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**ITU-R**  
Radiocommunication Sector of ITU

**Report ITU-R M.2176-1**  
(09/2012)

**Vision and requirements for the satellite  
radio interface(s) of IMT-Advanced**

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



International  
Telecommunication  
Union

## Foreword

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## REPORT ITU-R M.2176-1

**Vision and requirements for the satellite radio interface(s)  
of IMT-Advanced**

(2010-2012)

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## 1 Introduction

International Mobile Telecommunications-Advanced (IMT-Advanced) systems are mobile service 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 anywhere, 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 (i.e. wideband) to support advanced services and applications.

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.

The satellite component of IMT-Advanced will be an integral part of the future IMT infrastructure with the optimized service delivery.

Regarding the development of terrestrial radio interface(s) of IMT-Advanced, ITU-R Working Party 5D has already developed the Reports ITU-R M.2133, ITU-R M.2134 and ITU-R M.1235 in order to define service and technical minimum requirements and present evaluation guidelines and criteria for the terrestrial radio interface(s) of IMT-Advanced. However, it is indicated that ITU-R Working Party 5D did not take into consideration characteristics of satellite systems on the development of those Reports. Therefore, the requirements and evaluation guidelines developed by Working Party 5D should be considered for the development of satellite radio interface(s) of IMT-Advanced and modified considering specific satellite characteristics, such as longer transmission time between the satellite and earth terminal or earth station, if necessary.

## 2 Scope

The purpose of this Report is to build visions of the satellite component of IMT-Advanced in terms of application scenarios, services, system, radio interface and network aspects and the considered specific features, to address the high-level of constraints placed on the satellite radio interface(s) of IMT-Advanced, particularly with respect to service and technical requirements. In addition, this Report provides evaluation criteria and a methodology for evaluation of the requirements in order to produce Recommendations for development of the satellite radio interface(s) of IMT-Advanced.

### 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 definitions, acronyms and abbreviations.

Section 6 describes visions on the satellite component of IMT-Advanced.

Section 7 defines requirements for the satellite radio interface(s) of IMT-Advanced.

Section 8 provides guidelines for evaluation of candidate satellite radio interface(s) of IMT-Advanced.

Section 9 provides a list of references.

### 4 Related ITU documents

Resolution ITU-R 57

Recommendation ITU-R M.1645

Recommendation ITU-R M.1822

Report ITU-R M.2133

Report ITU-R M.2134

Report ITU-R M.2135.

### 5 List of definitions, acronyms and abbreviations

#### 5.1 Definitions

None.

#### 5.2 Acronyms and abbreviations

3GPP	Third Generation Partnership Project
ACM	Adaptive Coding and Modulation
ARQ	Automatic Repeat request
CDMA	Code-Division Multiple Access
CGC	Complementary Ground Component
DL	Downlink
e.i.r.p.	Equivalent Isotropically Radiated Power
FDD	Frequency-Division Duplexing
FDMA	Frequency-Division Multiple Access
FEC	Forward Error Correction
FH	Frequency Hopping
$G/T$	Antenna Gain to noise Temperature ratio
HARQ	Hybrid Automatic Repeat request
IDMA	Interleave Division Multiple Access

IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IPv6	Internet Protocol version 6
IMAP	Internet Message Access Protocol
IMT	International Mobile Telecommunications
ITS	Intelligent Transport Systems
LMS	Land Mobile Satellite
LTE	Long-Term Evolution
MAC	Media Access Control
MCW	Multi-Codeword
MIMO	Multiple-Input and Multiple-Output
MS	Mobile Station
MUD	Multi-User Detection
NGN	Next-Generation Network
OFDM	Orthogonal Frequency-Division Multiplexing
OFDMA	Orthogonal Frequency-Division Multiple Access
PAPR	Peak to Average Power Ratio
PF	Proportional Fairness
PHY	Physical
PN	Pseudo Noise
QoS	Quality of Service
POP	Post Office Protocol
RF	Radio Frequency
RIT	Radio Interface Technology
RRM	Radio Resource Management
RNC	Radio Network Controller
RX	Receiver
SCW	Single Codeword
SDMA	Space-Division Multiple Access
SDR	Software Defined Radio
SRIT	Set of Radio Interface Technology
STBC	Space-Time Block Coding
STC	Space-Time Coding
TDD	Time-Division Duplexing
TDMA	Time-Division Multiple Access
TX	Transmitter

UL	Uplink
UT	User Terminal
VoIP	Voice over Internet Protocol

## **6 Visions of the satellite component of IMT-Advanced**

IMT-Advanced systems are mobile service systems that include the new capabilities of IMT going 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 anywhere, providing a significant improvement in performance and quality of service.

As the terrestrial component alone would not be deployed all over the world, the satellite component of IMT-Advanced systems would be complementary in order to provide a seamless service with global coverage.

The aim of this section is to define visions of the satellite component of IMT-Advanced for an efficient IMT service delivery with respect to application scenarios, services, system, radio and network interface aspects, and to provide possible candidate system architectures.

### **6.1 Application scenarios**

The application scenarios include:

- two-way communications using a multibeam configuration with frequency reuse scheme; and,
- interactive digital multimedia broadcasting using a multibeam configuration.

The two-way communications can be regarded as a coverage extension for service continuity of the terrestrial component with vertical handover. One of the major advantages of using satellite is its capability to provide a global coverage. It can offer services in certain regions beyond terrestrial coverage. The areas not adequately covered by the terrestrial component include physically isolated regions, gaps in the terrestrial network coverage and areas where the terrestrial infrastructure is destroyed in the event of a disaster. In the scenario of “two-way communications using a multibeam configuration with frequency reuse scheme”, the handover technique between the satellite and terrestrial components of IMT-Advanced system is the most important aspect to consider. For cost-effective vertical handover, future satellite radio interfaces of IMT-Advanced should be compatible and have a high degree of commonality with the terrestrial interface. This offers the possibility of reusing the terrestrial component technology in order to reduce complexity of user terminal and network equipment allowing low cost and fast development.

In addition, this satellite radio interface, with some adaptation, can provide interactive multimedia broadcasting services in the same manner as the terrestrial radio interfaces of IMT-Advanced which are being developed to handle efficiently multimedia broadcasting and multicasting services as well as a bidirectional communication services. In the “interactive multimedia broadcasting” scenario, an integrated satellite and complementary ground component (CGC) infrastructure would be required taking into account that the satellite component of IMT-Advanced has an advantage over the terrestrial component when it is required to deliver the same contents to users spread over a wide geographical area.



## 6.2 Services aspects

The following high-level requirements are described in Recommendation ITU-R M.1822:

- Seamless connectivity
- Mobility management
- Interoperability
- Constant connections
- Applicability scalability
- Security
- Prioritization
- Location
- Broadcast/multicast
- Presence
- Usability including voice reconfiguration and user-friendly human-to-machine interface
- Support of a wide range of services.

Table 1 provides a wide range of telecommunication services provided by IMT that will increase as new applications are developed based on advances in technology.

TABLE 1  
IMT services and examples

User experience class	Service class	Example services
Conversational	Basic conversational	Voice telephony (including VoIP) Emergency calling Push-to-talk
	Rich conversational	Videoconference High-quality video telephony Remote collaboration e-education (e.g. video call to teacher) Consultation (e.g. video interaction with doctor) Mobile commerce
	Conversational low delay	Interactive gaming Consultation Priority service



TABLE 1 (*end*)

User experience class	Service class	Example services
Interactive	Interactive high delay	e-education (e.g. data search) Consultation (e.g. data search) Internet browsing Mobile commerce Location-based services ITS-enabled services
	Interactive low delay	Emergency calling e-mail (IMAP server access) Remote collaboration (e.g. desktop sharing) Public alerting (e.g. with feedback) Messaging (instant messaging) Mobile broadcasting/multicasting (mobile interactive personalized TV) Interactive gaming
Streaming	Streaming live	Emergency calling Public alerting e-education (e.g. remote lecture) Consultation (e.g. remote monitoring) Machine-to-machine (e.g. observation) Mobile broadcasting/multicasting Multimedia
	Streaming non-live	Mobile broadcasting/multicasting e-education (e.g. education movies) Multimedia Mobile commerce Remote collaboration
Background	Background	Messaging, Video messaging Public alerting e-mail (transfer RX/TX, e.g. POP) Machine-to-machine File transfer/download e-education (file download/upload) Consultation (file download/upload) Internet browsing Location-based service

The development of mobile telecommunication networks and the need for higher data rates is driving the development of new user services and concurrently creates the possibility of staying connected everywhere in the best possible condition. The services required for the satellite component of IMT-Advanced would be similar to those provided by the terrestrial component assuming that new applications and new user services may appear.

