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FIRST MEETING OF STUDY GROUP 1: GENEVA, 10 - 12 SEPTEMBER 1998
FIRST MEETING OF STUDY GROUP 2: GENEVA, 7 - 9 SEPTEMBER 1998

Question 9/2: Identify study group Questions in the ITU-T and ITU-R Sectors which are of particular interest to developing countries and systematically, by way of annual progress reports, inform them of the progress of work on the Questions to facilitate their contributions to the work on those Questions as well as, ultimately, to benefit from their outputs in a timely manner

STUDY GROUP 2

SOURCE: UNITED STATES OF AMERICA

TITLE: OPERATIONAL AND TECHNICAL CHARACTERISTICS FOR A TERRESTRIAL IMT-2000 SYSTEM USING HIGH ALTITUDE PLATFORM STATIONS (Technical information document)

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1. Introduction

This contribution contains an attachment entitled "Working Document Toward A Preliminary Draft New Recommendation On Operational and Technical Characteristics for a Terrestrial IMT-2000 System Using High Altitude Platform Stations", numbered Document 8-1/80-E ("Document 80") which was submitted by the United States to Task Group 8/1 during its 14th meeting in Geneva, 27 April through 8 May. At that meeting, Working Group 1, which addresses matters concerning Developing Countries, discussed Document 80 and concluded that HAPS offers the potential for an inexpensive infrastructure for the rapid implementation of IMT-2000 services in developing countries. Working Group 1 issued a liaison statement, numbered 8-1/TEMP/35-E, requesting that Study Group 2 of the ITU-D consider Document 80 and the potential inclusion of HAPS as an optional delivery system for IMT-2000 terrestrial services. This contribution is submitted in order to bring Document 80 before Study Group 2 for consideration.

2. Background

Following WRC-97's designation of the bands 47.2 - 47.5 GHz and 47.9 - 48.2 GHz for use by high-altitude platform stations (HAPS) in the fixed service, a number of administrations expressed interest in the ability of HAPS to provide terrestrial IMT-2000 mobile and fixed wireless access services. However, RR S4.15A (WRC-97) currently states that "Transmission to or from high altitude platform stations shall be limited to bands specifically identified in Article S5" thereby requiring a future WRC to adopt suitable regulatory provisions to enable the implementation of HAPS as an optional IMT-2000 terrestrial delivery technology. In response to the submission of Document 80 at its April-May meeting, TG 8/1 concluded that it was premature to consider the Preliminary Draft New Recommendation that was appended to Document 80 and instead established a Correspondence Group to study operational and sharing characteristics of HAPS within the terrestrial component of IMT-2000 with the objective of enabling contributions to the next meeting of TG 8/1 in Jersey, United Kingdom, in November 1988. In addition, as noted above, TG 8/1 Working Group 1 requested that Study Group 2 also consider Document 80.

3. Technical Information

Document 80 was submitted by the United States to the April-May meeting of ITU-R TG 8/1 to provide information concerning the operational and technical characteristics for a terrestrial IMT-2000 system using HAPS and to propose consideration of a Preliminary Draft New Recommendation regarding the use of HAPS as an optional IMT-2000 terrestrial system technology.

The document presents HAPS as “tall terrestrial towers” in the terrestrial component of IMT-2000 using air-interface and network standards according to IMT-2000 Recommendations. As such, the use of HAPS in bands designated for the terrestrial component of IMT-2000 does not involve the development of a new radio-transmission technology (RTT) and HAPS may be used with any approved RTT to provide terrestrial IMT-2000 service. In addition, Document 80 proposes that HAPS simply be made available as an option to administrations in bands designated for the terrestrial component of IMT-2000 and therefore does not require any additional spectrum allocation for use by HAPS.

This document is submitted as information for development sector members interested in the deployment of IMT-2000 services, and in conjunction with the liaison statement submitted to ITU-D Study Group 2 by Task Group 8/1 entitled “Liaison Statement to ITU-D Study Group 2 on High Altitude Platform Stations.” In addition, development sector members are urged to participate in the work of the TG 8/1 Correspondence Group to ensure that these important studies are completed in time to be reported to the next meeting of TG 8/1.

Attachments: 2

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

Delayed contribution
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United States of America

WORKING DOCUMENT TOWARD A
PRELIMINARY DRAFT NEW RECOMMENDATION ON

OPERATIONAL AND TECHNICAL CHARACTERISTICS FOR A TERRESTRIAL IMT-2000 SYSTEM USING HIGH ALTITUDE PLATFORM STATIONS

1 Introduction

The purpose of this contribution is to provide the baseline technical and operating characteristics for a terrestrial IMT-2000 system using high altitude platform stations (HAPS) and to propose a preliminary draft new recommendation concerning use of HAPS within the terrestrial component of IMT-2000. The terrestrial component of IMT-2000 is defined herein as the frequency range 1885-1980 MHz, 2010-2025 MHz, and 2110-2170 MHz in Regions 1 and 3, and 1885-1980 MHz and 2110-2160 MHz in Region 2 terrestrial component of IMT-2000. A HAPS system includes the stratospheric platform based telecommunications equipment, the user hand-held equipment, and the gateway stations. This contribution describes the HAPS concept and two example HAPS architectures that are capable of providing IMT-2000 services with spectrum efficiencies comparable to traditional terrestrial architectures. Annex 1 to this contribution is a preliminary draft new recommendation that recommends that the terrestrial component of IMT-2000 should include systems using HAPSs and that studies should be carried out regarding coordination and sharing between HAPSs and other stations and services. Existing IMT-2000 ITU-R Recommendations do not exclude HAPSs from the terrestrial component, but they assume the use of traditional towers, and therefore a new recommendation is necessary to enable a future WRC to remove regulatory uncertainty by confirming that the emerging HAPSs are terrestrial stations within the terrestrial component of IMT-2000. Amendment of existing recommendations to include HAPS as an IMT-2000 technology may also be appropriate in the future. However, HAPS is a new technology that warrants introduction by way of a single clear document.

This contribution is organized as follows:

- Section 1 provides a brief introduction;
- Section 2 describes the basic technology of a high altitude platform station (HAPS);

- Section 3 provides the characteristics of the general communications architecture and describes the expected parameters for HAPS systems using different radio interfaces;
- Section 4 outlines the terrestrial characteristics of a HAPS system, reviews the existing IMT-2000 Recommendations, and provides the rationale for a preliminary draft new Recommendation concerning HAPS and IMT-2000;
- Section 5 provides a summary;
- Annex 1 is the proposed preliminary draft new Recommendation; and,
- Annex 2 presents an example capacity calculation.

2 The High Altitude Platform Station (HAPS) System

An IMT-2000 terrestrial system utilizing HAPS consists of communication equipment on one or more HAPSs located by means of station-keeping technology at nominally fixed points in the stratosphere (at 20 – 50 km altitude), one or more ground switching/control stations, and a large number of fixed and mobile subscriber access terminals. The system uses radio transmission technologies (RTTs) that satisfy IMT-2000 requirements to offer high density and high-speed communications capacity to fixed and mobile stations. The HAPS architecture is in concept much like a very tall terrestrial tower that is sectorized into hundreds of cells. Figure 1 illustrates the primary components of a HAPS system network.

