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Planning and Management of the Land Mobile Radio Services at the National Level

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Summary. *This paper deals mainly with problems of managing the land mobile service in the frequency bands between 26 and 470 MHz. The conclusions are applicable to a small country with a relatively high spectrum occupation density and a variegated and often awkward topography. In these matters technical and administrative considerations are closely connected.*

1. The main frequency bands and their basic characteristics

1.1 The 27 MHz band

This part of the spectrum is often used for low-power AM equipment. The existence of a band for industrial, scientific and medical uses and the variable propagation conditions hardly lend themselves to reliable and good quality links.

1.2 The 30–47 MHz band

About 20 years ago this band, which is 17 MHz wide, was extensively used for various mobile services, especially public services. It was also used by the first FM equipments. Account has to be taken, however, of propagation conditions, which are often beyond the normal range and are therefore harmful, and also the noise level, which can be high and often seriously restricts the usefulness of the band. The cumbersome antennas required are no longer suited to the modern trends and miniaturization potentialities.

1.3 The 68–88 MHz band

This band lends itself well to longer links and has the advantages of the FM technique in the case of telephone connections. The useful range is about 100 km. The antennas are cumbersome, and hardly facilitate the installation of directional antennas at the base station end. There is also the possibility of temporary excessive propagation.

1.4 The 146–174 MHz band

In many countries, this may be regarded as the principal band for land mobile services. It combines the advantages of a considerable range and of powerful but small equipment.

1.5 The 460 MHz band

This band is particularly suitable for short-distance links, with a range of about 15 km. Fading en route is of short duration and reflections, especially in towns, help to provide an almost complete coverage of urban service areas. On the other hand, large topographical obstacles lead to clear separation between different assignment areas in the same channel.

2. Types of network for different operational requirements

The following descriptions are partial and are based on the requirements of radiotelephony. Special uses are subject to certain restrictions.

2.1 Simplex networks

In the case of two-station, star-shaped and multiple networks using *one frequency only,* each participant can hear all the traffic and can get into direct touch with each station in the network *(fig. 1.)*

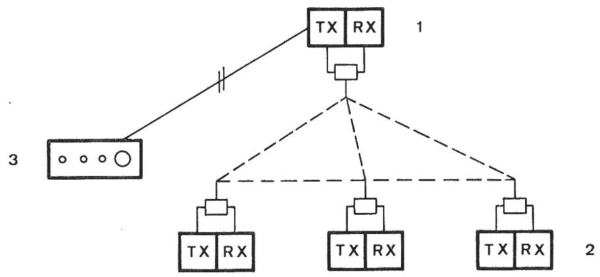

Fig. 1
One-frequency simplex
1 Base station
2 Mobile stations
3 Control desk

The use of *two frequencies* makes it possible to work with simultaneous relays and to group the transmission frequencies of mobile stations and those of base stations, thus avoiding assignment difficulties in adjacent channels *(fig. 2.)*

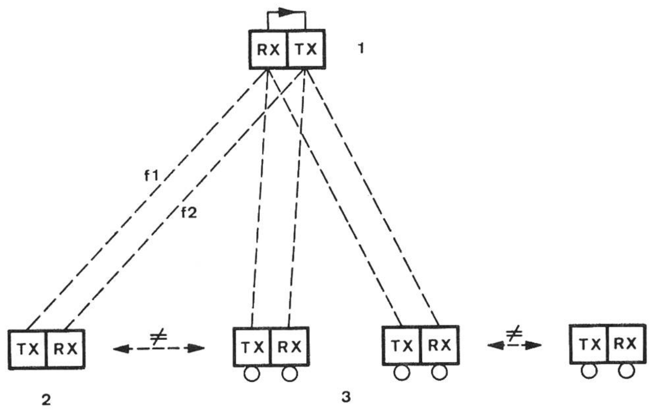

Fig. 2
Two-frequency simplex
1 Relay station
2 Fixed station
3 Mobile stations

Switching simplex links to the telephone network is difficult and is generally not authorized with the public telephone network.

