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SPECTRUM SPECTRE 20/20 '89

INNOVATIONS - Sharing the Challenge
Le Défi Commun

PROCEEDINGS - ACTES

Montreal, Quebec - November 28 and 29, 1989
Montréal, Québec - les 28 et 29 novembre 1989

SPECTRUM SPECTRE 20/20 '89

INNOVATIONS - Sharing the Challenge / Le Défi Commun

Jointly sponsored by the Radio Advisory Board of Canada (RABC) and the Department of Communications of Canada (DOC).

Parrainage conjoint du Conseil consultatif canadien de la radio (CCCR) et du ministère des Communications.

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WHAT IS THE RABC?

The Radio Advisory Board of Canada (RABC) is a non-profit association of some two-dozen organizations which are concerned with the use of the radio spectrum. These in turn represent the users of radio communications and related service providers, manufacturers, and professional societies.

There are nearly 2,000 organizations, 10,000 radio amateurs and 30,000 members of professional societies represented by the member organizations of the RABC.

The Board's purpose is to consult and advise the Department of Communications (DOC) on behalf of industry on the development, management, and regulation of radio services in Canada.

QU'EST-CE QUE LE CCCR ?

Le Conseil consultatif canadien de la radio (CCCR) est une association à but non lucratif réunissant plus d'une vingtaine d'organismes qui s'intéressent à l'utilisation du spectre des fréquences radioélectriques. Ces organismes, pour leur part, représentent les utilisateurs et les fournisseurs de services de radiocommunications, des fabricants et des associations professionnelles.

Les organismes membres du CCCR représentent, quant à eux, près de 2000 organismes, 10 000 radioamateurs et 30 000 membres d'assocations professionelles.

Le Conseil représente l'ensemble de l'industrie auprès du ministère des Communications et a pour mandat de consulter et de conseiller ses représentants sur le développement, la gestion et la réglementation des services de radiocommunications au Canada.

David L. Garforth
RABC President

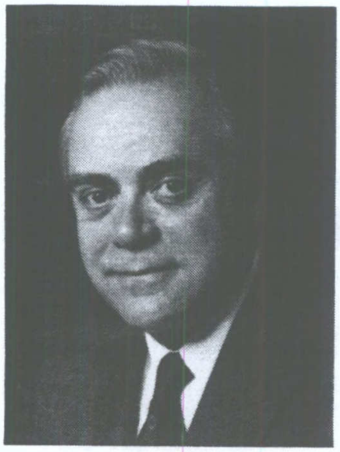
As President of the Radio Advisory Board of Canada (RABC) I welcome you to Spectrum 20/20 '89.

The first symposium of this kind was held in 1987. Since that time, spectrum usage has become increasingly congested as a multitude of diverse users clamor for their share; e.g. space services, land-mobile, fixed, broadcasting, etc.

The challenge of fairly allocating these limited resources and at the same time ensuring future needs are satisfied, will require creative management and the need for open discussions among users.

I sincerely hope you will find that this symposium provides you with an international forum to share your ideas. The papers presented under the theme "Innovations - Sharing the Challenge" will be informative and provocative. I invite you to participate in the discussions and help shape the plans for future spectrum use.

Signed,



The Honourable Marcel Masse
Minister of Communications

With its vast experience in radio communications, Canada has become a world leader in spectrum management. We are pioneers in this field, and we must now examine our strengths and needs in telecommunications to develop an effective spectrum management strategy to meet the challenges of the 21st century.

As members of the radio communications industry, you play a pivotal role in this task. It is your ingenuity, innovation and entrepreneurial spirit that will bring about the development of technologies and services needed in Canada and around the world.

The spectrum serves as an "electronic highway," communicating information by radio waves in our communities, coast to coast. It must be carefully managed to meet the current and future needs of all Canadians. Spectrum 20/20 is an appropriate forum to explore spectrum management issues and to develop a strategy for the future.

As Minister responsible for Communications in Canada, I am particularly pleased to welcome you to this symposium to share your vision.

Signed,

Edward Samuel Rogers
President and Chief Executive Officer, Rogers Communications Inc.

Luncheon Speaker
Wednesday, 29 November 1989

David L. Garforth
Président du CCCR

En qualité de président du Conseil consultatif canadien de la Radio (CCCR), je suis heureux de vous souhaiter la bienvenue à Spectre 20/20 '89.

C'est en 1987 qu'a eu lieu le premier colloque de cette nature et, depuis lors, le spectre est devenu de plus en plus encombré, au fur et à mesure que de nombreux utilisateurs provenant de tous les horizons réclament leur part à cor et à cri - services spatiaux, systèmes mobiles terrestres, services fixes, radiodiffusion, etc.

Le défi qui consiste à répartir de façon équitable ces ressources limitées, tout en s'assurant que les besoins futurs seront satisfaits, nécessitera sans conteste une gestion créative et la nécessité d'engager de franches discussions entre les utilisateurs.

J'espère sincèrement que ce symposium sera pour vous le forum international propice à l'échange de vos vues sur ces questions. Les communications présentées sous le thème "Innovations - Le défi commun" seront instructives et stimulantes. Je vous invite à participer aux discussions et à contribuer à la formulation des plans qui régiront l'utilisation future du spectre.

Signé,

L'honorable Marcel Masse
Ministre des Communications

C'est en raison de sa vaste expérience dans le domaine des radiocommunications que le Canada est devenu un chef de file mondial dans la gestion du spectre. Bien que nous soyons des pionniers dans le domaine, il vous incombe d'évaluer nos forces et nos besoins en matière de télécommunications de manière à mettre au point une stratégie portant sur la gestion efficace du spectre afin de relever les défis du 21e siècle.

À titre de membres de l'industrie des radiocommunications, vous jouez un rôle essentiel dans cette mission. Grâce à votre ingéniosité, votre créativité et votre esprit d'entreprise, vous contribuerez au développement de technologies et de services nécessaires pour le Canada et le monde entier.

Le spectre est en quelque sorte une "route électronique" qui achemine l'information par l'entremise des ondes dans vos communautés d'un acéan à l'autre. Il est donc indispensable que l'exploitation du spectre bénéficie d'une saine gestion afin que nous puissions répondre aux besoins actuels et futurs de tous les Canadiens et Canadiennes. Spectre 20/20 est l'occasion idéale pour faire le point sur les questions touchant à la gestion du spectre et pour concevoir une stratégie pour l'avenir.

Ministre responsable des Communications au Canada, je suis particulièrement heureux de vous accueillir à ce symposium pour partager votre vision.

Signé,

Edward Samuel Rogers
Président et directeur général
Rogers Communications Inc.

Conférencier-déjeuner
Mercredi, 29 novembre 1989

MEMBERS

Canada Post Corporation
Canadian Amateur Radio Federation
Canadian Association of Broadcast Consultants
Canadian Association of Broadcasters
Canadian Broadcasting Corporation
Canadian Cable Television Association
Canadian Electrical Association
Canadian Radio Relay League Inc.
CellNet Canada
Central General Radio Service Assoc.
CNCP Telecommunications Services
Ministry of Government Services
Government of Canada
Electrical & Electronic Manufacturers Association of Canada
Engineering Institute of Canada/Canadian Society for Electrical Engineering
Institute of Electrical & Electronic Engineers
Metropolitan Toronto Board of Commissioners of Police
Ministry of the Solicitor General
O.P.P. Telecommunications Project
Municipal Electric Association
National Defence
Ontario DX Association
Ontario Policing Services
Radiocom Association of Canada
Railway Association of Canada
Royal Canadian Mounted Police
Telecom Canada
Teleglobe Canada
Transport Canada
TVOntario (The Ontario Educational Communications Authority)
Western Canada Telecommunications Council

MEMBRES

Associaton canadienne de l'électricité
Association canadienne de télévision par câble
Association des radiocommunicateurs du Canada
Association Radiocom du Canada
Canadian Association of Broadcast Consultants
CellNet Canada
Central General Radio Service Assoc.
Computer & Telecommunication Services
Ministry of Government Services
Government of Ontario
Commission de Police de la communauté urbaine de Toronto
Défense nationale
Division des services internes de la Police d'Ontario
Fédération des radioamateurs du Canada
Gendarmerie royale du Canada
Institut canadien des ingénieurs/la société canadienne de génie électrique
Institute of Electrical & Electronic Engineers
L'Association canadienne des radiodiffuseurs
L'Association des chemins de fer du Canada
L'Association des manufacturiers d'équipement électrique et électronique du Canada
La ligue canadienne de la radio amateur, Inc.
La société canadienne de génie
Ministère des Services gouvernementaux
Ministère du Solliciteur général
P.P.O. Projet de télécommunications
Municipal Electric Association
Ontario DX Association
Ontario Police Commission
Services de police de l'Ontario
Socété canadienne des postes
Société Radio-Canada
Télécommunications CNCP et compagnies
Telecom Canada
Téléglobe Canada
Transports Canada
TVOntario (l'Office de la télécommunication éducative de l'Ontario)
Western Canada Telecommunications Council

COMMITTEES

EXECUTIVE COMMITTEE
Broadcasting Committee
Electromagnetic Compatibility Committee
Land Fixed & Mobile Committee
Marine Committee
Radio Relay Committee

COMIITÉS

COMITÉ EXÉCUTIF
Comité sur la radiodiffusion
Comité sur le brouillage électromagnétique
Comité sur les services radio terrestres fixes et mobiles
Comité sur les réseaux de relais hertziens
Comité sur les services radio mobiles marine

PROGRAM

Monday 27th November

18:30-21:00 REGISTRATION

19:00-21:00 WELCOMING RECEPTION
Sponsored by Motorola

Tuesday 28th November

7:00 REGISTRATION

8:30 OPENING ADDRESSES
David L. Garforth, President, Radio Advisory Board of Canada
Alain Gourd, Deputy Minister, Department of Communications

9:00 SESSION 1 - CHALLENGES

Session Chairman - Roger Poirier, Canadian Cable Television Association

1. ***Strategic Initiatives to Address Competition in Access to the Radio Spectrum***
Richard Stursberg, Assistant Deputy Minister, Department of Communications
2. ***The Challenge of Enhanced Entertainment***
Kenneth P. Davies/John C. Lee/François Conway, Canadian Broadcasting Corporation
3. ***The Military Spectrum Management Challenge***
Marc Drolet, Department of National Defence
4. ***Exploiting the Digital Radio Wave of the 90's***
Dr. Arunas G. Slekys, NovAtel Communications Ltd.
5. ***The E.M. Environment, E.M. Compatibility and Limitations to the E.M. Spectrum Utilization***
Professor T.J.F. Pavlasek, McGill University
6. ***Spectrum Congestion***
Jean-Marc Pellerin, Department of Communications

12:00 LUNCH

Guest Speaker - Marcel Masse, Minister of Communications, Government of Canada

With regard to SPECTRUM 20/20 '89, the Minister recently said:

> *"This will be a unique opportunity for industry and government to collectively address issues relating to use of the spectrum in the 21st century. Our evolving telecommunications technologies are vital to everyday life, but few people realize that the increased variety of broadcasting and new services such as cellular telephones, satellite communications, and radio-controlled equipment are crowding the radio spectrum, creating new challenges both for the managers and the users of this finite natural resource."*

14:00 SESSION 2 - INTERNATIONAL PERSPECTIVES

Session Chairman - Robert A. Gordon, Department of Communications

1. ***Spectrum Management in the United Kingdom***
Michael Goddard, Department of Trade and Industry, London
2. ***"Challenge 21"***
Richard D. Parlow, National Telecommunications and Information Administration, United States
3. ***Coordination Challenges Facing INMARSAT***
Jai P. Singh/Peter Poskett, INMARSAT, London
4. ***Commission of the European Communities and Frequency Management***
Jean-Louis Blanc, Commission of the European Communities
5. ***International Frequency Management Regulations in a Changing Technical and Operational Environment***
G.C. Brooks/G. Kovacs, International Telecommunications Union, Geneva

18:30-19:30 RECEPTION

19:30 BANQUET
Jeff Lumby, Radio Personality - CJFM FM 95.9
Kevin Dean Trio - Jazz

Wednesday 29th November

9:00 SESSION 3 - SOLUTIONS

Session Chairman - Lloyd Kubis, Motorola Canada Limited

1. ***The Future for Technical Standards***
Dr. Norman Aspin, Electrical and Electronic Manufacturers Association of Canada
2. ***A Broadband Urban Fiber Telecommunications Network***
Nick Hamilton-Piercy/George Hart, Rogers Engineering
3. ***Non-Spectrum Alternatives - Telecommunications***
Robert J. White, Telecom Canada
4. ***Greater Spectrum Efficiency and Use of Higher Frequency Bands***
Robert W. Breithaupt, Department of Communications
5. ***Advances in Modulation and Coding Techniques***
Dr. Al Javed, Bell-Northern Research

12:00 LUNCH

Guest Speaker - Edward "Ted" Rogers, President, Rogers Communications Inc.

14:00 SESSION 3 (cont'd)

6. ***Advanced Antenna Technology***
Craig M. Skarpiak/Dr. George Tong, Andrew Canada Inc.
7. ***New Satellite Opportunities***
Sheelagh Whittaker, Canadian Satellite Communications Inc.
8. ***New Spectrum Management Techniques***
Douglas Sward, Department of Communications
9. ***Spectrum Policy Solutions***
Wayne Longman, Department of Communications

15:30 SYMPOSIUM CLOSING

Robert A. Gordon, Department of Communications
David L. Garforth, President, Radio Advisory Board of Canada

PROGRAMME

Lundi 27 novembre

18 h 30 - 21 h **INSCRIPTION**

19 h - 21 h **RÉCEPTION D'ACCUEIL**
parrainée par Motorola

Mardi 28 novembre

7 h **INSCRIPTION**

8 h 30 **DISCOURS D'OUVERTURE**
David L. Garforth, président, Conseil consultatif canadien de la radio
Alain Gourd, Sous-ministre, Ministère des Communications

9 h **SÉANCE 1 - LES DÉFIS**

Président de séance - Roger Poirier, ACTC

1. ***Initiatives stratégiques destinées à régler les problèmes de concurrence quant à l'accès au spectre des fréquences radioélectriques***
Richard Stursberg, Sous-ministre adjoint, Ministère des Communications
2. ***Le défi de l'amélioration des services de divertissement***
Kenneth P. Davies/John C. Lee/F. Conway, Société Radio-Canada
3. ***La gestion du spectre des fréquences militaires : Un défi***
Marc Drolet, Ministère de la défense nationale
4. ***Exploitation des ondes radio numériques dans les années 90***
Arunas G. Slekys, NovAtel Communications Ltd.
5. ***Milieu électromagnétique, compatibilité électromagnétique à l'utilisation des fréquences électromagnétiques***
Professeur T.J.F. Pavlasek, Université McGill
6. ***La rareté des fréquences***
Jean-Marc Pellerin, Ministère des Communications

12 h **DÉJEUNER**

Conférencier - Marcel Masse, Ministre des Communications, Gouvernement du Canada

En ce qui concerne SPECTRE 20/20 '89, le Ministre déclarait dernièrement :

> *"Ce rassemblement sera une occasion unique pour l'industrie et le gouvernement d'aborder ensemble les questions qui se rattachent à l'utilisation du spectre au cours du vingt-et-unième siècle. Dans le domaine des télécommunications, nos technologies en plein essor jouent un rôle essentiel dans notre vie quotidienne, mais peu de gens réalisent que la diversité grandissante de la radiodiffusion et des nouveaux services tels que le téléphone cellulaire, les communications par satellite et les équipements radiocommandés encombrent le spectre des fréquences, source de nouveaux défis que les cadres et les utilisateurs de cette ressource naturelle limitée se doivent de relever."*

14 h SÉANCE 2 - LES PERSPECTIVES INTERNATIONALES

Président de séance - Robert A. Gordon, Ministère des Communications

1. ***La gestion du spectre au Royaume-Uni***
   Michael Goddard, Département du commerce et de l'industrie, Londres
2. ***"Défi 21"***
   Richard D. Parlow, Département du Commerce des États-Unis
3. ***Défis de coordination pour INMARSAT***
   Jai P. Singh/Peter Poskett, INMARSAT, Londres
4. ***La Commission des Communautés européennes et la gestion des fréquences***
   Jean-Louis Blanc, La Commission des Communautés Européennes
5. ***La réglementation internationale de la gestion des fréquences dans un contexte technique et opérationnel en évolution***
   G.C. Brooks/G. Kovacs, Union internationale des télécommunications, Genève

18 h 30 - 19 h 30 RÉCEPTION

19 h 30 BANQUET
Jeff Lumby, Personalité de la radio - CJFM FM 95.9
Kevin Dean Trio - Jazz

Mercredi 29 novembre

9 h SÉANCE 3 - LES SOLUTIONS

Président de séance - Lloyd Kubis, Motorola Canada Limitée

1. ***L'avenir des normes techniques***
   Norman Aspin, Association des manufacturiers d'équipement électrique et électronique du Canada
2. ***Réseau urbain de télécommunications à large bande, à fibres optiques***
   Nick Hamilton-Piercy/George Hart, Rogers Engineering
3. ***Solutions autres que spectrales - Télécommunications***
   Robert J. White, Telecom Canada
4. ***Efficacité accrue du spectre et utilisation des bandes de fréquences supérieures***
   Robert W. Breithaupt, Ministère des Communications
5. ***Progrès réalisés dans le domaine des techniques de modulation et de codage***
   Al Javed, Les Recherches Bell-Northern

12 h DÉJEUNER

Conférencier - Edward "Ted" Rogers, Président, Rogers Communications Inc.

14 h SÉANCE 3 (suite)

6. ***Technologie des antennes perfectionnées***
   Craig M. Skarpiak/George Tong, Andrew Canada Inc.
7. ***Nouvelles possibilités en matière de satellites***
   Sheelagh Whittaker, Canadian Satellite Communications Inc.
8. ***Nouvelles techniques de gestion du spectre***
   Douglas Sward, Ministère des Communications
9. ***Des solutions globales pour le spectre***
   Wayne Longman, Ministère des Communications

15 h 30 CLOTURE DU COLLOQUE

Robert A. Gordon, Ministère des Communications
David L. Garforth, président, Conseil consultatif canadien de la radio

ORGANIZATION/ORGANISATION

Steering Committee/Comité directeur

David L. Garforth, Chairman/président
Nisar Ahmed
Phil Diamente
Douglas Sward
Bob McCaughern
Murray Hunt
Janet West-Cyr

Organizing Committee/Comité d'organisation

Janet West-Cyr, Chairman/présidente
Darryl Perry
Douglas Sward
Marg Coll
Jean-Guy Gaudette
Gamet Stanzel

**Papers Program Committee/
Comité de programmation des communications**

Bob McCaughern, Chairman/président
John C. Lee
Phil Diamente
Roger Poirier
Douglas Sward

SESSION 1

CHALLENGES

SÉANCE 1

LES DÉFIS

ABSTRACT

STRATEGIC INITIATIVES TO ADDRESS COMPETITION IN ACCESS TO THE RADIO SPECTRUM

BY
RICHARD STURSBERG
ASSISTANT DEPUTY MINISTER
TECHNOLOGY, RESEARCH AND TELECOMMUNICATIONS
FEDERAL DEPARTMENT OF COMMUNICATIONS

In Canada, most of our experience with competition has been limited to competing users for the same spectrum - such as broadcasting vs. land mobile and microwave (common carriers vs. utilities and VHCM vs. satellite) - and competing suppliers for the same service - cellular radio, trunked radio systems and nationwide paging. Although competition plays a strong role in formulating spectrum policy, approval of radio licences has largely been done on a "first-come; first served" basis.

As the radio frequency spectrum is a limited and strategic resource, supporting much of our social, economic and cultural infrastructure new approaches and innovations will be required with the rapid advances in technology and increase in service demands. National priorities also need to be balanced against international directions and priorities.

This paper addresses several strategic initiatives to deal with competition in the future. One is the development of a comprehensive spectrum strategy to be the cornerstone of the entire radio spectrum structure and planning for future telecommunications requirements. The overall intent would be to use this strategy as a framework with appropriate guidelines to eventually meet Canadian long-term objectives and to maximize benefits to Canada.

The other initiative is the use of scenario modelling techniques to better assess the social, economic, technical and cultural trade-offs in Canada's best interest. One application of this model will be development of a spectrum impact model to assess various competitive delivery means for the implementation of advanced television services in Canada.

Both of these initiatives as well as others will be outlined as a means to address future competitive forces as they arise.

Résumé

Initiatives stratégiques destinées a régler les problèmes de concurrence quant à l'accès au spectre des fréquences radioélectriques

par

Richard Stursberg
Sous-ministre adjoint
Technologie, recherche et télécommunications
Ministère fédéral des communications

Au Canada, ce que nous savons de la concurrence se borne essentiellement à la lutte que se font les utilisateurs pour obtenir les mêmes fréquences - concurrence entre les radiodiffuseurs, les utilisateurs du service mobile terrestre et les utilisateurs de systèmes à micro-ondes (affrontement télécommunicateurs et services publics d'une part, et utilisateurs de systèmes à micro-ondes de très grande capacité et services par satellite d'autre part) - et à la concurrence entre les fournisseurs pour obtenir le même service - radio cellulaire, systèmes à partage de plusieurs canaux et téléappel national. L'adoption de politiques en matière de spectre fait l'objet d'une vive concurrence, mais l'approbation des licences radio se fait en grande partie suivant la formule du premier arrivé, premier servi.

Comme le spectre des fréquences est une ressource limitée et stratégique qui soutient une partie importante de notre infrastructure sociale, économique et culturelle, il faudra observer des idées et des approches nouvelles compte tenu des progrès rapides de la technologie et de l'augmentation de la demande de services. De plus, il sera nécessaire d'adapter les priorités nationales aux orientations et aux priorités internationales.

Le présent document expose plusieurs initiatives stratégiques qui permettront à l'avenir de régler les problèmes de concurrence. Une de ces initiatives consiste à élaborer, à l'égard du spectre, une stratégie globale sur laquelle reposera toute la structure du spectre radioélectrique et la planification des besoins de télécommunications futurs. Il s'agirait surtout d'utiliser cette stratégie comme cadre, assorti de lignes directrices appropriées, en vue d'atteindre les objectifs canadiens à long terme et maximiser les avantages pour le Canada.

L'autre initiative consiste à se servir des techniques d'élaboration de scénarios pour mieux évaluer les options sociales, économiques, techniques et culturelles dans l'intérêt du Canada. Une des applications de ces scénarios pourrait consister à concevoir un modèle d'impact spectral pour évaluer différents moyens concurrentiels de mise en oeuvre de services de télévision perfectionnée au Canada.

Ces deux initiatives, ainsi que d'autres, seront présentées comme un moyen de composer avec les forces de la concurrence au moment où elles se manifesteront.

Introduction

The radio frequency spectrum is a limited natural resource, and like many other natural resources it is exploited to provide a wide range of radiocommunications services to the general public, industry and government. As it is not contained by regional or national boundaries, it is contingent on an efficient and effective base of policies, regulations and management procedures which are designed to accommodate as many users as possible, and to facilitate equitable sharing among the users and different types of services in an environment as free as possible from harmful interference.

When the spectrum available is insufficient to meet all the demands being placed upon it, then a type of "resource allocation" methodology is required. The methodology may be similar to that used for the allocation of contracts, the letting of oil leases, the development of priorities or the allocation of financial resources to projects, but some type of decision-making model is necessary.

As the radio frequency spectrum is a limited and strategic resource, supporting much of our social, economic and cultural infrastructure, new approaches and innovations will be required with the rapid advances in technology and increase in service demands. National priorities also need to be balanced against international directions and priorities.

In Canada, most of our experience with competition has been limited to date. This paper addresses several initiatives to deal with the anticipated increase in competition for the radio spectrum in the future.

Initially, a brief overview of our traditional approaches is presented, some commentary on our experiences with competing applications is outlined, further details on initiatives in the past few years are presented, an overview of choices and challenges in the future are described and some potential new initiatives are presented.

The Traditional Approach

The traditional means of radiocommunications development has been to allocate bands of spectrum to particular radio services and then to subsequently licence applicants within each service. This processing and assigning of frequencies for radio applications is accomplished according to existing spectrum policy, licensing policy, general radio regulations, and radio system standards and is normally on a "first-come, first-served" basis, providing that the licensing will not totally pre-empt the licensing of other similar applications at a later date.

In areas where there has been excess demand, preference has been given to those applications providing greater public benefits, better spectrum utilization and overall efficiency, irrespective of the receipt dates of the applications.

Until recently, there has not been a need to diverge significantly from this method of system licensing. There has been an increase in user demand and no concomitant increase in spectrum supply or rapid adoption in improvements in usage technology. There is now more than ever a requirement to review the traditional radio systems licensing policies in such a manner to ensure that applications for spectrum are dealt with in a just and equitable manner.

Experiences with Competitive Licensing

In Canada, our experience with competitive licensing for spectrum has been rather limited.

One example is the Microwave Licensing Policy. The initial microwave system licensing policy dates back to the announcement by the Minister in the House of Commons on February 12, 1970 to ensure the consolidation of network facilities in Canada. This policy required the applicants for new microwave systems to demonstrate some public interest and need to be created by the new facility, and that existing facilities could not satisfy this interest and need. It allowed the Minister, in the granting of microwave licences, to determine that new facilities would provide significant advantages over existing facilities in terms of cost, convenience, quality and flexibility. Applicants for licences were required to obtain a quotation from a telecommunications common carrier in addition to their own proposal to assist in the determination of the public interest.

In 1981, this policy was reviewed against the objectives and obligations of broadcasters under the Broadcasting Act due to the rapid expansion of broadcasting programming and the increased activities of cable television program distribution. It resulted in establishing that equal importance would be given to the broadcasting objectives as to the telecommunications objectives. Hence, a licensing policy was announced in 1983 to allow the licensing of systems for private microwave broadcasting and cable television undertakings to deliver their program signals. This may have relieved some of the competitive aspects of systems licensing but on the other hand the result was a significant increase in private microwave applications which had to be coordinated. Fortunately, the rate of growth of microwave systems as a whole has tended to be static over the past few years.

With microwave systems and fixed systems in general, the allocation of spectrum, radio system licensing, availability of licensing policy and the filing and assessment of applications is more disciplined. Each application is considered on its own merit against criteria and principles based on the public interest. However, any liberalization of licensing policy to permit private systems and new types of commercial systems would place more demand on the spectrum.

On the other hand, with mobile and broadcasting systems the competition for radio spectrum is more intense. Often the application process is simpler and they are treated on a "first-come, first-served" basis. For mobile services, in those areas where the spectrum is limited, the Department routinely assigns radio channels on a shared basis to non-competitive users.

Where there have been no policy and/or regulatory guidelines and/or where licensing of an application on a "first-come, first-served" basis could have pre-empted licensing of other similar services, due to spectrum limitations or other considerations, a call for applications procedure has been employed on a selective basis. This has been done through a notice in the Canada Gazette with a specified cut-off date and an outline of the terms and conditions for the application process as a whole. Due to the expenditure of time and manpower resources which implementation of this process requires, it has been used only on a selective basis and only where in the Department's assessment the public interest would have been best served in such an undertaking.

The Department has made a call for application process in three instances where licensing decisions were required. The first was the October 1982 call for cellular radio telephone applications; the second was the January 1983 call for trunked mobile radio applications; the third was the May 1989 call for nation-wide paging at 900 MHz.

(a) Cellular Mobile Radio

During the period from 1980 to 1982, a public consultation process was carried out to determine the cellular frequency bands and the type of cellular systems which would meet the needs of Canadian users.

In October 1982 a call for applications was announced for the operation of cellular mobile radio in the 23 Metropolitan Areas of Canada. Applicants were given until February, 1983 to submit 12 separate items of information (called exhibits) which were evaluated in-house in a closed process by Departmental personnel. Following the review of this material, further written submissions were requested from the applicants and evaluated internally.

(b) Mobile Radio Trunked Systems

On June 5, 1982, the Department published a notice in the Canada Gazette on the "Proposed Policy for the Licensing of Mobile Radio Trunked Systems". Based on the public consultation, policy guidelines and criteria were released on January 1, 1983. A call for applications by April 1, 1983 was made for major urban areas to be followed by "first-come, first-served" licensing after the closing date for applications.

Written applications were evaluated on the basis of the following criteria: need for proposed system, technical considerations, service, system inauguration and expansion, experience and competition.

Both of these calls (a) and (b) have resulted in licensing decisions to the various successful applicants.

(c) <u>Nation-Wide Paging</u>

The latest call for applications was the May 1989 public notice for nation-wide paging in the 900 MHz band. This notice requested an expression of interest and established ownership eligibility requirements.

<u>Recent other initiatives</u>

As a general principle, the Department formally consults with the public before undertaking new policy or regulatory initiatives. After analyzing the public comments, the Department will announce policy guidelines or request further public consultation on proposed policy guidelines. It is our intent to continue with this approach to public consultation.

Taking into account our past experiences with competitive licensing, the growing demand for radio spectrum and advances in radio technology, a number of initiatives were undertaken in a public consultation context. These included:

(a) <u>Radio Licensing in Limited Spectrum Environments</u>

In March, 1987, the Department published a notice in the Canada Gazette to solicit comments on the policy and procedures which should be taken into account in dealing with those situations where the number of applicants exceeds the supply of frequencies for a particular service. Comments were requested on basic qualifying requirements for licensing, the procedure to be used for the provision of input to the department, the criteria to be used to evaluate applications, the procedure to select the successful applicant (Comparative hearings, auctions, lotteries, etc.) and post-licensing requirements.

The submissions expressed a preference for comparative hearings in evaluating the relative merits of one applicant versus another. It was clear from the submissions that a process which employed either lotteries or auctions would encounter opposition from prospective applicants and would not enjoy the confidence of those it seeks to serve.

(b) Implementation Strategies for the Introduction of Advanced Television Services in Canada

In July, 1987, a gazette notice was released for public comment to assist the Department in future decisions and strategies for the eventual implementation of advanced television services. These new services require substantial further consideration in the areas of standards, spectrum requirements, compatibility with conventional television and means of distribution.

As a means to address most of the areas of concern, the Canadian Advanced Broadcasting Systems Committee (CABSC) was formed to deal with the technical issues involved.

(c) Spectrum Utilization in the 30 to 960 MHz Range

A discussion paper was released in September 1987 to elicit comments on a number of theme issues and to determine the environmental framework for spectrum development in this range for the next 15 years. This range encompasses some of the most heavily used spectrum and encompasses most of the vital applications of radio systems today in the mobile, broadcasting and other services.

Further coordination and policy proposals will continue to be released and discussed through public consultation.

(d) Spectrum Utilization Policy for 10.7-11.7 GHz and 12.7-13.25 GHz

In April 1989, through the Canada Gazette, changes to these bands were proposed to support MSAT feeder links. These bands are now used by telephone and cable television companies and the proposal would determine the method of sharing of the bands.

(e) Radio Policy Guidelines Respecting Datacasting Services

In June 1989, comments were requested on guidelines for datacasting services concerning areas such as access to transmission channels, consistency of regulatory treatment between broadcasting and non-broadcasting services and licensing requirements.

(f) Local Microwave Systems

In November 1988, comments were requested on radio licensing policy for local private microwave due to the increased demand, the range of low-cost microwave systems, applications and services, the level of private network interconnections to public networks and greater flexibility demanded by business users. The first phase of public consultation was completed with a range of submissions received. In mid-October 1989, the Department initiated a radio licensing policy review for a restricted type of local public commercial service to provide specialized local radiocommunication services or innovative transmission distribution facilities.

(g) Transborder Satellite Services

A Canada Gazette notice in September 1989 requested comments on domestic arrangements for transborder telecommunications via satellite related to access to satellite facilities and earth station licensing. Comments were requested on use, markets and growth for services, applications of two-way micro terminals, mobile services and video and data receive-only earth stations.

These initiatives provide a good indication of the increasing complexity of the issues requiring decisions, the increasing time period before specific initiatives and policies are implemented and the increasing competition for access to the radio frequency spectrum.

Our approach has always been to ensure the orderly development of radio communications and it is likely to continue in this direction. However, over the next ten years and into the 21st Century there will be some hard decisions which will have to be taken. Some of these decisions will require new decision-making tools and new approaches.

Choices and Challenges in the Future

If we look forward to the future of the radio frequency spectrum, there are a number of major trends that will have to considered:

- Increasing competition for new radiocommunications services by more players.
- Increasing need for national service systems.
- Globalization of users, services and companies.
- Spectrum increasingly becoming an indispensable and highly used resource.
- Digitization of radio systems.
- Development of multi-service systems.
- Services becoming indistinguishable one from the other.
- Increasing numbers of multi-service providers.
- Increasing instances of spectrum shortages.

expected to take into account the market demands, the distribution technologies available for the delivery of services, the impacts of various strategies pursued by government in terms of social, economic, cultural and other predetermined objectives.

Thirdly, the Department is considering seriously initiating a full review of our spectrum allocation framework and bringing an appropriate policy strategy to be responsive to the development of radiocommunications to the 21st century and beyond.

These initiatives indicate a new emphasis by government to focus on this valuable resource, the radio frequency spectrum.

Conclusion

The radio frequency spectrum is being increasingly recognized as an indispensable resource for the distribution of a wide variety of services to industry and the general public. It is a cornerstone to support the efficient development of radiocommunications services, and an integral part of the Canadian telecommunications systems and the broadcasting system. It is also indispensable for the security, safety and sovereighty of this country.

New demands, particularly in areas where the spectrum is scarce, are placing new challenges and hard choices before the Department. In this paper, I have attempted to provide a general overview of our experiences with competition for access to the spectrum and some trends as well as new initiatives under taken by the Department.

As has always been the case, we intend to continue to consult with industry on a coordinating and partnership basis to ensure Canadian needs and objectives can be met. This is becoming more important and more critical with the rapid advances in technology and users insatiable requirement for services and information.

These trends translate in many instances to more demands and more competition in access to the spectrum. This will undoubtedly mean that hard choices will have to be made and new approaches will be required to deal with spectrum allocation and management in an environment of increasing spectrum scarcity.

For example, some of the challenges and choices include the following:

(a) Should part of the fixed terrestrial spectrum at the low end of the microwave bands be allocated to relieve spectrum congestion caused by mobile and broadcasting services?

For example, fibre optic systems are being deployed in the Canadian telecommunications system to provide an increasingly significant percentage of the intercity circuit requirements of the telephone and public data networks. Less pressure is being placed on many of the various microwave bands that provided the backbone networking of the telecommunications system.

(b) Is spectrum better directed from broadcasting to other services in urban areas, in an era of large capacity cable TV distribution and the prospect of alternative broadband service distribution to the home based on fibre?

For example, should fibre to the home become a reality, would it be feasible to directly distribute broadcasting signals through the fibre network and use the broadcast spectrum for new and innovative services.

(c) Should broadcast spectrum (VHF/UHF) be used for other services through a process of gradual termination?

As an example, in 1985 in the UK, VHF off-air television broadcasting was terminated and the spectrum was reassigned to mobile services.

As well, in Australia recently, AM radio stations were converted to FM stations, and the vacated AM frequencies were made available for Radio for the Print Handicapped services and a permanent Federal Parliamentary broadcast station.

(d) How will we meet the increasing demands for new services?

Service demands are growing at an incredible pace. Naturally, from a cost and product availability standpoint, many radio applicants for spectrum want to be in the VHF/UHF bands. However, the competition for spectrum that has taken place in the 30-960 MHz range is now moving into the 1-10 GHz range and eventually will occur above 20 GHz.

(e) How will advanced television services (HDTV) be delivered and what spectrum will be required?

As these deliberations are continuing, it is not likely that an answer can be found in the next year or so.

(f) Should spectrum be auctioned in competitive situations?

This is an appealing option for government due to the revenue potential.

During the 1990 budget deliberations in the U.S. for the F.C.C., it was estimated that 6 MHz of spectrum could yield $2.3 billion in 1990.

Cellular licenses in the United States are valued in the range of $89-141 per capita in the service area.

In Australia recently, tenders for six frequencies in the FM band realized $105 million.

These provide a number of examples of challenges that will have to be faced in the future. As any reallocation of spectrum is made, there will increasingly be competition for the use of that spectrum.

Instead of sitting idly by as decisions on spectrum are being made, the Department has decided to put greater emphasis on longer term developments and attempt to more thoroughly analyze some of the options available.

New Initiatives

In order to attempt to meet the new challenges associated with spectrum access and competition for spectrum, a number of initiatives have been undertaken.

First, in order to more precisely determine the future demands for services, a series of contracts have been let to assess mobile and satellite services requirements, to determine the timing of these demands and to outline the changes in technology which could occur. These should provide us with a more precise overview of where the demands are coming from and how these could be addressed from a spectrum standpoint.

Secondly, a spectrum decision-making model will be developed to enable the Department to be in a better position to assess the implications of various demands on the spectrum and to develop strategies and scenarios to meet specific objectives. This model is

THE CHALLENGE OF ENHANCED ENTERTAINMENT

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ABSTRACT

This paper outlines the current use of the spectrum for the provision of broadcast entertainment, information, and educational services, via AM Radio, FM Radio, terrestrial television, and satellite delivery mechanisms.

An overview of enhanced radio and television broadcasting services is provided. Included is an evaluation of the broad categories under which proposed advanced television services can be grouped, as well as a description of current efforts in digital and audio broadcasting. The spectrum issues associated with these various enhanced services is assessed.

This paper's conclusions address the delivery of enhanced services to the Canadian public, with emphasis on access, spectrum requirements, and efficiency.

Résumé

Le défi de l'amélioration des services de divertissement
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Ce document décrit l'utilisation qui est faite à l'heure actuelle du spectre des fréquences radioélectriques en vue de la prestation de services de divertissement d'information et de services éducatifs par l'intermédiaire de la radiodiffusion AM, de la radiodiffusion FM, de la télévision de Terre et de moyens de distribution par satellite.

On y donne un aperçu des services améliorés de radiodiffusion et de télévision. On y fait également une évaluation des grandes catégories dans lesquelles pourront être groupés les services projetés de télévision de pointe et l'on y présente une description des efforts actuellement déployés en radiodiffusion numérique et en radiodiffusion sonore. Les auteurs évaluent les questions relatives au spectre, associées à ces divers services améliorés.

Les conclusions de ce document sont axées sur la distribution des services améliorés à la population canadienne, en particulier sur la facilité d'accès à ces services, les besoins en fréquences et l'efficacité de l'utilisation du spectre.

1. INTRODUCTION

At the conclusion of the twentieth century, the world of audio-visual entertainment is experiencing both an evolution and revolution. Since their beginning, radio and television broadcasting have demonstrated, through their popularity, the need and the demand for home- and individually-oriented entertainment. While entertainment industries such as cinema, have responded to the competition by offering services of higher quality, the trend in the home environment was to increase the number of services. The emergence of cable-television, satellite television, VCR's, videodisc, audiodisc, and more radio and television channels is evidence of this trend and of the public demand for diversity and quantity of services.

Numerous new technologies designed to increase the realism of the viewing and listening experience by improving the quality of sound and picture are coming forth. Such factors as higher resolution, greater luminance range, better colorimetry, and wider aspect-ratio, increase the clarity, depth, and the overall realism of the images. The same is true in sound with wider frequency response and dynamic range, multichannel effects (i.e., stereo, surround-sound) and higher signal-to-noise ratios obtained with noise reduction systems or digital technology.

With the application of these new technologies in the home entertainment environment, it is now possible to produce and deliver to the individual improved sound and images of quality comparable to those in the world of outside entertainment. Broadcasters, cable and satellite television distribution companies, and the consumer electronic industry are planning to meet the demand and competition that will be created by this technological revolution.

The public has been exposed to such enhancements through 70 millimetre film, cinemascope, surround sound, "THX" sound system, high-definition television, digital sound, and this has considerably increased their expectations in terms of image and sound quality. It is likely that they will demand such high quality in their homes and cars. Recently, the rapid penetration of the compact disc in the homes has confirmed this.

Because of the geographical and socio-ecomomical situation in Canada (i.e., large territory with dispersed pockets of population, cultural/language diversity, and the wide range in the "niveau de vie" of the Canadians) over-the-air broadcasting plays a key role in the provision of audio and video entertainment to viewing and listening audiences as it enables each Canadian to access to the system at minimum costs. In addition, broadcasting has other social purposes (i.e., education, enlightenment, information, and cultural enrichment). In the interest of the Canadian public, it is therefore essential that broadcasters be able to offer and deliver new and enhanced services at the highest possible quality level afforded by technology.

As most are aware, broadcasting is allocated valuable portions of the radiofrequency spectrum below 1 GHz, providing radio, television, and data services to virtually all Canadians. In addition, broadcasters also employ spectrum above 1 GHz for private communication links and are allocated bands in the 12, 18, and 23 GHz range for satellite broadcasting and around 2.5 GHz for multichannel distribution. It is noteworthy that the development and regulation of broadcasting in Canada has already made good use of a balanced mix of terrestrial over-the-air, cable, and satellite delivery of services that is both cost and spectrum-efficient.

In many parts of the country, particularly in the densely-populated areas along the U.S. border, most of the spectrum currently allocated to broadcasting below 1 GHz is already assigned and used, respecting current service and system design criteria.

Because of the technological revolution, the demand for new and enhanced services is growing rapidly, expressed as both an increased number of services, frequently of a specialized nature, and by the introduction of enhanced services. Digital sound broadcasting, enhanced and advanced television services, HDTV broadcasting and data broadcasting are some of the elements in the action plan of the broadcaster. These new services require signals and coding formats which can transport more information and in more sophisticated formats than current systems, leading to a need for additional spectrum capacity, both in the form of more channels and of channels of improved performance (i.e., increased bandwidth, better carrier-to-noise ratio, lower interference, etc.), at a time when other non-broadcast services, some public, many private, are also seeking additional spectrum space. The result is a foreseeable squeeze on spectrum leading to a seemingly insoluble crisis in the years ahead.

While the responses to some of these needs might be found that do not demand further spectrum, all alternatives must be examined in an effort to determine the overall scenario that will benefit all Canadians.

This presentation first analyses the current situation and examines the proposed new and enhanced services, overlaying them on the present to develop an integrated view of the public's need for spectrum for the delivery of enhanced services to each Canadian.

2. CURRENT USE OF SPECTRUM FOR BROADCAST ENTERTAINMENT, INFORMATION, EDUCATION

As we are all aware, current broadcasting services in Canada are well developed. Seventy-one percent (71%) of all Canadians over the age of two listen to either English or French AM radio services at least once a week; sixty percent (60%) either English or French FM radio service; and ninety-eight percent (98%) either English or French television services. [1] The availability of such services to Canadians on a national basis is higher.

There are estimated to be 14,989,000 television receivers in Canada including colour or black and white sets, and 24,506,000 radio receivers, many of them in automobiles and other vehicles. [2, 3] The development and introduction of enhanced services in this environment requires careful planning to avoid major disruptions to the public.

2.1 AM Radio

AM radio services currently use the band 540-1605 kHz (one hundred and seven 10 kHz channels) with an expansion to 1705 kHz (ten additional channels) now in process. There are over 800 transmitting stations in Canada. It is now very difficult to find a frequency for a medium or high-power station in Canada.

AM radio in most populated areas has a difficult time competing in the marketplace, resulting in a trend towards specialized audiences such as in automobiles. The introduction of stereo has had only a minor effect in improving the audience share. The recent introduction of controlled pre-emphasis and better filtering via the NRSC characteristic to the extensive audio processing widely used in this service, will improve coverage due to the reduction in noise and interference, thereby making more efficient use of the spectrum assigned.

Due to propagation effects and electromagnetic noise levels in this band, coupled with unsophisticated receiver designs, the quality of the service is inadequate for enhanced entertainment. Accordingly, AM radio through the years has become more news and information-oriented with a migration of entertainment to FM radio. The technical quality of AM radio is unlikely to achieve that of FM radio or compact disc.

2.2 FM Radio

FM radio currently occupies the 88-108 MHz portion of the spectrum and most stations offer stereo services with some including auxiliary sound or data services through the use of subcarriers.

There are over 750 FM stations in Canada. The FM radio spectrum has become essentially fully utilized in most metropolitan areas, notably the Quebec City to Windsor corridor and the Vancouver/Victoria area.

Recent developments in FM radio include: FM-X, a compatible modulation process that extends the area of acceptable stereo service to be equivalent to that of monophonic services, and; Radio Data Service, a subcarrier-based data broadcast service developed in Europe to enhance current transmissions with related information. However, as all radio broadcasters are now aware, the quality-level of FM stereo broadcasting has been surpassed substantially by other consumer equipment, such as the Compact Disc and R-DAT.

2.3 Terrestrial Television Services

Currently the bands ranging from 54-72 MHz, 76-88 MHz, 174-216 MHz, and 470-806 MHz (excluding 608-614 MHz) are used for the broadcasting of television, totalling 72 MHz of the VHF band (12 channels) and 330 MHz of the UHF band (55 channels). There are currently approximately 1480 VHF-TV stations and 400 UHF-TV stations in Canada.

The status of receiver technology limits the possible selection of channels in any given geographic area to second-adjacent in the VHF area and fifth-adjacent in the UHF band, with other limitations based on image and cross-modulation products. Therefore, at any point, no more than approximately 15 channels can be assigned. However, these limitations are offset somewhat by the allotment and assignment of the locally unusable channels in nearby adjacent television markets, thereby leading to a much denser allotment and assignment plan than is apparent at first glance. In fact, in several cases, it is the short distances between metropolitan areas which limit the use of channels in a given location.

The distribution of television by cable, an area where Canada has been both a pioneer and a leader of this technology, has enabled viewers to exceed this limit in about 68 percent of households, but the remaining 32 percent of households must accept far less. In most of the heavily populated areas of Canada, especially those within 100 miles of the U.S. border, all currently possible VHF allotments are already assigned and in use. In regards to available UHF allotments, studies have shown that, considering only normal growth of traditional broadcast services, all allotments in ten of the largest metropolitan areas will be fully assigned by the year 2007. [4]

The quality of the NTSC signal delivered by terrestrial broadcasting and cable is becoming non-competitive with that deliverable by pre-recorded media (e.g., S-VHS). Providers of entertainment services, concerned with the potential loss of market share, are actively seeking delivery mechanisms to reverse this trend and to render their programs competitive and attractive from a quality viewpoint. In this quest they are joined by consumer equipment manufacturers who identify this as a major potential market.

2.4 Satellite Delivery

The delivery of television to viewers by satellite has developed in a perverse, though an eminently pragmatic fashion in Canada. A de-facto satellite broadcast service has developed in the FSS sections of C-band and Ku-band, using transmissions directed principally at broadcasters and cable system head-ends. In addition, some 250,000 homes are serviced in this way in rural and remote areas. However, the operating parameters and satellite designs in these FSS bands are not optimized for direct delivery to the homes.

Due mainly to the current difficulties related to the launching of a Direct Broadcasting Service (DBS), Ku-band allotments for high-powered broadcasting satellites remain unused. On the other hand, proposals to use the 2.5 GHz allocations for multipoint distribution systems (MDS) are now on the increase. Satellite delivery, while a cost-effective way to deliver services to certain viewers, is not competitive generally in urban areas, remaining a small, but nevertheless important portion of the delivery system. The interconnectability of satellite delivery with other delivery mechanisms is an important consideration for the future.

2.5 Broadcasters' Links

Broadcasters have important needs for spectrum in closed-circuit applications for such things as studio-to-transmitter links, ENG links, entrance links/satellite backhauls, cue and communications, and wireless microphones. Assignments in the VHF, UHF mobile bands and in the 6.930-7.125 GHz, 13.15-13.25 GHz, 15.075-15.175 GHz, and 20.2-23.6 GHz bands are employed.

Co-ordination of these frequencies continues to be a difficult problem at major public sports, news, or entertainment events when a large number of broadcasters are present, requiring flexibility in spectrum availability and co-ordination.

3. ENHANCED ENTERTAINMENT SERVICES

Current audio-visual entertainment/education/information services to the public are based on system standards developed some time ago, i.e., AM radio before 1920, FM radio the mid-1940's, and the current color-TV standard was added in 1951 to a monochrome TV system already 12 years old. Modern technology - transistors, integrated circuits, lasers, digital processing, etc., have served to improve the performance of these systems far beyond the best expectations of their creators but has also enabled the creation of new systems offering greatly improved results, many of which compete directly with the somewhat dated offerings of broadcasters.

Similar considerations have led to the availability of large numbers of new production tools and delivery mediums and to the development of consumer electronics equipment based on quite complex processing at remarkably low levels of cost.

Together, these form the basis of the enhanced entertainment revolution currently becoming visible. Its elements include:

- Digital sound broadcasting, both terrestrially and satellite-delivered;
- Enhanced television services;
- HDTV broadcasting, bringing theatre-quality sound and images to the home;
- Data broadcasting services, both associated with programming and as independent services.

Existing frequency allocations and broadcast systems do not readily lend themselves to the introduction of these new technologies. As mentioned in the introduction, with the expected public demands, this will create additional spectrum requirements. Allocations for such services within the next few years will have to be carefully considered. Due to the public nature of these developments, considerable pressure from both broadcasters and the public audience will be focussed on the regulators of spectrum to meet their needs.

3.1 Enhanced Radio Services

Radio broadcasters, in response to digitally-based media, such as the CD, are starting to convert their studio to digital. From this benchmark emerges the interest to deliver digital sound quality to consumers. The development of sound broadcasting services based on digital modulation is at an advanced state in Europe, lead by the efforts of European administrations, the EBU and, more recently, European industry, all in an effort to be able to offer new services and products in the middle 1990's. A combined source and channel digital coding system was demonstrated in Geneva last year. The system was developed for both satellite and terrestrial applications taking into account the characteristics of mobile reception.

The proposed transmission scheme is based on multiple narrowband subcarriers in a bandwidth of about 4 MHz, each modulated with a part of the data redundantly and using an advanced convolution coding process. [5, 6] By the use of multiple carriers, the effects of Rayleigh fading on portable and mobile reception can be minimized and significant advantages accrue in the case of interference and multipath effects, which become a thing of the past. Sixteen stereophonic channels plus additional data can be transmitted in 4 MHz. The quality of the received sound signal is comparable to compact disc.

The impressive claims made for this new approach merit serious consideration since it permits a reduction in bandwidth, energy density, terrestrial transmitter and satellite power requirements. This results in very efficient spectrum utilization. It also increases the viability of a satellite and terrestrial digital sound broadcasting service and makes it appear highly attractive. Other systems to reduce the bit-rate of the digital audio baseband signal have been proposed and they form part of this new approach to sound delivery.

Under the auspices of the Canadian Advanced Broadcast Systems Committee, or CABSC, the prototype equipment will be demonstrated in Canada in the spring-summer of 1990 in a series of field tests to fixed and mobile receivers under a variety of receiving conditions.

The precise parameters required for the planning of this service are currently under study. The new service will require spectrum in the region of 1 GHz ideally, the subject of discussion at WARC-ORB-88 and at the upcoming WARC-92. The proposed service would offer local service in a terrestrial implementation and regional service with relatively low-power spot-beams in a satellite implementation. Common receivers could be developed for both applications, opening the door to a new service in the late 1990's, if the spectrum can be allocated and planned in time.

There is therefore an urgent need to consider digital sound broadcasting from both a spectrum and system perspective in North America, due to the noncompetitive position current radio broadcasters may find themselves in, coupled with the exhaustion of spectrum capacity in the major radio markets.

3.2 Enhanced Television Services

Several technologies designed to improve the quality of television images and sound have been proposed, ranging from compatible NTSC improvements to full HDTV. High-definition television (HDTV) is defined as at least twice the vertical and horizontal spatial resolution; separate color-difference and luminance signals; improved colorimetry; wider aspect ratio; and multi-channel high-fidelity sound. The bandwidth of the HDTV baseband signal in comparison to NTSC is increased by a factor at least five. It, therefore, is difficult to transmit HDTV directly in that form on conventional television delivery mechanisms because of current channel bandwidths. Signal compression techniques, however, permit the transmission of HDTV in significantly less bandwidth with only small impairments to moving elements of the picture.

Current receiver standards and product base, spectrum availability, channelling plans, and regulatory issues make the question of compatibility with existing systems an important one for broadcasters.

The subject of HDTV and enhanced TV services has taken on major political and economic significance in the last few years, as broadcasters, consumer equipment makers, and administrations have come to realize the implications of such services in their respective areas.

While the television production sector, is directly addressing HDTV, broadcasters are somewhat less focussed in their objectives, stating a need for systems that provide service that are "significantly better than NTSC, and without cross-effects, CD-quality sound, maintaining NTSC service". [7]

The CABSC has further stated the need for an enhanced broadcast system to operate optimally over terrestrial, cable, and satellite delivery media with receiving equipment of maximum commonality, thereby reflecting the reality of the Canadian environment. Several proposals, under the name of Advanced Television Systems (ATV), have emerged to meet these stated objectives and can be summarized in the following broad categories: [8]

(i) - Enhancements to NTSC at the studio, in the receiver or both, that are fully compatible, leaving aspect-ratio and fundamental structures unchanged. As examples, complementary fore/post multi-dimensional filtering, line rate up-conversion at the display, non-linear pre-emphasis have all been proposed and demonstrated. These enhancements do not require extra spectrum and have no effect on coverage or planning criteria. They are hence likely to be incorporated at an early date.

(ii) - Channel and receiver compatible HDTV transmission schemes, in which an appropriate HDTV receiver will receive a wide-aspect ratio, enhanced resolution picture with high-quality sound, while a conventional NTSC receiver taking the same service would receive a normal picture in 4:3 aspect ratio, though perhaps with some new artifacts added. Proposals such as this employ typically additional subcarriers, carrying side-panel data during vertical blanking, and use temporal sub-sampling to achieve the results. Systems proposed by the David Sarnoff Research Laboratory (ACTV-1) and NHK (Narrow-MUSE) are typical examples. While not requiring additional spectrum space directly, such systems, of necessity, are potentially more sensitive to noise, interference, and multipath distortions that results in: a potential loss of service area; a need for improved protection ratios; and higher levels of interference to NTSC channels.

(iii) - An improved level of performance can be expected if the need for receiver compatibility is removed and the capacity of the 6 MHz channel is used to its fullest. Proposals, such as those published by Zenith and NHK (MUSE-6), fall into this category and certainly show promising improvements in performance. By the use of improved modulation techniques, a far higher level of spectrum utilization is achieved, while the channel can be made robust against interference and noise. It also lends itself to generating less interference into NTSC channels due to the absence of carriers and subcarriers.

(iv) - A number of proposals to improve the performance of systems of type (ii) and (iii) have been made which would require extra spectrum, in the form of a full 6 MHz channel or 3 MHz half-channel, assuming that this extra spectrum is non-contiguous. While in principle this seems an attractive concept, its practical application under "real-world" conditions of noise, interference, propagation differences, and ghosting has yet to be proven. The performance of this approach compared to a case (iii) approach coupled with a case (i) approach on two channels is questionable. This latter "simulcasting" approach would result in spectrum recovery, if and when the NTSC transmission became redundant.

(v) - The transmission of HDTV in its full form at the production level of quality is idealistic and a matter for the future. At WARC ORB-88, the frequency range 12.7-23 GHz has been identified for the selection of an appropriate band on a world-wide basis for the broadcasting of wide RF-band HDTV by satellite and this subject will be discussed at WARC 92. Both digital and analog modulation schemes have been discussed, but it is unlikely to be directly compatible with current services. While the spectrum requirements of about 50-120 MHz per channel might be accommodated under certain conditions in some countries of Region 2 (including Canada), this is not the case in the rest of the world. Therefore, if world-wide agreement is reached on an allocation above 12.7 GHz for wide-band HDTV, it could be expected that systems and equipment development would be concentrated on that band. For Region 2 countries, this could be simply an exchange of the existing allocation at 22.5-23 GHz with the new one, if agreement can be reached.

3.3 Data Broadcasting

Current proposals for data broadcasting are based on being auxiliary to other radio or TV services. There are thus no significant spectrum aspects to be considered in the short term.

4. DISCUSSION

4.1 Broadcasters Constraints

Broadcasting is a service different from others using the spectrum, as it involves a very large public receiver base over which the broadcaster exerts little control. When implementing a service based on a new technology, broadcasters must always be cognizant of the fact that the public will not immediately change receivers for the new system.

Therefore, the implementation of any new broadcasting services, such as the BSS, where new receivers are required, and a large initial capital cost in involved, will take a very long start-up time. Consequently, to enable the emergence of such a service, to initiate development, and inspire confidence in investors, receiver manufacturers, and the public, the frequency allocation and planning must therefore be done a long period of time before the service is used.

4.2 Radio

For radio, where mobile and vehicular reception is a key factor, over-the-air broadcasting is the most suitable delivery medium. For nation-wide radio coverage direct broadcast satellite may be the best alternative.

At WARC ORB-88, a number of countries expressed a need in the future for a DBS for Radio service (this new service has been under consideration for the past 25 years), and the frequency range 0.5-3 GHz was identified for consideration, although the 2-3 GHz portion has not been studied yet for this application. This frequency range is extensively used by other radio services and sharing will be very difficult. Recently, with the advent of digital modulation, it seems that the interest will move towards a combined terrestrial/satellite radio service. The UHF-TV band and other bands in this range are is being examined for this new service.

Digital radio broadcasting is still in its infancy, with the first Canadian demonstrations scheduled in Montreal early in 1990, through the CABSC. In consequence, there is little public awareness of the potential for such a service or direct activity on the part of broadcasters, other than recent CABSC undertakings, to develop plans for its introduction, though all those included in its study recognize the significant potential for improving radio broadcasting.

It is seen by experts as the next generation of radio service and as the best answer to maintain radio's competitive position in quality terms in an era of R-DAT and CD. The allocation of spectrum for such a service is a crucial step and the Canadian preparation for WARC-92 will have to take this into consideration. The service bandwidth and number of channels required is currently a question, however, all current radio assignments and allotments must be accommodated, capacity must be provided for narrowcasted services, regional/national services, and potentially specialty channels. The same prudence and foresight must be applied in this exercise as was applied in the development of, for example, the Canadian FM Allotment Plan.

There is little doubt that digital radio can develop rapidly and that the years 1995-2000 will see its beginning. Public and private radio broadcasters must do all they can to ensure that such a service as this is established.

4.3 Television

Enhancements to current television services can best be considered in the three respective categories:

A) Enhancements to the number of services offered to the viewer.

Current spectrum use and the lack of available channels in the VHF and UHF bands makes it unlikely that a large increase in over-the-air television services will occur, unless major improvements are made in receiver technology to permit the replanning of the UHF bands.

Even in this event, major policy issues would arise, such as, should any such "new" channels be assigned to "more" conventional television or to "new" television? The answer is unclear from a policy or technical viewpoint.

The most likely scenario is that new channels, often of a specialized nature, will be carried only on cable and satellite and hence have little spectrum impact. The fact that a significant portion of the viewing audience will then not receive these channels (as is currently the case with CBC's Newsworld, for example) may cause some concern.

B) Enhancements to current NTSC broadcasting.

A number of compatible enhancements to NTSC have been proposed and are likely to be adopted fairly rapidly, though only maintaining the status quo from a performance perspective.

Already IDTV (improved definition television) receivers are on the market offering digital processing and a high resolution 1050-line display with a minimum of cross-colour/luminance. Improvements on the broadcaster side such as prefiltering, non-linear pre-emphasis and ghost-elimination signals will be introduced slowly and will bring more improvement to all receivers but will demand a significant improvement in the source signal.

These enhancements will serve to delay the introduction of HDTV broadcasting by a few years, allowing a little time for the spectrum planning required and for broadcasters to upgrade production plants in the anticipation of HDTV transmission.

C) HDTV Broadcasting.

In the introduction of HDTV, the broadcaster is faced with dilemmas, especially from a business viewpoint, and also in the selection of an appropriate standard. It is desired that programming quality be competitive to the greatest extent possible with those of other delivery media, yet there is a recognition that the highest quality cannot be achieved with strict compatibility of HDTV/ATV services. Without it there could be a serious loss of audience share or large capital costs to implement "ancillary" or simulcast channels. There is thus a major dilemma for the broadcaster, aggravated by the uncertainty over the spectrum space needed for the alternative approaches.

A number of possible scenarios thus can be identified:

1. SINGLE-CHANNEL COMPATIBLE
   From a spectrum management viewpoint this will not demand additional channel capacity but the HDTV modulation format and accompanying digital sound will raise the in-channel spectrum occupancy. This will lead to a push for improved protection ratios, a potential reduction in effective service area and increased interference to adjacent- and co-channel assignments. The possibilities for sharing with other services will be severely reduced.

2. <u>2-CHANNEL COMPATIBLE</u>

There are some who believe that a single, compatible channel will be insufficient to deliver an adequate level of quality and propose the use of a second augmentation channel of 3 or 6 MHz bandwidth. A number of proposals have been made for such a solution. In some, the basic compatible channel is untouched (or possibly enhanced) and all augmentation signals for side-panels, resolution enhancements and additional audio are carried in the extra full-width channel. In this case, considerable bandwidth is required. In others, the single channel carries a significant augmentation load and the augmentation channel carries only video resolution and audio enhancements, in a limited bandwidth e.g., 3 MHz. This scenario is thus a simple extension of that described previously. Proposals of this nature could cause great difficulties for spectrum managers and large costs for broadcasters, cable operators, and viewers.

Current studies have shown that a 3 MHz augmentation channel could be theoretically accommodated, but its practicability is questionable when one considers the high price to be paid of using practically all of the currently unused allotments, thereby placing a severe limit on future service growth. In addition, there remain the problems of a rational allocation plan, service area matching, and additional interference with other channels or services, doubly difficult to predict until agreement is reached on the coding and modulation standard for the augmentation channel. This scenario does little to improve spectrum-efficiency and continues the current situation forward indefinitely.

3. <u>SINGLE-CHANNEL INCOMPATIBLE</u>

In this proposal, the 6 MHz television channel bandwidth would be retained but the coding and modulation would be incompatible with NTSC receivers or cable head-end processors. Current services would be maintained on a second simulcast channel, using the normal NTSC format, until there is a sufficient penetration of the new receivers for HDTV. This approach offers the highest spectrum efficiency over the long term and could be arranged to work with relatively low protection ratios, leading to further spectrum efficiencies. Current receivers would require a "black-box" converter to receive this service.

This proposal has much attraction for the spectrum manager, offering efficiency, flexibility, and the possibility to recover and re-use NTSC assignments in the future. In the present situation, the channels required would be somewhat simpler to allocate than those for the two-channel compatible scenario, due to the lower protection ratios. It is likely that much of the spectrum required for this proposal could come from the UHF taboo channels.

This approach has also some cost implications for the broadcasters (additional transmitter), cable operators, and viewers.

4. <u>TWO-CHANNEL INCOMPATIBLE</u>
Demonstrations have been performed of bandwidth compressed real HDTV systems in 12 MHz channels, adapting hardware developed for satellite use to the AM-VSB modulation of terrestrial broadcasting. It is unlikely that such systems will be practicable or desirable, offering no gain in spectrum efficiency and losing the benefit of compatibility.

Of the four scenarios, only the single-channel compatible and single-channel incompatible approaches appear to have long-term viability, with the technical advantage with the latter system. From a policy and business viewpoint, the creation of a new television broadcasting system in competition with current services could be questioned, particularly as the transitional period could be lengthy and costly. From a spectrum viewpoint, however, a system that offers a better service through improved interference immunity must be seriously investigated, opening the way to more and improved services in existing spectrum. The use of a black-box to grandfather existing receivers would appear then to be a small price to pay.

In summary, it may be possible to implement an HDTV/ATV terrestrial broadcast service within the existing VHF and UHF TV broadcast bands under current or modified technical criteria. Additional spectrum capacity in these bands could be obtained by modifying the current interference and protection standards and/or by reconfiguring the VHF and UHF channelling plans to provide additional channels. However, final spectrum requirements will only be known after careful objective testing and evaluation of the various ATV scenarios are completed and the options for implementation are determined.

There is also the question of Wide-Band HDTV delivery to the consumer, a new service which is expected in 15 to 20 years due to availability of technology and public demand. Up to now, satellite broadcasting has been considered. At WARC ORB-88, administrations agreed to look for an appropriate band for BSS-HDTV in the frequency range 12.7-23 GHz, while also continuing to study the long-range suitability of the present 12 GHz BSS bands for this new application. WARC 92 will address this question. It is noteworthy to mention that the CCIR has concluded that except for certain countries in Region 2, the 12 GHz BSS bands, as planned, will not accommodate single-wide RF channel HDTV. [9] A new frequency allocation will be required, preferably on a world-wide basis, to facilitate international standardization as mentioned earlier.

5. CONCLUSIONS

The public in Canada is well served by the current broadcast entertainment services and any erosion of this position or falling behind in the delivery of new or enhanced services will be met with much opposition. Canada must move ahead and this will demand careful planning of the spectrum, the potential allocation of new spectrum, and a continued concern for wide access to services by the integration of delivery methods. This will demand interconnectability of delivery mechanisms.

A number of key points can be identified.

- Enhanced NTSC/IDTV is already here in the receiver and will soon be in the transmitter. While not demanding new spectrum directly, noise, interference, and multipath problems will aggravate the need for planning.

- Pressure will continue for new channels as well as channels to enhance services to ATV. The provision of these channels may well need new technology and the acceptance of increased interference to terrestrial delivery in metropolitan areas.

- The ATV approaches of single-channel compatible and single-channel incompatible must be carefully examined. While the long-term solution may well be single-channel incompatible, the short-term effects of that decision could well be unacceptable. In either case, a large increase in spectrum is needed either on an interim basis or permanently. At present, the only alternative for broadcasters to find this additional spectrum capacity is to use the available UHF spectrum currently allocated to terrestrial broadcast television service.

- A continuation of the current "delivery-neutral" approach to planning and regulation seems justified with an emphasis on interconnectability and rationalization of delivery methods.

- Spectrum for digital radio broadcasting by terrestrial and satellite transmitters will be required in 6-8 years. Canadian activity at WARC-92 for this purpose and for obtaining BSS spectrum for wide-band HDTV delivery is of great importance to the Canadian broadcaster.

- Technical, marketing, and spectrum studies should be continued, supplemented with testing of the several new systems proposed for the new and enhanced entertainment services.

The challenge of enhanced entertainment will be to enable the universal over-the-air delivery of audio, video, and data services of improved quality with maximum spectrum efficiency, at minimal cost and minimum disruption to the public, since they are unlikely to accept radical solutions that could be costly or deprive them of access to enhanced services.

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THE MILITARY SPECTRUM MANAGEMENT CHALLENGE

MARC DROLET

DEPARTMENT OF NATIONAL DEFENCE PAPER

ABSTRACT

The success of Command and Control in the Canadian Forces in peace, periods of tension and war depends, in large measure, upon the judicious use of the frequency spectrum.

The present and near future spectrum requirements are presented along with examples of the special needs which would arise in a crisis.

The Canadian Forces have interests in spectrum management on a world wide basis. Canadian military units are based in Europe, the Middle East and the Mediterranean. Canadian units may be required to deploy anywhere in the world on short notice. An overview of the situations in Europe and the Middle East will illustrate aspects of spectrum management in periods of tension and war.

In order to understand future spectrum requirements it is necessary to analyse world wide Intelligence gathering and Electronic Warfare techniques. This will, of necessity, be a very general overview.

Based on these analyses it is possible to present a general view of the Department of National Defence's longer term spectrum requirements.

Finally, the Canadian Forces can and will make a two pronged attack on spectrum optimization: through the development and deployment of radio apparatus utilizing new, improved transmission techniques and by implementing procedures to share more information with civil users and developers in a timely manner.

Résumé

La gestion du spectre des fréquences militaires
Un défi

Marc Drolet
Document présenté par le ministère de
La défense nationale

Le succès des opérations de commande et de contrôle menées par les Forces canadiennes en temps de paix, pendant les périodes de tension et en temps de guerre dépend dans une large mesure de l'utilisation judicieuse du spectre des fréquences radioélectriques.

Ce document fait état des besoins actuels et futurs en matière de fréquences. Il donne des exemples des besoins spéciaux qui surgiraient lors d'une crise.

La gestion du spectre à l'échelle mondiale est une question importante pour les Forces canadiennes. Le Canada possède des bases militaires en Europe, au Moyen-Orient et en Méditerranée. Ces bases peuvent avoir à déployer leurs forces n'importe où dans le monde, sans préavis. Un survol de la situation en Europe et au Moyen-Orient va illustrer les aspects de la gestion du spectre pendant les périodes de tension et en temps de guerre.

Afin de comprendre les besoins futurs en matière de fréquences, il est nécessaire d'analyser les techniques de collecte des renseignements et de la guerre électronique qui sont utilisées un peu partout dans le monde. Cette analyse sera nécessairement un survol très rapide de la question.

A partir de ces analyses, il est possible d'avoir une idée générale des besoins de fréquences à long terme du ministère de la Défense nationale.

Enfin, les Forces canadiennes peuvent et vont faire une attaque sur deux fronts avec l'optimisation du spectre comme objectif. A cette fin, elles vont élaborer et déployer des appareils de radiocommunications utilisant des techniques de transmission nouvelles et améliorées et mettre en oeuvre des procédures pour permettre un plus grand partage de l'information avec les civils et les promoteurs en temps opportun.

NATIONAL DEFENCE SPECTRUM REQUIREMENTS

Introduction

In 1987 the Canadian Government published a white paper [1] which stipulates that the Canadian Defence policy's objective is to deter the use of force or coercion against Canada and Canadian interests and to be able to respond adequately should deterrence fail. Such deterrence requires standing and reserve forces equipped, trained and positioned to meet any likely threat. [1]

The requirement to maintain a military force ready for combat represents a difficult challenge especially when considering the international trend to reduce Defence funding. It is therefore vital to improve efficiency byexercising better Command and Control over the resources available. The way to ensure a high level of Command and Control is to provide reliable and efficient communications to the commanders; this through a judicious use of the frequency spectrum.

The frequency spectrum is therefore considered in the Canadian Forces, as an important resource which plays a key role in the optimization of our present capabilities and which will be a very important factor in the outcome of a crisis. Looking back in history, we note that the frequency spectrum is one of the first resources utilized to downgrade the enemies' capabilities, in times of conflict, whether they be military or civilian. This is referred to as Radio Electronic Warfare which took birth in August 1914 in the Battle of Tannenberg [2] and ever so present even in built up situation like the recent United States/Panama incident where frequency jamming took place.

Every international crisis has the potential to escalate into a general war. Canada and Allied Nations must be prepared to respond if a crisis which threatens their vital interests worsens. Canadian sea, land and air forces are required to deploy anywhere on the globe on very short notice, either with a UN peace keeping force or under other committments. When Military Forces are deployed, it is vital to maintain reliable communication links between Headquarters and Commanders in order to ensure that Canada's national policies are respected and goals achieved. This can only be accomplished through a coherent management of the frequency spectrum, extensive planning and serious efforts to develop techniques to optimize the present frequency usage.

Canadian Military Spectrum Management

Considering the increasing demand for frequencies and a fixed supply, the necessity for an efficient regulatory system is obvious. Since electromagnetic waves are not limited by geopolitical boundaries, international undertaking and cooperation on the use of the spectrum is essential.

Once international agreement has been established and the national organization determined, the National Defence usage can be structured. In Canada, setting the rules and priorities to govern the use of the radio frequency spectrum is the responsibility of the Federal Department of Communications (DOC). The jurisdiction and responsibility for radio frequency management within the Department of National Defence (DND) rests with the Director of Frequency Spectrum Management (DFSM). By joint agreement with DOC, DFSM has been delegated Canadian authority to manage the 225-400 MHz band and the aeronautical mobile (off route) bands.

