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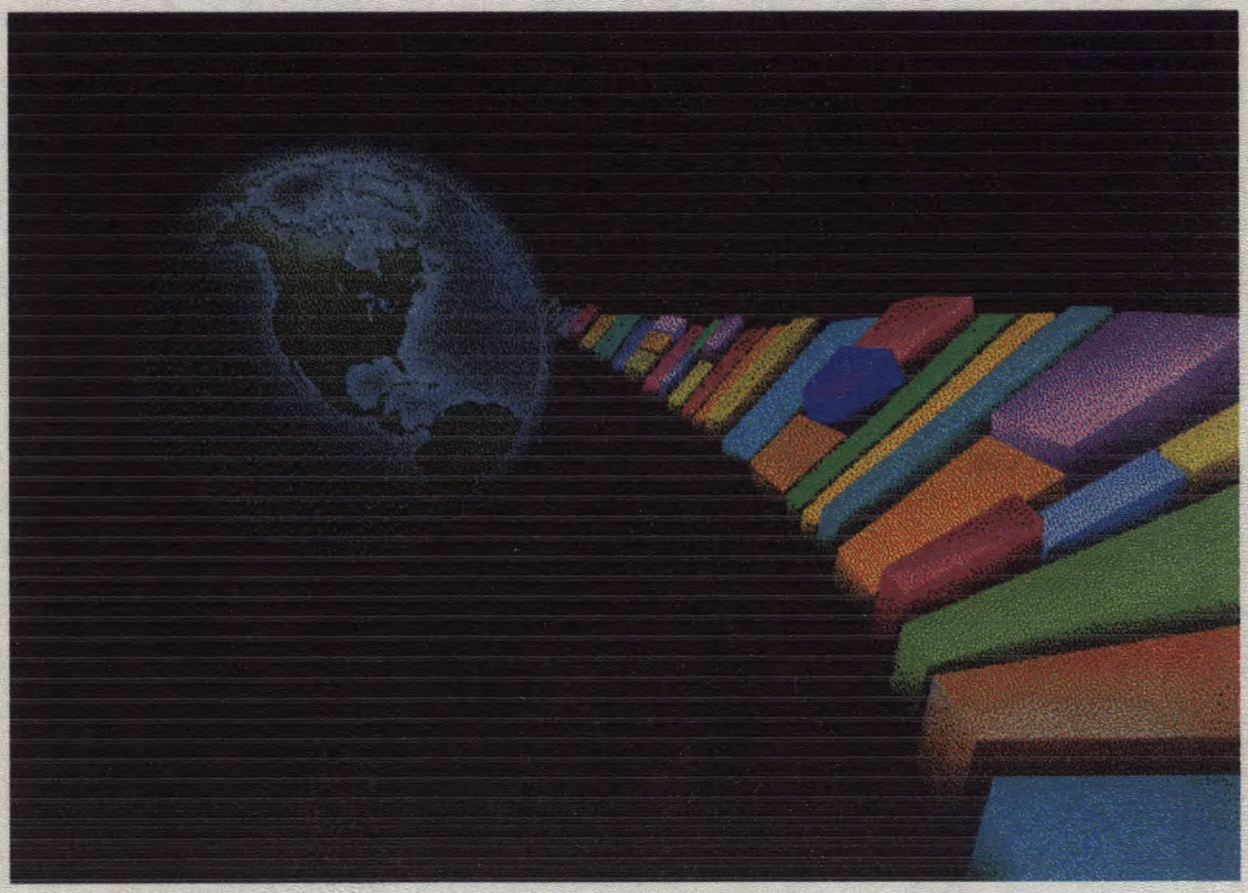
Introduction to Spectrum Management



STTC CFST

Spectrum/Telecommunications Training Committee

Comité de formation du Spectre/Télécommunications

Canada

Industry Canada Industrie Canada

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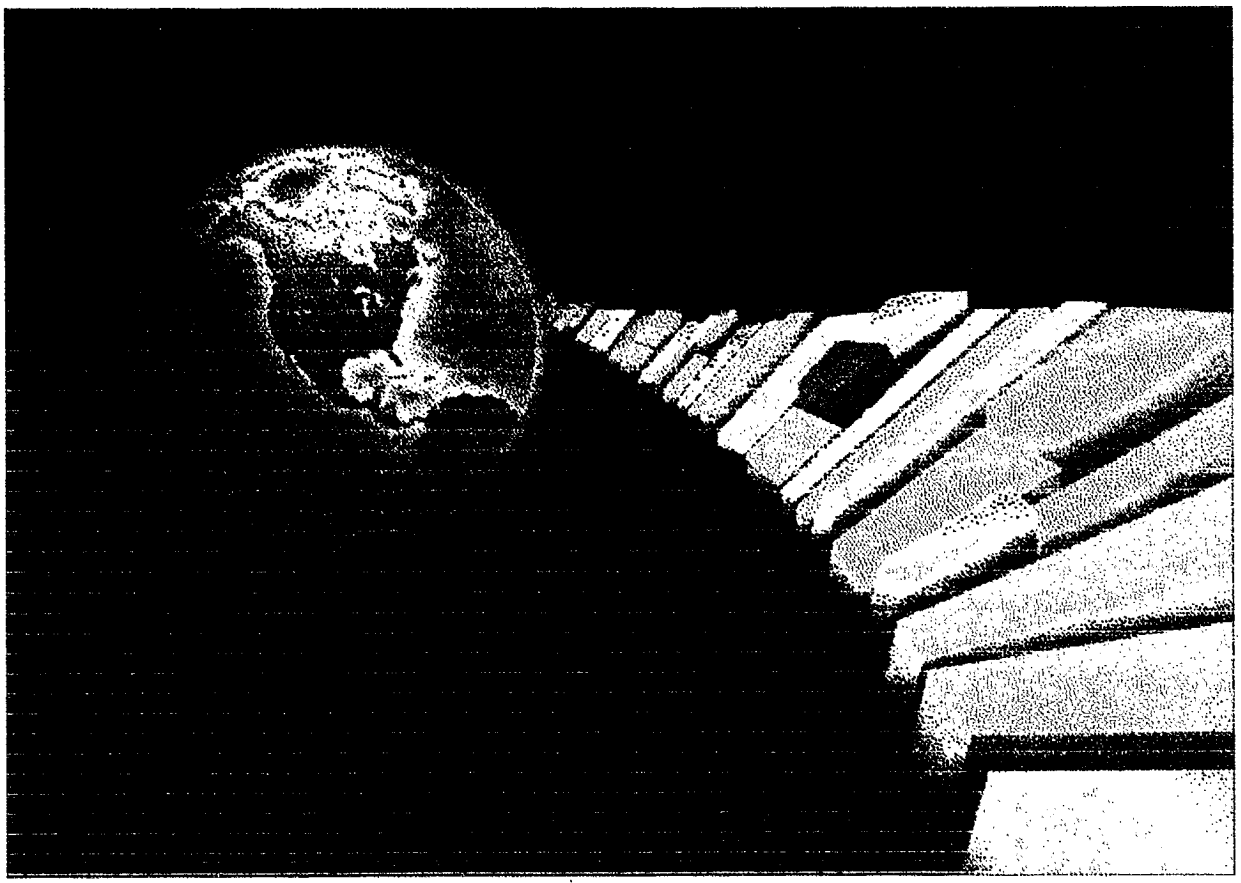

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Course title:	**Introduction to Spectrum Management**
Description:	This manual provides an outline of the basic concepts of radiocommunications and spectrum management activities. Technical concepts are described to make them easier to understand for employees who do not have technological expertise.
Course objective:	Participants will learn the basic concepts of radiocommunications and the principal radio spectrum management activities.
Prerequisite:	No training prerequisite has been set for course participants but they should preferably be aware of the role of the Department and its structure. Previous completion of the employee's orientation course is recommended.
Course duration:	The recommended course duration is 2 days, when taught in a classroom setting.

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September 1992

Revised by: Michel Castonguay
July 1999

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Chapter 1. Introduction

1.1 Session Schedule

Time	Day 1	Day 2
8:30 a.m.	Introduction Spectrum Management	Radio Station Verifications Examinations
10:00 a.m.	Break	Break
10:15 a.m.	Systems and Services	Planning, Regulations and Engineering Tools
Noon	Meal Break	Meal Break
13:00 p.m.	Authorization	Applying the Act and Prosecutions
14:30 p.m.	Pause	Pause
14:45 p.m. 16:00 p.m.	Interference	Reports and Computer Systems Conclusion

1.2 Participation Contract

In all training sessions, the aim is to find the information or details that enable us to carry out our responsibilities more effectively.

The following page will enable you to record your expectations regarding the present training session. Please take a few minutes to fill it in.

My expectations	Met Yes ✓	Met No ✓
.....		
.....		
.....		
.....		
.....		
.....		
.....		

1.3 What is spectrum management?

The radio frequency spectrum, also referred to as the electromagnetic spectrum, can be compared to a series of invisible telephone lines.

Therefore, radio frequency management is the sum of the effort the department makes to:

- ☐ on the one hand, guarantee that current users have access to good communications, in other words, clear communications with no interference and also,
- ☐ that there are frequencies available for future users.

By "users", we mean

- ✓ the general public who wants to listen to music or favorite television programs,
- ✓ industries of all sorts that need to communicate to conduct their business; for example, taxi companies, transportation companies in general, forestry and mining operations, etc.

Also included are

✓ departments and agencies on all levels of government;
✓ ship and aircraft owners;
✓ the military;
✓ amateur radio station operators;
✓ cellular phone companies, etc.

Cordless telephones and wireless microphones, such as those used to monitor babies, and microwave ovens also use radio frequencies.

All of these facilities, installations, individuals and users are the focus of our attention in radio spectrum management.

1.4 Exercise

List 10 examples of how frequencies are used:

TV Remote Control

Telephone (Cordless)

Wireless Lan

FM Radio

Sattellite TV

Microwave Televisions

Cellular Phones

Wireless Headphones

Walkie Talkies

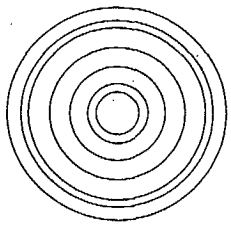
Chapter 2. Spectrum Management

2.1 Radio Waves

Radio waves are like telephone lines of varying lengths.

In theory, the longer the line for a constant transmission power level, the further the transmission will go.

Radio waves travel like the circles that appear on the surface of water when a stone is thrown into it.



2.2 Propagation

The radio wave's propagation - in other words its displacement in the air - will depend mainly on its frequency or its length.

Some waves travel by reflection on ionized layers in the atmosphere.

Layers described as ionized, such as clouds, act a bit like a mirror. As they bounce, the waves can travel over long distances and therefore CB's, amateur radio operators, Bell customers on Radio Alma, and ships on the ocean can communicate with each other.

Other waves only have an optical range and theoretically antennas must be within line-of-sight of each another for

the signal to pass.

For example, this is the case with microwave links that carry television or cellular telephone signals between different cities.

FM and television broadcasting waves are also transmitted within an optical range.

Still, others will follow the curve of the earth; for example this is the case with AM broadcasting stations such as: provide examples..... (CBF, CBJ or CKAC in Montreal).

2.3 Frequencies

We use the word frequency to describe or to characterize a sound or a radioelectric wave.

We define frequency as the number of oscillations per second.

The frequency unit is the **hertz, or one oscillation or one cycle per second.**

In music, the 3rd LA on the diapason has a frequency of 440 hertz. Hydro-Québec supplies us with an alternative current at a frequency of 60 hertz.

The CBF radio station in Montreal has a frequency of 690,000 hertz. The _____ radio station in _____ has a frequency of _____ hertz.

