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AIDE MEMOIRE

SPECTRUM POLICY ISSUES RELATED TO USAGE DEMANDS IN THE 20.05 to 200 KHz BAND

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Spectrum & Radio Systems Policy
Department of Communications
January, 1978

By Parke Davis and
Fred Cunningham

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AIDE MEMOIRE

SPECTRUM POLICY ISSUES RELATED TO USAGE DEMANDS IN THE 20.05 TO 200 KHz BAND

I INTRODUCTION

The purpose of this Aide Memoire is to provide an assessment of the issues which must be considered in determining the allocations in Canada for the frequencies from 20.05 KHz to 200 KHz in the LF band.

This document provides an analysis of the various alternatives which might be considered to meet domestic needs and form a basis for a Canadian position for the upcoming 1979 World Administrative Radio Conference (WARC).

II BACKBROUND

1. The 20.5 to 200 KHz portion of the LF band contains allocations to the fixed, maritime mobile, maritime radionavigation, radiolocation and radionavigation services (see Table 1). In addition, Footnote C2 to the Canadian Table of Frequency Allocations states that "carrier current[1] systems operate in this band. Convenient limits exist at either end of this range of spectrum within which to consider several pressing demands by users of these services. The lower limit is set by the exclusive world wide allocation to the standard frequency service from 19.95 to 20.05 KHz. The upper limit is set by a primary allocation to the aeronautical radionavigation service commencing at 200 KHz and going to 285 KHz and, thus, is difficult to alter due to agreements affecting civil aviation. In addition, this range of spectrum is somewhat defined by technical considerations related to the propagation characteristics of power line carrier. Although frequencies lower than 50 KHz can be used by PLC systems, it becomes increasingly difficult to efficiently couple them to electrical power lines by use of coupling capacitors at lower frequencies. The use of higher frequencies (for example 415 to 490 KHz) is restricted to relatively short power lines due to progressively higher attenuations at the higher frequencies.

2. As may be seen from a review of Table 2: Canadian Band Usage, the band is relatively heavily utilized and most assignments shown are to power line carrier systems. (It should be noted, however, that ships and aircraft operating in this band are not reflected in the table as they

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[1] The use of three-phase high voltage transmission lines as the medium over which low frequency radio currents are propagated is known as power line carrier.

#3

may operate in various bands). In addition to the PLC systems, the most significant uses are by a number of high power Loran C (1/Megawatt peak pulse power) installations operated by Dept. of Transport (and the US Coast Guard) and a great number of fixed point-to-point links and maritime mobile operations carried out by the Department of National Defence.

3. Power line carrier systems are used to connect major generating and transformer stations which , in many areas of Canada, form the bulk 230 kv, 500 kv and 750 kv power grids. The prime function of the PLC network is for the protection of transformers, remote control and automatic generation control of power generating machinery, acquisition of data for load control and the provision of essential operating voice circuits.

There are about 40,000 PLC terminals in use throughout the world. North American use is extensive with 2100 R.F. terminals controlling over 115,000 route miles in use in Canada. 12?

In Canada the majority of assignments are in the 50 KHz to 200 KHz band. A few Canadian assignments over 400 KHz have been made in locations where operation at these frequencies will not interfere with the primary maritime mobile allocation.

The electric utilities in Canada rely solely or in part on power line carrier to protect large blocks of electric power, mainly since PLC can most economically meet the low capacity needs of the utilities over long as well as short distances and to many scattered locations. In addition, PLC is not as susceptible to natural hazards as is wireline, cable, or microwave, (it is an integral part of the system it is protecting) and it is rugged.

PLC is, however, susceptible to power line noise, as well as interference from other users of the same frequency band, is capable of causing interference, and operates within a limited frequency spectrum.

In the presence of interference, correct operations of the PLC could be inhibited with possible adverse effects to the delivery of power.

4. The Department of National Defence (DND) has made and is continuing to make some use of the 30-200 KHz band for high power long range point-to point communications. DND provides maritime mobile communications in the same band. DND will continue to operate and expand in this band. In particular, some expanded use of the band will take place if a decision is made for DND to undertake a more active role in the north. In the future, therefore, more use will be made of the band by DND.

5. Use by the Department of Transport (DOT) of this band is mostly restricted to the area 90-110 KHz allocated on a primary basis to Radionavigation. The future additional installations of high power Loran C stations throughout North America will undoubtedly cause some interference to power line carrier systems operating in band (from 90-110 KHz).

// How many.

In addition, DOT-Canadian Coastguard operates a number of DECCA chains on the Atlantic coast using frequencies from 70-138 KHz; however, their continued existence beyond 1985 is uncertain.

6. In Europe (Region 1) there are also AM aural broadcasting operations in bands from 150 KHz to 285 KHz and these high-power signals, occasionally, cause interference to Canadian operations. More significantly, the use of these bands by broadcasters has raised the question of possible use of this band by North American AM broadcasters. These broadcasters find themselves

frustrated due to the present saturation of the AM band here. (It is noted that the Canadian Second Draft Proposals will expand the AM broadcast band from 1605 to 1705 KHz).

Broadcast use of a portion of this band from 20.05 to 200 KHz would require Region 2 approval at the 1979 WARC and some initiatives to this end are underway in the U.S.A.

III. THE PROBLEM.

From a review of the issues outlined in the Background, the following aspects of the problem appear clearly. Among the services allocated or proposed, to use the band, the fixed, aeronautical and maritime radionavigation services are experiencing heavy growth. Power line carrier systems which have traditionally provided control functions for electrical utility power lines throughout Canada are being faced with rising incidents of interference as growth in assignments to these primary services continue. The technical characteristics of PLC propagation bound the useful range of operations between approximately 50 KHz and 200 KHz (although some PLC systems operate in the 415-490 KHz range controlling power lines over short distances) precluding the shift of PLC systems to other less used bands. All substitute systems for providing control and protection of power grids are significantly more expensive, and their adoption as an alternative could result in premature obsolescence of sizeable investment in PLC systems. This would result in higher end-user electrical costs throughout Canada in the longer term.

what is this

In the short term, in preparation for the 1979 World Administrative Radio Conference (WARC) where frequency allocations to the various radio services will be revised internationally to cover the next 15 to 20 year period, two US initiatives have been proposed which have direct impact on present and future band usage.

The first, presented in the American WARC Fifth Notice of Inquiry suggests allocation in Region 2 of the aeronautical radionavigation service to include the band from 190-200 KHz (1). This would restrict the assignment of PLC systems in Canada in this band because of possible interference to the aeronautical navigation service due to radiation from power line carriers. There are presently 84 PLC systems licensed in Canada in the 190-200 KHz band.

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(1) A similar proposal has been made for the band 405-435 KHz.

The second proposal is for a new broadcast service allocation between 115 and 190 KHz to provide for an extension to commercial AM aural radio broadcasting in the US. Should this proposal be approved in the WARC 79 forum, the probable interference to power line carrier systems from broadcast transmitters operating in this band could seriously impair the control and protection of power grids. In addition, the forecast growth of fixed and maritime radionavigation services would be hampered and perhaps frustrated.

These two proposals are forcing an assessment of band use and priorities for use among services in Canada earlier than would otherwise be necessary.

IV. CURRENT STATUS

Some consideration has already been given to a Canadian domestic position for the 20.05-200 KHz band as part of the preparatory work leading to the 1979 WARC.

1. The Canadian Second Draft Proposals for WARC'79 deal with the band 190-200 KHz, which is covered by the frequency range of existing airborne receivers and is immediately adjacent to the current allocation to the aeronautical radionavigation service at 200-285 KHz. It is proposed that the band 190-200 KHz be allocated to aeronautical radionavigation, primarily to be used for aeronautical radiobeacons on oil exploration platforms operating in the coastal and remote areas of Canada.

2. There was only limited support from the broadcasting community for an allocation for a new broadcasting band from 115-190 KHz. Recognizing the pressing needs of the fixed and radionavigation services in this part of the radio spectrum, there are no changes proposed to the Canadian allocations in this range of spectrum.

3. Earlier in the Canadian First Draft, a proposal was made for an exclusive radionavigation allocation from 90-110 KHz and this has been retained. However, due to frequency coordination problems, it has been found necessary to propose a footnote, 166A, to give additional protection to Loran-C radionavigation systems.

This proposed footnote restricts use of the band by new assignments from 80-90 KHz and from 110-120 KHz by the fixed and maritime mobile services in order to provide additional protection to radionavigation. By implication, this footnote would also tend to restrict the use of powerline carrier frequencies and powers in areas where they might cause adjacent channel inter-interference to radionavigation.

