이동통신 주파수 동향

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- AI 1.13 (mmW 5G) 및 AI 10 (WRC-23 의제) -

GISC2020
Global ICT Standards Conference

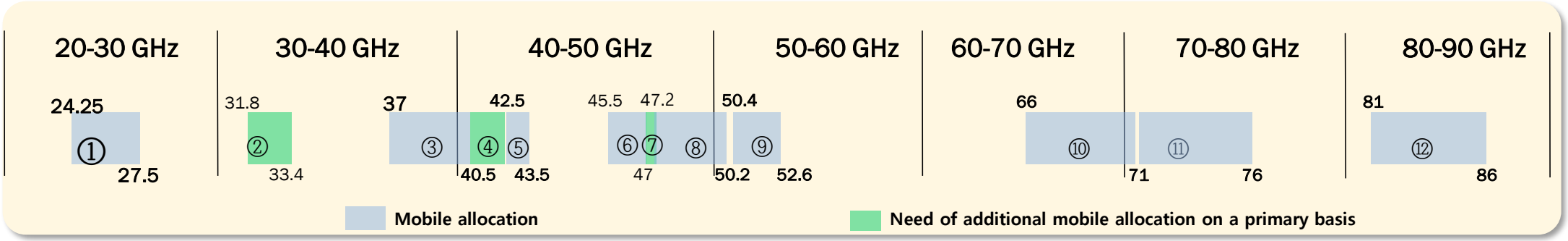
WRC-19 Agenda Item 1.13 개요

- 배경 : 5G 실현을 위한 광대역폭(~1GHz)의 주파수 수요 증대로 24.25GHz 이상 대역 필요성 대두
  (WRC-15 제안 지역기구 : APT, CITEL, CEPT, RCC, ASMG, ATU)
  ※ 한국: ITU-R WP5D 13차 회의('12.7월)에서 고주파 필요성 및 APG15-3 회의('14.6월)에서 고주파 5G 의제 **최초** 제안
- 내용 : 12개 대역(아래 그림 참조)에서 5G(IMT-2020) 용 주파수 소요량, 5G 시스템 특성, 전파모델 및 타 업무와의 주파수 공유방안 연구를 통한 IMT 주파수 지정 검토 (이동업무 1순위 분배 포함)

※ AI 1.13: To consider identification of frequency bands for the future development of International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 238 (WRC-15)

※ Resolution 238: Studies on frequency-related matters for IMT identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 GHz and 86 GHz for the future development of IMT for 2020 and beyond

〈 12개 후보 주파수 대역 〉

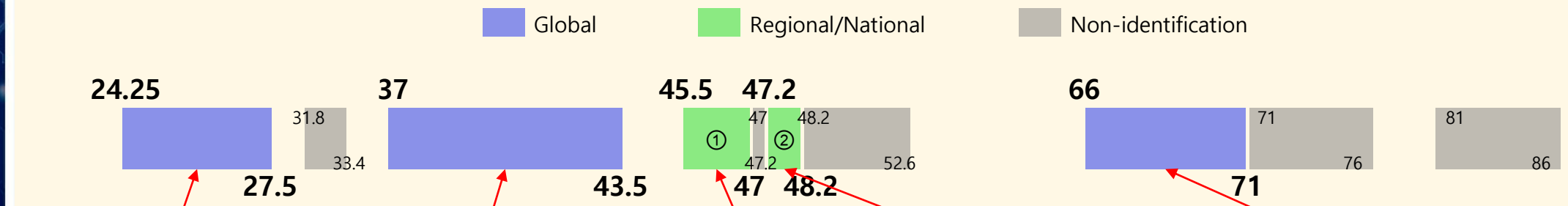


mmWave IMT 주파수 지정

❖ 5G용 mmWave IMT 주파수 지정(Identification)

- **글로벌 5G 주파수: 26 GHz 대역 (24.25-27.5 GHz), 40 GHz 대역 (37-43.5 GHz), 66-71 GHz**
- **지역/국가별 5G 주파수: 45.5-47 GHz, 47.2-48.2 GHz**
- 6개 지역기구 및 주요 국가 (미/유럽/러/중/일/아태) 설득 및 협력을 통한 주파수 확보 성공
  - ➢ 위성/과학업무 진영의 과도한 규제 결정 주장에 따른 IMT 주파수 분배 Risk → Risk 해소/완화

< WRC-19 mmWave 5G 대역 지정 결과 >



- FN 5.532AB
- Resolution 242 (WRC-19)

- FN 5.550B
- Resolution 243 (WRC-19)

- FN 5.553A
- Resolution 244 (WRC-19)

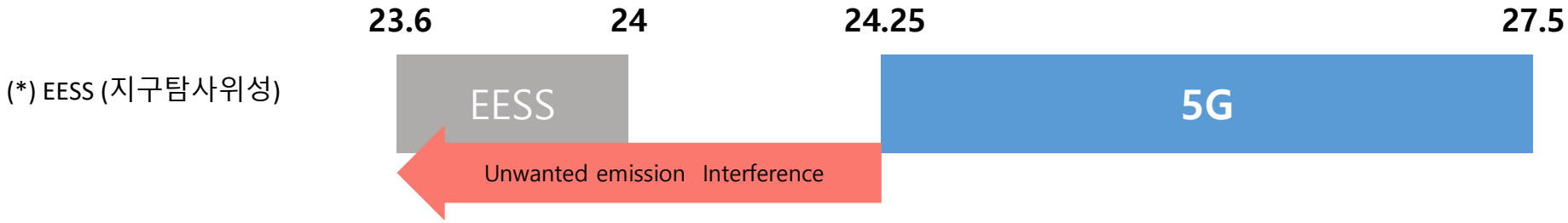
- FN 5.553B
- Resolution 243 (WRC-19)

- FN 5.559AA
- Resolution 241 (WRC-19)

26 GHz 대역 글로벌 규제 (Unwanted emission limit)

❖ Unwanted emission limit 규제

- Risk: 유럽/러시아/중국/일본/WMO 등은 지구탐사위성 수동센서 보호를 위해 구현 불가능한 규제를 주장
- 5G 도입 및 활성화와 지구탐사위성 보호 주장을 고려하여 2 Phase approach 규제 도입



OOBE (Out of Band Emission) 이슈

- 23.6-24GHz EESS(p) 보호용 불요발사 규제값(dBW/200MHz)
  - 유럽/러/中/日: 엄격한 값 (BS: -42~-49, UE: -38~-45)

  VS

  - 韓/미주/아랍/아프리카: 적정값 (BS: -28~-32, UE: -24~-28)