Networks often require several channels and are therefore fitted with multichannel devices. The choice of channels for

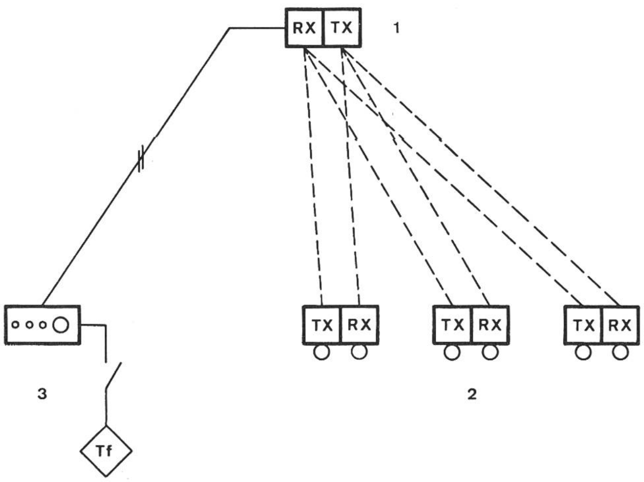

Fig. 3
Duplex network
1 Base station
2 Mobile stations
3 Control desk

the participants depends on whether or not they must be capable of switching to special channels, common to other users.

2.2 Duplex networks (fig. 3.)

These networks by definition need two frequencies, allowing for simultaneous two-way traffic. This type of working is warranted for switching with the public telephone network

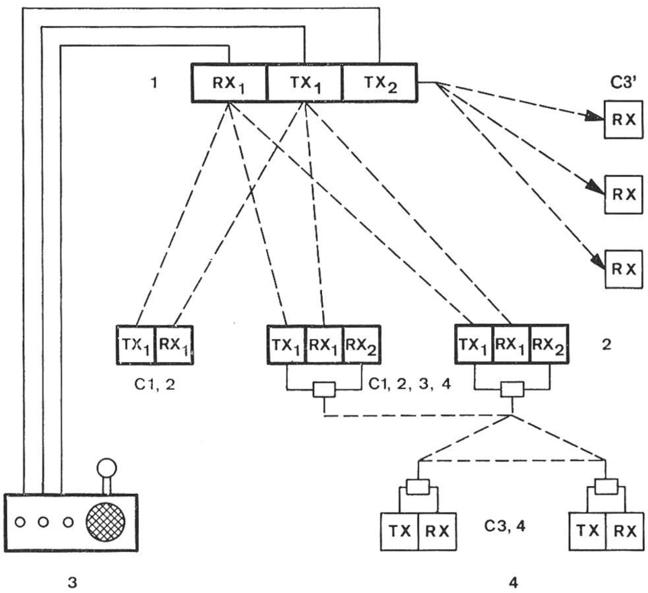

Fig. 4
Mixed-network operation
1 Base stations
2 Mobile stations
3 Control desk
4 Portable stations

and when it is necessary for a participant to intervene immediately in the network. Duplex networks can be switched to simplex networks by relays.

2.3 Half-duplex and mixed networks

For half-duplex networks, reference should be made to No. 6 of the Radio Regulations, Geneva, 1968. Here, mixed networks only are dealt with, which can operate in simplex and in duplex. An example is given in *figure 4.*

An analysis of the equipment of a public service might show the situation given in *table I.*

Table I.

