INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE: CENTRATOM TRIESTE

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
INTERNATIONAL CENTRE FOR SCIENCE AND HIGH TECHNOLOGY

H4.SMR/537-16

# SECOND COLLEGE ON THEORETICAL AND EXPERIMENTAL RADIOPROPAGATION PHYSICS

(7 January - 1 February 1991)

Co-sponsored by ICTP, URSI, ICSU and with the participation of ICS

## RADIO FREQUENCY SPECTRUM MANAGEMENT

R. G. Struzak
International Telecommunication Union
Geneve, Switzerland

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

## Part 1

## RADIO FREQUENCY SPECTRUM: A COMMON RESOURCE.

R.G. Struzak
International Telecommunication Union, International Radio Consultatiuve Committee
Geneva, Switzerland





The purpose of these notes is to provide an overview of current concepts of the radio frequency spectrum and geostationary satellite orbit resources.

## 1. INTRODUCTION

When Jean-Baptiste Fourier (1768 - 1830) introduced his transforms of mathematical functions from time-domain into frequency-domain and back, this was considered nothing more as a curious method of solving differential equations. His approach was strongly criticized and generated lots of doubts. Only after resolving the doubts by Dirichlet and Riemann, the Fourier Transforms and Fourier Spectrum became basic tools in many branches of science. The term *"radio-frequency spectrum"* appeared when it has been found that the concept of Fourier spectrum allows for defining conditions of interference-free operation of radio stations.

Today, the radio frequency spectrum is considered as a physical, measurable quantity, and not only as an abstract mathematical concept. The ability to carry energy and messages at a distance at no cost, and at the speed of light, made the spectrum of radio waves recognized as a valuable resource of the mankind. Free access to it, from any place and at any time, added to its attractiveness and made it a common welfare from which everyone can profit. The geostationary satellite orbit as a unique place for radio stations has been included later to the resource concept. The role of this resource is considered so important that its use is regulated by an international treaty - the International Telecommunication Convention. One of the articles of the treaty reads:

> *"... radio frequencies and geostationary satellite orbit are limited natural resources [...]; they must be used efficiently and economically [...] so that countries [...] may have equitable access to both..."* [I.T.C., Art. 33-154]

## 2. RESOURCE SHARING

### Pasture model

Common resources have several advantages and one disadvantage. The disadvantage has been explained best by Hardin taking as an example a pasture open to all. We will follow his example. Because the pasture is free of charge, it is to be expected that each herdsman try to maintain as many cattle on it as possible. Such an arrangement works well until the number of beast reaches the carrying capacity of the land. At this point, the inherent logic of the commons proceeds as follows:

*"As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks 'What is the utility to me of adding one more animal to my herd?' This utility has one negative and one positive component:*

*1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.*

*2) The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1.*

*Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is a tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons."* [Hardin, 1968]

Is this applicable to the radio frequency spectrum?..The pasture and the spectrum are quite different objects, but there are some analogies. Indeed, the spectrum cannot be fenced. It goes un-priced at international conferences. It has limited carrying capacity. A portion of spectrum space occupied by one radio system is denied to other ones - like as in the case of cattle and pasture. If, therefore, one replaces the word "animal" in Hardin's text by "radio station" and the word "herdsman" by "Administration", one obtains a "*pasture*" model of unrestricted use of the radio spectrum and geostationary orbit resources on the international scale.

Sharing problems

One conclusion from the free pasture model is that the complete freedom in use of a limited common resource may work satisfactorily it the competitive interactions between the users of the resource are negligible. As the number of users grows, competitive interactions develop, the resource becomes scarce, and the concept of its free use has to be abandoned.

Our past confirms that the approach to common resources changes, as does our understanding of their social role and value. Firstly, the commons in food gathering were abandoned. Farmland has been enclosed, and there is no free farmland now. Later, open pastures and free hunting and fishing areas have been restricted. Finally, using the commons as a place for waste disposal has been abandoned and restrictions on the disposal of sewage are now widely accepted throughout the world. Finally, a concept of environment and environmental protection was developed, and restrictions were also imposed on the pollution of land, water and air. Suddenly, we have discovered that many common resources, considered long time as being inexhaustible, have become scarce The issue of their rational use, conservation, and protection has become an essential element, on national and world-wide scales. Not so long ago, the radio spectrum and geostationary satellite orbit were added to the list of such resources critical for further development of mankind.

When discussing the future of resource sharing one can indicate several general approaches:

*"We might sell them off as private property. We might keep them as public property, but allocate the right to enter them. The allocation might be on the basis of wealth, by the use of an auction system. It might be on the basis of merit, as defined by some agreed-upon standards. It might be by lottery. Or it might be on a first-come, first-served basis... "* [Hardin, op.cit.]

Any of the options listed above implies that an organizational framework exists to allow for such activities, and to monitor if all commonly agreed rules and restrictions imposed on the resource use are observed by all parties involved. Negotiations, consultations, and coordination among all parties are necessary elements here.

Preferences

Which of the approaches above is the best one? Each of them can be questionable and objectionable, dependent on the criteria applied. The final answer results from human preferences of goals and hierarchies of values. Although discussion of non-technical issues is beyond the scope of this contribution, one must realize that, in practice, it is often impossible to separate technical aspects of resource sharing from their economical, social and political contexts, and from the interests affected by them. The sharing problem cannot be solved by technical means only, without involving systems of human values and ideas. Firey points out here a significant role of the social tradition and experience:

*"Every adoptable set of resource process will be one which is valued by some population in terms of that population's own system of activities. ... Where a resource process involves beliefs and techniques that are incongruous with a people's system of activities, it will not be adopted by that people, however superior it may be by other criteria."* [Firey, 1977]

However, in a pluralistic society the goals and hierarchies of values are often inconsistent and conflicting. Brooks indicates that

*"...The hierarchies of values and preferences of each individual are inconsistent among themselves, and different individuals and [...] groups have different hierarchies of preferences which are partially in conflict with those of other groups and individuals. Furthermore, the capacities of different groups to implement their preferences [...] are widely different."* [Brooks, 1972]

"Inconsistency" here means that progress toward realization of one value or goal is destructive of another value or goal held by the same individual or group, and the lack of consistency may be not obvious to the individual or group concerned. "Conflicting" goals or values mean such goals or values of two groups that cannot be served by the same policies: what enhances one will degrade the other. These remarks are of special significance in an international context of the world-wide issues of radio spectrum sharing.

## 3. COMPETITION AND COOPERATION

### Early years

It was at the turn-out of the century that a national and then world-wide competition in radio communication has been initiated and, consequently, mutual interference begun to limit further developments. Soon, however, major parties involved came to a conclusion that it would be more beneficial to coordinate their activities than to continue their rivalry. Such an activity started on a local scale, the global nature of the problem required, however, an international cooperation. Indeed, only two years after the first transatlantic wireless communication had astonished the world, the first international conference was called to improve the use of the radio frequency spectrum. This was the preliminary conference held in Berlin, in 1903. The first period of anarchy and uncontrolled rivalry in radio communication has been terminated.

The first radio conference held three years later, also in Berlin, agreed upon the principles of radio spectrum use. A major step at the conference was, among others, the establishment of the International Bureau in Bern. The operating frequencies of radio stations have been notified and a register of the use of the radio frequency spectrum, worldwide was maintained there. Today, that function is being continued by the International Frequency Registration Board (IFRB) of the International Telecommunication Union (ITU).

International treaties are all part of a world-wide game nations agree to play following certain rules. Agreement is an inevitable ingredient here, and there is nothing to force nations to abide by these rules. If competitive forces are stronger than cooperative ones, no progress could be made. In Berlin, due to competition and conflict of interests, it was not possible to reach consensus on issues related to inter-communications. Soon, a test of life showed in full light tragic consequences of that fact. It was the well-known disaster of Titanic in April 1912. Only three months later, and not without the influence of public opinion shocked by the disaster, the second radio conference was held in London. It finally settled the problem of inter- communication between ships on the sea.

The World War I interrupted international cooperation in the radio spectrum use for several years. Science and technology was harnessed to military applications. Radio got an enormous impetus. When the war finished, all the scientific progress, technical developments and operational experience gained during the war time could be used again in peaceful service for the mankind. In new circumstances, however, the old radio regulations were not appropriate, and the next international radio conference was called on in Washington in 1927. The problem of frequency demand exceeding the available spectrum resource appeared sharply there, and the unending battle of frequencies had started.

The spectrum shortage problem was settled in Washington by two actions. On the one hand more stringent technical standards, limiting the radiation out-of the band necessary for transmission of information were imposed. (The demand for a complete outlawing of spectrally inefficient spark-type transmitters was pressed strongly, but not passed because of competition and conflict interests.) On the other hand the resource limits defined in old radio regulations were moved to embrace additional portions of spectrum, not yet regulated. That approach was



copied also at other conferences. The drawing up of the first Frequency Allocation Table, regulating the use of the spectrum within these limits, was considered as one of the most important results of the Washington conference. Another one was to set up the International Radio Consultative Committee, CCIR.

The first radio conferences established principles of: (a) the use of radio spectrum as a public resource, free of charge, (b) equitable access to it, (c) negotiations and consensus, (d) allocation and administrative regulation of its use, (e) electromagnetic compatibility, however without using this term which has been introduced later. It is interesting to note that these principles have been maintained until the present time, with minor changes only.

### International Telecommunication Union

The use of the radio frequency spectrum is now coordinated through the International Telecommunication Union (ITU). The ITU, a Specialized Agency of the United Nations since 1947, is the oldest of all existing intergovernmental agencies, with a line-age dating back to 1865. The purposes and structure of ITU are prescribed by the International Telecommunication Convention, with the object "*...of facilitating peaceful relations, international cooperation, and economic and social development...* " This activity should not interfere with the principle of sovereignty, and " *...the sovereign rights of each country to regulate its telecommunications,..*" are fully recognized [I.T.C., Preamble]

The ITU Members, totalling more than 160 countries, agreed that the Union shall, in particular:

> "*a) effect allocation of the radio frequency spectrum and registration of radio frequency assignments in order to avoid harmful interference between radio stations of different*
>
> *b) coordinate efforts to eliminate harmful interference between radio stations of different countries and to improve the use made of the radio spectrum;...*" [I.T.C., Art.4-18, 19]

The agreed general rule of rational use of the resource is "*... to limit the number of frequencies and the spectrum space used to the minimum ...*" and "*... to apply the latest technical advances as soon as possible.*" *[I.T.C., Art.33]*

In accordance with the Convention, the Members of the Union meet, at intervals of normally about five years, at a Plenipotentiary Conference. This is the supreme authority which lays down the general policy of the ITU, reviews the Union's work and revises the Convention itself, if it considers this necessary. It also establishes the calendar of all ITU conferences, and sets a limit on expenditure until the next plenipotentiary conference. The last such a conference was held in 1989.

## 4. SHARING THE SPECTRUM RESOURCE

### Radio conferences

Further to the tradition originated in Berlin, London, and Washington, the use of the radio frequency spectrum is based on allocations of frequencies by geographical regions and service categories as agreed by all Members of ITU at Radio Conferences, called "Administrative". These may be world-wide or regional, general or specialized. They may establish and revise Radio Regulations, including frequency allocations, operational rules, standards, and procedures relevant to the spectrum sharing.

Since 1947, when ITU joined the United Nations System, there were two general world administrative radio conferences (WARC), one in 1959, and the other in 1979, and several specialized and/or regional conferences. The general WARCs were authorized to deal with virtually all aspects of spectrum use. The specialized WARCs dealt with particular services and/or particular portions of the spectrum. The regional conferences were held to solve specific spectrum use problems within particular geographic regions. As known, there are three ITU regions: Region 1 which consists of Europe, Africa and part of Asia (USSR and Mongolia), Region 2, containing both Americas, and Region 3, consisting of Australia, Oceania, and the remainder of Asia.

### Dual approach

As mentioned, the use of the radio frequency spectrum has been based on frequency allocation principles, which differentiate between geographical regions and service categories. The basic rules agreed upon by the ITU Members are published in the Table of Frequency Allocations of the Radio Regulations. "Allocation" means the distribution of a frequency band to a service, "allotment" - to a country or area, and "assignment" - to an individual radio station.

Some allocations are world-wide, i.e. identical throughout the world. In other cases allocations are regional, i.e. uniform throughout a particular region. In still other cases there are allocations specific for a single country, or a group of countries, in addition to, or different from, allocations approved by a majority of ITU Members (so-called "footnotes" to the Table of Frequency Allocations). Frequencies allocated to a service are available for use by any country, subject only to the limitations contained in the Radio Regulations.

A country can make an assignment to an individual station, or an assignment plan to a whole network of its stations. If that use could cause interference outside the territory of the country, or if it is intended for international communication, or if the assigning country seeks an international recognition for its assignment, it has to notify the IFRB and seek registration in the international list of frequency assignments and geostationary orbit positions. Each frequency and orbit assignment notified to IFRB is examined for its conformity with the radio regulations (including the Table of Frequency Allocations) and for compatibility with other registered frequency assignments and plans. If the result of examination is favourable, the assignment is registered, if not - it is returned for modification as appropriate. An advice concerning selection of proper frequency is given by IFRB, if needed.

This is so-called "ad hoc" frequency distribution method. There is one exception to that rule: there are certain services which are subject to so called "a priori" frequency plans. In "a priori" frequency plans specific bands allocated to specific services are parcelled among individual countries well in advance of their real use. Individual regions may have various allotment plans for specific services e.g. broadcasting, within their respective areas. "A priori" plans make a one-time distribution of the spectrum resource on the basis of present needs and predicted future requirements of all parties interested.

For services subject to "a priori" planning, a frequency assignment in accordance with the plan receives protection from any other assignment. In the case of "ad-hoc" managed services, the protection is given in accordance with priority of registration dates - a system frequently described as "first- come, first-served". In addition to that, one differentiates between three service categories: primary, permitted, and secondary. Primary and permitted services have equal rights, except when planning, stations of a primary service have priority in choice of frequencies. Stations of a secondary service should neither cause interference to, nor claim protection against interference from, stations of primary and permitted services.

### Discussion

Advocates of the "a priori" approach indicate that the "ad hoc" method is not fair because it transfer all the burden of coordination to the latecomers which must accommodate their requirements to the existing uses of the resource. It also excludes application of some optimization techniques that require full information about the spectrum uses. Replacement of "ad hoc" methods by systematic plans allows for fair sharing the spectrum resource and for its rational use, they say. Opponents, on the other hand, point out that "a priori" planning approach freezes technological progress. Moreover, is impossible to predict future requirements with a needed degree of accuracy, and plans based on un-realistic data are of no practical value. In addition, as the radio spectrum is available at no cost, there is no mechanism to limit the requirements. Although the International Telecommunication Convention calls for minimizing the use of the spectrum/orbit resource,

> *" ...each country has an incentive to overstate its requirements, and there are few accepted or objective criteria for evaluating each country's stated need. In fact, the individual country itself may have only the dimmest perception of its needs over the time period for which the plan is to be constructed ... Under these circumstances, it is easy to make a case that allotment plans are not only difficult to construct, but when constructed will lead to a waste of resources as frequencies and orbit positions are 'warehoused' to meet future, indeterminate needs..." [Robinson, 1980]*

One of the main advantages of the "ad-hoc" spectrum distribution is that it eliminates the "warehousing" problem, according to its advocates. Although that problem could be - at least in theory - alleviated also in the "a priori" planning approach, either by allowing frequency allotments to be transferred to another country or by imposing a condition of use within a specific period of time, or by imposing a tax or price system, nothing has been done till now.

## 5. TECHNICAL ASPECTS

As mentioned, a "used" or "occupied" portion of the spectrum/orbit resource means "denied to others". In this connection we have to distinguish between the physical and administrative denials [Berry, 1977]. The space physically denied depends on numerous processes and parameters which can be only roughly estimated, and is difficult to define with a precision. Thus, in order to simplify spectrum management, the administrative denial is usually used in organizational processing as a practical approximation to physical denial. Consequently, the space is administratively denied by spectrum management rules even if it is really not physically denied. One of the means to improve the use of the spectrum resource consist, therefore, in making (1) more precise estimations for physical denials, and (2) better approximations of administrative denials to them. To do that, however, further progress in radio sciences seems to be needed.

There are millions and millions of transmitters and receivers around the world, mutually interacting by means of radio waves. They would dissolve into chaos without a proper place assigned to each of them. Spectrum managers have to determine their operating frequencies and times, powers, antenna locations, heights, and patterns, as well as signal structures and signal processing methods. At the same time they have to fit in with budget, technology and other constraints. One can found here some similarity to the problems encountered in other fields. Indeed, radio spectrum management problem is a special case of a more general problem, which can be formulated as follows: given a collection of consumers who place demands upon a set of resources, find an assignment of consumers to resources that satisfies various constraints and that minimizes (or in some cases maximizes) a given objective function [Hale, 1980].

The usual question in optimization procedures is (in addition to the problem of the selection of proper objective function and identifying relevant constraints), how much time or how much work is required to find the solution. Sometimes, the exhaustive inspection of all possible solutions, their inter-comparison, and selection the best one, is the only exact method available. In our case, unfortunately, due to the complex interactions and an enormous amount of required data, any attempt to apply rigorous formal methods to real-life situations leads to the "intrinsically difficult" or "intractable" mathematical problems which cannot be solved in practice [Stockmeyer and Chandra, 1979].

As no exact solution method realizable is known, various informal, approximate, and heuristic methods have to be applied instead [Hale, 1980, Struzak, 1982]. Despite all efforts made, frequency management is still not yet based on stringent scientific and technical criteria [Sviridenko, 1977]. One may hope that some techniques and approaches developed in other areas, such as operation research, mathematical programming, graph theory, system theory, game theory, and computer simulation techniques could find applications in spectrum management problems, still waiting for efficient solutions.

## 6. CONCLUDING REMARKS

The disproportion between the demand for radio spectrum and geostationary orbit positions on one hand, and the available resource capacity on the other hand, calls for reconsideration of the existing order in the spectrum/orbit use. As mentioned, the current practice is based on the administrative allotment concept and "service separation" philosophy, elaborated at the times of the first radio conferences. In the meantime, the population of radio stations increased enormously, new radio technologies have been introduced, and the political situation over the world has changed dramatically. Many new countries appeared in the ITU family, with new needs. Digital signal processing, microelectronics, and computer technology opened new horizons for integration of services and techniques, and spread-spectrum techniques revolutionized the concept of frequency channel use. To follow these changes, proposals are published from time to time that the existing administrative regulation system should be replaced by a competitive market economy mechanism. Such a deregulation is urged as a means of allowing market forces to distribute spectrum/orbit equitably to the market sectors where demand is greatest. Advocates of this idea indicate that it match the demand to the available resource capacity. Moreover, relying upon administrative decision-making is inferior to relying on market forces because decisions are arbitrary and often mistaken in determining what is the best interest of users [Webbing, 1977, Deregulation, 1987].

One expected that WARC 79, the largest general conference in the history of the ITU, would be a major vehicle for debating a new order of the spectrum/orbit use. In reality WARC'79 did not established any new principles, and

> *"...it was rather to adjust existing regulations governing spectrum allocations and use to accommodate new and future requirements. The debate on general principles was left essentially untouched by the WARC..."[Robinson 1980].*

How radio communication activities can be developed to the advantage of all nations, raises global implications. Although the necessity of international coordination in the spectrum use is generally understood, it is not always clear whether coordination is desired in order to resolve conflicts where parties adhere to their own individual objectives, or in order to achieve certain common, collectively agreed objectives. Spectrum/orbit sharing, world-wide, requires every nation to study the best ways of the use of these resources, as well as to study the nations' needs and elaborate an adequate position and effective interface for negotiations in the international framework. The technical elements of that process remain very important and deserving the most competent attention. It seems that many problems encountered in the present use of the radio spectrum and geostationary orbit are symptoms of inadequacies in our knowledge, and that further scientific efforts may offer practical solutions. The specific role of science has been best described by Gvishiani:

> *"...By its very nature, science is well equipped for internationally coordinated efforts directed to the solution of common problems. Science is universal, independent of nationality, ideological convictions or political orientation, which makes joint efforts much easier than in any other field..."* [Gvishiani, 1982]

As the time between scientific discovery and its application becomes shorter and shorter, it is more and more difficult to separate the pure and applied aspects of disciplines, and the need for closer collaboration between scientist and engineers becomes essential more then ever.

* * *

Note: The views expressed herein are those of the author and do not necessarily reflect those of CCIR or ITU.

## References


Berry L.A., [1977], Spectrum Metrics and Spectrum Efficiency; IEEE Trans. Vol. EMC-19, pp. 254-258;

Brooks H., [1972], Framework for Science and Technology Policy; IEEE Trans., Vol. SMC-2, pp.584-588

Codding G.A., [1952], The International Telecommunication Union: An Experiment in International Cooperation; Brill, Leiden;

Deregulation of the Radio Spectrum in the U.K. [1987]; Her Majesty Stationary Office, London;

Firey W. [1977], Man, Mind and Land; Greenwood Press Publ., Westport CT, p. 28-29

Gvishiani D., [1982], Scientific Research and Social Goals; F. Mayor, (ed.), Pergamon Press;

Hale W.K., [1980], Frequency Assignment: Theory and Applications, Proc. IEEE, Vol. 68, pp. 1497-1514;

Hardin G., [1968], The Tragedy of Commons; Science, Vol. 162, pp.1243-1248;

ITC [1982], International Telecommunication Convention, Nairobi;

JITAC [1968], Spectrum Engineering - The Key to Progress, IEEE Press;

Matos F. (ed) [1985], Spectrum Management and Engineering, IEEE Press;

Robinson G.O., [1980], Regulating International Airwaves: The 1979 WARC; Virginia J. Internatl. Law, Vol 21, pp. 1-54;

Struzak R.G. [1982], Optimum Frequency Planning- a New Concept, Telecomm. Journal, Vol 49, pp. 260-265;

Sviridenko S.S., [1977], Spectrum Utilization Problems, IEEE Trans. Vol. EMC-29, pp. 260-265;

Webbink D.W., [1977], The Value of the Frequency Spectrum Allocated to Specific Uses, IEEE Trans. Vol. EMC-19, pp. 343-351;

Rotkiewicz W. [1982], Electromagnetic Compatibility in Radio Engineering, Elsevier Sci. Publ. Co., 1982

H.

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

## Part 2

## RADIO FREQUENCY SPECTRUM USE

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland

The purpose of these notes is to provide an overview of current usage of the radio frequency spectrum resource.



| Band Number | Symbols | Frequency Range (lower limit exclusive, upper limit inclusive) | Corresponding Metric Subdivision | Metric Abbreviations for the Bands |
|---|---|---|---|---|
| 4 | VLF | 3 to 30 kHz | Myriametric waves | B.Mam |
| 5 | LF | 30 to 300 kHz | Kilometric waves | B.km |
| 6 | MF | 300 to 3 000 kHz | Hectometric waves | B.hm |
| 7 | HF | 3 to 30 MHz | Decametric waves | B.dam |
| 8 | VHF | 30 to 300 MHz | Metric waves | B.m |
| 9 | UHF | 300 to 3 000 MHz | Decimetric waves | B.dm |
| 10 | SHF | 3 to 30 GHz | Centimetric waves | B.cm |
| 11 | EHF | 30 to 300 GHz | Millimetric waves | B.mm |
| 12 | | 300 to 3 000 GHz | Decimillimetric waves | |

*Note 1*: "Band Number N" (N = band number) extends from $0.3 \times 10^N$ Hz to $3 \times 10^N$ Hz.

*Note 2*: Prefix: k = kilo ($10^3$), M = mega ($10^6$), G = giga ($10^9$), T = tera ($10^{12}$).

RR

## 3 - 30 KHZ: VERY LOW FREQUENCIES - VLF

* * *

**COMMUNICATION USES:**

LONG DISTANCE NARROW-BAND COMMUNICATIONS.
RADIONAVIGATION (OMEGA SYSTEM).
STANDARD TIME & FREQUENCY BROADCAST.

**NON-COMM. USES:**

INDUCTION HEATING.
POWER INVERTERS.
MEDICAL & BIOLOGICAL APPLICATIONS.

**PROPAGATION:**

GUIDED WAVES BETWEEN THE EARTH SURFACE AND THE LOWER IONOSPHERE, LITTLE AFFECTED BY IONOSPHERIC DISTURBANCES. PENETRATES OCEAN WATERS.

**RANGE:**

SEVERAL THOUSAND km.

ENERGY QUANTUM $(h \cdot f)$: $1.2 \cdot 10^{-11} - 1.2 \cdot 10^{-10}$ [eV]

## 30 - 300 KHZ: LOW FREQUENCIES - LF

* * *

**COMMUNICATION USES:**

LONG DISTANCE NARROW-BAND COMMUNICATIONS.
RADIONAVIGATION (LORANC & DECCA SYSTEMS).
STANDARD TIME & FREQUENCY BROADCAST.

**NON-COMM. USES:**

INDUCTION HEATING.
POWER INVERTERS.
ULTRASONIC PROCESSES
MEDICAL & BIOLOGICAL APPLICATIONS.

**PROPAGATION:**

SURFACE WAVE AND SKY WAVE REFLECTED IN THE LOWER IONOSPHERE (REGIONS: UPPER D AND LOWER E). LITTLE AFFECTED BY IONOSPHERIC DISTURBANCES.

**RANGE:**

SEVERAL THOUSAND km (MULTIPLE HOPS RANGE).

ENERGY QUANTUM: $1.2 \cdot 10^{-10} - 1.2 \cdot 10^{-9}$ eV

$1 eV = 1.602 \cdot 10^{-19}$ J   $h = 6.62 \cdot 10^{-34}$ Js [Planck's const]

## 300 kHz - 3 MHZ: MEDIUM FREQUENCIES

• • •

COMMUNICATION USES:

BROADCASTING.

MARINE & LAND MOBILE SERVICES.

RADIONAVIGATION (LORANA SYSTEM).

NON-COMM. USES:

INDUCTION HEATING.

ULTRASONIC PROCESSES.

POWER INVERTERS.

MEDICAL & BIOLOGICAL APPLICATIONS.

PROPAGATION:

SURFACE WAVE FOR SHORT DISTANCES.

SKY WAVE REFLECTED IN THE IONOSPHERE (E & LOWER F REGIONS) FOR LONG DISTANCES.

AFFECTED BY IONOSPHERIC DISTURBANCES.

INTERFERENCE AND FADING AT NIGHT.

RANGE:

FEW THOUSAND km FOR IONOSPHERIC VAWE.

ENERGY QUANTUM: $1.2 \cdot 10^{-9} - 1.2 \cdot 10^{-8}$ eV

## 3 - 30 MHZ: HIGH FREQUENCIES - HF

• • •

COMMUNICATION USES:

BROADCASTING (LONG RANGE).

MARINE & LAND MOBILE SERVICES.

POINT-TO-POINT COMMUNICATIONS.

NON-COMM. USES:

DIELECTRIC & INDUCTION HEATING.

ULTRASONIC PROCESSES.

RF PLASMA GENERATION.

POWER INVERTERS.

MEDICAL & BIOLOGICAL APPLICATIONS.

PROPAGATION:

IONOSPHERIC WAVE (E AND ESPECIALLY F REGIONS)

AFFECTED BY IONOSPHERIC DISTURBANCES.

INTERFERENCE AND FADING.

RANGE:

SEVERAL THOUSAND km.

ENERGY QUANTUM: $1.2 \cdot 10^{-8} - 1.2 \cdot 10^{-7}$ eV

30 - 300 MHZ: VERY HIGH FREQUENCIES - VHF

* * *

COMMUNICATION USES:

BROADCASTING FM & TV.
LAND, AERONAUTICAL & MARINE MOBILE SERVICES.
POINT-TO-POINT COMMUNICATIONS.

NON-COMM. USES:

DIELECTRIC HEATING.
FOOD PROCESSING.
RF PLASMA GENERATION.
MEDICAL & BIOLOGICAL APPLICATIONS.

PROPAGATION:

LINE-OF-SIGHT PROPAGATION IN THE TROPOSPHERE.
TROPOSPHERIC & IONOSPHERIC SCATTERING.
MOUNTAIN & URBAN DIFFRACTION, SHIELDING, REFLECTIONS.

RANGE:

HORIZON (SEVERAL TEN km) FOR L.O.S. COMMUNICATIONS.
ABOUT 600 km FOR TROPOSCATTER COMMUNICATIONS.

ENERGY QUANTUM: $1.2 \cdot 10^{-7}$ – $1.2 \cdot 10^{-6}$ eV

300 MHZ - 3 GHZ: ULTRA HIGH FREQUENCIES - UHF

* * *

COMMUNICATION USES:

LINE-OF-SIGHT COMMUNICATIONS.
TV BROADCASTING.
RADAR.
SURFACE POINT-TO-POINT COMMUNICATIONS.
SATELLITE COMMUNICATIONS.
SHORT RANGE (CELLULAR) MOBILE SYSTEMS.
RURAL TELECOMMUNICATION SYSTEMS.

NON-COMM. USES:

DIELECTRIC HEATING.
FOOD PROCESSING. INSECT DESINFESTATION.
RF PLASMA GENERATION.
PARTICLE SEPARATION.
CRUMBLING ROCK.
MEDICAL & BIOLOGICAL APPLICATIONS.

PROPAGATION:

LINE-OF-SIGHT PROPAGATION IN THE TROPOSPHERE.
TROPOSPHERIC & IONOSPHERIC SCATTERING.
DIFFRACTION, REFLECTIONS & SHIELDING IN MOUNTAINS AND IN URBAN AREAS.

RANGE:

HORIZON (SEVERAL TEN km) FOR L.O.S. COMMUNICATIONS.
ABOUT 600 km FOR TROPOSCATTER COMMUNICATIONS.

ENERGY QUANTUM: $1.2 \cdot 10^{-6}$ – $1.2 \cdot 10^{-5}$

3 - 30 GHZ: SUPER HIGH FREQUENCIES - SHF

* * *

COMMUNICATION USES:

SATELLITE & SURFACE LINE-OF-SIGHT COMMUNICATION SYSTEMS.

NON-COMM. USES:

INSECT DESINFESTATION.

RF PLASMA GENERATION.

PARTICLE SEPARATION.

MEDICAL & BIOLOGICAL APPLICATIONS.

MICROWAVE POWER TRANSMISSION (FUTURE).

PROPAGATION:

LINE-OF-SIGHT PROPAGATION IN THE TROPOSPHERE.

ATTENUATION BY HYDROMETEORS & ATMOSPHERIC ABSORPTION (OXYGEN, WATER VAPOR)

RANGE:

HORIZON (SEVERAL TEN km).

ENERGY QUANTUM: $1{,}2 \cdot 10^{-5}$ . $1{,}2 \cdot 10^{-4}$

TABLEAU 1 : Les récepteurs de télévision dans le monde

| Régions | Population (1981) | Nombre de récepteurs (1981) | Nombre de récepteurs pour 1000 habitants (1981) |
|---|---|---|---|
| TOTAL MONDIAL | 4.415.000.000 | 527.000.000 | 152 |
| Afrique (sauf les Etats arabes) | 365.000.000 | 3.700.000 | 10 |
| Asie (sauf les Etats arabes) | 2.576.000.000 | 95.000.000 | 37 |
| Etats arabes | 169.000.000 | 9.500.000 | 56 |
| Europe (avec l'URSS) | 753.000.000 | 233.000.000 | 309 |
| Amérique du Nord | 254.000.000 | 157.000.000 | 618 |
| Amérique latine | 368.000.000 | 41.000.000 | 111 |
| Océanie | 23.000.000 | 6.700.000 | 291 |

Source : *Annuaire statistique de l'Unesco*, 1983.

TABLEAU 2 : Répartition comparative des émetteurs de télévision dans les différentes régions

| Régions | Superficie kilomètres carrés) | Nombre d'émetteurs de télévision classiques |
|---|---|---|
| TOTAL MONDIAL | 135.726.000 | 35.000 |
| Afrique (sauf les Etats arabes) | 21.391.000 | 160 |
| Asie (sauf les Etats arabes) | 23.843.000 | 12.600 |
| Etats arabes | 12.652.000 | 330 |
| Europe (avec l'URSS) | 27.275.000 | 21.800 |
| Amérique du Nord | 21.515.000 | 4.700 |
| Amérique latine | 20.555.000 | 1.000 |
| Océanie | 8.495.000 | 500 |

Source : *Annuaire statistique de l'Unesco*, 1983.

1988: 10.000 REQUIREMENTS FOR FREQ. ASSIGNM. IN BANDS I, III & IV/V FOR THE AFRICAN BROADCASTING AREA & NEIGHBOURING COUNTRIES

**TABLEAU 3 : Les dix premiers pays en nombre de téléspectateurs**

| | 1970 | 000 | % du total mondial réel | cumulé |
|---|---|---|---|---|
| 1 | Etats-Unis | 84.600 | 30,8 | 30,8 |
| 2 | URSS | 34.800 | 12,7 | 43,5 |
| 3 | Japon | 22.883 | 8,3 | 51,8 |
| 4 | République fédérale d'Allemagne | 16.750 | 6,1 | 57,9 |
| 5 | Royaume-Uni | 16.313 | 5,9 | 63,8 |
| 6 | France | 10.968 | 4,0 | 67,8 |
| 7 | Italie | 9.717 | 3,5 | 71,3 |
| 8 | Brésil | 7.100 | 2,6 | 73,9 |
| 9 | Canada | 7.100 | 2,6 | 76,5 |
| 10 | République démocratique allemande | 4.499 | 1,6 | 78,1 |
| | **1980** | | | |
| 1 | Etats-Unis | 142.000 | 29,5 | 29,5 |
| 2 | URSS | c. 85.000 | 17,7 | 47,2 |
| 3 | Japon | 28.439 | 5,9 | 53,1 |
| 4 | République fédérale d'Allemagne | 20.762 | 4,3 | 57,4 |
| 5 | Royaume-Uni | 18.522 | 3,8 | 61,2 |
| 6 | France | 15.978 | 3,3 | 64,5 |
| 7 | Brésil | 15.000 | 3,1 | 67,6 |
| 8 | Italie | 13.361 | 2,8 | 70,4 |
| 9 | Canada | 11.280 | 2,3 | 72,7 |
| 10 | Espagne | 9.424 | 2,0 | 74,7 |

Source : *Screen Digest*, 1983.



Table 1.5.2.-1 Radio/Optical spectrum

| Frequency band and denomination | Wave length range denomination | Propagation mode and medium | Distance covered without relaying |
|---|---|---|---|
| 3–30 KHz ($3-30 \times 10^3$ Hz) Very Low Frequency (VLF) | 100–10 Km ($10-1 \times 10^4$ m) Miriametric wave | Guided waves between the earth surface and the lower ionosphere. | Several thousand kilometers. Penetrates ocean waters. |
| 30–300 KHz ($3-30 \times 10^4$ Hz) Low Frequency (LF) | 10–1 Km ($10-1 \times 10^3$ m) Kilometric wave | Surface wave and sky wave reflected in the lower ionosphere (upper D region and lower E region) | Several thousand kilometers (multiple hops range). |
| 300 KHz–3 MHz ($3-30 \times 10^5$ Hz) Medium Frequency (MF) | 1 Km–100 m ($10-1 \times 10^2$ m) Hectometric wave. | Surface wave for low distances and ionospheric wave (E and lower F region reflections) for long distances. | Few thousand kilometers for ionospheric wave. |
| 3–30 MHz ($3-30 \times 10^6$ Hz) High Frequency (HF) | 100–10 m ($10-1 \times 10^1$ m) Decametric wave. | Ionospheric wave (E and especially F region reflections). | Several thousand kilometers. |
| 30–300 MHz ($3-30 \times 10^7$ Hz) Very High Frequency (VHF) | 10–1 m ($10-1 \times 10^0$ m) Metric wave. | Line of sight (LOS) propagation in the troposphere. Mountain knife-edge diffraction. Tropospheric and ionospheric scattering. | Several ten kilometers for LOS communications. Up to 600 Km for troposcatter communications. |
| 300 MHz–3 GHz ($3-30 \times 10^8$ Hz) Ultra High Frequency (UHF) | 1 m–10 cm ($10-1 \times 10^{-1}$ m) Centimetric wave | Line of sight (LOS) propagation in the tropo-sphere. Mountain knife-edge diffraction. Tropospheric scattering. | Several ten kilometers for LOS communications Up to 600 Km for troposcatter communications. |
| 3–30 GHz ($3-30 \times 10^9$ Hz) Super High Frequency (SHF) | 10–1 cm ($10-1 \times 10^{-2}$ m) Centimetric wave | Line of sight (LOS) propagation in the troposphere. | Several ten kilometers for LOS communications. |
| 30–300 GHz ($3-30 \times 10^{10}$ Hz) Extremely High Frequency (EHF) | 1 cm–1 mm ($10-1 \times 10^{-3}$ m) Millimeter wave | Line of sight (LOS) propagation in the troposphere. | Few kilometers in free atmosphere. |
| 300 GHz–3000 THz ($3 \times 10^{11}-3 \times 10^{15}$ Hz) Optical Frequency (OF) | 1 mm–1um ($1 \times 10^{-3}-1 \times 10^{-6}$ m) Micrometric wave | Optic fiber propagation. | Few kilometers. |

*Extract from: Handbook on Radio Propagation for Tropical & Subtropical Countries. URSI, 1987*

## SPECTRUM UTILISATION

| Main Limitations | Main Advantages | Communication Users |
|---|---|---|
| Large and expensive transmitting antennas. Very limited band-width of transmission. | Little affected by ionospheric disturbances. Reliable long distances low rate information flow communications. | Radionavigation (OMEGA-System). Standard time and frequency broadcast. |
| Large and expensive transmitting antennas. Limited band-width of transmission. | Little affected by ionospheric disturbances. Reliable long distances low rate information flow communications. | Radionavigation (LORANC and DECCA systems). Standard time and frequency broadcast. |
| Severe interference and fading, at night. Affected by ionospheric disturbances. | Reliable short distance surface wave day time broadcasting. | Broadcasting. Radionavigation (including LORANA system). Marine and land mobile services. |
| Mutual interference among users. Fading. Highly affected by ionospheric disturbances and aperiodic variations. | Simplicity and low cost of equipments. | Point to point communications. Land and marine mobile systems. Citizen Band (CB) systems. Long range broadcasting. |
| Line of sight distance limitation. Multiple reflections and shielding in urban and mountaneous areas. | High realibility of LOS communications. Normal rate information flow communications. | Frequency modulation (FM) and Television broadcasting (short range broad-casting). Land, aeronautical and marine mobile services. Point to point communications. |
| Line of sight distance limitation. Severe multiple reflections and shielding effects in urban and mountaneous areas. | High realibility of LOS communications. High rate information flow communications. | Surface microwave point to point communications. Television broadcasting. Cellular radio systems (mobile telephone). Rural telecommunication systems. |
| Line of sight distance limitation. Severe reflection and shielding effects in urban and mountaneous areas. Severe attenuation by intense hydrometeors (> 10 GHz). Attenuation by oxygen and water vapor absorption. | Very high realibility of LOS communications. High capacity microwave radio for transmission of voice, video and high speed data channels. Low power requirements. | Satellite and surface microwave communication with increasing use of terrestrial digital microwave radio systems. |
| Same limitations as in the case of centimetric waves. Severe attenuation by atmospheric absorption or scattering. | Communication channels with greater bandwidth capabilities for digital signal transmission. | Communication between widely spaced satellites in geosynchronous orbit. Short haul systems for transmission of voice, data and video. |
| Lack of accurate propagation models. Lack of accurate mathematical models for optical communications. | Very high information rate and transmitter power concentration. | Urban and sub-urban communications service including voices, video and data signals of high information flow. |





Table 2a. **ESTIMATED TOTAL NUMBER OF ISM EQUIPMENTS INSTALLED**

| Country | Number of equipments per capita | per 1 km2 | installed total | Source |
|---|---|---|---|---|
| Denmark | 0.0008 | 0.1 | 4 000 | [1] |
| Finland | 0.002 | 0.03 | 10 000 | [2] |
| Germany F.R. | 0.004 | 1 | 250 000 | [3] |
| Japan | 0.1 | 30 | 12 000 000 | [4] |
| United Kingdom | 0.01 | 2 | 580 000 | [5] |
| U.S.A. | 0.07 | 2 | 15 000 000 | [6] |
| * * * * * | | | | |
| World total | 0.02 | 0.9 | 120 000 000 | [7] |

Adapted from the following sources:

[1] Doc.CCIR IWP 1/4-20 (Larsen/DK) August 1981
[2] Doc.CCIR IWP 1/4-8 (Nikkila/SF) April 1981
[3] Doc.CCIR IWP 1/4-16 (Lehning/FRG) June 1981
[4] Doc.CCIR IWP 1/4-13 (Arai/J) May 1981
[5] Doc.CCIR IWP 1/4-17 (Whitehouse/UK) June 1981
[6] Doc.CCIR IWP 1/4-11 (Wall/USA) May 1981
[7] Doc.CCIR IWP 1/4-18 (Spash/UIE) June 1981

Note: The distribution of ISM equipment is highly non-uniform.

Table 2b. **ESTIMATED NUMBER AND POWER OF ISM EQUIPMENT**

| Application | Percentage of total number | power |
|---|---|---|
| Domestic | 78 % | 12 % |
| Industrial & Scientific | 20 % | 87 % |
| Medical | 2 % | 1 % |
| * * * * * | | |
| Total number | 100 % (580 000 units) | |
| Total power | | 100 % (2.5 GW) |

Note: Data for a developed country with the G.N.P. of ca 9000 US$ per capita (U.K.)

Adapted from Doc.CCIR IWP 1/4-17 (Whitehouse/UK) June 1981

Source: Nonlinear & Environmental Electromagnetics ... Amsterdam 1985

Table 1. ISM APPLICATIONS (Sample)

INDUSTRIAL

BUILDING OPERATIONS (CONCRETE DRYING & CRUSHING)
CHEMICAL INDUSTRY
CERAMIC AND GLASS INDUSTRIES
ELECTRONIC INDUSTRY
FOOD INDUSTRY
METALLURGICAL INDUSTRY
MINING INDUSTRY (CRUSHING ROCK)
PAPER INDUSTRY
PLASMA TECHNOLOGY APPLICATIONS
RUBBER INDUSTRY
TEXTILE INDUSTRY
WOOD INDUSTRY

SCIENTIFIC

ENERGY TRANSFER EXPERIMENTS
PARTICLE ACCELERATORS AND SEPARATORS
THERMONUCLEAR FUSION EXPERIMENTS

MEDICAL

MEDICAL TREATMENT (BONE FRACTURES TREATMENT, CANCER TREATMENT BY RF-INDUCED HYPERTHERMIA, MEDICAL DIATHERMY)
RF SURGICAL APPARATA
NUCLEAR RESONANCE IMAGING

OTHERS

DOMESTIC INDUCTION AND MICROWAVE OVENS
ROAD MAINTENANCE (ASPHALT MELTING)

Source: *Nonlinear & Environmental Electromagnetics* ed. By H. Kikuchi, Elsevier Science Publ. Amsterdam 1985

Table 3. TYPICAL FREQUENCIES AND POWERS USED CURRENTLY FOR ISM APPLICATIONS

| Nominal frequency, frequency variations, nominal power | Typical uses |
|---|---|
| Below 9 kHz<br>10 %<br>up to 20 MW | Metallurgical industry: induction heating hardening, soldering, melting, refining.<br>Medical applications. |
| 9 kHz - 1 MHz<br>10 %<br>100 W - 1 MW | Ultrasonic cleaning and welding.<br>Electro-erosion treatment.<br>Induction heating and melting of metals.<br>Power inverters.<br>Medical applications. |
| 1 MHz - 5 MHz<br>10 %<br>100 W - 100 kW | Induction heating.<br>RF excited arc welders<br>Sealing for packaging.<br>Production of semiconductor materials.<br>Medical applications. |
| 5 MHz - 20 MHz<br>2,5 %<br>100 W - 300 kW | Dielectric heating.<br>Wood drying and glueing.<br>Plasma heating.<br>Medical applications. |
| 20 MHz - 100 MHz<br>1 %<br>100 W - 300 kW | Dielectric heating.<br>Plastic welding<br>Food processing.<br>Plasma heating.<br>Particle separation.<br>Medical applications. |
| 100 MHz - 500 MHz<br>0.5 %<br>100 W - 1 MW | Food processing.<br>Medical applications.<br>Particle accelerators. |
| 500 MHz - 3 GHz<br>100 W - 100 kW | Food processing.<br>Insect desinfestation<br>Medical applications.<br>Materials manufacture.<br>Plasma heating.<br>Particle acceleration. |
| Above 3 GHz<br>up to 15 GW | Particle acceleration/separation.<br>Plasma heating.<br>Thermonuclear fusion experiments.<br>Microwave-powered vehicles (project).<br>Free-space power transmission by microwave beam (project).<br>Satellite Solar Power Station (project) |

Source: *Nonlinear & Environmental Electromagnetics* ed by H. Kikuchi, Elsevier Science Publ. Amsterdam 1985

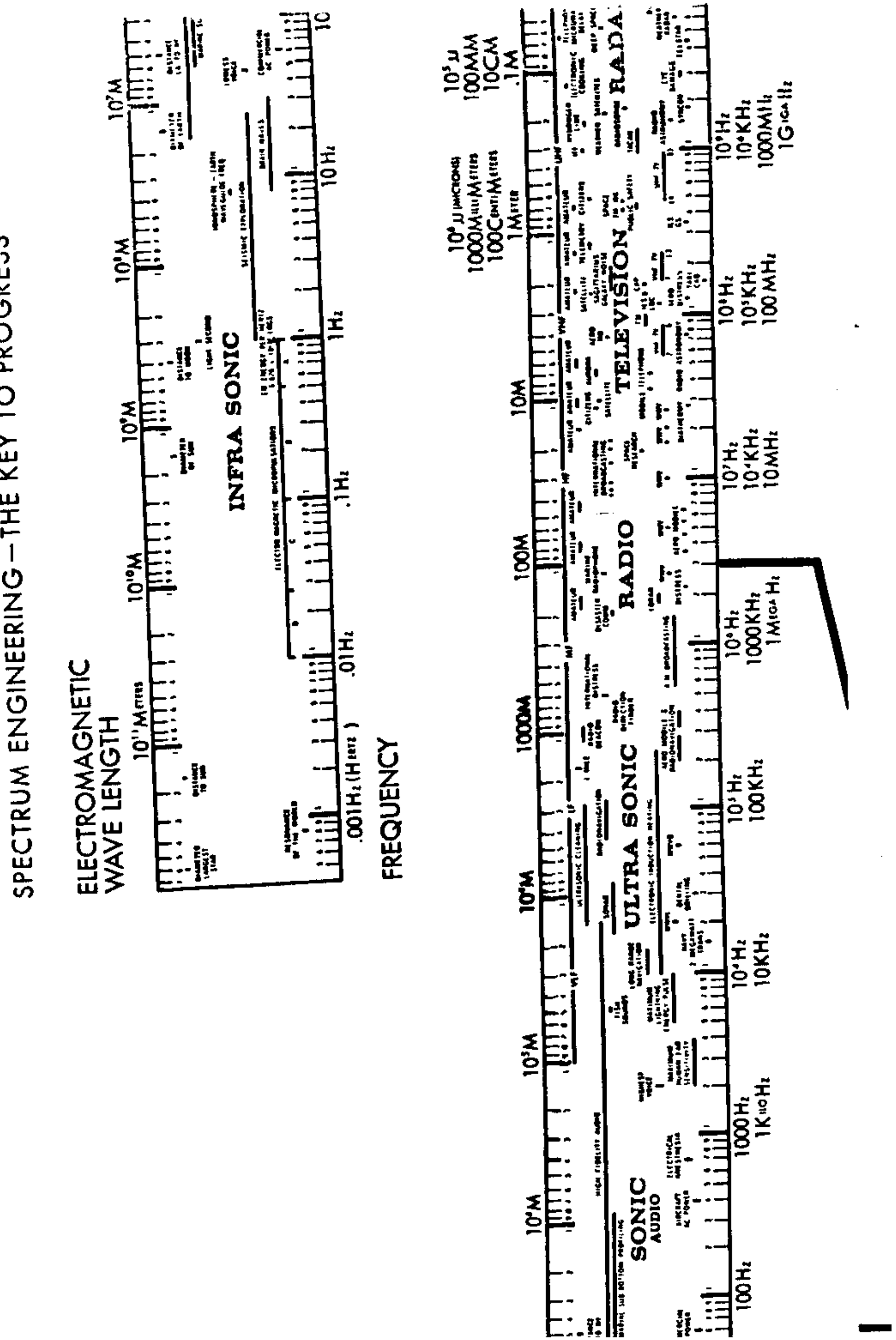
ANNEX I - Frequency bands designated for ISM applications in the ITU Radio Regulations

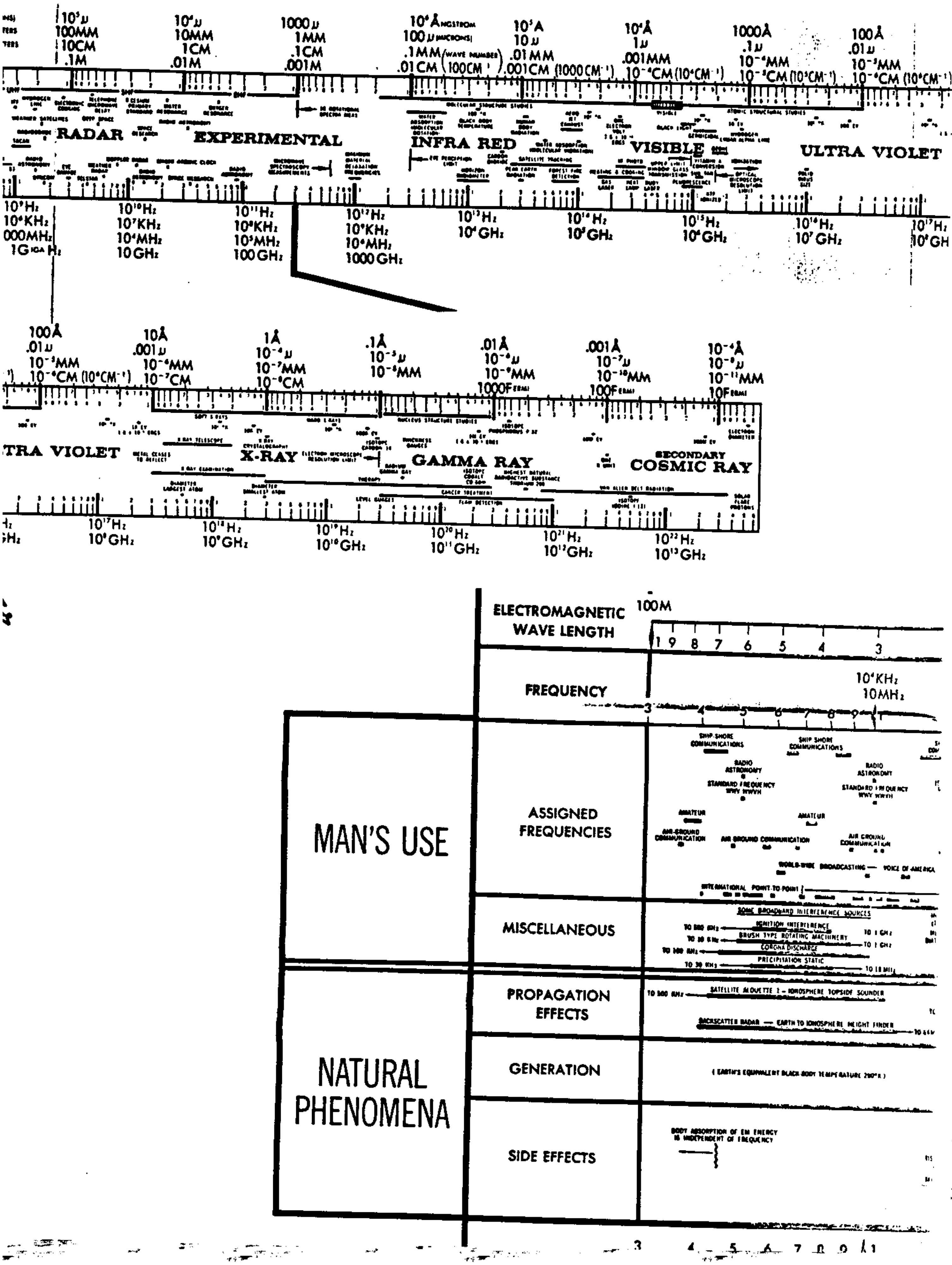
| Frequency band | Centre frequency |
|---|---|
| 6 765 - 6 795 kHz | 6 780 kHz** |
| 13 553 - 13 567 kHz | 13 560 kHz* |
| 26 957 - 27 283 kHz | 27 120 kHz* |
| 40.66 - 40.70 MHz | 40.68 MHz* |
| 433.05 - 434.79 MHz | 433.92 MHz** |
| 902 - 928 MHz | 915 MHz* |
| 2.4 - 2.5 GHz | 2.45 GHz* |
| 5.724 - 5.875 GHz | 5.8 GHz* |
| 24.0 - 24.05 GHz | 24.125 GHz* |
| 61.0 - 61.5 GHz | 61.25 GHz** |
| 122 - 123 GHz | 122.5 GHz** |
| 244 - 246 GHz | 245 GHz** |

* Radiocommunication services operating within this band must accept harmful interference which may be caused by ISM applications. Administrations shall take all necessary steps to ensure that radiation from ISM equipment is minimal and that, outside the bands designated for use by this equipment, is at a level that does not cause harmful interference to a radio navigation, or any other safety service, operating in accordance with the provisions of the Radio Regulations (RR 534, 546, 548, 707, 752, 806, 881, 1815).

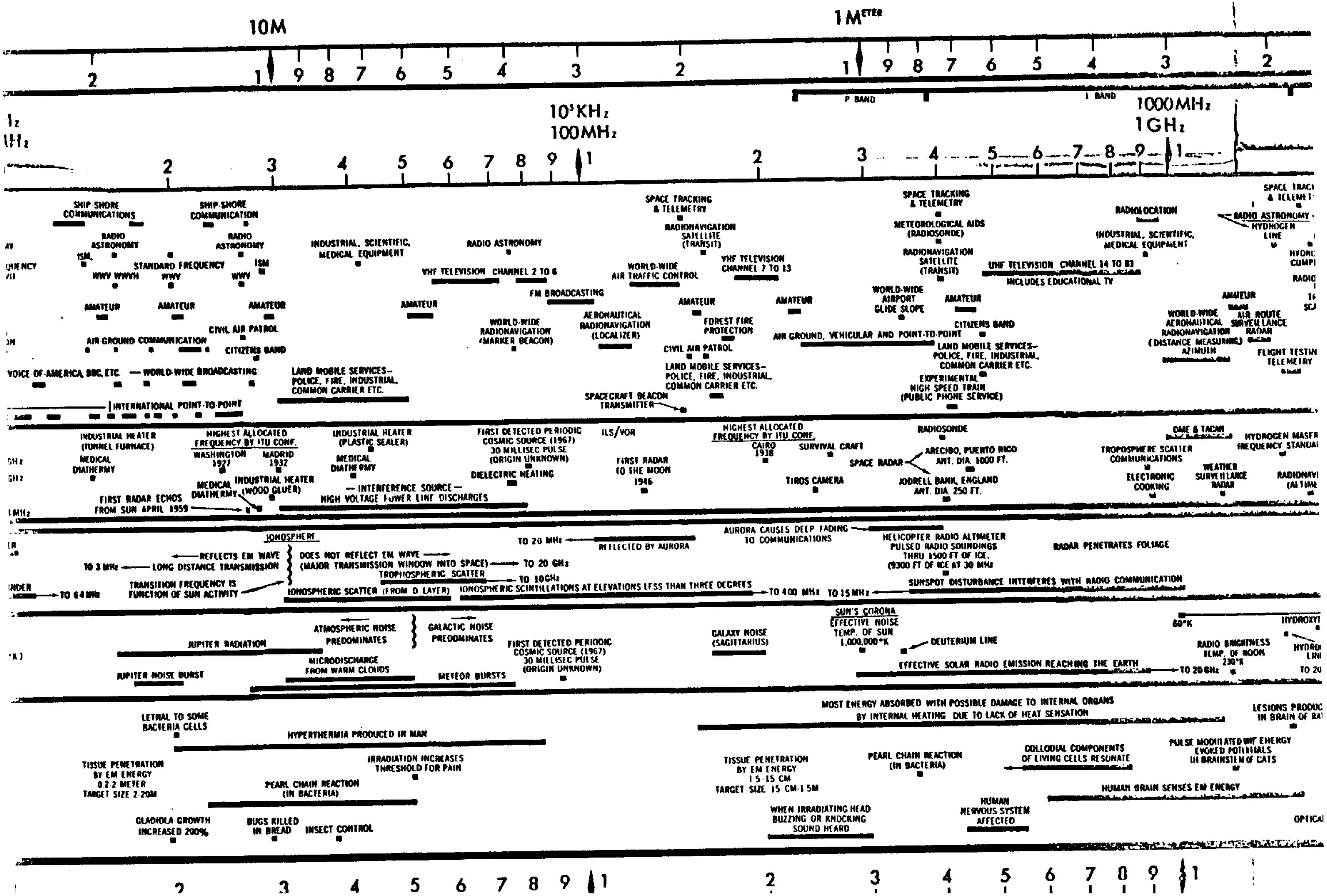
** The use of this frequency band for ISM applications shall be subject to special authorization by the administration concerned, in agreement with other administrations whose radiocommunications might be affected (RR 524, 661, 911, 916, 922).

Source: Nonlinear & Environmental Electromagnetics ed by H. Kikuchi, Elsevier Science Publ. Amsterdam 1985

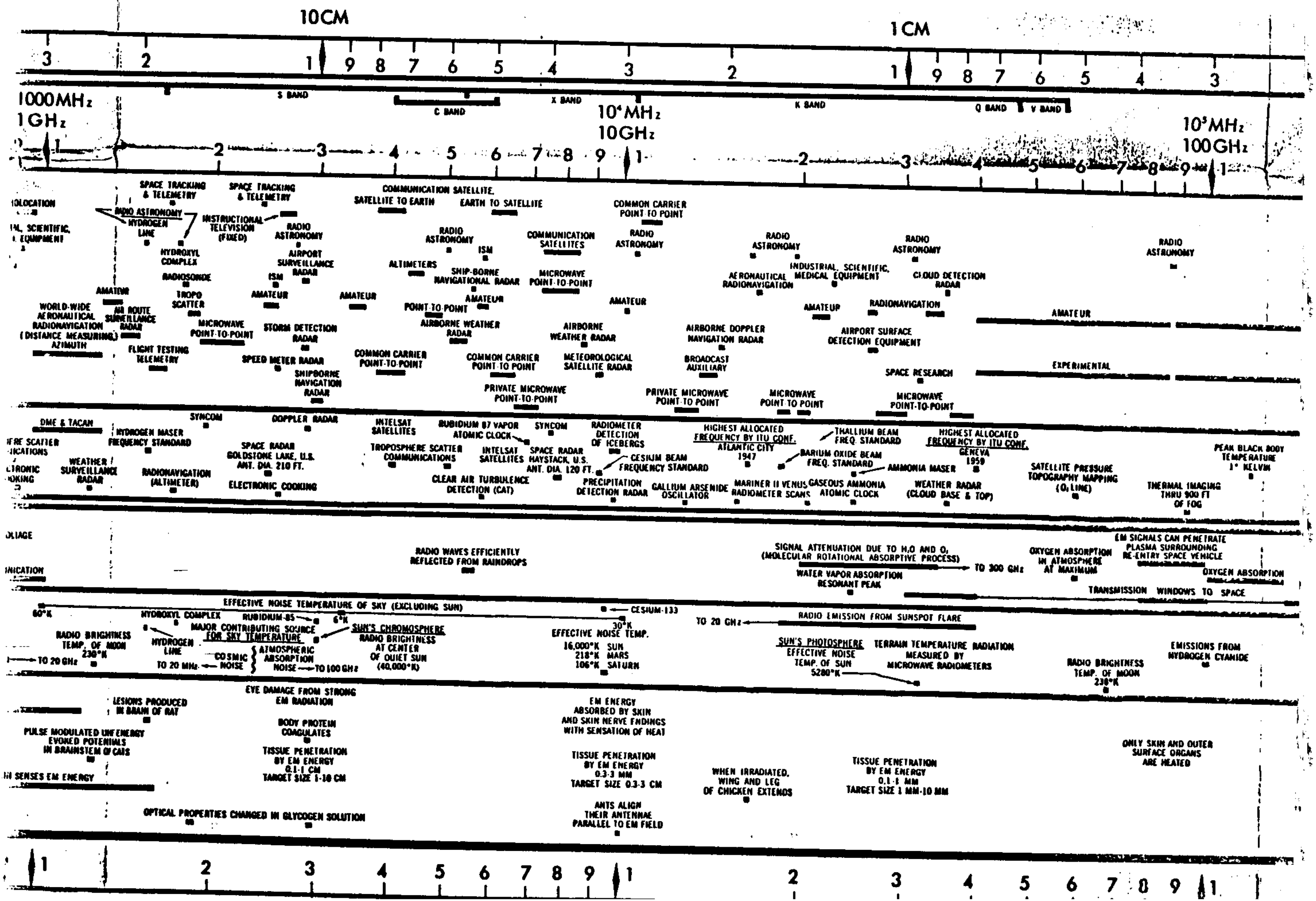


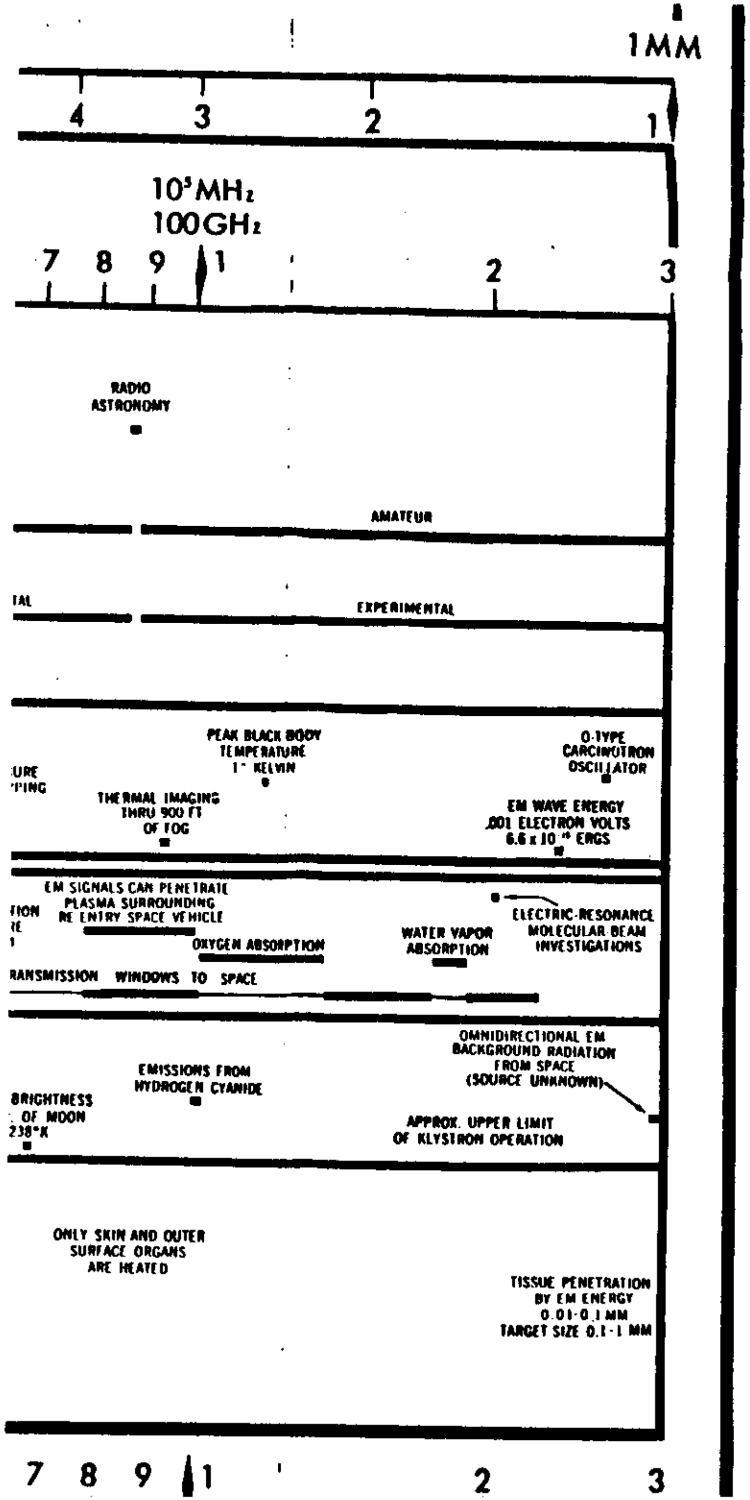


RADAR
EXPERIMENTAL
INFRA RED
VISIBLE
ULTRA VIOLET
X-RAY
GAMMA RAY
SECONDARY COSMIC RAY
ELECTROMAGNETIC WAVE LENGTH
100M
FREQUENCY
10⁴KHz 10MHz
MAN'S USE
ASSIGNED FREQUENCIES
MISCELLANEOUS
NATURAL PHENOMENA
PROPAGATION EFFECTS
GENERATION
SIDE EFFECTS



10M
1 METER
2
1 9 8 7 6 5 4 3 2
1 9 8 7 6 5 4 3 2
P BAND
L BAND
10⁵KHz
100MHz
1000MHz
1GHz
2 3 4 5 6 7 8 9 1
2 3 4 5 6 7 8 9 1
SHIP-SHORE COMMUNICATIONS
SHIP-SHORE COMMUNICATION
RADIO ASTRONOMY
ISM.
STANDARD FREQUENCY
WWV WWVH
WWV
ISM
INDUSTRIAL, SCIENTIFIC, MEDICAL EQUIPMENT
RADIO ASTRONOMY
SPACE TRACKING & TELEMETRY
RADIONAVIGATION SATELLITE (TRANSIT)
VHF TELEVISION CHANNEL 2 TO 6
FM BROADCASTING
WORLD-WIDE AIR TRAFFIC CONTROL
VHF TELEVISION CHANNEL 7 TO 13
METEOROLOGICAL AIDS (RADIOSONDE)
UHF TELEVISION CHANNEL 14 TO 83
INCLUDES EDUCATIONAL TV
RADIOLOCATION
RADIO ASTRONOMY
HYDROGEN LINE
AMATEUR
AIR-GROUND COMMUNICATION
CIVIL AIR PATROL
CITIZENS BAND
WORLD-WIDE RADIONAVIGATION (MARKER BEACON)
AERONAUTICAL RADIONAVIGATION (LOCALIZER)
FOREST FIRE PROTECTION
WORLD-WIDE AIRPORT GLIDE SLOPE
AIR-GROUND, VEHICULAR AND POINT-TO-POINT
WORLD-WIDE AERONAUTICAL RADIONAVIGATION (DISTANCE MEASURING) AZIMUTH
AIR ROUTE SURVEILLANCE RADAR
FLIGHT TESTING TELEMETRY
VOICE OF AMERICA, BBC, ETC.
WORLD-WIDE BROADCASTING
LAND MOBILE SERVICES— POLICE, FIRE, INDUSTRIAL, COMMON CARRIER ETC.
EXPERIMENTAL HIGH SPEED TRAIN (PUBLIC PHONE SERVICE)
SPACECRAFT BEACON TRANSMITTER
INTERNATIONAL POINT-TO-POINT
INDUSTRIAL HEATER (TUNNEL FURNACE)
MEDICAL DIATHERMY
HIGHEST ALLOCATED FREQUENCY BY ITU CONF.
WASHINGTON 1927
MADRID 1932
INDUSTRIAL HEATER (PLASTIC SEALER)
FIRST DETECTED PERIODIC COSMIC SOURCE (1967) 30 MILLISEC PULSE (ORIGIN UNKNOWN)
DIELECTRIC HEATING
ILS/VOR
FIRST RADAR TO THE MOON 1946
CAIRO 1938
SURVIVAL CRAFT
TIROS CAMERA
RADIOSONDE
SPACE RADAR
ARECIBO, PUERTO RICO ANT. DIA. 1000 FT.
JODRELL BANK, ENGLAND ANT. DIA. 250 FT.
DME & TACAN
TROPOSPHERE SCATTER COMMUNICATIONS
ELECTRONIC COOKING
WEATHER SURVEILLANCE RADAR
HYDROGEN MASER FREQUENCY STANDARD
INDUSTRIAL HEATER (WOOD GLUER)
INTERFERENCE SOURCE— HIGH VOLTAGE POWER LINE DISCHARGES
FIRST RADAR ECHOS FROM SUN APRIL 1959
IONOSPHERE
REFLECTS EM WAVE
DOES NOT REFLECT EM WAVE
TO 3 MHz
LONG DISTANCE TRANSMISSION
(MAJOR TRANSMISSION WINDOW INTO SPACE)
TO 20 GHz
TROPHOSPHERIC SCATTER
TO 10GHz
TRANSITION FREQUENCY IS FUNCTION OF SUN ACTIVITY
IONOSPHERIC SCATTER (FROM D LAYER)
IONOSPHERIC SCINTILLATIONS AT ELEVATIONS LESS THAN THREE DEGREES
TO 400 MHz
TO 15 MHz
TO 64 MHz
TO 20 MHz
REFLECTED BY AURORA
AURORA CAUSES DEEP FADING TO COMMUNICATIONS
HELICOPTER RADIO ALTIMETER PULSED RADIO SOUNDINGS THRU 1500 FT OF ICE. (9300 FT OF ICE AT 30 MHz
RADAR PENETRATES FOLIAGE
SUNSPOT DISTURBANCE INTERFERES WITH RADIO COMMUNICATION
JUPITER RADIATION
ATMOSPHERIC NOISE PREDOMINATES
GALACTIC NOISE PREDOMINATES
MICRODISCHARGE FROM WARM CLOUDS
JUPITER NOISE BURST
METEOR BURSTS
GALAXY NOISE (SAGITTARIUS)
SUN'S CORONA EFFECTIVE NOISE TEMP. OF SUN 1,000,000°K
DEUTERIUM LINE
60°K
RADIO BRIGHTNESS TEMP. OF MOON 230°K
EFFECTIVE SOLAR RADIO EMISSION REACHING THE EARTH
TO 20 GHz
LETHAL TO SOME BACTERIA CELLS
HYPERTHERMIA PRODUCED IN MAN
MOST ENERGY ABSORBED WITH POSSIBLE DAMAGE TO INTERNAL ORGANS BY INTERNAL HEATING DUE TO LACK OF HEAT SENSATION
TISSUE PENETRATION BY EM ENERGY 0.2-2 METER TARGET SIZE 2-20M
IRRADIATION INCREASES THRESHOLD FOR PAIN
PEARL CHAIN REACTION (IN BACTERIA)
TISSUE PENETRATION BY EM ENERGY 15-15 CM TARGET SIZE 15 CM-1.5M
COLLODIAL COMPONENTS OF LIVING CELLS RESONATE
PULSE MODULATED UHF ENERGY EVOKED POTENTIALS IN BRAINSTEM OF CATS
HUMAN BRAIN SENSES EM ENERGY
GLADIOLA GROWTH INCREASED 200%
BUGS KILLED IN BREAD
INSECT CONTROL
WHEN IRRADIATING HEAD BUZZING OR KNOCKING SOUND HEARD
HUMAN NERVOUS SYSTEM AFFECTED
OPTICAL
2 3 4 5 6 7 8 9 1
2 3 4 5 6 7 8 9 1


10CM
1CM
3 2 1 9 8 7 6 5 4 3 2 1 9 8 7 6 5 4 3
S BAND
C BAND
X BAND
K BAND
Q BAND
V BAND
1000MHz
1GHz
$10^4$MHz
10GHz
$10^5$MHz
100GHz
SPACE TRACKING & TELEMETRY
SPACE TRACKING & TELEMETRY
COMMUNICATION SATELLITE, SATELLITE TO EARTH
EARTH TO SATELLITE
COMMON CARRIER POINT TO POINT
RADIO ASTRONOMY HYDROGEN LINE
INSTRUCTIONAL TELEVISION (FIXED)
RADIO ASTRONOMY
HYDROXYL COMPLEX
RADIOSONDE
TROPO SCATTER
AIRPORT SURVEILLANCE RADAR
ISM
AMATEUR
ALTIMETERS
SHIP-BORNE NAVIGATIONAL RADAR
COMMUNICATION SATELLITES
MICROWAVE POINT-TO-POINT
INDUSTRIAL, SCIENTIFIC, MEDICAL EQUIPMENT
AERONAUTICAL RADIONAVIGATION
CLOUD DETECTION RADAR
RADIONAVIGATION
WORLD-WIDE AERONAUTICAL RADIONAVIGATION (DISTANCE MEASURING) AZIMUTH
AIR ROUTE SURVEILLANCE RADAR
FLIGHT TESTING TELEMETRY
STORM DETECTION RADAR
SPEED METER RADAR
SHIPBORNE NAVIGATION RADAR
POINT-TO-POINT
AIRBORNE WEATHER RADAR
COMMON CARRIER POINT-TO-POINT
COMMON CARRIER POINT TO POINT
PRIVATE MICROWAVE POINT-TO-POINT
AIRBORNE WEATHER RADAR
METEOROLOGICAL SATELLITE RADAR
AIRBORNE DOPPLER NAVIGATION RADAR
BROADCAST AUXILIARY
AIRPORT SURFACE DETECTION EQUIPMENT
SPACE RESEARCH
EXPERIMENTAL
PRIVATE MICROWAVE POINT TO POINT
MICROWAVE POINT TO POINT
MICROWAVE POINT-TO-POINT
DME & TACAN
HYDROGEN MASER FREQUENCY STANDARD
SYNCOM
DOPPLER RADAR
INTELSAT SATELLITES
RUBIDIUM 87 VAPOR ATOMIC CLOCK
RADIOMETER DETECTION OF ICEBERGS
HIGHEST ALLOCATED FREQUENCY BY ITU CONF. ATLANTIC CITY 1947
THALLIUM BEAM FREQ. STANDARD
HIGHEST ALLOCATED FREQUENCY BY ITU CONF. GENEVA 1959
PEAK BLACK BODY TEMPERATURE 1° KELVIN
WEATHER SURVEILLANCE RADAR
RADIONAVIGATION (ALTIMETER)
SPACE RADAR GOLDSTONE LAKE, U.S. ANT. DIA. 210 FT.
TROPOSPHERE SCATTER COMMUNICATIONS
INTELSAT SATELLITES
SPACE RADAR HAYSTACK, U.S. ANT. DIA. 120 FT.
CESIUM BEAM FREQUENCY STANDARD
BARIUM OXIDE BEAM FREQ. STANDARD
AMMONIA MASER
SATELLITE PRESSURE TOPOGRAPHY MAPPING ($O_2$ LINE)
ELECTRONIC COOKING
CLEAR AIR TURBULENCE DETECTION (CAT)
PRECIPITATION DETECTION RADAR
GALLIUM ARSENIDE OSCILLATOR
MARINER II VENUS RADIOMETER SCANS
GASEOUS AMMONIA ATOMIC CLOCK
WEATHER RADAR (CLOUD BASE & TOP)
THERMAL IMAGING THRU 900 FT OF FOG
RADIO WAVES EFFICIENTLY REFLECTED FROM RAINDROPS
SIGNAL ATTENUATION DUE TO $H_2O$ AND $O_2$ (MOLECULAR ROTATIONAL ABSORPTIVE PROCESS)
TO 300 GHz
WATER VAPOR ABSORPTION RESONANT PEAK
OXYGEN ABSORPTION IN ATMOSPHERE AT MAXIMUM
EM SIGNALS CAN PENETRATE PLASMA SURROUNDING RE-ENTRY SPACE VEHICLE
OXYGEN ABSORPTION
TRANSMISSION WINDOWS TO SPACE
EFFECTIVE NOISE TEMPERATURE OF SKY (EXCLUDING SUN)
60°K
HYDROXYL COMPLEX
RUBIDIUM-85
6°K
CESIUM-133
30°K
TO 20 GHz
RADIO EMISSION FROM SUNSPOT FLARE
RADIO BRIGHTNESS TEMP. OF MOON 230°K
TO 20 GHz
HYDROGEN LINE
MAJOR CONTRIBUTING SOURCE FOR SKY TEMPERATURE
COSMIC NOISE
TO 20 MHz
ATMOSPHERIC ABSORPTION NOISE
TO 100 GHz
SUN'S CHROMOSPHERE RADIO BRIGHTNESS AT CENTER OF QUIET SUN (40,000°K)
EFFECTIVE NOISE TEMP. 16,000°K SUN 218°K MARS 106°K SATURN
SUN'S PHOTOSPHERE EFFECTIVE NOISE TEMP. OF SUN 5280°K
TERRAIN TEMPERATURE RADIATION MEASURED BY MICROWAVE RADIOMETERS
RADIO BRIGHTNESS TEMP. OF MOON 230°K
EMISSIONS FROM HYDROGEN CYANIDE
LESIONS PRODUCED IN BRAIN OF RAT
EYE DAMAGE FROM STRONG EM RADIATION
EM ENERGY ABSORBED BY SKIN AND SKIN NERVE ENDINGS WITH SENSATION OF HEAT
PULSE MODULATED UHF ENERGY EVOKED POTENTIALS IN BRAINSTEM OF CATS
BODY PROTEIN COAGULATES
TISSUE PENETRATION BY EM ENERGY 0.1-1 CM TARGET SIZE 1-10 CM
TISSUE PENETRATION BY EM ENERGY 0.3-3 MM TARGET SIZE 0.3-3 CM
WHEN IRRADIATED, WING AND LEG OF CHICKEN EXTENDS
TISSUE PENETRATION BY EM ENERGY 0.1-1 MM TARGET SIZE 1 MM-10 MM
ONLY SKIN AND OUTER SURFACE ORGANS ARE HEATED
SENSES EM ENERGY
OPTICAL PROPERTIES CHANGED IN GLYCOGEN SOLUTION
ANTS ALIGN THEIR ANTENNAE PARALLEL TO EM FIELD
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1




## FREQUENCY SPECTRUM CHART

THE FREQUENCY SPECTRUM CHART ILLUSTRATES MAN'S AND NATURE'S ACTIVITY IN THE USE OF ELECTROMAGNETIC ENERGY AS A FUNCTION OF FREQUENCY. THE MOST USED TELECOMMUNICATION FREQUENCY RANGE HAS BEEN EXPANDED AND SHOWN IN TWO SECTIONS: (1) MAN'S USE OF ELECTROMAGNETIC ENERGY, AND (2) NATURAL PHENOMENA, WITH A SUBSECTION TITLED SIDE EFFECTS, SHOWING THE INTERACTION BETWEEN THE TWO.

THE PRESENTATION OF THE SPECTRUM IN THESE TWO CATEGORIES IS AN ATTEMPT TO SUGGEST A SIMPLE MEANS FOR SHOWING MAN'S USE AND NATURAL PHENOMENA IN SIMPLE TERMS OF A COMMON DENOMINATOR: FREQUENCY. ALTHOUGH EXTREME CARE HAS BEEN TAKEN TO PLACE ACTIVITIES IN THEIR PROPER FREQUENCY RELATIONSHIP, THIS CHART SHOULD NOT BE USED AS A BASIS FOR TECHNICAL REFERENCE.

THE FIRST SECTION, MAN'S USE, IS MADE UP OF (1) FREQUENCY ALLOCATIONS, AND (2) A LISTING OF MISCELLANEOUS ITEMS OF GENERAL APPLICATIONS. IN (1) THE OFFICE OF TELECOMMUNICATIONS MANAGEMENT ALLOCATES THESE FREQUENCIES FOR FEDERAL GOVERNMENT USE, AND THE FEDERAL COMMUNICATIONS COMMISSION FOR ALL OTHER USES. THESE ARE CURRENT ALLOCATIONS FOR USAGE IN THE UNITED STATES.

MAN'S UNINTENDED USE, BROADBAND INTERFERENCE, IS ALSO PLACED IN THE MISCELLANEOUS SECTION. THIS NOTATION INDICATES THE FREQUENCY RANGES AT WHICH THERE IS GENERATION OF SPURIOUS OR UNWANTED EM ENERGY RESULTING FROM MAN'S USE OF ELECTRIC AND ELECTRONIC PRODUCTS. THESE FREQUENCIES WOULD INCLUDE THE RADIATED AND CONDUCTED SIGNALS.

THE SECOND SECTION, NATURAL PHENOMENA, PRESENTS INFORMATION ON (1) PROPAGATION EFFECTS, INCLUDING THE ATMOSPHERIC WINDOWS, (2) THE GENERATION OF KNOWN NATURAL ATMOSPHERIC AND GALACTIC RADIATIONS, AND (3) SIDE EFFECTS OF ELECTROMAGNETIC ENERGY OBSERVED IN DISCIPLINES OTHER THAN ELECTRICAL AND ELECTRONIC.

THE INCIDENCES OF SUCH SIDE EFFECTS WHICH HAVE BEEN ENTERED ON THE CHART INDICATE FREQUENCIES AT WHICH EXPERIMENTS HAVE BEEN PERFORMED AND DO NOT IMPLY EVIDENCE OF A UNIQUE FREQUENCY EFFECT OR THE INTENSITY AND DURATION OF EXPOSURE NECESSARY TO INDUCE THE EFFECT.

Expanded by Luther Monell, member of JTAC 63.1.4, from his

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

Part 3

# RADIO FREQUENCY SPECTRUM ENGINEERING

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland



The purpose of these notes is to provide an overview of current problems of the radio frequency spectrum engineering.
Source: [6]

## Introduction

The term *Spectrum Engineering* has received wide acceptance after an IEEE report on radio frequency spectrum usage was published under the same title about twenty years ago [1]. At that time, scientists and engineers in the U.S.A. were concerned with the problem of electromagnetic compatibility (EMC) and potential disruptions of vital radiocommunication services due to interference. They concluded that, to avoid such situations, a new engineering discipline, spectrum engineering, must be developed and a system approach applied.

After a short discussion of current problems of the use of spectrum resources, basic spectrum engineering concepts are presented as they are understood today. Then follows an overview of relevant computer techniques and microcomputer tools.

## Problems

Since the publication of the IEEE report, new technologies and new applications of radio waves have been developed. Today, the number of artificial satellites launched has reached 3600 or so. Roughly 5.5 million subscribers use cellular mobile radio [2]. About 120 million domestic, industrial, scientific and medical (ISM) appliances act as unintentional transmitters, generating radio frequency energy to produce heat and other physical, chemical and biological effects [3]. The number of users of the spectrum grows continuously. The estimated yearly growth rate is 20% for private mobile radio, 26% for paging systems and 80% for cellular radio [4]. With liberalization, deregulation and privatization of the communication sector, one may expect that the demand for the spectrum will continue. Spectrum congestion and the threat of interference have became critical problems in many frequency bands and geographic areas [5].

