International Telecommunication Union

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Spectrum needs of high-altitude platform stations broadband links operating in the fixed service

F Series

Fixed service

International Telecommunication Union

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REPORT ITU-R F.2438-0

Spectrum needs of high-altitude platform stations broadband links operating in the fixed service

(2018)

1 Scope

The 2015 World Radiocommunication Conference (WRC-15) adopted agenda item 1.14 for WRC-19 along with Resolution **160 (WRC-15)** on facilitating access to broadband applications delivered by high altitude platform station (HAPS).

This contribution addresses *resolves* 1 of WRC-19 agenda item 1.14, which invites the ITU-R to study additional spectrum needs for gateway and fixed terminal links required for HAPS to provide broadband connectivity in the fixed service.

2 Introduction

This Report, including its Annexes, and under the framework of WRC-19 agenda item 1.14, provides the results of HAPS broadband applications spectrum needs.

3 Glossary

CDF	Cumulative distribution function
CPE	Customer premises equipment (serves fixed terminal links between HAPS and customer networks)
DL	Down Link
e.i.r.p.	Equivalent isotopically radiated power
G/T	Gain to equivalent system temperature ratio
GW	Gateway (provides feeder link service between ground and HAPS)
HAPS	High altitude platform station
LHCP	Left hand circular polarisation
PPDR	Public protection and disaster relief
Pfd	Power flux density
RHCP	Right hand circular polarisation
TX	Transmitter
UL	Up Link

4 Broadband HAPS applications

4.1 Broadband HAPS connectivity applications

The aim of HAPS broadband connectivity is to provide internet access to users on a medium to long-term basis. It can be direct to home access, or it can be a link to an access point.

4.2 Broadband HAPS for specific applications

In contrast to the broadband connectivity case described above, broadband HAPS for specific applications is designed to focus on various usage cases. Some broadband HAPS specific applications communication usages foreseen are:

– Natural disaster relief missions, where communication for coordination and situation awareness across help and humanitarian aid organisations is needed.

– Fire detection, monitoring and firefighting missions to ensure communication between actors.

– Law enforcement with communication needs across local actors and regional headquarters.

– Exploration missions with communication needs between exploration teams and regional home base.

5 Harmonization of spectrum

Experience has shown spectrum that is harmonized has benefits including economic benefits, the development of compatible networks and effective services. This also supports interoperability of equipment internationally and nationally for those agencies that require national and cross-border cooperation with other agencies and organizations. Specifically, some potential benefits are identified to be economies of scale in the manufacturing, competitive market for equipment, increased spectral efficiency, efficient planning of HAPS spectrum and effective response to disaster relief.

6 Analysis of broadband HAPS applications capacity demand

The characteristics of HAPS systems used to derive the broadband HAPS spectrum needs can be found in Report ITU-R F.2439.

Table 1 depicts the capacity demand for the different approaches envisaged (see Annex 1 for detailed analysis of the systems) for broadband HAPS applications.

TABLE 1

Capacity demand for the envisage systems providing broadband HAPS applications

Parameter		**System 2**	**System 4a**	**System 4b**	**System 5**	**System 6***	
Radius coverage	km	50	50	50	50	50	a
Population density	inhabitants/km^2	60	60	60	10	100	b
Penetration rate	%	33%	33%	2.7%	33%	33%	c
Number of users		160 000	160 000	12 663	25 920	250 000 (100% of cases) 125 000 (90% of cases)	d
Forward data volume	GB/month/user	30	22.7	366	26.25	30	e
Busy hour ratio		2	2	2	1.55	1.55	f

TABLE 1 (*end*)

Parameter		**System 2**	**System 4a**	**System 4b**	**System 5**	**System 6***	
Utilisation rate	%	100	100	100	60	60	g
Capacity per user to be provisioned	kbit/s	187	140.6	2 264	210	240	$h = \frac{e \times 8 \times f \times 100 \times 1e6}{30 \times 24 \times 3600 \times g}$
Forward link capacity per HAPS	Gbit/s	29.8	22.5	28.75	5.425	60 (100% of cases) 30 (90% of cases)	$i = d \times h$
Ratio between forward and return links	%	22	33	21.7	14.285	12.5	J
Return link capacity per HAPS	Gbit/s	6.56	7.5	6.25	0.775	3.75	$K = \frac{i \times j}{100}$

*System 3 is merged with System 6.

