International Telecommunication Union

HANDBOOK

Computer-Aided Techniques for Spectrum Management (CAT)

Radiocommunication Bureau

Edition 2005

International Telecommunication Union

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PREFACE

The present 4th edition of this Handbook – Computer Aided Techniques for Spectrum Management (CAT) is the result of substantial efforts invested by experts – volunteers that offered their excellent knowledge and experience on Spectrum Management matters in the service of the ITU constituencies.

It is intended for the use by Administrations of Member States and Sector Members as well as those individuals whose work is related to the Automated Spectrum Management processes. The Handbook consists of five (5) Chapters and eight (8) Annexes that offer basic guidelines as to the Automated Spectrum Management System and its implementation.

Description of computer techniques (Chapter 2) and spectrum management data (Chapter 3) are complemented with principles of electronic information exchange (Chapter 4) that includes a number of relevant case studies. The examples of automated spectrum management procedures conclude the core texts of the handbook (Chapter 5).

Annex 1 contains spectrum management data that, according to Recommendation ITU-R SM.667, should be used as the standard for specifying national needs for frequency assignments and notification data.

Various models of how to implement the Automated Spectrum Management and Spectrum Monitoring processes are given in Annexes 2-8.

Valery Timofeev
Director,
Radiocommunication Bureau

FOREWORD

The present Handbook on Computer Aided Techniques for Spectrum Management (CAT) should be seen as a complement to the other two ITU products on the related subject, i.e. the publication of the Handbook on National Spectrum Management (edition 2005) and Handbook on National Spectrum Monitoring (edition 2002).

The CAT first edition was published in 1983 and was subsequently updated in 1990 and 1999. Throughout this period, the topic of national spectrum management has evolved and became the central hot spot in the activities of all telecommunication administrations. This is particularly true for developing countries where dramatic development of ICT technologies and their wide application led to a heavy increase in related spectrum usage.

This has made the question of an efficient and automated spectrum management process a priority for each administration. The Group of Rapporteurs was created by ITU-R SG 1 in October 2003 in order to review the outdated texts and to prepare this new version of CAT Handbook.

It was chaired by Thomas Racine of Canada and included the Rapporteurs as follows: Roy Woolsey, United States of America (Chapter 1), Faouzi Ben Hadj Hassine and Pascal Forhan, CRIL (Chapter 2), Rob Haines, United States of America (Chapter 3), Philippe Mège, Thales (Chapter 4), Alex Pavliouk and Nikolai Vasekho, Russian Federation (Chapter 5), Thomas Racine, Canada (Annex 1) and Michel Lemaître, France (Annexes 2-8).

The key elements required for spectrum management have been reviewed and successfully updated with a view to make this publication user friendly. The user-reader may find basic material and numerous models for the efficient implementation of Automated Spectrum Management projects that may assist him/her in reaching the objective – implement Automated Spectrum Management as soon as possible.

Thomas Racine

Chairman, CAT Rapporteurs Group

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CHAPTER 1

INTRODUCTION

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1.1 Background

The use of computers in the spectrum management process has become crucial for most administrations that are faced with the ever-increasing use of the radio frequencies. Several aspects of this process, such as frequency coordination, administrative procedures (registration and issuing of licences) and notifications of assignments to the ITU according to the Radio Regulations, are crucial in the establishment of a computer-automated process. The first aspect to be considered is the establishment of a national body and associated regulations.

Recognition of these needs by the administrations led WARC-79 to approve Recommendation No. 31 that, followed by CCIR Decision 27-2, specified that a Handbook on “Spectrum Management and Computer-Aided Techniques” should be prepared and revised periodically. The first edition of this Handbook was produced in 1983 and revised twice (1986 and 1990). It was later recognized that, due to the complexity of the two subjects and the fact that spectrum management organization and associated computer-aided techniques were different disciplines, they should be dealt with in two separate Handbooks. As a consequence, decisions were taken in this respect by Radiocommunication Study Group 1. Based on these decisions and on the guidance established by Resolution ITU-R 12, the Handbook on National Spectrum Management was published in 1995 and updated in 2005 with emphasis on organizational and technical aspects rather than those related to the use of computers. This Handbook on Computer-Aided Techniques for Spectrum Management, originally published in 1999 and now revised, supplements the above-mentioned Handbook and offers state-of-the-art views on the possibilities of automation of various aspects of the spectrum management process. In general, the Handbook on National Spectrum Management provides only an introduction to automation, whereas this Handbook is much more detailed and provides substantial advice as to how to automate spectrum management operations.

1.2 When automation of the spectrum management process is needed

The first question that is raised when automation of the spectrum management process of a country is considered must be: “Is it really needed?”. The definitive answer in every case is “Yes”. However, if an automated spectrum management system is not properly designed, it could be a burden rather than a solution to an administration.

For any automated spectrum management system to be successful, several areas need to be addressed and clearly articulated by the administration proposing such a project. The areas that should be considered and the questions that should be answered include:

– Existence of a regulatory infrastructure for spectrum management. This means that a spectrum management authority and its supporting units are in place and effectively operating. These include, but are not limited to, legislation, regulations and operational policies and procedures.

– Definition of scope and project objectives for applying a computer-aided spectrum management system. Why is automation being considered? Have new directives been issued requiring that resources be redirected to other functions within the administration's mandate? Is automation seen as a tool for coping with an increasing workload? What portions of processes or tasks within each spectrum management unit are to be considered for automation? Are some manual processes better left untouched?

– Determination of available internal and external resource allocations. An assessment must be made as to what financial and human resources will be required and dedicated to the project. Also, will it be necessary to obtain special funding authority?

– How is the system to be developed or implemented, by in-house resources, by contract, by purchasing available software, or by a combination of these? Does the administration possess the necessary regulatory and technical experts or will it require assistance?

– What limits or boundaries, if any, are to be imposed in automation development? Will the magnitude of the project dictate its development over many phases or years?

– Development of work plans and schedules showing project phases, tasks and status reporting milestones. The use of any graphical illustrations, such as Gantt charts, for the work plan and scheduling should be considered.

– Definition of user specifications. Needs and requirements of the end users must be clearly defined to ensure their proper translation to detailed design specifications. The scope of the spectrum management functions that should be automated and the extent to which each will be automated must be clearly defined. Any contract to be awarded must contain a clear and comprehensive statement of work.

– Identification of operational requirements. Each task or activity contains its own operational requirements that must be easily interpreted into a sequence of steps such as flow charts or pseudo codes.

– Establishment of functional and technical specifications. These specifications chart out the development of the system and are the basis of the detailed design.

– Availability of organizational and procedural documentation of existing systems and operations. System developers will need access to this documentation as they will invariably need to become themselves quasi-regulatory/technical experts before the translation of existing operations and procedures can begin.

– If contractors are to be considered, their performance history must be examined. Does the contractor have the requisite skilled or experienced system developers to see the project through to completion and implementation? Previously delivered contracts should be reviewed to determine or assess any related experience that can be applied to the proposed contract.

The items listed above are for the guidance of an administration in considering the decisions on the establishment, design, development and implementation of a computerized spectrum management system.

1.3 The benefits of automation of the spectrum management process

Computer-aided techniques have become commonplace in administrations in order for them to be able to manage data and to perform the necessary analytical studies associated with spectrum management. Furthermore, technological developments have led to the continuous reduction in the cost of computer systems, in particular of powerful microcomputers, thus making the application of computer-aided techniques to spectrum management a practical solution.

To maximize the benefits of the introduction of computer-aided solutions for spectrum management, the first step should be to evaluate the application of computer systems to a specific spectrum management situation. The various types of existing computer hardware and software available should be analysed. Their use should be embedded in a clearly defined structure with well-defined functions of national spectrum management.

Once this is done, administrations may benefit from such an integrated system through timeliness and effectiveness of the following tasks:

– verification of the compliance of frequency assignment requests with the national and international table of frequency allocations and their associated footnotes;

– verification that a set of equipment (transmitter, receiver and antenna) proposed to be used in a certain radio link has previously been submitted and passed the appropriate certification process or meets other mutual recognition agreement standards;

– more accurate and optimized response to frequency assignment requests, through the selection of appropriate channels taking into account details such as terrain characteristics;

– automatic and decentralized on-line issue and renewal of licences with invoices (law must allow for electronic signatures);

– appropriate treatment of radio monitoring data (see ITU-R Handbook on Spectrum Monitoring (edition 2002));

– the establishment of a more expeditious and fully documented, timely billing of customers for their use of the spectrum;

– more accurate preparation and electronic submission of notification forms to be sent to ITU, in view of the automatic data validation process which can be implemented;

– the availability of electronic exchange of data between administrations or between an administration and the ITU (see Recommendation ITU-R SM.668);

– increased transparency and data availability to users inside and outside the administration.

The total number of data elements to support all these functions is rather large. The objectives of the national authority largely influence the need for many of the data elements. For example, the amount of data required to achieve meaningful and valid EMC computation grows with the state of congestion of the spectrum. They are related to the density of radiocommunication equipment in use in a country and thus to the infrastructure of the country. This can lead to hundreds of fields of data for all files according to Annex 1. However, in many cases, the required data may be reduced to a limited number of basic data elements.

The Telecommunication Development (ITU-D) and Radiocommunication (ITU-R) Sectors of the ITU have been cooperating since 1998 in a joint activity to assist developing countries with their national spectrum management functions. This activity was established by Resolution 9 of the World Telecommunication Development Conference 1998 (WTDC-98) and revised by WTDC-02. ITU-D and ITU-R established a joint group of spectrum management experts from developed and developing countries to identify the specific needs of developing countries. The work is done in stages using questionnaires, circulated to all administrations, to obtain detailed information on national spectrum practices and the use of the spectrum in frequency ranges identified as having particular interest to developing countries.

A report on the first stage of the work was published by the ITU during 2002, including a database. Among the findings from the first questionnaire was the need for assistance in setting up of computerized frequency management and monitoring systems – a need which this Handbook is intended to help address. During 2002 the joint group began its work on the second stage of the report, with an additional responsibility to complete the database of information on methods that administrations are using to calculate fees for use the spectrum. This work was completed and the report published in 2004.

Many ITU activities have been automated. The Radiocommunication Bureau's Terrestrial Analysis System (TeRaSys) and the Space Network System (SNS) are the computerized tools used by the Bureau to process the frequency assignment notices submitted by administrations. The systems also maintain the Master International Frequency Register, as well as the frequency assignment Plans. This data is available in a number of formats, including DVD. The data is thus readily available in the defined format for national use for enquiries or in a database. Also available in electronic form every two weeks is the International Frequency Information Circular (BR IFIC) with information on notified and recorded terrestrial and space assignments on DVD.

1.4 Steps to acquire automation of spectrum management

The transition from a manual or semi-manual spectrum management operation to a computerized one involves many considerations. Several factors should be taken into account before starting the transition to an automated system:

– there is an infrastructure that should be analysed, planned and carried out before starting an automated system. Some of the steps required for this planning are: a study of the methods that can be used to adapt established manual procedures to an automated system, including the possible acceptance of the new procedures by users; training of the core of specialized staff for carrying out the automated task; consideration of the source of funds required for automation; and consideration and analysis of the level of data to be made available to the automated system;

– the changeover from a manual to an automated process will initially create new types of challenges and requirements;

– the initial period of system development and implementation may be costly. The user should realise that it requires time before he can receive all the advantages and financial benefits of an automated system.

Each administration uses a unique set of documents (licences, application forms, allocation plans, invoices, etc.) in its spectrum management operations. These documents may be in paper or electronic form. In order to effectively transition to an automated spectrum management system, it is absolutely essential that these existing documents be considered carefully in order to meet the specific needs of the administration for spectrum management and to provide the requested output formats. A successful transition between the existing and the newly implemented automated system is critically dependent on the scheduling of the transition period and the effort invested in meeting these specific requirements and converting the necessary documents for use by the new system. These requirements should form part of the contractual framework for the necessary partnership between the administration and the contractor so important for a successful implementation.

Annex 1 of the 2002 ITU Handbook on Spectrum Monitoring provides a discussion of the procurement process for acquiring a spectrum monitoring system, but much of the discussion also applies to acquiring automated spectrum management systems. That annex discusses topics to be considered before issuing a tender, including planning a system and developing its specifications. It includes an outline of a representative tender document, and suggests requirements for site surveys, training, maintenance, documentation, and system acceptance – all of which are steps in the process of acquiring automation for spectrum management activities.

Formal project management is very important to the successful acquisition or development of an administration's automated spectrum management project. Project management establishes a work breakdown structure, which serves to decompose a project into essential work packages and cost components. Project management also divides a project into several sequential phases, which may include establishment of the project and selection of the project manager, establishment of the system concept, development of system specifications, implementation of the project, acceptance testing and project operation. Successful project management maximizes the chance of the success of the acquisition or development of an automated spectrum management capability.

In any tender process, it is recommended that the administration provide access to potential contractors to the input and output requirements and other appropriate information, so that the transition effort may be properly estimated and provided for in their offer. The administration should also properly estimate and ensure the availability of its own personnel required as a part of the transition effort. This will allow for a more stringent evaluation of the contractor's capabilities as well as make any guarantees more enforceable.

Many contractual problems have occurred in such projects in the past. Arguments over contractual provisions only leave both parties with bad feelings. It is best to design a transition process that recognizes the significant effort needed by all parties to ensure the process works smoothly. Finger pointing breakdowns do little to move the parties towards a successful conclusion. For these reasons, it is important to adhere to a formal process to document the existing data collection processes and data sources as follows:

– Identify the type and format of all existing data, including operational and management data, such as general administrative data (department, region codes, fee rules, workflow steps, types of licences, types of equipment certificates, types of holders, etc.) as well as general technical data (types of services, types of stations, types of equipment, types of mobiles, frequency plans, protection ratios, off-channel rejection curves, etc.).

– Define a detailed strategy to migrate the existing data including a list of the data to be migrated, the format and timetable for delivery of the data by the administration, the timetable for conversion of the data by the contractor, the tests that will be used to verify that the conversion process has been successful and complete.

This shared responsibility should form part of the contracting agreement to avoid misunderstandings. Contract documents should outline the work to be carried out, the timing of this work and the nature of the responsibilities attributed to each party. The basic data and the operational data will have been defined, the data will be collected in the proper format by the administration, and will be provided to the contractor at the beginning of the transition period. The data provided by the administration should be valid and redundancies should be eliminated. The data from any manual records is often transcribed into an intermediate electronic format. This data can then be integrated into the new system, using scripts provided by the contractor, in compliance with the requirements document.

During the data migration process, the administration must rigidly note any modifications made to the original data provided to the contractor, since these changes will not be made by the contractor in the migration. The administration will need to use the new system to input these modifications, once the data has been successfully migrated and verified. The process works most effectively if the partnership of the administration and the contractor is well understood and adhered to by all parties.

While many functions of the spectrum management process can be automated, many cannot be automated. As an administration considers automation of its processes, it should expect the following facilities from automation:

– A system to facilitate processing of applications and licences.

– An accounting system to administer fee collection.

– Engineering analysis tools to allow analysis to avoid interference.

– Geographic maps and a geographic information system.

– A readily available and straightforward interface to spectrum monitoring facilities.

For more details on facilities to be automated, see Recommendation ITU-R SM.1370.

A regulatory agency should not expect the following facilities from automation:

– Automatic assignment of frequencies.

– Automated frequency-site planning.

– Quality of service of cellular or broadcasting systems.

There are different ways to approach automation of spectrum management. A national spectrum management operation can be automated all at once, or just certain parts of an operation can be automated. Modularity is a very important consideration. Since spectrum management is ever growing and ever expanding, because of population growth and technological advances that give rise to new uses of the radio spectrum, a system needs to be expandable, flexible and modular so that it can grow as required over time.

The financial aspects of automating spectrum management must be considered by a regulatory agency. Automation costs money, and an administration must consider its requirements and the cost of satisfying these requirements. An administration should only acquire what it can afford. If it can only afford a limited initial capability, it should incrementally acquire its automated capability and ensure that the system is modular and can be easily expanded.

A regulatory agency should also consider the fact that spectrum management can be a source of self-financing for automation; specifically, fees for licences and renewals and fines for violations are a source of revenue that can fund the acquisition of automation of spectrum management procedures. Chapter 6 of the Handbook on National Spectrum Management (edition 2005) provides more detail on the economics of spectrum management.

1.5 Training and maintenance

Training is essential for any personnel who perform functions of spectrum management which are automated. Spectrum managers should be proficient in the use of computers, or they must be trained as computer users. Spectrum managers need to be trained on any newly automated functions in their operation. This training is best accomplished by relatively short courses, so that trainees are not required to absorb too much information at one time. Training is further accomplished by on-the-job training, and by help functions in the automated capabilities. Any automated capability should have context-sensitive help, so that when a spectrum manager is working with one screen or window in the system, the manager can immediately obtain help for that screen by pushing a help key. Further information on training is provided in § 2.8.3 of the Handbook on Spectrum Monitoring (edition 2002), and Annex 1 of the Handbook on National Spectrum Management (edition 2005).

Maintenance of an automated system is greatly facilitated by the ability of a computerized system to include built-in test equipment (BITE) and to be able to perform self-tests of its operation to detect faults or failures, and display on computer monitor information about any problem. Any newly acquired system should include comprehensive BITE as an aid to corrective maintenance.

Preventive maintenance should be performed for hardware and software according to a regular schedule. Filters may need to be cleaned and replaced. Operating system software should be updated with releases to correct system vulnerabilities, and anti-virus software must be kept current. Further information on maintenance, calibration and repair is provided in § 2.7 of the Handbook on Spectrum Monitoring (edition 2002).

1.6 ITU-R Recommendations and Handbooks

The following is a list of ITU Recommendations, Handbooks and other relevant references. This Handbook attempts to avoid extensive or detailed duplication of information readily available elsewhere, so these references should be consulted for further information regarding topics covered in this text. In every case, the latest edition of the Recommendation should be used.

There are several ITU-R Recommendations and other Handbooks which are important for automation of spectrum management:

Recommendation ITU-R SM.1370 – Design guidelines for developing advanced automated spectrum management systems. This Recommendation takes into account Recommendations ITU-R SM.1047 and ITU-R SM.1413 (RDD) and provides guidelines including:

- Operational requirements
  - Applications processing
  - Frequency allocation plan/channel processing
  - Licensing processing
  - Fee processing
  - Report processing

  - Complaint processing
  - Reference tables processing
  - Security processing
  - Transaction processing
- Record keeping requirements
- Engineering requirements
- Border coordination
- Licensing fees and fee collection
- Monitoring
- Equipment approval process
- Report generation
- User interface
- Data processing requirements (including hardware and software)
- Documentation.

Recommendation ITU-R SM.1537 – Automation and integration of spectrum monitoring systems with automated spectrum management.

This Recommendation notes that integrated, automated systems can process large amounts of information and measurements and draw to the attention of monitoring service operators that data which need to be further analysed by operators, so that these systems can aid operators in their work of supporting spectrum management.

Automation, through the use of computers, modern client/server architectures and remote communications, simplifies many of the duties and responsibilities of administration of the radio spectrum. Computerized equipment provides a means to perform mundane repetitive tasks rapidly and accurately, freeing service personnel for more demanding tasks. The use of databases and computer modelling streamlines spectrum management functions and can help prevent interference. Coupling of spectrum management and spectrum monitoring makes possible an integrated system, which can automatically use measured data from the monitoring system and licence information from the management database to detect unlicensed transmissions and other licensing violations; thus the integrated system can perform automatic violation detection.

A complete integrated computerized national spectrum management and monitoring system relies on one or more data servers within a network so that workstations or clients throughout the system can access the database. Management system servers include a main server and, occasionally, one or more servers for a database extracted from the main database, and/or a database dedicated to an application or at a local command centre. Each monitoring station, whether fixed or mobile, has a measurement server and one or more workstations. Each station uses a modular architecture based on server and workstation computers interconnected via Ethernet local area network (LAN). All stations are linked over a wide area network (WAN). This fully integrated network should provide rapid access by any operator position to any of the server functions available in the system.

Handbook on National Spectrum Management (edition 2005)

Chapter 1 of the Handbook – Spectrum Management Fundamentals – gives guidelines and discusses fundamental processes for effective management of the spectrum resource. Each administration will manage the spectrum differently, but these fundamental elements are essential to all approaches.

The others Chapters are: Spectrum Planning; Frequency Assignment and Licensing; Spectrum Monitoring, Spectrum Inspection and Investigation (with reference to ITU-R Spectrum Monitoring Handbook (edition 2002)); Spectrum Engineering Practices; Spectrum Economics (with reference to Report ITU-R SM.2012); Automation for Spectrum Management Activities which gives in Annexes examples of automated systems (case studies): WinBASMS of ITU, Venezuela, Central and Eastern Europe, Turkey, Peru; Spectrum Use and Spectrum Management Information available on the ITU-R Website. Annex 1 is Spectrum Management Training and Annex 2 gives the Best Practices for National Spectrum Management.

Handbook on Spectrum Monitoring (edition 2002)

The Handbook serves as a comprehensive reference on spectrum monitoring. Content of some of the key Chapters is as follows: Chapter 1 gives a brief overview of the spectrum management process and the role of spectrum monitoring as a key function in spectrum management. Chapter 2, § 2.3 describes the management information system consisting of database and associated reporting system. Chapter 3, § 3.4 discusses the importance of automated, multi-channel direction finders. Chapter 3, § 3.6 discusses automation of monitoring. Chapter 4 provides more detail on parameter measurements.

In addition the following ITU-R Recommendations and documentation may be consulted:

Recommendation ITU-R SM.667:	National spectrum management data
Recommendation ITU-R SM.668:	Electronic exchange of information for spectrum management purposes
Recommendation ITU-R SM.1048:	Design guidelines for a basic automated spectrum management system (BASMS)
Recommendation ITU-R SM.182:	Automatic monitoring of occupancy of the radio-frequency spectrum
Recommendation ITU-R SM.1047:	National spectrum management
Recommendation ITU-R SM.1413:	Radiocommunication Data Dictionary for notification and coordination purposes
Recommendation ITU-R SM.1604:	Guidelines for an upgraded spectrum management system for developing countries

ITU-R Catalogue of Software for Radio Spectrum Management, August 2002, Geneva.

1.7 Organization of the Handbook

The following Chapters of the Handbook describe in detail the areas of computer techniques, spectrum management data, computer communications and automated techniques for spectrum management. The work is organized as follows:

Chapter 2 – Computer techniques. This Chapter discusses background information on computer hardware, software, networking and implementation of automation techniques. It further addresses security matters as well as related services such as project management, training, maintenance and documentation. The Chapter concludes with a discussion on guidelines for choosing a computerized spectrum management system.

Chapter 3 – Spectrum management data. This Chapter provides information regarding spectrum management data, including quality assurance, as well as guidance on the spectrum management database and database management systems.

Chapter 4 – Electronic exchange of information for spectrum management. This Chapter discusses the various methods of data transport, both electronic and non-electronic, and then considers issues in systems implementation, including providing case studies of information exchange.

Chapter 5 – Examples of automation for spectrum management procedures. This Chapter provides examples of spectrum management procedures that can be automated, including computer-aided selection of frequencies, propagation analysis, equipment characteristics, and coordination distance calculations. The Chapter discusses the advantages of integrated systems.

Annexes – Annex 1 provides detailed tables of data elements. The other Annexes provide summaries of automated spectrum management systems which are commercially available, focusing on the spectrum management functions which can be automated. The listing of these systems in these annexes does not necessarily constitute a recommendation for their use.

CHAPTER 2

COMPUTER TECHNIQUES

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2.1 Introduction

The purpose of this Chapter is to present the different options available for administrations wishing to use computer systems for spectrum management.

This Chapter gives some definitions related to computer systems, as well as information related to computer systems security.

At the end of this Chapter, guidelines are given to assist administrations to choose computer systems designed for required spectrum management tasks.

2.2 Elements

This section describes system elements for readers not acquainted with computer language.

2.2.1 Hardware

Computer system hardware consists of several physical elements, such as central processing unit, memory unit (RAM), data storage devices, communication devices, input and output devices such as hard disk (HD), digital audio tape (DAT), CD-ROMs and digital video disk (DVD), etc. Together, these elements constitute a computer or a computer platform and its peripherals. Peripherals may extend to printers, plotters, scanners, etc.

The list of definitions is not intended to be exhaustive. It constitutes a basic guideline for the choice of a computer system.

2.2.1.1 Processors

The categorization of computers is usually based on the characteristics of the central processing unit, the main memory unit, architecture and operating system software. The central processing unit (CPU) controls the operation of the computer by interpreting the instructions of a program and directing the actions of the other elements. It also performs the arithmetic and logical operations of the machine.

Two main types of processors are available: CISC (Complex Instruction Set Chip) processors and RISC (Reduced Instruction Set Chip) processors. They are not used in the same type of computers. CISC processors are mainly used in IBM compatible PC computers based on LINUX or Microsoft operating systems. They may be used as stand alone computers, servers and workstations. RISC processors are mainly used in servers or workstations based on UNIX operating system. The two types are equivalent in quality and power. CISC processors operate at higher frequencies than RISC processors, but the faster CISC processors are equivalent to the faster RISC ones.

The processor is related to the computer main board, also known as motherboard, which comprises the circuit integration between the computer system components, and usually includes controllers, semaphores and timing of the communication between those different components, such as memory, processors, storage devices, and input/output devices. It may also include power supply and management capabilities.

Server: a computer whose main function is to provide some service to other computers in the network; these could include data, calculation or application; or might be gateway services to external communications networks.

Workstation: a computer, often more powerful than a PC, that provides multiple functions but usually includes specialized hardware for display or calculation purposes (such as 3D computer-aided design).

PC: a computer that is multi-purpose and has basic display and calculation capabilities.

2.2.1.2 Memory

Memory is one of the most critical elements for computer performance. The main memory stores the instructions of a program, as well as data to be immediately acted upon. Unless saved beforehand, this data is lost when the computer is shut down. The memory works at a specified frequency. This frequency measures the speed of the memory access time.

A good system has a large memory capacity working at a high frequency.

2.2.1.3 Data storage devices

These types of devices cover all the storage devices such as CD, DVD, floppy disk, hard disk, tape cartridges or memory sticks. These devices are designed to save and keep data even when the computer system is shut down. In addition, some of these devices can be transported from one computer to another.

Each actual computer has at least one hard disk and one CD or DVD device. Most of these devices have read/write capabilities (not read only).

These devices have different costs and different storage capacities. Access time and price of the media may also be a selection criterion.

2.2.1.4 Communications devices

These types of devices cover all communication devices such as network cards, modems, routers, hubs, etc. allowing a computer system to communicate through a network to other computers, work stations and servers, including to other networks through the Internet.

These devices are either integrated into the computer or connected to it as external components through wired or wireless means.

2.2.1.5 Input/output devices

The input and output devices are those devices used to allow the user to provide instruction and data input to the computer and to receive results from the computer. Theses devices cover equipment such as printers, terminals, plotters, scanners, mice and keyboards.

2.2.2 Software

The sequence of instructions followed by the computer in performing a specific task is called a "program". An integrated collection of programs that performs a specific activity is called a "system". The generic name of all systems is "Software". In a more general sense, software also includes operating manuals and other documentation, user training and equipment servicing. It is desirable for some components of the software (e.g. licensing, invoicing) to be available in the national language, where practical.

2.2.2.1 Operating system

The operating system is an integrated collection of programs that manages the resources of the computer. It accepts specifications of the jobs to be executed, allocates resources to obtain efficiency of hardware resources and time, and executes the jobs. Its primary purpose is to control the processing of work done by the computer.

For IBM PC compatible computers, the popular operating systems available are Microsoft Windows and Linux. For Apple computers, the operating system is designed by the manufacturer (the current name is Mac OS). Large workstations and servers generally use operating systems such as UNIX with its different “flavours” dependant on the hardware manufacturer, as well as Microsoft Windows and Linux.

In order to allow the operating system to recognize a given device, a specific program, called a driver, is required. Usually, the device manufacturer provides the appropriate device driver. However, for the common ones, the operating system already includes the driver. The purpose of the device driver is to provide for the unique communication requirements to move data between a peripheral device and the standard communication bus of the computer.

2.2.2.2 Applications

Programs which are running under the operating system and featuring a user interface are commonly named applications.

2.2.3 Networking

Several systems may communicate through networks of different types, configurations and sizes. They may be connected through a LAN if located in one site, or through a WAN.

Different networking configurations and architectures are available, such as client/server, terminal/server, Web server, application server, etc.

Systems may be interconnected using wired and/or wireless means, and communication devices. They may use private and/or public networks such as public switch telephone network (PSTN), Internet (public, intranet, extranet), wireless local loop (WLL), etc. with different communications protocols and layers.

The most common protocol used to move data in a network is the transmission control protocol (TCP). This protocol is often linked with the IP protocol (TCP/IP). The TCP protocol takes the message and breaks it into pieces. These pieces are numbered in sequence. These pieces are transmitted across the network to the recipient and reordered, checked for missing or garbled parts (a retransmission may occur in these cases). The message is then delivered to the client.

2.2.4 Internet

The Internet is the world’s largest computer network. The Internet could originally be described as “all the networks using the Internet Protocol (IP) that cooperate to form a seamless network for their collective users”. The connection between the computers is made by routers. Most of them are operated by Internet Service Providers (ISP).

There are a number of services available to the users on the Internet. All these services can be available in a LAN, called “intranet”.

A TCP/IP network such as the Internet or any modern intranet, is a “best efforts” transmission layer, which means that the network will do its best to accomplish the requested task, but there are no guarantees. Whenever needed, the application should handle lost packets and partial transmissions, and be robust enough to allow recovery whenever the network or any specific node fails. Effectiveness can be tested by trial or simulation and must be addressed on the system specification. Another important characteristic is the efficient use of the transmission medium. Despite the evolution of the communication systems, cost is generally proportional to the bandwidth. Systems should provide efficient transmission mechanisms (e.g. compression).

One should be aware of the security concerns while using the Internet, and needs therefore to take the necessary steps and means to secure his system from intrusion and hacking.

Telnet is a service that allows a user to login remotely to an application. It allows an operator to connect from his site to another computer across the network. The application runs as if the operator was sitting at the remote computer.

The ability to transfer files to a remote computer is another service. The tool for doing this is the “File Transfer Protocol” (FTP). Different ways of storing files (binary or ASCII, compressed or uncompressed) are accommodated in FTP transfers. One can browse the files on the remote (server) computer using UNIX-like commands or embedded commands in a graphical user-friendly interface. Very large files can be transferred between computers with simple “put” and “get” commands.

Electronic mail (email) is another service provided on the Internet. The purpose of email is to send messages between users. Email is addressed to an individual, whereas telnet and ftp communicate between computers.

Another service is a direct communication between users in real-time. Two types of such communication are available: the users are connected via a server or the users are connected directly without needing to connect to a server. The first type is called Internet relay chat (IRC) and the second is called “Instant Messenger”.

Another capability on the Internet is the World Wide Web. The Web is a multi-featured capability that incorporates many of the features of telnet, ftp, and direct communication, and provides them in a user-friendly graphical program named a “browser”. This capability uses the “http” (Hyper Text Transfer Protocol) to display graphical information into a browser as “pages” and to allow the user to interact with this information by clicking on links embedded into the page allowing him to go from one page to another. This activity of navigating from one page to another is called “surfing”. Sites are available to perform worldwide searches for almost any imaginable subject.

A group of related pages located in one computer is named “site”. Every company can have a website and almost every computer user that is able to connect to the Internet has the capability to create a website. These sites can be designed to remember every user who has ever connected to the site. It is possible to design complex sites with restricted access requiring people to login with a password.

Web access is one of the fastest growing Internet activities. It is also a major tool to increase the efficiency of data exchange as well as the transparency of the spectrum administration. In this context, Web access and the Internet can be used, among other applications, to do the following:

– notification to the ITU;

– information access to engineers who are responsible for the design of new links and stations;

– submission of new requests and projects;

– information access to pending requests and projects submitted to the administration for analysis;

– on-line billing;

– on-line licence issue and renewal;

– public access to regulations and information about the services in operation, including monitoring data and enforcement activities.

2.3 Project management, training, maintenance and documentation

2.3.1 Project management

A formal method of project management should be considered by any administration wishing to implement an automated spectrum management system. Some reasons are:

– the project is technically complex;

– there are many constraints to be considered, especially the regulatory issues that will define limitations to the extensions to the project;

– usually the budget and time available are limited;

– several tasks and areas might be involved: LAN/WAN implementation or upgrade; servers' availability; monitoring capabilities integration; training; data acquisition and/or digitization; etc.;

– there are several functional boundaries which must be crossed: all functional areas should be involved.

Many references are available dealing with project management and the objective of this section is to highlight its main aspects. Project management training should be seriously considered before beginning the automation of spectrum management.

It is important to note that project management for this type of automation initiative, is not something that can be bought in a box or can be left to others. All managers involved, either contractors or spectrum administrators should have the required knowledge and skills to lead such projects.

2.3.1.1 Work breakdown structure

Work breakdown structure (WBS) is a way of decomposing a project into its essential work packages and cost components, such as hardware, software, services, documentation, human resources, testing, delivery, installation, etc.

The WBS can be used to assign task responsibilities, track project costs, scheduling and project control.

Such a mechanism is not easily created but once it has been completed, one should be able to have a better understanding of the project, its main constraints in terms of resources, either human, money or time, and be able to act proactively to address issues as soon as they are detected.

2.3.1.2 Project phases

Usually a large project can be better understood and executed when it is divided into phases. A general division is presented as follows:

– Project Initiation and Project Manager Selection

– Concept

– Development

– Implementation

– Operation.

In considering an automation process, the last period must be viewed as a stabilization period, when the solution must be operationally tested and any lessons understood in order to define further development needed and new projects for added functionality.

2.3.2 Training

Training is critical for a successful system implementation and operation. Training should cover all system elements and focus on operation and maintenance, rather than design.

It should consist of academic type training as well as operational training on the day-to-day use of the system. The latter may consist of technical assistance and professional support.

The introduction of automation into the daily operations of an administration often requires the implementation of new processes and procedures, and the administration personnel may need to be supported in the early stages of the system implementation.

Periodic training sessions should be organized in the form of refresher courses for the operational system users in order to accommodate system changes; and for more in-depth training of new personnel dedicated to system operations. New personnel may be trained by the experienced system users. Indeed, an untrained person needs the support of an experienced user, or preferably a training session in order to take full advantage of the system.

2.3.3 Maintenance

Availability of the main system elements in the local market as well as the availability of appropriate warranty, maintenance and support are important considerations when acquiring a system. Upgrade capabilities and related cost may also be selection criteria. Availability of technical support is an equally important criterion.

It is therefore important to ensure that supplied systems offer a reasonable warranty period (usually one year), followed by a continuous maintenance contract that ensures the operational maintainability of the system through bug correction and reasonable functional changes such as regulatory and administrative changes. Training on system releases and versions should also form part of this ongoing maintenance.

2.3.4 Documentation

Documentation is critical to software development. It is very common to omit some documentation since it is expensive to the organization and tedious for the technical personnel to produce.

It must be understood that the lack of documentation is the major long term cause of failure of any automated system, since it might impose serious difficulties for later integration and/or expansion.

The documentation is usually composed of system, operational and maintenance documentation.

The system documentation should include a complete description of all components and functions and interfaces to allow easy replacement whenever needed.

For the DBMS, a complete database model description should be available, indicating relations and dependencies of all entities defined.

If one is considering an in-house development, the system documentation process should be done on a daily basis, each new function, interface or data structure should be properly registered on the documentation database. Several specialized software to facilitate the documentation process are available and could be used to accomplish this task more easily.

If one is buying an off-the-shelf package, it is reasonable to believe that all the documentation is already available and therefore, an initial version may be provided at the very beginning of the system integration. It is important to allow further additions on the integration of the new system within the existing process.

The operational documentation consists of user manuals required to operate the system. It may be available as printed material as well as context sensitive help, tutorials, knowledge base, and formal manuals that are designed to provide the end user with all the knowledge needed to make the best use of the available tools. Operational documentation normally consists of a set of reference manuals and does not contain spectrum management procedures. For instance, the assignment of a frequency depends on the specific requirements of each administration and is usually not described in the documentation.

The maintenance documentation is an extension of the system documentation that provides specific instructions about how the maintenance is carried out and logged. The content may vary according to the current maintenance contract but in general it should be complete enough so that operators have a good understanding on how to keep the system operating.

2.4 System security

Paper tools have their own risks like fire, water or losing papers. Computer tools also have risks. The purpose of this section is to present the main risks associated with computer tools.

2.4.1 Backup

A computer system and related databases may be lost at any time through fire or other risk elements. If the hardware can be replaced with only the inconvenience of re-installing all the applications and proper configuration, the database content may be definitely lost. A loss of power supply can also be destructive for the databases if the online storage media fails to save the live data. A common method to seek protection against such eventualities is to keep a copy of the databases in a location other than the location of the working databases. Most computer manufacturers and DBMS creators supply utility routines that enable the databases to be copied onto off-line storage media. Such copies should be made at regular intervals, daily or weekly, and stored at a different location. Then in the event of loss of data, recovery of the original database is simple and accurate and may be completed in a very short time. To prevent loss of the data entered into the working database between the time of the last copy and the time of the loss of the database, a log may be kept, on disk or tape, of all data entered into, or modified in, the database.

Several systems of disk information redundancy prevent disruptions of service. The most common is the RAID (redundant array of independent disks) system which prevents disk corruption and loss. An interesting feature of the RAID topology is the increase in the disk access efficiency that can have a positive impact on the general system efficiency. Several levels of RAID are available, each level having a different profile of disk access time and safety. For example: RAID 0 stripes the data between several disks which increases performance but decreases general security; RAID 1 does mirroring which increases security but has no effect on efficiency; RAID 5 stripes the data and parity information across all drives that compose the array providing efficiency increase with single drive failure recovery capability.

Another important feature of disk arrays is the hot-swap capability. This allows the replacement of any damaged disk without stopping the services. Hot-swap is also a desirable function for power supplies and other components that might be critical for the computer system operation.

2.4.2 Virus

A computer Virus is a malicious set of program instructions that are contained within a computer program and, when executed, propagates to other computer programs by modifying those programs to include the Virus instructions. A computer Virus normally performs two functions. The first function is to propagate to as many other computer programs as possible. The second function is to cause some unexpected action to occur. There is often a trigger that causes the unexpected action to occur. The trigger action can be a date, and the unexpected action does not occur before the trigger date. The trigger can be the execution of another program or any other function that the Virus programmer has instructed. One of the purposes of the trigger is to hide the Virus until the Virus has propagated to a number of other programs. Another purpose of the trigger is to cause unexpected action to occur at a time not related with the primary "infection". The unexpected action can be a relatively benign action such as displaying a message; can be malignant such as damaging or deleting programs, data files or entire directories; or the action can be destructive such as blocking the computer with no way to be able to use it further. Since a computer Virus remains hidden until the trigger event, the Virus can easily be introduced into additional computer systems. Additional computer systems can be "infected" when software is transferred between systems via communication means, networks, or exchanging media containing infected files. Computer systems attached to a computer network are particularly susceptible to be infected by computer Viruses. Some Viruses have been designed to specifically take advantage of the features provided on a computer network and to propagate to as many computer systems attached to the network as possible. Some Viruses have also been designed to specifically take advantage of security breaches included into the computer operating system to prevent detection and allow its rapid propagation. Users and system operators should minimize exposure to unknown programs and should test and remove any Virus program that is suspected to exist in a computer system. Users of computer systems attached to a computer network should be particularly careful about using unknown programs on their computer systems.

Computer "Worms" are similar to computer Viruses but do not contain a trigger. A computer Worm typically affects a computer system or a network of computer systems by consuming all the available resources (main memory and/or mass storage) of the system or network systems. Computer Worms can be specifically designed to propagate throughout a computer network. Computer Worms do not contain a trigger and it is important to recognize the presence of a Worm in the network and disconnect other computer systems from the network before the Worm can propagate to those systems. Many Worms, however, spread so quickly that it is impossible to notify other computer systems to disconnect from the network on time. Most of the time, the first infection of a Worm occurs by an infected email containing an executable file or a script file including the Worm code. Most of Worms are benign; they only consume resources without harming the computer and the data. However, some of them are very malignant and may be destructive.

A computer "Bomb" is similar to a Virus except that it does not propagate. A computer Bomb modifies the computer system to contain a trigger event. When the trigger event occurs, the computer system performs an unexpected action. The unexpected action can be relatively benign or can be seriously malignant.

Another threat in computer programs is the "Trojan Horse". This Virus is related to hacking (see § 2.4.3). The Trojan Horse is a computer program that appears to perform some desirable function but, in fact, contains a Virus, a Worm, or a Bomb, and can give access to the computer system to a foreign operator.

All these Viruses have as a principal goal to change any functional program into a Virus by replication. Computer Viruses are particularly malicious because they modify normal functional programs and files and propagate to other normal functional programs and files until the trigger event occurs. Thus, computer Viruses can quickly propagate to additional computer systems by seemingly trusted programs.

The major practices that can be used to minimize computer system exposure to a Virus are:

– Install a firewall to protect the computer system and have an up-to-date anti-Virus program installed and running with permanent detection function.

– Run only trusted programs, obtained from trusted sources.