To simplify matters, we will use the terms kilohertz and megahertz.

1,000 hertz	1 kilohertz	1 kHz
1,000,000 hertz	1 megahertz	1 MHz
1,000,000,000 hertz	1 gigahertz	1 GHz

Therefore, CBF Montreal is at 690 kilohertz on the AM receiver dial.

2.4 Wavelength

We also refer to wavelengths to characterize frequencies; short waves, medium waves, long waves, etc.

Light is a wave that we can see.

It is a very short wave, therefore it will not travel far unless the source has a high power force - this is the case with the sun, for example.

A battery-operated flashlight produces barely enough light to read a newspaper, but the sun sets everything around you blazing!

Sound in the air travels at a speed of approximately 340 metres per second.

If you count the number of seconds between the time we see a bolt of lightning and the time we hear a peal of

thunder, you can calculate how far away the lightning erupted.

Radio waves, light and electricity travel at a speed of 300,000 kilometers per second, which is called the speed of light.

When you turn on a light, it begins to shine immediately. This is because the distance between the switch and the bulb is short.

When you use the moon as a mirror to reflect a radio signal towards earth or when you use the telephone on a circuit that passes through a satellite, there is a delay in transmission.

During a communication via satellite, when you finish a sentence, you can hear the last words you've spoken. It takes a bit of time for the radio signal to arrive and return.

The wavelength is the quotient of the speed of the wave divided by its frequency.

A wave of 300 million hertz or 300 megahertz will have a wavelength of 1 metre.

For example:
300,000,000 metres/seconds (speed)
300,000,000 hertz
or
300
300 MHz = 1 metre, the length of the wave

Amateur radio operators use a frequency or

communications band that they refer to as "the 2 metre band".

300/2 metres = 150 MHz. These amateur radio stations are found between 144 and 148 MHz; it is called "the 2 metre band" to simplify matters.

By common agreement the range of radio frequencies begins at 3 kilohertz and the limit of what is currently used in radio goes beyond 30,000 megahertz.

As we saw previously, waves or frequencies travel in carrier waves and the strength or the height of these carrier waves depends on the distance as compared to the source and the source's power.

The further you are from a rock that you throw into the water, the smaller the wave will be when it returns to you. The further you are from a television station, the weaker the signal will be and the fuzzier the picture will be.

In radio, the waves that carry frequencies are electric currents.

2.5 Radiocommunication channels

When a radio frequency is authorized, it is referred to as a radiocommunication frequency or radio channel. The greater the amount of information that must be transmitted at one time, the wider the path or channel must be.

By analogy, a small country road may be wide enough for just one car to travel on it at any one time, but it requires a

highway to allow many cars to travel easily together.

Stereophonic FM radio and television require the transmission of a great deal of electrical information at the same time. This information will take up a relatively large or small space on each side of the authorized frequency. As a result, the term "channel" is used.

In the early days of radio technology, long waves were used and over time, as the number of stations increased and new developments emerged, shorter and shorter waves were used.

When stereophony and television were invented, much wider bands were required and they were available only in very short waves.

This is why stereo FM and TV are found on very high frequencies (higher than 30 megahertz) while medium frequencies can easily accommodate AM radio or other broadcasts that do not require wideband transmission.

"Electronic highways" are used by microwave systems; for example, where several television channels and a large number of telephone conversations are transmitted simultaneously.

Cable television systems are comparable to electronic highways, with the difference being that television and other signals are contained in the cable instead of being radiated into the air.

2.6 General Table of Frequency Allocations

Bands	Frequencies	Main Uses
VLF Very low frequencies or myrametric waves	10 - 30 kilohertz	Radionavigation
LF Low frequencies or kilometric waves	30 - 300 kilohertz	Radionavigation AM broadcasting in Europe
MF Medium frequencies or hectometric waves	Ranges from 300 to 3,000 kilohertz	Ship radio beacons, maritime telegraphy and telephony and AM broadcasting (standard broadcast band)
HF High frequencies or decametric waves	Ranges from 3 to 30 megahertz	Ships and aircraft, amateur radio, shortwave broadcasting,
VHF Very high frequencies or metric waves	Ranges from 30 to 300 megahertz	Land, mobile and fixed stations, television, channels 2 to 13, FM broadcasting, amateur, maritime and land mobile services
UHF Ultrahigh frequencies or decimetric waves	Ranges from 300 to 3,000 megahertz **Microwave starting range**	Television, channels 14 to 69 Cellular and PCS
SHF Superhigh frequencies or centimetric waves	Ranges from 3,000 to 30,000 megahertz	Point-to-point links across the country, telephone, etc.
EHF Extra high frequencies or millimetric waves	Ranges from 30,000 to 300,000 MHz (30 to 300 gigahertz)	Satellite television, radar, very high capacity links, etc.

2.7 The International Telecommunications Union (I.T.U.)

On 17 May 1865 after two and a half months of arduous negotiations, the first International Telegraph Convention was signed by the 20 participating countries and the International Telegraph Union (ITU) was set up to enable subsequent amendments to this initial agreement to be agreed upon. This marked the birth of

the I.T.U. Today, nearly 130 years later, the reasons which led to the establishment of the Union still apply and the fundamental objectives of the organization are basically unchanged.

The I.T.U. dates back to the period when telegraphy was introduced, before the invention of the telephone and radiocommunications. There was no need for international agreements or cooperation as long as wire-borne messages did not travel beyond the borders of individual countries, but when services began to develop and expand, they quickly became indispensable.

The I.T.U. is a union comprised of 166 members; Canada is one of its active members.

The I.T.U. Radiocommunications Regulations outline the basic standards and regulations and reserve specific frequency bands for specific uses throughout the world.

Some frequencies are reserved for AM, FM and TV broadcasting, others for ships, aircrafts, commercial service, amateur radio, satellites, etc.

There are also frequencies reserved specifically to carry distress signals sent out by aircrafts and ships.

Subsequently, each country made more specific provisions for certain bands, based on their respective criteria.

2.8 Frequency Allocations

Radio frequencies are a natural resource which belongs to the entire population.

To ensure that everyone can use them problem-free, their use must be controlled.

Some frequencies or frequency bands have been reserved for specific purposes; for example, the use of certain frequencies requires obtaining a radio licence while the use of others does not require a licence. The latter type of use is exempt from radio authorization; for example: cordless telephones and garage door openers.

Individuals are needed to receive and process requests from the public, select frequencies, examine operator candidates and issue radio authorizations.

Some radiocommunications services are authorized by frequency blocks and therefore companies that supply radio services can set up and operate communications networks for use by citizens (e.g.: PCS, cellular phones).

Individuals are also needed to verify that those who use frequencies do so under the conditions of their authorization and should non-compliance occur, to take appropriate measures to rectify the situation, a process which may at times involve drastic action.

In summary, this constitutes the day-to-day frequency management activities carried out in Industry Canada's district offices.

2.9 Planning

To facilitate this work, it was necessary to establish frequency plans, set standards and promulgate regulations.

Proper management of the radio frequency spectrum begins with international planning and representatives of the Department participate in I.T.U. deliberations to obtain international agreements that are in the best interests of Canadians.

Subsequently, Canadian Acts and regulations, in compliance with international agreements, are promulgated to ensure the sound management of this particular natural resource. Standards and policies are also established to make it possible to use this resource as efficiently as possible.

2.10 Table of Frequency Allocations

In Canada, we have a Table of Frequency Allocations. The table is available in the form of a poster or a manual. The table describes the planning for all the frequency bands that compose the radio spectrum.

The table shows that VHF or UHF bands have been planned for specific user groups; for example, ships, aircrafts, broadcasters and others.

In addition, all countries have promulgated regulations and standards that reflect their respective particularities.

2.11 The Canadian Radiocommunication Act

Our Radiocommunication Act serves as the regulatory basis that governs how Canadians use radiocommunications.

Based on the Act, various regulations have been set to govern:

- who can obtain a licence;
- at what cost (licence fees); and
- the general operating conditions applicable to authorized stations.

Under the Act's Regulations, it is also possible to operate stations that are exempt from licences.

For example, remote automobile starter systems, garage door openers and cordless telephones are all radio stations that are exempted from licence because their installation, frequencies and low power levels are all in compliance with the prescription of the Radiocommunication Regulations.

The Department formed a group responsible for reviewing the legislation. The group proposed a new regulation, more modern and easier to apply. The review resulted in the enactment of the Radiocommunication Act of November 27, 1996.

Several other policies, guidelines, standardized plans, procedures and specifications have been published to govern the use of radio in Canada.

They are found in the LRC, RIC, CPC, IPC, RA and RR specifications and in other publications used by radio inspectors and the general public.

2.12 Exercise

1- How are radio waves propagated?

.....

.....

.....

2- 1,000,000 hertz is also:(check)

- ☐ 1 kilohertz
- ☒ 1 megahertz or
- ☐ 1 gigahertz

3- The speed of light is:(check)

- ☒ 300,000,000 metres per second
- ☐ 300,000 metres per second
- ☐ 340 metres per second

4- There are "electronic highways":(check)

- ☐ in the low frequency range
- ☒ everywhere
- ☒ in the high frequency range

5- List three examples of radio equipment that can be used without a licence.

- cordless phone
- television
- baby monitor

Chapter 3. Systems and Services

3.1 Radio services

To facilitate the administration of the authorization process, users are classified in various **radiocommunication service categories.**

Fixed service, land mobile service, public information, aeronautical and maritime services, broadcasting etc. Perhaps the category that leads to the greatest number of questions is the amateur radio service.

In the beginning, this service was known as the amateur experimental service; it grouped together individuals who in theory are experimenters.

Some build their own equipment which they use to communicate. Others simply want to try new ways to communicate or to build antennas for their own use. Studying the phenomenon of propagation is something of a craze to many amateur radio operators. Depending on the wavelength or frequency used, they are able to communicate with other parties anywhere in the world.

The amateur radio service makes it possible for many people to become familiar with the theory and practice of the radiocommunication without necessarily taking any formal training courses.

Since October 1991, it is no longer necessary to know Morse Code to obtain an amateur radio certificate. It is estimated that this change will lead to a significant increase in the number of amateur radio operators.

The land mobile and fixed service groups together telephone companies, some radiocommunication users and the majority of other commercial users, including governments and municipalities.

Land mobile and fixed, amateur radio, aeronautical, and maritime, each represents a specific category of users to which different standards and regulations sometimes apply.

Depending on the service category, the user must ensure that all equipment has been tested for compliance with the appropriate **radio standards specifications**. Before equipment can be licenced, it must meet these standards.

For example, one of the specifications for ship station equipment requires that it be equipped with certain frequencies. It must also be possible to lower the VHF transmitter's power output easily.

This requirement makes it possible for all ships to communicate with each other, to reserve frequencies for distress communications and to lower it's power output so as not to cause any interference to other users when equipment will be used in port.

The land mobile and fixed radio service groups together the vast majority of our clients. To prevent interference, standards are rigorous where stations are installed and used in proximity of other stations.

Some radio uses do not require a licence. These include CBs, cordless telephones and wireless microphones, baby monitors, automatic garage door openers and several others. Microwave ovens, x-ray equipment in clinics, radio

and television receivers also fall into this category.

The definition of several Canadian radiocommunication services is found in the Radiocommunication Regulations.

The aeronautical service provides for the safety and navigation and other operations of aircraft and that may also include the exchange of air-to-ground messages on behalf of the public.

The developmental service provides for research and development, experimentation or demonstration of radio apparatus, or the assessment of the marketability of radio apparatus, new technologies or telecommunications services.

In the amateur radio service, radio apparatus are used for self-training, intercommunication or technical investigation by individuals who are interested in radio technique solely with a personal aim and without pecuniary interest.

