ETNO POSITION PAPER ON 6G

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Executive Summary

The European Union has set ambitious Digital Decade targets for 2030, among them the objective to cover all populated areas with wireless high-speed networks of at least 5G performance. Societies increasingly rely on high-speed mobile and broadband connections. We expect Europe's mobile data consumption per user to continue growing in the coming years with an annual growth rate of 25% . Mobile connectivity has a key role to play in attaining digital inclusion for all European citizens and businesses and enabling the twin digital and green transition.

Today, 80% of the European population is covered by 5G . As European telecom operators continue the rollout, the deployment of 5G standalone (5G SA i.e. a network that uses a 5G core network without dependency on LTE Evolved Packet Core) will progressively become a priority. The focus of mobile operators will be to meet the society demands by unfolding the technology's full potential, enabling increased network capacity, network slicing and use of Application Programming Interfaces (APIs), among other things, and showing how operators can develop services and pave the way for innovations of the next decade already today.

This paper looks at the communications technology 6G and assesses its expected benefits on innovation and society. It provides an overview of the state-of-play of 6G research, identifies key values that should drive the development of 6G, associated use cases and suggests ways in which international/EU public policy can contribute to 6G research, design and network deployment. We would however, underscore, from the outset, that Member States should be careful not to push 6G, not to set arbitrary deadlines and not to create a race that is not aligned with technological and market realities.

1. 6G: an overview

Every generation of communications technology comes with its own changes, focus and enabling capabilities. For 2G the primary objective was to allow people to communicate via text message or voice calls; 3G introduced mobile broadband capability; 4G introduced another significant technological shift, enabling high speeds for massive data traffic which enabled improved mobile application access for social networks and high-definition mobile streaming for example. Today, the focus of 5G is about connecting the Internet of Things (IoT) and industrial systems (industry 4.0) based on faster data speeds, lower latency, more capacity, and new features. Moreover, 5G will facilitate revolutionary use cases in the fields of education, healthcare and smart-living, industrial control as well as transportation. However, the full exploitation of advanced technological capabilities of 5G is yet to be unfolded. A precursor to these new services and user experiences will be 5G SA. In 2023, only 10 out of the 114 operational 5G networks in Europe were 5G SA although an acceleration of the deployment is expected depending on the user demands and the financial sustainability of the telecom sector.

The framework and overall objectives for IMT-2030 (i.e. 6G) have been agreed in the end of 2023[1]. Mobile vendors, operators, international and European institutions are now working together on researching and developing solutions for meeting the overall objectives. Consensus is still to be reached for various research topics in different fora.

The understanding is that 6G, as 5G is starting to, will primarily address current societal, economic and environment needs, making sustainability the most important and driving design criterion alongside other metrics such as capacity, data rate, latency, and reliability.

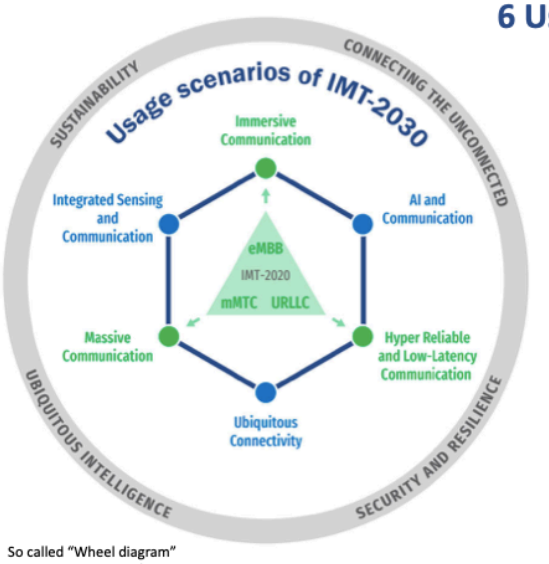
6G is most likely to become a natural evolution of 5G with new technical capabilities and features, that will support new innovative, perhaps very specific, use cases. The exact performance requirements of the next generation mobile communication technology are still being discussed within the community. Regarding the anticipated use cases, the wider transmission bandwidth associated with higher frequency bands are expected to provide substantially higher capacity to enable new areas of application. 6G is likely to be commercially available from 2030.

