Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**802.16 response to ITU-R WP 8F Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000**	
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Re:	In response to 802.16 call for input in the Chair's email on November 8, 2004.	
Abstract	To facilitate the development of the Service/Market Analysis Report in preparation of WRC-07, ITU-R WP 8F has issued a Questionnaire containing survey questions to gather information on the analysis and forecast of services and market aspects from a range of organizations including organizations outside the ITU. This is a proposal in respond to Question 4 of the above-mentioned Questionnaire on service and market forecast for other radio systems that might interwork with IMT-2000 and systems beyond IMT-2000.	
Purpose	Approve and submit to ITU-R WP 8F	
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802.16 Response to ITU-R WP 8F Questionnaire on the Services and Market for the Future Development of IMT-2000 and Systems Beyond IMT-2000

Reza Arefi *Margaret LaBrecque*

Introduction

In preparation for WRC-07, ITU-R Working Party 8F (WP 8F) is planning to deliver a Service/Market Analysis Report to on the matters such as mobile market and expected services, methodology to estimate spectrum requirements, and candidate frequency bands to address these requirements, with the goal of developing Recommendations on calculating spectrum requirements and estimates for the future developments of IMT-2000 and systems beyond IMT-2000. To facilitate the development of the Service/Market Analysis Report, WP 8F has issued a Questionnaire containing survey questions to gather information on the analysis and forecast of services and market aspects from a range of organizations including organizations outside the ITU.

The Questionnaire serves the purpose of determining and justifying the need for additional spectrum for IMT-2000 and its evolution. The more subscriber traffic flows through the networks, the more spectral resources are required to provide for the demand. Subscriber traffic generally consists of IMT-2000 traffic as well as other traffic from data-oriented applications such as WLAN in hotspots and elsewhere. There is, therefore, included in the Questionnaire a question[1] on "other radio systems" that IMT-2000 systems and beyond are envisaged to interwork with. We believe WiMAX/802.16 systems are an integral part of future broadband wireless services delivered to laptops and other user devices and will contribute to the overall demand for data services. Providing data to WP 8F on WiMAX/802.16 would lead to a more realistic spectrum estimation that would benefit administrations, spectrum license holders, and equipment manufacturers with vested interest in spectrum for broadband wireless access throughout the world.

Service and market forecast for WiMAX/802.16 systems

Authors' proposed response to Question 4 of the above-mentioned Questionnaire is included in an appendix to this contribution. The appendix contains the full text of the Questionnaire with answer to question 4 as marked up text (track changes "on").

It should be stated that service descriptions and market forecast contained in the appendix is based on industry market research data for 802.16 fixed/nomadic systems in the years to come and does not include forecast for the mobile extension of 802.16.

[1] Question 4

Appendix

Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000

Q1. Services and market survey for existing mobile services

Regarding the 2G and 3G mobile communication services and market, including mobile satellite and wireless LAN services, please list information on the following parameters as they existed at the end of 2003.

- Number of subscribers
- Traffic volume
- Expected time frame for transition from 2G to 3G
- Regional and geographical characteristics
- System type
- Area covered
- Commencement of operation
- Economics of network deployment.

Q2. Key market parameters

The market size of the future development of IMT-2000 and systems beyond IMT-2000 can be estimated from parameters such as density of potential users, call/session duration, service bandwidth and so forth. It is also necessary for the market size estimation to take account of key issues such as services usage and usage environments. Please list the key parameters and issues you consider necessary for the market size estimation, and comment on the impact of each parameter and issue on the market.

For example, the market study could provide the following parameters:

- the number of mobile voice service subscribers;
- the traffic volume for data service from mobile subscribers density of potential users in urban area during a specific time of day;
- density of potential users in a rural/remote area for specific time of day;
- average call duration of voice service during a specific time of day;
- session activation rate of web browsing service by heavy users;
- services and related Quality of Service parameters; guaranteed/best-effort, real time/non-real time, fixed/variable bit rate;
- usage environments; high/low mobility, indoor/outdoor, business/private, urban/non-urban.

For these parameters the following reporting units could be used:

- The number of service requests per unit time and area, i.e. session arrivals/s/m^2. The service request density is assumed to be identical in uplink and downlink direction. The value of this parameter could be provided for appropriate time intervals during the day, and separately for working days and non-working days, in order to account for non-simultaneously occurrence of the peak offered traffic of different service types.
- Percentage of users in a set of mobility classes (stationary, pedestrian and vehicular)
- Maximum required mobility support (km/h)
- Mean service duration (s or amount of data)
- Required minimum, average and maximum bit rate measured at the application layer (bit/s), for uplink and downlink
- Required end-to-end delay (s).

