



Report ITU-R M.2135-1
(12/2009)

**Guidelines for evaluation of radio interface
technologies for IMT-Advanced**

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



Documents
Document Sharing Hub

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Reports

(Also available online at <http://www.itu.int/publ/R-REP/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management

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

Electronic Publication
Geneva, 2010

© ITU 2010

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

REPORT ITU-R M.2135-1

**Guidelines for evaluation of radio interface technologies
for IMT-Advanced**

(2008-2009)

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

This Report provides guidelines for both the procedure and the criteria (technical, spectrum and service) to be used in evaluating the proposed IMT-Advanced radio interface technologies (RITs) or Sets of RITs (SRITs) for a number of test environments and deployment scenarios for evaluation. These test environments are chosen to simulate closely the more stringent radio operating environments. The evaluation procedure is designed in such a way that the overall performance of the candidate RIT/SRITs may be fairly and equally assessed on a technical basis. It ensures that the overall IMT-Advanced objectives are met.

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

This Report provides, for proponents, developers of candidate RIT/SRITs and evaluation groups, the common methodology and evaluation configurations to evaluate the proposed candidate RIT/SRITs and system aspects impacting the radio performance.

This Report allows a degree of freedom so as to encompass new technologies. The actual selection of the candidate RIT/SRITs for IMT-Advanced is outside the scope of this Report.

The candidate RIT/SRITs will be assessed based on those evaluation guidelines. If necessary, additional evaluation methodologies may be developed by each independent evaluation group to complement the evaluation guidelines. Any such additional methodology should be shared between evaluation groups and sent to the Radiocommunication Bureau as information in the consideration of the evaluation results by ITU-R and for posting under additional information relevant to the evaluation group section of the ITU-R IMT-Advanced web page (<http://www.itu.int/ITU-R/go/rsg5-imt-advanced>).

3 Structure of the Report

Section 4 provides a list of the documents that are related to this Report.

Section 5 describes the evaluation guidelines.

Section 6 lists the criteria chosen for evaluating the RITs.

Section 7 outlines the procedures and evaluation methodology for evaluating the criteria.

Section 8 defines the tests environments and selected deployment scenarios for evaluation; the evaluation configurations which shall be applied when evaluating IMT-Advanced candidate technology proposals are also given in this section.

Section 9 describes a channel model approach for the evaluation.

Section 10 provides a list of references.

Section 11 provides a list of acronyms and abbreviations.

Annexes 1 and 2 form a part of this Report.

4 Related ITU-R texts

Resolution ITU-R 57

Recommendation ITU-R M.1224

Recommendation ITU-R M.1822

Recommendation ITU-R M.1645

Recommendation ITU-R M.1768

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.2133

Report ITU-R M.2134.

5 Evaluation guidelines

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

The parameters presented in this Report are for the purpose of consistent definition, specification, and evaluation of the candidate RITs/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. These parameters have been chosen to be representative of a global view of IMT-Advanced but are not intended to be specific to any particular implementation of an IMT-Advanced technology. 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.

Further consideration has been given in the choice of parameters to balancing the assessment of the technology with the complexity of the simulations while respecting the workload of an evaluator or technology proponent.

This procedure deals only with evaluating radio interface aspects. It is not intended for evaluating system aspects (including those for satellite system aspects).

The following principles are to be followed when evaluating radio interface technologies for IMT-Advanced:

- Evaluations of proposals can be through simulation, analytical and inspection procedures.
- The evaluation shall be performed based on the submitted technology proposals, and should follow the evaluation guidelines, use the evaluation methodology and adopt the evaluation configurations defined in this Report.
- Evaluations through simulations contain both system level simulations and link level simulations. Evaluation groups may use their own simulation tools for the evaluation.
- In case of analytical procedure the evaluation is to be based on calculations using the technical information provided by the proponent.
- In case of evaluation through inspection the evaluation is based on statements in the proposal.

The following options are foreseen for the groups doing the evaluations.

- Self-evaluation must be a complete evaluation (to provide a fully complete compliance template) of the technology proposal.
- An external evaluation group may perform complete or partial evaluation of one or several technology proposals to assess the compliance of the technologies with the minimum requirements of IMT-Advanced.
- Evaluations covering several technology proposals are encouraged.

6 Characteristics for evaluation

The technical characteristics chosen for evaluation are explained in detail in Report ITU-R M.2133 – Requirements, evaluation criteria and submission templates for the development of IMT-Advanced, § 2, including service aspect requirements which are based on Recommendation ITU-R M.1822, spectrum aspect requirements, and requirements related to technical performance, which are based on Report ITU-R M.2134. These are summarised in Table 6-1, together with the high level assessment method:

- Simulation (including system and link-level simulations, according to the principles of simulation procedure given in § 7.1).
- Analytical (via a calculation).
- Inspection (by reviewing the functionality and parameterisation of the proposal).

TABLE 6-1

Characteristic for evaluation	Method	Evaluation methodology / configurations	Related section of Reports ITU-R M.2134 and ITU-R M.2133
Cell spectral efficiency	Simulation (system level)	§ 7.1.1, Tables 8-2, 8-4 and 8-5	Report ITU-R M.2134, § 4.1
Peak spectral efficiency	Analytical	§ 7.3.1, Table 8-3	Report ITU-R M.2134, § 4.2
Bandwidth	Inspection	§ 7.4.1	Report ITU-R M.2134, § 4.3
Cell edge user spectral efficiency	Simulation (system level)	§ 7.1.2, Tables 8-2, 8-4 and 8-5	Report ITU-R M.2134, § 4.4
Control plane latency	Analytical	§ 7.3.2, Table 8-2	Report ITU-R M.2134, § 4.5.1
User plane latency	Analytical	§ 7.3.3; Table 8-2	Report ITU-R M.2134, § 4.5.2
Mobility	Simulation (system and link level)	§ 7.2, Tables 8-2 and 8-7	Report ITU-R M.2134, § 4.6
Intra- and inter-frequency handover interruption time	Analytical	§ 7.3.4, Table 8-2	Report ITU-R M.2134, § 4.7
Inter-system handover	Inspection	§ 7.4.3	Report ITU-R M.2134, § 4.7
VoIP capacity	Simulation (system level)	§ 7.1.3, Tables 8-2, 8-4 and 8-6	Report ITU-R M.2134, § 4.8
Deployment possible in at least one of the identified IMT bands	Inspection	§ 7.4.2	Report ITU-R M.2133, § 2.2
Channel bandwidth scalability	Inspection	§ 7.4.1	Report ITU-R M.2134, § 4.3
Support for a wide range of services	Inspection	§ 7.4.4	Report ITU-R M.2133, § 2.1

Section 7 defines the methodology for assessing each of these criteria.