To make provision for mobile broadcasting/multicasting services, specific satellite resources may be dedicated to them.

The system network layer has to support these different types of services with different requirements. Moreover, the satellite system constraints will have an impact on the latency, jitter,

average and peak throughput and corresponding QoS parameters. In addition, support of VoIP at the same level of QoS as the terrestrial component may impose constraints on the satellite component of IMT-Advanced.

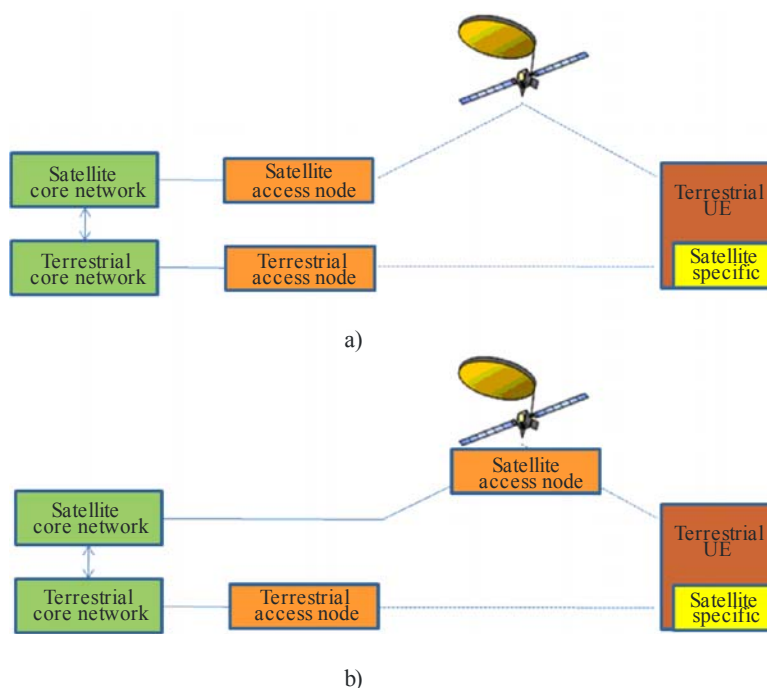
### 6.3 System aspects

As mentioned above, the integration between satellite and terrestrial components of IMT-Advanced is required in order to effectively utilize the respective areas of strength of each network within their traditional roles and mandate. An integrated satellite and terrestrial network can contribute to the emergence and utility of Next-Generation Networks (NGNs) in providing ubiquitous and universal broadband versatile IP-based services to end users who will require generalized mobility, accessed in a seamless fashion and, ultimately, will dictate its realization through market forces. A typical large-scale integrated system comprises multi-beam satellites and a nationwide or regional ensemble of CGC and terrestrial components wherein both satellite and CGC segments communicate with user equipment using a common set of mobile-satellite service (MSS) frequencies to handle broadcasting scenarios, while terrestrial components use a separate set of frequencies to provide ubiquitous coverage of broadband two-way communications to end users with generalized mobility requirements.

The satellite component of IMT-Advanced is expected to have sufficient power and receiver sensitivity to establish communications with end-user devices that are indistinguishable from the terrestrial component. Large satellite antennas, providing high-gain reconfigurable multi-beam are one of the key attributes of integrated systems. These features enable increased spectrum reuse as well as communications via typical low-cost handheld terminals. User equipment of an integrated system should have the capability of selecting the relevant component – either the satellite- or terrestrial-based – on the receiving signal level and network availability to keep a given service quality over a wide and continuous service area. It would be preferable that the integrated system could have roaming capability with a unique user/subscriber identifier across both terrestrial and satellite components. Handover between satellite and terrestrial components in an integrated system should be carried out within the extent that execution of handover does not significantly decrease the system capacity or increase system complexity.

A concept for this integrated system is shown in Figure 1.

FIGURE 1  
Concept for the integrated system



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## 6.4 Radio interface aspects

The objective of the integrated IMT-Advanced system is to use, as far as possible, the same equipment and protocols, i.e. the same hardware, software and facilities for both satellite and terrestrial components of IMT-Advanced to minimize costs. Therefore, the techniques (access parameters, bit rates, protocols, etc.) adopted for the satellite component have to be similar or even the same as those of the terrestrial component.

In particular, the satellite radio interface of IMT-Advanced should be compatible, and may have a high degree of commonality with, a terrestrial radio interface. This brings the possibility of reusing the terrestrial component technology in order to reduce complexity of user terminal and network equipment allowing low cost and fast development. It can also have several different features from the terrestrial radio interface to reflect the satellite-specific characteristics, such as long round-trip delay and power limitation.

As the candidate terrestrial radio interfaces of IMT-Advanced, 3GPP LTE-Advanced and IEEE WirelessMAN-Advanced (IEEE Std 802.16m) radio interfaces have been chosen. The technology of both radio interfaces is the orthogonal frequency-division multiplexing (OFDM), which is intrinsically able to handle the most common radio frequency distortion without the need for complex equalization techniques and scales easily to fit different bandwidth requirements, and multiple-input and multiple-output (MIMO), which increases peak throughput by transmitting and receiving multiple streams of information within the same spectrum. In general, the combined use of OFDM and MIMO will improve the spectral efficiency and capacity of the wireless network, and will prove to be a very valuable asset in maximizing usage of the scarce spectrum resource. With the requirement for commonality or similarity between satellite and terrestrial components in the integrated system, these advantages may urge the selection of OFDM and MIMO technology for the satellite radio interface of IMT-Advanced.

In addition, some advanced technologies considered in the terrestrial component can be applied to the satellite component as follows:

- multi-hop relay which is introduced to enable traffic/signalling forwarding between a satellite and user equipment by breaking a long-distance low-quality link into two or more high-quality segments resulting in improved user throughput and a better user experience;
- spectrum aggregation where two or more component carriers are aggregated in order to support higher data rates via wider bandwidth;
- support of scalable bandwidth wherein a satellite can support a plurality of maximum bandwidths and flexibly allocate bandwidths to user equipment from the maximum bandwidths;
- MIMO techniques in forward and return links from multi-satellites, and use of dual polarization;
- network MIMO in which antennas from neighbouring beams can be combined to transmit multiple streams to beam-edge users in order to minimize inter-beam interference;
- inter-beam interference management including inter-beam interference cancellation, interference avoidance and interference coordination techniques in order to increase beam-edge throughput;
- self-organizing/optimizing network which can automatically extend, change, configure and optimize the network coverage, capacity, beam size, topology, and frequency allocation and bandwidth, based on changes in interference, signal strength, location, traffic pattern, and other environment criteria.

