REPORT ITU-R F.2047

Technology developments and application trends in the fixed service

(Question ITU-R 221/9)

(2004)

1 Introduction

This Report provides guidance on the future development of the fixed service (FS) reflecting recent technology developments and application trends for fixed wireless systems, including fixed wireless access (FWA) applications, and frequency sharing studies to enhance spectrum utilization efficiency.

2 Scope

This Report addresses the following items in relation to the future development of the FS:

– FS technology trends overview;
– development of the role of FS systems in telecommunication networks;
– FS band usage trends in some countries;
– frequency sharing studies with other services;
– possible future applications in the FS.

The scope of this Report covers conventional radio-relay systems, FWA systems, fixed wireless links for back-haul communications, systems utilizing high altitude platform stations (HAPSs), and nomadic wireless access (NWA) systems, when operating in the FS, including consideration of technology convergence of terrestrial wireless systems.

3 List of acronyms and abbreviations

BS	Broadcasting service
BSS	Broadcasting-satellite service
BWA	Broadband wireless access
DVB	Digital video broadcasting
EESS	Earth-exploration satellite service
FDD	Frequency division duplex
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
ISM	Industrial, scientific and medical

ISP	Internet service provider
ISS	Inter-satellite service
LMCS	Local multipoint communication systems
LMDS	Local multipoint distribution systems
MDS	Multipoint distribution system
MP-MP	Multipoint-to-multipoint
MS	Mobile service
MWA	Mobile wireless access
MWS	Multimedia wireless systems
NWA	Nomadic wireless access
PDA	Personal digital assistant
P-MP	Point-to-multipoint
P-P	Point-to-point
QoS	Quality of service
RF	Radio frequency
RL	Radiolocation
RLAN	Radio local area network
RN	Radionavigation
RRS	Radio-relay system
SDH	Synchronous digital hierarchy
SDR	Software defined radio
SONET	Synchronous optical network
STM-1	Synchronous transport module 1
TDD	Time division duplex

4 Developments in the FS

4.1 FS technology trends overview

In terms of the evolution of the FS, issues that merit close attention include the following:

- convergence of services and technology offerings, e.g. the concept of multimedia wireless systems (MWSs);
- convergence of nomadic and fixed and mobile applications, including licence-exempt applications;
- HDFSs are used for both network infrastructure support and end user access. It is worth noting that WRC-2000 designated the following frequency bands as available for HDFS systems:
  - 32, 38, 42, 52, 56 and 65 GHz;
- a possible trend towards more flexible regulatory regimes;

– fairly rapid progress in design and development of more frequency agile, flexible and autonomous systems to give good spectral efficiency in a manner which also aids faster and cheaper deployment practices;
– user demands for greater quality of service (QoS), particularly in relation to the next 15 years or so of worldwide build-out of infrastructure that will support the explosive growth of the Internet;
– understanding of different development status of countries, and possible growth of FS spectrum needs;
– possibilities for review of applications in any current band that is used for the FS;
– possibilities for improved sharing with traditional FS and licence-exempt FS and MS applications.

Convergence in digital telecommunications (data, voice, sound, image and video) is giving rise to technology trends in the FS that are not only rapid but also highly unpredictable especially in time-frames beyond five years.

The role of the FS is changing. In the past, the FS served a variety of trunking and transport applications ranging from very low capacity applications (less than the primary rate) to very high capacity applications, where typically 1:*n* diversity protection was needed at system bit rates above the order of STM-1. For example, telecommunication operators could consume a large part of a given frequency band in these very high capacity applications. In the access network, the FS was used sparingly as an adjunct to cable networks. Over the last several years, however, these very high capacity radio-relay applications have largely been replaced with fibre optic transmission systems and this trend will continue for the foreseeable future.

On the other hand, the FS has, more recently, been establishing a stronger presence in the access network in licensed and licence-exempt spectrum. This is due in part to a growing demand and economical equipment which in turn is a result of agreed standards for FWA systems at the medium access control and physical-layers. In the future, the FS is expected to serve a greater role in the access network, complemented with low, medium and high-capacity trunking and transport applications. These new trunking applications will typically not require 1:*n* diversity protection and will complement fibre optic transmission systems in rugged, remote and difficult terrain areas of the world.

Increased flexibility of equipment through software control will enable varying traffic asymmetry (mainly in the access network) requirements in the FS.

Also, in some cases, the boundary between systems in the FS and MS is becoming less well defined. As next generations of P-MP fixed systems address non-line-of-sight, high performance and broadband challenges, as well as new mesh architectures in the access network, the FS could have a major role in the implementation of the transport network for IMT-2000 and systems beyond IMT-2000. This role may include not only the provision of service but also infrastructure support networks, as considered in the later section.