7 Evaluation methodology

The submission and evaluation process is defined in Document IMT-ADV/2(Rev.1) –Submission and evaluation process and consensus building.

Evaluation should be performed in strict compliance with the technical parameters provided by the proponents and the evaluation configurations specified for the deployment scenarios in § 8.4 of this Report. Each requirement should be evaluated independently, except for the cell spectral efficiency and cell edge user spectral efficiency criteria that shall be assessed jointly using the same simulation, and that consequently the candidate RIT/SRITs also shall fulfil the corresponding minimum requirements jointly. Furthermore, the system simulation used in the mobility evaluation should be the same as the system simulation for cell spectral efficiency and cell edge user spectral efficiency.

The evaluation methodology should include the following elements:

- 1 Candidate RIT/SRITs should be evaluated using reproducible methods including computer simulation, analytical approaches and inspection of the proposal.
- 2 Technical evaluation of the candidate RIT/SRITs should be made against each evaluation criterion for the required test environments.
- 3 Candidate RIT/SRITs should be evaluated based on technical descriptions that are submitted using a technologies description template.

In order to have a good comparability of the evaluation results for each proposal, the following solutions and enablers are to be taken into account:

- Use of unified methodology, software, and data sets by the evaluation groups wherever possible, e.g. in the area of channel modelling, link-level data, and link-to-system-level interface.
- Evaluation of multiple proposals using one simulation tool by each evaluation group is encouraged.
- Question-oriented working method that adapts the level of detail in modelling of specific functionalities according to the particular requirements of the actual investigation.

Evaluation of cell spectral efficiency, cell edge user spectral efficiency and VoIP capacity of candidate RIT/SRITs should take into account the Layer 1 and Layer 2 overhead information provided by the proponents, which may vary when evaluating different performance metrics and deployment scenarios.

7.1 System simulation procedures

System simulation shall be based on the network layout defined in § 8.3 of this Report. The following principles shall be followed in system simulation:

- Users are dropped independently with uniform distribution over predefined area of the network layout throughout the system. Each mobile corresponds to an active user session that runs for the duration of the drop.
- Mobiles are randomly assigned LoS and NLoS channel conditions.
- Cell assignment to a user is based on the proponent's cell selection scheme, which must be described by the proponent.
- The minimum distance between a user and a base station is defined in Table 8-2 in § 8.4 of this Report.
- Fading signal and fading interference are computed from each mobile station into each cell and from each cell into each mobile station (in both directions on an aggregated basis).

- The IoT^2 (interference over thermal) parameter is an uplink design constraint that the proponent must take into account when designing the system such that the average IoT^2 value experienced in the evaluation is equal to or less than 10 dB.
- In simulations based on the full-buffer traffic model, packets are not blocked when they arrive into the system (i.e. queue depths are assumed to be infinite).
- Users with a required traffic class shall be modelled according to the traffic models defined in Annex 2.
- Packets are scheduled with an appropriate packet scheduler(s) proposed by the proponents for full buffer and VoIP traffic models separately. Channel quality feedback delay, feedback errors, PDU (protocol data unit) errors and real channel estimation effects inclusive of channel estimation error are modelled and packets are retransmitted as necessary.
- The overhead channels (i.e., the overhead due to feedback and control channels) should be realistically modelled.
- For a given drop the simulation is run and then the process is repeated with the users dropped at new random locations. A sufficient number of drops are simulated to ensure convergence in the user and system performance metrics. The proponent should provide information on the width of confidence intervals of user and system performance metrics of corresponding mean values, and evaluation groups are encouraged to provide this information.³
- Performance statistics are collected taking into account the wrap-around configuration in the network layout, noting that wrap-around is not considered in the indoor case.
- All cells in the system shall be simulated with dynamic channel properties using a wrap-around technique, noting that wrap-around is not considered in the indoor case.

In order to perform less complex system simulations, often the simulations are divided into separate ‘link’ and ‘system’ simulations with a specific link-to-system interface. Another possible way to reduce system simulation complexity is to employ simplified interference modelling. Such methods should be sound in principle, and it is not within the scope of this document to describe them.

Evaluation groups are allowed to use such approaches provided that the used methodologies are:

- well described and made available to the Radiocommunication Bureau and other evaluation groups;
- included in the evaluation report.

Realistic link and system models should include error modelling, e.g., for channel estimation and for the errors of control channels that are required to decode the traffic channel (including the feedback channel and channel quality information). The overheads of the feedback channel and the control channel should be modelled according to the assumptions used in the overhead channels’ radio resource allocation.

² The interference means the effective interference received at the base station.

³ The confidence interval and the associated confidence level indicate the reliability of the estimated parameter value. The confidence level is the certainty (probability) that the true parameter value is within the confidence interval. The higher the confidence level the larger the confidence interval.

7.1.1 Cell spectral efficiency

The results from the system simulation are used to calculate the cell spectral efficiency as defined in Report ITU-R M.2134, § 4.1. The necessary information includes the number of correctly received bits during the simulation period and the effective bandwidth which is the operating bandwidth normalised appropriately considering the uplink/downlink ratio for TDD system.

