RECOMMENDATION ITU-R F.1401-1*

Considerations for the identification of possible frequency bands for fixed wireless access and related sharing studies

(Question ITU-R 215/5)

(1999-2004)

Scope

This Recommendation provides a methodology for identification of suitable frequency spectrum for FWA systems and a list of items to be addressed in identifying candidate bands. These take into account the results of ITU-R studies on compatible operations with systems in other radio services sharing the same bands, characteristics and operational requirements, spectrum requirements, and interference mitigation technologies. Bands identified using the methodology mentioned in § 6.1 could support traditional telephony wireless access applications or new and emerging broadband wireless access.

The scope of this Recommendation covers only FWA systems operating in the FS and MS allocations; i.e. terrestrial.

1 Introduction

1.1 Purpose

The objective of this Recommendation is to provide guidance for the identification of suitable frequency spectrum for terrestrial fixed wireless access (FWA) applications, taking due account of sharing issues. Both traditional wireless telephony applications as well as emerging broadband wireless applications are considered.

The potential for FWA to enhance availability of telecommunications services in both developing and developed countries is substantial.

1.2 Background

Wireless access has been defined (see Recommendation ITU-R F.1399 as "end-user radio connection(s) to core networks", where core networks include, for example, PSTN, ISDN, PLMN, PSDN, Internet, WAN/LAN, CATV, etc. Wireless access applications can be provided within the definitions of the radio services FS, MS, FSS and MSS contained in the Radio Regulations (RR) (see § 4 for list of acronyms). FWA is one of these wireless access applications in which the location of the end-user termination and the network access point to be connected to the end-user are fixed.

Technologies in use today for implementing wireless access include cellular systems, cordless phone and cordless telecommunication systems, satellite systems, and specialized point-to-point (P-P) and point-to-multipoint (P-MP) fixed wireless systems. New technologies and systems such as IMT-2000, wireless broadband ISDN, wireless ATM, etc., also form part of wireless access if their application satisfies the basic criteria of end-user radio connection(s) to core networks (see § 4 for list of acronyms).

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* Radiocommunication Study Group 5 made editorial amendments to this Recommendation in November 2011, in accordance with Resolution ITU-R 1.

1.3 Traditional telephony wireless access applications

Advances in technology and competitive access are driving the revolution towards wireless access infrastructure for the provision of basic telephone service. Traditionally the most difficult component of the network to build and the least cost-effective to maintain has proven to be the LAN, regardless of a developing or a developed economy. The sheer scope of investment and engineering efforts required to build and maintain copper-based networks has made high penetration rates for basic telephone service available only to industrialized nations of the world. Even the relatively low target subscriber density (teledensity) rate of 20 lines per 100 population set by the ITU, has been far beyond the capability of many nations until recently.

Wireless access is an application of radio technology and personal communication systems experiencing tremendous growth, especially in developing economies.

Generally, a wide range of radio system designs could be used for FWA and the suitability is a function of a number of factors. The most suitable system for a particular application will tend in general to depend on the requirements of the end-user, the cost of deployment (which will depend on the density of the subscriber population and the type of system being considered) and the availability of the appropriate radio-frequency spectrum for that system. The requirement for mobility or portability would tend to drive the deployment of systems derived from cellular technologies. Alternatively, the requirement for wireline quality and services (such as G3 FAX and voiceband data or even ISDN) would tend to be drivers towards special-purpose designed systems.

Understanding the drivers for the deployment of each technology is a key factor in minimizing the cost and maximizing the effectiveness of the solution. In some cases wireless access may offer potential for evolution and synergy with mobile services. An infrastructure supporting a fixed wireless system using an air interface developed for mobile services, (e.g. Recommendations ITU-R F.757, ITU-R M.622, ITU-R M.687, ITU-R M.819, ITU-R M.1033, and ITU-R M.1073) might be readily extended to support mobile users. Alternatively, special-purpose systems can be designed to meet the quality requirements in an optimal manner. Volume 1 of the ITU-R Land Mobile (including Wireless Access) Handbook, Second Edition, 2001, provides further information on the basic principles and descriptions of wireless access systems.

