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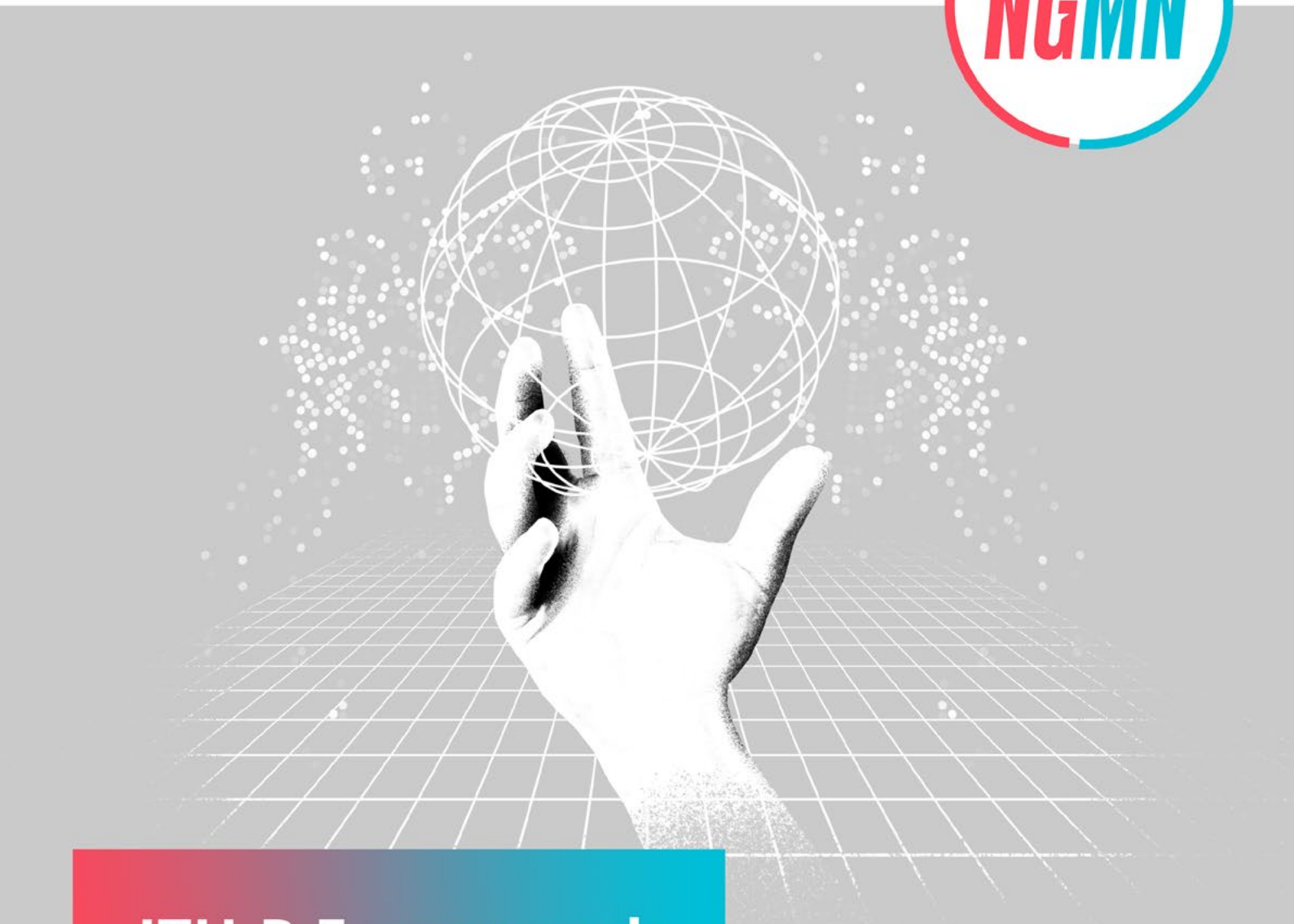

ITU-R Framework for IMT-2030: Review and Future Direction

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v1.0

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ITU-R FRAMEWORK FOR IMT-2030: REVIEW AND FUTURE DIRECTION

by NGMN Alliance

Version:	1.0
Date:	15.02.2024
Document Type:	Final Deliverable (approved)
Confidentiality Class:	P - Public
Project:	6G
Leadership:	Javan Erfanian, Bell Canada Quan Zhao, China Mobile Narothum Saxena, UScellular David Lister, Vodafone
Editor / Submitter:	Javan Erfanian, Bell Canada Jean Schwoerer, Orange
Programme office:	Reg Cox, representing NGMN
Approved by / Date:	NGMN Board, 14 February 2024

EXECUTIVE SUMMARY

The NGMN Alliance (NGMN) welcomes the ITU-R's publication on a "Framework and overall objectives of the future development of IMT for 2030 and beyond". Recognising the international nature of mobile networks and the multi-year endeavour associated with developing technologies to empower and enhance global societies, the ITU-R report sets an important framework for future technology discussions on IMT-2030 and toward 6G.

