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STUDY REPORT

ON

SPECTRUM MANAGEMENT STRATEGIC INITIATIVES

FOR THE

DEPARTMENT OF COMMUNICATIONS

Prepared by:

HN ENGINEERING INC.

HNE Project: 1359-02

June, 1990

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HN ENGINEERING INC.

Rapport sommaire

Contrat n° 36100-9-0247/03-ST
H.N. Engineering Inc.
Burnaby (C.-B.)

"Rapport de l'étude sur les initiatives stratégiques du ministère des Communications, concernant la gestion du spectre"

Exigence :

Effectuer une étude sur la faisabilité, les avantages, les répercussions et le cadre général de l'intégration des techniques du spectre de pointe et des initiatives stratégiques, dans le cadre des méthodes actuelles de gestion du spectre.

Processus:

Le travail comportait les deux phases suivantes :

Phase 1 : Élaboration des objectifs et des initiatives stratégiques clés.

Phase 2 : Recherche détaillée et justification des initiatives définies à la phase 1.

Énoncé de travail

Phase 1

1. Passer en revue la documentation actuelle sur la gestion du spectre au regard des techniques de pointe et des initiatives stratégiques. Intégrer les renseignements conformément au guide cadre fourni par la DLRP et recommander des améliorations au cadre stratégique, le cas échéant.

2. Rédiger un rapport concernant le cadre stratégique amélioré en soulignant les éléments clés. Fournir des prévisions concernant la main-d'oeuvre et les coûts directs associés à l'achèvement de l'étude complémentaire détaillée.

Phase 2

1. A l'aide du document découlant de la phase 1, rédiger un rapport détaillé concernant la raison d'être, les avantages, les répercussions, les solutions de rechange, la mise en oeuvre et la faisabilité des principales initiatives en matière de gestion du spectre.

2. Inclure les initiatives stratégiques additionnelles fournies par l'autorité scientifique.

3. Recueillir des renseignements et des arguments détaillés concernant les initiatives stratégiques. Maintenir une perspective technique de gestion du spectre à cette fin.

Résumé du rapport final

1. Le rapport présente une série d'initiatives stratégiques, avec leur raison d'être et leurs avantages, ainsi que des recommandations concernant leur mise en oeuvre. Conformément aux lignes directrices initiales de l'étude, l'étude a été réalisée dans la perspective de la gestion du spectre., Afin de maintenir l'impartialité des résultats de l'étude, l'entrepreneur a bénéficié d'une certaine marge de manoeuvre à cet égard.

2. Principales initiatives stratégiques en matière de gestion du spectre recommandées dans le rapport. (Tirées directement du résumé inclus dans le rapport.)

2.1 Effectuer un examen approfondi des attributions actuelles de fréquences

On a constaté que certaines bandes de fréquences attribuées par le passé n'étaient pas pleinement exploitées, alors que d'autres bandes étaient très encombrées. Les problèmes se font notamment sentir dans la gamme de fréquences 30 MHz - 1 GHz.

Suite à l'examen des différentes questions, nous formulons les recommandations suivantes :

- Il y a lieu que le MDC passe en revue toutes les attributions de fréquence de 3 kHz à 300 GHz pour :

  i) évaluer l'incidence de la modification des attributions actuelles;

  ii) évaluer le besoin de fréquences supplémentaires.

- Élaborer des dispositions plus souples concernant la définition des conditions d'exploitation du spectre.

- Élaborer un système de pondération technique et socio-économique.

- Étudier les possibilités d'utiliser des services différents mais compatibles en zones urbaines et en zones rurales.

- Garder des fréquences en réserve.

2.2 Promouvoir le rendement spectral

Trois méthodes visant l'amélioration du rendement spectral sont examinées et des recommandations concernant leur mise en oeuvre sont émises :

- Calculer les droits de licence en fonction du spectre utilisé.

- Instaurer un accès public à la base de données concernant les licences.

- Promouvoir le développement de technologies ayant un meilleur rendement spectral.

Suite à l'examen des systèmes de codage, des schémas de modulation, des méthodes d'assignation dynamique des canaux (systèmes à partage de canaux) et des antennes haute performance, nous faisons les recommandations suivantes :

- Le MDC doit continuer à promouvoir le codage de la parole.
- Le MDC devrait revoir l'exploitation spécialisée des bandes militaires.
- Élaborer une norme de partage à architecture ouverte applicable aux services mobiles de radiocommunications.
- Promouvoir l'utilisation d'antennes plus performantes.

2.3 Améliorer la gestion du spectre et les capacités techniques

Différents processus et méthodes qui permettent d'améliorer la gestion du spectre et les capacités techniques font leur apparition, notamment divers outils informatiques comme le SUM (mesure de l'utilisation du spectre), le SCF (facteur d'économie du spectre) et le TSEF (facteur technique de rendement spectral), ainsi que des outils élaborés par le MDC comme le SQI (indice de qualité du spectre) et le SEAS (système d'évaluation de l'environnement spectral).

Afin de stimuler le développement commercial des bandes de fréquences de la partie supérieure du spectre, nous recommandons au MDC d'appuyer les recherches concernant les caractéristiques de propagation dans les bandes de 20 à 300 GHz.

L'accroissement des pouvoirs ministériels en vertu de la Loi permet d'améliorer la gestion du spectre, mais uniquement si des règlements appropriés sont mis en oeuvre conformément aux dispositions de la Loi.

2.4 Accroître le recours à la surveillance du spectre

La surveillance est un outil efficace de gestion du spectre et il faut lui accorder plus d'importance de façon à :

- contrôler l'exploitation non autorisée du spectre;
- fournir une évaluation permanente de l'environnement spectral;
- évaluer l'exploitation du spectre.

2.5 Initiatives internationales permanentes

L'expansion des radiocommunications à l'échelle mondiale amène le besoin d'une meilleure planification internationale des fréquences, et donc le recours aux négociations, à la coordination et aux ententes à l'appui de cette planification. Le Canada est très actif dans le domaine des télécommunications par satellite et il prend donc une part active à l'étude des questions réglementaires internationales connexes. On prévoit que l'UIT apportera bientôt des modifications importantes concernant les tables d'attribution, l'assignation des fréquences et les procédures de coordination et qu'elle introduira de nouvelles procédures. Il est recommandé que le Canada continue de participer activement aux tribunes internationales pour défendre les intérêts de l'industrie canadienne et de la population dans son ensemble au regard des questions liées aux radiocommunications.

La mondialisation du marché des télécommunications ces dernières années exige l'harmonisation mondiale des normes. L'industrie et le gouvernement du Canada ont un rôle important à jouer au regard de l'établissement de normes internationales.

2.6 Mener des études tournées vers l'avenir

Deux des principaux objectifs de la gestion du spectre sont de répondre aux besoins actuels et futurs des utilisateurs et de prévenir le brouillage et l'encombrement du spectre. Pour respecter ces objectifs, il est nécessaire d'obtenir, au moment opportun, des renseignements exacts sur les besoins liés aux fréquences radioélectriques.

2.7 Révision des règles applicables à la radiodiffusion et questions connexes liées à la CEM

Un examen des règlements applicables aux services de radiodiffusion AM et FM nous amène à faire les recommandations suivantes :

- amorcer un examen des règlements techniques sur la radiodiffusion pour s'assurer qu'ils répondent aux besoins actuels et qu'ils ne sont pas trop restrictifs;
- réduire l'utilisation de renseignements démographiques dans les règlements sur la radiodiffusion;
- poursuivre l'élaboration de normes sur la CEM applicables aux dispositifs électroniques pour assurer leur compatibilité avec les services de radiodiffusion de grande puissance;
- introduire progressivement des normes sur les récepteurs de radiodiffusion.

2.8 Valeur marchande et assignation des fréquences

Aujourd'hui, les fréquences sont assignées au Canada en vertu du principe "premier arrivé, premier servi". Quand il y a plus d'un requérant, des audiences sont tenues et la demande qui contribue le plus au bien public est retenue.

La mise aux enchères des fréquences est à l'étude ou est mise en oeuvre par plusieurs administrations. Il existe actuellement deux types d'enchères : la mise aux enchères de licences de services radio visant des fréquences précises et la mise aux enchères de blocs de fréquences qui sont gérées par l'acheteur. La Nouvelle-Zélande procède actuellement à la mise aux enchères de blocs de fréquences.

Il s'agit là de quelques exemples des possibilités de mise aux enchères des fréquences. Cette procédure en est à ses tous débuts et il faut continuer d'étudier ce qui se fait ailleurs afin d'en établir les avantages au Canada.

2.9 Promouvoir les solutions de rechanges autres que les radiocommunications

Les différents types de transmission par câble sont des solutions de rechange viables aux services de radiocommunications aux fins des communications entre points fixes.

2.10 Promouvoir l'exploitation des bandes de fréquences de la partie supérieure du spectre

Le demande croissante de services radio ne pourra probablement pas être comblée sans le recours accru aux fréquences de la partie supérieure du spectre. L'exploitation de ces fréquences permettra de réduire l'encombrement actuel et futur des fréquences de la partie inférieure du spectre, notamment les fréquences UHF et VHF. Les caractéristiques techniques des fréquences supérieures offrent de nombreux avantages, y compris de grandes possibilités de réutilisation découlant de l'importance de l'affaiblissement, l'utilisation de petites antennes et de matériel compact et l'ouverture de faisceau étroite du signal, qui favorise le partage des canaux.

Contract Summary Report

Contract No. 36100-9-0247/03-ST
H.N. Engineering Inc.
Burnaby, B.C.

'Study Report on Spectrum Management Strategic Initiatives for the Department of Communications'

Requirement:

Conduct a study on the feasibility, benefits, implications and general framework of the integration of advanced spectrum engineering techniques and strategic initiatives within the current spectrum management practices.

Process:

The contract work was divided in two phases:

Phase 1: Development of key strategic objectives and initiatives.

Phase 2: Phase 1 initiatives - detailed research and substantiation.

Statement of Work:

Phase 1

1. Review existing spectrum management documentation relating to advanced engineering methods and strategic initiatives. Correlate information according to framework guide provided by DLRP and produce enhancements to the framework as necessary.

2. Prepare a report on the enhanced framework outlining the key elements. Also included are estimates of manpower and direct costs to complete the follow-up detail study.

Phase 2

1. Using the Phase 1 document, prepare a detailed report outlining the rationale, benefits, impact, alternatives, implementation factors and feasibility of the major spectrum management initiatives.

2. Include further strategic initiatives as provided by the scientific authority.

3. Research and document detailed information and arguments relative to the strategic initiatives. Maintain a technical spectrum management perspective in this work.

Summary of Final Report:

1. The report presents a series of strategic initiatives and provides the respective rationale, benefits and some implementation suggestions. The original guidelines for the study limited the scope to a spectrum management perspective. In order not to prejudice the results of the study the contractor was permitted some latitude in this area.

2. Major Spectrum Management Initiatives Recommended in the Report. (Edited directly from the executive summary contained in the report).

2.1 Conducting an Extensive Review of Current Frequency Allocations

It was found that some of the band allocations made in the past may not have been fully utilized, while other bands are experiencing extreme congestion. Of particular concern is the frequency range from 30 MHz to 1 GHz.

Based on a review of the various issues, the following recommendations are made:

- The DOC should examine all frequency allocations from 3 kHz to 300 GHz to:

  i) assess impact of revising present allocations;
  ii) assess need for additional spectrum

- Develop a less rigid arrangement for defining spectrum usage.

- Develop a techno-socio-economic weighting system.

- Explore use of different but compatible services for urban and rural areas.

- Maintain a frequency reserve.

2.2 Promoting Spectrum Efficiency

Three methods for improving spectrum efficiency are reviewed, with a recommendation regarding action for each:

- Relate the license fee to the amount of spectrum used.

- Public access to the radio licensing data base.

- Encourage the development of more spectrum efficient technologies.

A review of coding and modulation schemes, dynamic channel assignment concepts (trunk radio), and high performance antennas provides the following recommendations:

- Voice coding should continue to be promoted by the DOC.
- The DOC should review the dedicated use of military bands.
- Develop an open architecture trunking standard for the mobile radio.
- Encourage the use of higher performance antennas.

2.3 Enhancing Spectrum Management/Engineering Capabilities

Various methods and processes are emerging that can enhance spectrum management and engineering capabilities. Computer-aided tools such as Spectrum Use Measure (SUM), Spectrum Conservation Factor (SCF), Technical Spectrum Efficiency Factor (TSEF) and the DOC's Spectrum Quality Indicator (SQI) and the Spectrum Environment Assessment System (SEAS) are some recent examples.

In order to stimulate commercial development of the higher frequency bands, a recommendation is made that the DOC support research activities leading to a better understanding of propagation characteristics in the bands from 20 to 300 GHz.

The increased Ministerial powers in the Act can lead to the enhancement of spectrum management capabilities. This can only occur, however, with the implementation of appropriate regulations under the Act, giving force to the legislation's capabilities.

2.4 Increasing Reliance on Spectrum Monitoring

Monitoring is an efficient spectrum management tool and should be given a higher priority to:

- unauthorized use of the spectrum;
- provide an ongoing assessment of the spectrum environment;
- assist in assessing spectrum usage.

2.5 Continuing International Initiatives

The expansion of radio communications on a worldwide basis points to the need for a greater degree of international frequency planning, negotiation, coordination and agreement. Canada is heavily involved in the satellite sector, with the concurrent international regulatory issues that this entails. Significant change is soon anticipated in the ITU, regarding revision of the allocation tables, frequency assignment and coordination procedures, and the establishment of new procedures. A recommendation is made for continued strong Canadian representation in international forums, to put forward and argue for radio-related issues which impact on Canadian industry, and society in general.

The globalization of markets in telecommunications in recent years indicates a need for global harmonization of standards. Both Canadian industry and government have significant roles to play in the international standard-setting process.

2.6 Conducting Future-Oriented Studies

Two major goals of spectrum management are to provide for current and future requirements of spectrum users and to avoid congestion and interference. To meet these goals, accurate and timely information on spectrum requirements is necessary.

2.7 Reassessing Broadcast Rules & Related EMC Issues

A review of these types of rules for AM and FM broadcasting services leads to the following recommendations:

- initiate a review of the technical broadcast rules to ensure they are in tune with present day requirements and are not unduly restrictive,
- minimize the use of demographic information in broadcast rules,
- pursue the development of EMC standards for electronic devices to ensure compatibility with high power broadcast services,
- phase in minimum standards for broadcast receivers.

2.8 Considering Market Value Concepts in Radio Frequency Assignment

Currently in Canada frequency is assigned on a first come, first served basis, or, where more than one party is attempting to obtain spectrum, on a comparative hearings basis, with preference given to those applications providing greater public benefits.

Spectrum auction procedures are under consideration or are being implemented by several administrations. These procedures are currently in two forms: auction of licenses for radio services on specified frequencies; auction of blocks of spectrum, to be managed by the purchaser. The block auctions are currently being implemented in New Zealand. — no! studies are only being done

These are only examples of the many variations on spectrum auctions that could be put in place. Activities in this area are at an early stage, and monitoring of other administrations' activities should continue, with an eye to determining the benefits of this concept in a Canadian context.

2.9 Promoting Use of Non-Radio Alternatives

Cable systems of various types are a viable alternative to radio systems for communications between fixed points.

2.10 Promoting Use of Higher Frequency Bands

The growing demand for radio services likely cannot be met without increased utilization of higher frequencies. The use of higher frequencies will lessen present and future congestion of lower frequencies, particularly VHF and UHF. The technical characteristics of higher frequencies present numerous advantages, including high re-use due to high attenuation, the advantages of small antennas and compact equipment, and narrow signal beamwidth, providing more sharing opportunities.

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PREFACE

HN Engineering Inc. (HNE) was commissioned by the Department of Communications (DOC) to undertake a Study of issues related to the management of the radio frequency spectrum. Management of the spectrum can be understood as the set of policies, objectives, standards and regulations which allow for the harmonious existence of radiocommunications operations without causing harmful interference.

The starting point for this Study was a document entitled "A Spectrum Management Strategy Proposal", prepared by the Long Range Planning and Interconnect Directorate of the DOC, which outlined a number of major spectrum management initiatives. In the first phase of work, this list of initiatives and the issues involved was examined and revised. Subsequently, several initiatives were added to this list.

In this, the second phase of activity, issues relative to these initiatives have been researched with the intent of providing the rationale, benefits, impact, alternatives, proposals for implementation, and feasibility of the said initiatives. Information used in compiling this report has been derived from the broad experience of HNE staff, owing to their many years of direct experience in the telecommunications engineering and consulting field; from interviews with numerous DOC staff in Ottawa; from consultation with industry contacts; and from primary and secondary documentary research materials. HNE has, for the most part, approached these activities from a technical (as distinct from a policy) spectrum management perspective.

