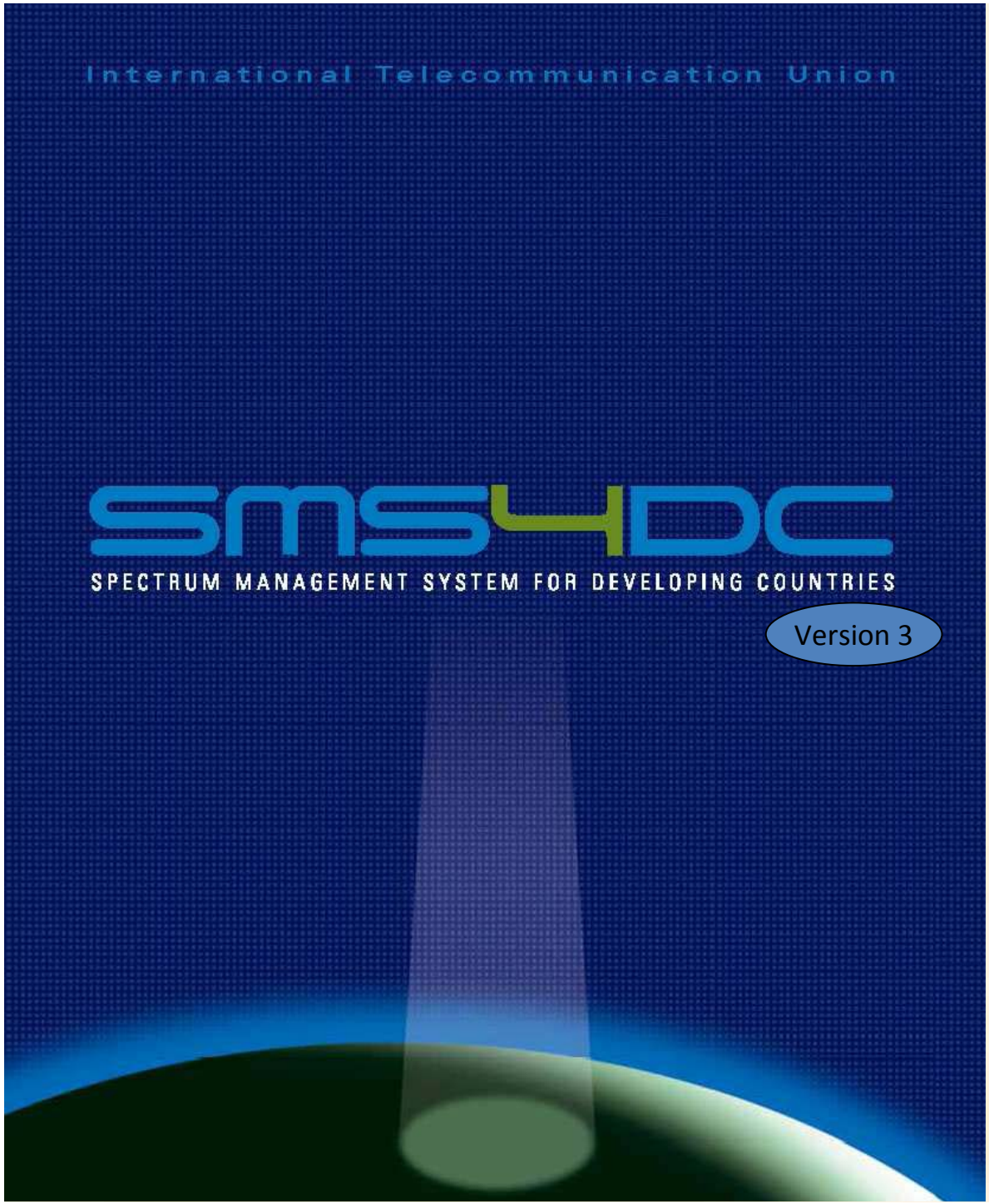


Spectrum Management Fundamentals

Part 2

National Spectrum Management

International Telecommunication Union

Committed to connecting the world

Spectrum Management Goals

Establishing a Management Framework

- Spectrum Management processes are established in a framework largely determined by national needs.
- The key elements of the framework are:
  - National objectives for the regulatory system;
  - Legislative direction;
  - Regulating authority structure;
  - Key functional responsibilities.

In the National Interest

- The question regulating authorities must ask as a starting point is “what is the National Interest.”
- To answer this question one must consider many, often difficult or controversial, issues about the social, economic and political directions the nation wishes for itself.

Consultation

- The decisions about national goals cannot be imposed from outside: they are rightly a matter for a sovereign government and the people, in the interests of the people.
- Therefore any process establishing a regulatory framework for spectrum access must involve the key stakeholders: the spectrum users and the public.

Planning Time Frame

- While users of the spectrum have immediate needs, which should be met if possible, there are also uses in the future which must be allowed for in the planning.
- The regulating authority must achieve a balance between the current use and possible future uses, such that growth is not hindered.

Range of Uses

- Potential uses for the spectrum include:
  - Public and private correspondence;
  - public and private business communication;
  - News, information and entertainment services;
  - Financial transactions;
  - Technology development and pure research;
  - Navigation services;
  - Remote monitoring of plant and industrial processes;
  - and so on.

