ARIB

Association of Radio Industries and Businesse

# Evaluation Methodology for IMT-2000 Radio Transmission Technologies

(Version 1 )

Evaluation Group
ARIB IMT-2000 Study Committee

Association of Radio Industries and Businesses (ARIB)

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## Version History and Status

Version 0.3

- This is a consolidated draft based on the materials of 5th meeting of the evaluation group, April 13, 1998.

Version 0.4

- It was reviewed by the evaluation group at its 6th meeting, May 13, 1998. It was approved as a baseline document with necessary modification and addition by the 6th evaluation group meeting.
- It was also introduced in the joint meeting of 5th System WG and 6th Radio Interface WG, May 15, 1998. The meeting approved to input it to forthcoming Standardization Sub-Committee with necessary modification and addition. The meeting requested all meeting members for comment to this version.

Version 0.5.1

- It was reviewed by the Standardization Sub-Committee, May 18, 1998. The meeting approved to submit this document to ITU-R in early June. It was also noted that it will be submitted with editorial modification, if necessary.

Version 1

- This is a first version officially delivered to ITU and other organizations.

## Copyright Notification

## 1. Introduction

ITU-R announced to initiate the process of IMT-2000 radio interface development by its Circular Letter 8/LCCE/47, 4 April 1997. The evaluation group in ARIB has been established and registered in ITU-R TG8/1 as an independent outside evaluation activity on RTT proposals to ITU in accordance with the Circular Letter. The evaluation group will evaluate candidate RTT proposals based on the ITU-R Recommendation M.1225 with some modifications and additional information required. The cut off date for submission of RTT proposals is June 30 1998, and the deadline for the outside evaluation groups to submit their reports to ITU-R is set to September 30 1998. This document describes the evaluation principles and methodology that has been established, developed, and agreed upon in the evaluation group under the IMT-2000 Study Committee in ARIB (Association for Radio Industries and Businesses). The evaluation group will use his document to evaluate various candidates for RTT's to IMT-2000 during the evaluation process.

## 2. SCOPE

This document entitled Evaluation Methodology from ARIB IMT-2000 Study Committee, Evaluation Group, establishes the technical procedure for evaluation of candidate radio transmission technologies for IMT-2000 to be performed within ARIB. This document will be sent out to other evaluation groups registered ITU for information about the principles and methodology of the evaluation group, and will also be posted on the ITU-R website. It will serve as an attachment to the submission of the evaluation report to ITU-R.

## 3. EVALUATION PRINCIPLE

### 3.1 Objectives of Evaluation

- The primary purpose of the evaluation is to confirm that all the ITU requirements are fulfilled.
- Evaluation activities should accelerate the convergence process in ITU, within standardization bodies and between standardization bodies.
- Evaluation would clarify the characteristics and advantages/disadvantages of the proposed RTT candidate. However, comparison through deliberation of advantages and disadvantages of the proposed systems is not the main purpose of the ARIB evaluation process.

### 3.2 Relative Evaluation and/or Absolute Evaluation

- Evaluation should be an absolute nature. Each RTT candidate should be evaluated individually. It should not be a process of relative comparison between RTT candidates.

### 3.3 Quantitative and/or Qualitative Evaluation

- The evaluation of the criteria is performed by the following steps:
    - Evaluate each attribute that comprises the criterion.
    - Evaluate the criteria comprehensively based on the evaluation results for each attribute.
- The relationship between the attribute evaluation results and criteria evaluation results needs to be defined for the second step.

- For objective evaluation of criteria, quantitative description shall be used for those attributes that require quantitative evaluation. For such attributes, the calculation method for numerical values shall be clearly defined by the ARIB evaluation group. (Example: voice traffic capacity (A3.1.1.1) in spectrum efficiency)
- For other types of attributes the objective evaluation or numerical evaluation methods are not defined.
- For the relationship between each attribute and criterion, only the degree of significance ranging from G1 (high) to G4 (low) could be defined. For example, the maximum user bit rate for data (A3.3.5) in Quality criterion gives a numerical value. However, the ARIB evaluation group shall not define a function of the maximum user bit rate in order to give a numerical score for Quality criterion.
- Even for the spectrum efficiency criterion, that is made of quantitative attributes, the method of determining the numerical value from its attributes (such as multiple data rates, circuit switched/packet switched, multiple velocities) should not be defined.
- Consequently each criterion is basically evaluated qualitatively.

### 3.4 Weighting of Criteria

- The purpose of the ARIB evaluation process is to clarify the features of the proposal. Therefore the weighting with numerical values for criteria's evaluation should not be defined.

### 3.5 Verification of submitted RTT performance

- The ARIB evaluation group asks proponents to provide an information document on the proposed RTT performance, including parameters and assumptions used for evaluation in submission of the RTT proposal. Considering the information, the correctness of the claimed RTT performance is verified. ARIB evaluation group asks proponents to provide further information during the verification process if required. Only when a specific situation requires it, does the ARIB evaluation group verify the RTT performance by its own simulation.

### 3.6 Summary evaluations

- Summary evaluations for a criterion are made based on the Annex 3 of M.1225, i.e. "detailed evaluation procedures," on a RTT basis. The overall evaluation of each RTT highlights its features based on criteria's summary evaluations. The evaluation group will compare across different RTTs, only when required by ARIB. However, this comparison shall not be for the purpose of selection but for clarifying the difference between RTT features.

## 4. EVALUATION PROCEDURE

This section describes the flow of ARIB evaluation process.

### 4.1 Receipt of the proposal

- Check if documents defined by ITU-R are complete.
- Check if documents required for ARIB evaluation, defined in section 6 of this document are complete. ARIB evaluation group requests proponents to provide their views and comments on each attribute in Annex 3 template, i.e. the evaluation criteria template.
- Determine if ARIB will evaluate the proposal. The evaluation group may not evaluate every RTTs proposed and posted to ITU-R.

### 4.2 Check on the minimum performance capabilities of the proposal

- Check if the proposal satisfies the minimum performance capabilities defined in Attachment 6 of the Circular Letter.

### 4.3 Check on the descriptions in the proposal

- Check the 'Requirement and Objective and Compliance template'.
  - For the items marked with [No], check the descriptions for the validity of the reasons.
  - For the items marked with [Yes], check the descriptions referring to the items in Annex 1, i.e. the technology description template.
  - Request additional information, if necessary.
- Check the contents of template described in Annexes 1 and 3.
  - Examine carefully the preconditions concerning the quantitative indices and check the numerical values.
  - Ask proponents, if necessary, to provide detail parameters and assumptions used for their simulations calculating the numerical values, e.g. the spectrum efficiency.
  - Check the validity of descriptions concerning the qualitative indices.
  - Check the consistency with the descriptions in corresponding Annex 1 template and request additional documents, if necessary.

### 4.4 Determination of the evaluation result

- Judge if the contents described in Annex 3 template by the proponent are adequate and request additional comments from the proponent, if necessary.
- Determine the evaluation as ARIB based on the evaluation result for each criterion. See section 3.

### 4.5 Preparation of the evaluation report

- Prepare an evaluation report for each proposed RTT separately based on the evaluation result determined by ARIB.
- Prepare, if necessary, a separate report indicating comparison results across different RTTs.

### 4.6 Submission of the evaluation report to ITU-R

- Submit the evaluation report to ITU-R as the evaluation result of ARIB.

## 5. CO-OPERATION AND HARMONIZATION WITH OTHER EVALUATION BODIES

ARIB has the primary objective to establish a worldwide common IMT-2000 standard. To reach this objective it has been a natural strategy for ARIB for some time to continuously coordinate and discuss with different standardization bodies regarding their activities towards an IMT-2000 standard. It has been decided that ARIB will base its RTT proposal to ITU-R TG8/1 on the Version 0.5 of the ARIB specification that is at the moment under study (Version 0 was finalized in December 1997). This RTT is based on a W-CDMA technology that consists of both FDD and TDD modes. With this technology in mind, ARIB is willing to undertake all possible cooperation with relevant standardization organizations to reach an as harmonized RTT proposal as possible.

With the primary objective in mind, the Evaluation Group under the IMT-2000 Study Committee in ARIB recognize the importance to cooperate and harmonize in order to reach a common understanding also regarding the evaluation methodology of RTT proposals to ITU-R TG8/1. The Evaluation Group believe it is important to ensure similarities and commonalities as far as possible in the evaluation methodology of different RTT's and the actual RTT proposal itself. With a good cooperation between evaluation groups, unnecessary duplication work can be avoided and instead work sharing can be utilized in the process that is beneficial for all parties involved.

# 6. ADDITIONAL EVALUATION METHODOLOGY (OTHER THAN M.1225)

This section describes the difference in methodologies with ITU-R M.1225 and the Circular Letter.

## 6.1 Requirements and objectives

ARIB evaluation group reviewed existing ITU Recommendations and 'Requirements and Objectives for a 3G Mobile Services and System', that is one of the ARIB's specification volumes for IMT-2000. The evaluation group defines additional requirements and objects that will be used in its evaluation process in addition to the original Requirements and Objectives shown Attachment 4 of the Circular Letter. Annex IV of this document provides ARIB's adendum.

## 6.2 Test Environments and Deployment Models

Considering fair comparison of multiple proposals and convenience of computer simulations, Annex 2 of M.1225 has been modified and further description has been added as shown in Annex-II of this document. In order to avoid excessively complex computer simulations, methods considered as optional are distinguished from evaluation requirements and added as appendices to this annex. Furthermore, methods or conditions that are not specified in this annex but proponents have to specify are introduced in each related section. The annex was editorially changed to remove ambiguous description of the original document. Meanwhile, it should be noted that the description for the satellite component has not been changed. The differences between the original Annex 2 of M.1225 and ARIB's Annex 2 are listed below.

1. List of test data rates for evaluation purposes shown in Table 1 are modified: delay requirements are added and ranges of bit rates are modified.
2. The value for shadowing correlation coefficients is defined as 0.5. Although the same value is determined in the link budget calculation in M.1225 Annex 2, it is defined more clearly in ARIB's Annex 2.
3. Following items are added to the link budget template (1.3.1).
   - A method for determining the interference power density using system simulations.
   - Brief description of the channel model to evaluate the antenna diversity gain.
   - Transmit power control requirement: No power control should be considered for link simulation in link budget calculation.
   - To remove inconsistency on channel model(s) for link level simulations, it is stated that both channel A and B should be used in the simulations.
   - A method for determining the traffic density for the low traffic conditions.
4. For each deployment model, a cell reference model is defined. Examples of cell layout, mobility model for mobile stations, and antenna radiation pattern are demonstrated. These reference models are shown in Appendix 3 to ARIB's Annex 2.
5. Detailed descriptions of packet traffic models are added.
6. A simple model of channel impulse response that can be used in link level simulations is proposed in Section 1.2.2. The detailed description of the model is presented in Appendix 4 to ARIB's Annex 2.
7. An expression for capacity evaluation for CDMA reverse link is proposed in Appendix 5.

8. Dynamic delay profiles that are required to evaluate interference canceller are not specified in ARIB's M.1225 Annex 2 but have to be described by proponents if these are used.
9. Performance measures that can be used in system level simulations are demonstrated in Appendix 6.

Furthermore, the structure of Annex 2 is also modified during editing the text according to modifications mentioned above. Table 1 represents the structural comparison between sections in the original Annex 2 and those of the modified Annex 2.

**Table 1: Structural comparison between the original M.1225 and ARIB's**

| Original | ARIB | Title | Status | Remarks |
|---|---|---|---|---|
| PART 1 | PART1 | Terrestrial component | - | |
| 1. | 1. | Test environment | Modified | Table 1 |
| 1.1 | 1.1 | Test environment descriptions | Not Changed | |
| 1.1.1 | 1.1.1 | Indoor office test environment | Not Changed | |
| 1.1.2 | 1.1.2 | Outdoor to indoor and pedestrian test environment | Not Changed | |
| 1.1.3 | 1.1.3 | Vehicular test environment | Not Changed | |
| 1.1.4 | 1.1.4 | Mixed test environment | Not Changed | |
| 1.2 | 1.2 | Propagation models | Not Changed | |
| 1.2.1 | 1.2.1 | Path loss models | Not Changed | |
| 1.2.1.1 | 1.2.1.1 | Path loss model for indoor office test environment | Not Changed | |
| 1.2.1.2 | 1.2.1.2 | Path loss model for outdoor to indoor and pedestrian test environment | Not Changed | |
| 1.2.1.3 | 1.2.1.3 | Path loss model for vehicular test environment | Not Changed | |
| 1.2.1.4 | 1.2.1.4 | Decorrelation length of the long-term fading | Not Changed | |
| (New) | 1.2.1.5 | Shadowing correlation | Added | |
| 1.2.2 | 1.2.2 | Channel impulse response model | Modified | Pointer to Appendix 4 |
| (New) | 1.2.3 | Channel model for antenna diversity | Added | |
| 1.3 | 1.3 | Link budget template and deployment models | Modified | Removal of the ambiguity on selecting channel A or B |
| 1.3.1 | 1.3.1 | Terrestrial link budget templates | Modified | Table 6 is NOT changed but definitions are modified. |
| (New) | 1.3.1.1 | Low traffic levels for coverage efficiency evaluation | Added | |
| (New) | 1.3.1.2 | Proposal methodology for coverage efficiency evaluation | Added | |
| 1.3.2 | 1.3.2 | Deployment model | Modified | Pointers to Appendices 5 and 6 |
| 1.3.2.1 | 1.3.2.1 | Indoor office test environment | Modified | Pointer to Appendix 3 |
| 1.3.2.2 | 1.3.2.2 | Outdoor to indoor and pedestrian deployment model | Modified | Pointer to Appendix 3 |
| 1.3.2.3 | 1.3.2.3 | Vehicular environment deployment model | Modified | Pointer to Appendix 3 |

| | | | | |
|---|---|---|---|---|
| 1.3.2.4 | 1.3.2.4 | Mixed-cell pedestrian/vehicular test environment deployment model | Modified | Pointer to Appendix 3 |
| 1.3.3 | 1.3.3 | Deployment model result matrix | Not Changed | |
| (New) | 1.4 | Packet traffic model | Added | |
| PART2 | PART2 | Satellite component | Not Changed | Not attached |
| App. 1 | App.1 | Propagation models | Not Changed | Not attached |
| App. 2 | App. 2 | Computation of Doppler shift for satellites | Not Changed | Not attached |
| (New) | App. 3 | Example cell layouts for deployment models | Added | |
| (New) | App. 4 | Example channel impulse response models for link level simulations | Added | |
| (New) | App. 5 | Expression for Capacity Evaluation | Added | |
| (New) | App. 6 | Performance Measure | Added | |

* The changes that are made to keep consistency of the text such as numbering to figures and tables are not considered in this comparison.

### 6.3 Evaluation Criteria

In order to make reasonable evaluation and to remove ambiguity, the Annex 3 of M.1225 indicating the attributes for each criterion has been modified a little.

The differences between M.1225 Annex 3 and ARIB's Annex 3 are listed below.

- To make the word 'data' more clear, word 'voice', 'voice and data', 'switched data', 'packet data' are added to following attributes. (A3.1.1.2, A3.3.4, A3.3.5, A3.4.1.1, A3.4.1.5)
- Because the core network and speech codec are not directly relevant to the RTT evaluation and the echo control is depend on speech codec, A3.2.1 'Need for echo control' is deleted.
- The round trip delay 'D1' is deeply depend on speech codec, the attribute 'D1' in A3.3.2 is deleted.
- Because speech codecs are not directly relevant for RTT evaluation process, the ranking of A3.3.7 'voice quality' is changed.
- The following attributes are deleted, since the core network releted matters are not directly relevant to the RTT evaluation. (A3.5.2, A3.5.3, A3.5.3.1, A3.5.3.2, A3.5.3.3, A3.5.3.4)
- Frequency band plans and frequency duplexing arrangements for IMT-2000 may differ with Regions, regions and countries. A new attribute A3.4.2.1.4 is added to evaluate how capable of flexible usage of the planed spectrum the proposed RTT can offer.

## 7. REQUIRED INFORMATION FROM PROPONENTS

### 7.1 Documents requested by ITU

- Cover Sheet for Submission of Proposed RTTs (Attachment 2 of the Circular Letter)
- Technologies Description Template (Attachment 1 of ITU-R M.1225)
- IMT-2000 Requirements and Objectives Compliance Template (Attachment 4 of the Circular Letter[1])
- List of any known patent or any known pending patent application of relevance to the proposal

[1] Addendum 1 (6 October 1997) and Addendum 2 (3 February 1998) to 8/LCCE/47

- Additional inputs that the proponent may consider relevant to the evaluation.