The radio-determination service provides for the determination of the position, velocity or other characteristics of an object or physical phenomenon, or for the obtaining of information relating to these parameters, by means of the propagation properties of radio waves.

The public information service provides for communications in which the transmissions are intended for the public, but does not include transmissions by a broadcasting undertaking.

The fixed service provides for communications between fixed stations or between fixed stations and space stations.

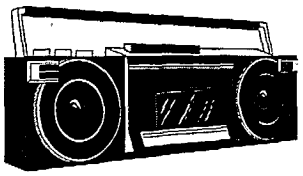
The intersatellite service provides for communications between space stations.

The maritime service provides for the safety and navigation and other operations of ships or vessels and that may also include the exchange of ship-to-shore messages on behalf of the public.

The land mobile service provides for communications between mobile stations and

a) fixed stations,
b) space stations, or
c) other mobile stations.

3.2 AM Broadcasting



CKAC, CHRC, CKRS an CJBR are AM radio stations.

AM is an acronym for Amplitude Modulation.

Transmitting the sound of voices and music involves a process called modulation, a carrier wave produced by the transmitter is modulated, in other words, it varies in amplitude.

The stronger the sound waves are, the higher the amplitude or strength of the carrier wave. At the receiver, a demodulator makes it possible to filter the carrier wave and recover the original modulation.

AM broadcasting stations generally use the 540 to 1705 kilohertz frequency band; for example, CHRC is at 800 on the dial, CKAC is at 730, etc.

3.3 FM Broadcasting

FM is an acronym for Frequency Modulation.

FM broadcasting involves a process of modulation of the frequency of the carrier wave.

While in AM broadcasting, the frequency of the carrier wave is constant and its amplitude varies, in FM broadcasting the frequency of the carrier wave varies according to the amplitude of the sound waves. The stronger a sound must be, the greater the variations in the carrier wave will be.

The FM technique results in better quality sound reproduction because of a process that eliminates parasitic noises.

The call letters of these stations are followed by "FM", as in CHOI-FM, CBF-FM, etc.

3.4 TV Broadcasting

Television broadcast is a combination of AM and FM transmitters.

The "video" portion is composed of a high-speed scan of images and is transmitted by amplitude modulation. Sound is transmitted by frequency

modulation.

While AM takes up very little space on the band, FM takes almost 10 times more. For television, some 30 FM transmissions could be contained on a single television channel.

3.5 Cable TV

Cable TV began in Pennsylvania in the late 1940s.

At the time, a few companies distributed amplifiers for use in apartment buildings. An enterprising television salesman thought that he could sell more television sets if he could supply the signal where it couldn't be picked up, in cities and where no TV transmitters existed. He went ahead with his idea and subsequently, many others followed suit.

To enable people to pick up distant stations, the cable television company installs antennas in an appropriate location, set up dishes to pick up satellite signals, and combines the whole into a cable to distribute it in subscribers' homes.

To go beyond the limited number of channels available on older television sets, a cable channel converter is used, providing access to close to 100 channels that can be available from certain cable TV systems. Modern television sets provide direct access to all these channels provided they are not encrypted or scrambled. This is usually the case with Pay-TV channels.

With Videoway and other techniques, we can now do our shopping, reserve theater tickets and try our luck at

lotteries via the cable system.

Other new gadgets will soon enable us to set up our own television menus through a combination of cellular techniques and satellite transmission. Systems of all kinds are emerging in broadcasting and an increasing number of services are becoming available.

3.6 Satellite TV

In FM and television frequency bands, the size of the coverage area of the station will depend on the altitude of the antenna. The higher the antenna, the wider will be its coverage area.

This is why the antennas of these transmitters are always erected on mountains or on buildings.

It is easy to understand that an antenna installed on a satellite will look out onto a huge coverage area and signal will be picked up over a very large area.

On satellites, some antennas transmit their signal toward specifically defined areas through steerable spot beams. This is called a beam footprint.

For example, instead of beaming on all of Canada, only one or a few provinces will be covered.

The frequencies and techniques used in these installations make it possible to distribute a greater number of television stations and, depending on the equipment that viewers have at their disposal, they can pick up a varying number of stations.

Some transmissions are coded, pay TV is one such example. Using a decoder supplied by the programs' owner, a user who subscribes to this type of service can pick up these transmissions.

3.7 Mobile Radio

Radio, mobile radio, cellular radio, telephone radio, base radio station and cellular telephone are all terms that have in common the use of a transmitter-receiver apparatus in the course of a specific use.

A large part of available radio frequencies is reserved and used for mobile radio.

Public transportation, buses, taxis, police forces and municipal services, several government departments, truckers and the general public are users of mobile radio.

Radio is the only practical mean that these users have to communicate with their offices, their supervisors and other individuals who are responsible for the proper functioning of their business activities.

Mobile radio is also used both for telephone communication, such as the cellular phone, as well as for direct communication with a dispatcher/coordinator or other mobile stations in the network.

Before the advent of radio, taxi drivers gathered at a central station and waited for telephone calls from customers. Today, these calls can be picked up directly in the taxi cab, regardless of where it may be, thus saving

time and money.

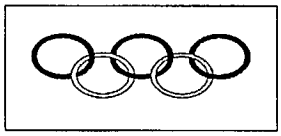
Mobile radio requires specific installations depending on the user's needs and on the topography of the territory where it will be located.

Two workers on a construction site could be equipped with low-power portable units operating on a single frequency.

If these two workers want to communicate with each other from two different sites, they may need to use the facilities of a **repeater station or a relay station.**

This type of station is usually set up on a high location. It receives the signal used on one frequency and instantly retransmits on a second frequency, with more power.

A representative who needs to receive and place telephone calls will use a cellular telephone or another specialized type of telephony device.



The cellular network divides each service zone into small geographic sectors called "cells", with an approximate range of 15 kilometers.

Since the number of frequencies is limited, the main reason for cells is to make it possible to reuse the frequencies in a sector without causing interference among cells.

Each cell is equipped with a group of transmitters-receivers using specific frequencies. All cells are linked to one computerized dispatcher (a system that

directs calls to their destination), either by Hertzian waves, fiber optic, or another communication system.

The cellular dispatcher is linked to other dispatchers in the network, to a telephone service and to suppliers of long-distance and international services.

Communication is then transmitted from this cell station to a dispatcher in the cellular network, which in turn transmits the call to another user or to an ordinary telephone center.

Usually, this process goes unnoticed by the caller. However, if the cellular telephone leaves the area serviced by the network, the call will be interrupted, unless there is an appropriate technical interface with the telecommunications service supplier which operates an adjacent system.

Ship and aircraft stations will have special radio installations that enable them to navigate at night, in fog and in storms.

They will use a selection of frequency ranges based on working areas or navigation zones.

3.8 Fixed Radio

Fixed radio - in other words point-to-point links - are required to cover long distances, to link two remote locations or to enable a forest station to connect with the telephone system.

As seen previously, cellular mobile radio can use radio links between sites, for example, to enable employees in the Laurentian National Park to contact their office in Montreal.

Someone fishing in the wilderness will use a point-to-point link to communicate through Bell Canada in Alma to tell his buddies his fishing stories before he gets back home.

To extend the area covered by a network of repeater stations, point-to-point links between stations are sometimes used to repeat the signals in a series of leaps.

A satellite may be used to enable a construction worker in the North to consult his office in the South.

3.9 New and future systems

MSAT is a system where the mobile has access to its correspondents through the antennas of a satellite or of several satellites in geostationary orbit.

Such a system was tested in Canada and a few district offices demonstrated its use.

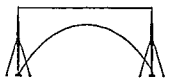
Personal communications systems (PCS) are now available in all major centres and are spreading.

Many people already have cordless telephones to take calls by the swimming pool. PCS enables users to connect with the telephone system from wherever they are within a 200 meters radius of a base station.

Increasingly, radiocommunications will be at the service of ordinary citizens, a constellation of satellites will offer a multitude of services (television, Internet, shopping, games, etc.) and technology will become more and more affordable.

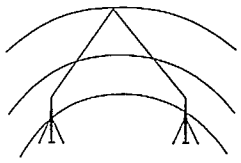
With all of these innovations and those to come, the mobile office is now a reality. Radio provides users with access to databases of all kinds, to accounts, to delivery schedules and to a host of other information required to respond to customer needs immediately.

3.10 Propagation and Services



There are three main types of radio wave propagation. The wave in **free space** exists where there is no physical obstruction between the antennas used by the communication systems. This type of propagation is the reference for all other types.

The **ground wave** is the portion of a signal's overall radiation that is directly affected by the presence of the earth and its surface features.



The **ionospheric wave** or skywave is the portion of a signal's overall radiation that is directed towards the ionosphere.

Depending on variable conditions and the length of the wave, the signal may or may not be returned to earth by

the effects of refraction and reflection on the ionized layers in the atmosphere.

Depending on radiocommunication services and the desired coverage area, frequencies and the type of propagation selected may be different

A communication system between land and aircraft or ship stations requires propagation by **skywave** if **very long distances** are to be covered.

Propagation in **free space** will be used in the case of line-of-sight communications, in other words where there is a **radio horizon** between the stations; for example, for the control of air and maritime traffic.

A local police department will use propagation in free space, as will television and FM radio.

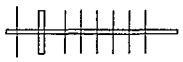
For long-distance communications, amateur radio operators can use communication via satellite or ionospheric waves.

Local or regional communications will also be possible for amateur radio operators and CB users if they use propagation in free space and the coverage area will vary with the height of antennas in relation to the average height of the surrounding ground.

3.11 Antennas

Depending on the communication desired, the user will choose a specific type of antenna and frequency band.

The **type of antenna** will make it possible to direct the wave beam omni-directionally (everywhere) or in a specific direction.



For example, a taxi company located in the heart of a city will use an omnidirectional pattern diagram, while in the case of a company located outside the city, a different type of antenna would be preferable to direct the transmitted signal towards the city.

Directional type antennas are usually composed of a number of elements.

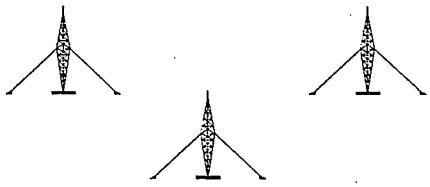
The simplest omnidirectional antenna is composed of an ordinary whip whose length varies depending on the operating frequency.

Stations that receive satellite transmissions use parabolic antennas and propagation in free space.

The size of the antenna will enable the user to pick up a stronger or weaker signal and will make it possible to discriminate between several satellites that may be in orbit relatively close to each other using the same frequencies.

In fact, for the same frequency, the closer satellites are to each other in orbit, the larger the dish must be to be able to separate properly the signals received. The quality of the image will depend on the receiver's sensitivity.

Frequencies are allocated based on the type of radiocommunication service and the type of propagation required by the user.



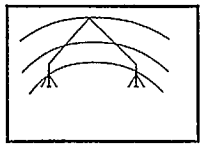
The height and the number of antenna towers used by AM broadcasting stations depends on the authorized frequency and the desired antenna pattern.

Theoretically, a single tower will provide a constant omnidirectional coverage around the station. With several towers and a specific technique, engineers can direct the ground wave towards a given region.

The height of AM broadcasting towers is critical. The lower the frequency (in the Saguenay, CKRS is at 590 kilohertz), the higher the towers should be.

In the case of a mobile radio system, the height compared to the surrounding ground will also be critical, especially when a user wants to contact mobile units within a predetermined service area.

With the presence of physical obstacles in the radio route or path - mountains, hills, etc. - the system designer must ensure a clear **radio horizon** when planning the network.



