5G and TDD Synchronisation

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Policy Positions – Realising 5G's full potential

80-100 MHz per MNO
IN MID-BANDS AND
1 GHz per MNO
IN mmW

5G needs a significant amount of new harmonised mobile spectrum. Regulators should aim to make available 80-100 MHz of contiguous spectrum per operator in prime 5G mid-bands and around 1 GHz per operator in millimetre wave bands.

5G needs LOW, MID and HIGH Bands

Governments should engage in the WRC-23 process to ensure that sufficient mid- and low-band spectrum is made available for 5G.

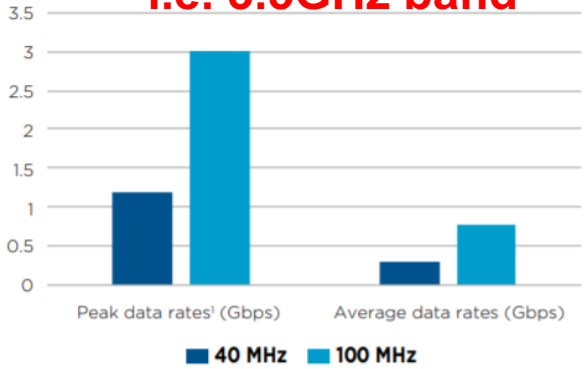
Exclusively licensed spectrum should remain the core 5G spectrum management approach. Spectrum sharing and unlicensed bands can play a complementary role.

Governments and regulators should avoid inflating 5G spectrum prices (e.g. through excessive reserve prices or annual fees) as they risk limiting network investment and driving up the cost of services.

Setting spectrum aside for verticals in priority 5G bands could jeopardise the success of public 5G services and may waste spectrum. Sharing approaches like leasing are better options where verticals require access to spectrum.

Regulators must consult 5G stakeholders to ensure spectrum awards and licensing approaches consider technical and commercial deployment plans.