### 7.2 Documents requested by ARIB evaluation group

- Cover Sheet for Submission of Proposed RTTs (Attachment 2 of the Circular Letter)
- Technologies Description Template (Annex I of this document)
- Link budget templates for test services (Table 6 in Annex II of this document)
- Compliance Template for the Minimum Performance Capabilities (Attachment 6 of the Circular Letter)
- IMT-2000 Requirements and Objectives Compliance Template (Annex IV of this document)
- List of any known patent or any known pending patent application of relevance to the proposal
- Views and comments of the proponents on each attribute in Annex III template in this document, i.e. the criteria evaluation template
- Additional information which the proponent may consider relevant to the evaluation

## 8. EVALUATION REPORTS

The evaluation report to ITU will contain following documents;

- For ARIB evaluation methodology
  - ARIB Evaluation Methodology (this document)
- For each RTT candidate proposal
  - RTT proposal in Annex I format, which may be different to the original corresponding input owing to information exchange between the proponent during the evaluation
  - RTT performance report with evaluator's verification comments
  - Evaluation Spreadsheet as in Section 9.3 of M.1225 which is made based upon RTT self evaluation report in Annex 3 format
  - IMT-2000 Requirements and Objectives and Compliance Template, which the proponent submitted based on Annex IV of this document and confirmed by the evaluation group
  - Summary of overall evaluation for the RTT candidate
- For candidate RTT proposals evaluated in ARIB, if necessary
  - Comparison results across different RTTs
  - Evaluation summary

## REFERENCES

1. Recommendation ITU-R M.1225, GUIDELINES FOR EVALUATION OF RADIO TRANSMISSION TECHNOLOGIES FOR IMT-2000, 1997
2. ITU BR Circular Letter 8/LCCE/47, Request for Submission of Candidate Radio Transmission Technologies (RTTs) for IMT-2000/FPLMTS Radio Interface , 4 April 1997
3. Corrigendum 1 to Circular Letter 8/LCCE/47, 25 April 1997
4. Addendum 1 to Circular Letter 8/LCCE/47, 6 October 1997
5. Addendum 2 to Circular Letter 8/LCCE/47, 3 February 1998
6. Corrigendum 2 to Circular Letter 8/LCCE/47, [XX May] 1998

7. ARIB's specification for IMT-2000, 'Requirements and Objectives for a 3G Mobile Services and System (Volume-1)', version-0, December 1997.
8. ETSI TR 101 112 V3.1.0, Selection procedures for the choice of radio transmission technologies of the UMTS, Nov. 1997.

# ANNEX I

## Modified version of ANNEX 1 of M.1225 to be used evaluation in ARIB

## Annex 1

## Radio transmission technologies description template

| |
|---|
| The radio transmission technologies description template for the ARIB's evaluation methodology of version 0.5 is identical with the Annex 1 of ITU-R M.1225 Recommendation. |

## ANNEX II

## Modified version of ANNEX 2 of M.1225 to be used evaluation in ARIB[2]

## ANNEX 2

## Test environments and deployment models

This Annex describes the reference scenarios (test environments and deployment models) and propagation models necessary to elaborate the performance figures of candidate terrestrial and satellite RTTs for IMT-2000. The terrestrial and the satellite component are subdivided in Parts 1 and 2, respectively.

## PART 1

## Terrestrial component

### 1 Test environments

This section will provide the reference model for each test operating environment. These test environments are intended to cover the range of IMT-2000 operating environments. The necessary parameters to identify the reference models include the test propagation environments, traffic conditions, user information rate for prototype voice and data services, and the objective performance criteria for each test operating environment.

The test operating environments are considered as a basic factor in the evaluation process of the RTTs. The reference models are used to estimate the critical aspects, such as the spectrum, coverage and power efficiencies. This estimation will be based on system-level calculations and link-level software simulations using propagation and traffic models. Critical aspects of RTTs, such as spectrum and coverage efficiencies, cannot be fairly estimated independently of appropriate IMT-2000 services. These IMT-2000 services are, as minimum, characterised by:

– ranges of supported data rates,
– BER requirements,
– one way delay requirements,
– activity factor,
– traffic models.

Table 1 provides a list of test data rates for evaluation purposes[3].

[2] PART 2 'Satellite component' is not included in this Annex III, since there are no modification.

[3] LDD Low Delay Data bearer service
LCD Long Constrained Delay data bearer service
UDD Unconstrained Delay Data bearer service

**Table 1.0 : List of test data rates for evaluation purposes**

| Test environments | Indoor Office | Outdoor to Indoor and Pedestrian | Vehicular Speeds 120 km/h |
|---|---|---|---|
| Test services | bit rates (values)<br>BER<br>Channel activity | bit rates (values)<br>BER<br>Channel activity | bit rates (values)<br>BER<br>Channel activity |
| Representative low delay data bearer for speech*[1] | 8 - 16 - 32 kbps<br>$\leq 10^{-3}$<br>50% | 8 - 16 - 32 kbps<br>$\leq 10^{-3}$<br>50% | 8 - 16 - 32 kbps<br>$\leq 10^{-3}$<br>50% |
| LDD Data<br>(circuit-switched, low delay)*[1] | 64 - 144*[2] - 384 - 512 - 1024 - 2048 kbps<br>$\leq 10^{-6}$<br>100% | 64 - 144*[2] - 384 kbps<br>$\leq 10^{-6}$<br>100% | 64 - 144*[2] kbps<br>$\leq 10^{-6}$<br>100% |
| LCD Data<br>(circuit-switched, long delay constrained)*[1] | 64 - 144*[2] - 384 - 512 - 1024 - 2048 kbps<br>$\leq 10^{-6}$<br>100% | 64 - 144*[2] - 384 kbps<br>$\leq 10^{-6}$<br>100% | 64 - 144*[2] kbps<br>$\leq 10^{-6}$<br>100% |
| UDD Data (packet)<br>Connection-less information types | 64 - 144*[2] - 384 - 512 - 1024 - 2048 kbps<br>$\leq 10^{-6}$<br>See Section 1.4 | 64 - 144*[2] - 384 kbps<br>$\leq 10^{-6}$<br>See Section 1.4 | 64 - 144*[2] kbps<br>$\leq 10^{-6}$<br>See Section 1.4 |

*[1] Proponents must indicate the achieved one-way delay (excluding propagation delay, delay due to speech framing and processing delay of voice channel coding) for all the test services.

*[2] The bit rate of 128 kbps can be used instead of 144 kbps.

NOTE 1: For LDD services, a BER threshold of $10^{-4}$ will be considered for the initial comparison phase of the different concepts in order to reduce simulation times. The BER threshold of $10^{-6}$ will be considered in the optimisation phase.

NOTE 2 : In packet services, automatic repeat request (ARQ) algorithms are usually employed as methods for error control. Proponents must first present the maximum allowable delay or the maximum allowable number of re-transmission and then calculate the spectrum and coverage efficiencies guaranteeing BER of equal to or less than $10^{-6}$ with assumed ARQ algorithm. As an another approach, it may be possible to calculate the spectrum and coverage efficiencies under the condition of FER of 10%, if the delay or the maximum allowable number of re-transmission requirements to guarantee BER of equal to or less than $10^{-6}$ is presented.

The delay values for various services are to be derived from service (e.g. speech) requirements which may vary from one test environment to another. Coordination between different evaluations is encouraged in order to achieve comparable evaluation results.

In the coverage and spectrum efficiencies evaluation procedure, proponents shall use:

- "speech" - one among the data rates given in Table 1;
- data - for each service at least the following data rates in the relevant environments and test services:
  - the minimum data rate in Table 1.
  - the highest data rate in Table 1 corresponding to the performance capability of the proposed technology.

In the case higher user bit rates can be provided, proponents should provide test results using the maximum data rate of the technology. For the Outdoor to indoor and Pedestrian or Vehicular test environment, proponents should use in their evaluation one of the test data rates suggested for the Indoor Office environment.

- data (circuit-switched) - at least one data services out of two services: low delay and long delay constrained.

It is open to the proponent of an RTT (or SRTT) to give corresponding performance testing evaluation for other data rates to show the advantages of the proposed technology.

## 1.1 Test environment descriptions

A central factor of mobile radio propagation environments is multi-path propagation causing fading and channel time dispersion. The fading characteristics vary with the propagation environment and its impact on the communication quality (i.e. bit error patterns) is highly dependent on the speed of the mobile station relative to the serving base station. These environments are described in Recommendation ITU-R M.1034.

The purpose of the test environments is to challenge the RTTs. Instead of constructing propagation models for all possible IMT-2000 operating environments, a smaller set of test environments is defined which adequately span the overall range of possible environments. The descriptions of these test environments may therefore not correspond with those of the actual operating environments.

This section will identify the propagation model for each test operating environment listed below. For practical reasons, these test operating environments are an appropriate subset of the FPLMTS operating environments described in Recommendation ITU-R M.1034. While simple models are adequate to evaluate the performance of individual radio links, more complex models are needed to evaluate the overall system-level reliability and suitability of specific technologies. For narrowband technologies, time delay spread may be characterized by its r.m.s. value alone; for wideband technologies, however, the number, strength, and relative time delay of the many signal components become important. For some technologies (e.g. those employing power control) these models must include coupling between all co-channel propagation links to achieve maximum accuracy. Also, in some cases, the large-scale (shadow fading) temporal variations of the environment must be modelled.

The key parameters to describe each propagation model would include:

– time delay-spread, its structure, and its statistical variability (e.g. probability distribution of time delay spread);
– geometrical path loss rule (e.g. $R^{-4}$) and excess path loss;
– shadow fading;
– multipath fading characteristics (e.g. Doppler spectrum, Rician vs. Rayleigh) for the envelope of channels;
– operating radio frequency.

Statistical models are proposed in § 1.2 to generate path losses and time delay structures for paths in each test environment.

It should be noted that IMT-2000 will be a world-wide standard. Therefore, the models proposed for evaluation of RTTs should consider a broad range of environment characteristics, e.g. large and small cities, tropical, rural, and desert areas.

The following sections provide a brief description of the conditions that might be expected in the identified environments. The specific channel parameters are found in the appropriate parts of § 1.2.

IMT-2000 may include both mobile wireless and fixed wireless applications. It should be noted that for the purpose of evaluation, operation in the fixed environment is considered to be covered by the mobile test environments. Generally, the fixed wireless channel model will be less complex due to lack of mobility. As a result, there is a trade-off possible between fixed and mobile users which should be considered while evaluating RTTs.

### 1.1.1 Indoor office test environment

This environment is also characterized by small cells and low transmit powers. Both base stations and pedestrian users are located indoors. Section 1.2.2 describes the channel impulse response model and its parameters. The path loss rule varies due to scatter and attenuation by walls, floors, and metallic structures such as partitions and filing cabinets. These objects also produce shadowing effects. A log-normal shadow fading standard deviation of 12 dB can be expected. Fading ranges from Rician to Rayleigh, with Doppler frequency offsets set by walking speeds.

### 1.1.2 Outdoor to indoor and pedestrian test environment

This environment is characterized by small cells and low transmit power. Base stations with low antenna heights are located outdoors; pedestrian users are located on streets and inside buildings and residences. Section 1.2.2 describes the channel impulse response model. A geometrical path loss rule of $R^{-4}$ is appropriate, but a wider range should be considered. If the path is a line of sight on a canyon-like street, for example, the path loss follows a $R^{-2}$ rule where there is Fresnel zone clearance. For the region where there is no longer Fresnel zone clearance, a path loss rule of $R^{-4}$ is appropriate but a range up to $R^{-6}$ may be encountered due to trees and other obstructions along the path. Log-normal shadow fading with a standard deviation of 10 dB is reasonable for outdoors and 12 dB for indoor. Building penetration loss averages 12 dB with a standard deviation of 8 dB. Rayleigh and/or Rician fading rates are generally set by walking speeds, but faster fading due to reflections from moving vehicles is occasionally seen.

### 1.1.3 Vehicular test environment

This environment is characterized by larger cells and higher transmit power. Assuming limited spectrum, higher cell capacity will be important. Section 1.2.2 describes the channel impulse response model and its parameters. A geometrical path loss rule of $R^{-4}$ and log-normal shadow fading with 10 dB standard deviation are appropriate in urban and suburban areas. In rural areas with flat terrain the path loss is lower than that of urban and suburban areas. In mountainous areas, if path blockage are avoided by choosing base station locations, a path loss rule closer to $R^{-2}$ may be appropriate. Rayleigh fading rates are set by vehicle speeds. Lower fading rates are appropriate for applications employing stationary terminals.

### 1.1.4 Mixed test environment

It is not sufficient for a RTT to have good performance in only one of the specified test environments defined in this section. The RTT should also have a good performance in a mixed environment, see Recommendation ITU-R M.1035, § 10. For example, it can be a “vehicular test environment” (macro cells) and an “outdoor to indoor test environment” (micro cells) in the same geographical area. In this area fast moving terminals (vehicles) should probably be connected to the macro cells to reduce the handoff rate (number of hand-offs per minute) and slow moving terminals (pedestrians) should be connected to the micro cells to achieve high capacity.

## 1.2 Propagation models

The following sections provide both path loss models and channel impulse response models for the terrestrial component.

For the terrestrial environments, the propagation effects are divided into three distinct types of model. These are mean path loss, slow variation about the mean due to shadowing and scattering, and the rapid variation in the signal due to multipath effects. Equations are given for mean path loss for each of the three terrestrial environments. The slow variation is considered to be log-normally distributed. This is described by the standard deviation (given in the deployment model section).

Finally, the rapid variation is characterized by the channel impulse response. Channel impulse response is modelled using a tapped delay line implementation. The characteristics of the tap variability is characterized by the Doppler spectrum. A detailed treatment of the propagation models is found in Appendix 1.

### 1.2.1 Path loss models

Equations are given for mean path loss as a function of distance for each of the terrestrial environments except the mixed-cell test environment. The slow variation is considered to be log-normally distributed. This is described by the standard deviation (dB) and the decorrelation length of this long-term fading for the vehicular test environment.

#### 1.2.1.1 Path loss model for indoor office test environment

The indoor path loss model (dB) is in the following simplified form, which is derived from the COST 231 indoor model presented in Appendix 1. This low increase of path loss versus distance is a worst-case from the interference point of view:

$$L = 37 + 30 \log_{10} R + 18.3\, n^{\left(\frac{n+2}{n+1} - 0.46\right)}$$

where:

$R$ : transmitter-receiver separation (m)

$n$ : number of floors in the path.

NOTE 1 – $L$ shall in no circumstances be less than free space loss. A log-normal shadow fading standard deviation of 12 dB can be expected.

#### 1.2.1.2 Path loss model for outdoor to indoor and pedestrian test environment

The following model should be used for the outdoor to indoor and pedestrian test environment:

$$L = 40 \log_{10} R + 30 \log_{10} f + 49$$

where:

$R$ : base station – mobile station separation (km)

$f$ : carrier frequency of 2 000 MHz for IMT-2000 band application.

NOTE 1– $L$ shall in no circumstances be less than free space loss. This model is valid for non-line-of-sight (NLOS) case only and describes worse case propagation. Log-normal shadow fading with a standard deviation of 10 dB for outdoor users and 12 dB for indoor users is assumed. The average building penetration loss is 12 dB with a standard deviation of 8 dB.

#### 1.2.1.3 Path loss model for vehicular test environment

This model, based on the same general format as in § 1.2.1.2, is applicable for the test scenarios in urban and suburban areas outside the high rise core where the buildings are of nearly uniform height:

$$L = 40 (1 - 4 \times 10^{-3} \Delta h_b) \log_{10} R - 18 \log_{10} \Delta h_b + 21 \log_{10} f + 80 \qquad \text{dB}$$

where:

$R$ : base station – mobile station separation (km)

$f$: carrier frequency of 2 000 MHz

$\Delta h_b$ : base station antenna height (m), measured from the average rooftop level.

To quantitatively evaluate each RTT, the base station antenna height is fixed at 15 m above the average rooftop ($\Delta h_b$ = 15 m). Each proponent has an option to specify an alternate base station antenna height to optimize coverage and spectrum efficiency in their proposal.

NOTE 1 – $L$ shall in no circumstances be less than free space loss. This model is valid for NLOS case only and describes worse case propagation. Log-normal shadow fading with 10 dB standard deviation are assumed in both urban and suburban areas.

NOTE 2 – The path loss model is valid for a range of $\Delta h_b$ from 0 to 50 m.

#### 1.2.1.4 Decorrelation length of the long-term fading

The long-term (log-normal) fading in the logarithmic scale around the mean path loss $L$ (dB) is characterized by a Gaussian distribution with zero mean and standard deviation. Due to the slow fading process versus distance $\Delta x$, adjacent fading values are correlated. Its normalized autocorrelation function $R(\Delta x)$ can be described with sufficient accuracy by an exponential function (Gudmundson, M. [7 November, 1991] Correlation Model for Shadow Fading in Mobile Radio Systems. *Electron. Lett.*, Vol. 27, **23**, 2145-2146):

$$R(\Delta x) = \mathrm{e}^{-\frac{|\Delta x|}{d_{cor}} \ln 2}$$

with the decorrelation length $d_{cor}$, which is dependent on the environment. This concept can be applied in the vehicular test environment with a decorrelation length of 20 m.

#### 1.2.1.5 Shadowing correlation

The value of mutual correlation coefficient between fluctuations of signal level due to shadowing arriving from multiple base stations should be set to 0.5. When the other assumptions are used in evaluating the performance of proposed SRTTs, the proponent must present it explicitly.