While it is still premature to discuss eventual use cases, the technological and market developments are expected to allow the merging of experiences across physical, digital and human worlds and to make it possible for users to move freely in the cyber-physical continuum. This would allow society to create new ways to live and work, and usher in novel forms of communication and experiences. On the basis of 6G, applications and services are expected to connect humans, machines with various other devices and systems, allowing for a convergence of connectivity, robotics, cloud and secure and trustworthy commerce. Further to this, it will give rise to immersive virtually generated experiences, intelligent and autonomous machines and continuous human-machine interactions in an increasingly digital world, which extends the real world with the help of advanced sensors and AI.

One of the new features of 6G is expected to be the integration of sensing and AI-related capability in communications, giving rise to new application trends. Sensing is thereby understood as the process of receiving reflections of transmitted signals in the network in order to yield spatial knowledge of the physical surroundings.

[1] Recommendation ITU-R M.2160-0, Framework and overall objectives of the future development of IMT for 2030 and beyond, November 2023.

Usage scenarios



So called "Wheel diagram"
Source: Document 5/131 and edited in SG 5

6 Usage scenarios

Extension from IMT-2020 (5G)

- eMBB → Immersive Communication
- mMTC → Massive Communication
- URLLC → HRLLC (Hyper Reliable & Low-Latency Communication)

New

- Ubiquitous Connectivity
- AI and Communication
- Integrated Sensing and Communication

4 Overarching aspects:

act as design principles commonly applicable to all usage scenarios

Sustainability, Connecting the unconnected,
Ubiquitous intelligence, Security/resilience

The ITU-R framework identified an initial set of six usage scenarios for 6G[1]:

1. Immersive communication to provide a rich and interactive video experience for users.
2. Hyper-reliable and low-latency communication to enable the scale-up of intelligent industrial applications including telemedicine and management of energy and power grids.
3. Enhanced ubiquitous connectivity, especially in rural, remote and sparsely populated areas with the aim of bridging the digital divide.
4. Massive communication to include expanded use of Internet of Things (IoT) devices and applications in smart cities, intelligent transport systems and sectors such as health, agriculture, energy and environmental monitoring.
5. Artificial intelligence (AI) and communications to support AI-powered applications.
6. Integrated multi-dimensional sensing to improve assisted navigation and high-precision positioning including object and presence detection, localization, imaging and mapping.

2. The benefits of 6G and the evolution of networks

European electronic communication networks have started a major technological shift that will be consolidated in the upcoming years. The softwarisation, cloudification and virtualisation of network operations and the establishment of cloud-native and disaggregated network architectures will fundamentally change the functionalities and services of networks. 6G systems, building on the capabilities that are still being introduced by 5G, will play a central role in the evolution of core technologies and other developments, such as AI-as-a-Service (AIaaS), energy efficiency and enabling ubiquitous connectivity coverage. Bringing forward the path that is currently being paved towards 5G SA, it will provide operators with the technological capabilities necessary for offering improved and differentiated services, allowing for the exploration of new market opportunities. Due to the service-

based architecture of 5G, it should additionally be significantly easier to build new 6G functions into the exiting systems.

6G capabilities will further improve the applications of previous mobile generations and build on the integrated service portfolios of network operators, creating an open Network-as-a-Service (NaaS) environment through standardised interfaces. Additionally, it will also introduce new ones by enabling seamless connectivity services for immersive extended technologies combining virtual, augmented and mixed realities, facilitating e.g. high-fidelity mobile holograms and paving the way for a more widespread use of digital twins of real-life objects. The increased convergence to a multi-access network will open new opportunities for service resilience across all types of access networks, and for optimising network operations to enable more affordable coverage.

Adding to that, it will be mandatory for 6G to be significantly more energy-efficient than existing mobile networks, turning off components and scaling down capacity when the demand is lower.