## **6.5 Possible system architectures for the satellite component of IMT-Advanced**

Figure 2 describes an overall system architecture for the system concept under consideration. The following factors can be considered:

- Satellite component: It will provide services and applications similar to those of the terrestrial component beyond terrestrial and CGC coverage, under the inherent constraints imposed by power limitation and long round-trip delay.
- CGCs: In order to provide mobile satellite broadcasting/multicasting services, they can be deployed in areas where satellite reception is difficult, especially in urban areas. They may be co-located with terrestrial cell sites or standalone. Several kinds of CGC can be considered, such as simple amplifying and forwarding CGC acting as simple repeaters, a demodulation and forwarding CGC for high modulation and a decoding and forwarding CGC for better traffic quality. It would require careful consideration to use the same frequency band in the satellite component and CGC, since the CGC would possibly cause harmful interference to their own terminal or radiocommunication systems which are operated in the adjacent band and which do not expect that the adjacent band originally allocated to the satellite component is used also for the CGC with higher power density than the satellite's one.
- Terrestrial component: The satellite component can provide voice and data communication services in regions beyond terrestrial coverage. The areas not adequately covered by the terrestrial component include physically isolated regions, gaps in the terrestrial network coverage and areas where the terrestrial infrastructure is permanently, or temporarily, destroyed in the event of a disaster. In order to provide the terrestrial fill-in service, vertical handover of the satellite component with terrestrial component is considered one of the most important techniques.

- Advanced technologies: the following “IMT-Advanced enabling technologies” can be considered in enhancing the cost-effectiveness and competitiveness of the satellite component.
  - i) Horizontal integration of services and networks on personal mobile devices via software defined radio (SDR) technology.
  - ii) Optimized communication techniques (MIMO, MUD, turbo detection, HARQ, ACM, pre-equalization, IPv6).
  - iii) Introduction of new concepts and techniques for increased coverage, data speeds and spectral efficiencies, such as ad-hoc networking, cooperative MIMO and relaying, cognitive radio techniques for dynamic spectral sharing.

## **7 Requirements for the satellite radio interface(s) of IMT-Advanced**

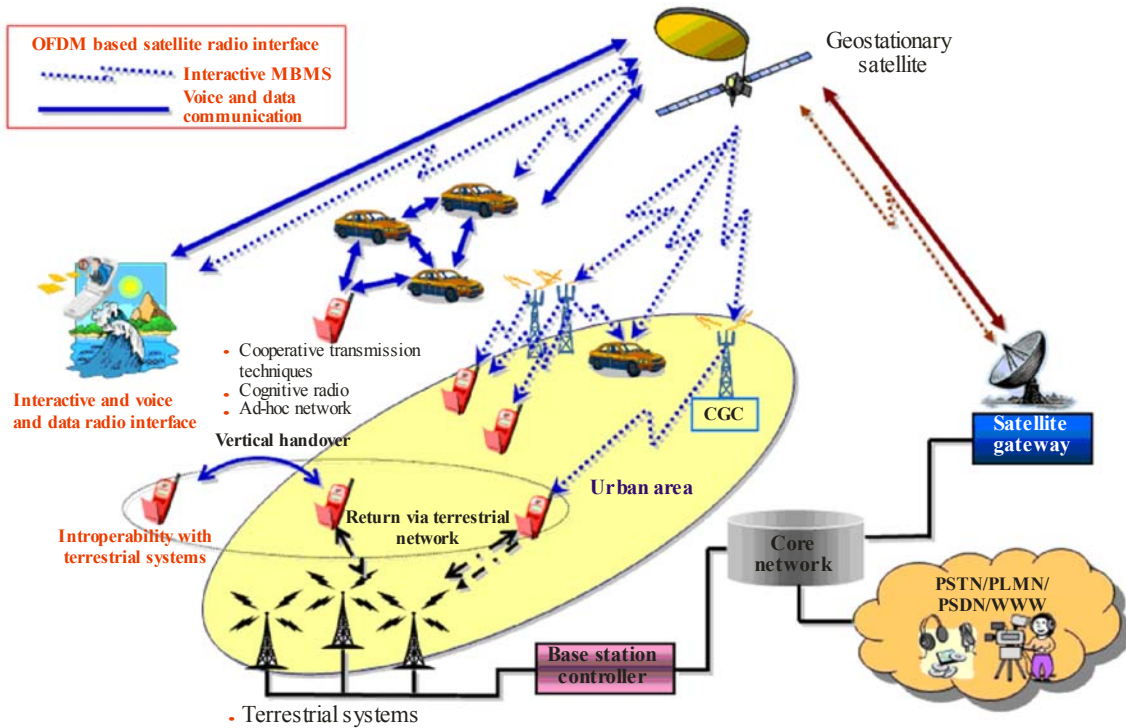
### **7.1 Service requirements**

Recommendation ITU-R M.1822 – Framework for services supported by IMT, addresses the high-level requirements for services and applications to be supported by IMT. It includes service parameters and service classifications of IMT, and service examples that may be supported by IMT.

While a specific set of services is not required, the service classifications in Recommendation ITU-R M.1822 should be used to ensure that a wide range of telecommunication services to mobile users is provided by IMT.

The service capability requirements are shown in the compliance template for services in Table 2. Services to be realized in the proposed system are included in Table 2. It is expected that a detailed explanation of each service feature or characteristics would be defined by the proponent of the satellite radio interface.

FIGURE 2  
System architecture for the satellite component of IMT-Advanced



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TABLE 2  
Compliance template for services

	Service related minimum capabilities within the RIT/SRIT	Evaluator's comments
7.1.1	<p><b>Support of a wide range of services</b></p> <p>Does the proposal support a wide range of services?: If bullets 7.1.1.1 – 7.1.1.3 are marked as “yes” then 7.1.1 is a “yes”. YES/NO</p>	
7.1.1.1	<p><b>Ability to support basic conversational service class</b></p> <p>Is the proposal able to support basic conversational service class?: YES/NO</p>	
7.1.1.2	<p><b>Support of rich conversational service class</b></p> <p>Is the proposal able to support rich conversational service class?: YES/NO</p>	
7.1.1.3	<p><b>Support of conversational low delay service class</b></p> <p>Is the proposal able to support conversational low-delay service class?: YES/NO</p>	

In the satellite environment, the maximum one way transfer delay for the real-time services at the bearer transport level should be less than 400 ms for bit error ratio (BER) within the range of values  $1 \times 10^{-3}$  to  $1 \times 10^{-7}$ .

## 7.2 Technical requirements

Requirements related to technical performance for candidate satellite radio interfaces of IMT-Advanced are described in this section. As mentioned above, the satellite component of IMT-Advanced systems would be complementary to the terrestrial component in order to provide a seamless service with global coverage. In particular, the satellite component can effectively offer services in certain regions beyond terrestrial coverage. Therefore, the main target service areas for the satellite component would be the rural, maritime and aeronautical environments since the terrestrial component has difficulties to penetrate in these areas due to its high deployment cost.

In that sense, the satellite component should support the technical requirements for the terrestrial component in the rural environment as a minimum, considering that the service provided by the satellite component should be of comparable quality to the terrestrial component of IMT.

### 7.2.1 Beam spectral efficiency

Beam spectral efficiency ( $\eta$ ) 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 beams. The channel bandwidth is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalized appropriately considering the uplink/downlink ratio.

The beam spectral efficiency is measured in bit/s/Hz/beam (see Table 3).

If  $\chi_i$  denotes the number of correctly received bits by user  $i$  (forward link) or from user  $i$  (return link) in a system comprising a user population of  $N$  users and  $M$  beams and  $\omega$  denotes the channel bandwidth and  $T$  the time over which the data bits are received. The cell spectral efficiency,  $\eta$ , is then defined according to equation (1):

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

TABLE 3  
Beam spectral efficiency

Test environment	Forward link (bit/s/Hz/beam)	Return link (bit/s/Hz/beam)
Open area (rural area)	1.1	0.7

### 7.2.2 Peak spectral efficiency

The peak spectral efficiency is the highest theoretical data rate (normalized 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 utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guardbands



and guard times). The peak data rate for the satellite component of IMT-Advanced should be greater than that of IMT-2000 and should be determined under the inherent constraint of satellite communication.

The minimum requirements for peak spectral efficiencies are as follows.

- Forward link peak spectral efficiency is 2.5 bit/s/Hz.
- Return link peak spectral efficiency is 1.2 bit/s/Hz.

### 7.2.3 Beam edge user spectral efficiency

The 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 normalized appropriately considering the uplink/downlink ratio. The beam edge user spectral efficiency is defined as the 5% point of the cumulative distribution function (CDF) of the normalized user throughput.

