



Report ITU-R M.2514-0
(09/2022)

**Vision, requirements and evaluation
guidelines for satellite radio interface(s)
of IMT-2020**

M Series
**Mobile, radiodetermination, amateur
and related satellite services**



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Note: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.

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REPORT ITU-R M.2514-0

**Vision, requirements and evaluation guidelines for satellite radio interface(s)
of IMT-2020¹**

(2022)

TABLE OF CONTENTS

Policy on Intellectual Property Right (IPR).....	ii
1 Introduction	2
2 Purpose and scope	2
3 Structure of the Report	3
4 Related ITU-R and ITU-T documents.....	3
5 Acronyms and abbreviations	3
6 Vision on the satellite component of IMT-2020	4
6.1 Use cases.....	5
6.2 Capabilities	6
6.3 System.....	7
6.4 Radio interface.....	9
7 Requirements for the satellite radio interface(s) of IMT-2020.....	10
7.1 Service aspects.....	10
7.2 Technical performance requirements.....	10
8 Guidelines for evaluation of the satellite radio interface(s) of IMT-2020	17
8.1 Evaluation criteria.....	17
8.2 Evaluation methodology	17
Annex 1 Minimum requirements of the satellite component of IMT-2020.....	29
Annex 2 (for information only) Potential performance requirements for satellite component radio interface of IMT-2020 supporting channel bandwidth up to 400 MHz	30

¹ This vision, requirements and evaluation guidelines document may not apply to TDD systems operating in the 1 616 to 1 626.5 MHz frequency band.

1 Introduction

As defined in Resolution ITU-R 56, International Mobile Telecommunications-2020 (IMT-2020) systems are mobile systems that include new radio interface(s) which support the new capabilities of systems beyond IMT-2000 and IMT-Advanced. Based on Recommendation ITU-R M.2083, the capabilities of IMT-2020, include three service categories i.e. enhanced Mobile Broadband (eMBB), massive Machine Type Communications (mMTC) and ultra-Reliable and Low Latency Communications (URLLC) which are defined to support the multitude of applications and services for IMT-2020. The specific minimum technical requirements for these service categories (eMBB, mMTC, URLLC) are defined in Report ITU-R M.2410. In Recommendation ITU-R M.2083 – IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond, it is presented that various access technologies including a combination of different fixed, terrestrial and satellite networks should interwork in IMT-2020. Each component should fulfil its own role, but also be integrated² with other components to provide service continuity as well as reinforced availability to achieve ubiquitous seamless coverage.

Regarding the development of terrestrial radio interface(s) of IMT-2020, the ITU-R has already developed Recommendations ITU-R M.2083, ITU-R M.2150 and Reports ITU-R M.2320, ITU-R M.2376, ITU-R M.2410, ITU-R M.2411 and ITU-R M.2412 in order to define service and minimum technical requirements and present evaluation guidelines and criteria for the terrestrial radio interface(s) of IMT-2020. This sequence of Reports and Recommendations could serve as a model for work on the satellite radio interfaces of satellite IMT-2020.

It is envisioned that the satellite use cases and technical requirements for the satellite radio interface for IMT-2020 will differ from that of the terrestrial interface of IMT-2020 developed in 2017. The use and objective of satellite radio interfaces is expected to be complementary to terrestrial IMT-2020 operations, given satellites' unique ability to address coverage challenges and use-cases. Certain aspects of IMT-2020 are not expected to be served by the satellite radio interface for IMT-2020, for example very high data throughputs of eMBB, very high connection density of mMTC and low latency for URLLC, given the inherent distance of satellites to associated terminals or earth stations and the challenge of resulting greater latency compared to terrestrial operations. Therefore, the requirements and evaluation guidelines developed previously for the terrestrial component of IMT-2020 may be considered for the development of satellite radio interface(s) of IMT-2020 and modified considering specific satellite characteristics, such as modified throughput and user data rates, as necessary.

