SAMSUNG

March 11, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Notice of *Ex Parte* Presentation
Use of Spectrum Bands Above 24 GHz for Mobile Radio Services *et al*., GN Docket No. 14-177, IB Docket No. 15-256, RM-11664, WT Docket No. 10-112, IB Docket No. 97-95

Dear Ms. Dortch:

On March 9, 2016, John Godfrey (Senior Vice President, Public Policy), Vazrik Hovsepian of Samsung Electronics America, Dr. Thomas Novlan of Samsung Research America ("Samsung"), the undersigned, and Tom Dombrowsky, Senior Engineering Advisor, Wiley Rein LLP for Samsung, met with Johanna Thomas, Legal Advisor to Commissioner Jessica Rosenworcel. In this meeting, the parties discussed Samsung's comments in the above-captioned proceeding as well as the attached presentations.

Consistent with Samsung's prior filings in this proceeding, the parties discussed Samsung's support for the Commission's proposal to make spectrum above 24 GHz available for 5G. Samsung noted its support for establishment of a regulatory framework for provision of mobile services in the 28 GHz (27.5-28.35 GHz), 39 GHz (38.6 to 40 GHz), and 37 GHz (37 to 38.6 GHz) bands. Samsung also urged the Commission to make development of a regulatory framework for the millimeter wave spectrum bands a priority.

Pursuant to Section 1.1206(b)(2) of the Commission's Rules, a copy of this letter is being filed electronically for inclusion in the above-captioned docket. Please direct any questions about this matter to the undersigned.

Respectfully submitted,

/s/ Robert Kubik.

Robert Kubik, Ph.D.
Director, Public Policy, Engineering and Technology
Samsung Electronics Washington Office
1200 New Hampshire Ave, NW #650
Washington, DC 20036

cc: Johanna Thomas

Attachments

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Spectrum Frontiers

March 9, 2016

5G Service Scenarios

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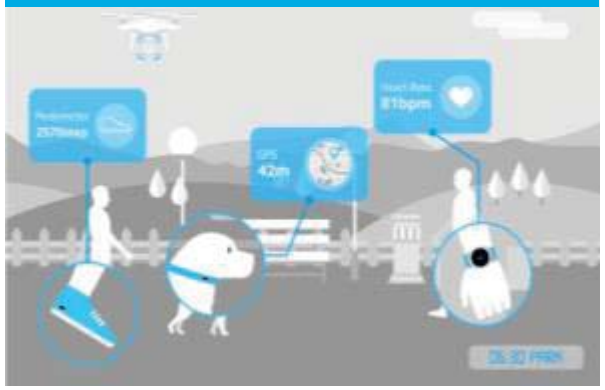
Mobile Cloud Service

Internet of Things



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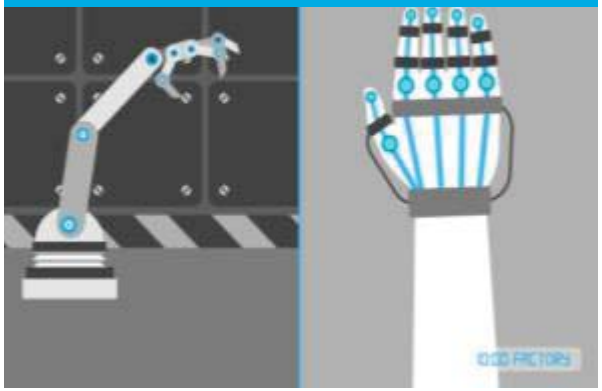
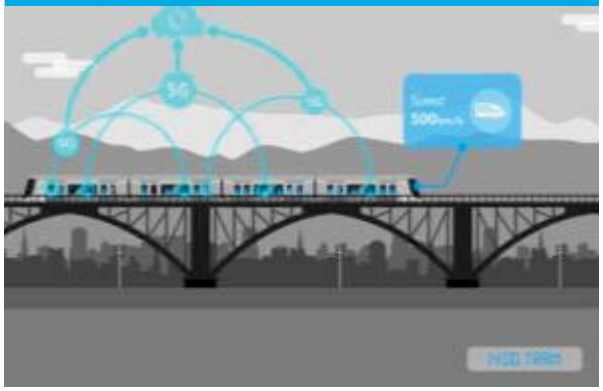


Mobile Giga Internet Service



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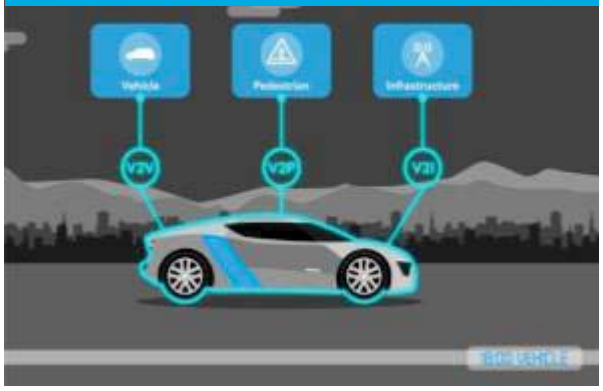

Wireless Backhaul Service

5G Use Cases and Requirements

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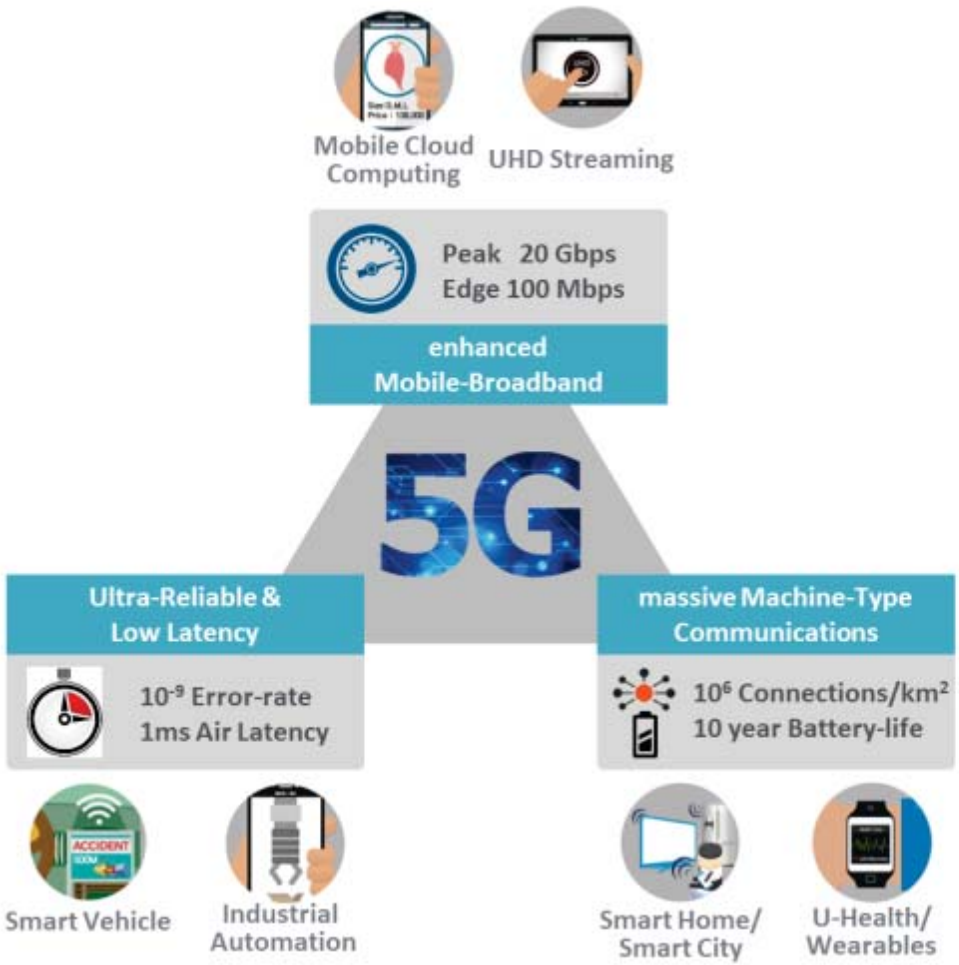