With  $\chi_i$  denoting the number of correctly received bits of user  $i$ ,  $T_i$  the active session time for user  $i$  and  $\omega$  the channel bandwidth, the (normalized) user throughput of user  $i$ ,  $\gamma_i$ , is defined according to equation (2).

$$\gamma_i = \frac{\chi_i}{T_i \cdot \omega} \quad (2)$$

Table 4 lists the beam edge user spectral efficiency requirements for the selected test environment.

TABLE 4  
Beam edge user spectral efficiency

Test environment	Forward link (bit/s/Hz)	Return link (bit/s/Hz)
Open area (rural area)	0.04	0.015

### 7.2.4 Bandwidth

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

The RIT/SRIT should support a scalable bandwidth up to and including 30 MHz, considering that possible satellite IMT bands are 1 980 to 2 010 MHz and 2 170 to 2 200 MHz for the return and forward links, respectively, and the maximum continuous bandwidth would be 30 MHz for each link.

### 7.2.5 Latency

In the IMT-Advanced satellite component, the requirement on latency has not been identified since it could be dependent on the targeted system configuration intended to use the proposed RIT/SRITs such as the satellite constellation and the satellite type. However, the latency measured in the proposed RIT/SRITs should be indicated in the technical performance template in order to provide evaluation groups with valuable information.

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 forward link paging delay and wireline network signalling delay), which should be achievable from the idle state to an active state in such a way that the user plane is established, should be noted in the technical performance template. It is noted that the long round-trip delay depending on the satellite constellation should be included in the value.

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 at the 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. The user plane latency achievable in unloaded conditions for small IP packets for both links should be noted in the technical performance template. It is noted that the long round-trip delay depending on the satellite constellation should be included in the value.

### 7.2.6 Mobility

Table 5 defines the mobility classes that should be supported in the respective test environment.

TABLE 5  
Mobility classes\*

	Test environments
	Open area
Mobility classes	Stationary, pedestrian, vehicular, high speed vehicular, aeronautical.

\* The service classes of mobility can be defined such as stationary, pedestrian and vehicular, high-speed vehicular, aeronautical.

### 7.2.7 Handover

In the IMT-Advanced satellite component, the requirement on handover has not been identified since it could be dependent on the targeted system configuration intended to use the proposed RIT/SRITs such as the satellite constellation and the satellite type. However, the handover interruption times measured in the proposed RIT/SRITs should be indicated in the technical performance template in order to provide evaluation groups with valuable information (see Table 6).

TABLE 6

**Handover interruption times**

<b>Handover type</b>	<b>Interruption time (ms)</b>
Intra-frequency	To be dependent on the targeted satellite system configuration
Inter-frequency <ul style="list-style-type: none"> <li>– within a spectrum band</li> <li>– between spectrum bands</li> </ul>	To be dependent on the targeted satellite system configuration
Inter-system with terrestrial component <ul style="list-style-type: none"> <li>– satellite to terrestrial</li> <li>– terrestrial to satellite</li> </ul>	To be dependent on the targeted satellite system configuration

**7.2.8 VoIP capacity**

The VoIP capacity is 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 of about 400 ms, considering the maximum one way transfer delay for the real-time services in the satellite component.

The VoIP capacity is the minimum of the calculated capacity for either link divided by the effective bandwidth in the respective link direction (see Table 7).

TABLE 7

**VoIP capacity**

<b>Test environments</b>	<b>Min. VoIP capacity (active users/beam/MHz)</b>
Open area (rural area)	30

**8 Guidelines for evaluation of the satellite radio interface(s) of IMT-Advanced**

This section provides guidelines for both the procedure and the criteria (technical, spectrum and service) to be used in evaluating the proposed IMT-Advanced satellite radio interface(s) for a number of test environments and deployment scenarios considered for evaluation.

**8.1 Evaluation criteria**

The requirements established in the last section are related to service and technical performance aspects. Regarding service aspects, a wide range of telecommunication services to mobile users should be provided by the satellite component of IMT-Advanced. In relation to technical aspects, it should be determined if candidate satellite radio interface(s) meets the technical requirements for several considered cases of the five test environments defined in § 8.2.1.1, depending on its deployment scenarios.

## **8.2 Evaluation methodology**

### **8.2.1 Test environments and evaluation configurations**

This section describes the test environments, selected deployment scenarios and evaluation configurations necessary to evaluate the performance figures of candidate RIT/SRIT.

The predefined test environments are assumed in order to specify the environments of the requirements for the technology proposals. The satellite component of IMT-Advanced should meet a wide range of performance requirements in a wide range of environments. The test environments should have been chosen appropriately depending on the deployment scenarios of the satellite system using the proposed RIT/SRIT.

#### **8.2.1.1 Test environments**

Evaluation of candidate RIT/SRITs will be performed in selected scenarios of the following test environments including the mandatory open area environment.

- Urban area
- Suburban area
- Open area
- Intermediate tree-shadowed area
- Heavy tree-shadowed area.

#### **8.2.1.2 Satellite system configuration**

Unlike the terrestrial component, since the overall capacity and the coverage of the satellite component are mostly determined by the targeted system configuration intended to use the proposed RIT/SRITs such as the configuration of the constellation including the type and altitude of the orbit, number of satellites, configuration of the spot beams, etc., the deployment models for evaluation cannot be fixed. Therefore, proponents should provide the targeted system configuration of the satellite system intended to use the proposed RIT/SRITs in the test environments and then, they should submit the self-evaluation results based on the specific deployment models. This information would also help the evaluation process of other evaluation groups.

##### **8.2.1.2.1 Antenna pattern**

Proponents should identify the antenna pattern which can be appropriately used in the targeted system configuration for evaluation. Especially, antenna characteristics which should be applied for the evaluation, e.g. antenna pattern, gain, side-lobe level, etc., for antennas at the satellite and user terminal should be specified. The characteristics do not form any kind of requirements and should be used only for evaluation.

###### **8.2.1.2.1.1 Satellite antenna**

The characteristics for the satellite antenna should be described depending on the targeted system configurations of proponents such as satellite constellation types and multi-beam patterns. These include antenna pattern, gain, side-lobe level, etc.

###### **8.2.1.2.1.2 User terminal antenna**

The user terminal antenna is assumed to be omnidirectional.

#### **8.2.1.3 Satellite configuration**

Proponents should provide the satellite information required for evaluation such as the operating frequency, polarization, e.i.r.p., beam-configuration, the number of satellites, antenna gain, etc.

#### 8.2.1.4 User terminal configuration

The following types of user terminals are considered (see also Table 8):

- **Handheld:** The basic assumption in UE power class 1, 2 and 3, equipped with standard omnidirectional antenna.
- **Portable:** The portable configuration is built with a notebook PC to which an external antenna is appended.
- **Vehicular:** The vehicular configuration is obtained by mounting an RF module or antenna only on car roof connected to the UE in the cockpit.
- **Transportable:** The transportable configuration is built with a notebook whose cover contains flat patch antennas (manually pointed towards the satellite).

TABLE 8

**User terminal maximum transmit power, antenna gain and e.i.r.p. for evaluation**

UE type	Maximum transmit power	Reference antenna gain	Maximum e.i.r.p.	System noise temp.	G/T
Handheld					
Class 1	2 W (33 dBm)	0 dBi	3 dBW	290 K	-24.6 dB/K
Class 2	500 mW (27 dBm)		-3 dBW		
Class 3	250 mW (24 dBm)		-6 dBW		
Portable	2 W (33 dBm)	2 dBi	5 dBW	200 K	-21 dB/K
Vehicular	8 W (39 dBm)	4 dBi	13 dBW	250 K	-20 dB/K
Transportable	2 W (33 dBm)	14 dBi	17 dBW	200 K	-9 dB/K

#### 8.2.2 Channel model

Channel models are needed in the evaluation of the IMT-Advanced candidate satellite radio interface(s) to allow realistic modelling of the propagation conditions for radio transmission in different environments. The channel model needs to cover all required test environments and scenarios of the IMT-Advanced evaluations.

