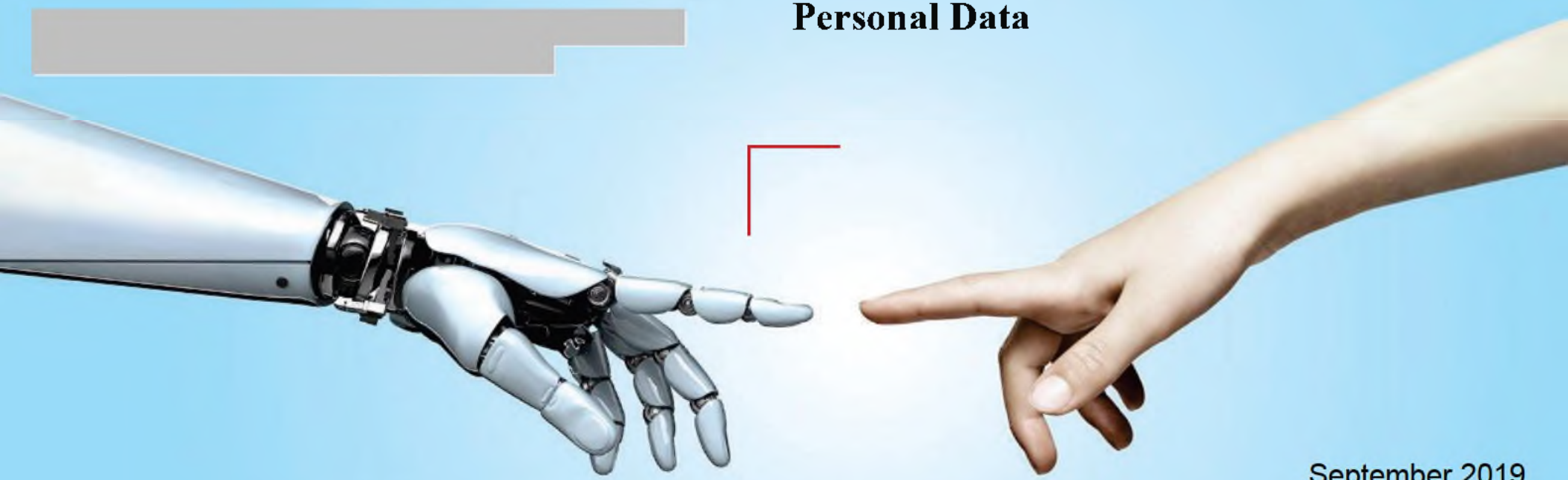
“Mid-bands” availability in medium / long term (WRC-23): 6425-7125 MHz

Personal Data



September 2019

HUAWEI

5G needs a multi-layer spectrum approach, sustainable

Short term views

"High-bands"

Super Data Layer

Addressing specific use cases
requiring extremely high data rates

Above 8 GHz

800 / 1000 MHz assignments
(contiguous)

"Mid-bands"

Coverage & capacity Layer

Best compromise between capacity and coverage
(wide area but no deep coverage)

2 to 8 GHz

100+ MHz assignments
(contiguous)

"Low-bands"

Coverage Layer

Wide area and deep indoor coverage

Below 2GHz

(up to 20MHz
paired / unpaired)

Timely and adequate spectrum availability is key to the success of 5G (access and backhaul spectrum).
5G requires spectrum from the three layers in parallel.
Each MNO will identify its specific most suitable combination of bands.
Regulators need to work on the availability of spectrum in the three layers in parallel.
Spectrum awards should be designed to encourage 5G deployment, not to raise revenue for the State.

Commercial Interest

Key messages

Target

- It is important for Europe / CEPT to support studies of **6425-7125 MHz** for IMT identification at WRC-23.
- This can be proposed under AI 10 in WRC-19.

