



**Recommendation ITU-R SM.1370-2**  
(08/2013)

**Design guidelines for developing  
automated spectrum  
management systems**

**SM Series**  
**Spectrum management**



International  
Telecommunication  
Union

## Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

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### Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

Series	Title
<b>BO</b>	Satellite delivery
<b>BR</b>	Recording for production, archival and play-out; film for television
<b>BS</b>	Broadcasting service (sound)
<b>BT</b>	Broadcasting service (television)
<b>F</b>	Fixed service
<b>M</b>	Mobile, radiodetermination, amateur and related satellite services
<b>P</b>	Radiowave propagation
<b>RA</b>	Radio astronomy
<b>RS</b>	Remote sensing systems
<b>S</b>	Fixed-satellite service
<b>SA</b>	Space applications and meteorology
<b>SF</b>	Frequency sharing and coordination between fixed-satellite and fixed service systems
<b>SM</b>	<b>Spectrum management</b>
<b>SNG</b>	Satellite news gathering
<b>TF</b>	Time signals and frequency standards emissions
<b>V</b>	Vocabulary and related subjects

*Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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## RECOMMENDATION ITU-R SM.1370-2

**Design guidelines for developing automated  
spectrum management systems**

(1998-2001-2013)

**Scope**

This Recommendation gives design guidelines for an automated spectrum management system, including the recommended functionality for such a system, and the data elements required for frequency management at national level while also ensuring the data is collected to meet the international obligations for frequency coordination and notification.

The ITU Radiocommunication Assembly,

*considering*

- a) that the demand for spectrum is increasing, that radio systems are becoming more complex and thus the task of frequency assignment is becoming more challenging;
- b) that an automated spectrum management system (ASMS) would facilitate national spectrum management and monitoring, coordination among administrations and exchange of information with the Radiocommunication Bureau (BR);
- c) that an ASMS has the capability to manage and maintain the data elements required for administrative records of frequency authorizations; billing and invoicing functionality for spectrum fees; technical analysis for aiding the decision process on the right parameters to assess potential for interference and the efficient use of spectrum;
- d) that data elements used in national spectrum management for international coordination and notification have been reflected in Appendix 4 of the Radio Regulations (RR) and Recommendation ITU-R SM.1413 – Radiocommunication Data Dictionary for notification and coordination purposes;
- e) that Recommendation ITU-R SM.1413 on a radiocommunications data dictionary may supplement the Preface to the International Frequency Information Circular of the Radiocommunication Bureau (BR IFIC);
- f) that many administrations have been successful in implementing an automated spectrum management system using relational databases and supporting online portals for processing of applications for the use of spectrum, in the development and maintenance of their national spectrum management data;
- g) that the functionality of automation and integration of spectrum monitoring systems with ASMSs is described and explained in some detail in Recommendation ITU-R SM.1537;
- h) that a spectrum management software has been developed by the Telecommunication Development Bureau (BDT), in cooperation with the ITU-R, for developing countries under the name SMS4DC (Spectrum management system for developing countries)<sup>1</sup>;
- j) that an ASMS may have the capability to assist in the preparation of electronic notices for the BR and use propagation databanks and computer programs associated with ITU-R

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<sup>1</sup> SMS4DC is an integrated user-friendly spectrum management software package which covers terrestrial fixed, mobile, broadcasting services in the bands above 30 MHz, including the GE06 Agreement as well as satellite earth stations in space services.

Recommendations of the P Series (Radiowave propagation) made available by BR in accordance with Resolution ITU-R 25;

k) that the ITU Handbook on computer-aided techniques for spectrum management provides a useful reference for ASMSs,

*recognizing*

Resolutions 55 (Rev.WRC-12), 906 (Rev.WRC-12), 907 (WRC-12) and 908 (WRC-12),

*noting*

a) that BR has several terrestrial and space services software packages available on its website and BR IFIC;

b) that Resolution ITU-R 11-4 resolves that Study Group 1 should continue to assist in the further development of SMS4DC,

*recommends*

the following design guidelines for an ASMS:

1 that the ASMS should use the data elements contained in RR Appendix 4, Recommendation ITU-R SM.1413 and the ITU Handbook on computer-aided techniques for spectrum management and provide a mechanism for transferring existing data to the ASMS data structure;

2 that the ASMS should allow multiple users and have appropriate data security features;

3 that the ASMS should contain engineering calculation features for radio services;

4 that the ASMS should be capable of using a terrain database for specific engineering calculations;

5 that the ASMS should, where feasible, operate in the customer's national language(s) and support Unicode for additional languages;

6 that output documents (e.g. licences and invoices) should be easily generated in the local language and character set;

7 that the implementation of such systems should include the necessary training and support;

8 that the design should consider the networking and computer hardware elements for ease of access, user control, security and other features;

9 that the specific administrative functions of spectrum management given in the Annex should be considered when developing an ASMS.



## Annex

### Design guidelines for developing automated spectrum management systems

#### 1 Operational guidelines

As a minimum, an ASMS should support the following functions:

##### 1.1 Processing of application for the use of spectrum

Following the national rules, this function should support the data entry of an application for radio service. This can be an application for new station, for modification to an existing licence, or modification to a pending application. The applications should be processed sequentially, typically through the following steps: check that all information is included; check specified equipment; check channel availability; check administrative compliance. If any of these checks fail, a standard notice should be produced for the applicant, indicating the nature of the problem. If the proposed site is located within a region of international coordination (i.e. border area), the system should produce a request for international coordination, including all the data required by ITU or by bilateral agreements with neighbouring administrations. In those cases where it is required, the system should also assist in the preparation of the appropriate BR coordination or notification notices, as appropriate. Once all approvals are granted and, if required, all fees are paid, the application may become a licence ready to be issued.