결과

26GHz OOBE 글로벌 규제 결정

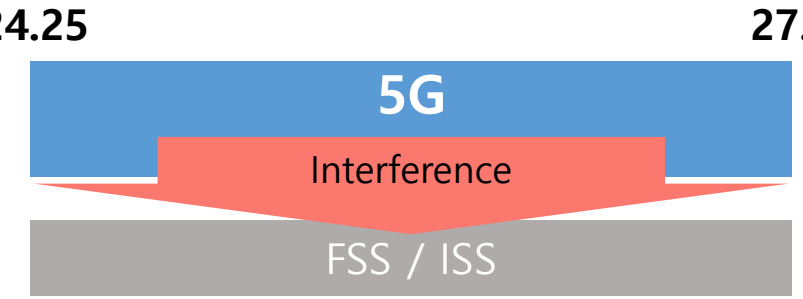
- **기지국 -33 dBW/200MHz, 단말 -29 dBW/200MHz**
  - '21년 1월 1일부터 효력 발효 (이전 구축 장비 소급 미적용)
- 단, 5G 확산에 따라 EESS에 전파간섭 증가 및 5G 기술 발전 등을 고려하여 '27년 9월 2일부터 신규 규제값 적용
  - 기지국 -39 dBW/200MHz, 단말 -35 dBW/200MHz
  - 단, '27년 9월 1일까지 도입된 5G 장비는 **소급 미적용**

26 GHz 대역 규제 (In-band power 및 기지국 운용 조건)

❖ 기지국 운용 조건

- Risk: 유럽/러시아/중국/인도/위성진영 등 동일 대역 내 고정위성/위성간 통신 서비스 보호를 주장
- 적정 수준으로 규제를 정의하되 국가별 자율 선택 규제로 정의

(*) FSS (고정위성), ISS (위성간 통신)



5G BS 출력 및 운용 조건 이슈

- 26GHz FSS/ISS 보호용 기지국 운용 조건
  - 유럽/러/中/日: BS 출력 제한(25~37 dBm), 안테나 강제 틸팅, 기지국 설치수 제한, 2nd Harmonics(-40dBm/MHz) 강제 규제화, 전파규칙 21.5 (40dBm 이하 최대 37dBm)
  - 韓/미주/아랍/아프리카: 별도 규제 불필요

결과

5G BS 출력/운용 조건 결정

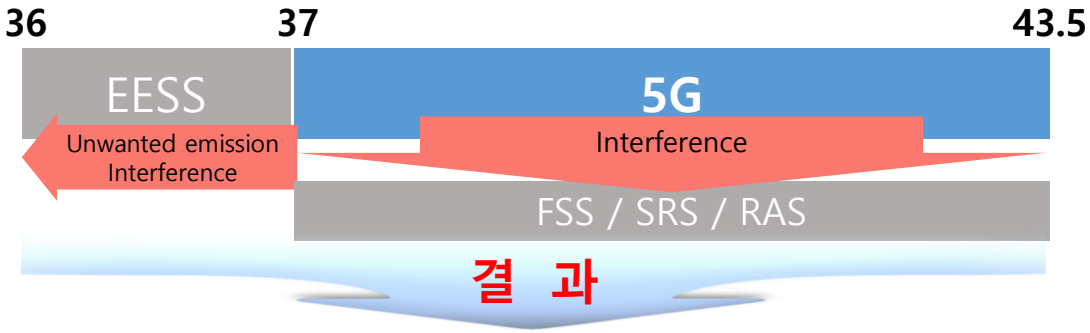
- **5G BS 출력 규제값 미정의**
  러시아 등은 5G 기지국 안테나 출력을 전파규칙 21.5 (10dBW) 기반에 저항손실 3dB를 강제 적용 제안하였으나 부결
- 안테나 일반적 Tilting, FSS↔와 5G간 LOS 환경에서 출력 제한, 2nd Harmonics (現 -30dBm/MHz) 등
  모든 규제 사항은 글로벌 강제 규제가 아닌 국가별 **자율 선택 규제로 완화**
- 국가별 기지국 설치 수 제한 등 **불필요 규제 제거**

40 GHz 대역 규제 (OOBE 및 BS 출력)

❖ OOBE 등 완화된 규제 및 5G BS 출력/운용 조건

- Risk: 유럽/러시아/중국 등은 고정위성, 우주연구, 전파천문, 지구탐사위성 보호를 강력 주장
- 지역/국가별 40GHz 대역 주파수 자율적 선택하여 5G 도입 가능 (37-43.5 GHz or portions thereof)

(*) EESS (지구탐사위성), FSS (고정위성), SRS (우주연구), RAS (전파천문)



완화된 OOBE 규제 결정

- 36-37 GHz EESS(p) 보호용 불요발사 규제값(dBW/200MHz)
  - **불요발사 평균 전력: -43 dBW/MHz (= -13 dBm/MHz) 및 36-37GHz 전체 대역 내에서 -23 dBW/GHz (=-23 dBm/MHz)**
    - 권고 불요발사 기준: -30 dBW/GHz (=-30 dBm/MHz)
  - 유럽/러/中/日: 엄격한 값 (-44 dBm/MHz)

BS 출력 및 완화된 BS 운용 규제 결정

- **26GHz와 동일하게 출력값 미정의**
- 안테나 일반적 틸팅, FSS↔와 5G간 LOS 환경에서 출력 제한 등 모든 규제 사항은 글로벌 강제 규제가 아닌 국가별 **자율 선택 규제로 완화**

