Communications Research Centre Canada
An Agency of Industry Canada
Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

Response of the Communications Research Centre to the Canadian Radio-television and Telecommunications Commission's Broadcasting Public Notice 2006-72

Canada

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0.0 EXECUTIVE SUMMARY

The Communications Research Centre Canada (CRC), the federal government's main research centre for communications technology R&D, is pleased to respond to the CRTC's call for comments on the future environment facing the Canadian broadcasting system. We have provided a description of various emerging technologies, which may have an impact on policy and regulations. A summary of these impacts can be found in Annex A.

The broadcasting industry around the world is going through exciting times driven by fast paced technological changes, challenges and opportunities. Broadcasters are living with a high degree of uncertainty over what form broadcasting will take and how it will impact their service, their distribution and ultimately their business model. The digitization of the broadcasting infrastructure opens unprecedented opportunities for the broadcasters to implement new services for customers, in competition or in collaboration with other sectors of the information and telecommunications industry. An advanced digital broadcasting infrastructure will also be key to the ability of Canadian firms to develop and apply advanced products and services for world markets

The following trends will have an impact on broadcasting policy and regulations:

- The convergence between Telecommunications, Internet and Broadcasting networks is accelerating and may require a convergence of regulation between telecommunication and broadcasting,
- The adoption of all-digital-broadcast transmission technologies and the introduction of advanced audio and video compression technologies is reshaping and re-defining our notion of broadcasting,
- Important regulatory changes will be necessary to accommodate a more modern vision of the Canadian communication infrastructure,
- More advanced standards as well as enhancements to the existing ones are in development,
- Broadcasting is continuing to be a major driving force behind the development of advanced high-quality audio, video and broadband wireless transmission technologies,
- New and innovative concepts and technologies are permitting the use of the broadcast spectrum in a much more efficient manner, by sharing it with other licensed and unlicensed systems,
- Broadcasting is taking a role of strategic importance for public safety needs,
- Broadcast spectrum and technologies could increasingly be used for the delivery of non-broadcast services such as public emergency services, tele-health, Intelligent Transportation Systems (ITS), government-on-line, e-commerce or broadband access for rural and remote locations.

Due to technical innovation and competitive market conditions, one-to-many broadcasting systems will remain the most economical and efficient way of distributing a huge quantity of information to very large audiences in a congested spectrum. As a matter of fact no country in the world has plans to terminate over-the-air broadcasting.

1.0 INTRODUCTION

The Communications Research Centre Canada (CRC) is the only organization in Canada with an R&D program and unique facilities dedicated to Broadcast Technologies. The studies and experiments done by CRC cover a broad range from audio/video coding and subjective evaluation, 3-D TV and surround sound, to Mobile Television, digital transmission techniques and software radio receivers. New concepts such as distributed transmitter networks and intelligent antennas could significantly improve coverage for digital radio and television as well as for multimedia broadcasting. These technologies should stimulate the creativity of broadcasters and enable them to offer innovative services while making profitable their investment in a new digital transmission infrastructure.

CRC expertise is used in Canada by organizations such as the CDTV, CBC, Telesat, IMAX, Algolith, and Genesis Microchips. Foreign organizations also refer to our well-respected technical capabilities. Most of our collaborations in the area of television are taking place with countries such as the United States, South Korea and Taiwan, which, like Canada, are using 6 MHz wide television channels. In radio broadcasting, we have a closer collaboration with the European countries, with which we share the same DAB standard. By collaborating with foreign organizations, CRC can share its expertise and also profit from the experience and knowledge of our foreign partners. Recently, we have done work for Zenith, MSTV and NAB in the United States, ETRI in Korea, British Telecom in the U.K., the World Broadcasting Union and the WorldDAB Technical Committee.

CRC is also looking at how broadcasting technologies can help enhance public safety. For example, we have been looking at how public safety communication services could share channels currently allocated for television transmission, and we are participating in a committee studying how broadcast systems could be used for public alerting in case of emergency.

In addition, an important part of our research is conducted to support our parent department, Industry Canada, in the allocation of frequencies to new digital television and radio broadcast services. We have also worked with other government departments, such as Health Canada and the Department of Justice to determine how broadcast technologies can be used in, or impact, their areas of responsibility.

It is therefore with great enthusiasm that CRC is responding to the CRTC's call for comments on the future environment facing the Canadian broadcasting system by providing a description of emerging technologies and their potential impact on future policy and regulations.

We believe that our input is relevant to the following matters raised in the Order in Council:

a) current state of audio-visual technologies and their predicted evolution over the coming years,

b) with respect to the usage of audio-visual technologies by Canadians:

   - (vi) how future generations will consume or access content,

- (vii) the impact this evolution of technologies has for content and programming choice,

c) with respect to the impact on the broadcasting system:

- ii) the economic and regulatory impact on the broadcasting system caused by these technologies,
- (iv) the different methods for providing programming.

For more information about the CRC Broadcast Technologies group, please visit their web site at: http://www.crc.ca/en/html/crc/home/research/broadcast/broadcast .

2.0 EMERGING TECHNOLOGIES

Descriptions of emerging technologies and their possible impact on the future of Broadcasting are divided into two sections. The first section deals with technologies more closely related to Television while those more related to Radio are found in the second. However, as you will notice, many of these descriptions belong to a new type of service called Multimedia Broadcasting and are part of the convergence now taking place between Telecommunications and Broadcasting systems.

2.1 TELEVISION

2.1.1 MOBILE TELEVISION

Due to recent advances in broadband wireless technologies and in digital video compression, Mobile Television is now being provided by cellular telephone (i.e. 3G) network operators. Specialized handheld devices can download pre-recorded or live audio-video services such as video-on-demand, live TV, music videos, etc. Due to the limited capacity of cellular networks, the fact that this capacity is shared among users and that digital video requires high data capacity, low resolution images and a limited number of available programs to a restricted number of users have characterized Mobile TV so far. Future wireless networks and possibly new spectrum allocation may, in the future, permit the delivery of higher resolution images and more programming material to a larger number of users.

Other technologies are becoming available, such as DVB-H and Media FLO (and also DMB described below), which use the broadcasting bands to transmit Mobile TV signals to portable devices or to vehicles. The number of viewers in these cases is unlimited since the signal is broadcast (one-to-many) instead of the unicast (one-to-one) links commonly used by the cellular networks.

The DVB-H and MediaFLO systems can typically use the same channel bandwidth as regular television transmission (e.g. 6 MHz in Canada). Their coverage can be improved using Single Frequency Networks a concept, which is described later in section 2.1.10.

Depending on the bit rate allocated to each Mobile TV program and the channel coding used, one DTV channel could support a large number of programs. For example, one channel could be used to distribute a low-resolution version of the TV programs available from all the conventional over-the-air TV stations in that region.

In addition, Mobile TV transmission can also take place in other parts of the spectrum than the TV spectrum. For instance, Modeo in United States is using spectrum at 1.675 GHz, while Look Communications in Canada operates at 2.5 GHz.

Mobile TV receivers are expected to become integrated in existing portable devices such as personal players (e.g. iPods), cellular phones and portable computers.

Enhancements to the Advanced Television System Committee's (ATSC) advanced digital television system, such as A-VSB (see 2.1.2 below), currently under investigation by the ATSC, are expected to enable the delivery of Mobile TV services using the DTV infrastructure instead of new dedicated networks of Mobile TV transmitters.

As mentioned above, small-size portable devices generally characterize Mobile TV, resulting in small size displays. Given the growth of Mobile TV, it would appear that consumers are willing to trade-off picture quality (and money!) for the benefit of having access to video services anytime, anywhere. Experiments have shown that simply down-sampling broadcast material to suit the resolution of Mobile TV is not the best way to provide Mobile TV. Mobile TV is more suited to news, short video clips, previews, news music video, etc., rather than full feature films for example. Content must be properly re-packaged to suit this new delivery medium. From this point of view, Mobile TV does not directly compete with regular television broadcasting, but may represent an opportunity for Broadcaster and program producers to reposition their program material for another market.

IMPACT

The expansion of Mobile Television services in Canada may be supported by continuing Industry Canada's allocation of spectrum for flexible use within or outside the television frequency band. This new spectrum would be of interest not only to existing broadcasters and to cellular networks operators but also to new players.

Since many Mobile TV programs can be transmitted over a single 6 MHz DTV channel, regulation could allow several program providers to share a single TV channel, the same way a cable network is not dedicated to one TV station but is used to distribute all the local stations of an area as well as distant signals, specialty and pay channels. For example, local TV stations could collaborate to set up one Mobile TV transmitter. Each station could then transmit a lower resolution version of its regular programs to portable or mobile devices. Cellular telephone service providers could sell cellular telephones able to receive these programs.