The above activities are in support of initiatives aimed at the optimization of radio spectrum management in Canada. Acting within a sometimes difficult environment that necessitated reactive as opposed to proactive measures, the DOC has to date managed to maintain its position on the leading edge of spectrum management. The DOC's activities in this regard are the reason Canada enjoys one of the finest communications systems in the world, serving a population of over 25 million spread over a vast and varied geographical area. In a period of increasing demands for spectrum, where the uses of radio spectrum are diverse and rapidly expanding, the task of spectrum management is now more important than ever. The need now is for measures which can be applied proactively, to address requirements before they become difficulties. In its recent activities, including the commissioning of this report, the DOC recognizes that the time is right to initiate these measures, continuing to provide a leadership role in the efficient management of the radio frequency spectrum.

ACKNOWLEDGEMENTS

A number of individuals and organizations contributed to the information required in preparing this report. HN Engineering Inc. would like to acknowledge the assistance provided by the following.

The numerous staff of DOC Ottawa, in particular those of the following Directorates and areas:

* Long Range Planning and Interconnect
* Regulatory Policy and Planning
* Spectrum Engineering
* Automated Spectrum Management Systems
* EMC Analysis and Consultation
* Space Services Frequency/Orbit Management
* Operational Policies, Procedures and Programs
* Spectrum and Orbit Policy
* Terrestrial Services Frequency Management

The Canadian High Commission, Wellington, New Zealand; in particular, Mrs. Colleen Poulter, Commercial Officer.

The Canadian High Commission, Canberra, Australia; in particular, Jennifer A. Brown, Commercial Officer.

Mr. Joseph Gattuso, of the National Telecommunications and Information Administration, Office of Policy Analysis and Development, Washington, D.C.

EXECUTIVE SUMMARY

With rapidly advancing technological change providing new and enhanced radiocommunication services, demands are being placed on radio frequency spectrum at an increasing rate. The Department of Communications (DOC) has recognized the need to develop specific management plans and policies which will adequately fulfil these demands, while ensuring equitable usage of the spectrum, and the control of harmful interference.

To assist the DOC in the development of these plans and policies, HN Engineering Inc. (HNE) was commissioned to perform this study of the feasibility, benefits, implications and general framework of the implementation of strategic initiatives aimed at the optimization of spectrum management practices. These initiatives were identified in an earlier phase of activity, which included an analysis and revision of a report prepared by the Long Range Planning and Interconnect Directorate of the DOC. The following provides an overview of the strategic initiatives studied, some of the major issues involved, and the recommendations which flow from the analysis conducted.

1. Conducting an Extensive Review of Current Frequency Allocations

   It is generally recognized that some of the allocations made in the past have not been effectively utilized, while other bands are experiencing extreme congestion. Of particular concern is the band of frequencies from 30 MHz to 1 GHz.

   Based on a review of the various issues involved, the following recommendations are made.

   a) The DOC should challenge all frequency allocations from 3 kHz to 300 GHz to:
      i) assess impact of revising present allocations;
      ii) assess need for additional spectrum.
      Give first priority to reviewing spectrum from 30 MHz to 3 GHz, and reassign spectrum as appropriate.

b) The DOC should examine the current spectrum allocation categories and develop a less rigid arrangement for defining spectrum usage.

c) The DOC should develop a techno-socio-economic weighting system to assist in making/revising national frequency allocations.

d) The DOC should explore use of different but compatible services for urban and rural areas within the same frequency allocation, eg. TV broadcast in rural areas with mobile in urban areas.

e) The DOC should maintain a frequency reserve in each major allocation.

2. <u>Promoting Spectrum Efficiency</u>

Three methods for improving spectrum efficiency are reviewed, with a recommendation for action for each.

a) Provide users with an incentive to conserve spectrum by relating the license fee to the amount of spectrum utilized.

b) Provide public access to the radio station licensing data base to facilitate spectrum sharing and draw attention to wasteful spectrum practices.

c) Encourage the development of more spectrum efficient technologies.

A review of coding and modulation schemes, dynamic channel assignment concepts (trunking radio), and high performance antennas provides the following recommendations:

i) In mobile radio systems, it is recommended that the most efficient methods of voice coding available should continue to be promoted by the DOC including orderly replacement of less efficient systems. An incentive should be considered where it becomes necessary for users to replace systems before their normal service life is completed.

ii) The DOC should reconsider the dedicated use of military bands and introduce trunking or other appropriate means of sharing the spectrum on a priority basis.

iii) The DOC should take a lead role in developing an open architecture trunking standard for the mobile radio bands.

iv) The DOC should continue to encourage the use of higher performance antennas where applicable, in both new and existing systems in congested areas.

3. Enhancing Spectrum Management/Engineering Capabilities

Various methods and processes are emerging that can enhance spectrum management and engineering capabilities. Computer-aided tools such as Spectrum Use Measure (SUM), Spectrum Conservation Factor (SCF), Technical Spectrum Efficiency Factor (TSEF) and the DOC's Spectrum Environment Assessment System (SEAS) are some recent examples. Recommendation is made for the DOC to continue its own research activities in this area, and to continue to monitor similar activities of other spectrum administrators.

Studies of the propagation characteristics of the various frequency bands can provide for greater utilization of the spectrum, thereby decreasing congestion and providing for emerging telecommunication services. In order to stimulate commercial development of the higher frequency bands, recommendation is made that the DOC support research activities leading to a better understanding of propagation characteristics in the bands from 20 to 300 GHz.

Recent changes in legislation, namely the new Radiocommunications Act, provide the opportunity to enhance spectrum management capabilities. Of greatest consequence is the expansion of regulatory criteria to specify not only radio apparatus, but also interference-causing equipment and radio-sensitive equipment. The increased Ministerial powers in the Act can lead to the enhancement of spectrum management capabilities. This can only occur, however, with the implementation of appropriate regulations under the Act, giving force to the legislation's capabilities.

4. Increasing Reliance on Spectrum Monitoring

Monitoring is an efficient spectrum management tool and should be given a higher priority to:

a) act as an aid in detecting and documenting unauthorized use of the spectrum;

b) assist in protecting existing users of the spectrum and provide an ongoing assessment of the spectrum environment;

c) assist in assessing spectrum usage, although the limitations of such assessments by off-air monitoring alone should be recognized.

5. Continuing International Initiatives

The expansion of radio communications on a worldwide basis points to the need for a greater degree of international frequency planning, negotiation, coordination and agreement. Canada is heavily involved in the satellite sector, with the concurrent international regulatory issues that this entails. Significant change is anticipated soon in the ITU, regarding revision of the allocation tables, frequency assignment and coordination procedures, and the establishment of new procedures. A recommendation is made for continued strong Canadian representation in international forums, to put forward and argue for radio-related issues which impact on Canadian industry, and society in general.

The globalization of markets in telecommunications in recent years indicates a need for global harmonization of standards. Both Canadian industry and government have significant roles to play in the international standard-setting process. Recommendation is made for both these groups to place a greater emphasis on these activities, if Canada is to be a part of the process, rather than belatedly reacting to changes decided by others.

6. Conducting Future-Oriented Studies

Two major goals of spectrum management are to provide for current and future requirements of spectrum users and to avoid congestion and interference. To meet these goals, accurate and timely information on spectrum requirements is necessary.

In the U.K., a process of ongoing spectrum reviews has been adopted, as a way of identifying and preparing for emerging demands for spectrum and services. Elsewhere, surveys of R & D activities have given some indication of new technologies and services, and a likely date for their availability. These inputs to the prediction of spectrum demand, while useful, should be used with caution, taking into account the subjectivity of the data they provide.

7. Reassessing Broadcast Rules & Related EMC Issues

Much of the rule-making for the broadcasting services has been formulated over the years as a reaction to complaints of impaired service. In some cases, a few reports of a service impairment have resulted in the development of a new set of rules to preclude further occurrence of that type of complaint. This has resulted in a proliferation of rules which must be adhered to in the design of new systems. Many of the old rules are now of doubtful merit. Unfortunately, the tendency has been to develop rules which constituted a significant overkill for the problem being corrected, with the result that spectrum utilization has been inhibited in a serious and unnecessary manner.

A review of these types of rules for AM and FM broadcasting services leads to the following recommendations:

a) The DOC should initiate a review of the technical broadcast rules to ensure they are in tune with present day requirements and are not unduly restrictive.

b) The DOC should refrain from using demographic information in their broadcast rules to limit RF interference.

c) The DOC should pursue the development of EMC standards for electronic devices to ensure compatibility with high power broadcast services.

d) The DOC should phase in minimum standards for broadcast receivers.

e) The DOC should pursue the development of receiver/system standards for the ILS service.

8. Considering Market Value Concepts in the System of Assigning Radio Frequency Spectrum

Currently in Canada frequency is assigned on a first come, first served basis, or, where more than one party is attempting to obtain spectrum, on a comparative hearings basis, with preference given to those applications providing greater public benefits, better spectrum utilization and overall efficiency.

The concept of receiving fair value for the use of the radio frequency spectrum has begun to take hold within some spectrum management agencies and governments worldwide. In addition to increased revenues for the administrations, significantly improved spectrum utilization could result.

In this regard, spectrum auctions are under consideration or are being implemented by several administration. These are currently seen in two forms: 1) auction of licenses for specified services or frequencies; and 2) auction of blocks of spectrum, to be managed by the purchaser. The former should have little impact on spectrum management activities, while the latter may have significant impact. With the block auctions currently being implemented in New Zealand, the successful bidder would take on significant spectrum management tasks, including the assignment (and selling) of specific frequencies to others, and to some degree, decisions on what services would be implemented.

In the initiation and operation of this block auction system, the administration's spectrum management tasks would include:

- the determination of user interest in a specified band;
- spectrum engineering, including band planning, adoption of technical parameters, and geographic and channel subdivision;
- determining the specifics of the auction process, including provisions to protect incumbents and non-profit users.

The above are only examples of the many variations on spectrum auctions. Activities in this area are at an early stage, and monitoring of other administrations' activities should continue, with an eye to determining the benefits of the process in a Canadian context.

9. <u>Promoting Use of Non-Radio Alternatives</u>

Cable systems of various types are a viable alternative to radio systems for communications between fixed points. In fact for most short range applications, multi-pair, coaxial or fibre optic cable is more competitive than radio.

Radio systems for point-to-point and point-to-multipoint communication services have traditionally been used where:

a) there is no existing cable plant and installation of cable is not feasible;

b) there is existing cable plant but the facilities are either inadequate, not cost-efficient, or, are unreliable.

The ongoing development of fibre optic systems could well address the issues outlined under (b) above, particularly if there is a competitive environment. For this reason the DOC should support the evolution towards a regulating environment permitting telephone and television cable network operators to offer competitive telecommunications services.

10. Promoting Use of Higher Frequency Bands

The growing demand for radio services likely cannot be met without increased utilization of higher frequencies. The use of higher frequencies will lessen present and future congestion of lower frequencies, particularly VHF and UHF. The technical characteristics of higher frequencies present numerous advantages, including high re-use due to high attenuation, the advantages of small antennas and compact equipment, and narrow signal beamwidth, providing more sharing opportunities.

Concerns with higher frequency usage include possible health hazards, especially when one considers the need to increase power to compensate for high attenuation. High hardware costs may also hamper active utilization of higher frequencies.

Any promotion of the use of higher frequency bands must go hand-in-hand with research into the bands' technical characteristics.

While increased utilization of higher frequencies would likely provide many opportunities, the above factors must be taken into consideration in developing any plan for promoting that increased utilization.

1.0 INTRODUCTION

The radio frequency spectrum is a finite resource which supports a broad range of services critical to the well-being of modern society. The demands on the spectrum are constantly growing. The DOC, as the custodian of this invaluable public resource, has the responsibility of regulating the spectrum in the best interests of the nation. The basic objectives of its mandate are to ensure the spectrum is used efficiently, that the spectrum is shared equitably and that harmful interference is kept under control. These basic objectives have provided guidance in identifying the spectrum management issues addressed in this report.

Specifically addressed in this report are the need for a review of present frequency allocations, the need to promote spectrum efficiency, the enhancement of spectrum management and engineering capabilities, the importance of spectrum monitoring, the importance of continuing international initiatives and conducting future-oriented studies, the need to review broadcast rules and related EMC issues, the technical implications of a market value system in assigning spectrum, and the promotion of non-radio alternatives and higher frequency bands. Recommendations have been developed to assist in formulating long-term spectrum management strategies.

The original frequency allocations were made when there was an abundance of spectrum. Now that demand exceeds supply in certain bands, the original allocation decisions need to be reviewed, especially in the mobile bands below 1 GHz. Decisions on who should get the spectrum in congested areas pose difficult questions. To aid in making the hard choices, the development of a techno-socio-economic weighting system is proposed.

To encourage the efficient use of the spectrum, a license fee structure is proposed which relates annual license fees to the amount and value of spectrum utilized. To facilitate equitable sharing of the spectrum, full public disclosure of the DOC radio license technical database is advocated; this disclosure is provided for in the new Radiocommunications Act, section 5 (1)(c). Spectrum management tools and legislative instruments which can enhance spectrum management are outlined. The importance of spectrum monitoring in managing the spectrum is highlighted. The importance of Canadian representation on the international scene is stressed, regarding the global harmonization of both spectrum usage and technical standards. As a vehicle for drawing attention to critically important EMC issues, some technical broadcast rules in need of revision are identified. An overview is provided of the spectrum auctioning experience of other national administrations and an assessment made of its technical implications to spectrum management. The report concludes with an examination of the issues and impacts of the promotion of non-radio alternatives and higher frequency bands.

The spectrum issues addressed and recommendations proposed are assembled to formulate ten spectrum management strategic initiatives:

1. Conducting an extensive review of current frequency allocations.

2. Promoting spectrum efficiency.

3. Enhancing spectrum management/engineering capabilities.

4. Increasing reliance on spectrum monitoring.

5. Continuing international initiatives.

6. Conducting future-oriented studies.

7. Reassessing broadcast rules and related EMC issues.

8. Considering market value concepts in the system of assigning frequency spectrum.

9. Promoting use of non-radio alternatives.

10. Promoting use of higher frequency bands.

2.0 SPECTRUM MANAGEMENT INITIATIVES

For each of the ten strategic initiatives identified, the following provides: a statement of the initiative with some background of the issues involved; the rationale supporting the initiative, with discussion as required; and finally, recommendations for action. In addition, expansion on some of the issues raised has been included in Annexes to this report.

2.1 Conducting Extensive Review of Frequency Allocations

The review now being undertaken by DOC in conjunction with the ITU and other national administrations provides an opportunity to stand back and examine how the spectrum is currently allocated. It is generally recognized that some of the allocations made in the past have not been effectively utilized. An example of this is seen in the currently low usage of the UHF-TV band. Other bands are experiencing heavy congestion, such as the 150 MHz and 450 MHz bands, especially in major metropolitan areas. In view of the overall concern regarding frequency congestion, current allocations should be reexamined to ensure they are optimal.

2.1.1 Present Allocations

As a starting point, there should be a broad understanding of the current allocations and how effectively they are being utilized. The spectrum allocated to the various broad categories of radio services is shown in Annex 1, Tables 1 to 3, for three major segments of the frequency band: 30 MHz to 1 GHz, 1 GHz to 3 GHz, and 3 GHz to 10 GHz. The information in the tables has been derived from Government of Canada, Department of Communications "Table of Frequency Allocations 9 kHz to 275 GHz", March, 1986. The frequency allotments can be summarized as follows:

why 1 GHz and not 30-300 MHz
300-3000
3000-30,... etc ?

30 MHz to 1 GHz; 970 MHz of Spectrum:

SERVICE	SPECTRUM ALLOCATIONS MHz	% of Band
Commercial Fixed & Mobile	250	26
Aeronautical Mobile & Navigation	75	8
Gov't of Canada Mobile	169	17
Miscellaneous	93	10
Amateur	59	6
Broadcast - Audio	20	2
Broadcast - Television	402	41

1 GHZ to 3 GHZ; 2000 MHZ of Spectrum:

SERVICE	SPECTRUM ALLOCATIONS MHz	% of Band
Aeronautical Mobile & Navigation	792	40
Radio Location	685	34
Satellite	369	18
Miscellaneous	239	12
Mobile	291	15
Fixed	1086	54
Broadcast	190	10

3 GHz to 10 GHz; 7000 MHz of Spectrum:

SERVICE	SPECTRUM ALLOCATIONS MHz	% of Band
Radio Navigation	2100	30
Radio Location	2600	37
Satellite	2600	37
Fixed	3325	48
Miscellaneous	780	11
Gov't of Canada Satellite	1400	20

The frequency band below 30 MHz was not summarized for the following reasons:

- the spectrum available is limited;
- this part of the spectrum is subject to long range propagation and requires extensive international coordination;
- bandwidth for systems using this spectrum is limited and consequently traffic handling capability is limited.

Spectrum above 10 GHz was not summarized because congestion is not as critical at this time as in the lower frequency bands.

Note that the "% of Band" figures total to more than 100%, reflecting that some frequency allotments are made to more than one category of service.