The new satellite-based service categories are reflected in the enhanced Mobile Broadband (eMBB-s), massive Machine Type Communications (mMTC-s) and High Reliability Communications (HRC-s) usage scenarios for the satellite component of IMT-2020. It is to be noted that these usage scenarios have been and are being provided by mobile satellite networks and systems, without these satellite services being part of the satellite component of IMT.

The vision presented in this Report for the satellite radio interface for IMT-2020 identifies new capabilities beyond that of the requirements defined for the satellite radio interface of IMT-Advanced in Report ITU-R M.2176.

2 Purpose and scope

The purpose of this Report is to build a vision, the requirements and evaluation guidelines for the satellite component of IMT-2020 including use cases, application scenarios, capabilities, system,

² Integration means that the satellite and terrestrial components of the network are able to work together seamlessly to provide coverage continuity to end users.

radio interface, and the considered specific features, particularly with respect to service and technical requirements.

3 Structure of the Report

- Section 4 provides a list of the documents that are related to this Report.
- Section 5 provides a list of acronyms and abbreviations.
- Section 6 describes visions on the satellite component of IMT-2020.
- Section 7 defines requirements for the satellite radio interface(s) of IMT-2020.
- Section 8 provides guidelines for evaluation of candidate satellite radio interface(s) of IMT-2020.

4 Related ITU-R and ITU-T documents

Recommendation ITU-R M.1182

Recommendation ITU-R M.1822

Recommendation ITU-R M.1850

Recommendation ITU-R M.2083

Recommendation ITU-R M.2047

Recommendation ITU-R M.2150

Report ITU-R M.2410

Report ITU-R M.2412

Report ITU-R M.2460

Report ITU-R SM.2423

Report ITU-R M.2176

Report ITU-R M.2411

Resolution ITU-R 56

Resolution ITU-R 65

Resolution 225 (Rev.WRC-12)

Recommendation ITU-T G.1010

5 Acronyms and abbreviations

CDF	Cumulative distribution function
DL	Downlink
eMBB	Enhanced mobile broadband
eMBB-s	Enhanced mobile broadband via satellite
GSO	Geostationary satellite orbit
HRC-s	High reliability communications via satellite
ICT	Information and communication technology
IMT	International mobile telecommunications

IoT	Internet of things
ISL	Inter-satellite link
LEO	Low earth orbit
MEO	Medium earth orbit
MIMO	Multiple input multiple output
mMTC	Massive machine type communications
mMTC-s	Massive machine type communications via satellite
MTD	Machine type device
PDU	Protocol data unit
QoE	Quality of experience
QoS	Quality of service
RIT	Radio interface technology
SDU	Service data unit
SRIT	Set of radio interface technologies
TDD	Time division duplex
TRxP	Transmission reception point
UE	User equipment
UL	Uplink
URLLC	Ultra-reliable and low-latency communications

6 Vision on the satellite component of IMT-2020

The ability to ensure global service continuity, high service reliability and availability is an important challenge for the whole ICT sector.

Meeting this challenge requires combining a variety of access technologies. Adding satellite component in the picture will contribute to extend the coverage of the IMT-2020 service in under and unserved areas where complementing the terrestrial component is most relevant. Moreover, the two types of network components will contribute to increase the overall reliability of the IMT-2020 systems.

Different levels of integration, as described in Recommendation ITU-R M.1182 may be used, which may benefit from adopting a common architecture framework to improve support of mobility management, multiconnectivity³, service continuity and enhance the reliability/quality of the service.

Given that the terrestrial component of IMT-2020 is already defined, the satellite component of IMT-2020 should take into account the capabilities, the system architecture and the radio interface(s) of the terrestrial component. Moreover, it should be clear that due to inherent physical constraints, the satellite component will feature different technical and performance characteristics (e.g. latency, data rate) compared to the terrestrial component.

³ Multiconnectivity in this instance refers to user equipment that may be connected to two or more network nodes.

The aim of this section is to define visions of the satellite component of IMT-2020 with respect to use cases, capabilities, system, radio and network interface aspects, taking into account the task of maintaining network coverage seamlessly based on the use of terrestrial and satellite communication links.

