Global 5G Event

Session1: Global Harmonization on 5G Spectrum Collaboration

Spectrum Needs Estimate and K-ICT Plan for IMT-2020 (5G Forum, Korea)

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Methodology for 5G Spectrum Needs (1)

- **Traffic forecast-based Approach**
- **Technical Performance-based Approach**
- **Application-based Approach**
  - $R_{ts} = (C \times A \times U) / I / S$
  - $R_t = \sum R_{ts}$
  - $R = \max(R_t)$

C =	Connection density (users/km^2);
A =	Application data rate (bits/s);
U =	Usage patterns (%);
I =	Number of cells/km^2 based on the ISD (km);
S =	Spectral efficiency (bits/s/Hz);
R_{ts} =	A set of spectrum needs in given teledensities and service types (Hz);
R_t =	A set of spectrum needs in given teledensities (Hz).

ITU-R WP5D

Working Doc. on Spectrum Needs Towards a Draft Liaison Statement to Task Croup 5/1
Spectrum needs for the terrestrial component of IMT in the freq. range (24.25-86 GHz)

Application-based Approach

Example	Teledensities	24.25-33.4 GHz	37-52.6 G Hz	66-86 GHz	Total
Example 1	Overcrowded, Dense urban and Urban areas	3.3 GHz	6.1 GHz	9.3 GHz	18.7 GHz
	Dense urban and Urban areas	2.0 GHz	3.7 GHz	5.7 GHz	11.4 GHz
Example 2	Highly crowded area	666 MHz	1.2 GHz	1.9 GHz	3.7 GHz
	Crowded area	333 MHz	608 MHz	933 MHz	1.8 GHz

■ Application-based approach

► Connection Density

Teledensity		Number of devices per area	Activity factor	Connection density
Ex.1	Overcrowded area	1 / 4m^2	90%	225 000 /km^2
	Dense urban area	5 / 100m^2	70%	35 000 /km^2
	Urban area	50 / 10 000m^2	50%	2 500 /km^2
Ex.2	Highly-crowded area			45 000 /km^2
	Crowded area			22 500 /km^2

► Application Data Rate

Service type	Application data rate
Medium data rate application	100 Mbits/s
High data rate application	500 Mbits/s
Super-high data rate application	1 Gbit/s

E.g., 360 view with 4K resolution: 65 Mbits/s (H.265) and 130 Mbits/s (VAR for peak).
E.g., 360 view with 8K resolution: 258 Mbits/s (H.265) and 516 Mbits/s (VAR for peak).
E.g., Spherical view for holography: 4 to 8 times more than 360 views.

ITU-R WP5D

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► Application usage pattern

Service type \ Range	24.25-33.4 GHz	37-52.6 GHz	66-86 GHz
Medium data rate application	5%	3%	2%
High data rate application	3%	6%	6%
Super-high data rate application	2%	4%	8%

Flurry Analytics et al.: YouTube (3%) and Entertainment (17%) in the US,
Flurry Analytics: Music, Media & Entertainment (10%) in some EU countries,
Ericsson Mobility Report 2015: Video streaming (6.5 to 13%) in the US, Sweden and Russia,
Ericsson Consumer Insight Summary Report 2015: Entertainment (6 to 21%) in some countries,
Forrester's US Consumer Technographics Behavioural Study: Video streaming (9%) in the US,
Nielsen: Entertainment including video, audio, and gaming (32%) in the US,
comScore Mobile Metrix: Multimedia (5%) in the US.

► Cell area and spectral efficiency

	Overcrowded area	Dense urban area	Urban area
ISD	100 m	200 m	500 m
Spectral efficiency	7.8 bits/s/Hz/cell		

AR/VR Application: 5G Forum(1)

- AR/VR Data Rate calculation

Service Types	Data rate	Peak Data Rate[2)]	Description
360° View (H.265CODEC)	8K(7680x4320), 60fps: 258Mbps[1)] 4K(3840x2160), 60fps: 65Mbps	8K: 516Mbps 4K: 130Mbps	2-D View supporting that follo ws eye's movement over 360°
3D View	Variable values that depends on original contents 2Gbps [3)]	Peak data rates depend on the contents	Supporting 3D structure

[1)] H.265 Coding is applied and 10% streaming overhead is assumed
[2)] 200% peak is assumed for VAR(Variable bit rate) encoding
[3)] General human 3D information is larger than 500MB, and we assume that 50% compression and down load is performed within 1 s.

- Basis of AR/VR Data Rate calculation

	FULL HD	4K	8K
Video Resolution (W)	1,920.0	3,840.0	7,680.0
Video Resolution (H)	1,080.0	2,160.0	4,320.0
Video Framerate(fps)	30.0	60.0	60.0
Raw video bitrate (Gbps) (A x B x 3(RGB) x C x 8(byte to bits) / (1000000000)	1.49	11.94	47.78
[H.264] Video Encoding Bitrate (Mbps)	9.5	76.0	304.0
[H.265] Video Encoding Bitrate (Mbps) 30% of H.264 coding	7.3	58.5	234.1
[H.265] Streaming rate (Mbps)	8.0	64.4	257.5

AR/VR Application: 5G Forum(2)