V. FACTORS.

As outlined above, the pressures to resolve these problems in the 20-.05-200 KHz band, although not severe, can be expected to increase over the coming months as various administrations prepare for the 1979 WARC and begin to seek support internationally for their positions. In this context, it is essential that Canada promote its present position in support of Canadian needs and requirements. The following factors must be considered:

A. Usage by the Department of National Defence (DND)

1. DND presently makes use of the 30-200 KHz band for high power long range point-to-point communications. The largest proportion of the 43 fixed assignments in this band (see Table 1) are operated by DND.

DND also carries on maritime mobile communications in portions of this band in certain areas of Canada.

DND indicates that they will continue to operate and may expand in this band. In particular, some expansion of use of the band will take place when a decision is made for DND to undertake a more active role in the North. While the use of other higher frequency bands (i.e., HF) might be possible as an alternative, and actually give a better grade of service during certain periods, the long distance, high reliability nature of circuits in the 30 to 200 KHz band make them particularly attractive for DND use and invaluable in case of hostilities. In future, even the use of satellite techniques may not replace communication in this band due to their relative vulnerability. Therefore, usage of this band by DND is expected to increase particularly in the more remote areas of the Canadian North.

2. Although the level of usage is forecast to increase, at least two aspects of this use by DND will reduce the impact on other services sharing in this band (primarily PLC systems). The first aspect is that

growth in DND assignment usage is forecast for the remote areas of Canada while PLC systems are concentrated in more populous areas. The distance separation between the zones of operation of each type of system should mitigate the likelihood of interference.

The second aspect to be considered is that many of the DND facilities in the band concerned are very narrow bandwidth (teletype) and in some instances, interference to other users, notably PLC, can be filtered out without affecting the operation of the power line carrier. The present departmental procedure of licensing PLC's provides the Department with the means to assess the effects that any new DND installation will have on the power utility systems and to co-ordinate any tests or changes in order that the power delivery system will not be upset when a new installation is put into operation.

B. Usage by the Department of Transport (DOT)

1. The federal Department of Transport operates assignments in the fixed, and radionavigation services in the band from 20.05 to 200 KHz and has proposed an extension of the aeronautical radionavigation band downward to 190 KHz which, if accepted, would add operations in that service to this band.

Of the 43 fixed assignments registered in the 20.05 to 200 KHz band only 11 are operated by the DOT. According to the assignment record, these are limited to radiotelegraphy operations by frequency shift keying without the use of a modulating audio frequency (one of two frequencies being emitted at any time). The circuits operated in this band provide service primarily to remote areas of Canada (e.g., Eureka, Isachsen, Mould Bay, Cartwright, Goose Bay, Resolute, Inuvik, Alert, Sachs Harbour and Schefferville). The traffic is generally administrative. Similar to the case with DND, fixed point-to-point circuits at this frequency range provide highly reliable back-up communications to DOT when radio conditions are not favourable in other bands. There are no plans to expand operations in this band in the future beyond the limited number of circuits presently operated.

There would appear to be little reason why frequency sharing of these point-to-point services could not continue indefinitely. Similar to the situation described earlier, the DOT areas of operation for these circuits are in remote Canada while PLC systems operate in more populous regions. In addition, DOT circuits, like those of DND, utilize narrow bandwidth radiotelegraphy which can be eliminated from PLC systems by filtering in most cases. Therefore, with care in the assignment of frequencies and knowledge of the radio frequency environment, the Department should be capable of avoiding or supressing interference between these two services.

2. As outlined earlier in this report, the U.S. WARC Fifth Notice of Inquiry has proposed the allocation of 190-200 KHz to aeronautical radionavigation. Adoption of this allocation in Canada might restrict the assignment of PLC systems in this band because of possible interference to the aeronautical navigation service due to radiation from power line carriers. The Canadian WARC Second Draft Proposals also supported the above allocation of the 190-200 KHz band to aeronautical radionavigation due to the forecast growth. The band 190-200 KHz was chosen as an extension of the 200-285 KHz aeronautical radionavigation band because the existing equipment operating in that band can tune down to 190 KHz. In addition, a recent DOC regional survey for assignment requirements over the next 10 year period indicated the need for 370 new aeronautical radionavigation service assignments, which appears to exceed the capacity of even the expanded allocation proposed. In this connection it is noted that the Second Draft Proposals provide for radionavigation (radio beacons) in the band 405-435 KHz. However, the proposed expansion capacity, albeit limited, is likely sufficient since the majority of aeronautical beacon requirements are in support of large capital projects of finite duration in remote areas of Canada, such as oil pipeline construction, and the Baie James hydroelectric project, etc. While it is not certain that the survey included all municipal, federal and private demands for aeronautical radionavigation, it is not unreasonable to forecast an average growth of 18 new assignments per annum over the next ten year period. (See Appendix I).

As well, installations of Omega, Loran C, etc., will also serve to diminish the need for aeronautical radionavigation beacons in populous areas.

As can be seen, the aeronautical radionavigation service will experience growth in remote areas over the foreseeable future and the existing and proposed extended allocation for this service will be fully utilized by ANDB (aeronautical non-directional beacons). While the establishment and extension of other radionavigation systems (e.g., Omega, Loran "C", etc.). may temper the requirement for ANDB's, they are complementary, not substitute systems, and the need for ANDB's in this band will likely continue indefinitely in remote areas.

The ANDB's emit a continuous modulated carrier signal (as do most PLC systems), however, with periodic keyed identification being given. As the ANDB "ident" may be missed or ignored, a PLC signal may be mistaken for it. In addition, a mixed PLC and ANDB signal received by an aircraft will give an incorrect heading to the ANDB location. Therefore, the potential for interference from a PLC system to an aircraft is present, and, in fact, there have been at least three unexplained aircrashes in Europe within the last few years in which there is evidence to suggest that the aircraft involved were subject to interference from PLC systems. On a national basis, frequencies for airfield marker beacons should, it appears, be kept separate from those used for PLC systems in the same vicinity. Further work is required to determine safe separation distances between ANDB's and PLC systems.

There are, at present, 84 PLC assignments operating in the 190-200 KHz band across Canada, including a few in the Northwest Territories. As ANDB's are established in this band, steps will have to be taken on a case by case basis to reassign PLC systems in the proximity to frequencies outside this band or to change their type of emission to be distinctly different from ANDB's to ensure the possibility of confusion between the two does not exist.

While there are fixed links in this band, 190-200 KHz, operated by DOT and DND, their radiotelegraphy emissions would be sufficiently distinct from CW-ANDB's to ensure that interference from the fixed service links would not be a problem.

3. The DOT also has extensive radionavigation maritime mobile operations

in the band from 20.05–200 KHz which may be extended to all maritime areas of Canada, depending on the outcome of a radionavigation aids policy presently under development in DOT. The DECCA system operating from 90–110 KHz which are fully described in Appendix 2 and 3 respectively, form the basis for DOT radionavigation operations in this band. [1] OMEGA ia a system designed for long range navigation. As would be expected, Loran C may give much more precise radio positioning than OMEGA.

The Loran C system which is ~~must~~ being established in Canada will likely be the prime domestic radio aid for maritime purposes. It provides radionavigation service in the coastal confluence areas, i.e., continental shelf and Great Lakes Basin. While subject to unforeseen technological developments, Loran C is expected to have an operational lifespan of at least 15 years. It should also be noted that, in addition to its use for radionavigation, Loran C can provide signals for setting and synchronizing clocks within an accuracy of 1 microsecond in all areas of groundwave coverage. While a secondary use at present, there are a great number of existing and potential applications for this type of service. The cost of a Loran C receiver ($2,000) is low compared to other alternatives for synchronization.

As well as the substantial growth foreseen in Canada for Loran "C", there will be extensive growth in the U.S.; however, there, it will cover all US territory, not just maritime areas to provide for accurate land as well as maritime radio positioning. Recently, the US has has abandoned its Loran "A" installations and is concentrating on Loran "C" and mini-Loran"C" (i.e., low power Loran "C" stations) to fulfill its radio positioning needs over the next 15 year time span. From the plans in both Canada and the U.S., Loran "C" installations will largely fill the radionavigation band from 90 to 110 KHz and will continue operations in that band over the next 15 years. To ensure that the proposed expansion of Loran "C" can take place, the Canadian Second Draft Proposals have strengthened the radionavigation service allocation in the band from 90 to 110 KHz and have added footnote 166A to give additional

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[1] The OMEGA system operates from 10–14 KHz which is below the range of the present study.

protection to Loran "C" receivers from operations in the adjacent bands 80-90 KHz and 110-120 KHz.