i.e. 3.5GHz band



100 MHz → 60 MHz =

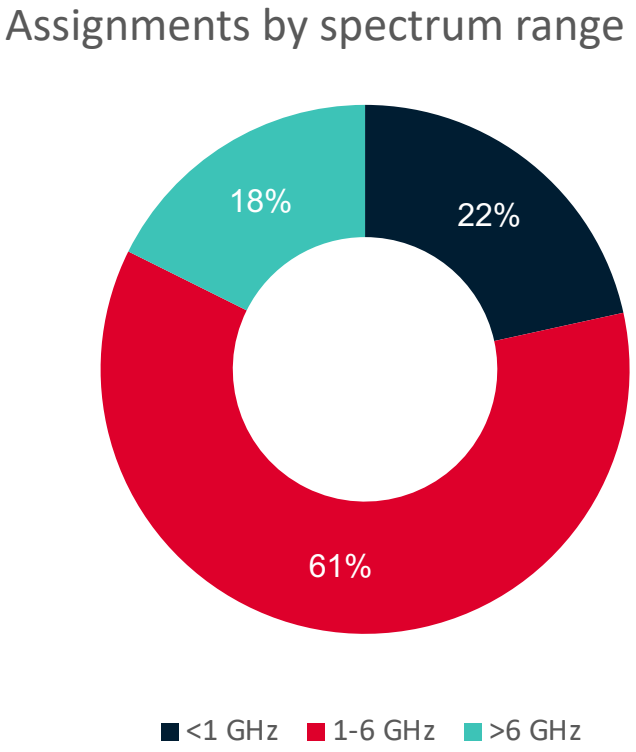
64% INCREASE IN NUMBER OF CELL SITES

www.gsma.com/spectrum

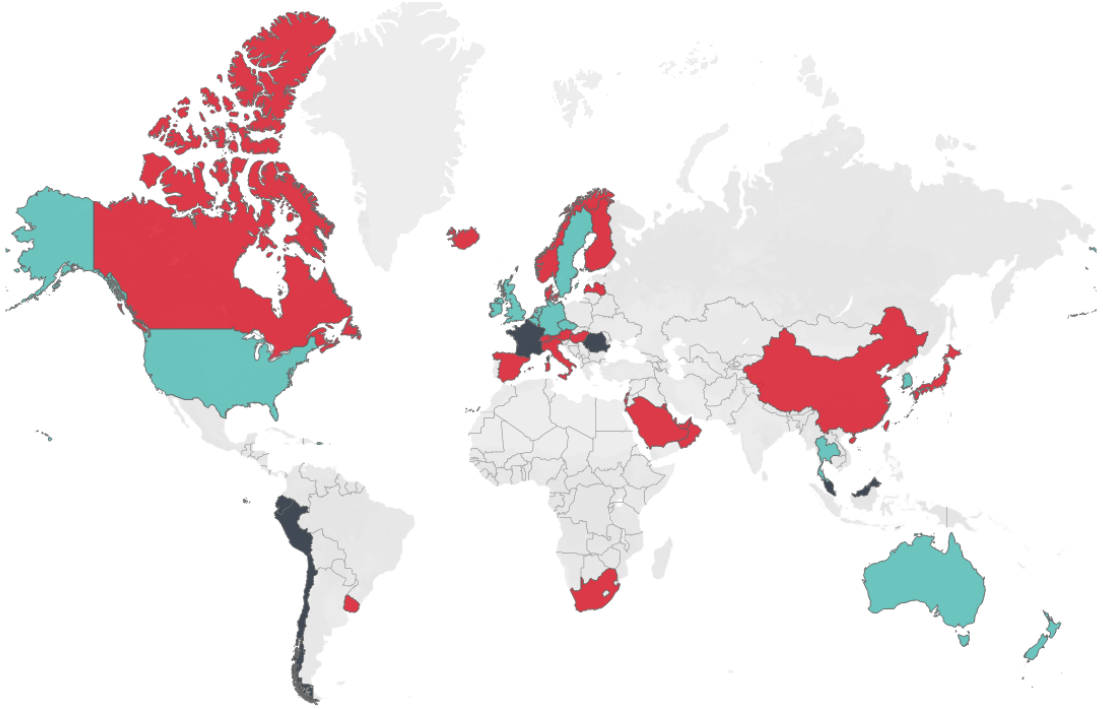
Spectrum Trends: New Bands

Various new bands have been earmarked for 5G (700 MHz, C-Band, mmWave)

- 3.5 GHz has emerged as key: assigned in 31 countries
- mmWave assignments much slower, partly due to the fact that spectrum has only been allocated for IMT at WRC-19
- Awards in 700 MHz are picking up momentum, however MNOs are yet to choose how to initially use the band. Currently there is a mix of 5G and 4G deployments in the band



