREQUENCY ARRANGEMENTS
according ECC Report 239



2x3+2x5 MHz option 1
(allocation in France, Finland, Lithuania);
(Sweden, UK, Switzerland 2X5+2X3 MHz plus agreement with MNO- cases different)

Practical case around TV stations operating in ch 49 and 54 v.s. PPDR

Practical cases: IMT/PPDR compatibility with TV stations

Russian Federation and Iran still using TV ch 49 and 54 .

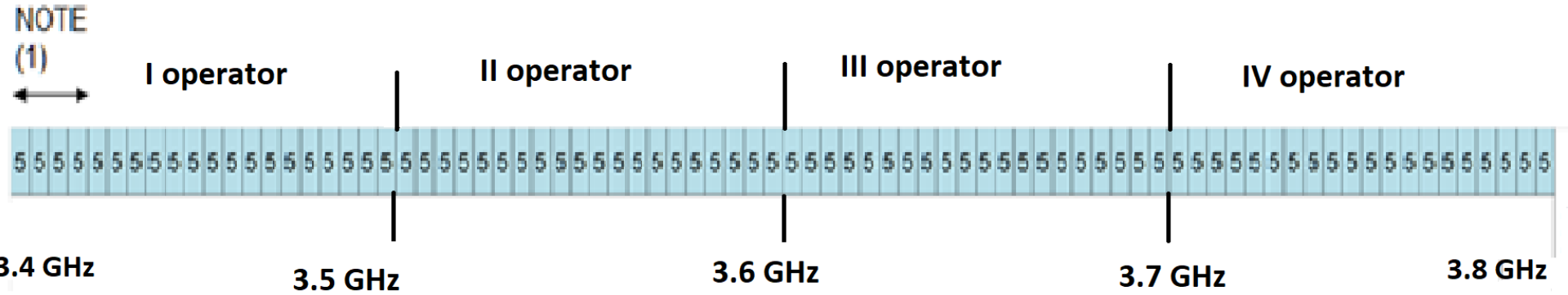
In case EaPa administrations decides to assign the frequencies by the schema 2x3 MHz and 2x5MHz for PPDR there could be potential interference between PPDR and mentioned TV stations.

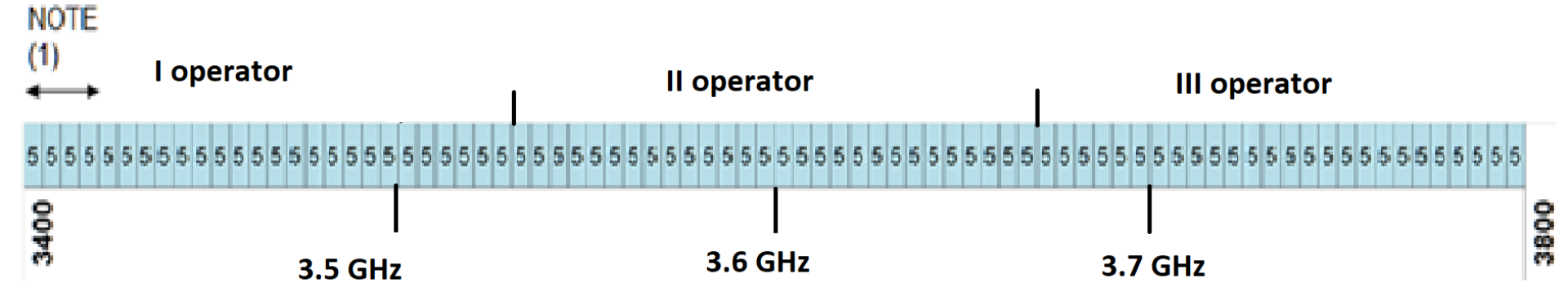
5G pioneer *band 3400-3800 MHz*
RSPG Opinion on 5G implementation challenges (RSPG 3rd opinion on 5G). RSPG19-007

"there shall be spectrum available providing the opportunity to access sufficiently large portions of contiguous spectrum, **preferably 80-100 MHz**, for wireless broadband electronic communications services".

ECC Dec. 11(06) Harmonized frequency arrangements and least restrictive technical conditions (LRTC) for mobile/fixed communications networks (MFCN) operating in the band 3400-3800 MHz

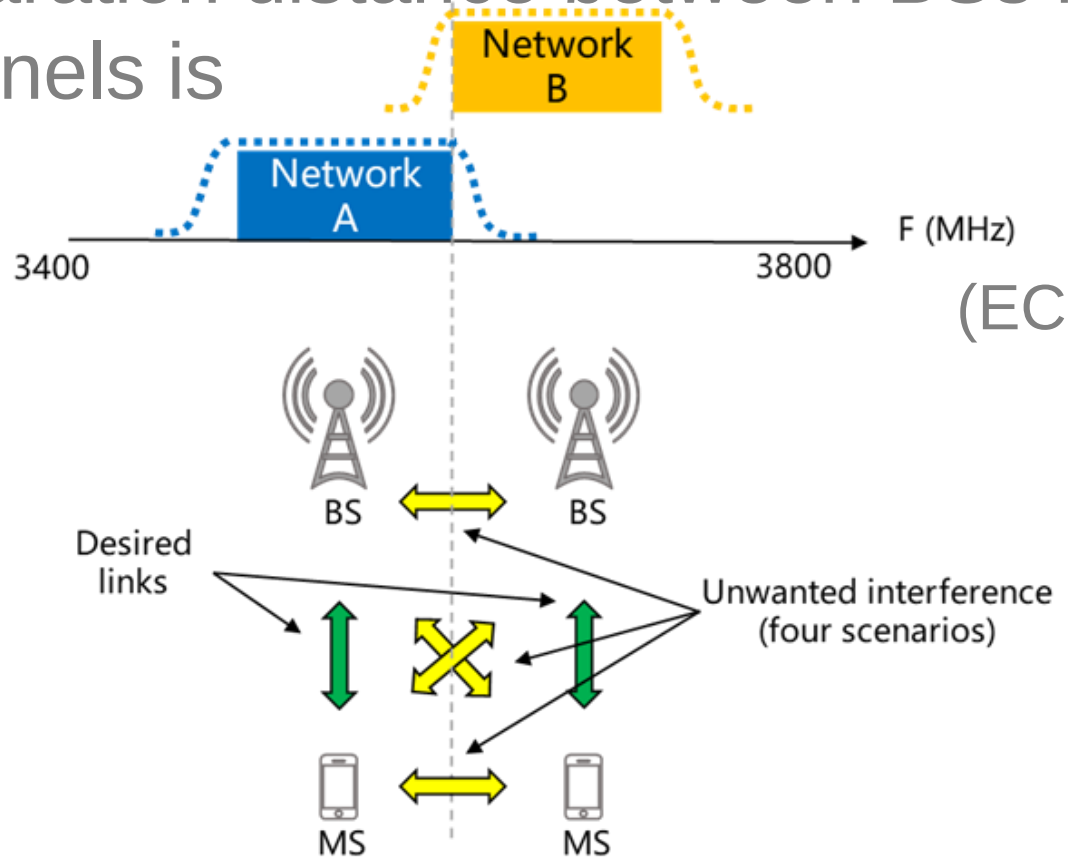
Amended 26 October 2018.





Conditions for 5G use in 3.5 GHz band, synchronization of TDD networks

separation distance between BSs in adjusted channels is 10-15 km



(ECC Rep.296)

Conditions for 5G use in 3.5 GHz band, synchronization of TDD networks

separation distance between BSs for co-channel in case of AAS is: 60-50km. (5% avg. throughput loss, ITU-R P.452 [21] 20% time)
Non AAS – 44 km. when I/N=-6 dB.

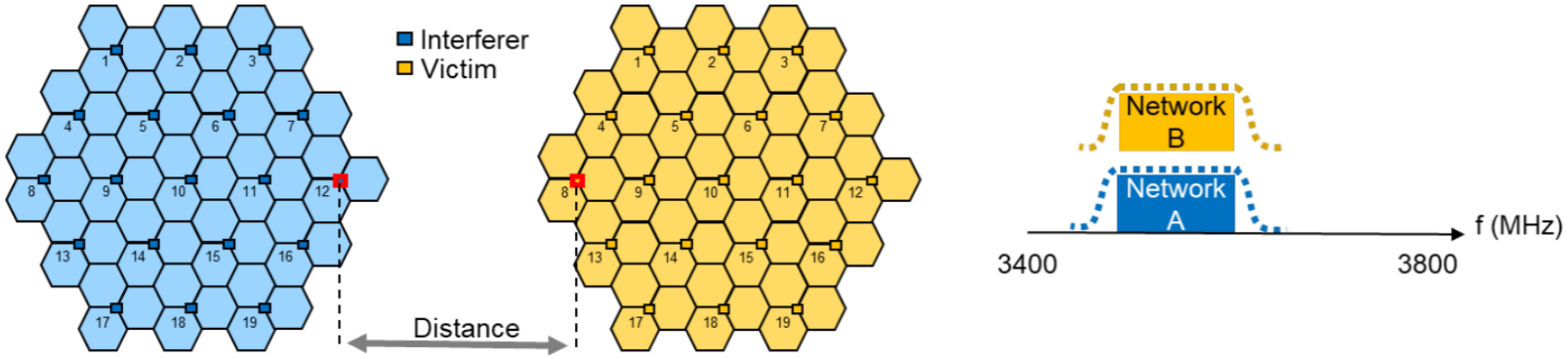


Figure 17: Separation distance between Networks A and B – co-channel

Conditions for 5G use in 3.5 GHz band, synchronization

Synchronized: **avoids** any BS-BS and MS-MS interferences, no need for guard bands or additional filters.

Simplifies the **network deployment** relatively to interference mitigation.

Leads to the selection of a **common frame structure**, which determines a **specific DL / UL transmission ratio** and **frame length** and has an impact on network performance (latency, spectral efficiency, throughput, coverage).

Conditions for 5G use in 3.5 GHz band, synchronization (Rep.296)

TDD mobile operators need to reach agreement on:

- ***A common phase clock reference*** *(e.g. UTC) and* ***accuracy****/performance constraints that depend on the underlining technology (e.g. +/-* ***1.5 µs*** *for LTE-TDD and 5G-NR), either using their own equipment to provide the clock, or sharing the same phase/time clock infrastructure;*
- *Permanent* ***monitoring of the agreed clock source****. If this is lost for some period, the system may start interfering other channels;*
- *A compatible* ***frame structure*** *(including TDD DL / UL ratio and frame length).*

Conditions for 5G use in 3.5 GHz band (unsynchronized networks)

Unsynchronised:- **no a common frame structure**.

Licensees can select the most appropriate frame structure independently and **can adapt the frame structure to service and end user requirements**, which may change depending on the location and **on time.**

However, such flexibility leads to a number of interference scenarios that need to be assessed and managed. The interfering BS transmitter requires **custom filters and guard band.** The victim BS receiver also requires custom filters to avoid blocking.