In parallel to these developments, the economic, social, political, and military significance of the radio frequency spectrum and geostationary satellite orbit has been better understood. Now, they are recognized as *common* and *limited resources* necessary to support vital functions of society. The concepts of "*use*" and "*management*" of these resources have been widely accepted. The spectrum, or orbit, is occupied or used if it is *made unavailable* for other potential uses (note that this concept applies equally to radiating and to receiving equipment). This usage involves *economic*, *political*, *legal*, *administrative* and *technical* issues, and spectrum engineering concentrates on the latter ones.

International competition for the access to the spectrum and orbit resources have been negotiated among all countries. *Equitable access* to the spectrum and orbit, their *rational use* and *fair sharing* have been accepted as basic *rights* and *obligations* of every country, and inscribed in the constitution of the International

Union of Telecommunication (ITU), a Specialized Agency of the United Nations. In order to coordinate the competitive use of the resources, many intergovernmental conferences, world-wide and regional, were held during the last decades. A special ITU Voluntary Group of Experts was created in 1989 to explore possible future improvements in their shared use. The discipline of spectrum engineering has been advanced. The International Radio Consultative Committee (CCIR), a permanent organ of ITU, devotes about 80% of its potential to spectrum engineering issues. The International Union of Radio Science (URSI) deals with its scientific aspects. Major scientific symposia have introduced the topic into their programmes. In spite of these development, however, the radio frequency spectrum shortage continues to increase.

## Solutions

### Increasing usable resources

The continuing demand for the spectrum can be met by increasing the usable resources, but there are some limitations. The geostationary satellite orbit cannot be expanded and the usable spectrum can only be expanded to higher frequencies. Due to the laws of nature, however, the highest frequency bands are inappropriate for many applications. The curvature of the Earth's surface and the frequency-dependent absorption of radio waves in the atmosphere impose basic limitations.

### Limiting the number of users

Non-communication use. Man-made radio noise, radiation from microwave ovens and other ISM equipment and radiation from receiver oscillators are examples of this type of use of the frequency spectrum. It is not related to transmission of intelligence and usually is unintended (except for the transmission of energy at distance by means of radio waves). This use can *pollute* the resource and make it unavailable for some communication applications. Limiting such non-communication use can free a part of the resource. The price to be paid for this is an extra investment in the relevant industries for the attenuation of the radiation.

Communication use. There are some applications which do not necessarily require radio, and can be served equally well, or even better, by wire, cable, or fiber optics technology. Fixed point-to-point communication links are examples. However, application of these technologies involve costs, whereas the radio frequency as a transmission medium is essentially free.

### Limiting excess use

Unnecessary emissions. Many systems use the radio frequency spectrum in excess of the amount really required to achieve the intended effect. For instance, double side band amplitude modulation systems use twice as much spectrum as necessary. Excess transmitter power does not improve the intended communication, but increases potential interference to other users. Limiting frequency bands used, geostationary satellite orbit slots occupied, and power radiated to the *minimum necessary* for the intended function, require special



efforts and expenses. In time-varying environments dynamic control of the power radiated and its spectral distribution might be necessary.

Unwanted emission and reception channels offer no useful effects and waste the spectrum. This apply to *out-of-band* and *spurious* emissions and/or receptions and unintended *antenna side-lobes*. Their elimination usually involves considerable costs.

### Increasing efficiency

*Hybrid modulation methods* can increase the information transmission capacity per bandwidth unit. The same frequency band may be used to convey *more information* or offer *improved services*. Adding stereo in FM sound- and colour in TV-broadcasting are examples of transmitting additional information without increasing the frequency band allocated. This solution also needs substantial expenses.

### Separation

Utilization of the radio frequency spectrum is usually described in terms of frequency, geographical space and time, but other factors, such as polarization, can also be important. To extract the desired information with an acceptable error probability, the desired signal must undergo special processing. The process involves the discrimination of power, time, frequency, etc. All parameters, by which one radiocommunication signal differs from another, form a multidimensional space, and each use made of the spectrum can be mapped as an area in that space. The areas representing individual spectrum uses must be separated one from another. The greater the separation distance, the better is isolation between individual uses, the lower is the interference probability, and the lower is the total number of spectrum users. It should be noted that the separation distance is a complex function of all parameters involved, in contrast to the "classic" distance which is known from elementary geometry.

The separation distance must correspond to the discrimination abilities of the victim system, and to radiation characteristics of interfering sources. Many variable parameters can contribute to the separation distance and it is not a trivial task to select their "best", or even "acceptable" combination. In order to avoid harmful interference, a large separation distance is required. With a heavy demand, the necessity to accommodate as many users as possible implies the opposite.

### Distance separation

The frequency-distance separation rules were the first technical regulations introduced to prevent interference. They were in the form of tables of minimum distance between transmitting stations as a function of the frequency difference and power radiated. They were elaborated in the USA some forty years ago. After some modifications, they were used as the basis for elaboration of broadcasting frequency plans by international conferences, for Europe in the sixties and for Africa in 1989. These conferences assigned the power, frequency and geographic position for each transmitting station over the relevant area.

## Separation by terrain obstacles

In some applications and frequency bands, local terrain features can increase transmission loss of undesired signals. Thus, the separation between interfering and victim systems can be improved by selection of an appropriate location for the radio stations with no extra costs involved. However, a suitable propagation model and detailed terrain data are necessary to make use of this possibility during the planning stage. Although many countries have digital terrain maps, and satellite techniques make it possible to produce such maps in a few weeks for any region of the globe, the world-wide terrain data for spectrum engineering purposes are unavailable. Appropriate propagation models, universally accepted, are also not available. The international planning conferences were using simplified propagation models, neglecting local terrain effects. Due to this fact, the demand for frequency assignments could not be fully satisfied.

## Direction & polarization separation

Both, the transmitting and receiving antenna radiation pattern can contribute significantly to separation distance. Especially promising are adaptive antenna systems, able to follow automatically the direction towards the radiation sources even if they are moving.

## Frequency separation

Frequency assignment and frequency planning are the oldest techniques of interference prevention, and still they determine the efficiency of the coordinated use of the spectrum/orbit resources. *Frequency division* permits the transmission of two or more signals over a common path by using different frequency bands for the transmission of the intelligence of each message signal. In satellite communications, for instance, multiple access to a satellite is provided by assigning a different frequency band to each respective earth station and satellite resources are used by all stations at the same time. In the satellite, the signals are simultaneously amplified, transposed and retransmitted. The earth station identifies its receiving channel according to its assigned frequency band in the satellite signal. It is known as *frequency division multiple access* (FDMA). These are static techniques. In some applications, significant gains can be achieved through *dynamic real-time frequency assignment* which can adapt the operating frequencies to the changing environment.

## Time separation

Time division permits the transmission of two or more signals over a common path by using different time intervals for the transmission of the intelligence of each message signal. In satellite communications, for instance, individual earth terminals can communicate with each other on the basis of non-overlapping time sequenced bursts of transmissions through a common satellite repeater using the same frequency band. This is known as *time division multiple access* (TDMA).

## Modulation separation

In conventional modulation systems such as AM, FM and PSK, information is conveyed by varying one of three parameters of the carrier wave (amplitude, frequency and phase). This feature can be used to increase the separation distance. For example, an amplitude limiter in FM systems can increase system immunity against AM interference, and a Doppler modulation detector can allow for the discrimination of signals from moving and fixed objects in radar applications.

## Code separation

In *code division multiple access* (CDMA), each signal transmitted over a common path is assigned a characteristic code and spread-spectrum techniques are used. At the reception station, the code is used to recognize the signal addressed to it and to extract information. To identify one signal among several ones sharing the same band at the same time, *correlation techniques* are generally employed. *Spread spectrum* is a modulation technique for multiple access or for increasing the immunity to noise and interference. Spread spectrum systems make use of a sequential noise-like signal structure, for example pseudo-noise (PN) codes, to spread the normally narrowband information signal over a relatively wide band of frequencies. The receiver correlates these signals to retrieve the original information signal. The signal occupies a bandwidth in excess of the minimum necessary to convey the information. The band spread is accomplished by means of a code which is independent of the information data, and a synchronized reception with the code at the receiver is used for despreading and subsequent data recovery.

# Constraints

New technology makes it possible to accomplish the intended purpose using a smaller amount of the resources. A possible solution to the spectrum shortage would be, therefore, to replace the existing systems by new ones, less "consuming". This is probably the most radical and effective approach, but requires enormous investments in new equipment and in development of new technologies and needs time. It is, therefore, inaccessible for countries lacking the necessary funds and industrial infrastructure. The history of spectrum-efficient single-side band (SSB) HF broadcasting is a good illustration. The SSB technique has been known for 60 years or so, but the greater cost of SSB receivers and the investment in the existing equipment have made it impossible, up to the present time, to introduce it. The new technology might, however, be practical when it is paralleled by a new application or service.

In many cases, more efficient *coordination* and *harmonization* of competing requirements results in the accommodation of a greater number of users sharing the spectrum resources. Such a coordination does not require changes in the spectrum use policy, also investments in new radio communication technologies are not necessary. Instead it needs more advanced spectrum engineering.

# Computer tools

Spectrum engineering problems are characterized by a large number of variables, complex interactions, and the huge collections of data which implies the application of computer techniques. Since the emergence of personal computers, declining prices of hardware and software and increasing computing power have resulted in a phenomenal growth in their use, with 40% increase yearly [4]. Easy access to computers and user-friendly software allows more and more people, even with modest budget and programming skills, to use them successfully in daily work. Analyses that, twenty years ago, might have required weeks, can now be completed in hours with laptop computers. Spectrum engineering has became *computer-aided*. This section gives a short overview of current trends in this field.

Simulation

Engineering decisions are usually based on experimental data and, when such data are unavailable or incomplete, special measuring campaigns are needed. Usually, such campaigns are too expensive and/or require too much time. In many cases, computer simulation may offer a more practical solution. Numerical simulation has become a powerful tool in various applications, supplementing traditional mathematical analyses and "real-world" experiments. A simulated experiment is less expensive and avoids the risks of the "real-world". It is easier to prepare, to perform, to control and to repeat. It can also modify the time scale, if the "real" experiment runs too quickly or too slowly. Processes which normally require months or years to develop can be accelerated to run in minutes.

Another important characteristic of numerical simulation is its ability to examine systems which are intractable to experimental manipulation or too complex for exact mathematical treatment. Examining new systems which exist only in conceptual forms, testing hypotheses, or examining postulated modifications to existing systems, are examples. The first simulations were limited to large computers. Now, microcomputers have as much computing capability as mainframes of only a few years ago, and the technique is becoming more and more popular.

In the future, simulation models of radiocommunication system might serve as working tools for efficient spectrum management on a national and world-wide scale. Such models would simulate unintended interactions between the systems and with the environment, and would use dynamic, real-time monitoring data bases on the actual use of the spectrum/orbit resources. Simulation techniques might also be applied to improve the mechanism of future spectrum allocation conferences.

Visualization

Visualization is vital in man-computer communication. *Colour graphics* in the form of diagrams and maps are in widespread use today. In the future, one may expect a wider application of *animation techniques* and *three-dimensional visualization*. Hardware for three-dimensional computer graphics has been available for 10 years or so, but only recently lower-priced systems have pushed the technology toward more widespread use. The left- and right-perspective are computed for each image from the same data set, and displayed consecutively. A pair of liquid-crystal eyeglasses, switched synchronously, routes the images accordingly to the viewer's right and left eyes, as required for stereo vision. The synchronization signal is fed to the glasses through a miniature infra-red link. It is expected that the greatest benefit will be obtained with the really complex data sets and many variables, as encountered in simulation of EMC problems.

User interface

User interface increases productivity. Early software took the form of separate programs or subroutines. Libraries of subroutines are still a common and useful form of software packaging. However, this form requires that special



driver programs be written. More recently, microprocessor software has become available in the form of *command- or menu-driven* packages not requiring any drivers. As the command set becomes richer, more control over data manipulation is offered, and the end product resembles a new programming language (macro). Another approach is to provide a prototype program that is designed to be easily modified by the user. It is the teaching-aid approach, not widely used commercially, as it discloses the source code. Special "tutor" programs are frequently offered to help learn new software.

Computer communication.

Interference-free exploitation of the common spectrum/orbit resources requires large amounts of data, technical and administrative, to be interchanged between all parties. The data are exchanged within and among the countries in bilateral and multilateral relations. The CCIR has elaborated detailed specifications which allow for such an exchange in computer-readable form. Although traditional paper-forms are still in use, more and more data related to the multilateral spectrum management are submitted to the ITU Headquarters on tapes and diskettes. All information gathered is published by ITU in the traditional form, and also on CD-ROM compact disks. The ITU Telecom Information Services (TIES), just commencing, has offered world-wide interactive electronic mail and computer conferencing, basically free of charge. Access to ITU software libraries and data bases with flexible query and extraction facilities, including updating where applicable, is being made available.

Software portability & transportability. A program is *portable* over a given range of machines and compilers if it can *run* to specified performance criteria on that range *without any alteration*. A program is transportable over a given range of machines and compilers if it can run on that range after *changes* which can be implemented *mechanically* by a processor and are *limited* in number, extent, and complexity. Lack of portability and transportability can create problems in program exchange and direct access to CCIR software.

CCIR Software

The CCIR software is of two types. Software of the first type has been developed through the CCIR Study Groups and complements the relevant CCIR Recommendations. It has been reviewed, verified and approved for dissemination by groups of experts from various countries. Software of the second type has been submitted under CCIR Resolution 88 by individual participants in CCIR work. It has been created independently of CCIR studies and may be unrelated to CCIR Recommendations. Some programs of this category have been, however, reviewed by CCIR Interim Working Party 1/2 (now Working Group 1A).

This software is available, basically free of charge, directly from the originators, and if it has been supplied, also from the CCIR Headquarters and through the ITU TIES network. On request, the CCIR Secretariat can copy and distribute it with the reimbursement of the costs of material, postage and processing. The distribution, however, does not imply any form of endorsement. CCIR software is provided on an "as is" basis, without any warranty, and some modification may be required before it can be utilized with a specific type of computer hardware. The proprietary and author's rights are reserved by the submitters/originators.

## Concluding remarks

Today, many countries and interest groups compete for the access to the common resources of the radio frequency spectrum and geostationary orbit. Most of the usable parts of them are already in use and the current demand cannot be fully satisfied. Conflict of interest and competition involve strong non-technical issues. It is easy to see, however, that this situation is not new. The same problems have plagued radio communications since the very beginning, modified only by the specific technology of the day. Every twenty years or so, the same questions are formulated concerning the lack of radio frequency spectrum and inadequacy of spectrum management rules. Current practices are then reviewed and adjusted to the new situation as minimally as necessary.

As use of the resources and demand for them increase, automated engineering tools are increasingly needed for spectrum management. Adequate criteria and measures are also necessary to encourage the replacement of systems that use excessively the spectrum resource with spectrum conserving ones. Circuit theory offers direct synthesis algorithms to design circuits in accordance with given requirements and criteria. This is not the case in spectrum engineering. Not only explicit synthesis methods are missing, but also generally accepted measures of "goodness" are lacking. Thus, partial solutions, heuristic methods, intuitive engineering practices and "do-it-yourself" techniques are often applied.

The spectrum engineering discipline needs to be developed further and backed by scientific support. Improved spectrum engineering is needed to coordinate and harmonize competing requirements of ever increasing number of the spectrum users in a cost-effective way. However, spectrum engineering remains not very popular and without a change of this situation it will be difficult to reach any significant progress.

Note: The views expressed in this paper are those of the author and do not necessarily represent those of the ITU or CCIR.

## References


[1] Spectrum Engineering - the Key to Progress. A *JITAC IEEE - EIA* Report on Technical Policies and Procedures for Increased Radio Spectrum Utilization; IEEE, 1968.

[2] Kirby R.C., The Changing World of Radio Communications; Internatl. Wroclaw Sympos. on EMC, Wroclaw, Poland, 26-29 June, 1990, Add., 7 pp.

[3] Struzak R.G., Vestigial Radiation from Industrial, Scientific and Medical Radio Frequency Equipment; *in:* Nonlinear and Environmental Electromagnetics, *ed. by. H. Kikuchi*; Elsevier Science Publ., 1985, pp. 223-252.




.and Mobile
, 28 Aug - 5

1990's: URSI
!3.

Sympos. on

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

## Part 4

## NATIONAL SPECTRUM MANAGEMENT

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland

INTERNATIONAL TELECOMMUNICATION UNION

**IFRB**

INTERNATIONAL
FREQUENCY
REGISTRATION BOARD

**CCIR**

INTERNATIONAL
RADIO CONSULTATIVE
COMMITTEE

# BOOKLET ON NATIONAL FREQUENCY MANAGEMENT

Second Edition

Geneva, 1988

ISBN 92-61-03851-4

Table I.5.5.-1 National management of radio spectrum use

| Objectives | Description | Main operations |
|---|---|---|
| 1. To develop policies for the national use of radio spectrum. | To produce a frame of reference for the use of radio spectrum in agreement with the general national sociological and economic policies. | a. Estimate of the national economic and social value of spectrum use.<br>b. Establishment of the adequate administrative regime for private and governmental spectrum users.<br>c. Establishment of national priorities for the radio spectrum utilization.<br>d. Estimate of radiocommunication future needs as a function of national development.<br>e. Estimate radio spectrum future use required by the telecommunication growth. |
| 2. To plan the national use of radio spectrum. | To provide a set of rules and procedures to facilitate and optimize the use of radio spectrum. | a. Frequency allotment by services.<br>b. Internal organization of each service allotment to maximize efficiency.<br>c. Preparation of the Spectrum Use National Index (SUNI).<br>d. Reference of the SUNI to the general ITU general frequency allocation table.<br>e. Update knowledge on radiopropagation characteristics and telecommunication technology. |
| 3. To allocate services and frequencies. | To provide efficient and technically sound allocation with the necessary equitability and celerity. | a. Pre-selection of possible frequencies based on radiopropagation conditions.<br>b. Electromagnetic compatibility evaluation.<br>c. Definitive selection of frequencies.<br>d. Fees calculations and collection of dues.<br>c. License allotment. |
| 4. To execute radio controller activities. | To establish and mantain a system of radio control to perform police duties over the radio spectrum in order to warrant its correct use. | a. Inspection and control of the radio spectrum use.<br>b. Application of penalties to transgressors. |

Extract from: Handbook on Radio Propagation for Tropical & Sub-tropical Countries, URSI, 1987, Radicella, ...

## PREFACE

Resolution No. 7 of the World Administrative Radio Conference, Geneva, 1979 (referred to hereafter as WARC-79), made provision for meetings to be organized between representatives of the International Frequency Registration Board (IFRB) and of the International Radio Consultative Committee (CCIR) and personnel involved in frequency management matters from administrations of developing and developed countries to discuss questions relating to the establishment and operation of frequency management units, taking into account the particular needs of the developing countries, to design possible standard structures for such units, and to identify the means required to satisfy those needs.

The first meeting on the development of national radio frequency management was held in Geneva from 24 to 28 October 1983, and 140 participants from 75 administrations attended. The report of this meeting was published by the Secretary-General of the ITU in his Circular-letter No. 13 of 22 March 1984.

In the time available the meeting could not deal with the question of standard structures of the frequency management units or with the means required to permit developing countries to set up these units. Need for a second meeting was identified with a view to completing the tasks outlined in Resolution No. 7. In this respect the meeting defined the work to be carried out by the administrations, the IFRB and the CCIR in the period preceding this second meeting.

One of the main goals identified in Resolution No. 7 is to define standard structures or models of national frequency management units for developing countries, and the first meeting adopted the principle of preparing a questionnaire to be sent to all administrations in order to assemble information on the current practices of administrations in this context. The questionnaire was distributed to administrations under IFRB Circular-letter No. 585 dated 30 July 1984. A consolidated report on the replies received was used as a basis for discussion at the second meeting. The report regarding standard structures for frequency management units was distributed through IFRB Circular-letter No. 677 of 14 November 1986. The second meeting took place in Geneva from 8 to 11 September 1987 and 76 participants from 34 administrations attended.

The first meeting concluded that it would be useful to the developing countries if the IFRB and the CCIR prepared a booklet describing the most basic functions, tasks and daily operations proper to a frequency management unit.

Following the recommendations made at the second meeting, the IFRB and the CCIR have collaborated in this revised version of the booklet, which it is hoped will be of assistance to administrations when establishing or developing their national frequency management units.



The booklet includes an annex which is a glossary of terms used in the text that have a particular meaning in the context of frequency management: when such a term appears for the first time in the text it is set in *italics*. The glossary also includes a selection of terms which, although not appearing in the booklet, are frequently encountered in the same context.

CONTENTS

# CHAPTER 1

## FREQUENCY MANAGEMENT IN GENERAL

### 1.1 BACKGROUND

Frequency management can be defined as the administrative and technical procedures necessary to ensure the operation of radio *stations* of different *radiocommunication services* at any given time without causing or receiving *harmful interference*.

Owing to the extensive use being made of the radio frequency spectrum it is now very difficult to allocate bands of interference-free frequencies to individual radio services: the requirements can be met only on a basis of sharing time, space and frequency.

This means that simple *assignment* procedures applied in the past and simple network plans for the use of frequencies may not always be satisfactory in the short or in the long term and are inadequate in congested areas. It is necessary to make *electromagnetic compatibility (EMC)* analyses before frequencies are assigned. The bulk of technical and administrative work involved requires detailed knowledge not only of the equipment characteristics used but also of the physical characteristics of propagation over the whole radio frequency spectrum. These activities need to be set within an organizational framework.

The administrative and regulatory procedures relevant in the international context are described in detail in the *IFRB* Handbook on Radio Regulatory Procedures. *CCIR* Recommendations, Reports and Handbooks provide a basis for the technical aspects.

The regulatory procedures adopted for internal application within a country are a matter to be decided by the country concerned, but they should embody the provisions contained in the International Telecommunication Convention and the Radio Regulations because the *telecommunication* administration of a country, as a Member of the ITU, has undertaken to apply them within the national territory as well as in its relations with other Member countries.

The principles of the technical procedures relevant in varying degrees to both national and international spectrum management, and general guidance based on these principles, are explained in general terms in the CCIR Handbook on Spectrum Management and Computer-Aided Techniques, and the CCIR Handbook for Monitoring Stations, and are documented in the relevant texts of CCIR Recommendations and Reports.

The present booklet sets forth the principles underlying the establishment and operation of a national spectrum management unit. It is based on official texts of the IFRB and the CCIR.

### 1.2 USE OF TERMS

In all documentation of the ITU relating to the use of the radio frequency spectrum the terms defined in RR17-19 are applied strictly in accordance with their definitions. These definitions are listed in the glossary in the annex to this booklet but in view of their importance in frequency management they are reproduced below.

RR17: *Allocation* (of a frequency band): Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more *terrestrial* or *space radiocommunication* services or the *radio astronomy* service under specified conditions. This term shall also be applied to the frequency band concerned.

RR18: *Allotment* (of a radio frequency or radio-frequency channel): Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more *administrations* for a terrestrial or space radiocommunication service in one or more identified countries or geographical areas and under specified conditions.

RR19: Assignment (of a radio frequency or radio-frequency channel): Authorization given by an administration for a radio station to use a radio frequency or radio-frequency channel under specified conditions.

It follows from these three definitions that allocations (of frequency bands to services) are made by appropriately authorized world administrative radio conferences of the ITU. Allotments (of frequencies to geographical areas) are made by appropriately authorized world administrative radio conferences which may also adopt a procedure for updating such allotments. The assignment of a frequency (to a station) is normally made by an administration, through the licensing process, but a world-wide, regional or sub-regional planning conference may adopt a frequency assignment plan indicating frequencies that an administration may assign to specific stations and the associated characteristics.

## CHAPTER 2

## THE OBLIGATIONS OF AN ADMINISTRATION IN THE CONTEXT OF FREQUENCY MANAGEMENT

### 2.1 PURPOSE OF AND NEED FOR INTERNATIONAL REGULATIONS

The radio frequency spectrum and the geostationary-satellite orbit are two limited natural resources available to all mankind. Each of these resources has the unique property of being conserved if it is used properly, and wasted if it is not used properly.

*Radio waves* propagate in space with no regard for political frontiers: thus, of three users who may be in the same country or two or three different countries, user A communicating with user B on a particular frequency may very well cause *interference* to the services of user C. There must therefore be some regulation in the use of the frequency spectrum. Moreover, since several countries may be involved in ensuring the interference-free use of a frequency by any station, that regulation must take the form of an international agreement, defining all the conditions of such use.

The first essential requirement for the orderly use of the frequency spectrum is the division of that spectrum into separate parts (referred to as bands), each of which can be utilized by one or more radiocommunication services.

The second essential step is the division of the world into three distinct Regions called Region 1, Region 2 and Region 3. These divisions find expression in the Table of Frequency Allocations in Article 8 of the Radio Regulations.

The next essential requirement is the application of pre-established regulatory procedures for the use of frequencies by stations in the same service or in different services in such a way that interference between different countries is avoided: appropriate procedures have been developed, and these too are prescribed in the Radio Regulations.

### 2.2 INTERNATIONAL REGULATIONS

The first international regulations in the field of telecommunications were adopted at a conference in 1865 in Paris, thereby creating the International Telegraph Union.

Owing to rapid developments in the field of telecommunications, revision and updating of the first regulations were continuously needed. This need has been met by successive conferences held under the aegis of the International Telegraph Union, subsequently renamed the International Telecommunication Union. With the advent of space technology and the need to regulate the use of space radiocommunications, and particularly the geostationary-satellite orbit, new provisions have been adopted in the Radio Regulations.



Today these regulations are contained in the International Telecommunication Convention (Nairobi, 1982), and the Administrative Regulations annexed thereto. The Radio Regulations are part of the Administrative Regulations which are annexed to the Convention. The Convention and the Regulations are binding upon those governments which have signed and ratified or have acceded to them. The underlying principle upon which the effectiveness of the Convention and the Regulations is based is the voluntary undertaking by each signatory to comply and ensure international cooperation.

### 2.3 THE RADIO REGULATIONS

2.3.1 Generally speaking, the Radio Regulations define the rules to be applied in using the spectrum and the orbit, as well as the rights and obligations resulting from this use. Successive radio conferences have refined these rules to adapt them to technological advances. The principles developed by the radio conferences can be categorized under five general headings:

a) the allocation of frequency bands to specific services;

b) the requirements to obtain prior agreement in cases where allocations are made to meet the specific requirements of a country or a group of countries;

c) the adoption of plans where practicable;

d) the prior coordination in some cases of the proposed utilization of frequencies in shared bands; and

e) the adoption of procedures for notification and registration of frequency assignments in the planned and unplanned frequency bands.

2.3.2 Chapter III of the Radio Regulations, Geneva, 1979, edition of 1982, revised 1988, constitutes a basic agreement and comprises

- general rules for the assignment and use of frequencies, Article 6
- provisions for special agreements, Article 7
- allocation of frequency bands among defined radio services, Article 8
- special rules for the assignment and use of frequencies, Article 9

The special rules relating to particular radio services are to be found in Part B of the Radio Regulations, Chapters VIII, X, XI and XII. Many of these special rules concern the use of frequencies and are obligatory in character.

2.3.3 The Radio Regulations are completed by 44 Appendices, most of them containing detailed provisions, some in tabular form, which cannot be included conveniently in the body of the Regulations. The Appendices have the same status as the other provisions of the Radio Regulations.

In addition to provisions of the Radio Regulations, a world administrative radio conference may adopt resolutions and recommendations. In its application of the Radio Regulations, the Board considers that when references to these resolutions or recommendations are made in a provision of the Radio Regulations (for example Resolution No. 500 in RR458 and Recommendation No. 504 in RR480), they become obligatory under that provision.

## 2.4 THE PROCEDURES IN THE RADIO REGULATIONS

2.4.1 In accordance with the provisions of the Radio Regulations, any frequency assignment, with certain specified exceptions, shall be notified to the IFRB:

a) if the use of the frequency is capable of causing harmful interference to any service of another administration;

b) if the frequency is to be used for international radiocommunication; or

c) if it is desired to obtain international recognition of the use of the frequency.

2.4.2 The procedures governing notification and registration of frequency assignments in the *Master International Frequency Register (MIFR)* may be broadly subdivided into the acts of coordination, notification, examination and registration.

Prior to 1947, the procedures for the selection and publication of frequencies, together with the procedures for the resolution of harmful interference problems, were not of a detailed nature and all negotiations concerning the use of the spectrum, including the resolution of harmful interference, were carried out entirely between the administrations concerned.

In 1947, with the rapidly expanding use of radiocommunication, the administrations found it necessary to develop more sophisticated, mandatory procedures governing the use of the spectrum. The intent of these procedures was in effect to permit a more coordinated use of the spectrum prior to the actual use of frequencies by administrations, thus reducing the probability of harmful interference. In the late 1950s and 1960s, with the widespread use of more advanced terrestrial systems (radio relay links) and with the advent of space radiocommunications, there was a need to develop procedures for increased prior coordination of the use of frequencies and even more complex technical criteria.

2.4.3 So far as the problem of harmful interference is concerned, each administration wishing to put into service a new station, likely to cause interference outside the territory of the country in which it is located, is under obligation to send a notice of its intentions to the IFRB, giving the technical characteristics of the station concerned. The Board examines the notice for its conformity with the Table of Frequency Allocations and the other provisions of the Radio Regulations and then assesses the extent to which the use of the frequency, under the notified conditions, could cause interference to stations of any other administration recorded in the Master International Frequency Register. If the Board finds that there is a probability of such interference, the notice is returned to the notifying administration which then, normally, searches for an alternative frequency or modifies the characteristics of the station in such a way as to obviate the probable harmful interference. If the Board finds that there is little or no probability of harmful interference with existing entries of other administrations in the Master Register, the notices will normally receive a favourable finding. The particulars of the assignment are entered in the Master Register, accompanied by all relevant remarks, which establishes the legal status of the assignment vis-à-vis other existing and future assignments.



## 2.5 THE INTERNATIONAL FREQUENCY REGISTRATION BOARD

The IFRB was created at the Atlantic City Plenipotentiary Conference, 1947. Although its composition, duties and working methods have undergone some changes since then, it remains a collegiate body possessing through its members a thorough knowledge of radiocommunications and the problems of their use in various regions throughout the world. The Convention specifies that members of the Board shall serve, not as representing their respective countries, or a region, but as custodians of an international public trust, and requires Members of the ITU to respect the international character of the Board and the duties of the Board members, and to refrain from any attempt to influence them in the exercise of these duties.

The Board at present comprises five Members elected at the Plenipotentiary Conference of the ITU, and is assisted by a specialized secretariat of about 150 persons working under the direction of the Board.

The composition and essential duties of the IFRB are defined in Articles 10 and 57 of the Convention. These may be summarized as follows:

- to effect an orderly recording of frequency assignments made by the different countries;
- to effect an orderly recording of the orbital positions assigned by countries to geostationary satellites;
- to advise countries on efficient utilisation of the spectrum and the geostationary-satellite orbit;
- to follow the procedures laid down in the Radio Regulations or by Administrative Conferences;
- to provide technical assistance in organizing and preparing for radio conferences in consultation with the other permanent organs of the Union, and to assist developing countries in their preparations for such conferences; and
- to maintain the records essential for the performance of its duties.

Article 10 of the Radio Regulations (Geneva, 1979, edition of 1982, revised 1988) gives a detailed description of the Board's duties and working methods, which may be summarized as follows:

- the processing of frequency assignment notices, including information about orbital locations of geostationary satellites, received from administrations for recording in the Master International Frequency Register (MIFR);

- the processing of information received in application of the procedures of the Radio Regulations (advance publication, coordination, notification, etc.);

- the processing and coordination of seasonal *HF* broadcasting schedules;

- the periodic compilation of the *International Frequency List (IFL)* reflecting the data recorded in the MIFR;

- the review and updating of the MIFR;

- the study, on a long-term basis, of spectrum utilization with a view to ensuring maximum efficiency;

- the investigation of cases of harmful interference;

- the provision of assistance to administrations in the field of radio spectrum utilization and the training of senior staff;

- the collection of the results of monitoring observations;

- the development of technical standards and rules of procedure for internal use by the Board.

The Board examines all frequency assignment notices submitted to it by administrations, and formulates in respect of each notice what the Radio Regulations term a "finding". Each finding is a statement of a juridical nature based on regulatory and technical grounds: it results in a decision either to record the assignment in the MIFR in accordance with the Radio Regulations or to return the notice to the notifying administration because of its nonconformity with one or more relevant provisions.

The procedures to be followed by the administrations and by the Board in the processing of notifications and the recording of assignments are prescribed in Chapter IV of the Radio Regulations and are described in detail in the IFRB Handbook on Radio Regulatory Procedures. The Board ensures uniformity in application of these procedures by establishing objective technical standards and rules of procedure, which are published in loose-leaf form as they appear (see IFRB Circular-letter No. 692 of 18 May 1987).



## 2.6 THE INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

The International Radio Consultative Committee (CCIR) is the permanent organ of the International Telecommunication Union whose duties under the International Telecommunication Convention are "to study technical and operating questions relating specifically to radiocommunication without limit of frequency range, and to issue recommendations on them" (International Telecommunication Convention, Nairobi, 1982, First Part, Chapter I, Article 11, No. 83).

The objectives of the CCIR are in particular:

a) to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient utilization of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;

b) to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications;

c) to collect, exchange, analyse and disseminate technical information resulting from studies by the CCIR, and other information available, for the development, planning and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.

The CCIR works through the medium of a number of Study Groups, each dealing with a particular aspect of radiocommunication (see Table 2.1). The Study Groups prepare draft Reports and Recommendations which are considered by the Plenary Assembly (which meets usually every four years), and many of those adopted form the basis for revision of the Radio Regulations at world administrative radio conferences. The approved Reports and Recommendations of the CCIR are not of themselves obligatory in the same context as the Radio Regulations, but serve as standards for use by the world's telecommunication community. They may be incorporated on a national basis within national legislation and through special procedures adopted by ITU Member countries as obligatory in certain cases, e.g. space services coordination.

An Interim Working Party (IWP) may be set up by a Study Group (or jointly by more than one Study Group) if it is necessary to expedite work on a particular study: for example, IWP 1/2 (set up by Study Group 1) is responsible for study of computer-aided techniques in frequency management, and IWP 1/5 (also set up by Study Group 1) is responsible for updating the CCIR Handbook for Monitoring Stations.

The Recommendations and Reports adopted by the Plenary Assemblies are published on a four-year cycle, in a set of volumes covering the subject matter of each Study Group (see Bibliography).

The CCIR may also be invited to participate in the preparatory work prior to an administrative radio conference, with the main objective of preparing a report on the technical and operational topics relevant to the agenda of the conference concerned.

In 1978 the CCIR Plenary Assembly recognized that with the increasing complexity of spectrum management it may be practicable to employ computer-assisted techniques to achieve more efficient spectrum utilization. Consequently, it decided to create an Interim Working Party (IWP 1/2) to prepare a special Handbook. According to Recommendation No. 31 of the World Administrative Radio Conference (WARC-79) the Handbook describes various aspects of radio frequency management as well as providing guidelines for various levels of practical application of computer techniques to this goal. This Handbook was published in 1983 and revised in 1986 (see section 5.3 and the Bibliography).

The CCIR Handbook for Monitoring Stations contains the essential information for the establishment, staffing and operation of a monitoring system. This Handbook was first published in 1968 and its updated version is in preparation.

---



TABLE 2.1

CCIR Study Groups

Basic technical

1 - Spectrum utilization and monitoring

5 - Propagation in non-ionized media

6 - Ionospheric propagation

Radiocommunication services

2 - Space research and radio astronomy

3 - Fixed service at frequencies below about 30 MHz

4 - Fixed-satellite service

7 - Standard frequencies and time signals

8 - Mobile services

9 - Fixed service using radio relay systems

10 - Broadcasting service - sound

11 - Broadcasting service - television

Joint CCIR/CCITT Study Groups administered by CCIR

CMV - Vocabulary

CMTT - Transmission of sound broadcasting and television signals over long distances

## CHAPTER 3

## THE OBJECTIVES AND FUNCTIONS OF AN ADMINISTRATION IN THE CONTEXT OF NATIONAL FREQUENCY MANAGEMENT

### 3.1 GENERAL OBJECTIVES OF NATIONAL FREQUENCY MANAGEMENT

3.1.1 The fact that the International Telecommunication Convention and the Radio Regulations annexed to that Convention are intergovernmental treaties, which have to be ratified and accepted by the governments of the countries Members of the ITU, means that the governments undertake to apply the provisions of the International Telecommunication Convention and the Radio Regulations in their countries as well as in the other geographical areas under their jurisdiction.

This also means that the governments of the Member countries of the ITU have to adopt national legislations that include, as the basic minimum, the essential provisions of the Convention and the Radio Regulations, which must apply to the radiocommunication services including those relating to national defence and national security (military, police, intelligence services, etc.).

3.1.2 The prime objectives of national frequency management are to permit a country to regulate the use of the radio frequency spectrum and the geostationary-satellite orbit, to ensure the availability of radio frequencies and orbit locations for the orderly use and development of radio services of the country, and to permit the country to fulfil its international obligations. To this effect, a country has to adopt national legislation (including means of enforcement) enabling its frequency management organization:

- to develop national policy and national regulations for the effective use of the spectrum on the basis of the internal priorities of the country;
- to identify the spectrum requirements to satisfy the needs of the country;
- to record and process users' requests, to coordinate them with other users nationally and with administrations of other countries and to authorize the use of radiocommunications by issuing licences in appropriate cases;
- to develop technical standards and engineering analysis models;
- to monitor and detect any operational or technical irregularities and take corrective action;
- to resolve cases of harmful interference;
- to promote and safeguard national interests relating to radiocommunications in international conferences and meetings.

3.1.3 To carry out these essential tasks and to implement the provisions of the Convention, the Radio Regulations, and bilateral or multilateral treaties as appropriate with neighbouring countries, there is a need for an identifiable frequency management authority in each country having the necessary powers and an appropriate supporting unit. It will be responsible for the planning and coordination of the use of radio frequencies by individuals, organizations and services in the country with particular regard to national security, safety of human life, public telecommunication, mass media (such as broadcasting and television), services for the public (such as transportation, supplies, health services, industries), scientific and technical research and development, and even the application of radiocommunication to personal hobbies of individuals. Contributing as it does to the social and economic development and well-being of the country, the planned and coordinated use of radio frequencies through a national frequency management authority deserves a high priority in each nation's considerations.

3.1.4 Each country should therefore establish a frequency management authority according to its particular requirements and available resources and adopt for it the organizational structure best suited for carrying out its tasks. The structure may differ from one country to another, but it is its essential duty to meet the objectives listed in section 3.1.2 and thus ensure that the radio frequency spectrum and geostationary-satellite orbit are rationally and properly used.

Recognizing that the international and national functions of frequency management are very closely interlinked, most countries have found it appropriate to set up a single authority whose responsibilities cover both aspects. This authority is the "administration" (defined in RR3) for the country concerned.

### 3.2 THE BASIC FUNCTIONS TO BE PERFORMED BY A NATIONAL FREQUENCY MANAGEMENT UNIT

The basic functions of a frequency management unit in support of the national authority can be identified as:

- long-term spectrum management policy and planning;
- establishment of a table of national frequency allocations and national regulations;
- assignment of frequencies;
- licensing and authorization of the use of radiocommunications;
- international relations in the context of spectrum management;
- establishment of technical standards and engineering support facilities;
- record keeping;
- inspection of installations;
- monitoring the use of the spectrum.

These functions are discussed individually in sections 3.2.1 - 3.2.9 below. More detailed information can be obtained from the CCIR Handbook on Spectrum Management and Computer-Aided Techniques.

3.2.1 Long-term spectrum management policy and planning

On the basis of social, economic and political requirements a national policy for management of the spectrum and long-term plans reflecting that policy have to be developed and kept under review. Such plans will be reflected in the national table of frequency allocations and supported by appropriate national regulations.

The primary goals of this function are to determine and periodically update the existing and future requirements for the various radiocommunication services on the basis of which a long-term national policy can be established, bearing in mind the national priorities, and to conduct necessary studies in this field.

3.2.2 Establishment of a table of national frequency allocations and national regulations

A table of national frequency allocations has to be established in accordance with the national priorities: this table has to be in conformity with the internationally adopted allocations prescribed in Article 8 of the Radio Regulations (see RR342), but may be more detailed - for example, a frequency band allocated internationally to the fixed and mobile services might be subdivided and allocated in accordance with the national priorities partly to the fixed service and partly to the mobile service, each on an exclusive basis. Further subdivision is possible: a band allocated nationally to the land mobile service might be split so that defined portions are allocated to particular categories of user such as the fire or ambulance services, services used by the public, or government services.

Figure 3.1 shows an extract from the International Frequency Allocation Table, taken from Article 8 of the Radio Regulations.

Figure 3.2 shows as an example the corresponding extract from a national allocation table which might be adopted by a country in Region 2. This example does not represent any particular or recommended national allocations or presentation.

Once the national frequency allocation table has been established, it must be kept under review to ensure that all national requirements can be met, and must be supported by appropriate national legislation and regulations prescribing the operating conditions applicable to the various services and frequency bands - for example power limitations, or prescribed areas of use - which will be reflected in the terms of the licence.



3.2.3 Assignment of frequencies

The frequency assignment function is responsible for ensuring the electromagnetic compatibility of all proposed or requested assignments with regard to existing assignments on a national or international basis, as appropriate. It will include the analysis of requirements for proposed radio services together with any relevant studies, and the assignment of the frequencies to be used in accordance with the national plan, and it may be responsible for the coordination and notification to the IFRB of assignments requiring to be so coordinated and notified in accordance with the Radio Regulations. It may also be responsible for related actions necessary to protect the country's radiocommunication systems from potential interference from another country's assignments published in the latest edition of the International Frequency List (IFL), List I, and in the weekly Circulars published thereafter by the IFRB.

Once a frequency has been assigned to a transmitting or a receiving station, all the technical and operating data indicating the spectrum space occupied by this assignment should be entered in the national frequency register. This register not only serves as a reference when subsequently selecting other usable frequencies but also provides the basic material for taking effective measures required to adapt national planning to the real requirements of the various users. The greatest care should be taken in compiling the national register and keeping it up to date; it must have room for recording a sufficient number of assignments and for all the information needed for the clear and complete description of each of them. If the size of the register and its use so require, it may be very useful to employ modern computer processing and recording techniques.

3.2.4 Licensing and authorization of the use of radiocommunications

Licensing is the process of conferring the legal authority to operate a radio station under conditions specified in the national regulations.

The Radio Regulations stipulate that no transmitting station may be established without a licence issued by the government of the administration to which the station belongs (RR2020). In some countries the right to use a radio receiving installation is also subjected to licensing under the rules adopted nationally.

Administrations may charge users of the spectrum a fee for their licences and the licensing function may be responsible for collection of these fees. The fee may reflect the degree to which the spectrum is used and the economic benefit derived by the user, as well as the administrative costs incurred by the administration.

Licensing thus plays a major role in any well-structured spectrum management system. This implies application of the national legislation and the regulations governing radiocommunications. Licensing activities may include:

- serving as the main interface between the frequency management authority and the general public;
- conducting an examination of licence applications and related documents to determine:

- the licensing eligibility of the applicant from a legal and regulatory point of view

- the technical acceptability of the radio equipment to be used

- whether other types of communication services would better suit the need of the applicant

- whether the frequencies requested are in a band allocated to the type of service involved and would be in keeping with national policy and planning requirements

- that the proposed system has been well designed, would not use excessive power, and would use the minimum number of frequencies necessary to provide a reliable service

- whether antenna mast or site clearance action is necessary (for example in connection with aircraft warning lights, or amenity considerations)

- forwarding approved submissions for the assignment of a frequency;

- ensuring that the information required for the production of licences is accurately recorded nationally;

- ensuring that relevant international service documents are updated;

- issuing licences to stations and, as relevant, to operators (see Articles 44 and 55 of the Radio Regulations) and collecting fees; and

- renewing and cancelling licences as appropriate.

3.2.5 International relationships in the context of spectrum management

In order to promote and preserve the national interests, participation in world and regional administrative radio conferences of the ITU and other meetings (such as those of the CCIR) dealing with radio matters is important: such meetings require a great deal of preparatory work. To participate effectively, each country should set up national Working Groups (in which the views of different users may be considered) in order to develop proposals and positions on the key issues of national importance and present these views in due course at the international conferences and meetings. Following a particular conference or meeting, the decisions taken need to be analysed and, if appropriate, the concluded Final Acts need to be ratified. Subsequently the decisions relevant to the country need to be implemented. The same considerations apply in the context of bilateral agreements with neighbouring countries to settle policy or operational issues, for the purpose of coordinating the establishment of radiocommunication systems, and for other items of mutual interest in the use of the radio frequency spectrum.



3.2.6 Establishment of technical standards and engineering support facilities

Technical standards have to be developed and applied nationally:

- to ensure that radio systems will meet the required national and international overall performance requirements (planning standards);

- to ensure that radio equipment will function satisfactorily under the relevant conditions (performance standards): these performance standards will be applicable to equipment used in the country concerned whether manufactured locally or imported from abroad. Testing is commonly carried out on representative samples of the equipment concerned (type approval);

- to ensure that equipment that generates RF energy (e.g. industrial, scientific and medical equipment) which might cause interference to radiocommunication systems performs satisfactorily in that respect (see RR1814, RR1815): the relevant standards may be those established by the ITU/CCIR, *IEC* and *CISPR*.

The technical standards concerned should take into account the latest developments in radio technology, and should be aimed at providing solutions to problems of radio interference and supporting timely policy formulation for the establishment of national frequency plans.

The provision of engineering support facilities, e.g. a radio laboratory or workshop, and expertise in the technical analysis of radio engineering and electromagnetic compatibility problems will greatly facilitate the development and application of technical standards, and will be a source of advice to sub-units carrying out other functions of the frequency management unit on technical matters.

3.2.7 Record keeping

Record-keeping activities are involved in almost all functions of a frequency management unit.

Accurate and up-to-date records are of utmost importance for effective national and international coordination, licensing and enforcement activities, policy formulation, interference investigations and resolution, and financial considerations. Depending on the amount of the data to be handled and the available resources, these records may be maintained either manually or by computer. Whichever method is used, the information is stored or filed in a data base in such a way that it can be consulted, extracted or amended in a manner which should reflect the importance of the data, how frequently it is to be consulted or modified, and the economics of collecting and storing it. In the development of a data base it is important to use compatible definitions, formats and codes for the data elements commonly used by more than one organization (for example, notified data should conform to the IFRB practice). It is also necessary to make generous allowance for expansion and provision for reliable and frequent updating of the information the data base contains.

To the extent practicable, it is helpful to centralize and integrate the data bases to eliminate duplication of records, as well as to facilitate the updating of the information. Extended considerations on data acquisition, maintenance and retrieval can be found in Chapter 4 of the CCIR Handbook on Spectrum Management and Computer-Aided Techniques.

To carry out the essential functions of national frequency management a number of manual or computerized data files may be established and maintained, covering, for example:

- frequency allocation data;
- frequency assignment and notification data;
- licence holder data;
- additional equipment characteristics data;
- monitoring data;
- other (e.g. administrative and financial) data.

Most of these data files are essentially interrelated, and therefore updating of them needs to be synchronized.

Frequency allocation data

In its simplest form the frequency allocation data file is derived from the Table of Frequency Allocations in Article 8 of the Radio Regulations, after adaptation to the national environment, and thus serves as the national frequency allocation table.

Frequency assignment and notification data

In general, the frequency assignment and notification data base contains all the information necessary to undertake a frequency assignment, and notify it to the IFRB if appropriate. Typical data elements contained in this data base would include:

- *assigned frequency*;
- transmitting and receiving station particulars;
- power;
- emission designation (comprises necessary bandwidth and class of emission);
- certain equipment and antenna characteristics;
- nature of service.



This data base serves as the national frequency register, and would contain information recorded in the same format as the IFL (see IFRB Circular-letter No. 583 of 6 July 1984) on all national assignments made, whether or not they have been notified to the IFRB. It will serve as the basic reference for other files such as the licensing data and monitoring data files, and should be correlated to these files.

Licence holder data

The licence holder data file contains all the data relevant to the licence holder (name, address, telephone/telex number, etc.), and could usefully contain information on licence application and renewal dates, and fees.

Additional equipment characteristics

The frequency assignment data file will contain certain items of information which are relevant to the equipment in the particular context of a given assignment: other, more general characteristics of the equipment, such as transmitter emission spectrum and receiver selectivity, may be recorded in the equipment characteristics file. Such data may include reference to relevant CCIR Recommendations and Reports.

Monitoring data

As a result of the functions outlined in section 3.2.9, monitoring and spectrum occupancy information will be generated, and may be stored in a dedicated data base.

Other data

Further files may be set up containing information on a wide range of subjects, such as planning standards, propagation, and topographical data. Such information will be useful in the planning of new radio stations and networks, and in EMC studies. Other subjects which might be covered include terrain roughness, ground conductivity, coastlines, building density in metropolitan areas etc., and the administrative and financial records necessary for spectrum management purposes.

Section 2.6.6 and Chapter 4 of the CCIR Handbook on Spectrum Management and Computer-Aided Techniques address the subject of record keeping/data *storage* in detail: although these texts may be particularly relevant in the context of computer assistance and automated data bases, they are perfectly valid in the context of manual data bases, or information files, and deserve careful study and consideration.

3.2.8 Inspection of installations

In connection with its responsibilities for issuing licences on behalf of the government, the national frequency management authority must be able to confirm that stations comply with the relevant provisions of the Radio Regulations, specifically RR312, and those of the national legislation which are indicated in the terms of the licence. For that purpose it must have the staff and equipment necessary for conducting inspections of stations and checking their operation on the spot; it is assumed that the authority is able to check emissions from a distance with the monitoring facilities at its disposal.

These various checks apply not only to non-mobile stations but also to mobile stations, that is to say to ship stations, aircraft stations and land mobile stations. In the case of mobile stations, the Radio Regulations stipulate that, when they are in the territory under the jurisdiction of an administration other than that by which the licence was issued, the stations may be inspected for the purpose of examining the licence, observing any irregularities in the equipment or its operation, and reporting them to the competent authorities of the licensing administration (see Articles 46 and 57 of the Radio Regulations). In the case of aircraft and ship stations, inspection also covers examination of the operator's certificates.

3.2.9 Monitoring the use of the spectrum

The frequency management unit should have access to monitoring facilities to check the emissions of radio stations and their technical characteristics, and to ensure that they are operated in conformity with the standards and various conditions on the basis of which their licences were issued. This would include ensuring compliance by stations with RR312 in the event that national priorities have supported sufficient monitoring capability.

An adequate monitoring service using fixed and/or mobile monitoring stations can be of great assistance in solving problems of harmful interference and in finding suitable frequencies not subject to such interference.

The monitoring service should be primarily designed to meet domestic needs. However, the stations of the monitoring service of an administration should be prepared to cooperate with other administrations as well as with the IFRB and the international monitoring system (see Article 20 of the Radio Regulations). They should then conform with the standards of performance prescribed by the CCIR. The CCIR Handbook for Monitoring Stations provides the guidance needed for administrations to establish priorities for monitoring resources; to site, construct and adequately equip monitoring facilities; and to appropriately carry out monitoring responsibilities of both a national and an international nature. It is noted that a monitoring system may have a great range of capabilities while still participating in the international monitoring system established under Article 20 of the Radio Regulations, depending upon the resources available. In practice, every administration may participate in the international monitoring system and contribute to the monitoring programmes organized by the IFRB, even with the most rudimentary system. An effective monitoring network, of whatever scale used, needs an accessible data base of nationally licensed stations, as well as the International Frequency List.



In essence, monitoring provides information needed for regulatory and enforcement purposes on the operation of radio stations, and may also provide statistical information on spectrum occupancy or propagation, which may be useful for:

- investigation of interference complaints;
- identification of usable frequencies;
- determination of the service area of a transmitting station;
- investigation of illegal operations and operations not in keeping with the terms of radio station licences;
- collection of information for prosecution cases and assistance to law enforcement agencies in carrying out the processes of the law;
- ensurance of compliance by radio station operators with national and international statutory and regulatory requirements.

3.3 THE POSITION OF THE FREQUENCY MANAGEMENT AUTHORITY WITHIN THE NATIONAL ADMINISTRATIVE STRUCTURE

The position occupied by the frequency management authority and its supporting unit within the national government depends on the nature of the administrative structure in the country concerned. Extended liaison between the frequency management authority and policy-making bodies is essential. The working relationships between the authority and other organizations inside or outside the country concerned will in a majority of cases be those shown in simplified form in Figure 3.3.

In determining the position of the authority within the national administrative structure the following considerations are relevant:

- the development of telecommunications is recognized to be closely linked to the economic development of a country, so the frequency management authority deserves a prominent position in the administrative structure because of its responsibility in the use of the radio frequency spectrum and the geostationary-satellite orbit;
- the frequency management authority maintains regular contact with:
  - the national legislature;
  - all users and potential users of the radio spectrum in the country, whether they are government, public or private organizations, or individuals;
  - the IFRB; and

  - its own counterparts in other countries directly, or through the IFRB or by other means;

- whether it is appropriate for the frequency management authority itself to be a user or potential user of the radio spectrum;

- whether any element(s) of the authority's responsibilities should be delegated to particular groups of users or potential users of the spectrum, e.g. the armed services, or civil authorities such as the fire and ambulance services;

- whether the frequency management authority should be given responsibility for coordinating and conveying the country's views on allied matters not directly concerned with frequency management as such, for example by participating in CCIR activities.

---



| Allocation to Services | | |
|---|---|---|
| Region 1 | Region 2 | Region 3 |
| 890 — 942<br>FIXED<br>MOBILE except aeronautical mobile<br>BROADCASTING 703<br>Radiolocation<br><br>704 | 890 — 902<br>FIXED<br>MOBILE except aeronautical mobile<br>Radiolocation<br><br>705 | 890 — 942<br>FIXED<br>MOBILE<br>BROADCASTING<br>Radiolocation<br><br>706 |
| | 902 — 928<br>FIXED<br>Amateur<br>Mobile except aeronautical mobile<br>Radiolocation<br><br>705 707 | |
| | 928 — 942<br>FIXED<br>MOBILE except aeronautical mobile<br>Radiolocation<br><br>705 | |

703 In Region 1, in the band 862 — 960 MHz, stations of the broadcasting service shall be operated only in the African Broadcasting Area (see Nos. 400 to 403) excluding Algeria, Egypt, Libya and Morocco. Such operations shall be in accordance with the Final Acts of the African VHF/UHF Broadcasting Conference, Geneva, 1963.

704 *Additional allocation:* in Bulgaria, Hungary, Mongolia, Poland, the German Democratic Republic, Roumania, Czechoslovakia and the U.S.S.R., the band 862 — 960 MHz is also allocated to the aeronautical radionavigation service on a permitted basis until 1 January 1998. Up to this date, the aeronautical radionavigation service may use the band, subject to agreement obtained under the procedure set forth in Article 14. After this date, the aeronautical radionavigation service may continue to operate on a secondary basis.

705 *Different category of service:* in the United States, the allocation of the band 890 — 942 MHz to the radiolocation service is on a primary basis (see No. 425) and subject to agreement obtained under the procedure set forth in Article 14.

706 *Different category of service:* in Australia, the allocation of the band 890 — 942 MHz to the radiolocation service is on a primary basis (see No. 425).

707 In Region 2, the band 902 — 928 MHz (centre frequency 915 MHz) is designated for industrial, scientific and medical (ISM) applications. Radiocommunication services operating within this band must accept harmful interference which may be caused by these applications. ISM equipment operating in this band is subject to the provisions of No. 1815.

FIGURE 3.1

**Extract from the Table of Frequency Allocations, Article 8 of the Radio Regulations, 1979**

| INTERNATIONAL ALLOCATION | | | NATIONAL ALLOCATION | | | | |
|---|---|---|---|---|---|---|---|
| Allocation to services : MHz | | | Band MHz | National provisions | Government Allocation | Non-Governmental Allocation | Remarks |
| Region 1 | Region 2 | Region 3 | | | | | |
| 890 — 942<br>FIXED<br>MOBILE except aeronautical mobile<br>BROADCASTING 703<br>Radiolocation<br><br>704 | 890 — 902<br>FIXED<br>MOBILE except aeronautical mobile<br>Radiolocation<br>705 | 890 — 942<br>FIXED<br>MOBILE<br>BROADCASTING<br>Radiolocation<br><br>706 | 890-902 | AA | BB | LAND MOBILE<br>CC | |
| | 902 — 928<br>FIXED<br>Amateur<br>Mobile except aeronautical mobile<br>Radiolocation<br>705 707 | | 902-928 | AA | RADIOLOCATION<br>BB | | DD |
| | 928 — 942<br>FIXED<br>MOBILE except aeronautical mobile<br>Radiolocation<br>705 | | 928-929 | AA | | FIXED | |
| | | | 929-942 | AA | | LAND MOBILE<br>CC | DD |

AA : Footnotes relevant to the national provisions for the band concerned, and references to relevant footnotes in the International Table.
BB : Footnotes relevant to government allocations.
CC : Footnotes relevant to non-government allocations.
DD : Remarks in amplification of allocations and/or other footnotes.

FIGURE 3.2

Sample extract from the national frequency allocation table of a country in Region 2 for the same frequency bands as in Figure 3.1



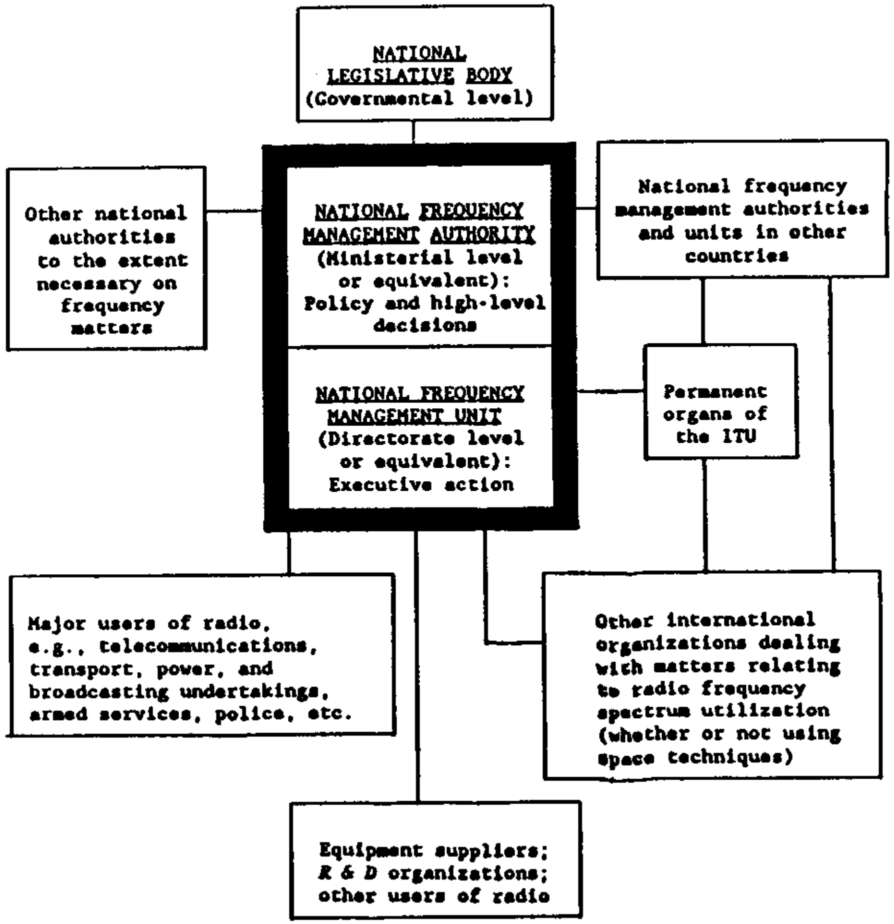



FIGURE 3.3

Principal working relationships of a national frequency management authority

# CHAPTER 4

## ESSENTIAL ELEMENTS OF A NATIONAL FREQUENCY MANAGEMENT UNIT

### 4.1 TASKS TO BE PERFORMED

The basic functions of a national frequency management unit in carrying out its mandate are described in section 3.2. The specific tasks arising therefrom are:

a) planning, coordinating, regulating and administering the use of radio frequencies within the country;

b) establishing regulations, technical parameters and standards governing the use of each frequency band or specific frequency by stations of different services, having regard to current international regulations and agreements;

c) optimizing the use of the radio spectrum and the geostationary-satellite orbit, ensuring the harmonious operation of the different services which use them;

d) allocating frequency bands in accordance with international regulations and the national priorities and assigning specific frequencies as appropriate;

e) authorizing the installation and operation of radio stations, assigning call signs, and granting appropriate licences;

f) updating all information on authorized radiocommunication systems such as frequencies, the location of stations, powers, call signs, etc., and their notification to the IFRB if necessary;

g) appropriate notification of information required for inclusion in the publications and service documents of the ITU;

h) representing, establishing relations, coordinating and issuing technical opinions concerning the use of frequencies in international forums;

i) measuring the technical parameters of the emissions of radiocommunication stations as appropriate;

j) conducting systematic inspections of radiocommunication stations to check that they meet the technical standards and parameters for which their equipment and operation were authorized;

k) participating, so far as the use of frequencies is concerned, in the development plans and projects of all radiocommunication services, ensuring that those plans are in accordance with current international and national regulations;

l) preparing for participation in international conferences convened by the ITU, participating in such conferences and implementing any decisions adopted;

m) conducting negotiations in connection with frequency spectrum management and related problems with other countries and international organizations;

n) providing a national technical forum for work relating to the Study Groups and Working Groups of the CCIR, preparing for the participation of specialists in meetings of the CCIR and participating therein;

o) constituting the national body for relations with international organizations other than the ITU on technical, regulatory and administrative matters, technical cooperation and other subjects related to utilization of the radio frequency spectrum and the geostationary-satellite orbit.

### 4.2 ORGANIZATION

4.2.1 A national frequency management unit capable of carrying out the tasks listed in section 4.1 may be organized in many different ways according to the requirements and resources of the country concerned; there is therefore no single ideal arrangement. However, Figure 4.1 illustrates the sub-units essential in a fully developed national frequency management unit. The role of each sub-unit is discussed in sections 4.2.2 - 4.2.7 below.

#### 4.2.2 <u>Policy and Regulations</u>

The Policy and Regulations sub-unit is typically responsible for the ongoing development of national regulations relating to the use of the radio frequency spectrum, taking into account advances in technology as well as social, economic and political realities. Ministerial regulations and regulations requiring approval at a higher level are drafted by this sub-unit.

In addition this sub-unit may be responsible for developing and updating manuals for procedures and practices to be followed by other sub-units.

National telecommunication policy aspects are commonly associated with regulation development because of their close relationship. Accordingly it might also be a primary function of this sub-unit to conduct studies to determine existing and future telecommunication needs of the country and to develop policies to ensure that the best combination of radio, wire line and cable systems is employed in meeting the identified needs.

Such policies must take into account the needs for telecommunications established by the authorities responsible for national security, national defence, industry and commerce. In addressing these matters, the sub-unit gives consideration to the type of agency and operation which would best suit the communication needs of the country.

The resulting national radio regulatory policies and regulations must be fully documented and must be in line with the Radio Regulations of the ITU and particularly the Table of Frequency Allocations.

This sub-unit could also function as the secretariat for any interdepartmental policy committee set up in response to particular needs, such as the development of long-term national policies and the preparation for international conferences.

4.2.3 Coordination of International Conferences and Meetings

World and regional administrative radio conferences of the ITU and other types of conferences and meetings can require a great deal of advance preparation depending on the level of participation desired by the administration and the issues under consideration. In order to participate effectively at such gatherings an administration may set up working groups to develop national positions on the key issues of interest, and this may be done under a coordinating sub-unit, which would work closely with the Policy and Regulations sub-unit, the Engineering Support sub-unit and users as necessary.

This sub-unit could also be responsible for the development of bilateral agreements with neighbouring countries to settle policy or operational issues for the purpose of coordinating the establishment of communication systems and other items of mutual interest in the radio field.

4.2.4 Coordination, Assignment, Licensing and Notification

The Coordination, Assignment, Licensing and Notification sub-unit could be organized as two interrelated sections:

Frequency assignment section

The frequency assignment section is responsible for conducting electromagnetic compatibility analyses, and for assigning appropriate frequencies to radiocommunication systems. It may also initiate requests to the Inspection and Monitoring sub-unit for the monitoring of specific frequencies or frequency bands to facilitate the engineering analysis of required assignments.

This section is also responsible for coordinating all proposed assignments with regard to existing assignments on a national, regional or international basis. It notifies frequency assignments to the IFRB as required under the Radio Regulations. It also carries out coordination and related actions on request to protect the country's radiocommunication systems from interference or when information on assignments notified by other administrations appears in the weekly Circular published by the IFRB.



Licensing section

The licensing section plays a major role in any well-structured spectrum management unit. This section applies the national legislation, regulations, policies and procedures governing radiocommunications. It also exercises control over the operation of stations and the use of frequencies by:

- examination of licence applications and related documents to determine the licensing eligibility of the applicant from a legal and regulatory point of view and the technical acceptability of the radio equipment proposed;
- granting authorization to entities which may not require a licence, such as government agencies;
- assigning call signs to individual stations;
- issuing licences and collecting fees, if appropriate;
- renewing and cancelling licences as appropriate;
- conducting examinations of operator competence and issuing operator certificates; and
- serving as the main information bureau to the general public.

4.2.5 Engineering Support

The role of the Engineering Support sub-unit is vital and central to the full development of a national frequency management unit because the management of the radio frequency spectrum is becoming increasingly dependent on technical support. These demands come about not only from the need to find technical solutions to the problems of radio interference and congestion but also from the rapid changes in communication techniques and technology and the consequent need for effective, timely and appropriate spectrum planning. Hence the Engineering Support sub-unit must not only keep abreast of the latest technical developments but should, as far as possible, actively participate in the formulation of technical recommendations and standards for performance and compatibility by internationally recognized bodies such as the CCIR. Effectiveness in these tasks may be dependent on expertise in other areas such as radio system design, technical performance objectives, techniques for the development of engineering models (propagation, power, antennas, statistical analysis of performance, optimization techniques, etc.).

The functions of the Engineering Support sub-unit can be carried out by three sections, as follows.

Spectrum planning section

The spectrum planning section develops standard radio system plans using current engineering and radio system planning practices. The purpose is to ensure the most effective use of the spectrum by radiocommunication services, taking into account the technical and operational factors applicable to each service.

Standards and specifications section

The standards and specifications section is responsible for the development of procedures for the approval of radio equipment, and radio standards specifications (documents which set forth the minimum performance standards required for the type approval of radio transmitters and receivers and other equipment).

Spectrum engineering section

The spectrum engineering section is an engineering support facility which typically provides the following services to frequency management operations as a whole:

- laboratory testing of transmitting and receiving equipment in keeping with prescribed type-approval procedures;
- maintenance and calibration of laboratory test equipment and other equipment used by the Inspection and Monitoring sub-unit;
- acceptance evaluation of equipment being purchased for inspection and monitoring purposes; and
- outfitting of special-purpose vehicles and calibration of equipment to be fitted in such vehicles.

4.2.6 Inspection and Monitoring

The Inspection and Monitoring sub-unit may be organized in two sections, which according to the size and requirements of the country concerned may be centralized or dispersed. Propagation conditions, particularly in the *VHF* and higher frequency bands, are such that inspection and monitoring cannot be carried out satisfactorily from a single site unless the country is very small: the use of multiple sites or appropriately equipped vehicles for these purposes then becomes essential.

Inspection section

The inspection section is provided with the inspection equipment and mobility needed to enforce the national and international statutory and regulatory requirements of frequency management. It works closely with the monitoring section and the Assignment and Licensing sub-unit in collecting information.

The functions of this section may include the following:

- to investigate interference complaints;
- to investigate radiation from industrial, scientific and medical appliances;
- to investigate illegal operations, and operations not in keeping with the terms of radio station licences;



- to collect information for prosecution cases and to assist law enforcement agencies in carrying out the processes of the law; and
- to ensure that radio station operators comply with national and international statutory and regulatory requirements.

Monitoring section

In the management of the frequency spectrum, the monitoring section has two basic responsibilities. One is to provide statistical information of a technical and operational nature on spectrum occupancy. The second is to obtain information for regulatory and enforcement purposes on the operation of individual radio stations.

The monitoring section also performs an important function in establishing the locations and identities of stations causing interference. Monitoring station capabilities may be employed in certain circumstances for basic research of a limited nature. If fixed, mobile or portable monitoring stations are advantageously located, propagation characteristics over specific paths can be measured and correlated to known influencing factors to enable synthesis of propagation prediction tables. Monitoring centres may also contribute to the development of new measurement techniques.

According to its resources a country may wish to participate in the international monitoring system which exists to assist, to the extent practicable, in the implementation of the Radio Regulations, in particular to ensure efficient and economical use of the spectrum, and to help in the prompt elimination of harmful interference (see Article 20 of the Radio Regulations, and the CCIR Handbook for Monitoring Stations).

4.2.7 Computer Support

The extent to which computer support facilities are available to and used by the frequency management authority depends on the resources, priorities, and particular requirements of the country concerned. In the early stages of its introduction, computer support may be limited to, say, licensing records or the more complex engineering calculations; ultimately the Computer Support sub-unit may assume responsibility for the development, provision and maintenance of support facilities for nearly all spectrum management activities, including record keeping, forecasting, and financial management related to licensing.

The CCIR Handbook on Spectrum Management and Computer-Aided Techniques addresses the use of computers in this context in considerable depth.

### 4.3 TRAINING OF PERSONNEL

In considering the needs and the possibilities for providing training of personnel for frequency management, the conditions of training have to be seen in relation to the structure of the frequency management unit in the country.

Whatever the size of the frequency management unit, it is considered necessary to have at least one person with suitable technical professional qualifications who, in addition, has knowledge of the relevant national legislation and of the Radio Regulations.

In the case of small units junior staff will mainly be trained on the job, and such training may be supplemented by various other methods, for example:

- international and regional seminars organized by the IFRB or by administrations;
- exchange of staff with other countries;
- bilateral contacts with other countries in which problems are analysed and mutually acceptable solutions are sought;
- "hands-on" operational experience in user departments within the administration;
- handbooks, manuals or similar texts provided by the administration or by another administration or by international organizations or their organs (e.g. IFRB, CCIR);
- individual training in another country;
- individual training in the IFRB.

Several years of experience may be necessary before a national frequency manager can deal with all aspects of national and international regulations. It is therefore vital that such experience should not be lost through frequent changes of staff: to the extent possible, administrations should take the necessary steps to recruit and retain personnel having the required qualifications and experience.

Although considerable efforts are necessary for initial training of personnel for frequency management, it must be borne in mind that the development of both radio techniques and administrative procedures necessitates constant updating of knowledge, and training will therefore be an ongoing process.

The CCIR, through the work of IWP 1/5, is developing the use of audio-visual cassettes as a companion training tool to the Handbook for Monitoring Stations. These cassettes will be obtainable separately from the ITU to provide detailed training in such specialized subjects as visual identification of situations (emissions) and how to use a spectrum analyser for complex measurements.



Information on further training possibilities in international and national training centres may be obtained from the Technical Cooperation Department of the ITU.

### 4.4 SPECTRUM MANAGEMENT IMPLEMENTATION STRATEGY

During the development of a spectrum management capability a number of key subjects need to be addressed. By addressing these subjects, an administration can follow a step-by-step process that will help it in its planning activities. The set of steps described below is fairly comprehensive but not necessarily exhaustive.

- Take action to get spectrum management recognized as an essential element in the development of an administration's telecommunication policy. This will help to ensure that requests for resources are given appropriate priority and that the spectrum management unit is represented in the policy development activities of an administration.
- Identify and prioritize the functions that the spectrum management unit will carry out. Consideration should be given to both national and international needs resulting from national legislations or obligations under the Radio Regulations.
- Size the process, taking into account the specified functions and the time phasing of this introduction. This will aid in identifying the resources necessary for implementation.
- Develop a time-phased functional implementation plan that recognizes both national and international obligations. The plan would identify short-term as well as long-term goals towards which the spectrum management unit is directed.
- Upon completion of sizing of the planning process, consideration should be given to the subject of automation support and a time frame for its introduction. This should encompass both data base and records, keeping technical and engineering support of appropriate monitoring capabilities.
- Establish detailed plans leading to the specification of *software* needs and support *hardware*. It is important that data base management software needs and specific design capabilities be established prior to the specification and purchase of hardware.
- Document a comprehensive time-phased implementation process that will involve both functional and automation aspects of the spectrum management planning activities. This can be used as a master plan, as a means to secure necessary resources, and as a means to periodically update and revise an administration's plans.

By following these basic steps, an administration can proceed towards the development of a spectrum management unit that will meet its immediate needs, be compatible with its available resources, and provide a guide for future growth towards more comprehensive and sophisticated capabilities.

---



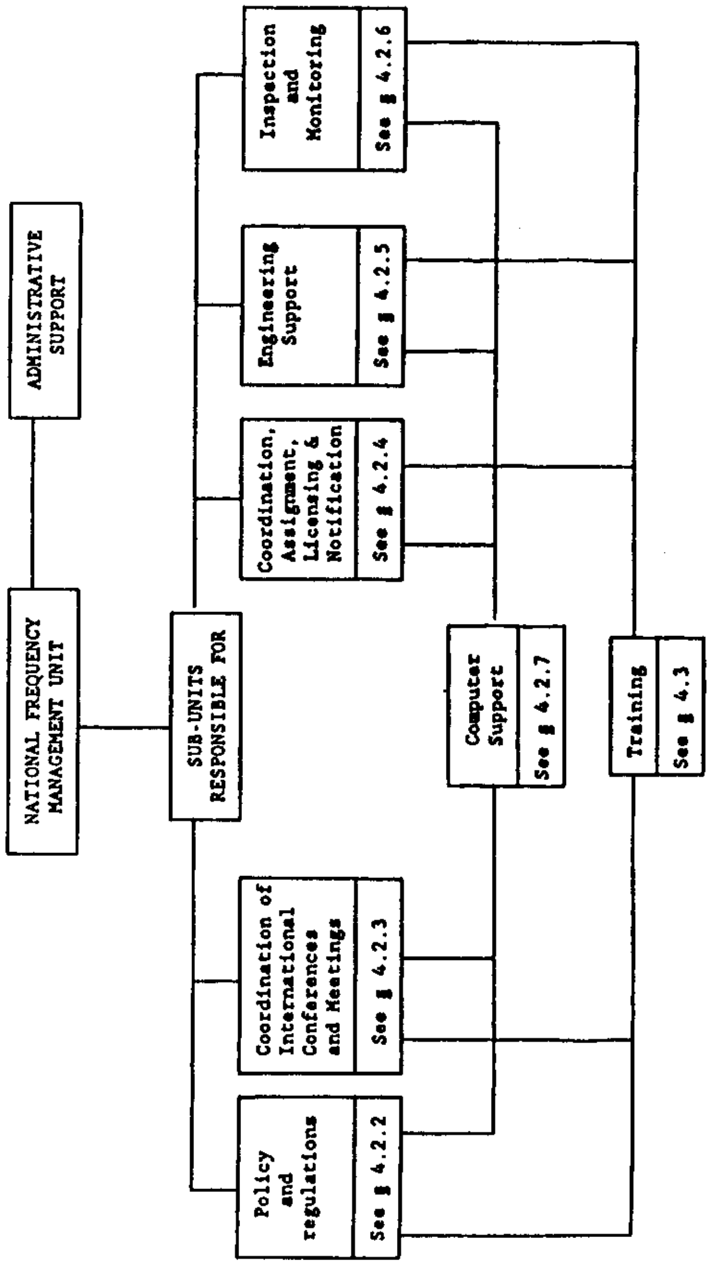



FIGURE 4.1

Sub-units in a national frequency management unit

## CHAPTER 5

## POTENTIAL SOURCES OF ASSISTANCE IN FREQUENCY MANAGEMENT MATTERS

As mentioned in section 4.3, personnel in a national frequency management unit need special training and experience suited to the prevailing conditions in the country. Since such training can only be provided in an active frequency management unit, administrations should encourage the staff concerned to approach their work with an innovative spirit, and seek external assistance only in cases which need an urgent solution.

The sources of assistance which an administration may find useful when such a need arises are described in the present Chapter.

The Chapter is divided into five sections, as follows:

5.1 - Assistance available from other administrations;

5.2 - Assistance available from the IFRB;

5.3 - Assistance available from the CCIR;

5.4 - Assistance available from the Technical Cooperation Department of the General Secretariat of the ITU;

5.5 - Assistance available from sources other than the ITU.

### 5.1 ASSISTANCE AVAILABLE FROM OTHER ADMINISTRATIONS

Discussions between administrations are helpful either in connection with the establishment and development of a frequency management unit, or in resolving particular problems of a technical or procedural nature in the operation of such a unit. Such discussions with neighbouring administrations might lead to bilateral or multilateral agreements which could simplify the treatment of any similar difficulties arising in the future (see also Article 7 of the Radio Regulations and RR1233). A short-term exchange of personnel between administrations can result in a mutual broadening of experience beneficial to both parties.

Several administrations have recently established formal training programmes in the fields of telecommunications and spectrum management. Others are under consideration in view of the demonstrated need for improved spectrum management on a global basis, and may be obtained directly from those administrations or via the Technical Cooperation Department of the ITU.

### 5.2 ASSISTANCE AVAILABLE FROM THE IFRB

#### 5.2.1 General

RR999 specifies that the functions of the IFRB shall include

"the provision of assistance to administrations in the field of radio spectrum utilization, in particular to those administrations in need of special assistance, and the recommendation to administrations, where appropriate, of adjustments in their frequency assignments in order to obtain a better use of the radio spectrum."

#### 5.2.2 Understanding the procedures of the Radio Regulations

In response to Resolution No. 6 of WARC-79 the IFRB has prepared the IFRB Handbook on Radio Regulatory Procedures. It is aimed at assisting administrations in the application of the procedures of the Radio Regulations. It contains many flowcharts which are to be inserted in the Radio Regulations as an aid to the understanding of the procedures.

#### 5.2.3 Application of procedures of the Radio Regulations

The IFRB's Technical Standards and the Rules of Procedure are developed in accordance with RR1001 and distributed to administrations in accordance with RR1001.1.

Many provisions of the Radio Regulations specify that if difficulties arise in connection with a particular procedure the Board may be requested to provide assistance in applying the procedure concerned or assistance of a technical nature.

In particular RR1218 provides for the Board to assist in the selection of a frequency assignment to a station in the fixed service between 3 and 27.5 MHz.

#### 5.2.4 Application of regional agreements

Certain regional agreements, such as the Regional LF/MF Broadcasting Agreement (Regions 1 and 3), Geneva, 1975, indicate assistance which may be provided by the IFRB in specified circumstances.

#### 5.2.5 Pre- and post-conference activities

RR1003 prescribes that the IFRB shall provide technical assistance in the preparation for and organization of radio conferences in consultation, as appropriate, with the other permanent organs of the Union.

To fulfil this obligation the Board prepares appropriate documentation. In order to assist administrations in implementing conference decisions, or in order to provide clarification and advice on the interpretation and application of the Radio Regulations, the Board issues IFRB Circular-letters when appropriate: these are distributed to all administrations.

#### 5.2.6 International monitoring

In accordance with RR1000 and RR1885 the IFRB records the results supplied by the monitoring stations participating in the international monitoring system, and periodically prepares summaries of the data it receives: the summaries are published by the Secretary-General and may be useful to a national frequency management unit in identifying less congested portions of the spectrum and/or sources of harmful interference. Special monitoring campaigns are initiated from time to time.

5.2.7 Cases of harmful interference

RR998 prescribes that at the request of one or more of the interested administrations the Board shall investigate cases of harmful interference and formulate recommendations with respect thereto: see Article 22 of the Radio Regulations, in particular RR1962-1966. The cases referred to the IFRB frequently include those in which communication between the administrations concerned is difficult: the IFRB acts as an intermediary in such cases, and tries to reach a satisfactory solution.

5.2.8 Training of personnel

RR1005 prescribes that at the request of an administration the Board shall provide assistance in the training of senior staff in the fields of spectrum management and utilization, particularly for those countries in special need: see section 4.3 in Chapter 4 of this booklet.

5.2.9 Publication of information of general interest

In compliance with the wishes of the first meeting on the development of national radio frequency management, from time to time the IFRB will arrange for publication in the ITU Telecommunication Journal of a short newsletter dealing with matters of interest to national frequency management authorities or units.

5.3 ASSISTANCE AVAILABLE FROM THE CCIR

5.3.1 Technical information

The main functions of the CCIR are listed in section 2.6. Administrations interested may find the information they need in existing CCIR texts (Recommendations, Reports, Handbooks and Documents).

The CCIR texts are published in the working languages of the ITU (English, French and Spanish). Relevant texts are contained in Volume I covering the activity of Study Group I, the CCIR Handbook on Spectrum Management and Computer-Aided Techniques and the CCIR Handbook for Monitoring Stations. Texts concerning specific services are contained in other Volumes (see Bibliography).

The Handbook on Spectrum Management and Computer-Aided Techniques describes engineering analysis techniques required for spectrum management, including frequency files, computer applications, and examples of automated aids for spectrum management. Examples are given of spectrum optimization techniques as well as indications where the data elements described in the Handbook are applied in the Radio Regulations.

The annexes contain a listing of frequency data files, computer models and data base management systems. There is a catalogue of data files and computer programs in use by various administrations and the ITU, with short descriptions.



The CCIR Handbook for Monitoring Stations describes, inter alia, various procedures and techniques used in monitoring stations. New subjects cover monitoring of the emissions from space stations and the use of computer techniques.

The publications entitled "CCIR Antenna Diagrams" (1978 and 1984) offer comprehensive information about various high frequency directional antennas, including technical and economic aspects.

5.3.2 Computer programs

There are computer programs available for carrying out technical calculations. One of them (NOISEY) predicts noise power and field strength at any frequency above 10 kHz for any geographic location and time, based on CCIR Reports 322 and 258. Programs WOMAP and MUFFY perform computations connected with ionospheric propagation. A package of antenna programs is dedicated to the calculation of the radiation pattern of a series of antennas of different types, from a single dipole to complex curtain antennas over imperfect ground.

The computer programs offered by various administrations and listed in the CCIR Handbook on Spectrum Management and Computer-Aided Techniques are being examined for their correctness, adequacy of documentation and program portability. It is expected that these programs will be made available through the CCIR when this examination has been completed.

The Telecommunication Journal publishes the information about computer software available through the CCIR. It is uneconomic to develop computer programs for radio-frequency management if they have been developed elsewhere. CCIR Resolution No. 88 invites administrations and other participants to exchange their own programs through the CCIR secretariat.

