GISC 2025

Global ICT Standards Conference 2025

(세션1) 6G 기술 및 표준화

Standardization progress of 3GPP Rel-20 6G RAN1

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ICT Standards and Intellectual Property:
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주최 과학기술정보통신부 지식재산처 주관 국립전파연구원 TTA IITP KEA kista ETRI

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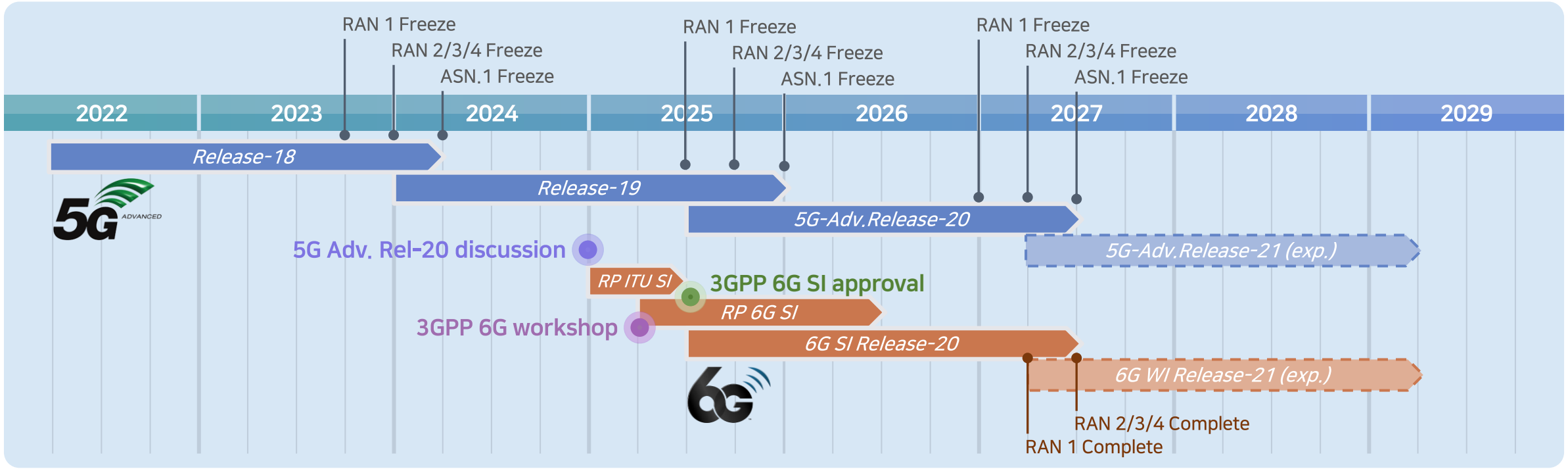
Abstract

In this presentation, we introduce 6G requirements that have been discussed to date in 3GPP and the ongoing 3GPP Rel-20 6G RAN1 standardization activities.

ICT Standards

01. 3GPP 6G Timeline

6G has officially started!!!



02. Study on 6G Scenarios and Requirements

- RAN-level study item for 6G was approved in RAN#107 (March/2025)
  - Study on 6G Scenarios and Requirements, CMCC, Verizon, NTT DOCOMO, INC., Deutsche Telekom (SID: RP-250810 → RP-251395)
- Regarding RAN-level study item for 6G, TR 38.914 was updated as v0.2.0 (RP-252882)
  - Deployment scenarios
  - Requirements and key technical principles
    - Key performance indicators
    - Requirements for architecture and migration
    - Operational requirements
    - Requirements of New and Existing Services
    - Key technical principles
    - Testing and Conformance requirements

Key performance indicators

- 14 items (#1 - #14) are the same as 5G NR, and 5 items (#15 - #19) are newly defined for 6GR
  - Most of the values in each item have been slightly improved