To further increase spectral efficiency and service flexibility, advanced FWA (including HDFS/BWA) systems are increasingly likely to employ a range of techniques that may include different duplex technologies, and mixes of them, and dynamic allocation of bit rate, of modulation and of antenna beamwidth/pattern. Such systems will likely have the functional capability of variable or flexible channelization; this better facilitates transmission of symmetrical or asymmetrical services, based on need, an important factor in the growth of wireless services.

In this connection it is attractive to consider SDR.

SDR is generally characterized as a radio technology in which the operating parameters, in particular spectrum-related parameters, can be changed via software without replacing the hardware components. Definition of SDR and its associated techniques are under study in ITU-R. It should be noted that some of today's radio equipment employ programmable memory modules as firmware or hardware components. In this sense there are already some forms of SDR in the existing networks.

In some aspects the SDR technology has been applied since the early 1990s in some parts of radio systems and more use of SDR is expected to be made in the future. SDR could provide an efficient solution to the problem of building multi-mode, multi-band, and multi-functional wireless devices. With software programmability, high-speed digital signal processing performs many of the functions previously carried out in hardware, and the radio can be made capable of transmitting and receiving over a range of frequencies.

One of the SDR impacts on radio equipment for the FS is that manufacturers could develop a common hardware platform on which various SDR functions are implemented, and that a single hardware is economically applied to many operators' different specifications. Such a feature may also affect equipment authorization, type approval standards or declaration of conformity.

Traditionally, manufacturers have been responsible for the approval of their fixed wireless equipment for a specific set of technical parameters. With SDR, this responsibility may need to be shared with the operators. In fact, operators must be aware of the potential technical and sharing constraints over the complete range of operating frequencies and modulation schemes. SDR could provide a leverage to harmonize emission standards across frequency bands on a global or regional basis.

In terms of FS deployment arrangements, in the near future there will be connected (ring) as well as conventional cascades ("daisy chain" or radio relay) for P-P schemes, and multipoint schemes will include MP-MP (mesh) structures as well as P-MP and various hybrid FS arrangements. The air-side concentration is a significant distinguishing feature in multipoint system usage as compared to conventional P-P systems. Some multipoint systems are already deployed in infrastructure support. Many more FS deployments will be needed as network infrastructure support for the rapidly growing cellular mobile/nomadic markets, i.e., these are not access but conventional infrastructure applications.

It should be noted that even P-P systems used in fairly conventional type of deployment architecture will benefit from these advances in systems design and in spectrum usage, including the use of block-based frequency arrangements rather than conventional channelization, and this will be influenced by the evolution in design of the multipoint, which are largely access systems.

4.2 Development of the role of FS systems in telecommunication networks

FS systems have been and continue to play a role in long-haul or inter-exchange links in telecommunication infrastructure networks. However, increasing demand for wireless access systems and development of optical fibre systems have brought about changes in the development of FS systems. ITU-R is experiencing an increased interest in systems used in the access portion of telecommunication networks.

Recent work in ITU-R reflecting the above developments can be summarized as follows:

– a new term "fixed wireless system" has been defined in Recommendation ITU-R F.592 on terminology instead of conventional "radio-relay system";

– many new or revised Recommendations on RF channel arrangements have been adopted in the frequency bands identified by WRCs for use for HDFS or other bands used for FWA systems (see Recommendations ITU-R F.1098, ITU-R F.1496, ITU-R F.1497, ITU-R F.1488, ITU-R F.748, ITU-R F.749, ITU-R F.1520, ITU-R F.1567 and ITU-R F.1568);
– studies on new delivery technologies such as HAPS that could also be utilized for access networks have been continuously facilitated (see Recommendations ITU-R F.1500 and ITU-R F.1501, ITU-R F.1569, ITU-R F.1607, ITU-R F.1608 and ITU-R F.1609);
– studies on frequency sharing between FS systems and other services have been carried out (see Recommendations ITU-R F.1489, ITU-R F.1509, ITU-R F.1570, ITU-R F.1612 and ITU-R F.1670).

4.2.1 Transport or trunking networks

Traditional transport or trunking networks operate in frequency bands in the range below 15 GHz. With the increase in traffic demand, many service providers are now deploying fibre optic networks instead of building new, very high capacity radio-relay networks (e.g. higher than SDH STM-1) or augmenting existing very high-capacity radio-relay networks. In some administrations, the frequency bands that have been used for very high capacity transport applications may be expected to be employed less in the future in these kinds of applications. In most administrations, existing trunking networks are likely to remain in use but are not expected to grow significantly, however an increase in traffic demand due to Internet access might be expected especially in rural areas.

In many cases existing bands for low, medium and high-capacity P-P, radio-relay networks will continue to be needed to satisfy a growing number of competing public and private telecom networks. Low and medium capacity short haul P-P links are serving an important role in providing links for an increasing number of organizations and corporations that are operating networks that are not part of public network infrastructure. Furthermore, there is expected to be increasing use of low, medium or high-capacity systems for short haul (a few hops or a single hop) applications, as well as for mobile and FWA backhaul networks.