Mobile Television also constitutes an excellent communication link that could be used in case of emergencies. It could offer all the advantages of radio broadcasting with the added benefits of video and picture.

2.1.2 ENHANCEMENTS TO DIGITAL TELEVISION TRANSMISSION STANDARD

Improvements to the Advanced Television System Committee's Television broadcasting standard (ATSC- 8 VSB) used in Canada and the United States, such as the Advanced VSB (A-VSB) proposed by Samsung and Rohde & Schwarz, are designed to support enhanced, robust modes of transmission that make broadcasting to portable or mobile receivers possible. This should allow broadcasters to compete with audio/video services that are now offered by cellular telephone network operators.

Such enhancements bring new and previously developed improvements together and intend to bring extensibility and new functionalities to the standard 8-VSB technology. It is claimed that they have the ability to:

- Support Single Frequency Network (SFN) operation, and provide transmitters synchronization schemes that are already endorsed by the ATSC A/110 synchronization standard,
- Insert more training sequences in the output data stream resulting in faster and better equalization in the receiver, which in turn results in more reliable reception in dynamic (i.e. portable/mobile) and high multipath environments,
- Incorporate a robust data stream (in the main data stream) to enable portable/mobile reception (TV to handheld sets) as well as security and safety services. Such a robust data stream may be based on the recently developed advanced video codecs,
- Provide backward compatibility.

An A-VSB proposal is currently under investigation by the Advanced Television System Committee (ATSC). Results from the upcoming tests to confirm its performance are expected before the end of 2006.

IMPACT

If successful, such a backward compatible system will enable broadcasters to use their over-the-air DTV stations to transmit HDTV and/or standard definition programs to fixed locations with the option of using part of their DTV channel data capacity to offer lower resolution TV programs to portable or mobile receivers.

This could be done without requiring new transmitters to be built nor new spectrum to be allocated, as would be the case if incompatible standards such as DVB-H or MediaFLO were used instead of the backward compatible enhanced ATSC standard.

2.1.3 ADVANCED VIDEO CODECS

The MPEG-2 video compression standard, developed by ISO/IEC in the 1990's, is used almost universally as the bit rate reduction method for digital television broadcasting. Both the European DVB and North-American ATSC standards utilize the MPEG-2 video compression. MPEG-2 is capable of providing broadcast quality at bit rates in the range of 15-20 Mbps for High Definition TV (HDTV) and 3-5 Mbps for Standard Definition TV (SDTV). However, new and more sophisticated compression technologies, such as H.264/AVC and VC-1, capable of providing a comparable video quality as MPEG-2 at approximately half the bit rate are now available. Yet even more powerful compression technologies are being investigated and no doubt will be developed in the future, but, at this time, none are expected to provide significant benefits over H.264/AVC or VC-1.

Given these two factors in compression efficiency provided by these advanced codecs, it can be expected that they will be adopted in the near future by the broadcast industry. For example, these codecs are a logical choice for applications using advanced modulation techniques such as A-VSB, where some of the channel capacity is traded off for robustness. Most Mobile TV and IPTV services already use H.264/AVC. Both HD-DVD and Blu-ray video disc format will support the three video compression techniques: MPEG-2, VC-1 and H.264/AVC.

The Advanced Television System Committee (ATSC) is currently investigating the opportunity of supporting multiple video codecs (i.e. MPEG-2 plus one or more advanced codecs). The decision to go from one codec to multiple codecs is not expected to have significant implications on the broadcasting infrastructure except for the important aspect of compatibility of the broadcast signal with the DTV sets already on the market. Fortunately, a limited number of these sets are in the hands of the consumers at this time in Canada. As these codecs use a similar architecture, newer integrated circuits will be able to support all of them for future DTV receivers.

IMPACT

It is likely that several video compression technologies will co-exist in television broadcasting in the future. Backward compatibility of legacy consumer equipment will be an issue in the short-term. Future equipment will support multiple codecs and transport stream signalling indicating which codec has been used to compress the video stream. This future equipment will make this issue transparent to the users as long as their receivers contain the required decoders. The addition of these new system features to the ATSC standard could create compatibility issues with legacy equipment for the Canadian consumer.

2.1.4 3D TELEVISION

Beyond HDTV, there is a newly emerging drive to develop 3D-TV and to bring it to market. Whereas HDTV provides enhanced picture quality and larger image size, 3D-TV will impart increased realism by displaying objects with volume and at different depth positions in a "solid" world outside of the flat screen. 3D-TV will provide virtual presence by allowing viewers to immerse themselves with television characters in a three-dimensional world. This will reduce the gap between reality and fiction.

Stereoscopic 3D-TV using shutter glasses can be transmitted now within the existing DTV infrastructure with only minimal changes and impact on normal HDTV viewing. However, consumers are reluctant to adopt this technology because of the discomfort of wearing glasses. Experts agree that glasses-free Multiview 3D systems will be needed for consumer acceptance of 3D-TV. Stereoscopic 3D-TV systems rely on two views (left and right) for depth portrayal, whereas Multiview systems use multiple views representing different viewpoints. Multiview systems provide a better look around than stereoscopic systems.

Progress in computing and display technologies have reduced the development time towards the realization of practical 3D-TV systems. In addition, there are strong international efforts underway to standardize formats for the transmission of multiple streams of images, consisting of different viewpoints of a scene (i.e. multiview). Advances in video processing and compression technologies are such that the additional amount of information that needs to be transmitted for multiview 3D-TV is reduced to a minimum. Compatibility with regular monoscopic (2D) television can be guarantied by transmitting a 2D signal plus one or more depth map(s) and using one of the compression technologies used for regular 2D-TV.

This multiview format will add new functionalities that will allow for greater interactivity such as the choice to select a specific viewpoint of a scene. Critical to the successful deployment of 3D-TV broadcasting is the development of multiview autostereoscopic displays that can be mass-produced for consumers at a reasonable cost. Current multiview display devices lack resolution and size, but progress is rapid.

IMPACT

It is expected that 3D-TV can be supported within the existing DTV infrastructure and with minimum impact on data rate requirements. The expectation is that 3D-TV should have little impact on spectrum demand and regulation.

This multiview format will allow for new functionalities such as the capability to select a specific viewpoint for a scene. Critical to the successful deployment of 3D-TV broadcasting is the development of multiview autostereoscopic displays.

2.1.5 SUPER HDTV

Super HDTV, also known as Super Hi-Vision or Ultra High Definition Video (UHDV) is a digital video format, currently proposed by NHK of Japan. Its video format uses 7,680×4,320 pixels (16 times more pixels than HDTV), and a 60-Hz frame rate progressive scanning scheme, making it possible to present an unparalleled amount of information on a screen. NHK has demonstrated the Super Hi-Vision at the 2005 World Exposition in Aichi, Japan, using a CCD camera that can take 4k x 8k images. The signal generates a raw data stream at a rate of 24 Gigabits per second.

IMPACT

Super HDTV represents an enormous technological challenge regarding camera and display technologies, storage, compression and transmission. Therefore it will not likely be considered for television broadcasting in the foreseeable future.

2.1.6 INTERNET TELEVISION

Internet TV is where the computer and the broadcast industries meet. It represents in many people's mind the best example of what is meant by convergence. With the increase in data rates available over broadband Internet connections, it has become increasingly common to find traditional television content accessible freely over the Internet. In addition, new Internet-only television content has appeared which is not distributed via cable, satellite, or terrestrial systems. Virtually all the major broadcasters are "webcasting" some of their regular program material: previews, archived material, and news clips. Movie and video "renting" downloaded over the Internet is a growing business.

Internet TV is convenient because it can be accessed from any web-enabled terminal, anywhere, anytime. The major drawbacks are:

- The limited number of channels and programs accessible through the Internet,

- The lack of picture quality due to the low resolution and low bit rates used,
- The restricted bandwidth on the Internet (this would be an increasing problem if more people decide to use Internet TV),
- There is currently no quality of service, i.e. video is delivered on the Internet network on a "best effort basis", that is, at the rate the network is capable of at the given time.

The lack of a quality of service is perhaps the most serious limitation of present-day Internet services. This is why the Internet is mostly used today for low quality video streaming applications while high quality video is generally downloaded before viewing but it is time consuming. This could change in the future with improvements in the Internet backbone and the adoption of network protocols (e.g. IPv6) that support multicasting and quality of service.