Q3. Service and Market forecast for future development of IMT-2000 and systems beyond IMT-2000

Regarding services and markets of the future development of IMT-2000 and systems beyond IMT-2000, please provide forecasts on the future status of the parameters listed in Q2. Future trends of the parameters should be described in this question. When answering this question, please qualify the forecast. The evolution of service capabilities should also be described.

Q.3.1 Service issues

Please describe the applications envisaged for the future development of IMT-2000 and systems beyond IMT-2000, which may be pervasive from 2010 to 2020. Examples of potential future applications are shown in Annex 1.

Q.3.2 Market issues

Please describe the trends and scale of the market related to mobile communication from 2010 to 2020. Regarding the market scale, quantitative information is desirable. Please state how this information was obtained (e.g., methods and parameter values). An example of a method that can be used for market evolution forecast is given in Annex 3.

Q.3.3 Preliminary traffic forecast

Please provide information related to service traffic to be provided by the future development of IMT-2000 and systems beyond IMT-2000 from the year2010 to 2020(e.g. 2010, 2015 and 2020). The volume of traffic may be derived from information such as the number of service subscribers, service activation rate, service duration, transferred data size taking into account affordable expenses of the subscribers for this service. It may also be derived from information such as uplink and downlink speed, traffic class, service environment and economics of network deployment.

Examples of parameters that may be used to characterize the volume of traffic of these applications are shown in Annex 2. It is preferable that the information related to traffic volume be provided for each service listed in the answer to Q.3.1.

Q.3.4 Related information

Please provide any related information such as:

– impact of the number of operators;

– peak hour / peak ratio of traffic volume;

– expected affordable expenses in average per subscriber for the services; and

– economics of network deployment.

Q4. Service and market forecast for other radio systems

The future development of IMT-2000 and systems beyond IMT-2000 are envisaged to interwork with other radio systems such as wireless LAN and broadcasting systems. Please list any radio systems that might interwork with the future development of IMT-2000 and systems beyond IMT-2000, and forecast the future status of the parameters from Q3. Please indicate the percentage of users that subscribe to multiple systems/operators.

Fixed and Nomadic/portable broadband access based on the 802.16[2] standard will be a significant part of future broadband wireless services delivered to a variety of user devices including fixed outdoor modems, indoor modems, laptops and other portable devices. Systems based on 802.16 standard are considered for deployments in several countries. These deployments first start by serving medium and small businesses but will expand into the greater residential market[3]. Lack of access to an affordable wired broadband solution around the world provides the potential for 802.16 to serve in the "last mile". Given the current and projected interest in 802.16-based broadband wireless access systems and their complementary nature to IMT-2000 systems, it is foreseeable that the interworking between the two systems will be achieved in the near future. Therefore, contribution of 802.16-based services to the overall demand for data services needs to be taken into account in the overall calculations for the spectrum requirements of future development of IMT-2000 systems, their enhancements, and systems beyond IMT-2000.

As requested in Q4, therefore, future status of the parameters in Q3 is being described below for 802.16 systems.

Response to Q3.1 – Service issues:

A wireless Metropolitan Area Network (MAN) based on the 802.16 air interface standard is configured in much the same way as a traditional cellular network with strategically located base stations using a point-to-multipoint architecture to deliver services over a radius up to several kilometres depending on frequency, transmit power and receiver sensitivity. The base stations are typically backhauled to the core network by means of fiber or point-to-point microwave links to available fiber nodes or via leased lines from an incumbent wire-line operator. The range and NLOS capability are two important parameters in deployments in a variety of environments. The technology was envisioned from the beginning as a means to provide wireless "last mile" broadband access with performance and services comparable to or better than traditional DSL, Cable or T1/E1 leased line services. The services that will be addressed by this technology are[4]:

1. Residential and SOHO High Speed Internet Access: Today this market segment is primarily dependent on the availability of DSL or cable. In some areas the available DSL or cable services may not meet customer expectations for performance or reliability and/or are too expensive. In many rural areas residential customers are limited to low speed dial-up services. In developing countries there are many regions with no available means for internet access. 802.16-based technology will help operators address this market segment.

2. Small and Medium Business: This market segment is very often underserved in areas other than the highly competitive urban environments. The 802.16-based technology can potentially meet the requirements of small and medium size businesses in low density environments and can also provide an alternative in urban areas competing with DSL and leased line services.

[2] http://www.ieee802.org/16/

[3] WiMAX/802.16 Opportunities for high speed wireless data in enterprise, SOHO, residential and portable markets; ABI Research, 2004

[4] Business case models for fixed broadband wireless access based on WiMAX technology and the 802.16 standard, WiMAX Forum, 2004

3. WiFi Hot Spot Backhaul: WiFi hot spots are being installed worldwide at a rapid pace. One of the obstacles for continued hot spot growth, however, is the availability of high capacity, cost-effective backhaul solutions. This application can also be addressed with the 802.16-based technologies. Nomadicity would also allow 802.16 to fill in the coverage gaps between WiFi hot spot coverage areas.

