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Recommendation ITU-R M.2160-0

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Framework and overall objectives of the future development of IMT for 2030 and beyond

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***Note**: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
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RECOMMENDATION ITU-R M.2160-0

Framework and overall objectives of the future development of IMT for 2030 and beyond[1]

(2023)

Scope

This Recommendation describes a framework and overall objectives for the development of the terrestrial component of International Mobile Telecommunications (IMT) for 2030 and beyond (IMT-2030). IMT is expected to continue to better serve the needs of the networked society, for both developed and developing countries in the future.

In this Recommendation, the framework of the development of IMT-2030, including a broad variety of capabilities associated with envisaged usage scenarios, is described. Furthermore, this Recommendation addresses the objectives for the development of IMT-2030, which includes further enhancement and evolution of existing IMT. Aspects of interworking with other networks are also addressed.

Keywords

IMT, IMT-2030

Abbreviations/Glossary

AI	Artificial intelligence
CA	Carrier aggregation
CPP	Carrier phase positioning
DOICT	Date, operation, information and communication technology
DTN	Digital twin network
E-MIMO	Extreme MIMO
eMBB	Enhanced mobile broadband
HIBS	High altitude platform stations as IMT base station
HR	Holographic radio
IBFD	In-band full duplex
IMT	International Mobile Telecommunications
LDPC	Low density parity check code
ML	Machine learning
mMTC	Massive machine type communication
NOMA	Non-orthogonal multiple access
NTN	Non-terrestrial network
OAM	Orbital angular momentum
RIS	Reconfigurable intelligent surface
SDGs	Sustainable development goals

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[1] This Recommendation focuses on the terrestrial component of IMT-2030.

SIC	Self-interference cancellation
TRxP	Transmission reception point
UAS	Unmanned aircraft system
UCN	User-centric network
UDN	Ultra-dense network
URLLC	Ultra-reliable and low-latency communication
XR	Extended reality

Related documents: ITU Recommendations, Reports, Documents and Handbook

Recommendation ITU-R M.687 – International Mobile Telecommunications-2000 (IMT-2000)

Recommendation ITU-R M.816 – Framework for services supported on International Mobile Telecommunications-2000 (IMT-2000)

Recommendation ITU-R M.1457 – Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)

Recommendation ITU-R M.1645 – Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000

Recommendation ITU-R M.2012 – Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced)

Recommendation ITU-R M.2083 – IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond

Recommendation ITU-R M.2150 – Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020)

Report ITU-R M.2134 – Requirements related to technical performance for IMT-Advanced radio interface(s)

Report ITU-R M.2243 – Assessment of the global mobile broadband deployments and forecasts for International Mobile Telecommunications

Report ITU-R M.2291 – The use of International Mobile Telecommunications for broadband public protection and disaster relief applications

Report ITU-R M.2320 – Future technology trends of terrestrial IMT systems

Report ITU-R M.2370 – IMT Traffic estimates for the years 2020 to 2030

Report ITU-R M.2376 – Technical feasibility of IMT in bands above 6 GHz

Report ITU-R M.2410 – Minimum requirements related to technical performance for IMT-2020 radio interface(s)

Report ITU-R M.2441 – Emerging usage of the terrestrial component of International Mobile Telecommunication (IMT)

Report ITU-R M.2516 – Future technology trends of terrestrial IMT systems towards 2030 and beyond

The ITU Radiocommunication Assembly,

considering

a) that ITU has provided the standardization and harmonized use of IMT, which has contributed to the enhancement of telecommunication services on a global scale;

b) that technological advancement and the corresponding user needs would promote innovation and accelerate the delivery of advanced communication applications to consumers;

c) that the development of IMT-2030 is to continue supporting an inclusive information society and expanding its goals towards societal considerations including environmental aspects, which would be an important enabler for the achievement of sustainable development goals;

d) that Question ITU-R 229/5 addresses further development of the terrestrial component of IMT, the study of which is in progress;

e) that Question ITU-R 262/5 addresses usage of the terrestrial component of IMT systems for specific applications, the study of which is in progress;

f) that for the global operation and economies of scale, which are key requirements for the success of mobile telecommunication systems, a harmonized appropriate timeframe for future development of IMT considering technical, operational and careful deliberation of spectrum related aspects is important,

considering further

a) that development of radio interface(s) that support the new capabilities of IMT-2030 is expected along with the enhancement of IMT-2000, IMT Advanced and IMT-2020 systems;

b) that IMT interoperability and/or interworking with other access systems is important,

recognizing

a) that Recommendation ITU-R M.1645 addresses the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000;

b) that Recommendation ITU-R M.2083 addresses the framework and overall objectives of the future development of IMT for 2020 and beyond,

recommends

that the Annex should be considered as the framework and the overall objectives to guide the future development of IMT-2030.

Annex

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1 Introduction

With the evolution of information and communications technologies, IMT-2030 is expected to support enriched and potential immersive experience, enhanced ubiquitous coverage, and enable new forms of collaboration. Furthermore, IMT-2030 is envisaged to support expanded and new usage scenarios compared to those of IMT-2020, while providing enhanced and new capabilities.

The objective of this Recommendation is to provide guidelines on the framework and overall objectives of the future development of IMT-2030, and is organized as follows:

– Trends of IMT-2030 are presented in § 2.

NOTE – Reference to spectrum contained in this Recommendation should in no way be seen as demanding of spectrum needs for IMT-2030.

– Usage scenarios and capabilities of IMT-2030 are derived in §§ 3 and 4, respectively.

– Considerations of ongoing development are described in § 5.

2 Trends of IMT-2030

2.1 Motivation and societal considerations

The motivation for the development of IMT-2030 is to continue to build an inclusive information society towards contributing to support the United Nations Sustainable Development Goals (SDGs). To this end, IMT-2030 is expected to be an important enabler for achieving the following goals, among others:

– **Inclusivity**: Contributing towards further bridging of digital divides, to the maximum extent feasible, by ensuring affordable access to meaningful connectivity to everyone.