##### 1.2 Frequency allocation plan/channel processing

This function should support the processing and analyses required to approve a requested frequency channel, or to respond to a request for international coordination from a neighbouring administration. This function may also be used to investigate the availability of unassigned RF channels, international and regional plans.

This function should have the following characteristics:

- provide utilities to create and maintain the national frequency allocation plan. Information to be recorded should include the relevant parts of the RR, including Article 5 as a minimum;
- provide capability to maintain channelling plans. Utility should be included for the automated generation of channelling plan with user entered parameters;
- capability to store and retrieve frequency plan footnotes;
- retrieval of frequency channel pairs and applicable footnotes confirming with user specified parameters;
- system should be able to access the national frequency allocation plan, channelling plans, footnotes, and other system maintained databases on user supplied parameters;
- provide the allocation table in an automated display that a frequency assignment can be checked against, to ensure that it is a valid frequency assignment.

##### 1.3 Licence processing

This function should support the following activities:

- issue a new or modified licence;
- renew an existing licence;
- adjust the fee for an existing licence;

- terminate a licence for non-compliance with the licensing conditions;
- query the database to locate one or a group of licences.

The system should support licensing processes if required, for stations in:

- aeronautical services;
- maritime mobile services;
- land-mobile and fixed services;
- the space services, e.g. earth stations; note that space services require extensive additional data elements;
- broadcasting service;
- radio amateur service;
- other services.

In addition, the system should:

- support assigning sets of frequencies for aeronautical and maritime mobile stations;
- support data collection for existing licences (data conversion);
- provide a convenient manner for printing of licences;
- detect licences due for renewal, and generate renewal invoices;
- support licence cancellation and cancelled licence re-instatement and automatically calculate the appropriate fees whenever applicable;
- provide online queries capability to permit perusal of technical and licence information contained in the database (more details in § 11.5);
- provide extensive management reporting capabilities (see § 9);
- control and track the processing of licence applications to ensure that the correct applications are available at each stage of the application cycle, and that applications are automatically progressed to the next stage as each process is completed.

#### **1.4 Fee processing**

This function should support the management of financial tasks, such as recording of fee payments, production of invoices, and production of financial statements in statistical or individual format. It should also allow the setting and changing of fee rates. The fee processing function should use the standard double-entry accounting method to record and report all transactions (see also § 6).

The choice of cash or accrual accounting should be in line with the administration's common practice. The system will provide fee:

- schedule maintenance;
- calculations for all transactions with charges and automatic interface to invoice generation. Fee calculation should be capable of applying and accounting for sales taxes or value added taxes.

#### **1.5 Report processing**

This function supports the query of the database and production of reports in graphic or text form. The ASMS should have a number of standard reports and standard letters, and should also support the production of customized reports as specified by the operator. (More details are given in § 9.)

## **1.6 Complaint processing**

This function should support the efficient processing of interference complaints through the following steps:

- record the complaint;
- check the complaint for administrative merit;
- analyse the complaint for technical merit (use engineering analysis tools);
- generate a monitoring task for the technical verification of stations;
- review the monitoring results and produce a complaint resolution report.

## **1.7 Reference tables processing**

This function should support the review, update and printing of all reference tables used by the system. The system administrator should be the only person with the authority to view or modify any table in the system. Equipment tables, such as antennas, transmitters, receivers may be viewed by all operators, but should be modified only by technical personnel. The security access table should only be viewed and modified by the system administrator. The frequency allocation table, which defines frequency plans used by the system may be viewed by all operators, but should be modified only by the system administrator.

## **1.8 Security processing**

Spectrum management staff should, in general, have read access to the data records. This function should restrict update access to specific data records or to certain types of transactions to only those operators who have the proper security access role. The required security roles should be built into the design of the ASMS. The allocation of operators to one of several security roles should be controlled by the password table or by some other mechanism created as each operator is registered by the system administrator.

## **1.9 Transaction processing**

This function creates a record in the database, registering the date, time and identity of the operator who performs each transaction, such as administrative approval of a licence, for instance. The system should also ensure that the operator attempting the transaction meets the security access criteria, and that all necessary preceding transactions have been completed. This function should also prevent an operator from repeating a transaction that has already been completed once. The transaction processing implemented by the ASMS should guarantee the integrity, reliability and recoverability of the database.

## **2 Record keeping guidelines**

The ASMS should support a database containing frequency assignment data and information concerning individual licence holders. Any data required to calculate propagation should be provided. RR Appendix 4 and the radiocommunication data dictionary (RDD) (Recommendation ITU-R SM.1413) should also be referenced in system design to ensure compatibility of definitions and formats for future coordination and notification purposes.

The ASMS should include a high-performance, Relational Data Base Management System (RDBMS) for distributed client-server or centralized operation depending on the configuration and needs of the administration. It should use friendly graphical user interface screens and forms to enter information and generate queries and reports. It should support user definable reports to provide a variety of data retrieval alternatives. It should have a built in audit trail function for

database transactions and it should allow multi-level security access protection. The DBMS should also allow new fields to be added to the database without losing or changing existing data; this provides for flexible, easy expansion as requirements change.

