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**RADIOCOMMUNICATION
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Working Party 8A**LIAISON STATEMENT TO WORKING PARTY 8F
AND EXTERNAL ORGANIZATIONS****RADIO INTERFACE STANDARDS FOR BROADBAND WIRELESS ACCESS
SYSTEMS, INCLUDING MOBILE AND NOMADIC APPLICATIONS, IN THE
MOBILE SERVICE OPERATING BELOW 6 GHz**

At the March 2006 meeting, WP 8A agreed to merge M.[BWA] and M.[NBWA] and develop a single recommendation on BWA standards that addresses both nomadic and mobile applications. WP 8A took into account all of the input contributions and appreciated the liaisons it received. WP 8A has created a preliminary draft new Recommendation M.[8A/BWA] on Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz ([Annex 17](#) to [Document 8A/376](#)).

In addressing liaison and collaboration with other organizations, ITU-R is aware that a number of organizations dealing with radiocommunications standardization exist. ITU-R is also aware that such organizations have the potential for identifying, defining and proposing solutions of particular problems of interest to the Radiocommunication Study Groups and for assuming responsibility for maintaining standards for such systems.

WP 8A is soliciting information on radio interface standards and characteristics for Broadband Wireless Access systems operating in the mobile service. The specific information being requested for each document is contained below.

Preliminary Draft New Recommendation M.[BWA]

WP 8A is soliciting further information for its September 2006 meeting to allow it to make further progress on the PDNR with the aim of completing its work at that meeting or as soon as possible. Input is being sought on specific points shown below taking into account the Scope of the PDNR:

- 1) Review Annexes 1-5 to ensure their accuracy and completeness.
- 2) Provide input to complete the table in Annex 6.

Preliminary Draft New Report M.[LMS.CHAR.BWA]

In addition, WP 8A has advanced its work on development of the preliminary draft new Report M. [LMS.CHAR.BWA] ([Annex 10](#) to [Document 8A/376](#)). This document is a preliminary draft new Report on characteristics of Broadband Wireless Access systems operating in the mobile service for frequency sharing and interference analyses. Specifically, WP 8A is soliciting comments on the essential operational and technical characteristics to be used in sharing and interference analyses.

Status: For Action

Deadline: 30 August 2006 (deadline for WP 8A meeting)

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Attachments: [Annex 17](#) to [Document 8A/376](#)

[Annex 10](#) to [Document 8A/376](#)

Distribution: ITU-R Working Party 8F & ACIF, ARIB, ATIS, CCSA, ETSI, IEEE, IETF, ISACC, PHS MoU Group, TIA, TTA, TTC, WiMax Forum



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Annex 17 to WP 8A Chairman's Report

PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[8A/BWA]

Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz (Questions ITU-R 212-2/8 and ITU-R 238/8)

1 Introduction

This Recommendation recommends specific standards for broadband wireless access¹ in the mobile service. These specific standards are composed of common specifications developed by standards development organizations (SDOs). Using this Recommendation, manufacturers and operators should be able to determine the best standards for their needs.

These standards support a wide range of applications in urban, suburban and rural areas for both generic broadband internet data and real-time data, including applications such as voice and videoconferencing.

2 Scope

This Recommendation identifies specific radio interface standards for BWA systems in the mobile service operating below 6 GHz. The standards included in this Recommendation are capable of supporting users at broadband data rates, taking into account the ITU-R definitions of “wireless access” and “broadband wireless access” found in Recommendation ITU-R F.1399².

This Recommendation is not intended to deal with the identification of suitable frequency bands for BWA systems, nor with any regulatory issues.

¹ “Wireless access” and “BWA” are defined in Recommendation ITU-R F.1399, which also provides definitions of the terms “fixed”, “mobile” and “nomadic” wireless access.

² *Broadband wireless access* is defined as wireless access in which the connection(s) capabilities are higher than the *primary rate*, which is defined as the transmission bit rate of 1.544 Mbit/s (T1) or 2.048 Mbit/s (E1). *Wireless access* is defined as end-user radio connection(s) to core networks.

3 Related ITU Recommendations

The existing Recommendations that are considered to be of importance in the development of this particular Recommendation are as follows:

Recommendation ITU-R F.1399: Vocabulary of terms for wireless access.

[Draft new] Recommendation ITU-R F.9BL19: Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz (Annex 6 to Doc. 9B/83).

Recommendation ITU-R M.1678: Adaptive antennas for mobile systems

4 Acronyms and abbreviations

AN	Access Network
AT	Access Terminal
ATM	Asynchronous Transfer Mode
BCCH	Broadcast Control Channel
BSR	Base Station Router
BWA	Broadband Wireless Access
CDMA	Code Division Multiple Access
CL	Connection Layer
C-plane	Control Plane
EGPRS	Enhanced General Packet Radio Service
FC	Forward Channel
FCC	Forward Control Channel
FDD	Frequency Division Duplex
FEC	Forward-Error Correction
GERAN	GSM Edge Radio Access Network
GPRS	General Packet Radio Service
GPS	Global Positioning System
HC-SDMA	High Capacity-Spatial Division Multiple Access
HiperMAN	High Performance Metropolitan Area Network
I-CDMA	Internet Code Division Multiple Access
IP	Internet Protocol
LAC	Link Access Control
LAN	Local Area Network
MAC	Medium Access Control
MAN	Metropolitan Area Network
MCSB	Multi-Carrier Synchronous Beamforming
MIMO	Multiple input multiple output
NLOS	Non-Line of Sight

OFDMA	Orthogonal Frequency Division Multiple Access
OSI	Open Systems Interconnection
PDCP	Packet Data Convergence Protocol
PHS	Personal Handyphone Systems
PLP	Physical Layer Protocol
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RLC	Radio Link Control
RLP	Radio Link Protocol
RAC	Reverse Access Channel
RTC	Reverse Traffic Channel
SC	Single Carrier
SDMA	Spatial Division Multiple Access
SL	Security/Session/Stream Layer
SNP	Signalling Network Protocol
SDO	Standards Development Organization
TCC	Traffic Code Channels
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
U-plane	User Plane
WirelessMAN	Wireless Metropolitan Area Network
WWINA	Wireless Wideband Internet Access

[Editor's Note: This list to be updated prior to finalization of document.]

5 Noting

The [draft new] Recommendation ITU-R F.[9B/BWA] recommends radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz.

6 Recommendation

The Radiocommunication Assembly recommends the radio interface standards in Annexes 1-5 for BWA systems in the mobile service operating below 6 GHz.

NOTE – Annex 6 provides a summary of the characteristics of the standards found in the Annexes 1-5.