In this publication, the ITU-R publication is reviewed against existing NGMN published statements. NGMN observes close alignment between the ITU-R and its contributions to ITU-R work on IMT-2030 as well as NGMN's publications that include vision, usage scenarios, and essential capabilities. We particularly highlight the aspects related to practical and sustainable deployment, where further consideration should be given.

NGMN believes IMT-2030 should not compromise existing services, for example voice, existing public safety services. Further national/regional regulatory requirements should be delivered with the launch of IMT-2030. Interworking between IMT-2030 and non-IMT systems will need to be embraced, and standards for mobile networks should be global, reflecting industry consensus. Any new radio interface should demonstrate significant benefits over and above IMT-2020 in key metrics such as spectrum, energy efficiency, and/or cost reduction.

The next stage of the ITU-R process will be the refinement and formal description of IMT-2030 and beyond. Accordingly, NGMN looks forward to providing guidance on aspects that ITU-R may wish to consider in formalising this next stage of work.

CONTENTS

01 INTRODUCTION

The NGMN Alliance Board published their "6G Position Statement, An Operators View"[1] ("6G Position Statement") demonstrating consensus around the principle that 6G will build on, and extend beyond, the existing 5G ecosystem. This further identified that 6G should cultivate new innovations that would focus on addressing customer needs and deliver a simplified network operation.

Meanwhile, the ITU Radiocommunication Assembly (RA-23) published recommendation, ITU-R M.21602, "Framework and overall objectives of the future development of IMT for 2030 and beyond [IMT-2030]"[2].

The purpose of this publication is to assess the IMT-2030 framework against NGMN's "6G Position Statement" and the learnings from previous 6G related NGMN publications [3] including "6G Drivers and Vision", "6G Use Cases and Analysis", "6G Requirements and Design Considerations", and "6G Trustworthiness Considerations".

The major sections of this document reflect the structure of the ITU-R report including Trends (Section 2), Usage Scenarios (Section 3), Capabilities (Section 4), and Considerations of Ongoing Development (Section 5) for IMT-2030.

In the section on Conclusions (Section 6) NGMN identifies the alignment of the IMT-2030 framework with NGMN's "6G Position Statement" and offers recommendations for ongoing work within ITU-R.

1 NGMN Board "6G Position Statement, an Operator View" (09/2023), www.ngmn.org
2 Recommendation ITU-R M.2160-0 (11/2023), www.itu.int
3 Details of all NGMN publications including "6G Drivers and Vision" (2021), "6G Use Cases and Analysis" (2022), "6G Requirements and Design Considerations" (2023), and "6G Trustworthiness Considerations" (2023) available in references.

02 TRENDS OF IMT-2030

The IMT-2030 framework report delineates goals, trends, and opportunities of IMT-2030 from four perspectives: motivation and societal considerations, user and application trends, network technology trends, and spectrum implications.

In a similar manner to the IMT-2030 framework report, NGMN in their "6G Drivers & Vision" publication recognised three fundamental needs facing society at large, and the telecoms industry in specific, namely:

- Societal goals
- Market expectations
- Operational necessities

With this background, the following sections compare where the IMT-2030 framework reflects the NGMN publication "6G Drivers & Vision", and where there are additional insights from NGMN that could contribute to further activities within ITU-R.

2.1 MOTIVATION AND SOCIETAL CONSIDERATIONS

Addressing societal needs, NGMN believes that 6G will contribute to achieving the seven goals outlined in the IMT-2030 framework encompassing inclusivity, ubiquitous connectivity, sustainability, innovation, enhanced security & resilience, standardisation & interoperability, and interworking.