Satellite propagation normally includes a line-of-sight component and diffuse/reflected multipath components, and hence tends to be Ricean distributed with fading rates by user and satellite motions. However, Rayleigh fading occurs when the line-of-sight path is obstructed. Time delay spreads are likely to be no more than a few tens or hundreds of nanoseconds and the levels of delayed components are low.

Doppler offset and rates of change are dependent upon relative motion between the user and satellite. Gross Doppler shift in the carrier is a function of satellite velocity, while Doppler spreading is dependent on the motion of the mobile station. For satellite applications in general a Ricean fading model should be used to assess the performance of the satellite radio interface(s). Further, the aspects of multipath propagation and the maximum Doppler shifts are taken into account. The gross Doppler shift in the carrier frequency due to the motion of the satellite and mobile terminals should be included in the link level simulation.

For the link and system level simulation, the Fontan's static model for the land mobile satellite (LMS) channel can be considered. This model is capable of describing both narrow- and wideband conditions. Other relevant characteristic is that it can be used to study links with geostationary as well as non-geostationary satellites. The model is of the generative type, i.e. it is capable of producing time series of a large number of signal features: amplitude, phase, instantaneous power-delay profiles, Doppler spectra, etc. Model parameters extracted from a comprehensive experimental data bank are also provided for a number of environments and elevation angles at around 1.5 GHz and around 2 GHz [1]. For evaluation, the LMS 3-states Markov chain model based on the measurements parameters for 40° elevation angle in S-band shown in Table 9, is adopted.

TABLE 9  
Markov chain metrics for 40° elevation angle

Environments	State transition probability P			State probability W
Urban	0.8628	0.0737	0.0635	0.4
	0.1247	0.8214	0.0539	0.2667
	0.0648	0.0546	0.8806	0.333
Suburban	0.8177	0.1715	0.0108	0.4545
	0.1544	0.79997	0.0459	0.4545
	0.1400	0.1433	0.7167	0.091
Open	0.9530	0.0431	0.0039	0.5
	0.0515	0.9347	0.0138	0.375
	0.0334	0.238	0.9428	0.125
Intermediate tree-shadow	0.7193	0.1865	0.0942	0.3929
	0.1848	0.7269	0.0883	0.3571
	0.1771	0.0971	0.7258	0.25
Heavy tree-shadow	0.7792	0.0452	0.1756	0
	0	0.9259	0.0741	0.5
	0	0.0741	0.9259	0.5

The following states are defined:

State 1: LoS condition,

State 2: moderate shadowing conditions,

State 3: deep shadowing conditions.

Each element in matrix  $P$ ,  $P_{ij}$  represents the probability of change from state  $i$  to state  $j$ . The overall probability for each state is contained in matrix  $W$  where each element,  $W_i$  represents the total probability of being in state  $i$ .

TABLE 10

## Average Loo Model [2] parameters for 40° elevation angle and different states

Environments	State 1: LoS			State 2: Shadowing			State 3: Deep shadowing		
	$\alpha$ (dB)	$\phi$ (dB)	MP (dB)	$\alpha$ (dB)	$\phi$ (dB)	MP (dB)	$\alpha$ (dB)	$\phi$ (dB)	MP (dB)
Urban	-0.3	0.73	-15.9	-8.0	4.5	-19.2	-24.4	4.5	-19.0
Suburban	-1.0	0.5	-13.0	-3.7	0.98	-12.2	-15.0	5.9	-13.0
Open	0.1	0.37	-22	-1.0	0.5	-22.0	-2.25	0.13	-21.2
Intermediate tree-shadow	-0.4	1.5	-13.2	-8.2	3.9	-12.7	-17.0	3.14	-10.0
Heavy tree-shadow	-	-	-	-10.1	2.25	-10.0	-19.0	4.0	-10.0

Average value of the attenuation on the LoS link for a state.

Standard deviation of the attenuation on the LoS link for a state.

The Loo distribution considers that the received signal originates from the sum of two components: the direct signal and the diffuse multipath [2]. The direct signal is assumed to be log-normally distributed with mean  $\alpha$  (decibel relative to LoS) and standard deviation  $\phi$  (dB), while the multipath component follows a Rayleigh distribution characterized by its average power, MP (decibel relative to LoS) (see Table 10).

### 8.2.3 Evaluation configuration

This section contains baseline configuration parameters that should be applied in analytical and simulation assessment of candidate satellite radio interface(s).

The parameters are solely for the purpose of consistent evaluation of the candidate satellite radio interface(s) and relate only to specific test environments used in these simulations. They should not be considered as the values that must be used in any deployment of any IMT-Advanced system nor should they be taken as the default values for any other or subsequent study in ITU or elsewhere. They do not necessarily themselves constitute any requirements on the implementation of the system.

Evaluation configuration parameters in each test environment depend on the identified satellite system configuration. Therefore, proponents should provide the evaluation configuration parameters such as shown in Tables 11 to 16 in the test environments considered in the satellite system intended to use the proposed RIT/SRITs and then, they should submit the self-evaluation results based on the specific configuration parameters. This information would also help the evaluation process of other evaluation groups.

The specific configuration parameters of examined systems should be provided by proponents when evaluation groups assess the characteristics of beam spectral efficiency, beam edge user spectral efficiency, control plane latency, user plane latency, mobility, handover interruption time and VoIP capacity in the evaluation of candidate satellite radio interface(s).



TABLE 11  
Baseline evaluation configuration parameters (example)

System deployment scenario for the evaluation process	Values/Types/Configurations				
Satellite constellation configuration					
Spot beam pattern configuration					
The number of satellites					
Service link frequency					
Frequency reuse plan					
e.i.r.p. per carrier					
Satellite Rx antenna gain					
Polarization					
Number of satellite antenna elements for MIMO					
Total satellite antenna power					
etc.					
	Urban area	Suburban area	Open area	Intermediate tree-shadowed area	Heavy tree-shadowed area
User terminal (UT) maximum transmit power					
UT antenna gain					
System temperature					
$G/T$					
etc.					

### 8.2.3.1 Evaluation configuration parameters for analytical assessment

The proponents should provide the evaluation configuration parameters used for self-evaluation such as shown in Table 12 when evaluation groups assess the characteristics of peak spectral efficiency in the evaluation of candidate satellite radio interface(s).

TABLE 12

**Evaluation configuration parameters for analytical assessment  
of peak spectral efficiency (example)**

<b>Deployment scenario for the evaluation process</b>	<b>Urban area</b>	<b>Suburban area</b>	<b>Open area</b>	<b>Intermediate tree-shadowed area</b>	<b>Heavy tree-shadowed area</b>
The number of satellite antenna elements for MIMO					
The number of UTs in cooperation					

### 8.2.3.2 Evaluation configuration parameters for simulation assessment

There are two types of simulation: system and link level simulations.

The proponents should also provide the parameters applied in the system level simulation for self-evaluation such as shown in Table 13 when assessing the characteristics of beam spectral efficiency, beam edge user spectral efficiency and VoIP capacity.

TABLE 13

**Additional parameters for system simulation (example)**

<b>Deployment scenario for the evaluation process</b>	<b>Urban area</b>	<b>Suburban area</b>	<b>Open area</b>	<b>Intermediate tree-shadowed area</b>	<b>Heavy tree-shadowed area</b>
Layout					
Inter-site distance					
Channel model					
User distribution					
User mobility model					
UT speed of interest					
Inter-site interference modelling					
Satellite noise figure					
UT noise figure					
Satellite antenna gain					
UE antenna gain					
Thermal noise level					
etc.					

When assessing the beam spectral efficiency and beam edge user spectral efficiency characteristics, the parameters such as shown in Table 14 should also be provided by the proponents.