Various radio interfaces may be considered, as different satellite systems could communicate only with terminals having compatible radio interfaces.

The QoE (Quality of Experience) by end-users should always be maximized to the extent possible with respect to the service requirement, regardless of what physical principles the communication and data transmission channels are based on.

6.1 Use cases

Recommendation ITU-R M.2083 on the IMT-2020 vision, identifies three usage scenarios for IMT-2020 and beyond: Enhanced Mobile Broadband (eMBB), Massive machine type communications (mMTC) and Ultra-reliable and low latency communications (URLLC). Satellite networks providing the satellite component of IMT-2020⁴ are envisioned to provide eMBB-s and mMTC-s usage scenarios that are satellite variants of eMBB and mMTC defined in Recommendation ITU-R M.2083. The suffix –s of the naming captures the satellite specificity in terms of expected performance. The satellite component of IMT-2020 will not address the URLLC, but will cover the satellite specific High Reliability Communications (HRC-s) usage scenario. Use cases specific to the three categories are described hereunder.

The satellite component can be used to provide many different applications, for example:

- Global connectivity to end user devices
- Network resilience through high availability combined with high reliability for HRC-s
- Connectivity for transportation purposes
- Content delivery in broadcast or multicast mode to end user devices
- Machine type communications

The Enhanced Mobile Broadband (eMBB-s) usage scenario, in the context of the satellite component of IMT-2020, should support high data rate applications in rural and remote areas, air and maritime environments, and, in some cases, suburban areas. Terminal devices on the move, capable of supporting communications at high velocity, should be supported to meet transportation needs and their associated users. Specifically, the following cases are identified:

- Coverage continuity: moving pedestrian (consumer smart phones) should be able to maintain access to a large range of communication services and applications while moving out to remote areas for e.g. remote working, leisure, etc.
- Connecting populations in unserved or underserved areas
- Connectivity to transport: buses, trains, vessels (leisure or cruise) or airplanes
- Public safety: to provide communication services (e.g. messaging, voice, video) to emergency responders (e.g. fire brigade, medical personnel).

The massive machine type communications (mMTC-s) provided through the satellite component of IMT-2020 should be able to address large number of scattered connected fixed or mobile devices

⁴ This Report describes RITs/SRITs key requirements related to the minimum technical performance of satellite component of IMT-2020. However, mobile broadband, machine type and high reliability communications can and have been provided by a variety of satellite technologies outside of the IMT-2020 ecosystem. Such technologies are outside the scope of this report.

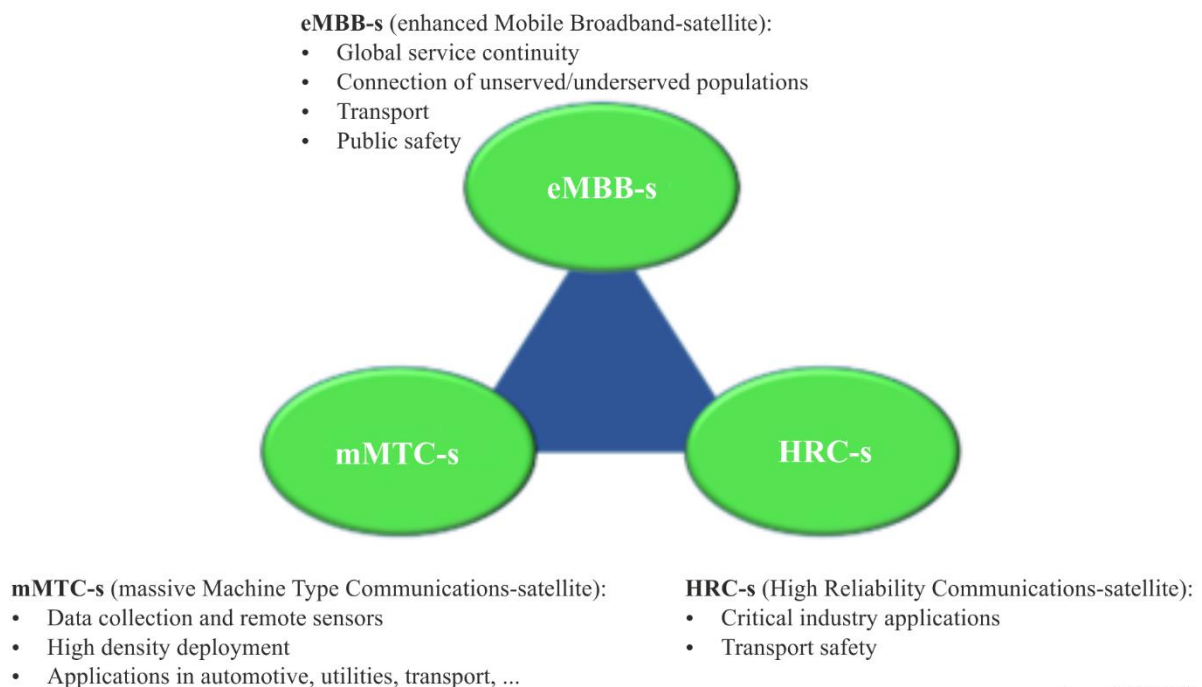
over wide areas. Such devices may be low cost and have long battery life. Several use cases typical of the mMTC-s usage scenario in a satellite context are identified below:

- Automotive: this may include traffic flow optimisation, automotive diagnostic, safety status reporting
- Utilities: e.g. surveillance of oil/gas, energy/water supply infrastructures, wind farms
- Transport (road, railway, maritime, aeronautic): Fleet management, asset tracking, digital signage, remote roads alerts.

The high reliability communications (HRC-s) scenario has specific requirements for availability and reliability.

Figure 1 below illustrates the use cases specific to the satellite component of IMT-2020.

FIGURE 1
Satellite component of IMT-2020 use cases



Report M.2514-01

Annex 1 provides a summary of the minimum requirements for the satellite component of IMT-2020 radio interface supporting channel bandwidth up to 30 MHz.

6.2 Capabilities

Recommendation ITU-R M.2083 considered the following eight parameters as key capabilities for IMT-2020 system:

- Peak data rate
- User experienced data rate
- Latency
- Mobility
- Connection density
- Energy efficiency

- Spectrum efficiency
- Area traffic capacity.

These parameters are also considered relevant for the satellite component of IMT-2020.

Due to inherent constraints resulting from the distance between satellite user equipment and the space station, the satellite component will feature different technical and performance capabilities compared to the terrestrial component. Also, it should be noted that different satellite networks and systems have unique characteristics and architectures in delivering their services.

6.3 System

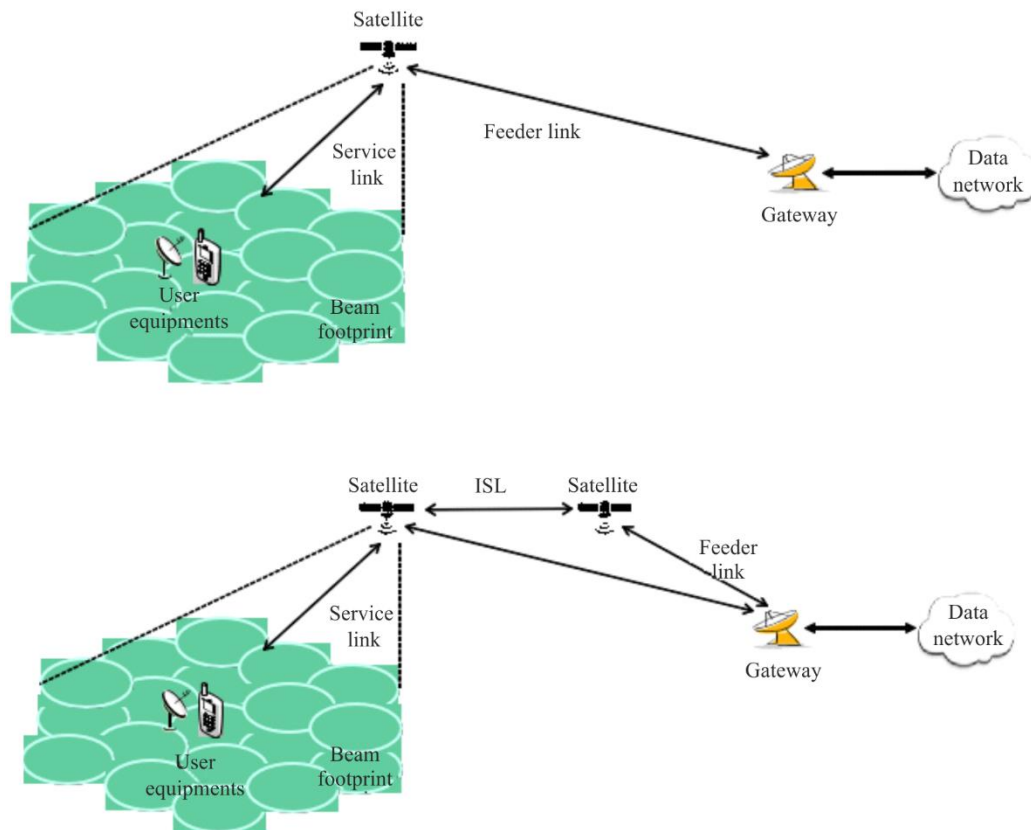
Recommendation ITU-R M.2083 states that: “Users should be able to access services anywhere, anytime. To achieve this goal, interworking will be necessary among various access technologies, which might include a combination of different fixed, terrestrial and satellite networks. Each component should fulfil its own role, but also should be integrated or interoperable with other components to provide ubiquitous seamless coverage.” These systems will rely on technologies to switch between the satellite and terrestrial components of IMT to enable a user to receive connectivity. In addition, terrestrial and satellite networks can complement one another to meet specific requirements for additional capacity and coverage in any areas, including in those areas underserved by terrestrial IMT, as well address other performance requirements.