– **Ubiquitous connectivity**: Towards connecting unconnected, IMT-2030 is expected to include affordable connectivity and, at minimum, basic broadband services with extended coverage, including sparsely populated areas.

– **Sustainability**: Sustainability refers to the principle of ensuring that today’s actions do not limit the range of economic, social and environmental options to future generations. IMT-2030 is envisaged to be built on energy efficiency, low power consumption technologies, reducing greenhouse gas emissions and appropriate use of resources under the applicable model of circular economy, in order to address climate change and contribute towards the achievement of current and future sustainable development goals.

– **Innovation**: Fostering innovation with technologies that facilitate connectivity, productivity and the efficient management of resources. These technological advances will improve user experience with a view to positively transform economies and lives everywhere.

– **Enhanced security and resilience**: IMT-2030 system is expected to be secure by design. It is expected to have the ability to continue operating during and quickly recover from a disruptive event, whether natural or man-made. Making security and resilience as the key considerations in the design, deployment and operation of IMT-2030 systems is fundamental to achieving broader societal and economic goals.

– **Standardization and interoperability**: IMT-2030 systems are expected to be designed from the start to use transparently and member-inclusively standardized and interoperable interfaces, ensuring that different parts of the network, whether from the same or different vendors, work together as a fully functional and interoperable system.

– **Interworking**: IMT-2030 is expected to support service continuity and provide flexibility to users via close interworking with non-terrestrial network implementations, existing IMT systems and other non-IMT access systems. IMT-2030 is also expected to support smooth migration from existing IMT systems, where including support of connectivity to IMT-2020 and potentially IMT-Advanced devices will be advantageous for inclusivity.

2.2 User and application trends

Applications and services enabled by IMT-2030 are expected to connect humans, machines and various other things together. With the advances in human-machine interfaces, interactive and high-resolution video systems such as extended reality (XR) displays, haptic sensors and actuators, and/or multi-sensory (auditory, visual, haptic or gesture) interfaces, IMT-2030 is expected to offer humans immersive experiences that are virtually generated or happening remotely. On the other hand, machines are envisaged to be intelligent, autonomous, responsive, and precise due to advances in machine perception, machine interactions, to the extent practicable, and demonstrated actionable management of artificial intelligence (AI). In the physical world, humans and machines are expected to continuously interact with each other, working with a digital world that extends the real world by using a large number of advanced sensors and AI. Such a digital world not only replicates but also affects the real world by providing virtual experiences to humans, and computation and control to machines.

IMT-2030 is expected to integrate sensing and AI-related capabilities into communication and serve as a fundamental infrastructure to enable new user and application trends. From these trends, it is expected that IMT-2030 provides a wide range of use cases while continuing to provide, *inter alia*, direct voice support as an essential communication. Furthermore, IMT-2030 technology is expected to drive the next wave of digital economic growth, as well as sustainable far-reaching societal changes, digital equality and universal connectivity. IMT-2030 is expected to further enhance security and resilience.

2.2.1 Ubiquitous intelligence

With the steady progress and fast spread of technologies in AI and particularly machine learning (ML), it is expected that intelligence would be present in every part of the communication system to support the building of smart cities and communities. Future connected devices may become fully context-aware for more intuitive and efficient interactions among humans, machines, and the environment. Possible autonomous management of networks by AI/ML may also be capable of, to some extent, performing self-monitoring, self-organization, self-optimization and self-healing without human intervention. It is expected that the air-interface would be enhanced by AI models.

IMT-2030 could serve as an AI-enabling infrastructure capable of providing services for intelligent applications. AI-enabled air interface along with distributed computing and intelligence could potentially allow for end-to-end AI applicability and the convergence of communication and computing. These systems would have functions of inferences, model training, model deployment, as well as computing distributed across networks and devices.

2.2.2 Ubiquitous computing

In addition to ubiquitous intelligence, it is expected that ubiquitous use of data computing resources would also expand throughout the IMT-2030. Emerging trends in this regard include expansion of data processing in the network infrastructure to the network cloud and devices that are closer to the origin of the data and support for proliferation of ubiquitous intelligence throughout the IMT-2030. This trend also contributes to the improvements for applications requiring real-time responses and data transport. Ubiquitous computing disseminated across IMT-2030 is expected to enable efficient utilization of resources and optimal placement of workloads, as well as scales and manages the infrastructure to run the applications.

2.2.3 Immersive multimedia and multi-sensory interactions

The future of multimedia and human-centric communication enabled by IMT-2030 is expected to give an immersive experience through multi-sensory interactions and in-depth integration between physical and digital worlds. This is expected to provide a real time interactive video experience. Extended reality is expected to be personalized and developed into a potential immersive experience for users. In addition to these trends, holographic telepresence might become common for work, social interactions, entertainment, tele-education, remote live performances, etc.

It is expected that new human-machine interfaces would enable immersive and intelligent interactions, where control is maintained remotely, e.g. remote operations of machines and machine interactions, leveraging edge cloud computing resources and AI to deliver tactile Internet and ambient awareness.

2.2.4 Digital twin[2] and virtual world

IMT-2030 is expected to be used to replicate the physical world into a digital virtual world as precise real-time representations or digital twins. Digital twins have the potential to provide ubiquitous tools and knowledge platforms for the modelling, monitoring, managing, analysing and simulating of physical assets, resources, environments and situations.

Using advanced technologies such as integration of communication with, to the extent practicable, AI, sensing and computing, digital twins could also synchronize the digital world to the physical world and provide connections between the digital replica components. Digital twins are expected not only to replicate but also to affect the physical world by providing digital maps for virtual experiences to humans and computed control to machines. Digital twins are envisaged to become a powerful tool in the evolution of multiple industries including health care, agriculture and construction.