In all other bands, DFSM retains responsibility for military frequency usage in Canada for all Canadian based CF elements and for CF units operating outside Canada. However, when such units are operating under United Nation (UN), the North Atlantic Treaty Organization (NATO) or other allied control, the responsibility for radio frequency management rests with NATO or the command concerned. In order to respond to these situations DFSM is member of the Allied Radio Frequency Agency (ARFA) in NATO and the Canadian representative on the Australia-Canada-New Zealand-United Kingdom-United States (AUS-CAN-NZ-UK-US) Frequency Planning Committee where agreements are developed to coordinate and manage military frequency requirements during, or in prevision of, joint operations.

The Canadian military is presently one of the main users of the spectrum. Figure 1. shows the number of assignments in the spectrum. We note the importance of HF communications when analyzing the numbers presented and one will also notice the important usage of the military band of 225 to 400 MHz.

In addition to assuming the responsibility of the military frequency management in Canada through the commands and units and internationally through the above mentioned organizations, DFSM is also responsible for the electromagnetic compatibility of all military systems. This implies that every piece of emitting equipment must be compatible with the environment it is intended to operate in, whether it be within or outside the country. This task is an extremely complex one when considering that the Canadian Forces are asked to operate anywhere in the world along side many allied countries operating different types of emitting devices. Planning in such cases becomes crucial.

Canadian Military Spectrum in Europe

The current Canadian Military commitments in Europe are spread over two widely separated regions; southern Germany and

Norway. The Canadian Forces must therefore coordinate their frequency spectrum requirements with our European Allies in order to ensure command and control and operation both in peace and war time. This is accomplished through the North Atlantic Treaty Organization (NATO).

Responsibility for spectrum management matters within NATO is assigned to the Allied Radio Frequency Agency as indicated in Figure 2. ARFA's functions cover the formulation of policies and procedures, the preparation of frequency plans for NATO military requirements and the establishment of a suitable electromagnetic compatibility program.

While allocation and assignment of radio frequencies remains a national responsiblity, within NATO Europe, coordination for radio frequency assignments is conducted by ARFA with the NATO national authorities concerned and Major NATO Commands. The use of frequencies in the European Theater in Wartime is under the overall control of the Supreme Allied Commander of the NATO forces in Europe where provisions exist to acquire the use of the spectrum as needed.

A major exception to the above is the 225-400 MHz band which by agreement of all NATO nations, is a military band and managed within the NATO European area by ARFA in peacetime and wartime.

Presently, Canada assumes its commitments by maintaining two major bases in southern Germany [1]. Operating two airfields from there location results in a reasonable heavy requirement in the frequency spectrum. Our peacetime needs in frequencies amount to over 300 different channels which range from communications, microwave links, navigational aids, radars to complex Defence systems. These frequencies must be coordinated with numerous countries mainly through the German's national organization and NATO.

The Frequency Spectrum in Time of Conflict

It is hard enough to avoid frequency conflicts between friends, when nations are at war there is a nearly insurmountable problem for those involved and the warring factions as, of course, for neutrals. Interested in maximizing their own benefit from the spectrum and will gleefully encroach upon the enemies allocations and take little notice of the protests when they infringe upon neutrals.

Electronic Warfare has been a key element of utmost importance since the WW1. Many are unacquainted with such a concept since the science of electronic warfare, in all countries in which it is practiced, numbers amongst their best-kept secrets.

Electronic warfare is a major weapon for sophisticated military forces - electronic warfare has two aspects: passive listening and direction finding called Electronic Support Measures and the active jamming called Electronic Counter Measures. Both require the closest possible liaison between the electronic warfare and frequency management communities. In case of passive electronic warfare it is necessary, in peace and war, to protect the frequencies which the EW people wish to exploit from unintentional interference from friendly sources. In the case of jamming it is necessary to protect friendly command and control systems from the effects of friendly jamming or harmful interference. This is avoided through close coordination.

Peacetime coordination and control of electronic warfare procedures are required to obtain and manage spectrum resources; these procedures are due to the high risk of adverse impact on civilian uses of the spectrum. Limitations and restrictions are imposed on certain types of active EW operations in a peacetime environment; this is done even at the expense of limiting realistic training. At the start of hostilities, most of these limitations and prohibitions are removed, however, the need for coordination and control does not cease. Wartime coordination channels, procedures and techniques are a logical extension of peacetime training aimed at minimizing mutual interference.

In order to provide flexible, reliable and robust command and control systems, military forces are obliged to consider electronic warfare as the normal operating environment.

The Battlefield

Planning the battlefield frequency spectrum operations represents a challenging task when considering that thousands upon thousands of emitting equipments covering DC to light may be located within one hundred kilometers of one another.

One must also consider the enemies EW elements which will make every effort to deny the use of the spectrum and interference from uncoordinated enemy communications.

Due to this EW threat, the conventional military communications and electronic systems are being replaced by those with passive Electronic Counter-counter Measures (ECCM), such as steerable null antennae power amplifiers and/or spread spectrum modulation [3].

The frequency supportability of spread spectrum technology challenges the frequency managers to develop strategies to optimize the compatibility of systems and provide the thousands of different combat nets with their hopsets for operations.

Since the peacetime frequency administration is not military. It is prudent to be extremely careful with civil systems. Due to the lack of large scale exercises and deployment, it is difficult to predict. The interference level which would certainly occur. However, the external military user communities which do not utilize spread spectrum techniques will be encouraged to accept a high level of interference [3].

The second element of EW which will be exploited by the enemy is the passive listening. This leads to the extensive use of encrypted system to foil enemy intercept and intrusion efforts in addition to innovative transmission techniques.

The need to secure and protect military communications using encryption devices poses problems in spectrum management. As a general rule, secure systems require more bandwidth than non secure systems. RSS 119, for instance, specifies 20 kHz channel spacing for the low VHF band used by the army's primary combat net radio. NATO standards require 25 kHz of bandwidth in order to accomodate an encrypted 16 kilobit data stream. This results in great difficulties to accomodate military and civil users in the same sub bands.

The battlefield communication frequency management remains a challenge requiring constant planning. The speed at which the technology is changing and new equipment introduced, force those managing the battlefield spectrum to develop new concepts and interoperability standards in order to ensure the success of a joint/combined multinational force.

One of these new concepts is the development of the Joint Tactical Information Distribution System (JTIDS). This is a cryptographically secure, ECM-resistant, high capacity integrated communication system, providing technical data, digitised voice communications, relative navigation and identification features which can be extended to all aspects of modern warfare. Pseudo-random frequency hopping and spread-spectrum techniques are employed to ensure the survivability of communications; 51 discrete frequencies are used and Time Division Multiple Access (TDMA) utilized as the means of ordering the transmission and reception of messages.

As one may see, projects like JTIDS become motivators for battlefield communications planners to invest sound EMC effort to ensure systems' survivability.

The Spectrum and its Military Future

It is interesting to note that spread spectrum techniques developed for battlefield communications offer a jamming advantage equal to the ratio by which the transmitted spectrum is expanded. [4]. This confirms that there is a spectrum cost to any new system being developed, and must provide specific objectives to the Research and Development world which will minimize the spectrum congestion and maximize the EMC potential.

There are many aspects which must be taken into account in planning and development of future electronic counter measure (ECM) resistant systems and networks. Technical measures presently exist which improve military communications, there are for example error-correction coding, spectrum spreading, adaptive nulling antennas and adaptive filtering.

The military community in NATO is encouraged to initiate and support research oriented towards a better spectrum usage and survivability of the communications on the battlefield. The latest Canadian defence contribution has been the initiation of a narrowband tactical communication system for the VHF and UHF mobile Radio Bands, conducted at the Communications Research Centre (CRC) in Ottawa. [5]. The objective of this research effort is to achieve good quality voice communications within a channel spacing of about 3 kHz. This aim, which is a success thus far, will increase the number of usable channel assignments, reducing the channel spacing in a spectrally efficient way. The new technology developed under this research effort will be available to industry in the near future.

Development of Technology relating to fiber optics (as well as more conventional cables) provides a potential method for reducing reliance on the radiation of electromagnetic energy. Optical fiber is mainly used in "trailing wire" guidance systems as well as for communications and data transmission while cables are mainly utilized for point-to-point operation.

One other aspect of modern technology provides the capability to transmit and receive electromagnetic energy from the so-called millimetre range through the infra-red and visible lights and beyond. Numerous piece of equipment operate in this frequency range and due to the extensive capabilities available, the number of systems using these frequencies will inevitably grow in magnitude. Operating in the millimetre range does not conserve spectrum space, but does provide and inherent improvement in EMC potential; the physics of propagation and antenna characteristics are such that the probability of unintentional interference being caused at frequencies above 30 GHz is extremely small.

One may assume that successful research accomplished to increase use of higher frequencies will have for effect to lessen the demand for low frequencies with resultant reduction in congestion. However it should be noted that the use of frequencies above 30 GHz is limited in applicability. Effective transmission distances on earth are quite short; in space they could be much longer.

The CF efforts in the research for better communications and more efficient use of the spectrum also include work in the satellites and space craft fields, multiple access techniques and, message coding. However there are many other potential areas which may be investigated to reduce the need for wide bandwidth requirements; development of small, sophisticated data processors, adaptive antennas, and the use of radiometry involving passive detection for various military functions.

__Conclusion__

Prediction is perilous, but based on past experience, it seems likely that advanced technology will place even greater demands on the spectrum in the future.

One can retain two major points to contemplate from the frequency manager's viewpoint; the first one being sharing and the second being the equipment EMC "goodness".

The most desirable solution to spectrum management is sharing. This approach may be difficult to implement in all situations, but it is obvious that if frequency bands are only needed in a few geographic areas, then these same frequencies can safely be used for other purposes in different areas.

The multinational military task force must coordinate sharing when planning operations. Both, sharing the spectrum in space and in time, are extensively exploited in the military community.

Technological advances, rapidly growing satellite communications, space techniques, and severe congestion of the electromagnetic spectrum now leave little room for unilateral frequency planning and management within any one of the Military Departments. Where once a capability existed to develop communications-electronics systems in-house with formal recognition, coordination and assignment of frequencies being an almost automatic follow-on, just the opposite is now true. Intensive research, engineering and coordination by, with, and between the Military Departments, other government agencies, and non-government interests are now prerequisites to the planning stages in the development of any new electromagnetic equipments. This change has resulted in a reorientation of effort within the frequency management community, where now more emphasis is placed on allocation, engineering and electromagnetic compatibility aspects prior to the initiation of radio frequency clearance actions.

Finally a much closer link is required between the military frequency management staff and the interested civilian agencies. Only through a full comprehension of one another expectations will we have a successful and efficient utilization of the spectrum. Organizations like the Radio Advisory Board of

Canada (RABC) are absolutely necessary to ensure that every user of the spectrum is served in an adequate manner and that the ultimate objectives of our country are met.

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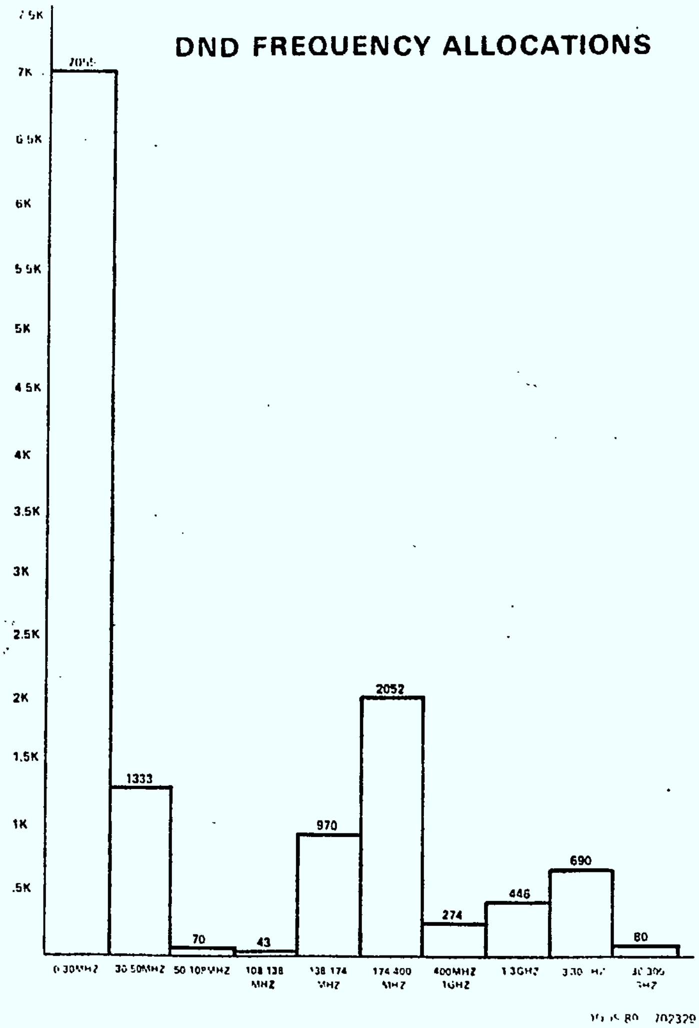

Figure 1: Canadian Military
Frequency Assignments

NATO MILITARY SPECIALIZED AGENCIES

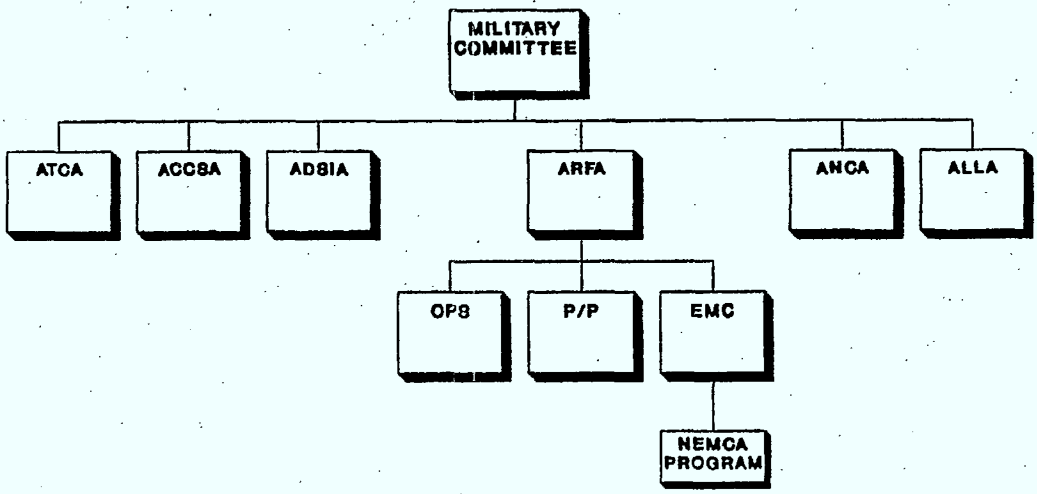

Figure 2: NATO Military Committee Organization

EXPLOITING THE DIGITAL RADIO WAVE OF THE 90's

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ABSTRACT

Since the introduction of commercial service a mere six years ago, cellular radio has far outstripped the growth predictions of even the most aggressive forecasters. With more than 5 million subscribers in over 30 countries, cellular already represents an installed equipment base exceeding $10B, and at 40% annually, is the fastest growing sector of the world's telecom industry. Cutthroat competition among all the major electronics multinationals, including several new manufacturers spawned by this emerging business has stimulated rapid product evolution cycles and severe price erosion, positioning the industry at the brink of a *mass consumer* opportunity. But affordability without capacity cannot deliver the dream. Capacity limits of analog transmission represent a fundamental barrier, which will be broken in several stages during the early to mid 90's. Supply of radio channels per system will be increased five times in 1991 and ten fold by 1995, without additional spectrum, or disruption to analog system users. Exciting new technology developments in RF components, digital signal processing, artificial intelligence, and batteries, will complement the transition to digital transmission, creating a plethora of radio-based voice and data communications products. If free market forces are allowed to prevail, and with the right system and component building block architecture, then by the late 90's cellular, dispatch, paging, navigation and in-building cordless products will naturally converge, thereby unlocking the full potential of universal, affordable personal communications.

Résumé

Exploitation des ondes radio numériques Dans les années 90

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Depuis son introduction comme service commercial il y a six ans à peine, la radio cellulaire a progressé beaucoup plus rapidement que ne l'avaient prévu même les plus enthousiastes. Ce service, avec plus de cinq millions d'abonnés dans plus de trente pays, compte déjà un parc d'installations dont la valeur dépasse les dix milliards de dollars; en outre, avec un taux de croissance annuelle de 40 %, ce secteur affiche la croissance la plus marquée dans l'industrie des télécommunications mondiales. Une concurrence sans merci entre les grandes multinationales de l'électronique, combinée à l'arrivée de plusieurs nouveaux fabricants sur ce nouveau marché, a favorisé une évolution rapide des produits et une importante érosion des prix de sorte que l'industrie devrait bientôt faire face à un marché de consommation de masse. Mais la capacité de se procurer un bien sans la capacité de l'utiliser ne fait pas du rêve une réalité. Les limites de capacité des transmissions analogiques représentent une barrière fondamentale, qui sera peu à peu abolie entre le début et le milieu des années 90. On comptera cinq fois plus de voies radioélectriques par système en 1991 et dix fois plus en 1995, sans que cela nécessite pour autant une augmentation du nombre d'assignations ou perturbe la clientèle qui utilise des systèmes analogiques. Des perfectionnements technologiques fascinants dans les domaines des composants RF, du traitement numérique des signaux, de l'intelligence artificielle et des piles vont assurer le passage à la transmission numérique en donnant lieu à toute une variété de dispositifs radioélectriques de transmission de la voix et des données. Si l'on donne libre cours au jeu de la concurrence et si l'on utilise l'architecture voulue pour organiser composants et systèmes de façon modulaire, alors, d'ici la fin des années 90, il y aura naturellement convergence des produits intégrés sans fil dans les secteurs de la radio cellulaire, de la répartition, du téléappel et de la navigation, ouvrant toute grande la porte aux communications personnelles et universelles, à coût abordable.

1. WHY DIGITAL?

1.1 Analog's Success

In less than six years since introduction, analog cellular has met with enormous success worldwide. As illustrated in Table 1.1, over 5M subscribers are currently estimated to be using cellular phones, operating on various 400/450/800/900 MHz systems in more than 30 countries. Summarized in Reference (1), the dominant systems are based on the North American 800 MHz (EIA IS-3) and the U.K. 900 MHz (ETACS) standards, together accounting for over 80% of all users.

Besides having more spectrum allocated than for 400 MHz systems (50 MHz for EIA and 66 MHz for ETACS), these markets are flourishing because of competitive dual carrier service environments. Throughout major metropolitan service areas the intense competition to sign up customers has completely distorted cellular phone prices. Carriers routinely subsidize dealers with "activation bonuses" ranging anywhere from U.S. $100 to U.S. $600 or more, fuelling demand by even the most conservative customers. There are cases on record where buyers can actually receive money when purchasing a phone and committing to six months of connect time!

Feeding on this chaos and the resulting high volume opportunity are over 20 of the world's largest multi-national electronics firms, along with one successful cellular-only start-up. They are all investing heavily to drive technology size and cost curves towards improved performance and affordability, obsoleting products annually. Today cellular portables with 0.6 watts of RF power typically range from around 300 to 450 cc in volume, weigh from 350 to 550 grams, provide 0.5 to 1.5 hours airtime, 10 to 15 hours standby, offer a multitude of features that are rarely used or even understood by most users and sell from U.S. $600 to U.S. $2,000. Five years ago they were three times the size and price. Size reductions through advanced component and packaging developments could lead to 200 cc or smaller units within three years, selling at well below $500, considered the mass consumer price point by many forecasters. By the year 2000 the smallest phones will be like Dick Tracy's wristwatch. And if the annual rate of growth were only maintained at the current 40% estimate, then there would be 150M users worldwide!

STANDARD / REGION	EIA-IS3	TACS/ ETACS	400/450 MHZ	OTHER	TOTAL
NORTH AMERICA	3,100		40		3,140
EUROPE		690	760	470	1,920
AUSTRALIA	100				100
CHINA		10	5		15
MIDDLE EAST		25			25
FAR EAST	35	35			70
JAPAN				500	500
TOTALS	3,235	760	805	970	5,770

TABLE 1.1 - Approximate Cellular Subscribers Worldwide

1.2 Capacity Limits

Unfortunately analog systems have insufficient capacity to realize this dream. Most major metropolitan areas have already exceeded practical RF capacity limits. In the U.S. for example, Los Angeles, Chicago and New York each have over 300,000 subscribers operating on congested systems. The same is true in London, where 66 MHz is inadequate to consistently deliver a desirable grade of service (less than 1% call blocking during the maximum busy hour) to an estimated 500,000 subscribers. And this has occurred in spite of operators' attempts to increase efficiency of spectrum utilization, using techniques such as cell splitting, sectorization, overlaying cells, and channel borrowing.

Additional spectrum to break congestion barriers is not likely in the near future. The only viable strategy is to increase spectrum efficiency by using digital radio transmission schemes, whereby more digital voice channels can be packed into the same frequency allocations than by employing analog/FM modulation schemes. Furthermore, beyond capacity, the potential of enhanced data services, improved privacy/security and lower operating costs are driving both North America and Europe towards digital.

1.3 The Opportunity of Universality

If designed with the right architecture and core components, digital cellular products could converge with digital radio versions of dispatch, paging, navigation and in-building cordless products, thereby unlocking the full potential of universal, affordable personal communications. The dream of one person, one phone, anywhere on the face of the earth is irresistable. The major standards and technology challenges to achieve such a universal product strategy are reviewed in this paper.

2. TRANSITION TO DIGITAL

Before exploring a universal radio strategy, the unfortunate reality is that there will not be a single world standard for digital cellular. In North America, the overwhelming objective of the CTIA (Cellular Telephone Industry Association) including both operators and manufacturers is to increase capacity. On the other side of the Atlantic, the primary challenge in setting the GSM (Groupe Speciale Mobile) standard has been to achieve Pan European harmony. (No less than 13 countries signed the Memorandum of Understanding in September 1987!) Perhaps most importantly, GSM products are intended to obsolete existing analog products operating in the same frequency bands, whereas the CTIA has insisted on a seamless transition from analog to digital, without service disruption to analog users.

2.1 Digital Cellular: North America versus Europe

Table 2.1 summarizes the key functional objectives of the next generation North American EIA and European GSM digital cellular systems. As shown, the primary differences are capacity and orderly co-existence.

EIA/CTIA	GSM
• **CAPACITY:** 10x increase over current analog	2X increase over current analog
• **QUALITY:** Similar audio quality to analog	User confidentiality and open network architecture
• **DATA:** In voice band; multiples of 9.6 kbps	ISDN compatible
• **EMISSIONS:** Compatibility with existing emission standards	New standard: CEPT-GSM 05
• **COEXISTENCE:** Coexistence with analog systems and orderly transition	Replacement
• **LIFETIME:** 10 year minimum technology lifetime	Not specified
• **COSTS:** Commensurate with value-added	Uniformity above all

TABLE 2.1 - Objectives of Digital Cellular: EIA/CTIA vs GSM

2.1.1 CTIA: Capacity and Co-existence

In North America, ten times capacity over a ten year lifetime is an absolute requirement. In Europe, initial GSM products will still effectively require 25 kHz per user, and hence provide limited capacity relief over current analog systems. Improved noise immunity of digital radio modulation schemes will result in perhaps a twofold capacity improvement through reduced carrier to interference (C/I) requirements, and hence a higher frequency reuse factor.

2.1.2 GSM: Security and Open Network Architecture

The major objectives for GSM are compatibility with the evolving ISDN (Integrated Services Digital Network) network, improved user privacy and a well-defined open network architecture (Reference 2). CTIA does not require ISDN compatibility, only that data rate requirements be compatible with the existing data communications world (up to 9.6 kbps per user channel).

Concerning the issue of open architecture, GSM has specified virtually all radio, switch and control interfaces, whereas the EIA system allows for proprietary base stations, handoff algorithms, control protocols and operational features. For inter-system signaling, the EIA/TIA 45.2 committee has already established the IS-41 standard. It currently defines how to hand-off calls between foreign systems, with inter-system call delivery targeted for completion by the end of 1989. The first commercial field trial of IS-41 was successfully demonstrated in mid-October of this year, between a NovAtel 800CM system operated by Alberta Government Telephones (AGT) and a Northern Telecom DMS switch operated by Edmonton Telephones. Digital cellular systems in North America will continue to adhere to IS-41, effectively allowing for contiguous system networking across the entire continent. Hence customers will enjoy continuous coverage on both sides of the Atlantic, although GSM will result in greater system operational uniformity for the carriers.

From an administrative and security perspective, roamers are already accommodated in the EIA system. Users can operate their phones on any foreign system and are identified as either "pre-authorized" or "spontaneous" roamers. To screen out fraudulent users, there are two clearinghouses in service (Appex and GTEDS) which positively verify roamer credit status. In the GSM specification, each country's system maintains all users as if they are "home" subscribers and will accommodate roamers from other countries in a similar manner as the EIA system. In both markets, fraudulent use is therefore inhibited, although it will continue to be prevalent as bandits find ever more devious ways to break the system. This is a large topic in itself and a sub-committee of the EIA/TIA 45.3 has now been established to address this issue specifically. For user authentication, the GSM specification is highly secure, incorporating what amounts to a key encryption system. Some degree of privacy coding is also now under deliberation by the TIA 45.3 committee for the radio channel. Furthermore, more secure access and channel encryption schemes will likely be introduced in future on a proprietary basis by different manufacturers in North America. The degree to which they close the security "gap" is still unclear.

2.2 Standards: Barriers to Universality

Table 2.2 summarizes the key specification parameters of EIA and ETACS, the two most dominant analog cellular systems, and EIA/digital and GSM, the next generation digital systems.

SPEC \ SYSTEM		ANALOG CELLULAR		DIGITAL CELLULAR	
		EIA-IS3	ETACS	EIA/DIGITAL	GSM
Frequency Bands (MHz)	to system	824 - 849	872 - 905	824 - 849	890 - 915
	to mobile	869 - 894	917 - 950	869 - 894	935 - 960
Access Method		FDMA	FDMA	FDMA/TDMA	FDMA/TDMA
Modulation		NBFM	NBFM	π/4 DQPSK	GMSK
Voice/Channel Coding		N/A	N/A	13.2 kbps CELP Convolutional / Phase 2 8 kbps TBD	13 kbps Speech 9.6 kbps Data RPE-LTP/Convolutional
Subscriber Unit Power Level (Watts) & PA Class		.6, 1.2, 3 Class C	.6, 1.2, 3 Class C	.6, 1.2, 3 Class AB	2, 5 (HH); 8, 20 (MOB) Class C
Carriers		832	1320	832	125
Channels/Carrier		1	1	3, 6	8
Carrier Separation (kHz)		30	25	30	200
Year of First Introduction		1983	1984	1991	1991

TABLE 2.2 - Major Cellular System Standards

In today's analog world, a transceiver product can be designed that is identical for both EIA and ETACS applications, apart from a handful of components and signaling software. Differences in frequency band (900 MHz vs. 800 MHz), channel bandwidth (25 kHz vs. 30 kHz), signaling and control protocols (software) have marginal cost impact if a common product is designed at the outset, although the ETACS version is approximately 8 to 10% higher in material cost due to the greater bandwidth and tighter audio specifications.

When comparing EIA/digital and GSM however, the differences in certain critical specifications are so extreme as to prevent the design of a common product architecture. To name a few, carrier separation, voice and channel codecs, power amps, signaling and control protocols are incompatible. As already mentioned, GSM is intended to obsolete ETACS and hence a common product architecture is not possible.

Finally, comparing EIA and EIA/digital, it is evident that the specifications are readily amenable to design a dual mode product architecture, one that can fulfill CTIA's two primary goals of increasing capacity yet maintaining orderly co-existence.

2.3 Dual Mode Product Architecture

A summary follows of the key transceiver and system product building blocks required to deliver dual mode service.

2.3.1 Transceiver Building Blocks

Figure 2.1 illustrates the major building blocks in a dual mode EIA transceiver.

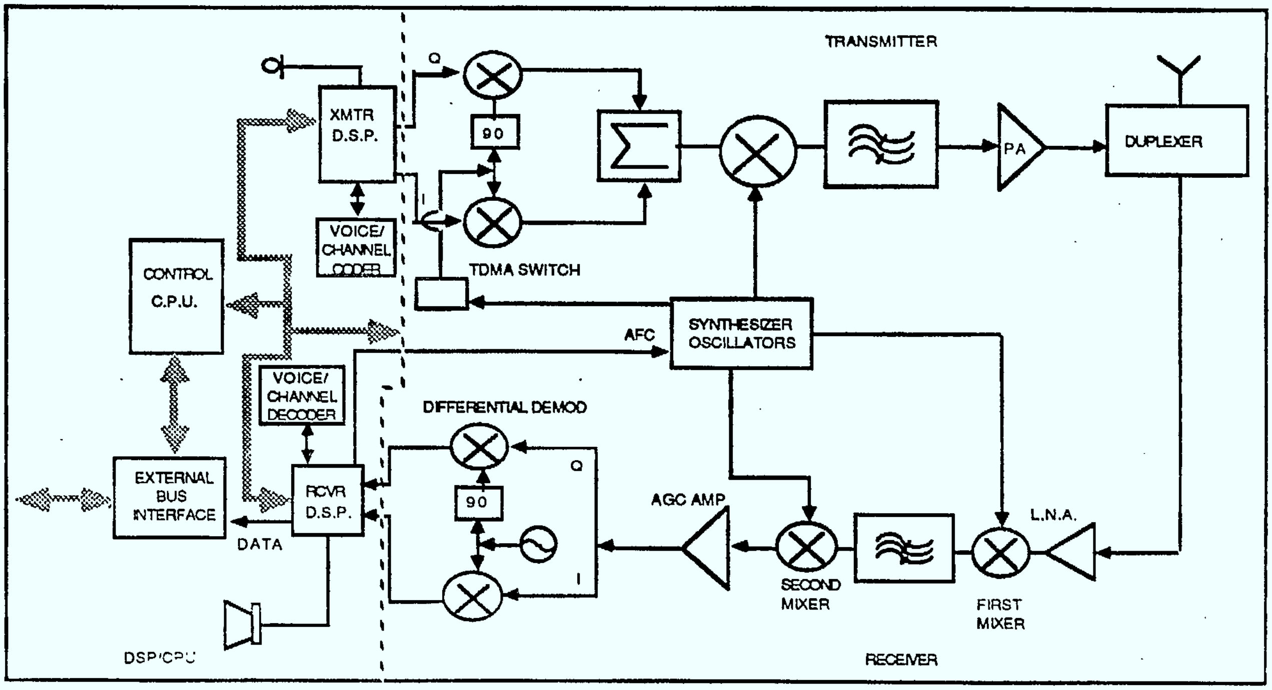

FIGURE 2.1 - DUAL MODE TRANSCEIVER BUILDING BLOCKS

Receiver

The receiver front end converter and IF stages operate identically whether the source channel information is narrowband analog/FM or the EIA specified π/4DQPSK (Differential Quadrature Phase Shift Keyed) scheme. Filter stability, group delay and oscillator stability specifications are more strict for the digital system, and the material cost increase is estimated to be 20 to 30% over an analog version.

Transmitter/PA

A linear class AB or linearized class C power amp is required for digital operation, due to the chosen linear modulation scheme. Such a linear design will likely cost 20% more than the existing class C analog designs, however volume cost reductions will reduce the net impact on total product cost to a small percentage increase. Furthermore, this same PA can operate as a higher efficiency class C circuit when in the analog/FM mode.

Mod/Demod/DSP

In the baseband modulation and demodulation stages, the source analog or digital information can be handled as balanced In-Phase (I) and Quadrature (Q) signals, a detailed explanation for which is given in Reference (3). This is the realm of so-called DSP or Digital Signal Processing, where high powered software algorithms can be invoked to process either an analog or digital information stream. Processing overheads for these functions increase material cost by perhaps 20% beyond analog.

Voice/Channel Coder

The voice and channel coder stages including control, framing and equalization logic are also represented by DSP-based software algorithms. The combined CPU and software requirements for these features represent a direct processing overhead in either a digital or dual mode product, and as in the case of mod/demod logic are estimated to increase material cost by around 20% beyond analog.

Power

Neither a digital nor dual mode handheld will be likely in the first generation of digital cellular products due to the large power consumption required in the DSP stages. Today's 0.6 watt analog handhelds operate at typically 3 watts d.c. in full power mode and .3 watts in standby. Power budgets for equivalent digital or dual mode handheld units are estimated initially to be 3 times their analog counterparts. This gap is not expected to close until the second or third rev of products in the '92/'93 timeframe, and will occur as a result of reduction in complexity of DSP algorithms and lower power consumption of associated integrated circuits.

2.3.2 System Building Blocks

A detailed discussion of how existing analog cellular switching systems could evolve to support digital cellular operation would require an analysis of each manufacturer's product strategy, which is beyond the scope of this paper. However, a strategy based on the NovAtel 800CM system product architecture illustrates that a graceful transition is possible (See Reference 4.)

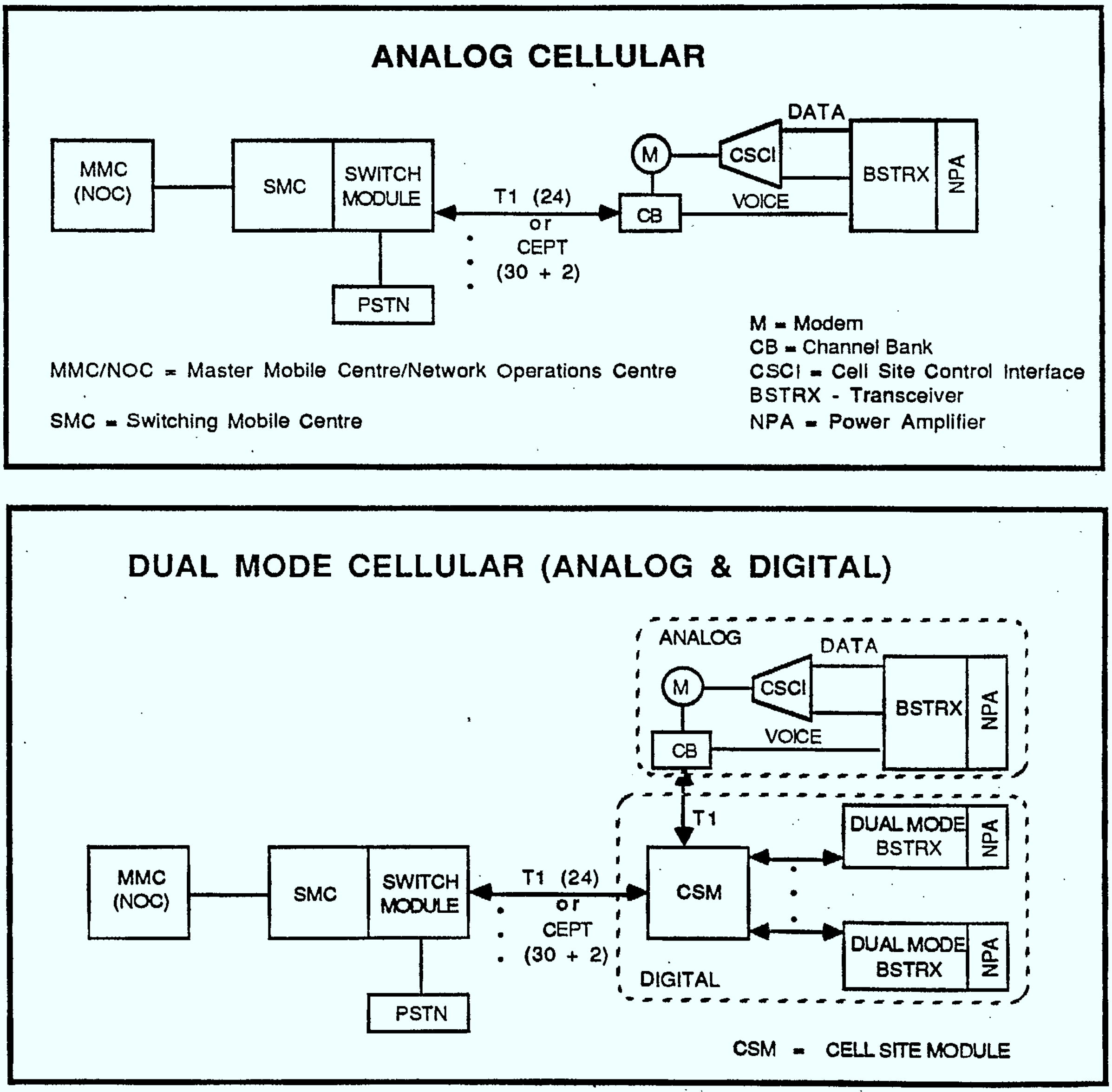

FIGURE 2.2 - Analog and Dual Mode System Building Blocks

Figure 2.2 shows the key system building blocks. At a cell site, current analog transceivers (BSTRX) and PA's (NPA) are replaced or augmented by dual mode versions. As in the mobile transceiver, the same philosophy of dual mode operation follows, meaning that the base station transceiver can operate in analog or digital mode depending on which type of mobile is being serviced. The EIA/digital spec calls for an extended IS-3 setup protocol, whereby a digital mobile will identify itself as such, from which point the base station will operate in digital mode and control information will be managed within each user time slot. Handoffs can be effected between single and dual mode base stations, although the degree of RF coverage overlap required for such "mixed mode" networks remains to be fully resolved.

Other common equipment in the cell site such as the alarm unit, local oscillator, multiplexer and locate transceiver requires upgrades to support the higher volume of digital traffic. Combiners and multicouplers remain unchanged, which is a major advantage. If a new frequency plan is introduced to accommodate higher volume traffic (for example N = 4 plan from N=7 plan where N is the number of cells in each repeated cluster) then this of course will necessitate more channels and corresponding allocations of different combiner and multicoupler channel groups.

If properly planned, such a dual mode transition strategy can limit the changeout to cell site equipment only. Furthermore, if transceivers, PA's, and other common equipment are packaged to be mechanically and electrically plug-compatible with analog units, then the system can support combined dual mode <u>and</u> analog hardware within a common set of equipment frames. This allows the operator to grow into digital as the market demands, while maximizing investment in existing analog cell site equipment and infrastructure.

2.4 EIA/Digital: Capacity and Cost Advantages

Before understanding capacity limits, some understanding is required of the behaviour of the mobile radio channel. A detailed treatise of capacity in a mobile radio environment is beyond the scope of this paper. Reference (5) is just one of many that deal with this fascinating topic.

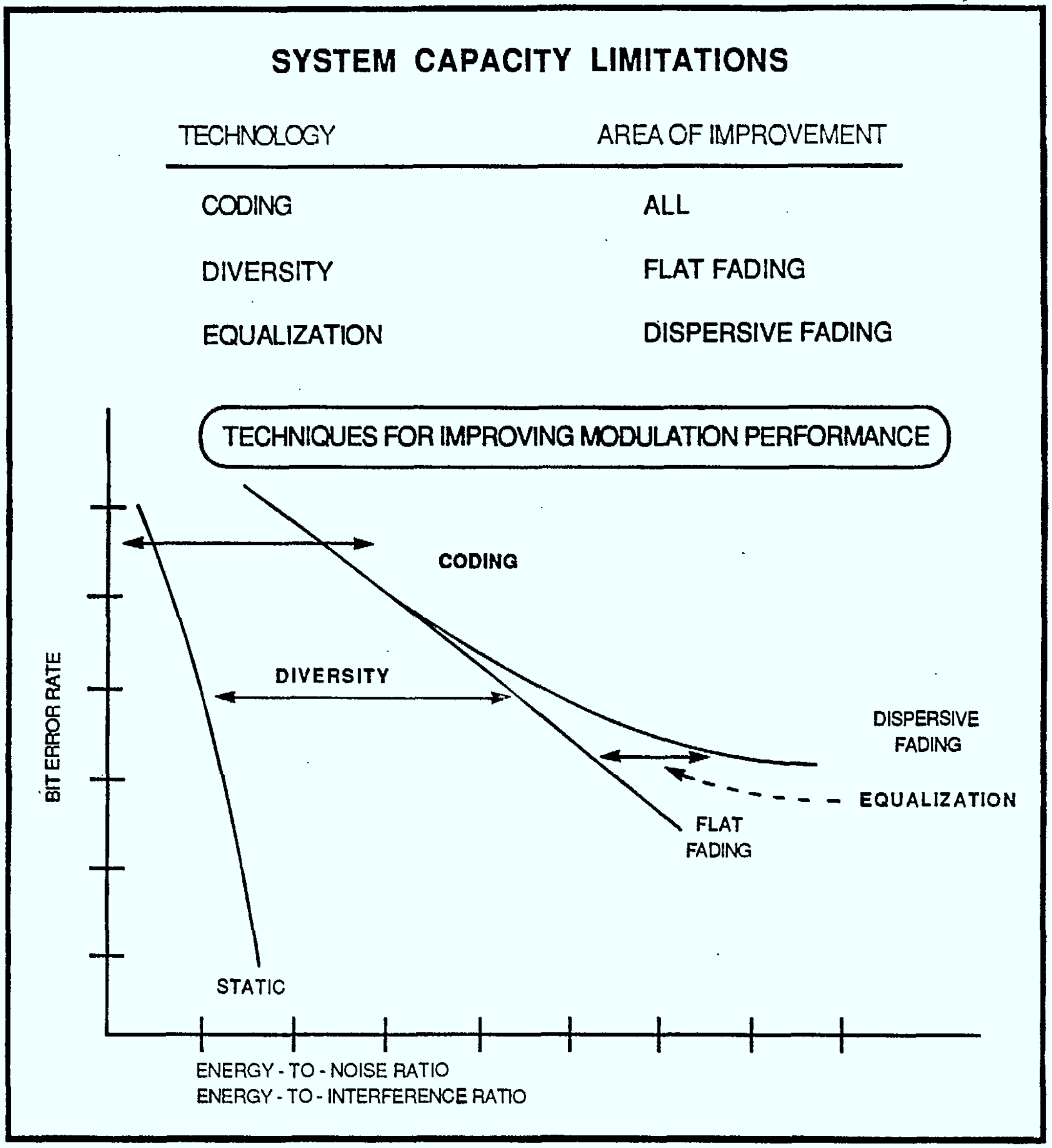

FIGURE 2.3 - The Mobile Fading Channel

2.4.1 The Mobile Radio Channel

As illustrated in Figure 2.3, fading and multipath propagation are the two primary effects on the radio channel that deteriorate performance and therefore impact capacity. In the static case, representative of a point-to-point/microwave setup for example, the Bit Error Rate (BER) drops exponentially as the signal energy to noise (or energy to interference) ratio is increased. Flat fading, as encountered in mobile channels causes this profile to deteriorate. Fades of 40 to 50 dB reduction in signal strength can regularly occur within fractions of a second in a fast moving mobile environment. Delay spread and random phase and frequency shift caused by multipath propagation can further degrade digital signals in particular, manifested as inter-symbol interference or "smearing". Delay spread effectively sets a limit on the digital transmission rate possible over a fading radio channel.

Diversity refers to one of many methods to improve the received signal strength at a receiver by combining or selecting reasonably uncorrelated samples of the signal. Two antennas separated by half a wavelength is an example of space diversity; polarization diversity involves receiving both horizontally and vertically polarized signals. In either case, diversity can reduce fades by typically 5 to 10 dB.

Digital countermeasures include robust voice coding, channel coding, and adaptive equalization, all based on the principle of improving resistance to errors by helping to recover either physical or logical levels of coded information. Adaptive equalization in particular is a critical issue. The basic idea is to establish prior information of distortion and attenuation effects of the channel, which can then be employed to correct the received signal by reshaping incoming pulses. The degree of delay equalization required for acceptable system performance has been a hotly debated issue in the EIA Standards bodies. Whereas GSM has defined a minimum 10 µsec delay compensation, the EIA committee appears to be converging to a 40 µsec figure. Studies have shown that delays beyond 20 µsec appear to be statistically of very low probability. The more CPU processing allocated for equalization, the greater the overall power required in a transceiver, thereby inhibiting introduction of digital portables.

2.4.2 Overall System Capacity

A desirable system performance figure of merit is a BER of 10^{-5} or lower, for which it has been estimated that from 9 to 14 dB of desired signal to co-channel interferor signal (C/I) is required. This C/I parameter is therefore at least 4 dB lower than for analog cellular, which is expected intuitively since digital signals can be encoded to be more immune to channel noise.

The relationship between C/I and the cell distance to reuse ratio, or D/R, is described by Lee (Reference 6), namely:

$$D/R = \sqrt[4]{(N-1)\ (S/I)}$$

where N = cell reuse plan
(S/I) = absolute values of (C/I) dB.

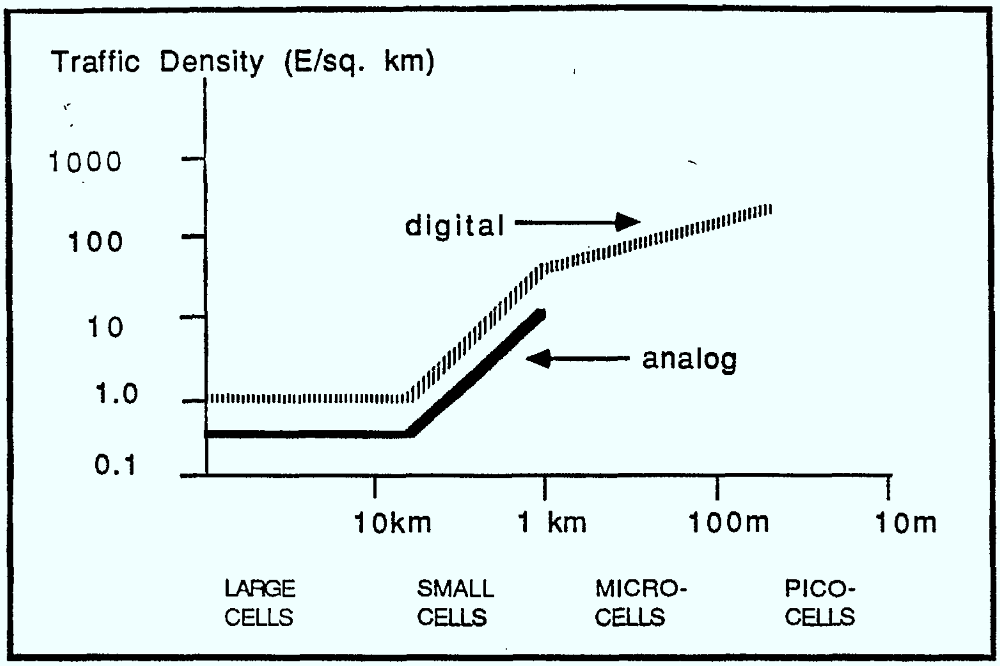

FIGURE 2.4 - Trafffic Density vs Cell Size (Analog vs Digital)

As described in Reference (6) and illustrated in Figure 2.4, there is an exponential relationship between smaller cells (and hence smaller D/R) and increased traffic density. The net effect of a 4 dB reduction in (C/I) translates into about 40% greater system capacity. Hence, for the EIA/digital system, which specifies 3 digital voice channels per existing analog channel initially, then the overall system capacity increase is extrapolated to be 4 to 5 times. With 6 digital channels per analog channel, the overall capacity is then expected to be 8 to 10 times greater than analog, thereby meeting CTIA's objective.

2.4.3 User Channel Capacity

As shown in Table 2.2, each user is assigned one of 3 equally spaced TDMA time slots. The details of this structure remain to be fully defined by the TIA 45.3 standards committee. The gross data rate is 48 kbps, derived from the fact that the $\pi/4$DQPSK modulation scheme results in 1.6 bits per second per hertz, and each analog channel is 30 KHz. Hence, each user's time slot is assigned a 16 kbps gross data rate, of which 13.2 kbps represents the coded voice and channel error correction information, and the balance of 2.8 kbps is system control information.

The specification assumes that a 6 slot TDMA scheme will eventually be adopted, without a specific timeframe. It is expected that within 5 years voice and channel coder rates can be compressed by 50% and still deliver equivalent quality, resulting in a gross data rate requirement of only 8 kbps per user time slot. Hence with 6 time slots per analog channel and assuming the same 4 dB lower (C/I) requirement, EIA digital cellular will deliver 8 to 10 times capacity over EIA/IS-3 analog. This will occur in effect with two seamless transitions, namely, from analog to 3 slot digital and then to 6 slot digital.

2.4.4 Cost Advantages

It is estimated that a digital cell site will cost from 1.5 to 2 times that of a current analog version. However, since subscriber capacity is tripled on a per channel basis in the first transition, the net cost per subscriber will correspondingly drop by 30 to 50%. Hence even in smaller markets where capacity is not an issue, digital cellular will present an opportunity to lower costs and provide value-added services, assuming there is a sufficient critical mass of dual mode or digital mobiles in operation. By the second transition to 6 slot digital, system costs per subscriber could be further reduced, although it is too early to speculate on the net savings.

2.5 Digital Cellular Conclusions

The Pan-European GSM system, due to be introduced in 1991, will provide higher quality digital radio services, but will not be compatible or significantly improve on capacity limits of existing ETACS analog systems, or be compatible with EIA/digital in North America. System costs per subscriber are not yet determined.

North America's EIA/digital system, due for commercial service in early 1991, is designed to co-exist with its analog predecessor and will increase capacity initially by at least 4 and then 8 to 10 times in two seamless transitions, while also lowering system costs per subscriber by 40% or more. Dual mode subscriber products will initially cost perhaps 30% more than analog units, but volume and system cost advantages will likely mask this difference through creative pricing.

Assuming universality and affordability are goals, then the opportunity still exists in North America to define a compatible in-building digital radio system standard that can capitalize on EIA/digital cellular core technologies.

3. TOWARDS UNIVERSAL DIGITAL RADIO

In spite of the incompatibility between Europe's GSM and North America's EIA digital cellular systems, the joint capacity goal of 150M users by the year 2000 can likely be realized and perhaps exceeded. The greater goal of achieving a universal personal communications system compatible with digital cellular is explored in this section.

3.1 In-Building Digital Radio

The whole premise of cellular is to reuse subsets of RF channels within a two dimensional cellular pattern in order to increase capacity. Beyond mobile applications, service can also be provided to some limited percentage of in-building users. However, illuminating buildings from outside creates spotty RF coverage (Reference 7), and even digital cellular systems are just not designed to handle the significant extra traffic that would result.

On the other hand, illuminating buildings with low-power RF coverage from inside can realize the necessary capacity to succeed, as described in several articles (References 7, 8, 9). But none of these are based on the strategy of utilizing digital cellular core technologies. To date, there have been no specific proposals to exploit digital cellular systems for in-building applications.

3.1.1 European Standards

On the contrary, the European CCIR (International Consultative Committee on Radio), IWP8/13-3 (Interim Working Party) decided in 1988 that in-building and mobile usage within the same radio system should not be mixed. As a result, standards for in-building radio systems in Europe are evolving along 4 initiatives, namely the CT1 (Cordless Telephone 1) (CEPT - Conference of European Postal and Telecommunications Administrations) and CT2 (Cordless Telephone 2) (UK) cordless specifications, the future DECT (Digital European Cordless Telephone) "Pan-European" (CEPT) digital cordless system, and the UK's recently announced Personal Communications Network (PCN).

SYSTEM / SPEC	CTI (CEPT)	CT2 (UK)	DECT (CEPT)	PCN (UK)
FREQUENCY	900 MHz band	864-868 MHz	1-88-1.9 GHz	1.7 GHz Area
ACCESS METHOD	Channelized	FDMA, TDD	TDMA, TDD	TBD
MODULATION	Analog FM	MSK	GMSK	TBD
VOICE CODING	N/A	32kbps ADPCM	32 kbps ADPCM	TBD
POWER	10mW	Up to 10mW	300mW max. peak	GSM & DECT
CARRIERS	40	40	TBD	GSM & DECT
CHANNELS/CARRIER	1	1	12	TBD
CARRIER SEPARATION	50 kHz	100 KHz	1.3 MHz	TBD
INITIAL MARKET	Residential	Public telepoint Originate only	Business	All
HANDOFF	No	No	Yes	Yes

TABLE 3.1 - European In-Building Cordless Systems

Table 3.1 outlines the key specifications for these systems. Other than the PCN initiative which is largely undefined and may yet be compatible with DECT or GSM, they are incompatible among themselves and GSM. CT2 is an improved digital version of CT1, however both are only designed to offer "telepoint" or single line cordless services, rather than becoming full blown RF alternatives to wired PBX's or Local Area Networks (LAN's). DECT, which is not due for introduction until the mid-1990's is designed to operate in the 1.8 to 1.9 GHz band, whereas PCN is in the 1.7 GHz band. As a result, both are incompatible with cellular, CT2, and may conflict with other radio services in North America currently authorized to operate in these bands. The degree to which PCN and DECT co-exist remains to be seen.

Pending the PCN definition, greater exploitation of digital cellular technologies for in-building applications will not occur in Europe.

3.1.2 North American Initiatives

There are no standards in North America for in-building digital radio systems. However, several initiatives have surfaced, including the Wireless Communications Working Group at Brown University and the Radio Advisory Board of Canada, initiated by Canada's Department of Communications. It seems likely that an EIA Committee will be established in the near future to wrestle with this issue.

3.2 Convergence of Digital Cellular and Cordless

3.2.1 Cost of Portability

The current cost of a wired PBX connection is in the range of $500 per subscriber. Cost of adds, moves or changes can easily exceed that same figure and in many major corporations will occur typically at least every 1.5 years. As digital cellular systems come on line in the 90's, the per subscriber port cost will drop below that of current PBX's, while cost of moves or changes will continue to increase at least at the annual inflation rate. Figure 3.1 illustrates the RFPBX concept, which could readily be extended to an RFLAN.

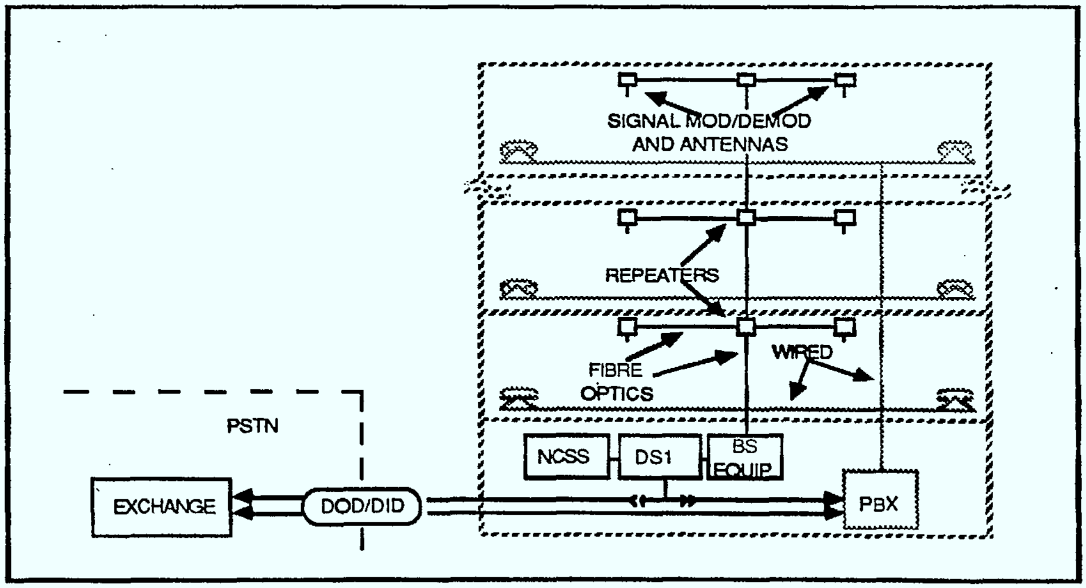

FIGURE 3.1 - Digital RF PBX (or RFLAN)

In establishing the in-building standard in North America, the opportunity should not be lost to capitalize on the future decreasing price spiral offered by digital cellular technology. A pocket sized digital cordless flip-phone could be sold for under U.S. $100 and systems competitive with wired RBX's and LAN's could be developed by 1993, within two years after introduction of digital cellular.

3.2.2 Interference and Capacity

Interference between low power in-building and external systems can be avoided by implementing a modulation scheme that has high noise immunity, such as spread spectrum, and also limiting handheld RF power to milliwatts. With as little as 10 MHz of spectrum, traffic densities within a given floor could easily reach 10,000 E/system (See Figure 2.4) resulting in perhaps 100,000 E/system over an entire building. Indeed, in-building spectrum efficiency, expressed as (E/MHz/sq. km.) is at least ten times greater than in the mobile environment for a given C/I because of the small cell sizes. Frequencies could be reused, perhaps every 3 floors, like a layer cake. (See Reference 7)

In-building RF power levels will be from 1 to 2 orders of magnitude less than cellular, which precludes sharing of common spectrum. Ideally in-building spectrum should be dedicated and reasonably adjacent to existing 800/900 MHz cellular bands, in order to maximize RF component commonality. Higher capacity modulation schemes could be realized, likely 5 or 6 bits per second per hertz. Assuming an equivalent 30 KHz channel as in the EIA system, each full user channel could deliver the basic ISDN 2B+D rate, making the radio link compatible with other ISDN delivery media.

3.2.3 Cordless Booster Concept

Relay and booster systems between the micro cordless and the digital cellular system could readily be developed, creating a transparent cordless service for mobile customers roaming up to several hundreds of meters from their vehicles. They wouldn't need to be aware of the frequency and power conversion taking place in these boosters, as depicted in Figure 3.2.

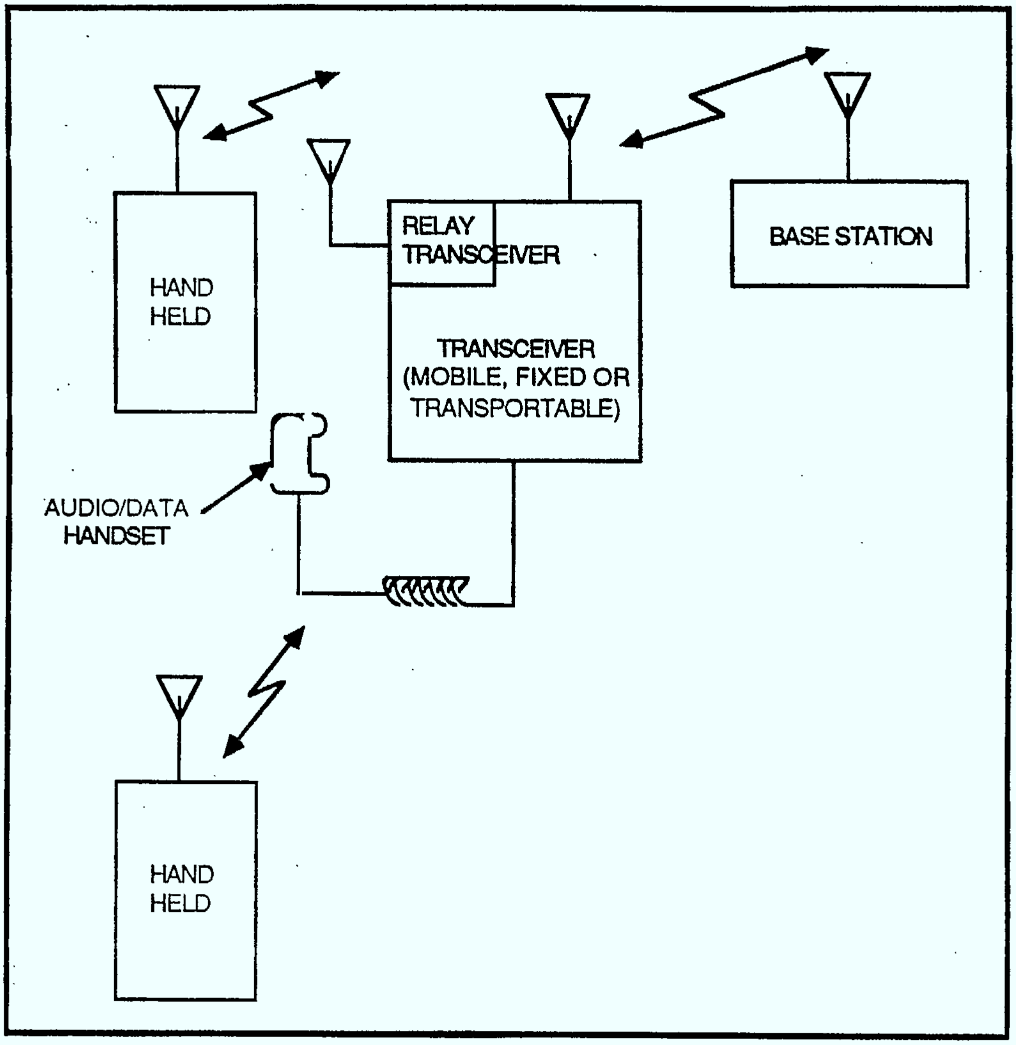

FIGURE 3.2 - Cordless Booster Concept

At home, one or more flip-phones could be used with one or more cordless base stations to access either two wire telephone loops, "fixed" digital cellular links or BETRS (Basic Exchange Telephone Radio Service) loops.

3.3 The Dream of Personal Communications

Figure 3.3 illustrates the full scope of the universal personal communications opportunity. As already described, in-building cordless RFPBX and RFLAN systems could evolve from a common digital cellular technology base. In addition, existing SMR (Specialized Mobile Radio) systems, operating in the 806 - 821 MHz and 851 - 866 MHz bands could readily be upgraded to provide

• THE CONVERGENCE OF DIGITAL CELLULAR AND DIGITAL CORDLESS TECHNOLOGIES

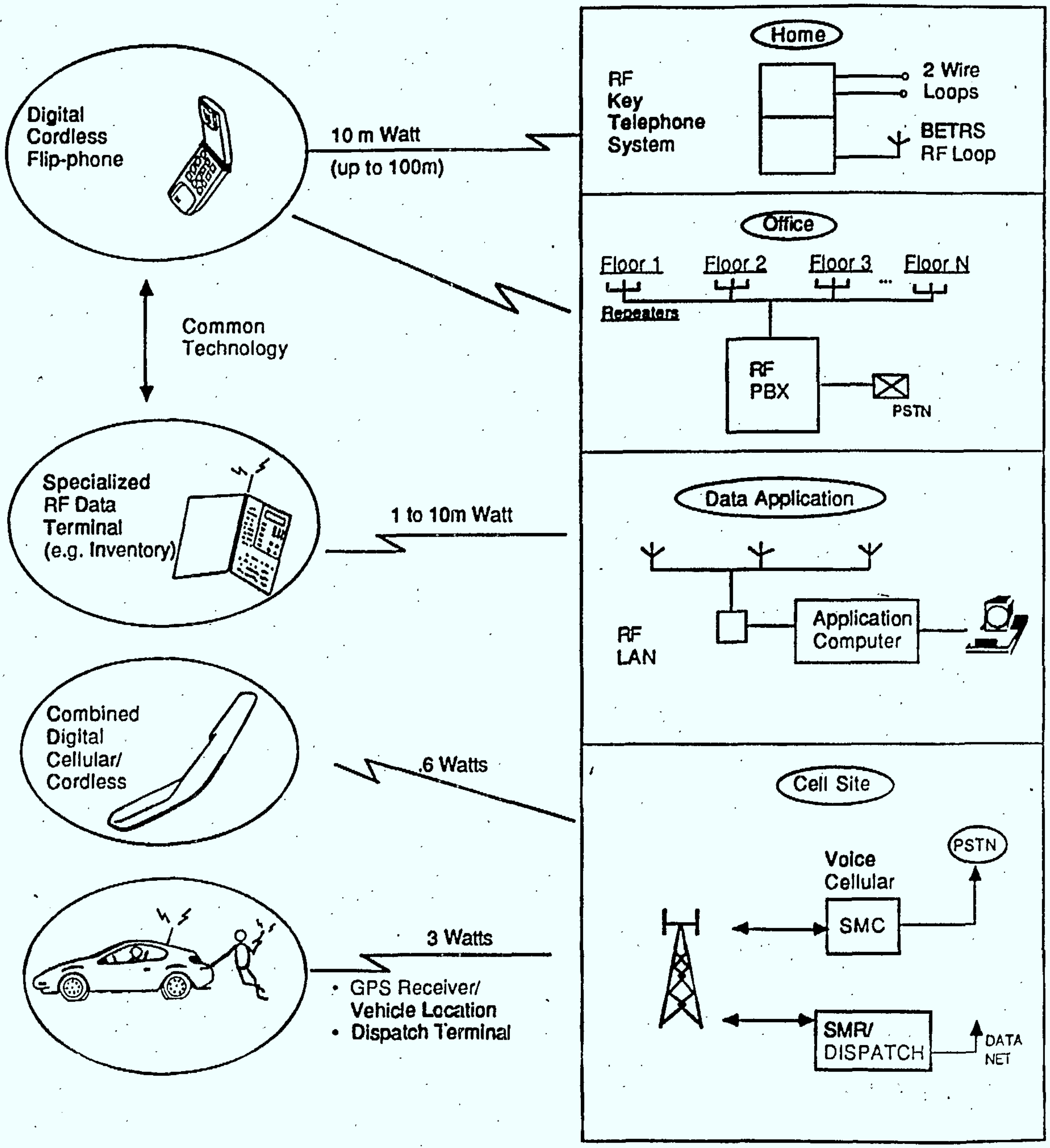

FIGURE 3.3 - Universal Personal Communications

higher quality, lower cost data and dispatch services incorporating digital cellular signaling and control structures.

Paging receivers in the 800/900 MHz bands could also be added to this vision of a universal radio transceiver, as could navigating systems such as the GPS (Global Positioning Navigation System), which operates in the 1.5GHz area.

Hence a convergence of digital cellular, in-building digital cordless and RFLAN, digital BETRS and digital SMR services is feasible. Technologically such a strategy can be conceived to realize the greatest degree of universality at the lowest possible cost to users. But to realize such an ambitious goal will call for commitment and compromise on the part of operators, manufacturers and regulatory bodies.

4. Conclusions

- Analog cellular radio systems are choking on their own success;
- The next generation EIA digital cellular system in North America will expand in two seamless transitions from analog, increasing capacity in North America tenfold, and providing service to possibly 100 million subscribers by the end of the century;
- The Pan European digital system, GSM, will be limited to two times capacity and obsolete the current ETACS system;
- Europe is moving towards at least two different standards for in-building digital radio applications, namely DECT and PCN, and the degree of compatibility with GSM is not yet clear;
- North America has only just launched initiatives for defining in-building digital radio standards, and therefore could realize the highest degrees of product and service universality and affordability by exploiting the core technologies of digital cellular.

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THE E.M. ENVIRONMENT, E.M. COMPATIBILITY AND LIMITATIONS TO THE E.M. SPECTRUM UTILIZATION

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ABSTRACT

The historical and current growth is described of the electromagnetic environment (E.M.E.) due to "electrical apparatus" of all types. The characterization of the E.M.E. in spatial, spectral and temporal terms is considered. Particular attention is given to field levels that may exist. In considering the E.M.E. due to all sources as a potential Threat, it is noted that the recent and current evolution of electrical devices and systems renders them inherently less rugged electromagnetically thus making them potential Victims.

The systematic Threat - Victim relationship is defined, in analogy to communications or power systems, emphasizing the unintentional aspect of the relationship and the essential scientific and engineering challenges involved in minimizing Threat - Victim Systems, especially in view of their random, non-deterministic and unpredictable nature.

Methods are described of assessing some features of the E.M.E. on regional, micro-regional, local and interior bases and some results of such assessments are presented. Measurement survey and monitoring techniques are described, statistical processing procedures of measured data are discussed and results of sample measurements for high density urban locations, both outside and inside buildings, are presented.

The traditional and current roles of regulatory and standards bodies on the international (e.g. ITU, IEC, CISPR), national (e.g. DOC, CSC, CSA) and scientific society levels will be considered. The activities of the CSA Advisory Committee on E.M.E. will be described.

In conclusion, it is noted that the current evolution of various E.M. Threat - Victim Systems poses a potentially serious limitation on the planning and implementation of not only intentional communications systems, but of all 'electrical' devices and systems and that the challenge of the E.M.E./Compatibility problem requires a broad-based holistic approach on the part of designers, manufacturers and operators of all 'electrical' devices and systems.

Résumé

Milieu électromagnétique, compatibilité électromagnétique à l'utilisation des fréquences électromagnétiques

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Ce document décrit l'évolution passée et présente du milieu électromagnétique en égard aux "appareils électriques" de toute nature. L'auteur y caractérise le milieu électromagnétique du point de vue spatial, spectral et temporel. Une attention particulière est accordée aux niveaux d'intensité de champ éventuels. Dans ce document, où l'on présente les rayonnements électromagnétiques de toutes sources comme une menace éventuelle, l'auteur fait observer que l'évolution récente et actuelle des dispositifs et des systèmes électriques a rendu ceux-ci moins résistants du point de vue électromagnétique et qu'ils sont donc des victimes éventuelles de ce type de brouillage.

L'auteur définit la relation menace systématique-victime par analogie avec les systèmes de communications ou d'alimentation en faisant ressortir l'aspect non intentionnel de la relation et les défis scientifiques et techniques essentiels que pose la réduction au minimum de la dualité menace-systèmes victimes, particulièrement du point de vue de la nature aléatoire, imprévisible et non déterministe de la question.

Dans le document en question, on décrit des méthodes pour évaluer quelques-unes des caractéristiques du milieu électromagnétique à l'échelle régionale, micro-régionale, locale et intérieure et on présente un certain nombre de résultats de ces évaluations. On y décrit les techniques de mesure, de relevé et de contrôle utilisées, on y examine les méthodes de traitement statistique des données mesurées et on y présente les résultats des mesures d'échantillonnage pour les emplacements urbains à forte densité, tant à l'intérieur qu'à l'extérieur des immeubles.

L'auteur examine le rôle traditionnel et actuel d'organismes de règlementation et de normalisation internationaux (UIT, CEI, CISPR), nationaux (MDC, CCN, ACNOR) et de sociétés scientifiques. Il y décrit en outre les travaux du Comité consultatif de l'ACNOR sur le milieu électromagnétique.

En conclusion, l'auteur indique que le brouillage électromagnétique qui guette dorénavant les divers systèmes de radiocommunications peut limiter gravement la planification et la mise en oeuvre des systèmes de communications intentionnelles comme des autres dispositifs et systèmes "électriques". Qui plus est, le défi que pose le problème du milieu et de la compatibilité électromagnétique nécessite une approche "holistique" générale de la part des concepteurs, des fabricants et des exploitants de dispositifs et de systèmes électriques de tout genre.

SOME BASIC PRINCIPLES

Electromagnetic Energy

In contemplating the electromagnetic environment and the problems being encountered in increasing measure in relation to the manner in which 'electrical' systems and devices affect each other, it is important to re-iterate that we are dealing with one of the fundamental forms of energy, namely electromagnetic energy. The immutable characteristics of this energy are that it is dynamic, moves in the form of waves (in vacuum with the invariant speed of "light") and that any physical condition involving time-varying charges will result in e.m. waves. These in turn propagate, either in unbounded regions (e.g. "radiate"), or are guided by physical boundaries (e.g. "conducted"). The e.m. energy thus transported in turn causes charge motion in materials and becomes converted into a variety of energetic responses in the material.

In simple terms therefore, any physical arrangement with time varying charges is a source of e.m. waves (acts as a transmitting antenna), these waves propagate into the surrounding regions (the environment) and in turn affect other physical objects (which act as the receiving antennas and energy receptors).