	Channel No.	MHz TX_1	TX_2	RX_1	RX_2
Base station	1	172,625	172,725	168,025	—
	2	172,650	172,725	168,050	—
Mobile stations	1	168,025	—	172,625	—
	2	168,050	—	172,650	—
	3	168,125	—	172,725	168,125
	4	168,175	—	172,775	168,175
Portable stations	—				
	—				
	3	168,125	—	—	168,125
	4	168,175	—	—	168,175
Receivers only	3'	—	—	172,725	—

The switching width of equipments is first taken into account and then an attempt is made to balance the necessary assignments in the lower and upper bands *(fig. 5.)*

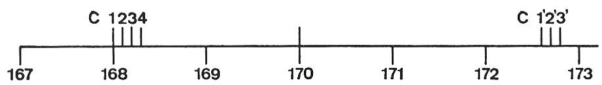

Fig. 5
Example of frequency assignment in the lower and upper bands

3. Conclusion for frequency planning

3.1 Organization of partial bands for duplex working

To group the necessary frequencies in the case of duplex networks, they must be distributed between the lower and the upper bands. The location of the transmitting frequencies for mobile and base stations must then be specified.

The requirements of duplex networks can always be met with a distribution as in *figure 6.* For simplex networks, it is enough to divide the pair of frequencies. On the other hand, seeking out duplex frequencies without prior organization is difficult and uneconomical.

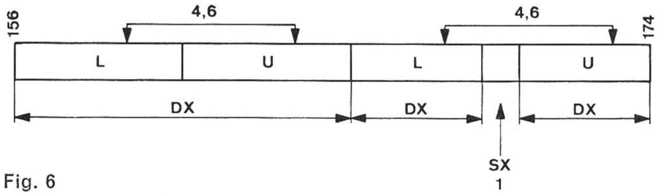

Fig. 6
Organization of partial bands for duplex working

3.2 Distribution of sub-bands for different users

There are often mutual relations in the operation of radio networks by the same group of users. This necessitates a subdivision of bands by similar users, e.g.:

Railways	B
Power	E
Fire service	F
Transport	K
Public mobile services	L
Security services	P
Broadcasting	R (news links)
Rescue services	S
Industry	U
Taxis	W
Various private services	X

This distribution may be represented as in *figure 7.*

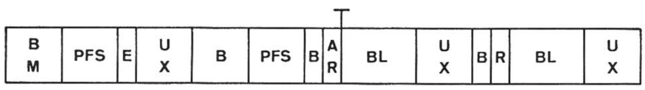

Fig. 7
Example of sub-band distribution

It is thus possible to introduce common frequencies for different users of the same type of service or even for users belonging to different groups. This technical possibility has proved very useful in the case of rescue operations, provided the respective users maintain exemplary radio traffic discipline.

3.3 Intermodulation between adjacent channels

This well-known phenomenon, which is primarily the result of non-linearity of receiver input stages, considerably restricts the choice of assignable frequencies. The harmful intermodulation products are the odd orders, such as the 3rd, 5th, 7th, etc. The probability of harmful intermodulation in time declines rapidly in the high orders and we shall therefore confine ourselves to the 3rd order.

The resultant products are:

$2f_1-f_2$	$2f_1-f_3$	$f_1+f_2-f_3$
$2f_2-f_3$	$2f_2-f_1$	$f_1-f_2+f_3$
$2f_3-f_1$	$2f_3-f_2$	$-f_1+f_2+f_3$

The total spectrum width liable to be affected is 3n—2 channels, n being the width between the end channels of the frequency group concerned *(fig. 8.)*

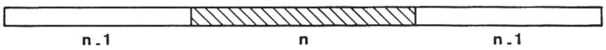

Fig. 8
Spectrum width affected by intermodulation

On n consecutive channels, a number of channels p without intermodulation remains available. If n is relatively small, the number p (always lower than n) is still quite large. For a very high value of n, however, the number p is small and efficiency in this case is very limited.