1.4 Broadband wireless access

Local access and other high density fixed wireless system planning and system deployments have developed in the last few years in many administrations. This development is due in large part to the trend towards increased demand and competition in the provision of high bit-rate local telecommunications and video distribution services. Because of cost and speed of deployment considerations, these developments are placing a major new focus on the provision of services directly to end-users via FWA systems.

Current broadband wireless access data rates over individual circuit paths range from about 1.5 Mbit/s to about 51 Mbit/s, and are expected to reach at least 310 Mbit/s within the next few years, as radios utilizing higher order modulation schemes become available (see Recommendations ITU-R F.758 and ITU-R F.1499).

The variety of possible broadband FWA network configurations includes: conventional P-P, conventional P-MP, and combinations thereof, e.g. P-P systems deployed in multisectored P-MP configurations. High density deployment of independent P-P links similarly results in clusters that assume the essential characteristics of P-MP deployment. An emerging system architecture is that of MP-MP, similar to mesh systems used at, for example, HF.

These broadband FWA systems are predominantly deployed in dense urban, suburban, and campus environments where transmission path elevation angles may reach up to about 40° to 60° in particular in the higher frequency bands (see Recommendation ITU-R F.1498 dealing with the

38 GHz band). Links are regularly deployed on an on-demand basis to meet specific end-user requirements as they develop.

2 References

This list of references includes general references relevant to the topic of FWA.

– Recommendation ITU-R F.746: Radio-frequency channel arrangements for fixed service systems

– Recommendation ITU-R F.748: Radio-frequency arrangements for systems of the fixed service operating in the 25, 26 and 28 GHz bands

– Recommendation ITU-R F.749: Radio-frequency arrangements for systems of the fixed service operating in the 38 GHz band

– Recommendation ITU-R F.755: Point-to-multipoint systems used in the fixed service

– Recommendation ITU-R F.757: Basic system requirements and performance objectives for fixed wireless access using mobile-derived technologies using telephony and data communication services

– Recommendation ITU-R F.758: Considerations in the development of criteria for sharing between the terrestrial fixed service and other services

– Recommendation ITU-R F.1249: Maximum equivalent isotropically radiated power of transmitting stations in the fixed service operating in the frequency band 25.25-27.5 GHz shared with the inter-satellite service

– Recommendation ITU-R F.1399: Vocabulary of terms for wireless access

– Recommendation ITU-R F.1400: Performance and availability requirements and objectives for fixed wireless access to public switched telephone network

– Recommendation ITU-R F.1402: Frequency sharing criteria between a land mobile wireless access system and a fixed wireless access system using the same equipment type as the mobile wireless access system

– Recommendation ITU-R F.1488: Frequency block arrangements for fixed wireless access systems in the range 3 400-3 800 MHz

– Recommendation ITU-R F.1489: A methodology for assessing the level of operational compatibility between fixed wireless access and radio-location systems when sharing the band 3.4-3.7 GHz

– Recommendation ITU-R F.1498: Deployment characteristics of fixed service systems in the band 37-40 GHz for use in sharing studies

– Recommendation ITU-R F.1499: Radio transmission systems for fixed broadband wireless access based on cable modem standards

– Recommendation ITU-R F.1509: Technical and operational requirements that facilitate sharing between point-to-multipoint systems in the fixed service and the inter-satellite service in the band 25.25-27.5 GHz

– Recommendation ITU-R F.1518: Spectrum requirement methodology for fixed wireless access and mobile wireless access networks using the same type of equipment, when coexisting in the same frequency band

– Recommendation ITU-R M.478: Technical characteristics of equipment and principles governing the allocation of frequency channels between 25 and 3 000 MHz for the FM land mobile service