Motivation

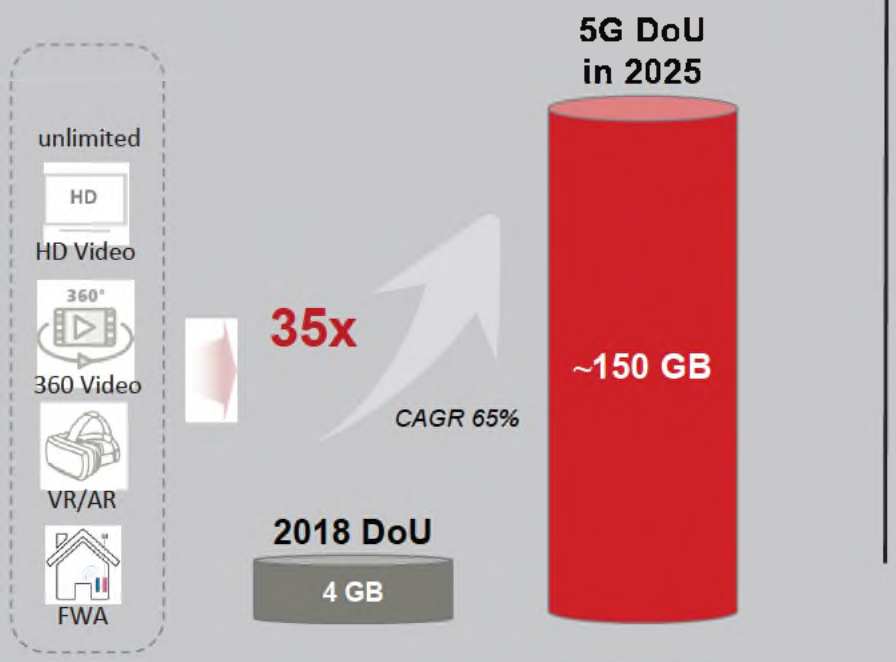
- Data of users (DoU) is expected to increase greatly, ~35x by 2025 for VR/HD video services alone, not to mention vertical applications. Additional mid-band spectrum is required.
- Mid-band frequencies are most cost effective, i.e. allow high system performance (due to good radio propagation and large available bandwidths).

Facts

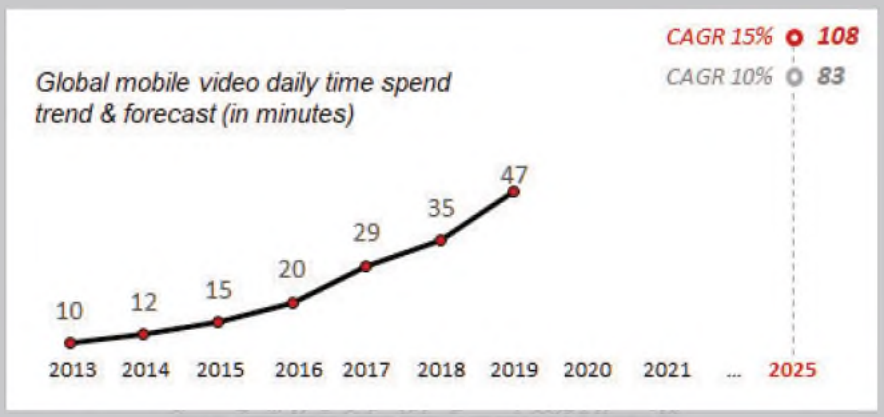
- A proposal under AI 10 of WRC-19 would only trigger studies of co-existence with incumbent services.
- This does not mean that **6425–7125** MHz would be available for IMT usage right now.

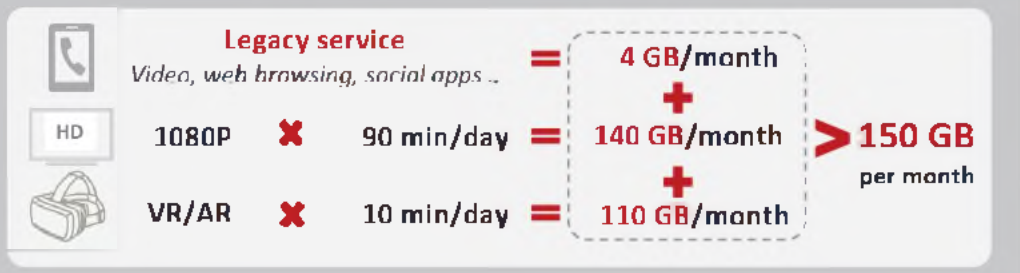
DoU will increase by 35x, reaching 150 GB/user/month by 2025

