Views on 6G RAN WG SI

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This document provides general aspects to be considered for the definition of the scope of RAN 6G studies. In addition, we provide a set of topics (concrete elements and keywords) that in our view muss be part of the studies.

The intention is to indicate these are our priorities and to express our support to the topics listed herein.

Table of Contents

1 **General Aspects**

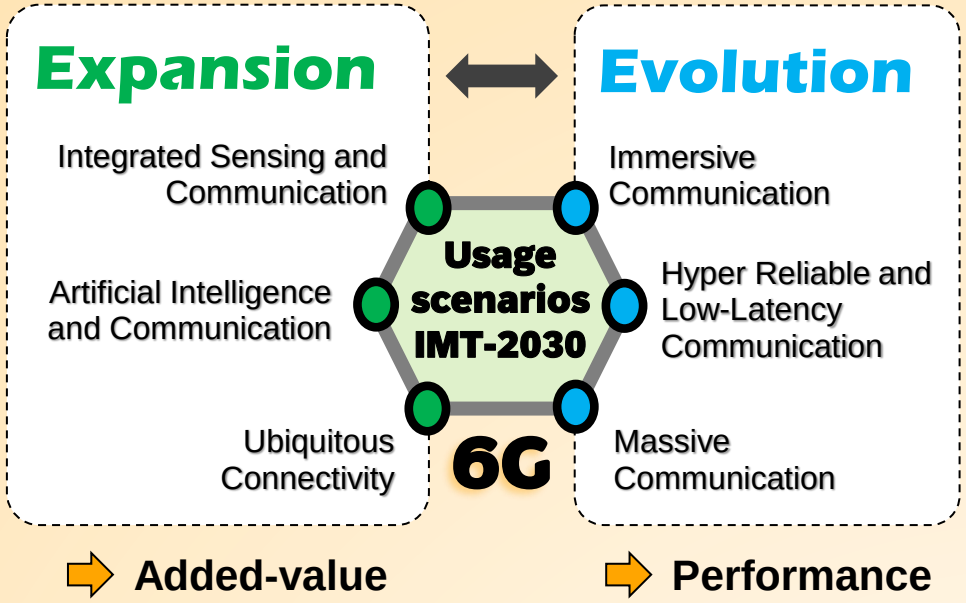
2 **Vision, Priorities, and Added-value aspects for 6G RAN**

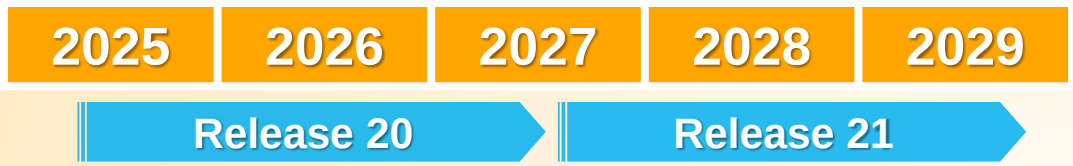
3 **Final Remarks and Proposals**

IMT-2030 and 6G Timeline in 3GPP

- **IMT-2030** has defined a set of 6 usage Scenarios for 6G. They can be regarded as follows:
  - ***Evolutions*** of the originally-defined 5G use cases: eMBB, URLLC, and mMTTC.
  - ***Expansions*** of later additions made during 5G timeframe: ISAC, AI/ML, and NTN.

- Currently, RAN faces the important task of completing the **scope definition** for the 6G studies, which will eventually shape how 6G would look like (and for what it could in-reality be used).
  - For automotive, a smooth transition to 6G is foreseeable (at some point after first specification is released) as the deployment/adoption of 5G is ongoing now; with the expectation that 6G will provide **clear and substantial enhancements and benefits** (business opportunities).
  - Thus, 6G should not be perceived as an alternative to 5G now, but as a **necessary/potential complement** later on.





What do we expect from 6G?

In general terms, successful adoption of 6G will depend on providing clear and substantial improvements in the aspects indicated here. Those enclose most of the key drivers for 6G development.

Performance

- Verticals and costumer KPIs and requirements.
- For all usage scenarios.

Business Opportunities

- Unprecedented user experience and value for customers (use cases).

Cost/Complexity

- Reduction by introducing higher level of Modularity and more specialization for verticals, e.g., different UE-types.
  - Simple: *Less is more*.
  - Allow people to pay for what they need only.

Sustainability

- Industry responsibility: environment and society.
- Lifecycles: production, operation, disposal.

Security and Trustworthiness

- Functional safety type-of concepts should/could be considered/discussed.

Interoperability

- At least some forms of interoperability or coexistence with 5G, e.g., for V2X, are needed.
- While we support not-having so many deployment options, few basic configurations would provide an appropriate *flexibility* in Day-1.

What's on beyond-2030 horizon?