Natural Occurence

In nature, such conditions occur at all times and in a very large variety of forms. The environment is permeated by e.m energy, albeit at relatively low power levels except for the obviously higher levels from the sun, or such natural high energy occurences as lightning.

The naturally occuring e.m. waves are thus generally characterized by their low power levels and by their random behaviour. They are said to be incoherent, have a broad spectral distribution or are aperiodically impulsive and are randomly polarized. In time-harmonic terms, they range from extremely low frequency, as in the case of earth currents, to the very high frequency (short wavelengths) of light. The effect of this natural e.m. energy on equipment and devices is variously referred to as 'noise', 'static' and interference.

Practical Use of E.M. Energy

The utilization of electromagnetic energy to useful purposes has generally taken two forms. The first form is that in which the energy is utilized in its own right, as energy, as a means of performing useful work. The second form is that of using the e.m energy as a transporter of signals for the transmission and processing of information. The notions of 'power systems' and 'communications' systems are clearly recognizable. More complex, hybrid forms however, are also formed from the two basic ones, as for example in the case of instrumentation, control, computer and robotic systems.

The useful, humanly devised and structured systems are thus generally characterized by higher power levels of operation, by the specific frequency or range of frequencies of their operation and above all by their deliberate intended purpose and structure.

HISTORICAL EVOLUTION

The E.M. Environment Problem

The practical exploitation of e.m. energy has from the earliest period of development been accompanied by problems of coordination and avoidance of interference among adjacent systems. Thus even in the era of simple power and wire communications, a major problem, known then as "inductive coordination" needed very careful attention. The problems of "cross-talk" between telephone lines, or the "hum" on a telephone line due to a nearby power line, are classical examples of the technical problems which required solution. Both represent cases of one system producing an e.m. environment which affects another.

In addition to being a technical problem, it was soon recognized to be a legal and regulatory one as well. International agencies such as the ITU and analogous state administrative bodies were established precisely for the purpose of avoiding chaos and anarchy which would result from uncontrolled and uncoordinated exploitation of e.m. energy. Thus, for example, was conceived the concept of E.M. Spectrum Management.

The Growing Problem

While the basic nature of the e.m. environment problem has always been present, and has been dealt with through considerations of e.m.c (e.m. compatibility), e.m.s. (e.m. susceptibility), e.m.i. (e.m. interference) and other members of this family of ideas for managing the problem, it is now evident that the general situation has in recent years begun to reach proportions serious enough to merit more fundamental and global re-examination. Such a re-examination may be essential to ensure further development in the practical exploitation of e.m. energy.

The factors which are contributing to the presently evolving e.m environment problem are increasingly complex. Two major factors are at work:

1. the sources which create the environment and
2. the devices which are subjected to it.

The Evolving Environment

The electromagnetic environment (i.e. ambient field levels) has been steadily growing in magnitude and complexity since 1850. This environment is due to "electrical apparatus" of all types, which, in the developed countries has penetrated intensively into all areas of activity : industrial, commercial, administrative, government, education, health services, public and private institutions and into the home. Such "apparatus", initially involving power and communications systems only, has in recent decades expanded into innumerable other applications as the exploitation of control and system concepts have combined with the so-called computer and digital 'high technology' to produce a host of new contributors to the e.m. environment.

To illustrate the growth of the e.m. environment a graphical representation, indicating its various features is shown in Figure 1. This is only a qualitative sketch, intended to indicate the manner in which the e.m. environment is evolving.

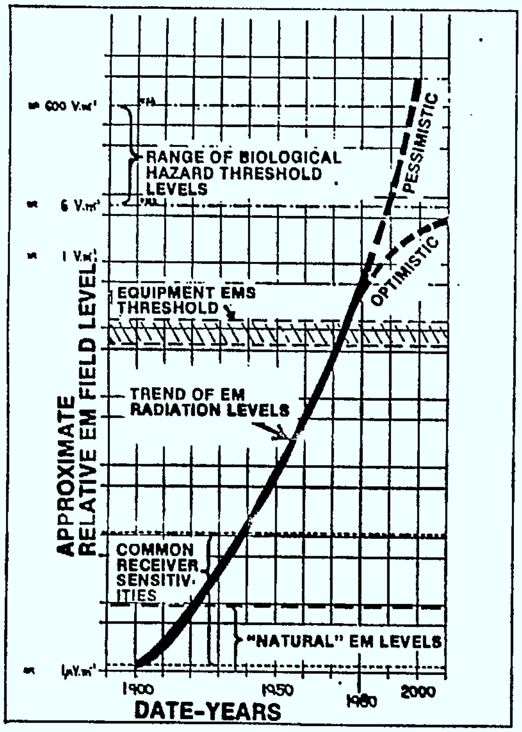

Figure 1. A Qualitative representation of E.M.E trends.

The Evolution of Susceptible "Victims"

The second factor of the e.m. environment problem as noted above is that of the effect of the environment on the electrical devices and systems themselves.

With the onset solid state devices, of microcircuits and VLSI's, the devices of which systems are constructed, have themselves become inherently less rugged and increasingly less immune to the growing environment. This is due to their decreasing size and because of their basic form, design and construction. In particular, the present day microminiaturized, solid state devices operate at inherently low energy levels, are inherently more sensitive and are internally fragile electrically, thermally and mechanically. They and the systems constructed from them are thus susceptible to intrusive energy which may cause physical damage or even their destruction. More importantly, they are sensitive to extraneous signals which may result in faulty behaviour or in malfunction. Such possibility of malfunction is particularly of concern in systems which may affect human safety.

If the inherent ability of devices and systems to withstand unwanted effects of intrusive e.m. energy is described as their **Immunity Threshold**, then another illustrative sketch may be made to represent the abovementioned trend, as shown in Figure 2. Comparing this now with Figure 1, makes it evident that as the e.m. environment grows, its potential victims also proliferate and are increasingly more susceptible to it.

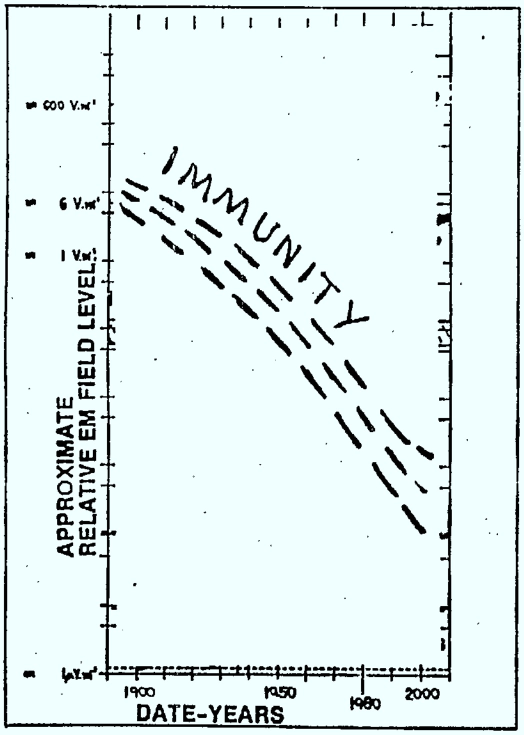

Figure 2. The General Trend of Immunity Thresholds

THE E.M.E. PROBLEM AS A "SYSTEM"

In considering the causal relationships between e.m. energy sources, the environment they produce and the devices or systems which succumb to it, a system approach may be suggested as a useful tool to investigate the problem.

An analogy can be drawn betweenp the interference process and a communications or a power system. There is, however a basic difference in objectives. Communications, power and other planned systems are intentional, whereas 'interference' systems is are unintentional (and unwanted).

Intentional Systems

In an intentional system a known, deliberate source (a transmitter, generator) is linked through a planned transmission medium (radiated e.m. waves, transmission line) to a deliberate receptor (receiver, power load). Such systems are characterized by the fact that they are intended to produce defined, intentional results.

Such intentional systems, as in the case of power and communications are represented in their fundamental canonic forms, by the diagrams in Figure 3. (other 'systems' have similar basic forms):

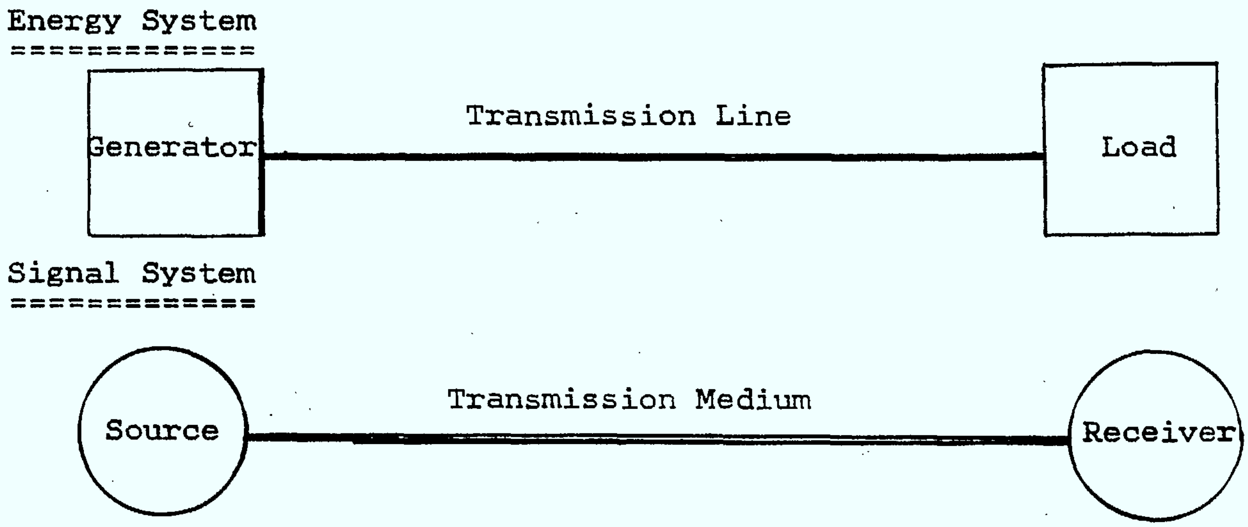

Figure 3. Canonic Forms of Intentional Systems

It is evident that the above systems are shown in their most primitive, simplest forms. Real systems are multiple, complex combinations of these. Furthermore, other systems, such as those encountered in process control, automatic manufacturing systems, in robotics, in computer and digital systems, especially when interfaced to mechanical devices, are complex, hybrid combinations of the above.

The Unintentional E.M.E. System

In the interference process, the same system structure occurs with the vital difference that:
- the source is unwanted and much of the time is unknown and unforseen
- the medium of trasmission is complex and often unpredictable
- the receptor is unintentional and its response unexpected

The following canonic system diagram applies:

The Unintentional System
========================

Figure 4. The E.M.Environment Threat/Victim System

A comparison of Figure 4. with the diagrams of Figure 3. clearly highlights the structural similarities while allowing consideration of the basic differences bewteen the intentional and unintentional systems.

In the intentional communications/power transmission cases, the system efficacy is deliberately optimized and the three system components are deliberately harmonized. Thus the three basic components, the source, tranmission medium and receptor, are planned to operate at particular frequencies, at specified voltage , current and power levels, with specified forms of signals (sinusoidal a.c., d.c., a.m., f.m., pulsed etc. modulation).

On the other hand, in the interference process (the unintentional system) the ultimate aim is to eliminate or at least minimize its effects. To do so, however the sources (the threats), the transmission medium and the receptors (victims) have to be identified and the total process understood. To compound the problem, very often some Victims may themselves constitute Threats to others while the Threats in turn may be Victims of others.

A more difficult aspect is that while an intentional system is à priori well defined, the unintentional one is not, except on the basis of prior experience. Furthermore, intentional systems are hopefully deterministic whereas the unintentional ones behave largely in a random, unpredictable manner. In addition, in the unintentional system, it must not be presumed that the interfering source and its victim need necessarily to be harmonized to each other. Thus impulsive sources affect single frequency systems, high frequency sources affect audio and t.v. baseband sytems, r.f sources will influence process controllers. The problem is further compounded by the inconstant, temporal behaviour (e.g. hit and run) nature of many of the threats.

Management of the E.M.E. Problem

In view of the above, it is evident that the elimination or minimization of an unintentional system poses a novel and challenging engineering, technological task. In attempting to "minimize" an unintentional system a number of difficult and tedious processes have to be undertaken.

1. It would be comforting to say that the 'unintentional" system can always be predicted in a deterministic fashion. The reality is that the mulfunctioning of equipment due to emi, is discovered by experience in most cases and that it first has to be noticed and identified. It is for this reason that a phenomenological study and ongoing observation is essential. This process serves only to 'identify' the victims.,

2. The identification of the 'threats' and the 'transmission medium' is then undertaken. This requires correlating potential threat sources and the transmission mechanism. Since the threats and the victims are not necessarily harmonized in a known fashion, then this must be done by extensive systematic searches, and frequently depends on intuitive, heuristic good fortune.

3. Once the unintentional system is identified,the process of minimization can proceed. Some threats may be removed or controlled. Others, being deliberate parts of an intentional system themselves, cannot be removed. The transmission mechanism minimization and the immunization of the victim form two separate essential activities, starting with the design of the equipment and an analysis of the environment and the manner in which it is used.

ASSESSMENT OF THE CONDITION OF THE E.M.ENVIRONMENT

The general trends in the evolution of the E.M.E. need to be evaluated more specifically then by the qualitative graphs shown above. Two approaches are taken to quantify the problem:

1. By computed predictions of field strengths in terms of known intentional sources
2. By measurement of the environment itself

Both approaches have severe limitations, but they represent what it feasible in terms of present knowledge and in terms of currently available instrumentation and field metrology techniques. An important point is that in general very little effort has been invested into the assessment of the E.M.E., in comparison to the massive investments being in the development of the intentional systems. Some selected examples of calculated field strength predictions and of actual measured outdoor and indoor conditions are shown below.

In both cases, the principal limitations are that attention is given, for reasons of practicality, to those sources which are known and which are continuously active. The problem of predicting or measuring occasional or impulsive sources is clearly more difficult and becomes impossible until they are known and identified.

Prediction of Maximum Peak or Average Field Strengths

The technique for predicting the possible peak or average field strength due to known sources results in graphs known as Envelope Graphs, which show the possible field levels as a function of frequency. The production of such graphs requires extensive data banks giving the geographic and technical data of the known sources. Computational propagation models are then assumed and the resulting field levels determined, from which the graphs are then plotted. A historically ground-breaking graph of this type was published by Communications Canada in 1978 (DOC EMCAB I), describing the maximum expected environment in Canadian populated areas. This graph is reproduced below as Figure 5.a. The field levels indicated may be termed to be "interesting". It should be noted that this graph was structured to represent conditions over a substantial region, such as a major city.

It is evident that special conditions may prevail in particular localities and that it is important to consider these as "microregions". A further problem is to study the conditions inside buildings, not only at a single point but throughout the floor plan and at all floors.

In the case of a microregion, such localities as airports assume particular significance. Figure 5.b. has been selected as an example from an extensive set of envelope graphs calculated for major world civilian airports.

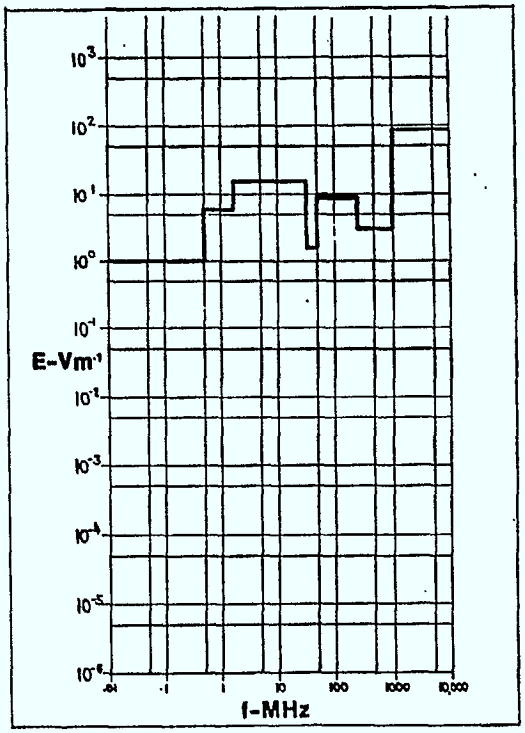

Fig. 5.a. Maximum expected radio environment in populated areas (DOC EMCAB 1 1978)

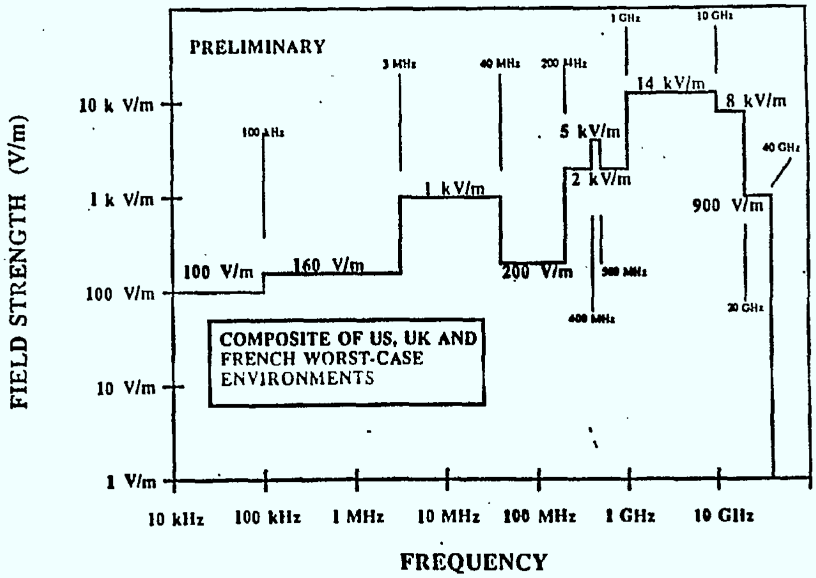

Fig. 5.b. Predicted peak field strength for the total worst case environments of U.S., U.K., and French Airports.

Figure 5.b. is taken from from A. Gross, "Guidelines for Developing Maximum Peak and Average Field Strength Envelope Graphs for Aircraft", D.O.D. Electromagnetic Compatibility Analysis Center, Washington, Presented at the International Meeting on Susceptibility of Avionic Systems in High Energy Radio Frequency Fields, March 1988, Brighton, U.K. It is a rather startling illustration of the E.M.E. problem which may be encountered by "high technology systems" (in this case aircraft), under some circumstances.

Measurement of the E.M. Environment

The problem of measuring the e.m. environment starts with the process of identifying the potential "threats". This implies the accumulation of large quantities of data and tracking down the threat source.

Once the above task is accomplished, the straightforward measurement of the fields is within the reach of current technology. Even then, most measurement techniques anticipate repeatable, usually narrow band or known waveform conditions. The challenge is to look for means of sensing, in a monitoring fashion, aperiodic, single event phenomena.

Even in the so-called straightforward problems, such as the measurement of the field due to a t.v. transmitter as it penetrates into a building, into a vehicle, into an aircraft, the measurement technology and the analysis of the results, is only now becoming practicable. It must also be noted that it nevertheless very costly and time consuming and still poses very challenging technical problems. In order to achieve a meaningful measured assessment, large amounts of data need to be accumulated and then suitably processed, usually by statistical techniques.

The following figures are samples of the results of such measurements in a microregion (a university campus) both outside and inside buildings. The measurements and the analysis were carried out as a joint research program of DOC and McGill University. The downtown campus is effectively at the center of a ring of approximately fourteen relatively high power transmitters for FM and TV broadcasting, at a mean distance of approximately one kilometre. Although most of the transmitters are collocated on a single tower on Mount Royal, a significant number are located on a circular arc, surrounding the Campus. Figure 6 illustrates the geographic configuration.

The equipment for such measurements, especially inside the buildings poses a number of challenging technical problems and, in fact, requires to be specially designed for the purpose. The statistical analysis also requires to be specially structured in order to characterize the results into a meaningful form.

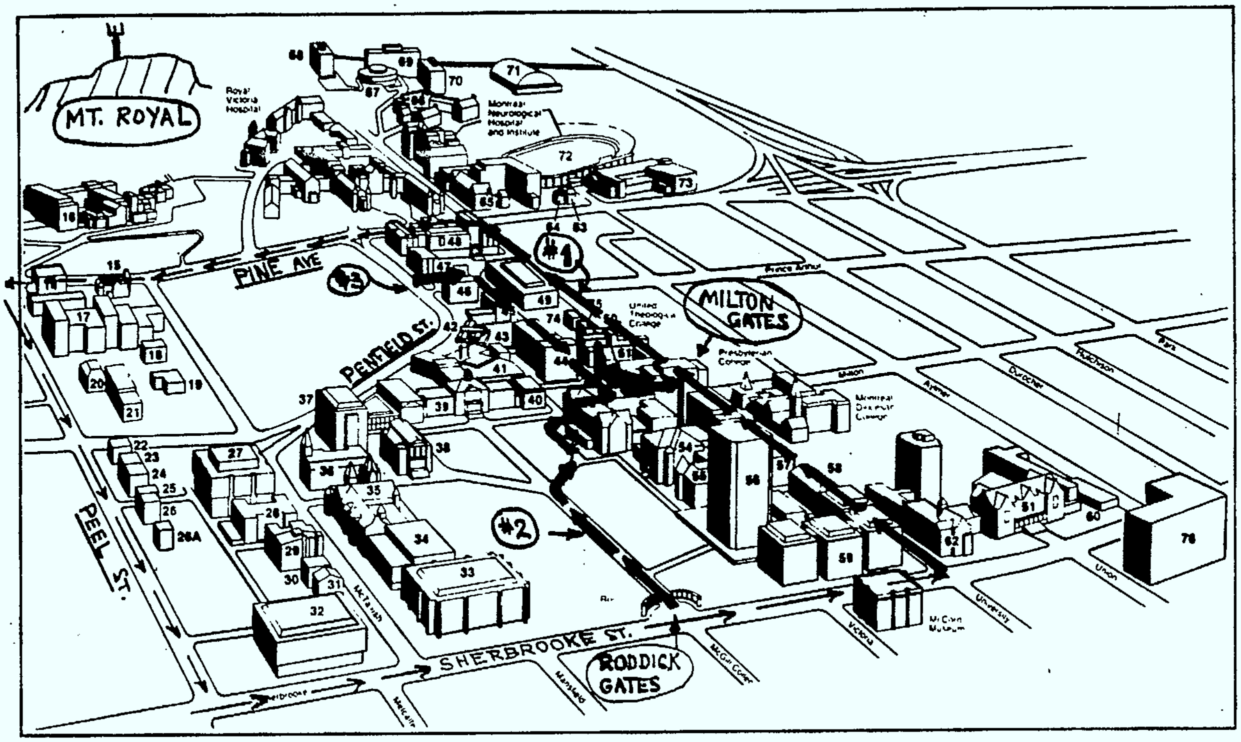

Figure 6. The geography of a metropolitan microregion
(The McGill University Campus)

Typical measurements involve recording the field strengths due to a single source, along a chosen trajectory. In order to obtain meaningful results, measurements need to be taken at intervals of a fraction of a wavelength. Such basic data is shown in Figure 7.

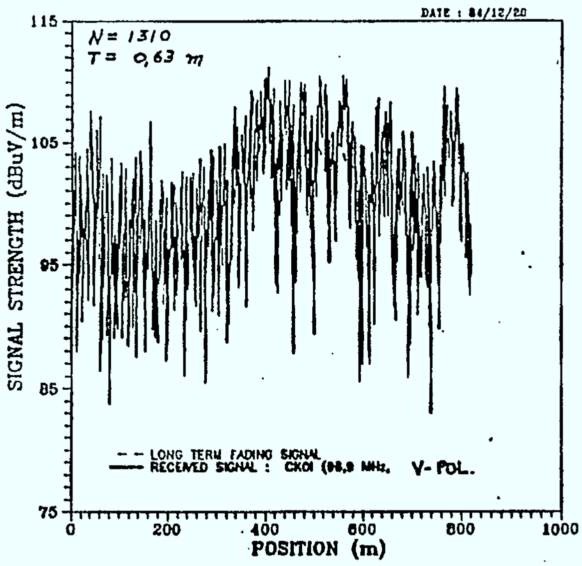

Figure 7. A typical signal strength profile measurement along a city street, at a single frequency (96.9 MHz)

The "raw" measured data requires statistical processing to yield interpretable results. Thus, digital filtering yields spatial long term fading information which may indicate the basic propagation geometry of the environment (Figure 8), while the remaining short term fading component (Figure 8), may be structured into a probability density function as in Figure 9, which provides information about the propagation statistics of the environment.

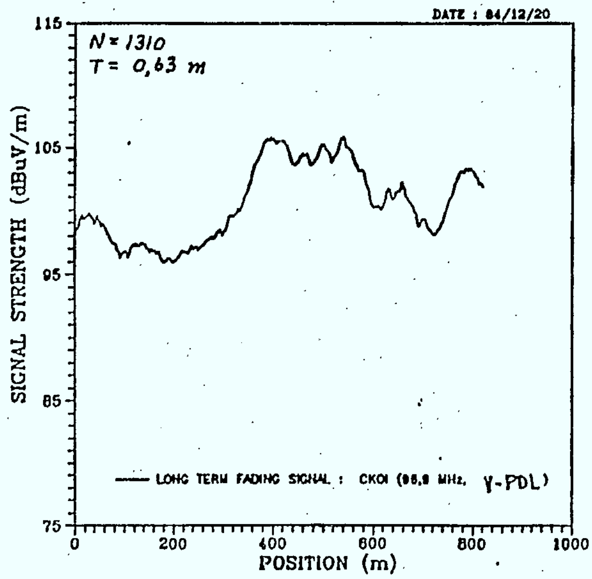

Figure 8. Spatial long term fading of signal in Fig. 7.

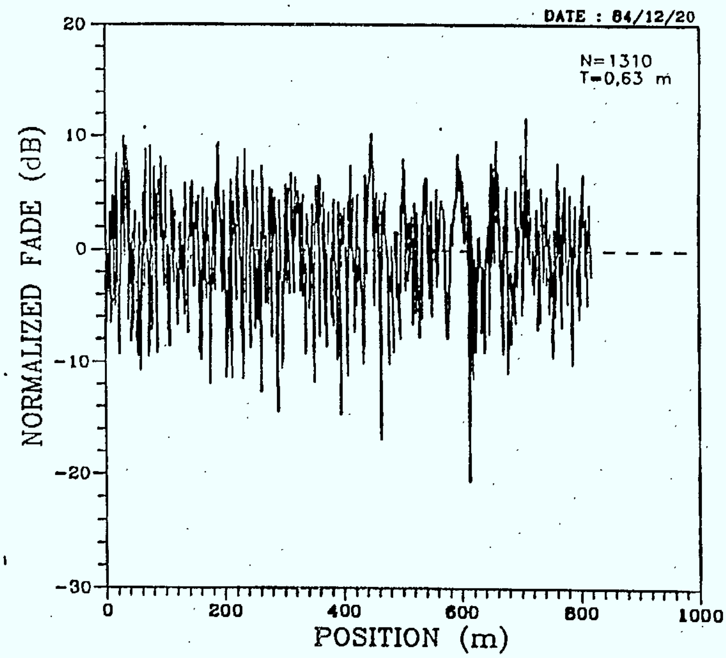

Figure 9. Short term fading component of Fig. 7 signal

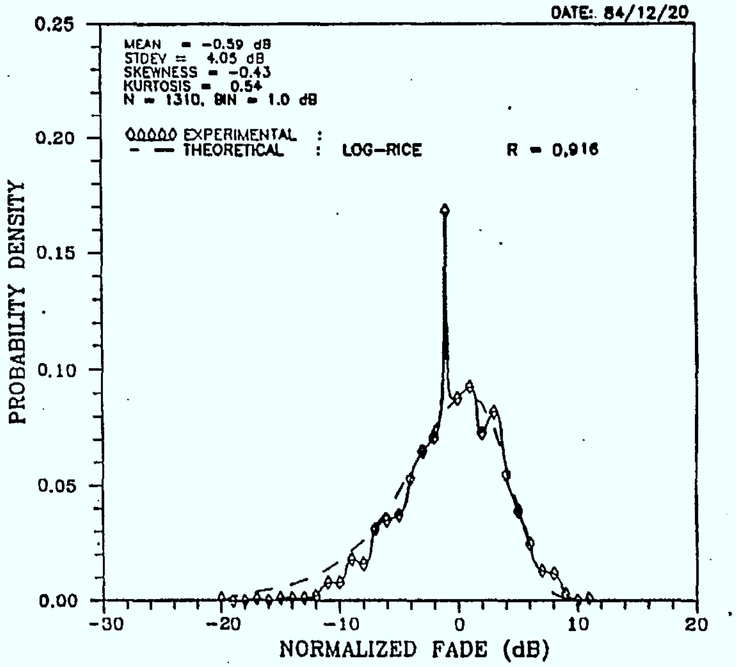

Figure 10. Probability density function of short term fading component of Fig. 9 and best fit Rician PDF.

In some cases, such as indoor field measurements, it is useful to measure and plot the two dimensional distribution of the field at a given height above the floor. The resulting maps provide useful information about the ambient field structure, as shown in Figure 11, for a particular frequency and polarization.

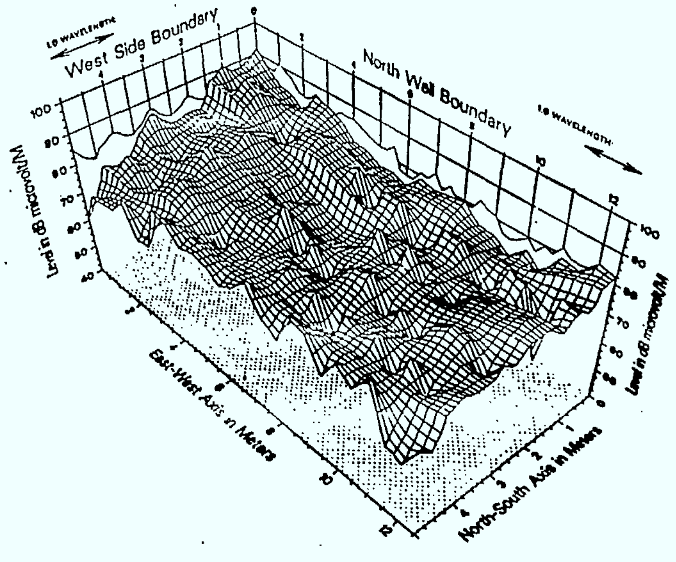

Figure 11. Field strength surface in a lobby of a University building for a 205,25 MHz source

The basic data of field measurements for a large number of sources, in a variety of locations, may be combined into plots which show the cummulative effect of sources operating in a particular service band of the spectrum. It has been found that the so called Q-Q (quantile-quantile) plots are useful for this purpose. These allow a ready comparison of the e.m.e. levels under different conditions and may also be useful for some predictive purposes. Figure 12 shows such a plot for the cummulative effective field strength resulting from fourteen transmitters in the FM and TV service band. The plots are for different street locations outside a building and for several floor levels inside the building. (The McConnell Engineering Building at McGill University). The plot has been used also to estimate the field strength on the roof of the building. Subsequent measurements have corroborated that the estimate is of the correct order. Perhaps more importantly, the measured field levels on one of the adjacent streets, are of the order predicted in the DOC EMCAB 1 graph shown in Figure 5.a., thus corroborating the usefulness of the calculated Profile Graphs as a predictive tool for <u>known</u> sources.

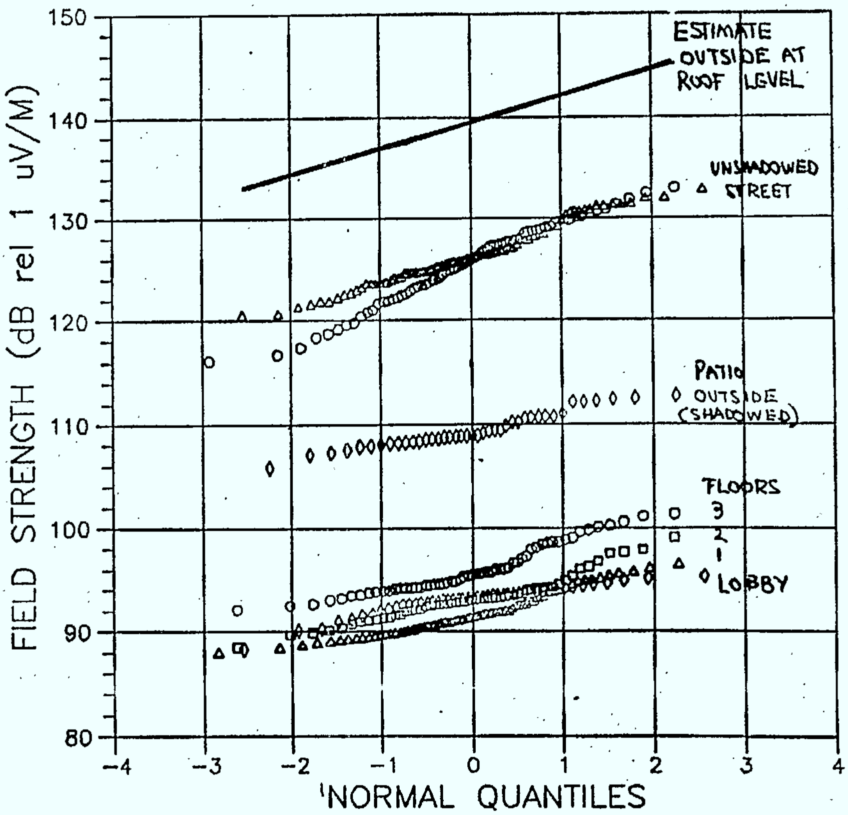

Figure 12. Composite level comparisons of FM and TV broadcast signals inside and outside a ferro-concrete builing and on two neighbouring streets. The solid line indicates the extrapolated estimate of field levels on the building roof.

REGULATORY BODIES, STANDARDS, ETC.

As is evident from the foregoing discussion that although it is an old one, there is indeed evolving a major, possibly critical, condition of the electromagnetic environment. This condition cannot but affect and limit unhampered growth in the multifacetted applications of devices and systems whose operation depends on the use of electromagnetic energy.

A number of topics have deliberately not been detailed here, such as the problem of determining, by measurement or otherwise, the immunity of equipment from the surrounding e.m.e.

Another discussion which has been omitted has been a narration of an almost endless number of incidents, ranging from amusing to tragically fatal, which document the fact that a serious condition indeed exists. In this respect, sufficient proof exists in the fact that a large number of agencies at the international and national levels, governmental, industrial and scientific, are seized by the problem. A listing of such organizations, a description of their efforts and a catalogue of existing or proposed rules, regulations and standards, would form a substantial library.

It is of course important to note here the intensive work of international bodies working in this area, such as the ITU and its two committes, CCITT and CCIR, of the IEC and CIGRE and of CISPER, along with their local national committees.

In Canada, in addition to the National Committees of the above bodies and of Canadian government bodies, there is now at work a Canadian Standards Association Advisory Committee on the Electromagnetic Environment, whose mandate is to advise the CSA on the preparation of Standards on Electromagnetic Compatibility.

Many standards and regulations already exist, and it would be comforting to believe that compliance to them would readily resolve all problems. Such a belief, unfortunately would be a dangerous illusion. The specification of standards and rules and blind compliance to them would imply that the problems are well and thoroughly understood. Unfortunately that is not so, for the following reasons:

Firstly, as indicated above, the problem of the unintentional systems is not a deterministic one and is only partially predictable and then only in the light of bitter previous experience.

Secondly the state and level of knowledge and understanding of the physical phenomena involved is by no means complete. In different sectors of the "electrical game" conceptual simplifications leave the designers, builders and users only partly equipped to deal with the e.m.e. problem.

Thus it will be noted that different approximation techniques are used in different technologies for problem modelling. In the power and low frequency areas, lumped parameter, voltage/current models are traditional and the question needs to be raised whether such modelling continues to be appropriate, especially in approaching time-space domain problems. At the other end of the frequency spectrum scale, high-frequency asymptotic, (quasi-optical) models are used and material properties tend to be represented in very simplified idealized forms.

An interesting example of dangerously primitive and misleading concepts is that of the idea of a "ground". What is it ? Where did the idea originate ? Is it meaningful ? What is the meaning of a ground in a high rise building when considering nano-second pulse systems? What does "ground" mean in an aircraft or a ship?

Above all, the present state of e.m. theory as it has developed in the past 150 years, is almost entirely in terms of the steady-state frequency domain, linearity is usually assumed thus allowing the application of Fourier techniques. Although time-domain analysis is now receiving intensive attention it is still in its infancy and the number of useful solved problems is still minimal, and yet, a vast number of interference problems fall precisely into the category of time domain, transitory impulsive phenomena.

The conclusion to be drawn from this is that whatever standards and regulations are evolved at this stage, must be clearly considered tentative. Unfortunately, designers, manufacturers and operators, in the process of complying with standards and regulations, acquire a vested interest in them and later changes even in the light of better understanding and new techniques become extremely difficult. (In Law an interesting example of this human trait is in Maritime Law. Despite the centuries of development in geographic discovery, ship construction & propulsion, navigation techniques, etc. present day maritime law doctrine is still based on that of the Phoenicians and their oar driven vessels !)

CONCLUDING OBSERVATIONS

In summary, the following points are evident:

1. There exists indeed an increasingly serious problem involving the Electromagnetic Environment and its consequent effect on the ability to ensure the electromagnetic compatibility of all systems.

2. In general the E.M.E. problem cannot but help to influence further growth in the development of "electrical" equipment and systems of all types.

3. The proliferation of applications, beyond the "merely" power and communications systems ideas, means that it is no longer appropriate to compartmentalize according to specific industries and applications, but that a more holistic approach is required.

4. It is evident that the E.M.E. problem probably cannot be adequately resolved using the currently evolved knowledge and understanding of electromagnetic theory and that considerable effort of solving difficult problems in the time domain, in the presence of complex materials and structures, has yet to be carried out. This represents a major basic research effort.

5. While the technology is well advanced to provide useful instrumentation and metrology techniques for the measurement of the e.m. environment, and allied problems, insufficient effort has been made so far in this area. Furthermore, very difficult measurement problems still remain unsolved and these also will require considerable further research.

LA RARETÉ DES FRÉQUENCES

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SOMMAIRE

Les facteurs contribuant à la rareté des fréquences sont nombreux, complexes et souvent étranges ou imprévisibles.

Malgré l'exigence d'une ingénierie des systèmes conforme aux règles de l'art, de protocoles et méthodes d'exploitation efficaces, et le développement des banques de données et des logiciels nécessaires à une assignation satisfaisante des fréquences, notre travail nous a permis d'identifier les situations suivantes comme agents principaux concourant à créer la rareté des fréquences:

- une population dense et nombreuse (les grandes zones métropolitaines);
- la topographie locale, régionale ou nationale;
- la nature et la quantité de services radio;
- le nombre de fréquences ou de bandes de fréquences disponibles pour une service donné;
- la pertinence des communications;
- l'utilisation simultanée d'une fréquence (partage);
- l'état de la technologie employée;
- le dynamisme de l'activité économique.

SPECTRUM CONGESTION

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ABSTRACT

The factors contributing to spectrum congestion are many, complex and often strange or unforseeable.

Despite state-of-the-art systems engineering, effective operating methods and procedures, and development of the data banks and software required for satisfactory assignment of frequencies, spectrum congestion exists, and our work has enabled us to identify the following as the main factors contributing to this situation:

- dense and large population (major metropolitan areas)
- local, regional or national topography
- nature and quantity of radio services
- number of frequencies or frequency bands available for a given service
- importance of communications
- simultaneous use of a frequency
- technology used
- high level of economic activity

Introduction

Le spectre représente une ressource limitée, dont la disponibilité peut être optimalisée par une saine gestion. Afin de bien remplir son rôle de gestionnaire dans ce domaine, le ministère des Communications doit évaluer les besoins, promouvoir l'utilisation de technologie efficace et ajuster les allocations des bandes de fréquences pour faire face à cette évolution changeante.

L'utilisation croissante de moyens de communications de plus en plus complexes survenue depuis les années 1950 oblige le gestionnaire du spectre à suivre de façon particulièrement attentive la situation. Les changements technologiques et la réduction des coûts de production de l'équipement ont amené l'introduction de nouveaux services à un rythme où la délivrance des licences radio double à tout les 5 ou 10 dix ans selon les services.

Pour leur part, les compagnies spécialisées en communication se doivent de s'assurer que l'outil indispensable à leur industrie, le spectre des fréquences radio, est disponible à court et moyen terme afin non seulement de permettre de supporter leur croissance anticipée mais aussi d'offrir une porte ouverte à une diversification de leurs services en communication en prenant avantage de l'avancement technologique et de leur créneau respectif dans un marché très compétitif. Cette présentation devrait vous permettre de vous tracer une image du degré de concentration dans l'utilisation des fréquences, groupées par bandes, dans les grands centres urbains du Canada. Vous pourrez avec l'aide des experts du ministère, établir une planification stratégique qui tient compte de ce facteur essentiel. En tant que pourvoyeur de moyens de communication, vous pourrez possiblement orienter vos études de marketing vers l'introduction de services faisant usage de bandes de fréquences dont les caractéristiques de propagation n'ont pas favorisé leur utilisation à grande échelle jusqu'à maintenant. Les manufacturiers, pour leur part, voudront non seulement améliorer l'efficacité spectrale de leur équipement mais aussi initier des programmes de recherche pour favoriser l'utilisation de ces bandes de fréquences.

Au cours de la présentation les données et les figures feront ressortir qu'il existe une corrélation entre la rarete des fréquences et les facteurs suivants:

-Population dense et nombreuse.
-Topographie.
-Nombre de canaux disponibles pour un service donné.
-Pertinence des communications.
-Utilisation simultanée d'une fréquence.
-Etat de la technologie employée.
-Dynamisme de l'activité économique.

Afin de mesurer la concentration de l'utilisation des fréquences sur une base spatiale, nous avons d'une façon bien arbitraire défini le centre-ville des villes choisies comme étant la surface d'un cercle d'un rayon de 8 Km. Dans la même foulée, l'aire d'un cercle de 90 Km englobe la zone d'influence radio d'une métropole. Ces deux valeurs nous ont semblé convenables pour bien illustrer l'utilisation du spectre des fréquences et, par déduction, la rareté des fréquences.

Les villes représentées exposent les différents degrés de rareté des fréquences au pays en passant par Vancouver, Edmonton, Calgary, Winnipeg, London, Toronto, Ottawa, Montréal, Québec, Halifax et, pour la radiodiffusion , Saint-John, Terreneuve.

La Radiodiffusion

Pour la bande de radiodiffusion sonore à modulation de fréquence et la télévision, la rareté est définie à partir des plans d'allotissement établis par le Ministère en étroite collaboration avec le CRTC, les gouvernements provinciaux et l'industrie. Ces plans tiennent compte des besoins exprimés et sont optimisés en fonction d'une saine gestion du spectre. Naturellement, seules les fréquences destinées aux stations de puissance régulière et protégées sont prévues. Il existe cependant des dispositions qui permettent de trouver d'autres fréquences pour les stations de faible puissance. Les canaux des stations de faible puissance et non protégées sont inscrits dans le régistre des assignations afin d'éviter, pour des raisons économiques, de les modifier sans motifs valables mais leur protection n'est pas assurée.

Dans les grands centres, où la population est dense et nombreuse, nous notons une pénurie de fréquences dans les bandes destinées à la radiodiffusion sonore à modulation d'amplitude (MA) pour le moment et à modulation de fréquence (MF) ainsi qu'à la télévision VHF.

Cette rareté de fréquences en radiodiffusion est causée en grande partie par la technologie utilisée: la modulation d'amplitude à double bande latérale pour le MA et la modulation à bande latérale résiduelle pour la télévision. Au cours de leur histoire, la radiodiffusion MA et la télévision ont aussi vu se créer et se perpétuer des parcs très important de récepteurs bon marché dont la conception technique comporte des faiblesses bien connues. Lors de la rédaction des plans d'allotissement, pour de nombreuses raisons, ces contraintes ne peuvent pas être ignorées et il faut rayer certains canaux tels que les canaux adjacents, les canaux à la fréquence image, ceux pouvant causer des battements à la fréquence intermédiaire, les canaux dits "Tabous" en télévision UHF, etc..., d'où une réduction du nombre de canaux disponibles.

Le graphique (Fig 1) sur la radiodiffusion sonore MA montre qu'un très grand nombre de canaux sont déjà utilisés dans la plupart des centres urbains importants et qu'il existe une pénurie de fréquences dans les grands centres comme Toronto et Montréal. Nous n'avons pas inclus la bande de 1605-1705 kHz qui sera bientôt ouverte pour améliorer la situation.

Le graphique (Fig 2) sur la radiodiffusion MF n'indique pas de pénurie de fréquences dans les grandes métropoles, parce qu'il inclut les allotissements des petites villes se trouvant dans un rayon de 90 Km des grands centres et les allotissements 201-220 dont les programmes (information) sont assujettis à des règles différentes de celles applicables aux canaux traditionnels 221-300. Il ne faut donc pas croire que la recherche d'une fréquence compatible est assurée, tout d'un coup, d'un bon résultat.

Le graphique (Fig 3)sur la télévision montre des allotissements encore disponibles mais il s'agit uniquement de la bande UHF; il n'existe plus de canaux VHF dans les grandes métropoles. Il faut aussi se souvenir que dans un passé récent, la bande UHF a été diminuée de 14 canaux (70 à 83) lesquels sont aujourd'hui utilisés pour les fins du service mobile terrestre.

La topographie et la nature des services peuvent aussi conduire à une plus grande utilisation des fréquences tel qu'on peut le remarquer à Vancouver, Edmonton et Halifax. A la périphérie de ces régions, de petites stations de télévision à plusieurs canaux de faible puissance sont utilisées pour distribuer des services de Cancom dans des villages éloignés du centre de ces villes, et où il n'est pas économique de câbler.

Nous constatons donc qu'en radiodiffusion, il existe une certaine pénurie dans les grands centres urbains.

LE SERVICE MOBILE TERRESTRE

Le Ministère est conscient de la grande demande de fréquences pour le service mobile terrestre et, en tant que gestionnaire de cette richesse naturelle, il a établi des mécanismes appropriés de consultation avec les usagers.

L'utilisation des fréquences dans les bandes attribuées au service mobile terrestre se fait sous le couvert d'un nombre impressionnant de documents publiés. Les PS (politiques d'utilisation du spectre) énoncent les contraintes particulières d'une bande de fréquences attribuées alors que les PR (politiques des systèmes radio) visent des types génériques d'équipement de radio pouvant être utilisés au Canada. A ces deux séries de documents, il faut ajouter les PNRH (plan normalisé de réseaux hertziens) où sont exposées les prescriptions techniques relatives aux réseaux de stations radio et les CNR (cahier des charges sur les normes radioélectriques) où se retrouvent les normes minimales d'homologation des émetteurs-récepteurs.

L'espacement normal entre les canaux est le suivant:

a)	27,41 à 50 MHz	: 20 KHz
b)	138 à 174 MHz	: 30 KHz
c)	406,1 à 430 et 450 à 470 MHz	: 25 KHz
d)	806 à 821 et 851 à 866 MHz	: 25 KHz
e)	825 à 845 et 870 à 890 Mhz	: 25 KHz

Les bandes du 30 - 40 MHz et du 40 - 50 MHz (Fig 4 et 5)

Nos données sur ces deux bandes montrent bien leur sous-utilisation relative. A l'exception de Toronto, le nombre de fréquences assignées est de beaucoup inférieur à la quantité de canaux allotis et le nombre de stations mobiles par assignation varie de 1 à 10. Les critères de charge des canaux varient de 30 à 90 stations mobiles par canal dans une zone donnée afin de tenir compte des catégories d'utilisateurs et des types de système radio. Même si en pratique toutes les fréquences ne peuvent pas être assignées, on ne peut certainement pas parler de rareté et encore moins de pénurie. Ce sont des bandes dont le potentiel pourrait être mieux exploité.

La situation du 30 -40 MHz n'étonne pas. Le niveau du bruit radio ambiant est très élevé, les brouillages mutuels causés par la transmission à très grande distance sont fréquents et cycliques, les dimensions des antennes sont beaucoup plus grandes que celles employées dans les bandes supérieures, etc... Le 40 - 50 MHz souffre à un moindre degré des mêmes inconvénients et, en conséquence, nous constatons une plus forte densité du trafic radioélectrique et une faible disponibilité dans les grands centres.

Le 138 - 150.8 MHz (Fig 6)

Il s'agit en fait des bandes 138 - 144 et 148 - 150.8 MHz, le 144 - 148 MHz étant attribué au service amateur. Les systèmes radio sont exploités selon le mode de fonctionnement à une seule fréquence ou à deux fréquences. La figure 138 - 150.8 MHz montre une utilisation plus importante que pour les bandes sur des fréquences inférieures. Le ratio Nombre d'assignations/ Nombre de canaux varie de 1 à 2.8 et le ratio Nombre de mobiles/Nombre d'assignations oscille entre 5 et 15. A Toronto, le nombre de mobiles/canaux allotis est d'environ 25 et, compte tenu des exigences de la coordination dans les zones frontalières, le taux d'occupation de certains canaux doit s'approcher du seuil de saturation. Il est aussi permis de croire que dans la plupart des régions métropolitaines le nombre de mobiles pourrait encore croître sans que les problèmes de partage deviennent intolérables pour les utilisateurs. Cependant d'autres facteurs tels les stations téléappels (dont les téléavertisseurs ne sont pas inscrits dans nos registres), les types d'utilisateurs, le nombre de canaux simples VS duplex nous amènent à penser que nous pourrions avoir atteint le point de saturation dans d'autres centres urbains.

Le 150.8 - 174 MHz (Fig 7)

Depuis le milieu des années cinquante et jusqu'à environ 1975, cette bande a servi de réservoir d'où était tiré les fréquences assignées à la majorité des stations du service mobile au Canada. Les centres-villes comptent un très grand nombre de stations et il n'est généralement pas possible d'assigner toutes les fréquences à cause des problèmes d'intermodulation, de canaux adjacents, etc., et du partage de cette bande avec les Etats-Unis.

Il faut mentionner qu'environ 40000 mobiles se rattachent au district d'Edmonton, qui dépasse Toronto (36000 mobiles) et Montréal (25000 mobiles). L'Alberta Government Telephone et les compagnies pétrolières exploitent d'une façon utile et efficace cette bande de fréquences. Le ratio "nombre de mobiles/canaux allotis" atteint 55, un indicateur positif d'une bonne gestion locale des fréquences. Le nombre de mobiles par cent milles de population est de 1150 à Vancouver, 5100 à Edmonton, 910 à Toronto et 850 à Montréal.

Dans les grands centres, et surtout à Toronto et Montréal, il est presqu'impossible de trouver une fréquence compatible ou partageable.

Le 410 - 414 et le 415 - 419 MHz (Fig 8)

Dans ces bandes, le PNRH 501 énonce les prescriptions techniques applicables. Sauf pour Montréal et Toronto, ces bandes sont relativement peu utilisés et en général on y retrouve les gouvernements provinciaux et municipaux. Il s'agit de services de sécurité et les critères de charge des canaux sont beaucoup moins exigeants. La figure 8 fait ressortir un bon potentiel de croissance dans la plupart des régions.

Le 421 - 425 et le 426 - 430 MHz (Fig 9)

Le PNRH 501 s'applique aussi dans ces bandes attribuées en 1983. Les critères d'exploitation particuliers limitent l'accès du grand public à environ 40 % des fréquences. Quelques fréquences sont réservées pour le téléappel et dans ce cas les appareils mobiles ne sont pas enregistrés. Les données mettent en lumière une sous-utilisation qui n'est donc pas surprenante. Cependant, nos experts confirment une congestion sévère dans quelques grands centres urbains.

Le 450 - 470 MHz (Fig 10)

Au début des années 1970, cette bande a permis d'absorber l'excès de demande dans la bande du 150.8 - 174 MHz. Dans la mesure du possible, le mode d'opération à deux fréquences a été privilégié et le PNRH 501 prescrit les exigences techniques. Le ratio du "nombre de mobiles/nombre d'assignations" prend des valeurs comprises entre 4 et 12; pour les assignations du service auxiliaire de radiodiffusion, ce ratio est encore plus bas. Un trait remarquable de cette bande touche la grande concentration des assignations à l'intérieur des centres-villes par comparaison avec la zone métropolitaine afférente:

	CENTRE-VILLE RAYON 8 km % DES ASSIGNATIONS	ZONE METROPOLITAINE RAYON 90 Km NOMBRE D'ASSIGNATIONS
Toronto	= 21%	2400
London	= 28%	500
Vancouver	= 37%	1550
Montréal	= 40%	1800
Edmonton	= 45%	850
Winnipeg	= 49%	550
Québec	= 50%	450
Ottawa	= 59%	850
Calgary	= 61%	700
Halifax	= 69%	500

Dans le cas des métropoles moins peuplées, ce phénomène indique simplement que dans la périphérie il est encore possible de répondre aux besoins pour des canaux de radiocommunications en assignant des fréquences des bandes traditionnelles (VHF). La position de London au tableau s'explique par la présence des villes de Kitchener/Waterloo et Brantford à l'intérieur du rayon de 90 Km et dont la population est aussi importante que celle de London. Un pourcentage des assignations élevé dans le centre- ville nous apparaît donc comme un indicateur valable d'une disponibilité relative de fréquences (nouvelles ou partagées) pour les stations radio situées dans les zones éloignées.

Dans le cas de Toronto et Montréal l'augmentation du nombre de mobiles demeure possible mais de nouvelles assignations demandent des études complexes dont le succès est problématique.

<u>Le 806 -821 et le 851 -866 MHz (Fig 11)</u>

On retrouve dans ces bandes surtout des systèmes à partage de plusieurs canaux ou à fréquences appariées. Le PNRH 502 énonce les prescriptions techniques,les règles du partage des fréquences le long des frontières canado-américaines ainsi que les critères de charge des canaux. Excepté pour Toronto et, dans une certaine mesure, Montréal le potentiel de ces bandes de fréquences est à peine entamé; le premier plan normalisé n'a été publié qu'en janvier 1983.

Le 825 - 845 et le 870 - 890 MHz (Fig 12, 13, 14 et 15)

Le PNRH 503 est publié en septembre 1985, les premières cellules entrent en opération le premier juillet 1985 et aujourd'hui le nombre de stations mobiles des systèmes cellulaires représentent plus de 50 % de toutes les stations mobiles fonctionnant sur des fréquences supérieures à 30 MHz.

Le cellulaire est une extension du réseau téléphonique canadien et les objectifs de performance du système sont très élevés. Le nombre maximum de mobiles par fréquence assignée à l'intérieur d'une cellule varie entre 20 et 25 et cette valeur peut sembler faible et indiquer que le cellulaire n'utilise pas efficacement le spectre disponible. Au contraire, les mêmes fréquences étant réutilisées systématiquement dans d'autres cellules, le nombre de mobiles par MHz attribué est déjà de beaucoup supérieur aux meilleurs résultats obtenus dans les autres bandes de fréquences; par exemple, ce nombre est 2 fois plus grand à Toronto. La clientèle continuera de grandir et, compte tenu que les bandes de fréquences ne changeront pas, l'efficacité du cellulaire dans l'utilisation du spectre ne peut que s'améliorer.

Dans toutes les zones métropolitaines, les cellules du centre-ville utilisent toutes les fréquences disponibles. Pour les cellules en périphérie le nombre de fréquences utilisées est fonction de l'importance de la population locale, du dynamisme et des types d'activités du secteur industriel et de la distance du centre-ville.

Autres données (Fig 16, 17 et 18)

Les graphiques 16 et 17 illustrent des phénomènes bien montréalais : le taux d'occupation relatif des bandes 150 - 174 MHz (VHF) et 450 - 470 MHz (UHF) sur l'ensemble du territoire du Montréal métropolitain. La somme de toutes les communications à l'heure la plus occupée d'une région de 75 Km par 75 Km donne 100 % . Les graphiques montrent l'occupation relative de chaque parcelle de 5 Km par 5 Km. Il faut noter que pour le VHF, une de ces parcelles, une sur 225, compte pour 20.92 % des communications. Les parcelles du centre-ville, sur le graphique on dirait un obélisque, en accaparent plus de 50 % . C'est une réalité dont il faudra tenir compte dans notre gestion des fréquences.

Les fréquences supérieures à 900 MHz

L'analyse des bandes du service fixe ne peut se faire qu'à l'aide d'outils sophistiqués et le ministère consacre actuellement des ressources importantes afin de surmonter de nombreux problèmes concrets qui compliquent l'illustration de la rareté des fréquences. D'autres personnes viendront vous énumérer et vous décrire les nombreuses difficultés rencontrées et vous présenteront les résultats de leurs travaux.

Fig.1

Radiodiffusion sonore MA
535 - 1605 kHz

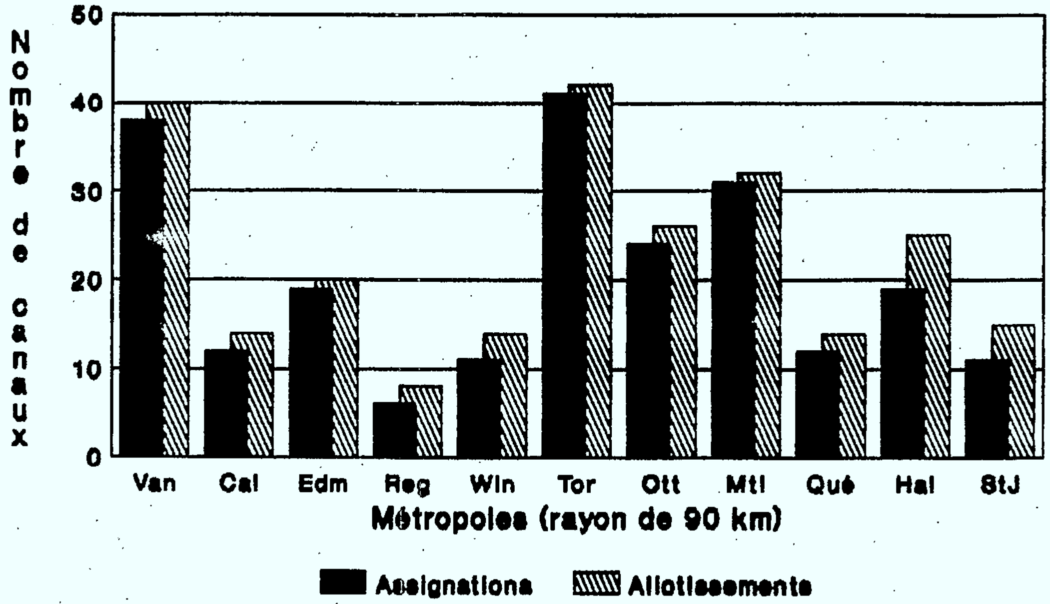


Fig.2

Radiodiffusion sonore MF
88 - 108 MHz

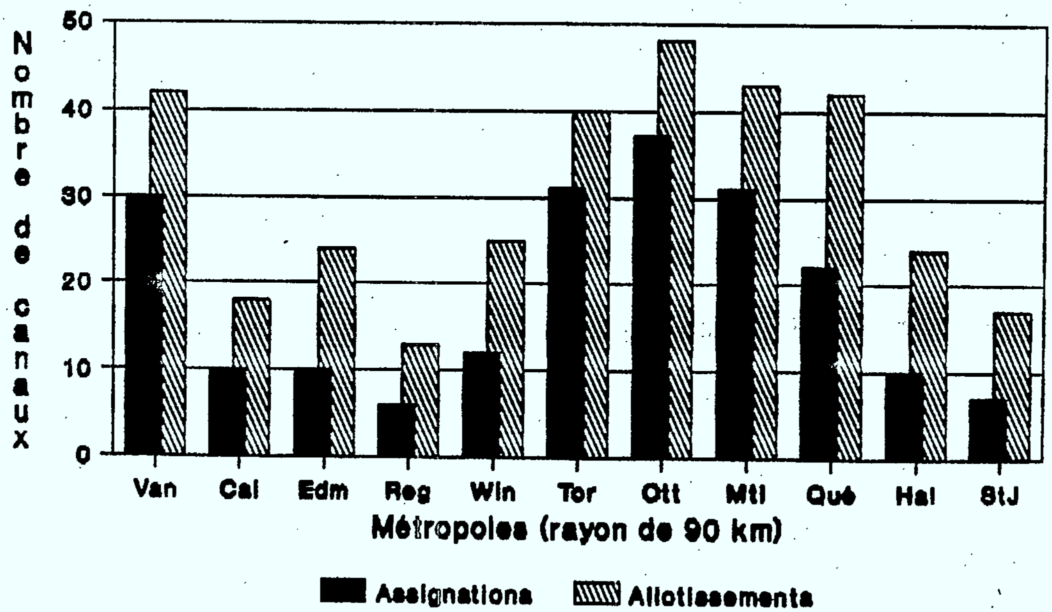
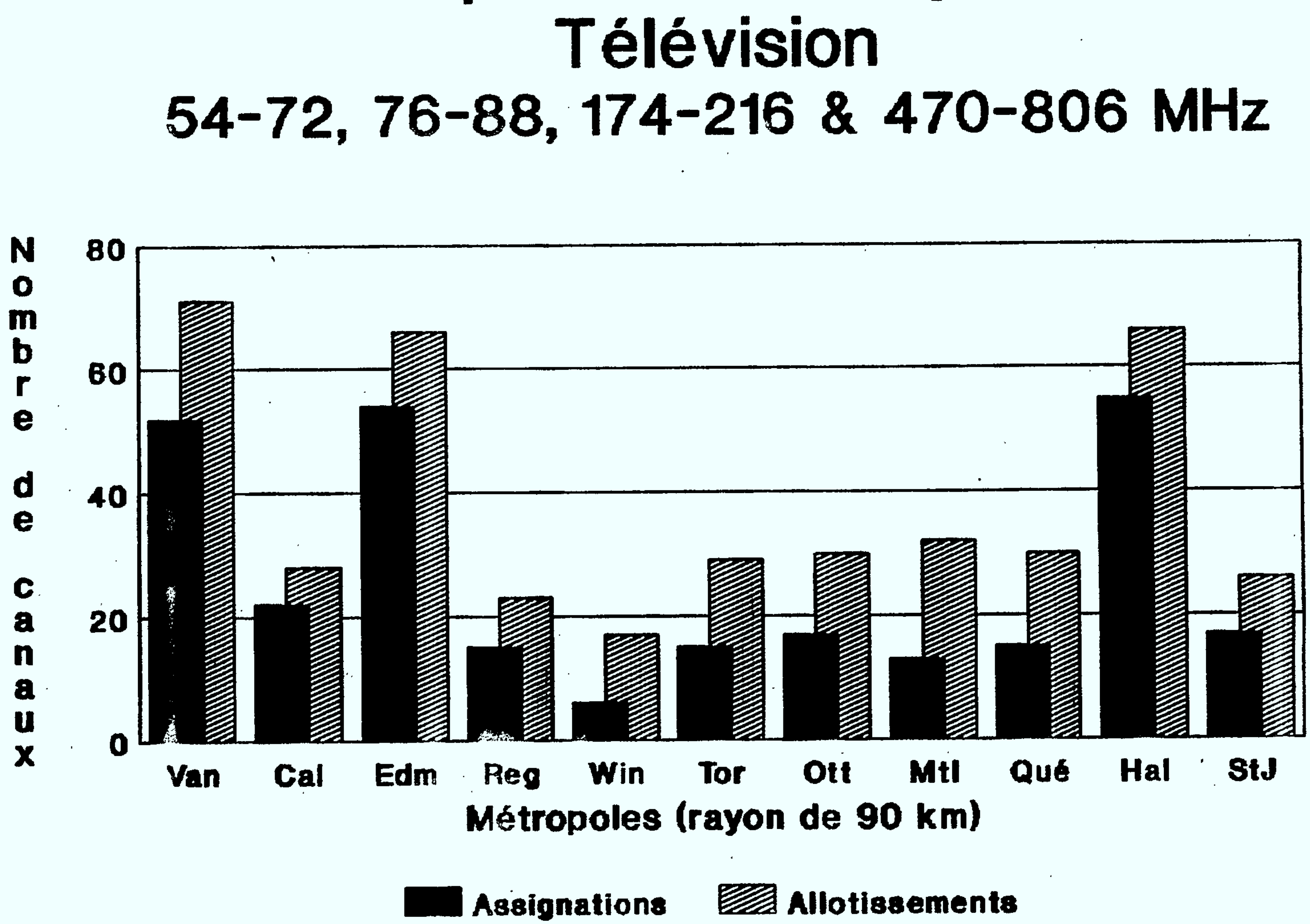
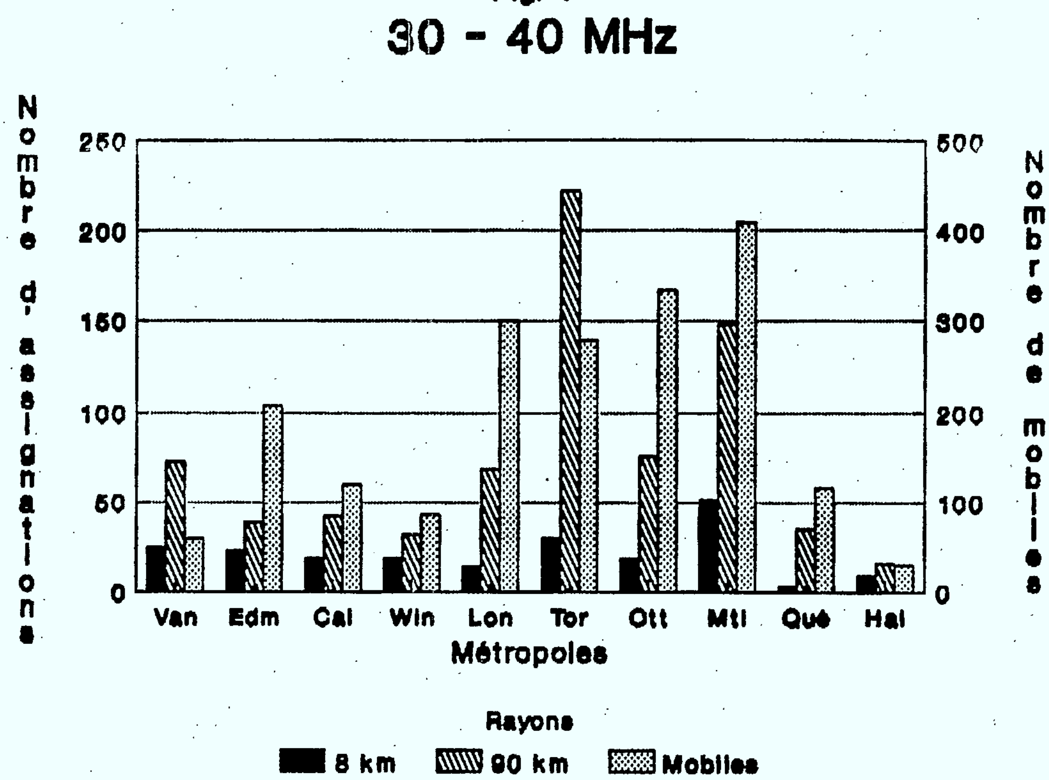