These goals can be distilled into three aspects:

- **Bridging the Digital Divide**: With ubiquitous connectivity, 6G should ensure everyone has access to the wireless service necessary supporting essential services.
- **Sustainable Development**: Envisioned as a green network, 6G should play a pivotal role in reducing carbon emissions, improving energy efficiency, and enhancing social governance efficiency. The IMT-2030 framework also recognises the role of economic and social sustainability.
- **Development of the Digital Economy**: 6G should catalyse the emergence of new immersive applications, usage scenarios, and a pervasive information infrastructure under a secure and resilient framework.

There is good alignment between IMT-2030 and NGMN on societal considerations.

2.2 USER AND APPLICATION TRENDS

Addressing user trends, NGMN note that 5G technologies deliver capabilities for high capacity, throughput, reliability, and low latency, to support the continued journey towards digital transformation and automated industries. A further significant generational step should be associated with enabling novel capabilities, new services, and greater market opportunities – to be justified by market and commercial needs.

The IMT-2030 framework outlines nine user and application trends, including ubiquitous intelligence and computing, immersive multimedia, and more. NGMN believes that 6G should fulfil these trends and market expectations across multiple sectors. Some noteworthy sectors include:

- **Smart Cities**: Leveraging multidimensional sensing capabilities for monitoring and managing atmospheric, hydrological, firefighting, and transportation data to enhance risk prevention, unified dispatch, and resource sharing.
- **Industrial Production**: empowering industrial IoT networks, to improve manufacturing efficiency through real-time data, virtual-physical operating systems, and human-machine collaborations.
- **Daily Life Enhancement**: elevating daily life experiences through personalised digital health care, smart homes, and high-bandwidth immersive smart education

NGMN noted a similar set of user and application trends. However, it is also noted that the development of new technology should consider the law-of-diminishing returns through product life-cycle management.
Among others, quantifying demand for it in terms of market

and societal value and comparing it against the cost and environmental impact of implementation. From a business model perspective, new paradigms need to emerge to ensure value to the society and sustainable return on investment for communication service providers and the various partners and players of the value chain.

2.3 TECHNOLOGY TRENDS AND SPECTRUM IMPLICATIONS

In technology trends, NGMN identified that attention should be given to operational necessities – reflecting the need to manage complexity, drive efficiency, and reduce costs. This includes the need to support end-to-end visibility and automation, advanced spectrum and energy efficiency procedures, device management functions, and electromagnetic field (EMF) measurement and management. In the recent "6G Position Statement", NGMN's Members reinforced the need for a graceful evolution of communication systems, building on and extending the developing 5G ecosystem. NGMN recognises that some new IMT frequency bands are needed for IMT-2020 and beyond technologies, and that deployment in sub-THz bands, which is in an earlier phase of research, may adopt a new IMT-2030 technology.

The IMT-2030 framework report proposes multiple technologies and enablers with the potential to improve network and air interface efficiency. This includes features that impact the radio interface, e.g., modulations schemes, extreme-MIMO, self-interference-cancellation, reconfigurable surfaces, non-orthogonal-access, full-duplex. In addition, it is proposed that a combined system that includes ISAC would give new capabilities, enabling innovative services and applications. The framework also recognises that solutions must be brought forward that are applicable in a range of frequency bands considering the international regulatory framework for spectrum identification at ITU-R and regional initiatives.

NGMN recommendations on trends and technology enablers

NGMN encourages SDO's to assess new technology enablers in a rigorous manner, through appropriate studies, e.g., 3GPP feasibility study items prior to starting normative work. Assessments of efficiency benefits must be made in comparison to the state-of-the-art 5G-advanced radio standards reflecting realistic deployment scenarios, and which consider forecasted new mobile bands and their bandwidth, and the potential need for new metrics beyond traditional performance indicators.

SDO's are encouraged to consider how new capabilities can be introduced in a way that is consistent with the operational necessities, as identified in the NGMN "6G Position Statement", for example managing complexity, improving efficiency, and reducing cost and that address market demand.

03 USAGE SCENARIOS OF IMT-2030

NGMN, in their publication of "6G Use Cases and Analysis" identified four broad classifications of use cases: (1) enhanced human communications, (2) enhanced machine communications, (3) enabling services, and (4) network evolution. These encompass sensing, AI as a service, energy efficiency, and ubiquitous coverage. Furthermore, its publication on "6G Trustworthiness Considerations" addressed design considerations and the holistic and foundational nature of security and privacy across all identified usage scenarios. In its "6G Position Statement" the NGMN Alliance Board notes that 6G must allow for certain usage scenarios to be realised through software-based feature upgrades to be deployed as and when required.