ECC REC. 20(03) OF 23 OCTOBER 2020 ON FRAME STRUCTURES TO FACILITATE CROSS-BORDER COORDINATION OF TDD MFCN IN THE FREQUENCY BAND 3400-3800 MHZ

Table 1: Recommended frame structures for TDD MFCN cross-border coordination in 3400-3800 MHz

	Frame A			Frame B		
DL/UL slot pattern	DDDSU DDDSU DDDSU DDDSU (see note 1)			DDDSUUDDDD DDDSUUDDDD (see notes 1, 4)		
Frame duration	10 ms			10 ms		
Slot Duration	0.5 ms			0.5 ms		
Slot pattern periodicity	2.5 ms			5 ms		
Special slot "S" configuration (i.e., DL:GP:UL symbols)	Downlink	Guard period	Uplink	Downlink	Guard period (note 5)	Uplink
	10	2	2	6	4	4
				4	6	4
Time base (see note 3)	Start of UTC second epoch (see note 2) +/- 1.5 µs			Start of UTC second epoch (see note 2) +/- 1.5 µs		

Note 1: D = Downlink slot; S = Special slot; U = Uplink slot

Frame B is compatible with the LTE-TDD

CROSS-BORDER COORDINATION ACCORDING ECC REC 15(01) FOR 3400-3800 MHZ BAND:

(UNDER REVISION)

*The **3400-3600 and 3600-3800** MHz bands may be used for unsynchronised MFCN TDD systems without coordination if the mean field strength of each cell produced by the base station does not exceed a value of **32 dBμV/m/5** MHz at a height of 3 m above ground level at the borderline between countries. **(loss of capacity in UL by 50%** in case of 2 operators). When MFCN TDD systems are synchronised across the border - **67 dBμV/m/5 MHz** at a height of 3 m above ground level at the borderline between countries and a value of **49 dBμV/m/5 MHz** at a height of 3 m above ground level at a distance of 6 km inside the neighbouring country.*

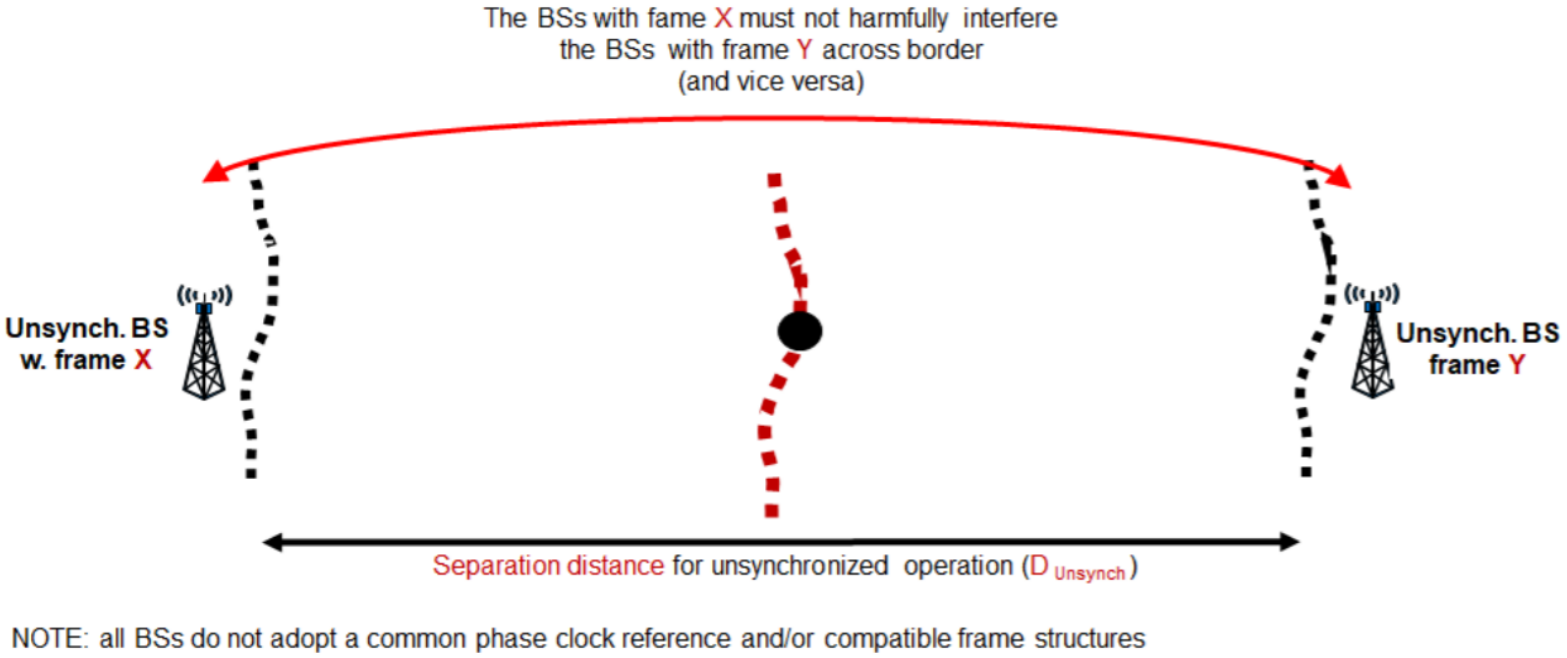
Efficient usage of the spectrum at the border of CEPT countries between TDD MFCN in the frequency band 3400-3800 MHz. ECC Rep.331 2021 11 05

1. Synchronised operation **2.** Unsynchronised operation with partial duplex misalignment and ECC Rec. (20)03 recommended scenario3 with Downlink Symbol Blanking (DSB)
3. Unsynchronised operation with partial duplex misalignment and ECC Rec. (20)03 recommended scenario without DSB.
4. Fully-unsynchronised operation (100% duplex misalignment) without preferential frequency blocks **5.** Fully-unsynchronised operation (100% duplex misalignment) with preferential frequency blocks

	Slot numbers in the NR half Frame									
	0	1	2	3	4	5	6	7	8	9
Frame A DDDSU	D	D	D	S	U	D	D	D	S	U
Frame B DDDSUUDDDD	D	D	D	S	U	U	D	D	D	D

Figure 2: Frame structures recommended in the ECC Recommendation (20)03

Separation distance and field strength trigger values for unsynchronised operation



NOTE: all BSs do not adopt a common phase clock reference and/or compatible frame structures

Unsinchronised operation with preferential blocks- adjacent channel interference still exists.

The downlink symbol blanking (DSB)

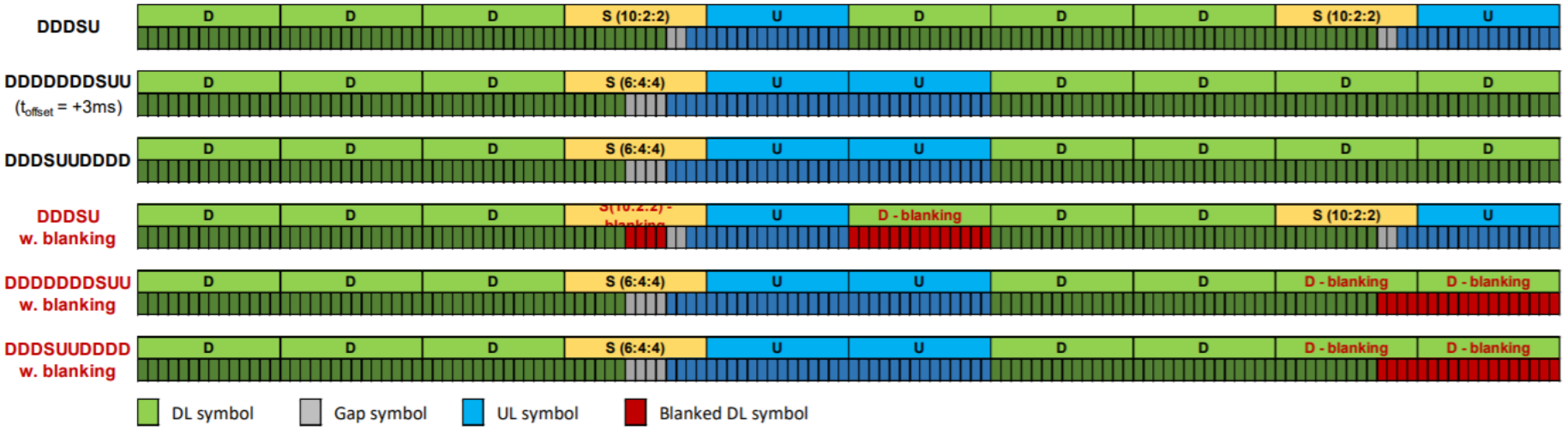
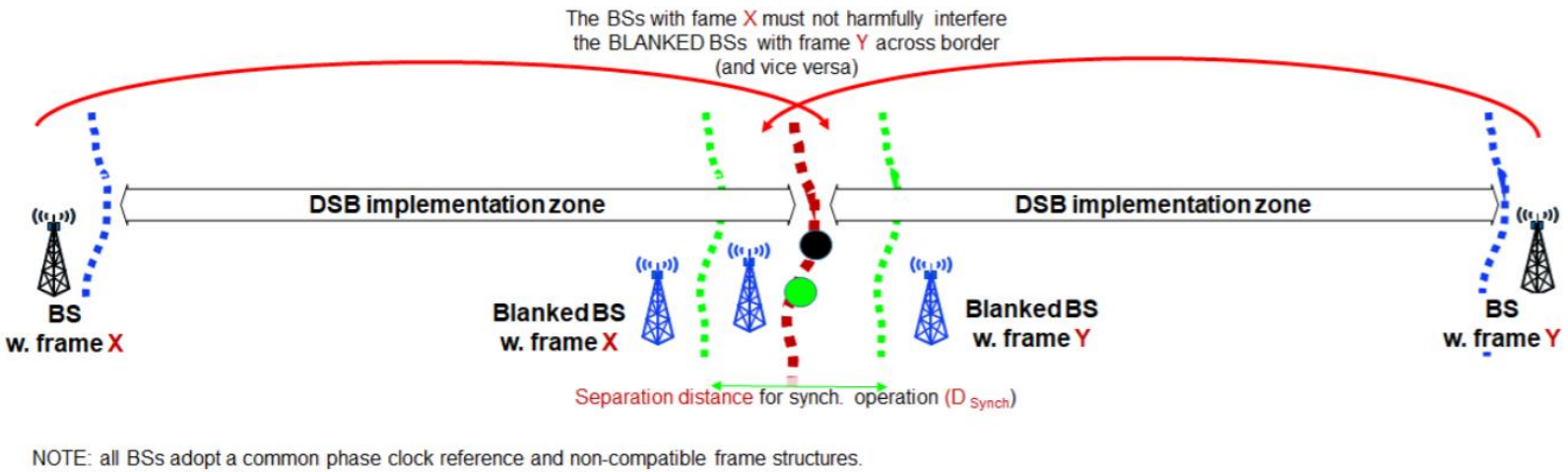


Figure 7: Application of DSB to "Frame A" and "Frame B" recommended by ECC Recommendation (20)03 – symbol level view

DSB allows the base stations' schedulers to switch off transmissions ("blanking") for those downlink symbols ("blanked DL symbols") of each network that correspond to simultaneous uplink reception or simultaneous gap symbols for the other network.

The downlink symbol blanking (DSB)



NOTE: all BSs adopt a common phase clock reference and non-compatible frame structures.

The DSB implementation zone;

Blanking of some selected DL symbols leads to the following downlink symbol loss: 17.3% DL capacity loss in the country where frame A is used; 17.3% DL capacity loss in the country where frame B is used;
A common phase clock reference (e.g. UTC, Coordinated Universal Time) with an accuracy of +/-1.5 μs; Frame time shift.

Table 8: field strength values at borderline 3m height for operation modes 4, 5 and 1

AAS mode	Scenario	Fully unsynchronised (worst-case)						Fully unsynchronised with preferential freq.			Synchronised	
	Environment	Suburban			Rural			Suburban			Suburban	Rural
	UL TP Loss	10%	20%	30%	10%	20%	30%	10%	20%	30%	(DL) 5%	(DL) 5%
AAS to AAS	E_median (dBµV/m/(5 MHz))	-4.41	4.49	8.59	2.19	10.49	15.89	37.19	44.39	49.59	77.99	78.79
	E_max (dBµV/m/(5 MHz))	25.65	34.35	38.35	18.65	27.05	32.35	65.75	72.05	76.55	99.05	98.05
	E_SSB single-beam (dBµV/m/(30 kHz))	-9.39	-0.61	3.43	-12.06	-3.64	1.67	31.74	38.67	43.66	69.20	68.84
	E_SSB multi-beam (dBµV/m/(30 kHz))	-13.08	-4.09	0.09	-6.32	2.12	7.45	31.13	39.91	45.91	75.82	75.61
AAS to Non-AAS	E_median (dBµV/m/(5 MHz))	-7.22	-2.63	0.82	4.04	11.26	15.54	31.69	35.49	39.47	77.59	
	E_max (dBµV/m/(5 MHz))	22.68	27.34	30.81	20.37	27.72	31.99	60.56	64.19	67.74	98.96	
	E_SSB single-beam (dBµV/m/(30 kHz))	-12.37	-7.68	-4.19	-10.34	-2.97	1.31	26.23	30.07	33.90	69.09	
	E_SSB multi-beam (dBµV/m/(30 kHz))	-16.12	-11.33	-7.75	-4.59	2.79	7.09	24.64	29.14	33.80	75.73	
Non-AAS to AAS	E (dBµV/m/(5 MHz))	5.94	11.42	14.79	8.26	17.07	21.66	59.01	63.68	69.69	83.89	51.97