Spectrum State of Play



Assignments planned

Assignments completed and planned

Assignments completed

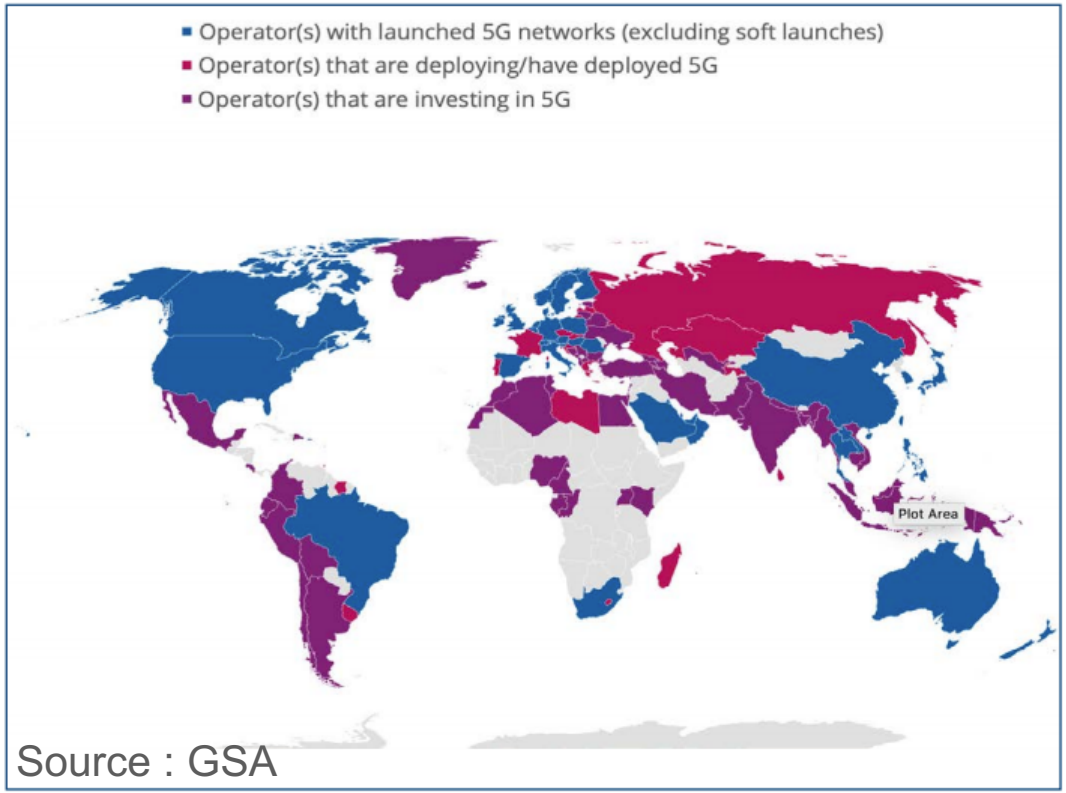
Completed assignments

- As of Q3 2020, 'new' spectrum specifically earmarked for 5G had been assigned in 35 markets.
- 121 operators received spectrum across low, mid and high bands to date:*
  - 48** operators in low band
  - 91 operators in mid band
  - 35** operators in high band.

* Low = <1 GHz, mid = 1–6 GHz, high = >6 GHz

** excludes US and Canada regional operators/winners

5G Networks and Devices



Source : GSA

5G Networks and Devices

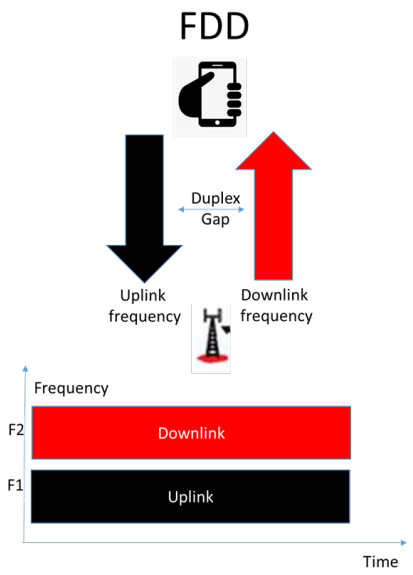
OVER 100 COMMERCIAL 5G NETWORKS NOW LAUNCHED WORLDWIDE

- 397 operators in 129 countries/territories were investing in 5G, including trials, acquisition of licences, planning, network deployment and launches.

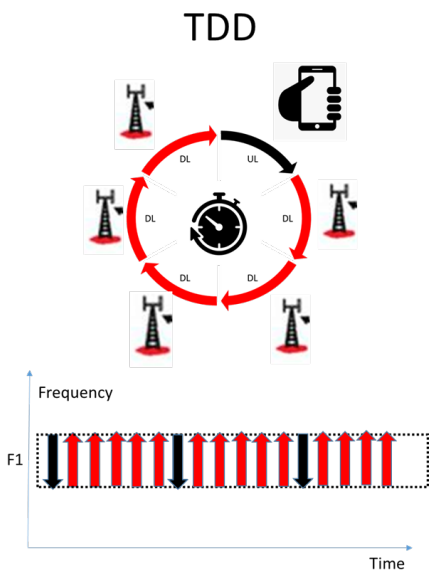
444 5G devices announced

- By end-September 2020, 222 5G devices were commercially available
- The number of commercially available 5G devices has almost doubled since end-May 2020.