### 1.2.2 Channel impulse response model

For each terrestrial test environment, a channel impulse response model based on a tapped-delay line model is given. The model is characterized by the number of taps, the time delay relative to the first tap, the average power relative to the strongest tap, and the Doppler spectrum of each tap. A majority of the time, r.m.s. delay spreads are relatively small, but occasionally, there are “worst case” multipath characteristics that lead to much larger r.m.s. delay spreads. Measurements in outdoor environments show that r.m.s. delay spread can vary over an order of magnitude, within the same environment. Although large delay spreads occur relatively infrequently, they can have a major impact on system performance. To accurately evaluate the relative performance of candidate RTTs, it is desirable to model the variability of delay spread as well as the “worst case” locations where delay spread is relatively large.

As this delay spread variability cannot be captured using a single tapped delay line, up to two multipath channels are defined for each test environment. Within one test environment channel A is the low delay spread case that occurs frequently, channel B is the median delay spread case that also occurs frequently. Each of these two channels is expected to be encountered for some percentage of time in a given test environment. Table 2 gives percentage of time the particular channel may be encountered with the associated r.m.s. average delay spread for channel A and channel B for each terrestrial test environment. If other models than these channel A and B models, for example, dynamic delay profile models, are used, detailed description on the models must be presented.

TABLE 2

**Parameters for channel impulse response model**

| | Channel A | | Channel B | |
|---|---|---|---|---|
| Test environment | r.m.s. (ns) | *P* (%) | r.m.s. (ns) | *P* (%) |
| Indoor office | 35 | 50 | 100 | 45 |
| Outdoor to indoor and pedestrian | 45 | 40 | 750 | 55 |
| Vehicular – high antenna | 370 | 40 | 4 000 | 55 |

Tables 3 to 5 describe the tapped-delay-line parameters for each of the terrestrial test environments. For each tap of the channels three parameters are given: the time delay relative to the first tap, the average power relative to the strongest tap, and the Doppler spectrum of each tap. A small variation, ± 3%, in the relative time delay is allowed so that the channel sampling rate can be made to match some multiple of the link simulation sample rate.

TABLE 3

**Indoor office test environment tapped-delay-line parameters**

| Tap | Channel A | | Channel B | | Doppler spectrum |
|---|---|---|---|---|---|
| | Relative delay (ns) | Average power (dB) | Relative delay (ns) | Average power (dB) | |
| 1 | 0 | 0 | 0 | 0 | Flat |
| 2 | 50 | –3.0 | 100 | –3.6 | Flat |
| 3 | 110 | –10.0 | 200 | –7.2 | Flat |
| 4 | 170 | –18.0 | 300 | –10.8 | Flat |
| 5 | 290 | –26.0 | 500 | –18.0 | Flat |
| 6 | 310 | –32.0 | 700 | –25.2 | Flat |

TABLE 4

**Outdoor to indoor and pedestrian test environment tapped-delay-line parameters**

| Tap | Channel A | | Channel B | | Doppler spectrum |
|---|---|---|---|---|---|
| | Relative delay (ns) | Average power (dB) | Relative delay (ns) | Average power (dB) | |
| 1 | 0 | 0 | 0 | 0 | Classic |
| 2 | 110 | –9.7 | 200 | –0.9 | Classic |
| 3 | 190 | –19.2 | 800 | –4.9 | Classic |
| 4 | 410 | –22.8 | 1 200 | –8.0 | Classic |
| 5 | – | – | 2 300 | –7.8 | Classic |
| 6 | – | – | 3 700 | –23.9 | Classic |

TABLE 5

**Vehicular test environment, high antenna, tapped-delay-line parameters**

| Tap | Channel A | | Channel B | | Doppler spectrum |
|---|---|---|---|---|---|
| | Relative delay (ns) | Average power (dB) | Relative delay (ns) | Average power (dB) | |
| 1 | 0 | 0.0 | 0 | –2.5 | Classic |
| 2 | 310 | –1.0 | 300 | 0 | Classic |
| 3 | 710 | –9.0 | 8.900 | –12.8 | Classic |
| 4 | 1 090 | –10.0 | 12 900 | –10.0 | Classic |
| 5 | 1 730 | –15.0 | 17 100 | –25.2 | Classic |
| 6 | 2 510 | –20.0 | 20 000 | –16.0 | Classic |

For an example of channel impulse response models of the link simulation, refer to Appendix 4.

### 1.2.3 Channel model for antenna diversity

The channel model for antenna diversity is defined by independent path model. The propagation models and channel impulse response models in each path are characterized in 1.2.1 and 1.2.2. See1.3.1(o).

## 1.3 Link budget template and deployment models

In the sections that follow a link budget template and deployment models are proposed to be used for evaluation in each of the terrestrial test environments.

For the terrestrial SRTTs, the deployment models are used to extract critical parameters, such as coverage efficiency and spectrum efficiency. They also give a general idea of the amount of infrastructure required to provide service to the specified model deployment area.

The spectrum efficiency is defined in Erlangs/cell/MHz or kbit/s/cell/MHz for speech and in kbit/s/cell/MHz for data services.. Spectrum efficiency is dependent on the frequency bandwidth allocation and is not linearly scaleable between different bandwidth allocations. For the purpose of evaluation, a duplex bandwidth of 30 MHz is assumed and is to be divided between forward and reverse link as required by the SRTT implementation. An indication of the guardband needed between operators using the same SRTT should be given by the SRTT proponent.

The coverage efficiency is defined as the total number of cell sites per square kilometre required to meet the coverage requirements specified for each test environment. Coverage efficiency is to be calculated at low traffic levels (as specified in deployment tables) since the system will most probably be interference limited at high traffic load.

A specific deployment scenario is given for each terrestrial test environment. This contains information on market requirements including grade of service, traffic level, coverage requirements and subscriber penetration. Also given for each deployment scenario are the physical parameters of that environment which includes: area to cover, population density, and mobile terminal velocity (for Doppler frequency)**.**

Along with a link budget template for each terrestrial test environment a deployment model results matrix is to be completed for each specified traffic. The results matrix is found in Table 11. The simulations used to complete the link budget template are required to complete the model deployment for each test environment. Each system proponent must use only the propagation models given in section 1.2 of this document.

System proponents will assume a centre frequency of 2.0 GHz when completing the deployment models.

### 1.3.1 Terrestrial link budget templates

The link budget template shall be completed for both the forward and reverse links for each test environment and each test case service in Table 1. In the case of the mixed environment, the link budget template should be completed for the pedestrian and vehicular test environments. The link budget template should not be considered as a tool for planning since essential parts are missing such as body loss, penetration loss into cars etc. To facilitate comparable results SRTT independent parameters are pre-set.

Link level simulations based on channels A and B of the impulse response models are used to determine the required Eb/(No+Io) and hence the required C/I of their SRTT to meet the performance criteria given in Table 1. For calculations of coverage efficiencies, the worst case among channels A and B has to be assumed, but link level results should be given for both cases. Path loss formulas are then used to determine the maximum range and the coverage area.

In case of hexagonal deployment of sectored cells, the area covered by one sector is defined as $S = 3\sqrt{3}\,x\left(\frac{R}{2}\right)^2/2$,

where R is the range obtained in the link budget. This means that the sectors are hexagonal with base stations placed in the corners of the hexagons. Coverage efficiency is to be evaluated with tri-sectored antennas for macrocells and with omnidirectional antennas for microcells and picocells coverages.

Implementation independent parameters (*ii*) are fixed in the link budget template to avoid divergence not directly related to radio technology differences. The proponents must provide coverage efficiency values using these fixed *ii* values.

Implementation dependent and independent link budget items are indicated by *id* and *ii* in the template.

An infrastructure is determined by the proponent to meet the service objectives and coverage requirements for the deployment. Calculation of coverage efficiency is done based on the proposed deployment for the given low traffic levels.

TABLE 6

**Link budget template**

| id/ii | Item | Forward link | Reverse link |
|---|---|---|---|
| | Test environment | | |
| | Test service | | |
| | Multipath channel class | A, B | A, B |
| ii/id | (a0) Average transmitter power per traffic channel (NOTE 1) | dBm | dBm |
| id | (a1) Maximum transmitter power per traffic channel | dBm | dBm |
| id | (a2) Maximum total transmitter power | dBm | dBm |
| ii | (b) Cable, connector, and combiner losses (enumerate sources) | 2 dB | 0 dB |
| ii | (c) Transmitter antenna gain | 13 dBi (vehicular)<br>10 dBi (pedestrian)<br>2 dBi (indoor) | 0 dBi |
| id | (d1) **Transmitter e.i.r.p. per traffic channel = (a1 – b + c)** | dBm | dBm |
| id | (d2) **Total transmitter e.i.r.p. = (a2 – b + c)** | dBm | dBm |
| ii | (e) Receiver antenna gain | 0 dBi | 13 dBi (vehicular)<br>10 dBi (pedestrian)<br>2 dBi (indoor) |
| ii | (f) Cable and connector losses | 0 dB | 2 dB |
| ii | (g) Receiver noise figure | 5 dB | 5 dB |
| ii | (h) Thermal noise density<br>(H) (linear units) | –174 dBm/Hz<br>$3.98 \times 10^{-18}$ mW/Hz | –174 dBm/Hz<br>$3.98 \times 10^{-18}$ mW/Hz |
| id | (i) Receiver interference density (NOTE 2)<br>(I) (linear units) | dBm/Hz<br>mW/Hz | dBm/Hz<br>mW/Hz |
| id | (j) **Total effective noise plus interference density = 10 log ($10^{((g + h)/10)}$ + I)** | dBm/Hz | dBm/Hz |
| ii | (k) Information rate (10 log ($R_b$)) | dB(Hz) | dB(Hz) |
| id | (l) Required $E_b/(N_0 + I_0)$ | dB | dB |
| id | (m) **Receiver sensitivity = (j + k + l)** | | |
| id | (n) Hand-off gain | dB | dB |
| id | (o) Explicit diversity gain | dB | dB |
| id | (o′) Other gain | dB | dB |
| id | (p) Log-normal fade margin | dB | dB |
| id | (q) **Maximum path loss**<br>**= {d1 – m + (e – f) + o + n + o′ – p}** | dB | dB |
| id | (r) Maximum range | m | m |

*NOTES to Table 6 :*

NOTE 1 – Proponents must provide coverage and spectrum efficiencies values using the following proposed average transmitter power per traffic channel. However they should provide additional values based on optimized transmitter power for their proposed SRTT.

| | Forward link | Reverse link |
|---|---|---|
| (a0) Average transmitter power per traffic channel | 30 dBm vehicular<br>20 dBm pedestrian<br>10 dBm indoor | 24 dBm vehicular<br>14 dBm pedestrian<br>04 dBm indoor |

NOTE 2 – Since the significance and method of calculating this value will vary from SRTT to SRTT, the proponent must give a detailed explanation of their method for calculating this value and its significance in determining capacity and coverage of the SRTT. In particular, the proponent must state explicitly what frequency reuse ratio and traffic loading per sector are assumed in determining this quantity. Interference has to be evaluated for the specified low traffic level given for each test environment.

The following sections provide descriptions of the individual link budget template items. Descriptions apply to both forward and reverse links unless specifically stated otherwise. For the forward link the base station is the transmitter and the mobile station the receiver. For the reverse link the mobile station is the transmitter and the base station the receiver.

**(a0) Average transmitter power per traffic channel (dBm)**

The average transmitter power per traffic channel is defined as the mean of the total transmitted power over an entire transmission cycle with maximum transmitted power when transmitting.

**(a1) Maximum transmitter power per traffic channel (dBm)**

Maximum transmitter power per traffic channel is defined as the total power at the transmitter output for a single traffic channel. A traffic channel is defined as a communication path between a mobile station and a base station used for user and signalling traffic. The term traffic channel implies a forward traffic channel and reverse traffic channel pair.

**(a2) Maximum total transmitter power (dBm)**

Maximum total transmit power is the aggregate maximum transmit power of all channels.

**(b) Cable, connector, and combiner losses (transmitter) (dB)**

These are the combined losses of all transmission system components between the transmitter output and the antenna input (all losses in positive dB values). The value is fixed in the template.

**(c) Transmitter antenna gain (dBi)**

Transmitter antenna gain is the maximum gain of the transmitter antenna in the horizontal plane (specified as dB relative to an isotropic radiator). The value is fixed in the template.

**(d1) Transmitter e.i.r.p. per traffic channel (dBm)**

This is the summation of transmitter power output per traffic channel (dBm), transmission system losses (–dB), and the transmitter antenna gain (dBi), in the direction of maximum radiation.

**(d2) Transmitter e.i.r.p. (dBm)**

This is the summation of the total transmitter power (dBm), transmission system losses (–dB), and the transmitter antenna gain (dBi).

**(e) Receiver antenna gain (dBi)**

Receiver antenna gain is the maximum gain of the receiver antenna in the horizontal plane (specified as dB relative to an isotropic radiator).

**(f) Cable, connector, and splitter losses (receiver) (dB)**

These are the combined losses of all transmission system components between the receiving antenna output and the receiver input (all losses in positive dB values). The value is fixed in the template.

**(g) Receiver noise figure (dB)**

Receiver noise figure is the noise figure of the receiving system referenced to the receiver input. The value is fixed in the template.

**(h), (H) Thermal noise density, $N_0$ (dBm/Hz)**

Thermal noise density, $N_0$, is defined as the noise power per Hertz at the receiver input. Note that (h) is logarithmic units and (H) is linear units. The value is fixed in the template.

**(i), (I) Receiver interference density $I_0$ (dBm/Hz)**

Receiver interference density is the interference power per Hertz at the receiver front end. This is the in-band interference power divided by the system bandwidth. The in-band interference power consists of both co-channel interference as well as adjacent channel interference. Thus, the receiver and transmitter spectrum masks must be taken into account. Note that (i) is logarithmic units and (I) is linear units. Receiver interference density $I_0$ for forward link is the interference power per Hertz at the mobile station receiver located at the edge of coverage, in an interior cell. Note: Interference density can be estimated by system level simulations. See 1.3.3.

**(j) Total effective noise plus interference density (dBm/Hz)**

Total effective noise plus interference density (dBm/Hz) is the logarithmic sum of the receiver noise density and the receiver noise figure and the arithmetic sum with the receiver interference density, i.e:

$$j = 10 \log (10^{((g + h)/10)} + I)$$

**(k) Information rate (10 log Rb) (dB(Hz))**

Information rate is the channel bit rate in (dB(Hz)); the choice of Rb must be consistent with the Eb assumptions.

**(l) Required $E_b/(N_0 + I_0)$ (dB)**

The ratio between the received energy per information bit, Eb, to the total effective noise and interference power density needed to satisfy the quality objectives specified in Table 1 under condition of section 1.2.2 channel model. This value should be determined by link level simulations. Power control should not exceed the ceiling established by the sum of the log-normal fade margin plus hand-off gain. This ceiling may cause the quality degradation because the fast transmit power control does not work well any more at the cell edge. Proponents should present their assumptions on the transmit power control clearly in the link level simulations.

Note: Diversity gains included in the $E_b/(N_0 + I_0)$ requirement should be specified here to avoid double counting. The translation of the threshold error performance to $E_b/(N_0 + I_0)$ performance depends on the particular multipath conditions assumed. Note: Proponents should define the term of information bit and must show how to calculate the

Eb, explicitly.

**(m) Receiver sensitivity (j + k + l) (dBm)**

This is the signal level needed at the receiver input that just satisfies the required $E_b/(N_0 + I_0)$.

**(n) Hand-off gain/loss (dB)**

This is the gain/loss factor (+ or –) brought by hand-off to maintain specified reliability at the boundary. Assume equal average loss to each of the two cells. The handoff gain/loss shall be calculated for 50% shadowing correlation. The proponent must state explicitly the other assumptions made about hand-off in determining the hand-off gain.

**(o) Explicit diversity gain (dB)**

This is the effective gain achieved using diversity techniques. It should be assumed that the correlation coefficient is zero between received paths. See also 1.2.3. Note: Diversity gain should not be double counted. For example, if the diversity gain is included in the $E_b/(N_0 + I_0)$ specification, it should not be included here.

**(o') Other gain (dB)**

An additional gain may be achieved due to future technologies. For instance, Space Diversity Multiple Access (SDMA) may provide an excess antenna gain. Assumptions made to derive this gain must be given by the proponent.

**(p) Log-normal fade margin (dB)**

The log-normal fade margin is defined at the cell boundary for isolated cells. This is the margin required to provide a specified coverage availability over the individual cells. See also 1.3.3.

**(q) Maximum path loss (dB)**

This is the maximum loss that permits minimum SRTT performance at the cell boundary.

$$\text{Maximum path loss} = d1 - m + (e - f) + o + o' + n - p$$

**(r) Maximum range (km)**

The maximum range is computed for each deployment scenario. Maximum range, $R_{max}$, is given by the range associated with the maximum path loss. The equations to determine path loss are given in section 1.2 of this document.

