INTERNATIONAL TELECOMMUNICATION UNION

TELECOMMUNICATION DEVELOPMENT BUREAU

ITU-D STUDY GROUPS

Document 2/068-E
10 June 1999
Original: English

SECOND MEETING OF STUDY GROUP 1: GENEVA, 30 AUGUST - 3 SEPTEMBER 1999
SECOND MEETING OF STUDY GROUP 2: GENEVA, 6 - 10 SEPTEMBER 1999

FOR INFORMATION

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: ITU-R TASK GROUP 8/1

TITLE: LIAISON STATEMENT TO ITU-D STUDY GROUP 2 ON HAPS IN IMT-2000

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Abstract:

The liaison statement contains the Report of the Ad Hoc Group on High Altitude Platform Stations (HAPS) in IMT-2000 that was considered by ITU-R Task Group 8/1 at its meeting in November 1998. ITU-D Study Group 2 is invited to consider the report.

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

Document 8-1/TEMP/99-E
18 November 1998
Original: English only

15th Meeting of Task Group 8/1
9 - 20 November 1998, Jersey, Channel Islands

Task Group 8/1

LIAISON STATEMENT TO ITU-D SG 2

ON

HAPS IN IMT-2000

Status: For consideration

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ITU-R Task Group 8/1 at its meeting in November 1998 at Jersey considered the attached report on the use of High Altitude Platform Stations (HAPS) for delivery of IMT-2000 services. TG 8/1 observed that HAPS is a new technology and may be an option to provide rapid deployment of mobile and fixed wireless services in large areas which is of interest to developing countries. TG 8/1 requests ITU-D SG 2 to consider the attached report on the on-going work of TG 8/1 Ad-Hoc HAPS for implementation in developing countries.

Attachment: 1 [Doc. 8-1/TEMP/77(Rev.3)]

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

Revision 3 to Document 8-1/TEMP/77-E
17 November 1998
Original: English only

15th Meeting of Task Group 8/1
9 - 20 November 1998, Jersey, Channel Islands

Task Group 8/1

REPORT OF THE AD HOC GROUP ON HIGH ALTITUDE PLATFORM STATIONS (HAPS) IN IMT-2000

1 Background

At the fourteenth meeting of Task Group 8/1 (Geneva, 27th April to 8th May 1998), an input document about a new technology for the provision of terrestrial wireless coverage using High Altitude Platform Stations was considered (this Report uses the term HAPS to refer to one or more High Altitude Platform Stations). The meeting agreed to establish a correspondence group to consider the technical, operational and sharing factors bearing on the potential use of HAPS for providing IMT-2000 services.

The objectives of the correspondence group on HAPS were established at the fourteenth meeting of Task Group 8/1 as:

1. to analyze the characteristics and properties of HAPS when delivering IMT-2000 services and to establish a reference set of characteristics to be used in the sharing and co-ordination studies described below;
2. to conduct technical analyses of frequency sharing between HAPS and other IMT-2000 stations and between HAPS used for IMT-2000 and stations of other services operating in the bands already identified in the Radio Regulations for IMT-2000;
3. to identify potential operational constraints resulting from sharing between HAPS and other IMT-2000 stations in the frequency bands already identified for IMT-2000;
4. to examine the implications of the use of HAPS technology on the IMT-2000 deployment;
5. to the extent possible, complete its work in time for the 15th meeting of TG 8-1 (November 1998) and produce input contribution(s) to the meeting.

The group worked by correspondence through the exchange of electronic mail using a dedicated ITU-R TG 8/1 list server (***tg8-1hap@itu.int***).

The Ad Hoc group on HAPS was established at the opening plenary session of the 15th meeting of Task Group 8/1 to continue the work of the Correspondence Group.

2 Activities of the HAPS Correspondence Group to date

The group comprised 84 registered participants and considered the following input contributions.

a) United States - Technical and Operational Parameters for Typical IMT-2000 Terrestrial Systems Using High Altitude Platform Stations. The document was submitted as document 8-1/202 to the 15th Meeting of Task Group 8/1 (see Ref. 3). It describes: the general components of a HAPS IMT-2000 terrestrial system; two example IMT-2000 HAPS systems for use in the sharing studies (one deploying a TDMA payload system that is similar to UWC-136 and one using a CDMA payload that is similar to W-CDMA/NA); and a more detailed calculation of the capacity of an example HAPS CDMA system. The paper concludes that a HAPS located at a nominally fixed location 22 kilometers above a city can be designed to service a wide range of coverage area sizes. A CDMA system can cover an area up to 500 kilometers in radius whereas a TDMA system can serve up to a 75 kilometer radius area. The study assumes that the service links for a HAPS IMT-2000 terrestrial system would be in frequencies in or near the 2 GHz band. The study also assumes that backhaul links will not be in IMT-2000 bands and will be in either 47 GHz bands or alternative bands authorized in the future for such use. The HAPS IMT-2000 subscriber units will be identical to the mobile stations ("MSs") used by tower based terrestrial IMT-2000 systems (referred to herein as "base station systems"). The study contains antenna reference radiation patterns for use in the studies. Annex 3 to the study contains a more detailed capacity study for an example CDMA system and concludes that a 1,000 cell system consisting of 900 macro and 100 micro cells with a 5 MHz by 5 MHz license can support 258,000 simultaneous 16 kbps transmissions.