IMPACT

Because of technical limitations, the present Internet network is not well suited for real-time television broadcasting. Internet TV is likely to remain a delivery method that complements regular broadcasting rather than replacing it. For example, programs delivered in this format are mostly used for promotional clips.

This situation could change in the future as technological improvements are introduced that allow the Internet to adequately support real-time applications.

2.1.7 INTERNET PROTOCOL TELEVISION (IPTV)

IPTV is defined as "multimedia services such as television/video/audio/text/graphics/data delivered over IP (Internet Protocol) based networks managed to provide the required level of Quality of Service, security, interactivity and reliability". Although Internet TV and IPTV both use the Internet Protocol to carry video (as well as other services), their main difference is that IPTV guarantees a certain level of quality of service and includes security and copyright protection.

Many networks and distribution systems rely on the Internet Protocol (IP) for the transmission of voice, data and Internet services. With the appropriate network configuration needed to guarantee an end-to-end quality of service, these same networks can also carry streaming video and digital TV services.

IPTV is often associated with DSL-TV. New generation ADSL (Asymmetric Digital Subscriber Line) technologies (e.g. ADSL2 and ADSL 2+) support faster data transmission over traditional copper telephone twisted pair wires, which is the last link connecting Telcos to the homes. Whereas present-generation Asymmetric DSL (ADSL) has a limited capacity of up to 8 Mbps from the network to the subscriber (downstream), ADSL2 and ADSL 2+ technologies enables downstream data rates of up to 12 and 24 Mbps respectively, over short distances from the Central Office. In conjunction with advanced video compression technologies (e.g. H.264/AVC and VC-1), these new ADSL technologies now enable telecom operators to offer multiple SDTV and HDTV programs simultaneously over copper wire, thus competing with Over-the -air (OTA), Cable and Satellite television broadcasting.

Television over IP is becoming more readily available and as the use of personal video recorders is becoming widespread, there may come a time when the viewer will not care to know where his television programs come from or when they were transmitted. This will not happen tomorrow, but with the younger generation more used to portability and personal control, the traditional broadcast business model may become less adequate and profitable, especially if the broadcast industry is heavily regulated and the providers of content over IP are relatively unencumbered by regulations.

IMPACT

Improved ADSL and new video compression technologies enable telecom operators to offer multiple SDTV and HDTV programs simultaneously over copper wire, thus competing with OTA, Cable and Satellite television broadcasting.

The broadcast industry (over-the-air broadcasters, cable and satellite distributors) is now limited by regulation in the content that it can offer. If some forms of IPTV are implemented without these restrictions, the consumer could then get unregulated access to new content. This raises questions about the impact of regulations on domestic broadcasters when consumers can freely access unregulated service providers located outside the country. As well, new technologies may enable new "grey markets", such as those experienced for American satellite television and radio services, where consumers sometimes bypass regulated Canadian suppliers, who hold Canadian distribution rights for programming. They could access the same programs directly from unregulated foreign distributors who may offer a larger selection of material, better price or both.

2.1.8 DIGITAL BROADCASTING BY SATELLITE AND DIRECT-TO-HOME SERVICE

Satellite television broadcasting is offered in Canada via two services: Digital Broadcasting by Satellite (DBS) operated in the 12 GHz Broadcasting Satellite Service (BSS) band and Direct-to-Home (DTH) operated in the 12 GHz Fixed-Satellite Service (FSS) band.

In July 2006, Industry Canada issued a call for applications for 29 satellite licenses. Out of these 29 licenses, 10 are for new orbital positions for broadcasting satellite service in the 17 GHz BSS band, commonly referred as the unplanned band given that it is identified by international regulation for BSS but has not been planned as the 12 GHz band is. These new orbital positions, combined with the upcoming introduction of the new signal format (DVB-S2), will increase the capacity for DBS/DTH offering by at least 4 times. For Canada, it means an impressive increase in capacity, which could address the need for more local programming television and HDTV.

In the 1990's, CRC along with the industry conducted R&D activities to address the requirement to offer Internet services by satellite to rural and remote consumers. As a result, in 2000 the Canadian Space Agency (CSA) funded in partnership with industry a payload flight demonstration program to develop and launch a payload to provide such a service. Under the technical leadership of CRC in this program, Telesat and its partners introduced an Internet service to consumers via satellite in the 30/20 GHz FSS (Ka) band in spring 2005. The introduction of such a service required the development of low cost ground terminal technologies. Although the ground terminals are currently still relatively expensive (i.e. a few hundreds dollars), their cost is expected to become as low as the current 12 GHz BSS receivers (e.g., free as part of a few years service contract) in the years to come i.e. once a significant volume is reached. Other foreign satellite operators are also planning to offer a similar service within the next few years.

This new Internet service combined with the opening of new orbital positions in the 17 GHz BSS band may potentially have a dramatic impact on the delivery of services by satellite. It is expected that the introduction of the 17 GHz BSS service will enable the use of a single outdoor terminal (antenna and microwave front end) to address both broadcasting and Internet access services. As such, the Internet access will provide a return channel for video-on-demand services, enabling, for instance, an increase of the use of personal video recorders. In addition, the Internet and broadcast traffic could be blended based on which channel (FSS or BSS) is less busy, increasing the issue created by the convergence of services of the different regulatory regimes in Canada for each service.

It is to be noted that the Internet service is blended to the broadcast service in Europe with a forward channel (to the users) in the 12 GHz BSS band and a return channel (user to gateway) in the 30 GHz FSS band or via other terrestrial wired or wireless channels. Such systems have been in operation for many years.

Broadcasting to mobile users in the 12 GHz BSS band is currently commercially available. In the medium term, it is anticipated that broadcasting to mobile users in the 30/20 GHz FSS band will be developed. The technology does exist to do so but not yet at a cost attractive to users.

Broadcasting of video content by satellite to personal devices in the Ka FSS band or the new 40 GHz BSS band is also being discussed at the present time. However, significant technology developments are required to do so and it is not believed to be technically and/or commercially viable in the near future.

IMPACT

Current and forthcoming technology developments are likely to increase the amount of services available to consumers via satellite and to compete head-to-head with terrestrial digital services delivery technologies.

There is a trend that mobile, fixed and broadcast satellite services could be offered by satellite in various frequency bands as the technology evolves. For this reason, the review and development of regulatory regimes and policies should take this trend into account.

2.1.9 OVER-THE-AIR DTV MULTIPLEX FLEXIBILITY

The Digital Television (DTV) over-the air (OTA) transmission standard from the Advanced Television System Committee (ATSC) provides a flexible channel, which can be used to distribute either one HDTV program, one HDTV program along with one low-definition TV program, or 3 to 5 standard definition programs. Viewers will choose a station and then will often have the choice among two or more programs from that station.

The multiplex can also carry more than one sound track for each of the transmitted video programs.

Finally, the multiplex can carry other information such as web pages or computer games, which can provide supplementary information to the viewers particularly for those who may receive the DTV signal using a tuner connected to a personal computer.

IMPACT

Regulations need to take into consideration that one TV channel may transmit more than one program at the same time. In particular the Must-Carry rules, which require Cable networks to carry local television stations as part of their basic service need to be clarified in the context of DTV and mixed HDTV/SDTV services.

The availability of multiple sound tracks makes it possible to offer a TV program with a multilingual soundtrack. This may be particularly easy for movies or documentaries for which the multiple languages sound tracks are readily available. Regulations could therefore make it possible for TV Broadcasters to offer their programs with a choice of language just as that available on DVD menus.

Data transmitted on a TV channel may or may not be related to the TV program and could be sold by a TV network for non-program-related applications such as video games. Regulation and distribution rights agreements should take this into consideration.

2.1.10 SINGLE FREQUENCY NETWORK FOR DTV BROADCASTING

The single (central high power) transmitter configuration is currently the conventional method of covering a large service area by a television station. This conventional method, however, faces some economical and technical problems:

- As the radiated power of the transmitter is designed to provide enough signal strength at the edges of the coverage area, the signal level is not uniform throughout the service area and in locations closer to the transmitter, the signal strength is unnecessarily much higher than that required for a satisfactory reception,
- Since a large amount of power is used to reach the edge of the coverage area, interference can extend much farther into the service contour of neighbouring stations,
- Extending coverage by increasing transmitter power can be very expensive because covering the last kilometre of coverage from the transmitter is far more costly than the first kilometre.

A possible approach that can solve the above-mentioned problems is to use a network of low power transmitters distributing the transmission across the coverage area.

Digital TV transmission systems allow the use of synchronized Distributed Transmission Networks (DTxN) that can use far fewer channels than the number of its constituting transmitters. Under certain circumstances, the number of channels used by all the transmitters of a DTxN can be reduced to one to form the so-called Single Frequency Network (SFN).