#### 1.3.1.1 Low traffic levels for coverage efficiency evaluation

The coverage efficiency has to be evaluated for some specified traffic levels corresponding to a low network load, since the system will be most probably interference limited at high traffic loads.

This section defines some low traffic density levels in kbit/s/km=, thus being independent of the service bit rate being used. For each test service, the user density is to be derived from these traffic density values, taking into account both the user bit rate and the channel activity factor :

*User density (Erlangs/km=) = Traffic density / (User Bit Rate (kbit/s) . Activity Factor)*

| **Environment** | **Traffic density (kbit/s/km=)** | |
|---|---|---|
| Indoor Office | kbit/s per floor | 20 (uni-directional) |
| Outdoor to Indoor and Pedestrian | kbit/s per square km | outdoor : 1.44 |

| | | |
|---|---|---|
| | | indoor : 1.92 |
| Vehicular | kbit/s per square km | 0.35 |

NOTE1: The values of traffic density displayed above are given by the calculation of the following equation using the parameters in the deployment models (Table 7a - 9b)

*Traffic density*
= *User density* X *User Bit Rate* X *Activity Factor*
= (*Potential users* / *Area*) X *Subscriber penetration* X *Traffic level* X *Activity Factor* X *User Bit Rate*

NOTE2: It is pointed out that these traffic density values have been derived from original low traffic densities in REVAL. However they have not been tested yet, and may then not correspond to 'low traffic levels' depending on the achieved range and system capacity. They may need to be revised once first coverage and capacity results will be obtained, but it is anyway important that all systems are evaluated using the same traffic values. For instance, they could be adjusted in order to correspond to 10 % of the network load at the averaged capacity limit.

#### 1.3.1.2 Proposed methodology for coverage efficiency evaluation

First rough estimation of range can be made using the link budget template with link level simulations only. This provides results for noise limited systems assuming rough values for interference density, hand-off gain and diversity gain. The maximum range is obtained from the maximal pathloss value obtained in the link budget and using pathloss models given in section 1.2.

An alternative approach consists in using system simulations to determine coverage efficiency. This should be used in order to properly take into account interference density due to a specified traffic load and mobility effects.

For each Test environment, coverage efficiency should be evaluated assuming an hexagonal cell lay-out, with tri-sectored antennas for macrocells (using the antenna pattern specified in Appendix 3 and omnidirectional antennas for microcells and picocells, and using the pathloss models given in section 1.2. Traffic density has to be fixed according to the specified low traffic values, and the cell size has to be increased until the following coverage criteria is not longer met:

*Probability (BER > BER_Threshold) < 5 %* (where BER_Threshold refers to Table 1)

The maximal range is given by the distance between two base stations. Implementation independent (ii) parameters specified in the link budget template should be accounted for in simulations.

The maximal range should be evaluated for each circuit switched Test service since it will depend on the user bit rate.

For the indoor to outdoor and pedestrian environment, the range should be evaluated with the first pathloss model. For the indoor environment, the range could probably be evaluated using one floor only.

The Forward link channel structure and relative power ratio between the channels used in the simulation should be explicitly defined by proponents.

### 1.3.2 Deployment model

In spectrum efficiency computation, the offered traffic level has to be adjusted to reach the grade of service and coverage criteria as defined in Tables 7 to 10. The offered traffic is calculated as:

$$\text{offered traffic} = \text{user density} \times (\text{bhca/sub}/3600) \times \text{call duration}$$

where:

bhca: busy hour call attempts

sub: subscriber.

For spectrum efficiency evaluation for the reverse link of the system based on Code Division Multiple Access, a simple expression is available. The expression is presented in Appendix 5. Furthermore, performance measures which defines the system capacity and can be used in system level simulations are presented Appendix 6.

#### 1.3.2.1 Indoor office test environment deployment model

This deployment scenario describes conditions relevant to the operation of a IMT-2000 system that might be found in the indoor office test environment. The test service requirements for the indoor office environment are listed in Table 1. General assumptions about market requirements are summarized in Table 7a.

TABLE 7a

**Indoor office deployment model market requirements**

| Grade of service | Traffic level (bhca/sub)(1) | Coverage(2) | Subscriber penetration (% of potential users) |
|---|---|---|---|
| 1% blocking | 3 for speech<br>3 for data | 95% | 50 for spectrum efficiency<br>5 for coverage efficiency |

(1) bhca: busy hour call attempts e.g., assuming a call duration of 2 min (speech) and 2 min (data).

(2) Let “A” be the declared geographical area over which the service is planned. It is required that good operating conditions (for the receivers) be maintained over $X$% (95%), of the area “A” during $Y$% (95%) of the time. Further definition of “A” is needed.

For this indoor deployment scenario a model office environment is specified below and consists of a large office building with an open floor plan layout. Office cubicles are separated by conducting moveable partitions. These partitions create a large degree in signal variation as is borne out in the log-normal standard deviation given in Table 7a. Traffic levels are given in Erlangs per floor. In this scenario users in elevators and stairwells are not considered though realistically they would have to be accounted for.

The specific assumptions about the indoor physical deployment environment are summarized in Table 7b.

TABLE 7b

**Indoor office deployment model physical environment**

| Area per floor ($m^2$) | Potential users per floor | Number of floors | Log-normal standard deviation (dB) | Mobile velocity (km/h) |
|---|---|---|---|---|
| 10 000 | 1 000 | 10 | 12 | 3 |

For an example of a cell layout of the indoor office test environment, refer to Appendix 3.

#### 1.3.2.2 Outdoor to indoor and pedestrian deployment model

Note that the physical environment description includes both indoor and outdoor users. However, for the spectrum and coverage efficiencies evaluation, at least the outdoor environment should be considered. The indoor coverage is to be provided by the outdoor base stations. This requires that the additional loss due to building penetration be accommodated in the link budget. The test service requirements for the outdoor to indoor pedestrian environment are listed in Table 1.

TABLE 8a

**Outdoor to indoor and pedestrian deployment model market requirements**

| Grade of service | Traffic level (bhca/sub)(1) | Coverage(2) | Subscriber penetration (% of potential users) |
|---|---|---|---|
| 1% blocking | 1.2 for speech<br>1.2 for data | 95% | 10 for spectrum efficiency<br>0.1 for coverage efficiency |

(1), (2) See Table 7a.

The specific assumptions about the outdoor physical deployment environment are summarized in Table 8b.

TABLE 8b

**Deployment model physical environment**

| Type | Area ($km^2$) | Potential users per $km^2$ | Building penetration loss/standard deviation (dB) | Log-normal standard deviation (dB) | Mobile velocity (km/h) |
|---|---|---|---|---|---|
| Outdoor | 40 | 9000 | Not applicable | 10 | 3 |
| Indoor | 25 | 12 000 | 12/8 | 12 | 3 |

For an example of a cell layout of the outdoor to indoor and pedestrian test environment, refer to Appendix 3.

#### 1.3.2.3 Vehicular environment deployment model

The test service requirements for the vehicular environment are listed in Table 1. General assumptions about market requirements are summarized in Table 9a. The base station antenna height must be above the average roof top height of 12 m.

TABLE 9a

**Vehicular deployment model market requirements**

| Grade of service | Traffic level (bhca/sub) (1) | Coverage (2) | Subscriber penetration (% of potential users) |
|---|---|---|---|
| 1% blocking | 0.75 for speech<br>0.75 for data | 95% | 10 for spectrum efficiency<br>0.1 for coverage efficiency |

(1), (2) See Table 7a.

The specific assumptions about the vehicular physical deployment environment are summarized in Table 9b.

TABLE 9b

**Vehicular deployment model physical environment**

| Area ($km^2$) | Potential users per $km^2$ | Log-normal standard deviation (dB) | Mobile velocity (km/h) |
|---|---|---|---|
| 150 | 3 500 | 10 | 120 |

In addition, proponents should provide information on how high speed up to 500 km/h can be handled. For an example of a cell layout of the vehicular test environment, refer to Appendix 3.

### 1.3.2.4 Mixed-cell pedestrian/vehicular test environment deployment model

This deployment scenario describes conditions relevant to the operation of a IMT-2000 system that might be found in the mixed test environment. The test service requirements for the mixed-cell environment are listed in Table 1. The general assumptions about market requirements are summarized in Table 10a. The link budget uses the pedestrian and vehicular ones which have been calculated before. The interference from the large cells to the small cells and *vice versa* should be accounted for, if necessary.

TABLE 10a

**Mixed test deployment model market requirements**

| Grade of service | Traffic level (bhca/sub) (1) | Coverage (2) | Subscriber penetration (% of potential users) |
|---|---|---|---|
| 1% blocking | 1 for speech<br>1 for data | 95% | 10 for spectrum efficiency<br>0.1 for coverage efficiency |

(1), (2) See Table 7a.

The specific assumptions about the outdoor and vehicular physical deployment environment are summarized in Table 10b.

TABLE 10b

**Mixed test deployment model physical environment**

| Path loss type | Area ($km^2$) | Log-normal standard deviation (dB) | Mobile velocity (km/h) | % users |
|---|---|---|---|---|
| Pedestrian (outdoor) | 4 | 10 | 3 | 60 |
| Vehicular | 150 | 10 | 120 | 40 |

For an example of a cell layout of the mixed test environment, refer to Appendix 3.

### 1.3.3 Deployment model result matrix

Results from the system deployment model are to be tabulated as specified in Table 11.

TABLE 11

**Deployment model result matrix**

| Input assumptions | | | | |
|---|---|---|---|---|
| Test environment | | | | |
| Test service | | | | |
| Base station antenna height (m) | | | | |
| Any other assumptions made by the proponent (e.g. antenna pattern, sectorization etc.) | | | | |
| Deployment results | | | | |
| Total number of cell sites | Total number of RF channels | Number of voice channels per RF channel | Coverage efficiency ($km^2$/site) | Spectrum efficiency (E/MHz/cell) for speech (Mbit/s/cell) for data |

## 1.4 Packet Traffic Model

Non-real time services

Figure A depicts a typical WWW browsing **session**, which consists of a sequence of **packet calls**. We only consider the packets from a source which may be at either end of the link but not simultaneously. The user initiates a packet call when requesting an information entity. During a packet call several **packets** may be generated, which means that the packet call constitutes of a bursty sequence of packets, see [ref 1] and [ref 2]. It is very important to take this phenomenon into account in the traffic model. The burstyness during the packet call is a characteristic feature of packet transmission in the fixed network.

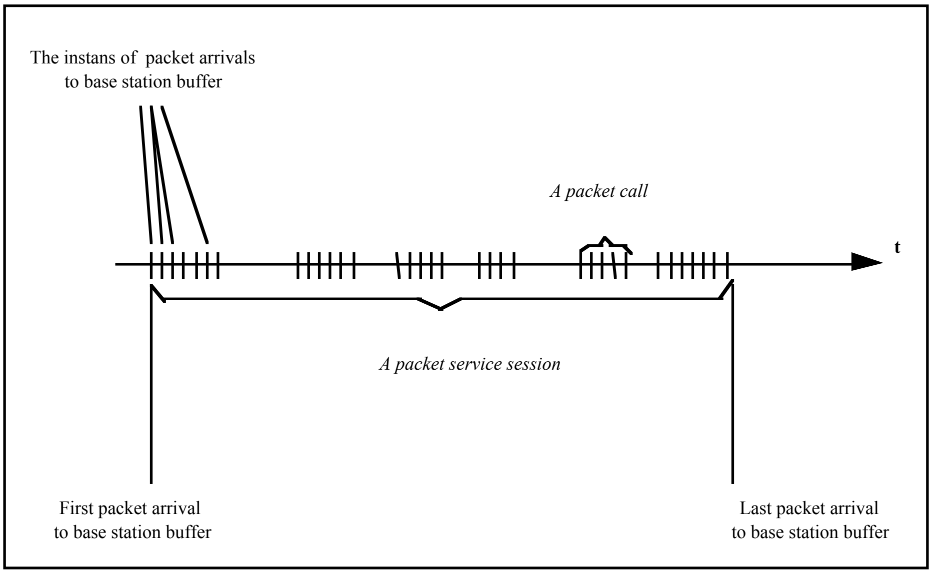

**Figure A. Typical characteristic of a packet service session.**

A packet service session contains one or several packet calls depending on the application. For example in a WWW browsing session a packet call corresponds the downloading of a WWW document. After the document is entirely arrived to the terminal, the user is consuming certain amount of time for studying the information. This time interval is called **reading time**. It is also possible that the session contains only one packet call. In fact this is the case for a file transfer (FTP). Hence, the following must be modelled in order to catch the typical behaviour described in Figure A:

- Session arrival process
- Number of packet calls per session, $N_{pc}$
- Reading time between packet calls, $D_{pc}$
- Number of datagrams within a packet call, $N_d$
- Inter arrival time between datagrams (within a packet call) $D_d$
- Size of a datagram, $S_d$

Note that the session length is modelled implicitly by the number of events during the session.

Next it will be described how these six different events are modelled. The geometrical distribution is used (discrete representation of the exponential distribution), since the simulations are using discrete time scale.

***Session arrival process:*** How do session arrive to the system. The arrival of session set-ups to the network is modelled as a Poisson process. For each service there is a separate process. It is important to note that this process for each service only generates the time instants when service calls begin and it has *nothing to do with call termination*.

***The number of packet call requests per session, $N_{pc}$:*** This is a geometrically distributed random variable with a mean $\mu_{Npc}$ [packet calls], i.e.,

$$N_{pc} \in Geom(\mu_{Npc}).$$

***The reading time between two consecutive packet call requests in a session, $D_{pc}$: :*** This is a geometrically distributed random variable with a mean $\mu_{Dpc}$ [model time steps], i.e.,

$$D_{pc} \in Geom(\mu_{Dpc}).$$

Note that the reading time starts when the last packet of the packet call is completely received by the user. The reading time ends when the user makes a request for the next packet call.

***The number of packets in a packet call, $N_d$:*** *The traffic model should be able to catch the various characteristic features possible in the future traffic. For this reason different statistical distributions can be used to generate the number of packets.* For example $N_d$ can be geometrically distributed random variable with a mean $\mu_{Nd}$ [packet], i.e.,

$$N_d \in Geom(\mu_{Nd}).$$

It must be possible to select the statistical distributions that describes best the traffic case under study should be selected. An extreme case would be that the packet call contains a single large packet.

***The time interval between two consecutive packets inside a packet call, $D_d$:*** This is a geometrically distributed random variable with a mean $\mu_{Dd}$ [model time steps], i.e.,

$$D_d \in Geom(\mu_{Dd}).$$

Naturally, if there are only one packet in a packet call, this is not needed.

***Packet size, $S_d$:*** The traffic model can use such packet size distribution that suits best for the traffic case under study. Pareto distribution with cut-off is used.

**The normal Pareto distribution (without cut-off) is defined by:**

$$\begin{cases} f_x(x) = \dfrac{\alpha \cdot k^{\alpha}}{x^{\alpha+1}}, x \geq k \\ F_x(x) = 1 - \left(\dfrac{k}{x}\right)^{\alpha}, x \geq k \\ \mu = \dfrac{k\alpha}{\alpha - 1}, \alpha > 1 \\ \sigma^2 = \dfrac{k^2 \cdot \alpha}{(\alpha-2)\cdot(\alpha-1)^2}, \alpha > 2 \end{cases}$$

PacketSize is defined with the following formula:

$$\text{PacketSize} = \min(\text{P}, \ \text{m}),$$

where P is normal Pareto distributed random variable (α=1.1, k=81.5 bytes) and m is maximum allowed packet size, m=66666 bytes. The PDF of the PacketSize becomes:

$$f_n(x) = \begin{cases} \dfrac{\alpha \cdot k^{\alpha}}{x^{\alpha+1}}, k \leq x < m \\ \beta, x = m \end{cases}$$

where β is the probability that x>m. It can easily be calculated as:

$$\beta = \int_m^{\infty} f_x(x)dx = \left(\frac{k}{m}\right)^{\alpha}, \alpha > 1$$

Then it can be calculated as:

$$\mu_n = \int_{-\infty}^{\infty} x f_n(x)dx = \int_k^{m-} x \frac{\alpha k^{\alpha}}{x^{\alpha+1}} dx + m\left(\frac{k}{m}\right)^{\alpha} = \ldots calculating \ldots = \frac{\alpha k - m\left(\frac{k}{m}\right)^{\alpha}}{\alpha - 1}$$

with the parameters above the average size is:

$$\mu_n = 480\text{bytes}$$

Table A gives default mean values for the distributions of typical www service. According to the values for α and k in the Pareto distribution, the average packet size μ is 480 bytes. Average requested filesize is $\mu_{Nd}$ x μ = 25 x 480 bytes ≈ 12 kBytes. The interarrival time is adjusted in order to get different average bit rates at the source level.