The IMT-2030 framework highlights sustainability, security, and resilience, connecting the unconnected, and ubiquitous intelligence as overarching aspects which act as design principles commonly applicable to all usage scenarios.

It goes on to describe six usage scenarios, three of which expand existing IMT-2020 usage scenarios and three new usage scenarios.

The first three categories of IMT-2030 framework - immersive, reliable, massive - can directly be taken as an expansion of IMT-2020 usage scenarios such as eMBB, URLLC and mMTC.

These usage scenarios are to cover a range of environments including hotspots, urban and rural, and together create increasing demands on aspects such as spectrum efficiency, higher data rates, lower latency, and increasing density. The IMT-2030 framework goes on to identify new capabilities related to sensing, AI, and positioning that may be used to enhance usage experience of each. NGMN recognises some of these new capabilities may exist in deployed networks.

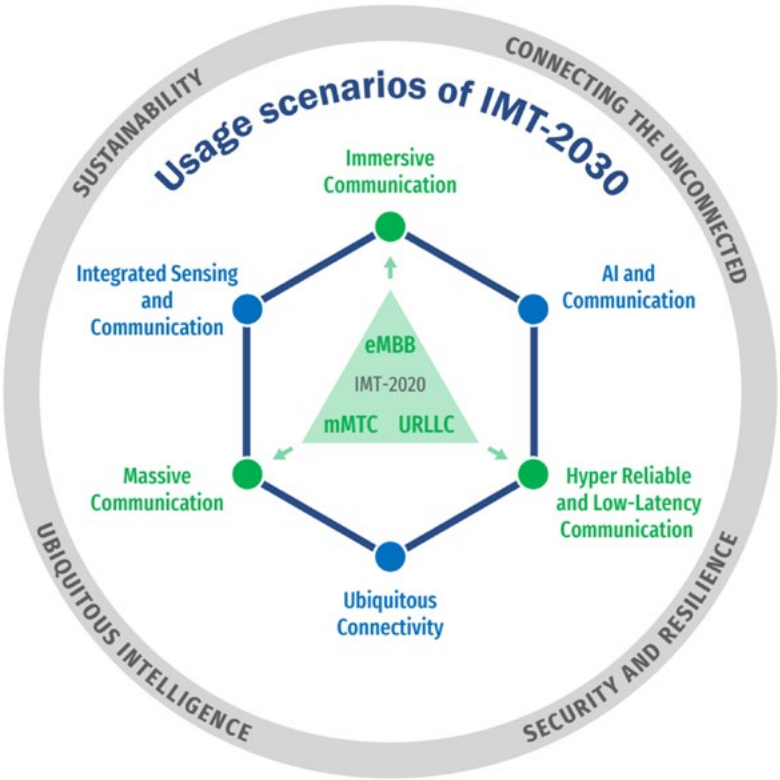

Figure 1: Usage scenarios and overarching aspects of IMT-2030 (source: ITU-R M.2160)

In addition, three new usage scenarios related to ubiquitous connectivity, AI, and integrated sensing are included:

- **Ubiquitous connectivity** is intended to bridge the digital divide through interworking with other systems – including satellites, high-altitude-platforms, broadcast, and RLANs (Wi-Fi) – and to maintain a consistent user experience between different locations by integration of indoor and local networks.

- **Artificial Intelligence and Communication** is expected to facilitate distributed computing and AI applications. This is anticipated to encompass a range of new capabilities, such as data acquisition, preparation and processing from different sources, distributed AI model training, model sharing, distributed inference, and computing resource orchestration.

- **ISAC** is a new capability to provide high-precision positioning and localisation of devices and objects in the proximity of a sensor, where both UEs and base stations offer sensing capabilities. Opportunities include activity and gesture recognition, movement detection, localisation and tracking, environment monitoring and material inspection.

Given the wide range of different features, the IMT-2030 framework states that features will be designed and function in a modular manner, and added incrementally as the need arises.

A comparison between NGMN publications and ITU-R IMT-2030 framework

When the IMT-2030 framework is compared against the NGMN publication on "6G Use Cases and Analysis" there is commonality, consistent with our contributions; the same set of use cases are identified in each case albeit with slightly different grouping. The NGMN Alliance Board notes in their "6G Position Statement" the importance of 6G facilitating seamless integration and interoperability with non-IMT networks such as fixed and satellite, which is aligned with the IMT-2030 framework identifying the need for interworking with other systems.