Annex 1

(to Annex 17 to Doc. 8A/376)

Broadband radio local area networks

RLANs offer an extension to wired LANs utilizing radio as the connective media. They have applications in commercial environments where there may be considerable savings in both cost and time to install a network; in domestic environments where they provide cheap, flexible, connectivity to multiple computers used in the home; and in campus and public environments where the increasing use of portable computers, for both business and personal use, while travelling and due to the increase in flexible working practices, e.g. nomadic workers using laptop personal computers not just in the office and at home, but in hotels, conference centres, airports, trains, planes and automobiles. In summary, they are intended mainly for nomadic wireless access applications, with respect to the access point (i.e. when the user is in a moving vehicle, the access point is also in the vehicle).

Recommendation ITU-R M.1450 recommends standards for broadband radio local area networks, which can be grouped as follows:

- IEEE Project 802.11
- ETSI BRAN HIPERLAN
- Japan MAC HSWA HiSWAN a

IEEE Project 802.11 has developed a set of standards for RLANs, which have been harmonized with IEC/ISO³. The medium access control (MAC) and physical characteristics for wireless local area networks (LANs) are specified in ISO/IEC 8802-11:2005, which is part of a series of standards for local and metropolitan area networks. The medium access control unit in ISO/IEC 8802-11:2005 is designed to support physical layer units as they may be adopted dependent on the availability of spectrum. ISO/IEC 8802-11:2005 contains five physical layer units: four radio units, operating in the 2 400-2 500 MHz band and in the bands comprising 5.15-5.25 GHz, 5.25-5.35 GHz, and 5.725-5.825 GHz, and one baseband infrared (IR) unit. One radio unit employs the frequency-hopping spread spectrum (FHSS) technique, two employ the direct sequence spread spectrum (DSSS) technique, and another employs the orthogonal frequency division multiplexing (OFDM) technique.

ETSI BRAN HIPERLAN

[To be completed.]

Japan MAC HSWA HiSWAN a

[To be completed.]

³ ISO/IEC 8802-11:2005, Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications.

Annex 2

(to Annex 17 to Doc. 8A/376)

IMT-2000 terrestrial radio interfaces

5.1⁴ IMT-2000 CDMA Direct Spread

The UTRAN radio-access scheme is Direct-Sequence CDMA (DS-SS) with information spread over approximately 5 MHz bandwidth using a chip rate of 3.84 Mcps. Advanced modulation (16QAM) and coding techniques (turbo codes) are used to provide high-speed packet access.

A 10 ms radio frame is divided into 15 slots (2 560 chip/slot at the chip rate 3.84 Mcps). A physical channel is therefore defined as a code (or number of codes). For HS-DSCH (High-Speed Downlink Packet Access – HSDPA), E-DCH (High-Speed Packet Uplink Access – HSUPA) and associated signalling channels, 2 ms subframes consisting of 3 slots are defined. This technology achieves a channel transmission rate above 14 Mbit/sec.

The radio interface is defined to carry a wide range of services to efficiently support both circuit-switched services (e.g. PSTN- and ISDN-based networks) as well as packet-switched services (e.g. IP-based networks). A flexible radio protocol has been designed where several different services such as speech, data and multimedia can simultaneously be used by a user and multiplexed on a single carrier. The defined radio-bearer services provide support for both real-time and non-real-time services by employing transparent and/or non-transparent data transport. The quality of service (QoS) can be adjusted in terms such as delay, bit error probability, and frame error ratio (FER).

The radio access network architecture also provides support for multimedia broadcast and multicast services, i.e. allowing for multimedia content distribution to groups of users over a point-to-multipoint bearer.

5.2⁵ IMT-2000 CDMA MC

The cdma2000 radio interface provides two options: nX operation where multiple 1.25 MHz carriers ($n = 1, 3, 6, 9$) are utilized or high-rate packet data 1X-EV-DO where a dedicated 1X RF channel is utilized.

For high-rate packet data (1X-EV-DO) the forward CDMA channel, deployed on a dedicated 1X RF channel, consists of the following time-multiplexed channels: the pilot channel, the forward medium access control (MAC) channel, the control channel and the forward traffic channel. The forward traffic channel carries user data packets. The control channel carries control messages, and it may also carry user traffic. Each channel is further decomposed into code-division-multiplexed quadrature Walsh channels.

⁴ Section number from Recommendation ITU-R M.1457.

⁵ Section number from Recommendation ITU-R M.1457.

The MAC channel consists of two subchannels: the reverse power control (RPC) channel and the reverse activity (RA) channel. The RA channel transmits a reverse link activity bit (RAB) stream. Each MAC channel symbol is BPSK modulated on one of sixty-four 64-ary Walsh codewords.

The forward traffic channel is a packet-based, variable-rate channel. The user data for an access terminal is transmitted at a data rate that varies from 38.4 kbps to 2.4576 Mbps. The forward traffic channel and control channel data are encoded, scrambled and interleaved. The output of the channel interleaver are fed into a QPSK/8-PSK/16QAM modulator. The modulated symbol sequences are repeated and punctured, as necessary. Then, the resulting sequences of modulation symbols are demultiplexed to form 16 pairs (in-phase and quadrature) of parallel streams. Each of the parallel streams are covered with a distinct 16-ary Walsh function at a chip rate to yield Walsh symbols at 76.8 ksps. The Walsh-coded symbols of all the streams are summed together to form a single in-phase stream and a single quadrature stream at a chip rate of 1.2288 Mcps. The resulting chips are time-division multiplexed with the preamble, pilot channel, and MAC channel chips to form the resultant sequence of chips for the quadrature spreading operation.

Forward traffic channel physical layer packets can be transmitted in 1 to 16 slots. When more than one slot is allocated, the transmitted slots use a 4-slot interlacing. That is, the transmitted slots of a packet are separated by three intervening slots, and slots of other packets are transmitted in the slots between those transmit slots. If a positive acknowledgement is received on the reverse link ACK channel that the physical layer packet has been received on the forward traffic channel before all of the allocated slots have been transmitted, the remaining untransmitted slots are not transmitted and the next allocated slot is used for the first slot of the next physical layer packet transmission.