**Table A: Characteristics of connection-less information types**

| Packet based information types | Average number of packet calls within a session | Average reading time between packet calls [s] | Average amount of packets within a packet call [] | Average interarrival time between packets [s][4] | Parameters for packet size distribution |
|---|---|---|---|---|---|
| WWW surfing UDD 8 kbit/s | 5 | 4 | 25 | 0.5 | k = 81.5<br>α = 1.1 |
| WWW surfing UDD 32 kbit/s | 5 | 4 | 25 | 0.125 | k = 81.5<br>α = 1.1 |
| WWW surfing | 5 | 4 | 25 | 0.0625 | k = 81.5 |

[4] The different interarrival times correspond to average bit rates of 8, 32, 64, 144, 384 and 2048 kbit/s.

| | | | | | |
|---|---|---|---|---|---|
| UDD 64 kbit/s | | | | | $\alpha = 1.1$ |
| WWW surfing UDD 144 kbit/s | 5 | 4 | 25 | 0.0277 | k = 81.5<br>$\alpha = 1.1$ |
| WWW surfing UDD 384 kbit/s | 5 | 4 | 25 | 0.0104 | k = 81.5<br>$\alpha = 1.1$ |
| WWW surfing UDD 2048 kbit/s | 5 | 4 | 25 | 0.00195 | k = 81.5<br>$\alpha = 1.1$ |

[1] The different interarrival times correspond to average bit rates of 8, 32, 64, 144, 384 and 2048 kbit/s.

[ref 1] Anderlind Erik and Jens Zander " A Traffic Model for Non-Real-Time Data Users in a Wireless Radio Network" IEEE Communications letters. Vol 1 No. 2 March 1997.

[ref 2] Miltiades E et al. “A multiuser descriptive traffic source model” IEEE Transactions on communications, vol 44 no 10, October 1996.

## PART 2

## Satellite component

**Same as PART 2 of Annex 2 of Recommendation ITU-R M.1225.**

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## APPENDIX 1
## TO ANNEX 2

## Propagation models

**Same as APPENDIX 1 to Annex 2 of Recommendation ITU-R M.1225.**

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## APPENDIX 2
## TO ANNEX 2

## Computation of Doppler shift for satellites

**Same as APPENDIX 2 to Annex 2 of Recommendation ITU-R M.1225.**

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# APPENDIX 3[5]
# TO ANNEX 2

## Example cell layouts for deployment models

This Appendix describes cell layouts for the test environments. The following description is presented as examples of cell layouts in the deployment models for system level simulations. Proponents may use the other layouts in evaluating their proposed RTTs, in that case, however, proponents have to present it explicitly.

### 1 Example cell layout for indoor office test environment

The indoor model is illustrated on Figure 6a together with a default deployment scheme, where base stations use omnidirectional antennas. For spectrum efficiency evaluation, quality statistics should only be collected in the middle floor.

NOTE – The test area of a floor in Figure 6a is different from that of Table 7b. Also three floors are assumed in the model against ten floors in Table 7b. Proponents should use the physical parameters shown in Table 19a when the example layout is used for evaluation.

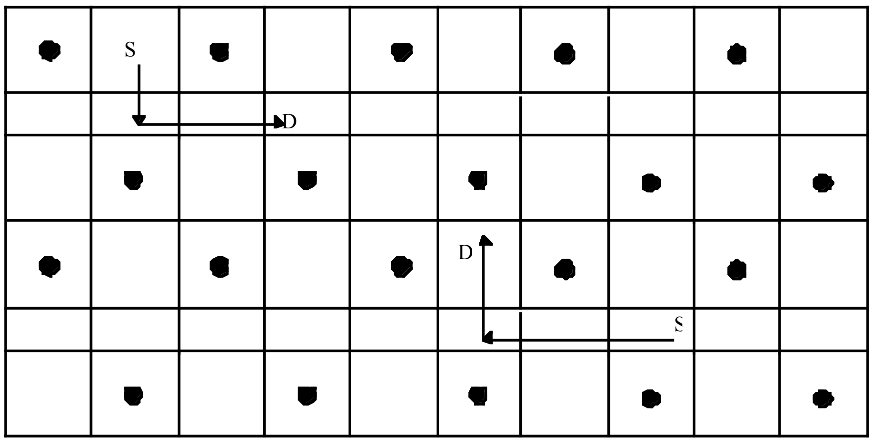



FIGURE 6a

**Example layout for indoor office test environment**

Table 19a

**Physical parameters for indoor office layout**

| Area per floor (m=) | Number of floors | Room dimension |
|---|---|---|
| 5000 | 3 | 10 x 10 x 3 m (room)<br>100 x 5 x 3 m (corridor) |

<u>Mobility model</u>

The mobility model is characterised as follows:

[5] This is new appendix.

- there are no mobility between the floors,
- mobiles are either stationary or moving with constant speed from an office room to corridor or vice versa,
- if a mobile is in an office room, it has higher probability to be stationary,
- if a mobile is in the corridore, it has lower probability to be stationary.

Each mobile is either in the stationary or the moving state. The transition from the stationary state to the moving state is random process. Time duration each mobile spends in the stationary state is drawn from the geometric (discrete exponential) distribution with different mean values depending whether the mobile is in an office room or in the corridore. The transition from the moving state to the stationary state takes place when mobile reaches its destination. Figure 6b illustrates the state transition.

When a mobile is in an office room and it is switched to the moving state it moves to the corridor, see Figure 6a, according to the following procedure:

Select the destination co-ordinates in the corridor with uniform distribution. (Each place in the corridor has equal probability to become the destination point.)

The mobile 'walks' from its current location to the destination location so that first the vertical (y) co-ordinate is matched with the new co-ordinate and next the horizontal co-ordinate is matched with the destination co-ordinate. The speed is constant during the 'walking'.

When the mobile reaches the destination point it is transferred into the stationary state.

By letting mobiles simply walk straight out from the office room, it is simply assumed that the door dividing each office room and corridore is as wide as the office room itself. When a mobile is in a corridor and it is switched to the moving state it moves either to any of the office rooms with equal probability. The following 4 step procedure defines the movement along the corridor and from the corridor to an office room.

Select the destination office room by using discrete uniform distribution.

Select the destination co-ordinates with uniform distribution. (Each place in the corridor or in an office room has equal probability to become the destination point.)

The mobile 'walks' from its current location so that first the horizontal (x) co-ordinate is matched with the new co-ordinate and next the vertical (y) co-ordinate is matched with the destination co-ordinate. The speed is constant during the 'walking'.

When the mobile reaches the destination point it is transferred into the stationary state.

At the stationary state mobiles do not move at all.

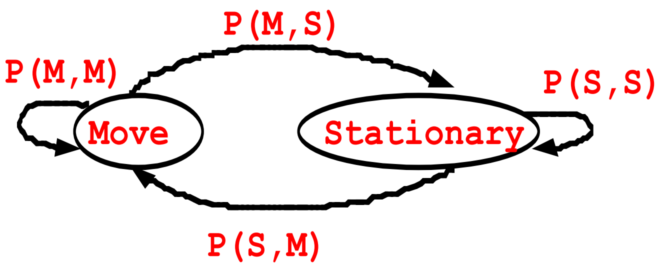



FIGURE 6b

**State automate presentation MS movement**

To derive transition probabilities from the stationary state to the move state the following parameters must be set: ratio of mobiles at office rooms (r), mean office room stationary time (mr) and iteration time step (Δt). With these parameters the transition probabilities per iteration time step (1-Δt/mr, 1-Δt/mc) and mean corridor stationary time(mc) can be derived so that flow to the office rooms equals to the flow from the office rooms.

$$r \cdot \frac{\Delta t}{mr} = (1-r) \cdot \frac{\Delta t}{mc}$$ ,

with the default parameters, enlisted in the table below, the following values are obtained.

P(S,S) in office room = 1-0.005/30=0.999833

P(S,M) in office room = 0.005/30=0.0001667

P(S,S) in office room = 1-0.0009444=0.9990556

P(S,M) in office room = 0.005*85/(30*15)=0.0009444

and average stationary time in the corridor becomes Dt/P(S,M)=5.294 seconds.

The following table presents the default parameters for the indoor mobility model :

| | |
|---|---|
| **ratio of mobiles at office rooms** | 85% |
| **mean office room stationary time** | 30 s |
| **simulation time step** | 0.005 s |
| **number of office rooms** | 40 |
| **mobile speed** | 3 km/h |

## 2 Example cell layout for outdoor to indoor and pedestrian test environment

The physical environment description presented in this section includes only outdoor users, and is to be used for spectrum efficiency evaluation using system simulations. However in order to evaluate the indoor coverage provided by the outdoor base stations, an additional loss due to building penetration is to be taken into account in the link budget for coverage efficiency evaluation. Coverage figures for both outdoor and penetration should be provided.

A Manhattan-like structure shown in Figure 6c is defined for the outdoor to indoor and pedestrian environment to be used together with the three slopes path loss model defined in the later part of this section. A default deployment scheme is also proposed with base stations using omnidirectional antennas, and quality statistics should only be collected among cells marked with a T on the figure.

NOTE – The test area in Figure 6c is different from that of Table 8b. Proponents should use the physical parameters shown in Table 19b when the example layout is used for evaluation.

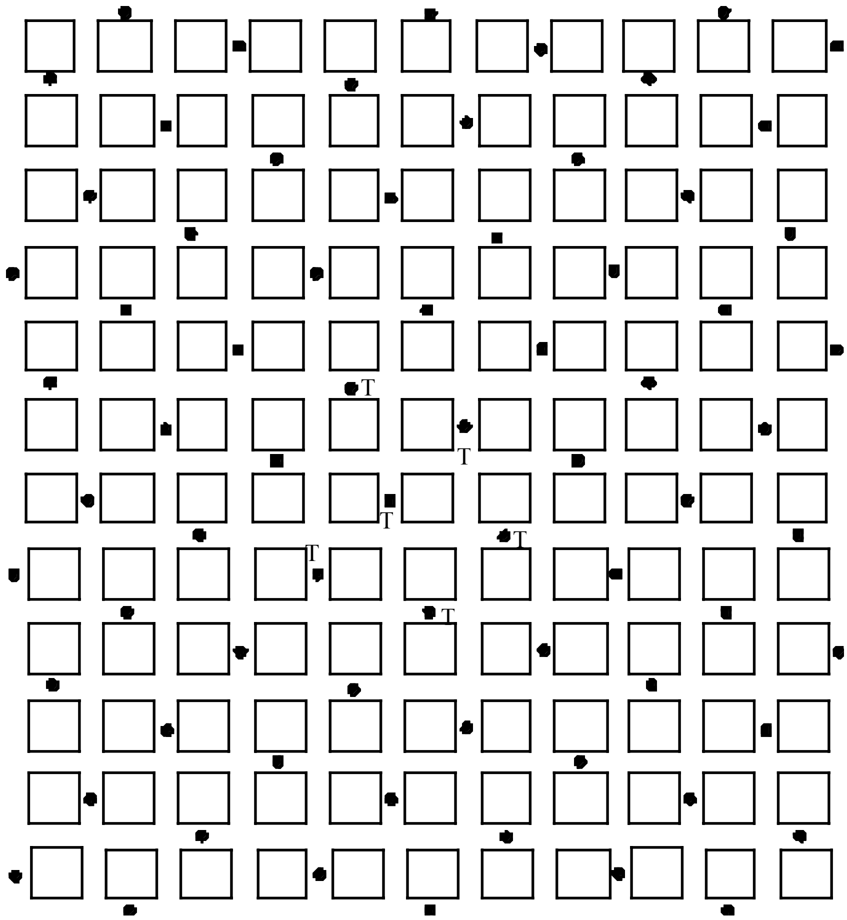



FIGURE 6c

**Example layout for outdoor to indoor and pedestrian test environment**

TABLE 19b

**Physical parameters for outdoor to indoor and pedestrian layout**

| Area | Block size | Street width | Base station - mobile height difference |
|---|---|---|---|
| 6.5 km= | 200 m x 200 m | 30 m | 10 m |

Mobility model

The urban mobility model is highly related to the Manhattan-like structure defined in Figure 6c. In such a structure, mobiles move along streets and may turn at cross streets with a given probability. Mobile's position is updated every 5 metres and speed can be changed at each position update according to a given probability. The mobility model is described by the following parameters:

Mean speed : 3 km/h

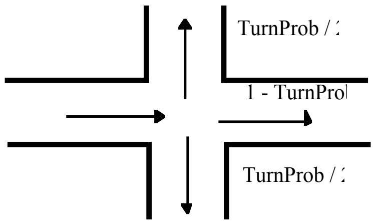
Minimum speed: 0 km/h

Standard deviation for speed (normal distribution): 0.3 km/h

Probability to change speed at position update : 0.2

Probability to turn at cross street : 0.5

The turning probability is illustrated on the figure below :




Mobiles are uniformly distributed in the street and their direction is randomly chosen at initialisation.

NOTE – It is pointed out that the outdoor to indoor and pedestrian wideband propagation channel B may not be relevant for the Manhattan structure due to high delay spreads.

<u>Path loss model</u>

For coverage efficiency evaluation and simple capacity evaluation, the path loss model described in 1.2.1.2 should be used. For spectrum efficiency evaluation in urban environments modelled through the Manhattan structure, the path loss model defined by the following description should be used in order to properly evaluate the performance of RTTs in microcell situations that will be common in cities at the time of IMT-2000/FPLMTS deployment.

The model is a recursive model[6], that calculates the path loss as a sum of LOS and NLOS segments. The shortest path along streets between the BS and the MS has to be found within the Manhattan environment.

The path loss in dB is given by the well-known formula $L = 20\log_{10}\frac{4\pi d_n}{\lambda}$,

where $d_n$ is the 'illusory' distance,

$\lambda$ is the wavelength,

n is the number of straight street segments between BS and MS (along the shortest path).

The illusory distance is the sum of these street segments and can be obtained by recursively using the expressions $k_n = k_{n-1} + d_{n-1} \cdot c$ and $d_n = k_n \cdot s_{n-1} + d_{n-1}$ where c is a function of the angle of the street crossing. For a 90 degree street crossing the value c should be set to 0.5. Further, $s_{n-1}$ is the length in meters of the last segment. A segment is a straight path. The initial values are set according to: $k_0$ is set to 1 and $d_0$ is set to 0. The illusory distance is obtained as the final $d_n$ when the last segment has been added.

The model is extended to cover the micro cell dual slope behaviour, by modifying the expression to :

$L = 20\log_{10}\left(\frac{4\pi d_n}{\lambda} \cdot D\left(\sum_{j=1}^{n} s_{j-1}\right)\right)$ where $D(x) = \begin{cases} x / x_{br}, & x > x_{br} \\ 1, & x \le x_{br} \end{cases}$.

Before the break point $x_{br}$ the slope is 2, after the break point it increases to 4. The break point $x_{br}$ is set to 300 m. x is the distance from the transmitter to the receiver.

To take into account effects of propagation going above roof tops it is also needed to calculate the path loss according to the shortest geographical distance. This is done by using the commonly known COST Walfish-Ikegami Model and with antennas below roof tops :

$L = 24 + 45\log(d+20)$

where d is the shortest physical geographical distance from the transmitter to the receiver in metres.

The final path loss value is the minimum between the path loss value from the propagation through the streets and the

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[6] J.E. Berg , A recursive Method For Street Microcell Path Loss Calculations, PIMRC '95, Vol 1, pp 140-143

path loss based on the shortest geographical distance :

*Pathloss= min(manhattan path loss, macro path loss)*

NOTE – This path loss model is valid for microcell coverage only with antenna located below roof top. In case the urban structure would be covered by macrocells, the former path loss model should be used.

**3 Example cell layout for vehicular test environment**

The vehicular cell layout is shown in Figure 6d. The cell radius is 2000 m. The base station antenna height must be above the average roof top height of 15 metres. The deployment scheme is assumed to be an hexagonal cell layout with distances between base stations equal to 6 km. Tri-sectored cells should be used with the antenna pattern defined in the later part of this section.

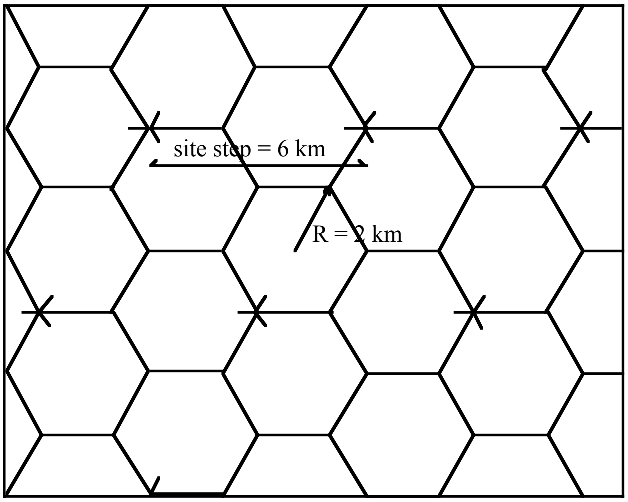



FIGURE 6d

**Example layout for vehicular test environment**

The specific assumptions about the vehicular physical deployment environment are summarized in Table 9b.