By submitting software for distribution under Resolution No. 88, the submitter grants permission to use the software free of charge. The submitted software and all subsequent copies (but not the physical media on which it is recorded) remain the property of the original submitter. The software (and documentation) is provided "as is", and some modifications may be required before the software can be utilized with specific computer hardware. Neither the submitter nor the CCIR makes any warranty or assurance as to its performance, and no liability is accepted for the content or applicability of the software and documentation, the results of using them, or their support and maintenance. The entire risk must be assumed by the user. The dissemination of the software by the CCIR secretariat does not imply any form of endorsement or recommendation. The CCIR secretariat copies the software (together with the accompanying documentation) at the request of interested parties and distributes it free of charge (except for the cost of material, processing, handling and postage), without necessarily reviewing it. In accordance with Resolution No. 88, CCIR Study Group 1, IWP 1/2 examines its portability, adequacy of documentation and correctness, and the results are published separately.

### 5.3.3 Studies of technical problems

If a specific problem of an administration is not covered by the existing CCIR texts, the administration may propose a special question, according to the provisions of No. 327 of the Convention. If the proposal is supported by at least twenty administrations the necessary studies are carried out by one of the CCIR Study Groups and the results are published as a CCIR text. The most detailed source of information on current studies carried out flows at the level of CCIR Working Parties and CCIR Study Groups, and thus active participation in their work is most beneficial for all those interested.

## 5.4 ASSISTANCE AVAILABLE FROM THE TECHNICAL COOPERATION DEPARTMENT OF THE GENERAL SECRETARIAT OF THE ITU

Within the framework of the United Nations Development Programme (UNDP), assistance can be provided to developing countries.

Generally, this type of assistance consists of the provision of a frequency management expert, who can take up an assignment for an appropriate period in the requesting country in order to assist the administration in any matters related to frequency management and monitoring. Alternatively, or in addition, fellowships can be granted to staff members of the requesting administration. These are usually arranged in the frequency management and monitoring services of other member administrations.

As a regular activity of the ITU and in accordance with Resolution No. 22 of the Convention (Nairobi, 1982), the ITU can also provide specialist advice and short missions of up to four weeks by specialists to assist the requesting administration on specific problems in the field of frequency management and monitoring.

## 5.5 ASSISTANCE AVAILABLE FROM SOURCES OTHER THAN THE ITU

An administration may be able to obtain assistance in the context of frequency management from several sources outside the ITU. A few of these sources are mentioned in this section.

### 5.5.1 Assistance from handbooks or works of reference

Handbooks, conference proceedings, manuals, or other works of reference are helpful sources of information which can range from the very general to the extremely detailed in both subject matter and treatment.

The bibliography presented at the end of this booklet may serve as a starting point for study, which might be augmented by text books appropriate to the subject concerned, be it technical (in the context of radio engineering) or administrative (in the context of business management). It may be noted that several of the sources listed in the bibliography contain further references to allied subject matter.

Handbooks or manuals produced by certain countries for their own use may be made available to other countries.



### 5.5.2 Assistance in radio matters from other specialized organizations

Although not directly concerned with frequency management activities as discussed in this booklet, assistance in the field of radiocommunication may be derived from discussions with, or the documents of, such organizations as the CISPR, *ICAO*, IEC, *IMO* and *ISO*, as well as from radio equipment manufacturers, suppliers, or *R & D* organizations.

Regional and multinational organizations such as *ATU*, *EBU*, *IEE*, *IEEE* and *URSI* offer seminars and technical forums from time to time for examination of new techniques and on new strategies applicable to frequency management on all levels, from the most simple to the most complex.

## BIBLIOGRAPHY

### ITU REFERENCE DOCUMENTS FOR NATIONAL FREQUENCY MANAGEMENT

The bibliography contains a list of texts which administrations may find useful when establishing or developing a national frequency management unit.

Items carrying the comment "Basic reference" are considered to be essential documents which should be available within the unit for consultation.

| Documents | Comments |
| --- | --- |
| International Telecommunication Convention, Nairobi, 1982 | Basic reference |
| Radio Regulations, Geneva, 1979, edition of 1982, revised 1988 (together with Appendices 26 and 27 Aer2 which are published separately) | Basic reference |
| Regional Agreements applicable to specific services, frequency bands and countries concerned (e.g. Regional MF Broadcasting Agreements, Geneva, 1975 (for Regions 1 and 3), and Rio de Janeiro, 1981 (for Region 2)) | Basic references |
| Texts of the CCIR as adopted by its most recent Plenary Assembly | Basic references |
| VOLUME I | Spectrum utilization and monitoring (Study Group 1) |
| VOLUME II | Space research and radioastronomy (Study Group 2) |
| VOLUME III | Fixed service at frequencies below about 30 MHz (Study Group 3) |
| VOLUME IV-1 | Fixed-satellite service (Study Group 4) |
| VOLUME IV/IX-2 | Frequency sharing and coordination between systems in the fixed-satellite service and radio-relay systems (Study Groups 4 and 9) |
| VOLUME V | Propagation in non-ionized media (Study Group 5) |
| VOLUME VI | Propagation in ionized media (Study Group 6) |
| VOLUME VII | Standard frequencies and time signal services (Study Group 7) |
| VOLUME VIII-1 | Land mobile service (terrestrial) (Study Group 8) |
| VOLUME VIII-2 | Maritime mobile service (terrestrial), amateur and amateur satellite service (Study Group 8) |
| VOLUME VIII-3 | All mobile satellite services and aeronautical mobile service (terrestrial) (Study Group 8) |
| VOLUME IX-1 | Fixed service using radio-relay systems (Study Group 9) |
| VOLUME X-1 | Broadcasting service (sound) (Study Group 10) |
| VOLUME X/XI-2 | Broadcasting-satellite service (sound and television) (Study Groups 10 and 11) |
| VOLUME X/XI-3 | Recording (sound and television) (Study Groups 10 and 11) |
| VOLUME XI-1 | Broadcasting service (television) (Study Group 11) |
| VOLUME XII | Transmission of sound broadcasting and television signals over long distances (CMTT) |
| VOLUME XIII | Vocabulary (CMV) |

| Documents | Comments |
|---|---|
| Supplement to CCIR Report 252-2 | Second CCIR computer-based interim method for estimating sky-wave field strength and transmission loss at frequencies between 2 and 30 MHz |
| CCIR Report 322-3 | Characteristics and application of atmosphere radio noise data |
| The International Frequency List (IFL) | Basic reference: the IFL is List I of the Service Documents - see Appendix 9 to the Radio Regulations |
| The weekly Circular (of the IFRB) | Basic reference: see RR1455, RR1456 and RR1583 |
| Service Documents other than List I | Selected according to requirements: see Appendix 9 to the Radio Regulations |
| IFRB Handbook on recommended techniques for better utilization and reduction of congestion of the high frequency radio spectrum (1973) | - |
| IFRB Handbook on Radio Regulatory Procedures | Handbook (2 volumes) published in 1984 with subsequent revisions |
| CCIR Handbook on Spectrum Management and Computer-Aided Techniques | Latest version published in 1987: includes many references to CCIR and other published texts |
| CCIR Handbook for Monitoring Stations | Handbook published in 1968 and at present under revision |
| CCIR Antenna Diagrams (1978 and 1984) | - |
| CCIR Handbook on Broadcasting-Satellite Systems, Geneva, 1983 | - |
| CCIR Handbook on Satellite Communications (fixed-satellite service), Geneva, 1985 | - |
| IFRB Circular-letters | Basic references, issued when appropriate: contain information on particular matters relating to frequency management. |



| Documents | Comments |
|---|---|
| Economic and Technical Impact of Implementing a Regional Satellite Network, GAS 8, CCITT, Geneva, 1983 | - |
| Documents of the first and second meetings on the development of national radio frequency management, Geneva (24 to 28 October 1983/8 to 11 September 1987) (Note 1) | - |
| Documents of the regular IFRB Seminar on frequency management and the use of the radio frequency spectrum and the geostationary-satellite orbit - Geneva, 4 to 11 March 1988 (or later versions thereof) (Note 1) | - |
| Documents on frequency management matters of ICAO, IMO, INTELSAT, INTERSPUTNIK and similar international organizations | - |

Note 1 - Several of the documents referred to mention further reference material.

## ANNEX

## GLOSSARY OF TERMS

This glossary explains terms which are used in this booklet and often encountered in the field of frequency management. Terms defined in Article 1 of the Radio Regulations have been so identified.

| | |
|---|---|
| Administration | Any governmental department or service responsible for discharging the obligations undertaken in the Convention of the International Telecommunication Union and the Regulations (RR3). |
| Allocation (of a frequency band) | Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services or the radio astronomy service under specified conditions. This term shall also be applied to the frequency band concerned (RR17). |
| Allotment (of a radio frequency or radio-frequency channel) | Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space radiocommunication service in one or more identified countries or geographical areas and under specified conditions (RR18). |
| Assigned frequency | The centre of the frequency band assigned to a station (RR142). |
| Assigned frequency band | The frequency band within which the emission of a station is authorized; the width of the band equals the necessary bandwidth plus twice the absolute value of the frequency tolerance. Where space stations are concerned, the assigned frequency band includes twice the maximum Doppler shift that may occur in relation to any point of the Earth's surface (RR141). |
| Assignment (of a radio frequency or radio-frequency channel) | Authorization given by an administration for a radio station to use a radio frequency or radio-frequency channel under specified conditions (RR19). |
| ATU | Arab Telecommunications Union |
| CCIR | International Radio Consultative Committee |
| CCITT | International Telegraph and Telephone Consultative Committee |
| CISPR | International Special Committee on Radio Interference (this Committee works under the IEC). |
| e.i.r.p. | Equivalent isotropically radiated power; the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain) (RR155). |
| Electromagnetic compatibility (EMC) | EMC is the condition which prevails when telecommunications equipment is performing its individually designed function in a common electromagnetic environment without causing or suffering unacceptable degradation due to unintentional electromagnetic interference to or from other equipment in the same environment. |
| EBU | European Broadcasting Union |
| Frequency tolerance | The maximum permissible departure by the centre frequency of the frequency band occupied by an emission from the assigned frequency, or by the characteristic frequency of an emission from the reference frequency. The frequency tolerance is expressed in parts per million or in hertz (RR145). |
| Hardware | Physical equipment used in data processing as opposed to computer programs, procedures, rules and associated documentation. |
| Harmful interference | Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with the Radio Regulations (RR163). |
| HF | High-frequency (decametric waves) (see RR208). |
| ICAO | International Civil Aviation Organization |

| | |
|---|---|
| IEC | International Electro-technical Commission |
| IEE | Institution of Electrical Engineers |
| IEEE | Institute of Electrical and Electronics Engineers |
| IFL | International Frequency List |
| IFRB | International Frequency Registration Board |
| IMO | International Maritime Organization |
| ISO | International Organization for Standardization |
| Industrial, Scientific and Medical (ISM) Applications (of radio frequency energy) | Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications (RR16). |
| Interference | The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy (RR160 - see "Harmful interference", above). |
| MF | Medium frequency (hectometric waves) (see RR208). |
| MIFR | Master International Frequency Register. |
| Necessary bandwidth | For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions (RR146). |
| pfd | Power flux-density. |
| Protection ratio | The minimum value of the wanted-to-unwanted signal ratio, usually expressed in decibels, at the receiver input determined under specified conditions such that a specified reception quality of the wanted signal is achieved at the receiver output (RR164). |



| | |
|---|---|
| R & D | Research and development. |
| Radio astronomy | Astronomy based on the reception of radio waves of cosmic origin (RR14). |
| Radiocommunication | Telecommunication by means of radio waves (RR7). |
| Radiocommunication service | A service as defined in Section III of Article 1 of the Radio Regulations involving the transmission, emission and/or reception of radio waves for specific telecommunication purposes (RR20).<br>In the Radio Regulations, unless otherwise stated, any radiocommunication service relates to terrestrial radiocommunication. |
| Radio waves or Hertzian waves | Electromagnetic waves of frequencies arbitrarily lower than 3 000 GHz, propagated in space without artificial guide (RR6). |
| RR... | Reference to a provision of the Radio Regulations. |
| SHF | Super high frequency (centimetric waves) (see RR208). |
| S/I | Signal-to-interference ratio. |
| S/N | Signal-to-noise ratio. |
| Software | Computer programs, procedures, rules and any associated documentation concerned with the operation of a data processing system. |
| Space radiocommunication | Any radiocommunication involving the use of one or more space stations or the use of one or more reflecting satellites or other objects in space (RR9). |
| Spurious emission | Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions (RR139). |

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

Part 5

# SPECTRUM MANAGEMENT DATA

R.G. Struzak
International Telecommunication Union, International Radio Consultatiuve Committee
Geneva, Switzerland

The purpose of these notes is to provide an information on the standard spectrum management data. [Source: CCIR Handbook for Spectrum Management and Computer-aided Techniques, Annex IV & V]

# ANNEX IV

## SPECTRUM MANAGEMENT DATA TABLES

**1.** Tables A IV-I to A IV-V were prepared as inventories of data elements which should be used during a data-analysis phase to design and implement an automated inter- and intra-administration spectrum management system. These inventories were compiled during studies carried out by CCIR Interim Working Party (IWP) 1/2 in conjunction with the IFRB.

**2.** It is essential that spectrum management data for intra-administrations use comply with the following requirements:

2.1 the data should contain, as a minimum, the "Basic" data required for National Spectrum Management and notification to the IFRB;

2.2 the sub-set of data used for IFRB notification purposes should be compatible with IFRB data record and data element specifications.

**3.** Tables A IV-I, A IV-II and A IV-IV describe data element characteristics and specify whether the data is Basic or Optional. Basic data is required for National Spectrum Management. The frequency assignment and notification data in Table A IV-II is the primary data that should be stored by all administrations and represents about 80% of the data required for a typical administration. In the 1st Edition of this Handbook, Table A IV-II listed 31 fields of Basic data. The data in Table A IV-II of this Annex has been reviewed by the IFRB and aligned with their latest data specification. This alignment has increased the number of Basic data elements to 63.

Some administrations have indicated that this increase results in a large requirement for storage of frequency assignment data. A number of administrations only maintain approximately ten data elements with their present manual system. A change from a ten-element system to a system that requires 63 elements is difficult to practically implement. Most of the 63 elements of data are, however, required for international coordination and most are also required in a national data file. It is, therefore, recommended that every attempt be made to create a data base with as many of the 63 Basic data elements as possible that is consistent with the past history and policy of the administration and proposed administration plans. The Basic data elements in Table A IV-II will be further examined in the future by the CCIR to determine if a particular subset of the 63 elements can be recommended for a particular spectrum management application.

**4.** The International Frequency Register (IFR) "stored format" column of Table A IV-II uses a COBOL picture format to describe its structure. This column represents the format of the particular element as distributed by the IFRB on the magnetic tape version of the International Frequency List (IFL). It should be noted that some numeric fields are actually stored on the tape in COMP-3 format. For those administrations wishing to read the IFL tape it is recommended that the latest copy of "Structure and content of the MRF on tape", Reference PM-60-20, Serial No. 01232, be obtained from the ITU in Geneva.

**5.** The latest version of the Preface to the IFL does not contain Tables 1E1 and 4G1. They are consequently included as Table A IV-VI and Table A IV-VII.

# ANNEX IV

TABLE AIV-I – *Frequency allocation data*

| No. | Data element | Origin: Article 5 | Origin: Derived | Number of characters (A + B.C)(1): A | Number of characters (A + B.C)(1): B.C | Definitions | Basic data required for most applications | Optional data required for specific applications |
|---|---|---|---|---|---|---|---|---|
| 1 | Lower band limit | x | | 1 | 9.4 | The lower limit of the band being allocated.<br>The first character indicates the units:<br>K: kHz<br>M: MHz<br>G: GHz | x | |
| 2 | Upper band limit | x | | 1 | 9.4 | The upper limit of the band being allocated.<br>The first character indicates the units:<br>K: kHz<br>M: MHz<br>G: GHz | x | |
| 3 | Service | x | | 30 | | The name of the service being allocated.<br>(Code still to be established) | x | |
| 4 | Category of service | | x | 10 | | The category of the service being allocated.<br>(Code still to be established) | x | |
| 5 | Function | | x | 40 | | The name of a function within the service to which the band is allocated | x | |
| 6 | Allocation footnotes | x | | | 30.0 | The footnote number that allocates the service to the band. More than one footnote can be entered in the field by separating each footnote with a space | | x |
| 7 | Other footnotes | x | | | 30.0 | The footnote number that restricts the use of the service. More than one footnote can be entered in the field by separating each footnote with a space | | x |
| 8 | Class of station | | x | 30 | | Indicates the class of station permitted by the allocation using the symbols shown in Appendix 10 of the ITU Radio Regulations. More than one class of station can be entered separating each class of station by a space | | x |
| 9 | ITU Region | x | | | 3.0 | Indicates the ITU Region in which the service is allocated. Suggested length is three characters. A1 in character position 1 indicates that the service is allocated in Region 1. A2 in character position 2 indicates that the service is allocated in Region 2. A3 in character position 3 indicates that the service is allocated in Region 3 | x | |

(1) A + B.C
A: number of alphanumeric characters.
B: total number of numeric characters.
C: number of decimal characters.

TABLE A IV-II – *Frequency assignment and notification data*

| No. | Data element | Number of characters (A + B.C) (1) A | Number of characters (A + B.C) (1) B.C | Definitions | Basic data required for most applications (2) | Optional data required for specific applications | IFR stored format (3) |
|---|---|---|---|---|---|---|---|
| 1. | *Characteristics concerning the frequency and its use* | | | | | | |
| 1.1 | Frequency:<br>Assigned frequency *or* lower assigned frequency of a frequency pair *or* lower limit of an assigned frequency band | 1 | 10.5 | The first character indicates the unit:<br>K: kHz 9 kHz ⩽ *f* ⩽ 28 000 kHz in kHz<br>M: MHz 28 MHz < *f* ⩽ 10 500 MHz in MHz<br>G: GHz 10.5 GHz < *f* upwards in GHz<br>(see Radio Regulations, Appendix 1, Column 1).<br>If in data element 1.2, "Nature of frequency usage" S, O, D or U is given, the assigned frequency (RR 142) is to be indicated; if P is given, the lower assigned frequency is to be indicated; and if R is given the lower limit of the assigned frequency band (RR 141) is to be indicated<br>*Note.* – In computer files letter G (Giga) is stored as U for sorting purposes | 1A | | X9(5)V9(5) |
| 1.2 | Nature of frequency usage | 1 | | Code, e.g.:<br>S: single frequency<br>P: frequency pair<br>G: group of synchronized frequencies<br>R: frequency band<br>U: frequency without offset carrier<br>O: frequency with offset carrier<br>D: frequency with precision offset carrier | | × | |
| 1.3 | Mode of operation<br>— | 1 | | Code, e.g.:<br>S: simplex operation<br>D: duplex operation<br>H: semi-duplex operation<br>B: broadcast transmission<br>M: broadcast transmission with synchronized transmitters (additional information on the network required) | | × | |

(1) A + B.C
- A: number of alphanumeric characters
- B: total number of numeric characters (excluding decimal point)
- C: number of decimal characters

(2) This column will contain the column No. from IFL where appropriate.

(3) The "IFR stored format" contains the COBOL picture describing IFL element where:
- X : alphanumeric
- 9 : numeric
- V : implied decimal point
- S : indicates a signed numeric value

Values in parentheses indicate the number of characters of the preceding character type.

(4)

| Column | Format | Column | Format |
|---|---|---|---|
| 13A1 | XX | 13B1 | X(4) |
| 13A2 | XX | 13B2 | X(4) |
| 13A3 | XX | 13B3 | X(11) |
| 13A4 | XX | 13B4 | YYYY MM DD |
| | | | YYYY MM DD |
| | | | YYYY MM DD |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.4 | Additional frequency information<br>Reference frequency *or* upper assigned frequency of a frequency pair *or* upper limit of an assigned frequency band | 1 | 10.5 | The first character indicates the unit:<br>K: kHz 9 kHz $\leqslant f \leqslant$ 28 000 kHz in kHz<br>M: MHz 28 MHz $< f \leqslant$ 10 500 MHz in MHz<br>G: GHz 10.5 GHz $< f$ upwards in GHz<br>(see Radio Regulations, Appendix 1, Column 1).<br>If in data element 1.2, "Nature of frequency usage" S, O, D or U is given, the assigned frequency (RR 142) is to be indicated; if P is given, the upper assigned frequency is to be indicated; and if R is given the upper limit of the assigned frequency band (RR 141) is to be indicated<br>*Note.* – In computer files letter G (Giga) is stored as U for sorting purposes | | × | X9(5)V9(5) |
| 1.4.1 | Preferred band | | 2.0 | Frequency band in MHz, for notification under RR 1218 only | 1C | | 99 |
| 1.4.2 | Assigned frequency band | | 8.1 | In kHz, needed for TV and space services only | 1D | | 9(7)V9 |
| 1.5 | Frequency channel number | 5 | | Channel number as listed in an agreement between administrations (see also data element 8.18) | | × | |
| 1.6 | Frequency offset:<br>vision carrier offset<br>sound carrier offset | 3 | | This is a basic element for TV broadcasting.<br>The first character defines the units used:<br>T: one-twelfth line<br>Z: one-tenth Hz<br>H: Hz<br>K: kHz<br>The remaining characters contain the offset value as an integer, with sign | 1E | | X(3) |
| 1.7 | Frequency stability | 1 | 6.0 | The first character defines the unit or the denominator of a fraction<br>M: one-millionth<br>H: Hz<br>K: kHz<br>The remaining characters contain the value or numerator of the fraction | | × | |
| 1.8 | Schedule of operation<br>– Duty cycle | 1 | | C: continuous operation during the hours of operation specified below<br>I: no continuous operation during the hours of operation without fixed programme times<br>S: no continuous operation during the hours of operation with fixed programme times<br>N: non-geostationary satellite system | | × | |
| | – Hours of operation either | 2 | 8.0 | First four digits indicate the UTC of the beginning of the usage, the next four digits indicate the end. The beginning of usage may be preceded by the letter "I" to indicate repetition of transmission | 10B | | 9(8) or X(2) |
| | or | | | If the format x (2) is used, the symbols can be HJ, HN or HT, HY (see Radio Regulations, Appendix 1, Column 10) | | | |
| | – Percentage of use | | 3.0 | Percentage of time of the hours of operation during which the frequency is used | | × | |

| No. | Data element | Number of characters (A + B.C) (¹) A | B.C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (¹) |
|---|---|---|---|---|---|---|---|
| 1.8 | *(continued)* | | | | | | |
| | – Seasonal periods | 3 | | Two letters indicating month or season:<br>JA January · JL July · ET Summer<br>FE February · AU August · HV Winter<br>MR March · SE September · EQ Equinox<br>AR April · OC October<br>MA May · NV November<br>JN June · DC December<br>immediately followed by a letter indicating the solar activity:<br>A : High<br>L : Low<br>M : Medium | 10C | | X(3) |
| 1.9 | Class of station | 2 | | Indicate the symbols for the class of station according to Appendix 10 of the Radio Regulations (see Radio Regulations, Appendix 1, Column 6 and Table 6A1 of the Preface to the IFL) | 6A | | XX |
| 1.10 | Nature of service | 2 | | Indicate the symbols for the nature of service according to Appendix 10 of the Radio Regulations and Table 6B1 of the Preface to the IFL | 6B | | XX |
| 1.10.1 | Experimental station | 2 | | EX: experimental station, otherwise blank | 6C | | XX |
| 1.11 | Function of the station | 1 | 3.0 | First character:<br>C: civil<br>M: military<br>Following three characters code e.g.:<br>1xx: air traffic control<br>100: local taxiing (ground movement)<br>101: aerodrome traffic<br>102: approach (radar)<br>103: procedural approach<br>...<br>2xx: airborne operations<br>...<br>3xx: special transmissions<br>etc. | | × | |

TABLE A IV-II – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.12 | User group | 1 | | Code, e.g.:<br>A: airborne navigation, airborne security<br>B: railways<br>C: corps diplomatique<br>...<br>G: military (internal usage)<br>etc. | | × | |
| 1.13 | Equipment mobility | 1 | | F: fixed, permanently installed<br>T: fixed during operation, but transportable<br>M: mobile but not portable, operation possible during movement<br>P: portable | | × | |
| 1.14 | Equipment platform | 1 | | Code, e.g.:<br>A: airborne<br>L: ground<br>R: on rivers, canals, lakes | | × | |
| 1.15 | Number of mobile stations with which communication is to be established | | 4.0 | Number | | × | |
| 2. | *Characteristics concerning transmitting station and transmitting site* | | | | | | |
| 2.1 | Identification number of transmitting site | | 6.0 | Number to be specified by the national administration | | × | |
| 2.2 | Name of transmitting station | 20 | | For mobile stations, indicate the service area (see Radio Regulations, Appendix 1, Column 4a and Table 4A1 of the Preface to the IFL) | 4A | | X(20) |
| 2.3 | Type of location or area | 1 | | C: community<br>A: airport<br>H: hill<br>P: port<br>R: river or canal<br>S: space station | | × | |
| 2.4 | Type of terrain | | 1.0 | Type of vegetation and built-up area, code e.g.:<br>1: area with high-rise buildings or high vegetation (> 20 m) in the immediate vicinity<br>2: area with medium height buildings or vegetation (5 to 20 m) in the immediate vicinity<br>...<br>5: area without any obstacle in a distance of 1000 m in the direction of the receiving or transmitting station | | × | |

| No. | Data element | Number of characters (A + B.C) (¹) A | B.C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (¹) |
|---|---|---|---|---|---|---|---|
| 2.5 | Terrain characteristics | | | | | | |
| | – azimuth | | 3.0 | | | × | |
| | – $\Delta h$ parameter | | 4.0 | A parameter indicating the irregularity of the terrain in metres, as defined in CCIR Rec. 370 | | × | |
| | – effective height over the average level of the ground | | 5.1 | As defined in Rec. 370, in metres, for the azimuth of maximal radiation (This data element may be required for several azimuthal directions) | 9E | | S9(4)V9X |
| 2.6 | Country in which the transmitting station is located | 3 | | According to Column 4B of the IFL (see Radio Regulations, Appendix 1, Column 4b and Table B1 of the Preface to the IFL) | 4B | | X(3) |
| 2.7 | Longitude and latitude of transmitter site (degrees, minutes and seconds) | 15 | | The coordinates are to be indicated as follows:<br>(see Radio Regulations, Appendix 1, Column 4c)<br>3 characters: degrees longitude<br>1 character: E (East) or W (West)<br>2 characters: minutes longitude<br>2 characters: seconds longitude<br>2 characters: degrees latitude<br>1 character: N (North) or S (South)<br>2 characters: minutes latitude<br>2 characters: seconds latitude | 4C | | 9(3)X9(2)9(2)<br>9(2)X9(2)9(2) |
| 2.7.1 | Nominal radius of the transmitting area | | 5.0 | In km. This data element is used in association with data element 2.7 (coordinates of centre of circular area) | 4D | | 9(5) |
| 2.7.2 | Standard defined area of transmission | 20 | | Standard defined areas are given in Tables B1 and 4E1 of the Preface to the IFL | 4E | | X(20) |
| 2.7.3 | Ground conductivity code | | 1.0 | Codes for ground conductivity values are given in Table A IV-VII | 4G | | 9 |
| 2.8 | Height of the transmitter site above sea level | | 4.0 | Height in metres if negative, with minus sign | | × | |
| 2.9 | Call sign or other identification | 20 | | (see Preface to the IFL) | 3A | | X(20) |
| 2.10 | Space station type or utilization | 6 | | A group of symbols as given in Table 3B1 of the Preface to the IFL required for space stations only: first letter indicates the celestial body with principal gravitational influence; second letter, type of orbit; third letter, type of transponder; two figures, number of space stations; last letter, type of station with which there is communication | 3B | | X(3)99X |

TABLE A IV-II – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.10.1 | Information on the orbit and the space station | | | | | | |
| | – Nominal longitude of station | 1 | 5.2 | E – East; W – West (in degrees) | 5G | | 9(3)V99X |
| | – Longitude tolerance (West) | 1 | 3.2 | in degrees W – West | 5H | | 9V99X9V99X |
| | – Longitude tolerance (East) | 1 | 3.2 | in degrees E – East | | | |
| | – Inclination excursion of geostationary-satellite orbit | | 3.2 | in degrees | 5I | | 9V99 |
| | – Visibility arc (West) | 1 | 3.0 | E – East; W – West (in degrees) | 5J | | 9(3)X9(3)X |
| | – Visibility arc (East) | 1 | 3.0 | This visibility arc should always be given "from West to East". | | | |
| | – Service arc (West) | 1 | 3.0 | E – East; W – West (in degrees) | 5K | | 9(3)X9(3)X |
| | – Service arc (East) | 1 | 3.0 | | | | |
| | – Inclination angle of non-geostationary orbit | | 4.2 | in degrees | 5I | | 99V99 |
| | – Period of satellite | 1 | 5.0 | Enter D if period is in days and hours<br>Enter H if period is in hours and minutes | 5Q | | 9(3)X99 |
| | – Altitude of the apogee | | 7.0 | in km | 5R | | 9(7) |
| | – Altitude of the perigee | | 7.0 | in km | 5S | | 9(7) |
| 3. | *Characteristics concerning transmitting equipment* | | | | | | |
| 3.1 | Code number of transmitting equipment | 10 | | Number to be specified by the national administration | | × | |
| 3.2 | Designation of emission | 9 | | The first 4 characters indicate the necessary bandwidth as defined in RR 271-273.<br>The following 5 characters indicate the class of emission as a set of characteristics conforming to RR 269 | 7A | | X(9) |
| 3.2.1 | Class of operation | 1 | | Indicates the relative importance of the assignment.<br>Used only for HF fixed service, MF broadcasting and astronomy services. See Table 7B1 of the Preface to the IFL | 7B | | × |
| 3.3 | Designation of TV system | 2 | | Code as given in Tables 7C1 and 7C2 of the Preface to the IFL | 7C | | ×× |
| 3.4 | Maximum authorized radiated power in the direction of maximum radiation | 2 | 4.1 | First character: type of power:<br>C: carrier power<br>D: effective radiated carrier power<br>M: average power<br>N: effective radiated average power<br>P: peak envelope power<br>Q: effective radiated peak envelope power<br>R: equivalent isotropically radiated power<br>S: maximum power averaged over any 4 kHz delivered to the antenna<br>T: maximum power averaged over any 1 MHz delivered to the antenna | | | |

| No. | Data element | Number of characters (A + B,C) (¹) A | B,C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (¹) |
|---|---|---|---|---|---|---|---|
| 3.4 | *(Cont.)* | | | Second character: unit<br>U: microwatt<br>L: milliwatt<br>W: watt<br>K: kilowatt<br>M: megawatt<br>G: gigawatt<br>Remaining characters: value of authorized radiated power<br>For TV give vision e.r.p. Sound e.r.p.: in % of vision e.r.p. | | × | |
| 3.5 | Power designation | 1 | | X, Y or Z. This column does not appear in the weekly circular or in the IFL: however a symbol indicating the type of power recorded as peak envelope power (RR 151 – symbol X), mean power (RR 152 – symbol Y), or carrier power (RR 153 – symbol Z) is printed to the left of the value appearing in Columns 8A and/or 8B, as appropriate | 8 | | × |
| 3.5.1 | Power delivered to the antenna | | 3.1 | dBW | 8A | | S99V9 |
| 3.5.2 | Radiated power | 1 | 4.1 | Radiated power, in direction of maximum radiation, in dBW, followed by symbol X where:<br>X = E: effective radiated power (e.r.p.)<br>X = I: equivalent isotropically radiated power (e.i.r.p.)<br>X = V: effective monopole-radiated power (e.m.r.p.) | 8B | | S999V9X |
| 3.5.3 | Maximum power spectral density | | 3.1 | in dB (W/Hz) | 8C | | S99V9 |
| 3.6 | Pulse width | | 3.0 | First character: unit<br>N: nanoseconds<br>U: microseconds<br>L: milliseconds<br>Following characters: value | | × | |
| 3.7 | Pulse repetition frequency | 1 | 4.0 | First character: unit<br>H: Hz<br>K: kHz<br>Following characters: value | | × | |

TABLE A IV-II – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4. | ***Characteristics concerning transmitting antennas*** | | | | | | |
| 4.1 | Code number of transmitting antenna | | 6.0 | Code to be established by the national administration | | × | |
| 4.2 | Height of transmitting antenna above ground | 1 | 5.1 | Last character: height measured at:<br>– H for physical height,<br>– E for equivalent (effective) height,<br>– S for altitude above sea level | 9E | | S9(4)V9X |
| 4.2.1 | Electrical height of antenna | | 4.1 | In degrees with one decimal position. Only used for MF broadcasting in Region 2 | | 9F | 9(3)V9 |
| 4.3 | Type of transmitting antenna | | 3.0 | Code, e.g.:<br>01: dipole<br>02: half-wave dipole<br>03: full-wave dipole<br>...<br>73: horn<br>...<br>80: phase-corrected horn<br>etc.<br>See also Column 9J of the Preface to the IFL | | × | |
| 4.4 | Polarization of transmitting antenna | 5 | | Code as given in Table 9D1 of the Preface to the IFL | 9D | | X(5) |
| 4.5 | Characteristics of transmitting antenna | 1 | | N: non directional<br>D: directional<br>X: special antenna (terrestrial)<br>Frame of reference for space station antenna pattern:<br>G: antenna pointing defined relative to a right cartesian coordinate system centred on the centre of mass of the spacecraft, and in which the y-axis is parallel to the instantaneous direction of motion of the spacecraft along its orbit, and the z-axis is the line joining the spacecraft centre of mass to the geocentre<br>P: antenna pointing defined in a right cartesian coordinate system using the nominal aim point of the antenna on the Earth. It is centred on the centre of mass of the spacecraft, and the y-axis lies in the plane of the orbit, the positive direction being in the resolved direction of motion of the spacecraft. The z-axis is the line joining the centre of mass of the spacecraft to the nominal aim point | | × | |
| 4.6 | Special transmitting antenna pattern. Coordinated and/or in use | 1 | | If X is indicated, the pattern cannot be fully described in data elements 4.7 to 4.15. In such cases, separate sheets are required | | × | |

| No. | Data element | Number of characters (A + B.C) (¹) A | Number of characters (A + B.C) (¹) B.C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (³) |
|---|---|---|---|---|---|---|---|
| 4.7 | Pointing of spacecraft antenna | 2 | 7.2 | Two parameters to be used<br>For option "G": the angle between the nominal pointing direction and the z-axis; the angle between the y-axis and the projection of the nominal pointing direction onto the x-y plane, measured anti-clockwise from the positive y-axis when viewing along the z-axis.<br>For option "P", the longitude and latitude of the nominal pointing position on the Earth, specified as follows:<br>degrees longitude (to one decimal place)<br>7 characters: E (East) or W (West)<br>degrees latitude (to one decimal place)<br>7 characters: N (North) or S (South) | 5V | × | 9(3)V9X99V9X |
| 4.7.1 | Orientation of spacecraft antenna | | 7.0 | In a plane normal to the antenna boresight, the angle between a reference line and the intersection of that plane with the y-z plane. The angle is measured counter-clockwise from the intersection line taken in the positive y-direction when viewing in the direction of the boresight, preferably $180° \geq \varphi > -180°$. Orientation of all antenna polar diagrams will be given relative to this reference line (Degrees + minutes + seconds = 7 characters) (see Fig. A IV-1) | | × | |
| 4.7.2 | Name of transmitting satellite beam | 3 | | Only for geostationary space stations | 4F | | X(3) |
| 4.8 | Pointing accuracy of antennas | | 3.2 | In degrees. Relevant only for a space station on board a geostationary satellite | 5L | | 9V99 |
| 4.9 | Azimuth of maximum radiation or non-directional | 2 | 4.1 | In degrees with one decimal position. Note that for non-directional antennas, the IFRB stores the symbol ND in this field | 9A | | 999V9<br>or<br>×× |
| 4.9.1 | Sector of azimuths | | 2.(4.1) | An azimuth or an azimuthal sector defined by two limits, in which the antenna gain, the radiated power, the effective antenna height or the radiation may have specific values. For earth stations operating with non-geostationary satellites, this column contains the planned range of operating azimuthal angles (in degrees) clockwise from True North of the earth station. For earth stations operating with geostationary satellites, this column contains the azimuthal angles corresponding to the station keeping tolerance of the geostationary satellite concerned | 9H | | 999V9<br>999V9 |
| 4.9.2 | Radiation in sector of azimuth | 1 | 8.1 | In dBW. Used to indicate the maximum allowed value of apparent radiated power in a given sector of azimuth (data element 4.9.1). Usually given in a table of two or more columns. Note the character stored is always D to indicate dBW. See also Table 9-1 of the Preface to the IFL | 9I | | S9(7)V9X |

TABLE A IV-II – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4.10 | Horizontal beamwidth | 1 | 5.2 | In degrees with two decimal positions, preceded sometimes by a letter or an asterisk:<br>– H corresponds to a 6 dB aperture,<br>– * corresponds to a 3 dB aperture (IFRB).<br>If the first position is blank it corresponds to a 3 dB aperture notified by the administration | 9C | | X9(3)V99 |
| 4.11 | Elevation angle of the main lobe | | 3.1 | In degrees with one decimal position, preceded by the sign + or –.<br>Reference: horizontal plane | 9B | | S99V9 |
| 4.12 | Vertical beamwidth | 1 | 5.2 | In degrees with two decimal positions, preceded sometimes by a letter or an asterisk:<br>– H corresponds to a 6 dB aperture,<br>– * corresponds to a 3 dB aperture (IFRB).<br>If the first position is blank it corresponds to a 3 dB aperture notified by the administration | | × | |
| 4.13 | Front-to-back ratio of the antenna | | 3.1 | In dB | | × | |
| 4.14 | Gain of transmitting antenna | 1 | 3.1 | In dB. A group of figures preceded by the + or – sign and followed by a symbol indicating the type of gain:<br>– I for isotropic gain ($G_i$)<br>– V for gain relative to a short vertical antenna ($G_v$)<br>– D for gain relative to a half wave dipole ($G_d$)<br>(I, V, D: See RR 154) | 9G | | S99V9X |
| 4.15 | Transmission line attenuation | | 3.1 | In dB. Attenuation loss between antenna and transmitter | | × | |
| 4.16 | Scanning motion method | | 1.0 | Code to be established | | × | |
| 4.17 | Type of scan | | 1.0 | Code to be established | | × | |
| 4.18 | Scans per minute | | 4.0 | Number of scanning cycles per minute | | × | |
| 4.19 | Antenna rotations per minute | | 3.0 | Rotations per minute | | × | |
| 4.20 | Circuit or programme number | | 5.0 | If required, radio circuit designation or programme number (e.g. TV programme) | | × | |
| 4.21 | Space station antenna polar gain diagram relative to peak gain | | 80.0 | First record: Two characters:<br>First character<br>C: co-polar diagram<br>X: cross-polar diagram<br>Second character as in 4.4<br>Second record: Six numbers:<br>$\theta_{max}$: maximum value of $\theta$<br>$\theta_{min}$: minimum value of $\theta$<br>$\Delta\theta$: increment in $\theta$<br>$\varphi_{max}$: maximum value of $\varphi$<br>$\varphi_{min}$: minimum value of $\varphi$<br>$\Delta$ : increment in $\varphi$<br>(Six numbers: See Fig. A IV-1) | | × | |

TABLE A IV-II – *(continued)*

| No. | Data element | Number of characters (A + B.C) (¹) A | Number of characters (A + B.C) (¹) B.C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (³) |
|---|---|---|---|---|---|---|---|
| 4.21 | *(Cont.)* | | | [6 × (degrees + minutes) = 30 characters]<br>θ: angle off boresight of a given direction<br>φ: orientation of that direction measured in a plane normal to the boresight counter-clockwise (180° > θ, φ > −180°)<br>Subsequent records: each record contains 10 values of antenna gain relative to peak gain, loss being measured positively in decibels. The values are ordered in terms of θ and φ with the order: $(\varphi_{min}, \theta_{min}), (\varphi_{min}, \theta_{min} + \Delta\theta), \ldots (\varphi_{min}, \theta_{max}), (\varphi_{min} + \Delta\varphi, \theta_{min}), \ldots (\varphi_{max}, \theta_{max})$<br>The resolutions and ranges of θ and φ should be chosen such that linear interpolation of an antenna polar diagram between the given points shall be sufficiently accurate for coordination studies.<br>Per record: 10 × 8.3 ≃ 80 characters | | | |
| 5. | ***Characteristics concerning receiving station and station site*** | | | | | | |
| 5.1 | Identification number of receiver site or receiving area | | 6.0 | Number to be specified by the national administration | | × | |
| 5.2 | Name of the receiving station or name of space station or satellite | 20 | | According to Column 5A of the IFL. For mobile stations, indicate the service area (see Radio Regulations, Appendix 1, Column 5a and Table 4A1 of the Preface to the IFL) | 5A | | X(20) |
| 5.3 | Type of location or area | 1 | | Coding according to data element 2.3 | | × | |
| 5.4 | Type of terrain | | 1 | Coding according to data element 2.4 | | × | |
| 5.5 | Terrain characteristics | | | Coding according to data element 2.5 | | × | |
| 5.6 | Country in which the receiving station is located | 3 | | Coding according to Table B1 of the Preface to the IFL | 5B | | X(3) |
| 5.7 | Longitude and latitude of receiver site (degrees, minutes, seconds) | 15 | | Code according to data element 2.7 | 5C | | 9(3)X9(2)9(2)<br>9(2)X9(2)9(2) |
| 5.8 | Height of receiver site above the average level of the sea | | 4.0 | Height in metres, if negative, with minus sign | | × | |

TABLE A IV-11 – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.9 | Length of circuit | | 5.0 | In kilometres | | × | |
| 5.10 | Orbital information (for space stations) | 6 | (see 2.10) | Same as for data element 2.10 | × | | |
| 6. | *Characteristics concerning receiving equipment* | | | | | | |
| 6.1 | Code number of receiving equipment | 10 | | Number referring to the equipment characteristics record | | × | |
| 6.2 | Receiver selectivity | 2 | | Code, e.g.:<br>The first character indicates the −6 dB, F1:<br>1 ⩽0.05 kHz<br>2 ⩽0.1 kHz<br>...<br>O ⩽16 kHz<br>A ⩽25 kHz<br>...<br>Z ⩾500 kHz<br>The second character indicates the ratio F1/F2, (F2: −60 dB bandwidth):<br>A <1.25<br>B <1.5<br>...<br>Z >25 | | × | |
| 6.3 | Receiver sensitivity | 1 | 4.0 | First character:<br>K: $kT_0$<br>V: μV/m<br>Remaining characters: value | | × | |
| 6.4 | *S/N* protection ratio | | 2.0 | In dB | | × | |
| 6.5 | Sensitivity to interference | 1 | | Code, e.g.:<br>1: very sensitive for harmful interference<br>2: very sensitive for harmful interference automatic<br>...<br>5: not sensitive for harmful interference | | × | |
| 6.6 | Receiving system noise temperature | | 5.0 | In degrees Kelvin | 9K | | 9(5) |
| 6.6.1 | Equivalent satellite-link noise temperature | | 5.0 | In degrees Kelvin. For space services only | 9L | | 9(5) |
| 6.6.2 | Transmission gain | | 3.1 | In dB | 9M | | S99V9 |

TABLE A IV-II – *(continued)*

| No. | Data element | Number of characters (A + B.C) (¹) A | B.C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (³) |
|---|---|---|---|---|---|---|---|
| 7. | *Characteristics concerning receiving antennas* | | | | | | |
| 7.1 | Code number of receiving antenna | | 6.0 | Code number to be established by the national administration | | × | |
| 7.2 | Height of receiving antenna above ground | 1 | 5.1 | Code according to data element 4.2 | | × | |
| 7.3 | Type of receiving antenna | | 3.0 | Code e.g. according to data element 4.3 | | × | |
| 7.4 | Polarization of receiving antenna | 5 | | Code according to data element 4.4 | | × | |
| 7.5 | Characteristics of receiving antenna | 1 | | Code according to data element 4.5 | | × | |
| 7.6 | Special receiving antenna pattern | 1 | | Code according to data element 4.6 | | × | |
| 7.7 | Pointing of spacecraft antenna | 2 | 7.2 | Exactly as 4.7 but referring to receiving antennas | | × | |
| 7.7.1 | Orientation of spacecraft antenna | | 7.0 | Exactly as 4.7.1 but referring to receiving antennas | | × | |
| 7.7.2 | Name of receiving satellite beam | 3 | | Only for geostationary space stations | ST | | X(3) |
| 7.8 | Pointing accuracy of antenna | | 3.2 | Exactly as 4.8 but referring to receiving antennas | | × | |
| 7.9 | Azimuth of maximum reception | 2 | 4.1 | Code according to data element 4.9 | | × | |
| 7.10 | Horizontal beamwidth | 1 | 5.2 | Code according to data element 4.10 | | × | |

TABLE A IV-II – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7.11 | Elevation angle of the main lobe or elevation scanning sector | | 3.1 | Code according to data element 4.11 | | × | |
| 7.12 | Vertical beamwidth | 1 | 5.2 | Code according to data element 4.12 | | × | |
| 7.13 | Front-to-back ratio of the receiving antenna | | 3.1 | In dB | | × | |
| 7.14 | Gain of receiving antenna | 1 | 3.1 | In dB. Code according to data element 4.14 | | × | |
| 7.15 | Receiving line attenuation | | 3.1 | In dB. Attenuation loss between antenna and receiver | | × | |
| 8. | ***Administrative, management and status characteristics*** | | | | | | |
| 8.1 | Frequency assignment/coordination number (registration number) | 10 | | Code to be specified by the national administration | | × | |
| 8.2 | Notifying administration | 3 | | ITU country code for the country notifying the data (see Table B1 of the Preface to the IFL) | 3B | | X(3) |
| 8.2.1 | International satellite system identifier | 3 | | In the case of space radiocommunications, the country symbol may be followed by a symbol indicating an international satellite system (INTELSAT, INTERSPUTNIK, etc.) (see Table B2) | 3B | | X(3) |
| 8.3 | Date of dispatch notice | | 6.0 | Date | | × | |
| 8.4 | Type of transaction for frequency assignment | | | Code to be specified by the national administration | | | |
| | – purpose of transaction | 1 | | A: new assignment<br>M: modification<br>S: suppression | × | | × |
| | – transaction number | 10 | | In the case M: a serial number | × | | X(10) |
| 8.5 | Security classification | 1 | | U: unclassified<br>R: restricted<br>C: confidential<br>S: secret<br>T: top secret | | × | |

TABLE A IV-II – *(continued)*

| No. | Data element | Number of characters (A + B.C) (¹) A | B.C | Definitions | Basic data required for most applications (²) | Optional data required for specific applications | IFR stored format (³) |
|---|---|---|---|---|---|---|---|
| 8.6 | Frequency assignment usage category | 1 | | Code to be specified by the national administration (restrictions for utilization in times of tension) | | × | |
| 8.7 | Status of administrative frequency assignment data | 1 | 60 | Status of the assignment and date on which this status was effective<br>Reserve<br>Assignment<br>Modification<br>Notification<br>Temporary authorization<br>Cancellation | | × | |
| 8.8 | Date of putting into use | | 8.0 | Date stored as YYYY, MM, DD (see Radio Regulations, Appendix 1, Column 2c, Appendix 3, Column 3) | 2C | | 9(8) |
| 8.9 | Lifetime of satellite | | 2.0 | In years, for space stations only | 2G | | 99 |
| 8.10 | IFRB frequency notification data | | | | | | |
| | – type of notification | 1 | | R: registered by IFRB<br>U: notified to IFRB but not accepted for registration<br>I: registered by IFRB through explicit demand<br>S: not notified to IFRB due to security classification<br>O: not notified to IFRB due to other reasons | | × | |
| | – result of examination | 124 | | Code indicating the results of examination by the IFRB<br>(see Preface to the IFL, Columns 13A, 13B, 13C) | | × (⁴) | |
| | – IFRB identification number | 15 | | The first figure is to accommodate the year 2000 and is at present always zero.<br>The next two figures indicate the notification year,<br>the next six figures indicate the assignment number,<br>the next three figures indicate the entrance number,<br>the last three figures indicate the sub-entrance number<br>(see Preface to the IFL, Column A) | A | | |
| 8.11 | IFRB circular number and year | | | | | | |
| | – number | | 4.0 | Number of circular containing the publication of the recorded assignment | | × | |
| | – year | | 2.0 | Year of publication | | × | |

TABLE A IV-II – *(continued)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8.11 | *(Cont.)* | | | | | | |
| | – number of special section/ advanced publication | 16 | | | 2E | | X(16) |
| | – number of special section/ coordination | 16 | | | 2F | | X(16) |
| 8.12 | Date of IFRB registration | | | | | | |
| | – type | 1 | | A: date in Column 2A<br>B: date in Column 2B<br>D: date in Column 2C<br>(see Preface to the IFL, Column 2D) | 2A, B, D | | × |
| | – date | | 6.0 | Date in the column mentioned above stored as YY, MM, DD | X | | 9(6) |
| 8.13 | Operating administration/company | | | | | | |
| | – administration/company | 3 | | Code number of the operation licensee, administration or agency (see Preface to the IFL, Column 12A) | 12A | | X(3) |
| | – point of contact | 2 | | Code referring to the address of contact (see Preface to the IFL, Column 12B) | 12B | | ×× |
| 8.14 | Responsible offices | | | | | | |
| | – monitoring centre | 1 | | Code of the national monitoring centre | | × | |
| | – monitoring station | 1 | | Code of the national monitoring station | | × | |
| | – regional office | 2 | | Code to be specified by the national administration | | × | |
| | – local office | 2 | | Code to be specified by the national administration | | × | |
| 8.15 | Class of licence charge rate | 2 | | Code to be specified by the national administration | | × | |
| 8.16 | Reference to international agreements | 3 | | Codes, e.g. according to special arrangements between the administrations concerned | | × | |
| 8.17 | International coordination | | | Organizations with which the coordination procedure has been carried out | 11 | | X(42) |
| | – organization | 42 | | | | | |
| | – result | 10 | | | | × | |
| 8.18 | Coordination within own country | | | | | | |
| | – result | 2 | | Code to be established by the national administration | | × | |
| 8.19 | Completion date of coordination | | 6.0 | Actual completion date | | × | |

# TABLES OF DATA ELEMENT APPLICATIONS

The following Table A IV-IIa summarizes the regulatory applications of the "basic" and "optional" frequency assignment and notification data elements described in Table A IV-II.

The various applications of the data elements are grouped into two main clusters:

- data elements, which are to be passed on to the IFRB for frequency notification, recording in the Master International Frequency Register, etc., as stipulated in the applicable *Appendices of the Radio Regulations*;
- data elements, which are to be exchanged between administrations or certain organizations for coordination purposes, etc., as stipulated in *Special arrangements* between the parties concerned.

## 1. Radio Regulations

*Appendix 1* (see Article 12 of the Radio Regulations: Notification and recording in the Master International Frequency Register of frequency assignments to terrestrial radiocommunications stations.)

*Basic characteristics to be furnished to the IFRB for notification under:*

*Section A* Nos. 1214 to 1217 RR: any frequency assignment to a fixed, land, broadcasting (except 5950-26 100 kHz), radionavigation land, radiolocation land or a standard frequency and time signal station or to a ground-based station in the meteorological aids service.

*Section B* No. 1219 RR: any frequency to be used for the reception of mobile stations by a particular land station.

*Section C* Nos. 1223 to 1227 RR: stations of the same service using a band of frequencies above 28 000 kHz in a specific area, the particulars should relate only to a *typical station.*

*Appendix 2* (see Article 17: procedure for the bands allocated exclusively to the broadcasting service between 5950 and 26 100 kHz). Form of notice submission of seasonal high frequency broadcasting schedules.)

*Appendix 3* (see Articles 11, 13: Coordination, notification and recording in the Master International Frequency Register of frequency assignments to *radio astronomy and space radiocommunication stations* except stations in the broadcasting-satellite service.)

*Basic characteristics to be furnished in notices relating to:*

*Section B* *Frequencies used by earth stations for transmitting*

*Section C* *Frequencies to be received by earth stations*

*Section D* *Frequencies used by space stations for transmitting*

*Section E* *Frequencies to be received by space stations*

*Section F* *Frequencies to be received by radio astronomy stations*

*Appendix 4* (see Article 11: Advance publication information to be furnished for a satellite network.)

*Section C* Characteristics of the satellite network in the Earth-to-space direction.

*Section D* Characteristics of the satellite network in the space-to-Earth direction.

*Section E* Characteristics to be furnished for space-to-space relay.

*Appendix 5* (see Article 16: Procedure for bringing up to date the frequency allotment plan for coast radiotelephone stations operating in the exclusive maritime mobile bands between 4000 and 23 000 kHz.)

*Appendix 9* List 1

International Frequency List (IFL).

## 2. Special arrangements

*Terrestrial radiocommunications in general*

Data elements which are relevant for standardized data exchange between administrations or certain organizations.

*Broadcasting sound and television* (BC/BT)

Data elements which are relevant for data exchange between broadcasting organizations e.g. data furnished to the EBU (European Broadcasting Union) from the different national broadcasting organizations and administrations.

*FX/FB/ML-Coordination*

Data elements which are relevant for data exchange between administrations conforming to special frequency coordination agreements concerning fixed, fixed base and mobile stations, e.g.: special agreement between the administrations of BEL, D, HOL, LUX relating to the use of metric and decimetric waves for fixed and mobile services in border areas (Brussels 1963).

*Space radiocommunications in general*

Data elements which are relevant for data exchange between administrations and space agencies.

*Earth stations*

Data elements which are relevant for earth stations.

*Space stations*

Data elements which are relevant for space stations.

3. **Monitoring** (IFRB C.L. 241)

Data elements which are to be passed to the IFRB for the preparation of the Periodic Summaries of Monitoring Information.

TABLE AIV-IIa – *Frequency assignment data element applications*

| No. | Data element | Radio Regulations App. 1 Section A | Radio Regulations App. 1 Section B | Radio Regulations App. 1 Section C | Radio Regulations 2 Appendix | Radio Regulations App. 3 Section B | Radio Regulations App. 3 Section C | Radio Regulations App. 3 Section D | Radio Regulations App. 3 Section E | Radio Regulations App. 3 Section F | Radio Regulations App. 4 Section C | Radio Regulations App. 4 Section D | Radio Regulations App. 4 Section E | Radio Regulations 5 Appendix | Radio Regulations 9 Appendix 9 (IFL) | Special arrangements Terr. radiocom. (in gen.) | Special arrangements Broadcasting BC/BT | Special arrangements FX/FB/ML coordination | Special arrangements Space radiocom. (in gen.) | Special arrangements Earth stations | Special arrangements Space stations | Monitoring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.1 | Frequency | x | x | x | x | x | x | x | x | x | | | x | x | x | x | x | x | x | x | x | x |
| 1.2 | Nature of frequency usage | | | | | | | | | | | | | | | x | x | | | | | |
| 1.3 | Mode of operation | | | | | | | | | | | | | | | x | x | x | | | | |
| 1.4 | Additional frequency information | | | | | | | | | | | | | | | x | x | x | x | | | x |
| 1.5 | Frequency channel number | | | | | | | | | | | | | | | x | x | x | x | | | |
| 1.6 | Frequency offset: | | | | | | | | | | | | | | | | | | | | | |
| | Vision carrier offset | | | | | | | | | | | | | | | | x | | | | | |
| | Sound carrier offset | | | | | | | | | | | | | | | | x | | | | | |
| 1.7 | Frequency stability | | | | | | | | | | | | | | | x | x | | x | | | |
| 1.8 | Schedule of operation | | | | | | | | | | | | | | | | | | | | | |
| | – duty cycle | | | | | | | | | | | | | | | x | x | | x | | | |
| | – hours of operation | x | x | x | x | x | x | x | x | x | | | | x | x | x | x | x | x | | | |
| | – percentage of use | | | | | | | | | | | | | | | x | x | | x | | | |
| | – seasonal periods | | | | x | | | | | | | | | | | x | x | | | | | |
| 1.9 | Class of station | x | x | x | | x | x | x | x | | | | | | x | x | | x | x | | | |
| 1.10 | Nature of service | x | x | x | | x | x | x | x | | | | | x | x | x | | x | x | | | |
| 1.11 | Function of the station | | | | | | | | | | | | | | | x | | | x | | | |
| 1.12 | User group | | | | | | | | | | | | | | | x | | x | x | | | |
| 1.13 | Equipment mobility | | | | | | | | | | | | | | | x | | | | | | |
| 1.14 | Equipment platform | | | | | | | | | | | | | | | x | | | | | | |
| 1.15 | Number of mobile stations | | | | | | | | | | | | | | | x | | | x | | | |
| 2.1 | Identification number of transmitting site | | | | | | | | | | | | | | | x | x | | x | | | |
| 2.2 | Name of location | x | | | x | x | | x | | | | | | | x | x | x | x | x | | | x |
| 2.3 | Type of location or area | | | | | | | | | | | | | | | x | | | x | | | |
| 2.4 | Type of terrain | | | | | | | | | | | | | | | x | x | | | x | | |
| 2.5 | Terrain characteristics | | | | | | | | | | | | | | | | | | | | | |
| | – $\Delta h$ parameter | | | | | | | | | | | | | | | x | x | | | | | |
| | – effective height | | | | | | | | | | | | | | | x | x | x | | | | |
| 2.6 | Country | x | | x | | x | | | | | x | x | x | | x | x | x | x | | x | | |
| 2.7 | Longitude and latitude of transmitter site | x | | | | x | | | | | | x | x | | | | | | x | | | |

TABLE AIV-IIa – *(continued)*

| No. | Data element | Radio Regulations | | | | | | | | | | | | | | Special arrangements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | App. 1 | | | 2 | App. 3 | | | | | App. 4 | | | 5 | 9 | | | | | | | |
| | | Section A | Section B | Section C | Appendix | Section B | Section C | Section D | Section E | Section F | Section C | Section D | Section E | Appendix | Appendix 9 (IFL) | Terr. radiocom. (in gen.) | Broadcasting BC/BT | FX/FB/ML coordination | Space radiocom. (in gen.) | Earth stations | Space stations | Monitoring |
| 2.8 | Height of the transmitter site | | | | | | | | | | | | | | | x | x | | | x | | |
| 2.9 | Call sign or other identification | x | | x | | | | | | | | | | | x | x | | | | | | x |
| 2.10 | Orbital information | | | | | | | | | | | | | | | | | | x | | | |
| 3.1 | Code number of transmitting equipment | | | | | | | | | | | | | | | x | | | | | | |
| 3.2 | Designation of emission | x | x | x | x | x | x | x | x | x | x | | | | x | x | x | x | x | | | x |
| 3.3 | Designation of TV-system | | | | | | | | | | | | | | | | x | | | | | |
| 3.4 | Maximum authorized radiated power | | | | | | | | | | | | | | | x | x | x | | | | |
| 3.5 | Actual radiated power | x | x | x | x | x | x | x | x | x | | | | | x | x | x | x | x | | | |
| 3.6 | Pulse width | | | | | | | | | | | | | | | x | | | x | | | |
| 3.7 | Pulse repetition frequency | | | | | | | | | | | | | | | x | | | x | | | |
| 4.1 | Code number of transmitting antenna | | | | | | | | | | | | | | | x | | | x | | | |
| 4.2 | Height of transmitting antenna above ground | | | | | | | | | | | | | | | x | x | x | | x | | |
| 4.3 | Type of transmitting antenna | | | | | | | | | | | | | | | x | x | | x | | | |
| 4.4 | Polarization of transmitting antenna | | | | | | | | | | | | | | | x | x | | x | | | |
| 4.5 | Characteristics of transmitting antenna | | | | | | | | | | | | | | | x | x | x | x | | | |
| 4.6 | Special transmitting antenna pattern | | | | | | | | | | | | | | | | | x | x | | | |
| 4.7 | Pointing of spacecraft antenna | | | | | | | | | | | | | | | | | | x | | | |
| 4.7.1 | Orientation of spacecraft antenna | | | | | | | | | | | | | | | | | | x | | | |
| 4.8 | Tolerance of spacecraft antenna pointing | | | | | | | | | | | | | | | | | | x | | | |
| 4.9 | Azimuth of maximum radiation | x | | | x | x | | | | | | | | x | x | x | x | x | | x | | |
| 4.10 | Horizontal half-power beamwidth (3 dB) | | | | | x | | | | | | | | x | x | | | | x | | | |
| 4.11 | Horizontal angular width of main lobe (6 dB) | x | | | | | | | | | | | | x | x | x | | | x | | | |
| 4.12 | Elevation angle of the main lobe | | | | | x | | | | | | x | | | | x | | | | x | | |
| 4.13 | Vertical half-power beamwidth (3 dB) | | | | | | | | | | | | | | | | | | x | | | |
| 4.14 | Vertical angular width of main lobe (6 dB) | | | | | | | | | | | | | | | | | | | x | | |

TABLE AIV-IIa – *(continued)*

| No. | Data elements | Radio Regulations | | | | | | | | | | | | | | Special arrangements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | App. 1 | | | 2 | App. 3 | | | | | App. 4 | | | 5 | 9 | | | | | | | |
| | | Section A | Section B | Section C | Appendix | Section B | Section C | Section D | Section E | Section F | Section C | Section D | Section E | Appendix | Appendix 9 (IFL) | Terr. radiocom. (in gen.) | Broadcasting BC/BT | FX/FB/ML coordination | Space radiocom. (in gen.) | Earth stations | Space stations | Monitoring |
| 4.15 | Front-to-back ratio of the antenna | | | | | | | | | | | | | | | x | | | x | | | |
| 4.16 | Relative gain of transmitting antenna | x | | | x | x | | x | | | | | | x | x | x | | | x | | | |
| 4.17 | Transmission line attenuation | | | | | | | | | | | | | | | x | | | x | | | |
| 4.18 | Scanning motion method | | | | | | | | | | | | | | | x | | | x | | | |
| 4.19 | Type of scan | | | | | | | | | | | | | | | x | | | x | | | |
| 4.20 | Scans per minute | | | | | | | | | | | | | | | x | | | x | | | |
| 4.21 | Antenna rotations per minute | | | | | | | | | | | | | | | x | | | x | | | |
| 4.22 | Circuit or programme number | | | | | | | | | | | | | | | | x | | | | | |
| 4.23 | Space station antenna polar gain diagram | | | | | | | | | | | | | | | | | | | x | | |
| 5.1 | Identification number of receiver site | | | | | | | | | | | | | | | x | | | x | | | |
| 5.2 | Name of location of the receiver | x | x | x | x | | x | | x | x | | | | | x | x | | x | | | | x |
| 5.3 | Type of location or area | | | | | | | | | | | | | | | x | | | x | | | |
| 5.4 | Type of terrain | | | | | | | | | | | | | | | x | | | | x | | |
| 5.5 | Effective height | | | | | | | | | | | | | | | x | | | | x | | |
| 5.6 | Country | x | x | x | | | x | | | x | | | | | x | x | | | | x | | |
| 5.7 | Longitude and latitude | | | | | | | | | | | | | | | x | | | | x | | |
| 5.8 | Height of receiver site above sea level | | | | | | | | | | | | | | | x | | | | x | | |
| 5.9 | Length of circuit | x | x | | | | | | | | | | | | x | x | | x | | x | | |
| 5.10 | Service volume | | | | | | | | | | | | | | | | x | | | | | |
| 5.11 | Orbital information (for space stations) | | | | | | | | | | | | | | | | | | | | x | |
| 6.1 | Code number of receiving equipment | | | | | | | | | | | | | | | x | | | | | x | |
| 6.2 | Receiver selectivity | | | | | | | | | | | | | | | x | | | x | | | |
| 6.3 | Receiver sensitivity | | | | | | | | | | | | | | | x | | | x | | | |
| 6.4 | *S/N* protection ratio | | | | | | | | | | | | | | | x | | | x | | | |
| 6.5 | Sensitivity to interference | | | | | | | | | | | | | | | x | | x | x | | | |
| 6.6 | Minimum link noise temperature | | | | | | | | | | | | | | | | | | x | | | |

TABLE AIV-IIa – *(continued)*

| No. | Data element | Radio Regulations App. 1 Section A | App. 1 Section B | App. 1 Section C | 2 Appendix | App. 3 Section B | App. 3 Section C | App. 3 Section D | App. 3 Section E | App. 3 Section F | App. 4 Section C | App. 4 Section D | App. 4 Section E | 5 Appendix | 9 Appendix 9 (IFL) | Special arrangements Terr. radiocom. (in gen.) | Broadcasting BC/BT | FX/FB/ML coordination | Space radiocom. (in gen.) | Earth stations | Space stations | Monitoring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.1 | Code number of receiving antenna | | | | | | | | | | | | | | | x | | | x | | | |
| 7.2 | Height of receiving antenna above ground | | | | | | | | | | | | | | | x | | | | x | | |
| 7.3 | Type of receiving antenna | | | | | | | | | | | | | | | x | | | x | | | |
| 7.4 | Polarization of receiving antenna | | | | | | | | | x | | | | | x | x | | | | | | |
| 7.5 | Characteristics of receiving antenna | | | | | | | | | | | | | | | x | | | x | | | |
| 7.6 | Special receiving antenna pattern | | | | | | | | | | | | | | | x | | | x | | | |
| 7.7 | Pointing of spacecraft antenna | | | | | | | | | | | | | | | | | | | | x | |
| 7.7.1 | Orientation of spacecraft antenna | | | | | | | | | | | | | | | | | | | | x | |
| 7.8 | Tolerance of spacecraft antenna pointing | | | | | | | | | | | | | | | | | | | | x | |
| 7.9 | Azimuth of maximum reception | | | | | | x | | | x | | | | x | x | | | | x | | | |
| 7.10 | Horizontal half-power beamwidth (3 dB) | | | | | | x | | | | | | | x | | | | | x | | | |
| 7.11 | Horizontal angular width of main lobe (6 dB) | | | | | | | | | | | | | | | x | | | x | | | |
| 7.12 | Elevation angle of the main lobe | | | | | | x | | | x | | | | x | x | | | | | x | | |
| 7.13 | Vertical half-power beamwidth (3 dB) | | | | | | | | | | | | | | | x | | | | x | | |
| 7.14 | Vertical angular width of main lobe (6 dB) | | | | | | | | | | | | | | | x | | | | x | | |
| 7.15 | Front-to-back ratio of the receiving antenna | | | | | | | | | | | | | | | x | | | x | | | |
| 7.16 | Relative gain of receiving antenna | | | | | | x | | x | x | | | | x | x | | | | x | | | |
| 7.17 | Receiving line attenuation | | | | | | | | | | | | | | x | | | | x | | | |
| 8.1 | Frequency assignment/coordination number | x | x | x | x | x | x | x | x | x | | | | x | x | | x | | x | | | |
| 8.2 | Notifying administration | x | x | x | x | x | x | x | x | x | | | | x | x | x | x | | x | | | |
| 8.3 | Country, group of countries or international organization | x | x | x | x | x | x | x | x | x | | | | x | x | x | x | | x | | | |
| 8.4 | Date of notice | x | x | x | x | x | x | x | x | x | | | | x | x | x | | | x | | | |
| 8.5 | Intention of data transfer | | | | | | | | | | | | | | | | x | x | | x | | |
| 8.6 | Type of transaction for frequency assignment | | | | | | | | | | | | | | | | | | | | | |
| | – purpose of transaction | x | x | x | x | x | x | x | x | x | | | | x | x | x | x | | x | | | |
| | – transaction number | | | | | | | | | | | | | | | x | | | | | | |

TABLE AIV-IIa – *(continued)*

| No. | Data element | Radio Regulations | | | | | | | | | | | | | | Special arrangements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | App. 1 | | | 2 | App. 3 | | | | | App. 4 | | | 5 | 9 | | | | | | | |
| | | Section A | Section B | Section C | Appendix | Section B | Section C | Section D | Section E | Section F | Section C | Section D | Section E | Appendix | Appendix 9 (IFL) | Terr. radiocom. (in gen.) | Broadcasting BC/BT | FX/FB/ML coordination | Space radiocom. (in gen.) | Earth stations | Space stations | Monitoring |
| 8.7 | Security classification | | | | | | | | | | | | | | | x | | | x | | | |
| 8.8 | Frequency assignment usage category | | | | | | | | | | | | | | | | | | x | | | |
| 8.9 | Status of frequency assignment | | | | | | | | | | | | | | | x | | | x | | | |
| 8.10 | Date of putting into use | x | x | x | x | x | x | x | x | x | | | | x | x | x | x | x | x | | | |
| 8.11 | Expiration date of frequency usage | | | | | | | | | | | | | | | x | x | | x | | | |
| 8.12 | IFRB frequency notification data | | | | | | | | | | | | | | | | | | | | | |
| | – type of notification | | | | | | | | | | | | | | x | x | x | | x | | | |
| | – result of examination | | | | | | | | | | | | | | | x | x | | | | | |
| 8.13 | IFRB circular number and year | | | | | | | | | | | | | | | x | x | | x | | | |
| 8.14 | Date of IFRB registration | | | | | | | | | | | | | | x | x | x | | x | | | |
| 8.15 | Operating administration/agency | | | | | | | | | | | | | | | | | | | | | |
| | – administration/agency | | | | | | | | | | | | | | x | x | x | | x | | | |
| | – point of contact | | | | | | | | | | | | | | x | x | x | | | | | |
| 8.16 | Responsible offices | | | | | | | | | | | | | | | x | | | | | | |
| 8.17 | Class of licence charge rate | | | | | | | | | | | | | | | x | | | x | | | |
| 8.18 | Reference to international agreements | | | | | | | | | | | | | | | x | x | x | x | | | |
| 8.19 | Coordination with international organizations | | | | | | | | | | | | | | | x | x | | x | | | |
| 8.20 | Coordination with foreign administrations | | | | | | | | | | | | | | | x | x | | x | | | |
| 8.21 | Coordination within own country | | | | | | | | | | | | | | | x | x | | | | | |
| 8.22 | Completion date of coordination | | | | | | | | | | | | | | | | | x | x | | | |

TABLE AIV-III – *Licence holder data*

| No. | Data element | Number of characters | Definitions |
|---|---|---|---|
| 1 | Reference number to assignment/ proposal data | 7 | Code to be specified by the national administration |
| 2 | Regional authority for assignment | 2 | |
| 3 | Type of registration | 1 | N: new entry<br>M: modification<br>D: deletion |
| 4 | Name of licence holder | 30 | If required the same data elements can be used additionally for the point of contact |
| 5 | Postal code | (6) | |
| 6 | Town | 30 | |
| 7 | Street | 24 | |
| 8 | Abbreviated name | 12 | |
| 9 | Telephone number | 12 | If required, 3 more characters for country codes |
| 10 | Telex code | 12 | |

*Note.* – ( ) indicates that number depends upon code size being used.

# ANNEX IV

TABLE AIV-IV – *Equipment characteristic data*

| No. | Data element | Status: Basic | Status: Optional | Number of characters (A + B.C)(1): A | Number of characters (A + B.C)(1): B.C | Definitions |
|---|---|---|---|---|---|---|
| 1. | *General data* | | | | | |
| | *Transaction and date of action* | | | | | |
| 1.1.1 | Kind of transaction | x | | 1 | | Code, e.g.:<br>N: new registration<br>M: modification<br>D: deletion |
| 1.1.2 | Date of transaction | x | | | 4.0 | Indicates month and year of action |
| 1.2 | Source of data | | x | 1 | | Code, e.g.:<br>T: technical description of equipment<br>R: measuring test report<br>etc. |
| 1.3 | Security classification | x | | 1 | | Code, e.g.:<br>U: unclassified<br>R: restricted<br>C: confidential<br>S: secret<br>T: top secret |
| 1.4 | Type of equipment | x | | 1 | | Code, e.g.:<br>S: complex system<br>C: combined TX/RX facility<br>T: independent transmitter<br>R: independent receiver<br>A: antenna<br>etc. |
| 1.5 | System or equipment nomenclature | x | | 16 | | Indicates code designation of system or equipment |
| | *Manufacturer and country of origin* | | | | | |
| 1.6.1 | Manufacturer | x | | 12 | | |
| 1.6.2 | Country of origin | | x | 3 | | Code, e.g.:<br>abbreviations according to the preface of the IFL |
| | *Equipment deployment and function* | | | | | |
| 1.7.1 | Deployment | x | | | 1.0(2) | Code, e.g.:<br>1: civil<br>2: military<br>3: civil/military |
| 1.7.2 | Function | x | | 1(2) | | Code, e.g.:<br>A: radiotelephone<br>B: sound broadcasting<br>C: television-broadcasting<br>D: radio-relay<br>etc.<br>The second character indicates supplementary characteristics |

(1) A + B.C
A: number of alphanumeric characters.
B: total number of numeric characters.
C: number of decimal characters.

(2) The number of characters is still under consideration and will be established later.

TABLE AIV-IV – *(continued)*

| No. | Data element | Status | | Number of characters (A + B.C) | | Definitions |
|---|---|---|---|---|---|---|
| | | Basic | Optional | A | B.C | |
| | *Equipment platform and mobility* | | | | | |
| 1.8.1 | Equipment platform | | x | 1 | | Code, e.g.:<br>A: airborne<br>L: ground<br>R: on rivers, canals, lakes<br>S: space<br>etc. |
| 1.8.2 | Mobility | | x | 1 | | Code e.g.:<br>F: fixed, permanently installed<br>T: fixed during operation, but transportable<br>M: mobile, but not portable, operation possible during movement<br>P: portable |
| | *Type approval* | | | | | |
| 1.9.1 | Executing office | | x | 1 | | Code is to be established depending on requirements |
| 1.9.2 | Type approval number | | x | | 8.0 | |
| 1.9.3 | Year of certification | | x | | 2.0 | |
| 1.10 | Number of equipments | | x | | 5.0 | Indicates the number of equipments in use on the territory of a state |
| | *Number of transmitters, receivers and antennas incorporated by the system* | | | | | |
| 1.11.1 | Number of transmitters | | x | | 1.0 | |
| 1.11.2 | Number of receivers | | x | | 1.0 | |
| 1.11.3 | Number of antennas | | x | | 1.0 | |
| 2. | *Transmitter data* | | | | | |
| 2.1 | Transmitter nomenclature | x | | 15 | | Indicates manufacturer's designation of transmitter type |
| | *Tunable frequency range* | | | | | |
| 2.2.1 | Tunability | x | | 1 | | Code, e.g.:<br>F: fixed TX-frequency<br>S: TX-frequency switchable in steps<br>T: TX-frequency continuously tunable |
| 2.2.2 | Lower limit of frequency range | x | | | 9.4 | |
| 2.2.3 | Upper limit of frequency range | x | | | 9.4 | |
| 2.2.4 | Unit | x | | 1 | | Code:<br>K: kHz<br>M: MHz<br>G: GHz |

TABLE AIV-IV – *(continued)*

| No. | Data element | Status | | Number of characters (A + B.C) | | Definitions |
|---|---|---|---|---|---|---|
| | | Basic | Optional | A | B.C | |
| | *Pulse width* | | | | | |
| 2.9.1 | Tunability | | x | 1 | | Code, e.g.:<br>F: fixed pulse width<br>T: tunable pulse width |
| 2.9.2 | Lower limit of pulse width range | | x | | 3.0 | |
| 2.9.3 | Upper limit of pulse width range | | x | | 3.0 | |
| 2.9.4 | Unit | | x | 1 | | Code, e.g.:<br>N: nanoseconds<br>U: microseconds<br>L: milliseconds |
| | *Pulse repetition frequency* (PRF) | | | | | |
| 2.10.1 | Tunability | | x | 1 | | Code, e.g.:<br>F: fixed pulse repetition frequency<br>T: tunable pulse repetition frequency |
| 2.10.2 | Lower limit of PRF | | x | | 4.0 | PRF in kHz |
| 2.10.3 | Upper limit of PRF | | x | | 4.0 | PRF in kHz |
| | *Pulse rise time and decay time* | | | | | |
| 2.11.1 | Rise time | | x | | 3.1 | |
| 2.11.2 | Unit | | x | 1 | | Code, see 2.9.4 |
| 2.11.3 | Decay time | | x | | 3.1 | |
| 2.11.4 | Unit | | x | 1 | | Code, see 2.9.4 |
| | *FM-CW deviation ratio* | | | | | |
| 2.12.1 | Tunability | | x | 1 | | Code, e.g.:<br>F: fixed<br>T: tunable |
| 2.12.2 | Lower limit of FM-CW deviation ratio | | x | | 4.0 | |
| 2.12.3 | Upper limit of FM-CW deviation ratio | | x | | 4.0 | |
| 2.12.4 | Unit | | x | 1 | | Code:<br>H: Hz<br>K: kHz |
| | *Attenuation of harmonics* | | | | | |
| 2.13.1 | Attenuation of the 2nd harmonic | x | | | 3.0 | Attenuation in dB |
| 2.13.2 | Attenuation of the 3rd harmonic | x | | | 3.0 | Attenuation in dB |

TABLE AIV-IV – *(continued)*

| No. | Data element | Status: Basic | Status: Optional | Number of characters (A + B.C): A | Number of characters (A + B.C): B.C | Definitions |
|---|---|---|---|---|---|---|
| 3. | *Receiver data* | | | | | |
| 3.1 | Receiver nomenclature | x | | 15 | | Indicate manufacturer's designations of receiver type |
| | *Tunable frequency range* | | | | | |
| 3.2.1 | Tunability | x | | 1 | | Code, e.g.:<br>F: fixed RX-frequency<br>S: tunable in steps<br>T: continuously tunable |
| 3.2.2 | Lower limit of frequency range | x | | | 9.4 | |
| 3.2.3 | Upper limit of frequency range | x | | | 9.4 | |
| 3.2.4 | Unit | x | | 1 | | Code:<br>K: kHz<br>M: MHz<br>G: GHz |
| | *Switchable modulation types* | | | | | |
| 3.3.1 | Bandwidth | x | | 4 | | Code according to RR 146 |
| 3.3.2 | Class of emission | x | | 5 | | Code according to RR 269.<br>These records are furnished several times to accommodate different classes of emission, if switchable |
| 3.4 | Type of receiver | | x | 1 | | Code, e.g.:<br>A: detector<br>B: single superheterodyne<br>C: multiple superheterodyne<br>etc. |
| 3.5 | Receiver sensitivity | x | | | 3.0 | Sensitivity in – dBm |
| 3.6 | Number of pre-set channels | x | | | 4.0 | |
| | *Channel separation* | | | | | |
| 3.7.1 | Value of channel separation | x | | | 9.4 | |
| 3.7.2 | Unit | x | | 1 | | Code:<br>H: Hz<br>K: kHz<br>M: MHz |
| | *Receiver selectivity*<br>*Bandwidth of the passband* | | | | | |
| 3.8.1 | At the 3 dB point | x | | | 9.4 | |
| 3.8.2 | At the 20 dB point | x | | | 9.4 | |
| 3.8.3 | At the 40 dB point | x | | | 9.4 | |
| 3.8.4 | At the 60 dB point | x | | | 9.4 | |
| 3.8.5 | Unit | x | | 1 | | Code, see 3.7.2 |

TABLE AIV-IV – *(continued)*

| No. | Data element | Status: Basic | Status: Optional | Number of characters (A + B.C): A | Number of characters (A + B.C): B.C | Definitions |
|---|---|---|---|---|---|---|
| | *Mixer and IF stages* | | | | | |
| 3.9.1 | Mixer type | | x | 1 | | Code, e.g.:<br>A: additive mixing<br>B: broadband ring mixing with pulse shaper<br>M: multiplicative mixing<br>S: self-heterodyning mixing |
| 3.9.2 | Value of intermediate frequency | x | | | 9.4 | |
| 3.9.3 | Unit | x | | 1 | | Code, see 3.2.4 |
| 3.9.4 | IF bandwidth | x | | | 9.4 | |
| 3.9.5 | Unit | x | | 1 | | Code, see 3.2.4 |
| 3.9.6 | Local oscillator position | | x | 1 | | Code, e.g.:<br>A: up-conversion in normal position<br>B: up-conversion in inverted position<br>C: down-conversion in normal position<br>D: down-conversion in inverted position<br>These records are furnished 3 times to accommodate the data for the 2nd and 3rd IF-stage, if necessary |
| 3.10 | Image frequency rejection | x | | | 3.0 | Indicates image frequency rejection in dB |
| 3.11 | Special circuitry | | x | | 3.0 | Code is to be established depending on requirements |
| 4. | *Antenna data* | | | | | |
| 4.1 | Antenna nomenclature | x | | 15 | | Indicates manufacturer's designation of antenna type |
| | *Frequency range* | | | | | |
| 4.2.1 | Adjustability | x | | 1 | | Code, e.g.:<br>F: antenna frequency range not adjustable<br>T: antenna frequency range is adjustable |
| 4.2.2 | Lower limit of frequency range | x | | | 9.4 | |
| 4.2.3 | Upper limit of frequency range | x | | | 9.4 | |
| 4.2.4 | Unit | x | | 1 | | Code:<br>K: kHz<br>M: MHz<br>G: GHz |
| 4.3 | Class of antenna | x | | 1 | | Code:<br>T: transmitting antenna<br>R: receiving antenna<br>C: transmitting and receiving antenna |
| 4.4 | Type of antenna | x | | | 2.0 | Code, e.g.:<br>01: dipole<br>02: half-wave dipole<br>03: full-wave dipole<br>etc. |

TABLE AIV-IV – *(continued)*

| No. | Data element | Status | | Number of characters (A + B.C) | | Definitions |
|---|---|---|---|---|---|---|
| | | Basic | Optional | A | B.C | |
| 4.5 | Antenna characteristic | x | | 1 | | Code, e.g.:<br>N: non-directed<br>D: directional (unidirectional)<br>X: directional (revolving) |
| 4.6 | Antenna polarization | | x | 1 | | Code, e.g.:<br>H: horizontal<br>V: vertical<br>C: circular<br>etc. |
| | *Isotropic gain of antenna* | | | | | |
| 4.7.1 | For horizontal polarization | x | | | 3.1 | Gain in dB |
| 4.7.2 | For vertical polarization | x | | | 3.1 | Gain in dB |
| | *Type of antenna feed and line attenuation* | | | | | |
| 4.8.1 | Antenna feed | | x | 1 | | Code, e.g.:<br>A: parallel-wire line<br>B: coaxial line<br>C: rectangular wave guide<br>etc. |
| 4.8.2 | Line attenuation | | x | - | 3.1 | Line attenuation in dB |
| | *Antenna scanning cycles* | | | | | |
| 4.9.1 | Adjustability | | x | 1 | | Code, e.g.:<br>F: fixed scanning rate<br>T: variable or adjustable scanning rate |
| 4.9.2 | Lower limit of scanning cycles | | x | | 4.0 | Scanning cycles per minute |
| 4.9.3 | Upper limit of scanning cycles | | x | | 4.0 | Scanning cycles per minute |
| | *Antenna rotations* | | | | | |
| 4.10.1 | Adjustability | | x | 1 | | Code, e.g.:<br>F: fixed rotation rate<br>T: variable or adjustable rotation rate |
| 4.10.2 | Lower limit of rotation cycles | | x | | 4.0 | Rotation cycles per minute |
| 4.10.3 | Upper limit of rotation cycles | | x | | 4.0 | Rotation cycles per minute |
| | *Antenna dimension* | | | | | |
| 4.12.1 | Dimension | | x | 1 | | Code, e.g.:<br>L: effective length of antenna<br>D: effective area of antenna<br>etc. |
| 4.12.2 | Value | | x | | 3.0 | Value in metres |

TABLE AIV-IV – *(continued)*

| No. | Data element | Status | | Number of characters (A + B.C) | | Definitions |
|---|---|---|---|---|---|---|
| | | Basic | Optional | A | B.C | |
| 4.13 | Antenna scan method | | x | 1 | | Code, e.g.:<br>E: rotary scan within a limited sector<br>R: 360° rotary scan<br>V: vertical sector scan<br>N: horizontal and vertical sector scans<br>etc. |
| | *Half-power beam width* | | | | | |
| 4.14.1 | Horizontal | | x | | 4.1 | Horizontal half-power beam width in degrees |
| 4.14.2 | Vertical | | x | | 4.1 | Vertical half-power beam width in degrees |
| 4.15 | Horizontal antenna diagram | | x | | 36.0 | Indicates the isotropic gain of the antenna at 20° intervals beginning at 0° (peak of the directional diagram) sense clockwise (each value: two characters) |
| | *Vertical antenna diagram* | | | | | |
| 4.16.1 | Multiplication factor | | x | | 2.0 | Indicates the value of the factor (in degrees) which is to be multiplied with 9 values: +2.0, +1.5, +1.0, +0.5, 0, −0.5, −1.0, −1.5, −2.0, to obtain 9 desired angular values |
| 4.16.2 | Values of isotropic gain at 9 desired angles | | x | | 18.0 | (Each value: 2 characters) |

TABLE AIV-V – *Description of frequency monitoring data*

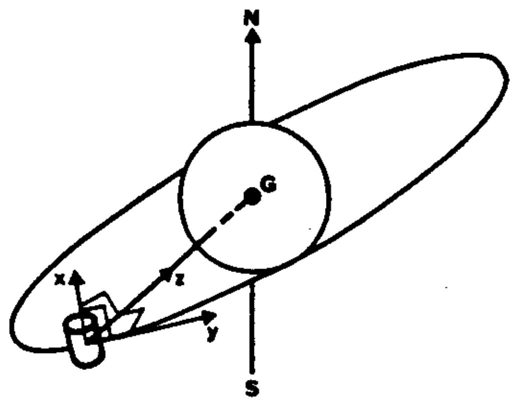
| No. | Data elements | Number of characters | Volume of information | | |
|---|---|---|---|---|---|
| | | | IFRB | | Administration |
| | | | Reduced | Comprehensive | |
| 1 | Monitoring station | 4 | x | x | x |
| 2 | Date of observation | 6 | x | x | x |
| 3 | Time of observation | 8 | x | x | x |
| 4 | Frequency measured | 8 | x | x | x |
| 5 | Lower and upper limit of measured frequency range | 16 | | | x |
| 6<br>7 | Class of emission (RR, Article 4 and Appendix 6) | 3 | x | x | x<br>x |
| 8 | Type of system | 6 | x | x | x |
| 9 | Type of user and operational equipment function | 4 | | | x |
| 10 | Class of station | 2 | x | x | x |
| 11 | Nature of service | 1 | | | x |
| 12 | Country in which transmitter is located | 3 | | | x |
| 13 | Name or call sign | 12 | x | x | x |
| 14 | Location information | 12 | | x | x |
| 15 | Corresponding station | 12 | | x | x |
| 16 | Remarks | 18 | | x | x |
| 17 | Assigned frequency | 10 | | x | x |
| 18 | Notice of IFRB registration | 1 | | | x |
| | Total | 126 | 8 | 12 | 18 |

TABLE A IV-VI – *IFL Table IEI*

| Symbol | Vision carrier offset as a fraction of the line frequency for the television system concerned | Symbol | Vision carrier offset as a fraction of the line frequency for the television system concerned |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 P | + 1/12 | 1 M | – 1/12 |
| 2 P | + 2/12 | 2 M | – 2/12 |
| 3 P | + 3/12 | 3 M | – 3/12 |
| 4 P | + 4/12 | 4 M | – 4/12 |
| 5 P | + 5/12 | 5 M | – 5/12 |
| 6 P | + 6/12 | 6 M | – 6/12 |
| 7 P | + 7/12 | 7 M | – 7/12 |
| 8 P | + 8/12 | 8 M | – 8/12 |
| 9 P | + 9/12 | 9 M | – 9/12 |
| 10 P | + 10/12 | 10 M | – 10/12 |
| 11 P | + 11/12 | 11 M | – 11/12 |
| 12 P | + 12/12 | 12 M | – 12/12 |
| 13 P | + 13/12 | 13 M | – 13/12 |
| 14 P | + 14/12 | 14 M | – 14/12 |
| 15 P | + 15/12 | 15 M | – 15/12 |
| 16 P | + 16/12 | 16 M | – 16/12 |
| 17 P | + 17/12 | 17 M | – 17/12 |
| 18 P | + 18/12 | 18 M | – 18/12 |
| 19 P | + 19/12 | 19 M | – 19/12 |
| 20 P | + 20/12 | 20 M | – 20/12 |

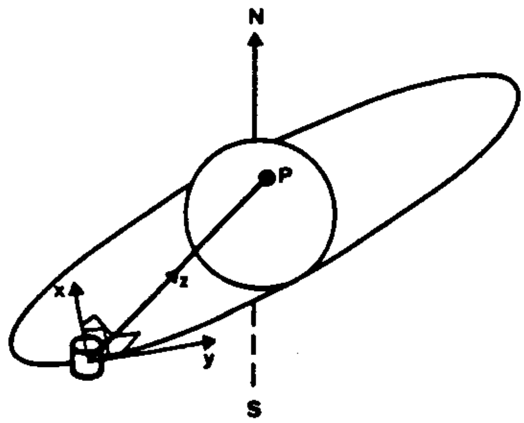
TABLE A IV-VII – *IFL Table 4GI*

| Symbol | Conductivity (S/m) |
|---|---|
| 1 | 4 |
| 2 | $3 \times 10^{-2}$ |
| 3 | $10^{-2}$ |
| 4 | $3 \times 10^{-3}$ |
| 5 | $10^{-3}$ |
| 6 | $3 \times 10^{-4}$ |
| 7 | $10^{-4}$ |
| 8 | $3 \times 10^{-5}$ |
| 9 | $10^{-5}$ |




*a)* Pointing of spacecraft antenna "boresight" – System "G"

G: geocentre
y-axis lies in plane of orbit
z-axis passes through G

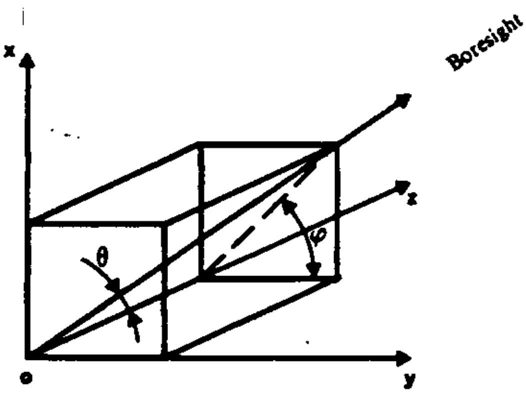



*b)* Pointing of spacecraft antenna "boresight" – System "P"

P is point on the earth visible from the spacecraft
y-axis lies in plane of orbit
z-axis passes through P

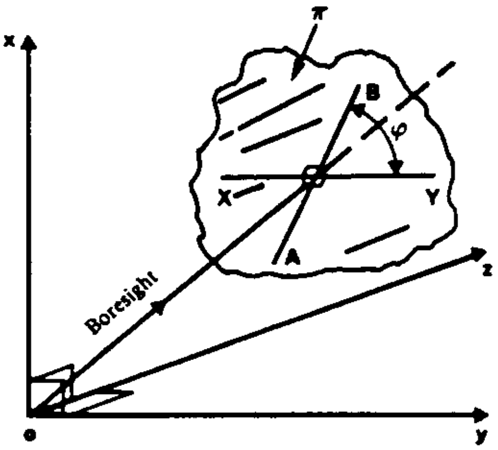
FIGURE A IV-1 – *Sketches of angles used in data definitions*

*Note.* – Different authors label the x, y and z axes differently. These examples are only suggestions but of course any alteration should be consistent.