FIG. 3: Occupation du spectre



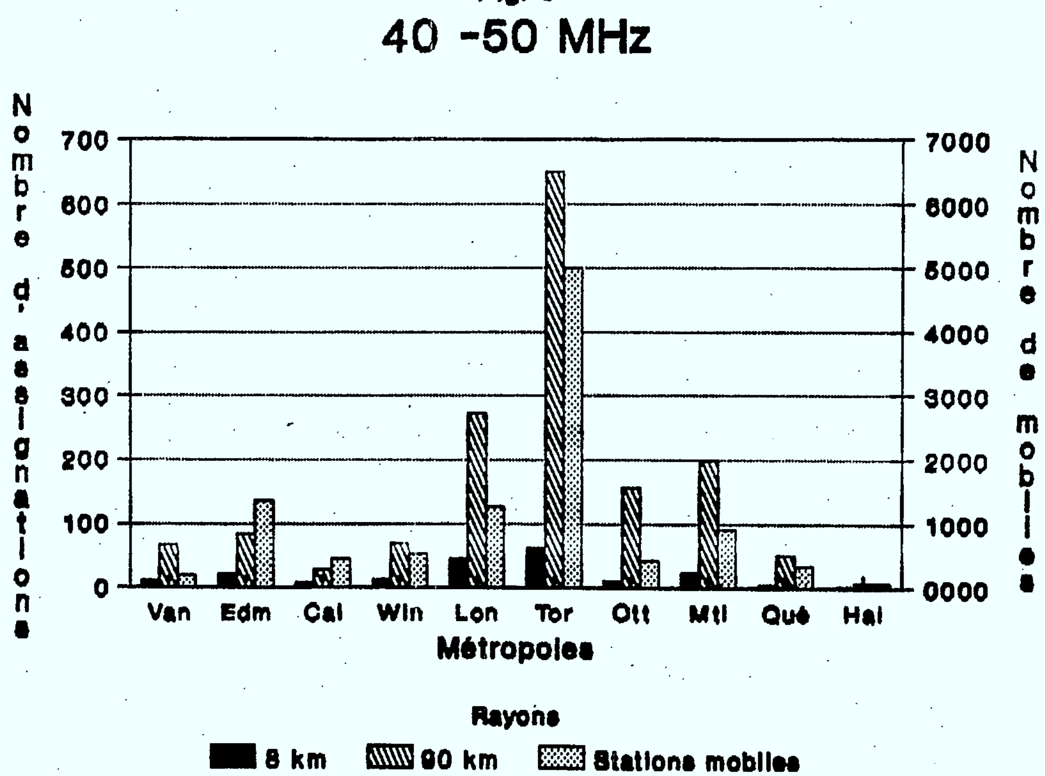
1.6.13

Fig. 4



Allotissement: 500 canaux

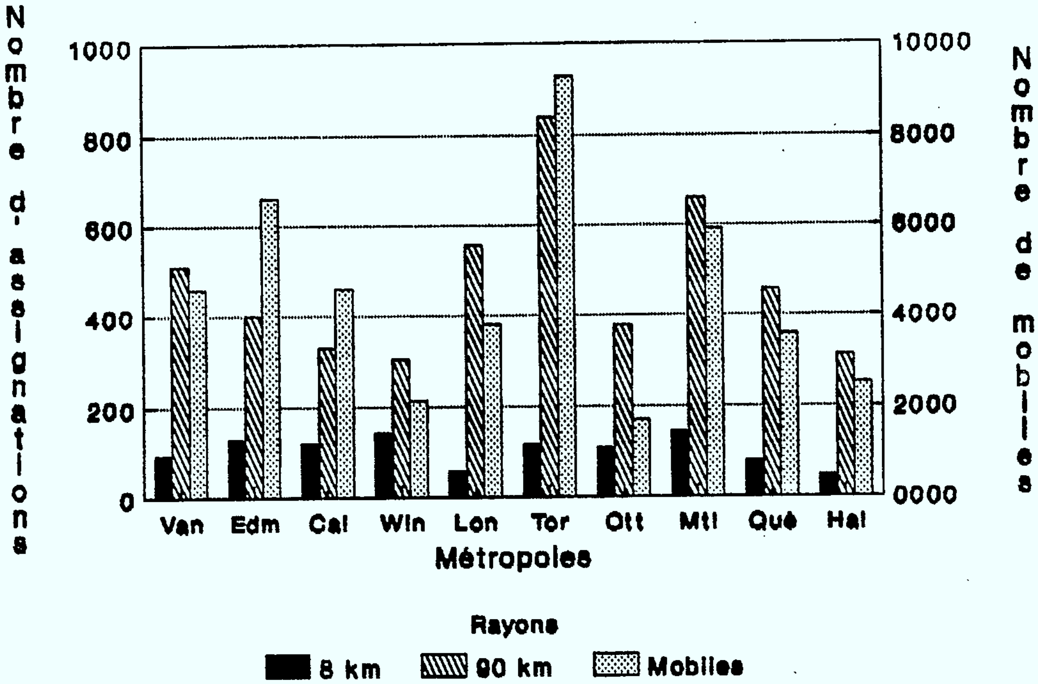
Fig. 5



Allotissement: 500 canaux

Fig. 6

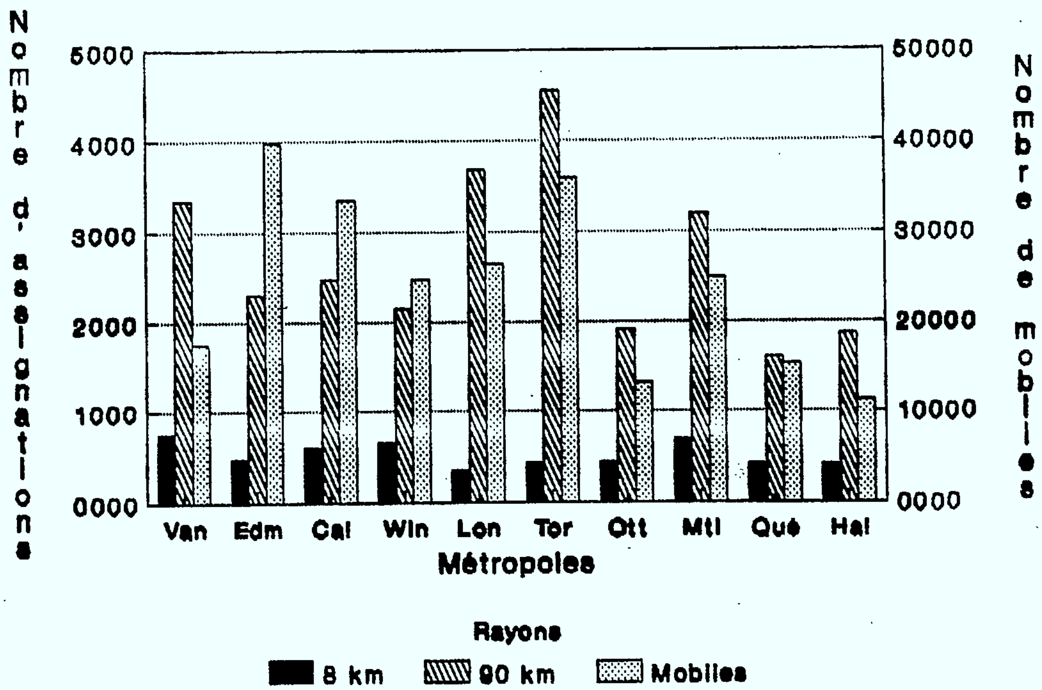
138 - 150.8 MHz



Allotissement: 293 canaux

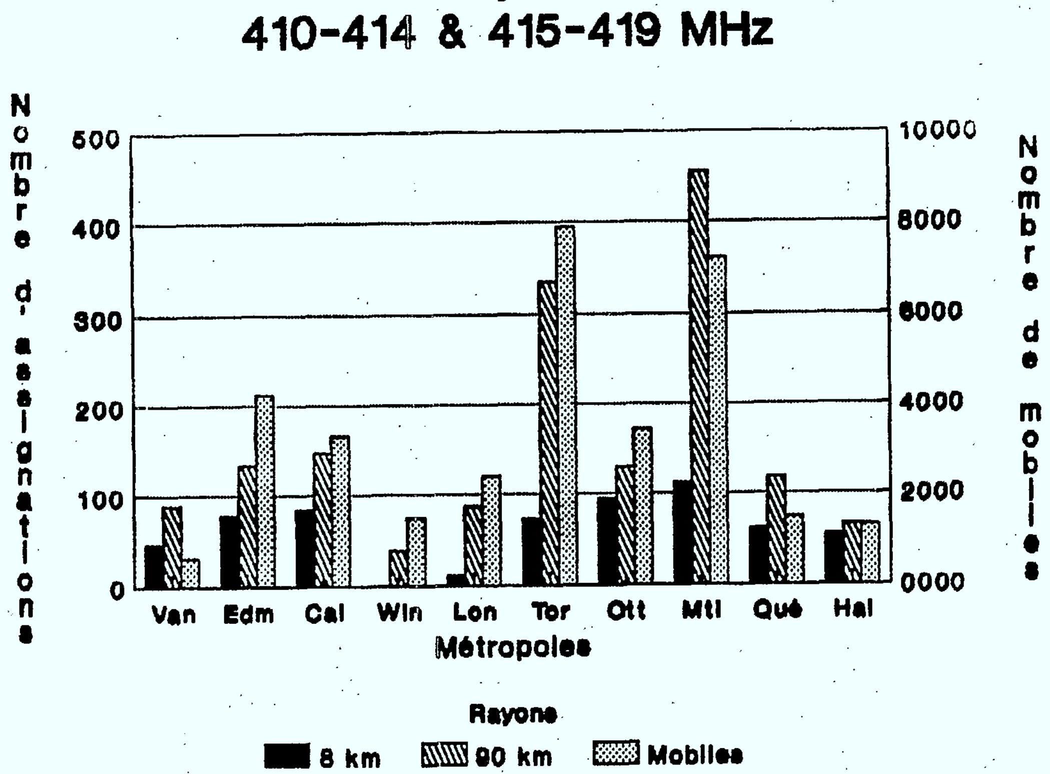
Fig. 7

150.8 - 174 MHz



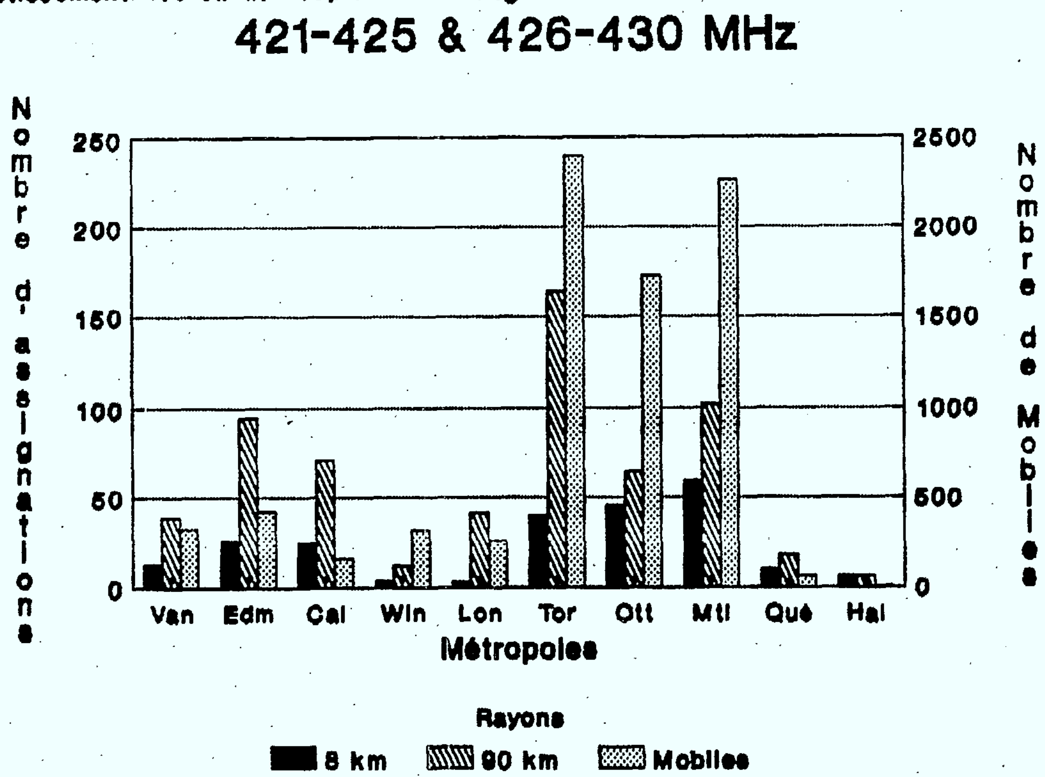
Allotissement: 730 canaux

Fig. 8



Allotissement: 160 canaux duplex

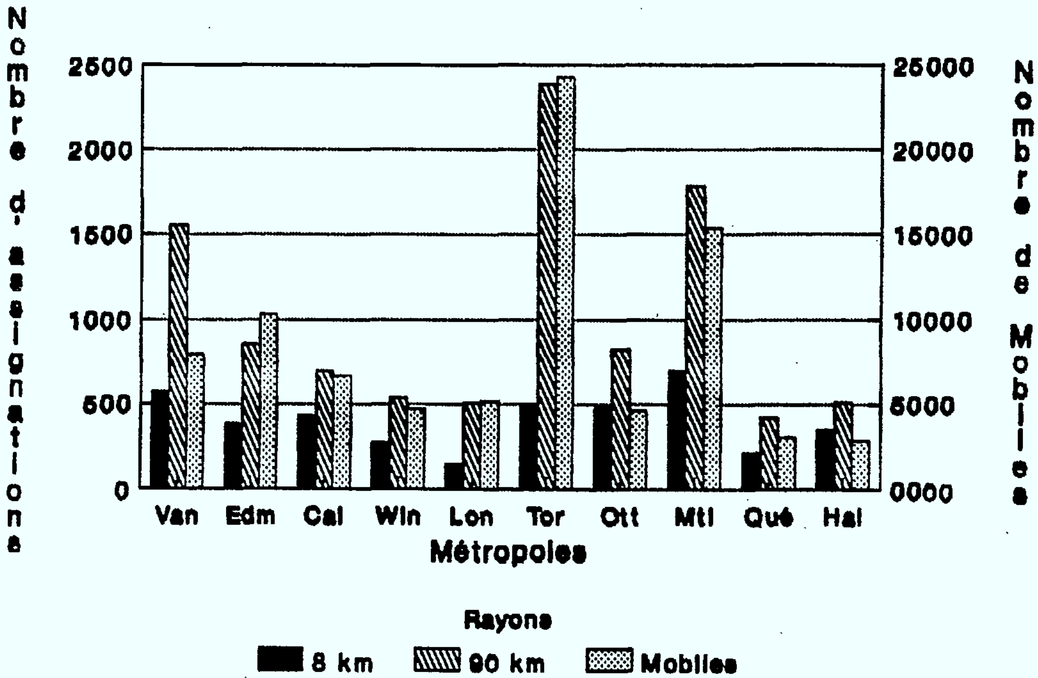
Fig. 9



Allotissement: 160 canaux duplex

Fig. 10

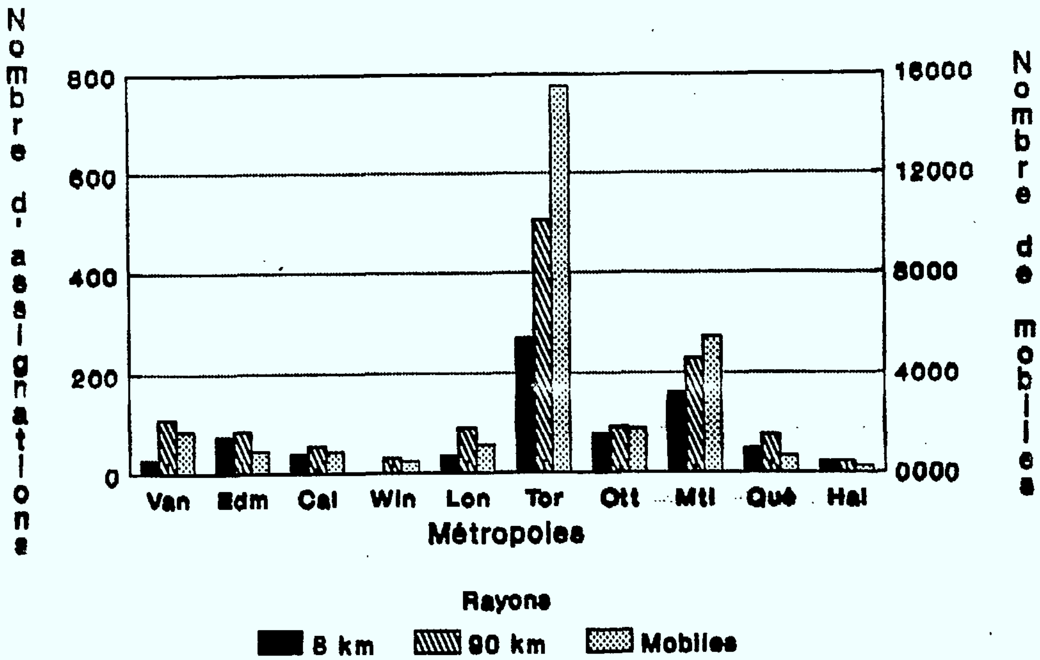
450 - 470 MHz



Allotissement: 241 canaux duplex
------------- 236 canaux simplex

Fig. 11

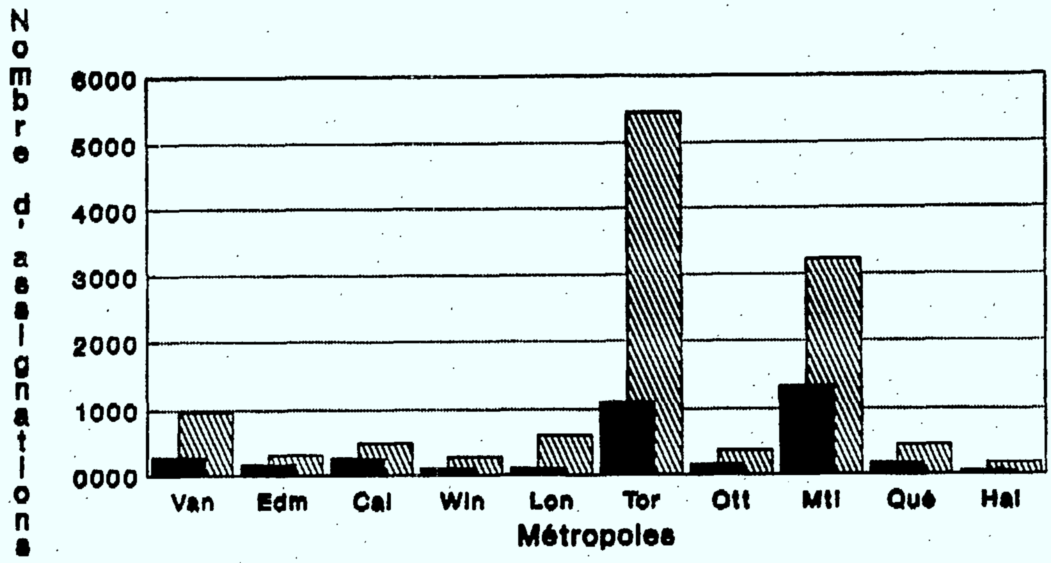
Systèmes à partage de plusieurs canaux 806 - 821 & 851 - 866 MHz



Allotissement: 600 canaux

Fig. 12

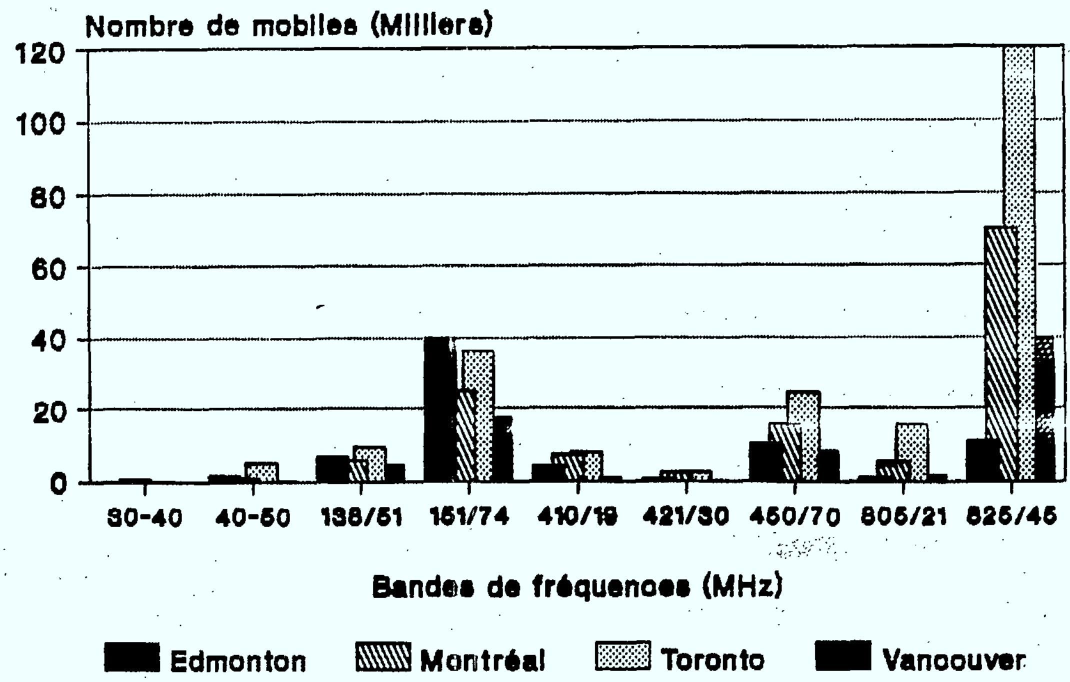
Cellulaire
825 - 845 & 870 - 890 MHz



Allotissement: 666 canaux

Fig. 13

Cellulaire Vs autres bandes mobiles



1.6.19

Fig. 14

Nombre de mobiles / MHz

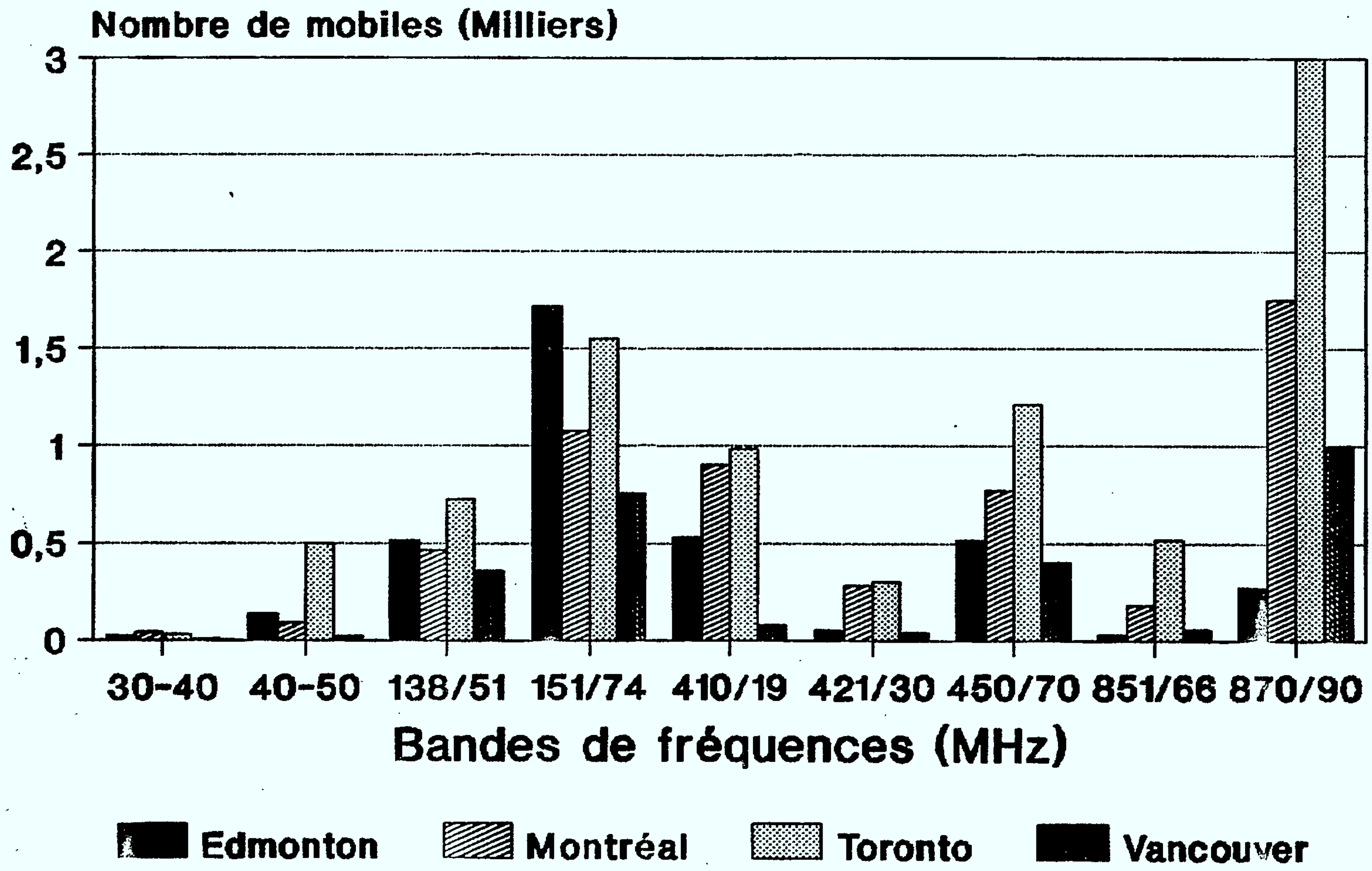


FIG. 15:

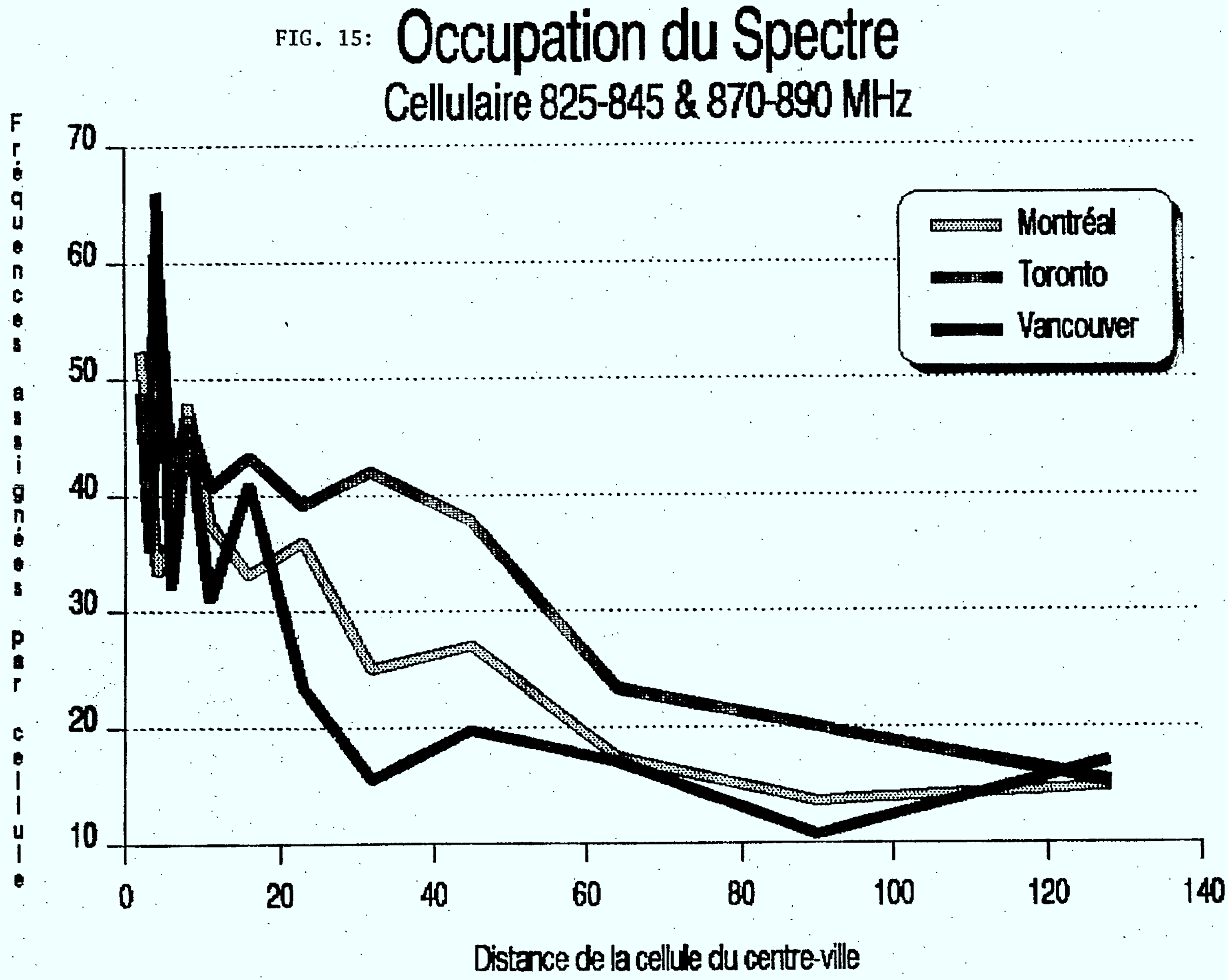
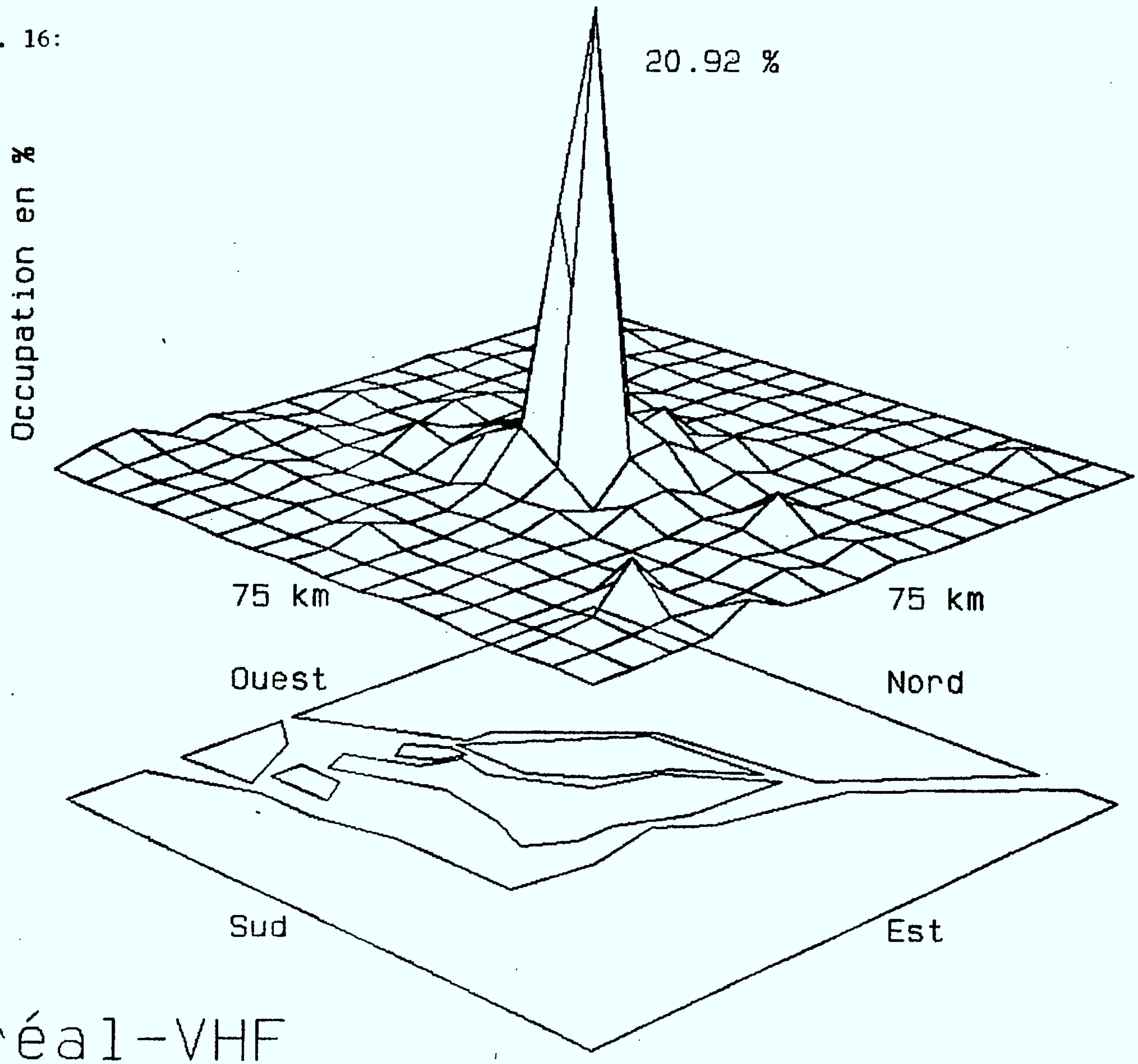
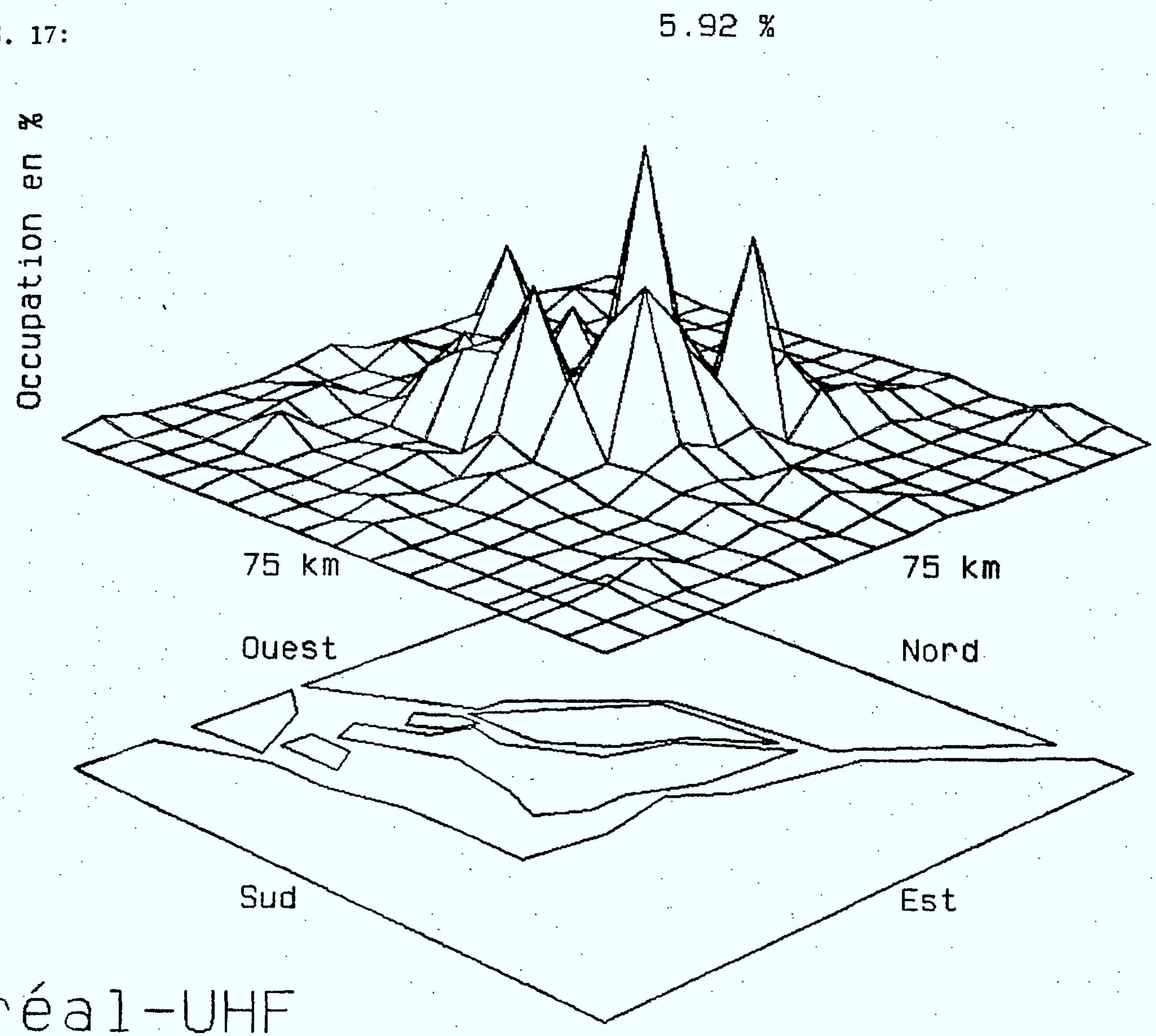

Occupation du Spectre
Cellulaire 825-845 & 870-890 MHz
Fréquences assignées par cellule
Distance de la cellule du centre-ville
Montréal
Toronto
Vancouver
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140

FIG. 16:



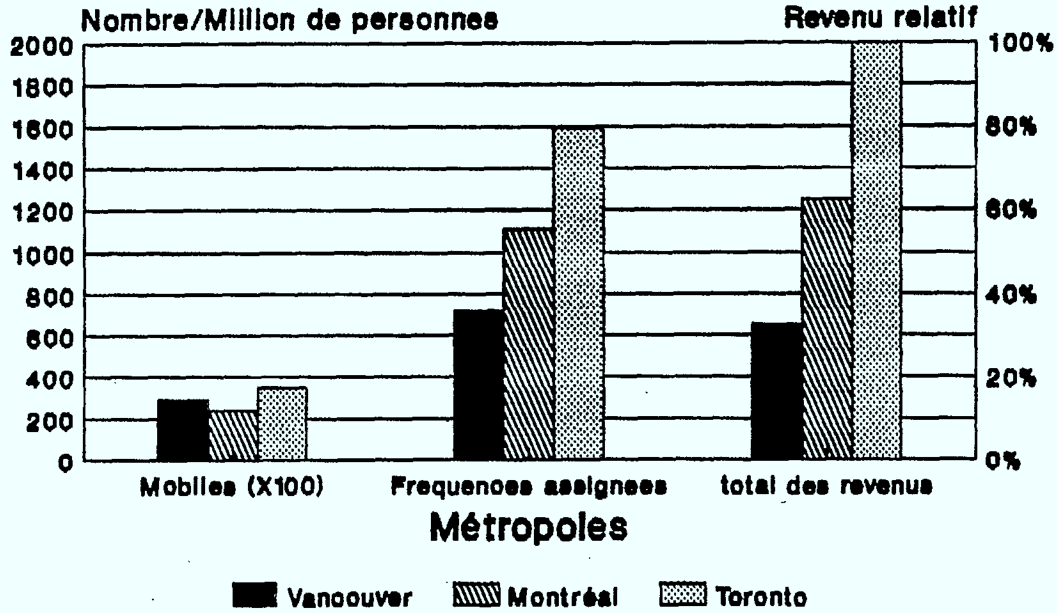
Montréal-VHF

FIG. 17:



Montréal-UHF

FIG. 18
Cellulaire
825 - 845 & 870 - 890 MHz



Source: Statistiques Canada

SESSION 2

INTERNATIONAL PERSPECTIVES

SÉANCE 2

LES PERSPECTIVES INTERNATIONALE

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ABSTRACT

Spectrum Management in the United Kingdom

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Ten years ago the UK regulatory authority was being criticised for taking decisions behind closed doors with minimal consultation and very little information flow. Today the Radiocommunications Division of the Department of Trade and Industry consults widely and publishes information; it pursues a policy of deregulation; and it delegates frequency planning tasks where possible. It has been responsive to demand and in several cases has even triggered the development of new services by taking the initiative in releasing spectrum, particularly in the mobile radio field.

In preparing for the future, a series of comprehensive reviews of spectrum usage and demand is being undertaken, the first of these covering 470 - 3400 MHz having been completed and the next, covering up to 30 GHz is underway. On the wider policy front the question of introducing market forces into spectrum management ("spectrum pricing") has been debated at length and a number of alternative approaches evaluated.

Advanced technologies and applications will present unprecedented challenges for the spectrum manager but at the same time may help to overcome some of the problems of spectrum congestion. New approaches to national spectrum management will develop in parallel with an important ITU frequency allocation conference in 1992 and a separate comprehensive review of the definitions of radio services, inevitably involving the structure of the international frequency allocation table. The future looks exciting.

Résumé

La gestion du spectre au Royaume-Uni

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Il y a dix ans, on critiquait les organes de règlementation du Royaume-Uni en les accusant de se réfugier derrière des portes closes pour prendre leurs décisions et de n'avoir que des consultations minimales et des échanges de renseignements très restreints. De nos jours, la division des radiocommunications du Département du commerce et de l'industrie procède à de multiples consultations et publie l'information qu'elle possède, elle poursuit une politique de dérèglementation et elle délègue, lorsque c'est possible, la planification des fréquences. Elle est à l'écoute des demandes et elle a même, à plusieurs reprises, été à l'origine de la mise sur pied de nouveaux services en prenant l'initiative de libérer des fréquences, notamment dans le domaine des radiocommunications mobiles.

En prévision de l'avenir, une série d'examens complets de l'utilisation du spectre et de la demande de fréquences est en voie d'être entreprise. Le premier de ces examens, portant sur la bande 470 - 3 400 MHz, vient d'être fait et le suivant, qui aura trait à la bande des 30 GHz, est en cours. Sur le plan plus général des politiques, on a débattu de long en large la question du libre exercice du jeu de la concurrence dans le secteur de la gestion du spectre ("mercantilisation du spectre") et plusieurs solutions de rechange ont été examinées.

Des technologies et applications évoluées vont poser au gestionnaire du spectre des défis sans précédent mais, en revanche, elles vont peut-être contribuer à la solution de quelques-uns des problèmes d'encombrement du spectre. On va trouver de nouvelles façons d'aborder la gestion nationale des fréquences pendant que l'UIT va tenir une importante conférence sur l'attribution des fréquences en 1992 et procéder à un examen distinct de la structure globale du tableau international d'attribution des bandes de fréquences. L'avenir est prometteur.

Introduction

So much is happening in the field of spectrum management in the United Kingdom and indeed worldwide that it is difficult to know where to start and where to stop. This paper describes the formal spectrum management regime and role of the Radiocommunications Division of the Department of Trade and Industry. It focusses in particular on the work being carried in a series of spectrum reviews, the first of which is very closely related to the planned 1992 World Administrative Radio Conference. Some particular examples are given of recent frequency allocation changes and possibilities for the future. The paper also includes a brief discussion of delegation and deregulation of the frequency management task.

The formal structure of spectrum management in the UK

Within the United Kingdom, the broad sub-division of the spectrum is the responsibility of an interdepartmental committee. The Department of Trade and Industry, represented by the Radiocommunications Division, is a major participant and represents nearly all civil non-government users of the spectrum. Other players include the Ministry of Defence, the Department of Transport and the Home Office (with both broadcasting interests and the police and fire services). At the international level the Department of Trade and Industry acts as the UK administration in the ITU and generally speaks on all radio regulatory matters representing all national users at ITU conferences, meetings of the CEPT (European Conference of Posts and Telecommunications Administrations) etc. Thus although formally limited at the national level to the management of the spectrum for most civil applications, the DTI has a very broad interest in all spectrum usage.

The Radiocommunications Division is also the public mouthpiece of the government on spectrum matters. Some years ago it was criticised as being bureaucratic, authoritative and secretive. However following an independent review of spectrum management in the UK in the early 1980s (the 'Merriman Review'), a significant change in management style and a transfer from the Home Office to the Department of Trade and Industry, much has changed. The thrust of the Merriman Review's recommendations was to make the division more forward-looking, that is to plan for the future rather than being reactive to demand, to consult more widely and to inform. Early action was taken to publish the National Frequency Allocation Table and the division now produces Annual Reports on its activities and which highlight future opportunities and developments. The Merriman Report also proposed the introduction of Spectrum Reviews (of which more later).

In pursuing the theme of openness and consultation in the field of spectrum management, the Division regularly gives presentations to industry and users on its plans, it organises regular consultative committees on specific topics (fixed links, land mobile and more recently broadcasting and CEPT activities) and it provides stands at trade exhibitions etc. Information is readily available in user-friendly form on most licensing and policy issues.

Europe

A major feature of the current spectrum management policy in the UK is the quest for finding solutions wherever possible on a European-wide basis. Not only is this highly desirable technically in view of the relatively small geographical distances between countries but it creates large potential markets for equipment suppliers benefitting both them and the users. Several major developments in the mobile radio field have resulted in common frequency allocations in Europe which have become or are becoming the subject of European Community Directives. These cover digital cellular radio (GSM), digital cordless telephones (DECT) and pan-European paging (ERMES). Less well-publicised agreements cover much wider issues and all new major spectrum management decisions in the UK are taken with a view to European harmonization wherever possible.

Spectrum Reviews

As mentioned above, the Merriman report recommended that regular reviews be undertaken of defence and civil spectrum usage. The concept was 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 whole spectrum had been covered, whereupon the process would begin again.

The first review undertaken covered the range 470 - 3400 MHz. This was seen as a part of the spectrum where many new developments were likely to take place over the next few years. The development of new mobile services around 2 GHz and the scope of the 1992 World Administrative Radio Conference demonstrate the value of selecting this range for the first stage of the review process.

In accordance with the Merriman recommendations, a separate review of the defence spectrum was undertaken by an independent committee, which was served by the Radiocommunications Division of DTI and the Ministry of Defence. The committee report was published in June 1988 and its recommendations accepted by the Government. In brief the review concluded that the balance of civil and defence allocations was about right (in this particular frequency range defence communications account for a relatively small part of the spectrum) but that there was more scope for civil and military sharing of spectrum particularly in two specified frequency bands.

The Civil Spectrum Review was conducted by the Radiocommunications Division. The committee's membership was drawn from within the Division with a Ministry of Defence observer. Extensive consultation took place with outside organizations, users, operators, manufacturers etc following a formal call for evidence. Once the basic information-gathering exercise had been completed and provisional conclusions drawn, a public seminar was held to present these findings and to solicit further comments before the final report was prepared. It was published in April 1989.

The aim of the review was to draw up a comprehensive picture of current spectrum usage, backed in some cases by monitoring rather than relying simply on recorded usage. This alone proved to be a very valuable exercise in informing industry, in providing a basis for decision-making within the Division and for highlighting areas in which the Division's records were incomplete, inconsistent or even inaccurate. In addition the review sought to identify and quantify new requirements for spectrum and also for spectrum growth for existing services over the next 10-15 years. This 'shopping list' of requirements will 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. This task had necessarily been carried out in the past in preparation for major ITU allocation conferences but had not been conducted on a systematic basis at other times.

The review had no authority to make decisions on spectrum allocation changes but its recommendations will provide a set of powerful signals as to the way forward and in particular will have a major impact on the development of UK policy on spectrum allocation issues for the 1992 WARC. Key recommendations of the first stage of the Civil Spectrum Review covering the range 470 - 3400 MHz include:

a) The need for frequency planning to maintain a long-term perspective and the introduction of a mechanism for a more structured approach to be taken to evaluating new requirements and reaching allocation decisions.

b) High priority to be given to those services which cannot reasonably be located in higher frequency bands, with mobile users of all types warranting such priority.

c) The results of the review to form a basis for the UK's preparation for the 1992 WARC.

d) Improvements required in the recording of frequency assignments within the Division.

e) Consideration to be given to a review of telecommunication requirements of the emergency services (that is police and fire).

f) The need to draw up a long-term strategy for the band 1.7 - 2.3 GHz as far as possible on a European basis but preferably world-wide.

g) An urgent need to review the spectrum requirements for broadcasting ancillary services.

h) The need to commission technical evaluations of the merits of increased sharing between different services.

i) The need to set firm dates for the removal of certain applications from the range of spectrum under consideration.

The review also recommended that the next stage should concentrate on the frequency range 3.4 - 30 GHz and that a combined review should be undertaken covering all users of the spectrum both civil and defence. At the time of writing the formal announcement of the next stage of the review process has yet to be made but internally work has already started in gathering the information necessary as the basis for this review.

Major Frequency Allocation Developments

Some examples of specific frequency allocation developments in the UK may be of interest. They show the rapidly changing scene driven by the never-ending growth in the demand for spectrum for existing or new services (particularly in the land mobile area) which in turn is encouraged by user awareness, a strong competition policy and general liberalisation of the telecommunications market.

Mobile Radio

a) The development of national and regional trunked private mobile radio systems at VHF in spectrum previously used for television broadcasting.

The UK now relies entirely on UHF for terrestrial television broadcasting (having vacated the two VHF bands) and has had to cope with unique problems of sharing mobile radio with television in neighboring countries.

b) The extension of cellular radio services at 900 MHz by sharing spectrum previously reserved exclusively for defence use.

The pre-emptive sharing arrangements is of tremendous value to the cellular radio operators and yet retains access to the spectrum for defence purposes as necessary. Further exploitation of defence allocations by civil users on a shared basis is a high priority for the future (and already many private mobile radio allocations, particularly at UHF, are shared on a geographical basis with defence allocations).

c) The UK government announcement early in 1989 of its intention to introduce public mobile radio systems (personal communications networks) in the 2 GHz band.

Applications have been received from 8 potential operators of which 2 or 3 are likely to be licensed. Attention is being focussed on the band 1700 - 1900 MHz and the first systems are expected to be operational around 1992. Furthermore, frequencies have been designated in Europe for a new generation of cordless telephones operating in the band 1880 - 1900 MHz and consideration is being given to an allocation in the longer term of spectrum in the range 1900 - 2300 MHz for future land mobile systems.

Broadcasting

a) The release of spectrum in UHF television channels 35 and 37 by the aeronautical radionavigation service in the early '90s providing the opportunity for a 5th television service serving up to 70% of the population.

The present 4 television channels each provide close to 100% coverage using a total of 11 channels per network.

b) An announcement made earlier this year that frequencies near 40 GHz would be made available for multipoint video distribution systems (MVDS or MDS).

Further consideration will be given to the possible use of the 12 GHz satellite broadcasting band.

Millimetric Bands

A public consultation issued in 1988 outlining the potential for exploiting spectrum above 30 GHz with a view to stimulating interest from users and manufacturers and to assist in developing the Division's policy in this area.

In addition to the announcement on MVDS mentioned above, the use of the 38 GHz band has already been identified for providing the fixed links required in the infrastructure of the new personal communication networks which, for mobile radio, will operate near 2 GHz.

Delegation and Deregulation

At the level of frequency assignment, as opposed to allocation, the Division has adopted a policy of delegating the task outside government whenever practicable to do so. The main public telephone operators (common carriers) have traditionally maintained authority for frequency planning within their own fixed link allocations. This has been extended to the cellular radio operators and also to certain responsible user groups such as the fuel and power industries (for the mobile radio services of the gas and electricity supply industries) and to the broadcasters (for broadcast ancillary services in certain bands, that is for radio microphones, transportable video links etc). Apart from reducing the pressure on government resources, there has been a major advantage in spectrum management terms. The user groups are made more aware of the pressures on their 'block of spectrum' and appreciate the need for spectrum efficiency. In the case of the fuel and power industries for example this has led to a realisation fo the benefits of switching to data communications in place of voice and the sponsorship of trials of techniques offering greater spectrum efficiency such as single side band modulation. Previously it had been very difficult for the Division to persuade users or manufacturers of the potential benefits of such developments.

An alternative approach to delegating the frequency management task is to provide the intelligence in the radio system to enable the equipment to select channels in real time. Such techniques are being used in the 900 MHz cordless telephone system (CT2) and will be a feature of the 900 MHz digital short range radio system, specification for which was developed by the British mobile radio industry with little government intervention. There is much to be learned in this area from the application of military radio techniques to the civil sector and the potential benefits are very significant.

A further way of reducing the administrative frequency assignment and licensing burden is simply to exempt certain services from the need for licenses. Many applications including low power devices and domestic cordless telephones have been treated in this way.

More radical proposals have been discussed for the deregulation of the spectrum management process, delegating frequency assignment and allocation decisions to the private sector and for introducing market forces as a more efficient (in economic terms) means of taking spectrum management decisions.

The Future

Given the rapid pace of development in relatively recent history it is extremely difficult to predict accurately what the future will hold for spectrum managers. Undoubtedly there will be new applications for the use of spectrum which are difficult to imagine now. There will be an inevitable increase in demand for nearly all services, especially those concerned with mobile applications, business use, computing and entertainment. At the National level, it will be impossible to cope with the demand without resorting to additional spectrum sharing. New technological developments will have to be relied upon to make sharing more feasible and to cope with the otherwise intolerable administrative burden of licensing and regulating spectrum usage.

At the International level some means must be found for maintaining the essential international harmonization whilst enabling services to continue to develop at a faster and faster rate. Perhaps the role of the ITU will develop into one of providing the forum for developing a broad framework which will allow sufficient flexibility in allocations and timescales for exploitation at the regional or even national level. 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 geographical 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 compartmentalised approach of the current Article 8.

Whatever the developments in store for the next 5, 10 or 15 years there is no doubt that spectrum management will be a growth business and one which will assume a higher profile as the true value of the spectrum becomes more greatly appreciated not only by those involved in its management but particularly a much wider political and commercial audience.

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"CHALLENGE 21"

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"ABSTRACT"

Sweeping changes occurred in almost all telecommunications with the advent of microelectronics. Silicon chips enabled us to reduce costs, weights and power demands. We now fit sophisticated, complex "machinery" into vehicle, space and desk top applications never before contemplated. This, in turn, has induced a demand for more such devices in a broadening array of applications.

Meanwhile, globalization of traditionally national and regional activities, and an unparalleled fluidity of people, things and information, has also developed. Satellite communications, cellular mobile systems, widespread application of digital technology, and other advances have supported this. The result, as the year 2000 nears, is an emerging global economy, ever more dependent on leading-edge telecommunications as a way of conducting business. This is Challenge 21.

From the spectrum manager's perspective, increasing demands for greater information handling capacities, extended and expanded coverage in a more fluid environment, and more personalization of telecommunications lie before us.

To meet these challenges we foresee: a thorough review of spectrum management processes, both domestically and internationally; full participation in the ITU review of its structure and radio regulatory process; comprehensive preparation for the ITU radio conferences scheduled for 1992 and 1993; exploration of propagation phenomena and high capacity information handling at the higher frequencies; improved models for evaluating spectrum use; greater compatibility of data bases; and improved, more responsive, international coordination.

Most importantly, only by examining each of these programs in a global light can we be sure that Challenge 21 will be met.

Résumé

"Défi 21"
Présenté par
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L'avènement de la microélectronique a provoqué des changements radicaux dans la plupart des secteurs des télécommunications. Les puces de silicium nous ont permis de réduire les coûts, le poids des appareils et la demande d'énergie. Nous pouvons dorénavant munir les véhicules, les engins spatiaux et le matériel de bureau de "machines" complexes et sophistiquées dont nous n'avions jamais rêvé auparavant. Ces perfectionnements ont à leur tour entraîné une augmentation de la demande de tels dispositifs dans une gamme croissante d'applications.

Pendant ce temps, la "globalisation" des activités nationales et régionales traditionnelles et une fluidité sans pareille des individus, des choses et de l'information s'est également développée. Les communications par satellite, les systèmes mobiles cellulaires, l'application généralisée de la technologie numérique et d'autres progrès y ont contribué. Le résultat de tout cela, à l'aube du XXIe siècle, c'est une nouvelle économie mondiale, qui dépendra toujours plus de moyens de télécommunications ultramodernes pour la conduite des affaires. C'est ce qu'on a appelé le "défi 21".

Du point de vue du gestionnaire du spectre, nous devrons faire face à une croissance de la demande de moyens de traitement de l'information, nous connaîtrons une couverture accrue et plus étendue dans un milieu plus fluide et une plus grande personnalisation des télécommunications.

Afin de relever ces défis, nous prévoyons une révision complète des procédés de gestion du spectre aussi bien au pays que sur le plan international; la participation pleine et entière à la révision que l'UIT va faire de sa structure et de son processus de règlementation de la radio; des préparatifs élaborés en vue des conférences que l'UIT organisera sur les radiocommunications en 1992 et en 1993; l'exploration des phénomènes de propagation et une grande puissance de traitement de l'information dans les bandes de fréquences supérieures; des modèles améliorés d'évaluation de l'utilisation du spectre; une plus grande compatibilité des bases de données; et une coordination internationale améliorée qui répond mieux aux besoins.

Il importe toutefois de noter que seul un examen global de ces programmes nous permettra de relever le "Défi 21".

As a result of the complex interaction of these various factors, imagine a world scenario in 2000 characterized by:

- o Globalization of many operations or enterprises historically considered as being national or regional in nature -- business ownership, teaming arrangements, partnerships, etc.

- o A degree of international cooperation never before experienced in the areas of:

  - Commerce (open borders, lowering of trade barriers);

  - Banking (streamlining of international monetary transactions, global "smart" credit cards);

  - Public Safety (international police cooperative initiatives, worldwide search and rescue);

  - Environmental and Resource Conservation (endangered species and habitat agreements, oil spill prevention and cleanup, fishing quotas);

  - Scientific Research, Development and Exploration (Manned Space Station, Polar exploration);

  - Transportation and Travel (French-U.K. "Chunnel");

  - Education and Entertainment (instantaneous, emphasizing space techniques); and

  - Health (food distribution, epidemic control).

- o A previously unparalleled fluidity of people, things and <u>information.</u>

To support this scenario the world will see the greatest international exchange of information ever experienced. Information, in the form of sounds (words, music, tones), values (numbers, bits), and images (pictures, icons) will be exchanged in quantities, and at speeds, barely conceivable as little as 20 years ago.

INTRODUCTION

Who, among those that started their careers learning vacuum tube theory, could have predicted the wonders we've seen in the 37 years since the invention of the transistor?

Even more sweeping changes have occurred since the advent of microelectronics. With them, reduced costs, weight, size and power demands have progressed to a point where we now routinely fit sophisticated, complex "machinery" into vehicle, space, desk top and pocket applications never before contemplated.

Perhaps more amazing is that the coming decade may, quite easily, equal the advances seen in telecommunications since the introduction of solid state devices nearly four decades ago. Very large scale, and very high speed, integrated circuitry; the accompanying trend to digital technology supported by robust automated control systems; advanced modulation techniques; all are presenting - at once - the means to meet the telecommunications challenges of the 21st century: Challenge 21.

In the forefront of this challenge is an increasing demand for spectrum driven by new service offerings on existing frequencies, new technology that allows exploitation of relatively unused portions of the resource, and globalization trends that complicate the spectrum management process.

THE WORLD IN 2000

The telecommunications challenge spectrum managers might expect to face at the start of the 21st century may best be understood by projecting the world in which we will be living in the year 2000.

We are entering an extremely dynamic era, rife with major social and political changes. What has been, and is, the driving force behind these sweeping changes? Historically, politics, economics, and technology have been the dominant influences in the course of international events. Politics, predominant leading into, during, and since WWII is rapidly being overtaken by economic considerations as the driver of international energies. Technology has provided the implementing instrument. Each day the news alerts us to dynamic economic forces and the status of resources, inflation, business, trade, or - in the larger sense - the current economics of the world.

TELECOMMUNICATIONS FOR CHALLENGE 21

Communications, in the generic sense, will be the servant of this flood of information. Communications will be what makes it happen, and communications will assume many forms. Some of these forms are already familiar to us; others will be new. New or old, our major adjustment will be to focus on the challenges presented by the:

- o volume of communications to be handled,
- o increased quality standards required by users,
- o quantity and variety of equipments and systems,
- o scope and pervasiveness of systems, and
- o demand pressures of the users.

The systems devised and developed to meet these challenges will most likely fall into one or more of the following categories: high capacity, volume trunk systems; dedicated networks; open networks (private and public); specialized, single-purpose systems; multi-point distribution systems; and multiple access systems.

The paths over which these systems and networks travel will consist of both radio and non-radio media. But, their characteristics and features will undoubtedly change dramatically as we head towards the next decade.

This is one snapshot of a worldwide communications environment which might evolve to support a global scenario in the year 2000.

SPECTRUM MANAGEMENT PERSPECTIVE ON CHALLENGE 21

The Task

In the telecommunications environment of the future both radio and non-radio telecommunications will continue to play their traditional roles. Non-radiocommunications will expand greatly in coverage and capacity, and improve in quality. This will be achieved, largely, through the increased use of fiber optic cables.

Radiocommunications, too, will undergo significant changes. We will see greater integration of radio and non-radiocommunications; large increases in the information handling capacities of various radio systems; extension, or expanded coverage, on a global basis; a more fluid, mobile environment; and a personalization of many telecommunication services.

Vital considerations must then become the guiding factors of spectrum managers as they evaluate, improve and apply their management tools to the task of solving 21st century problems. Translated into applicable spectrum management terms:

- greater integration means more radio/non-radio interfaces, with the attendant problem of accommodating appropriate bandwidth and emission requirements, and for providing additional frequencies;

- larger information handling capacities equates to greater bandwidth requirements, and probably higher powered emissions;

- extension or expansion of radiocommunications on a worldwide basis implies a much greater degree of international frequency planning, negotiation, coordination, and agreement;

- more fluid, mobile operations tells the spectrum manager that an ever increasing number of user systems will require wide area assignments, and be less amenable to precise site engineering; and

- personalization of communications conveys the implications of organizing to respond to a broader, less technical but probably more vociferous user community.

The Tools

A review of some of the tools traditionally used by the spectrum manager to do his job is appropriate. What are they and how effective will they be in meeting Challenge 21 in light of the factors just discussed?

- Whatever the current status, planning will become crucial to spectrum management as we move towards the new century. Our planning efforts must anticipate an unprecedented demand for spectrum and provide for:

    - early recognition of new services and identification of new system requirements;

- more and broader international arrangements;
- wider bandwidths;
- higher powered emitters;
- wide area frequency assignments; and
- quicker response times in allocating and assigning frequencies.

o Allocation of the spectrum, in the form of tables and footnotes, is one form of a plan. The proposals, negotiations, and agreements are the planning effort; the tables are the manifestation of that planning effort. These tables have served us well over the years in providing guidance as to the use of the spectrum, but it cannot be concluded now that the status quo will meet the Challenge 21. The planning process should be thoroughly examined with a view towards making it more responsive.

o Frequency assignments are the "enablers" of our radiocommunications systems. As radio telecommunications grow in numbers and complexity the task in Challenge 21 will require:

- greater capability to process more assignments,
- improved bases of data to support decisions,
- refined assignment methods and techniques,
- more responsive procedures, and
- more expeditious coordination arrangements, both domestically and internationally.

o As the information age gains momentum, we are faced with providing more and more telecommunications pathways and larger pipelines to accommodate the flow. As spectrum managers, we have two options.

1. Rearrange, or re-pack, the bands currently allocated to the various services, using more advanced engineering techniques.

2. Where feasible, extend or shift the operations of certain services to the less crowded higher frequency bands.

So we do both. But it is most often a costly, difficult and time consuming task. Much work lies ahead, particularly in research of the microwave and millimeter wave frequency bands. As we learn more about the characteristics of these upper bands, we must develop and perfect the analysis capabilities used to support assignments and operations in them.

- Advancements in automated data processing (ADP) support over the years have provided us with the ability to record more data; sort faster; access the data bases from remote locations; perform calculations such as propagation loss based on the data values; model electromagnetic environments; combine assignment data with terrain data; and many other such capabilities.

  Unfortunately, many of these advancements have been developed in isolation. As a result, spectrum manager A can not readily exchange data with spectrum manager B, and spectrum manager C can not readily analyze the frequency assignment data of either spectrum manager A or B. Because of the global expansion of these future systems and the concomitant need for international coordination, spectrum management data must be in a form and format that facilitates transfer of this vital information between all cognizant parties.

  Along with this, we must develop the models and other engineering tools which will permit us to analyze and use the data in our decision making processes. Today, a large percentage of the U.S. frequency assignments are in that portion of the spectrum below 10000 MHz. Most of our current ADP analytical models are oriented to these frequencies. This range, however, represents about 3% of the potential bandwidth capacity of the allocated electromagnetic spectrum. There is a vast, largely unexplored resource "out there" and we must develop tools to efficiently and effectively use, and manage it.

Divestiture, privatization and liberalization are old, familiar terms to the spectrum management community of the United States. Since our Communications Act of 1934 we have worked long and hard at encouraging liberal and private use of the radio spectrum.

Fifty-five years of experience has been gained, for the most part, in addressing domestic telecommunications issues.

Additionally, we have participated heavily in numerous bilateral, multi-lateral, and international spectrum management fora over the years. Yet, we recognize that the organization and procedures may be inadequate to meet Challenge 21.

A Plan for Meeting Challenge 21.

To meet Challenge 21, there are a number of activities either underway or in the planning stages in the United States. These encompass efforts at the NTIA, the State Department and the FCC. The primary purpose of these efforts is to focus our resources on those areas where we see both the greatest need of our attention and where we are most likely to reap the greatest return on our investment of time, staff and work.

A comprehensive review of the U.S spectrum management process

This fall, NTIA is undertaking a complete review of current policies and processes for management of the radio spectrum in the U.S. No comprehensive review of U.S. spectrum use and management has occurred for almost a generation. Yet, demands on this resource continue to expand exponentially and we see no end in sight.

Even with advances in technologies such as fiber optics which may free spectrum resources for other needs, or the introduction of spectrum efficient modulations will not, in the conventional sense, meet our future needs. In light of the economic value of the radio spectrum, economic forces as a tool in managing this resource deserves consideration.

The goals of this year long review will include affording maximum opportunity for existing and new services; ensuring that U.S. national defense, law enforcement and other essential government service requirements are met; ensuring that international frequency management accommodates U.S. interests; and providing U.S. spectrum users and innovators ready access to the resource.

One of our first actions will be to issue a Notice of Inquiry (NOI) to request public comment on specific economic, technical, and regulatory issues to be studied concerning U.S. spectrum policy. This is all part of an overall effort to have extensive consultations with the private sector, the

FCC, Government spectrum users, and the Congress. During this comprehensive policy review we are currently planning to address at least the following issues in the NOI:

(1) Does the current "Block" allocation procedures which are tied to specific services and technical standards provide adequate flexibility in the spectrum access process?

(2) Can the current criteria for apportioning spectrum resources be improved -- market forces, demand forecasting, alternative delivery systems, etc.?

(3) Is there adequate coordination between the regulators of the Government and non-government spectrum and are there ways of improving it and the spectrum planning process?

(4) Will technology that stresses spectrum efficient techniques meet future demands within the present allocations -- is repacking of the spectrum possible, can interference resistance modulation schemes allow overlaying of users, etc.?

(5) Does the current regulatory process promote innovation, quick access to spectrum for new applications, are databases adequate to support adequate planning and use measurements, and are there adequate personnel and financial resources available to address the future national and international needs of the U.S.?

(6) What are the spectrum requirements that must be addressed in the near term and the distant future in order to keep our telecommunications infrastructure growing, technologically current, and competitive in the national and international marketplace?

Review of the ITU structure and regulatory process

The Nice Plenipotentiary conference developed a resolution (COM7/1) calling for a formal, in-depth review of the structure and functioning of the ITU by a high-level committee. This committee will be made up of experts "enjoying the highest reputation in international telecommunications and having broad ITU experience". This study could have a significant impact on the ITU and its international radio regulatory, standards activities and telecommunication development efforts.

The U.S. intends to participate fully in this review and has established a coordinating committee chaired by the State

Department to prepare for the November 89 Administrative Council -- where the "high-level" committee will be named and a detailed statement of tasks will be developed. In addition, two additional groups - one for each CCI- have been formed under the U.S. CCI National Committees. The Department of State has named key individuals from industry to chair these groups that will provide inputs into the structure examination of the ITU and to the CCIR Plenary Assembly preparations.

One of the specific tasks of the CCIR group will be to examine alternatives to the existing spectrum allocation and radio regulatory process (Nice Res. PL-B/3) that will be addressed by a voluntary group of experts. This latter subject is particularly important since it could form the basis for a revised, more flexible, and responsive spectrum allocation process to support innovative radio services and technologies.

Comprehensive preparation for 1992 and 1993 WARCs

Following the Plenipotentiary meeting, formal preparations for these conferences were started at NTIA, State Dept. and the FCC. The 92 conference and the associated allocation decisions will form the basis for development of mobile, space and broadcasting services leading into the 21st Century. Specifically, a NTIA chaired preparatory group has been established to coordinate Federal Government preparations while the FCC is developing a detailed NOI to solicit comments from the private sector -- both of these efforts will be closely coordinated.

Our 93 HF Planning WARC preparations will continue to develop improved planning processes. The 93 WARC will plan based on current allocations plus whatever additional spectrum is allocated to H.F. by the 92 allocations conference. It is our view that this conference should be able to satisfy the broadcasting needs of all administrations.

These conferences are important to the U.S. and we will put considerable effort into our preparatory efforts. The high frequency broadcast allocations; satellite sound broadcasting; mobile services; high definition television; and space services are all key areas, with worldwide applications, and must be clearly defined before we enter the 21st century.

A regulatory climate that encourages technical innovation

The current regulatory environment in the U.S. is viewed by many as a hindrance as opposed to an incentive to technical innovation and the introduction of new radio services. FCC Chairman Sikes has stated that it is his intention to make the "overall regulatory environment more conducive" to the development of new communications technology and services so that the public can enjoy their benefits as soon as possible and the U.S. can maintain its global competitiveness.

It is the FCC's intention to look at the process of obtaining spectrum for new services, recognizing that some don't fit into well tailored service categories, and to reexamine the incentives for bringing new applications to the market place.

Other ways being pursued by the U. S. to improve its technological posture are through use of research tax credits and revision of antitrust laws that can help speed the development of new radio communication services.

The goal is a streamlined and cost efficient spectrum access and regulatory process.

Exploration of propagation phenomena and high capacity communications at the higher frequencies

Much work remains in the area of millimeter wave applications at frequencies above 60 GHz. NTIA has embarked upon a limited measurement program that is directed at earth-to-space propagation phenomena in this region. 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.

In 1992, the U.S. intends to launch the Advanced Communications Technology Satellite (ACTS) to pave the way for next generation communications satellites. ACTS will incorporate electronically hopping spot-beam antennas, onboard processing and switching and Ka band transmission. Whereas current communications satellites have a capacity of about 320 T1 circuits, the ACTS will be capable of 1000 to 1500 T1 circuits. Its ability to reuse frequencies four to six times will give it a total satellite capacity, assuming 500 MHz of spectrum, of two to three GHz. Propagation experiments to be conducted in the Ka band will also add to our knowledge in this area.

Improved models for evaluating spectrum use

One of the more important aspects of spectrum management is knowing how well the spectrum is being used at any given time, in any band, at any location. NTIA is developing three primary tools for evaluating the efficiency of spectrum use, and intends to pursue this effort as a way of "taking inventory". By having a firm grasp on current use, we are much more able to plan for future use. The Spectrum Use Measure, or SUM, allows us to quantify and graphically present spectrum use, in a specified band, in a geographically specific manner. We have successfully applied it to the fixed and land mobile services, and are in the process of adapting it to other radio services. The Spectrum Conservation Factor (SCF) uses engineering methodology to evaluate technologies for their spectrum conserving properties. This technique is based on the concept in CCIR Report 662-2 that addresses a measure of the ratio between communications achieved and spectrum space used. The Technical Spectrum Efficiency Factor, or TSEF, is used to evaluate equipment relative to the amount of spectrum required and the power radiated by a proposed system. Refinement of these tools will continue and we will be looking for ways to further improve our ability to evaluate our use of the spectrum.

Achieving greater compatibility of data bases

In the United States, we are primarily concerned with two bases of frequency authorization data: that of the FCC; and that of our Federal Government authorizations, the Government Master File. Internationally, we must consider the data base of the International Frequency Registration Board. Additionally, we have frequent need to exchange data with numerous other authorities and administrations. No two spectrum management data bases use the same data elements, record structures, or file formats. This leaves us with three options: 1) pursue the adoption of a common, worldwide data base; 2) work on the development of compatible interface standards to facilitate all necessary exchanges of data; or 3) continue to struggle. In the next few years we will be evaluating these options, and pursuing the most efficient, effective path to overcoming this problem.

Telecommunication policy concerns and related issues

Two areas having both domestic and international implications will be examined by the NTIA -- U.S Telecommunications Infrastructures role in economic development, and Globalization of Communications, Information and Mass Media Markets.

The first will be the subject of a comprehensive examination of the U.S. Public Switched Network (PSN) as a key infrastructure for enhancing future economic development in the U.S. During the study, a wide range of pending policy matters now being debated at the FCC, in Congress, and at the State level will be examined. These will include, for example, the development of regulatory flexibility for ATT, consideration of restraints on the Bell Companies under the ATT Consent Decree, and the role of the telephone companies and the cable industry.

The second concerns globalization of the mass media and the global nature of its participants, e.g., Sony/Columbia, Time/Warner, etc. With this trend towards globalization, are there any implications regarding the development and distribution of mass media information on a worldwide basis? What will be examined, among other things, is the role of the multinational organization on the development and distribution on information -- the results could lead to the development of policy recommendations as deemed appropriate.

Although these policy areas do not have direct spectrum implications, they are important to both national and international policy development because of the overall globalization of networks, organizations and their influence on radio spectrum.

<u>Development of improved, more responsive, international coordination processes</u>

This final point incorporates many of the issues involved in the other points of our program. The results of our U.S. spectrum policy review; the outcome of the ITU review; the experiences of the scheduled Conferences; the improved spectrum access that promotes innovation and new services, the sharing of propagation and modeling knowledge; and the achievement of data base compatibility will each, in its own way, promote better international coordination. These separate events must, however, be considered holistically if we are to realize an enhanced level of international cooperation and coordination.

SUMMARY

This, then, is how we view Challenge 21.

We see a world scenario characterized by global economic forces driving greatly extended and expanded telecommunications systems. Advanced technologies will be applied to these systems, enabling them to accommodate the vast quantities of information which will flow. Many of these systems will employ radio, and thus increase demand for spectrum.

As spectrum managers, we must prepare to meet this demand. We must anticipate the technical and operational requirements levied by more and more systems using advanced technologies, in all regions of the spectrum. And, we must optimize use of the spectrum, both in the bands with which we are familiar and at the higher, unfamiliar frequencies.

To do this, we must first analyze where we are today in order to plan for where we must be in the year 2000. The U.S., the ITU, and several other administrations have already commenced these reviews. It is vital that they be continued and supported in the most open, objective and comprehensive manner so that we may achieve the level of national and international cooperation needed to meet Challenge 21.

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Faster turnaround

COORDINATION CHALLENGES FACING INMARSAT

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ABSTRACT

The paper briefly reviews the purposes and mandate of INMARSAT, with particular reference to recent amendments to its Convention enabling the Organization to provide aeronautical and land mobile satellite services in addition to maritime communications and radiodetermination.

From the perspective of an international cooperative of 57 member countries providing a multiplicity of services to more than 110 countries around the world, the paper addresses the spectrum coordination issues facing INMARSAT.

The paper refers to various INMARSAT initiatives towards the development of new, spectrum efficient INMARSAT services and space-segment capabilities, but notes that despite the application of new technical developments, the difficulties faced by INMARSAT and others in technical coordination of their mobile satellite systems in the extremely limited (29 / 34 MHz wide) L-band mobile satellite services band are formidable. Some of the possibilities for minimizing the coordination difficulties are described.

The paper also refers to the decision of the ITU Plenipotentiary Conference to convene a World Administrative Radio Conference (WARC) in 1992, which among other things would have the competence to reallocate spectrum for mobile satellite services, and notes that ultimately more spectrum and, possibly, separate allocations for the emerging national mobile satellite systems are the only solutions to the long term viability and a satisfactory co-existence of the existing and growing multi-administration multi-service international system (INMARSAT) and the planned national mobile satellite systems.