2.2.5 Smart industrial applications

Future IMT-2030 for smart industrial applications could support the capability to exchange real-time intelligence and cooperate to enable efficient use of resources and energy, optimizations of manufacturing, automated product delivery, etc. Industrial applications would further require connectivity to intelligent devices with extremely reliable and low-latency connections, as well as highly accurate environment awareness, e.g. positioning to enable ubiquitous and real-time information collection, sharing and intelligent control and feedback.

Sensing supported 3D measurement and modelling of the environment has also an application in industrial use.

2.2.6 Digital health[3] and well-being

IMT-2030 is expected to further contribute to improving digital-health and well-being delivery services, e.g. digital health delivery was used effectively during COVID pandemic by many countries. Through the leveraging of appropriate AI, edge computing, ubiquitous connectivity, multi-sensory

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[2] As addressed in Recommendation ITU-T Y.4600, a digital twin is a digital representation of an object of interest and may require different capabilities according to the specific domain of application, such as synchronization between a physical thing and its digital representation, and real-time support.

[3] As addressed in "Global strategy on digital health 2020-2025" of WHO, "Digital health: The field of knowledge and practice associated with the development and use of digital technologies to improve health. Digital health expands the concept of eHealth to include digital consumers, with a wider range of smart-devices and connected equipment. It also encompasses other uses of digital technologies for health such as the Internet of things, artificial intelligence, big data and robotics."

communication, positioning and sensing related capabilities, IMT-2030 is expected to facilitate the digital health services including interactive and remote monitoring, tele-diagnosis, remote tele-medical assistance (including tele-connected ambulances), tele-rehabilitation, digital clinical trials and telemedicine. The increased number of connections of wearable devices and body sensors may also make this technology pervasive. In some scenarios, these pervasive IoT devices are expected to function without battery as well.

2.2.7 Ubiquitous connectivity

Ubiquitous connectivity is critical for delivering a wide range of services such as access to, *inter alia*, education, health, agriculture, transport, logistics and business opportunities. IMT-2030 is expected to contribute to achieving the UN SDGs, bridging digital divide, by connecting the unconnected and under-connected areas in an efficient manner, by addressing the challenges of connectivity, coverage, capacity, data rate and the mobility of terminals.

IMT-2030 is therefore expected to continue to support further development of ubiquitous connectivity that would provide digital inclusion for all by meaningfully connecting the rural and remote communities, further extending into sparsely populated areas, and maintaining the consistency of user experience between different locations-including deep indoor coverage.

2.2.8 Integration of sensing and communication

In IMT-2030, the integration of sensing and communication is expected to become a key enabler for a wide range of use cases. Moreover, sensing the physical surroundings together with appropriate AI could further enhance situational awareness.

Sensing information while preserving security is envisaged to be communicated in certain environments and across networks in a distributed manner to facilitate specialized services. Sensing would support various innovative applications such as high precision positioning and localization of devices and objects, high resolution and real-time 3D-mapping for automated and safe driving/transport, digital twins and industrial automation. Other opportunities include human activity (e.g. gesture) recognition, personal health sensing, sports analytics, environment monitoring and material inspection.

2.2.9 Sustainability

Sustainability is a foundational aspiration of future IMT systems. IMT-2030 is expected to help address the need for increased environmental, social, and economic sustainability, and also support the goals of the Paris Agreement of the United Nations Framework Convention on Climate Change. IMT-2030 implementations are expected to be designed to achieve the least possible environmental impact and to use resources efficiently by minimizing power consumption, using energy efficiently and reducing greenhouse gas emissions[4]. Leveraging circular economy principles helps retain and recover value from resources and extend lifetime through such important considerations as reusing, repairing, repurposing or recycling. Moreover, IMT-2030 may allow for efficient deployments and operation, thereby improving both environmental sustainability and the affordability necessary to support social sustainability.

Beyond its own environmental impact, IMT-2030 is expected to contribute towards empowering other industries/sectors to reduce their environmental impacts[5] by promoting digital transformation.

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[4] As presented in Recommendation ITU-T L.1450 “Methodologies for the assessment of the environmental impact of the information and communication technology sector”, 2018.

[5] As presented in Recommendation ITU-T L.1480 “Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors”, 2022.

2.3 Technology trends

Report ITU-R M.2516 provides a broad view of future technical aspects of terrestrial IMT systems considering the timeframe up to 2030 and beyond, characterized with respect to key emerging services, applications trends, and relevant driving factors. It comprises a toolbox of technological enablers for terrestrial IMT systems, including the evolution of IMT through advances in technology and their deployment. In the following sub-sections, a brief overview of emerging technology trends and enablers, technologies to enhance the radio interface and technologies to enhance the radio network are presented.

2.3.1 Emerging technology trends and enablers

IMT-2030 is expected to consider an appropriate AI-native new air interface that uses to the extent practicable, and proved demonstrated actionable AI to enhance the performance of radio interface functions such as symbol detection/decoding, channel estimation etc. An appropriate AI-native radio network would enable automated and intelligent networking services such as intelligent data perception, supply of on-demand capability etc. Radio networks that support applicable AI services would be fundamental to the design of IMT technologies to serve various AI applications, and the proposed directions include on-demand uplink/sidelink-centric, deep edge, and distributed machine learning.

The integration of sensing and communication functions in IMT-2030 systems would give new capabilities, enable innovative services and applications, and provide solutions with a higher degree of sensing accuracy. It would lead to benefits in enhancing performance and aimed at reducing overall cost, size and power consumption of both systems, when it is combined with technologies such as an applicable AI, network cooperation and multi-nodes cooperative sensing.

Computing services and data services are expected to become an integral component of the IMT-2030 system. It is expected to include processing data at the network edge close to the data source for real-time responses, low data transport costs, high energy efficiency as well as scaling out device computing capability for advanced application computing workloads.

Device-to-device wireless communication with extremely high throughput, ultra-accuracy positioning and low latency would be an important communication paradigm for IMT-2030. Technologies such as THz technology, ultra-accuracy sidelink positioning and enhanced terminal power reduction can be considered to support new applications.