Driven by unlimited data plans and video services, 5G DoU will grow rapidly



150 GB/month DoU will be prevalent in 2025





DoU growth drives great need for new mid-band spectrum

Sites

5G site numbers will not increase

Difficulties in acquiring new sites

CAPACITY

Technology

Massive MIMO

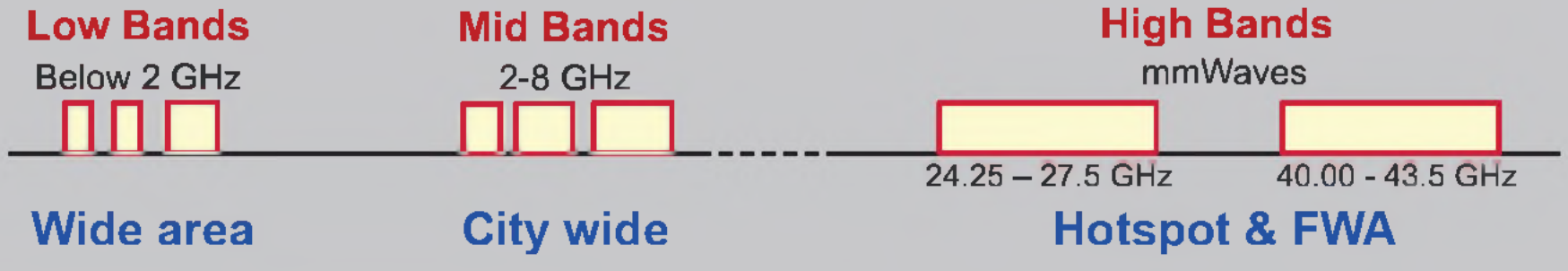
Up to 6x increase in spectrum efficiency

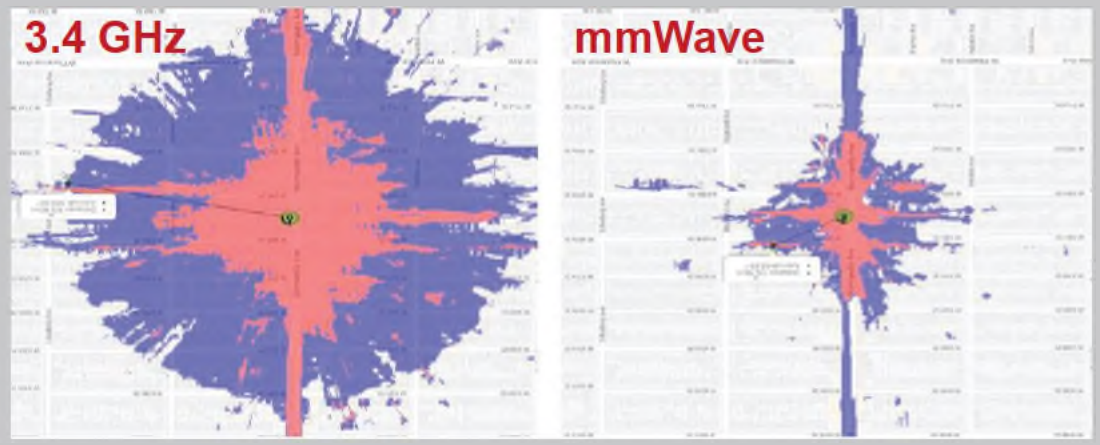
Spectrum

New mid-band frequencies

An optimal balance between wide-area coverage and high capacity

Mid-band frequencies are most efficient and cost effective for city-wide coverage





Field test at Los Angeles shows significant coverage gain is achieved at mid bands (3.4 GHz) over high bands (28 GHz).

Commercial Interest

More 5G applications will need additional spectrum in 2025

Various vertical applications will be supported by 5G networks in 2025

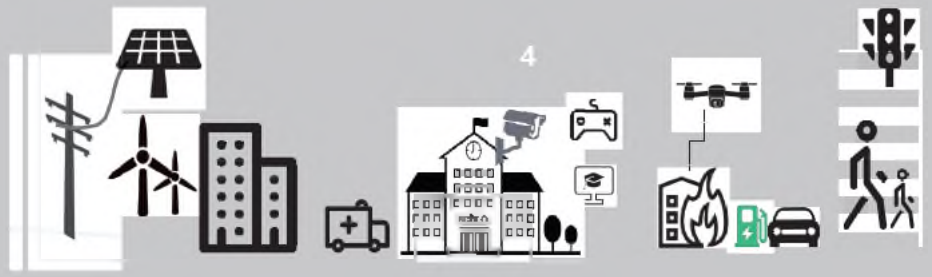
Connected Vehicles

Smart Manufacturing

Wireless eHealth

Wireless Robotics

Exponential growth in connections



Massive data created by IoT

HD Surveillance	Automated driving	Aviation	Smart factory
10GB/day	4TB/day	40TB/day	1PB/day

6 GHz is the best choice to feed the 2nd wave of 5G deployments

6 GHz is a good match for 5G

- **Characteristics**: Globally allocated to the mobile service on a primary basis. Good balance between coverage and capacity (similar to 3-5 GHz), good outdoor to indoor coverage compared to mmWaves, can provide large contiguous blocks (700 MHz in total, harmonised in Europe, or R1 and R3).
- **Use cases**: eMBB, FWA, and vertical applications.
- **Authorisation**: Many 5G applications require a guaranteed QoS, best addressed through IMT identification and individual licensing frameworks, and also ensures easier coordination with incumbent services.

Sharing with incumbents

- **Fixed service** (FS) links are usually long-hop links in suburban areas (i.e. co-existence in urban areas is unlikely to be a problem).