On this basis it is possible to calculate groups of frequencies without intermodulation in the various sub-bands of the different users *(fig. 9.)*

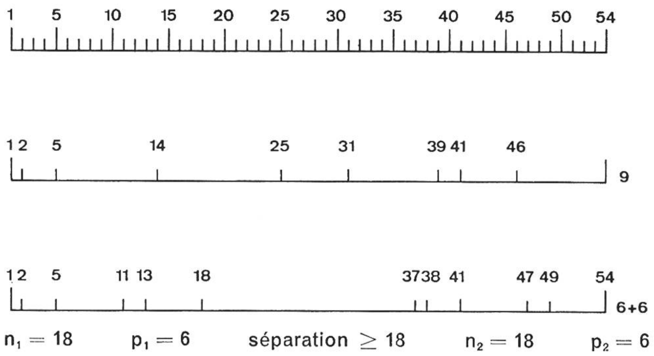

Fig. 9
Distribution of frequencies without intermodulation

The fact that the adjacent channels of different users are not free from intermodulation *(fig. 10.)* is less inconvenient in view of the distance between the various radio centres. (Examples: Railway radio centres at stations, radio centres of public services, etc. on other detached sites in the service area concerned.)

The groups of frequencies thus obtained can be distributed in towns or areas of probable use. This distribution may take into account the population density and the local topography, thus allowing for distribution distances which are variable but offer optimum spectrum economy.

For example, Swiss planning of the 460 MHz band is essentially based on this procedure. Since this is the band for

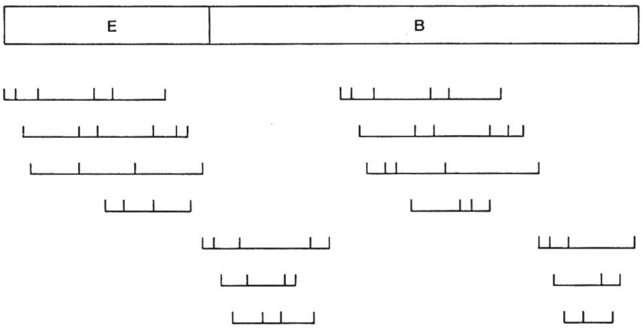

Fig. 10
Distribution of frequency groups in the sub-bands

short distance links, the plan must first take into account precalculated groups of frequencies and the repetition distances which can be obtained; it is only then that the distribution among users is fixed.

To conclude this chapter on constraints on the planner in choosing frequencies for radio centres, it is hoped that one day it will no longer be necessary to take intermodulation into account in this sphere. By making the primary stages more linear by means of appropriate circuits, the sensitivity of equipments to intermodulation will be reduced to negligible values. Tests conducted by Swiss PTT have led to satisfactory results.

4. Technical and administrative principles in dealing with applications for licences

On the basis of all the explanations already given, we shall try to deal with specific cases.

4.1 Technical principles

Before going into the subject, the first question that arises is the following:

Does the applicant need the radio or does he not, that is to say, *is his application justified?* This is a delicate question to solve, but frequency management administrations are obliged to deal with it. Only too often the radio is wanted because it is the cheapest or the most modern medium. As far as the mobile services are concerned, however, it must be borne in mind that radio is the only means of communication. Therefore, the available frequencies should be used to meet justified needs only, other applications being either turned down or satisfied by alternatives such as cable and inductive, optical or acoustic systems.

4.1.1 Choice of the appropriate frequency band

So far as circumstances permit, the frequency band that should be chosen is the highest that can be used for a given service area.

Examples:

460 MHz	All public or private *local* services, such as the police, taxis and railway stations.
160 MHz	District services with a range between about 15 and 100 km, such as public radiotelephones, the district police, etc.
70 MHz	Regional services, such as road transport networks, car radiophones, etc.

4.1.2 Choice of operating system

To the extent to which this is compatible with the needs, the number of channels per network should be reduced to a bare minimum and, if possible, to one-frequency simplex working. From the point of view of spectrum economy, these conditions are essential in most cases, but the overall economy obtainable must be borne in mind: for instance, a station of the public radiotelephone service might have 12 channels, but it might be possible to accommodate several thousand subscribers on these channels.