IMT-2030 systems are expected to continue to utilize a mixture of different frequency bands as in the current IMT system, but with potentially larger bandwidths and higher operating frequencies. Spectrum utilization can be further enhanced by efficiently managing resources through different technologies such as advanced carrier aggregation (CA) and distributed cell deployments, as well as spectrum sharing technologies and technologies for broader frequency spectrum.

It is expected that IMT-2030 technologies consider energy efficiency and low power consumption for both, the user device and the network’s perspectives. Promising technologies include energy harvesting, backscattering communications, on-demand access, etc.

To achieve real-time communications with extremely low latency, two essential technology components could be considered: accurate time and frequency information shared in the terrestrial network and fine-grained and proactive on-time radio access.

There is a need to ensure security, and resilience when allowing for a legitimate exchange of sensitive information through network entities. Potential technologies to enhance security include those for RAN, such as distributed ledger technologies, differential privacy and federated learning, quantum technology with respect to the RAN and physical-layer security technologies.

2.3.2 Technologies to enhance the radio interface

New advanced modulation methods to overcome RF impairments at high frequencies may be considered to achieve better performance. Technologies may also consider advanced coding schemes such as advanced versions of polar coding, Low-Density Parity-Check codes (LDPC), and other coding schemes. Advanced waveform design among orthogonal, bi-orthogonal, non-orthogonal methods would be beneficial in guaranteeing desirable performance in specific scenarios. For multiple access, technologies including non-orthogonal multiple access (NOMA) and grant-free multiple access are expected to be considered to meet future requirements.

Extreme MIMO (E-MIMO) would be deployed with new types of antenna arrays, much larger-scale antenna arrays, a distributed mechanism, and AI assistance. This is expected to achieve better spectrum efficiency, larger network coverage, more accurate positioning, more accurate sensing, higher energy efficiency, etc.

Self-interference cancellation (SIC) technology in devices and networks would enable in-band full duplex (IBFD) in future mobile communications, enhancing the spectrum efficiency and suppressing interference between co-located heterogeneous systems, especially for high-power and massive MIMO scenarios.

Techniques such as reconfigurable intelligent surfaces (RIS), holographic radio (HR), and orbital angular momentum (OAM) are potential technologies that would improve performance and overcome challenges in traditional beam-space antenna array beamforming.

Communications using appropriate frequency resources are to be explored and envisioned to be key enablers for many future use cases (e.g. use cases with extremely high-data-rates, low latency, high-resolution sensing, high-precision positioning).

Ultra-high accuracy positioning can be supported by ultra-wide bandwidth and E-MIMO in a millimetre wave or THz band, as well as carrier phase positioning (CPP) based on cellular signals, AI/ML positioning techniques and integrating data communication and device positioning.

2.3.3 Technology enablers to enhance the radio network

Radio Access Network (RAN) slicing allows multiple independent logical networks to be created on a common shared physical infrastructure. IMT-2030 is expected to configure the slices to satisfy the specific needs of applications, services, customers or network operators.

Quality of service (QoS) requirements vary from one user to another. The future network would need to be resilient and dynamic in QoS provisioning (e.g. user-centric, service-oriented, flexible and powerful in capabilities, guaranteed in QoS, and consistent in user experience). Technologies such as the QoS guarantee mechanism, deterministic RAN, etc. can be considered.

RAN architecture would be reformed and simplified to achieve the goals of stronger capabilities, simpler architectures and plug-and-play into IMT-2030 systems. This reform and simplification may be attained with further development of approaches like data, operation, information, and communication technologies (DOICT), convergence-driven RAN architecture, native-AI enabled RAN functions, a thinner or lighter protocol stack design, RAN node cooperation and aggregation, the user-centric network (UCN) architecture, etc.

With real-time interactive mapping between the physical and virtual twin networks, digital twin networks (DTNs) can help efficiently and intelligently verify, simulate, deploy and manage IMT-2030 networks.

The interworking of IMT-2030 terrestrial network with its non-terrestrial networks (NTN), including satellite communications, high altitude platform stations as IMT base stations (HIBS), is expected to enhance achieving required connectivity objective.

An ultra-dense network (UDN) is implemented by the densification of transmission reception points (TRxPs). It may be an effective way to fulfil various requirements such as user experienced data rates, connection density, energy efficiency, spectrum efficiency, area traffic capacity, coverage, etc.

New technologies such as trusted data storage and secure sharing would enhance RAN infrastructure sharing in terms of transparency, reliability and rapid response.

2.4 Envisaged frequency bands

No single frequency range satisfies all the criteria required to deploy IMT systems and the same is expected to apply for IMT-2030. There are differences in the deployments and timings of mobile data growth in different countries. Multiple frequency ranges would be needed to meet the capacity and coverage requirements of IMT systems and to serve the emerging services and applications. It is envisaged that IMT-2030, similar to the previous IMT systems, would be used in a variety of deployments. Research and development into enhanced coexistence and spectrum sharing approaches (including technical aspects) will continue.

New generations of IMT may expect new spectrum for increasing data rates, capacity, new applications and to provide for new capabilities. IMT-2030 is envisaged to utilize a wide range of frequency bands ranging from sub-1 GHz up to frequency bands above 100 GHz. Low bands will continue to be crucial to enable nationwide coverage, in particular addressing the digital divide and expanding deep indoor coverage. Mid bands provide a balance between wide area coverage and capacity.

2.5 Spectrum harmonisation

The benefits of spectrum harmonization include facilitating economies of scale, enabling global roaming, reducing complexity of equipment design, improving spectrum efficiency including potentially reducing cross border interference. Harmonization of spectrum for IMT would lead to increased commonality of equipment and is desirable for achieving economies of scale and affordability of equipment, thus promoting digital inclusion.

2.6 Studies on technical feasibility of IMT in bands above 100 GHz

The development of IMT for 2030 and beyond is expected to enable new use cases and applications with high data rate and low latency, which will benefit from large contiguous bandwidths of tens of GHz. This suggests the need to consider spectrum in higher frequency ranges above 92 GHz as a complement to the use of lower frequency bands.