Legal Framework

National Legislation

- What is deemed, after suitable consultation, to be the national priorities would usually be described in national legislation.
- The statements of purpose and intent should be general and non-political, such that they are relatively insensitive to technological or political changes.

Typical National Objectives

- Typical national objectives may include:
  - to facilitate national and international personal and business communication;
  - to foster development of technological infrastructure and research capacity;
  - to safeguard life, property and to protect national sovereignty;
  - to support global transportation systems;
  - to foster conservation of natural resources;
  - to educate, inform and entertain the public;
  - promote the development of new technologies and resources; and
  - to stimulate social and economic progress.

Regulatory Framework

- The regulatory framework must therefore facilitate equitable and timely access to the spectrum, while striving to achieve the national goals.
- Where personal or international interests conflict with the national goals, the regulatory framework should facilitate the resolution of the conflict.

Other Policy Support

- National legislation enshrines the national goals in the law of the land, but to be useful this law has to be further divided into:
  - clear national policy statements and regulation; and
  - a national long range spectrum use development and management plan.

Administration

- The legislative platform must be given practical implementation.
- The detailed regulation package which supports the legislation puts the broadly stated policy guidelines into effect.
- National governments usually delegate the administration, and the generation of policy advice, to expert managers in a regulatory authority.

What of the Future?

- However well we frame legislation or develop policy for now, change inevitably takes most of us by surprise.
- The regulatory authority therefore must have as part of its charter, the task of using its expert knowledge to try to predict the future from current trends: the aim is to minimise the surprise of change.

Regulatory Predictability

- With a stable regulatory environment, users of the spectrum can consider their own future directions, and can confidently plan for investment.
- The continuity provided by an authority at arms length from governments, and therefore relatively buffered from political whim, while still remaining sensitive to changing political agenda.

Development Plan

- An analysis of the technology, changing needs and national development goals can provide a basis for planning for future spectrum use.
- The plan must be flexible enough to respond to the changing spectrum environment, and allow for the provision of timely policy advice in the public interest

How Detailed are the Plans?

- National interest and development stage will determine how detailed the spectrum management plan is.
- Emphasis for emerging nations will be on building spectrum use.
- For developed users the spectrum management goals must be clear and detailed.

Establishing a Regulatory Base

- There are three key areas to be considered when establishing a regulatory base:
  - the legal base;
  - national guidelines for spectrum use;
  - detailed regulations and procedures.

Legal Focus

- The focus of radiocommunication law should be on recognising the sovereign rights in the spectrum resource, and the right of the national government to regulate it in the interests of all citizens.
- There must also be a clear distinction between the law relating to general telecommunications and that for radio based uses.

Citizen's Rights

- The legal framework must clearly establish a legal basis for the rights of citizens and the government to own and operate radio communications equipment.
- These rights are crucial to business operations, general information flow and research.

National Guidelines for Use

- A table showing current and proposed spectrum allocations provides information for managers and users about where new services can operate.
- The ITU International Table of Frequency Allocations can form the base of more detailed national allocation tables.

National vs International Allocation

- Naturally national governments provide spectrum allocation to meet local needs, but the spectrum uses in other countries must be considered to ensure compatibility with neighbouring services and the ready availability of equipment to use the services.

Regulatory Detail

- The legal framework is expanded in detailed regulations by the authority charged with administering the spectrum resource.
- These regulations detail the procedures to obtain access to the services.
- Failure to provide the detailed regulatory framework encourages uncontrolled use and puts investment in infrastructure at risk.

Organizational Structure

Organizational Structures

- The structures for spectrum management agencies are rightly the responsibility of the national government, and will depend in part of the political and economic structure of the government itself, and in part on the organizational philosophy of those establishing and operating the agencies.

One Organization or Many?

- The answer to this question always involves a trade-off.
- A single organization has the advantage that coordination of spectrum use is simplified and policy advice comes from a single source.
- The disadvantages include unmanageably large organizations, or potentially one-sided policy advice.
- Dividing the labour across many smaller organizations:
  - encourages simplified functional management;
  - increases the variety of sources for policy advice; and
  - encourages specialisation.
- On the other hand, fragmentation creates:
  - coordination problems; and
  - limited and territorial vision.

Publishing Structure and Relationships

- Regardless of the structure chosen by the national government, the organisational structures and their relationships to one another, to government and to international bodies must be published.
- Where many authorities are created, a single supervising body can coordinate their activities, resolve conflict and speak for the nation with a single voice.

Decision Making

- The keys to effective and useful decision making are:
  - Consultation and the participation of key stakeholders;
  - Publicly stated procedures for decision making;
  - Openness, certainty and predictability;
  - Independence from government and private spectrum users.

Expert Advisory Groups

- Expert groups work well when:
  - Issues are well defined;
  - All key interested parties are represented;
  - A common interest is served.
- Expert groups do not work well when:
  - Self interest biases discussions;
  - group is not truly representative.