SSB- Synchronisation Signal Block

ITU regulations

Conditions for 5G use in 3.4-3.6 GHz band

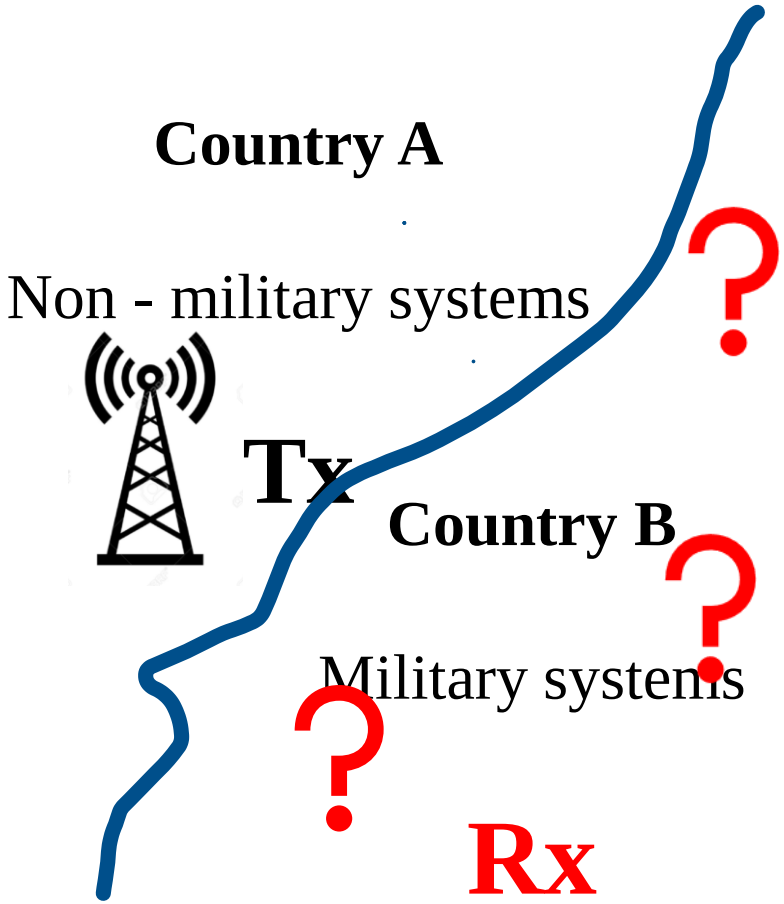
- **5.430A** The allocation of the frequency band 3 400-3 600 MHz to **the mobile,** except aeronautical mobile, service is subject to **agreement** obtained under No. **9.21**. This frequency band is identified for International Mobile Telecommunications (IMT)... Before an administration brings into use a (base or mobile) station of the mobile service in this frequency band, it shall ensure that the power flux-density (pfd) produced at 3 m above ground **does not exceed −154.5 dB(W/(m^2 · 4 kHz)) for more than 20% of time at the border** of the territory of any other administration.... In case of disagreement, calculation and verification of the **pfd shall be made by the Bureau**,.. (Edition of 2004, WRC-15)

Conditions for 5G use in 3.5 GHz band RRB approved RoP Part B, section B6

„ „3.8 For the protection of the fixed and fixed-satellite services in the frequency bands between 3 400 MHz and 3 700 MHz from the mobile, except aeronautical mobile, service in the context of the provisions of Nos. 5.430A, 5.431A and 5.432B, and from IMT in the context of the provisions of Nos. 5.431B and 5.434, the power flux density of **–154.5 dB(W/m2·4 kHz)2** produced at the height of 3 m above ground level is used. Based on the above pfd value the coordination distances are calculated using Recommendation **ITU-R P.452-16 for 20%** of time with **smooth Earth terrain profile**.“

Invocation of ITU CS art. 48 for terrestrial stations

- Art. 48, 1. Member States retain their entire freedom with regard to military radio installations.
- cases when an administration, which is not agreeing to the request for coordination of terrestrial stations invokes ITU CS Article 48
- creates uncertainties for the right application of examination procedures for Bureau and for evaluation of potential interference
- Does Country A have to **protect receivers** of military systems of Country B ?
- Issue brought to the attention of BR, RRB, CPG and for clarification to ITU **PP-2022**

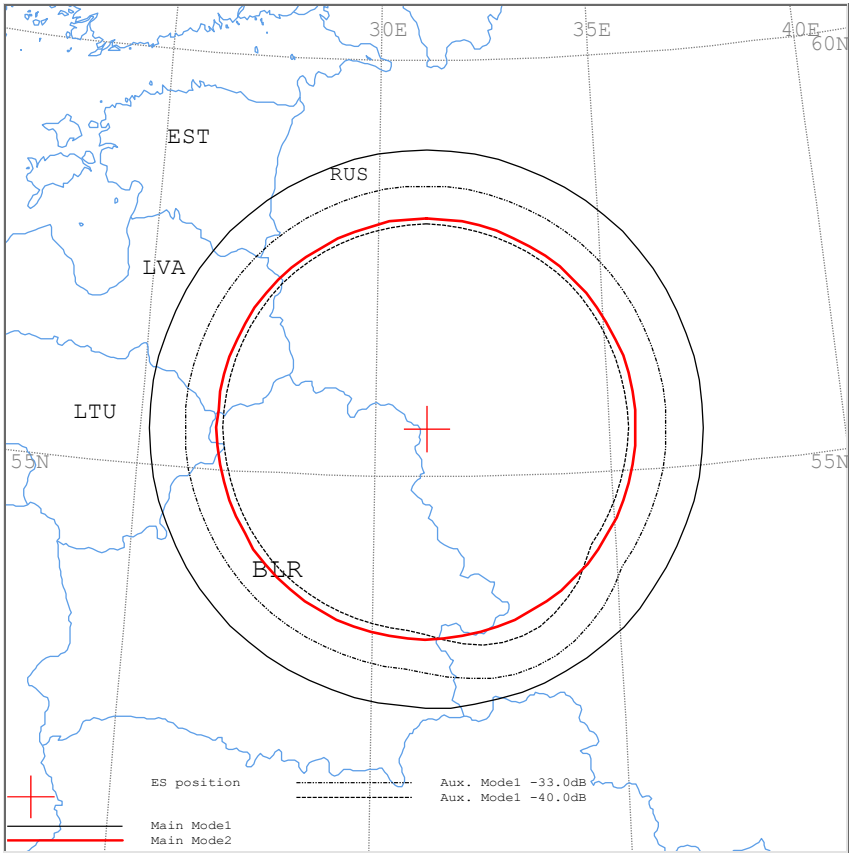


Possibility to mitigate coordination of earth stations and IMT in the 3400 – 3800 MHz frequency band

According to the ITU RR App 7

Appendix 7 Annex 6 para 2

supplementary contours may be prepared by the administration seeking coordination in order to define smaller areas, based on more detailed methods, for consideration **when agreed bilaterally between the concerned administrations.** These contours can be a useful aid for the rapid exclusion of terrestrial stations or earth stations from further consideration.



FX/MS EIRP
(92 dBm/100 MHz)
42 dBW/1MHz
22 dBW/1 MHz
15 dBW/1 MHz

t=0.0016% or this corresponds to 8.4 min./year

Methodology for compatibility analysis

Long-term interference criterion

– Based on Recommendation ITU-R S.1432

I/*N* = –10 dB (D*T*/*T* = 10%) corresponding to the aggregate interference from co-primary allocation for 20% of any month.

Short-term interference criterion

– Based on Recommendation ITU-R SF.1006.

– In-band sharing studies: *I*/*N* = –1.3 dB that may be exceed by up to 0.001667% time (single entry).- Propagation model ITU R P 452-14 and 452-15.

Methodology for compatibility analysis

Report ITU-R S.2368-0 (06/2015)

Sharing studies between International Mobile Telecommunication-Advanced systems and geostationary satellite networks in the fixed-satellite service

in the **3 400-4 200 MHz** and

4 500-4 800 MHz frequency bands

in the WRC study cycle leading to WRC-15

Methodology for compatibility analysis, results

TABLE 7 (Report ITU-R S.2368-0)

Required separation distances to protect FSS earth stations associated with in-band emissions

Cases 1,2 – no specific, without terrain,3-5 specific with terrain

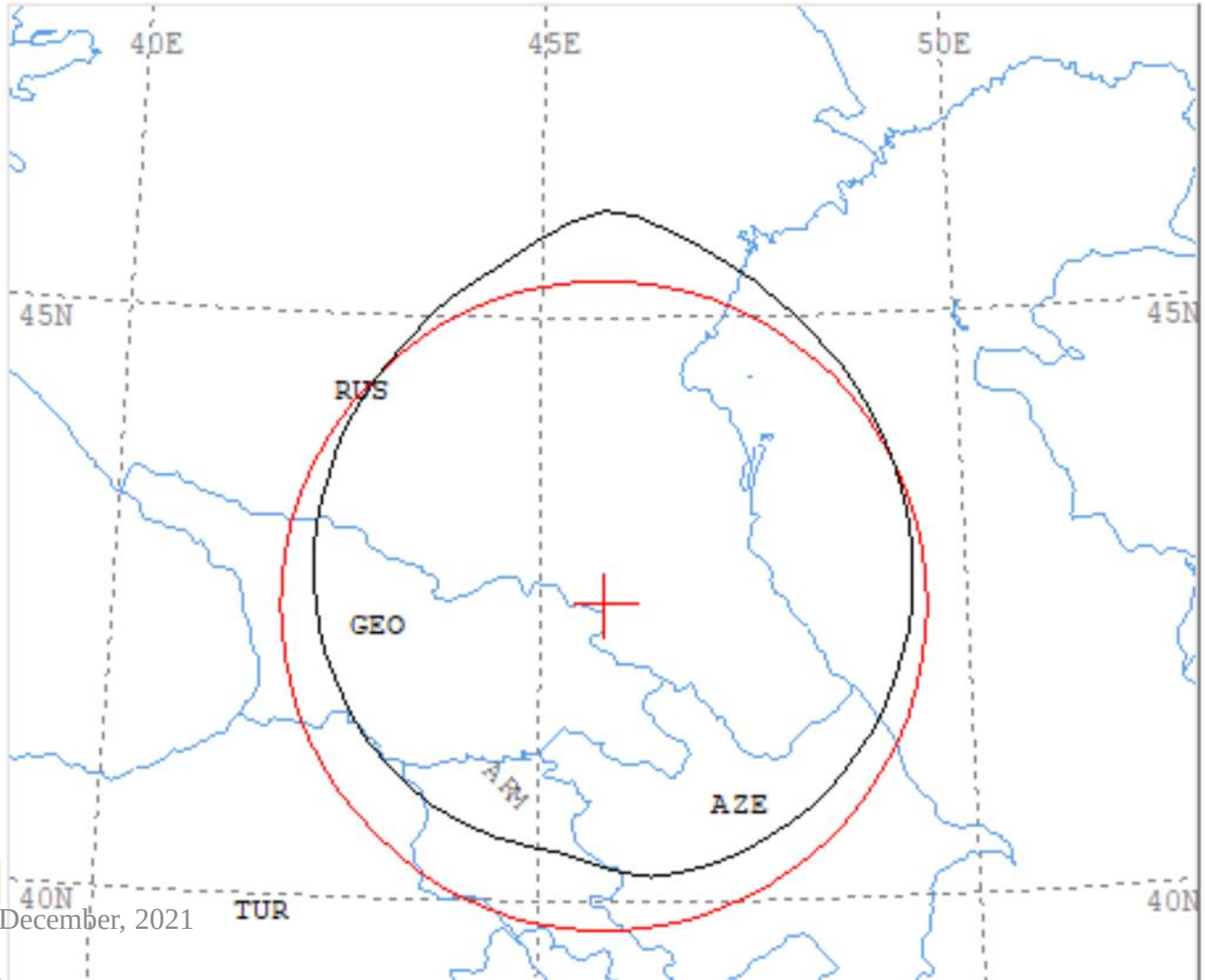
Study #	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Scenario			IMT-Advanced networks using suburban macro-cell deployment								
Long-term interference	61-84 km (FSS antenna elevation angle of 5°)	56-61 km (FSS antenna elevation angle from 48° to 5°)	30-40 km / **10-20 km** (FSS antenna elevation angle of 6.5/36º with mountain terrain profile)	Single entry: 58.1 km Aggregate: 63.0 km (FSS antenna elevation angle of 5°)	57.1-87.1 km (FSS antenna elevation angle of 5°)	N/A	N/A	About **100 km** (FSS antenna elevation angle of 9.4º)	N/A	27-50 km (FSS antenna elevation angle of 5°)	N/A
Short-term interference	486-628 km (FSS antenna elevation angle of 5°)	44-224 km, main lobe 2-62.7 km, side lobe (FSS antenna elevation angle from 48° to 5°)	**30-70 km**/ 10-26 km (FSS antenna elevation angle of 6.5/36º with mountain terrain profile)	**525 km** (FSS antenna elevation angle of 5°)	312.2-487.6 km (FSS antenna elevation angle of 5°)	N/A	N/A	About 450 km on partly over-sea path; about 300 km on overland path (FSS antenna elevation angle of 9.4°)	N/A	N/A	N/A