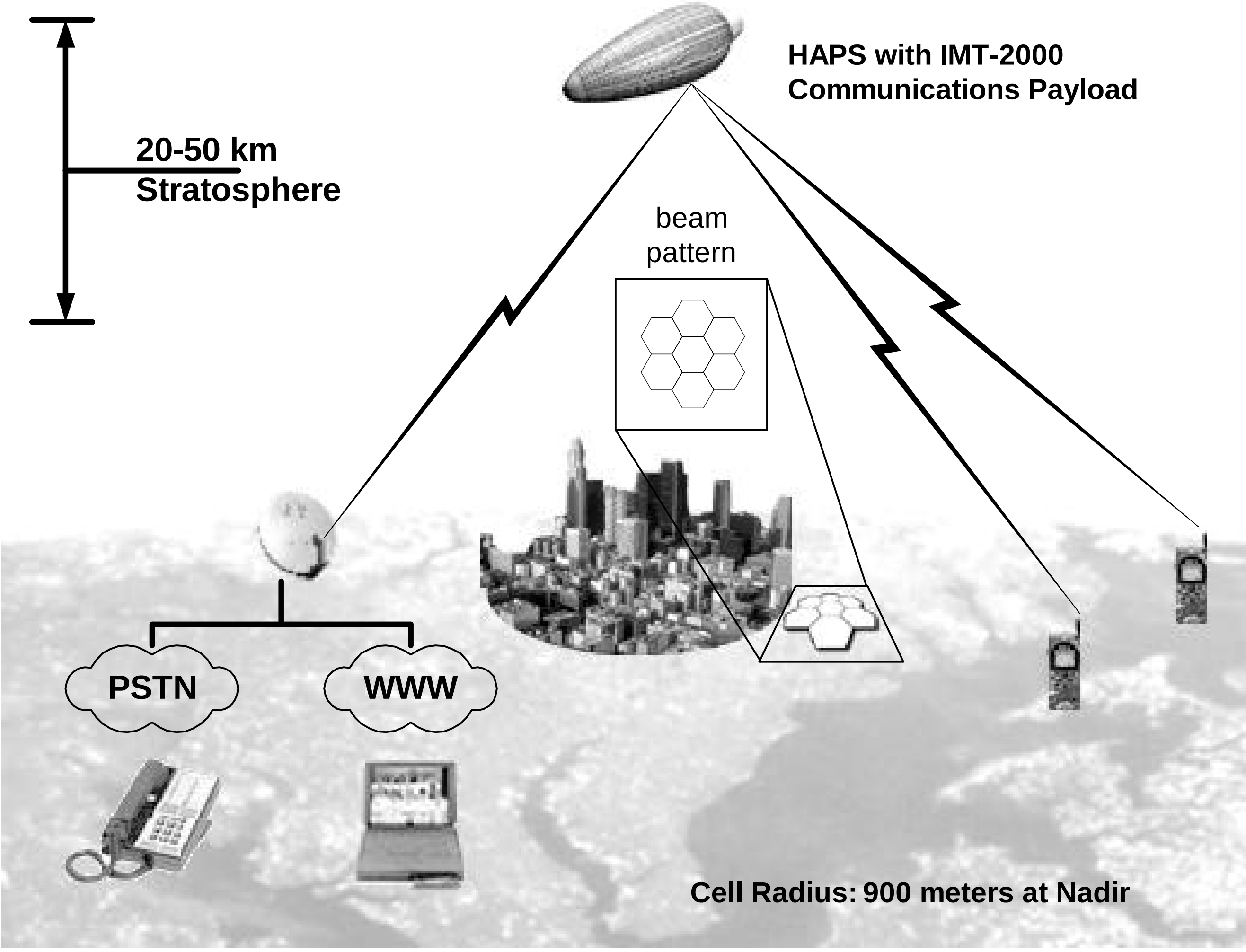

FIGURE 1

IMT-2000 Fixed and Mobile Service Using a High Altitude Platform Station

A HAPS is a helium filled lighter than air platform with a telecommunications payload. The platform is approximately 150 meters in length and 40 meters in diameter. Solar cells covering the majority of the surface of the airship generate all necessary power for station-keeping, telecommunications, and fuel cell charging. Fuel cells provide power for all operations during the night and eclipses. Onboard and remote power management controls automatically adjust the power mix to meet ever changing demands from the propulsion module, the communications modules, and the control module.

A HAPS is deployed from a launch center through cleared air space. The buoyancy of the helium carries it to an altitude of about 21 kilometers within several hours. Propellers move the HAPS to its service location at speeds of up to 200 km/h. The HAPS is stationed at an altitude far above commercial aircraft but below the protective covering of the outer atmosphere.

Electric motor driven propellers and a thermal control system are used for station-keeping. The propellers maintain position against the wind. The atmosphere at 21 kilometers altitude is about 5% the density of the atmosphere at sea level and therefore the drag from wind is greatly reduced. A HAPS employs both passive and active thermal controls to limit the temperature variation inside the platform to within a few degrees. This enables the platform to maintain a stable altitude and provides a protective environment for the structure and the payload. Multiple redundant GPS receivers and the station-keeping technologies enable the HAPS to remain in a nominal fixed position in all three dimensions, and further enable the antenna assemblies to maintain a fixed coverage pattern on the ground. HAPSs are returned under a controlled descent to ground facilities for payload upgrades, routine maintenance and redeployment, or recycling. A HAPS does not leave the atmosphere and therefore is subject to inspection and regulation by national aviation and telecommunications authorities.

A HAPS is environmentally neutral. It does not generate pollution or debris, and does not impact the ozone layer. A HAPS also does not pose a danger to the public. The great majority of the platform consists of the soft envelope. If the on-board sensors indicate that a platform must be serviced, it is brought under control to a service facility. Redundant platforms are deployed to provide coverage during maintenance or repair. In the unlikely event that a platform develops leaks, the slight difference in pressure between the interior and exterior of the envelope delays helium loss for several hours, and then the airship begins a gradual descent.

Each platform provides instant telecommunications infrastructure for an entire region and does not require the deployment of additional, or a constellation of, stations to provide service. Therefore, each HAPS constitutes a stand-alone regional system that can be individually deployed. The deployment of 250 platforms over the 250 most populous cities will create a worldwide system covering more than 80% of the world's population. The platforms can be linked directly to one another by hop stations located midway between the platforms or by interplatform links, and can also be linked indirectly via satellite or the PSTN. The HAPS user terminals will be designed to share the same radio interface as traditional terrestrial systems and, therefore, a single handset will work with both a HAPS and traditional terrestrial towers. This will enable regional and worldwide roaming with a single handset.

A HAPS is designed with a lifespan of 5 to 10 years. Service beyond this term is limited by the gradual degradation of solar and fuel cells, structural fatigue and the decomposition of gas-storage modules. Ongoing advances in high strength, light-weight, UV-resistant composite materials, fuel cells, solar cells, and compact, high speed semiconductor device will likely extend the lifespan of second generation HAPSs.

3 Example IMT-2000 Communications Architectures Using HAPS

3.1 General Architecture

The HAPS telecommunications payload consists of multibeam light-weight reflector or phased-array antennas, transmit/receive antennas for gateway links with ground switching stations, and a very large bank of processors that handle receiving, multiplexing, switching and transmitting functions. The payload can utilize various multiple-access techniques and standards (e.g., TDMA, CDMA) that meet IMT-2000 requirements. The HAPS telecommunications payload can be designed to serve as the sole station in a stand-alone infrastructure (essentially, replacing the tower basestation network with a “basestation network in the sky”) or can be integrated into a system that employs traditional terrestrial basestation towers, satellites, and HAPSs.

The high gain transmit/receive antennas used on the HAPS project a large number of cells onto the ground in a pattern similar to that created by a traditional cellular system. The size of the HAPS coverage area and of the spot beams within the coverage area are determined by the antenna array which is designed to match the demand for capacity within any selected coverage area. The precise power allocated to each cell, and the cell's boundaries, are controlled to maximize overall system capacity. Small cells serve high-density zones in order to provide a high level of capacity whereas larger cells serve less dense zones. In general, the cells directly beneath a HAPS will be smaller than those farther away from the center of the coverage area.

The system dynamically reassigns capacity among the cells on a minute by minute basis in order to focus the capacity where it is most needed at any given time. For instance, the HAPS can direct additional capacity toward automobile traffic during rush hour and then shift it to a stadium during an evening sports event or performance. This gives the HAPS greater flexibility than traditional systems and can be used along or in concert with traditional terrestrial systems to prevent system overload in hot spots.

A HAPS system will provide mobile cellular coverage and fixed wireless services to several regions ranging from a high-density (urban) area to low-density (rural) areas. The planned cellular coverage is illustrated in Figure 2. The coverage depicted by Figure 2 employs circular 5° antenna beams to provide high-density coverage to a dense urban area near the nadir of the HAPS while wider circular beams (5°-10° or larger) in lower density service regions. In addition, small “hot” spot beams will also provide increased capacity to special places with a large concentration of users such as a shopping center or business district. Figure 3 illustrates these localized “hot” spot beams with the overlay of basic cells. While circular beams indicate the basic anticipated coverage, HAPS will likely used shaped beams and/or phased array antennas that will provide contour shaping of the coverage beams—these shaped beams are not depicted in Figure 2 or Figure 3.