Spectrum Management

- Work well when:
  - Coordinating advice from many expert sources;
  - Open consultative bodies provide public access and wide representation;
  - specific issues have been identified.
- Do not work well:
  - when issues are ill defined;
  - rapid decisions required.

International Coordination

- The ITU brings interested parties together in technical and policy-making groups. The radiocommunication sector includes:
  - World Radiocommunication Conference;
  - Radiocommunication Assembly;
  - Regional Radiocommunication Conferences;
  - Radio Regulations Board;
  - Radiocommunication Study Groups;
  - Radiocommunication Bureau.

ITU Radiocommunication Study Groups

- The work of the major international conferences is informed by specialist study groups. These study groups further divide the work into working parties and task groups investigating and reporting on particular issues as required. These study groups are listed on the next slide.

ITU Radiocommunication Study Groups

SG 1 SPECTRUM MANAGEMENT

SG 3 RADIO WAVE PROPAGATION

SG 4 FIXED-SATELLITE SERVICE

SG 7 SCIENCE SERVICES

SG 8 MOBILE, RADIODETERMINATION, AMATEUR AND RELATED SATELLITE SERVICES

SG 9 FIXED SERVICE

SG 10 BROADCASTING SERVICE (SOUND)

SG 11 BROADCASTING SERVICE (TELEVISION)

National Consultation

- National spectrum management agencies may establish consultative groups broadly relating to subject areas as defined by the ITU study groups, but they may also establish other local consultative groups to extend the consultation process to other interested parties.

Spectrum Management Agency Functions

Functional Responsibilities

- The basic functions of a spectrum management agency are:
  - spectrum management policy and spectrum allocation;
  - frequency assignment and licensing;
  - standards, specifications and equipment authorisation;
  - spectrum control (enforcement and monitoring);
  - liaison and consultation;
  - spectrum engineering support;
  - computer support;
  - administrative and legal support.

Core Activities

- While all of these functions must be provided, administrative, legal, engineering and computer support are peripheral to the core business of the agency.
- Policy and planning; liaison and consultation; international cooperation; assignment and licensing; and equipment standards are all parts of the core business.

Policy

- Spectrum management policy must be formulated having regard to the uses which best serve the public interest.
- Key issues are:
  - public need and benefit;
  - Technical considerations:
  - apparatus limitations.

Public Benefit

- The key public benefit issues include:
  - access by radio rather than through wired infrastructure;
  - service reach;
  - social and economic importance;
  - public demand;
  - impact of new technology.

Technical Issues

- Technical issues include:
  - propagation characteristics and compatibility with other services;
  - bandwidth required;
  - minimum signal strength;
  - interference levels;
  - technological viability.

Apparatus Issues

- Efficiency of spectrum use is limited by:
  - the practical limit of the useful spectrum;
  - transmitter operating characteristics, including stability and power;
  - practical antenna characteristics;
  - receiver complexity and availability.

Standards

- National standards for equipment and system performance, and electromagnetic compatibility, minimise interference and raise system reliability.
- Standards facilitate international cooperation and equipment interoperability.
- International standards already exist and should be used where possible.