The reverse CDMA channel for 1X-EV-DO, deployed on a dedicated 1X RF channel, consists of the access channel and the reverse traffic channel. The access channel is used by the access terminal to initiate communication with the access network or to respond to an access terminal directed message. The access channel consists of a pilot channel and a data channel. The reverse traffic channel is used by the mobile station to transmit user-specific traffic or signalling information to the access network. The reverse traffic channel comprises a pilot channel, a reverse rate indicator (RRI) channel, a data rate control (DRC) channel, an acknowledgement (ACK) channel, and a data channel. The RRI channel is used to indicate the data rate transmitted on the reverse traffic channel. The RRI channel is time-multiplexed with the pilot channel. The DRC channel is used by the mobile station to indicate to the access network the supportable forward traffic channel data rate and the best serving sector on the forward CDMA channel. The ACK channel is used by the access terminal to inform the access network whether or not the data packet transmitted on the forward traffic channel has been received successfully.

For the enhanced HRPD access, physical layer H-ARQ (Hybrid Automatic Repeat Request), shorter frame sizes, fast scheduling/rate-control, and adaptive modulation and coding are implemented to increase the peak data rate and system throughput of the reverse link.

5.3⁶ IMT-2000 CDMA TDD

The Universal Terrestrial Radio Access (UTRA) time division duplex (TDD) radio interface is defined where two options, called 1.28 Mcps TDD (TD-SCDMA) and 3.84 Mcps TDD can be distinguished.

⁶ Section number from Recommendation ITU-R M.1457.

The UTRA TDD radio interface has been developed with the strong objective of harmonization with the FDD component (see § 5.1) to achieve maximum commonality. This was achieved by harmonization of important parameters of the physical layer and a common set of protocols in the higher layers are specified for both FDD and TDD, where 1.28 Mcps TDD has significant commonality with 3.84 Mcps TDD. UTRA TDD with the two options accommodates the various needs of the different Regions in a flexible way and is specified in a common set of specifications.

The radio access scheme is direct-sequence code division multiple access. There are two chip-rate options: the 3.84 Mcps TDD option, with information spread over approximately 5 MHz bandwidth and a chip rate of 3.84 Mchip/s and the 1.28 Mcps TDD option, with information spread over approximately 1.6 MHz bandwidth and a chip rate of 1.28 Mchip/s. The radio interface is defined to carry a wide range of services to efficiently support both circuit-switched services (e.g. PSTN- and ISDN-based networks) as well as packet-switched services (e.g. IP-based networks). A flexible radio protocol has been designed where several different services such as speech, data and multimedia can simultaneously be used by a user and multiplexed on a single carrier. The defined radio bearer services provide support for both real-time and non-real-time services by employing transparent and/or non-transparent data transport. The QoS can be adjusted in terms such as delay, BER and FER.

The radio-interface specification includes enhanced features for high-speed downlink packet access (HSDPA), allowing for high speed downlink packet-data transmission and simultaneous high-speed packet data and other services such as speech on the single carrier. This technology achieves a channel transmission rate above 14 Mbit/sec.

The radio access network architecture also provides support for multimedia broadcast and multicast services, i.e. allowing for multimedia content distribution to groups of users over a point-to-multipoint bearer.

5.4⁷ IMT-2000 TDMA SC

This radio interface provides two bandwidth options for high-speed data, both using TDMA technology. The 200 kHz carrier bandwidth option (EDGE) utilizes 8PSK modulation with hybrid ARQ and achieves a channel transmission rate in dual-carrier mode of 1.625 Mbit/s while supporting high mobility. A second 1.6 MHz bandwidth is provided for lower mobility environments which utilizes binary and quaternary offset QAM modulation with hybrid ARQ. This 1.6 MHz bandwidth option supports flexible slot allocation and achieves a channel transmission rate of 5.2 Mbit/s.

A rich broadcast or point-to-multipoint service known as multimedia broadcast/multicast service (MBMS) is provided. Point-to-multipoint services exist today which allow data from a single source entity to be transmitted to multiple endpoints. MBMS efficiently provides this capability for such broadcast/multicast services provided by the home environment and other value-added service providers (VASPs).

The MBMS is a unidirectional point-to-multipoint bearer service in which data is transmitted from a single-source entity to multiple recipients. It will also be capable of expanding to support other services with these bearer capabilities.

Multicast mode is interoperable with IETF IP multicast. This will allow the best use of IP service platforms to help maximize the availability of applications and content so that current and future services can be delivered in a more resource-efficient manner.

⁷ Section number from Recommendation ITU-R M.1457.

5.5^s IMT-2000 FDMA/TDMA

The IMT-2000 radio interface for FDMA/TDMA technology is called digital enhanced cordless telecommunications (DECT).

This radio interface specifies a TDMA radio interface with time division duplex (TDD). The channel transmission rates for the specified modulation schemes are 1.152 Mbit/s, 2.304 Mbit/s, 3.456 Mbit/s, 4.608 Mbit/s and 6.912 Mbit/s. The standard supports symmetric and asymmetric connections, connection-oriented and connectionless data transport. Using multicarrier operation with, for example, three carriers, allows bit rates up to 20 Mbit/s. The network layer contains the protocols for call control, supplementary services, connection oriented message service, connectionless message service and mobility management, including the security and confidentiality services.

The radio access frequency channels as well as a time structure are defined. The carrier spacing is 1.728 MHz. To access the medium in time, a regular TDMA structure with a frame length of 10 ms is used. Within this frame 24 full slots are created, each consisting of two half slots. A double slot has a length of two full slots, and starts concurrently with an even numbered full slot.

The modulation method is either Gaussian frequency shift keying (GFSK), with a bandwidth-bit period product of nominally 0.5 or differential phase shift keying (DPSK) or phase amplitude modulation (QAM). Equipment is allowed to use 4-level and/or 8-level and/or 16-level and/or 64-level modulation in addition to 2-level modulation. This increases the bit rate of single radio equipment by a factor 2 or 3 or 4 or 6. The 4-level modulation shall be $\pi/4$ -DQPSK, the 8-level modulation $\pi/8$ -D8PSK, the 16-level modulation 16-QAM and the 64-level modulation 64-QAM

The MAC layer offers three groups of services to the upper layers and to the management entity:

- broadcast message control (BMC);
- connectionless message control (CMC);
- multibearer control (MBC).

The BMC provides a set of continuous point-to-multipoint connectionless services. These are used to carry internal logical channels, and are also offered to the higher layers. These services operate in the direction FT to PT, and are available to all PTs within range.

The CMC provides connectionless point-to-point or point-to-multipoint services to the higher layers. These services may operate in both directions between one specific FT and one or more PTs.

Each instance of MBC provides one of a set of connection-oriented point-to-point services to the higher layers. An MBC service may use more than one bearer to provide a single service.