The DBMS software should provide the following features:

*Security:* The database administrator defines the operations (read, write, modify) that each user can perform on each database object.

*Performance:* The DBMS engine should be highly integrated with the operating system to provide the highest throughput for the platform selected.

*Replication/scalability:* The DBMS engine should support replication in order to increase the availability of the database in remote locations and reduce the number of transactions executed in the main database. If decentralized operation is an important requirement, the system will have some objects replicated in each remote location. If replication is not used, care should be taken to ensure that the DBMS is scalable in order to handle future growth.

*Reliability/integrity:* The DBMS engine should guarantee that every transaction that was executed successfully will not be lost despite a system failure.

*Transaction based operations:* Transaction based databases guarantee that an operation will be done in a discrete fashion. The operation will be done completely or not at all. This capability guarantees semantic integrity in the database. Database definition languages also include the ability to impose constraints in order to assure referential integrity in the data.

*Multi-user:* The DBMS engine should allow multiple users to be connected to the database and handle concurrent access to the information. A large number of users can be connected to the system.

*Contentions:* The database will handle the contentions of users trying to access the same piece of data and appropriately lock data that are being updated.

The database should implement the data content recommended by the ITU publications. The following types of data may be stored in the database:

- National Table of Frequency Allocations
- Frequency assignments
- Block assignments for concessions
- Licence/concession holder
- Equipment characteristics
- Monitoring
- Applications
- Fees
- Complaints
- Violations/infractions
- Spectrum occupancy statistics
- Unidentified transmitters
- Assigned frequency(ies)
- Cancelled licences.

Appropriate descriptions of the transmitter, receiver and antenna characteristics are essential for optimal spectrum management. In order to facilitate data entry, the system should highlight the suitable fields and suggest defaults according to the designation of emission or type of service.



For example, only for broadcasting TV (BT) should the system prompt for TV. When the antenna pattern is unknown, the system should estimate the side-lobes using an appropriate reference radiation pattern, such as given in Recommendation ITU-R F.699.

All data needed to define the site should be included: coordinates, height above sea level from the digital terrain map. The specific azimuth and elevation angles are part of the station defined in the licence.

The data elements in the system should be based on the latest edition of the ITU Handbook on computer-aided techniques for spectrum management. To ease data input, the operator should be allowed to choose the element from predetermined tables; the system should be capable of using defaults for most inputs. Screens should allow “remarks” to add information not coded as data elements to be recorded. Where applicable, the definitions of the fields should be in accordance with the Preface to the BR IFIC and the RDD (Recommendation ITU-R SM.1413).

### **Vendor management**

Some administrations are required by the laws of their countries to license or provide certification of spectrum management vendors, including individuals and companies which manufacture, sell, install, repair and perform other functions associated with spectrum management systems and equipment, such as spectrum management software and spectrum monitoring equipment. The ASMS should have the optional capability to accommodate these administrations by supporting vendor licensing or certification functions, including processing applications, issuing and printing certificates, generating renewal notices, and performing other functions similar to those for licenses for use of spectrum.

## **3 Engineering analysis guidelines**

The ASMS should automatically identify interference-free frequencies for an applicant if such a frequency is available; if not, it should identify the acceptable interference case. Such automatic techniques should be included where practicable. The process is to use appropriate calculations in conformity with commonly used interference assessment methods, frequency-distance functions or tables that allow for the user specification of minimum acceptable distance separations for co- and adjacent channels for each service in each band. It should also be possible to analyse a specific proposed frequency assignment using the same models to determine its interference potential. An option to calculate the power density from a transmitter should be provided, such as for human hazards assessment.

This module provides tools to assist frequency assignment. Tools should include:

#### *Transmitters search*

- Identify radio stations in the licensed station database with parameters specified by the user. This function should allow the user to specify the interested area of study on a displayed map, and display search results on the map.
- Display details of selected station and associated frequency information identified by the search function.
- Produce a report identifying the search results and the parameters used.

#### *General characteristic of all electromagnetic compatibility (EMC) tools*

- Frequency plan look-up function to assist in the selection of candidate frequencies based on user given national frequency allotment plans, planned types of services/operations, user categories.

- Facility for spectrum management officers to produce lists of several candidate frequencies for a more detailed analysis, if needed.
- Automatic validation of user selected candidate frequencies against frequency plan.
- Facilities to retrieve occupancy data held in monitoring database.
- Integral part of the licensing system and be available for a station to station analysis.
- Operating in a temporary system area allowing the user to experiment with different technical parameters without affecting actual records in the system.
- Update actual system records upon completion of analysis.
- Analysis of candidate frequency assignments requested by applicants or incoming coordination requests against existing licence records and coordination records in the database using predetermined criterion which are user changeable at execution time.
- Capability to be executed online.
- Retrieval of analysis results.
- Analyse both existing and proposed transmitters/receivers as potential offenders and victims.
- Provide the following levels of reporting:
  - the relevant administrative, technical and operational details for each interference case;
  - identification of all stations/frequency assignments involved in each interference case.

The ASMS should include a set of engineering analysis tools to assist in the assignment of frequencies in accordance with ITU-R Recommendations, as well as national frequency plans, and the local policies established by the spectrum management authority. Six types of analysis tools should be provided: broadcasting analysis tools, HF analysis tools, VHF/UHF analysis tools, microwave analysis tools, intermodulation analysis tools and EMC analysis tools.