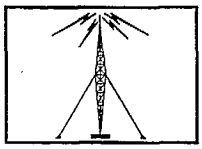
Ionospheric propagation makes use of the ionized layers in the atmosphere and the height of these

layers ranges from five to six hundred kilometers depending on the time of day or night.

With this type of propagation, the signal is reflected in one or several leaps to reach the remote station.

To optimize the system, the user will require an antenna height that will make it possible to reach an efficient layer and the desired station in a single leap.

3.12 The Radio Horizon



The **radio horizon** of a site depends on its height as compared to the site's average height.

This distance, in miles, is determined by calculating the square root of twice the height of the antenna in feet.

Radio Horizon Calculation: $D = \sqrt{2 * H}$

D = distance to radio horizon (miles)
H = Height of antenna above average terrain (feet)

Converting to metric: $D = 4.11 * \sqrt{H}$

D = distance to radio horizon (km)
H = Height of antenna above average terrain (m)

Thus, an antenna that is 25 feet above flat ground will have a radio horizon of 7 miles; one that is 40 feet high will be able to reach a mobile close to 9 miles away. If the antenna of the corresponding station also has an effective height of 25 feet, the distance is doubled and the communication will have a coverage area of 14 miles.

When the radio horizon is blocked by a physical obstacle - a mountain or a building for example - the signal is affected to the point of sometimes being completely obliterated and rendered unusable.

This is why repeater stations are sometimes installed on elevated sites to prevent such problems, thus improving the coverage area.

3.13 Noise and Interference Levels

Usually, broadcast signals are relatively strong. A source of interference 100 times weaker than a given signal will still be strong enough for the interference to be noticeable and to influence the reception.

Even if broadcasting stations (AM, FM and TV) are usually close to cities, it can happen that their signals are disturbed by noise from the hydroelectric system and by other types of electrical equipment in use in the area.

In general, for signals received in the heart of urban agglomerations, television transmission facilities are set up to accommodate average levels in the order of 1 millivolt (1 thousandth of 1 volt).

In the radiocommunication, the signals received usually feature an intensity of up to 1,000 times lower than those

found in broadcasting.

Therefore, users should definitely locate as far away as possible from electrical distribution and transmission lines to lower the intensity of possible radio-electric noise.

For installations close to an electrical system, the first consideration is safety. Therefore, the practice is that the installation should be such that under no circumstances can it come into contact with the system.

3.14 Exercise

1- **Radio standards specifications:**

- ☐ defines the frequency plan ?
- ☐ specifies the compliance standards for equipment ?
- ☐ are used only for inspections ?

2- Where specifically is the acronym FM used ?

. . . . . .

. . . . . .

3- A repeater station is:(check)

- ☐ used in the aeronautical service ?
- ☐ used to increase the coverage of portable stations ?
- ☐ used only for ship stations ?

4- List three examples of a **point-to-point link:**

. . . . . .

. . . . . .

. . . . . .

5- A **ionospheric wave** is said to be:(check)

☐ one where the wave is a direct line between two points ?

☐ one that is reflected by the ionosphere ?

☐ one that is used in all short-distance radiocommunication services ?

6- The **radio horizon** : (check)

☐ is shorter than the optical horizon ?

☐ is longer than the optical horizon ?

☐ is equal to the optical horizon ?

☐ depends on the height of the antenna ?

Chapter 4. Authorization

4.1 Who can obtain a licence?

As seen previously, certain types of equipment can be exempt from licensing (microwave ovens, for example).

District offices deal mainly with users who need licences and who require our services so that one or more frequencies can be selected and so that they can obtain the necessary authorization.

Licence application forms are provided for different services and station categories.

Amateur radio stations, mobile stations such as taxis, police cars and security guard company cars, aircraft and ship stations and fixed stations are authorized under a framework of radio services including:

- amateur radio service;
- fixed service;
- land mobile service;
- aeronautical service;

and several others.

Who can obtain a radio licence?

Radiocommunications regulations stipulate that a licence can be issued to:

* a Canadian citizen;

* a corporation that is incorporated or continued under the laws of Canada or a province;

* Her Majesty in right of Canada or a province or an agency thereof;

* a person who is the registered owner of an aircraft registered in Canada;

* a person who is the registered or licenced owner of a ship or vessel;

* a landed immigrant;

* (other cases as defined in the Radiocommunication regulations).

An application for a radio licence must be verified and is completed by the selection of a frequency and the issuance of a licence.

The following requirements must be verified:

- is the applicant eligible? (age, citizenship, Canadian corporation, etc., based on the regulations);

- if the proposed equipment is a type and model that can be licenced in Canada, has it been type-approved?

- do the needs expressed justify the issuing of a licence? (example: what is the nature of service planned for the mobile station? will it be used to communicate with a public telephone carrier system?)

These requirements are usually the same for all licence application categories.

4.2 How will the licence be used?

Of course, the process will be different depending on whether a particular case involves complex networks, where we must carry out studies to ensure that the arrival of a new user in a given location will not prevent existing users from operating their system and that the new user will not be subject to interference from existing users.

Whether in the microwave frequency band or other bands, we must ensure that our authorization is compatible with the environment; this is called a **electromagnetic compatibility** study.

Some applications such as a base station, which requires a new frequency, will require a special study before authorization can be delivered.

These applications are considered as **variable parameter applications**, where the user needs a specific installation in a particular environment and where the user's arrival in the frequency environment may have an effect on existing users.

In contrast, **fixed parameter applications** are those for which a study has already been carried out and where it has been confirmed that the user's arrival in a frequency environment will have no interfering effect on other users.

For example, fixed stations that communicate with mobile stations through the repeater services of an RCCMRS service provider, are fixed parameter installations if the power of the transmitter and the antenna installation are in compliance with the specifications set out by the Department,namely:

- ✓ a power output equal to or lower than 30 watts,
- ✓ an inside antenna or,
- ✓ if the antenna is outside, a power output equal to or higher than 10 watts.

Some mobile radio station applications are also described as fixed parameter applications.

Aircraft, pleasure-craft, and portable stations operated on frequencies reserved exclusively for portable equipment do not require a special study. Therefore, these applications can easily be processed by technical and administrative support staff.

4.3 Frequency Selection

Depending on the case, it may be necessary to consider the **applicant's type of occupation** and the **nature of service required.**

When planning the use of frequencies, as discussed previously in the course, individual countries have developed **frequency allocation plans and tables.**

In the case of an aircraft or a ship, the frequency plan stipulates specific frequencies, manufacturers have designed equipment based on these plans and frequency selection involves no difficulty.

In the case of an installation for a police department or taxi company, specific frequencies in the allocation table have been reserved for these purposes and one of them must be selected and it's compatibility must be studied before it can be authorized.

Therefore, when we receive a licence application it is important to know the occupation of the client and/or what the client intends to do with the system before we can select the appropriate frequency.

The authorized frequency will be selected based on the needs the client expresses.

4.4 Compatibility

It is not sufficient to know that frequencies have been reserved for particular purposes; one must also ensure that the frequencies in question can be used without causing interference.

Interference or adverse effects of electro-magnetic energy can come from anywhere.

A defective installation in a hydro transmission line, your mother-in-law's sewing machine and Denise's aquarium may all be causes of interference.

A user with a very close frequency separation or very close in distance to another station or one using a defective radio apparatus can also cause interference.

To select a frequency, the technician who studies an application must be aware of the electromagnetic environment in which the proposed station will be operated. This will require an Environment Search on the Spectrum Management System (SMS).

The frequency that will be selected must be compatible; in other words, it must not cause interference or adverse effects for other users in the zone and it must not be

adversely subjected to interference from them.

In highly congested area, it may be necessary for the new user to add a band pass filter, also called a cavity, to the installation.

It is hard to get a wide table through a narrow door.

A cavity can be compared to a narrow door and depending on its characteristics, it will be wide enough only for the client's wave to go through so that it will not be subjected to interference from others on adjacent channels.

4.5 Frequency Sharing

Because there are not enough frequencies for each user to be alone on a given frequency, sharing is mandatory.

In telephony, one frequency can accommodate more than 50 mobile stations in the same environment.

Authorizations will be granted accordingly and the decision of frequency sharing will be based on several factors including potential competition between users assigned on the same frequency.

We use the term **frequency sharing** when users can hear the communications of others who share the same frequency, and when their coverage areas are approximately the same. Sharing occurs among users in neighboring cities and therefore, will involve special

working conditions.

Several factors make it necessary to share frequencies among users.

✓ The limited number of frequencies available in each of the different bands.

✓ The allocation of frequencies among the different radiocommunications service categories such as:

* commercial use
* maritime service
* safety uses
* municipal services, etc.

✓ The fact that many frequencies cannot be reassigned because of incompatibility between sites and installations, as for example the interaction between transmitters and receivers, transmitter noise and the proximity of stations.

✓ The impossibility of coordinating frequencies with other regions of Canada or the United States because some are already in use, could create conditions leading to interference.

To a certain extent, we avoid allocating the same frequency to companies in competition with each other.

It should be noted that as spectrum usage increases, congestion becomes more acute and as such makes frequency sharing necessary. Users must be informed of this fact.

The disadvantages of sharing can be partially reduced by

the use of **tone coded squelch**.

Such a system opens and closes the receiver's loudspeaker based on whether the communication on the air is directed to a receiver with a similar device.

The use of directional antennas and a minimum power outage to optimize the coverage area is also suggested in order to minimize the effects of sharing.

The system's engineering must be designed to ensure that the mobiles are received by the base station at the same intensity level as the base is received by the mobiles (**system balancing**).

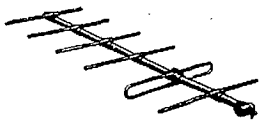
4.6 Antenna Selection

Depending on whether the user wants to communicate with portable stations on the company's operating territory or whether he wants to reach his mobile stations located many miles away, the supplier will install an antenna of varying sophistication.

The antenna may be a simple whip only a few inches high, installed on the corner of a desk or it may be an installation that is many feet high, attached to a pylon that is hundreds of feet high.

In the case of a base to mobile communication, a particular type of antenna is required so that signals can be transmitted in an omnidirectional manner.

In the case of a user who wants only to communicate with one station, in a given direction, a directional antenna



of the type used for television (a "rake"; the real name being a "yagi") will be installed.

4.7 Standard Industrial classification codes

Our Spectrum Management System (SMS) includes an indication of the economic activity linked to the use of the radio frequency. The economic activity code or standard industrial code is used:

- to measure the increase in the number of licences issued and in particular the allocation of licences throughout the various sectors of economic activity in the district;

- to compare the use of frequencies with the allocation plans for each service category and eventually make any necessary corrections to the plans.

4.8 Equipment Approval

Before it can be used in a radio station, communication equipment must be **approved**. This requires that it be subjected to tests to confirm that it is in compliance with radio standards specifications.

As seen previously, equipment must comply with certain radio standards specifications before it can be used in a particular service.

For example, one of the specifications for aircraft stations stipulates which frequencies must be installed in this type of station.

The Department has published several different radio standards' specifications for cellular radios, land communications equipment, radio and television broadcasting equipment, etc.

When equipment has been approved or when it has been declared technically acceptable, the make and model will be listed in the **Radio Equipment List**.

4.9 Licence fees

Many people wonder about the purpose of licence fees. The radio frequency spectrum is a natural resource like mines, water and forests.

This resource belongs to the public and the licence is a privilege that the public in general accords to someone who has justified a need by submitting a licence application.

The government has the responsibility of managing this resource. The work required to accord this privilege and to ensure that optimal use is made of the resource calls for a substantial budget.

It should be noted that substantial budgets are also required for **research activities** in Ottawa and in Montreal and for Canada's participation in international activities and meetings where we ensure that Canada has access to its fair share of the spectrum.