– Recommendation ITU-R M.819: International Mobile Telecommunications-2000 (IMT-2000) for developing countries

– Recommendation ITU-R M.1033: Technical and operational characteristics of cordless telephones and cordless telecommunication systems

– Recommendation ITU-R M.1073: Digital cellular land mobile telecommunication systems

– Recommendation ITU-R M.1390: Methodology for the calculation of IMT-2000 terrestrial spectrum requirements

– Recommendation ITU-R M.1450: Characteristics of broadband radio local area networks

– Recommendation ITU-R M.1454: e.i.r.p. density limit and operational restrictions for RLANs or other wireless access transmitters in order to ensure the protection of feeder links of non-geostationary systems in the mobile-satellite service in the frequency band 5 150-5 250 MHz

– Recommendation ITU-R SF.1484: Maximum allowable values of power flux-density at the surface of the Earth produced by non-geostationary satellites in the fixed-satellite service operating in the 37.5-42.5 GHz band to protect the fixed service

– Recommendation ITU-R SF.1486: Sharing methodology between fixed wireless access systems in the fixed service and very small aperture terminals in the fixed-satellite service in the 3 400-3 700 MHz band

– Recommendation ITU-R SF.1573: Maximum allowable values of power flux-density at the surface of the Earth by geostationary satellites in the fixed-satellite service operating in the 37.5-42.5 GHz band to protect the fixed service

– RR Number 5.547

– Volume 1 of the ITU-R Handbook on Land Mobile (including Wireless Access): Fixed Wireless Access, 2nd edition, 2001.

3 List of acronyms

ATM: Asynchronous transfer mode

CATV: Community antenna television

CDMA: Code division multiple access

FDD: Frequency duplex division

FS: Fixed service

FSS: Fixed satellite service

FWA: Fixed wireless access

HAPS: High altitude platform stations

HDFS: High density applications in the fixed service

IMT-2000: International Mobile Telecommunications-2000

ISDN: Integrated services digital network

LAN: Local area network

LMCS: Local multipoint communications systems

LMDS: Local multipoint distribution systems

MMDS: Multichannel multipoint distribution systems

MP-MP: Multipoint to multipoint

MS: Mobile service

MSS: Mobile satellite service

MVDS: Multipoint video distribution systems

MWS: Multimedia wireless systems

PCS: Personal communications systems

PLMN: Public land mobile network

P-MP: Point-to-multipoint

P-P: Point-to-point

PSDN: Public switched digital network

PSTN: Public switched telephone network

RLAN: Radio local area network

TDD: Time division duplex

TDMA: Time division multiple access

WAN: Wide area network

4 Considerations related to the use of the spectrum for FWA

4.1 General

The terms fixed (radio) service and mobile (radio) service are defined by the RR. The radio service definitions form the basis for the allocation of radio spectrum internationally by the ITU as well as domestically by each country. For the most part, the ITU has made joint allocations to the mobile and fixed services in various frequency bands. In some countries a choice has been made to limit use to one of the two services.

Certain evolving wireless access applications do not fit explicitly into the definitions of either the FS or the MS. The appropriate approach is to apply some flexibility in the interpretation of these definitions to be able to embrace these integrated applications under the umbrella of the FS and the MS. A key to the interpretation of the use of these terms is the concept of mobility. If the device is intended to be used in motion or is normally moved from place to place, it is considered as part of the MS. On the other hand it is generally understood that portable systems, which are transportable but operate always in the fixed state, belong to the FS.

Applications are envisaged for fixed radio service systems where the integration of wireless access devices that function as mobile (requiring mobile allocations) radio stations might be required. These situations have resulted from the converging requirements of both mobile and fixed radio services and the use of wireless access devices in integrated radio applications.

In order to facilitate the introduction of FWA systems the following factors should be considered:

– There is a growing trend in certain frequency bands that fixed and mobile applications are converging.