With the expansion of Loran "C" foreseen, it is unlikely that other services will be able to continue to operate in the band. Fixed and maritime mobile services presently operate in the 90-110 band now as secondary services; however, as they must accept any interference and would not be protected from new Loran "C" operations, their reassignment to new bands is anticipated. From reference to Table 1, there are no licensed Canadian fixed or maritime mobile links in this band. There are, however, 236 PLC systems in operation. Due to the very high power Loran "C" operations (1 Megawatt), it is unlikely that PLC systems operating at 20-30 watts would interfere with ship or airborne Loran "C" receivers; however, it is anticipated that the 236 PLC systems operating between 90-110 KHz will experience significant interference, particularly, those in the Great Lakes Basin, and may have to vacate the band. It is possible that users of Loran "C" for time and synchronization purposes might be interfered with by PLC systems in locations of low Loran "C" field strength and in very close proximity to PLC systems. While such cases of interference might occur, their resolution and suppression would have to be dealt with on a case by case basis as the need arises.

In this band 90-110 KHz B

It is anticipated that PLC systems operating adjacent to the radionavigation band (i.e., 80-90 KHz and 110-120 KHz) will not interfere with or be interfered with by Loran C operations.

The DOT Canadian Coast Guard operates a series of DECCA chains on the Atlantic coast using a number of discrete assignments which range between 70 and 138 KHz. The continued existence of this radio navigational aid beyond 1985 is presently under review and its future is uncertain. No expansion of DECCA facilities is contemplated—only its continued operation or abandonment as a radio aid.

C. Usage by the Electrical Utilities.

As discussed earlier in this paper, the electrical utilities are the major users of the band from 20.05 to 200 KHz and their powerline carrier operations account for 92% of all licensed assignments. Table 3: Power Line Carrier Operations gives the number of assignments regionally and by frequency across Canada. As may be seen with reference to Table 3, there are approximately 1800 PLC assignments presently licensed by the Department in operation in all areas of Canada.

Frequencies in the range of 30 to 200 KHz and 415 to 490 KHz are used for power line carrier systems. The lower band is high enough that the 60 Hz power frequency, can be ignored, and the power line noise is greatly reduced. At the same time, the carrier frequency line attenuation is still fairly low, so reasonable signal-to-noise figures can be obtained. Frequencies lower than 50 KHz can be used but it is difficult to efficiently couple them to the line by using coupling capacitors.

Power line carrier is used to connect major generating and transformer stations which in many areas of Canada, form the bulk 230 kV, 500 kV and 750 kV power grids. The prime function of the PLC network is for protection of transformers, remote control and automatic generation control (AGC) of power generating machinery, and acquisition of data for load control. PLC is also used to provide essential operating voice circuits.

Power line carrier is especially attractive for a number of reasons. First, it is most economical for providing a relatively small number of communication channels over long as well as short distances. Second, it is attractive in that the cost per station is relatively independent of the distance over which it must operate. However, the frequency and the length of the transmission line combined, dictate the transmitter power. Some other advantages of PLC are its capability to transmit economically to many scattered locations; it is not as susceptible to natural hazards as wire line or cable, and it is inherently rugged. Nor does PLC require repeaters for long distances as does microwave. PLC, however, is susceptible to power line noise and must operate within a limited frequency spectrum.

In the future, PLC systems are not expected to grow significantly in number as they already are used along the bulk of the 230 kV, 500 kV and 750 kV power #17 grids. New growth in assignments would occur only as these power grids are extended. In addition, in areas where interference from other radio sources to PLC operations is evident, these PLC systems are being replaced by other facilities (microwave, leased lines, etc) although much more expensive.

There are a number of substitute systems for replacing PLC which can, if necessary, be used by electrical utilities; however, as outlined in a brief by the Canadian Electrical Association (CEA) to the Department in September, 1977, all are significatnly more expensive and some cannot offer the same grade of service in control,protection and location of faults as PLC systems. For example, the material costs of a 200 mile PLC system are estimated at $100,000. By comparison, those for the equivalent link by microwave employing 8 hops would be $1.5 to $2.7 million, excluding land purchase, access roads and A.C.power. In addition to these money costs, the Department would be concerned in certain areas with the spectrum costs (i.e., the replacement of a non-radio means of communication, PLC, by a microwave radio link). Most alternative systems for provision of communication for electrical power grid protection suffer from the twin drawbacks of being more costly in money and spectrum terms than PLC.

While Canadian Footnote C2 notes the use of PLC systems in the band from 20.05 to 200 KHz, as outlined earlier, the actual band available for PLC operations is shrinking due to the increasing use of the band by the primary services. It appears that the band from 90-110 KHz will become unusable for PLC systems due to the expansion of the Loran "C" installations in the near future.

There appears to be little alternative for the electrical utilities seeking additional communications links in future but to use a different technology (not PLC) in areas where the ~~band from~~ 20.05-200 KHz can not accommodate additional assignments. While there have been some PLC assignments in the 415-490 KHz range due to higher line attenuation at these freuqnecies, the use of PLC systems in this band must be limited to the shorter distance. In summary, there appears to be little alternative spectrum for PLC systems.

D. Other Users of the Band (Existing or Proposed)

All the major users of the band have already been dealt with in this report. Although some small private users may still be operating (remote control, etc.,) their use or discontinuance of use will not have any material affect on total band usage and, therefore, will not be dealt with in this report.

As was outlined earlier, in the Background, the US Fifth Notice of Inquiry has proposed that the band 115-190 KHz be allocated to broadcasting internationally. The Department is also considering various options for the extension of the sound broadcast (AM) band.

At the present time, the AM broadcast band (535-1605 KHz) is very congested in Region 2, and it is becoming increasingly difficult and expensive to engineer new assignments in most areas of Canada.

In view of the fact that almost all homes in the country are equipped with AM receivers, aural broadcasters have traditionally preferred this band, even though very heavy costs are incurred in establishing new stations as multi-tower arrays are almost always required and nighttime service is often extremely poor as a result of skywave interference.

A review was carried out by the CRTC (see Appendix 4)) to investigate the extent to which Canada's need for additional aural broadcasting channels could be met by extending the existing AM band to the same extent as that proposed by the U.S. in its Fifth Notice of Inquiry.

This review stated that the first choice for extension of AM aural broadcasting would be from 1605 to 1800 KHz. Based on this and the lack of interest and enthusiasm on the part of Canadian broadcasters for the 115-190 KHz band, Canada's Second Draft WARC proposals support the status quo in the 115-190 KHz ban

The consequences of acceptance of a broadcast allocation from 115-190 KHz would have been severe on the existing band users and most particularly, PLC systems. In a proposal to the Department, the Canadian Electrical Association (CEA) underlined the importance of powerline carrier systems for the control and protection of power grids and anticipated major disruption and interference from broadcast operations in this band.

One other existing but unlicensed user of this band are the telephone carriers. In certain areas, rural telephone service is provided to subscribers on open wire on a multiplexed system using frequencies which include the band under study. Similar to PLC systems, these open wire systems are unprotected and are susceptible to interference from other co-channel radio signals. The Loran C operations pose a serious interference threat to this usage; however, open wire facilities are not extensive. The Department has had discussions with Bell Canada concerning the plans for expansion of Loran C facilities and there would appear to be little problem, given sufficient warning, of obviating interference problems. In future, as open wire facilities are obsoleted and replaced, the interference potential, already minimal, will be eliminated entirely.

ALTERNATIVES

Having reviewed the various factors affecting the use of this band, it is clear that the existing primary service users will increase , or at least, maintain their present level of usage in the future. The Canadian position, as outlined in the Second Draft Proposals will support and strengthen the allocation to the radionavigation service from 90-110 KHz and promote the expansion of Loran C facilities throughout this band. In addition, the downward extension of the aeronautical radionavigation service to include 190-200 KHz will allow and promote growth in that band in more remote areas of Canada by aeronautical non-directional beacons (ANDB). Until 1985, usage of the DECCA system by DOT will be maintained on the Atlantic coast. Well prior to that date, a radio aids policy now under review by DOT will be issued which may initiate or accelerate the development of new or existing radio aids in this band with a consequent growth in assignment. Due to the high reliability of both DND and DOT fixed point-to-point links operating to remote areas of Canada, these will be maintained at their present level. Should a decision be made for DND to play a more active rôle in support of Canadian sovereignty in the North, a significant expansion of DND fixed assignments would be required in this band for logistics support. It would, therefore, appear,that prospects for growth or even continued extensive use of this band by non-primary service users (i.e., PLC systems) are not bright.

In addition to the forecast growth by the primary service users, technical factors of their use to not favour sharing with PLC systems. The high power widespread Loran C installations will cause significant interference to PLC systems operating in the band from 90-110 KHz. The possibility of interference from PLC systems to airborne receivers in the band from 190-200 KHz exists. These forecast problems can only be remedied by PLC systems abandoning the bands from 190-200 KHz (in proximity to ANDB's) and 90-110 KHz.