Further, both the IMT-2030 framework and NGMN recognise that not all new capabilities are always necessary in all locations and should be able to be deployed as and when required in a modular manner. NGMN further noted that use cases are 'provisional' in the sense that many could be served over advanced 5G networks, and therefore it is challenging to identify those that will be addressed after 2030 and aligned with 6G. These observations support the need for a modular and flexible approach, so features are introduced that respond to market and user demand. Notwithstanding a modular approach, the need to support native voice services, existing public safety services, and national/regional regulatory requirements must not be compromised and should be delivered with the launch of IMT-2030.

04 CAPABILITIES OF IMT-2030

In the publication on "6G Requirements and Design Considerations", NGMN described the essential needs related to network evolution, proposed capabilities, and overall conditions for the introduction of new service creation.

The essential needs identified by NGMN include digital inclusion and coverage, environmental and energy efficiency, security and trustworthiness, end-to-end service delivery and optimisation, distributed computing for AI, and support for essential regulated and public safety services. Qualitative outcomes are described recognising that many of the capabilities associated with the most important usage scenarios are application and environment specific. In its review on design considerations, practical deployment issues are introduced related to site densification and subsequent environmental, energy and economic trade-offs. Further, industry trends including disaggregated networks, neutral hosts, and shared networks are identified as requiring support in 6G standardisation and networks.

NOTE: The range of values given for capabilities are estimated targets for research and investigation of IMT-2030.

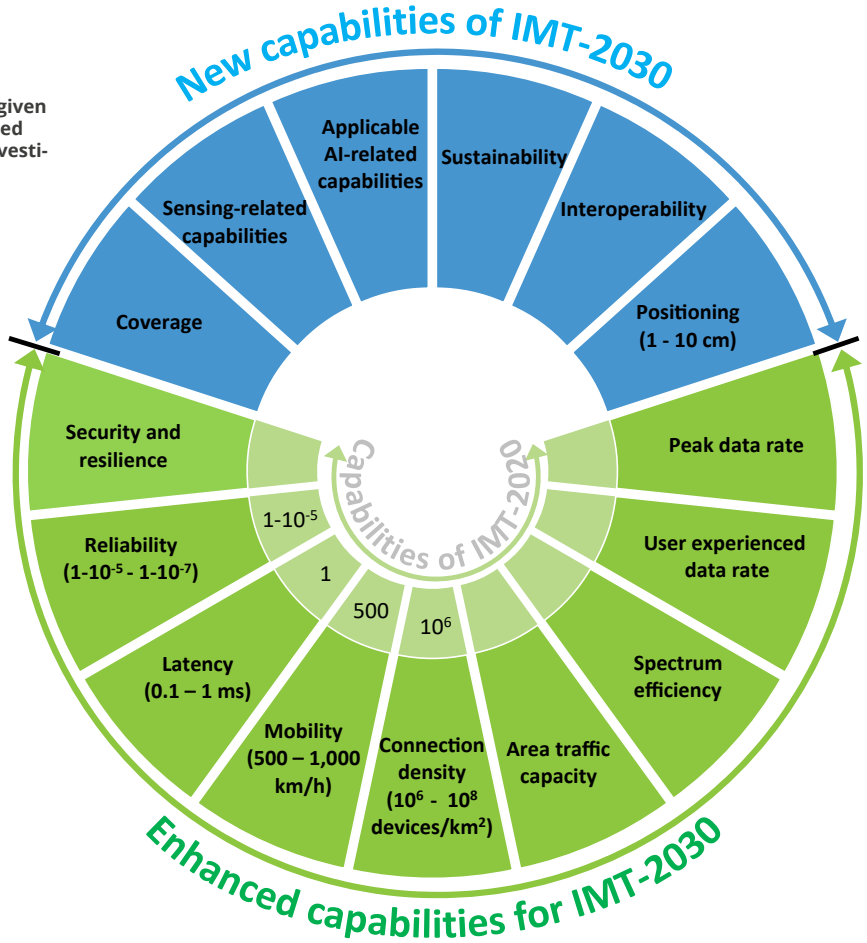

Figure 2: Capabilities of IMT-2030 (source: ITU-R M.2160)

In a similar manner, the IMT-2030 framework section on "Capabilities" describes the characteristics required to support its six usage scenarios and application trends.