TABLE 14

**Additional parameters for assessment of beam spectral efficiency  
and beam edge user spectral efficiency (example)**

<b>Deployment scenario for the evaluation process</b>	<b>Urban area</b>	<b>Suburban area</b>	<b>Open area</b>	<b>Intermediate tree-shadowed area</b>	<b>Heavy tree-shadowed area</b>
Evaluated service profile	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort
Simulation bandwidth					
Number of users per beam	10	10	10	10	10

The simulation needs to be done over a time period long enough to assure convergence of the simulation results.

When assessing the VoIP capacity characteristics, the required parameters such as shown in Table 15 should also be provided by the proponents.

TABLE 15

**Additional parameters for assessment of VoIP capacity (example)**

<b>Deployment scenario for the evaluation process</b>	<b>Urban area</b>	<b>Suburban area</b>	<b>Open area</b>	<b>Intermediate tree-shadowed area</b>	<b>Heavy tree-shadowed area</b>
Evaluated service profile	VoIP	VoIP	VoIP	VoIP	VoIP
Simulation bandwidth					
Simulation time span for a single drop	20 s	20 s	20 s	20 s	20 s

The required parameters such as shown in Table 16 should also be provided in link level simulation when assessing the characteristic of mobility.

TABLE 16

**Additional parameters for link level simulation (for mobility requirement) (example)**

<b>Deployment scenario for the evaluation process</b>	<b>Urban area</b>	<b>Suburban area</b>	<b>Open area</b>	<b>Intermediate tree-shadowed area</b>	<b>Heavy tree-shadowed area</b>
Evaluated service profile	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort
Channel model	Urban profile	Suburban profile	Open profile	Intermediate tree-shadowed profile	Heavy tree-shadowed profile
Simulation bandwidth					
Number of users in simulation	1	1	1	1	1

## 8.2.4 Description template

The description template is a template for the description of the characteristics of a candidate satellite radio interface(s) (see Table 17). It should be used by the proponents to describe their proposal for a satellite radio interface for IMT-Advanced to a level of detail that will facilitate sufficient understanding of the proposed technology to enable an independent technical assessment of compliance with the IMT-Advanced requirements as specified in this Report.

### 8.2.4.1 Description template – characteristics template

TABLE 17  
Characteristic template

Item	Item to be described
<b>8.2.4.1.1</b>	<b>Test environment(s)</b>
8.2.4.1.1.1	What test environments does this technology description template address?
<b>8.2.4.1.2</b>	<b>Radio interface functional aspects</b>
8.2.4.1.2.1	<i>Multiple access schemes</i> Which access scheme(s) does the proposal use: TDMA, FDMA, CDMA, OFDMA, IDMA, SDMA, hybrid, or another? Describe in detail the multiple access schemes employed with their main parameters.
8.2.4.1.2.2	<i>Modulation scheme</i>
8.2.4.1.2.2.1	What is the baseband modulation scheme? If both data modulation and spreading modulation are required, describe in detail. Describe the modulation scheme employed for data and control information. What is the symbol rate after modulation?
8.2.4.1.2.2.2	<i>PAPR</i> What is the RF peak to average power ratio after baseband filtering (dB)? Describe the PAPR (peak-to-average power ratio) reduction algorithms if they are used in the proposed RIT.
8.2.4.1.2.3	<i>Error control coding scheme and interleaving</i>
8.2.4.1.2.3.1	Provide details of error control coding scheme for both downlink and uplink? For example: – FEC or other schemes? – Unequal error protection? Explain the decoding mechanism employed.
8.2.4.1.2.3.2	Describe the bit interleaving scheme for both uplink and downlink.
<b>8.2.4.1.3</b>	<b>Describe channel tracking capabilities (e.g. channel tracking algorithm, pilot symbol configuration, etc.) to accommodate rapidly changing delay spread profile</b>
<b>8.2.4.1.4</b>	<b>Physical channel structure and multiplexing</b>
8.2.4.1.4.1	What is the physical channel bit rate (Mbit/s) for supported bandwidths? i.e. the product of the modulation symbol rate (in symbols per second), bits per modulation symbol, and the number of streams supported by the antenna system.
8.2.4.1.4.2	<i>Layer 1 and Layer 2 overhead estimation</i> Describe how the RIT accounts for all Layer 1 (PHY) and Layer 2 (MAC) overhead and provide an accurate estimate that includes static and dynamic overheads.

TABLE 17 (continued)

Item	Item to be described
8.2.4.1.4.3	<p><i>Variable bit rate capabilities</i></p> <p>Describe how the proposal supports different applications and services with various bit rate requirements.</p>
8.2.4.1.4.4	<p><i>Variable payload capabilities</i></p> <p>Describe how the RIT supports IP-based application layer protocols/services (e.g. VoIP, video-streaming, interactive gaming, etc.) with variable-size payloads.</p>
8.2.4.1.4.5	<p><i>Signalling transmission scheme</i></p> <p>Describe how transmission schemes are different for signalling/control from that of user data.</p>
<b>8.2.4.1.5</b>	<b>Mobility management (Handover)</b>
8.2.4.1.5.1	<p>Describe the handover mechanisms and procedures which are associated with</p> <ul style="list-style-type: none"> <li>– Inter-System handover;</li> <li>– Intra-System handover;</li> <li>– Intra-frequency and Inter-frequency;</li> <li>– Within the RIT or between RITs within one SRIT (if applicable).</li> </ul> <p>Characterize the type of handover strategy or strategies.</p>
8.2.4.1.5.2	<p>What are the handover interruption times for:</p> <ul style="list-style-type: none"> <li>– within the RIT (intra- and inter-frequency);</li> <li>– between various RITs within a SRIT;</li> <li>– between the RIT and another IMT system.</li> </ul>
<b>8.2.4.1.6</b>	<b>Radio resource management</b>
8.2.4.1.6.1	<p>Describe the radio resource management, support of:</p> <ul style="list-style-type: none"> <li>– centralized and/or distributed RRM;</li> <li>– dynamic and flexible radio resource management;</li> <li>– efficient load balancing.</li> </ul>
8.2.4.1.6.2	<p><i>Inter-RIT interworking</i></p> <p>Describe the functional blocks and mechanisms for interworking (such as a network architecture model) between heterogeneous RITs within a SRIT, if supported.</p>
8.2.4.1.6.3	<p><i>Connection/session management</i></p> <p>The mechanisms for connection/session management over the air-interface should be described. For example:</p> <ul style="list-style-type: none"> <li>– the support of multiple protocol states with fast and dynamic transitions;</li> <li>– the signalling schemes for allocating and releasing resources.</li> </ul>
<b>8.2.4.1.7</b>	<b>Frame structure</b>
8.2.4.1.7.1	<p>Describe the frame structure for downlink and uplink by providing sufficient information such as:</p> <ul style="list-style-type: none"> <li>– frame length;</li> <li>– the number of time slots per frame;</li> <li>– the number and position of switch points per frame for TDD;</li> <li>– guard time or the number of guard bits;</li> <li>– user payload information per time slot;</li> <li>– control channel structure and multiplexing;</li> <li>– power control bit rate.</li> </ul>

TABLE 17 (continued)