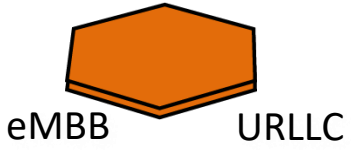
WRC-19 AI 10 (WRC-23 Agenda Items) 결과

의제	의제 제목	담당그룹	참여그룹
1.1	to consider, based on the results of the ITU-R studies, possible measures to address, in the frequency band **4 800-4 990 MHz,** protection of stations of the aeronautical and maritime mobile services located in international airspace and waters from other stations located within national territories, and to review the pfd criteria in No. **5.441B** in accordance with Resolution **223 (Rev.WRC-19)**;	WP 5B 및 **WP 5D**	WP 1B, WP 3K, WP 3M, WP 5C, WP 7D
1.2	to consider identification of the frequency bands **3 300-3 400 MHz, 3 600-3 800 MHz, 6 425-7 025 MHz, 7 025-7 125 MHz and 10.0-10.5 GHz** for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution **COM6/2 (WRC-19)**; – 3 600-3 800 MHz and 3 300-3 400 MHz (Region 2), 3 300-3 400 MHz (amend footnote in Region 1), 7 025-7 125 MHz (globally), 6 425-7 025 MHz (Region 1), 10 000-10 500 MHz (Region 2),	**WP 5D**	WP 4A, WP 4B, WP 4C, WP 3K, WP 3M, WP 5A, WP 5B, WP 5C, WP 7B, WP 7C
1.3	to consider primary allocation of the **band 3 600-3 800 MHz** to mobile service within Region 1 and take appropriate regulatory actions, in accordance with **Resolution COM6/3 (WRC-19)**;	WP 5A	WP 3K, WP 3M, WP 4A, WP 5B, WP 5C, **WP 5D**
1.4	to consider, in accordance with Resolution **COM6/4 (WRC-19)**, the use of high-altitude platform stations as IMT base stations **(HIBS)** in the mobile service in certain frequency bands below 2.7 GHz already identified for IMT, on a global or regional level; – 694-960 MHz, 1 710-1 885 MHz (1 710-1 815 MHz to be used for UL only in Region 3), 2 500-2 690 MHz (2 500-2 535 MHz to be used for UL only in Region 3, except 2 655-2 690 MHz in Region 3);	**WP 5D**	WP 3K, WP 3M, WP 4A, WP 4C, WP 5A, WP 5B, WP 5C, WP 6A, WP 7B, WP 7C, WP 7D
1.5	to review the spectrum use and spectrum needs of existing services in the frequency band **470-960 MHz in Region 1** and consider possible regulatory actions in the frequency band 470-694 MHz in Region 1 on the basis of the review in accordance with Resolution **235 (WRC-15)**;	TG 6/1 (신설)	WP 3K, WP 3M, WP 5A, WP 5B, WP 5C, **WP 5D**, WP 6A
1.18	to consider studies relating to spectrum needs and potential new allocations to the mobile-satellite service for future development of narrowband mobile-satellite systems, in accordance with Resolution **COM6/15 (WRC-19)**;	WP 4C	WP 3M, WP 4A, WP 4B, WP 5A, WP 5B, WP 5C, **WP 5D**, WP 7B
9.1 Topic c)	Study the use of International Mobile Telecommunication system for fixed wireless broadband in the frequency bands allocated to the fixed services on primary basis, in accordance with Resolution **COM6/18 (WRC-19)**;	WP 5A 및 WP 5C	WP 1B, WP 4A, WP 4C, **WP 5D**, WP 6A, WP 7B, WP 7C, WP 7D
9.1 Topic d)	Protection of EESS in the frequency band 36-37 GHz from non-GSO space stations;	WP 7C	WP 4A, WP 5A, WP 5C, **WP 5D**

- (기타)
  의제 1.13 In-band 출력(TRP) 관련, 전파규칙 21.5 기반 IMT 기지국 출력 규제 정립이 미결정됨에 따라
  러시아는 전파규칙 21.5 및 전파규칙 표 21-2 (주관청 통고) 개정을 신규 의제로 채택할 것을 제안 → 다수 반대로 부결
- 단, AAS 안테나 적용된 5G 기지국의 출력을 전파규칙 21.5 적용 가능 여부를 WP5D에서 연구하도록 합의

5G 주파수 동향

5G 실현을 위한 다양한 주파수 필요



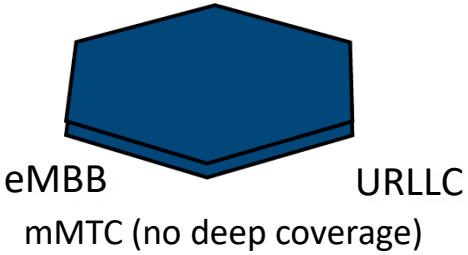
High Band

e.g. 24.25 – 29.5 GHz | 37.0 – 43.5 GHz etc.

Extreme Capacity

800-1000 MHz spectrum per MNO/Network contiguous from 2020/2021 onwards

Additional High band spectrum may be required for MNOs by 2023/2025



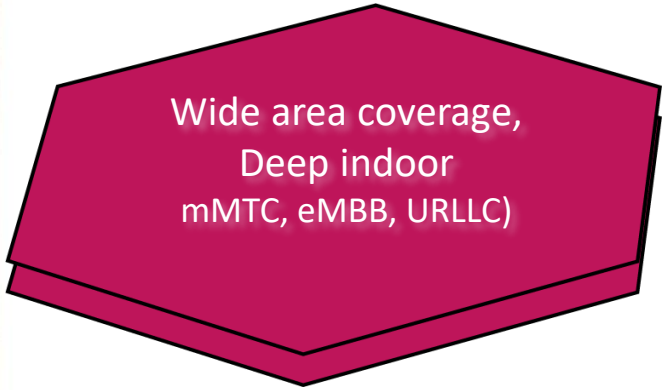
Mid Band

e.g. 2.3, 2.6 GHz | 3.3 – 4.2 GHz | 4.4 – 5 GHz etc.

Coverage & Capacity

80-100 MHz spectrum per MNO/Network contiguous from 2020/2021 onwards

Additional Mid band spectrum may be required for MNOs by 2023/2025



Low Band

e.g. 600 MHz | 700 MHz etc.

Extended Coverage

Up to 20 MHz channel bandwidth from 2020/2021 onwards

Additional Low band spectrum may be required for MNOs by 2023/2025

Various applications and services require access to spectrum from low, mid and high bands

❖ Source: GSA

❖ Source: GSA

5G Network 글로벌 현황

- Nearly 10% of all LTE Operators have Deployed 5G
  - 8% have launched
- 61 Commercial Networks in 34 Countries

By the end of 2019 348 operators in 119 coun had announced they were investing in 5G.

77 operators had announced that they had deployed 3GPP compliant 5G technology in th networks.