2.1.2 Need for Change

Allocations or changes to existing allocations are made in response to:

- Congestion in a particular band; examples include congestion in the 150 MHz and 450 MHz mobile bands, and in the FM broadcast band, in major metropolitan areas.
- Technological development; examples include development of cellular radio systems, and satellite communication services.
- Manufacturers or service providers desire to market a product or service; examples include mobile data services, nation-wide paging, etc.
- Users' or potential users' desire to have access to a particular service; examples include satellite links to remote camps, cellular telephone service, etc.

- Users vacating a particular band because of better service or product availability in an alternate band. An example of this scenario is the migration of users from the 30 - 50 MHz band (which exhibits "skip" phenomena) to the 150 MHz and 450 MHz bands. Manufacturers have to some extent both led the way and followed this migration of users, with the result being a lack of radio product in the lower band, and good product availability in the higher band.

- Non-utilization or under utilization of a particular band; an example of this is the current low usage of the UHF-TV band.

Currently there is significant pressure for reallocation of the bands between 30 MHz and 3 GHz, with particular pressure on the frequencies in the range 30 MHz to 1 GHz. There is a major disparity in the utilization of this latter band with some allocations facing severe congestion (eg. the mobile radio communication services and the FM radio broadcast services) while others are under utilized (eg. the UHF television service and the Government of Canada allocations). Note that these latter examples occupy a large percentage of the 30 MHz - 1 GHz band. By reallocating some of this spectrum, there is a significant opportunity for relieving pressure in the congested portions of the band. (See observations following).

2.1.3 <u>Observations with Regard to Present Allocations</u>

The following observations with respect to the current spectrum allocations are relevant.

Observations - 30 MHz to 1 GHz Band:

a) The Government of Canada mobile service occupies a significant portion (17%) of the band for a relatively small user group, compared to the 26% allocated to all other mobile users. Note that the latter group includes all private dispatch services, including many Government of Canada users (RCMP, Fisheries, DOC, etc.), and all public mobile services. Further, this commercial spectrum also supports light route point-to-point systems.

b) The television broadcast service, which is basically a point-to-multipoint service, occupies a very significant part of the band (41%) and is presently not shared with any other service.

c) The audio broadcast service, (the FM broadcast band), which is very much a mobile service, occupies only a very small percentage (2%) of the spectrum and currently there is very limited frequency availability, particularly in the urban areas, for additional stations.

Observations - 1 GHz to 3 GHz Band and 3 GHz to 10 GHz:

d) Radio location and aeronautical navigation services occupy over 50% of the spectrum in these bands. A detailed study on the utilization of this spectrum should be considered if a current analysis is not presently available.

2.1.4 Examination of Functions for Which Spectrum is Used

To assist in evaluating spectrum requirements, there needs to be an appreciation of the services or functions for which spectrum is utilized.

For purposes of discussion, two broad categories of services are considered.

a) Telecommunications Services

This category of spectrum usage includes all message traffic (voice, video and data), as well as broadcast services, and can usefully be considered under three sub-categories or service functions:

Mobile Systems:

These systems provide communication between individuals, vehicles, ships and aircraft, using mobile radio units, and between those units and fixed locations.

Examples include:

- cellular mobile telephone systems;
- private radio dispatch systems and paging systems;
- AM & FM entertainment radio broadcasting.

Point-to-Multipoint Systems:

Here communication is between one fixed location and many other fixed locations. Television broadcasting, which delivers entertainment video to many fixed locations is an obvious example of spectrum usage in this area. Note also that there are non-radio alternatives via "closed" systems such as CATV systems and telephone networks.

Point-to-Point Systems:

Here communication is between two fixed locations with point-to-point microwave systems being the most common application. Again, note that there are non-radio alternatives such as cable and fibre optic links.

b) <u>Non-Telecommunication Services</u>

Non-telecommunication services can usefully be considered under two broad categories:

Positioning Systems:

Included in this group would be radar, navigation beacons, Loran, etc. Frequency allocations for these services occupy a significant portion of the spectrum above 1 GHz.

Industrial/Commercial/Experimental Systems:
Included in this group would be industrial RF heating, home convenience devices such as garage door openers, security systems, etc. as well as the spectrum set aside for radio astronomy. Overall, the allocations for these services occupy a relatively small portion of the spectrum.

2.1.5 Alternatives to Existing Allocation Categories

Current frequency plans allocate frequency bands to quite specific services (eg. maritime mobile, land mobile, aeronautical mobile). Rapidly increasing demand on spectrum will require innovation in methods of determining allocations. As noted by Michael Goddard in the Spectrum 20/20 '89 Proceedings (Page 2.1.9),

> "Certainly, long established definitions of radio services and the rigid sub-division of the spectrum between different applications will be very hard pressed to cope with future demands. Already for example the fixed-satellite allocations are supporting what are in effect satellite broadcasting services, and various multi-function systems fit uncomfortably into the present table of allocations. One way forward might be for the spectrum to be split up according to the technology used, the system characteristics, the geographic characteristics (ie point-to-point or area coverage) etc. It may not be totally unrealistic to consider in the future for example an allocation to satellite-to-mobile communications using digital technology as opposed to allocations for mobile satellite, satellite broadcasting and radiodetermination satellite services. This would enable a common system and frequency allocation to provide for car telephone services, sound entertainment broadcasting and vehicle navigation information. Such integration of applications is clearly a logical development and it is not unreasonable to ask why, under the present regulations, such a system has to be separated into its component parts to suit the traditional compartmentalized approach..."

Such a suggestion will give the spectrum administration much more flexibility in assigning spectrum to new, developing services as they emerge.

2.1.6 Weighting System to Prioritize Allocation of Spectrum

A techno-socio-economic weighting system would be a useful tool to assist in the allocation of spectrum. Factors which might be considered include the following:

a) Potential Number of Users

In general, the greater the number of users who would benefit from the service, the higher the priority given to the service.

b) Function or Service Provided

For mobile telecommunication systems and/or non-telecommunication radio services, there is generally no practical alternative to the use of the radio spectrum. Therefore, it would seem that first priority for spectrum should be given to these services.

For point-to-multipoint and point-to-point systems there are alternatives (eg. closed systems such as cable and fibre optics). These alternatives are not always the most economic and consequently, a considerable allowance must continue to be made for radio spectrum to provide for these services. The option is there, however, to provide these services over closed systems and an effort should consequently be made to promote an environment that attracts users to utilize closed systems.

c) Proposed Area of Usage

The impact a system will have on the spectrum environment is related both to the size of area served by the system and the location where the system will be deployed. The size of area served ranges from local coverage, (for example, within a building) to wide area coverage such as that provided by a satellite service. Obviously the wide area coverage systems have the greatest impact on spectrum planning.

d) Location of Usage

The location where a system might be deployed could be in urban, rural or remote areas. Urban areas usually have the highest frequency congestion, and remote areas the least, consequently more flexibility is possible in allocating spectrum to rural and remote areas.

e) Frequency Band Proposed

Some portions of the spectrum are more desirable and hence more congested than others. Proposed services using the less congested portions of the spectrum should be given a higher priority for development.

To use the above factors, it would be useful to quantify them in some way in order to develop a "figure of merit" for spectrum usage. A possible simplistic model arrangement follows.

Factor	Classification	Figure of Merit
Number of Users	Service available to the public at large	5
	Restricted availability, but large user group	3
	Limited availability	1
Service or Function	Mobile	5
	Point-to-Multipoint	3
	Point-to-Point	1
Coverage Area	Restricted (less than 0.5 km radius)	5
	Local (few km radius)	3
	Regional or International	1
Location	Remote	5
	Rural	3
	Urban	1
Frequency Band	Above 15 GHz	5
	Between 2 and 15 GHz	3
	Below 2 GHz	1

Each service or proposed service would be evaluated, with a figure of merit assigned for each factor, which would then be totalled. The higher totals would represent services that would provide the greatest public benefit and/or have the lowest impact on the overall spectrum environment. Some examples follow:

Figures of Merit

Example	Users	Srvc.	Areas	Loc'n.	Band	Total
Cellular Telephone	5	5	3	1	1	15
Cordless Telephone	5	5	5	1	1	17
Private point-to-multipoint system with frequency below 2 GHz in urban area.	1	3	3	1	1	9
Point-to-multipoint TV broadcast in rural and remote area in 2.5 GHz band.	5	3	3	4	3	18
Private LAN network link in urban area using frequency below 15 GHz.	1	1	3	1	3	9
Government of Canada mobile service below 2 GHz.	3	5	3	1	1	13

Other issues will of course also play a part in the evaluation, but such a weighting scheme should help in setting priorities for spectrum usage.

2.1.7 Flexibility with Respect to Shared Use of the Spectrum

Present allocations permit shared use of some portions of the spectrum for different services. There would seem to be merit in continuing, and perhaps expanding, this practise. An example would be to share the UHF - television spectrum with mobile services, by allocating mobile use of the spectrum in urban areas served by cable television, but maintaining or expanding the UHF television allocations in rural and remote areas where cable television systems are not practical. It is recognized that major policy changes will be required for such reallocations, but current spectrum congestion would seem to warrant that such changes be considered.

2.1.8 Spectrum Reserve

All evidence indicates that there will be a continuing evolution and development of new services requiring spectrum usage. Some of those developments might be expected to free up currently used spectrum as users migrate to the new services operating in different sectors of the spectrum. However, the migration usually takes some considerable time and new services often need blocks of dedicated spectrum in which to develop (rather than an overlay of the new technology on existing frequency allocations). Recent examples include the requirement to provide dedicated spectrum for the cellular radio and mobile trunking systems, because of the congestion and incompatibility of overlaying these systems in the 150 MHz and 450 MHz mobile bands. Consequently, there would be merit in reserving some spectrum in order to permit the development and reasonably expeditious deployment of new services. Care would be needed to ensure that these reserves are not overly restrictive in limiting the expansion of existing services, as the spectrum, while limited, is also time dependent, and non-utilization now cannot be recovered in the future.

From the viewpoint of spectrum management, this balance between using the spectrum now and keeping a reserve for future development is not a trivial task. Factors which need to be considered include:

- the current trends in spectrum usage;
- the bands where allocations have been made, but where the spectrum is not being effectively utilized;
- technical developments;
- all the factors considered under 2.1.6 to prioritize allocation of spectrum.

2.1.9 Recommendations

Following is a summary of recommendations based on the above discussions.

a) The DOC should challenge all frequency allocations from 3 KHz to 300 GHz to:
   i) assess impact of revising present allocations;
   ii) assess need for additional spectrum.
   Give first priority to reviewing spectrum from 30 MHz to 3 GHz, and reassign spectrum as appropriate.

b) The DOC should examine the current spectrum allocation categories and develop a less rigid arrangement for defining spectrum usage, such as permitting the integration of services into one band.

c) The DOC should develop a techno-socio-economic weighting system to assist in making/revising national frequency allocations.

d) The DOC should explore use of different but compatible services for urban and rural areas within the same frequency allocation, eg. TV broadcast in rural areas with mobile in urban areas.

e) The DOC should maintain a frequency reserve in each major allocation.

2.2 Promoting spectrum efficiency

In this section, three methods for improving spectrum efficiency are reviewed:

i) Provide users with an incentive to conserve spectrum by relating the license fee to the amount of spectrum utilized. (and the band)

ii) Provide public access to the radio station licensing data base to facilitate spectrum sharing and draw attention to wasteful spectrum practices.

iii) Encourage the development of more spectrum efficient technologies.

2.2.1 License Fee

To encourage more efficient use of the spectrum, license fees should be related to the amount of spectrum resource utilized. The utilized spectrum can be defined as the product of the frequency bandwidth utilized and geographic area impacted. A simple and practical methodology for relating the license fee to the amount of spectrum resource utilized is presented in Annex 2. Application of this methodology would require establishing a monetary value for each unit of spectrum resource. This per unit monetary value could be set to recover spectrum management administrative costs, could be different for each frequency band allocation, and could also be scaled to reflect the higher administrative costs in congested areas. Alternatively, the unit value could be set to reflect market value. Besides the obvious beneficial revenue implications for the public treasury, a market value system would further encourage more efficient use of the spectrum and would tend to automatically bring demand into equilibrium with supply.

Relating license fees to the amount of spectrum utilized would present the station operator with both an incentive and a methodology for minimizing his requirements for spectrum. Even if the license fees are only a relatively small part of his operating costs, if the system operator is given the opportunity to significantly reduce his licensing fees, he will undoubtedly do so. The natural outcome would be a closer examination of implementation alternatives, leading to a more efficient use of the spectrum.

Recommendation

The DOC should introduce a license fee structure which relates fees to the amount of spectrum utilized or impacted. To further encourage spectrum efficiency and promote non-radio alternatives, the DOC should seriously consider relating license fees to market value.

2.2.2 Access to License Data Base

To facilitate efficient use of the radio spectrum, the public should have full access to the radio station licensing database. The spectrum is a public resource and every individual, company or government agency (including DND and police forces) which choose to utilize this resource should hold a radio license which is entered into the public register, with possible limited exceptions for reasons of national security. Access to this database would promote sharing of the spectrum, expedite the planning of new radio systems, aid in the resolution of interference problems, assist in identifying underutilized spectrum and generally assist in making more effective use of the spectrum.

Some agencies, companies and members of the public would undoubtedly object to disclosing information on their radio stations, preferring to keep such information private and out of the hands of any competitor or adversary. When faced with a motivated competitor or adversary, such attempts at privacy are futile and only serve to frustrate other potential users and generally lead to inefficient use of the spectrum.

If the intent is to prevent eavesdropping, it is more effective to use encryption or some other technology to achieve privacy.

It is relevant to note that under section 5.(1)(c) of the new Radiocommunications Act, the Minister has the authority to make available to the public any information set out in radio licenses.

Recommendation

The DOC should expedite regulations and implement procedures enabling the radio station licensing database and related technical files to be made available to the public in a timely manner. On-line access to the computer database should also be made available as an option.

2.2.3 Promote development of more spectrum efficient technologies.

There has recently been an emergence away from the traditional allocation of spectrum on an individually licensed user/channel assignment basis to a shared concept made possible by the availability of microprocessor and computer technology. In the past, a sophisticated approach to spectrum utilization would not have been practical. Benefits of the new technology may be seen in Cellular Radio and Mobile Trunking systems, and these advances should be applied more widely. For a brief overview on spectrum efficient technologies, see the article in Annex 3.

Coding and modulation schemes

Coding and modulation scheme developments have significantly improved spectrum efficiency. An example of the use of more efficient coding is in the planned introduction of digital technology for Cellular Radio. Advanced speech coding will initially permit three times the traffic currently being handled on analog systems and industry observers expect that additional enhancements will bring a six times improvement in two years. The U.S. is in the process of finalizing the standards for digital cellular, having tested the relative merits of a number of voice coding schemes. The Telecommunications Industries Association made use of competition between various industry promoted technologies to arrive at their selection.

Since the earliest digital radio systems were introduced, spectral efficiencies have been increased as various modulation schemes have been developed from 2-PSK to 512 QAM. However, the particular service environment, whether satellite, terrestrial point-to-point or mobile, determines the best compromise between modulation method and other system design considerations.

Dynamic Channel Assignment Concepts -- Trunking Radio

Dynamic channel frequency/time slot assignment concepts improve spectrum efficiency. An example of this may be seen in trunking radio systems which replace the conventional single user or users being assigned to a dedicated frequency. Trunking systems not only provide efficient sharing of a number of channels between a larger number of users but also offer greater ease of use. Such systems are now in service in many centres across Canada. Trunking systems which utilize channel sharing techniques are following the practice in telephone systems which have used these concepts in providing for shared voice paths. In this regard, it is noted that the DOC have recently awarded a contract to the University of Montreal to develop an Erlang C traffic engineering model for mobile voice communications systems.

The trunking radio method could also be applied to areas of the spectrum which have traditionally been held in reserve against emergency situations such as National Defense and the needs of the RCMP. Software is available through existing trunking applications to provide emergency users with the equivalent to a dedicated channel. With the appropriate priority built into the software, military users, for example, would have immediate access to a private channel. They would either have access to the last free channel, or their request for service would cause another non-military user's conversation to be immediately terminated thus freeing the channel.

Trunking radio has been developed to meet certain guidelines, notably the US APCO 16 standard, yet systems built by different manufacturers conforming to this standard are not necessarily compatible with one another. Two conforming proprietary standards dominate: Motorola and Johnson. The Motorola version is a closed system using a dedicated control channel, hence users must deal with that supplier for any of their requirements. The Johnson system, without a dedicated control channel, employs an open architecture available to other manufacturers allowing for freer competition. A preliminary comparison of the Motorola and Johnson systems is included in Annex 4.

Antennas

Congestion may also be relieved to some extent by the use of higher performance antennas. Advanced antennas are available having superior sidelobe suppression, increased front-to-back ratios and improved cross-polarization from the specifications generally available in the past. Thus there is some scope for greater frequency reuse and interference reduction by means of improved antennas. These should be required for new systems and in certain cases retrofitted on existing systems.