– Do not allow anyone to upload, or run, programs, from an un-trusted source, on a computer system, unless the program has been subjected to rigorous testing that is designed to detect, neutralize and destroy computer Viruses. This type of test can be done by anti-Virus software.

– Isolate all programs of unknown origin.

– Conduct testing of suspect programs on an isolated computer. Computers used for this purpose should not be used to run other programs or be operated in a network. No computer disk used to test a suspect program should ever be used for any other purpose and should never be used on another computer system.

– Establish rigorous testing procedures, programs and regulations designed to test suspect programs for presence of viral infections and enforce regulations regarding use of the test programs and uploading of programs of unknown origin.

– Restrict access to the computer system to only those persons who require access to perform authorized tasks. These restrictions should also include other restrictions that limit the authorized user's capability to access files and to perform tasks to only that capability necessary to accomplish assigned duties.

– Do not open attached files in email from un-trusted sources.

2.4.3 Hacking

When an unauthorized person uses a computer system, especially from a distant location, this person is hacking the computer system. For manual systems, security from unauthorized access is relatively simple since it can be maintained at a high level by use of locks on the doors and files used to store documents. However, a computerized database is subject to a larger problem, especially when it is realized that some administrations may, because of economic or organizational reasons, share a computer with others users. To restrict access to the data, the software routines may be written in a way that it requires passwords to authorize access to the database and/or the programs that use that database. Passwords may also be applied to allow access to specific records in the database. Each terminal on a machine may have a unique code and the security can be extended in such a way that only specific terminals may access specified data and programs. Some terminals may also require a physical key or a magnetic badge to be inserted by a user before operation is permitted. These procedures may not be adequate for certain levels of security so that sharing is not possible.

Networked computers have the weakest security. An access to a part of a network can give access to all parts if the hacker has the necessary knowledge and passwords. Hackers use Trojan Horses to retrieve passwords sent along the network. The best way to avoid this security breach is to isolate the computer network. With this solution, no-one can access from outside the network, and only the authorized users can access the computers and the network.

A solution to prevent unauthorized access is to add to the network a specific program (which can be embedded into a router or in a computer) called a "firewall". This firewall filters all the communication and has rules to forbid access from unauthorized people. The firewall can also embed an antivirus program. The firewall is able to prevent Hacking and Virus attack.

Another solution is to use encryption. All the information sent through the network can be encrypted and only the application is able to decrypt the information. It is also possible to directly encrypt the databases to be sure that the disks are safe in case of robbery.

All these solutions can be used together to enhance the security.

For more information see the Report on ITU-WTSA (Brazil, Florianopolis, 2004) and the Report on Security of Cyberspace (ITU-D, 2005).

2.5 Guidelines for choosing a computerized system

This section will present some best practices in order to migrate from a manual spectrum management system to an automated/computerized one.

2.5.1 Analytical considerations

The implementation of a computer system often brings more benefits than the associated cost. The benefits achieved usually result from consideration of four categories:

Category 1: Improved performance of repetitive tasks: the computer can perform a calculation or provide an item of information with consistency and accuracy over and over again.

Category 2: Increased volume of repetitive tasks: the computer can usually perform a task much more quickly than a human being.

Category 3: Human beings released for discretionary tasks: human beings may better utilize their talents to work at unique problems or to work at problems requiring judgment.

Category 4: Improved control method: the computer procedures impose a type of logical approach and provide a source of information that can improve decisions or judgments made by human beings; this also permits enhanced planning for future operations.

Benefits may be tangible and measurable such as saving of manpower, saving of working and storage space, saving of materials and equipment, decreased processing time, increased workload capacity, etc., or they may be intangible such as improved management and accessibility of information, better quality of results, improved service to users, etc.

Costs usually fall into four categories:

Category 1: Hardware cost: the cost of computer systems, peripherals and communication devices.

Category 2: Software cost: the cost of analysis, design, programming and testing of the software or the cost of licences for existing software.

Category 3: Installation cost: the cost of system installation, site preparation, conversion of the existing data and training.

Category 4: Operating cost: the cost of maintaining hardware and software, rental of equipment (or amortized purchase price) and space, and the cost of additional or more specialized personnel.

2.5.2 Identification of the needs

The first phase in the migration to a computerized system is to analyse the needs according to the operational requirements. What do we really want the computer to do?

In order to complete this analysis, it is mandatory to identify each task done by the administration and point out each process. For these processes, a choice must be made between computerize the process or leave it manual. For an adequate and efficient work, all data should be digitized. Some processes can be accomplished without the intervention of a user (like create an invoice, all calculations are performed by the computer and the invoice is printed by the printer), some others need the intervention of a user to interpret or launch the calculation even when all the calculation is made by the computer (like interpreting a coverage or adjusting the thresholds for interference calculations).

In many instances, an administration wishing to implement automated spectrum management techniques will have a working experience with certain manual techniques. Such experience usually results in an organization structured along service lines; i.e., there will be a unit with experience in broadcasting, a unit with experience in mobile services, etc. This disciplinary expertise should be taken into account when the operational structure needs to operate a computerized system, and during the design of the system. An integrated system can be designed so that the database contains detailed files, with particular data elements for specific services and in a way that particular processes are used for the assignment and recording of frequencies in specific services. Such a system would also contain data files with elements and processes common to the services necessary for comprehensive management. For example, a system could contain data files pertaining to the technical characteristics of land mobile service assignments and a particular assignment process for granting licences in the land mobile service. It could also contain general files of topographic data and administrative or financial data that pertain to a number of services, including land mobile, and processes for the use and maintenance of those data. The engineers and technical personnel experienced in land mobile would continue to operate in a similar manner within the new organization. Such considerations could lower the design and implementation cost, personnel relocation and training, and could lower the risks associated with the introduction of the automated techniques. Computerized systems and associated application software are meant to be a means to assist qualified personnel in achieving their tasks faster while accomplishing more rewarding activities in an automated manner rather than automatic systems that would impose solutions or results without understanding the real reasoning behind the applied routines.

This phase documents the processes of the administration and gives a clear picture of the ways computers could be used to make improvements.

At this stage, it is possible to create specifications and functional requirements for all the requirements of the spectrum management team.

2.5.3 System design

In general, the spectrum manager will not directly design, program and implement, or maintain the automated system. These functions are usually performed by computer specialists. However, the spectrum manager does bear a great responsibility for ensuring that the functions are performed adequately. The spectrum manager must play a major role in defining the requirements an automated system should satisfy, and then must become involved continuously in the automation process. The design of the system should be reviewed to determine that it will satisfy the requirements (several iterations of the design may be necessary before a satisfactory system emerges). Realistic data for testing of the system should be provided, the sufficiency of documentation and user-training should be monitored, and the operational system should be periodically reviewed to determine areas for improvements.

It is important that the system design allows for flexible and adaptable functionality in order to facilitate its future maintenance.

2.5.4 Selecting a company for the project realization

In general, the spectrum manager does not have the resources to achieve automation and to implement a computerized system. The spectrum manager usually chooses a company to perform this task. Two possibilities are usually available.

The first one is to choose a company to develop a custom system based on specific requirements of the spectrum manager. This solution would better fit the spectrum manager's needs, but this is usually very expensive and long to implement, because the contractor company has to perform a custom development for a quite complex system. The system tuning and testing phases can be very complex and expensive.

The second solution is usually cheaper. It consists in purchasing an already developed system: "Off the Shelf". This solution may not fit every possible requirement of the spectrum manager, but it is always possible to ask for minor adjustments/customization in the software solution to meet most critical requirements.

If the amount of customization required by the administration is significant, the development and maintenance cost may become larger than the development cost of a custom system.

In any case, it is important to have a mutual (contractual) agreement between the parties for the adjustment and customization.

The main advantage of this solution is that the software purchased is proven, tested and can be demonstrated to determine if the requirements are met.

Some criteria may help better select the Contractor.

The first one is the quality of the services offered. The spectrum manager should pay attention to the quality of the procedures followed by the company to ensure that the service is adequately performed.

The second main topic is training of the personnel intended to use the computer system. The training must be long enough to cover all the parts of the system, from the basic use of the system to the most advanced activities, as well as system administration.

The third topic is warranty and post-warranty maintenance including preventive, corrective and evolving maintenance, where patches and new releases are made available. Application software must evolve to accommodate new technologies, new recommendations and regulations. This should cover as well computer platform upgrades, as computers rapidly become out of date due to fast technological improvements. It is recommended that system elements are chosen for which maintenance is easily available and reasonably affordable in the local market.

The last topic is data acquisition. This part should not be underestimated. The migration of the data from one system to another may be time consuming and great care must be given to this sensitive task. It is important to retrieve all available data and the format in which they are available. The most important element of a spectrum management system is its data. The conversion of existing data should be carefully considered in the migration to a computerized system. Methods must be designed to perform editing and validation during the data collection phase. If the existing data is in paper form, a data capture method must also be designed. One strategy is to convert the data to machine-readable form according to the existing paper format and then to use a computer program to convert to the desired format. This eliminates clerical errors in transcription and conversion, and is likely to decrease the time and costs of conversion. Where there is a large volume of existing data, more efficient entry into the new database can usually be obtained by organizing the existing data in accordance with the design of the new data files before beginning the operation. When the data is collected, the completeness of the data and its consistency must be carefully examined. Sometimes, information needed by the computer system is missing in the data collected (lost of data, data never given, etc.). This missing data must be filled in with default values initially and then completed at a later stage.

2.5.5 Selecting a computer system

The required power of the processor in a frequency management system is determined by several factors. These are the sizes and rates of transactions associated with data files, the complexity and rate of application of engineering models, and the desired response time for carrying out specified procedures. The volume factors (sizes and rates) are usually determined by an administration’s geographical size and the state of development of telecommunications usage. The frequency manager must decide upon necessary response times in order to provide a satisfactory level of service to users and the administrative authority. The level of service must be provided within appropriate budgetary constraints. Although a powerful computer can process a large amount of data or perform lengthy, complex calculations in a short period of time, a slower and less expensive computer may be able to process the required amount of data or perform the required calculations within time constraints acceptable to the manager. Increased processing time will also reduce the hardware and software costs associated with more complex data storage/access methods.

The frequency manager may be required to utilize an existing computer system that is also serving other users, or he may be required to acquire a computer system for his specific task. In the first instance he will usually have access to a large general-purpose system. These systems are capable of performing large-scale data processing and solving complex engineering problems; however, the frequency management application will be required to co-exist with the other applications on the computer system. This could cause constraints on available storage and calculation time.

Computer usage usually expands and grows after the automated system has been implemented. An automated system is usually designed to alleviate a particular problem, and it is often found that the original problem had obscured other different problems. The incremental cost of solving these new problems is often small in comparison with the benefits obtained. A computer system should be designed to permit expansion due to the automation of additional applications, as well as to accommodate the normal growth expected from existing applications. A system should be designed with excess storage capacity, about 100% for the main memory and auxiliary storage, as well as with the ability to replace input/output devices with higher speed models or to add additional input/output devices without a major system overhaul. Where possible, central processors should be selected to allow for the increase of the processor capabilities through upgrades, while maintaining software performance.

The availability of the spare parts for all parts of the computer system should be taken into account. Parts must be quickly replaced in case of failure. If required spare parts are not easily available in the local market, a failure can have significant consequences.

The cost of the consumable parts should also be taken in consideration. Ink cartridges for printers or CD-ROM or floppy disks could have very different cost schemes from one manufacturer to another. It is important to look at these costs carefully before making a final choice. These consumable parts should also be easily available.

2.5.6 Conclusions

According to the system design and the operational requirements adopted, the main guidelines for a computerized system implementation are:

– *For hardware:* to purchase fairly fast computers with adequate memory and storage space, as well as relevant peripherals.

– *For software:* to purchase the most compatible "off the shelf" product fitting with most processes of the frequency management administration, and providing for table driven parameterization allowing for easy minor customization and adjustments to more specific needs, such as monitoring system interface.

Systems acquisition should take into account performance versus operational use and related cost, as well as the familiarity of the administration personnel with the chosen technology and the availability of its main elements in the local market together with appropriate training, warranty, maintenance and support.

CHAPTER 3

SPECTRUM MANAGEMENT DATA AND DATABASE MANAGEMENT

TABLE OF CONTENTS

3.1 Introduction

The goal of using computer-aided techniques for national spectrum management is to be able to answer practical questions of national interest, such as:

– How many transmitters operate nationally in the 235-267 MHz frequency band?

– What effect would a new transmitter at a particular location be expected to have on an certain existing receiver using the same frequency?

– Whom should I contact about a suspected source of interference?

The type of questions to be answered determines the type of spectrum management information an administration must collect and maintain. If only administrative tasks are envisioned, it may only be necessary to maintain information regarding frequency assignments. In this case, only simple retrieval and manipulation of the data (such as sorting and counting) would be required, capabilities typically included in database management systems.

More likely, however, an administration will need to answer technical questions regarding, for example, levels of emissions from suspected interference sources. Effective use of the computer-aided techniques described in this Handbook requires the capability to retrieve the necessary technical data from a spectrum management database.

To control costs, administrations should carefully consider what data must be collected and maintained. Such decisions will be influenced by ITU-R requirements, as well as the requirements of regional organizations. The spectrum management databases used by various administrations may also serve as examples for administrations developing new systems.

The ITU-R maintains extensive administrative and technical data related to its various spectrum management activities, including advance publication, coordination and notification. Online sources, such as the record of ITU-R spectrum management seminars found at http://www.itu.int/ITU-R/conferences/seminars/geneva-2004/ provide detailed information on ITU-R data requirements.

This Chapter describes administrative and technical spectrum management data, as well as the organization and maintenance of that data using a database management system. Annex 1 of this Handbook lists and describes the types of data usually required to answer spectrum management questions.

3.2 Spectrum management data: Entities, properties and relationships

Data can be usefully described in terms of *entities*, *relationships* between those entities and *properties* of those entities. Entities related to spectrum management include tangible transmitters, receivers, antennas and platforms, as well as intangible frequency allocations, frequency assignments, and many others.

Entities will generally have a variety of properties of interest in spectrum management. The properties of entities may be viewed as a data table having rows for entities of a similar type and columns for the properties.

Relationships between the entities provide information such as what type of transmitter is used at a particular station. Relationships are so central to the efficient organization of data that tables of data are known as *relations* and the usual type of modern database is the *relational database*.

The cardinality of the relationship between two entities can be any of three types:

– *One-to-one:* the relationship between stations and call signs is a one-to-one relationship because a station can have only one call sign and a call sign can be assigned to only one station.

– *One-to-many:* the relationship between a license and the responsible party is a one-to-many relationship because a license can have only one responsible party, while that party may hold multiple licences.

– *Many-to-many:* the relationship between frequency bands and radio services is a many-to-many relationship because frequency bands can have multiple allocated services and services can be allocated to multiple bands.

Understanding relationships helps to avoid a major problem in data maintenance: redundancy of data, or the existence of the same data in more than one place in the database. If, for example, the mailing address of an individual holding numerous licences were to be maintained as a property of the licences, the same address would appear under each licence held by that individual. A change of address for the individual would require updating each of the affected licences, requiring unnecessary effort and possibly leading to errors. If, instead, the mailing address were properly understood as a property of the licence *holder*, the relationship between the licence and the licence holder would indicate the proper mailing address for notices related to that licence.

The following subsections describe relationships and properties pertaining to types of entities of interest in spectrum management. Some provide definitions from the *Radio Regulations* (RR) along with their corresponding margin numbers.

3.2.1 Frequencies and radio services (frequency allocations)

No. 1.16 *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.

By this definition, frequency allocations are relationships between frequency bands and services, as designated in RR Article 5. Arranged by frequency band, the allocations cover one or more of the three ITU Regions and have either a primary or a secondary status. A system of footnotes qualifies certain allocations, for example, by limiting them to specified administrations, by limiting the level of emissions, etc.

The use of "country footnotes", though discouraged by the ITU-R, indicates that many administrations have national allocations that differ somewhat from those in Article 5. Information on national allocations should be maintained in a form similar to the international allocations so that the two may be readily compared.

3.2.2 Frequency assignments and licenses

No. 1.18 *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.

No. 1.61 *station:* One or more transmitters or receivers or a combination of transmitters and receivers, including the accessory equipment, necessary at one location for carrying on a *radiocommunication service*, or the *radio astronomy service*.

The definitions indicate that frequency assignments are one-to-many relationships between stations and frequencies or frequency channels. This information is especially important because frequency assignments represent national authorization to use frequencies.

Since frequency assignments are the basis of international coordination and notification, data maintained must be consistent with ITU-R requirements. RR Appendix 4 and the Radiocommunication Data Dictionary (RDD), Recommendation ITU-R SM.1413, lists frequency assignment data generally needed for these national and international procedures. RR Articles 4, 20, 30, 30A and 30B, along with regional allotment plans, provide additional information on necessary data for frequency assignments.

In general, a one-to-many relationship exists between licences and frequency assignments. A licence has relationships with the associated frequency assignment or assignments, as well as the licence-holder.

3.2.3 Licence holders

The properties of licence holders will be exclusively or primarily administrative information, such as contact information. This information may need to be maintained securely, a capability of some database management systems.

3.2.4 Stations and equipment

The many-to-many relationship between stations and the equipment (transmitters, receivers, antennas, etc.) used at the stations is a key area in which redundancy should be avoided. While many extant data recording systems consider properties of the equipment to be properties of the frequency assignment, the entities must be kept distinct to avoid the redundancy pitfalls. Since an administration may use a particular model of transmitter (with its set of properties) at many stations, the properties should be recognized as those of the transmitter, while recognizing the relationship between multiple stations and that particular transmitter.

Handling data for antennas may be less obvious. While certain properties, such as the antenna pattern and bandwidth, may be common to all instances of a particular antenna, other properties, such as the antenna height and bearing (for directional terrestrial systems) are properties of the station.

Link budget equations indicate what properties should be included for equipment. Using the database and computer-aided techniques, the spectrum manager should be able to analytically predict signal levels that a monitoring station would measure. Properties related to the licence-holder’s authorization to use the equipment at a particular station should also be maintained.

3.2.5 Geography of the administration and the surrounding areas

For the determination of emission levels distant from a transmitter, as needed when estimating interference power levels, a rough approximation considering only path length and antenna heights will prove inadequate over most terrain. Other factors, primarily terrain, but also structures and vegetation, must be considered to refine the analysis by more accurately predicting propagation loss. This information is required not only within one's country, but also in adjacent areas to facilitate coordination of frequency assignments. Administrations may encounter difficulties obtaining terrain and other data for adjacent administrations, but less detailed, widely-available data may be sufficient for coordination.

Terrain dependent models for propagation loss require samples of terrain elevation at many points along the path to determine the dominant propagation mode and the role of multi-path propagation. Geophysical properties such as ground conductivity and permittivity will also affect the propagation statistics at some frequencies.

In data terms, elevation and geophysical properties are properties of locations (the entities) within national boundaries. Radiocommunication Study Group 3, which addresses radio wave propagation issues, has developed methods to collect and maintain such geographic data.

Building attenuation can also be a large factor in predicting signal levels, particularly in urban areas. A practical approach to inclusion of this factor is the collection of data on the density of structures as a property of geographic locations.

3.2.6 Levels of emissions (monitoring)

Many administrations routinely monitor emission levels for purposes such as ensuring operation of transmitters in conformance with national and international regulations, locating suspected sources of interference, and verifying levels of spectrum occupancy. Administrations may also participate in the International Monitoring System (List VIII of ITU-R), a cooperative group for sharing HF monitoring data. The use of monitoring is described in detail in the Handbook on Spectrum Monitoring maintained by ITU-R Working Party 1C.

Monitoring data is a record of emission levels detected at a monitoring station at a point in time. As such, it represents properties of a monitoring station. Using computer-aided techniques, an administration can compare monitoring data to emission levels estimated, based on frequency assignment data to verify the assignment data and detect unauthorized operations, in compliance with Recommendation ITU-R SM.1537.

3.2.7 Licence fee schedules

Administrations often have a schedule of fees based on properties of licences, such as the number and type of transmitters, the number of frequencies used and the transmitter power.

3.2.8 Spectrum management events

Administrations may also wish to record the occurrence of events such as:

– interference complaints filed by licence-holders,

– violations of national or international radio regulations by a licence-holder,

– inspections of stations.

3.2.9 Spectrum management data

In a database of entities, properties and relationships, the data itself is an entity with properties. The properties of the spectrum management data of interest to the ITU are described in Recommendation ITU-R SM.1413.

3.3 Data quality

The quality of decisions using computer-aided techniques demands that the available data be reliable, a great challenge to administrations. Data reliability or "quality" describes how accurately data represents some aspect of the actual electromagnetic environment.

Data can be acquired from specialized providers, such as census organizations, mapping companies, military forces or government representatives. Other data, such as station information and antenna diagrams, must be collected and maintained by the national spectrum management organization.

3.3.1 Quality of contractor data

Determining the quality of data from an outside source can be very difficult. The following general guidelines can be given whenever trying to acquire data from a third party:

– clearly specify what data is required and how accurate quantitative data must be;

– ensure that the data is recent enough for the intended application;

– explore the possibility of obtaining data maintenance services (periodic updates) from the contractor;

– use contractors who specialize in the region and the type of data requested;

– where appropriate, obtain data from those who collected it.

3.3.2 Quality of data acquisition and maintenance

An administration must also ensure the quality of data it collects as part of its spectrum management activities. Various computer-aided techniques are available to help ensure the validity of the data collected.

3.3.2.1 Data filters

Data filters take advantage of redundancy in existing information and use other techniques to help prevent and detect errors in new data. Examples include:

– *Check digits:* Identification numbers (e.g. credit card numbers) often have one or more digits appended to the number for validation. Similar validation techniques can be used to identify errors in manual data entry.

– *Redundant geographic information:* Information about the location of stations and licence-holders often contain redundancies that can be used to identify errors.

– *Selection boxes:* Whenever applicable, drop-down lists can be used to ensure valid entries. The content of the drop-down list can be determined by entries for other data elements.

3.3.2.2 Access control and historical data

Access control – ensuring that only authorized personnel can write to the database – is critical to data quality. Unauthorized editing of data can have serious consequences, such as incorrect fees charged to licence-holders.

Maintaining a simple log of all revisions to the database, indicating the substance of the change, the time of the change and the person making the revision, will also help to ensure data quality. This simple method usually is enough for most applications but is of limited value for auditing purposes. The type of log maintained will determine how it may be used. For example a simple log file will not provide information about how spectrum was used in the past.

3.4 Spectrum management databases and database management systems

3.4.1 Spectrum management databases

A spectrum management database is a collection of spectrum management data. Early spectrum management databases were simple tables in a row-column format in which the rows represented frequency assignments and the columns contained data regarding properties of the assignments. For administrations envisioning only the simplest administrative tasks, such a database could be developed using nothing more than a basic spreadsheet application.

Since entities such as, for example, maritime platforms and satellite platforms have vastly different relationships and properties, administrations are likely to find that database systems based on the relational model better fit their needs. Relational databases consist of tables in row-column format, also known as “relations”. These tables consist of rows of individual entities and columns indicating properties of the entities or relationships to other entities, described in other tables.

Some administrations may find the type of applications packaged with word processors and spreadsheets in business software adequate for their needs, though the relational capabilities of these applications are generally weak. More robust systems can be designed to meet an administration’s particular needs, though such systems are more costly.

3.4.2 Database management systems

The database management system (DBMS) is a computerized system that maintains spectrum management data and makes it available to a variety of users. A well-designed, modern database will allow easy input and modification of data and provide useful “views” of data to users without the users having to understand the details of the DBMS, such as how the required data is organized in the database. The DBMS should also be designed to minimize redundancy across the database, provide validation of data, provide security for sensitive data, provide data backup to avoid catastrophic losses in the event of system failures.

When considering the design of a database management system, an administration should consider systems used by administrations with which they must often exchange data, as well as systems used by the ITU-R.

The system design should be modular and flexible. One method of achieving a portion of this flexibility is to use table-driven functionality where the program operation can be determined by code values in the database. In this way, the system can be somewhat customized without the need for coding changes. Some examples of this are:

– Storage of screen prompts in the database so that the language of operation of the system can easily be changed.

– Storage of all user messages to facilitate the system's availability in multiple languages.

– Storage of fee parameters and fee values in tables to enable easy customization for different administrations.

A DBMS can be implemented such that files containing the reference administrative and technical parameters in a central location are replicated or "mirrored" at the user sites. This technique, while transparent to the users, improves response time.

3.4.2.1 Geographic information systems

Geographic information systems (GIS) can be integrated with the DBMS to help administrations to account for environmental effects (terrain, population, etc.) in spectrum management. They usually offer two-dimensional geographic information representation and often three-dimensional capabilities as well.

The ITU Digitized World Map (IDWM), available at www.itu.int/ITU-R/software/IDWM, includes databases for geographical (coastlines, seas, islands, lakes), political (country borders and regional boundaries), meteorological (rain and climatic zones) and technical information (ground conductivity areas, noise zones and allotment areas). The IDWM resolution, however, is only 5 km, which may not offer adequate precision for some radio services.

The IDWM is comprised of two main parts: the IDWM database and the subroutines and link libraries. The IDWM may be incorporated into the administration's spectrum management applications and used for determining and plotting, for example, satellites gain contours, elevation angles and spot beam coverage. More advanced spectrum management applications use integrated geographical information systems (GIS) for enhanced displays and better use of digitised maps. Many other mapping sources of varying capabilities, such as the GTOPO30 database and the NASA database, are available online.

The accuracy and consistency of geographical coordinates is important when using GIS applications. An administration should therefore employ a standard geodesic system, which could be any national or other widely-used system, such as the WGS84. Administrations may need to use multiple suppliers to provide all the required maps.

Data used by GIS systems is usually provided in raster or vector format. Clutter type, population density, ground conductivity, and refractivity layers are among data usually presented in raster format. Geographical and political boundaries, main rivers, roads and railways networks, and district limits are among data usually presented in vector format. GIS facilities include mechanisms for the storage and retrieval of the geographical and associated data, database maintenance tools and drivers for printers and plotters.

Usually, geographic spectrum management data, such as transmitter station locations or coverage areas, can be superimposed on the geographical data in real time. GIS manipulates data rapidly and displays maps and diagrams based on users' criteria. They are designed for use by either novice or experienced operators using a system of menus. Some use sophisticated modelling packages for particular applications, such as network coverage for broadcasting services, path profiles between desired locations, or visualization of the horizon.

3.4.3 Input to the database

An administration establishing or upgrading a national spectrum management database is probably doing so because it already has an abundance of data that it wants to manage more effectively. The significant task of initial data input can be simplified somewhat with advanced data input techniques (e.g. a graphical user interface) or by requiring licensees and equipment suppliers to provide data in an electronic form that is compatible with the database. Though administrations with only paper records will most likely need to enter data manually, those with an existing electronic data storage system should be able to use software to map the available data into the new data files, at a significant savings.

It is critical that an administration allocate sufficient resources to keep the database accurate and current. Further resources may be required to modify the database if new capabilities (such as maintenance of newly-required data) are needed.

To help maintain the accuracy of the data, validation checks should be part of the data input process. Basic validation checks flag invalid data, such as a frequency assignment application number in the wrong format or an equipment parameter outside an acceptable range, and provide an error message for the entry. More sophisticated systems could recognize, for example, incompatible equipment specified for use at a station.

3.4.4 Output from the database

Database output consists of information provided directly to the user via a query of the database, or provided to an application for use in analysis. In each case, the DBMS should be designed to give the user or application designer powerful query capabilities through an easy-to-use interface.

Though a relational database consists of tables stored in files, known as "base" tables, direct examination of these base tables would be of little use to most users. Instead, the users require "virtual" tables, known as "views", which the DBMS displays to the user to answer the user's question. As an example, a user may be asking, "What are the names and telephone numbers of all licence holders having ten or more HF licences?" The DBMS would identify the licences for HF systems based on licence and frequency assignment tables, identify the holders of those licences from the licence table, determine which licence-holders have ten or more HF licences and retrieve the names and telephone numbers from the licence-holder table. No actual table would be created based on this data, but a virtual table (view) would be displayed or printed for the user.

An administration's continued and expanding use of its spectrum management database will suggest new, unforeseen requirements for views of the data. To accommodate this need for additional views, the DBMS should recognize all valid relationships between data.

CHAPTER 4

ELECTRONIC EXCHANGE OF INFORMATION FOR SPECTRUM MANAGEMENT

TABLE OF CONTENTS

4.1 Introduction

This Chapter provides guidance to spectrum managers in organizations who want to implement or improve electronic data exchange. It considers among other things the hardware, software, data storage media, data file format and dictionary, library, security, procedures, communications networks, and the personnel required to accomplish this task.

The term "spectrum management information" includes, but is not limited to, the information which is needed to carry out the following functions:

a) portraying frequency band allocations; national frequency plan;

b) national frequency assignments and allotments;

c) licensing and billing;

d) coordinating and/or notifying frequency assignments or orbital positions;

e) monitoring spectrum activity;

f) specifying equipment/antenna/system characteristics;

g) using and transferring analytical models; and

h) accessing regulatory documents.

The process of exchanging information via electronic or computer related means and transforming that information into a suitable form for automatic processing is commonly referred to as electronic data interchange (EDI). Further, it is implied that the exchanged data will convey information that must be understood by the receiving party. For successful information exchange, both the sender and receiver must adhere to agreed standards for the conversion and transmission or transportation of the data. These standards may be human or computer-related. The former may be understood as a common cultural or technical background and is rarely explicitly formulated. The latter is standardized as a set of accepted formats.

Electronic data exchange may be facilitated in a number of ways; from the use of physical media such as diskettes, magnetic tape, CD-ROM, optical disc, to the use of electronic file transfer protocols that permit transmitting information via wirelines, fibre optic cables, or radio wave transmission media. The cost of implementation and the benefits available to administrations will depend on their existing computer facilities, their requirements, and their desired solution.

In employing an electronic system to exchange spectrum management information, a degree of efficiency and effectiveness is expected to be gained. Search and retrieval of documents or technical data are vastly improved. Response times associated with evaluating frequency coordination proposals are reduced or minimized. The time associated with the capture and submission of notification data to the Radiocommunication Bureau is also substantially reduced. These benefits permit improvements in efficiency and may result in savings in personnel time.

Electronic data exchange provides the ITU with the same benefits as administrations but on an international scale. To aid the exchange of data electronically, the ITU has established a network facility called TIES (Telecommunication Information Exchanges Service) that provides diverse telecommunication services to its Members. Within this network, the ITU has developed an electronic document database (ITUDOC), forming an integral part of the TIES computer-based electronic information services.

4.2 Transport methods

When planning to electronically exchange spectrum management information, a number of alternative transport methods may be used. The challenge facing the spectrum manager is to select one method or a combination of methods that best satisfies the requirements. Making this selection requires considering a number of factors including the estimated costs, timeliness for accomplishing the task, accuracy of the information transferred, capacity of the information transfer medium, availability and reliability of the communications medium, availability and reliability of required hardware/software, security of information and availability of trained staff to assist in the execution of the procedures and operations.

From a data storage, transmission, or processing perspective there is no difference between the data files representing spectrum management information and any other data files. Consequently, the spectrum manager should draw on the experience gained by other managers who have successfully implemented effective systems and procedures for satisfying their electronic information exchange requirements.

The discussion below presents some of the major transport methods together with some factors that should be considered in selecting the appropriate methods to use.

4.2.1 Surface mail

Surface mail is the simplest exchange of data using postal or package/courier services. The data can be held in a variety of different media (diskette, magnetic tape, CD-ROM, optical disc, etc.). For a limited number of exchanges, with a limited number of recipients this method may prove to be highly efficient and cost-effective.

When considering this method, however, consideration needs to be given to the staff time and the materials costs for copying the data to the chosen transport media, packaging, and the costs of the postal, package/courier service. In some cases, the use of third party support for performing these copying and packaging activities may be cost-effective.

The sender should be aware of the postal or package/courier services' reliability and the likely time/location of the delivery when selecting the service provider.

4.2.2 Facsimile (fax)

Facsimile (fax) is a technology which permits the transmission of images from one machine to another using the public switched telephone network (PSTN). The sending machine may be a dedicated fax machine or a PC with fax image conversion software and a fax modem. The receiving machine reproduces the original image on a printed page, or in the case of a PC based fax modem, stores it in an image file. Since an image of the entire printed page is transmitted, faxes can be used to exchange both text and graphic information.

Fax image conversion is performed to set standards and therefore PC software will not achieve any greater resolution than a dedicated fax machine. The principal advantages of PC software over a dedicated machine include:

– no manual scanning/paper feed problems;

– PCs have a larger memory than dedicated fax machines and therefore larger files can be sent to a greater number of recipients (this can however become a disadvantage if it ties up a user's PC for any significant length of time);

– the information exchanged can be stored in an image file.

4.2.3 Electronic mail (email)

Electronic mail (email) is a technology that permits a message to be transmitted between computer systems through data and/or telecommunications networks. This transfer is accomplished without any requirement for human intervention. A number of multi-featured email systems are available on the market and new products are constantly emerging. Using email services offers certain benefits over the use of surface mail and facsimile; however, the factors discussed below in the implementation and use of email systems should be considered taking into account the inter-connection(s) with a data network(s).

The system's capability for establishing a message path to intended users is a critical element of any email service. Email services available to the users connected to a LAN may be adequate for coordinating local spectrum management activities, but the use of email services to coordinate regional or international activities will require access to communications servers that can be connected either through the PSTN or a backbone network such as the Internet. While a variety of methods may be used within a given LAN or WAN to establish a "connection" between computers, the protocol used on the Internet permits message transmission in a "store and forward" manner. Information regarding local access to the PSTN may need to be obtained from the authority regulating the local telephone utilities, and information regarding local access to the Internet can be obtained by contacting the Internet Society at:

email: editor@isoc.org; World Wide Web: http://www.isoc.org.

While most email systems permit sending identical messages to multiple addresses, software (known as listservers) can be used to manage electronic mailings. Listserver software is not included in standard email installations and the installation of some multi-featured listserver software may require specialized expertise to achieve full compatibility with existing email systems. However, if a requirement exists for frequent electronic distribution to an extensive list of addressees, a listserver can be cost-effective.

4.2.4 Remote data access – Bulletin boards, WWW servers, FTP sites and "Connections"

Remote data access is a set of procedures and technologies which permits users to:

– connect their computers (local) to other computers (remote) in distant locations and view, copy, delete, revise, or execute files/programs located on the remote computer;

– transfer (upload) files between the local and remote computers.

As was noted in the previous section, email services operate as store and forward systems; consequently, the message path between computers sending and receiving email messages need not be a continuous connection. Remote data access services operate as “on-line” services; this means that a continuous connection (referred to as a “login session”) must be maintained while the user is using or exchanging data with the remote computer. Because of this need for continuous connection during login session, spectrum managers considering the use of these types of services need to examine the availability and reliability of the communications facilities (LANs, WANs, PSTN, Internet, etc.).

Various forms of remote data access services can be established using what are commonly known as “servers”. These servers are comprized of computers and specialized applications software that offer various types of services (bulletin boards, World Wide Web, FTP) to users.

4.2.5 Standards compliance

Standards are required to enable a product manufactured in one country to be compatible with similar equipment in another country. In the area of telecommunications, there are a large number of sometimes very complex standards. These standards are related to both hardware and software and are required for the use and growth of complex networks. Without these standards, data could not be transferred between the thousands of nodes in networks whose various segments may be controlled by different organizations around the world.

In June 1992, an Internet mail standard was approved (MIME). MIME is an acronym for Multipurpose Internet Mail Extensions. This standard builds on the 1982 standard with additional fields for mail message headers that permit new types of content and organization for messages. MIME allows mail messages to contain:

– multiple objects in a single message,

– text having unlimited line length or overall length,

– character sets other than ASCII,

– multi-font messages,

– binary or application specific files,

– images, audio, video, and multi-media messages.

Efficient and effective use of the electronic information exchange methods requires strict adherence to approved standards. Where the information exchanges cross national boundaries, international standards are required. When specialized data files are to be exchanged, agreements need to be established between all the intended users of this data to assure reliable retrieval of the information. Failure to use accepted standards will make the intended electronic transfer of data unreliable.

4.3 Issues in systems implementations

The introduction of data exchange by electronic means can have a major impact on an administration's procurement and computer system operations. The extent of the impact is dependent on the existing levels of computerization, the type of electronic data exchange required including the BR notification and regional agreements, the administration's security requirements, and the level of personnel skills available. All these factors must be considered as they will determine the cost effectiveness of implementing a data exchange mechanism and the level of benefits that the administration can achieve.

The starting point for the introduction of electronic data exchange must be an assessment of both the existing computer system and what the administration wants to achieve in terms of electronic data exchange. The result of the assessment analysis, combined with infrastructure considerations, will provide the administration with an overall view of how much a move to electronic data exchange will cost including training, the potential benefits and the timescale required. One factor that may emerge from the analysis could be that the proposed method of data exchange is not achievable in the short term and that a programme of controlled change over a period of, for example, 1-2 years is more practical, cost effective and manageable.

4.3.1 Existing computer facilities

An administration's existing computer facility may consist of stand alone computers, networked computers or both. Some administrations may not have a computer. Computers may have a simple operating system where the features available are largely dependent on the application software or a more powerful operating system with many intrinsic features. An administration's computers may have different operating systems or they may be located at a number of different sites within the country. The simplicity or complexity of an administration's computers or the diversity of their location is not a barrier to implementing electronic data exchange.

4.3.2 The administration's electronic data exchange requirements

The essential question for any administration implementing electronic data exchange is "What do we want to achieve?" Does the administration wish to exchange data solely with the BR, or in addition, with other administrations? Is there a requirement to exchange data with other sites in their country or in addition with foreign Web sites? Does the administration want to link the introduction of electronic data exchange of spectrum management information with the development of a networked computer facility using a LAN or WAN? Will the administration's requirements change with time?

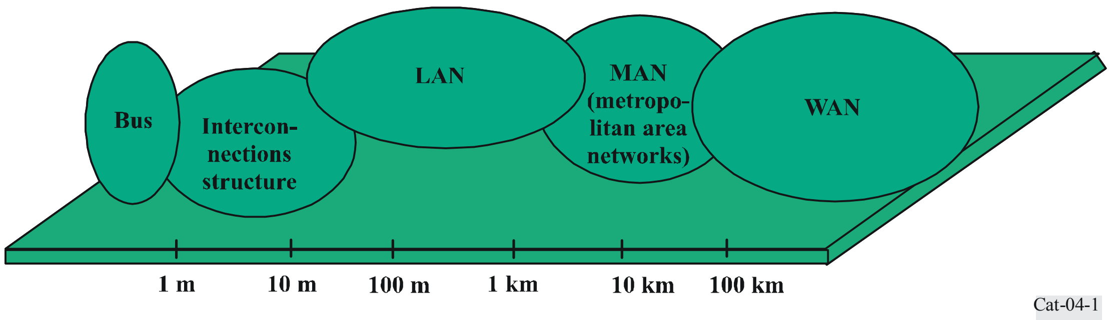
An administration's computing infrastructure will affect the implementation and operation of electronic data exchange. The extent of the impact will depend on the administration's requirements.

For electronic data exchange, it is necessary to implement in the national structure an information network allowing the files transfer from a computer to other computers, to link distant terminals to the central site, computers amongst themselves, and terminals such as workstations with servers.

Generally, five informatics network types are recognized depending on the maximum distance between the furthest points:

FIGURE 4.1

The different kinds of informatics networks



The data transfer technique used is the packet transfer: all the information is segmented (packetized) and packets are transported to the final users. The ISO Standard, adopted by ITU, defines a reference model with a 7 layer architecture, necessary for defining the functions required for the data transfer and data management. This architecture is also called Open Systems Interconnection (OSI). One difficulty involved by the packet transfer is synchronization acquisition. The packet transfer time depends of the number of packets waiting in the outgoing buffers of the nodes and the retransmissions corresponding to line errors.

For this reason, a *de facto* architecture is used, instead of packet transfer; the TCP/IP architecture, to connect networks via the Internet (information highway with other administrations including the ITU):

– IP (Internet Protocol): protocol at the packet level

– TCP (Transmission Control Protocol): protocol at the message level.

For implementation of a spectrum management network, the managers choose a network responding to their specific needs including TCP/IP. The Internet is the result of the interconnection of different physical networks by means of routers. To reach the different networks, the IP protocol is routed in the nodes. Internet is a network with packet transfer, the packets cross one or several sub-networks to reach their destinations. Each packet follows its route in an optimized way.

NOTE 1 – Internet Corporation for Assigned Names and Numbers (ICANN), a private company is responsible to manage the address space of the Internet Protocol (IP); to manage the protocol identifiers, to manage the domain name system (DNS) of the first level for generic codes (gTLD) and national codes (ccTLD) and to ensure the functional management of the root servers system. The DNS allows the users to surf the Internet: each computer linked to the Internet has a unique address named "IP address" (see www.icann.org).

The arbitration centre for the DNS is a United Nations specialized agency – WIPO (World Intellectual Property Organization) in Geneva.

Network operators must take into account the ITU-T Recommendations concerning quality of service (QoS) and particularly:

– ITU-T Recommendation G.1000 (Communications quality of service: a framework and definitions) gives a framework for QoS so as to establish a uniform approach, and improved consistency regarding QoS especially in IP-related areas.