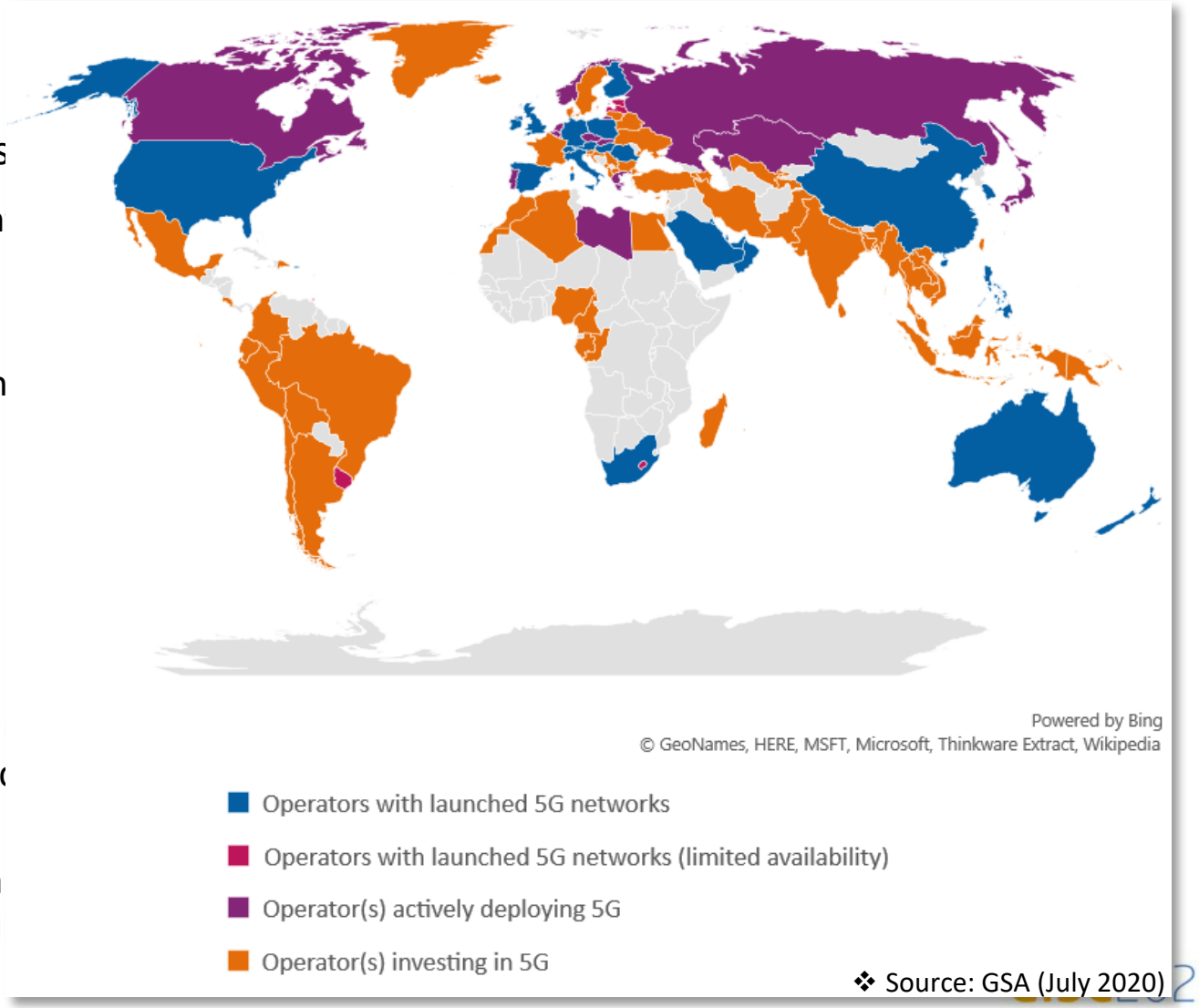
A total of 61 operators in 34 countries had launched one or more 3GPP-compliant 5G services:

Of those...

49 operators had launched 3GPP-complia mobile services (46 full launches, 3 limite availability launches).

34 operators had launched 3GPP-complia FWA or home broadband services (27 full launches, 7 limited availability launches).

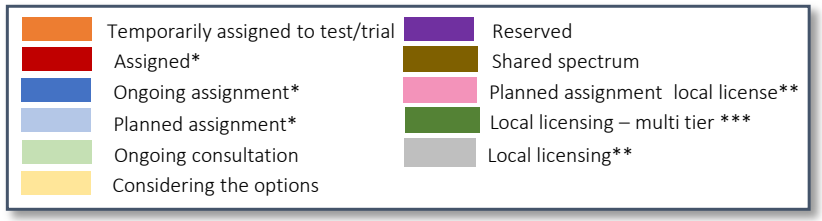
Global 5G Map



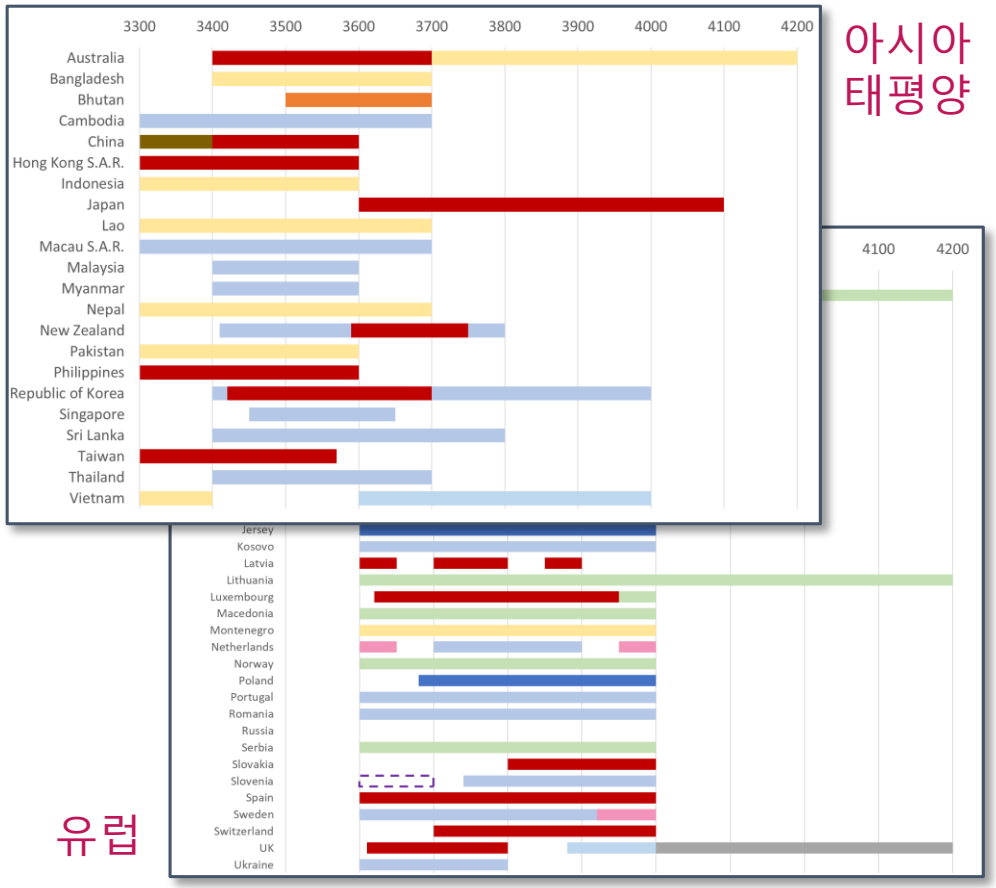
❖ Source: GSA (July 2020)

글로벌 Mid-band 5G 현황

❖ Source: GSA (July 2020)