#### *Broadcasting analysis tools*

This function supports the assignment of frequency channels based on a search of the database. The frequency of the new transmitter is compared to the transmitters already licensed in the area. The program checks for geographic proximity with co-channel and adjacent channel frequencies when assigning new frequencies. This method is based on the calculation of interference levels or on minimum frequency-distance rules, which must take into account the type of service under consideration, the operating frequency, and the maximum transmitter power.

Results of analysis should be displayed on screen with user selectable map background. System should support printing of analysis results as displayed on screen together with parameters used in the analysis. The following zone predictions should be provided:

- station and network coverage;
- station interference.

#### *EMC of broadcasting services with other services*

Analyses to ensure compatibility, following Recommendation ITU-R SM.1009 – Compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band 108-137 MHz; and Recommendation ITU-R SM.851 – Sharing between the broadcasting service and the fixed and/or mobile services in the VHF and UHF bands, should be available.

*HF analysis tools*

These tools should use an appropriate propagation model to compute propagation loss and field strength in the HF frequency range. The model should compute both groundwave and skywave propagation. The model may use the following inputs in the computation: transmitter characteristics, antenna characteristics, terrain conditions, ionospheric conditions, geographic coordinates, time-of-day, and month of the year. Based on these inputs the model computes the propagation path at any desired distance from the transmitter site. The HF analysis tools could include the following:

- a) HF link analysis
- b) HF path propagation loss
- c) HF field strength contour
- d) Service area analysis
- e) HF interference analysis.

*HF point-to-point service*

Optimal operating frequency ranges should be calculated, taking into account time-of-day and period-of-year.

*VHF/UHF analysis tools*

These tools should use an appropriate propagation model (e.g. Recommendation ITU-R P.1546) to compute propagation loss and field strength in the VHF/UHF frequency range. A selection of propagation models may also be offered for user choice. The models should take into account transmitter characteristics, antenna characteristics, antenna heights above average terrain, topographic terrain profile, and average soil and climate conditions. The VHF/UHF analysis tools could include the following:

- a) VHF/UHF link analysis
- b) VHF/UHF path propagation loss
- c) VHF/UHF field strength contour
- d) Service area analysis
- e) VHF/UHF interference analysis.

**Land-mobile, maritime mobile and fixed services***General*

- Analysis tools provided should utilize propagation models which consider the effects of terrain (using digital terrain elevation and surface cover data), and should be consistent with the procedures discussed in Recommendation ITU-R P.1144 – Guide to the application of the propagation methods of Radiocommunication Study Group 3.
- The supplied analysis tools should be able to function in the absence of digital terrain elevation and surface cover data.
- Potential interference cases identified after an analysis run should be displayed on screen with user selectable map background.

*EMC analysis tools*

The EMC analysis tools could include the following interference mechanisms:

- receiver desensitization analysis;
- transmitter noise analysis;

- frequency interference (co-channel, interstitial and adjacent channel or distant channel) analyses;
- multi-signal third order intermodulation analysis. Intermodulation analysis module should provide frequency combination reports identifying all combinations of existing frequency assignments within search limits which combine to produce a given intermodulation frequency product;
- co-site analysis.

System engineering tools should be provided to:

- calculate the base station coverage for base station to mobile and pager applications;
- calculate the mobile talk-back range.

#### *Microwave analysis tools*

These tools should use the free space (Recommendation ITU-R P.525) or other appropriate propagation models to compute propagation loss and field strength. The following microwave analysis tools should be provided:

- a) microwave link analysis
- b) microwave path propagation loss
- c) microwave field strength computation
- d) microwave interference analysis
- e) antenna height analysis (Fresnel zone clearance)
- f) microwave frequency planning.

#### *General*

- The propagation model provided should be implemented specifically for the purpose of interference analysis and should consider the effects of terrain (use of digital terrain elevation and surface cover data).
- The supplied analysis tools should be able to function in the absence of digital terrain elevation and surface cover data.
- Analysis results after an analysis run should be displayed on screen with user selectable map background.
- Analysis results should also be available in the form of reports.

The EMC analysis tools should consider the following interference mechanisms:

#### *Terrestrial microwave networks*

- Evaluate the potential interference of a selected candidate fixed terrestrial microwave network against other fixed terrestrial microwave stations.
- Analysis of potential interference between terrestrial microwave assignments and geostationary satellite earth stations.
- Orbit avoidance verification and power limits calculations.
- Health safety distance calculations for terrestrial antennae.

#### *Earth station (optional)*

- Coordination contour calculation for earth station as per RR Appendix 7.
- Utilize GIS-based terrain information to perform automatic horizontal elevation angle and distance calculation.

- Provides analysis of potential interference between earth station and terrestrial microwave assignments.

#### *Intermodulation analysis tool*

This tool should compute the near and far field intermodulation products (at least 3 frequency, third order) produced by two or more transmitters.

## **4 International frequency coordination**

The ASMS should identify licence applications requiring international frequency coordination and automatically create a coordination document to be used for coordination with other administrations. The RR make mandatory or recommend international coordination for certain frequency assignments, depending essentially on the frequency (and power) of the transmitter. Recommendation ITU-R SM.1049 – A method of spectrum management to be used for aiding frequency assignment for terrestrial services in border areas, is an example of coordination practices.