Also, the NetZero commitments taken by most operators by 2040 or 2050 put strong constraints on 6G design and deployment. From this perspective, the environmental impacts of 6G will need to be evaluated over the overall network (including 5G, fixed networks, potentially non-terrestrial networks). As the manufacturing of hardware has a significant impact on the greenhouse gases emissions, 6G deployment by means of software upgrades of cloud-based network infrastructure should be privileged in the compatible deployment scenarios, to save on material. Similarly, terminals flexibility for software upgrades from late 5G versions to 6G should be investigated.

3. Laying the foundation to enable a natural shift necessary for 6G

In order to achieve the 6G ecosystem of the future, it will be crucial to set the right technological, regulatory and market conditions already today. This will require substantial and sustainable investments throughout 6G development, ranging from network research and innovation to the identification of specific 6G uses cases by design. To accomplish this, and ultimately be at the forefront of its progression, it will be necessary to mobilise viable investment and ensure the 6G business case is commercially mature and its operation becomes affordable. This is particularly true as the costs for 6G are to a large extent not yet considered in the current investment needs of telecom operators and the potential of 5G is still to be unfolded.

Moreover, it will be important to build end-to-end intelligent network automation systems thanks to the application of AI and machine learning. These rely heavily on highly programmable connectivity platforms that deliver fully integrated connectivity services. Further efforts are also needed to master network integration and ways to manage complexity, and in order to find alternatives to densification, considering the practical limits of wide-area mobile systems.

As radio spectrum is the lifeblood of mobile communications, preparing the foundation for 6G also means making sure there is spectrum available in a timely manner, matching the expected trends in end user demand. In the long term, increasing capacity in mobile networks in a financially and environmentally sustainable way will require both access to new nationwide/wide-area spectrum bands,

and refarming of existing bands. New bands currently being discussed, such as the upper 6 GHz band, should be made available for terrestrial mobile networks in due time in a technology neutral way - as discussed above, 5G still has large untapped potential, therefore additional spectrum needs should not be exclusively linked to an accelerated development of 6G. Also, spectrum demand requires considering new bands above 1 GHz, beyond what is currently discussed, allowing for widespread deployment, as well as sub-1 GHz spectrum to improve digital equality in less dense areas. Refarming of existing bands is another valuable tool to increase spectral efficiency and link the availability of spectrum for a new technology with trends in end user demand. Dynamic Spectrum Sharing (DSS) is already used to allow the smooth transition between 4G and 5G technologies in same bands. Similar solutions are expected to be available also with 6G.

Finally, it will be necessary to further orchestrate 6G networks with the infrastructure of other parties. These include but are not limited to non-terrestrial high-altitude-platforms or satellite-based services.

4. Institutional work advancing and 6G industrial use cases

a) Research:

Research on 6G has already started since several years and recently more announcements of national, regional, corporate 6G programmes and 6G visions with large investment in 6G research were published. Research activities have also been in place in various EU Member States (AT, CH, CZ, DE, DK, ES, FI, FR, IT, LT, NL, SE) and other European countries. In some countries, various institutions, universities and companies are participating in European research projects such as Hexa-X-II, 6G Flagship, One6G, and MyWave. Many ETNO members are also contributing to various 6G research related projects together with other stakeholders: vendors, governments, academics. Currently, use cases predict major trends in usage scenarios and indicate potential consumption needs and technological requirements. However, all use cases are provisional for the time being.

The EU's research and innovation programmes have for a long time funded studies for the development of connectivity and mobile technologies. Under Horizon 2020, supported activities included the 5G-PPP institutional partnership, programmes on networking/5G under the European Institute of Technology (EIT) and multiple research and innovation projects.

The **Horizon Europe programme 2021-2027**[2] will continue to support mobile technology development "beyond 5G" including 6G. The EC has set-up a Public-Private Partnership the **Smart Networks and Services Joint Undertaking** (SNS JU)[3] in coordination with Member States that funds projects that shape research and innovation (R&I) roadmap and deployment agenda. One of their two missions is "fostering Europe's technology sovereignty in 6G by implementing the related research and innovation (R&I)

[2] Originally, the European Commission proposed to allocate some 86 million euros on Horizon Europe programme in the Multiannual Financial Framework (MFF) for 2021-2027.