Based on the different approaches considered in the table, the overall capacity to be considered for determining the spectrum needs is of the order of 30 Gbit/s per HAPS for the forward links. For more detail, see Annex 1 for the broadband HAPS connectivity capacity demand, and Annex 2 for the broadband HAPS specific applications capacity demand.

7 Analysis of broadband HAPS specific applications capacity demand

Based on the analysis presented in Annex 2 that contains the computation of the broadband HAPS specific application demand, it can be concluded that 120 Mbit/s for the forward link as well as for the return link will be sufficient to cover the broadband HAPS specific applications needs except the needs for PPDR applications (e.g. high resolution video, images, etc.) for which an additional capacity of 100 Mbit/s is needed for the HAPS forward link and return link.

8 Spectrum needs

The spectrum needs are summarised in the following Tables.

Table 2 below contains the various systems that have been studied for the estimation of spectrum needs for HAPS. All of these systems are considered to provide broadband connectivity applications, except System 1, which is serving specific applications (e.g. PPDR missions).

TABLE 2

Broadband HAPS spectrum needs

System 1						
	Forward		**Return**		**Downlink**	
	GW to HAPS	**HAPS to CPE**	**CPE to HAPS**	**HAPS to GW***	**HAPS to GW***	
Capacity (Gbit/s)	0.12	0.12	0.12	0.12	0.1	a
Spectral efficiency (bit/s/Hz)	1	1	1	1	1	b
Overall required bandwidth (MHz)	120	120	120	120	100	$c = \frac{a \times 1e3}{b}$
Number of beams	1	16	16	1	1	d
LHCP and RHCP polarisation factor	2	2	2	2	2	e
Reuse factor	1	4	4	1	1	f
Spectrum needs taking into account the polarisation and reuse factors (MHz)	60	15	15	60	50	$g = \frac{c \times f}{d \times e}$
* For System 1 HAPS to GW, Return and downlink, see Annex 2 section 2.						

System 2					
	Forward		**Return**		
	GW to HAPS	**HAPS to CPE**	**CPE to HAPS**	**HAPS to GW**	
Capacity (Gbit/s)	28.8	28.8	6.336	6.336	a
Spectral efficiency (bit/s/Hz)	4	4	3.3	3.3	b
Overall required bandwidth (MHz)	7 200	7 200	1 920	1 920	$c = \frac{a \times 1e3}{b}$
Number of beams	2	16	16	2	d
LHCP and RHCP polarisation factor	2	2	2	2	e
Reuse factor	1	4	4	1	f
Spectrum needs taking into account the polarisation and reuse factors (MHz)	1 800	900	240	480	$g = \frac{c \times f}{d \times e}$

TABLE 2 (*continued*)

System 4a					
	Forward		**Return**		
	GW to HAPS	**HAPS to CPE**	**CPE to HAPS**	**HAPS to GW**	
Capacity (Gbit/s)	22.5	22.5	7.5	7.5	a
Spectral efficiency (bit/s/Hz)	5.05	4.9	4.4	5.05	b
Overall required bandwidth (MHz)	4 457	4 604	1 702	1 486	$c = \frac{a \times 1e3}{b}$
Number of beams	2	16	16	2	d
LHCP and RHCP polarisation factor	2	2	2	2	e
Reuse factor	1	4	4	1	f
Spectrum needs taking into account the polarisation and reuse factors (MHz)	1 114	576	213	371	$g = \frac{c \times f}{d \times e}$
System 4b					
	Forward		**Return**		
	GW to HAPS	**HAPS to CPE**	**CPE to HAPS**	**HAPS to GW**	
Capacity (Gbit/s)	28.75	28.75	6.25	6.25	a
Spectral efficiency (bit/s/Hz)	5.05	4.28	3.2	5.05	b
Overall required bandwidth (MHz)	5 695	6 710	1 969	1 238	$c = \frac{a \times 1e3}{b}$
Number of beams	2	67	67	2	d
LHCP and RHCP polarisation factor	2	2	2	2	e
Reuse factor	1	4	4	1	f
Spectrum needs taking into account the polarisation and reuse factors (MHz)	1 424	200	59	310	$g = \frac{c \times f}{d \times e}$