Synchronized Distributed Transmission Networks, along with their special instance, Single Frequency Networks, are new possibilities provided by DTV transmission systems. They are not feasible with analog TV systems since this would result in the creation of harmful ghosts.

A Distributed Transmission Network has the following benefits over the single central transmitter configuration:

- More uniform and higher average signal levels throughout the service area,
- More reliable outdoor and indoor reception as a result of higher average signal levels,
- Less overall effective radiated power (ERP) and/or antenna height needed, resulting in less interference,
- Stronger signals at the edges of the service area without increasing interference to neighbouring stations, and
- Spectrum savings.

Operation of a DTxN requires however that all the transmitters of a DTxN using one particular channel carry the same content at all time. The transmitters of two DTxNs operating on adjacent channels need also to be co-sited in order to minimize interference. The receivers used in some locations where strong signals are received from more than one transmitter may need to incorporate high performance equalizer able to discriminate between long delay multipaths.

By using DTxN, the number of channels required for covering a large service area will be reduced. This will decrease spectrum congestion and could thus allow applications such as new HDTV stations, interactive TV, multimedia broadcasting, or any other future applications added in the TV bands.

The Advanced Television System Committee (ATSC) has already devised a standard for synchronizing the time and frequency of the transmitters constituting a DTxN.
Various studies and tests have been conducted on some of the possible configurations of the Distributed Transmission Networks and so far, the results have been very encouraging. The test results have demonstrated feasibility of implementation and satisfactory operation of such networks in their target areas, as well as their superior performance over the single transmitter configuration with respect to reception availability.

IMPACT

If Single Frequency Networks were to be used, revisions and modifications to spectrum regulations would be required including the possible consideration of incentives for the use of lower power transmitters wherever it can yield spectrum savings.

Use of SFN for over-the-air television could lead to significant reduction on the number of channels required to cover a given areas. Some of the saved spectrum could be reallocated to new type of services such as Mobile Television (described in section 2.1.1) or wireless return channel (section 2.1.13).

There are two types of benefits from using SFN: a more uniform service coverage; and freeing spectrum. Individual broadcasters may readily see benefits in offering a better coverage but may be reluctant to free spectrum that could be used by competitors. Incentives should be available, for example broadcasters if they release frequencies, or if they collaborate to use adjacent channels by co-sitting their transmitters and enabling SFN to be the more efficient.

As interference is possible in proximity of each SFN transmitter to the signal of a broadcaster operating on an adjacent channel and using a traditional single transmitter. Configuration, guidelines and regulations need to be developed on how to decrease this interference and to determine what would be the acceptable level of such interference.

2.1.11 DTV RECEIVERS

2.1.11.1 OVER-THE-AIR RECEIVERS

Consumer electronics manufacturers consider Canada and the USA to be the same market and normally sell the same TV receivers on both side of the border. With the FCC mandating that all television receivers and television related equipment, such as video recorders, sold after March 2007 support DTV over-the-air reception, it is possible that without such a rule in Canada, receivers not able to receive over-the-air DTV, will continue to be sold in Canada after that date.

The Canadian public needs to be educated about this coming change in technology. Labelling of DTV receiving equipment should be considered. Labelling could include indication on additional video decoders and on ability to function in a SFN environment since the receiver's equalizer performance affects the receiver's performance under SFN conditions (See section 2.1.10 above).

Any labelling should take into consideration that DTV receivers will be integrated into devices other than television sets such as computers, cellular telephones and portable media players.

2.1.11.2 CABLE RECEIVERS

Although cable companies prefer that consumers use dedicated cable decoders, a number of American consumers use integrated cable ready receiving equipment (unidirectional). In the meantime Canadians generally do not have this option.

While in the USA, cable companies have been forced by the FCC to offer low-cost digital cable service (CableCARD), in Canada there has been no regulation to this effect and cable companies are not offering service to integrated cable-ready digital receivers. The current CableCARD standard is for one-way services only; a number of advanced features such as pay-per-view are therefore not available.

The CableCARD version 2.0 standard is currently in the works to address many of the issues. The new CableCARD 2.0 standard should support high definition digital cable, two-way features such as Pay-Per-View, Video On Demand, and advanced electronic program guide information and allow for up to 5 channels to be tuned in at once. However the standard is not currently finalized and equipment with CableCARD 2.0 support is still to come. Furthermore CableCARD version 2.0 will not be compatible with existing CableCARD enabled products.

Canada needs to consider whether cable companies should be encouraged or required to support CableCARD or a similar system. If not, consumers are likely to be frustrated if they buy DTV cable-ready equipment that cannot be used with the local cable company, at least not without a dedicated cable decoder device.

IMPACT

For a number of years after the transition to DTV, the average consumer will need guidance and/or protection to ensure that they can take full advantage of the various distribution systems despite their increasing complexity.

The United States government will be distributing rebate coupons to citizens who want to buy a converter box to convert DTV signals received over-the-air to their old analog NTSC television equipment.

Canadians are now buying expensive equipment without ATSC reception capabilities and this type of equipment may still be sold in Canada for many years after March 2007 while they will no longer be available in the United States. Consumers may be very disappointed when their almost new TV receivers stop working when the NTSC signals are no longer available in Canada.

Canada could then consider:

Setting a date to terminate Analog NTSC transmissions and a corresponding earlier date to end the sale of NTSC only equipment,

- Labelling equipment that is not DTV compatible,
- Labelling equipment with enhanced features such as additional video decoders and enhanced equalizer,

- Providing viewers who do not own DTV-ATSC compatible equipment with a means to continue receiving free TV over-the-air,

- Supporting CableCARD or similar technology.

Availability of TV receivers integrated in portable devices would make common international standards more desirable, as they would need to provide services when the device is used in different countries.

2.1.12 PERSONAL VIDEO RECORDER

Personal Video Recorders (PVR) are now available. They are now commonly used to record TV programs distributed over-the-air, by cable or by satellite. They are or will soon be able to record downloaded TV programs and other video content from anywhere in the world using an Internet connection. This source of content may be of great interest to Canadians who wish to watch TV programs produced in other countries where a time zone difference makes the PVR a particularly useful way to watch TV. It may also be used to view content not available in Canada.

IMPACT

Video programs from everywhere in the world will be available locally through Internet without any regulation. Content, price and other considerations could be decided outside Canada and increase the competition to the programs distributed by the Canadian broadcast industry.

2.1.13 WIRELESS RETURN CHANNEL

With the data carrying capability of the DTV system comes a number of services not possible with the traditional analog television system. Given the availability of television spectrum in rural and remote areas away from urban centres and from the Canada-US border, networks could be set up to deliver Internet services to people residing in these areas. Technologies that make use of the television spectrum to offer a link back to the transmitter (return channel) are being developed and will be able to carry the traffic from a small community back to the transmitter. As with other technologies using the TV spectrum, precautions will have to be taken to ensure that the systems do not interfere with each other.

IMPACT

Wireless return channels would enable free over-the-air TV to offer two-way services similar to the ones now available from Cable networks.

The introduction of such services would require the allocation of new spectrum allotments.

2.1.14 WIRELESS REGIONAL AREA NETWORKS

In an effort to maximize the use of the spectrum now allocated to Broadcast Television, especially where this spectrum is lightly used such as in rural areas, the FCC proposed in its Notice of Proposed Rule Making (NPRM 04-186) to allow the use of licensed-exempt devices in the Broadcast TV spectrum.

These devices could be deployed in vacant parts of the TV spectrum for the provision of Internet access services, similar to Wireless Local Area Networks (WLAN) services, provided that there is no harmful interference caused to the TV broadcast operation. Fixed devices could be deployed anywhere in the network up to a limit of 4 Watts Effective Radiated Power (ERP) where a portable terminal devices would be allowed to roam within the network of access points with an ERP power limit of 400 milliwatts. It may be concluded that, given the allowable power limits for both the fixed and portable license-exempt devices, some controls need to be implemented in order to mitigate the interfering effects on TV broadcast operation. The devices would need the ability to determine if a channel is used before it could transmit (control signal, sensing, geolocation, etc.) and it would need to be able to move off a previously vacant channel if the licensed user starts to transmit.

This problem was studied in the IEEE Working Group 802.18 and comments were produced on behalf of the IEEE 802 Standards Committee for the on this issue. As a result of the positive findings for the use of fixed licensed-exempt devices in a point-to-multipoint system based on a master-slave relationship between the wireless base station and the associated user terminals, the IEEE Working Group 802.22 was formed and is developing a standard for cognitive radio-based Wireless Regional Area Networks ("WRANs"), for use by license-exempt devices on a non-interfering basis in spectrum that is allocated to but not locally used by the TV Broadcast Service.