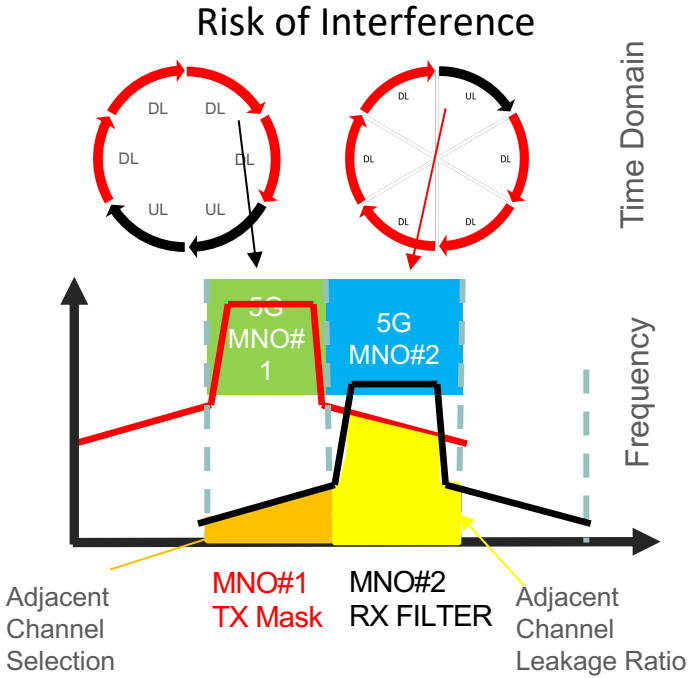
FDD, TDD and The Risk of Interference



2 dedicated frequency bands at the same time



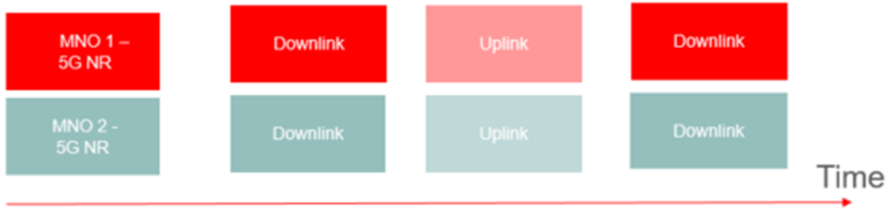
1 dedicated frequency band but different time slots



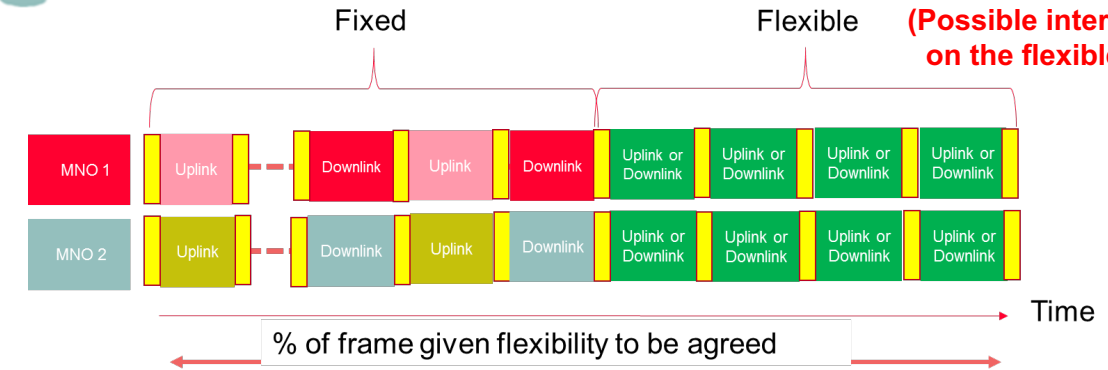
No synchronisation , semi-synchronisation or full sync?