4.1.3 Occupation of a given frequency

Before assigning additional frequencies, it is desirable to occupy each assigned frequency by the maximum number of stations compatible with an acceptable service, in spite of frequent requests of users wishing to minimize traffic restrictions and mitigate the effects of competition.

These considerations have led to the following administrative provisions for frequency assignment.

4.2 Administrative principles

The following three classes of frequencies apply to the mobile services:

1. *Exclusive frequencies,* allocated to no other licensee in the authorized service area.

   Examples:
- Special security services
- Railways: marshalling
- Public radiotelephone services.

2. *Common frequencies,* allocated in the authorized service area to several licensees operating similar enterprises. The occupation density is limited and controlled.

   Examples:
- Ordinary security services
- Railways: checking and control services, etc.
- Most public or private operational services where there is no need to enter the network at a specific time, e.g., transport networks, etc.

3. *Collective frequencies,* allocated throughout the country, irrespective of occupation density or possible mutual interference.

Examples:

- Portable sets operating in the 27 MHz band
- Various remote control systems.

The choice between classes 2 and 3 may be left to the applicant, but the frequency management administration must consider exclusive assignments very carefully.

The convenience and facilities obtained according to frequency classes may be reflected in the licensing fees. A further distinction may be made by dividing users into such categories as:

Category I Authorities, administrative services, public corporations or institutions.

Category II Individuals carrying out public duties; Individuals operating their radio installations under the instructions of authorities; Individuals placing their installations at the service of the community without seeking large commercial gains.

Category III Other individuals.

With this classification, a simple table of charges can be used to take into account the importance of the assignment as well as the facilities (valuable frequencies, the often difficult coordination, etc.) made available by the licensing authority.

Table II

Classes	Categories		
	I	II	III
1	10	30	100
2	2	6	20
3	1	3	10

The figures represent the number of charging units levied per transmitter/receiver according to the user concerned. (At present, 1 charging unit in Switzerland is 6 francs.)

The figures are increased by 50% for duplex equipment.

Registration fees are also charged, e.g., 50.— francs for classes 2 and 3, and 500.— francs for class 1.

5. Coordination of assignments

Coordination is essential in frontier areas and for networks crossing frontiers.

The coordination distances to be observe depend on several factors, such as:

- the frequency band
- the required protection ratio
- the equivalent height of antennas
- the radiated power

The following characteristics must also be taken into account:

- the working frequency or frequencies
- coordinates and service areas
- the occupied bandwidth
- the radiation diagrams
- service hours
- probable occupation density.

Coordination is preferably effected by means of bilateral or multilateral agreements, which establish the procedure with the necessary precision.

But even the most effective coordination instrument cannot in itself guarantee optimum frequency utilization in frontier areas.

This is in particular facilitated by the following measures:

- Use of the same frequency bands for the same services.
- Standardization of separation for duplex traffic.
- Use of identical lower and upper bands.
- Standardization of spacing between adjacent channels.
- Setting aside a certain number of frequencies for new needs, for instance at the international level, which entails maximum occupany per assigned frequency.
- *Partial* standardization of sub-bands for various users, so that the same technical and operational criteria can be applied in frontier areas, without neglecting the different needs of each country and its user categories.

Examples:

  - Railways
  - Power stations
  - Emergency services
  - Public radiotelephone services

- In specific cases, avoiding sites which are too high in relation to the authorized range of communication.
- Exchange of service plans, frequency lists and any other documents which can facilitate an appropriate choice of frequencies.

Unfortunately, these advantages cannot always be obtained in practice, since many shortcomings have to be remedied. From the point of view of frequency planning, this is often difficult for small countries surrounded by many neighbours.

6. Conclusions

In frequency planning and management for land mobile services, it is important to

- check the justification of requested assignments (network planning);
- choose the appropriate frequency bands;

- coordinate the organization of frequency sub-bands from the technical and operational points of view;
- use each channel to maximum capacity,
- prepare precalculated channel arrangements and distribute them according to the terrain and the probable requirements;
- ensure careful and regular coordination between frequency management and coordinating bodies.