4. Cellular Backhaul: In the US the majority of backhaul is done by leasing T1 services from incumbent wire-line operators. With 802.16, cellular operators will have the opportunity to lessen their independence on backhaul facilities leased from their competitors. Outside the US, the use of point-to-point microwave is more prevalent for mobile backhaul, but 802.16 can still play a role in enabling mobile operators to cost-effectively increase backhaul capacity using 802.16 as an overlay network. This overlay approach will enable mobile operators to add the capacity required to support the wide range of new mobile services they plan to offer without the risk of disrupting existing services. In many cases this application will be best addressed through the use of 802.16 based point-to-point links sharing the Point-to-Multipoint infrastructure.

5. Public Safety Services and Private Networks: Support for nomadic services and the ability to provide ubiquitous coverage in a metropolitan area provides a tool for law enforcement, fire protection and other public safety organizations enabling them to maintain critical communications under a variety of adverse conditions. Private networks for industrial complexes, universities and other campus type environments also represent a potential application for 802.16.

Response to Q3.2 – Market issues:

Demand for Internet services is and will be increasing throughout the world at a fast pace. On the other hand, current and emerging applications such as the ones described in response to Q3.1 are leading to a growing demand for wireless broadband services and, therefore, the number of 802.16 subscribers is expected to grow quite considerably by the year 2009 in all regions of the world[5].

It is important to note that the following tables containing subscriber and equipment shipment forecasts do not include 802.16e services on portable devices such as handsets. These tables only reflect the incremental growth in 802.16 fixed/nomadic services that would interwork with IMT-2000 systems and beyond and affect the spectrum requirements.

Table 1 shows the subscriber growth forecast for 802.16 subscribers based on region.

[5] WiMAX/802.16 Opportunities for high speed wireless data in enterprise, SOHO, residential and portable markets; ABI Research, 2004

Table 1: 802.16 Subscriber growth by region (in millions)

Moderate	2005	2006	2007	2008	2009	CAGR[6] (05-09)
Asia Pacific	0.00837	0.08424	0.42244	1.29031	3.68023	358%
North America	0.00404	0.03938	0.22559	0.65105	1.60822	347%
Latin America	0.00196	0.01346	0.09014	0.22954	0.58663	316%
Europe	0.00412	0.04470	0.29949	0.87944	2.13810	377%
Rest of World	0.00138	0.00940	0.07440	0.20543	0.55736	348%
Total	0.01987	0.19118	1.11206	3.25577	8.57054	356%

Aggressive	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00879	0.09454	0.51842	1.53808	4.44115	374%
North America	0.00429	0.04476	0.27103	0.79567	1.99506	364%
Latin America	0.00199	0.01456	0.10119	0.27613	0.70602	334%
Europe	0.00437	0.05135	0.35957	1.10485	2.64515	396%
Rest of World	0.00150	0.01068	0.08358	0.24608	0.69671	365%
Total	0.02093	0.21588	1.33379	3.96081	10.48409	373%

This growth is not uniform among various environments or market segments. Residential and SOHO users are exoected to grow at a much faster pace that other segments. Table 2 through Table 4 contain subscriber growth forecast information on various market segments.

Table 2: Residential/SOHO subscribers growth by region (in millions)

Moderate	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00242	0.01920	0.18256	0.53978	1.45923	395%
North America	0.00140	0.01184	0.13092	0.38039	0.81312	391%
Latin America	0.00129	0.00614	0.05813	0.13378	0.31382	295%
Europe	0.00187	0.02062	0.20822	0.59025	1.26572	410%
Rest of World	0.00085	0.00281	0.04114	0.09312	0.21815	300%
Total	0.00784	0.06060	0.62095	1.73733	4.07004	377%

Aggressive	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00242	0.02080	0.23235	0.64774	1.71812	416%
North America	0.00140	0.01258	0.15546	0.46941	0.99099	415%
Latin America	0.00129	0.00645	0.06394	0.16439	0.37658	313%
Europe	0.00187	0.02268	0.24657	0.75308	1.55050	437%
Rest of World	0.00092	0.00302	0.04330	0.11175	0.27765	317%
Total	0.00791	0.06552	0.74162	2.14637	4.91385	399%

[6] CAGR, Compound Average Annual Growth Rate, is calculated as CAGR=(end year value / start year value)$^{(1/steps)}$-1.