  Co-existence between FS links and licensed IMT will be possible with coordination. FS use varies from one country to another.

- 6425-7025 MHz is allocated to **Fixed satellite service** (FSS) UL. This pairs with 3.4-3.7 GHz, and 4.5-4.8 GHz for FSS DL where 5G is being deployed

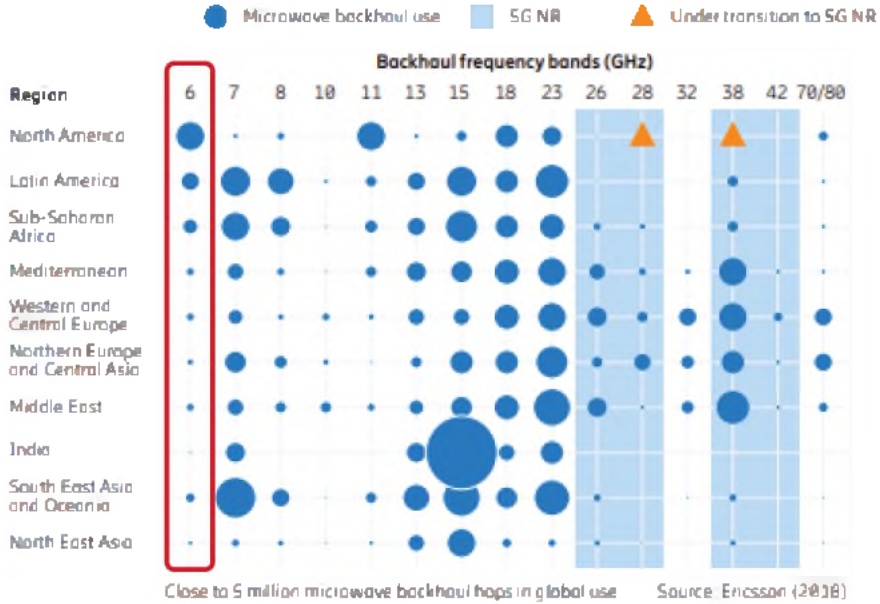
  Co-existence between FSS UL and IMT will be possible with certain restrictions. Longer term, operation of advanced satellite systems at Ku/Ka bands should be accounted for in policy decisions.

- New FSS/FS coexistence studies are needed to account for mitigations such as active antenna systems (see **Annex-2**).

Existing users of 6425-7125 MHz

Fixed service (FS)

Figure 7: 5G in former backhaul spectrum – large regional and national differences



Fixed satellite service (FSS)

Uplink ↑

6425–6725 MHz | 6725–7025 MHz

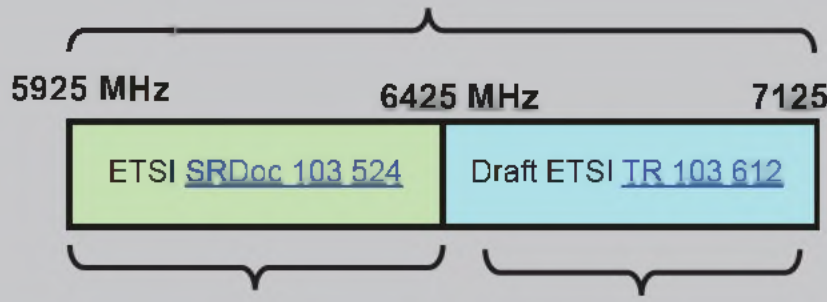
3400–3700 MHz … 4500–4800 MHz

Downlink ↓

European 5G pioneer band

Global/regional positions on 6 GHz towards WRC-23

ASMG, APT, ATU and CITEL:
agreed on common regional positions to propose to study portions or entire 5925 – 7125 MHz range (including as a part of a wider band) for IMT identification at WRC-23 (details on next slides)



3GPP: TR 37.890 "Feasibility study on 6 GHz for licensed and unlicensed use".

In **CEPT**, 5925-6425 MHz, has been studied for unlicensed use by WAS/RLANs.

Note: the proposal from the WAS industry to study 6425-6725 MHz for unlicensed use was not accepted by EU administrations.

RCC & Russia propose to study 6525-7100 MHz for IMT identification at WRC-23 (final approval: RCC meeting 9-12 September 2019, Almaty)

CEPT view on 6 GHz for IMT identification at WRC-23: **neutral**, i.e. no ECP on 6 GHz AI for WRC-23, or against such a proposal from other regions, is agreed

WRC-19 AI 10: growing support for 6GHz study for WRC-23 (1)

Outcomes of the final WRC-19 regional preparatory meetings:

APT (Asia Pacific) – meeting dates: 31 July to 6 August 2019

- Agreement for a common position for studies for IMT identification for the **7025-7125 MHz** frequency range;
- The frequency band 5925-6725 MHz was also considered for which consensus is yet to be reached at this stage: **China** and some other APT countries promoted 5925-7125 MHz for IMT identification at WRC-23.