As the usage of the 20.05-200 KHz band by PLC systems is quite extensive and difficulty does exist in certain areas in finding additional PLC assignments, the future loss of many or all assignment from 90-110 KHz and 190-200 KHz will cause significant problems. Some alternatives for meeting the communications needs of electrical utilities using PLC systems are discussed below.

In some areas of Canada, it may be possible to relocate some of the shorter PLC systems above 190 KHz. Unfortunately, PLC systems with frequencies above 190 KHz exhibit increased line attenuation which restrict assignments in this range to shorter transmission line sections.

An alternative would call for co-use of the band above 190 KHz by ANDB's and PLC systems in the same geographic area; however, the PLC systems would have emissions or signal patterns distinctly different from ANDB's to prevent misinterpretation of a signal from a PLC system by an airborne navigational receiver.

An example of this is the use of power line carrier systems using pulse techniques presently operating in Europe. The use of short duration pulses to perform the protection function would make the problem of interference to the power line carrier from outside sources much less likely. In addition, a pulsed type system would be much less likely to interfere with other radio services, particularly in this case, the aeronautical radionavigation service.

In a report* by the United Kingdom on the two types of PLC system quiescent (pulsed) and continuous (most PLC systems in Canada are of this type), they state:

> "In the United Kingdom, the frequencies used are within the range 70-1,000 kHz and the carrier systems are for two types, i.e. quiescent carrier systems and continuous carrier systems. The difference between the two systems is that in respect of the quiescent carrier system the transmission of the RF signalling frequency is only of very short duration during the fault condition, whereas in the case of the continuous carrier system there is a continuous transmission of the RF signalling frequency. The need for continuous carrier systems results from the requirement, where large quantities of power are transmitted, for signalling systems capable of reacting quickly enough to power line faults to prevent instability of the power networks and at the same time not reacting to stray interference signals.
>
> It has been established that the transitory nature of the radiation from quiescent carrier systems presents virtually no risk of interference to aeronautical and other services operating in the frequency range 70-1,000 kHz (e.g. DECCA, MF Beacons). Continuous carrier systems are however a potential source of harmful interference to radio services operating in the same frequency band and the steps taken in the United Kingdom to safeguard services are described in Sections 2, 3 and 4."

It would, therefore, appear that quiescent or pulsed systems would permit the co-use of spectrum above 190 KHz by aeronautical radionavigation and other services with PLC systems and discussions on such possibilities should be undertaken with the CEA to ascertain the viability of this alternative.

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* NATO UNCLASSIFIED - ANNEX III to AC/9217574(2nd revise) CONTROL OF FREQUENCIES FOR POWER LINE CARRIER SYSTEMS - Note by the United Kingdom.

A third alternative and one which would have definite support by the CEA, at least in the short term, is continued co-existence by PLC systems in the band from 20.05 to 200 KHz with the other primary services. This alternative is attractive to all parties since, in essence, the status quo is maintained. It is possible that with proper engineering and careful selection of frequencies, the status quo would be retained in the band indefinitely.

The exception would be the areas from 90 to 110 KHz and from 190 to 200 KHz where there are 236 and 84 PLC assignments respectively. PLC assignments from 90-110 KHz will be subjected to interference in the near term as Loran C radionavigation installations are set up and go into service. PLC assignments from 190-200 KHz in the more remote areas of Canada may be required to change their type of operation into a pulsed mode or change frequency as ANDB's are established by DOT in that band.

Overall, throughout the band from 20.05 to 200 KHz, there will be increasing pressure for reassignment of PLC systems to frequencies not yet assigned to the primary services to prevent interference to and from PLC systems.

At this point in time, there are a number of other technological substitutes for PLC systems to provide protection and control for power grids. Although these may not be completely interchangeable substitutes, they do provide for at least the basic communications needs of the electrical utilities.
All are more costly alternatives in economic terms and most, employing radio communications also consume spectrum. Due to their higher spectrum and economic costs, the alternatives presented above if viable would likely be favoured.

CONCLUSIONS AND ACTION ITEMS

After a review of the current problems, background and factors affecting the usge of the 20.05-200 KHz band, the following conclusions and action items are proposed:-

1. Immediately after the WARC 1979 and, if the proposal by Canada to extend the aeronautical radionavigation band down to 190 KHz is accepted, a revised policy on the licensing of PLC systems in the band 190-200 KHz should be put into effect. This policy would have the objective of ensuring that PLC systems do not interfere with aircraft navigational systems using ANDB's. The policy might set minimum separation distances between PLC systems and ANDB's, and require PLC systems operating within the separation distances to be reassigned below 190 KHz or change their emission to be distinctly different from that used by ANDB's.

   Work should commence on determining the minimum safe separation distance and regions should be asked not to authorize additional PLC systems in the frequency range from 190-200 KHz and 405-435 KHz until the results of the WARC are known. Should frequencies in this range have to be authorized by regions for PLC systems, the licencee should be warned of the possibility of reassignment being necessary by the early 1980's.

2. Although it would appear to be unclear whether or not PLC systems can be licensed as radio systems under the Radio Act, the practice of licensing these systems should be retained by the Department. In this way, the Department can be aware of the existence and the technical parameters of all PLC systems and can take steps to mitigate interference by radio services allocated to use this band or, at the very least, coordinate the reassignment of PLC

systems to minimize any disruption of service.

3. In the long-term future, growth of assignments in the band should be monitored. Should the radio aids policy of DOT presently under review not favour further extention of the Loran "C" navigation system or abandonment of DECCA, the use of the band by PLC systems could continue indefinitely or until technological or economic factors favoured substitute systems. If growth in radionavigation assignments increases sufficiently to jeopardize the continuance of PLC systems in the band, then the Department should coordinate with the power utilities a research and planning effort to find a viable substitute for PLC systems which presently operate in this band.

4. From an analysis of the factors presented in the proposals to establish a new aural broadcast band, major dislocation of PLC operations would likely take place. Due to the high social priority which must be placed on the control and protection of power grids versus the need for an additional broadcast service, the Department does not support the proposed broadcast service from 115-190 KHz. If necessary, Canada should be prepared to take a reservation on the use of broadcasting in that band, if that proposal is accepted at the '79 WARC.

TABLE I: FREQUENCY ALLOCATIONS 20.05-200 KHz

Present Allocations		Canadian Assignment Usage (DFL)	
	20.05 KHz		
FIXED MARITIME MOBILE		Power Line Carrier * Maritime Mobile Fixed (Point-to-Point)	268 2 3
FIXED MARITIME MOBILE MARITIME RADIONAVIGATION Radiolocation	70	Power Line Carrier * Radiolocation Radionavigation	194 6 27
RADIONAVIGATION Fixed Maritime Mobile	90	Power Line Carrier * Radionavigation	236 4
FIXED MARITIME MOBILE MARITIME RADIONAVIGATION Radiolocation	110	Fixed (Point-to-Point) Power Line Carrier * Radiolocation Maritime Mobile Radionavigation	13 246 19 5 42
FIXED MARITIME MOBILE	130	Power Line Carrier * Fixed (Point-to-Point) Maritime Mobile Radionavigation	432 11 8 2
FIXED MARITIME MOBILE	150		
FIXED	160	Fixed (Point-to-Point) Power Line Carrier Radiolocation Maritime Mobile	16 409 1 4
	200		