A series of propagation measurement activities are being carried out in frequencies above 100 GHz under several different environments (such as outdoor urban and indoor office). ITU-R is developing a Report on the technical feasibility of IMT technologies in bands above 92 GHz, including coverage, link budget, mobility, impact of bandwidth and needed capabilities to support new use cases of IMT.

Further studies on the enabling antenna and semiconductor technologies, material technologies including reconfigurable intelligent surfaces, MIMO and beamforming technologies are needed to overcome major challenges of operating in bands above 92 GHz such as limited transmission power, the obstructed propagation environment due to high propagation losses and blockage.

Given the large bandwidth and high attenuation characteristics of bands above 92 GHz, some typical use cases include indoor/outdoor hot spots, integrated sensing and communication, sidelink, flexible wireless backhaul and fronthaul, etc.

The radio wave propagation assessment, measurements and technology development done so far indicate that utilizing the bands above 92 GHz could be feasible for some IMT deployment scenarios and could be considered for the development of IMT-2030.

3 Usage scenarios of IMT-2030

IMT-2030 is expected to expand and support various user, application and technology trends as described in § 2, while providing prospects towards a sustainable digital transformation.

IMT-2030 is expected to be built on overarching aspects which act as design principles commonly applicable to all usage scenarios. These distinguishing design principles of the IMT-2030 are including, but are not limited to, sustainability, security and resilience, connecting the unconnected for providing universal and affordable access to all users independent of the location, and ubiquitous intelligence for improving overall system performance.

Usage scenarios of IMT-2030 are envisaged to expand on those of IMT-2020 (i.e. eMBB, URLLC, and mMTC introduced in Recommendation ITU-R M.2083) into broader use requiring evolved and new capabilities. In addition to expanded IMT-2020 usage scenarios, IMT-2030 is envisaged to enable new usage scenarios arising from capabilities, such as artificial intelligence and sensing, which previous generations of IMT were not designed to support.

The usage scenarios of IMT-2030 include:

Immersive Communication

This usage scenario extends the enhanced Mobile Broadband (eMBB) of IMT-2020 and covers use cases which provide a rich and interactive video (immersive) experience to users, including the interactions with machine interfaces.

This usage scenario covers a range of environments, includingg hotspots, urban and rural, which arise with additional and new requirements compared with those of eMBB from IMT-2020.

Typical use cases include communication for immersive XR, remote multi-sensory telepresence, and holographic communications. Supporting mixed traffic of video, audio, and other environment data in a time-synchronized manner is an integral part of immersive communications, including also stand-alone support of voice.

Capabilities that aim for enhanced spectrum efficiency and consistent service experiences along with leveraging the balance between higher data rates and increased mobility in various environments are essential. Certain immersive communication use cases may also require support of high reliability and low latency for responsive and accurate interaction with real and virtual objects, as well as larger system capacity for simultaneously connecting numerous devices.

Hyper Reliable and Low-Latency Communication

This usage scenario extends the Ultra-Reliable and Low-Latency Communication (URLLC) of IMT-2020 and covers specialized use cases that are expected to have more stringent requirements on reliability and latency. This is typically for time-synchronized operations, where failure to meet these requirements could lead to severe consequences for the applications.

Typical use cases include communications in an industrial environment for full automation, control and operation. These types of communications can help in realizing various applications such as machine interactions, emergency services, tele-medicine, and monitoring for electrical power transmission and distribution.

This usage scenario would require support of enhanced reliability and low latency, and depending on the use case, precise positioning, and connection density.

Massive Communication

This usage scenario extends massive Machine Type Communication (mMTC) of IMT-2020 and involves connection of massive number of devices or sensors for a wide range of use cases and applications.

Typical use cases include expanded and new applications in smart cities, transportation, logistics, health, energy, environmental monitoring, agriculture, and many other areas such as those requiring a variety of IoT devices without battery or with long-life batteries.

This usage scenario would require support of high connection density, and depending on use cases, different data rates, low power consumption, mobility, extended coverage, and high security and reliability.

Ubiquitous Connectivity

This usage scenario is intended to enhance connectivity with the aim to bridge the digital divide. Connectivity could be enhanced, *inter alia*, through interworking with other systems (see § 5.1.2).

One focus of this usage scenario is to address presently uncovered or scarcely covered areas, particularly rural, remote and sparsely populated areas.

Typical use cases include, but not limited to, IoT and mobile broadband communication.

Artificial Intelligence and Communication

This usage scenario would support distributed computing and AI applications. Typical use cases include IMT-2030 assisted automated driving, autonomous collaboration between devices for medical assistance applications, offloading of heavy computation operations across devices and networks, creation of and prediction with digital twins, and others.

This usage scenario would require support of high area traffic capacity and user experienced data rates, as well as low latency and high reliability, depending on the specific use case. Besides communication aspects, this usage scenario is expected to include a set of new capabilities related to the integration of AI and compute functionalities into IMT-2030, including data acquisition, preparation and processing from different sources, distributed AI model training, model sharing and distributed inference across IMT systems, and computing resource orchestration and chaining.

Integrated Sensing and Communication

This usage scenario facilitates new applications and services that require sensing capabilities. It makes use of IMT-2030 to offer wide area multi-dimensional sensing that provides spatial information about unconnected objects as well as connected devices and their movements and surroundings.