Layer 1 and Layer 2 overhead should be accounted for in time and frequency for the purpose of calculation of system performance metrics such as cell spectral efficiency, cell edge user spectral efficiency, and VoIP. Examples of Layer 1 overhead include synchronization, guard and DC subcarriers, guard/switching time (in TDD systems), pilots and cyclic prefix. Examples of Layer 2 overhead include common control channels, HARQ ACK/NACK signalling, channel feedback, random access, packet headers and CRC. It must be noted that in computing the overheads, the fraction of the available physical resources used to model control overhead in Layer 1 and Layer 2 should be accounted for in a non-overlapping way. Power allocation/boosting should also be accounted for in modelling resource allocation for control channels.

7.1.2 Cell edge user spectral efficiency

The results from the system simulation are used to calculate the cell edge user spectral efficiency as defined in Report ITU-R M.2134, § 4.4. The necessary information is the number of correctly received bits per user during the active session time the user is in the simulation. The effective bandwidth is the operating bandwidth normalised appropriately considering the uplink/downlink ratio for TDD system. It should be noted that the cell edge user spectral efficiency shall be evaluated using identical simulation assumptions as the cell spectral efficiency for that test environment.

Examples of Layer 1 and Layer 2 overhead can be found in § 7.1.1.

7.1.3 VoIP capacity

The VoIP capacity should be evaluated and compared against the requirements in Report ITU-R M.2134, § 4.8.

VoIP capacity should be evaluated for the uplink and downlink directions 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 permissible VoIP packet delay bound of 50 ms. The VoIP packet delay is the overall latency from the source coding at the transmitter to successful source decoding at the receiver.

The final VoIP capacity which is to be compared against the requirements in Report ITU-R M.2134 is the minimum of the calculated capacity for either link direction divided by the effective bandwidth in the respective link direction⁴.

The simulation is run with the duration for a given drop defined in Table 8-6 of this Report. The VoIP traffic model is defined in Annex 2.

7.2 Evaluation methodology for mobility requirements

The evaluator shall perform the following steps in order to evaluate the mobility requirement.

⁴ In other words, the effective bandwidth is the operating bandwidth normalised appropriately considering the uplink/downlink ratio for TDD systems.

Step 1: Run system simulations, identical to those for cell spectral efficiencies, see § 7.1.1 except for speeds taken from Table 4 of Report ITU-R M.2134, using link level simulations and a link-to-system interface appropriate for these speed values, for the set of selected test environment(s) associated with the candidate RIT/SRIT proposal and collect overall statistics for uplink C/I values, and construct cumulative distribution function (CDF) over these values for each test environment.

Step 2: Use the CDF for the test environment(s) to save the respective 50%-percentile C/I value.

Step 3: Run new uplink link-level simulations for the selected test environment(s) for both NLoS and LoS channel conditions using the associated speeds in Table 4 of Report ITU-R M.2134, § 4.6 as input parameters, to obtain link data rate and residual packet error rate as a function of C/I . The link-level simulation shall use air interface configuration(s) supported by the proposal and take into account retransmission.

Step 4: Compare the link spectral efficiency values (link data rate normalized by channel bandwidth) obtained from Step 3 using the associated C/I value obtained from Step 2 for each channel model case, with the corresponding threshold values in the Table 4 of Report ITU-R M.2134, § 4.6.

Step 5: The proposal fulfils the mobility requirement if the spectral efficiency value is larger than or equal to the corresponding threshold value and if also the residual decoded packet error rate is less than 1%, for all selected test environments. For each test environment it is sufficient if one of the spectral efficiency values (of either NLoS or LoS channel conditions) fulfil the threshold.

7.3 Analytical approach

For the characteristics below a straight forward calculation based on the definition in Report ITU-R M.2134 and information in the proposal will be enough to evaluate them. The evaluation shall describe how this calculation has been performed. Evaluation groups should follow the calculation provided by proponents if it is justified properly.

7.3.1 Peak spectral efficiency calculation

The peak spectral efficiency is calculated as specified in Report ITU-R M.2134 § 4.2. The antenna configuration to be used for peak spectral efficiency is defined in Table 8-3 of this Report. The necessary information includes effective bandwidth which is the operating bandwidth normalised appropriately considering the uplink/downlink ratio for TDD systems. Examples of Layer 1 overhead can be found in § 7.1.1.

7.3.2 Control plane latency calculation

The control plane latency is calculated as specified in Report ITU-R M.2134, § 4.5.1.

The proponent should provide the elements in the calculation of the control plane latency and the retransmission probability.

Table 7-1 provides, for the purpose of example, typical elements in the calculation of the control plane latency. The inclusion of H-ARQ/ARQ retransmissions in each step of the connection set up is to ensure the required reliability of connection which typically has a probability of error in the order of 10^{-2} for certain Layer 2 control signals and 10^{-6} for some RRC control signals.

TABLE 7-1
Example C-plane latency template

Step	Description	Duration
0	UT wakeup time	Implementation dependent
1	DL scanning and synchronization + Broadcast channel acquisition	
2	Random access procedure	
3	UL synchronization	
4	Capability negotiation + H-ARQ retransmission probability	
5	Authorization and authentication/key exchange +H-ARQ retransmission probability	
6	Registration with the BS + H-ARQ retransmission probability	
7	RRC connection establishment + H-ARQ retransmission probability	
	Total C-plane connection establishment delay	
	Total IDLE_STATE → ACTIVE_ACTIVE delay	

7.3.3 User plane latency calculation

The user plane latency is calculated as specified in Report ITU-R M.2134, § 4.5.2. The proponent should provide the elements in the calculation of the user plane latency and the retransmission probability.

Table 7-2 provides, for the purpose of example, typical elements in the calculation of the user plane latency:

TABLE 7-2
Example user-plane latency analysis template

Step	Description	Value
0	UT wakeup time	Implementation dependent
1	UT processing delay	
2	Frame alignment	
3	TTI for UL data packet (piggy-back scheduling information)	
4	HARQ retransmission (probability)	
5	BS processing delay	
6	Transfer delay between the BS and the BS-Core Network interface	
7	Processing delay of the BS-Core Network interface	
	Total one way delay	

7.3.4 Intra- and inter-frequency handover interruption time derivation

The intra- and inter-frequency handover interruption time is calculated as specified in Report ITU-R M.2134, § 4.7. The handover procedure shall be described based on the proposed technology including the functions and the timing involved.