Coordination contour of one Russian earth station's

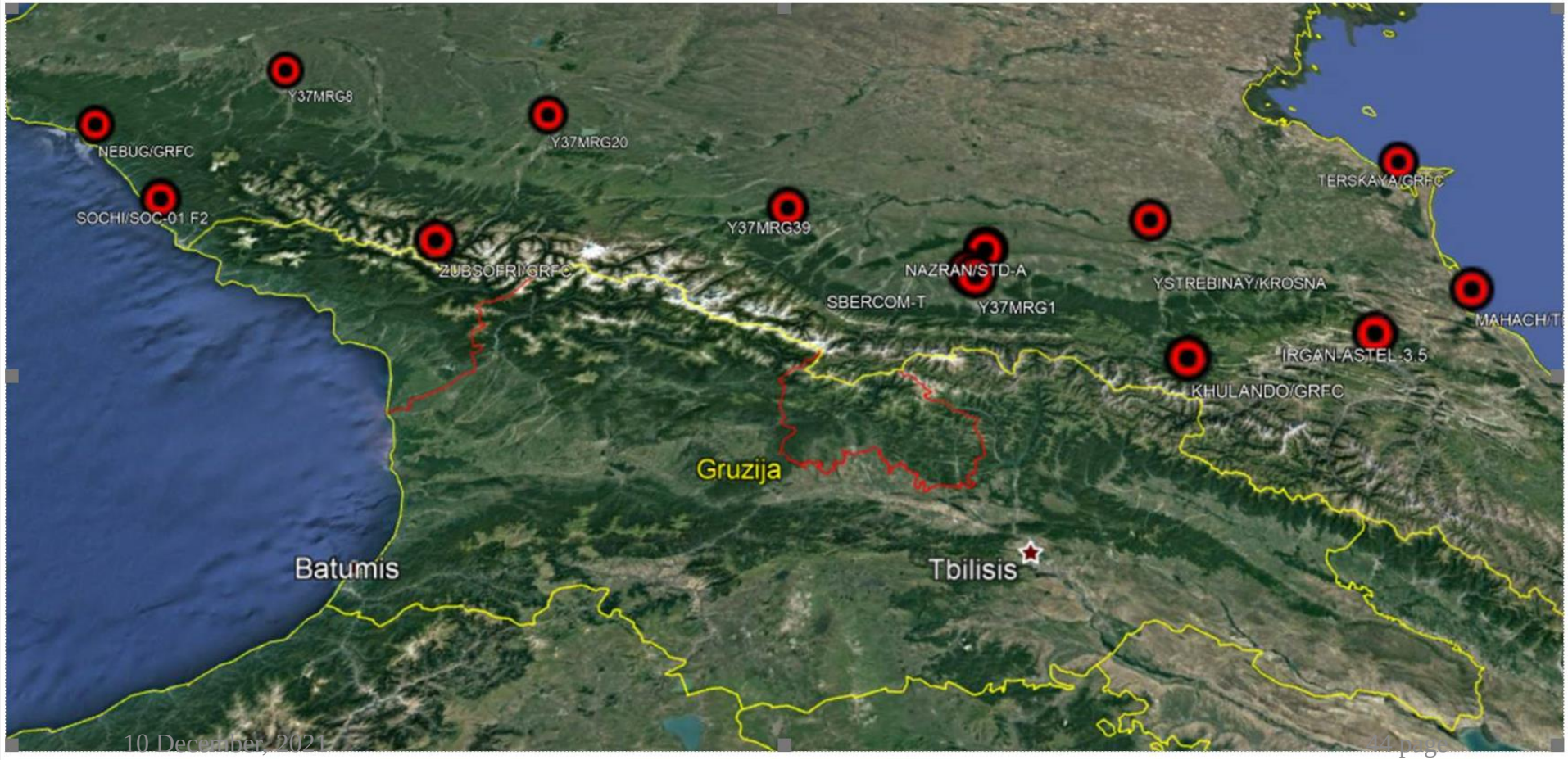
Diagram 1: 2.1_TABLE8. RECEIVING GSO ES in FIXED-SATELLITE SERVICE W.R.T. TRANSMITTING TERRESTRIAL STATIONS. TS: fixed, mobile

Notice ID: 110505560
Administration/Geographical area: RUS/RUS
Satellite orbital position: 53.00
Frequency band: 3407.0000-4193.0000 MHz

Earth station name: KHULANDO/GRSC
Earth station position: 045E450042N3300
Satellite name: EXPRESS-5

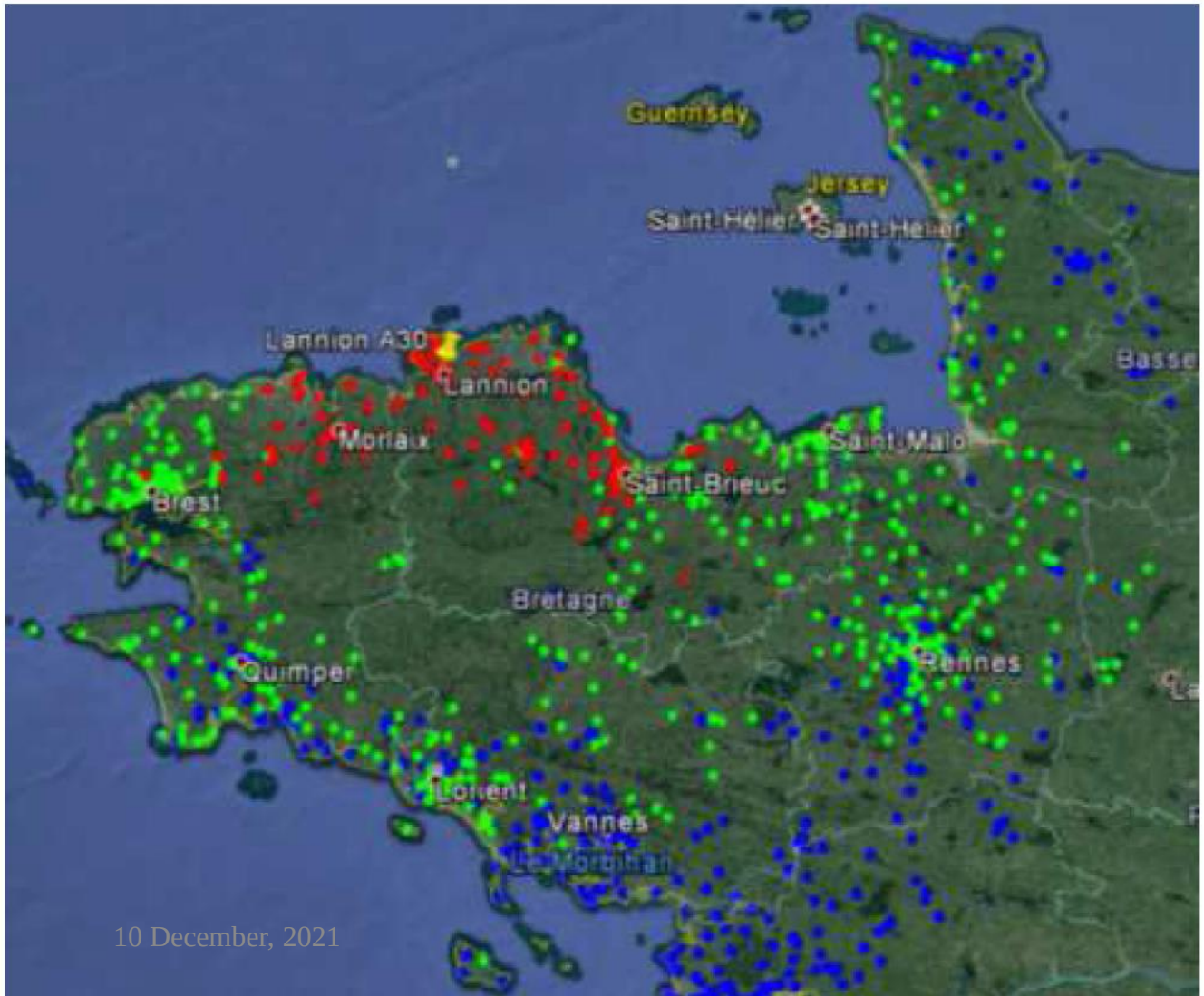


Practical case: earth station's within frequencies 3407-3793 MHz along Georgian border



Co-channel EMC of earth station in Lannion and IMT.

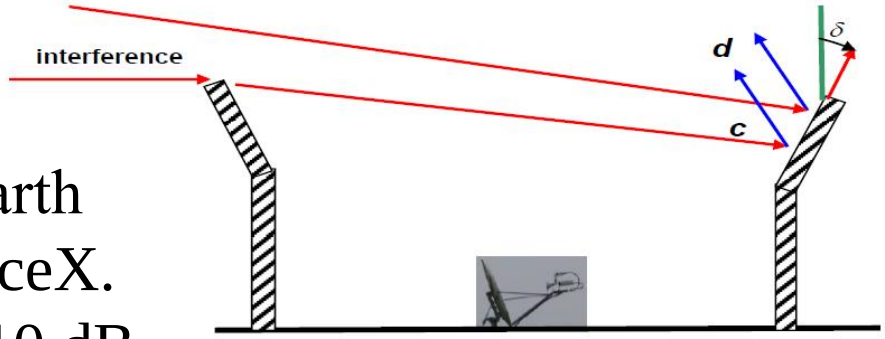
Secteurs dépassant le critère de protection (rouge)	Secteurs initialement agrégés (bleu)	Puissance agrégée reçue par la station SFS (dBm)	Limite de brouillage de la station SFS (dBm)	Marge (dB)	Secteurs exclus pour respecter le critère de protection (vert)
286	2966	-101.3	-119	-17.7	874



Eirp =74dBm/20 MHz. (71 dBm/20 MHz)

Antennas of BS ITU-R F1336; tilt-=-3,4,8 for rural, suburban, urban

Mitigations of coexistence of FSS Earth Stations and IMT systems



It’s planned to build shielded earth stations close to Vilnius by SpaceX. Attenuation of metallic fence -10 dB.

Spectrum sharing workload of earth stations

HANDBOOK ON SATELLITE COMMUNICATIONS

(Third Edition) 2002 ITU, Geneva

AN2.1 a) satellite transponder and earth station parameters…

Frequency bands 3625-4095 MHz; Earth stations

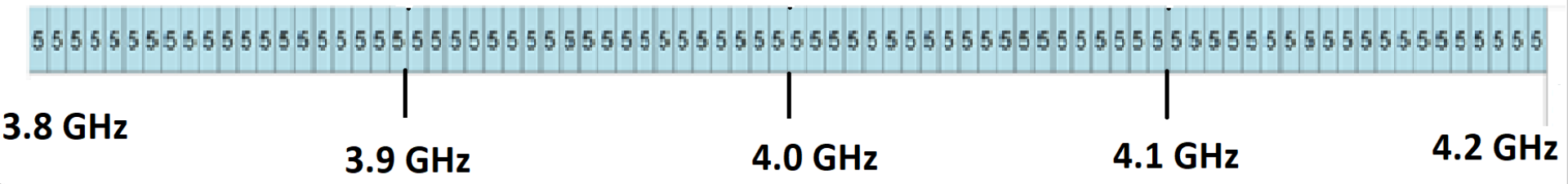
Antenna gain receive 61 dBi; Minimum G/T(clear sky) =40.7 dB/K; (C/N) clear sky =14,5 dB.

"This result indicates that an INTELSAT –VI **72 MHz** hemi-zone transponder can accommodate, as example, up to approximately **1000 channels:**

4 (252 channels/15 MHz) carriers, or"…

Extension of C- band applicable for 5G: 3.8-4.2 GHz

3GPP TS, 38.104 V15.3.0: Technical specification group Radio Access Network; NR, Base station radio transmission and reception.