TABLE 2 (*end*)

System 5					
	Forward		Return		
	GW to HAPS	**HAPS to CPE**	**CPE to HAPS**	**HAPS to GW**	
Capacity (Gbit/s)	5.425	5.425	0.775	0.775	a
Spectral efficiency (bit/s/Hz)	5.5	3.3 (averaged)	3.3 (averaged)	5.5	b
Overall required bandwidth (MHz)	986	1 644	235	141	$c = \frac{a \times 1e3}{b}$
Number of beams	2	20	20	2	d
LHCP and RHCP polarisation factor	2	2	2	2	e
Reuse factor	1	4	4	1	f
Spectrum needs taking into account the polarisation and reuse factors (MHz)	247	164	24	35	$g = \frac{c \times f}{d \times e}$
System 5 is designed to cover rural areas with a population density of 10 inhabitants/km^2.					
System 6					
	Forward		**Return**		
	GW to HAPS	**HAPS to CPE**	**CPE to HAPS**	**HAPS to GW**	
Capacity (Gbit/s)	30	30	3.75	3.75	a
Spectral efficiency (bit/s/Hz)	5.5	4	4	5.5	b
Overall required bandwidth (MHz)	5 454	7 500	937.5	681	$c = \frac{a \times 1e3}{b}$
Number of beams	1	4	4	1	d
LHCP and RHCP polarisation factor	2	2	2	2	e
Reuse factor	1	1	1	1	f
Spectrum needs taking into account the polarisation and reuse factors (MHz)	2 727	938	117	341	$g = \frac{c \times f}{d \times e}$

9 Existing HAPS identifications in FS bands

The existing HAPS designations have not been fully utilized in the past partly due to particular physical constraints and technical and regulatory conditions.

Further modifications to the footnotes of existing identifications could be considered to revise technical conditions to facilitate the use of the existing identifications for services at worldwide level. As noted in Resolution **160 (WRC-15)**, common worldwide identifications for HAPS are desirable in order to improve and harmonize their utilization of the radiofrequency spectrum. The studies that have been carried out on spectrum needs to satisfy HAPS capacity demand demonstrate that spectrum needs for broadband HAPS applications may not be fully accommodated within current HAPS identifications, even if modified to make them global and co-primary, with technically favourable conditions. However, existing HAPS identifications may be enough spectrum for some number of broadband HAPS system use cases. Whereas the majority of broadband HAPS systems could not be satisfied using the existing spectrum identifications. Please see the Table below for the existing identifications, and Annex 3 for more detailed information on these identifications.

TABLE 3

Existing HAPS identifications in FS bands

Frequency band	Use	Direction	Bandwidth	Identification
6 440-6 520 MHz	GW	↓	80 MHz	5 Admins (R1, R3)
6 560-6 640 MHz	GW	↑	80 MHz	5 Admins (R1, R3)
27.9-28.2 GHz	GW, CPE	↓	300 MHz	23 Admins (R1, R3)
31-31.3 GHz	GW, CPE	↑	300 MHz	23 Admins (R1, R3)
47.2-47.5 GHz	GW, CPE	↑↓	300 MHz	Worldwide
47.9-48.2 GHz	GW, CPE	↑↓	300 MHz	Worldwide

10 Summary

Given the existing identifications and the HAPS spectrum needs, additional spectrum candidate bands were studied for the delivery of broadband via HAPS links in the fixed service.

The spectrum needs for HAPS operating in the fixed service to provide broadband connectivity presented in this document are taken into account in the studies called for in the resolves to *invite ITU-R* 2, 3 and 4 of Resolution **160 (WRC-15)**.

The spectrum needs are summarized in Table 4 below based on the system characteristics and descriptions for a variety of HAPS systems for broadband applications used in sharing and compatibility studies in support of WRC-19 agenda item 1.14.

Additional details of the analysis conducted on the spectrum needs for HAPS are available in the annexes.

TABLE 4

Summary of spectrum needs

	Forward		Return	
Capacity for	GW to HAPS Ground to HAPS	HAPS to CPE HAPS to ground	CPE to HAPS ground to HAPS	HAPS to GW HAPS to ground
specific applications (MHz)	110	15	15	110
connectivity applications (MHz)*	247-2727	164-938	24-240	35-480

* The ranges are covering several possible use cases with different targeted markets.