7.4 Inspection

7.4.1 Bandwidth and channel bandwidth scalability

The support of maximum bandwidth required in Report ITU-R M.2134, § 4.3 is verified by inspection of the proposal.

The scalability requirement is verified by demonstrating that the candidate RIT or SRIT can support at least three bandwidth values. These values shall include the minimum and maximum supported bandwidth values of the candidate RIT or SRIT.

7.4.2 Deployment in IMT bands

The set of IMT bands supported is demonstrated by inspection of the proposal.

7.4.3 Inter-system handover

The support of inter-system handover as required in Report ITU-R M.2134, § 4.7 is verified by inspection of the proposal.

7.4.4 Support of a wide range of services

A mobile transmission system's ability to support a wide range of services lies across all elements of the network (i.e. core, distribution and access), and across all layers of the OSI model. The evaluation of a candidate IMT-Advanced RIT focuses on the radio access aspects of the lower OSI layers. There are quantifiable elements of the minimum technical requirements identified within Report ITU-R M.2134 that indicate whether or not a candidate RIT is capable of enabling these services as defined in Recommendation ITU-R M.1822. If the candidate RIT meets the latency, peak spectral efficiency and bandwidth requirements in Report ITU-R M.2134, then it can be regarded as enabling the following service aspects requirements.

The support of a wide range of services is further analysed by inspection of the candidate RIT's ability to support all of the service classes of Table 7-3. This is considered in at least one test environment (similar to evaluation of the peak spectral efficiency) under normal operating conditions using configuration supported by the candidate RIT/SRITs.

TABLE 7-3
Service classes for evaluation

User experience class	Service class	Inspection
Conversational	Basic conversational service Rich conversational service Conversational low delay	Yes/No Yes/No Yes/No
Interactive	Interactive high delay Interactive low delay	Yes/No Yes/No
Streaming	Streaming live Streaming non-live	Yes/No Yes/No
Background	Background	Yes/No

8 Test environments and evaluation configurations

This section describes the test environments, selected deployment scenarios and evaluation configurations (including simulation parameters) necessary to evaluate the performance figures of candidate RIT/SRITs (details of test environments and channel models can be found in Annex 1).

The predefined test environments are used in order to specify the environments of the requirements for the technology proposals. IMT-Advanced is to cover a wide range of performance in a wide range of environments. Although it should be noted that thorough testing and evaluation is prohibitive. The test environments have therefore been chosen such that typical and different deployments are modelled and critical questions in system design and performance can be investigated. Focus is thus on scenarios testing limits of performance related to capacity and user mobility.

8.1 Test environments

Evaluation of candidate RIT/SRITs will be performed in selected scenarios of the following test environments:

- **Indoor:** an indoor environment targeting isolated cells at offices and/or in hotspot based on stationary and pedestrian users.
- **Microcellular:** an urban micro-cellular environment with higher user density focusing on pedestrian and slow vehicular users.
- **Base coverage urban:** an urban macro-cellular environment targeting continuous coverage for pedestrian up to fast vehicular users.
- **High speed:** macro cells environment with high speed vehicular and trains.

8.1.1 Indoor test environment

The indoor test environment focuses on smallest cells and high user throughput or user density in buildings. The key characteristics of this test environment are high user throughput or user density in indoor coverage.

8.1.2 Microcellular test environment

The microcellular test environment focuses on small cells and high user densities and traffic loads in city centres and dense urban areas. The key characteristics of this test environment are high traffic loads, outdoor and outdoor-to-indoor coverage. This scenario will therefore be interference-limited, using micro cells. A continuous cellular layout and the associated interference shall be assumed. Radio access points shall be below rooftop level.

A similar scenario is used to the base coverage urban test environment but with reduced site-to-site distance and the antennas below rooftops.

8.1.3 Base coverage urban test environment

The base coverage urban test environment focuses on large cells and continuous coverage. The key characteristics of this test environment are continuous and ubiquitous coverage in urban areas. This scenario will therefore be interference-limited, using macro cells (i.e. radio access points above rooftop level).

In urban macro-cell scenario mobile station is located outdoors at street level and fixed base station antenna clearly above surrounding building heights. As for propagation conditions, non- or obstructed line-of-sight is a common case, since street level is often reached by a single diffraction over the rooftop.

8.1.4 High-speed test environment

The high-speed test environment focuses on larger cells and continuous coverage. The key characteristics of this test environment are continuous wide area coverage supporting high speed vehicles. This scenario will therefore be noise-limited and/or interference-limited, using macro cells.

8.2 Deployment scenarios for the evaluation process

The deployment scenarios that shall be used for each test environment are shown in Table 8-1:

TABLE 8-1
Selected deployment scenarios for evaluation

Test environment	Indoor	Microcellular	Base coverage urban	High speed
Deployment scenario	Indoor hotspot scenario	Urban micro-cell scenario	Urban macro-cell scenario	Rural macro-cell scenario

Suburban macro-cell scenario is an optional scenario for the base coverage urban test environment.

8.3 Network layout

In the rural/high-speed, base coverage urban and microcell cases, no specific topographical details are taken into account. Base stations are placed in a regular grid, following hexagonal layout. A basic hexagon layout for the example of three cells per site is shown in Fig. 1, where also basic geometry (antenna boresight, cell range, and inter-site distance ISD) is defined. The simulation will be a wrap-around configuration of 19 sites, each of 3 cells. Users are distributed uniformly over the whole area.

The amount of channel bandwidth used in a link direction that is used in the simulation is defined as the product of the spectrum bandwidth identified in the tables (Tables 8-5, 8-6, 8-7) as “simulation bandwidth” and the frequency reuse factor, when conventional frequency reuse scheme (e.g. 3-cell and 7-cell frequency reuse) is considered. The cell spectral efficiency, cell edge user spectral efficiency, and VoIP capacity are calculated taking into account the amount of channel bandwidth used for each link direction.

