

RECOMMENDATION ITU-R F.1500*

**PREFERRED CHARACTERISTICS OF SYSTEMS IN THE FIXED
SERVICE USING HIGH ALTITUDE PLATFORMS OPERATING
IN THE BANDS 47.2-47.5 GHz AND 47.9-48.2 GHz**

(Question ITU-R 212/9)

(2000)

The ITU Radiocommunication Assembly,

considering

- a) that new technology utilizing telecommunication relays located at fixed points in the stratosphere is being developed (see Note 1);
- b) that systems utilizing one or more high altitude platform stations (HAPS) located at a fixed point in the stratosphere may possess desirable attributes for high-speed broadband digital communications, including interactive video and other applications, with significant potential for frequency reuse;
- c) that such systems would be able to provide coverage to metropolitan regions with high elevation angles, and to outlying rural areas or neighbouring countries with low elevation angles;
- d) that broadband digital services provided by such systems in the fixed service (FS) are intended to provide widespread communications information infrastructures promoting the global information infrastructure;
- e) that radio links between HAPS relays may provide a nationwide or regionwide telecommunication network;
- f) that the radio spectrum above 30 GHz is allocated to a variety of radio services and that many different systems are already using or planning to use these allocations;
- g) that there is an increasing demand for access to these allocations;
- h) that because systems in the FS using HAPS can use the full range of elevation angles, sharing with other FS systems and systems in other services in the bands 47.2-47.5 GHz and 47.9-48.2 GHz may present difficulties;
- j) that according to RR No. S5.552A the allocation to the FS in the bands 47.2-47.5 GHz and 47.9-48.2 GHz, is designated for use by HAPS;
- k) that according to Resolution 122 (WRC-97), administrations are urged to facilitate coordination between HAPS in the FS operating in the bands 47.2-47.5 GHz and 47.9-48.2 GHz and other co-primary services in their territory and adjacent territories,

recommends

- 1** that the characteristics of systems in the FS using HAPS as shown in Annex 1 be provisionally used in analysing the frequency reuse and the sharing possibilities between such systems and other systems in the FS in the bands 47.2-47.5 GHz and 47.9-48.2 GHz.

NOTE 1 – It is recognized that systems utilizing HAPS in the stratosphere have a potential applicability to various services such as mobile and broadcasting services. This Recommendation is focused only on the FS applications.

* This Recommendation should be brought to the attention of Radiocommunication Study Groups 1 (Working Party (WP) 1A), 3 (WPs 3K and 3M), 4 (WP 4A), 6 (WPs, 6E and 6S), 7 (WP 7D), 8 (WPs, 8A, 8D and 8F) and Telecommunication Development Study Group 2.

Preferred characteristics of systems in the FS using high altitude platforms operating in the bands 47.2-47.5 GHz and 47.9-48.2 GHz

1 Introduction

Resolution 122 (WRC-97) requested urgent studies on the appropriate technical sharing criteria between systems using HAPS in the FS and systems in the fixed, fixed-satellite and mobile services in the bands 47.2-47.5 GHz and 47.9-48.2 GHz.

As a part of those studies, this Annex presents a set of technical parameters for high-density applications in the FS using high altitude platforms.

2 The high altitude platform system

The system comprises a high altitude platform in a nominally fixed location in the stratosphere at a height of 21 to 25 km. Communication is between the platform and user terminals on the ground in a cellular arrangement permitting substantial frequency reuse. User terminals are described as being within one of three zones: urban, suburban and rural area coverages (UAC, SAC and RAC, respectively).

In addition, communications are established in the same frequency bands, between the platform and a number of gateway stations on the ground, located in the UAC or SAC, which provide interconnection with the fixed telecommunication network.

2.1 Operating characteristics

The high altitude platform is powered by efficient solar cells and regenerative hydrogen-oxygen fuel cells. The components of the regenerative fuel cell and electrolyzer subsystem converts water into fuel during the day and the fuel is used to generate the electrical power needed for night operation. The electrolyzer converts water into hydrogen and oxygen gas for fuel cell operation at night. The propulsion subsystem consists of variable speed electric motor-driven stern propellers, although other types of propulsion means with similar performance characteristics can also be employed. The HAPS uses a differential GPS sensor for closed loop control maintenance of its spatial location to a 400 m radius circle and a vertical dimension to ± 700 m at altitude.

The payload will be supported by a 3-axis gimbal system. The payload will have its own stabilization system to compensate for the motion of the platform and maintain a stable coverage pattern on the ground. The payload will also provide its own thermal control. The payload will be cooled by a pressurized forced flow.