– ITU-T Recommendation Y.1541 (Network performance objectives for IP-based services) defines classes of network QoS and specifies provisional objectives for IP network performance parameters. These classes are intended to be the basis for agreements among network providers, and between end users and their network providers

NOTE 1 – The ITU-T lead study group on QoS is Study Group 12.

– ITU-T Recommendation X.140 (General quality of service parameters for communications via public data networks) defines a set of general QoS parameters for public data networks.

The following list contains typical factors requiring consideration: the layout of the building can affect network costs; the number of sites to be connected in a country and that country's topography and national communications system, will determine the type of communications network needed; the cost of communicating via the PSTN or/and Internet varies considerably from country to country and therefore may be of primary importance to one administration and insignificant to another. Skilled personnel who understand the communications and network requirements are essential for implementing any network solution.

Moving to electronic data exchange does not require any major computing skills. However, it is essential to implement security measures appropriate to the value of the data and system (e.g. virus protection).

The following guidance will help to secure the spectrum data network:

– The system manager must control the access rights of the users for all the different elements of the system: management at the computer network level and the access to the system. This management needs to allow the definition of several access levels according to the user tasks and also the user's creation, modification, and deletion privileges.

– The manager should have the capacity to verify the network utilization of each authorized user. A data information storage and access network control system needs to be implemented to allow this supervision task.

– At the network level, it is necessary to implement up-to-date techniques to control external intrusions by means of informatics tools such as firewalls, anti-virus, etc. These tools must prevent non-authorized accesses.

– At the system level, the data has to be protected vis-à-vis operators. The authorized user, in accordance with his rights has access only a part of the global data according to his privileges. The system manager should have at his disposal the tools to define the accreditation level and the ability to grant or revoke these rights.

– The data servers should include physical data safeguard methods (such as disk redundancy using RAID techniques) as well as periodic backup on external media (back-up on magnetic tapes or to CD-ROM each night or each week). Data restoration tools must also be available with the goal of restoring the system.

– Finally, the accesses at the WAN network have to be secured and the data encryption considered.

As the electronic data exchange mechanism becomes more sophisticated then potentially more benefits accrue to the administration. However with this increase in sophistication and benefits, there is a corresponding increase in the complexity of the installation and the cost of both implementation and maintenance.

In a stand alone computer facility and with today's elaborate modern software, most users do not need to acquire computing skills beyond those necessary for using the application software. The support required to maintain these computers can therefore be provided either by the users or by specialist computer support staff. Administrations are more likely to have specialist support services if they already have either local or wide area network systems or if any of their computer systems are running some of the more powerful operating systems such as UNIX. More extensive computing facilities are also likely to have more highly developed system security arrangements. If an administration already has these facilities in place, it may be easier for them to implement more sophisticated electronic data exchange systems, since the impact on their existing computer systems operations may then be small.

4.3.3 Procurement

All administrations will have an approach to procurement, whether the selection of the hardware and software is made by specialist support staff or in collaboration with the spectrum users. Procurement can be based on standardization around a particular brand of software, hardware or on the desire for the best possible solution to meet individual work requirements. The more elaborate the electronic data exchange system becomes, the more software and hardware is needed to meet the administration's needs. However, care needs to be exercised in selecting software or hardware since not all network or communications software is necessarily compatible. There may also be additional problems with some application software and operating systems. Identifying the potential problems and successfully implementing electronic data exchange may therefore require the administration to take a pragmatic approach to procurement by selecting the best overall fit of software and hardware to meet the administrations needs. Successful implementation may also mean acquiring experience in data communications.

4.3.4 Managing change

It is necessary for administrations to consider how they will manage the transition to their required standard of electronic data exchange. If the transition is considered to be significant, the implementation of one or more pilot schemes is highly recommended (perhaps with more than one type of software) to gain experience. This approach also allows in-house personnel time to gain new skills and experience under controlled conditions, without the pressure of working on an operational system.

The selection criteria for the computer systems is very important, especially the software (both operating system and application software). Software is efficient for many reasons; speed, user-friendly interface for the programmer and end-user, customer support, etc. If software is extensively used, one can usually assume that the product works reasonably well. There is also a good probability that if additional staffing is required, trained personnel may be available if the product selected is in wide use.

4.4 Case studies

The following case studies are examples of the existing and planned use of electronic data exchange by the ITU and a number of administrations. They are intended to demonstrate both the variety of information that administrations wish to exchange and the potential benefits for administrations and the BR.

These case studies range from document exchange, which is the simplest but most common form of electronic data exchange, to the more elaborate and complex requirements of coordination.

The example in the monitoring environment perhaps best typifies the need for electronic data exchange as well as the need for international agreement on the format. This example shows how as the quantity of monitoring data collected increases, the most suitable method of handling it is for it to be directly loaded into a computer for analysis. It is also an indication of how remote automated monitoring equipment may be accessed from other distant locations.

Case Study 1: Document exchange via ITU-TIES

The ITU Telecom Information Exchange Services (TIES) is a set of networked information services and resources for the global telecommunications community. Most of these services are available via the World Wide Web. One of the main goals of TIES is to help make ITU activities, such as telecommunication standardization work, more rapid and efficient. Another goal is to make a wide range of ITU (telecommunication) information available to all interested parties. In general, ITU information is public with no need for prior registration. ITU electronic publications are available for on-line purchase or by annual subscription.

a) *TIES registered users*

Some information, such as working documents of Study Groups and contributions for treaty-making conferences may be accessed only by Government Telecommunication Administration of Member States and Sector Members. These officials are “TIES registered users”. They may access the Electronic Document Handling (EDH) services, including working documents, FTP “drop boxes” for document submission, and set up mailing lists.

Internet: helpdesk@itu.ch.

b) *TIES services*

The TIES service is a set of networked information resources and services offered by the International Telecommunication Union (ITU). The goal of TIES is to support the requirements for electronic exchange of ITU-related information by the general public and ITU Member States (189 as of 2005).

The electronic exchange of documents is of considerable importance to the BR as it offers a potential solution to the rising cost of document production and distribution. It enables contributions to be sent quickly and easily to the BR, reducing effort on the part of the contributor and giving the BR more time for processing the document. For administrations, the electronic document exchange reduces the cost of the paper copies in addition to space saving in terms of storage of paper documents.

Services	Available to
Public ITU information on the Web	– General public
Registered FTP server containing information from the ITU document store	– Government Telecommunication Administrations of Member States – Sector Members
Electronic Document Handing (EDH) Services, Study Group documents using the FTP "drop-boxes"	– Government Telecommunication Administrations of Member States – Sector Members
Conference Documents	– Government Telecommunication Administrations of Member States – Sector Members
ITU Publications including ITU-T and ITU-R Recommendations; Handbooks – ITU Publications Online – ITU Electronic Bookshop	 – General public (subscription) – General public (credit card)
Dial-up internet Services – email – FTP, WWW – Newsgroups	– Government Telecommunication Administrations of Member States – Sector Members
Web site hosting and Internet services	– Geneva-based Permanent Missions

Case Study 2: Example of electronic exchange of data concerning RR Article 11

At World Radiocommunication Conferences, the Member States develop and adopt the modifications to the Radio Regulations (RR), a set of rules and procedures that serve as a binding international treaty, governing the use of the radio-frequency spectrum (some 40 different services) in the three Regions of the world. The ITU-R Sector also acts, through its Radiocommunication Bureau (BR) as a central register of international frequency usage that includes the recording of around 1 265 000 terrestrial frequency assignments, 325 000 assignments servicing 1 400 satellite networks and 4 265 assignments related to satellite earth stations.

The BR is a specialized secretariat of the Radiocommunication Sector and applies the provisions of the RR and various regional Agreements. It records and registers frequency assignments and associated orbital characteristics of space services and is maintaining up to date the Master International Frequency Register (MIFR). In addition to the database, specialized software is developed by the BR for the purpose of facilitating the tasks involved in the application of the RR (www.itu.int/ITU-R/software/index.html). Two specific entities of BR are in charge of the application of RR provisions: Terrestrial Services Department (TSD) and Space Services Department (SSD), each Department includes a Publication and Registration Division (TPR and SPR).

Why should Member States notify frequency assignments to the BR?

Because the Member States of ITU must apply the provisions of the RR (International Treaty), it is necessary for each Member State to notify frequency assignments to BR according to RR provisions. For example, below we show the terrestrial services notification to the BR (methodology), we can also apply the space services BR methodology, using in both cases electronic exchange.

The ITU spectrum allocation mechanism and the RR already serve as a *de facto* umbrella treaty for the global harmonization of spectrum-related satellite licensing procedures. In particular, the RR are consciously constructed in a non-restrictive manner, intended to facilitate the broadest possible use of space-based orbital and spectrum resources by users in all countries, and relying on the good-faith coordination activities of administrations as the means by which maximum use of these resources is achieved.

Under this treaty, regional efforts at spectrum harmonization practices can also be particularly beneficial in ensuring that spectrum utilization is not artificially constrained by individual national regulations.

RR Article 11 and Appendix 4 give the notification and frequency assignment procedures. (No. 11.1-11.26 and No. 11.27-11.49 of RR Article 11).

Every assignment shall be notified to the BR if:

1 it could cause **harmful interference** to assignments of other Member States

2 it is used for **international communications;**

3 it is subject to **world or regional plan;**

4 it is subject to **coordination procedures** according to RR Article 9;

5 it is desired by the Member State to have an **international recognition**.

1 – 2 – 3 – 4 = OBLIGATION	5 = RIGHTS

When an assignment is not in conformity with the Table of Frequency Allocations or the other provisions of the RR, an Administration may also request its recording in the MFIR for information purposes only (this special case involves the OBLIGATION of stopping the emissions if harmful interference to other assignments recorded with favourable findings occurs.

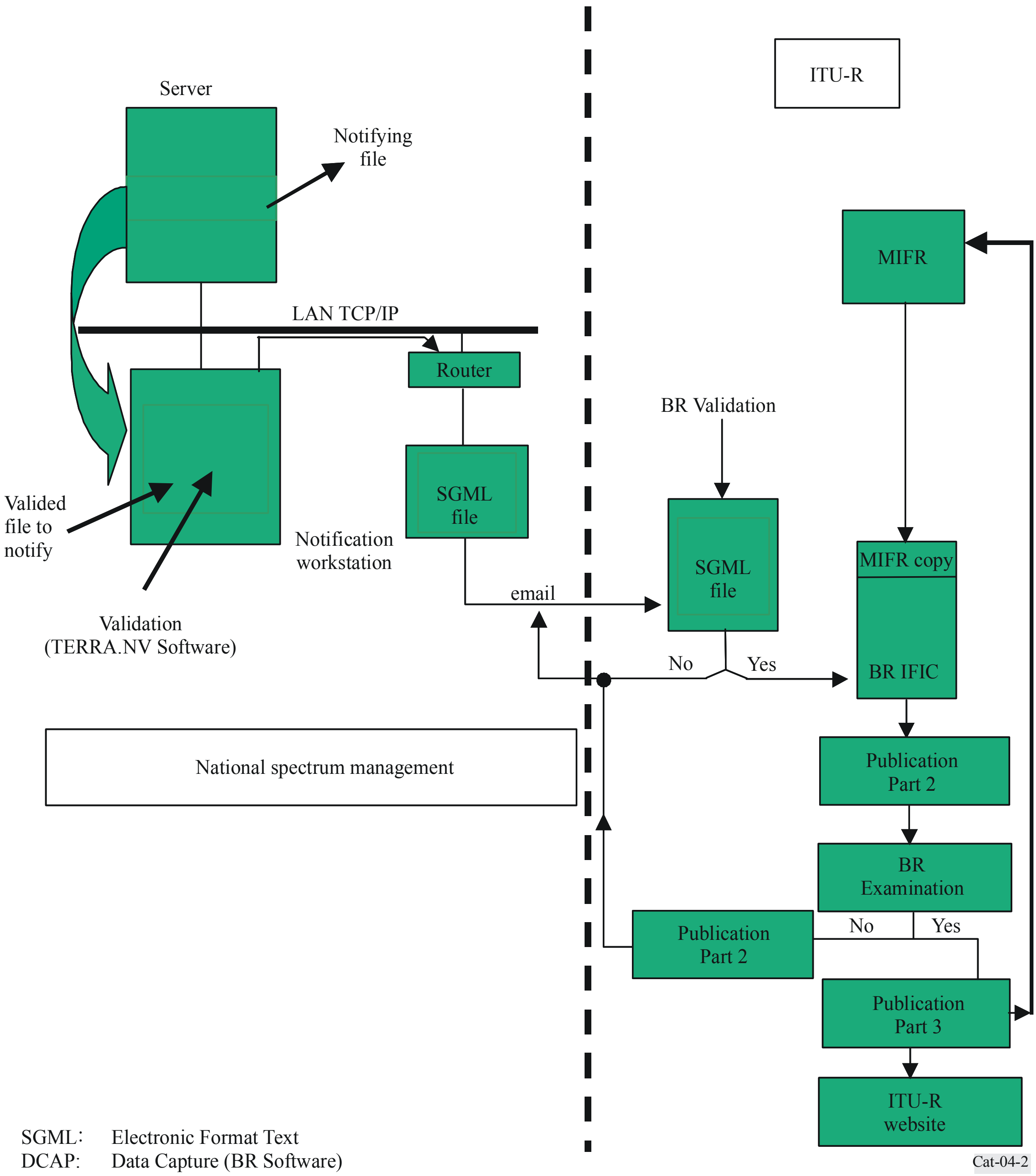
According to No. 11.17 of RR Article 11, if the Member State intends to comply with notification conditions, it sends to the BR an electronic format notification: one notice form per assignment and per station with three options to add, to modify and to suppress the assignment in the MIFR. The RR indicates cases not be notified radio amateur, ship-to-ship communications, mobile station in the aeronautical mobile service (Appendix 26 and 27), common frequencies.

Circular Letter CR/118 for fixed and mobile services, and Circular Letters CR/120, CR/123 for broadcasting services give the instructions to the Member State concerning the assignment notification in electronic format.

When an administration must or may notify after identification and selecting assignments within its national frequency management system, it should create an electronic format SGML according to the BR Data Capture software (DCAP) supplied by ITU-R, the validation of the data is given by another BR software TERRA-NV. The DCAP and TERRA-NV software are supplied free of charge by the BR (see Fig. 4.2).

FIGURE 4.2

ITU-R terrestrial notification scheme



SGML: Electronic Format Text
DCAP: Data Capture (BR Software)
MIFR: Master International Frequency Register
BR IFIC: BR International Frequency Information Circular

The administration sends to the BR its notification and the BR:

1) Receives the electronic format SGML sent by the administration and *validates* the data to ensure that they are "complete and correct".

The Bureau cannot begin processing a notification that does not contain the minimum information indicated in RR Appendix 1 and in any regional agreement that may apply. If the notification is incomplete the BR asks, by return mail, to provide the missing information; if no reply is received by a specified deadline (≈ 30 days), the notification is returned to the notifying administration.

2) Publishes the data in the bi-weekly circular (Part 1) BR IFIC which represents the Bureau's acknowledgement of receipt. The BR IFIC is disseminated free of charge to all Member States (one copy per administration on CD-ROM) (www.itu.int/ITU-R/publications/brific-ter/index.html).

The administration should check the data published to ensure that it fully matches its request.

The BR International Frequency Information Circular (Terrestrial Services) is a service document in CD-ROM format, published once every two weeks by the Radiocommunication Bureau in accordance with provision Nos. 20.2 to 20.6 and 20.15 of RR Article 20 (see Publication Notice 282-04).

The BR IFIC (Terrestrial Services) consists of the following:

– the International Frequency List (IFL) (including all the frequencies prescribed for common use);

– the Terrestrial Plans annexed to the Regional Agreements;

– the Special Sections associated with the Plans;

– notices under investigation in accordance with RR Article 11 (published at least once);

– notices submitted for modification of a frequency assignment or frequency allotment Plans (published at least once);

– the TerRaQ program, used for query, display, exporting of the data, etc. and the TerRaNV program which enables the preliminary validation of the electronic notices before submission to the Bureau;

– the latest version of the Preface in Help format.

3) Carries out the regulatory and technical *examination*.

4) Publishes its findings in the bi-weekly circular with favourable findings in Part 2 and unfavourable findings in Part 3.

5) *Records* all assignments that are receiving a favourable finding in the MIFR.

Those that are receiving an unfavourable finding are returned to the notifying administration.

BR IFIC N° 2521 Index/Indice

International Frequency Information Circular (Terrestrial Services)
Circular Internacional de Información sobre Frecuencias (Servicios Terrenales)
Circulaire Internationale d'Information sur les Fréquences (Services de Terre)

ITU - Radiocommunication Bureau
UIT - Oficina de Radiocomunicaciones
UIT - Bureau des Radiocommunications

Part 1 / Partie 1 / Parte 1

Date/Fecha: 15.06.2004

	Description of Columns	Description des colonnes	Descripción de columnas
No.	Sequential number	Numéro séquenciel	Número sequencial
BR Id.	BR identification number	Numéro d'identification du BR	Número de identificación de la BR
Adm	Notifying Administration	Administration notificatrice	Administración notificante
1A [MHz]	Assigned frequency [MHz]	Fréquence assignée [MHz]	Frecuencia asignada [MHz]
4A/5A	Name of the location of transmitting / receiving station	Nom de l'emplacement de la station d'émission / réception	Nombre del emplazamiento de estación transmisora / receptora
4B/5B	Geographical area	Zone géographique	Zona geográfica
4C/5C	Geographical coordinates	Coordonnées géographiques	Coordenadas geográficas
6A	Class of station	Classe de station	Clase de estación
Intent	Purpose of the notification: ADD-addition MOD-modify SUP-suppress W/D-withdraw	Objet de la notification: ADD-additioner MOD-modifier SUP-supprimer W/D-retirer	Propósito de la notificación: ADD-añadir MOD-modificar SUP-suprimir W/D-retirar

No.	BR Id	Adm	1A [MHz]	4A/5A	4B/5B	4C/5C	6A	Part	Intent
1	104044430	ARM	935.2000	VAIK VK 1	ARM	45E27'38" 39N41'14"	FB	1	ADD
2	104044385	ARM	935.4000	KAPAN KP 1	ARM	46E23'59" 39N11'40"	FB	1	ADD
3	104044389	ARM	935.4000	SPITAK SP 1	ARM	44E15'45" 40N49'54"	FB	1	ADD
4	104044458	ARM	935.4000	YEREVAN YE 20	ARM	44E26'51" 40N11'0"	FB	1	ADD
5	104044431	ARM	935.8000	VAIK VK 1	ARM	45E27'38" 39N41'14"	FB	1	ADD
6	104044464	ARM	936.0000	SEVAN SE 1	ARM	44E55'35" 40N33'33"	FB	1	MOD
7	104044459	ARM	936.2000	YEREVAN YE 20	ARM	44E26'51" 40N11'0"	FB	1	ADD
8	104044390	ARM	936.4000	SPITAK SP 1	ARM	44E15'45" 40N49'54"	FB	1	ADD
9	104044465	ARM	936.6000	ARARAT AR 1	ARM	44E41'42" 39N51'17"	FB	1	MOD
10	104044386	ARM	936.8000	KAPAN KP 1	ARM	46E23'59" 39N11'40"	FB	1	ADD
11	104044466	ARM	937.4000	ARARAT AR 1	ARM	44E41'42" 39N51'17"	FB	1	MOD
12	104044423	ARM	937.6000	TASHIR TR 1	ARM	44E17'5" 41N7'19"	FB	1	ADD
13	104044432	ARM	937.6000	VAIK VK 1	ARM	45E27'38" 39N41'14"	FB	1	ADD
14	104044424	ARM	937.6000	YEREVAN YE 26	ARM	44E30'35" 40N9'52"	FB	1	ADD

BR IFIC N° 2521 15-06-2004

Case Study 3: ITU-D Spectrum Fees Database (SFDB)

Resolution 9, first adopted by the World Telecommunication Development Conference (WTDC-98) and revised by WTDC-02, requires the Directors of ITU-D and ITU-R to develop a report, in several stages, on current and foreseen national uses of the radio-frequency spectrum. A Joint Group between the Telecommunications Development Sector and the Radiocommunication Sector was established in 1999 to develop the reports required by Resolution 9. The reports on the first and second stages are available on the ITU-D website. In addition to the work programme to develop the second stage of the report, WTDC-02 requested that the Joint Group should include in its scope the preparation of a report in answer to Question 21/2 – Calculation of frequency fees.

The elaboration of a national frequency fee calculation model is a very complex matter and is the source of major difficulties for numerous developing countries and particularly LDCs for which the need is extremely urgent. Question 21/2 requested the establishment, in electronic format, of a document structure bringing together the calculation formulas and frequency fee amounts applied by different countries for different radiocommunication uses in the various frequency bands. The Question also requests a report on the various frequency fee calculation formulas currently applied in different countries.

Comprehensive information from administrations for this part of the report was obtained through Part III of a Questionnaire (Questions 1 to 9) circulated by Administrative Circular CR/12 (ITU-D) and CR/10 (ITU-R), dated 11 September 2002. In order to store the results in electronic format, as requested by Question 21/2, the BDT Secretariat has developed a suitable database, the "Spectrum Fees Database" (SFDB).

The SFDB may be accessed in read-only mode through the ITU-D website using the website address below. No passwords are required for reading the database:

http://www.itu.int/ITU-D/study_groups/SGP_2002-2006/SF-Database/index.asp

To remain a useful tool, the SFDB depends on administrations to keep it up to date with any changes to their national spectrum fees information. It is the responsibility of administrations to use the procedures below to update the SF with this information:

– Only one person shall be entitled to enter or modify the data in the database. The relevant authority should notify the BDT Secretariat if the administration should decide to change the person already nominated.

– Once a person is designated, the BDT Secretariat will communicate to her/him, the password for entering or modifying the data of the country concerned.

The SFDB structure is based on the structure of the questionnaire as follows:

– Questions 1 to 9 called **Q1-Q9**

– CHARTS A – E (to be filled by yes or no) called **CHARTS**

– CHARTS A – E (Parts to be filled with free text) called **SCALES**.

A version of the questionnaire is given on the ITU TIES website:

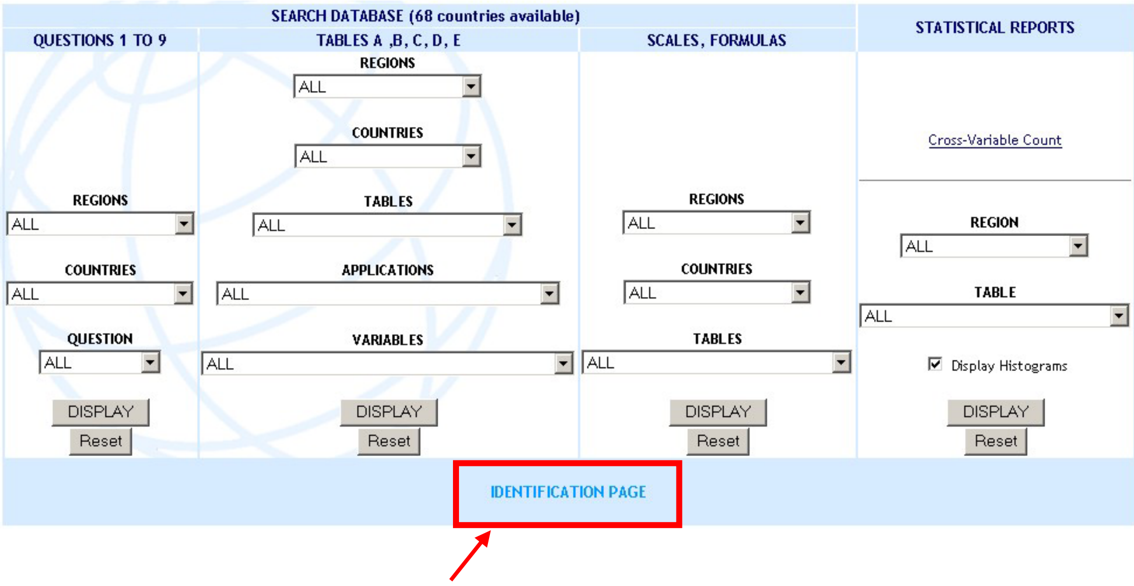
English version: http://www.itu.int/ITU-D/study_groups/SGP_2002-2006/circular/12-E.doc

French version: http://www.itu.int/ITU-D/study_groups/SGP_2002-2006/circular/12-F.doc

Spanish version: http://www.itu.int/ITU-D/study_groups/SGP_2002-2006/circular/12-S.doc

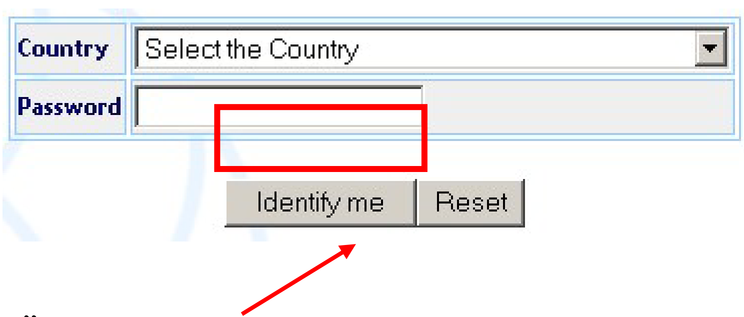
ITU-D Document JGRES09/043 (Rev.1) gives the user guide of SFDB and below you have a summary:

I Go to the website SFDB, you see the following screen and the Administration accesses its data:



Click on "IDENTIFICATION PAGE"

Choose your country and enter the password that you received from ITU.

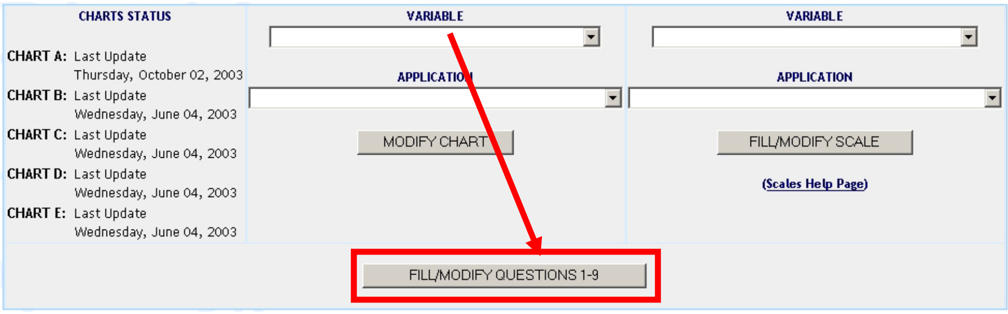


Click on "**Identify me**"

II Fill or modify Questions 1 to 9

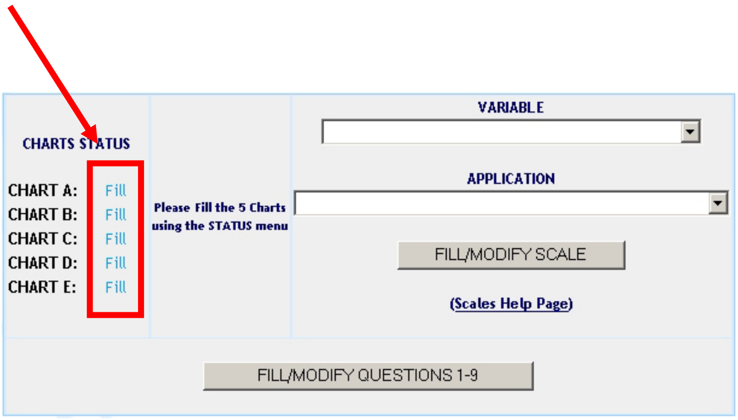
You will see the 9 Questions in the same page and can enter free text.

Click on the concerned button

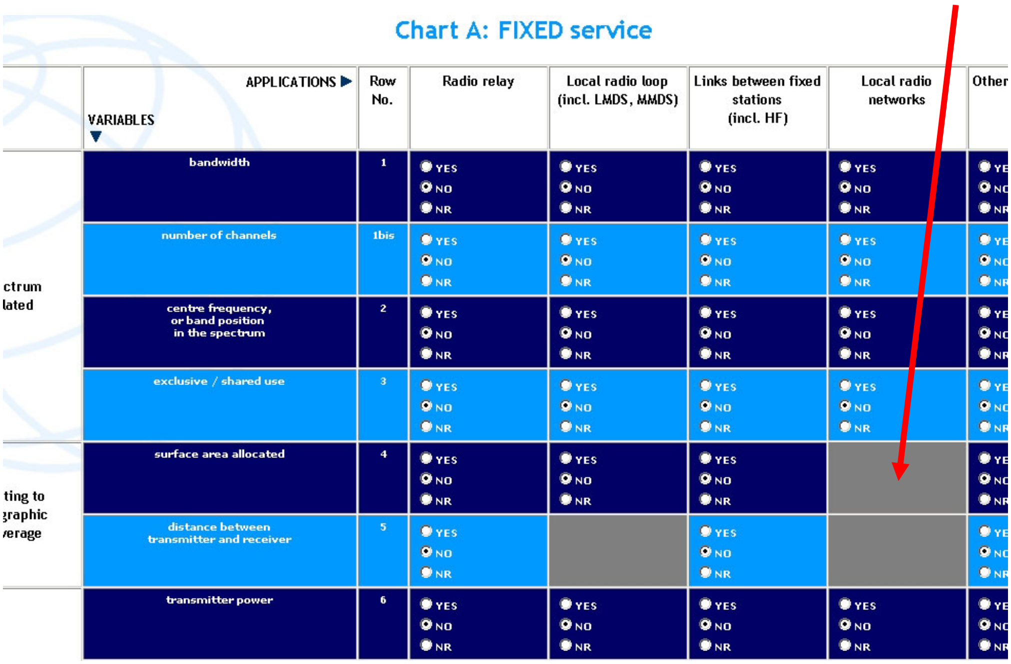


III Fill or modify the charts

Click on "**Fill**" to fill the selected CHART.



The choices are YES, NO, NR (No Response), except for the impossible cases (grey cells).



Modify a chart

You cannot modify any CHART until you have filled the 5 CHARTS.

Choice of the CHART to modify:

– Choose the Variable

– Choose the Application

– Click on "MODIFY CHART"

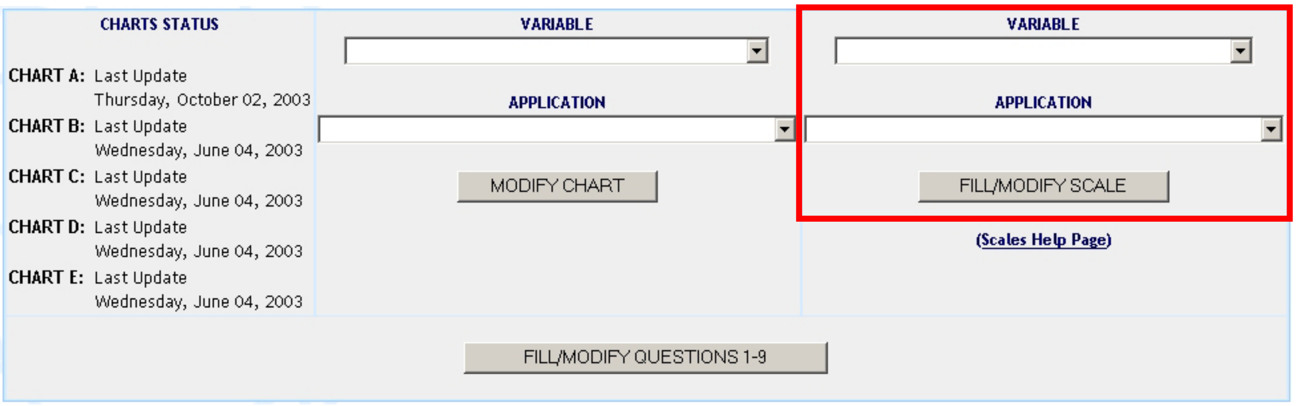
IV Fill or modify scales

Choice of the SCALE to modify

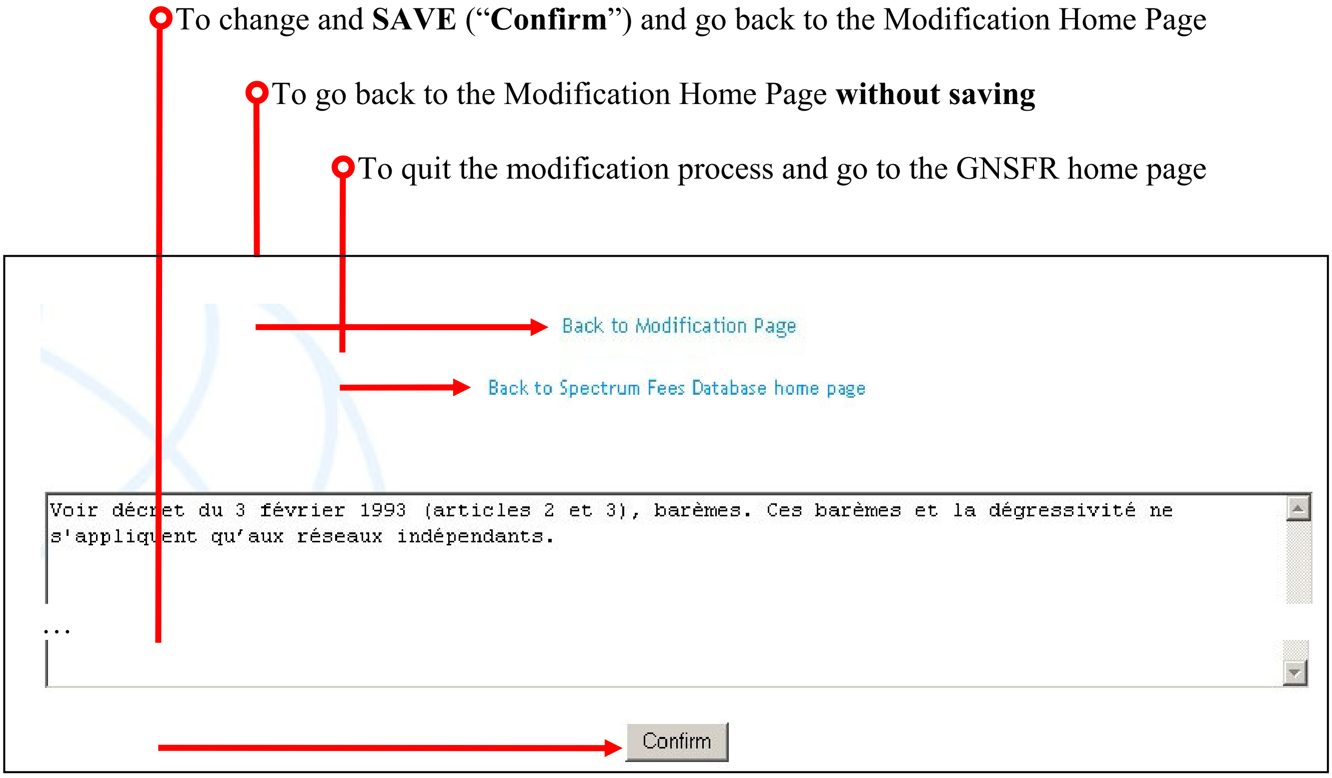
– Choose the Variable

– Choose the Application

– Click on **"FILL/MODIFY SCALES"**



Type the text for the concerned information



Case study 4: G-REX, The Virtual Tool For Regulators ITU website

The Global Regulators' Exchange (G-REX) is a password protected website just for communications regulators and policy makers. This initiative, launched by the Telecommunication Development Bureau (BDT) of the International Telecommunication Union (ITU), in May 2001, provides a vehicle for sharing information, views and experiences on pressing regulatory issues. BDT believes that well-informed regulators are more effective regulators and that effective regulators are key to helping to bridge the digital divide.

The most popular feature of G-REX is the Regulators' Hotline through which regulators and policy makers can pose any question they wish and seek feedback from their colleagues around the world. Since launching G-REX, there have been over 120 queries posted on the Hotline. Twenty were posted in 2001, 23 in 2002 and 51 in 2003. For 2004, 27 queries had been posted by June 2004. In other words, G-REX currently receives more than one new question every week. But G-REX is about more than questions. It also provides answers. In 2003, for example, there were approximately 220 replies posted to the Hotline queries.

BDT is helping to encourage more information exchange through its G-REX advisors, bilingual experts who translate all postings into French, Spanish and English, and also research regulators' websites to find additional information responsive to the Hotline queries. G-REX advisors post links and relevant documents, providing an essential addition to the online regulatory discussion.

In addition to the Regulators' Hotline, G-REX offers both text-based and virtual conferences. G-REX has hosted text-based conferences on topics such as interconnection dispute resolution. G-REX also hosted the "Interconnection Emergency Room" through which the Rapporteur for ITU-D Study Group 1, Question 6-1/1 was available to answer countries' interconnection queries.

G-REX virtual conferences combine telephone conference calls with a dedicated website through which participants can, in real time, share power point presentations, documents on their hard drives and engage in online chat. G-REX has hosted virtual conferences on Wi-Fi for Rural and Public Access; Interconnection Dispute Resolution and Spam. Virtual conferences are a cost-effective way to organize live conferences on targeted subjects among a small group of participants obviating the need to travel. G-REX Virtual Conferences have united participants from all five regions of the ITU membership, in developing as well as in developed countries.

G-REX is managed by the Regulatory Reform Unit (RRU) of the BDT. Any regulator or policy maker interested in registering for G-REX is invited to do so at http://www.itu.int/ITU-D/grex/register.asp.

Case Study 5: ITU TREG website

TREG is the world's pre-eminent online one stop shop for ICT regulatory information. Key information on all ITU Member States can be found on the TREG website. TREG contains up-to-date information on Regulatory events organized by the Telecommunication Development Bureau (BDT). Publications, case studies and model best practices developed by BDT on specific regulatory issues are accessible on TREG. The documents section provides references and links to ITU and non-ITU documents, reports and studies stored by topics.

The related links section provides links to international and regional organizations dealing with telecommunications, regional regulators' Associations, telecom online magazines and much more!

Thanks to ITU Member States' responsiveness and continued loyalty to BDT's annual telecommunication regulatory survey, now in its ninth year, the TREG website is the premium regulatory source of information searchable by country, region or topic. The Address book, legislative information and profiles section offer national contact and legislation summary data, profiles for regulatory organizations and regional data on level of competition, licensing and interconnection agreements and ownership status of the main fixed-line operators. Universal service profiles and Regulators profiles for individual countries are also available to visitors to the TREG website. The profiles, based on data collected through the annual Survey, provide a snapshot of the national Universal Service definitions, initiatives, actors and financing.

Two new features were recently added:

– *The self-training modules*. The first modules cover Interconnection and are accessible from the homepage and Dispute resolution is next on the agenda!

– *The news corner*: Regulatory News from around the World, can be found on the News Corner. This new web page features short updates on the latest regulatory developments. The updates are drafted by two G-REX advisors (G-REX, the ITU password protected website for regulators and policy makers).

TREG had more than 75 000 hits in 2003, http://www.itu.int/ITU-D/treg.

Case Study 6: Agreement for common use of HF direction finders within CEPT

Introduction

This agreement (September 2003) provides the possibility for any Administration of the European Conference of Postal and Telecommunications (CEPT) to access and to undertake measurements with HF direction finders in the range below 30 MHz from other administrations.

Due to the physical characteristics of short wave and the costly nature of HF direction finding equipment, it is agreed that it is appropriate to establish a European common approach to share the HF direction finders amongst the CEPT administrations having signed this agreement. The aim of this agreement is to create a common understanding and to provide cooperation among the signatories for using HF direction finders from other administrations for the purpose of spectrum monitoring and clearance of radio interference.

This agreement establishes the procedures for a common use of HF direction finders on a non-profit making basis within the CEPT. The Universal Control Software allows access to the HF direction finders.

HF direction finders are commonly used for:

– Locating unknown HF transmitters

– Regular and systematic monitoring of the radio-frequency spectrum

– Support of ITU and CEPT measurement campaigns

– Investigation of harmful interference

– Monitoring of the parameters of HF transmissions.

An Internet web page is available and contains the necessary general and technical information as well as the capacity to check the status of the different HF direction finders, or updating the version of the application software “UCS”. The access to this page is limited to signatories (member area).

The coordinating administration is responsible for updates to the general information as well as the technical information of the HF direction finders on the Internet page. Signatories and Operators should provide the information and also all changes immediately to the coordinating administration.

The technical information of the HF direction finders, available on the website are:

– Operational contact points of the Signatories
– Technical contact points of the Operators
– Location name
– Station ID
– Country
– Latitude ("WGS 84" geodetic system)
– Longitude ("WGS 84" geodetic system)
– Frequency range
– Access hours on the HF direction finder
– Manufacturer
– Type of the HF direction finder
– Accuracy of the bearing
– Demodulation
– Bandwidth (D/F)
– Bandwidth (audio)
– Bandwidth (spectrum)
– Attenuation,

and are stored in a configuration file called "Config_file_siteID.ini".