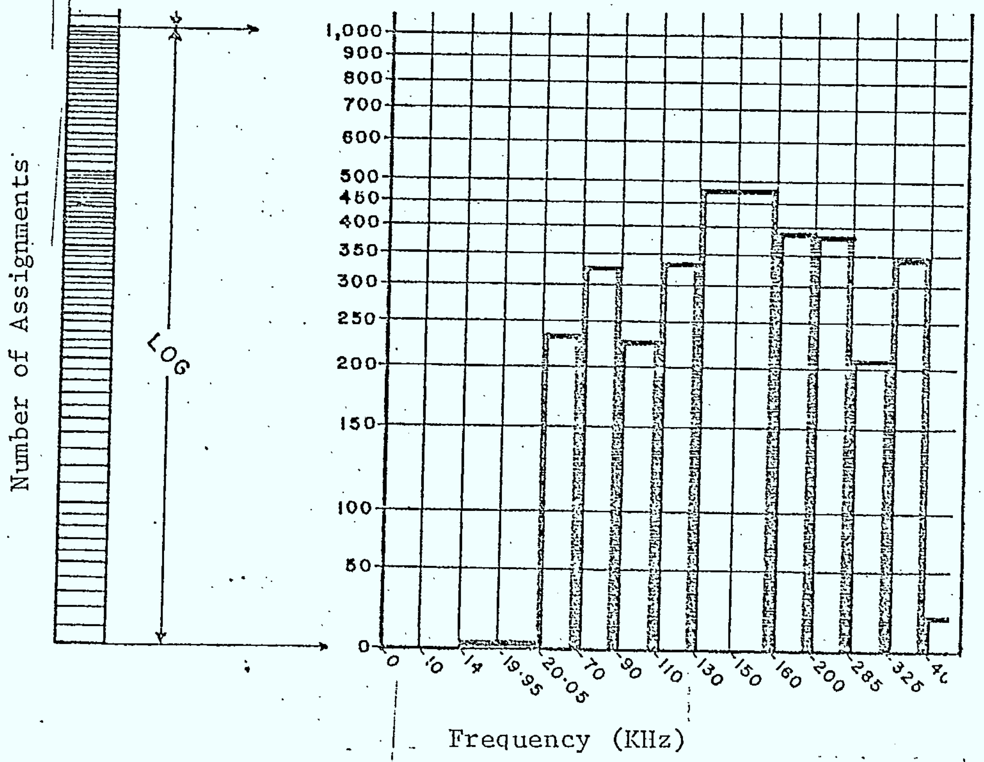
*Power line carrier systems are not defined as radio services.

Table 2: Canadian
Band Usage (March
(Assignments versus
Frequency)

BAND ASSIGNMENTS BY SERVICE

Power Line Carrier *	1785	92%
Maritime Mobile	19	1%
Fixed (Point-to-Point)	43	2%
Radiolocation	26	1%
Radionavigation	75	4%
	1948	

*Power line carrier systems are not defined as radio services



Services

PRIMARY					F,MM	F,MM,MR	R	F,MM,MR	F,MM	F,MM	F				
PERMITTED															
SECONDARY						RL	F, MM	RL							

LEGEND

F - FIXED
MM - Maritime Mobile
MR - Maritime Radio-navigation
R - Radio navigation
RL - Radiolocation

TABLE 3: POWER LINE CARRIER OPERATIONS
(NUMBER OF ASSIGNMENTS BY FREQUENCY BLOCK AND REGION)

Provinces	CANADA	B.C.	ALTA	SASK	MAN	ONT	QUE	N.B.	N.S.	P.E.I.	NFLD	NWT	YT	TOTAL	Number of Freqs. Being Used
BANDS	NUMBER OF STATIONS														
Below 10 KHZ															
10 - 14 KHZ															
14 - 19.95 KHZ															
19.95 - 20.05 KHZ															
20.05 - 70 KHZ		42	3	29	19	95	23	2			8			221	58
70 - 90 KHZ		27	11	25	16	62	20	6	1		14	3		185	38
90 - 110 KHZ		23	23	18	15	107	31	13			4	2		236	53
110 - 130 KHZ		56	4	18	6	96	31	8	11		3	3	2	238	53
130 - 150 KHZ		53	8	22	8	63	31	12	11		11	2	1	222	58
150 - 160 KHZ		21		10	2	30	20	5	4		3			95	25
160 - 200 KHZ		76	10	37	14	83	74	19	30		31	11		385	86
200 - 285 KHZ															
285 - 315 KHZ															
315 - 325 KHZ															
325 - 405 KHZ															
405 - 415 KHZ															
415 - 490 KHZ		2				6	3							11	10
490 - 510 KHZ															
515 - 525 KHZ															
525 - 535 KHZ															

August 22, 1977

APPENDIX I

AERONAUTICAL RADIONAVIGATION

190 - 535 kHz

U. S. studies show the vast majority of ADF equipment tunes the range 190 - 200 kHz. Frequency assignment problems which now exist in Canada may be alleviated by looking at this and additional bands for allocation to aeronautical purposes. The 1605 - 1800 kHz band has proven disappointing and is not expected to provide congestion relief.

DOC tabulation of frequency usage in 1974 yields the following table:

Band (kHz)	Bandwidth (kHz)	No. Assignments	Assignments/kHz
160 - 200	40	379(PLC)	9.4
200 - 285*	85	332	3.9
285 - 325	40	189	4.75
325 - 405*	80	309	3.86
405 - 415	10	20	2
415 - 490	75	47	0.62
490 - 510	20	1	0.65
510 - 535	25	1	0.04

*These bands contain the majority of ANDB's

Congestion appears to be reached in Canada when the number of ANDB assignments/kHz equals 4.

The USCG has stated that sharing between ANDB's and coast stations is not feasible because of the large separation distances involved. Assuming this is correct and assuming Power Line Carrier problems can be solved, a new "capacity" table would be as follows:

Band (kHz)	Bandwidth (kHz)	*Assignment Capacity	Existing Assignments	Available Assignments
190 - 200	10	40	0	40
200 - 285	85	340	332	8
285 - 325	40	160	189	-(29)**
325 - 405	80	320	309	11
405 - 415	10	40	20	20
415 - 490	75	300(NA)	(NA)	-
490 - 510	20	80(NA)	(NA)	-
510 - 535	25	100	1	99
			TOTAL	178

*Assuming 4 assignments per kHz
**Omitted - assume full capacity

A DOC region survey for assignment requirements over the next 10 year period indicated the need for 370 new assignments, which appears to exceed the capacity of an expanded allocation. However the proposed expansion capacity is likely suitable, as the majority of beacon requirements are for large capital projects of finite duration in remote areas of Canada. Acceptance of Omega, Loran "C",

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etc. will also serve to diminish this need. However, it is not certain that the survey included all municipal, federal and private demands. It is not unreasonable to expect an average of 18 new assignment demands per annum over the next 10 year period.

The bands 415 - 490 kHz and 490 - 510 kHz should be examined for PLC use, in areas separated from navigable waters. Should it be necessary to share between ANDB and PLC, a major safety problem arises when ANDB's used for aircraft let-down procedures are involved. On a national basis, frequencies for let-down beacons may be kept separate from PLC. Further work is required to determine separation criteria between enroute ANDB and PLC.

Proposal:

Add Aeronautical Radionavigation (Primary) to 190 - 200 and 510 - 535 kHz. Examine feasibility of suppression of Fixed and Broadcasting in respective bands.

DECCA

The Decca system employs continuous wave transmission and utilizes phase comparision of received signals to determine position fixes.

Decca chains consist of three or four transmitting stations operating in the frequency band 70-138 kc/s. Stations forming a "chain" are designated as Master and Red, Green and Purple Slaves. Usually the Slaves are deployed in star formation at distances of 70 to 100 miles from the Master but neither symmetry nor distance is critical. The transmissions from a Decca chain bear a simple harmonic frequency relationship and those from each Slave are phase locked to the Master transmission. By this means overlapping phase patterns are produced between the Master and each Slave which form an omnidirectional navigational grid in space. The grid is comprised of hyperbolae or lines of constant phase difference between transmissions from the Master and Slaves.

In Fig 1, page (v) points A and B represents two transmitting stations radiating signals of equal and constant frequency and rigidly locked in phase. CD is the right bisector of base line between A and B, therefore, it follows that at any point on CD the signals from A and B will be in phase since they have travelled equal distances at the same velocity. A phase comparision meter would read zero degrees at point O or at any point along the hyperbolae CD. If the phase meter is moved towards B the signals will be out of phase at point O'. This out of phase condition will exist everywhere along the hyperbolae EF. If the phase meter is moved still closer to B a point O" will be reached at which the phase difference between stations A and B will be 360° or one whole cycle. This condition will exist everywhere along the hyperbolae GH in passing from points O to O" the phase meter will have traversed one complete lane. On the base line AB the width of a lane or the distance between any adjacent hyperbolae of equal phase-difference value is equal to half a wavelength. In Fig 1, the distance between any adjacent pair of similar lines (solid or broken) is called a lane.

The Decca stations transmit on different frequencies; in the case of the Newfoundland Chain for example, the Master operates on 84.465 kc/s, the Red Slave on 112.62 kc/s, green on 126.697 kc/s and Purple on 70.387 kc/s. This frequency relationship is based on a fundamental frequency "f" which is 14.077 kc/s. The Master therefore transmits on 6f, Red on 8f, Green on 9f and Purple on 5f.

The received signals are subsequently multiplied in such a manner that a common phase comparision frequency is produced. The Master signal is multiplied by 4 and the Red by 3, i.e. 6f x 4 and 8f x 3 to produce a frequency of 24f.

This comparision frequency in the case of the Newfoundland Chain is approximately 339 kc/s or 884.6 metres and since the wave fronts are approaching from opposite directions synchronously, the in-phase points will correspond to half this wave length, i.e. 442.3 metres.