Consider as an example the urban macro cell scenario column for full buffer services in Table 8-5. According to this table the simulation bandwidths are 10 + 10 MHz for FDD and 20 MHz for TDD based systems.

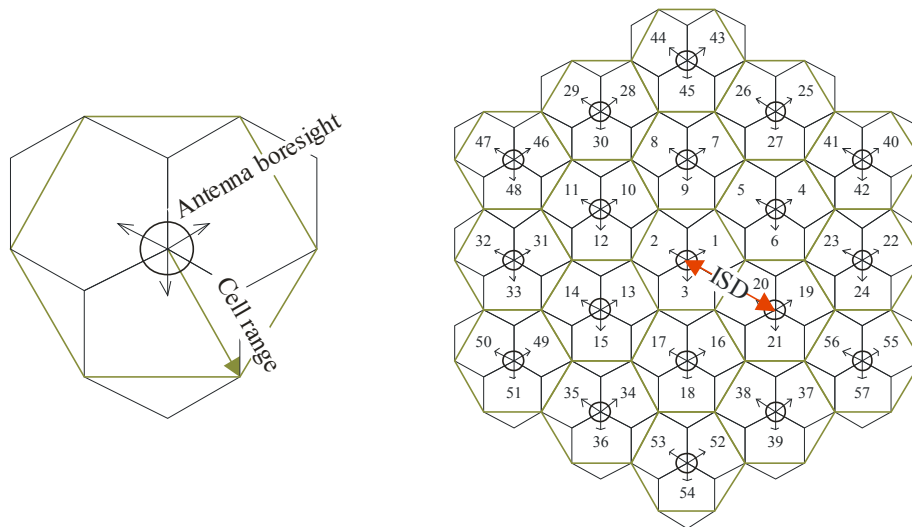
Assuming that an FDD based proposal has frequency reuse factor 3 the resulting amount of spectrum is $3 \times 10 = 30$ MHz for each link, or 60 MHz summed over both directions.

Alternatively, assuming a TDD based proposal with frequency reuse factor of 3 the resulting amount of spectrum is $3 \times 20 = 60$ MHz (also used for both directions). The fraction of time each link direction is taken into account. However, for TDD also the fraction of time each link direction is active should be taken into account to get the effective bandwidth (as an example, the proponent could specify these figures as 60% for UL transmissions and 40% for DL transmissions).

When calculating spectral efficiencies and VoIP capacities for FDD the total spectrum for each individual link should be used in the calculation (30 MHz for each direction in the example), while for TDD the amount of spectrum used for any link direction should be used (60 MHz in the example).

FIGURE 1

Sketch of base coverage urban cell layout without relay nodes



Report 2135-01

The indoor hotspot scenario consists of one floor of a building. The height of the floor is 6 m. The floor contains 16 rooms of 15 m × 15 m and a long hall of 120 m × 20 m. Two sites are placed in the middle of the hall at 30 m and 90 m with respect to the left side of the building (see Fig. 2).

FIGURE 2

Sketch of indoor hotspot environment (one floor)



Report 2135-02

8.4 Evaluation configurations

This section contains baseline configuration parameters that shall be applied in analytical and simulation assessments of candidate RIT/SRITs.

The parameters (and also the propagation and channel models in Annex 1) are solely for the purpose of consistent evaluation of the candidate RIT/SRITs 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 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.

Configuration parameters in Table 8-2 shall be applied when evaluation groups assess the characteristics of cell spectral efficiency, cell edge user spectral efficiency, control plane latency, user plane latency, mobility, handover interruption time and VoIP capacity in evaluation of candidate RIT/SRITs.

TABLE 8-2

Baseline evaluation configuration parameters

Deployment scenario for the evaluation process	Indoor hotspot	Urban micro-cell	Urban macro-cell	Rural macro-cell	Suburban macro-cell
Base station (BS) antenna height	6 m, mounted on ceiling	10 m, below rooftop	25 m, above rooftop	35 m, above rooftop	35 m, above rooftop
Number of BS antenna elements ⁽¹⁾	Up to 8 rx Up to 8 tx	Up to 8 rx Up to 8 tx	Up to 8 rx Up to 8 tx	Up to 8 rx Up to 8 tx	Up to 8 rx Up to 8 tx
Total BS transmit power	24 dBm for 40 MHz, 21 dBm for 20 MHz	41 dBm for 10 MHz, 44 dBm for 20 MHz	46 dBm for 10 MHz, 49 dBm for 20 MHz	46 dBm for 10 MHz, 49 dBm for 20 MHz	46 dBm for 10 MHz, 49 dBm for 20 MHz
User terminal (UT) power class	21 dBm	24 dBm	24 dBm	24 dBm	24 dBm
UT antenna system ⁽¹⁾	Up to 2 tx Up to 2 rx	Up to 2 tx Up to 2 rx	Up to 2 tx Up to 2 rx	Up to 2 tx Up to 2 rx	Up to 2 tx Up to 2 rx
Minimum distance between UT and serving cell ⁽²⁾	≥ 3 m	≥ 10 m	≥ 25 m	≥ 35 m	≥ 35 m
Carrier frequency (CF) for evaluation (representative of IMT bands)	3.4 GHz	2.5 GHz	2 GHz	800 MHz	Same as urban macro-cell
Outdoor to indoor building penetration loss	N.A.	See Annex 1, Table A1-2	N.A.	N.A.	20 dB
Outdoor to in-car penetration loss	N.A.	N.A.	9 dB (LN, $\sigma = 5$ dB)	9 dB (LN, $\sigma = 5$ dB)	9 dB (LN, $\sigma = 5$ dB)

⁽¹⁾ The number of antennas specified by proponent in the technology description template (§ 4.2.3 of Report ITU-R M.2133) should be used in the evaluations. The numbers shall be within the indicated ranges in this table.

⁽²⁾ In the horizontal plane.