The attached excerpt from the Radiocommunication Regulations outlines the fee schedule for different services and station categories.

4.10 Exercise

1- Who can obtain a radio licence in Canada? The Regulation stipulates several categories, name four of them:

.....

.....

2- A **compatibility study**: (check)

- ☐ is always required?
- ☐ is only necessary for fixed parameters applications?
- ☐ is used to determine the effects of a new radio installation in the environment?

3- Why are frequencies shared?

.....

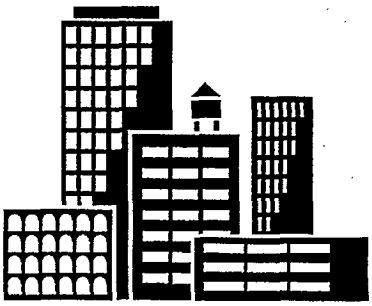
4- A **yagi-type** antenna will be used for communications with: (check)

- ☐ a ship station?
- ☐ a fixed station?
- ☐ a mobile station?

5- **Equipment approval**: (check)

- ☐ is required during radio operator examinations?
- ☐ confirms that equipment is in compliance with the Radio Standards Specifications?
- ☐ is used to establish a station's licensing fee?

Chapter 5. Interference



Radio interference is any phenomenon which makes it difficult to receive a transmission or may at times prevent a transmission from being received.

It may involve radio and television reception or mobile or fixed communications.

The **interference signal** need not be very powerful to create a problem.

This is why the area where a broadcast receiving apparatus can be interfered with will usually be much larger than the interfering signal's coverage area.

In television, for example, an interfering signal can be several hundred times weaker than the desired signal and still have a perceptible effect on the picture.

5.1 Interference can come from different sources

Generally, it can be said that everything related to electrical power can be the cause of interference and could influence the reception of your favourite program on cable TV or on radio.

Radiocommunications users can also experience interference from a defective transmitter, from motors or

from a defective power line distribution system.

Depending on the atmospheric conditions, one user may hear another one located several hundred miles away. The radio inspector must be able to recognize these cases of abnormal propagation and all other sources of interference so that he may provide quick assistance to the customer looking for help.

There is also **voluntary interference**; for example, when a country does not want its citizens to receive programs from another country. For a long time, this was the case in communist countries. But more often, interference is involuntary.

5.2 Radioelectric Interference

Broadcasting interference can take the form of a frying sound, like butter heated in a pan, a crackling or a buzzing noise.

On a television set, the symptom can be black lines that travel horizontally through the picture or wavy vertical lines across the screen. The picture can also disappear completely.

The cause may be a defect in the insulators or the hardware on electrical power lines, the motor on the neighbors' sewing machine or your aquarium's water heater. In fact, anything related to the electrical system, from near or far, can cause interference known as radio-electric interference.

5.3 Radio Frequency Interference

Radiocommunication installations can also be the cause or the source of interference known as radio frequency interference.

Such difficulties can take several forms:

- interference on the same frequency (frequency sharing);
- transmitter radiation (harmonics or unwanted signals produced by defective equipment);
- intermodulation (two signals intertwine to produce a third);
- receiver desensitization (the receiver's sensitivity is reduced by the presence of a signal on an adjacent channel);
- overload (a signal that is too strong on an adjacent channel hinders the proper operation of your equipment); and
- transmodulation (another user's communication is superimposed on the signal you are listening to).

Interference can also entail other problems and can affect the telephone, CD player and amplifiers, VCRs and even pacemakers. This is the same phenomenon as transmodulation, described above.

5.4 Sources of Interference and Solutions

Sometimes the source of interference is easy to find and you can do it yourself.

For example, if you hear crackling on your radio, the problem could be caused by your electrical installation, a dimmer switch, your aquarium's water heater, any type of relay switch, like the switch on the electric outlet for your razor or the switch that protects the doorbell circuit or those found on other types of electric appliances.

You can identify the source of this kind of interference by using a simple battery-operated receiver, a "walkman", for example.

Standing close to the fuse or breaker panel, listen to the interference on the "walkman" and cut the circuits one by one until you find which circuit is feeding the equipment causing the interference. To make sure you have the right circuit, switch it back on; if the interference returns, you have the right circuit.

The next step is determining which equipment, lights or appliances are connected to the fuse or to the circuit in question.

A standard installation will feature indications directly on the panel: living room, master bedroom, kitchen, etc. Go to the appropriate room and disconnect each appliance one by one until the noise stops.

Finding other sources of interference usually involves the same process, except that technicians may use a more sophisticated "walkman" unit, depending on the type of interference they are investigating.

Solutions vary depending on the type of interference.

Of course, a defective appliance must be repaired if the problem is to be solved. In other cases, the cure may be to insert the type of filter appropriate for the kind of interference being experienced or modifying the installation so that reception returns to normal.

5.5 Processing Complaints

The Department is responsible for applying the terms and conditions of the Radiocommunication Regulations, which stipulates conditions on interference. The process calls for the **determination of harmful interference**. Such a determination makes it possible to identify the party responsible for interference and impose corrective measures.

The Department no longer investigates interference experienced by the general public; instead, it provides self-help material needed to resolve the problem. The complainant is encouraged to use the services of repair shops or manufacturers to help find the cause of problems.

When we decide to intervene, we must obtain as much information as possible. When a complainant reports a case of interference, we need his full address, including a telephone number, the hours at which he can be reached or when we can meet him, if needed.

We must also know the type of interference he is experiencing, what radio stations or television channels are affected, is he using an outside antenna or cable TV, what form does the interference take, noise, lines, snowy picture, etc., and the action taken so far to determine the cause and source of the interference.

The information document enti-tled **"Cutting through radio interference"** is available via Internet on our STRATEGIS site and is available in various other forms as well (brochures, video, CD-ROM).

Depending on the type of interference,

- study the interference,
- if it is interference from another station, identify it, locate the source:

  - either by direct listening, call letters, message content, etc.,

  - or by technical means, goniometry, antenna effects, ultrasound microphones and others.

When the source has been determined, it is necessary to find the exact cause of the problem so that the owner and user can be informed and so that adequate repairs or modifications can be made.

To facilitate their work, technicians proceed by elimination, following a series of steps to ensure that nothing is overlooked.

The following is a sample procedure:

1. There is interference.

2. The 110-volt cord is disconnected and the appliance is put on batteries, if possible, or a similar battery-operated device that is also affected when connected to the same power source.

3. There is no longer any interference:

- the cure is the installation of a filter at the power source.

4. Interference continues.

5. Does varying the volume control have an effect on the interfering signal; is the interference stronger when the volume is increased?

- if so, the interference may be received at the appliance's entry point. In this instance, the solution is usually the installation of a filter on the volume control terminals.

6. If varying the volume has no effect on the interference, the entry is likely the speaker wiring which acts as an antenna and carries part of the interference signal back to the amplifier:

- use shielded wires between the loud-speakers and the appliance.

7. Usually, these three techniques are effective in eliminating audio interference.

For additional details, consult the two attached sample information sheets.

5.6 Exercise

1- List four forms of interference which can affect the operation of radiocommunications installations:

.....

.....

2- Certain sources of interference can be identified using the electrical panel's circuit breakers? (check)

- ☐ Yes - for certain sources of radio-electric interference;
- ☐ Yes - for all sources of interference;
- ☐ No

3- Name which formats the Department uses to provide information on interference:

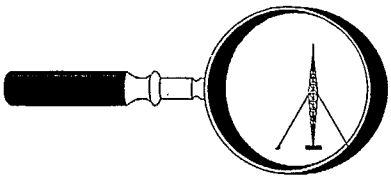
.....

.....

Chapter 6. Radio Station Verifications

6.1 Licences are issued under certain conditions

The user must be on a given frequency or wavelength, use a certain transmission power output, a particular antenna model at a determined height and at location X to communicate with particular stations.



This data serves as the basis for authorization and originally, are required to guarantee that a user at a given address in a city will not cause interference to other users in the same city.

This is why we carry out frequency compatibility studies during the authorization process.

Verifications *(Inspections)* will confirm whether spectrum users are actually installed in accordance with the information that we have in the SMS data base; if not, certain measures must be taken, such as the submission of a revised application or demanding that the licensee reinstall his station as stated on the original licence application.

There are two ways to verify *(inspect)* a station:

- on the site itself or
- through the airwaves (Off-air verifications or surveillance)

6.2 On-Site Inspections

On site, the main elements of the inspection include visual examination of equipment, verification of make and model of equipment to confirm compliance, measurement of technical parameters such as frequency, power and others, examination of the installation site, antennas and cabling, and verification of the site on a topographical map to confirm the station's geographic coordinates.

Measuring equipment such as frequency meters, wattmeters, spectrum analyzers, modulation analyzers and monitors are required when proceeding with on-site inspections.

6.3 Off-air verifications (or surveillance)

Off-air inspections using receivers or communication monitoring equipment, make it possible to record information on almost as many parameters.

Some details may escape us, such as determining whether a user's equipment is of a model which is type-approved by the Department.

Using direction finders, we can determine the exact location of the radio station, on such a street or even at such an address. Integrated Spectrum Observation Centres (ISOC) feature remote-control surveillance equipment and are used to verify spectrum use and the compliance of stations and to investigate interference affecting radiocommunication systems.

Generally, inspections involve almost all the same actions or technical measures.

While a private commercial station is inspected with the objective of ensuring sound spectrum management of radio frequencies and preventing the possibility of interference to other users, other station categories or installations are inspected for different reasons.

6.4 Inspection of broadcasting undertakings

The inspection of broadcasting stations such as television or cable is carried out to confirm that the installations are operated in compliance with data provided by an engineer in a technical brief submitted prior to the broadcaster obtaining a Technical acceptance certificate and a Licence.

The inspection will be followed by a recommendation from the district to the region and eventually to Headquarters, regarding the eventual renewal of the broadcaster's licence.

6.5 Exercise

1- List two ways of verifying *(inspecting)* a radio station:

.....

2- Which of the following types of measuring equipment are used during station inspections? (check)

- ☐ frequency meters
- ☐ ultrasonic meter
- ☐ wattmeter
- ☐ spectrum analyzer
- ☐ photometer

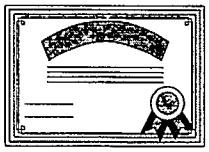
3- Integrated Spectrum Observation Centres (ISOC) are used to:

.....

.....

Chapter 7. Examinations

7.1 Certificates



Depending on the different classes of radio services, regulations require that operators be certified.

A **radio operator certificate** is somewhat similar to a driver's licence.

You should not drive an automobile if you don't have a licence. You should not operate certain types of radio stations if you don't have an operator's certificate.

A radio operator's certificate is required for:

- airplane pilots;
- ship radio station operators;
- individuals who operate radio stations on high frequency (HF) bands; and
- individuals who want to obtain an amateur radio operator's licence.

7.2 Amateur Radio Certificates

The amateur radio service was set up for people who want to experiment with radio-communications techniques.

This group includes people of all ages and all professions.

Researchers, doctors, technicians, astronauts, students - the list is endless and all these individuals are looking for exchange on topics of common interest, perhaps the weather, the results of their most recent research or work projects, etc.

Many build their own apparatus or antenna from scratch and they are naturally interested in finding out how their equipment will perform on the air; other amateur radio operators will answer back using codes and expressions that are familiar only to the initiated.

The amateur radio operator must be familiar with the basic concepts of electronics and radiocommunications and the regulations that apply to the service. To obtain a licence, the minimum requirement is a **Certificate in Basic Qualification.**

Depending on the type of operation planned, the amateur radio operator can also be asked to demonstrate his competency in morse code and may take the Advanced Qualification examination.