Recommendations

a) In mobile radio systems, it is recommended that the most efficient methods of voice coding available should continue to be promoted by the DOC including orderly replacement of less efficient systems. This should be the case especially in highly congested urban centres. An incentive should be considered where it becomes necessary for users to replace systems before their normal service life is completed.

b) The DOC should reconsider the dedicated use of the VHF/UHF military bands and introduce trunking or other appropriate means of sharing the spectrum on a priority basis.

c) The DOC should mandate an open architecture trunking standard for the mobile radio bands.

d) The DOC should continue to encourage the use of higher performance antennas where applicable, in both new and existing systems in congested areas.

2.3 Enhancing Spectrum Management/Engineering Capabilities

Technological advancements in recent years have provided, and continue to provide, improved methods for day-to-day as well as long-range spectrum management planning activities. In order to maintain Canada's position in this field, it is important to utilize these methods, as they are deemed appropriate. Rapid advancements in telecommunications in general necessitates the use of the most advanced spectrum management tools available. In addition, legislative changes can and are providing opportunities to enhance spectrum management capabilities.

2.3.1 Computer-Aided Tools

General advancements in computer technology over the years have provided spectrum managers with the ability to record more data; sort data faster; access databases from remote locations; model electromagnetic environments; combine assignment data with terrain data; and many other capabilities. As a result of these advancements, there are now a number of computer-aided tools available or being developed to assist with spectrum management activities. Currently in development by the NTIA in the U.S. are:

- Spectrum Use Measure (SUM), which allows the quantification and graphical presentation of spectrum use. This system has already been successfully applied to the fixed and land mobile services.

- Spectrum Conservation Factor (SCF), which uses engineering methodology to evaluate technologies for their spectrum-conserving properties.

- Technical Spectrum Efficiency Factor (TSEF), which is used to evaluate equipment relative to the amount of spectrum required and the power radiated by a proposed system.

Similar work is under way in Canada, with the DOC examining ways to quantify the usage of the radio spectrum in a meaningful format. The DOC Spectrum Environment Assessment System (SEAS) employs conventional transmission and propagation models and spatial analysis techniques to produce a profile of spectrum availability.

Recommendation

In conjunction with their own research activities into new spectrum management computer tools, the DOC should continue to monitor the activities of other spectrum administrators in this area with the view of evolving the management tools most appropriate for the Canadian requirements.

2.3.2 Propagation Studies

An ongoing process of propagation studies will help advance the knowledge of the specific propagation characteristics of the various frequency bands. This in turn can provide for greater utilization of the spectrum, thereby decreasing congestion as well as providing for emerging telecommunications services.

In view of the spectrum congestion situations in frequency bands below 20 GHz, the large spectrum resource above 20 GHz appears very attractive for future utilization. The large bandwidth, small number of users, high beam directivity, low potential interference and improving hardware costs all point towards increasing usage of the upper SHF and EHF bands in a number of areas in the coming decades. More research is required, however, in studying the propagation characteristics of these bands, and in developing new models to support calculation of attenuation levels, coordination distances, interference levels and sharing parameters.

In the frequencies above 60 GHz, the NTIA in the U.S. has embarked upon a limited measurement program that is directed at earth-to-space propagation phenomena in this region of spectrum. This compliments an ongoing research program in millimeter wave propagation conducted at its laboratories in Boulder, Colorado. The goal is to develop a knowledge base from which this part of the spectrum can be exploited.

Recommendation

To stimulate commercial development of the higher frequency bands, the DOC should support research activities leading to a better understanding of the radio propagation characteristics in the bands from 20 to 300 GHz.

2.3.3 Legislative Impacts

Spectrum management and engineering capabilities appear to be enhanced now as a result of significant changes introduced in the new Radiocommunications Act, in the area of interference criteria. Previously, the Act provided for spectrum management through the principles of regulating radio apparatus, and to a lesser extent, interference-causing equipment. The revised Act now specifically includes the latter, and in addition includes regulation of radio-sensitive equipment. For example, paragraph 5, sub-paragraph 1(d) of the Act states that the Minister may: "establish technical requirements and technical standards in relation to: i) radio apparatus, ii) interference-causing equipment, and iii) radio-sensitive equipment, or any class thereof;..."

In addition, the revised Act permits the Minister to require a technical acceptance certificate for any radio apparatus, interference-causing equipment or radio-sensitive equipment manufactured, imported or sold in Canada.

Over the longer term, these changes may have a significant impact on spectrum management activities. The variable involved is the degree to which these new capabilities and powers are in fact utilized.

Recommendation

With the powers granted to the Minister by the new Radiocommunications Act, it is clear that the opportunity now exists to make significant improvements in the technical aspects of spectrum management. It is recommended that the senior levels of the DOC make a commitment for change. This will be evidenced by the implementation of the appropriate regulations, giving force to the intent of the new Act.

2.4 Increasing Reliance on Spectrum Monitoring

2.4.1 Purpose for Monitoring

Government agencies responsible for spectrum assignments and usage usually have some means of monitoring at least a portion of the spectrum. This monitoring activity is typically carried out by off-air measurements using a vehicle equipped with suitable antenna and receivers, or for major centres, a permanent station may be established. The reasons this surveillance is carried out include:

a) search for unauthorized use of the spectrum;

b) to trace or identify interference sources and to ensure licensed system operators are meeting the conditions of their license;

c) to measure spectrum usage.

Some government agencies (eg. police, military, CRTC etc.) and some individuals or companies may also monitor for surveillance purposes; usually the concern here is with the content of the traffic being carried on the radio channel rather than with the technical parameters.

2.4.2 Issues

There are three essential parameters which need to be considered when developing a monitoring program: geographical locations where measurements will be made; which frequency bands will be measured; and times when measurements will be made. It is obviously only practical or economical to deploy a monitoring system which will cover a small portion of this three dimensional matrix. Consequently, there is a need to focus the monitoring activity.

Monitoring can be used to detect or confirm unauthorized or unlicensed use of the radio spectrum. Unauthorized use of the spectrum probably occurs most often in the mobile radio and broadcast bands (usually low power television or radio broadcast stations). Often the regulator is aware of this unlicensed use but will not take action because of the political ramifications (eg. turning off a television broadcast service to a small remote community). The popularity of a particular service (such as occurred with the citizen (GRS) band) can also overwhelm the normal licensing procedure. The extent of the "abuse" will often force the licensing agency to either streamline and simplify the licensing procedures (the bureaucracy involved in getting a license is often the inhibiting factor) or give up on licensing altogether (as has occurred for the citizens band).

Monitoring is useful in tracing sources of interference to licensed system users. These interference sources can be from: other radio systems which are not operating within prescribed parameters; unauthorized or unlicensed radio transmissions; leakage from closed systems such as cable television systems; or from non-radio sources such as power lines, industrial equipment etc. A mobile monitoring facility with directional antenna is useful for locating such sources of interference.

Monitoring to measure channel usage or loading is an interesting concept which can be used by a licensing agency to evaluate the utilization of select radio bands. Such monitoring programs are particularly applicable to mobile radio systems where transmitters are only active when carrying traffic. The results from such programs can be used by the licensing agencies to evaluate how effectively the existing channel assignments are being utilized and where shared channel usage might be possible. The measurements, however, must be used with caution. Some users will only have peak loads at certain times of the year and under certain conditions. Examples include: the Federal Department of Fisheries where there is significantly increased communication activity during the opening of particular areas for fishing; Forest Services, where there is increased mobile communications during fire suppression activities; public safety agencies where there may be high channel usage during an emergency situation but little or no traffic otherwise. The grade of service expected by various agencies under peak loading demand must also be considered.

Channel usage monitoring of public access mobile telephone systems and trunked radio systems operated by common carriers or restricted common carriers is effective in determining how effectively the spectrum allocated is being utilized, and can corroborate any application for additional spectrum because of congestion. These systems more closely resemble telephone systems as there are a pool of channels or circuits available to a diverse group of users. Consequently, telephone engineering parameters, involving determining the acceptable grade of service during the "busy hours", will apply.

Note that such monitoring by a licensing body can often lead to dispute with the radio system operating agency, over interpretation of the data, the grade of service which is acceptable, etc. Considering this and people's natural unease of any surveillance of what they might consider as their private activity, any monitoring program needs to be deployed with caution. If efficient spectrum usage is the main objective, then other means of achieving this, for example by the design of the license fee structure, might be a more effective management tool.

2.4.3 Recommendations

More effective use should be made of the spectrum monitoring facilities within the DOC, in order to:

a) act as an aid in detecting and documenting unauthorized use of the spectrum;

b) assist in protecting existing users of the spectrum and provide an ongoing assessment of the spectrum environment;

c) assist in assessing spectrum usage, although the limitations of such assessments by off-air monitoring alone should be recognized.

2.5 Continuing International Initiatives

Extension or expansion of radiocommunications on a worldwide basis points to the need for a much greater degree of international frequency planning, negotiation, coordination and agreement. In addition, the extent to which markets in telecommunications products and services have become global in recent years, underscores the need for global harmonization of technical standards.

2.5.1 Global Harmonization of Spectrum Usage

Existing and emerging services operating on a global basis, or impacting worldwide spectrum use, points to a further global harmonization of spectrum usage. Telecommunications activities in the international arena have a significant impact on Canada, and on Canadian spectrum management activities. There are several reasons for this, including the fact of Canada's heavy involvement in the satellite sector, seen in broadcasting, VSAT, MSAT and ongoing industry initiatives such as the Aeronautical Mobile Satellite Service.

While the international regulatory environment, in particular the ITU, is slow to change, there have recently been indications that significant changes may soon occur. Revision of the allocation tables, a simplification of frequency assignment and coordination procedures, and the establishment of new procedures are some areas currently being examined.

As an example specifically relating to satellite services, the WARC-92 conference is expected to result in reallocations in the 1-3 GHz band, in part for the extension of mobile satellite services.

Given the high level of Canadian government and industry involvement in internationally regulated telecommunications areas, it is critical that Canada maintain a strong voice in the international arena.

A continued strong representation in WARC, CCIR and other international forums is essential for Canada to put forward and argue for radio-related issues with significant impact on Canadian industry, and society in general.

2.5.2 Global Harmonization of Standards

The degree to which markets in telecommunications have globalized in recent years, points to the need for global harmonization of standards.

Recent and near-future events will further the globalization of markets in many goods and services; this is especially true in the telecommunications field. In Europe, the reality of one massive market is almost upon us, scheduled for 1992. In North America, the Free Trade Agreement between Canada and the U.S., and current trade discussions between the U.S. and Mexico highlight activities on this continent.

In the former case, the European Community (EC) has established a commission which is presently preparing technical directives with respect to standards. Concerns have arisen in North American industry regarding the closed nature of this process for developing EC standards. This is in contrast to the system in North America which allows participation by other countries from the outset.

Recent events, however, point to a more open system in the EC. The Canadian External Affairs Department reached agreement with the EC late in 1989 wherein the latter would provide draft copies of EC standards to the Standards Council of Canada, with a six-month comment period. It is clear that North American standards philosophy will only influence the EC standards to the extent that we participate in the international standard setting process. This underscores the need for not only a continued, but a strengthened Canadian presence in international standard setting forums.

In the North American context, chapter IV of the Free Trade Agreement (FTA) calls on Canada and the U.S. to "endeavour to make respective standards-related measures more compatible to reduce obstacles to trade, and costs of exporting which arise from having to meet different standards." The FTA does not, however, provide specific goals for the harmonization of standards, nor does it set a timetable for the completion of such a process. It should be noted that the process for North American standards harmonization began prior to passing of the FTA, but has been slow in progressing. The CSA in Canada and the UL in the U.S. signed a Memorandum of Understanding on the matter in 1986.

There is a body of opinion that is predicting a shakeout among the large telecommunications suppliers around the world. These companies cannot afford to make product that can only be sold in one market, and global harmonization of standards would result in larger markets, while making lower prices possible.

Both Canadian industry and government have significant roles to play in this process. Canadian manufacturers must dramatically increase their participation in the international standard setting processes. While a relatively minor player on the world manufacturing scene, it is in this way that Canadian industry can exert at least some degree of influence on the direction of world standards.

On the government side, the new Radiocommunications Act allows the Minister of Communications to "incorporate by reference", which provides the ability to easily incorporate technical standards (such as CSA   in their entirety as they are developed and deemed suitable, without going through an extensive and time-consuming process. This will allow for easier implementation of the Act's regulations which in turn will facilitate and advance the harmonization of Canadian and international standards. To further advance the cause, organizations such as the Standards Council of Canada, which accredits participation in international conferences, must be given a higher priority than at present. Untold benefits could result from any degree of standards harmonization, and the process of spectrum management would be a likely beneficiary.

2.5.3 <u>Summary</u>

Canada should continue to put forward strong representation in international telecommunications forums. This is particularly important with regards to international spectrum usage and to technical standards, as globalization of telecommunications services and markets takes place. The lines of communication must remain open between regulatory and standard setting bodies in Canada, the U.S., Japan and Europe.

Canadian industry and government must place a greater emphasis on these areas if Canada is to be part of the process, rather than belatedly reacting to changes decided elsewhere.

2.6 Conducting Future-Oriented Studies

Two of the goals of any spectrum management system are to provide for the current and future requirements of spectrum users and to avoid congestion and interference. In order to ensure that spectrum is available for these requirements, the management process must have accurate and timely information on specific requirements. The radiocommunications environment is extremely dynamic. There has been tremendous technological growth during the past three decades, expanding the level and variety of spectrum use. Growth and expansion are expected to accelerate in the future, and will make the need for timely information and better forecasting methods even greater.

Little progress has been made toward planning spectrum allocations based upon methods of forecasting other than projections based on what spectrum has been used in the past. Not only is it sometimes difficult to determine what spectrum use has been in the past, since data is collected by assignment only and not by actual use of the assignment, but these projections make certain assumptions about growth patterns. Such straightline projections of future use based upon past activity appear to have limited success in such a rapidly changing field.

2.6.1 Spectrum Reviews

The United Kingdom has adopted a process of an ongoing series of spectrum reviews, as a way of identifying and preparing for emerging demands for spectrum and services. The concept is to review the use of and likely future pressures on a particular part of the spectrum, then to move on to a different frequency range and so on until the entire spectrum has been covered, whereupon the entire process would begin again. This process is seen to enable considered decisions to be taken and a long-term strategy for spectrum usage developed, rather than simply responding to demand on a case-by-case basis with little perception as to the likely ultimate overall demand.

2.6.2 <u>R & D Surveys</u>

Another input to the process of forecasting spectrum requirements can involve an assessment of new technologies being developed through R & D activities. Forecasts based on a "Delphi" method, which might survey a large number of specialists working in the telecommunications field, can give some indication of new technologies and services and a likely date for their availability. The weakness of this process, however, is in its lack of a significant market demand component. In the early 1980s, terrestrial services were shifted in order to accommodate direct broadcast satellites (DBS), for which serious demand has yet to materialize. On the other hand, most forecasts of the market for cellular telephone service failed to anticipate the phenomenal popularity and growth of this technology and thus the need for additional spectrum to support it. For this reason it is crucial that information derived from R & D surveys be tempered by expert and objective market assessments. It must be recognized that new products and services are often developed first, to be followed by the attempt to create a demand for them. This fact must be taken into consideration in any forecasts of future spectrum requirements.

2.6.3 <u>Recommendations</u>

The DOC should consider the implementation of a systematic spectrum review process, as a tool in identifying future demand for spectrum. Other inputs to the prediction of spectrum demand such as R & D surveys and projections based on past activity are useful as well. All of these sources of information should be used with caution, however, taking into account the subjectivity of the data they provide.

2.7 Reassessing Broadcast Rules & Related EMC Issues

Much of the rule-making for the broadcasting services has been formulated over the years as a reaction to complaints of impaired service. In some cases, and as is detailed in this section, a few reports of a service impairment have resulted in the development of a new set of rules to preclude further occurrence of that type of complaint. This has resulted in a proliferation of rules which must be adhered to in the design of new systems. Many of the old rules are now of doubtful merit. Unfortunately, the tendency has been to develop rules which constituted a significant overkill for the problem being corrected, with the result that spectrum utilization has been inhibited in a serious and unnecessary manner. Examples of these types of rules and regulations which are still in effect for the AM and FM broadcasting services are summarized below. A more in-depth discussion of current broadcasting rules and related EMC issues is given in Annex 5. It should be noted that this section is not intended as an overview of all broadcast issues impacting on spectrum management, but instead addresses broadcast rules and the rule-making process.

2.7.1 AM Image Rule

The image rule was introduced as a result of many AM receivers experiencing difficulty with a new CBC station that was installed in the Maritimes at a frequency two times the receiver IF frequency from an existing station. The problem occurred because many radio receivers at that time did not use a preselector stage. Current AM radio receivers use a different design, and image interference is no longer a major problem. Cancellation of the image rule would make available additional AM frequencies across Canada.

2.7.2 AM NIL Rules

Night interference limit (NIL) contour rules are based on propagation criteria established for mid-USA latitudes. At the Canadian latitudes the propagation losses are greater and the adoption of the USA criteria has unnecessarily restricted the coverage achieved by broadcasters in Canada.