Table 3: SMB subscriber growth by region (in millions)

Moderate	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00551	0.04511	0.10093	0.19839	0.36781	186%
North America	0.00260	0.01861	0.03779	0.06882	0.11222	156%
Latin America	0.00062	0.00514	0.01536	0.03002	0.05233	204%
Europe	0.00215	0.01617	0.03401	0.06362	0.11163	168%
Rest of World	0.00044	0.00369	0.01115	0.02202	0.03899	208%
Total	0.01131	0.08871	0.19923	0.38287	0.68299	179%

Aggressive	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00587	0.04940	0.11235	0.22319	0.40459	188%
North America	0.00283	0.02127	0.04446	0.08259	0.15029	170%
Latin America	0.00064	0.00548	0.01654	0.03252	0.05414	203%
Europe	0.00239	0.01902	0.04147	0.07952	0.14353	178%
Rest of World	0.00048	0.00418	0.01287	0.02569	0.04437	210%
Total	0.01222	0.09935	0.22769	0.44351	0.79692	184%

Table 4: Enterprise subscriber growth by region (in millions)

Moderate	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00044	0.00223	0.00525	0.00979	0.01561	145%
North America	0.00004	0.00018	0.00035	0.00056	0.00090	112%
Latin America	0.00005	0.00028	0.00071	0.00142	0.00254	172%
Europe	0.00010	0.00048	0.00108	0.00192	0.00298	135%
Rest of World	0.00009	0.00062	0.00176	0.00374	0.00700	199%
Total	0.00071	0.00378	0.00915	0.01744	0.02903	153%

Aggressive	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00050	0.00270	0.00659	0.01259	0.02147	157%
North America	0.00005	0.00022	0.00044	0.00074	0.00130	126%
Latin America	0.00005	0.00030	0.00079	0.00159	0.00288	176%
Europe	0.00011	0.00055	0.00128	0.00233	0.00391	145%
Rest of World	0.00009	0.00068	0.00197	0.00419	0.00817	205%
Total	0.00080	0.00446	0.01107	0.02144	0.03773	162%

In addition to the growth rate, subscriber density among various environments (urban, suburban, and rural) is certainly not the same. Tables 5 and 6 contain subscriber density data for residential and business subscribers, respectively[7]. Subscriber density slightly varies from region to region. The following data is based on observations in the United States. Studies around the world, however, report similar numbers for major population centers in various countries.

[7] Business case models for fixed broadband wireless access based on WiMAX technology and the 802.16 standard, WiMAX Forum, 2004

Table 5: Residential subscriber density (number of households per sq. km)

Urban core	6000
Suburban	1500
Rural	600

Table 6: SMB subscriber density (number of SMB per sq. km)

Urban core	200
Suburban/Rural	50

In order to determine the total traffic volume, the number of base stations and their throughput are required to be known. Additionally, the number of subscriber CPEs is also needed to calculate the aggregate traffic volume in both uplink and downlink. Table 7 contains the forecast for the number of base stations that are expected to be shipped in various regions of the world by the year 2009.

Table 7: WiMAX/802.16 BTS shipments growth by region (shipped units)

Moderate	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	550.48	1,456.19	2,234.29	2,973.37	3,977.63	64%
North America	205.75	443.22	762.26	970.26	1,122.20	53%
Latin America	64.73	178.98	402.44	508.17	675.53	80%
Europe	191.22	475.09	896.54	1,164.19	1,690.16	72%
Rest of World	66.05	215.71	437.60	565.48	768.03	85%
Total	1,078.23	2,769.19	4,733.14	6,181.47	8,233.54	66%

Aggressive	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	601.43	1,687.35	2,681.41	3,565.30	4,461.17	65%
North America	223.56	513.70	934.08	1,280.09	1,811.44	69%
Latin America	67.95	193.92	440.71	582.54	756.53	83%
Europe	211.40	566.30	1,108.26	1,473.32	2,077.70	77%
Rest of World	72.05	242.54	495.36	663.59	964.94	91%
Total	1,176.39	3,203.82	5,659.82	7,564.84	10,071.77	71%

The growth in the expected number of CPEs to be shipped, however, varies with subscriber type and market segment. Tables 8 through 10 contain growth forecast information on the number of CPEs that are expected to be shipped in various regions of the world by the year 2009.