<table>
<tr><th>Proposed TPR items</th><th>Proposed requirement values</th><th>IMT-2020 (5G) Target values</th></tr>
<tr><td>1. Peak Data Rate</td><td>TBD</td><td>DL: 20Gbps, UL: 10Gbps</td></tr>
<tr><td>2. Peak Spectral Efficiency</td><td>DL: 60bps/Hz
UL: 30bps/Hz</td><td>DL: 30bps/Hz
UL: 15bps/Hz</td></tr>
<tr><td>3. User Experienced Data Rate</td><td>DL: 300Mbps
UL: 50Mbps</td><td>DL: 100Mbps
UL: 50Mbps</td></tr>
<tr><td>4. 5th percentile user Spectral Efficiency</td><td>
<table>
<tr><th>Test environment</th><th>Downlink (bit/s/Hz)</th><th>Uplink (bit/s/Hz)</th></tr>
<tr><td>Indoor Hotspot - IC</td><td>0.9</td><td>0.63</td></tr>
<tr><td>Dense Urban - IC</td><td>0.675</td><td>0.45</td></tr>
<tr><td>Rural - IC</td><td>0.36</td><td>0.135</td></tr>
</table>
</td><td>
<table>
<tr><th>Test environment</th><th>Downlink (bit/s/Hz)</th><th>Uplink (bit/s/Hz)</th></tr>
<tr><td>Indoor Hotspot - eMBB</td><td>0.3</td><td>0.21</td></tr>
<tr><td>Dense Urban - eMBB</td><td>0.225</td><td>0.15</td></tr>
<tr><td>Rural - eMBB</td><td>0.12</td><td>0.045</td></tr>
</table>
</td></tr>
</table>

Key performance indicators

<table>
<tr><th>Proposed TPR items</th><th>Proposed requirement values</th><th>IMT-2020 (5G) Target values</th></tr>
<tr><td>5. Average Spectral Efficiency</td><td>
<table>
<tr><th>Test environment</th><th>Downlink (bit/s/Hz)</th><th>Uplink (bit/s/Hz)</th></tr>
<tr><td>Indoor Hotspot - IC</td><td>27</td><td>20.25</td></tr>
<tr><td>Dense Urban - IC</td><td>23.4</td><td>16.2</td></tr>
<tr><td>Rural - IC</td><td>9.9</td><td>4.8</td></tr>
</table>
</td><td>
<table>
<tr><th>Test environment</th><th>Downlink (bit/s/Hz)</th><th>Uplink (bit/s/Hz)</th></tr>
<tr><td>Indoor Hotspot - eMBB</td><td>9</td><td>6.75</td></tr>
<tr><td>Dense Urban - eMBB</td><td>7.8</td><td>5.4</td></tr>
<tr><td>Rural - eMBB</td><td>3.3</td><td>1.6</td></tr>
</table>
</td></tr>
<tr><td>6. Sustainability / Energy Efficiency</td><td>TBD</td><td>The sleep ratio is the fraction of unoccupied time resources (for the network) or sleeping time (for the device) in a period of time corresponding to the cycle of the control signalling (for the network) or the cycle of discontinuous reception (for the device) when no user data transfer takes place.</td></tr>
<tr><td>7. Area Traffic Capacity</td><td>40 Mbit/s/m^2 in Indoor Hotspot
TBD in Dense Urban IC</td><td>10 Mbit/s/m^2</td></tr>
<tr><td>8. User Plane Latency</td><td>IC: 4ms
HRLLC: 1ms</td><td>URLLC: 1ms
eMBB : 4ms</td></tr>
<tr><td>9. Control Plane Latency</td><td>20ms</td><td>20ms for eMBB and URLLC
(encouraged to consider lower value, e.g., 10ms)</td></tr>
<tr><td>10. Connection Density</td><td>10^6 (devices/km^2) for massive communication</td><td>For mMTC, 10^6 devices per km^2</td></tr>
<tr><td>11. Reliability</td><td>1-10^{-5} with same IMT-2020 assumptions</td><td>For URLLC, 1-10^{-5} success probability</td></tr>
</table>