Additional details of the analysis conducted on the spectrum needs for HAPS are available in Table 5 below:

TABLE 5

Spectrum needs for a variety of system characteristics

Type of HAPS system	GW to HAPS Ground-to-HAPS	HAPS to CPE HAPS-to-ground	CPE to HAPS Ground-to-HAPS	HAPS to GW HAPS-to-ground	Total uplink	Total downlink
Connectivity 1 (MHz)	1 800	900	240	480	2 040	1 380
Connectivity 2 (MHz)	2 727	938	117	341	2 844	1 279
Connectivity 3 (MHz)	1 114	576	213	371	1 327	947
Connectivity 4 (MHz)	1 424	200	59	310	1 483	510
Connectivity 5 (MHz)	247	164	24	35	271	199
Minimum (MHz)					271	199
Maximum (MHz)					2 844	1 380
Specific (MHz)	110	15	15	110	125	125
Minimum (including specific applications) (MHz)					396	324
Maximum (including specific applications) (MHz)					2 969	1 505

Noting the variety of HAPS systems characteristics and targeted services, there is also a variation in the spectrum needs. The results of studies that estimate the total spectrum needs for HAPS systems to be:

– in the range of 396 MHz (for lower capacity) to 2 969 MHz (for higher capacity) for the ground to HAPS platform links;

– in the range of 324 MHz (for lower capacity) to 1 505 MHz (for higher capacity) for the HAPS platform to ground links.

These ranges include the spectrum needs to cover those of specific applications (e.g. disaster relief missions) plus that for connectivity applications (e.g. commercial broadband).

The above spectrum needs are based on assumed HAPS throughputs, user densities and the operation of a single HAPS platform over a given service area. Different assumptions would result in spectrum needs that would differ than those provided.

The existing identifications prior to WRC-19 for HAPS as an application in the fixed service were adopted prior to the advent of multi-gigabit broadband and technology that make broadband HAPS viable. Prior to WRC-19, there was only one global identification for HAPS as a fixed service application (47.2-47.5 GHz/ 47.9-48.2 GHz), and it is in a band particularly challenging due to rain fade in some countries. In addition to the single global identification, there is an identification in 28/31 GHz that is currently effectively secondary and available in 23 countries. There is a third fixed identification in the 6 GHz band that is also currently effectively secondary, is limited to five gateway links per HAPS, and subject to agreement from neighbouring administrations within 1 000 km.

Given the regulatory provisions in the existing identifications and the current demand for multi-gigabit broadband, the existing identifications associated with current HAPS regulatory provisions are not sufficient to accommodate the largest case requirements of all HAPS systems in their more demanding spectrum scenarios. Consequently, sharing and compatibility studies on possible new HAPS identifications were conducted per Resolution **160 (WRC-15)**.

Annex 1

Broadband connectivity – Capacity analysis

1 Introduction

This Annex includes the assumptions and capacity analyses for the gateway and fixed terminal links for Systems 2, 4, 5 and 6.

2 Capacity analysis for Systems 2 and 4

2.1 Assumptions

Streaming of Standard Definition video requires 2 Mbit/s which would be representative for internet videos e.g. YouTube. A value of 2.5 Mbit/s per user is assumed to be provided by a HAPS-based connectivity solution.

Providing a minimum population density of 60 inhabitants/km^2. With an assumed penetration rate of 33% this gives a user density of 20.4 users/km^2. With the coverage area diameter (up to 100 km) a maximum number of 160 000 active users can be considered as upper boundary for system sizing. This will even grow for more densely populated areas.

2.2 Capacity demand

2.2.1 Bottom-up approach

Table 6 compares the lower and upper boundary requirements for sizing.

TABLE 6

Comparison of lower/upper boundary throughput

Parameter	Min throughput need (40 km diameter)	Max throughput need (100 km diameter)
Average datarate per user	30 Gbyte / month = 100 kbit/s	30 Gbyte / month = 100 kbit/s
Average datarate for all users in footprint of HAPS	93 kbit/s * 25 600 users = 2.56 Gbit/s	93 kbit/s*160 000 users = 16 Gbit/s
Capacity to simultaneously stream videos	1000 users	6 400 users
Peak hour streaming capacity (factor 2)	2 000 users simultaneously	12 800 users simultaneously
Total sizing datarate requirement per HAPS	4.76 Gbit/s	29.8 Gbit/s

From Table 6 above, it appears the maximum capacity per HAPS is 29.8 Gbit/s.