*c)* Angles defining boresight pointing in coordinate system "G"

The angles marked θ and φ are respectively the first and second data items in data element 4.7, Table AIV-II.




*d)* Antenna orientation round its boresight "Reference orientation" data element 4.7.1, Table AIV-II.

Plane π is perpendicular to the boresight

Line XY in π is parallel to y-z plane

Line AB in π defines angle of reference orientation, φ; 180° ≥ φ > −180°

Line AB is this "horizontal"

Angles φ used in 4.23 of Table AIV-II are mesured from AB

FIGURE AIV-1 – *Sketches of angles used in data definitions*

*Note.* – Different authors label the x, y and z axes differently. These examples are only suggestions but of course any alterations should be consistent.

# ANNEX V

## GENERIC DATA BASE MANAGEMENT SYSTEM CHARACTERISTICS FOR SPECTRUM MANAGEMENT

The following tables describe those features which are considered to be necessary and/or desirable in a data base management system that is used in computer-aided spectrum management applications.

The following assumptions have been made:

- microcomputers, due to operating system restrictions, cannot, at the time of writing, run a full multi-user data base management system. A full multi-user data base management system permits more than one user to simultaneously access the data base. Adequate protection must be provided to prevent two or more users from simultaneously changing the same data. This protection is normally provided by temporarily "locking" a record that is being changed, to prevent that record from being accessed by any other user;
- a microcomputer is assumed to be capable of handling a maximum of 15 000 frequency assignments. Systems which require the handling of more than 15 000 frequency assignments should consider using a minicomputer. This is due to the fact that even when a hard disk is used, the processing, response and disk access times and storage requirements would be too great for practical use with a larger number of records.

TABLE A V-I – *Microcomputer data base management system characteristics*

| | |
|---|---|
| *Operating systems supported* | MS-DOS (PC-DOS)<br>CP/M-86<br>UNIX<br>CP/M-68K |
| *System characteristics* | |
| Minimum memory required ([1]) | 250 - 500 kilobyte |
| *Program characteristics* | |
| On-screen help menu available at all levels | Required |
| On-screen interactive tutorial | Desirable |
| Screen-generator | Desirable |
| Input data validation ([2]) | Desirable |
| Stored command files ([3]) | Desirable |
| Data dictionary | Desirable |
| Installation program ([4]) | Desirable |
| Ease of use ([5]) | Required |
| Natural language error messages | Desirable |
| Multi-user ([6]) | Desirable |
| *Media* | |
| Media on which software is supplied | 5 1/4 inch diskette |
| Copy protected ([7]) | No |
| Hard disk compatible | Required |
| *File characteristics* ([8]) | |
| Number of fields per record | 128 |
| Number of characters per field | 80 |
| Number of physical records per schema ([9]) | 65 000 |
| Number of schema files opened concurrently | 10 |
| Number of characters per index key ([10]) | 40 |
| Number of fields per index key | 5 |
| Number of index keys per schema file ([11]) | 3 |
| *File structure* | |
| Modification | |
| Add fields/elements | Required |
| Delete fields/elements | Required |
| Add records | Required |
| Delete records | Required |
| Data field/Element types supported | |
| Numeric | Required |
| Character | Required |
| Date | Desirable |
| Sorting/Index | |
| Ascending | Required |
| Descending | Required |
| Allow duplicate keys ([12]) | Required |
| On multiple field/element ([13]) | Required |
| File compatibility ([14]) | |
| ASCII | Required |
| Accessible to external applications | Required |

TABLE A V-1 – *(continued)*

| | |
|---|---|
| *Report generator* | |
| Free form placement of headings, titles | Desirable |
| Free form placement of output values | Required |
| Mathematical operations | Desirable |
| Output destination selection (15) | Required |
| Generate report from multiple files | Required. |
| Minimum number of break levels (16) | 5 |
| Generate multi-line reports | Required |
| Ease of use | Required |
| *Security* (17) | |
| Write protection | Desirable |
| User passwords | Desirable |
| Security levels | Desirable |
| *Support* | |
| Vendor telephone support | Required |
| Vendor updates of new versions | Desirable |

(1) The DBMS must be capable of executing within the available main memory. When more than one user is supported, additional memory is required. User response time is minimized when there is sufficient memory to simultaneously support all user programs. In some applications additional memory may improve the DBMS response time. Typical main memory requirements are from 250 to 500 kilobytes.

(2) Input data validation is the capability to check that a particular data element conforms to certain rules. These rules may specify that the data element is of a particular type (i.e. numeric, alphabetic, etc.) and/or the data element is within a range of values.

(3) A user must enter a sequence of commands or instructions in order to produce a specific output, report or capture input data. It is useful to be able to store this sequence of commands in a file when the report is produced frequently. This allows the report to be produced, using the command file, without retyping the individual commands.

(4) Many commonly used microcomputer data base management systems are designed to operate with a number of different microcomputer systems. These data base systems require an installation program to set certain parameters to match the parameters required by the specific microcomputer system being used.

(5) Ease of use must be evaluated from the perspective of the users, the application programmers and the computer operations staff. Ease of use is a function of the specific application or applications being performed. For an application requiring a large number of transactions to be processed, the ease with which the data base can be updated is a significant factor in determining the overall ease of use. In this case, a data base management system, which includes the ability to update the data base using batch processing, may have a high ease of use rating. For an application which requires a limited number of transactions to be processed, the ease with which the data base can be updated is not a significant factor in determining the overall ease of use. In this case, a data base management system including the ability to update the data base on-line may have a high ease of use rating. Other factors affecting ease of use are:

- the ability to produce recurring reports;
- the ability to produce *ad hoc* reports;
- the ability to modify the data base structure;
- the ability to recover from a hardware or software failure;
- the ability to identify who has accessed the data base and to identify the information requested from the data base; and the percent of the total available ADP capability (processor speed, memory, etc.) required by the data base management system.

(6) Many commonly used microcomputer data base management systems are single-user systems and should not be used on a multi-user computer system. When two or more users have the capability to update the data base at the same time, the data base management system must contain adequate controls to prevent two users from updating the same record at the same time.

(7) Some vendors provide copy protected software to prevent illegal duplication. Software protected in this way is generally not capable of being duplicated by any method. No back-up or security copy of the software can be kept. In this case, if the software becomes corrupted (i.e. unusable or unreadable), a new copy is required.

(8) The file characteristics listed, although unable to support a fully implemented computer-aided spectrum management system using the data elements specified in Annex IV, represent the minimum requirement to handle a practical implementation taking into account the capability of DBMS systems commonly available for microcomputers.

(9) A microcomputer data base management system should be capable of processing at least 65 000 physical records. To ensure adequate, continuing performance, the data base management system should be capable of processing two to three times the number of records expected five years into the future. The performance of some data base management systems degrades significantly as the total number of records in the data base becomes close to the maximum capacity of the data base.

(10) The number of characters in the index key may affect the time to retrieve records from the data base. In general, records are retrieved faster for shorter keys than they are for longer keys.

(11) An index key points to a record or group of records containing specific information and therefore, provides a method of rapidly retrieving these records. When information is retrieved without using indexes, the entire data base must be searched. This takes significantly longer than retrieving records using an index key. Therefore, the data base management system must allow most retrievals to be made using index keys.

(12) The data base management system should permit duplicate keys. Duplicate keys permit more than one record to have the same key. Duplicate keys permit retrieving the entire set of records having a particular common characteristic.

(13) The data base management system should be capable of sorting and/or indexing on more than one data element. Sorting on more than one data element is normally specified using minor sort keys. This provides the capability to order the data base on a secondary data element within the order specified by the primary data element. For example, when the major sort key is assigned frequency and the minor sort key is location, a data base in frequency order is produced. Those records that have identical frequencies are also ordered by location. All records having the same frequency and having the same location are grouped together.

(14) There are a large number of software programs available for microcomputers. The programs include word processing, spreadsheets, communications and data base management systems. In order to use these programs together, the files produced by one program must be capable of being read by another program. Many vendors are ensuring file compatibility between the various capabilities above by producing integrated software packages that combine those capabilities into a single software system.

(15) It should be possible to specify whether a report is displayed on the user's terminal or is printed on a high speed or letter quality printer.

(16) Break levels are used with sorted data to specify when information from a record should be placed on a new page and when subtotals are required. For example, if a report is produced in station class order and station class is used as a break level, the information for each record that contains a station class different from the preceding record will be placed at the top of a new page.

(17) Access control should be placed at the data set or record level. Functional security should be applied e.g. read only access. The ability to place security locks at the item level would be an advantage.

TABLE A V-II – *Minicomputer data base management system characteristics*

| | |
|---|---|
| *Operating systems supported* (1) | |
| *System characteristics* | |
| Minimum memory required (2) | |
| Transportability (3) | Required |
| Multiple user views (4) | Required |
| Cold restarts (5) | Required |
| COBOL/FORTRAN interfaces (6) | Required |
| End user facilities (7) | Required |
| Multiple data bases (8) | Required |
| Security (9) | Desirable |
| On-line implementation (10) | Required |
| Product life-cycle (11) | Desirable |
| On-line updating (12) | Required |
| Tuning (13) | Desirable |
| Multiple-threading (14) | Desirable |
| Data independence (15) | Desirable |
| Prototype data base development (16) | Desirable |
| Hot restarts (17) | Desirable |
| Data encryption (18) | Desirable |
| Back-up facilities (19) | Desirable |
| *Program characteristics* | |
| Global security (20) | Required |
| Logical/physical restructuring (21) | Required |
| Ease of use (22) | Required |
| Data dictionary | Required |
| Report writer (23) | Required |
| Key definition (24) | Required |
| Documentation (25) | Required |
| Unauthorized access (26) | Desirable |
| Multi-user | Required |

TABLE A V-II – *(continued)*

| | |
|---|---|
| *Media* | |
| Media on which software is supplied | 1/2 inch, 9 track, 1600 BPI tape |
| *File characteristics* | |
| Number of fields per record | 128 |
| Number of characters per field | 80 |
| Number of physical records per schema (27) | 65 000 |
| Number of schema files opened concurrently | 10 |
| Number of characters per index key (28) | 40 |
| Number of fields per index key | 5 |
| Number of index keys per schema file (29) | 6 |
| *File structure* | |
| Modification (30) | |
| Add fields/elements | Required |
| Delete fields/elements | Required |
| Add records | Required |
| Delete records | Required |
| Data field/Element types supported | |
| Numeric | Required |
| Character | Required |
| Date | Required |
| Sorting/Index | |
| Ascending | Required |
| Descending | Required |
| On multiple field/element | Required |
| File compatibility | |
| ASCII | Required |
| Accessible to external applications | Required |
| *Report generator* | |
| Free form placement of headings, titles | Desirable |
| Free form placement of output values | Required |
| Mathematical operations | Desirable |
| Output destination selection (31) | Required |
| Generate report from multiple files | Required |
| Minimum number of break levels | 5 |
| Generate multi-line reports | Required |
| Ease of use | Required |
| *Security* | |
| Write protection | Desirable |
| User passwords | Required |
| Security levels | Required |
| *Support* | |
| Vendor support (32) | Required |

([1]) There is no generally accepted operating system available for minicomputers. Users are restricted to operating systems supplied by the hardware manufacturer. However, the UNIX operating system is being supplied by many manufacturers and may become a standard operating system. Use of a data base management system supported by UNIX may increase software portability.

([2]) The DBMS must be capable of executing within the available main memory. When more than one user is supported, additional memory is required. User response time is minimized when there is sufficient memory to simultaneously support all user programs. In some applications additional memory may improve the DBMS response time. Typical main memory requirements are from one to two million bytes.

([3]) It is highly desirable that all application software be independent of any specific hardware. Hardware independence permits the application to be moved to another vendor's hardware if that hardware provides additional capability or reduced costs. To provide hardware independence, a DBMS should:

- fully comply with the CODASYL specification, or
- be available on hardware from at least three different manufacturers.

([4]) The data base management system should provide multiple user views of the data base. Each user should only be able to view that portion of the data base required for his/her specific application.

([5]) The DBMS must at least allow cold restarts that is, non-automatic post incident recovery.

([6]) Higher level language interfaces – the package should interface to both ANSII COBOL and FORTRAN 77 as host language to the DML (Data Management Language).

([7]) End user facilities focus on a high level enquiry language suitable for satisfying *ad hoc* information retrieval on line. The enquiry language should be able to access both data base and non data base files.

Many of the information requirements which are traditionally satisfied by formal reports can be satisfied by an *ad hoc* on-line enquiry.

([8]) This characteristic describes the ability to interrelate data bases and schema at run time i.e. a program should have access up to many different data bases/schema. Non data base files should also be accessible from the same program. The DBMS package selected should be able to manage a non-integrated data base – essentially a number of discrete but interrelated data bases.

([9]) Access control should be placed at the data set or record level. Functional security should be applied e.g. read only access. The ability to replace security locks at the time level would be an advantage.

([10]) An on-line implementation, within the DBMS or as a "bolt on" package of a suitable transaction processor (TP)/screen handler, is required. This TP should be transportable, and would ideally form part of a transportable DBMS package.

([11]) The DBMS package should be in the "growth" phase of its product life cycle i.e. within five years of the first installation unless the product has been through a major upgrade.

Above all, the product should be neither on the "leading edge" nor marked to be superseded but should be in the mid range of its product life cycle curve.

([12]) The package should be designed to permit effective on-line updating. This implies that the package has sufficient security provisions to adequately provide item or record "lock out" and to process partial transaction errors. Hot restarts are a necessity. Simultaneous batch and on-line processing should be allowed.

([13]) Most DBMS packages include software to facilitate optimization of the data base structure and access paths. It should ideally have facilities for:

- data structure display,
- statistical monitoring routines,
- structural simulation.

([14]) Multi-threading/Re-entrancy – the ability of the DBMS software to process more than one transaction simultaneously. Multiple users should not require multiple copies of the DBMS software. The degree to which this characteristic is achieved can be evaluated during benchmarking.

([15]) Higher level languages, including COBOL and FORTRAN, should be able to access data items without specifying the physical data structure.

([16]) The data base administrator or an authorized user should be able to make trial modifications to the data base structure or content without destroying the production data base. This is normally accomplished by creating a second parallel prototype data base that coexists with the production data base.

([17]) Automatic real time recovery. This would incorporate a roll back facility which automatically "unpicks" partially completed transactions.

([18]) Extremely sensitive data should be protected by encryption. This facility would be useful to protect certain sensitive areas which exist in spectrum management data bases.

([19]) Transactions should be journalized. Back-up of the entire DBMS to disk or tape (selective SAVE and RESTORE) should be easy to use and resource efficient.

([20]) The package must provide security at the global/file level. The sensitivity of certain areas of spectrum management data bases requires file security as a minimum.

([21]) The DBMS should provide the capability to logically restructure (modify the user view) or physically restructure (modify the physical storage of the data including adding, deleting or modifying data items) without recreating the entire data base.

([22]) Ease of use must be evaluated from the perspective of the users, the application programmers and the computer operations staff. Ease of use is a function of the specific application or applications being performed. For an application requiring a large number of transactions to be processed, the ease with which the data base can be updated is a significant factor in determining the overall ease of use. In this case, a data base management system, which includes the ability to update the data base using batch processing, may have a high ease of use rating. For an application which requires a limited number of transactions to be processed, the ease with which the data base can be updated is not a significant factor in determining the overall ease of use. In this case, a data base management system including the ability to update the data base on-line may have a high ease of use rating. Other factors affecting ease of use are:

- the ability to produce recurring reports;
- the ability to produce *ad hoc* reports;
- the ability to modify the data base structure;
- the ability to recover from a hardware or software failure;
- the ability to identify who has accessed the data base and to identify the information requested from the data base; and the percent of the total available ADP capability (processor speed, memory, etc.) required by the data base management system.

([13]) This refers to the utility available for producing formal structured reports and *ad hoc* reports required by an organization. Reports should be produced by the user and easily changed to meet changing requirements.

The report writer should provide the user with the flexibility to specify page headers and page footers, column headers, and the content of the report. It should be possible to create a multi-line report when the information in the report does not fit on a single line. It should also be possible to include information from a number of related files in a single report.

([14]) Key definition within a DBMS should be completely flexible including dynamic redefinition of keys. Multiple key access with up to 10 keys should be possible.

([15]) Documentation should be:
- comprehensive, i.e. 3 levels:
  - general
  - application design
  - technical,
- clear,
- complete.

The best documentation set appears as a series of self-teaching manuals.

([16]) Monitoring of unauthorized attempts to access all or part of the data base.

([17]) A minicomputer data base management system should be capable of processing at least 65 000 records. To ensure adequate, continuing performance, the data base management system should be capable of processing two to three times the number of records expected five years into the future. The performance of some data base management systems degrades significantly as the total number of records in the data base becomes close to the maximum capacity of the data base.

([18]) The number of characters in the index key may affect the time to retrieve records from the data base. In general, records are retrieved faster for shorter keys than they are for longer keys.

([19]) An index key points to a record or group of records containing specific information and therefore, provides a method of rapidly retrieving these records. When information is retrieved without using indexes, the entire data base must be searched. This takes significantly longer than retrieving records using an index key. Therefore, the data base management system must allow most retrievals to be made using index keys.

([20]) Unloading and reloading a data base can take a significant amount of time. Therefore, it should be possible to modify the file structure without unloading and reloading the data base.

([21]) It should be possible to specify whether a report is displayed on the user's terminal or is printed on a high speed or letter quality printer.

([22]) Vendor should have a "track record" of providing a solution to software problems within a 2-3 day time frame.

---

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

**RADIO FREQUENCY SPECTRUM MANAGEMENT**

Part 6

ANALYSIS TECHNIQUES

R.G. Struzak
International Telecommunication Union, International Radio Consultatiuve Committee
Geneva, Switzerland

The purpose of these notes is to provide an overview of the measures of usage of the radio frequency spectrum resource and of relevant analysis techniques. [Source: D.M. Jansky, Spectrum Management Techniques, Don White Consultants, Inc., 1977, Chapter 6, pp. 6.1-6.24)





# CHAPTER 6

# ANALYSIS TECHNIQUES

The previous chapters have dealt with the operational, technical, and planning methods of spectrum management. Associated with these have been a variety of newly-developed techniques which have influenced the decision-making processes in each of these areas. The quality of the decision making, and therefore the quality of the management, is dependent upon the analytical capabilities utilized. This chapter is devoted to a description of these techniques and their application.

## 6.1 SPECTRUM UTILIZATION CRITERIA

This section discusses those methods and metrics in being, and those being developed, which are intended to be measures of spectrum use effectiveness. A book on spectrum management techniques would not be complete without reference to spectrum utilization criteria. This refers to a continuous set of efforts to develop and implement a comprehensive methodology for ascertaining a means for determining the relative effectiveness with which various spectrum users make use of spectrum resources.

None of the concepts discussed below are being used in practice. However, one or another has achieved varying degrees of acceptability. The need for developing such criteria or measures has been predicated on the assumption that they would promote a basis for making judgements with regard to the appropriate amounts to be provided to different users. There is also, implicit in the development of such measures, the requirement that the electromagnetic spectrum be viewed as a resource; and is therefore, an economic factor whose value can be determined by market forces.

It is the intent of this section to describe some of these measures. These include: Situation, Autonomous and Uniform Metric, Relative Value Index (RVI), and several simplistic measures of Spectrum Utilization Efficiency. In 1968, the JTAC in its *Spectrum Engineering - A Key to Progress* indicated several concepts dealing with spectrum use, an efficiency, as descibed below.[1]

### 6.1.1 PODAF

PODAF - meaning Power Density exceeding a specified level over an Area within an assigned Frequency band. The purpose of this concept was to provide a simple, standard unit of spectrum space utilization based on a specified level of radiated energy density over a specified bandwidth within a specified geographical area. This concept envisions that when a spectrum user is given an assignment or license, it would have a certain number of PODAF's associated with it.

This approach would provide both a record of spectrum space assigned and the basis for calculating the degree to which all spectrum space is actually assigned in any one area.

### 6.1.2 Spectrum Usage Efficiency

Spectrum Usage Efficiency is a basically more sophisticated extension of the PODAF. Under this concept, spectrum utilization efficiency (s) is obtained by a combination of the volume (v), bandwidth (B), and time factors (t), for an idealized system*. It is then compared to an actual system; thereby deriving an efficiency. Such an efficiency is represented by:

$$E_s = \frac{S_i}{S_d} = \frac{V_i\ B_i\ T_i}{\sum_{1}^{n}\left[V_{dj}\ B_{dj}\ T_{dj}\right]} \qquad j = \text{no. of users}$$

The terms in this equation are:

Volume Utilization: The ideal volume, $V_i$, is defined as the minimum required to effect communications at a specified grade of service. The volume actually used is the volume denied, $V_d$, to other potential users. The volume denied is further defined as that volume within which another user cannot operate due to two factors: technical considerations and rules and regulations.

Bandwidth Utilization: The ideal bandwidth, $B_i$, is defined as the minimum required to effect communications with a specified modulation and grade of service. That part of the spectrum used is that bandwidth denied, $B_d$, other users. The denied frequency spectrum is considered to include total spectrum occupancy of the receivers and transmitters comprising a specific system. This includes spectrum occupied by such factors as sideband splatter spurious emissions, spurious responses, and intermodulation.

* The *ideal system* is defined as that system of transmitters and receivers which accomplishes a required mission with minimum use of the spectrum.





Time Utilization Efficiency: The ideal time, $T_i$, is defined as the minimum required to render a specific type of service. The time utilized is that denied other users, $T_d$.

Systems Spectrum Utilization Efficiency: Systems utilization efficiency is defined as the ratio of the product of the ideal volume, bandwidth, and time to the denied product of volume, bandwidth, and time.

### 6.1.3 Effective Service Sum

Under this concept, it is assumed that all operations requiring radio frequencies may be defined as services; and that each service requirement can be expressed in terms of specific time periods that the service is available or required to be available. The Service Sum is therefore the sum of the number of services multiplied by the required hours, and has the dimension of service hours, e.g.:

$$S(t_o) = \sum_{k=o}^{k=n} k\ t\ A\ \phi$$

where:
- $A$ = relative utility of each service
- $\phi$ = likelihood each service available
- $t_o$ = time service is available
- $k$ = # radio services.

This concept is illustrated by the following example: In the State of Illinois, 6 MHz of VHF spectrum is used for the land mobile service. Channeling is 25 kHz per channel to provide 240 channels. Forty channels provide fire protection to 100 communities. This yields a relative utility per channel of 50, and a service probability of 0.8. The other 200 channels are used in 100 communities with 20 users per channel. The relative utility is 1 and the service probability is 0.7. The service can then be calculated as below to give $10^7$ hours per day.

$$S = (40)\ (100)\ (50)\ (0.8)\ (24)$$

$$+ (200)\ (100)\ (20)\ (1)\ (0.7)\ (24) = 1.056 \cdot 10^7 \text{ service}$$

hours per day.

For comparison with television, when normalized to a 6-MHz bandwidth, as shown:

$$TV/6\ MHz = 6.048 \cdot 10^7 \div 11 = 0.55 \cdot 10^7 \text{ service}$$

hours per day.

The conclusion is reached, that with the above assumptions, land mobile is about twice as effective in spectrum usage as VHF TV.

### 6.1.4 Relative Value Index (RVI)2

The above approaches are absolute measurement approaches. In contrast, the RVI was developed to (1) demonstrate the feasibility and utility of a relative measurement approach for determining spectrum value; (2) indicate the common technical, economic, and socio-political dimensions of different spectrum uses which determine value; (3) identify the parameters necessary to measure spectrum value; and (4) provide a decision model to incorporate the variables into the management process. The RVI model is:

$$RVI = (1/S)\ \frac{Y(Iu + Ip)}{C}\ PTa + \frac{1/Up \cdot Tp/T}{B}$$

where:

- PTa = average number of hours a population may be served a day.
- B = unit B of spectrum required to perform service.
- 1/Up = Urgency of Need designation.
- Tp/T = ratio of channel hours devoted to a particular purpose to the total number of channel hours service is on-the-air.
- Y/C = Economic activity ratio, where
  - C = Annual operating costs
  - Y = Annual contribution to GNP
- Iu = Spectrum user investment
- Ip = Public investment.

The spectrum manager is then to use this model in the following way:

1. The nation is divided into K spectrum/geographic regions (1 to K).

2. Each request for spectrum is for a given number of units of spectrum space in bandwidth, and crossing 1 to K regions with N units of spectrum available in each region. The total amount of spectrum to be allocated may thus be viewed as a matrix, KN, shown in Fig. 6.1, with individual requests being for blocks of this matrix. In this regard, the white cells indicate available space, not requiring any accommodation. The dark cells indicate occupied space, the reallocation of which requires effective accommodation.

3. Each request for one unit of spectrum bandwidth, crossing one to K regions, is assigned one individual RVI score.





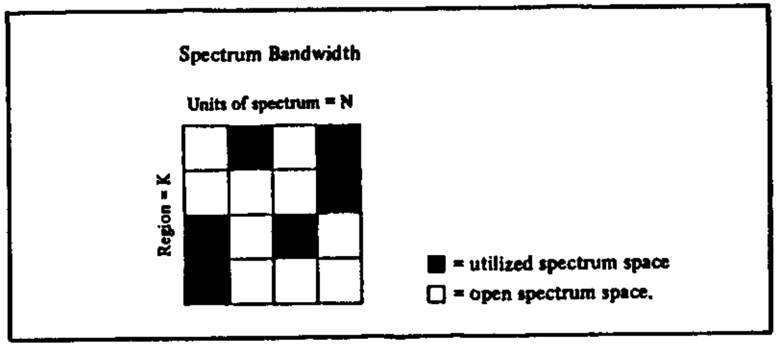



Figure 6.1 - Region/Spectrum Matrix

4. The assignment aim is to maximize the sum of RVI's subject to the constraints of spectrum availability within each individual region, and across spectrum regions.

5. The general form of the alerithm for this assignment may be restated as:

MAX - RVI, subject to the constraints:

1. Total units of spectrum assigned in each region:

$$\sum_{i=1}^{N} Rij \leq N$$

2. Total units of spectrum assigned for the nation:

$$\sum_{i=1}^{N} \sum_{i=1}^{K} Rij \leq KN$$

Placing the problem in this form allows the explicit introduction of the concept of diminishing marginal payoffs as additional units of spectrum bandwidth are assigned to the same user, which is especially relevant when these are to be used for separate purposes. Conversely, if this concept is not relevant, then the total RVI of any user's request can be divided by the number of units of bandwidth requested to give a constant RVI per unit. Even in this case, the intersection of the space constraints and the RVI may dictate a partial fulfillment of a request for multiple units of bandwidth; provided this is technically feasible. The minimum usable bandwidths, for each user in this latter regard, can be introduced as separate constraints.

## 6.1.5 Spectrum Metrics[3]

Each of the above measures has certain deficiencies. The PODAF oversimplifies the actual physical situation. the Effective Service Sum and the RVI deal with only efficiency and not actual quantity, and the Effective Service Sum uses service as a basic commodity. It is too difficult to define the ideal system in the Spectrum Use Efficiency.

Several recent attempts have been made to develop explicit spectrum metrics which give balanced consideration of the use of spectrum by both transmitter and receiver. These metrics attempt to incorporate realistic information about the emission and selectivity of radio systems; and yet, are easily calculable.

### 6.1.5.1 Situation-Specific Denial

This measure is the volume of spectrum space that a system denies actual existing systems that are competing for allocations. The result of application of such a metric are shown in Fig. 6.2 for various receivers. The combined spectrum space that a system denies to all competing systems is the measure of its spectrum space usage.

### 6.1.5.2 Uniform Denial

The measure can be the volume of the spectrum space denied by a transmitter (receiver) to an idealized *reference* receiver (transmitter). Once the reference is chosen, this measure depends only on the characteristics of the station being evaluated. This metric is illustrated by determining the space denied to a reference transmitter by a particular receiver, R. Assume the transmitter has an isotropic antenna ($G_T(\phi) = 1$) and a perfect narrow spectral density function, $P(f_1 f_T) = 0$; $P_T$ = emitted power of the reference transmitter. Then:

$$P_R \text{ (the interference threshold of evaluated/receiver)} = \frac{P_T g_R(\phi)}{g(f_T;\ f_R)}\, \ell(f_T d);$$

where:
- $\ell(f_T, d)$ = transmission loss
- $\phi$ = azimuth angle
- $g(\phi)$ = gain of receiver antenna
- $g(f,f)$ = selectivity function

This equation is applied to a system having three receivers, located at $R_1$, $R_2$, and $R_3$, in Fig. 6.3. Then for a particular frequency separation; the area denied by each receiver is indicated by the light lens, with overlapping prediction areas shaded.





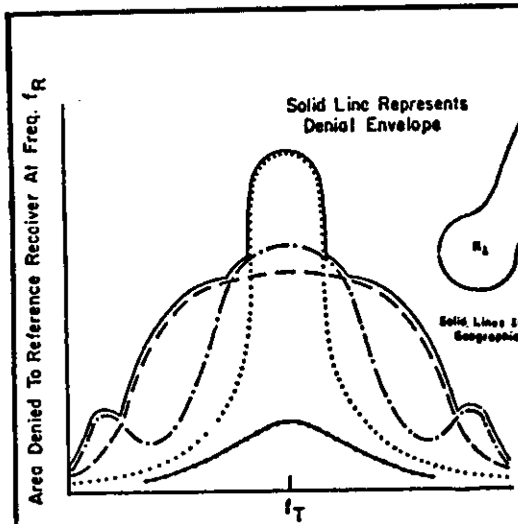



Fig. 6.2 - Measure of Composite Denial of Spectrum-Space by Transmitter T to the 4 Receiver Types

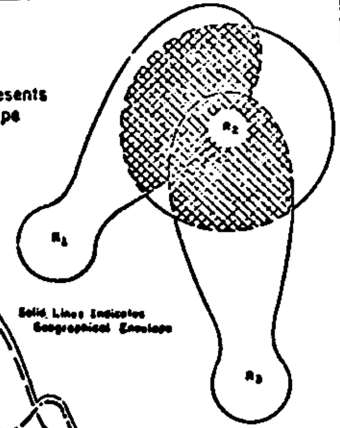



Fig. 6.3 - Overlapping Receiver Denial Areas.

### 6.1.5.3 Autonomous

The measure is dependent only upon the characteristics of a particular station (receiver or transmitter) which deny space to others. The most important characteristics are the emission or admission characteristics of the station, and grade of service required.

This metric is not inherently a calculation of spectrum space denied to other systems, but it is proportional to the amount of spectrum space used for the important special case of free space transmission loss and two spatial dimensions. The transmitter and receiver metrics in this case can be simplified to:

$$M_T = \tau P\, go\ ;\ M_R = \frac{\tau}{\phi\, go^1}$$

where,
- P = transmitter power; go is the maximum gain of the antenna,
- $\tau$ = time,
- $\phi$ = selectivity

These metrics are an attempt to provide a more realistic measure of spectrum use. However, until perfected, they are not likely to be utilized as real spectrum management tools.

## 6.2 COMPATIBILITY OF C-E SYSTEMS WITHIN BAND

As mentioned in the chapter on planning techniques, it is becoming increasingly important to have analytical techniques which can provide rapid macroscopic evaluation of the potential interference problems within a band. Such techniques are important in the context of both system review and band assessments.

Such band-sharing analyses are intended to provide quantitative indications of potential problems in a frequency band of concern, as well as to identify the options available to the spectrum manager for dealing with the problems.

The assessment normally proceeds in several phases. These are described in Table 6.1.

Table 6.1 - Phases of Spectrum Resource Analysis

| | |
|---|---|
| Phase I: | Systems are identified, along with availability of technical and operational data. Potential interactions are assessed. |
| Phase II: | All possible system interactions are given quantitative analysis. Analyses are based on best available data. Courses of action are identified that promote compatibility. |
| Phase III: | Additional periodic assessments are carried out to take into account new inputs, such as new systems or design changes |

The critical techniques in these analyses are (1) those which identify required distance separations between systems, and (2) those which analyse the effects of additional intersystem isolation through off-tuning (or other means) on distance separation.

Fig. 6.4 is a block diagram of a generalized band-sharing assessment analysis procedure.

The basic factors considered in generating frequency-distance relationships are shown in Fig. 6.5. The transmitter is tuned to some frequency $f_T$ and generates a power spectrum which is a function of modulation type and equipment. A signal from the transmitter passes through the propagation path and enters the interfered-with receiver; which has certain band-pass characteristics, dependent on modulation, signal parameters, and filtering. The objective of the analysis is then to determine the amount of power in the interfered-with receiver, due to the interfering transmitter. When this is related to a threshold of user interference tolerance, decisions can be made with regard to optimum separation distances. The procedure is to determine the amount of interference protection required for a given frequency





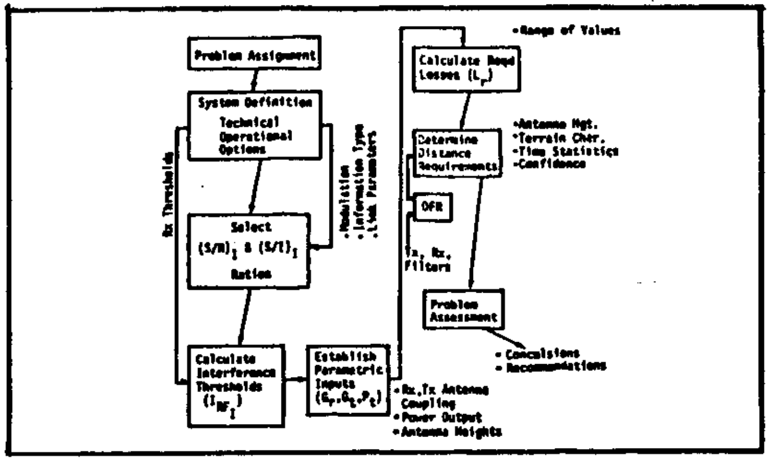



Figure 6.4 - A Generalized Band-Sharing Assessment Analysis Procedure.

separation and interference level, and then to solve the propagation calculation backwards (i.e., given loss, find distance) to determine the separation required to give protection. These analyses may be performed by using the system performance measure of I/N (interference-to-noise power ratio) at the interfered-with receiver. Fig. 6.6 shows frequency/distance curves for four values of I/N. These could represent four values of transmitter power or antenna gain.

The analysis described above are predicated on assumed discrete values of the electronic systems. In truth, the parameters of a system will vary statistically with time.

Analysis of frequency/distance relationships which may occur in a statistically-varing situation requires a comprehensive model. Fig. 6.7 indicates the functional block diagram for such a model.[4] The statistical frequency/distance curves which can be generated using such a model can provide the basis for trade-offs which apply for the full range of probabilities of occurance. Such a tool has great utility, which can be applied to problems over a broad range of conditions. For example, curves such as that in Fig. 6.8 can be generated. This figure indicates that when antennas for the interfering transmitter (TEST XMTR) and the interfered-with receiver (TEST RCVR) are physically separated by 15 nm, and the systems have tuned frequencies which are separated by 8 MHz, the interference criterion of I/N = 10 will be violated 90% of the time. On the other hand, if the tuned frequencies are separated by 9 MHz, the I/N of 10 dB will be exceeded 50% of the time. If they are 11 MHz apart, the I/N will only be greater than 10 dB for 10% of the time.

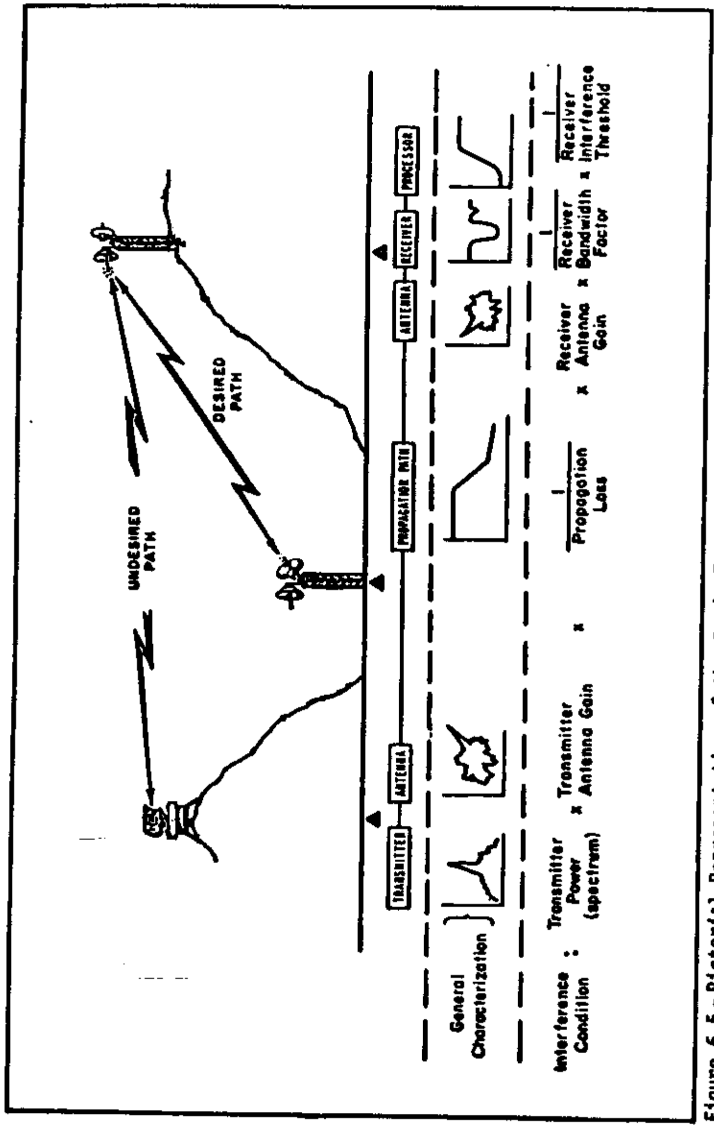



Figure 6.5 - Pictorial Representation of the Basic Factors Considered in Generating a Frequency-Distance Curve.





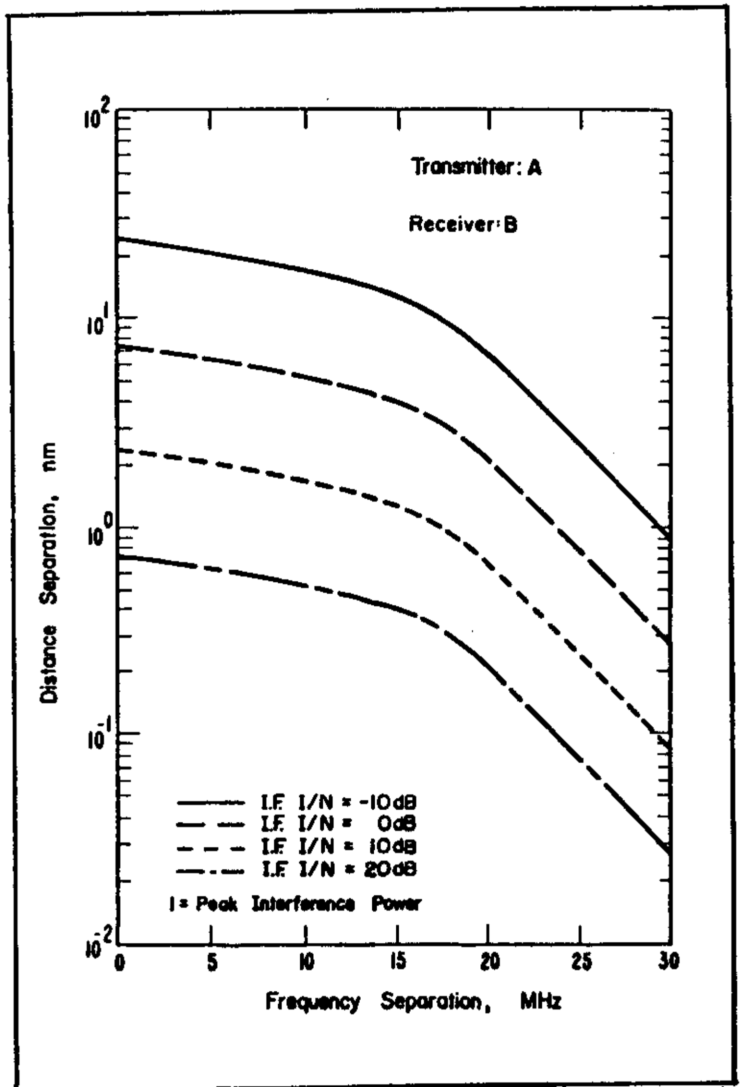



Figure 6.6 - Sample Frequency-Distance Separation Curves Generated from Discrete Data to Illustrate Parametric Treatment of the I.F.I/N Criterion.

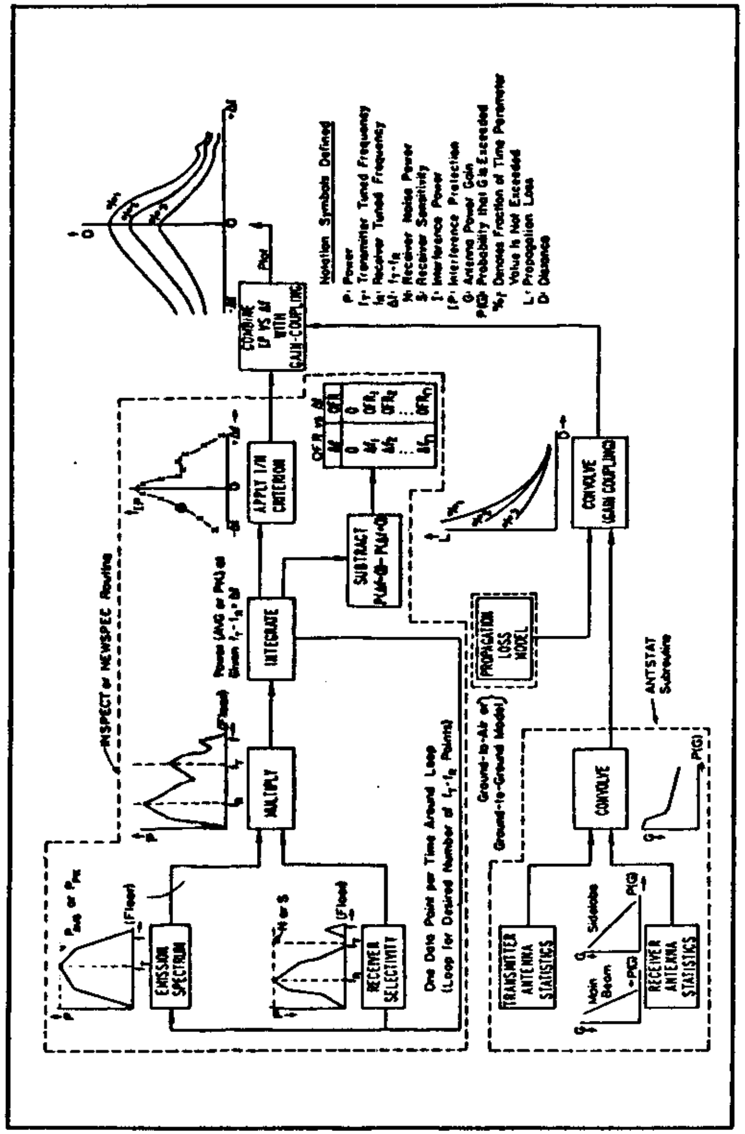



Figure 6.7 - Functional Block Diagram of the Statistical Frequency-Distance Curves Model.





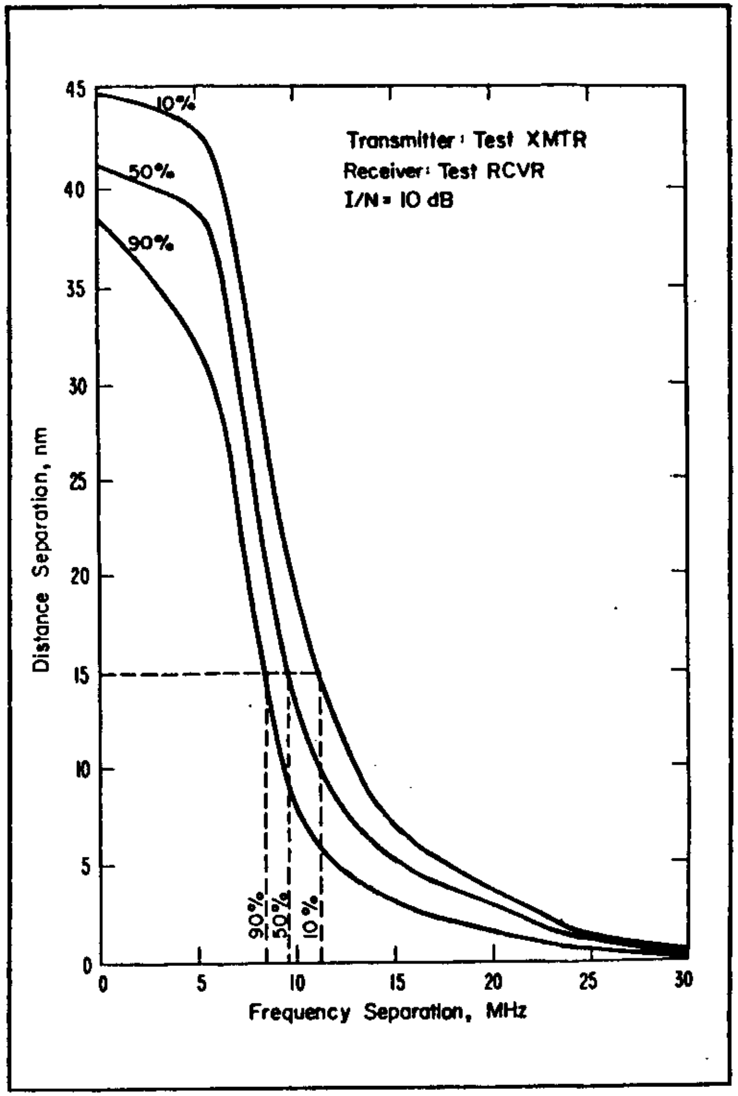



Figure 6.8 - Sample Statistical Frequency-distance Separation Curve Illustrating Application for a Specified Distance Deparation

The application of these techniques, on a systematic basis to each of the interfering situations among the systems within a particular band, provides the basis for stating whether there are serious problems, managable problems, or no problems. Furthermore, if there are problems, these analyses will point out directions of solutions.

## 6.3 SYSTEM-TO-SYSTEM COMPATIBILITY

This section will describe techniques for addressing compatibility between two specific C-E systems. Such techniques come into play once the procedures and analyses of the previous sections have identified interference interactions between two systems which are either serious or manageable. The techniques used to solve these situations involve a combination of detailed testing and coordination analyses.

Illustrative of the techniques which have broad applicability, are those which have been developed and utilized to solve system-to-system compatibility problems between terrestrial microwave systems operating in the same band as a satellite system; and an airborne terminal operating over wide geographical areas.[5]

The system links are symbolically illustrated in Fig. 6.9. The links involving the satellite, its earth terminal station and the terrestrial microwave stations are manageable problems. The analysis techniques used in the management include the following.

### 6.3.1 Earth Station Coordination Distances

In general, fixed satellites have been allocated to share bands with terrestrial microwave stations. Procedures have been developed to compute coordination distance as a function of azimuth angle relative to the earth station near beam direction. Calculations are based on a set of specified interference signal levels for each source that can be exceeded no more than a percent (normally .01%) of the time. Individual coordination curves are calculated, considering the earth station as a source, as well as the interfered-with station. Examples of coordination contours are shown in Fig. 6.10.

### 6.3.2 Earth Station-to-Microwave

If a microwave station lies within one of these contours, coordination must take place. This coordination must examine the predicted signal-to-interference (S/I) ratios and compare them to those required for satisfactory performance. Predicted S/I ratios may be given by:

$$S/I = S/N - (P_t + G_0 - L_f - \Delta f - R_s)$$





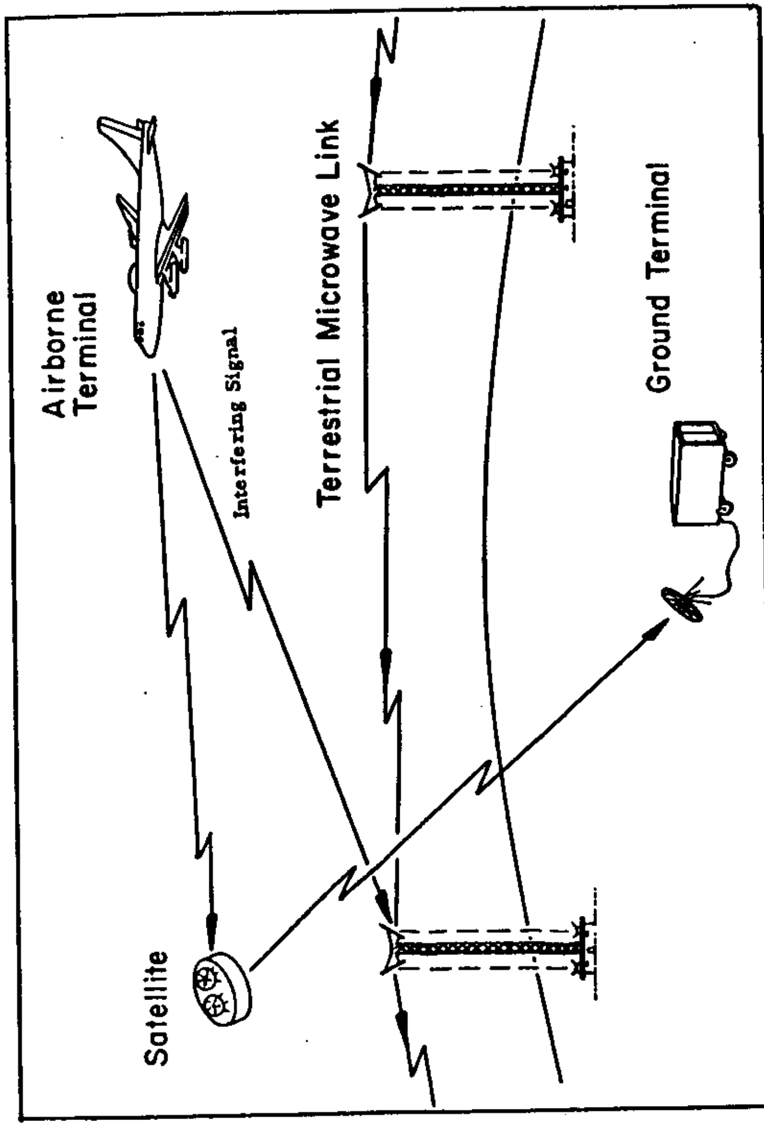



Figure 6.9 - Interference to Microwave Link from Airborne Satellite Terminal

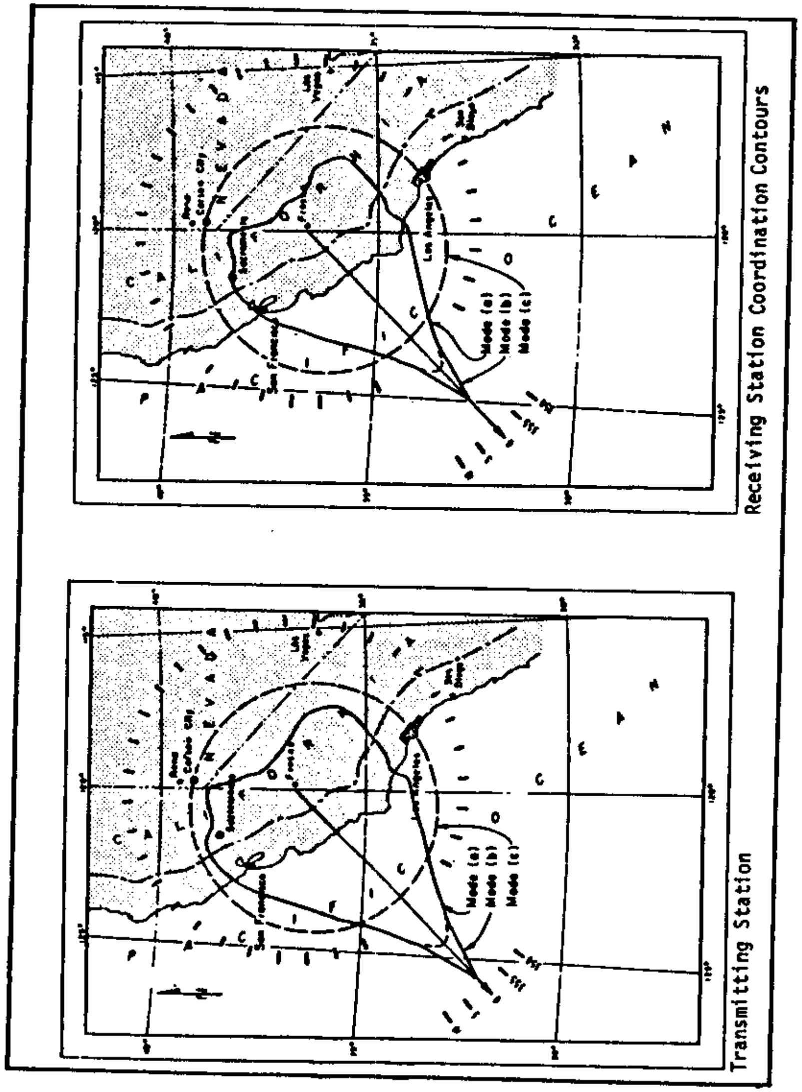



Figure 6.10 - Earth Station Coordination Contours.

Figure 6.10 - Earth Station Coordination Contours.





where, $S/N$ = design input signal-to-noise, dB

$P_t$ = transmitter interference power

$G_o$ = antenna coupling

$L_f$ = path loss

$\Delta f$ = off-frequency system

$R_s$ = receiver sensitivity

G(o), the antenna coupling, may be analyzed as illustrated in Fig. 6.11 for the two dimensional case. It is considered the cumulative angular isolation, $\delta\theta = \theta_1 + \theta_2$. Additional techniques are used to select performance values, for these, combined with the above, give the predicted S/I's.

### 6.3.3 Satellite Link Interference

When the combined characteristics of satellite antenna pattern and gain, and power are factors in an interference calculation, the technique of plotting satellite *footprints* may be utilized. Such a footprint is shown in Fig. 6.12. The contours in this figure are plots of power flux density on the earth's surface. These contours are constructed by searching outward along rays emanating from the maximum power point for the desired signal level and its corresponding location.

This specific serious problem involved the mobile airborne terminal, and the terrestrial microwave stations. In such a case, tests were required to ascertain the nature of interference. The rationale and methodology for carrying out such tests is indicated in Fig. 6.13. The specific problem was the interference created by the back lobe and the side lobe radiation patterns of the airborne terminal.

The tests revealed that unacceptable interference would take place under certain circumstances at certain locations. A technique which can be utilized to avoid these locations is illustrated in Fig. 6.14. This figure consists of interference contours which indicate those regions where levels from an interference source would exceed specified thresholds at the receiver. These thresholds are specified in terms of signal-to-interference ratios, which are directly related to performance. The contours have been developed by a computer program which considers the geometric relationship between an elevated signal source and specific points on the earth's surface.

More and more, techniques such as those detailed above are being developed to handle system-to-system interference situations. The rereferences at the end of this chapter are sources of additional information on this subject.

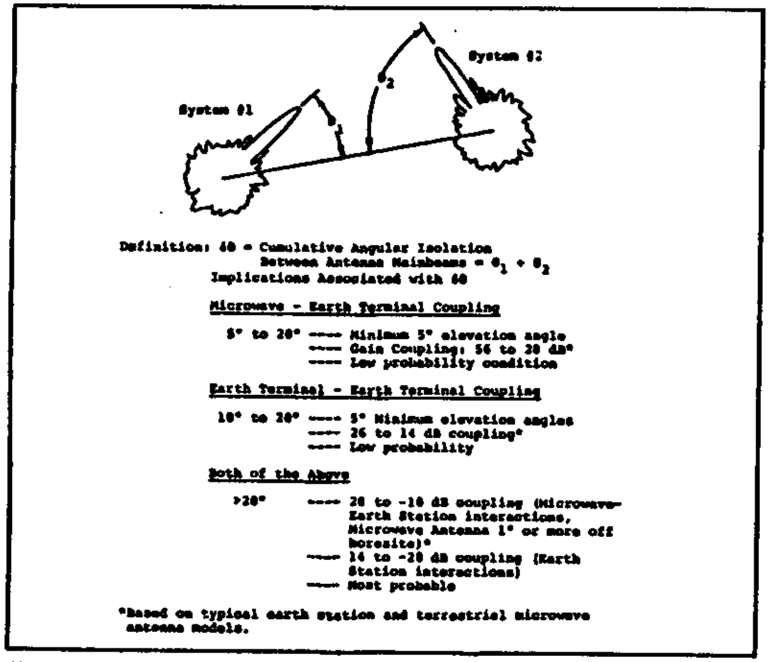



Figure 6.11 - Antenna Coupling Relationships

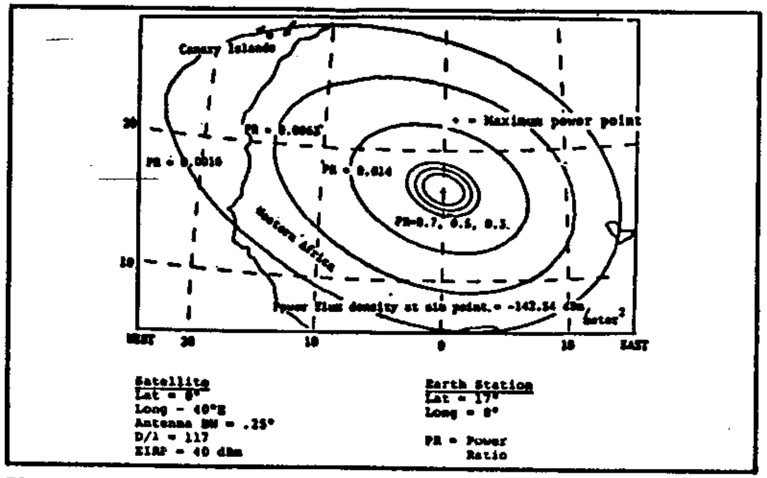



Figure 6.12 - Representative Satellite Footprint





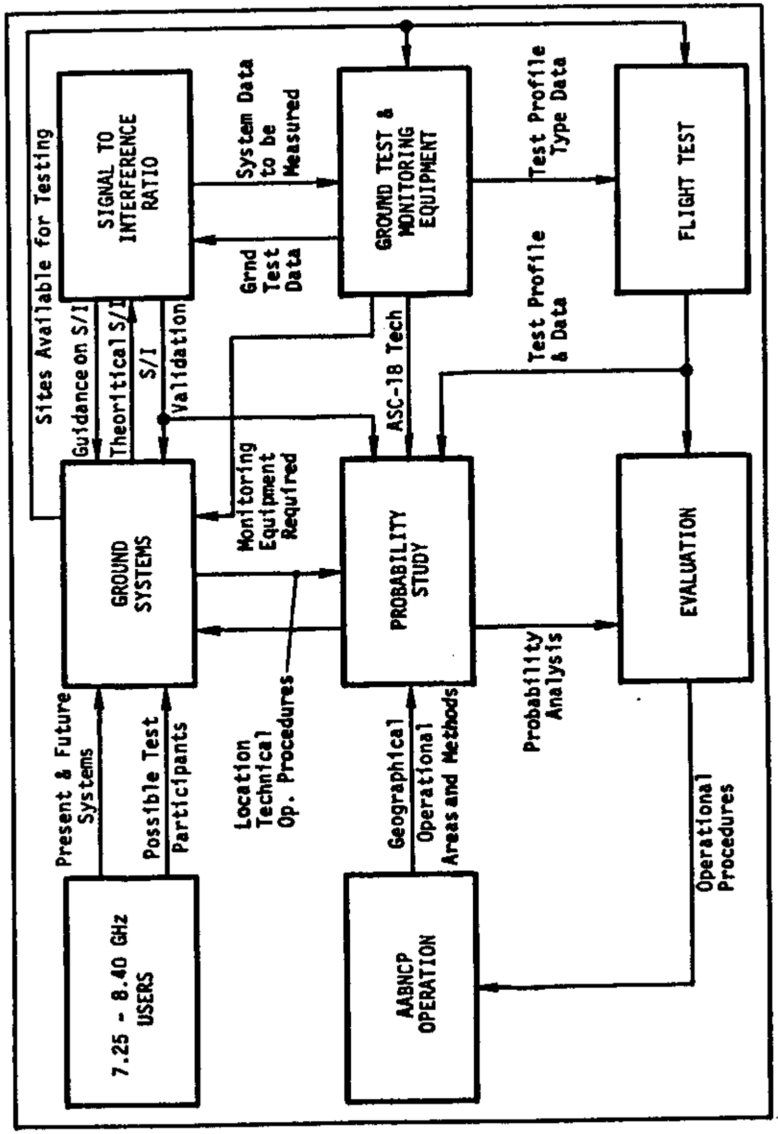



Figure 6.13 - Block Diagram for Interference Tests

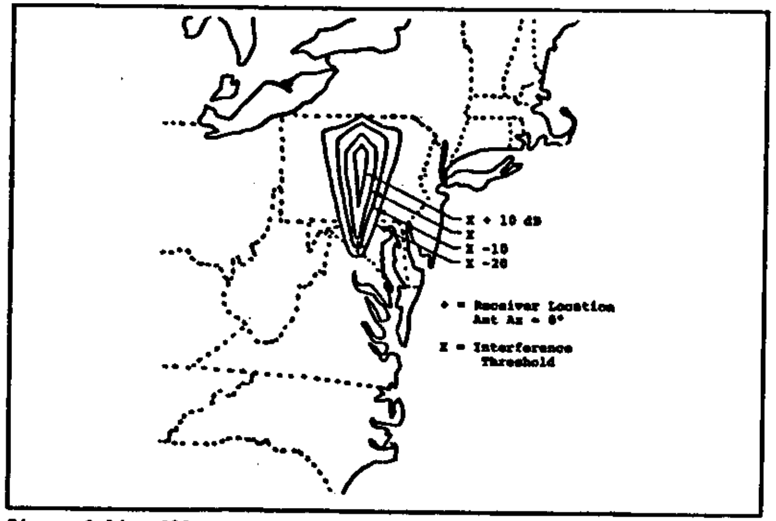



Figure 6.14 - Illustrative Co-Channel Interference Regions About A Terrestrial Receiving System.

## 6.4 PROBABILISTIC APPROACHES TO COMPATIBILITY ANALYSIS [6]

Previous sections have described techniques presently in use and being developed, which can be used to ascertain whether a particular communication-electronic system will be able to perform its intended function in the particular EM environment in which it finds itself. However, these techniques are all based on assumptions, which lead to conservative engineering judgements. These, in turn, determine how close two or more systems may be configured without unacceptable interference to each other.

There does not exist a general theory for the performance of telecommunication systems in the spectral-use environment. This situation is characterized by a number of deficiencies:

1. Lack of availability: Pertinent data are scattered under various types and classifications, etc.

2. Lack of standardization: Experimental and theoretical results obtained under a variety of more-or-less limited and incomplete criteria of measurement and performance.

3. Limitations on reliability: i.e., on the *quality* of the data: inadequate "ground truth" for adequate assessment of





performance. (e.g., missing environmental factors, inadequate modeling, and interpretation);

4. Limitations on applicability: for example, S/N criteria vs the more realistic error probability measures; optimality vs sub-optimality criteria for actual use; and lack of adequate environmental models;

5. Limitations on predictability: This is a consequence of 1 - through 4 above. Also, it is the result of the inadequacy of many current EM environmental models and predictions made therefrom;

6. Lack of decision costing and evaluation: Performance evaluations need to include the "costs" of decisions stemming from the communication process. These also are part of the more realistic criteria required for assessment, cf. 4 above.

7. Limitations on technical scope: While the single-link system (transmitter - EM environment - receiver) in the interference environment is necessarily the fundamental unit for study; the analysis techniques appropriate here need to be extended to multiple-link and inter-system structures, with particular emphasis on communication trade-offs and efficiencies, costs, and pay-offs, etc.

Attempts are presently being made to rectify these deficiencies.

Such a general theory of telecommunications systems performance would permit the determination of the characteristics of electronic communication systems of all types and applications in both actual and potential interference environments. To accomplish this will require the development of procedures, analyses, and concepts by which the necessary data base may be established and by which deficiencies of current approaches may be mitigated.

The functional relationship of the theoretical analysis to the end-product performance predictions is shown in Fig. 6.15. The physical parameters are well known.

A first step in the development of the general theory is definition of models of the EM environment. The various environmental factors are interralated in the manner illustrated in Fig. 6.16, where:

where, (a) = Single link in EM environment

(i) other intelligent links
(ii) unintelligent EM interference fields

(b) = $\sum_{i=1}^{N} T_i(R)$ multiple links incorporated as a system in an EM environment.

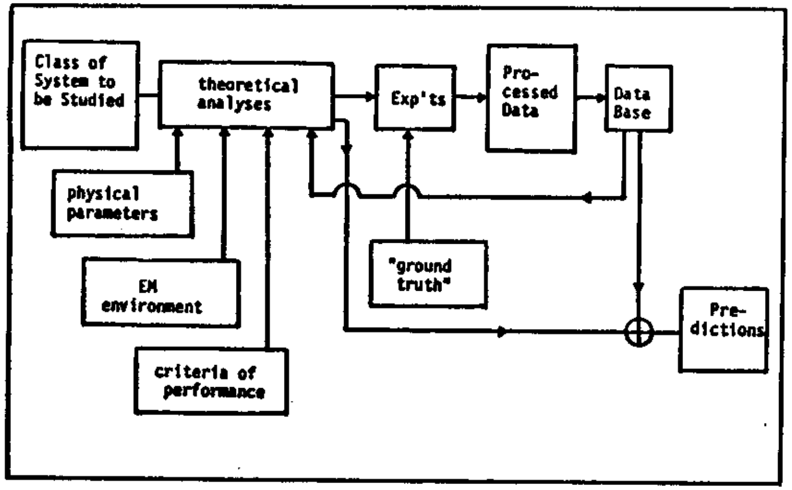



Figure 6.15 - Relation of Theoretical Analyses to End-Product: Performance Predictions

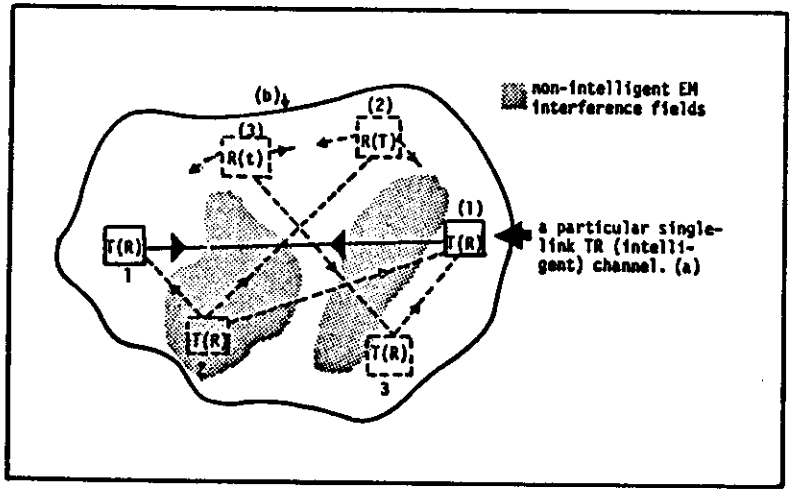



Figure 6.16 - Schematic of EM Environment; (a) and (b), above.





(i) other intelligent systems
(ii) unintelligent EM fields.

Models of the EM environment are required to indicate the relevant parameters, and to show how they appear in the underlying physics of the situation. Models 9150 tell what parameters to measure, and how significant they are as environmental descriptors. Models of the EM environment are necesary for the analysis of system performance (which are a critical part of the general data base). They are related to the basic environment parameters; e.g., the error probabilities which are used as performance measures and predictors are themselves explicit (and implicit) functions of the environment models and have been classified for EM interference as follows:

<u>Class A Interference:</u> This noise is typically narrower in spectral width than the receiver in question, and, as such, generates ignorable transient decay in the receiver's front-end (e.g., aperture-RF-IF) stages when a source emission terminates.

<u>Class B Interference:</u> Here the bandwidth of the input noise is larger than that of the receiver's front-end stages; so that transient effects, both in build-up and decay, predominate. The receiver is, to varying extents, "shock-excited"; typically for inputs of short duration.

<u>Class C Interference:</u> This is the sum of Class A and Class B interferences, which can occur either because of the presence of sources of mixed types (Class A, Class B emissions), and/or because any received emission is itself strictly Class C; i.e., there is always a build-up period and a decay transient period in any front-end receiver reaction to an input emission.

Fig. 6.17 shows typical waveforms (of the envelope) at the output of the (linear) stages of a receiver for the different classes.

The above-defined categories for interference, <u>as it impacts on a typical (narrow-band) receiver,</u> (i.e., alternatively, as the receiver responds in an EM environment), provide a useful way of describing the different types of interference and their effects on reception. The method of classification may be extended further to distinguish between man-made and natural interference, and between "intelligent" and "non-intelligent" emissions. Thus:

(i) <u>*Intelligent* noise or interference</u> is man-made and intended to convey a message of some sort;

(ii) <u>*Nonintelligent* noise or interference</u> may be due to natural phenomena (e.g., atomospheric noise), or may be man-made, but conveying no intended communications; (e.g., automobile ignition noise).

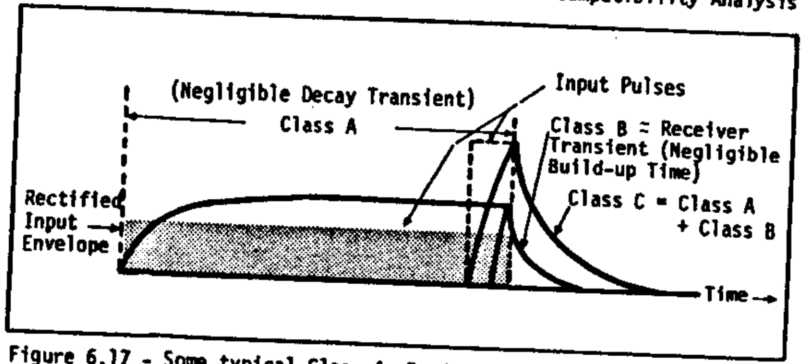



Figure 6.17 - Some typical Class A, B, & C Interference Waveforms at output of receiver (aperture x RF x IF) stages.

This section has presented excerpts of efforts presently underway which will lead to a completely generalized set of techniques for predicting the performance of communication-electronic systems in an electromagnetic environment. The development of such techniques should ultimately lead to an enhanced capability to effectively manage the radio spectrum.

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

## Part 7

## TELECOM INFORMATION EXCHANGE SERVICES - TIES

R.G. Struzak
International Telecommunication Union, International Radio Consultatiuve Committee
Geneva, Switzerland

The purpose of these notes is to provide an information about TIES. [Source: TIES User Notes 01, 02, 03, 04, 06, 09, 10, 14, 00 and 12.

These notes are for internal distribution only

# WHAT IS TIES

## 1. Objectives

The overall goal of the ITU Telecom Information Exchange Services (TIES) is to provide means for all concerned partners of the world telecommunication community to obtain up-to-date ITU-related information quickly and to exchange information and views rapidly. The use of computer-based communication services can aid participants in ITU activities by allowing effective flow and timely availability of information on regulatory, administrative and standards activities.

TIES provides participants in ITU activities and others in the world telecommunication community with access to an ensemble of computer-based communication tools and ITU-related information. TIES is a flexible platform for further services and the information resources made available via TIES will be added to in successive phases. These capabilities are important in aiding the ITU community to deal with the expected increase in CCI work, as well as regulatory and other matters.

## 2. Examples of use of TIES services and tools to meet ITU information exchange requirements

| Information exchanged (examples) | Service | TIES Tools |
|---|---|---|
| CCI contributions<br>Working texts, draft recommendations<br>Adopted texts | **Document interchange** | eMail interactive<br>eMail X.400<br>Kermit file transfer |
| Organization structure and contacts<br>Meeting schedules<br>Circular letters<br>User guide<br>Support functions | **Bulletin Board with Secretariat posting** | *ITU Info* System<br>(Videotex-like user interface) |
| Meeting announcements and notices<br>Meeting summary records and reports<br>Lists of participants<br>Development schedules (e.g. Reports)<br>Project status<br>Study Group/Working Party news | **Bulletin Board with rapporteur posting** | Conferencing System<br>(with moderator) |
| Views on texts<br>News of interest | **Bulletin Board with user posting** | Conferencing System<br>(without moderator) |
| Meeting arrangements, news, texts, etc.<br>Meeting summary records and reports<br>Document abstracts, working texts, texts status | **Messaging** | eMail interactive<br>eMail X.400<br>FAX, telex |
| CCI terminology<br>CCI book indices<br>Document abstracts<br>Document tracking<br>Directory of participants (names, addresses, telephone/FAX numbers,...)<br>Lists of participants (major meetings) | **Bulletin Board with search functions** | *ITU Info* System<br>(Videotex-like user interface) |
| Structured group discussion on subjects of common interest (e.g. traffic forecasting, alternative solutions to a question, etc.) | **Conferencing** | Conferencing system |
| International Frequency List<br>Ship and Coast Stations<br>Telecommunications Statistics<br>World and Regional Plan Data | **Information query/reply** | Database access |

## 3. Benefits of TIES

a) More efficient interaction and exchange of information between Headquarters, administrations and other partners.

b) Time savings for participants in ITU activities due to more rapid availability of documents.

c) Improvement of CCI and Administrative Conference preparatory work - speedier and potentially less costly with the use of electronic mail and computer conferencing to settle some issues in a more expeditious fashion. Use of these tools is important for the new CCI accelerated procedures, leading to faster distribution of information and possibly shorter meetings and work schedules.

d) More equitable information access and distribution, reducing the effects of postal delays.

e) Increased openness of ITU activities (e.g., the standards process), by possible inclusion of a wider base of participants in "discussions" by having access to computer-based conferencing systems of various groups - where formerly correspondence was limited to those directly active. This may be particularly attractive, for example, to participants from developing countries.

f) Possibility of specialized computer-based bulletin boards or conferencing subjects on various practical matters. Computer conference topics such as Rural Telephone Networks, Traffic Forecasting, etc. would provide source of advice and information for interested members. Participants might include ITU staff as well as experts from administrations, RPOAs and SIOs.

g) Access to databases of ITU with flexible query and extraction facilities, including updating where applicable.

h) Accessibility of an extensive library of ITU material, without the need to maintain an organized collection of this material at the member's site.

i) Rapid access to recent and previous versions of ITU texts with the query, browsing and index facilities which computers make possible. This will provide a qualitative, as well as speed, improvement in information availability.

j) Experience in the use of new telematic services, techniques for consultation and research using on-line information sources, standard query languages, open document architecture, OSI systems, etc.

k) Cost savings in document preparation due to availability of an increased part of texts in machine readable form. This will become increasingly important as the ITU makes further progress in computer assisted translation.