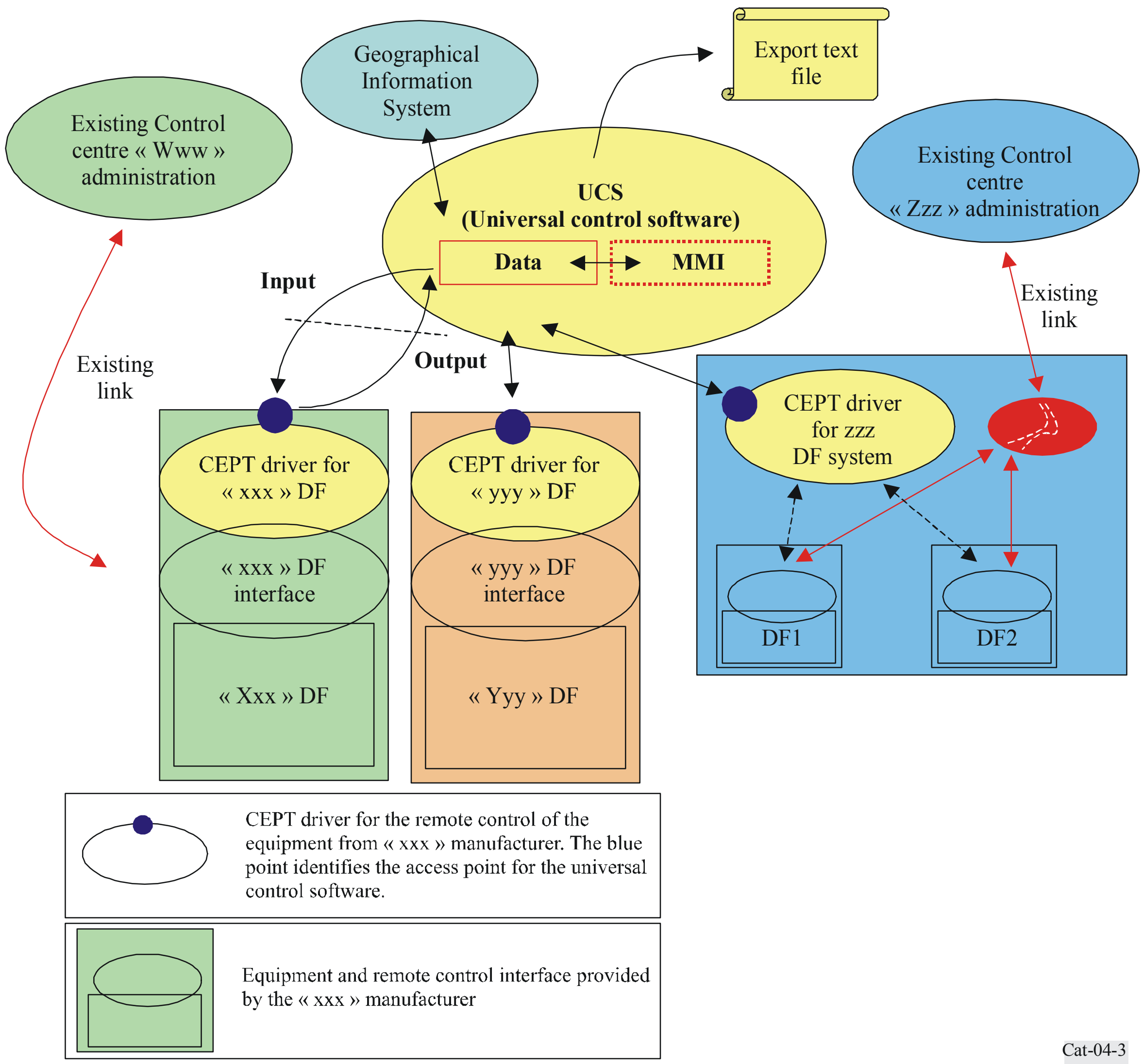
The architecture and description of interfaces

The concept of the HF DFs interconnection is based on a "*common data exchange structure*" (developed by CEPT) for the technical information (measurement commands and results). All equipment, irrespective of the manufacturer, understands these commands and functions in the same manner. It is done by the way of "CEPT device drivers" and "Universal control software (UCS)".

The architecture is introduced in Fig. 4.3:

FIGURE 4.3

Structure of the HF DFs interconnection



– The *existing control centres*, are the equipment and software applications (working in administrations and provided by manufacturers or developed for specification requirements) which are used to control the direction finders in the present situation (not interconnected).

– The existing *Direction Finders*, are provided by the manufacturers with a remote control interface whose commands and results are specific to the equipment.

Case Study 7: Data exchange within the coordination Agreement (Berlin 2003)

The Agreement 2003 is an agreement concluded by the representatives of the administrations of Austria, Belgium, the Czech Republic, Germany, France Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, Slovakia, Slovenia and Switzerland (17 European countries), under RR Article 6, on the coordination of frequencies between 29.7 MHz and 39.5 GHz for the purposes of preventing harmful interference to the Fixed and Land Mobile Services and optimizing the use of the frequency spectrum above all on the basis of mutual agreements.

The first version of this Agreement was the Vienna Agreement (VA) signed in 1986 with revision in 1993 and 1999 and further revised Berlin 2001 and 2003.

Principles

The general principle of this agreement is to facilitate the coordination through an equitable distribution of the frequencies at the borders on bi- or multilateral base in "preferential frequencies"; defined as frequencies usable without prior coordination procedure, subject to respecting the pre-defined technical criteria (agreements, annexes).

Frequency bands

For the frequency bands, two types of coordination are applicable:

– *First list: Land mobile service*

  For the land mobile service in frequency bands other than those defined in Article 1.2.1 (Berlin, 2003) and for all other services in these frequency bands, the coordination procedure set out in the Agreement may be used, and, if necessary, the technical parameters shall be agreed separately.

– *Second list: Fixed services*

  The coordination procedure laid down in the Agreement for the fixed service is only valid if in both countries involved in the coordination process the respective frequency band is allocated to the fixed service and the respective frequency falls under the responsibility of the Administrations. As first list, for other bands not given in Article 1.2.3 (Berlin, 2003), the administrations can apply the Agreement.

Frequency register

The frequency register is made up of lists set out by every administration indicating its coordinated frequencies, its assigned preferential frequencies, its shared frequencies, its frequencies coordinated for planned radiocommunication networks, and its frequencies used on the basis of geographical network plans and frequencies using preferential codes. All frequency assignments in this register shall be protected according to their status of coordination.

Technical provisions

– In the case of the land mobile service, the effective radiated power and the effective antenna height of stations shall be chosen so that their range is confined to the area to be covered. Excessive antenna heights and transmitter outputs shall be avoided by using several locations and low effective antenna heights. Directional antennas shall be used in order to minimize the potential of interference to the neighbouring country.

  A transmitting frequency shall be coordinated if the transmitter produces a field strength, at the border of the country of the Administration affected, which at a height of 10 m above ground level, exceeds the maximum permissible interference field strength as defined in Annex 1 of the Agreement. A receiving frequency shall be coordinated if the receiver requires protection.

– In the case of the fixed service, the effective radiated power and the antenna height of stations shall be chosen according to the radio links lengths and the required quality of service. Excessive antenna heights, excessive transmitter outputs and too low antenna directivities shall be avoided in order to minimize the potential of interference to the country affected. Annex 9 gives the maximum permissible threshold where the basic transmission loss is calculated in accordance with Annex 10.

Agreement carry out

The carrying out is made according the following principles:

– A common computation method, based on the propagation models defined by ITU-R and standard HCM (harmonized calculation method) used on DTM and borders lines agreed on bi- or multilateral basis.

  The HCM Program is a program developed for the harmonized application of the calculation methods as provided in the Annexes of the Agreement.

  New versions of the HCM program have to be implemented by all Administrations at the same point in time to avoid keeping different versions for different neighbouring countries. Because the HCM software is only a subroutine, this subroutine has to be implemented in national surrounding programs. A methodology is given in the Agreement to adopt new versions.

  The HCM program is listed in the ITU-R catalogue of software.

– Data exchange

  a) *Procedures*

  Overall list

  According to the Agreement, frequency registers (overall list) have to be exchanged twice a year using disc or CD-ROM or other mutually agreed media.

Coordination and notification

Coordination request as well as, answers to coordination requests or notifications may be exchanged on disc or CD-ROM or other mutually agreed media.

Data to be exchanged during the coordination procedure may be of the following type:

– new entries

– modifications

– deletions

– answers.

Each Administration shall prepare an up-to-date Frequency Register to be supplied to each Administration with which coordination is carried out. These Frequency Registers shall be exchanged bilaterally at least once every six months.

b) *Transmission media*

The following transmission media are agreed standards:

– email

– floppy disk

– CD-ROM.

For coordination procedures through the other media such as printed paper, transmission or data links can be used.

The following specifications have to be met when disks or email are used:

– MS-DOS format

– IBM-PC 8-bit ASCII character code

– For the land mobile service:

  Fixed length of data record; omitted positions or fields are filled with blank character(s)

– For the fixed service:

  – Variable length of data record

  – Data items are separated with semicolons

  – The end of each record is marked with a carriage return.

Case Study 8: Space Query and Extract BR System: Space Qry

Preamble

In Circular Letter CR/211 dated 10 May 2004 the Radiocommunication Bureau (BR) informed all administrations of the availability of a restructured Space network System database Version 5 (SNS v5) and an accompanying software package of new electronic notification software applications (capture, query, publication and validation) BRsoft Version 5 (BRsoft 5.x), fully reflecting all modifications and additions made by the World Radiocommunication Conference (Geneva, 2003) (WRC-03) to RR Appendix 4. The same circular letter also indicated that the Bureau was working on adjusting its internal procedures in order to publish special sections and other filings on the BR IFIC (space services) CD-ROM in SNS v5 format.

By the Circular Letter CR/222 dated 5 November 2004, BR informs the Administrations that as of BR IFIC 2532/16.11.2004, all special sections and other filings including associated databases (IFICxxxx.mdb, SPS_ALL_IFICxxx.mdb) on the BR IFIC (space services) CD-ROM will be available in SNS version 5 format only. The CR/222 provides updated information and guidance to users on the SNS v5 and BRsoft 5.x.

Queries relating to assignments under RR Appendices 30 and 30A are now covered by the Space-Qry software (SpaceQuery 5.1). Use of SpaceQry 5.1 together with the SPS_ALL_IFICxxx.mdb database allows the retrieval of characteristics and reference situations of assignments under those Appendices.

Introduction

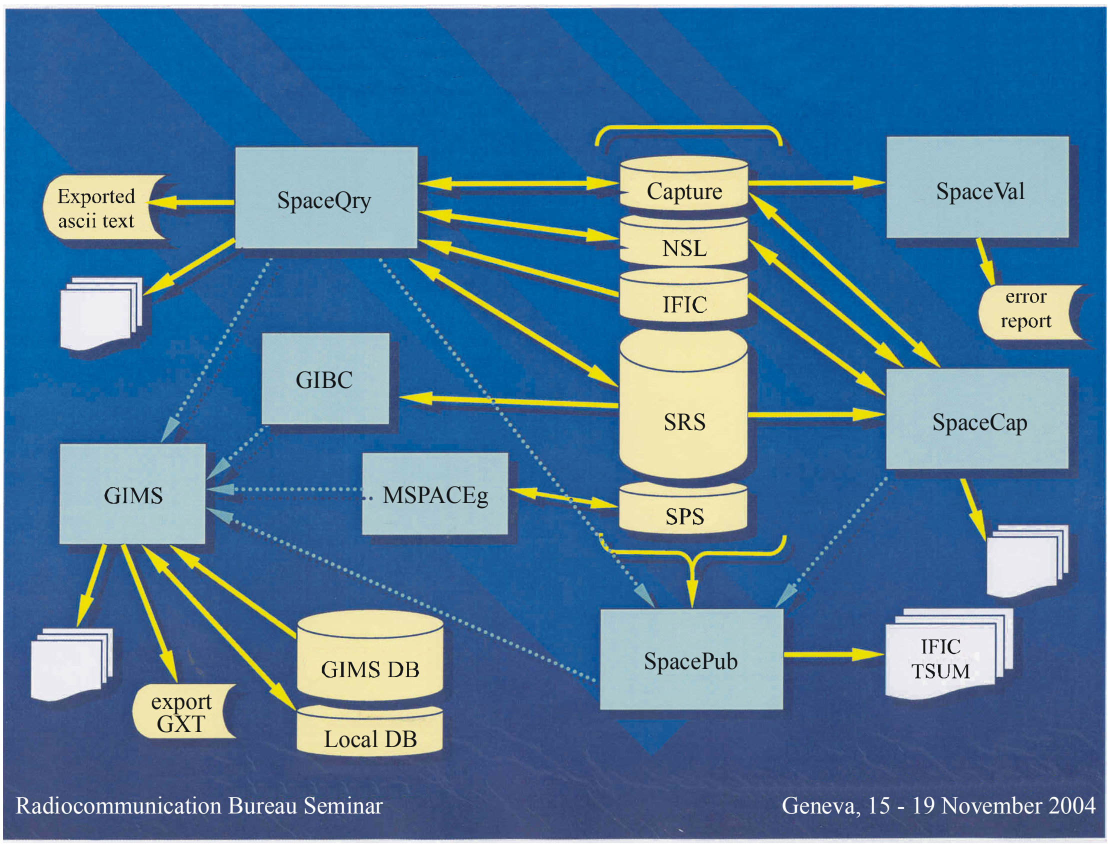
The Radiocommunication Bureau's Space Data and Publication Circular Query and Extract System, known as SpaceQry, is a software package that supplies both the BR's internal and external users with a tool that accesses and queries all BR formatted Space Databases: these include the Space Weekly Circular (SWIC) databases, Space International Frequency Information Circular (IFIC) databases, Network Station List (NSL) databases, Space Capture databases, and Space Radiocommunication Station (SRS) databases.

The purpose of this Chapter is to provide, as a SpaceQry user, an understanding of how to use the criteria-specifying dialogue, which is invoked each time a BR Space Database is opened.

Figure 4.4 shows where the SpaceQry software package fits within the BR Space PC Software Suite.

FIGURE 4.4

Space PC-Software Suite



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GIBC: Graphical Interface to Batch Calculations

GIMS: Graphical Interference Management System

GXT: Graphical Exchange Text format (GIMS)

IFIC: International Frequency Information Circular

NSL: Network Station List

SNS: Space Network System

SRS: Space Radiocommunication Station

TSUM: Transaction Summary Report

Space Capture: Filing capture according to Resolution 49 (WRC-03) includes an on-line data capture validation and assisted error-correction facility (display of erroneous data items and the corresponding validation rules) for the data capture of notices submitted under RR Article 9 (not yet implemented for advance publication information) and RR Article 11. Users are advised to run the SpaceVal 5.0.2 software application in order to perform a complete validation of the filing after its capture or modification.

SpaceVal: The SpaceVal software can be used in stand-alone mode to validate any relevant electronic filing in the SNS v5 MS-Access database format. The results of the validation may be viewed and printed using the Bureau's query software application SpaceQry 5.1 or later.

SpacePub: Space Publication System

Main characteristics

The SpaceQry software:

- reads the Electronic Space Circular Information
- queries the Space Radiocommunication Station (SRS) database
- creates the space networks lists/earth stations (NSL)
- updates the SRS database and NSL list from Space Circular Data
- maintains a “query database”.

What does SpaceQry software query?

- SRS database
- Electronic Space IFIC publications
  - Show only data relative to publications, IFIC filter on
  - Show all the data for networks, IFIC filter off
- SpaceCap results (MS-Access 97,200)
- SNS Capture results (MS-Access 2.0)
- Networks/Stations Lists (NSL).

The different types of queries are:

Standard queries

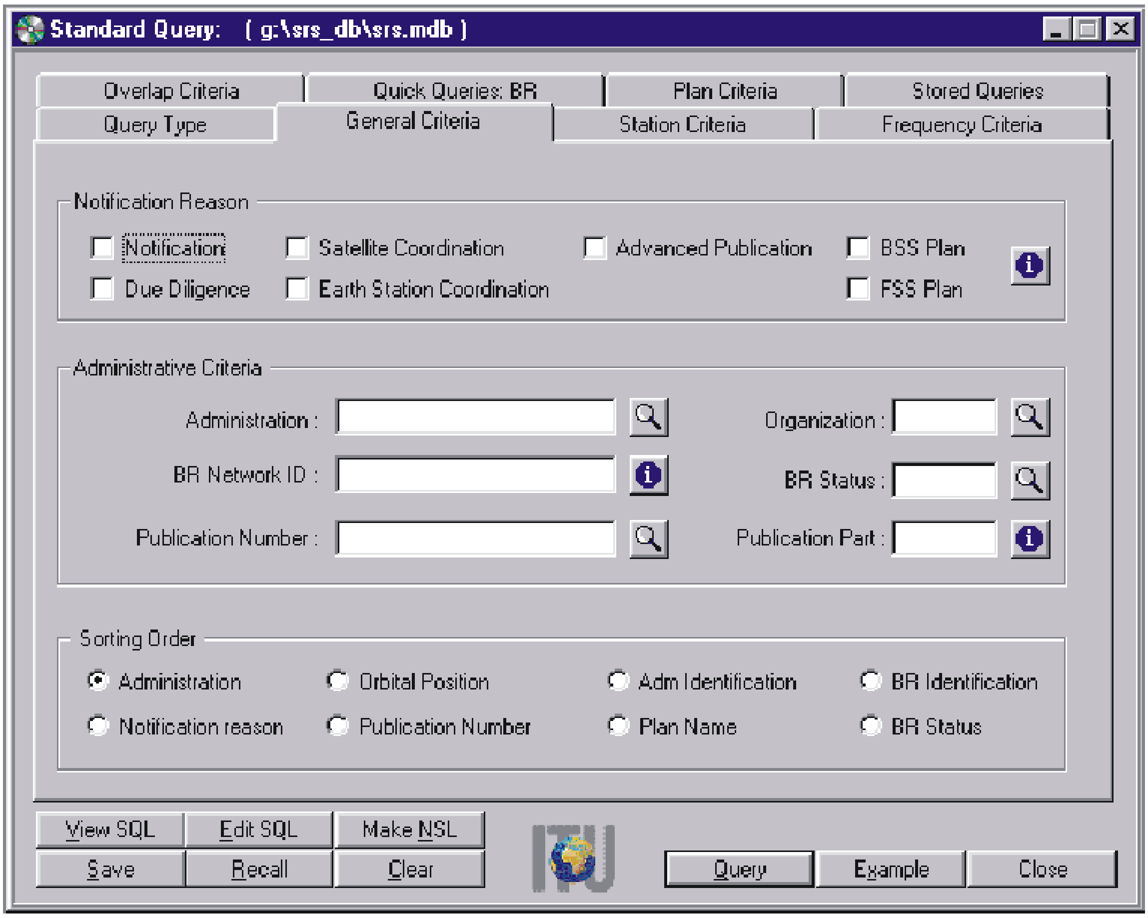
For perusing the data, the standard query criteria:

- Notification reason
- Administration/organization/country
- Satellite/earth station type
- Satellite earth station name
- Orbital position geographical location
- Publication number and part.

Due to the expanding requests for additional querying criteria and the inclusion of the Plans, Advanced Publications and Due Diligence data into the SRS database, a single criteria screen, or window, is no longer sufficient to display and capture the querying information. For this reason, the SpaceQry Criteria window is now presented as a series of tab-windows (similar to what you will see in many Microsoft products as option or preference dialogue). The criteria are organized logically on to the appropriate table window, each of which can be accessed by clicking on its associated tab.

FIGURE 4.5

Standard Query Screen



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Frequency overlap and slot queries

This includes two different queries: the first one is what networks overlap a given frequency band? The second is what networks operate within a frequency band (slot)?

The overlap and slot queries criteria are:

– All criteria available to standard queries

– Multiple frequency bands

– Beam type (receiving/transmitting)

– Group-level publication numbers

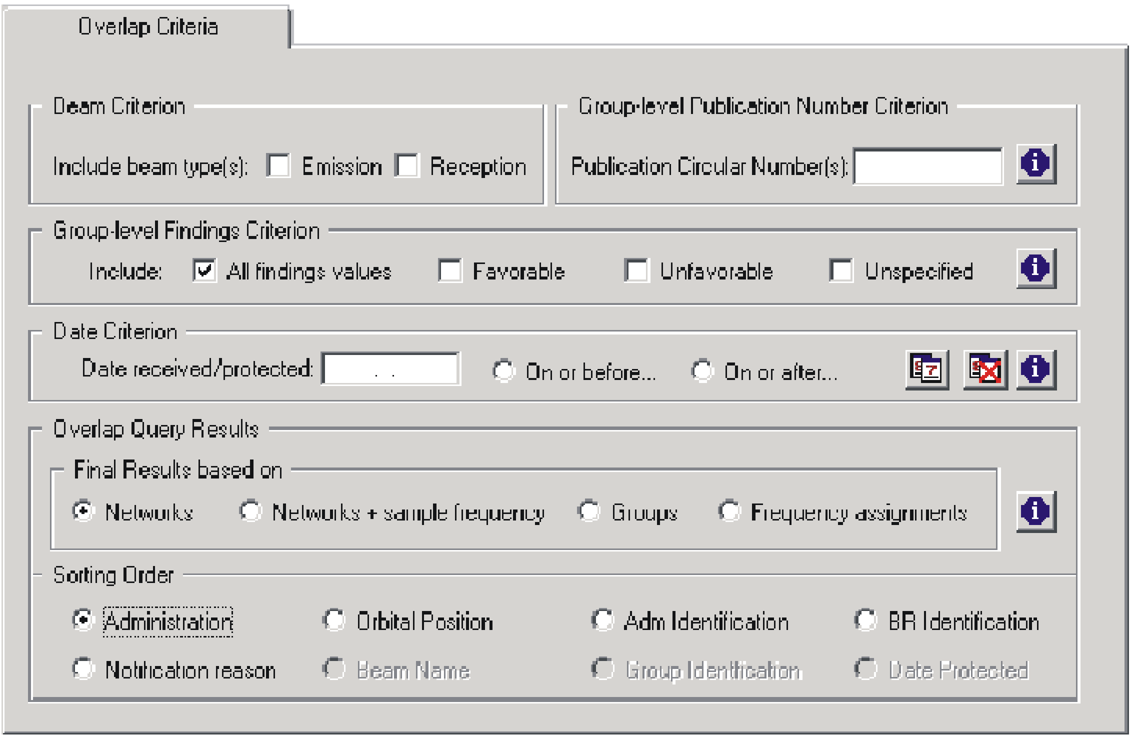
– BR (examination, finding values)

– Date of receipt/date of protection.

The Overlap Criteria Table lists all querying criteria which specifically relate to Frequency Overlap and Frequency Slot Queries (and, consequently, is only available when the Overlap Query Type has been selected):

FIGURE 4.6

Overlap Criteria Screen



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"Quick" queries

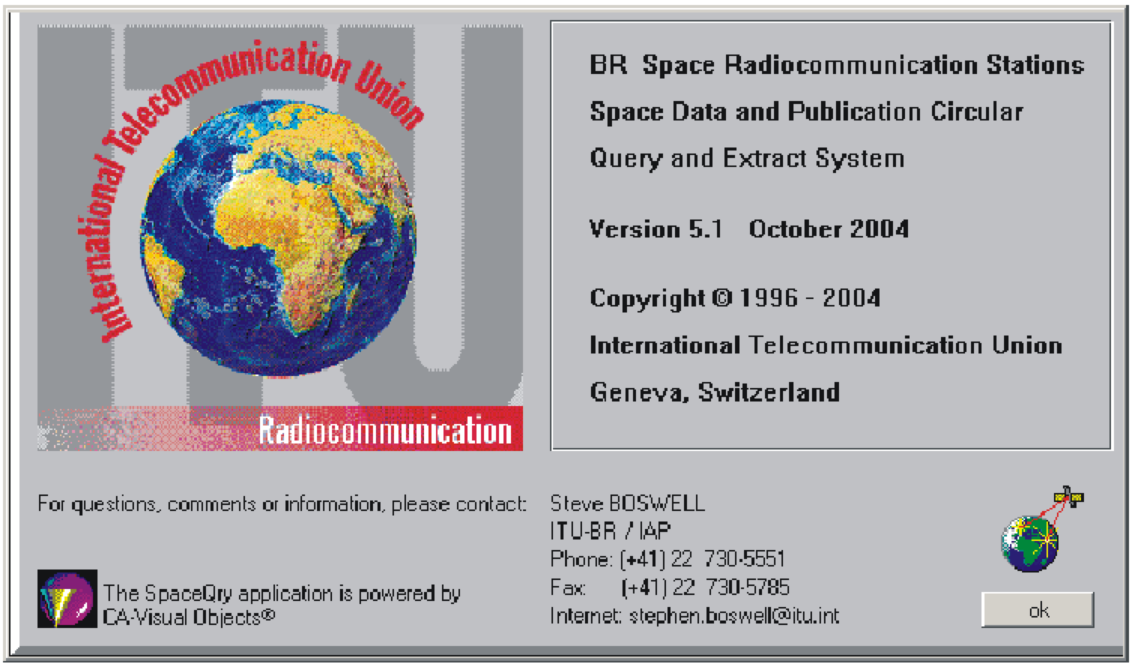
The Quick Queries Tab lists a number of pre-defined, specialized queries (usually) returning specific information about a given network. These queries were given the name quick because they require a very minimal number of criteria parameters (in some cases only the network ID), and therefore, are easy or quick to specify and run. Although these queries have evolved from the engineering and administrative requests and needs of the Space Services Department of the BR, it is assumed that they will be of interest to the SpaceQry users outside the ITU, as well.

Ad hoc SQL queries

This query type allows the user to design his/her own queries and to modify the pre-defined queries. Moreover, it supplies aids for query design: select statement templates, database table and field lists.

The Adhoc Query tab allows you to either edit the SQL statement which is generated by your specified criteria, or to create your own query against any BR Space Frequency Management (SNS-format) database.

For more information see:



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CHAPTER 5

EXAMPLES OF AUTOMATED SPECTRUM MANAGEMENT PROCEDURES

TABLE OF CONTENTS

5.1 Introduction

This Chapter illustrates the practical use of methods described in the Handbook on National Spectrum Management and in the previous Chapters of this Handbook to aid the spectrum management process. Computer techniques can help in at least two ways: managing and examining large amounts of data; and performing calculations, whether complex, or simple but repetitive.

The examples illustrate both of these features. However, these samples are illustrative only, and do not necessarily represent recommended procedures. Each administration may establish its own procedures, which may also differ from service to service. The real criterion for measuring the success of an automated system is the extent to which it relieves the frequency manager from the tedious manual chores of searching through data files, performing repetitive calculations, and to which it presents results in a clear, concise format.

Each of the following examples uses different computer procedures. These procedures can be of great help in spectrum management and can be used independently. It is not necessary to combine them into a fully automated spectrum management system. However, maximum benefits accrue when such integration is possible.

Some examples show how the data can be applied in more complicated calculations. In many cases, standardised programs for handling data and performing automated co-ordination calculations have been developed by administrations or other organisations. The ITU publishes a free catalogue (Catalogue of software for radio spectrum management) of such programs and provides the programs to administrations at a nominal charge for handling. Developing countries can obtain these programs at a reduced price. The models described later in this chapter are, in many cases, implemented in the programs described in this catalogue.

An application of computer aided techniques concerning monitoring is presented at the end of this Chapter (Case Study 9). The example presents a short description of software for optimal planning and design of spectrum monitoring networks.

Short descriptions of automated systems for spectrum management can be found in Annexes 2-8. Further examples of the use of computers in monitoring can be found in the ITU Handbook on Spectrum Monitoring (edition 2002).

5.2 Manipulating data in computer systems

Although database management systems attempt to de-couple application programs from the underlying data, the hoped for data independence is never perfect and the applications are invariably tied in some way to the chosen structure of the data. This coupling prevents the easy wholesale reuse of applications in situations where the underlying structures are dissimilar. Administrations are therefore cautioned that adapting the programs developed by others to work with their particular data structures can sometimes be just as difficult as re-developing them from scratch.

Some administrations may wish to access data they have previously notified to the ITU in their internal spectrum management or to access data from neighbouring administrations. The ITU-R publishes this data in the form of the IFL on CD-ROM. This data and the extraction software for the Local Frequency List Management System included with the BR IFIC can be used effectively in many countries. It should be noted that effort will still be required to verify the validity of these assignments and to complete any technical data which is missing but may be required by the analysis programs.

The ITU-R also has available data for space radiocommunication stations and frequency assignment plans (ST61, GE75, RJ81, GE84, GE85, and GE89) on DVD. Please see the software catalogue and appropriate subscription circulars for more information.

5.2.1 Allocation database

In order to effectively manage the use of the radio-frequency spectrum, it is necessary to know how the spectrum is allocated among the various services. It is also necessary to know how the allocated spectrum is being used by the various services. An automated allocation database can be used to answer these questions. The allocation database should be structured in such a way that the total portion of the spectrum used by a particular service or a particular combination of services can be found. This information can be used to show how the available spectrum is distributed among the various services.

The allocation database should also be structured in such a way that each allocation record can be the "owner" of one or more frequency assignment records. Cross-referencing the allocation database and the frequency assignment database permits actual usage of the spectrum to be estimated for specific services. This information can be used to determine, by service, where the spectrum is congested and where the spectrum is underutilized.

Contents of the allocation database

The allocation database will be more useful if it can be cross-referenced by the frequency assignment data base. The most effective method of providing this cross-referencing is to include authorized station classes as part of the allocation record and should be limited to those that are actually authorized by the Table of Frequency Allocations. The effect of any restrictions placed on the service by footnotes to the Table of Frequency Allocations should be included when selecting the station classes which are permitted.

It is generally recognized that the form of presentation of the Table of Frequency Allocations of RR Article 5 is more suitable for manual usage and limits its usefulness in various computerized applications. The ITU-R has therefore created a preliminary version of a prototype database. Other administrations have similar systems which are sometimes also used to subdivide the bands even further for national purposes. These sub-allocations further restrict the range of frequencies available for assignment for a specific purpose and move part of the workload of frequency assignment to the spectrum planning framework.

5.3 Computer-aided frequency selection

5.3.1 Problem description

To illustrate the application of simple computer techniques, a frequency assignment for a new transmitting station in the mobile service will be made.

Since land mobile services are usually channellised, only one set of discrete frequencies need be considered. The data file shown in Table 5-1 will be used as an example. It will be assumed that this file contains data describing all potential emissions, which can possibly affect the choice of frequency. In practice, a much larger file would probably exist.

TABLE 5-1

Example assignment data file including new frequency assignment

Frequency (MHz)	Channel No.	Station, Location	Power (kW)	Latitude	Longitude	Location	Call sign
160.005	1	Areawide Courier Delivery	0.075	38 58 33 N	077 06 01 W	Bethesda, MD	KED427
160.020	2	W.T. Cowan	0.12	38 56 54 N	076 50 22 W	Hyattsville, MD	DEX523
160.035	3	H.j. Kane Delivery Service	0.12	38 58 57 N	077 05 36 W	Bethesda, MD	KTZ830
165.050	4	Joseph M. Dignanson	0.12	38 55 15 N	076 54 10 W	Ardwick, MD	KDX790
160.065	5	Central Delivery Service	0.12	38 59 49 N	077 06 18 W	Bethesda, MD	KFB424
160.080	6	Hemingway Transportation	0.075	37 30 25 N	077 29 54 W	Richmond, VA	KES899
160.095	7	Halls Motor Transit Company	0.06	39 45 05 N	075 33 39 W	Wilmington, DEL	KQG594
160.095	7	Halls Motor Transit Company	0.12	39 41 47 N	077 30 46 W	Mont Quirauk, MD	KWT696
160.110	8	Jones Express Trash Removal	0.12	38 56 54 N	076 59 49 W	Washington, DC	KJB937
160.125	9	Central delivery Service	0.075	38 57 49 N	077 06 18 W	Bethesda, MD	KFB424
160.140	10	Purolator Services	0.12	38 57 49 N	077 06 18 W	Bethesda, MD	KFB424
160.155	11	Preston Trucking Company	0.075	38 56 15 N	076 51 42 W	Ardmore, MD	KEQ762
160.170	12	Hemingway Transport	0.075	39 19 53 N	076 39 28 W	Baltimore, MD	KGG997
160.185	13	Metro Messenger and Delivery	0.12	38 56 50 N	077 04 46 W	Washington, DC	KGX548
160.185	13	A.J. Trucking	0.12	39 19 35 N	076 30 04 W	Baltimore, MD	KVN353
160.200	14	Clarence Wyatt transfer	0.12	37 30 46 N	077 36 06 W	Richmond, VA	KVZ573

The choice of frequency sharing criteria (Recommendation ITU-R SM.337) is the responsibility of the frequency manager. A choice that involves large protection ratios may be simple to analyse, yet ultimately wasteful of spectrum. Given the choice of criteria, the computer system must perform the analysis of the data to determine (in this case) whether a new frequency can be introduced while still satisfying the sharing criteria. The frequency manager should not need to make tedious or repetitive manual calculations. The selection of a frequency will be made in the following examples on two levels of complexity.

5.3.2 Basic selection procedure

A very simple frequency-sharing criterion can be defined as follows: “A given frequency may not be used simultaneously by two transmitters which are separated by a distance less than “*R*” km.” To this can be added, if appropriate, “Adjacent frequencies (i.e., channels, in this example) may not be used simultaneously by two transmitters separated by a distance less than “*D*” km.” For frequency sharing situations, the co-channel criteria should not be used.

Criteria of this type are very simple to apply, and are typical of the criteria used in certain designs of “cellular” mobile radio systems. The simplicity of the criteria is a big help in designing mobile networks involving hundreds of fixed transmitters.

A computer-aided selection procedure could be implemented in many different ways. One example method is outlined in Fig. 5.1. Each frequency (channel) in the allocated band of available frequencies is examined in turn, beginning at the lowest frequency. The program extracts records from the file in sequence. If the frequency found in the record is equal to that under examination, or is adjacent to it, the program will calculate the distance from the proposed transmitter to the existing assigned transmitters. If this distance is greater than *R* (for co-channel) and *D* km (adjacent channel), then the frequency will be assigned. Otherwise, the program proceeds to read further records until the “end of file” is reached. The program then returns to the beginning of the data file, and examines the next frequency if necessary.

The program as shown stops as soon as an acceptable frequency (channel) is found, but it could also be arranged to find all acceptable frequencies, and a further criterion could be later applied manually to choose among them.

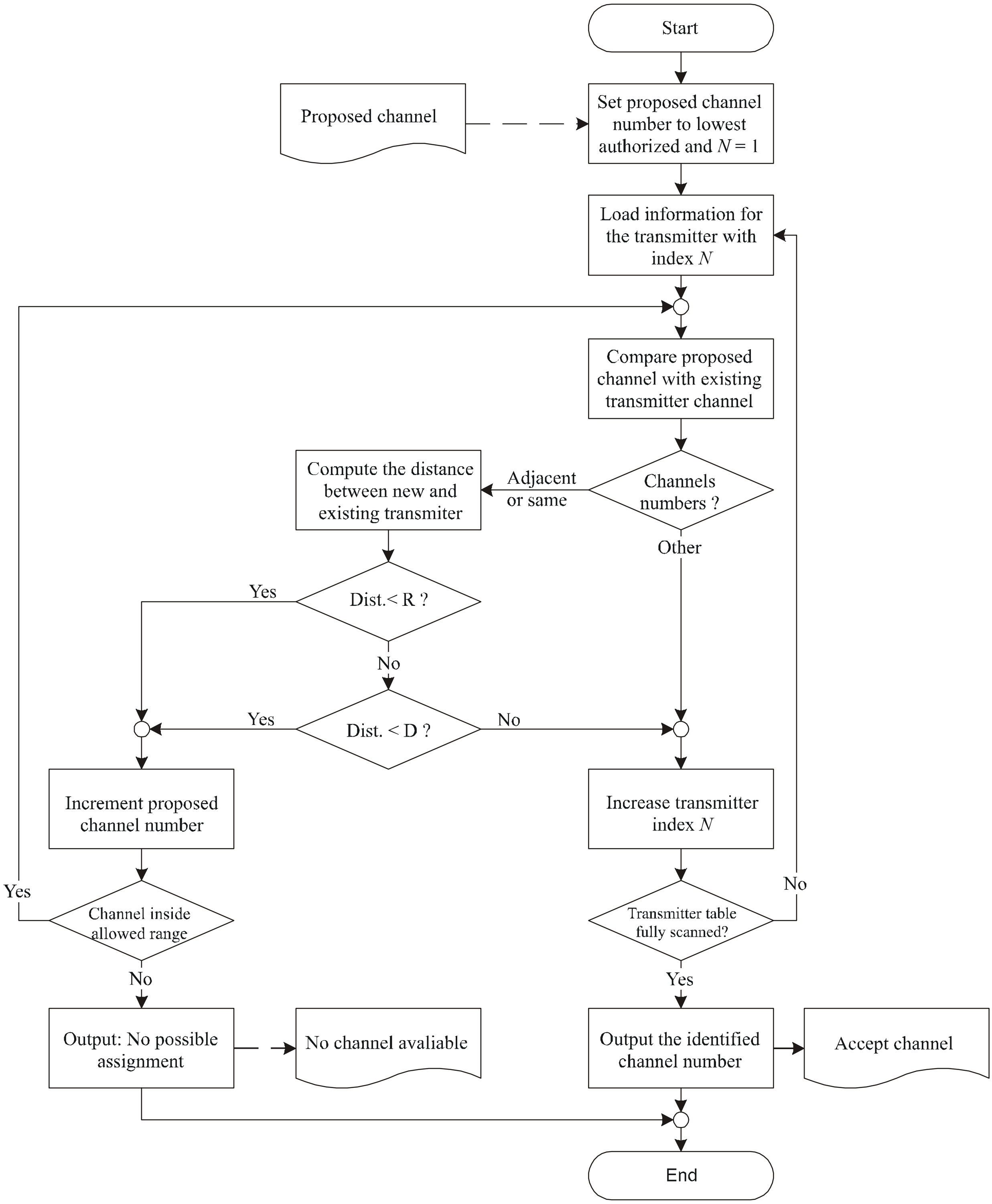
This example is a simple one; the only calculation performed finds the distance between two transmitters. Nevertheless, the use of a computer technique permits the whole procedure to be performed very rapidly. The frequency planner is relieved of the tedious task of performing hundreds of distance calculations (in a realistic case) and of the need to extract information from printed documents, which is prone to error.

5.3.3 An example of implementation of basic selection procedure

Using the existing assignments listed in Table 5-1, the State of Maryland, United States of America, desires a channel assignment for a transmitter location at latitude 39°10'45" N, longitude 76°40'07" W. Frequency-distance rules (assumed for this example) require 100 km separation for co-channel, and 40 km separation for adjacent channels. The solution is an assignment on channel 6, which satisfies all requirements. The new assignment list is shown in Table 5-2. This list could provide the frequency manager with additional useful information by including a listing of the distance of each existing transmitter location from the proposed site. The calculations can be readily made by the computer. The results allow the frequency manager to evaluate alternatives and to bring to bear his expertise and judgement on the selection process.

FIGURE 5.1

Basic frequency assignment routine



Note 1 – Consider R ≤ D, i.e. distance between transmitters that uses adjacent channel is equal or smaller than the distance between transmitters that uses the same channel.

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5.3.4 Frequency selection using more detailed sharing criteria

The Table of Frequency Assignment data used in the previous example contains the total radiated power of each transmitter, which was not used in the example. Some sharing criteria would need to use this information. For example, consider the following criterion: "No transmitter assignment may be introduced into the existing assignment table at a given frequency if it will produce a power flux-density at any other transmitter using that frequency that exceeds a certain value." (This is a simplified version of a more general procedure in which a frequency manager could define a number of test points, perhaps several hundred, and require that at each test point the power flux-density from a desired transmitter exceeds by a certain ratio the sum of that from all undesired transmitters combined, including the proposed new assignment.)