Table 8: WiMAX/802.16 residential/SOHO CPE shipments growth by region (in millions)

Moderate	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00249	0.01775	0.17244	0.40057	1.03938	352%
North America	0.00145	0.01103	0.12550	0.28015	0.50434	332%
Latin America	0.00133	0.00518	0.05488	0.08717	0.20690	253%
Europe	0.00193	0.01976	0.19790	0.42995	0.78682	350%
Rest of World	0.00088	0.00212	0.04031	0.06004	0.14370	257%
Total	0.00808	0.05584	0.59102	1.25787	2.68115	327%

Aggressive	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00249	0.01942	0.22294	0.46820	1.21233	370%
North America	0.00145	0.01181	0.15044	0.35144	0.60920	353%
Latin America	0.00133	0.00550	0.06066	0.11415	0.24466	268%
Europe	0.00193	0.02191	0.23601	0.56649	0.93564	370%
Rest of World	0.00095	0.00228	0.04236	0.07775	0.18926	276%
Total	0.00815	0.06092	0.71242	1.57803	3.19109	345%

Table 9: WiMAX/802.16 SMB CPE shipments growth by region (in millions)

Moderate	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00568	0.04111	0.06020	0.10644	0.18641	139%
North America	0.00267	0.01665	0.02087	0.03423	0.04883	107%
Latin America	0.00063	0.00470	0.01084	0.01602	0.02478	150%
Europe	0.00222	0.01456	0.01935	0.03254	0.05327	121%
Rest of World	0.00045	0.00338	0.00791	0.01186	0.01880	154%
Total	0.01165	0.08040	0.11916	0.20110	0.33209	131%

Aggressive	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00604	0.04519	0.06780	0.12090	0.20024	140%
North America	0.00292	0.01916	0.02516	0.04194	0.07469	125%
Latin America	0.00066	0.00502	0.01172	0.01745	0.02421	146%
Europe	0.00246	0.01727	0.02427	0.04168	0.07070	131%
Rest of World	0.00049	0.00384	0.00920	0.01398	0.02078	155%
Total	0.01258	0.09049	0.13815	0.23595	0.39062	136%

Table 10: WiMAX/802.16 Enterprise CPE shipments growth by region (in millions)

Moderate	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00045	0.00190	0.00341	0.00552	0.00773	104%
North America	0.00005	0.00014	0.00019	0.00023	0.00038	70%
Latin America	0.00005	0.00024	0.00049	0.00085	0.00142	133%
Europe	0.00010	0.00040	0.00068	0.00104	0.00143	94%
Rest of World	0.00009	0.00056	0.00127	0.00234	0.00406	159%
Total	0.00073	0.00325	0.00604	0.00998	0.01502	113%

Aggressive	**2005**	**2006**	**2007**	**2008**	**2009**	**CAGR (05-09)**
Asia Pacific	0.00051	0.00234	0.00443	0.00739	0.01177	119%
North America	0.00005	0.00017	0.00025	0.00033	0.00062	86%
Latin America	0.00005	0.00027	0.00055	0.00097	0.00167	139%
Europe	0.00011	0.00047	0.00083	0.00131	0.00211	109%
Rest of World	0.00010	0.00062	0.00144	0.00268	0.00503	168%
Total	0.00082	0.00388	0.00750	0.01268	0.02120	125%

Response to Q3.3 – Preliminary traffic forecast

This question requests information regarding traffic volume to be provided for the 802.16 system. The traffic volume could be derived from information on the number of subscribers, session activation rate, session duration statistics, mean packet size, etc. Alternatively, the question suggests that traffic volume data could be derived from uplink and downlink speeds for various traffic classes and in various environments by linking them to other data provided to answer other questions. Tables 11 and 12 describe the capacity of an 802.16 base station for various channel bandwidths and coding/modulation schemes. By assuming a deployment scenario (available bandwidth and MHz per cell, distribution of various user types, and application breakdown) it is then possible to calculate the total traffic volume of a base station.

It should be noted that the numbers reported in Table 11 and Table 12 are raw, theoretical data rates. Reporting raw data rates has the advantage of not making any deployment-specific assumptions. Actual data rates, namely the throughput provided by the base station throughout the cell and experienced by users, are a function of several factors including user distribution and propagation conditions, for which calculation methodologies are to be agreed upon in WP 8F.

Table 11: Base station throughput of 802.16 OFDM[8] (in Mbps)

Modulation / Code Rate	QPSK 1/2	QPSK 3/4	16 QAM 1/2	16 QAM 3/4	64 QAM 2/3	64 QAM 3/4
1.75 MHz	1.45	2.18	2.91	4.36	5.82	6.55
3.5 MHz	2.91	4.37	5.82	8.73	11.64	13.09
5.0 MHz	4.16	6.23	8.31	12.47	16.62	18.70
7.0 MHz	5.82	8.73	11.64	17.45	23.27	26.18
10.0 MHz	8.31	12.47	16.63	24.94	33.25	37.40
20.0 MHz	16.62	24.94	33.25	49.87	66.49	74.81

Table 12: Base station throughput of 802.16 OFDMA (in Mbps)