IMPACT

The operation of wireless regional area networks using vacant TV channels in rural areas has the potential of bringing Internet access in a cost-effective way in areas that are difficult to serve with this service. However, the operation of an unrestricted number of license-exempt devices in the TV broadcast bands is likely to create scenarios where harmful interference to the Television services will result, especially in the more densely populated areas. Studies have shown that the ERP levels suggested by the FCC in its NPRM can create problems if there is no restriction on the deployment and operation of these license-exempt devices. In anticipation of the implementation of such license-exempt device networks, regulators and policy makers need to ensure that the incumbent TV broadcast operators are sufficiently protected.

Regulators may have to give clear guidance to the development of the license-exempt equipment standard and define rules for the deployment of these networks, for example, by imposing additional channel separation limits on licence exempted devices to ensure transparent operation of the TV broadcast system. Features such as cognitive radio, dynamic frequency selection, transmit power control and geolocation could be requested from the technology standardization whereas centralized control of the operation at the base station, access to broadcast stations databases, professional installation and registration of base stations and association of user terminals to the base station under specific non-interfering conditions could be requested at the time of the network deployment.

Ultimately it is the unsuspecting consumers who could be affected with random losses of service for which they will have no control.

2.2 RADIO

2.2.1 DIGITAL RADIO: A DIGITAL PIPELINE

The rapid evolution of other delivery media (wireless broadband Internet, 3G and 4G, satellite, wireless pit stops, cordless peer-to-peer data exchange, etc) is having an impact on the radio broadcasting audience. Over-the-air broadcasting is evolving from the "only" source to "one of many" sources of content. The strength of radio broadcasting in the future wireless environment will be its ability to adapt to enhanced services and very economically to reach a very large number of mobile and portable receivers outside the service area of other delivery pipelines (WiMax, 4G, etc.).

To remain competitive, digital broadcasting systems could evolve from the conventional radio services to a much wider variety of services with richer multimedia content coupled with a certain degree of interactivity, and a broad spectrum of datacasting services, related or not to the broadcast content.

IMPACT

Flexible regulation will be needed to encourage innovation and to enable broadcasters to fully exploit the potential of their digital delivery network in a complex and competitive environment

2.2.2 TECHNOLOGY OPTIONS FOR RADIO BROADCASTING CONVERSION TO DIGITAL

In the early 1990's DAB Eureka 147 seemed to be the only viable solution for the conversion of analog AM and FM stations to digital. This belief led to the current regulation on L-band (1.5 GHz) DAB broadcasting in Canada. Since then, remarkable progress was made on other technologies such as In-Band On-Channel (IBOC) and S-DARS, and other viable solutions have emerged. Today and in the near future, Canadian broadcasters will offer a choice of options, which we will describe briefly in the following paragraphs. It is important to note that each of these digital technologies has the potential to evolve with time as technological breakthroughs emerge keeping in mind the importance of backward compatibility with consumer equipment already in the hands of the public.

An obvious example is research into audio coding that has produced several new techniques since the adoption of MPEG Layer 2 for the DAB Eureka 147 system. It is expected that in due time, the existing standard will be modified to incorporate more advanced and efficient codecs to allow broadcasters to exploit the extra channel capacity within their existing spectrum allocation for more audio programs or to offer new multimedia and datacasting services.

2.2.2.1 IN-BAND ON-CHANNEL (IBOC)

This technology is promoted by iBiquity (USA) under the brand name HD Radio. IBOC is designed to allow a smooth transition from all analog to "all digital"; with an initial and transitory phase where some digital signals are added to the existing AM and FM analog signal. This is called Hybrid IBOC. In due time, the analog signal will be removed and replaced by more digital signals to reach the final goal of "all digital". The digital signals are positioned in the adjacent channels on both sides of the analog carrier. The level of the digital signal is low and is designed to avoid interference for adjacent analog stations. The main advantage of the IBOC technology is that no new spectrum is required by the radio broadcasters to make the transition to digital. However, the limitations are that the coverage is limited due to this lower power limit on the digital content and that cannot be improved by using SFN. The HD Radio falls-back to analog FM when the receiver is outside the reduced digital coverage.

2.2.2.2 DAB EUREKA 147:

This technology was adopted in Canada in 1995 and was initially intended as a replacement technology to conventional AM and FM radio. A new spectrum band was allocated to introduce the new service. The Canadian plan included a mix of terrestrial and satellite stations and this made the choice of L-band (1452 to 1492 MHz) the best compromise for such a system. Later, the satellite component had to be abandoned due to various constraints. However, the terrestrial component alone, being at L-band, could not provide large area coverage, as would have been the case for the full system with a satellite component. Most other countries that have successfully introduced DAB have opted for a different band: Band III, 174 to 240 MHz. By using several transmitters in a network arrangement called Single Frequency Network (SFN), a broadcaster can extend and tailor its coverage when and as needed.

2.2.2.3 DRM:

The DRM (Digital Radio Mondiale) is an international consortium, which created a universal digital system for the AM broadcasting bands below 30 MHz. This open, non-proprietary world-wide standard for broadcasting in the LF/MF/HF bands was formally launched at the World Radio Conference in 2003, and several broadcasters began regular short-wave transmissions in the HF bands.

2.2.2.4 DRM+:

This is an extension of the original DRM standard, which would allow digital broadcasting operations up to 120 MHz, thereby encompassing the commercial FM band. While still in development, DRM+ will offer an attractive option for those FM broadcasters who wish to do a direct transition from an all-analog to an all-digital signal.

2.2.2.5 DMB AND DAB-IP:

DMB and DAB-IP are built on the DAB Eureka 147 broadcast standard. They can take advantage of the current DAB infrastructure (spectrum, transmitters, receivers, etc) but, in addition to conventional DAB services, will allow the delivery of radio with pictures related to the audio content ("visual radio") and Mobile TV to cars and portable/handheld receivers. DMB is based on the MPEG coding and transport protocols while DAB-IP is based on the IP packet transport protocol.

IMPACT

Options for the AM broadcaster:

In order to retain a large coverage area, the typical feature of an AM analog system, it is important to remain in the AM band for long signal propagation, unless the technology adopted is compatible with the SFN concept described earlier. Two options exist for operation in the AM band: AM-IBOC (HD Radio) and DRM (Digital Radio Mondiale). Both are not compatible with current AM receivers. These two technologies are being tested and deployed in other countries. In the case of a low power AM station satisfied with a relatively small coverage area, L-band DAB could be an interesting option.

Options for the FM broadcaster:

Many options are offered to the FM broadcaster: FM-IBOC, L-band DAB, Band III DAB and DRM+ (DRM plus). The choice will be dictated by factors such as spectrum availability, the size of the coverage contour, receiver availability, requirement for SFN transmitter networks, backward compatibility with existing receivers, etc.

Broadcasters are currently evaluating the new technology options. A digital transition strategy need to be developed and this will probably lead to the adoption of several technologies to complement DAB (or DRB). New spectrum will be needed to accommodate the transition phase (ex: AM to DRM) and to enable the delivery of new multimedia services (DMB, DAB-IP, subscription radio, etc)

2.2.3 RADIO RECEIVERS

A person living in Toronto today could be using a radio receiver for AM and FM services, another one for XM radio or Sirius, and one for L-band DAB. This person probably also carries a cellular phone with an MP3 player. The era of "a single (or universal) radio standard" is over. The new reality is that each market will adopt a mix of broadcasting systems that fits its specific context, and the mix will evolve with time, more so than the AM and FM service did in the past . It seems that a more logical solution for the consumer would be to have a multifunction, multi-service, multi-standard device instead of the redundancy of many devices which all have batteries, memory, dial and display, audio system, etc. Our Toronto citizen would invest in such a device and expect to receive all available services in the areas where he lives and travels. Receiver manufacturers have recognized this growing requirement and a number of them are developing multi-standard integrated circuits. Organisations such as WorldDAB and the DRM Forum have agreed to collaborate and encourage manufacturers to put both technologies (DAB-DRM) in their receivers. Manufacturers will make models with a specific mix of standards if they are convinced that there is a sizeable market for that particular mix.

There are some significant technical challenges associated with this vision of a multi-standard handheld receiver. The list includes:

- Power consumption and limited battery power,
- Processing power,

- Antenna gain (loss),
- Size, picture resolution and brightness in daylight of colour displays,
- Operation at low temperatures,
- Voice command in noisy environment,
- Complexity and cost.

