REPORT ITU-R M.2134

Requirements related to technical performance for IMT-Advanced radio interface(s)

(2008)

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1 Introduction

International Mobile Telecommunications-Advanced (IMT-Advanced) systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-2000. Such systems provide access to a wide range of telecommunication services including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet-based.

IMT-Advanced systems support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments. IMT-Advanced also has capabilities for high-quality multimedia applications within a wide range of services and platforms providing a significant improvement in performance and quality of service.

The key features of IMT-Advanced are:

– a high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost efficient manner;
– compatibility of services within IMT and with fixed networks;
– capability of interworking with other radio access systems;
– high-quality mobile services;
– user equipment suitable for worldwide use;
– user-friendly applications, services and equipment;
– worldwide roaming capability;
– enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research)[1].

These features enable IMT-Advanced to address evolving user needs.

The capabilities of IMT-Advanced systems are being continuously enhanced in line with user trends and technology developments.

2 Scope and purpose

This Report describes requirements related to technical performance for IMT-Advanced candidate radio interfaces. These requirements are used in the development of Report ITU-R M.2135.

This Report also provides the necessary background information about the individual requirements and the justification for the items and values chosen. Provision of such background information is needed for a broader understanding of the requirements.

This Report is based on the ongoing development activities from external research and technology organizations.

[1] Data rates sourced from Recommendation ITU-R M.1645.

3 Related ITU-R texts

Recommendation ITU-R M.1224

Recommendation ITU-R M.1645

Recommendation ITU-R M.1768

Recommendation ITU-R M.1822

Report ITU-R M.2038

Report ITU-R M.2072

Report ITU-R M.2074

Report ITU-R M.2078

Report ITU-R M.2079

Report ITU-R M.2135

Report ITU-R M.2133.

4 Minimum requirements

IMT-Advanced can be considered from multiple perspectives, including the users, manufacturers, application developers, network operators, and service and content providers as noted in § 4.2.2 in Recommendation ITU-R M.1645 – Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000. Therefore, it is recognized that the technologies for IMT-Advanced can be applied in a variety of deployment scenarios and can support a range of environments, different service capabilities, and technology options. Consideration of every variation to encompass all situations is therefore not possible; nonetheless the work of the ITU-R has been to determine a representative view of IMT-Advanced consistent with the process defined in Resolution ITU-R 57 – Principles for the process of development of IMT-Advanced and the requirements defined in this Report.

The requirements presented in this document are for the purpose of consistent definition, specification, and evaluation of the candidate RITs or SRITs for IMT-Advanced in ITU-R in conjunction with the development of Recommendations and Reports, such as the framework and key characteristics and the detailed specifications of IMT-Advanced. The intent of these requirements is to ensure that IMT-Advanced technologies are able to fulfil the objectives of IMT-Advanced and to set a specific level of minimum performance that each proposed technology needs to achieve in order to be considered by ITU-R for IMT-Advanced.

These requirements are not intended to restrict the full range of capabilities or performance that candidate technologies for IMT-Advanced might achieve, nor is it intended to describe how the IMT-Advanced technologies might perform in actual deployments under operating conditions that could be different from those presented in ITU-R Recommendations and Reports on IMT-Advanced.

Requirements are to be evaluated according to the criteria defined in Report ITU-R M.2135 – Requirements, evaluation criteria, and submission templates for the development of IMT-Advanced.

NOTE 1 − The values herein are for a radio interface technology (RIT) or a set of radio interface technologies (SRIT).

4.1 Cell spectral efficiency

Cell[2] spectral efficiency (η) is defined as the aggregate throughput of all users (the number of correctly received bits, i.e. the number of bits contained in the service data units (SDUs) delivered to Layer 3, over a certain period of time) divided by the channel bandwidth divided by the number of cells. The channel bandwidth for this purpose is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalised appropriately considering the uplink/downlink ratio.

The cell spectral efficiency is measured in bit/s/Hz/cell.