TABLE 5-2

Example assignment data file including new frequency assignment

Frequency (MHz)	Channel No.	Station, Location	Power (kW)	Latitude	Longitude	Location	Call sign
160.005	1	Areawide Courier Delivery	0.075	38 58 33 N	077 06 01 W	Bethesda, MD	KED427
160.020	2	W.T. Cowan	0.12	38 56 54 N	076 50 22 W	Hyattsville, MD	DEX523
160.035	3	H.j. Kane Delivery Service	0.12	38 58 57 N	077 05 36 W	Bethesda, MD	KTZ830
165.050	4	Joseph M. Dignanson	0.12	38 55 15 N	076 54 10 W	Ardwick, MD	KDX790
160.065	5	Central Delivery Service	0.12	38 59 49 N	077 06 18 W	Bethesda, MD	KFB424
160.080	6	Commonwealth of Maryland	0.12	39 10 45 N	076 40 07 W	Anne Arundel, MD	KAS454
160.080	6	Hemingway Transportation	0.075	37 30 25 N	077 29 54 W	Richmond, VA	KES899
160.095	7	Halls Motor Transit Company	0.06	39 45 05 N	075 33 39 W	Wilmington, DEL	KQG594
160.095	7	Halls Motor Transit Company	0.12	39 41 47 N	077 30 46 W	Mont Quirauk, MD	KWT696
160.110	8	Jones Express Trash Removal	0.12	38 56 54 N	076 59 49 W	Washington, DC	KJB937
160.125	9	Central delivery Service	0.075	38 57 49 N	077 06 18 W	Bethesda, MD	KFB424
160.140	10	Purolator Services	0.12	38 57 49 N	077 06 18 W	Bethesda, MD	KFB424
160.155	11	Preston Trucking Company	0.075	38 56 15 N	076 51 42 W	Ardmore, MD	KEQ762
160.170	12	Hemingway Transport	0.075	39 19 53 N	076 39 28 W	Baltimore, MD	KGG997
160.185	13	Metro Messenger and Delivery	0.12	38 56 50 N	077 04 46 W	Washington, DC	KGX548
160.185	13	A.J. Trucking	0.12	39 19 35 N	076 30 04 W	Baltimore, MD	KVN353
160.200	14	Clarence Wyatt transfer	0.12	37 30 46 N	077 36 06 W	Richmond, VA	KVZ573

To select a frequency according to this criterion, the radiated power of each transmitter must be considered; also the attenuation of radiated power flux-density as a function of distance from the transmitter (i.e., propagation information), is needed. For this example, it will be assumed that a single propagation model is used to describe every path considered. The propagation data stored in the computer is, therefore, a simple function listing attenuation as a function of distance increments. For distances not in the list, interpolation is used to find the loss value.

A further degree of complexity is incurred by considering the effects of inter-modulation products. Several "transmitters" may be located at a single site. In fact, they could even use a common antenna and radio-frequency amplifier. The existing frequency plan assigns carrier frequencies to the transmitters at a given site, but there will be radiations at additional new frequencies formed by inter-modulation between the main carrier frequencies. Such products are likely to be insignificant when received at other sites, but can be very damaging in the region of the transmitting site. The treatment of inter-modulation is in general rather complex, so for this example, the problem will be simplified to the following additional selection criterion: "No proposed frequency may be assigned to a new transmitter at a given site if any third order inter-modulation product formed from any frequencies already assigned to that site equal the proposed frequency."

To further simplify the example, only co-channel inter-modulation signals will be examined; adjacent channel power flux-density will not be considered.

Figure 5.2 shows a possible method of automating the selection procedure for this example. In this case, it is clear that the effort needed to perform the task manually is prohibitive; but for even a modest computer system the procedures used are easy to implement, fast, and not prone to errors in data handling.

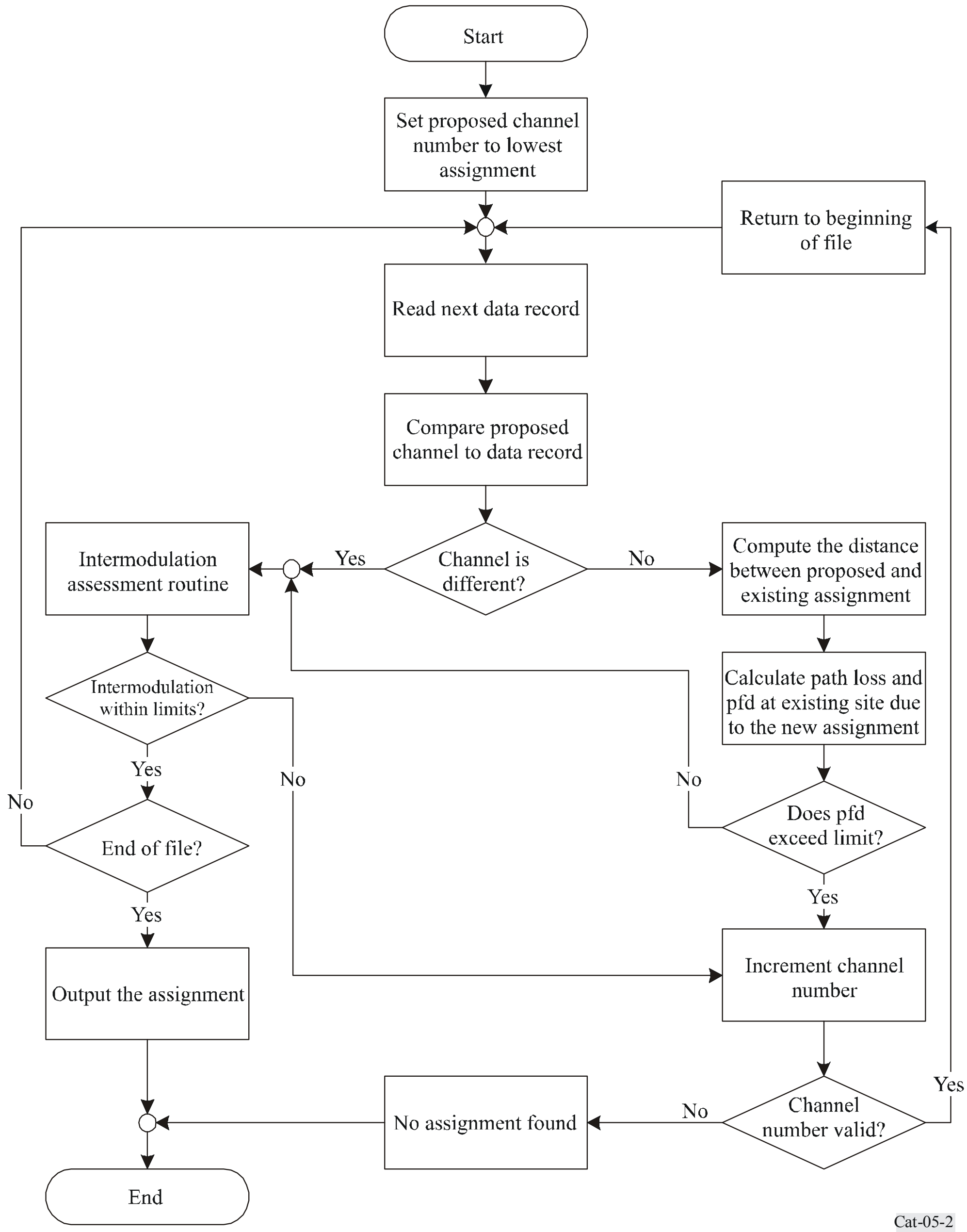
5.3.5 Land mobile radio-frequency assignment

For land mobile radio computerized frequency assignment systems, it is necessary to consider certain operational aspects in addition to a basic frequency assignment routine such as that shown in Fig. 5.1. For example, in order to provide the co-channel protection required by high grade mobile radio services, a computer model is required which assigns channels in accordance with permissible coverage area overlap between adjacent co-channel services areas. If low grade mobile radio services, which require no co-channel protection, operate in the same area, then the computer model should calculate the channel time occupancy and check that this occupancy is less than limits stored in "look-up" tables. The two models form segments of the simplified land mobile radio-frequency assignment system shown in Fig. 5.3.

The degree of sophistication and accuracy of the mobile radio-frequency assignment model determines the frequency re-use achievable in a zone and hence the efficiency of spectrum utilization. For example, a simple "free space" propagation model can be used to give worst-case prediction with reasonable results in areas where VHF and UHF mobile radio services are sparse and channels are underutilized. In areas containing congested mobile radio services it is necessary to use a more accurate propagation model which needs to take into account terrain characteristics in order to estimate diffraction loss.

FIGURE 5.2

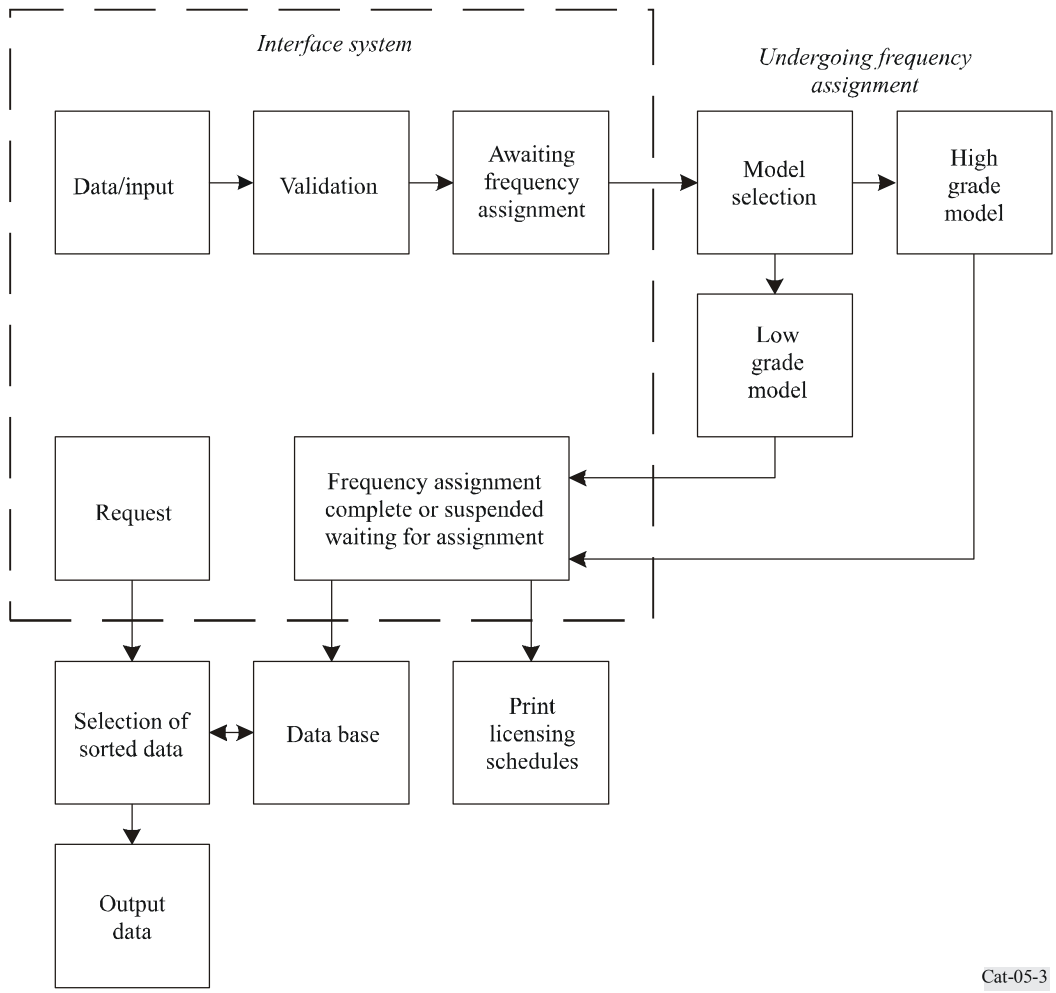
Advanced frequency assignment routine



An operational system should contain a database that is readily accessible for updating and is capable of providing information for spectrum management and licensing purposes. Spectrum management requirements include listings of records or groups of records for various characteristics. The licensing function consists essentially of printing frequency assignment schedules or records for account purposes.

FIGURE 5.3

Simplified land mobile radio computerized frequency assignment system



An operational computerised frequency assignment system for mobile radio services based on Fig. 5.3, incorporates the following features:

– contains a database of service users, technical parameters, and administrative details. The database can be readily amended with new user data or incorporate changes to existing records;

– validation checks are made to ensure that data is acceptable to the frequency assignment system;

– frequency assignment of a new exclusive user (requiring protection) is based on calculating the field strength contours of the base station service area and ensuring the overlap of the contours with existing base stations is limited to an acceptable level. The frequency assignment program accesses a terrain data file;

– time occupancy is assessed for channels which are shared in the same area. Checks are also performed on user business class to ensure the selection of a suitable channel, e.g. users having the same business class are not necessarily allowed to share the same channel;

– if a suitable channel cannot be found, the failed assignment will be queued until it can receive the attention of a frequency assignment officer who will then make the appropriate decisions;

– on the completion of a batch of automatic frequency assignments, technical schedules giving details of the assignment are printed automatically for issue to the service users;

– a management information system is provided to examine frequency assignment files, and to produce plots of terrain profile and of field-strength contours;

– the frequency assignment program refers to an interference source file which lists channels unavailable in certain areas of the country due to a potential interference between existing radio services and mobile radio services.

The frequency assignment program calculates the overlap of a proposed base station (PBS) signal upon other existing base station (EBS) service areas. This overlap routine applies to exclusive (protected) assignments and is repeated for all channels listed in a "pre-scan" routine which selects the possible suitable channels based on a simplified version of the overlap routine. The channel with minimum EBS/PBS overlap is selected automatically.

The frequency assignment program, including the service area overlap and channel time occupancy calculation have been designed to maximize the re-use of channel frequencies leading to the more efficient utilization of frequency spectrum. The automatic frequency assignment system permits rapid assignments to be made of consistent high quality for mobile radio services and will continue to do so as the number of service users continues to increase in the future.

The problem with this simplified system is that it gives rules to eliminate some channels from consideration, but it does not provide the capability to choose between the possible channels, which can be numerous. In other words, it tells which channels are impossible, but it does not say which channels are best.

5.4 Propagation analysis

Automated techniques for determining losses based on real conditions (curved Earth, obstructions, varying soil conditions) allow accurate propagation predictions to be made routinely, thus increasing the accuracy of EMC analyses and finally, improving the efficiency of spectrum usage.

Two examples are provided in this section. The resulting outputs of an automated calculation for propagation loss as a function of distance for an assumed smooth Earth compared to free-space losses are shown in Table 5-3.

TABLE 5-3

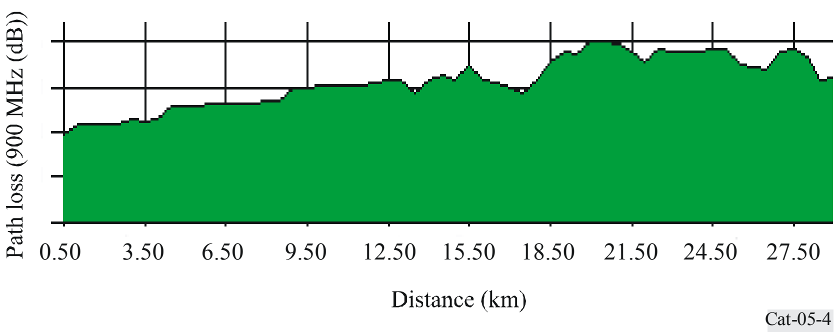
Comparison of free-space and smooth-Earth propagation losses
(Frequency: 800 MHz)

Distance (km)	Free-space loss (dB)	Smooth-Earth loss (dB)
1	90.5	90.5
2	96.5	97.5
5	104.5	108.0
10	110.5	119.5
20	116.5	135.0
50	124.5	166.9
100	130.5	212.1

An example of propagation loss versus distance derived from a terrain profile is shown in Fig. 5.4.

FIGURE 5.4

Propagation loss versus distance



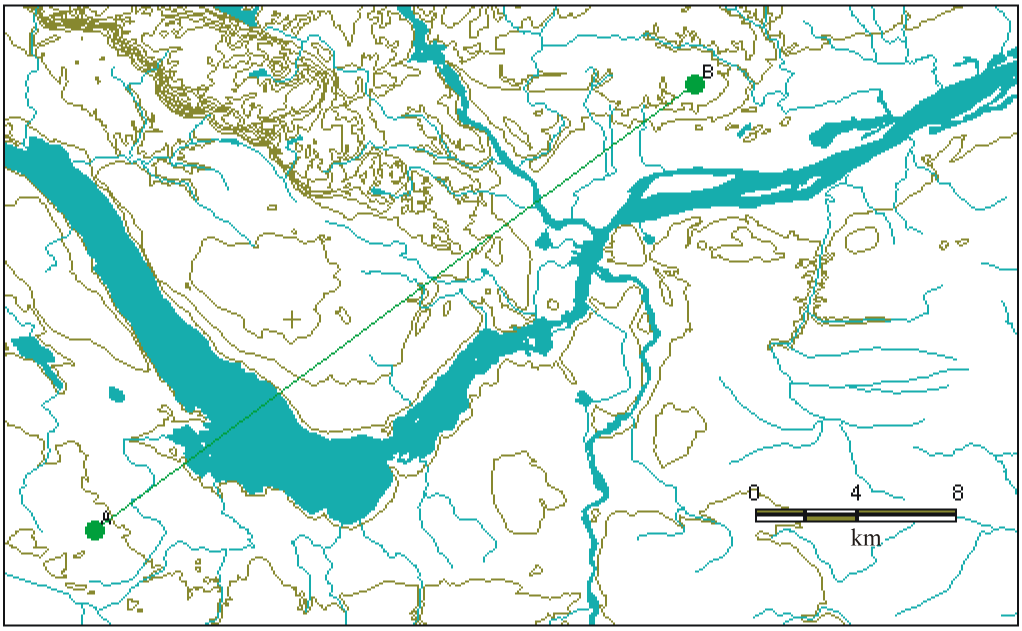
These examples are not intended to explain the programming involved, but to illustrate available information.

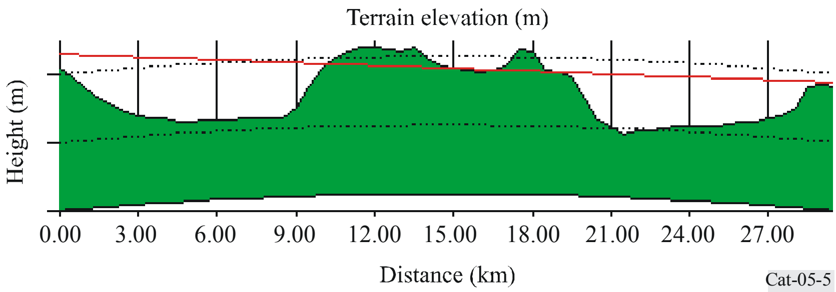
Automated techniques may include statistical data for fading, and actual terrain features in the desired signal path. Terrain features would normally be stored in a terrain data bank, and automatically accessed by the propagation calculation program.

Using stored terrain data, a path profile (Fig. 5.5) can be generated between any two geographical points included in the terrain data base. These profiles are useful in determining line-of-sight points for radio-relay, or to determine the shielding effects of surrounding terrain.

FIGURE 5.5

Path profile generated using a digital topographic database





Cat-05-5

Examples of typical propagation models are given in the ITU Handbook on National Spectrum Management, (edition 2005).

5.5 Equipment characteristics

Many EMC problems require the repeated use of technical characteristics concerning transmitters, receivers and their associated antennas. Certain of these characteristics do not consist of fixed values, but rather vary parametrically as a function of frequency, or the direction of antennas.

Converting the shape of the function into incremental data points and storing them in a data bank provides an input to the calculations of many EMC problems. The data files explained in this Chapter may be used in the analysis shown in § 5.6.

In addition, many administrations require that equipment imported or used within their boundaries meet specific standards that are updated from time to time. They usually publish the requirements that must be met by transmitters (and in some cases receivers) and document test methodologies for use in ensuring that these criteria are met. The administration then tests samples of each equipment type or allows approved test laboratories to test equipment against the standards and maintains a list of equipment makes and models that are approved for use and are therefore licensable. This list often forms part of the spectrum management database.

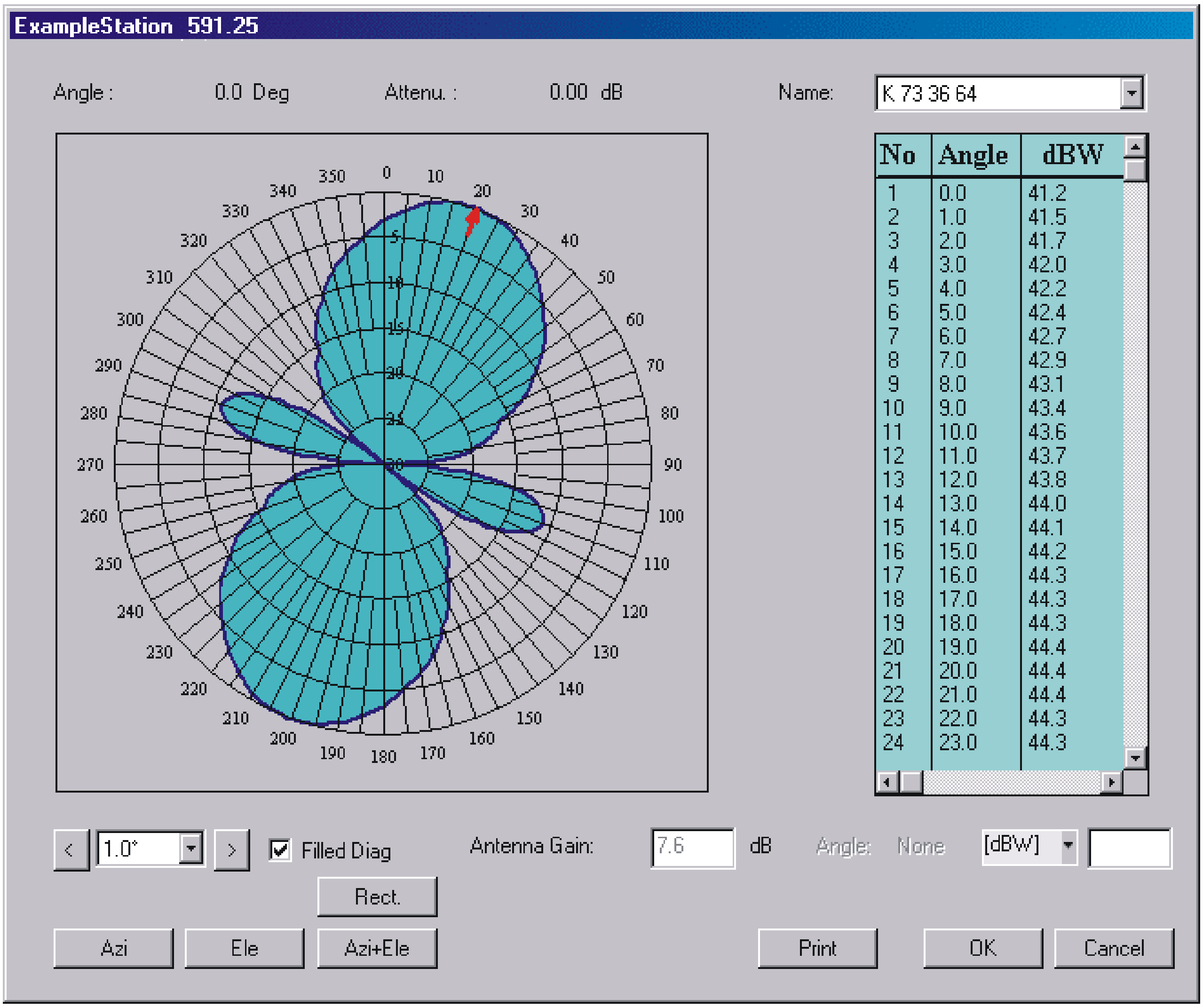
The minimum acceptable equipment characteristics established for the type approval process described in the last paragraph can then be used for interference analysis purposes rather than actual specific equipment parameters, thus facilitating the task somewhat.

5.5.1 Antenna patterns

Except for omnidirectional antennas, the gain of an antenna is a function of relative direction. In EMC calculations, it is desirable to know the antenna gain in the direction of a potential victim or interferer. Frequency assignment files may include antenna type and main beam direction. If the antenna type is known, the antenna data file may be automatically accessed to enter the appropriate antenna gain figure for computational purposes. The data is entered as gain as a function of direction relative to the main beam (highest gain) direction (Fig. 5.6).

FIGURE 5.6

Gain as a function of direction relative to the main beam (highest gain) direction (in horizontal plane)



Cat-05-6

This is an example of a look-up table approach to modelling. When a value for gain is required, a value for direction is specified, which is then used by the computer to interpolate for the correct value between two of the tabulated values. The antenna pattern may also have been represented by an analytical function which approximates the data (e.g. $G = 32 - 25 \log \varphi$).

5.5.2 Emission spectra of transmitters

The emission spectrum of a transmitter in mathematical terms is often complex, and difficult to apply to EMC problems. To describe the amplitude of the spectrum as a function of frequency is relatively simple, however, and can be graphically illustrated. By converting points on the spectrum curve to data points, a data table may be constructed. This data may then be used by computer programs that require spectral information.

5.5.3 Receiver selectivity

In a manner similar to § 5.5.2, the envelope of a receiver pass-band may be converted into data points and stored for use in EMC calculations.

5.6 Frequency dependent rejection

For EMC calculations, it is desirable to know the effect on receivers by transmitters which are not co-tuned, but are in the same frequency band. As the transmitter and receiver are separated in frequency, less of the transmitted energy is coupled into the receiver. The exact amount of coupling is a function of the transmitter emission spectrum, the receiver selectivity, and the frequency separation (see Recommendation ITU-R SM.377).

If the undesired signal power at which the receiver performance is degraded is known, calculations can be performed to determine the distance the interfering transmitter must be removed from the receiver to preclude interference, as a function of frequency separation. This results in a set of distance and frequency separation points, which, when connected, form a frequency-distance curve. Pre-calculated propagation data may be stored as distance/loss values or propagation calculation routines as in § 5.4 may be used. Automated calculations allow practical application of this technique. Inputs to the program are:

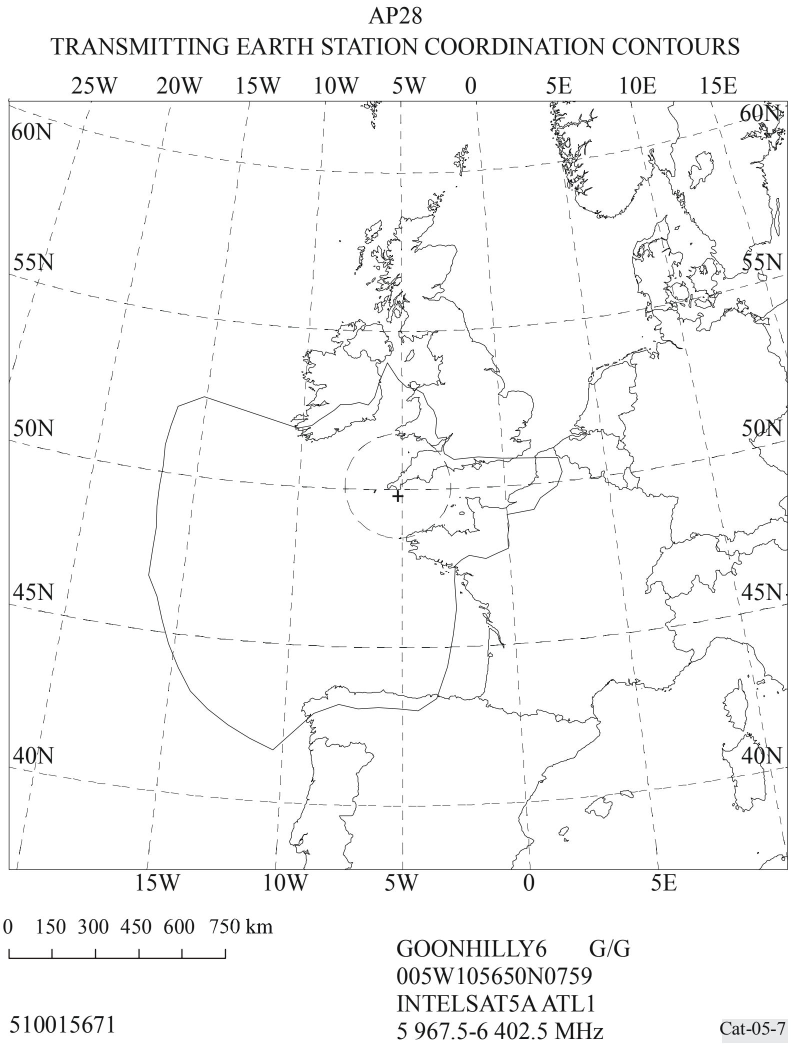
– frequency;
– emission spectrum;
– receiver selectivity;
– transmitter e.i.r.p. (transmitter power multiplied by antenna gain in direction of receiver);
– receiver interference threshold.

5.7 Coordination distance calculations

Automated methods are applicable to the procedure outlined in RR Appendix 7 for determining the coordination area around an earth station in frequency bands between 1 and 40 GHz shared by space and terrestrial services. Computer programs developed by the ITU-R and other administrations are available in the BR Catalogue and now used to calculate coordination distances during technical examination of frequency assignment notices as outlined below. A coordination diagram has been automatically drawn on a computer-generated map (see Fig. 5.7).

FIGURE 5.7

Coordination contours for a transmitting earth station



The full contour is the main mode (1) contour. The dotted contour is the mode (2) contour.

5.7.1 Program capabilities and procedures

This program computes the coordination distance as a function of azimuth angle from true North in 5° increments and draws the coordination contour using computations as follows:

– with the help of a simple program, the user prepares an extract from a database containing the points of geographical coordinates defining coastlines and political boundaries of the surface of the Earth where the earth station under examination is situated. These data are stored on an intermediate tape and used later for an analysis of mixed paths;

– the user enters the earth-station parameters that are required for the computations;

– the program calculates the permissible interference power (dBW) in the reference bandwidth to be exceeded no more than *p*% of the time at the receiver input of a station subject to interference, from each source of interference;

– the user enters horizon elevation angles around the earth station;

– the program then calculates the earth station off-axis antenna gain as a function of azimuth, antenna elevation angle and horizon elevation angle;

– the program calculates a minimum permissible transmission loss in a particular azimuth from the earth station;

– to determine the final coordination distance for propagation mode 1, the program performs an analysis of mixed paths as required, automatically checking radio-climatic zone boundaries using data from the ITU-R Digitized World Map (IDWM);

– the user defines the rain climatic zone and the program calculates the coordination distances for rain scatter propagation (mode 2);

– along each azimuth the values of coordination distances for propagation mode 1 and mode 2 are compared and the greatest are taken to form the final coordination contour around the earth station;

– the program calculates (if necessary) auxiliary contours for great circle propagation mechanisms;

– the program draws a map including political boundaries of a part of the surface of the Earth which is of interest. The map is drawn in azimuthal-equidistant projection. Calculated values of final coordination distance are used to draw the nominal and auxiliary coordination contours on the map;

– the program can be used for determination of the coordination contours for earth stations which operate with geostationary and non-geostationary satellites.

5.7.2 Other coordination and notification assistance

In many cases, administrations have used electronic data interchange to facilitate the coordination and notification processes. The RDD specifies the data elements for the items required for coordination with neighbouring countries. BASMS and WinBASMS determine the list of the countries with whom to coordinate using the IDWM routines of the ITU-R.

5.8 Integrated spectrum management systems

Many uses can be found for computers in the spectrum management process. The ultimate goal is to integrate the computer into as many spectrum management processes as it makes sense to do so. In order to give the reader an appreciation of the tasks and requirements involved in doing so, several Annexes have been included in the Handbook.

The description of some available integrated spectrum management systems is presented in Annexes 2-8.

The listing of these systems (Annexes 2-8) does not necessarily constitute a recommendation for their use.

5.9 Management – Monitoring integration

The ITU recommends in Recommendation ITU-R SM.1537 that spectrum management and monitoring functions be automated and fully integrated so that the management and monitoring portions of a system share database information and operate seamlessly together to perform the functions required by the spectrum manager. Integration of spectrum management and monitoring is also discussed in ITU-R Handbooks, including Chapter 3, § 3.6 of the 2002 ITU Handbook on Spectrum Monitoring, which provides information on equipment and illustrates typical system block diagrams, and Annex 3 to Chapter 7 of the 2005 ITU Handbook on National Spectrum Management, which gives an example of an integrated system.

5.9.1 Definition of an integrated management and monitoring system

An automated, integrated spectrum management and monitoring system typically consists of a national spectrum management centre and multiple fixed and mobile monitoring stations. The stations are interconnected via a network to allow voice and data communications. All of the stations in the network, including both spectrum management and spectrum monitoring stations, exchange information electronically and/or share common databases. Monitoring stations can be remotely controlled. Computer software at all stations in the system has the same “look and feel”, providing a common human interface throughout the system.

A typical integrated system is illustrated in Fig. 5.8. The configuration (number of stations, number of workstations at each station, etc.), methods of communication (transmission control protocol/Internet protocol (TCP/IP) or other protocol; use of the public switched telephone network (PSTN); radio or satellite), and other details will vary according to the application. In some configurations, a monitoring centre may be present which is connected directly to the monitoring stations and in turn to the management centre.

The spectrum management system consists of a database server with one or more workstations and software which:

1) manages the database of frequency assignments;

2) provides a variety of engineering analysis tools to analyse propagation and determine if a given path with given communications equipment will support the desired communications;

3) displays geographic maps superimposed with results of analyses, and

4) interfaces to a spectrum monitoring system to perform a variety of functions including automatic detection of licensing violations.

The spectrum management system includes a large relational database, accepts a variety of inputs including applications for licences, issues a variety of notices and reports, and connects to monitoring stations.

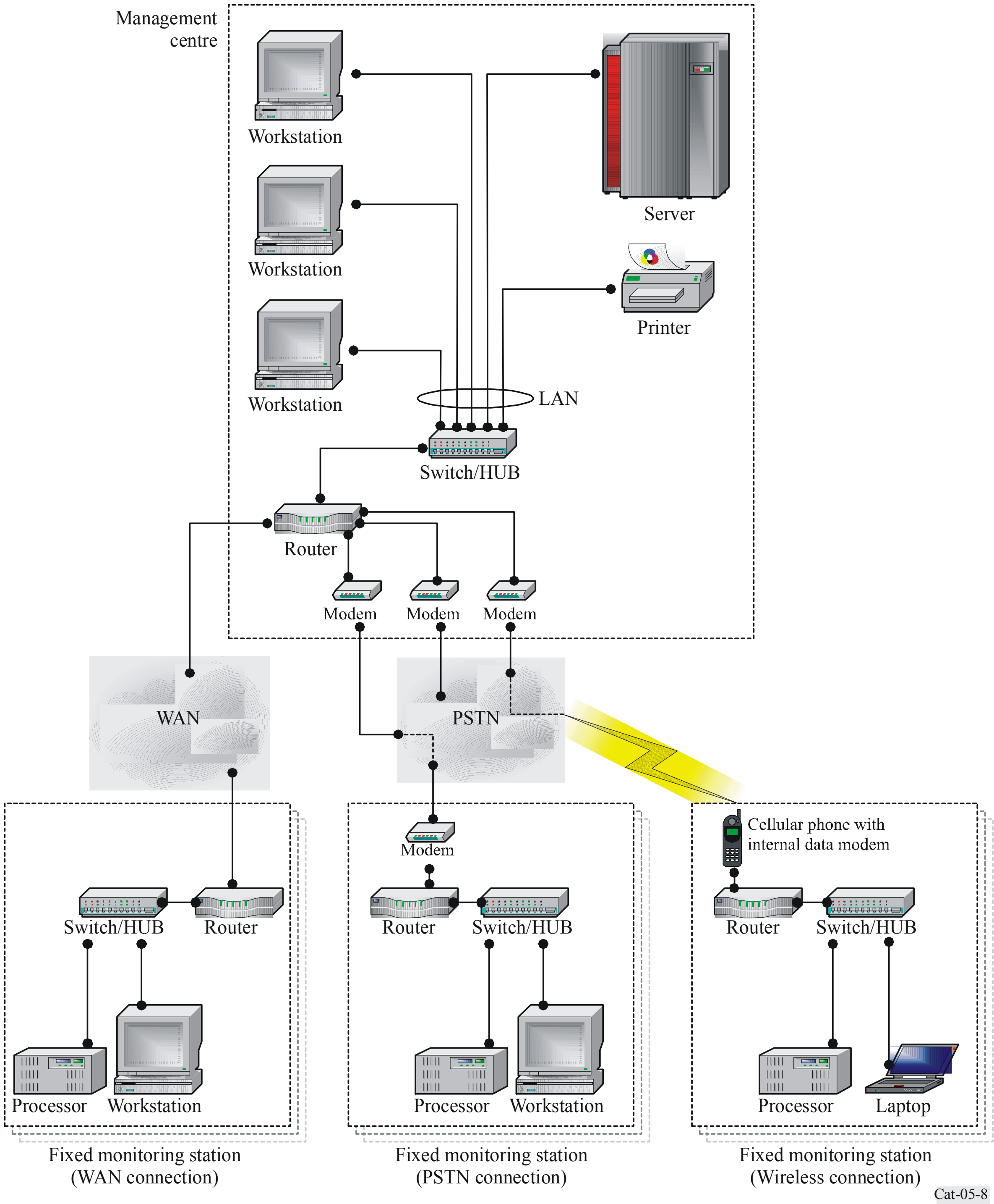
Monitoring systems automate the process of performing spectrum occupancy, parameter measurement and direction finding (DF) to verify clear channels and identify and locate sources of interference. In the past, monitoring systems have included a large collection of test and measurement equipment to perform spectrum occupancy and specific signal parameter measurements. With the recent revolution in digital signal processing (DSP), a monitoring system now consists of only two elements:

1) a small group of sophisticated measurement equipment modules, including antennas and receivers, operated by a computer which is often referred to as a measurement server; and

2) computer workstations or clients which are used for operator interface and which contain computer software which make the system easy to use and maintain.

FIGURE 5.8

Typical integrated spectrum management and monitoring system



5.9.2 Importance of an integrated system

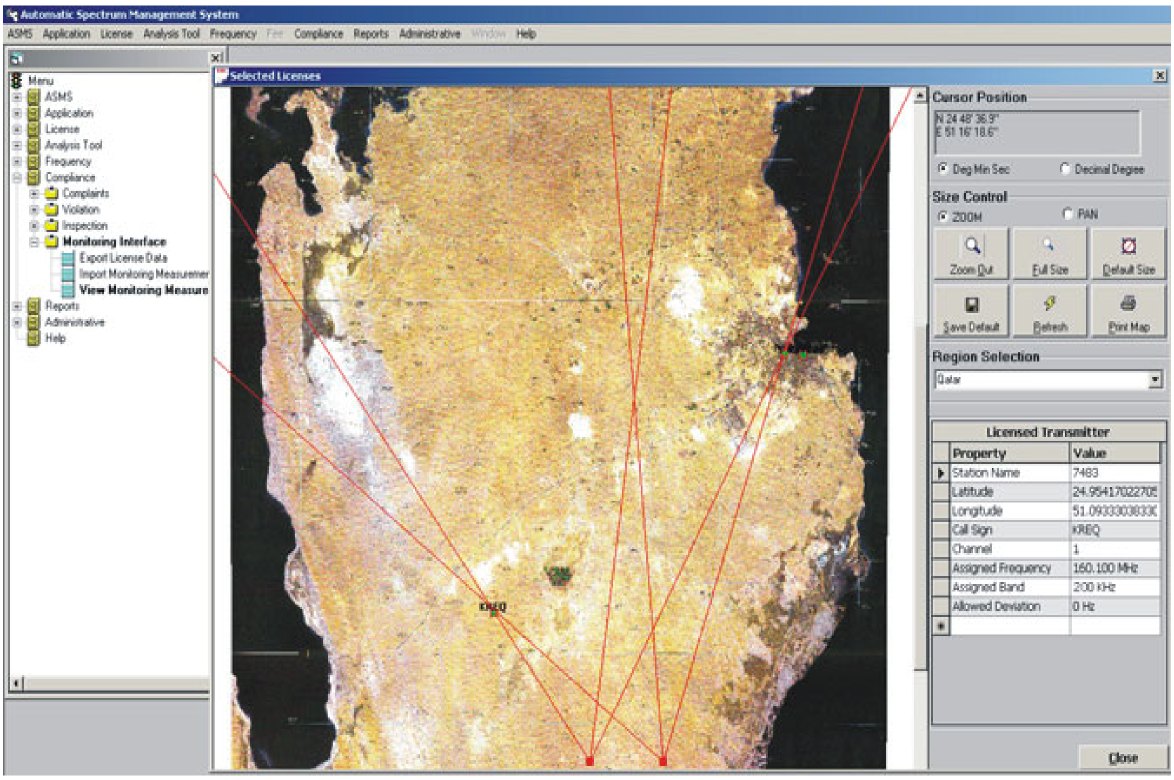
A key feature of an integrated, automated spectrum management and monitoring system is its ability to access and compare information from the management and monitoring databases to automatically determine stations which are likely to be unlicensed or operating outside their licensed parameters.

The operator specifies a frequency band of interest, and the system performs spectrum occupancy, and parameter and DF measurements and compares these measurements against information in the licence database. The system flags frequencies where signals are found where there is no corresponding licence, and frequencies where the parameter measurements do not correspond with those licensed. This function is known as automatic violation detection (AVD) and is a very important function of a modern, automated, integrated system.

The results of the AVD function may be displayed in tabular or graphical form. A tabular display shows for each channel whether a signal has been found, and if so whether there is a licensed station at this frequency and whether the measured signal is compliant or not compliant with its licensed parameters. The measured locations of signals and the locations of corresponding licensed stations may be displayed on a geographic map, such as the map illustrated in Fig. 5.9, to allow the operator to visualize the results. This Figure illustrates the locations of two monitoring stations (red squares at the bottom of the figure) and three licensed stations (green squares), and shows the measured locations (lines of bearing intersection) of the two currently transmitting stations. The Figure shows one licensed station is currently not transmitting (a green square with no lines of bearing), and shows the location of an unlicensed transmitter (lines of bearing intersection with no green square).