2.7.3 AM Maximum Field Strength Rule

The 1% AM transmitter rule and subsequent derivatives have been put in place to limit the number of people located within the high field strength area near the transmitter. The rule is designed to reduce the number of interference complaints the public lodge with the DOC. In the main, the interference experienced by the public results from inadequately designed or poorly installed electronic equipment.

The demographic based approach presently used by the regulator addresses the wrong issue, i.e. the reduction of complaints and not the control of interference. The long term solution should be the introduction of appropriate EMC standards for all consumer and commercial electronic equipment. The DOC has a mandate to manage the spectrum and cannot control where people choose to reside.

2.7.4 Co-Location of FM Stations Operating at 800 KHz Separation

As the FM broadcasting services expanded, many stations were approved in Canada for operation in a city with an 800 KHz separation. This was deemed to be an adequate separation for contemporary receivers. Unfortunately, it was discovered that the reception quality of some receivers was adversely affected when these adjacent stations were received at signal levels much higher than the desired station. The DOC resolved the problem by implementing the co-location rule. A better long term solution would have been to implement an appropriate receiver standard.

2.7.5 Restrictions on FM Allocation to Protect TV Channel 6

The use of FM broadcast channels in the band 88 to 92 MHz is severely restricted in areas where TV Channel 6 is licensed. The restriction is intended to assure at least 90% of Channel 6 TV viewers will receive a good quality signal. The restriction on the FM channels should be removed, as TV reception in urban/suburban areas is now predominantly via cable, and rural areas are not subject to the high level urban signals which initiated the restriction.

2.7.6 ILS/FM Broadcast Service Conflict

Severe limitations on the use of FM broadcast channels are imposed in areas where ILS services are provided for local airports. Unfortunately, the ILS service was allowed to develop without adequately considering the interference potential from the adjacent spectrum service. At this point there appear to be only two basic alternatives to resolving this service conflict: move one of the services to a different spectrum allocation or develop appropriate receiver/system standards for the ILS service which would limit its susceptibility to interference from FM broadcast stations.

2.7.7 Recommendations

To remedy the spectrum issues outlined above, it is recommended that the following action items be undertaken:

a) The DOC should initiate a review of the technical broadcast rules to ensure they are in tune with present day requirements and are not unduly restrictive.

b) The DOC should refrain from using demographic information in their broadcast rules to limit RF interference.

c) The DOC should pursue the development of EMC standards for electronic devices to ensure compatibility with high power broadcast services.

d) The DOC should phase in minimum standards for broadcast receivers.

e) The DOC should pursue the development of receiver/system standards for the ILS service.

2.8 Considering Market Value Concepts in the System of Assigning Radio Frequency Spectrum

Currently in Canada frequency is assigned on a first come, first served basis, or, where more than one party is attempting to obtain spectrum, on a comparative hearings basis, with preference given to those applications providing greater public benefits, better spectrum utilization and overall efficiency.

2.8.1 Fair Value for Spectrum

The concept of receiving fair value for the use of the radio frequency spectrum has begun to take hold within some spectrum management agencies and governments worldwide. In addition to the possibility of increased revenues for the administrations concerned, there are numerous other reasons this idea is being considered, and in some cases enacted. Simply put, the higher prices for the use of spectrum which would likely result, would encourage the obtaining of the least amount of spectrum needed, and the most efficient use of that spectrum, and would extend to the use of spectrum-conserving technologies as they are developed.

2.8.2 Spectrum Auctions

The question which then arises is how best to determine a fair value for the spectrum. Several administrations have begun to consider the auctioning of radio spectrum, either in the form of licenses for specified services and frequencies, or in the form of blocks of spectrum, to be managed by the purchaser. These two possible approaches to spectrum auctioning present distinct impacts on the current management of the spectrum.

A. License Auctioning

The situation in Australia can be cited as an example of this form of auction. The administration in that country has undertaken a program wherein the number of FM stations would be increased, with new FM licenses awarded on a highest bid basis.

The program will incorporate two distinct scenarios. Stage 1 will satisfy the desire of many AM broadcasters to convert to FM. In certain cities, existing AM broadcasters will be invited to submit tenders for FM licenses. Once the successful bidder has been identified (based on highest qualified bid), an independent valuation of the bidder's AM site and facilities is undertaken. This dollar value would then be deducted from the total dollar amount bid, to arrive at a net cash balance to be paid. The vacated AM facilities and site would then be transferred to the Commonwealth for non-commercial use, such as Radio for the Print Handicapped and Parliamentary broadcasts.

In Stage 2, the process is quite straightforward. Applications, including a sealed bid, will be invited for the granting of new FM licenses. A simplified license grant inquiry will determine and eliminate any unsuitable applicants. Once this has been done, the FM license will be awarded to the highest bidder (provided the bid is equal to or greater than a pre-set reserve price). Further details of Australia's two-stage program can be found in Annex 7.

The impact on spectrum management of this form of spectrum assignment appears minimal. The allocation of spectrum to particular services could continue as before. It is also assumed that spectrum management provisions regarding technical standards, frequency coordination and interference issues would be retained. Perhaps the only issue would be possible changes to and weakening of provisions for the revoking of a license of an operator contravening regulations. Once again, it is expected that any administration taking this approach to spectrum assignment would take this issue into consideration, and institute appropriate remedies.

B. Block Auctioning

An example of this more all-encompassing approach is seen in the New Zealand situation. In that country, legislation has been passed and amended which to a large extent deregulates the telecommunication industry. This deregulation is expected to lead to an increased demand for some radio frequencies. In addressing this increased demand, the government is implementing an auction system for the assignment of the majority of frequency bands, to be phased in over a period of time, and with certain constraints and exceptions. The following are some of the systems' main features; additional details are contained in Annex 6, comprised of the text of an address by Michael Lear, manager of Telecommunications and Postal Policy for the government of New Zealand.

- The provision for the definition of "spectrum property rights", which "will allow operators far greater freedom to manage and develop their use of spectrum than before."

- Rights would be of long duration (likely 20 years), and would be tradeable and sub-dividable.

- Tenders would be held on a sealed bid basis.

- Auctions would include current assignments, but incumbent licensees will have specified provisions for protection, for a limited time period.

In terms of management of the spectrum, the most significant feature of this system is the delegation of some spectrum management tasks to the successful bidder. While the operating parameters of the band being auctioned would be clearly specified -- including the frequencies, levels of interference, limitations on emissions outside the band, the time period for which the right applies and conditions which apply to the right -- the successful bidder would take on significant management tasks. This would include the assignment (and selling) of specific frequencies to others, and to some degree, decisions on what services would be implemented.

The New Zealand scenario anticipates continued government management of: frequencies below 44 MHz, due to long distance propagation; frequencies above 3.6 GHz, due to lack of demand; frequencies to provide for short-term broadcasting uses; and residual frequency management where a particular service is tendered (e.g., if a high power FM radio service is defined for a specified location, use of that frequency in a wide geographic area may have to be managed.

To initiate and operate the system being discussed, the government's broad spectrum management tasks would include:

- The determination of user interest in a specified band. This would include a request for views on their likely interest in right ownership, together with technical or operational factors seen to influence subsequent spectrum engineering activities.

- Spectrum planning, seen to be potentially the most complex part of the system. This might include creation of a band plan, with geographic and channel subdivision, and the adoption of technical parameters, including spectrum edge criteria for interfacing with the adjacent spectrum.

- Determination of the allocation process, which would set out the specifics of the auction system, including protection provisions for incumbents and non-profit users.

Additional responsibility for the government's spectrum management agency is seen in the operation of a spectrum registry, very similar to a land registry, and forming the legal basis of tenure of the spectrum. This would be a publicly available record, containing information on ownership and details of usage of the specified frequencies. There will be certain requirements for the title holder to ensure that uses which are recorded against a title are practical and that existing spectrum use has been taken into account. Therefore, the requirement for some form of certification process would continue.

2.8.3 Conclusions

The above having been said, it should be stressed that these two scenarios are only examples of the many variations which could exist in an auction environment. There is no way to know precisely the impacts of this process, as any administration considering this approach can introduce myriad restrictions and controls over its implementation and operation. In addition, the implementation of auction systems in other countries is at a very early stage, with the results of these activities not yet available, or very preliminary at best. Nevertheless, some of the issues outlined above should give an indication of some possible impacts of spectrum auctioning on current spectrum management activities in Canada. Monitoring of the early results of other administrations' activities in this regard should continue, with an eye to determining the benefits of the process in the Canadian context.

2.9 Promoting Use of Non-Radio Alternatives

Cable systems of various types are a viable alternative to radio systems for communications between fixed points. In fact for most short range applications, multi-pair, coaxial or fibre optic cable may be more competitive than radio. Even microwave radio is giving way to fibre optic cable systems in many cases for long-haul high capacity transmission systems.

Radio systems for point-to-point and point-to-multipoint communication services have traditionally been used where:

a) there is no existing cable plant and installation of cable is too expensive, and/or not practical because of terrain, the cost of acquiring access to a right-of-way, etc;

b) there is existing cable plant but:
   i) the existing cable facilities are not capable of carrying the type of communication services desired;
   ii) the lease cost for carrying the services on the cable system cannot be justified when compared with the cost of deploying a radio system;
   iii) the cable system is not considered to be sufficiently reliable.

Both the telephone companies and the cable television operators have extensive cable networks with each operating as a monopoly within its own jurisdiction. As the cost effectiveness of installing fibre optic cable becomes ever more attractive, both the telephone companies and cable operators are positioning themselves to deploy an extensive broadband network. Such networks would have the capability of providing point-to-point and point-to-multipoint distribution services including telephone, data, television, etc.

The ongoing development of fibre optic systems could well address the issues outlined under (b) above, particularly if there was a competitive environment. The example of cellular telephone development, where competition was a major driving force in providing a cost effective service, might well be used when considering policy with respect to the evolution and advancement of new cable systems.

2.9.1 Recommendation

The DOC should support the evolution towards a regulatory environment which would permit the telephone companies and cable TV operators to offer competing cable-based telecommunications services. This would result in improved service to consumers at more competitive prices, with a wider range of services becoming available.

The implications of these developments with respect to spectrum management are that the point-to-point and point-to-multipoint services currently using radio spectrum will evolve toward closed cable systems, thus freeing up spectrum for other services. An example of this is the trend which is occurring in television broadcast. Very few new local transmitting facilities are being applied for or licensed. Rather, new video services are using satellite for national distribution and cable television for local distribution. At some point, as the availability of cable television to the households in an area approaches 100%, the need for the high power local television broadcast transmitting facilities must be questioned. The reallocation of this spectrum, at least in areas where cable penetration is high, could have a significant impact on spectrum availability for other services.

2.10 Promoting Use of Higher Frequency Bands

While it is true that a great deal of progress has been made in more efficient exploitation of the VHF and UHF bands, it is clear that the growing demand for radio services cannot be met without moving to higher frequency bands. While it is generally recognized that congestion problems are being experienced now in the VHF and UHF bands, some estimates indicate that by the year 2000, congestion will also be evident in some areas in the lower SHF band. In addition, the growing global interest in the utilization of higher frequencies was reflected in the 1979 WARC, during which the ITU Table of Frequency Allocations above 20 GHz was revised to stimulate new development of these bands. It seems, therefore, that the time is right to consider the specific promotion by government agencies of the use of higher frequency bands. The following examines some of the issues surrounding this initiative.

2.10.1 Rationale

The most obvious reason to promote the use of higher frequency bands is to lessen present and future congestion in the lower bands, especially VHF and UHF. In addition to this, the re-allocation of spectrum -- which can be described as a reactive solution to congestion problems -- is expensive and slow to implement. Global trends toward personal communications will undoubtedly accelerate the need for utilization of higher frequencies.

2.10.2 Advantages of Higher Frequencies

There are a number of clear advantages in a move to utilizing higher frequencies:

- the spectrum is relatively abundant;
- much frequency re-use can occur due to high attenuation;
- smaller antennas and more compact equipment;
- narrow antenna beamwidth, allowing more sharing opportunities, as the possibility of interference is reduced; this can also provide for security of transmission.

To illustrate some of the above: At 60 GHz a sharp peak occurs in atmospheric absorption, which can provide high-security short-range tactical military communications; similarly, a civil application exists for in-building LANs.

Many possibilities exist for increased usage of spectrum above 20 GHz, with services now available or in development. These include space research; intersatellite links; broadcasting, in particular HDTV and multipoint TV distribution systems; broadband high speed data transmission; personal satellite radio; radiolocation; in-building broadband systems, including LAN, cordless phone and wireless PABX; microcellular systems; and satellite applications involving mobile and very small aperture terminals.

While many of the above are currently seen by their proponents as eventually utilizing frequency below 20 GHz, their development for the utilization of higher frequencies is feasible.

2.10.3 Concerns

Several problems exist in the utilization of higher frequency bands, and this extends to the promotion of that utilization. Two major difficulties are atmospheric attenuation and hardware costs (especially above 40 GHz). High attenuation restricts usage and can mean a need for many repeaters, even in short-range operation. With regard to high hardware costs, the situation is slowly improving, with applications in the 40-100 GHz range perhaps becoming affordable in this decade.

Generally speaking, as the frequency band of operation increases, the cost and power efficiency of the RF technology are both adversely affected. This becomes especially clear when one looks at the emergent field of personal communications. A need for increased power would adversely impact battery operation. And it is not currently clear what frequency limits there will be for integrated circuit technology, in order to yield adequate performance in high volumes and low cost.

Others caution against requirements for high circuit availability in the utilization of higher frequency bands, as circuit cost will be a very sensitive function of the desired circuit availability. This would appear to indicate that a good case could be made not to overdesign commercial systems by requiring an excessively high circuit availability, particularly for private systems, as the cost burden will fall on the user, for something that is probably not required.

Another area of concern in the utilization of higher frequency bands, and which has not been thoroughly explored, is the health hazards posed by radio frequency radiation. Frequency-related power absorption studies indicate that, in general, average absorbed power increases by a factor of 100 for every increase in frequency by a factor of 10, in the 1 MHz to 400 MHz range [As stated in: "Future Public Land Mobile Telecommunications Systems", CCIR Interim Working Party Document IWP 8/13-45, dated June 8, 1989, at page 57]. As frequency is increased, 2.10.3 Concerns

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2.10.4 Research

It is critical that any promotion of the use of higher frequency bands go hand in hand with research into the characteristics of these bands. The importance of research into the various aspects of the radio frequency spectrum has been discussed elsewhere in this report, but is especially significant in the higher frequency bands. It is extensive and ongoing research which will enable the full and efficient utilization of these bands. The promotion of higher spectrum utilization must be preceded and supported by this research, or significant levels of usage will simply not result. Related benefits of research in the higher frequency bands can be a leadership role for Canada in leading edge technology, with related possibilities for new services, products and industries, and the opportunity of export markets for them.

2.10.5 Summary

The utilization of higher frequencies by both current and emergent services should be actively promoted. The degree to which this evolution will occur rests on an increased base of knowledge regarding the technical characteristics of the higher bands; hardware costs will also play a significant role. These factors must be taken into consideration in developing a plan for encouraging the use of higher frequency bands.

3.0 CONCLUSION

The initiatives and their related recommendations discussed herein provide a basis for the optimization of spectrum management in Canada. The Department of Communications has acted prudently in foreseeing a need for changes to enable the highest level of spectrum management to be maintained in the future. The recent (October, 1989) implementation of a substantially revised Radiocommunications Act provides the Communications Minister with greater discretionary powers in the management of the radio frequency spectrum. Conditions now seem right for the consideration of initiatives aimed at optimizing frequency management.

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ANNEXES

ANNEX 1

Spectrum Allocation Tables for Major Canadian Services

ANNEX 1

SPECTRUM ALLOCATION TABLES FOR MAJOR CANADIAN SERVICES

General Notes to the Tables

1. Information in the tables has been derived from Government of Canada, Department of Communications "Table of Frequency Allocations 9 KHz to 275 GHz" March, 1986.

2. Frequencies have been rounded to the nearest 1 MHz.

3. Note that some frequency bands are allocated to more than one category of service.

4. An asterisk ("*") indicates a secondary service allocation.

Table 1

CANADIAN FREQUENCY ALLOCATIONS 30 MHz - 1 GHz

(Total Spectrum 970 MHz)

	SPECTRUM ALLOCATION [MHz]						
Frequency [MHz]	Commerc. Fix./Mob.	Aeronaut Mob./Nav	Govt of Canada Fix./Mob.	Misc.[1]	Amateur	Broadcast Audio	Broadcast TV
30 - 50	20						
50 - 54					4		
54 - 72							18
72 - 76				4			
76 - 88							12
88 - 108						20	
108 - 137		29					
137 - 138				1			
138 - 144	6						
144 - 148					4		
148 - 174	26						
174 - 216							42
216 - 220	4						
220 - 225					5		
225 - 329			104				
329 - 335		6					
335 - 400			65				
400 - 410				10			
410 - 430	20						
430 - 450				20 [3]	20 *		
450 - 470	20						
470 - 608							138
608 - 614				6 [4]			
614 - 806							192
806 - 902	96			12 [5]*			
902 - 928	26			26 [5]	26 *		
928 - 960	32			14 [5]*			
960 -1000		40					
Spectrum Allocation Totals	250	75	169	93	59	20	402
% of Band.	26%	8%	17%	10%	6%	2%	41%

See notes on following page

Notes to Table 1 - Canadian Frequency Allocations 30 MHz - 1 GHz

[1] Miscellaneous use unless otherwise noted includes narrow band allocations set aside for:

-Radio Astronomy
-Fixed
-Mobile
-Aeronautical Radio Navigation
-Space Operation
-Meteorological Satellite
-Space Research
-Radionavigation - Satellite
-Standard Frequency and Time Signal Satellite
-Meteorological Aids
-Mobile - Satellite

[2] Mobile use sometimes includes narrow bands or specific frequencies set aside specifically for emergency and distress calling.