CITEL (Americas) – meeting dates: 12-16 August 2019

- Agreement on a common position for studies for IMT identification (including possible additional allocations to the mobile service on a primary basis) for the **3300 MHz - 15.35 GHz range.**

WRC-19 AI 10: growing support for 6GHz study for WRC-23 (2)

Outcomes of the final WRC-19 regional preparatory meetings:

ASMG (Arab countries) - meeting dates: 27 July – 1 August 2019

- Agreement on an initial common position to consider identification of additional frequency bands for IMT (including possible additional allocations to the mobile service on a primary basis) for:
  - 3.3-3.4, 3.6-3,8, 3.8-4.2 GHz;
  - **Portions of 6 - 24 GHz;**
  - 470-694 MHz or portions.

ATU (Africa) - meeting dates: 26-30 August 2019

- Agreement on a common position for studies for IMT identification (including possible additional allocations to the mobile service on a primary basis) for:
  - 4800–4990 MHz;
  - **5925-6425 MHz, 6425-7125 MHz;**
  - 7125–8500 MHz, 8.5–10.0 GHz, 10.0-10.5 GHz, 14.3/14,8–15.35 GHz, 15.35–15.63 GHz, 15.63-17.3 GHz.

RCC (CIS countries) – meeting dates: 9-12 September 2019

- Common RCC proposal to study 6525-7100 MHz for IMT identification at WRC-23 is expected

CEPT view on 6 GHz as a new AI of WRC-23

Industry support (CEPT CPG PTA #6, #7 meetings in 2019)

GSMA (doc 036, doc 073):

- Bands between 6 and 24 GHz for IMT identification, including 3800-4200 MHz, **5925/6425-7125 MHz**, 7125-8500 MHz, 10.7-11.7 GHz, 14.3/14.5-15.35 GHz.

ETNO: (doc 035, doc 087):

- 3800-4200 MHz, **6425-8500 MHz**,14.3-15.35 GHz for IMT identification.

Huawei-Ericsson (doc 062, doc 089):

- **6425-7125 GHz** for IMT identification.

CEPT view on 6 GHz as a new AI of WRC-23

(CEPT CPG19-9 meeting, 26-30 August 2019)

Slovenia (doc CPG(19)110):

- ❑ Support for **6425-7125 MHz** as a new AI of WRC-23 for IMT

Azerbaijan:

- ❑ Support proposal from Slovenia for **6425-7125 MHz**.

Russia (doc CPG(19)120):

- ❑ Support of **6525-7100 MHz** as a new AI of WRC-23 for IMT. Global primary status of the Mobile Service in 6 GHz is very important. RCC will likely support 6-7 GHz to

- ❑ Several other countries expressed concerns with regards to the demand for additional spectrum for IMT in the mid-band range and co-existence potential between IMT and incumbent services (FSS, FS).

CEPT position: neutral, i.e. no ECP on 6 GHz under AI 10 of WRC-19 is agreed

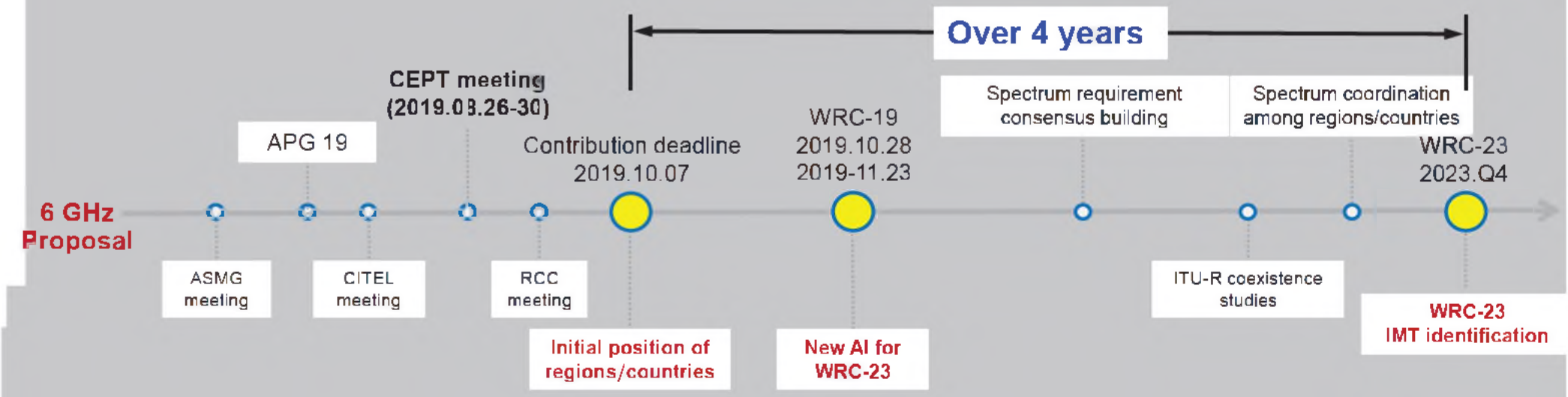
CEPT countries' discussion on 6 GHz towards WRC-19