Advances in satellite technology which could also benefit IMT-2020 satellite component services include:

- Flexible payloads enabling
 - Beam forming of up to thousand beams
 - Moving or earth-fixed cells, through continuous beam steering
 - In-orbit reconfigurability (e.g. beam pattern, frequency plan)
 - Support of part or all of radio access network functions
- Large antennas: large aperture onboard antennas to provide high directivity towards users
- Large constellation thanks to optimized manufacturing, deployment and operation processes
- Inter-satellite links (ISL) where relevant through RF or optical bands.

FIGURE 2

Example of typical system scenarios whereby the satellite implements respectively a transparent and a regenerative payload



Report M.2514-02

Figure 2 illustrates two typical system scenarios whereby the satellite implements respectively a transparent and a regenerative payload. In both cases, the Satellite Radio Interface (SRI) is implemented on the service link between the satellite and the User Equipment (UE). The UE is the termination point at the user side of the IMT-2020 satellite radio interface link.

In the satellite context, the base station is the network termination point of the satellite radio interface link serving the UE. In the case of a transparent satellite, the base station is located on the ground, e.g. at the gateway earth station. In the case of a regenerative satellite, the base station may be located (all or in part) on board the satellite.

The other links (feeder links, ISL) and functional units are represented only for information to show the overall operational context of the Satellite Radio Interface.

In Fig. 2 above:

- The first image illustrates a transparent payload: the satellite payload forwards the SRI protocol between the service link and the feeder link. For example, such payload may implement radio frequency filtering, frequency conversion, signal processing and amplification. Protocol-related base station functions are handled at the gateway earth stations. The use of inter-satellite links is not foreseen in this case.
- The second image illustrates a regenerative payload: the payload processes the SRI protocol between the service link and the feeder link, with potential use of inter-satellite links depending on the chosen architecture. For example, such payload may implement radio frequency filtering, frequency conversion, signal processing, routing/switching, protocol