Key performance indicators

<table>
<tr><th>Proposed TPR items</th><th>Proposed requirement values</th><th>IMT-2020 (5G) Target values</th></tr>
<tr><td>12. Mobility</td><td>
<table>
<tr><th>Test environment</th><th>Normalized traffic channel link data rate (Bit/s/Hz)</th><th>Mobility (km/h)</th></tr>
<tr><td>Indoor Hotspot - IC</td><td>2.25</td><td>10</td></tr>
<tr><td>Dense Urban - IC</td><td>1.68</td><td>30</td></tr>
<tr><td rowspan="2">Rural - IC</td><td>[0.88 ~ 1.2]</td><td>120</td></tr>
<tr><td>[0.495 ~ 0.675]</td><td>500</td></tr>
</table>
</td><td>
<table>
<tr><th>Test environment</th><th>Normalized traffic channel link data rate (Bit/s/Hz)</th><th>Mobility (km/h)</th></tr>
<tr><td>Indoor Hotspot - eMBB</td><td>1.5</td><td>10</td></tr>
<tr><td>Dense Urban - eMBB</td><td>1.12</td><td>30</td></tr>
<tr><td rowspan="2">Rural - eMBB</td><td>0.8</td><td>120</td></tr>
<tr><td>0.45</td><td>500</td></tr>
</table>
</td></tr>
<tr><td>13. Mobility Interruption Time</td><td>For minimum requirement, 0ms</td><td>For eMBB and URLLC, 0ms</td></tr>
<tr><td>14. Bandwidth</td><td>400MHz (same definition as IMT-2020)</td><td>At least 100MHz, Shall support up to 1GHz for operation in higher frequency bands (e.g., above 6GHz)</td></tr>
<tr><td>15. Positioning</td><td>
<table>
<tr><th>[Test Environment]</th><th>Horizontal Accuracy</th><th>Vertical Accuracy</th></tr>
<tr><td>Indoor Factory - ISAC</td><td>TBD</td><td>TBD</td></tr>
<tr><td>[Urban Macro – ISAC / Urban – ISAC]</td><td>TBD</td><td>TBD</td></tr>
</table>
</td><td></td></tr>
<tr><td>16. Sensing-related capabilities</td><td>Detection Probability
Horizontal/Vertical Localization Accuracy
Velocity Accuracy
[Sensing Resolution]</td><td></td></tr>
</table>

<table>
<tr><th>Proposed TPR items</th><th>Proposed requirement values</th><th>IMT-2020 (5G) Target values</th></tr>
<tr><td>17. AI-related capabilities</td><td>Qualitative TPR</td><td></td></tr>
<tr><td>18. Joint/composite requirement</td><td>
<table>
<tr><th>[Test environment]</th><th>Data rate (Mbit/s)</th><th>Latency (ms)</th><th>Packet success probability</th><th>Number of users (TRxP)</th></tr>
<tr><td>Dense Urban - Immersive Communication</td><td>DL = 30 Mbps /UL=10 Mbps</td><td>DL=10 ms / UL =30 ms (or DL +UL total 40 ms)</td><td>99%</td><td>6</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>19. Resilience</td><td>TBD</td><td></td></tr>
</table>

Deployment scenarios

- Indoor hotspot
- Dense urban
- Rural
- Urban macro
- Sub-Urban macro
- High speed
- Extreme long distance coverage in low density area
- Urban coverage for massive connection
- Air-to-Ground Scenario
- Non-Terrestrial Network
- [Urban grid]
- [Highway Scenario]
- XXXX

03. Study on 6G Radio

- New WG-level Study Item for 6G was approved in RAN#108 (June/2025)
  - Study on 6G Radio, NTT DOCOMO, China Mobile, AT&T, Vodafone (SID: RP-251881 → RP-252912)
- Justification
  - The 6G Radio Access Technology study aims to make a transformative leap beyond 5G by addressing future demands with a simplified, flexible, and backward-compatibility-free system design.
  - The study seeks a unified and flexible 6G design that enhances user experience and system performance while reducing complexity, cost, and energy use across diverse services and devices.
  - 6G architecture aims to meet evolving service demands by minimizing complexity and legacy constraints, ensuring cost-effective, high-performance deployment across consumer and industrial sectors.
  - The 6G Radio Access Technology study lays the groundwork for next-generation wireless systems by addressing future use cases and deployment challenges, forming the foundation for communication in the coming decade.

Objective

- The study aims to develop one non-backward compatible radio access technology (hereafter "6GR") to meet a broad range of use cases, and requirements as defined during the RAN requirements study [TR38.914].
- The study should strive at dimensioning an appropriate set of functionalities, minimizing the adoption of multiple options for the same functionality, focusing on practical user experience. The study should identify principles to ensure extensibility and deliver superior performance.
- From a technology perspective, the study will address frequency ranges up to 52.6GHz, including at least the full range of FR1 (up to 7.125GHz), the range between FR1 and FR2-1 (including around ~7GHz), and FR2-1 (24.25 GHz – 52.6GHz).
- NOTE: Frequency ranges beyond 52.6 GHz are not in scope of the work.

Objective (Cont'd)

1) Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
   a. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
   b. Energy efficiency and energy saving: both for network and device.
   c. Enhanced spectral efficiency.
   d. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
   e. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
   f. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
   g. Target scalable and forward compatible design for diverse device types.
   h. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
   i. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
   j. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
   k. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

   Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion.