An Automotive Perspective

Five Important Goals

Scope selection in RAN's 6G studies must consider guaranteeing support of these objectives.

It's all about data

- Collection
- Storage
- Sharing
- Processing

- **Inmersiveness**
- **Secure, trustworthy, and reliable V2X communication, including high mobility scenarios**
- **Digital Twins and Cooperative Environment perception**
- **Coverage for off-road scenarios and industries**
- **Autonomous and tele-operated driving**

1 General Aspects

2 **Vision, Priorities, and Added-value aspects for 6G RAN**

3 Final Remarks and Proposals

Spectrum

400 MHz – 7 GHz	7 GHz – 24 GHz	24 GHz – 52.6 GHz	52.6 GHz – 71 GHz	71 GHz –
FR1	FR3	FR2-1	FR2-2	Above 71 GHz and sub-THz

- **6G should consider <u>all</u> frequency ranges**. They are all important (and have some pros and cons) from different points of view. In addition, there are important region-specific aspects.
  - FR1:
    - ☑ Essential long-range layer and important for IoT.
    - ☒ Spectrum availability leading to capacity limitations.
  - FR2: Peak data rates in (outdoor and indoor) hotspots.
    - ☑ Peak data rates in (outdoors and indoor) hotspots.
    - ☑ Good resolution for sensing applications.
    - ☑ Additional unlicensed and ITS spectrum.
    - ☒ Outdoor-to-indoor. Consider lessons learnt from 5G.
  - FR3:
    - ☑ Capacity expansion. Spatial diversity and MIMO layers.
    - ☒ Regional availability, e.g., Japan. Coexistence with incumbents must be considered.
  - Sub-THz:
    - ☐ At least the frequency range 100-275 GHz can be considered for 6G studies [1-3].
- Spectrum aggregation schemes (CA and/or DC) should consider cost and implementation complexity aspects, which could be vertical-specific.

[1] ITU Radio Regulations. Vol 1, Articles. Geneva 2020.
[2] ETSI GR THz 001: TeraHertz modeling (THz); Identification of use cases for THz communication systems, 2024.
[3] ETSI GR THz 002: TeraHertz technology (THz); Identification of frequency bands of interest for THz communication systems, 2024.

Physical Layer

Waveforms

- In our view, it is clear that 5G NR waveforms (CP-OFDM + DFT-s-OFDM) should be supported in 6G, as baseline. Merits and limitations are well-known from experience. Backward compatibility would be facilitated.
- However, we are also supportive to study **other waveforms** in the 6G studies. There is strong evidence of their merit and feasibility. Criteria for selection should include performance (e.g., spectral efficiency, PAPR, etc.), complexity, *fitting* to other services and **multi-functionality** (e.g., sensing/ISAC), high mobility conditions, multiple-access schemes, etc.

Modulations

- 5G modulation schemes can be used as baseline.
- We support including **new modulation schemes** as part of 6G studies. Potential techniques and enhancements, with significant well-demonstrated benefits, for certain scenarios/applications including AI-based modulation, index modulation, non-uniform constellations, adaptive modulations, joint channel coding and modulation, etc.

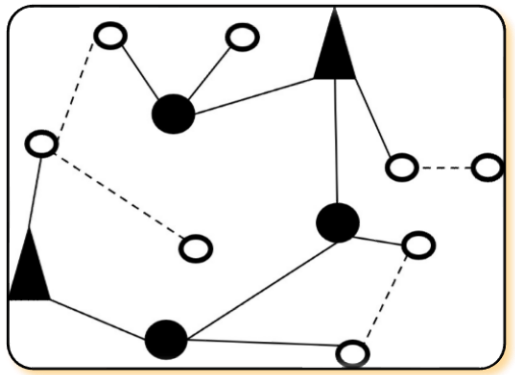
Duplexing schemes

- 6G should flexibly provide several duplex schemes, including conventional TDD; FDD, and newer modes, such as sub-band full-duplex (SBFD), in-band full duplex (IBFD), dynamic duplexing, and full-duplex.
- The relevance and compatibility of these techniques with several features, such as ISAC and Reconfigurable Electromagnetic Structures (REMS), e.g., Reflexive Intelligent Surfaces (RIS), is also known.

Artificial Intelligence and Machine Learning (AI/ML)

- AI/ML framework was introduced few releases after baseline specifications of 5G were made. We consider that despite of the several difficulties found, it was a right decision to align among companies and gain common understanding and experience. The motivation was to leverage AI/ML to improve certain features, such as beam management, positioning, and CSI.
- **AI/ML must be a day-1 design consideration for 6G**, i.e., AI/ML should be a native feature. Both paradigms, AI for Network (AI4NET) and Network for AI (NET4AI) shall be supported in 6G, and hence, included and discussed in 6G studies.
  - Suggested focus: latency and processing requirements and schemes for integration of (distributed) computing resources.