– In circumstances stated in the above, systems can use technologies derived from mobile and fixed systems.

– Frequency reuse becomes increasingly effective at higher (millimetre wave) frequencies.

– Adaptive technologies and other advances are likely to afford greater effective capacity and spectrum efficiency in the future.

– Flexibility is needed in the frequency band structure to provide for multiple technologies and a variety of applications.

– Area-wide and site-by-site frequency assignments are commonly used for FWA.

– Service providers may benefit from economies of scale in bands where there is significant regional or worldwide harmonization.

– In the future the convergence of telecommunications and broadcast applications may prompt the development of hybrid FS/broadcasting service applications.

4.2 Spectrum characteristics for FWA

This section points out relevant characteristics of the radio spectrum for FWA implementation. Most of these characteristics are also relevant for other services.

The main characteristics and applications of the frequency bands allocated to FS and MS that may be suitable for FWA are summarized as follows:

4.2.1 Below 1 GHz

– telephony and low-speed data;
– good propagation for long reach – beyond horizon (rural systems);
– high-level of coverage reliability;
– limited bandwidth available;
– many bands heavily used for MS, broadcasting and other services;
– difficult to achieve high antenna gains with small antenna structures;
– easy to generate high transmit power at base station;
– components very readily available;
– coordination distances between co-channel systems are quite large;
– frequencies below 50 MHz suffer from propagation anomalies – ducting due to temperature inversion – ionosphere skip.

4.2.2 1-3 GHz

– telephony and low/medium speed data;
– good propagation – limited-trans-horizon path (particularly suitable for both fixed and mobile applications);
– good coverage reliability – limited blockage problems;
– many bands already heavily used by existing MS, FS, satellite and radiolocation/ radionavigation services;
– moderate bandwidth available;
– good range for urban and rural applications;
– antenna structures can be quite small (e.g. cellular, cordless);
– easy to generate high transmit power at base station;
– components readily available.

4.2.3 3-10 GHz

– telephony and low/medium/high speed data;
– propagation generally limited to near line of sight (LoS);
– propagation through foliage is relatively good;
– path length generally less than 20 km for P-MP, more for P-P;
– more bandwidth available;
– many fixed/mobile bands shared with satellite services:
– sharing constraints more favourable to P-P systems;
– components of reasonable cost and availability;
– more difficult to generate transmit power;
– coverage reliability is moderate-poor due to blockage;
– bands can be suitable for FWA applications employing high-gain antennas at the base station and subscriber station.

4.2.4 10-30 GHz

- telephony, low, medium and high data rates, video;
- mature P-P and multipoint technology;
- propagation:
  - LoS required;
  - rain attenuation is a factor;
  - urban/suburban applications;
- employ small antenna structures;
- path lengths generally less than 10 km for P-MP, more for P-P, that utilize directional antennas in both sites of the link;
- substantial contiguous bands of FS spectrum are available;
  - support broadband applications;
- transmit power is more difficult;
- high-level of frequency reuse, especially in the 20-30 GHz range;
- many FS/MS bands shared with satellite services;
- in high-density applications, sharing between FS (including FWA) and FSS/MSS may be difficult.

4.2.5 30-50 GHz

- telephony, low-medium and high data rates, video;
- propagation: LoS is essential;
- rain attenuation – a significant factor;
- antenna structures can be very small, and have high levels of gain;
- path lengths generally less than 5 km for P-MP, more for P-P, that utilize directional antennas in both sites of the link;
- large contiguous bands of spectrum available for broadband FWA applications;
- applications are urban/suburban;
- very high level of frequency reuse;
- in high-density applications, sharing between FS (including FWA) and FSS/MSS may be difficult;
- some countries have broadband FWA systems in the 38 GHz band and others have planned FWA/MWS systems in the 40 GHz band.

4.2.6 Above 50 GHz

- high atmospheric losses in the 55-66 GHz range;
- propagation: LoS is essential;
- rain attenuation – a significant factor;
- generally the range is up to 2 km;
- very high level of frequency reuse;
- technology under development.