## 4. The TIES Concept

The general concept of TIES is an "umbrella" covering the different types of electronic information transfer and consultation which ITU may provide. Services will be made available gradually, on a schedule which maximizes synergy with other developments both at ITU (e.g., document processing system) and with outside suppliers. Expansion of usage, and guidance in emphasis and directions will also be driven by feedback from participating administrations and other users.

A key policy is to prefer practical results, on a reasonable scale, to a grandiose all-encompassing scheme. The implementation includes a sufficiently open architecture to facilitate the addition of further services as demanded and the establishment of regional TIES nodes.

Key implementation criteria are: easy user interface widely known and supported in many geographic areas, multi-language capability and documentation, support of widely available terminal equipment, and use of international standards,.

## 5. The TIES Implementation

The initial TIES services include those identified as being the most urgently required (electronic mail including X.400 and other computer based messaging) as well as database access services for which many parties have indicated a strong interest. The following services are *ready for test and use*:

- Computer-based communication
  - a) Interactive Electronic Mail
  - b) X.400 Mail Interchange
  - c) Computer-based conferencing
- *ITU Info* service (similar to videotex)
- Access to databases of telecommunication information
- File transfer (Kermit)

Future services will include:

- Integration with various telematic services such as Telex, Teletex and facsimile (short term)
- File transfer (FTAM)
- Document reference system with rich query and retrieval capabilities.

## 6. Available TIES tools

***Interactive Electronic Mail*** - may be used for messaging and for submission of documents in simple IA5 or ASCII code. In addition to simple messages these could be documents in Rich Text Format including tables, graphics, and formulas. For further information see User Notes TIES-04 and TIES-10 (TIES User Notes are available from the ITU Computer Department).

***X.400 Electronic Mail*** - allows users in organizations with their own electronic mail system or with access to a public system to send and receive ITU-related mail with their regular eMail system. Documents can also be sent this way, but as simple IA5 or T.61 text only, as the CCITT Recommendations do not currently provide for attachment of binary files. See User Notes TIES-05 and TIES-10. RTF documents, which are mapped into a stream of 7-bit ASCII characters, can be included in X.400 messages.

***ITU Info System*** - a Bulletin Board system with a Videotex-like user interface. See User Note TIES-03.

***Computer based conferencing*** - can supplement face-to-face meetings and reduce time required to achieve results. Conferences may be open to the TIES "public" or limited to authorized individuals. Entries (messages) may be posted by all participants or a conference may be set up so as to allow only the moderator to add entries. See User Note TIES-06.

***File transfer*** - means of exchanging binary files such as documents in various word processing formats. See User Note TIES-08.

***Database access*** - query, data extraction and submission for certain ITU databases, e.g. International Frequency List, Ship and Coast Stations, World and Regional PLAN.

## 7. Access to TIES

TIES provides for wide connectivity (PSTN, PSPDN) and supports a wide variety of user equipment types. ISDN support will be included when international ISDN capabilities are widespread. TIES is equally available to users in all time zones, with an initial target of 95% availability around the clock.

## 8. Costs

***TIES services are basically free of charge.***

The dissemination of some ITU databases via TIES is, in effect, electronic publishing and as such subject to pricing policies as other forms of ITU publishing. For example, the yearly cost for the on-line access to the Global Telecom Directory is the same (72 Swiss francs) as the yearly cost of the three printed editions. For the time being, the access to the Global Directory (part of the *ITU Info* service) is the only service requiring a subscription.

No communication costs, in addition to the usual ones paid by the users to their carriers, is charged by TIES.

**Acknowledgements**

The TIES design and implementation enjoys excellent technical and material support from recognized private operating agencies (AT&T and KDD) and industrial organizations (Fujitsu and, the major contributor, Digital Equipment Corp.).

# Getting Connected

The ITU Telecom Information Exchange Services (TIES) located at the ITU Headquarters in Geneva - Switzerland, is currently accessible through the public telecommunication networks, PSTN - Public Switched Telephone Network - and PSPDN - Packet Switched Public Data Networks (X.25 Packet Switched Data Networks).

Users access TIES services through asynchronous CRT terminals with ANSI control sequences (e.g., VT type terminals) or personal computers running communications software packages emulating ANSI/VT terminals.

Once connected, users get access to a menu oriented User Interface which constitutes the ITU's entry point for computer-based communications tools for information exchange. TIES offers an ensemble of services which includes for the current implementation phase: Electronic Mail, Computer-Based Conferencing, a videotex-like Info Service, Remote Access to ITU Databases, and File Transfer.

# What is needed ?

Suitable terminal equipment, either a Terminal or Personal Computer, communications arrangements (modem and access to telecommunications networks), and an Identification Code furnished by the ITU.

## EQUIPMENT REQUIREMENTS

Terminal

- An asynchronous terminal with ANSI/VTXXX (VT1XX, VT2XX, VT3XX) mode capability.
- An asynchronous serial port interface for modem interconnection.

A printer port for output and screen logging may be useful.

or

Personal Computer

- A Personal Computer running a software communications package capable of emulating one of the ANSI/VTXXX type terminals mentioned above.
- A serial asynchronous port for the modem interface, or an internally installed modem.

Connection to modems or the PSPDN through a LAN Gateway or any Organizations' central host computer systems may also be possible.

Modems

For access through the PSPDN's and PSTN users should have a modem complying with one of the following CCITT Recommendations: V.21, V.22, V.22bis, V.32 and Bell 212A. Support for Bell 103/113 may also be offered.

Users may contact their national telecommunications authority or local operator for further information and advice on obtaining and operating data communications over PSTN and PSPDN.

Generally, PSPDN users should connect in the manner and speed supported by their National or local PSPDN's. Possibilities may include dialup asynchronous modem connections to Public PAD's (X.3/X.28) at various speeds, or X.25/X.32 connection using suitable adapter cards and software, direct line modem connections or synchronous dial-up modems. Please refer to the section below that deals with the PSPDN connection requirements.

Modems can be external desktop/standalone units or, for those using PC's, they can be internal boards.

## IDENTIFICATION CODES

Users will need to have an Identification Code (Username and Password) that is personally assigned and furnished to each individual.

To receive it you must complete and sign an agreement form established by the ITU for TIES.

The Identification Codes are independent of the access method chosen by users.

The Username INFO, with no password, can be used by any person for the access to the Public Information available on the *ITU Info* service.

Computer Department, International Telecommunication Union, Place des Nations, 1211 Geneva 20, Switzerland
Telephone: National (022) 730 55 54; International +41 22 730 55 54
X.400 Address: C=CH ADMD=ARCOM PRMD=ITU S=HELPDESK
Telegram: BURINTERNA GENEVE; Telex: 421 000 UIT CH; Telefax: +41 22 730 53 37 (group 2/3)

# LOGIN PROCEDURE

**Access from PSPDN**

Users should call the following ITU TIES X.25 DTE address, on TELEPAC, the Swiss National PSPDN:

- DTE number: #228468111112

  the # symbol refers to the local PSPDN Code for international routing which is different for each local PSPDN. Please contact your Telecommunications authority.

**Access from PSTN**

Users should call the following Telephone Number for the access to ITU TIES through the International PSTN:

- Telephone number: +41 22 7337575

  which provides access to a multistandard modem interface, presently complying with the CCITT V.21, V.22, V22bis, V.32 modem Recommendations and Bell 212A.

Communication programs should be set up to allow about 30-45 seconds for pulse dialing plus modem handshake completion.

**User Identification**

A successful communications connection either through PSPDN or PSTN to ITU is recognized once the following prompts are displayed (pressing [RETURN] may be necessary to get to this message):

I.T.U. Telecom Information Exchange Services

Username:

as well as any particular messages that might be displayed, for example, by your National PSPDN (e.g. Call Connected to remote DTE 228468111112).

- To the prompt

  Username:

  answer entering your Username, as supplied by ITU, followed by [Return ]

  (e.g. Username: Smith_Junior [Return]

  or INFO [Return] - with no password needed)

- A new prompt will be displayed by the system:

  Password:

  answer entering your Password, followed by [Return]

  (e.g. Password:XXXXXX [Return])

After the call is successfully established to the ITU system, you are able to make three attempts to enter the correct combination of Username/Password. If a valid username/password has not been entered after three tries, the system disconnects the call. To make a further attempt one must restablish the call.

**Login to TIES Menu**

After a successful login, the ITU TIES system displays some messages concerning the use of your account:

- The date of your last interactive login.
- The number of failures in the combination Username/Password, if there were any.
- A message that, for legal reasons, warns that unauthorized access is prohibited. Registered TIES users, using their own Identification Codes are, of course, authorized users.
- After this, some seconds will be required for the activation of the software that allows access to the TIES Menu Interface. This Menu includes the services from TIES that one is entitled to use.
- For details on how to use the services, please consult the on-line TIES User Guide which is part of the *ITU Info* service (menu choice 50).

# USER SUPPORT

The recommended approach for support requests is the use of mail (postal, telex, facsimile, or electronic mail). Messages can be in English, French or Spanish.

Electronic mail messages should be sent to TIES user HELPDESK.

Telephone support - to be used at last resort - is also available.

TIES Users Support Service between 9:00 - 12:00am and 2:00 - 5:00pm Central European Time, Monday to Friday, excluding holidays.

ITU, Computer Department, TIES
Place des Nations, 1211 Geneva 20, Switzerland

Telephone : +41 22 730-5555 - For general TIES related questions

+41 22 730-5323 - For technical data communication questions

Telefax +41 22 730 5337

Telex 421000 uit ch

X.400 eMail Address: Country=CH ADMD=ARCOM PRMD=ITU Surname=HELPDESK

# ITU *Info*

The ITU Telecom Information Exchange Services (TIES) includes a Videotex-like service (*ITU Info*) which supports quick and easy access to a variety of ITU information.

**Getting connected**

See TIES User Note 02 for details. For best results a VT2xx/VT3xx terminal or corresponding PC-emulation program is necessary. Support of 8-bit characters is recommended for display of accented characters and basic drawing symbols.

The username **INFO**, with no password, can be used by any person to access the public information in the *ITU Info* service.

Registered TIES users access *ITU Info* from the main TIES menu. Access to some specific information (e.g. ITU Global Directory) requires a subscription.

***ITU Info* user interface**

The ***ITU Info*** access method is based on a menu driven interface which standardizes the retrieval regardless of the type of information. Keyword retrieval, when applicable, includes user instructions displayed directly on the screen. The service is partially tri-lingual (English, French and Spanish).

**Some Infobases Available**

The **Global Telecom Directory** is the official list of addresses of the ITU (members, recognized private operating agencies, scientific and industrial organizations, etc.). This is presently the only infobase which requires a subscription. The yearly cost is 72 Swiss francs. Please write to the ITU, Sales Section, to get a subscription form.

Under **CCITT** (option 22 in the main menu) one finds, for example, the index to all the volumes of the **Red Book**, the list of recommendations, etc.

The **Terminology Infobase** includes about 30,000 telecommunication terms in three working languages of the Union. Retrieval can be done from any of the three languages (English, French and Spanish).

Under **ITU** (option 20 in the main menu) one can select option 3 (**Organization**) which presents a graphical representation of the ITU organization. This is a simplified organization chart (e.g., limited by constraints of the screen size) and is not official.

Other ITU information resources (schedule of meetings, Headquaters telephone list, vacancies, list of publications, etc.) are also available. Option 50 in the main menu gives access to the **TIES User Guide**.

**Bulletin Board**

***ITU Info*** is also a form of **bulletin board**. The schedule of ITU meetings (option 2 in the main menu) and the information on Telecom (option 30) illustrate this possibility. Information relating to specific Study Groups, Working Parties or other ITU activities can readily be added to ***ITU Info***.

**Use of *ITU Info* Menus and Paging**

The use of ***ITU Info*** is very simple. The basic ***ITU Info*** functions are shown in the table at the end of this Note.

- From any menu enter the number of the choice and press **<Return>**. In this way you can go from menu to menu until the "page" with the information searched is reached.
- To return to the previous menu page press the <BackUp> key (usually the "cursor up" key).
- When the information or menu does not fit in one screen, press the **<Next Page>** key (usually "cursor right") to browse forward and the **<Previous Page>** key (usually "cursor left") to browse backwards.

**Searching by Keyword**

The **Terminology Infobase** (option 13 in the main menu) illustrates the searching by keyword. Clearly it would be impractical to reach any of the 30,000 terms by a succession of menu choices. A "direct access" to the term is necessary.

- Press the key **<Find>** (e.g. PF1 7 in a VT100 terminal)
- Enter the term in the source language (or its first letters followed by *).

  There will be either none, one or more matches. In the first case a message indicates no match, in the second case the term in the three languages is displayed and in the third case ***ITU Info*** displays a numbered list of all source terms matching the keyword given. This is called a "**dynamic menu**" from which the desired term is selected by entering the corresponding number.

- Use <Next Page> and <Previous Page> keys to browse through when the dynamic menu is composed of multiple continuation pages.

This **local keyword** search is generic and is used whenever one reaches a situation where it would be impractical to continue searching the "menu tree". In such situations, a page of instructions is displayed explaining how keywords can be used. This technique is consistently used throughout the *ITU Info* service.

**Global keywords** are also used. They provide a good way of exploring the contents of the *ITU Info* service. They are usually associated with important menus which start a particular branch of the *ITU Info* Videotex-like "tree". A global keyword is distinguished from a normal one by the presence of a special starting character (?). For example, regardless of where one is, by pressing <Find> and entering ?ORG* one would get a numbered list of all pages (usually menu pages) dealing with ORGANIZATION (e.g., "ITU Organization", "CCITT Organization", etc.) as well as any other pages indexed with other terms starting with "ORG". By entering the number of the choice one can go directly to the corresponding branch. By pressing <Find> and entering ?* one gets a list of all global keywords and corresponding page titles which is the "**table of contents**" of the *ITU Info* service.

**Exiting *ITU Info***

**Press PF1** followed by . (the "period" in the main part of the keyboard).

**Basic *ITU Info* keyboard functions**

| Function | Description | VT320/220 | VT100 | User | Minitel |
|---|---|---|---|---|---|
| *HELP* | General help | Help | PF2 | | * GUIDE |
| *PAGE HELP* | Page specific help | PF1 PF2 | PF1 PF2 | | GUIDE |
| *MAIN* | Go to main menu | PF1 PF3 | PF1 PF3 | | *SOMMAIRE |
| *EXIT* | Exit *Info* | PF1 . | PF1 . | | CONNEX/FIN |
| *FIND* | Retrieval by keyword | Find | PF1 7 | | * ENVOI |
| *BACKUP* | Go to previous menu | Cursor up | PF3 | | SOMMAIRE |
| *NEXT PAGE* | Go to next page | Cursor right | PF4 | | SUITE |
| *PREV.PAGE* | Go to previous page | Cursor left | PF1 PF4 | | RETOUR |

In the column "User" you may enter the keys which apply to your situation. If you are using a VT emulation program, check the documentation carefully before logging to *ITU Info* (e.g. position of PFi keys).

**Typical mappings of the basic *Info* functions on keys of an IBM enhanced keyboard**

| Program | PF1 | PF2 | PF3 | PF4 | Help | Find |
|---|---|---|---|---|---|---|
| PROCOMM | F1 | F2 | Shift F1 | Shift F2 | F2 | F1 7 |
| CROSSTALK* | F1 | F2 | F3 | F4 | F2 | F1 7 |
| DEC VT320* | Keypad / | Alt Kp / | Keypad * | Keypad - | Alt Kp / | <Home> |
| DEC SETHOST | NumLock | Keypad / | Keypad * | Keypad - | Keypad / | <Home> |
| REFLECTION 2 | NumLock | Keypad / | Keypad * | Keypad - | Keypad / | <Insert> |
| User | | | | | | |

* MS-Windows versions Kp : Keypad

You can enter in the line "User" the keys which apply to your situation. The emulators mentioned for illustration do not have any particular preference. There are dozens of ANSI/VT emulators in the market for different hardware plataforms.

Please address your **suggestions and comments** to:

ITU Computer Department
Place des Nations
1211 Geneva 20
Switzerland

Telefax:+41 22 730-5337
Telex: 421 000 uit ch

*X.400 eMail Address*

Country=CH
ADMD=ARCOM
PRMD=ITU
Surname=HELPDESK

# Interactive Electronic Mail

**TIES eMail Services**
Electronic mail, also known as "interpersonal messaging," is the TIES service by which an individual can exchange messages with other individuals or group of individuals. TIES offers two types of electronic mail: interactive electronic mail, disscussed in this note, for users who choose to send and receive their TIES electronic mail while connected to the TIES system, and X.400 message exchange for users who wish to exchange TIES messages via their organization's own electronic mail system. X.400 electronic mail is discussed in a separate note. Reference information on electronic mail as well as other TIES services can be found in the TIES Info On-line User Guide.

**Starting up TIES Electronic Mail**
To use the interactive electronic mail, connect to the TIES host following the procedure described in TIES User Note 02 - "Getting Connected." After logging in with your individual TIES User Identification, select "EM" - Electronic Messaging on the main TIES menu. A menu specific to Electronic Messaging will then be presented. The commands available on the menu are described later in this note. In addition to the menu of commands, the current message ("document") is identified in the upper-right corner of the screen. The identification includes the name of the folder holding the message ("document"), the message title, the date of last modification, an automatically attributed number uniquely identifying each message and the status of the message.

**Folders to store messages**
Messages are kept in electronic "folders." The system automatically handles 5 folders:

- Inbox: to receive incoming mail
- Read : to store messages after reading
- Created : to prepare outgoing mail
- Outbox : to store messages after they are sent
- Wastebasket : to temporarily hold messages after they are deleted

Each user can sort and refile his messages in his own set of folders. A new folder is created by specifying a new folder name when creating or moving a message. There is no restriction on the number of folders per user, or the number of documents per user, but there is a limit on the total amount of storage space available for each user. Users are advised to handle messages carefully, with a well structured filing plan and regular deletion of outdated documents.

**Storing messages on your PC**
Users with PCs may prefer to copy their messages to the PC using their PC communications software "download" or "receive file" feature. The messages should then be deleted from the TIES mail system. In the future a PC program will be available which automates exchange of mail between PCs and the TIES host.

**Electronic Mail Menu Commands**
The main electronic mail menu offers a choice of commands and then prompts:

Enter option and press RETURN

Enter the one to three letter code for one of the commands, and then press "Return"

The purpose of each command in the main electronic mail menu is:

| | | |
|---|---|---|
| **C** | Create | write a new message |
| **E** | Edit | revise a message which has already been created |
| **D** | Delete | delete a message that is no longer needed |

(commands continued on next page)

| | | |
|---|---|---|
| **P** | Print | print a copy of the current message |
| **R** | Read | Read (display) the current message |
| **I** | Index | display a list of messages - may select by folder or subject |
| **RI** | Recall index | display the last index |

| | | |
|---|---|---|
| **RN** | Read New Mail | read any new mail messages which may be waiting |
| **A** | Answer | create a new message replying to the current message |
| **S** | Send | send out the current message which was created or edited |
| **F** | Forward | Forward a message to another TIES user |
| **TR** | Training | computer based training on the use of the electronic mail system |
| **M2** | Electronic Mail-2 | more mail commands on Electronic Mail-2 menu |

there are also commands to select a message or folder:

| | |
|---|---|
| **SEL** | to select a specific message from any folder |
| **II** | to select the "Inbox" folder of incoming mail not yet read |
| **IR** | to select the "Read" folder of messages which have already been read |
| **IC** | to select the "Created" folder of messages which were created but not yet sent |
| **IO** | to select the "Outbox" folder of messages which have been sent |

**Displaying and answering incoming messages**
If any messages have been sent to you, the information "n NEW MAIL MESSAGES" will appear next to EM on the main TIES menu, and at the top of the Electronic Mail menu. To see the new mail, type "RN" and Return. The message will be displayed (if there is more than one screen of text, pressing Return will cause successive screens to be displayed). After reading the message it can be answered by using the command "A", forwarded to another user with the command "F", filed in another folder, copied down to your PC (using the "download" or "receive file" facilities of your terminal emulation program), printed on a printer attached to your PC or terminal, and finally, deleted from your TIES account by using the "D" command.

**Creating and sending a mail message**
To create a new message press "C" and Return. A form to enter the recipients (TO), copy recipients (CC), SUBJECT of the message, and delivery instructions will appear. On each TO or CC line an individual recipient name or the name of a distribution list may be entered. After entering the first letter or letters of a name, pressing Return (or FIND, or PF1 L) will cause the name to be completed if it is unique, or a list of matching names to be displayed if it is not. Use TAB to move to the next area of the form. After entering recipient names, enter the Subject of the message.

Pressing Return will then activate the editor. Type in the message, or upload it from your PC. The editor allows corrections to be made with the backspace key, or DEL W to delete words. Blocks of text may be removed or copied by using the SELECT key to select and then shade the desired text by moving the cursor. Pressing DEL deletes the text, copying it to a buffer. The cursor may be re-positioned and the text inserted elsewhere by pressing Insert. More detailed information is available in menu entry 31 of the on-line TIES User Guide, or by requesting Help (PF1 H) while editing.

When the text of the message is complete, press PF1 and F (or press once CTRL/Z simultaneously then type "exit" and press Return) to leave the message editor and return to the mail menu. The message has now been created and filed. Press "S" and Return to send it.

**Additional mail commands**
More mail commands are available by pressing "M2" and then M3 Use the "Exit Screen" key to return to the previous menu page. Of particular interest is the command MH (Modify message Header) to modify recipients, subject or delivery instructions of current message

Information on all the menu pages is in the on-line TIES User Guide (50 in main menu of ***ITU Info*** service; a tutorial is provided via the Electronic Mail Training ("TR") option.

# Computer-based Conferencing

## 1. Introduction

TIES offers Computer-based Conferencing (CC) as a group communications oriented computer service. It allows TIES users in different geographical locations and time zones to participate in computer-mediated discussions on specific subjects. It offers everyone an equal chance to participate and at a time most convenient to each individual. It also provides a structured record of the discussions for latecomers to read.

TIES CC is designed to supplement face-to-face meetings. Entries posted by participants in a "conference" may be read and discussed (e.g. comment, reply, make suggestions, raise new topics, etc.) by the authorized audience.

Being an effective way to disseminate information, present ideas and receive public or group reaction, this tool is proposed as a TIES service not only in the format of a Bulletin-Board system, but also to facilitate group communications around a topic, a document, a question, preparation for Study Group meetings, or other matters.

## 2. Basic Concepts

Typically each "computer-based conference" deals with a certain number of topics, has a designated moderator, and participants who may comment on existing topics.

The setup is quite flexible and allows for conferences to be established in different ways:

- generally available to the TIES "public";
- restricted to authorized participants;
- bulletin board where entries may be posted only by the moderator or a restricted group of authorized individuals, but offering read-only access to a larger audience;
- bulletin board on which any participant may post entries.

The system controls participant authorization, organizes the comments around the different topics, keeps track of unread messages of each participant, interfaces with the electronic mail system, etc.

Moderator -The moderator is the individual authorized to create conferences, add members to restricted conferences, delete members and perform coordination and "housekeeping". He maintains the conference under its objectives and context (e.g. by opening new topics), deletes or "hides" members' inappropriate replies or suggestions, and promotes discussions.

Notebook - The first time each TIES user accesses the Computer-based Conferencing service an electronic notebook is created. It holds information such as the names of the conferences you have joined and are interested in and keeps track of what information you have already seen in each conference.

Entry - A conference added to your notebook is referred to as an entry. An entry can be accessed by using the appropriate commands and specifying the name of the entry.

Topics/Notes - Within a conference a topic is a major item of discussion. Topics may be established by the moderator, or by participants, depending upon how the conference is set up. A conference might have several topics. Participants' comments to the topics are called **Replies**. Topics and replies are numbered and referred to collectively as Notes. Each topic and its associated replies constitute a **Discussion**. The user chooses which topics and replies he wants to read at any time.

**Keyword** - Keywords are used to group conference notes dealing with the same subject. For example, a keyword such as *satellite* could group all notes dealing with satellite. For each topic you can list all the keywords that were assigned. Normally the right to assign keywords to notes belongs to the moderator.

**Marker** - Is a word or phrase that you associate with a particular note so that you can refer to the note by the word or phrase instead of its note number. Markers must be unique within an entry.

## 3. Activating Computer-based Conferencing

To use the Computer-based Conferencing service, connect to the TIES server following the procedure described in TIES User Note 02 - "Getting Connected". After logging in with your individual TIES User Identification, select the option "CC" - VAXnotes Computer-based Conferencing on the main TIES menu.

The system responds with a prompt - **Notes>** . At this point you are at the Notebook level. You can now proceed by entering any of the commands as described below, or by getting on-line Help by typing **Help** and pressing **Return**.

## 4. Getting Started Commands

Help - To get on-line help on the use of various commands. It supplements the present User Note and provides a complete list of available commands, their syntax and allowed qualifiers, and a full description of the functions for each of them.

Help ***command*** to get direct instructions on the use of the *command*.

You can abbreviate commands to the fewest unambiguous characters (e.g. Directory can be abbreviated to Dir).

### 4.1. Listing available conferences on TIES

**Directory/Conferences** - To display a listing of all TIES public conferences or conferences added to your Notebook and to which you have authorized access. All TIES users have access to a public sample conference named NOTES$SAMPLE. It is suggested that first time users follow it to get acquainted with the system.

### 4.2. Accessing a Conference

To access a conference for the first time, you have to start by adding it to your notebook, and then by opening it. Subsequently, just issue an Open command to access any conference previously added to your notebook.

Add Entry ***conference-name*** - To add a conference to your Notebook. ***conference-name*** is the name of a conference for which you have authorized access. Please obtain the conference-name(s) from the moderator designated for your specific group of users within the TIES community.

**Open** ***conference-name*** - Opens a conference that was previously added to your Notebook. *conference-name* must be a name from the list provided by the **Directory/Conferences** command. After opening a conference the system immediately announces the number of notes that you have not yet seen under it. *Conference-name* may be abbreviated to the fewest unambiguous characters.

## 4.3. Navigating in a Conference

After opening a conference, there are various commands to select and view the conference content. Type the command at the "Notes>" prompt.

| | |
|---|---|
| **Dir** | for a list of topics in the conference |
| **Dir/All** | to see the titles of replies as well the topics |
| **Dir nn.*** | to see the titles of replies to topic number **nn** |

You can navigate through a conference by specifying which notes you want to read, which discussions you want to skip. You can read a particular note by typing the note number at the note prompt:

Notes> **aa.bb** or **Read aa.bb** where **aa** stands for the topic number and bb (preceded by a decimal point) stands for the bb<sup>th</sup> reply to topic **aa**.

**Next** - Displays the next reply to the current topic. **Back** - Displays the previous reply to the current topic. **Last** - Displays the last topic in the conference. **Next Topic** - Displays the next topic. **Back Topic** - Displays the previous topic. **Next Unseen** - To force the system to display the next note that you have not yet seen. **Return** or **Enter keys** - If the current note is more than a screen, **Return** or **Enter** will cause the next screen to be displayed. The next reply is displayed if you are at the end of the current note and you press either **Return** or **Enter**.

**CTRL/Z** or **EXIT** - Used to signal the end of an activity. It will exit a conference and return you to your notebook.

## 4.4. Participation in a Conference

You can actively participate in a conference by replying to conference notes and by raising new topics for discussions. The commands below will enable you to perform these tasks.

**Reply** - To add a reply to a discussion. You can be anywhere in the discussion, and do not have to be reading the topic or the last reply. Your reply would be added as the last one in the discussion. The **Answer** and **Reply** commands are synonyms and can be used interchangeably. First read the note you want to comment on (e.g. Notes> **Read aa.bb**) and then issue the command **Reply**.

Once you have issued the command the system starts the text editor **EDT** (see TIES User Note 07 or the on-line TIES Guide) and inserts the content of the note in the editor buffer. This allows you to re-read the note while commenting. At the end you must delete it from the buffer and just leave in the buffer the text you have inserted. Press **CTRL/Z** to leave the editor, enter a title for your reply, and answer the final prompt asking whether your reply is ready to be written.

**Write** - To start a discussion on a new topic. If the item to be added is not germane to any existing topic - but is on the general subject of the conference - it should be entered as a new topic. In some conferences this is a function available only to Moderators. Regardless of where you are in the conference, the new topic will be added as the last one. After entering the text through the editor, **EDT**, press **CTRL/Z** to end editing. You will be required to enter a title for the new topic, and answer the final prompt asking whether your reply is ready and should proceed to write it.

**Write** ***filename*** or **Reply** ***filename*** allows you to use the text contained in a previously prepared text file stored in your current default directory. The section below on how to edit replies and topics explains how to prepare replies off-line.

### 4.4.1. Editing Replies and Topics : Hints

There are multiple ways for a TIES user to edit and add replies or topics to a conference:

- By going directly to the discussion and preparing the reply "**on-line**" using the **EDT** editor. This is as described in the section above. Help in using the editor is part of the on-line TIES Users Guide. An EDT Editor TIES User Note is also available..

- By "**uploading**" a previously prepared text file from your local equipment (e.g. personal computer). Go directly to the discussion and activate the EDT editor as if you were preparing an on-line reply. Then upload the text file from your local equipment by activating the upload function of your communications package. You can further edit your reply using the EDT editor.

  On a PC you can use any editor that produces an ASCII output.

- By using the text contained in a previously prepared file, which you have stored in your TIES default directory through "**File Transfer**", "**Electronic Mail**" or "**Database Extract**":

  . Through **File Transfer** the text file is "**sent**" from your local equipment to your TIES **default** directory by using any of the file transfer protocols offered by TIES (e.g. Kermit).

  . Through **Electronic Mail** the text file is extracted from the body part or enclosure of a received mail message and "**filed**" in your current default directory.

  . Through **Database Extract** on the Videotex-like *ITU Info* service or on the Computer-based Conferencing service, which offers mechanisms to extract information.

The TIES Main Menu option UTIL / FM "**File Maintenance**", allows users to delete, get the index and type the contents of files stored in the users TIES default directory.

## 5. Other commands and hints

The following commands will enable you to perform other specific functions on notes and interface the conferencing system.

**Directory** - To list conference notes. This command has qualifiers (see **Help Directory**) enabling to list notes according to the user's specifications.

**Directory/All** - To list all replies and topics in the directory.

**Directory/Author=*username*** - Lists notes written by the specified user.

**Directory/Unseen** - Lists notes that you have not seen.

**Save *file-name*** [***note-range*** ] - Saves notes in the indicated note-range into the indicated file (e.g **Save *mynotes.txt* 1.*-8.*** will save topics 1 to 8 and their replies to the current conference in the file ***mynotes.txt***) on your default directory. **Save *mynotes.txt* 1-8** will save the topic entries only, without replies. The extracts are normally ASCII text files. The **Extract** and **Save** commands are synonyms and can be used interchangeably.

The **Save** or **Extract** function combined with the **File Transfer Utility** option "FTU" - on the TIES Main menu enables you to transfer, "**download**" or "**Get**" any file from your TIES default directory to the remote PC or Host you are using for access to TIES. Through **Electronic Mail** the saved file can also be "**mailed**" as an enclosure or included in the message's body to any other TIES users or correspondents.

If you access TIES through a PC, you can also "**download**" or "**log**" the contents of the computer conference notes to your local disk through the appropriate functions of your communications package, by selecting and logging specific parts of the conference while you are reading and "browsing" through it. You can also use the **Save/Append** function to extract locally on TIES, into a single file, the contents of the notes you are interested. You would afterwards, with the option from the TIES Main Menu - UTIL / FM - File Maintenance, read the entire file on TIES and in a one time action "download" the saved file to your remote PC, again through the appropriate function of your communications package. After downloading the file to your PC remember to delete it from your TIES default directory.

Delete Note ***note-number*** - To delete the note whose number is specified in *note-number*. If no number is specified, the note you are currently reading will be deleted. The system prevents you from deleting someone else's note. However, the conference Moderator might have the privilege to delete any note.

Print [***note-range***] - Remote TIES users should not attempt to use the Print function. Remote users would currently be able to "log" the notes being displayed on screen to an auxiliary printer if using a "dumb" terminal equipped with a printer, or directly to a printer or to a local file for later printout if using a PC.

Users on the ITU Headquarters LAN (TELnet) are able to specify the appropriate output queue when printing.

**Show** - Displays informational messages about the current conference. To find out the name of the Moderator(s) of the current conference, type **Show Moderator**. To know all the members of the conference, type **Show Member**. **Show Marker** and **Show Keyword** are also possible for a given entry.

Add Marker ***mark-name*** [***aa.bb***] - To add a marker to the note you are currently reading or to the note aa.bb.

Read/Marker ***mark-name*** - To display the note marked with the specified marker name.

Delete Marker [***marker-name***] - To delete a marker from the current entry.

Delete Entry [***entry-name***] - To delete an entry from your Notebook.

Forward - Forwards the note you are currently reading using the Electronic Mail utility. The system prompts you for the address of the correspondent. You have to enter it in the format:

**0::MRGATE::"A1::*Username*"**

(e.g. 0::MRGATE::"A1::ROBERTSON" )

The system automatically inserts the note contents into the EDT editor and gives you the option of prefacing it with a message that you type on-line with the editor EDT or upload from your PC.

**Forward/Members** - Forwards the note by e-mail to all the conference members.

**Send/Author** - To send a mail to the author of the note you are currently reading.

**Set Profile** - To change the settings in your profile. Please see the allowed qualifiers through the Help function. You are strongly warned not to change the default editor (EDT is the editor officially supported in the TIES environment) and the default printer setup.

**Set Seen** - Sets notes you have not yet read as "seen".

## 6. Ending a Computer-based Conferencing Session

First close the conference and then exit from Computer based-Conferencing and return to the TIES main menu.

**Close** - To leave a conference and return to your notebook. After this command, another conference can be opened.

**Exit** - To exit Computer-based Conferencing and return to the TIES main menu.

## 7. Quick Summary of Basic Commands and Qualifiers

### 7.1. Control Key sequence for command line editing

| CTRL Key | Action |
|---|---|
| CTRL/A | Switches between insert mode and overstrike mode. |
| CTRL/B | Recalls up to 20 previously entered commands. You can also use the up and down arrows to scroll through previously entered commands. |
| CTRL/E | Moves to the end of the command line. |
| CTRL/H | Moves to the beginning of the command line. |
| CTRL/J | Deletes the previous word. |
| CTRL/U, or CTRL/X | Deletes the command from the current cursor position to the beginning of the line. |

### 7.2. Notation for Specifying Notes and Note-Ranges

| Notation | Specification | Example |
|---|---|---|
| n or n.0 | A single topic | 12 or 12.0 |
| n.r | A single reply to topic n | 4.9 |
| n-m | Topics only from n.0 to m.0, inclusive. | 12-18 |
| * or ALL | All the topics in the conference | * or ALL |
| .* or .ALL | All replies to the current topic | .* or .ALL |
| n.* or n.ALL | All replies to topic n | 12.* or 12.ALL |
| n1.r1-n2.r2 | A range of notes, including all replies | 5.2-17.4 |
| *.* or ALL.ALL | All topics and all replies in the conference | *.* or ALL.ALL |

### 7.3. Basic Dictionary of Commands and Qualifiers

| Format | Qualifiers/Specification |
|---|---|
| ADD ENTRY *entry-name* | Adds a new entry to your notebook. *Entry-name* can be a conference name as given at creation time or a conference file specification.<br>/FILE=*filename* - To invoke the conference by specifying the filename.<br>/NAME=*entry-name* - Can be used to specify an alternate name for the entry. |
| ADD MARKER *marker-name [note-ID]* | Adds a marker to the current or specified note in the current entry. |
| ANSWER *[filename]* | Enters a reply to the current topic or reply.<br>/[NO]EDIT - Specifies whether or not to invoke the editor.<br>/[NO]EXTRACT - Specifies whether or not to include the current note into the editor buffer.<br>/LAST - To re-use the most recent editor buffer contents, for further editing. |
| BACK | Displays the previous reply in the current discussion. |
| BACK NOTE | Displays the note previous to the one you are currently reading. |
| BACK REPLY | Displays the previous reply for the current topic. |
| BACK TOPIC | Displays the topic previous to the one you are currently reading. |
| CLOSE | Closes the currently open conference. |
| DELETE ENTRY *entry-name* | Deletes an entry from your notebook. |
| DELETE MARKER *marker-name* | Deletes a marker from the current entry. |
| DELETE NOTE *[note-ID]* | Deletes a reply from the conference. You must be its author. |
| DIRECTORY *[note-range]* | Displays a directory for the currently open conference or, if none, of your notebook.<br>/ALL - Includes all topics and replies to the list.<br>/AUTHOR=*username*- Lists only notes written by the specified user.<br>/BEFORE=*date-time* - Lists only notes entered before the date-time specified.<br>/KEYWORD= *keyword-name* - Lists only notes or replies having the specified keyword.<br>/OUTPUT=*filename* - Specifies the output file for the output of the directory command.<br>/SINCE=*date-time* - Lists notes entered since the date-time specified (dd-mmm-yyyy:hh:mm:ss).<br>/UNSEEN - Lists only notes you have not yet seen. |
| DIRECTORY /CONFERENCES | Displays a directory of conferences you are allowed to access, and indicates which conferences you are not allowed to access.. |
| DIRECTORY /ENTRIES or DIRECTORY /NOTEBOOK | Displays a listing of the entries in your notebook. |
| EXIT | Exits from the current conference or computer-conferencing system. |
| EXTRACT *output-file [note-range]* | Creates a text file in your default directory containing the specified note or range of notes.<br>/ALL - Specifies that topics and replies in the desired range are to be extracted.<br>/APPEND - Appends the extracted notes to the output file.<br>/AUTHOR=*username*- Extracts only notes entered by the specified user.<br>/BEFORE=*date-time*- Extracts only notes entered before the specified date-time.<br>/[NO]HEADER - Specifies whether or not to include the note header in the extracted output.<br>/SEEN - Marks the extracted notes as seen.<br>/SINCE=*date-time*- Extract only notes entered since the specified date-time (dd-mmm-yyyy:hh:mm:ss).<br>/UNSEEN - Extracts only unseen notes. |
| FORWARD | Forwards a copy of the note you are currently reading using the electronic mail utility.<br>/[NO]EDIT - Specifies whether or not the system puts you on the editor to include a message.<br>/[NO]HEADER - Specifies whether or not to include the note header at the top of the mail message.<br>/LAST - To retrieve the text of the last mail message sent.<br>/MEMBERS - Forwards the note to all the conference members. |
| HELP *[command]* | Displays the list of commands for which on-line help is available, or displays on-line help for a particular command. |
| LAST | Displays the last topic in the conference. |
| .LAST | Displays the last reply to the current or specified topic. |
| MARK *marker-name [note-ID]* | Marks the current or specified note in the current entry. |
| MODIFY ENTRY *entry-name* | Modifies information for a notebook entry.<br>/FILE=*new-filename* - Changes the note file specification.<br>/NAME=*new-entry-name* - Changes the entry name from the old name to the new one specified. |
| NEXT | Displays the next reply. |

| | |
|---|---|
| NEXT NOTE | Displays the note following the one you are currently reading. |
| NEXT REPLY | Displays the reply following the one you are currently reading. |
| NEXT TOPIC | Displays the topic following the one you are currently reading. |
| NEXT UNSEEN | Displays the next unseen note. |
| OPEN *entry-name* | Opens a conference in your notebook. |
| PRINT *[note-range]*<br><br>***PRINT is reserved for TELnet users at ITU Headquarters***<br>***Other TIES users should use EXTRACT and down-load the file to their local system for printing*** | Prints the specified note or range of notes.<br>/ALL - Prints all topics and replies in the specified range.<br>/AUTHOR=*username* - Prints only notes entered by the specified user.<br>/BEFORE=*date-time* -Print notes entered before the specified date-time (dd-mmm-yyyy:hh:mm:ss) only.<br>/COPIES=n<br>/QUEUE=queue-name - Specifies a print queue to which the specified notes will be sent.<br>/SEEN - Marks the printed notes as seen.<br>/SINCE=date-time - Print notes entered since the specified date-time (dd-mmm-yyyy:hh:mm:ss) only.<br>/UNSEEN - Prints only unseen notes.<br>/[NO]WAIT - Specifies whether to print immediately or wait until you exit the system. |
| READ *note-ID* | Displays the specified note. |
| READ/MARKER *marker-name* | Displays the note marked with the specified marker name. |
| REPLY *[filename]* | Enters a reply to the current topic or reply.<br>/[NO]EDIT - Specifies whether or not to invoke the editor.<br>/[NO]EXTRACT - Specifies whether or not to include the current note into the editor buffer.<br>/LAST - To re-use the most recent editor buffer contents, for further editing. |
| SAVE *filename [note-range]* | Synonym of command EXTRACT. |
| SEND *[filename]* | Sends a mail message to one or more users without leaving the conferencing system.<br>/AUTHOR -Sends the message to the author of the note you are currently reading.<br>/[NO]EDIT - Specifies whether or not to invoke the editor.<br>/LAST - To re-use the most recent editor buffer contents, for further editing.<br>/MEMBERS - Sends the mail message to all the conference members. |
| SET NOTE *[note-ID]* | Sets attributes for the specified note. Only the moderator or the author of a note can use it.<br>/[NO]HIDDEN - Specifies whether users can display this note.<br>/TITLE="*string*" - Sets or changes the title to the string you specified.<br>/[NO]WRITE - Specifies whether users can enter further replies to this topic. |
| SET PROFILE | Sets information in your profile.<br>/[NO]AUTOMATIC[={DIRECTORY\| UNSEEN}] - Specifies whether an automatic directory or next unseen command is issued when you open an entry.<br>/PERSONAL_NAME="*string*" - Sets a personal name which would appear in the heading of topics and replies you enter.<br>/PRINT="*qualifier-list*" - See the list of possible qualifiers through the help facility. |
| SET SEEN | Sets notes you have not yet read as seen. This is useful when you are first joining an active conference and you want to limit the quantity of notes shown by the NEXT UNSEEN command.<br>/BEFORE=*date-time* - Selects and marks as seen the notes entered before the date time. |
| SHOW CONFERENCE | Shows information about the current conference. |
| SHOW ENTRY | Shows information about the specified entry. |
| SHOW ERROR | Shows the full text of the last error message. |
| SHOW KEYWORDS *[keyword-name]* | Shows information about keywords in the current conference.<br>/ALL - Lists all keywords for the current conference.<br>/FULL - Displays a listing of all notes that refer to the specified keyword. |
| SHOW MARKER *[marker-name]* | Shows information about the specified marker or all markers for the current entry.<br>/ALL - Shows all markers, and the note number marked by each, for the current entry. |
| SHOW MEMBER *[username]* | Shows information about the specified members in the current conference.<br>/ALL - Shows information for all members in the current conference.<br>/MODERATOR - Shows only users who have moderator privilege. |
| SHOW MODERATOR | Shows the name of the moderator for the current conference. |
| SHOW NOTE *[note-ID]* | Shows information about the specified or current note.<br>/KEYWORDS - To see the keywords that are associated with the note. |
| SHOW PROFILE | Shows your current profile settings. |
| TOPIC | Displays the topic for the current discussion. |
| UPDATE *[entry-name]* | Queries the specified entry to determine whether or not it contains notes you have not yet seen. |
| WRITE *[filename]* | Enter a new topic in the conference.<br>/[NO]EDIT - Specifies whether or not to invoke the editor.<br>/LAST - To re-use the most recent editor buffer contents, for further editing. |

# TIES Document Exchange

## Purposes, Shared Folders, User Groups

### 1. Purposes

TIES Document Exchange provides simple means for participants in ITU activities to:

- search and view documents;
- download documents to the participant's PC;
- submit (upload) documents to ITU Headquarters;
- exchange documents with other participants.

Section 3 enumerates several other applications of this TIES service.

TIES User Note 15 (*TIES ALL-IN-1 User Interface*) is prerequisite reading to the use of the facilities described in this note.

### 2. Features

TIES Document Exchange includes the following features:

- documents stored in well organized file cabinets and folders for easier retrieval;
- keyword indexing for additional retrieval possibilities;
- support of IBM-compatible or Macintosh personal computers with the appropriate VT emulation program (e.g., Reflection or Kermit) or other computers with communications software such as Kermit;
- a TIES **document** is an e-mail message, an ASCII text, a word processing file (e.g. Rich Text Format, Word for Windows, WordPerfect, etc.), a computer program (e.g., the Kermit emulation package, etc.). The usual sense is of a document in ASCII or in Rich Text Format (please see TIES User Note 10: *Document Interchange Formats*).

### 3. Uses

Uses of the TIES Document Exchange include the following:

- exchange of documents among members of a group;
- dissemination of working documents (e.g., from a Chairman/Rapporteur to the members of the particular group);
- access to documentation being prepared for a meeting;
- dissemination of document templates (e.g., for Word for Windows templates) to interested TIES users;
- dissemination of computer programs (e.g. Kermit package to access TIES, CCIR technical programs).

### 4. Folders and File Cabinets

The TIES Document Exchange uses standard possibilities of the ITU ALL-IN-1 software which provides the common user interface to the TIES services. Please see TIES User Note 15.

### 5. Shared Folders

Each TIES user has a default file cabinet containing all his/her folders - the five standard e-mail folders (INBOX, READ, CREATED, OUTBOX, WASTEBASKET) - and any other folder created by the user. All these folders in the user's default file cabinet are **private**, only accessible by the specific user.

TIES users also have access to **shared folders** containing information which can be shared. Examples of shared folders are those containing CCITT documents (circular letters, white documents, temporary documents, etc.), TIES documents (TIES User Notes, last version of Kermit program, etc.), CCIR programs, etc. Shared folders are usually stored in file cabinets ("**shared file cabinets**") of special TIES accounts set up for this purpose. You must know the name of a shared file cabinet in order to access the shared folders as explained in section 8. For example, [TIES] is the name of a public shared file cabinet, "public" meaning that it is accessible to all registered TIES users.

The following are shared file cabinets which are or could be made available:

CCITT for generic CCITT information (e.g. Circ. Letters)
CCITT.SG.II for CCITT Study Group II information
TIES for generic TIES information

### 6. User Groups

A TIES **user group** is a subset of TIES users who have something in common. For example, the participants in the activities of a CCITT Study Group form a **user group**. Often there is no need to explicitly specify in TIES that a specific user belongs to a particular user group. This is the case when the group decides to use electronic mail for the exchange of any non-public information. In this situation the use of distribution lists facilitate the sharing of information. Once a text worked by the group becomes an official document, it can be posted in the respective shared folder (e.g. shared folder **White** in the file cabinet CCITT.SG.III). The concept of open shared folders is in line with directions towards increased openness and transparency of ITU activities.

**Closed user groups** can be created on special demand when there is a need for restricted read access to the information. The number of closed groups will have a direct impact on the workload of TIES administration. Each user needs a special identification for each closed group that he/she is member of. Before requesting the creation of a closed user group, interested parties should fully explore the possibilities offered by simple electronic mail, which is private by definition, complemented by an open shared folder.

Computer Department, International Telecommunication Union | Place des Nations, 1211 Geneva 20, Switzerland | Telephone: National (022) 730 55 54, International +41 22 730 55 54 | X.400 Address: C=CH ADMD=ARCOM PRMD=ITU S=HELPDESK | Telegram: BURINTERNA GENEVE | Telex: 421 000 UIT CH | Telefax: +41 22 730 53 37 (group 2/3)

Each closed user group has one **shared file cabinet** which is managed by a designated user (e.g., a Chairman/Rapporteur, a CCI Counsellor, etc.). The shared file cabinet belongs to a special TIES group account. For example, if Mr. Dupont is the Chairman of Joint Interim Working Party 22, he has his personal account like other TIES users and, in addition, he receives an additional TIES username and password to manage the [JIWP22] shared folders. In this example, Mr. Dupont could also share the responsibility with a CCI Counsellor (both would know the username and password of the special TIES account having the shared folders of the [JIWP22] group).

> All users belonging to a group have **read only access** to the documents stored in the **shared folders** which are created by the responsible user.

A TIES user can be a member of different user groups. User groups are created upon request and are maintained by the TIES administration staff, based on information provided by the responsible officers.

**8. Selecting a Shared Folder**

Select EM (electronic mail) in the main TIES menu. The first option in the e-mail menu is SELect. You can activate this option by typing SEL and pressing RETURN or by pressing the SELECT key (e.g., **Delete** in the Reflection emulation). In both cases you will be presented with a form similar to:

```
        Select Message

    Folder:

    Title:

    Number:

    Enter information and press RETURN
```

The cursor is positioned in the **folder** field. If you press GOLD L (or FIND) you get a list of your private folders (the folders in your default file cabinet). You can then select a folder and a document following the procedure explained in what follows.

In order to select a **shared** folder you do the same with one exception: *you should precede the folder name with the name of the shared file cabinet between square brackets.*

The following series of steps illustrate the access to [TIES] shared folders:

a) Type sel and press RETURN (or press SELECT key if known).

b) The **Select Message** form is displayed. If necessary, erase the contents of the **Folder** field using the ERASE LINE key (e.g. ALT-E in Reflection) or using the BACKSPACE key. Enter [TIES] in the **Folder** field and press **GOLD** L (or FIND key). Note: GOLD is the PF1 key (you should know the location of the GOLD or PF1 key before using TIES).

c) A list of TIES shared folders is displayed. You may have to press RETURN if the listing takes more than one page. A line number precedes the name of each folder. Enter the line number of the desired folder and press RETURN. The name of the selected folder is displayed in the **Folder** field, after the name of the shared file cabinet ([TIES] in this example). The cursor is positioned in the **Title** field.

d) Press GOLD L (or FIND key) to get a list of documents in the selected shared folder. Enter the line number of the desired document and press RETURN. The name of the selected document is displayed in the **Title** field.

e) Press RETURN and the document is made current: the information on the selected document is displayed in the standard block in the top right of the screen.

f) You can move through the list of documents in a folder by pressing the up and down cursor keys.

At any step one can back up by pressing the EXIT key.

This technique can be used in the **Simple e-mail based Bulletin Board** service provided by TIES (see TIES User Note 14). By entering [JIWP22]BB in the Folder field and pressing GOLD L the list of all Bulletin Board folders in the JIWP22 user group is displayed, if the group decides to use such a facility. You can then select, for example, BB-NEWS to have the new items in your user group.

**8. Locating, Viewing, Downloading and Uploading Documents**

Once you have selected a shared folder, the facilities for locating, viewing, copying, etc., documents are the same as for normal folders. These facilities are presented in TIES User Note 16 *Retrieving and Downloading Documents*. It should be kept in mind that *group members have read access to the documents. Only the authorized officers can create shared folders, post and delete documents in the shared folders.* These functions are explained in TIES User Note 17 *Uploading Documents*.

**9. Forming User Groups**

After having a clear idea of the possibilities of electronic mail (including its distribution list capabilities) to coordinate the work of a group in a confidential manner and the possibilities of open read-only shared folders for the posting of public information, the responsible person for a particular group might decide that, in addition, there would be a need for **closed** shared folders. If this is the case, the necessary information should be provided to the TIES administration staff at the ITU so that the group can be created. Updating information (e.g. new members) should also be relayed as soon as possible.

**10. Joining Closed User Groups**

The responsible person in charge of the closed group (e.g. Chairman/Rapporteur or CCI Counsellor) should be contacted to give the approval and submit the information to the TIES administration staff at the ITU.

# Document Interchange Formats

## 1. INTRODUCTION

The widespread use of PC word processing programs has enhanced the possibility of document interchange in electronic form. Unfortunately, the problems of document exchange are more complex than at first believed. This note describes a main problem area (document interchange format) and recommends solutions for electronic document interchange between ITU and Administrations and other participants in meetings and conferences of the Union.

## 2. DOCUMENT INTERCHANGE FORMATS

### 2.1 The problem

Although the technology is understood, there is a lack of adherence to standards necessary to transparently interchange documents created by different word processors. There are hundreds of different PC word processors available and document interchange is essentially a "Tower of Babel" situation: each has its own proprietary file format typically incompatible with all other formats.

The document interchange problem is further complicated because the ITU must deal with very complex documents. For example, CCITT Fascicles are complex compound documents containing line art, equations, tables, and multilingual text. Therefore, interchange formats must revolve around a document architecture that can represent all these objects.

There is general consensus that the use of structured documents is a key prerequisite for document portability. Structured documents put the focus on identifying the elements of a document and not the formatting of the elements. The high-end mainstream PC word processors are now implementing functionality that permits identification of document elements through the use of "style sheets" or "templates". While the benefit of these features is being "sold" on the basis of facilitating fomatting, a serendipitous benefit is the possible creation of well structured documents.

A number of standards exist to facilitate electronic document interchange between different systems., but many do not have the level of generality and completeness required to ensure an exchange of information without loss. This note briefly summarizes some well known formats, recommends today's solutions and states the direction being followed by the ITU.

### 2.2 ASCII

Often the only format that different word processors have in common is a line-oriented final form document using ASCII characters. ASCII document interchange essentially means that all document formatting information is lost including paragraph structure, indentation, enhancements, footnotes, headers, footers, font information, foreign characters, special characters, superscripts, subscripts, tables, etc.. That's usually just the beginning of problems: because an ASCII file has no method of representing paragraphs, converted files will require heavy re-editing since carriage returns and line feeds will have to be stripped out of the file to rebuild paragraph structure. Quite often, users have found it is easier to completely retype a document than to "clean up" an ASCII conversion.

ASCII file conversion is also unacceptable for working with non-English languages (which the ITU must support). The ASCII character set does not contain multinational characters necessary for ITU working languages such as French and Spanish. Quite often word processors can do ASCII "conversion" from their proprietary formats into files containing the IBM PC extended character set (whose lower half is "roughly" ASCII). This character set allows a limited interchange of multinational characters. Future ITU document interchange character set support will revolve around the international standard character set defined in ISO 8859/1 (also known as ANSI-8) and extensions built on this standard.

### 2.3 DIF

The Document Interchange Format (DIF) was developed for the USA Department of Navy by the National Bureau of Standards. A DIF document is a linear stream of 7-bit ASCII characters for the exchange of text and formatting instructions (control codes prefixed by an Escape character). DIF does not support graphics and complex text structures. Many escape sequences are compatible with those of other standards (e.g. ANSI).

### 2.4 IBM DCA

IBM's Document Content Architecture (DCA) interchange format has gained some acceptance. Most major word processors are now providing some form of conversion to and from DCA format (although some implementations are less than complete). There are two forms of DCA: revisable form text (RFT) and final form text (FFT). Only DCA-RFT is of interest as an interchange format to the ITU. DCA-RFT provides document formatting information but it has its limitations (the document model is essentially typewriter oriented): DCA does not support graphics, tables, equations, etc. However, despite these shortcomings, DCA-RFT is clearly superior to using ASCII as an interchange format.

### 2.5 CCITT ODA/ODIF

The Open Document Architecture (ODA) and the Open Document Interchange Format (ODIF) are CCITT Recommendations (T.410 series) also adopted by ISO (8613). ODA is a modern, object-oriented document architecture for the description of both the logical and layout structures of a document. Examples of logical objects are abstracts, titles, sections, paragraphs, figures, tables, etc. Examples of layout objects are pages, columns, frames, etc. ODA provides for the representation of documents in *processable* form, which allows revision by a recipient, and *formatted* form, which allows the precise specification of the document layout. ODA also supports the transfer of documents in *formatted processable* form. ODIF defines the bits and bytes of the actual interchange format which can be transmitted using X.400 (ODA is one of the defined X.400 body parts). ODA defines *character* content architectures (character sets, fonts, indentations, subscripts, spacing, etc.), *raster graphics* content architectures (e.g. Group 3/4 facsimile) and *geometric graphics* content architectures (e.g Computer Graphics Metafile (CGM)). The standard is evolving. It does not yet support tables and mathematical formulas. Native ODA editors are not yet widely available and used.

***Support of CCITT ODA/ODIF is a strategic commitment of the ITU.***

### 2.6 Digital CDA

Digital's Compound Document Architecture (CDA) is based on ODA. CDA specifications define a complete networked environment for creating, revising, managing, and distributing compound documents containing text, graphics, images, spreadsheets, charts and tables, in addition to "live links" which cause automatic updating of data contained in a compound document when the source of information is changed by another application. Today, CDA - a "superset" of ODA- is one of the most

Computer Department, International Telecommunication Union | Place des Nations, 1211 Geneva 20, Switzerland | Telephone: National (022) 730 55 54, International +41 22 730 55 54 | X.400 Address: C=CH ADMD=ARCOM PRMD=ITU S=HELPDESK | Telegram: BURINTERNA GENEVE, Telex: 421 000 UIT CH, Telefax: +41 22 730 53 37 (group 2/3)

advanced document architectures and is supported by applications (e.g. DECwrite).

### 2.7 SGML

The Standard Generalized Markup Language, an outgrowth of IBM's mainframe-based batch-oriented Generalized Markup Language, is an international standard developed by ANSI and ISO (8879). SGML uses descriptive markup for enhanced document portability. The SGML representation of ODA documents, specified in ISO 8613, was not included in the CCITT T.410 series of recommendations.

### 2.8 Microsoft RTF

The Rich Text Format (RTF) is a standard form of encoding for text and graphics interchange that can be used with different microcomputers, operating systems and output devices.

*RTF can represent most if not all objects contained in ITU documents* (e.g multilingual text, footnotes, headers, footers, symbol sets, tables, mathematical formulas, geometric and raster graphics, font information, layout, structure elements). ***A standard RTF file consists of only 7-bit ASCII characters for ease of transport.***

### 2.9 Widely used word processor formats

The main stream word processors (WordPerfect, MS Word, etc.) use proprietary formats. The related documents are *binary files* defined for efficient processing and not for ease of transport. Non-graphics oriented word processors (e.g. WordPerfect up to version 5) do not directly support all objects included in ITU documents.

## 3. ITU FORMAT CONVERSION CAPABILITIES

The ITU is using Microsoft Word for Windows for document format conversion. Word for Windows can read directly documents prepared with practically all commonly used word processing packages. Since conversions are typically done by operators who have no experience with word processors not used in the ITU, there is no recourse for a conversion failure. Even more subtle are conversion problems where a feature in one word processor (e.g. special characters, columns, footnotes) are not supported in another. Conversion programs quite often will ignore unsupported features in the destination file format (omitting parts of the document!). Care should be exercised when doing electronic translation and a printed copy of the original file should also be made available.

As it is unrealistic to install all packages in the ITU and train operators in all of them, *it is essential to focus on formats which support all the complexity of ITU documents and which are easy to transport by communication links.*

## 4. RECOMMENDATIONS

### 4.1 Use Rich Text Format (RTF)

Considering that RTF supports today almost all the complexities of ITU documents, is available for the IBM PC and Macintosh (40,000,000 and 3,000,000 installed by the end of 1989, respectively), is easy to transport (7-bit representation) and includes structure/style information essential for flexible document processing

***the recommended approach today is to interchange RTF documents.***

Word (MS/DOS, MS Windows, OS/2 or MAC versions as well as versions for some flavors of UNIX) could be used by those submitting texts to the ITU as a *conversion program* if their preferred word processor does not support conversion to and from RTF. For those using Word for Windows, the ITU plans to make available templates applicable to the main ITU document types (e.g. CCITT Recommendations). This will greatly facilitate the preparation of ITU documents.

As *electronic mail is the preferred document transfer mechanism*, combining the addressing, distribution and content identification functions, it is essential for TIES eMail to support the transfer of RTF documents. The Kermit file transfer protocol, also supported by TIES, is not necessary for the transfer of RTF documents (7-bits only).

***Today RTF documents can be included in TIES X.400 messages or uploaded - as interactive TIES eMail messages - from PC files using ANSI/VT terminal emulators.***

### 4.2 Formats supported

The following formats, listed in order of preference, are the ones supported by the ITU (*high preference for first two and very low preference for the rest*):

| |
|---|
| **MS Word for Windows** (Version 1.0) |
| **Rich Text Format** (e.g. from MS DOS-WINDOWS-OS/2-Macintosh Word or Works programs) |
| MS Word (through Version 5.0) |
| Windows Write (through Version 3) |
| Microsoft Works (through Version 2.0) |
| Samna (through Version 2.0) |
| DCA-RFT |
| WordPerfect (Versions 4.1, 4.2, 5.0) |
| WordStar (Versions 3.3, 3.4, 4.0, 5.0, 5.5) |
| Text (PC-8) (IBM PC character set) |
| Text (ASCII) |

***It is essential to focus on formats which support all the complexity of ITU documents and which are easy to transport by communication links.***

## 5. FUTURE CAPABILITIES

Use of the CCITT ODIF (Open Document Interchange Format) is a priority as soon as it includes support for the objects (e.g. tables and formulas) used in ITU documents. Word for Windows filters are being developed for the current ODIF capabilities. Expected availability is the first semester of 1991.

Word for Windows filter for Digital CDA (Compound Document Architecture) is also expected for the first semester of 1991.

Microsoft has also announced, in the press, work on DTD (Document Type Definition) driven Word for Windows filters for SGML documents. Availability is expected for 1991.

*Note:* The ITU-wide ***Advisory Group on Information Exchange Policies and Practices*** has set up a Working Group on Document Exchange to study the problem and recommend the related policies and practices. Revised versions of this note will reflect updated policies and practices adopted. This type of information is also available in the TIES ***ITU Info*** service.

# Simple Electronic Mail Based Bulletin Board

**1. Purposes**

The TIES e-mail based Bulletin Board (BB) provides simple means for the dynamic sharing of information among groups of TIES users.

**2. Features**

TIES e-mail BB includes the following features:

- minimum learning effort as it is based on the TIES e-mail and document exchange tools;
- full integration with e-mail;
- direct input of X.400 e-mail;
- downloading and uploading of revisable documents using standard TIES document exchange procedures;
- uses same TIES group accounts created for shared folders.

The *Simple e-mail based Bulletin Board* facility illustrates the flexibility of the TIES tools for the implementation of different computer-based communications services.

TIES User Notes 09 (*TIES Document Exchange: Purposes, Shared Folders, User Groups*), 16 (*Retrieving and Downloading Documents*) and 17 (*Uploading Documents*) provide useful additional information, particularly for the downloading and uploading of documents from/to the Bulletin Board folders.

If the facilities described in this note are not sufficient for the needs of a particular group, TIES provides a comprehensive computer-based conferencing system (see TIES User Note 06) which supports the requirements of many types of group conferencing.

**3. User groups and Bulletin Board shared folders**

TIES user groups (see TIES User Note 09, section 6) can use the facilities described in this note.

If SGXXI is an established user group with shared folders addressed as *[SGXXI]folderid* then the prefix **BB-** could be used to identify all SGXXI Bulletin Board folders. For example,

BB-NEWS

BB-REPORTS

BB-ADDRESSES

BB-MEETINGS

etc.

**4. Updating the Bulletin Board**

For consistency, user groups would use BB-NEWS as the shared folder containing news items .

The BB "moderator" or "manager" (e.g., CCI engineer, Chairman, Rapporteur) reads the messages addressed to user group name (e.g, SGXXI) and moves them to the appropriate BB folder. Interactive and X.400 e-mail can be addressed to the user group name.

In the case of the SGXXI user group, TIES interactive e-mail would be addressed to SGXXI, while X.400 e-mail would be addressed to:

C=CH ADMD=ARCOM PRMD=ITU S=SGXXI

The user group BB "manager" accepts items for inclusion in the Bulletin Boards, delete items, assign keywords for easier retrieval, etc.

**5. Accessing the Bulletin Board**

After selecting **em** in the TIES main menu (**em** is the electronic mail menu option), the following series of steps illustrate the access to the CCITT Bulletin Board shared folders (in place of [CCITT] other user group names - e.g. [TIES] or [JTWP101103)] - could be used):

a) Type **sel** and press RETURN (or press SELECT key if known).

b) The **Select Message** form is displayed. Enter [CCITT]BB in the **Folder** field and press GOLD L (or FIND key). Note: if you need to erase the field before entering [CCITT]BB use the ERASE LINE key (F13 key on VT200, ALT-E on Reflection).

```
Select Message

Folder: [CCITT]BB_

Title:

Number:

Enter information and press RETURN
```

c) A list of CCITT Bulletin Board shared folders is displayed. You may need to press RETURN if the listing takes more than one screen page. A line number precedes the name of each folder. Enter the line number of the desired folder (e.g., BB-NEWS) and press RETURN. The name of the selected Bulletin Board folder will be displayed after the name of shared file cabinet (CCITT in this example) in the **Folder** field . The cursor is positioned in the **Title** field.

```
Select Message

Folder: [CCITT]BB-NEWS

Title: _

Number:

Enter information and press RETURN
```

d) Press **GOLD L** (or FIND) to get a list of the titles of the documents in the selected shared folder (in the example, the list of the items in the BB-NEWS folder). Enter the line number (e.g. 9) of the desired document (e.g. Deadline for contributions) and press RETURN. The name of the selected document is displayed in the Title field.

e) Press RETURN to make the selected document current: the information on the selected document is displayed in the standard block in the top right of the screen. If the document is an ASCII file, enter r to read its contents. If the document is "binary" (e.g., a WordPerfect document) it can be downloaded to your PC for local processing.

At any of the above steps one can escape by pressing the EXIT key.

A well organized set of Bulletin Board folders and a well planned item/document naming strategy minimize the need for additional search criteria. If, however, one needs additional search criteria, the Index command can be used (see TIES User Note 16, section 3).

# List of TIES User Notes

| Subject | Number | Date |
|---|---|---|
| **General** | | |
| What is TIES | 01 | 21 May 1990 |
| Request for TIES User Identification | 12 | 21 May 1990 |
| Getting Connected | 02 | 21 May 1990 |
| TIES ALL-IN-1 User Interface | 15 | 11 June 1990 |
| EDT Editor | 07 | 11 June 1990 |
| | | |
| **Videotex-like Service** | | |
| ITU Info Service | 03 | 21 May 1990 |
| | | |
| **Electronic Mail** | | |
| Interactive Electronic Mail | 04 | 21 May 1990 |
| X.400 Electronic Mail | 05 | in preparation |
| | | |
| **Document Exchange** | | |
| Document Interchange Formats | 10 | 21 May 1990 |
| Document/File Transfer with Reflection | 13 | 4 June 1990 |
| Document/File Transfer with Kermit | 08 | in preparation |
| Purposes, Shared Folders, User Groups | 09 | 24 Sept 1990 |
| Retrieving and Downloading Documents | 16 | 24 Sept 1990 |
| Uploading Documents | 17 | 24 Sept 1990 |
| | | |
| **Bulletin Board / Computer Conferencing** | | |
| Simple Electronic Mail based Bulletin Board | 14 | 24 Sept 1990 |
| Computer-based Conferencing | 06 | 21 May 1990 |
| | | |
| **TIES Newsletters** | | |
| No. 1: Your Geneva X.400 Address, Reflection and KERMIT VT Emulation Packages, etc. | 11 | 21 May 1990 |

*Before using TIES, you need to know where certain of the VT-type terminal function keys are found on your keyboard. The PF1 key, known as the GOLD key, is especially important. For example, MS-KERMIT and CROSSTALK usually map PF1 to the F1 key of the PC keyboard, REFLECTION maps it to the NumLock key, etc. Combinations starting with the GOLD key are very useful (see TIES User Note 15, section 9). For example, GOLD K is the sequence for "EXIT Screen". Please see TIES User Notes 03 and 15 for additional information on this matter.*

*The latest version of TIES User Notes are available for consultation, printing or downloading in the shared folders [TIES]User Notes - RTF and [TIES]User Notes - ASCII.*

Computer Department, International Telecommunication Union — Place des Nations, 1211 Geneva 20, Switzerland — Telephone: National (022) 730 55 54, International +41 22 730 55 54 — X.400 Address: C=CH ADMD=ARCOM PRMD=ITU S=HELPDESK — Telegram: BURINTERNA GENEVE — Telex: 421 000 UIT CH — Telefax: +41 22 730 53 37 (group 2/3)

# Request for TIES User Identification

The International Telecommunication Union (ITU) is offering participants in ITU activities the opportunity to register for the use of TIES on a trial basis. As these services are still under development, the technical characteristics may be modified. User comments on all aspects of TIES are welcome.

Connection to TIES requires a terminal or personal computer with terminal emulation software, a modem and access to the international Public Switched Telephone Network (PSTN) or to the international Packet Switched Public Data Network (PSPDN - X.25). See TIES User Note 02, *Getting Connected*, for more information.

Please supply the information requested below to the Computer Department (see address at the bottom of the form; new direct FAX number is **+41 22 730 5337**).

**User Information**

Name ______________________

Title ______________________

Organisation ______________________

Department./Service ______________________

Address:

street ______________________

city ______________________ postal code __________

country ______________________

Telephone ______________ Telefax ______________ Telex __________

Email address ______________________

**ITU Activities (Study Groups, Working Parties, AC, etc.)**

______________________ ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

**Technical Information**

The following optional information would be helpful

Means of connection:

[ ] in-house X.25 [ ] Dial-out to X.25 Packet network name: ______________

[ ] direct dial modem type and speed: ______________

Communication software: ______________________

Terminal or PC type: ______________________

Date ______________ Signature ______________________

The ITU Global Directory is available on-line via TIES at a cost of 72 francs per year.

Please check here as well if you wish to receive a copy of the Subscription Agreement [ ]

Computer Department, International Telecommunication Union — Place des Nations, 1211 Geneva 20, Switzerland — Telephone: National (022) 7 30 55 54, International +41 22 730 55 54 — X.400 Address: C=CH ADMD=ARCOM PRMD=ITU S=HELPDESK — Telegram: BURINTERNA GENEVE, Telex: 421 000 UIT CH, Telefax: +41 22 730 53 37 (group 2/3)

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

Part 8

## CCIR AND DEVELOPING COUNTRIES

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland

These notes are for internal distribution only



The purpose of these notes is to provide an overview of the CCIR work related to the radio frequency spectrum. [Source: CCIR RES61-4]

### 1. The CCIR

The International Radio Consultative Committee, CCIR, is one of the two consultative committees of the International Telecommunication Union, ITU. The International Telegraph and Telephone Consultative Committee (CCITT) is the other. Both of these committees are permanent organs of the ITU, which is one of specialized Agencies of the United Nations.

The CCIR has been created to study technical and operating questions relating specifically to radio communications without limit of frequency range, and to issue Recommendations on them. The work of the CCIR provides the basis for decisions that lead to efficient use of the spectrum for telecommunication applications. The reports and recommendations of the CCIR are used by radio conferences to establish technical criteria that area the basis for spectrum, allocation decisions and spectrum use on a global and regional basis. Therefore, it is important to all countries that CCIR documents reflect their positions, and that positions of other countries published within the CCIR are known to them on time.

CCIR recommendations include technical bases for inter-service sharing and management radio-frequency spectrum and geostationary-satellite orbit resources, standards of radio systems on world-wide basis and technical information for the development, planning and operation of radio systems.

All of the member countries of the ITU as well as certain Private Operating Agencies, Scientific and Industrial Organizations and International Organizations can participate under conditions defined in the ITU Convention. The governing body of the CCIR is the Plenary Assembly which meets every four years, at the end of a Study Period to consider reports of the Study Groups set up by the previous Plenary Assembly.

### 2. The CCIR and developing countries

The work of the CCIR is global in nature and is directed to answer the needs of all members of the ITU. Trends in radiocommunication system development are publicized by the CCIR. The documents and publications of the CCIR provide an invaluable source of current practical information for radiocommunication engineers, in all countries, but especially in developing ones. That information enables efficient and effective planning and operation of radio communication systems. The Recommendations and Reports of the CCIR are widely used in the preparations of specifications of radiocommunication systems and equipment. They serve as the technical reference in the examination of development plans and in selection of equipment to be installed or produced.

There is considerable technical expertise available in the Study Groups and in the Secretariat of the CCIR. The CCIR has given special emphasis to channeling this expertise to the benefit of the developing countries, within the limits of resources available to the ITU and to the sponsoring administrations and organizations. A number of CCIR experts from administrations have participated in technical cooperation projects funded by their administrations or by resources provided through the ITU Technical Cooperation Department. It should be noted that technical cooperation-related work carried out by the CCIR Secretariat is done within normal staff resources provided for the basic CCIR work.

The XVIIth CCIR Plenary Assembly (Düsseldorf, 1990) reconfirmed the importance of the interests of the developing countries in the work of the CCIR by adopting or revising a number of relevant Resolutions and Opinions:

Resolution 33-6 on technical cooperation,

Resolution 39-3 on participation of CCIR staff in technical cooperation work,

Resolution 79-3 on radio propagation studies in tropical regions,

Resolution 81-2 on handbooks and special publications,

Resolution 95-1 on participation by the developing countries in the CCIR work

Resolution 101 on cooperation between the CCIR and the Telecommunications Development Bureau (BDT) in radio propagation measurement campaigns in the developing countries,

Resolution 108 on information meetings,

Opinion 63-1 on the dissemination of CCIR texts, and

Opinion 77-2 on CCIR involvement in the work of the Special Autonomous Groups (GAS).

CCIR texts of special importance to the developing countries

Most of the handbooks and special publications of the CCIR are intended to be of special benefit to the developing countries. These include:

The CCIR Handbook for Monitoring Stations

The CCIR Handbook on Spectrum Management and Computer-Aided Techniques



The CCIR Handbook on Satellite Communications (Fixed-Satellite Service)

The CCIR Special Publication: Broadcasting Satellite Systems

The CCIR Special Publication: Antenna Diagrams

The CCIR Special Publication: Sound Tape Recording, Television Tape Recording and Film Techniques for the International Exchange of Programmes

The CCIR Special PublicationSpecifications of Transmission Systems for the Broadcasting-Satellite Service

Specialists from CCIR Study Groups have participated actively in preparing GAS manuals which are specifically directed to the needs of the developing countries:

GAS 3 -Economic and technical aspects of the choice of transmission systems

GAS 7 - Rural telecommunications

GAS 9 -Economic and technical aspects of transition from an analogue to a digital telecommunication network.

Microcomputer programs

Special emphasis has been given to Decides 3.4.5 of CCIR Resolution 33-5 urging the CCIR to develop programs for inexpensive microcomputers which may be available in the developing countries. A comprehensive set of microcomputer programmes has been prepared by the CCIR Secretariat covering the calculation of broadcasting antennas from the L.F. band up to the U.H.F. band, thus offering the broadcast engineer new tools for the planning and designing activity in a more practical form of technical information presentation. Seminars and workshops have been organized in several developing countries sessions conducted by the authors who developed the programs. A wide selection of software is available from administrations under CCIR Resolution 88. The software is described in the CCIR Handbook on Spectrum Management and Computer-aided Techniques, in Telecommunication Journal, and in CCIR Administrative Circular AC 290 including Addenda 1 to 5. The full list is available from the CCIR Secretariat.

Propagation measurements

Considerable activity has taken place in response to CCIR Resolution 79-1 on radio propagation studies in tropical regions. For instance, CCIR Study Group 6 has prepared a campaign of HF field strength measurements in order to provide a substantial body of new data with which to study improved prediction methods. The background to the campaign, with details concerning its technical specification and implementation, is contained in a series of CCIR Administrative Circulars despatched to members of CCIR and other organizations participating in its work between August 1988 and December 1989. (A.C.s 293, 299 and 302. Copies available on request.) The circulars invited participation in the campaign, and at the same time, stressed the importance of having an adequate number of transmitters and receivers deployed world-wide. Unfortunately, response from administrations and broadcasters participating in the work of the CCIR has not been adequate as regards the number of transmitters offered for a short-term, intensive campaign. Nevertheless, following further review, Study Group 6 continues to encourage administrations and organizations to consider participation in a world-wide campaign to be conducted over a prolonged time period, with as many transmitters and receivers as can be made available.

As a result of a kind offer of transmitting facilities from the Administration of Australia, the CCIR is pleased to announce that dedicated transmissions for the campaign have recently commenced from Melbourne, details of which are as follows:

| | |
|---|---|
| Identification signal (Morse code): | AUS1MLB |
| Transmitter power: | 1 kW |
| Antenna: | omni-directional spiral |
| Hours of transmission: | currently 24 hours per day (this cannot be guaranteed indefinitely) |

Frequencies and times of transmission:

| F1B centre frequencies | Time of transmission | | |
|---|---|---|---|
| 5470.845 kHz | 00 | 20 | 40 minutes past hour |
| 7870.845 kHz | 04 | 24 | 44 minutes past hour |
| 10407.845 kHz | 08 | 28 | 48 minutes past hour |
| 14407.845 kHz | 12 | 32 | 52 minutes past hour |
| 20945.845 kHz | 16 | 36 | 56 minutes past hour |

Signal duration and format: as specified in Report 1149 (formerly Report AA/6); 4 minutes for each frequency, 20 minutes for all five frequencies, according to the schedule above.

Whilst recognizing that reception of the transmissions may not be feasible in all regions of the world, administrations and organizations are never- theless strongly invited to monitor the relevant frequencies and, if possible, to commence long-term measurements according to the specifications contained in Report 1149 (formerly Report AA/6).

All results from such monitoring and measurements would be gratefully received at the CCIR Secretariat which, in turn, is ready to supply any further details on the measurement campaign.



A review of CCIR propagation studies at higher frequencies has been published elsewhere (Hughes K., CCIR Propagation Studies for Africa, Telecommunication Journal, I/1988, Vol. 55, I, pp. 50-66).

## 3. XVIIth Plenary Assembly

The XVIIth Plenary Assembly of the CCIR was held in Düsseldorf (Federal Republic of Germany) in May-June 1990 with the participation of 520 delegates representing some 75 administrations, 32 recognized private operating agencies, 15 international organizations and two United Nations specialized agencies. The results of the work of all Study Groups were examined. A number of Recommendations have been adopted. New working methods and structure were adopted, together with the programme of work for the Study Period 1990-1994.

### Working methods and organization

Under new working methods, the studies are conducted by individual participants on a voluntary basis, at their own expenses, in accordance with the commonly agreed programme and specific Questions. CCIR Study Groups perform an coordination function, including the planning, scheduling, supervision, delegation and approval of the work and other related matters within the defined scope. Continuing Working Parties and Task Groups can be set up to carry out the on-going technical studies. The organization of CCIR work is given in Resolution 24-7. A general outline of the organization is presented in Annex 1. The new structure of Study Groups is presented in Annex 2.

Working Parties study the Questions assigned and prepare draft Recommendations and other texts for consideration by the Study Group. When a Question is categorized as "urgent" and cannot be reasonably carried out by a Working Party, it may be assigned to a Task Group for the development of a new Recommendation or conference report within three years or less. The establishment of Task Groups is the subject of a Decision of the Study Group. After completion of its specific assignment, the Task group will be dissolved. Working Parties and Task Groups operate continuously during the Study Period. Considerable work can be accomplished by correspondence, and all activities are being encouraged to take advantage of the electronic conferencing facilities provided by the ITU Telecommunications Information Exchange System (TIES).

### Recommendations approval

A new procedure for approval of Recommendations between Plenary Assembly by correspondence has been adopted to better respond to the requirements of the scientific, technical and user communities. Now each Study Group has the authority to approve draft Recommendations using this procedure. The intention to use this procedure is to be communicated to all participants at least three months before the meeting of the Study Group. The decision by the participants to apply this procedure must be unanimous. After that the text of the draft Recommendation should be circulated among all Members of the CCIR. Other participants in the work of the CCIR are also informed of the consultation. If 70% or more of the replies from the Members indicate approval, the Recommendation is adopted. The Secretary-General of the ITU shall publish the adopted Recommendation indicating a date of entry into effect. If not, it is referred back to the Study Group for further study.

Meeting schedules for Working Parties and Task Groups were tentatively established for the new Study Period (1990-1994). The character of Study Group meetings is completely changed. Study Group meetings will deal mainly with work programmes (including proposals for Questions), scheduling of activities and formal approval of draft Recommendations and other texts prepared by Working Parties and Task Groups (but without substantive technical discussion during the Study Group meeting). Application of the accelerated approval procedure to draft Recommendations will also be decided by Study Group meetings.

THE CCIR STUDY GROUPS, 1990 - 1994 Study Period

STUDY GROUP 1: SPECTRUM MANAGEMENT TECHNIQUES

STUDY GROUP 4: FIXED-SATELLITE SERVICE

STUDY GROUP 5: RADIO WAVE PROPAGATION IN NON-IONISED MEDIA

STUDY GROUP 6: RADIO WAVE PROPAGATION IN IONIZED MEDIA

STUDY GROUP 7: SCIENCE SERVICES

STUDY GROUP 8: MOBILE, RADIODETERMINATION AND AMATEUR SERVICES

STUDY GROUP 9: FIXED SERVICE

STUDY GROUP 10: BROADCASTING SERVICES - SOUND

STUDY GROUP 11: BROADCASTING SERVICES - TELEVISION

STUDY GROUP 12: INTER-SERVICE SHARING AND COMPATIBILITY

CCV: COORDINATION COMMITTEE FOR VOCABULARY

CMTT: CCIR/CCITT JOINT STUDY GROUP FOR TELEVISION AND SOUND TRANSMISSION



## STUDY GROUP 1
## SPECTRUM MANAGEMENT TECHNIQUES
### SPECTRUM ENGINEERING, PLANNING, SHARING, MONITORING AND UTILIZATION

Scope:

Development of principles and techniques for effective spectrum management, methods for solving spectrum sharing problems, techniques for spectrum monitoring and general spectrum utilization applications.

Chairman: M.J. Hunt (Canada)
Vice-Chairmen: R.N. Agarwal (India)
T. Boe (Norway)
R. Mayher (United States)
K.J.B. Yao (Cote d'Ivoire)

## STUDY GROUP 4
## FIXED-SATELLITE SERVICE

Scope:

Systems and networks for the fixed-satellite service and inter-satellite links in the fixed-satellite service. Included are associated tracking, telemetry and telecommand functions.

Chairman: E. Hauck (Switzerland)
Vice-Chairmen: J.M.P. Fortes (Brazil)
T. Muratani (Japan)
P. Remedi (Indonesia)

## STUDY GROUP 5
## RADIO WAVE PROPAGATION IN NON-IONIZED MEDIA

Scope:

Propagation of radio waves and related noise phenomena in non-ionized media at and above the surface of the Earth for the purpose of improving radiocommunication systems.

Chairman: A. Kalinin (USSR)
Vice-Chairmen: F. Fedi (Italy)
Y. Hosoya (Japan)

## STUDY GROUP 6
## RADIO WAVE PROPAGATION IN IONIZED MEDIA

Scope:

Propagation of radio waves in ionized media at and above the surface of the Earth and the characteristics of radio noise for the purpose of improving radiocommunication systems.

Chairman: L.W. Barclay (United Kingdom)
Vice-Chairmen: G. Pillet (France)
D. Cole (Australia)
A. Giraldez (Argentina)
M. Zamanian (Iran (Islamic Rep.))