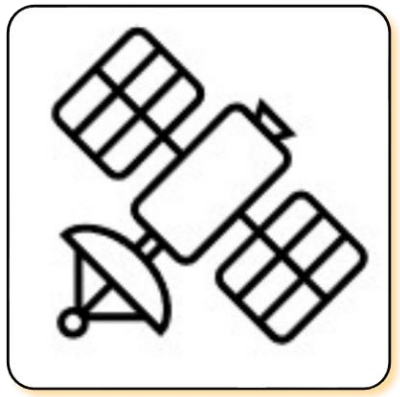
Network Elements, Topology, and Interfaces



- **Sidelink**: direct communications (e.g., ad-hoc communications) is an essential paradigm in wireless communications, and particularly important for V2X.
  - While there is no critical commercial need to have sidelink in Day-1 of 6G, our preference is to **include it as part of the 6G studies** to identify potential challenges, technology components, features and confirm evaluation scenarios/assumptions.
  - For 6G, basic functionalities that can be provided over sidelink could include communication, relaying, positioning, and (UE-based) sensing.
  - Finally, due to its nature and practical relevance for V2X, enhancements to facilitate the adoption and deployment of smart/connected infrastructure, e.g., Road-side Units (RSU) should also be identified and discussed.

- Other aspects whose inclusion in 6G (perhaps not in Day-1) could be discussed in the studies include relaying/repeaters (including sidelink-based), integrated access and backhauling, aerials/HAPS, cell-free, UE-centric-cells, moving-cells, etc.

Non-Terrestrial Networks



- Support of Non-Terrestrial Networks (NTN) has been developed for 5G NR. The relevance and momentum of NTN is currently, and in the 6G era, out-of-question. This is true for the automotive industry as well.
- In our view, NTN is an essential part of the discussions in the 6G studies, and hence, appropriate design considerations to guarantee the best possible integration and interworking between terrestrial and non-terrestrial components, including spectrum, **should be addressed in Day-1**.

Other Relevant Aspects (1/2)

Last and listed below, but, **<u>definitely</u> not least** …

… a set of topics we fully support to be included as part of the scope of 6G studies:

- Advanced/cooperative **positioning**, including **rigid body localization** (RBL). Solutions should comprise network-based, UE-based, and hybrid schemes.
- Strategy principles for **6G device types**. For automotive, this is particularly important when considering TN and NTN components. Number and characteristics of antennas is also relevant.
- **Trustworthiness** in 6G system. Taking into consideration the set of critical applications that will be supported by 6G, including inmersiveness, autonomous vehicles and safety, digital twins, etc., it is of utmost important that 6G guarantees an operation that ensures **privacy, reliability, safety, and resiliency**.
- **ISAC**. As 5G will primarily focus on network-based sensing, we support that Day-1 ISAC scope focuses on **UE-based sensing** (services). It should be discussed whether ISAC functions should enable sensing-assisted communication, communication-assisted sensing, and distributed/AI-assisted sensing. For sensing operations, FR2 is our preference. Finally, full interworking with non-3GPP sensing-data sources should be discussed/considered as well.
- Integration of **computation**, **communication**, and **sensing**. We consider that addition of integrated computing paradigms from Day-1 would enable 6G to become an **end-to-end intelligent system** able to collect, transmit, and process information in the most efficient and effective manner.

Other Relevant Aspects (2/2)