Objective (Cont'd)

2) Physical Layer structure for 6GR,

a. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
b. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
c. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
d. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
e. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
f. MIMO operation [RAN1, RAN4]
g. Duplexing [RAN1, RAN4]
h. Initial access [RAN1, RAN2, RAN4]
    - Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
    - Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
i. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
j. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
k. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
    - RAN4 can be involved, if necessary, based on the LS from RAN1

Objective (Cont'd)

3) Radio interface protocol architecture and procedures for 6GR [RAN2, RAN1, RAN4, RAN3],
   a. User Plane architecture and protocol design [RAN2]
   b. Control Plane architecture (including RRC states) and protocol design [RAN2, RAN3]
   c. Access stratum security aspects, in alignment with requirements from SA3 [RAN2]
   d. Radio signalling framework for UE capabilities, aiming at improvements and simplification compared to 5G NR [RAN2, RAN1, RAN4]
   e. Data transfer design to support various types of data (e.g. AI/ML, Sensing, etc) [RAN2, RAN3]

4) Mobility for 6GR (for all RRC states), including related RRM [RAN2, RAN1, RAN4, RAN3]

Objective (Cont'd)

5) 6GR core and performance requirements

a. General RF aspects [RAN4]
   - Intra-3GPP co-existence studies
   - Study RF related system parameters and requirements

b. BS RF requirement aspects including band [RAN4]
   - BS RF requirement and testing framework aiming at improvements and/or simplification compared to 5G NR, including MSR and AAS operation
   - Study how to improve 6G BS core, conformance specifications, including structure and drafting principles

c. UE RF requirement aspects including band and band combination [RAN4]
   - UE RF requirement framework aiming at improvements and/or simplification compared to 5G NR
   - Study how to improve 6G UE RF specification(s), including structure, drafting principles, and database for band combination
   - Study UE RF capabilities considering different device types and implementations

Objective (Cont'd)

5) 6GR core and performance requirements (Cont'd)

d. RRM aspects for 6GR [RAN4, RAN1, RAN2]
- RRM requirement and procedure aspects aiming at improvements and/or simplification compared to 5G NR
- Study how to improve 6G requirement specification, including structure and drafting principles

e. Demodulation and performance aspects [RAN4]
- Demodulation and performance requirement framework and key assumptions, aiming at improvements and/or simplification compared to 5G NR for UE and BS
- Study how to improve 6G demodulation and performance specifications, including structure and drafting principles for UE and BS

f. Aspects related to the testability [RAN4]
- Testability methodology framework and key assumptions, aiming to ensure that requirements can be properly tested considering the applicability and feasibility of conductive and/or OTA testing with reasonable complexity

g. Other aspects
- Handling irregular channel bandwidths including the definition [RAN4, RAN1]
- Definition of 'frequency range(s)'[RAN4]

Objective (Cont'd)

6) Radio Access Network architecture, interface protocols and procedures considering support of various services and functionalities (e.g. AI/ML, sensing, etc). [RAN3, RAN2]
   a. Overall RAN architecture aspects [RAN3, RAN2]
   b. RAN-CN functional split, interface, protocol stack and procedures [RAN3]
   c. RAN internal functional split, interfaces, protocol stacks and procedures, [RAN3, RAN2]

7) Migration from 5G NR to 6GR as well as interworking and mobility between 5G NR and 6GR:
   a. 5G-6G Multi-RAT Spectrum Sharing for migration [RAN1, RAN2, RAN4, RAN3]
   b. Study if any additional migration option(s) is needed (other than standalone, MRSS, and inter-RAT mobility between NR-6G). [RAN] [RAN2, RAN1, RAN3, RAN4]
      RAN plenary starts this study in March 2026 and will make a decision by September 2026 whether to expand WG SI scope to cover additional migration option(s).
   c. Mobility between 5G NR and 6GR [RAN2, RAN3, RAN4]

   Note: Inclusion of LTE/6G interworking/coexistence aspects may be further discussed based on the requirement from RAN plenary

Objective (Cont'd)

8) AI/ML for 6GR and Radio Access Network, leveraging 5G AI/ML framework, as appropriate [See TR38.843] [RAN1, RAN2, RAN3, RAN4]

   a. Identify Use Case(s) of interest (either existing or new) with compelling trade-off between e.g., performance, complexity, etc...

      Coordinated discussion needs to be ensured with related design areas, where needed (e.g., MIMO, Mobility, etc...)