A further emerging application is for fibre optic network back-up that will require very high capacity FWSs. Whatever the application, effective spectrum utilization will require the preparation of new and flexible RF channelization plans. In preparing such channelization plans however, account will need to be taken of continued coexistence with other primary services in these bands.

4.2.2 FS use in IMT-2000 infrastructure networks

After WRC-2000 identified additional mobile service bands for IMT-2000, the global build-out of IMT-2000 began, which is placing demands on FS spectrum for network infrastructure. Some of the network infrastructure will be supplied by optical fibre systems, and this trend needs to be carefully assessed in the deployment of future FWSs in this application.

A study has shown that by the year 2010 the required transmission capacity for access links to individual base stations (except for indoor environments) will increase several times or more than that compared with pre-IMT-2000 systems. Moreover, according to recent studies in ITU-R, the objective for a potential new radio interface is to support up to 50-100 Mbit/s in the mobile environment in the down-stream direction by around the year 2010 to 2015 (see Recommendation ITU-R M.1645). Such a trend may lead to further demands for the FS use on interconnecting the different layers of IMT-2000 networks.

In many administrations, low and medium capacity microwave facilities support backhaul applications for pre-IMT-2000 cellular systems. The deployment of 3G networks has already begun and utilization of frequency bands between 4-57 GHz is expected. In addition, mobile service operators are considering the use of P-MP systems for backhaul purposes. In the future, there is likely to be a substantial demand for new fixed wireless infrastructure to support the deployment of new mobile base stations in an expedited manner.

4.2.3 Consideration of frequency bands used for FWA systems

FWA systems and technologies include:

- P-P, P-MP, MP-MP;
- FDD and TDD;
- applications using large RF bandwidth:
  - operate in bands above 20 GHz;
  - bandwidth: 50 to 100 MHz per RF carrier or RF block, several hundreds MHz per system.

    Example: LMCS/LMDS or other systems providing BWA in urban areas and operating around 22-28 GHz, 38 GHz and 42 GHz;
- applications using medium RF bandwidth:
  - operate in bands between 1 GHz and 20 GHz;
  - bandwidth: 6 to 50 MHz per RF carrier or RF block, several tens to several hundreds MHz per system.

    Example: multipoint communication system or other systems providing last kilometre wireless access in suburban or rural areas and operating between 2 and 11 GHz;
- applications using small RF bandwidth in frequency bands currently allocated to FS:
  - operate in bands below 1 GHz[1];
  - bandwidth: up to 8 MHz per RF carrier or RF block, few tens MHz per system.
  - *Example*: P-MP and mesh wireless access systems providing broadband Internet connectivity in rural and remote areas (where the spectrum below 1 GHz is more lightly used).

Recommendation ITU-R F.1401 considers possible frequency bands for FWA systems and the existing sharing studies or results of these studies. These band ranges are:

- 450 MHz, 800-900 MHz, 1.8/1.9 GHz, 3.5 GHz, 24/29 GHz, 32 GHz, 38 GHz and 40 GHz.

Total bandwidth of the frequency bands for FWA which are referred to in many F Series Recommendations can be summarized as follows:

- 623.5 MHz, for the frequency range between 400 MHz - 3 GHz, (24.0%)
- 700 MHz, for the frequency range between 3-11 GHz, (8.7%)
- 5 250 MHz, for the frequency range between 11-30 GHz, (27.6%)
- 10.82 GHz, for the frequency range between 30-70 GHz (27.0%)

[1] Some administrations use frequency bands below 1.6 GHz to provide broadband connectivity in rural areas.

It should be noted that the above bandwidths are not always available within administrations, and it is expected that interest in FWA systems will continue on a worldwide basis. Therefore attention should be paid to the following subjects:

– consideration on possible spectrum, in bands currently allocated to FS, below 1 GHz to support FWA systems in rural or remote areas;

– review of applications within the FS bands (e.g. P-P radio-relay/FWA) between 3 GHz and 11 GHz;

– technical consideration on use of the FS (including FWA systems) in the range between 57 GHz and 100 GHz;

– use of optical-free space transmission for FS applications.

4.2.4 Evolving applications

A number of new applications, such as HDFS, NWA systems and radio local area networks (RLANs), will grow over the next few years.

As mentioned earlier, with the convergence of fixed and mobile applications, it is becoming hard to differentiate between the two types of applications. Nomadic applications may operate in both fixed and mobile service bands. In fact, majority of the bands allocated to the FS are also allocated to the mobile service. Consequently, this eases the implementation constraints for administrations since action can then be taken on a national, bilateral or multilateral basis.

In some cases, as the situation demands, a single terminal may be able to reconfigure itself to operate as a fixed station or a mobile station and networks will be able to recognize and accommodate such terminal adaptation. For example, equipment designed for the FS may technically be used to provision the BWA requirements of the mobile service.