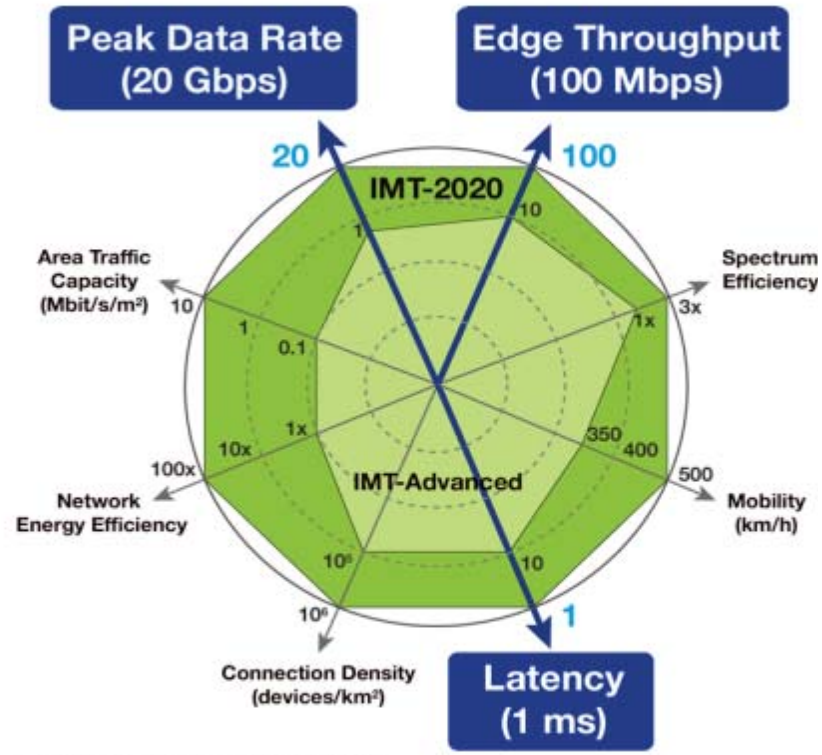

※ ITU-R document 5D/TEMP/625

※ ITU-R document 5D/929 (June 2015)

5G Standardization Timeline

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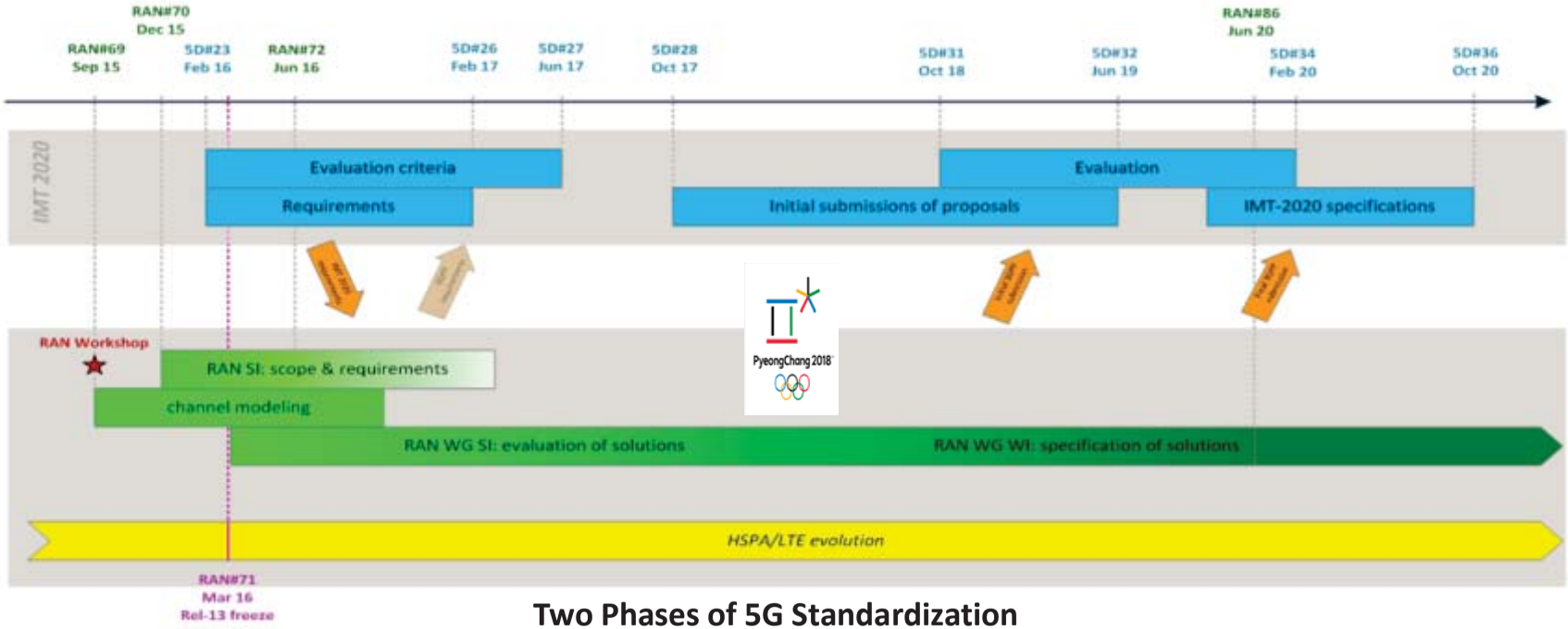

Two Phases of 5G Standardization

'16. 3 — '17. 6 — '18. 9 — '19.12

Phase I

New RAT SI (Rel-14)
- Primary focus on eMBB
- Both > 6 GHz and < 6 GHz

New RAT WI (Rel-15)
- Optimized for eMBB
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- Target Spectrum : Up to 40 GHz
- Deployment Scenario : HetNet / UMi for eMBB
- Waveform : OFDM-based (Potentially w/ Filtering)
- Mobility : Optimized for Low Mobility
- TDD, Massive-MIMO

Phase II

Further Enhancements (Rel-16)
- Optimized for all use cases

- Optimized for All Scenarios
- Both TDD and FDD
- D2D
- Unlicensed Bands Operation

Key Enabling Technologies

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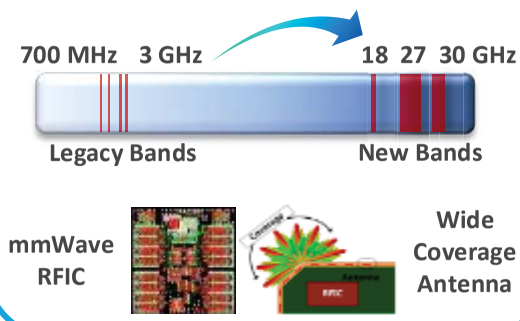
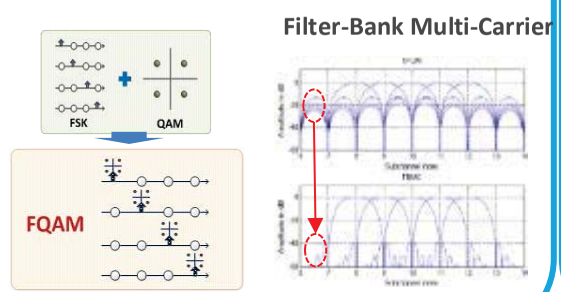
- Disruptive Technologies for Significant Performance Enhancement

> 6 GHz System/RFIC/Ant.