[3] HOME - SNS JU (europa.eu)

programme leading to the conception and standardisation starting around 2025. More than 2.5 billion Euro of EU investments were allocated from the EU budget (2021-27) for the Smart Networks and Services initiative, to be matched by at least 7.5 billion Euro of private investments. The partnership began in 2021 and is expected to deliver "in the 2025-2030 range"[4].

Additionally, the SNS JU project brings about economies of scope in 6G definition leveraging multilateral MoUs with peer initiatives in other regions of the world (e.g. USA, China, South Korea, Japan, Taiwan, Brazil, India) while collaborating with other representatives of the mobile value chain to gather synergies and strategic alignment (es. with chipset industry and vertical industries associations).

The EU is increasingly focusing on 6G research, providing financial support to 35 6G projects. They will receive 250 million Euros of funding via the Horizon Europe programme starting from October 2022. Funding is allocated to four different research streams:

- Stream A targets the further development of 5G and focuses on Open RAN- and AI-based edge platforms that will help with the roll-out of 6G.
- Stream B supports entirely novel research projects that will not be commercialised for many years. These aim to produce new architectures for 6G systems and to improve non-terrestrial networks and low-latency communications.
- Stream C is assisting three projects that are developing smart networks and services (SNS) infrastructure that can act as a 6G enabler.
- Stream D will fund experimental SNS deployments throughout Europe that are intended to enable real use cases to be tested in vertical sectors such as healthcare and manufacturing.

An example for an ongoing research project on 6G in which telcos are involved and that is financed through public and private means:

Hexa-X-II project[5]

This EU flagship research programme is led by Ericsson and Nokia together with European operators such as Orange, Telefonica, Telenor and TIM, and other industry players such as Qualcomm. It is co-funded by the European Commission. It is bringing together key players and technical enablers for joint 6G research around intelligence, networks, sustainability, coverage, extreme experience and trustworthiness. It aims at establishing a foundation for an end-to-end system architecture towards 6G, developing and assessing key radio technology components for the next generation and delivering methodology, algorithms, and architectural requirements for an AI-native network, through AI-driven air interface and AI governance.

[4] Secure 5G deployment in the EU - Implementing the EU toolbox, European Commission

[5] https://hexa-x-ii.eu

b) Standardisation:

3rd Generation Partnership Project (3GPP)

3GPP is currently working on Release 18 which is to be completed in June 2024, and is starting development of Release 19. Both of them relate to 5G-Advanced. The upcoming 3GPP Release 19, which is foreseen to be completed in December 2025, will further unlock the 5G-Advanced potential laying the groundwork for 6G.

As the delivery of a new mobile generation is a multi-year process, 3GPP endorsed in December 2023 the following high-level timeline for 6G:

- preliminary studies on use cases are expected to start in Q2 2024 and radio requirements are expected to start in Q1 2025 within the Release 20 framework,
- the 1st set of 3GPP 6G technical specifications will be issued as part of the Release 21, in time to be used for the ITU-R IMT-2030 submission before 2030.

International Telecommunication Union (ITU)

ITU has published the framework for the development of standards and radio interface technologies for 6G in its Recommendation ITU-R M.2160 on the "IMT-2030 Framework" approved by the ITU Radiocommunication Assembly (RA-23) in November 2023. The ITU-Radiocommunication Sector will now focus on defining technical requirements, the submission process, and the evaluation criteria for potential 6G radio interface technologies.

EU-US Trade and Technology Council (TTC)

Following TTC2, the EU and US published a 6G Outlook[6] including “Guiding principles and key themes for a common vision” on 6G.

The transatlantic partners agree on several high-level principles related to standards below:

- 6G standards should be developed in close cooperation with all the stakeholders and especially the private sector in order to avoid standard fragmentation.
- The success of 6G will hinge upon harmonised international standards for mobile networks in order to achieve global economies of scale.
- 6G standards should be set in a transparent manner by standard setting organisations in conformity with relevant WTO principles on trade.
- 6G services proposed will need to be analysed in terms of their alignment with market demands and relevance before engaging into specifying the associated formal requirements in standards.