Compliance Testing

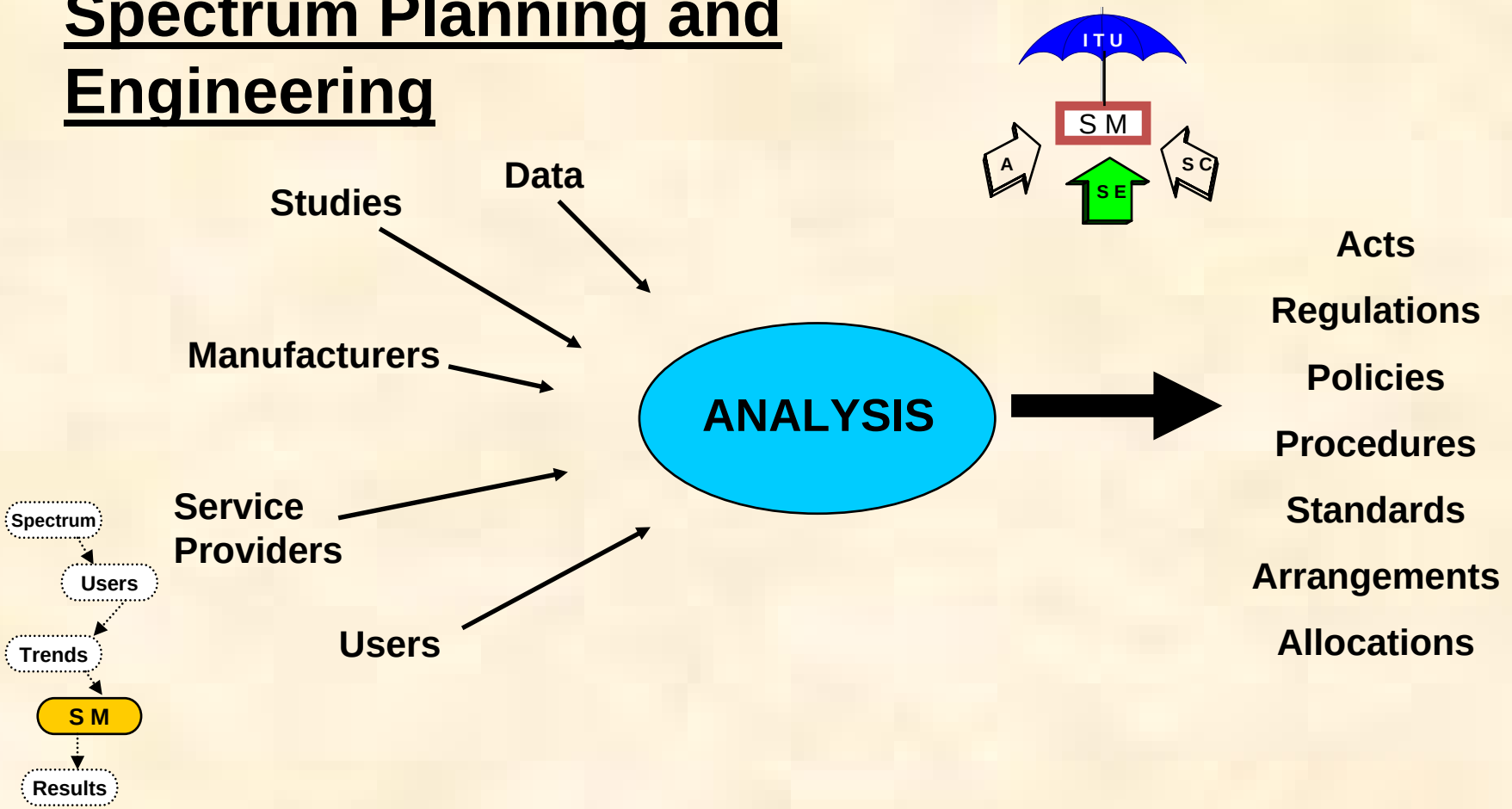
- Equipment compliance with established standards is used to ensure compatibility with the electromagnetic environment and to ensure adequate service provision.
- Standards compliance certification can be by:
  - type approval of equipment;
  - self certification and spot checks.

Type Approval

- Where individual frequency coordination is not needed, but equipment must comply with minimum performance conditions, classes or types of devices can be approved, provided compliance is assured.
- Compliance at several levels can be assured by a regime of setting standards, declarations of conformity and measurements in approved testing laboratories.

Spectrum Planning and Engineering

Spectrum Planning and Engineering



Checking New Assignments

- National agencies must examine notices of introduction of, or modification to, frequency assignments published in the Radiocommunication Weekly Circulars.
- Notified international frequency allocations should be checked for potential harmful interference to existing or planned national radio services.
- Comment on potential interference must be received by the due date published in the circular.

Electromagnetic Compatibility

- As part of the frequency planning process it is necessary to carry out an analysis of the electromagnetic compatibility (EMC) of the proposed service with other users of the spectrum.
- The work of ITU study groups has produced detailed procedures for this analysis, published in ITU-R recommendations.

Time Space

- Broadcast transmitters typically radiate their signal continuously while on the air, but some broadcast stations are on the air only during certain parts of the day, and the frequency is available for other services for the rest of the time in the day.
- Rotating radar systems may be considered as having a regular periodic intermittent transmission characteristic in a particular direction.
- Duty cycle factor in pulsed radar or Time-Division-Multiple-Access signals may be considered time or frequency factors depending on the modelling process.

Frequency Applications

- Information provided in frequency applications should be consistent with ITU-R Recommendations. Basic data includes:
  - station operators identity, address and call sign, etc.;
  - date of notification, date put into service, and duration of licence;
  - technical transmission characteristics;
  - topographical data and service area;
  - required protection ratio.

Optimal Frequency

- An optimal frequency assignment for either base stations for a mobile communication network or for fixed broadcasting (television or radio) transmitters produces a complete coverage of the network service area, without causing co-channel or adjacent channel interference.

Frequency Selection

- There are several methods commonly used to select appropriate frequencies; all of which use the technical data maintained in the frequency register database or in the application for frequency allocation.
- The method used depends on many factors, including the nature of the service and the complexity and detail of analysis required.

Frequency Planning

Choosing Frequencies

- Frequency assignments must provide dedicated spectrum for the operation of existing and future radio services.
- But to cater for growing public demand for access, frequency assignment procedures must provide access without creating interference or reducing the efficiency of spectrum use.
- To ensure effective global coordination of the limited spectrum resource, national frequency allocations must be consistent with:
  - ITU Radio Regulations;
  - ITU Frequency Plans;
  - ITU-R Recommendations;
  - ITU operating rules and procedures; and
  - national legislation and operating procedures.

National Procedures

- A national process for assigning frequencies needs to ensure that any new frequency does not create an interference problem, either nationally or in the international community.
- It must also document the service requirements and any impact that service will have in the spectrum.

Considering Other Users

- The procedures for allocating frequencies must also consider the impact of other countries' assignments as published in:
  - ITU Frequency Plans;
  - the ITU International Frequencies List (IFL); and
  - Weekly information circulars published by the Radiocommunication Bureau.