Post-OFDM



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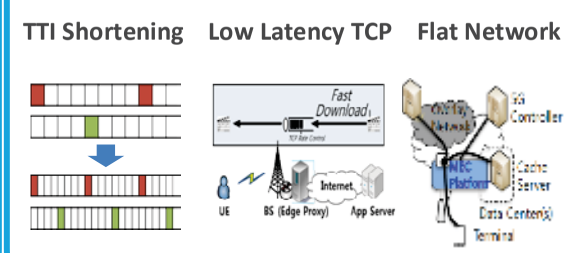
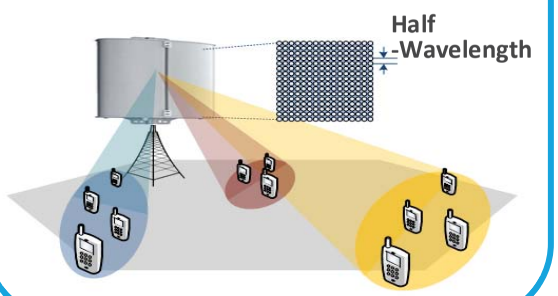
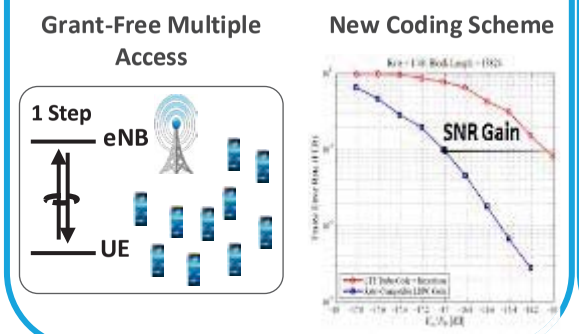


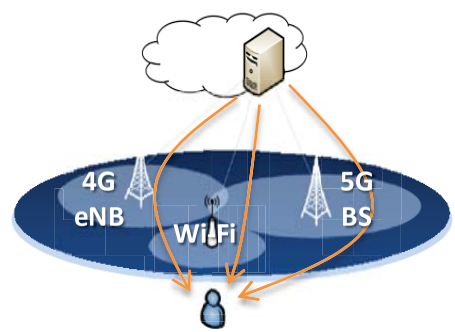
< 6 GHz Massive MIMO



Massive Connectivity



Multi-RAT Interworking



5G Trials and Initiatives

SAMSUNG

- Global pre-commercial 5G initiatives are accelerating with multiple field trial plans announced in the 2016-2018 timeframe
- **Open Trial Specification Alliance** announced in February plans to develop an aligned 5G trial specification between members that would serve as a common, extendable platform for different 5G trial activity around the world
- Provide input to specification bodies, by complementing simulation studies with real data from different trial deployments

mmWave 5G system demo in Basking Ridge, NJ

5G Technology Demo

SAMSUNG

- Radio Link speeds in MIMO and SISO Transmission
  - Maximum 1.83 Gbps in SISO mode
  - Maximum 3.77 Gbps in MIMO mode
- Beam Switching
  - Adaptive Beam Switching between Base Station and CPE to provide high beam-forming gain
- Adaptive Modulation & Coding Scheme
  - Adapting modulation and coding based on channel conditions
- Ultra High Definition Video (4K)
  - Stream high bitrate 4K video from Base Station to CPE

Rulemaking Comments

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- FCC can move forward with a decision that will solidify the Framework for 5G deployment
- Licensed operation for mobile broadband in 27.5-28.35 GHz and 37-40 GHz bands
  - Support
    - Common licensing scheme and band plan in 37-40 GHz
    - License Certainty critical for 5G Deployment
      - Current LMDS licensees be granted mobile deployment rights
      - Licenses retain current geographical licensing and 10 year license terms
      - Reasonable and flexible performance requirements
  - Oppose
    - Hybrid licensing scheme in 37 GHz
    - Proposals for use of Spectrum Access System in 28 GHz and 37-40 GHz
    - Interoperability requirement between different air interfaces

Thank You!

SAMSUNG

Questions?

Contact Information:

John Godfrey (John.Godfrey@Samsung.com)

Rob Kubik (Robert.Kubik@Samsung.com)

Thomas Novlan (T. Novlan@Samsung.com)

Vazrik Hovsepian (V.Hovsepi@Sea.Samsung.com)

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Spectrum Frontiers

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AGENDA

- TECHNOLOGY UPDATE
- RULEMAKING DISCUSSION
- Q&A

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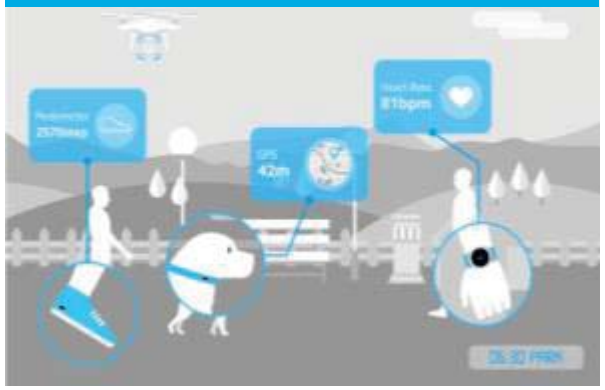
Internet of Things



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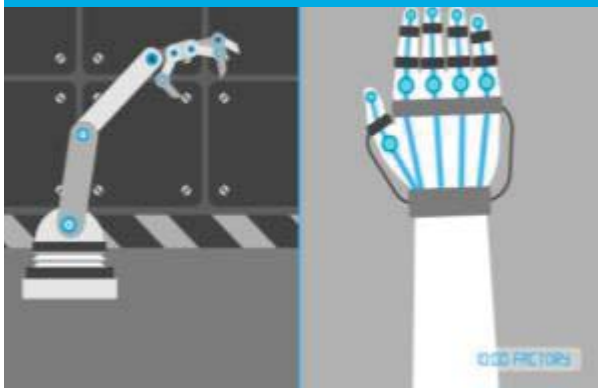

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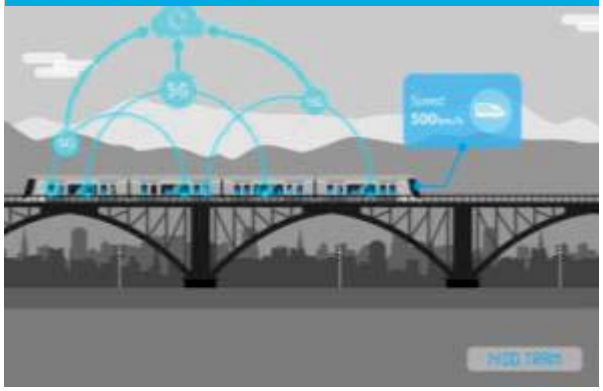