Four types of MAC bearer are defined:

- Simplex bearer: a simplex bearer is created by allocating one physical channel for transmissions in one direction.
- Duplex bearer: a duplex bearer is created by a pair of simplex bearers, operating in opposite directions on two physical channels.
- Double simplex: a double simplex bearer is created by a pair of long simplex bearers operating in the same direction on two physical channels.
- Double duplex bearer: a double duplex bearer is composed by a pair of duplex bearers referring to the same MAC connection.

⁸ Section number from Recommendation ITU-R M.1457.

A bearer can exist in one of three operational states:

- Dummy bearer: where there are normally continuous transmissions (i.e. one transmission in every frame).
- Traffic bearer: where there are continuous point-to-point transmissions. A traffic bearer is a duplex bearer or a double simplex bearer or a double duplex bearer.
- Connectionless bearer: where there are discontinuous transmissions. A connectionless bearer is either a simplex or a duplex bearer.

The MAC layer defines a logical structure for the physical channels. The user bit rate depends on the selected slot-type, modulation scheme, level of protection and number of slots.

Annex 3

(to Annex 17 to Doc. 8A/376)

IEEE and ETSI radio interface standards, for broadband wireless access (BWA) systems including mobile and nomadic applications in the mobile service

1 Overview of the radio interface

The IEEE 802.16e and ETSI HiperMAN v.1.3.2 standards define harmonized radio interfaces for the OFDM and OFDMA modes and MAC/DLC features, including various hand-off types, however the ETSI BRAN HiperMAN targets only the nomadic applications, while the IEEE 802.16e standard is intended for full vehicular applications.

The use of frequency bands below 6 GHz provides for an access system to be built in accordance with this standardized radio interface to support a range of applications, including enterprise applications, residential applications in urban, suburban and rural areas nomadic and mobile applications. This interface is also optimized for dynamic mobile radio channels and provides support for hand-offs and roaming. The specification could easily support both generic internet-type data and real-time data, including applications such as voice and videoconferencing.

This type of system is referred to as a wireless metropolitan area network (WirelessMAN in IEEE and HiperMAN in ETSI BRAN). The word “metropolitan” refers not to the application but to the scale. The design is primarily oriented toward outdoor applications. The architecture for this type of system is primarily point-to-multipoint, with a base station serving subscribers in a cell that can range up to a few km. Users can access various kinds of terminals, e.g. handheld phones, smart phone, PDA, handheld PC and notebooks in a mobile environment. The radio interface supports a variety of channel widths and operating frequencies, such as 1.25, 3.5, 7, 8.75, 14, 17.5, 28 MHz and operating frequencies below 6 MHz. The use of orthogonal frequency division multiplexing access (OFDMA) offers flexibility when managing different user devices with a variety of antenna types and form factors. It brings a reduction in interference for user devices with omnidirectional antennas and improved NLOS capabilities that are essential when supporting mobile subscribers. Sub-channelization defines sub-channels that can be allocated to different subscribers depending on the channel conditions and their data requirements. This gives the operator more flexibility in managing the bandwidth and transmit power, and leads to a more efficient use of resources, including spectrum resources.

The radio interface supports a variety of channel widths and operating frequencies, providing a peak spectral efficiency of up to 4 bits/s/Hz.

The radio interface includes a physical layer (PHY) as well as a medium-access control layer (MAC). The MAC is based on demand-assigned multiple access in which transmissions are scheduled according to priority and availability. This design is driven by the need to support carrier-class access to public networks, both internet protocol (IP) and asynchronous transfer mode (ATM), with full quality-of-service (QoS) support.

The MAC supports several PHY specifications, depending on the frequency bands of interest and the operational requirements. In particular, the alternatives include, typically, below 6 GHz.

WirelessMAN-OFDM and HiperMAN, the OFDM PHY mode: this specification is based on orthogonal frequency-division multiplexing (OFDM).

- ii) WirelessMAN-OFDMA and HiperMAN, the OFDMA PHY mode: this specification is based on orthogonal frequency-division multiple access (OFDMA).
- iii) WirelessMAN-Sca: this specification uses single-carrier transmission.

All of the PHYs use the same MAC, harmonized between IEEE 802.16 and ETSI HiperMAN (named DLC in HiperMAN).

The SDOs define profiles for the recommended interoperability parameters⁹. IEEE 802.16 profiles are included in the main standards document, while HiperMAN profiles are included in a separate document.

2 Detailed specification of the radio interface

IEEE 802.16e

IEEE Standard for local and metropolitan area networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands.

IEEE 802.16TM is an emerging suite of standards for broadband wireless access (BWA). IEEE Std 802.16e-2005, an amendment to the IEEE Std 802.16-2004 base specification, enables combined fixed and mobile operation in licensed frequency bands under 6 GHz. This combination of IEEE Std 802.16-2004 and the IEEE Std 802.16e-2005 amendment is designed as a high-throughput packet data network radio capable of supporting several classes of IP applications and services based on different usage/mobility and business models. To allow such a diverse combination of usage, mobility, and deployment models, the IEEE Std 802.16-2004 and IEEE Std 802.16e-2005 air interface is designed with a high degree of flexibility and an extensive number of options.

Abstract: This amendment IEEE Std 802.16e-2005 updates and expands IEEE 802.16-2004 to allow for mobile stations.

Scope: This document provides enhancements to IEEE 802.16-2004 to support stations moving at vehicular speeds and thereby specifies a system for combined fixed and mobile broadband wireless access. Functions to support higher layer handover between base stations or sectors are specified. Operation is limited to licensed bands suitable for mobility below 6 GHz. The fixed subscriber capabilities given in IEEE Std 802.16-2004 are not compromised.

[Editor's Note: A copy of the current draft has been provided to the BR (SG 8 counsellor) so that it can be made available to members for review purposes as needed. The document will be attached electronically to the document to be submitted to SG 8 for adoption.]

ETSI standards

The specifications contained in this section include the following standards for BWA, the last available versions being:

- ETSI TS 102 177 v1.3.2: Broadband Radio Access Networks (BRAN); HiperMAN; Physical (PHY) Layer.
- ETSI TS 102 178 v1.3.2: Broadband Radio Access Networks (BRAN); HiperMAN; Data Link Control (DLC) Layer.

⁹ [WiMAX and WiBro are profiles defined for the recommended interoperability parameters. The WiBro standard (TTAS.KO-06.0082/R1,2005) was developed by TTA and it uses WirelessMAN TDD/OFDMA which is one of the IEEE 802.16 alternatives.]

- ETSI TS 102 210 v1.2.1: Broadband Radio Access Networks (BRAN); HiperMAN; System Profiles.