b) United States - HAPS IMT-2000 System Co-Channel Sharing With Conventional IMT-2000 Systems and With the Fixed Service. The document was submitted as Doc. 8-1/197 to the 15th Meeting of Task Group 8/1 (see Ref. 1). This detailed study describes the co-channel interference characteristics of both CDMA and TDMA based HAPS IMT-2000 systems serving a coverage area of 15 kilometers in radius (an urban coverage system) and both CDMA and TDMA based HAPS IMT-2000 systems serving a coverage area that is 75 kilometers in radius. The study only addresses a victim receiving unit located at 25 kilometers from nadir in the case of the 15 kilometer coverage area and 100 kilometers from nadir with respect to the 75 kilometer coverage area. Based on the conclusions of the study, it is apparent that: (1) a HAPS system cannot service the same geographic area in the same channel as a base station system except where both systems use CDMA, in which case, would suffer a reduction in its capacity; (2) the CDMA HAPS can operate using much smaller co-channel separation distances than a TDMA HAPS system; and (3) CDMA based HAPS systems can be designed that require only a few kilometers of separation distance from a co-channel base station system coverage area whereas a TDMA HAPS system will likely cause interference with any co-channel system operating within 500 kilometer radius of the HAPS nadir. The contribution supports a conclusion that geographic coordination (small separation distances) with a HAPS CDMA system using a high sidelobe performance antenna and 15 kilometer radius coverage area is feasible. The use of moderate sidelobe performance HAPS antennas or larger radius coverage areas (e.g. 75 kilometers) would require much larger separation distances.

c) France - Discussion on Coordination Distance Between HAPS and Conventional IMT-2000. The document was submitted as Doc. 8-1/153 to the 15th meeting of Task Group 8/1 (see Ref. 5). This document provides further analysis of co-channel interference patterns for potential HAPS TDMA and CDMA systems but assumes an interference pattern based on one beam at the edge of a coverage area rather than the aggregation of all beams within the coverage area. The US co-channel sharing document limits studies to interference characteristics only at positions 25 kilometers and 100 kilometers from nadir. This contribution from France extrapolates out interference levels on a continuum from the edge of the coverage area out to 100 kilometers from nadir with respect to the 15 kilometer radius system and out to 400 kilometers for the 75 kilometer radius system. The study concludes that co-channel separation distances are very sensitive to several factors, including the size of the coverage area, the access method (TDMA/CDMA) and the antenna performance. The

document further concludes that the CDMA antenna performance used in the US co-channel sharing document is “extremely good” and “is not expected to be met in practice.” Depending on the above sensitivity factors, the co-channel separation distances can be either reasonable or they can reach to the horizon (about 500 kilometers).

d) Portugal – Further Comments on Co-Channel Coordination Distance Between HAPS and Conventional IMT-2000. The document was submitted to the Correspondence Group and was attached as Attachment A to document 8-1/156 (Rev.1), (see Ref. 6) . This document builds upon the information in the French and U.S. contributions regarding co-channel sharing and refines and expands on the characteristics of HAPS CDMA (TDMA is not considered since the previous studies already concluded that HAPS TDMA systems require very large separation distances). This study relies on reasonable and achievable antenna performance requirements in response to the concerns raised in the contribution from France. It also examines a full range of coverage area sizes and the resulting necessary geographic separation distances. The document concludes that CDMA-based HAPS systems can require small separation distances. For example, a HAPS system with a 15 km radius coverage area will require a 2 kilometer geographic separation from a co-channel base station CDMA system and about a 60 km separation distance from a TDMA based system, and a HAPS system with a 75 km radius coverage area will require a 20 km separation distance from the base station CDMA system and about a 125 km separation distance from a TDMA system. The study assumes use of a multi-beam phased array antenna on board the HAPS described in Annex 1 to Doc. 8-1/80 submitted by the U.S. to the 14th meeting of Task Group 8/1, and a permissible interference threshold equal to 10% of designed co-channel interference plus noise level of MSs.