Another aspect that has an impact on the type of telecommunications seen in the future is the convergence of voice and data applications. For example, products such as wireless PDAs that include not only data (e.g. e-mail, web browsing) but also voice telecommunications, are starting to appear on the market. With an evolution towards packet-based and IP-based wireless deployments that may include voice over IP, more of these kinds of products will be available in the market.

4.2.5 Summary of the future role of the FS and new applications

– The FS is establishing a new and greater presence in the access network. As the cost of subscriber equipment continues to decrease, through standardization efforts at the medium access control and physical-layers, the need for more FWA and BWA deployment will grow. This presents opportunities for global technical standardization.

– Some of the traditional radio-relay bands in the range below 15 GHz could be considered for use in FWA/BWA applications, noting that some of these bands, which may be compatible with other primary services, would be probable candidates.

– Many bands allocated to the FS used for P-P applications will be required for this role in the future to satisfy backhaul requirements for IMT-2000 (and beyond) networks, for FWA/BWA networks, and for low, medium and high-capacity short haul trunking applications in public and private networks.

– One of the subjects for consideration will be to develop possible technologies to implementing FWA/BWA systems operating below 1 GHz, within the bands currently allocated to the FS, for broadband telecommunication services in high cost serving areas, typically in remote or rural areas of the world.

4.3 Fixed systems using HAPS

The past WRCs identified the following frequency bands allocated to FS for use for systems using HAPS subject to the provisions of the relevant RR Resolutions:

– 47.2-47.5 GHz and 47.9-48.2 GHz (subject to Resolution 122 (Rev.WRC-03)),

– 27.5-28.35 GHz and 31.0-31.3 GHz (for some administrations and subject to Resolution 145 (WRC-03) and operating on non-harmful interference, non-protection basis).

ITU-R has carried out studies on technical and operational aspects of HAPS systems as well as sharing and compatibility issues between HAPS and other systems including conventional FS systems. These studies have resulted in a number of F Series Recommendations (e.g. Recommendations ITU-R F.1500, ITU-R F.1501, ITU-R F.1569 and ITU-R F.1570). Furthermore, WRC-03 requested ITU-R to conduct studies on the remaining subjects identified in the above Resolutions by WRC-07.

4.4 FS band usage trends in some countries

4.4.1 Impact of licensing methods on the FS equipment design[2]

Spectrum licensing is a grant to access the RF spectrum defined in terms of frequency band and geographic area. A set of technical spectrum access conditions is provided to licensees including maximum transmitter power, coordination requirements among operators; and where applicable, inter-service sharing (e.g. emission masks).

On the other hand, apparatus licensing is the means employed by some administrations. It specifies the type of service that can be delivered under the licence as well as conditions including transmitter sites, power, etc. Apparatus licensing will continue in the future as not all bands or applications are suitable for spectrum licensing. However, rules for apparatus licensing may need to be reviewed to accommodate new interfaces, e.g. Ethernet, possibly requiring different bandwidths, and to consider new or developing technologies such as SDR or TDD P-P radios. In the case of SDR, the responsibility for meeting the coexistence technical requirements may need to be shared between the service provider and the manufacturer.

In some countries, the growing acceptance of common use (licence-exempt) bands has created an array of new products and applications for the consumer. With new advances in radio technology, there is a growing commercial interest in developing products that utilize such bands.

Licence-exempt spectrum is used for a number of telecommunications applications, including short-range data transmissions and wireless LAN/WAN connections. In addition, many service providers, including ISPs, have started to use bands around 2.4 GHz and in the 5 GHz range to provide high-speed terrestrial, fixed wireless Internet to suburban, rural and remote communities. In some countries, these licence-exempt bands, particularly in the 5 GHz range, are also used to provide communications between base-stations (backhaul communications). Smaller telecommunication service providers and private users have chosen to use the licence-exempt bands for a number of reasons: economic, technical and logistical. Higher frequency common use bands such as 24 GHz and 57/59 GHz are also used by several administrations.

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[2] Licensing (or exemption from licensing) of spectrum access is a national regulatory issue.

Also, in these countries, there is an increasing demand for higher data rate broadband wireless communications. To address these issues, the following is under consideration:

– provide additional use of licence-exempt spectrum either exclusive or common use, with apparatus licensed FS and other radio services;

– utilize techniques that will help mitigate interference.

4.4.2 Review of applications

Due to congestion in many portions of the RF spectrum, some administrations are addressing the need to optimize the use of the spectrum by accommodating applications based on new technologies under development or being implemented.

Review of applications for frequency band which has been deployed in some countries, is a method to deal with the increasing demand for spectrum. In this method, particular bands may be recovered by the national regulator from their existing uses and reassigned for potential new FS architectures or technologies. The possibility of reusing some radio-relay bands in the 2-15 GHz range is being explored to satisfy the anticipated demands of spectrum for broadband and narrow-band network access growth.

NOTE 1 – As an example, one administration has reported that in its network use of 4 and 5 GHz frequency bands by RRSs will be terminated by 2012 with a view to utilize these bands for terrestrial wireless systems for access networks including systems beyond IMT-2000.