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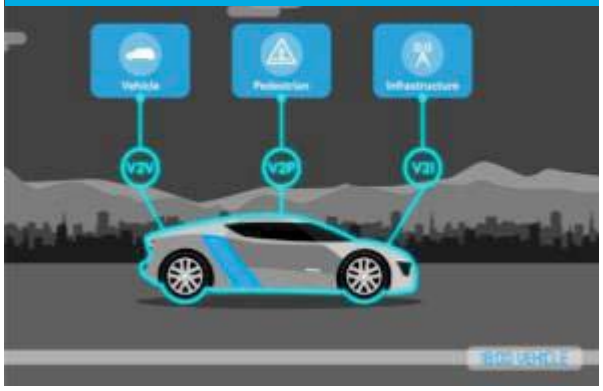

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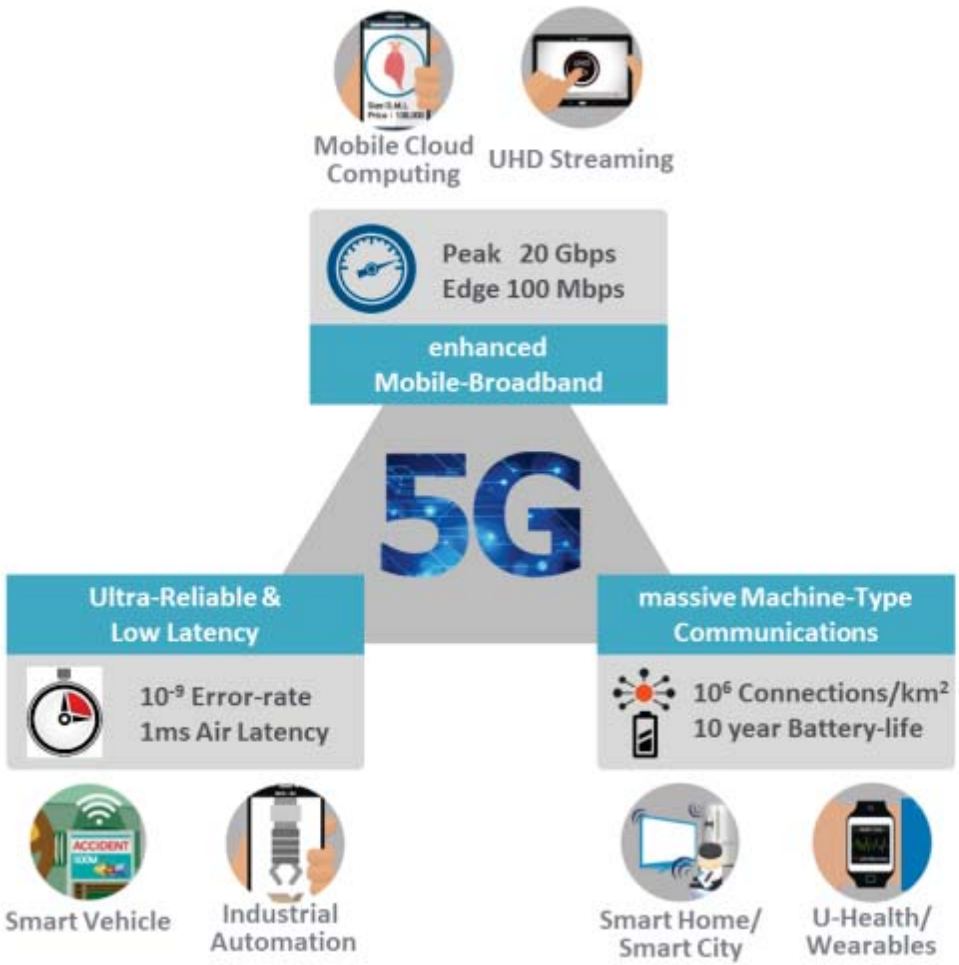

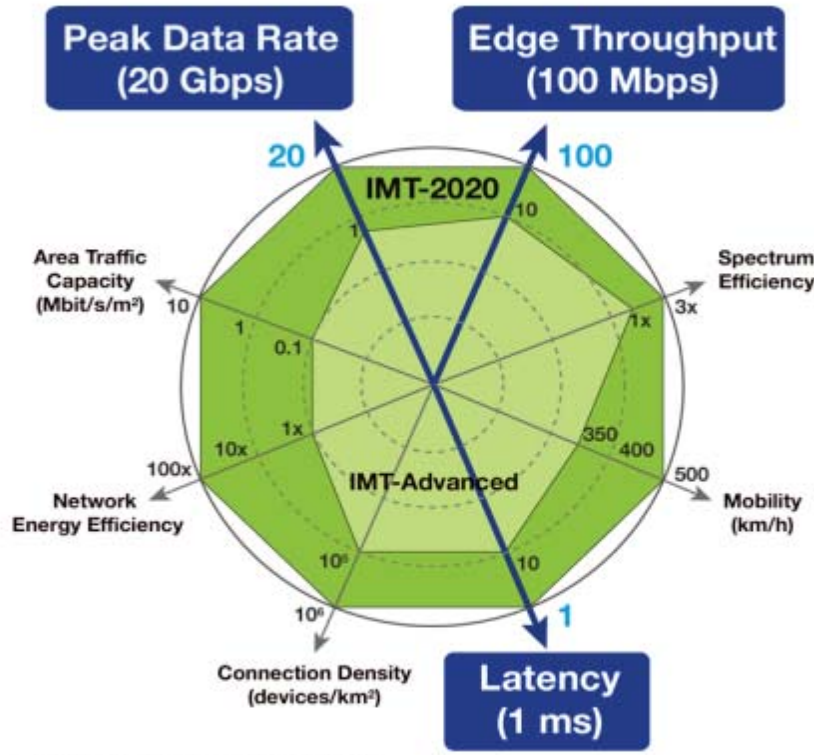

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5G System Design Principles

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Ultra Wideband & Gbps Support