In total, a set of fifteen categories are associated with IMT-2030 proposed capabilities. This includes nine research targets that extend the set of IMT-2020 capabilities: peak data rate, user experienced data rate, spectrum efficiency, area traffic capacity, connection density, mobility, latency, reliability, and security & resilience. Notable proposed target values for research that significantly influence mobile network design and deployment include peak data rates of 50, 100, or 200Gbps, user experienced rates of 300 or 500Mbps, spectrum efficiency improvements of x1.5 or x3 relative to IMT-2020, and one-way over-the-air latency in the range of 0.1 to 1ms. In addition to the nine, a set of six further capabilities are identified on coverage, sensing, AI-related, sustainability, interoperability, and positioning, that are described in more general, qualitative, terms. It is stated that the values for the capabilities apply only to some of the usage scenarios and may not be reached simultaneously in a specific usage scenario.

A comparison between NGMN Publications and ITU-R IMT-2030 Framework

When compared against the NGMN “6G Drivers & Vision” publication and the “6G Position Statement” we identify common areas. Both NGMN and IMT-2030 recognise that capabilities are application and environment specific, however NGMN also highlights practical issues related to deployment such as site densification and environmental, energy and economic trade-offs that need to be considered.

The setting of future requirements is particularly important when considering the demands on sustainability as it is essential that actions taken do not limit the range of economic, social, and environmental options for future generations. This has significant implications as it would be counter-productive to aspire for outcomes that are inconsistent with competing objectives seeking sustainability.

To enable service providers to select services aligned with their ambitious sustainability goals - most of them having committed to carbon neutrality by 2040 - appropriate observability and metrics should also be available.

A lower latency, relative to IMT-2020, has significant implications in the design of radio systems and compromises other essential capabilities such as spectrum efficiency and system capacity. These broader considerations must be considered to ensure a system is specified to reflect customer demand and is economically sustainable.

NGMN therefore encourages the ITU-R when setting expectations of service, that IMT practical issues are fully considered, for example site density, power and EMF limits, realistic demand for extreme capabilities, and the trade-off between seeking higher peak data rates or lower latency with the consequential impact on site density, environmental implications, and cost.

05 CONSIDERATIONS OF ONGOING DEVELOPMENT

In its considerations for ongoing development, the IMT-2030 framework notes the importance in the relationship between existing IMT, other access systems, and timelines.

5.1 RELATIONSHIP BETWEEN IMT-2030 AND EXISTING IMT

The NGMN publication on "6G Requirements and Design Considerations" states that it does not rule out 6G as an evolution of 5G, either for the core network, the radio access network, or both. In the "6G Position Statement" the NGMN Alliance Board outlines that 6G should build on, and extend beyond, the existing 5G ecosystem. Network related APIs that foster new service offerings, and 6G introduction through software-based feature upgrades, with new features enabled as and when required, are anticipated.

In the IMT-2030 framework it is stated that requirements could potentially be met by adding enhancements to existing IMT, incorporating new technology components and functionalities and/or the development of new radio interface technologies.

A similar position is therefore acknowledged between NGMN and the IMT-2030 framework.

5.2 RELATIONSHIP BETWEEN IMT-2030 AND OTHER ACCESS SYSTEMS

Recognising the diverse set of capabilities being proposed for 6G, the extreme requirements, and the environments ranging from hot spots in dense urban regions, to extensive coverage in rural areas, the "6G Position Statement" acknowledges the need for 6G to facilitate seamless integration and interoperability with fixed and satellite networks.

The IMT-2030 framework also recognises the need for interworking between different access networks including satellites, high altitude systems, and other non-IMT terrestrial networks such as RLAN (Wi-Fi) and broadcast.

A similar position is therefore acknowledged between NGMN and IMT-2030 framework.

5.3 TIMELINES

NGMN believes that the 6G services proposed will need to be analysed in terms of alignment with market demands and relevance before specifying the associated formal requirements in standards. At some stage, it is anticipated that 3GPP will submit one, or multiple, Radio Interface Technology (RIT) candidates to the ITU-R for evaluation. These candidates may include the evolution of 5G-NR and/or a new 6G radio candidate.

The IMT-2030 framework recognises that system deployment will consider practical aspects such as cost of infrastructure and plans to complete standardisation process no later than 2030, to support implementation from 2030 onwards.

Whilst NGMN does not explicitly call out a date for standardisation, there is an expectation that 6G will be relevant in the 2030's time frame. With the identified relationship between IMT-2030 with existing IMT and / or other access systems, it can be envisaged that a candidate solution may incorporate multiple access systems.