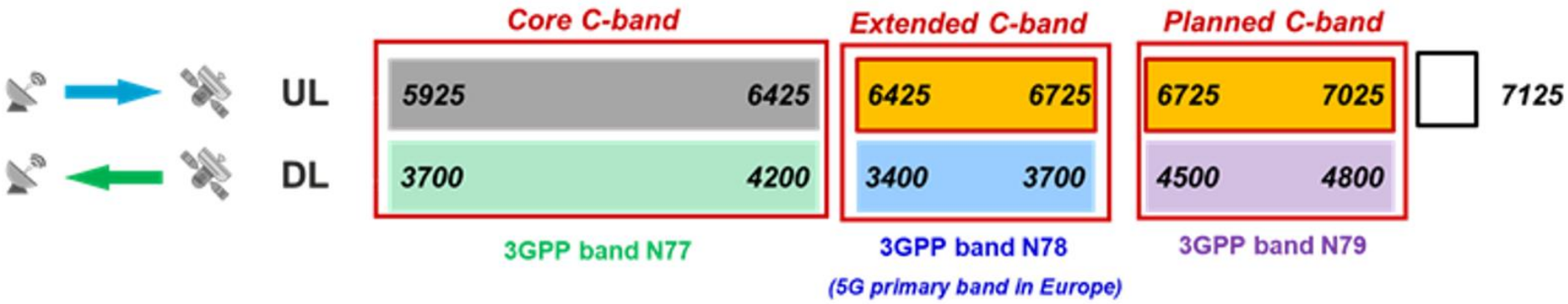


Plans in **UK, NOR** (up to 4,2 GHz), **JAP** (3.3-4.1 GHz), US (3.3-4.2 GHz)

3GPP 5G NR Band 77. TDD, channel bandwidth: Δf=10MHz;20MHz;30MHz;40MHz;50MHz;60MHz;80MGz;100 MHz.

EMC with aeronautical telemetry above 4.2 GHz

6 GHz band.
Co-existense with satellites



CEPT, EU 2021/1067: Wi-Fi 5945- 6425 MHz.

WRC- 23 agenda item 1.2 IMT 6425-7025 MHz in Region 1 and 7025- 7125 MHz globally.

CITEL: Wi-Fi 5925-7125 MHz.

Draft EC Mandate on 3.8-4.2 GHz for low/medium power RLAN. (Brussels, 13 October 2021 DG CONNECT/B4 RSCOM21-40)

The 6 GHz opportunity for IMT 5G area traffic demand vs. area traffic capacity supply. **Study by Coleago Consulting 1 August 2020**

- Spectrum needs in the 2025-**2030** timeframe – up 2 GHz
- user experienced data rate of **100 Mbit/s** in citywide in an economically feasible manner, in areas with a population density greater than 6,000 per km2 and the area traffic capacity of 10 Mbit/s/m2.
- Low bands (600, 700, 800, 900, 1500 MHz);
- Lower mid-bands (1800, 1900, 2100, 2300, 2600 MHz);
- Upper mid-bands (3.3-4.2, 4.5-4.99, 6 GHz);
- High bands (26, 28, 40, 66 GHz);
- Conclusion: **6425-7125 MHz - essential for IMT**

Mid – band spectrum for city wide- speed coverage

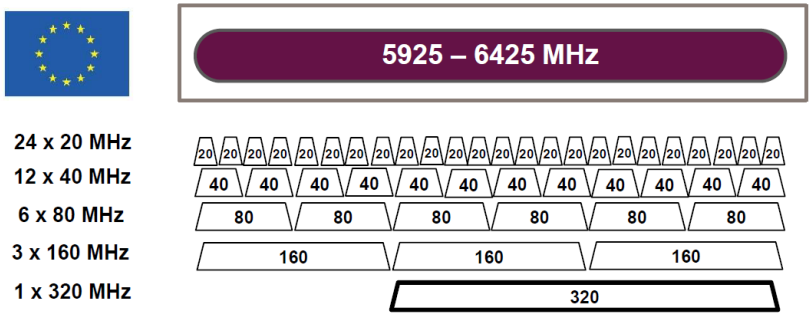
Additional mid-bands spectrum need for cities based on DL and UL requirements

City	Activity factor 10%			Activity factor 15%			Activity factor 20%			Activity factor 25%		
	High bands offload			High bands offload			High bands offload			High bands offload		
	30%	20%	10%	30%	20%	10%	30%	20%	10%	30%	20%	10%
Paris	870	1110	1350	1590	1960	2320	2320	2800	3290	3040	3650	4250
Lyon	50	130	240	340	490	640	640	850	1050	950	1210	1460
Marseille	10	40	110	200	330	460	460	640	810	730	940	1160
Berlin	220	360	490	630	830	1030	1030	1300	1570	1430	1770	2110
Hamburg	160	290	410	540	720	910	910	1160	1410	1280	1600	1910
Munich	50	160	260	370	530	690	690	900	1110	1000	1270	1530
Rome	330	490	640	790	1020	1250	1250	1560	1870	1710	2100	2480
Milan	300	450	590	740	960	1180	1180	1480	1770	1620	1990	2360
Madrid	820	1060	1290	1530	1880	2230	2230	2700	3170	2930	3520	4100
Barcelona	490	660	840	1020	1290	1560	1560	1910	2270	2090	2540	2980
Amsterdam	30	80	170	270	410	550	550	740	930	840	1070	1310

Spectrum need	< 10 MHz	10 to 500 MHz	500 - 1000 MHz	1000-2000 MHz	> 2000 MHz

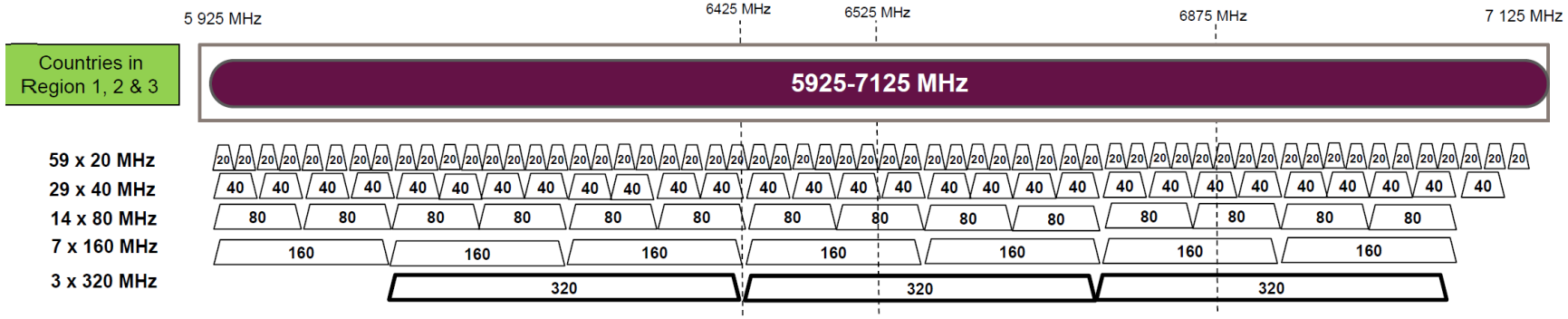
Source: Coleago Consulting

Wi-Fi 7 Spectrum needs

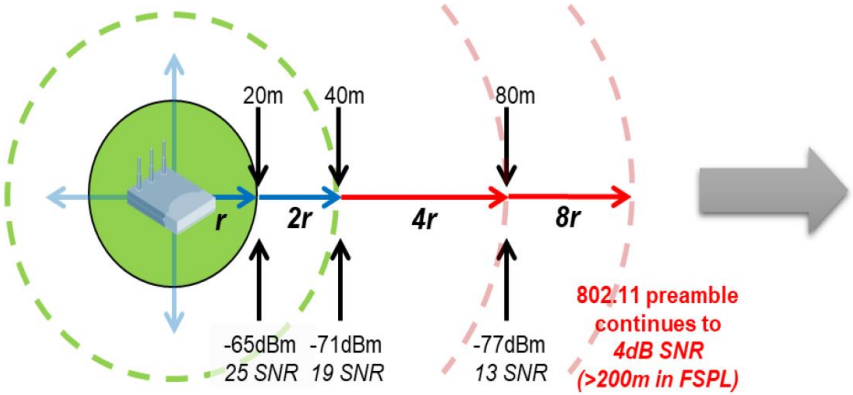


- *Need Multiple Channels*: Wi-Fi-7 relying on dynamic random spectrum access and contention-based protocols **require access to multiple channels** to maintain acceptable performance

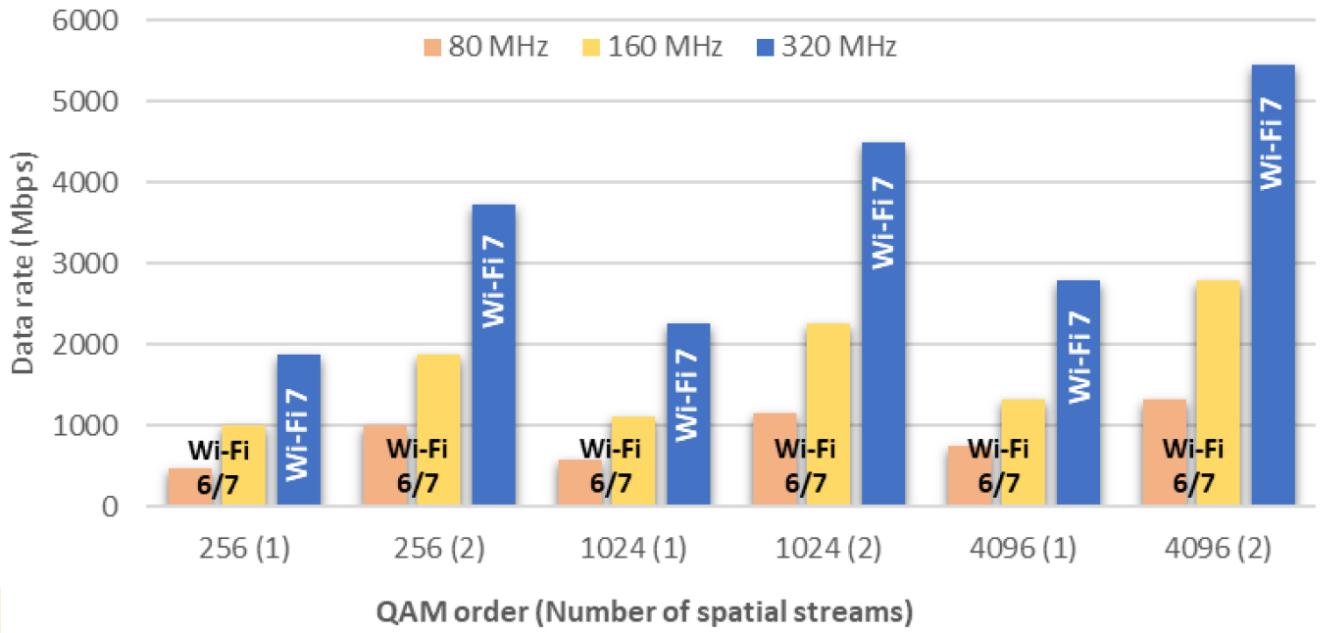
- *Need Wider Channels*: Wi-Fi-7 designed for Extremely High Throughput -- channel bandwidth of **up to 320 MHz**