4.2.7 Categorization

Table 1 provides a generalized categorization of frequency bands by service and constituency. For the purposes of this Recommendation, the types of services are defined in Recommendation ITU-R F.1400 – Performance and availability requirements and objectives for fixed wireless access to public switched telephone network.

Type 1: Analogue signals such as voice and voiceband data at rates up to 64 kbit/s (minimum 3.1 kHz audio as identified in ITU-T Recommendation G.174).

Type 2: Access bearer service from 64 kbit/s to bit rates below the primary rate.

Type 3: Digital services operating at the primary rate or above.

TABLE 1

Frequency bands broadly categorized by service and constituency

Class of service	Service constituency		
	Rural (GHz)	**Suburban (GHz)**	**Urban (GHz)**
Type 1	< 4(1)	< 5	< 5
Type 2	< 4(1)	1-11	1-11
Type 3	< 1-4	3-70	3-70

(1) Frequency bands below 1 GHz may be preferred where typical paths are beyond the radio horizon or subject to terrain blockage.

5 Recommendations

The ITU Radiocommunication Assembly recommends that the following points be taken into consideration in the identification of suitable frequency bands for the implementation of FWA systems.

5.1 Methodology to identify possible bands for FWA

Step 1: Identify either or both FS and MS bands taking into account the following considerations:

- bands already in use for FWA or for which equipment is available;
- bands allocated to FS or MS in the RR;
- bands with greatest possibility for global harmonization (less sharing constraints);
- FS bands which may be under-utilized (candidates for re-farming).

Step 2: Consider the spectrum implications of the performance and availability requirements for the required telecommunication services.

Step 3: Consider cost-effectiveness and equipment availability of the bands under consideration.

Step 4: Identify sharing and regulatory constraints:

- List of applicable ITU-R Recommendations (technical);
- Radio Regulations, including footnotes (regulatory).

Step 5: Identify complementary sharing studies with other primary radio services in the bands identified in accordance with Step 1.

Step 6: If Steps 4 and 5 indicate ITU-R sharing studies are inconclusive or there is potential for interference, perform analysis to determine if sharing between FWA systems and these services is feasible.

Step 7: Identify the frequency bands that have passed the tests above.

5.2 Information to be compiled for the identification of frequency bands

Based on the above methodology, the following items are necessary for studies to identify possible FS and MS bands eligible for FWA systems covering the range 400 MHz to 70 GHz:

– frequency band,

– bandwidth,

– ITU-R Recommendations on radio-frequency arrangements,

– other ITU-R Recommendations,

– regional Recommendations on radio-frequency arrangements,

– other regional Recommendations,

– ITU-R Recommendations on sharing studies,

– current use,

– other information.

Annex 1 presents examples of frequency bands used in some countries for which RF channel arrangements for FWA systems or results of sharing studies are given in ITU-R Recommendations. Other countries may use other frequency bands for FWA systems.

Annex 1

Information on the sharing studies to identify frequency bands for FWA systems

Table 2 provides information on sharing studies in the bands listed below that may be applicable to FWA systems. These bands were selected based upon existing or planned use by some administrations or regional Recommendations (or standards) and equipment availability. The results of these sharing studies should be taken into account as indicated in the methodology given in § 6.1. Additional information on regional Recommendations may be found in Volume 1 of the ITU-R Handbook on land mobile (including wireless access): fixed wireless access, 2nd edition, 2001 (§ 4.3.2, p. 14-17).