No Synchronisation

Full Synchronisation



Semi-Synchronisation



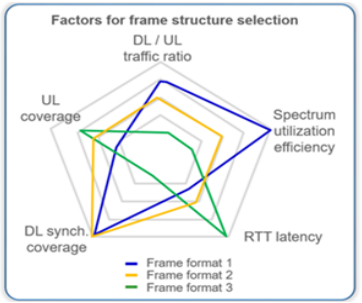
Synchronisation impact deployments and performance

Deployments considerations

- TDD networks must be synchronised to avoid interference (or semi-synchronised to reduce interference)
- Guard band and semi-synchronisation are not economically viable at this stage
  - No harmonisation on the channel plan
  - Complexity in filtering
- When is synchronisation required?
  - Co-channel separation distances below 60km
  - Adjacent channel separation distance below 16km

- All parties must use the same frame structure to achieve synchronisation

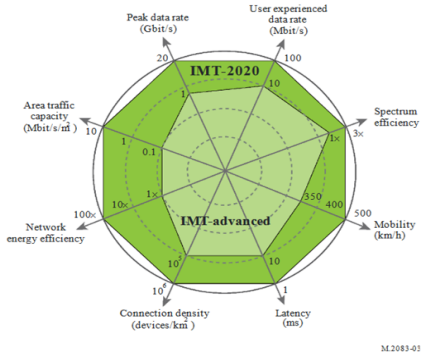
Performance



Rec. ITU-R M.2083-0

FIGURE 3

Enhancement of key capabilities from IMT-Advanced to IMT-2020



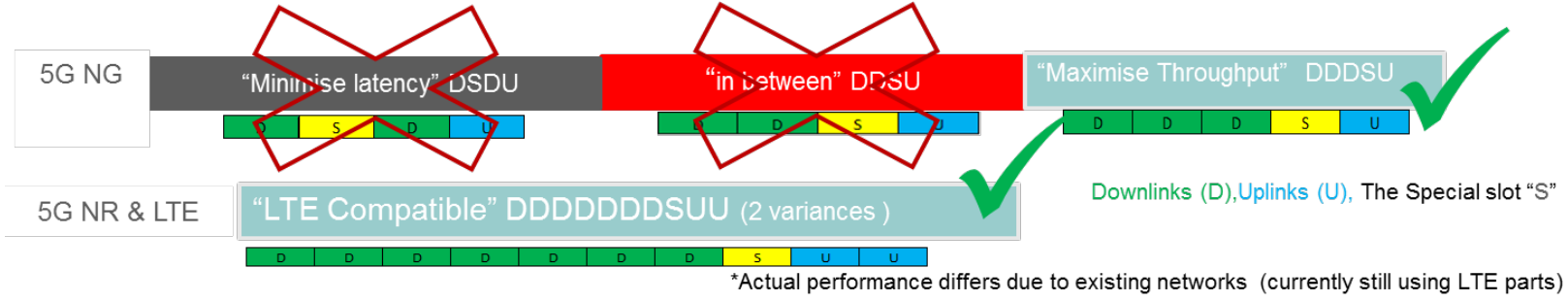
A Common Frame ?

DL/UL	Latency (ms)* (round trip time)		Throughput per cell (Mbits/s)* for 100MHz channel	
	DDDSU	DDDDDDDSUU	DDDSU	DDDDDDDSUU
DL	**1.77**	**3.02**	**6 740**	**7 147**
UL	**1.71**	**2.95**	**1 389**	**1 389**

Basic rules of thumb :

1. **For higher throughput** – the frame structure should contain a high number of consecutive Downlinks (D)
2. **For higher uplink data** – the frame structure should contain a high number of consecutive Uplinks (U)
3. **For lower latency and more accurate coverage** (and higher speed mobile) - the frame structure should have a lower number of consecutive Downlinks (D) and Uplinks and more frequent switching. More frequent switching decreases throughput.