Spectrum Use Register

- A national spectrum register must be included in the procedures, recording:
  - Carrier frequency;
  - channel bandwidth;
  - service spectrum and channel occupancy;
  - service radiated power;
  - antenna characteristics;
  - geographical service area;
  - and so on.
- The register must be:
  - regularly maintained;
  - sufficiently large to record a clear and complete description of each frequency assignment;
  - amenable to rapid data retrieval;
  - searchable.
- These are characteristics of computer data bases.

National Frequency Coordination

- National frequency coordination is needed because most frequency bands are shared by different services and different users.
- National guidelines (rules), made enforceable by legislation, standardise the frequency allocation process and ensure appropriate analysis of the impact of each frequency allocation.
- Since the electromagnetic spectrum is a global shared asset, otherwise autonomous administrations must agree to cooperate for the benefit of all.
- The ITU Radio Regulations are the basis for this agreement.
- The agreed procedures aim to avoid mutual interference by exchanging and analysing frequency allocation data.

Coordination Procedures

- There are three main parts to formal coordination procedures:
  - how the process will be administered;
  - how information is to be recorded, and exchanged;
  - how technical information is to be gathered, analysed and reported.
- Coordination procedures will also specify restrictions on uses of assigned frequencies.

International Registration

- International registration provides:
  - international recognition of services and frequency plans;
- It is usual to notify international frequency use after successful negotiations between countries.
- There are some circumstances detailed in the ITU Radio Regulations when an administration is obliged to notify its use of the spectrum.

Other Notification

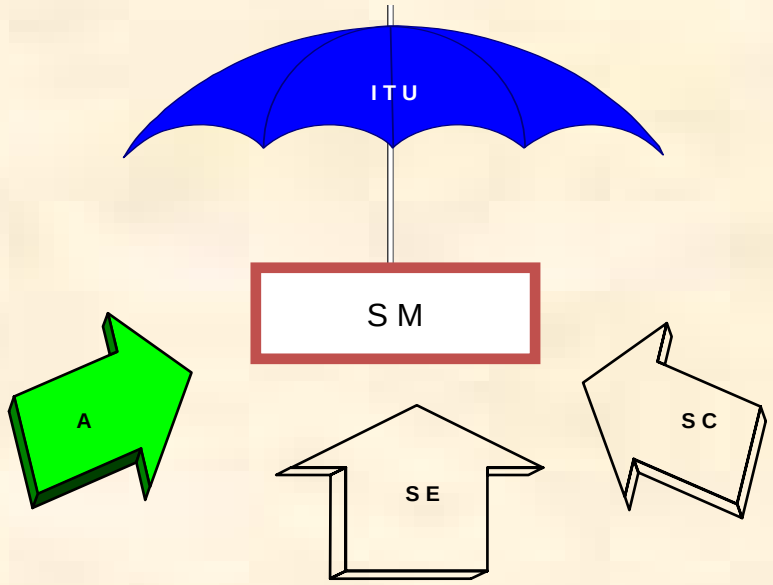
- The Radio Regulations require notification of:
  - frequency use likely to cause harmful interference to any service of another administration;
  - frequencies to be used for international radio communication
  - where it is desirable to obtain international recognition of frequency use.

Frequency Allocation and Licensing

- This function of the regulatory agency:
  - maintains lists of existing spectrum uses;
  - coordinates proposed uses with existing services;
  - applies the regulations to exercise control over spectrum use;
  - coordinates with international regulatory bodies, like the ITU.

Authorization

- Allotments and assignments
- Process
- Analysis
- Certification



Licensing

Licensing Administration

- Licensing administrations:
  - examine applications for licences for eligibility and technical compliance with equipment standards;
  - grant authorisation to use an allocation, whether a licence is needed or not;
  - assign and register call signs;
  - issue licences and collect fees;
  - review, renew or cancel licences;
  - ensure the technical competence of licence holders.

Licence Conditions

- General conditions apply to individual licences or to groups of licences. They also are enforceable. Conditions include:
  - operating a licensable radio service without a licence is an offence;
  - changes to the radio service must be notified and authorised by the spectrum management authority;
  - conditions of the licence must be observed;
  - where appropriate, all messages should start and end with a call sign;
  - licence provisions should include information on electromagnetic compatibility, interference immunity, and intrinsic safety;
  - provisions include reference to appropriate quality assurance standards for equipment, maintenance and site engineering.

Immunity

- Standards must be established for a wide range of equipment capable of generating electromagnetic interference, to limit the potential for creating interference from this equipment.
- Radio communication equipment must be designed to have an intrinsic immunity to electromagnetic disturbance so it will operate as intended.

Site Engineering

- Where services share a site or transmission tower, frequency assignments must be such that they do not cause mutual interference.
- Typical potential interference mechanisms include:
  - intermodulation products produced at transmitter output or at receiver input;
  - spurious radiation; and
  - receiver blocking from high power nearby transmitters.
- Regulators or service owners should have the statutory responsibility to ensure freedom from interference when proposing a new service at a site.