Those interested in further details should consult RIC 24.

7.3 Professional Certificates

To hold a **professional operator certificate** in radiotelephony, the individual must demonstrate to an inspector or delegated examiner that the individual:

* has the operating knowledge for the type of station that he wishes to implement or to operate (aircraft, ship or land station);

* has knowledge of procedures for calls, message transmission and safety communications, including the terms and procedures in case of distress and emergency;

* is familiar with the frequencies and channels that are reserved for calls and for traffic exchanges;

* knows the phonetic alphabet used to ensure that his correspondents understand messages;

For maritime operators, there will also be questions on the maintenance of the batteries needed to operate that station in case of an emergency.

There are many different categories of certificates and they allow the operation of many types and classes of commercial stations in land, maritime and aeronautical services.

The Department distributes Learning Guides for the restricted operator's radiotelephony certificate including:

- RIC-21 - Study Guide for the Radiotelephone Operator's Restricted Certificate (Aeronautical);
- RIC-22 - Study Guide for the Radiotelephone Operator's Restricted Certificate (Land); and
- RIC-23 - Study Guide for the Restricted Operator's Certificates

7.4 Examinations

The examination may take the form of a written or oral questionnaire.

Usually, the candidate must:

- answer multiple-choice questions on regulations and station operation;

- provide examples of calls and exchange of messages; and also

- in the instance of maritime service, for example, based on a hypothetical situation, describe how he would send out or answer a distress call.

Example of a Hypothetical Situation

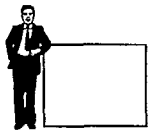
There is a collision between the Explorer II and The Wanderer pleasure crafts.

The two ships sink at latitude 44 degrees 15 minutes 50 seconds and longitude 62 degrees 13 minutes and 30 seconds, 85 miles from Halifax.

There is thick fog.

For the examination, the inspector or accredited examiner ensures that the candidate has the necessary competencies to operate the radio station satisfactorily.

7.5 Accredited *(delegated)* Examiners



To improve service availability for clients, the Department has accredited individuals for the administration of examinations in the aeronautical service.

For the past several years, pilot instructors and certain staff members of Transport Canada and airline companies have been **accredited as examiners**.

To increase the availability of examination services for the mobile maritime service and for amateur radio operators, members of recreational boating groups and boating security associations and several instructors and members of amateur radio clubs have been accredited by inspectors of the Department's district offices to administer examinations for maritime and amateur radio operator certificates.

Recruiting is done through contacts between the inspectors and the members of various organizations, either during inspections or meetings or as a result of our participation in exhibitions.

The accredited examiner administers examinations free of charge, receives no remuneration from the Department, and contributes to the sound management of radio frequencies as a service to the public, to make it easier to obtain cooperation on the proper use of the spectrum, to ensure greater safety on waterways, etc.

7.6 Exercise

1- List two types of radio qualification certificates:

.....

2- A radio operator certificate: (check)

- ☐ is always required
- ☐ is identical to a licence
- ☐ is like a driver's licence

3- Accredited *(delegated)* examiners: (check)

- ☐ improve service availability
- ☐ contribute to a sound spectrum management
- ☐ administer radio operator's qualification examinations

Chapter 8. Planning, Regulations and Engineering

A sound radiofrequency management starts with favorable international agreements and with regulations and policies that ensure an efficient and orderly use at the national and international levels.

The usage of the radio spectrum is subjected to multiple conditions and factors. Types of technologies, manufacturing, importation, sale of apparatus, communication services, countries level of development, technical parameters (power, frequency, modulation, etc.) and propagation are some of the numerous factors that must be considered when the use of spectrum is debated by the international community. These factors are also influencing sharing agreements' negotiations between two countries.

Laws and regulations are established at international and national levels and provide a legal framework to manage and use this natural resource. This regulation determines all the conditions related to the use of the radio spectrum:

- ✓ eligibility
- ✓ operator's qualifications
- ✓ exemptions
- ✓ authorization fees
- ✓ technical requirements
- ✓ standards
- ✓ procedure governing the making of applications
- ✓ allocation plan
- ✓ radiocommunication services
- ✓ inspector's nomination and powers
- ✓ determination of harmful interference

- ✓ inspection powers
- ✓ prosecutions and fines
- ✓ suspensions
- ✓ revocations

Almost every employee working for spectrum management contributes in a way or another to the regulation, planning, policy, operation and engineering processes. The three following main activities group these important functions:

- Policy and planning
- Regulations
- Engineering

8.1 Policy and planning

The basis of the spectrum management program depends on policies that reflect the government objectives and priorities. Therefore, it is essential to establish telecommunication policies that will provide a clear and precise framework.

Canada is participating regularly to the ITU administrative activities in order to influence international telecommunication policies and decisions so that Canadian needs are fulfilled. It is also crucial to establish agreements with different countries, specially with neighboring countries. International coordination agreements facilitate information exchanges and enable radio stations' coexistence even when propagation conditions are not favorable.

To establish clear spectrum management national objectives, the department introduces spectrum

management framework policies and provides a strategic plan for employees managing this resource.

8.2 Regulations

Many activities are linked to the regulations that provide the radio spectrum usage rules. The main related activities are:

- Regulatory Policy and Planning
- Spectrum Management Operations
- Spectrum Engineering
- Automated Applications management

The department publishes a multitude of documents establishing the policies, regulations, guidelines, standards and information for the general public, here are the main categories:

<u>Information</u>

✓ Allotment Plans
✓ Booklets, Pamphlets and Reports
✓ Electromagnetic Compatibility Advisory Bulletins (EMCAB)
✓ Forms
✓ Radio Equipment List (REL) / Terminal Equipment List (TEL)
✓ Radiocommunications Information Circulars (RIC)
✓ Technical Bulletins (TB)
✓ Telecommunications Regulation Circulars (TRC)

Guidelines

- ✓ Guidelines for the Measurement of Radio Frequency Fields (NIR)
- ✓ Guidelines for Compliance with the Radio Authorization Condition of Licence Relating to Research and Development

Legislation, Regulations and Treaties

- ✓ International Agreements
- ✓ Legislative and Regulatory Circulars
- ✓ Other Federal Laws - Department of Justice
- ✓ Terrestrial Broadcasting Agreements and Arrangements
- ✓ Terrestrial Radiocommunication Agreements and Arrangements

Policies

- ✓ Radio Systems Policies (RP)
- ✓ Redeployment Plans (RDP)
- ✓ Spectrum Advisory Bulletins (SAB)
- ✓ Spectrum Utilization (SP)

Procedures

- ✓ Broadcasting Equipment Standards Procedures (BESP)
- ✓ Broadcasting Procedures (BP)
- ✓ Broadcasting Procedures and Rules (BPR)
- ✓ Broadcasting Circulars (BC)
- ✓ Terminal Equipment - Certification Procedure (CP)
- ✓ Client Procedures Circulars (CPC)
- ✓ Conformity Assessment Procedures

- ✓ Internal Procedures Circulars (IPC)
- ✓ Radio Standards Procedures (RSP)

Standards

- ✓ Broadcasting Specifications and Standards (BTS & BS)
- ✓ Broadcasting Equipment Technical Standards (BETS)
- ✓ Digital Television Standards (DTV)
- ✓ Interference Causing Equipment Standards (ICES)
- ✓ Radio Equipment Technical Standards (Lists)
- ✓ Radio Standards Specifications (RSS)
- ✓ Standard Radio System Plans (SRSP)
- ✓ Terminal Equipment - Technical Specifications List

These documents are made available for the public and the Canadian telecommunication industry from the Strategis Internet site: **(http://strategis.ic.gc.ca/SSG/sf01347e.html)**.

The Broadcast service is particular since it is accessible to the general public and because there is another government ruling organization: the Canadian Radio-Television and Telecommunications Commission (CRTC). The department must therefore consider the CRTC decisions, notices, orders and regulations and provide it with technical evaluations and recommendations.

A dynamic and organized spectrum management requires a very complex technical infrastructure. The department operates one of the worlds most sophisticated spectrum management automated system. This system was designed and produced by the department employees and is actively used to support current operations. This system contains all the required information: administrative, financial and

technical.

8.3 Engineering

Many spectrum engineering activities are required to realize the policies, standards, and guidelines.

Terrestrial and spatial spectrum engineering divisions must participate actively to ITU world conferences to ensure that the international agreements, regulations and standards will fulfill Canadian radiocommunication actual and future needs.

The electromagnetic spectrum is a limited resource that has complex technical characteristics. Viable spectrum management starts with a spectrum allocation plan and judicious frequency assignments. Electromagnetic compatibility is one of the most important technical aspects and requires a system that will realize numerous and complex calculations.

The spectrum management system must be updated on a regular basis to be adapted to the changing spectral environment. Regular introducing of new technologies requires resource's management strategy modifications and these changes have an impact on our automated systems. Canada has an excellent worldwide reputation for the quality of its spectrum management and the department provides support to Canadian companies who intend to export his automated systems. These systems consist not only in softwares and databases, but include measurement systems developed by the department.

An efficient spectrum management involves the use of quality radio apparatus. The department establishes for

this reason standards for the importation, manufacturing and operation in order for Canadians to use radio apparatus meeting a satisfactory technical quality level. Standards and a certification procedure have been established and a Certification and Engineering Bureau is mandated to control them.

Chapter 9. Tools

9.1 Measuring Equipment

Tools are required to monitor spectrum usage, to record what is happening on the spectrum and to take measurements to ensure that authorized stations are where they should be.

Such tools include receivers, frequency meters, field-strength meters, wattmeters, generators, oscillators, spectrum analysers and others.

A **frequency meter** is used to measure the exact frequency of stations to ensure that they are on the their authorized frequency and operate within the applicable standards.

A **wattmeter** is used to measure the power of transmitters, while a **field-strength meter** is used to measure the intensity or strength of a signal, for example signals transmitted by a television station.

Need we describe the many things that can be done with a **computer**? Of course not - the computer is your main work tool! However, I would add that in addition to storing data on licences, computer software has replaced time-consuming calculations that technicians formerly did manually before authorizing systems.

The computer has also made it possible to automate several operations, for example, inspecting cable television

systems (CATV) or to monitor and **measure the degree of frequency occupation**. The department has developed a unique automated monitoring system called **ISOC** (Integrated Spectrum Observation Center) that can achieve remote and automated technical measurements. Another example is the **Direction finder network**, capable of locating transmitters.

To **detect interference**, the inspector may use antennas of every type, adjusted to the frequency bands of interest and whose radiation pattern (ability to receive a signal more efficiently in a given direction) will be chosen based on the work to be accomplished.

In the case of interference from electrical power lines and installations, the inspector may use an **ultrasonic microphone** which makes it possible to listen to noise caused by defects in the hardware and to pinpoint their location on a pole, for example.

Receivers of all types are also used, from the smallest portable hand-held unit to sophisticated, multi-band receivers with a built-in microprocessor to store frequency information and other data in memory.

A **spectrum analyser** is a sophisticated receiver which enables us to see rather than hear what is happening on the spectrum. It is a type of "radio window" that can be transported to wherever it is needed.

The technician can adjust his window at will, widening it or narrowing it to see a bigger or smaller slice or segment of the spectrum.

Manipulation of the controls enables the technician to

analyze signals, ensure whether or not a station is taking up too much space and encroaches on others, study a second station to see if it is emitting parasite signals that could interfere with other users, find spectrum space that additional applicants could be authorized to use and take other measurements as well.

9.2 Accessories

Audio recorders are used to record illegal conversations, while **graphic recorders** provide a graphic record of inspection data or of radiation diagram verifications.