The HAPS cellular coverage will likely include three regions: (i) high-density (urban); (ii) moderate density (suburban); and (iii) low-density. Many users concentrated in a limited geographical area characterize the high-density (urban) region. This service region needs to support both vehicular (typically low-speed) and pedestrian traffic. The moderate density (suburban) region is characterized by a mix of users mostly high and moderate-speed vehicular users but with some pedestrian users. The low-density region typically includes fixed wireless users and mobile users (voice only). These users will be spread over a wide geographical area.

Although the example TDMA system described below is configured to provide contiguous coverage to a 150 kilometer diameter footprint with selective rural coverage beyond that range, the CDMA-based system can be deployed on a HAPS that would provide broad beam contiguous coverage to a very low density rural area stretching nearly 1,000 kilometers in diameter by using horizon-grazing 3^{o} beam-width antennas. The very low loading factor in the low-density area means that the radio link will be noise-limited rather than interference-limited. This allows the use of low power beams which does not cause any interference to the high-density cells.

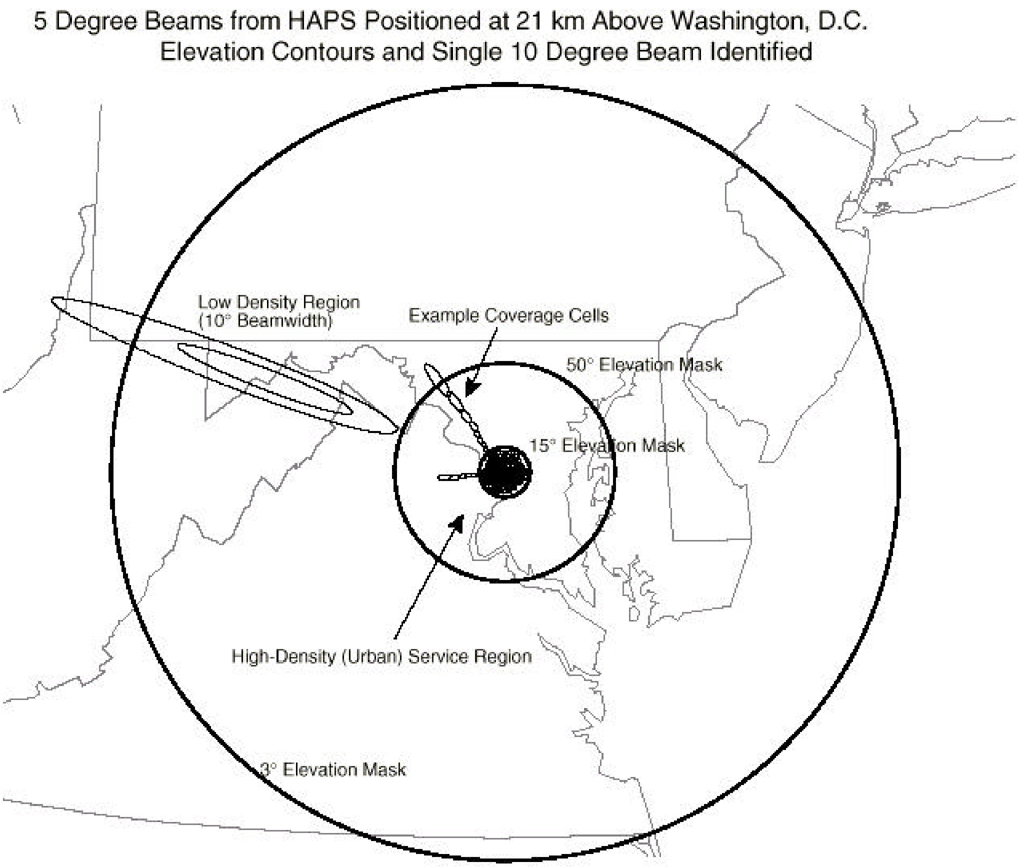

FIGURE 2

Example HAPS Cellular Coverage Regions

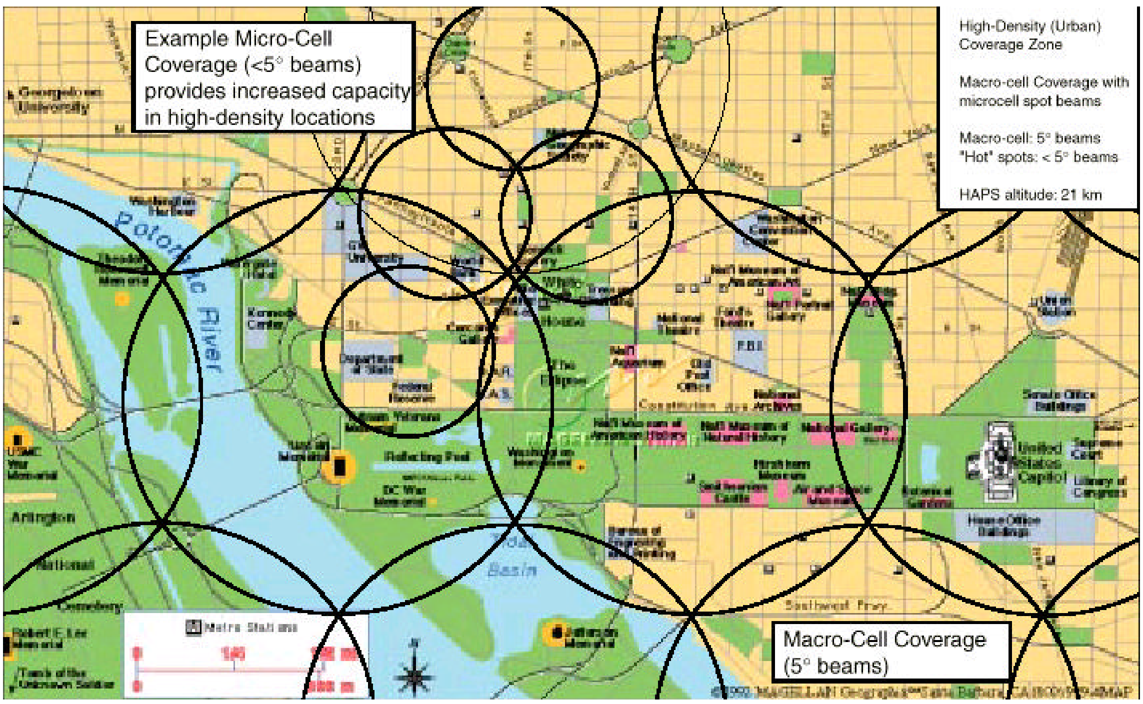

FIGURE 3

Example High-Density (Urban) HAPS Cellular Coverage

3.2 Two Examples of HAPS IMT-2000 System Architectures

3.2.1 Example TDMA System

A terrestrial system using HAPS can implement a TDMA based radio interface derived from standards such as IS-136 (and its extensions) and GSM (and its extensions). The cell size and the frequency reuse factor are determined by the antenna characteristics of the HAPS communications payload, rather than by the terrain features of the coverage area as in terrestrial deployment.

An example TDMA HAPS communications payload contains multi-beam lightweight reflector antenna or phased array antennas. Each antenna will have an approximate aperture of 2 meters in diameter and contain 25 beams. In the 2 GHz frequency range, the corresponding antenna gain is 30 dBi and the beamwidth is 5 degrees. Twenty-eight such antennas can thus cover an urban area up to 75 kilometer in radius with 700 cells. The smallest cell at nadir has an approximate radius of 900 meters. Cell sizes increase toward the edge of the coverage area, which extends to 75 kilometers from the nadir with a minimum elevation angle of 15 degrees. In addition, the system can provide selective rural coverage to an area up to 300 kilometer in radius. Conservatively, the frequency reuse factor is set as 7, so the assigned bandwidth is reused 100 times within the high-density (urban) coverage area. In the selective rural coverage area, a smaller number of narrow beams provide fixed service to selective communities. In this case the entire assigned bandwidth can be used due to space division.

Assuming an assigned bandwidth of 30 MHz (30 MHz for TDD or 15 MHz forward and 15 MHz return for FDD) and a reuse factor of 7, each cell will have a bandwidth of 2.1 MHz and a capacity of 2.1 Mbps. Thus, the total system capacity will be 1.5 Gbps. This TDMA HAPS system can therefore provide 175 simultaneous 9.6 kbps user channels per cell, excluding 20% overhead. The entire system is capable of supporting 122,500 such channels simultaneously.