4.4.3 Frequency use toward standardized RF interfaces

The requirement for new interfaces or bandwidths is an opportunity for worldwide standardization. For example, Ethernet interfaces and SDH/SONET bit rates are the same worldwide.

In order to facilitate the evolution of radiocommunication systems in the FS, global standardization is highly desirable. In fact, an international drive to reach a sufficient level of standardization will help to ensure the availability of low cost equipment.

WRC-97 and WRC-2000 recognized this point and nearly 12 GHz of spectrum in bands above 30 GHz were identified for HDFS in the RR. Through economies of scale, potential equipment cost advantages are realized by concentrating HDFS systems in selected bands. Above 30 GHz, there is a pool of spectrum identified for HDFS systems, which may be sufficient to support current requirements of FWA systems above 30 GHz. Below 30 GHz, there is need for further studies, particularly in the 2-15 GHz and below 1 GHz ranges, similar to that of HDFS in bands above 30 GHz. Also, sharing with other services in these lower bands (e.g. FSS, MSS and BSS) will require careful evaluation before designations for FWA systems are made.

4.5 Frequency sharing studies with other services

The FS often shares frequency bands with other services, e.g. FSS. With a view to possible study of new frequency bands for FS (including FWA) systems, if requested by WRC, it is becoming more and more important to consider sharing issues between the FS and other services.

In the past a lot of studies have been made on frequency sharing between the FS and other services in particular FSS. Recently studies on sharing criteria between FS systems in the access network and other radio services have been well conducted, and the results are summarized in Table 1.

TABLE 1

Summary of sharing study results between the FS (including FWA) and other services

Other service sharing the same band with FS	Frequency band[(1)]	Recommendation ITU-R
FSS	3.4-3.8 GHz	SF.1486
	37.5-42.5 GHz	SF.1484, SF.1573
MS	800/900 MHz	F.1402
	1.8/1.9 GHz	F.1402, F.1518
BSS	1.4/1.5 GHz	F.1338
RL	3.4-3.7 GHz	F.1489
ISS	24-27 GHz	F.1249, F.1509
RN	31.8-33.4 GHz	F. 1571
EESS	5.25-5.35 GHz	F.1613
BS	174-230, 470-862 MHz	F.1670

(1) Use of frequency bands may be different in different Regions.

The methodologies developed in the above Recommendations may provide useful reference applicable to the future sharing studies in other frequency bands.

4.6 Possible future applications in the FS

4.6.1 Use of the higher frequency bands

In addition to various applications discussed in § 4.2 and4.3, it will be possible to deploy wireless media in private telecommunication networks, i.e. various scales of RLANs, including in-building environments. Such applications include:

– links connecting RLANs operating in different buildings;

– links connecting RLAN base stations (access points) to the local core network.

Frequency bands above 70 GHz may also be utilized for these applications as well as others. Studies on characteristics of FS systems operating in the band above 57 GHz are ongoing within ITU-R.

Furthermore, studies on optical free-space fixed links are also being conducted under a new ITU-R Question on FS applications using frequency bands above 3 000 GHz, initially focusing on 375-385 THz (780-800 nm in the wavelength) range.

In order to determine the amount of spectrum bandwidth required, the methodology based on Recommendation ITU-R M.1390 as given below will be useful.

a) *Basic considerations*

– geographical considerations;

– traffic considerations.

b) *Technical and system considerations*

– number of service channels and service channel bit rate;

– system capability.

There are several factors which affect FS system capability in terms of Mbit/MHz and deployment characteristics:

– modulation scheme (multilevel modulation: 4-level to 256-level);
– use of dual polarization;
– waveform shaping scheme;
– enhanced antenna characteristics.