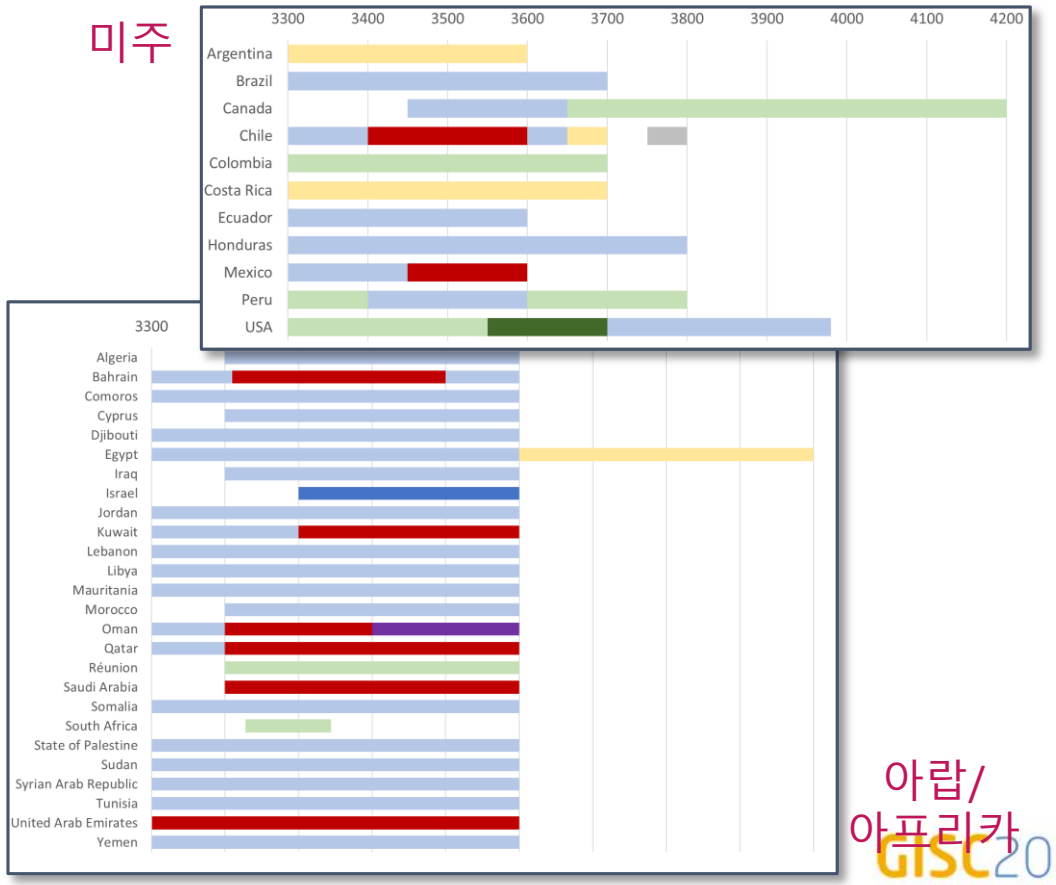


- 3.4-3.8 GHz 대역이 mid-band 5G를 견인
  - 3.3-3.4 GHz, 3.8-4.0/4.2 GHz 및 4.8-4.99 GHz 대역도 일부 국가들 중심으로 관심



