RECOMMENDATION ITU-R SM.1132*

GENERAL PRINCIPLES AND METHODS FOR SHARING BETWEEN RADIO SERVICES

(Question ITU-R 203/1)

(1995)

The ITU Radiocommunication Assembly,

considering

a) that efficient and effective use of the radio spectrum often requires the sharing of frequency bands by different services;

b) that general principles are needed for considering services to group within shared bands;

c) that technical methods to facilitate sharing need to be delineated,

recommends

1 that, when determining the potential for sharing services within specific bands, administrations should consider the general principles and methods described in Annex 1.

ANNEX 1

General principles and methods related to spectrum sharing

1 Dimensions of allocation sharing

Interservice sharing exists when two or more radiocommunication services effectively use the same frequency band. Article 1 of the Radio Regulations (RR) (Nos. 160-168) defines the parameters to be taken into account in frequency sharing. Utilization of the radio spectrum is dependent on frequency, time, spatial location, and orthogonal signal separation. Any sharing of the spectrum will have to take into account one or more of these four dimensions. Sharing can be accomplished in a straightforward fashion when any two of these dimensions are in common and the third and/or fourth dimension differs by a degree sufficient to ensure that all the involved services (two or more) can operate satisfactorily. Sharing can also be accomplished when services have all four dimensions in common. In such cases, sharing is accomplished by applying technical conditions which do not compromise the performance requirements of the services involved.

2 Technical basis for sharing allocations

Table 1 shows some of the methods which can be used to facilitate sharing, grouped in columns based on the four dimensions: frequency, time, spatial location and signal separation.

* This Recommendation should be brought to the attention of Telecommunication Development Study Groups 1 and 2 (ITU-D).

TABLE 1

Technical methods to facilitate sharing

Frequency separation	Spatial separation	Time separation	Orthogonal signal separation
Channelling plans	Site selection	Duty cycle control	Code-oriented multiple access schemes (CDMA)
Dynamic real-time frequency assignment	Antenna pattern discrimination	Dynamic real-time frequency assignment	Antenna polarization
Frequency-oriented multiple access schemes (FDMA)	Physical barriers Site shielding	Time-oriented multiple access schemes (TDMA)	
Coding: – error correction – compression	Interference power: – dynamic transmitter level control – pfd limitation – power spectral density limitation (energy dispersal)	Coding: – error correction – compression	
Control of emission spectrum characteristics			
Dynamic variable partitioning			
Frequency tolerance limitation			

Within Table 1 some of the methods are new or innovative and may make more efficient use of the spectrum or provide flexibility. Many of these methods result from the introduction of new equipment technologies, computerization of analysis and new ideas. Some of the methods are complex, involving real-time computer controlled frequency management.

Often, the specification of particular technical parameters for equipment is necessary to implement sharing methods shown in Table 1.

3 Sharing approaches

3.1 Digital communication system sharing

There is a trend to change to digital communication systems which often employ error detection and forward error correction algorithms and can improve system performance in the presence of interference sources. This potentially enhances sharing possibilities. Additionally, in many instances the digital signal structures used by differing sharing services are often identical or similar.

3.2 Spectrum and time overlay sharing (spread spectrum, packet radio, frequency agility)

One recent alternative method of sharing is based upon the principle of overlay. The principle of overlaying involves superimposing the operation of equipments in a new service in such a manner that all primary allocated services can coexist. Several new technologies may have characteristics that may prove effective for overlay sharing. These are spread spectrum modulation (CDMA), intermittent packet communication and real-time spectrum occupancy measurements to find unused channels.

Spread spectrum systems can be defined as ones in which the average energy of the transmitted signal is spread over a bandwidth which is much wider than the information bandwidth. These systems usually trade the wider transmission bandwidth for a lower average power spectral density and increased rejection to interfering signals operating in the same frequency band. They therefore have the potential of sharing the spectrum with conventional narrow-band systems because of the potentially low power that is transmitted in the narrow-band receiver passband. In addition the spread spectrum systems are capable of rejecting the narrow-band interference.

Another factor which affects sharing of spread spectrum systems is the “near-far” problem which results when an interfering spread spectrum system is geographically nearby and the wanted signal is from a source spatially some distance away. When, because of the near-far problem, interference occurs between equipment in different services, sharing is difficult to accomplish.

A number of new technologies such as mobile data systems and low earth orbiters (LEO satellites) may transmit their information as low duty cycle packet communications. These types of communications are candidates for overlay sharing. However, studies must be undertaken to determine the probability of interference and to define applicable performance protection criteria.

Both spread spectrum and packet radio systems are multiple access communication systems and sharing can best take place when the number of active equipments in the overlay is small. The limitation to any sharing of these schemes is dependent upon the number of active users in any particular frequency band. Each overlay increases the noise level slightly and therefore increases the probability of interference. The important issue is how to control the use of a block of spectrum which contains spread spectrum or intermittent packet users. When an overlay sharing is effected among services, it may be necessary to regulate the number of users that are present in the overlay to be sure that the interference level is below a pre-defined level. This is similar to present procedures where, by assignment methods, there is a limit to the number of users and their bandwidth.

New systems such as intelligent frequency agile radios also operate as an overlay and could facilitate frequency sharing. These devices are intelligent enough to determine in real time if the spectrum is occupied. Intelligent radios could find and utilize unused spectrum in the allocated shared spectrum block.

3.3 Multifunction system sharing

There are numerous areas in which systems that support multiple functions can be expected to appear. The systems that support multiple functions can, and do employ fully integrated waveforms which make it difficult to explicitly identify portions of the various signal structures. Sharing of these multifunction systems should be based on an electromagnetic compatibility (EMC) analysis.

3.4 Geographical shared allocations

Another possible sharing method is to allocate a block of spectrum to two or more services and then implement the sharing within administrations by geographically separating users in the different allocated services. This utilizes sharing by separation in the spatial coordinate of spectrum. An example is the sharing between television broadcasting and terrestrial mobile services where geographical separation has facilitated sharing.

The allocation tables contain a number of country footnotes which define a different service for use within a particular administration. These footnotes provide flexibility for countries to utilize an allocated service differently from the world or regional allocation. These footnotes define a *de facto* sharing arrangement among users who utilize the Table of Allocations and the administrations utilizing a service defined by the footnote. This type of sharing has the greatest possibility of success for terrestrial services. However, operations in adjoining administrations may be affected. It is more difficult to effect the sharing when one or both of the services involves a space or satellite communication service. The advantages and disadvantages of allocation footnotes need to be carefully considered.

3.5 Time sharing

3.5.1 Dynamic pre-emptive time sharing

One time sharing method is abrupt “dynamic time sharing” which adds flexibility for the use of the spectrum. This method utilizes spectrum based on a priority pre-emptive basis. Such a scheme is being tried in one administration to allow public services to utilize a portion of the spectrum with the provision that in an emergency these users would vacate the spectrum for priority government/non-government communications. In this arrangement software programs are utilized to reclaim frequencies, as needed, for the priority communications.

3.5.2 Dynamic variable partitioning

Another sharing method which results in a flexible use of the spectrum is dynamic variable partitioning which is real-time sharing of a block of spectrum among two services for which one service has priority over the other. In dynamic variable partitioning there is a partition that divides the channels contained in a block of spectrum into two portions, one for service A and the other for service B. The partition moves in real time in response to actual or perceived demand from service A. A network operation centre is required to respond immediately to provide the channels necessary for service A. The method is based upon the establishment of a buffer of channels to respond immediately to requests. This method of sharing has been simulated using a Monte Carlo simulation but has not, as yet, been validated operationally.