There is a lot of progress being made in the development of Software Defined Radio (SDR) technology but its applicability is currently limited to professional radio systems such as military, public safety and base stations. The power consumption of a reconfigurable all-digital signal processing radio is still too large for small handheld devices. In the meantime, it will take some years before this technology finds its way to the consumer market. It is expected that the consumer receiver manufacturers would rather aim at packaging specific mixes of standards for specific markets, as explained earlier.

IMPACT

With the integration of several services in a common receiver, consumers will not easily differentiate the various sources for the information they receive. They will be able to access broadcast services (regulated) and Internet (unregulated) and with the same device. They may need guidance to determine which device is needed to access particular content and to understand the limitations of these devices due to technical or regulatory constraints. Alignment of the regulations to this new technical reality could be needed.

The question of obsolescence of consumer radio receivers will also need to be addressed in this conversion toward a multi-standard digital radio environment.

2.2.4 EMERGENCY WARNING

The needs in security measures and emergency preparedness have evolved since Sept.11, 2001. This has spurred the development of advanced emergency services and the quest for more spectrum. Broadcasting will take a role of strategic importance for public safety needs since it is and will be for some time the most effective way to reach Canadians and alert them of an imminent danger, wherever they are, during day and night time. Public warning, guidance to security forces, traffic control, and many other functions are best done with a broadcast delivery system. For example, the low cost FM receivers in homes, cars, offices, alarm clocks, cell phones and even in toasters. It is the communication device of choice to ensure the largest audience possible during an emergency. The sheer number of FM receivers presently in use leaves the other candidate systems far behind in the race.

The principal advantages of the analog Broadcast systems (AM, FM, NTSC TV) are:

- Ubiquitous receivers,
- Low cost portable, battery operated receivers,
- Large coverage area,
- No overload of the transmission system,
- Instantaneous transmission of the information and simultaneous reception,
- Work in progress to standardise alerting protocols.

The transition to digital, the convergence and the integration of various communication services into a single personal device will open new options for the delivery of emergency information to Canadian citizens. The authorities will be in a position to target the portable/handheld "personal" devices to reach and interface with people, anytime, wherever they are. The more advanced digital broadcasting systems (DAB, ATSC, DMB, DVB-H, MediaFLO, etc.,) are broadcast digital pipelines which were designed to carry audio, video, data, files, etc., hence "multimedia" content, and, when integrated in a cell phone, will provide the benefits of a big "one way" data pipe in addition to the rather narrow "two way" return pipe provided by the wireless telecom services (2.5G, 3G, GPRS, EDGE, etc.). The big data pipe has the advantage of reaching everybody at the same time, no matter how many users there are. This is certainly not the case for the cell phone system, even less in an emergency situation where concerned people quickly overload the network.

It will be a long time before digital systems' coverage matches that afforded by the analog systems (AM, FM, NTSC TV). However, certain markets have more options than others, depending on the penetration and take-up of the new services offered (ATSC, DAB, Sirius Radio, XM Radio, etc.).

The digital systems offer new features and functions, which are not possible with the analog systems. As an example, CRC has developed and proposed a new position location technique using the transmitter identification (TxID) sequences embedded in ATSC signals. This technique makes possible the localization of a TxID receiver if DTV signals from more than three DTV transmitters can be used. This technique could be used in lieu of or to complement the conventional Global Positioning System (GPS) system in places such as inside buildings since the broadcast off-air DTV signal can penetrate buildings and other structures more easily than satellite signals. Signals from Terrestrial TV broadcasting stations can then be used to improve the accuracy of GPS for emergency situations and Public Safety

It seems logical at this point in time to predict that over-the-air broadcasting, in one form or another, will always be a fundamental element of a public alerting infrastructure. A long transition period may be needed to reach a point where the analog broadcast infrastructure is surpassed by the more modern converged multimedia network.

IMPACT

The decisions concerning the phasing out or termination of the analog services should take into consideration the impact this will have on the governments' ability to reach citizens and alert them of emergencies.

The new digital broadcasting system should be implemented so that it can take over from the analog systems and play its critical role in emergency situations.

2.2.5 MOBILE INTERNET AND BROADBAND WIRELESS NETWORKS

Internet gives Canadian consumers access to an unlimited number of radio stations. Some offer a streaming service while others offer podcasting services (i.e. downloading of audio files). Consumer devices can access these "unregulated" sources to record and playback the content. Internet will soon be even more easily accessible thanks to the emergence of wideband wireless networks such as WiMax and WiBro (Broadband Wireless Access (BWA) technology, IEEE 802.16).

Local radio markets risk audience erosion as these BWA networks are deployed. A similar effect will be felt on the Mobile TV services currently offered by Telecom Providers (2.5 G, 3G) and soon to be offered by broadcasters (DVB-H, DMB, DAB-IP, MediaFlo) since, again, an unlimited number of "unregulated" sources of video content can be found on the Internet. In those localities with available BWA services, Canadian consumers owning portable PVRs equipped with a IEEE 802.16 transceiver will be able, for example, to select and download content at will from the Internet for subsequent viewing, thus completely bypassing broadcasting services.

A number of factors, such as spectrum availability, the number of simultaneous users, and other technical constraints, will impose a ceiling in the number of streaming video and audio services that can be offered simultaneously in a given geographical area to mobile and handheld device users using BWA. However, the podcasting approach overcomes this impediment since users can download the files from their Internet access at home and play the files later when they are on the move.

The use of wireless means to provide broadband Internet is seen as a cost-effective way in cities where access to cabled facilities is difficult and to residential customers in rural areas where the cable facilities have insufficient capacity to deliver broadband Internet or cable does not reach.

IMPACT

The regulation of broadcasting content as currently exercised may be rendered futile when universal content can be easily accessible by Canadians living in the urban centres and in the rural areas where these BWA systems will be deployed.

2.2.6 SATELLITE DIGITAL AUDIO RADIO SERVICE (S-DARS)

Satellite Digital Audio Radio Service (S-DARS) was introduced in Canada in 2005 in the S-band. The service is currently in operation and is expected to be a permanent offering. It is anticipated that all technology developments in audio coding and compression for terrestrial digital radio broadcasting services will find their way into the satellite offering over time.

Current satellite system offer limited capacity but the next generation of satellite technologies and signal processing capabilities could increase the capacity if there is a commercial need. However, it is not anticipated that S-DARS will meet by itself all radio broadcasting needs in Canada.

IMPACT

Current spectrum allocation in the S-band, even with forthcoming new satellite technologies, is expected to limit the number of channels that can be accommodated to service the North American market. There is no indication at the present time that other bands will be commercially developed for this service.

Local programming will likely continue to be offered via either terrestrial over-the-air or wired services given the capacity limitation of the current S-DARS.

2.2.7 AUDIO CODING TECHNOLOGY

All of the major audio encoders in use today (i.e., MPEG Layer 2, MPEG Layer 3, MPEG AAC, Dolby AC-3, Lucent PAC) are transform-based perceptual audio coding systems and have reached a high level of development maturity. As such, it is very difficult to further increase the performance of existing audio encoders. Formal comparative subjective tests performed in 1997 at the Communications Research Centre Canada (CRC) between the five prominent audio coding schemes listed above have shown that the MPEG AAC codec was the best and can deliver high quality at a bit rate of 96 Kbps per stereo program.

Recently, two new technologies were developed in an attempt to further reduce the bit rate of existing perceptual audio codecs: Spectral Band Replication (SBR) and Parametric Stereo Coding.

The SBR technology has been incorporated into various codecs including MPEG layer 2, MPEG Layer 3 and AAC, where they are commercially known as mp2+SBR, mp3Pro and aacPlus respectively.

Another major step to enhance the efficiency of perceptual audio encoders for stereo signals is Parametric Stereo Coding also known as Binaural Cue Coding (BCC). The BCC technique reduces the number of source signals or a multichannel audio signal to one audio channel plus side information. Parametric Stereo Coding is optimized for the range of 16-40 Kbps and provides medium audio quality at bit rates as low as 24 Kbps.

The trend in audio coding is to reduce the bit rate for high quality coding of stereo-pair or multichannel audio (also known as surround sound or home theatre) to less than 64

Kbps. This trend even demands more bandwidth-efficient coding systems while delivering high quality audio. The traditional coding schemes fail to achieve the desired bit rate. Therefore, new coding systems are being developed to accomplish this goal.