The system should check if the area of interference is crossing a border using the ITU-Digitized World Map (IDWM). IDWM contains: geographical data-coastlines, seas, islands, lakes; political data-borders, regional boundaries, as well as meteorological and technical information data. The program provides the name of the country for specific “geo” coordinates, and the distance from a transmitter to the closest border. All available data in BR IFIC and other ITU documents should be used to check whether there is overlap with channels allotted by regional Agreements such as Geneva 1975, Rio de Janeiro 1981 and 1988, Geneva 1984, Geneva 1985 and GE06 (Geneva 2006).

The system should enable the identification of licence applications requiring border coordination. For this purpose, the field strength coverage in the neighbouring countries’ transmitters should be calculated, as well as interference. In this manner, the system should support interference calculations and forms for coordination.

The system should automatically identify whether stations under evaluation are located in a coordination zone using a GIS-based map. It should also provide a query function to enable online viewing of coordination data and status of selected coordination records using user specified parameters.

## **5 Submission of notices to the BR**

The system should automatically identify applications requiring the submission of notices to the BR in accordance with relevant RR procedures (e.g. Articles in RR Chapter III, Appendices 30, 30A and 30B, Resolutions 49 (Rev.WRC-12) and 552 (WRC-12)) and create appropriate coordination/notification data information suitable for the preparation of notices to the BR, according to RR Appendix 4 – Consolidated list and tables of characteristics for use in the application of the procedures of Chapter III, by using the related BR software packages and the associated guidelines provided on the BR website. The system should print on request the frequency assignments for internal verification and draw the notice to the attention of the spectrum manager if the request is inappropriate. It should create appropriate entries in the ASMS for tracking notification progress.

## **6 Licensing fees and fee collection**

The system should provide for recording fee payments and payment status associated with licensing and certification functions. Simple facilities should be included for recording fees and identifying

payment status since methods of calculating fees and requirements for billing vary from administration to administration. The programs should be open for modification by the administration in this area so that they can be adapted to the particular local circumstances.

The system should have facilities to accept prepayment from applicants and, at a later time, apply the prepaid sum to invoices.

The system should produce invoices conforming with specified formats. Invoice amounts should be automatically calculated by the system based on fee schedule. Invoice generation and fee calculation are an integral part of the licensing process. System should support the functionality that allows an invoice to be created manually, without being integrated to the licensing process.

The system should have an invoice query and reprint function.

A payment reminder function should be provided to print reminders to applicants or licence holders for overdue invoices.

Authorized users should be able to cancel any invoice line item or the entire invoice.

Facilities should be provided to record payment against any number of invoices. This should be an integrated function of the licensing process.

Authorized users should be able to cancel invoice, cancel prepayment, cancel payment, and perform journal adjustments.

The system should allow for refund of payment by authorized users.

Maintain a financial ledger to record all transactions within the licensing system, including: invoice payment distribution, client cash and/or cheque payment, client advance payments, adjustments such as refunds, inter-account fund transfers, etc.

Provide a user-definable chart of accounts and other financial transaction codes and procedures necessary to maintain an independent and auditable ledger facility related to licensing activities consistent with the national accounting standards and practices.

Provide ledger reports including: ledger and account summary, account posting record, voucher detail, account detail, fee collection reconciliation reports, etc.

Provide general ledger queries including: ledger and account summary, ledger and account detail, outstanding customer balance, past due accounts, fee payment histories for individual clients.

The system should provide functions to query ledger, journal, client account, invoice, and payment records.

The system should have extensive management reporting capabilities.

## **7 Monitoring**

The ASMS should provide spectrum management data to the monitoring system to assist the operators. The monitoring data should be available to the spectrum managers. Recommendation ITU-R SM.1537 – Automation and integration of spectrum monitoring systems with automated spectrum management, describes these functions in detail.

As described in Recommendation ITU-R SM.1050 – Tasks of a monitoring service, monitoring assists spectrum management by being its eyes and ears, enabling the verification of proper technical and operational characteristics of authorized (and unauthorized) transmitters, the detection and location of unauthorized transmitters, the identification and resolution of interference problems, and the validation of propagation and sharing models.



Penalties may be enforced on licensees whose emitting parameters are different than in the database of authorized stations. The system should provide spectrum management data, tasks and priorities to the monitoring stations as explained in the ITU Handbook on spectrum monitoring. The data are essential for comparing the monitored signal (in a particular frequency channel within a certain geographic area) to the licensed data, and to draw attention to discrepancies and ensure their correction.

### **Inspection**

The following capability, related to the preparation and execution of on-site inspections of stations, may be provided:

- produce inventory report of all equipment (transmitters, receivers, antenna, filters, etc.) and frequency assignments expected to be found (on the basis of the licence granted) for each station inspected;
- record inspection results of the station;
- record future inspection requirements for the station;
- produce reports of stations requiring inspection according to planned inspection date and geographic area.

## **8 Equipment approval process**

The ASMS may, when required according to national legislation, provide for the authorization, certification, type acceptance, or type approval processes of the administration. Such a computer-aided tool could be used to ensure that new applications entered into the system for approval are using approved or acceptable equipment.

## **9 Report generation**

An ASMS should be capable of producing a number of built-in standard notices, invoices, correspondence, text format reports, and graphic reports, available to the operator via the report processing function. In addition, the system should be equipped with all the tools required to produce customized reports, using only simple operator commands.

### **Notices, invoices, correspondence**

The spectrum management system should be capable of producing the following outputs:

*Notices:* Notice of application incomplete, notice of application rejected, notice of licence approval, notice of licence modification, notice of licence renewal, notice of licence termination, notice of fee increase, notice of warning, notice of violation.