High Freq. / Ultra-Wideband
mmWave BF Technology

Flexible & Scalable System

Flexible Spectrum Usage
New Waveform
New Multiple Access
Dynamic TDD

Low Power/ Low Complexity

LDPC
Low PAPR Waveform
Lean Design Principle

Spectrum Efficient System

Massive MIMO Technology
New Modulation & Coding

5G Standardization Timeline

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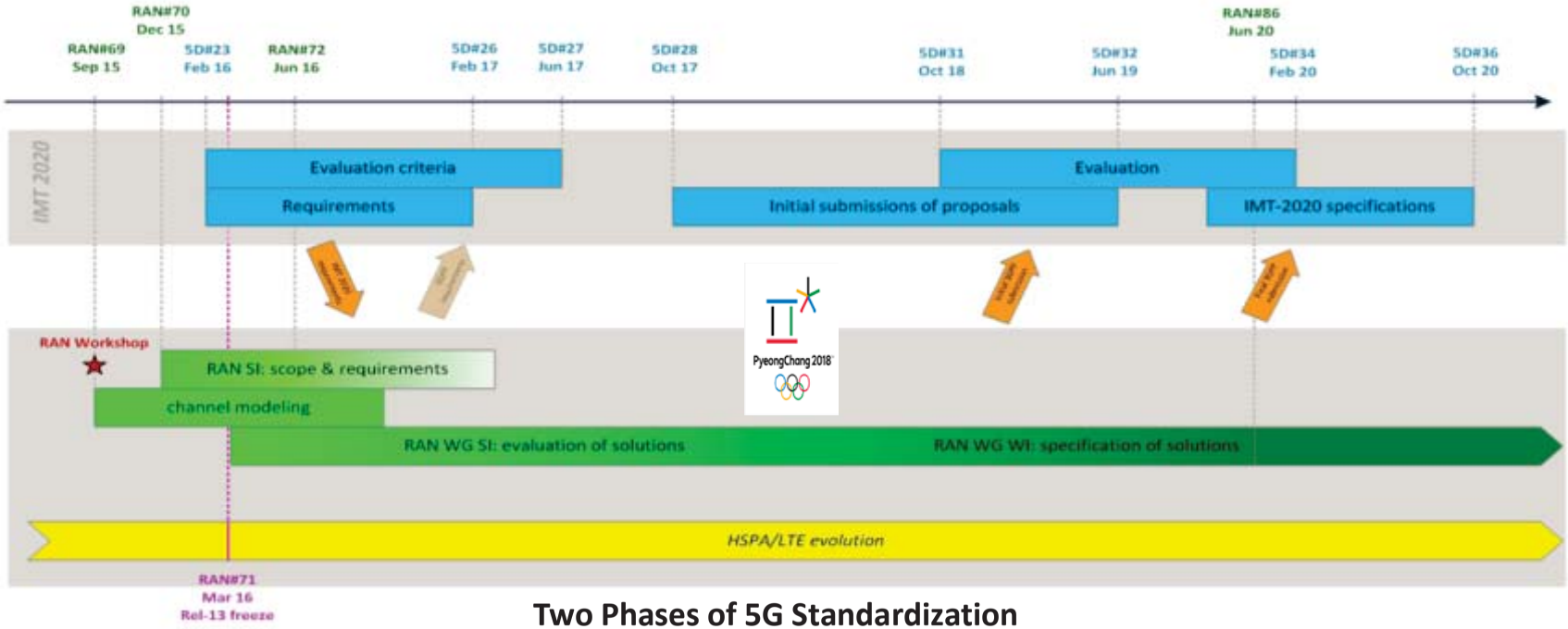

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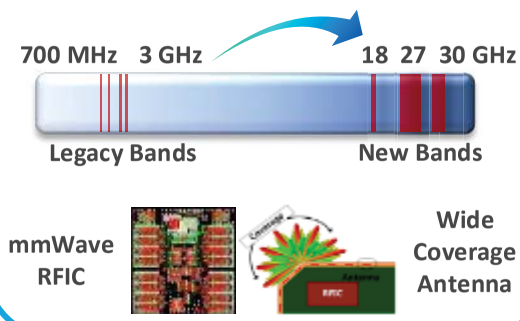

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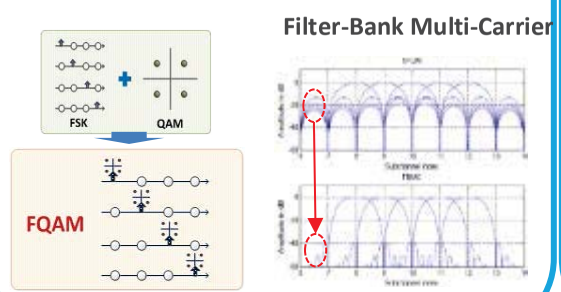

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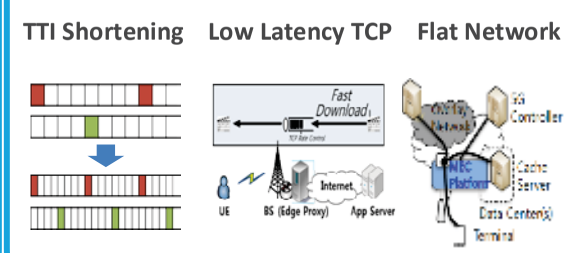

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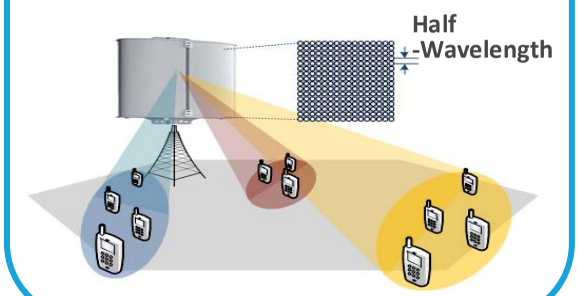

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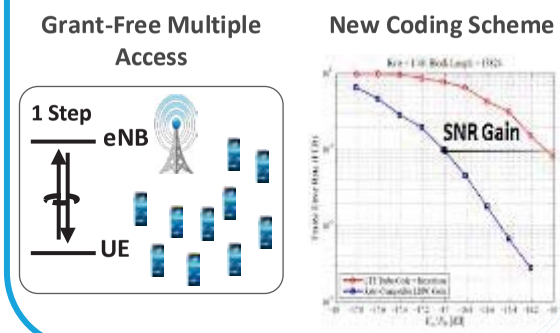

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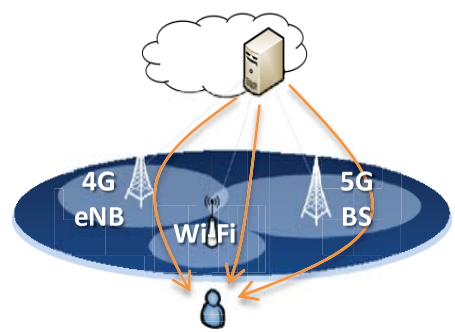