[3] The indicated band is allocated to the Radiolocation service category.

[4] The indicated band is allocated to the Radio Astronomy service category.

[5] The indicated band is allocated to the Radiolocation service category but limited to Government of Canada shipborne radars.

Table 2

CANADIAN FREQUENCY ALLOCATIONS 1 GHz - 3 GHz

(Total Spectrum 2000 MHz)

Frequency [MHz]	Aero Mob/Nav	Radio Location	[3] Satellite	Misc.	Mobile	Fixed	Bdcst
	SPECTRUM ALLOCATION [MHz]						
1000 - 1215	215						
1215 - 1240		25	25 (S-E)				
1240 - 1300	60	60					
1300 - 1350	50						
1350 - 1370	20	20					
1370 - 1400		30					
1400 - 1429				29 [1]			
1429 - 1525					96 [2]	96	
1525 - 1530				5 [1]	5 [2]		
1530 - 1559			29 (S-E)				
1559 - 1610	51		51 (S-E)				
1610 - 1626	16						
1626 - 1660			34 (E-S)				
1660 - 1670				10 [1]			
1670 - 1700			30 (S-E)	30 [4]			
1700 - 1710			10 (S-E)	10 [4]		10	
1710 - 2290						580	
2290 - 2300				10 [1]		10	
2300 - 2450	80	150		50 [5][6]		150	
2450 - 2500		50		50 [6]		50	
2500 - 2550		50	50 (S-E)		50 [2]*	50	50 [7]
2550 - 2596			46 (S-E)		46 [2]*	46	46 [7]
2596 - 2690			94 (S-E)	35 [1]*	94 [2]*	94 *	94 [7]
2690 - 2700				10 [1]			
2700 - 3000	300 [8]	300 *					
Spectrum Allocation Totals	792	685	369	239	291	1086	190
% of Band.	40%	34%	18%	12%	15%	54%	10%

See notes on following page

Notes to Table 2 - Canadian Frequency Allocations 1 GHz - 3 GHz

[1] Miscellaneous use unless otherwise noted includes allocations set aside for:

- -Earth Exploration Satellite
- -Radio Astronomy
- -Space Research
- -Space Operation
- -Fixed
- -Meteorological Aids

[2] Mobile allocations in the indicated band are for the exclusive use of the Government of Canada.

[3] The following codings are used under the satellite allocations:

S-E indicates space to earth transmissions
E-S indicates earth to space transmissions

[4] These bands are allocated to the meteorological satellite service.

[5] The band 2400 - 2450 MHz may be used by the amateur satellite service on a secondary basis.

[6] The band 2400 - 2500 is designated for industrial, scientific and medical applications.

[7] The broadcast satellite services allocated in the band 2500 - 2690 MHz are limited to national and regional systems.

[8] This band has been allocated for radar systems.

Table 3

CANADIAN FREQUENCY ALLOCATIONS 3 GHz - 10 GHz

(Total Spectrum 7000 MHz)

Frequency [MHz]	Radio Nav.	Radio Location	[2] Satellite	Fixed	[1] Misc.	Govt. of Canada
	SPECTRUM ALLOCATION [MHz]					
3000 - 3100	100	100 *				
3100 - 3500		400			200 *	
3500 - 4200			700 (S-E)	700		
4200 - 4400	200					
4400 - 4500				100		100 *[3]
4500 - 4800			300 (S-E)	300		300 *[3]
4800 - 5000				200	200	
5000 - 5250	250					
5250 - 5350		100			5 *	
5350 - 5650	300	300 *				
5650 - 5850		200			200 *	
5850 - 7075			1225 (E-S)	1225	75 *	
7075 - 7250				175		
7250 - 7750						500 [4]
7750 - 7900				150		
7900 - 8025						125 [4]
8025 - 8400		[5]	375 (E-S)	375		375 [5]
8400 - 8500				100	100	
8500 - 8750		250				
8750 - 10000	1250	1250				
Spectrum Allocation Totals	2100	2600	2600	3325	780	1400
% of Band.	30%	37%	37%	48%	11%	20%

See notes on following page

Notes for Table 3

[1] Miscellaneous use unless otherwise noted includes allocations set aside for:

-Amateur
-Radio Astronomy
-Space Research

[2] The following codings are used under the satellite allocations:

S-E indicates space to earth transmission
E-S indicates earth to space transmission

[3] The indicated band is allocated to the Government of Canada mobile services.

[4] The indicated band is allocated to the Government of Canada satellite service.

[5] The indicated band is allocated to the Earth exploration satellite shared with Government of Canada satellite service.

ANNEX 2

Relating License Fee to Utilized Spectrum

ANNEX 2

Relating License Fee to Utilized Spectrum

To relate radio station license fees to the utilized spectrum, it is first necessary to carefully define what is meant by "utilized spectrum". For this analysis, it is convenient to use the following definition:

$$\text{Utilized Spectrum} \triangleq \text{Utilized Signal Bandwidth} \times \text{Geographic Area Impacted}$$

In the case of a transmitter, the signal bandwidth is taken to be the necessary bandwidth as calculated per TRC-43. For receivers it is defined to be the bandwidth between the 80dB attenuation points as filed in the Engineering Brief for multichannel radios, and the spacing between adjacent RF channels for single channel radios. The principal geographic area impacted is that area within the main lobe of the antenna out to a distance where the transmitter power has decayed to an insignificant level, i.e. the interference boundary.

The distance to the interference boundary is a function of the transmitter power and, in the worst case, the free space path loss (FSPL). Since the FSPL varies with the square of the distance, it follows that the distance to the interference boundary varies with the square root of the transmitter power.

From antenna theory, it is well known that the beamwidth between the first nulls, or other points on the main lobe can be closely estimated using the appropriate scale factor times the 3 dB beamwidth.

Combining the above factors, we can establish that the Geographic Area Impacted is given by:

$$\begin{aligned}\text{Sector Area} &= 1/2 \text{ X } (\text{Radius})^2 \text{ X Sector Width in Radians} \\ &= \text{Constant X (Transmitter Power) X Antenna 3 dB Beamwidth}\end{aligned}$$

And therefore,

Utilized Spectrum = Constant X (Transmitter Power)
X Antenna 3 dB Beamwidth
X Utilized Signal Bandwidth

$$= \text{Constant} \times W\,[A_R\ B_R + A_T\ B_T]$$

where,

A_R = Receive antenna horizontal 3 dB beamwidth in degrees

A_T = Transmit antenna horizontal 3 dB beamwidth in degrees

B_R = Receiver RF/IF selectivity response bandwidth to the 80 dB rejection points as filed in the Engineering Brief for multichannel radios,and for single channel radios, the spacing between adjacent RF channels

B_T = Transmitter necessary bandwidth as calculated per TRC-43

W = Transmitter RF power into the antenna in watts

The license fee (L) can therefore be related to the utilized spectrum using the following relationship:

$$L = VW\,[A_R\ B_R + A_T\ B_T]$$

where V is a constant multiplier in $/MHz/degree/watt. The value of V could be different for each frequency band and could be set to yield revenues comparable to the present fee structure. Alternatively, it could be set to reflect the degree of frequency congestion, spectrum value or any other combination of factors deemed appropriate. For radio stations which share a frequency assignment in their service area, the license fee could be prorated in accordance with relative usage.

The above approach for establishing license fees has several significant benefits, i.e.:

a) The operator is given a financial incentive to reduce transmitter power and spectrum utilized to a minimum.

b) The operator is encouraged to use more efficient coding/modulation schemes as the license fee is related to the utilized spectrum and not the amount of traffic carried by the radio channel.

c) The basic data required to calculate the license fee are readily available.

The limitation of the above fee proposal is that it does not take into account the terrain characteristics. However, this could be considered at some future date should appropriate digitized topographic maps become generally available.

Following are two examples of how this licensing concept might apply in the microwave bands. V is arbitrarily set to $5.00/MHz/degree/watt and $B_R = B_T = 19.5$ MHz.

1.9 - 2.3 GHz Band

Antenna Size (ft.)	Antenna Gain (dB)	Antenna 3dB Beamwidth (degrees)	Reference Link EIRP Required (dBW)	Tx Pwr Required (Watts)	License Fee (L)
6	29.5	5.5	34	2.82	$3,024
8	32.0	4.1	34	1.58	1,263
10	33.9	3.3	34	1.02	656
12	35.5	2.8	34	0.71	387
15	37.4	2.2	34	0.46	197

7.1 - 7.7 GHz Band

Antenna Size (ft.)	Antenna Gain (dB)	Antenna 3dB Beamwidth (degrees)	Reference Link EIRP Required (dBW)	Tx Pwr Reqired (Watts)	License Fee (L)
6	40.5	1.5	45	2.82	$ 825
8	43.0	1.1	45	1.58	339
10	44.7	0.9	45	1.07	188
12	46.7	0.7	45	0.68	93
15	48.1	0.6	45	0.49	57

Note that the license fee increases rapidly for transmitter powers in excess of 1 Watt and that the license fee is less in the higher band. The rapid increase with transmitter power results from tying the fee directly to the area impacted, whereas the decrease at higher frequencies is a result of the narrower antenna beamwidth.

Summary

A method has been developed for relating license fees to the amount of spectrum resource utilized, making use of readily available data. The approach used has a sound technical base and logically should encourage more efficient use of the spectrum if implemented.

ANNEX 3

Greater Spectrum Efficiency and Use of Higher Frequency Bands

GREATER SPECTRUM EFFICIENCY AND USE OF HIGHER FREQUENCY BANDS

R. W. Breithaupt

Department of Communications

Communications Research Centre
Ottawa, Ontario, Canada

ABSTRACT

We are all aware of the dramatically increasing demand for frequency assignments across many parts of the radio spectrum to meet the growing demand for new services. This is manifested by recent battles regarding international and domestic frequency allocations and also over the subsequent coordination and licensing, particularly in the UHF area. The problem is most severe in large congested metropolitan areas. There are a number of ways to resolve this dilemma, including off-loading to "wired or fibre" services, more efficient use of existing allocations, and the use of higher frequency bands. This paper intends to briefly review some possibilities for these latter two options.

Increased spectrum efficiency can be achieved in a number of ways, which depend on whether a terrestrial or satellite radio system is considered. They include new coding and modulation techniques (which are making mobile satellite services commercially viable), demand assignment, multiple beam reuse, spacecraft-switched TDMA, spread spectrum overlay, polarization reuse, cellular pattern reuse, and others.

Similarly, a global trend exists for the use of higher frequency bands, with both military and civil use of EHF satcom frequencies, either for experimental or operational systems. Innovative use of these bands is also proposed for terrestrial systems. It is notable that renewed interest in the use of HF frequencies exists, as well as the pressure to exploit higher frequency bands.

CURRENT UTILIZATION AND CONGESTION

A thorough review of current utilization of the domestic frequency allocations has been provided elsewhere in this Conference (eg. La Rareté des Fréquences - Jean-Marc Pellerin), and this need not be repeated here. The review reveals an increasing congestion, generally in the VHF - UHF region.

The General Radio Service or CB appears almost unusable, or at least unattractive due to congestion. VHF is becoming increasingly crowded for marine and aeronautical application, to the point where aeronautical control is becoming a concern. The explosive growth of cellular mobile systems in the 800 MHz band is already causing serious congestion in Canada's major urban areas. As a result, cell sizes are decreasing to a few km to accommodate more users, but a limit is approaching, determined in part by hand-off requirements.

Satellite systems cannot compete with the frequency reuse factors possible for terrestrial cellular mobile systems, because small cell sizes are much more costly to achieve. However for fixed satellite services, geostationary orbit spacing has been reduced to approximately two degrees at C band, and at Ku band. This narrow orbital separation essentially dictates the ground terminal size necessary to avoid interference. The use of dual polarization has now become commonplace.

It would appear that TV and FM radio transmission are large inefficient users of spectrum, due to the large guard bands allowed for each TV channel, as well as the use of frequency modulation.

TECHNIQUES FOR IMPROVED SPECTRUM EFFICIENCY

Modulation and Coding

A great deal of progress has been made over the past few years in regard to digital and analog voice coding. Whereas NBFM 30 kHz bandwidth voice channels are presently the norm for toll quality in a cellular system, it is now possible to consider both ACSSB (Amplitude Companded Single Sideband) analog and LPC (Linear Predictive Coding) digital implementations which provide good voice quality in a 5 kHz channel. This saving of a factor of six is achieved through the routine use of advanced digital signal processors (eg. TI TMS 320 series) in implementation. A toll quality goal using 4.8 kbps vocoders exists for new systems under development. The traditional problem of robustness against background noise experienced with lower rate LPC has been minimized with codebook excitation techniques, although analog techniques continue to have an advantage in degrading gracefully against increasing noise levels. This fact gives ACSSB an advantage in deep fading environments such as mobile satellite channels. A number of Canadian companies are presently involved in the implementation of both ACSSB and LPC, exploiting technology developed initially at the Communications Research Centre. The term ACSSB is now being replaced by NSQAM (Narrowband Speech Quadrature Amplitude Modulation).

It appears that 4.8 kbps is emerging as a standard for aeronautical satellite communications including both commercial and general aviation; being the choice for AUSSAT, INMARSAT Standard M, and a strong candidate for MSAT and AMSC. At the present time 4.8 kbps performance is closer to communications quality than toll quality.

For particularly difficult spectrum congestion, new spectral efficient modulation techniques are emerging which involve dynamic spectral reduction of the voice signal. These techniques can produce communications quality and are robust against background noise. A real-time transformation between the time and frequency domain is achieved through microprocessors. Voice channel bandwidths as low as 750 Hz are possible, with a current potential application in military tactical radio.

Current digital modulation techniques to maximize spectrum efficiency for terrestrial or satellite systems involve continuous phase modulation (CPM) and trellis coded modulation (TCM), which combines modulation and channel coding. Examples include JPL's 8 DPSK and DOC's 16 QAM. New modulation techniques take advantage of dynamic channel equalization, particularly for mobile or personal applications.

Demand Assignment and SSTDMA

Demand assignment is now the norm for FDM channels in cellular mobile systems, and this ensures a high trunking efficiency, which maximizes the number of users and ensures the dynamic and efficient use of power and spectrum. DAMA systems are considered essential for the commercial viability of mobile satellite systems.

Next generation satellite systems will incorporate an increasing degree of on-board processing and a dynamic selection from multiple antenna beams, thus allowing easy reconfiguration and dynamic signal routing to meet changing traffic demand.

Spread Spectrum

Spread spectrum is a hotly-debated code-division multiple-access scheme, where each user slightly increases the effective background noise over the total utilized bandwidth. It is seen as a convenient means of overlaying a new service into a frequency band already allocated to another service, or to other users. The technique clearly lends itself to secure communications, and increasing interest and use is evident in its various civil applications. However, its performance claims are conditional on many assumptions, and it is not clear whether any increase in communications capacity would occur for a given bandwidth over FDM or TDM systems. For satellite application, stringent discipline in ground terminal output power control is required. Viable commercial operation for a large user community remains to be demonstrated. Position-location systems employing this concept have recently been introduced.

Reverse Band

The reverse band technique for satellite communications has been proposed for some time, but has not yet been exploited due to high risk and associated cost. It would provide a frequency reuse factor of two, as a result of reuse of spectrum in the forward and return links to the satellite, by interchanging them. The two primary interference problems to be managed include interference from one satellite's transmission directly into the receive band of an adjacent satellite, and interference between mobile terminals interfering directly into other terminals. The first of these problems is dealt with through suitable spacecraft antenna sidelobe control, and the second through more pattern discrimination in the ground terminal antenna.

Orthogonal Polarization

Although originally intended, co-channel orthogonal polarization has not yet been used for terrestrial (8 GHz) systems in Canada, due to multipath depolarization effects and antenna design problems. As a result of limited capacity and increasing demand, as well as of limitations in improvement through more complex modulation schemes, this technique is being reconsidered for high capacity terrestrial links below 10 GHz. Considerable international development work is underway on 256 QAM co-channel systems which might be considered as competition to long haul fibre, but in any case would serve as a suitable backup for long-haul terrestrial fibre networks which are probably more vulnerable to damage than radio systems. Radio systems are expected to retain an advantage in areas of severe terrain.

On terrestrial links above about 10 GHz, rain depolarization is a greater problem than multipath depolarization . Above about 15 GHz, rain attenuation outages dominate those due to rain depolarization on earth-space links.