- Multi-country inputs to WRC-19 to propose studies of 6425-7125 MHz for IMT identification at WRC-23 are being discussed among the supporting CEPT countries (other CEPT countries can join multi-country inputs before and during WRC-19)

- Several new CEPT countries have expressed interest to discuss the new AI on 6 GHz at WRC-23 in the preparation and during CPG19-9 meeting 26-30 August 2019 in Ankara

- Discussions in CEPT (and other Regions) on the possible multi-regional options of the new AI of WRC-23 on 6 GHz will continue up to WRC-23

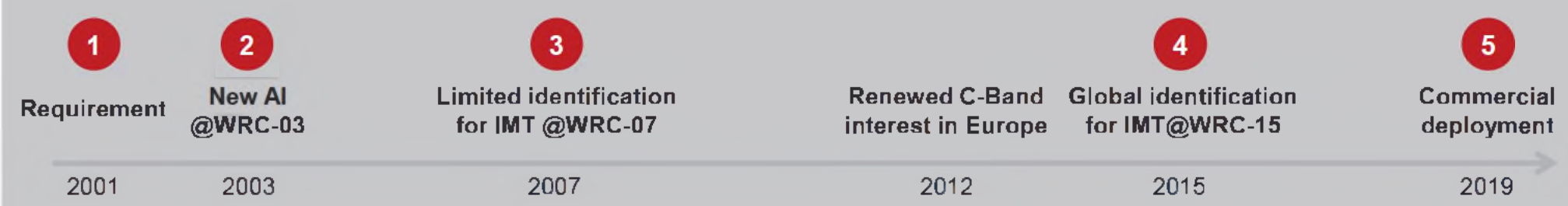
Years of study needed before IMT identification



Recall WRC procedure for C-Band:

It took over **18 years** from requirement discussions to commercial deployment

Need to act early!



1. **2001**: Requirement discussion was triggered due to the booming of initial 3G deployments in 2001.
2. **2003**: A new agenda item for C-Band was established at WRC-03 to initiate feasibility studies.
3. **2007**: After 4 years of study, C-Band was identified for IMT at WRC-07 with only 10+ countries worldwide.
4. **2015**: C-Band was identified for IMT globally at WRC-15 (3.4-3.6 globally, 3.3-3.4 & 3.6-3.7 in Regions 1 & 3).
5. **2019**: Commercial deployments at C-Band were launched in 2019 as the primary 5G band.

5G high frequency bands: status and post-WRC-19 expectations

26 GHz and other high frequency bands are very important for the success of 5G in Europe! but…

Capacity vs. coverage:

- High frequencies offer great capacity for multi-Gbit 5G services, but a city-wide 5G coverage in high frequencies is very expensive: to a large extent, they will contribute to off-loading 5G mobile traffic in localized congested city areas in a similar way as WiFi does today for indoor users;
- Also, outdoor-to-indoor coverage becomes problematic above appr. 20 GHz frequency

Market demand:

- Key European MNOs see high frequency bands as complementary to the key mid-band spectrum which will be used for urban and suburban core 5G coverage;
- Demand for high frequencies will increase after 3400-3800 MHz band is fully utilized
- But high frequencies will not satisfy the traffic demand on a city-wide scale

Outcome of WRC-19:

- It is important that no additional restrictions for the protection of the satellite services (compared with the current European framework) are introduced at WRC-19, to maintain 26 GHz as an attractive 5G band for MNOs

3800-4200 MHz vs. 6425-7125 MHz

Differences:

- Potentially available bandwidth:
  - 400MHz @ 3800-4200 MHz vs. 700MHz @ 6425-7125 MHz

- Target applications:
  - European regulators see 3800-4200 MHz band for vertical use cases and not for MBB;
  - We are asking for 6425-7125 MHz primarily for MBB but it can also be used for verticals

- Co-existence:
  - Different constraints from incumbent users vary from country to country, depending on the FSS and FS national usage.