06 CONCLUDING REMARKS

NGMN has identified several other aspects that ITU-R may wish to consider as it moves forward in the next stage of the IMT-2030 process:

Firstly, and central to NGMN's "6G Position Statement" is that 6G must deliver value to customers and simplify network operations ensuring commercial sustainability of IMT networks, extending its role as infrastructure delivering important societal, environmental, and economic benefits. NGMN recognises that new generations of IMT technologies cumulatively add to the complexity of network management and customer devices. Consequently, NGMN expects that the 6G framework builds upon, and extends, the IMT-2020 network. For a new IMT-2030 Radio Interface Technology (RIT) to become widely adopted for 6G, i.e., generation change, it must demonstrate significant benefits over and above IMT-2020 in key metrics such as spectral and/or energy efficiency, traffic capacity and cost reduction. An IMT-2030 RIT should therefore consider the practical issues related to IMT deployments including frequency bands, bandwidth, traffic demands, and propagation characteristics, as this will determine whether an economic solution is appropriate for wide-area mobility.

Furthermore, NGMN Members have commented that many of the more extreme IMT-2020 capabilities, e.g., 20 Gbps, or 1msec latency, have been difficult to deliver. In addition, it was an objective for IMT-2020 that the energy consumption for the radio access networks should not be greater than IMT networks deployed earlier, e.g., IMT-Advanced, 4G, which has become increasingly difficult to fulfil with increasing traffic, despite the greater 5G energy efficiency, as more advanced antenna techniques (massive-MIMO), along with higher capabilities and larger bandwidths, are introduced.

IMT-2020 has fulfilled and exceeded other aspects delivering customer benefits. Typical downlink data rates in many networks often exceed 100 Mbps (although 5th percentile values[4] might not reach this IMT-2020 target figure) and capacity has been greatly enhanced with the introduction of newly identified IMT frequency bands, and network efficiency per unit of data carried has been improved in terms of cost and energy. Taken together this indicates relative success of certain aspects of IMT-2020 related to mobile broadband on which innovation and new services continue to be developed, and capabilities where IMT-2030 can realistically be extended.

Therefore, NGMN makes the following recommendations, for the next stage of the process related to IMT-2030:

- New features should be able to be deployed as and when required, without compromising existing core connectivity services, that reflect customer need and generate new value.
- Evaluation should include interworking of IMT-2030 candidates with non-IMT systems.
- NGMN would like to reinforce the importance of global standards for mobile networks within industry consensus-based standards organisations, e.g., 3GPP, which are necessary to drive economies of scale and support the significant investment required in developing new products for IMT.
- ITU-R should take into consideration that advanced features introduced with the IMT-2020 network and/or a new radio interface might be candidates for IMT-2030.
- Any new radio interface must demonstrate significant benefits over and above IMT-2020 in key metrics such as spectral and/or energy efficiency, overall energy consumption reduction, and/or cost advantages.
- Further work would be beneficial, as input to the process and next steps, to understand the commercial imperative for any extreme requirements of IMT-2030.

4 Minimum requirements related to technical performance for IMT-2030 radio interfaces, https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-PDF-E.pdf, Equation 3 (2017)

- IMT-2030 will continue to evolve based on IP communications, considering cloud native solutions, disaggregation, and service-based architecture, ensuring both forward and backward compatibility, with support for self-organisation to manage complexity and emerging capabilities.

- IMT-2030 candidates technologies should consider how to support a roll-out option in which 6G builds upon, and extends, the existing, e.g., IMT-2020, network supporting innovative and emerging technologies.

NGMN looks forward to the ongoing work within the ITU-R and the subsequent phases of activity including requirements, standards development, and evaluation.

07 ABREVIATIONS

AI	Artificial Intelligence
eMBB	Enhanced mobile broadband
EMF	Electromagnetic Field
IMT	International Mobile Telecommunications
IMT-2020	Requirements issued by the ITU-R for networks beyond 2020 (5G)
IMT-2030	Requirements issued by the ITU-R for networks beyond 2030 (6G)
ISAC	Integrated Sensing and Communications
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunications Sector
MIMO	Multi-Input Multi-Output
mMTC	massive Machine Type Communication
NGMN	Next Generation Mobile Network Alliance e.V.
RIT	Radio Interface Technology
RLAN	Radio Local Access Network
SDO	Standard Development Organisations
URLLC	Ultra-reliable and low-latency communication
5G-NRx	5G New Radio

08 REFERENCES

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6G Trustworthiness Considerations (2023) https://www.ngmn.org/wp-content/uploads/NGMN_6G_Trustworthiness.pdf

[4] Minimum requirements related to technical performance for IMT-2020 radio interfaces (5th percentile user experienced data rates) https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-PDF-E.pdf (Section 4.3, equation 3)

09 ACKNOWLEDGEMENTS

The following people and companies participated in the development of this publication.