A promising alternative to the existing audio coding systems is Object-based Audio Coding. This is a new paradigm to code audio signals using a parametric representation of the audio signal. A recent realization of object-based audio encoders is SinuSoidal Coding (SSC) parametric encoder (developed by Philips) and has recently been included in MPEG-4 for low rate audio coding. Although the SSC encoder has successfully increased the compression ratio to around 20:1 for many sounds, it is still far from high quality at a bit rate of around 60 Kbps per stereo audio. Significant development in the object-based audio coding paradigm are expected within 5-10 years.

An emerging technology is Software-Defined Radio (SDR). As development of new audio coding systems is going on, a software-defined radio will allow use of more advanced coding systems without the restriction of backward compatibilty. A software-defined radio will require a powerful processor, available today only on state-of-the-art personal computers. The current trend in the processors' market may, however, make it possible in the future to implement this concept in lower cost equipment.

IMPACT

Introduction of more advanced audio encoders will result in spectrum saving up to 50% compared to current operating bit rates. As such, broadcasters can air more radio programs while delivering high quality audio.

Use of Software-Defined Radio could provide enough flexibility to decode new formats of encoded data just by running a new decoding software. This paradigm will allow the exploitation of new coding technologies without significant hardware modification to deployed equipment. Availablility of very low cost processors is still however a serious impediment for such software implementation to become widespread in consumer-type radio receivers.

2.2.8 MULTICHANNEL SOUND IN BROADCAST APPLICATIONS

Three main factors are likely to be pivotal in determining the future of multichannel sound (also known as surround sound) in broadcast applications. The first factor is the availability of suitable multichannel content. At present, the vast majority of multichannel audio content consists of the film soundtracks found on DVDs. Another source of multichannel content comes from high-definition television programs that have a corresponding multichannel soundtrack. While this is still limited to a relatively small selection of the more popular television programs, it is an area that is steadily growing. Currently there is very little musical content available in multichannel format due to the added expense associated with producing a multichannel recording, and the lack of demand for such content.

The second factor relates to the number of consumers who own some form of multichannel playback system. Currently, more than 30% of US households have some form of multichannel playback capability. This is invariably integrated with their television system, and therefore there are already a large number of home systems to support multichannel television broadcasts. This installed base of systems does not support multichannel radio and thus some form of additional hardware would be required. A very significant portion of radio listening occurs while the listener is in the car. However, the vast majority of cars sold today do not have multichannel playback capability.

The third factor is the emergence of so-called "upmix" technologies. Upmix technologies take a stereo audio signal as their input and create a multichannel version of the signal. That is, they automatically synthesize a multichannel signal from a stereo source. If the performance of the upmix technology can be refined to provide high-quality multichannel signals, then this technology offers a virtually unlimited source of multichannel content. There are several companies that currently offer upmix technologies intended primarily for music. In the near future all consumer multichannel playback systems will include some form of upmix technology. Therefore, in some broadcasting applications, it may not be necessary to broadcast in multichannel since the listener's receiver will be able to instantly synthesize a suitable multichannel signal in real time. An important advantage to this approach is that it does not require any change to the existing broadcast infrastructure, or any increase in broadcast bandwidth.

IMPACT

It appears likely that multichannel sound for television and radio will evolve differently. Multichannel sound is already part of the standard for digital television broadcast, and a significant amount of content is available for this application. Therefore, multichannel sound for television is likely to evolve as planned, using the existing infrastructure.

Conversely, there is presently no established standard for multichannel radio broadcasting and there is a lack of suitable multichannel musical content. Multichannel radio will likely be achieved using the existing stereo infrastructure along with an upmix technology in the receiver.

2.2.9 ADVANCED DAB/DMB RECEIVER TECHNOLOGIES

The Eureka 147 DAB system was selected in Canada and in some countries around the world to broadcast digital radio services. This system can operate in four different transmission modes to accommodate transmission at RF frequencies ranging from 50 MHz to 3 GHz. In Canada, broadcasters are currently using Mode II at L-band (1452-1492 MHz) but they would prefer to use Mode IV because it allows for a larger separation between on-channel re-transmitters than in the case of Mode II. This implies that fewer transmitters should be required to cover a given service area resulting in lower cost. However, computer simulations as well as lab and field trials have shown that for proper reception, using Mode IV at L-band in a vehicle, speed is limited to less than 100 km/h in some locations with the current generation of DAB receivers. The main cause of this limitation is the Doppler effect, which introduces inter-carrier interference (ICI) between the OFDM subcarriers of the Eureka 147 systems. The Terrestrial Digital Multimedia Broadcast (T-DMB) system recently developed in Korea is based on the Eureka 147 DAB system and suffers from the same Doppler effect.

The Communications Research Centre Canada has undertaken research during the past several years to find techniques to mitigate the Doppler effect in DAB/DMB. CRC has developed an advanced COFDM demodulation technique for DAB/DMB receivers, which is based on a *single receive antenna*. Satisfactory performance was obtained with this advanced technique for vehicle speeds up to about 150 km/h with Mode IV at L-band in a Typical Urban mobile channel. This technique is entirely compatible with the transmitted DAB/DMB signal and, as such, does not require the transmission of additional pilot or training signals.

Research was also conducted to develop Doppler mitigation techniques based on *two receive antennas*. Two dual-antenna schemes were investigated. The first scheme is based on conventional differential detection (CDD) used in most DAB/DMB receivers currently on the market. The other scheme is based on the advanced COFDM detection technique mentioned above. Simulation results show that the CDD-based dual antenna receiver extends the maximum vehicle speed for satisfactory audio service from about 100 to 155 km/h while the dual antenna receiver based on the CRC advanced COFDM demodulation extends it to 200 km/h.

IMPACT

The novel techniques to mitigate the Doppler effect in DAB/DMB receivers are being further investigated in field tests. If their performance is proven, these technologies could be implemented in a new generation of DAB/DMB receivers and pave the way to the deployment of DAB/DMB service at L-band in Mode IV. This would result in lower implementation costs for the broadcasters as less transmitters are required to cover a given service area and also to better receiver performance for mobile users.

3.0 CONCLUSION

In a spectrum-limited world, one-to-many broadcasting systems are still the most efficient way to instantaneously reach a large audience, particularly in the mobile environment.

The digitization of broadcasting opens up unprecedented opportunities for the broadcasters to implement new services for customers, in competition or in collaboration with other sectors of the information and telecommunications industry. An advanced digital broadcasting infrastructure will also be key to the ability of Canadian firms to develop and apply advanced products and services for world markets

The following trends will have an impact on broadcasting policy and regulations:

- The adoption of all-digital broadcast transmission technologies and the introduction of advanced audio and video compression technologies is reshaping and re-defining our notion of broadcasting,
- Broadcasting will continue to be a major driving force behind the development of advanced high-quality audio, video and broadband wireless transmission technologies,
- Broadcast spectrum and technologies could be used increasingly for the delivery of non-broadcast services such as public emergency services, tele-health, Intelligent Transportation Systems (ITS), Government-On-Line, e-commerce or broadband access for rural and remote locations,
- The convergence between Telecommunications, Internet and Broadcasting networks will accelerate,
- More advanced standards as well as enhancements to the existing ones are in development,
- Demand for spectrum will continue to increase,
- New and innovative concepts and technologies will permit the use of the broadcast spectrum in a much more efficient manner, by sharing it with other licensed and unlicensed systems,
- Broadcasting will take a role of strategic importance for public safety needs,
- Important regulatory changes will be necessary to accommodate a more modern vision of the Canadian broadcasting system. Different content regulation on different distribution systems may handicap or advantage a particular industry.

Due to technical innovation and to competitive market conditions, broadcasting will most likely remain the most economical and efficient way of distributing a huge quantity of information instantaneously to a very large audience in a spectrum-congested environment. As a matter of fact no country in the world has plans to terminate over-the-air broadcasting.

CRC researchers will be pleased to provide any supplementary information that may be useful for the CRTC to prepare its report on the future environment facing the Canadian broadcasting system.