Operator Licensing

- Some administrations require operators of some services to hold a minimum qualification, recognised by a licence, certifying the capability of that person to operate or maintain the service to the required standard.
- Additionally, the Safety of Life at Sea convention and the ITU Radio Regulations specify that only licensed people operate or be responsible for transmitter radiation under certain circumstances.
- International recognition of suitable qualifications facilitate efficient and consistent operator certification.

Preventing Interference

- A key issue in spectrum management is to prevent services using the spectrum from interfering with each other.
- The key control mechanism is through licensing, or, a process of conferring the legal authority to operate a transmitter under specified conditions.

Licence De-regulation

- The administrative burden on spectrum administrations can be reduced if transmitters that are unlikely to cause significant interference can be operated without licences or with a class licence.
- Licences may be needed though, where low powered devices share spectrum with higher priority services.

Licence Fees

- Licence fee structures are the responsibility of the agency charged with managing the spectrum.
- Fee structures are a way of optimising spectrum use, and should reflect the extent of spectrum used and the economic benefit derived from that use.

Licensing Structures

- Possible structures include:
  - government control;
  - government regulation, but management rights sold to private organisations providing frequency planning services and assignments as commercial activities;
  - privatization of spectrum management agency, with safeguards against monopoly powers and government control of civil use;
  - direct sale of spectrum licences;
  - secondary markets trading in licences.

Spectrum Pricing

- Pricing should be determined based on the extent of use, considering:
  - frequency band and extent of demand in that band;
  - spectrum used, and spectrum efficiency;
  - grouping similar services, and equitable distribution of fees between providers of similar services;
  - channel loading;
  - transmitter power, service area and geographical location

Spectrum Pricing Policy

- Spectrum pricing policy should work to encourage economic growth and diversity.
- It should continue to support business communication, ensuring equitable access while not acting as a barrier to entry.
- It should provide for scientific, social and entertainment services.
- Exemptions or concessions should be available to services providing safety of human life functions.
- Monopoly control of access to the detriment of the country or of the pricing system should be avoided.

Direct and Indirect Costs

- Direct costs should relate to the spectrum in which services operate and the amount of spectrum used. The spectrum is a resource that can be traded and priced as any other commodity resource is. Total spectrum value should be equitably distributed between users.
- Depending on the national goals, as far as possible the indirect costs of maintaining the spectrum management service should be recovered from the licence fees. Indirect costs should be distributed in proportion to the direct costs.

Improving Spectrum Use

- Licensing practices and pricing policies should:
  - reflect the value users place on their spectrum use, and the impact of those services;
  - act as an incentive to consider alternatives to radio spectrum use, so freeing congested spectrum space;
  - encourage existing users to relinquish unused spectrum allocations;
  - increase the probability of new users gaining access to the spectrum.

Spectrum Control

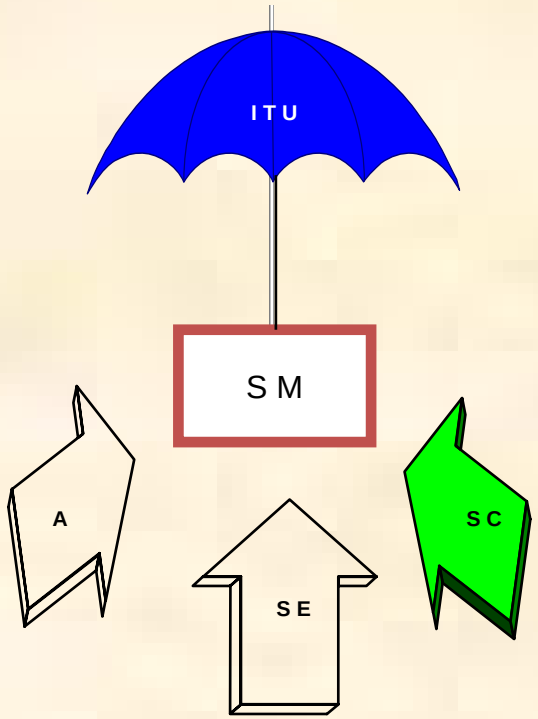
- One cannot manage spectrum use unless one knows who is using the spectrum.
- Spectrum monitoring allows detection of unauthorised users or interference sources.
- With appropriate legal mechanisms in place, compliance with national regulations can be enforced.

Regulation and Enforcement

- Because licensing carries with it the power, established by statute, to enforce licence provisions, the licensing process should itself be regulated by an equitable and transparent statutory framework.
- Licensing enshrines the legal power to investigate sources of interference.
- Licensing can restrict manufacture, ownership or use of equipment likely to cause interference.
- Licensing enforces a discipline on spectrum users, thus assuring protection from harmful interference under normal operating conditions.

Spectrum Control

- Measurements
- Services
- Corrective Action



International Cooperation

- Radio signals do not respect national borders, so international cooperation is needed to protect national radio communication systems from external interference.
- Participation in the activities of bodies like the ITU can facilitate international regulation while presenting the national position.

Liaison and Consultation

- National users of the services also need to participate in the consultation as part of the policy evaluation process.
- Equitable access to the consultation process is necessary to ensure that all relevant needs are considered.
- Thus a means of bringing about change is established.