2.2.2 Top-down approach

The forward link capacity is the driving factor for determining the spectrum needs. In the case of heavier than air platform, the maximum forward link capacity will be limited by the maximum available transmit power. The current technology allows a maximum transmit power for that type of platform of around 8 watts for the HAPS to CPEs links (e.g. 500 mW per beam in case of 16 beams towards CPEs). In less than 10 years, it is expected that this value could be double and become

16 watts. This value of 16 watts is then used in the study to determine the maximum forward link capacity per HAPS.

For the heavier than air platform the maximum spectral efficiency of 4 bit/s/Hz is used in the study for the forward link. This corresponds to a *C*/*N* of 15 dB using DVB-S2X. For transparent platform and in order to obtain a combine *C*/*N* of 15 dB it is assumed a *C*/*N* forward uplink of 22 dB and a *C*/*N* forward downlink of 16 dB.

Based on the above assumptions, the maximum forward link downlink budget is derived.

TABLE 7

Maximum forward link capacity

	HAPS=>CPE
Availability (%)	99.6
CPE location	Long 7.37° and Lat 9°
Elevation CPE (degrees)	20.99
Frequency (GHz)	26
TX antenna gain (dBi)	29
TX power (dBW)	12.00
Output back off (dB)	4
e.i.r.p. (dBW)	37.0
Free space loss (dB)	155.37
Atm. gas attenuation (dB)	0.42
Rain attenuation (dB)	14.77
Maximum RX gain (dBi)	47
G/T (dB/K)	22.1
Boltzmann (dB)	−228.60
C/*N*o (dBHz)	117.14
Bandwidth (GHz)	7.200
Pointing loss (dB)	0.50
C/*N* (dB)	18.07
Margin (dB)	2.07
Spectral efficiency (bit/s/Hz)	4
Maximum capacity (Gbit/s)	**28.8**

The maximum forward link capacity per HAPS for System 2 is 28.8 Gbit/s. The ratio between forward link and return link is assumed to be 22% and therefore the associated maximum return link capacity is 6.34 Gbit/s.

3 Capacity analysis for System 5

3.1 HAPS broadband capacity demand

Besides, considering that HAPS system might be deployed in the area lacking of commercial terrestrial telecommunication systems due to construction difficulty, low population density might be considered. Providing connectivity to underserved communities with minimal ground-level infrastructure and maintenance, HAPS system can therefore be an effective tool to help closing the digital divide in rural and remote communities, particularly those with challenging terrain or climate. Therefore, the areas with low population density scenarios should be considered.

At minimal ground-level infrastructure and maintenance place, according the population statistics in 2015 in the west of China, namely more than one third of land area in Chinese, average population density was 9.05 inhabitants/km^2, and it could be increased to around 9.54 inhabitants/km^2 in 2020 by considering an annual natural population growth rate of 1.05%. In the following calculation the population density is round up slightly to 10 inhabitants/ km^2.

TABLE 8

Traffic model

Parameters	**Value**	**Comments**
Number of subscribers per HAPS	78540	Predicting value in 2020
Adoption rate	33%	Minimal ground-level infrastructure and maintenance
Data consumption per month per user	30 GB	The sum of forward link and return link capacity
End user throughput requirement	2.5 Mbit/s	Be able to carry the 480p video stream
Busy hour ratio	1.55	Busy hour ratio
Utilization	0.6	
Download/Upload ratio	7:1	

The demands of user link are shown below:

TABLE 9

Capacity demand

Parameters	**Value**	**Comments**
Average data rate per end user	93 kbit/s	30 GB/30 days/24 hours/3 600 seconds
Data rate in busy hour per end user	144 kbit/s	
Oversubscription ratio	17.4	2.5 Mbit/s/144 kbit/s
Link throughput	6.20 Gbit/s	
Provisioned throughput per end user	240 kbit/s	

In conclusion, a HAPS system should provide an overall 6.20 Gbit/s link throughput. The ratio between forward link and return link is assumed as 7:1, which means the maximum forward link capacity is 5.425 Gbit/s.