- Connection density and active connection density

Parameter \ year	2018	2020	2022	2025	2030
Population in Seoul	9,792,581	9,761,875	9,735,262	9,689,738	9,564,220
Subscription rate of Mobile Phone(2014: 113.5%)	120%	126%	132%	141%	150%
Number of Mobile Subscription	11,751,097	12,299,963	12,850,546	13,662,531	14,346,330
Smart Phone penetration rate(2015: 73%)	80%	82%	84%	90%	95%
# of Smart Phone	9,400,878	10,085,969	10,794,459	12,296,278	13,629,014
VR equipment retention ratio[1)]	3.0%	9.0%	15.0%	25.0%	40.0%
# of VR equipment holders[2)]	282,026	907,737	1,619,169	3,074,069	5,451,605
Max. # of VR equipment holders[3)]	874,282	2,813,985	5,019,423	9,529,615	16,899,977
Connection density(km^2)[4)]	2,330	7,500	13,378	25,399	45,043
Active connection density(km^2)[5)]	35	111	198	376	667

[1)] VR equipment retention ratio estimation is based on the increasing rate of SKB mobile IPTV charged members (mobile IPTV showed 6%/year increasing rate and VR increasing rate is half of that of mobile IPTV:3%/year)

[2)] # of VR equipment holders is # of smart phone * VR equipment retention ratio

[3)] Max. # of VR equipment holders is estimated that top 5% LTE dense cell load in most busy hours (3.1 times)

[4)] Area of Seoul: 375.2km^2 (Non-residential area such as forest, farmland, and river are excluded from the total area (605.2km^2))

[5)] Based on video service usage rate of LTE data users **(1.48%)**

Spectrum Needs Estimates

Assumption

- ► AR/VR streaming data rate: 516Mbps
- ► ISD: 0.05km (ISD of Munhak stadium is 0.08km, Dense Urban ISD: 0.2km)
- ► Connection density:
  - Overcrowded :88800/ km^2 : 6 persons/ $1m^2$ * 10^6 (km^2)*activity factor (0.0148)

    59200/ km^2 : 4 persons/ $1m^2$ * 10^6 (km^2)*activity factor (0.0148)
  - Highly-Crowded: 400/ km^2 : 25400/ km^2 *activity factor (0.0148)

Spectrum Needs

- ► Stadium (Overcrowded)
  - 4.23 GHz (6 persons in $1m^2$), 2.83 GHz (4 persons in $1m^2$)
- ► Dense Urban (Highly-Crowded)
  - Around 300 MHz

K-ICT Plan (2017.01)

History

2012

Mobile Broadband Plan 1.0 ('12.1)

☞ (Plan) Allocate 600MHz for mobile Comm. (by 2020)

☞ (Outcome) Allocate Spectrum on 700㎒, 1.8㎓

2013

Mobile Broadband Plan 2.0 ('13.12)

☞ (Plan) Allocate more than 1㎓ for next 10 years

☞ (Outcome) Secure 2.6㎓, 2.5㎓ band/ refarming 3.5㎓ band

2017

K-ICT Spectrum Plan ('17.01)

☞ 5G/Mobile Comm. / Smart Industry &Life Public/ Satellite

Vision & Goal

Develop New Spectrum for Global Leadership of the 4th Industrial Revolution

Provide Double Spectrum through Supplying 40GHz Bandwidth by 2026

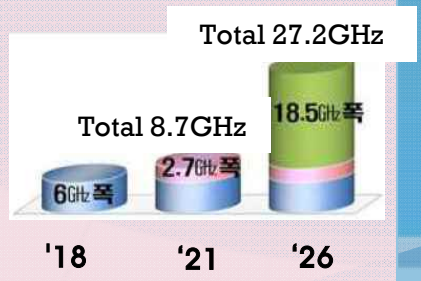
44㎓ (2016) → 84㎓ Bandwidth(2026)

Mobile Comm

World First Commercial 5G

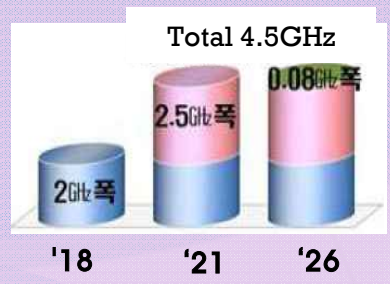
Industry & Life

4th Industrial Rev. & Smart Life



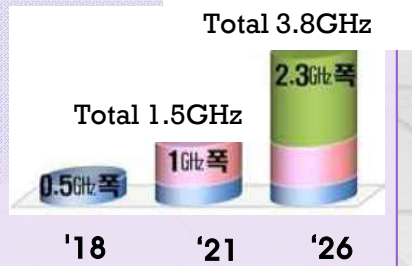
Public Service

Most Advanced Public Service



Satellite

Reinforce Satellite



Improve Frequency Regulation

Efficient Spectrum Utilization

Develop Tech / International Cooperation

Spectrum Plan for 5G

Provide 4,440㎒ of bandwidth for World First 5G Commercialization & Upgrading 4G

5G Wideband Spectrum

Release 4,300MHz Bandwidth by 2026

'17~'18

- Above 6GHz :
  28㎓ Band(27.5~28.5㎓) 1㎓ BW
- Under 6GHz :
  3.5㎓Band(3.4~3.7㎓) 300㎒BW

'18~'21

- Near 28㎓ Bands (26.5~27.5, 28.5~29.5㎓), 2㎓ BW (WRC-19 recommended bands etc.)

✓If the condition for supplying near 28㎓ bands is satisfied, release it at the 1st stage

'21~'26년

- Securing at least 1 ㎓ BW to support increasing 5G Traffic

THANK YOU FOR YOUR ATTENTION !