Massive MIMO

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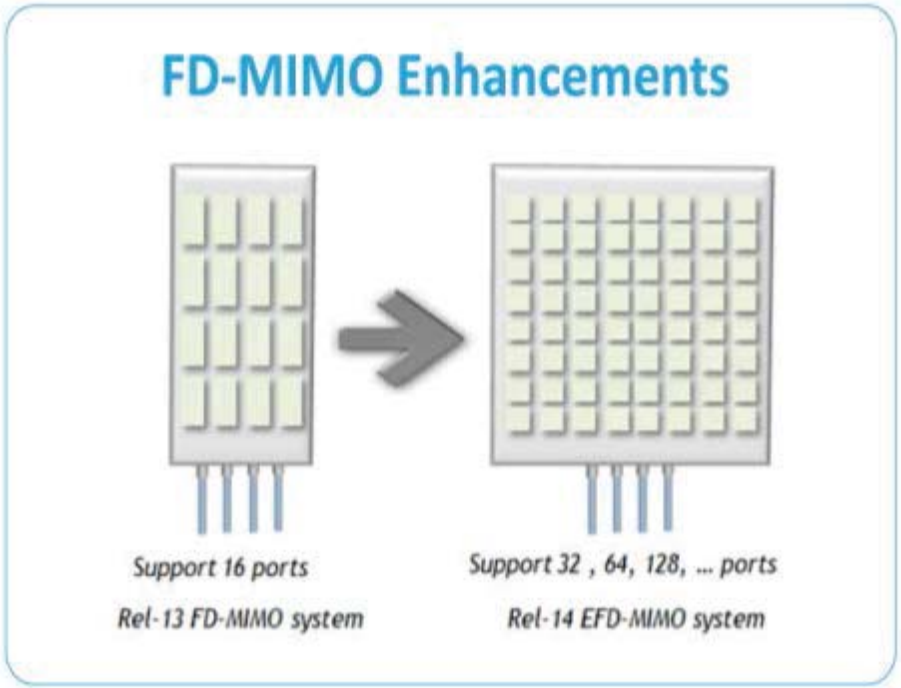
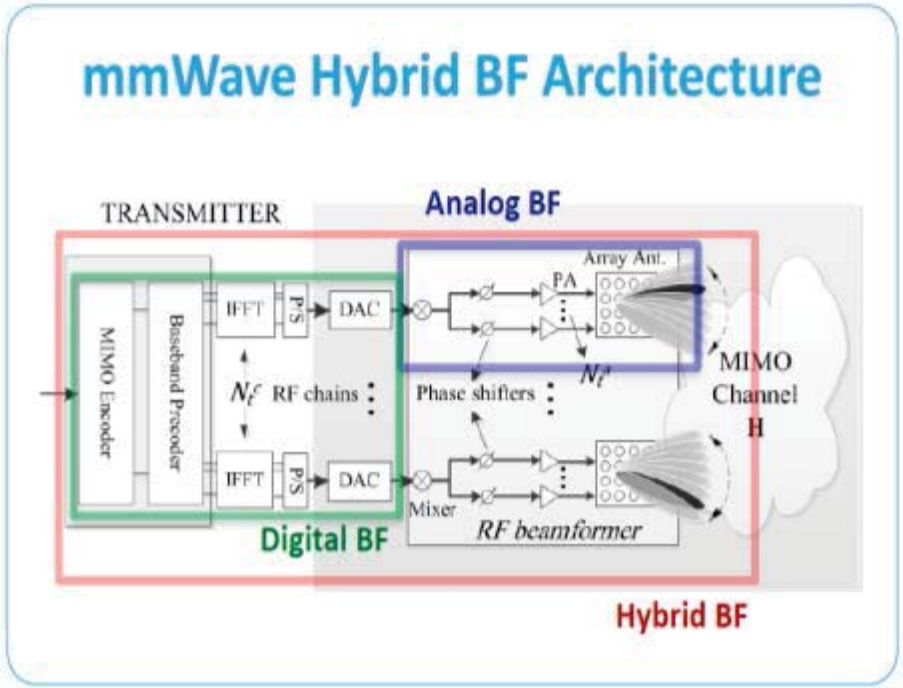
- Evolution of Full Dimension (FD) MIMO to use a massive number of antennas
- Hybrid beamforming is a key technology with reasonable RF complexity for operation at high frequency bands, e.g., 28GHz





mmWave Channel Modeling

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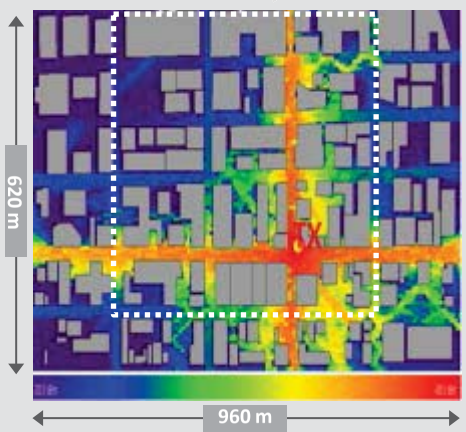
- Leading Channel Modeling Activity toward Outdoor Cellular Deployment
  - Path loss measurements, environmental attenuation factors (e.g. rain and foliage), indoor penetration loss

Channel Modeling

Ottawa, Canada

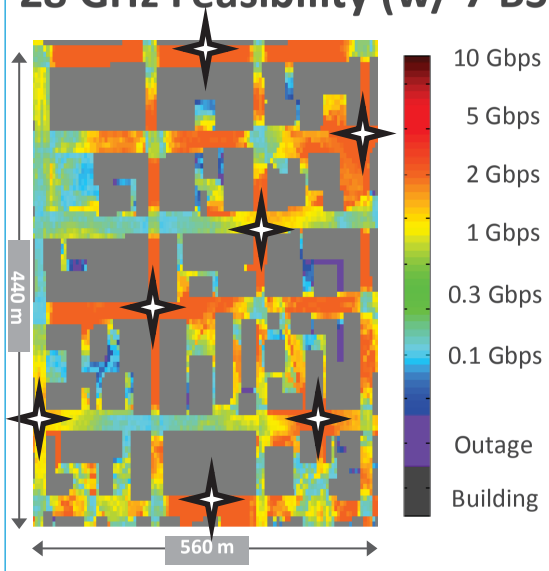
3D Building Model



Ray-tracing Simulation (Urban Micro Scenario)

Multi-Cell Analysis

28 GHz Feasibility (w/ 7 BS)



System Margin : 146 dB
Bandwidth : 500 MHz
Peak Data Rate : 2.2 Gbps

Samsung's Role on Channel Modeling

- Universities & Research Centers
  - NYU, USC, KAIST, CATR, BU
- Research Projects
  - mmMAGIC in 5G PPP, COST IC1004 Action
- **Standardization**
  - **5G Channel Model SI in 3GPP ('15.3Q)**

mmWave System Capacity

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- Throughput boost is substantial, especially with high traffic loads
- Nature of mmWave channel and RF architecture will have impact on all aspects of system design
  - Everything beamformed with a focus on power efficiency

Simulation Conditions

- 10 small cells deployed per macro sector (macro ISD 500m)
- FTP traffic model 1, SISO
- Light traffic load : 300 Mbps/km^2
- Heavy traffic load : 150 Gbps/km^2 (10 Gbps per macro cell)

	Macro Cell (2 GHz LTE)	Small Cell (3.5 GHz LTE)	Small Cell (mmWave-band)
Carrier Freq.	2 GHz	3.5 GHz	28 GHz
System Bandwidth	20 MHz	80 MHz	800 MHz
BS Tx Power	49 dBm	39 dBm	39 dBm
BS Antenna Element Gain	17 dBi	5 dBi	5 dBi
Tx Array Gain	0 dB	0 dB	9 dB
Rx Ant. Gain	0 dBi	0 dBi	7 dBi

Evaluation Results

- mmWave HetHet shows > 300 Mbps 5%-tile user T'put even in heavy traffic load

Traffic Load	Throughput	LTE HetNet		mmWave BF HetNet	
		LTE BS [Mbps]	LTE SC [Mbps]	LTE BS [Mbps]	mmWave BF SC [Mbps]
Light	Average UE	49.94	246.01	60.80	2095.10
	5% Edge UE	19.42	246.72	34.10	2097.20
Heavy	Average UE	Outage	Outage	60.89	1560.50
	5% Edge UE	Outage	Outage	34.10	358.21