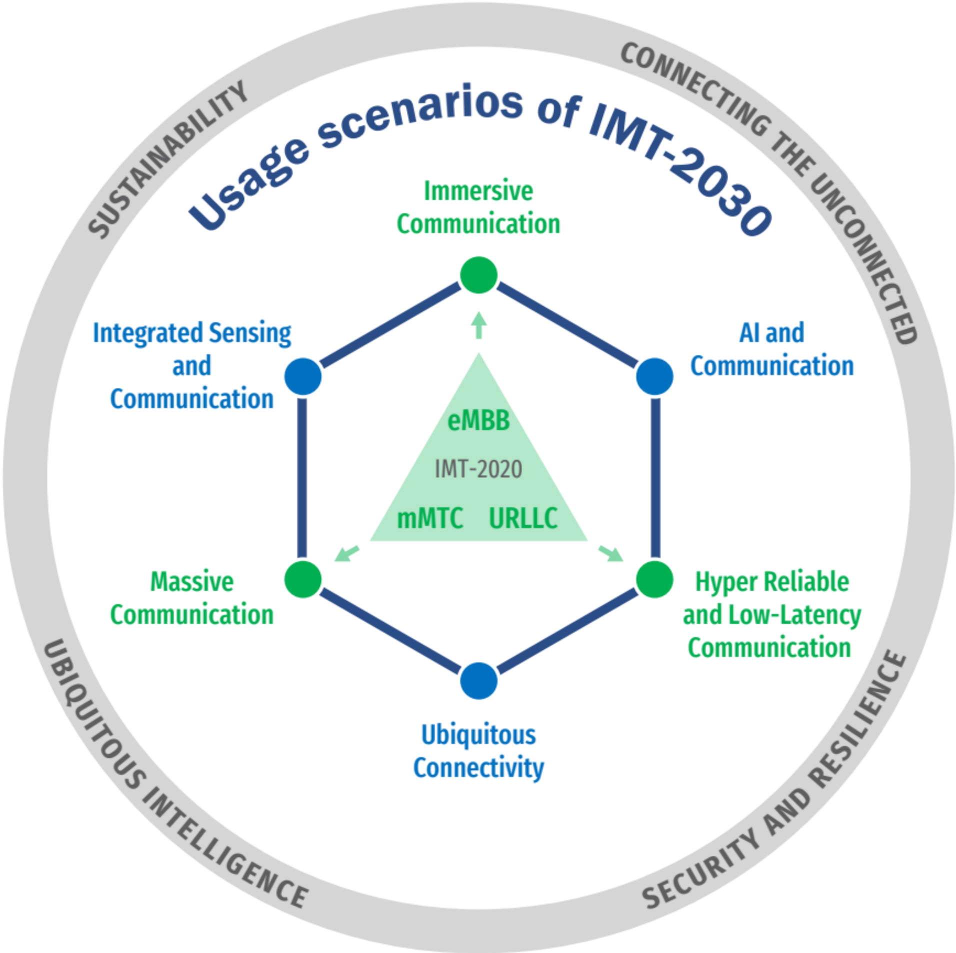
Typical use cases include IMT-2030 assisted navigation, activity detection and movement tracking (e.g. posture/gesture recognition, fall detection, vehicle/pedestrian detection), environmental monitoring (e.g. rain/pollution detection), and provision of sensing data/information on surroundings for AI, XR and digital twin applications.

Along with the provided communication capabilities, this usage scenario requires support of high-precision positioning and sensing-related capabilities, including range/velocity/angle estimation, object and presence detection, localization, imaging and mapping.

Figure 1 illustrates the usage scenarios for IMT-2030.

FIGURE 1

Usage scenarios and overarching aspects of IMT-2030



For the development of IMT-2030, flexibility would be necessary to adapt to new and unforeseen usage scenarios that may come up with a range of requirements. IMT-2030 is envisaged to encompass a large number of different features. Depending on the circumstances and the different needs in different countries, IMT-2030 is expected to be designed and function in a modular manner so that features can be added incrementally as the need arises.

4 Capabilities of IMT-2030

IMT-2030 is expected to provide enhanced capabilities compared to those described for IMT-2020 in Recommendation ITU-R M.2083, as well as new capabilities to support the expanded usage scenarios of IMT-2030. In addition, each capability could have different relevance and applicability in the different usage scenarios.

The range of values given for capabilities are estimated targets for research and investigation of IMT-2030. All values in the range have equal priority in research and investigation. For each usage scenario, a single or multiple values within the range would be developed in future in other ITU-R Recommendations/Reports. These values may further depend on certain parameters and assumptions including, but not limited to, frequency range, bandwidth, and deployment scenario. Further these values for the capabilities apply only to some of the usage scenarios and may not be reached simultaneously in a specific usage scenario.

The capabilities of IMT-2030 include:

1) Peak data rate

Maximum achievable data rate under ideal conditions per device.

The research target of peak data rate would be greater than that of IMT-2020[6]. Values of 50, 100, 200 Gbit/s are given as possible examples applicable for specific scenarios, while other values may also be considered.

2) User experienced data rate

Achievable data rate that is available ubiquitously[7] across the coverage area to a mobile device.

The research target of user experienced data rate would be greater than that of IMT-2020[8]. Values of 300 Mbit/s and 500 Mbit/s are given as possible examples, while other values greater than these examples may also be explored and considered accordingly.

3) Spectrum efficiency

Spectrum efficiency refers to average data throughput per unit of spectrum resource and per cell[9].

The research target of spectrum efficiency would be greater than that of IMT-2020. Values of 1.5 and 3 times greater than that of IMT-2020 could be a possible example, while other values greater than these examples may also be explored and considered accordingly.

4) Area traffic capacity

Total traffic throughput served per geographic area.

The research target of area traffic capacity would be greater than that of IMT-2020[10]. Values of 30 Mbit/s/m^2 and 50 Mbit/s/m^2 are given as possible examples, while other values greater than these examples may also be explored and considered accordingly.

5) Connection Density

Total number of connected and/or accessible devices per unit area.

The research target of connection density could be $10^6 – 10^8$ devices/km^2.

6) Mobility

Maximum speed, at which a defined QoS and seamless transfer between radio nodes which may belong to different layers and/or radio access technologies (multi-layer/multi-RAT) can be achieved.

The research target of mobility could be 500 – 1 000 km/h.

7) Latency

Latency over the air interface refers to the contribution by the radio network to the time from when the source sends a packet of a certain size to when the destination receives it.

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6 20 Gbit/s in Recommendation ITU-R M.2083.

7 The term "ubiquitous" is related to the considered target coverage area and is not intended to relate to an entire region or country.