Abstract: The HiperMAN standards addresses interoperability for BWA systems below 11 GHz frequencies, to provide high cell sizes in non-line of sight (NLoS) operation. The standard provides for FDD and TDD support, high spectral efficiency and data rates, adaptive modulation, high cell radius, support for advanced antenna systems, high security encryption algorithms. Its existing profiles are targeting the 1.75 MHz, 3.5 MHz and 7 MHz channel spacing, suitable for the 3.5 GHz band.

The main characteristics of HIPERMAN standards, v. 1.3.2, which is fully harmonized with IEEE 802.16-2004 and the IEEE 802.16e-2005 amendment, with the exception of the single-carrier PHY mode, include:

- all the PHY improvements related to OFDM and OFDMA modes, including MIMO for the OFDMA mode;
- flexible channelization, including the 3.5 MHz, the 7 MHz and 10 MHz raster (up to 28 MHz);
- scalable OFDMA, including FFT sizes of 512, 1 024 and 2 048 points, to be used in function of the channel width, such that the subcarrier spacing remains constant;
- uplink and downlink OFDMA (sub-channelization) for both OFDM and OFDMA modes;
- adaptive antenna support for both OFDM and OFDMA modes;
- MIMO support for OFDMA mode.

Standards: All the ETSI standards are available in electronic form at:

<http://pda.etsi.org/pda/queryform.asp>, by specifying in the search box the standard number.

Annex 4

(to Annex 17 to Doc. 8A/376)

ATIS WTSC radio interface standards for broadband wireless access (BWA) systems in the mobile service

ATIS WTSC wireless wideband internet access (WWINA) and other standards

The Wireless Technologies and Systems Committee (WTSC, formerly T1P1) of the Alliance of Telecommunications Industry Solutions (ATIS), an ANSI-accredited standards development organization, has developed three American National Standards (ANS) that adhere to its adopted requirements for wireless wideband internet access (WWINA) systems as well as other standards applicable to nomadic wireless access. The WWINA air interface standards enable wireless portability and nomadic roaming subscriber services that complement the DSL and cable modem markets. These systems are optimized for high-speed packet data services that operate on a separate, data-optimized channel. The WWINA requirements specify a non-line-of-sight wireless internet air interface for full screen, full performance multimedia devices.

These air interfaces provide for portable access terminal (AT) devices with improved performance when compared to other systems that are targeted for high-mobility user devices. More specifically, the WWINA air interfaces optimize the following performance attributes:

- system data speeds;
- system coverage/range;
- network capacity;
- minimum network complexity;
- grade-of-service and quality-of-service management.

I T1.723-2002 I-CDMA spread spectrum systems air interface standard

1 Overview of the radio interface

The I-CDMA (Internet Code Division Multiple Access) standard uses CDMA technology operating at a chip rate of 1.2288 Mcps and using a frequency assignment of 1.23 MHz similar to commercial CDMA cellular systems. QPSK/BPSK modulation along with turbo product code (TPC) and BCH forward-error correction and ARQ protocol ensure robust data delivery. Channel rasters of 12.5 kHz, 25 kHz, 30 kHz or 50 kHz are used to derive the centre channel transmit and receive frequencies to provide compatibility with current cellular FDD frequency assignments.

2 Detailed specifications of the radio interface

The I-CDMA radio interface consists of three layers which follow the OSI model. These layers are the physical layer, the link layer comprising LAC and MAC, and the network layer.

The physical layer sends and receives packet data segments from the link layer. It provides forward-error correction (FEC) coding, interleaving, orthogonalization and spreading to allow code division multiple access, and modulation.

The link layer contains two sublayers: media access control (MAC) and link access control (LAC). The MAC layer is responsible managing the physical layer resources for data services. The LAC layer is responsible for initiation of a link layer connection between the AT and the BSR (Base Station Router). The link layer is responsible for segmentation and reassembly, data services, and ARQ error recovery.

The network layer receives user payload in the form of IP packets and processes those packets to and from the link layer. The network layer communicates to its peer entity over the I-CDMA radio interface to provide the setup and control of the network layer functions. It provides AT configuration and management, connection maintenance, device authentication, user authentication support. The network layer also provides QoS support, session services and mobility support via mobile IP.

II ATIS-0700001.2004 MCSB physical, MAC/LLC, and network layer specification

1 Overview of the radio interface

The MCSB (Multi-Carrier Synchronous Beamforming) standard uses a combination of CDMA technology and smart antennas to achieve a point-to-multipoint system with enhanced transmission quality in order to achieve broadband data rates in non-line-of-sight (NLOS) environments.

2 Detailed specifications of the radio interface

The MCSB radio interface consists of three layers which follow the OSI model. These layers are the physical layer, the data link layer comprising LLC and MAC, and the network layer:

TABLE 2

Radio interface layer function

Layer	Function
Network layer (L3)	Packet classification/prioritization, bridging, OA&M
Data link (L2)	LLC: Segmentation/reassembly, resource management, selective retransmission error recovery
	MAC: Segmentation/reassembly, resource management, forward-error correction
Physical (L1)	Channelization, CDMA spreading, modulation, power control, synchronization

As shown in Table 2 above, the physical layer defines modulation, multiplexing, time division duplex (TDD) framing, power control, and timing synchronization. It treats both circuit-switched and packet-switched data in the same way.

The data link layer contains two sublayers: media access control (MAC) and logic link control (LLC). The MAC layer is responsible for channel assignment, reassignment, release, and processing of data packets. The LLC layer processes both circuit-switched and packet-switched data. The LLC for circuit-switching packs and unpacks the control signal packets, processes them, and sets up the voice connection with an appropriate vocoder channel. The LLC for packet-switching implements the data framing and the selective retransmission error recovery protocol.

The network layer performs packet classification/prioritization, ethernet bridging, and operation, administration and maintenance (OA&M) messaging, and is the interface to the core network.

The radio interface utilizes subcarriers of 500 kHz for the traffic/access/broadcast channels, while the sync channel utilizes subcarriers of 1 MHz. Therefore using a 5 MHz bandwidth, 10 subcarriers can be accommodated for the traffic/access/broadcast channels or 5 subcarriers for the sync channels. Each subcarrier has the capability of accommodating up to 32 traffic code channels (TCC).

Reed-Solomon forward-error correction coding is used and the data stream is modulated using QPSK, 8PSK, 16QAM, or 64QAM. The data in each TCC are combined and then combined with other code channels for summation.

The reverse traffic channel can utilize a maximum of 2 or 4 contiguous subcarriers.