8.4.1 Evaluation configurations parameters for analytical assessment

Configuration parameters in Table 8-3 shall be applied when evaluation groups assess the characteristics of peak spectral efficiency in evaluation of candidate RIT/SRITs.

TABLE 8-3

Evaluation configuration parameters for analytical assessment of peak spectral efficiency

Deployment scenario for the evaluation process	Indoor hotspot	Urban micro-cell	Urban macro-cell	Rural macro-cell	Suburban macro-cell
Number of BS antenna elements	Up to 4 rx Up to 4 tx	Up to 4 rx Up to 4 tx	Up to 4 rx Up to 4 tx	Up to 4 rx Up to 4 tx	Up to 4 rx Up to 4 tx
UT antenna system	Up to 2 tx Up to 4 rx	Up to 2 tx Up to 4 rx	Up to 2 tx Up to 4 rx	Up to 2 tx Up to 4 rx	Up to 2 tx Up to 4 rx

8.4.2 Evaluation configurations parameters for simulation assessment

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

8.4.2.1 Additional parameters for system simulation

Parameters in Table 8-4 shall also be applied in system simulation when assessing the characteristics of cell spectral efficiency, cell edge user spectral efficiency and VoIP capacity.

TABLE 8-4
Additional parameters for system simulation

Deployment scenario for the evaluation process	Indoor hotspot	Urban micro-cell	Urban macro-cell	Rural macro-cell	Suburban macro-cell
Layout ⁽¹⁾	Indoor floor	Hexagonal grid	Hexagonal grid	Hexagonal grid	Hexagonal grid
Inter-site distance	60 m	200 m	500 m	1 732 m	1 299 m
Channel model	Indoor hotspot model (InH)	Urban micro model (UMi)	Urban macro model (UMa)	Rural macro model (RMa)	Suburban macro model (SMa)
User distribution	Randomly and uniformly distributed over area	Randomly and uniformly distributed over area. 50% users outdoor (pedestrian users) and 50% of users indoors	Randomly and uniformly distributed over area. 100% of users outdoors in vehicles	Randomly and uniformly distributed over area. 100% of users outdoors in high speed vehicles	Randomly and uniformly distributed over area. 50% users vehicles and 50% of users indoors
User mobility model	Fixed and identical speed $ v $ of all UTs, randomly and uniformly distributed direction	Fixed and identical speed $ v $ of all UTs, randomly and uniformly distributed direction	Fixed and identical speed $ v $ of all UTs, randomly and uniformly distributed direction	Fixed and identical speed $ v $ of all UTs, randomly and uniformly distributed direction	Fixed and identical speed $ v $ of all UTs, randomly and uniformly distributed direction
UT speeds of interest	3 km/h	3 km/h	30 km/h	120 km/h	Indoor UTs: 3 km/h, outdoor UTs: 90 km/h
Inter-site interference modeling ⁽²⁾	Explicitly modelled	Explicitly modelled	Explicitly modelled	Explicitly modelled	Explicitly modelled
BS noise figure	5 dB	5 dB	5 dB	5 dB	5 dB
UT noise figure	7 dB	7 dB	7 dB	7 dB	7 dB
BS antenna gain (boresight)	0 dBi	17 dBi	17 dBi	17 dBi	17 dBi
UT antenna gain	0 dBi	0 dBi	0 dBi	0 dBi	0 dBi
Thermal noise level	-174 dBm/Hz	-174 dBm/Hz	-174 dBm/Hz	-174 dBm/Hz	-174 dBm/Hz

⁽¹⁾ See § 8.3 for further detail.

⁽²⁾ See § 7.1.

When assessing the cell spectral efficiency and cell edge user spectral efficiency characteristics, parameters in Table 8-5 shall also be applied.

TABLE 8-5
Additional parameters for assessment of cell spectral efficiency
and cell edge user spectral efficiency

Deployment scenario for the evaluation process	Indoor hotspot	Urban micro-cell	Urban macro-cell	Rural macro-cell	Suburban macro-cell
Evaluated service profiles	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort
Simulation bandwidth	20 + 20 MHz (FDD), or 40 MHz (TDD)	10 + 10 MHz (FDD), or 20 MHz (TDD)	10 + 10 MHz (FDD), or 20 MHz (TDD)	10 + 10 MHz (FDD), or 20 MHz (TDD)	10 + 10 MHz (FDD), or 20 MHz (TDD)
Number of users per cell	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 characteristic, parameters in Table 8-6 shall also be applied.

TABLE 8-6
Additional parameters for assessment of VoIP capacity

Deployment scenario for the evaluation process	Indoor hotspot	Urban micro-cell	Urban macro-cell	Rural macro-cell	Suburban macro-cell
Evaluated service profiles	VoIP	VoIP	VoIP	VoIP	VoIP
Simulation bandwidth ⁽¹⁾	5 + 5 MHz (FDD), 10 MHz (TDD)	5 + 5 MHz (FDD), 10 MHz (TDD)	5 + 5 MHz (FDD), 10 MHz (TDD)	5 + 5 MHz (FDD), 10 MHz (TDD)	5 + 5 MHz (FDD), 10 MHz (TDD)
Simulation time span for a single drop	20 s	20 s	20 s	20 s	20 s

⁽¹⁾ While it is recognized that the bandwidth associated with VoIP implementations could be significantly larger than the bandwidth specified herein; this bandwidth was chosen to allow simulations to be practically conducted. Using larger bandwidths and the corresponding larger number of users to be simulated increases the simulation complexity and time required to perform the simulations.

8.4.2.2 Additional parameters for link level simulation

Parameters in Table 8-7 shall also be applied in link level simulation when assessing the characteristic of mobility.