Item	Item to be described
<b>8.2.4.1.8</b>	<b>Spectrum capabilities and duplex technologies</b> NOTE 1 – Parameters for both downlink and uplink should be described separately, if necessary.
8.2.4.1.8.1	<i>Spectrum sharing and flexible spectrum use</i> Does the RIT/SRIT support flexible spectrum use and/or spectrum sharing for the bands for IMT? Provide details.
8.2.4.1.8.2	<i>Channel bandwidth scalability</i> Describe how the proposal supports channel bandwidth scalability, including the supported bandwidths. Describe whether the proposed RIT supports extensions for scalable bandwidths wider than 30 MHz. Consider, for example: – the scalability of operating bandwidths; – the scalability using single and/or multiple RF carriers. Describe multiple contiguous (or non-contiguous) band aggregation capabilities, if any. Consider for example the aggregation of multiple channels to support higher user bit rates.
8.2.4.1.8.3	What are the frequency bands supported by the RIT? Please list.
8.2.4.1.8.4	What is the minimum amount of spectrum required to deploy a contiguous network, including guardbands (MHz)?
8.2.4.1.8.5	What are the minimum and maximum transmission bandwidth (MHz) measured at the 3 dB down points?
8.2.4.1.8.6	What duplexing scheme(s) is (are) described in this template? (e.g. TDD, FDD or half-duplex FDD). Describe details such as: – What is the minimum (up/down) frequency separation in case of full- and half-duplex FDD? – What is the requirement of transmit/receive isolation in case of full- an half-duplex FDD? Does the RIT require a duplexer in either the mobile station (MS) or space segment? – What is the minimum (up/down) time separation in case of TDD? – Whether the DL/UL Ratio variable for TDD? What is the DL/UL ratio supported? If the DL/UL ratio for TDD is variable, what would be the coexistence criteria for adjacent cells?
<b>8.2.4.1.9</b>	<b>Support of advanced antenna capabilities</b>
8.2.4.1.9.1	Fully describe the multi-antenna systems supported in the MS, Space segment, or both that can be used and/or must be used; characterize their impacts on systems performance; e.g. does the RIT have the capability for the use of: – spatial multiplexing techniques; – space-time coding (STC) techniques; – beam-forming techniques (e.g. adaptive or switched).
8.2.4.1.9.2	How many antennas are supported by the Space segment and MS for transmission and reception? Specify if correlated or uncorrelated antennas in co-polar or cross-polar configurations are used. What is the antenna spacing (in wavelengths)?
8.2.4.1.9.3	Provide details on the antenna configuration that is used in the self-evaluation.

TABLE 17 (*continued*)

Item	Item to be described
8.2.4.1.9.4	If spatial multiplexing (MIMO) is supported, does the proposal support (provide details if supported): <ul style="list-style-type: none"> <li>– Single codeword (SCW) and/or multi-codeword (MCW).</li> <li>– Open and/or closed loop MIMO.</li> <li>– Cooperative MIMO.</li> <li>– Single-user MIMO and/or multi-user MIMO.</li> </ul>
8.2.4.1.9.5	<i>Other antenna technologies</i> Does the RIT/SRIT support other antenna technologies, for example: <ul style="list-style-type: none"> <li>– remote antennas;</li> <li>– distributed antennas.</li> </ul> If so, please describe.
8.2.4.1.9.6	Provide the antenna tilt angle used in the self-evaluation.
<b>8.2.4.1.10</b>	<b>Link adaptation and power control</b>
8.2.4.1.10.1	Describe link adaptation techniques employed by RIT/SRIT, including: <ul style="list-style-type: none"> <li>– the supported modulation and coding schemes;</li> <li>– the supporting channel quality measurements, the reporting of these measurements, their frequency and granularity;</li> </ul> Provide details of any adaptive modulation and coding schemes, including: <ul style="list-style-type: none"> <li>– hybrid ARQ or other retransmission mechanisms?</li> <li>– algorithms for adaptive modulation and coding, which are used in the self-evaluation;</li> <li>– other schemes?</li> </ul>
8.2.4.1.10.2	Provide details of any power control scheme included in the proposal, for example: <ul style="list-style-type: none"> <li>– power control step size (dB);</li> <li>– power control cycles per second;</li> <li>– power control dynamic range (dB);</li> <li>– minimum transmit power level with power control;</li> <li>– associated signalling and control messages.</li> </ul>
<b>8.2.4.1.11</b>	<b>Power classes</b>
8.2.4.1.11.1	<i>Mobile station emitted power</i>
8.2.4.1.11.1.1	What is the radiated antenna power measured at the antenna (dBm)?
8.2.4.1.11.1.2	What is the maximum peak power transmitted while in active or busy state?
8.2.4.1.11.1.3	What is the time averaged power transmitted while in active or busy state? Provide a detailed explanation used to calculate this time average power.
8.2.4.1.11.2	<i>Space segment emitted power</i>
8.2.4.1.11.2.1	What is the base station transmit power per RF carrier?
8.2.4.1.11.2.2	What is the maximum peak transmitted power per RF carrier radiated from antenna?
8.2.4.1.11.2.3	What is the average transmitted power per RF carrier radiated from antenna?



TABLE 17 (*continued*)

Item	Item to be described
<b>8.2.4.1.12</b>	<b>Scheduler, QoS support and management, data services</b>
8.2.4.1.12.1	<p><i>QoS support</i></p> <ul style="list-style-type: none"> <li>– What QoS classes are supported?</li> <li>– How QoS classes associated with each service flow can be negotiated.</li> <li>– QoS attributes, for example: <ul style="list-style-type: none"> <li>– data rate (ranging from the lowest supported data rate to maximum data rate supported by the MAC/PHY);</li> <li>– control plane and user plane latency (delivery delay);</li> <li>– packet error rate (after all corrections provided by the MAC/PHY layers), and delay variation (jitter).</li> </ul> </li> <li>– Is QoS supported when handing off between radio access networks? Please describe.</li> <li>– How users may utilize several applications with differing QoS requirements at the same time.</li> </ul>
8.2.4.1.12.2	<p><i>Scheduling mechanisms</i></p> <ul style="list-style-type: none"> <li>– Exemplify scheduling algorithm(s) that may be used for full buffer and VoIP traffic in the technology proposal for evaluation purposes.</li> </ul> <p>Describe any measurements and/or reporting required for scheduling.</p>
<b>8.2.4.1.13</b>	<b>Radio interface architecture and protocol stack</b>
8.2.4.1.13.1	<p>Describe details of the radio interface architecture and protocol stack such as:</p> <p>Logical channels</p> <ul style="list-style-type: none"> <li>– Control channels.</li> <li>– Traffic channels.</li> </ul> <p>Transport channels and/or physical channels.</p>
8.2.4.1.13.2	What is the bit rate required for transmitting feedback information?
8.2.4.1.13.3	<p><i>Channel access</i></p> <p>Describe in details how RIT/SRIT accomplishes initial channel access, (e.g. contention or non-contention based).</p>
<b>8.2.4.1.14</b>	<b>Beam selection</b>
8.2.4.1.14.1	Describe in detail how the RIT/SRIT accomplishes cell selection to determine the serving cell for the users.
<b>8.2.4.1.15</b>	<b>Location determination mechanisms</b>
8.2.4.1.15.1	Describe any location determination mechanisms that may be used, e.g. to support location based services.
<b>8.2.4.1.16</b>	<b>Priority access mechanisms</b>
8.2.4.1.16.1	Describe techniques employed to support prioritization of access to radio or network resources for specific services or specific users (e.g. to allow access by emergency services).

TABLE 17 (continued)

Item	Item to be described
<b>8.2.4.1.17</b>	<b>Unicast, multicast and broadcast</b>
8.2.4.1.17.1	Describe how the RIT enables: <ul style="list-style-type: none"> <li>– broadcast capabilities;</li> <li>– multicast capabilities;</li> <li>– unicast capabilities;</li> </ul> using both dedicated carriers and/or shared carriers. Please describe how all three capabilities can exist simultaneously.
8.2.4.1.17.2	Describe whether the proposal is capable of providing multiple user services simultaneously to any user with appropriate channel capacity assignments?
8.2.4.1.17.3	Provide details of the codec used for VoIP capacity in the self evaluation. Does the RIT support multiple voice and/or video codecs? Provide details.
8.2.4.1.17.4	If a codec is used that differs from the one specified in Report ITU-R M.[IMT-Advanced SAT], specify the voice quality (e.g. PSQM, PESQ, CCR, E-Model, MOS) for the corresponding VoIP capacity in the self-evaluation.
<b>8.2.4.1.18</b>	<b>Privacy, authorization, encryption, authentication and legal intercept schemes</b>
8.2.4.1.18.1	Any privacy, authorization, encryption, authentication and legal intercept schemes that are enabled in the radio interface technology should be described. Describe whether any synchronization is needed for privacy and encryptions mechanisms used in the RIT. Describe how the RIT may be protected against attacks, for example: <ul style="list-style-type: none"> <li>– man in the middle;</li> <li>– replay;</li> <li>– denial of service.</li> </ul>
<b>8.2.4.1.19</b>	<b>Frequency planning</b>
8.2.4.1.19.1	How does the RIT support adding new cells or new RF carriers? Provide details.
<b>8.2.4.1.20</b>	<b>Interference mitigation within radio interface</b>
8.2.4.1.20.1	Does the proposal support Interference mitigation? If so, describe the corresponding mechanism.
8.2.4.1.20.2	What is the signalling, if any, which can be used for inter-beam interference mitigation?
8.2.4.1.20.3	<i>Link level interference mitigation</i> Describe the feature or features used to mitigate inter-symbol interference.
8.2.4.1.20.4	Describe the approach taken to cope with multipath propagation effects (e.g. via equalizer, rake receiver, cyclic prefix, etc.).