## STUDY GROUP 7
## SCIENCE SERVICES

Scope:

1. Systems for space operation, space research, earth exploration and meteorology, including the related use of links in the inter-satellite services:

2. Radioastronomy and radar astronomy.

3. Dissemination, reception and coordination of standard-frequency and time-signal services, including the application of satellite techniques, on a world-wide basis.

Chairman: H.G. Kimball (USA)
Vice-Chairmen: J. Saint-Etienne (France)
S. Leschiutta (Italy)
J. Whiteoak (Australia)

## STUDY GROUP 8
## MOBILE, RADIODETERMINATION AND AMATEUR SERVICES

Scope:

Technical and operating aspects of systems for the mobile, radiodetermination and amateur services, including related satellite services.

Chairman: E. George (Germany (Fed. Rep. of))
Vice-Chairmen: Y. Hirata (Japan)
O. Villanyi (Hungary)
R.C. McIntyre (United States)
A. Dharab (Saudi Arabia)



## STUDY GROUP 9
## FIXED SERVICE

Scope:

Systems and networks of the fixed service operating via terrestrial stations.

Chairman: M. Murotani (Japan)
Vice-Chairmen: R. Coles (Canada)
O.M. Langer (Germany (Fed. Rep. of))
V. Minkin (USSR)
G. Hurt (United States)
R. Moumtaz (Lebanon)

## STUDY GROUP 10
## BROADCASTING SERVICES - SOUND

Scope:

International exchange of programmes and the technical and operating aspects of the broadcasting and broadcasting-satellite services, including audio frequency and recording equipment, as well as the overall performance of the means of delivering signals to the general public, where they are used for sound, data and ancillary services accompanying sound.

Chairman: C. Terzani (Italy)
Vice-Chairmen: H. Kussmann (Germany (Fed. Rep. of))
A. Keller (France)
K.P. Ramaswamy (India)
M. Yunus Khan (Pakistan)

## STUDY GROUP 11
## BROADCASTING SERVICES - TELEVISION

Scope:

International exchange of programmes and the technical and operating aspects of the broadcasting and broadcasting-satellite services, including video frequency and recording equipment, as well as the overall performance of the means of delivering signals to the general public, when they are used for television, data and associated ancillary services.

Chairman: M. Krivosheev (USSR)
Vice-Chairmen: S. Aguerrevere (Venezuela)
O. Mäkitalo (Sweden)
Wu Xianlun (China)
R. Zeitoun (Canada)
T. Nishizawa (Japan)

## STUDY GROUP 12
## INTER-SERVICE SHARING AND COMPATIBILITY

Scope:

Development of Recommendations in answer to a limited number of urgent Questions on inter-service sharing and compatibility requiring special atten- tion, as referred by the Plenary Assembly, or if the Question arises during the interval between Plenary Assemblies, by the Director after consultation with interested Chairmen and administrations, to work in association with Study Group 1.

Chairman: J. Karjalainen (Finland)
Vice-Chairmen: A. Pavliouk (USSR)
H. Weiss (United States)
Kang Songshi (China)

## CCV
## COORDINATION COMMITTEE FOR VOCABULARY

Scope:

Coordination within the CCIR, and liaison with the CCITT, the ITU General Secretariat and other interested organizations (mainly the IEC) concerning:

-vocabulary, including abbreviations and initials;

-related subjects (quantities and units, graphical and letter symbols).

Chairman: M. Thué (France)
Vice-Chairmen: J. Fairbrother (United Kingdom)
V. Miralles Mora (Spain)

## CMTT
## CCIR/CCITT JOINT STUDY GROUP FOR TELEVISION AND SOUND TRANSMISSION

Scope:

Study, in cooperation with the Study Groups of the CCIR and CCITT, the specifications to be satisfied by telecommunication systems to permit the transmission of sound and television broadcasting programmes.

Chairman: W.G. Simpson (United Kingdom)
Vice-Chairman: G. Zedler (Germany (Fed. Rep. of))

WORLD PLAN COMMITTEE (WORLD PLAN)

**General Plan for the development of the International Telecommunication Network**
(Joint CCITT/CCIR Committee administered by the CCITT)

Chairman: C.R. CRUMP (USA)

Chairman Designate: L. TEROL MILLER (E)
Vice Chairmen: SAGOE KOW (CTI)
P. GONIN (F)
Y. KAWASUMI (J)

PLAN COMMITTEE FOR AFRICA (PLAN AF)

**General Plan for the development of the Regional Telecommunication Network in Africa**
(Joint CCITT/CCIR Committee administered by the CCITT)

Chairman: E. KAMDEM-KAMGA (CME)
Vice-Chairmen: M.M KEITA (MLI)
J.C. KOUNKOU (CAF)
R.M.J. SHINGIRAH (KEN) |
CHEIK T. MBAYE (SEN) |
A.S. DLAMINI (SWZ) |

PLAN COMMITTEE FOR LATIN AMERICA (PLAN AL)

**General Plan for the development of the Regional Telecommunication Network in Latin America**
(Joint CCITT/CCIR Committee administered by the CCITT)

Chairman: A.F. GARCIA (ARG)
Vice-Chairmen: R. PEDROSA PEREZ (CUB)
J.S. POLLONI (CHL)
F. CASTRO ROJAS (CLM)
J. RICO (VEN)



PLAN COMMITTEE FOR ASIA AND OCEANIA (PLAN AS)

**General Plan for the development of the Regional Telecommunication Network in Asia and Oceania**
(Joint CCITT/CCIR Committee administered by the CCITT)

Chairman: J.L. PARAPAK (INS)
Vice-Chairmen: H. MAHYAR (IRN)
A.A. AL-FEHAID (ARS)
HAN SONGLING (CHN)

PLAN COMMITTEE FOR EUROPE AND THE MEDITERRANEAN BASIN (PLAN EU)

**General Plan for the development of the Regional Telecommunication Network in Europe and the Mediterranean Basin**
(Joint CCITT/CCIR Committee administered by the CCITT)

Chairman: L. TEROL MILLER (E)
Vice-Chairmen: M. POPOVIC (YUG)
A. OLKKONEN (FNL)
A. FRANCHI (I)
A. AIDOUNI (MRC)
E. EID (LBN)

SPECIAL AUTONOMOUS GROUP GAS 7

RURAL TELECOMMUNICATIONS

Chairman: G. RUDILOSSO (I)

Vice-Chairmen: J. DOMINGUEZ SANZ (E)
0. KURITA (J)
A. NUGROHO (INS)
S. SHADKAM (IRN)
E.J. ANTARI (MRC)
L. LOPEZ CELAYA (MEX)
M. GOUDELIS (GRC)
B. LENTCHOU KOUAYEB (CME)
D. DIAKITE (MLI)
M. MORRIS (CAN)

SPECIAL AUTONOMOUS GROUPGAS 9

**ECONOMIC AND TECHNICAL ASPECTS OF TRANSITION FROM AN ANALOGUE TO A DIGITAL NETWORK**

| | |
|---|---|
| Chairman: | M. GHAZAL[1] (LBN) |
| Vice-Chairmen: | M. HOSHI (J) |
| | G. HATZOPOULOS (GRC) |
| | P.D. LANSARD (F) |
| | J.H. BOBSIN (USA) |
| | P.G. TOURE (SEN) |
| | A. SANATI (IRN) |
| | A.S. ABU REZQ (KWT) |
| | N.O.O. ADJEBU (GHA) |
| | S. BIJAYENDRAYODHIN (THA) |
| | J. YONGORO (CAF) |
| | CHEIK SIDI M. NIMAGA (MLI) |

1) Senior Chairman for coordinating the activities of the GAS and the associated technical assistance questions including liaison with the Plan Committee in such matters.

SPECIAL AUTONOMOUS GROUP GAS 12

**STRATEGY FOR THE INTRODUCTION OF NEW NON-VOICE TELECOMMUNICATION SERVICES**

| | |
|---|---|
| Chairman: | J.B. PECRESSE (F) |
| Vice-Chairmen: | K. BOUFARHAT (LBN) |
| | K. AYIKOE (TGO) |
| | C. MOTEGI (J) |
| | D. DE MAIO (I) |
| | K. SORO (CTI) |
| | M. LHOR (MRC) |
| | D. TOURE (MLI) |
| | J. KONDAOULE (CAF) |
| | H. SUROSO (INS) |
| | A. MOHSENZADEH (IRN) |



**Annex 1: CCIR Programme of work for the 1990 - 1994 Study Period**

Source: Administrative Circular A.C./306 of 17 August 1990

1. Introduction

The XVIIth Plenary Assembly of the CCIR, Düsseldorf, May - June 1990, approved a new work programme, new Study Group structure, and new working methods for the 1990 - 1994 Study Period. Resolution 109 defines the work programme and lists Questions approved for study. It also categorizes Questions into urgent, important, and other. Resolution 61-4 lists Study Groups, their scopes, Chairmen and Vice-Chairmen. Resolutions 24-7 and 97 describe the working methods. A further Circular will deal with application of Resolution 97 relating to the new procedure for approval of Recommendations in the interval between Plenary Assemblies. The CCIR texts resulting from the XVIIth Plenary Assembly are now in course of preparation for publication.

2. Organization of CCIR work

The work of each Study Group will be organized by the Study Group itself, according to the Questions assigned by the Plenary Assembly. Study Groups assign these Questions to Working Parties and Task Groups, and schedule and monitor their activity. Recommendations and other relevant texts will be drafted by the Working Parties or Task Groups and approved by the Study Group. A general rule is that each Question shall be assigned to a single Working Party or Task Group within a single Study Group. (Exceptionally, for a transitional period, Study Groups 4 and 9 have maintained one, and Study Groups 10 and 11 two, Joint Working Parties. Each will report to a single Study Group.) Their work should, as far as possible, be conducted by correspondence. [...]

The Plenary Assembly approved Resolution 106, in accordance with which an ad hoc Advisory Group on Strategic Review and Planning will be created to advise on issues important for strategic planning of CCIR work.

Resolution 107 set up a Working Party of the Plenary on Restructuring CCIR Study Groups for the future. The Working Party will issue a preliminary Report to the Interim Meetings of Study Groups and a final Report to the XVIIIth Plenary Assembly. Invitations to participate in these activities will be circulated in due course.

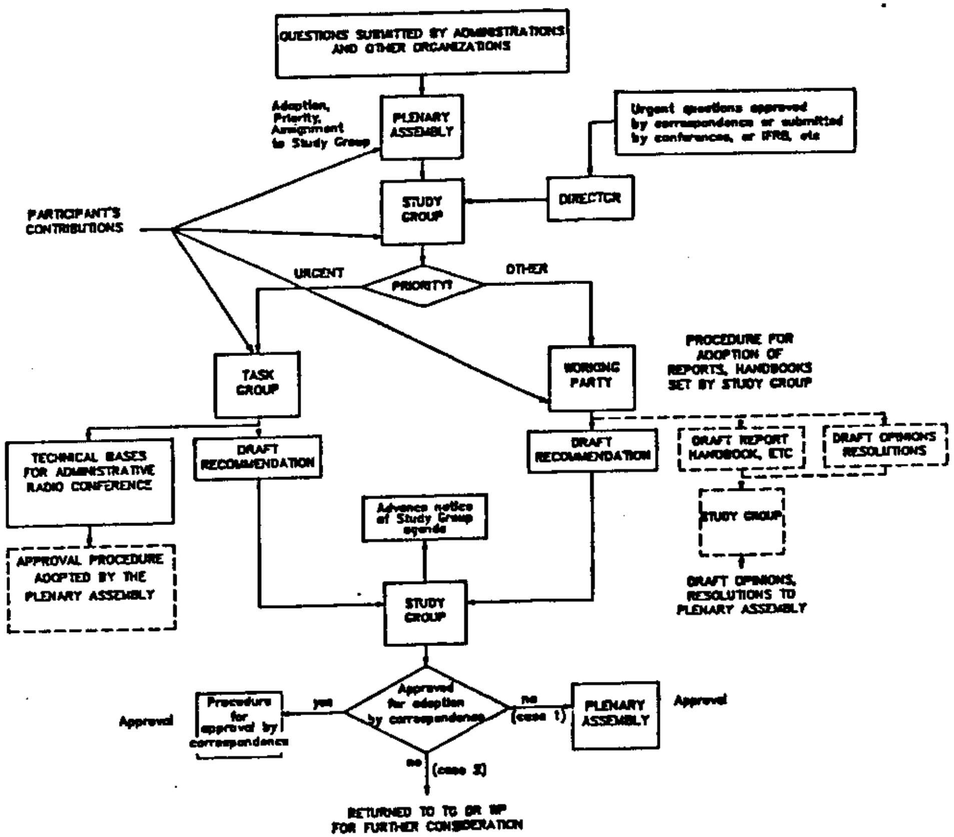
3. Contributions

Contributions to Questions approved for study, especially to urgent ones, are invited. The XVIIth Plenary Assembly has placed focus on CCIR studies leading to Recommendations, in accordance with the CCIR terms of reference (ITU Convention, Nairobi 1982, and Nice 1989). Contributions should be directed to draft new and revised Recommendations, and should cite the specific Questions to which they refer. We would draw your attention to Resolutions 24-7 and 97. They give instructions for document submissions, and impose time limits. In accordance with Resolution 24-7, contributions should be sent to the Chairman and Vice-Chairmen of the Study Group concerned, the Chairman of the Working Party or Task Group and any relevant Special Rapporteur. At the same time, five copies should be sent to the Director, for numbering, translation, reproduction and distribution in advance of the meetings. (Participants are also encouraged to submit contributions on magnetic diskettes along with paper copy, or by electonic mail. Instructions will be made available on request.)

Documents received at least four months in advance of the meeting will be translated as required and dispatched to participants. Late contributions which cannot be submitted by the above-mentioned four-month time limit can be accepted up to seven days before the meeting for reproduction and distribution at the opening. No commitment, however, can be made regarding their translation. Those which can be provided by the administrations in at least one of the working languages and published before the meeting, can be placed on the agenda of the first session of the meeting but will be considered only if the meeting concerned so decides (Res. 24-7, 8.9).



## Annex 2. PROCEDURE FOR APPROVAL OF QUESTIONS, RECOMMENDATIONS AND TECHNICAL BASES FOR RADIO CONFERENCES (Resolutions 24-7 and 97)



Technical Cooperation Committee

RESOLUTION 95-1

PARTICIPATION BY THE DEVELOPING COUNTRIES IN THE WORK OF THE CCIR

(1986-1990)

The CCIR,

CONSIDERING

*(a)* Resolutions Nos. PL/7, COM6/11 and COM6/12 of the ITU Plenipotentiary Conference (Nice, 1989) concerning respectively:

- the holding of meetings or conferences away from Geneva, particularly RESOLVES 2 of Resolution No. PL/7, relating to Study Groups which provides that in the case of developing countries equipment need not necessarily be provided free of charge by the host government, if the government so requests;
- the Special Voluntary Programme for Technical Cooperation, which "urges Member countries, their recognized private operating agencies, scientific or industrial organizations and other entities and organizations to support the Special Voluntary Programme by making available the required resources in whatever form may be convenient to meet the telecommunication needs of the developing countries more effectively";
- special measures for the least developed countries (Resolution COM6/12), particularly section 3, which instructs the Secretary-General of the ITU "to propose concrete measures intended to bring about genuine improvements and provide effective assistance to these least developed countries from the Special Voluntary Programme for technical cooperation, the Union's own resources and other sources";

*(b)* Resolutions 33-6 and 39-3 of the XVIIth CCIR Plenary Assembly concerning, respectively, technical cooperation and the participation of CCIR staff in technical cooperation work;

*(c)* that participation by Members from all regions in the world and particularly by the developing countries enhances the quality of CCIR documents;

*(d)* that participation by developing countries in the work of the CCIR leads to a greater understanding of the technical content of CCIR texts;

*(e)* that the developing countries have sound experiences in operating various kinds of radio services;

*(f)* the very limited material and financial resources available to the developing countries, preventing them from participating regularly in the work of the CCIR;

*(g)* the adverse effects which the absence of the developing countries from Study Group activities has on the universal nature of CCIR decisions and, possibly, on their effective application in the countries,

UNANIMOUSLY DECIDES

1. that during the intervals between Plenary Assemblies, the Director of the CCIR should:





1.1 encourage the organization of some CCIR meetings in the developing countries, in accordance with Resolution No. PL/7 of the Plenipotentiary Conference (Nice, 1989);

1.2 invite the Secretary-General of the ITU:

- to explore every possible means of securing financing for developing country participation in the work of the CCIR Study Groups from the ITU's own resources and to study the financial implications;
- to secure the funds required for these technical cooperation activities, make proposals for their distribution among the countries concerned and submit as soon as possible a report to the Administrative Council for approval;

2. that when the developing countries face difficulties, which may be of interest to other administrations during the course of operating radio services, they should be encouraged to submit contributions to the CCIR describing these difficulties. The Director of the CCIR will communicate these contributions to the appropriate Study Group(s).

3. that the developing countries inform the Director, CCIR, as to which Study Groups are of most interest to them;

4. that the Members of the Union should attempt to step up their participation in the Special Voluntary Programme for Technical Cooperation in order to provide the Secretary-General of the ITU with additional resources other than those of the Union, so as to broaden the scope of application of the present Resolution.

# INTERNATIONAL AND REGIONAL ORGANIZATIONS

### EUROPEAN SPACE AGENCY (ESA)

8-10, rue Mario-Nikis
F – 75738 Paris Cedex 15

### ASSOCIATION OF STATE TELECOMMUNICATION UNDERTAKINGS OF THE ANDEAN SUB-REGIONAL AGREEMENT (ASETA)

Avenida Coruña 2669
y Gónzález Suárez
Casilla postal 6042
Quito, Ecuador

### INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

IATA Building
2000, Peel Street
Montréal, Québec H3A 2R4, Canada

### INTERNATIONAL ASSOCIATION OF BROADCASTING (IAB)

Calle Yi No. 1264
Montevideo, Uruguay

### INTERNATIONAL ASSOCIATION OF LIGHTHOUSE AUTHORITIES (IALA)

13, rue Yvon-Villarceau
F – 75116 Paris

### INTERGOVERNMENTAL BUREAU FOR INFORMATICS (IBI)

P.O. Box 10253
23, viale Civiltà del Lavoro
I – 00144 Roma

### INTERNATIONAL TIME BUREAU (BIH)

61, avenue de l'Observatoire
F – 75014 Paris

### COMMITTEE ON SPACE RESEARCH (COSPAR)

51, boulevard de Montmorency
F – 75016 Paris

### INTERNATIONAL MARITIME RADIO ASSOCIATION (CIRM)

Southbank House
Black Prince Road

### INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE (CISPR)

British Standards Institution
2, Park Street
GB – London W1A 2BS

### INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

3, rue de Varembé
CH – 1211 Genève 20

### INTER-UNION COMMISSION ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE (IUCAF)

c/o Dr. A. R. Thompson
National Radio Astronomy Observatory
Edgemont Road
Charlottesville, Virginia 22903, USA

### INTER-AMERICAN TELECOMMUNICATIONS CONFERENCE (CITEL)

1889 F Street, N.W. OAS
Washington, DC 20006, USA

### INTERNATIONAL CONFERENCE ON LARGE HIGH VOLTAGE ELECTRIC SYSTEMS (CIGRE)

122, boulevard Haussmann
F – 75008 Paris

### GULF COOPERATION COUNCIL (GCC) FOR ARAB COUNTRIES

P.O. Box 26831
Manama, Bahrain

### INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS (ICSU)

51, boulevard de Montmorency
F – 75016 Paris

### INTERNATIONAL ASTRONAUTICAL FEDERATION (IAF)

3-5, rue Mario Nikis
F – 75015 Paris

### GULFVISION

P.O. Box 6802



### NORTH AMERICAN NATIONAL BROADCASTERS ASSOCIATION (NANBA)

1500, Bronson Avenue
Ottawa, Ontario K1G 3J5, Canada

### ARAB SATELLITE COMMUNICATIONS ORGANIZATION (ARABSAT)

P.O. Box 1038
Riyadh, Saudi Arabia

### IBERO-AMERICAN TELEVISION ORGANIZATION (OTI)

Varsovia 44, 4° piso
México 6, D.F., México

### EUROPEAN TELECOMMUNICATIONS SATELLITE ORGANIZATION (EUTELSAT)

Tour Maine-Montparnasse
33, avenue du Maine
F – 75755 Paris Cedex 15

### INTERNATIONAL RADIO AND TELEVISION ORGANIZATION (OIRT)

Skokanska
16956 Praha 6, Czechoslovakia

### INTERNATIONAL MARITIME SATELLITE ORGANIZATION (INMARSAT)

40, Melton Street
GB – London NW1 2EQ

### INTERNATIONAL TELECOMMUNICATIONS SATELLITE ORGANIZATION (INTELSAT)

3400, International Drive, N.W.
Washington, DC 20008-3098, USA

### INTERNATIONAL ORGANIZATION OF SPACE COMMUNICATIONS (INTERSPUTNIK)

2, Smolensky 1/4
Moskva 121099, USSR

### INTERNATIONAL SOCIETY FOR AERONAUTICAL TELECOMMUNICATIONS (SITA)*

112, avenue Charles-de-Gaulle
F – 92522 Neuilly-sur-Seine

### ASIA-PACIFIC TELECOMMUNITY (APT)

Soi 5, Chaengwattana Road
Thungsonghong, Bangkhen
Bangkok 10210, Thailand

### AFRICAN POSTAL AND TELECOMMUNICATIONS UNION (UAPT)

Avenue Patrice Lumumba
Boîte postale 44
Brazzaville, Congo

### ARAB TELECOMMUNICATION UNION (ATU)

P.O. Box 28015
Baghdad, Iraq

### INTERNATIONAL ASTRONOMICAL UNION (IAU)

61, avenue de l'Observatoire
F – 75014 Paris

### ASIA-PACIFIC BROADCASTING UNION (ABU)

P.O. Box 1164
Kuala Lumpur 22-07, Malaysia

### ARAB STATES BROADCASTING UNION (ASBU)

17, rue El-Mansoura
Boîte postale 65 El Menzah
El Menzah IV
Tunis 1014, Tunisia

### UNION OF NATIONAL RADIO AND TELEVISION ORGANIZATIONS OF AFRICA (URTNA)

Centre technique
Boîte postale 39
Bamako, Mali

## EUROPEAN BROADCASTING UNION (EBU)

Centre technique
32, avenue Albert-Lancaster
B – 1180 Bruxelles

## INTERNATIONAL AMATEUR RADIO UNION (IARU)

225 Main Street
P.O. Box AAA
Newington, Connecticut 06111, USA

## PANAFRICAN TELECOMMUNICATION UNION (PATU)

Boite postale 8634
Kinshasa 1, Zaire

## INTERNATIONAL UNION OF RADIO SCIENCE (URSI)

32, avenue Albert-Lancaster
B – 1180 Bruxelles



# SPECIALIZED AGENCIES OF THE UNITED NATIONS *

## INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO)

Place de l'Aviation internationale
1000, rue Sherbrooke Ouest
Montréal, Québec H3A 2R2, Canada

## INTERNATIONAL MARITIME ORGANIZATION (IMO)

4, Albert Embankment
GB – London, SE1 7SR

## WORLD METEOROLOGICAL ORGANIZATION (WMO)

41, avenue Giuseppe-Motta
CH – 1211 Genève 20

* Agencies participating in the work of the CCIR under Article 39 of the International Telecommunication Convention, Nairobi, 1982.

# SCIENTIFIC OR INDUSTRIAL ORGANIZATIONS

## *GERMANY (Federal Republic of)*

### AEG AKTIENGESELLSCHAFT

z.Hdn. Herrn Tandler/VB-F
Theodor-Stern-Kai 1
6000 Frankfurt am Main 70

### ANT NACHRICHTENTECHNIK GmbH

Herrn Dr. Ing. Reinhard Till
K1 E312
Gerberstrasse 33
7150 Backnang

### FUBA, HANS KOLBE & CO.

Postfach 1160
3202 Salzdetfurth

### PHILIPS KOMMUNIKATIONS INDUSTRIE A.G.

Thurn-und-Taxis-Str. 10
Postfach 3538
8500 Nürnberg 10

### ROHDE & SCHWARZ

Mühldorfstrasse 15
Postfach 80 14 69
8000 München 80

### SIEMENS A.G.

NCCI-Referat
Hofmannstrasse 51
Postfach 700072
8000 München 70

### STANDARD ELEKTRIK LORENZ A.G.

Herrn W. Polnik ZT/TMSF
Hellmuth-Hirth-Strasse 42
7000 Stuttgart 40

### WANDEL & GOLTERMANN

z.H. Frau S. Jetter, Abt. PA
Postfach 45 – Mühleweg 5
7412 Eningen u.A.

## *CANADA*

### BELL-NORTHERN RESEARCH LTD.

P.O. Box 3511, Station C
Ottawa, Ontario K1Y 4H7

### SPAR TECHNOLOGY LIMITED

21025 Trans Canada Highway
Ste-Anne-de-Bellevue, Québec H9X 3R2

## *SPAIN*

### TELETTRA ESPAÑOLA S.A. *

Apartado de Correos 61.278
28080 Madrid

## *UNITED STATES OF AMERICA*

### GTE INTERNATIONAL INC.

One Stamford Forum
Stamford, Connecticut 06904

### HARRIS CORPORATION, FARINON DIVISION

1691 Bayport Avenue
San Carlos, California 94070

### HUGHES AIRCRAFT COMPANY

Space and Communications Group
P.O. Box 92919 – Airport Station
Los Angeles, California 90009

### ITT CORPORATION

320 Park Avenue
New York, NY 10022

### MOTOROLA, INC.

1776 K Street, NW
Suite 300
Washington, DC 20006



### ROCKWELL INTERNATIONAL CORPORATION

Washington Office (Department 020)
1745 Jefferson Davis Highway
Arlington, Virginia 22202

### SYSTEMATICS GENERAL CORPORATION

Communications and Electronics Division
1606 Old Ox Road
P.O. Box 28
Sterling, Virginia 22170

## *FINLAND*

### OY NOKIA

P.O. Box 226
00101 Helsinki 10

## *FRANCE*

### COMPAGNIE INDUSTRIELLE DES TELECOMMUNICATIONS (CIT-ALCATEL)

Département Transmission
Etablissement de Villarceaux
Route de Villejust – Nozay
91620 La Ville-du-Bois

## *HUNGARY*

### INSTITUT DE RECHERCHES DE TÉLÉCOMMUNICATIONS (TKI)

II. Gabor Aron utca 65-67
Pf 15
Budapest 1525

## *ITALY*

### ANIE – ASSOCIAZIONE NAZIONALE INDUSTRIE ELETTROTECHNICHE ED ELETTRONICHE

Via Algardi 2
20148 Milano

### CSELT – CENTRO STUDI E LABORATORI TELECOMUNICAZIONI

Via Guglielmo Reiss Romoli 274
10148 Torino

### FONDAZIONE UGO BORDONI

Segreteria di Direzione
Via B. Castiglione 59

### GTE TELECOMUNICAZIONI s.p.a.

Cassina de Pecchi
20060 Milano

### ITALTEL s.p.a.

Piazzale Zavattari 12
20149 Milano

### SOCIETÀ ITALIANA RETI TELEFONICHE INTERURBANE (SIRTI)

Via G. B. Pirelli 20
20124 Milano

### SOCIETÀ MARCONI ITALIANA

Via Ambrogio Negrone 1
16153 Genova-Cornigliano

### STET – SOCIETÀ FINANZIARIA TELEFONICA

Direz. Generale Roma
Corso d'Italia 41
00198 Roma

### TELETTRA – TELEFONIA ELETTRONICA E RADIO s.p.a.

Viale Fulvio Testi 136
20092 Cinisello Balsamo (Milano)

## *JAPAN*

### ELECTRONIC INDUSTRIES ASSOCIATION OF JAPAN

Tosho Building
2-2, Marunouchi 3-chome
Chiyoda-ku
Tokyo 100

### FUJITSU LIMITED

Marunouchi Center Building
6-1, Marunouchi 1-chome
Chiyoda-ku

**HITACHI LIMITED**

Hitachi Omori Second Building
27-18 Minamioi 6-chome
Shinagawa-ku
Tokyo 140

**MATSUSHITA COMMUNICATION INDUSTRIAL CO., LTD.**

600 Saedo-chou
Midori-ku
Yokohama 226

**MITSUBISHI ELECTRIC CORPORATION**

Planning and Administration Department
Electronic Products and Systems Group
2-3 Marunouchi 2-chome
Chiyoda-ku
Tokyo 100

**NEC CORPORATION**

Office of ITU Affairs
33-1 Shiba 5-chome
Minato-ku
Tokyo 108

**OKI ELECTRIC INDUSTRY COMPANY LTD.**

1-7-12 Toranomon
Minato-ku
Tokyo 105

**TOSHIBA CORPORATION**

Systems Division
1-1 Shibaura 1-chome
Minato-ku
Tokyo 105

*NETHERLANDS*

**AT&T EN PHILIPS TELECOMMUNICATIE BEDRIJVEN B.V.**

P.O. Box 1168
1200 BD – Hilversum

*UNITED KINGDOM*

**PLESSEY TELECOMMUNICATIONS RESEARCH LTD.**

Stoke Park House
Stoke Poges
Slough, Berkshire SL2 4NY

*SWEDEN*

**TELEFONAKTIEBOLAGET LM ERICSSON**

126 25 Stockholm

*YUGOSLAVIA*

**ISKRA**

Center za elektrooptiko
Stegne 7, P.O.B. 59
61210 Ljubljana-Sentvid

**NIKOLA TESLA**

P.O. Box 120-10
Zagreb

INTERNATIONAL TELECOMMUNICATION UNION

CCIR
INTERNATIONAL
RADIO CONSULTATIVE
COMMITTEE

# HANDBOOK

## SPECTRUM MANAGEMENT AND COMPUTER-AIDED TECHNIQUES

Edition of 1983
Revised in 1986

CCIR

Geneva, 1987

ISBN 92-61-01701-0

## INTRODUCTION BY THE CHAIRMAN OF CCIR IWP 1/2

It gives me great pleasure to introduce this first revision of the Handbook on Spectrum Management and Computer-Aided Techniques. Although there are many handbooks on a variety of subjects, this is the only handbook on this subject. I hope that the new material will add additional insight in methods of achieving effective spectrum management through computer automation. Numerous discussions were held between administrations to complete this revision. It is especially important in the future that administrations continue their participation in the CCIR and other forums to examine ways to achieve more efficient use of the radio frequency spectrum through more effective spectrum management practices.

The First Meeting on National Spectrum Management [CCIR, 1983] addressed a number of questions to CCIR Study Group 1 on how to automate spectrum management systems. In particular, questions about computer software and hardware requirements, methods of exchanging data and standard programming language were considered. Annexes V and VI of the Handbook contain a summary of Data Base Management System (DBMS) software and hardware characteristics for micro and mini computers respectively that was also sent to the Second Meeting on National Spectrum Management. The question about methods of exchanging data was again examined with the conclusion that the preferred standard for exchanging large quantities of data was with magnetic tape while 5 1/4" diskettes are preferred for smaller quantities of data. In addition, ANSI Fortran 77 is still the recommended language for spectrum management software development where portability is required.

During the 1982-1986 study period, a practical examination of the Handbook was undertaken by many administrations by applying the methods to their spectrum management system. The methods contained in the Handbook were generally found to be very useful. There were, however, certain areas which the Handbook did not address and will still not be considered in this revision due to a lack of available information. This, in particular, concerns application of the methods to the spectrum management systems of administrations of different sizes. A discussion of "application experience" took place at the Eighth International Wrocław Symposium on Electromagnetic Compatibility [Mayher, 1986] and can be briefly summarized as: "It is initially necessary to use a criteria to determine if automation is required. If the national spectrum management structure is effectively organized and frequency assignment data files greater than typically 5000 complex records are required then automation methods should be considered. Initially changeover problems can be minimized through proper planning. The primary design of the automated system should be centred around the requirements of the frequency assignment data base that represents 85% of the data requirements excluding terrain data. In addition automation is advantageous for interference analysis requirements that lead to more efficient use of the spectrum. The criteria for selecting a computer system should first be based on the functional requirements, then the DBMS, then the availability of software and finally the availability of computer hardware in a particular country. The computer hardware cost is the lowest overall cost of automating a national spectrum management system".

Finally, the key to effective spectrum management is the collection of adequate frequency assignment data that serves the basic management needs of the administration and can be easily exchanged between administrations. During the past period, the frequency assignment data in Table AIV-II was reviewed by administrations and the IFRB. The recommended "basic" data has been increased from 31 to 63 fields due mainly to increased requirements of the IFRB. Since some administrations have concerns about managing the size of the data file created by this large structure, this data file will be re-examined by IWP 1/2 to determine the minimum number of fields that is required to be stored by some administrations. In addition, all other spectrum management data files will be re-examined for recommended data formats that can form the cornerstone for effective spectrum



The Handbook could not have been developed without the expertise of many individuals around the world, cooperating within the framework of the CCIR. For its preparation and further updating, CCIR Interim Working Party 1/2 has been created within Study Group 1 (CCIR Decision 27). The membership of IWP 1/2 was as follows (in alphabetical order): R. Bisner (France), G. F. Block (ESA), A. P. Chaudhury (India), E. D'Andria (Italy), M. Garidou (France), I. R. Hutchings (New Zealand), D. Kopitz (EBU), J. K. Lady (United States of America), R. McCaughern (Canada), P. Major (United States of America), H. Mallau (Federal Republic of Germany), M. Menchén (Spain), C. A. Merchan Escalante (Mexico), P. Pettersson (Sweden), T. E. Racine (Canada), G. H. Railton (Papua New Guinea), J. A. Reymundo (Spain), T. Saruwatari (Japan), G. Smith (Papua New Guinea), W. Spycher (Switzerland), R. G. Struzak (People's Republic of Poland), V. N. Volkov (USSR), J. Warden (United Kingdom) and W. L. Wilson (Papua New Guinea). The Working Party was supported by the staff of the CCIR Secretariat, with participation of the IFRB, and the ITU Computer Department.

### REFERENCES

CCIR [1983] Report of the First Meeting on the Development of National Radio Frequency Management. (Geneva, 24 to 28 October) (Document 24).

MAYHER, R. J. [1986] Experience in automating national spectrum systems. Round Table Discussion at the Eighth International Wrocław Symposium on Electromagnetic Compatibility. CCIR, IWP 1/2, 182.

R. J. Mayher (United States of America)
Chairman, CCIR IWP 1/2

# TABLE OF CONTENTS

Chapter 5





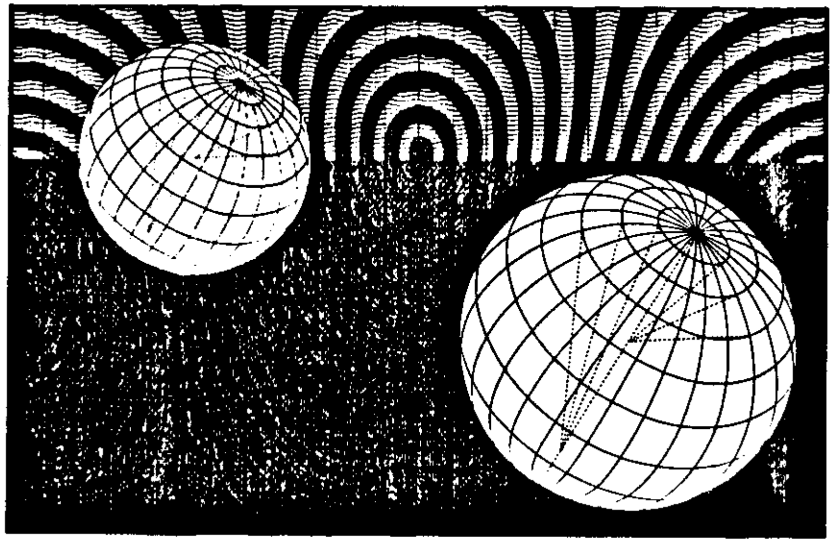
Page

Chapter 6

RAPPORT 340-5 | REPORT 340-5 | INFORME 340-5

COMITÉ CONSULTATIF INTERNATIONAL DES RADIOCOMMUNICATIONS
INTERNATIONAL RADIO CONSULTATIVE COMMITTEE
COMITÉ CONSULTIVO INTERNACIONAL DE RADIOCOMUNICACIONES

CCIR



# ATLAS CCIR DES CARACTÉRISTIQUES IONOSPHÉRIQUES

# CCIR ATLAS OF IONOSPHERIC CHARACTERISTICS

# ATLAS CCIR DE LAS CARACTERÍSTICAS IONOSFÉRICAS

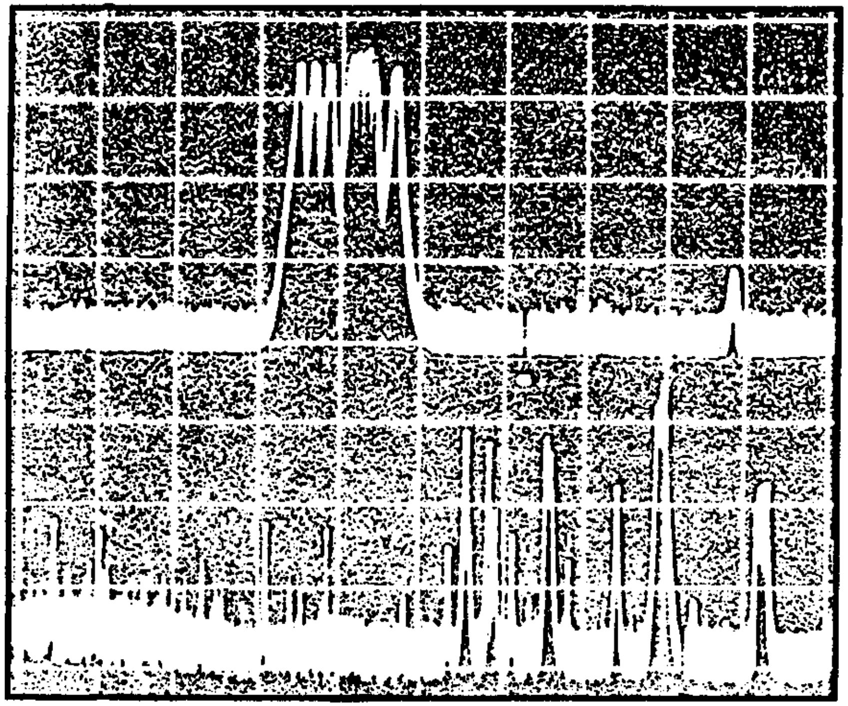
UNION INTERNATIONALE DES TÉLÉCOMMUNICATIONS
INTERNATIONAL TELECOMMUNICATION UNION
UNIÓN INTERNACIONAL DE TELECOMUNICACIONES



CONTENTS

CCIR

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE



# HANDBOOK FOR MONITORING STATIONS

INTERNATIONAL TELECOMMUNICATION UNION

Geneva, 1988



## INTRODUCTION BY THE CHAIRMAN OF CCIR IWP 1/5

It gives me great pleasure to present the updated edition of the Handbook for Monitoring Stations.

In Resolution 16-1, the XIth Plenary Assembly of the CCIR (Oslo, 1966) decided to provide monitoring station operators with a training aid geared to their very specific needs and, in implementation of the provisions of the Resolution, the CCIR published the first edition of the Handbook in 1968 (supplemented in 1971).

Our thanks go to the eight administrations and two international organizations who drafted the Handbook's 19 chapters, for their work has proved very useful to monitoring stations, as the members of IWP 1/5 can certainly confirm. However, no provision was made to prevent the Handbook from "ageing" and, consequently, some of the administrations attending the Final Meeting of CCIR Study Group 1 (Geneva, 1981) were prompted to request the establishment of an Interim Working Party to be responsible for updating it. To this end, IWP 1/5 was set up under Decision 53 of the XVth Plenary Assembly of the CCIR (Geneva, 1982); it is composed of representatives from ten administrations, three international or industrial organizations and the IFRB.

At its first meeting in Paris in 1982, IWP 1/5 decided to retain the original titles of the 19 chapters and to add a new chapter on space station monitoring.

With regard to organization of work, it was agreed that the workload should be shared among the group and the following allocation of tasks was approved:

| | | | |
|---|---|---|---|
| Chapter 1 | Portugal | Chapter 11 | EBU |
| Chapter 2 | United States of America | Chapter 12 | Japan |
| Chapter 3 | United States of America | Chapter 13 | France, United States of America |
| Chapter 4 | United States of America | Chapter 14 | United Kingdom |
| Chapter 5 | United Kingdom | Chapter 15 | Italy |
| Chapter 6 | Germany (Federal Republic of) | Chapter 16 | Iran (Islamic Republic of) |
| Chapter 7 | United States of America | Chapter 17 | France |
| Chapter 8 | France | Chapter 18 | France |
| Chapter 9 | Japan | Chapter 19 | IFRB |
| Chapter 10 | Portugal | Chapter 20 | Germany (Federal Republic of) |

The members of the IWP representing the above-mentioned administrations and organizations were therefore appointed coordinators for updating the chapters assigned to them, but they were to receive assistance from the group as a whole.

The IWP also decided:

- that the new or revised texts should be submitted for comment and, possibly, amendment;
- that the chapters should not be sent to the CCIR Secretariat without the consent of the IWP.

The coordinators were naturally requested to take account of technical progress in radio monitoring, together with the development and impact of the use of the VHF, UHF and even SHF bands.

The IWP has worked well on the above basis and an excellent atmosphere has prevailed throughout its nine meetings. It has fulfilled a significant part of its mandate by supplying the CCIR with material for a Second Edition of the Handbook. However, I venture to hope that CCIR Study Group 1 will take the necessary steps to arrange for the text to be updated as training methods (such as the use of audiovisual facilities) and monitoring techniques evolve, thus ensuring that the Handbook remains a valuable tool for monitoring station operators.

Finally it would not have been possible to update the Handbook without the assistance of the following members of IWP 1/5, listed in alphabetical order:

Mr. Balfroid (IFRB), Mr. Barbadoro (Italy), Mr. Betts (United Kingdom), Mr. Bisner (France), Mr. Bottcher (Federal Republic of Germany), Mr. Canei (EBU), Mr. Dell'Ovo (Italy), Mr. Fevereiro (Portugal), Mr. George (Federal Republic of Germany), Mr. Giacopello (Italy), Mr. Khatami (Islamic Republic of Iran), Mr. Kilpatrick (United States of America), Mr. Labay (CCRM, Belgium), Mr. Luther (United States of America), Mr. Moreno Peral (Spain), Mr. Nedelchev (Federal Republic of Germany), Mr. Nakagawa (Japan), Mr. Olms (IFRB), Mr. Patricio (Portugal), Mr. Proenca (Portugal), Mr. Schiff (France), Mr. Susumo Sato (Japan), Mr. Vacani (Italy), Mr. Warden (United Kingdom) and Mr. Yukio Yahamoto (Japan).

The Working Party also received help from the CCIR Secretariat as a whole, in particular Mr. Rutkowski and Mr. Struzak (Senior Counsellors) and Mr. Pavliouk and Mr. Nalbandian (Counsellors), as well as from Mr. Hunt, Chairman of Study Group 1.

I thank you all and wish the Handbook every success.

Chairman of IWP 1/5
R. LEFORT

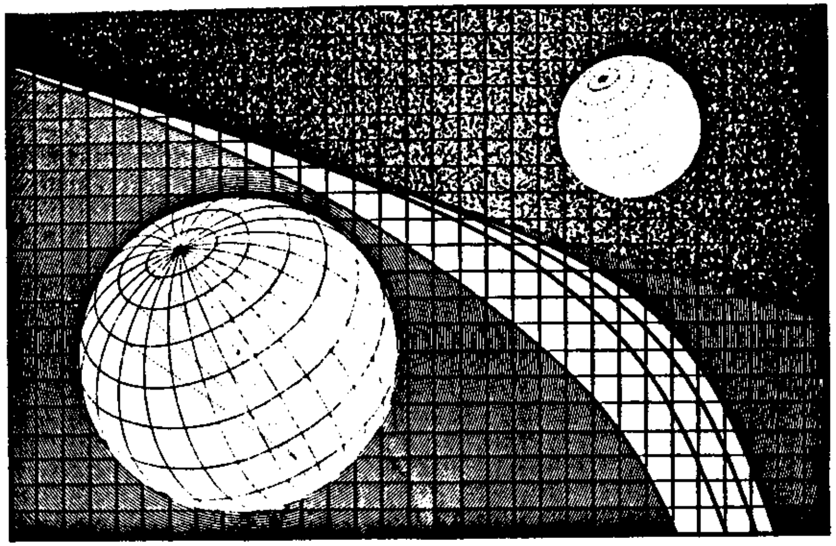
SUMMARY



RAPPORT 717-2 | REPORT 717-2 | INFORME 717-2

CCIR

COMITÉ CONSULTATIF INTERNATIONAL DES RADIOCOMMUNICATIONS
INTERNATIONAL RADIO CONSULTATIVE COMMITTEE
COMITÉ CONSULTIVO INTERNACIONAL DE RADIOCOMUNICACIONES



# ATLAS MONDIAL DE LA CONDUCTIVITÉ DU SOL

# WORLD ATLAS OF GROUND CONDUCTIVITIES

# ATLAS MUNDIAL DE LA CONDUCTIVIDAD DEL SUELO


UNION INTERNATIONALE DES TÉLÉCOMMUNICATIONS
INTERNATIONAL TELECOMMUNICATION UNION
UNIÓN INTERNACIONAL DE TELECOMUNICACIONES

Genève, 1988

TABLE DES MATIÈRES



CONTENTS



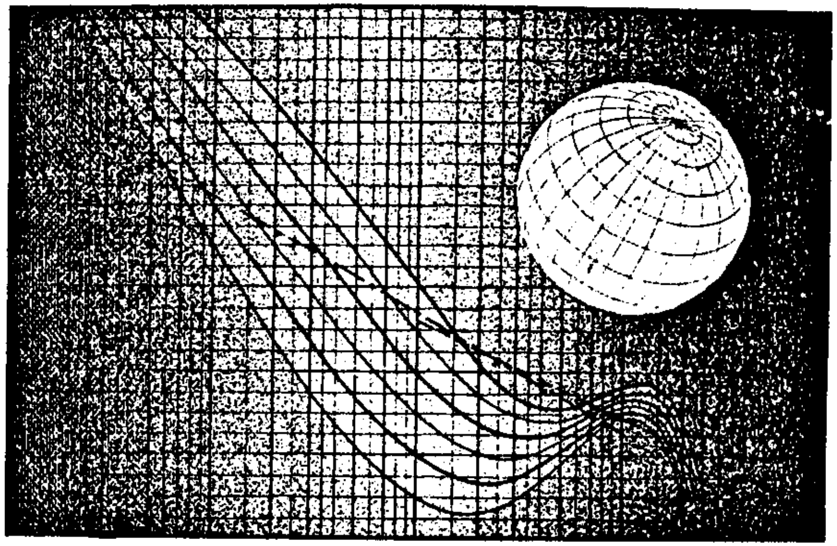
ÍNDICE



RAPPORT 322-3 | REPORT 322-3 | INFORME 322-3


CCIR

COMITÉ CONSULTATIF INTERNATIONAL DES RADIOCOMMUNICATIONS
INTERNATIONAL RADIO CONSULTATIVE COMMITTEE
COMITÉ CONSULTIVO INTERNACIONAL DE RADIOCOMUNICACIONES

# CARACTÉRISTIQUES DU BRUIT ATMOSPHÉRIQUE RADIOÉLECTRIQUE ET APPLICATIONS

# CHARACTERISTICS AND APPLICATIONS OF ATMOSPHERIC RADIO NOISE DATA

# CARACTERÍSTICAS DEL RUIDO ATMOSFÉRICO RADIOELÉCTRICO Y APLICACIONES


UNION INTERNATIONALE DES TÉLÉCOMMUNICATIONS
INTERNATIONAL TELECOMMUNICATION UNION

TABLE DES MATIÈRES



CONTENTS



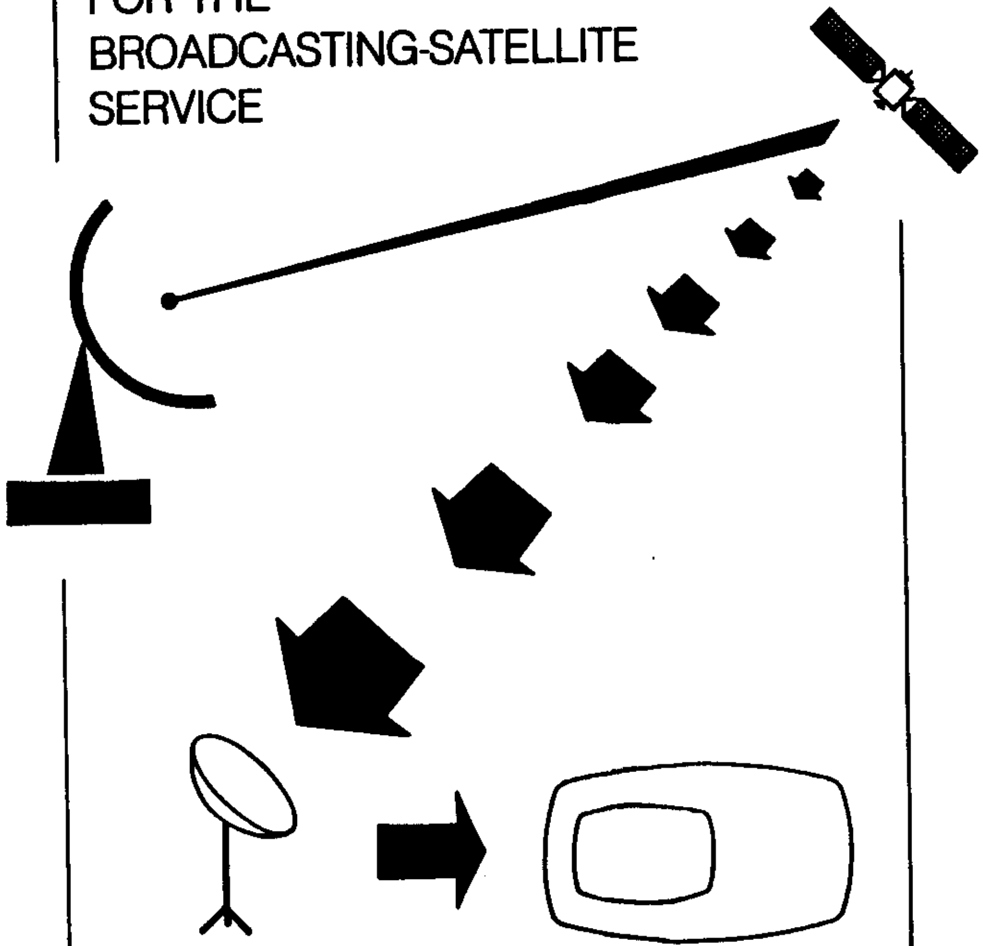
ÍNDICE




CCIR

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE


# SPECIFICATIONS OF TRANSMISSION SYSTEMS FOR THE BROADCASTING-SATELLITE SERVICE




INTERNATIONAL TELECOMMUNICATION UNION

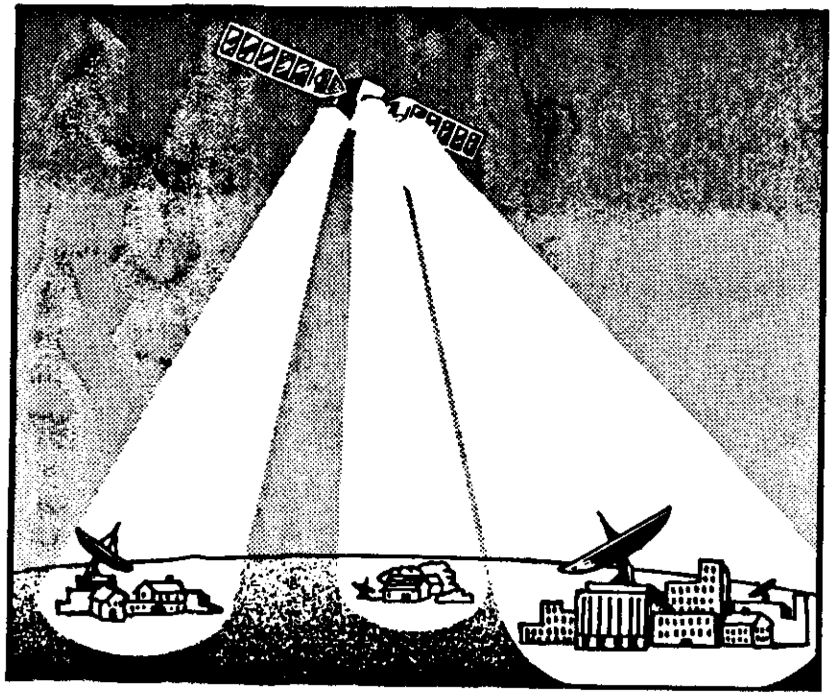
Geneva, 1988

## SPECIFICATION OF TRANSMISSION SYSTEMS FOR THE BROADCASTING-SATELLITE SERVICE

## TABLE OF CONTENTS

INTERNATIONAL RADIO CONSULTATIVE COMMITTE

CCIR



HANDBOOK

# SATELLITE COMMUNICATIONS

## FIXED-SATELLITE SERVICE

INTERNATIONAL TELECOMMUNICATION UNION Geneva, 1988



TABLE OF CONTENTS

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

**RADIO FREQUENCY SPECTRUM MANAGEMENT**

Part 9

RADIO FREQUENCY SPECTRUM MONITORING

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland

The purpose of these notes is to provide an overview of current developments in monitoring of the usage of the radio frequency spectrum resource. [Source: R.G. Struzak: Radio Monitoring; in "Electromagnetic Compatibility in Radio Engineering" edited by W. Rotkiewicz and published by Elsevier Scientific Publishing Company, Amsterdam, Oxford, New York, 1982, Chapter 9, pp.249-278 + insert.

These notes are for internal distribution only



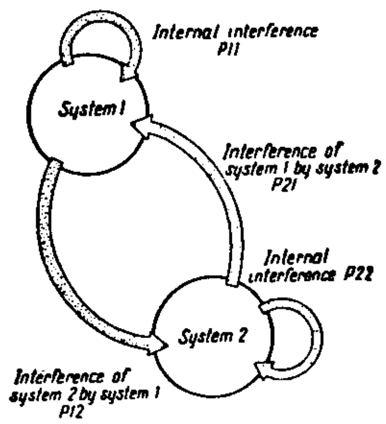
# 9

# Radio monitoring (general aspects)

RYSZARD G. STRUŻAK

## 9.1 Introduction

Unintentional radiations of EM energy, and undesired system responses, are at present the major factors limiting the transmission of information by electrical signals. Fig. 9-1 illustrates a simple case of two systems, indicated by numbers 1 and 2. These systems produce both intentional and unintentional emissions as well as desired and undesired responses which are po-




9-1. System interferences (after Strużak [57]) tential sources of interference. Four general types of interference can be distinguished:

1. Interference (P11) generated by, and influencing system 1 (internal interference or noise).

2. Interference analogous to 1, but related to system 2 (P22).

3. Interference (P12) resulting from unintentional radiations of system 1 and undesired responses of system 2, i.e. interference of system 2 by system 1.

4. Interference analogous to 3, but with the roles reversed, i.e. interference of system 1 by system 2.

The number of such collisions grows with the number of co-existing systems.

As was pointed out in chapter 2, the number of systems and equipment generating EM emissions, or susceptible to them, rises with population growth and the development of civilization. At the same time the requirements concerning the quality of systems of information transmission and processing rise, too. This is one of the reasons for the continuous growth of radio networks and services, improvements in radio technology, and introduction of new frequency ranges. However, all of this is quite ineffective if adequate requirements and standards, ensuring compatibility are not observed. Failure to establish such requirements and standards would undoubtedly lead to a situation in which, not only radio and TV reception, but also all kinds of electrical communication and data processing would be practically impossible. The economic, political, and cultural damage to society would be almost unimaginable.

The radio frequency spectrum is a natural resource, which is limited in quantity. Consequently it should be used in a rational manner to avoid wastage and pollution. Therefore, the factors causing wastage and pollution should be investigated and eliminated, and appropriate steps should be taken which will lead to an efficient and economic utilization of the resource. A planned distrubution of spectrum use accommodating the needs of the maximum number of users should be the basic consideration. For any plan of radio frequency management it is essential that a permanent record of the actual realization of the plan and real occupancy of the spectrum be maintained.

Therefore, in its utilization and management, it is necessary to check, observe and oversee constantly the radio frequency spectrum (or more generally, the electromagnetic environment). This is what is meant by the term „*monitoring*" in radiocommunication.

## 9.2 Monitoring activity

In radio spectrum management, monitoring activity usually includes the following:

- measurement of the spectrum occupancy,



- measurement of emission frequency,
- measurement of emission bandwidth,
- measurement of the modulation parameters,
- measurement of the field strength and the power flux density,
- measuring of the directions from which the emissions emanate,
- identification of emissions,
- solution of radio interference problems,
- radio spectrum surveillance.

The activities depend on needs which may be different in different countries and in different regions within a country. No list of activities assigned to a monitoring service can claim to be exhaustive. Technical developments are bound to give rise to new problems, thus creating new functions for a monitoring service.

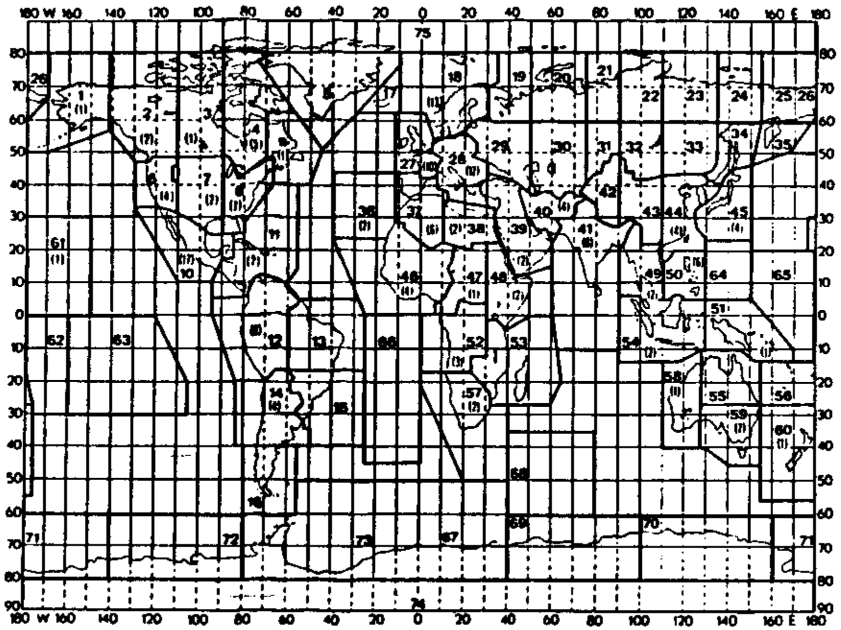
Almost all measurements carried out for monitoring purposes are remote measurements under actual traffic conditions. According to the requirements, the measurements may be performed to obtain relatively instantaneous results at one location, or to obtain data compiled from several locations or from long-term observations.

Measuring the spectrum occupancy is one of the basic activities in monitoring. Indeed, it gives a general insight into the world of radio waves and it is indispensable for rational radio frequency management. Frequency measurements are made mainly to determine whether the tolerances imposed on the transmitter frequency (including stability) are observed. The field strength measurements are needed to delineate the service area of a transmitter, to appraise the interference potential of radiation, to determine the propagation phenomena etc. Direction finding is indispensable in locating an unidentified, or unknown, source of emission. It should be noted that the Radio Regulations prohibit transmission without (or with false) identification. An emission can be identified by listening to, or analyzing, the identifying message contained in the emission. In the absence of „built in" information, any clearly distinguishing feature (including direction, location etc.) of the emission may be used for identification. Solving an interference problem is another activity of great importance. Its substance is illustrated in Fig. 9-2.

The effectiveness of monitoring activity depends upon its organization and the equipment used. Since it is based on remote measurements, antennae play a great role. Other equipment includes various receivers and dedicated sets for measurements of frequency, field strength, spectrum occupancy, power stability, bandwidth etc. and special equipment for identification of radio signals.

Stationary radio emissions, i.e. emissions constant with respect to time, are relatively easy to detect and identify. Monitoring of short-term emissions with frequencies varying rapidly in an unpredictable manner, is a difficult task requiring especially effective methods and systems. In such cases the search process has to be realized in a multi-dimensional space of time, frequency, direction, distance and the structural feature of the signal. The process, consisting of many routine elements has, in this case, to be quite rapid. Automation can accelerate the search process and improve it greatly.

The origin of monitoring activity was purely national. It soon became evident, however, that international cooperation in this field is indispensable for achieving effective use of the radio spectrum. Now, the Radio Regulations put great emphasis on international monitoring. It is also obvious that an international monitoring system cannot be fully effective unless it covers all areas of the world. Many countries cooperate in this field and there are 157 stations participating in the ITU international monitoring system. Fig. 9-3 shows their distribution. The ITU/IFRB registers the



9-3. For international monitoring purposes the world is divided into 74 numbered areas according to the Geographical zones for Broadcasting given in Radio Regulations. The numbers appearing between brackets on the map represent the number of monitoring stations notified to the ITU for the Geographical Zones concerned [5]

results supplied by the stations and publishes periodic summaries. Mobile and amateur stations, as well as transmitters working at frequencies over 28 MHz, are not internationally monitored: they are monitored at the national level.

## 9.3 Monitor stations

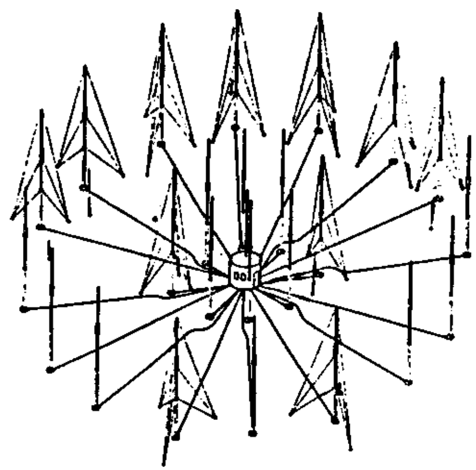
### 9.3.1 Fixed monitor stations

Monitoring consists of different functions of various degrees of complexity, requiring different procedures and different measuring instruments. For example, the registration of call signs is simpler than direction finding, which, in turn, is less complicated than power density measurements. The basic goal of monitoring is to verify whether or not a given radio emission conforms to the ITU Radio Regulations and moreover, to detect and identify unlicensed emissions, noise, and interference sources.

"Classical" radio monitoring is based upon a network of stationary receivers searching for signals within given frequency, space, and time, intervals.

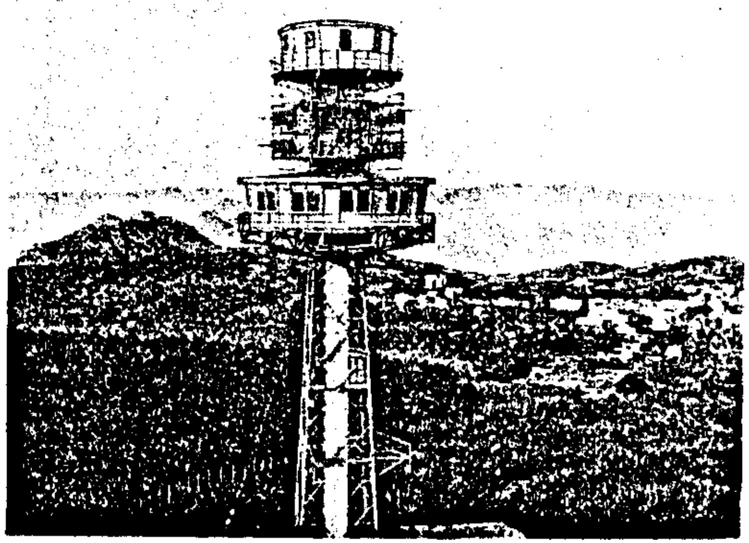
The detected radiation is further analyzed and measured in detail. The receiver's sensitivity and the features of the antenna determine the monitoring threshold, i.e. decide, how weak emissions and how remote sources can be detected and identified.

Fixed monitor stations are located where radio reception is good. As an illustration, in Fig. 9-4 a typical antenna system (containing 24 dipole



9-4. Typical H-Adcock antenna system used for direction finding up to 30 MHz (after [16])

antennae) used in direction-finding within the frequency range 1–30 MHz is shown. Fig. 9-5 shows the RAI (Radiotelevisione Ital ana) monitor station in Sorrento. This station is situated by the sea in the Bay of Naples, at an altitude of 526 m. above sea level. It is located in a tower 42 m high and consists of 2 measuring rooms and several additional chambers. The first measuring room is cylindrical in form (10 m in diameter) and is situated at the top of the tower. It protects field intensity meters for frequencies up to 30 MHz and frame antennae. It is built entirely of dielectric materials, so that the field strength inside it is practically the same as in free space. The second room is 10 m below the first one. It contains measuring and



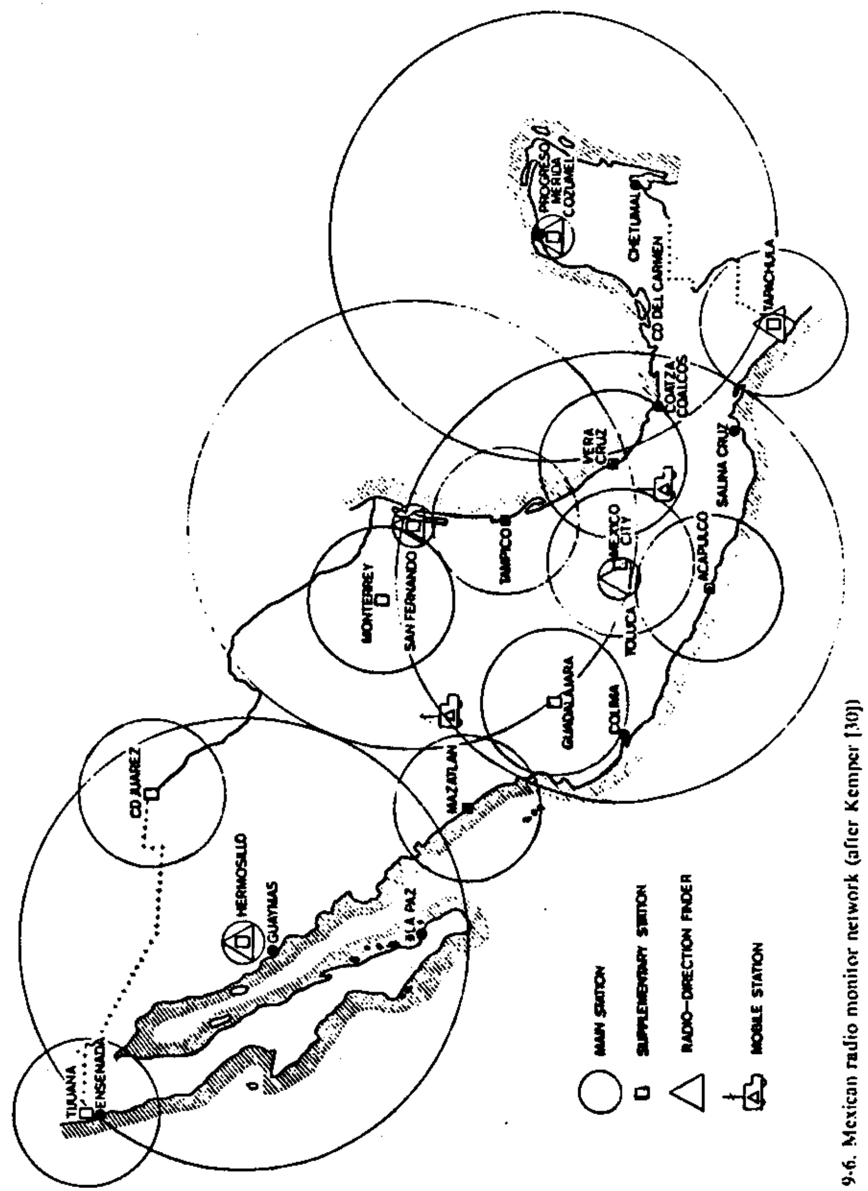
9-5. Photograph of RAI monitor station in Sorrento (after Lari [33])

monitoring equipment for the frequency range 0.1–1000 MHz which makes possible field strength measurement, emission identification, frequency, bandwidth and modulation measurements, and recording of the results. Between these rooms a rotary directional antenna system for frequencies over 30 MHz (for both vertical and horizontal polarizations) is located. The whole construction weighs over 7.000 kg. At the base of the tower the frequency standards are kept. The whole arrangement is supplemented by technological equipment and additional rooms which are used for auxiliary and social activities.

The station described allows continuous monitoring of RAI transmitters (AM and FM broadcasting and TV band I, III and IV) as well as many foreign stations. The total number of monitored emissions exceeds 1.500.

A typical site for a monitoring station is a flat, uniform and open terrain. The area, covered by the station and its antennae systems is of the order of a few square kilometers. The limited sensitivity of a monitoring system restricts the geographical area monitored by the station. Several such stations are therefore necessary for a large region. Usually they are interconnected creating a regional monitoring network. For example, in Italy, there are two such stations: the RAI main station (Monza) and a supplementary station (Sorrento). In Mexico there is a network of four main, 10 supplementary and 2 mobile stations. Their distribution is shown in Fig. 9-6. The nominal boundaries of the regions monitored by individual stations are marked. The main stations cover a frequency range of 100 kHz–960 MHz and are equipped with radio direction finders. The supplementary stations work principally within the VHF and UHF ranges.

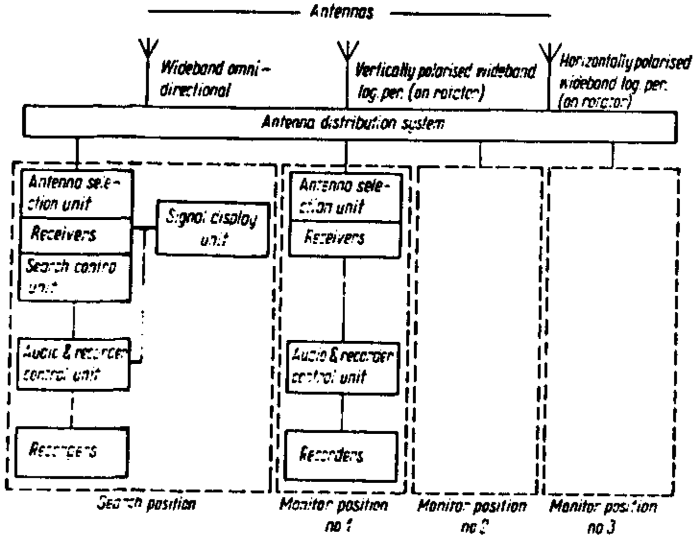





9-6. Mexican radio monitor network (after Kemper [30])

## 9.3.2 Mobile and transportable stations

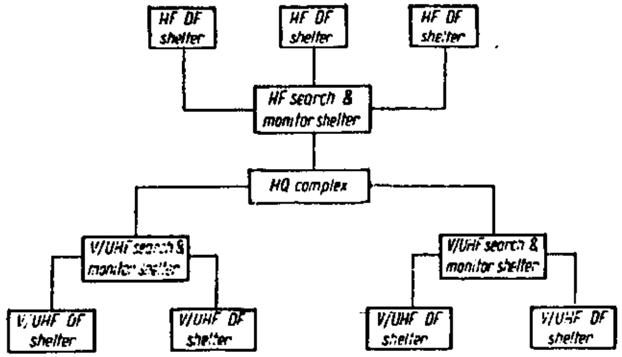
Because of its limited and constant monitor ranges, fixed stations often cannot fulfil all the duties connected with radio monitoring. At high frequencies their monitor boundaries are limited by the horizon. When conflicting situations (interference) arise, the reaction time of the monitoring system plays the essential role. The time between the appearance of a conflict and its solution should be minimum. In such cases the mobile stations proved to be very useful. The number of necessary mobile stations depends on several factors such as: the size of the region to be monitored, the number of the emission sources, the mobility of the station and the accessibility of the terrain, as well as the required reaction time of the system. The simplest mobile station is an autonomic transportable setup (antenna, receiver, recorder, source of energy) adapted for work in different locations.
An example of a modern transportable station is shown in fig. 9-7.



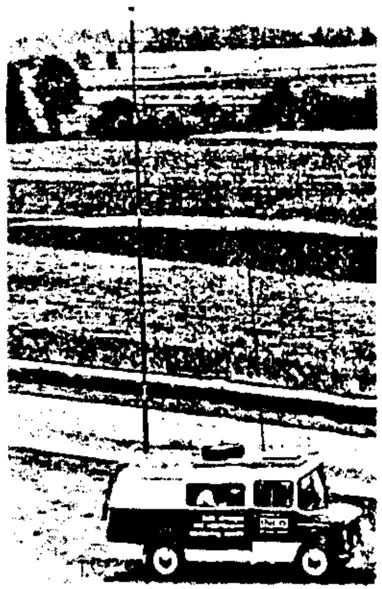

9-7. Example of transportable VHF/UHF search and monitor station (after [50])

The signals discovered in the search post and designated for detailed observation are distributed among the monitor posts. The more developed systems enabling location of emission sources with a relatively high precision are shown in Fig. 9-8. These stations can only be operated as transportable. Mobile stations are usually installed in cars. Depending on the purpose, their equipment and size can vary considerably. The smallest stations use mini-cars and the largest need heavy trucks of 15 m² or more of floor surface. Their mobility, limited by the vehicle's maximum speed, usually does not exceed 100 km/h. An example is shown in Fig. 9-9. During measurements, the speed is, as a rule, much lower and some monitoring functions cannot be performed in motion at all, e.g. field intensity measurements with great






9-8. Example of combined search, monitor and direction finding facilities of a transportable station (after [50])



9-9. Photograph of a vehicular monitor station (courtesy of INCO, Poland)

antenna heights. Precision frequency measurements also cannot be made in motion. If, e.g. the measuring car moves with a speed of $V = 60$ km/h, the measured frequency differs from the real one by

$$\frac{V}{c} = \frac{60\ \text{km/h}}{3\cdot 10^8\ \text{m/s}} = 5{,}6\cdot 10^{-8}$$

because of the Doppler effect. However, using a mobile station instead of a fixed one, the location of an unknown source (as well as other tasks) is much easier and less time-consuming.
Of course, mobile stations located on air-borne vehicles have the greatest mobility. Helicopter-stations are probably the most practical. An example is shown in Fig. 9-10. Use of a helicopter instead of a motor vehicle can

9-10. Photograph of flying mobile monitor station (courtesy of Instytut Łączności, Poland)

prove more economic and time saving. The cost of air surveillance can equal 10% of the cost of the surface measurements. One can expect that in the future, some of radio monitoring functions will be performed automatically from spacecrafts orbiting the earth.

## 9.4 Automation problems in monitoring

### 9.4.1 General

The Radio Regulations determine the basic monitoring tasks. Generally, their substance is the characterization of the environment. At a specified observation point, three fundamental characteristics can be determined:

1. Time characteristic, i.e. emission intensity (energy, EM field intensity) versus time (other variables, i.e. frequency, and direction being constant).
2. Frequency characteristic, i.e. intensity versus frequency (other variables being constant).
3. Directional characteristic, i.e. intensity versus observation direction (all other variables being constant).

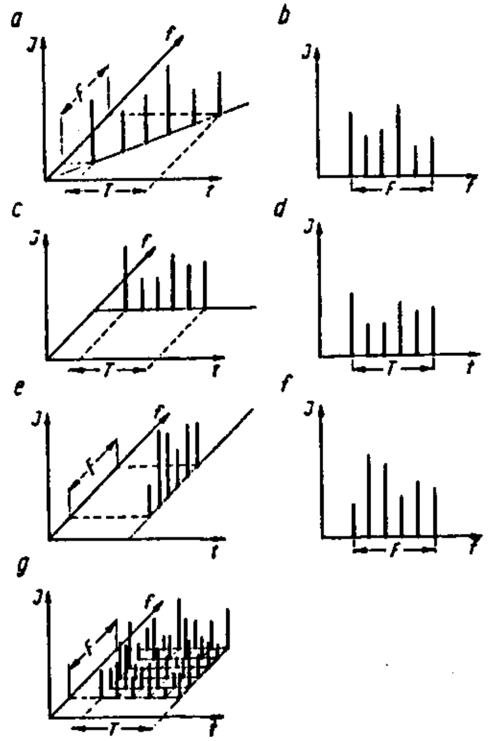
To these three characteristics, other specialized data may also be added (e.g. call signs). Modulation parameters of the signal are not mentioned. In principle they can be deduced from the fundamental characteristics.

It should be pointed out, however, that these characteristics can be determined only up to a certain resolution. This resolution depends on the precision of the applied methods and instruments. For example, useful information is contained only in those points of frequency spectrum characteristics which are separated from each other by the bandwidth of the spectrum analyzer. Similarly in the time characteristic, useful information is carried by the points separated by the transient response time of the meter.

The three above mentioned fundamental characteristics comprise, in fact, six measurable quantities: intensity, frequency, time, and three other co-



ordinates, defining the direction. Such multidimensional space may be hard to imagine, and for illustration we reduce the problem to three dimensional space. If the vertical axis represents results of intensity measurements and the horizontal axes – frequency and time, all measurements will form a surface. In analogy with a geographical terrain, one can speak of hills and valleys, corresponding respectively to the high and low intensities of the observed radiations. The narrow-band radiations from sharp „peaks", and the broad-band from "flat tops". The classic (point by point) measurements give the heights of separate points of the terrain, while the continuous registrations give terrain profiles. Examples are shown in Fig. 9-11.




9-11. Various measuring methods for the EM environment characterization at a given point (after Strużak [57])
a, b – point-by-point measurement, c, d – time characteristic sampling, e, f – frequency characteristic sampling, g – total characteristic sampling

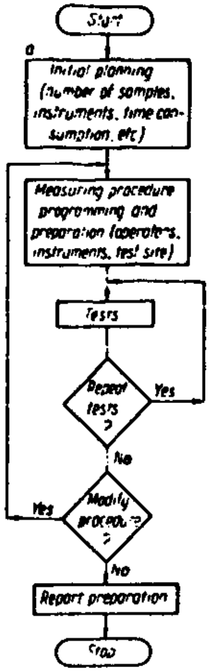
In the case of Fig. 9-11a, each measurement is made at a different frequency and a different time. This is typical point by point measurement technique, appropriate for measurements of stationary processes. A result of the time characteristic registration is illustrated in graphs 9-11c, and d, whereas registration of the frequency characteristic appears in 9-11e, and f. All these measurements define a part of the characteristic surface shown in fig. 9-11g (for simplification, the random character of these processes is neglected). Examining the diagrams, one can conclude, that the repetition of the measurements and the storage of the results will enable us to define the whole surface, characterizing completely the electromagnetic environment.

This surface describes the EM environment at a given point. Distributing a greater number of monitoring stations over a given territory, one can define the EM environment in this region. Naturally, this increases the number of dimensions of our multi-dimensional space by the geographical coordinates of these stations. Knowledge of the EM environment makes location of emission sources possible. For such a location, or bearing, knowledge of the EM environment at three points is needed theoretically. It should be pointed out, however that in essence, the EM environment can be correctly described only by a statistical approach, by means of appropriate probability distributions.

## 9.4.2 Measurement procedure

As previously stated, the monitoring consists primarily of measurements of several parameters. We will not discuss their specific measuring methods here; the relevant information can be found in the publications listed at the end of the chapter.

For discussion of a typical measuring process Fig. 9-12 may be useful.



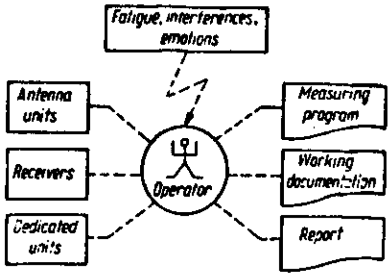

9-12. Flow diagram of measuring procedure



Three basic stages of the process are distinguished on the figure: conceptual, planning, and execution stage. The first consists of preliminary planning. Its aim is to determine the type of measurements, number of investigated parameters and objects, and determination of the place and duration of the measurements. This enables us to plan the number of sample-measurements (test frequencies, polarizations etc.), and necessary equipment, and personel. At this stage the cost factor should be taken into account. For example, with full automation the cost of work is low but the cost of the equipment is high. On the other hand, traditional man-operated facilities are generally work- and time-consuming, but the cost of the equipment is low. However, in this case, it may happen that the measurements needed may be unfeasible, because of technical difficulties, of the allowed time, or other factors. The next step is to determine the procedure of the measurements and its detailed program (including calibration) and establish, if necessary, the form of the final report. All the measurement details should be specified at this step. Remaining stages shown on the figure are obvious, except perhaps for the "feedback". This "feedback" illustrates the possibility of modification of the measuring procedure dependent on the partial results.

In principle, the procedure has to be repeated for each measurement, and, therefore, its standardization and automatization could be profitable.

Fig. 9-13 illustrates the measuring procedure with man-operated measuring equipment. The operator plays the focal role in the measuring process and




9-13. Traditional man-operated measuring process

performs all logic as well as executive functions. The measurement results may be erroneous due to fatigue and the emotional state of the operator. Some measurements, which require continuous concentration for a prolonged period of time cannot be performed by one operator.

The number of measurements may reach millions at the national level, and the measurements are performed on thousands of objects. One measurement may take several hours, if it is done manually, point by point, and an analysis of the results obtained is tedious and almost impossible if the number of measurements is high.

It follows from these considerations that classic man-operated measuring equipment is not always fully adapted for monitoring service. Measuring facilities should make possible:

- automatic processing of measurement results and data reduction,
- automation of the repetitive elements of the measuring process,
- unattended measurements,
- easy service, exploitation, maintenance, repair and exchange,
- flexibility in collaboration with specialized auxiliary devices.

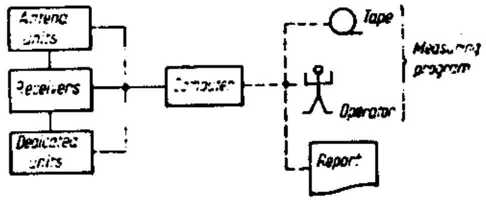
These requirements are not listed in any particular order. Moreover, many of them are interrelated, e.g. there is an obvious correlation between the cost and the technical and exploitational parameters. Another, more subtle correlation exists between the accuracy and speed of the measurements. Moreover, some of these requirements are contradictory and a compromise must be sought. Naturally, the compromise solution depends on the actual technology. The cost factor plays a great role, too. At present, it seems that the best solution from the technical point of view is an automatic, modular measuring and monitoring system based on uniform technology, built of standard elements and interconnected in a standard mode.