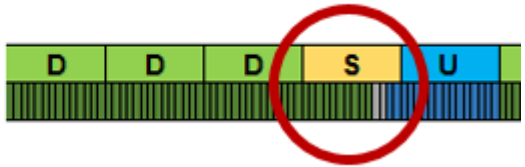
✓ Options to compensate the performance (other bands, CA, SUL)



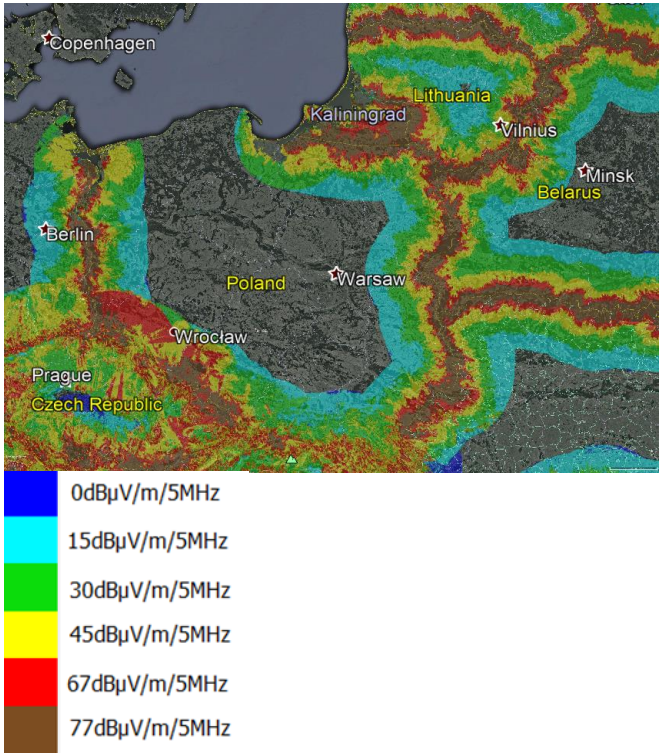
The Special slot “S” – in DSU and never in USD

- Found in nearly all frame structures i.e DDDSU or DDDDDDDSUU.
- Normal slot in structure (contains 14 symbols) and may contains Uplink(s),Downlink (s) and a Guard Period (GP) symbols.
  - GP is the time between Downlink and Uplink transmission
  - Its purpose is to avoid interference within a cell and ensure coexistence among cells by compensating for propagation delays
  - GP is not required between Uplink and Downlink, as there is less chance of collision because of the base station timing advance feature
  - The GP duration varies with the size of the cells and depends on the propagation delays
    - A GP of 2 symbols would cater for cell sizes of up to 10.7 km
    - A GP of 4 symbols would cater for cell sizes of up to 21.4 km
    - A GP of 6 symbols would cater for cell sizes of up to 32.1 km
  - More than 2 symbols should be allowed to be configured as guard period by reducing number of symbols available for the downlink
- No incumbent “S” is : **10:2:2** (10DL, 2GP, 2UL)
- LTE incumbent “S” is : **6:4:4** (6DL, 4GP, 4UL)

DDDSU



Cross border Issues



Trigger values at a height of 3 m above ground between synchronised TDD systems with beamforming and non-beamforming

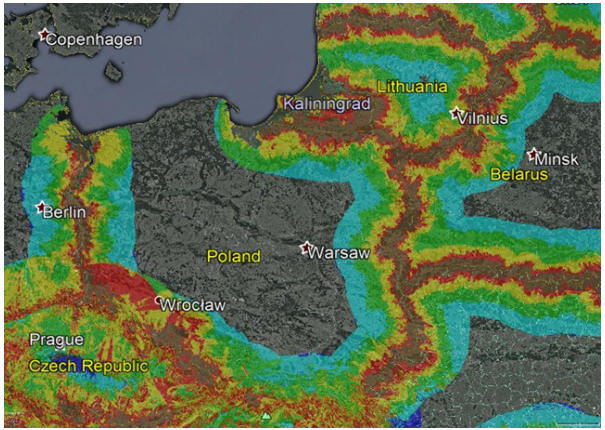
SYNCHRONISED CASE		
Centre frequencies aligned		Centre frequencies not aligned
Preferential PCIs	Non-preferential PCI	All PCIs
67 dBµV/m/5 MHz @ 0 km and 49 dBµV/m/5 MHz @ 6 km	49 dBµV/m/5 MHz @ 0 km	67 dBµV/m/5 MHz @ 0 km and 49 dBµV/m/5 MHz @ 6 km
@ stands for "at a distance inside the neighbouring country". Note (1): It should be noted that for NR BS, in case of same PCIs use when centre frequencies are not aligned, the field strength levels for synchronised operation should be further studied. In fact, in NR, if the centre frequencies are not aligned it doesn't imply automatically that SSB blocks are not aligned. In case of LTE centre frequencies alignment is equivalent to synchronisation signals alignment. Note (2): However, in case of AAS systems, these thresholds are not sufficient to deploy networks in border areas without further measures to be studied.		