Using the link budget template of Recommendation ITU-R M.1225, Table 1 provides an example link budget for a TDMA HAPS system in a vehicular environment. Unlike a traditional terrestrial base station, the base station antenna gain is higher (30 dBi at boresight, 27 dBi at edge of cell). The multipath fading is also less severe, but a value similar to a traditional terrestrial environment is retained since there is sufficient margin. As shown by Table 1, a handset used for a traditional terrestrial system will have sufficient power to operate with a HAPS system; thus, handsets using a TDMA RTT can operate with both a traditional and a HAPS terrestrial system.

By using larger antennas in the HAPS communications payload, the capacity per cell can be increased to the same level as terrestrial microcell systems. Usually such high-density coverage is only required in small areas like the Central Business Districts. A microcell/macrocell overlay system may be optimal.

TABLE 1

Example Link Budget for TDMA HAPS IMT-2000 System

	ITEM	Forward	Reverse
(a0)	Average transmitter power per traffic channel	30 dBm	24 dBm
(a1)	Maximum transmitter power per traffic channel	34.77 dBm	28.77 dBm
(a2)	Maximum total transmitter power	(varies)	28.77 dBm
(b)	Cable, connector, and combiner losses	2 dB	0 dB
(c)	Transmitter antenna gain	27 dBi	0 dBi
(d1)	Transmitter e.i.r.p. per traffic channel = (a1-b+c)	59.77 dBm	28.77 dBm
(d2)	Total transmitter e.i.r.p. = (a2-b+c)	(varies)	28.77 dBm
(e)	Receiver antenna gain	0 dBi	27 dBi
(f)	Cable and connector losses	0 dB	2 dB
(g)	Receiver noise figure	5 dB	5 dB
(h)	Thermal noise density	-174 dBm/Hz	-174 dBm/Hz
(H)	(linear units)	3.98E-18 mW/Hz	3.98E-18 mW/Hz
	Interference power level	-160 dBm	-160 dBm
	30 kHz is the channel bandwidth	44.77 dB(Hz)	44.77 dB(Hz)
(i)	Receiver interference density	-205 dBm/Hz	-205 dBm/Hz
(I)	(linear units)	3.33E-21 mW/Hz	3.33E-21 mW/Hz
(j)	Total effective noise plus interference density = 10 log (10^((g+h)/10)+I)	-169.0 dBm/Hz	-169.0 dBm/Hz
(k)	Information rate = (10 log Rb)	46.87 dB(Hz)	46.87 dB(Hz)
(l)	Required Eb/(No+Io)	16.99 dB	16.99 dB
(m)	Receiver sensitivity = (j+k+l)	-105.14 dBm	-105.14 dBm
(n)	Hand-off gain	4 dB	4 dB
(o)	Explicit diversity gain	0 dB	0 dB (6 dB original)
(oí)	Other gain	0 dB	0 dB
(p)	Log-normal fade margin (95% over the cell area)	11.4 dB	11.4 dB
(q)	Free space loss (90-15 deg. elevation angle)	124.9-136.6 dB	124.9-136.6 dB
(r)	Link margin = (d1+e-f-m+n+o+oí-p-q)	32.6-20.91 dB	26.6-14.91 dB

3.2.2 Example CDMA System

A terrestrial IMT-2000 system using HAPS may also use CDMA based IMT-2000 radio transmission techniques derived from standards such as IS-95 (and its extensions) and other emerging wideband CDMA standards. An example HAPS system using a CDMA payload using a phased array antenna provides continuous coverage to an area that is 500 kilometer in radius. The cell size and the capacity are determined by the antenna characteristics of the HAPS communications payload, rather than by the terrain features of the coverage area as in terrestrial deployment.

An example CDMA system may project 700 macrocells with a minimum diameter of 900 meters within a 75 kilometers radius region each using the same frequency (or frequencies for an FDD system). A phased array antenna generates spot beams with approximately 1024 elements. In addition to the 700 spot beams, which form contiguous macrocell coverage, there are 300 or more microcell coverage spot beams with a minimum beam radius of about 150 meters.

A key issue for terrestrial IMT-2000 systems using HAPS and a CDMA radio interface is the required power of the user mobile terminal. The link budgets in Table 2 and Table 3 indicate that for both voice and high-speed data services, the power required by the mobile terminal is comparable to that required for traditional terrestrial systems. The large link margin provides the possibility that service can be provided to users even in extremely shadowed regions (e.g., urban canyons and inside buildings).

The channel capacity of a CDMA system is interference limited, not noise limited as in the case of TDMA, hence the signal to noise plus interference ratio saturates at a rather modest power level. An increase of the signal power also leads to an increase of the interference. Therefore, the link margin of a CDMA system is defined with respect to a percentage of the maximum capacity. So, for example, if the link margin is defined with respect to 90% of the maximum capacity, then the interference level should be nine times the noise level. This in turns implies that the SNR (actually $\mathbf{E_b/N_o}$) should be ten times the required $\mathbf{E_b/N_o}$ in order to achieve the same BER in the absence of interference. Mathematically,

$$\mathbf{E_b/N_o} = (\mathbf{E_b/N_o})_{\text{required}} / (1 - \mathbf{D/D_m}),$$

where $\mathbf{D}$ is the offered capacity and $\mathbf{D_m}$ is the maximum capacity in the limit when the interference level is an order of magnitude higher than the noise level.

The example HAPS CDMA system assumes that orthogonal codes are used in the forward link. This will remove same cell multiple access interference for the forward link. Together with forward link power control, this will allow the forward link to have a much higher capacity than the reverse link.

An example of a wideband HAPS CDMA architecture will use QPSK modulation with a variable length Walsh code for the forward link. The Walsh code length can be varied to achieve variable information bit rates. The direct PN spreading is through a long code with variable spreading factor (processing gain) of from 4 to 256. Multiple spreading code is also used to vary the information bit rate. A K=9 convolution code with code rates ranging from 1/8 to 1/2, together with a variable block size interleaver is used for Forward Error Correction. For high-speed data, optional high rate Reed-Solomon and Turbo codes can be used in addition to the convolutional coder to provide better performance of better than 10^{-10} BER. No diversity antennas are assumed for the user terminals.

The example CDMA reverse link will use either BPSK (GMSK) or QPSK with direct sequence long PN code spreading utilizing both I and Q channels. The spreading will also be variable length with spreading factor from 4 to 256. Walsh codes are used for the control and timing channels before combining with the data channels. Convolution coding with K=9 and rates from 1/8 to 1/2 is used together with variable length interleaving. Optional Reed-Solomon and Turbo coding are also used for better BER performance for high speed data. The reverse link can take advantage of platform antenna diversity which provides additional gain and can mitigate signal fading due to shadowing.

For forward links, OTD (Orthogonal Transmission Diversity) is used to provide diversity gain without the need of multiple antennas in mobile terminals.

For both forward and return channels of this example system, coherent demodulation is used for optimal E_b/N_o performance using the pilot signal for precise timing. The coherency is achieved through the use of a continuous pilot waveform and a separate synchronous channel. The pilot channels use unique spreading codes with over 30 dB spreading gain transmitted at low power. Frame lengths can be from 4.615 ms (GSM compatible) to 20 ms, which provides better interleaving gain. Fast open and closed loop power control is used for optimal capacity and link quality. Data, control and synchronization are multiplexed either through orthogonal channels or by carrier phase (I and Q channels).

Both FDD and TDD can be used. Synchronization among different beams is inherent because a single system timer is used on the platform. All handoff operations use fast softer handoff without the need to resynchronize for millisecond handoff operations. Rake receivers are used at both ends to provide space diversity and to facilitate softer handoffs.

The capacity of a HAPS system using a CDMA based radio interface is comparable, if not better than, that for a traditional terrestrial system using towers and roof-top basestations. By using antennas with sharp focused beams, a HAPS system provides greater protection from interference generated by users in neighboring cells than does a traditional terrestrial system relying on the propagation loss from a neighboring basestation. A sample capacity calculation is provided in Annex 2.