Résumé

Défis de coordination pour INMARSAT

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Dans cet article, l'auteur examine brièvement l'objet et le mandat d'INMARSAT. Il y aborde notamment les modifications apportées récemment à la Convention de l'organisation qui permettent à celle-ci de fournir des services mobiles aéronautiques et des services mobiles terrestres par satellite en plus des services de communications maritimes et de radiorepérage.

L'article traite des problèmes de coordination des fréquences auxquels INMARSAT doit faire face, sous l'angle d'une collaboration internationale entre 56 pays membres assurant de multiples services à plus de 110 pays du monde entier.

L'article traite de la mise sur pied de nouveaux services qui seraient assurés par INMARSAT à l'aide d'un nombre minimal de fréquences, mais indique qu'en dépit des progrès techniques, INMARSAT et d'autres organisations éprouvent d'énormes difficultés à coordonner les aspects techniques de leur système mobile à satellites.

On y décrit quelques-uns des moyens à prendre pour réduire au minimum les difficultés de coordination.

L'article fait également allusion à la décision de la Conférence de plénipotentiaires de l'UIT de convoquer une Conférence administrative mondiale des radiocommunications pour 1992 qui aurait, entre autres, le mandat de procéder à une réattribution des fréquences pour les services mobiles par satellite; on y précise également que l'accès à un nombre accru de fréquences est finalement le seul moyen d'assurer la viabilité à long terme des systèmes mobiles à satellites, existants ou projetés.

INTRODUCTION

The Organization

INMARSAT, the international cooperative of 57 member countries with steadily expanding membership covering West as well as East and North as well as South, was created some 10 years ago to provide space-segment and system capabilities for maritime satellite communications and radiodetermination. In October 1985, the INMARSAT Assembly of Parties unanimously approved amendments to INMARSAT's Convention and Operating Agreement to give the Organization the institutional competence to provide aeronautical satellite communications services. These amendments became effective in October 1989 after two thirds of INMARSAT member countries representing two thirds of the total investment share in the Organization formally accepted them. Following the WARC-87 allocation of frequencies for land-mobile satellite services, in January 1989 the INMARSAT Assembly of Parties approved another set of amendments to the INMARSAT Convention to give the Organization the institutional competence to provide land mobile satellite communication services.

Being an international "not-for-profit" cooperative, INMARSAT caters to the vital safety services on an international basis with the requisite sensitivity, commitment and care along side the public and administrative / operational correspondence communications that bear more revenues. The vital role of INMARSAT satellite communications and equipment in the Global Maritime Distress and Safety System (GMDSS) and INMARSAT's hosting the Secretariat for the COSPAS-SARSAT system are examples of INMARSAT's commitment to safety services.

As such, in the short time of 10 years, the inter-governmental and multi-national "not-for-profit" INMARSAT cooperative has evolved into the space-segment and system provider for a complete, comprehensive and worldwide set of mobile satellite services for all mobile user communities -- maritime, aeronautical and land. Canada has been and continues to be an important, valuable and respected member of this international cooperative.

INMARSAT -- THE WORLD LEADER IN MOBILE SATCOM

INMARSAT Services and Systems

INMARSAT has been in the forefront of the mobile satellite communications revolution. The system has been in operation since February 1982 with L-band space-segment capacities leased from COMSAT General (MARISAT), European Space Agency (MARECS), and INTELSAT (I-V MCS) and referred to as "first generation space-segment". Some 10,000 Standard-A Ship Earth Stations (SESs) including transportable / portable fixed use versions, supported by a global network of some 21 in service Land Earth Stations (LESs), are in use worldwide; these provide telephony, facsimile, voice-band data and telex communications using analog modulation techniques. Some 10 new LESs are under implementation. Currently, the system operates on the basis of three regions -- AOR, IOR and POR (Figure 1). Splitting AOR operations into two regions, and thus introduction of a fourth operating region before end of 1990 for capacity augmentation (with the resultant improved coverage and bandwidth efficiency), is under active consideration.

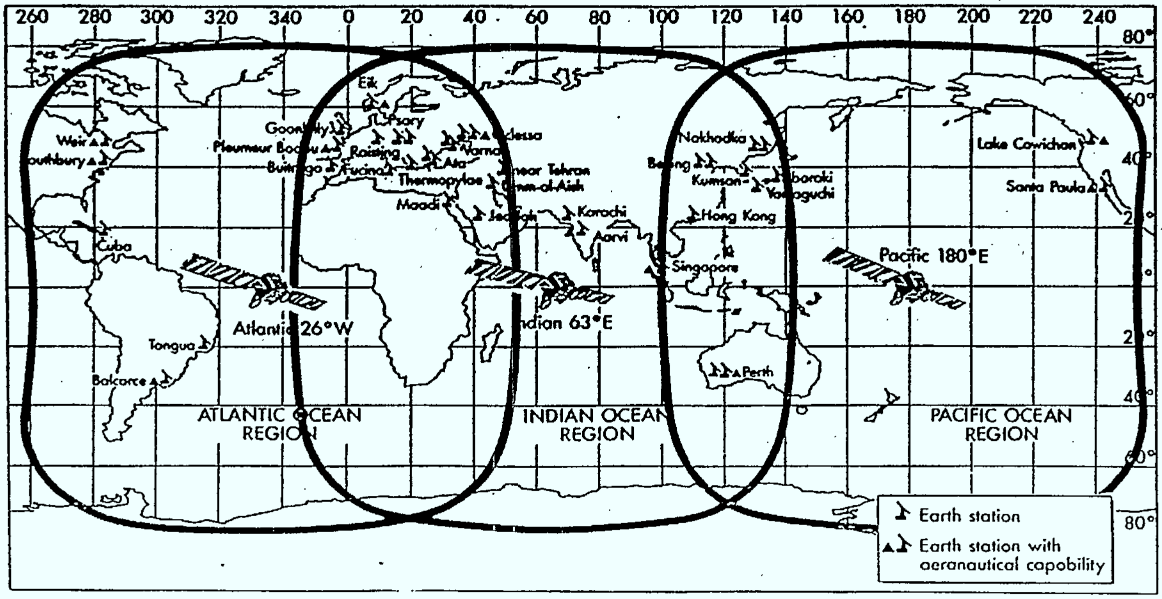

Figure 1. Current INMARSAT coverage

The era of aeronautical satellite communications began in February 1989 when the first public voice call was made from a British Airways Boeing 747 aircraft equipped with an INMARSAT terminal. The pre-operational phase is on and the regular commercial operation for aeronautical voice and data services is slated to commence later this year. Four avionics manufacturers are committed to making INMARSAT aeronautical terminals. So far some 10 ground earth stations (GES) are committed in various parts of the world; two of these are being built by the Teleglobe Canada. INMARSAT Signatories have organized themselves into several more-or-less formal groupings for providing aeronautical services. These are: the "Skyphone" consortium, consisting of BTI, Norwegian Telecom Administration, and Telecom Singapore; the "SITA" consortium, comprising the Signatories of Australia, Canada and France, who will be providing aeronautical service through the Societe International des Telecommunications Aeronautiques (SITA); and the Signatories of Japan and USA who have announced an agreement to work together in the provision of services.

INMARSAT's Standard-C communication system is a versatile, low-cost, compact mobile satellite data terminal (-23 dB/K) for maritime as well as land mobile messaging (including group call or broadcast transmissions), data reporting, position reporting / fleet management, remote monitoring and control applications. Worldwide commercial services will be available from the next year (1990). However, a limited (messaging only) pre-operational capability is already available in the Atlantic Ocean Region (AOR) to support tests, trials and demonstrations. Presently, some 200 Standard-C terminals are using this pre-operational capability and some 20 new terminals from the existing single manufacturer are joining this limited service every week. Several other manufacturers are developing Standard-C terminals and new type approvals are expected from later this year.

INMARSAT is also developing a more bandwidth efficient digital SES (Standard-B) and low-cost more bandwidth efficient maritime / land mobile earth stations (Standard-M), using digital voice coding techniques, for introduction in the early 1990s. Table 1 gives a summary of the technical parameters of existing and under development INMARSAT mobile earth stations.

PARAMETER	STANDARD A	STANDARD B	STANDARD C	STANDARD M	AERONAUTICAL
Antenna					
Steering	Steerable	Steerable	no	Steerable Az only	Electronic
Type	Parabolic	Parabolic	Omnidirectional	Phased array	Phased array
eirp	36 dBW	25-33 dBW	12 dBW min at 5°	22-28 dBW	
Receive G/T	-4 dBK min	-4 dBK	-23 dBK at 5°	-12 dBK	-26 dBK low gain -13 dBK high gain
Telex & Data					
Rates	50 baud telex 9.6 Kbps	50 baud telex 16 Kbps	600 bps BPSK data	2.4 Kbps	600,1200,2400, 10,500 bps
Telephony	FM	Digital coded	Data only	Digital coded	Digital coded
Rates	narrow band	16 Kbps		4.8 Kbps	9.6 Kbps
Transmit Range	1636.5-1645.5	1626.5-1646.5	1626.5-1646.5	1631.5-1660.5	1626.5-1660.5
Receive Range	1535.0-1543.5	1530-1545	1530.0-1545.0	1530.0-1559.0	1530.0-1559.0
Channel Spacing	50 KHz	20 KHz	5 KHz	10 KHz	5 KHz & 17.5 KHz
Environmental					
Ambient Temp (EME)*	-35°to+55°C	-35°to+50°C	-35°to+55°C	-25°to+50°C	to meet RTCA spec DO 160-B
Ambient Temp (IME)**	0 - 45°C	0 - 45°C	0 - 55°C	-25°C to +55°C	to meet RTCA spec DO 160-B

* Externally Mounted Equipment
** Internally Mounted Equipment

Table 1. Technical parameters of INMARSAT MESs

Forthcoming INMARSAT Space-Segment

Four second-generation INMARSAT satellites are at an advance stage of construction. These are planned to be launched progressively from late 1990. These satellites will enable greater capacity than the first-generation leased space-segment through greater power and bandwidth. In addition to covering the full maritime, lower land mobile and the 1 MHz search and rescue allocations in the L-band (1530 - 1545 MHz satellite-to-mobile / 1626.5 - 1646.5 MHz mobile-to-satellite), these satellites also cover three MHz of aeronautical (R) allocations (1545 - 1548 MHz / 1646.5 - 1649.5 MHz). While the first generation satellites are variously able to provide from 10 to 50 two-way simultaneous voice-grade (Standard-A) communications channels over a life of five to seven years in orbit, each second-generation spacecraft will accommodate no less than 125 simultaneous calls (Standard-A type) in the fixed-to-mobile direction and 250 channels in the other direction during at least 10 years in orbit. The capacity in the fixed-to-mobile direction is being increased from 125 channels to 250 by the use of a technique called partial carrier suppression, which ensures that the voice carrier is partially suppressed during pauses in telephone conversations. Its effect is to release satellite power for additional telephone and data connections which otherwise could not have been made.

Third-generation INMARSAT satellites are aimed for introduction from late 1994 as replacement for first-generation space-segment capabilities. These satellites, for which the RFP was issued on 2 October 1989, will introduce the full L-band mobile satellite services spectrum (1530 - 1559 MHz

/ 1626.5 - 1660.5 MHz) for aeronautical and land mobile services, and a much higher power (total EIRP) and spot beams for realization of much greater capacities to meet traffic demands projected for the INMARSAT system during mid-through-end '90s, for better satellite G/T in certain areas for specific services, for achieving a significant reduction in production costs per dBW of satellite EIRP for new and more flexible services to the INMARSAT users, and for more efficient use of scarce L-band mobile satcom radio frequency spectrum resource. The third-generation spacecraft RFP also includes, as "must bid" options, (i) a navigation payload, transmitting in the navigation L-band, for an international civil "integrity" augmentation of national GPS and GLONASS navigation satellite systems, (ii) a limited direct L-to-L mobile communications capability, and (iii) a CxC capability for taking the network control and management overheads out of the scarce L-band.

Competition and Cooperation

Today there is already a considerable amount of competition in mobile communications -- both inter-modal as well as intra-modal. With the pace of technical and service development, there is every likelihood that the competition will become even more intense in the future. Although at present INMARSAT is the world's only civil mobile satellite communications system, it is not a stranger to competition. From its very inception, it has had to compete with other modes of mobile communications. Further, there is competition within the INMARSAT partnership as the INMARSAT Signatories compete among themselves to provide international services within their respective INMARSAT operating regions. Our Chief Executive, Olof Lundberg, is on record welcoming the competition when it, as extolled by FCC in its rule making notice of 30 March 1987, benefits the public by maintaining or improving services and enhancing the economical and efficient provision of communication services.

INMARSAT, for its part, has taken a very constructive approach to the emerging competing mobile satcom systems. The two competing systems in North America (TMI and AMSC) will owe the early realization of their initial operating capabilities to the cooperation extended by INMARSAT through domestic space-segment leases to them via the INMARSAT Signatories. For the benefit of the public users who will roam around the world, INMARSAT has also taken initiatives to build cooperation with the future mobile satellite system operators through certain standardization of user terminals.

THE COORDINATION CHALLENGE

Earlier it was said that power is the real limitation in the use of L-band, that there was enough bandwidth. It has now become apparent that bandwidth is the real limitation. Technology is available to provide the required power capability, of course at cost. But additional L-band spectrum cannot be had with money.

The L-band RF spectrum currently allocated internationally by the International Telecommunication Union (ITU) to the mobile satellite communications services (maritime, aeronautical and land mobile), in which the INMARSAT system operates, is extremely limited -- a total of 29 MHz (1530 - 1559 MHz) in the satellite-to-mobile direction and a total of 34 MHz (1626.5 - 1660.5 MHz) in the mobile-to-satellite direction, including 1 MHz in between (1544 - 1545 MHz / 1645.5 - 1646.5 MHz) for distress and safety communications.

There are other frequency bands that are provided in the ITU Radio Regulations for mobile-satellite service on a national or regional basis, e.g., 806-890 MHz in ITU Region 2 (the Americas), 806-890 MHz and 942-960 MHz in ITU Region 3 (Australasia), 890-896 MHz in Brazil, Canada and the United States, 2500-2535 MHz in ITU Region 3. However, to date, with the exception of Japan where interest has been indicated in the use of S-band (2.5 GHz) for a possible future domestic land-mobile system, no other nation has indicated plans to take advantage of these other mobile-satellite service bands for their national systems. All the national civil mobile-satellite networks notified so far to the International Frequency Registration Board (IFRB) are in the L-band.

This current extremely limited L-band spectrum resource availability on an international basis for mobile satellite communication services, coupled with (i) the emerging separate national systems also in L-band (Figure 2 gives all other L-band networks so far published by IFRB), (ii) lack of discrimination in the L-band mobile antennae (specially those for smaller, more portable, models), and (iii) coverage overlap between the INMARSAT system and the spot-beams of the planned / projected separate national L-band systems, has resulted in a very difficult situation. The problem is worst when the INMARSAT coverage overlap with those of the national spot beam systems, where the mobiles with smaller non-directive antennae are designed to take advantage of the characteristics of spot-beam systems, which allow high forward carrier levels and low return carrier levels. For example, lack of mobile antenna discrimination means that down link interference from the global beam forward carriers into the spot beam system forward carriers is substantial, to the point that the spot beam mobile has to be out of the coverage area of the global beam system to avoid interference, implying an orbital separation of up to 150 degrees or so. There is also substantial interference between the downlink high EIRP forward carriers of the spot beam system into the global beam carriers, but this affects INMARSAT mobiles only within the coverage of the spot beam system.

The L-band mobile satellite systems inter-system coordination problem has dimensions that have never been felt before in the fixed satellite system coordination exercises. The bilateral coordination processes based essentially on RF segmentation methods, used successfully in so many fixed satellite systems coordinations, are not making much headway, especially due to (i) the diversity in the utilization planning of the separate national systems that have to be coordinated with the worldwide INMARSAT system, and (ii) the permanent loss of scarce bandwidth implied in RF segmentation in the L-band mobile satellite systems context.

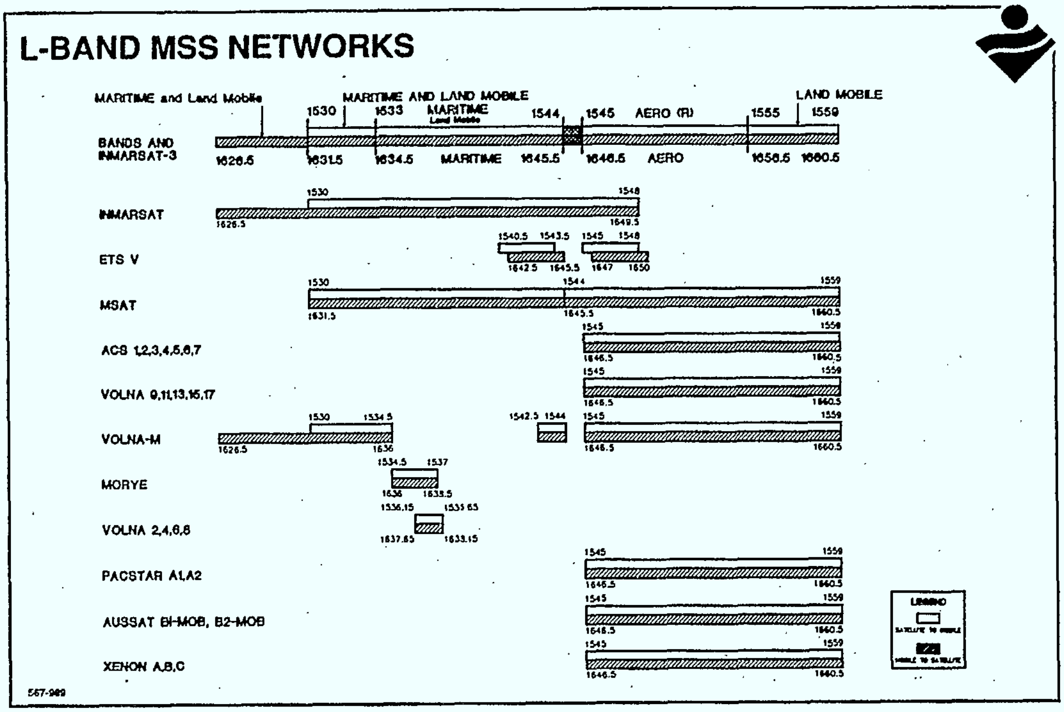

Figure 2. L-band MSS spectrum and published networks

As suggested some time ago, solutions to the difficulties created by the spectrum shortages and the need to coordinate competing systems could have been handled in a multi-owner space-segment or a "condominium" approach. Under the latter approach, system operators can each buy a piece of the satellite. This no longer appears realistic as a single solution.

The INMARSAT Response

INMARSAT has approached the challenge in a pragmatic and responsible manner. On the mobile terminals and utilization side, INMARSAT has taken steps to introduce more bandwidth efficient service standards as should be evident from Table 1. Use of frequency assignment by location (FABL) by INMARSAT's new standards also go a long way in facilitating sharing.

The INMARSAT-3 Request for Proposals (RFP) released on 2 October reflects an approach to the spectrum utilization which recognizes all known potential national L-band mobile-satellite service (MSS) systems to achieve maximum frequency reuse -- both inter- and intra-system. Isolation of potential national / regional systems is indicated; for example, an INMARSAT beam directed towards Europe must have sufficient discrimination from a North American system to permit inter-system reuse of frequencies. Additionally, sufficient isolation has been specified between those INMARSAT-3 spot-beams illuminating high density traffic areas to permit intra-system reuse. The coverage of the four / five L-band spot-beams (depending upon the operating region) is designed to carry around 90% of the expected INMARSAT traffic.

The above investment in very demanding antenna characteristics / performance would, of course, be inadequate without a complementary flexible channelization plan. Firstly, the INMARSAT-3 spacecraft are required to have flexible access to the full 29/34 MHz L-band mobile allocations. This is in response to the L-band coordination experience which indicates that a full and flexible access can avoid bandwidth segmentation and prove more efficient in the long term. Secondly, the INMARSAT-3 RFP calls for continuous bandwidth flexibility allowing up to 60% of any band (eg maritime, aeronautical, or land-mobile) to be allocated to any of its spot-beams. The EIRP can also be flexibly moved around. This flexibility is important for achieving coordination with national-coverage domestic systems. But the INMARSAT-3 spacecraft performance requirements also recognize the existence of global-coverage national networks, e.g., the Soviet VOLNA, MORE systems. Certain bands have been further channelized to permit some potential losses to global coverage national systems while retaining full spot-beam access in those bands.

For intra-system frequency reuse, the channelization in INMARSAT-3 is expected to permit around 40% reuse when all beams are operating; i.e., the case where the expected traffic distribution materialises. However, there is also a mode for unforeseen traffic distribution where a given band can be split between only two spot-beams, and in this case frequency reuse can exceed 75%.

Many simpler designs for achieving L-band bandwidth flexibility are at the expense of excessive feeder-link utilization; however, INMARSAT-3 RFP requires 29 MHz of bi-directional feeder link (6/4 GHz), with dual polarization access. One other spectrum-efficient innovative feature of INMARSAT-3 channelization specifications is that dual polar feeder-link access be used to overlap L-band spectrum and minimize guard-band losses to less than 10% of the overall L-band spectrum.

In summary, L-band frequency coordination experience and transmission and operational planning expertise have been used to specify INMARSAT-3 spacecraft which uses available technology to set new standards in the efficient use of L-band spectrum.

These efficiencies are only realised by a significant additional cost in very demanding antenna and channelization requirements. It is important that such a "burden", which enables an efficient use of the scarce L-band spectrum with flexibilities to permit efficient inter-system technical co-existence, be shared by the national systems with INMARSAT in an equitable manner. It would not be fair to allocate this burden disproportionately to the large majority of nations who are not planning their separate national systems and thus depend on the international INMARSAT system for access to their fair share of the scarce geostationary orbit / L-band mobile spectrum resource to derive the benefits of the mobile satellite services.

1992 WARC

The ITU Plenipotentiary Conference (May - June 1989, Nice) has decided to hold a World Administrative Radio Conference in 1992 (WARC-'92) for dealing with frequency allocations in certain parts of the RF spectrum taking into account the output of WARC HFBC-87, WARC MOB-87 and WARC ORB-88. While the agenda for this WARC will be determined at the 1991 Administrative Council, it is evident that frequency reallocations in 1 - 3 GHz band for extension of the mobile and mobile-satellite services will be a particular focus.

It is not difficult to foresee competition between mobile and mobile-satellite services for more spectrum in the 1-3 GHz band. It is an acknowledged fact that the satellites can never be as spectrum efficient as terrestrial solutions. For example, a cellular system might reuse the same frequencies several times across a large city like Montreal whereas a mobile satellite system will have difficulty achieving reuse of the frequencies even once within the same hemisphere. As such the mobile-satellite services interests would need to work very hard to develop and present their case, in terms of economic value per additional MHz of spectrum vis-a-vis terrestrial mobile systems, for additional L-band spectrum. Indeed, there will be exceptions to the Million $ / MHz argument for services / areas where there is no practical terrestrial alternative.

From the viewpoint of satisfactory technical co-existence of the international system (INMARSAT), which provides world wide coverage, and the aspirations for further national systems, perhaps the question of separate allocations for national systems also needs to be looked into.

Then there is also the need to find a suitable solution to the debate for a generic mobile-satellite service (with the maritime, aeronautical and land-mobile distinctions eliminated) vis-a-vis the concerns of the aeronautical community for ensuring the availability of the current AMSS(R) allocation for their future needs to enable them to implement satellite services under their FANS perspective and also the requisite real priority protection for safety of flight applications (i.e., dedicated channels / capacities). The Future Air Navigation Systems (FANS) Committee of the International Civil Aviation Organization (ICAO) has developed a system concept for aeronautical communication, navigation and surveillance (CNS), which is largely satellite based. The FANS proposed CNS system, largely satellite-based, is designed to overcome the limitations of the existing terrestrial system and meet the needs of civil aviation into the 21st century. As such, it is important to safeguard the interests of the civil aviation community.

CONCLUDING REMARKS

Practical solutions to satisfactory technical co-existence of world-coverage international mobile-satellite services system (INMARSAT) and the national systems in the extremely scarce L-band pose significant challenges if the growth oriented flexible operational environment is to be preserved for future system and services evolution. INMARSAT, the international cooperative, is doing more than its fair share in this direction. In the mutual as well as the larger world interests, cooperation amidst competition is necessary to achieve the delicate balance between national interests and international obligations, especially to protect the interests of the large majority of the nations of the world who will be depending on the international INMARSAT system for their access to their fair-share of the benefits of the mobile-satellite services spectrum through INMARSAT. If the interests of such nations for access to the L-band MSS spectrum / services are not suitably safeguarded, there is always a danger of a demand for WARC-88 type rigid geostationary orbit / spectrum "a priori" planning.

As such apart from cooperation among the existing and emerging MSS operators to find an equitable sharing and efficient utilization of the extremely scarce L-band MSS spectrum resource, it is important that the "burden" of additional costs for incorporating requisite features in the space- and ground-segments are equitably shared. Further, it would appear to be vital to get from WARC-'92 additional spectrum in 1-3 GHz band for mobile-satellite services, and possibly separate allocations for international systems and national-coverage systems to provide a growth oriented flexible operating environment for the future to serve those user segments who cannot be economically served by the terrestrial systems.

ABSTRACT

Commission of the European Communities and Frequency Management

J-L Blanc
Commission of the European Communities

1. **Commission of the European Communities**

Established by the Treaty of Rome (1957), the Commission has a certain amount of jurisdiction in the area of frequency management. In particular, creating a single market in 1992 in radiocommunications would be impossible without a prior harmonization of frequencies. However, one cannot examine the role of the Commission without looking at all of the European institutions - the European Parliament, the Economic and Social Council, the Council of Ministers - which allow adoption of the constraining rules called directives. The directives established by the European Community have a place in the hierarchy of legal standards which take precedence over national laws. To properly understand their development, their adoption and, finally, their execution, we will look successively at each of the steps in the whole process for developing rules which may be applied by the member states.

2. **Constraining actions (directives) which have already been brought into play in the area of frequency management by the Commission**

These actions flowed from a recommendation of the 1984 Council of Ministers, which was confirmed by a resolution of the 1988 Council. The object is harmonization of the new European telecommunications services. The actions related essentially to pan-European mobile services. The first of these actions was aimed at harmonizing the 900 MHz bands for the European digital system called GSM. The second was aimed at reserving bands for a pan-European paging system called ERMES. The third was aimed at allowing introduction of the DECT (Digital European Cordless Telephone) in Community countries. Some other subjects which might be covered by future directives are now being reviewed.

3. **Actions to reorient European policy**

In addition to the above-mentioned constraining actions in the form of directives, the following should be noted:

- Steps have been taken to come up with a strategy for harmonious use of frequencies in Europe. In this connection, note that ETCO conducted a study for the Commission which clarified the role of the various European frequency structures and pointed out the problems which had been raised, but for which no appropriate solutions had been found.

- Following the proposal that a European Telecom Standards Institute (ETSI) be created, the Commission proposed to the European governments and to the CEPT that an entity with a permanent resources be created to reflect on long-term application with respect to frequencies.

- The Commission wishes to participate in radiocommunications harmonization activities (ITU, IRCC, WARC and so on).

Résumé

La Commission des Communautés européennes
et la gestion des fréquences
J-L Blanc
La Commission des Communautés Européennes

1. **La Commission des Communautés européennes**

Etablie par le Traité de Rome (1957), elle a un certain nombre de compétences dans le domaine de la gestion des fréquences. En particulier, il serait impossible d'arriver au marché unique de 1992 dans le domaine des radiocommunications sans une harmonisation préalable des fréquences. Toutefois, on ne peut examiner le rôle de la Commission sans envisager l'ensemble des institutions européennes: le Parlement, le Conseil Economique et Social, le Conseil des ministres qui permettent l'adoption des règles contraignantes appelées Directives. Les Directives établies par la Communauté européenne ont une place dans la hiérarchie des normes juridiques supérieure aux lois nationales. Pour bien Comprendre leur élaboration puis leur adoption et enfin leur exécution on examinera successivement l'ensemble du processus permettant d'élaborer des règles applicables par les Etats membres.

2. **Les actions contraignantes (Directives) déjà engagés dans le domaine de la gestion des fréquences par la Commission.**

Ces actions ont découlé d'une Recommandation du Conseil des ministres de 1984, confirmée par une Résolution du Conseil de 1988 dont l'objet est l'harmonisation des nouveaux sevices européens de télécommunications. Les actions ont concerné essentiellement les services mobiles paneuropéens. La première de ces actions a eu pour objet l'harmonisation des bandes de fréquences à 900 MHz pour le système européen numérique appelé GSM. La seconde a eu pour objet de réserver des bandes de fréquences pour un système de paging paneuropéen appelé ERMES. La troisième a pour finalité de permettre l'introduction du DECT (Digital European Cordless Telephone) dans les pays de la communauté. Un certain nombre de sujets pouvant faire l'objet de Directives futures sont actuellement à l'étude.

3. **Actions d'inflexion de la politque européene**

En plus des actions obligatoires sous forme de Directive mentionées précédemment il convient de noter:

- des actions entreprises pour aboutir à une stratégie harmonisée d'utilisation des fréquences en Europe. On peut noter à ce propos une étude menée par ETCO pour la commission qui a permis de clarifier le rôle des différentes structures européennes de fréquences et de souligner les problèmes posés qui n'avaient pas trouvé de réponse appropriée;

- que suit à la proposition de création d'un institut européen ETSI (European Telecom Standards Institute), la Commission a proposé la création d'une entité disposant de ressources permanentes pour réfléchir à une application à long terme dans le domaine des fréquences aux administrations européennes et à la CEPT.

- que la Commission souhaite une participation avec travaux d'harmonisation des radiocommunications (UIT, CCIR, WARC, etc.).

LA COMMUNAUTE EUROPEENNE ET LA GESTION DES FREQUENCES

par Jean-Louis BLANC

DG XIII D-2

Les structures européennes sont en train de transformer en quelques années une mosaïque de douze pays parlant neuf langues différentes en une unité économique et sociale. Afin d'examiner le rôle de l'Europe pour la gestion des fréquences, il convient de retracer succinctement l'ensemble du fonctionnement des structures européennes avant d'analyser les résultats déjà obtenus dans le domaine des mobiles puis d'envisager les actions futures.

1. LES STRUCTURES EUROPEENNES

1.1 Rappel historique

La première structure européenne date de 1951 et avait pour objectif d'établir une politique commune pour l'acier (CECA). Dès 1957 le Traité de Rome a jeté les bases d'une politique européenne commune dans les domaines suivants:

- la réglementation de la concurrence, en particulier les articles 85, 86 et 90;
- la libre prestation des services et la liberté d'établissement, en particulier les articles 52 à 66;
- la libre circulation des biens, en particulier les articles 30 à 37;
- la politique commerciale commune, en particulier les articles 110 à 116;
- les dispositions générales sur le rapprochement des dispositions législatives, réglementaires et administratives des Etats membres ayant une incidence directe sur l'établissement ou le fonctionnement du marché commun, en particulier l'article 100 A.

On peut décrire succinctement ainsi le fonctionnement des structures européennes.

1.2 Description des structures européennes

Les structures européennes reposent essentiellement sur quatre entités: la Commission qui élabore les propositions, le Parlement et le Comité économique et social qui les discutent et fournissent des avis, et le Conseil qui les adopte pour en faire la loi communautaire.

1.2.1 La Commission

La Commission est en fait la structure administrative permanente. A sa tête sont placés 17 commissaires nommés pour quatre ans, dont les pouvoirs s'étendent sur 22 directions générales. Elle exerce des compétences d'initiative, de contrôle et d'exécution. Les cinq Etats les plus peuplés proposent chacun deux commissaires (France, Allemagne, Royaume-Uni, Italie, Espagne). Les sept autres Etats désignent chacun un commissaire.

Les commissaires européens sont indépendants des gouvernements. Ils prennent leurs décisions collégialement. Chaque commissaire a un domaine de compétence spécialisé (agriculture, fiscalité, politique sociale, etc.). La Commission actuelle a été renouvelée en janvier 1989 pour quatre ans (1989-1993). Elle est présidée par Jacques Delors.

1.2.2 Le Parlement

Il est composé des représentants des peuples des Etats de la Communauté. Ceux-ci sont élus au suffrage universel depuis 1979 avec un mandat de 5 ans. Toutefois à l'opposé des parlements nationaux, le Parlement européen ne dispose actuellement ni d'un véritable pouvoir d'initiative (établissement des projets de lois) ni d'un pouvoir de décision (vote des lois), le pouvoir législatif revient en effet, dans le Traité de Rome, au Conseil, organe politique composé des Ministres représentant les gouvernements des 12 Etats membres de la Communauté.

Cependant les pouvoirs du Parlement européen ont été peu à peu élargis en particulier depuis l'Acte Unique européen de 1986.

Ces pouvoirs sont de 3 types:

- Pouvoirs de coopération (en matière législative)

- Pouvoirs d'approbation (en matière budgétaire)

- Pouvoirs de contrôle (général sur l'activité de la Commission et du Conseil).

<u>Pouvoirs de coopération législative</u>

En matière législative, les lois européennes (qui portent les noms de règlements et de directives) sont élaborées et approuvées par le Conseil, soit sur initiative de la Commission, soit sur initiative du Conseil lui-même.

<u>Pouvoirs d'approbation budgétaire</u>

Le budget européen, (45 milliards d'Ecus) est voté par le Parlement. Celui-ci a le dernier mot pour les dépenses non obligatoires (recherche, politiques régionales et sociales) qui représentent près de 30 % du budget.

Pouvoirs de contrôle sur l'activité de la Commission et du Conseil

Le pouvoir de contrôle du Parlement sur la Commission s'est accentué au fil des ans. Ce contrôle s'exerce principalement, lors des réunions des Commissions du Parlement, réunions auxquelles participent les membres ou des hauts fonctionnaires de la Commission.

Le contrôle sur le Conseil est plus limité, cependant le Conseil (qui est un peu le gouvernement de l'Europe) n'est naturellement pas responsable devant le Parlement et celui-ci ne peut en conséquence pas voter la motion de censure à son encontre.

On voit donc que les pouvoirs du Parlement européen, limités dans les textes, se sont étendus pour permettre à cette Assemblée d'occuper progressivement une place plus importante dans les institutions européennes.

1.2.3 Le Conseil

Il est l'organe politique et décisionnel de la Communauté (son gouvernement). Il est formé par les représentants des 12 Etats membres. Il regroupe les ministres des douze Etats membres de la Communauté.

Ceux-ci se réunissent dans leurs domaines de compétence: Conseil des ministres des finances, de l'agriculture (fixation des prix agricoles), des télécommunications.

Ses décisions sont prises soit à l'unanimité, soit dans certains domaines à la majorité qualifiée.

La présidence du Conseil est exercée à tour de rôle, pour une durée de six mois par chaque Etat membre. Actuellement la présidence du Conseil est assurée par la France.

1.2.4 Le Comité Economique et Social

Composé de représentants des diverses catégories économiques et sociales (employeurs, travailleurs, etc.), le Comité Economique et Social est un comité consultatif qui donne des avis sur les projets de législation qui lui sont soumis par le Conseil ou la Commission.

Il regroupe 189 membres (dont 24 pour la France, l'Allemagne, l'Italie et le Royaume-Uni) qui se répartissent par tiers entre les employeurs, les travailleurs et les autres catégories (commerce, agriculture, professions libérales, etc.).

Ses membres sont nommés pour 4 ans par le Conseil. Les avis rendus par le Comité Economique et Social sont publiés au Journal Officiel.

Le CES a son siège à Bruxelles.

1.3 Les instruments juridiques européens

Les instruments juridiques créés par le Traité de Rome sont les suivants:

- les directives CEE: une directive a force obligatoire dans les Etats membres. Ceux-ci peuvent choisir les moyens propres pour atteindre, au sein de l'ordre juridique national, les objectifs fixés au niveau communautaire. Dans certains pays ayant valeur de traité international, elles sont placées au-dessus des lois dans la hiérarchie des normes juridiques. Les directives sont en général émises par le Conseil sur proposition de la Commission. Néanmoins, en vertu de l'article 90, paragraphe 3, la Commission peut émettre des directives (ou des décisions) pour "veiller à l'application des dispositions du présent article" en ce qui concerne les entreprises publiques et les entreprises auxquelles les Etats membres accordent des droits spéciaux ou exclusifs;

- les règlements CEE: un règlement est une mesure juridique qui a une application générale; il a force obligatoire dans sa totalité et est directement applicable dans tous les Etats membres. Il est émis soit par le Conseil, soit, dans certains cas, par la Commission;

- les décisions CEE: une décision est une mesure adressée soit à un Etat membre soit à une personne physique ou juridique. Elle a force obligatoire dans sa totalité uniquement pour ceux à qui elle est adressée. elle est émise soit par le Conseil, soit, dans certains cas, par la Commission;

- les recommandations CEE émises soit par le Conseil soit par la Commission, n'ont pas force obligatoire sur le plan juridique.

1.4 L'Acte Unique européen

L'Acte Unique européen approuvé par les parlements de tous les Etats membres a défini comme objectif pour 1992 l'achèvement du marché intérieur.

L'Acte Unique européen est la réforme la plus importante du Traité de Rome depuis 1957. Il introduit un certain nombre de nouveaux articles dans le traité, en particulier:

- il a formellement défini l'objectif de 1992 comme objectif du traité (article 8 A);

- il a fixé l'objectif de la Communauté européenne de la technologie et reconnu le programme cadre de R & D comme son mécanisme;

- il a réaffirmé et renforcé l'engagement de la Communauté vis-à-vis des objectifs sociaux et régionaux ("cohésion économique et sociale");

- il a introduit dans le traité la protection de l'environnement en tant que nouveau secteur;

- il a créé un nouveau contexte institutionnel et un nouveau mécanisme de décision. En particulier, il a introduit le vote à la majorité qualifiée en remplacement de l'unanimité pour un certain nombre de questions et a sensiblement revalorisé le rôle du Parlement européen.

L'Acte Unique européen a également ancré la politique monétaire de la Communauté, le système monétaire européen, dans le traité. Il a également établi dans le traité une base solide pour la coopération politique européenne sur les problèmes de politique extérieure.

2. LES ACTIONS DE LA CEE DANS LE DOMAINE DES TELECOMMUNICATIONS

La Commission des Communautés européennes consciente des enjeux de l'harmonisation des services de radiocommunications en Europe a mis en place en 1984 un sous-groupe de travail du SOGT (Senior Official Group of Telecommunications), le GAP (groupe d'analyse et de prospective), pour réfléchir aux principes directeurs d'une politique européenne commune pour les services mobiles. Le SOGT (Senior Official Group of Telecommunications) a donc aidé la Commission à élaborer les lignes de cette politique harmonisée.

Dans sa Recommandation du 12 novembre 1984 résultant des travaux menés au GAP, le Conseil des Communautés européennes a confirmé la nécessité d'introduire des sens de télécommunications à partir de 1985 "sur la base d'une approche commune harmonisée". Peu après, le Conseil a défini les principaux objectifs de cette politique dont l'un des buts essentiels est d'accélérer le développement des services et réseaux avancés de télécommunications dans la Communauté. La Commission a donc présenté un ensemble de textes pour des services paneuropéens. Ces textes sont basés systématiquement sur une directive pour libérer les fréquences dans l'ensemble des Etats membres et sur une Recommandation pour spécifier les services.

Pour l'ouverture progressive du marché, la Commission a proposé un programme d'action et a procédé à une vaste consultation pour aboutir à la rédaction en juin 1987 d'un document appelé "Livre Vert". Après un bref rappel de la mise en application du Livre Vert, on examinera les actions entreprises par la Commission dans le domaine des fréquences, premiers résultats de l'harmonisation des services mobiles à l'occasion de trois exemples: le GSM, ERMES et DECT.

2.1 Mise en application du Livre Vert

Dans le document "Vers un marché communautaire compétitif en matière de télécommunications en 1992", la Commission annonce le calendrier des mesures prévues:

- ouverture rapide et complète du marché des équipements terminaux à la concurrence au plus tard le 31 décembre 1990;

- ouverture progressive du marché des services de télécommunications à la concurrence à partir de 1989; cela concerne en particulier tous les services à valeur ajoutée. Une attention particulière devra être réservée aux services télex et aux services de transmission de données par commutation de circuits ou de paquets;

- ouverture du marché des antennes de réception, pour autant qu'elles ne soient pas connectées au réseau public.

Un certain nombre de mesures complémentaires sont annoncées:

- séparation claire des activités de réglementation et d'exploitation en conformité avec les règles de concurrence de la Communauté;
- définition de l'offre de réseau ouvert (ONP - Open Network Provision);
- création d'un institut européen de normalisation des télécommunications (ETSI) situé à Sophia-Antipolis, Nice;
- reconnaissance mutuelle des agréments des équipements terminaux.

2.2 La Commission des Communautés européennes et les radiocommunications mobiles

2.2.2 Les actions passées

Les communications mobiles publiques se caractérisaient par une multiplicité de systèmes incompatibles entre eux et de prix très différent (six systèmes se partagent le marché des pays de la Communauté avec des niveaux de prix de 1.600 Ecus à 6.000 Ecus pour un téléphone mobile). Ceci ne permettait évidemment pas les économies d'échelle d'un système paneuropéen et entraîne le gaspillage bien connu sous le titre "coût de la non Europe".

Aussi la Commission a proposé au Conseil en Juin 1987 un projet de Recommandation et de Directive permettant l'entrée en service coordonnée du nouveau système de communications mobiles cellulaires numérique dans l'ensemble des pays de la Communauté.

La Recommandation (87/371/CEE)

La Recommandation demande que le futur système paneuropéen de communications mobiles cellulaires numériques utilise les bandes de fréquences 890-915/935-960 MHz, permette des connexions plus rapides que les systèmes actuels avec une meilleure qualité de transmission de la voix ainsi que l'usage de portatifs.

La Directive (87/372/CEE)

La Directive requiert des Etats membres qu'ils réservent progressivement l'ensemble des bandes de fréquences 890-915/935-960 MHz pour le futur service paneuropéen numérique mobile. La Directive prévoit la libération de 2 x 10 MHz dès 1991 dans l'ensemble des pays de la Communauté, puis la libération progressive jusqu'à 2 x 25 MHz en tenant compte de la demande commerciale.

Conclusion

Le service serait introduit en 1991, les grands centres urbains devraient être couverts au plus tard en 1993, les principales liaisons entre ces centres dès 1995.

2.2.3 Les actions actuelles

La radiomessagerie ERMES

De même que pour le système cellulaire la Commission a préparé, en vue de la soumettre au Conseil, un projet de Recommandation et de Directive dans le même esprit que le travail qui avait été mené pour les systèmes cellulaires numériques. Le projet de texte a déjà été examiné par le groupe des questions économiques et sociales du Conseil mais la version définitive devrait être adoptée avant la fin de l'année.

La Recommandation

La Recommandation prévoit que le système ERMES de radiomessagerie entre en service en 1992. Il utilisera la bande de fréquences 169,4 à 169,8 MHz, avec des canaux à 25 kHz, permettra une augmentation du nombre d'utilisateurs, et le fonctionnement simultané de deux ou plusieurs systèmes indépendants dans la même zone géographique.

La Directive

La Directive demande aux Etats membres de désigner 4 canaux à réserver pour ERMES dans la bande de fréquences 169,4-169,8 MHz. Ceci permettrait un démarrage du service ERMES sans apporter de contraintes inacceptables pour les réseaux radioélectriques privés occupant actuellement dans plusieurs Etats membres cette bande de fréquences. Ultérieurement dans les zones où le service le demande, l'ensemble de la bande 169.4 - 169.8 MHz sera réservée pour ce service.

Conclusion

Le service pourrait être introduit à partir de 1992 et dès 1995, 50 % de la population de chaque Etat membre pourrait être couverte.

Les étude de marché montrent que le nombre de récepteurs de radiomessagerie devrait augmenter de 1,3 millions en 1987 à plus de 13 millions en l'an 2000, et que le marché potentiel devrait croître de 115 millions d'écus en 1988 à 415 millions d'écus en 1995.

En conclusion ERMES devrait permettre de contribuer à la demande des utilisateurs et des entreprises grâce à une mobilité et efficacité accrue et faire bénéficier aux fabricants de l'ouverture d'un grand marché européen en bénéficiant des économies d'échelle pour accroître leur compétitivité sur les marchés mondiaux et enfin faire bénéficier les exploitants de réseaux de possibilités commerciales accrues.

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* en annexe, exemple de l'adoption de la directive relative à ERMES.
Annexe 1: projet présenté par la Commission
Annexe 2: projet de la Commission après consultation avec les Etats membres dans les groupes du Conseil
Annexe 3: rappel du Parlement sur le projet de directive ERMES

Le DECT

Le Digital European Cordless Telephone (DECT) ou téléphone sans fil numérique est, lui, un produit nouveau dont l' objectif est de remplir les trois fonctions suivantes: téléphone sans cordon résidentiel, autocommutateur sans fil, télépoint: c'est à dire d'accès à partir de bornes dans les rues, les aéroports, gares ...

Le combiné DECT pourra donc être utilisé indifféremment à la maison, au bureau, ou dans la rue.

De même que pour le cellulaire numérique et ERMES les textes prévus par la Commission s'articulent autour d'une Recommandation et d'une Directive pour réserver les fréquences. La bande de fréquence retenue est la bande 1880 - 1900 MHz. Elle présente en effet l'avantage d'être facilement libérale et d'être située à côté des bandes où se développent en Europe les futures services de télécommunications mobiles (1900 - 2100 MHz).

Il convient de noter que ce texte est le moins avancé et que le projet préparé par la Commission n'a pour l'instant, et compte tenu du calendrier, été discuté dans aucune enceinte formelle.

Conclusion

Le marché, pour les téléphones sans cordon résidentiels, est estimé à 10 millions d'unité par an après 1992 si le taux de pénétration est semblable à celui des Etats Unis. Pour les télépoints les études de marché indiquent un chiffre d'un demi million de combinés par an. Pour les autocommutateurs sans fil on estime dès 1992 le nombre à 400.000 combinés.

3. LES ACTIONS FUTURES

On peut noter que la Commission a par ailleurs mené une étude avec l'aide d'un consultant (ETCO) pour décrire et analyser les différentes structures de gestion de fréquences en Europe. Suite aux résultats de cette étude, il convient de noter que la Commission considère que compte tenu des aspects de souveraineté liés aux utilisations militaires, la gestion des fréquences doit rester au sein des Etats membres, que toutefois un accroissement de la coopération entre les Etats membres est nécessaire afin d'améliorer l'harmonisation dans les Etats membres.

A cet effet, la Commission a proposé au SOGT un projet pour l'établissement d'un Institut de recherche des Télécommunications qui, équivalent à l'Institut des Normes Européennes (ETSI), aurait pour effet d'entreprendre et de mener des études pour permettre avec les apports des industriels, des opérateurs, des administrations et des utilisateurs permettrait de définir à long terme les objectifs à assumer par les Etats membres. Suite à cette proposition, la CEPT qui est chargé actuellement de rechercher l'harmonisation des fréquences en Europe a réfléchi à cette invitation de la Commission et va prendre position d'ici quelques mois mais pourrait proposer afin de rechercher le même objectif de créer un noyau permanent du groupe de gestion des fréquences de la CEPT qui permettrait de disposer des ressources permanentes pour mener à bien les études nécessaires. Toutefois les principes de discussion avec des groupes extérieurs à la CEPT intéressés par la gestion des fréquences n'ont pas encore été complètement définis.

Par ailleurs la Commission a obtenu le statut d'observateur à l'UIT et a l'intention de participer aux travaux de cette organisation internationale, en particulier dans les groupes pertinents du CCIR ou à l'occasion des conférences administratives.

CONCLUSION

L'harmonisation européenne en matière de gestion de fréquences est un processus nouveau. On peut noter la nécessité souhaitée par les Etats membres de rechercher et d'obtenir des fréquences communes comme préalable à toute action commune pour l'harmonisation des équipements en vue de parvenir au marché unique de 1992. Cette action nouvelle de la Commission a déjà obtenu des résultats tangibles par les directives prévues relatives à des dégagement de fréquences et par l'ensemble des actions indirectes menées par la Commission dans les différents fora où elle est invitée.

A ADOPTÉ LA PRÉSENTE DIRECTIVE:

Article premier

Aux fins de la présente directive, « système paneuropéen de télé-appel public terrestre » signifie un service de télé-appel public basé sur une infrastructure terrestre et fourni dans chaque État membre, conformément à une spécification commune permettant aux personnes qui le souhaitent d'envoyer et/ou de recevoir des messages d'alerte et/ou numériques ou alphanumériques partout dans le rayon de couverture du service dans la Communauté.

Article 2

1. Les États membres prennent les mesures appropriées pour que la bande des 169,6-169,8 MHz soit réservée exclusivement à l'usage du service paneuropéen de télé-appel public terrestre et soit mise à la disposition de ce service pour le 1er janvier 1992.

2. La Commission, après consultation des États membres, prend une décision définissant dans la bande des 169-170 MHz, et pour le 1er janvier 1990 au plus tard, un autre bloc de 200 KHz à réserver exclusivement pour le service paneuropéen de télé-appel public terrestre.

3. Les États membres prennent les mesures appropriées pour que le bloc de 200 KHz des fréquences définies au paragraphe 2 soit disponible pour l'usage exclusif du système paneuropéen public terrestre pour le 1er janvier 1995.

Article 3

La Commission rend compte au Conseil de la mise en œuvre de la directive au plus tard fin 1996.

Article 4

1. Les États membres prennent les mesures nécessaires pour se conformer à la présente directive pour le 1er janvier 1990 en ce qui concerne l'article 2 paragraphe 1, et pour le 1er janvier 1993 en ce qui concerne l'article 2 paragraphe 3. Ils en informent immédiatement la Commission.

Les dispositions adoptées en vertu du premier alinéa se réfèrent explicitement à la présente directive.

2. Les États membres communiquent à la Commission le texte des dispositions de droit interne qu'ils adoptent dans le domaine régi par la présente directive.

Article 5

La présente directive est adressée aux États membres.

A ADOPTE LA PRESENTE DIRECTIVE :

Article premier

Aux fins de la présente directive, "Système paneuropéen de télé-appel public terrestre" signifie un service de télé-appel public basé sur une infrastructure terrestre dans les Etats membres, conformément à une spécification commune permettant aux personnes qui le souhaitent d'envoyer et/ou de recevoir des messages d'alerte et/ou numériques et/ou alphanumériques partout dans le rayon de couverture du service dans la Communauté.

Article 2

1. Conformément à la Recommandation (1), les Etats membres doivent désigner, avec une priorité et sur une base de protection, quatre canaux dans la bande 169,4 - 169,8 MHz, de préférence :

   169,6 MHz
   169,65 MHz
   169,7 MHz
   169,75 MHz

   pour le service de télé-appel paneuropéen public terrestre au plus tard le 31 décembre 1992.

2. Les Etats membres doivent s'assurer que des plans soient préparés aussitôt que possible pour permettre au service de télé-appel paneuropéen public terrestre d'occuper la totalité de la bande 169,4-169,8 MHz selon les exigences commerciales.

Article 3

1. Les Etats membres prennent les mesures législatives, réglementaires ou administratives nécessaires pour se conformer à la présente directive au plus tard 18 mois à compter de sa notification. Ils en informent immédiatement la Commission.

   [Les dispositions adoptées en vertu du premier alinéa se réfèrent explicitement à la présente directive].

2. Les Etats membres comuniquent à la Commission le texte des dispositions de droit interne qu'ils adoptent dans le domaine régi par la présente directive.

Article 4

La Commission rend compte au Conseil de la mise en oeuvre de ladirective au plus tard fin 1996.

Article 5

La présente directive est adressée aux Etats membres.

(1) Lors de la rédaction finale, les références précises decette recommandation seront ajoutées.

ANNEXE 3

La commission économique, monétaire et de la politique industrielle soumet au vote du Parlement européen, sur la base de l'exposé des motifs ci-joint, les amendements suivants à la proposition de la Commission ainsi que le projet de résolution législative ci-après :

Proposition de la Commission concernant une directive du Conseil relative aux bandes de fréquence à réserver pour l'introduction coordonnée d'un système paneuropéen de télé-appel public terrestre dans la Communauté.

Texte de la Commission	Amendements présentés par la commission économique, monétaire et de la politique industrielle

Préambule inchangé

Considérants 1 à 8 inchangés

	Amendement n° 1
	Supprimer le neuvième considérant et le remplacer par le texte ci-après :
	"considérant que l'établissement d'un véritable service paneuropéen de radiomessagerie demande la disponibilité maximale de fréquences dans la bande précitée ;"
	Amendement n° 2
	Après le neuvième considérant, insérer le nouveau considérant ci-après :
	"considérant qu'une certaine souplesse est requise en vue de tenir compte des besoins en matière de fréquence qui diffèrent selon les Etats membres; que cette souplesse indispensable ne doit pas être utilisée comme une excuse pour freiner l'expansion rapide d'un système paneuropéen ;"

Amendement n° 3

Après le considérant 9 bis, insérer le nouveau considérant ci-après :

"considérant que des procédures de coordination devront le cas échéant être établies entre pays voisins ;"

Amendement n° 4

Modifier le dixième considérant comme suit :

considérant que la mise en application de la recommandation ../../CEE du Conseil du... relative à l'introduction coordonnée d'un système paneuropéen de télé-appel public terrestre dans la Communauté assurera le démarrage d'un système paneuropéen pour le 1er janvier 1992 au plus tard ;	considérant que la mise en application de la recommandation ../../CEE du Conseil du... relative à l'introduction coordonnée d'un système paneuropéen de télé-appel public terrestre dans la Communauté assurera le démarrage d'un système paneuropéen pour le 1er juin 1991 au plus tard ;

Amendement n° 5

Supprimer le onzième considérant et le remplacer par le texte ci-après :

"considérant que, sur la base des tendances technologiques et commerciales actuelles, il s'avère réaliste d'envisager la désignation de la bande des 169,6 - 169,8 MHz pour sélectionner les fréquences requises selon les besoins par la mise en oeuvre et l'expansion d'un système paneuropéen de télé-appel ; que toutefois, certains canaux européens doivent être réservés dès à présent au système paneuropéen ; que, enfin, d'autres canaux peuvent être éventuellement nécessaires dans la bande 169,4 - 169,8 sous condition d'un accord entre les administrations concernées ;"

Considérants 12, 13, 14 et 15 inchangés

Article 1 inchangé

Amendement n° 6

Remplacer l'article 2 par le libellé suivant :

Article 2-1

Les Etats membres désignent pour le 1er juin 1991 les fréquences 169,6, 169,5, 169,7 et 169,75 MHz comme canaux européens pour le système paneuropéen de télé-appel public terrestre.

Article 2-2

Les Etats membres prennent les mesures appropriées pour que la bande des 169,6 - 169,8 MHz soit désignée comme bande à partir de laquelle d'autres fréquences peuvent être rendues disponibles selon les besoins pour être utilisées par le système paneuropéen de radiomessagerie public terrestre pour le 1er juin 1991.

Article 2-3

Les Etats membres s'assurent que d'autres canaux puissent être rendus disponibles pour le système paneuropéen à partir de la bande 169,4 - 169,8 selon les besoins et sous condition d'un accord entre les administrations concernées.

Article 3 inchangé

Amendement n° 7

Modifier l'article 4-1 comme suit :

1. Les Etats membres prennent les mesures nécessaires pour se conformer à la présente directive pour le 1er janvier 1990 en ce qui concerne l'article 2, paragraphe 1 et pour le 1er janvier 1993 en ce qui concerne l'article 2 paragraphe 3. Ils en informent immédiatement la Commission.

1. Les Etats membres prennent les mesures nécessaires pour se conformer à la présente directive pour le 1er janvier 1990.

Deuxième paragraphe inchangé

Article 5 inchangé

INTERNATIONAL FREQUENCY MANAGEMENT REGULATIONS
IN A CHANGING TECHNICAL AND OPERATIONAL ENVIRONMENT

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ABSTRACT

The paper gives an overview of the current system of international frequency management and indicates possible changes in the international regulation of the use of the radio frequency spectrum and geostationary orbit. These international regulations are based on the allocation of specific frequency bands to one or more radio services with the main objective of obtaining interference free communications. In their present framework, they were established after the Second World War. They require the notification of frequency assignments to the International Frequency Registration Board (IFRB) for recording in the Master International Frequency Register thereby obtaining international recognition and protection from interference caused by other frequency assignments put into use at a later date. For some radiocommunication services and in certain frequency bands, another approach has also been accepted by the international community, i.e. the establishment of frequency plans intended to remedy the drawbacks of the system based on the "first come first served" principle. The accelerated growth in the use of the radio spectrum and the rapid development of the telecommunications technology as well as the complexity of the present regulations now call for the reconsideration of the international frequency management procedures. Some suggested changes are outlined in this paper.

Résumé

La réglementation internationale de la gestion des fréquences dans un contexte technique et opérationnel en évolution

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Le document présente un aperçu du système international actuel de gestion des fréquences et il indique les modifications qui pourront être apportées au règlement international qui régit l'utilisation du spectre des fréquences radioélectriques et de l'orbite des satellites géostationnaires. Ce règlement international est fondé sur l'attribution de certaines bandes de fréquences à un ou à plusieurs services de radiocommunications principalement afin d'obtenir des radiocommunications libres de brouillage. Ce règlement a été établi sous sa forme actuelle après la Deuxième guerre mondiale. Il exige que les assignations de fréquences soient notifiées au Comité international d'enregistrement des fréquences (FIRB) pour y être inscrites au Fichier de référence international des fréquences et obtenir ainsi une reconnaissance internationale et la protection contre le brouillage qui pourrait leur être occasioné par d'autres assignations de fréquences susceptibles d'être utilisées à une date ultérieure. Dans le cas de certains services de radiocommunications et dans certaines bandes de fréquences, une autre façon de procéder a également été acceptée par les milieux internationnaux, notamment l'établissement de plans de fréquences destinés à remédier aux lacunes du système, fondés sur le principe "premier arrivé, premier servi". La montée en flèche de l'utilisation du spectre des fréquences radioélectriques et l'évolution rapide de la technologie des télécommunications jointes à la complexité du règlement actuel, commandent aujourd'hui un réexamen de la procédure de gestion internationale des fréquences. Quelques-unes des modifications recommandées sont exposées dans ce document.

CURRENT SYSTEM OF INTERNATIONAL FREQUENCY MANAGEMENT

Historical overview

Radiocommunications were first used to assist maritime communications at the beginning of the twentieth century. The earliest international regulations were drawn up for the maritime service, first, to provide operational instructions to radiotelegraph operators. Regulations for the orderly use of the radio frequency spectrum were based on the division of the used spectrum into specific frequency bands, which were allocated to given groups of users according to the different types of service rendered and the different modes and purpose of the emissions. These groups were called radiocommunication services. Interference-free operation became an important issue after the Second World War when the spectrum became used intensively. The problem was mainly identified in the domain of HF communications where the particular propagation conditions produced interference between geographically widely separated localities. In the late 40s virtually all international telecommunications depended upon the availability of frequencies in the bands between 3 MHz and 30 MHz and it was then that the idea of the protection of internationally recognized emissions was started. Protection was obtained through a frequency register maintained by an international organization also charged to manage a public procedure of notification, examination and recording of the national frequency assignments. While a simple international frequency list had existed already before the Second World War ("Bern List"), the MIFR giving right to international recognition/protection was established according to the decision of an ITU Conference (Atlantic City, 1947). The Atlantic City Conference (1947) based international frequency management on the following concepts:

a) an obligatory Table of Frequency Allocations and its associated procedures;

b) creation of the Master International Frequency Register;

c) creation of an independent body (IFRB).

This international conference clearly identified the need to create an internationally elected body (IFRB) to undertake the orderly registration of frequency assignments and the management of an international procedure based on the following main principles:

a) the selection and assignment of frequencies by each country to its own stations;

b) the notification of frequency assignments to the IFRB under certain conditions;

c) the examination of these notifications by the IFRB following an established procedure leading to the formulation of IFRB findings and to their recording into the Master International Frequency Register (MIFR);

d) "protection" of the recorded frequencies in certain frequency bands, through the procedure mentioned in c) above, against frequency assignments notified to the IFRB at a later date.

In order to set up the initial frequency register (MIFR), the Conference of Atlantic City (1947), first created the Provisional Frequency Board (PFB) to establish, on the basis of the requirements of the national administrations, a frequency list or plan which would permit an interference-free operation of the frequency assignments. At the end of the mandate of the PFB, in 1951, the Extraordinary Administrative Radio Conference, convened to formally adopt the new frequency list, had to recognize that the number of the requirements were too high in relation to the available spectrum. When adopting the MIFR as a basis of further frequency management activities it requested the administrations to make every effort to clear harmful interference cases by direct negotiations with the assistance of the IFRB if required.

With the evolution of the system, in certain frequency bands and for some radiocommunication services, another approach has also been accepted by the international community, i.e. the establishment of frequency plans for future use. By this, it was intended to remedy the "inequities" of the system based on the principle of "first come first served". In fact, some frequencies or radio channels were set aside for individual administrations to put into use at any time during the lifetime of the plan. The frequency plans were established on the basis of national requirements taking into consideration the principle of equality of rights and of access to the use of the spectrum by large and small countries. Such frequency plans have been adopted for almost all the broadcasting services (sound and TV, satellite or terrestrial; only AM broadcasting in the Americas), and some of the safety services (maritime and aeronautical mobile services in the HF frequency bands). The details of the emission characteristics included in these plans are very different, there are so called allotment plans with some envelop parameters permitting flexible implementation and there exist frequency assignment plans in which practically all the technical and geographical parameters of the stations are predetermined and included in the plan. A detailed procedure was included for implementation or modification of the plan.

During the last 40 years, ITU World or Regional Administration Radio Conferences (WARCs, RARCs) have modified the regulations very extensively for different frequency bands and services, new methods and concepts as well as new services have been added to the international frequency management system. However, the main principles have been kept and one may at present note that, while the selection and assignment of the frequencies to radio stations or networks remains the sovereign right and individual task of the national administrations, this choice is not only limited by technical possibilities of sharing between frequencies simultaneously used by different radio stations, but the administrations have also to cooperate on an international level to find solutions through agreements and compromises. In order to reduce these difficulties of coordination on one hand, and to achieve an optimal frequency spectrum use on the other hand, the national assignment of frequencies is carried out in the framework of mutually accepted international regulations which are based on:

- frequency band allocations to "services";

- the protection of assignments recorded in the Master International Frequency Register or the previous planning of portions of the frequency spectrum;

- bilateral or multilateral agreements and coordination.

The above elements of the mutually agreed regulations have been incorporated, by Administrative Radio Conferences, in the Radio Regulations which, being part of the ITU Constitution/Convention, have the status of an international treaty. The basic concepts concerning frequency selection, protection and operation incorporated in the Radio Regulations are the following.

Frequency allocations

International frequency management regulations are largely based on the distribution of the frequency bands to specific user groups called radiocommunication services. Frequency allocations are made for worldwide or regional use on equal or differential basis between services. The allocation arrangements have been established and successively amended by several ITU conferences (WARCs) taking into account radio propagation conditions, user requirements, general technical specifications of the equipment used by the services and possibilities of sharing between the different services. The Frequency Allocation Table is included in Article 8 of the Radio Regulations.

International recognition of frequency assignments

Different mechanisms/procedures have been set up to obtain international recognition or protection. These procedures are included in Articles 11 to 17 and Appendices 25 to 27, 30 to 30B of the Radio Regulations as well as in Regional Agreements established by RARCs. The principle mechanisms applicable to different bands/services are one or more of the following:

- notification of frequency assignments by the national administration to the IFRB, examination and recording, by the IFRB, in an international frequency register and "protection" once recorded (Articles 12 and 13 of RR);
- coordination of frequencies prior to their notification to the IFRB and their bringing into use (Article 11 for space networks, specific resolutions for Maritime HF use, etc.);
- use of frequencies according to pre-established frequency plans and notification to the IFRB of the putting into use of the frequency assignments of an allotment plan (HF Aeronautical and maritime mobile services, Fixed satellite service) or of an assignment plan (Broadcasting plans LF/MF, VHF/UHF (sound, TV), Satellite-broadcasting and feeder link plans);
- use of frequency assignments according to seasonal plans revised four times a year (HF broadcasting service, Article 17 of RR);
- use of frequencies in some band/services without notification (e.g. fixed, mobile in bands above 28 MHz).

Monitoring of frequencies and actual harmful interference

The ITU Convention (Article 35) and the Radio Regulations (Articles 18 to 22) recognize the importance of international monitoring of the radio frequency spectrum to help ensure efficient and economical use of the spectrum and to help in the prompt elimination of harmful interference. However, monitoring activities have been left mainly to the national organizations. The few regular, internationally coordinated actions on this domain concern the quarterly publication, by the IFRB, of the monitoring data provided by the national administrations on emissions in the frequency bands below 28 MHz and the collection, in a CCIR Handbook, of the information available on the techniques used by monitoring stations. The elimination of the harmful interference sources remains principally in the hands of the national administrations concerned. While the affected administration may request the assistance of the IFRB, the final solution of these problems can only be found in a bilateral agreement.

IFRB INVOLVEMENT IN THE INTERNATIONAL FREQUENCY MANAGEMENT SYSTEM

Functions of the IFRB

Since its foundation, the International Frequency Registration Board has been directly concerned with the assignment of frequencies to stations. It has been given a growing role in the effective, equitable and economic utilization of the radio frequency spectrum and the geostationary-satellite orbit. It is, at present, mainly involved in the following activities:

a) reception, examination and processing of information received from the national administrations;

b) maintenance of the Master Register (examination and recording of frequency assignment notices);

c) management of assignment and allotment Plans (procedures of modification and updating of plans, as well as implementation);

d) management of the international coordination procedures (advanced publication and coordination procedures for space networks and several other coordination/agreement procedures);

e) assistance to administrations in frequency management activities (general, technical);

f) interpretation of the Regulations (decisions, jurisdiction, IFRB Technical Standards and Rules of Procedure);

g) conference preparatory actions and post-conference activities.

Assistance to administrations

The IFRB´s activities mentioned under paragraphs a) to d) above have been covered partially in this paper and they are widely known within the national administrations. It is worth mentioning that, in addition to these daily "routine" activities, the IFRB provides a wide range of assistance to administrations. These activities include the selection of one or more parameters requested for a radio network (frequency to be assigned to a station, power or antenna parameters, etc.) or the application, on behalf of the requesting administration, of administrative or technical procedures defined in the Radio Regulations in order to coordinate the frequency use with the other users. Within the framework of special assistance to administrations the IFRB receives officials from the administrations for training with the main purpose of informing them of the procedures applied by the IFRB including computer applications.

Interpretation of the Radio Regulations

When the IFRB was created the legislators also adopted the only procedure then required. This procedure for the bands below 28 MHz was described in such detail that there was little need for interpretation. The evolution of the radiocommunications and the consequent increase in the complexity of the associated procedures resulted in the need for the IFRB, practically on a daily basis, to interpret the provisions of the Radio Regulations, of a Regional Agreement or Resolutions of Conferences. These interpretations are normally made for the formulation of a finding or the establishment of the IFRB Rules of Procedures (instructions of the IFRB to its technical secretariat for the daily activities of the IFRB) or the establishment of computer programs used by the IFRB in its technical procedures as well as at the request of one or more administrations. By interpreting the provisions of the Radio Regulations the Board tries to find the precise meaning and the extent of application of each provision on which there is a doubt. These interpretations lead to decisions or findings of the Board which will have some impact on the international status of the individual frequency assignments. During the last 40 years there have been very few cases when the IFRB´s interpretations resulted in objections from the administrations concerned. All these cases have been settled by reviewing, by the IFRB, the disputed interpretations. However, there are signs that this may change due to the heavy competition between different space networks. It should be noted that Resolution No. 35 contains a procedure for the resolution of the cases of continuing disagreement between the IFRB and the Administration concerned.

Conference related activities

In the last decade, with the high number of Administrative Radio Conferences, the IFRB has had to put more and more emphasis, within its activities, on conference preparation, intersessional work and post-conference tasks. These activities may involve, for these frequency planning conferences, the compilation of the requirements submitted by the administrations, the development of computer programs to contain the planning algorithm and to deal with the data base established from the requirements. The draft plan resulting from the application of the software so established is normally submitted to the Conference concerned, for adoption or for further modification. Conferences have frequently charged the IFRB with post-conference tasks to resolve, within well defined terms of reference, those problems (incompatibilities with administrations non-participating, or with other radiocommunication services) which could not be settled during the conference. At other, non-planning type conferences the IFRB has often been requested to participate in its capacity of manager of or expert in the international procedures. For almost all the Conferences the IFRB has prepared a comprehensive report on its activities, as well as on the difficulties encountered and experience in the application of the relevant provisions of the Radio Regulations.

OBJECTIVES OF THE CURRENT SYSTEM, ADVANTAGES AND INCONVENIENCES

Frequency management legislators in the late 1940s and their successors at later ITU Conferences had two main objectives that they wished to achieve through the procedures described in the Radio Regulations:

a) an orderly distribution of the radio frequency spectrum among radio services, and

b) an interference free operation of the stations.

The current system based on regulations established in the time of HF radiocommunications and successively amended to take into account new services and new techniques still responds to these main objectives and we may state that the above goals have been achieved more or less. This system is also based on the goodwill and cooperation of all administrations.

The system, though it is far from being a uniform code for international frequency management:

- guarantees, in general, the interference free operation of radio stations for which the corresponding procedures have been applied by giving international recognition or protection;

- provides a mechanism for international coordination of those radio networks (space networks) for which the high initial investment requires pre-operational agreements between users of the systems;

- enables countries to accede to spectrum for future utilization ("equitable access" to the spectrum and the geostationary-satellite orbit guaranteed through frequency plans).

When assessing the merits of the international system of frequency management, we should also examine the drawbacks of this system. The telecommunication administrations charged with the application of the procedures rightly complain of the extreme complexity of the regulations, which, in addition to the administrative burden, take a long time to be completed. This may endanger the realization of the network project and, in some cases, may change the situation of priorities between users in those part of the spectrum where "first come first served" principles are utilized (e.g. in the space network coordination domain). Another, often heard criticism is that some regulations are too rigid or out of date and do not keep pace with technology and the changing operational needs and the possibility of their modification is restricted. In fact, the provisions of the Radio Regulations can only be modified by specific ITU Conferences (WARCs). The convening of such conferences requires not only detailed technical preparation, but the administrative mechanism is also complex and the convening of the conference may take years from the moment of identification of the problem.

In addition to the above drawbacks, the main inconvenience of the current system is that it does not lead necessarily to an efficient and economical spectrum use. The main problem areas are the following:

- there are, in these days, doubts as to the validity of the basis for the current frequency management system, i.e. the notion of the allocation of the frequency bands to many very specific radio services (there are over 35 radio services now);

- the method of frequency or channel allotment by frequency plans may no longer be considered an efficient use of the spectrum; the plans are usually based on the technology available when the Plan is adopted and the procedures often do not provide for any updating of the technical criteria, in fact, the planned bands are neither exploited sufficiently (partially blocked bands) nor used proportionally with the requirements;

- on the other hand, in the non-planned bands the problems are identified through the blockage by no longer used recorded assignments which misuse the international recognition or protection of the recorded status. It should be noted that the MIFR includes many HF fixed stations, however, a recent monitoring program has not confirmed a corresponding usage;

- the frequencies used but not recorded may also be the source of trouble in the system; the assignment of frequencies being based on an interference probability analysis, those frequency uses which are not registered in the Master Register cannot be taken into account and the IFRB's finding providing an international status may not be based on correct data.