HAPS total coverage area is divided into three zones. These zones are necessary to ensure users have consistent broadband service across HAPS's wide footprint of about 1 000 km in diameter. The zones are:

- UAC: the UAC extends from 36 to 43 km out from a point directly under the platform. Users in these zones can use portable user terminal modems with a beamwidth of about 11° , or 26 dBi antenna gain, and 10 cm $\times$ 10 cm antennas. The antennas on the platform should have a gain of 30 dBi (1 W of RF power per channel). All users in these zones will have a 30° to 90° angle of elevation from the ground to a HAPS platform. The user terminals require approximately 0.15 W of transmission RF power.
- SAC: the SAC extends from the UAC to 76.5/90.5 km, depending on the operating altitude. Users in the SAC will use higher gain (41 dBi) directional antennas with a transmission power of 0.2 W. The same antennas can also be used in the UAC zones for fixed rooftop installation. The platform transmit antennas are the same as in UAC. The elevation angles range from 15° to 30° .
- RAC: the elevation angles are from 15° to 5° . This is reserved for dedicated high-speed point-to-point access and wide-area coverage at lower frequency bands such as 800 MHz to 5 GHz bands. There is too much atmospheric and rain attenuation at 47/48 GHz.

TABLE 1
Coverage zones

Coverage area	Elevation angles (degrees)	Ground range (km)	
		Platform at 21	Platform at 25
UAC	90-30	0-36	0-43
SAC	30-15	36-76.5	43-90.5
RAC	15-5	76.5-203	90.5-234

A typical HAPS platform payload will have gimbaled slotted array antennas with polarizer insert to ensure proper cross-polarization isolation. The array antennas will project a total of 700 beams in each of the UAC and SAC zones, and selective coverage in the RAC zone with up to 700 beams. The cell pattern will have a 7:1 frequency reuse factor.

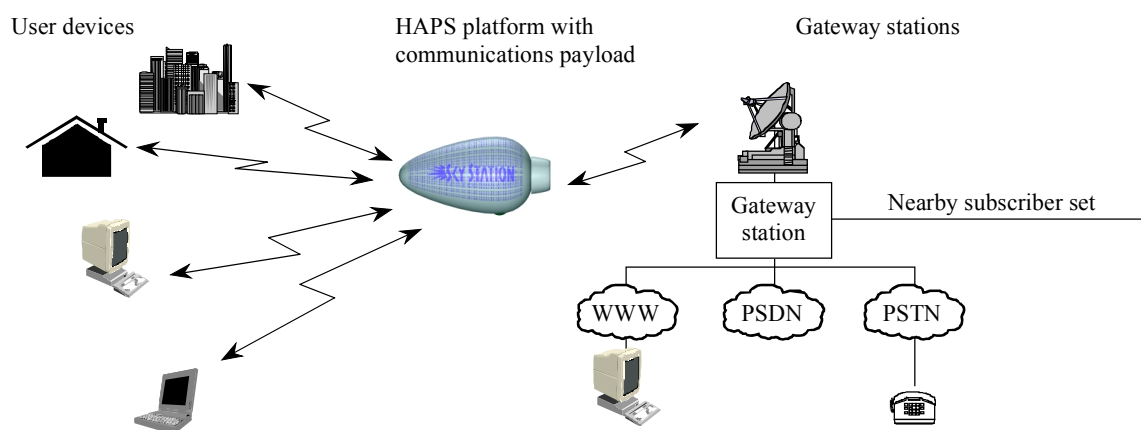
To maximize spectral efficiency, a dynamic assignment multiple access (DAMA) scheme is used to allow users to share bandwidth efficiently, and there are on-board asynchronous transfer mode (ATM) switches and ATM multiplexers to statistically multiplex the user traffic. Both uplink and downlink use QPSK modulation and rate 0.6 concatenated FEC coding (Reed-Solomon + rate 2/3 convolutional coding with constraint length 9). Interleave coding is also used to mitigate burst errors. Because of efficient sharing of bandwidth and the low-duty factor of most types of broadband traffic, all 110 560 users can expect to achieve a maximum upload speed of 2.048 Mbit/s and download speed of 11.24 Mbit/s with a frequency allocation of only 2×100 MHz. Assuming an average of 10% of the total subscriber population to be active at any given time, a single HAPS network (HAPN) can thus support a subscriber population of about one million users given the 2×100 MHz allocation. If the frequency allocation is increased to 2×300 MHz, then a single HAPN can be expected to support more than five million subscribers.