*Invoices:* Request for fee payment.

*Others:* Operating licence, complaint acknowledgement, complaint resolution report, request for international coordination, response to international coordination.

*Database records:* Printouts of licence information, equipment information, site information, fee information, complaint information, monitoring task information, frequency allocation information.

*Engineering analysis results:* Graphic plots of field strength threshold contour, shadow plot, interference plots, terrain profile for given path, interference computation report, and EMC computation report.

### Text format reports

An ASMS should be capable of producing the following reports in text format:

*Frequency allocation report or chart:* This report or chart may include the following data items: lower band limit, upper band limit, service name, class of station, RR Region.

*Licensed station report:* This report may include the following data items for each licence:

Licence holder data, including reference number, regional authority, type of registration, name of legal licence holder, address of licence holder, name and address of point of contact, telephone number and e-mail address of point of contact.

*Frequency assignment report,* including the following data items as appropriate: frequency, preferred band, assigned band, frequency offset, schedule of operation, hours of operation, seasonal periods, class of station nature of service, experimental station, effective height above average terrain, country, latitude and longitude of transmitter, nominal radius of transmitting area, standard defined area of transmission, ground conductivity code, height above sea level, call sign emission designator, class of operation, designation of TV system, power delivered to antenna, radiated power, height of antenna above ground, type of antenna, polarization of antenna, characteristics of antenna, azimuth of maximum radiation, horizontal beam width, elevation angle of main lobe, gain of antenna, name of receiving station, longitude and latitude of receiving site, equipment code, interconnection to telecommunications net, notes.

*Licence general report:* This report includes the licence holder data from the previous report, plus the following additional data items:

- 1) date licence issued;
- 2) date of expiration;
- 3) class of licence fee;
- 4) amount of fee;
- 5) date of next payment;
- 6) reason and date of termination.

*Customized reports:* The operator should have the capability to specify customized reports, either based on the above reports with only selected information included in the report, or different reports based on selected sets of data from the database. The following customized reports are available to the operator:

- 1) report on number of applications, pending resolution, approved, rejected, or incomplete;
- 2) report on number of licences, valid, terminated, or due to expire;
- 3) financial reports of amount invoiced and amount collected;
- 4) report of number of complaints, received, rejected, or solved.

### Graphic format reports

An ASMS should be able to produce the following reports in graphic format:

*Licensed transmitter plot:* This plot shows a geographic map background, the location of the licensed transmitter, its call sign, frequency, effective radiated power (e.r.p.), field strength coverage contour, interference contour. This plot can show one single transmitter, or multiple transmitters on the same channel, on adjacent channels, or on different channels.

*Shadow plot:* This plot shows the colour-coded field strength values around a transmitter site.

*Terrain profile plot:* This plot shows the terrain elevation as function of distance on the path between two sites. This plot is calculated as a cross section through the topographic map data.

*Band allocation plots:* This plot shows in graphic format the allocation of the radio spectrum to different services, as a function of frequency.

### **9.1 Licence printing**

Print licences at the spectrum manager's request. Licences should follow a format determined by each administration or be configurable by the user.

### **9.2 Record summary**

Provide one-line summary data from each of the records selected by the user.

### **9.3 Record detail**

Provide a full listing of all data contained in selected records.

### **9.4 Transaction activity reports**

Provide periodic reports of transaction activity at the spectrum manager's request; such reports to include, but not necessarily be limited to: number of applications in process (total, by service, by band); total number of applications.

### **9.5 Expiration and renewal notice**

Create a list of applications due to expire at some user-specified future date. Optionally generate hard-copy expiration notices.

### **9.6 Summary status reports**

Provide summary statistics and specific record summaries for records in each processing status category.

### **9.7 Status reports**

Provide a list of all records in any user-designated status category (such as pending, incomplete, etc.).

## **10 User interface**

User interfaces should, where feasible, operate in the language(s) of the administration. The user interface should be graphical with extensive use of help features, menus, etc.

An ASMS should provide for the ease of use of operators, as illustrated by the following features:

- Database implementation should follow a simple structure that mirrors the manual process.
- The system should use graphical user interface forms that are easy to understand and intuitive to use.
- Data entry fields should be defined by titles to prevent confusion of the operator over what quantity to enter.
- The display cursor should point automatically to the field where the next data needs to be entered so operators cannot miss an entry.
- Data entries should be checked for type of data and range of values.
- Invalid data should be rejected by the system. Operators should be given a warning message giving a description of the mistake and the correct range of values.

- Should be designed to utilize client-server computing system architecture.
- The RDBMS used should be a product in use by most other government organizations worldwide to support large volume of operational data and complex applications.
- The system should support multiple regional office operation if required by the administration.
- Should provide record level data access security control.
- Should provide audit trail upon data record status change and provide such information as: identification of records being changed, identification of user causing the change, time and date, from status, to status.
- The operators at workstations should not be required to have knowledge of the software details.
- Should have self-explanatory instructions for the user available in the form of “help windows” on screen.
- All data entered by users should be validated upon entry to ensure that the data being entered are valid and within desired range.
- The system should provide ad hoc query capabilities to meet a variety of operational requirements.

### **System administration**

An ASMS should:

- have utilities to perform all necessary user administration;
- maintain user access control through predefined user roles;
- provide capabilities for reference table maintenance;
- have extensive automatic housekeeping functions, e.g. record purging;
- provide automated procedures for routine backup, database integrity validation, and recovery;
- have query functions for on-line on screen viewing of system administration data;
- have extensive management report capabilities.