[6] 6G outlook | Shaping Europe’s digital future (europa.eu), May 2023.

5. A common vision for 6G and policy considerations

a) When designing/developing 6G

1. 6G should, by design, be developed with new monetisable services, also via the Network-as-a-service[7] paradigm, in order to ensure economic sustainability from its earliest inception.

2. It is crucial that it enhances innovation in existing 5G and 5G-Advanced networks to further develop, enable cloudification and Open RAN solutions and facilitate the use of AI in networks. Furthermore, we would recommend that Member States should be careful not to push 6G, not to set arbitrary deadlines and not to create a race that is not aligned with the technological and market realities.

3. The work should build on an industrial policy approach to advanced network technology and the progress already made and ongoing in the telecom sector and the connectivity 5G value chain at large.

    - Keeping the same worldwide process, i.e. in 3GPP in order to grant, as it is now, worldwide scale economy and full standard solutions, without fragmentation in different ITU-R regions for both technology solutions and spectrum allocation.
    - This is also true for policies such as spectrum, for which 5G good practices should be leveraged.[8]
    - An exercise to identify and harmonise spectrum that matches with the expected demands should be analysed **for 6G**. A sufficient amount of spectrum that is suitable also for outdoor and macro deployments should be made available in due time and at fair price consistently with market needs. It is important to carefully look into spectrum-related considerations of 6G given the long spectrum allocation cycles.
    - Furthermore, it will be crucial to ensure 6G standardisation is based on scientific evidence gathering and the experiences of the telecommunications research community.

4. 6G technology should be based on common principles and value/horizontal policy priorities: environmental sustainability, (reduced carbon footprint and energy efficiency, enabler for other sector) privacy, security and resilience.

    - Compelling societal value needs to be at the heart of future technology design. Construction of services and use cases with future users is key to ensure value for them, and thereby to

[7] Network as a Service (NaaS) allows operators to expose network capabilities to 3rd parties in a programmatic manner (through APIs), offering them consumer-like experience with choice, scalability, visibility and control. Linux Foundation and the GSMA have together unveiled a new open source project called CAMARA. GSMA | GSMA Open Gateway - Open Gateway

[8] ETNO's comments on access to 5G radio spectrum related to the EC Recommendation on EU toolbox for reducing the cost of deploying VHCN and ensuring timely and investment-friendly access to 5G radio spectrum, 2021.

increase the industry confidence on the relevance of the technology design and its future return on investment.

- The uncertainty about the future availability of critical material at affordable costs, either due to limited natural resources or geopolitical constraints, calls for a particular attention on the technology choices that may rely on these materials.

5. EC and Member States could develop a 6G strategy together with the industry to facilitate the launch of 6G services across the EU by carefully considering the 6G development and needs, in particular the 6G research linked to use cases, traffic increase and spectrum demand.

6. For that, we need European and international cooperation: TTC, ITU along with an inclusive dialogue between future users, industry stakeholders and regulators.

7. Finally, we believe the time has come to revisit the way our industry communicates with the public about mobile communication technologies. Indeed, while generation changes used to trigger visible change in the user experience for the public, we have seen with 5G that the generations paradigm can generate misunderstandings and false expectations. We think our industry should from now on rather communicate on new capabilities enabling value to end users, which are in fact introduced regularly, instead of a new technology generation every 10 years.

Links to literature research:

- Analysys Mason, State of Digital Communication, January 2024
- Arthur D. Little, The Evolution of Data Growth in Europe, May 2023
- https://digital-strategy.ec.europa.eu/en/library/6g-outlook
- NGMN-6G-Use-Cases-and-Analysis (ngmn.org)
- NGMN POSITION STATEMENT SETTING THE COURSE FOR 6G NETWORKS
- Advancing 6G: A Vision for Transatlantic Collaboration

ETNO (European Telecommunications Network Operators' Association) represents Europe's telecommunications network operators and is the principal policy group for European e-communications network operators. ETNO's primary purpose is to promote a positive policy environment allowing the EU telecommunications sector to deliver best quality services to consumers and businesses.

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