※ Outage: system capacity is not able to support offered traffic

Multi-Connectivity

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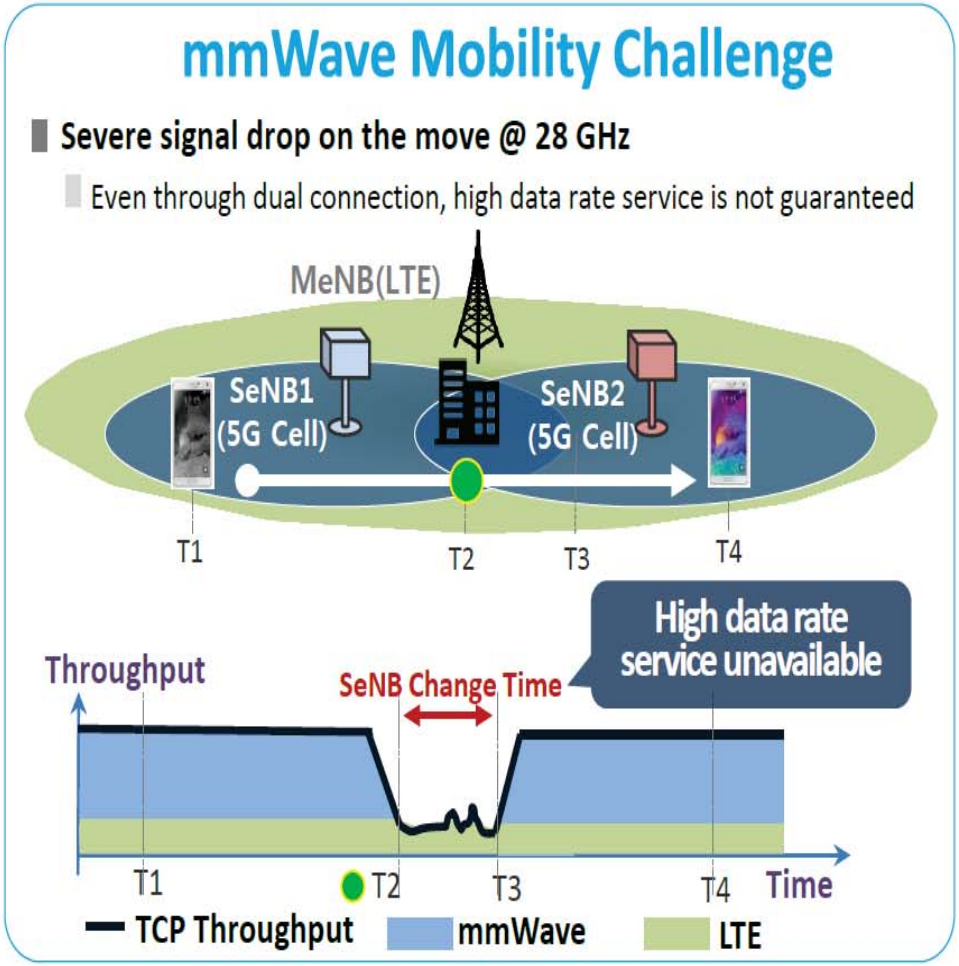
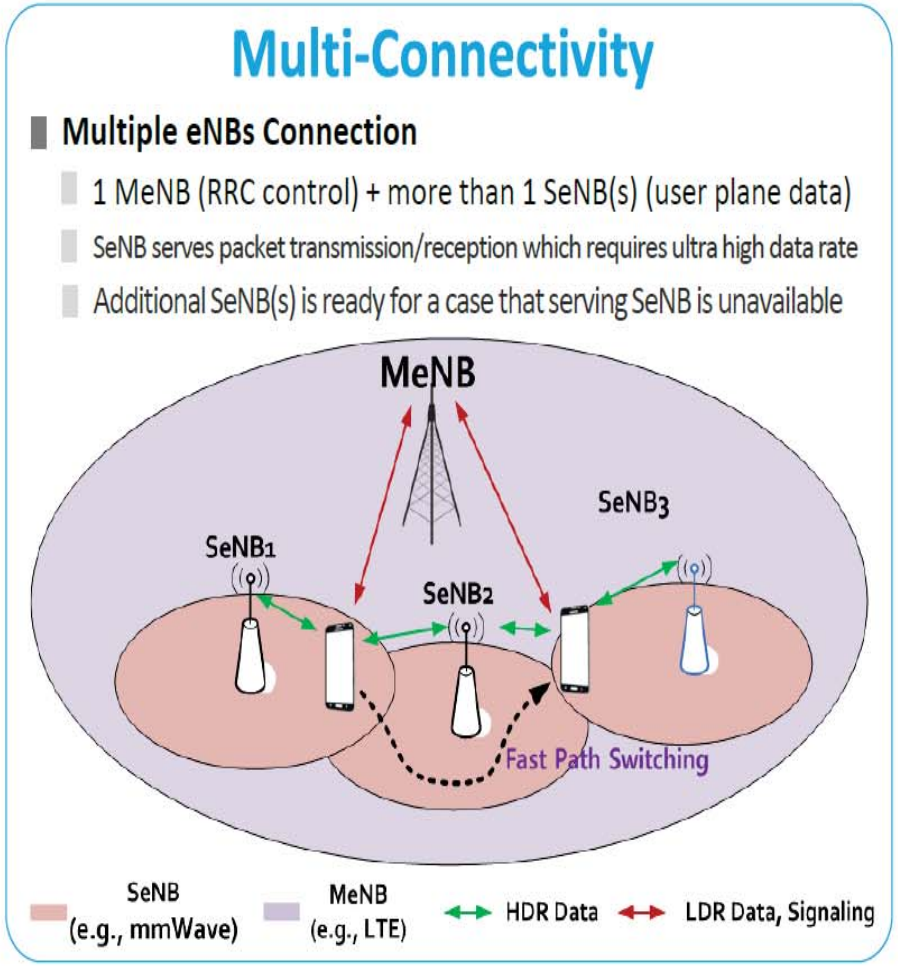
- 5G Next Gen RAT enables seamless high data rate experience everywhere
- 4G can augment as a coverage layer





5G Next Gen. Radio Access Technology

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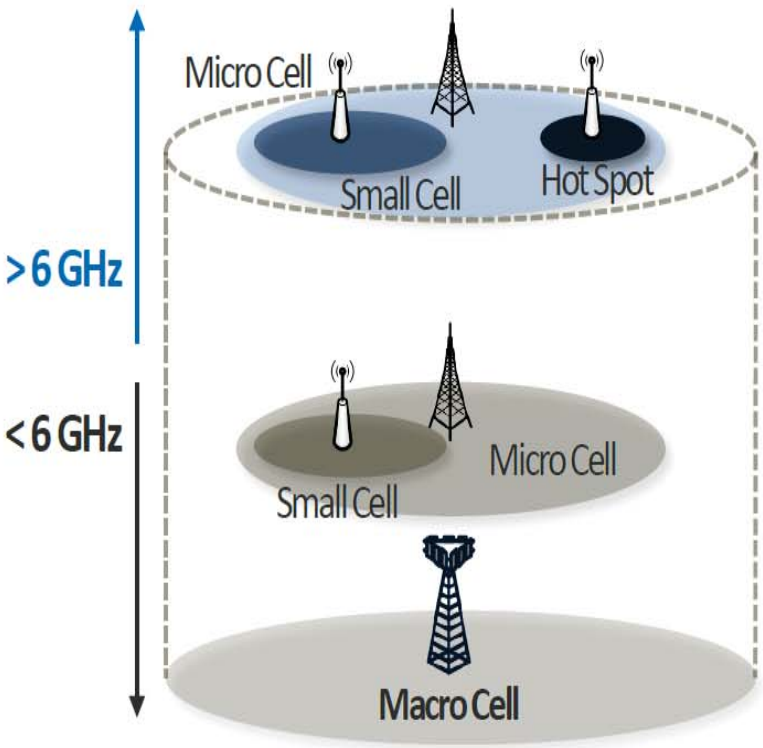