TABLE 2

Example CDMA HAPS Link Budget for Voice Service

			Urban Zone	Urban Zone	Suburban Zone	Suburban Zone	Rural Zone	Rural Zone
			Voice 16 kbps	Voice 16 kbps	Voice 16 kbps	Voice 16 kbps	Voice 16 kbps	Voice 16 kbps
			forward	return	forward	return	forward	return
1	Frequency band	MHz	2000	2000	2000	2000	2000	2000
2	WaveLength	m	0.15	0.15	0.15	0.15	0.15	0.15
3	Bandwidth	MHz	5	5	5	5	5	5
4	Transmitted power	watt	0.005	0.025	0.02	0.025	0.05	0.025
5	Transmitted power	dBW	-23.01	-16.02	-16.99	-16.02	-13.01	-16.02
6	Transmitted power	dBm	7.0	13.98	13.01	13.98	16.99	13.98
7	Transmitter antenna gain	dBi	30	0	30	0	30	0
8	Offpointing Loss	dB	13	13	13	13	13	13
9	Power Control Gain	dB	12	12	12	12	12	12
10	Cable, connector, and combiner losses	dB	2	0	2	0	2	0
11	Transmitter EIRP per traffic channel	dB	3.99	-17.02	10.01	-17.02	13.99	-17.02
12	Elevation angle	deg	65	65	30	30	15	15
13	Altitude	m	2.1E+04	2.1E+04	2.1E+04	2.1E+04	2.1E+04	2.1E+04
14	Slant Path	m	2.3E+04	2.3E+04	4.2E+04	4.2E+04	8.1E+04	8.1E+04
15	Free Space Loss	dB	125.8	125.8	130.9	130.9	136.6	136.6
16	Atmospheric Loss	dB	0	0	0	0	0	0
17	Rain Attenuation (99.999 % avail.)	dB	0	0	0	0	0	0
18	Receiver Antenna Gain	dBi	0	30	0	30	0	30
19	Antenna/OTD diversity Gain	dB	3	3	3	3	3	3
20	Cable, connector losses	dB	0	2	0	2	0	2
21	Boltzman Constant	dB	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
22	Sky temperature	K	290	290	290	290	290	290
23	Thermal noise temperature	dBm/Hz	-173.98	-173.98	-173.98	-173.98	-173.98	-173.98
24	Receiver noise figure	dB	5.00	5.00	5.00	5.00	5.00	5.00
25	G/T: Receiver Figure of Merit	dB	-29.62	0.38	-29.62	0.38	-29.62	0.38
26	Polarization losses	dB	0	0	0	0	0	0
27	Received power	dBW	-118.77	-111.78	-117.92	-116.95	-119.66	-122.67
28	Noise Density	dBW/Hz	-198.98	-198.98	-198.98	-198.98	-198.98	-198.98
29	CDMA system factor	-	0.635	0.635	0.635	0.635	0.635	0.635
30	Required EbN0	dB	2.6	2.6	2.6	2.6	2.6	2.6
31	Information Rate	bps	16000	16000	16000	16000	16000	16000
32	Bit Rate	dB(Hz)	42.0	42.0	42.0	42.0	42.0	42.0
33	Receiver Interference Density	watt/Hz	4.6E-17	2.3E-16	5.5E-17	6.9E-17	3.7E-17	1.9E-17
34	Effective Noise Density	dB/Hz	-163.41	-156.42	-162.55	-161.59	-164.29	-167.30
35	Received Eb	dB	-160.81	-153.82	-159.96	-158.99	-161.70	-164.71
36	Received EbN0	dB	38.16	45.15	39.02	39.99	37.28	34.27
37	Reliability (percent)	-	90%	90%	90%	90%	90%	90%
38	Soft Margin	dB	28.16	35.15	29.02	29.99	27.28	24.27

TABLE 3

Example CDMA HAPS Link Budget for High Speed Data (micro-cell beam)

			Urban Zone	Urban Zone	Rural Zone	Rural Zone
			HS 512 kbps	HS 384 kbps	HS 512 kbps	HS 384 kbps
			forward	return	forward	return
1	Frequency band	MHz	2000	2000	2000	2000
2	WaveLength	m	0.15	0.15	0.15	0.15
3	Bandwidth	MHz	5	5	5	5
4	Transmitted power	watt	0.1	0.025	0.1	0.1
5	Transmitted power	dBW	-10.0	-16.0	-10	-10
6	Transmitted power	dBm	20.0	14.0	20	20
7	Transmitter antenna gain	dBi	50	0	50	50
8	Offpointing Loss	dB	13	13	13	13
9	Power Control Gain	dB	12	12	12	12
10	Cable, connector, and combiner losses	dB	2	0	2	2
11	Transmitter EIRP per traffic channel	dB	37.00	-17.02	37	37
12	Elevation angle	deg	65	65	15	15
13	Altitude	m	21000	21000	21000	21000
14	Slant Path	m	23170.9	23170.9	81137.8	81137.8
15	Free Space Loss	dB	125.8	125.8	136.6	136.6
16	Atmospheric Loss	dB	0	0	0	0
17	Rain Attenuation (99.999 % avail.)	dB	0	0	0	0
18	Receiver Antenna Gain	dBi	0	50	0	0
19	Antenna/OTD diversity Gain	dB	3	3	3	3
20	Cable, connector losses	dB	0	2	0	0
21	Boltzman Constant	dB	-228.6	-228.6	-228.6	-228.6
22	Sky temperature	K	290	290	290	290
23	Thermal noise temperature	dBm/Hz	-173.98	-173.98	-173.98	-173.98
24	Receiver noise figure	dB	5	5	5	5
25	Receiver Figure of Merit	dB	-29.62	20.38	-29.62	-29.62
26	Polarization losses	dB	0	0	0	0
27	Received power	dBW	-85.76	-91.78	-96.65	-96.65
28	Noise Density	dBW/Hz	-198.98	-198.98	-198.98	-198.98
29	CDMA system factor	-	0.635	0.635	0.635	0.635
30	Required EbN0	dB	4.2	4.2	4.2	4.2
31	Information Rate	bps	512000	384000	512000	384000
32	Bit Rate	dB(Hz)	57.09	55.84	57.1	55.8
33	Receiver Interference Density	watt/Hz	2.0E-15	6.6E-16	1.6E-16	2.1E-16
34	Effective Noise Density	dB/Hz	-147.05	-151.82	-157.9	-156.7
35	Received Eb	dB	-142.85	-147.62	-153.7	-152.5
36	Received EbN0	dB	56.12	51.35	45.2	46.5
37	Reliability (percent)	-	90%	90%	90%	90%
38	Soft Margin	dB	46.12	41.35	35.24	36.49

4 IMT-2000 ITU-R Recommendations and HAPS

As outlined in the general framework and requirements Recommendations (e.g., Recommendations ITU-R M.816, M.1034, and M.1079), the key features of IMT-2000 are:

- high degree of commonality of design world-wide,

- compatibility of services within IMT-2000 and with the fixed networks,
- high quality,
- use of a small pocket terminal worldwide.

A terrestrial system using HAPS provides these features and supports service to the operating environments defined in ITU-R M.1034. Section 4 outlines the characteristics of a HAPS system that are similar to a traditional terrestrial system. In addition, Section 4 reviews the existing IMT-2000 recommendations and provides the rationale for a new recommendation concerning HAPS and IMT-2000.

4.1 Characteristics of a Terrestrial IMT-2000 System Using HAPS

Terrestrial systems using HAPS and accepted IMT-2000 Radio Transmission Technologies (RTTs) can provide the same functionality and meet the same service and operational requirements as traditional terrestrial systems. This section provides a basic comparison between traditional terrestrial systems and terrestrial systems using HAPS.