TABLE 2

Examples of frequency bands used in some countries for FWA systems and related sharing studies

Frequency range and reference ITU-R Rec. for frequency arrangements		**Band**	**RF carrier spacing**	**Reference ITU-R Rec. for sharing consideration (with other service)**
450 MHz	F.1567	413.05-423.05 MHz paired with 440-450 MHz	250, 300, 500, 600, 750 kHz, 1, 1.75, 3.5 MHz	These bands are shared with mobile service and partly with amateur service and space research service. SA.1236, SA.1260
		406.1-413.05 MHz paired with 423.05-430 MHz	50, 100, 150, 200, 250 and 600 kHz	
800-900 MHz	M.1073	824-849 MHz paired with 869-894 MHz; 890-915 MHz paired with 935-960 MHz	10, 30 and 200 kHz	M.478 principles to assigning channels 25-3 000 MHz
1.8/1.9 GHz	F.757, M.1073	1 710-1 785 MHz paired with 1 805-1 880 MHz	200 kHz	
	F.757, M.1073	1 850-1 910 MHz paired with 1 930-1 990 MHz	30 kHz	These bands are shared partly with MSS
	F.757, M.1033	1 880-1 900 MHz	1 728 kHz	F.1518 (mobile service)
	F.757, M.1033	1 893.5-1 919.6 MHz	300 kHz	F.1402 (mobile service), F.1518 (mobile service)
3.5 GHz	F.1488 (Annex 1) (Annex 2)	3.4-3.8 GHz	25 MHz block (250 kHz × n blocks)	F.1489 (radiolocation service), SF.1486 (FSS)

TABLE 2 (*end*)

Frequency range and reference ITU-R Rec. for frequency arrangements		Band	RF carrier spacing	Reference ITU-R Rec. for sharing consideration (with other service)
24/29 GHz	F.748 (Annex 3), (§ 1)	24.25-24.45 GHz paired with 25.05-25.25 GHz	40 MHz block	These bands are shared with radionavigation service (RNS) and FSS
	F.748	24.25-27.5 GHz	(2.5 MHz × *n*) (3.5 MHz × *n*)	F.1249 (inter-satellite service (ISS)), F.1509, SA.1278 (ISS)
	F.748 (Annex 1)	24.5-26.5 GHz	3.5, 7, 14, 28, 56, 112 MHz	F.1249 (ISS), F.1509, SA.1278 (ISS)
	F.748 (Annex 3), (§ 2)	25.27-26.98 GHz	60 MHz block	F.1249 (ISS), F.1509, SA.1278 (ISS)
	F.748 (Annex 2)	27.5-29.5 GHz	3.5, 7, 14, 28, 56, 112 MHz	These bands are shared with FSS and MS
32 GHz	F.1520 (Annex 1), (Annex 2)	31.8-33.4 GHz	3.5, 7, 14, 28, 56 MHz 56 MHz block	F.1571 (RNS) SA.1157
38 GHz	F.749	36.0-40.5 GHz	(2.5 MHz × *n*) (3.5 MHz × *n*)	SF.1484 (FSS) SF.1573 (FSS) SA.1396
	F.749 (Annex 2)	36.0-37.0 GHz paired with 39.5-40.5 GHz	3.5, 7, 14, 28, 56, 112 MHz	SF.1484 (FSS) SF.1573 (FSS) SA.1396
	F.749	37.0-39.5 GHz	3.5, 7, 14, 28, 56, 140 MHz	SF.1484 (FSS) SF.1573 (FSS) SA.1396
	F.749 (Annex 3), (§ 2)	38.06-38.48 GHz paired with 39.06-39.48 GHz	60 MHz block	SF.1484 (FSS) SF.1573 (FSS) SA.1396
	F.749 (Annex 3), (§ 1)	38.6-40.0 GHz	50 MHz block	SF.1484 (FSS) SF.1573 (FSS)
40 GHz[1]	Q.108-1/9	40.5-43.5 GHz	Block allocation depending on demand	SF.1484 (FSS) SF.1573 (FSS)[2]

[1] The band 40.5-43.5 GHz is presently addressed in some European countries in accordance with the European Radiocommunications Committee (ERC) DEC(99)15.

[2] Sharing with FSS applies up to 42.5 GHz.