A frame period of 10 ms is used with a total number of symbols of 125 contained in the frame (including uplink and downlink). The forward traffic can occupy $55 + n * 7$ symbols while the resulting reverse traffic occupies $55 - n * 7$ symbols where n can range from 0 (symmetric) to 7.

III ATIS-700004.2005 high capacity-spatial division multiple access (HC-SDMA)

1 Overview of the radio interface

The HC-SDMA standard specifies the radio interface for a wide-area mobile broadband system. HC-SDMA uses time division duplex (TDD) and adaptive antenna (AA) technologies, along with multi-antenna spatial processing algorithms to produce a spectrally efficient mobile communications system that can provide a mobile broadband service deployed in as little as a single (unpaired) 5 MHz band of spectrum licensed for mobile services. HC-SDMA systems are designed to operate in licensed spectrum below 3 GHz, which is the best suited for mobile applications offering full mobility and wide area coverage. Because it is based on TDD technology and does not require symmetrical paired bands separated by an appropriate band gap or duplexer spacing, systems based on the HC-SDMA standard can easily be re-banded for operation in different frequency bands. The HC-SDMA technology achieves a channel transmission rate of 20 Mbps in a 5 MHz licensed band. With its frequency reuse factor of $N = 1/2$, in a deployment using 10 MHz of licensed spectrum the 40 Mbps transmission rate is fully available in every cell in an HC-SDMA network, which is a spectral efficiency of 4 b/s/Hz/cell.

2 Detailed specifications of the radio interface

The HC-SDMA air interface has a TDD/TDMA structure whose physical and logical characteristics have been chosen for the efficient transport of end-user IP data and to extract maximum benefit from adaptive antenna processing. The physical aspects of the protocol are arranged to provide spatial training data, and correlated uplink and downlink interference environments, for logical channels amenable to directive transmission and reception such as traffic channels. Conversely, channels not amenable to directive processing, such as paging and broadcast channels have smaller payloads and receive a greater degree of error protection to balance their links with those of the directionally processed channels. Adaptive modulation and channel coding, along with uplink and downlink power control, are incorporated to provide reliable transmission across a wide range of link conditions. Modulation, coding and power control are complemented by a fast ARQ to provide a reliable link. Fast, low-overhead make-before-break inter-cell handover is also supported. Authentication, authorization, and privacy for the radio access link is provided by mutual authentication of the terminals and access network, and by encryption.

The HC-SDMA air interface has three layers designated as L1, L2, and L3.

Table 3 describes the air interface functionality embodied in each layer. Each layer's features are briefly described below; more detailed overviews of key aspects are described in subsequent sections of this document.

TABLE 3
Air interface layers

Layer	Defined properties
L1	Frame and burst structures, modulation and channel coding, timing advance
L2	Reliable transmission, logical to physical channel mapping, bulk encryption
L3	Session management, resource management, mobility management, fragmentation, power control, link adaptation, authentication

Table 4 summarizes the key elements of the HC-SDMA air interface.

TABLE 4
Summary of the basic elements of the HC-SDMA air interface

Quantity	Value
Duplex method	TDD
Multiple access method	FDMA/TDMA/SDMA
Access scheme	Collision sense/avoidance, centrally scheduled
Carrier spacing	625 kHz
Frame period	5 ms
User data rate asymmetry	3:1 down:up asymmetry at peak rates
Uplink time slots	3
Downlink time slots	3
Range	> 15 km
Symbol rate	500 kbaud/sec
Pulse shaping	Root raised cosine
Excess channel bandwidth	25%
Modulation and coding	<ul style="list-style-type: none"> – Independent frame-by-frame selection of uplink and downlink constellation + coding. – 8 uplink constellation + coding classes – 9 downlink constellation + coding classes – Constant modulus and rectangular constellations
Power control	Frame-by-frame uplink and downlink open and closed loop
Fast ARQ	Yes
Carrier and time slot aggregation	Yes
QoS	DiffServ policy specification, supporting rate limiting, priority, partitioning, etc.
Security	Mutual AT and BSR authentication, encryption for privacy
Handover	AT directed, make-before-break
Resource allocation	Dynamic, bandwidth on demand

IV T1.716/7-2000(R2004) air interface standard for broadband direct sequence CDMA for fixed wireless PSTN access – Layer 1/Layer 2

1 Overview of the radio interface

This radio interface uses direct sequence CDMA with chip rates defined from 4.16 Mcps to 16.64 Mcps resulting in RF bandwidths from 5 MHz to 20 MHz. FDD operation is defined with minimum uplink and downlink band separations of 40 to 60 MHz depending upon chip rate.

2 Detailed specifications of the radio interface

The broadband direct sequence CDMA radio interface consists of two layers; Layer 1 (L1) and Layer 2 (L2 – partitioned into MAC and DLC sublayers) which differ from the classical OSI model as shown in Table 5:

- DLC is limited to data link control of the dedicated control channels. Dedicated traffic channels are not managed by the DLC.
- MAC – not the physical layer (PHY) – performs encoding/decoding for forward-error correction (FEC), encipherment/decipherment, symbol repetition/combining, and power control for quality of service (QoS).

TABLE 5
Air interface layers

Layer	Function
Layer 2 (L2)	DLC: Data link control of dedicated control channels
	MAC: Encoding/decoding, symbol repetition/combining, power control, encryption/decryption
Layer 1 (L1)	Channelization, CDMA spreading, modulation/demodulation, synchronization, RF combining/splitting

Layer 1 provides physical channels (bearers) of 128 Kbps. Multiple 128 Kbps bearers can be aggregated to provide higher data rate services to an individual user. Layer 1 multiplexes multiple physical channels into the same RF spectrum by the use of direct-sequence spread spectrum with a distinct spreading sequence for each channel.

The data sequence for each physical channel modulates the spreading sequence, and the resulting sequence modulates the RF carrier. The chip rate of the spreading sequence determines the transmit bandwidth.

Pilot symbols are generated by Layer 1 as necessary and transmitted with the modulated data signals.

The DLC sublayer of Layer 2 provides control plane services. The DLC sublayer provides error control through a balanced link access protocol, designated LAPC_c, based upon LAPC which in turn is based on LAPD (ITU-T Q.920 and Q.931). The control plane services provides a point-to-point service that operates in acknowledged mode. The point-to-point service includes the addressing, error control, flow control, and frame sequencing, multiplexing/demultiplexing of network layer information fields, and partitioning of DLC frames.

Annex 5

(to Annex 17 to Doc. 8A/376)

“Next-generation PHS” for broadband wireless access (BWA) systems in the mobile service

1 Overview of “next-generation PHS”

Requirement factors for “next-generation PHS”

Considering requirements of new BWA systems in the mobile service, the following factors are needed in “next-generation PHS”.