Orthogonal systems are, in fact, used on the ANIK C and other Ku-band satellites, thus effectively increasing usable bandwidth by a factor of two. Multipath is not a factor for C or Ku-band direct line-of-sight signals, causing problems only for lower frequency mobile services where the discrimination of ground terminal antennas is not sufficient to avoid multipath, and associated depolarization effects.

Multiple Beams and Reuse

Frequency reuse through the use of multiple beams or geographically separated cell-sites is used for terrestrial cellular systems, and cell size has been pushed to a minimum in order to achieve maximum reuse. For satellite systems, the spacecraft antenna size has a first order effect on spacecraft cost (and hence on commercial viability). This is largely due to the need for more sophisticated reaction control and pointing, greater mass, and the need for complex deployment mechanisms. As a result, typical existing domestic communications satellite systems may have antenna beams of two degrees or larger, which do not lend themselves to any significant frequency reuse. In mobile satellite systems where frequency reuse is highly desirable, plans for the Canadian MSAT and US domestic systems utilize only about 10 beams for North America, resulting in an overall frequency reuse factor of less than two.

The answer for satellite systems is clearly to move to higher frequency bands where smaller beamwidths, more beams and greater frequency reuse can be achieved for the same spacecraft antenna size.

USE OF HIGHER FREQUENCY BANDS

Terrestrial Radio Systems

The move to higher frequency bands is largely motivated by the availability of large amounts of unused spectrum, and also by other factors such as smaller antenna beamwidths leading to greater security, and relative freedom of interference from other systems.

At higher frequencies one has to deal with atmospheric absorption and rain effects which may be severe. In the region 10 to 55 GHz, rain attenuation is the main cause of outage. In addition to this, atmospheric absorption increases with frequency, having a broad peak at about 22 GHz (H2O line), a very sharp peak at 60 GHz (O2), where the path loss changes from a few tenths of a dB per km to about 10 dB per km, and further absorption lines at about 120 GHz (O2 line), and 180 GHz (H2O line). It is not entirely clear, if one is operating at one of the absorption lines where signals have higher attenuation, whether unwanted noise levels in the system actually decrease or increase.

Sharing of services, for instance between fixed, broadcast (eg. HDTV satellite broadcast) and mobile around 23 GHz, will require a careful consideration of the effects of interference between these different systems. Furthermore, it can be demonstrated that in these frequency bands, circuit cost will be a very sensitive function of the desired circuit availability, particularly in the region above 99.9 percent. This would appear to indicate that a good case could be made not to "overbuild" commercial systems by requiring an excessively high circuit availability, particularly for private systems, as the cost burden will obviously fall on the user, for something he or she probably does not really require.

A considerable amount of work remains to be done to properly characterize the propagation environment for frequencies above 20 GHz. In particular the dispersive effects of multipath fading must be explored and better understood, especially as they apply to broadband digital signals. Corresponding development will then be needed to apply adaptive equalization techniques to compensate for these effects. Other adaptive techniques such as the use of dynamic channel evaluation and variable rate modems must also be developed and applied to compensate for fading, noise increases, or other outages.

Both civil and military interest has grown over the past few years in the feasibility and potential use of terrestrial short range communications systems at 60 GHz, which would take advantage of the atmospheric absorption line there. For military application this could provide short range secure tactical communications in the field, and for civil application the feasibility of in-building radio LANS (Local Area Networks) could be explored. The in-building propagation environment is very difficult due to complex and fast changing multipath effects, and investigation to obtain a better understanding of this, including dispersive effects, path loss and noise is presently underway at VHF and UHF, and planned for EHF.

Satellite Systems

Interest in the use of higher Ka band frequencies was sparked by U.S. military satcom architecture in the early 1970's, largely to generate narrow spot beams for secure communications as well as steerable nulls to defeat jamming interference. As a result, the U.S. MILSTAR system was planned to operate at 20/44 GHz. Other advantages lie in the design of both passive and active components which can operate over a wide instantaneous bandwidth, which is normally a fixed percentage of the center frequency.

Civil interest in the use of Ka band is catching up, with a serious need for spectrum for HDTV broadcast, as well as the need for expansion of first generation mobile satellite communications services. Indeed, as part of a global trend to personal communications, it would appear very natural for second generation mobile satellite communications systems to support truly "personal" communications in rural and remote areas. A hand-held transceiver would include a small conformal antenna array, and allow voice or data communications, ported into a lap-top PC. The next generation mobile communications, then, will take the communications capability out of the vehicle (aircraft, ship, or land vehicle) and this capability will be associated directly with the person, wherever he or she is located.

A long term strategy for the further development of satellite communications in Canada has recently been completed. This study was jointly sponsored by both government and industry, and one of the principal recommendations is to proceed quickly with the development of technologies, systems and services at Ka band, which could support both broadcast and next generation personal communications requirements. This is expected to constitute a focus for the next major federal satellite communications initiative following MSAT.

Few measurements of earth-space attenuation and depolarization are available for planning satellite systems in the 20/30 and 20/44 GHz bands. An experiment is planned with the European Olympus satellite to make attenuation and depolarization measurements using the 12, 20 and 30 GHz beacons. In order to separate the effects of various propagation media such as rain, melting layer and ice clouds, simultaneous radar scattering measurements and background noise measurements are also planned.

Other studies of backward and forward scattering from melting snow are also planned to estimate interference between space and terrestrial systems which share the same frequency band (eg. at 23 GHz).

CONCLUSIONS

It is perhaps obvious that a great deal of recent progress has been made in exploiting the UHF and VHF bands, and also in developing much more spectrum-efficient coding and modulation techniques with adaptive characteristics to combat a variable fading environment. Nevertheless, even though various spectrum reuse techniques have been considered, and many introduced, it is clear that the growing demand for radio services cannot be met without moving to higher frequency bands. This will be the case particularly for mobile and broadcast services by satellite.

The move to exploitation of Ka band and beyond must be accompanied by propagation research, as well as a continuing effort in the area of coding, modulation and adaptive systems. The global trend to personal communications will undoubtedly accelerate the demand to exploit these higher frequencies.

ANNEX 4

A Comparison of Current Trunking Systems

ANNEX 4

A Comparison of Current Trunking Systems

The comparisons below are based on the two leading systems in current use and illustrate alternative means of achieving a trunking system architecture.

FEATURES	JOHNSON	MOTOROLA
Traffic channels	All available	All-1 Cont. Ch.
Control Channel	Distributed	Dedicated
Control Channel Fail	Back-up channel	Stay on last ch
Privacy (mon. 1 ch.)	Random trunk	Same trunk
Busy Syst Access	Random	Queue
Recent user priority	No	Within 10 sec
Drop out time	None	1 sec

Differences between the two systems are due in part to a choice of operating philosophy which is software controlled, and in part due to the choice of signalling method. While there may be certain advantages in having a separate control channel, these are outweighed by the greater spectrum useability for systems which use sub-audible data on voice channels. System hardware reliability is less when there is a dedicated control channel.

The utilization advantage for systems without a dedicated control channel is clearly greater on smaller systems. For example, a system not requiring a control channel would be able to utilize all three channels for voice traffic in a system licensed for three channels. In the same three channels for a dedicated control channel system, only two would be available for traffic. On larger systems, however, the greater volume of signalling information which must be carried on the one dedicated channel would introduce delays in assigning channels.

Based on the above it may be seen that the Johnson system using distributed control channel information is more spectrum efficient. All of the necessary features such as user recognition, group identification and priority are programmable in software and are applicable to either the Motorola or Johnson approach. Therefore, the only argument seen in favour of using a dedicated control channel could lie in the robustness of the control channel operation under adverse conditions.

However, in the event of a failed control channel, the mode of operation to which the Motorola system presently defaults leaves users on their last assigned channel. Users on the distributed control channel systems make use of a back-up control channel and the loss of one channel is then only the loss of a voice channel. This aspect could be investigated further. However, it would appear that the distributed control channel system utilized by Johnson and others is to be preferred as an industry standard.

ANNEX 5

A Discussion of Broadcasting Rules & Related EMC Issues

ANNEX 5

A Discussion of Broadcasting Rules & Related EMC Issues

1.0 INTRODUCTION

Since the end of WW2, much of the broadcast rule making has been a reaction to perceived problems and incidents which have developed from an ever increasing use of the spectrum. Use of channels in the broadcast spectrum has increased at an amazing rate. The DOC, from time to time, has received complaints of impaired service in the broadcast spectrum, resulting from expanded use which developed after the assembly of the basic administrative rules and procedures which were used by the DOC for administration of these spectrum sections following the cessation of WW2 in 1946. In some instances, a few cases of reported service impairment resulted in the development of a whole set of new rules to preclude further occurrence of that type of complaint. This has resulted in a proliferation of rule making, and rules which are on the books, which must be recognized and adhered to in the design of systems, many of which are now of doubtful merit. Because much of the rule making was related to single or limited numbers of experience in a particular problem, theoretical approaches were developed to quantify the problem to enable development of protection standards and concepts which would preclude repeat incidents of the type which had been found offensive. Unfortunately, the tendency was to develop rules which constituted a significant overkill for the problem being corrected, with the result that spectrum utilization was inhibited in a serious and unnecessary manner. Examples of these types of rules and regulations which are still in effect follow.

2.0 EXAMPLES OF INAPPROPRIATE RULE MAKING

Rules and regulations have been developed by the DOC which inhibit the use of spectrum in both the AM and FM sound broadcasting services. Examples of these are assembled herewith.

2.1 AM Sound Broadcasting

Over the years, rules have been introduced which govern the use of channels in the AM sound broadcasting spectrum. Some of these rules are no longer applicable and should therefore be cancelled.

2.1.1 Image Rule

The "Image Rule" was introduced following an incident wherein the Canadian Broadcasting Corporation experienced difficulty with a station which they had implemented in the Maritimes. The channel selected for the station was related to an existing station by two times the IF frequency of many receivers used in the area. In other areas, the "IF transformers" of local receivers were slightly adjusted to correct for this interference problem. However, after this incident, a rule was introduced which prohibited the licensing of a radio station on a frequency which was "two times the IF frequency" below the frequency of an existing area radio station.

The image problem was exacerbated at that time because many of the "AC/DC mantel" radios used at the time had no preselector stage and therefore were particularly susceptible to image interference. Radios which are used contemporarily are totally different in concept, and image interference is no longer a major problem. Therefore, the image rule which has seriously inhibited the use of spectrum for new applications may now be safely removed. It is interesting to note that private sector stations do operate with an image relationship to other existing area stations of the private sector with no apparent impairment of their market penetration. Therefore, if these private sector stations can continue to operate without perceived market impairment, the redundancy of the image rule is further demonstrated. Cancellation of this rule would make a significant number of additional channels available for broadcasters across Canada.

2.1.2 NIL Rules

Domestic night interference limit (NIL) contour rules and protected contours in Canada are calculated based on criteria which relate to mid-latitude USA conditions. The conditions in Canada are significantly different because Canada is some 600 miles north of the USA section where the data was assembled on night propagation. Furthermore, most of the interference situations in Canada are east/west, and propagation absorption is much higher than it is in the north/south mode, which is so much more prevalent in the USA. Adopting the USA-based criteria for establishing the night interference calculations between Canadian stations, and therefore the permissable levels of radiation which they may generate, has unnecessarily inhibited the utilization of scarce Canadian AM channels. The CBC has suffered significantly because of these features of the Canadian protection rules, in that their channels have been overprotected and underutilized.

It would be appropriate for the DOC to re-evaluate the NIL rules in light of the propagation conditions which exist in Canada.

2.1.3 Maximum Field Strength Rule

In the 1950s, a high power 50,000 Watt AM broadcasting station was constructed to serve Vancouver when one of the Canadian "A" class channels was relinquished by the CBC. This station was built immediately south of Vancouver. When it commenced service, it generated a somewhat larger number of interference complaints to DOC than had been experienced heretofore by the turn-up of a Canadian station. Engineers of the Department were dismayed by this incident and proceeded to design rules which would preclude a recurrence of this situation.

A 1% rule was designed and implemented. Broadcast engineers attempted to design stations to meet this rule, and in general the designs were unsatisfactory. The rule forced the radio station to be located so far from the principal community which it was seeking to service that its service was significantly impaired in that community. The rule was amended, but still found to be unacceptable. The rule is still bad and the current rule amendments indicate that engineers of the DOC fully recognize this fact.

Examples exist in Toronto and other communities where broadcast stations have been designed and licensed which flagrantly contravene this rule as it existed at the time. It is contended that a rule which is so inappropriate that it is disregarded on many occasions is an unacceptable rule and therefore should be removed from the statutes.

2.2 FM Sound Broadcasting

The basic rules which were established for the regulating of FM sound broadcasting services have stood the test of time with the exception of a few problems which have developed principally through inadequacies in the equipment being used to provide other services.

2.2.1 Co-Location of Stations Operating at 800 KHz Separation

As the number of FM broadcasting stations increased in Canada, many stations were approved for operation in a city with a separation of 800 KHz. This was deemed to be a completely acceptable separation and should have resulted in the design of receivers which could properly discriminate against two signals with that frequency separation. However, many receivers started to appear on the Canadian scene which were incapable of providing good quality FM reception when two stations were operating at 800 KHz separation if these stations were separated geographically. This phenomenon resulted because of the differing field strengths established at many locations by FM stations when they are not co-located. To overcome this receiver problem, the DOC ruled that for allotments in a city that are at 800 KHz separation, applications for stations should be predicated on co-locating those stations.

Were regulation to have been in effect which required that receivers being offered the Canadian public, be designed to effectively discriminate against signals 800 KHz removed from the desired frequency, these siting requirements would never have become necessary. The requirement to co-locate has imposed restrictions on spectrum management. It also has generated an additional hazard in that the levels of radio frequency energy which are being generated in the vicinity of these multi-station sites are such as to cause concern with respect to the hazard from non-ionizing radiation.

2.2.2 Restrictions on FM Allocation to Protect TV Channel 6

The use of FM broadcast channels between 88-92 MHz in areas where TV channel 6 has been licensed is seriously restricted to assure that 90% of TV viewers shall enjoy a signal grade of 4 or better. Initially, these restrictions were imposed as a temporary measure in response to reported impairment of channel 6 service. Extensive tests were conducted to determine the seriousness of the impairment resulting from the impact of high power FM signals on a receiver which is already receiving high level television signals. These tests have taken a number of years. In the interim, the television service originating with the channel 6 station has been placed on cable. In those communities where channel 6 is the principal channel, 80 to 90% of viewers now receive their television service through the cable medium. The intent was originally to ensure that 90% of all viewers would be able to enjoy over-the-air channel 6 service without impairment, generating the perceived need for the drastic restrictions in the use of channels 201-220 by FM broadcasters. The over the air television services in urban areas for channel 6 have been replaced by cable. Therefore, there are good reasons for cancelling these service restrictions to FM services. First, the need does not exist because the channel 6 feed television service in the urban areas is via cable. Second, viewers in the suburban and rural areas being served by the channel 6 station do not have the high level of television signal or FM broadcast signal, and therefore receivers are not subject to the same overload hazard as those receivers in the principal city areas.

2.2.3 <u>ILS/FM Broadcast Service Conflicts</u>

The DOC has imposed serious limitations on the use of FM broadcast channels in areas where ILS services are being provided at the local airport. Criteria which the DOC has adopted to evaluate the acceptability of FM allocations proposals are so restrictive that many of the existing stations which now operate without hazard or impairment of the area ILS service fail to meet the evaluation criteria which are used for evaluating new applications.

The approach which appears to have been adopted by DOC and MOT places the total onus on protecting ILS channels on the FM spectrum user. Responsible spectrum management would place the principal onus for selecting appropriate ILS channels for a particular area on the MOT engineers. The FM broadcast allotments for each city within Canada have been documented for many years. The unfortunate incidents which have happened in the Mirabel area of Montreal and in the vicinity of Toronto/Hamilton could have been anticipated if effective intermodulation studies had been conducted by MOT staff. Should ILS services be deemed to be a safety service, responsible spectrum management would appear to require that any receiver installed in a commercial aircraft operating into a Canadian airport should meet criteria which would ensure the safety of operation for the aircraft regardless of the environment which is presented in adjacent spectrum sections.

2.2.4 Receiver Standards

The serious restrictive regulations which have been applied to the use of the FM broadcast spectrum in Canada relate to the practice of imposing use restrictions on sections of the spectrum to accommodate deficiencies in unrelated receiver designs. The fact that the operating parameters of transmitting equipment in the FM broadcast section of both the lower 4 MHz and the upper half of the allocated spectrum are seriously restricted, demonstrate the need for a policy that would establish receiver standards which would avoid the necessity of serious restrictions on adjacent spectrum services.