Mobility model

The mobility model for the Vehicular Test environment is a pseudo random mobility model with semi-directed trajectories. Mobile's position is updated according to the decorrelation length (as defined in section 1.2.1.4), and direction can be changed at each position update according to a given probability. Direction can be changed within a given sector to simulate semi-directed trajectory.

Mobile's speed is constant and the mobility model is defined by the following parameters :

| | |
|---|---|
| Speed value : | 120 km/h |
| Probability to change direction at position update : | 0.2 |
| Maximal angle for direction update : | 458 |
| Decorrelation length : | 20 metres |

Mobiles are uniformly distributed on the map and their direction is randomly chosen at initialisation.

Sectored antenna pattern (from GSM networks) is defined here to be used in case of the vehicular deployment scheme. Only the horizontal pattern diagram is considered and a typical pattern corresponding to a main sector of 90 degrees is proposed in Figure 6E. Pattern tables specify the gain for each degree. The gain has to be selected according to the angle between the antenna pointing direction and the mobile-base station direction.

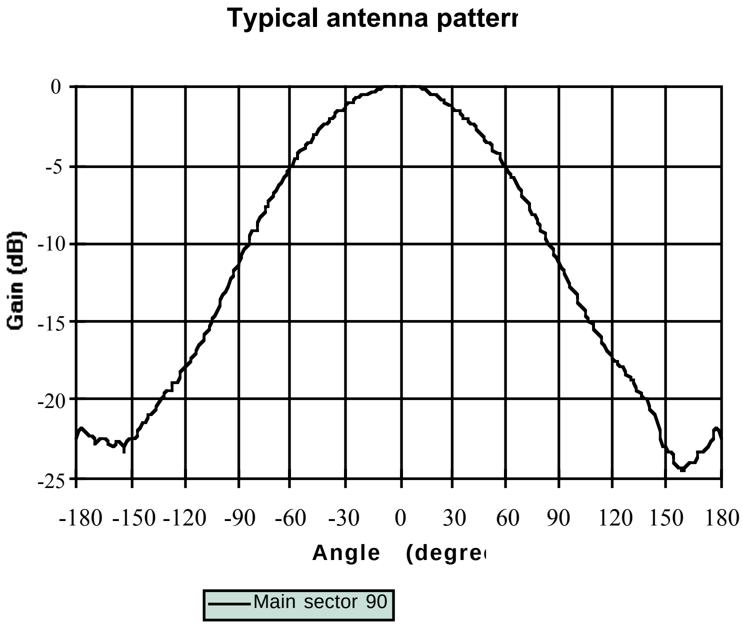



FIGURE 6e

**Horizontal antenna pattern**

## 4 Example cell layout for mixed-cell pedestrian/vehicular test environment

The physical environment consists in a urban area covered with microcells (with antenna below roof top) and overlayed by macrocells (with antenna above roof top). It can be considered as a mixture of outdoor to indoor and vehicular test environments. The surrounding open area covered by macrocells has to be large enough so that umbrella macrocells above the urban area are fully interfered by a full tier of co-channel interfering cells. An example is presented on figure 6f below, together with a proposed default deployment scheme. The cell radius of the cell layout is same as defined for vehicular and pedestrian.

Mobility model

Users move according to the outdoor to indoor and pedestrian model in urban area, and according to the vehicular mobility model in the open area.

Handover between macrocells and microcells are allowed for all users, but the handover strategy used in the evaluation has to be given. The whole bandwidth can be partitioned between macrocells and microcells as desired for the proposed system.

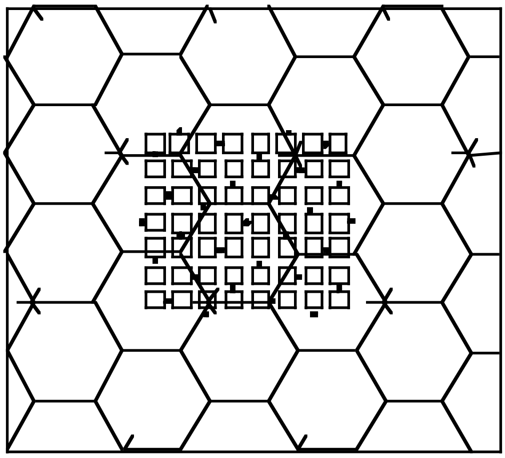


FIGURE 6f

**Example cell layout for mixed test environment**

# APPENDIX 4[7]
# TO ANNEX 2

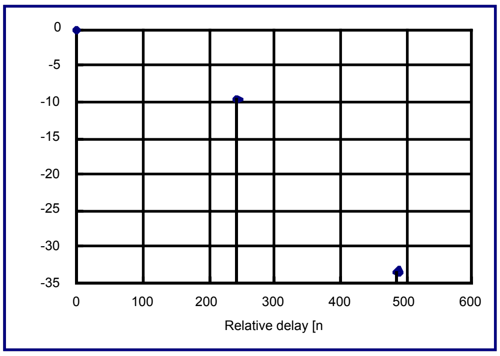
## Example channel impulse response models for link level simulations

This Annex describes channel impulse response models. The following description is presented as examples of the modified models of channel impulse response models described in 1.2.2 for link level simulations. Proponents may use the other models in evaluating their proposed RTTs, in that case, however, proponents have to present it explicitly.

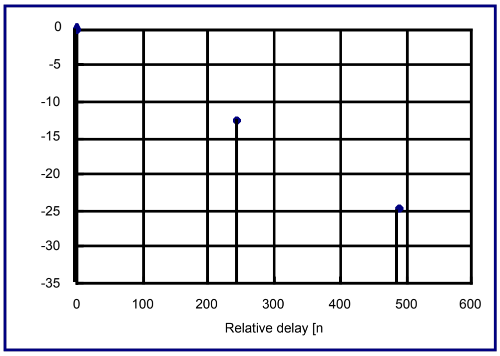
Each ray is split into two rays, one to the sample to the left and one to the sample to the right. The power of these new rays is such that the sum is equal to the original power, and the power of each of the new rays is inversely proportional to the distance to the original ray. Finally, the power of all rays on one sample are added up and normalized. This yields a model with a number of independently Rayleigh fading rays on the sampling instants.

In the Vehicular B channel, the delay spread is very large, so moving the rays to the nearest sampling instant have only marginal impact on the look of the impulse response. Hence, for this channel the rays are moved instead of interpolated to sampling instants.

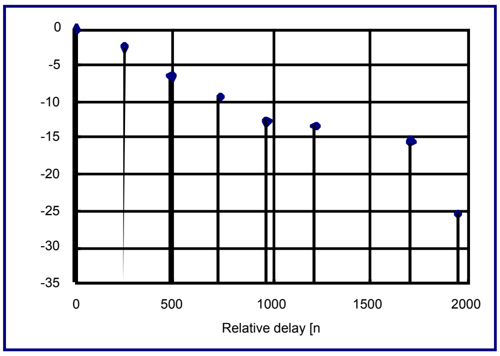
For example, in the case of the link simulations with sampling time of 4.096MHz, resulting in the modified channel models in Figure.1 that can be used in simulations.



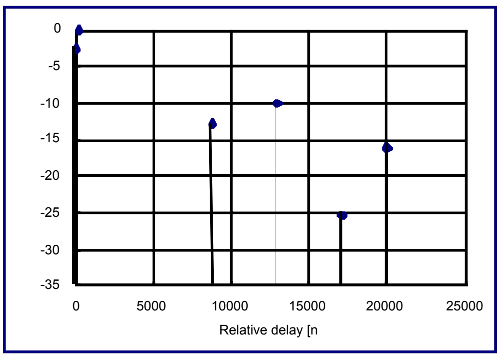

(a) Indoor office Channel A




(b) Outdoor to indoor and pedestrian Channel A




(c) Vehicular Channel A




(d) Vehicular Channel B

Fig.7 Modified channel models used in link simulations

[7] This is new appendix.

# APPENDIX 5[8]
# TO ANNEX 2
## Expression for Capacity Evaluation

This section presents an expression for capacity evaluation. This expression can be used to evaluate the capacity of systems that employ direct sequence code division multiple access (DS-CDMA) technology. The system capacity is calculated based on the results of link level simulations. System level simulations are not always required to evaluate the system capacity. However, the expression is applied only to reverse (mobile station to base station) link.

The system capacity C [users/cell] is calculated as

$$C = \frac{PG}{(E_b / I_0)_{req}} \cdot \frac{1 - \eta^{-1}}{\exp\{(\sigma \beta)^2 / 2\} + f \cdot g} \cdot \frac{h \cdot N_{sector}}{\rho}.$$

Furthermore, the traffic capacity in Erlangs is calculated using Erlang's B formula specifying certain blocking rate, for example, 1%. The parameters are defined as follows:

(a) **C**:

The number of users per cell.

(b) **PG**:

PG stands for processing gain.

(c) **$(E_b/I_0)_{req}$**:

This is the required value for $E_b/I_0$ in order to maintain the specified quality that is shown in Table 1. $(E_b/I_0)_{req}$ is generally the result from a link level simulation. $E_b$ and $I_0$ represent respectively the bit energy and the interference power density. The bit energy is calculated dividing the total received power by information bit rate. This calculation should be done carefully because the bit energy directly controls the capacity and because the bit energy can be defined in several ways. The total received power should include all bits in radio frames such as pilot symbols, TPC symbols, rate information and so on while information bit rate should include only user information. Proponents must present how the bit energy is calculated referring the radio frame format, if the expression is used.

(d) $\eta$:

This represents the ratio of the maximum allowable interference power density to the thermal noise power density. A typical value of $\eta$ is 10 dB. This value would be larger than it is in link budget calculation. This is because the system capacity should be calculated under an interference-limited situation while the coverage efficiency is calculated under a noise-limited situation.

(e) $\sigma$:

This is the power control error measured in dB. It should be noted that only this value is scaled in dB while all other values are in linear scale. This power control error is derived from link level simulations. In the expression, $\exp\{(\sigma\beta)^2/2\}$ is the coefficient that represents the own-cell interference increase from its short-term median value.

(f) $\beta$:

This represents the constant value of ln10/10.

(g) f:

[8] This is new appendix.

This represents the ratio of other-cell interference power to own-cell interference power. A typical value of f is 0.66 for the standard deviation of shadowing of 10 dB, the distance attenuation constant of 4, and the correlation coefficient between the shadowing fading to base stations of 0.5. Values for f may be derived from system level simulation.

(h) g:

This is the coefficient that represents the other-cell interference increase from its short-term median value. Using the power control mechanism, the receiving level at the communicating base station is kept constant (of course power control error exists). However, this means that the another temporal variation is introduced when it goes to other base stations because fast fading is almost independent from each path to each base station. Then, temporal variation of other-cell interference consists of two components: power control error and fast fading. This variation, therefore, should be considered separately from that of own-cell interference. Values of g are obtained through link level simulations and are not constant because they are dependent upon the simulation parameters such as fading frequency, power control step size and so on.

(i) $N_{sector}$:

This is the number of sectors per cell.

(j) $\rho$:

This represents an activity factor and ranges from 0 to 1. The values from 0.4 to 0.5 seem to be typical values if voice traffic is considered. However, from the viewpoint of capacity evaluation, higher values for $\rho$ may be required. This is because the transmit power is not zero even when the user keeps silent due to the transmission of the pilot symbols, TPC symbols and so on. The proponent, therefore, must present how the activity factor is defined referring the transmit power during talk period and silent period of voice user. In another approach, the transmit power during silent period may be added to total receiving power when $E_b$ is calculated. In any case, as far as the expression is used for capacity evaluation, the proponent must describe how the voice or data activity is considered.

(k) $h$:

This represents a sectorization factor and ranges from 0 to 1. The value shows the degrading ratio due to misalignment of sectorizing equipment such as directional antennas. Therefore when sectorization is perfect, the value becomes 1. For example, if maximum ration combining (MRC) between multiple sector sites is employed, h is considered to be unity. The value is commonly dependent on the number of sectors. Referring [1], a typical value for h is 0.75. However, the proponent must describe how the value is derived.

Reference:

[1] F. Adachi et al., "Coherent Multicode DS-CDMA Mobile Radio Access," IEICE Trans. Commun., Vol. E79-B, No. 9, pp. 1316 – 1324, Sept. 1996.

# APPENDIX 6[9]
# TO ANNEX 2
# Performance Measure

## 1 Spectrum efficiency evaluation

This section presents the definition of system capacity to be used for spectrum efficiency evaluation, and a methodology to derive these figures using system simulations.

The proponent shall not only provide spectrum efficiency numbers, but also additional results, specified in Section 0.

### 1.1 Active Session Throughput

The active session throughput, *S*, is defined as the ratio of correctly received user bits during the entire session and the session length excluding the time where there is nothing to transmit (i.e. empty buffer).

### 1.2 Satisfied user

For *circuit switched services*, we define a satisfied user as a user that have all three of the following constraints fulfilled:

1. The user do not get blocked when arriving to the system. If blocking is applied, the proponent must specify used blocking criteria.
2. The user have sufficiently good quality more than a certain time (fraction) of the session, i.e., Probability (BER > BER_Threshold) < $x_1$ %
3. The user does not get dropped. A call is dropped if BER > BER_Threshold more than $t_{dropp1}$ seconds.

In order to get comparable results for good quality percentage, quality statistics have to be collected every $t_l$ seconds.

For *packet services*, we define a satisfied user as a user that have all three of the following constraints fulfilled:

1. The user do not get blocked when arriving to the system[10]. If blocking is applied, the proponent must specify used blocking criteria.
2. The active session throughput, *S*, of the session is equal to or greater than $S_{threshold}$.
3. The user does not get dropped. If dropping is applied, the proponent must specify used dropping criteria. Note: for TDD refer to Annex D

### 1.3 System Load

The system load, $\nu$, is measured in [kb/s/cell/MHz].

For circuit switched users, the system load, $\nu_{cs}$, is derived as follows:

$\nu_{cs} = \omega_{cs}$ * user_bitrate * activity_factor / system_bandwidth [kb/s/cell/MHz],

where $\omega_{cs}$ is the average number of (simultaneous) circuit switched users per cell, i.e. the offered load (Erlangs).

System load for packet users, $\nu_{pkt}$, is derived as follows:

$\nu_{pkt} = D/T/Cells/$system_bandwidht [kb/s/cell/MHz],

where *D* is total number of correctly received user bits within the cells from where the statistics are collected

*T* is the simulation measuring time, defined as the time during the simulation when the statistics are

[9] This is new appendix.

[10] The most common way of treating packet users is not to block them but to queue them. However, if the proponent applies some kind of admission control for packet users, there will exist a ratio of blocked packet users. Thus blocking of packet users, means that they are not put in a queue but entirely blocked from the system.

collected

*Cells* is the number of cells in the system from where the statistics are collected.

The system load is calculated separately for uplink and downlink respectively.

In the case of mixed services configurations, the system load is derived as:

$$\nu = \sum_{i=1}^{N_{sc}} \nu_{cs,i} + \sum_{i=1}^{N_{pkt}} \nu_{pkt,i}$$

where $N_{cs}$ is the number of circuit switched services and $N_{pkt}$ is the number of packet services.

### 1.4 Spectrum Efficiency

For single service scenarios, the spectrum efficiency, ν*, is defined as the system load where there are exactly $x_2$ % satisfied users.

In the case of mixed services configurations, there must be at least $x_2$ % satisfied users for each service independently. The spectrum efficiency is defined as the system load where any of the services has exactly $x_2$ % satisfied users, whereas the rest of the services have at least $x_2$ % satisfied users each. This is exemplified in Figure 8.

The spectrum efficiency should be given separately for uplink and downlink respectively.

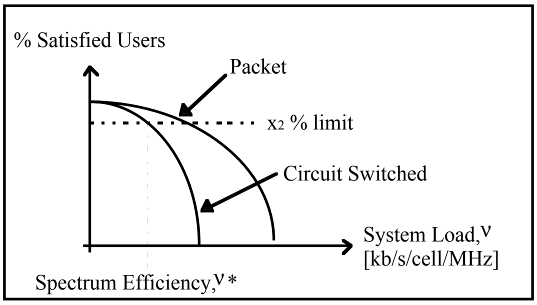



**Figure 8: Example of spectrum efficiency for a mixed service scenario with one circuit switched service and one packet service.**

### 1.5 Parameter values

In Table 20 the values of the parameters previously mentioned are presented.