TABLE 8-7

Additional parameters for link level simulation (for mobility requirement)

Deployment scenario for the evaluation process	Indoor hotspot	Urban micro-cell	Urban macro-cell	Rural macro-cell	Suburban macro-cell
Evaluated service profiles	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort	Full buffer best effort
Channel model	Indoor hotspot model (InH)	Urban micro-cell model (UMi)	Urban macro-cell model (UMa)	Rural macro-cell model (RMa)	Suburban macro-cell model (SMa)
Simulation bandwidth	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz
Number of users in simulation	1	1	1	1	1

8.5 Antenna characteristics

This sub-section specifies the antenna characteristics, e.g. antenna pattern, gain, side-lobe level, orientation, etc., for antennas at the base station (BS) and the user terminal (UT), which shall be applied for the evaluation in the deployment scenarios with the hexagonal grid layout (i.e., urban macro-cell, urban micro-cell, rural macro-cell, and suburban macro-cell). The characteristics do not form any kind of requirements and should be used only for the evaluation.

8.5.1 BS antenna

8.5.1.1 BS antenna pattern

The horizontal antenna pattern used for each BS sector⁵ is specified as:

$$A(\theta) = -\min \left[12 \left(\frac{\theta}{\theta_{3\text{dB}}} \right)^2, A_m \right] \quad (1)$$

Where $A(\theta)$ is the relative antenna gain (dB) in the direction θ , $-180^\circ \leq \theta \leq 180^\circ$, and $\min [.]$ denotes the minimum function, $\theta_{3\text{dB}}$ is the 3 dB beamwidth (corresponding to $\theta_{3\text{dB}} = 70^\circ$), and $A_m = 20$ dB is the maximum attenuation. Figure 3 shows the BS antenna pattern for 3 sector cells to be used in system level simulations.

A similar antenna pattern will be used for elevation in simulations that need it. In this case the antenna pattern will be given by:

$$A_e(\phi) = -\min \left[12 \left(\frac{\phi - \phi_{\text{tilt}}}{\phi_{3\text{dB}}} \right)^2, A_m \right] \quad (2)$$

where $A_e(\phi)$ is the relative antenna gain (dB) in the elevation direction, ϕ , $-90^\circ \leq \phi \leq 90^\circ$, $\phi_{3\text{dB}}$ is the elevation 3 dB value, and it may be assumed to be 15° , unless stated otherwise. ϕ_{tilt} is the tilt angle, which should be provided by proponents per deployment scenario.

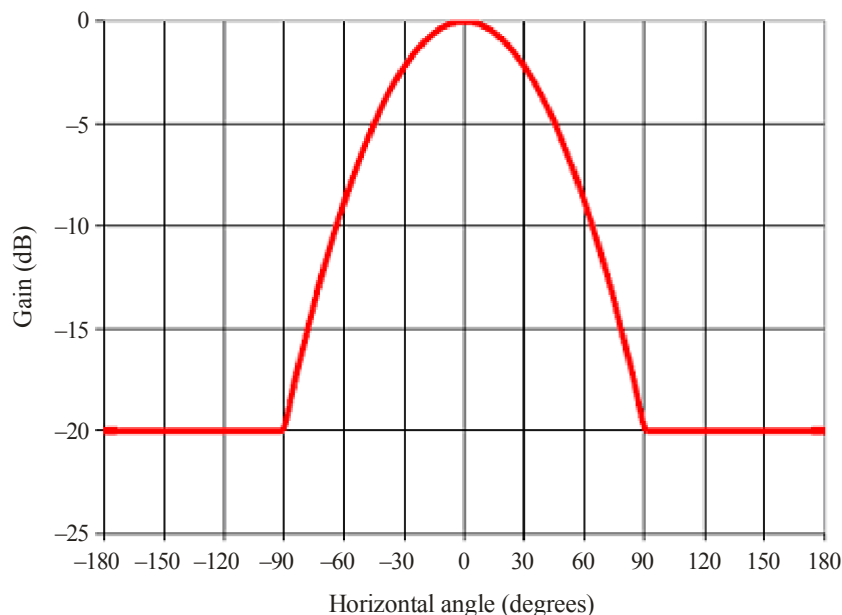
⁵ A sector is equivalent to a cell.

The combined antenna pattern at angles off the cardinal axes is computed as:

$$-\min\left[-(A(\theta) + A_e(\phi)), A_m\right]$$

FIGURE 3

Antenna pattern for 3-sector cells



Report 2135-03

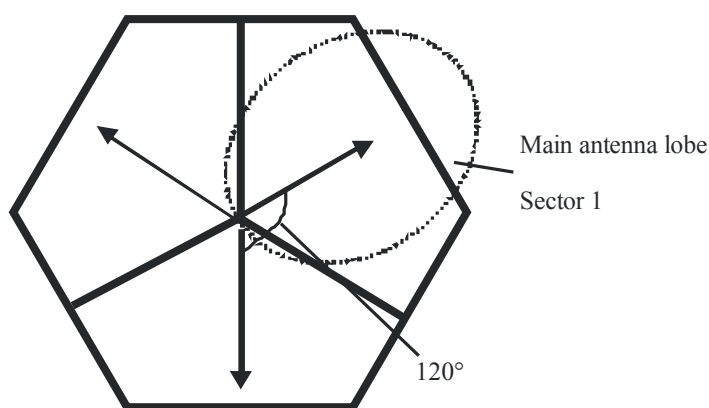
8.5.1.2 BS antenna orientation

The antenna bearing is defined as the angle between the main antenna lobe centre and a line directed due east given in degrees. The bearing angle increases in a clockwise direction. Figure 4 shows the hexagonal cell and its three sectors with the antenna bearing orientation proposed for the simulations. The centre directions of the main antenna lobe in each sector point to the corresponding side of the hexagon.

For indoor test environment, omni antenna should be used for the BS.

FIGURE 4

Antenna bearing orientation diagram



Report 2135-04

8.5.2 UT antenna

The UT antenna is assumed to be omni directional.