아시아 태평양

유럽



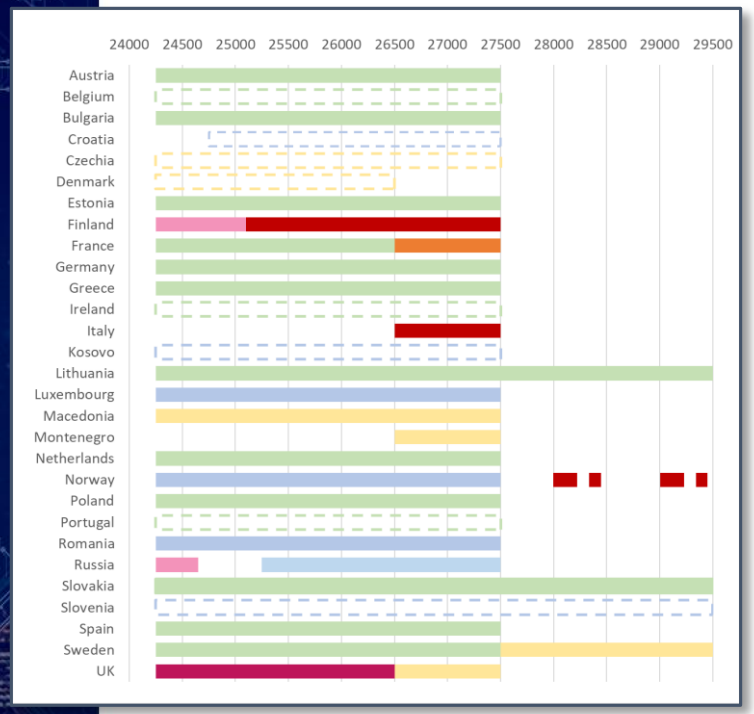
미주

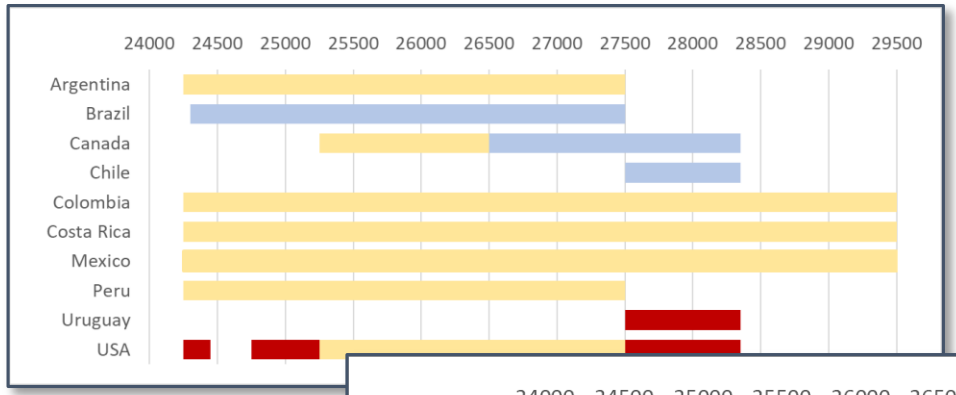
아랍/ 아프리카

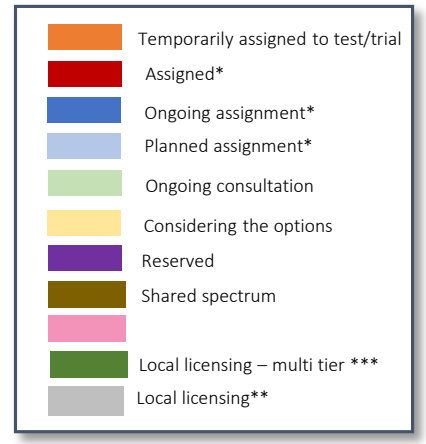
글로벌 mmWave 5G 현황

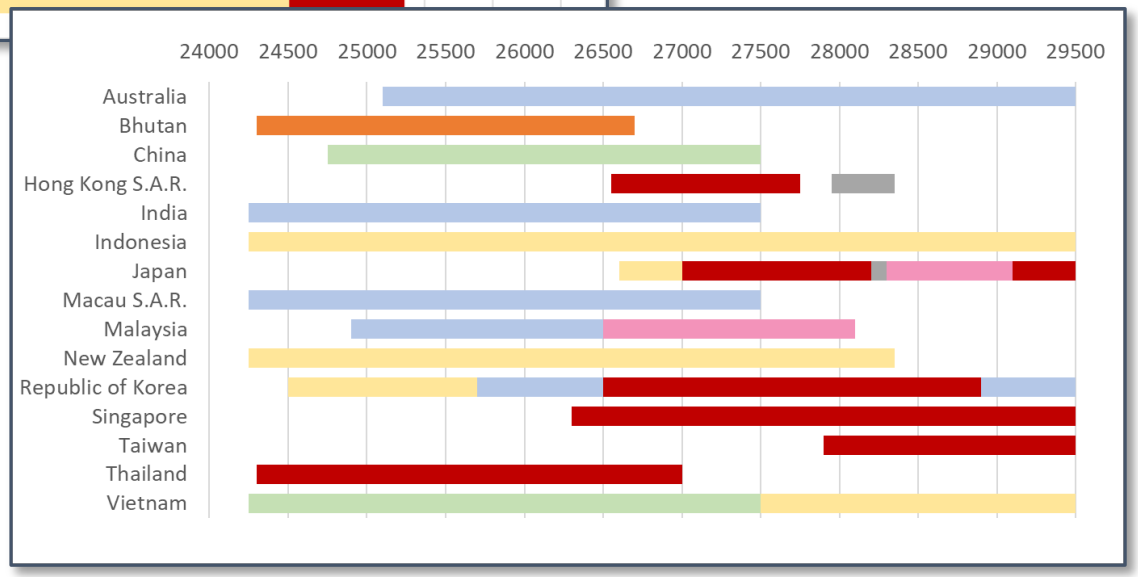
❖ Source: GSA (July 2020)

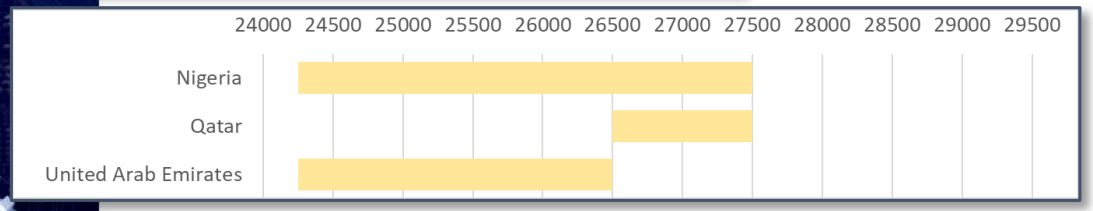
- 28 GHz 대역이 mmWave 5G를 견인 중
  - 26 GHz 도입 국가 확산 및 40 GHz 대역도 도입 시작











THz 주파수 동향

- WRC-19 AI 1.15 (275-450 GHz), 한국, 미국, 영국 -

WRC-19 Agenda Item 1.15

❖ **APT: 275-1000GHz의 LMS/FS 주파수 지정 연구용 WRC-19 후보의제 제안 접수** ('15년)

- 일본: 2015년 아태지역 WRC 준비회의(APG)에서 WRC-19용 차기 WRC 의제 후보로 275-1000 GHz의 능동업무(육상이동업무 및 고정업무) 지정 아이템을 제안
  - ❖ ITU RR (Radio Regulations, 전파규칙)에서 275-3000GHz 대역은 이동업무(Mobile Service) 및 고정업무(Fixed Service) 미분배
  - ❖ RR의 275GHz 이상 대역 중 일부는 Footnote 5.565에 따라 전파천문업무와 지구탐사위성(수동)업무로 지정 (Identification)
- APG는 일본 제안을 수용하여 WRC-15에 WRC-19용 후보의제로 제안

❖ **WRC-15: 275-450 GHz로 한정하여 WRC-19 의제 1.15로 채택**

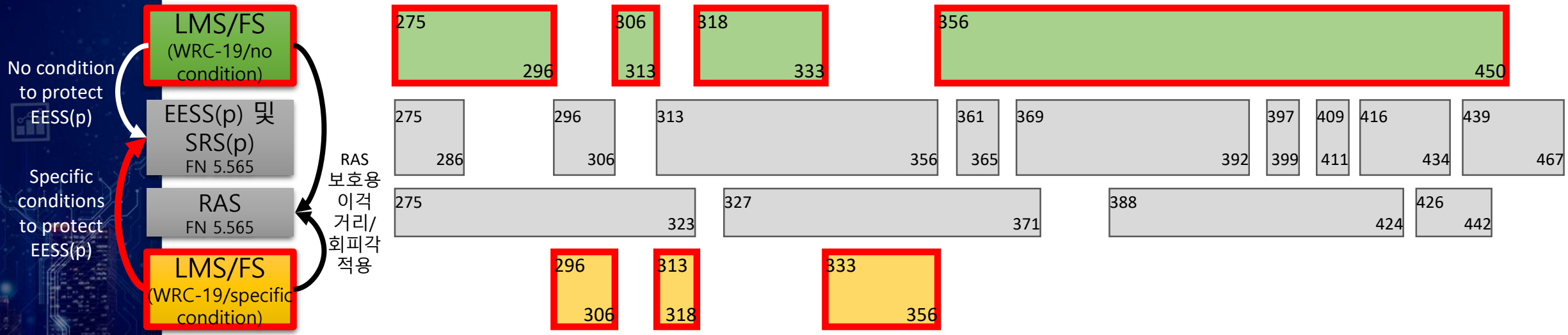
❖ APT 외 CEPT도 의제 제안

- 의제 1.15: to consider identification of frequency bands for use by administrations for the land-mobile and fixed services applications operating in the frequency range 275-450 GHz, in accordance with Resolution 767 (WRC-15);
- 주요 연구 범위 (WRC 결의 767): 275-450 GHz 대역의 LMS 및 FS 기술 특성, 주파수 소요량, Radio propagation model, Passive(EESS/SRS) 업무들과 전파 간섭 분석, LMS/FS를 위한 후보대역 발굴