      NOTE: lead WG depends on the use case.

   b. AI/ML framework: Extensible AI/ML enablers based on the identified Use Case(s), including
      - LCM procedures [RAN2, RAN1, RAN3, RAN4]
      - Data collection and data management, in coordination with SA WGs [RAN2, RAN3, RAN1]

Note: NW for AI is assumed to be covered by new services

6GR and RAN design shall ensure that the 6G System can also operate without AI/ML

Objective (Cont'd)

9) Sensing – Studies to be based on use cases and associated requirements, as defined in [TR38.914]
   a. PHY functions and procedures for sensing technology (e.g., waveform. reference signals, measurement feedback, etc…) [RAN1, RAN4]
   b. Evaluate sensing performance and if necessary, extend channel modelling, for the selected use cases [RAN1]
   c. Aspects of integration with communication services [RAN1]
   d. Higher layer procedures and protocol aspects [RAN2]
   e. RAN4 aspects of sensing including RF, coexistence, and testability in coordination with other WGs [RAN4]

Note: RAN1 identify detailed requirements, if triggered by TSG RAN

Interim Milestone

- Interim results shall be delivered as per the milestones below, in coordination with the RAN Plenary 6G Study

TSG#112 (June/2026):

- RAN1 to provide interim assessment on the following areas:
  - Waveform, modulation, channel coding: scope of enhancements beyond NR baseline ((2) a, c)
  - Channel bandwidth (min and max), frame structure, numerology ((2) b, d)
  - Basic sync signal structure and associated periodicity(ies) ((2) h)
- For objectives where RAN4 may be impacted, RAN1 shall coordinate with RAN4 early to enable the above assessment.
- RAN3 to provide interim study results to allow TSGs to make a decision on:
  - RAN-CN interface: P2P vs SBI
  - RAN internal interfaces: CU-DU split, CP-UP split.
- NOTE: It is planned to decide on Release-21 timeline in June/2026.

TSG#113 (September/2026):

- RAN plenary to make a decision on additional migration option(s) (other than standalone, MRSS, and inter-RAT mobility between NR-6G). This includes decision on additional 6G-6G aggregation beyond 6G CA: 6G-6G DC. RAN plenary will task relevant RAN WGs for any specific technical analysis, as needed.

RAN1 Agenda Items & Work Plan for Rel-20 6GR Study

We are here!

Interim RAN#112

	2025			2026						2027
	Aug	Oct	Nov	Feb	Apr	May	Aug	Oct	Nov	Feb
TU	8	10	10	12	14	14	16	16	16	16
Overview of 6GR air interface				Distributed to related agendas						
Evaluation assumptions for 6GR air interface										
Waveform							Remaining details per interim assessment			
Frame structure							Remaining details per interim assessment			
Channel coding							Remaining details per interim assessment			
Modulation, joint channel coding and modulation							Remaining details per interim assessment			
Energy efficiency						Distributed to related agendas				
AI/ML						Distributed to related agendas				
Initial access							Details per interim assessment			
MIMO										
Physical layer control, data scheduling, HARQ										
Duplexing										
6GR spectrum utilization and aggregation										
NTN										
Other physical layer signals, channels, procedures										
Sensing										
Performance evaluation										

- Work plan
  - High level design of 6GR air interface

2025			2026						2027
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			Distributed to related agendas						

- Scope
  - Scalable 6GR design
    - Diverse device types
  - Minimum bandwidth
    - Minimum spectrum allocation & smallest maximum supported UE BW
  - MRSS
  - Sync signal structure ~~and periodicity~~
  - Overall coverage
  - Operation of bandwidth/band adaptation
  - Spectrum utilization and aggregation framework
  - Harmonization of TN and NTN

Scalable 6GR design

- Study a scalable 6GR design for diverse device types, considering aspects:
  - What should be commonly applicable to all 6G device types
- The device type(s) will be decided by RAN Plenary

Bandwidth

- Design considerations for smallest maximum UE BW for at least one low-tier device type
- Case where minimum spectrum and smallest maximum UE BW can't match
- The minimum spectrum allocation and smallest maximum supported UE BW will be decided by RAN Plenary

Duplex operation

- Study and identify the lessons learned from NR duplex modes
- On 6GR duplexing study, RAN1 considers at least following duplex types
  - FD-FDD, Semi-static TDD, gNB semi-static SBFD, HD-FDD on UE side, Dynamic TDD
- Study whether to consider following duplexing types
  - gNB dynamic SBFD, UE SBFD, gNB FD