A terrestrial mobile system using HAPS supports most of the same environments as traditional networks. In addition, both HAPS and traditional terrestrial systems have many of the same features as outlined in Table 4. Although the delivery platform for HAPS (base stations consolidated on a geostationary platform in the stratosphere) is very different from traditional systems (base stations distributed on towers and rooftops), the mobile network operates in the same fundamental manner transparent to the user. Only very small pico-cell (< 100 m) and indoor high-speed operations are not supported by HAPS. Although comparable in many ways to traditional terrestrial systems, the HAPS system offers certain additional features. First, a single HAPS can serve a footprint that extends over an entire 500km radius footprint. Second, the delivery of service from the stratosphere enables a softer handoff operation from cell to cell. All the cell antennas in the system are collocated on the platform thereby eliminating the need to use time delay correction to synchronize the codes used by the beams involved in the handoff operation[1]. Third, the system executes handoff operations in several chip times thereby enabling service to extremely fast moving vehicles. Fourth, dynamic beam assignment allows the system to provide service to traffic hot spots throughout the footprint and also enables point to point high speed coverage throughout the coverage area[2]. Last, the HAPS system provides an improved radiation pattern for beams than the R^{-x} law (x ~ 4) used by terrestrial base station antennas This enables higher spectrum efficiency across the entire coverage area since other cell interference is greatly reduced[3]. The HAPS system can employ JD(D) (Joint-Detection-Demodulation) or IC (Interference-Cancelling) for both intra-cell interference mitigation and adjacent cells to achieve even higher spectrum efficiency[4].

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1 Traditional terrestrial CDMA Base Stations employ sectorized antennas that are all collocated within each cell. This enables a very soft handoff within each cell.

2 Dynamic beam assignment is available within each cell in traditional terrestrial systems through either sectorized antennas or adaptive array antenna technology but the dynamic radio resource allocation cannot extend beyond the confines of a single cell.

3 New antenna designs can improve sectorization performance of traditional terrestrial CDMA systems to realize similar capacity gain within a single cell.

4 Although JD/IC techniques are currently being used by some terrestrial systems, it has not been practical to apply joint techniques to combat interference from adjacent base stations.

TABLE 4

Terrestrial System Comparison: Traditional & HAPS

Parameters	**Traditional Terrestrial System**	**HAPS**
System Coverage		
Cell size (r = radius)	Different sizes supported: pico: *r* < 100 m micro: 100 m < *r* < 1 km macro: *r* > 1 km	Different sizes supported: micro: 150 m < *r* < 1 km macro: 1 km < *r* < 20 km regional: *r* > 20 km
Environments		
Business indoor environment	Supported (specialized indoor systems)	Not supported
Neighbourhood indoor/outdoor environment	Supported	Supported
Home environment	Supported (specialized systems)	Not supported
Urban vehicular outdoor environment	Supported	Supported
Urban pedestrian outdoor environment	Supported	Supported
Rural outdoor environment	Supported	Supported
Terrestrial aeronautical environment	Supported	Supported
Fixed outdoor environment	Supported	Supported
Local high bit rate environment	Supported	Supported
Mobile Station		
Power (EIRP)	< 1 W	< 1 W
Antenna	Omni (Ú 0 dBi gain)	Omni (Ú 0 dBi gain)
Base Station		
Infrastructure	Tower or roof-top	Geostationary platform in stratosphere
Power (EIRP)	[30 dBW]	30 dBW
Antenna gain	13 dBi (vehicular) 10 dBi (pedestrian) 2 dBi (indoor)	30-50 dBi (peak)

4.2 IMT-2000 Recommendations & HAPS

The series of ITU-R Recommendations developed by ITU-R Task Group 8/1 provide the fundamental definition of IMT-2000 and the requirements for IMT-2000 systems. These recommendations focus on the framework for IMT-2000, service requirements, and radio-interface requirements. These recommendations outline the framework for both a terrestrial component and a satellite component with correspondingly different requirements in several specific areas. The recommendations assume the use of traditional tower or rooftop based base stations. However, they do not limit terrestrial stations to the traditional tower configuration and they do not preclude the use of a basestation network located in the stratosphere (i.e., systems using HAPS). Table 5 provides a summary of the existing ITU-R Recommendations concerning IMT-2000. Except for differences involving the specific channel environment parameters (e.g., propagation model), this contribution proposes that IMT-2000 architectures and services can be met with a terrestrial system using HAPS and IMT-2000 compatible RTTs.

The existing ITU-R Recommendations concerning IMT-2000 assume the use of traditional tower and rooftop deployed basestations as the terrestrial component's infrastructure. This assumption informs the choice of propagation models, terminology, and other subtle references to the terrestrial component. This assumption, however, is general and focuses on the functionality of services, and does not describe the terrestrial infrastructure. A new Recommendation is important to ensure that Administrations, network operators, and other organizations deploying IMT-2000 systems understand that a terrestrial system can, as an option, use high altitude platform stations as part of their deployment of a terrestrial IMT-2000 system.

Annex 1 presents a proposed preliminary draft new Recommendation indicating that HAPSs are terrestrial stations within the IMT-2000 terrestrial component. The preliminary draft new Recommendation provides a simple clear statement that a terrestrial IMT-2000 can use HAPS as part of, or as a stand-alone terrestrial network providing IMT-2000 services. While this preliminary draft new recommendation does not focus on radio transmission technologies (which is the focus of many of the IMT-2000 recommendations), this recommendation is important to enable a WRC to inform Administrations, network operators, and other organizations that HAPS are authorized IMT-2000 terrestrial stations. Service providers are not obligated to use HAPSs, but they do provide an option for those wishing to use this emerging technology.

TABLE 5

IMT-2000 ITU-R Recommendations and HAPS

ITU-R Rec.	Title	Purpose	Impact of HAPS
M.687	Future Public Land Mobile Telecommunication Systems (FPLMTS)	Defines IMT-2000 objectives and provides overall concept emphasizing world-wide roaming and compatibility	ï None
M.816	Framework for services supported on Future Public Land Mobile Telecommunication Systems (FPLMTS)	Describes framework for IMT-2000 services	ï None
M.817	Future Public Land Mobile Telecommunication Systems (FPLMTS): Network Architecture	Outlines IMT-2000 architecture	ï None
M.819	Future Public Land Mobile Telecommunication Systems (FPLMTS) for developing countries	Describes objectives to meet the needs of developing countries	ï HAPS systems provide cost-effective deployment of services
M.1034	Requirements for the radio interface(s) for Future Public Land Mobile Telecommunication Systems (FPLMTS)	Provides high-level view of the constraints placed on the radio interface(s)	Some of the assumed characteristics do not accurately portray a HAPS operational environment (e.g., propagation models)
M.1035	Framework for the radio interfaces and radio subsystem functionality for Future Public Land Mobile Telecommunication Systems (FPLMTS)	Presents overview and guidelines for radio subsystem development	ï None
M.1036	Spectrum considerations for implementation of Future Public Land Mobile Telecommunication Systems (FPLMTS) in the bands 1Ü885-2Ü025ÜMHz and 2Ü110-2Ü200ÜMHz	Defines spectrum considerations for IMT-2000	ï None
M.1079	Speech and voiceband data performance requirements for Future Public Land Mobile Telecommunication Systems (FPLMTS)	Defines performance requirements for IMT-2000	ï None
M.1224	Vocabulary of terms for Future Public Land Mobile Telecommunication Systems (FPLMTS)	Defines IMT-2000 terms	Additional definition for HAPS is suggested for inclusion

ITU-R Rec.	Title	Purpose	Impact of HAPS
M.1225	Guidelines For Evaluation Of Radio Transmission Technologies For IMT-2000	Provides guidelines for evaluating RTTs	Some methodologies do not replicate the HAPS operational environment (e.g., propagation models)

5 Summary and conclusions

This paper provides the preferred characteristics of a terrestrial IMT-2000 system using high altitude platform stations (HAPS) and indicates further study is required to determine the conditions for sharing and co-ordination between high altitude platform stations and other stations in IMT-2000 networks, the fixed service, the mobile service, and the space research service. A new Recommendation is needed to provide a framework for WRC-99 to ensure that this emerging technology is included within the terrestrial component of IMT-2000. The HAPS communications payload can utilize various multiple-access techniques and standards (e.g., TDMA, CDMA) that meet IMT-2000 requirements. In addition, the HAPS system can be designed to serve as the sole station in a stand-alone infrastructure (essentially, replacing the tower basestation network with a “basestation network in the sky”) or can be integrated into a system that employs traditional terrestrial basestation towers, satellites, and HAPS.

The existing ITU-R Recommendations concerning IMT-2000 assume, without precluding a HAPS based terrestrial architecture, the use of traditional tower and rooftop deployed basestations as the terrestrial component’s infrastructure. Because of this underlying assumption in the IMT-2000 Recommendations, a new Recommendation is necessary to draw the attention of Administrations, network operators, and other organizations deploying IMT-2000 systems to the emerging technology of high altitude platform stations within the terrestrial component of IMT-2000.