FIGURE 5.9

Typical map display illustrating AVD data



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Another important feature of a fully integrated system is the ability of an operator, with proper authority, at any management or monitoring workstation, to access and utilize the resources of the entire system, including:

– use of the licence database;

– remote tasking and control of monitoring stations;

– production and review of reports which combine information from the management and monitoring databases;

– performance of other functions an operator needs to do to effectively manage the radio spectrum.

A fully integrated spectrum management and monitoring system provides common human and computer interfaces throughout the system, which greatly facilitates training and use of the system.

Case study 9: Planning and design of spectrum monitoring networks

Software is available for planning and optimization of spectrum monitoring networks or groups of monitoring stations. As an investment in a monitoring sub-system is a major part of the total spectrum management system investments, the optimisation and efficient planning of the monitoring networks have great technical and economic significance.

The software permits administrations and operators:

– to obtain exact and quantitative information on the real situation with capabilities of their actual national monitoring networks or groups of fixed monitoring stations in fulfillment of all monitoring functions: emission parameter measurements (including listening), DF and location by triangulation; detailed atlases of monitoring coverage at different frequencies (in the range 30-3 000 MHz) and with various test transmitter parameters (power and antenna height) can be developed;

– to assess, by considering various options, a gain which can be achieved by upgrading monitoring equipment parameters (mainly – monitoring receiver sensitivities for different monitoring functions and DF instrument or system accuracies) as well as monitoring antenna heights and gains of fixed monitoring stations;

– to identify areas where one or another monitoring function is not fulfilled or fulfilled with limited quality by existing fixed monitoring stations; these areas can be candidates for optimized installation of new monitoring stations;

– to identify those fixed monitoring stations that do not provide significant contribution to the overall monitoring coverage and can be eliminated or transferred to other places to achieve better coverage;

– to develop technically and economically sound plans for upgrading and extension of the existing monitoring networks or groups of fixed monitoring stations;

– to develop plans for the creation of new monitoring networks or groups of fixed monitoring stations in the most efficient manner;

– to optimize the operation of mobile monitoring/DF stations during their missions by a prior calculation of relevant service areas at different points along their route.

As an additional function, the software permits the calculation of coverage areas of radio transmitters working in the "point-to-area" mode (mainly broadcasting and land mobile ones) based on minimum usable field strength threshold values (Recommendation ITU-R BS.638).

The software implements a methodology initially developed in [Kogan and Pavliouk, 2004a and b]. It calculates actual monitoring coverage areas for all monitoring functions (listening, measurements, DF and location) based on field strength determination taking into account terrain features of the region under consideration, using provisions of Recommendation ITU-R P.1546. The calculation routine is outlined in Fig. 5.10.

Due to the fact that location by triangulation requires availability of DF coverage by at least two DF stations in a test point under consideration, in this case it is not possible to use a field strength calculation methodology along propagation paths given by various azimuths from each station as it is usually used for broadcasting and mobile communications coverage calculations. It is necessary to implement more sophisticated (and more time consuming) methodology – to calculate field strength values at each fixed monitoring station created by a test transmitter placed in each test point (upper part and sequence of operations A, Fig. 5.10).

By a field strength data matrix calculated for each pixel of the screen, borders of coverage areas for listening, measurements and DF are calculated and can be displayed. Using the data for terrain elevation profile along any selected path, together with related field strength, the distribution data can be calculated and displayed (display 4, Fig. 5.10). Example of coverage area calculation for one of monitoring stations in the group of three stations, together with a terrain elevation profile along the path *k*, is presented in Fig. 5.11.

The field strength data matrix is the basis for calculation of overall location coverage area and sub-zones of different location accuracies with known probability (location coverage templates), as it is shown at lower part and sequence of operations A, Fig. 5.10. At each pixel of the display screen, it is determined at which DF in the group field strength exceed a threshold level necessary for reliable DF operation, and then instrumental (system) errors of these DFs are re-calculated into location uncertainty achieved with known probability under triangulation operation. It is clear that for location by triangulation there should be a minimum two DFs at which the field strength exceeds the threshold level. Therefore location is the most sensitive and limiting monitoring operation and location coverage calculations should be taken as a basis for monitoring network planning and optimization, if sufficient coverage within a certain region is required.

FIGURE 5.10

System for optimal planning and design of spectrum monitoring networks

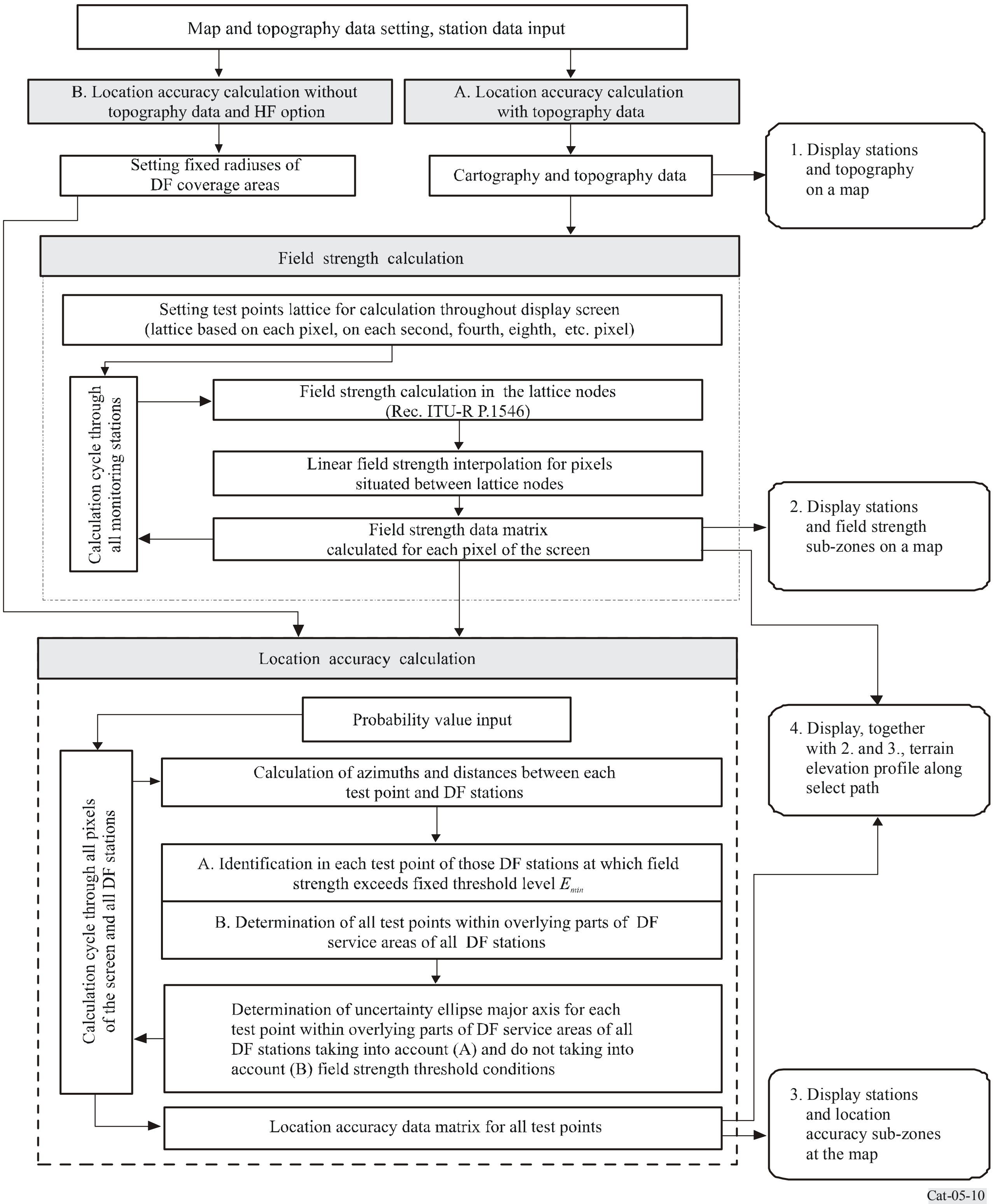
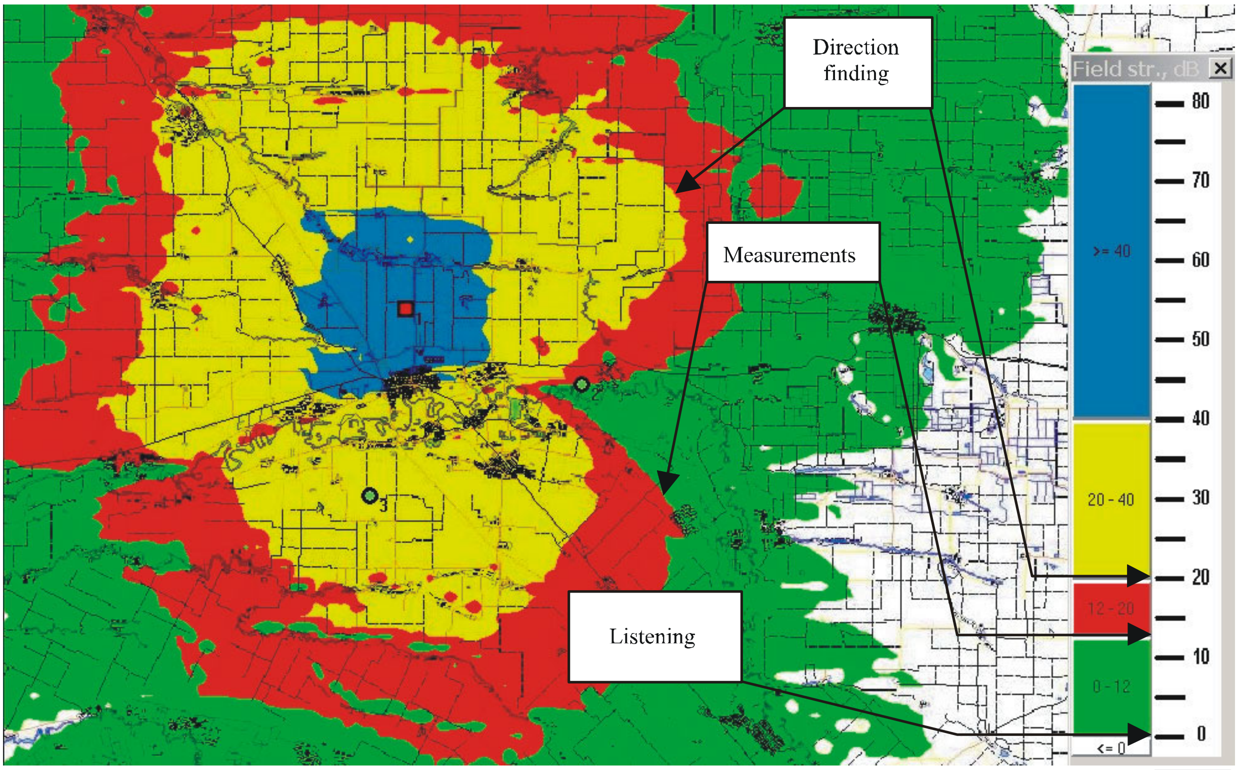


FIGURE 5.11

Monitoring coverage areas



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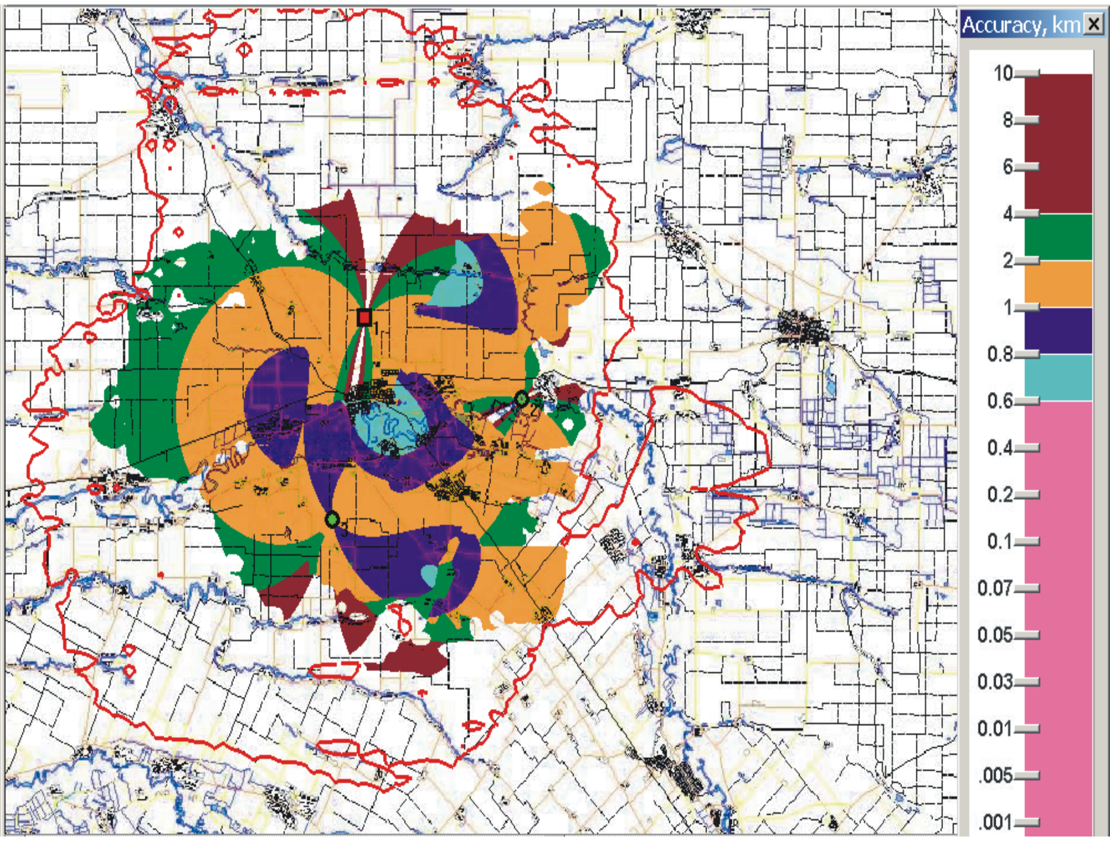
Example of location coverage area calculation for the same group of three monitoring/DF stations (as in Fig. 5.11), together with a terrain elevation profile along the path *m*, is presented in Fig. 5.12a). Red (thick in black and white display) line gives overall DF coverage area of these three monitoring/DF stations). As it follows from the right-hand palette at this Figure, the program permits to display up to 16 colour gradations of location accuracy, covering the range from 10 m to 10 km (for V/UHF option). Some of these gradations can be combined resulting in decreasing number of gradations (Fig. 5.12b)) for more distinctive their visibility in black and white display.

For comparison purposes, the program permits calculation of location coverage templates without taking into account exact terrain features in the region under consideration, with fixed radiuses of circular DF coverage areas (sequence of operations B, Fig. 5.10). The same procedure is used for location coverage calculation in HF frequency band. It estimates maximum possible location coverage areas and templates under smooth Earth condition in VHF/UHF frequency band and under perfect HF propagation conditions – uniform propagation in all directions from the HF DF stations within their DF coverage areas.

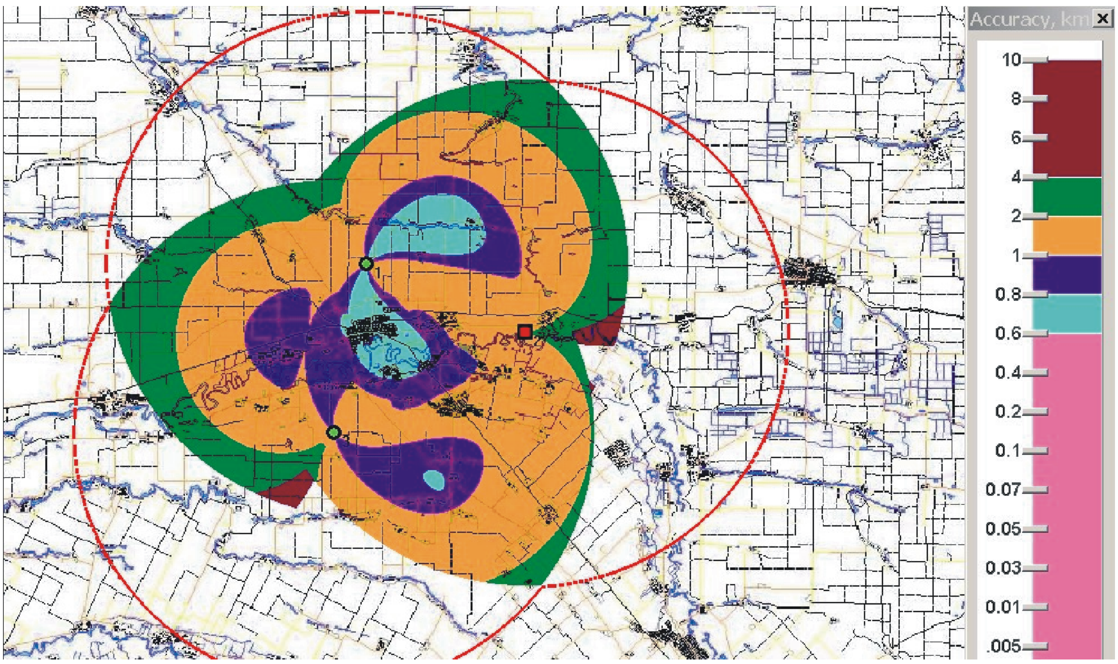
Example of such location coverage calculations in VHF/UHFN frequency band for the same group of three monitoring/DF stations (as in Fig. 5.11) is presented in Fig. 5.12b). Comparison of Figs 5.12a) and 5.12b) permits a better evaluation of particular terrain features that influence location coverage templates.

FIGURE 5.12

Location coverage templates



a)



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b)

References

KOGAN, V. V. and PAVLIOUK, A. P. [June 2004a] Methodology of spectrum monitoring networks planning. Proc. of the Seventeenth International Wroclaw Symposium on EMC. Wroclaw, Poland.

KOGAN, V. V. and PAVLIOUK, A. P. [June 2004b] Analysis of location coverage templates in spectrum monitoring. Proc. of the Seventeenth International Wroclaw Symposium on EMC. Wroclaw, Poland.

ANNEX 1

SPECTRUM MANAGEMENT DATA TABLES

1 Tables A1-1 to A1-6 were prepared as inventories of data elements which should be considered during a data-analysis phase to design and implement an automated inter and intra-administration spectrum management system. These inventories were first compiled during studies carried out by CCIR Interim Working Party (IWP) 1/2 in conjunction with the IFRB. They have been updated by Radiocommunication Study Group 1. The definite source for data requirements for coordination and notification remains RR Appendix 4 with additional descriptions and formatting outlined in the Radiocommunications Data Dictionary (Recommendation ITU-R SM.1413) and therefore these requirements are not repeated in this Annex.

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 data required for National Spectrum Management and notification to the ITU-BR. Recommendation ITU-R SM.667 recommends that the data fields specified in previous versions of this Annex should be used.

2.2 the sub-set of data used for ITU-BR notification purposes should be compatible with ITU-BR data record and data element specifications. In order to ensure that this is so, Administrations are invited to review all the relevant Circular Letters on the ITU website on a regular basis.

3 The following abbreviations are used in the Tables:

BC: broadcasting

RR: Radio Regulations

TX: transmitting

BR IFIC: (ITU International Frequency Information Circular that includes the PIFL (Preface to the International Frequency List))

GE 75: the LF/MF Broadcasting Agreement (Region 1 and Region 3), Geneva, 1975

GE 84: the Regional Agreement for FM Broadcasting (Region 1 + , Geneva 1984

RJ 81: the Regional Agreement for MF Broadcasting (Region 2), Rio de Janeiro, 1981.

TABLE A1-1

Basic national frequency allocation data

No.	Data element	Number of characters (A or B.C)[(1)]		Definitions
		A	B.C	
1	Lower frequency band limit		12.6	The lower frequency limit of the band being allocated
2	Frequency unit	1		H = Hz; k = kHz; M = MHz; G = GHz
3	Nature of the frequency limit	1		I = international (ITU); N = national
4	Upper frequency band limit		12.6	The upper frequency limit of the band being allocated
5	Service	30		The name of the service being allocated. (Code still to be established) (RR 20-57)
6	RR category of service	1		The RR category of the service being allocated (P = Primary, S = Secondary)
7	National category of service	1		If different from the RR category
8	Function	40		The name of a function within the service to which the band is allocated (ex.: radio-beacon, distress and calling)
9	Band allocation footnote	7		The footnote number that allocates the service to the band (where appropriate)
10	Service footnote	7		Footnote number that restricts the use of the service
11	Band footnote	7		Footnote number that restricts the use of the band
12	Class of station	30		Indicates the class of station permitted by the allocation, using the symbols shown in Table 6A1 of the PIFL or RR Appendix 10. More than one class of station can be entered separating each class of station by a space
13	National spectrum management agency or ministry	10		National spectrum management agency or ministry managing the assignments in a given band and for a given service
14	ITU Region	1		Indicates the ITU Region in which the service is allocated

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

TABLE A1-2

Licence holder: indicative list of data

No.	Data element	Number of characters (indicative)	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; M: modification; 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	Billing name	30	
10	Billing address	60	
11	Licence fee		To be defined
12	Date licence fee is due		
13	Date licence fee is paid		
14	Telephone number	12	If required, 3 more characters for country codes
15	Telefax number	12	
16	email address	20	
17	X-400 address	40	
18	Telex code	12	

NOTE – ( ) Indicates that number depends upon code size being used.

TABLE A1-3

Equipment characteristics data: indicative list

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	Optional	A	B.C	
1.	*General data*					
1.1	Transaction and date of action					
1.1.1	Kind of transaction	x		1		Code, e.g.: N: new registration M: modification D: deletion
1.1.2	Date of transaction	x			4.0	Indicates month and year of action
1.2	Source of data			1		Code, e.g.: T: technical description of equipment R: measuring test report; etc.
1.3	Security classification		x	1		Code, e.g.: U: unclassified R: restricted C: confidential S: secret T: top secret
1.4	Type of equipment	x		1		Code, e.g.: S: complex system C: combined TX/RX facility T: independent transmitter R: independent receiver A: antenna, etc.
1.5	System or equipment nomenclature	x		16		Indicates code designation of system or equipment
1.6	Manufacturer and country of origin					
1.6.1	Manufacturer	x		12		
1.6.2	Country of origin		x	3		Code, e.g.: abbreviations according to the PIFL

TABLE A1-3 (*continued*)

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	Optional	A	B.C	
1.7	Equipment deployment and function					
1.7.1	Deployment				1.0	Code, e.g.: 1: civil 2: military 3: civil/military
1.7.2	Function			1		Code, e.g.: A: radiotelephone B: sound broadcasting C: television-broadcasting D: radio-relay; etc. The second character indicates supplementary characteristics
1.8	Equipment platform and mobility					
1.8.1	Equipment platform		x	1		Code, e.g.: A: airborne L: ground R: on rivers, canals, lakes S: space; etc.
1.8.2	Mobility					Code e.g.: F: fixed, permanently installed T: fixed during operation, but transportable M: mobile, but not portable, operation possible during movement P: portable
1.9	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 equipment		x		5.0	Indicates the number of equipment in use on the territory of a state

TABLE A1-3 (*continued*)

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	Optional	A	B.C	
1.11	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				1.0	
1.11.3	Number of antennas				1.0	
2.	*Transmitter data*					
2.1	Transmitter nomenclature	x		15		Indicates manufacturer's designation of transmitter type
2.2	Tunable frequency range					
2.2.1	Tunability	x		1		Code, e.g.: F: fixed TX-frequency S: TX-frequency switchable in steps 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: H: Hz k: kHz M: MHz G: GHz
2.3	Switchable modulation types					
2.3.1	Necessary bandwidth	x		4		Code according to RR Appendix 1
2.3.2	Class of emission	x		5		Code according to RR Appendix 1. These records are furnished several times to accommodate different classes of emission if switchable

TABLE A1-3 (*continued*)

No.	**Data element**	**Status**		**Number of characters (A or B.C)**		**Definitions**
		Basic	**Optional**	**A**	**B.C**	
2.4	Number of pre-set channels	x			4.0	
2.5	Channel separation					
2.5.1	Unit	x		1		Code: H: Hz k: kHz M: MHz
2.5.2	Value of channel separation				9.4	Channel separation
2.6	Transmitter power					
2.6.1	Tunability	x		1		Code, e.g.: T: TX-power tunable F: TX-power fixed
2.6.2	Type of power					Code, e.g.: C: carrier power D: effective radiated carrier power M: mean power N: effective radiated mean power P: peak envelope power Q: effective radiated peak envelope power R: equivalent isotropically radiated power S: maximum power averaged over any 4 kHz delivered to the antenna T: maximum power averaged over any 1 MHz delivered to the antenna
2.6.3	Lower limit of tunable power range	x			4.1	Value
2.6.4	Upper limit of tunable power range	x			4.1	Value
2.6.5	Unit	x		1		Code: U: microwatt L: milliwatt W: watt K: kilowatt M: megawatt G: gigawatt

TABLE A1-3 (*continued*)

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	**Optional**	**A**	**B.C**	
2.7	Transmitter output type		x		2.0	Code, e.g.: 01: transistor 02: magnetron 03: klystron; etc.
2.8	Special pulse modulation description		x		2.0	Code, e.g.: 01: pulse CW 02: pulse FM/CW 03: pulse compression; etc.
2.9	Pulse width					
2.9.1	Tunability		x	1		Code, e.g.: F: fixed pulse width 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.: N: nanoseconds U: microseconds L: milliseconds
2.10	Pulse repetition frequency (PRF)					
2.10.1	Tunability		x	1		Code, e.g.: F: fixed PRF T: tunable PRF
2.10.2	Lower limit of PRF		x		4.0	PRF (kHz)
2.10.3	Upper limit of PRF		x		4.0	PRF (kHz)
2.11	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

TABLE A1-3 (*continued*)

No.	**Data element**	**Status**		**Number of characters (A or B.C)**		**Definitions**
		Basic	**Optional**	**A**	**B.C**	
2.12	FM-CW deviation ratio					
2.12.1	Tunability		x	1		Code, e.g.: F: fixed T: tunable
2.12.2	Lower limit of FM-CW deviation ratio				4.0	
2.12.3	Upper limit of FM-CW deviation ratio		x		4.0	
2.12.4	Unit		x	1		Code: H: Hz k: kHz
2.13	Attenuation of harmonics					
2.13.1	Attenuation of the 2nd harmonic	x			3.0	Attenuation (dB)
2.13.2	Attenuation of the 3rd harmonic	x			3.0	Attenuation (dB)
3.	*Receiver data*					
3.1	Receiver nomenclature	x		15		Indicate manufacturer's designations of receiver type
3.2	Tunable frequency range					
3.2.1	Tunability	x		1		Code, e.g.: F: fixed RX-frequency S: tunable in steps T: continuously tunable
3.2.2	Lower limit of frequency range	x			9.4	
3.2.3	Upper limit of frequency range				9.4	
3.2.4	Unit	x		1		Code: H: Hz k: kHz M: MHz G: GHz
3.3	Switchable modulation types					
3.3.1	Bandwidth	x		4		Code according to RR Appendix 1

TABLE A1-3 (*continued*)

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	Optional	A	B.C	
3.3.2	Class of emission	x		5		Code according to RR Appendix 1. These records are furnished several times to accommodate different classes of emission, if switchable
3.4	Type of receiver		x	1		Code, e.g.: A: detector B: single superheterodyne C: multiple superheterodyne, etc.
3.5	Receiver sensitivity				3.0	Sensitivity (dBm)
3.6	Number of pre-set channels				4.0	
3.7	Channel separation					
3.7.1	Value of channel separation				9.4	
3.7.2	Unit					Code: H: Hz; k: kHz; M: MHz
3.8	Receiver selectivity 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
3.9	Mixer and IF stages					
3.9.1	Mixer type		x	1		Code, e.g.: A: additive mixing B: broadband ring mixing with pulse shaper M: multiplicative mixing 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

TABLE A1-3 (*continued*)

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	Optional	A	B.C	
3.9.6	Local oscillator position		x	1		Code, e.g.: A: up-conversion in normal position B: up-conversion in inverted position C: down-conversion in normal position D: down-conversion in inverted position These records are furnished three 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 (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
4.2	Frequency range					
4.2.1	Adjustability	x		1		Code, e.g.: F: antenna frequency range not adjustable 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: k: kHz; M: MHz; G: GHz
4.3	Class of antenna	x		1		Code: T: transmitting antenna R: receiving antenna C: transmitting and receiving antenna

TABLE A1-3 (*continued*)

No.	**Data element**	**Status**		**Number of characters (A or B.C)**		**Definitions**
		Basic	**Optional**	**A**	**B.C**	
4.4	Type of antenna	x			2.0	Code, e.g.: 01: dipole 02: half-wave dipole 03: full-wave dipole etc.
4.5	Antenna characteristic	x		1		Code, e.g.: N: non-directed D: directional (unidirectional) X: directional (revolving)
4.6	Antenna polarization		x	1		Code, e.g.: H: horizontal V: vertical C: circular, etc.
4.7	Isotropic gain of antenna					
4.7.1	For horizontal polarization	x			3.1	Gain (dB)
4.7.2	For vertical polarization	x			3.1	Gain (dB)
4.8	Type of antenna feed and line attenuation					
4.8.1	Antenna feed		x	1		Code, e.g.: A: parallel-wire line B: coaxial line C: rectangular wave guide; etc.
4.8.2	Line attenuation		x		3.1	Line attenuation (dB)
4.9	Antenna scanning cycles					
4.9.1	Adjustability					Code, e.g.: F: fixed scanning rate 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				4.0	Scanning cycles per minute
4.10	Antenna rotations					
4.10.1	Adjustability		x	1		Code, e.g.: F: fixed rotation rate T: variable or adjustable rotation rate

TABLE A1-3 (*end*)

No.	Data element	Status		Number of characters (A or B.C)		Definitions
		Basic	Optional	A	B.C	
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
4.11	Antenna dimension					
4.11.1	Dimension		x	1		Code, e.g.: L: effective length of antenna D: effective area of antenna, etc.
4.11.2	Value				3.0	Value (m)
4.12	Antenna scan method		x	1		Code, e.g.: E: rotary scan within a limited sector R: 360° rotary scan V: vertical sector scan N: horizontal and vertical sector scans, etc.
4.13	Half-power beam width					
4.13.1	Horizontal		x		4.1	Beam width (degrees)
4.13.2	Vertical		x		4.1	Beam width (degrees)
4.14	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)
4.15	Vertical antenna diagram					
4.15.1	Multiplication factor		x		2.0	Indicates the value of the factor (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
4.15.2	Values of isotropic gain at 9 desired angles		x		18.0	(Each value: 2 characters)

TABLE A1-4

Frequency monitoring data: indicative list

No.	Data elements	Number of characters	Volume of information		
			BR IFIC		Adminis-tration
			Reduced	Compre-hensive	
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			
6	Designation of emission (RR Appendix 1)	5	x	x	x
7	Type of system	6	x	x	x
8	Type of user and operational equipment function	4			x
9	Class of station	2	x	x	x
10	Nature of service	2			x
11	Country in which transmitter is located	3			x
12	Name or call sign	20	x	x	x
13	Location information	15		x	x
14	Corresponding station	20		x	x
15	Remarks	18		x	x
16	Assigned frequency	11		x	x
17	Notice of ITU-BR registration	1			
	Total	149	8	12	15

TABLE A1-5

Data elements for monitoring: indicative list

No.	Data element	(1)	No. of characters	
			(A or B.C)(2)	
			A	B.C
1	Monitoring station: name or call sign location (3)	1 1	20 15	
2	Data of measurement	10		6.0
3	Time of measurement (UTC)	10		6.0
4	Frequency (4)	1	1	10.5

TABLE A1-5 (*end*)

No.	Data element		(1)	No. of characters (A or B.C)(2)	
				A	B.C
5	Frequency offset	(4)	10	1	6.1
6	Field strength	(5)	10		4.1
7	Harmonic	(5)	10		4.1
8	Harmonic	(5)	10		4.1
9	Sub-harmonic	(5)	10		4.1
10	Sub-harmonic	(5)	10		4.1
11	Azimuth of the emission	(6)	10		5.0
12	Name of other monitoring stations and their evaluation of the azimuth	(3), (6), (7)			
	1. Station: name or call sign		1	20	
	location		1	15	
	azimuth		10		5.0
	2. Station: name or call sign		1	20	
	location		1	15	
	azimuth		10		5.0
	3. Station: name or call sign		1	20	
	location		1	15	
	azimuth		10		5.0
	4. Station: name or call sign		1	20	
	location		1	15	
	azimuth		10		5.0
13	Location of the emission	(3), (8)	10	15+1	
14	Class of emission		1	5	
15	Maximum modulation deviation	(4)	10	1	4.1
16	Maximum modulation depth	(9)	10		4.1
17	Maximum modulation frequency	(4)	10	1	4.1
18	Code (teletype)		10	16	4.1
19	Baud rate (teletype)	(10)	10		5.0
20	Shift (teletype)	(11)	10		4.0
21	Bandwidth	(4), (12)	1/10	1	4.1
22	AF information (comment)	(13)	1	80	
23	Readability	(14)	1	2	
24	Receiver and analyser settings. Test system description	(15)	1	x	
25	Activity list (concluded events)	(16)	x	26	
26	Class of station		1	2	
27	Name or call sign		1	20	
28	Country of transmitter location		1	3	
29	Corresponding station		1	20	
30	Operators comments			80	

Legend to Table A1-5:

(1) Number of data fields (some parameters are measured and stored more often to achieve higher reliability of data).

(2) A or B and C

A: number of alphanumeric characters;

B: total number of numeric characters;

C: number of decimal characters.

(3) Coordinates of locations are defined by longitude and latitude as follows:

3 characters: degrees longitude;

1 character E (East) or W (West);

2 characters: minutes longitude;

2 characters: seconds longitude;

2 characters: degrees latitude;

1 character: N (North) or S (South);

2 characters: minutes latitude;

2 characters: seconds latitude.

Location coordinates of mobile monitoring stations have to be stored for evaluation of the collected data.

(4) The first character indicates the unit: H (Hz), k (kHz), M (MHz), G (GHz).

(5) Values (dB(μV/m)).

(6) The azimuths are stored by a value from 0 (=North) clockwise to 359 with standard deviation (2 digits).

(7) The azimuths obtained from other monitoring stations could be displayed on a map (preferably on a colour video screen).

(8) Besides the location, a quality factor is stored.

(9) Values (%).

(10) Values (Bd).

(11) Values (Hz).

(12) If bandwidth is measured manually, one data field should be efficient.

(13) A tape number can be stored here, if the AF was recorded.

(14) Readability is stored in numbers from 0 to 5. The storage of two numbers is possible, if the signal quality fluctuates significantly.

(15) The quantity of data depends on the equipment used.

(16) A concluded event could contain the following information:

– Time of appearance and disappearance (12 characters)
– Minimum and maximum measured level (4 characters)
– Minimum and maximum frequency offset (10 characters).

Some additional information is needed for a list of concluded events.

The number of concluded events depends on the observation period, on the resolution of data (pause time) and the stability of the activity status.

TABLE A1-6

Automated monitoring of licensed frequencies data: indicative list

No.	Data element		(1)	No. of characters (A or B.C)(2)	
				A	B.C
1	Monitoring station: name or call sign		1	20	
4	Frequency	(3)	1	1	10.5
5	Frequency offset	(3)	2	1	6.1
6	Field strength	(4)	2		4.1
7	Harmonic	(4)	2		4.1
8	Harmonic	(4)	2		4.1
11	Azimuth of the emission	(5)	2		3.0
12	Name of other monitoring stations and their evaluation of the azimuth	(5)			
	1. Station: name or call sign		1	20	
	azimuth		2		3.0
	2. Station: name or call sign		1	20	
	azimuth		2		3.0
	3. Station: name or call sign		1	20	
	azimuth		2		3.0
	4. Station: name or call sign		1	20	
	azimuth		2		3.0
15	Modulation deviation	(3)	2	1	4.1
16	Modulation depth	(6)	2		4.1
17	Modulation frequency	(3)	2	1	4.1
18	Code (teletype)		1	16	4.1
19	Baud rate (teletype)	(7)	2		5.0
20	Shift (teletype)	(8)	2		4.0
21	Bandwidth	(9)	2	1	4.1
24	Receiver and analyser settings; Test system description	(10)	1	x	
25	Time schedule of transmission	(11)	x		8.0

A reference number should be stored for access to the corresponding data of the frequency assignment file.

Legend to Table A1-6:

(1) Number of data fields:

1: The measured parameter must be exactly equal to the stored parameter in the data field.

2: The measured parameter must be within the boundaries stored in the data fields.

(2) A or B or C

A: number of alphanumeric characters;

B: total number of numeric characters;

C: number of decimal characters.

(3) The first character indicates the unit: H (Hz), k (kHz), M (MHz), G (GHz).

(4) Values (dB(μV/m)).

(5) The limits of an acceptance section are defined by two numerical values from 0 (=North) to 359 (clockwise). Rotation to the first value followed by a clockwise rotation to the second value defines the angular range of acceptance. An azimuth outside the acceptance section could imply a deterioration in signal quality.

(6) Values (%).

(7) Values (Bd).

(8) Values (Hz).

(9) This data field is only necessary if emission bandwidth is measured automatically.

(10) The quantity of data depends on the equipment used.

(11) A time schedule of the allowed transmission can consist of single blocks which contain the time of appearance and disappearance (8 characters).

ANNEX 2

ELLIPSE – Spectrum Automated Spectrum Management System

Managing the radio-frequency spectrum means that several aspects must be taken into account: frequency assignments, file management, fee calculations, technical standards set-up, radio frequency monitoring. The large quantity of information and the volume of data to be handled have generated a time-consuming manual process (e.g. creation, update, analysis). The implementation of information technology systems is nowadays vital, economically viable and highly recommended by the ITU.

Cril Telecom Software (CTS) has studied the principles and techniques of optimized spectrum management as defined by ITU related Conferences, Handbooks, Recommendations (e.g. Recommendation ITU-R SM.1370), and the Radio Regulations (RR).

CTS has designed and developed ELLIPSE Spectrum, a state-of-the-art Automated Spectrum Management System compliant with the above-mentioned publications and covering all the ITU Recommendations for frequency planning, licensing, fee collection, administration, engineering studies and international coordination. ELLIPSE Spectrum is also in line with other international and regional relevant standards such as ICAO, CEPT/ECC, ETSI, etc. It is a versatile tool dedicated to spectrum regulatory authorities for their administrative and technical spectrum management tasks. In addition to the high quality of its spectrum management scope of functions, ELLIPSE Spectrum also provides a high level of interactivity with spectrum monitoring systems, as recommended by the ITU-R (Recommendation ITU-R SM.1047 and ITU-R SM.1537). ELLIPSE Spectrum addresses these issues, while leaning as well towards the financial and business aspects of spectrum management.

ELLIPSE Spectrum is a multi-user, multi-task and multilingual fully integrated and highly modular software tool. It offers a user-friendly GUI interface, uses ORACLE as a Relational Database Management System (RDBMS), and features a full-fledged Geographical Information System (GIS).

ELLIPSE Spectrum is based, in its standard configuration, on a scalable Client/Server architecture, where the Server could be a UNIX SUN SOLARIS Server, a Linux or a Windows INTEL Server. The Client is a Windows Personal Computer (PC). It is also available on a standalone PC, or a mixed platform: A stand alone PC that could connect to a Client/Server Platform or operate in a disconnected mode. Its multi-user client/server configuration allows different departments to work together on the same and unique ORACLE relational reference database, while having appropriate data protection and security features. It allows user specific access roles. This provides a consistent and seamless software package. It may be web enabled. ELLIPSE Spectrum features a unique versatile workflow module. This module’s flexibility allows any regulator’s internal organization or processes to be entered in the system.

ELLIPSE Spectrum provides for a significant level of parameterization allowing for easy customization by the users for modules such as: licensing, reporting, workflow, billing, etc.

ELLIPSE Spectrum is field-proven and has been in service, while evolving, since 1993. ELLIPSE Spectrum has an unprecedented list of references in its field being used by many important telecommunications regulatory bodies around the world.

ELLIPSE Spectrum has been designed to assist regulatory bodies and administrations in their daily tasks to achieve efficient frequency management in accordance with national and international related regulations. It covers both administrative and technical aspects of spectrum management activities.

1 Administrative and technical modules

ELLIPSE Spectrum features modules to cover the following administrative and technical spectrum activities.

Data entry and output

- Intuitive and user friendly graphical user interface (GUI) for technical and administrative data entry
- Reference data libraries
- Spectrum user management and associated accounts
- Statistics on important database elements such as users, geographical areas, equipment, services, licenses, etc.
- Static and dynamic reports and administrative document generation in different languages (e.g. English, French, Spanish, Arabic)
- Interface with MS OFFICE®
- Customized reports using CRYSTAL REPORTS®, virtually limited only with database elements.

Policies and Regulations

- Service definition according to ITU Radio Regulations
- Frequency allocations and footnotes (RR Article 5)
- National frequency plan management
- Libraries for ITU technical parameters
- Equipment type approval.