Self-Coordination Requires 2+ Cell Isolation



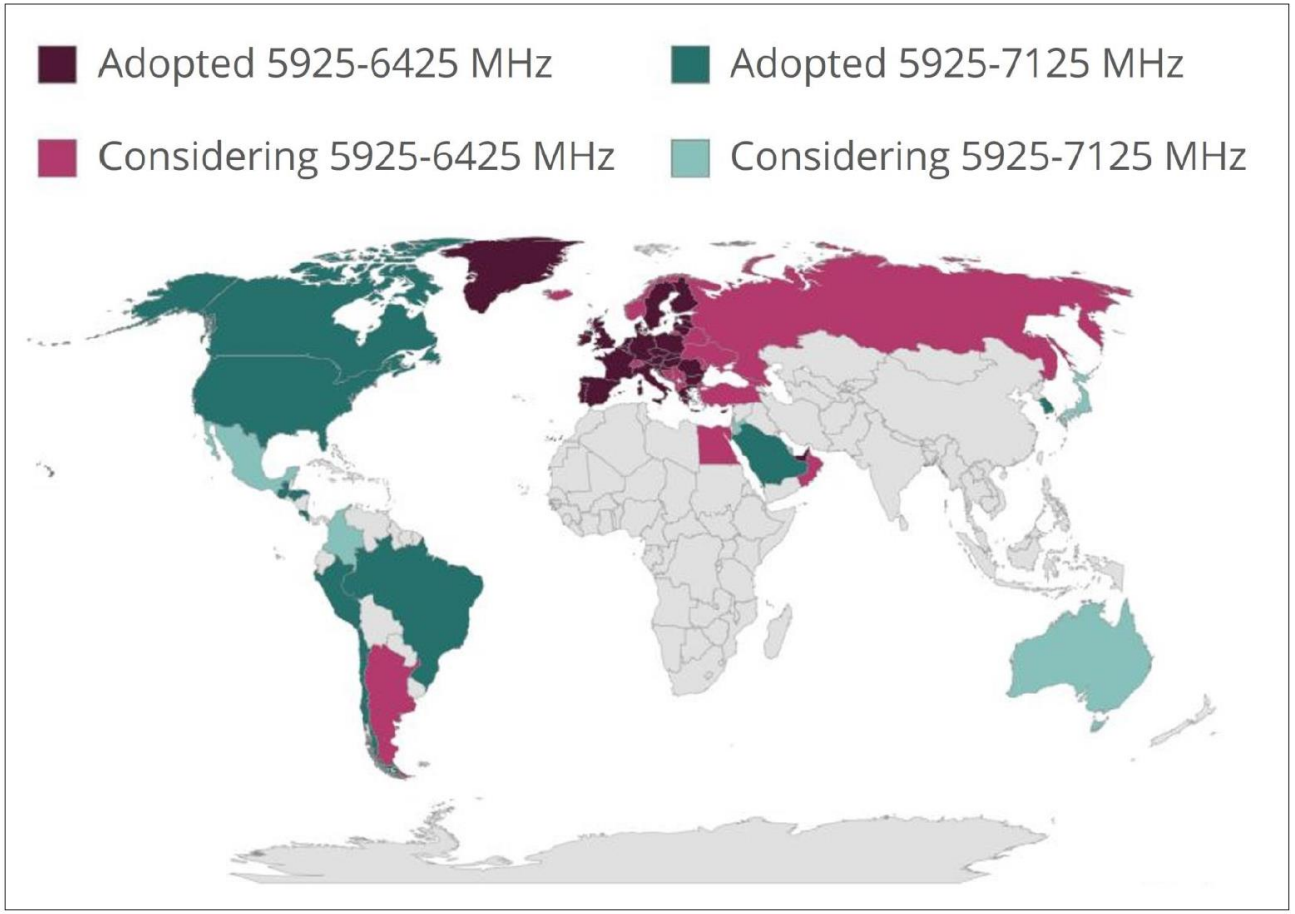
Wi-Fi 7 vs Wi-Fi 6 Data Rate Comparison



Countries Enabling Wi-fi 6E

*80% of mobile data traffic originates or terminates indoors, prediction - 90%**.

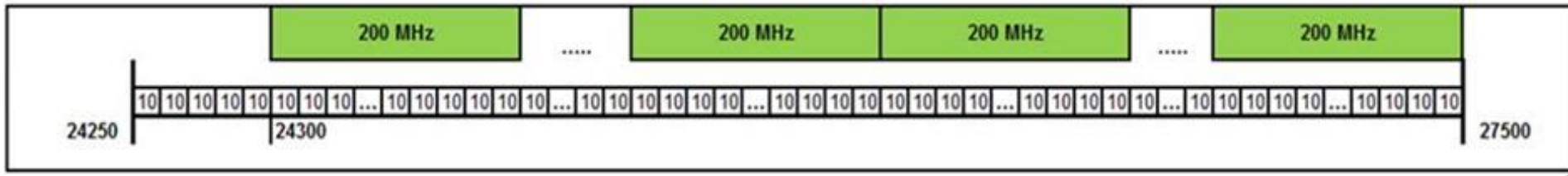
(*RSPG18-001, BEREC and RSPG joint report on Facilitating mobile connectivity in “challenge areas”, December 2017)



https://www.wi-fi.org/countries-enabling-wi-fi-6e

Next pioneer band - 26 GHz. ECC Decision (18) 06 "Harmonised technical conditions for Mobile/Fixed Communications Networks (MFCN) in the band 24.25-27.5 GHz", corrected 2018 October.
EU Decision 2019/784 of 14 May 2019

- Member States that they make a sufficiently large portion of that band, e.g. 1 GHz, available for 5G by 2020 in response to market demand.



MFCN BS additional baseline requirement: maximum emissions into the 23.6-24.0 GHz band

Frequency range	Maximum Total Radiated Power (TRP) (see note)	Measurement bandwidth
23.6-24.0 GHz	-42 dBW	200 MHz

Note: This level requirement applies for BS for all foreseen modes of operation (i.e. maximum in-band power, electrical pointing, carrier configurations)

EU DECISION 2020/590 of 24 April 2020 Corrections after WRC-19

Base station additional baseline power limit

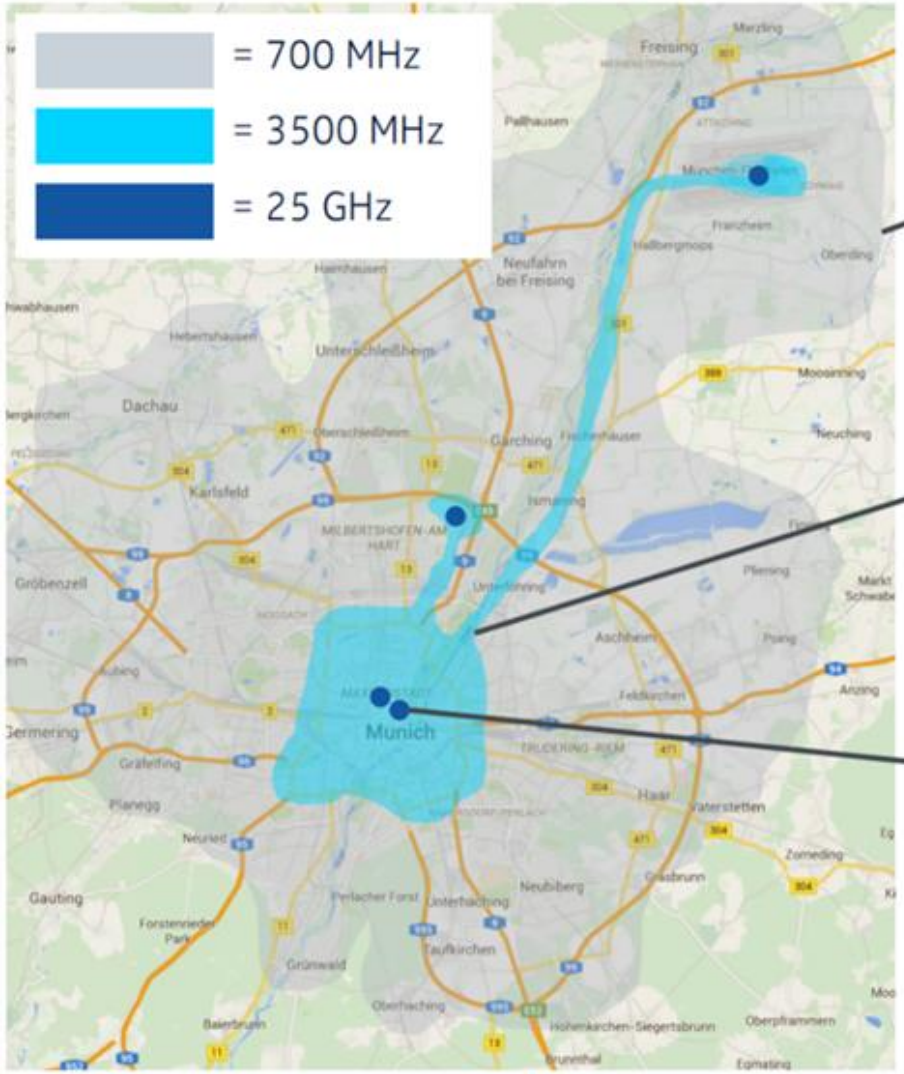
Frequency range	Maximum TRP	Measurement bandwidth	Entry into force
23,6-24,0 GHz	– 33 dBW	200 MHz	Entry into force of this Decision (a)
	– 39 dBW	200 MHz	1 January 2024 (b)

Terminal station additional baseline power limit

Frequency range	Maximum TRP	Measurement bandwidth	Entry into force
23,6-24,0 GHz	– 29 dBW	200 MHz	Entry into force of this Decision
	– 35 dBW	200 MHz	1 January 2024 (a)

(a) This limit applies to terminal stations brought into use after 1 January 2024. This limit does not apply to terminal stations that have been brought into use prior to that date. For those terminal stations, the limit of – 29 dBW/200 MHz continues to apply after 1 January 2024.'

COVERAGE AND DATA SPEED REQUIREMENTS FOR 5G



700 MHz layer
- Wide coverage with indoor penetration
- Massive IoT and ultra reliable low latency
- Reusing existing sites for 800/900 MHz

3.5 GHz layer
- Dense urban coverage
- Supports enhanced mobile broadband
- Reusing existing sites for 2 GHz

25 GHz layer
- Hot spots like airports and stadiums
- Supports full enhanced mobile broadband
- Data rates exceed 10 Gbps

Other Frequency Bands for 5G

- ECC Decision (05)05 on the band 2500-2690 MHz. Approved 18 March 2005 Latest amended 5 July 2019.
- ECC Decision (06)01 on the bands 1920-1980 MHz and 2110-2170 MHz. Approved 24 March 2006 Amended 8 March 2019
- ECC Decision (06)13 on the bands 880-915 MHz, 925-960 MHz, 1710-1785 MHz and 1805-1880 MHz. Approved 01 December 2006 Amended 8 March 2019 and XYZ 2022. (in public consultation)
- Draft ECC Report and update of ECC Decision (14)02: on the band 2300-2400 MHz. extended up to 29 March 2023.
- EU Decision 2018/661 of 26 April 2018 amending Implementing Decision (EU) 2015/750 on the 1 427-1 452 MHz and 1 492-1 517 MHz frequency bands.
- ECC (2021 11 12) has agreed the way forward for the work in ECC PT1 on 40.5-43.5 GHz based on no additional technical measures are needed to MFCN or FSS to enable compatibility at the 40.5 GHz boundary.

PRACTICAL CASE: AERONAUTICAL TELEMETRY STATIONS IN 1427-1518 MHZ BAND NEAR GEORGIA

RR 5.341A , 5.342, Res. 223 are applied.

ITU AND CEPT REGULATION OF L BAND

5.341A In Region 1, the frequency bands 1 427-1 452 MHz and 1 492-1 518 MHz are identified for use by administrations wishing to implement International Mobile Telecommunications (IMT) in accordance with Resolution **223 (Rev.WRC-15)**. This identification does not preclude the use of these frequency bands by any other application of the services to which it is allocated and does not establish priority in the Radio Regulations. The use of IMT stations is subject to agreement obtained under No. **9.21** with respect to the aeronautical mobile service used for aeronautical telemetry in accordance with No. **5.342**. (WRC-15)

5.342 *Additional allocation:* in Armenia, Azerbaijan, Belarus, the Russian Federation, Uzbekistan, Kyrgyzstan and Ukraine, the frequency band 1 429-1 535 MHz is also allocated to the aeronautical mobile service on a primary basis, exclusively for the purposes of aeronautical telemetry within the national territory. As of 1 April 2007, the use of the frequency band 1 452-1 492 MHz is subject to agreement between the administrations concerned. (WRC-15)

ECC Rep. 295 Guidance on Cross border coordination between MFCN and Aeronautical Telemetry Systems in the 1429-1518 MHz band.