For convenience Decca Lanes are grouped into "Zones" and the number of lanes per Zone is related to the comparison frequency of each pair of stations, the Zone width however is constant, being related to the fundamental frequency f.

When phase comparision has been effected in the receiver, the resultant is displayed on a meter known as a decometer: three of these are provided, one for each Master/Slave combination, i.e., Red, Green and Purple. As the mobile unit passes through Decca cover these decometers will indicate accurately its position in the pattern. In practice the meters may either be set to known Decca coordinates before departure, or may be set later using Lane Identification transmissions which occur automatically each minute, on the minute as follows: 8f and 9f Signals are transmitted simultaneously from the Red Slave and 5f and 6f from the Master, 15 seconds later similar transmissions are made from the Green Slave and Master and 30 seconds later from the Purple Slave and Master.

By this means a course pattern, which corresponds in width to a Zone, is radiated and this enables the actual Decca Lane in which the mobile unit is travelling to be identified. This facility allows the accuracy of the decometer readings to be confirmed at any time during journey and provides an additional check on the functioning of the system.

TYPICAL VALUES FOR FREQUENCY AND LANE WIDTH - RADIATED FREQUENCIES

	Multiple	Frequencies (kc/s)	Wavelengths (Metres)
MASTER	6f	85.000	3,521
RED SLAVE	8f	113.333	2,640
GREEN SLAVE	9f	127.500	2,347
PURPLE SLAVE	5f	70.833	4,225

COMPARISON FREQUENCIES

RED	24f	340.000	880
GREEN	18f	255.000	1,174
PURPLE	30f	425.000	704

LANE WIDTH ON BASE LINES ASSUMING VELOCITY OF 299,250 KM/SEC.

LANE WIDTH

	Metres	Yards
RED	440.074	(481.28)
GREEN	586.765	(641.70)
PURPLE	352.059	(385.02)

The primary function of the Master station is to provide a highly stable carrier at a frequency of 6f (where f is appriximately 14 kc/s). The Master signal source comprises an oscillator using a quartz crystal of low temperature co-efficient mounted in a thermostatically-controlled oven. Automatic phase correction circuits maintain control over the phase characteristics of the transmitter and antenna system. For lane identification the Master station radiates intermittently a signal of 5f (Purple frequency) with the 6f. Since the basis of lane identification is that the 5f and 6f signals shall yield a 1f beat note of high phase stability, the Master station control equipment includes a system of phase-locking between the 5f and 6f signals. In addition, the Master station provides the signals that initiate the necessary lane identification switching process at the Slave stations and in the receivers. The timing of these is determined by clock controlled switching and a one-minute signaling cycle, starting from the instant of the Red lane identification signal. The signal takes the form of a small shift in the 6f frequency three times per minute; immediately preceding the transmission of the combined 6f and 5f signals. The latter, in common with the Slave lane-identification transmissions, lasts for one-half second.

As a primary function of a Slave station is to radiate a carrier of a frequency that is harmonically related with the Master transmission, each Slave has an antenna system for receiving the Master signal. In the Slave control equipment, this signal is phase-compared with the Slave transmission and the phase relationship between the two is rigidly held at a predetermined value. This process is carried out in two stages. The signal source is a crystal oscillator working at the Master frequency 6f, the amplified output of which is passed to a pulse-forming circuit which produces pulses at a recurrence frequency of 6f. A divider circuit derives from this signal a 1f pulse which is fed to an 8f (Red Slave frequency) amplifier of sine-wave form and drives the 8f (i.e., the normal pattern) transmitter. Associated with the transmitting antenna coil circuit is a pick-up loop which feeds back a voltage whose phase is that of the 8f radiated field, this voltage being compared with the drive signal in a discriminator circuit. The discriminator output is applied as an error voltage to a reactor phase control circuit which maintains the radiated transmission with constant phase shifts occuring in the transmitter and antenna circuits. A similar phase control is exerted on the 6f oscillator by comparing the received Master signal with the 6f sine-wave derived from the 1f phase output of the divider, thus locking the phase of the oscillator with that of the Master.

The Lane identification pattern is generated by momentarily adding a 9f transmission to the 8f so as to produce a 1f beat note for phase comparison, in the users' receivers, with the 6f-5f Lane identification transmission from the Master. Thus a relay actuated by the triggering signal for Red Lane identification completes the drive circuit of the 9f transmitter for one half second. A similar relay in the normal-pattern 8f drive circuit opens during Green and Purple Lane identification so as to avoid interference with the 8f signals radiated in turn from those stations.

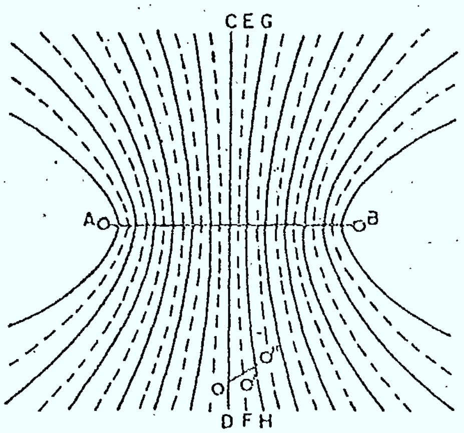
The transmitters feed an output of approximately 2.4 kilowatts into the antenna via a double-tuned coil. The antenna comprises either a vertical base-insulated tower or a flat-top system supported on three masts in line, together with a system of radial ground wires.

The Decca chains operating in Eastern Canada are listed below:

a) Newfoundland Chain
b) Cabot Strait "
c) Nova Scotia "
d) Anticosti "

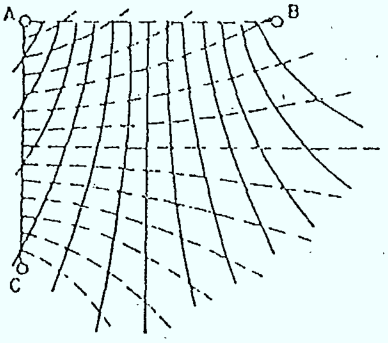
(For particulars concerning frequencies and stations involved in these chains refer to "Radio Aids to Marine Navigation - Atlantic and Great Lakes").

FIG.-1



SET OF HYPERBOLIC POSITION LINES GENERATED BY SYNCHRONIZED TRANSMISSIONS FROM STATION A AND B

FIG.-2



HYPERBOLIC GRID GENERATED BY SLAVE STATIONS B AND C LOCKED TO MASTER A

LORAN

Loran (Long Range Navigation) is a hyperbolic system of radio navigation, employing pulse techniques, which provides a ship or aircraft with position data.

Loran A systems operate in the frequency band 1.7 to 2 Mc/s and Loran C systems operate in the frequency band 90 - 110 kc/s.

Operation of Loran involves the accurate measurement of the time interval between the reception of pulses from master and slave stations operating in pairs. The master station of a Loran pair transmits pulses at a constant repetition rate, several hundred miles away the slave transmitter retransmits a corresponding series of pulses synchronized to those of the master after a known and accurately monitored delay. Ground stations are located so that signals from two or more pairs of stations may be received in the same area so that a Loran fix is obtained by plotting two or more position lines. In order to economize on ground installations the master station is common to two Loran pairs, the transmitter being double pulsed and virtually two separate stations at the same location.

A line along which the difference in arrival time of the pulses from master and slave is constant is called a line of constant path difference (hyperbola) so that for each pair of stations there exists a family of hyperbolae and position is determined by taking the path difference readings from two pairs of stations [see page (iii) Fig. 1.] If both pulses were transmitted simultaneously they would be received simultaneously on the base line right bisector and the time difference would be zero. In practice the slave pulse is delayed so that the master pulse is always received first thus eliminating any ambiguity in the identification of the pulses.

Signals received are displayed on a cathode ray tube from which the operator can determine the difference in arrival time between the two pulses. The reading in microseconds is obtained directly from numerals displayed on a time difference indicator eliminating the necessity for mental computations from time markers and thus reducing the possibility of error. A single reading gives only a position line so that a fix requiring the intersection of two such position lines cannot be obtained simultaneously, however, under good reception conditions the observations can be made and plotted in a short time.

Position lines are plotted on charts overprinted with hyperbolic lattices in colour. Pairs of stations are selected by reference to these charts in order to obtain a fix.

Identification of Loran chains is carried out by two distinguishing characteristics, radio frequency and pulse repetition rate. Loran stations forming a chain operate on the same frequency but the number of pulses transmitted per second (the recurrence frequency) differs for each pair. By adjusting the receiving equipment for the correct p.r.f. (pulse recurrence frequency) any desired pair of signals can be selected. Signals from a number of Loran stations on the same channel will appear on the display scope but the signals will drift at varying speeds, the operator selects the required pair of stations by adjusting the sweep recurrence rate of the indicator to match the p.r.f. of the required pair. These signals become stationery while signals from other pairs will continue to drift across the display scope.