International coordination

- ITU regional agreements (e.g. ST61, GE75, RJ81, GE84, GE89)
- Generation of ITU-R notification forms on paper or electronic output formats compatible with ITU TeRaSys (e.g. T01-T04, T11-T17, RR Appendix 4)
- Direct access to SRS and BR IFIC DVDs
- International coordination process follow-up
- Set up of technical studies to optimize coordination results
- Coordination contour generation for geostationary satellite earth station according to RR Appendix 7
- Interface with ITU tools for coordination in space services.

Inspection and control (frequency monitoring)

- Inspection planning, results and history management
- Interference and complaints management
- Interface with monitoring and surveillance systems as recommended by Recommendations ITU-R SM.1047 and ITU-R SM.1537 allowing to initiate control missions and collect results.

Licensing and billing

- License processing management
- User definable license format and layout
- Fee calculation and billing
- Workflow module for automatic application management. This unique versatile workflow module's flexibility allows any internal organization or process to be entered in the system
- Online license application form through web browser interface
- Possible interface with general ledger system.

Engineering analysis and technical data management

- Advanced engineering calculation features for radio services, e.g.:
  - Fixed services: point-to-point, point-to-multipoint and broadcasting feeder links
  - Mobile services: land mobile (e.g. cellular, PMR), maritime mobile and aeronautical mobile networks
  - Broadcasting services: LF, MF, HF, FM radio, analogue TV, T-DAB, DVB-T

  - Radio amateur services
  - Fixed satellite services
  - HF communications.
- Availability of a wide range of propagation models, including Tunable Proprietary ELLIPSE Model.
- Choice of fast and powerful applications to assign new frequencies for each type of service
  - *C*/*I* analyses and electromagnetic compatibility (EMC), including intermodulation, receiver sensitivity and transmitter noise analysis
  - Aeronautical versus VHF-FM broadcasting compatibility calculations (LEGBAC)
  - Orbit avoidance
  - Frequency assignment according to National Frequency Plan
  - Route/area coverage.

2 Geographical Information System (GIS) and Cartographic Database

ELLIPSE Spectrum features a full-fledged Geographical Information System (GIS).

- Full cartographic database availability:
  - Digital Terrain Model (DTM)
  - Clutter maps
  - Vectors and Planimetry
  - Digital (Building) Elevation Model (DEM)
  - Raster Maps
  - Ortho-images
  - Measurement result import and display.
- Interface with External GIS tools (e.g. ArcView, MapInfo)
- Easy correlation between terrain, network and propagation models
- Fast and efficient user-friendly engineering process:
  - Multi-layer overlay: transparent or interleaved modes
  - User defined colour legend associated to thresholds
  - 3D-viewer
  - 4-split mosaic window.

3 Architecture and platform

Ellipse Spectrum offers a powerful and scalable architecture that is capable of managing hundreds of thousands of sites and guarantees secured data sharing in a multi-user/multitask environment.

– Access rights management through operator profile

– ORACLE Relational Database Management System (RDBMS)

– UNIX SOLARIS, Linux or Windows server with MS Windows PC client stations. Available as well on a stand alone PC, or a mixed platform: A stand alone PC that could connect to a Client/Server Platform or operate in a disconnected mode.

– Unique Reference Database together with User Working Database

– Multi-thread computation

– Web enabled.

4 Security

ELLIPSE Spectrum features several levels of security at operating system, application and data level. This allows the system to be shared between various organizations (e.g. civil and military) that can work independently from one another not knowing the other user's data while still taking this data into account in technical calculations.

5 Customization

ELLIPSE Spectrum provides for a significant level of parameterization allowing for easy customization by the users for modules such as: licensing, reporting, workflow, billing, etc.

6 Documentation

User Application Operational Manuals are available directly from the application and where fields are context sensitive.

7 Licensing mode

The ELLIPSE Spectrum licenses are floating licenses per module:

– Virtually no limitation in the number of users that may connect to the application

– Virtually no limitation in the number of user profiles/logins that can be created

– All application modules can be used from any workstation on the network (satisfying the minimal hardware, basic software, application software configuration and networking requirements).

The limitation only applies to the number of simultaneous users for a given module: if N users are licenced, the $N + 1$ user trying to use the module simultaneously will be rejected by the system.

8 Data migration

A set of program tools is customizable to migrate existing electronic data into ELLIPSE Spectrum Database.

9 Training

Efficient training is essential for proper use and operation of ELLIPSE Spectrum. Training programmes are designed and carefully structured to provide necessary skills for productive and effective daily System's operation. Training may be arranged either on client sites or in France, near Paris.

CTS may offer on site on-the-job training and technical assistance to allow its customers to make the best possible use of its solutions.

10 Warranty, maintenance and support

ELLIPSE Spectrum is usually provided with a minimum of 12 months of warranty, maintenance and support. The maintenance and support contract is renewable. The maintenance contract includes an access to a Hotline via phone, fax and email; support through a remote access to the system using dedicated tools through Internet (e.g., WEBEX Service) or dial-up modem. It includes bug corrections and provision of new versions releases of the software within the same scope of functionalities. First level of support and limited services may eventually be provided by CTS local partners.

ANNEX 3

IRIS – Spectrum Management System

General

The Spectrum Management System (SMS) performs several basic functions that altogether form an integrated system that supports nationwide frequency management administration activities. The users of SMS share a central database through LAN/WAN data communication network. The SMS consists of the following basic software applications:

– Iris Spectrum Management Software Application

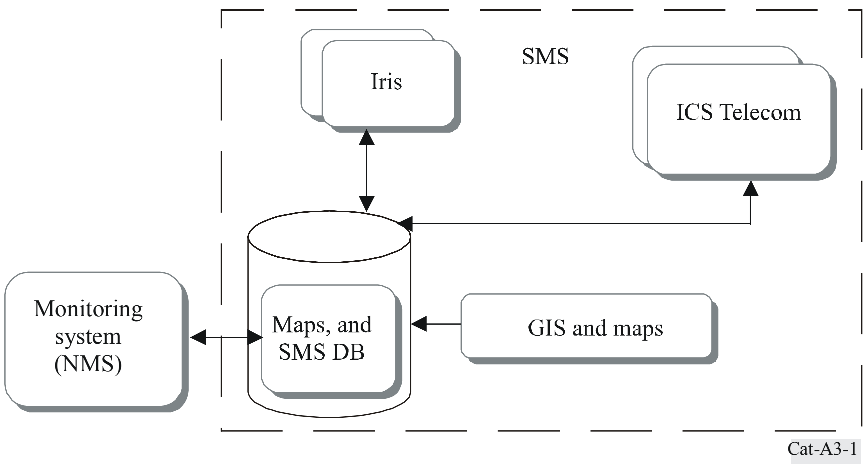
– ICS Telecom Spectrum Engineering Software Application

– Geographic Information System (GIS).

Figure A3.1 describes the integrated Automated Spectrum Management System configuration. It features the main software components and the interfaces between them.

FIGURE A3.1

SMS configuration



Iris uses advanced engineering simulation tools, when dealing with the engineering stages of each procedure (for instance: choosing a suitable site location).

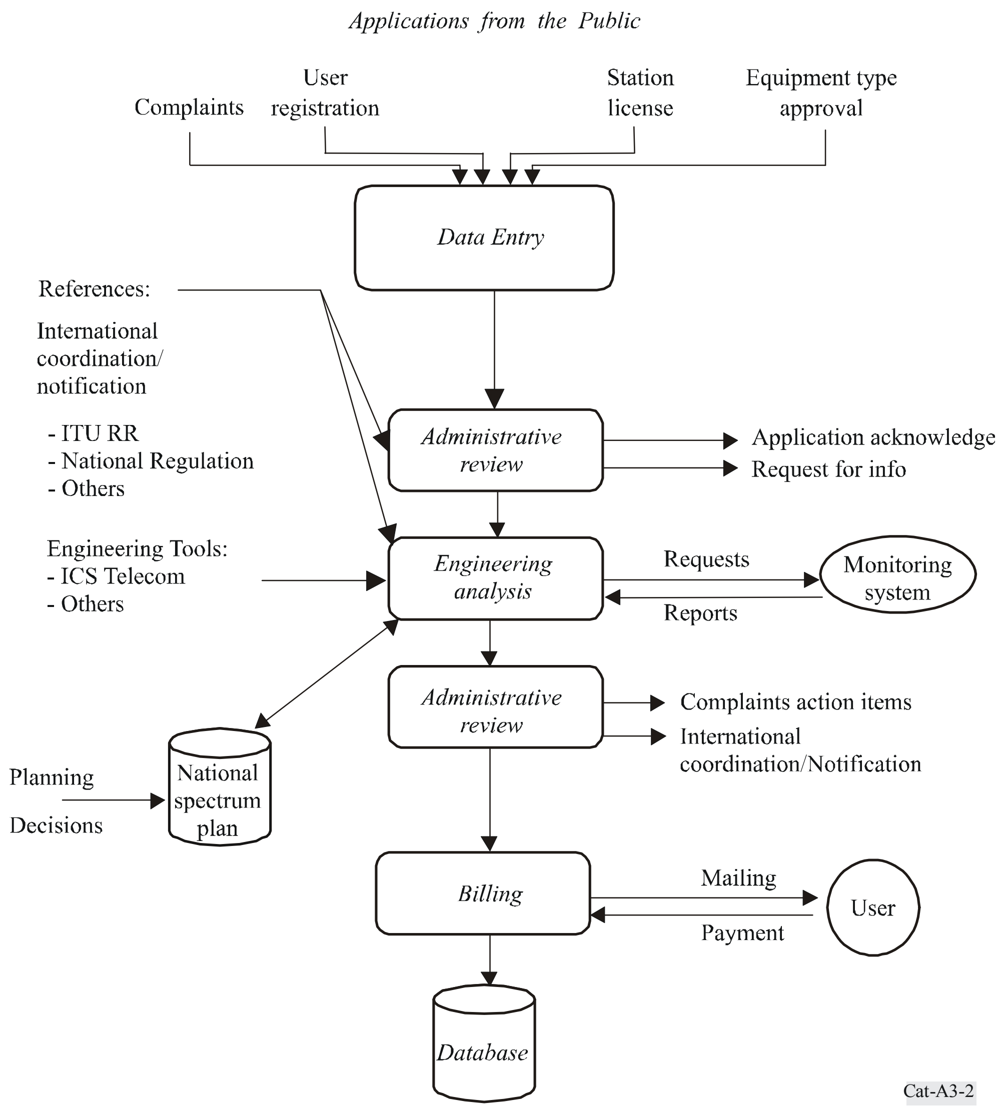
The related Iris system data is exported to the ICS Telecom system, where it is utilised for engineering simulations and calculations.

Iris functional description

Figure A3.2 depicts the functional diagram of Iris and its interface with the Monitoring System, and ICS Telecom engineering application as part of the frequency management process.

FIGURE A3.2

***Iris* functional diagram**



Iris controls and tracks the processes, which comprise the Spectrum Management as described in the Figure. The system ensures that the correct forms are available at each stage of the process and that applications are automatically progressed to the next stage, as each process is completed.

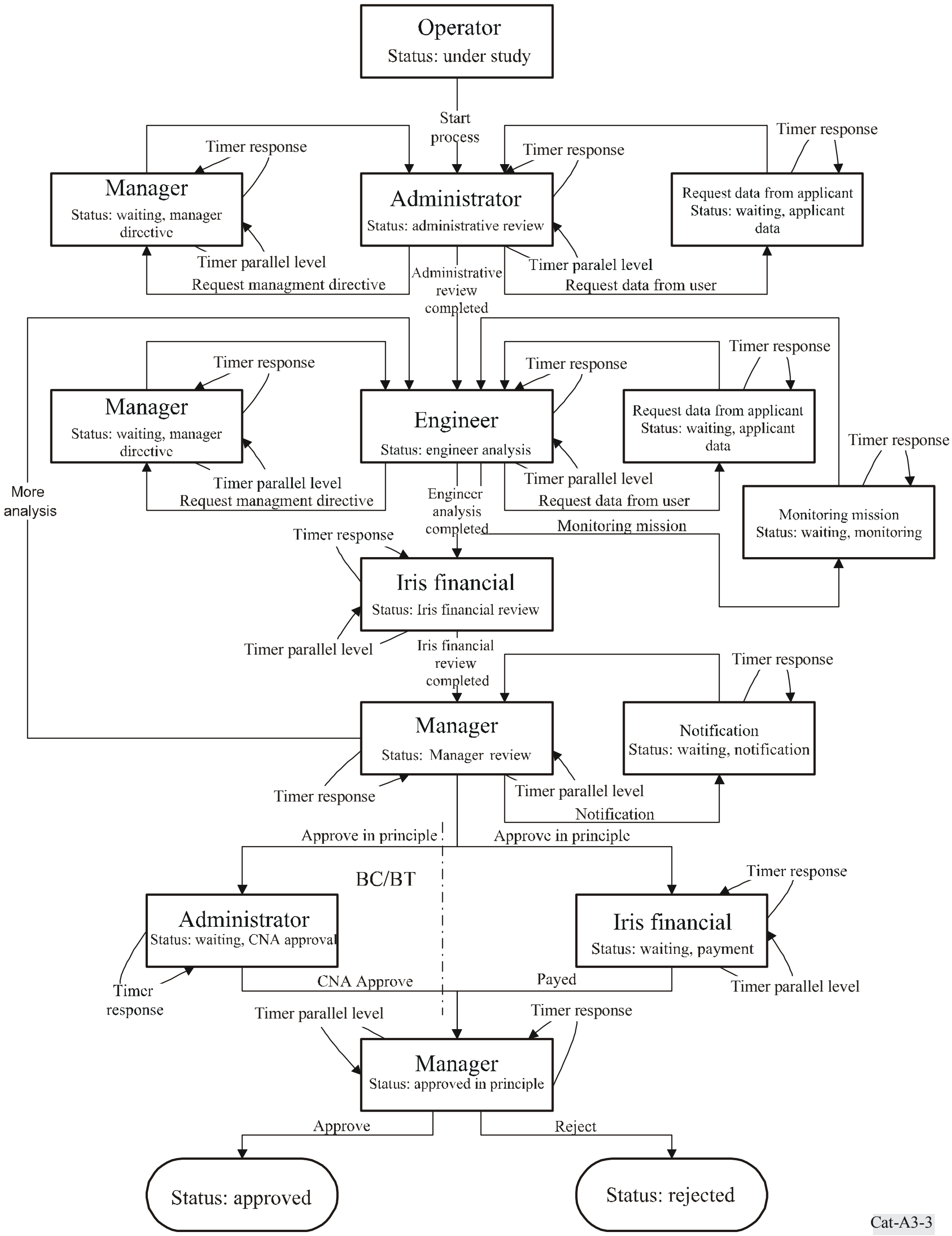
Processes in Iris

Iris has a capability of managing main records through a controlled process. The controlled process is based on transfer of records through predefined Iris operators. Each operator will check his received records, add to it data, or perform certain tests or checkups regarding that data. When finished, he will transfer the record to the next Iris operator with his recommendations for further handling of the record.

As an example, the process of licensing a station is described below. The process itself is graphically delineated Fig. A3.3.

FIGURE A3.3

Station Licensing Process



2 RFI analysis

2.1 The system provides the following spectrum engineering support:

2.1.1 Transmitter station area coverage for one or more stations (composite coverage, best server coverage, power sum display, margin display, simultaneous or overlapping display, reliability coverage, DF coverage).

2.1.2 Interference: co channel (C/I mode), adjacent channel (IRF mode), coverage + interference.

2.1.3 Network and microwave assignment and planning

This tool enables to user to evaluate the potential interference of a selected candidate fixed terrestrial microwave network against other fixed terrestrial microwaves stations.

2.1.4 Radar coverage

One of the features of the radar object is its maximum covering range or "radar limit" expressed by R/RO (km). This range is used in the radar coverage calculation.

2.1.5 Traffic analysis + grade of service (for cellular networks, CDMA GSM).

2.1.6 Jamming (global jamming efficiency) and statistics options.

2.1.7 Human hazards and electromagnetic risks (EEC 1999/519 is used for the field strength calculations).

2.1.8 Satellite (GEO or non-GEO coverage analysis, coverage on map, space to earth interference).

The program provided new functions dealing with satellites:

Satellite database functionalities; Spatial coverage and PTP calculation with: user defined attenuation or Recommendation ITU-R P.618 attenuation component.

2.2 Border coordination

International coordination is needed for certain frequency assignments. Recommendation ITU-R SM.1049 is used for coordinating terrestrial assignments in border areas.

ANNEX 4

RAKURS – An applications package for Spectrum Management in the broadcasting service

Introduction

The applications package known by the Russian acronym RAKURS, providing analysis and simulation for spectrum management, is designed to handle the tasks of geographical spectrum planning and frequency assignments within a given country for the broadcasting service (analogue and digital television and sound broadcasting in the VHF and UHF bands) and other services sharing the broadcasting service's bands on an equal basis. Applications include: examining frequency assignments, developing recommendations for selecting frequency channels for new or modified frequency assignments, and tracking frequency assignments. It is also widely used for the purposes of bilateral and multilateral coordination of frequency assignments in border regions and their recording by ITU.

The current version of RAKURS is in fact the fourth generation of the package. The first version entered service at the end of the 1970s, and since then it has not only been in continuous operation, but also undergone constant improvements, as spectrum management and computer experts have refined it to keep pace with developments in information technology and the appearance of new ITU-R Recommendations, and to take into account the experience acquired.

Design philosophy

An overall block diagram of the system's design is given in Fig. A4.1. An important component is the subsystem for high-volume data collection, storage, search and processing. The system uses a database created with Informix dynamic server technology, with software designed to protect data integrity and perform administrative tasks, entry and correction of information in the database, and search and classification of information. The database contains information about administrative and technical characteristics of frequency assignments, equipment models and specifications, synchronous digital broadcasting networks and so on.

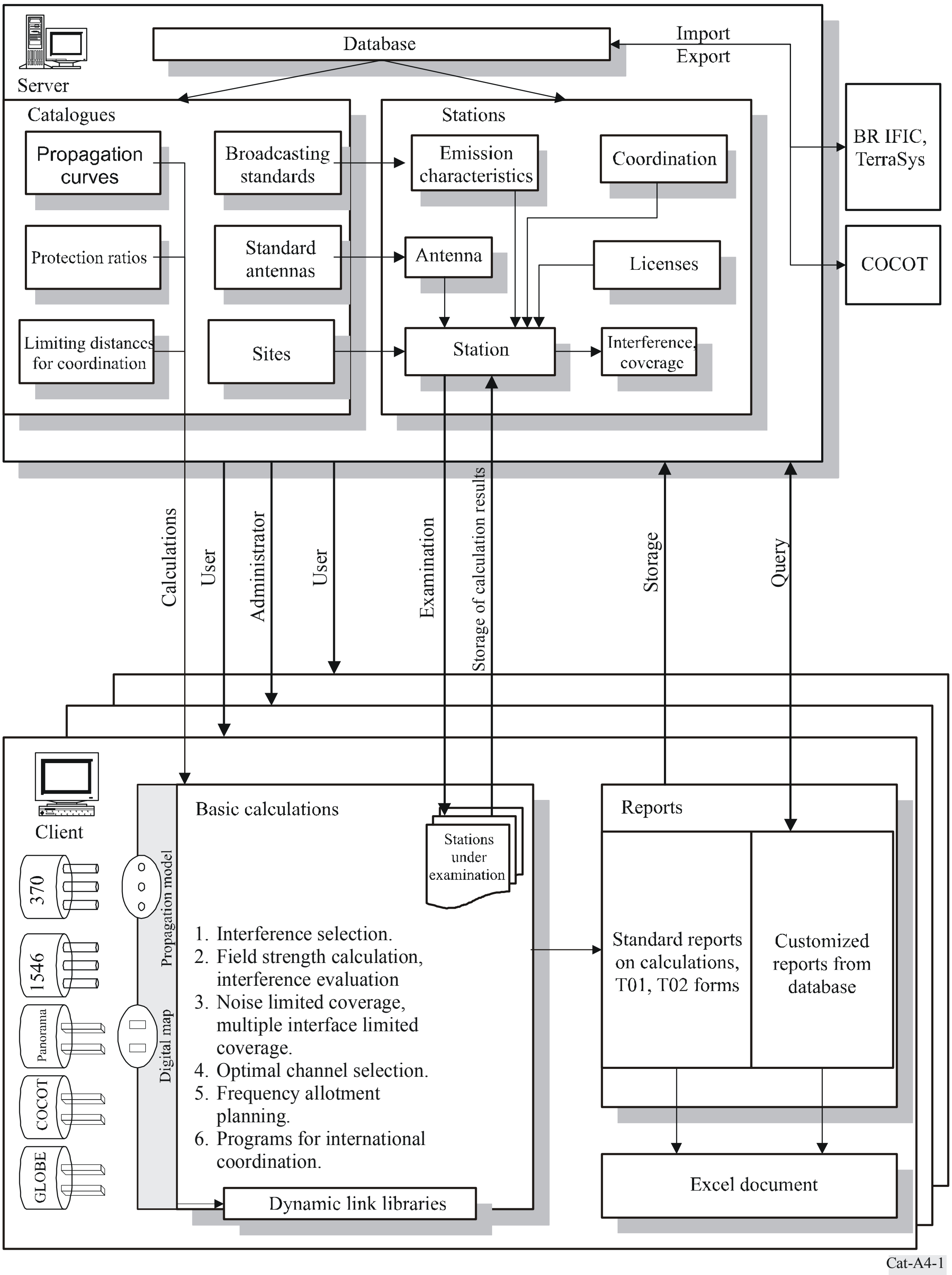
RAKURS allows data to be loaded or saved in a variety of standard formats; thus, it is possible to import data from Radiocommunication Bureau circulars and export data in all generally accepted international formats.

The applications package also includes a command set for the Informix server which can be used for backing up and restoring databases, greatly enhancing the operational reliability of the system.

RAKURS was designed for a maximum of flexibility, to enable it to meet different requirements for frequency planning data without changes to the software code. For example, the system can handle tables of propagation curves, service allocations among frequency bands, broadcasting standards and frequencies, protection ratios etc. Thus, the database consists, not only of entries for transmitting stations and frequency assignments, but also of a great number of electronic catalogues.

RAKURS works on a client-server basis, with users communicating with the server through a local network. It can thus support a large number of users working at any one time. The package supports customized access rights for each user, identified by a login and password. In this way it is possible to define user groups, each with its own set of access rights.

FIGURE A4.1



Analysis software

The applications package was developed in accordance with ITU-R Recommendations and international agreements on technical parameters and methods of spectrum planning and multilateral coordination. The basic parameters for geographical spectrum planning are taken from the ITU-R documentation listed in Table A4-1.

TABLE A4-1

	Recommendation ITU-R
Terms and definitions	BS.638, V.431
Transmission standards, technical requirements for broadcasting	BS.450, BS.707, BS.774, BT.470, BT.804, BT.1206
Radiowave propagation	P.370, P.1145, P.1146, P.1546
Minimum field strengths, protection ratios, space separation, etc.	BS.412, BS.599, BS.773, BT.417, BT.419, BT.565, BT.655, SM.851

Analysis is always based on a calculation of the field strength generated by the transmitting station at a given geographical location. Two calculation methods have been implemented in the software, the first corresponding to Recommendation ITU-R P.370 and the second to Recommendation ITU-R P.1546. The desired method is selected via dynamic link libraries (DLLs); in this way, new methods can be incorporated with an appropriate interface. The two standard methods require data about terrain relief and bodies of water; accordingly, the system has been designed to work with digital terrain data.

The software supports different formats of terrain data for example: Panorama (www.gisinfo.ru), GLOBE (www.ngdc.noaa.gov/seg/topo), etc. As digital maps are also handled via DLLs, it is possible to use other terrain data without any need to change the core of the program.

Analysis programs

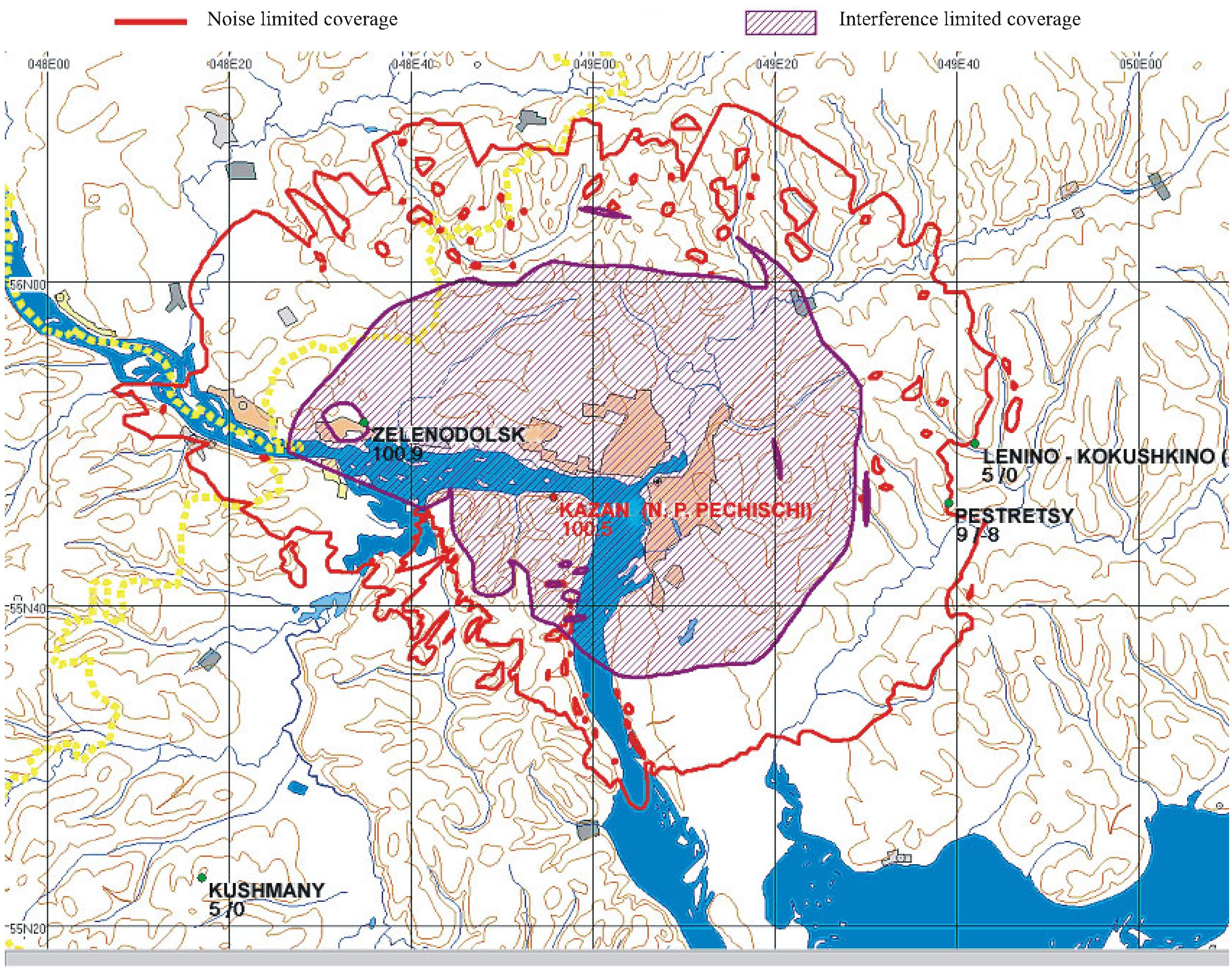
The software includes a variety of different tools for performing EMC calculations and analysis. Analysis is based on a selection of interference for a given station. Interference is considered in the form of stations in shared, overlapping, adjacent, mirror, or heterodyne channels, as well as stations with frequencies which have a second or third-order harmonic coinciding with the given station's frequency.

The simplest kind of analysis is to examine EMC at a single geographical location specified by the operator. It gives a value of field intensity, a list of interference sources, and their respective interfering fields (taking into account protection ratios, space and polarization discrimination, and the terrain), as well as the value of overall interference in accordance with the different methods.

Another type of analysis is used to determine the shape of a station's service area. The service area may be calculated under ideal conditions, or with actual interference taken into account. In constructing the service area, the local terrain profile is used, identifying the resulting shadow zones inside the service area. The system can construct the line-of-sight area for a station and overlay it on a map of the service area. The service area is determined by performing calculations for different directions and plotting the results on a digital administrative map. An example of such a simulation is shown in Fig. A4.2. Both analogue and digital scenarios are supported. Results are provided in two forms: tables of numerical results, and graphic results plotted on a map.

FIGURE A4.2

Coverage calculation



Cat-A4-2

The system features a channel selection optimization program that can recommend the best analogue and digital TV channel in the light of existing spectrum use in the area. Another module can prepare frequency allotment plans for digital broadcasting systems.

The system includes several modules for international coordination. They include a module that can indicate whether a given station requires coordination with other countries' stations in various services, based on EMC considerations; a module that determines the changes in the electromagnetic situation resulting from a station that has been notified for coordination; a module that be used to determine the necessary changes to a station's technical parameters to comply with sharing criteria; and others.

Any of these calculations can be performed either for a single station, or for an entire group of stations. The system is also capable of performing a batch analysis for all stations of a given network, taking into account their mutual interaction.

The results are stored in the database until such time as the user decides to delete them actively. This allows users to draw on historical analysis results whenever needed.

Reports and queries

The reporting module makes up a separate part of RAKURS. It can be launched from inside the latter, or in autonomous mode. The documents created are in Excel spreadsheet format. In autonomous mode, the reporting module creates an output document in response to a database query. Queries can be formulated without any knowledge of SQL (Structured Query Language), thanks to a straightforward but powerful interface that gives access to the database for virtually any type of query. If the module is called up from inside RAKURS, it remains in the background, creating standard reports for each concrete situation. When a user works with a particular station, all the documents generated are compiled into a single Excel workbook.

Bibliography

Elektrosvyaz [2003], **7**.

ANNEX 5

SIRIUS – National System for Spectrum Management

1 Introduction

An Automated National System for Spectrum Management, known as SIRIUS was developed in Kyrgyz Republic and has been in operation since 2003. The system was designed to be simple and intuitive in its design and operation, and to be used effectively under conditions typical for developing countries, i.e. limited staff resources without any specialized training beyond basic radio technology. The system fully complies with Recommendation ITU-R SM.1604 – Guidelines for an upgraded spectrum management system for developing countries. It was further designed to perform all of the core functions that are typically performed by more powerful and complex systems, including multi-user access and simulations using digital terrain data. SIRIUS has shown itself to be very user-friendly in an environment where the number of frequency assignments is not too large (up to 50 000-100 000), which is also typical of developing countries.

2 The SIRIUS system

The automated spectrum management system SIRIUS was developed using modern technological platforms, topology and IT architecture, ensuring a high level of security, reliability, integrity, safety of information and rapidity of response. Multi-user data processing on the basis of client-server technology provides many advantages for the organization of a central database, unique user interface, security and audit systems, and strategies for backing up, restoring, logging, and importing and exporting data.

SIRIUS was developed in compliance with the following:

– ITU-R Recommendations (ITU-R SM.1370, ITU-R SM.1604, ITU-R SM.1048, ITU-R SM.1413, ITU-R SM.667).

– Evaluation methods and analysis models for EMC and calculation procedures given in relevant ITU-R Recommendations and regional and inter-regional agreements.

SIRIUS is capable of performing the following core functions.

– Administrative module:
  – licensing of frequency assignments;
  – domestic and international coordination and notification;
  – invoicing and fines.

- Engineering analysis module:
  - spectrum use planning;
  - different analytical methods of assessing station SNR and EMC;
  - general-purpose engineering analysis tools for calculating interference and coverage areas for stations, path analysis etc. using digital terrain data.
- Monitoring module:
  - recording interference complaints, investigating and eliminating interference;
  - preparation of spectrum monitoring jobs for monitoring stations;
  - collection and analysis of spectrum monitoring data;
  - analysis of emission measurements for comparison with database.

SIRIUS operates with the following inputs:

- administrative and technical data of frequency assignments;
- data from domestic and international tables of frequency allocations;
- hardware and antenna catalogues;
- data from coordination distance tables;
- service data required for operation of SIRIUS;
- terrain data.

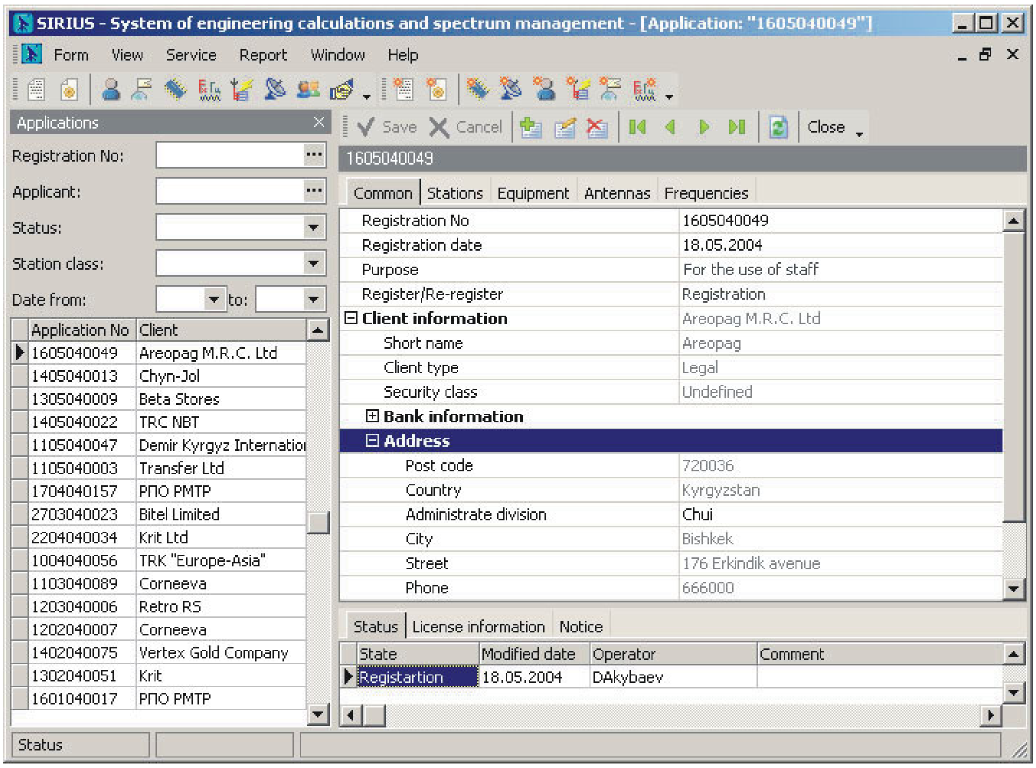
3 Administrative module

The following functions are included in the administrative module:

- Recording of frequency assignment notices in the system. Verifying that information provided is complete and correct.
- Verification of notified frequency assignment for compliance with international and domestic tables of frequency allocations.
- Registration of licences for frequency assignments in the system.
- Entry of data from certification and approval of antennas in the system.
- Generation of notices for coordination of frequency assignments (domestic and international coordination).
- An adaptable system for calculation of fees and fines for spectrum utilization.
- Administrative and technical reports.
- Data storage for domestic and international tables of frequency allocations.
- Importing and exporting data.
- Backing up and restoring data.
- Registration of system users, audits.

FIGURE A5.1

Administrative module



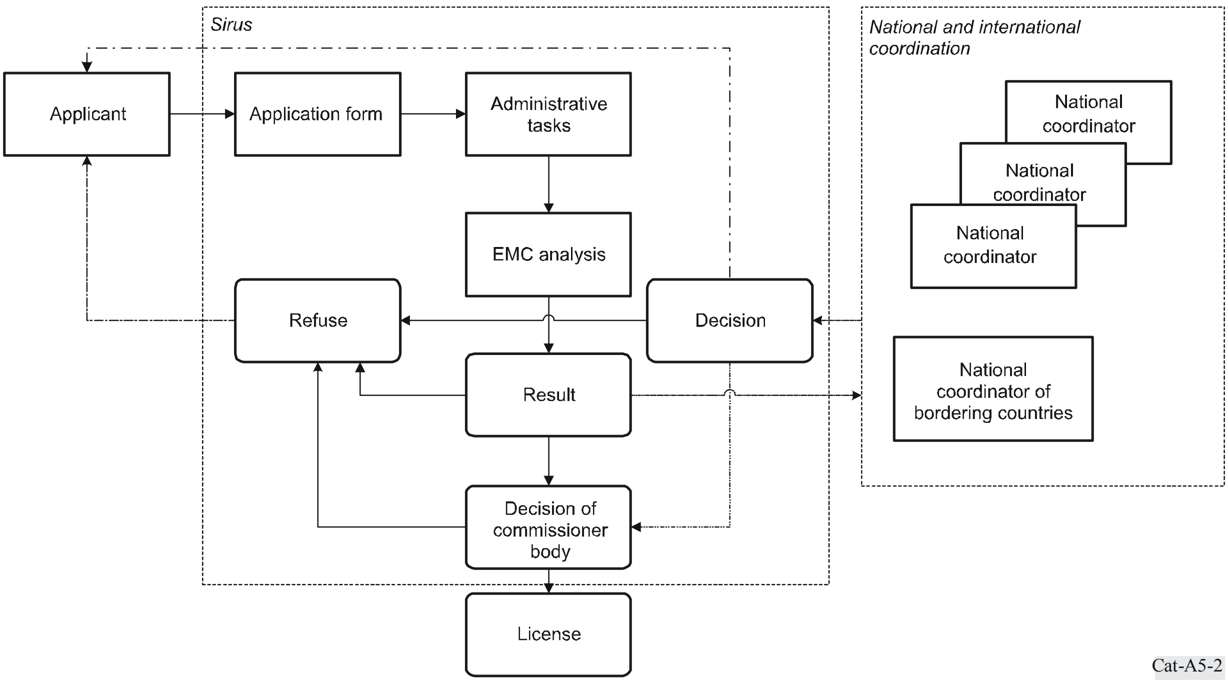
Cat-A5-1

Licensing frequency assignments

The client completes a form for notification of a frequency assignment and submits it to the national administration, in paper or electronic form. The flow diagram in Fig. A5.2 illustrates the sequence of actions taken in SIRIUS for the licensing process.

FIGURE A5.2

Flow diagram



Cat-A5-2

The operator enters the application for a frequency assignment in the system. After verifying that the information provided is correct and complete, the system assigns the application the status “under consideration”. If the applicant failed to supply all of the information required, the status “registration” is assigned. If the results of the EMC analysis are positive, the application is forwarded for coordination at the domestic and international level. The frequency assignment is only carried out if the results at every stage are positive. If there is an unsatisfactory result at any stage, the operator changes the notice parameters in consultation with the client. The system is capable of automatically extracting data from notices submitted electronically.

4 Domestic and international coordination, notification to ITU-R

SIRIUS can prepare requests for inter-agency and international coordination using the correct ITU-R notification forms required for the category of station to be coordinated. The coordination process is based on existing regulations and agreements, concluded between the coordinating parties or in the form of regional agreements. To this end SIRIUS incorporates the coordination methods and procedures contained in regional agreements such as Geneva 1984, Geneva 1989, Stockholm 1961, Berlin 2003 and others.

Coordination requests are handled in SIRIUS like any other request for a frequency assignment, except that specific statuses are assigned.

Once the forms have been prepared, they can be forwarded to ITU-R for notification purposes in either electronic or paper form, indicating the coordinating countries.

5 Reports

The system offers the following reports:

– *Standard reports:* statistical, administrative, technical and financial reports. Examples: number of applications received, applications with positive results, rejected applications, results of examination of applications, coordination results, etc.

– *Report generator:* a flexible system that can be used to formulate different reports, based on templates and scripts.

The report generator creates reports by means of a report wizard. The report wizard selects the necessary data (entries) and selection criteria, and formulates the query. It is also possible to create reports using macro scripts.

6 Technical and administrative database

The structure of database complies with Recommendation ITU-R SM.667, providing for performance of the core system functions.

SIRIUS has an adaptable interface which allows the user to customize the forms used to enter and edit data, depending on technical characteristics and administrative requirements.

For the main objects, the system tracks all changes in status, giving the date, the operator and an explanation of the change. Logging status changes makes it possible to determine the delays for administrative processing of applications received, and to formulate administrative queries to determine spectrum utilization effectiveness and efficiency.

7 Engineering analysis module

The following functions are included in the engineering module:

– Spectrum planning tools.

– Analytical tools for the broadcasting, mobile and fixed services.