e) United States – Study of Out-of-Band Emissions From CDMA and TDMA Terrestrial IMT-2000 Payloads On Board A High Altitude Platform Station. This document was submitted as Doc. 8-1/199 to the 15th Meeting of Task Group 8/1 (see Ref. 2). This contribution studies the level of out-of-band emissions that the HAPS TDMA and CDMA example IMT-2000 systems will generate at nadir beneath the platform. The study addresses only HAPS links to subscribers (forward links) and their impact on adjacent bands or channels used by MSs and MESs. The study is limited to these scenarios for the following reasons: (1) HAPS subscriber terminals are identical to base station system MSs and therefore the user terminal transmissions do not raise any scenarios unique to HAPS; (2) HAPS and base station system reverse links will be in bands adjacent to MSS uplink and forward links will occur in bands adjacent to MSS bands designated for use by downlinks and, therefore, there is no potential scenario where HAPS forward links will impact receiving MSS earth stations or receiving base station base stations. The study assumes that -173 dBW/4 kHz is the permissible level of interference to TDMA receiving subscriber units and that -150 dBW/4kHz is the permissible level of interference to CDMA receiving subscriber units.

The study concludes that the CDMA HAPS forward links will generate out-of-band emissions that are less than the assumed permissible interference levels for the adjacent band subscriber units of a CDMA system and are 6 dB higher than the assumed permissible levels for an adjacent band TDMA system. The study also concludes that the TDMA HAPS forward links will generate out-of-band emissions that are less than the assumed permissible levels for adjacent band CDMA subscriber units and are 4 dB higher than the assumed permissible levels for an adjacent band TDMA system. The study concluded that the interference from the HAPS systems to adjacent band TDMA systems can be reduced by the use of filters or a narrow guard bands.

f) United Kingdom - Comments on HAPS Unwanted Emission Compatibility Paper 8-1/199. This document was submitted as Doc. 8-1/198 to the 15th Meeting of Task Group 8/1 (see Ref. 4). The contribution examines the potential for interference from the unwanted emission of a HAPS carrying IMT-2000 traffic (using an IMT-2000 terrestrial RTT) into adjacent allocations based on

the information contained in Doc. 8-1/199 (Ref. 2). The study notes that Appendix 7 to Doc. 8 -1/45, 23 February 1998, Summary of Conclusions Reached at the Expert Meeting (the "Expert Report"), states a maximum permissible interference power, due to unwanted emissions, of –186.8 dBW/4 kHz. This permissible interference level is based on an allowance of 1% increase in thermal noise. The document also discusses applicable mobile earth station ("MES") antenna gain and concludes that a range of gains of about 0 to 10 dBi should be considered. The contribution concludes that the out-of-band emissions from HAPS that are identified in Document 8-1/199 are higher than the permissible level identified in Annex 7 to Expert Report and that more investigation is required before any conclusions can be drawn regarding the acceptability of HAPS out-of-band emissions. The contribution further states that, in terms of adjacent band compatibility, IMT-2000 delivery using HAPS may give different results than those for terrestrial IMT-2000.

g) Portugal – Comments Regarding HAPS Unwanted Emission Compatibility. This document was submitted to the Correspondence Group and was attached as Attachment B to doc. 8-1/156 (Rev. 1), (see Ref. 7). This contribution builds upon the U.S. and U.K. contributions on HAPS out-of-band emissions. The study addresses only emissions from the HAPS CDMA based system and concludes that out-of-band emission levels from HAPS are lower than those from base station systems at locations close to the base stations. It further concludes that the HAPS out-of-band emissions levels meet the permissible level contained in Annex 1 to the Expert Report which is based upon an allowance of 10% increase in thermal noise (the limits in Annex 7 are based on a 1% allowance as noted above).

3 Ad Hoc HAPS Group

The meetings of the Ad Hoc group in Jersey discussed the input documents described above. A number of questions were discussed. The most important points were as follows:

3.1 During the introduction of the documents, the group noted that the HAPS parameter document (see Ref. 3) did not identify the size of the antenna used in the diagram on page 11. The antenna was subsequently identified as a 5 meter antenna. Questions regarding the U.S. HAPS co-channel sharing document (see Ref. 1), including about Figure 1 and Table 6, were answered.

3.2 The group noted that the contributions from the US were based on the aggregate of traffic in all beams in a fully saturated system whereas the contribution from France was based on the traffic in one beam at the edge of the coverage area.

3.3 The group discussed the Portugal contribution on co-channel sharing (see Ref. 6) and concluded that the CDMA HAPS multi beam system with a 15 kilometer radius coverage area would require separation distances that could range from 2 to 15 kilometers between the center of the outermost beam of the HAPS system and the edge of the coverage area of an adjacent CDMA system. The group also noted that the figures plotted in the document were based on the assumption that "N" was the total thermal noise plus Intra system interference (N + Intra) and that N + Intra was around 23 dB larger than N. The actual difference between N + Intra and N in a CDMA system is implementation dependent, but a range of 3 to 13 dB was mentioned as a potential range to consider. The impact external interference is mainly a reduction of coverage and has little effect on capacity. The conclusion on separation distance was therefore that, depending on the access format(s) used by the HAPS and the victim subscriber units, potentially up to 60 kilometers for urban area sharing and up to 125 kilometers for wide area sharing could be required. This issue needs further work and clarification.