Modulation /Code Rate MHz	QPSK 1/2	QPSK 3/4	16QAM 1/2	16QAM 3/4	64QAM 1/2	64 QAM 2/3	64 QAM 3/4
1.25 MHz	1.04	1.56	2.08	3.12	3.12	4.16	4.68
1.75 MHz	1.45	2.18	2.91	4.36	4.36	5.82	6.55
3.5 MHz	2.91	4.36	5.82	8.73	8.73	11.64	13.09
5.0 MHz	4.16	6.23	8.31	12.47	12.47	16.62	18.70
7.0 MHz	5.82	8.73	11.64	17.45	17.45	23.27	26.18
10.0 MHz	8.31	12.47	16.62	24.94	24.94	33.25	37.40
20.0 MHz	16.62	24.94	33.25	49.87	49.87	66.49	74.81

Q5. Driving forces of the future market

Please list any items which will be the driving forces in the markets of the future development of IMT-2000 and systems beyond IMT-2000, and estimate their impact and timing. There may be different drivers for different market areas, e.g., urban vs. rural/remote, in respective countries.

Q6. Any other views on future services

If there are any other views on the services to be provided by the future development of IMT-2000 and systems beyond IMT-2000, which are not described in the Recommendation ITU-R M.1645, please express and elaborate on them.

Annex 1: Examples of applications envisaged for the future development of IMT-2000 and systems beyond IMT-2000

Annex 2: Examples of parameters for answers to Q.3.3

Annex 3: An example of a method to forecast market evolution

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Annex 1

Examples of applications envisaged for the future development of IMT-2000 and systems beyond IMT-2000

It is expected that there will be a large number of applications which will be provided by future development of IMT-2000 and systems beyond IMT-2000. The applications may be grouped into service categories. They could differ on a region or country basis.
The following table provides examples of potential future applications and their allocation to service categories and gives guidance to be used in the elaboration of answers to the Questionnaire. Respondents are encouraged to provide information according to this guidance.

Service categories	Examples of applications
Speech	• Voice
Multimedia messaging	• Mobile ordering enabling easy purchase of products or obtainment of information simply by holding a mobile terminal toward printed materials (magazines, brochures, posters, etc.) or images. Information pertaining to the product (video, CM, specifications) may be automatically delivered to the mobile terminal from the product centre, and displayed in 3D images, which can be viewed from multiple angles. Users, if they like, can order the product on the spot, make the payment and settle the accounts from a mobile terminal. Sales status in the areas nearby, and other related information on the product could also be obtained.
Low rate data	
Low multimedia	• Navigation System: users accessing information services from inside moving vehicles. The information should be provided adequately depending on time, location and properties of user. Users may also be able to receive discounts at shops by presenting the information retrieved through the above.

Medium multimedia	• Location information service (locating service, route guide, traffic information, etc.) • Vehicle information service (automobile information, vehicle tune-up information, etc). • Entertainment service (radio, TV programs, etc). • Control service (vehicle control in the event of earthquake, accident, etc). • Emergency service (accident, sudden illness, etc). • Logistics service (parcel delivery, etc). • Entertainment: Simply by instructing the name of video (which does not necessarily have to be precise; ambiguous input will do) of users' choice (TV programs broadcast in the past, news, dramas, movies, or concerts, etc.) through voice input, etc., users will be able to watch it on a mobile terminal through streaming from the network anytime and anywhere they like. The charges for the content—which should be decided taking into account the requests of the rights holder, the number of accesses from users (popularity), video quality, the number of copies, the time of viewing, location, etc.—will be presented on the spot, and if the user agrees, the video will be made available for viewing. Also, when the user wants to see a movie using some spare time, for instance, during a trip, he/she can search information concerning the movies currently on show and see a preview on the player. If he/she decides to watch the whole movie in a cinema, it is possible to search the theatre that can be reached from the current location before the start of the movie, and if necessary, make a seat reservation and purchase electronic tickets, too. The videos can be viewed in trains on a spectacles-type display, which can be suspended for a moment when changing trains.
High multimedia	
Very high multimedia	
Ultra high multimedia	
Super high multimedia	

Note that there is presently limited understanding as to the specific applications that will fit within the Very High, Ultra High or Super High categories. It is therefore proposed that these categories be reviewed once further information is available.

Annex 2

Examples of parameters for answers to Q.3.3

In order to establish spectrum requirements estimates, it is essential that the services envisaged are described in terms of technical characteristics. Therefore it is encouraged to establish a list of parameters and the values of these parameters for the various services. This annex lists examples of parameters that may be used to describe the characteristics of the various services.

A2.1 Traffic class

The different services can be divided into four traffic classes as follows:

– Constant Bit Rate (CBR) – CBR is a traffic class in which the peak bit rate takes a constant fixed value and is guaranteed. CBR is used for services that require a very low end-to-end delay as well as a low level of delay variation (jitter).