- **MRSS**
  - Identify the high-level aspects which impact on the NR-6GR MRSS support
    - Including the lessons learned from LTE-NR DSS
  - Discussion on radio resource utilization for NR-6GR MRSS support
- **Basic sync signal structure**
  - High-level aspects to consider for the 6GR sync signal structure include, but not limited to
    - Sync raster design, Spectrum allocation, Smallest maximum supported RF and BB UE BW without spectrum aggregation, Mobile broadband service requirements as high priority, Energy efficiency for both BS and UE, Detection/tracking performance, latency, and complexity, Including initial cell search, Coverage target, Common design for diverse device types, Consideration of the supported deployment, Consideration on whether the single sync signal structure is sufficient
    - Note: Aspects impacting on the periodicity is to be discussed under Energy Efficiency agenda
- **Coverage**
  - RAN1 provides methodology and corresponding initial analysis of potentially achievable coverage to RAN#110 to determine the coverage target(s)
  - The coverage target(s) will be determined by RAN Plenary

- **BWP framework**
  - Study and identify the lessons learned from NR BWP framework
- **Spectrum utilization and aggregation framework**
  - Study and identify the lessons learned from NR spectrum utilization and aggregation framework
- **NTN**
  - Aspects to consider for supporting NTN include, but not limited to
    - Initial access, including cell search and SSB periodicity
    - Coverage
    - Duplexing
    - Capacity
    - Signalling overhead
    - GNSS-less/resilient/based operation
    - Large/varying doppler and propagation delay
    - Beamforming / beam management / beam hopping

Work plan

- Identify candidate technologies for NW power saving, UE power saving, and joint NW and UE power saving
- Target to categorize proposals by RAN1#123
  - From RAN1#124, proposals will be distributed to respective related agenda

2025			2026						2027
Aug	Oct	Nov	Feb	Apr	May	Aug	Oct	Nov	Feb
			Distributed to related agendas						

Scope

- Evaluation methodology and assumptions
- Cell-specific power saving designs
  - SSB periodicity, SIB-1 enhancements, PRACH, paging, cell DTX/DRX, multi-carrier and CA, etc.
- UE-specific power saving designs
  - UE DRX, wake-up mechanism, PDCCH monitoring and adaptation, RRM/RLM/BFD, BW adaptation, energy efficient MIMO, etc.

- **Evaluation**
  - Metrics and Evaluation methodology for 6G energy efficiency evaluation (analysis, LLS, SLS)
  - BS and UE power model
    - Reuse/update of existing model, power scaling rule, introduction of around 7 GHz
- **Increasing SSB periodicity**
  - Study and evaluate NW energy savings and the impact on UE performance and user experience with respect to 20ms and longer periodicities of sync signal(s) at least for initial access
- **On-demand SSB**
  - Study and evaluate on-demand sync signal(s) mechanisms for 6GR energy efficiency
- **On-demand SIB1**
  - Study and evaluate on-demand and/or periodic SIB-1 transmission
- **Low-power WUS**
  - Study and evaluate DL WUS of OFDM based sequence and corresponding mechanisms
- **Multi-carrier and CA**
  - Study and evaluate multi-carrier/cells/TRPs mechanisms for 6GR NES

Work plan

- Collect AI/ML use cases in all potential components in physical layer design
- Target to select some use cases by RAN1#123
  - From RAN1#124, selected use cases will be distributed to respective related agenda

2025			2026						2027
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			Distributed to related agendas						

Scope

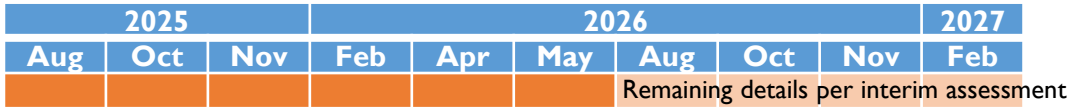
- Use cases
  - CSI prediction and CSI-RS overhead reduction
  - DMRS design with AI receiver
  - CSI compression and feedback
  - Beam management and extension
  - (De-)Modulation, DPD handling, TPMI, SRS, PAPR reduction, HARQ-ACK, …
- Framework and evaluation
  - Evaluation and KPIs, LCM framework, data collection framework

AI/ML use cases

- For 6GR AI/ML use cases identification/categorization
  - Collect preliminary simulation results and analysis
  - Collect evaluation assumptions and initial analysis
- Proposed Use cases
  - Low overhead CSI-RS or CSI prediction [24 sources]
  - Low overhead DMRS with AI/ML receiver [23 sources]
  - CSI compression and feedback [13 sources]
  - AI/ML for beam management and extension [13 sources]
  - (De)modulation [5 sources]
  - AI-based none-linearity handling at transmitter or receiver [5 sources]
  - Low overhead SRS with AI/ML [4 sources]
  - AI-enabled UL precoder indication [3 sources]
  - AI/ML based waveform for PAPR reduction [3 sources]
  - AI/ML based HARQ-ACK feedback [2 sources]
  - Improved scheduling/HARQ for token traffic [2 sources]
  - Etc.