c) *Spectrum result consideration*

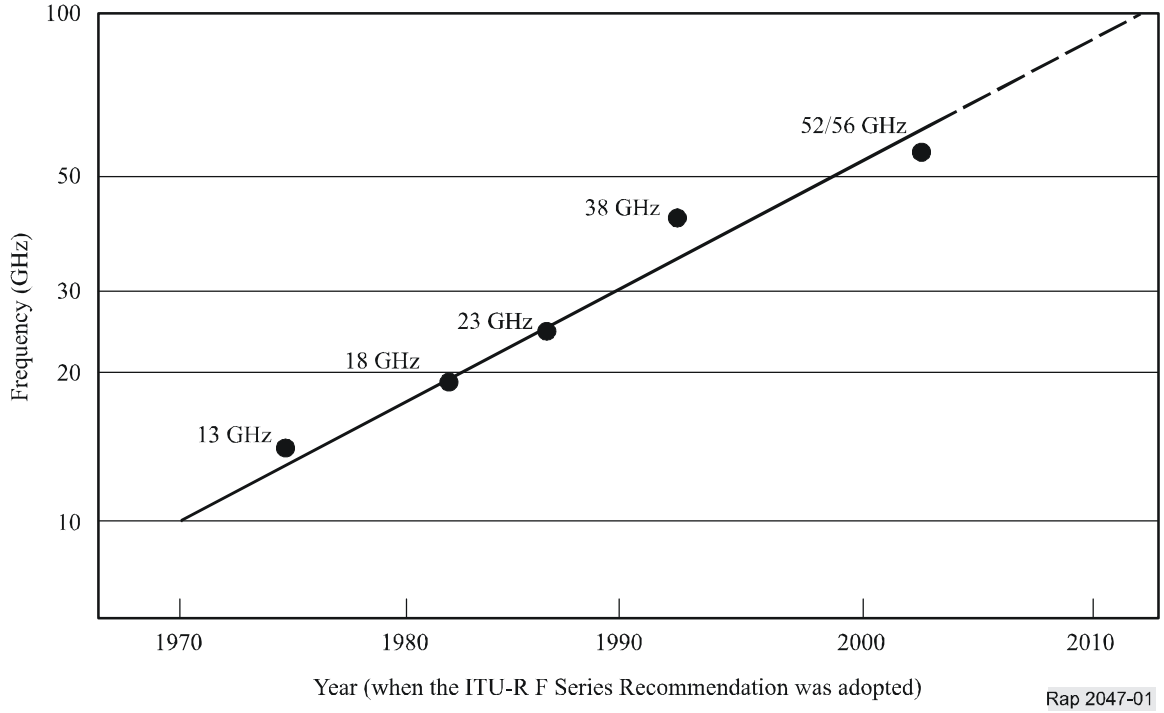
The total required spectrum could be calculated by the following process:

– decision of system capacity per RF carrier to efficiently convey the offered traffic;
– calculation of necessary bandwidth of RF carrier;
– estimation of the number of RF carriers accommodated in the band considering frequency reuse pattern.

Exploitation of higher frequency bands has been limited by the state of technology development of wireless devices. Figure 1 illustrates the trend of the use of higher frequency bands by the FS, which could be seen in the ITU-R F Series Recommendations on RF frequency arrangements.

FIGURE 1

Exploitation of higher frequency bands in the FS



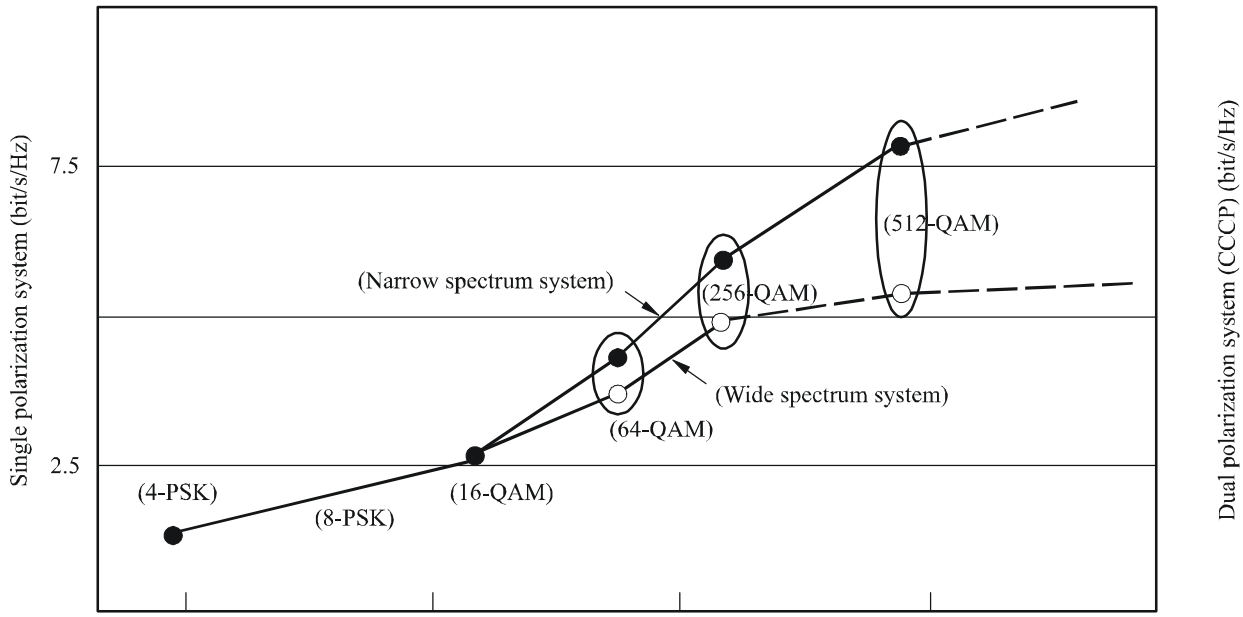
From this trend it is envisaged that ITU-R F Series Recommendations addressing characteristics, frequency arrangements, etc. in the 57-100 GHz range will be required before the 2010 time-frame.