### **System customization**

Customization of the ASMS to the specific needs of the administration may be required, such as:

- geographic definitions – regions, province and cities;
- license forms and system letter templates;
- existing spectrum Plan;
- licensing process and procedure work flow;
- tariffs and fees’ calculation.

## **11 Data processing guidelines**

An ASMS should use an appropriate database management language, chosen for its suitability to spectrum management requirements. An ASMS program should be designed to support the functionality described in the following sections:

## **11.1 Records**

The system should support standard data transaction record creation, record editing/modification, and record deletion, which should be accomplished in a multi-user environment.

## **11.2 Data entry**

Provisions should be made to make data entry as simple as possible, including the use of logical full screen editing and data entry validation and logical, user-changeable defaults. Data entry should be optimized for input data validation taking into account, where applicable, the guidelines provided on the relevant BR web pages for the use of BR notice types and for the mandatory submission of electronic notices/filings by using BR software packages.

## **11.3 Data modification**

Changes to records should be made using the same screen-editing specified for new data entry whenever possible.

## **11.4 Data back-up and archiving**

Standard features should be included that support routine back-up for data loss protection. Archiving should be provided for any deleted records identified by the spectrum manager for archive retention.

Records should be identified individually and by class attributes (which should be specified in a user changeable data table).

It may be desirable to maintain historical records in order to allow the retrieval of prior licence awards or renewals that may affect the processing of a new application.

Audit trails should also be maintained for each application. The audit trail includes all database changes, time and date of those changes, and name or ID code of the individual authorizing the changes.

Time and date stamps are recorded in the system as the application completes the various processing steps allowing the reports module to calculate throughput times and statistics relating to the percentage completion of applications in process by category.

## **11.5 Database inquiry**

Records of interest should be easily identified and extracted. Primary selection is to use a set of standard selection screens incorporating standard selection criteria. The ASMS is also to support selection using query by example and extended query techniques.

Inquiries could include, *inter alia*: selection by frequency range; selection by frequency range and bandwidth; a designated frequency or channel; selection by unique record identifier; selection by geographic area; selection by services; selection by user; selection by call sign or station identifier; selection by equipment manufacturer; selection by transmitter output power; selection by licence status.

Outputs from all data inquiries should be ordered according to fields specified by the user.

## **11.6 Validation**

Validation is the process whereby data entered into the ASMS are tested to see that it is permissible or appropriate. An ASMS should include validation on every input field.

### **11.7 Record status**

Information in the ASMS data files will be subject to continual change. For planning purposes, the ASMS recognizes multiple record status categories (although records will not necessarily be kept in different files matching these categories). Provision should be made to assign and track record status. Status attributes should be user assignable, but will typically identify processing status like preliminary processing, hold for data correction, hold for coordination, approved, etc.

### **11.8 Program parameters modification**

The program should be as simple as possible to maintain and modify. Modifications that are allowed should be minimal.

### **11.9 Data migration**

The issue of migrating the existing data to the new system, either from paper form or from an existing electronic format, is often underestimated. Special programs are often necessary to accomplish this data migration and can sometimes add significantly to the cost of acquiring a computerized spectrum management system. Differences in data structure from the old to the new system can sometimes render such a process nearly impossible and manual decisions and intervention may be necessary during the migration process. This again can significantly add to the cost of the system.

### **11.10 Data content**

Recommendation ITU-R SM.1413, the ITU Handbook on computer-aided techniques for spectrum management and the Preface to the BR IFIC provide data items to be included in a spectrum management database. Data elements should include those required for the submission of notices to the BR. An ASMS should optionally provide for the import and export of data in the specified formats. For internal use, such data should be stored in that format most efficient for the specific applications. For efficiency, consider total data storage requirements, data precision requirements, and needs for processing speed. In general, data should be stored in compact, internal format until required for some external application. Display formats should be chosen as appropriate to individual output forms. An ASMS should provide facilities to import data from the BR IFIC.

### **11.11 Data export**

It should be possible to export selected data to other applications.

## **12 Hardware/software environment**

### **12.1 Hardware guidelines**

The ASMS computer hardware should include the following elements:

#### **Network servers**

- One or more network server computers capable of running all elements of the ASMS software are required. It should be sized appropriately to support the amount of data processing and the number of users expected during the next five year period – after which the hardware should be upgraded. Typically, this server will have multiple processing cores, many GBytes of RAM and adequate hard disk space to support normal operations with 200 to 300% spare disk. It is highly recommended to have a backup network server to eliminate a single point of failure on this important element of the ASMS.



- *Back up hard drive.* All data should be backed up on a regular schedule to a storage device(s) independent of those supporting normal operations.
- *Displays.* Large flat panel displays should be provided to accommodate work on the server. If multiple operator positions are needed, keyboard, video, mouse (KVM) switches are recommended to easily move control of the network servers to different operator positions.
- *Optical drive(s)* should be included in each server to accommodate local storage and movement of files.
- *Laser printer(s).* These should be sized based on anticipated workload and local need for hard document generation.

### **Workstations (Client stations)**

- These computers should meet or exceed the processing and memory requirements called for by the applications they will need to run. As a minimum, they should have two processor cores, multiple GBytes of RAM and hard drive capacity to support operations over a five-year period.
- The workstations should include one (or more) large flat panel displays to accommodate a complex multi-window work environment.
- *Optical drive(s)* should be included in each workstation to accommodate local storage and movement of files.
- *Network interface card(s)* (NIC) should be included with each workstation to accommodate a high speed connection to the server, the Internet, other workstations and storage devices.