– Variable Bit Rate (VBR) – VBR class allows its bit rate to dynamically vary in response to the throughput actually required for the service. This class guarantees at least its sustainable bit rate and provides up to its peak bit rate if possible. The VBR has two subclasses according to its real-time nature; rtVBR (real-time VBR) and nrtVBR (non real-time VBR). In rtVBR, the peak bit rate is allowed to vary but real-time transmission is guaranteed, in which a tightly constrained delay and delay variations are required. The rtVBR is used for real-time applications, such as a voice and video communication. The nrtVBR is required to achieve a low packet loss ratio and mainly user for the applications of reliable and quick response like an electronic transaction. No delay bounds are defined in this category

– Available Bit Rate (ABR) – The ABR has no delay or delay variation requirements. This class is not intended for the use of real time applications. In this class, only peak bit rate and minimum usable bit rate are specified when establishing its connection. The minimum usable bit rate can be set to zero. The available bit rate may vary according to its network condition.

– Unspecified Bit Rate (UBR) – This class specifies no traffic related service guarantees. This class is intended for non-real-time applications, such as conventional computer communication applications; file transfer, or E-mail.

TABLE 1

Example mapping of potential applications on to Service types

Service Categories	CBR	VBR	ABR	UBR
Speech	Voice	–	VoIP	–
Multimedia messaging	–	–	High/Medium priority MMS	Low priority MMS
Low rate data	–	–	Organiser Sync Simple transactions	–
Low multimedia	–	–	Mobile commerce	–
Medium multimedia	Micro movies	Video telephony	Mobile commerce Location based advertising	 Web browsing
High multimedia	–	HD video telephony Video conferencing	Mobile commerce Down loads	
Very high multimedia	–	–	Desk top applications	
Ultra high multimedia	–	Streaming video Multiplayer gaming	Spooling video	
Super high multimedia	–	–	High volume applications	

A2.2 Bit rates

Bit rates are extremely important within the spectrum calculation and each service is likely to have different requirements. The peak bit rates are used here to categorize the services. For the purposes of modelling, however, it is possible to group together services demanding similar rates into a common category. To aid understanding of the hierarchy of categories, they are defined in terms of their peak user rate. This is distinct from the effective user rate which represents all services within the category for the purposes of spectrum calculation. Average bit rate may also be a parameter used to describe the characteristics of the service. For some services the delay may be relevant in addition to or instead of the peak bit rates.

A2.3 Degree of asymmetry

A driving parameter for categorisation is the degree of asymmetry for the Service. Precise asymmetries will vary between services, however, it is possible to group together services having similar asymmetry. The representative asymmetry for each group is subject to market assessment, but it is likely that there will be at least three variants to represent whether the service is fundamentally upload, download or symmetric. Download services are expected to use high bit rates on the down link and low bit rates on the uplink or even no uplink data. Up load services use the reverse.

A2.4 Quality of service parameters

Quality of services parameters such as delay may be used to describe the characteristics of the various applications and services.

A2.5 Mobility

Terminal mobility is closely related to application usage scenarios. The requirements depend upon the relative speed between the mobile stations and the stations in the radio access network with which they are interacting. For example, the mobility may be categorized as follows:

– stationary (0 km/h);

– pedestrian (>0 and <10 km/h);

– vehicular (>10 km/h);

  – Low/Medium (>10 and <100 km/h)

  – High (>100 and <250 km/h)

  – Super-high (>250 km/h)

A2.6 Service usage patterns

A service usage pattern may be categorized according to an area where users exploit similar services and expect similar quality of service.

  – Home

  – Office

  – Public area

  – Wide area

The service usage pattern may be further categorized according to the time of day. The time-of-day variation of traffic volume depends on the type of application, which might have different usage such as:

  – busy time

  – non-busy time.

A2.7 Teledensity

Teledensity may be categorized into the following:

  – Dense Urban

  – Urban

  – Sub-urban

  – Rural

  – Remote

A2.8 Relations between the different parameters

Detailing all the combinations of parameters for each service would lead to very big amount of possibilities. Since not all these combinations reflect real cases, and in order to simplify the studies, a limited set of combinations of parameters may be used. The following tables provide some possible sets of combinations.

TABLE 2

Summary of service categories

Peak bit rate	Service categories
< 16 kbit/s	Speech
< 128 kbit/s	Multimedia messaging, Low multimedia, low rate data
< 384 kbit/s	Medium multimedia
< 2 Mbit/s	High multimedia
< 10 Mbit/s	Very high multimedia
< 30 Mbit/s	Ultra high multimedia
< 100 Mbit/s	Super high multimedia
Unspecified bit rate	Background

Note that there is presently limited understanding as to the specific applications that will fit within the Very High, Ultra High or Super High categories. It is therefore proposed that these categories be reviewed once further information is available. Similarly, it is premature to define the asymmetry associated with the up load and down load multimedia categories until further market data is available and the likely applications are better understood. Indeed it would be prudent to review all parameters associated with service categories in the light of market input before finalising the definition of each service category.
Table 3 describes the parameters that may be needed for the various traffic classes.
Note that all services which will be handled on a best effort basis are collected together under the service category Background. Thus the UBR traffic class is not required as a parameter in the definition of the other service categories.