4 Capacity analysis for System 6

This study used a geospatial simulation-based approach for a selection of 32 countries (with an emphasis on those countries where a large percentage of the population lacks connectivity). It was based on the following assumptions:

– Target year: 2020

– 50 km radius coverage and 33 users/km^2, with a number of users rounded to 250 000
– Target availability level: 99.5%
– Target connectivity level: 30 GB
– End user throughput requirement: 2.5 Mbit/s
– Data volume: 30 GB per month per user
– Busy hour ratio of 1.55
– Utilisation rate: 60%.

This first part of the assessment concluded that the maximum capacity of HAPS is 60 Gbit/s.

Then a geospatial simulation-based approach has been run for a selection of 32 countries (with an emphasis on those countries where a large percentage of the population lacks connectivity).

Figure 2 shows the cumulative distribution function of throughput per HAPS. The conservative 90th percentile was used as a planning threshold for spectrum allocation (30 Gbit/s). Similarly, the 90th percentile of HAPS will provide coverage for 130 000 users.

FIGURE 1

CDF of HAPS throughput (Gbit/s)

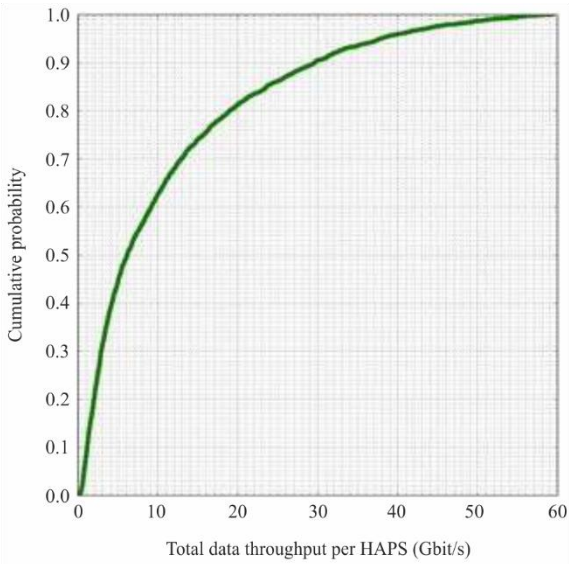

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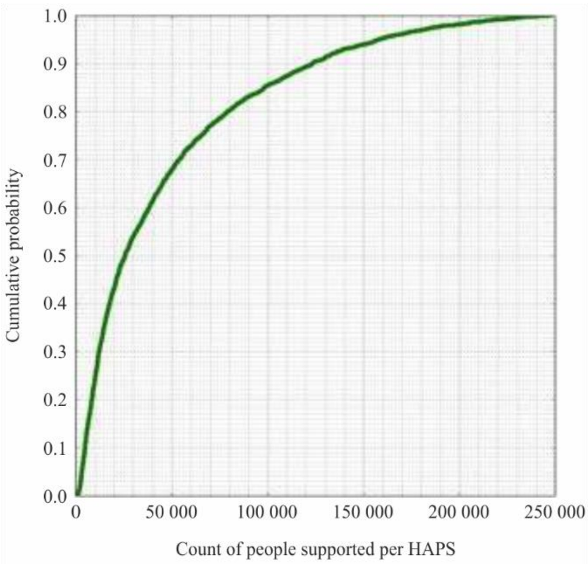
FIGURE 2

CDF of number of users



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Annex 2

Broadband HAPS specific applications capacity demand

1 Introduction

This Annex provides the capacity demand for gateway and fixed terminal links for system 1. The demand of specific broadband applications is based on Report ITU-R M.2377, which provides elements on the capacity for PPDR applications.

2 Broadband HAPS specific applications capacity

It is estimated that the broadband HAPS specific applications total capacity demands are similar to the broadband Public Protection and Disaster Relief (PPDR) total capacity demand except the download of the HAPS sensors measurements data (high resolution video, optical and radar images) for which an additional capacity of 100 Mbps is assumed.

The broadband PPDR capacity demand is addressed in the Report ITU-R M.2377-0 (Annex 7)[1] in which three scenarios are considered:

– PP1: day-to-day operation;

– PP2: Large emergencies or public events;

– Disasters.