- Enabling continuous connectivity at IP level

Considering the convenience of continuous connection provided on the cable modem circumstance, etc., the continuous connectivity at IP level that enables users to start high-speed transmission in a moment is essential.

- High transmission data rate over 3G systems

Transmission data rate over 20 Mbps ~ 30 Mbps that exceeds the highest data rate of 3G/3.5G is indispensable.

It is also important to keep throughput of some extent for practical use even in case that serious concentration of traffic occurs.

- High transmission data rate for uplink

Considering future demand of bidirectional broadband communication such as a videoconference, an uplink transmission data rate over 10 Mbps is considered to become still more important in near future.

- High efficiency in spectral utilization

When serious traffic congestion occurs concentrically at a business district or downtown area, some problems by shortage of frequency would hamper enough services. In order to avoid such situations, the highly efficient spectral utilization is necessary.

Taking the above factors into account, “next-generation PHS” is designed.

Features of “next-generation PHS”

“Next-generation PHS” adopts OFDMA-TDD, MIMO and, as one of the most impressive features, its service coverage areas consist of many microcells whose radii are much shorter than the typical mobile phone cells.

In addition, it has the ability of highly efficient spectral utilization by adopting the technologies described below.

- Adaptive array antenna technology and space division multiple access technology enable the frequency reuse factor more than 4.
- Autonomous decentralized control technology contributes to make cell designing plans unnecessary, and as the result, the cell radius down to less than 100 m is realized.

Because many cells can basically overlap each other in “next-generation PHS”, a handset can access multiple cell stations around it at the same time. Therefore, this system is able to provide all users

with continuous stable throughput by way of spreading traffic volume that might occur intensively and temporarily.

Since “next-generation PHS” adopts the autonomous decentralized control method, which enables several operators to share the same frequency band, more efficient spectral utilization would be realized.

“Next-generation PHS” is the superior system for the highly efficient spectral utilization and can realize huge transmission capacity at limited frequency bands.

2 Specification of the radio interface

The detailed specification of “next-generation PHS” is now continuously being developed to standardize by PHS MoU Group, which is an international standardization organization for PHS.

[Editor’s Note: The detail specification will be introduced at the next meeting.]

Summary of the basic elements of “next-generation PHS”.

Access	OFDMA+TDMA/TDD
Bandwidth	5 MHz ~ 20 MHz
Maximum data rate	over 20 Mbps (for uplink/downlink)
Framing	5 ms/symmetric
Modulation	BPSK ~ 256QAM
Cell size	Microcell
Channel assign	Autonomous decentralized control
Technologies of efficient spectral utilization	Adaptive array antenna, SDMA, MIMO

Annex 6

(to Annex 17 to Doc. 8A/376)

Table 1 provides a reference of key technical parameters of each of the systems.

TABLE 1
Key technical parameters

System	Nominal RF channel bandwidth	Modulation/coding rate ¹⁰ – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/mobile)
Example	<ul style="list-style-type: none"> – 2 × 1.25 MHz – 2 × 5 MHz – 2 × 10 MHz 	Up: – QPSK – 16QAM 3/4 Down: – QPSK – 64QAM 3/4	Convolutional Convolutional turbo	Up: 10 Mbit/s in 5 MHz Down: 20 Mbit/s in 5 MHz	No	Yes	FDD	FDMA	Variable: 5 ms to 15 ms	Mobile
IEEE 802.16e-2005 WirelessMAN/ ETSI HiperMAN										
T1.723-2002 I-CDMA spread spectrum systems air interface standard										

¹⁰ Including all applicable modes, or at least the maximum and the minimum.

System	Nominal RF channel bandwidth	Modulation/coding rate – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/mobile)
IMT-2000 CDMA Multi-Carrier										
IMT-2000 CDMA TDD										
IMT-2000 TDMA Single-Carrier										
IMT-2000 FDMA/TDMA										



Source: Document 8A/TEMP/171

Annex 10 to WP 8A Chairman's Report

PRELIMINARY DRAFT NEW REPORT ITU-R M.[LMS.CHAR-BWA]

Characteristics of broadband wireless access systems operating in the mobile service for frequency sharing and interference analyses

1 Introduction

This Report provides the baseline characteristics of terrestrial broadband wireless access (BWA)¹¹ systems operating in the mobile service for use in frequency sharing and interference analysis studies between these terrestrial BWA systems and other fixed or mobile systems.

2 Characteristics

Table 1 contains the typical technical and operational characteristics of mobile BWA systems to be used for interference and sharing studies for both mobile stations and base stations.

3 IMT Radio interfaces¹²

In addition to the characteristics found in Table 1, sharing characteristics of IMT-2000 systems can be found in Report ITU-R M.2039, "Characteristics of terrestrial IMT-2000 systems for frequency sharing/interference analyses", and are not duplicated herein. The terrestrial IMT-2000 systems¹³ meeting the definition of BWA found in Recommendation ITU-R F.1399 should also be considered in interference and sharing analysis involving BWA systems¹⁴.

IMT-Advanced systems will also meet the criteria to be considered BWA, and as those systems are developed their characteristics should also be considered for interference and sharing studies with BWA systems. They may be incorporated into future revisions of this Report directly or by reference.

¹¹ "Wireless access" and "BWA" are defined in Recommendation ITU-R F.1399.

¹² IMT, IMT-2000 and IMT-Advanced are defined in the "draft new Resolution ITU-R M. [IMT.NAME]" Naming for International Mobile Telecommunications.

¹³ See Recommendation ITU-R M.1457.

¹⁴ Recommendation ITU-R M.[LMS.CHAR.CELL] may provide additional characteristics for some IMT-2000 systems applicable to BWA.