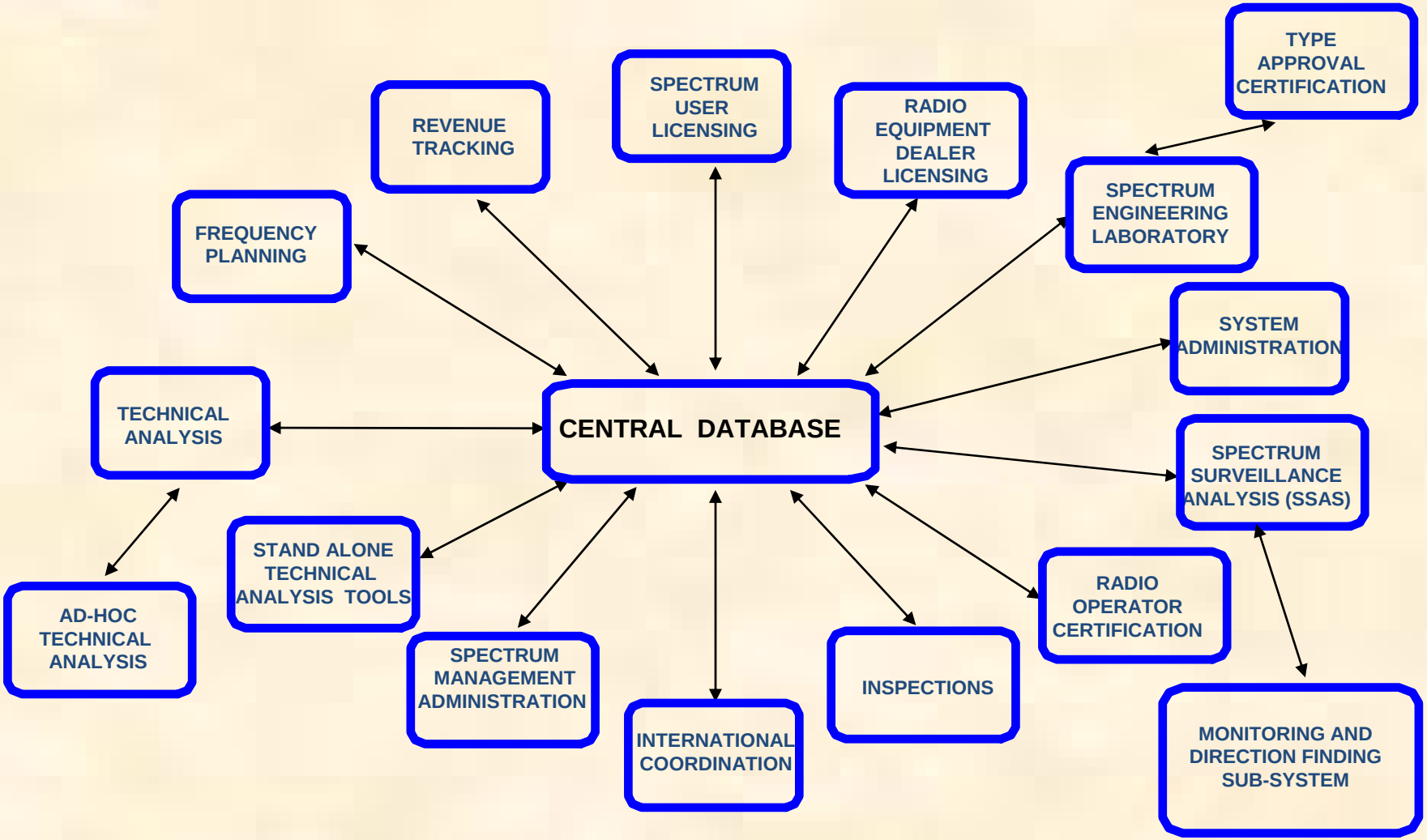
Engineering Support

- While the spectrum management role is mainly concerned with social, economic and political considerations, engineering knowledge or analysis skills may provide an unbiased technical answer to a policy problem.

Computer Support

- With the ready availability of inexpensive computing facilities, many of the functions of the spectrum management agency can be supported with computers, from record keeping, accounting, engineering calculations, and so on.

Spectrum Management Sub-systems



Frequency Database

- Develop a database (computer or manual) including:
  - a frequency register, including coordinated frequency assignments;
  - a register of all operating radio stations;
  - a register of station geographical locations and service areas;
  - transmission characteristics;
  - topographical data and path profile analyses.
- Use the database and a frequency management system to assign frequencies.