8 100 Mbit/s in Recommendation ITU-R M.2083.

9 The coverage area over which a mobile terminal can maintain a connection with one or more units of radio equipment located within that area. For an individual base station, this is the coverage area of the base station or of a subsystem (e.g. sector antenna).

10 10 Mbit/s/m^2 in Recommendation ITU-R M.2083.

The research target of latency (over the air interface) could be 0.1 – 1 ms.

8) Reliability

Reliability over the air interface relates to the capability of transmitting successfully a predefined amount of data within a predetermined time duration with a given probability.

The research target of reliability (over the air interface) could range from $1\text{-}10^{-5}$ to $1\text{-}10^{-7}$.

9) Coverage

Coverage refers to the ability to provide access to communication services for users in a desired service area. In the context of this capability, coverage is defined as the cell edge distance of a single cell through link budget analysis.

10) Positioning

Positioning is the ability to calculate the approximate position of connected devices. Positioning accuracy is defined as the difference between the calculated horizontal/vertical position and the actual horizontal/vertical position of a device.

The research target of the positioning accuracy could be 1 – 10 cm.

11) Sensing-related capabilities

Sensing-related capabilities refer to the ability to provide functionalities in the radio interface including range/velocity/angle estimation, object detection, localization, imaging, mapping, etc. These capabilities could be measured in terms of accuracy, resolution, detection rate, false alarm rate, etc.

12) Applicable AI-related capabilities

Applicable AI-related capabilities refer to the ability to provide certain functionalities throughout IMT-2030 to support AI enabled applications. These functionalities include distributed data processing, distributed learning, AI computing, AI model execution and AI model inference, etc.

13) Security and resilience

In the context of IMT-2030:

- Security refers to preservation of confidentiality, integrity, and availability of information, such as user data and signalling, and protection of networks, devices and systems against cyberattacks such as hacking, distributed denial of service, man in the middle attacks, etc.
- Resilience refers to capabilities of the networks and systems to continue operating correctly during and after a natural or man-made disturbance, such as the loss of primary source of power, etc.

14) Sustainability

Sustainability, or more specifically environmental sustainability, refers to the ability of both the network and devices to minimize greenhouse gas emissions and other environmental impacts throughout their life cycle. Important factors include improving energy efficiency, minimizing energy consumption and the use of resources, for example by optimizing for equipment longevity, repair, reuse and recycling.

Energy efficiency is a quantifiable metric of sustainability. It refers to the quantity of information bits transmitted or received, per unit of energy consumption (in bit/Joule). Energy efficiency is expected to be improved appropriately with the capacity increase in order to minimize overall power consumption.

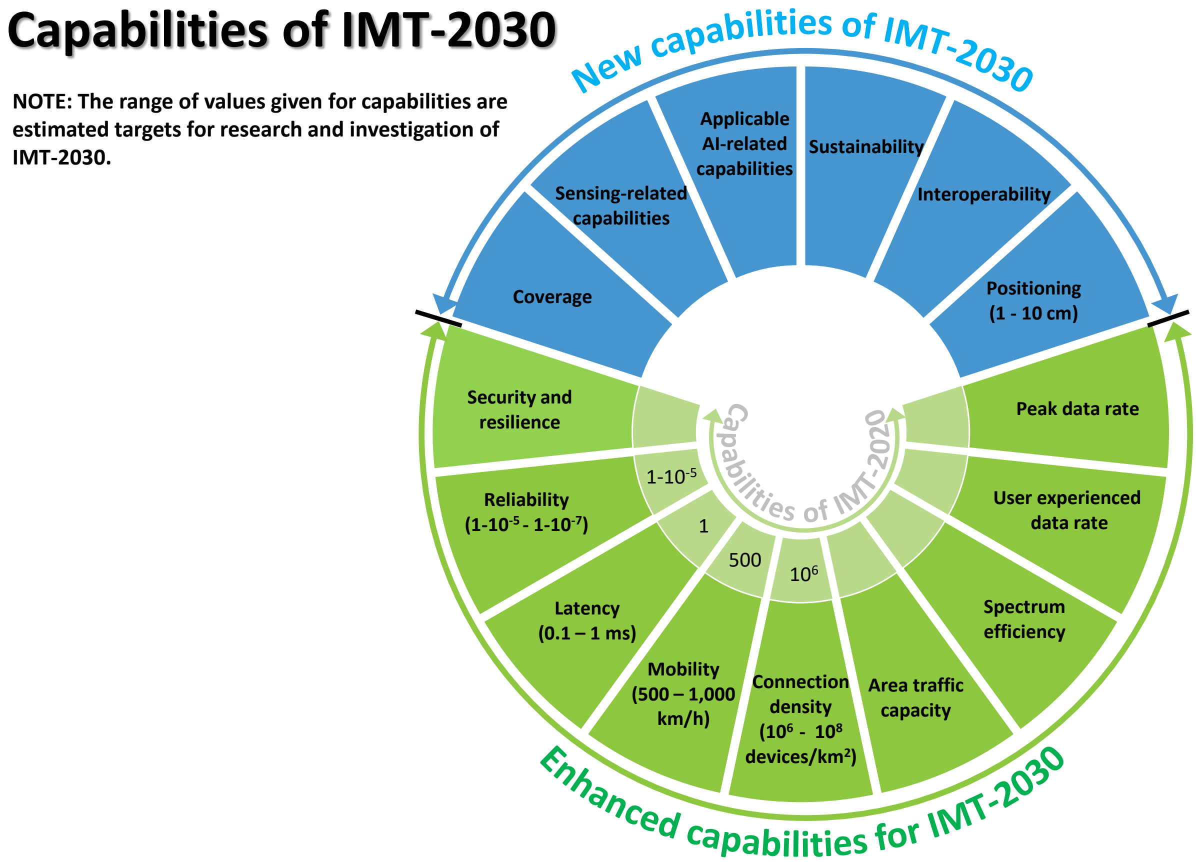
15) Interoperability

Interoperability refers to the radio interface being based on member-inclusivity and transparency, so as to enable functionality(ies) between different entities of the system.