ECC Recommendation (15)01 *For the cross-border coordination of 5G networks. Coordination with* ***BSS*** *in the frequency band 1452-1492 MHz is required since WRC19.*

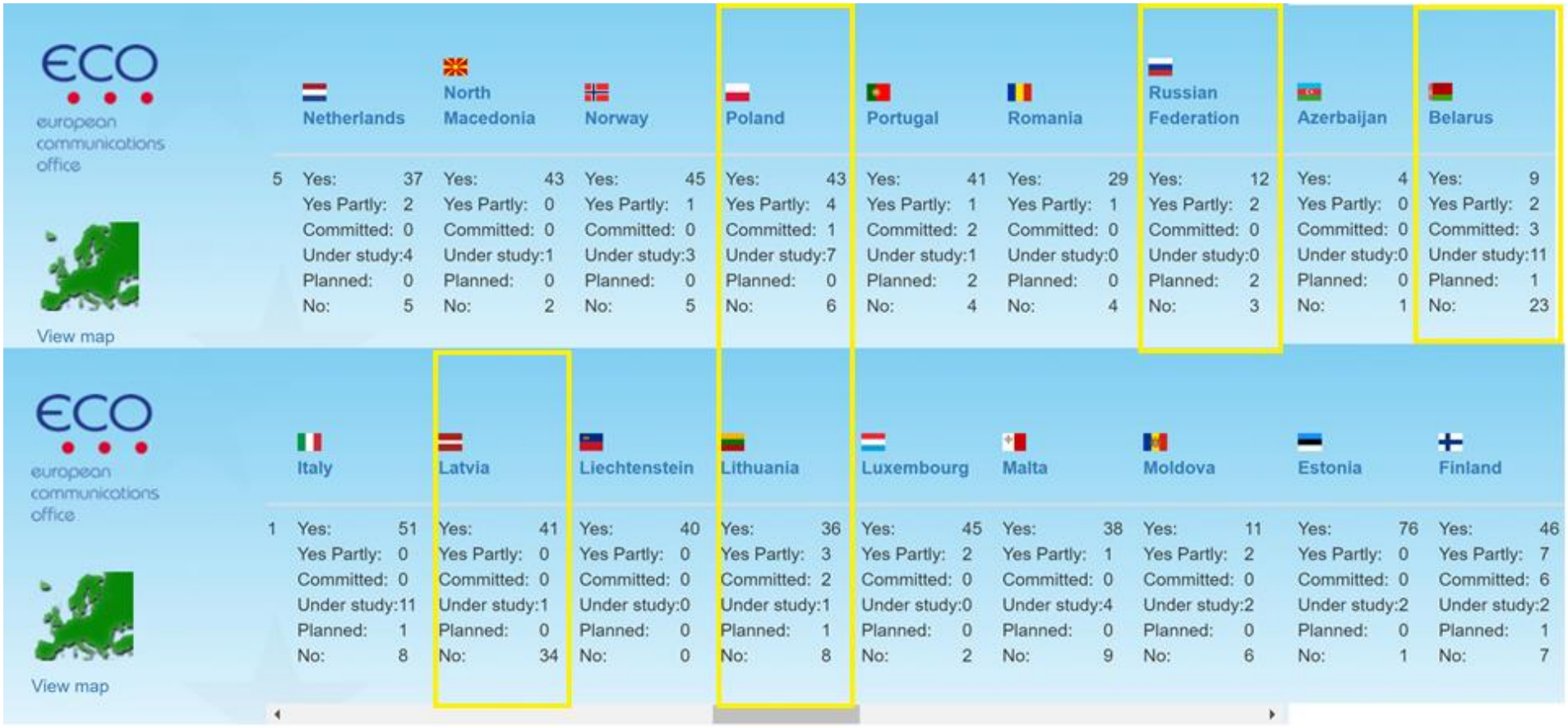
CROSS-BORDER COORDINATION OF FREQUENCIES FOR 5G ,ACCORDING REC 15(01) FOR 1400 MHZ BAND:

The **1452-1492** MHz band may be used for MFCN SDL systems without coordination if the mean field strength of each cell produced by the base station does not exceed the value of **65 dBµV/m/5** MHz at a height of 3 m above ground level **at the borderline** between concerned countries and a value of **47 dBµV/m/5** MHz at a height of 3 m above ground level at a distance of **6 km** inside the neighbouring country.

ITU RR Article 21.5 Adenga item 9 WRC-23. Regulation since 1960: no reference bandwidth

- **21.5** 3) The power delivered by a transmitter to the antenna of a station in the fixed
- or mobile services shall not exceed +13 dBW in frequency bands between 1 GHz and 10 GHz, or
- +10 dBW in frequency bands above 10 GHz, except as cited in No. **21.5A**. (WRC-2000)
- A. CEPT position for the 26 GHz band (i.e., using the TRP + Bandwidth adjustment factor)
- B. ECC/PT1 is tasked to investigate alternative metrics to TRP (e.g. taking also into account power per element, number of elements), provided that such metrics are derived on the basis of the effective protection of satellite reception..

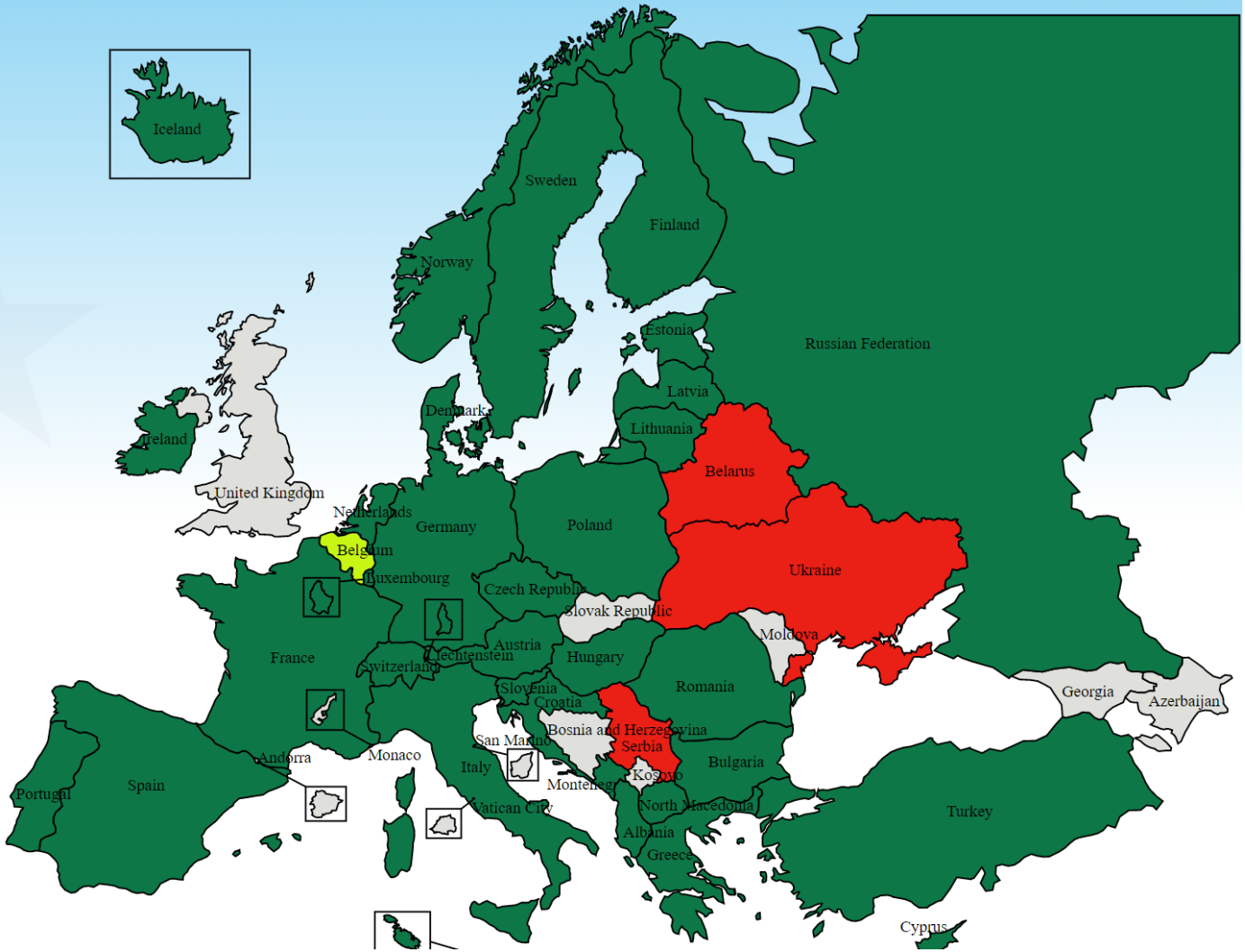
CEPT -Forum for Harmonization



	Netherlands	North Macedonia	Norway	Poland	Portugal	Romania	Russian Federation	Azerbaijan	Belarus
5	Yes: 37	Yes: 43	Yes: 45	Yes: 43	Yes: 41	Yes: 29	Yes: 12	Yes: 4	Yes: 9
	Yes Partly: 2	Yes Partly: 0	Yes Partly: 1	Yes Partly: 4	Yes Partly: 1	Yes Partly: 1	Yes Partly: 2	Yes Partly: 0	Yes Partly: 2
	Committed: 0	Committed: 0	Committed: 0	Committed: 1	Committed: 2	Committed: 0	Committed: 0	Committed: 0	Committed: 3
	Under study:4	Under study:1	Under study:3	Under study:7	Under study:1	Under study:0	Under study:0	Under study:0	Under study:11
	Planned: 0	Planned: 0	Planned: 0	Planned: 0	Planned: 2	Planned: 0	Planned: 2	Planned: 0	Planned: 1
	No: 5	No: 2	No: 5	No: 6	No: 4	No: 4	No: 3	No: 1	No: 23

	Italy	Latvia	Liechtenstein	Lithuania	Luxembourg	Malta	Moldova	Estonia	Finland
1	Yes: 51	Yes: 41	Yes: 40	Yes: 36	Yes: 45	Yes: 38	Yes: 11	Yes: 76	Yes: 46
	Yes Partly: 0	Yes Partly: 0	Yes Partly: 0	Yes Partly: 3	Yes Partly: 2	Yes Partly: 1	Yes Partly: 2	Yes Partly: 0	Yes Partly: 7
	Committed: 0	Committed: 0	Committed: 0	Committed: 2	Committed: 0	Committed: 0	Committed: 0	Committed: 0	Committed: 6
	Under study:11	Under study:1	Under study:0	Under study:1	Under study:0	Under study:4	Under study:2	Under study:2	Under study:2
	Planned: 1	Planned: 0	Planned: 0	Planned: 1	Planned: 0	Planned: 0	Planned: 0	Planned: 0	Planned: 1
	No: 8	No: 34	No: 0	No: 8	No: 2	No: 9	No: 6	No: 1	No: 7

Implementation Overview: ECC/DEC/(06)02



RRT

Exemption from Individual Licensing of Low e.i.r.p. Satellite Terminals (LEST) operating within the frequency bands 10.70–12.75 GHz or 19.70–20.20 GHz space-to-Earth and 14.00–14.25 GHz or 29.50–30.00 GHz Earth-to-Space

ECC/DEC/REC for Wifi

	Documentation	Status
2	Albania	Under study
3	Andorra	Yes
4	Austria	Yes
5	Azerbaijan	Yes Partly
6	Belarus	Yes
7	Belgium	Yes
8	Bosnia and Herzegov	Yes
9	Bulgaria	Yes
10	Croatia	Yes
11	Cyprus	Yes
12	Czech Republic	Yes
13	Denmark	Yes
14	Estonia	Yes
15	Finland	Yes
24	Latvia	Yes
25	Liechtenstein	Yes
26	Lithuania	Yes
27	Luxembourg	Yes
28	Macedonia (FYROM)	Yes
29	Malta	Yes
30	Moldova	No info
31	Monaco	No info
32	Montenegro	Yes
33	Netherlands	Yes
34	Norway	Yes
35	Poland	Yes
36	Portugal	Yes
37	Romania	Yes
38	Russian Federation	Yes Partly

Ark1 Ark2 Ark3

ECC Decision (04)08 on the harmonised use of the **5 GHz** frequency bands for Wireless Access Systems including Radio Local Area Networks (**WAS/RLAN**)

ECC REC 70-03 WiFi in **2,4 GHz** - limited implementation

ECC Decision of 14 March 2008 on the harmonised use of Safety-Related Intelligent Transport Systems (ITS) in the 5875-5935 MHz frequency band. Amended on 3 July 2015 and amended on 6 March 2020.