Filters are used to eliminate radio frequency interference, to reduce the width of a receiver band or to improve conditions harmful to reception.

Low-pass filters, high-pass filters, band-pass filters, band-rejection filters commonly called cavities, and tunable or fixed filters are all especially useful in frequency spectrum management.

Several other instruments are available including amplifiers, tone decoders, packets, oscilloscopes and encoders.

9.3 Exercise

1- A spectrum analyzer is: (check)

- ☐ a receiver
- ☐ a scanner
- ☐ a transmitter

2- A wattmeter is used: (check)

- ☐ to measure frequency
- ☐ to measure modulation
- ☐ to measure power

Chapter 10. Applying the Act and Prosecution

10.1 The Steps Involved in a Prosecution

The **Radiocommunications Act** provides for several sanctions, ranging up to fines of several thousand dollars and even imprisonment for those who contravene its statutes and application.

Legal action is not a common occurrence. The Department resorts to legal action only when those who contravene the law continue to do so after we have notified them verbally and/or in writing and given them every possible chance to be heard.

Prosecution involves effort and significant costs and whenever possible, we try to avoid it. The steps involved in prosecution are usually as follows:

- an infraction *(contravention)* is observed;
- a verbal and/or written notification is sent to the operator of the station responsible for the infraction;
- a repetition of the irregularity is observed;
- a new notification is sent;
- the file is submitted to the regional office to obtain approval for prosecution;
- a warrant is obtained from the court; and

- the warrant is served and the case is heard.

In serving the warrant, inspectors must ensure that they collect all pertinent information and keep a record of all facts to facilitate the preparation of the case and a successful outcome.

10.2 Ticketing

The Contravention Act provides for the implementation of a ticketing system that may serve as an alternative to prosecutions and that is available to all Federal government departments including Industry Canada and its radio inspectors. Ticketable offences are identified in schedules that are published in the Canada Gazette, Part II. In accordance with the Act and the published schedules, an inspector may issue a ticket to a person that contravenes a provision of the Radiocommunication Act or the Radiocommunication Regulations.

Tickets may only be issued in those provinces where the Provincial government has agreed to the application of the Contravention Act and its schedules on its territory. It is hoped that the ticketing system will offer the advantage of obtaining cooperation more readily from various users of the radiofrequency spectrum.

Chapter 11. Reports and Computer Systems

11.1 Business Plans

The business plan is the result of the strategic objectives that the Department sets for the current year. Usually, it contains the strategic plan and the operational plan.

It includes the description of various activities and objectives that we have targeted to participate in the Department's overall strategic objectives for the year.

The operational plan sets out the scope and the time frame for various activities and outlines the operational initiatives worthy of note.

Also included are budgetary plans (salaries, telephones, travel, etc.), and a training plan.

11.2 Operational Reviews

The operational review outlines the achievements to date and details the options and/or target adjustments, if needed, should there be any indication that one or more objectives will not be reached.

It can also be used to examine additional resource needs for particular or unforeseen events.

11.3 Computerized Systems

Several computerized systems are used in day-to-day spectrum management operations, on the technical, administrative and financial levels. They also make it possible to collect information used for the operational reviews.

SCOMS is used in the spectrum control program for inspection and investigation data.

OLDE is the on line data entry software used to capture administrative, technical and financial data and is feeding the **Spectrum Management System** (SMS).

The **"Registre des demandes"** software used in the Quebec Region and **APPTRAC** used in the other regions enable the inspector to follow the progression of files under study. It is a program developed by our region. **CARDEX**, also developed in Quebec, is used to enter the names and addresses of clients and to manage the central file. It makes it possible to assign company codes or client file numbers. It is linked to OLDE and makes it possible to transmit the information SMS needs to generate invoices. The **GDOC** software will replace these systems shortly.

SYSEXAM is used to enter data on operator certificates, certificate printing and to maintain a data base for the purposes of control, archiving and statistics.

The **STMIS/STRS** is used to record time and salary spent on each activity and is the main basis for operational reviews.

Several other statistical reports are produced from the data entered using the main programs. One of these is the report available in SYSEXAM, showing the number and category of radio operator certificates issued by inspectors and by accredited examiners.

Additional software has been developed by personnel in regional and district offices, leading to greater efficiency.

Some, such as SYSPARC and PRESEL, have earned special recognition for their developers.

SYSPARC is used to group together data on antenna farms and to facilitate frequency compatibility studies on these parks.

PRESEL has led to a considerable improvement in the time required to identify frequency bands for new allocations, whether for transmission or reception.

Still others are used for inventory control, updating mailing lists, remote inspection and surveillance control equipment, in libraries and for many other purposes.

Computerization has enabled us to absorb the annual increase in the clientele - a consistent phenomenon in the past several years - without increasing resources.

11.4 Management Manuals

Management Manuals are available in paper or computerized form and contain governmental directives on human resources and financial management.

A multitude of directives and guidelines have been

developed to facilitate management and employees have access to these documents as needed. Each department and Region also has specific directives, for example standards for services provided to the public

Chapter 12. Conclusion

We hope that this course has enabled you to learn the basics of spectrum management.

We recommend that you return to the participation contract at the beginning of the manual to evaluate whether the course has fulfilled your expectations.

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- Fixed land station
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Appendix H : Cutting through interference on a telephone

Appendix A

(extract from a 1992 Treasury Board Submission)

Spectrum Management Program

Importance of the spectrum

Electromagnetic radiation is defined as "a form of oscillating electrical and magnetic energy capable of traversing space without the benefit of physical inter-connections"[1]. Frequency is the rate of oscillation and is expressed in cycles per second or hertz. The entire range of frequencies form the electromagnetic spectrum, and the band from 10 kilohertz to 3000 gigahertz is known as the radio frequency spectrum.

This vital natural resource, which we cannot see, touch or smell, provides the basis for the $21 billion Canadian telecommunications industry, one of the fastest growing sectors in our economy. In fact, Canada is a recognized world leader in telecommunications and spectrum management. The two are closely linked. Our highly mobile population and the vast distances and rough terrain which separate a scattered population mean that spectrum is fundamental to efficient communications systems in every walk of life and in all parts of Canada.

The spectrum is used for radio and television broadcasting, and the microwave and satellite links which carry long distance telephone calls, facsimiles, telexes and data communications across the country. It is also used by mobile radio, cellular service and paging companies. Commercial airlines, taxi and trucking companies, towing companies, couriers and delivery agents, construction companies and building contractors, oil exploration and utilities companies, farmers and retailers also depend on the effective management of the spectrum for the operation of private communications systems.

Federal and provincial departments and agencies and large municipalities also use the spectrum for armed forces, police, ambulance, air traffic control, marine safety, emergency and public safety services. Ambulance paramedics use the spectrum to transmit vital patient cardiac information while en route to hospital, allowing diagnosis to begin before arrival. Police officers use radiocommunications to coordinate their movements and consult central police computers from their vehicles. Radio signals in the form of radar are used by air traffic controllers to establish aircraft positions and prevent collisions, and in aircraft instrument landing systems, guiding pilots to safe landings at night or when visibility is poor. Shipboard radar and radiocommunication systems play a vital role in marine navigation, particularly in bad weather and in communication with shore-based stations.

The use of spectrum related technology is becoming more prevalent in the work

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1 Harvey J. Levin, The Invisible Resource: Use & Regulation of the Radio Spectrum, The John Hopkins Press, Baltimore & London, 1971, p.15.

environment with the use of wireless networks linking several computers in the same building, city or across the country. In our homes, spectrum is increasingly being used, not only for the reception of radio and television broadcasts, but to operate alarm systems, cordless telephones, remote controls, microwave ovens and garage door openers.

Description of the Spectrum Management Program

The Department of Communications manages the use and development of the spectrum for the benefit of all Canadians. Radio emissions cannot be confined within national borders, and thus the use of the spectrum must first be coordinated through multilateral and bilateral agreements. Within this international framework, the Department of Communications allocates frequencies to the specific types of radiocommunication services required to meet Canada's needs, licences businesses and individuals to use particular frequencies for prescribed periods of time, and ensures that all users operate as licenced, without causing interference to other radio users.

The spectrum management program has been in existence for over 50 years. It is delivered by over 800 staff, who look after approximately 5,000 broadcast stations and 857,000 non-broadcast radio licences.

Although spectrum management is solely within federal jurisdiction, the program has long been delivered at a local level to provide better service to clients located in all parts of Canada. Two thirds of the program's staff work outside of the National Capital in a nationwide network of five regional offices, 43 field offices and three spectrum surveillance centres. Almost all aspects of spectrum management activities and decision-making have been delegated to the local level, including licence authorization and control, interference investigations, monitoring of spectrum use, provincial and municipal consultations, and financial and administrative functions.

The Department of Communications manages this program within an annual allocation of approximately $70 million while generating revenues of more than $100 million from radio licence fees. In addition, the Canadian Radio-television Telecommunications Commission recovers more than $57 million from broadcasting licence fees, approximately $14 million of which is collected on behalf of the department to cover the Department's costs of managing spectrum for broadcasting.

Program performance

Canada is internationally recognized as a world leader in managing and monitoring the radio frequency spectrum, and we have been very successful in international negotiations over its use. The sophisticated automated management and surveillance systems used in Canada are much in demand abroad, and our private sector partners involved in their development estimate revenues from the sale of their services to other nations to be in the order of $500 million over the next few years.

The 1988/89 evaluation of the program concluded that the department had excelled at managing the radio frequency spectrum. The program was found to be highly relevant and effective in achieving its objectives. Overall, 80% of radio licensees and 90% of broadcasters were satisfied with the department's performance. There were some areas of marked client

dissatisfaction, however, and the evaluators recommended that these be addressed. The evaluators also queried the extent to which the program was well equipped to address emerging challenges such as technological change and spectrum congestion, and recommended that alternative organizational structures be studied.

Other evidence of past program performance can be gleaned from the Auditor General's report of 1988 which singled out the spectrum management program as a well performing organization. The Auditor General concluded that the spectrum management staff had achieved a high level of performance, in particular with respect to problem-solving, due to a progressive corporate culture and continual investment in training and new computer and information technologies.

The economic climate has placed further emphasis on good management practices and efficient delivery, to which spectrum management has responded commendably. Many innovative measures have been exploited which have reduced the regulatory burden for spectrum users or the department's workload. These include exempting certain classes of users from licensing, delegating spectrum management functions to client groups, and introducing system and fleet licensing. The latter is projected to drop the licence caseload by approximately two thirds while maintaining revenues. These measures, however, will be insufficient in themselves to respond to pressures currently on the program.

CURRENT ENVIRONMENT

A number of factors are undermining our ability to ensure the integrity of key spectrum management activities, the orderly introduction of new communications technologies and the steady growth in revenues.

Shift to wireless technologies

There has been a marked shift over the past decade from the use of copper wires to the airwaves for the distribution of telecommunications, computing and audio-visual services. It is being fuelled by consumer and business demands for mobile services that can keep up with us as we walk, drive or fly, and developments in microelectronics. The price, weight and size of radio equipment have fallen drastically over the past decade. At the same time, performance has improved, resulting in an explosion in the demand for and the diversity of applications using the radio spectrum.

As one indication of the resulting increase in demand for spectrum, the Geneva-based International Telecommunication Union, the oldest of the UN specialized agencies, reports that as many new frequency assignments were recorded in the past decade as in all the previous 80 years of radiocommunications[2].

These trends will accelerate in the future, making spectrum the preferred medium for the

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[2] Business Week, July 23, 1990 / 23 juillet 1990, p.48.

majority of applications which will be available in the year 2000. In fact, some industry analysts forecast a seven to eight fold increase in the number of devices using radio waves over the next decade[3]. Major new services expected over the decade include public air-to-ground services, digital cordless telephones, mobile satellite voice and data communications services, digital radio (DAB or digital audio broadcasting), low earth orbit satellites, high definition television (HDTV) and personal communications networks.