4.0 LIST OF ABBREVIATIONS

3G: Third Generation
ADSL: Asymmetric Digital Subscriber Line
ATSC: Advanced Television System Committee
BCC: Binaural Cue Coding
BSS: Broadcasting Satellite Service
BTS: Broadcast Television System
BWA: Broadband Wireless Access
CDTV: Canadian Digital Television
CRC: Communications Research Centre Canada
DAB: Digital Audio Broadcasting
DBS: Digital Broadcasting by Satellite
DRB: Digital Radio Broadcasting
DMB: Digital Multimedia Broadcasting
DTH: Direct-to-Home
DTV: Digital Television
DTxN: Distributed Transmitters networks
DVB-H: Digital Video Broadcasting-Handheld
DVD: Digital Versatile Disc
ERP : Effective Radiated Power
FCC: Federal Communication Commission (USA)
FLO: Forward Link Only
FSS: Fixed-Satellite Service
ICI: Inter-Carrier Interference
IP: Internet protocol
IPv6: Internet Protocol version 6
IPTV: Internet Protocol Television
ITU: International Telecommunication Union
MHz: Megahertz
MPEG: Motion Pictures Experts Group
NPRM: Notice of Proposed Rule Making
NTSC: National Television System Committee
OTA: Over-the-Air
SBR: Spectral Band Replication
S-DARS: Satellite-Digital Audio Radio Services
SDR: Software Defined Radio
SDTV: Standard Definition Television
SFN: Single Frequency Networks
SSC: SinuSoidal Coding
T-DMB: Terrestrial-Digital Multimedia Broadcasting
TxID: Transmitter identification
UD: Unlicensed Devices
UHDV: Ultra High Definition Video
VSB: Vestigial Side Band
WLAN: Wireless Local Area Networks
WRAN: Wireless Regional Area Networks

5.0 ANNEX A - SUMMARY OF THE CRC RESPONSE TO THE CRTC BROADCASTING PUBLIC NOTICE 2006-72

1.0 MATTERS ADDRESSED IN THE CRC RESPONSE

d) current state of audio-visual technologies and their predicted evolution over the coming years,

e) with respect to the usage of audio-visual technologies by Canadians:

- (vi) how future generations will consume or access content,
- (vii) the impact this evolution of technologies has for content and programming choice,

f) with respect to the impact on the broadcasting system:

- ii) the economic and regulatory impact on the broadcasting system caused by these technologies,
- (iv) the different methods for providing programming.

2.0 LIST OF THE TECHNOLOGIES AND SUMMARY OF THEIR IMPACT

2.1 TELEVISION

2.1.1 MOBILE TELEVISION

The expansion of Mobile Television services in Canada may be supported by continuing Industry Canada's allocation of spectrum for flexible use within or outside the television frequency band.

Since many Mobile TV programs can be transmitted over a single 6 MHz DTV channel, regulation could allow several program providers to share a single TV channel.

2.1.2 ENHANCEMENTS TO DIGITAL TELEVISION TRANSMISSION STANDARD

A backward compatible system will enable broadcasters to use their over-the-air DTV stations to transmit HDTV and/or standard definition programs to fixed locations with the option of using part of their DTV channel data capacity to offer lower resolution TV programs to portable or mobile receivers.

2.1.3 ADVANCED VIDEO CODECS

It is likely that several video compression technologies will co-exist in television broadcasting in the future. The addition of these new system features to the ATSC standard could create compatibility issues with legacy equipment for the Canadian consumer.

2.1.4 3D TELEVISION

The expectation is that 3D-TV should have little impact on spectrum demand and regulation.

2.1.5 SUPER HDTV

Super HDTV will not likely be considered for television broadcasting in the foreseable future.

2.1.6 INTERNET TELEVISION

Because of technical limitations, the present Internet network is not well suited for real-time television broadcasting. Internet TV is likely to remain a delivery method that complements regular broadcasting rather than replacing it.

This situation could change in the future as technological improvements are introduced that allow the Internet to adequately support real-time applications.

2.1.7 INTERNET PROTOCOL TELEVISION (IPTV)

Improved ADSL and new video compression technologies enable telecom operators to offer multiple SDTV and HDTV programs simultaneously over copper wire, thus competing with OTA, Cable and Satellite television broadcasting.

If some forms of IPTV are implemented without regulations, the consumer could then get unregulated access to new content.

2.1.8 DIGITAL BROADCASTING BY SATELLITE AND DIRECT-TO-HOME SERVICE

Current and forthcoming technology developments are likely to increase the amount of services available to consumers via satellite and to compete head-to-head with terrestrial digital services delivery technologies.

There is a trend that mobile, fixed and broadcast satellite services could be offered by satellite in various frequency bands as the technology evolves.

The review and development of regulatory regimes and policies should take this into account.

2.1.9 OVER-THE-AIR DTV MULTIPLEX FLEXIBILITY

Regulations need to take into consideration that one TV channel may transmit more than one program at the same time. In particular the Must-Carry rule, which require Cable networks to carry local television stations as part of their basic service need to be clarified in the context of DTV and mixed HDTV/SDTV services.

The availability of multiple sound tracks makes it possible to offer multilingual television sound.

Data transmitted on a TV channel may or may not be related to the TV program. Regulation and distribution rights agreements should take this into consideration.

2.1.10 SINGLE FREQUENCY NETWORK FOR DTV BROADCASTING

If Single Frequency Networks were to be used, revisions and modifications to spectrum regulations would be required including the possible consideration of incentives for the use of lower power transmitters wherever it can yield spectrum savings.

2.1.11 DTV RECEIVERS

For a number of years after the transition to DTV, the average consumer will need guidance and/or protection to ensure that they can take full advantage of the various distribution systems despite their increasing complexity.

Canada could consider setting a date to terminate Analog NTSC transmissions and a corresponding earlier date to end the sale of NTSC only equipment,

Availability of DTV receivers integrated in portable devices would make common international standards more desirable, as they would need to provide services when the device is used in different countries.

2.1.12 PERSONAL VIDEO RECORDER

Video programs from everywhere in the world will be available locally through Internet without any regulation. Content, price and other considerations could be decided outside Canada and increase the competition to the programs distributed by the Canadian broadcast industry.

2.1.13 WIRELESS RETURN CHANNEL

Wireless return channels would enable free over-the-air TV to offer two-way services similar to the ones now available from Cable networks. The introduction of such services could require new regulations and the allocation of new spectrum allotments.

2.1.14 WIRELESS REGIONAL AREA NETWORKS

The operation of wireless regional area networks using vacant TV channels in rural areas has the potential of bringing Internet access in a cost-effective way in areas that are difficult to serve with this service. However, the operation of an unrestricted number of license-exempt devices in the TV broadcast bands is likely to create scenarios where harmful interference to the Television services will result and policy makers need to ensure that the incumbent TV broadcast operators are sufficiently protected.

2.2 RADIO

2.2.1 DIGITAL RADIO: A DIGITAL PIPELINE

Flexible regulation will be needed to encourage innovation and to enable broadcasters to fully exploit the potential of their digital delivery network in a complex and competitive environment

2.2.2 TECHNOLOGY OPTIONS FOR RADIO BROADCASTING CONVERSION TO DIGITAL

Two options exist for operation in the AM band: AM-IBOC (HD Radio) and DRM (Digital Radio Mondiale). Neither is compatible with current AM receivers.

Many options are offered to FM broadcaster: FM-IBOC, L-band DAB, Band III DAB and DRM+ (DRM plus). The choice will be dictated by factors such as spectrum availability, the size of the coverage contour, receiver availability, requirement for SFN transmitter networks, backward compatibility with existing receivers, etc.

2.2.3 RADIO RECEIVERS

Consumers may need guidance to determine which device is needed to access particular content and to understand the limitations of these devices due to technical or regulatory constraints. Alignment of the regulations to this new technical reality could be needed.

2.2.4 EMERGENCY WARNING

The decisions concerning the phasing out or termination of the analog services should take into consideration the impact this will have on the governments' ability to reach citizens and alert them in case of emergencies.

2.2.5 MOBILE INTERNET AND BROADBAND WIRELESS NETWORKS

The regulation of broadcasting content as currently exercised may be rendered futile when universal content can be easily accessible by Canadians living in the urban centres and in the rural areas where these BWA systems will be deployed.

2.2.6 SATELLITE DIGITAL AUDIO RADIO SERVICE (S-DARS)

Local programming will likely continue to be offered via either terrestrial over-the-air or wired services given the capacity limitation of the current S-DARS.

2.2.7 AUDIO CODING TECHNOLOGY

Introduction of more advanced audio encoders will result in spectrum saving up to 50% compared to current operating bit rates. As such, broadcasters can air more radio programs while delivering high quality audio.

Use of Software-Defined Radio could provide enough flexibility to decode new formats of encoded data just by running a new decoding software. Availability of very low cost processors is still however a serious impediment for such software implementation to become widespread in consumer-type radio receivers.

2.2.8 MULTICHANNEL SOUND IN BROADCAST APPLICATIONS

Multichannel sound for television is likely to evolve as planned, using the existing infrastructure. Multichannel radio will likely be achieved using the existing stereo infrastructure along with an upmix technology in the receiver.

2.2.9 ADVANCED DAB/DMB RECEIVER TECHNOLOGIES

These technologies could be implemented in a new generation of DAB/DMB receivers and pave the way to the deployment of DAB/DMB service at L-band in Mode IV.

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