6-7 GHz to

Therefore:

- 3800-4200 MHz and 6425-7125 MHz are NOT MUTUALLY EXCLUSIVE: either one or the other, or both, could be considered at national level for the 2nd wave of 5G deployments;

Recommendation to administrations

- The band 6425-7125 MHz is a unique and key band for 2nd wave of 5G deployments in Europe and globally.
- It is important that 6425-7125 MHz is considered in a new Agenda Item for WRC-23 (via agenda item 10 of WRC-19).
- Given the lengthy process for IMT identification, it is necessary to set-up a new agenda for WRC-23 in order to trigger co-existence studies at the ITU-R soon after WRC-19.
- Otherwise, 5G will NOT keep up with the growth of demand for data on a city-wide scale beyond 2023.

Thank You

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Annex 1

Spectrum needs calculations for the example of the UK

Worked example: UK future spectrum needs

Step 1: Current spectrum status

- **Total spectrum used today as 4G capacity layer is: 290 MHz (FDD)**
  - 3UK (800 MHz/1.8GHz): 10+30 – 40 MHz
  - O2 (1.8 GHz): 20 MHz
  - EE (1.8/2.6 GHz): 90+70 – 160 MHz
  - VDF (2.1/2.6 GHz): 30+40 – 70 MHz

- **By the year 2025, most of the spectrum used by 3G/4G is expected to be refarmed to 5G:**
  - FDD: 2.1 GHz / 2.6 GHz (N7) / 700 MHz – 120+140+60 – **320 MHz**
  - TDD: 2.3 GHz / 2.6GHz (N38) – 100+50 – **150 MHz** (Assumption: 60 MHz @ 2.3 GHz will be released by MOD by 2025)
  - **Note:** 800 MHz / 900 MHz / 1.8 GHz will be still used for 4G in 2025
- **C-Band availability is 270 MHz (2019), with a further 120 MHz to be released (2020), implying 390 MHz in 2025**

Step 2: DoU forecast

- **Based on public data, UK DoU in 2019 is 4.1 GB/month**

Source: OECD Broadband statistics (oecd.org/sti/ict/broadband) & https://www.giffgaff.com/sim-only-plans/campaign

- Based on public data, UK DoU will reach **130 GB/month** in 2025
- Assumption: FWA and FTTH will each have the same DoU in 2025: **716 GB/month**

Source: https://www.giffgaff.com/sim-only-plans/campaign & Cisco Visual Networking Index: Forecast and Trends, 2017–2022

Parameters	4G (2018)	5G (2025)	Notes
Population (10,000s)	6590	6850	Assume similar network loading for 4G and 5G Assume similar site densities for 4G and (non mmWave) 5G.
User penetration rate	77%	60% (conservative), 77% (high)	
mmWave traffic absorption rate for eMBB & FWA	0 & 0	0.5 & 0.9	
TDD site type	8TR	64TR : 32TR : 8TR – 6 : 3 : 1	
FDD site type	2TR	32TR : 16TR : 4TR – 6 : 3 : 1	
Proportion of sites FDD : TDD	1 : 0	0.4 : 0.6	
FDD DL spectrum efficiency (bits/s/Hz)	1.87	5	
TDD DL spectrum efficiency (bits/s/Hz)	4.56	10.6	
FWA user penetration ratio	0	1/14	

	Parameters	4G (2018)	5G (2025)	Note
Spectrum	Current FDD spectrum (DL+UL)	290 MHz	NA	
	Current/expected TDD spectrum	0	390 MHz	C Band
	FDD spectrum refarmed for 5G (DL+UL)	NA	320 MHz	N1/N7/N28
	TDD spectrum refarmed/available for 5G	NA	150 MHz	N40/N38
DoU	eMBB	4.1 GB	130 GB	Extrapolation
	FWA	NA	716 GB	CISCO report and extrapolation

Step 4: Calculation

$$\frac{(4G\ DOU_{eMBB} \times (1 - FWA\ user\ ratio_{4G}) + 4G\ DOU_{FWA} \times FWA\ user\ ratio_{4G}) \times Population\ 2018 \times 4G\ penetration\ rate}{(5G\ DOU_{eMBB} \times (1 - FWA\ user\ ratio_{5G}) \times (1 - mmW\ traffic\ absorption\ rate_{eMBB}) + 5G\ DOU_{FWA} \times FWA\ user\ ratio_{5G} \times (1 - mmW\ traffic\ absorption\ rate_{FWA})) \times Population\ 2025 \times 5G\ penetration\ rate}$$

$$= \frac{(4G\ FDD\ current\ spectrum \times 4G\ FDD\ spectrum\ efficiency \times 4G\ FDD\ sites\ ratio) + (4G\ TDD\ current\ spectrum \times 4G\ TDD\ DL\ spectrum\ efficiency \times 4G\ TDD\ sites\ ratio)}{(5G\ TDD\ NEW\ spectrum\ needs + 5G\ TDD\ current\ spectrum + 5G\ TDD\ refarm\ spectrum) \times 5G\ TDD\ spectrum\ efficiency \times 5G\ TDD\ sites\ ratio) + (5G\ FDD\ refarm\ spectrum \times 5G\ FDD\ spectrum\ efficiency \times 5G\ FDD\ sites\ ratio)}$$