Spectrum scarcity

The explosion in demand for a finite resource has decreased the availability of usable frequencies and congested the spectrum in Canada's metropolitan areas. Finding suitable frequencies for new applicants and new services is becoming increasingly complex and time consuming. The battle over spectrum is also becoming more heated, as could be seen from the debate over the award of the last FM channel in Toronto in August 1990. Increased investment in research and development will be required to open up new spectrum bands for commercialization and to improve the spectrum efficiency of existing technologies. There will also be mounting pressure on new entrants to pay other users to move to less desirable allocations. This will become a critical concern for providers of safety and security services and other groups who lack the ability to pay. Many will turn to government for relief.

Global competition

Businesses in all sectors of the economy, and the general public, want quick access to a wide range of sophisticated new communications services at affordable prices. Delays in access mean that Canadian business and industry will lag their competitors in access to services which could reduce their operating costs, increase productivity, and support new business lines. This will have a deleterious effect on Canadian competitiveness and prosperity.

New technologies also offer important growth opportunities for Canadian telecommunications equipment manufacturers and service providers, at home and abroad, and industry predictions of the revenues expected from the introduction of new mobile radio communications applications are optimistic. The telecommunications industry expects the department to successfully represent their interests in international conventions, to select technical standards which maximize their market access, and to provide rapid access to the spectrum. From a government point of view, these new technologies will generate substantial new revenues from licence fees, as well as jobs and tax revenues.

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3 Japanese Telecommunications, Vol. 2, No. 9, September 15, 1991 / 15 septembre 1991, p.3.

Appendix B

The astonishing PIONEER 10 probe

(Agence France-Presse, CAPE CANAVERAL) March 1992

Transmitting data to Earth, 8 billion kilometres away, after travelling by Jupiter, Neptune, Saturn and after leaving the solar system nine years ago, such is the astonishing technical accomplishment of the American Pioneer 10 probe, whose 20th anniversary NASA is celebrating today.

Launched on March 2, 1972, the probe originally embarked on a mission scheduled to last 21 months, the time required to approach the mysterious planet Jupiter. Despite the scientific fears surrounding its resistance capacity, it succeeded in getting through the asteroid belt unscathed and withstood Jupiter's intense radiation undamaged, sending back exceptional photographs taken from "only" 130,000 km away.

Then, propelled to other destinations by the force of Jovian gravity, Pioneer 10 (at a weight of 285 kg) left the solar system for good on June 13, 1983, embarking on a long journey after a brief encounter with Neptune.

As it did, it became the first manmade machine to leave the Sun's universe.

Since then, the probe has never missed a single daily rendez-vous with earth and since 1972, it has transmitted millions and millions of pages of data on its inter-sidereal adventure, conducted at an average speed of 46,240 km per hour.

"Receiving intelligible data from 8 billion kilometres away using only an 8-watt radio is a technical miracle. It is a remarkable human achievement," commented James Van Allen, a physicist at the University of Iowa and the principal designer of one of the probe's telescopes.

"It is mind-boggling, truly impressive," is the simple description of retired engineer B.J. O'Brien, who worked on the Pioneer program.

Pioneer 10's performance is exceptional indeed. After 20 years in Space, seven of eleven of the probe's scientific instruments are still operational, including the Van Allen telescope. They continue to provide Earth with information on solar winds, cosmic particles and ultraviolet radiation.

Each day, scientists meticulously pour over the data to gauge what effect the Sun has beyond the solar system, hoping to find traces of a possible tenth planet.

"Unquestionably, the most significant discovery since the view of Jupiter is the discovery of the Sun's effects, which extend beyond the limits previously imagined," explained Mr. Van Allen.

Transmitted once or twice a day, the radio signals from Pioneer currently take seven hours and a half to reach the ultra-sensitive antennas used by NASA, which spends approximately one million dollars each month for Pioneer 10 and five other "sisters" still in service (Pioneer 6, 7, 8, 11 and 12).

On its long odyssey, Pioneer 10 also carries a message from Earth, in the form of a plaque showing a male and a female, nude and standing side by side, the man with his right hand raised in a gesture of greeting - humanity's greeting to the possible inhabitants of the extraterrestrial world.

Appendix C

How to complete a license application

FIXED OR TRANSPORTABLE LAND STATION

Form IC 2365BB (6/97)

This form is used in cases where a licence for a fixed or transportable station is required.

1.0 PARTICULARS OF APPLICANT

1.6 The licence can be issued only to an individual or to a company or corporation. No licence can be issued to the name of a registered business.

1.2 It is important to indicate the applicant's telephone number and postal code and if applicable, the place and date of incorporation.

2.0 DETAILS ON THE LOCATION

2.1 The location of the proposed station and the geographic coordinates of the site, to the exact second, are very important if a compatibility study is required.

2.2 Erroneous coordinates may cause the station to experience interference from a neighboring station not taken into account during the study, precisely because the first station was not correctly positioned in the environment.

3.0 NATURE OF SERVICE

3.1 The nature of service allows us to identify from a frequency plan the frequency that corresponds to the applicant's needs.

4.0 FREQUENCIES AND OPERATIONS

4.1 In the case of a new installation, indicate the frequency band in which you plan to operate.

4.2 Furthermore, if the licence is for communications on an existing system, indicate the

desired frequencies to the exact kilohertz. Indicate the corresponding reception frequency.

4.3 The necessary bandwidth and the type of emission are:

a) in VHF or UHF <16F3EJN> for telephony and <16F2DFN> when tone coded squelch is used (private line and other terms);

b) in HF (USB) <2.8J3EJN> for telephony on single sideband (SSB).

4.4 Usually, the transmitter's power output is indicated.

4.5 The applicant's frequency requirements must be indicated.

For HF bands, operating hours are very important because depending on the time of day, one or more different frequencies may be required.

4.6 Indicate stations (Call Signs)with which communication is desired.

5.0 ANTENNA SYSTEM DETAILS

5.1 During the compatibility study, information regarding the make and type of the antenna in use will enable us to determine the system's performance level and to select the most appropriate frequency.

5.2 The antenna gain (in reference to a dipole) the type and length of transmission lines are part of the computerized analysis of the system's calculation parameters.

5.3 In the case of base-mobile communications, the usual antenna is omnidirectional or bidirectional, with vertical polarization.

A point-to-point link usually requires a yagi-type directional antenna with horizontal polarization.

5.4 The beamwidth is usually indicated in the manufacturer's catalogue. This information is used to determine the potential for frequency sharing.

5.5 The height of the antenna above ground and the ground elevation above sea level are used to determine the coverage area.

6.0 POWER COMPUTATIONS

6.1 These data are used during the compatibility analysis, to determine the potential of interference on the site and in the environment.

The interference possibilities that are analyzed are:

a) transmitter noise that can interfere with the receiver;
b) transmitters and receivers intermodulation products;
c) receiver desensitization caused by facilities that are close in frequency and distance.

6.2 The transmitter power expressed in dBW is the result of 10 times the logarithm, in base 10, of the transmit-ter's power in watts.

For example, a 10-watt transmitter - 10 dBW
log10 of 10 = 1 multiplied by 10 = 10 dBW

6.3 Refer to the manufacturer's specifications for infor-mation line losses, in reference to the frequency in use.

For example, at 150 megahertz, 20 meters of RG8- or RG213-type cable gives a loss of:
(0.09 dB / meters) X 20 meters - 1.8 dB

6.4 When the transmitter's output power in dBWatts (DBW) and the total line losses are known, the mathematical difference between the values and the antenna gain results in the effective radiated power (ERP) in dBWatts (DBW).

6.5 If filters are used, it is important that details are provided so that they can be taken into account when calculating compatibility.

6.6 A loss of 0.5 dB is allocated for connectors.

6.7 Calculations and details must be provided for each of the desired frequencies.

7.0 PARTICULARS OF PROPOSED EQUIPMENT

7.1 The type-approval number usually appears on the back of the radio unit.

If not, the information is available from the supplier, based on the name of the manufacturer and the type or model number of the equipment.

In general, material which is not type-approved cannot be the object of a licence.

The user may change the equipment without informing the Department if the replacement is type-approved and the ERP remains the same as the previously approved ERP.

8.0 CERTIFICATION

8.1 The applicant must sign the application.

8.2 The holder of a power of attorney from the applicant may sign the application. An original copy of the authorization must accompany the application.

9.0 DETAILS ON CHANGES, IF APPLICABLE

9.1 Section 9 is designed to facilitate the study of an application to obtain the authorization to modify a licenced installation.

Complete the appropriate sections.

10.0 Licence FEES

10.1 Licence fees must accompany the application.

At the end of the fiscal year (in March), the payment of licensing fees for the current year and renewal for the following year must accompany the application.

MOBILE RADIO STATION Licence APPLICATION

Form IC-2366 (6/97)

1. This form is required for mobile radio station licence applications.

2. The same application may be used for more than one station. In this case, data must be identical for all mobiles concerned, in other words power output of the equipment and frequencies must be the same for the entire group of stations.

2. In cases where more than four frequencies are required, use the back of the form.

3. For amendments to an existing licence, check the appropriate box. If possible, the licence numbers of stations to be modified should appear in the section reserved for this purpose, at the top of the form. If space is insufficient, include a separate list.

4. A radio licence can be issued only to an individual or to a company or corporation. Applications where a "registered" company name appears in the "Applicant's name" section will be refused.

5. In the case of a corporation, the location and date of the organization's incorporation is required.

6. Generally, licences may be issued only to Canadian citizens or Canadian companies.

7. The maximum power usually authorized is 30 watts, even if the radio apparatus is type-approved for a higher power output.

8. The coordinates of the area of operation and the mobile radius of operation are required to ensure frequency compatibility in the desired coverage area.

9. Clearly indicate the required frequency ranges or in the case of an existing system, the exact frequencies. Similarly, the names of the licensees or call signs of the stations with which you wish to communicate must appear on the application.

10. The area of operation will be specified on the licence.

11. The nature of service provided by the applicant, taxi, construction or other, will enable us to select one or more frequencies based on predetermined frequency plans.

12. Licence fees must accompany the application.

13. In the case of applications submitted at the end of the fiscal year, the payment of the licensing fees for the current year and of the renewal for the following year must accompany the application.

Appendix D

Notes on Effective Radiated Power

The effective radiated power is the figure obtained using a simple calculation based on the transmitter's output power, the signal losses experienced by the signal in the transmission line, the connectors and filters installed between the transmitter and the antenna, and the antenna gain factor itself.

Properly installed, a 10-watt transmitter could behave as if it were a transmitter of 50 watts and more.

The power required for a system is determined on the basis of several factors:

- the applicant's actual needs; the installation will depend on the required coverage area;
- the station's location; whether the station must be installed in an urban center or in the wilderness;
- the system's equilibrium; the range of the base station's signal must not exceed unnecessarily the range of the mobile stations' signals.

Appendix E

Schedule III of the Radiocommunication Regulations

To bring to class

Available on Industry Canada Strategis Web site
(http://strategis.ic.gc.ca)

Appendix F

Communication Interference in Radiocommunications Systems

To bring to class

Available on Industry Canada Strategis Web site
(http://strategis.ic.gc.ca)

Appendix G

Cutting through interference on a variety of electrical or electronic equipment

To bring to class

Available on Industry Canada Strategis Web site
(http://strategis.ic.gc.ca)

Appendix H

Cutting through interference on a telephone

To bring to class

Available on Industry Canada Strategis Web site
(http://strategis.ic.gc.ca)

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