The methodology used for determining the broadband HAPS applications capacity demand can be considered as an incident approach where traffic is summed over several separate incidents and background traffic is then added in order to define the total capacity demand and finally the spectrum needs.

Methodology for Disasters: It is considered that the estimated spectrum needs for PP2 scenarios are sufficient to cover basic disaster relief capacity demands.

2.1 PP1 capacity

The following Table is extracted from Report ITU-R M.2377-0 (Annex 7A) and provides the peak traffic per incident in kbps within Europe.

TABLE 10

Traffic demand per incident within Europe

		Peak traffic /incidents (kbit/s)
Road accident	UL	1 300
	DL	1 300
Traffic stop	UL	1 300
	DL	1 300
Background	UL	1 380
	DL	876

1 See ECC Report 199 for more details on broadband PPDR spectrum requirements within CEPT.

The total estimated total required traffic/capacity can also be derived from Report ITU-R M.2377-0 (Annex 7A) and is presented in Table 11.

TABLE 11

PP1 traffic demand per HAPS within Europe

		Urban	Suburban	Rural
Population	pop/km^2	> 3000	> 300 and < 3000	< 300
Incident density	/km^2	0.0233	0.002	0.00001644
Incident traffic	kbit/s/km^2	30.3 UL 30.3 DL	2.6 UL 2.6 DL	0.0214 UL 0.0214 DL
Background traffic	kbit/s/km^2	10.7 UL 6.8 DL	0.9 UL 0.57 DL	0.0076 UL 0.0048 DL
Total traffic per km^2	kbit/s/km^2	41 UL 37.1 DL	3.5 UL 3.17 DL	0.029 UL 0.0262 DL
HAPS coverage radius	km	30	40	56
HAPS coverage area	km^2	2 800	5 000	10 000
Total capacity per HAPS (forward link)	Mbit/s	**104**	**15.9**	**0.262**
Total capacity per HAPS (return link)	Mbit/s	**115**	**17.5**	**0.29**

2.2 PP2 and disasters capacity

The estimated total PP2 required traffic/capacity can also be derived from Report ITU-R M.2377-0 (Annex 7A) and is presented in Table 12.

TABLE 12

PP2/disasters traffic demand per HAPS within Europe

		Royal Wedding	London Riots
Video cameras	kbit/s	5*768	4*768
Pictures	kbit/s	1 000	1 000
Background traffic	kbit/s	1 380	1 380
Total traffic	**kbit/s**	**6 220**	**5 452**

2.3 Overall capacity demand for broadband HAPS specific applications

The PP1 urban case is the driving factor for determining the capacity demand. From the above Tables it can then be concluded that 120 Mbit/s for the forward link as well as for the return link will be sufficient to cover the broadband HAPS specific applications requirement except the requirement for PPDR applications (e.g. high resolution video, images, etc.), for which an additional capacity of 100 Mbit/s is needed for the HAPS forward link and return link.

Annex 3

Existing HAPS identifications in FS bands

HAPS is defined in No. **1.66A** of the Radio Regulations as "[a] station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth." It should be noted that HAPS are a type of radiocommunication station within the scope of this Report, operating under the FS attribution. The ITU-R adopted three identifications in fixed service allocations for HAPS over a number of World Radiocommunication Conferences.[2] In addition, No. **4.23** of the Radio Regulations states "Transmissions to or from high altitude platform stations shall be limited to bands specifically identified in Article **5**."

1 47.2-47.5 GHz and 47.9-48.2 GHz bands

There is only one globally harmonized fixed service identification for HAPS. The 47.2-47.5 GHz and 47.9-48.2 GHz bands are allocated to the fixed, fixed satellite (Earth-to-space) and mobile services on a co-primary basis. Radio Regulations No. **5.552A** states that the allocation to the fixed service in the bands 47.2-47.5 GHz and 47.9-48.2 GHz is designated for use by high altitude platform stations. The use of the bands 47.2-47.5 GHz and 47.9-48.2 GHz is subject to the provisions of Resolution **122 (Rev.WRC-07)**, which establishes maximum transmit e.i.r.p. levels, antenna beam patterns and pfd levels for HAPS operations.

The ITU has published the following Recommendations on HAPS usage in these bands: ITU-R F.1500, ITU-R F.1501, ITU-R F.1608, ITU-R F.1764, ITU-R F.1819, ITU-R F.1820, ITU-R P.1409, ITU-R SF.1481, ITU-R SF.1843.