Features	LTE Evo.	5G New RAT	
	< 6GHz		> 6GHz
Duplexing	TDD/FDD	TDD/FDD	TDD(/FDD)
Bandwidth	1.4/3/5/10/15/20 MHz	Up to 100MHz	At least 100MHz
Waveform	OFDM	OFDM based (potentially with additional filtering)	OFDM based (potentially with additional filtering)
Multiple Access (DL/UL)	OFDMA (DL) SC-FDMA(UL)	OFDMA (DL/UL)	OFDMA (DL/UL)
MIMO Type	FD-MIMO	FD-MIMO	FD-MIMO or Hybrid-BF
MIMO Order (DL)	~8 layers for SU Total 4-8 layers for MU	~8 layers for SU Total 4-8 layers for MU	~8 layers for SU Total 8 layers for MU
Channel Coding	Turbo Code	LDPC	LDPC
LTE Integration	-	Dual Connectivity	Dual Connectivity

5G Trials and Initiatives

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- Adaptive Modulation & Coding Scheme
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- Ultra High Definition Video (4K)
  - Stream high bitrate 4K video from Base Station to CPE

5G Test Bed Technical Parameters

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Technical Specification Fields	Values
Operation	Indoor, Fixed
Center Frequency	27925 MHz
Emission Bandwidth	800 MHz
Radio Units	
CPE Antenna	2 Transmit 2 Receive 16-element Array in 4X4 formation
BS Antenna	2 Transmit 2 Receive 48-element Array in 8X6 formation
EIRP	
BS	Maximum 58 dBm (Attenuated for indoor use)
CPE	43 dBm (Attenuated for indoor use)
Antenna Height:	
Base Station	2 meters (installed indoors in cabinet)
CPE	2 meters (installed indoors in cabinet)

Rulemaking Comments

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    - Hybrid licensing scheme in 37 GHz
    - Proposals for use of Spectrum Access System in 28 GHz and 37-40 GHz
    - Interoperability requirement between different air interfaces

Technical Rulemaking Aspects

SAMSUNG

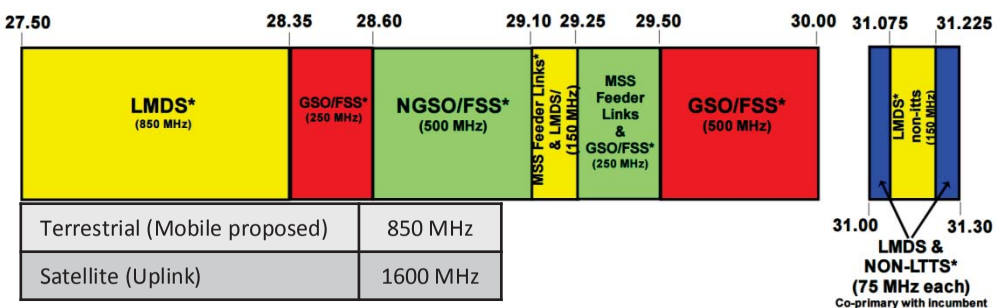
- Transmitter power levels
  - Base station EIRP power levels of at least 75 dBm/100 MHz
  - Mobile station EIRP power levels of 43 dBm
  - Customer Premise Unit (CPE) EIRP more than 43 dBm for mobile
    - But less than the 85 dBm permitted for fixed stations under proposed rule 30.202(b)
- Emission limits
  - Support FCC proposal rule 30.203
- Space Research Service
  - Agree with coordination of operation with-in a limited range of SRS facilities.

Satellite Uplink Compatibility

SAMSUNG

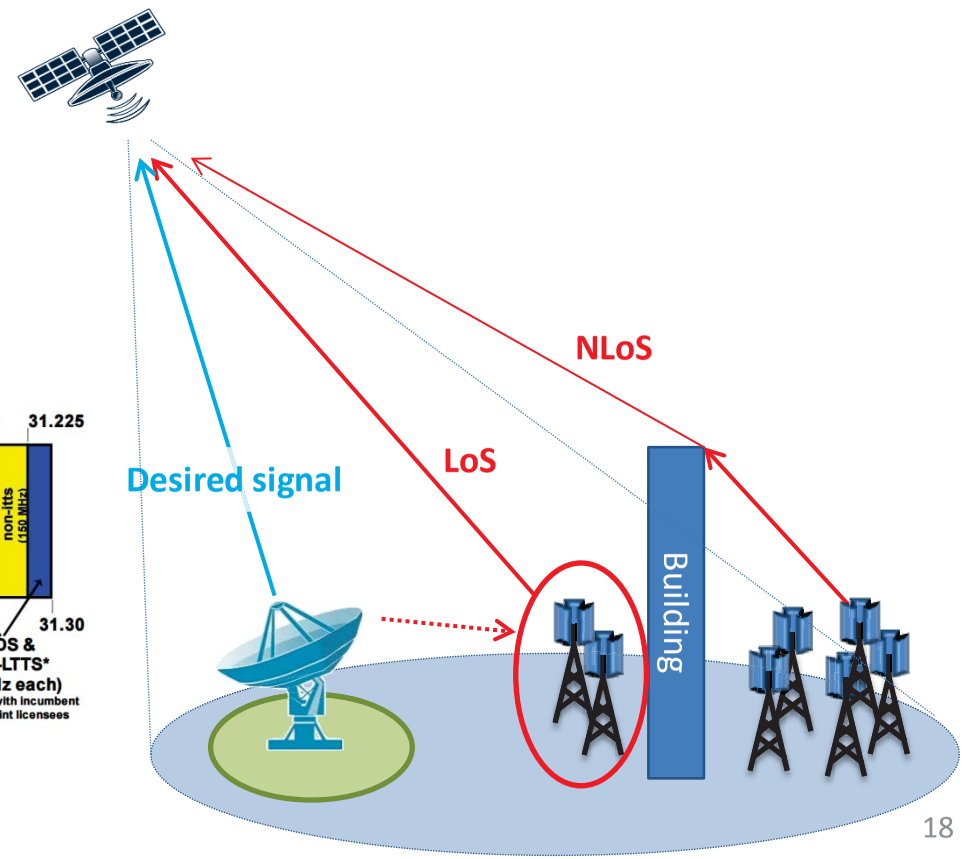
- Analysis to/from Mobile Base Stations to Fixed Satellite Stations (FSS)
- Evaluate C/(I + N) to understand impact to/from FSS uplinks
- Realistic number of Mobile base station will be taken into account, in aggregation, for compatibly analysis of 5G Mobile deployment environment
- FCC decision remains true for Fixed and Mobile (CC Docket 92-297, July 22, 1996)

"co-frequency sharing between either GSO/FSS or NGSO/FSS **ubiquitously** deployed terminals and LMDS with its **ubiquitously** deployed subscriber terminals, is not feasible at this time"



Terrestrial (Mobile proposed)	850 MHz
Satellite (Uplink)	1600 MHz

Satellite has additional 2500 MHz at 17.7-20.2 providing downlink



Thank You!

SAMSUNG

Questions?

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