Annexes: 2

ANNEX 1

Framework for a preliminary draft new recommendation

Task Group 8/1

PRELIMINARY DRAFT NEW RECOMMENDATION

OPERATIONAL AND TECHNICAL CHARACTERISTICS FOR A TERRESTRIAL IMT-2000 SYSTEM USING HIGH ALTITUDE PLATFORM STATIONS

(Question ITU-R 39/5-8)

The ITU Radiocommunication Assembly,

considering

a) that S5.388 (MOD WRC-97) indicates that the bands 1885-2025 MHz and 2110-2200 MHz are intended for use, on a worldwide basis, by administrations wishing to implement International Mobile Telecommunications-2000 (IMT-2000);

b) that the segments of the bands that are intended for the terrestrial components of IMT-2000 and that are not shared with the mobile-satellite service in Regions 1 and 3 are the bands 1885-1980 MHz, 2010-2025 MHz, and 2110-2170 MHz; and in Region 2 the bands 1885-1980-MHz and 2110-2160 MHz;

c) that new technology utilizing high altitude platform stations (RR S1) in the stratosphere is being developed (see [§2 of paper]);

d) that systems utilizing one or more high altitude platform stations located at a fixed point in the stratosphere offer desirable attributes for IMT-2000 mobile services and wireless access systems, comprising voice, data, and video services (see [§3 of paper]);

e) that such systems would be able to provide coverage to metropolitan regions with high elevation angles and short path lengths, and to outlying rural areas with low elevation angles while satisfying IMT-2000 service requirements (see [§3 of paper]);

f) that such systems provide coverage on a regional (“macro” cell) or local (“micro” cell) scale, consistent with the terrestrial component of IMT-2000, but do not provide coverage on a global scale like the satellite component of IMT-2000;

g) that high altitude platform stations, as defined in RR Article S1, are located at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth, and, as such, are within the Earth’s atmosphere and are not in orbit like a space station;

h) that such systems provide delivery platforms that are expected to use standards adopted for IMT-2000 radio interfaces and networks;

j) that decides 5, 6 and 12 of Question ITU-R 39-5/8 seek recommendations on the system structure, overall system characteristics and special criteria for spectrum sharing for the terrestrial and space components of IMT-2000, *recommends*

1 that for the bands mentioned in considering b), the terrestrial component of IMT-2000 should include systems using either traditional ground-based stations or high altitude platform stations or both types of stations (see Note 1);

2 that high altitude platform stations, as defined in **RR Article S1**, may provide both mobile and fixed wireless access services in bands designated for the terrestrial component of IMT-2000;

3 that high altitude platform stations should provide IMT-2000 services using air-interface and network standards according to IMT-2000 Recommendations;

4 that further study is required to determine the conditions for sharing and co-ordination between high altitude platform stations and stations in IMT-2000 networks, the fixed service, the mobile service, and the space research service.

NOTE 1 - Considering RR S4.15A (WRC-97), which states that “Transmissions to or from high altitude platform stations shall be limited to bands specifically identified in Article S5”, a future WRC will need to adopt suitable regulatory provisions to enable the implementation of HAPS as a terrestrial component of IMT-2000.

ANNEX 2

Capacity Calculations for Example CDMA HAPS System

The capacity of a CDMA HAPS system is defined by the interference caused by the simultaneous communications between the HAPS and the users. The local noise level is on average much weaker than the interference level under normal operating conditions and therefore the capacity is essentially independent of the noise level. The relationship between the signal to noise ratio (SNR) and the network capacity can be expressed as

$$\mathbf{E_b/N_o} \geq (\mathbf{E_b/N_o})_{\text{required}} / (1 - \mathbf{D/D_m}) \quad (1)$$

Where **D** is the actual network data throughput and $\mathbf{D_m}$ is the maximum network capacity. $(\mathbf{E_b/N_o})_{\text{required}}$ is the minimum SNR needed to achieve a particular BER (bit error rate) performance. So, for example, in order to provide 90% of the maximum capacity level, the SNR must be ten times the minimum SNR in the absence of the interference. The right hand side of Equation 1 can be considered to be the SNR threshold in the presence of interference. This is a soft threshold since a reduction of the network traffic lowers the threshold.

The interference level can be obtained from the carrier-to-interference ratio C/I that is determined by the antenna radiation pattern. At 2 GHz, the wavelength is approximately 15 cm. To project a spot beam of sufficiently small size on the earth from an altitude of 21 km, the antenna aperture must be at least 2 m in diameter. A multi-beam phased-array antenna with dimensions on the order of 10 - 15 m is sufficient to project a 150 m radius microcell-size spot near nadir. With all digital beam forming network, it is possible to project a thousand spot beams from a single array antenna containing 64 x 64 elements. Such an array antenna is capable of projecting both microcell and macrocell sized beams.

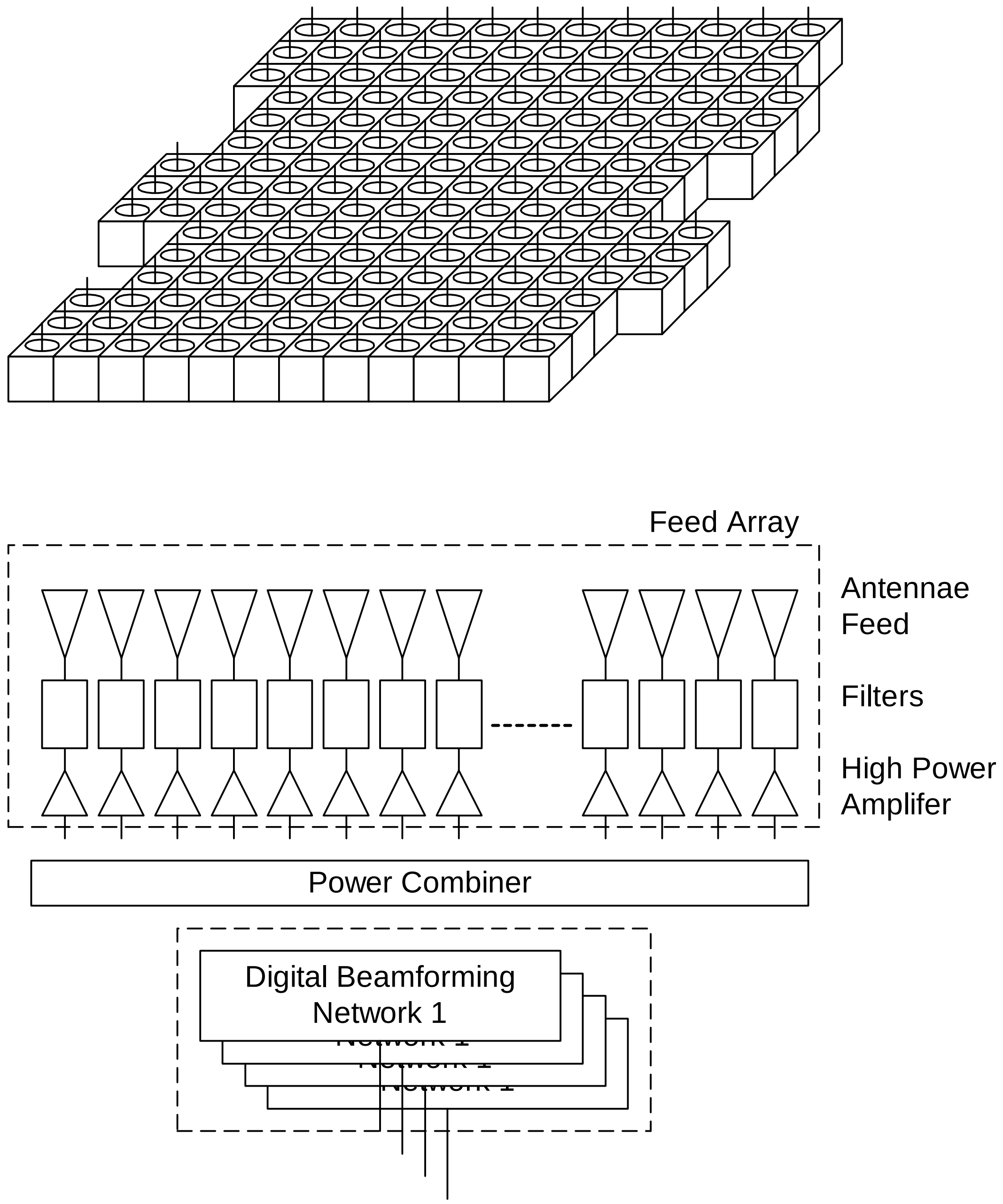

FIGURE B-1

Example CDMA Phased Array Antenna Architecture

To reduce adjacent cell interference, a two-dimensional cosine-squared amplitude taper is used to provide a –32 dB peak sidelobe level and a fast inverse 6th power law sidelobe decay. The radiation pattern for a 32 x 32 element phased array along the center line along one of its axis is shown in Figure B-2.