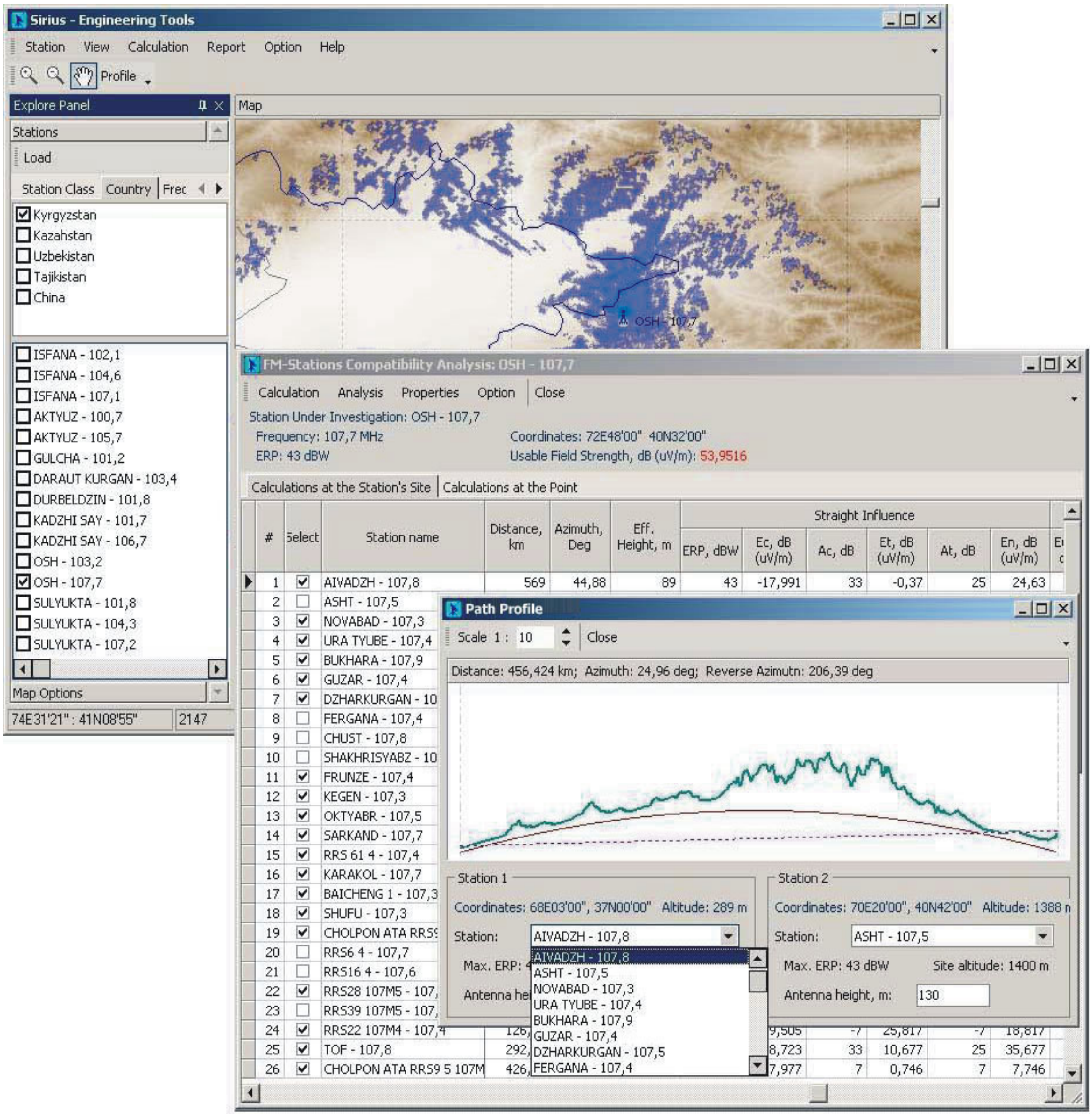
– Analytical tools for assessing EMC between stations in different services.

– General-purpose engineering tools for spectrum analysis.

– Forecasting models for radio wave propagation in SIRIUS.

FIGURE A5.3

Engineering analysis module operating windows



Cat-A5-3

Spectrum planning tools

SIRIUS offers the following capabilities for spectrum planning:

– Support of domestic and international tables of frequency allocations, including services and footnotes.

– Entry and editing of new and existing tables of frequency allocations.

– Editing of allocation plans and channels.

– Flexible reporting system for tables of frequency allocations (display in graphic and table form).

– Functions for verifying that frequency assignments are in accordance with tables of frequency allocations.

Analytical tools for the broadcasting, mobile and fixed services

These tools allow SIRIUS users to do the following:

– Analyse and assess the effects of existing and planned stations on a given station (individual and overall effect) at any geographical location within the service area of the station (by service), using calculations based on digital terrain data.

– Perform a quick calculation or a detailed analysis of the effect that a given station will have on existing and planned stations (by service).

– Channel-by-channel analysis of interference at a given location (for purposes of frequency assignments).

– Analysis of intermodulation products.

Analytical tools for assessing EMC between stations in different services

These tools allow engineers to perform an EMC analysis for stations operating in different services.

– The calculation methods described in Recommendation ITU-R IS.851-1 have been implemented. The following features are provided:

  – protection of the broadcasting service from systems in the fixed and land mobile service;

  – protection of the land mobile service from the broadcasting service;

  – protection of the fixed service from the broadcasting service.

– Analysis of compatibility between systems in the sound broadcasting service (87-108 MHz band) and the aeronautical services (108-137 MHz band) using the methods of Recommendation ITU-R SM.1009-1.

General-purpose engineering tools for spectrum analysis

– Indexed station search in database. Results are displayed geographically, with user-selected layers (national boundaries, urban areas, relief, morphological data, etc.).

– Calculation and graphic depiction of coverage areas and areas of interference for a given station, using different models of radio wave propagation.

– Display of path profiles and attenuation values for propagation (depending on propagation model selected) between any two stations, and path parameters (azimuth, geographical coordinates, altitude) between any two locations.

– Distribution of channels between stations in accordance with frequency-space separation.

Forecasting models for radio wave propagation in SIRIUS

SIRIUS contains a large collection of radio wave forecasting models, covering a broad range of frequencies and different types of applications, from elementary ones such as a free-space wave propagation model, to complex models that take into account terrain, climate, ground and morphology over the path profile. Some of the models included are:

– free-space wave propagation model;

– smooth Earth model;

– Okumura-Hata model;

– NSM model;

– Recommendation ITU-R P.370 model;

– Recommendation ITU-R P.1546 model;

– Recommendation ITU-R P.530 model.

8 Monitoring module

Interference complaints, investigation and elimination

SIRIUS records complaints and classifies them by type of interference. The investigation and elimination of interference sources, and measures taken for those sources are systematically logged, for use with future cases of interference of a similar nature. If the source is determined to be a licensed station, then an internal procedure is launched to re-evaluate the parameters of the frequency assignments to the stations involved. If the source is not a licensed station, then measures are taken to terminate the interfering emissions.

Preparation of spectrum monitoring jobs for monitoring stations

SIRIUS offers a list of standard jobs for different monitoring stations, with the necessary sets of job data. Stations then prepare and return results for each job, which can be stored in the system.

Collection and analysis of spectrum monitoring data

The system makes it possible to collect and store monitoring data, so that changes in the characteristics of emissions can be tracked. The spectrum monitoring database is set up in accordance with [Touré *et al*., 2002].

9 Multi-user operation

SIRIUS can support the simultaneous operation of up to 20 workplaces. It is possible to increase the number of parallel user sessions still further by upgrading certain portions of the system.

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ANNEX 6

SPECTRA – National Spectrum Management System

1 General information

The SPECTRA system, developed by LS telcom AG, Germany, is one of the most comprehensive and advanced automated spectrum management systems covering the whole range of administrative and technical functionalities for all radio services. Numerous SPECTRA system installations are operational all over the world in a significant number of countries typically at regulating authorities. Proven integration with radio monitoring systems provides additional benefit to administrations. The system is continuously supported and further developed, i.e. kept up to date both in terms of functionalities and modern IT technologies.

1.1 The task of the SPECTRA system

To carry out all required frequency management related activity in a country.

1.2 The procedures

All procedures and all calculations are strictly in line with the latest ITU, CEPT/ECC, ETSI, etc. resolutions, recommendations, decisions, standards and all relevant bi- and multilateral international coordination agreements. Possible future changes in these procedures are usually introduced to the SPECTRA system by module upgrades even for systems, which are already in operation.

1.3 Modularity

The SPECTRA system has a client server architecture with various modules connected to a central database. This architecture allows projects to be started with basic systems configurations which may be extended to more complex and comprehensive configurations in later project phases when required. In this way, the modularity of the system may help to find an optimum balance between need, urgency and financial considerations in the country.

1.4 Maintenance

Maintenance schemes are established with clients in order to secure investments made on the system. Standard maintenance services include keeping the system operational, the updating of modules in terms of general technological improvements and in accordance with the latest resolutions, recommendations, decisions and international agreements.

1.5 Usage of local programs and migration of existing databases

In case of existence of locally developed modules at client side, which need to be used without change also in the new environment, the SPECTRA system supports various interfaces for their integration. Migration of existing client databases is a key issue when putting into operation a new spectrum management system. This task may include also developments of jointly agreed rules for data validation, data completion and data consistency checks. Advanced migration tools and comprehensive experience are available for successful completion of this crucial and difficult task.

1.6 Digitalized maps

Digitalized Terrain Maps (DTM) are used in the SPECTRA system as basis of administrative and technical procedures. Commonly used commercial GIS data formats can be migrated to internal formats for efficient data access. The system can handle different types of layers, among others topographical, land usage and population data. For LF and MF calculations ground conductivity maps are used. In case sufficiently detailed maps are not available for the country, these can be supplied together with the SPECTRA system.

1.7 Integration with radio monitoring systems

The SPECTRA system offers interfaces for integration with national radio monitoring systems (NRMS). The detailed functions depend on the NRMS, but typically exchange of data is supported bidirectionally. The operator of the NRMS query detailed administrative and technical data from the central database as basis for setting up dedicated monitoring missions. On the other hand, the operator of the spectrum management system can order monitoring data to support various procedures as frequency assignment, spectrum planning, complaint processing, etc. All requested ITU measurements are processed manually or fully automatically depending on the capabilities of the NRMS. The data provided by the NRMS, which correspond to ITU measurements, can be stored in the central database for later analysis by any authorized user of the system. The system has the option of automated violation detection (AVD).

1.8 Localization/customization of the system

The SPECTRA system has already been localized to a big number of languages including completely different character sets (e.g. Chinese, Sanskrit, Cyrillic, Arabic). This localization often includes the major functions of the system and also documentation. The documents created by the SPECTRA system can be localized in case they are used for national procedures. In case of international frequency coordination the language is usually English, French or Spanish.

1.9 Training

Training is very important for the SPECTRA users. A part of the training usually is provided at the supplier's premises in addition to detailed hands-on user trainings at the Administration's premises because of greater efficiency. An annual refreshing training is advisable in order to use and practice the whole set of possible features, learn about updates and bring in new user staff.

2 Description of the SPECTRA system

The main features of the SPECTRA system can be briefly summarized as follows:

– Administration of national and international frequency plans
– Specific workflows for the licensing procedures of different radio services
– Deadline management/set up of user roles with specific permissions on workflow actions

– Frequency assignment procedures based on calculations (propagation models) and technical data specific for the particular radio service

– Coordination procedures based on ITU recommendations or other international/national agreements for the particular radio service

– Analysis of monitoring data from radio emissions to be in compliance with licenses.

– Central Spectrum Management database including:

  – Administrative data

  – Technical data

  – Frequency plan data

  – Monitoring data

  – Highly modular client-server-architecture

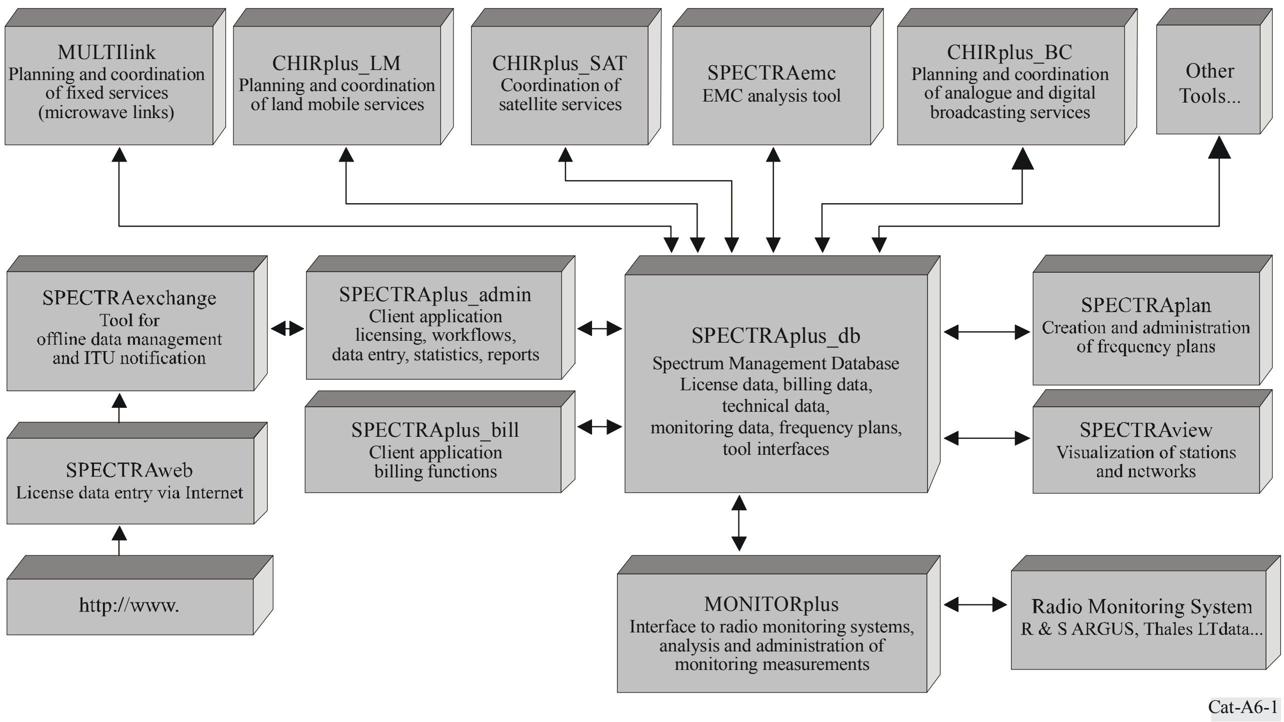
  – Adaptation of the system to customers needs

  – Extension of capabilities by including new modules for specific tasks.

Figure A6.1 illustrates the general overview including modules for license administration, technical analysis and coordination for all radio services, administration of frequency plans and interface to radio monitoring with analysis of measurement data.

FIGURE A6.1

LS telcom Spectrum Management System – SPECTRA



The standard configuration displayed above and designed primarily for civilian spectrum managing Administrations has been successfully extended for civilian aviation authorities including aeronautical compatibility calculations according to the ICAO Convention of International Civil Aviation (Annex 10) and other dedicated functions for aeronautical radio services.

3 Brief module description

SPECTRAplus_db

The central database that contains: license data, billing data, technical data and history, monitoring data, tool interfaces. It is typically ORACLE based.

SPECTRAplus_admin

Administration of license data for all radio services, project tracing, workflow management, user guidance, automatic printing of licenses and other documents, deadline management, complaint processing, type approval, statistical and management reporting capabilities. All license processes can be customized to the national rules and regulations.

SPECTRAplus_bill

Fee calculation based on national fees decrees, bookkeeping, automated invoice generation, credit notes reminder, income prediction. All billing procedures can be customized to the national financial rules and regulations.

SPECTRAplan

Creation and administration of national and international frequency plans including channel allotments. Worldwide ITU and European CEPT frequency plans available in standard configuration. Interfaces to ERO/EFIS and BR-IFIC, Notification editor with export to T01-T17 ITU notification forms and/or electronic ITU formats

SPECTRAexchange

Offline data entry tool including import/export functions for the central SMS database based on standard file formats (XML, ACCESS, EXCEL, ITU formats) and T01-T17 ITU notification forms.

SPECTRA_web

Customizable E-licensing and E-reporting via web browser. Role based user management. Used for electronic entry of license application data by any web browser and the validation of application data.

MONITORplus

Interface functions to connect the SPECTRA system with radio monitoring systems. Advanced 2D/3D visualization and cross correlations of technical license data with monitoring measurements for investigation of spectrum usage, detection of unlicensed emissions and detection of emissions that are not working with licensed parameters.

Multilink

Planning tool for point-to-point and point-to-multipoint fixed service networks. Includes: availability, and interference calculations, 2D or 3D visualization, printing of ITU coordination forms.

CHIRplus_LM

Planning and coordination tool for land mobile service. Provides frequency assignment according to coordination agreements. Includes HCM calculations according to the Vienna/Berlin Agreements. Calculates area-wide and point-to-point field strength maps, searching for optimum frequency.

CHIRplus_BC

Covers all planning and coordination tasks for broadcast services (FM, TV, DVB-T, T-DAB, LF, MF, HF and DRM). Main features include fully automated coordination calculations, network and coverage analysis considering population data, wide variety of 2D and 3D propagation prediction models, powerful GIS, automated frequency search, interference contours, day and night coverage for LF and MF, MFN and SFN planning for T-DAB and DVB-T. Synchronized FM as well as LEGBAC aeronautical compatibility calculation are available as special options. Extensions concerning propagation model, exchange data formats, etc. are available according to the decisions of the first session of the Regional Radiocommunication Conference (RRC-04).

CHIRplus SAT

Planning and coordination module for satellite services. Includes databases for satellites, earth stations, terrestrial stations and ITU plans. Direct access to SRS and BR IFIC DVD including FXM data import to carry out interference analysis between satellite plans, earth and terrestrial stations. Provides full support for all ITU space service software modules.

SPECTRAemc

Intra and inter-service compatibility calculations for all radio services. Wave propagation models from 9 kHz to 300 GHz. Interference calculations based on spectral densities. Two and three signal intermodulation calculations up to fifth order. Safety zone calculation according to the European Recommendation 1995/519 CE. Frequency assignment and desensitization for inter service scenarios. ICAO compatibility calculations for aeronautical radio services.

Other available modules

– *xG-planner:* mobile network planning tool for GSM, UMTS and TETRA technology.

– *CATCHit:* creates, transforms and maintains digital GIS information, like terrain data, land-use information, scanned maps, vectors, etc.

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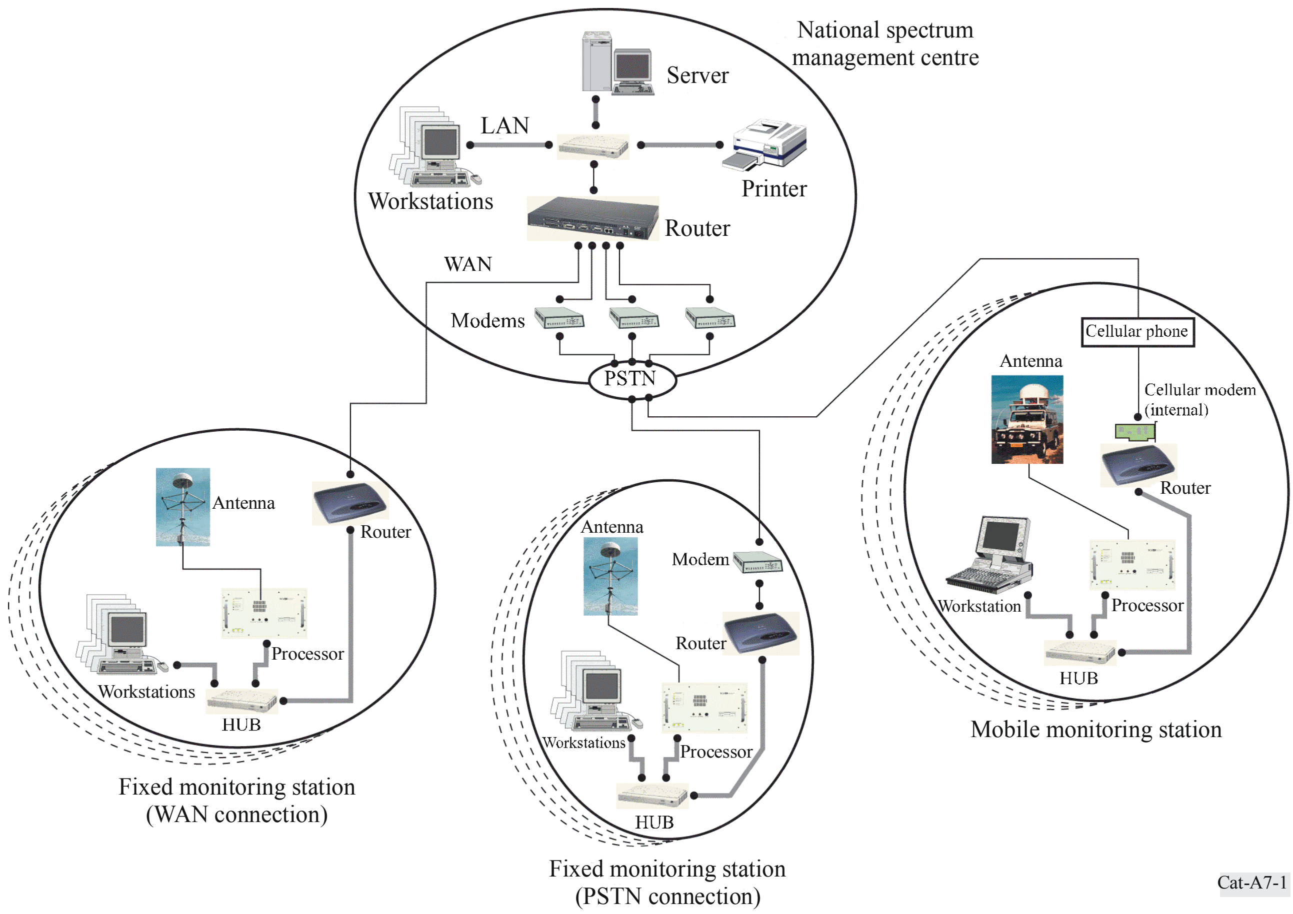
ANNEX 7

TCI – Automated Spectrum Management and Monitoring System

TCI provides fully automated and integrated spectrum management and monitoring systems. A complete system typically consists of a national spectrum management center, with its database server and workstations, and multiple fixed and mobile monitoring stations, each with a measurement server and one or more workstations. The centre and stations are interconnected via a network to allow voice and data communications. The block diagram of a typical system is illustrated in Fig. A7.1.

FIGURE A7.1

TCI Integrated Management and Monitoring System



1 Management system summary

1.1 Functions automated by the system

The TCI system supports automation and/or automates the following spectrum management functions:

– Planning the use of frequencies, through a complete set of engineering analysis tools covering all frequency ranges from LF/MF/HF up to microwave frequencies.

– Maintaining national and international frequency allocation plans.

– Reviewing applications and granting radio operating licences.

– Making computer-assisted frequency assignments.

– Automating ITU notification.

– Handling border coordination, including import of neighbouring countries' frequencies.

– Creating a record of applications, licenses, complaints, inspections, type approved equipment, ITU documentation and other data relative to frequency management.

– Monitoring licensees and concessions to ensure compliance and fee payment.

– Updating fee schedules and calculating and recording collection of fees and fines, including the flexibility to change fee calculation formulas in compliance with changing laws.

– Generating a large variety of text and statistical reports on applications, licenses, financial and technical issues, including customized reports and historical reports.

– Printing licenses, reports, bills and notifications.

– Providing seamless integration between the spectrum management system and the spectrum monitoring system.

– Performing automatic violation detection (AVD), where license information from the management system database and measurements from the monitoring system database are combined to alert the operator those stations that are apparently operating without a license or are operating outside their licensed parameters.

– Providing robust security, with views tailored to the security privileges of each user.

1.2 Use of the system

The spectrum management system facilitates data entry and management of application and license information, including site and equipment information; the system draws upon its database of clients, equipment, etc. to help with this process. The spectrum manager uses the system to help assign frequencies; he can request the system to search its database to display all the channels in the appropriate band, and any existing assignments on those channels. The manager can assign a clear channel if one is present, or can select a channel assigned to a distant transmitter and perform an interference calculation to determine whether or not either use of the channel would create interference for the other use of the channel. The spectrum manager uses the frequency assignment screen illustrated in Fig. A7.2 for these tasks. To assure that a frequency will support propagation, the spectrum manager can task the system to perform an engineering analysis – such as link analysis, field strength contour, or service area analysis – to determine whether the received field strength is acceptable.

1.3 Navigation through system screens

The system has standard forms for entry and display of site, operator, equipment, assignment and other data. The system has a convenient graphical user interface with navigation tools to access this data. An example of the use of a wizard to easily navigate through the various data entry and analysis forms required for an application for a radio station license is given in Fig. A7.3. The wizard minimizes training time and greatly facilitates use of the system.

FIGURE A7.2

Frequency assignment screen

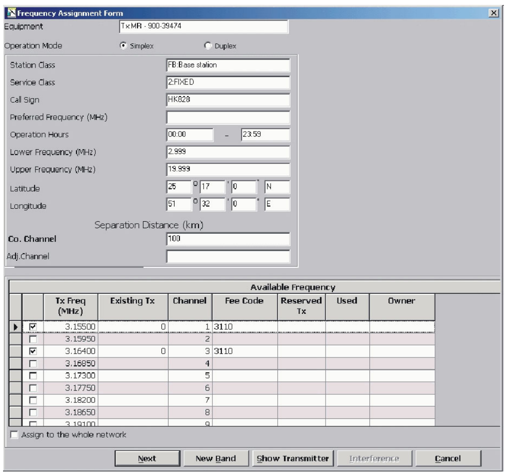
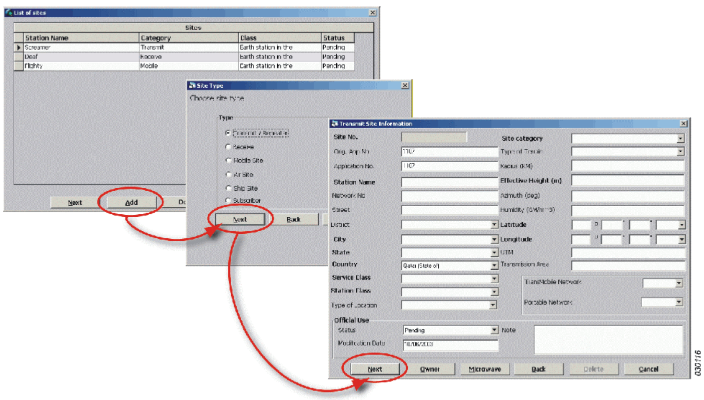


FIGURE A7.3

Example of wizard for navigation



Cat-A7-2

1.4 Localization, accounting interface, and ITU compliance

The system operates in the native language of the spectrum manager, and has already been provided in English, French, Spanish and Arabic. The system also includes an interface to an accounting package, to allow invoicing for license and renewal fees and processing of payments. The ITU Recommendations on design guidelines for advanced automated spectrum management systems are contained in Recommendation ITU-R SM.1370-1, and the system complies with those Recommendations.

2 Monitoring system summary

2.1 Functions performed by the system

Functions that the monitoring system performs include:

– monitoring, recording, demodulation and decoding;

– technical parameter (metrics) measurements and analysis including frequency and frequency offset, level/field strength, modulation parameters and bandwidth;

– spectrum occupancy;

– direction finding;

– automatic detection of illegal or unknown transmissions (AVD).

These functions are performed using digital signal processing technology. The system is wideband, with up to 10 MHz of instantaneous bandwidth to receive modern wideband communications signals. DF is performed with a large-aperture antenna and a multi-channel receiving system to make greatest use of the information in the arriving signal and to provide the greatest accuracy.

2.2 Modes of operation

The system performs these functions with three modes of operation – interactive mode, automatic or scheduled mode, and background mode – that are used to perform monitoring tasks with varying levels of automation.

Interactive mode allows direct interaction with various functions that provide instantaneous feedback such as monitor receiver tuning, demodulation selection and pan-display selection. DF homing to track down a source of interference is an important example of interactive operation. DF may be commanded at any frequency over the full frequency range in a mobile unit as the unit is in motion. DF results are presented with respect to the front of the vehicle, and allow the driver to decide which direction to drive to approach the interfering transmitter.

Automatic or scheduled mode may schedule tasks to be executed immediately or to be executed at specified times in the future. Functions performed in scheduled mode include technical measurement and analysis, and direction finding.

Background mode is used for performing spectrum occupancy, DF scan and automatic violation detection – tasks where it is desirable to collect data over long periods of time. The system is scheduled to perform an automatic scan over particular frequencies or ranges of frequencies, and upon detecting a signal, initiate operator specified activity, such as DF or technical measurement. These data may be combined with license data in the management system database to perform AVD – to automatically detect license violations.

2.3 Compactness and mobility

The spectrum monitoring system is very compact. The electronics are contained in a small transit case as illustrated in Fig. A7.4. A mobile station including antenna and electronics is installed in a small van, such as that illustrated in Fig. A7.5. Mobile stations are very useful to search for, identify and locate sources of interference. A mobile station can make measurements with the antenna down while the vehicle is in motion.

FIGURE A7.4

Compact monitoring electronics

FIGURE A7.5

Complete mobile monitoring station

Cat-A7-4

3 Integrated management and monitoring system

3.1 Seamless operation of hardware and software

TCI manufactures all of the major hardware elements of its spectrum management and monitoring systems, including antennas, RF distribution and switching electronics, receivers and related equipment, and has developed the computer software for both management and monitoring systems. Since the hardware and software is all provided by the same company, TCI is able to provide the most fully integrated system, which allows seamless operation of the complete system.

3.2 Support, including customisation, data migration, training and maintenance

TCI also provides the support that clients need to utilize the system within their operations. Because the National Telecommunication Acts of different countries have differing provisions, and because different administrations have different practices and procedures, inevitably an automated spectrum management system is customized to a particular administration's needs. Automating existing computerized processes poses different challenges than automating all-paper operations. Programs may need to be developed to assist in data migration, so that data from existing systems may be automatically transferred to the system described here. TCI addresses all of these issues for its clients.

Training in the use of the system is facilitated by a training database, which provides representative applications for licenses, frequency assignments and other data, and through a training simulator, which simulates the behavior of monitoring equipment. Through these training aids, extensive classroom training can be conducted using just computers, without interfering with routine system operations and without the need for additional monitoring equipment. Maintenance of the system is facilitated through automated test procedures and built in test equipment.

3.3 Compliance with ITU recommendations on automation and integration

The system described in this Annex meets the recommendations of Recommendation ITU-R SM.1537 on automation and integration of spectrum management and monitoring systems. The system is completely compliant with the guidelines on automation discussed in Chapter 3, § 3.6 of the ITU 2002 Spectrum Monitoring Handbook. It is used in a variety of countries around the world. The application of this system to the administration in Venezuela is described in Annex 3 of Chapter 7 of the 2004 ITU National Spectrum Management Handbook. Further information is available at www.tcibr.com and in [Woolsey, 2000 and 2004].

References

WOOLSEY, R. B. [2000] Automatic Tools for Telemetry Test Range Spectrum Management. Proc. ITC/USA 2000.

WOOLSEY, R. B. [2004] An Automated, Integrated Spectrum Management and Monitoring System. Proc. Seventeenth International Wroclaw Symposium and Exhibition on Electromagnetic Compatibility.

ANNEX 8

WINBASMS – Basic Automated Spectrum Management System

The Windows Basic Automated Spectrum Management System (WinBASMS) has been developed according to specifications prepared by the ITU Telecommunication Development Bureau (BDT) and the Radiocommunication Bureau (BR) on the basis of Recommendation ITU-R SM.1048. BASMS is a multifunction and multilingual computer program providing spectrum managers automated support for:

- record keeping for all radio service licenses and related technical and administrative information;
- frequency assignment and interference calculations for fixed, mobile, broadcasting and other similar services;
- frequency coordination for both national and international applications;
- recording and notifying license fee data;
- generating national frequency licenses.

The purpose of the WinBASMS software is to give least developed and developing countries a tool to efficiently and effectively manage the radio spectrum primarily for broadcasting, fixed and mobile radio services and therefore to accelerate the development of wireless technology in the countries. The WinBASMS is designed for ease of use and maintenance by a single user. The WinBASMS can be used to support most functional requirements defined in the ITU Handbook on National Spectrum Management.

In 2002, Radiocommunication Study Group 1 approved a new Recommendation ITU-R SM.1604 calling for improvements/upgrades to WinBASMS to meet further needs of developing countries as expressed during WinBASMS training and at World Telecommunication Development Conferences. A voluntary group of experts met on several occasions informally in an attempt to draft specifications for this upgrade, the results are expected during year 2005.

Frequency assignment and interference calculations

- Provides for interference calculation and frequency selection for a new assignment above 30 MHz:
  - point-to-multipoint (broadcasting and land mobile services);
  - point-to-point (fixed service);
- provides the following propagation models:
  - free space (Recommendation ITU-R P.525);
  - smooth earth (Recommendation ITU-R P.526);
  - point-to-multipoint services in VHF/UHF (Recommendation ITU-R PN.370).

Frequency licenses

– Provides data required to produce frequency license.

Border coordination

– Identifies applications and stations requiring coordination.

Notification to Radiocommunication Bureau

– Creates AP1/A1 form with appropriate data.

NOTE 1 – This form is no longer in use.

License fees and fee collection

– Provides data for billing and keeps status records.

Monitoring data

– Provides data to assist monitoring.

Equipment approval process

– Provides basic required data.

Report generation

– License printing
– Record summary
– Record detail
– Transaction activity report
– Expiration and renewal notice.

WinBASMS has been developed and tested for operation under the following versions of the Microsoft Windows Operating system:

– Windows 3.1;
– Windows 95;
– Windows NT.

NOTE 1 – This software is no longer available and may soon be replaced.

GLOSSARY

Algorithm	A statement of the logical steps to be followed in the program for solution of a specific problem.
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 radioastronomy service under specified conditions. This term shall also be applied to the frequency band concerned.
Allotment (of a frequency or 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.
Alphanumeric data	Pertaining to a character set that contains letters and digits, and usually other characters.
Application program	A routine developed to perform a specific function or solve a particular problem of concern to the computer user organization.
APs	Appendices to the Radio Regulations
ASCII	American Standard Code for Information Interchange – a numerical code used to represent letters, numerals and symbols
Assigned frequency	The centre of the frequency band assigned to a station.
Assignment (of a frequency or frequency channel)	Authorization given by an administration for a radio station to use a radio frequency or radio-frequency channel under specified conditions.
AVD	Automatic violation detection
Bit	A digit in the binary number system; it may have a value of zero or one which can be represented in an electrical circuit by a condition of off or on; the basic unit in a digital computer.
BR	Radiocommunication Bureau
Byte	A binary character string operated upon as a unit and usually shorter than a computer word.
CD-ROM	A type of data storage medium (a disc) that uses optical technology to read the data. Typically these discs are write once read many. Each disc can store 600 MB of data.

Central processing unit CPU	A unit of a computer that includes circuits controlling the interpretation and execution of instructions.
Circular letter CR/26	A circular letter from the BR addressing the introduction and operation of electronic notification for terrestrial systems.
Compiler	A translation program or processor that translates the macro instructions of a symbolic (high level) language into a machine language object code.
Computer virus	A software programme designed to affect and possibly catastrophically damage data held on a computer system and/or the computers operating system.
Data	A representation of facts, conceptions or instructions in a formalized manner suitable for communication, interpretation or processing by human beings or by automatic means.
Databank	A comprehensive file of data, usually stored on a direct access storage device.
Database	A file of data so structured that appropriate applications draw from the file and update it but do not themselves constrain the file design to satisfy a specific, limited application.
Data dictionary	A data dictionary describes the data elements contained in the data base.
Data element	Any item of data which for a given situation may be considered as a unit, e.g., field, record.
Data field	A subdivision of a record containing a unit of information
Data file	An organized collection of data records. The organization of records on a file may be for a common purpose, common format or common data source, and may or may not be sequenced.
Data format	The term format explicitly applied to data and meaning the formalized manner in which the data is stored or represented.
Data link	The connection between one location and another for the purpose of transmitting and receiving information.
Data record	A logical unit of data representing a particular transaction or a basic element of a file consisting in turn of a number of interrelated data elements or data items.
DBMS	Database Management System

Designator	A key character, word or phrase used to indicate the beginning or end of a specific data list.
Diskette	Magnetic storage medium (commonly used to refer to the 3.5 inch 1.44 MByte floppy disk).
DTM	Digital terrain model
DSP	Digital signal processing
DVD	Digital video disk
EDI	Electronic data interchange
e.i.r.p.	Equivalent isotropically radiated power; the product of the RF power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).
Format	A general term describing the structure or other details defining how information is stored or represented. It can be used for individual data values or for a complete data file, equally it could apply to the structure of a letter or other text document.
FTP	File Transfer Protocol – a standard for transferring files electronically
GIS	Geographical Information System
Hardware	Physical equipment used in data processing as opposed to computer programs, procedures, rules and associated documentation.
HF	High-frequency (decametric waves)
IDWM	The ITU Digital World Map
IFIC	International Frequency Information Circular, published by the BR
Input/output device	A device in a data processing system by which data may be entered into the system, received from the system, or both.
Interactive mode (conversational)	A mode of operation of a computer system in which a sequence of alternating entries and responses between a user and the system takes place in a manner similar to a dialogue between two persons.
Interactivity	The degree of response and interconnection available between electronic data exchange systems.
Internet	A public electronic network for providing access to electronic information.
ISO	International Organization for Standardization

IT	Information Technology – abbreviation for description of computer and communications systems.
Item of data	Any data treated as a unit within a data record or a program or a process, e.g. a single entry in a record or a table.
ITUDOC	One of the ITU's open services available in TIES.
ITU-R (formerly CCIR)	Radiocommunication Sector
ITU-T (formerly CCITT)	Telecommunication Standardization Sector
LAN	Local area network
Logical data description	The description or format of the data as it is required for processing by an application programmer or as it must appear to a user.
MB	megabyte
Memory	See "storage (device)"
MF	Medium frequency
MIFR	Master International Frequency Register
MIME	Multipurpose Internet Mail Extensions – the 1992 Internet email standard
MS-DOS	The most commonly available operating system for the IBM-PC compatible microcomputer.
Natural language	A spoken language e.g. English, French, etc.
Object Oriented Techniques	Any technique that utilizes the principles of object theory.
Off-line	A situation where a device is not directly connected to the computer system.
On-line	A situation where a device is connected to the computer system and is readily accessible by the computer processing unit.
OFR	Off-frequency rejection
Operating system	Software for controlling the execution of computer programs that may provide scheduling, debugging, input/output, control, accounting, compilation, storage allocation, data management and related services.
Path profile	The topographic data along a line around the Earth's surface between two points represented in two dimensions.
PC	Personal computer
Physical storage organization	The organization of the data as determined by the access characteristics of physical storage.

Preface to the IFL (PIFL)	Preface to the International Frequency List, produced and distributed by the BR it describes the data used in the notification forms.
Proforma	An empty form indicating the size and structure of the data required.
Program	The sequence of instructions, which is followed by the computer in performing a specific task.
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.
PSTN	Public switched telephone network: the global telephone network.
Q code (QTE)	Abbreviations and signals to be used in radiotelegraphy communications.
Raster data	Type of data where the information is stored inside a cell matrix structure and each cell has a specific value. Raster data is commonly used for information such as DTM, population density, etc.
RDD	Radiocommunication Data Dictionary – a set of rigorously defined data models describing the information needed by administrations and the BR in order to communicate electronically details of radio systems (Recommendation ITU-R SM.1413)
RAID	Redundant Array of Independent Disks. This system is preventing the disk corruption and associate losses using an arrangement of several disks working in parallel. It may also be used for system performance improvement.
Resolution	The smallest difference in value permitted by a given format. Normally only significant for a single data item. A small resolution does not necessarily mean high accuracy.
RR	Radio Regulations
RRB	Radio Regulation Board which replaced the IFRB
S/N	Signal-to-noise ratio
Site shielding	The use of local topographical features to reduce or eliminate, interference from or to a radio system.
Server	A computer whose main function is to provide service to other computers in the network; these could include data, calculation or application or might be a gateway service to external communication networks.
Software	Computer programs, procedures, rules and any associated documentation concerned with the operation of a data processing system.

SQL	Structured Query Language
Storage (device)	A functional unit into which data can be placed, in which they can be retained, and from which they can be retrieved.
Subroutine	A sequenced set of statements that may be used in one or more computer programs and at one or more points in a computer program.
System	The computer hardware, its operating system and the associated data.
Throughput	A measure of the amount of work performed by a computer system over a given period of time.
TCP/IP	Transmission control protocol/Internet working protocol
TIES	Telecommunication Information Exchange Service – an ITU information service.
Transfer standard	A file format optimized for the transfer of information, not necessarily suitable for direct use by computer applications.
UHF	Ultra-high frequency (decimetric waves)
VHF	Very high frequency (metric waves)
UNIX	An operating system used on minicomputers and larger computer systems originally developed at Bell Laboratories in the United States of America.
VDA	Visual data analysis
Vector data	Type of data where the information is stored as a set of predefined elements such as points, lines polygons, circles, arcs, etc. These elements may be associated with values or database keys to other data types such as flow direction, number of lanes, road conditions, station licence information, etc. Vector data is commonly used for information such as streets, roads, rivers, borders, etc.
Word	A character string that is convenient for some purpose to consider as an entity.
WAN	Wide area network
Workstation	A computer, often more powerful than a PC, that provides multiple functions and usually includes specialized hardware for display or calculation purposes such as 3D computer aided design.
World Wide Web	A group of information resources accessible over the Internet.
X.400	An email transfer standard.

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