TABLE 17 (continued)

Item	Item to be described
8.2.4.1.20.5	<p>Diversity techniques</p> <p>Describe the diversity techniques supported in the MS and at the BS, including micro diversity and macro diversity, characterizing the type of diversity used, for example:</p> <ul style="list-style-type: none"> <li>– Time diversity: repetition, Rake-receiver, etc.</li> <li>– Space diversity: multiple sectors, etc.</li> <li>– Frequency diversity: frequency hopping (FH), wideband transmission, etc.</li> <li>– Code diversity: multiple PN codes, multiple FH code, etc.</li> <li>– Multi-user diversity: proportional fairness (PF), etc.</li> <li>– Other schemes.</li> </ul> <p>Characterize the diversity combining algorithm, for example, switched diversity, maximal ratio combining, equal gain combining.</p> <p>Provide information on the receiver/transmitter RF configurations, for example:</p> <ul style="list-style-type: none"> <li>– number of RF receivers;</li> <li>– number of RF transmitters.</li> </ul>
<b>8.2.4.1.21</b>	<b>Synchronization requirements</b>
8.2.4.1.21.1	<p>Describe RIT's timing requirements, e.g.:</p> <ul style="list-style-type: none"> <li>– is synchronization between inter-beam signals or inter-satellite signals required? Provide precise information, the type of synchronization, i.e. synchronization of carrier frequency, bit clock, spreading code or frame, and their accuracy;</li> <li>– is space segment-to-network synchronization required?</li> </ul> <p>State short-term frequency and timing accuracy of space segment transmit signal.</p>
8.2.4.1.21.2	Describe the synchronization mechanisms used in the proposal, including synchronization between a user terminal and a site.
<b>8.2.4.1.22</b>	<p><b>Link budget template</b></p> <p>Proponents should provide the link budget results to this description template for the environments supported in the RIT.</p>
<b>8.2.4.1.23</b>	<b>Other items</b>
8.2.4.1.23.1	<p><i>Coverage extension schemes</i></p> <p>Describe the capability to support/coverage extension schemes, such as relays or repeaters.</p>
8.2.4.1.23.2	<p><i>Self-organization</i></p> <p>Describe any self-organizing aspects that are enabled by the RIT/SRIT.</p>
8.2.4.1.23.3	Describe the frequency reuse schemes (including reuse factor and pattern) for the assessment of cell spectrum efficiency, cell edge user spectral efficiency and VoIP capacity.
8.2.4.1.23.4	Is the RIT an evolution of an existing IMT-2000 technology? Provide details.
8.2.4.1.23.5	Does the proposal satisfy a specific spectrum mask? Provide details. (This information is not intended to be used for sharing studies.)
8.2.4.1.23.6	Describe any MS power saving mechanisms used in the RIT.
8.2.4.1.23.7	<p><i>Simulation process issues</i></p> <p>Describe the methodology used in the analytical approach.</p> <p>Proponent should provide information on the width of confidence intervals of user and satellite system performance metrics of corresponding mean values, and evaluation groups are encouraged to provide this information.</p>

TABLE 17 (*end*)

Item	Item to be described
8.2.4.1.24	<p><b>Other information</b></p> <p>Please provide any additional information that the proponent believes may be useful to the evaluation process.</p>

#### 8.2.4.2 Description template – link budget template

Link budget templates for considered cases of the five deployment scenarios are not clearly defined. Link budget templates may depend on the specific system configuration of the satellite systems intended to use the proposed RIT/SRITs. Therefore, proponents should provide the appropriate link budget results, considering their targeted satellite system configurations, to this description template for the environments supported in the RIT in order to ease the conduct of the evaluation process by the evaluation groups.

#### 8.2.5 Compliance templates

This section provides templates for the responses that are needed to assess the compliance of a candidate satellite radio interface with the requirements of IMT-Advanced.

##### 8.2.5.1 Compliance template – service template

Service related minimum capabilities within the satellite radio interface(s)	Evaluator's comments
<p><b>Support of a wide range of services</b></p> <p>Does the proposal support a wide range of services?</p> <p>Yes/No</p>	

##### 8.2.5.2 Compliance template – spectrum template

Spectrum capability requirements	Evaluator's comments
<p><b>Spectrum bands</b></p> <p>Is the proposal able to utilize at least one band identified for IMT?</p> <p>Yes/No</p> <p>Specify in which band(s) the candidate satellite radio interface(s) can be deployed</p>	

## 8.2.5.3 Compliance template – technical performance template

Minimum technical requirements items	Category		Required value	Value	Requirement met?	Comments
	Test environment	Downlink or uplink				
Beam spectral efficiency (bit/s/Hz/beam)	Urban	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
	Suburban	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
	Open	Downlink	1.1		Yes/No	
		Uplink	0.7		Yes/No	
	Intermediate tree-shadowed	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
	Heavy tree-shadowed	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
Peak spectral efficiency (bit/s/Hz)	–	Downlink	2.5		Yes/No	
		Uplink	1.25		Yes/No	
Bandwidth	–	Up to and including (MHz)	30		Yes/No	
		Scalability	N/A		Yes/No	
Beam edge user spectral efficiency (bit/s/Hz)	Urban	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
	Suburban	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
	Open	Downlink	0.04		Yes/No	
		Uplink	0.015		Yes/No	
	Intermediate tree-shadowed	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
	Heavy tree-shadowed	Downlink	N/A		N/A	
		Uplink	N/A		N/A	
Control plane latency (ms)	N/A	N/A	N/A		N/A	
User plane latency (ms)	N/A	N/A	N/A		N/A	
Mobility	Urban	N/A	N/A		N/A	
	Suburban	N/A	N/A		N/A	
	Open	N/A	Stationary, pedestrian, vehicular high speed vehicular, aeronautical		Yes/No	
	Intermediate tree-shadowed	N/A	N/A		N/A	
	Heavy tree-shadowed	N/A	N/A		N/A	

Minimum technical requirements items	Category		Required value	Value	Requirement met?	Comments
	Test environment	Downlink or uplink				
Intra-frequency handover interruption time (ms)	N/A	N/A	N/A		N/A	
Inter-frequency handover interruption time within spectrum band (ms)	N/A	N/A	N/A		N/A	
Inter-frequency handover interruption time between spectrum band (ms)	N/A	N/A	N/A		N/A	
Intersystem handover	N/A	N/A	N/A		N/A	
Number of supported VoIP users (active users/beam/MHz)	Urban	As defined in subclause 7.2.8	N/A		N/A	
	Suburban	N/A	N/A		N/A	
	Open	N/A	30		Yes/No	
	Intermediate tree-shadowed	N/A	N/A		N/A	
	Heavy tree-shadowed	N/A	N/A		N/A	

N/A: Not Applicable.

## 9 References

- [1] FONTAN, F.P., VAZQUEZ-CASTRO, M., CABADO, C.E., GARCIA, J.P. and KUBISTA, E. [November, 2001] Static modelling of the LMS channel. IEEE Trans. on Vehicular Technology, Vol. 50, 6.
- [2] LOO, C. [August, 1985] A statistical model for land mobile satellite link. IEEE Trans. Veh. Technol., vol. VT-34, p. 122-127.