The baseline system also includes multiple gateway ground stations which use high-speed synchronous time division multiplexed (TDM) per link for feeder traffic interconnecting HAPN to PSTN and the Internet. The feeder link speed is up to 0.72 Gbit/s for a 300/300 MHz frequency allocation. 64-QAM modulation and rate 0.71 FEC coding are used to optimize the available bandwidth. Additional high-speed point-to-point links can also be provided for corporate customers and service providers.

2.2 Communications system performance characteristics

HAPN has a star configuration, with the HAPS platform serving as the main hub. The payload projects multiple spot beams onto the ground and provides ubiquitous coverage over a roughly 150 km diameter circle.

FIGURE 1
Network configuration



PSDN: packet switched data network

User terminals are portable devices that communicate with the payload directly. A user terminal consists of an antenna unit and a digital interface unit. A variety of digital interface units are envisioned, including PC cards and multi-function set-top boxes. User-to-user communications are switched directly by the payload, which contains a large ATM switch.

Gateway stations are provided to allow user access to the existing public networks, such as PSTN and Internet. The system is designed to allow gateway stations to be located essentially anywhere within the coverage area, so as to minimize the ground infrastructure requirement. Typically they will be co-located in a carrier's central office (CO) or an Internet service provider (ISP) point-of-presence (PoP). Gateway stations on the ground can be added, as business requires.

In the first generation systems there will be no direct link between two HAPNs. Inter-HAPN communications will be carried out via gateway stations. The gateway capacity is 4-12 Gbit/s, capable of handling 60% of all user traffic. The total capacity of the payload is therefore 11-33 Gbit/s.

The HAPS system is designed to provide variable rate, full duplex, digital channels to homes and the so-called small office/home office (SOHO). The intended services are multimedia applications such as videoconferencing and videophones in addition to high-speed Internet access. The high bit rates, a large metropolitan coverage, and the fact that the user terminals are not dependent upon a ground infrastructure, also makes the HAPS an ideal platform for telecommuting and working-at-home, your own home or your client's home. Therefore, the system is designed to support a large number of virtual local area networks (LANs), so users can access their corporate networks as if they were in the office.

In the downlink each user terminal will receive all the time, but it will only keep those cells it has rights to. This way we can take maximum advantage of the statistical multiplexing of the ATM switch.

A gateway station uses the same frequencies except for the one segment used by the cell in which it is located. So each gateway uses a major portion of the total allocated bandwidth. It also uses the other polarization to provide additional isolation.

The HAPS system will use a pair of bands in the 47.2-48.2 GHz, with a bandwidth of 100 MHz to 300 MHz. With a frequency reuse factor of 7, a 2×100 MHz allocation will be reused 100 times in each of the coverage zones. Each uplink TDMA time slot carries one ATM cell. The asynchronous nature of ATM provides great flexibility. For example, no burst time plan is required. The aforementioned DAMA scheme will be integrated with ATM call and traffic management to maximize the efficiency of communication resource management.

On the user side, intelligent ATM multiplexers are used to reduce the number of ports on the main switch. Each ATM Mux multiplexes 16 beams into an OC3 (optical carrier, level 3 (155.52 Mbit/s)) port on the switch. At least 44 ports are needed to handle $>1\,400$ beams. The dynamic TDMA turns each beam into a shared bus. Up to 1 000 user terminals can be registered at any time. The design basically requires the ATM Mux to handle the non-standard part of the signalling protocols, so we can use standard ATM switches.

The gateway stations provide interface with the public networks, such as a carrier's long-distance backbone and the Internet. The actual configuration depends on the deployment scenario. It is conceivable that a gateway can be devoted to a large ISP like America Online. The system is designed to be able to recognize users when they log on and allow them to connect to their service providers only.

The weight and power budget includes all the baseband equipment, namely the ATM switch and the multiplexers.

The ground system consists of gateway stations and the HAPS control centre. Each gateway station will use high-gain steerable antennas with narrow beams. The RF equipment is similar to those on the payload. The ATM switch required is not large - about four OC3 ports plus whatever is necessary for local servers and/or network management. A multitude of interfaces may be required to connect to the existing public networks, most of which are available today, or soon to be available, as standard options from many vendors. The system is designed to be compliant with existing standards.

For interface with the public ATM network, private network node interface (P-NNI) is preferred because it allows dynamic loading balancing among the multiple gateway stations. The internal addressing scheme is designed to allow load balancing even with broadband-interchange carrier interface (B-ICI), but not as dynamic.