Implementation status

*: No info (default value) N: Not implemented U: Under study P: Planned L: Limited implementation Y: Implemented

Frequency Band	BLR	HNG	HOL	HRV	I	IRL	ISL	KOS*	LIE	LTU	LUX	LVA	MCO	MDA	MKD	MLT	MNE	NOR	POL	POR	ROU	RUS	S	SI
a: 26960kHz - 27410kHz	L	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	L	Y	Y	Y	L	L	Y	Y
c: 446MHz - 446.2MHz	Y	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L	Y	Y
d: 1880MHz - 1900MHz	Y	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
e1: 5150MHz - 5350MHz	Y	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
e2: 5470MHz - 5725MHz	Y	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
f: 5875MHz - 5935MHz	U	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L	Y	Y
g: 63.72GHz - 65.88GHz	N	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
h: 77GHz - 81GHz	Y	Y	Y	Y	Y	Y	Y	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
i: 5945MHz - 6425MHz	*	*	*	*	*	*	Y	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Coordination of earth stations operating in 14,25-14,50 GHz (1)

There are countries which uses terrestrial systems in this band and therefore neighboring countries have to coordinate every **VSAT** or **ESIM** terminal
Current regulation in CEPT: ECC/DEC/(03)04, ECC/DEC/(17)04, ECC/DEC/(18)04 and ECC/DEC/(18)05 and implementation is very diverse

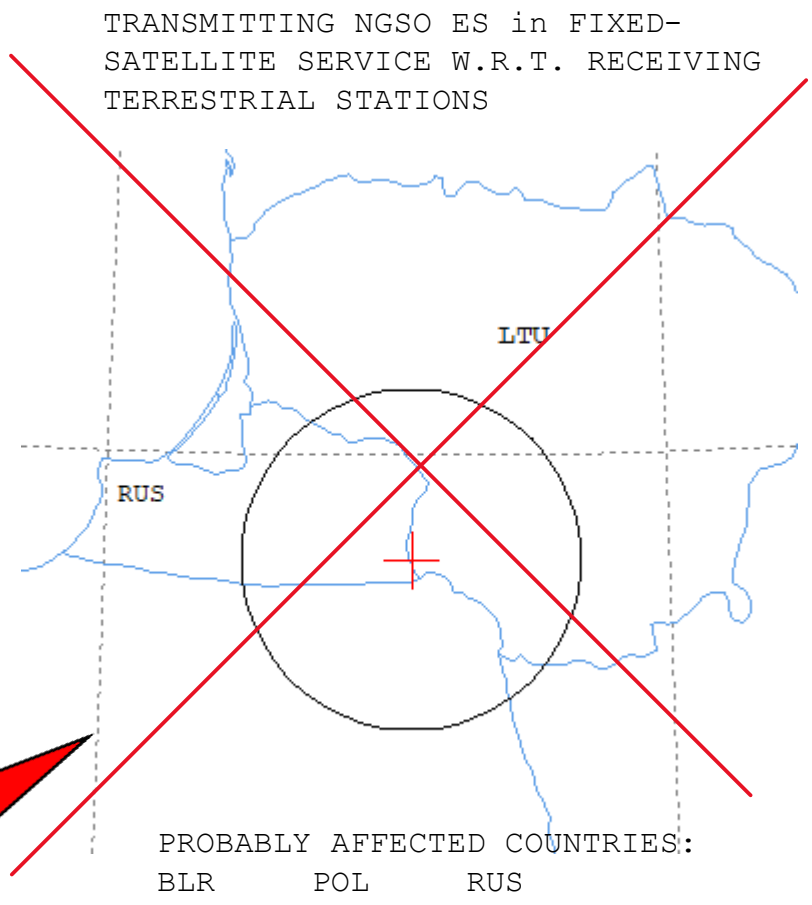
ECC/DEC/(03)04

ECC/DEC/(17)04, ECC/DEC/(18)04, ECC/DEC/(18)05

Yes: Yes partly: Committed: Planned/Under Study/See Remarks: No: No Info:

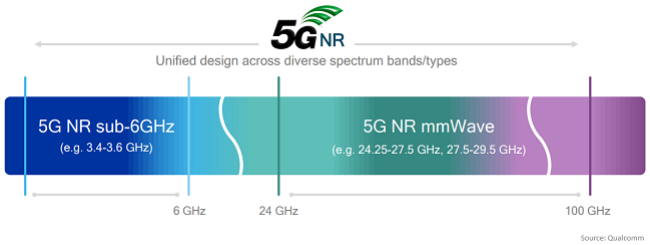
Coordination of earth stations operating in 14,25-14,50 GHz (2)

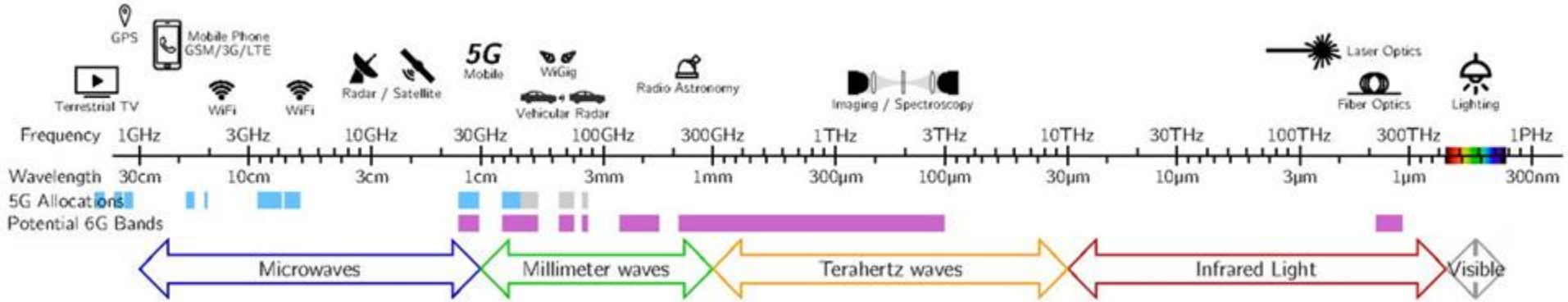
- New NGSO systems and new operation modes like ESIM
- Additional workload for both administrations as coordination could be required for every network or terminal
- No option in BR sat software to calculate coordination contour for typical earths stations in this band
- Solution: agree on specific conditions of use or accept conditions established in ECC decisions

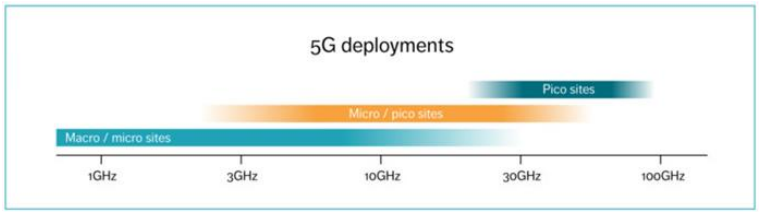


No more needed

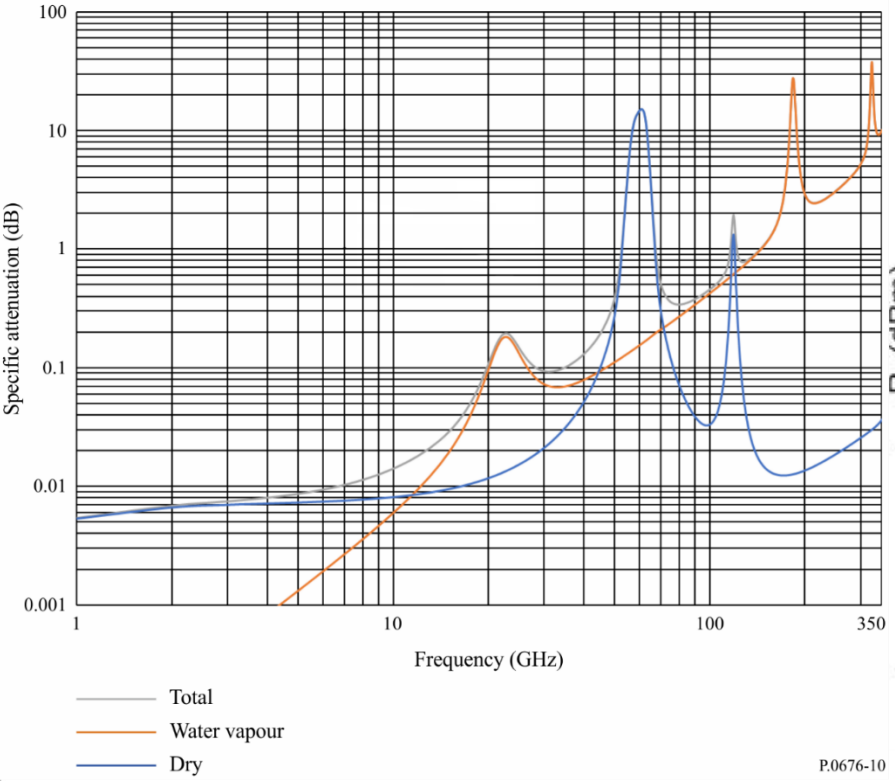
MOVING TO 6G AND ABOVE 100 GHZ

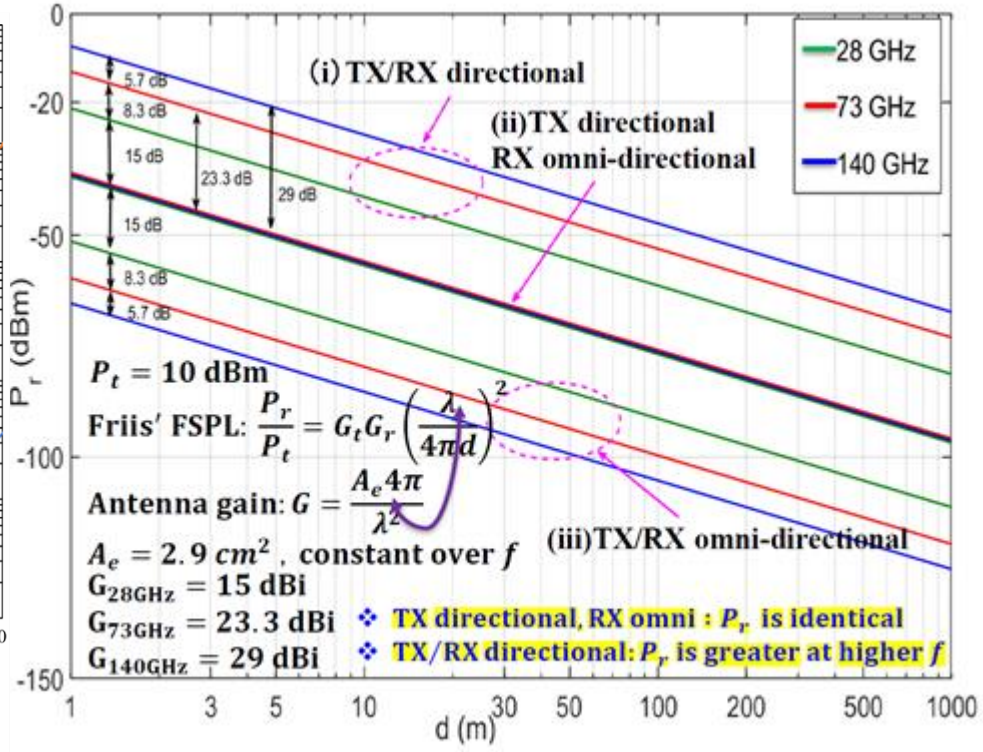






THZ COMMUNICATIONS (6G)





Y. Xing and T. S. Rappaport, "Propagation Measurement System and Approach at 140 GHz-Moving to 6G and Above 100 GHz," in IEEE 2018 Global Communications Conference, Dec. 2018, pp. 1–6.

WHY IS SHARING NECESSARY AT ALL?

- Assuming, that interference to Radio Astronomy can be handled (operated in very high remote areas only!) the most critical passive service w.r.t. THz Communication is Earth Exploration Satellite Service (EESS):

  - Transmission in remaining bands only would allow
    - small bandwidths
    - distributed over entire THz range

    Not feasible for data rates >> 10 Gbit/s

  - **Coexistent spectrum usage**

    Interference investigations inevitable to have a safe basis for the operation of THz Communications

Remaining Frequency Bands not used by EESS	Total available Bandwidth
286-294 GHz	8 GHz
307-313 GHz	6 GHz
356-361 GHz	5 GHz
366-369 GHz	3 GHz
392-397 GHz	5 GHz
399-409 GHz	10 GHz
411-416 GHz	5 GHz
434-439 GHz	5 GHz

Thank you

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