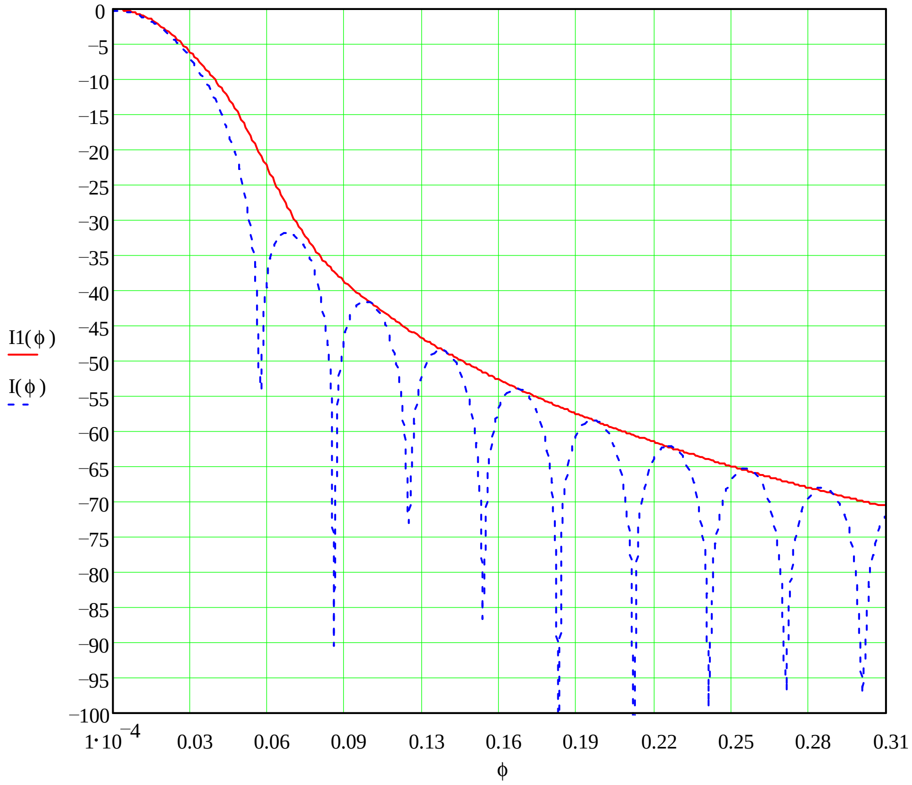

FIGURE B-2

The radiation pattern for a phased array

The antenna has a directivity pattern given by

$$E(j\,,f)=\frac{\sin(u(j\,))\cdot\sin(u(f))}{u(j\,)\cdot u(f)}\cdot\frac{1}{1-\left(\frac{u(f)}{p}\right)^{2}}\cdot\frac{1}{1-\left(\frac{u(j\,)}{p}\right)^{2}}$$

(2)

Where φ and ϕ are the directional angles along the two axis and u(φ) = (πL/λ)sin(u(φ). L is the length of the antenna, and λ is the wavelength.

Also shown in the graph is an analytical upper bound given by the following expression:

$$I1(f)=10\cdot\log\left[\exp(-b\cdot u(f)^{2})+\frac{1}{\frac{225}{64}\cdot p^{2}\cdot\exp\left[-b\cdot\left(u(f)^{2}-\frac{9}{4}\cdot p^{2}\right)\right]+u(f)^{2}\cdot\left(1-\frac{u(f)^{2}}{p^{2}}\right)^{2}}\right]$$

(3)

(3)

where b is $\pi^2/3 - 2/\pi^2$. The bound removes the oscillatory behaviour of the radiation pattern that is sensitive to phase errors. For $\boldsymbol{u(f)} < \pi$, the radiation pattern is well approximated by a two dimensional Guassian of the form $e^{-b(u(f)^2+u(j)^2)}$.

The cells are arranged in such a way that two adjacent cells intercepted at –13 dB level down from the main peak. Such a choice reduces other cell interference if both forward and reverse power control are used. The power control is considerably simpler than in the terrestrial situations where more than 45 dB dynamic range is usually required for effective power control.

To reduce same cell interference on the forward link, orthogonal Walsh codes are utilised. This is necessary since forward link power control will actually increase intra-cell interference if non-orthogonal PN codes are used. Forward power control reduces the average power transmitted to mobile terminals by a factor of $(1-e^{-3})/3 = 0.317$ using the Gaussian approximation, noting that e^{-3} (-13 dB) is the edge of cell signal reduction factor and circular boundary has been used to approximate the real boundary. By taking into account the two nearest interfering beams plus the next 3 interfering beams and by bounding the remaining beam sidelobes, the following expression for C/I at the edge of the cell for the forward link is obtained:

$$C/I = 1/(0.635M). \quad (4)$$

Note that the intra-cell interference is not counted because of the use of orthogonal spreading code. M is the average number of interfering channels. Note also that because of the lack of intra-cell multipath interference, the forward link orthogonality factor is taken to be less than 0.03 for indoor-to-outdoor and pedestrian environments. We expect that for vehicular environment, the forward link orthogonality factor will be higher, which will lower the capacity for vehicular voice and data traffics.

For reverse link, orthogonal codes are not used. Using reverse link power control, the other-cell interference contribution can be bounded by 0.33 of the intra-cell interference. Thus the channel-to-interference ratio C/I at the cell edge has the following expression:

$$C/I = 1/(1.33M). \quad (5)$$

Clearly, the reverse link has roughly half the capacity of the forward link. Hence the symmetric two way traffic capacity is determined by the capacity of the reverse link. However, for Internet applications, a higher forward link speed is actually an advantage. In TDD mode, the asymmetry can be partially compensated for by using unequal time slots in the forward and reverse directions.

The maximum capacity can be determined by the relation:

$$E_b/I_o = CW/(IR) > \text{SINR threshold} \quad (6)$$

where W is the bandwidth and R is the data bitrate of the individual user channel. The signal to interference plus noise ratio threshold is determined by the FEC coding and modulation method. Here QPSK and 1/4-rate convolution coding with K=9 is assumed. At BER of 10^{-6} under AWGN fade condition, including hardware implementation loss, the threshold is 4.2 dB. For a 5 MHz bandwidth, this gives 89 16 kbps channels (using 13.3 kbps vocoder) on the reverse link. The forward link has much higher capacity. For the same bandwidth, it can provide 183 16 kbps channels. If the BER requirement is reduced to 10^{-3} for voice, then the threshold is 2.6 dB. Assuming voice activity factor of 50%, the number of 16 kbps channels the reverse link can support increases to 258, the same number for the forward link at 33 kbps. In practical terms, with just

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10 MHz (5 MHz for each direction for FDD), HAPS can provide 180,600 simultaneous 16 kbps calls for the 700 macro-beams. A license of 5 MHz (for both directions using TDD) for the 300 microcell beams will provide 19,350 16 kbps calls.

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Task Group 8/1
(WG 1)

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Liasion Statement to ITU-D Study Group 2 on High Altitude Platform Station

Task Group 8/1 at its April 98 Meeting at Geneva has considered the input document from USA Doc. 8-1/80 “working Document towards a Prelimenary Draft New Recommendation on Operational and Technical Characteristics for a terrestrial IMT-2000 System Using High Allitude Platform stations”(HAPS). Working Group 1 observed that a single HAPS may deliver mobile and fixed wireless services in a large area at low cost. Further, WG 1 noted the use of this new technology and it might be an option to provide rapid deployment of terrestrial IMT-2000 services to the developing countries . WG 1 would like to send the document 8-1/80 for further consideration by ITU-D Study Group 2.

Ashok Kumar

Chairman Working Group 1