2 27.9-28.2 GHz and 31.0-31.3 GHz bands

HAPS has an identification at 27.9-28.2 GHz, which is allocated to the fixed, fixed satellite (Earth-to-space) and mobile service on a primary basis. Additionally, RR No. **5.540** makes a secondary allocation to the fixed satellite service (space-to-Earth) for beacon transmissions intended for up-link power control at 27.501-29.999 GHz. The HAPS identification in RR No. **5.537A** permits use within the territory of a number of countries.[3] Such use is limited to operation in the HAPS-to-ground direction and requires HAPS systems to avoid causing harmful interference to, and precludes HAPS systems from claiming protection from, other fixed service systems or co-primary services.

The 31.0-31.3 GHz band is allocated to the fixed and mobile service on a primary basis, and the standard frequency and time signal satellite service and space research service on a secondary basis. Pursuant to RR No. **5.543A**, the same countries mentioned above are permitted to use this band for HAPS in the ground-to-HAPS direction. Such use may not cause harmful interference to, nor claim

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[2] In addition to the fixed service identifications, the bands 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz were identified for HAPS operating in the mobile service as IMT base stations at WRC-2000.

[3] Bhutan, Cameroon, Korea (Rep. of), the Russian Federation, India, Indonesia, Iran (Islamic Republic of), Iraq, Japan, Kazakhstan, Malaysia, Maldives, Mongolia, Myanmar, Uzbekistan, Pakistan, the Philippines, Kyrgyzstan, the Dem. People's Rep. of Korea, Sudan, Sri Lanka, Thailand and Viet Nam.

protection from, other types of fixed service systems or mobile service systems.[4] HAPS must also avoid harmful interference to the radio astronomy service, which has a primary allocation in the 31.3-31.8 GHz band. Resolution **145 (Rev.WRC-12)** ensures protection of the adjacent radio astronomy service by placing a pfd limit on the HAPS ground station antenna, while adding mandatory coordination and agreement with considered neighbouring administrations.

The ITU has published the following Recommendations on HAPS usage in the 27.9-28.2 GHz and 31.0-31.3 GHz band[5]: ITU-R F.1569, ITU-R F.1570, ITU-R F.1607, ITU-R F.1609, ITU-R F.1612, ITU-R F.1764, ITU-R P.1409, ITU-R SF.1601.

3 6 440-6 520 MHz (HAPS-ground) and 6 560-6 640 MHz (ground-HAPS)

The 6 440-6 520 MHz and 6 560-6 640 MHz bands are allocated to the fixed, fixed satellite (Earth-to-space) and mobile services on a primary basis. RR No. **5.457** identifies these bands in Australia, Burkina Faso, Cote d'Ivoire, Mali and Nigeria for HAPS use within each countries' territory. Such use is limited to operation in HAPS gateway links and may not cause harmful interference to, and may not claim protection from, existing services. HAPS use must comply with Resolution **150** (**WRC-12**). Additionally, existing services may not be constrained in future development by HAPS gateway links. The use of HAPS gateway links in these bands requires explicit agreement with other administrations whose territories are located within 1 000 km from the border of an administration intending to use the HAPS gateway links.

Resolution **150** (**WRC-12**) provides a number of regulatory provisions that govern the use of HAPS in the 6 440-6 520 MHz and 6 560-6 640 MHz bands, including antenna beam patterns, aggregate pfd criterion and a maximum e.i.r.p. value.

The ITU has published the following Reports and Recommendations on HAPS usage in the 6 440-6 520 MHz (HAPS-ground) and 6 560-6 640 MHz (ground-HAPS) band: ITU-R F.2240, ITU-R F.1764, ITU-R F.1891, ITU-R F.2011, ITU-R P.1409.

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[4] The space research service is also subject to these protections in the following countries: Armenia, Georgia, Kyrgyzstan, Tajikistan and Turkmenistan.

[5] Several of the referenced documents provide information on the 27.5-28.35 GHz fixed service band for potential HAPS use. Despite the broader range of the fixed service allocation studied in the ITU-R, the identification in RR No. **5.537A** is limited to the band 27.9-28.2 GHz.