The future evolution of the system will, probably, remedy some of the problems. In the following, some ideas are given on the possible trends for future changes in the frequency regulatory domain. They have been assembled on the basis of the experience gained by the IFRB and its secretariat within their daily activities or through participation in international conferences or discussions with experts in administrative or technical matters. These suggestions represent the views of the authors and not the official views of the IFRB. **The purpose of these suggestions is to open discussions on the possible improvements that could be made,** recognizing that ITU Plenipotentiary Conference, Nice, 1989 adopted Res. PL-B/3 dealing with a Group of Experts to study this question of Allocations and Use of Spectrum as well as the simplification of the procedures.

SUGGESTIONS FOR CHANGES IN THE REGULATIONS

"Revision" of the Allocation Tables

One of the major problems identified in this paper has been the matter of frequency allocation. The main questions are the following:

- allocations are too complex and confusing; by different Conference decisions (changes in the allocation table, addition of footnote allocations for some regions, exclusion of some regions from the general allocation, different categories of allocations, i.e. primary, permitted and secondary allocations, etc.) the originally simple allocations have become very complex with over 530 footnotes providing either exceptions, alternative allocations or a different category of allocation to the main table or specifying conditions of use. In addition the present approach may no longer provide an efficient means for distribution of the frequency bands between services which may share the same band (e.g. around 2 GHz, WARC-1987). However, it is recognized that many of these complexities are as a result of compromises between groups of administrations at Conferences;

- the emergence of new techniques or requirements blurs the old boundaries between services (e.g. fixed-satellite service and broadcasting-satellite service or broadcasting program distribution services available for direct, individual reception; the use of transportable Earth stations in the fixed or mobile-satellite services; new techniques enabling generic mobile services; portable telephones in the fixed service, etc.);

- some techniques overlap more than one radio-communications service (e.g. radiodetermination services with mobile communication functions; broadcasting services including paging functions; community reception of BSS; data-broadcasting for professional use, etc.);

- in some particular areas there have been radical changes in the requirements of the services on the basis of which the frequency allocations were established by Conferences convened for allocation purposes (e.g. Mobile-satellite spectrum requirements seem to exceed greatly the forecasts taken into account when the allocations were made around 2 GHz; in the HF bands there still exists a large amount of allocations for the fixed service, while other services (HF-BC) seem not to have sufficient spectrum).

The above examples indicate a need for a detailed revision of the concept of frequency allocations for radio services. Only a few ideas have been proposed on this very important matter. Though some experts advocate the suppression of the allocation tables by basing the management of frequencies onto purely economical or financial basis, drastic changes cannot be expected in a near future because the current system still needs such guidelines, it still serves positive purposes. As mentioned previously, the mandatory Table of Frequency Allocations was one of the major concepts introduced in 1947, and certain rights of usage are derived from this Table, and this factor must also be taken into consideration when revising the Table. On the other hand, those who favour gradual suppression of the allocation tables have not yet proposed detailed workable solutions as a replacement. The preparatives to the next WARC to be convened in 1992 for frequency allocation purposes in the frequency bands between 0.5 to 3 GHz (decision by the Plenipotentiary Conference, Nice, 1989) are still based on conventional allocation provisions.

Some possible improvements to the allocation tables are suggested:

- keeping rigid allocations for safety and broadcasting services where equipment standardization is important;

- merging fixed and broadcasting satellite services into fixed and distribution satellite service";

- merging all mobile satellite services into a single mobile satellite service;

- merging of radiodetermination and its associate sub-services.

Simplification of the procedures

Discussions between frequency managers and experts in trade and industry are being developed on possible "simplifications" of the frequency assignment and coordination procedures. Pressure is also being exerted on frequency managers by representatives of new services (HDTV, RDSS, generic mobile satellite, etc.) and of powerful interest groups (quasi broadcasting-satellite services). While being of the opinion that many of the Radio Regulatory procedures have made a positive contribution to the interference-free frequency use and efficient spectrum management, one could admit that many of these procedures have become extremely complex and this was recognized by the recent Plenipotentiary Conference. Some procedures may be simplified or even suppressed without much harm, such as some procedures for the Maritime Mobile Services. In this domain an in-depth analysis should be carried out in the near future to identify candidates for simplification or suppression. One approach to simplification might be along the lines of including in the Radio Regulations only sufficient detail to specify what has to be done in terms of major steps, rights and obligations, and then, leaving the details of "how" to an independent body such as the IFRB. This would have the advantage of:

- simplifying the Radio Regulations;

- providing greater flexibility in the "how".

This could be elaborated by a consultation with administrations on the "how", and then there is Res. 35 which provides a form of appeal.

Establishment of new procedures

When identifying a need for simplification of regulatory procedures, we should also recognize that in order to maintain a certain order in the spectrum for efficient and economical use some means should be found to deal with new problems such as treatment of new techniques (new sharing situations, spread spectrum, HDTV requiring more spectrum, etc.) or new operational conditions (slightly inclined orbit). These problems may raise major questions in the present system of frequency management. To illustrate this problem, let us take the example of the use for geostationary satellites, at the end of their period of life, a slightly inclined geostationary orbit. This practice is foreseen as one of the strategies for extending the operational life of geostationary satellites. When a satellite has nearly exhausted its station-keeping fuel, but otherwise operating satisfactorily its useful "in orbit" life could be extended significantly if its remaining fuel was used only for longitudinal station-keeping. While this method presents major economic advantages, it causes problems, too. In addition to the possible interference increase in other space and terrestrial networks, it may change the whole regulatory environment also. At present a geostationary satellite network should be coordinated with other registered space networks, and according to the results of this coordination the new network may then have a priority status vis-à-vis other future systems. This coordination is foreseen only between geostationary satellites. Beyond a certain orbit inclination a satellite is no longer considered geostationary and it becomes considered as "non-geostationary" and is therefore no longer included in the coordination process to be protected.

Impact of computer techniques on frequency management

The benefits of the computer-aided frequency management techniques are well known and exploited in the national administrations. The ITU, and in particular the IFRB, have made major efforts to enhance services rendered to the administrations by increasing the ITU's computer facilities in the domain of frequency management. At present almost all the data capture and publication activities on frequency assignment notices are carried out within the integrated IFRB Frequency Management System (FMS). This system contains the necessary software packages for the technical examinations foreseen in the different procedures of the Radio Regulations. All the data bases and software applications used by the IFRB may be made available for the national frequency management administrations. A further step in this cooperation is also planned, i.e. the development of the remote access possibilities. The following short and long term possibilities are being considered (for gradual implementation):

- direct access (read only) to the IFRB data bases;

- publications of the IFL on CD-ROM;

- publication of parts of the IFRB Weekly Circular on diskette;

- data capture or downloading from an administration's own national system of data for submission to the IFRB. This may also include some of the IFRB's validation tests in order to maximize the percentage of receivable notices;

- provision of some IFRB technical programs for use by administrations.

Further studies

The next decade will certainly be crucial in the ITU regulatory activities. Future legislators, i.e. national administrations having interest in settling international regulatory environments should start thinking about the possible objectives of a new framework for the international frequency management system. We have seen the need for simplification of the regulations and we have also noted new techniques and modes of operations to be still considered and included in the system. A workable solution for these regulations may well be one in which the permanent elements would be separated from those that might change with the changing technical and operational environment. The possibility of a two level regulation system should be explored, similar to some of the national frequency management legislations where the permanent elements of the governing rules are included in high level national regulations (e.g. Telecommunications Act approved by the Parliament) and the detailed rules are included in lower (government) level orders, decrees or ordinances. In the ITU context this would imply that the present, very complex regulations may be split into two (or more) parts: keeping in the Radio Regulations, approved by major WARCs, the permanent main principles of the international frequency management including an updated and hopefully a more flexible Table of Allocation, and regulating the details through lower level rules, established by a more flexible mechanism of agreements by administrations or elaborated by the existing and independent international body of the IFRB. These preliminary ideas should necessarily be further studied and probably amended. However, what would be difficult to admit is to pretend that the present rigid and complex regulatory system can operate in a very rapidly changing technical and operational environment.

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SESSION 3

SOLUTIONS

SÉANCE 3

LES SOLUTIONS

THE FUTURE FOR TECHNICAL STANDARDS

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ABSTRACT

As spectrum demands become greater, the importance of product and performance standards increases.

Most standards arise from national needs and are often unsuitable in the global village. For example, open protocols are required for worldwide telecommunications traffic. Harmonizing those standards is not an easy task as the Free Trade Agreement has shown. Setting no dates and containing no definition of what has to be done, the Agreement glosses over a detailed and controversial process.

The controversy occurs in the defence of vested interests, both commercial and political. These interests can be as small as one company's market niche or as large as the 1992 move by European countries to form one trading block with its own standards.

It is one spectrum that we all share and we must move to global standards in its use. There is a big opportunity before us in the creation of international standards. Industry and other spectrum users must strongly support that process, not just in principle, but in participation and cooperation.

Résumé

L'avenir des normes techniques

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L'importance de normes sur les produits et sur le rendement croît avec la demande de fréquences.

La plupart des normes qui sont adoptées découlent de besoins nationaux et sont bien souvent inadaptées aux besoins du village global. Par exemple, on a besoin de protocoles ouverts pour l'acheminement des télécommunications mondiales. Harmoniser ces normes n'est pas une mince tâche comme l'a montré l'Accord du libre-échange. L'Accord, en ne définissant pas les tâches à exécuter et en ne fixant pas non plus de date pour celles-ci, passe sous silence un processus détaillé et controversé.

La controverse concerne la défense de droits acquis, sur le plan aussi bien commercial que politique. Ces intérêts peuvent être aussi modestes que le créneau commercial d'une entreprise ou aussi importants que le regroupement que vont opérer en 1992 les pays d'Europe pour former un même bloc commercial possèdant ses propres normes.

Nous partageons tous le seul spectre des fréquences existant et nous devons en régir l'utilisation par des normes mondiales. Nous avons la chance inespérée d'adopter des normes internationales. L'industrie et d'autres utilisateurs des fréquences radioélectriques appuient cette démarche, non pas seulement en principe, mais dans les faits, par leur participation et leur collaboration.

GEORGE ZURAKOWSKI

THE FUTURE FOR TECHNICAL STANDARDS

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There is, in the annals of the ITU, the International Telecommunications Union, a story that shows how the international dimension of the new art of telegraphy was handled in 1852. Strasbourg stood at the border of France and the Grand Duchy of Baden and a telegraphy station was established there with one employee from the French administration and another from Baden. On the arrival of a message from Paris, for example, the Frenchman would write it out by hand on a special form and pass it across the table to his German colleague. He translated it into German and sent it on its way.

The parallel with what is now happening in equipment standards will not be lost on any of you. The story may sound laughable to us but remember that there are still parts of the world where goods are transhipped to deal with differences in the gauge of railway lines. In digital telecommunications there are international gateways where bit streams have to be converted from one format convention to another. Incompatibility is all around us. Sometimes it originates from a desire to protect domestic industries but more often it is basic commercial competition. Look at the great examples that come to mind from the world of home entertainment -regional TV standards, 45 and 33 rpm records, VHS and Beta, and heaven knows how many cassette tape standards there might have been if Philips had not made their compact cassette standard freely available.

Our competitive system has encouraged non-standardization by letting the market make a choice. But that was a local market and now we are more than ever dealing with a global market. In world terms it would be unrealistic and wasteful to have the market choose between standards. The need to internationalize our telecommunications systems and products must be deliberately addressed. It is probably an oversight that, I am told, a North American cellular unit will not access the UK system, and presumably systems elsewhere. It is a matter which is probably complicated by the billing arrangements but, if we are to believe in open protocols, thought must given to avoiding problems like that. Since the growth areas in telecommunications are so dependent on microwave communications, spectrum management has more than a passing interest in the impact of technical standards.

These trends have already been widely identified. The new president of the International Electrotechnical Commission, Richard Brett of the Australian Electrical and Electronics Manufacturers Association, has referred to two emerging trends which will have a profound impact on international standardization in electrotechnology. The first is the globalization of industry, characterized by transnational mergers and joint international projects. The other is the formation of trading blocks around the world. He has stressed the need for closer cooperation among the international standards bodies and with the regional standards groups. These opinions have been echoed by Roy Phillips, the President of the International Standards Organization who, several months ago, called for closer cooperation between ISO and IEC. As a former President of The Canadian Manufacturers' Association he is no stranger to the problems of standardization and is a staunch supporter of rationalizing the system.

I mention the opinions of these two leaders of international standards organizations to indicate that the concern for harmonized standards is worldwide and reaches to the top. Do we have reason to be optimistic about the trend to global standardization? To answer that question, let's consider recent developments in Japan, in Europe, and in North America.

Japan has long been considered an impenetrable market for North American manufactured products. A unique set of product standards was just one of many mechanisms which excluded foreign goods. Recently, under intense pressure from the United States and other trading partners, Japan has radically reduced the number of products that require certification by the Ministry of International Trade and Industry. In addition, Japan has designated a number of foreign laboratories to undertake product testing where it is necessary. While I am sure that we would still not define Japan as a free market this recent development suggests many products are now entering Japan based on their conformity to international standards rather than an onerous regional standards regime. We can only hope that Japan will continue to open its market to foreign manufactured goods in this fashion.

Let us next turn our attention to Europe. It is worth spending a little time on what we now know about the future of product standards there. The European Community 1992 directive raises some intriguing questions as to the type of standards regime which North American manufactured goods will face in that marketplace.

Extracting information on this subject from the European Community in Brussels is not easy and influencing its actions is even more difficult. A recent article described the situation as follows:

> "The EC has 25,000 civil servants distributed among three institutions: the European Commission, the Council of Ministers, and the European Parliament. In its almost medieval complexity, the EC combines elected officials who have no legislative power with civil servants who enact laws. The Commission members, the most prestigious and visible officials of the European legislative process, are politically appointed. The Parliament, which is directly elected, has no legislative power. The Council of Ministers, the body that finally enacts law, is not elected."

To facilitate the development of a unified internal market, the Commission is preparing technical directives with respect to standards. These contain very general "essential requirements" which are mandatory in nature and are applicable to regulated products. The standards bodies have been instructed to prepare voluntary standards to define means of meeting the essential requirements. These standards will flesh out the essential requirements spelled out in the directives. It is expected that approximately 2,500 standards will be required under EC directives to be prepared by CEN (the European Committee for Standardization), CENELEC (the European Committee for Electrotechnical Standardization), and ETSI (the European Telecommunication Standards Institute). These organizations have a mammoth task to prepare the required number of standards by 1992.

A great concern to North American industry has been the closed nature of the process for developing EC standards. This is in marked contrast to the North American system of developing standards which allows participation from the outset by other countries. As you know, Pacific and European companies are active in the North American standards process.

A few weeks ago, the Department of External Affairs announced that it had reached agreement with the European Community to provide draft copies of EC standards to the Standards Council of Canada with a six-month comment period. EEMAC has offered to assist the Standards Council of Canada in undertaking a technical assessment of these draft standards.

Thus, we see that Europe has an ambitious goal. By 1992, it has undertaken to produce a uniform set of product standards to be based as far as possible on international standards which are to be used through the twelve countries of the European community. For the North American manufacturer this process offers many benefits, the most important of which will be the requirement to have a product meet only one standard to give it entree into the twelve countries of the community. This is certainly to be preferred over the present plethora of European standards. Unfortunately, North American manufacturers have had no input into the development of these standards and North American standards philosophy will only influence the EC standards to the extent that we, in North America, have participated in the international standard setting process. This further reinforces the need for Canadians to be participating in IEC activities.

The process being followed for the development of European standards in relation to regulated products, like telecommunications, is fairly clear. It is certainly not clear what standards will be used for unregulated products. These could be either international standards or one of the European country's national standards. We, in North America, will obviously have to pay great attention to the announcements regarding standards for unregulated products.

How will North American manufacturers be able to demonstrate conformity with EC standards? EC directives spell that out and the requirements will vary with the degree of hazard presented by the product. In some instances, the manufacturer can simply declare conformity to the applicable standard. In others, a third party certification will be required. These processes are described in certification modules and the EC directives will list all of the possible modules applicable to a given product. Thus, the manufacturer has a choice of which modules to use and, obviously, the choices will be influenced by factors such as the risk of product liability, practicality, and costs.

One fact is clear - North American manufacturers wishing to market products in Europe will have to meet quality assurance programs described in the EN 29000 series standards, essentially a duplication of the ISO 9000 standards. The quality system in a plant must be registered by an accredited organization. There are several organizations within North America, including CSA and UL, that are offering to register plants to ISO 9000 and the identical EN 29000. It is not clear if such registrations will be accepted in Europe.

The EC has adopted a single community mark, a CE mark, which can be placed on products or containers to indicate conformity with the essential requirements but not necessarily to all of the provisions of the European standard which go beyond the essential requirements. The CE mark signifies that the manufacturer or testing organization have carried out the relevant conformity assessment operations. The CE mark serves as a passport to enter the European market. It does not assure acceptance in all the jurisdictions of Europe where local requirements and national treatment may exist for some period of time.

It appears that North American manufacturers will have open access to the EC product approval process. The EC policy states unequivocally that any foreign manufacturer can sell in the community on the same basis as a European manufacturer, that they may use the EC mark under the same compliance modules, that where third party certification is required foreign manufacturers will be eligible to have their products approved by an appropriate testing lab. In other words, equal access is provided for foreign manufacturers.

But can this whole process be carried further? Will CSA and UL, for example, be able to certify products to European standards? Obviously, if the European community grants equal access to North American products and were to allow North American certification bodies to test products to EC standards, what will Europe demand in return by way of access to the North American marketplace? This is a rather profound question that will evolve over the next few years. We must obviously give some serious thought to what we are prepared to give up in order to have unlimited access to the European market.

Despite the uncertainties for us in Canada, I believe we would all applaud the direction that the European community is taking in developing a unified set of standards, particularly if they adhere closely to international standards. There is no doubt in my mind that the process taking place in Europe will severely challenge our North American standards setting process over the next few years. I think that we will be forced to reconsider our North American way of doing things and the need to maintain unique North American standards.

Let us now turn to the third area, that is the harmonization of North American standards. Chapter IV of the Free Trade Agreement calls on Canada and the United States to "endeavour to make respective standards related measures more compatible to reduce the obstacles to trade, and the costs of exporting which arise from having to meet different standards." Chapter IV then elaborates in very general terms on this basic principle. It does not provide specific goals for the harmonization of North American standards, nor does it set a timetable for the completion of such a process.

One would expect that the harmonization of North American standards would be a relatively simple task in comparison to that being undertaken by the European community. We have the benefit of a common electric power system and a common telecommunications network. Many manufacturing companies operate both in Canada and the United States and with product standards which are similar but not identical it would appear that harmonization would be within our grasp.

Unfortunately, North American standards harmonization has been agonizingly slow. And we started on the process long before the Free Trade Agreement was signed into law. CSA and UL signed a Memorandum of Understanding on this matter as long ago as 1986. In my view, North American industry has not taken the aggressive leadership role that is required to expedite this process. In addition, CSA and UL increasingly find themselves as competitors in the North American market rather than collaborators working under an MOU.

In recent weeks there have been some encouraging announcements as the standards organizations are going to seek ways to implement harmonization and the moves toward the mutual acceptance of test data for certain product items are encouraging. Despite the steps in the right direction, however, it is my belief that, under the present conditions, a vision of North America where each product could be marketed under a single product standard and with a single certification test is far off in the future. Last week in Washington, for example, UL stated that it had grave reservations about the development of North American product standards and had no enthusiasm at all for a single North American certification mark. It is my conviction that, if we are to achieve North American harmonization of standards, and I believe that end is highly desirable, we in industry must vigorously and relentlessly pursue this objective. We, in industry, should set the agenda and we, in industry, should set the timetable and drive the process.

If we believe in the principle of Free Trade in the ever expanding global marketplace, then in my view a corollary to Free Trade is the development of global standards systems. As I have briefly indicated, in all the major markets of the world standards are in a state of ferment the like of which has never been seen before. It is difficult, however, to detect any unity of purpose in the processes which are taking place. There is no grand celestial plan and for me, at least, it is difficult to predict the overall outcome of the various processes for change that are taking place. I have reached one inescapable conclusion: Canadian manufacturers must dramatically increase their participation in the international standard setting processes. It is by this means that Canada, a relatively minor player on the world manufacturing scene, can exert any influence on the direction of world standards. It's unfortunate that this increased need for participation in an expensive and time-consuming international process has come at a time when Canadian industry is losing many of its standards veterans and these individuals are frequently not being replaced. In addition, budget restraints by industry and government are making it increasingly difficult for Canadians to participate on the international standards stage.

The resources consumed by the standards setting operation are huge but the stakes are high. International standards aside, the task of dealing with CSA standards and the harmonization of North American standards places a heavy load on industry. It comes at a time when corporations have become leaner with thinning having taken place in the very middle management ranks from which we have traditionally recruited the support for standards work. The challenge is to be able to attract competent young engineers into standard writing. Perhaps this can only be done if their corporate leaders publicly endorse the great importance of this work.

Having a world market for a uniform product is a marketer's dream. But the marketers seldom participate in the huge international standards meetings where most attendees are observers and the actual standards writing is done by a relatively small group of people. Canada is not a big player in this arena but should do more than it is doing at present. The Standards Council of Canada, which accredits participation in international conferences, has undergone heavy budget cuts recently. It is a quasi-government organization and is therefore very acceptable in the European Community where things are done that way and organizations set up like that are considered impartial.

In the US it is done in a slightly different way. There is no organization similar to the Standards Council. Industry associations decide the area in which they are going to participate and then fund the activity. Once that commitment has been made it is sanctioned through the American National Standards Institute (ANSI). Industry sees itself as having control and direct access to the process since they provide the human and financial resources. Industry in Canada should, I believe, play a larger role in the process and should, like the Americans, be prepared to supply the active participation and funding needed to get the job done.

Despite all the difficulties inherent in standards there is reason to be optimistic about the future. A slow move is beginning towards harmonization at least within the trading blocks. It may take longer to get meaningful cooperation at the international level but the will to do so is starting to show. Telecommunications standards are being driven by a further factor. 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 they need, and are working for, world standards. Untold benefits could result from any degree of standards harmonization and spectrum management would be a likely beneficiary. The events taking place in Japan, Europe and North America could mean that, in conjunction with the existing ITU standards, de facto world telecommunications standards and a process to maintain them could emerge. Let's hope so.

A BROADBAND URBAN FIBER TELECOMMUNICATIONS NETWORK

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ABSTRACT

A new fiber based architecture has been developed that allows evolutionary growth in cable television system capacity and quality. The capability of delivering over 150 high quality National Television Standards Committee (NTSC) or some equivalent number of fewer high definition television (HDTV) video signals to subscribers is possible without requiring fiber to the home. Segmenting large urban cable television systems into 8,000 home areas also substantially increases the flexibility of the transmission infrastructure allowing it to support other telecommunications facilities such as cellular telephone cell interconnections and broadband business communications links. Deployment of fiber in this way may help to alleviate some of the demand for spectrum, but does not totally eliminate the traditional requirements for radio.

Résumé

Réseau urbain de télécommunications à large bande, à fibres optiques

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Une nouvelle architecture utilisant les fibres optiques a été mise au point et permettra l'augmentation progressive de la capacité et de la qualité des systèmes de télévision par câble. Cette architecture permet de distribuer aux abonnés plus de 150 signaux de grande qualité selon le standard du National Television Standards Comittee (NTSC) ou un nombre équivalent ou inférieur de signaux vidéo de télévision à haute définition (TVHD), sans qu'il soit nécessaire que le domicile de l'abonné soit raccordé au moyen de fibres optiques. La segmentation des grands systèmes de télévision par câble en région de 8 000 foyers augmente en outre la souplesse de l'infrastructure de transmission en permettant de desservir d'autres installations de télécommunications, comme le raccordement des cellules du service téléphonique cellulaire et l'établissement de liaisons à large bande de communications d'affaires.

Cette façon d'utiliser les fibres optiques promet d'alléger en partie la demande de fréquences, mais elle n'élimine pas entièrement les besoins traditionnels dans le domaine des radiocommunications.

INTRODUCTION

Cable system network architectures in urban centres must undergo substantial changes in topology if they are to adequately meet the transmission challenges of the next decade and provide an infrastructure for new revenue producing transmission facilities.

The demand for additional video channel capacity will persist. The demand for substantially higher quality television signals will escalate as the population moves towards larger screen TV receivers with higher resolution capabilities. The introduction of advanced television formats means anything but near perfect transmission will be considered unacceptable.[1,2]

Accommodating additional channel loading severely stresses existing coaxial technologies, especially in larger networks. Simultaneously, achieving substantially superior transmission quality while accommodating the extra channel loading becomes an engineering challenge not seen by the cable television industry since the early innovative days of trying to operate cascaded amplifiers at very high frequencies (VHF).[3,4]

Customers are not only demanding quality, they want reliability. Their tolerance for interruption in video services rapidly diminishes as monthly rates increase. Customers taking non-programming services such as data transmission for businesses or private network voice communications are totally intolerant of interrupted service. Yet the incremental revenues from these sources are essential for the industry's growth. Compounding the foregoing challenge is the need to control rapidly increasing operating costs and to somehow accommodate the growing reluctance amongst field personnel to working outside normal business hours. Whatever technology is devised to meet the performance and reliability objectives of the 1990's must also address this operating issue through the provision of effective diagnostic aids and automation of transmission circuit and equipment redundancy.

Rarely can cable television engineers start with a clean slate in developing an optimum architecture to meet the foregoing challenges. They must take an existing network and devise an evolutionary approach in upgrading that network while utilizing as much as they can of the existing infrastructure to conserve capital while providing minimum interruption to the on-going cable services. Many cable operators are confronted with this challenge. For competitive reasons, existing plant has to be rapidly upgraded for at least 58 channel capacity and in some markets 77 channels or more. Simultaneously, transmission quality must be substantially improved for television signals with a target of 49 dB carrier to noise at the subscriber's outlet together with non-linear distortion performances equal to or better than that presently provided at the present lower channel loadings.[5]

In general the existing coaxial cable itself, the cable supporting strand, and other hardware are quite sound, so logically should be utilized as much as possible. Furthermore, it is also logical to implement the new architecture utilizing existing cable routes due to the difficulties in obtaining access to utility structures especially in major urban centres. Trunkline bridging amplifiers, distribution and feeder cables should remain as presently located, as should equipment vaults, pedestals and ducts.

An initial architecture was derived based on current coaxial technology, utilizing high performance feed-forward configured electronics trunk line amplifiers, multiple amplitude modulated microwave links to distribution nodes (hubs), back-up supertrunks and other conventional approaches.[6] The performance requirements could be met, however the complexity of the hubbing network, the very high demand on alternating current (AC) power, a very large number of active components and limited ability to evolve past the 77 channel capability make the exercise cost ineffective and operationally unattractive.

Engineers at American Television and Communications (ATC), a Multiple System Operator (MSO) in the U.S., have set forth ideas concerning the use of fiber optics to upgrade existing cable television plant which are much more attractive than conventional techniques.[7]

Encouraged by these ideas, an upgrade architecture was devised applying fiber optic technology. The cable industry was already familiar with using fiber optics for a number of specialized programming feeds. Canadian cable engineers also had some earlier experience with multiple channel digitized video transmission over fiber links.[8] Operationally, the use of fiber seemed very attractive due to the minimization of cascaded repeater electronics so the rebuild and upgrade plans were prepared accordingly. The architecture adopted is explained in the following paragraphs.

HUB DEPLOYMENT

The deployment of fiber to connect many newly created hubs allows evolution of the cable television network to meet the future needs of higher channel capacity and signal quality referred to earlier. The establishment of additional hubs is needed to reduce the length of amplifier cascades, the key to achieving the above goals. An additional benefit of the hub configuration is the capability to configure a wide area network, with redundant paths between hubs, to provide cable television signal distribution and a support infrastructure for reliable data transmission with very high reliability.

The upgrading of plant to 550 MHz and improvement of carrier to noise ratio (CNR) to 49 dB at the subscriber outlet requires trunk cascades be restricted to 10 feed-forward amplifiers.[9] The establishment of additional hubs allows existing trunk and feeder cable to be left as is. Existing trunk amplifiers are upgraded but no respacing is required. Approximately half of the amplifiers need to be turned around since long cascades will be broken mid-span. A study made on all Rogers' cable divisions in Canada showed it will require approximately 200 hubs to service 1,600,000 subscribers with 550 MHz capacity which supports 77 video channels. The hub structure will be able to support capacity upgrades to 150 channels when required.

The 8,000 home areas served by each hub are effectively miniature cable systems. Reliability will be much higher and maintenance will be easier due to the substantial shortening of repeater cascades. In urban regions, these areas are approximately 10 square kilometres in size. This degree of network segmentation forms a very convenient architecture for supporting the interconnection of fourth level cells in a cellular radio network and multiplexing/bridging nodes for a high speed metropolitan area data network. This infrastructure in a dense urban area can service most intracity broadband data and voice transmission requirements. The voice channel based infrastructure of telephone networks is not as well suited to video or high speed data. With an analog based fiber infrastructure, it should be possible to drastically reduce the need for radio spectrum in the more congested urban areas of Canada. In particular, fiber interconnection of fourth level cellular sites alleviates the need for a large number of digital microwave radio links.

The additional benefit from cooperation with a cellular operator is the sharing of common facilities at the hub sites. In particular, savings may be realized through shared powering, environment control, real estate and fiber cable installation services. These costs are a very significant issue when building a broadband urban network.

In large cable systems, exceeding approximately 100,000 subscribers, the hubs must in turn be grouped and are best served by **Primary** Hubs via amplitude modulated vestigial side band (AM/VSB) on fiber. The number of Primary Hubs should be kept to a minimum due to their high cost in terms of equipment, environment control and real estate (approximately 8 times the cost of a Secondary Hub). This grouping is necessary to limit the maximum fiber path length to 15 km from a Primary Hub to all hubs. This limit is imposed to support AM links with 56 dB CNR and 15 channels per fiber. Table 1 shows the budgeting of noise and distortion among the various video transmission segments of a hybrid fiber/coaxial cable television system. Not included is the quality of the source signal to the Primary Hub backbone. A direct broadcast feed is desirable to avoid further signal deterioration. A very high quality backhaul link between the television broadcasters' facilities and a Primary Hub will provide optimum delivery of both current NTSC as well as new HDTV signals to all cable subscribers. Since over 85% of urban television viewers are connected to cable this a practical method of delivering the highest quality possible to almost all viewers.

TABLE 1

550 MHZ PERFORMANCE ALLOCATIONS

	CNR	**CTB**
Primary Hub Backbone	60 dB	-65 dB
Secondary Hub Supertrunk	56 dB	-65 dB
Coaxial Trunk (10 Amps)	55 dB	-62 dB
Distribution	57 dB	-60 dB
System Total	50 dB	-51 dB

Note:

1. CTB CW Specification
2. For worse case configuration (9 medium gain trunk stations, a dual output bridger module and 3 line extenders) at 50°C the system CNR may degrade by 1 dB to 49 dB.

CNR - Carrier to Noise Ratio
CTB - Composite Triple Beat
CW - Continuous Wave

The Primary Hubs are served by a **backbone** fiber network that employs either digital or frequency modulation (FM) carriage of the video signals to deliver 60 dB signal to noise ratio. The choice of FM or digital depends on the distance between Primary Hubs and the number of times signals are repeated. Digital is preferred where either of these are large. Due to its critical nature (it serves essentially 100% of all subscribers), redundant backbone routes are utilized to ensure continuity of transmission should a path failure occur. Figure 1a illustrates the ring configuration as applied to a multiple Primary Hub system. Each Primary Hub may launch signals for delivery to any other hub(s), or act as termination points for intercity links so a distributed headend is effectively created. All hubs receive a total complement of signals on each of two feeds. The signal flow path illustrated is that for signals originating at York Mills. In the event of fiber breakage, the redundant paths are used to serve affected hubs as illustrated in Figure 1b.

It is not always possible to cost effectively implement this ideal ring architecture, particularly in rural areas. A fiber backbone will often be possible for primary transport. The backup facilities will often be microwave radio. In general, microwave will be less prevalent in urban systems but remain critical to providing reliable cable television service in more sparsely populated areas of the country.

PRIMARY HUB SIGNAL PROCESSING

The signal processing at each Primary Hub is illustrated in Figure 2. Fibers are depicted entering the hub from two directions, referred to as East and West. Several receivers and transmitters are connected to fibers for each direction as it is assumed that several fibers are required to provide sufficient capacity for the number of signals to be carried. The following paragraphs further explain the generic structure depicted.

A set of broadband A/B switches selects between East or West signal feeds as required for normal or back-up operation. A splitter for each broadband switch output delivers signals to each of the FM video demodulators, which are remotely tunable. Remote tuning facilitates substitution switching of programs from the control centre for the network. Alternatively, a demultiplexer separates the channels in a multiple video channel digital transmission system.

FIGURE 1(A): SIGNAL FLOW UNDER NORMAL CONDITIONS

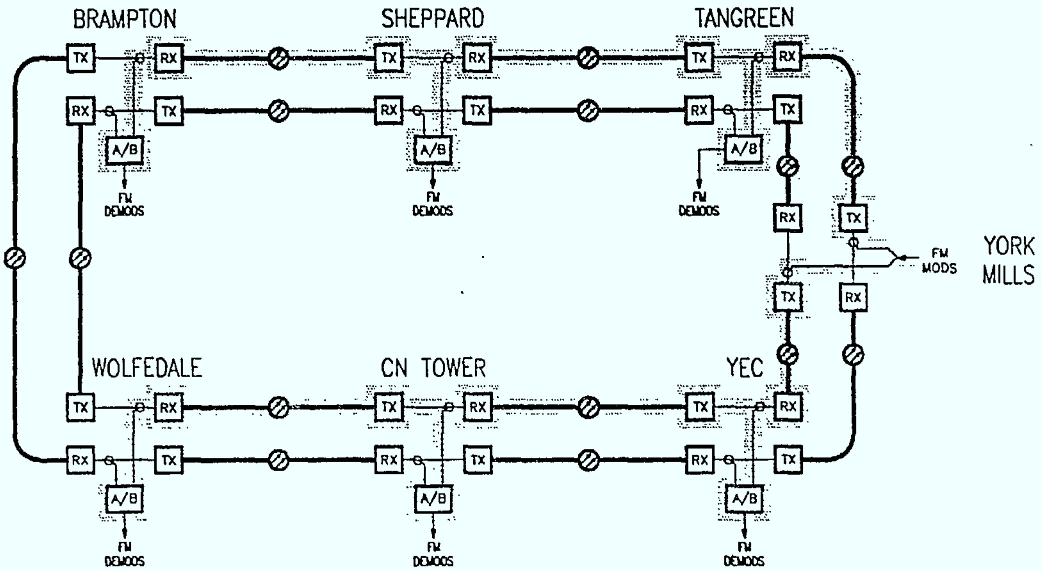
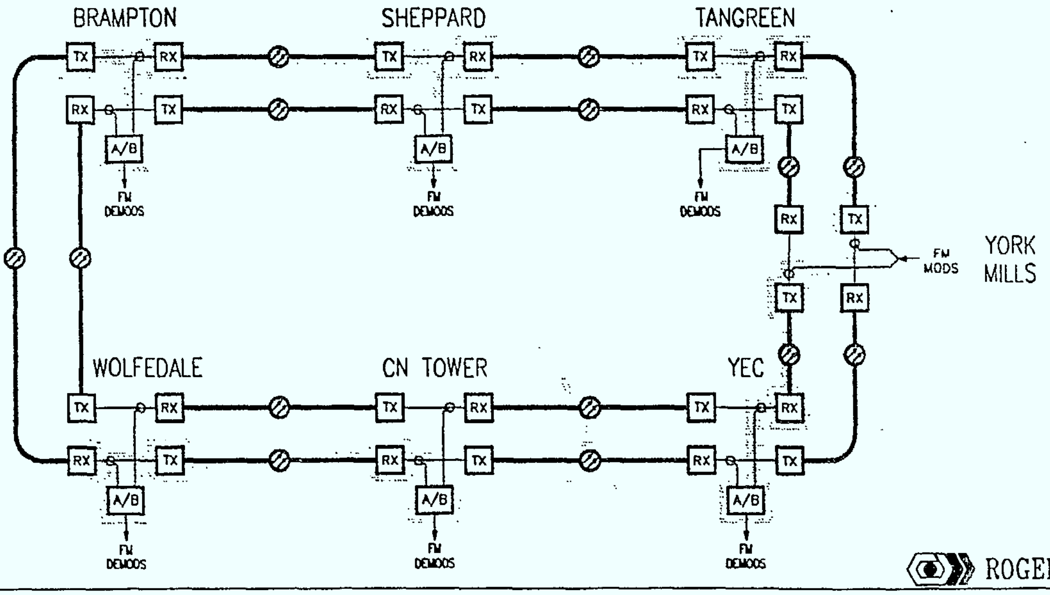
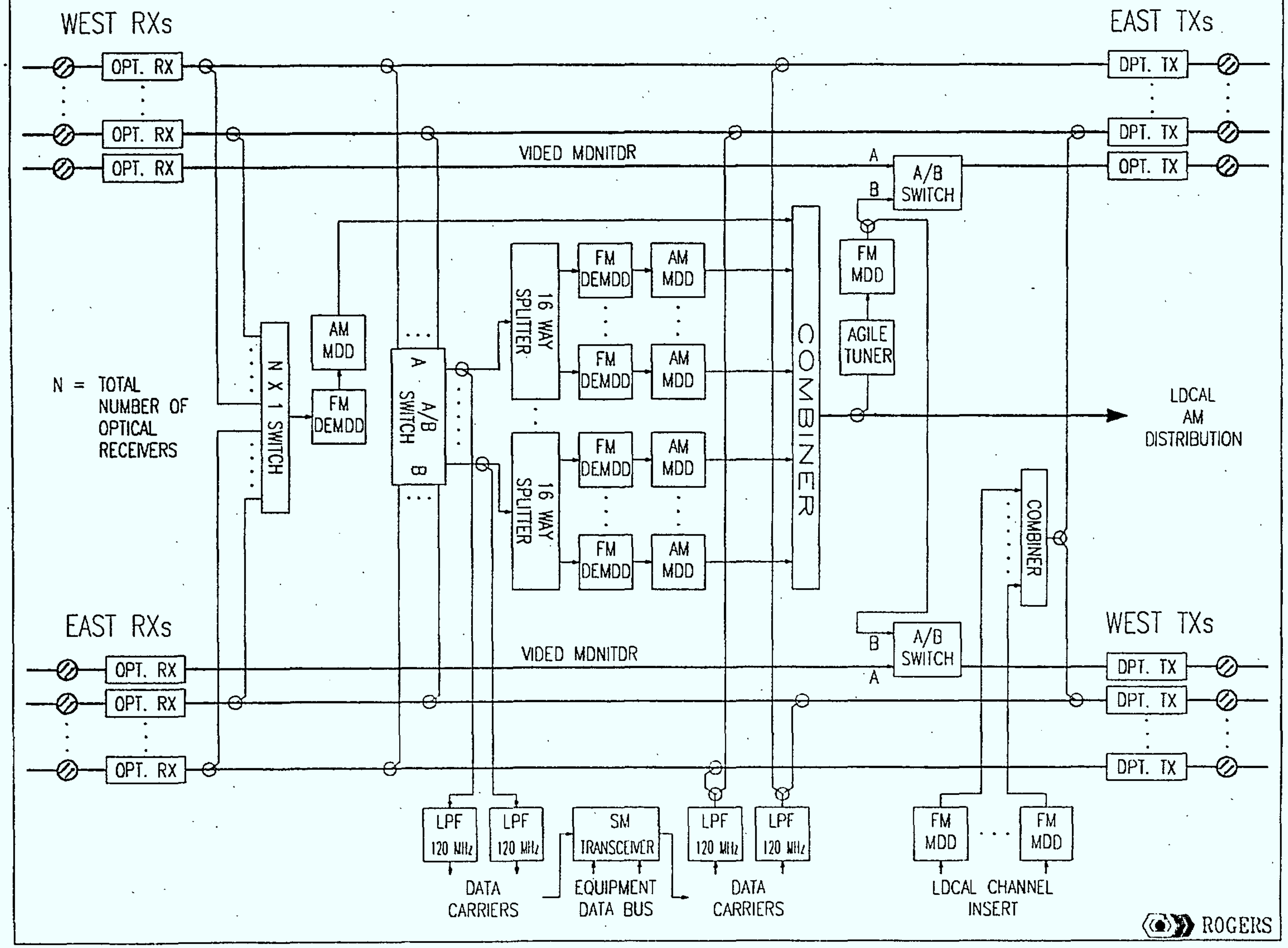


FIGURE 1(B): SIGNAL FLOW UNDER BACKUP CONDITIONS



ROGERS

FIGURE 2: PRIMARY HUB PROCESSING



Each broadband switch output is tapped for serving radio frequency (RF) data modems. Data carriers are envisaged on each fiber link, frequency division multiplexed below 120 MHz and approximately 15 dB lower than the video carrier levels. Similarly, optical transmitter inputs have couplers to allow insertion of data modem RF carriers into both East and West transmissions. In the case of digital transmission, supplementary low speed (several MBits/s) digital channels are typically available for data and audio signals. A broad range of data rates can be supported by the network to satisfy the transport requirements of any user without being constrained by switching electronics. All switching performed in the network is for redundancy only and is done effectively at broadband.

All cable television signals available from the optical receivers, whether from East or West, are switched to a spare agile FM demodulator and agile AM modulator for monitoring purposes. This equipment also serves as back-up to the normal complement of FM to AM conversion hardware described below, and is therefore fed to the combiner for launching onto the cable television distribution network. In order to achieve the desired hardware back-up described, it is necessary to be able to remotely mute the output of each AM modulator. In this way, the agile FM to AM conversion equipment can be tuned to replace on-channel any set of defective FM to AM conversion hardware. A similar failsafe scheme can be devised in the case of digital transmission.

Each video signal to be delivered to a Primary Hub via the backbone fiber network is demodulated to composite baseband complete with 4.5 MHz audio subcarrier. The composite signal is then AM modulated and available as Amplitude Modulation/Vestigial Sideband (AM/VSB) at the Intermediate Frequency (IF) of 45.75 MHz. An upconverter transfers the signal to its on-frequency assignment. The output of the upconverter can be muted remotely via the status monitor and control system. This is required to allow the agile upconverter to replace a failed unit or achieve substitution switching. The equipment is capable of processing some types of baseband scrambling employing sync suppression techniques.

A remotely controlled agile AM demodulator receives signal from a tap off the combined AM output of the Primary Hub electronics. The output of the demodulator is connected to a FM modulator capable of transmitting video and audio to RS-250B short haul specifications. Remote monitoring of any AM channel is achieved by selecting the appropriate AM tuner frequency. The output of the FM modulator is inserted onto both East and Westbound dedicated fibers via A/B switches for delivery of the selected channel to the network monitoring centre. The FM modulator output is normally muted to allow shared use of the same spectrum by all hubs. Only the hub being monitored transmits a signal on this shared spectrum.

Video signals originating at any hub are FM modulated or digitally encoded, as appropriate, and inserted onto fibers both East and Westbound. A unique fiber and frequency allocation is made for each signal since all signals must reach all hubs via two separate paths without collisions.

The same techniques used to transport very high quality video for cable television distribution can be applied to point-to-point or point-to-multipoint video transport for private networks. A fiber infrastructure shared by a multiplicity of users and traversing a city interconnecting hubs spaced every 3 km. is within connecting range of any urban user.

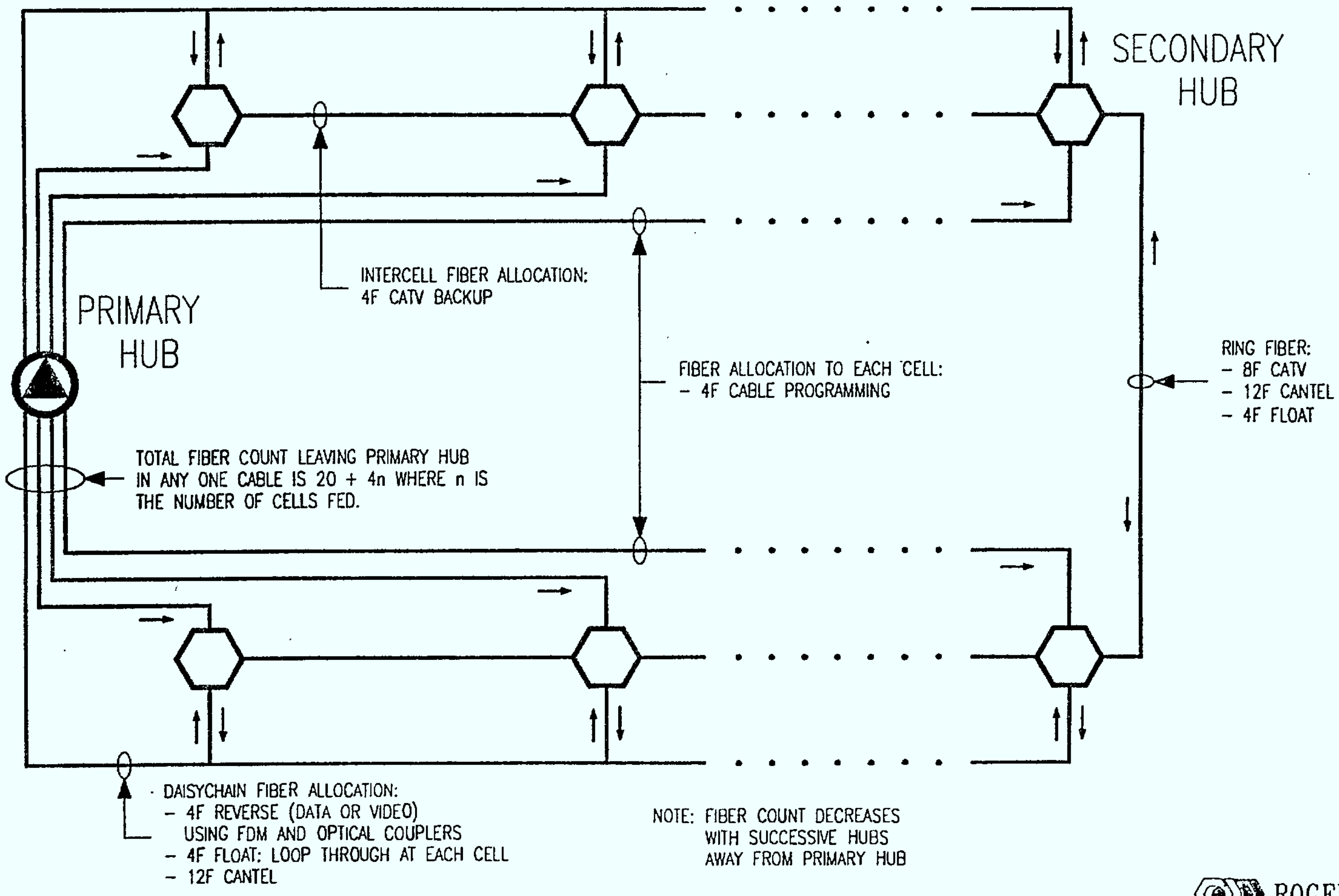
SECONDARY HUB INTERCONNECT

Each **Primary** Hub serves approximately fifteen **Secondary** Hubs. Each secondary hub serves an average of 8,000 homes. The signal format leaving the secondary hub is AM, initially on coaxial trunks but eventually on fiber to support channel capacity greater than 77. The Secondary Hubs are connected in a number of rings with typically five to eight hubs per ring. The size of the ring is limited by the capabilities of the current AM on fiber equipment performance. As performance improves, the current 7 dB optical loss limit will improve allowing greater distances between Primary and Secondary Hubs and hence potentially fewer Primary Hubs.

The 77 cable broadcast signals are delivered on four dedicated fibers to each hub. This connection scheme is illustrated in Figure 3. Additional capacity is available by using the second optical wavelength to support future interactive video services.

A hub to hub allocation of four fibers has been made for redundancy of cable broadcast signals. Should the normal path fail, the 77 broadcast signals can be fed to affected hubs from the opposite direction, albeit at reduced quality. A failsafe switch senses the loss of primary feed and connects the hub to the alternate signals available. Hubs are spaced approximately every

FIGURE 3: REDUNDANT RING CONNECTION OF HUBS



ROGERS

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3 km, which corresponds to fourth level cellular telephone cells. The low optical loss between hubs (approximately 2 dB) means that a transmitter at a Primary Hub will be able to serve a number of Secondary Hubs. Similarly, transmitters are not required at every hub to supply backup signals to its upstream neighbour. Rather, a total loss budget of 10 dB is allowed in the backup path which accommodates several hubs, with couplers at intermediate hubs, before retransmission is required.

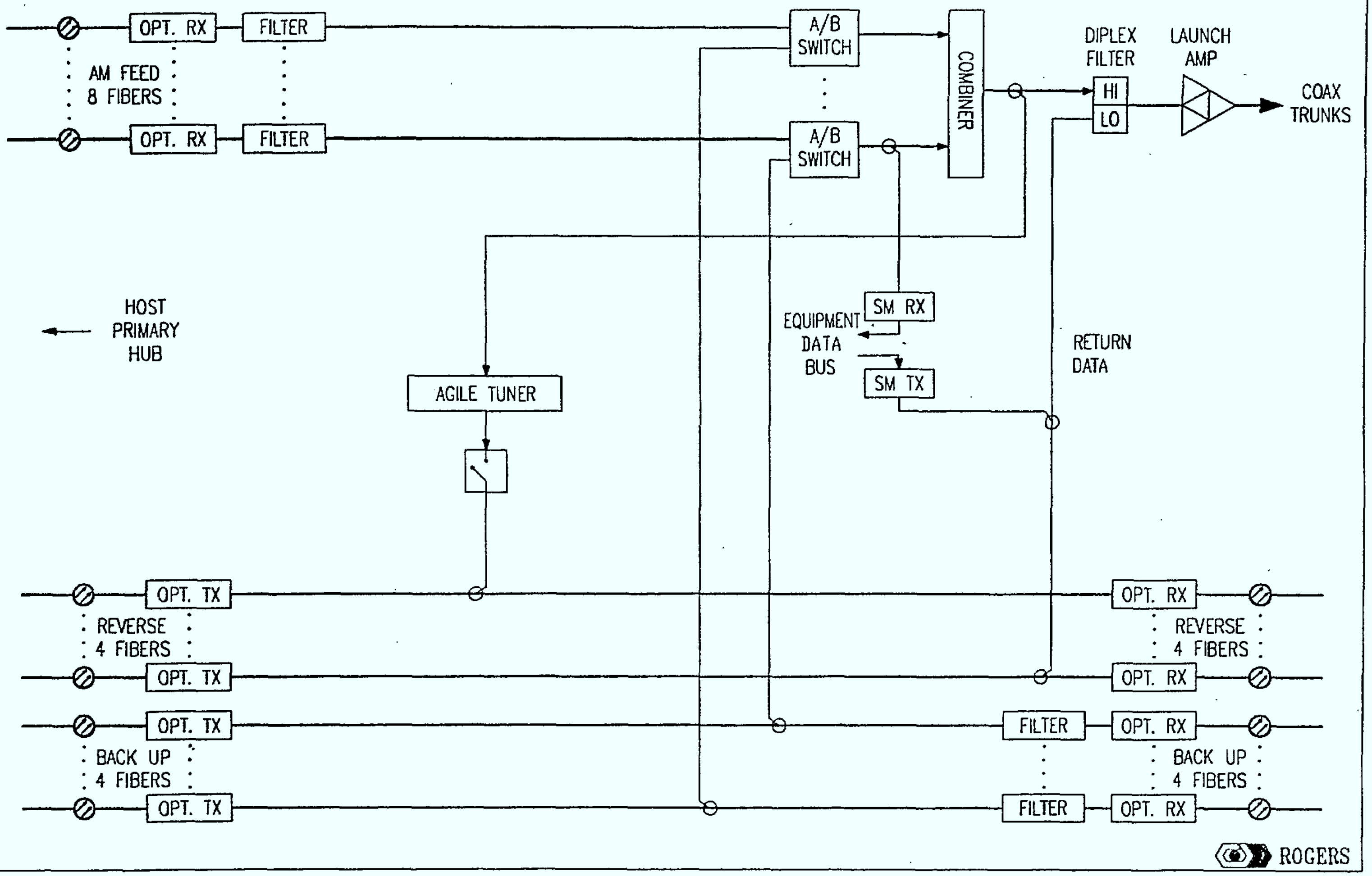
In rural areas, hubs may be connected in strings leaving a Primary Hub, rather than rings. In this case the backup system would normally be microwave radio. The failsafe switch in this configuration selects a microwave receiver output if the fiber link fails.

In addition to cable television signals, the hub interconnect cable supports the requirements of cellular telephone cell interconnection and high speed business communications with 12 daisy chained fibers. There are also four fibers allocated to reverse residential data communications and network monitoring and an additional four spare fibers in the daisy chain which may be allocated to multipoint distribution of audio, data or video for private networks. The network monitoring signals include the carriage of status information from the terminal equipment at each secondary hub to the Primary Hub. These monitoring signals are crucial to maintaining a very high degree of transport reliability for all signals being carried.

A block diagram for the secondary hub is shown in Figure 4. Redundant fiber paths are illustrated, with receivers allocated to each. A coupler in the output path allows any signal delivered to the hub to be monitored via the agile tuner. The output of the tuner is switched onto the reverse fiber under the control of the status monitor system and delivered to the host Primary Hub where it is connected into the video monitoring hardware.

A set of A/B switches selects the back-up fiber paths in the case of failure in the normal link. A combiner and diplex filter prepares the AM video signal for delivery to a launch amplifier and injection onto coaxial trunk cables. The 5 - 33 MHz return signals carried on two-way coaxial cable plant for pay per view, and other interactive services are combined with other return data onto the reverse fibers for delivery to the Primary Hub.

FIGURE 4: SECONDARY HUB PROCESSING



Signal quality requirements for cable television at the Secondary Hubs dictate that the transmission path from Primary Hub to Secondary Hubs exhibit a signal-to-noise ratio of 56 dB for the television signals (see Table 1).

It is important that the terminal electronics of the secondary hub not occupy more space than one rack and preferably less to facilitate outdoor placement. This includes the optical transmitters required to serve optical bridgers.

OPTICAL BRIDGER

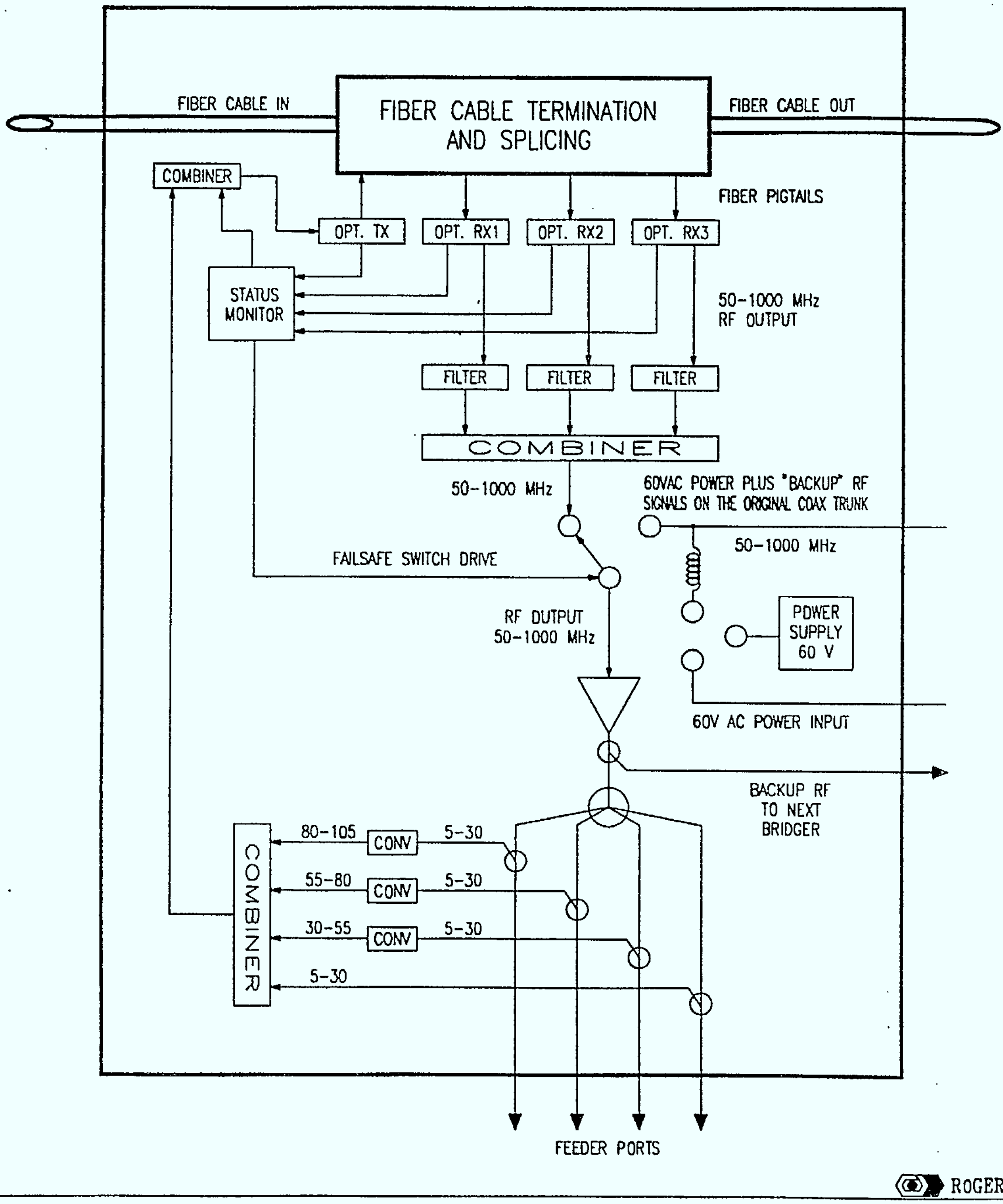
The expansion of transmission capacity beyond 77 video channels to as many as 150 is accomplished by extending fiber beyond the Secondary Hubs to serve individual trunk bridging locations. A fiber to coax interface device, termed the **optical bridger**, will be located at each conventional bridger amplifier. This is interconnected by four dedicated fibers which launch up to 150 channels onto coaxial based distribution feeder plant which in turn delivers signals to approximately 200 homes. Figure 5 illustrates the functional elements for an optical bridger.

The large number of channels available (uniquely, if desired, since dedicated fibers feed each optical bridger in a star configuration) makes possible all of the interactive video services being discussed by Broadband Integrated Services Digital Network (BISDN) proponents.[10] When fully implemented, no residence or office will be more than a few hundred meters from a broadband fiber node.

Provision for four fiber terminations are made to support three receivers and a transmitter within the optical bridger. Delivery of 150 channels requires that each receiver process 50 channels which are subsequently combined. The launch amplifier may be either a single block as depicted or each receiver output could be amplified separately and then combined. The decision is one of economics for the level of performance required. It is currently budgeted (see Table 1) that the AM fiber optic link performance to the optical bridger (4 km maximum) will need to meet a carrier-to-noise ratio of 55 dB for 50 channels.

An A/B switch is incorporated to allow back-up support to the fiber based equipment by using the existing coaxial trunk cable. Performance will be

FIGURE 5: OPTICAL BRIDGER BLOCK DIAGRAM



inferior in the back-up configuration but at least limited service will be maintained in the case of failure. Status monitoring equipment in the optical bridger is consistent with a philosophy of a comprehensive system to maintain high quality and reliability. Signal loss is detected by the monitoring electronics and switches the A/B selector to the back-up path.

Interactive subscriber data in the 5-33 MHz range is separated from the feeder cables and combined with a status monitor signal for upstream transmission via a laser transmitter. Upconverters may be added, as shown, to augment the signal carrying capacity in the upstream direction.

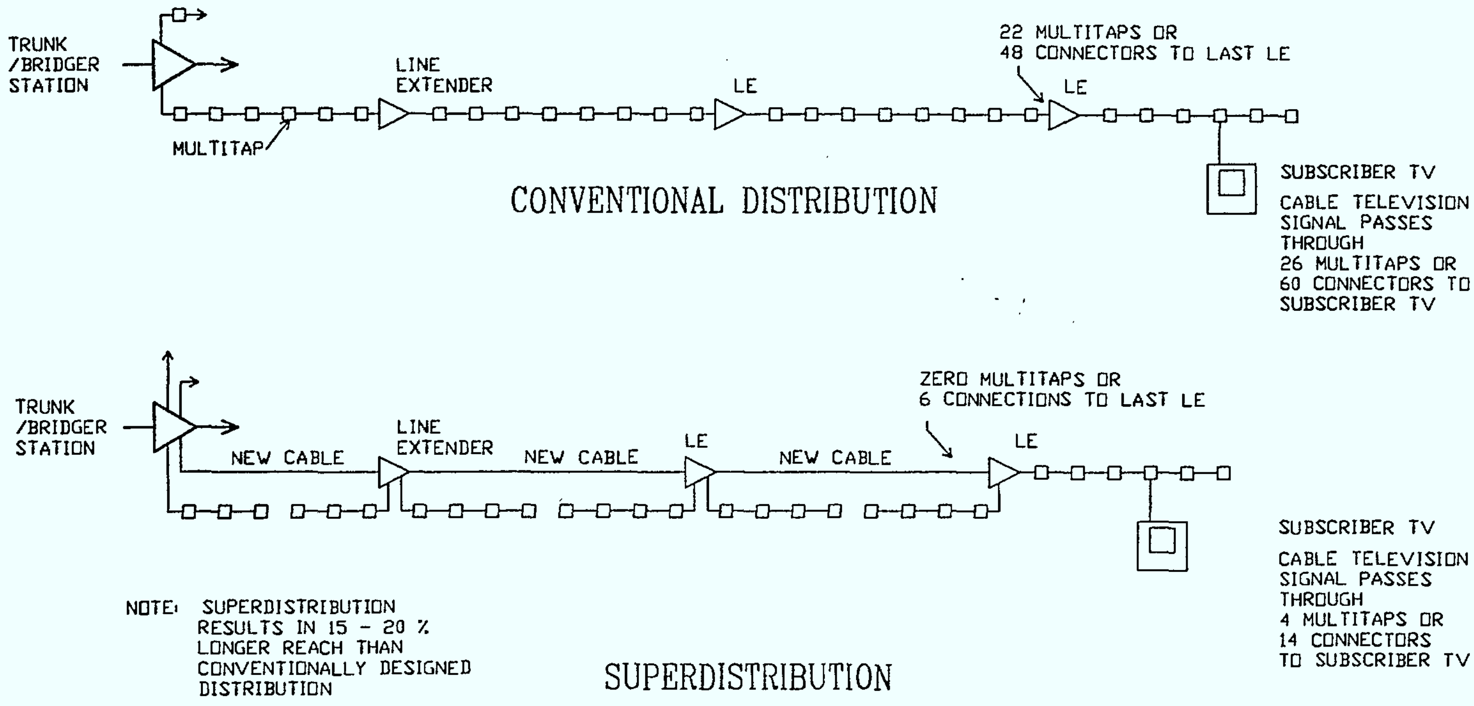
Powering for the optical bridger may be via the existing trunk cable or through a separate powering port. In either case, conventional 60V AC powering is envisaged.

SUPERDISTRIBUTION

With the fiber network able to deliver 150 or more channels to the bridger locations, it is necessary to devise a coaxial feeder architecture with commensurate transmission performance and capacity. A novel feeder concept termed **Superdistribution** fulfils this requirement. Super-distribution (See Figure 6) uses a combination of forward-feeding and backward-feeding the multitap cascades via directional couplers at the output of the bridger and line extender amplifiers. The bridger output and each line extender are directly interconnected by untapped 500/625 distribution cable in a mini-trunk configuration. This arrangement permits line extender AC powering without the necessity of current flowing through the multitaps and their internal chokes. As the flat loss of multitap attenuation is removed from the line extender interconnection, existing line extender spacing can often be maintained, even for plant operating close to 1000 MHz

This plant configuration is substantially more reliable than that of a conventional tapped feeder line as it avoids the most common faults which are power related: ie. fuses, short circuits, hum and intermittent connections. It also provides a much flatter frequency response with far fewer reflections which should be advantageous for the distribution of advanced television signals.

FIGURE 6: COMPARISON OF CONVENTIONAL DISTRIBUTION VS. SUPERDISTRIBUTION



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One way to quantify the improvements inherent in this revised feeder design is by counting the number of connectors a signal must pass through prior to reaching the customer at the extremity of the feeder. Traditional tapped feeder would have 60 connectors and 26 multitap between the bridger and extremity while the revised architecture features 14 connectors and 4 multitaps (see Figure 6).

The superdistribution config-uration generally cascades a maximum of four taps which already minimizes cascaded loss and removal of the choke extends the bandwidth. Field experience has shown 300 MHz taps modified this way can reach close to 500 MHz with certain multitap types.

SUMMARY

A new hybrid fiber/coax architecture for broadband urban telecommunications has been devised to allow evolutionary growth in quality, and broadband capacity. Large urban systems are segmented into areas that require 10 amplifier cascades or less to serve cable subscribers from Secondary Hubs. Secondary Hubs serve approximately 8,000 homes each and have similar locations as that required for 4th level cellular telephone cells. Fiber networks to serve Secondary Hubs allow high capacity and high quality to be achieved without changing trunk amplifier spacing. Secondary Hubs are grouped and served by Primary Hubs using AM on fiber. The infrastructure that results can serve the intracity communications requirements of any private network, thereby alleviating some of the demand for radio spectrum.

Extension of fiber to optical bridgers, each serving in the neighborhood of 200 homes, allows an evolutionary upgrade to channel capacity, up to 150 channels. This star-bus architecture can achieve all of the interactive video services and telecommunications envisaged by BISDN proponents without requiring fiber to the home.

All hubs are served with fiber from two directions to achieve very high reliability. A comprehensive status monitor and control system communicates with every part of the network. The use of superdistribution allows coaxial feeder cable to be used to deliver up to 150 channels to the home. Benefits include fewer tap cascades to each subscriber, flatter frequency response and extended line extender reach.

ACKNOWLEDGEMENTS

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Since joining Rogers Engineering in 1978, George has been involved in the design of two-way cable systems in the U.S. and the development of interactive pay-per-view systems. He has been responsible for signal scrambling systems and continues to be involved in the EIA Committee efforts to produce a universal baseband descrambler interface. He has kept Rogers informed of developments in consumer electronics and recently co-authored a study on the impact of digital television on the cable industry.

George is a member of the Association of Professional Engineers of Ontario, the IEEE and SMPTE. He is actively involved in the Advanced Television Systems Committee and the Channel Characterization Committee of the Canadian Advanced Broadcast Systems Committee.

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Prior to this, Nick was with the Canadian Marconi Company where he managed an analogue and R. F. engineering department responsible for the design development and manufacture of a wide range of telecommunications equipment including microwave radio systems, multi-channel UHF tactical relay systems and microwave R.F. hardware.

Nick graduated in Engineering from the Medway College of Technology in Chatham, England, during 1961 where he specialized in electrical engineering and qualified for full Chartered Engineering status. He is a member of the Institute of Electrical Engineers (IEE) U.K., a member of the Association of Professional Engineers of Ontario (APEO), a Senior Member of the Institute of Electrical and Electronic Engineers (IEEE) and a Senior Member of the Society of Cable Television Engineers (SCTE).

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NON-SPECTRUM ALTERNATIVES - TELECOMMUNICATIONS

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ABSTRACT

Fibre optic networks are being rapidly deployed and expanded by nearly all major national and international communications carriers. The advantages of fibre optic transmission systems are well known. They include very large and expandable capacity, low unit costs when this capacity is effectively utilized, and excellent transmission performance. However, fibre systems also have significant disadvantages when compared to spectrum - based alternatives such as terrestrial microwave and satellite systems. Initial placement costs of fibre in hostile terrain may exceed radio by an order of magnitude. It is not usually practical to build a single route cable system which has the overall reliability of radio or satellite transmission. Experience of the major carriers in North America has shown that, on average, land based fibre cables are cut or damaged about once per year per 500 kilometres. The cost of providing stand-by restoration facilities for fibre systems should normally be included in any cost comparison with spectrum - based alternatives. This paper attempts to give a balanced view of fibre optic technology and to show that it can be applied in harmony with radio and satellite systems to effectively provide for heavy route communications requirements.

Résumé

Solutions autres que spectrales - Télécommunications

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Presque tous les grands télécommunicateurs nationaux et internationaux procèdent au déploiement et à l'expansion rapides de réseaux à fibres optiques. Les avantages des systèmes de transmission par fibres optiques sont bien connus. Une très grande capacité extensible, de faibles coûts unitaires lorsque cette capacité est effectivement utilisée et d'excellentes transmissions comptent parmi ces avantages. Cependant, les systèmes à fibres optiques présentent aussi des inconvénients majeurs comparativement aux modes utilisant le spectre comme les systèmes à micro-ondes de Terre et les systèmes à satellites. Les coûts d'installation initiale des fibres en terrain difficile peuvent dépasser les coûts des installations radioélectriques par un ordre de grandeur. En général, construire un système de câblodistribution à une seule artère présentant la fiabilité globale des transmissions radioélectriques ou par satellite n'est pas pratique. D'après l'expérience des grandes entreprises de télécommunications nord-américaines, les câbles constitués par des fibres optiques qui entrent dans les installations terrestres sont en moyenne coupés ou endommagés une fois par année, tous les 500 kilomètres. Les coûts à prévoir pour les installations en attente qui seront éventuellement utilisées pour rétablir le service des systèmes à fibres optiques devraient généralement être inclus dans toute comparaison des coûts des systèmes à fibres optiques et des coûts des installations de communications par ondes radioélectriques. Dans ce document, l'auteur cherche à présenter une analyse équilibrée de la technologie des fibres optiques et à montrer qu'il est possible de l'utiliser en harmonie avec les systèmes radioélectriques et les systèmes à satellites pour répondre efficacement aux besoins de communications de forte densité.

INTRODUCTION

In the late 1970s our first digital toll switching machine was installed. Shortly after that, in the early 1980s, our first long-haul digital radio route was turned up for service. Since that time the Telecom Canada network has been evolving into a digital telecommunications network designed to meet our customer's changing service requirements. As we approach the 1990s, it is expected that the increasing demand for our existing digital based services coupled with future Integrated Services Digital Network (ISDN) based services, will necessitate the provisioning of high capacity - high quality digital transmission systems which will link all of the major metropolitan centres across Canada. What I intend to present today is:

- an indication of the direction in which Telecom Canada and our member companies are headed with respect to the provisioning and utilization of digital transmission facilities.
- how spectrum based technology will be applied.

I will first discuss current trends and then future prospects.

CURRENT TRENDS

The Telecom Canada network is comprised of a multitude of different types of transmission facilities. Both analog and digital microwave radio as well as satellites are currently being used for our long haul inter-provincial facilities. In order to maintain our reputation of providing high quality service to our customers, fibre optics are now being used extensively as a transmission medium where high capacity systems are required.

Existing in the Telecom Canada network is our first high capacity route which consists of a fibre optic structure from Halifax to Edmonton. By 1990 it will be extended to Vancouver. This is the first step in providing the inter-provincial network which will meet our existing and future digital service requirements on a nation wide basis.