4.6.2 Frequency utilization efficiency

FWSs can employ multistate modulation schemes to realize high utilization efficiency of the frequency spectrum. Frequency utilization efficiency in term of bit/s/Hz relates not only to multistate modulation but also to spectrum shaping and use of dual polarization. From early implementation of high capacity digital RRS in 1980s, FWSs have greatly contributed to efficient use of the spectrum by applying these techniques, as shown in Fig. 2. The abscissa of Fig. 2 provides the year when each multistate modulation was first reported in the ITU-R F Series Recommendation on RF arrangements or the Tables in Recommendation ITU-R F.758 on system parameters for sharing studies.

FIGURE 2

Increase of frequency utilization efficiency (bit/s/Hz) in the FS



As can be seen in Fig. 2 it may be difficult to envision that the utilization efficiency will further increase. Since future FS applications are focused on FWA systems in particular operating in a P-MP configuration, another evaluation factor of frequency utilization efficiency will be needed in relation to how densely they could be deployed or how many radio channels become available in certain geographical areas.

4.6.3 Future role of FWSs

As discussed in § 4.2, the role of FS systems in telecommunication networks is evolving toward access network applications. A quantitative analysis to demonstrate this trend is given in Fig. 3, which roughly illustrates FS bandwidths specifically available for RRS or access links (FWA or back-haul links). In order to simplify the subject, this analysis, until the year 2003, has been done in the following manner.

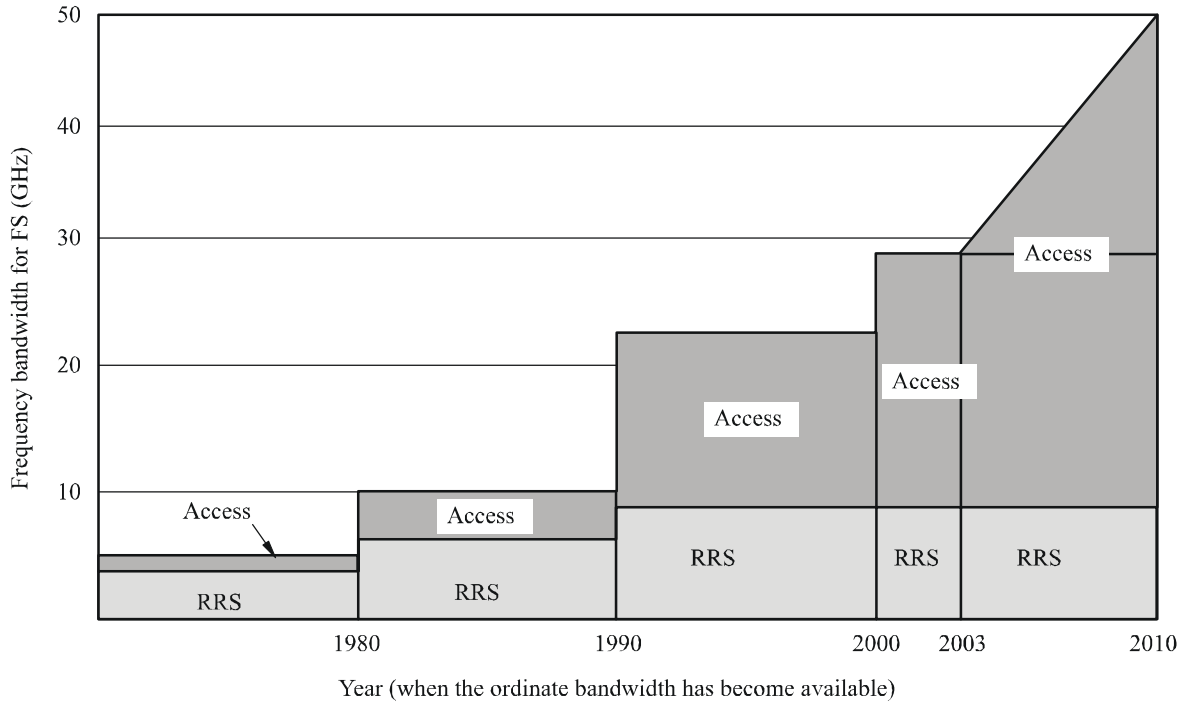
– all the frequency bands are considered to become available for FS use when they are reported to ITU-R and reflected in Recommendations;

– the bands above 3 GHz and below 17 GHz are considered to be used for RRS;

– the bands below 3 GHz and above 20 GHz are considered to be used for access links;
– the band between 17-20 GHz (more specifically 17.7-19.7 GHz) is considered to be used, in equal ratio, for both RRS and access links.