Accenture, Arnau Mata-Llenas
Amdocs, Andrew Dsouza, Steve Plain
Anritsu, Jonathan Borrill, Marsh Dsouza
Apple, Mona Mustapha, Kome Oteri
AsiaInfo, Sen Bian, Yun Li
Bell Canada, Javan Erfanian
BT, Kevin Holley, Stan Wong (formerly BT)
China Mobile, Huili Liu, Hua Song, Tong Zhang, Quan Zhao, Shiying Zheng
Chunghwa Telecom, He-Wei Yeh
CICT Mobile, Guobing Chang , Shaoli Kang
Cisco, Russ Gyurek
Deloitte, Alireza Zamani
Deutsche Telekom, Konstantinos Chalkiotis, Peter Stevens
Ericsson, Janne Peisa
Fraunhofer Institute, Marc Emmelmann, Kenan Turbic, Zoran Utkovski
Huawei, Yan Chen, Hui Lin, Fei Lui, Peiying Zhu
Institute of Information Industry, Yountai Lee, Frank Su
Intel, Gary Li
InterDigital Europe Ltd, Sebastian Robitzsch
ITRI, Mitch Tseng, Allen Wen
Juniper, Andreas Meisinger
King's College London, Toktam Mahmoodi
KPN, Mohammad Salimi
Lenovo, Andrei Stoica
LG Electronics, Ki-dong Lee
Liberty Global, Viraj Abhayawardhana
Meta, Francois Blouin, Xinli Hou
Nokia, Omar Elloumi, Philippe Sehier
NTT DOCOMO, Atsushi Minokuchi, Yoichiro Seto
Orange, Eric Hardouin, Jean Schwoerer
Qualcomm, Mungal Dhanda
Rohde & Schwarz, Olaf Heisch, Goce Talaganov
SK Telecom, Gi Wan Choi, Minsoo Na
Smart, Lauro Roxas
T-Mobile US, Jean Trakinat
TIM, Giovanna D'Aria
Telia Company, Ulf Nilsson
TELUS, Aleksandar Prekajski
TNO, Ljupco Jorguseski
TU Dresden, Ahmad Nimr
Turkcell, Mehmet Basaran, Izzet Saglam
University of Duisburg-Essen, Mohammed El-Absi
UScellular, Jaideep Abichandani, Narothum Saxena, Sebastian Thalanany
Vodafone, Rishikesh Chakraborty, David Lister, Joerg Sternagel
ZTE, Chuangxin Jiang, Richie Leo, Hu Yuzhou, Ling Xu

NEXT GENERATION MOBILE NETWORKS ALLIANCE

NGMN, established in 2006, is a global, operator-led alliance of over 80 companies and organisation spanning operators, manufacturers, consultancies and academia.

VISION

The vision of the NGMN Alliance is to provide impactful guidance to achieve innovative and affordable mobile telecommunication services for the end user with a particular focus on supporting 5G's full implementation, Mastering the Route to Disaggregation, Sustainability and Green Networks, as well as 6G.

MISSION

The mission of the NGMN Alliance is

- To evaluate and drive technology evolution towards 5G's full implementation and the three major priorities for 2021 and beyond:

  Route to Disaggregation: Leading in the development of open, disaggregated, virtualised and cloud native solutions with a focus on the end to end operating model.

  Green Future Networks: Building sustainable and environmentally conscious solutions.

  6G: Emergence of 6G highlighting key trends across technology and societal requirements plus use cases to address.

- to establish clear functional and non-functional requirements for mobile networks of the next generation.

- to provide guidance to equipment developers, standardisation bodies and cooperation partners, leading to the implementation of a cost-effective network evolution

- to provide an information exchange forum for the industry on critical and immediate concerns and to share experiences and lessons learnt for addressing technology challenges

- to identify and remove barriers for enabling successful implementations of attractive mobile services