Our member companies are also expanding their own fibre based networks within their operating territories, and have been installing fibre optic facilities to meet the increased demand for inter-city digital services. Also, in addition to their inter-city networks, the member companies are installing fibre optic facilities to meet their intra-city requirements.

The provisioning of fibre optics on a grand scale has taken place mainly because of the following reasons:

- fibre optic transmission systems provide a large and expandable capacity.

- fibre optic transmission systems have a low unit cost based on the total system capacity.

- fibre optic transmission systems have excellent performance characteristics.

- fibre optic transmission systems provide facilities to meet both Telecom Canada's and our member company's requirements within the same structure.

In addition to the previous advantages of using fibre optic systems, these additional advantages become evident in many major metropolitan areas:

- fibre optic facilities are not dependent on the availability of radio spectrum.

- fibre optic facilities are not susceptible to radio frequency interference.

- fibre optic facilities are not susceptible to transmission path obstruction such as buildings being constructed on the facility route.

When these additional advantages are combined with the economic advantages of using fibre optics for high capacity requirements, the tendency is to eliminate the microwave radio terminal locations from within downtown city cores. Instead, metropolitan junction points are established on the outskirts of the city and long haul radio systems are terminated at these locations. High capacity digital connectivity is provided through an elaborate fibre network connecting the switching office locations within the metropolitan area thus providing our customers with access to the member company's inter-city and our inter-provincial networks.

All of this tends to paint a picture that indicates the use of fibre optics by Telecom Canada and our member companies is eliminating the need for radio spectrum based facilities in our telecommunications networks. This is not the case. The following two disadvantages associated with fibre optic systems can be offset by the use of digital microwave radio.

- the installation of fibre optic cable requires a high initial investment in capital.

- fibre optic facilities are susceptible to failure.

Let me expand on these two points.

The initial cost of installing fibre optic cable to provide long haul transmission facilities is very high, especially when the geographical terrain is as hostile as the Canadian Shield in Northern Ontario or the mountains in British Columbia. In the not too distant future, high capacity digital radio equipment will be available. This new technology equipment will provide a viable alternative to the provisioning of fibre optics in rough terrain locations. It is possible to over-build our existing radio routes and reduce our capital requirements.

Fibre optic cables are susceptible to damage. We go to great lengths to minimize the likelihood of a failure by employing very stringent placement criteria, but we cannot eliminate the possibility of failure. Our digital transmission facilities are capable of carrying a fantastic quantity of circuits. However, if all of our customer's requirements are concentrated on one high capacity facility, a failure would be catastrophic. In order to protect our customers and provide the high level of service expected, we must have a network which will not be put out of service in the event of a facility failure.

We in Telecom Canada accomplish this by providing more than one facility route which allows for diverse routing of customer's circuits and as such, if one route fails then all of the customer's circuits are not lost. The diverse routes also provide adequate facilities on which the circuits from the failed route are restored until such time as the damaged facility is repaired. Our existing digital radio facilities as well as satellite, are currently being used to provide the diverse facilities for our high capacity inter-provincial fibre optic system.

FUTURE PROSPECTS

We provide many different types of services to our customers such as switched voice, non-switched point to point private line, Dataroute™, Datapac™, Datalink™, Megaroute™, Envoy 100™, and iNet 2000™ to name just a few. It is expected that there will be a great increase in telecommunications requirements in the future. Our customer requirements will grow and become more sophisticated. They will require increased flexibility as well as the associated network management capabilities for many new wide-band services. As our customer requirements grow and we expand our network to meet the demand, the question of network survivability becomes very important. Our customers expect a service which is available to them whenever they require it.

In the case of our first inter-provincial high capacity fibre route, our existing digital radio facilities will provide sufficient capacity to meet our diversity and restoration requirements until the early 1990s. We have plans to install our second high capacity digital transmission facility. Spectrum based technology is being included where it proves to be more economical than fibre.

In addition to our inter-provincial applications, our member companies have inter-city as well as local exchange requirements in both remote and rough terrain areas, where the most feasible method of providing transmission facilities is through the use of spectrum based technology. The equipment used may be of either high or low capacity depending on the total circuit requirements, or possibly even satellite facilities if practical.

CONCLUSION

In conclusion, I would like to re-emphasize that we expect the future to bring us a host of new services which will increase our network requirements dramatically. We will be dealing with customers who are knowledgeable and who have very high expectations with regard to the quality of the service which we provide. Our reputation is based on our service, and without a quality network we cannot provide quality service. Without top quality service we cannot survive.

We will be challenged by these expectations and we will meet this challenge by providing the best telecommunications network found anywhere.

Our network will include both spectrum and non-spectrum based transmission facilities, in order to meet the increasing demands which will be realized.

GREATER SPECTRUM EFFICIENCY AND USE OF HIGHER FREQUENCY BANDS

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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.

Résumé

Efficacité accrue du spectre et utilisation de bandes de fréquences supérieures

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Nous savons tous que la demande d'assignations de fréquences augmente de façon spectaculaire dans toutes les parties du spectre en raison de la demande croissante de nouveaux services. Cette situation est ressortie clairement dans les batailles récentes au sujet d'attributions nationales et internationales et aussi dans les activités ultérieures de coordination et de délivrance des licences, notamment dans la bande UHF. Le problème se manifeste avec le plus d'acuité dans les grandes régions urbaines encombrées. Plusieurs correctifs sont possibles. On peut entre autres alléger le spectre en ayant recours à des services par câble ou par fibres, faire une utilisation plus efficace des attributions existantes et utiliser des bandes de fréquences supérieures. Dans ce document, l'auteur examine brièvement quelques-unes des possibilités d'application de ces deux dernières options.

Il est possible d'accroître l'efficacité du spectre de plusieurs façons, mais celles-ci diffèrent selon qu'on utilise un système de radiocommunications terrestre ou un système à satellites. Au nombre de ces moyens, il y a l'emploi de nouvelles techniques de modulation et de codage (qui font des services mobiles par satellite des services viables sur le plan commercial), l'assignation en fonction de la demande, la réutilisation de faisceaux multiples, l'AMRT avec commutation de l'engin spatial, la superposition d'étalement du spectre, la réutilisation des polarisations, la réutilisation des diagrammes cellulaires, ainsi que d'autres techniques.

On constate également une tendance mondiale à utiliser les bandes de fréquences supérieures. En effet, civils et militaires commencent à utiliser les fréquences EHF (extrêmement hautes) pour assurer des communications par satellite à l'aide de systèmes tant expérimentaux qu'opérationnels. Il est également proposé d'avoir dorénavant recours à ces bandes pour l'exploitation des systèmes de Terre, ce qui est une innovation. On constate que les pressions en vue d'exploiter les bandes de fréquences supérieures s'accompagnent d'un intérêt accru pour l'utilisation des hautes fréquences (HF).

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 1970s, 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.

ADVANCES IN MODULATION & CODING TECHNIQUES

BY

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ABSTRACT

This paper provides a summary of the recent evolution of the modulation and coding techniques as applied to radio systems in order to increase the spectrum utilization efficiency. Application in both the microwave line-of-sight radio and mobile/portable radio systems are discussed.

In fixed radio-relay systems, considerable progress has been made in the hardware technologies and associated techniques. Modulations up to 512 QAM are now considered practical and 1024 QAM may become practical soon. High Efficiency Forward Error Correction codes from BCH and convolution codes family are used to maintain very low error rates for systems using such high level of modulations. Combined modulation and coding schemes such as TRELLIS Coding are under active investigation and show a great deal of promise.

Cellular mobile/portable radio systems which rely on frequency reuse and are hence interference limited, lower order modulation schemes (e.g. 4-PSK) gives better overall spectrum utilization efficiency. These systems require heavy forward error correction with codes like Reed-Solomon Codes, providing some protection against very adverse propagation conditions.

Résumé

Progrès réalisés dans le domaine des techniques de modulation et de codage

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Développement des réseaux hertziens
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Le présent document fournit un résumé des derniers progrès réalisés dans le domaine des techniques de modulation et de codage applicables aux réseaux hertziens, afin d'accroître l'efficacité de l'utilisation du spectre. On y étudie la possibilité d'utiliser ces techniques aux fins des réseaux hertziens à micro-ondes en visibilité directe et des systèmes mobiles transportables de radiocommunications.

Pour ce qui est des systèmes fixes de relais hertziens, des progrès marquants ont été réalisés dans le domaine des technologies liées au matériel et celui des techniques connexes. Des modulations d'amplitude en quadrature pouvant aller jusqu'à des niveaux de 512 sont considérés comme faisables et il se peut qu'on puisse bientôt atteindre des niveaux de 1024. On utilise les codes à correction aval des erreurs, de grande efficacité, fournis par BCH, et la famille des codes convolutifs pour obtenir des taux très faibles d'erreurs dans le cas des systèmes qui utilisent des modulations de niveau aussi élevé. Des schémas combinés de modulation et de codage comme les codes TRELLIS font actuellement l'objet d'une étude et ils font briller des perspectives intéressantes.

Les systèmes radiotéléphoniques mobiles/portatifs cellulaires qui font appel à la réutilisation des fréquences et qui sont, par conséquent, plus susceptibles de subir du brouillage, utilisent des schémas de modulation d'un ordre de grandeur plus faible (4 PSK) et permettent une utilisation généralement plus efficace du spectre. Ces systèmes qui nécessitent un fort taux de correction aval des erreurs à l'aide notamment des codes Reed Soloman, assurent une protection contre des conditions très défavorables de propagation.

I. INTRODUCTION

The first generation of line-of-sight digital microwave introduced in 1975-76 time frame used low-speed modulation such as 2-PSK and 4-PSK. Shortly afterwards systems were introduced using a level quadrature partial response signalling and 8-PSK [1, 2] This was followed by systems using high level quadrature amplitude modulation (QAM) systems. Specifically 16 and 64-QAM has become common place [3]. Very recently, a radio system based upon 512 QAM with spectral efficiency of the order of 8 bits/sec/Hz has been announced by Northern Telecom. Research on higher-order modulations including 1024 QAM as well as combined modulation and coding schemes such as Trellis coding continues in the research laboratory around the world.

In satellite systems, on-board weight limitations place a premium on power as efficiency and to low-level modulations (e.g., 4-PSK) with spectral of 1 bit/sec/Hz, tend to be used instead.

Cellular mobile systems, in contrast, rely on frequency reuse, resulting in an interference limited system. Lower order modulation schemes (such as 4-PSK) in conjunction with error-correction codes provides overall optimum spectral utilization efficiency.

2. MODULATION & CODING FOR LINE-OF-SIGHT MICROWAVE RADIO SYSTEMS

Digital Microwave radio systems have the following two special features; First feature being the need for higher digital speed and higher spectral efficiency. Due to limited radio spectrum, there is a great deal of emphasis on realizing higher spectral efficiency. Higher order modulation schemes are necessitated to realize this goal.

The second feature is the susceptibility of microwave digital radio to frequency selective (dispersive) fading which is caused by multipath fading on the line-of-sight links. The consequences are more severe for higher levels of modulation and more difficult to combat at high speed.

Fig. 1 displays carrier-to-noise (C/N) vs bit-error rate (BER) for various modulation schemes [4]. It shows that QAM is more power efficient than PSK for M > 16, resulting in widespread use of QAM in high capacity systems. Moreover, doubling of QAM constellation (eg. from 16-QAM to 32-QAM) is accompanied by a minimum of 3 dB increase in the power requirement; thus increase in the spectral efficiency is obtained at the cost of power efficiency which is a measure of how much received power is needed to achieve a specified BER.

Fig. 2 shows transmitted spectra for a system in which half of the cosine roll-off shaping is done in the transmitter. By choosing lower values of filter roll-out factor and greater spectral efficiencies can be obtained. Current 64-QAM digital radio systems uses between 0.3 and 0.5 and achieves a spectral efficiency of 4.5 bits/sec/Hz. New filter technologies such as Surface Acoustic Wave (SAW) allows even tighter filtering, thus increasing spectral efficiency. Northern Telecom's recently announced 512 QAM radio system deploys SAW filter and achieves spectral efficiency in the order of 8 bits/sec/Hz.

This functional block diagram of modulator and demodulator sections of the digital microwave radio are shown in Fig. 3. figure 4 displays the constellation and eye diagram of QAM signals. It is clear that higher order modulation systems require carrier recovery process to be sufficiently accurate so that the phase error is low in both its status value and fluctuations (phase jitter). The decision directed approach is especially suited for high level QAM. Timing recovery is less critical, in terms of performance sensitivity, than carrier recovery, is important nonetheless. A popular approach is to square the outputs of the low speed filters and extract from their sum the spectral line component at I/T frequency.

Both carrier and timing recovery errors can cause serious performance degradations. Harder to minimize is the jitter of carrier and timing phase which is due to both randomness of the data patters and additive noise. The designs of higher order modulation systems are very demanding and are geared to minimize the jitter of carrier and clock phase to contain the resulting impairments.

To meet stringent performance standards despite the sensitivities of these high level modulations to impairments, we need to deploy the following techniques:

(i) Diversity Methods.
Space diversity and frequency diversity are both widely used method for enhancing digital radio availability.

ii) Equalizer.
Where space diversity improves the probability of a strong received signal, equalization improves the end-to-end frequency response in the presence of multi-path fading. Both transversal and decision feed-back equalizers are used and these adaptive circuits reshape the pulses so as to end up with as low as a intersymbol interference as possible.

(iii) Forward-Error Correction Coding

The use of high-level modulations requires special measures to maintain very low error rates (eg. BER+10-13 or less). FEC coding helps to relax the stringent hardware design requirements, that might otherwise be imposed for high-level modulation systems. High-efficiency codes must be used to limit the erosion of spectral efficiency. One example is BCH double error correcting code (511, 493) which gives a coding gain of 3 dB at 10^{-8} BER and adds about 4% overhead, as shown in Fig. 5.

3. TRELLIS-CODED MODULATION (TCM)

Trellis-Coded Modulation (TCM) has evolved over the past decade as a combined coding and modulation technique for digital transmission over band-limited channel. Its main attraction comes from the fact that it allows the achievement of significant coding gains over uncoded multi-level modulation without comprising bandwidth efficiency TCM schemes employ redundnat non-binary modulation in combination with a finite state encoder which governs the selection of modulation signal to generate coded signal sequences. In the receiver, the noisy signals are decoded by a soft-decision maximum likelihood sequence decoder. Simple four-state TCM schemes can improve the robustness of digital transmission against additive noise by 3 dB, compared to conventional uncoded modulation with more complex TCM schemes, the coding gain can reach 6 dB or more. These gains are obtained without any bandwidth expansion.

Fig. 6 shows the error-event probability of the two systems as a function of signal-to-noise radio [5].

4. MODULATION & CODING IN DIGITAL CELLULAR MOBILE SYSTEMS

Cellular mobile systems rely on frequency reuse, where users in different cells may simultaneously use the same carrier frequency at the same time as shown in Fig. 7. This unfortunately induces co-channel interference, one of the major problems associated with high capacity cellular frequency reuse systems.

In considering frequency reuse, 4-level phase modulation is the most spectrally efficient for the portable radio environment. Higher level modulation systems (e.g. 8-PSK) through requiring less bandwidth, results in significant reduction in the reuse factor due to higher susceptibility to co-channel interference with the net loss of the overall spectrum utilization efficiency.

For digital cellular systems, error correction coding provides a powerful method of combating co-channel interference. Though coding reduces spectral efficiency by increasing the required bandwidth per channel, it makes the signal more robust against co-channel interference, resulting in overall increase of spectral efficiency by allowing increased reuse of the spectrum. Thus the digital cellular systems choose error correction systems so as to maximize spectral efficiency.

Fig. 8 shows the carrier-to-interference ratio (CIR) required to obtain a decoded bit error probability of 10^{-5} for all extended Reed-Solomon codes of length 2^k, k=4, 6, 8 [6]. Reed-Solomon codes perform better than BCH codes at high rates. However, they perform worse at low code rates.

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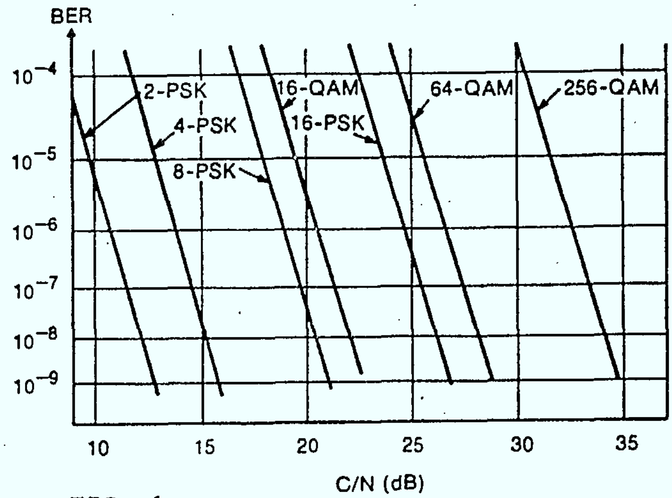


FIG. 1

BER curves for several modulations.

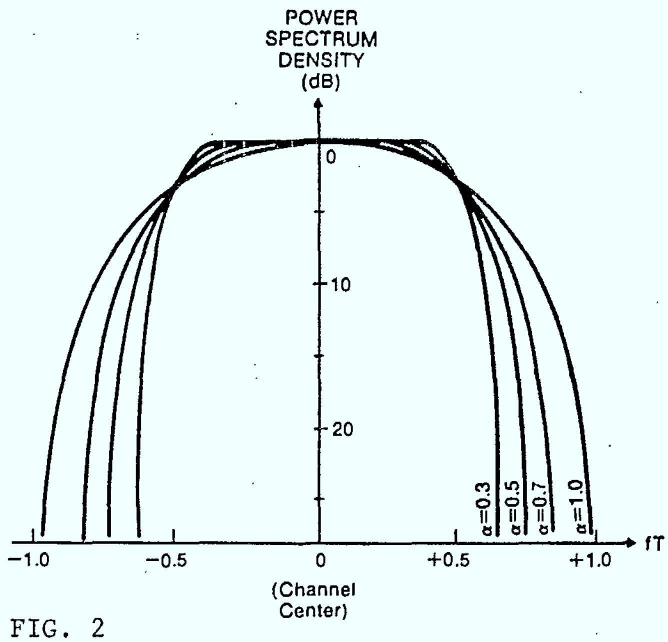


FIG. 2

Transmitted spectra for cosine rolloff shaping.

October 1986—Vol. 24, No. 10
IEEE Communications Magazine.

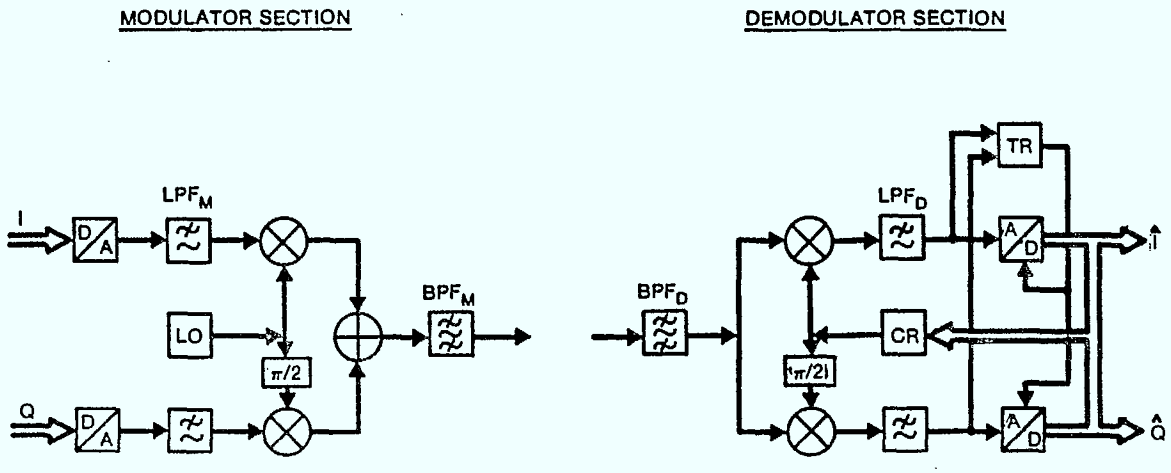


FIG. 3 *Modulator and demodulator sections used in digital radio links.*

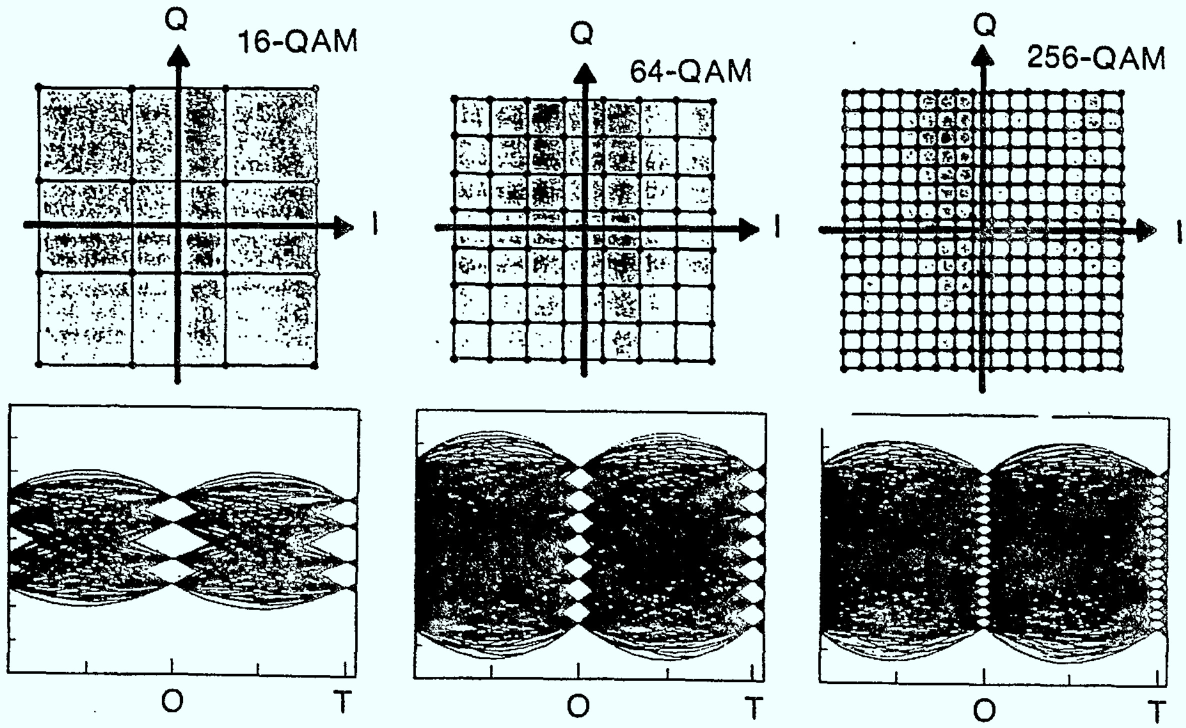


FIG. 4 *Constellations and eye diagrams for PSK and QAM signals.*

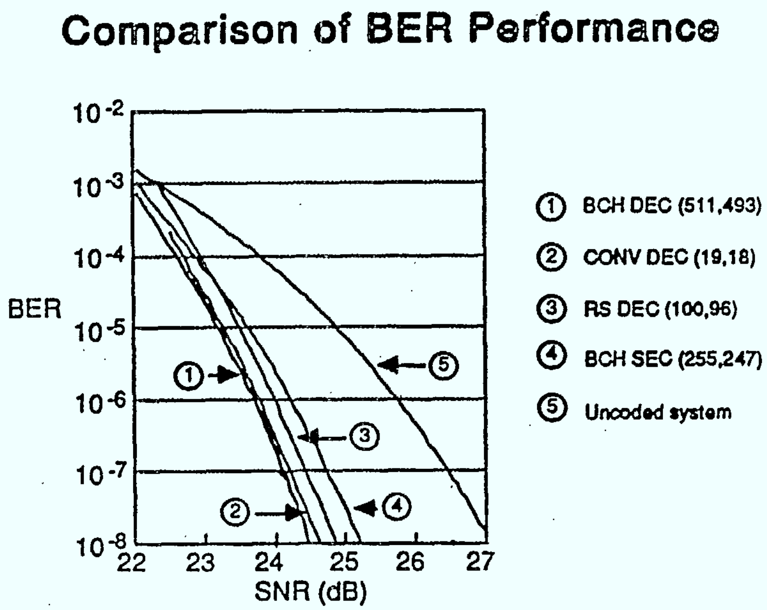

Comparison of BER Performance
BER
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
22
23
24
25
26
27
SNR (dB)
① BCH DEC (511,493)
② CONV DEC (19,18)
③ RS DEC (100,96)
④ BCH SEC (255,247)
⑤ Uncoded system

FIG. 5

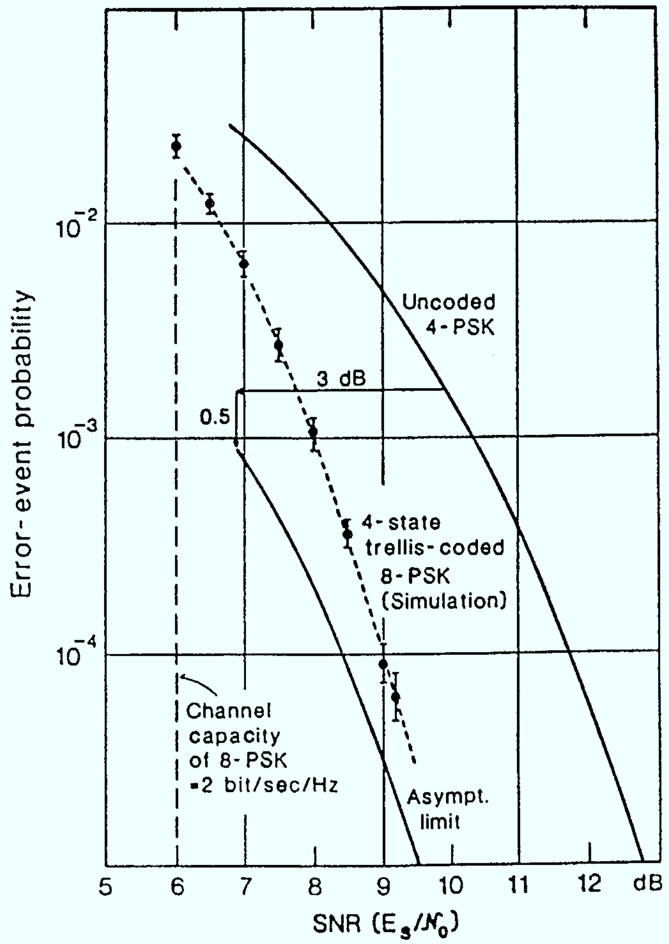
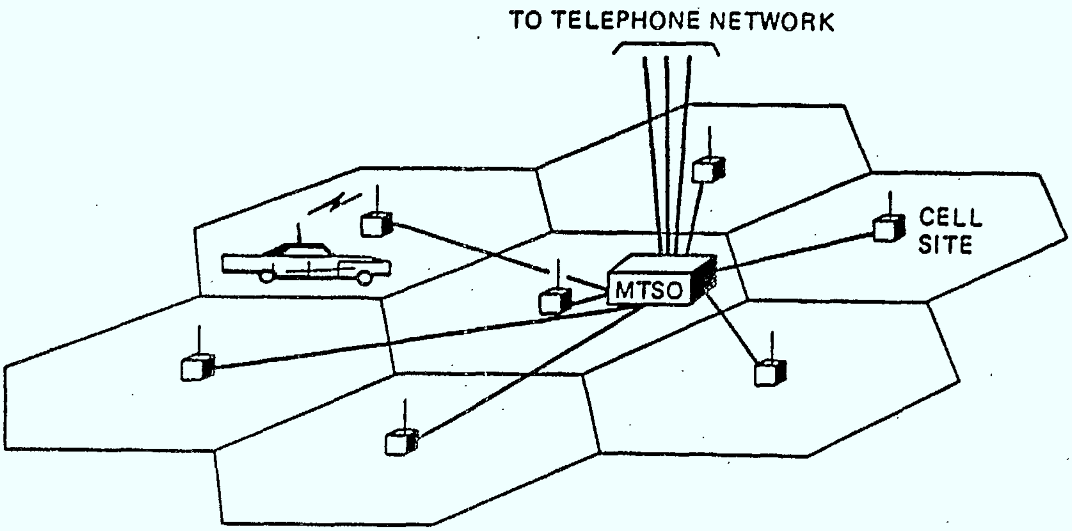


FIG. 6 *Error-event probability versus signal-to-noise ratio for uncoded 4-PSK and four-state coded 8-PSK.*

BNR

FIG. 7 DIGITAL CELLULAR MOBILE SYSTEM LAYOUT



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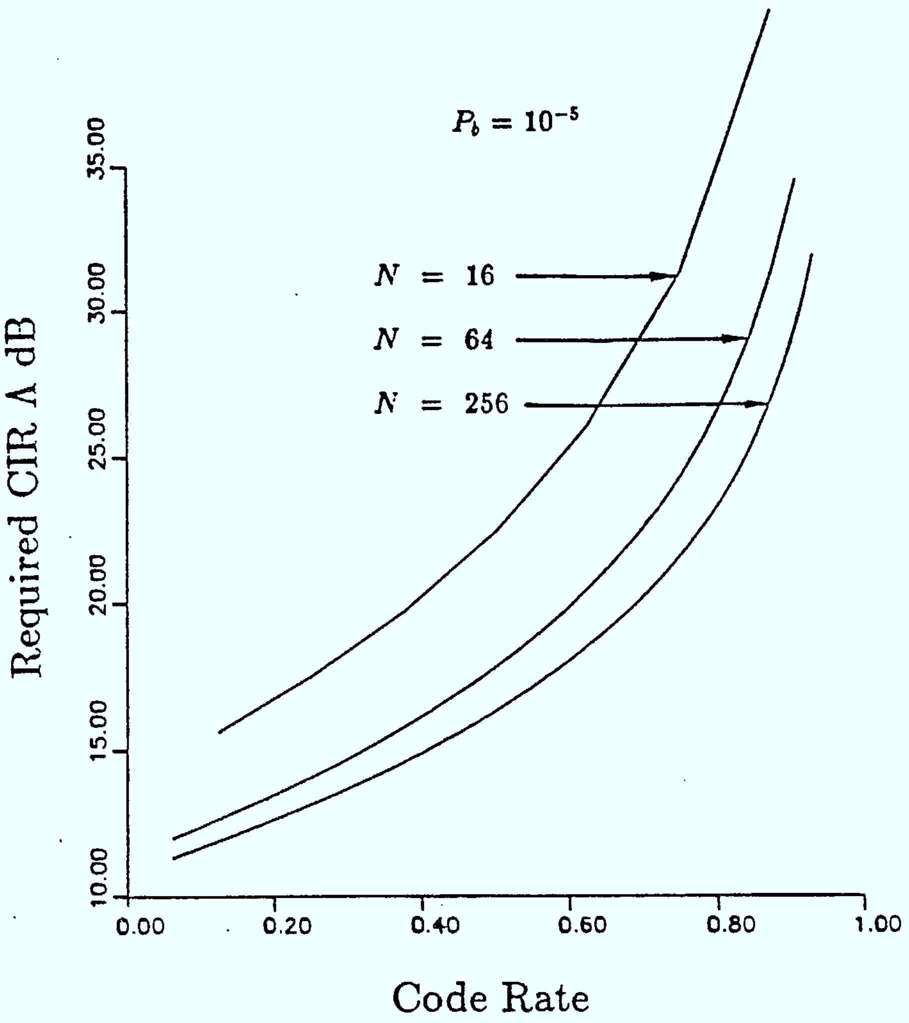

FIG. 8 CIR Required for $P_b = 10^{-5}$ with RS Codes

ADVANCED ANTENNA TECHNOLOGY

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ABSTRACT

As we enter the 1990's and look towards to the 21st Century, radio frequency spectrum conservation and maximum spectrum utilization looms as the major technical challenge for the radio telecommunication industry. In response to this challenge, current state-of-the art radio systems are utilizing modulation schemes which increase system data capacity while limiting the required radio spectrum. Radio systems coordinators are reviewing and upgrading their coordination algorithms and techniques to facilitate the implementation of these radio systems while improving overall system performance. Through advanced design techniques, antenna manufacturers are tailoring antennas to conform with the requirements of the new advanced radios while minimizing antenna side-lobe and cross polarization response.

Andrew is continuously improving antennas and design techniques to satisfy the requirements of these advanced radio systems. Within this paper we will review the current state-of-the-art parabolic antennas for terrestrial and earth station communication systems and how these advanced antennas are improving spectral usage by enhanced radiation characteristics.

Résumé

Technologie des antennes perfectionnées

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Au moment où nous entrons dans les années 90 et à l'aube du XXIe siècle, la conservation des fréquences radioélectriques et l'utilisation optimale du spectre apparaissent comme les principaux défis techniques de l'industrie des radiocommunications. Pour relever ces défis, les utilisateurs des systèmes de radiocommunications d'avant-garde ont recours à des techniques de modulation qui accroissent la capacité de transmission de l'information tout en limitant la portion du spectre requise pour ces communications. Les coordonnateurs de systèmes de radiocommunications revoient et améliorent leurs techniques et algorithmes de coordination pour faciliter la mise en oeuvre de ces systèmes et améliorer le rendement global de ces installations. Grâce à des techniques de conception perfectionnées, les fabricants réalisent des antennes qui répondent aux besoins particuliers des nouvelles installations de radiocommunications perfectionnées et parviennent en même temps à réduire au minimum les lobes latéraux et les réponses à la polarisation croisée des antennes.

Andrew Corporation travaille sans cesse à améliorer les antennes et conçoit des techniques pour satisfaire aux besoins de ces systèmes de radiocommunications perfectionnés. Dans cet article, les auteurs passent en revue les versions avant-gardistes actuelles des antennes paraboliques dont on peut équiper les stations terriennes ou de Terre et ils montrent de quelle manière ces antennes perfectionnées, grâce à de meilleures caractéristiques de rayonnement, conduisent à une utilisation plus judicieuse du spectre.

INTRODUCTION

In the 1990's, our society will witness the coming to term of the information era. An era where communications between two hand held cellular telephones carrying a single conversation to a multi-channel computer communications system transmitting several megabytes of information per second will have to coexist in a mutually acceptable environment. This will be a period in which the demand for communications, and therefore the need for conservation of the communication medium, will play a critical role in our everyday lives.

Acknowledging the frequency conservation and optimum spectrum utilization requirements of the 1990s, the microwave telecommunication industry has looked towards the radio and antenna manufacturers to develop solutions. Focused on spectrum optimization, the radio industry has developed advanced systems which implement higher order digital modulation schemes to increase system capacity. These advanced radios optimize frequency utilization by increasing data volume within the same frequency spectrum. Through innovative design techniques, antenna manufacturers have addressed frequency conservation with enhanced antenna radiation performance. These advanced antennas permit multiple radio system coordination using co-channel and adjacent channel frequencies within a geological area.

Within this paper, the antenna solutions will be reviewed. We will examine some of the advanced antenna designs, for both the terrestrial and earth station microwave applications, and analyze the performance characteristics of these antennas.

TERRESTRIAL MICROWAVE ANTENNAS

In and out of highly developed urbanized areas, the demand for subscriber communications via long and short haul radio systems is at an extreme. In these regions, where the relative microwave environment is highly congested, coordination of new systems for harmonious coexistence with currently operating systems requires the utilization of advanced antenna systems. These antennas must exhibit superior sidelobe suppression, increased front-to-back ratio, improved cross-polarization response, and optimum gain performance. All of these antenna characteristics will determine the ability of the radio system to be coordinated in terms of intra and inter-system interference.

Within this section, we will examine the performance parameters for two of Andrew's advanced microwave antenna systems, namely, the UHXII*, ultra-high performance, and SHX*, super-high performance, antenna product lines.

UHXII, Ultra-High Performance Antennas

The UHXII antenna series is a highly advanced version of the basic prime focus parabolic microwave antenna. In the UHXII antenna series, we enhance the electrical performance standard basic antenna by introducing three new features.

The first feature is the addition of a metallic shield or shroud attached to the periphery of the reflector forming a cylinder around the aperture. This shield, which is fully lined with high

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* *UHXII, UMX, SHX, and TEGLAR are registered trade marks of Andrew Corporation.*

performance microwave absorbing material, improves both the wide angle side-lobe suppression and antenna front-to-back (F/B) ratio.

The second feature is an advanced feed system of patented design which shapes the energy launched from the feed system for improved antenna gain and side-lobe suppression. These advanced feed systems support dual polarized operation and are typically lined with microwave absorber to reduce energy scattering from the feed system itself.

In order to protect the microwave absorber within the antenna and improve wind loading, the final feature added to the antenna is a TEGLAR* radome. Woven from fiberglass and coated with a hydrophobic material, TEGLAR is both environmentally durable and basically invisible to microwave energy ensuring optimum antenna performance.

Figures 1 and 2 illustrate the typical UHXII shielded antenna configuration and the radiation pattern performance from this antenna type.

Continuing advances in the feed system design have maintained the state-of-the-art status for the UHXII family by introduction the UHXII "J" antenna operating within the 5.925 to 6.425 and 6.425 to 7.125 GHz bands and the UMX* multi-band antenna operating in both 3.54 to 4.20 and 4.40 to 5.00 GHz frequency bands.

SHX, Super High Performance Horn Antenna

In extremely congested microwave environments, the SHX horn antenna becomes the antenna of choice. This antenna is a design based on a special configuration of the parabolic antenna known as the offset antenna. With the offset design, only a portion of the parabolic reflector is used, so that the antenna feed system can be positioned outside of the antenna's aperture. Placing the feed outside the antenna's aperture enhances the electrical performance by eliminating reflector feed system blockage and scattered energy inherent in the standard parabolic antenna design.

For terrestrial applications, the SHX design encloses both the reflector and feed system with an absorber lined shield to prohibit outside radiation. Figure 3 displays the SHX horn antenna configuration. The advantages of the SHX design are its superior sidelobe suppression and excellent front-to-back radiation characteristics, making it least likely to interfere with other systems. Figure 4 compares the relative radiation performance of the SHX, UHXII, and standard antenna types.

An additional advantage of the SHX is that it is broad-banded and hence, the system designer can add several frequency bands utilizing both polarizations in each band. The only limitation is producing a multi-band combining network that can be used to launch the energy into the antenna. Currently, several dual-band and tri-band combiner networks exist for the SHX antenna. Some examples of available dual band networks are: 3.58 to 4.2 / 5.925 to 6.425 GHz, 3.54 to 4.2 / 6.425 to 7.125 GHz, and 5.925 to 6.425 / 10.70 to 11.70 GHz.

The disadvantages of the SHX antenna are the expense and the large antenna wind loads. As compared to the prime focus antenna, the SHX antenna cost can be several times higher. Due to the large antenna surface area, the wind loads will be much higher and will result in a more expensive tower and mounting system.

** UHXII, UMX, SHX, and TEGLAR are registered trade marks of Andrew Corporation.*

EARTH STATION ANTENNAS

The closer spacing of orbital synchronous satellites and the spectrum congestion on the terrestrial point-to-point microwave system, has demanded stringent radiation characteristics on earth station antennas. Avoiding interference with adjacent satellites or ground communication systems requires a state-of-the-art design approach to optimize parameters such as antenna sidelobes and cross-polarization response. Innovative construction techniques are also needed for expansion into the higher frequency bands. Organizations, for example, CCIR, DOC, and FCC**, have in recent years been updating their ground stations antenna radiation requirements to reflect tighter electrical performance characteristics. Within this section, we will review the design approaches used within Andrew's 4.2 metre and 2.4 metre earth station antenna systems which comply with the highly restrictive performance criterion.

The 4.2 Metre Earth Station Antenna

The performance characteristics of the 4.2 metre Ka-band+ earth station antenna, designed and manufactured by Andrew, are particularly well suited for high density data and voice telecommunication systems. The need to meet the stringent antenna radiation standards, while still maintaining the high gain performance requires that both the main and sub-reflector of the dual reflector antenna to deviate from a true parabola or ellipse. An in-house proprietary software package capable of predicting first and second order effects, is used to optimize the 4.2 metre main and sub-reflector for the Ka-band frequencies. A Gregorian optics (concave sub-reflector) with a corrugated horn is used for the feed system (Figure 5). With the highest frequency of operation at 30 GHz, it is essential to maintain a rigid and highly accurate main and sub-reflector profile. The main reflector is fabricated from aluminum stretch formed reflector panel skins which are vacuum molded and permanently bonded to a honeycomb core. The honeycomb construction results in (and maintains) a highly accurate reflector surface with no more then 0.25mm RMS deviation from the design contour. Figure 6 depict the measured radiation pattern at 29.25 GHz showing pattern compliance to the Canadian DOC RSP114, FCC 25-209, and CCIR 580 recommendations. The result of the main and sub-reflector shaping provides not only low sidelobes at close-in angles for minimizing potential interference to adjacent satellites, but also suppresses sidelobe radiation at wide angles to reduce interference into and from terrestrial microwave communication systems operating within the same frequency band. As measured at the output of the antenna combining network, the antenna gain at mid-frequency of the transmit band is 60.4 dBi, which represents an aperture efficiency of 66 percent.

** *CCIR 580, FCC 25-509, DOC RSP114*

+ *Ka-band; Transmit: 27.5 to 31.0 GHz Receive: 17.70 to 21.2 GHz*

The 2.4 Metre Prime Focus Offset Antenna

Another design that Andrew has adopted for antenna sidelobe suppression is the prime focus offset reflector configuration. With its blockage-free reflector concept as compared to the symmetrical antenna design, the offset antenna offers a more attractive radiation pattern performance. The disadvantages of with the offset approach are the higher manufacturing cost for the larger antenna sizes and the inherent high off-axis cross-polarization characteristics.

Operating within Ku-band++, the 2.4 metre prime focus offset fed antenna, illustrated in Figure 7, belongs to a family of Andrew G/T series earth station antennas. The exclusively designed prime focus beam shaping feed, together with a precision manufactured aluminum reflector, results in an antenna gain of 48.3 dBi at 11.85 GHz. This gain value represents an aperture efficiency of 74 percent. The radiation pattern performance for this offset antenna is compliant with the CCIR, DOC, and FCC requirements, as illustrated in Figure 8. The on axis cross-polarization discrimination ratio level is 35 dB, however, the off-axis cross-polarization performance will be lower. To maintain cross-polarization performance within 30 dB, a heavy-duty antenna mount provides a pointing accuracy of 0.1 degrees RMS for 50 km/hr (30 mph), with wind gust to 75 km/hr (45 mph). Due to the highly accurate rigid construction of the reflector, the antenna can also be used at the higher Ka-band frequencies while achieving similar radiation performance as in the Ku-band frequencies.

CONCLUSION

In the 1990's and beyond, into the 21st Century, the demand for information via communications facilities will grow at an enormous rate. The telecommunications industry has positioned itself correctly for entry into the 1990's by reviewing and implementing communications medium conservation methods. Designs of state-of-the-art radio and antenna hardware are becoming available by which optimum spectrum utilization and conservation are obtained. However, we must realize that today's state-of-the-art systems will still require advancement to quench the needs for communications in the 21st Century.

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++ *Ku-band; Transmit: 14.00 to 14.50 GHz Receive: 10.95 to 12.75 GHz*

FIGURE 1
UHX Ultra High Performance Shielded Antenna

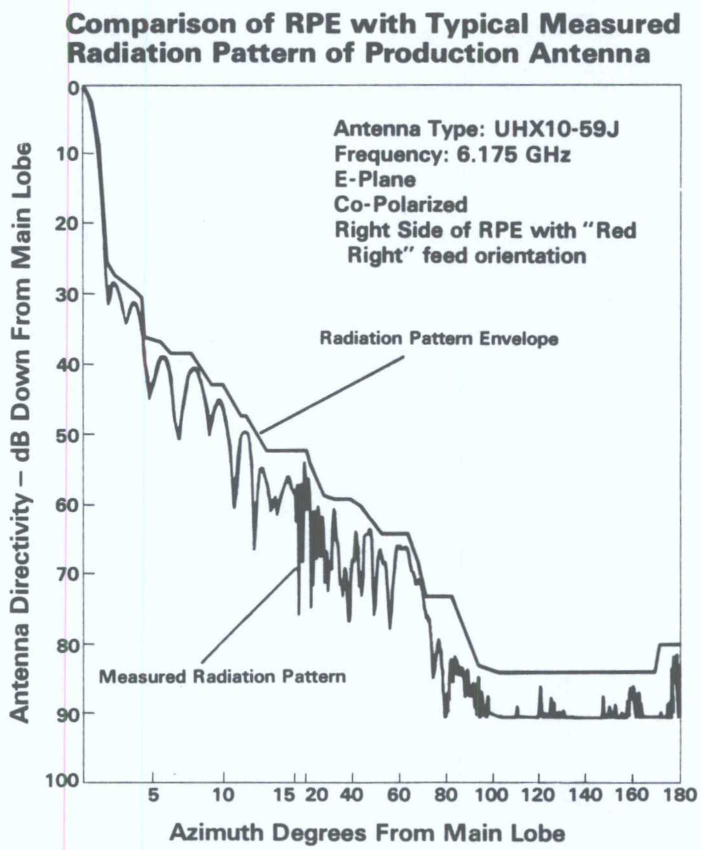
Comparison of RPE with Typical Measured Radiation Pattern of Production Antenna
Antenna Type: UHX10-59J
Frequency: 6.175 GHz
E-Plane
Co-Polarized
Right Side of RPE with "Red Right" feed orientation
Radiation Pattern Envelope
Measured Radiation Pattern
Antenna Directivity – dB Down From Main Lobe
0
10
20
30
40
50
60
70
80
90
100
5
10
15
20
40
60
80
100
120
140
160
180
Azimuth Degrees From Main Lobe

FIGURE 2

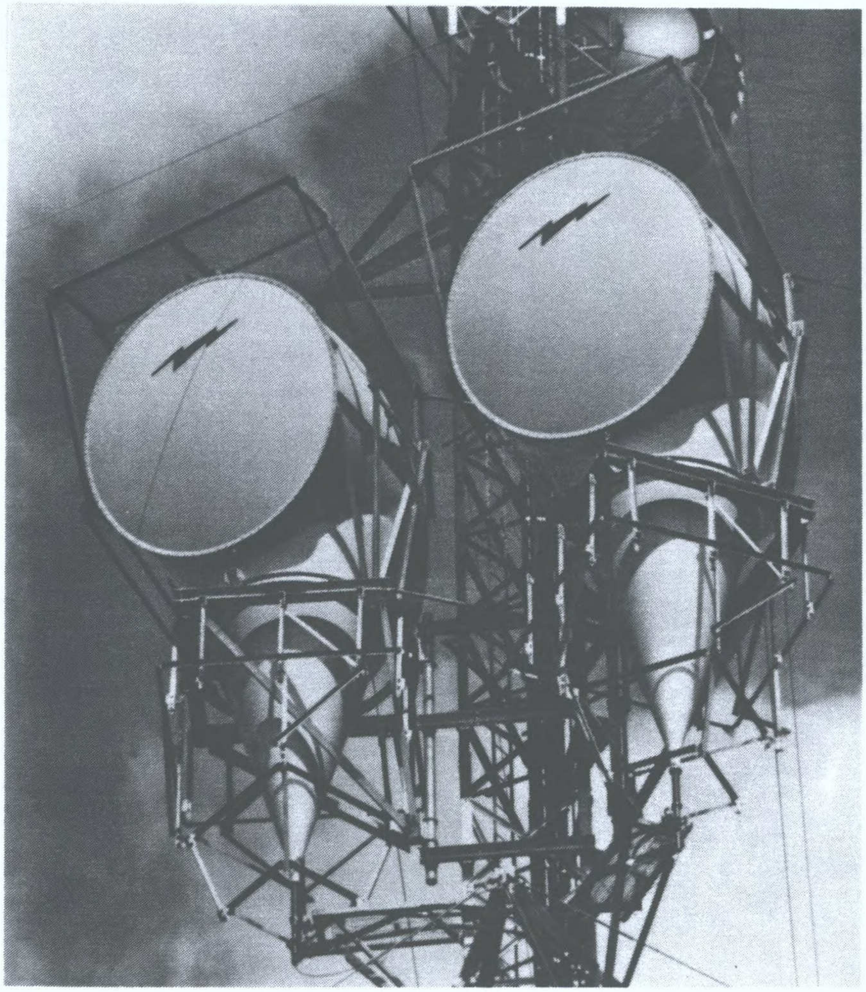

FIGURE 3
SHX Super High Performance Antenna

RPE Comparison at 6 GHZ

Typical 10-foot (3.0 m) Antennas

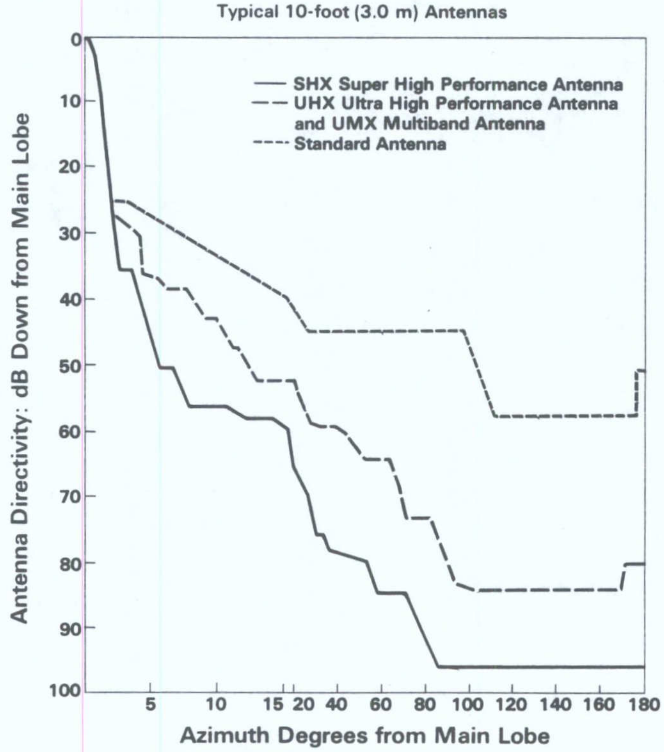

FIGURE 4

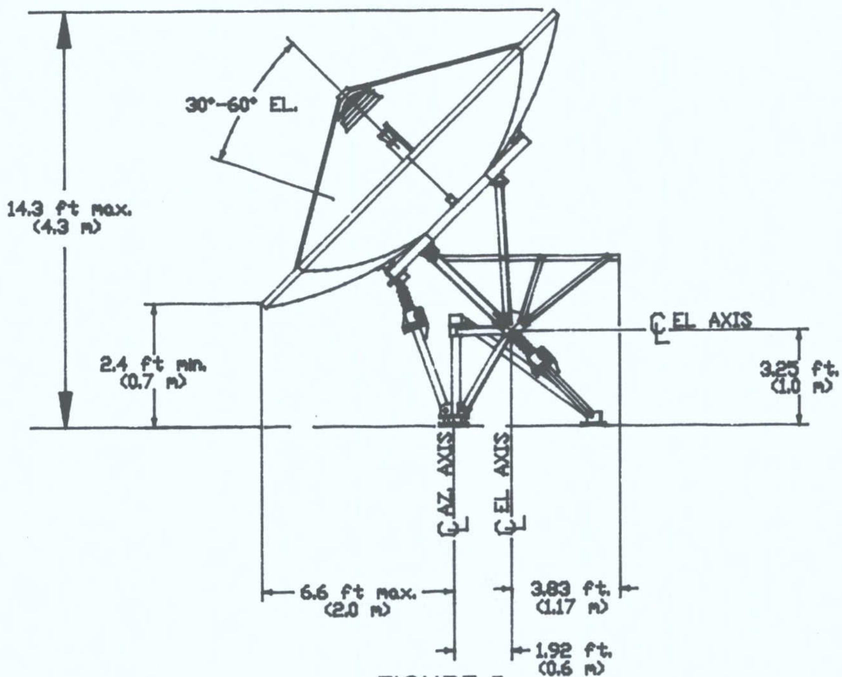

FIGURE 5

Actual Antenna Range Pattern
of 4.2 Metre At 29.25 GHz

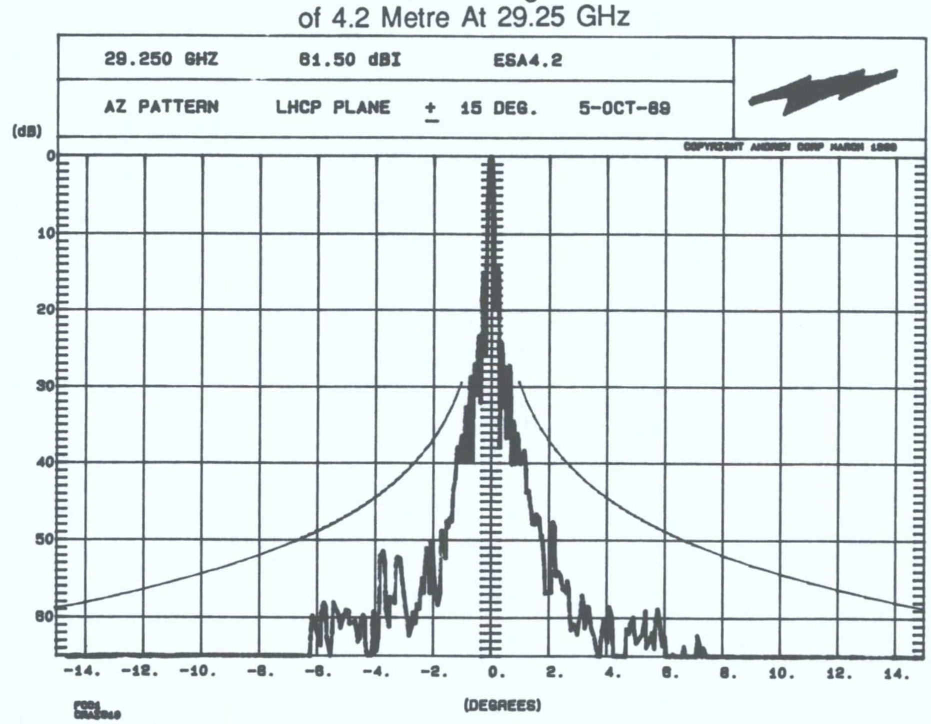

FIGURE 6

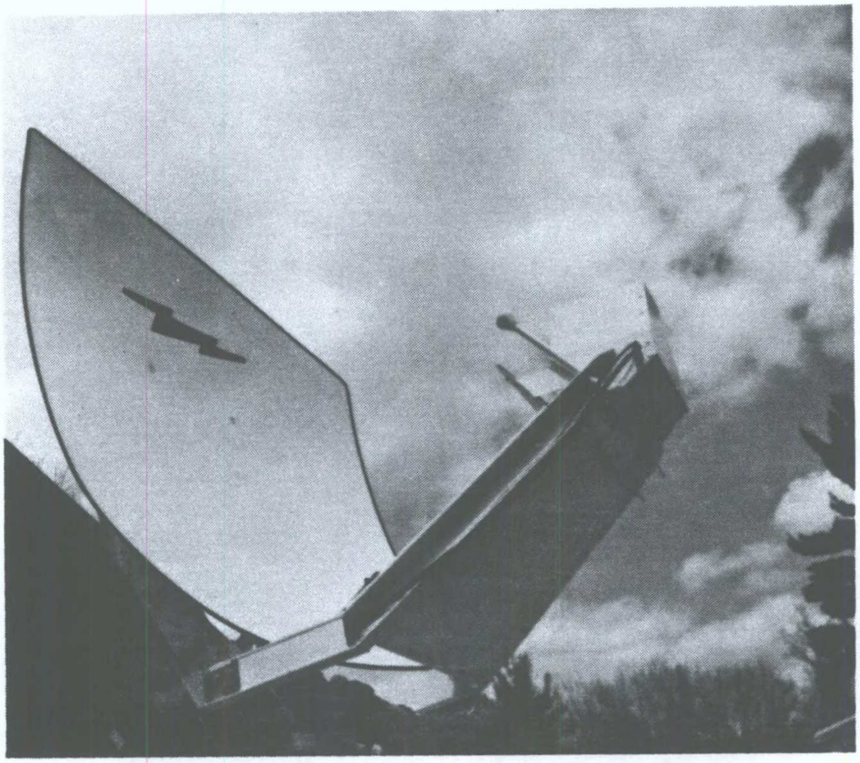

FIGURE 7
2.4 Metre Offset Antenna: ESA24VSM

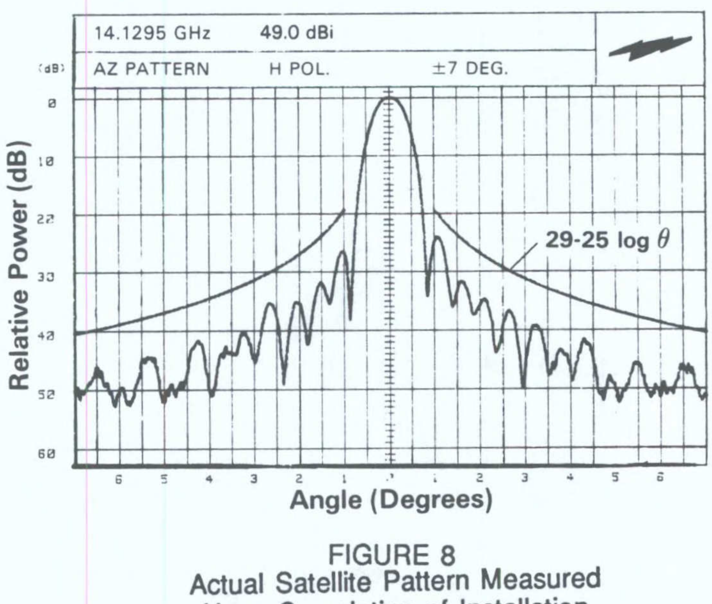

FIGURE 8
Actual Satellite Pattern Measured
Upon Completion of Installation

NEW SATELLITE OPPORTUNITIES

Sheelagh Whittaker

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Mississauga, Ontario, Canada

ABSTRACT

For the past decade and more, satellites have been held up as the ultimate distribution system for a wide range of telecommunication and broadcast services.

Some years ago, all the major telephone companies across Canada installed uplinks, and in some cases elaborate video teleconferencing facilities, in a number of larger cities for an expected proliferation in satellite based voice, data and video transmission services. Other organizations like the IBM backed SBS group undertook ambitious programs to link up businesses all across America with satellite based "Office of the Future" technology. With cost-saving innovations such as today's VSAT (Very Small Aperture Terminal) technology, we have finally crossed the threshold of a new era in realizing our dreams of a satellite facilitated world. What will that mean for traditional methods of carriage.

Other innovations involve technological improvements like HDTV and stereo. Do we need these so called advances, or is the cost in spectrum too great when the decades ahead promise new utilization requirements for medical, environmental and other purposes? It's time to make some radical shifts from the status quo.

Résumé

Nouvelles possibilités en matière de satellites

Sheelagh Whittaker
Canadian Satellite Communications Inc.
Mississauga, Ontario, Canada

Depuis au moins dix ans, on estime que les satellites constituent les meilleurs systèmes de distribution d'une multiplicité de services de radiodiffusion et de télécommunications.

Il y a quelques années, toutes les grandes compagnies de téléphone canadiennes ont décidé d'avoir recours à des liaisons ascendantes et, dans certains cas, ont constitué des installations de vidéoconférences, dans un grand nombre de villes importantes parce qu'elles prévoyaient la prolifération des services de transmission de la voix, des données et des images par satellite. D'autres organisations, dont le groupe SBS qu'appuyait IBM, ont mis sur pied des programmes ambitieux en vue de relier entre elles les entreprises à travers toute l'Amérique par la technologie "satellisée" du bureau de l'avenir. Grâce aux innovations qui se traduisent par des économies comme l'actuelle technologie TTPO (terminaux à très petite ouverture), nous avons finalement franchi le seuil d'une ère nouvelle et réalisé notre rêve d'un monde où le satellite rend la vie plus facile. Quelles seront les conséquences de cette évolution pour les modes de transmission classiques?

D'autres innovations font intervenir des perfectionnements technologiques comme la TVHD et la stéréophonie. Avons-nous besoin de ces prétendus perfectionnements ou le coût de cette utilisation des fréquences sera-t-il trop élevé si l'on considère que de nouveaux besoins médicaux, environnementaux et autres s'annoncent dans les prochaines décennies? Le moment est venu de rompre le statu quo.

NEW SPECTRUM MANAGEMENT TECHNIQUES

Douglas Sward
Department of Communications

ABSTRACT

Future management of the radio spectrum will become more demanding from a political, technical and social standpoint. Rapidly advancing communication technology and increasing demand for both conventional and new radio services will continue to put pressure on the radio spectrum.

The introduction of more radio services in the 1990's will generate a need to better understand the radio resource in terms of its availability and efficiency of use. The role of the spectrum manager will have to expand from a frequency allocation function to include environmental management techniques.

New ways are being developed to quantify the usage of the spectrum in a meaningful format. Modern resource management tools such as geographical information systems are being married to electromagnetic compatibility analysis models to generate new profiles of spectrum availability. Large geographical areas can be assessed as to the availability of a single channel or a group of channels. Other attributes such as population density, land use and road accessibility can be included to create a composite profile. The strength of this approach comes from the use of the existing radio environment; the results are based on the actual radio systems in use, not a hypothetical model.

Environmental assessment of the radio spectrum will provide the insight needed to determine the 'health' of a frequency band. It will allow spectrum managers to forecast the depletion of channels in a band and to assess the impact on the available spectrum resulting from a change in policy, regulation or technical standards. Furthermore it will help in the development of long term strategies and indices of usage efficiency that will promote optimum use of the spectrum.

Résumé

Nouvelles techniques de gestion du spectre

Douglas Sward
Ministère des Communications

Au cours des prochaines années, il sera plus difficile de gérer le spectre des fréquences radioélectriques du triple point de vue politique, technique et social. Les progrès rapides que connaîtra la technologie des communications et la demande accrue aussi bien de services classiques que de services radio nouveaux vont continuer à exercer une pression sur le spectre des fréquences radioélectriques.

Par suite de la mise en oeuvre d'un nombre accru de services de radiocommunications dans les années 90, il faudra mieux comprendre la disponibilité et l'efficacité d'utilisation du spectre en tant que ressource. Le rôle du gestionnaire du spectre, qui s'est limité jusqu'à maintenant à l'attribution des fréquences, devra désormais comprendre l'utilisation de techniques de gestion du milieu.

De nouveaux moyens sont élaborés pour quantifier l'utilisation du spectre sous une forme utile. On utilise conjointement des outils de gestion des ressources modernes comme les systèmes d'information géographique et des modèles de compatibilité électromagnétique pour obtenir de nouveaux profils de disponibilité des fréquences. On peut ainsi déterminer la disponibilité d'une voie unique ou d'un groupe de voies dans de vastes zones géographiques. Il est également possible de tenir compte d'autres paramètres comme la densité de la population, l'utilisation des terrains et l'accessibilité des routes pour obtenir, par superposition, un profil composite. L'avantage de cette approche réside dans l'utilisation du milieu radioélectrique existant; les résultats reposent sur les systèmes de radiocommunications effectivement utilisés, non sur un modèle hypothétique.

C'est par l'évaluation du milieu radioélectrique qu'on parviendra à déterminer "l'état de santé" d'une bande de fréquences. Les gestionnaires du spectre pourront alors prévoir l'appauvrissement des voies dans une bande donnée et évaluer les répercussions d'un changement de politique, de règlement ou de normes technique sur la portion de spectre disponible. En outre, il sera ainsi plus facile d'élaborer des stratégies à long terme et des indices de l'utilisation efficace du spectre qui contribueront à optimiser son emploi.

1.0 Introduction

The radio spectrum touches the everyday lives of nearly all Canadians - while someone is listening to their favorite radio station as they drive to work; a 747 is making its final approach using a radio guidance system; a fireman at the scene of a warehouse fire calls for assistance using a radio, and a satellite is relaying critical weather information to ground stations. Hundreds of thousands of radio systems are working throughout Canada to support essential cultural, commercial, industrial and public service requirements.

Since the second World War, Canadians have seen a tremendous growth in radio services. Canada's vast distances have prompted the use of radio as an economical means of providing basic communication services. Over the years, Canadian expertise gained international status as a leader in the development of radio services and technology.

As radio technology and services rapidly evolve, industry and government will be faced with an increasing problem of how to coordinate the cumulative spectrum requirements. The scope of the issues, both on a national and international scale, are substantive, requiring not only reactive measures but effective long term strategies.

The solutions that are needed to accommodate future demands on the radio spectrum will be broad-based, including technical, political, economic and social initiatives. They will have to take many factors into account, such as the following:

- Changing character of radio services
- Impact of allocation changes
- International markets
- New business opportunities
- Mobility
- Public and Political Awareness

Long term strategies will be required to focus Canadian spectrum management activities in both the national and international forums in order to obtain timely and beneficial spectrum allocations and assignment schemes. Initiatives such as the promotion of higher frequency bands (above 20 GHz), more spectrally efficient modulation/coding schemes, the use of non-spectrum alternatives, and a greater regulatory differential between urban and rural use of the spectrum are just a few of the options which could be considered.

The exercise of developing solutions to meet the continuing pressures on the radio spectrum will generate a need to better understand the radio resource in terms of its availability and efficiency of use. New ways are being developed to quantify the usage of the spectrum in a meaningful format. One such method currently under development in the Department of Communications utilizes modern resource management techniques and conventional spectrum engineering models to generate a profile of spectrum usage in a given geographical area. This method, "Spatial Assessment of the Radio Spectrum", is the subject of the balance of this paper.

2.0 Spatial Assessment of the Radio Spectrum

2.1 Concept

Spatial Assessment of the radio spectrum may be defined in a number of ways depending upon the issue to be examined. For example, the study of immunity problems requires a knowledge of the levels of R.F. fields in various urban, industrial and rural environments. The context of spatial assessment as it pertains to spectrum usage deals with the examination of service allocated frequency bands, the areas of operation and the determination of the reserve capacity to meet future needs. It is in effect the study of the accessibility of a frequency band for either additional 'like' radio systems or the introduction of a new type of service.

The concept of spatial assessment has been used by resource industries such as forestry and mining for many years. Geographical and geological surveys generate profiles of available resources for various regions of the country. Modern resource management techniques employ computer based spatial analysis systems, sometimes referred to as geographical information systems (G.I.S.) to help make land use trade-off decisions. In rural areas, land allocations may involve trade-offs between agricultural viability, urbanization requirements, recreational areas, transportation routes, soil conditions and topography. The example in Figure No. 1 shows the use of spatial analysis in determining the optimum area for sugar crops.

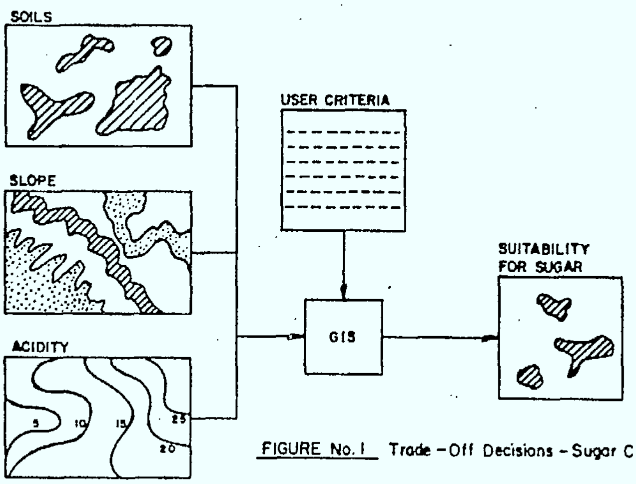


FIGURE No. 1 Trade-Off Decisions - Sugar Crop Example

Spatial analysis techniques also may be applied to spectrum management activities such as the following:

- Spectrum Usage/Availability

- Investigating Relationships Between Spatial Data (Radio coverage areas, population, transportation systems, land use, etc).

- Radio Spectrum Trade-Off Decisions

- Impact Assessment of Proposed Changes to the Use of the Radio Spectrum

In each of the above, the minimum requirement is to have some knowledge of the environment and to know how to model the relationship between the attributes. Figure No. 2 illustrates an example of investigating the spatial relationships between cellular radio, microwave backhaul systems and major highways.

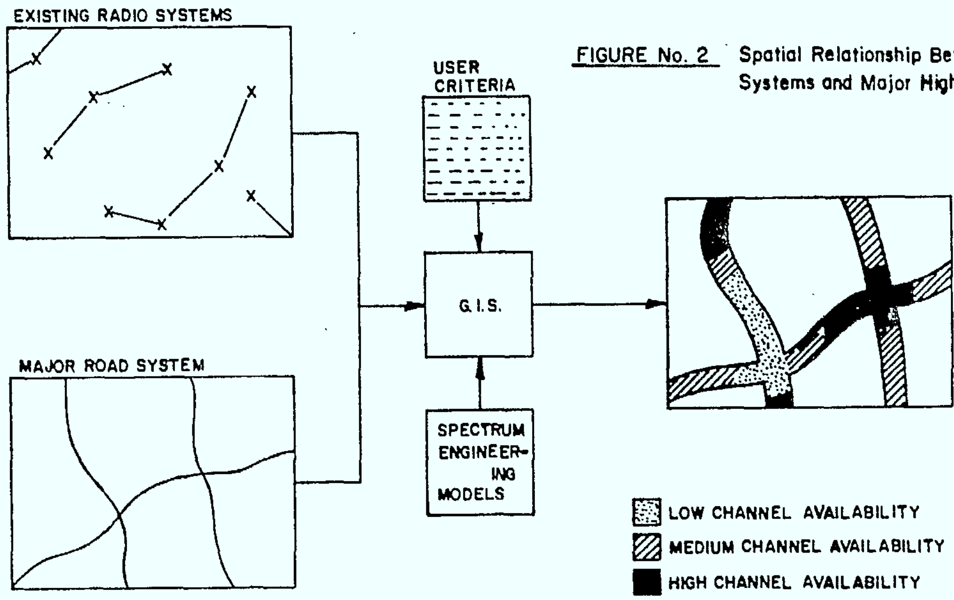


FIGURE No. 2 Spatial Relationship Between Cellular Backhaul Systems and Major Highways

In order to assess the spectrum in the example shown in Figure No. 2, it was necessary to transform the point-to-point, transmit-receive description of the microwave transmission into an area (or spatial) description of spectrum use. This is done by calculating the net interference effect in each unit area as caused by the existing stations in the environment and subsequently determine the number of available channels. The spatial representation of spectrum allows other attributes (such as road systems) to be further included to reveal a composite profile.

2.2 The Model

A model that has an objective to examine the availability of the radio spectrum must consider three factors:

1. Frequency

2. Time

3. Space

Most radio services operate according to a channeling plan in specified bands, and well established propagation models assist in the coordination of transmitters and receivers. The time element, for those services that time share channels, is managed through channel loading criteria, which specifies the number of users per channel.

The criteria for managing the frequency and time factors are, in most cases, well established and are only modified from time to time to reflect changes in technology and new propagation data. The challenge lies in the inclusion of spatial element in a model which reflects the availability of the radio spectrum.

There are a number of ways the spatial model could be developed. Two such methods are outlined below:

1. Test Point Sampling

A grid of test points is superimposed on the area under study. Each test point is examined against all interference sources to determine if the frequency under study can be used (transmitted or received). Also any restrictions of use are identified. The grid spacing is determined by nature of the service, the density of existing stations and the desired level of confidence. For a given study area, each test point should be reasonably representative of its zone of influence.