Let χ_i denote the number of correctly received bits by user i (downlink) or from user i (uplink) in a system comprising a user population of N users and M cells. Furthermore, let ω denote the channel bandwidth and T the time over which the data bits are received. The cell spectral efficiency, η, is then defined according to equation (1).

$$\eta = \frac{\sum_{i=1}^{N} \chi_i}{T \cdot \omega \cdot M} \tag{1}$$

TABLE 1

Cell spectral efficiency

Test environment (1)	**Downlink (bit/s/Hz/cell)**	**Uplink (bit/s/Hz/cell)**
Indoor	3	2.25
Microcellular	2.6	1.80
Base coverage urban	2.2	1.4
High speed	1.1	0.7

(1) The test environments are described in Report ITU-R M.2135.

These values were defined assuming an antenna configuration of downlink 4 × 2, uplink 2 × 4. However, this does not form part of the requirement and the conditions for evaluation are described in Report ITU-R M.2135

4.2 Peak spectral efficiency

The peak spectral efficiency is the highest theoretical data rate (normalised by bandwidth), which is the received data bits assuming error-free conditions assignable to a single mobile station, when all available radio resources for the corresponding link direction are utilised (i.e., excluding radio resources that are used for physical layer synchronisation, reference signals or pilots, guard bands and guard times).

[2] A cell is equivalent to a sector, e.g. a 3-sector site has 3 cells.

The minimum requirements for peak spectral efficiencies are as follows[3]:

– Downlink peak spectral efficiency is 15 bit/s/Hz

– Uplink peak spectral efficiency is 6.75 bit/s/Hz.

These values were defined assuming an antenna configuration of downlink 4 × 4, uplink 2 × 4. However this does not form part of the requirement and the conditions for evaluation are described in Report ITU-R M.2135.

4.3 Bandwidth

Scalable bandwidth is the ability of the candidate RIT to operate with different bandwidth allocations. This bandwidth may be supported by single or multiple RF carriers.

The RIT shall support a scalable bandwidth up to and including 40 MHz.

Proponents are encouraged to consider extensions to support operation in wider bandwidths (e.g. up to 100 MHz) and the research targets expressed in Recommendation ITU-R M.1645.

4.4 Cell edge user spectral efficiency

The (normalized) user throughput is defined as the average user throughput (the number of correctly received bits by users, i.e., the number of bits contained in the SDU delivered to Layer 3, over a certain period of time, divided by the channel bandwidth and is measured in bit/s/Hz. The channel bandwidth for this purpose is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalised appropriately considering the uplink/downlink ratio. The cell edge user spectral efficiency is defined as 5% point of the cumulative distribution function (CDF) of the normalized user throughput. Table 2 lists the cell edge user spectral efficiency requirements for various test environments.

With χ_i denoting the number of correctly received bits of user i, T_i the active session time for user i and ω the channel bandwidth, the (normalized) user throughput of user i, γ_i, is defined according to equation (2).

$$\gamma_i = \frac{\chi_i}{T_i \cdot \omega} \tag{2}$$

TABLE 2

Cell edge user spectral efficiency

Test environment(1)	Downlink (bit/s/Hz)	Uplink (bit/s/Hz)
Indoor	0.1	0.07
Microcellular	0.075	0.05
Base coverage urban	0.06	0.03
High speed	0.04	0.015

(1) The test environments are described in Report ITU-R M.2135.

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3 For information, theoretical peak data rates can then be determined as in the following examples, which are calculated by multiplying the peak spectral efficiency and the bandwidth:

– Example downlink peak data rate in 40 MHz is 600 Mbit/s.

– Example downlink peak data rate in 100 MHz is 1 500 Mbit/s.

– Example uplink peak data rate in 40 MHz is 270 Mbit/s.

– Example uplink peak data rate in 100 MHz is 675 Mbit/s.

These values were defined assuming an antenna configuration of downlink 4 × 2, uplink 2 × 4. However, this does not form part of the requirement and the conditions for evaluation are described in Report ITU-R M.2135.

4.5 Latency

4.5.1 Control plane latency

Control plane (C-Plane) latency is typically measured as the transition time from different connection modes, e.g., from idle to active state. A transition time (excluding downlink paging delay and wireline network signalling delay) of less than **100 ms** shall be achievable from idle state to an active state in such a way that the user plane is established.