5G new spectrum needs in 2025 (sub 10 GHz)

5G penetration rate 60%: 462 MHz Conservative

5G penetration rate 77%: 775 MHz High

Annex 2

Coexistence with the fixed service and fixed satellite service

Outline

- Review of WRC-15 sharing studies with UL FSS (S.2367) for 5925-6425 MHz
- Developments in mobile industry and in ITU-R since WRC-15
  - Positive factors contributing to co-existence between IMT and FSS (Earth-to-satellite) at 6 GHz
- Analysis of impact on microwave fixed links at 6 GHz
- Summary

Review of WRC-15 sharing studies with UL FSS (S.2367) for 5925-6425 MHz

- Report ITU-R S.2367: Sharing and compatibility between International Mobile Telecommunication systems and fixed-satellite service networks in the 5850-6425 MHz frequency range, conducted during the study period 2012-2015 (for WRC-15).

- Our view is as follows:
  - Free space path loss model was used in the ITU-R S.2367 study, which did not consider important factors such as:
    - Depolarization attenuation, atmospheric gasses attenuation, clutter loss, etc.
    - The Recommendation ITU-R P.619 was revised in 2017 which considered above factors and should be used in future study.
  - The clutter loss considered in the ITU-R S.2367 study was based on terrestrial-to-terrestrial model in ITU-R Rec P.452; while Earth-space statistical clutter loss model should be used for this study.
    - New Recommendation ITU-R P.2108 (Section 3.3 : earth space clutter loss) was published in 2017 and should be used.

Review of WRC-15 sharing studies with UL FSS (S.2367) for 5925-6425 MHz

Continued…

- The building entry loss considered in the ITU-R S.2367 study did not consider any ITU-R propagation Recommendation
  - New Recommendation ITU-R P.2109 (building entry loss) was published in 2017 and should be used.
- The study focused on IMT-Advanced systems and only omnidirectional antenna is considered.
  - New techniques such as AAS with beamforming were not considered.
- Did not consider Monte Carlo simulation to calculate aggregated IMT interference
  - New ITU-R Rec M.2101 was published in 2017 and can be used for Monte Carlos simulation.

Review of WRC-15 sharing studies with UL FSS (S.2367) for 5925-6425 MHz

❑ Summary:

- Report ITU-R S.2367 did not take into account many important factors for propagation models and technology advances for IMT.
- Sharing and compatibility studies should be re-conducted for IMT-FSS at 6 GHz band, using the latest ITU propagation models and the agreed IMT network model (as in Recommendation ITU-R M.2101), taking into account the latest technology developments.

Developments in mobile industry and in ITU-R since WRC-15: Active antenna systems for 5G/IMT-2020

- Active antenna systems: beamforming technique implemented over Massive MIMO antennas
  - Transmission with a narrow radiation beam directed at a particular UE, or UEs.
  - Beamforming can be used to minimize the radio emissions in the direction of potential victims that need to be protected.
    - Regular antenna radiates energy in fixed direction or all direction (omnidirectional antenna). This results in wasted RF energy and interference. Beamforming focuses the radio beam in the needed direction. This results in more effective signal and less wasted RF energy.
  - Beamforming is more effective to protect space service.

Developments in mobile industry and in ITU-R since WRC-15: IMT modelling for sharing and compatibility studies

- Recommendation ITU-R M.2101: Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies (published in 2017)
  - It provides guidance on a number of aspects that are very important to conduct sharing and compatibility studies for IMT, e.g.:
    - different IMT base stations densities for different scenarios;
    - method to carry out Monte Carlo analysis, which is important for calculation of aggregated interference
    - antenna pattern for BS and UE beamforming

Developments in mobile industry and in ITU-R since WRC-15: Revision of ITU-R propagation models

- In 2017 the following ITU-R Recommendations were published
  - P.2108 on clutter loss
  - P.2109 on building entry loss
  - P.619 on propagation model
- The introduction of accurate clutter loss, building entry loss and propagation models as agreed in above Revisions of ITU Documents, provide additional margin for co-existence of IMT systems with FSS (Earth-to-satellite) at 6 GHz.

Commercial Interest

Commercial Interest