Trigger values at a height of 3 m above ground for preferential frequency blocks of unsynchronised TDD systems with beamforming and non-beamforming

UNSYNCHRONISED CASE		
PREFERENTIAL FREQUENCY BLOCKS		NON-PREFERENTIAL FREQUENCY BLOCKS
Preferential PCIs	Non-preferential PCI	All PCIs
45 dBµV/m/5 MHz @ 0 km and 27 dBµV/m/5 MHz @ 6 km	27 dBµV/m/5 MHz @ 0 km	0 dBµV/m/5 MHz @ 0 km
@ stands for "at a distance inside the neighbouring country"		

Cross border issues when two operators pick different frames

1. Localised change of frame structure (i.e indoor usage);
2. Network optimisation (such as base station location, antenna direction, and power limits);
3. Protection of 4G systems should take into account their real deployment (i.e take into account that they are mainly fixed wireless access systems);
4. Downlink blanking where operators, on both sides of the border, agree to stop the use of some of their downlink slots when the other operators are using an uplink slot. Although, this will impact performance and may not be built in to all equipment, especially legacy 4G;
5. A step-by-step migration based on the regional timings of 5G deployments and 4G migrations;



Cross border issues when two operators pick different frames (cont)

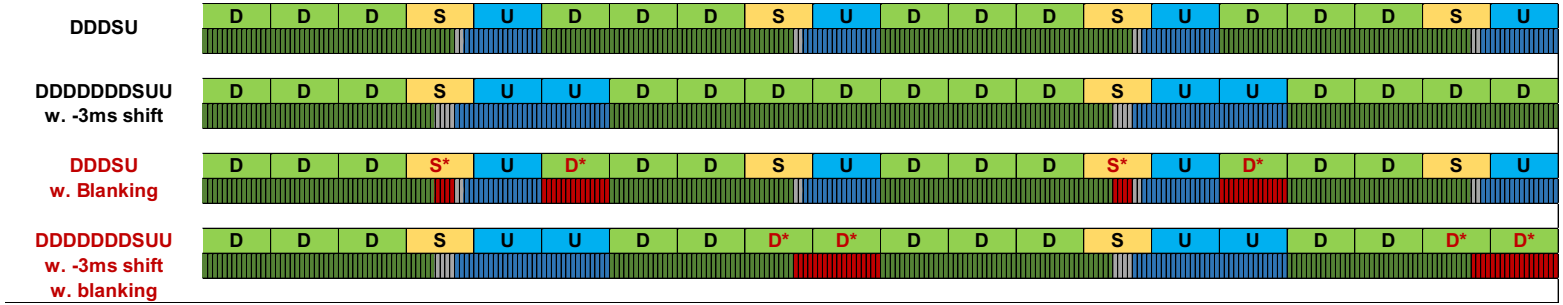
6. Migrate 4G networks to a different band or to 5G technology;
7. Commercial agreement between 5G operators and incumbent 4G operators (including purchasing the company, re-farming, and reprogramming);
8. Reduce capacity near the borders, i.e. by only using a part of allocated spectrum;
9. Use alternative bands within the cross border area (including existing bands, mmWaves, additional new/temporary frequencies, or LSA in a different band);
10. Avoid co-channel use and aim to have operators only using adjacent channels – temporary band plan at the border; or,
11. Use club licences, spectrum and infrastructure sharing along border.