MS (Mobile Service, 이동업무), FS (Fixed Service, 고정업무), LMS (Land Mobile Service, 육상이동업무), EESS (Earth Exploration Satellite Service, 지구탐사위성업무), SRS (Space Research Service, 우주연구업무), RAS (Radio Astronomy Service, 전파천문업무)

WRC-19 AI 1.15 결과

- WRC-19를 통해 275-450 GHz 대역 일부를 LMS 및 FS용으로 지정
  - 지구탐사위성(EESS-passive), 전파천문(RAS) 및 우주연구(SRS) 업무와 공존
  - EESS passive 보호를 위한 별도 조건 없이 LMS와 FS로 사용: 275-296 GHz, 306-313 GHz, 318-333 GHz 및 356-450 GHz
  - EESS passive 보호를 위한 별도 조건 하에 LMS와 FS로 사용: 296-306 GHz, 313-318 GHz, 333-356 GHz
  - RAS (전파천문) 보호 조건: RAS 보호용 이격 거리 및 회피각 적용



※ 275-450 GHz 대역 EESS passive 보호용 별도 조건은 지속 ITU-R 연구 예정 (WRC-19 결의 731)

- to continue its studies to determine if and under what conditions sharing is possible between active and passive services in the frequency bands above 71 GHz, such as, but not limited to, 100-102 GHz, 116-122.25 GHz, 148-5-151.5 GHz, 174.8-191.8 GHz, 226-231.5 GHz and 235-238 GHz
- to conduct studies to determine the specific conditions to be applied to the land mobile and fixed service applications to ensure the protection of Earth exploration-satellite service (passive) applications in the frequency bands 296-306 GHz, 313-318 GHz and 333-356 GHz;

(한국) 6G R&D 추진 전략 (6G 시대를 선도하기 위한 「미래 이동통신 R&D 추진전략」, '20.8.6)

- '28~'30년 경 상용화를 위한 6G R&D 추진 전략 내 주파수 관련 Key word
  - "Tera-"

(미국) Spectrum Horizon (1/2)

- **Spectrum Horizon** (1st R&O, March 21, 2019)
  - Will permit "① **experimental licensing**" and "② **unlicensed applications**" within 95 GHz to 3 THz

- **① Experimental radio license (Part 5) for experiments & demonstrations of equipment**
  - To accelerate the development of new technologies
  - Available frequency: Spectrum Horizons License within **95 GHz to 3 THz**

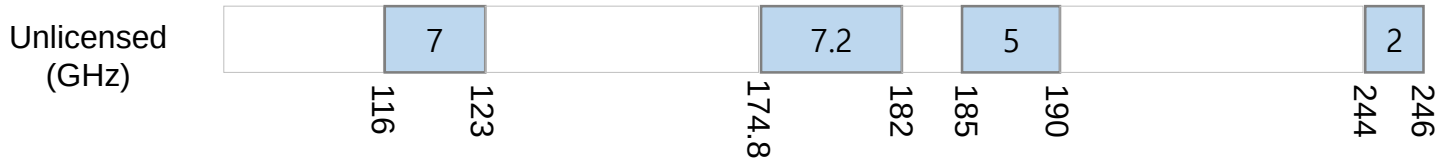
> *"We will not, by rule, preclude the use of any specific frequencies."*
>
> *"We seek to foster an environment where innovators can develop new products and applications absent unnecessary imitations."*
>
> *"Given the unique characteristics of these bands, we are hesitant to take any action that may stifle innovation or limit an applicant from developing new and novel methods for coexisting with existing services. We appreciate the important research that is conducted by passive operations in these bands but, as discussed below, find no reason to explicitly prohibit use of these frequencies as long as existing and future operations operating in accordance with the Table of Frequency Allocations are adequately protected."*

  - **Maximum 10 years experimental license** (no renewal of the license due to sufficient time)
    - ✓ Licensing requirement: (1) Each application must include a narrative statement describing in detail how its experiment could lead to the development of innovative devices and/or services on frequencies above 95 GHz and describe, as applicable, its plans for marketing such devices. The statement should include technical details, including the requested frequency band(s), maximum power, emission designators, area(s) of operation, and type(s) of device(s) to be used. (2) Licensee must submit to the Commission an interim progress report 5 years after grant of its license.
  - Spectrum Horizons License may be authorized over any geographic area
  - Marketing: FCC will permit licensees to market experimental devices designed to operate in the bands above 95 GHz via direct sale.
    - ✓ i.e. To allow direct sales to members of the general public

(다음 페이지 계속)

(미국) Spectrum Horizon (2/2)

- **② Unlicensed operation with conditions not to cause harmful interference to other services in/adjacent bands**
  - **21.2 GHz bandwidth**
    - ✓ 116-123 GHz (7 GHz BW), 174.8-182 GHz (7.2 GHz BW), 185-190 GHz (5 GHz BW) and 244-246 GHz (2 GHz BW)

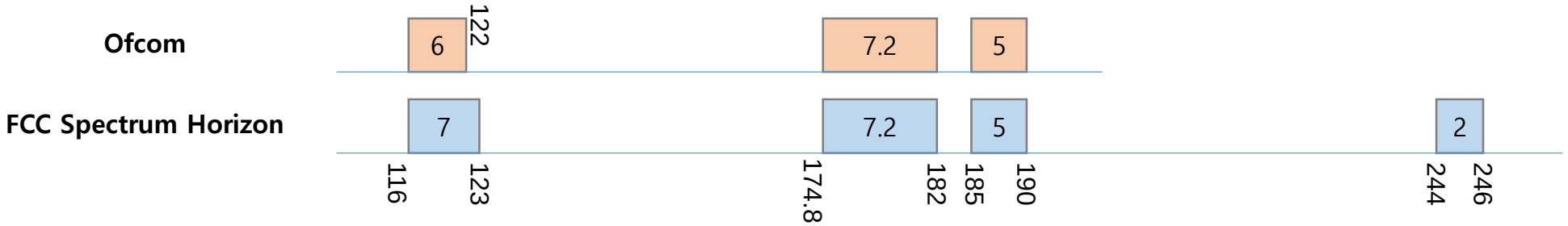


    - ✓ To consider protection of Radio Astronomy service, Protection of EESS, etc.
    - ✓ Technical rules for those unlicensed operation: 47 CFR – Part 15.258
    - ✓ **Tx regulations**
      - ❖ Max EIRP 40 dBm (average) and 43 dBm (peak); OR
      - ❖ Outdoor fixed P2P devices: max EIRP 82 dBm (average) and 85 dBm (peak): Use of the higher power limits also requires that devices use antennas with a minimum gain of 51 dBi, with a 2 dB reduction in the maximum permissible EIRP for each dB the antenna gain falls below 51 dBi.
    - ✓ **OOBE regulations**: 90 picowatts/cm^2 @ 3m distance