If we succeed in overcoming all these difficulties, we shall be contributing to the general welfare of the community, which often does not realize the inestimable value of the unique resources of the radio frequency spectrum.

Summaries and Notices

Summaries

p. 444...459

PCM Trunk Network for Telephony, Data Transmission and Telex

J.F. Bütikofer, Berne

The demand for data communications between large Swiss towns is analyzed and calculated for the year 1980. The author shows that this demand cannot be satisfied by using the 12-MHz FDM technique. PCM systems, on the other hand, both enable the information to be economically transmitted in digital form and telephone channels to be derived at the same time. A PCM network to link the major Swiss towns is discussed. The PCM signals will be transmitted over multiple twin cable or primary multiplex systems for HDB-3 coding.

p. 460...463

Reorganization of the Swiss DM cable networks

H. Burger, Berne

The reorganization of the DM cable network mainly consists in adapting the bandwidth of the telephone channel on NF cables to the existing standard; at the same time the wishes of the users of data transmission with regard to the bandwidth available can be met and a PCM data network on the major axes will be established.

p. 464...478

Overflow traffic

Laurent Praz, Berne

First, several traffic streams, each flowing in a primary circuit group and spilling over to a common overflow group – a condition which mainly occurs in large trunk networks – are described. Then, the dimensioning of the overflow circuit groups of perfect and imperfect accessibility is studied, when the different overflow traffic streams are assumed to be practically independent from one another. Further, the dimensioning of a multi-stage coupling network is discussed, in which the traffic offered is an overflow traffic. In conclusion, the optimum dimensioning of the primary and of the overflow circuit groups is considered.

News Items

Posts

Up to the end of July, **2130 bookings** were registered for the **Swiss Alpine Tours by Europabus.**

Advertised by the Swiss National Tourist Office, the **Jura Hiking Pass,** which enables its owner to explore the Jura range by alternative walks and postal-coach rides, has met with wide interest both in Europe and overseas.

Tentatively introduced a year ago, the **Swiss Holiday Pass,** a document enabling tourists to travel the country by rail and postal coach at substantially reduced fares, has proved a success. Of the 20,000 copies issued so far, 40% have been sold overseas.

Telephone

Swiss PTT are testing a **new light-alloy telephone booth.** It is to replace the 1948 steel-and-glass model, which corrodes easily and requires frequent maintenance.

The charge for a 3-minute call to **Botswana, Lesotho, Rhodesia, South-West Africa, Swaziland and the Republic of South Africa** has been **reduced by 10%** to 36 francs. The charge for a 3-minute call to **Bulgaria** has been **increased** to 12 francs.

A **third satellite circuit** has come into operation between **Switzerland and Australia.**

Operating hours on the **Berne–Jedda (Saudi Arabia) radiotelephone link** have been increased by 3 to 8 hours on weekdays because of heavily increasing traffic.

At the **Swiss satellite earth station,** which is being erected near **Leuk** (Valais), the mechanical structure of the antenna has been completed and most of the communication equipment installed.

Radio, Television

During a series of **2,600 inspections** in the Zurich region, it was found that **672 radios and 208 television sets** were being used **without a licence.**

In August the new **great Zurich TV production studio** came into operation. Equipped with 5 colour cameras, 2 video tape recorders and a colour slide scanner, it will be used above all for major drama productions. At the same time, the **Geneva TV facilities** were extended by a **news studio** and a **production control room.**

The **14th simplex relay for Switzerland's mobile radiophone service** has been put into operation in the Zurich region.

Miscellaneous

The **Swiss Customs at Iselle** (Italy) have been **connected to Switzerland's telephone system** by a direct link to the Brig (Valais) exchange.

At the **Geneva** International Conference Centre, machinery and a mechanical exchange have been installed for **automatic control of the City's pneumatic tube system.**