FIGURE 3

Development of FS applications and future trends



Access: FWA and back-haul systems, and HAPS systems in some countries

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After the year 2003, the following assumption is made: that all the frequency bands between 59 GHz (the highest frequency referred to in the ITU-R F Series Recommendation) and 100 GHz, which are allocated to the FS will become available under certain technical/operational compatibility conditions with other services. This trend, as in the past three decades, would possibly continue until 2010. It is envisaged that bandwidths of 40-50 GHz may be used for FS applications, corresponding to 50% of the highest frequency available (see Fig. 1). Most of these applications will be those used in the access networks, however many bands are still required for RRS (even though the number of required RRS bands may remain essentially stable).

6 Future subjects for the development of the FS applications

The essential elements of the future subjects include:

– technology developments and their impact on various FS applications;
– traffic-based estimation for the required bandwidth for each application;
– initial estimation of increased demands for wireless access systems other than HDFS for which available bands have been already identified (e.g. HAPS, FWA/BWA);
– summarization of the frequency sharing scenarios in various bands to evaluate whether the FS deployment in each band could be recommended on a worldwide basis;
– frequency arrangement issues including those based on frequency blocks;

- global and regional trends and possible differences;
- overview of the frequency spectrum in the range 2-100 GHz (e.g. available bandwidth, system capacity requirements, channel reuse scheme, possible sharing with other services):
  - in particular, technical considerations on the use of the FS in the 57-100 GHz range;
- overview of the frequency spectrum in the range 400 MHz-2 GHz especially for BWA in rural and remote areas (e.g. available bandwidth, system capacity requirements, channel reuse scheme, possible sharing with other services);
- investigation of methods to further improve spectrum efficiency (e.g. in terms of bits/s/Hz/km^2).

References

Recommendation ITU-R F.592:	Vocabulary of terms used for the fixed service
Recommendation ITU-R F.748:	Radio-frequency channel 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 bands
Recommendation ITU-R F.757:	Basic system requirements and performance objectives for fixed wireless access using mobile-derived technologies offering 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.1098:	Radio-frequency channel arrangements for fixed wireless systems in the 1 900-2 300 MHz band
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.1338:	Threshold levels to determine the need to coordinate between particular systems in the broadcasting-satellite service (sound) in the geostationary-satellite orbit for space-to-Earth transmissions and the fixed service in the band 1 452-1 492 MHz
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.1401:	Considerations for the identification of possible frequency bands for fixed wireless access and related sharing studies
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 radiolocation systems when sharing the band 3.4-3.7 GHz

Recommendation ITU-R F.1496:	Radio-frequency channel arrangement for fixed wireless systems operating in the band 51.4-52.6 GHz
Recommendation ITU-R F.1497:	Radio-frequency channel arrangement for fixed wireless systems operating in the band 55.78-59 GHz
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
Recommendation ITU-R F.1501:	Coordination distance for systems in the fixed service (FS) involving high altitude platform stations (HAPSs) sharing the frequency bands 47.2-47.5 GHz and 47.9-48.2 GHz with other systems in the fixed service
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 F.1520:	Radio-frequency channel arrangements for systems in the fixed service operating in the band 31.8-33.4 GHz
Recommendation ITU-R F.1567:	Radio frequency channel arrangements for digital fixed wireless systems operating in the frequency band 406.1 to 450 MHz
Recommendation ITU-R F.1568:	Radio-frequency block arrangements for fixed wireless access systems in the range 10.15-10.3/10.5-10.65 GHz
Recommendation ITU-R F.1569:	Technical and operational characteristics for the fixed service using high altitude platform stations in the bands 27.5-28.35 GHz and 31.0-31.3 GHz
Recommendation ITU-R F.1570:	Impact of uplink transmission in the fixed service using high altitude platform stations in the Earth exploration-satellite service (passive) in the 31.3-31.8 GHz band
Recommendation ITU-R F.1571:	Mitigation techniques for use in reducing the potential for interference between airborne stations in the radionavigation service and stations in the fixed service in the band 31.8-33.4 GHz
Recommendation ITU-R F.1613:	Operational and deployment requirements for fixed wireless access (FWA) systems in the fixed service in Region 3 to ensure the protection of systems in the Earth exploration-satellite service (active) and the space research service (active) in the band 5 250-5 350 MHz
Recommendation ITU-R F.1670:	Protection of fixed wireless systems from terrestrial digital video broadcasting systems in the VHF and UHF shared bands
Recommendation ITU-R M.1390:	Methodology for the calculation of IMT-2000 terrestrial spectrum requirements
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 bands 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
Resolution 122 (Rev.WRC-03):	Use of the bands 47.2-47.5 GHz and 47.9-48.2 GHz by high altitude platform stations (HAPS) in the fixed service and by other services
Resolution 145 (WRC-03):	Potential use of the bands 27.5-28.35 GHz and 31-31.3 GHz by high altitude platform stations (HAPS) in the fixed service
Resolution 802 (WRC-03):	Agenda for the 2007 World Radiocommunication Conference
Resolution 803 (WRC-03):	Preliminary agenda for the 2010 World Radiocommunication Conference