**TABLE 20: Values of parameter in spectrum efficiency evaluation**

| Parameter | Name/Description | Value |
|---|---|---|
| $x_1$ | "Bad quality probability threshold" | 5 % |
| $t_1$ | sampling time for quality statistics | 0.5 second |
| $t_{dropp1}$ | "Dropping time-out, circuit switched" | Max (5, 10/(bit rate . BER_threshold) seconds |
| $S_{threshold}$ | "Active Session Throughput Threshold" | 10% of the average bit rates in footnote of Table 1.1[11] (i.e., $S_{threshold}$ = 0.8, 3.2, 6.4, 14.4, 38.4 and 204.8 kbit/s for average bit rates of 8,32,64,144,384 and 2048 kbit/s respectively). |

[11] The values of the active session throughput thresholds are chosen to make it possible to perform re-transmission, queuing, etc. in order to make the packet services effective from a system point of view.

| | | |
|---|---|---|
| $x_2$ | "Threshold for ratio of satisfied users" | 98 % |
| BW | Bandwidth | 30 MHz duplex |

### 1.6 Required results

Within the spectrum efficiency evaluation the proponent shall, provide the following results for each test case:

1. Numerical value of the spectrum efficiency [kb/s/cell/MHz]
2. Numerical value for ratio of satisfied users for the case from where the spectrum efficiency value (in 1.) is obtained.
3. In case of UDD: Average active session throughput [kb/s], *mean*(S), for the case from where the spectrum efficiency value (in 1.) is obtained.
4. In case UDD: A sample density function of the active session throughput values (per session) for the case from where the spectrum efficiency value (in 1.) is obtained. Such a sample density function is exemplified in Figure 9.

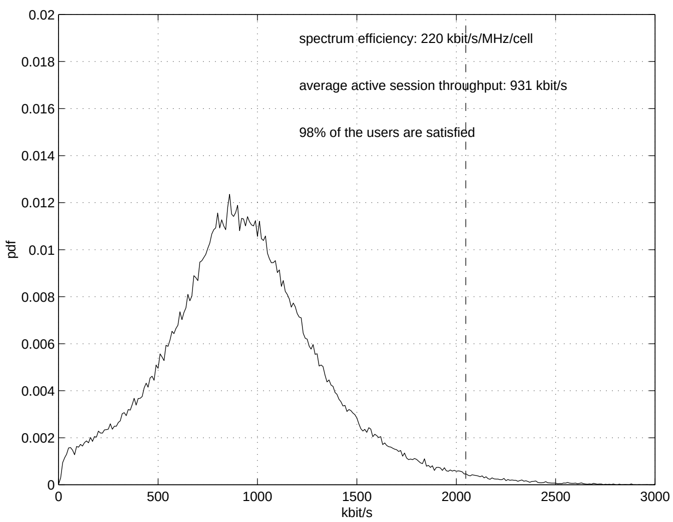



Figure 9 - Example of a sample density function for UDD 2048.

## 2 Deployment Model Result Matrix

Results from the system deployment model are to be tabulated as specified below.

**Table 21: Deployment model result matrix**

| Input Assumptions | |
|---|---|
| Test environment | |
| Test service mixture | |
| Total Number of cell sites | |
| Total bandwidth | |
| Base Station Antenna Height (m) | |
| Any other assumptions made by the proponent (e.g. antenna pattern, sectorization etc.) | |

| Deployment Results | | | | | |
|---|---|---|---|---|---|
| In addition to the results specified in Section 1.6.5.6, coverage vs. cell radius should also be presented. | | | | | |
| | | | | | |

# ANNEX III
# Modified version of Annex 3 of M.1225

# ANNEX 3
# Detailed evaluation procedures

## Introduction

This Annex lists technical attributes which should be considered for the evaluation of RTTs against each of the criteria and gives indication on what possible impact they may have upon the different criteria. Other information submitted based on the template in Annex 1, or additionally relevant information, may be considered during the evaluation. The evaluation described in this Annex shall be done on the basis of the deployment models in Annex 2. RTT performance evaluation is to be based on a common set of verifiable parameter assumptions for all evaluation criteria for each test environment; if conditions change the technology descriptions should explain it. This Annex identifies which attributes can be described qualitatively (q) and quantitatively (Q).

When more than one candidate RTT is evaluated, it is useful to provide evaluation summaries for each evaluation criteria. A criteria evaluation summary may be difficult to make when both qualitative and quantitative attributes must be considered and when each technical attribute may have different relative importance with the overall evaluation criteria.

To facilitate such criteria evaluation summaries, this Annex identifies the importance or relative ranking of the various technical attributes within each evaluation criteria by giving a grouping G1 (most important), G2, G3, G4 (least important). Ranking of some attributes may be different for different test environments, in particular for the satellite environment. These rankings are based upon current anticipated market needs within some countries. It is recognized that the market needs may differ in the various countries in which IMT-2000 may be deployed and that they may also change during the time in which RTTs are being evaluated. It is also recognized that some new technical attributes or important considerations may be identified during the evaluation procedure that could impact any evaluation criteria summary. As such, evaluation groups may, if appropriate, modify the groupings of technical attributes, or add new attributes or considerations, in determining a criteria evaluation summary. Therefore, all evaluation groups are requested to include in their evaluation reports, information of the criteria evaluation summaries including the relative importance which was placed on each technical attribute and any other considerations that affected the summaries.

The evaluation methodology is discussed in § 9.

| Index | Criteria and attributes | Q or q | Gn | Related attributes in Annex 1 | Proponent's Comment | Evaluator's Comment |
|---|---|---|---|---|---|---|
| A3.1 | Spectrum efficiency<br>The following entries are considered in the evaluation of spectrum efficiency: | | | | | |
| A3.1.1 | For terrestrial environment | | | | | |
| A3.1.1.1 | Voice traffic capacity (E/MHz/cell) in a total available assigned non-contiguous bandwidth of 30 MHz (15 MHz forward/15 MHz reverse) for FDD mode or contiguous bandwidth of 30 MHz for TDD mode.<br>This metric must be used for a common generic continuous voice bearer with characteristics 8 kbit/s data rate and an average BER $1 \times 10^{-3}$ as well as any other voice bearer included in the proposal which meets the quality requirements (assuming 50% voice activity detection (VAD) if it is used). For comparison purposes, all measures should assume the use of the deployment models in Annex 2, including a 1% call blocking. The descriptions should be consistent with the descriptions under criterion § 6.1.7 – Coverage/power efficiency. Any other assumptions and the background for the calculation should be provided, including details of any optional speech codecs being considered. | Q and q | G1 | A1.3.1.5.1 | | |
| A3.1.1.2 | Information capacity (Mbit/s/MHz/cell)for voice and data(see Table1 of ANNEX2) in a total available assigned non-contiguous bandwidth of 30 MHz (15 MHz forward/15 MHz reverse) for FDD mode or contiguous bandwidth of 30 MHz for TDD mode.<br>The information capacity is to be calculated for each test service or traffic mix for the appropriate test environments. This is the only measure that would be used in the case of multimedia, or for classes of services using multiple speech coding bit rates. Information capacity is the instantaneous aggregate user bit rate of all active users over all channels within the system on a per cell basis. If the user traffic (voice and/or data) is asymmetric and the system can take advantage of this characteristic to increase capacity, it should be described qualitatively for the purposes of evaluation. | Q and q | G1 | A1.3.1.5.2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| A3.1.2 | For satellite environment<br>These values (§ A3.1.2.1 and A3.1.2.2) assume the use of the simulation conditions in Annex 2. The first definition is valuable for comparing systems with identical user channel rates. The second definition is valuable for comparing systems with different voice and data channel rates. | | | | | |
| A3.1.2.1 | Voice information capacity per required RF bandwidth (bit/s/Hz) | Q | G1 | A1.3.2.3.1 | | |
| A3.1.2.2 | Voice plus data information capacity per required RF bandwidth (bit/s/Hz) | Q | G1 | A1.3.2.3.2 | | |
| A3.2 | Technology complexity – Effect on cost of installation and operation<br>The considerations under criterion § 6.1.2 – Technology complexity apply only to the infrastructure, including BSs (the handportable performance is considered elsewhere). | | | | | |
| A3.2.2 | Transmitter power and system linearity requirements<br>NOTE 1 – Satellite e.i.r.p. is not suitable for evaluation and comparison of RTTs because it depends very much on satellite orbit.<br>The RTT attributes in this section impact system cost and complexity, with the resultant desirable effects of improving overall performance in other evaluation criteria. They are as follows. | | | | | |
| A3.2.2.1 | Peak transmitter/carrier ($P_b$) power (not applicable to satellite)<br>Peak transmitter power for the BS should be considered because lower peak power contributes to lower cost. Note that Pb may vary with test environment application. This is the same peak transmitter power assumed in Annex 2, link budget template (Table 6). | Q | G1 | A1.2.16.2.1 | | |
| A3.2.2.2 | Broadband power amplifier (PA) (not applicable to satellite)<br>Is a broadband power amplifier used or required? If so, what are the peak and average transmitted power requirements into the antenna as measured in watts. | Q | G1 | A1.4.10<br>A1.2.16.2.1<br>A1.2.16.2.2<br>A1.5.5<br>A1.2.5 | | |
| A3.2.2.3 | Linear base transmitter and broadband amplifier requirements (not applicable to satellite) | | | | | |
| A3.2.2.3.1 | Adjacent channel splatter/emission and intermodulation affect system capacity and performance. Describe these requirements and the linearity and filtering of the base transmitter and broadband PA required to achieve them. | q | G3 | A1.4.2<br>A1.4.10 | | |
| A3.2.2.3.2 | Also state the base transmitter and broadband PA (if one is used) peak to average transmitter output power, as a higher ratio requires greater linearity, heat dissipation | Q<br>and | G2 | A1.4.10<br>A1.2.16.2.1 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | and cost. | q | | A1.2.16.2.2 | | |
| A3.2.2.4 | Receiver linearity requirements (not applicable to satellite)<br><br>Is BS receiver linearity required? If so, state the receiver dynamic range required and the impact of signal input variation exceeding this range, e.g., loss of sensitivity and blocking. | q | G4 | A1.4.11<br>A1.4.12 | | |
| A3.2.3 | Power control characteristics (not applicable to satellite)<br><br>Does the proposed RTT utilize transmitter power control? If so, is it used in both forward and reverse links? State the power control range, step size (dB) and required accuracy, number of possible step sizes and number of power controls per second, which are concerned with BS technology complexity. | Q<br>and<br>q | G4 | A1.2.22<br>A1.2.22.1<br>A1.2.22.2<br>A1.2.22.3<br>A1.2.22.4<br>A1.2.22.5 | | |
| A3.2.4 | Transmitter/receiver isolation requirement (not applicable to satellite)<br><br>If FDD is used, specify the noted requirement and how it is achieved. | q | G3 | A1.2.2<br>A1.2.2.2<br>A1.2.2.1 | | |
| A3.2.5 | Digital signal processing requirements | | | | | |
| A3.2.5.1 | Digital signal processing can be a significant proportion of the hardware for some radio interface proposals. It can contribute to the cost, size, weight and power consumption of the BS and influence secondary factors such as heat management and reliability. Any digital circuitry associated with the network interfaces should not be included. However any special requirements for interfacing with these functions should be included.<br><br>This section of the evaluation should analyse the detailed description of the digital signal processing requirements, including performance characteristics, architecture and algorithms, in order to estimate the impact on complexity of the BSs. At a minimum the evaluation should review the signal processing estimates (MOPS, memory requirements, gate counts) required for demodulation, equalization, channel coding, error correction, diversity processing (including Rake receivers), adaptive antenna array processing, modulation, A-D and D-A converters and multiplexing | Q<br>and<br>q | G2 | A1.4.13 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | as well as some IF and baseband filtering. For new technologies, there may be additional or alternative requirements (such as FFTs).<br><br>Although specific implementations are likely to vary, good sample descriptions should allow the relative cost, complexity and power consumption to be compared for the candidate RTTs, as well as the size and the weight of the circuitry. The descriptions should allow the evaluators to verify the signal processing requirement metrics, such as MOPS, memory and gate count, provided by the RTT proponent. | | | | | |
| A3.2.5.2 | What is the channel coding/error handling for both the forward and reverse links? Provide details and ensure that implementation specifics are described and their impact considered in DSP requirements described in § A3.2.5.1. | q | G4 | A1.2.12<br>A1.4.13 | | |
| A3.2.6 | Antenna systems<br><br>The implementation of specialized antenna systems while potentially increasing the complexity and cost of the overall system can improve spectrum efficiency (e.g. smart antennas), quality (e.g. diversity), and reduce system deployment costs (e.g. remote antennas, leaky feeder antennas).<br><br>NOTE 1 – For the satellite component, diversity indicates the number of satellites involved; the other antenna attributes do not apply. | | | | | |
| A3.2.6.1 | *Diversity*: describe the diversity schemes applied (including micro and macro diversity schemes). Include in this description the degree of improvement expected, and the number of additional antennas and receivers required to implement the proposed diversity design beyond and omni-directional antenna. | Q | G2 | A1.2.23<br>A1.2.23.1<br>A1.2.23.2 | | |
| A3.2.6.2 | *Remote antennas*: describe whether and how remote antenna systems can be used to extend coverage to low traffic density areas. | q | G2 | A1.3.6 | | |
| A3.2.6.3 | *Distributed antennas*: describe whether and how distributed antenna designs are used. | q | G3 | A1.3.6 | | |
| A3.2.6.4 | *Unique antenna*: describe additional antenna systems which are either required or optional for the proposed system, e.g., beam shaping, leaky feeder. Include in the description the advantage or application of the antenna | q | G4 | A1.3.6 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | system. | | | | | |
| A3.2.7 | BS frequency synchronization/time alignment requirements<br><br>Does the proposed RTT require base transmitter and/or receiver station synchronization or base-to-base bit time alignment? If so, specify the long term (1 year) frequency stability requirements, and also the required bit-to-bit time alignment. Describe the means of achieving this. | Q<br>and<br>q | G3 | A1.4.1<br>A1.4.3 | | |
| A3.2.8 | The number of users per RF carrier/frequency channel that the proposed RTT can support affects overall cost – especially as bearer traffic requirements increase or geographic traffic density varies widely with time.<br><br>Specify the maximum number of user channels that can be supported while still meeting ITU-T Recommendation G.726 performance requirements for voice traffic. | Q | G1 | A1.2.17 | | |
| A3.2.9 | Base site implementation/installation requirements (not applicable to satellite)<br><br>BS size, mounting, antenna type and height can vary greatly as a function of cell size, RTT design and application environment. Discuss its positive or negative impact on system complexity and cost. | q | G1 | A1.4.17 | | |
| A3.2.10 | Handover complexity<br><br>Consistent with handover quality objectives defined in criterion § 6.1.3, describe how user handover is implemented for both voice and data services and its overall impact on infrastructure cost and complexity. | Q<br>and<br>q | G1 | A1.2.24<br>A1.4.6.1 | | |
| A3.3 | Quality | | | | | |
| A3.3.1 | Transparent reconnect procedure for dropped calls<br><br>Dropped calls can result from shadowing and rapid signal loss. Air interfaces utilizing a transparent reconnect procedure – that is, the same as that employed for hand-off – mitigate against dropped calls whereas RTTs requiring a reconnect procedure significantly different from that used for hand-off do not. | q | G2 | A1.4.14 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| A3.3.2 | Round trip delay, D2 (without vocoder (ms)) (See Fig. 6).<br><br>NOTE 1 – The delay of the codec should be that specified by ITU-T for the common generic voice bearer and if there are any proposals for optional codecs include the information about those also. (For the satellite component, the satellite propagation delay is not included.) | Q | G2 | A1.3.7.1<br>A1.3.7.2 | | |
| A3.3.3 | Handover/ALT quality<br><br>Intra switch/controller handover directly affects voice service quality.<br><br>Handover performance, minimum break duration, and average number of handovers are key issues. | Q | G2 | A1.2.24<br>A1.2.24.1<br>A1.2.24.2<br>A1.4.6.1 | | |
| A3.3.4 | Handover quality for switched data and packet data(see Table1 of ANNEX2)<br><br>There should be a quantitative evaluation of the effect on data performance of handover. | Q | G3 | A1.2.24<br>A1.2.24.1<br>A1.2.24.2<br>A1.4.6.1 | | |
| A3.3.5 | Maximum user bit rate for switched data and packet data(see Table1 of ANNEX2) (bit/s)<br><br>A higher user bit rate potentially provides higher data service quality (such as high quality video service) from the user's point of view. | Q | G1 | A1.3.3 | | |
| A3.3.6 | Channel aggregation to achieve higher user bit<br><br>There should also be a qualitative evaluation of the method used to aggregate channels to provide higher bit rate services. | q | G4 | A1.2.32 | | |
| A3.3.7 | Voice quality<br><br>Recommendation ITU-R M.1079 specifies that FPLMTS speech quality without errors should be equivalent to ITU-T Recommendation G.726 (32 kbit/s ADPCM) with desired performance at ITU-T Recommendation G.711 (64 kbit/s PCM).<br><br>NOTE 1 – Voice quality equivalent to ITU-T Recommendation G.726 error free with no more than a 0.5 degradation in MOS in the presence of 3% frame | Q<br>and<br>q | G2 | A1.2.19<br>A1.3.8 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | erasures might be a requirement. | | | | | |
| A3.3.8 | System overload performance (not applicable to satellite)<br><br>Evaluate the effect on system blocking and quality performance on both the primary and adjacent cells during an overload condition, at e.g. 125%, 150%, 175%, 200%. Also evaluate any other effects of an overload condition. | Q and q | G3 | A1.3.9.1 | | |
| A3.4 | Flexibility of radio technologies | | | | | |
| A3.4.1 | Services aspects | | | | | |
| A3.4.1.1 | Variable user bit rate capabilities for voice and data(see Table1 of ANNEX2)<br><br>Variable user bit rate applications can consist of the following:<br><br>– adaptive signal coding as a function of RF signal quality;<br>– adaptive voice coder rate as a function of traffic loading as long as ITU-T Recommendation G.726 performance is met;<br>– variable data rate as a function of user application;<br>– variable voice/data channel utilization as a function of traffic mix requirements.<br><br>Some important aspects which should be investigated are as follows:<br><br>– how is variable bit rate supported?<br>– what are the limitations?<br><br>Supporting technical information should be provided such as<br><br>– the range of possible data rates,<br>– the rate of changes (ms). | q and Q | G2 | A1.2.18<br>A1.2.18.1 | | |
| A3.4.1.2 | Maximum tolerable Doppler shift, $F_d$ (Hz) for which voice and data quality requirements are met (terrestrial only)<br><br>Supporting technical information: $F_d$ | q and Q | G3 | A1.3.1.4 | | |
| A3.4.1.3 | Doppler compensation method (satellite component | Q | G3 | A1.3.2.2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | only)<br>What is the Doppler compensation method and residual Doppler shift after compensation? | and<br>q | | | | |
| A3.4.1.4 | How the maximum tolerable delay spread of the proposed technology impact the flexibility (e.g., ability to cope with very high mobile speed)? | q | G3 | A1.3.1.3<br>A1.2.14<br>A1.2.14.1<br>A1.2.14.2<br>A1.3.10 | | |
| A3.4.1.5 | Maximum user information bit rate, $R_u$ (kbit/s)for switched data and packet data(see Table1 of ANNEX2)<br>How flexibly services can be offered to customers ?<br>What is the limitation in number of users for each particular service? (e.g. no more than two simultaneous 2 Mbit/s users) | Q<br>and<br>q | G2 | A1.3.3<br>A1.3.1.5.2<br>A1.2.31<br>A1.2.32 | | |
| A3.4.1.6 | Multiple vocoder rate capability<br>– bit rate variability,<br>– delay variability,<br>– error protection variability. | Q<br>and<br>q | G3 | A1.2.19<br>A1.2.19.1<br>A1.2.7<br>A1.2.12 | | |
| A3.4.1.7 | Multimedia capabilities<br>The proponents should describe how multimedia services are handled.<br>The following items should be evaluated:<br>– possible limitations (in data rates, number of bearers),<br>– ability to allocate extra bearers during of the communication,<br>– constraints for handover. | Q<br>and<br>q | G1 | A1.2.21<br>A1.2.20<br>A1.3.1.5.2<br>A1.2.18<br>A1.2.24<br>A1.2.30<br>A1.2.30.1 | | |
| A3.4.2 | Planning | | | | | |
| A3.4.2.1 | Spectrum related matters | | | | | |
| A3.4.2.1.1 | Flexibility in the use of the frequency band<br>The proponents should provide the necessary information related to this topic (e.g., allocation of sub-carriers with no constraints, handling of asymmetric services, usage of non-paired band). | q | G1 | A1.2.1<br>A1.2.2<br>A1.2.2.1<br>A1.2.3<br>A1.2.5.1 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| A3.4.2.1.2 | Spectrum sharing capabilities<br>The proponent should indicate how global spectrum allocation can be shared between operators in the same region.<br>The following aspects may be detailed:<br>– means for spectrum sharing between operators in the same region,<br>– guardband between operators in case of fixed sharing. | q and Q | G4 | A1.2.26 | | |
| A3.4.2.1.3 | Minimum frequency band necessary to operate the system in good conditions<br>Supporting technical information:<br>– impact of the frequency reuse pattern,<br>– bandwidth necessary to carry high peak data rate. | Q and q | G1 | A1.2.1<br>A1.4.15<br>A1.2.5 | | |
| A3.4.2.1.4<br>(New attribute) | Band plans and frequency duplexing<br>The proponent should describe how their system will provide global service delivery in the different regional/national band plans and frequency duplexing arrangements for IMT2000 systems. | Q and q | G1 | A1.2.1<br>A1.2.2<br>A1.2.2.1<br>A1.2.4 | | |
| A3.4.2.2 | Radio resource planning | | | | | |
| A3.4.2.2.1 | Allocation of radio resources<br>The proponents and evaluators should focus on the requirements and constraints imposed by the proposed technology. More particularly, the following aspects should be considered:<br>– what are the methods used to make the allocation and planning of radio resources flexible?<br>– what are the impacts on the network side (e.g. synchronization of BSs, signalling,)?<br>– other aspects.<br>Examples of functions or type of planning required which may be supported by the proposed technology:<br>– DCA,<br>– frequency hopping,<br>– code planning,<br>– time planning, | q | G2 | A1.2.25<br>A1.2.27<br>A1.4.15 | | |