The capabilities of IMT-2030 are shown in Fig. 2.

FIGURE 2

Capabilities of IMT-2030



5 Considerations of ongoing development

The objective of the development of IMT-2030 is to address the anticipated needs of users of mobile services in the years 2030 and beyond. This section provides relationships between IMT-2030 and existing IMT, other access systems, timelines and focus areas for further study.

5.1 Relationships

5.1.1 Relationship between IMT-2030 and existing IMT

In order to support emerging usage scenarios and applications for 2030 and beyond, it is foreseen that development of IMT-2030 would be required to offer enhanced capabilities as described in § 4. The values of these capabilities go beyond those described in Recommendation ITU-R M.2083. The minimum technical requirements (and corresponding evaluation criteria) are to be defined by ITU-R based on these capabilities for IMT-2030. They 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. Furthermore, IMT-2030 is envisaged to interwork with existing IMT.

5.1.2 Relationship between IMT-2030 and other access systems

The user experience could be enhanced when users have the option to access a variety of services, anytime and anywhere. This objective can be facilitated through interworking between different access networks. External standards developing organizations involved in the development of IMT radio interface technologies have ongoing standardization activities that facilitate IMT interworking with non-terrestrial networks of IMT (including satellite communication systems, HIBS and UASs), as well as with other non-IMT terrestrial networks (including RLAN and broadcast). IMT-2030 should continue this path of interworking to offer users an improved connectivity experience, including the option of offering ubiquitous and continuity of services, in line with service and operational goals.

5.2 Timelines

In planning for the development of IMT-2030 and in addition to ongoing enhancement of existing IMT systems, it is important to consider the timelines associated with its realization, which depends on several factors:

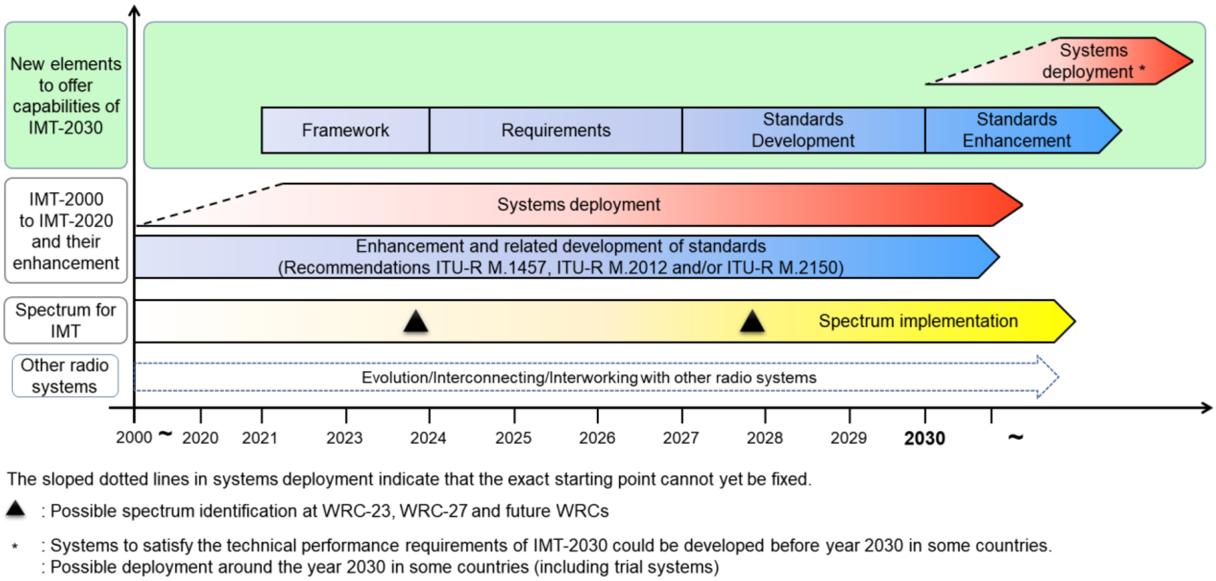
– user trends, requirements and user demand;
– technical capabilities and technological development;
– standards development and their enhancement;
– spectrum matters;
– regulatory considerations;
– system deployment.

These factors are interrelated, and have been and will continue to be addressed within ITU by relevant and responsible ITU entities, while system deployment would consider various practical aspects such as the cost of additional infrastructure investment, the time for customer adoption of services, etc. ITU plans to complete its initial standardization process of IMT-2030 no later than the year 2030 to support IMT-2030 deployment by ITU members from the year 2030 onwards.

The timelines for IMT-2030 are depicted in Fig. 3.

FIGURE 3

Anticipated perspective of the timelines for IMT-2030



Up to around the year 2030, it is envisaged that the further development of IMT-2000, IMT-Advanced and IMT-2020 will continue with the ongoing enhancement of their capabilities in current deployments, as demanded by the marketplace and allowed by technical developments. This term will be led by a growth in traffic and emerging new use cases within the existing IMT spectrum on both an exclusive and shared basis with other services. The development of IMT-2000, IMT-Advanced and IMT-2020 during this time will be distinguished by incremental or evolutionary changes to the existing radio interface specifications (i.e. Recommendations ITU-R M.1457 for IMT-2000, ITU-R M.2012 for IMT-Advanced and ITU-R M.2150 for IMT-2020, respectively).

Beginning around the year 2030, it is envisaged that the potential introduction of IMT-2030 could be deployed in some countries. IMT-2030 is envisaged to add the capabilities described in § 4.

IMT-2030 is expected to support the continuous evolution of features for future IMT systems, reducing the associated sustainability impact.

5.3 Focus areas for further study

Research forums and other external organizations that wish to contribute to the future development of IMT-2030 are encouraged to focus in the following key areas, and are not limited to:

– radio interface(s) standards development;

– access network related issues;

– traffic characteristics;

– spectrum related issues.

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