2.Unique Conditions

There are two steps in developing a unique conditions profile. First, the signal level contours of each of the stations in the area under study are determined using conventional transmission and propagation models. The contours of each transmission are superimposed on a single map.

The second step is to identify unique condition zones or polygons. These are defined as areas of homogeneous signal levels from each of the transmissions. The size of each zone depends on the number of overlapping contours and the contour spacing.

The unique conditions profile is a good spatial representation of the radio environment. In some ways it can be viewed as a variable grid where the test point sampling density increases in more complex (or rapidly changing) radio environments.

Both methods have advantages. The test point sampling is useful where there is a large number of transmissions over a sizable area. For example, this method could be used to examine the upper 2 GHz band (1900-2290MHz), point-to-point radio relay systems in Southern Ontario. The result, given a reasonable test point density, would be a good approximation of spectrum availability. However, it probably would not answer questions on whether systems can be squeezed in the highly precluded areas. Improvements in resolution may be achieved by varying the sample point density in the congested areas.

The contouring method is useful in relatively small areas where a detailed examination of spectrum availability is required for a small population of transmissions. This is ideal for studies of radio services in urban areas, where other factors such as road systems, land use and population density are to be considered.

Either method produces a spatial representation of the radio spectrum which can be modeled with other geo-referenced attributes including other radio systems.

Frequency bands normally have a channeling plan which prescribes the number of channels potentially available for the intended radio service. In order to determine the available channels in a given area, it is necessary to create a spatial profile for each channel. In effect each channel has its availability plotted on a map. By overlaying the map for every channel in the band, it is possible to count the number of available channels at each test point. This technique rolls up the frequency analysis to single spatial entity covering the whole band. The result is a map showing the number of available channels over the area under study.

The exercise of spatially representing the radio spectrum can be summarized in three steps.

1. Using transmission, propagation, and channel loading (time) models, calculate the required signal level contours or interference conditions at the test points, for all frequency channels under study.

2. The spatial profile of the spectrum is generated by either the test point or unique conditions method for each frequency channel in the band under study.

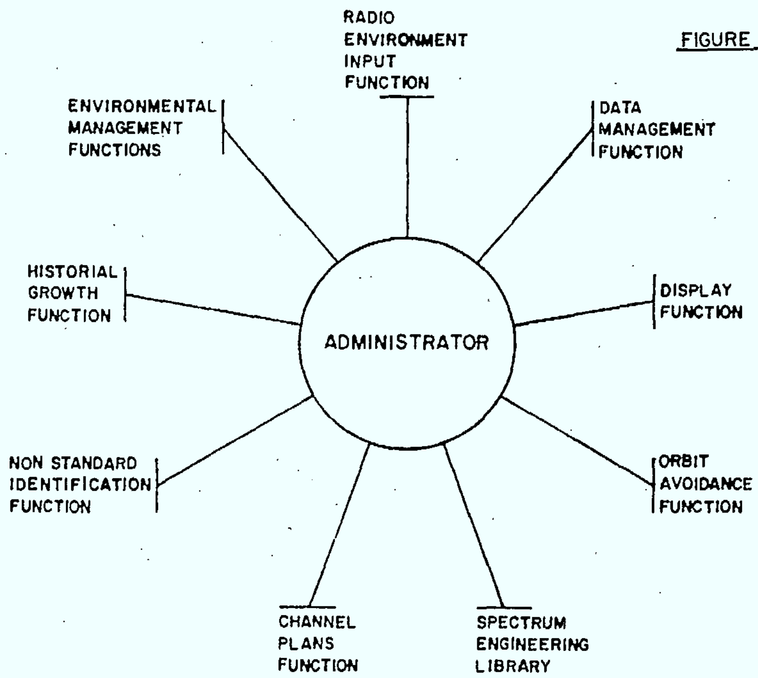
3. The spectrum availability of the full band is generated by combining the individual spatial profiles of each frequency.

2.3 The System

A computerized system was developed to control and process the large amounts of data as required by the spatial assessment model. Data files containing the existing radio stations and transmission/reception parameters, a point grid large enough to store all desired attributes, and raster or vector maps of other attributes such a population density, transportation systems and communication routes are just a few of the large cells of information which must be employed.

Figure No 3. illustrates the functional framework of the Spectrum Environment Assessment System (SEAS). The heart of SEAS is the Administrator which controls all input/output activities and provides the necessary interfaces between the function modules. Essentially the system accepts a group of radio stations and provides the user with a number of analytical or display options.

FIGURE No. 3 Spectrum Environment Assessment System



The options, shown as function modules in Figure No. 3 are outlined below:

Radio Environment Input Function

- The main purpose is to move an external data file containing the radio stations and their technical parameters for the frequency band and geographical area to be studied, into the Administrator module.

- Licensee information, station data (location, coordinates, elevation, etc.), transmit and receive frequency data (antenna gain, line losses, azimuth, polarization, transmit power, elevation angle, etc.)

- Currently 50 data elements per transmission are brought in.

Data Management Function

- In some instances it is desirable to modify the radio environment to suit the objectives of a particular study. For example, a study may call for an assessment of available channels in a band where frequency diversity has been permitted. The user may wish to look at the existing channel usage, with and without the diversity channels. In this case the diversity channels would be extracted from the stations in the environment using the data management function.

- Other procedures such as searches and parameter modifications may also be done.

Display Function

- The radio stations are plotted on a map and where applicable, the routes are also indicated.

- Stations can be labeled with the name of the location.

- Zoom capability for congested areas.

- Using the data management function, the display can be user tailored. For example, stations owned by company 'X', operating in British Columbia, on channels, F1, F2 and F3, employing and E.I.R.P. of 30dBW or greater, with a tower height of 100 meters or more may be extracted and displayed.

Orbit Avoidance Function

- For each transmission in the radio environment, the boresite direction is tested to determine if it illuminates the geo-stationary orbit.

- The result is displayed showing the geo-stationary orbit (east and west of Greenwich) and the longitude position of each illumination case.

- A detailed report indicating the power flux density of each illumination is also available.

Spectrum Engineering Library

- Contains all transmission and propagation models.
- Interference criteria (C/I curves, maximum permissible interference levels).
- Antenna patterns (typical, manufacturer's patterns).
- Geometry models (distance, azimuth, earth-to-space distances and angles, etc).
- Frequency sharing models.

Channel Plans Function

- Allows the user to identify the radio channels that are to be examined in the study.
- The user may also assign channel numbers to the transmissions in the area under study. This may be useful to identify radio systems which operate under a certain schema of channels.

Non Standard Identification Function

- Each transmission within the radio environment is tested against the operational requirements of the band and identified as either standard or non-standard.
- This function accepts new operational requirements to allow the user to determine the impact of the changes.

Historical Growth Function

- Identification of radio stations that were put in service during a specified period of time. (e.g. 1970-1980)

Environmental Management Function

- There are two major components: The spectrum engineering functions which handle the transmission and propagation calculations and the Geographical Information System (G.I.S.) which generates the spatial representation of the spectrum and allows the investigation of relationships between spatial data.

Figure No. 4 shows how the spectrum engineering and G.I.S. functions work together to produce spectrum availability profiles.

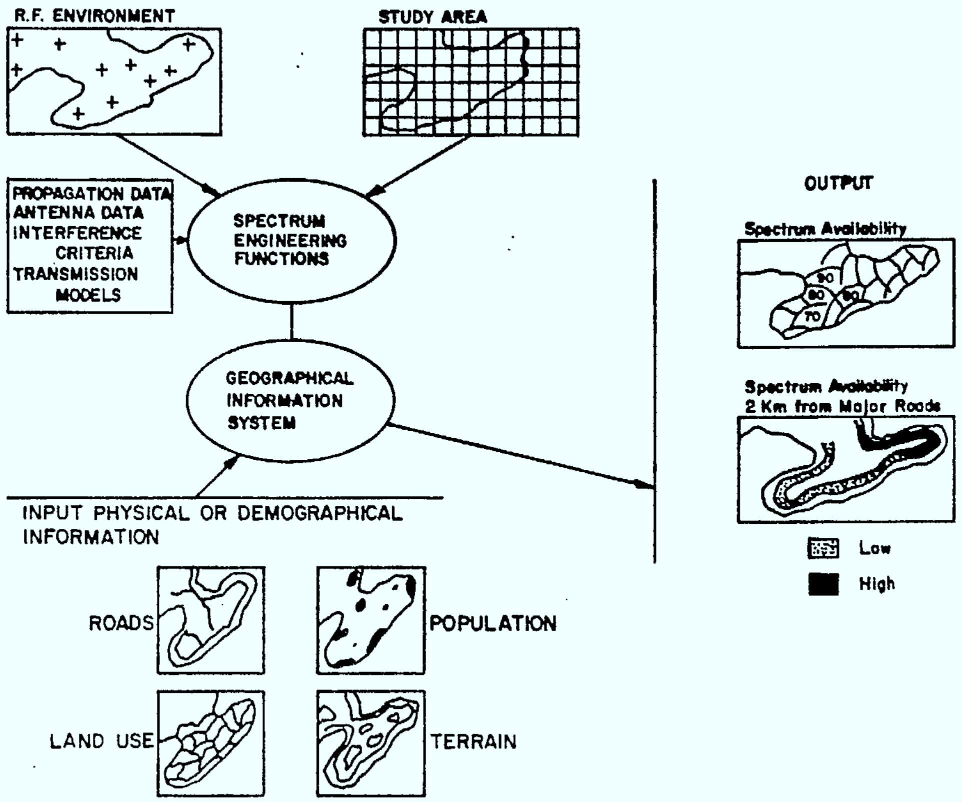


FIGURE No. 4 Environmental Management Function

- The R.F. environment is a data file containing all the stations and their respective transmission parameters which have a potential effect on the area under study. For example a study of FM broadcast channels in Nova Scotia would likely require a R.F. environment of FM and TV Channel 6 stations in Nova Scotia and surrounding provinces.

- The study area is the geographical zone which is to be examined for spectrum availability.

- Spectrum Engineering Functions: A series of routines calculate the signal levels at each test point in the study area. The user specified channel availability criteria is employed, for each channel under study, and a profile of availability is generated at each point.

- Geographical Information System: A commercially available G.I.S. with analytical spatial modeling capability is required. It should accept geo-referenced data, in a raster or vector form and perform basic spatial manipulations such as overlays, points modeling, contouring, unique conditions, voroni diagrams and chloropleth mapping.

3.0 Case Study

The objective of the case study is to illustrate the utility of the spatial assessment technique described in the previous section. The case study is as follows:

> 'Assessment of the spectrum availability in the 1710-1900 MHz band in the Province of New Brunswick'

The frequency band 1710-1900 MHz was selected for a number of reasons: it has a fairly complex channel plan arrangement; it is a well used band by radio-relay operators; and the highly directional antennas employed in this band generate unique spatial requirements.

In Canada, there are five types of fixed service radio systems currently permitted in this band:

1. Very Low Capacity (VLC) Analogue
2. Low Capacity (LC) Analogue
3. Medium Capacity (MC) Analogue
4. Very Low Capacity Digital
5. Low Capacity Digital

In order to accommodate the range of VLC to MC systems the band was assigned four channel plans, A, B, C, D which are described below:

PLAN A

93 channels in lower half of band , (A)
93 channels in upper half of band, (A')
Bandwidth: less than or equal to 0.875 MHz
Loading: 0-24 SSB-FDM telephony channels
VLC-LC digital modulation

PLAN B

46 channels in lower half of band, (B)
46 channels in upper half of band, (B')
Bandwidth: less than or equal to 1.75 MHz
Loading: 25-59 SSB-FDM telephony channels
VLC-LC digital modulation

PLAN C

24 channels in lower half of band, (C)
24 channels in upper half of band, (C')
Bandwidth: less than or equal to 3.5 MHz
Loading: 60-120 SSB-FDM telephony channels
VLC-LC digital modulation

PLAN D

12 channels in the lower half of band, (D)
12 channels in the upper half of band, (D')
Bandwidth: less than or equal to 7.0 MHz
Loading: greater than 120 SSB-FDM telephony channels
VLC-LC digital modulation

Each plan occupies the same frequency range by locating the center frequencies of one band between the center frequencies of the plan with the next highest bandwidth.

Using the SEAS system, the radio relay stations in this band were displayed for the greater New Brunswick area (see Figure No. 5). As expected, there is a substantial population of stations and the highest concentrations were found in the urban regions of the province. Further investigation of the types of systems using the data management functions reveals that there is a fairly even distribution of VLC, LC and MC systems.

Given the large area, approximately 73,000 sq km, and an R.F. environment of approximately 320 transmissions, the test point sampling method was considered most appropriate for this study. In order to define the availability profile it was necessary to establish some test point criteria:

R.F. Environment:	Quebec, New Brunswick, P.E.I., Nova Scotia (U.S. Stations not included)
Test Point Density:	1 Point per 2 sq. km
Test Point Definition:	Receive

Test Point Antenna:	Andrew P(L) 10-17 (A)(C), 3.05m Parabolic, 33.2 dB gain
Interference Criteria:	Maximum permissible co-channel interference level of -135 dBW
Test Point Antenna Height (AMSL):	Set equal to the height of the interfering transmitting station
Availability Criteria:	90%, 75%, 50% of 360^{o} arc around the test point

The test point definition governs the type of availability to be generated in the study. In the receive mode the availability of spectrum is measured by the degree each channel can be received at the test points. In this case study, this mode may produce a good profile of spectrum availability as the antennas used in this band are highly directional and interference reduction measures may be incorporated in the site selection and system design activities.

The availability criteria refers to the number of azimuth degrees around the test point that are clear for reception. If the criteria is set at 50%, then at least 180^{o} of arc would have to be free of interference. The model essentially rotates the test point antenna 360^{o} and determines which portions of the arc experience interference from the transmissions in the local vicinity. The SEAS system uses threshold techniques to determine the precluded arcs as opposed to testing each of the 360 radials.

The study examined the individual channel groupings, A, A', B, B', C, C' and D, D' to develop a profile for very low capacity, low capacity and medium capacity systems. To comment in detail on each of the eight profiles would not serve the purpose of this paper; therefore, the presentation of the results will be limited to the lower half of the band which is covered by the channel groupings A, B, C and D.

Figures No. 6, 7, 8 deal with the availability of the 93 A channels which accommodate low and very low capacity digital and analogue systems. The effect of using very high availability criteria is evident in Figure No. 6 where at least 90% (324^{o}) of arc must be clear for reception. Less than 40 channels are available in the greater Fredericton/St. John, Moncton and Bathurst areas which account for the major populated regions of the province and a total land mass of 19,700 sq. km (27%).

Figure No. 7 and 8 illustrate the effect of reducing the availability criteria to 75% (270^{o}) and 50% (180^{o}) of available arc. The range 0-19 channels drops from the maps because none of the test points registered less than 20 available channels. Looking at the 'less than 40 channels' ranges, the 75% availability criteria (Figure No. 7) generated much smaller areas around the urban centres totaling 5,527 sq. km(8%). The 50% criteria (Figure No. 8) shows further improvement; only 2421 sq. km (3%) of urban areas have less than 40 channels.

In practice, it may be reasonable to accept the 50% criteria due to factors such as the following:

1. The interference analysis is slightly biased to the worst case scenario (eg. path terrain not considered).

2. Slight shifts in site location from the test point may reduce or eliminate an interference source. This is possible as each test point represents 2 sq. km.

3. It may be possible to change the polarization of the test point receiver, thus reducing or eliminating interference.

For the purposes of this study, the 50% criteria was considered suitable. Figures No. 8, 9, 10 and 11 show the availability profile for the A, B, C, and D channel groupings. In reviewing each map the following observations can be made:

1. The A and B channels are in good supply outside the urban areas. Within the urban areas there are approximately 30 A and 15 B channels in reserve. Comparison of the range 0-60 A channels to 0-30 B channels on the respective maps indicate that they occupy very similar areas. (A detailed report on the classification area reveals that 12,670 sq. km have 0-60 A channels and 13,100 sq. km have 0-30 B channels).

2. The C and D channels are in very limited supply in the greater populated areas. There are 12 or less C channels available in the 17,470 sq. km surrounding the populated areas. The D channels are also very scarce, with 6 or less channels available in 21,160 sq. km of the same general area. The range of 0-6 available C channels is found only in a relatively small area (3280 sq. km), however the range 0-3 D channels is nearly 4 times that size (12,010 sq. km).

The final step in the study is to examine the areas of the province which are suitable for point-to-point radio system development and to factor this element in to the spectrum availability profile. A key consideration is accessibility ability of the site. Although not absolutely essential, all-weather road access to the site is very desirable from both a capital and operation cost stand point.

Figure No. 12 is an accessibility map which shows the probability of access from an all weather road for each vicinity of the province. By overlaying the A channel map (50%) and cutting out those areas deemed inaccessible for microwave systems (Poor and no access areas shown in Figure No. 12), a new profile is created. (See Figure No. 13).

This exercise eliminated 34,690 sq. km (47%) of the area in the province which is not likely to accommodate new systems in this band. The spectrum availability is dramatically reduced in the rural and sparsely populated regions as shown in Table No. 1.

Table No. 1

No. of Available Channels	Figure No. 8 A channels (50%) Area (%)	Figure No. 13 A channels (50%) + Access Area (%)
0-39	3	3
40-59	17	12
60-79	31	20
80-93	50	18

4.0 Conclusions

As radio technology and services rapidly evolve, there will be a need for industry and government to better quantify the radio spectrum in terms of its availability.

A technique currently under development in the Department of Communications employs conventional transmission and propagation models and spatial analysis techniques to produce a profile of spectrum availability. The net product is an area profile showing the zones of availability for a single or a group of channels. These profiles may be modeled with other attributes, such as road systems, population, etc. to generate a new measure of spectrum availability.

Future work within the Department of Communications on the spatial assessment of the radio spectrum will likely include:

1. Inclusion of a terrain model.

2. Developing forecasting models for specific applications.

3. Mobile and satellite radio service case studies.

4. Expand library of map databases (land use, population, transportation systems, etc.

REFERENCES

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2. Policy for the Fixed Service in the Band 1710-1900 MHz, SP-301.71, Telecommunications Policy Branch, Department of Communications, Government of Canada, December 1982.

3. SPANS, Spatial Analysis System, Reference Manual and Appendices, Installation Concepts and Tutorials, Version 4.0, 1988, TYDAC Technologies Inc.

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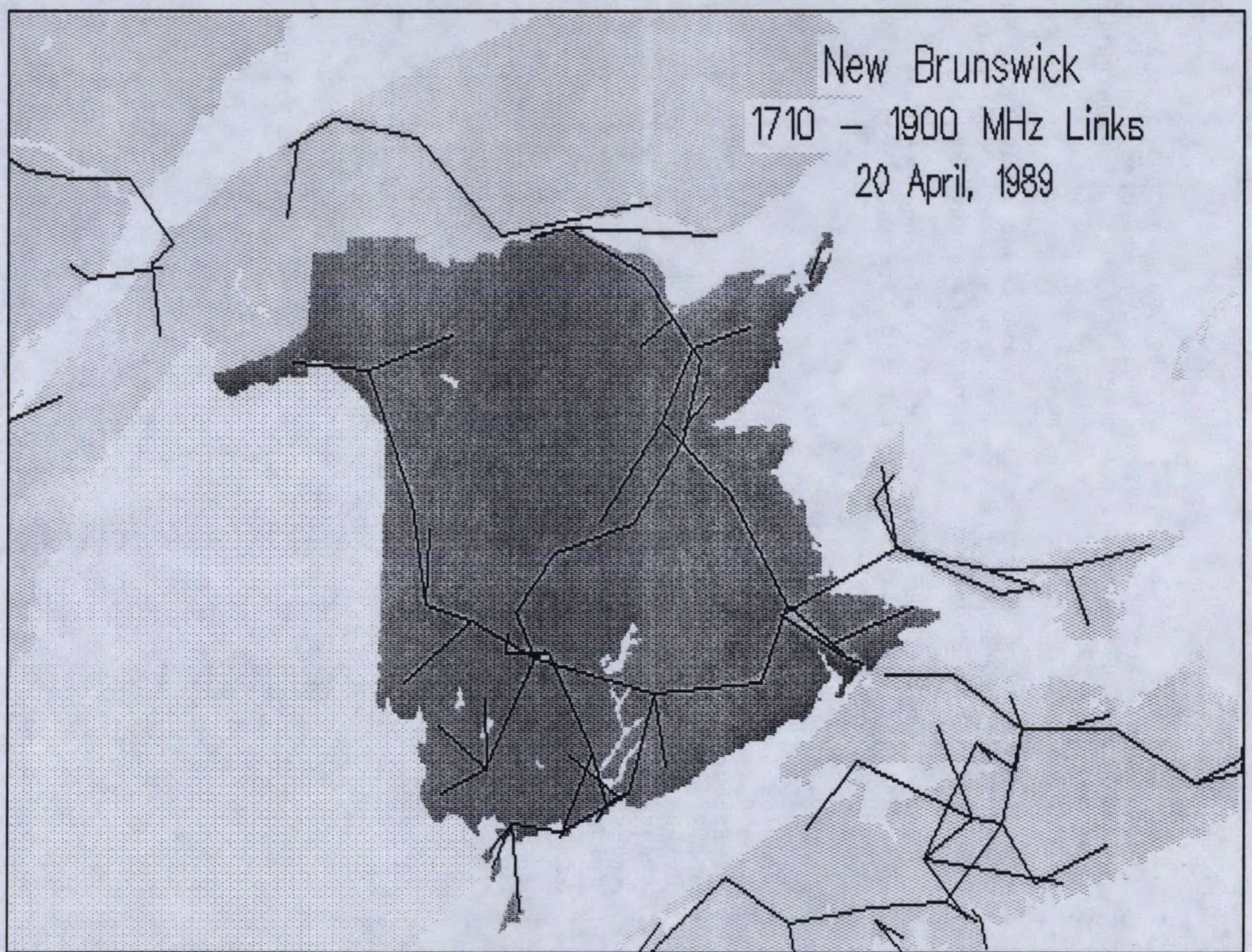


FIGURE No. 5

FIGURE No. 6

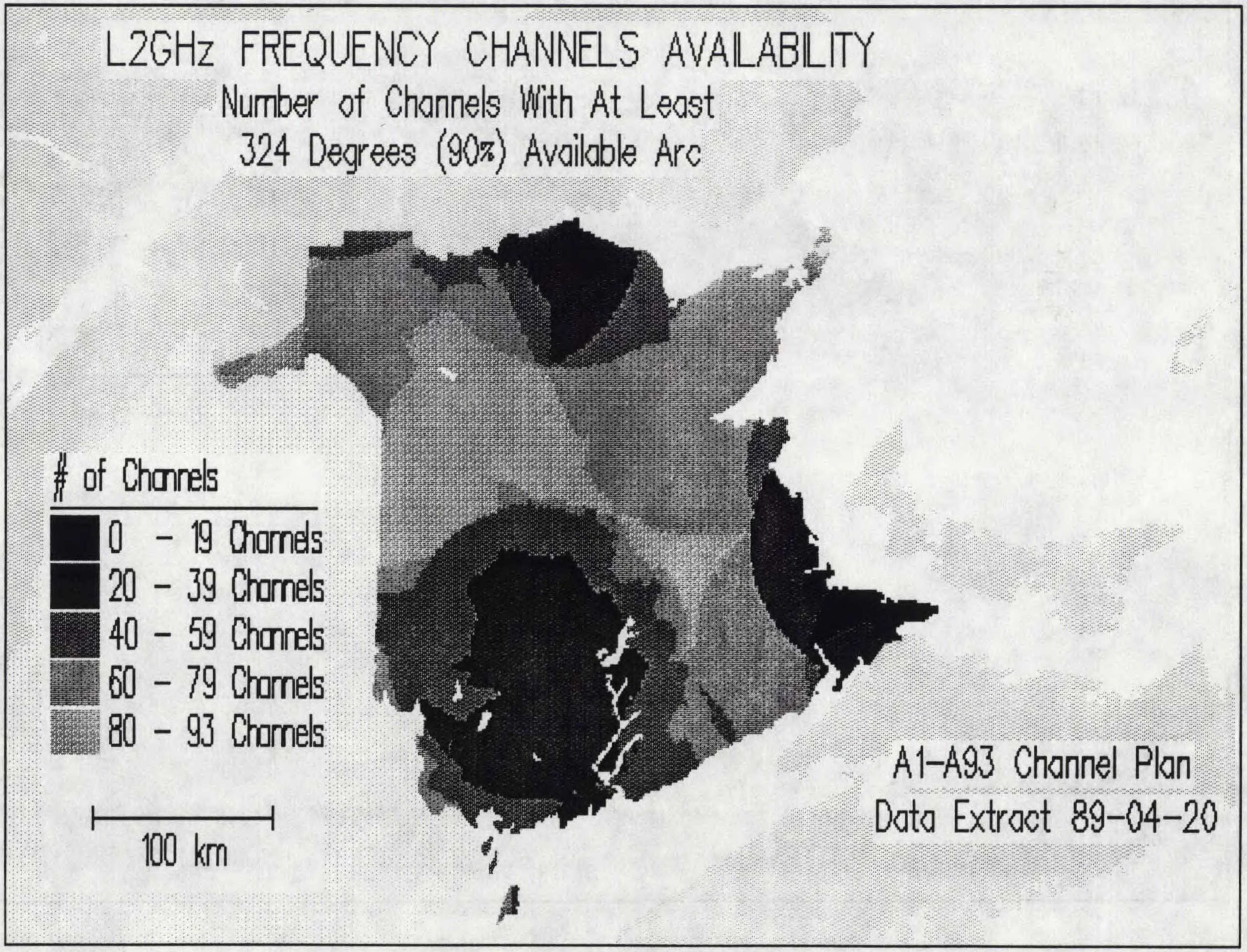
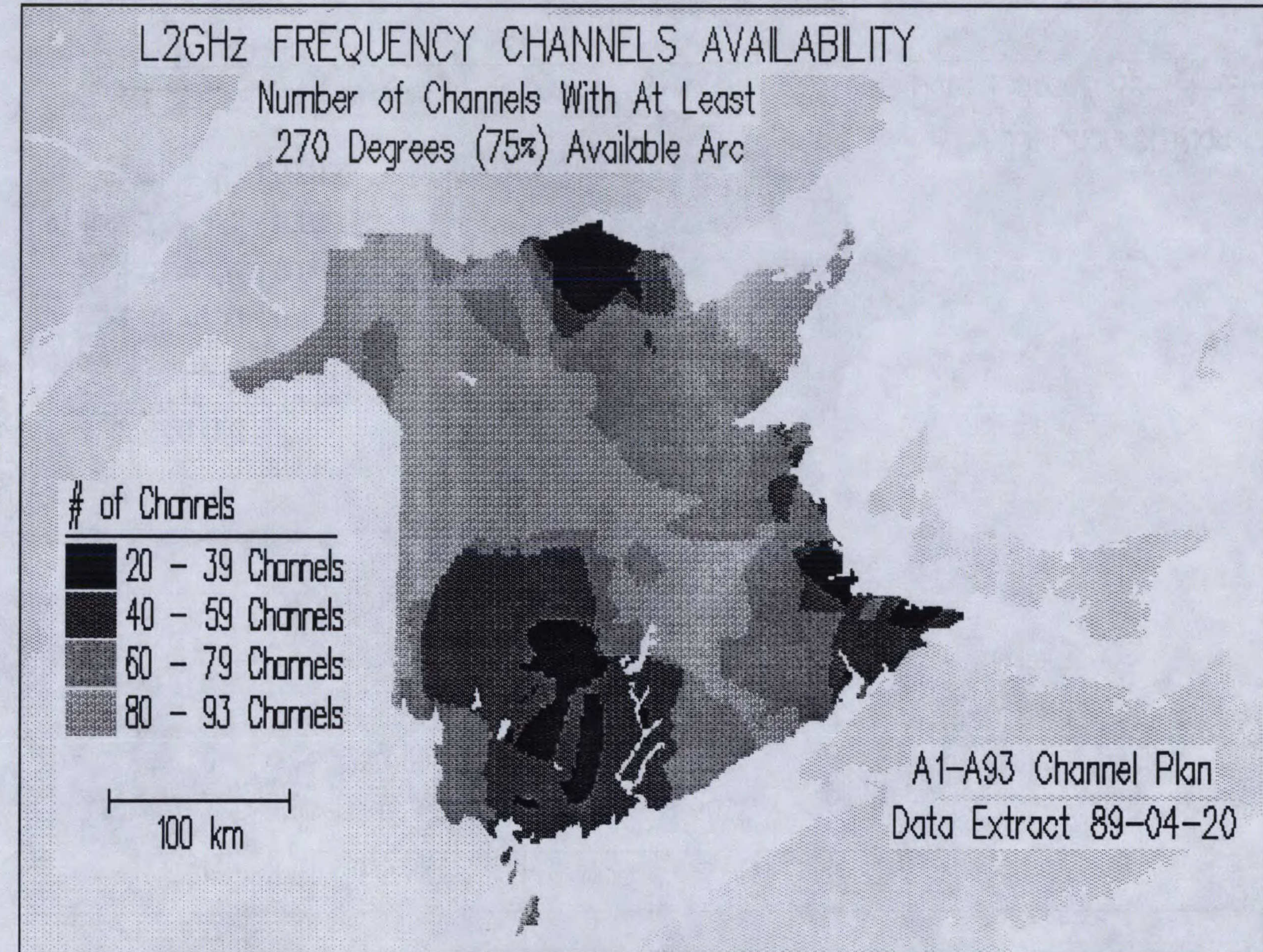

L2GHz FREQUENCY CHANNELS AVAILABILITY
Number of Channels With At Least
324 Degrees (90%) Available Arc
# of Channels
0 - 19 Channels
20 - 39 Channels
40 - 59 Channels
60 - 79 Channels
80 - 93 Channels
100 km
A1-A93 Channel Plan
Data Extract 89-04-20

FIGURE No. 7

3.8.20



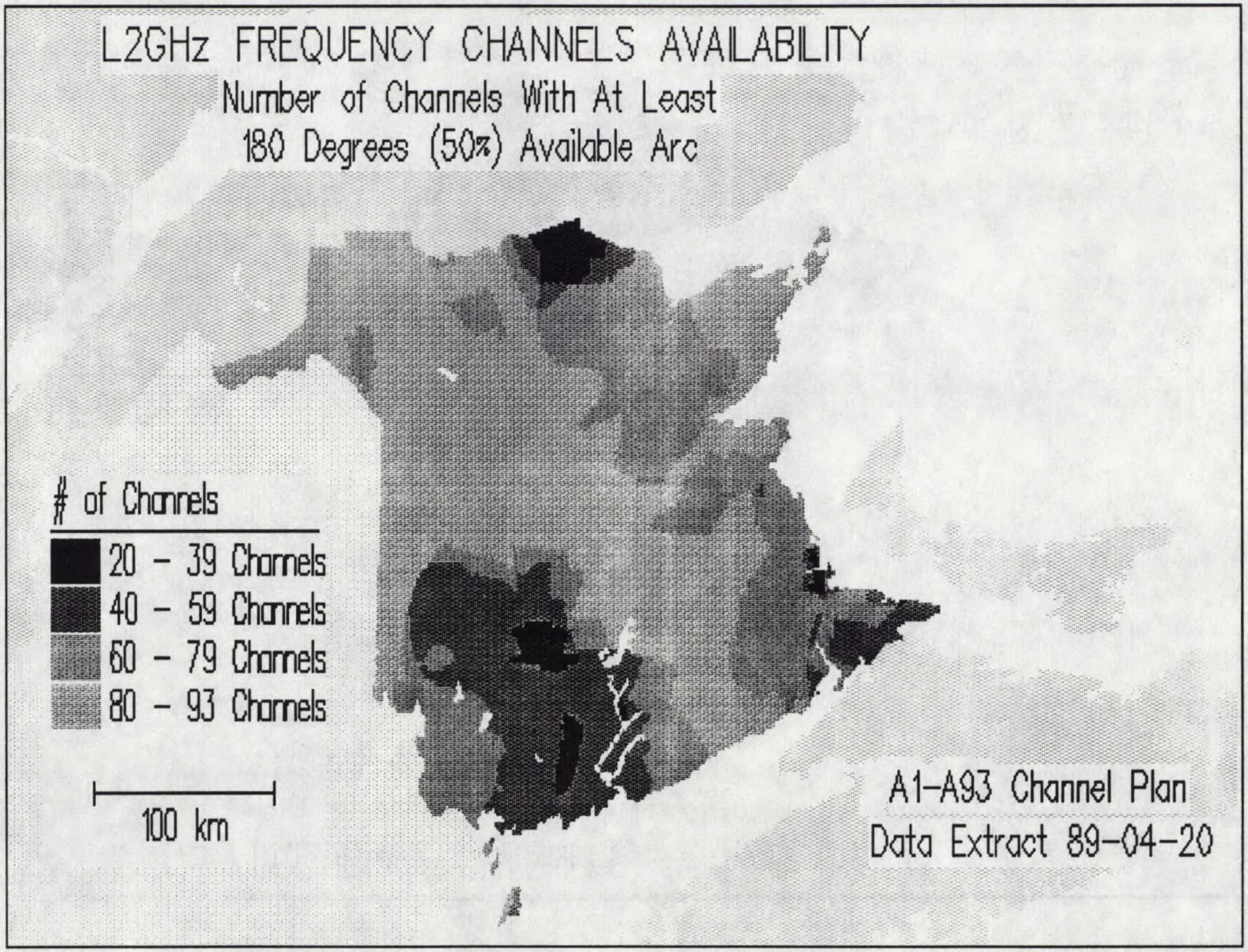


FIGURE No. 8
3.8.21

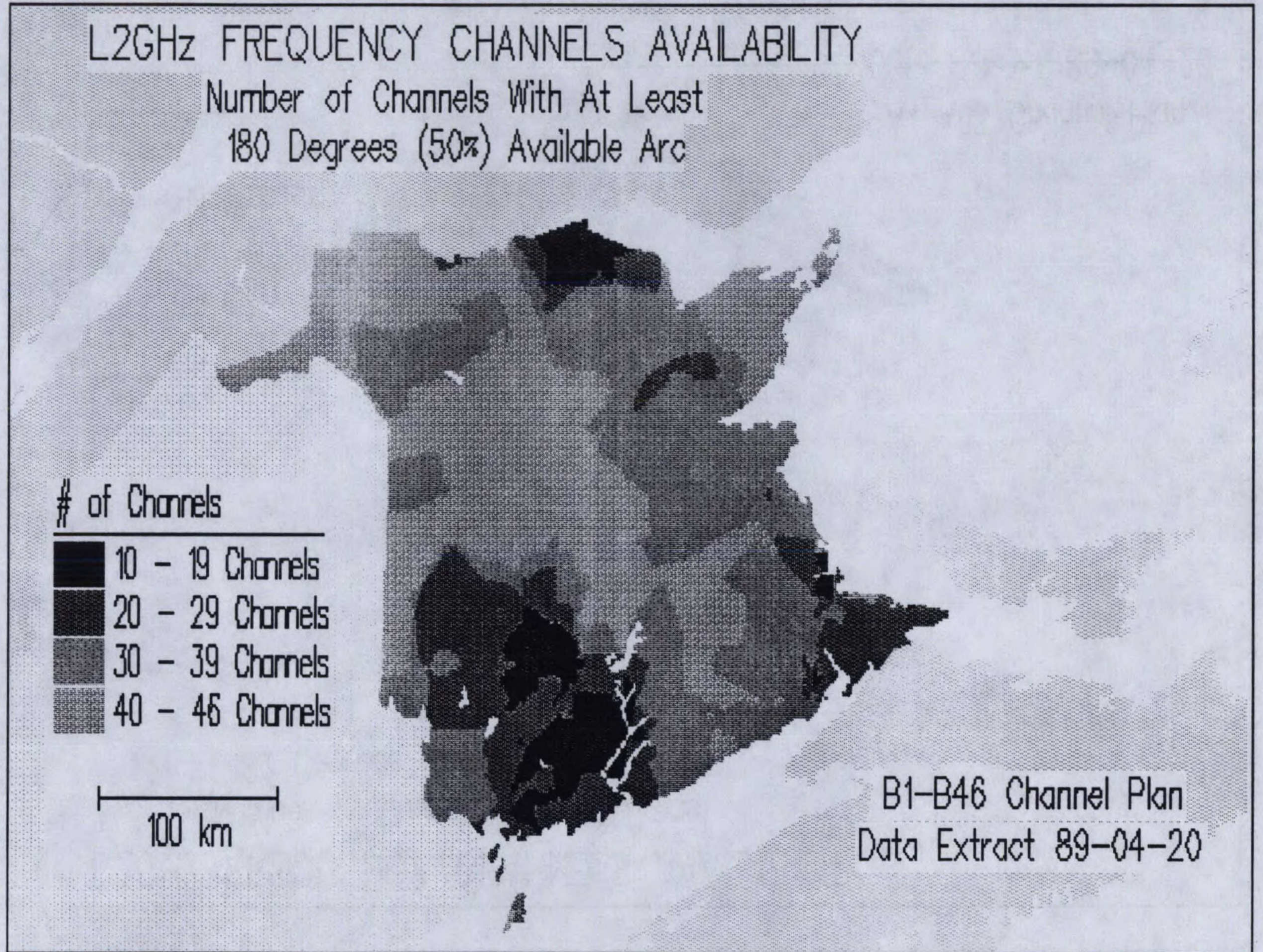


FIGURE No. 9

3.8.22

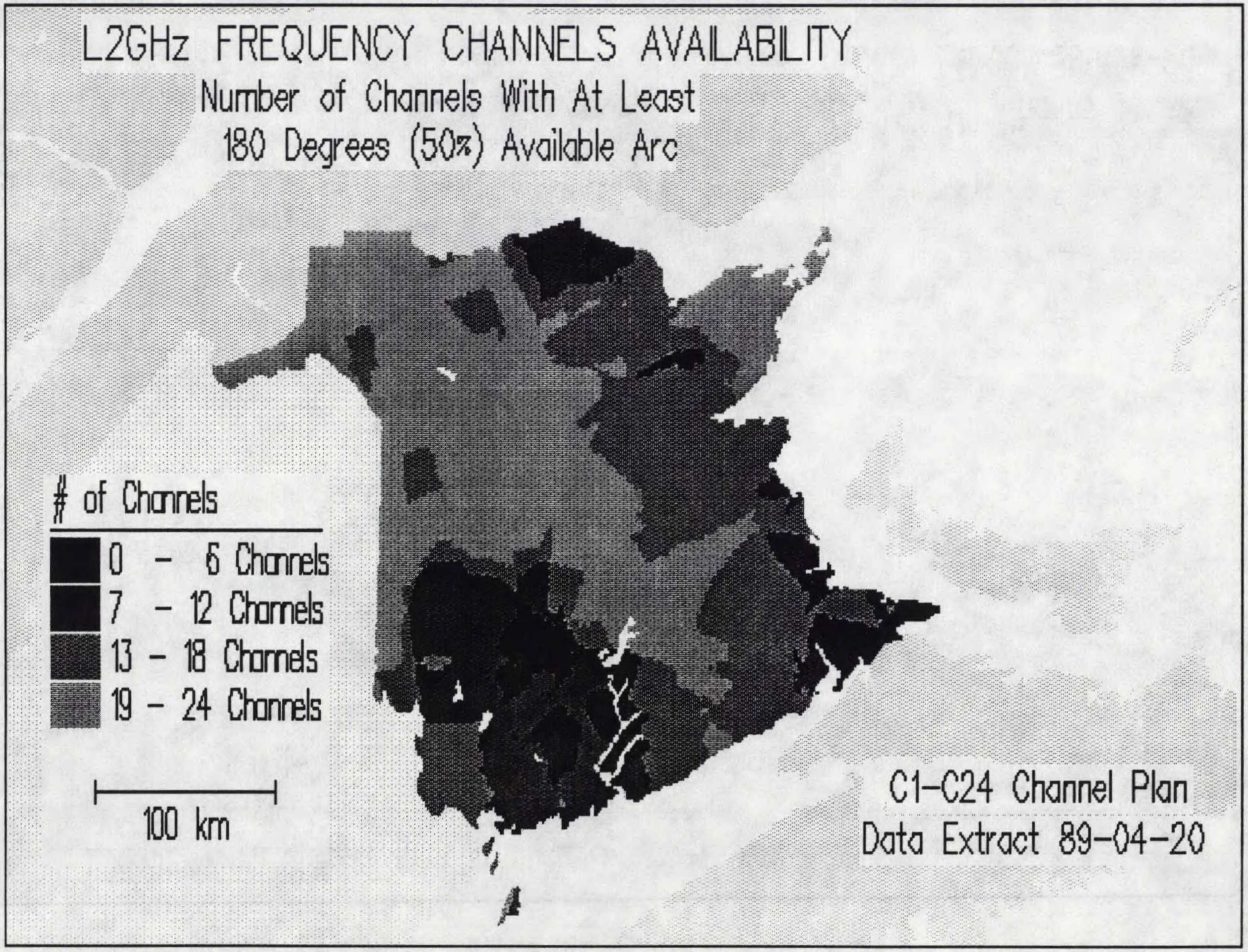

L2GHz FREQUENCY CHANNELS AVAILABILITY
Number of Channels With At Least
180 Degrees (50%) Available Arc
# of Channels
0 - 6 Channels
7 - 12 Channels
13 - 18 Channels
19 - 24 Channels
100 km
C1-C24 Channel Plan
Data Extract 89-04-20

FIGURE No. 10

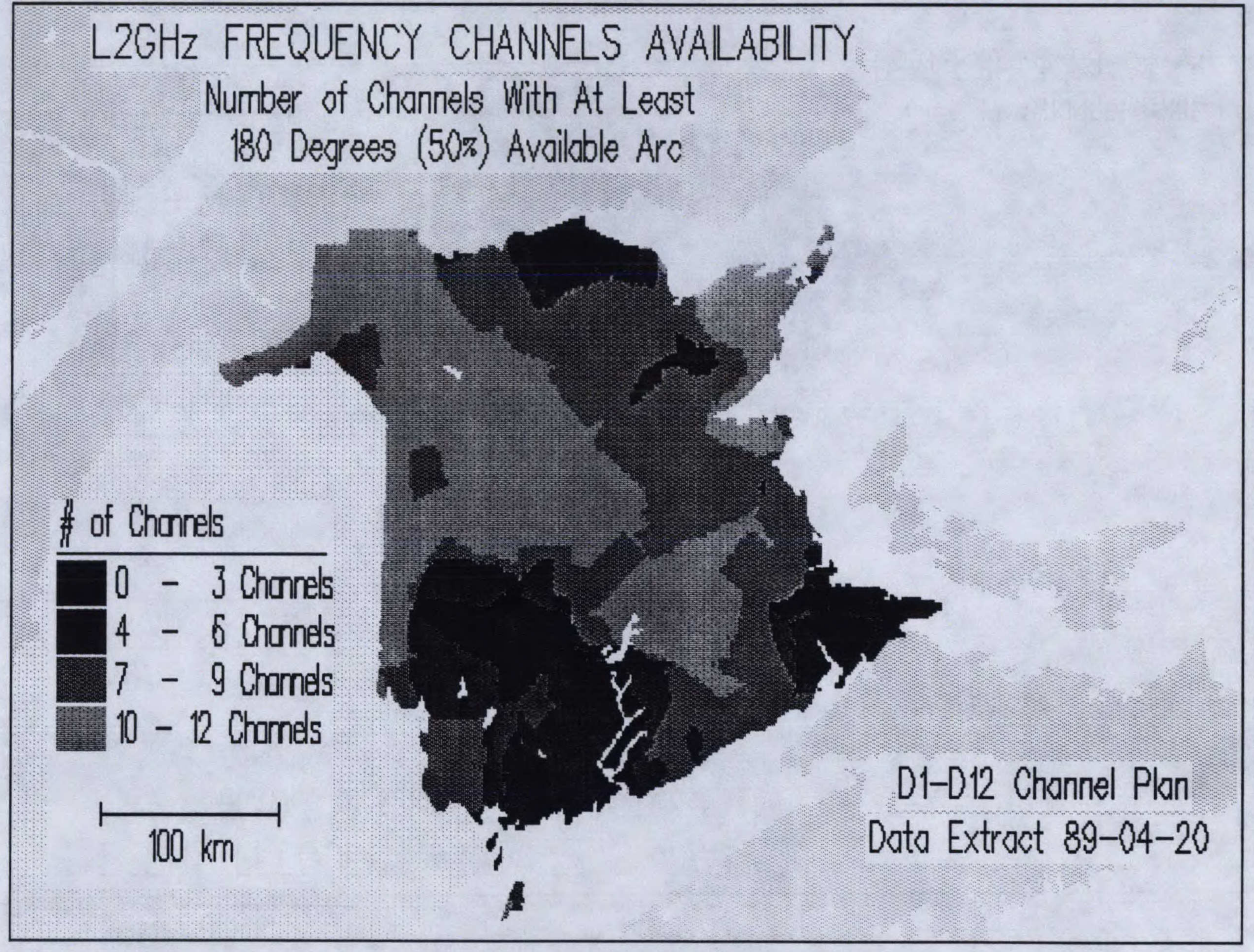
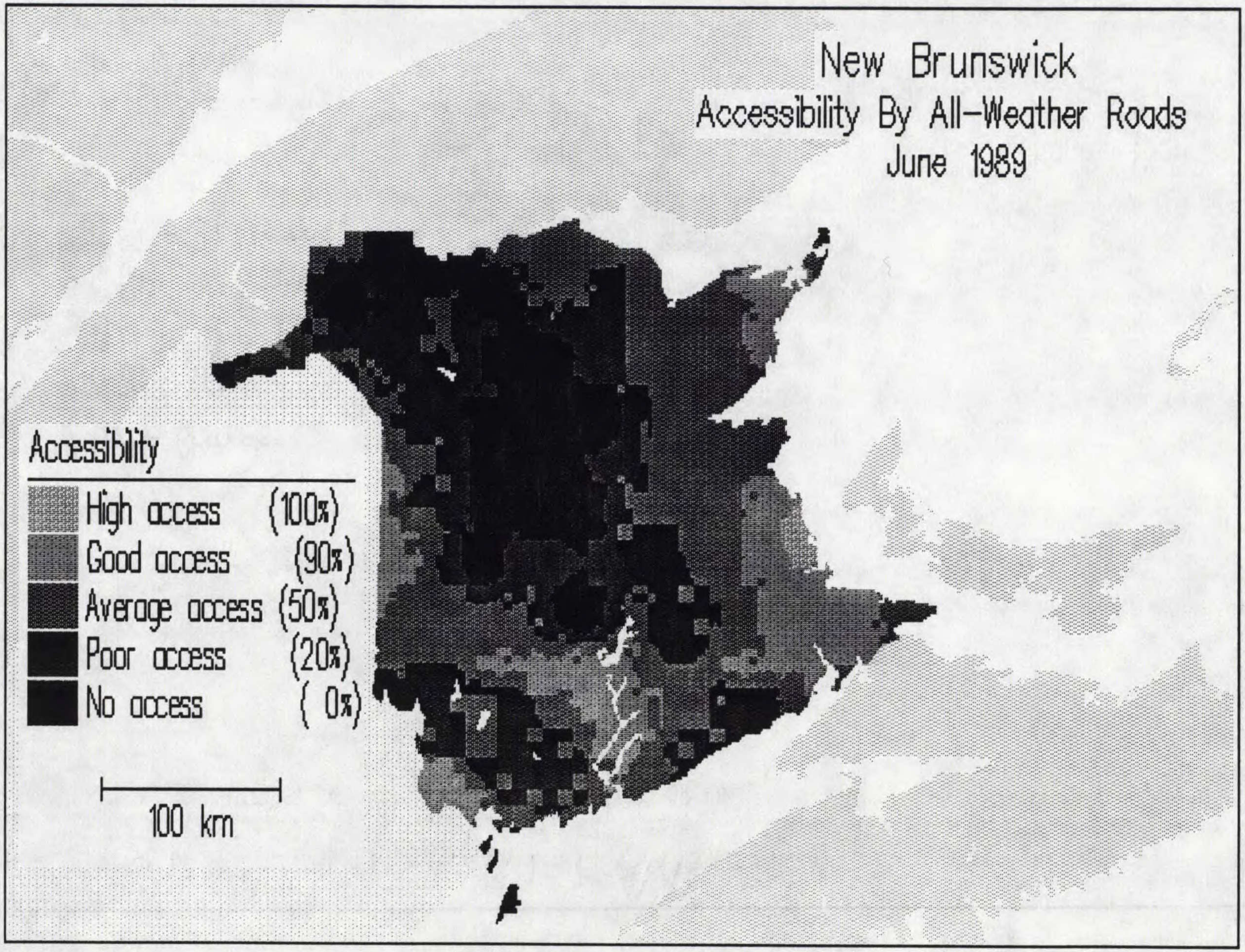

L2GHz FREQUENCY CHANNELS AVAILABILITY
Number of Channels With At Least
180 Degrees (50%) Available Arc
# of Channels
0 - 3 Channels
4 - 6 Channels
7 - 9 Channels
10 - 12 Channels
100 km
D1-D12 Channel Plan
Data Extract 89-04-20

FIGURE No. 11

FIGURE No. 12

3.8.25



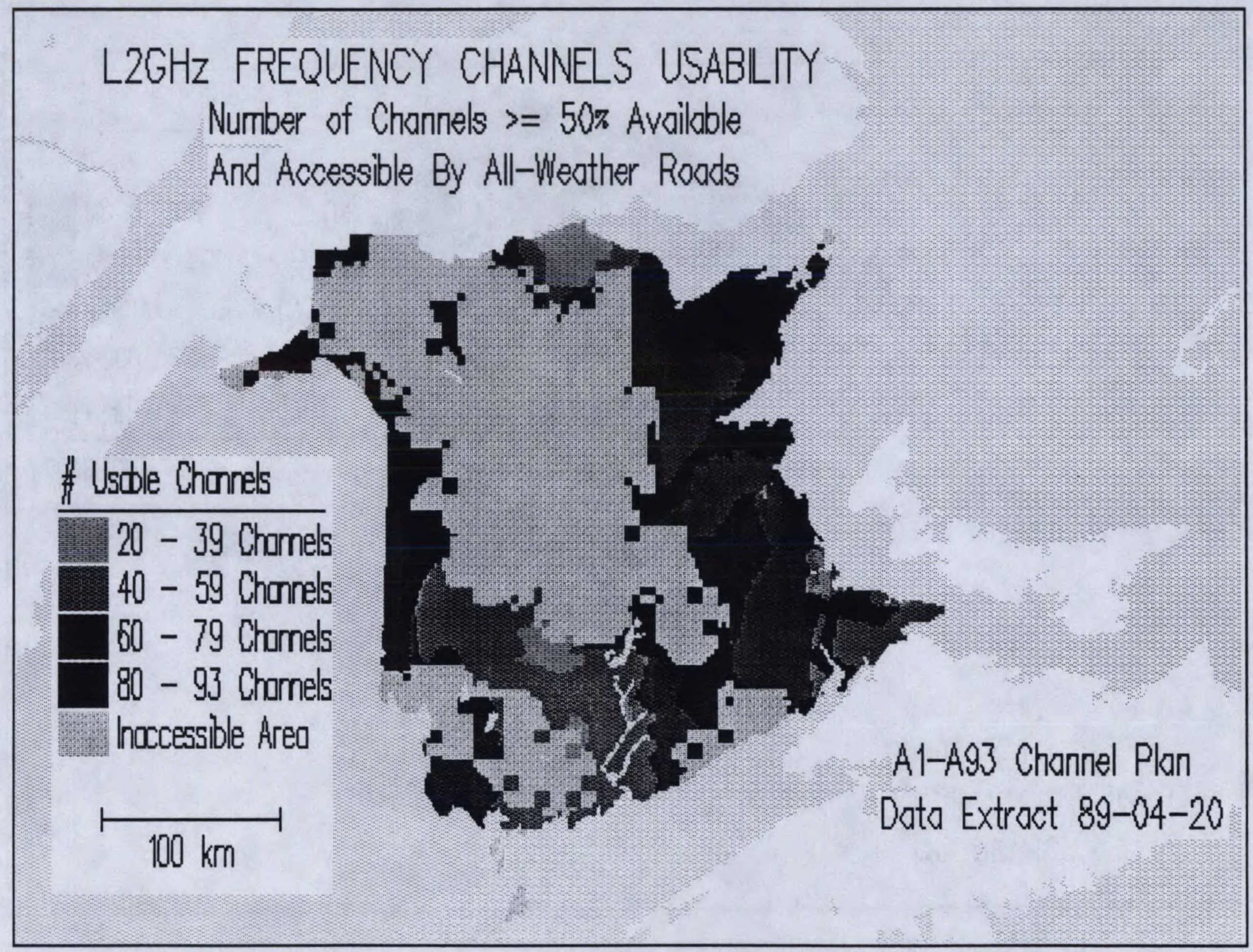

L2GHz FREQUENCY CHANNELS USABILITY
Number of Channels >= 50% Available
And Accessible By All-Weather Roads
Usable Channels
20 - 39 Channels
40 - 59 Channels
60 - 79 Channels
80 - 93 Channels
Inaccessible Area
100 km
A1-A93 Channel Plan
Data Extract 89-04-20

FIGURE No. 13

SPECTRUM POLICY SOLUTIONS*

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ABSTRACT

Spectrum policy decisions provide solutions to the use of the spectrum in the long term, in contrast to "operational" decisions which lead to specific frequency assignments and their characteristics. Often these policy decisions must be made without reliable forecasts of either the market or the technology which will exist at implementation. The time frames and complexities involved with these decisions are also influenced by international activities.

A World Administrative Radio Conference (WARC) is scheduled for 1992 which will make international spectrum policy decisions. The early scheduling of this WARC may cause some problems with regard to future domestic use and strategic spectrum planning. This is not atypical of the problem facing the spectrum planner. Most of the impetus to hold such an early conference came from narrow interest groups at earlier specialized conferences. The spectrum policy challenge will be to address these particular demands without jeopardizing the broader needs of all users of the spectrum in the long term.

The International Telecommunication Union (ITU) will convene a group of experts to examine different ways to allocate the spectrum. Some alternatives which can be investigated may yield greater spectrum flexibility and a better fit with long term planning. Hopefully, the recommendations of the group of experts will create new methods which are more responsive to modern needs, while satisfying the long term requirements of users as well as the concerns of the developing countries.

Résumé

Des solutions globales pour le spectre

Wayne Longman
Ministère des Communications
Ottawa (Ontario)

Les grandes décisions d'orientation concernant le spectre fournissent des solutions relativement à l'utilisation à long terme du spectre, contrairement aux décisions "opérationnelles" qui conduisent à des assignations particulières et à leurs caractéristiques. Souvent, ces décisions de principe doivent être prises sans que l'on puisse vraiment prévoir quel sera le marché ou quelle sera la technologie existante au moment où se fera la mise en oeuvre du système projeté. Les délais et les complexités qu'entraînent ces décisions varient également suivant les activités internationales.

Il se tiendra, en 1992, une Conférence administrative mondiale des radiocommunications (CAMR) au cours de laquelle de grandes décisions d'orientation à l'échelle internationale seront prise à l'égard du spectre. La tenue hâtive de cette CAMR peut causer certains problèmes en ce qui concerne les utilisations nationales futures et la planification stratégique du spectre, mais les problèmes que le planificateur du spectre doit affronter ne sont pas différents. Ce sont surtout de petits groupes d'intérêts qui, lors de conférences spécialisées antérieures, ont exercé des pressions pour que la Conférence ait lieu à une date aussi rapprochée. En matière de politique du spectre, le défi consistera à répondre à ces demandes particulières sans mettre en danger la satisfaction des besoins plus généraux de tous les utilisateurs du spectre, à long terme.

L'UIT a par ailleurs constitué un groupe d'experts pour examiner les différents modes d'attribution des fréquences. Certaines solutions, qu'il est possible d'explorer, peuvent conduire à une plus grande souplesse en matière de gestion du spectre et à une meilleure planification à long terme. Il est à souhaiter que les recommandations du groupe d'experts donneront lieu à l'adoption de nouvelles méthodes qui seront mieux adaptées aux besoins actuels, tout en permettant de répondre aux besoins à long terme des utilisateurs et d'apaiser les préoccupations des pays en développement.

DOMESTIC AND INTERNATIONAL SPECTRUM POLICY PROCESS

The basic function of spectrum policy is to divide a limited resource between competing interests. The first level of this policy making is carried out by sovereign states at an ITU World Administrative Radio Conference. The result is the International Table of Frequency Allocations. The next level is the creation of national allocation tables, to execute domestic priorities within the international framework. Canada attends allocation conferences with the objective of fulfilling its domestic spectrum needs. Many countries also employ a third level to identify which specific radio systems should use the broadly defined allocations. Such decisions may be found in the Department of Communications spectrum utilization and radio system policies.

Whether the spectrum policy decisions are made at the ITU or at home, we must resolve conflicting spectrum demands. Domestically, it is possible to obtain 5 and 10 year growth forecasts which have some degree of reliability. Internationally, such forecasts are not available, since participating Administrations seldom make them available, if they exist at all. This increases the difficulty in achieving a balance between the supply and demand of spectrum for different services. It is safe to say that conference decisions have less relevance as time goes on. Only time will prove if the allocation is too large or too small. In any case, the international allocations will probably remain unchanged well beyond any reliable forecast period.

Sometimes, a WARC will decide to remove a service from a band. Radio systems already in use provide radiocommunication services at a price which may need to increase if they must be replaced. In terms of economic benefit there should be certainty that this increase in cost is offset by the gain from the new service. Since this type of information is not available to the conference, each country must base its position on its own national situation. Too often, the majority of administrations attending the WARC have little or no investment in a band, and the situation can become quite difficult in terms of a satisfactory solution.

A change to the Table of Frequency Allocations is more readily accomplished in lightly used parts of the spectrum. The issues are simpler, and there is less opposition from the present occupants. Figure 1 shows a first order approximation of the relative occupancy of the radio spectrum in Canada. One spectrum solution successfully used in the past is to look to the higher frequency bands.

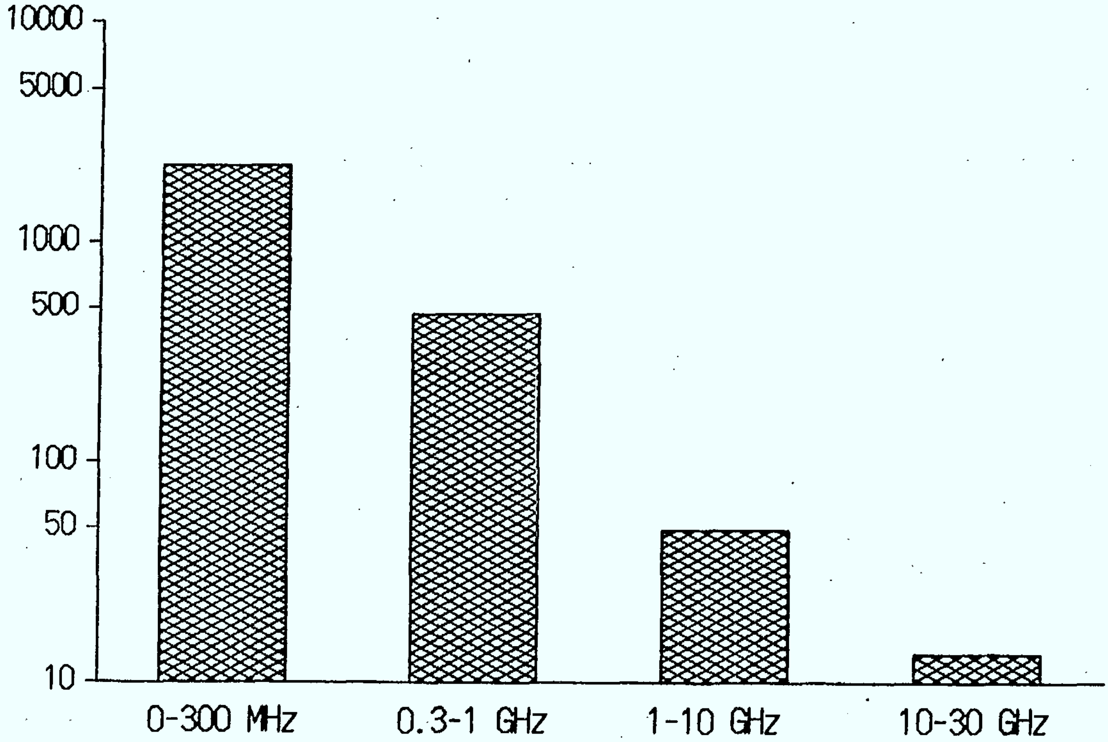

Figure 1. Number of frequency assignments per Megahertz in four parts of the spectrum. This does not reflect actual spectrum occupancy, nor is it an indication of usage of any specific frequency allocation.

The Timescale of Allocation Changes

Many radio systems can successfully operate 25 years or longer, provided they still provide an economic and useful service. If these systems are displaced before that time, the owners often believe that they are being denied rightful benefits. On the other hand, entrepreneurs who want to introduce innovative radio systems are driven by the need for their investors to have a foreseeable return on investment. In an era of rapidly accelerating technology, these new users also fear the development of a competitive replacement product. They do not want their market entry to be delayed because of spectrum unavailability.

If the user is fortunate, his solution will be to find a vacant part of the spectrum which already has the proper allocation support. If a spectrum policy change is required to provide new spectrum, there will be an unavoidable delay from the public consultation process the Department uses to make a change. There may be technical standards to create, and international frequency coordination to carry out. Unfortunately all of these processes can take up to five years in some parts of the spectrum. It will be worse if the change must await an international agreement.

General World Administrative Radio Conferences which have the mandate to make overall allocation changes have been held in 1949, 1959 and 1979. It is unlikely the next general WARC would occur before 1999. Conferences which were restricted to certain types of changes, were held in 1963 and 1971. These limited WARCs responded to a compelling need at the time to provide international regulation of space satellites. Another limited WARC will be convened in 1992 to deal with requirements stated for at least 5 radio services. The 1992 WARC topics so far identified are all outstanding service demands, that is, all had been considered in previous conferences, and had been left unsatisfied. If history continues to repeat itself, it is possible that a new user might have to wait 10 to 20 years or more for international support.

In general, the time between WARCs can be expected to increase, as Member Administrations strive to hold the costs of operating the ITU to a minimum. Since Administrative Radio Conferences are discretionary meetings they are a more ready target for fiscal restraint than, for example, the ITU International Radio Consultative Committee (CCIR) which holds meetings based on a fixed cycle of activity. In addition to delaying change, less frequent conferences will create a backlog of needed international policy decisions. An overwhelming agenda of unsatisfied demands can adversely affect the quality of conference decision making, once it takes place. The telecommunications industry should decide if this tendency to hold fewer WARCs is a desirable course of events.

From the above, some of the time factors which affect spectrum policy solutions are:

i) changes to existing spectrum will be opposed in increasing degree by existing users, as the need for the change drops below 25 years;

ii) realistic forecasts, if any, are for 10 years or less;

iii) except for the most critical situations, international allocation changes may take 10 to 20 years or longer to make;

iv) international policy decisions are likely unchangeable for 10 to 20 years or longer;

v) new users will press to implement new systems in about 5 years or less, and,

vi) there are some inevitable delays involved in the procedures of the spectrum regulator, which can take several years.

To resolve some of these problems, the Department has tried different approaches to facilitate new uses of the spectrum. One example is the general early notice given to fixed users in the 900 MHz band in 1976 for allocation changes that are being implemented only now. Spectrum users in the 1-3 GHz range are now being advised that there will be changes in those bands in the next 10 to 20 years as a result of WARC 92. Some users of the 900 MHz band have been unaffected, and so will some of the 1-3 GHz users. We are often unable to accurately forecast the type or extent of change in the early stages.

When a specific change in spectrum policy can be identified, the five and two year rule can be invoked. This rule limits the tenure of the existing system to five years. In addition there will be a specific notice given two years before the change is required. If the actual need for the spectrum is delayed beyond 5 years the old user can continue to operate on the two year buffer, living on borrowed time. The Department is in the process of changing this rule to deal with frequency congestion. This will recognize congestion itself as need for immediate improvement in a band. The five and two year periods have been varied to suit unusual circumstances. Although this rule was developed for the fixed service we are now planning to apply it to all services.

POTENTIAL SOLUTIONS

Conventional methods of providing new allocation support become more difficult to apply as the spectrum becomes more heavily used. With time, the increasing investment in a band tends to entrench the existing service. As this investment increases, Administrations are less willing to subject the allocations to change by a WARC. Inevitably, the Table will increasingly reflect the status quo.

The 1989 ITU Plenipotentiary Conference agreed to establish a Voluntary Group of Experts (VGE) to examine allocation matters in the ITU. In summary, the VGE will:

- review the definitions of radio services;

- review the structure and status of frequency allocations;

- examine simplification of the Radio Regulations;

- report the results to Administrative Council.

The intent of the VGE is to find alternatives which might improve the speed, quality and flexibility of allocation decisions. There is a long list of topic areas which might be usefully explored (see Annex 1).

One interesting possibility is to broaden the frequency allocations to provide more flexibility. A digital signal in one service may be indistinguishable from one in another. Is it time for a new digital radio service? A large number of services and subsets of services have been introduced into the Table of Frequency Allocations, see Figure 2. Can the number of these be reduced?

Another possibility is to rely more on bilateral or multilateral agreements. In the terrestrial services perhaps the ITU should give formal recognition to decisions between countries to use different allocations. In 1988 the WARC agreed to such a change for an allocation in a footnote to the Table. What was surprising was that the conference was not exactly competent to do so, except that all other administrations who were affected were present and agreed to the change.

Sometimes finding the right answer means asking the right question. Since we are still dealing with concepts, we can ask a wide variety of questions. Is there a place for an annual WARC which can deal with specific issues as they arise? Can we provide a stronger technical basis for allocation decisions? Can we better codify the role of the CCIR in WARC matters? Can we combine some of the activity of WARC's and the CCIR? What alternatives are available to mitigate the imposition of the will of many countries on the need of the few? Are there intrinsic ways of satisfying the differences between developed and developing countries needs? Is there a need for a long term allocation plan? Is there a market related mechanism that would automatically seek the right balance of spectrum between services?

Aeronautical Fixed
Aeronautical Mobile
Aeronautical Mobile (OR)
Aeronautical Mobile (R)
Aeronautical Mobile-Satellite
Aeronautical Mobile-Satellite (Earth-to-space)
Aeronautical Mobile-Satellite (R)
Aeronautical Mobile-Satellite (R) (Earth-to-space)
Aeronautical Mobile-Satellite (space-to-Earth)
Aeronautical Radionavigation
Amateur
Amateur-Satellite
Amateur-Satellite (space-to-Earth)
Broadcasting
Broadcasting-Satellite
Earth Exploration-Satellite
Earth Exploration-Satellite (active)
Earth Exploration-Satellite (Earth-to-space)
Earth Exploration-Satellite (E-s) (space-to-space)
Earth Exploration-Satellite (passive)
Earth Exploration-Satellite (space-to-Earth)
Earth Exploration-Satellite (s-E) (space-to-space)
Earth Exploration-Satellite (space-to-space)
Fixed
Fixed-Satellite
Fixed-Satellite (Earth-to-space)
Fixed-Satellite (Earth-to-space) (space-to-Earth)
Fixed-Satellite (space-to-Earth)
Inter-Satellite
Land Mobile
Land Mobile-Satellite (Earth-to-space)
Land Mobile-Satellite (space-to-Earth)
Maritime Mobile
Maritime Mobile (distress and calling)
Maritime Mobile-Satellite
Maritime Mobile-Satellite (Earth-to-space)
Maritime Mobile-Satellite (space-to-Earth)
Maritime Radionavigation
Maritime Radionavigation (radiobeacons)
Meteorological Aids
Meteorological-Satellite
Meteorological-Satellite (Earth-to-space)
Meteorological-Satellite (space-to-Earth)
Mobile
Mobile (distress and calling)
Mobile (except aeronautical mobile)
Mobile (except aeronautical mobile) (R)
Mobile-Satellite
Mobile-Satellite (except aeronautical mobile-satellite)
Mobile-Satellite (except aeronautical mobile-satellite) (E-s)
Mobile-Satellite (Earth-to-space)
Mobile-Satellite (space-to-Earth)
Radio Astronomy
Radiodetermination-Satellite (Earth-to-space)
Radiodetermination-Satellite (space-to-Earth)
Radiolocation
Radionavigation
Radionavigation-Satellite
Radionavigation-Satellite (Earth-to-space)
Radionavigation-Satellite (space-to-Earth)
Space Operation
Space Operation (Earth-to-space)
Space Operation (Earth-to-space) (space-to-space)
Space Operation (space-to-Earth)
Space Operation (space-to-Earth) (space-to-space)
Space Research
Space Research (active)
Space Research (deep space)
Space Research (Earth-to-space)
Space Research (Earth-to-space) (deep space)
Space Research (Earth-to-space) (space-to-Earth)
Space Research (passive)
Space Research (space-to-Earth)
Space Research (space-to-Earth) (deep space)
Standard Frequency and Time Signal
Standard Frequency and Time Signal-Satellite (E-s)
Standard Frequency and Time Signal-Satellite (s-E)
Standard Frequency and Time Signal-Satellite
(not allocated)

Figure 2. Allocations appearing in the table proper of Article 8 of the International Telecommunication Union Radio Regulations. These may be allocated on a primary, secondary or permitted basis.

We can also look to the VGE to provide new domestic tools, because of the strong influence that ITU spectrum practices have on those of its members. Administrative Council will set the terms of reference for the Voluntary Group of Experts in June 1990. The VGE deserves a strong mandate to cover a broad range of topics. Those who are interested in new spectrum solutions should lend their active support to this initiative.

—•—

Annex 1 - Possible List of Areas of Investigation of the VGE To Improve International Frequency Allocations

Sequence

Periodicity:	20 year, 10 year, Annual
Scheduling:	Plenipot, Res & Rec basis
Pre-conference:	Alignment of proposals, Preparation time; CCIR; Submission of proposals
Inter-conference:	2 stage allocation WARCs
Conference:	Duration, Committee structure, Proposal presentation, Proposal amalgamation, Documentation, Approval
Post-conference:	Final Acts, Ratification Implementation

Substance

Composition:	Diplomatic, Technical, Bilateral, Multilateral
Competence:	Limited Service, Limited Band, Limited Region
Definitions:	Services, Regions, Primary, Secondary, Assignment, Allotment, Allocation
Sharing:	Models, Limits (pfd etc.)
Rules:	First come-first served, Article 14, Harmful interference
Allocations:	Sharing decisions, Band decisions, Bandwidth decisions

Presentation

Table Layout:	Band/Service/Region etc., Footnotes, Electronic DTP, Data base,AI

*The views expressed in this paper are those of the author and do not necessarily reflect those of the Department of Communications

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Présidente du Comité
Spectre 20/20 '89

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CANADA, H4W 1R5

RABC RABC RABC RABC RABC
CCCR CCCR CCCR CCCR CCCR
RABC RABC RABC RABC RABC
CCCR CCCR CCCR CCCR CCCR
RABC RABC RABC RABC RABC
CCCR CCCR CCCR CCCR CCCR
RABC RABC RABC RABC RABC
CCCR CCCR CCCR CCCR CCCR
RABC RABC RABC RABC RABC
CCCR CCCR CCCR CCCR CCCR
RABC RABC RABC RABC RABC
CCCR CCCR CCCR CCCR CCCR

RABC RABC RABC RABC RABC
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