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| | – nterleaved frequency planning.<br>NOTE 1 – The use of the second adjacent channel instead of the adjacent channel at a neighbouring cluster cell is called “interleaved frequency planning”.<br>In some cases, no particular functions are necessary (e.g. frequency reuse = 1). | | | | | |
| A3.4.2.2.2 | Adaptability to adapt to different and/or time varying conditions (e.g., propagation, traffic)<br>How the proposed technology cope with varying propagation and/or traffic conditions?<br>Examples of adaptive functions which may be supported by the proposed technology:<br>– DCA,<br>– link adaptation,<br>– fast power control,<br>– adaptation to large delay spreads.<br>Some adaptivity aspects may be inherent to the RTT. | q | G2 | A1.3.10<br>A1.2.27<br>A1.2.22<br>A1.2.14 | | |
| A3.4.2.3 | Mixed cell architecture (not applicable to satellite component) | | | | | |
| A3.4.2.3.1 | Frequency management between different layers<br>What kind of planning is required to manage frequencies between the different layers? e.g.<br>– fixed separation,<br>– dynamic separation,<br>– possibility to use the same frequencies between different layers.<br>Possible supporting technical information:<br>– guard band. | q and Q | G1 | A1.2.28<br>A1.4.15 | | |
| A3.4.2.3.2 | User adaptation to the environment<br>What are the constraints to the management of users between the different cell layers? e.g.<br>– constraints for handover between different layers,<br>– adaptation to the cell layers depending on services, mobile speed, mobile power. | q | G2 | A1.2.28<br>A1.3.10 | | |
| A3.4.2.4 | Fixed-wireless access | | | | | |
| A3.4.2.4.1 | The proponents should indicate how well its technology | q | G4 | A1.1.3 | | |

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| | is suited for operation in the fixed wireless access environment.<br>Areas which would need evaluation include (not applicable to satellite component):<br>– ability to deploy small BSs easily,<br>– use of repeaters,<br>– use of large cells,<br>– ability to support fixed and mobile users within a cell,<br>– network and signalling simplification. | | | A1.3.5<br>A1.4.17<br>A1.4.7<br>A1.4.7.1 | | |
| A3.4.2.4.2 | Possible use of adaptive antennas (how well suited is the technology) (not applicable to satellite component)<br>Is RTT suited to introduce adaptive antennas? Explain the reason if it is. | q | G4 | A1.3.6 | | |
| A3.4.2.4.3 | Existing system migration capability | q | G1 | A1.4.16 | | |
| A3.5 | Implication on network interface | | | | | |
| A3.5.1 | Examine the synchronization requirements with respect to the network interfaces.<br>*Best case* : no special accommodation necessary to provide synchronization.<br>*Worst case* : special accommodation for synchronization is required, e.g. additional equipment at BS or special consideration for facilities. | q | G4 | A1.4.3 | | |
| A3.6 | Handportable performance optimization capability | | | | | |
| A3.6.1 | Isolation between transmitter and receiver<br>Isolation between transmitter and receiver has an impact on the size and weight of the handportable. | Q | G2 | A1.2.2<br>A1.2.2.1<br>A1.2.2.2 | | |
| A3.6.2 | Average terminal power output $P_0$ (mW)<br>Lower power gives longer battery life and greater operating time. | Q | G2 | A1.2.16.1.2 | | |
| A3.6.3 | System round trip delay impacts the amount of acoustical isolation required between handportable microphone and speaker components and, as such, the physical size and mechanical design of the subscriber unit.<br>NOTE 1 – The delay of the codec should be that | Q<br>and<br>q | G2 | A1.3.7<br>A1.3.7.1<br>A1.3.7.2<br>A1.3.7.3 | | |

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| | specified by ITU-T for the common generic voice bearer and if there are any proposals for optional codecs include the information about those also. (For the satellite component, the satellite propagation delay is not included.) | | | | | |
| A3.6.4 | Peak transmission power | Q | G1 | A1.2.16.1.1 | | |
| A3.6.5 | Power control characteristics<br>Does the proposed RTT utilize transmitter power control? If so, is it used in both forward and reverse links? State the power control range, step size (dB) and required accuracy, number of possible step sizes and number of power controls per second, which are concerned with mobile station technology complexity. | | | | | |
| A3.6.5.1 | Power control dynamic range<br>Larger power control dynamic range gives longer battery life and greater operating time. | Q | G3 | A1.2.22<br>A1.2.22.3<br>A1.2.22.4 | | |
| A3.6.5.2 | Power control step size, accuracy and speed | Q | G3 | A1.2.22<br>A1.2.22.1<br>A1.2.22.2<br>A1.2.22.5 | | |
| A3.6.6 | Linear transmitter requirements | q | G3 | A1.4.10 | | |
| A3.6.7 | Linear receiver requirements (not applicable to satellite) | q | G3 | A1.4.11 | | |
| A3.6.8 | Dynamic range of receiver<br>The lower the dynamic range requirement, the lower the complexity and ease of design implementation. | Q | G3 | A1.4.12 | | |
| A3.6.9 | Diversity schemes<br>Diversity has an impact on handportable complexity and size. If utilized describe the type of diversity and address the following two attributes. | Q<br>and<br>q | G1 | A1.2.23<br>A1.2.23.1<br>A1.2.23.2 | | |
| A3.6.10 | The number of antennas | Q | G1 | A1.2.23.1 | | |
| A3.6.11 | The number of receivers | Q | G1 | A1.2.23.1 | | |
| A3.6.12 | Frequency stability<br>Tight frequency stability requirements contribute to handportable complexity. | Q | G3 | A1.4.1.2 | | |
| A3.6.13 | The ratio of “off (sleep)” time to “on” time | Q | G1 | A1.2.29<br>A1.2.29.1 | | |

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| A3.6.14 | Frequency generator step size, switched speed and frequency range<br><br>Tight step size, switch speed and wide frequency range contribute to handportable complexity. Conversely, they increase RTT flexibility. | Q | G2 | A1.4.5 | | |
| A3.6.15 | Digital signal processing requirements<br><br>Digital signal processing can be a significant proportion of the hardware for some radio interface proposals. It can contribute to the cost, size, weight and power consumption of the BS and influence secondary factors such as heat management and reliability. Any digital circuitry associated with the network interfaces should not be included. However any special requirements for interfacing with these functions should be included.<br><br>This section of the evaluation should analyse the detailed description of the digital signal processing requirements, including performance characteristics, architecture and algorithms, in order to estimate the impact on complexity of the BSs. At a minimum the evaluation should review the signal processing estimates (MOPS, memory requirements, gate counts) required for demodulation, equalization, channel coding, error correction, diversity processing (including Rake receivers), adaptive antenna array processing, modulation, A-D and D-A converters and multiplexing as well as some IF and baseband filtering. For new technologies, there may be additional or alternative requirements (such as FFTs).<br><br>Although specific implementations are likely to vary, good sample descriptions should allow the relative cost, complexity and power consumption to be compared for the candidate RTTs, as well as the size and the weight of the circuitry. The descriptions should allow the evaluators to verify the signal processing requirement metrics, such as MOPS, memory and gate count, provided by the RTT proponent. | Q and q | G1 | A1.4.13 | | |
| A3.7 | Coverage/power efficiency | | | | | |
| A3.7.1 | Terrestrial<br><br>Coverage efficiency: | | | | | |

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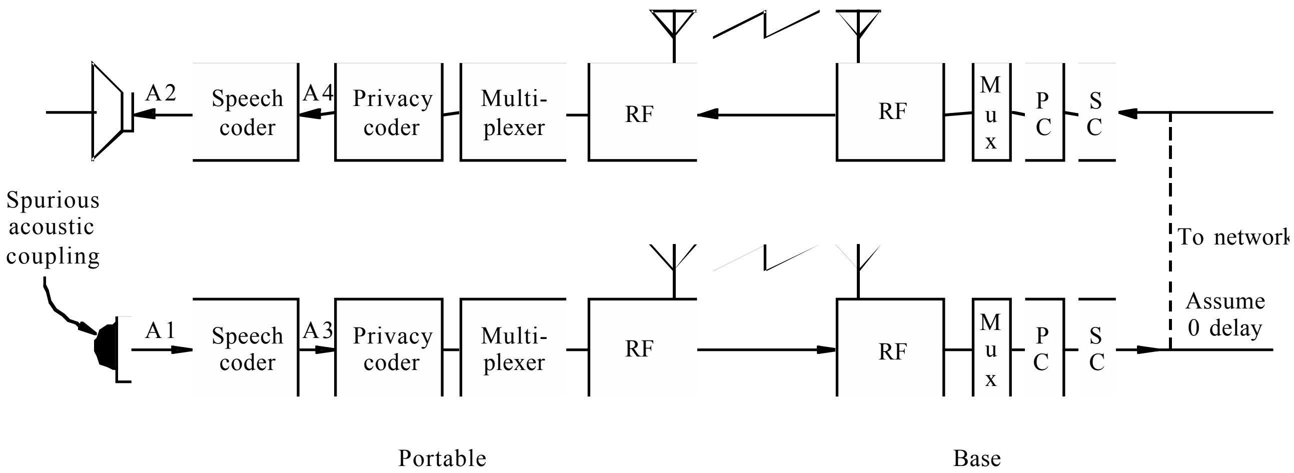
| | – the coverage efficiency is considered for the lowest traffic loadings;<br>– the base site coverage efficiency can be quantitatively determined by addressing coverage limitation and/or by calculating the maximum coverage range for the lowest traffic loading. | | | | | |
| A3.7.1.1 | Base site coverage efficiency<br>The number of base sites required to provide coverage at system start-up and ongoing traffic growth significantly impacts cost. From § 1.3.2 of Annex 2, determine the coverage efficiency, $C$ (km$^2$/base sites), for the lowest traffic loadings. Proponent has to indicate the background of the calculation and also to indicate the maximum coverage range. | Q | G1 | A1.3.1.7<br>A1.3.1.7.1<br>A1.3.1.7.2<br>A1.3.4 | | |
| A3.7.1.2 | Method to increase the coverage efficiency<br>Proponent describes the technique adopted to increase the coverage efficiency and drawbacks.<br>Remote antenna systems can be used to economically extend vehicular coverage to low traffic density areas. RTT link budget, propagation delay system noise and diversity strategies can be impacted by their use.<br>Distributed antenna designs – similar to remote antenna systems – interconnect multiple antennas to a single radio port via broadband lines. However, their application is not necessary limited to providing coverage, but can also be used to economically provide continuous building coverage for pedestrian applications. System synchronization, delay spread, and noise performance can be impacted by their use. | q | G1 | A1.3.5<br>A1.3.6 | | |
| A3.7.2 | Satellite<br>Normalized power efficiency<br>Supported information bit rate per required carrier power-to-noise density ratio for the given channel performance under the given interference conditions for voice<br>Supported information bit rate per required carrier power-to-noise density ratio for the given channel performance under the given interference conditions for voice plus data mixed traffic. | Q | G1 | A1.3.2.4<br>A1.3.2.4.1<br>A1.3.2.4.2 | | |

FIGURE 6




D1: delay between A1 and A2
D2: delay between A3 and A4
Mux: multiplexer
PC: privacy coder
SC: speech coder

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# ANNEX IV

## Additional Requirements and Objectives

ARIB Evaluation group requests additional requirements and objects that will be used in its evaluation process in addition to the original Requirements and Objectives shown ATTACHMENT 4 of the Circular letter.

**Table 2**
**Generic Requirements and Objectives Relevant to the Evaluation of Candidate Radio Transmission Technologies**

| IMT-2000 Item Description | Obj/Req | Source | Meets?* |
|---|---|---|---|
| **Radio interfaces and subsystems, network related performance requirements** | | | |
| Support of IP(Internet Protocol)-based services which provide a number of multimedia and data application via the Internet | Obj | ARIB (**)<br>§ 5.1.1.6 | ❒ Yes<br>❒ No |
| Support Location services using position identification information with appropriate accuracy | Obj | M.816 § 8.2.2 | ❒ Yes<br>❒ No |
| Support Priority Access and The Emergency services as are contained in ITU-T Recommendation F.115. | Req | M.1034-1 § 10.16 | ❒ Yes<br>❒ No |

** :ARIB Requirements and Objectives for a 3G Mobile Services and System

* Explanation is requested when the candidate SRTT checks the No box.