There are four Loran channels in the frequency band 1.7 to 2 Mc/s: channel 1 at 1.95 Mc/s, channel 2 at 1.85 Mc/s, channel 3 at 1.90 Mc/s and channel 4 at 1.75 Mc/s.

Each pair of Loran stations is designated by a three character identification symbol. The first character indicates the channel, the second the basic rate and the third the station recurrence rate.

PULSE RECURRENCE RATES

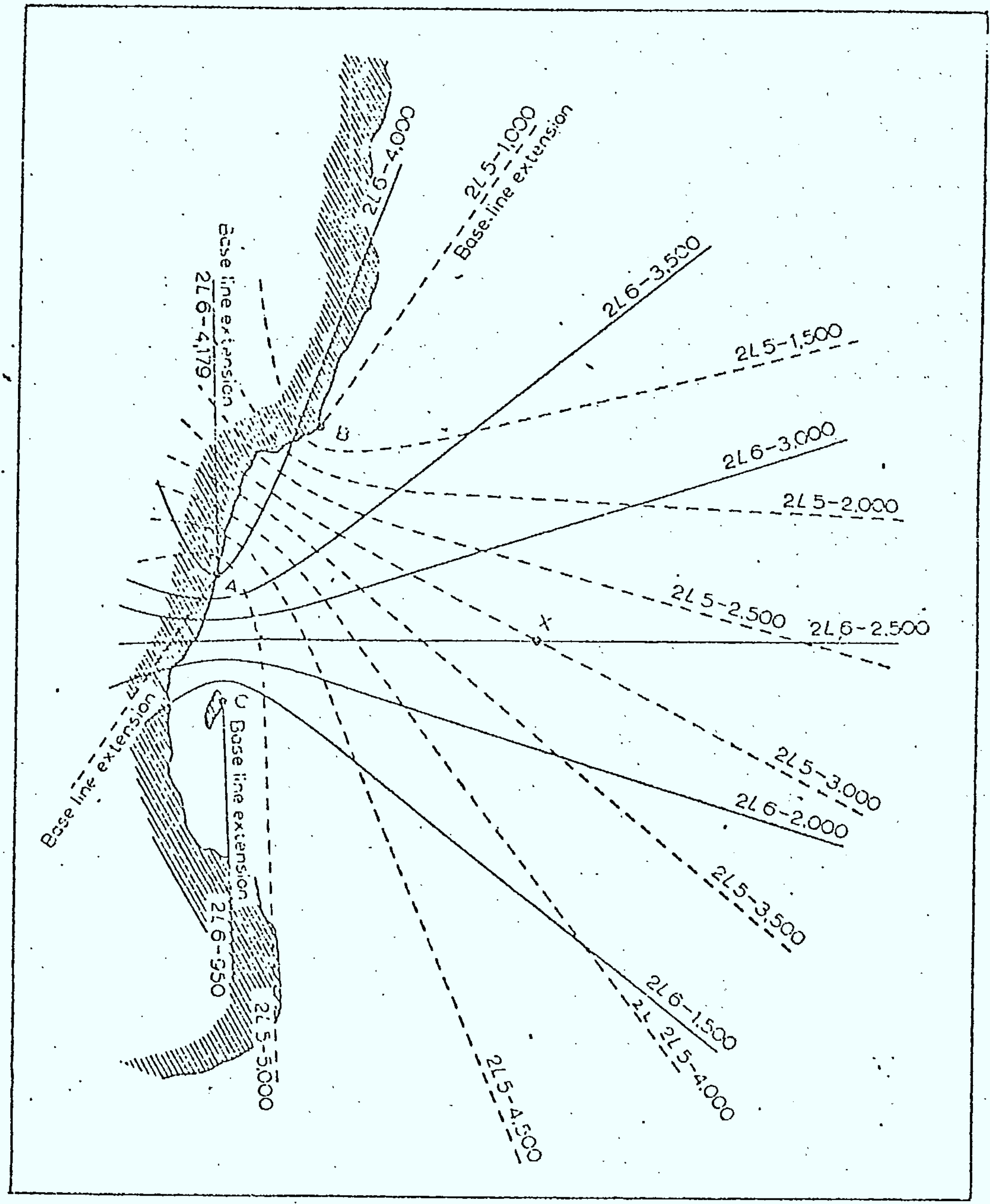
LOW RATE	PPS	HIGH RATE	PPS
L 0	25	H 0	33- 1/3
L 1	25-1/16	H 1	33- 4/9
L 2	25-2/16	H 2	35- 5/9
L 3	25-3/16	H 3	33- 6/9
L 4	25-4/16	H 4	33- 7/9
L 5	25-5/16	H 5	33- 8/9
L 6	25-6/16	H 6	34
L 7	25-7/16	H 7	34- 1/9

The accuracy of Loran depends primarily upon the synchronization of the master and slave pairs. If synchronization of the transmitters involved breaks down pulses drift horizontally on display scope thus providing a warning against their use for navigation purposes.

The use of a low frequency (100 kc/s) in Loran C permits greater distances between the master and slave and increases the ground wave reception range to approximately 1200 nautical miles, thereby providing navigational data of greater accuracy and reliability.

This system uses a single master and two or more slaves with the same pulse repetition rate. Stations may be arranged in star, square or triad configurations. Since master and slave stations use the same pulse repetition rate a position fix can be obtained from one master and two slaves automatically and simultaneously.

FIGURE-I



LORAN TRIPLET SHOWING POSITION LINES FORMED BY A, THE COMMON MASTER FOR BOTH PAIRS, AND THE TWO SLAVES B AND C. THE FIX INDICATED AT X IS THE INTERSECTION OF TWO HYPERBOLIC POSITION LINES, ONE FROM EACH PAIR

APPENDIX 4

Presented at Working Group A of
Frequency Allocation Sub-Committee
WARC'79 by CRTC - October 12,1977.

EXTENSION OF THE SOUND BROADCAST (AM) BAND

535-1605 KHz

1. INTRODUCTION

At the present time, the AM broadcast band (535-1605 KHz) is very congested in Region 2, and it is becoming increasingly more difficult and expensive to engineer new assignments in most areas of Canada.

In view of the fact that almost all homes in the country are equipped with AM receivers, aural broadcasters have traditionally preferred this band, even though very heavy costs are incurred in establishing new stations as multi tower arrays are almost always required and nighttime service is often extremely poor as a result of skywave interference. More recently, however, FM receiver penetration has greatly improved, and new stations, both private and CBC owned and operated, are springing up to take advantage of the relatively low cost of implementation and the interference-free service available on the FM band. This growth of FM has occured so rapidly that it is becoming increasingly difficult to find channels for new aural services even on the FM band.

In fact in some areas of Zone 1 (the Windsor-Quebec City corridor) there is insufficient spectrum to implement the Corporation's existing plans (Accelerated Coverage Plan, Radio Replacement Plan and extension of the English and French Stereo networks) even if no more private services are licenced.

Furthermore, provision must be made for organizations outside of the broadcasting industry, such as local community groups ethnic associations and universities who are now held back by a shortage of channels in the metropolitan centers (a number of universities, McMaster and Waterloo among others, have however been licenced).

In summary, the existing broadcast spectrum (aural), even assuming an optimum match of demand and channel availability will be saturated in Zone 1 by 1984 if the growth rate of the last five years continues. Additional spectrum is urgently needed to meet the services presently planned as well as the expected growth in the private sector.

One of the proposals emanating from the United States for WARC 1979 to increase the number of channels available for aural broadcasting is to extend the existing AM band. Currently, the U.S. is giving consideration to the use of 115-190 KHz, 525-535 KHz and 1605-1800 KHz for new AM broadcast services.

In view of the above, it is considered timely to investigate the extent to which Canada's need for additional aural broadcasting channels could be met by extending the existing AM band to the same extent as that proposed by the U.S.

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The Comments contained herein are intended to explore several related areas including:

(i) The degree to which interference to and from existing stations would be caused by stations operating in the new bands.

(ii) Receiver availability.

(iii) Economic feasibility.

(iv) International implications.

Conclusions will then be drawn, based upon the above considerations.

2. INTERFERENCE LIMITATIONS ON THE NEW FREQUENCIES

In order to specifically assess the degree to which the bands 115-190, 525-535, and 1605-1800 KHz could be used to relieve the demand for additional sound broadcasting services in Canada, it was decided to examine each of the 10 largest metropolitan radio markets to determine the technical feasibility of each frequency in that band.