ANNEX 6

Additional Details of New Zealand's Revised System of Spectrum Assignment

RADIO SPECTRUM MANAGEMENT SEMINAR
AUCKLAND, FRIDAY 17 MARCH 1989

MAIN FEATURES OF RADIO SPECTRUM MANAGEMENT: TELECOMMUNICATIONS

MICHAEL LEAR

MANAGER TELECOMMUNICATIONS AND POSTAL POLICY

MINISTRY OF COMMERCE

In this address I will outline the main features of the new regime for allocating frequencies with a particular focus on telecommunications. I will draw particular attention to the overall process of bringing spectrum rights within the new regime, the tendering process, implications for existing users and competition policy aspects. Later speakers will look at details of legal aspects, implementation of the new system and engineering.

The New Regime

As you all know we are on the eve of a quite radical new era in telecommunications in New Zealand. The new Telecommunications Act, which comes into force in a couple of weeks, allows anyone to provide whatever telecommunications services they wish, subject in essence only to the constraints of general law, some rules in providing international services and the need to obtain rights to use radio frequencies where these are required. This massive change in the regulatory environment will result in substantially increased demand for some radio frequencies. This in turn will result in scarcity of some frequencies most notably cellular radio or mobile telephony, and to a much lesser extent for radio paging, fixed links and land mobile user in one or two areas.

The Government has looked for a simple, easily understood, fair, and efficient system of spectrum allocation to cope with these competing demands and situations of scarcity.

Main Features

The main features of the new system are set out in slide A. At the top of the list is the definition of legal property rights in spectrum. This simply means that the rights to use a particular frequency will be defined so that it is as clear as possible what they are to both the rights holder and other rights holders.

The definitions will need to spell out the limits of the frequencies (for example a band from 494 to 550 Megahertz), the levels of interference which must be tolerated within the band, any limitations on emissions outside the band, the time period for which the right applies and conditions which apply to the right. To provide for flexibility, rights holders could be permitted to modify interference limits where all parties with a significant interest agree. We are well aware that the full nature of these rights will need to be spelled out well in advance of any auction.

Rights could be tendered either as bands, capable of accommodating several users, or as products, designed for one particular use, for example for cellular radio.

Rights are to be fully tradeable. This recognises that uses of spectrum differ over time as demand and technology changes. Tradeability is simply a way to smooth the way for these sorts of changes. Spectrum users will be able to trade their rights in much the same way as most other legal rights. It will be necessary, however, to maintain records of usage, both to meet international obligations and to provide for quick resolution of any interference problems which might arise. Probably the best way to do this is through a central registry, to which details of transactions must be advised as are land transactions.

Tradeability will also allow rights holders to sub-divide and sell part of their rights.

Definitions of rights must facilitate likely uses, in order to allow for users needs to be met. Where several uses are possible and likely, for example for cellular radio or fixed links, definitions should ideally be framed in a way which could provide for all uses, to allow the spectrum to move to whichever is the more valuable use. Those with interests in particular rights will be invited to make them known and comment on just how these rights should be defined.

According to our consultants, NERA, the duration of rights should be as long possible on economic grounds, although if rights are of limited duration, the efficiency loss will be small if rights are retendered well in advance of expiry. The new regime will provide for long-life rights, normally expected to be of 20 years duration, in order to encourage investment to use the rights.

As the initial work of defining each category of rights is completed, that category could be moved from the present system of radio licences administered by the Radio Frequency Service to within the provisions of the new legislation. Cellular radio would be moved into the system at an early stage, followed by selected bands suitable for fixed links and UHF land mobile bands. Much work will be required in bringing additional categories of frequencies into the new system, necessitating a staged process.

As spectrum rights are brought within the new system, they will be allocated by competitive tender. Slide B lists the main features of the system.

Tenders will be held on a sealed bid basis, rather than in an open auction room. This simply means that written tenders will need to be received by a particular time, then opened and the winner determined. The procedure helps to ensure bidding is fully competitive.

Second price tendering is proposed in order to ensure that tenders are based upon the true economic worth of the spectrum (its opportunity cost). Slide C provides an example of second price bidding under which the successful bidder pays only the next highest bid. The system ensures that the successful bidder is asked to pay no more than necessary to beat the next bid. By contrast, under a system where the top bidder pays its actual bid, there is an incentive to bid strategically, attempting to reduce bids below what the spectrum is worth to the bidder, in case the bid is substantially higher than the next bid. The second price system should assure bidders that they can safely bid up to what they consider the spectrum is worth, without fear of paying any more than they have to. The system suffices to meet the Government's objective of ensuring the spectrum goes to its most valuable use, without it costing the winner more than necessary.

It may sound like a cliche to suggest that an "open and competitive" system is wanted, having already stated that tendering will be the means of allocation. "Open and competitive" in this case, however, simply means allowing all bona fide bidders to participate. In general tenders will be held wherever more than one person is interested in particular spectrum. To ensure bids are bona fide, upfront cash deposits will be required, probably based on a proportion of the bid, to ensure that bidders are serious about wishing to acquire what they bid for.

As you would normally expect in any tender, the ability to decline any or all bids will be a feature of spectrum allocation, as a final safeguard against impropriety.

Existing Uses of Spectrum

The question of how existing users' spectrum can be brought within the new spectrum management system is of vital importance. In essence, it is proposed that spectrum already in use under existing one year licences be treated in the same way as unallocated spectrum, that is put up for open competitive tender. Other speakers will identify the choices available in designing the spectrum prior to tendering.

NERA identified a number of reasons for this approach, including efficiency and equity. It can readily be seen that if new entrants must pay the full cost of their spectrum, but not existing users, the newcomers would be at a significant competitive disadvantage. Managing all spectrum in the same way, through initial tendering, will allow the full efficiency gains of the new system to be realised, as all spectrum can be quickly included in the new system.

Alongside these considerations, however, is the need to have a smooth transition to the new system, without unnecessary disruption to ongoing services. This will be provided for through the following special provisions, also listed in Slide D:

- Second price bidding (which ensures incumbents do not pay any more than necessary)

- Pre-emptive bidding rights. These will allow incumbents an option to retain spectrum simply by matching the top bid after a tender has been held. This process provides an absolute guarantee that incumbents can retain use of spectrum already in use, provided they are willing to match what it is worth to the winning bidder.

- Three year incumbency rights. These will allow an incumbent whose tender is unsuccessful to retain an absolute right to continue to use their current frequencies for three years. Continued use would be subject to a resource rental related to the market value of the spectrum. The breathing space allowed by the three year rights would allow time to develop alternatives to use of that spectrum, purchase of alternative spectrum, purchase of alternative services from other spectrum holders, or perhaps uses of other means of communication (eg substitution of cable based communication for fixed links).

- Other provisions of the new system which will favour incumbents will be that for the first time, long term rights will be available rather than one year radio licences or five year warrants; the Commerce Act will restrain anticompetitive bidding behaviour; the design of parcels of spectrum for tender will take into account existing uses; and there will be provisions to ensure participation in the tendering process is bona fide, such as requiring cash deposits to accompany bids.

Another important feature of the new system will be continued Ministry of Commerce management of certain spectrum bands at least for an interim period. This will probably apply in the following instances:

a Residual frequency management where spectrum products are tendered, eg if a high power FM radio product suitable for Auckland is defined, use of that frequency elsewhere in New Zealand may have to be managed

b Frequencies below 44 Mhz which can cause long distance interference, except AM broadcasting frequencies which are already internationally allocated

c Frequencies above 3.6 Ghz, if there is no significant demand

d Frequencies to provide for short term broadcasting uses.

Administrative charges for Ministry of Commerce frequency management will remain for spectrum users currently paying fees, but there is a good prospect that they will drop, as the new system is introduced, and the Ministry's expenses fall.

Finally, I wish to specifically mention competition safeguards. Generally, it is expected that the Commerce Act should provide adequate safeguards, provided it is amended to ensure the Commerce Commission can scrutinise competition issues affecting broadcasting or telecommunications, where large companies wish to acquire spectrum assets. Particular scrutiny may be needed where a monopoly or market dominance already exists, as in cellular radio or television currently. The Commerce Act, as it stands, could also be invoked in the event that anticompetitive spectrum hoarding occurs.

Conclusion

In summary, the new system will provide for the definition of spectrum property rights, which will allow operators far greater freedom to manage and develop their use of spectrum than before. This should bring advantages for both new and existing operators. Safeguards for existing users interests will be built into the transition to the new system as will safeguards to ensure competition in markets for which spectrum remains a critical resource.

The final message of this address is probably the most important. We would welcome any comments you wish to make to us, either here or in Wellington, about how to make the new system work effectively.

SLIDE A

MAIN FEATURES OF NEW SYSTEM OF SPECTRUM ALLOCATION

1 Legal Property Rights in Spectrum will be defined

2 Rights to be tradeable

3 Rights to be defined to meet likely needs

4 Rights to be of long duration

5 Progressive transfer of spectrum to the new system

6 Rights to be initially allocated by tender

7 Tenders to be on sealed bid, second price basis

8 Existing spectrum users to be protected

9 Government to continue to manage certain frequencies

10 Safeguards to preserve competition.

SLIDE B

FEATURES OF TENDERING SYSTEM

1 Sealed bid basis

2 Second price tendering system

3 Open and competitive basis of tendering

4 Deposits to accompany tenders

5 Ability to decline tenders if serious distortions or impropriety occur.

SLIDE C

SECOND PRICE BIDDING

Under second price bidding the highest (successful) bidder is asked to pay the price of the next highest, unsuccessful bid, rather than the highest bidder's own bid. Say there are four bids for a radio frequency as set out below:

Bid A	Successful	$50,000
	Bidder	
Bid B	Pays	$30,000
Bid C		$20,000
Bid D		$500

In this case, the successful bidder pays $30,000, not the $50,000 it was prepared to pay.

SLIDE D

PROTECTION FOR INCUMBENTS

1 Second price bidding

2 Right to match the highest bid

3 Three Year Guarantee of Incumbency

4 Funding to assist certain non-commercial broadcasters

5 Resource rental to apply to those whose spectrum is not auctioned immediately

6 Availability of long term rights

7 Commerce Act Scrutiny of Anti-competitive behaviour

8 Definition of rights to correspond to existing users

9 Provisions to ensure bidding is bona fide

ANNEX 7

Australia's "National Plan for Development of Metropolitan Radio Services: More FM Radio Services in Capital Cities"

Media Statement

AUSTRALIA

Minister for Transport and Communications
Senator Gareth Evans Q.C.

83(b)/88
9 August 1988

NATIONAL PLAN FOR DEVELOPMENT OF METROPOLITAN RADIO SERVICES: MORE FM RADIO SERVICES IN CAPITAL CITIES

New commercial FM radio services will be provided in Sydney, Melbourne, Brisbane, Adelaide and Perth under the National Plan for Development of Metropolitan Radio Services announced today.

The Plan involves two stages: in Stage 1, two existing AM commercial services will be converted to FM (with the AM frequencies in question being relinquished for non-commercial allocation); in Stage 2, two new FM services will be offered for which anyone (either an existing AM station owner or a new player) can bid.

The Plan will be implemented progressively as frequencies become available in each mainland State capital (see Attachment A). The number of frequencies available for FM radio has been severely limited pending the "Band II" clearance process - ie until those television channels which use the frequencies normally used for FM radio (ie VHF Channels 3, 4 and 5) are reallocated.

During Stage 1 of the Plan:

- existing AM broadcasters with technically suitable transmission facilities will be invited to tender for two frequencies in each city covered by the scheme, under an arrangement which will include the value of the broadcasters' existing AM transmitters and transmission sites; and

- successful tenderers will be offered an alternative FM frequency in exchange for their existing AM transmitters and frequencies, which will be transferred to the Commonwealth. These facilities will then be available to licensees for RPH services and to the ABC to operate a separate network for parliamentary broadcasting.

During Stage 2:

- two further FM frequencies will be released in each city for open tender. The licences will be awarded to the highest bidders, who will also have satisfied the ABT that they are capable of meeting the criteria to provide a commercial service.

Further details on the proposed allocation process (which is subject to further consultation with industry and refinement as necessary) are set out in Attachment B.

The commercial success of a number of broadcasters on the FM band has produced strong demand for additional services of this type, both from AM broadcasters wishing to convert and from aspirants for new licences.

The plan released today allows these demands to be addressed, while ensuring that the public return from this scarce national resource - the radio spectrum - is applied to improving the quality and range of non-commercial services as well.

An important element of the Plan is to maintain a balance in the allocation of services on both the AM and FM bands between the three sectors of broadcasting (national, commercial and public).

The plan for the development of radio services in metropolitan areas reflects the Government's long-term commitment to greater diversity for the public in radio and television. Hobart and Darwin will soon have new commercial FM radio services. Canberra has already gained two new commercial FM services provided by supplementary licences granted to the existing AM operators; and the ABT has recently awarded new FM radio licences in Geelong, Shepparton, Newcastle and the Gold Coast. Work is proceeding to provide new services in other regional centres across Australia.

* * * * *

CANBERRA

For further information: John Stanton (062) 777200

ATTACHMENT A

PLANNING TIMETABLE FOR STAGE 1 AND STAGE 2

OF NATIONAL PLAN FOR DEVELOPMENT OF RADIO SERVICES

	STAGE 1	STAGE 2
Sydney	1989	1990
Melbourne	1989/1992*	1992
Brisbane	1989/1991**	1991
Adelaide	1989	1990
Perth	1989	1990

* First channel available 1989, second channel available 1992.

** First channel available 1989, second channel available 1991.

ATTACHMENT B

NATIONAL PLAN FOR DEVELOPMENT OF METROPOLITAN RADIO SERVICES - OUTLINE OF PROPOSED ADMINISTRATIVE ARRANGEMENTS

The following material gives a broad indication of procedures and conditions which are proposed for the two stages of the National Plan. They are still subject to further consultation with industry, the ABT and relevant Departments.

STAGE 1 - AM/FM CONVERSION

Introduction

1. In Stage 1 of the National Plan for the development of radio services in metropolitan areas, applications will be invited for two commercial AM licensees in each mainland capital city to convert to FM. Conversion will be on the condition that the successful applicant possesses useable AM transmission facilities (including transmission site) and transfers the vacated facilities for use in each city by the Radio for the Print Handicapped (RPH) licensee and by the ABC to transmit Parliamentary broadcasts.

2. It is proposed that the Radio Licence Fees Act 1964 be amended to require the payment of a tender fee by metropolitan commercial AM licensees applying for FM conversion, subject to such procedures and conditions as the Minister may determine.

Tender Specifications

3. In inviting applications for AM/FM conversion, the Minister would publish tender specifications with the following effect:

(a) tender bids would be accepted only from AM commercial licensees with service areas and transmission facilities covering the whole of the metropolitan area;

(b) minimum technical standards for AM facilities would be detailed as part of the tender specifications;

(c) acceptance of applications would be subject to an agreement that the licensee will transfer AM transmission facilities (including site) to the Commonwealth - the licensee's tenure of the transmission site, if leasehold, would need to be capable of supporting the objectives of continuing delivery of RPH and Parliamentary services; and

(d) the successful applicant would be required to make arrangements to ensure that the transmission site and facilities are available at no cost to the Commonwealth.

Lodgement of Bids

4. Tender bids would be invited by the Minister for lodgement with the Department of Transport and Communications by a specified date. A closed tender process would be conducted with sealed confidential bids.

Assessment of Bids

5. The total value of a tender bid would be made up of the value of the cash bid, the dollar value of the AM broadcast facilities and the dollar value of the transmission site.

6. Tender bids would be subject to a confidential reserve price. Failure to reach the reserve price within a round of tenders would result in re-tendering.

7. The Department of Transport and Communications would open all sealed bids. The successful applicant would be the licensee that has bid the highest total dollar value including the value of the transmission facilities and site subject to compliance with the minimum requirements set out in the Tender Specifications.

8. The fee would be paid in two components - transmission facilities, including site, transferred to the Commonwealth and a cash balance. To determine the amount of the cash balance, the facilities and site of the successful applicant would be independently valued. The value of these facilities would then be deducted from the total dollar amount bid, to arrive at a net cash balance to be paid in addition to the transfer of facilities.

TRANSFER OF FACILITIES

9. The Commonwealth, through the agencies of the Department of Administrative Services and the Department of Transport and Communications, would enter into contracts for appropriate transfer of property, leases and facilities.

STAGE 2 - TENDER PROCESS FOR GRANT OF METROPOLITAN COMMERCIAL FM RADIO LICENCES

10. In Stage 2, applications will be invited for the grant of new metropolitan commercial FM radio licences, with the effect that:

(a) in inviting applications, the Minister shall establish a reserve price for the licence and advise the ABT of that reserve price;

(b) when lodging applications, prospective applicants are required to lodge a sealed bid for the licence;

(c) the Tribunal will then conduct a simplified licence grant inquiry to determine whether any applicants are unsuitable; and

(d) when any unsuitable applicants have been eliminated, the Tribunal will award the licence to the highest bidder (providing the bid is equal to or greater than the reserve price).

11. It is also proposed, in order to clarify the relevant market structure and accordingly make more certain the operation of the tender processes in both Stages 1 and 2, that the Broadcasting Act be amended with the effect that the Tribunal is obliged, in considering applications for the grant of a metropolitan commercial radio licence, not to have regard to the effect on the commercial viability of other broadcasting services in the service area of the licence.

* * * *