(영국) 100-200 GHz 규제 연구 (Consultation)

- Supporting innovation in the 100-200 GHz range: Proposals to increase access to Extremely High Frequency (EHF) spectrum
  - Consultation: (1차) 2020.01.17 ~ 03.20, (2차) 2020.05.20 ~ 06.17

- 100-200GHz 대역 잠재성: 혁신적인 기술로 신규 서비스 및 application 활용을 도모
  - 기술 혁신을 위한 116-122GHz, 174.8-182 GHz 및 185-190GHz 대역 활용 검토



  - EESS 보호를 위한 Technical Condition 필요: 다음 페이지 참고
    - ✓ 비면허 기반
    - ✓ 면허 기반

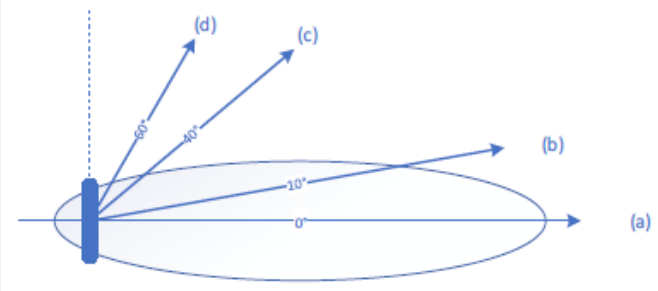
(다음 페이지 계속)

(영국) 3개 대역 활용을 위한 규제(안)

소출력 비면허 장비용 규제(안)

- 실내: 최대 40 dBm EIRP
- 실외: 최대 20 dBm EIRP (116-122 GHz 및 174.8-182 GHz), 최대 40 dBm EIRP (185-190 GHz)

Power limits (*max EIRP in dBm*) and emissions restrictions on outdoor use			
USE	**116-122 GHz**	**174.8-182 GHz**	**185-190 GHz**
Indoor	40	40	40
Outdoor	20(a)	20 (a)	40 (a)
For outdoor use, EIRP at angles (degrees°) relative to main beam in elevation shall not exceed			
	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	25 at > 10°(b) 14 at > 40°(c) 10 at > 60°(d)

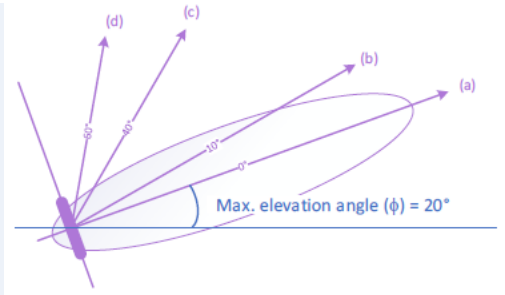


- EESS 보호 및 프랑스/스페인의 RAS 보호를 위해 airborne 사용 미허용
- Out of band Emission: -10 dBm/MHz (116-122 GHz, 174.8-182 GHz 및 185-190 GHz)

면허 장비용 규제(안)

- 실내 및 실외: 최대 55 dBm EIRP
- 실외 사용 시 안테나 지향성 및 앙각 등 EESS 보호를 위한 부가적인 규제 필요

Power limits (*max EIRP in dBm*) and emissions restrictions for outdoor use			
	116-122 GHz	**174.8-182 GHz**	**185-190 GHz**
	55(a)	55 (a)	55 (a)
For outdoor use, EIRP at angles (degrees°) relative to main beam in elevation shall not exceed			
	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	25 at > 10° (b) 14 at > 40°(c) 10 at > 60°(d)
Main beam elevation angle (ϕ) shall not exceed 20 degrees above horizontal when devices are used outdoors.			



- 주파수 관리 명목으로 취소를 위한 3년 통지 기간이 적용되는 무기한 면허 (5년마다 75 파운드의 면허비 지불, 면허권자는 무선 장비의 위치/안테나 주빔 앙각 기록 필요)
- Out of band Emission: -10 dBm/MHz (116-122 GHz, 174.8-182 GHz 및 185-190 GHz)

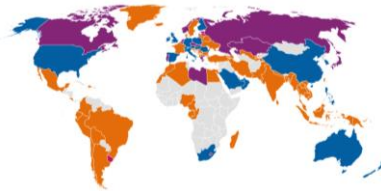
맺음말

Summary

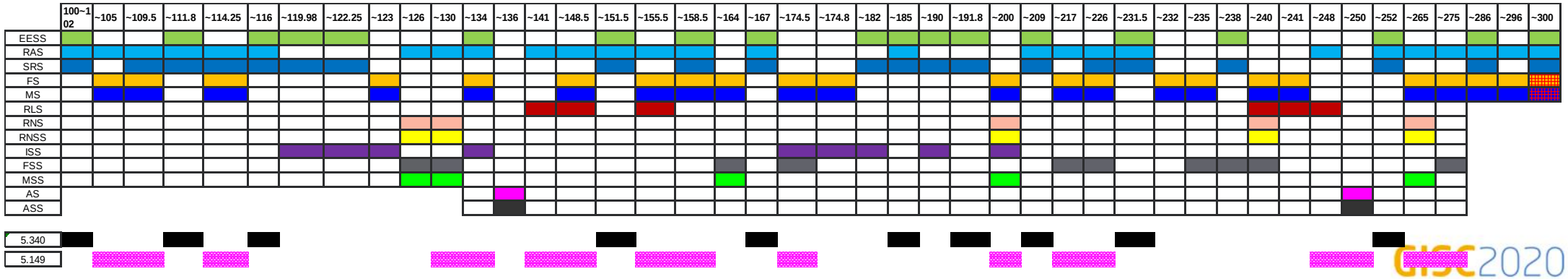
In total,
14.75 GHz
is thus available for IMT globally.

An additional
1.5 GHz + 1 GHz
is identified in country footnotes

- **Identification to IMT "mmWave bands for 5G"**
  - 24.25-27.5 GHz, 37-43.5 GHz and 66-71 GHz as Global band
  - 45.5-47 GHz and 47.2-48.2 GHz as country-basis
- **Readiness of 5G spectrum will accelerate 5G deployment.**
  - Low/Mid/High-band are needed for successful 5G.
  - Currently, mid-band and high-band are leading spectrum bands for 5G.



- **Movements on (sub-)*THz spectrum* above 95 GHz**
  - KOR MSIT 6G R&D Strategy, US FCC Spectrum Horizons R&O, UK Ofcom 100-200 GHz consultations,, WRC-19 AI 1.15
- **The time is now *to start studies on (sub-) THz spectrum* *(e.g. Bands [95-300] GHz).***
  - e.g. Usage (Licensed, Unlicensed and/or Experimental, etc.), Candidate bands, Spectrum needs, etc.⇒ Policy



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Thank you