TABLE 1

Parameter	IEEE 802.16e ¹⁵		HC-SDMA ¹⁶	
	BS	MS	BS	MS
System-wide				
Nominal channel BW (MHz)	5 {1a}		0.625 {1b}	
Carrier frequency	< 6 GHz		< 4 GHz	
Emission type	Digital		Digital	
Deployment type	Cellular		Cellular	
Modulation type	BPSK, QPSK, 16-QAM, 64-QAM	BPSK, QPSK, 16-QAM, 64-QAM	BPSK, QPSK, 8-PSK, 12-QAM, 16-QAM, 24-QAM	BPSK, QPSK, 8-PSK, 12QAM, 16-QAM
Duplex method	TDD		TDD	
Access technique	TDMA/OFDMA		TDMA/FDMA/SDMA	
No. of sectors	3 (2a)	n/a	3(2b)	n/a
Reuse factor	1:1, 1:3		1:1(3a)	
Antennas per sector			12 (3b)	1
Co-located antenna minimum coupling loss (dB) {3}	30	n/a	30	n/a
TX				
Average power (dBm)	36 {4a}	20 {4a}	24.2 {4b}	20
TDD activity factor (dB) {5}	3		-1.76(5a)	-4.77(5b)
Antenna gain (dBi)	18 {6}	0 to 6 {6}	15	0
Antenna height AGL (m)	15 to 30 {7}	≤ 1.5	15 to 45	≤ 1.5
Loss of gain due to downtilt (dB)	0	n/a	0	n/a
Misc. losses (dB)	2 {8a}	0	1 {8b}	0
Adjacent channel leakage ratio, ACLR (dB)	{9a}		{9b}	
ACLR 1 (dB)	53.5	33	53.5 {9c}	45
ACLR 2 (dB)	66	51	66 {9c}	50
RX				
Antenna gain (dBi)	18 {6}	0 to 6 {6}	18	from 0 to 6
Antenna height AGL (m)	15 to 30 {7}	≤ 1.5	15 to 45	≤ 1.5
Misc. losses (dB)	0 {8a}	0	1 {8b}	0
Loss of gain due to downtilt (dB)	0	n/a	0	n/a
Noise Figure (dB)	3 {10}	5 {10}	5	7
Thermal noise density (dBm/Hz)	-174		-174	
Adjacent channel selectivity, ACS (dB)	{11}			
ACS 1 (dB)	70	40	46	47
ACS 2 (dB)	70	59	46	60
Interference criterion, <i>I/N</i> (dB) {12a}	-6 or -10	-6 or -10		
Required SINR (dB) {12b}			1-17	0-14
Max. tolerable interference power (dBm) {13}	-110 or -114	-108 or -112		
Active interference selectivity (dB)			20-30 {14}	n/a

¹⁵ IEEE 802.16e, an amendment to IEEE 802.16-2004, forms the basis of WiMAX™ for mobile applications.

¹⁶ ANSI ATIS 0700004-2005, High Capacity – Spatial division multiple access (HC-SDMA) is commercially known as the iBurst™ system.

NOTES:

- 1a) While other nominal channel bandwidths are allowed in the standard, 5 MHz is chosen as a typical configuration for the frequency band of interest.
- 1b) The HC-SDMA standard uses a 625 kHz carrier bandwidth. For a 5 MHz channel bandwidth, deployment of multiple 625 kHz carriers is assumed.
- 2a) No. of sectors ranges from 1 (omnidirectional) to higher numbers such as 6. For the sake of sharing studies three-sectored sites are being considered.
- 2b) No. of sectors ranges from 1 (omnidirectional) to higher numbers such as 3. Three-sectored sites should be considered in sharing studies.
- 3) For co-located base stations, this parameter captures the minimum coupling loss between two systems. Note: Higher values are achievable. For example, Report ITU-R M.2045 suggests that Coupling Loss of up to 70 dB is achievable with a few meters of antenna separation.
- 3a) System can support reuse of less than 1 through Spatial Division Multiple Access wherein up to 4 users can simultaneously share the same carrier/time slot combination. Reuse 1 is considered in the sharing study.
- 3b) The HC-SDMA system utilizes a multi-antenna architecture with multiple antennas per sector.
- 4a) TX power reported is typical and higher values may be available based on region. TX power is the RF power averaged during the transmit burst, without considering traffic statistics or lowered-power operation or UL/DL ratio.
- 4b) Average power per antenna per carrier. Equivalent Isotropic Radiated Power for victim systems should be computed statistically based on the Average Power per Antenna and array geometry.
- 5) A function of UL/DL ratio of the TDD mode, this parameter is not applicable to FDD operation.
- 5a) BS transmit duty cycle expressed in dB.
- 5b) MS transmit duty cycle expressed in dB.
- 6) Base station antenna gains are typical of wide area terrestrial cellular deployments and very much consistent with ETSI BRAN document BRAN40d048r2, "Liaison Letter to ITU-R". Mobile Subscriber Station antenna gain ranges from 0 dBi, for PDA and other handheld terminals, to 6 dBi, for laptops.
- 7) Previous ITU-R studies on sharing of IMT-2000 systems (ITU-R M.2030, and ITU-R M.2045) use 30 meters as base station antenna heights. Assuming the same height of 30 meters for 802.16 systems would create the worst case situation for coexistence with IMT-2000 by creating the possibility of main-beam coupling of interfering systems. It should be, however, noted that base station height of 15 meters is considered a more typical number for 802.16 systems.
- 8a) Miscellaneous losses account for cable/connector losses in the TX path. In the RX path, these losses are assumed to be avoided by using tower-top LNA.
- 8b) Miscellaneous losses account for cable/connector losses in the TX and RX path.
- 9a) Defined as the ratio of the on-channel transmitted power to the power transmitted into a notional rectangular filter of 4.5 MHz bandwidth centred on the adjacent channel, ACLR represents out-of-band emission of the transmitter. $ACLR_n$ in the table are ACLR values at n 5-MHz channels away. The values suggested in the table do not include any mitigatory factors such as the ones included in the Report ITU-R M.2045 which reports that better values are achievable using cost-effective power amplifier linearization techniques. It should be noted that for compliance with FCC mask imposed for situations where interference is a problem and/or distance between the stations is less than 1.5 km, ACLR values suggested in Report ITU-R M.2045 would be required.
- 9b) Defined as the ratio of the on-channel transmitted power to the power transmitted in adjacent channels, ACLR represents out-of-band emission of the transmitter. $ACLR_n$ in the table are ACLR values at n 5-MHz away. Values are quoted as dBc per 625 kHz.

- 9c) ACLR values dependent on filter roll off and number of carriers.
 - 10) Suggested values are based on general industry-accepted numbers.
 - 11) Suggested ACS numbers are based on expected performance in the industry achievable with reasonable cost.
 - 12a) The I/N of -10 dB, corresponding to about half a dB impact on the receiver sensitivity, is a stringent criterion which is recommended in certain cases including in some ITU-R Recommendations. The number of -6 dB, corresponding to 1 dB impact on the receiver sensitivity, however, is also recommended in Recommendation ITU-R F.758-3.
 - 12b) Required SINR (dB) measured after array processing/equalization dependent on modulation class.
 - 13) Numbers are based on I/N of -6 dB or -10 dB respectively (see row above).
 - 14) Multi-antenna SDMA systems can achieve 20-30 dB active interference rejection of signals from interfering system.
-