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It was assumed in the analysis that frequencies would be allotted on a 10 KHz spacing basis consistent with the practice in the 535-1605 KHz band. That is, stations would only be assigned on frequencies which are multiples of 10 KHz on the assumption that receiver manufacturers wish to develop frequency synthesized receivers, which would have to be compatible over the whole band from 115-1800 KHz.

In each of the 10 largest markets, each of the 29 new channels was analyzed in order to ascertain the degree to which a new station on that frequency would cause, or be subject to, interference from existing stations in the same area. The technical problems examined were as follows:

(i) Oscillator Radiation - In each market, a frequency was flagged as a potential problem if a station operating on that frequency would have a potential oscillator radiation problem with an existing station which is ± 450 or ± 460 KHz removed in frequency. (DOC Broadcast Procedure 1, Rule 11).

(ii) Harmonic Interference - In each market a frequency was flagged as a potential problem if a local station is licensed on a frequency with a 2nd harmonic relationship to that being considered (DOC Broadcast Procedure 1, Rule 4). Higher harmonics, especially of the Lf band, will also have an impact, but they were not considered here.

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(iii) Image Interference - In each market a frequency was flagged as a potential problem if a station operating on that frequency has a potential image interference problem with an existing station which is ± 910, ± 920 or ± 930 KHz removed in frequency. (DOC Broadcast Procedure 1, Rule 14).

(iv) Adjacent Channel Interference - In each market a frequency was flagged as a potential problem if a station operating on that frequency would not be able to render protection in accordance with DOC domestic procedures and/or NARBA to an existing station ± 10 KHz, ± 20 KHz or ± 30 KHz removed in frequency.

Table I indicates the results of the above analysis in the ten largest radio markets. It may be seen from the Table that many frequencies in the new bands would be either questionable or unusable as a result of interference caused to, or suffered from, existing stations in the same area.

In situations where the incoming station would have to accept a limitation it may be possible to use the frequency but it is unlikely that a new broadcaster would be willing to cope with both interference from a local station and a lack of receivers in the hands of the public. Where the new station would cause interference to an existing station it is extremely unlikely that the frequency could be used at all.

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TABLE 1

POTENTIAL NEW FREQ. (KHz) / CITY	120	130	140	150	160	170	180	190	530	1610	1620	1630	1640	1650	1660	1670	1680	1690	1700	1710	1720	1730	1740	1750	1760	1770	1780	1790	1800
Montreal	1	1	1	1	3	1,3	1,3	3	1,3,4	3	3		3	3	3				2	3	3	1,3	1		3	1,3	1,3		
Toronto	3	1,3	1,3	1	1			3	3,4	1,4	3	3	1,3	1,3	3	3			1,3	1,3	2,3				1	1,3	3	3	
Vancouver			1,3	1,3	3				1,4	3	3		3	3	3	1	1			3	1,3	1,3			3	3	3		
Ottawa-Hull	1	1				1	1,3	3	3	1	1	1				1	1		1	1					1	1			1
Winnipeg	1,3	1,3	3			1	1		1	3	2								1	1	3	3	1,3	1					
Edmonton	1	1				1	1,3	3			1	1		3	3	3			3	1,3	1,3				3	3	3		
Hamilton	3	3	3	1	1			3	3,4	4	3,4	3	1,3	1,3	3	1,3	1		1	1	2	1	1			1,3	1,3	3	2
Quebec		3	3	3					1,2,4											3	3	1,3	1					1	1
Calgary		3	3	3					2		1,2	1				1	1				3	1,3	1,3		3	3	3		
St. Catharines-Niagara	3	3	3	1	1			3	3,4	4	3,4	3	3	1,3	1,3	1,3	1		1	1	2	1	1			1,3	1,3	3	2

INTERFERENCE CODE	DESCRIPTION
1	Frequency would cause or suffer oscillator radiation interference from a local station.
2	Frequency would cause or suffer harmonic interference from a local station.
3	Frequency would cause or suffer image interference from a local station.
4	Frequency would cause or suffer adjacent channel interference from a local station.

It is interesting to note that, in most markets, the "usable" frequencies are clustered together, which further reduces the number of discrete channels which could be used in any one market. In Hamilton, for instance only 170, 180, 1690, 1750 and 1760 KHz show any promise. Since only one each of the 170-180 pair and the 1750-1760 pair could be used in the same area, there are only 3 channels out of 29 which could potentially be used in Hamilton.

It should also be noted that each location was examined in isolation from all the others, which means that the channels shown as workable in one location may also be workable in an adjacent centre, and must therefore be shared. For example, the same 5 frequencies (170, 180, 1690, 1750 and 1760) are shown as "clear" frequencies in both Hamilton and St. Catharines-Niagara.

3. RECEIVER AVAILABILITY

In any situation where new or extended broadcast bands are to be considered, it is imperative that the matter of receiver availability be discussed. It is certain that broadcasters will not make extensive use of new frequencies unless a sufficiently large number of receivers are in the hands of the public. Similarly, the public will not spend extra money to buy a receiver which tunes frequencies upon which no stations are operating.

The problem rests with the "rate of replacement" factor. That is, assuming that extended-band receivers were to come on the market at a certain point in time, how long would it take until a sufficient number of homes are equipped with the new sets to make a station operating on a "new" frequency commercially viable?

Obviously, it would be difficult to project exactly when such a viable situation would occur in each market unless it can be guaranteed that all new receivers sold after a specific date will be equipped to receive the new frequencies.

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This "guarantee" could be made if it can be proven that an extended-band AM receiver could be produced at essentially the same cost as a receiver which only tunes the existing band. If this were the case, presumably receiver manufacturers would produce extended-band sets on a voluntary basis. If this is not the case, then government action similar to the VHF/UHF all-channel regulation for TV would be necessary.

In either of the above situations, it is evident that Canada could not consider using extended AM frequencies different from those chosen by the U.S. because of the relatively small consumer market in this country.

4. ECONOMIC FEASIBILITY

As discussed in the previous section the matter of economics arises when one considers the extent to which extended AM frequencies would appeal to aural broadcasters. The receiver question is primarily concerned with the revenue side of the ledger. There are also cost factors which would have to be considered by a broadcaster contemplating the use of "New" AM frequencies.

The most attractive new frequencies, from a cost point of view, would be those above the existing band. At these frequencies antenna arrays would be quite reasonable in cost because tower heights would be lower and the amount of land needed to accommodate the array would be smaller.

The same cannot be said of the frequencies from 115 to 190 KHz, since even a non-directional antenna at these frequencies assumes monumental proportions if it is to achieve reasonable efficiency. Since the greatest shortage of aural broadcasting frequencies occurs in the largest metropolitan centres, the land costs for such antenna systems may be prohibitive.

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For this reason, it is expected that any broadcast use of new L.F. AM frequencies would be by operators such as the CBC, who could use them for wide area coverage in the more remote regions of the country.

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4. INTERNATIONAL IMPLICATIONS

In the event that the AM band were to be extended, it is probable that each country in Region 2 would wish to maximize the number of channels available to it. If the new bands were to be split only into Regional (Class III) channels, (i.e. on a first come-first served basis) it is evident that the United States would move quickly to occupy the new frequencies, leaving little for the other Region II countries. For this reason it is considered essential that any new AM bands be divided on a shared basis, similar to the arrangements contained within the Canada-U.S. TV and FM Agreements, or in NARBA (North American Regional Broadcasting Agreement) as it relates to Class I (Clear) channels.

Given that the U.S. and Mexico will be able to lay claim to certain of the 29 channels envisaged for the new bands, it is evident that a further reduction in usable channels for each location will occur once international agreements have been worked out.

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5. CONCLUSIONS

As a result of the above analysis the following conclusions may be drawn:

(a) In the event that the U.S. moves to extend the AM band to include 115-190, 525-535 and 1605-1800 KHz, it would be in Canada's interest to support this re-allocation since some channels may be made available in areas where the AM band is now saturated. However if all these bands can't be made available, then the first choice would be the 1605-1800 KHz band.

(b) Any such agreement to support U.S. initiatives should be made on the understanding that there will be an equitable distribution of any new channels between all Region 2 countries.

(c) It is unlikely that Canada could rely upon an AM band extension to provide more than a handful of aural broadcasting frequencies in the areas where they are most needed, (i.e.) in the 10 largest markets). This is because stations operating in the new bands would be

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subject to and would cause interference to existing stations operating in the 535-1605 KHz band.

(d) If new AM bands are allocated it will be necessary for government agencies to determine if an "all-channel" regulation will be required to promote the penetration of AM receivers capable of receiving the new frequencies.

(e) Attachment I details the recommended spectrum reallocation.

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