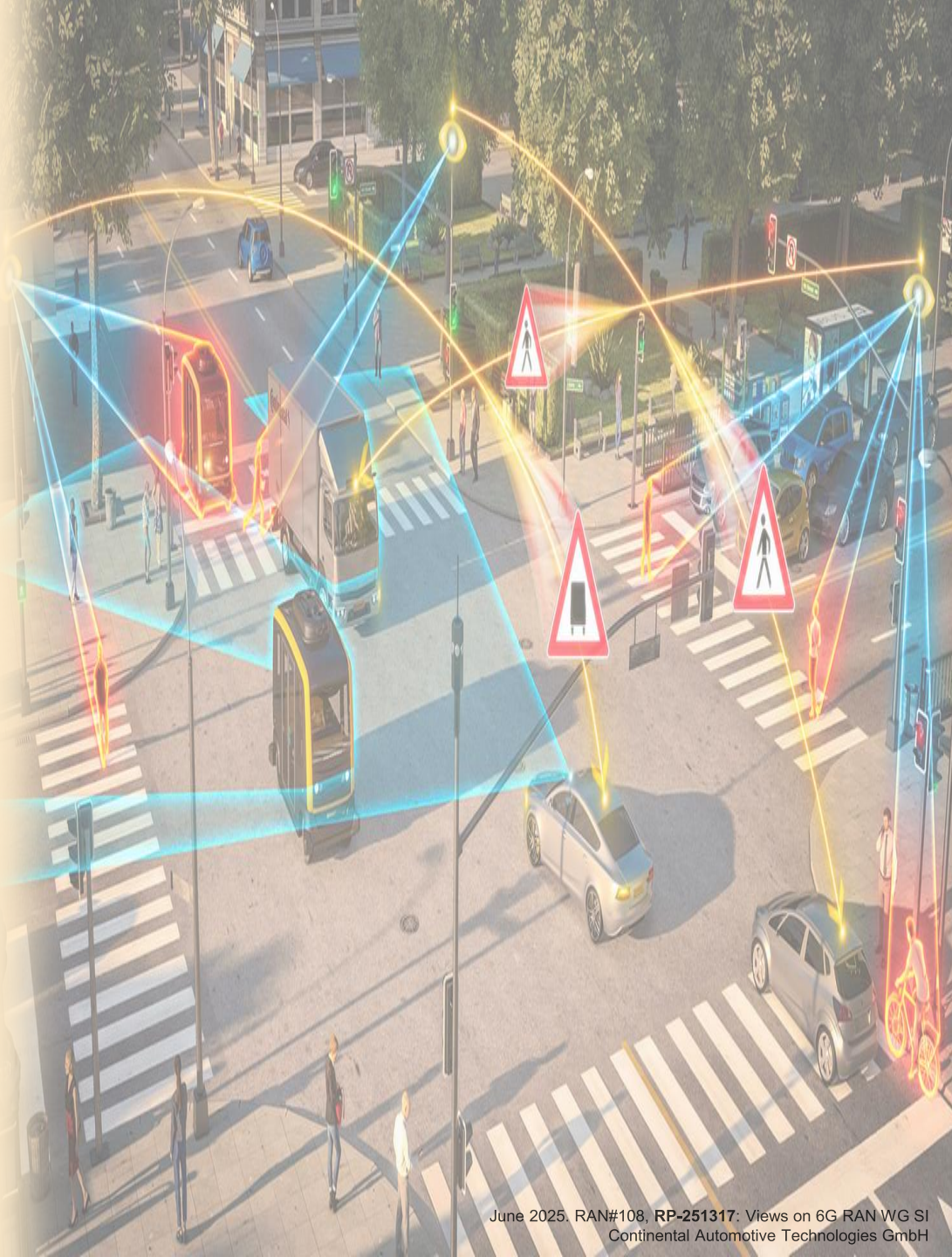
- **REMS/RIS**. Initial focus should be coverage enhancements. Focus: FR2 and FR3, outdoor-to-indoor and outdoors.
- **Multiple Access**. A discussion on the feasibility of enable **orthogonal** (OMA), **non-orthogonal** (NOMA), and other recent multiple access schemes (e.g., Rate splitting multiple access, RSMA) is of utmost importance to be part of 6G studies. Distributed resource allocation, ad-hoc networking, and sub-networking are also of interest.
- Continue development and evolution of **IoT** and **A-IoT** technology within the 6G timeline.
- Introduction of a **Data-Plane**, in addition to user and control plane. Important and beneficial for sensing services and possibly for the overall AI/ML framework.

1 General Aspects

2 Vision, Priorities, and Added-value aspects for 6G RAN

3 **Final Remarks and Proposals**

- **Do not forget**: every new "**G**" is a *particularly good* and somehow unique opportunity to introduce new technology components.
  - Decisions made today will have impact on the adoption and commercialization of 6G systems, and 3GPP technology.
- The automotive sector is, and expects to continue being, **one of the most important users of 3GPP technology**, with significant impact on several aspects of people: mobility, transportation, environmental impact, safety, etc.
  - It is essential to consider circumstances (time scales and product life-cycles), requirements, expectations, and objectives provided by verticals.
- Proposals and recommendations indicated in this document are mainly **automotive-driven**, but are *well-aligned* with several 3GPP requirements for 6G Radio targeting overall **performance**, **user experience**, and **TCO reduction** as indicated in [4].



[4] TSG RAN Meeting 108. RP-250810: Revised SID: Study on 6G Scenarios and requirements. March 2025.

Proposal: Include in the scope of RAN 6G Studies, the topics listed below.

☑ Spectrum: FR1, FR2, FR3, and sub-THz		
☑ Waveforms	☑ Modulations	☑ Duplexing Schemes
☑ Native AI/ML Framework		☑ IoT / A-IoT
☑ Network Elements/Topology/Interfaces		☑ Advanced Positioning
☑ Harmonized 6G Design for TN and NTN		
☑ 6G Device Types	☑ Trustworthiness	☑ ISAC
☑ Integrated Computation (in-network, over-the-air, etc.)		
☑ REMS/RIS		☑ Multiple Access
☑ Data-Plane