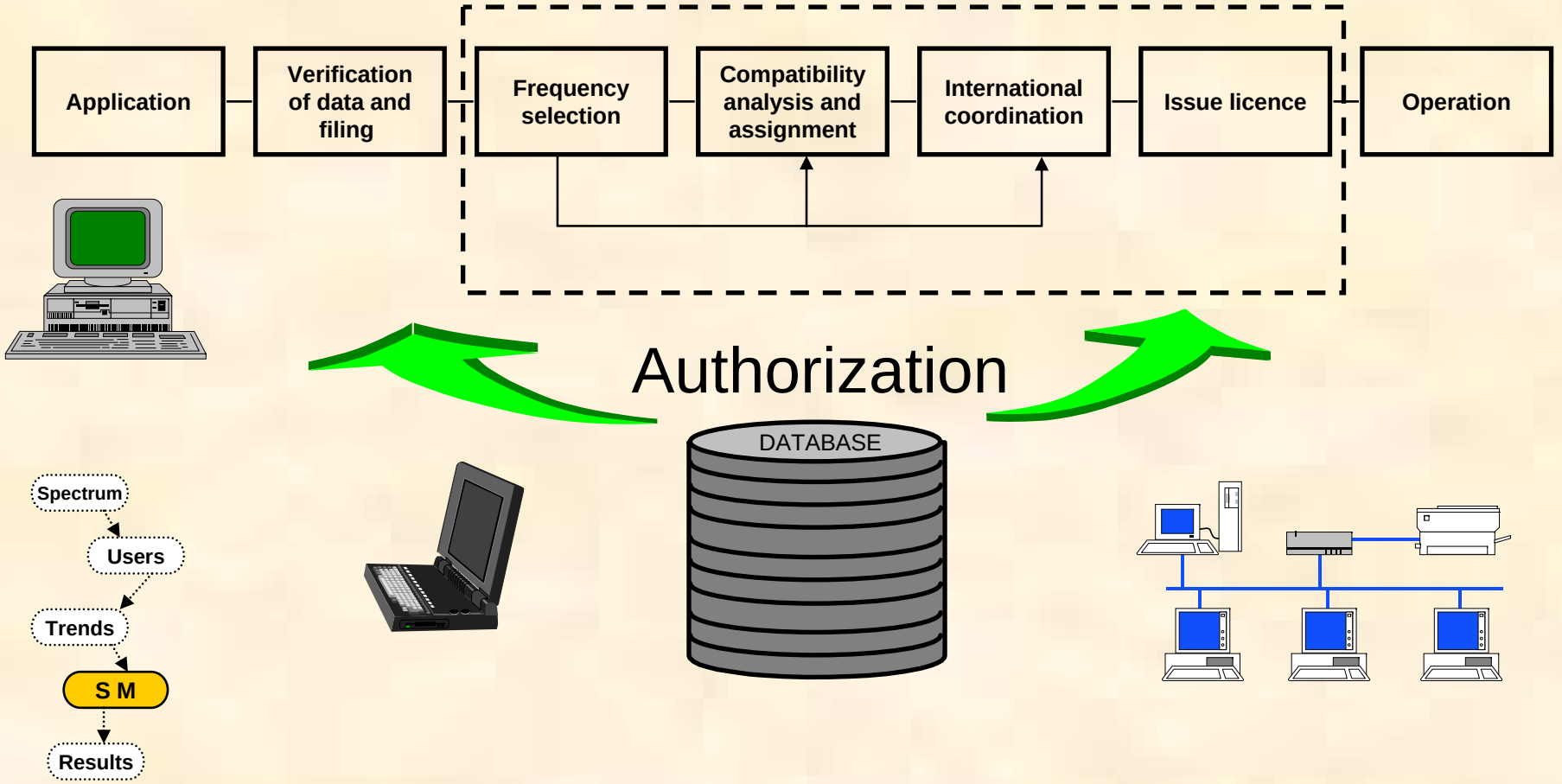
Master International Frequency Register

- The procedures for registration in the Master International Frequency Register as defined in the Articles of the ITU Radio Regulations may be subdivided into:
  - coordination;
  - notification;
  - examination; and
  - registration.

Worldwide and Regional Frequency Assignments and Allotment Plans

- Frequency assignments may be included in Regional Allotment (Assignment) plans.
- Such plans may also include coordination procedures for modifications or additions.
- Frequencies must still be notified according to the procedures in the Radio Regulations when they are brought into service.

Assignment and Licensing Computer System



Automation in Spectrum Management

- Authorization
- Spectrum Control
- Administration

Software

- The ITU Radiocommunication Bureau and several spectrum management administrations have developed suitable software packages to perform electromagnetic compatibility calculations and frequency planning.
- A list of available software can be obtained from the ITU Radiocommunication Bureau.

Spectrum Control

- Spectrum Control Operations and Management System (SCOMS)
- Integrated Spectrum Observation Centres (ISOC)
- Integrated Remote Monitoring Apparatus (IRMA)
- Occupancy (OCCLAN)

Administration

- Personal computers accessing LAN
- LAN’s connected to WAN’s
- E-mail, shared data and application software
- Officer has access to all computer tools at personal desk

Summary

- The process of establishing a spectrum management agency consists of:
  - defining the national and organisational goals;
  - establishing a legal framework to guide operations;
  - defining an organisational structure for an agency to achieve the specified goals; and
  - defining the functions the agency is charged with performing.

For More Information

- *ITU Handbook on National Spectrum Management. Geneva: ITU* Radiocommunication Bureau. Chapter 2 and 5.

- An internet tutorial guide containing learning outcomes, discussion questions and more references is available through the ITU.

Thank you!

Any Questions please?