## 9.4.3 Computer-controlled measuring/monitoring systems

An automatic, computer-operated measuring system, from the functional point of view, idealizes the measuring and surveillance procedures.
The user gives a command and the computer executes all connections, regulations, etc. for him. This frees the user to concentrate on the measurement problem itself, rather than on measurements execution. By eliminating human factors, such as fatigue and operator mistakes, the computer makes unattended, uninterrupted spectrum surveillance practical.
Identity of procedure at repeated measurement/surveillance functions is guaranted by the program stored in the computer memory. Feedback from the computer, dependent upon the data, can modify the program, making the system self-adaptive to the actual circumstances without the operator's intervention. The versatility of this closed-loop real-time operation is the main power of computer-controlled systems. An almost unlimited number of programms and applications can be derived for such a self-adaptive system. It can be instructed, for example, to skip the frequency measurement or to repeat the measurement a given number of times, depending on a certain set of conditions.
Editing the measurement/surveillance results can be automatic and in a convenient form of tables, diagrams or complete reports ready to read, in the required number of copies, almost simultaneously with the measurements.
The computer-controlled system not only makes available a hard copy of measurements performed, but also an analysis of their results. As the data is automatically collected multiple calculations, complex comparisons, and statistical analysis can be made, or data can be stored for future processing.

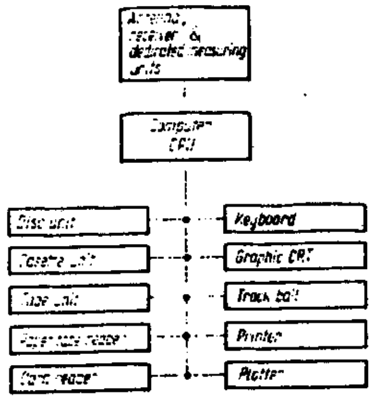


Data being collected can be compared with previously stored data, analyzed, and sorted out, and one can display only relevant, or alarm information.
The computer-controlled system can be automatically calibrated. Error tables may be stored during calibration, and then used to remove systematic errors from measurements executed later, and thus the measurement uncertainty is lowered.
The system's functioning is illustrated in Fig. 9-14. The system is controlled by orders given by the program stored in the computer memory, or directly by user's orders. The program can be formulated in one of the standard




9-14. Computer-controlled measuring process

languages (e.g. BASIC, FORTRAN) depending on the user requirements. The user can communicate with the system by teletype, display-unit keyboard, or a light-pen. Generally, the program consists of three parts: a part concerning the connections, a part concerning the measurement procedure, and a part concerning the storage, processing and presentation of data.
The automatic system replaces several specialized instruments. A specialized program rather than specialized construction ensures adaptation to specific measuring procedures. What is essential, is the fact that usually it is cheaper, and faster, to furnish a new specialized software (measurement program) then to make a new hardware (specialized measuring device).
The „heart" of the system is a measuring receiver, while its „brain" is the computer. The receiver may be built along traditional lines; however all its functions and regulations including calibration, have to be electronically controlled. This of course dose not exclude its manual operation. The control




9-15. Typical measuring system hardware

signals may by of analogoue or digital type. The first solution may be cheaper while the second generally ensures higher accuracy. The receiver operation is controlled by computer orders. To eliminate mistakes, status returns are provided from the receiver indicating that functions ordered have actually been accomplished. In case of faulty response, the order may be repeated several times until a confirmation is obtained, or special diagnostic procedure is ordered and appropriate information is displayed. Antenna system operation is similar.

Communication within the system generally uses a language other than the internal language of the computer, or a symbolic language convenient for the operator. The receiver can e.g. react only to the analogue signals, while the computer uses digital ones. An interface plays the role of an interpreter. In Fig. 9-14 a typical computer configuration is shown. It consists of a central processor, memory and peripheral equipment.

## 9.4.4 Standard interface

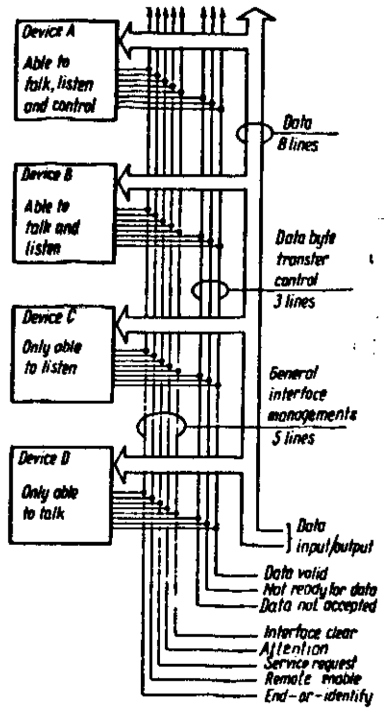
As mentioned above, an interface is necessary to interconnect different measuring instruments into a common computer-controlled system. The traditional approach has been to provide access to specialized control, data, and status lines at an individual instrument level. Most of these systems have been custom designed mixtures of standard instruments and special products. This approach is, however, not practical when a number of devices are required to communicate with one another. Thus, many different interface adaptors are needed to cope with the wide variety of signal levels, logic conventions, codes, command formats, and so on, which are in use throughout the world. International agreement on a standard instrument interface can remove many of the difficulties in handling incompatible inputs of a system using devices of different makes, and a lot of work has already been done by the IEC in this direction [27].

No single interface method can be a panacea for all possible interface requirements, however, and the IEC standard is no exception. Nevertheless, it has a great advantage, namely it is internationally agreed upon, and is becoming more and more popular. Moreover, it is relatively simple and economic because all its active circuitry is contained within the participation devices, and the interface bus by itself is entirely passive. Thus, the interface circuitry can be tailored at a minimum cost to meet the specific needs of an individual system. It should be pointed out that, as a practical matter, device dependent operational characteristics have been excluded from the IEC standards. In this way users retain maximum flexibility in selecting instruments from different manufacturers. Up to 15 units can be interconnected by the IEC standard interface bus, each of them being identified by its own address (one address per one principal role).

Every device in the system is able to perform at least one of the roles of TALKER, LISTENER or CONTROLLER (see Fig. 9-16). A talker can



transmit a message to other devices via the interface bus, and a listener can receive messages from other devices the same way. Some devices can perform both roles. For example, a programmable instrument is the listener when it receives its control instructions, and the talker — when it sends its

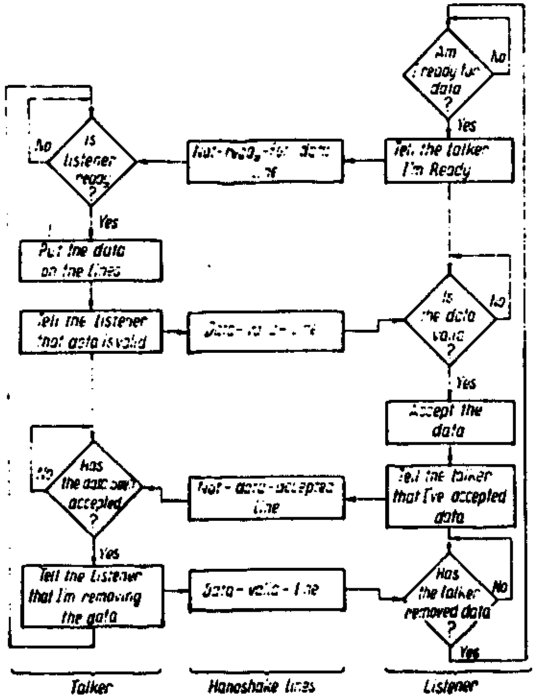



9-16. IEC standard interface connections and bus structure

measurements. A controller manages the operation of the system. It designates which device is to send or receive data, and it may also command specific actions within devices. Several listeners can be active simultaneously, but only one talker can be active at a time. The communication between the devices in a system is therefore organized in a similar way as in a well organized meeting, where people talk one at a time while the rest listen to what is of interest to them, and the chairman decides who should do the talking at a given moment.

The signal lines of the interconnecting cable are grouped into three sets according to their function. Each "DATA" line carries coded messages in bit-parallel, byte-serial form, to and from devices with each byte being transferred from one talker to one or more listeners. Data flow is bi-directional, and the same lines are used both for input program data and for output measurement data from an individual device. Data is exchanged asynchronously making possible compatibility among a wide variety of devices. The message transmitted via these lines may also be a device's

address. In this case, all devices in the system should listen to see whether they are being called. A special "ATTENTION" sign is therefore given on one of the five "GENERAL INTERFACE MANAGEMENTS" lines. It attracts the attention of all devices and informs them that this message is of general interest and should be listened to by everyone.
The interface "CLEAR" line provides a uniform starting point for any operation. The "SERVICE REQUEST" line is used by a device to indicate its need for attention from the controller. The "REMOTE ENABLE" line, switches devices from local (front panel) control to system (remote) control. The "END-OR-IDENTIFY" line is used to execute the so-called pooling sequence.
Three "HANDSHAKE" or "DATA TRANSFER" lines help to organize a transfer of each byte of data on the data lines (see Fig. 9-17). The "DATA VALID" line indicates that the message at the moment is correct and suitable for acceptance. Via the "NOT READY FOR DATA" line listeners indicate whether they are ready to listen to new information. The function of the "DATA NOT ACCEPTED" line is selfexplanatory.




9-17. Flow diagram outlines the sequence of events during transfer of data byte. More than one listener at a time can accept data. No step in the system can be initiated until the previous step is completed. Information can proceed as fast as the slowest device that is being addressed can respond

Building up an automated measuring system of instruments already fitted with standard interface circuitry is greatly simplified: it is enough to link together cooperating devices by interface cables. Hovewer, the standard



interface does not simplify the process of designing and programming the measurements. Although the common interface solves the electrical and functional problems of communication between devices in a system configuration, it does not eliminate operational differences. Instruments may have different programming commands, data output formats, etc. Neglecting the syntax needs for each device can cause readings to be taken at the wrong time, cause the controller to interpret the data incorrectly etc.
There are many instances where interactive instruments in system configuration provide superior results, as compared with conventional manual methods offering:
- more consistent results in repeated measurements (elimination of operator errors),
- greater efficiency because systems are generally faster,
- more thorough testing because system speed allows more parameters to be measured in a shorter time,
- results expressed in engineering units,
- greater accuracy because system errors can be measured automatically, stored and accounted for in the results,
- automatic reduction and statistical analysis of measuring data in a real time,
- automatic transmission of measuring data to the central base or other places, via telecommunication links.

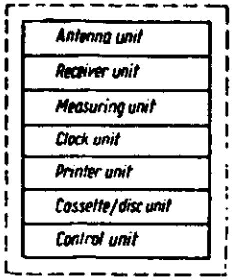
Three things now combine to speed up applications of computerized measuring systems. These are: the existence of the standard IEC interface, the growing number of "smart" interactive instruments with built-in interface circuitry, and the broad choice of controllers, from the simplest readers to computers.

## 9.5 Examples of smart instruments and computer-controlled systems

### 9.5.1 General

Figs. 9-18 and 9-19 show two examples of possible systems. In the first system, the controller, receiver, and other units, are directly interconnected and built-in into one compact, automatic device, capable of unattended, automatic operation.
Only a few years ago the measuring/monitoring systems were quite large and heavy. Since then, great progress in miniaturization of electronic eguipment has taken place and now, with the LSI technology, a series of separate functional blocks can be realized as single chips with a volume of only a few cm$^3$. Thus, the possibility of integrating the whole system into one "smart", device, relatively small in volume, with built-in controllers, microprocessors, memories, multiplexers and other components is becoming quite practical.

A smart integrated device could carry out practically all monitoring activity. The possibilities of processing the measurement data, however, are not so great because of the limited power of its internal intelligence. Although monitoring receivers may be very fast and able to survey thousands of radio channels per second, in some instances they may be too slow. For example,



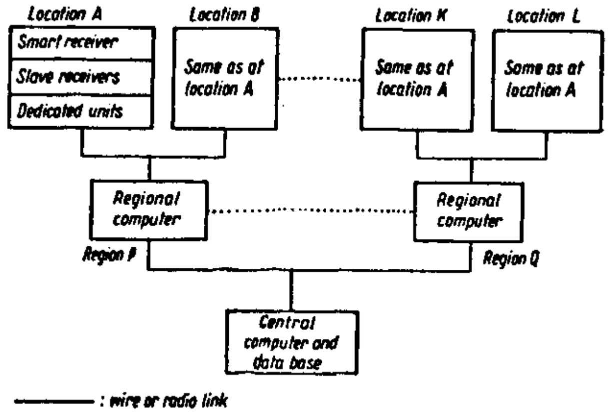

9-18. Smart, self-contained monitoring/measuring receiver

if the 10 kHz to 1 GHz frequency range should be surveyed with a resolution of 100 Hz then the necessary number of frequency steps is $10^9:10^2 = 10^7$. Assuming 10 μsec per step, the surveying of the whole range lasts $10^7 \cdot 10^{-5} = 100$ sec. Thus, each channel can be surveyed periodically once every 100 sec only. If some additional measurements, or records are required, this period must be even longer, and during this time the electromagnetic environment can change considerably.

This difficulty can be overcome simply by multiplying the receivers and dividing the frequency range into smaller sub-ranges, so that each receiver scans one sub-range only, and the total time can be shorter. (The same can be done with radio direction finding). In order to perform additional measurements, specific dedicated units, and auxiliary receivers are used in a "master-slave" configuration. In this configuration one (master) monitoring receiver controls several auxiliary (slave) receivers and related instruments. "Suspected" signals can automatically be transferred to slave receivers and related units for detailed examination, or record, or they can be presented directly to the operator for special observation.

The second real-time system would be much more powerful. As can be seen from Fig. 9-19, it consists of several smart receivers of the type described above, as well as slave receivers, and related auxiliary devices. All these instruments cooperate through regional computers with a central computer and data base. In this way, a receiver with a relatively small internal intelligence can take full advantage of the much greater hardware and software resources of the supporting computer.

The receivers and computers can be located at various places and interconnected via telecommunication links, wire or radio. They may be stationary or mobile, installed on a vehicle, helicopter, etc. Such a distributed system can make unattended radio surveillance over large geographical areas extremely effective. The system can cooperate with a central register of legal radio frequency users and support an up-to-date EM environment data file. The automatic comparison of both information, on legal and actual signals can be an invaluable aid to the radio frequency administrator.



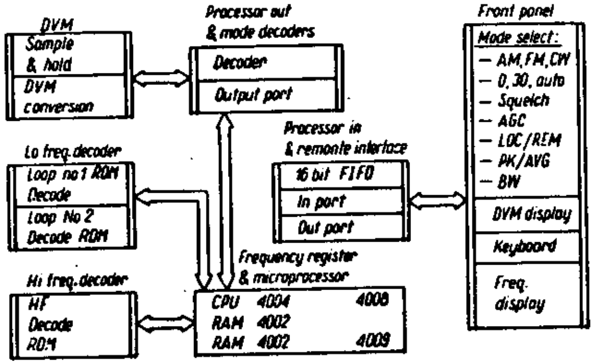

9-19. Automatic, real-time monitoring system, distributed over a territory and controlled by a central computer

Performances of computer-controlled instruments and systems are incomparably higher than traditional man-controlled ones. For an illustration of the complementary functions of computer and measurement parts of the system, consider a measurement of channel occupancy in a communication band by an automatic spectrum analyser. During a week of continuous measurements the system gathers $7 \times 10^7$ measurement results. The computer processes the data statistically during the few milliseconds following each measurement when the measuring hardware is busy tuning to the next channel. Statistical summary files recorded each hour are compiled daily and at the end of week. They are compared with nominal frequency assignment data, listed and graphed, producing report-ready material.

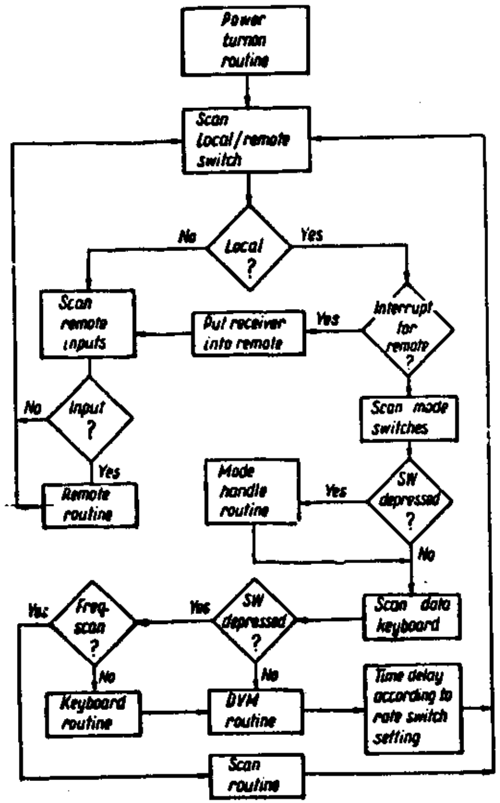
## 9.5.2 Smart test receivers

As far as can be determined, one of the first computer-controlled radio monitoring receivers is the FSR – Fairchild Surveillance Receiver (introduced 1974). It was designed specifically for wide range surveillance, frequency management and EMC analysis applications, and for several reasons it may be considered a typical example of smart test receivers of this type. The FSR features include 5 kHz to 16 GHz frequency range and 10 dB noise figure, 120 dB dynamic range and synthesized local oscillators. It can be operated alone as a semi-automatic receiver with scan and direct printer drive or it can be externally computer-controlled in an automatic detection system.

The key to the flexibility of the FSR and to its self-contained capability is its microprocessor logic control which is added to functional blocks already encountered in traditional test receivers. The processor contains most of the features of a general purpose computer: arithmetic logic unit, input/output capability and central data memory with about 40 Programmable ROMs. Each PROM is programmed with specific instructions, which are erasable and alterable by the user according to his particular requirements. The mi-




9-20. Block diagram of the microprocessor system built in the FSR receiver (after Ryan [53])




9-21. Basic FSR receiver control routine (after Ryan [53])



croprocessor provides the interface with an operator or with peripheral (remote) equipment. It also contains diagnostic capabilities for self-testing and pinpointing of defective subassembles. Modular design and construction not only results in a variety of options of the basic instrument version but also facilitates its field maintainance. As a result a faulty module can be found and replaced, and the receiver reactivated, within minutes.

In a stand-alone configuration, the receiver can be controlled by the operator on the front panel keyboard. When scanning, it may use either linear or logarithmically expanding frequency step sizes. With linear scanning, the receiver bandwidth remains fixed throughout the scan, and when log scan is selected the bandwidth adjusts automatically to the variable step size.

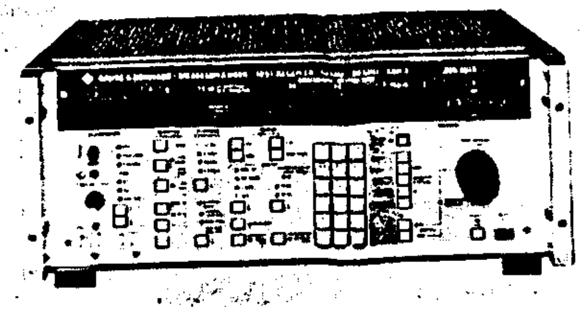
When the receiver is under the control of an external computer, the microprocessor interfaces directly with them without additional converters.

A functional block diagram of the microprocessor is shown in Fig. 9-20, and 9-21 shows a flow chart of its basic control routine.

After determination as to whether local or remote control is selected, the processor scans the front panel keyboard switches for status changes, and appropriate sub-routines are called when a change is noted. After exercise of the relevant sub-routine, control is returned to the main routine.

A control loop is completed by taking a digital voltage meter reading and displaying it. When a scan mode is selected, the DVM loop is completed prior to the next frequency setting. All these capabilities are contained in a box 180 mm high, 450 mm wide, 600 mm deep, weighing about 30 kG.

Fig. 9-22 presents another (introduced in 1980), smart, test receiver for the 10 kHz to 30 MHz frequency range: the RS-ESH3. It is intended primarily



9-22. Programmable test receiver, 10 kHz to 30 MHz type ESH3. Measuring range (with antennae): −3 dB (μV/m) to +140 dB (μV/m)
Resolution: level 0.1 dB; frequency: 100 Hz
Dimensions: 490 × 200 × × 520 (mm), weight ca 23 kG (courtesy of Rhode u. Schwarz, DBR)

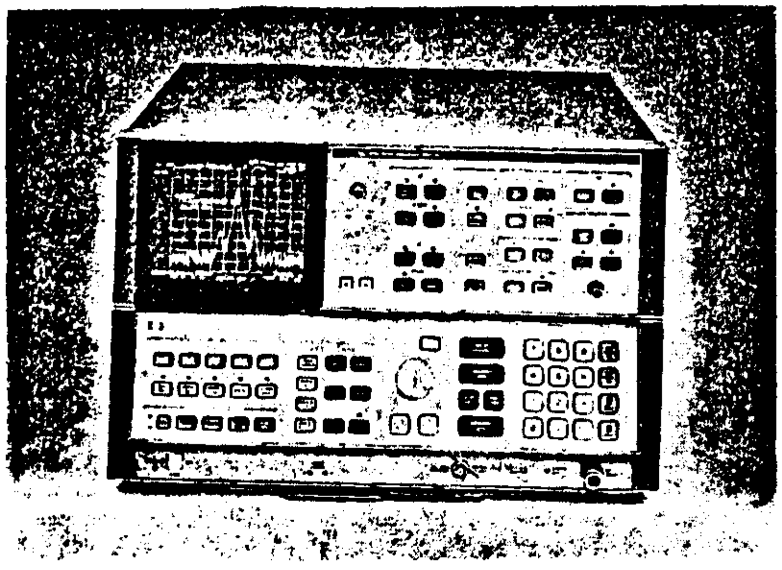
for radiosurveillance and monitoring, for selective measurements of field strength, and for remote frequency measurement. Its functioning is similar to that described above. The ESH-3 contains standard test receiver circuitry (synthetized local oscillator, triple frequency conversion etc.) and two built-in microprocessors. The processors control all receiver modules, calibration and measurement procedures, readings, standard-bus interface, as well as the XY/YT outputs provided for registration for monitoring and surveillance purposes. The calibration procedure is automatically controlled over the whole frequency range by just one calibration. A 13-digit alphanumeric readout serves for output data display and for communication with the operator for proper data input. Storage of ten complete settings and data-block for automatic scanning, as well as their automatic recovery in case of power failure, is possible.

The receiver can cooperate with a computer via the IEC interface bus, as listener or talker, taking full advantage of its support.

It is also able to talk only when registering results without computer-controller, using a printer or a digital cartrige tape recorder.

## 9.5.3 Smart spectrum analyzer

Fig. 9-23 presents a modern (introduced in 1980), smart, computer controllable spectrum analyzer for the 100 Hz – 22 GHz frequency range: the HP8566. As is common in spectrum analyzers, the input signal goes through a series of frequency converters to a fixed IF frequency, where the resolution bandwidth filtering takes place. A synthetized local oscillator brings its high frequency accuracy and stability to microwave spectrum analysis. High resolution and sensitivity, and a large spurious-free dynamic range make possible precision measurements of small signals in the presence of large ones over the entire frequency range up to microwaves.



9-23. Smart spectrum analyzer, 100 Hz to 22 GHz, Model 8566. Measuring range (without antennae): –134 dBm to +30 dBm Digital display. Tunable marker with amplitude and frequency readout. Frequency resolution 10 Hz. Spurious responses 70 dB below input signal for signals up to –40 dBm. Dimensions: 280 × 430 × 600 mm, weight ca 50 kG (courtesy of Hewlett Packard, USA)



The analyzer uses three built-in microprocessors. The first microprocessor is the main internal controller. It controls all functions of the instrument and the interface with the operator, via the analyzer keyboard. The second one is responsible for cooperation with other devices via the IEC interface bus. The third microprocessor controls the data storing, processing and displaying. The detected signal is sampled and stored digitally with 1000 × × 1000 point resolution. This makes possible not only a flicker-free read-out by the display circuits, but also comparisons of two spectra, and other data manipulations such as, e.g. subtracting errors stored during a calibration sweep. The storage/display processor also handles the storing and display of control settings and the generation of the graticule on the CRT.

The analyzer's main microprocessor automatically adjusts the sensitivity of the knob and step keys for the current range of each parameter. Coupled functions, such as resolution bandwidth and sweep time change automatically as frequency span is reduced to maintain a calibrated display.

Moreover, it enhances analyzer performance by calculating corrections which are automatically introduced to compensate for errors due to hysteresis, self-heating, and transient effects. All this activity is controlled by the program stored in an internal memory. The total number of machine instructions exceeds 10,000.

In operator-controlled mode, the operator changes control settings through the control keyboard or knobs. Once the analyzer's controls have been adjusted, all settings can be saved in memory and later recalled to repeat the measurements. An internal battery maintains the contents of the memory in the event of a power failure.

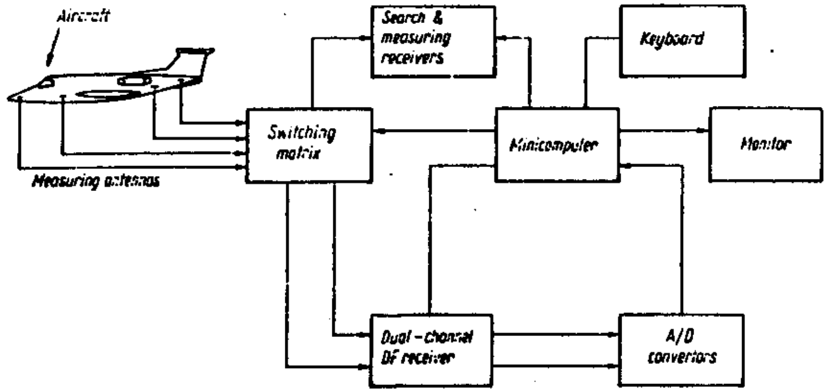
In computer-controlled mode, the analyzer cooperates with an external computer via the IEC-bus. All front-panel control settings (except for video trigger level and CRT intensity) can be set by means of the bus, and all of the information stored in the analyzer is available to the bus controller. The controlling computer can also write into the analyzer's memory. This enables us to take data, re-format it in the computer and then display the information in the new format.

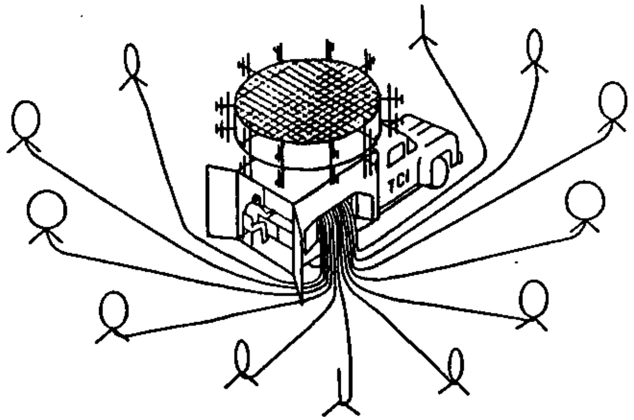
## 9.5.4 HF mobile signal acquisition and direction finding system

The computer controlled system shown in Fig. 9-24 is designated primarily for application in mobile monitor stations, making the radio direction finding (azimuth and elevation) possible within a few seconds, with a few degrees of accuracy.

The method of determining frequency and time characteristics is similar to those described previously.

The direction finding of an incident radio wave is based on a principle similar to that of determination of the sun's position from the shadows of known objects on the earth's surface. The EM wave emitted by a source induces currents of unique amplitude-phase distributions in the conducting elements of the vehicle. Knowing this distribution, one can calculate the direction from which the wave emanates. For this purpose special probe-antennae are located in suitable places on a vehicle. The signals induced in these antennas come through a suitable switch, to a dual channel receiver,




9-24. HF mobile signal acquisition and direction finding system Model TCI 801 (after [24])
a – airborne version,
b – vehicular version

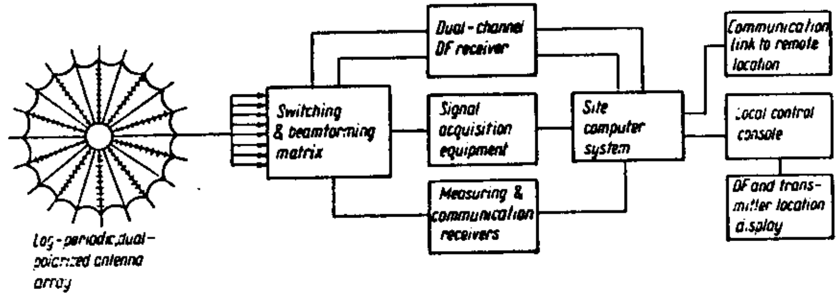
where their amplitudes and phase angles are measured. These data are used by the computer for direction finding calculations, together with constant antenna factors stored in the memory. These calculations involve vector and matrix manipulations and simple interpolations.
The operational memory of the computer used has a capacity of 16 K bytes minimum and an external memory of up to 150 K bytes.
As was mentioned, the system in question can be installed on a ship, car,



or airplane, or on a stationary monitor station. Fig. 9-24 presents another version of the system, adapted to direction finding with higher accuracy. For this purposes, the antenna system is more complicated.

## 9.5.5 HF stationary signal acquisition, direction finding and emitter location system

This stationary, computer-controlled system, shown in Fig. 9-25 is intended for rapid HF signal acquisition, direction finding and emitter location. It obtains elevation and azimuth angle-of-arrival information and combines it with ionospheric data to give geographic coordinates of the emitter. The system uses an antenna array consisting of 20 inward looking, log periodic




9-25. Block diagram of the HF stationary signal acquisition, direction finding and emitter location system Model TCI 410 (after [23]). The computer controls the switching matrix and beam forming network to provide appropriate beams. The dual channel receiver provides signal amplitude and phase information in a digital form which is used by the computer. The antenna system diameter is 300 m

dual-polarized elements (40 m high max). The antenna elements are over a common ground screen and in the center of the array is an underground operations room housing all system electronic components. The array patterns are stored in the computer. The system measures both signal amplitude and phase on each of two channels simultaneously. This provides direction-finding processing against weak and short duration signals in spite of modulation and fading. The D.F. instrument accuracy is of the order of 1°, and D.F. computation time is about 1 second. The HF spectrum is swept at a rate of 10 MHz to 20 MHz per second and a new signal can be acguired typically in one or two seconds. Once found, the signal can be examined by optional recognition/classification equipment. The classification process typically takes approximately one-half second per signal. Consequently, a signal can automatically be found, recognized, classified and geographically located in about five seconds. The location accuracy from a single site is about 25 km to 400 km range and 10% of range to 1000 km. Two or more distant systems can be netted to provide much higher accuracy using triangulation.

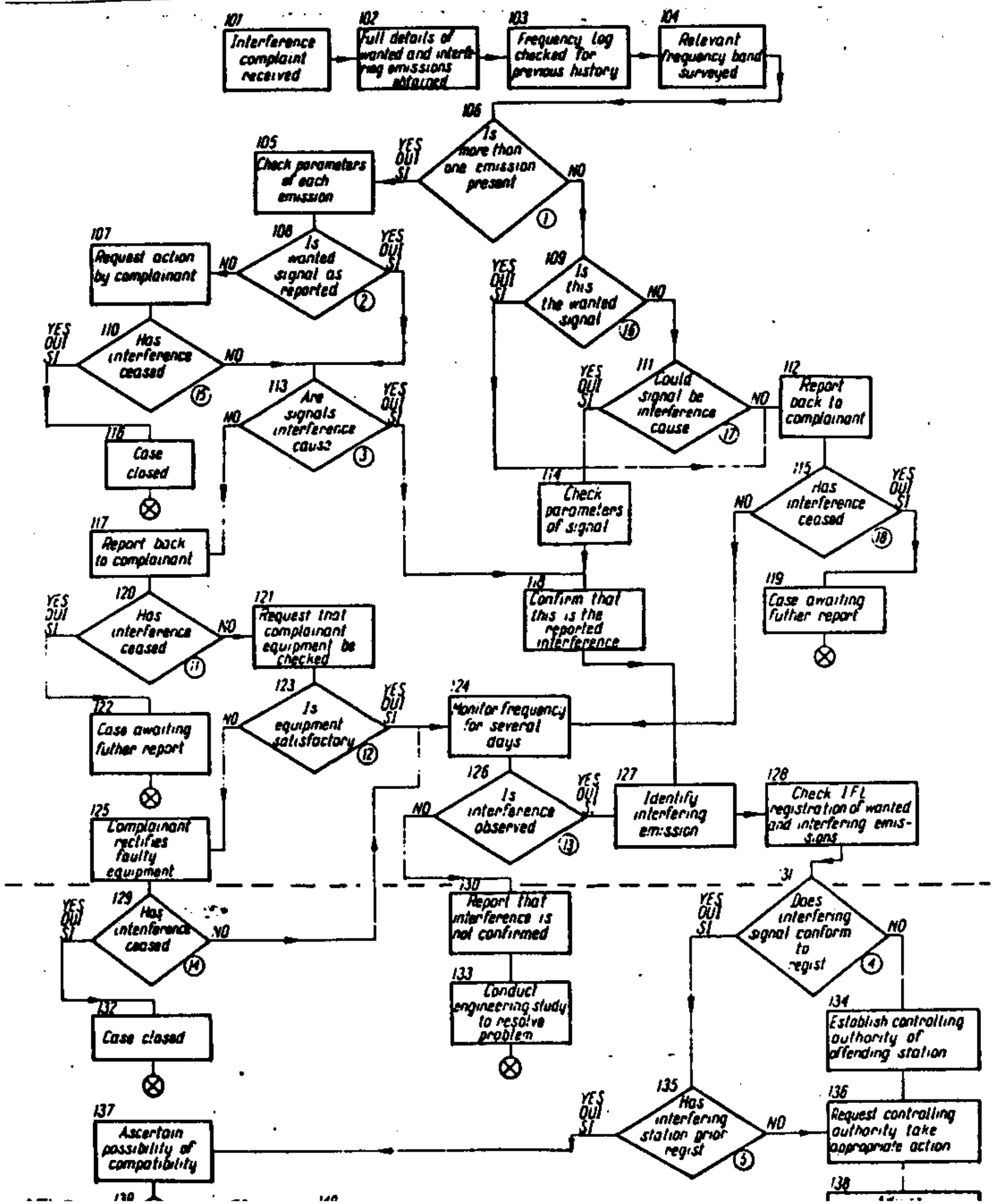
1. Barghausen A. F., *Radio spectrum measurement system-current applications, experience, results*, IEEE Trans. EMC, July, 1974.
2. Boscamp von G. V. W., *Facilities and organization of modern radio monitoring ...*, ITU (IFRB) Seminar on Freq. Managem. and Use of Radio Freq. Spectrum. Doc. 27/74, Sept. 1974.
3. CCIR Doc. 1/152: *Electronically controlled receiving and measuring system for radio monitoring service*, Fed. Rep. of Germany, Sept. 1977.
4. *CCIR Handbook for Monitoring Stations*. Publ. ITU, Geneva 1968.
5. CCIR Vol. I: *Spectrum utilization and monitoring*, Recommendations and Reports of the International Radio Consultative Committee CCIR, 1978, ITU, Geneva, 1978.
6. Cherot T. E., *Electromagnetic compatibility operational system*, 1968 IEEE Electrom. Compatib. Sympos. Rec., Seattle Wash. July 23–25, 1968.
7. Creel J. D., *The application of computers to radio engineering functions*, IEEE Trans. on Comm. Technol., Dec. 1970.
8. Cunningham M., Wheelwright L., *Introducing the automatic spectrum analyzer*, Hewlet Packard Journ., June 1972.
9. Danzenstein K., *Frequenzfernmessung mit VHF-UHF Empfangern*, Funktechnik No. 11, 1977.
10. DiMarzio A. W., *Concepts in computer control for frequency surveillance*, IEEE Trans. AES No. 4, 1970.
11. ElBehery I. N., MacPhie R. H., *Maximum likelihood estimation of the number, direction and strengths of point radio sources from variable baseline interferometer data* IEEE Trans., AP-26, March 1978.
12. Fox K. A., et al., *A human interface for automatic measurement systems*, Hewlett Packard Journ., April 1972.
13. Frazer J. W., et al., *Time response and bandwidth in laboratory automation*, Proc. IEEE, October, 1975.
14. Freytag H. H., Kriegskotten-Thiede A., *Konception programmierbares Messgerate mit IEC-Standard-Interface*, Frequenz No. 7, 1976.
15. Freiss W., *Fernüberwachungssystem für Fernsehsender*, Neues v. Rhode u. Schwarz, Juli, 1975.
16. *Funkerfassung*; Rhode u. Schwarz, Munchen (Application Note, 1978).
17. Gabriel W., *Adaptive arrays – an introduction*, Proc. IEEE No. 2, 1976.
18. Gentile G., *The VHF and UHF receiving aerials at the RAI's Monitoring Station at Sorrento*, EBU Rev. A, Feb. 1970.
19. Gentile G., *Field strength measurements at frequencies in excess of 30 Mc/s*, EBU Review, 1966, No. 97A.
20. Geringer N., et al., *Mobile unit for measurement of fieldstrength and frequency*, EBU Tech. Monograph, No. 3113, Bruxelles, 1973.
21. Hagn G. H., Dayharsh T. J., *Land mobile radio communication channel occupancy, waiting time, and spectrum saturation*, IEEE Trans., Vol. EMC 19, No. 3, 1977, p. 281.
22. Hagn G. H., Jansky D. M., Dayharsh T. J., *Definition of a measurement capability for spectrum managers*, IEEE Trans., Vol. EMC 19, No. 3, 1977, p. 216
23. *HF signal acquisition, direction finding and emitter location system model 410*, TCI-Technology for Telecommunications International, 1978 (technical data).
24. *HF vehicular signal acquisition and direction finding system model 801*, TCI-Technology for Communication International, 1976 (technical data).
25. Holdway S. N., Humpherys M. D., *The next generation RF spectrum analyzer*; Hewlett Packard Journ., June 1978.
26. Humann K., *Definition und Messung der Empfindlichkeit von Funkempfangs- und Peil-geraten*, Tech. Mitt. AEG – Telefunken, No. 7, 1977.
27. IEC Doc. 66 (Bur. Centr.) 22: *Interface system for programmable measuring apparatus. Byte serial bit parallel*, (Nov. 1975).

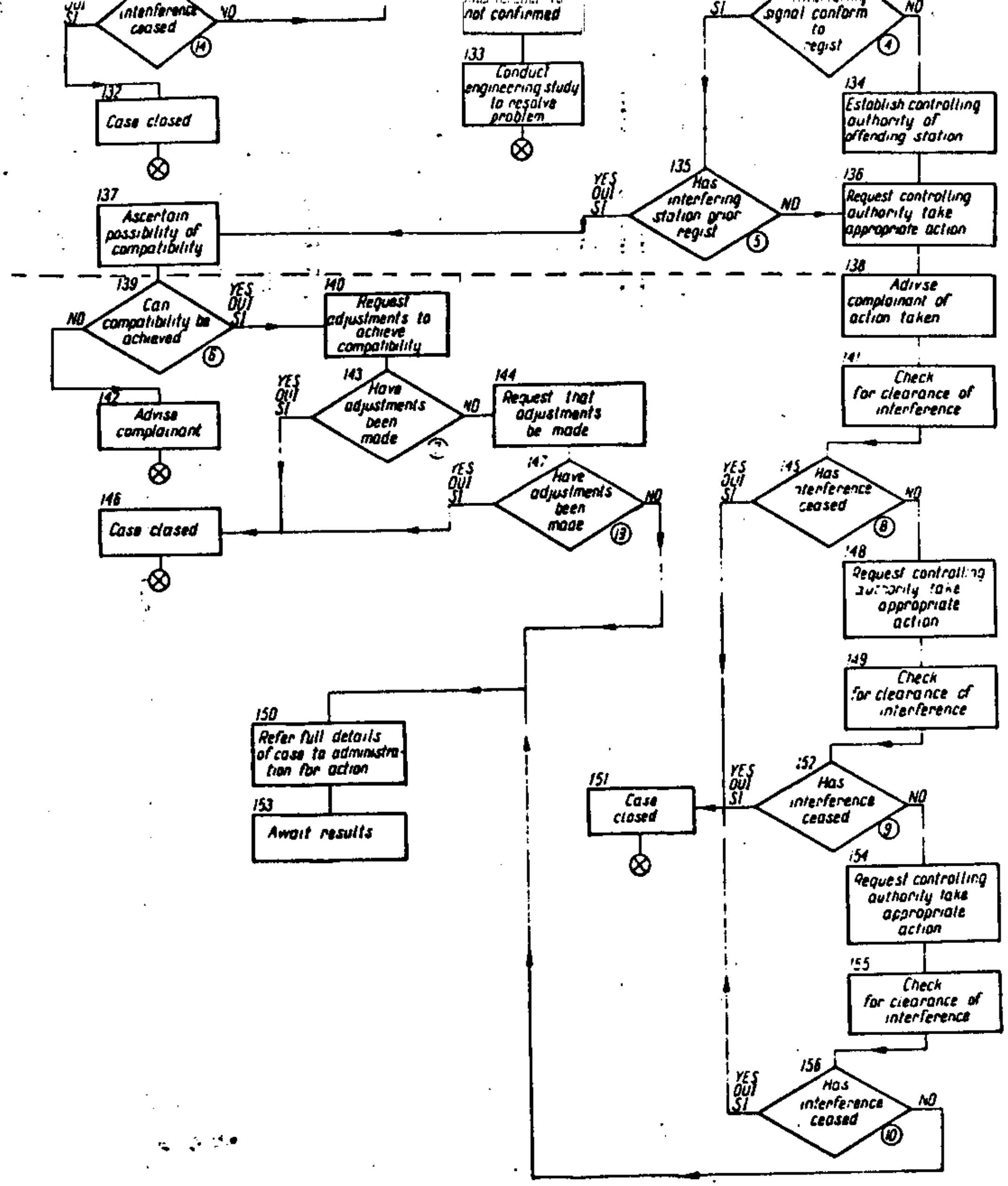




28. *ITAC – Spectrum engineering – the key to progress*. A report of the ITAC on technical policies and procedures for increased radio spectrum utilization, New York, 1968.
29. Kay R., et al., *Cost effectiveness of computerized laboratory automation*. Proc. IEEE, October 1975.
30. Kemper H., *Funküberwachungsnetz Mexico*, Neues v. Rhode u. Schwarz, No. 55, 1972.
31. Klaus J., *Wie funktioniert der IEC-Bus*, Elektronik, No. 4 and 5, 1975.
32. Künzle H., *Die Radiokontrolle*, Tech. Mitt. PTT, No. 3, 1972.
33. Lari G., *Le centre satellite de controle de la RAI a Sorrento*, Revue de l'UER A, No. 119, 1970.
34. Linkwitz S. H., *New performance standards in microwave spectrum analysis*, HP Journal, August 1972, p. 2.
35. Loughry D. C., *A common digital interface for programmable instruments: the evolution of a system*, Hewlett Packard Journ. Oct. 1972.
36. Loughry D. C., *The HP interface Bus: Current perspectives*, Hewlett Packard Journ., Jan. 1975.
37. Lutzmann R., *TV Überwachungseinrichtungen zur zentralen programmierten Fernsehsender-Überwachung*, Neues v. Rhode und Schwarz, Sommer 1978.
38. Matheson R. J., *A radio spectrum measurement system for frequency management data*, IEEE Trans. Vol. EMC 19, No. 1977.
39. Matheson R. J., *Automated spectrum analysis*, Proc. IEEE, No. 4, 1978.
40. McKay H. D., *Application of computer-controlled spectrum surveillance systems to crime countermeasures*, IEEE Trans. Vol. MTT, No. 1, 1972.
41. Means D. L., *Microwave mobile monitoring techniques*, IEEE Trans. Vol. EMC 19, No. 3, 1977, p. 236.
42. Metcalfe D., *Instrument interfaces to ease system design*, Electron. Engineering. Febr. 1977.
43. Mezin V. K., *Automatic radio direction finders*, Sov. Radio, Moskva, 1969 (in Russian).
44. Minor P. C., Wood L. E., *A new state-of-art in EMC field measurements instrumentation*, IEEE Trans. vol. EMC 19, No. 3, 1977.
45. Monitoring; *ITU/IFRB Seminar on freq. managem. and use of radio freq. spectrum*, Doc. 17/76, Sept. 1976.
46. Nelson G. B., Ricci D. W., *A practical interface system for electronic instruments*, Hewlett Packard Journ., October 1972.
47. Parker P. N., *The organization and operation of a radio-monitoring service*, ITU (IFRB) Seminar on freq. managem. and use of radio freq. spectrum, Doc. 30/74, Sept. 1974.
48. Pittman P., *The microprocessor in a data acquisition system*, Electron, Nov. 1975.
49. *Radio Regulations*; Publ. ITU, Geneva.
50. *Radio surveillance – the system approach*; Racal Rev. No. 7, 1978.
51. Rappolt F., Stone N., *Receivers for signal acquisition*, Microwave Journ., Jan. 1977.
52. Ricci D. W., Stone P. S., *Putting together instrumentation systems at minimum costs*, Hewlett Packard Journ., Jan. 1975.
53. Ryan T., *New Fairchild receiver contains microprocessor*, Electronic Warfare, Sept./Oct. 1974.
54. Smith D. D., *International telecommunication control*, A. W. Sijthoff, Leyden, 1969
55. Stawski W., *A review of foreign approaches to radio-monitoring systems*, Problemy Łączności, No. 116, 1976 (in Polish).
56. Spaulding A. D., Hagn G. H., *On the definition of spectrum occupance*, IEEE Trans. Vol. EMC 19, No. 3, 1977, p. 269.
57. Strużak R. G., *Today and tomorrow of radio monitoring instrumentation*, Problemy Łączności, No. 116, 1976 (in Polish).

58. Stružak R. G., *Terrestrial electromagnetic environment.* In this book, Chapter 2.
59. Vakin S. A., Shustov L. N., *Electronic-counter-measures and radio-surveillance*, Sov. Radio, Moskow, 1968 (in Russian).
60. Vincent W. R., *Examples of signals and noise in the radio-frequency spectrum*, IEEE Trans., Vol. EMC 19, No. 3, 1977, p. 241.

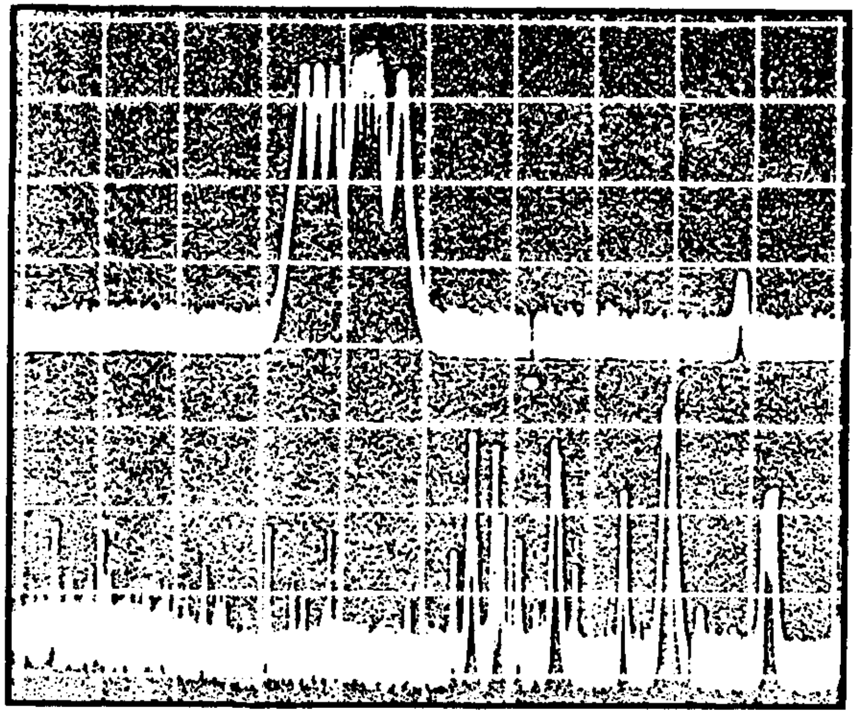



9-2. Typical flow chart for radio interference investigation procedure (after Parker [47])

CCIR

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE



# HANDBOOK FOR MONITORING STATIONS

INTERNATIONAL TELECOMMUNICATION UNION

Geneva, 1988



## INTRODUCTION BY THE CHAIRMAN OF CCIR IWP 1/5

It gives me great pleasure to present the updated edition of the Handbook for Monitoring Stations.

In Resolution 16-1, the XIth Plenary Assembly of the CCIR (Oslo, 1966) decided to provide monitoring station operators with a training aid geared to their very specific needs and, in implementation of the provisions of the Resolution, the CCIR published the first edition of the Handbook in 1968 (supplemented in 1971).

Our thanks go to the eight administrations and two international organizations who drafted the Handbook's 19 chapters, for their work has proved very useful to monitoring stations, as the members of IWP 1/5 can certainly confirm. However, no provision was made to prevent the Handbook from "ageing" and, consequently, some of the administrations attending the Final Meeting of CCIR Study Group 1 (Geneva, 1981) were prompted to request the establishment of an Interim Working Party to be responsible for updating it. To this end, IWP 1/5 was set up under Decision 53 of the XVth Plenary Assembly of the CCIR (Geneva, 1982); it is composed of representatives from ten administrations, three international or industrial organizations and the IFRB.

At its first meeting in Paris in 1982, IWP 1/5 decided to retain the original titles of the 19 chapters and to add a new chapter on space station monitoring.

With regard to organization of work, it was agreed that the workload should be shared among the group and the following allocation of tasks was approved:

| | | | |
|---|---|---|---|
| Chapter 1 | Portugal | Chapter 11 | EBU |
| Chapter 2 | United States of America | Chapter 12 | Japan |
| Chapter 3 | United States of America | Chapter 13 | France, United States of America |
| Chapter 4 | United States of America | Chapter 14 | United Kingdom |
| Chapter 5 | United Kingdom | Chapter 15 | Italy |
| Chapter 6 | Germany (Federal Republic of) | Chapter 16 | Iran (Islamic Republic of) |
| Chapter 7 | United States of America | Chapter 17 | France |
| Chapter 8 | France | Chapter 18 | France |
| Chapter 9 | Japan | Chapter 19 | IFRB |
| Chapter 10 | Portugal | Chapter 20 | Germany (Federal Republic of) |

The members of the IWP representing the above-mentioned administrations and organizations were therefore appointed coordinators for updating the chapters assigned to them, but they were to receive assistance from the group as a whole.

The IWP also decided:

- that the new or revised texts should be submitted for comment and, possibly, amendment;
- that the chapters should not be sent to the CCIR Secretariat without the consent of the IWP.

The coordinators were naturally requested to take account of technical progress in radio monitoring, together with the development and impact of the use of the VHF, UHF and even SHF bands.

The IWP has worked well on the above basis and an excellent atmosphere has prevailed throughout its nine meetings. It has fulfilled a significant part of its mandate by supplying the CCIR with material for a Second Edition of the Handbook. However, I venture to hope that CCIR Study Group 1 will take the necessary steps to arrange for the text to be updated as training methods (such as the use of audiovisual facilities) and monitoring techniques evolve, thus ensuring that the Handbook remains a valuable tool for monitoring station operators.

Finally it would not have been possible to update the Handbook without the assistance of the following members of IWP 1/5, listed in alphabetical order:

Mr. Balfroid (IFRB), Mr. Barbadoro (Italy), Mr. Betts (United Kingdom), Mr. Bisner (France), Mr. Bottcher (Federal Republic of Germany), Mr. Canei (EBU), Mr. Dell'Ovo (Italy), Mr. Fevereiro (Portugal), Mr. George (Federal Republic of Germany), Mr. Giacopello (Italy), Mr. Khatami (Islamic Republic of Iran), Mr. Kilpatrick (United States of America), Mr. Labay (CCRM, Belgium), Mr. Luther (United States of America), Mr. Moreno Peral (Spain), Mr. Nedelchev (Federal Republic of Germany), Mr. Nakagawa (Japan), Mr. Olms (IFRB), Mr. Patricio (Portugal), Mr. Proenca (Portugal), Mr. Schiff (France), Mr. Susumo Sato (Japan), Mr. Vacani (Italy), Mr. Warden (United Kingdom) and Mr. Yukio Yahamoto (Japan).

The Working Party also received help from the CCIR Secretariat as a whole, in particular Mr. Rutkowski and Mr. Struzak (Senior Counsellors) and Mr. Pavliouk and Mr. Nalbandian (Counsellors), as well as from Mr. Hunt, Chairman of Study Group 1.

I thank you all and wish the Handbook every success.

Chairman of IWP 1/5
R. LEFORT

SUMMARY

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

## Part 10

## PREPARATIONS FOR FUTURE RADIO CONFERENCES

R. G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland



The purpose of these notes is to provide information on the preparatory work for two major world-wide Radio Conferences planned for 1992 and 1993, respectively.

### 1. INTRODUCTION

In 1989, all countries-members of the ITU decided at the Plenipotentiary Conference in Nice (France) that two World Administrative Radio Conferences (WARCs) will be held during the 1990 - 1994 period. The first of these (WARC-92) will be held in1992. The second WARC will be a high-frequency broadcasting planning conference to be held in 1993. Preparatory work for these conferences has already started in the framework of the International Radio Consultative Committee, CCIR.

### WARC-92

The World Administrative Radio Conference (WARC-92) will be held in Spain in February 1992. This conference will deal with many questions of proposed reallocations to many frequency bands across the entire radio spectrum, establishing the basic frequency bands that various services may use. After the frequency bands are established for various services, separate conferences can be set to address the particulars of how radio bands are to be used within a given service. For example, a 1993 WARC is already planned to determine exactly how HF broadcasting assignments are to be made within the bands allocated by WARC-92.

In June 1990, based on requests from member countries, the ITU announced an agenda for WARC-92. The agenda allows the possibility of many spectrum allocation changes, including allocations for direct broadcast satellite digital sound and HDTV, additional HF broadcast bands, mobile service for aircraft and other uses via satellite (including low orbiting satellites), etc. Since there will be many more proposed allocations that there are frequency bands to accommodate these allocations, and since many countries have different relative priorities which they assign to the uses of the spectrum, there will be many difficult decisions made at WARC-92.

Preparations for this conference are being done in a CCIR Joint Interim Working Party JIWP WARC92. This party is developing the necessary sharing criteria; and preparing the consolidated CCIR report to WARC-92. It will meet in Geneva in March 1991. The Chairman of JIWP WARC-92 is Mr. M. Hunt from Canada. The following specific issues will be considered by the conference.

High-frequency broadcasting

The agenda of the conference includes consideration of possible extension of the frequency spectrum allocated exclusively to HF broadcasting, which implies that any possible additional allocation of frequency spectrum to the broadcasting service will be on an exclusive basis. JIWP10-3-6-8/1, under the Chairmanship of Mr. J. Finnie (UK) deals with inter-service compatibility between the broadcasting, fixed and mobile services in the HF bands, together with related propagation issues.

The satellite broadcasting of HDTV

WARC-Orb 88, in Resolution 521, asked for specific information from the CCIR to allow a future WARC to select a suitable frequency band, preferably on a world-wide basis, for the satellite broadcasting of wide RF band HDTV. In response, JIWPs 10-11/3 and 10-11/1 have been created. Both met in Sydney, Australia in November 1990 and prepared reports that will be delivered to JIWP WARC-92.

Satellite sound broadcasting in the UHF band

WARC-Orb 88, in Resolution 520, asked for specific information from the CCIR to allow a future WARC to consider the provision of a suitable allocation for satellite sound broadcasting, somewhere in the range 500-3000 MHz. JIWP 10-11/1 was assigned the responsibility to complete the CCIR preparatory work on satellite sound broadcasting in the UHF band. A meeting of this JIWP was held in Australia as noted above.

Mobile services

Preparation for WARC-92 concerning the mobile and mobile-satellite services is being done in Study Group 8 in three Interim Working Parties. IWP 8/13 on Future Public Land Mobile Telecommunication Systems (FPLMTS) held its meeting in July 1990 under its Chairman, Mr. M. Callendar (Canada), and prepared a report. The IWP concluded that the minimum spectrum bandwidth needed for FPLMTS is 230 MHz and that for international use a common worldwide band is preferred. The IWP also considered sharing possibilities between FPLMTS and a limited number of other radio services.

IWP 8/14 held its meeting in September 1990 in Melbourne under its chairman, Dr. Y. Hirata (Japan). This IWP deals with technical and operational issues, available and future technology, spectrum requirements and relevant inter-service and intra-service sharing issues for all mobile-satellite services. It also determined the technically preferred frequency band for a future world-wide terrestrial aeronautical public correspondence system.

IWP 8/15 held its meeting in November 1990 under the Chairmanship of Mr. J. Karjalainen (Finland). It prepared a report which incorporates the contributions from IWP 8/13 and IWP 8/14 and includes issues of the radiodetermination and radiodetermination-satellite and amateur and amateur-satellite services. This report will be submitted to the JIWP WARC-92.



Fixed-satellite service

CCIR preparations for WARC-92 concerning the fixed-satellite service have been entrusted to IWP 4/1, which held a meeting in December 1990. The principal task undertaken by the IWP relates to the technical considerations of the allocation of the frequency band 14.5-14.8 GHz to the fixed-satellite service and the other services currently allocated. IWP 4/1 also examined several other items that appear on the WARC-92 agenda, but which are the primary responsibility of other CCIR groups. These are:

-the characteristics and sharing criteria of new space service applications that may be considered for new frequency allocations above 20 GHz;

-satellite-sound broadcasting (especially with respect to feeder links);

-wide RF-band HDTV (especially with respect to feeder links);

-in the range 1-3 GHz, mobile and mobile-satellite service allocations, public correspondence with aircraft, and the development of the international use of the mobile service for future public land mobile telecommunication systems, with respect to sharing and feeder-link considerations.

Space research and radioastronomy

Interim Working Party 2/2 was established to carry out preparations for the WARC-92 with the following terms of reference:

-to examine the potential inter-service frequency sharing problems that may arise between Study Group 2 services and other radio services as a result of the various Resolutions and Recommendations of WARC MOB-87 and WARC ORB-88.

-to study any proposed new space services in frequency bands above about 20 GHz with a view to defining their technical characteristics and to establish sharing criteria between those new services and existing services to which the bands are allocated;

-to study other services, technical regulations and frequency bands which were included on the agenda of WARC 1992 by the Administrative Council;

-to report to JIWP WARC-92 in accordance with the provisions of Section 4 of Resolution 24-7.

Mr. H.G. Kimball (United States of America) is Chairman of IWP 2/2. The IWP met in Washington in October 1990.

Propagation aspects

No special action was taken and, in particular, no IWPs dedicated to the topic were established.

HFBC-93

Study Group 10, at its meeting in Geneva (9-23 October 1989), took note of Resolution PL-B/1 of the ITU Plenipotentiary Conference (Nice, 1989) to hold a World Administrative Radio Conference for dealing with matters connected with the HF broadcasting service, in Geneva during the first quarter of 1993.

It also took into account that the HFBC-87 revised or adopted a number of Recommendations and Resolutions, with explicit instructions to the CCIR:

i. Recommendation No. 503 (WARC-79) concerning HF broadcasting, with a specific invitation to the CCIR to carry out further studies with a view to updating CCIR Recommendations 328, 332 and 205 concerning (1) out-of-band spectrum provisions, (2) receiver selectivity and (3) synchronized-frequency transmitter operation, respectively;

ii. Recommendation No. 510 concerning planning parameters for the double-sideband (DSB) system in the HF bands allocated exclusively to the broadcasting service, with an invitation to the CCIR to continue to study the values of the planning parameters listed in the Annex to Recommendation No. 510;

iii. Recommendation No. 514 concerning improvements to the propagation prediction method to be used for the HF bands allocated exclusively to the broadcasting service, with an invitation to the CCIR to undertake studies of the propagation prediction method adopted by the Conference and to recommend both improvements in the method and later, if necessary, an improved method to be used in the future;

iv. Recommendation No. 515 concerning the introduction of transmitters and receivers capable of both double-sideband (DSB) and single-sideband (SSB) modes of operation, with an invitation for the CCIR to complete its studies into receivers for SSB;

v. Recommendation No. 517 concerning relative RF protection ratio values for single-sideband (SSB) emissions in the HF bands allocated exclusively to the broadcasting service, with an invitation to the CCIR to continue to study the values of relative RF protec- tion ratio for the different cases and frequency separations covered in the Annex to Recommendation No. 517;

vi. Resolution No. 514 concerning the procedure to be applied by the IFRB in the revision of the relevant parts of its technical standards used in the HF bands allocated exclusively to the broadcasting service, which resolves that the IFRB review its Technical Standards relating to the technical parameters of HF broadcasting following each CCIR Plenary Assembly, in consultation with administrations, and with specific interaction with the CCIR;

vii. Resolution No. 516 concerning antennas to be used for the planning of the HF bands allocated exclusively to the broadcasting service, with an invitation for the CCIR to continue to update the CCIR special publication on HF Antenna Diagrams and for the IFRB to base its Technical Standards for HF antenna characteristics on the CCIR special publication on Antenna Diagrams and information supplied by administrations;

Since the studies called for in iii. above are in progress in IWP 6/1, and the studies called for in vii above are in progress in IWP 10/1, and since no recent contributions have been received by the CCIR concerning the other requested studies, and the present schedule of the Conference does not permit approval of the CCIR consolidated report to the HFBC-93 during scheduled Study Group Meetings, the CCIR adopted Resolution 98 that charges IWP 10/10, under the chairmanship of Mr. W. Richards (USA), to carry out the relevant studies taking into account the results of the work of JIWP 10-3-6-8/1 and IWP 10/1 and to prepare the consolidated CCIR report to the HFBC-93. Resolution 98 also assigns tasks to Study Groups 6 and 1.

The final report of IWP 10/10 will be submitted to the Chairmen of Study Groups 10, 6 and 1 for approval of their respective sections so that the consolidated CCIR report to the HFBC-93 may be submitted to the Secretary-General as a conference document at least ten months before the opening of the Conference.

Activities in IWP 6/1

Study Group 6's involvement is described in CCIR Resolution 98 and concerns improvements to the propagation prediction method adopted by HFBC-87. The studies are being undertaken in IWP 6/1 (Chairman: P.A. Bradley (UK)) which aims to complete its work in time to submit its final report to Administrations and to the IFRB 16 months prior to the Conference. The IWP held a meeting in January 1990, in London, and prepared an interim report which was approved at the XVIIth CCIR Plenary Assembly in accordance with Decision 85. The report was subsequently submitted to the IFRB. The second and final meeting of IWP 6/1 is planned for May 1991 (venue unknown), soon after which the final report shall be submitted to Administrations and to the IFRB.

The interim report by IWP 6/1 (Addendum 1 to CCIR Plenary Assembly Doc. No. 6/1001) contains a recommendation that six technical elements of the HFBC-87 prediction method be replaced by those adopted in the current CCIR prediction method contained in Report 894 (and recommended in Recommendation 533). It also identifies further areas where changes could be made but which would lead to only marginal improvement in prediction accuracy. Finally, the report describes on-going work where it is hoped further recommendations can be made in the final report of the IWP.

Activities in IWPs 10/1 and 10/10

The first meeting of Interim Working Party 10/10 was held in Geneva from 14 to 16 February 1990, immediately following the meeting of IWP 10/1. The main objective was to efficiently organize the future work. The structure of the CCIR report to the WARC-93 shown in Annex was agreed upon. It was announced that Mr. G. Thiam (Senegal) will act as a Vice-Chairman of IWP 10/10 for Region 1, and that India will nominate a Vice-Chairman acting for Region 3.

A second meeting is scheduled for Vatican City from 19 to 22 February 1991. This schedule will provide sufficient time to circulate the draft CCIR Report to WARC-93 for approval by the Study Group Chairmen concerned and to subsequently finalize the report in the CCIR Secretariat for dissemination as a Conference Document. The meeting dates of IWP 10/10 have been coordinated with those of IWP 10/1. Intensive work by correspondence will take place until the next meeting.

Satellite news gathering (SNG)

New Report 1237 on satellite news gathering was adopted by a joint meeting of Study Groups 10, 11 and CMTT in October 1989 and new Recommendation 722 entitled: "Uniform technical standards and uniform operational procedures for satellite news gathering" was adopted by the XVIIth Plenary Assembly. These texts were prepared by Joint Interim Working Party CMTT-4-10-11/1 under the chairmanship of Mr. J. Colson (NANBA) with active Vice-Chairmen from EBU, ABU and OIRT. The XVIIth Plenary Assembly extended the terms of reference of the JIWP to include satellite news gathering for HDTV. In the new structure of the CCIR, the JIWP becomes Task Group CMTT/5 and will carry out all work assigned to the CMTT concerning outside broadcasts and satellite news gathering.

High definition television (HDTV)

The CCIR work on high definition television is comprehensive. In addition to the intensive work on the studio standard, which has been in progress for several years, major activities in HDTV recording, film transfer, terrestrial and satellite emission and transmission are also in progress. Displays, including the use of HDTV for computer and graphics displays, in medicine and the publication industry, are being taken into account in the work. The relationship to non-radio delivery means is being given careful attention. Close liaison has been established with the CCITT with respect to the delivery of HDTV by means of the broadband ISDN and other digital networks, and with the IEC and the ISO with respect to information technology and consumer applications such as video cassette recorders and optical recorders.

As a result of the CCIR studies, five new Recommendations relating to HDTV that cover the following areas were adopted by the XVIIth CCIR Plenary Assembly:

-Recommendation 709 defines 23 of the 34 basic parameter values considered necessary for the HDTV studio standard and for the international exchange of HDTV programmes.

-Recommendation 710 provides methods for the subjective assessment of image quality in HDTV. This Recommendation along with new Report 1216 on the subjective assessment of HDTV pictures represent a major step forward, in that worldwide agreement has been reached on the procedures, analysis and context of HDTV measurements.

-Recommendation 713 concerns the recording of HDTV images on cinematographic film.

-Recommendation 714 concerns the international exchange of recorded HDTV programmes.

-Recommendation 716 defines the area of a 35mm motion picture film to be scanned for HDTV telecines (non-anamorphic pictures).

The work of Study Group 11 on HDTV is continuing in the new Study Period. The urgent studies on the HDTV studio standard have been assigned to Task Group 11/1 under the chairmanship of Mr. R. Green (USA). Vice-Chairmen are Mr. W.



Habermann (Germany, (Federal Republic of)), Mr. K. Davies (Canada) and Mr. Y. Ninomiya (Japan). The first meeting of the Task Group was scheduled for 14 to 18 January 1991, in Geneva.

The urgent studies on digital television, including HDTV, are assigned to Task Group 11/2 under the chairmanship of Mr. D. Nasse (France). Vice-Chairmen are Mr. F. Barbieri (Italy), Mr. V. Khleborodov (USSR) and an expert from Canada who was to be designated. The first meeting of this Task Group was scheduled for Geneva from 21 to 24 January 1991.

The remaining work on digital television is being done in Working Party 11B, under the chairmanship of Mr. T. Nishizawa (Japan), with Vice-Chairmen from Mexico, the United Kingdom and the USSR.

Terrestrial television emission and planning parameters are assigned to Working Party 11C under the chairmanship of Mr. S. Perpar (Yugoslavia). Vice-Chairmen are Mr. S. Dinsel (Germany, (Federal Republic of)), Mr. F. Fayoumi (Egypt) and Mr. S. Aguerrevere (Venezuela).

The satellite broadcasting of HDTV is dealt with by Joint Working Party 10-11S, under the chairmanship of Mr. R. Zeitoun (Canada). Vice-Chairmen are Mr. K. P. Ramaswamy (India) and Mr. O. Mäkitalo (Sweden).

Recording and exchange on film for HDTV are the responsibility of Joint Working Party 10-11R, chaired by Mr. P. Zaccarian (CBS). Vice-Chairmen are Mr. H. Schachelbauer (Germany, (Federal Republic of)) and Mr. Y. Ohba (Japan).

A liaison group chaired by a Special Rapporteur (Mr. R. Bedford (United Kingdom), assisted by Mr. H. Tanimura (Japan) and B. Sidran (USA)) has been established to work on harmonization of HDTV standards between broadcast and non-broadcast applications, i.e. to perform as a link between various standardizing bodies (IEC, ISO, CCITT and CCIR) in the field of HDTV. Its first meeting took place in Tokyo from 2 to 10 October 1990.

Digital satellite radio (DSR) and digital audio broadcasting (DAB)

The technology now exists to provide economical, high quality sound broadcasting by satellite to portable and mobile receivers (including automobiles). Study Groups 10 and 11 adopted a new Report on this subject. Study Group 10 prepared a new Study Programme and adopted a new Report concerning the terrestrial application of the same techniques to digital sound broadcasting (DAB).

The Region 3 sharing conference (CARR-3)

A Joint Working Party, JIWP/VHF-UHF Sharing R3,1/SG1 was formed by the XVIth CCIR Plenary Assembly (Dubrovnik, 1986) to prepare technical information for a proposed Regional Administrative Radio Conference to establish criteria for the shared use of the VHF and UHF bands allocated to the fixed, mobile and broadcasting services in Region 3 (CARR-3) (see CCIR Resolution 94 of the Dubrovnik Plenary Assembly).

In accordance with CCIR Resolution 94, Study Group 1 coordinated the work of the Joint Interim Working Party (JIWP/CARR-3/SG1) under the Chairmanship of Australia, and, in collaboration with Study Groups 5, 6, 8, 9, 10 and 11, participated in the preparation of a draft CCIR report for the Regional Administrative Radio Conference of Region 3 (CARR-3). Work proceeded by correspondence and two meetings were held. The report contains the technical bases for the establishment of criteria for the shared use of the VHF and UHF bands allocated to the broadcasting, fixed and mobile services in Region 3 (Resolution 702 of WARC-79).

When the JIWP was established by CCIR Resolution 94, it was assumed that the CARR-3 conference would be held within the near future. A decision was never made on the timing nor the agenda of the CARR-3 Conference, therefore, the matter was reconsidered by the Plenipotentiary Conference in 1989. According to Resolution PL-B/1 of that Conference, a Region 3 conference on sharing among services and, if necessary, on broadcasting planning, will be determined by the Administrative Council after consultation with the Members concerned. This situation leaves the future of the CARR-3 conference uncertain.

Under these circumstances, Study Group 1, during its Final Meeting in 1989 approved the report and recommended that the tasks defined in CCIR Resolution 94 should be considered as fulfilled by the JIWP.

**DRAFT OUTLINE OF THE CCIR REPORT TO WARC 1992***

**Technical and operational bases for the World Administrative Radio Conference 1992**
**Annex 3 to A. C. 305**

Foreword by the Director, CCIR

1. Introduction
1.1 Origin and purpose of the JIWP WARC-92
1.2 Organization of the JIWP WARC-92 preparation and meeting
1.3 Participation
1.4 Documents
1.5 Presentation and structure of the report

Annex 1.1 - Resolution [Document 7042] of the 45th ITU Administrative Council (WARC-92 Agenda)
Annex 1.2 - CCIR Resolution 100

2. Frequency sharing considerations in the allocation of the radio spectrum (IWP 1/6)

3. Frequency allocations for new space service applications above 20 GHz

3.1 Technical aspects of definitions for certain new space applications (IWP 2/2 with others) (Resolves 2.1)**

3.2 The charactertistics and sharing criteria of new space service applications that may be considered for new frequency allocations above 20 GHz (IWP 2/2 with 9/6, 4/1, 8/15) (Resolves 2.2.1)

4. Compatibility considerations arising from the allocation of spectrum to the HF broadcasting (JIWP 10-3-6-8/1) (Resolves 2.2.2)

5. The characteristics and sharing criteria of the broadcasting-satellite service in the consideration of the allocation of frequency bands and the associated feeder links

5.1 For the broadcasting-satellite service (sound) in the range 500-3000 MHz, as indicated in Resolution 520 (ORB-88) including the accommodation of complementary terrestrial sound broadcasting uses within this allocation; (JIWP 10-11/1 with IWPs 9/6, 2/2, 8/15 and 4/1) (Resolves 2.2.3(a))

5.2 For wide RF-band high definition television on a world-wide basis, as indicated in Resolution 521 (ORB-88); (JIWPs 10-11/1 and 10-11/3 with IWPs 4/1, 9/6, 2/2, 8/15) (Resolves 2.2.3(b))

6. The characteristics and sharing criteria of mobile and mobile-satellite services and associated feeder-links in the consideration of an allocation of frequency bands to these services

6.1 In the approximate range 1-3 GHz, as indicated in Resolution No. 208 (MOB-87); (IWP 8/15 with 9/6, 2/2, 4/1) (Resolves 2.2.4(a))

6.2 For the development in the approximate range 1-3 GHz of a world-wide system of public correspondence with aircraft, as indicated in Recommendation No. 408 (MOB-87); (IWP 8/15 with 9/6, 2/2, 4/1) (Resolves 2.2.4(b))

6.3 For the development of the international use of the mobile service for future public land mobile telecommunication systems, as indicated in Recommendation No. 205 (MOB-87); (IWP 8/15 with 9/6, 2/2, 4/1) (Resolves 2.2.4(c))

6.4 For the consideration of possible allocations of up to 5 MHz of a frequency band below 1 GHz to low-orbit satellites on the basis of appropriate sharing criteria; (IWP 8/15 with 9/6, 2/2, ...) (Resolves 2.2.4(d))

7. The technical considerations of the allocation of the frequency band 14.5-14.8 GHz to the fixed-satellite service and the other services currently allocated; (IWP 4/1 with JIWP 10-11/1, IWPs 9/6 and 8/15) (Resolves 2.2.5)

8. Technical and operational considerations in the examination of the frequency bands 2025-2110 MHz and 2200-2290 MHz for the space operations and space research services, as indicated in Recommendation 716 (ORB-88); (IWP 2/2 with 9/6 and 8/15) (Resolves 2.2.6)

9. The consideration of sharing criteria in the radiodetermination- satellite service indicated in Resolution No. 708 (MOB-87); (IWP 8/15 with 9/6) (Resolves 2.2.7)

10. To take account of any appropriate technical aspects related to the consideration of the Resolves 2.7 and 2.8 of the WARC-1992 agenda (IWP 2/2, 8/15)

-----------

* Document PLEN/78

**Document 7042 of the 45th ITU Administrative Council



CCIR REPORT
TO THE WORLD ADMINISTRATIVE CONFERENCE (HFBC-93)
DEALING WITH MATTERS CONNECTED WITH THE HF BROADCASTING SERVICE

DRAFT TABLE OF CONTENTS

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

## Part II

## CCIR SOFTWARE RELEVANT TO SPECTRUM MANAGEMENT

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland



The purpose of these notes is to provide an overview on the CCIR computer software relevant to the spectrum engineering.

In accordance with Resolution 88-1 of the XVII$^{th}$ Plenary Assembly of the CCIR (Düsseldorf-Neuss, 1989), Administrations and Organizations which are in possession of computer programs relating to radio frequency management are invited to consider the possibility of making them available to other Administrations and participants in the CCIR work. A number of them responded positively to the invitation. Information about the program made available is published in CCIR Circular letters, in the Telecommunication Journal and in the "CCIR LIST OF COMPUTER PROGRAMS" [1]. This list is up-dated when necessary and made available on request, free of charge. The inclusion in the list does not imply any form of endorsement and recommendation of any specific software. Almost all programs made available under Resolution 88 have been developed for IBM PC AT or 100% compatible computers. Some of them are distributed in source code and require the corresponding interpreter or compatible compiler.

The CCIR software is of two types. Software of the first type has been developed through the CCIR Study Groups and complements the relevant CCIR Recommendations. It has been reviewed, verified and approved for dissemination by groups of experts from various countries. Software of the second type has been submitted under CCIR Resolution 88 by individual participants in CCIR work. It has been created independently of CCIR studies and may be unrelated to CCIR Recommendations. Some programs of this category have been, however, reviewed by CCIR Interim Working Party 1/2 (now Working Group 1A). A summary description of individual microcomputer CCIR software packages is given below. Software for large computers rarely is portable or transportable and, therefore, has not been included.

CCIR software is provided on an "as is" basis, without any warranty, and some modification may be required before it can be utilized with a specific type of computer hardware. The proprietary and author's rights are reserved by the submitters/originators. The dissemination of the software by the CCIR Secretariat does not imply any form of endorsement or recommendation. This software is available, basically free of charge, directly from the originators, and if it has been supplied, also from the CCIR Headquarters and through the ITU TIES network. On request, the CCIR Secretariat can copy and distribute it with the reimbursement of the costs of material, postage and processing. In the time of writing, the cost of copying and mailing by the CCIR Secretariat amounts for SFR 100 per program. Inquiries concerning the programs should be addressed to the submitting Administration/Organization (or to the Director, CCIR, 2 rue Varembé, CH-1211 Geneva 20, Switzerland).

## Frequency assignment

The program package MSAM from the USA (#90/1.16*) contains the following twelve programs.

(1) Bearing-Distance Program which calculates the distance and bearings between two points on the Earth surface.

(2) Satellite Azimuth Program to calculate the bearing and distance to a satellite relative to an earth station.

(3) Intermodulation Program which analyzes transmitter frequencies and receiver frequencies to identify potential interference due to intermodulation products or harmonics (it is also available separately, #90/1.13). Intermodulation products up to the seventh order can be identified when two or three signals are mixed.

(4) Integrated Propagation System which is a collection of four smooth-earth propagation algorithms. The most appropriate algorithm is automatically selected.

(5) Frequency Dependent Rejection program which calculates the minimum distance separation required between a victim receiver and an unwanted transmitter to satisfy given compatibility criteria (it is also available separately, #90/1.10).

(6) Program "Annex I" which implements procedures contained in Annex I of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management.

(7) Antenna Field Intensity program to estimate the near-field power density and checks for compliance with the U.S. radiation hazard standard.

(8) Personal Computer Plot program which plots data on a plotter, monitor, or printer.

(9) Profile program which produces a terrain elevation profile between two locations, given a topographic data base (not provided with the program).

(10) Horizon. This program calculates the distance and elevation angle to the radio horizon (requires a topographic data base).

(11) Single Emitter Analysis Model. This program estimates the received signal level at a specified distance from the transmitter.



(12) Terrain Integrated Rough-Earth Model. This program predicts propagation loss between two locations, using the terrain profile. It considers ground-wave and tropospheric-scatter propagation modes, but does not include sky-wave propagation. The terrain profile can be input manually or derived from the topographic data base.

The program KANP from Czechoslovakia (#90/1.9) solves a frequency assignment problem using a Monte Carlo method.

The JCAL program from Japan (#90/1.11) computes potential adjacent, co-channel, and third order interference, and desensitization effects using a transmitting station data base.

The software package MAPKI from Poland (#90/1.4) performs the following five tasks.

(1) Terrain profile extraction and analysis. The terrain elevation profile is extracted from the data base. Horizon distances elevation angles, terrain roughness factor "delta h" and the first Fresnel zone ellipse are calculated.

(2) Point-to-point propagation prediction using various propagation models and topographic data base.

(3) Spectrum occupancy prediction. All signals expected at a given test point are identified and the frequency, level, azimuth of arrival and source is determined for each signal.

(4) Line-of-sight coverage prediction.

(5) Transmitter file management. Transmitter data may be added, corrected, or deleted. Transmitters may be selected by name, frequency, power, geographic area, or by a combination of these parameters.

This software has been developed to assist in the planning low-power rebroadcasting television transmitters and requires transmitter and topographic data bases

## Propagation predictions

Three programs from CCIR Study Groups SG5 and SG6 deal with propagation predictions.

(1) The program GRWAVE (#90/2.3) calculates the ground-wave field strength and transmission loss in an exponential atmosphere as a function of distance, frequency, antenna height, polarization and electrical characteristics of the Earth. Its approximate frequency range is 10 kHz to 10 GHz.

(2) The program REP8942 (#90/2.8) provides an estimation of MUF, sky-wave field strength, signal-to-noise ratio, LUF and basic circuit reliability.

(3) The MINIFTZ program (#90/2.5) estimates the basic MUF and sky-wave field strength.

The program package MPS11 from the USA (#90/1.14) contains seven programs for point-to-point propagation predictions.

(1) The program TIREM11 computes the path loss expected for the particular terrain profile between the transmitter and receiver. It is applicable in the 40 MHz to 20 GHz frequency range. The terrain information required is extracted from a topographic data base or may be input manually.

(2) The program IPS11 is a smooth-earth propagation model, applicable in the frequency range 1 MHz to 20 MHz.

(3) The program NLAMBDA11 is a smooth-earth propagation model applicable in the 0.1 MHz to 20 GHz.

(4) The program MXPATH11 is a smooth-earth model applicable for mixed paths.

(5) The program VLF11 is applicable in the 10 to 100 kHz frequency range. It accounts for both the ground wave and the wave reflected from the ionosphere.

(6) The program SATPROP applies to line-of-sight Earth-space links in the 100 MHz to 100 GHz frequency range. It computes the median path loss and deviations due to ionospheric scintillation and rain attenuation.

(7) The MMW11 program provides predictions to signal attenuation and phase dispersion of radio waves in the 1 to 300 GHz range. It applies to both Earth-space and terrestrial line-of-sight transmission links.

The program package MLINK from Japan (#90/1.18) is intended for radio-relay link propagation path analysis. It consists of 29 modules. Modul 1 gives an information on microwave frequency bands and their applications. Modules 2, 3 and 4 deal with the free-space-, line-of-sight- and tropospheric propagation, respectively. Modules 5 and 6 explain the concept of the Fresnel zone and diffraction. Modul 7 describes basic parameters of relay route. Modul 8 draws the profile and direct and reflected waves. Modul 9 deals with the path clearance. Moduls 10, 11 and 12 calculate difraction and reflection losses. Modul 13 calculates the ground reflection point. Modul 14 calculates the angle between the direct and reflected waves. Modul 15 gives an information about the antenna directivity. Modul 16 describe effects of fading. Moduls 17 and 18 describe standards relating to allowable noise and EIRP. Modul 19 deals with short term fading. Moduls 20, 21 and 22 describe space diversity system, calculate antenna elevation angle and determine azimuth and distanceto stations, respectively. Modul 23 estimates propagation path performances. Modul 24, 25, 26and 27 calculate interference noise. Modul 28 deals with the field survey. Modul 29 uses the results of the computations to draw conclusions.

The three following programs from Poland make use of the topographic data base.

(1) The program SHADOW (#90/1.5) determines the line-of-sight coverage area of a fixed transmitting station.

(2) The program PROFILE (#90/1.6) determines the radio propagation path profile between the transmitting and receiving antennas.

(3) The program DELTAH (#90/1.7) evaluates the effective antenna height and the terrain roughness factor following CCIR Rec. 370.

The terrain data base is not included in the programs.

## Coordination & EMC analysis

The program APP28 from Sweden (#90/1.1) determines the coordination area around an earth station, in the frequency bands between 1 to 40 GHz, shared between space and terrestrial services. It follows Appendix 28 of the Radio Regulations.

The three software packages for analysis of potential interference that a VHF sound broadcasting transmitter can cause to an aeronautical radionavigation (ILS/VOR) system are from Germany (#90/1.2) and Poland (#90/1.3, #90/1.19). All are interactive and based on the procedures and criteria specified in CCIR Report 929.