Cross border : Downlink Blanking (DL)

Agreement from all operators that they will not use all their DL blocks (High downlink capacity loss) to protect the UL of others to avoid interference and allows deploying different NR frame structures across borders

DDDSU vs DDDDDDDSUU – 3 ms shift

17.3% throughput loss



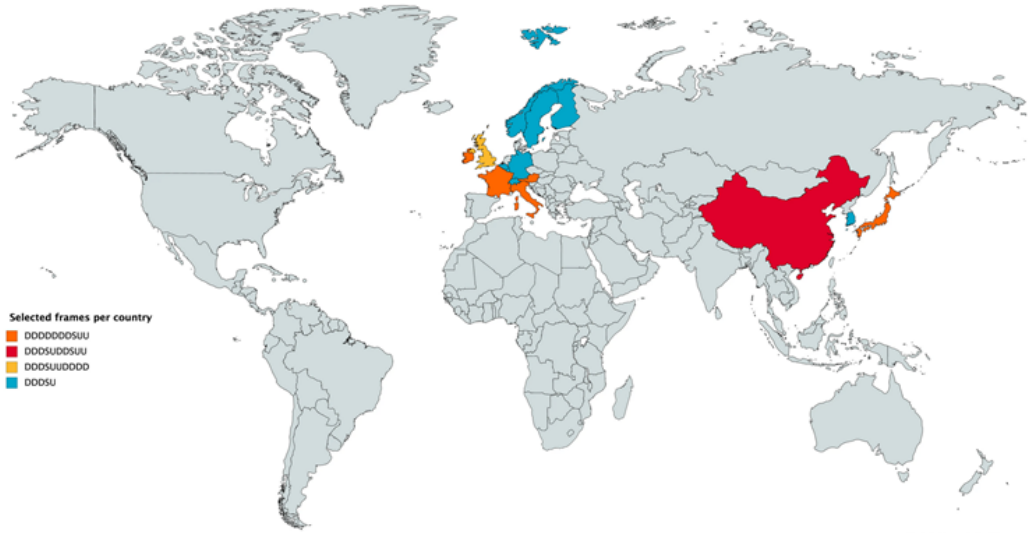
The GSMA's recommendations

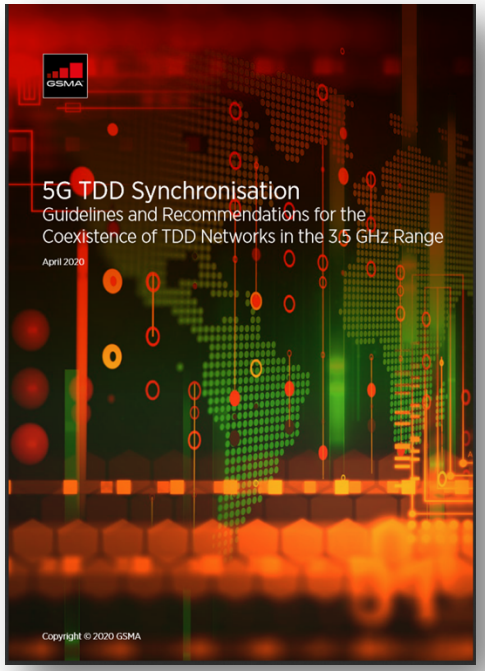
1. The default national TDD synchronisation parameters should be defined before awarding the spectrum.
2. A migration roadmap of all LTE and WiMAX legacy systems in the relevant bands should be defined.
3. All networks should use the same frame structure at a national level (ideally DDDSU if there is no LTE- and DDDDDDDSUU or DDDDSUDDSUU where there is nationwide LTE networks to protect)
4. Networks should be synchronised at an international level whenever possible
5. To manage cross-border coordination, use a common frame structure or consider alternatives to find localised solutions

The GSMA's recommendations (cont)

6. Consider using the following options to identify practical solutions to coexistence of networks using different synchronisation frame structure.
7. Operators should be permitted to agree on localised arrangements including different synchronisation frame structure
8. Public mobile operators should be permitted to update the agreed national TDD synchronisation parameters.
9. All networks should use the same UTC clock reference with a common starting point
10. All networks should use the same Special slot "S" format at national level

3.5GHz TDD Synchronisation





Access to report