### **Network equipment**

The ASMS network equipment should be sized appropriately for the number of users expected during a five-year period. This equipment would include a multi-port network switch(es) and router/modem if connection to the Internet will be necessary.

#### *Warranty*

All deliverables should carry a full warranty of 12 months from date of acceptance of the provisional acceptance test.

#### *Auto-diagnostics*

The automatic spectrum management system should be equipped with tools for the continuous monitoring of system performance and auto-diagnostics.

## **12.2 Software guidelines**

An ASMS should be designed to run on computers configured with at least 2 GBs of RAM. A good quality operating system and database management system is required. GIS software is also useful.

## **13 Geographic map display functions**

The ASMS should include the software for the storage, processing and display of geographic data and terrain/topography data. The system should be capable of accepting map data in standard formats. The spectrum management system should be capable of storing, processing and displaying of the digital map data with no degradation in accuracy, up to a scale of 1:24 000 and a height accuracy of 10 m.

The first layer is the digital terrain map as detailed in Recommendation ITU-R P.1058 – Digital topographic databases for propagation studies. On this layer by geo-coding conforms a map that

includes by raster or vector all needed geographical, political, cultural landmarks, drainage, land cover, populations, utilities data. Conductivity parameters of the ground  $\sigma$  and  $\epsilon$  are retrieved from GRWAVE or IDWM.

### 13.1 Point-to-point profile

On the digital terrain model (DTM) and image layers we add the best propagation and fading models with proven accuracy: Recommendations\* ITU-R P.1546 for the broadcasting services, ITU-R P.525 for free-space attenuation, ITU-R P.526 for diffraction, ITU-R P.618 for Earth-space prediction, ITU-R P.833 for attenuation in vegetation and ITU-R P.834 for tropospheric refraction. On the Map, the system should be capable of showing a specific station with its coordinates, e.i.r.p., azimuth and elevation, altitude above sea level and antenna pattern. The basis for EMC analysis is the profile estimation along the interference and wanted signal paths. Without digitized terrain data, Recommendation ITU-R P.1546 should be used to estimate the field-strength for stations. In this case, for determined percentages of time and place, kind of topography, you only need to know the effective height of the antenna.

### 13.2 Coverage

The system should calculate the estimated field strengths for any contour from the transmitter, e.g. every 10 m, 25 m, 50 m, 100 m ..., depending on the DTM pixel resolution.

### 13.3 GIS system

To provide a system that generates electronic maps, that are required for the analysis programs, through the use of multiple kinds of input data. Hardware and software components to ensure the proper functioning of the map scanner and plotting system are also necessary.

### 13.4 GIS software

The GIS software should have the following characteristics:

- full topological data structure (nodes, arcs and features both implicit and explicit topology), feature object oriented design;
- full SQL and RDBMS support;
- support for one or more current operating systems;
- built-in mapping facility for data capture and map production. Integrated and fully functional DTM, including provision for clutter data;
- display of the data associated with a chosen object depicted on a map background on the screen should be possible;
- display information in user-definable scales and projections;
- display positions of specific points, lines, and areas over the map background with associated descriptive texts;
- hard or soft copy of the screen (including graphics) produced by the application modules.

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\* See also Recommendation ITU-R P.1144 – Guide to the application of the propagation methods of Radiocommunication Study Group 3.

## 14 Documentation

A complete user's manual should be supplied. The manual should include a description of all operating features of the program sufficient to allow a user untrained in the use of the program:

- to specify the computer required for the use of this program;
- to install this program on the computer;
- to explain the procedure used to arrive at a frequency assignment;
- to train others in the proper use of the program;
- to change the parameters which control the operation of the program through the use of user changeable data tables;
- to back-up and archive data as required to ensure data security.

Administrations should specify their further requirements for documentation.

For example:

- Number of copies and format.
- All documents should have a table of contents and an index.
- Text in the documents should be in a 12-point, easy to read font. The administration should specify the language(s) that it requires the documentation to be delivered in.
- Whenever possible documents should use descriptive diagrams, screen copies, photographs, flow charts, and graphical illustrations.
- Documents from original vendors should conform as much as possible with the requirements above; however, the administration should be aware that bidders do not necessarily have control over the format of documentation from original vendors. Documents from original vendors of equipment or software should be in hard or soft copies and in the specified number of copies.
- System diagram showing details of system configuration.
- Installation drawing detailing the site layout and the interconnections of various equipment.
- System manager manual describing system management procedures and utilities.
- Reference manual organized in accordance to logical operation areas of operation with flow charts detailing the operations of the specific functional areas. This manual should include instructions to users on how specific operations can be achieved.
- Operator manuals from original equipment and software vendors. Programmer manuals from original software vendors.
- Administrator manuals from original RDBMS software vendor.

## 15 Training

Training requirements should be estimated according to the skill level, previous training, and type and number of staff to be trained on each subject. The administration should specify clearly where the training courses are to take place, how many staff are to be trained on each subject, and what facilities are provided or to be provided by the administration. Training manuals and other necessary materials should be provided to the trainees, one set per trainee.

Training is also discussed in the ITU Handbook on national spectrum management and in the ITU Handbook on spectrum monitoring.

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