The RS3 simulation program package from the CCIR Secretariat is a simulation tool for the analysis of a co-channel man-made interference threat to radiocommunication systems.

The PRODSIR program from the USA (#90/1.15) computes the probability distribution of the signal-to-interference ratio from co-channel interferers in a congested radio environment.

## Antenna analysis/design

The program ELLIPSE from Czechoslovakia (#90/5.1) determines ellipse of the minimum area enclosing a given polygon. It is intended to best fit elliptical satellite antenna beam parameters optimization

The following three program packages are from the CCIR Secretariat.

(1) The program LFMFANT (#90/2.4) calculates long-wave and medium-wave vertical antenna arrays.

(2) The software package HFANT (#90/2.7) calculates the HF antennas of various types.

(3) The programs FMTVANT and FMTVSYNT perform an analysis and synthesis, respectively, of VHF-UHF broadcasting antenna systems.

## Propagation data banks

The CCIR propagation data banks have been created to verify propagation prediction algorithms.

The data bank of SG6 comprises measurement data for about 180 combinations of path lengths (175 to 26000 km) and frequencies (2.5 to 26 MHz).

Data banks of SG5 contain measurement data on terrestrial and Earth-space paths, grouped in three categories: terrestrial line-of-sight, Earth-space, and terrestrial over-the-horizon.

## Noise data

The NOISEDAT program from Study Group 6 (*90/2.6) gives estimates of atmospheric, man-made and galactic noise following CCIR Report 322-3.

## Subscription Circulars for the software available from the ITU

No. 22bis Microcomputer program package for antenna diagram calculations "HFARRAYS" and "HFRHOMBS"

No. 64bis Microcomupter program for antenna diagram calculations "LFMFANT"

No. 95 Computer programs for HF antenna diagram calculations HFMULSLW and HFDUASLW

No. 135 Microcomputer program package for VHF and UHF broadcasting antenna system design "FMTVANT"

~~Rec.~~ 705 Microcomputer program package for HF antenna pattern calculation - HFANT

The above-listed software may be ordered from the ITU Sales Service, Place des Nations, 1211 Geneva 20, Switzerland.

*) Identification number in Ref. [1]

## References


[1] CCIR List of Computer Programs, ITU, Geneva, January 1990.

[2] CCIR Handbook on Spectrum Mangement and Computer-aided Techniques, ITU, Geneva, 1983, updated 1986

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

RADIO FREQUENCY SPECTRUM MANAGEMENT

Part 12

# RADIO RELAY LINK PROPAGATION PATH DESIGN "MLINK"

R.G. Struzak
International Telecommunication Union, International Radio Consultatiuve Committee
Geneva, Switzerland

Source: CCIR Doc. IWP1/2-214/1988





The purpose of these notes is to provide an overview of one of the computer programs relevant to the radio frequency spectrum management and offered under CCIR Resolution 88.

## 1. Introduction

This software has been generously made available by the Telecommunication Bureau, Ministry of Posts and Telecommunications, Japan. It has been written in the BASIC language for the IBM-AT/IBM-XT/IBM-PS2 type computers by the ITU Association of Japan, Inc. The software and all its subsequent copies (but not the physical media on which it is recorded) remain the property of Telecommunication Bureau, Ministry of Posts and Telecommunications, Japan. Enquiries concerning the software should be addressed to:

"Frequency Planning Division, Radio Department
Telecommunication Bureau
Ministry of Posts and Telecommunications
1-2-3, Kasumigaseki, Chiyoda-ku, Tokyo
100-90, Japan"

### Limitation of liability

Permission to copy and use the software without fee is granted under CCIR Resolutioin 88 provided that: (1) the copies are not offered for sale or distribution and (2) the liability limitation note appear without modifications. Making the software available does not imply any form of endorsement or recommendation by the CCIR. The software (and accompanying text) is made available "as is". It may contain errors and/or may require modifications before it can be utilized with a specific typeof computer hardware. Neither the Author(s), nor the submitter, nor the CCIR make any warranty or assurance as to its performance, and no liabilities are acccepted for the content or applicability of the software and documentation, results of using them, or for their support/maintenance. The entire risk for their use must be assumed by the user.

## 2. Program outline

This software is intended to analyse propagation condition and to help to find an appropriate location for microwave link stations. It contains 28 task modules. Each task can be selected from the task menu, startred independently, and accessed directly. The user interface is conversational: the program asks you to input parameters one-by-one. Full color display makes the operation easy to understand. Fig 1. shows how the modules relate to each other. There are information modules containing design information, and calculation modules. A data file contains propagation parameters and typical antenna data taken frm CCIR texts. These are used in calculations. Fig. 2 shows the task menu, the first screen to appear when the program is started.

**Task 1** **Microwave frequency bands and their application**

- Actual microwave frequency bands
  - Long distance circuit : 4, 5, 6, 8 Ghz bands .
  - Branch circuit : 11,15 Ghz bands .
  - Short distance circuit : 2, 7,11,15 Ghz bands.
- Indication of input parameter : frequency band, bandwidth, center frequency, system capacity , and CCIR recommendation number correspond to the description.

**Task 2** **Free space propagation**

- Input of input parameters : frequency , section distance, transmitter output power, transmitting/receiving antenna gain, feeder loss.
- Calculation and indication of free space loss and received input power.

**Task 3** **Line-of-sight propagation**

- Description and illustration show how a height pattern occurs at the receiving point becouse of the ground reflected wave.

**Task 4** **Tropospheric propagation**

- Description of how radio propagation in the troposphere is affected by weather .
- Description of three propagation types characterized by the effective radius of earth (K).
- Description of applicable value by classification of K value accordinate the regional weather .

**Task 5** **Fresnel zone theorem**

- Illustration of the radius of the first fresnel zone.
- Description says that the path must be designed to have two-thirds of the radius of the first fresnel zone.



**Task 6** **Diffraction**

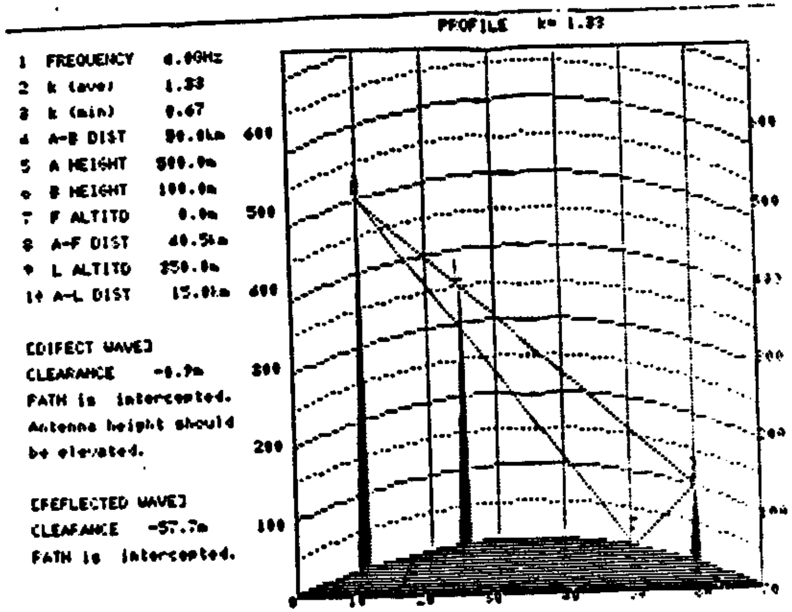
- Description and illustration show how the height of the obstacls affects the received input power.

**Task 7** **Planning of relay route**

- Description and indication of the basic data of route planning : relay distance, path clearance, ground reflection, repeating angle, and station frequency .

**Task 8** **Profile drawing**

- Input of input parameters : frequency, section distance, transmitting/receiving antenna height, distance to the reflection point , altitude of reflecion point, altitude of ridge, distance to ridge, and K value.
- Illustration of profile. We have prepared 24 scales of profile, which are adopted automatically to suit the given input parameters.
- Calculation and illustration of a profile showing the clearance by direct wave and reflected waves. These route are judged by the propagation standard. A comment is shown to help the designer choose whether to continue the calculation of the input parameters of this section or to change the route plan.



Task 9 Path clearance at ridge point

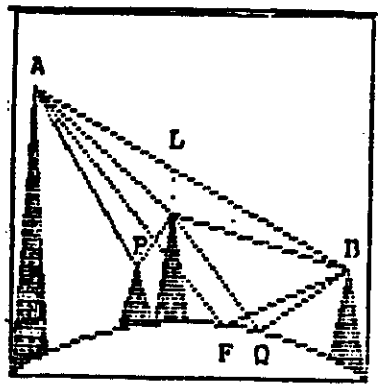
- Calculation and illustration of the clearance.
- Calculation of procedure and illustration of the clearance of reflected wave.

Task 10 Ridge diffraction loss

- Input of input parameters : K value (average, minimum), section distance, transmitting/ receiving antenna height, distance to the obstacle, altitude at the reflection point.
- Calculation and illustration of the ridge diffraction loss by direct wave and reflected wave.

Task 11 Direct wave and reflected wave losses

- Description of the effective ridge loss by direct wave and reflected wave.
- Description of the path of the reflected wave.




Task 12 Ground reflection loss

- Illustration of the reflected wave loss (experimental value for Japanese territory) by the classification of frequency and geographical and geological features at the reflect point.

Task 13 Locating the reflection point

- Input of input parameters : hop distance, transmitting/ receiving antenna height, K value (average) and altitude of reflect point.
- Calculation and illustration of the location of reflection point.
- The 3rd equation uses Newton's approximate quantity value calculation method.

Task 14 Included angle between direct and reflected waves

- Input of input parameters : hop distance, transmitting/ receiving antenna height, K value (average) and altitude of reflection point.
- Calculation and illustration of the included angle between direct and reflected wave.
- The third equation in Newton's approximate quantity value calculation method is used.

Task 15 Antenna directivity

- Description of the general pattern of antenna directivity. Uses the experimental values of the four meter diameter parabolic antenna that generally in Japan.

Task 16 Fading in line-of-sight transmission

- Description of increase of thermal noise by fading, and fading margin.

Task 17 Transmission quality standard on hypothetical reference circuit

- Illustration and description of the constitution of Hypothetical Reference Circuit.
- Description of standard of the allowable noise.
- Description of standard of the circuit dropout rate.

Task 18 Regulation regarding max. EIRP

- Description of standard of antenna radiated power limitation to limit mutual interferance between terrestrial and satellite systems.

## Task 19 Distribution of received power during short term fading

- Description of standard of Rayleigh Fading Occurrence Probability and circuit dropout rate.
- Input of input parameters : frequency, hop distance, geographical features, effective reflective attenuation, transmitting/receiving antenna height.
- Calculation of Rayleigh Fading Occurrence Probability and circuit dropout rate, and comparison with CCIR Recommendation.
- Indication of whether the space diversity system is needed.

## Task 20 Space diversity system

- Description and illustration of applicable condition of space diversity and antenna spacing pitch.

## Task 21 Antenna elevation angle

- Calculation and illustration of transmitting/receiving antenna elevation and depression angle from the horizontal.

## Task 22 Azimuth and distance to each station

- Input of latitude and longitude of each station.
- Calculation and illustration of azimuth from true north and distance toward station.
- Spherical trigonometry is adopted and the distance calculated is the great circle distance.

## Task 23 Estimation of propagation path performances

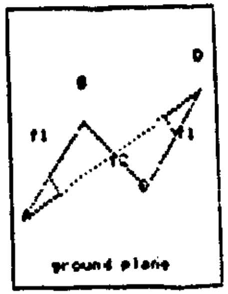
- Calculation together from item 2 until item 21 for propagation performances.
- Input parameter and output data are registered by data file and indicate together in item 29.

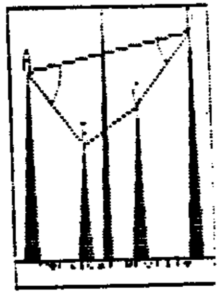
## Task 24 Over-reach interference

- Input of input parameters : frequency, antenna height, each section distance, azimuth toward respective station, altitude of ridge, distance to ridge point.
- Calculation and illustration of interference noise (D/U value).

OVER-REACH (SELF ROUTE INTERFERENCE) 4.0 GHz

| | | |
|---|---|---|
| 1 | A HEIGHT | 500.0m |
| 2 | B HEIGHT | 300.0m |
| 3 | C HEIGHT | 400.0m |
| 4 | D HEIGHT | 600.0m |
| 5 | A-B DISTANCE | 10.0km |
| 6 | B-C DISTANCE | 10.0km |
| 7 | C-D DISTANCE | 10.0km |
| 8 | A-D DISTANCE | 26.6km |
| 9 | ANGLE BAD | 4: 0: 0 |
| 10 | ANGLE ADC | 30: 0: 0 |
| 11 | RIDGE ALTITO | 700.0m |
| 12 | RIDGE DISTANCE | 14.0km |




| ---- A side ---- | | | ---- D side ---- | | |
|---|---|---|---|---|---|
| A side span loss difference | | 8.5dB | D side span loss difference | | 8.5dB |
| horizontal deflection | 4.0deg | 23.0dB | horizontal deflection | 30.0deg | 43.0dB |
| vertical deflection | 1.3deg | 8.0dB | vertical deflection | [illegible] | 4.5dB |
| A-D ridge loss | | 32.9dB | A-D ridge loss | | [illegible] |
| A side D/U | | 72.4dB | D side D/U | | 84.4dB |

**Task 25** Interference with other routes

- Input of input parameters : frequency, each latitude and longitude, transmitter output power, transmitting feeder loss, antenna polarization.
- Calculation and illustration of interference noise (D/U value).
- Can calculate mutual D/U for up to four routes.
- This program can be used by the relative location of station method, marking selection is needed but in this case.

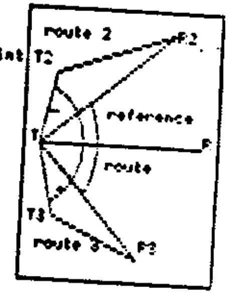
** Relative location of transmitting and receiving stations in each route **

(1) Designate a reference route and a reference point from among the routes to be examined.

(2) The reference point is meant for the transmitting point in the reference route.

(3) By using maps, obtain azimuths and distances towards the transmitting and receiving points in other routes measured from the reference point.

(4) Azimuth should be expressed as
plus(+) sign for clockwise direction,
minus(-) sign for anti-clockwise direction.




**Task 26** Interference to geostationary satellite orbit

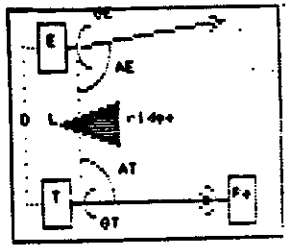
- Calculation of direction angle difference between a station in the radio relay links and a geostationary satellite orbit.
- Judgement of whether the direction angle difference is greater or less than two degrees. The mutual interference is observed to help make this judgement.

**Task 27** Interference between terrestrial station and earth station

- Judgement of mutual interference between terrestrial station and earth station by total transmission loss.

** Interference between terrestrial station and earth station (4.0 GHz) **

| | | |
|---|---|---|
| 1 | E ANT HEIGHT(m) | 100.0 |
| 2 | E ANT GAIN (dB) | 50.0 |
| 3 | ANGLE AE(d.m.s) | 100:30: 0 |
| 4 | E ANT DIRECTIVITY(dB) | 66.0 |
| 5 | T ANT HEIGHT(m) | 500.0 |
| 6 | T ANT GAIN (dB) | 42.5 |
| 7 | ANGLE AT(d.m.s) | 90: 0: 0 |
| 8 | T ANT DIRECTIVITY(dB) | 61.5 |
| 9 | E-T DISTANCE(km) | 20.0 |
| 10 | RIDGE ALTITD (m) | 400.0 |
| 11 | E-L DISTANCE(km) | 10.0 |
| 12 | k(average value) | 1.50 |




(E-T SPAN PROPAGATION LOSS 130.5dB)
(RIDGE DIFFRACTION LOSS 30.7dB)

EFFECTIVE TRANSMITTING LOSS 183.2dB

This path meets the standards. the route plan is acceptable.

Task 28　Field survey

- Description of necessary items for desk work, primary survey and secondary survey.

| ITEM | CONTENT | DESI. | PRIM. | SECO. |
|---|---|---|---|---|
| Route map | hop distance, altitude | ○ | | |
| | azimuth | ○ | | |
| Site | topography, geology (steep,plain,sandy,rocky) | | ○ | ○ |
| | latitude, longitude | ○ | | |
| | altitude | ○ | | ○ |
| | land area (land readjustment) | ○ | | ○ |
| | acquisition of water for installation | | | ○ |
| Road | path, driveway | ○ | ○ | |
| | necessary length for new construction, repair | | ○ | ○ |
| Tower | antenna height above roof/ground | ○ | | ○ |
| | radome | ○ | ○ | |
| Power supply | in-take line length, reliability | | | ○ |
| Propagation path | profile | ○ | | ○ |
| | visibility(mirror test) | | | ○ |
| | topography around the reflection point | ○ | | ○ |
| | topography in the proximity of the site | | | ○ |
| | sketch | | | ○ |
| Maintenance | access route, time (summer, winter) | | | ○ |



Task 29　Determination of system meeting required performances

- Description of various calculation necessary for judgement, and indication of actual dimensions.
- Indicate refer to the conclusion of works after read out data from datafile.

| EXECUTIVE SUMMARY | POINT A | POINT B |
|---|---|---|
| Antenna Height(m) | 554.3 m | 108.0 m |
| Antenna elevation angle | -0.6[illegible]deg | 0.3[illegible]deg |
| Included angle(direct and reflected waves) | 0.[illegible]deg | 1.45deg |
| Antenna directivity effect | 1.0 dB | 6.5 dB |
| Distance(km) to reflection point | 41.4 km | [illegible] km |
| Diffraction loss of ridge | 12.5 dB | |
| Geographical feature at reflection point | waterface | |
| Reflection loss | 0.0 dB | |
| Altitude(m) at reflection point | 0.0 m | |
| Effective loss of reflected wave | 20.0 dB | |
| Span distance(km) | 54.0 km | |
| Span loss | 141.4 dB | |
| Clearance(m) | [illegible] m | |
| Circuit dropout rate(month) of path | 1.[illegible]-10 [illegible] | |
| Circuit dropout rate(month) of CCIR REC.[illegible] | [illegible]-10 [illegible] | |
| Space diversity system | not necessary | |

Task 30　Termination

## 4. Annex

Fig.1 STRUCTURE CHART OF M-LINK SOFTWARE

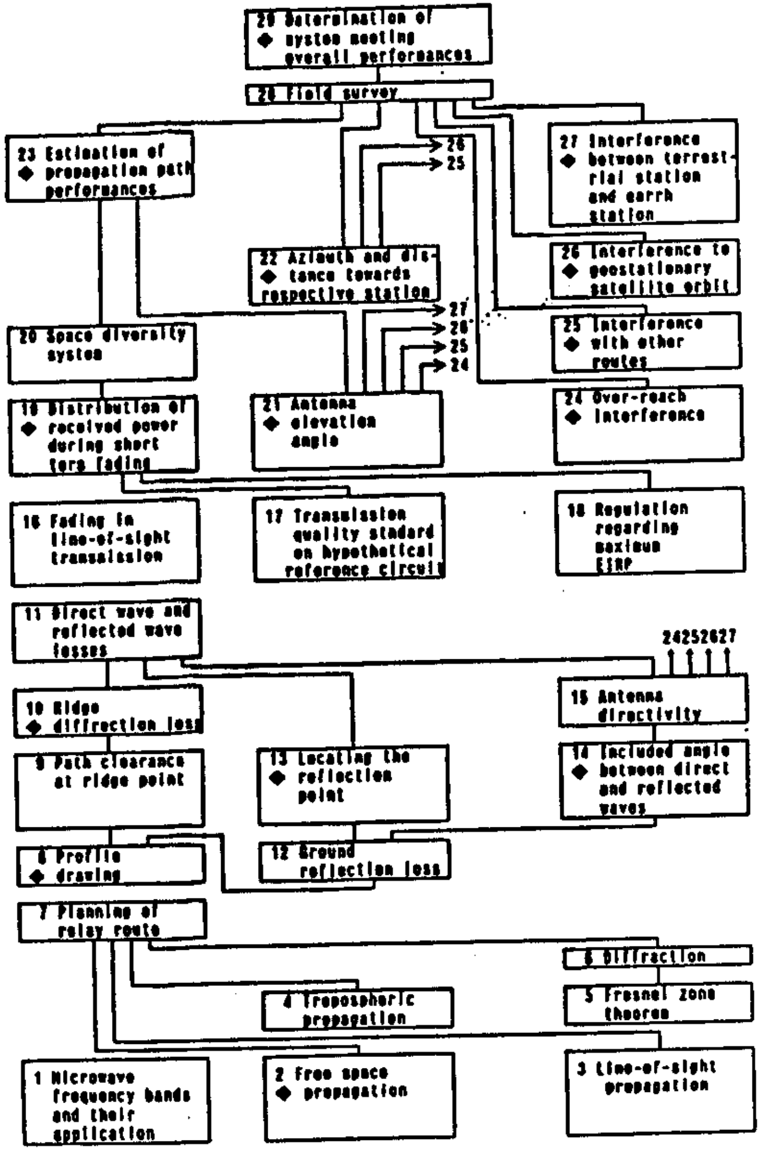





Fig.2 TASK MENU OF M-LINK SOFTWARE

| | |
|---|---|
| 1 Microwave frequency bands and their application | |
| 2 Free space propagation | ◇ |
| 3 Line-of-sight propagation | |
| 4 Tropospheric propagation | |
| 5 Fresnel zone theorem | |
| 6 Diffraction | |
| 7 Planning of relay route | |
| 8 Profile drawing | ◇ |
| 9 Path clearance at ridge point | |
| 10 Ridge diffraction loss | ◇ |
| 11 Direct wave and reflected wave losses | |
| 12 Ground reflection loss | |
| 13 Locating the reflection point | ◇ |
| 14 Included angle between direct and reflected waves | ◇ |
| 15 Antenna directivity | |
| 16 Fading in line-of-sight transmission | |

| | |
|---|---|
| 17 Transmission quality standard on hypothetical reference circuit | |
| 18 Regulation regarding maximum EIRP | |
| 19 Distribution of received power during short term fading | ◇ |
| 20 Space diversity system | |
| 21 Antenna elevation angle | ◇ |
| 22 Azimuth and distance towards respective station | ◇ |
| 23 Estimation of propagation path performances | ◇ |
| 24 Over-reach interference | ◇ |
| 25 Interference with other route | ◇ |
| 26 Interference to geostationary-satellite orbit | ◇ |
| 27 Interference between terrestrial station and earth station | ◇ |
| 28 Field survey | |
| 29 Determination of system meeting overall performances | |
| 30 Termination | |

◇ Calculation or Estimation

Select item number (1-30) ?

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

**RADIO FREQUENCY SPECTRUM MANAGEMENT**

**Part 13**

# MICROCOMPUTER SIMULATION OF MAN-MADE INTERFERENCE

R.G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland



ABSTRACT. *An interactive microcomputer simulation model is described. The model is intended to serve as an engineering tool for the analysis of man-made interference threat to a radiocommunication system. Simulation technique is used to imitate experiments with the system, environment and their interaction. Various modifications can be simulated and their effects on the system performance analyzed. Input data are supplied by the user, and the computer produces pictures, maps and statistics, describing the interference threat. The model allows for experiments with directive antennas, multiple man-made interference sources randomly located in three dimensional space and with various propagation mechanisms. The areas occupied by the interference sources and victim receivers can be separate or coinciding, totally or partially. Assumptions, limitations, algorithms, performance criteria and application examples are presented.*

*Source:"Simulation Model for Evaluating Interference Threat to Radiocommunication Services" Telecommunication Journal, Dec. 1990; pp. 827-839*

## 1. INTRODUCTION

This paper describes an interactive microcomputer simulation model, developed to analyze electromagnetic compatibility problems. Electromagnetic compatibility (EMC) is the ability of a system to function satisfactorily in its electromagnetic environment without introducing intolerable disturbance to that environment. In the paper, we discuss the interference threat to radiocommunication systems due to man-made interference environment. Limiting of man-made interference is vital to many applications and services, and has been included in the programmes of several national, regional and world-wide organizations. A list of these organizations includes the *International Telecommunication Union* [*ITU*, 1989], *International Electrotechnical Commission* [*IEC*], *International Radio Consultative Committee* [*CCIR*, 1986], *International Special Committee on Radio Interference* [*CISPR*, 1987] and *European Community* [*EEC*, 1989], among others. Interference-free operation of communication systems is becoming more and more difficult to ensure, due to the growing number of users of the radio frequency spectrum and growing competition between them [*Rotkiewicz*, 1982]. The problem of undesired RF radiation from industrial, scientific and medical (ISM) equipment is an example [*Struzak*, 1985]. In spite of the intentions of 160 or so country-members of the ITU [*WARC*, 1979], and in spite of many years of efforts [*CISPR*, 1987], widely acceptable recommendations on ISM radiation limits have not been reached [*CCIR*, 1986].

Recommendations relating to electromagnetic compatibility are usually a compromise between two parties representing opposite interests. Evaluating the interference threat is one of the key problems in finding a compromise. When one party is claimed to overestimate, and another one to underestimate the interference threat, the only reasonable way is to refer to experimental evidence. As the experimental data available are incomplete, special measuring campaigns would be needed for that purpose. Such campaigns would be too expensive and would require too much time. In seeking a more practical solution, a simulation approach was proposed [*Struzak*, 1984]. Numerical simulation has become a powerful tool in various applications, supplementing traditional mathematical analyzes and "real-world" experiments (see e.g. *Shannon*, 1975). A simulated experiment is less expensive and avoids all risks of the "real-world". It is easier to prepare, to perform, to control and to repeat. It can modify the time scale, if the "real" experiment runs too quickly or too slowly. Processes which normally require months or years to develop can be accelerated to run in minutes.

Another important characteristic of numerical simulation is its ability to examine systems which are intractable to experimental manipulation and too complex for exact mathematical treatment. Examining new systems which exist only in conceptual forms, testing hypotheses, or examining postulated modifications to existing systems, are examples of such applications. The first simulations were limited to large computers. Now, microcomputers have as much computing capability as mainframes of only a few years ago, and the technique is becoming more popular. In spite of this trend, the literature on simulation of electromagnetic compatibility problems is scarce. The bibliography by Dudewicz [*Dudewicz* and *Karian*, 1985] contains about 500 papers on simulation and lists more than 80 application areas, but disregards the EMC issues. Simulation of certain EMC problems is addressed by Lee [*Lee* and *Smith*, 1983], Koester [*Koester* et al. 1986] and Cook [*Cook*, 1987]. All of them use large computers. Microcomputer models are proposed by Struzak [*Struzak*, 1984] and Weinberg [*Weinberg* and *Wilson*, 1986] to study ISM interference. These models, however, are limited to two-dimensional space, omni-directional antennas and simplistic propagation mechanisms. The objective of this work was to examine the feasibility of microcomputer simulation of EMC problems involving three-dimensional space, directive antennas, more elaborate propagation mechanisms and random influences.

The remaining part of the paper is organized as follows. The input data and general algorithm are presented in Section 2. Major assumptions, limitations and device models are discussed in Section 3. Section 4 deals with the output of the simulation. Computational aspects are treated in Section 5, and application examples in Section 6. Comments on future work are given in Section 7, and concluding remarks in Section 8.

## 2. General Algorithm

The aim of the simulation is to imitate modifications to various parameters of the radiocommunication system, its environment, or both, and to predict the effects of these modifications on system performance. The simulation process involves input data, simulation software, simulation hardware and output data. The input data are transformed into the output data in accordance with the algorithms included in the software. The general algorithm of simulation consists of three major steps illustrated by Fig. 1. The first step is to determine that which is to be simulated. The input data are applied to define the fixed parameters of the model and the boundaries for its pseudo-random variables, and to determine the EMC criteria and simulation scope. The input data are listed in Fig. 2 (see [*CISPR*, 1987]). They are read from default files or supplied by the user, and have to be selected from populations that might occur in an actual situation. The second step is the simulation of system-environment interaction,



and evaluation the performance of individual transmitter-receiver links of the system.

Fig. 3 illustrates the algorithm applied. Here, concepts of simulation scenes and test points are used. A simulation scene represents a specific configuration of the transmitter, receivers and interference sources: Fig. 4 shows an example. The test points are the points at which the receivers might be installed. Simulation scenes are generated and the performance of transmitter-receiver links analyzed. For that purpose, the relevant input data are applied to the computer programs which contain models of the devices and processes involved. The models are discussed in Section 3. Each transmitter-receiver link is examined separately, and the expected values of the signal level and noise margin are computed. These raw simulation results are compared with the EMC criteria. The third and last simulation step is the determination of the system performance and evaluation of the interference threat. On the basis of the examination of the individual communication links, various global measures of the system performance are computed, as discussed in Section 4. All phases of the simulation process are displayed on a control panel on the screen. The panel contains several windows, each of them representing a set of data, see Fig. 5.

Deterministic or Probabilistic Simulation. The model can be used for deterministic and for probabilistic simulation. In the deterministic simulation, the values of all variables can be predicted with precision. In the probabilistic simulation some of the variables are random and only the boundaries within which they are confined can be determined. Flipping a coin is a good example. Although laws of physics to predict its position (given the initial velocity, spin, etc.) are well known, it is practically impossible to determine in advance whether the coin lands on heads or tails. The probabilistic simulation (known also as the Monte Carlo simulation) amounts to a repetition of simulated trials and a collection of statistics representing global results. In the deterministic simulation, a simulation scene is generated and analyzed once for all. There is no reason to repeat deterministic experiments because each of them gives, in principle, the same results. When random input components are present, however, the system performance is subject to statistical dispersion, and each trial may give a different result. In order to obtain results which are statistically significant, the simulation experiment has to be repeated. Simulation scenes are sequentially generated, each time with a new set of random components, and the system performance is determined and treated as a "sample" of statistical data. Section 5 gives more details on repeated trials.

## 3. Assumptions, Limitations, Device Models

In computer modelling, all assumptions, variables, and relationships must be described by numbers, with an accuracy commensurate with the accuracy required of the results. Even external influences, left out in real-world experiments, have to be precisely defined. The assumptions, on which our model is based, are discussed below, together with the model limitations.

The RADIO COMMUNICATION SYSTEM simulated in the computer consists of one transmitting and one or more receiving stations. If two or more wanted transmitters are involved, as e.g. in hyperbolic navigational systems, each of them has to be treated separately. If there is more than one receiving station, all are of the same type. A narrow frequency band is taken into account. It means that a separate model has to be created to simulate each spurious or non-linear response of the receivers. The distribution of the wanted signal is defined by the transmitting antenna and propagation model. Reflected signals are disregarded.

ANTENNAS. The transmitting and receiving antennas can be isotropic or directional; adaptive antennas are not included. Receiving antennas are situated at test points and, if they are directional, they are pointed toward the transmitter. An antenna model represents the directive radiation pattern of the original antenna in consistency with the objectives of the simulation. In our case, there are two models provided: one for the transmitting antenna and another one for the receiving antenna. The models are in the form:

ANTENNA GAIN = (ANTENNA GAIN IN THE AZIMUTH PLANE
+ ANTENNA GAIN IN THE ELEVATION PLANE
+ RANDOM COMPONENT) [dB] (1)

The gains are relative to the maximum gain. The gain in the azimuth plane and in the elevation plane are mutually independent. Examples are shown in Fig. 5.

The INTERFERENCE ENVIRONMENT simulated in the computer consists of two components. The first is the background environmental noise. It is assumed to be independent of direction and distance. The second component is the noise from unwanted man-made radio-frequency interference (RFI) sources. It depends on the distance from, and direction to, the sources. Only radiation phenomena are taken into account. The sources are randomly distributed in space and have random radiation patterns. The area occupied by them is in the form of a three-dimensional rectangular box, as shown in Fig. 4. It can be separate or coinciding, totally or partially, with the area occupied by the communication system. The RFI sources are of the point-type; distributed sources (e.g. power lines) are not included in the model. Radiation limits are usually defined as the level of unwanted signal at a reference distance from the source, and the simulation model accepts this definition. Local attenuation of radiation by buildings, or by additional screening structures, is taken into account. The distribution of interfering signals is determined by the propagation model. The interference sources are co-frequency with the transmitter. Off-channel interference can be simulated by introducing equivalent co-channel interference source(s). Frequency-hopping and intermittent sources are excluded. Anarrow frequency band is taken into account. It means that a separate model has to be created to simulate each harmonic or spurious radiation.

PROPAGATION. A propagation model determines the level of wanted (or unwanted) signal which is exceeded (or not exceeded, respectively) at the receiving antenna during a given proportion of time. For instance, the level of the wanted signal may be required to be not less than A dB during 99.9% of time, and the level of undesired signal - not greater than B dB during 0.1% of time. Zero-gain antennas are assumed at both the transmitting and receiving stations. The software offers a class of models simulating different propagation mechanisms, from which the user selects a model which is the most appropriate for his application (see e.g. *CCIR*, 1986). Propagation loss is assumed to be dependent on distance, but independent of the bearing to the radiation source. It means that actual terrain shadowing, reflections, and multipath propagation are disregarded. Two separate propagation models are provided, one for the wanted signal and another one for interfering signals. The models are in the form:

SIGNAL LEVEL = (REFERENCE SIGNAL LEVEL
+ PROPAGATION LOSS
+ RANDOM COMPONENT) [dB] (2)

All variables are relative to a given reference level. An example is shown in Fig. 5.

EMC CRITERIA AND LINK PERFORMANCE. It is assumed that the degradation of communication links is attributable to two elements. The first is the internal (receiver) noise, the second is the external noise and unwanted signals. The signal level and the noise level serve as the measure of performance of each individual transmitter-receiver link. They are computed using formulas listed in Fig. 6. The computations involve models of antennas and propagation processes, and require determination of distances and direction angles between the receivers and radiation sources, see Fig. 7. "Signal" is the wanted signal, and the *resultant noise* includes the internal and external noise (*background noise*) and all *undesired signals*. The effect of multiple interference signals and noise is calculated by means of the power sum method. This seems to be a reasonable approach to continuous disturbances; discontinuous ones may require another approximation. The noise causes a degradation of the link performance and, in some cases, can lead to a disruption of the normal operation of the link. "Normal", in this context, refers to "satisfying given technical and operational requirements". The criterion of the "normal" operation built in the model requires that both, the wanted signal level and the noise margin are greater than their respective minimum acceptable values. The *noise margin* is the difference between the levels of the wanted signal level and resultant noise. It is called also "protection margin", "signal/noise ratio", etc.. (In some systems, the *noise temperature* concept is used; such systems can be simulated, if the temperature is "translated" into an equivalent noise margin.) Numerical values of the minimum signal and minimum noise margin are set up by the user, depending on the application, signal processing method, error correction, etc. (see *CCIR*, 1986).

NOISE AND RANDOM COMPONENTS. Random components, like the receiver noise and environmental noise, are modelled using a standard random number generator. It produces pseudo-random numbers, uniformly distributed.

TEST DOMAIN. The performance of the radiocommunication system depends on the performance of its transmitter-receiver links. With mobile systems, as for instance in aeronautical communications, all expected locations of transmitting and receiving stations must be taken into account. In the simulation model, these locations coincide with the test points. Such an approach may require a great number of computations. A quick order of magnitude analysis illustrates this point. The test domain should be large enough to embrace a significant part of the system and its behaviour in time. On the other hand, the resolution of the model has to be fine enough to capture the smallest scales that are relevant. The number of test points, with a regular time-space grid, yields

$$N_{4D} = \left(\frac{D_{max}}{D_{min}}\right)^4 \qquad (3)$$

where $N_{4D}$ is the number of nodes of the grid. $D_{max}$ and $D_{min}$ denote the length scales associated with the largest and smallest distances in space or in time, respectively. If $D_{max}$ is 100 times greater than $D_{min}$, then there are $10^8$ test points. At each of them, all relevant signals have to be evaluated. With $10^2$ RFI sources, there are $10^8 * 10^2 = 10^{10}$ signals to evaluate. Even with 0.1 millisecond per signal, this would require $10^6$ seconds, or about 300 hours, of computing time. To keep the simulation time within practical limits, we exclude the time variable and restrict the test domain to a plane. The plane can, however, be fixed at different positions, which is equivalent to a series of cuts through the volume of interest. Thus, a possibility exists to explore the system performance in three dimensions (Fig. 4). The number of test points, $N_{2D}$, amounts now to

$$N_{2D} = \left(\frac{D_{max}}{D_{min}}\right)^2 \qquad (4)$$

The data of the previous example would give $10^4$ test points and 100 seconds of computing time. With the time variable not involved explicitly, the simulation model is valid for a short instant of time. During that time, neither the system, nor the environment, nor their interaction, can change significantly. The test points are now distributed over a test plane, which may be inadequate for those systems for which the curvature of the Earth is relevant (e.g. satellite systems).

## 4. System Performance Measures

During the simulation process, the system performance is examined at each test point. With a large number of test points, this produces huge collections of numerical data. The analysis of such collections surpasses the possibility of human perception and, as an aid, we use maps. Colour maps of the test area provide a visual display of the variable values and status of communication links at all test point. There are several kinds of maps produced: signal maps, noise maps, noise-margin maps, and coverage maps, which give information about the operation conditions of communication links. Examples are shown in Fig. 5 (see also Figs. 11 to 13). Such a pictorial representation of abstract concepts helps to identify interference structures which may be too complex to conceptualize otherwise. Moreover, some statistical indices are provided which characterize the overall situation by a few numbers only, see Fig. 8. Basic statistics and interference statistics are provided to quantify the degree of interference threat; we will discuss them below. In addition to the maps and statistics, histograms of distributions of variables are provided, see Fig 9.

Coverage area and Coverage Loss. At any given moment of time, each communication link may be in one of two possible states: "normal operation" or "unacceptable operation". The *coverage area* is defined as the set of test points under "normal operation". In reality, we refer to the *actual* coverage area which



is defined with the actual interference environment. However, we introduce here also the concept of the *ideal*, or *potential* coverage area which is determined with an *ideal environment*. The ideal environment consist of the background noise only: all RFI sources are inactive or removed. Note that it is unrealistic to expect that all existig RFI sources can be really switched-off or removed, but the concept is useful for reference purposes. The actual coverage area is usually less than the potential coverage area, and the difference, or *coverage loss*, indicates the degree of interference threat. In order to quantify this threat, the potential and actual coverage areas are compared one with another point-by-point, and each test point is marked "0" or "1". The "0" means "no harmful interference", the "1" means "unacceptable interference". The characteristics "1" and "0" are qualitative in nature and follow the binominal distribution. The requirement of exact representation of the coverage areas calls for a large sample, i.e. a large number of test points. With too small a sample, the results are statistically insignificant. With too large a sample, the simulation time is too long. Some aspects of the sample size are discussed in Section 5.

The Coverage Loss Index represents the expected likelihood that a receiver, operating normally without RFI sources, will suffer unacceptable interference after the RFI sources are activated. Its definition is given in Fig. 8. It involves the relative difference between the actual and potential coverage areas of the system, (see [*Anderson*, 1976]). This index has a straightforward interpretation. In addition to the *loss in the geographical coverage area*, it represents the relative *loss in the population served*, if the population is distributed uniformly over the area of interest. In economic terms, it may be interpreted as the *loss of capital* due to radio interference. A simple reasoning leads to that conclusion. The total cost of the radio communication system is distributed among these radio links which work normally in the absence of RFI sources. When the RFI sources are active, the Coverage Loss Index gives the proportion of the links which cannot continue to work normally. It is exactly the proportion of the total cost which cannot be used as intended. In the literature, rather than the Coverage Loss Index, the Interference Complaint Index and the Probability of Interference have been applied. They are discussed below.

Interference Complaint Index. The International Special Committee on Radio Interference uses a concept which we will call "Interference Complaint Index" [*CISPR*, 1975]. It is the likelihood of unacceptable interference suffered by a receiver. It is defined as the number of interference complaints divided by the total number of receiver licences, see Fig. 8. Under some conditions, it can be derived from the Coverage Loss Index. If the number of receiver locations is the same as the number of licences, NRP = NRL, and if the number of receivers suffering interference coincides with the number of complaints, NRI = NIC, then the both indices are equal. (The equality is valid as well if these numbers remain in the same proportion). The Coverage Loss Index involves uniform criteria and characteristics of the system, whereas the Interference Complaint Index relates to a population of different receivers and subjective, case-by-case, EMC criteria. As a result, the two indices can only approximatively be equal.

The Probability of Interference is used by Weinberg [*Weinberg* and *Wilson*, 1986]. He takes into account all receivers, all RFI sources, and all possible interactions between them. Under certain conditions, this probability can be derived from the Coverage Loss Index. As is seen from Fig. 8, the

Probability of Interference involves the number of receivers *and* the number of RFI sources, whereas the Coverage Loss Index involves *only* receivers. Thus, if the same interference criteria are applied, the Coverage Loss Index is NIS times greater than the Probability of Interference, where NIS is the number of interference sources.

## 5. COMPUTATIONAL ASPECTS

TEST SAMPLE. The sample size (i.e. the number of test points) determines the uncertainty with which statistical performance measures of the system are estimated. Let the "population mean" of a variable relate to an unlimited set of all possible test points, and let the "sample mean" relate to a limited set of test points involved in the experiment (sample). Because of a limited sample, the population mean and the sample mean of the same variable may differ. The probability that they differ by no more than a quantity ERR is subject to the following Tchebysheff's Inequality [*Burington*, and *May*, 1953]:

$$P((\text{MEAN} - \text{MEAN}^*) < \text{ERR}) > 1 - \frac{(\frac{\text{VARIANCE}}{\text{ERR}})^2}{n} \quad (5)$$

P{x} is the probability of event x, MEAN is the population mean, MEAN* is the sample mean, VARIANCE is the population variance, and n is the sample size. By selecting a sufficiently large sample (n), the probability that the sample mean will fall within a small interval about the population mean can be made as near to unity as desired. If, for example, the maximum acceptable error equals 10% of the VARIANCE with a probability of 0.95 or greater, then the sample size should be not less than 2,000 test points.

The COVERAGE AREA SIZE imposes a limit on the Coverage Loss Index. Let the total number of test points diminishes, other conditions being constant. Then, the number of test points without interference, and the number of test points suffering interference, will change. As long as there are many test points, their ratio remains constant. With too small coverage area size, the model resolution imposes a limit. A simple example illustrates this point. Let the potential coverage area consists of 100 test points, and let one of these points suffer unacceptable interference. The Coverage Loss Index is 1/100. If the number of test points is diminished by one, then there are two cases possible: either the test point suffering interference is a member of the new potential coverage area, or it is not. In the first case the Coverage Loss Index is 1/99 and in the second it equals zero. The limit imposed on the Coverage Loss Index is:

$$\text{COVERAGE LOSS INDEX} >= \frac{1}{n} \quad (6)$$

For example, if a low Coverage Loss Index is of interest, say $10^{-3}$, then the potential coverage area should contain 1,000 test points or more

REPEATING TESTS. In Monte Carlo simulations, the required number of runs can be determined at the beginning of the simulation experiment. However, the simulation model also accepts another approach. Instead of taking a decision before the simulation experiment begins, a sequential analysis of cumulated data indicates when sufficient number of observations have been made. For that purpose, the cumulative mean and standard deviation of the Coverage Loss Index is calculated after each run. After a sufficient number of runs, the mean differs from its asymptotic or "true" value by no more than a given quantity (see formula (5)). This shows that further repetitions are superfluous. The cumulative mean is the final result of the repeated simulation experiment. The variance shows how the individual scenes are spread out from the mean. Fig. 10 shows an example.

ACCELERATION OF COMPUTATION. To keep simulation time short, two provisions are made. Firstly, simulation variables are represented as integers, as much as possible. Secondly, the number of repeated computations is kept to a minimum. The antenna and propagation models are stored in the computer memory. To use them, vectors joining the test points and radiation sources have to be determined (Fig. 7). With 100 sources and 1,000 test points, there are $10^5$ vectors. Instead of computing each vector from original formulas, we use precomputed tables. In order to determine the resultant level of the unwanted signal at the test points, we process the signals in pairs. The greater signal of the pair is selected and the difference between the signal levels is calculated. If the difference is greater than 30 dB, then the lower signal is disregarded. Otherwise a correction factor is applied to the greater signal. The correction factor is computed only once.

## 6. APPLICATIONS

The simulation model is "user friendly". It is "menu driven" and does not require any knowledge of programming languages. Its input data can easily be adapted to the user's needs. It is not restricted to any specific EMC problem, communication system, or radio interference source, except for limitations indicated in Section 3. A typical application example is shown in Fig. 11. This figure presents results of experiments which imitate actual measurements of signal level at the output of the receiving antennas. It takes only a few minutes to collect the results from thousands of test points distributed over a large area and to analyse them statistically. Based on such data, one can evaluate the interference threat without the necessity of a costly "real-world" measuring campaign. (Such a campaign, however, may be required to validate the model, or to verify the conclusions.) An important feature of the simulation model is its flexibility in creating a variety of interference scenarios. This facilitates sensitivity analyses and helps to examine the effects of variation of the technical design decisions. It also allows for the generation of "if-then" data for such decisions.

The results, even complex ones, are presented in graphical form, easy to understand. This makes the model a useful tool for didactic application and also for examining relative effectiveness of the various measures undertaken to reach EMC. The simulation model does not contain any optimization algorithm to generate explicitly a "best" solution with respect to predetermined criteria. Instead, such a solution can be approached experimentally, utilizing a step-by-step simulation and evaluation process. Iterative application of simulation and evaluation leads to a learning process regarding the impact of alternative solutions. When a compromise solution is sought to satisfy conflicting interests, the alternatives may be proposed by the various interest groups involved. This may be helpful in overcoming those difficulties in deriving the EMC recommendations which result from the lack of experimental data. Another characteristic of the model is that it introduces a number of variables permitting the examination of complex interference situations in more detail than previously possible. It is to be remembered, however, that the model cannot correct errors in the input data. Some errors may even cumulate. In practical applications, simulation results have to be critically reviewed, with allowance for an uncertainty margin.

## 7. Future work

Future work is planned to remove certain limitations of the model and to answer some new questions related to its applications. Two examples illustrate this point. On Fig. 12 an interference-free area is visible, in the form of the figure "8". What conditions must be met to generate such interference-free areas? How to maximize them? Fig. 13 shows interference regions on a coverage map. With a single source, a single interference region might be expected; the map, however, shows a few such regions, some of them far away from the source. In which circumstances do such "far" RFI regions appear? How to minimize them? A general answer is that these are the effects of the spatial distribution of the equipment, propagation processes antenna radiation patterns etc.. A detailed analysis is beyond the scope of this paper; however, such an analysis might offer new elements in discussions of EMC issues.

## 8. Concluding remarks

A new microcomputer model, imitating interactions between radiocommunication systems and the environment, has been described. The histograms, maps, and statistical indices produced by the model may help to evaluate interference effects on the system performance. The coverage loss index has been introduced to quantify the interference threat. The model is a new simulation tool, creating new opportunities. The essential characteristic of simulation is the use of models for experimentation. Having a simulation model of a real system or process, it is quite easy to alter the various parameters of the model and observe how it operates with these changes. If the model and input data are correct, conclusions drawn from these observations are applicable to the original system or process. This characteristic makes simulation techniques promising as regards engineering and management applications. Both, good engineering and effective management, require an understanding of the system of concern and a means of studying the impact of the various alternatives possible. The simulation model fulfills these requirements.

## 9. Acknowledgment



The first prototype of the simulation model described in this paper was created when the author was with the Institute of Telecommunications, Wroclaw [*Struzak*, 1984]. At that time, he served also as the Chairman of CCIR Interim Working Party IWP1/4 on ISM radiation limits, and various versions of the simulation software were submitted for tests by the Members of the Working Party. Their cooperation is gratefully acknowledged, as is the encouragement of Director R. C. Kirby. Comments of Prof. Dr. T. Dvorak, Prof. Dr. R. Showers and Dr. K. Hughes are greatly appreciated.

## 10. Bibliography

*Anderson D.P.*, 1976: Service Area Lost Due to Interfering Transmissions; IEEE Internatl. Sympos. on EMC, July 13-15, Washington, DC, pp. 53-58;

*Burington R.S., May D.C.* 1953: Handbook on Probability and Statistics with Tables; Handbook Publ., Sandusky, Ohio, p.152;

*CCIR*, 1986; Recommendations and Reports of the CCIR, Vol. I, V, and VI, Geneva;

*CISPR*, 1975: Publ. 7B, Statistics of Complaints and Sources of Interference;

- 1987: Publ. 23, Determination of Limits for Industrial, Scientific and Medical Equipment;

*Cook C.E.*, 1987: Modelling Interference Effects for Land-Mobile and Air-Mobile Communications; IEEE Trans., Vol. COM- 35, No.2, Febr. pp. 151-165;

*EEC*, 1989: Council Directive No. 336 of 3 May 1989 on the Approximation of the Laws of the Member States Relating to EMC; Official Journal of the European Communities, 23 May;

*Dudewicz E.J., Karian Z.A.*, 1985: Modern Design and Analysis of Discrete-Event Computer Simulations; IEEE Computer Society Press;

*ITU*, 1989; Constitution of the International Telecommunication Union, Nice, Article 30, Item 156;

*Koester D.P, Smith L.E, Stevens R.R. Jr., Cook C.E*, 1986: A Computer Model to Evaluate Receiver Performance in Interference Environments; IEEE Trans. Vol. COM-34, No.5, May, p. 462-474;

*Lee W.C.Y, Smith H.L.*, 1983: A Computer Simulation Model for the Evaluation of Mobile Radio Systems in the Military Tactical Environment; IEEE Trans., Vol. VT-32, No.2., May, pp. 177-190;

*Shannon R.E.*, 1975: Systems Simulation; Prentice Hall, Inc.;

*Rotkiewicz W.* (ed.), 1982; Electromagnetic Compatibility in Radio Engineering; Elsevier Scient. Publ. Co.;

*Struzak R.G.*, 1984: Computer Simulation Model Proposed for Use in Studies of ISM Radiation Limits; Doc. CCIR IWP1/4-71;

- 1985; Vestigial Radiation from Industrial, Scientific, and Medical Radio-Frequency Equipment; in "*Nonlinear and Environmental Electromagnetics*", ed. by Kikuchi K.; Elsevier Sci. Publ. B.V.;

- 1990; Simulation Model for Evaluating Interference Threat to Radiocommunication Servicers; Telecommunication Journal, Dec., pp. 827-839

*WARC* 1979: Protection of Radiocommunication Services Against Interference Caused by Radiation from ISM Equipment; Resolution No. 63 of the ITU World Administrative Radio Conference;

*Weinberg D.I., Wilson T.L.*, 1986: A Model for Predicting Changes in the Probability of Television Interference by Industrial, Scientific, and Medical (ISM) Equipment; IEEE Internatl. Sympos. on EMC, Sept. 16-18, San Diego CA, pp. 313-321;

Note. The opinions expressed in this paper are the author's personal views, and do not necessarily reflect those of the CCIR or ITU.

Author: Ryszard G. Struzak is the Head of CCIR Department which deals with the spectrum management techniques, radio wave propagation, and space research Study Groups of the CCIR. He is also a Senior Counsellor to the Director, CCIR. Earlier, he served as a Professor at the Technical University, Wroclaw, and as the Head, Institute of Telecommunications, Wroclaw Branch. He was nominated Chairman CCIR IWP1/4, (80-85), elected V-Chairman CCIR SG1, (74-85) and elected V-Chairman URSI Comm. E, (84-87). Dr. Struzak is a Fellow of IEEE.

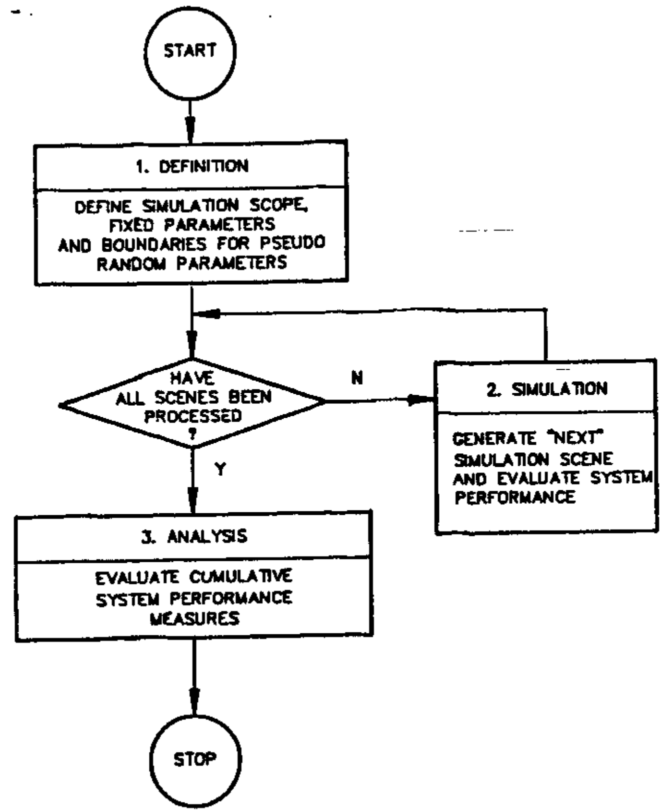



Fig.1. General algorithm of simulation experiment (simplified)

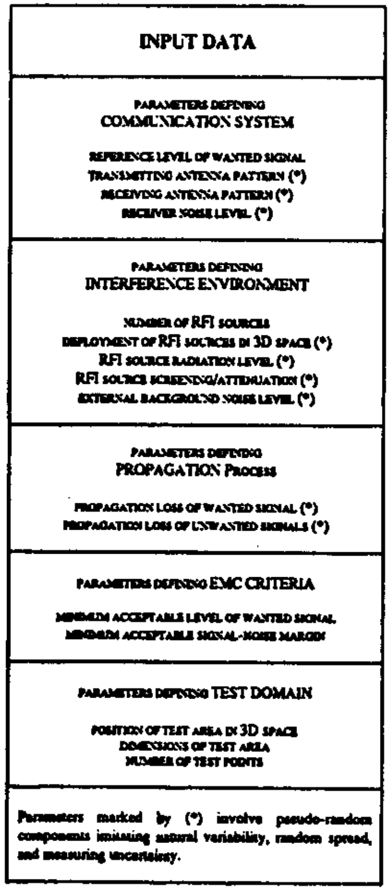



Fig. 2 Input parameters of the simulation model

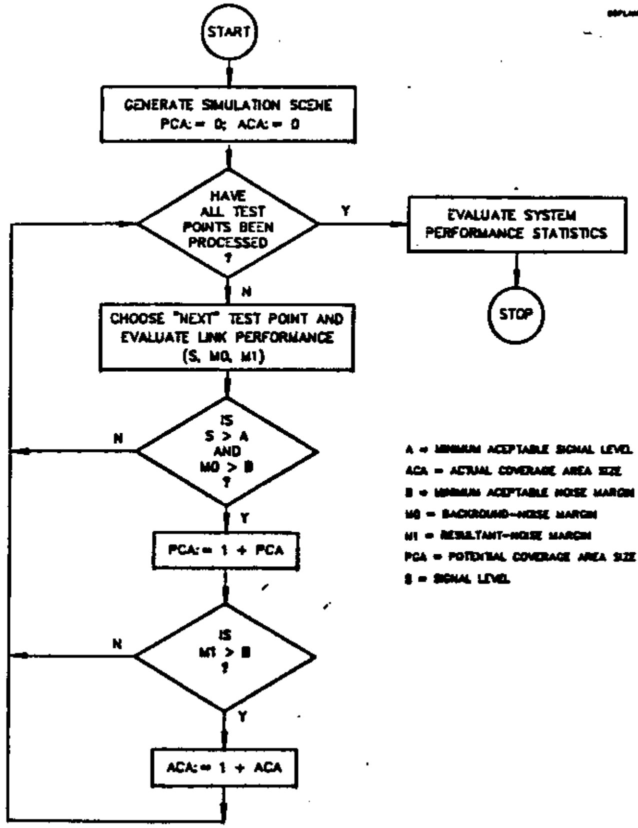



Fig.3. System performance evaluation algorithm (simplified)

FIGU2.DOC R.G. Struzak 10/08/90

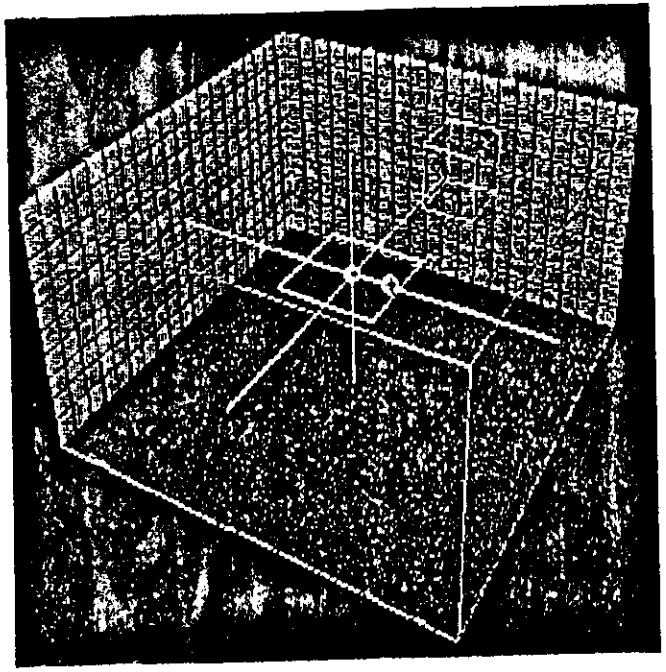


Fig. 4. Simulation scene as shown on the computer display.

| | |
|---|---|
| Red point: | transmitter position |
| Blue point: | reference point |
| Green lines: | coordinate axes |
| Yellow lines: | test area borders |
| Red lines: | interference source area borders |

The system performance is determined at a number of test points distributed over the test area. The size and position of the test area is defined by the user.

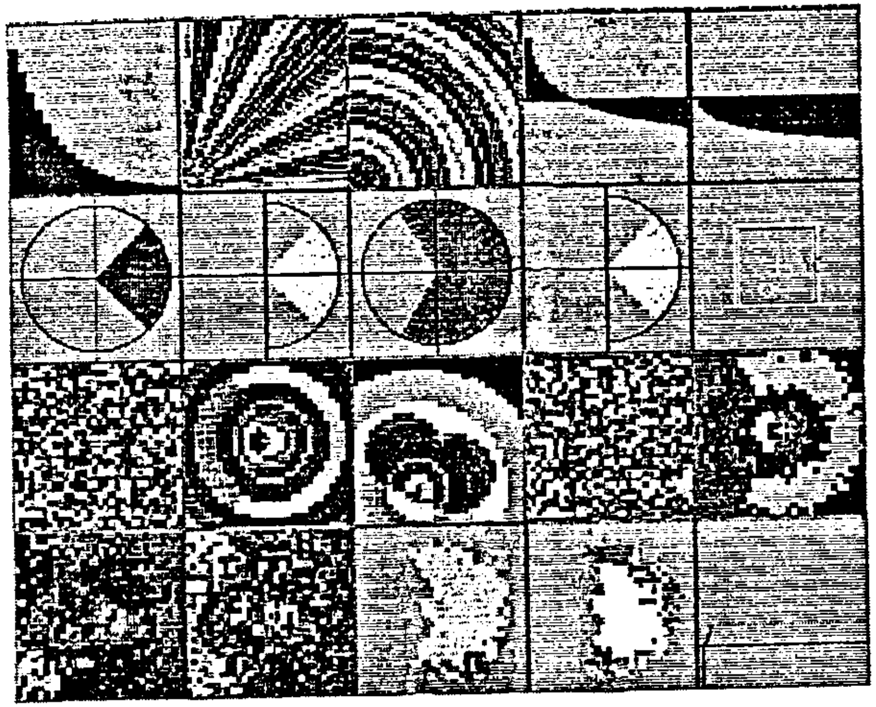


Fig. 5. Control panel displaying various phases of simulation experiment on the computer screen. The windows represent the following data (letters indicate the rows and numbers indicate columns):

A1: signal correction factor; A2: direction angles; A3: distances; A4: wanted signal propagation; A5: unwanted signals propagation

B1: receiving antenna pattern (azimuth); B2: receiving antenna pattern (elevation); B3: transmitting antenna pattern (azimuth); B4: transmitting antenna pattern (elevation); B5: test area and view of interfering source area;

C1: noise map; C2: wanted signal map; C3: interfering signal map (current); C4: interfering signal map (cumulative); C5: noise margin map (background) ;

D1: noise margin map (resultant); D2: wanted-unwanted signal margin map; D3: coverage map (potential); D4: coverage map (actual); D5: coverage loss index (current, cumulative, maximum and minimum values)

**OUTPUT DATA:**
**LINK PERFORMANCE MEASURES**

DATA ON SIGNAL RECEIVED

$$S = 10^{\left(\frac{S_o + PA + TA + RA}{20}\right)}$$

DATA ON NOISE MARGIN

$$M0 = 20 \log \left[\frac{S}{\sqrt{NR^2 + NB^2}}\right]$$

$$M1 = 20 \log \left[\frac{S}{\sqrt{NR^2 + NB^2 + \sum_{i=1}^{NIS} I_i^2}}\right]$$

$$I_i = 10^{\left(\frac{I_{io} + LA + PA + RA}{20}\right)}$$

$i = 1, 2, 3, \ldots, NIS$
$I_i$ is the unwanted signal from i-th RFI source [V]
$I_{io}$ is the signal $I_i$ at the reference distance [V]
LA is the local screening /attenuation factor
M0 is the background-noise margin [dB]
M1 is the resultant-noise margin [dB]
NB is the background noise [V]
NR is the receiver noise [V]
NIS is the number of RFI sources
PA is the propagation attenuation factor
RA is the receiver antenna discrimination factor
S is the wanted signal [V]
$S_o$ is the signal S at the reference point [V]
TA is transmitter antenna discrimination factor

Fig. 6. Output simulation data (raw): definition of performance measures of individual radiocommunication link

**DISTANCE & DIRECTION**
FROM POINT $P_2$ TO POINT $P_1$

$$\text{Distance} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

$$\text{Azimuth Angle} = \text{Arctan}\left(\frac{y_1 - y_2}{x_1 - x_2}\right)$$

$$\text{Elevation Angle} = \text{Arctan}\left(\frac{z_1 - z_2}{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}}\right)$$

$x_1, y_1, z_1, x_2, y_2, z_2$ are coordinates of the points

Fig. 7. Distance and direction (vector) from point $P_2$ to point $P_1$

| OUTPUT DATA: SYSTEM PERFORMANCE MEASURES | |
|---|---|
| **BASIC STATISTICS** | **INTERFERENCE STATISTICS** |
| $\text{MEAN} = \frac{\sum_{i=1}^{n}(X_i)}{n}$ | $\text{COVERAGE LOSS INDEX} = \frac{NRI}{NRP}$ |
| $\text{VARIANCE} = \frac{\sum_{i=1}^{n}(\text{MEAN} - X_i)^2}{n}$ | $\text{INTERFERENCE COMPLAINT INDEX} = \frac{NIC}{NRL}$ |
| $\text{STANDARD DEVIATION} = \sqrt{\text{VARIANCE}}$ | $\text{PROBABILITY OF INTERFERENCE} = \frac{NRI}{NRP \cdot NIS}$ |
| $i = 1, 2, 3, \ldots, n$<br>$n$ is the sample size<br>$X_i$ is signal level, noise level, or noise margin at i-th test point | NIC is the number of interference complaints<br>NRI is the number of receiver locations excluded from the potential coverage area due to RFI<br>NRL is the number of receiving stations licences<br>NRP is the size of the potential coverage area<br>NIS is the total number of RFI sources |

Fig. 8. Output simulation data: definition of system performance statistics

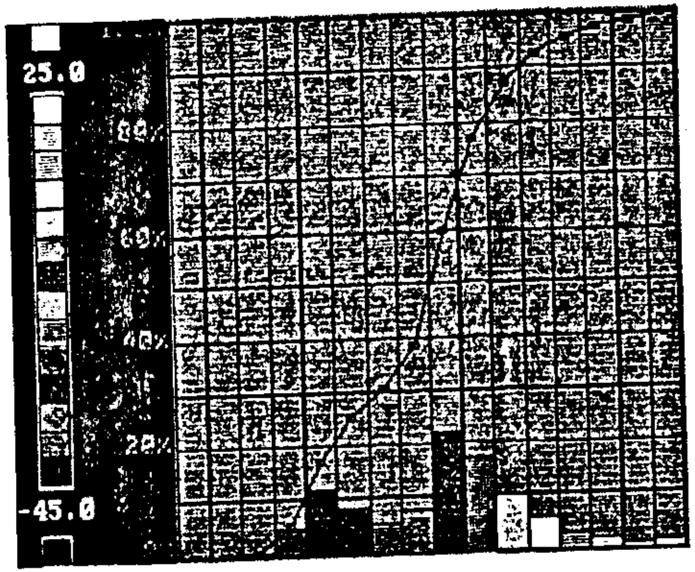



Fig. 9. Histogram of noise margin over the test area as shown on the computer isplay. The colour scale on the left indicates the 5-dB value intervals, between -45 dB and 25 dB. The vertical bars indicate the percentage of test points at which the noise margin falls into the specific interval. The cumulative curve represents the percentage of test points having a noise margin less or equal to a specific value.

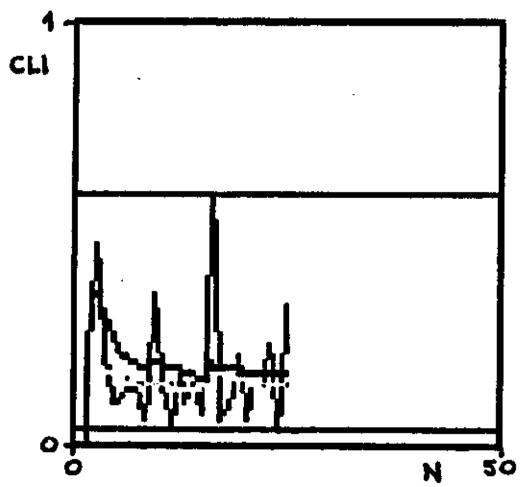



Fig. 10.Coverage Loss Index versus the number of repetitions in a repeated experiment as shown on the computer display.

| | |
|---|---|
| Red horizontal line: | maximum value observed (about 60%) |
| Blue horizontal line: | minimum value observed (about 3%) |
| Green line: | values observed for individual simulation scenes |
| Black line: | cumulative mean value |
| Light-blue line: | cumulative standard deviation |

Probabilistic simulation, a single interference source, 1600 test points, 25 repetitions.

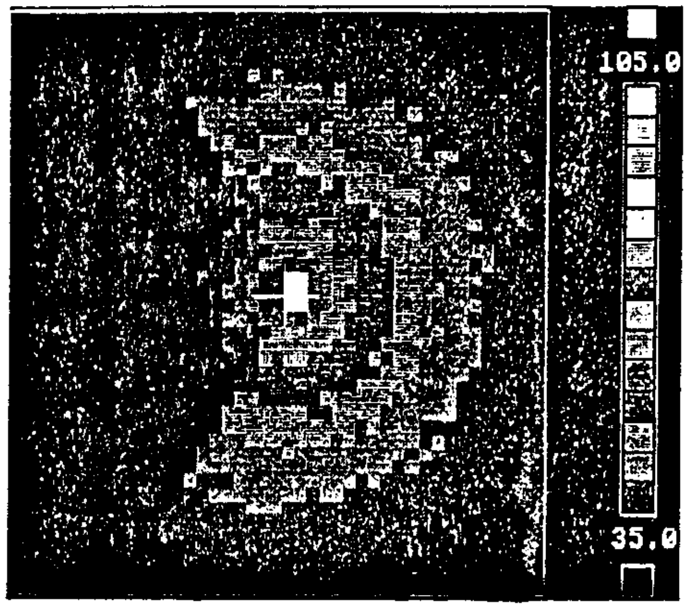



Fig. 11. Map of the wanted signal level over the test area as shown on the computer display. The colour scale at the right side indicates the signal level in 5-dB steps. Areas where the signal level is below 35 dB are in black; areas with the level above 105 dB are in white. The transmitter position coincides with the white cross. Probabilistic simulation, a single interference source, 1600 test points, simulation time about one minute.

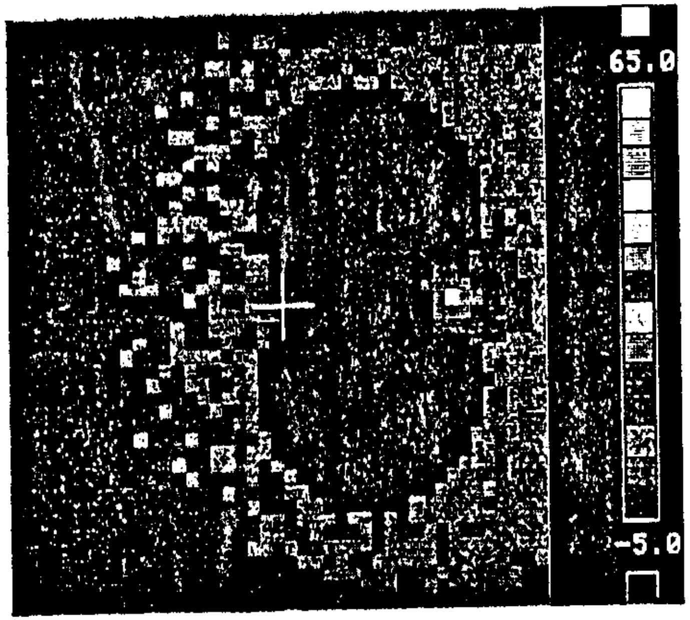



Fig. 12. Map of the interfering signal level over the test area as shown on the computer screen. The colour scale at the right side indicates the signal level in 5-dB steps. Areas where the signal level is below -5 dB are in black; areas with the level above 65 dB are in white. The transmitter position is marked by "+"; the interference source position coincides with the white square. Note the interference-free region in the form of "8" between the transmitter and interference source. Probabilistic simulation, a single interference source, 1600 test points.

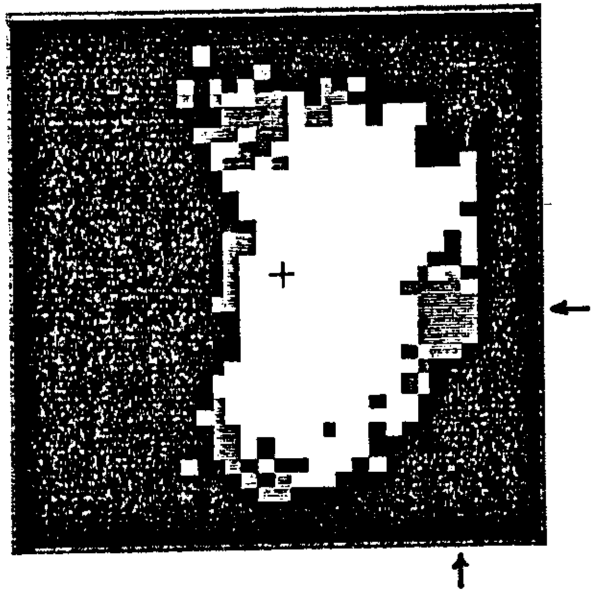


Fig. 13. Map of the coverage area as shown on the computer screen.

| | |
|---|---|
| Yellow: | the actual coverage area |
| Red: | the area lost due to unacceptable interference |
| Red + Yellow | the potential coverage area |

The interference source position is indicated by the arrows. Probabilistic simulation, a single interference source, 1136 test points. The Coverage Loss Index is about 20%.

International Atomic Energy Agency
United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics
34100 Trieste (Italy) . P.O.B. 586 . Miramare . Strada Costiera 11

Second College on Theoretical & Experimental Radiopropagation Physics,
7 January - 1 February, 1991

# RADIO FREQUENCY SPECTRUM MANAGEMENT

Part 14

# MICROCOMPUTER SIMULATION OF TV STATIONS
(Software description)

R. G. Struzak
International Telecommunication Union, International Radio Consultative Committee
Geneva, Switzerland



The purpose of these notes is to provide an overview of one of the computer programs related to spectrum management and offered under CCIR Resolution 88. The text is based on the paper [7].

## Introduction

This paper presents a computer-aided technique developed to aid in the planning of low-power re-broadcast television stations. Such stations are used to fill-in gaps in the signal coverage by high-power transmitters. The gaps are unavoidable in hilly areas, where terrain obstacles attenuate the signal excessively. Cable television, satellite television, or auxiliary low-power re-broadcast stations are used to fill-in the coverage gaps, and re-broadcasting is often the most practical solution.

An auxiliary station must be fitted in with both its signal environment and its geographic environment. Numerous complex analyses are required to reach that goal during the planing stage. "Planning" is understood here as the determining of the technical parameters and geographical location of the station. Simplified approaches, elaborated for the high-power stations (e.g. [2], [3]), are not applicable here, and new tools are required. For this purpose, a special software has been developed. Its short description is given below.

## The software

The software simulates a test station and its actual terrain and signal environment. The user selects the place for the test station and determines its technical parameters. The software analyses the influence of the environment on the work of the station. The results are displayed for the user's evaluation. If needed, the simulation/analysis process is repeated, with input data modified. Usually, a few variants are evaluated, and the best is selected.

The software is interactive, with a simplified user's interface. The necessary data are introduced by the user and/or automatically extracted from the two associated data banks. Other elements needed for engineering analyses, such as propagation data, minimum usable field-strength, protection ratios etc., are incorporated in the software. These are taken from the relevant CCIR texts [2]. The results of simulation are presented in a graphical form. Relevant colour diagrams and maps are displayed in various "windows" on the screen. Depending on the user's selection, the maps can be presented in various scales. The results can also be written into computer files for further reviewing, processing, or printing. The micro- computer version of the software works with a personal computer (IBM AT compatible) with a mathematical co-processor, 1 MB RAM, EGA (or VGA) graphic card, and 30 MB hard disk.

The specific tasks performed by the software include, among others, the following [1], [4]:

- terrain-profile analysis;
- line-of-sight coverage analysis;
- propagation analysis;
- frequency channel analysis;
- interference analysis.

**Terrain data bank**

The software uses detailed geographic data stored in a digital terrain data bank. The bank contains information about the actual terrain heights, coverage, etc. The basic data are the terrain elevations extracted from the 1:50.000 source map with a 20m elevation increment between adjacent contours. The elevations have been determined at the nodal points of a regular grid, approximately 250m x 250m. For flat regions, the distance between the points is 500m. The regular structure allows for quick access to the data by its address, derived from the geographical coordinates. The heights are grouped in files, each file (about 260 kB in size) representing a geographic rectangle of 1 degree latitude and 1 degree longitude.

Additional geographic data contain the extreme terrain heights at specific points (mountain peaks, hill tops), and information about the built-up areas, forests, lakes, country borders, roads, and rivers.

**Transmitter data bank**

All technical and administrative information about existing or planned stations which needs to be taken into account is incorporated in the transmitter data base. The technical data include the geographic coordinates, frequency channels, offset, polarization, and power radiated at various azimuths. The administrative data, consistent with IFRB standards, include the country symbol, name, and status of the station. Three possibilities are foreseen. Firstly, existing stations must remain intact. Secondly, non-existing stations which are already coordinated, notified, and included in an approved plan should not be changed, except for minor modifications. Lastly, newly-proposed stations are unrestricted and can undergo any changes.

Access to information is possible by indicating the name of the transmitting station, its frequency channel, or its location. The transmitter data can be added, modified, or deleted, as appropriate.

**Terrain profiles**

Predictions of the wanted-signal, interference, etc., require that terrain elevation profiles be analyzed. Such profiles are automatically generated, given



the transmitter and receiver locations. To facilitate the task, two cursors on the map are provided, representing the transmitter and receiver, respectively.

The terrain profile is produced along the great-circle path connecting the transmitting and receiving antennas. To accelerate computations, the path is approximated by a number of straight lines. The coordinates of 400 uniformly-spaced points along the path are generated, and terrain heights are determined there. For points not included in the terrain data base, linear interpolation between the nearest data-base points is applied. The effective Earth's radius is introduced, to allow for the tropospheric refraction of electromagnetic waves. The terrain profile analysis includes the determination of the terrain roughness propagation parameter "delta h", distance between the antennas, and azimuth angles at which one antenna "sees" the another.

**Line-of-sight coverage**

To fit in a new station with its geographic environment, terrain relief is analyzed. To select an appropriate position for the antennas, line-of-sight coverage maps are produced. Such maps identify "shadow" regions (with excess attenuation) and "visible" regions by different colours.

To produce a line-of-sight map, the region of interest is divided into small surface elements, each of them being represented by its central point. The position of the transmitting antenna and borders of the region to be analyzed are determined by the user. The program generates the coordinates of the receiving antenna, and moves it from one point to another over the entire region. For every position, the terrain elevation profile is produced as described earlier. The first Fresnel zone ellipse is constructed and examined for terrain obstacles, given the frequency and antenna positions. Common points of the ellipse and terrain profile are interpreted as lack of visibility.

**Propagation prediction**

The software performs propagation predictions necessary for further analyses. Propagation over the land in the VHF/UHF frequency ranges is assumed, and two propagation models are incorporated. The first one uses the actual terrain elevation profile between the transmitter and receiver. The profile is analyzed, and propagation parameters, such as horizon distances and terrain clearance angles, are determined and used for the prediction. The model is applied when the transmitter and receiver are both located on the same map being displayed.

The second model is automatically selected if either the transmitter or the receiver is outside the current map. Instead of the actual terrain profile, it uses the terrain roughness parameter "delta h". Numerical values of that parameter are pre-computed for the whole country and incorporated in the program.

The field strength is determined for 1%, 10% and 50% of the time. The 10% value relates to the potential interference allowed for auxiliary stations. For the main stations, the 1% value applies. Corrections for attenuation by forests and built-up areas are included, as appropriate.

**Frequency channel analysis**

To fit in a re-broadcast station with its signal environment, two frequency channels, mutually compatible, should be found. One channel is needed to receive the signal, and another one to re-transmit it. Ideally, the transmission channel should be free from any other signal. Moreover, its use should not interfere with the existing signal environment. In this context, stations planned at an earlier stage are considered as existing. The reception channel should contain only a single, interference-free, strong signal, the wanted one. In practice, the finding of such channels can be difficult. Special selection techniques may be required in certain cases these, however, are beyond the scope of the paper.

To facilitate the task, the software determines, channel by channel, all signals which exceed a given threshold value at a given test point. Together with the signal level, the signal source is identified. All transmitters included in the transmitter data bank can be considered. Alternatively, only the transmitters selected by the user can be taken into account. For each frequency channel, the maximum signal is displayed, together with the results of the interference analysis.

**Interference analysis**

The software facilitates further the task of channel selection by performing simplified interference analyses. SECAM D/K (VHF/UHF) systems are assumed. All signals, observed at the place selected by the user, are analyzed. When two of them are co-channel, or differ by one, four, or nine channels, a potential co-channel, adjacent-channel, local-oscillator, or image-channel interference is signalized, respectively. In addition, there may be conflicts with harmonics from receiver local-oscillators which fall within the frequency band of interest. Appropriate protection ratios are taken into account, and the minimum level of the wanted signal, required to overcome interference, is indicated.

The results of the interference and channel occupancy analyses are displayed together. This facilitates the selection of the reception and transmission channels. In critical situations, where the number of appropriate frequency channels is insufficient, only the transmitting channel is to be determined. The signal for retransmission must then be delivered via satellite or microwave link, or by cable.

**Concluding remarks**

A microcomputer engineering tool for the planning of re-broadcast TV stations has been presented. It is the first software to be submitted to the CCIR which incorporates the terrain and transmitter data banks and which combines numerical simulation with data base management. The first version of the software was developed during the 70s for use with a main-frame computer. Since that time, it has been verified, tested, modified, and finally used as a working tool. References [1] and [4]-[6] offer additional information. In 1989, the microcomputer version of the software was developed.

In an early stage of development, a comparison between the digital terrain elevation map and the source map was made [5]. The mean difference between the computer- and hand-made data was 2m, the mean-square difference was 15m. The coefficient of correlation was 0.97. The test sample contained 512 points between 400m and 1000m above sea level. Another comparison was made between the signal levels measured and predicted. The mean difference was 3 dB, the mean-square difference was 5 dB, the correlation coefficient was 0.87. The test sample contained 36 transmitter-receiver links in a hilly region.

The experience gained with the software in the planning and coordinating of re-broadcasting TV stations in hilly and mountainous regions (about 500 in total) is positive. The software was also useful for solving a few problems of local shadowing and ghost-type television interference in cities. It seems that its wider application would be possible, after appropriate modifications. We can indicate, for example, the planning of microwave links, high-power transmitters, base stations for rural telephony or for cellular mobile radio, and other VHF/UHF stations, in terrain of diversified relief.

**Acknowledgment**

The software, including data bases, has been developed, tested, and used at the Institute of Telecommunication, Wroclaw Branch (Poland). It has been offered to CCIR free of charge by the Polish Administration, under CCIR Resolution 88. Copies are available on an "as is" basis from the Director, CCIR, or directly from the Polish Administration. The first main-frame version of the software was written by W. Sega and W. Waszkis, and the microcomputer version by A. Marszalek.

**References**

[1] CCIR Handbook on Spectrum Management and Computer-Aided Techniques; ITU, Geneva, 1986 (Annex I, pages 17-19, 24-26, 34-35, 37- 39)

[2] CCIR Recommendations and Reports, Vol. V "Propagation in Non- ionized Media", Vol. XI/1 "Broadcasting Service (Television)", ITU, Geneva, 1986.

[3] Final Acts of the Regional Administrative Conference for the Planning of VHF/UHF Television Broadcasting in the African Broadcasting Area and Neighbouring Countries, Geneva, 1989.

[4] Sega W., Struzak R.G., Waszkis W., Interactive Computer Simulation System for Analysis of Television Broadcast Networks, (in Polish), Przegl. Telekom. No. 2/3, 1982, p. 35-40.

[5] Sega W., Struzak R.G., Waszkis W., Computer Prediction of VHF/UHF Transmitting Station Coverage Area; Proc. Internatl. Sympos. on EMC, Wroclaw, 17-19 Sept. 1980, p. 497-505.

[6] Struzak R.G., Radio Frequency Spectrum Management, Telecomm. Journal, Vol. 48-VII/1981, p. 410-413.

[7] Struzak R.G., Low-power TV Station Planning Using Personal Ccomputer and Terrain Data Bank; Seminar on Frequency Management and the Use of the Radio Frequency Spectrum and the Geostationary-Satellite Orbit, Geneva, 8-12 October 1990

• • •

The Author, R.G. Struzak, Head of Department, Senior Counsellor, CCIR, ITU, is responsible for Spectrum Management, Space Research, and Propagation CCIR Study Groups. Earlier, he was a Professor at the Technical University, Wroclaw, and the Head of the Institute of Telecommunication, Wroclaw Branch. Dr. Struzak is an IEEE Fellow.