4.5.2 User plane latency

The user plane latency (also known as transport delay) is defined as the one-way transit time between an SDU packet being available at the IP layer in the user terminal/base station and the availability of this packet (protocol data unit, PDU) at IP layer in the base station/user terminal. User plane packet delay includes delay introduced by associated protocols and control signalling assuming the user terminal is in the active state. IMT-Advanced systems shall be able to achieve a user plane latency of less than **10 ms** in unloaded conditions (i.e., a single user with a single data stream) for small IP packets (e.g., 0 byte payload + IP header) for both downlink and uplink.

4.6 Mobility

The following classes of mobility are defined:

– Stationary: 0 km/h

– Pedestrian: > 0 km/h to 10 km/h

– Vehicular: 10 to 120 km/h

– High speed vehicular: 120 to 350 km/h

Table 3 defines the mobility classes that shall be supported in the respective test environment.

TABLE 3

Mobility classes

	Test environments[1]			
	Indoor	**Microcellular**	**Base coverage urban**	**High speed**
Mobility classes supported	Stationary, pedestrian	Stationary, pedestrian, Vehicular (up to 30 km/h)	Stationary, pedestrian, vehicular	High speed vehicular, vehicular

[1] The test environments are described in Report ITU-R M.2135.

A mobility class is supported if the traffic channel link data rate, normalized by bandwidth, on the uplink, is as shown in Table 4, when the user is moving at the maximum speed in that mobility class in each of the test environments.

TABLE 4

Traffic channel link data rates

	Bit/s/Hz	Speed (km/h)
Indoor	1.0	10
Microcellular	0.75	30
Base coverage urban	0.55	120
High speed	0.25	350

These values were defined assuming an antenna configuration of downlink 4 × 2, uplink 2 × 4. However, this does not form part of the requirements and the conditions for evaluation are described in Report ITU-R M.2135.

4.7 Handover

The handover interruption time is defined as the time duration during which a user terminal cannot exchange user plane packets with any base station. The handover interruption time includes the time required to execute any radio access network procedure, radio resource control signalling protocol, or other message exchanges between the user equipment and the radio access network, as applicable to the candidate RIT or SRIT. For the purposes of determining handover interruption time, interactions with the core network (i.e., network entities beyond the radio access network) are assumed to occur in zero time. It is also assumed that all necessary attributes of the target channel (that is, downlink synchronisation is achieved and uplink access procedures, if applicable, are successfully completed) are known at initiation of the handover from the serving channel to the target channel.

The IMT-Advanced proposal shall be able to support handover interruption times specified in Table 5.

TABLE 5

Handover interruption times

Handover type	Interruption time (ms)
Intra-frequency	27.5
Inter-frequency	
– within a spectrum band	40
– between spectrum bands	60

In addition, inter-system handovers between the candidate IMT-Advanced system and at least one IMT system shall be supported, but are not subject to the limits in Table 5.

4.8 VoIP capacity

VoIP capacity was derived assuming a 12.2 kbit/s codec with a 50% activity factor such that the percentage of users in outage is less than 2% where a user is defined to have experienced a voice outage if less than 98% of the VoIP packets have been delivered successfully to the user within a one way radio access delay bound of 50 ms.

However, this codec does not form a part of the requirements and the conditions for evaluation are described in Report ITU-R M.2135.

The VoIP capacity is the minimum of the calculated capacity for either link direction divided by the effective bandwidth in the respective link direction[4].

These values were defined assuming an antenna configuration of 4 × 2 in the downlink and 2 × 4 in the uplink. However, the antenna configuration is not a minimum requirement and the conditions for evaluation are described in Report ITU-R M.2135.

TABLE 6

VoIP capacity

Test environment[(1)]	**Min VoIP capacity (Active users/sector/MHz)**
Indoor	50
Microcellular	40
Base coverage urban	40
High speed	30

(1) The test environments are described in Report ITU-R M.2135.

[4] In other words, the effective bandwidth is the operating bandwidth normalised appropriately considering the uplink/downlink ratio.