Work plan

- Identify candidate waveform for improving spectrum efficiency, power efficiency, coexistence and coverage
- Decide the scope of waveform enhancements beyond NR baseline to provide interim assessment



Scope

- Baseline waveform for DL for communication
- Baseline waveform for UL for communication
- DFT-s-OFDM for DL
- Other waveforms
- Low-PAPR for DFT-s-OFDM and CP-OFDM
- DFT-s-OFDM with Rank > 1 for UL

DL waveform

- CP-OFDM waveform as defined in 5G NR is supported as the basis for 6GR for downlink
  - Study enhancements/modifications on CP-OFDM as potential additions
  - Study DFT-s-OFDM or any other OFDM-based waveform as a potential additional waveform for downlink

UL waveform

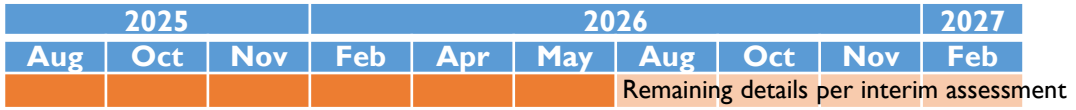
- CP-OFDM and DFT-s-OFDM waveforms as defined in 5G NR are supported as the basis for 6GR for uplink
  - Study enhancements/modifications on CP-OFDM/DFT-s-OFDM as potential additions
- For uplink low-PAPR proposals, link level performance evaluation criterion
  - Net Gain [dB] = Tx power gain – SNR degradation @10% BLER
- Study the evaluation method for evaluating DFT-s-OFDM for UL with number of layers > 1

Other waveforms

- List of candidate proposals for new waveforms
  - AFDM, DFT-s-OFDM GMSK, eDFT-s-OFDM (DFT-s-OFDM with enhanced time domain resource multiplexing in symbol-level), GFB-OFDM, OFDM-OOK (for low end devices), OSDM, Interlace OFDM, Single carrier TDMA (for NTN), SP-DFT-s-OFDM (for UL), SP-OFDM (for DL and UL), Spread OFDM, Zak-OTFS, OTFDM

Work plan

- Identify candidate numerology and frame structure (for all duplex types), as well as compatibility with 5G NR to allow for efficient 5G-6G MRSS
- Decide the numerology and frame structure (for all duplex types) to provide interim assessment



Scope

- Numerology
  - SCS, bandwidth, and FFT size
- Frame structure
  - Including dynamic TDD, and BS-side semi-static SBFD
- NTN-related
- ISAC-related

Numerology

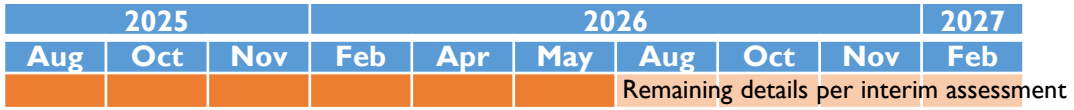
- 6GR takes the following SCS as start point for discussion for all signals/channels except PRACH
  - Sub 6GHz: support at least 15kHz for FDD, 30kHz for TDD
    - FFS: 30kHz SCS for FDD for around e.g., 1-2.5GHz; FFS: 7.5kHz SCS for sub1GHz (FDD)
  - Around 7GHz: support 30kHz
    - RAN1 assumes 400MHz maximum channel bandwidth at network side and 30kHz SCS around 7GHz
  - FFS: Around 15GHz, study 30kHz, 60kHz, 120kHz
  - Between 24.25GHz - 52.6GHz: support 120kHz
- 6GR supports normal CP, i.e., same as the normal CP defined in NR (FFS: other CP)
- 6GR study assumes same SCS btw 6GR sync signals and other channels/signals (except PRACH) for a given band (FFS: for FR2-1)
  - Note: ISAC is separately discussed in ISAC session

Frame structure

- For communication, 6GR considers NR frame structure used as a starting point
  - Same as NR for Resource element (RE), Resource block (RB), Radio frame, Subframe, Slot, Symbol duration, normal CP length, symbol boundary