TABLE 3

Additional parameters needed in addition to traffic class

Traffic class	CBR	VBR	ABR	UBR
Information required	Quality of service Average bit rate Delay requirement	Quality of service Average bit rate Peak bit rate	Quality of service Average bit rate Minimum bit rate (or maximum delay)	None

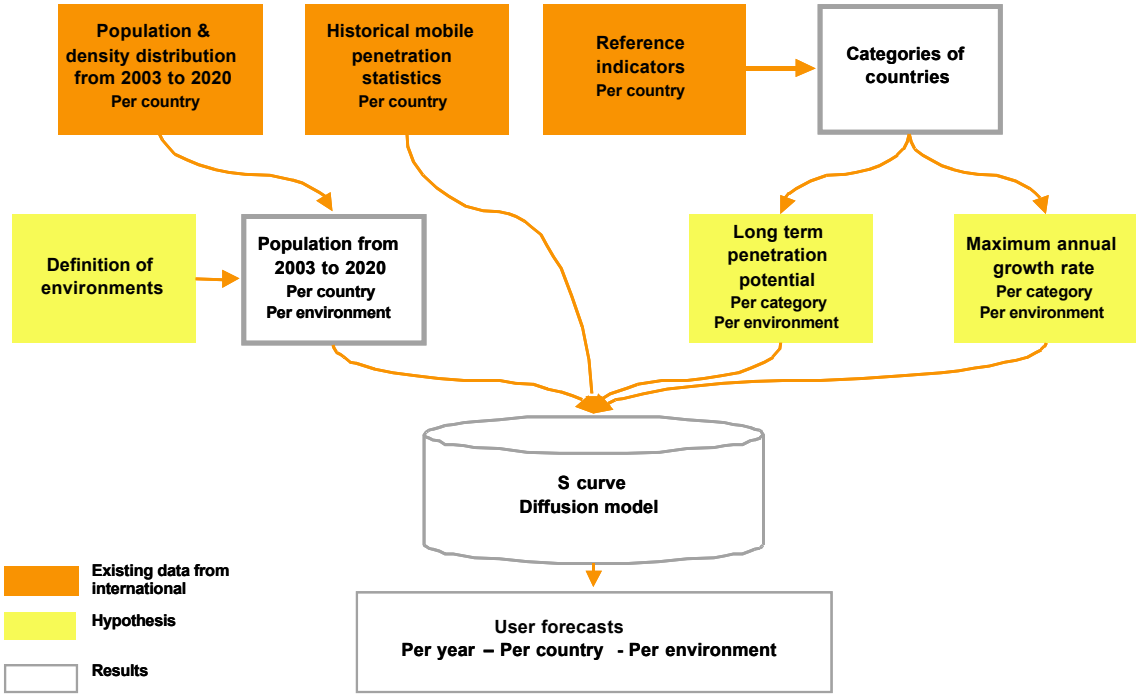
Annex 3

An example of a method to forecast market evolution

Anticipating the evolution of the worldwide mobile communication penetration for the next twenty years is a challenging work. In this timeframe, as the world population increases by 22% (from 6,2 Billion in 2002 up to 7,6 Billion in 2020)[9], many factors will influence the particular situation of each country and their telecommunication development. The forecasts for the evolution of telecommunication penetration developed from this method are based on the general socio-economic context and perspectives of each country.
For example, the penetration forecast could be set in two steps:

- First, the long-term mobile penetration levels that the countries are expected to reach in 2020 are determined, as well as the maximum speed of penetration increase over the timeframe.
- Second, the penetration evolution for every country, and for every year in the period 2003-2020 is computed using the so called S-Curve model.

An example of a particular method is presented in the figure below:



Synopsis of the mobile penetration forecast method

[9] Source: UNO, World Population Prospect – 2001 Revision

Four major reference indicators could be considered to estimate the future mobile telecommunication market in each country:

- Income
- Human Development
- Technology Affinity
- Urbanisation.

The evolution of the mobile penetration could be modelled per country and per environment as an S-curve diffusion process with the following parameters:

– the historical mobile penetration in the country;

– the long-term mobile penetration potential for the country;

– the maximum year-on-year penetration growth rate (which occurs at the inflexion point of the penetration curve).