9 Channel model approach

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

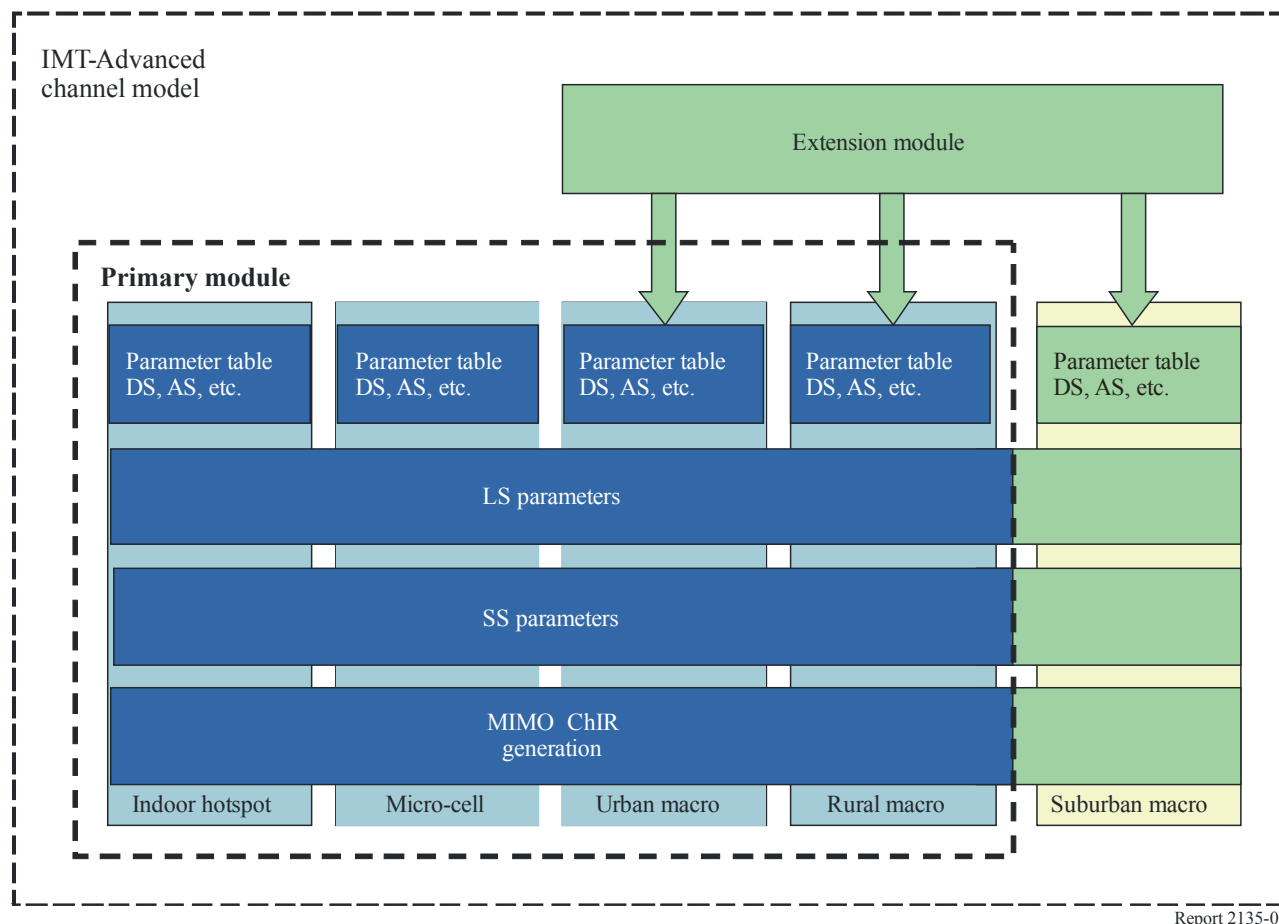
Realistic system performance cannot be evaluated by single link simulations. Even the performance of a single link depends on other links due to the influence of advanced radio resource management (RRM) algorithms, interference generated by other links and so on. Multi-link models for system level evaluations have been developed in the family of geometry-based stochastic channel models.

The IMT-Advanced channel model for the evaluation of IMT-Advanced candidate RITs consists of a Primary Module and an Extension Module as shown in Fig. 5. The framework of the primary module is based on the WINNER II channel model*, which applies the same approach as 3GPP/3GPP2 SCM model**. Different evaluation scenarios are shown in parallel in Fig. 5.

* IST-WINNER II Deliverable 1.1.2 v.1.2. WINNER II Channel Models, IST-WINNER2. Tech. Rep., 2007 (<http://www.ist-winner.org/deliverables.html>).

** 3GPP TR25.996 V6.1.0 (2003-09) Spatial channel model for multiple input multiple output (MIMO) simulations. Release 6.

FIGURE 5
The IMT-Advanced channel model



The scenarios chosen for the evaluations of the IMT-Advanced candidate RITs are: indoor hotspot, urban micro-cell, urban macro-cell and rural macro-cell. The primary module covers the parameter tables and channel model definition for the evaluations. The IMT-Advanced channel model contains parameters from Table A1-7 for evaluating the IMT-Advanced candidate RITs in the four scenarios of the primary module.

Mandatory channel model parameters for evaluation of RITs for the scenarios indoor hotspot, urban micro-cell, urban macro-cell, and rural macro-cell are contained in the primary module as shown in Fig. 5 and in Table A1-7 and are not generated from the extension module. In addition, the channel model could also be applied for other cases, i.e., if some of the parameters described in § 8.4 for macro-cell scenarios, e.g., BS antenna height, street width, city structure, etc. could be varied to cover other cases not described in this Report. The extension module can extend the capabilities of the IMT-Advanced channel model to cover those cases beyond the evaluations of the IMT-Advanced candidate RITs by allowing the usage of modified parameters to generate large scale parameters in the scenarios or usage of other scenarios.

The ITU-R IMT-Advanced channel model is a geometry-based stochastic model. It can also be called double directional channel model. It does not explicitly specify the locations of the scatterers, but rather the directions of the rays, like the well-known spatial channel model (SCM)*. Geometry-based modelling of the radio channel enables separation of propagation parameters and antennas.

* 3GPP TR25.996 V6.1.0 (2003-09) Spatial channel model for multiple input multiple output (MIMO) simulations. Release 6.