Work plan

- Identify candidate channel coding
- Decide the scope of channel coding enhancements beyond NR baseline to provide interim assessment



Scope

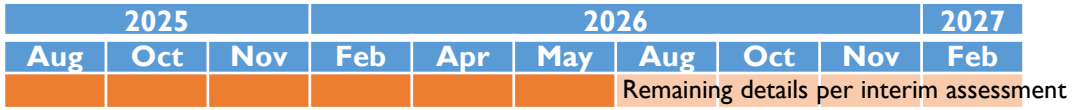
- Data channel coding
  - Motivation
  - Data channel coding scheme
  - Data channel coding chain
- Control channel coding
  - Motivation
  - Code construction
- Evaluation methodology

Channel coding

- For 6G channel coding, LDPC is used for data (including SIBs) and Polar code is used for L1 control information (larger than 11 bits, including PBCH)
- For 6G LDPC code:
  - Working assumption: For data rate within NR range, reuse of NR LDPC design is supported
  - For data rate beyond NR range, study LDPC extension with acceptable performance-complexity tradeoff for both NW side and UE side
    - Note: Applicability of the potential LDPC extension to data rate within NR range will be further discussed
- For 6G Polar code:
  - Working assumption: For control information within NR range (larger than 11 bits), reuse of NR Polar code design is supported
  - For control information beyond NR range, study Polar code extension with acceptable performance-complexity tradeoff for both NW side and UE side
    - Note: Necessity for control information beyond NR range is to be further discussed

Work plan

- Identify candidate modulation, including joint channel coding and modulation
- Decide the scope of modulation enhancements beyond NR baseline to provide interim assessment



Scope

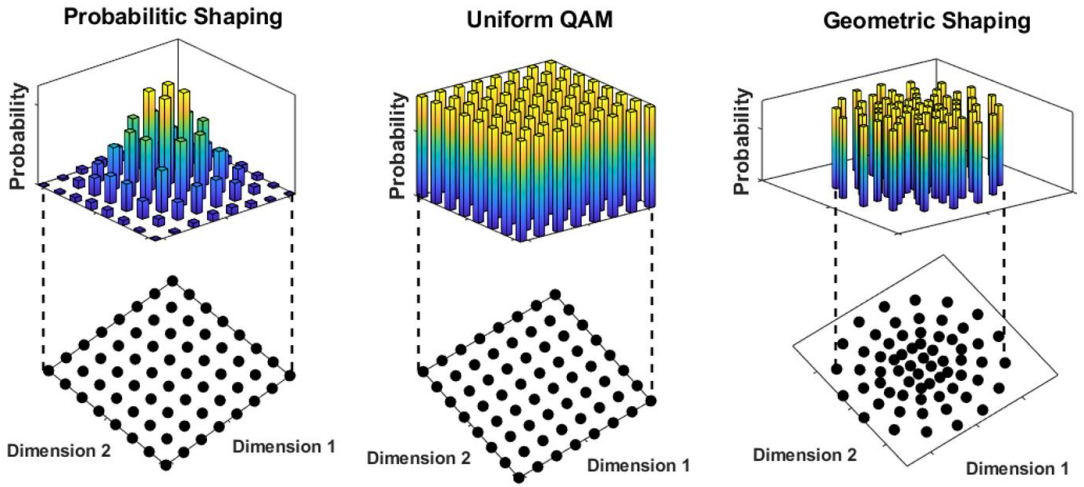
- Uniform QAM constellations
  - Including support of 4096QAM for DL and 1024QAM for UL
- MCS table enhancements
- Constellation shaping
- New modulation for PAPR reduction
  - Interpolated pi/2-BPSK, Offset-QPSK, and rotated-QPSK
- Joint channel coding and modulation

Uniform QAM constellation

- For 6GR DL, 5G NR uniform QPSK, 16QAM, 64QAM, 256QAM and 1024QAM are supported as basis for study for data channel
- For 6GR UL, 5G NR uniform QPSK, 16QAM, 64QAM, and 256QAM are supported as basis for study for CP-OFDM for data channel
- For 6GR UL, 5G NR pi/2 BPSK, uniform QPSK, 16QAM, 64QAM, and 256QAM are supported as basis for study for DFT-s-OFDM for data channel
- Study uniform 4096QAM for DL and uniform 1024QAM for UL

Constellation shaping

- For 6GR constellation shaping study,
  - Probabilistic shaping for CP-OFDM and DFT-s-OFDM
  - Geometric shaping for CP-OFDM and DFT-s-OFDM



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