3.4 The group addressed the variation in permissible out-of-band ("OOB") levels that were contained in the UK contribution on OOB emissions, (see Ref. 4) the US OOB contribution (see Ref. 2), and the information in the Portugal contribution (See Ref. 7), and concluded that:

a) the preliminary studies in the US contributions indicated that HAPS systems, and particularly CDMA systems, could be designed using guard bands or filters to satisfy assumed permissible interference levels for MSs;

b) the Portugal contribution on OOB noted that the US OOB contribution relied upon a 10% allowance of a 910 K receiver and the U.K. contribution relied upon a 1% allowance of about a 350 K receiver;

c) it is difficult to apply results for HAPS OOB interference into terrestrial MSs to that into MESs due to the significant differences in the scenarios;

d) studies are underway in the ITU-R on permissible interference levels for the MSS; and

e) any further studies should address MES antenna gain ranging from 0 to 10 dBi.

4 Questions that Require Additional Study

a) The group needs to study further the assumptions appropriate to determine the coordination distances required for co-channel systems geographically adjacent to HAPS CDMA and TDMA systems in order to refine the coordination distance conclusions of the studies to date.

b) The group needs to consider further whether the geographic coordination procedures for base station systems are sufficient for implementation of HAPS or whether additional or alternative procedures should be developed.

c) The group needs to study whether the permissible levels for out-of-band emissions for HAPS need to differ in any respect from those used for base station systems in connection with potential interference into MESs operating in adjacent bands.

5 Conclusions and Recommendations

5.1 A HAPS uses a phased array antenna to project hundreds of spot beams to provide telecommunications services to coverage areas that range in size from metropolitan to wider areas. In essence, they operate in a manner similar to tall terrestrial towers.

5.2 The contributions also show that HAPS have the possibility of delivering IMT-2000 mobile and fixed wireless access services using the proposed IMT-2000 Protocols and by employing the proposed Radio Transmission Technologies.

5.3 For base station systems, the illumination of areas outside the intended operational area is dependent on the characteristics of the tower mounted antenna and the propagation attenuation. For HAPS the dependence is more on the characteristics of the HAPS mounted antenna especially the sidelobe performance and pointing accuracy. As the area of coverage of a HAPS increases the antenna performance becomes more demanding.

5.4 HAPS have the potential to have a significant impact on the IMT-2000 deployment by providing an optional means for service providers to rapidly deploy IMT-2000 services over a large area. This potential may provide particular benefits for deployment of IMT-2000 in developing countries.

5.5 The HAPS system separation distances from co-channel systems operating in adjacent geographic areas are dependent on the access format used by the HAPS, the performance of the antenna, and the size of the HAPS coverage area. The preliminary conclusions from the studies are that co-channel sharing and coordination: (a) the CDMA based HAPS with a metropolitan coverage area and high performance antennas is feasible using terrestrial coordination procedures; (b) the CDMA based HAPS with a wider coverage area and high performance antennas is feasible but requires further study to determine appropriate coordination procedures; and (c) the TDMA HAPS

requires larger separation distances and may be feasible and may require additional appropriate coordination procedures.

5.6 HAPS systems can be designed using filters or guard bands that limit out-of-band emissions levels that satisfy the permissible levels with respect to interference into receiving MSs.

5.7 The permissible interference levels for OOB into MESs are under study by the ITU-R at the present time. Further studies of HAPS to MES interference scenario, including relevant parameters, are needed before any conclusions can be reached .

5.8 It is proposed that the Correspondence Group should continue and also address the questions that require additional study that are described in paragraph 4 above.

List of reference documents:

1 Document 8-1/197 USA. HAPS IMT-2000 System Co-Channel Sharing with Conventional IMT-2000 Systems and with the fixed service.

2 Document 8-1/199 USA. Study of Out-Of-Band emissions from CDMA and TDMA Terrestrial IMT-2000 Payloads on board a High Altitude Platform Station.

3 Document 8-1/-202 USA. Technical and Operational Parameters for a typical IMT-2000 terrestrial system using High Altitude Platform Stations.

4 Document 8-1/198 UK. Discussion on High Altitude Platform Stations unwanted emissions.

5 Document 8-1/153 France. Discussion on Co-ordination Distance between HAPS and Conventional IMT-2000.

6 Attachment A to Doc. 8-1/156(Rev.1) Portugal. Further Comments on Co-channel co-ordination distance between HAPS and conventional IMT-2000.

7 Attachment B to Doc. 8-1/156(Rev.1) Portugal. Comments Regarding HAPS Unwanted Emissions Compatibility.