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Department of Communications

Report on Cable Compatible TV Receivers

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CABLE COMPATIBLE TELEVISION RECEIVERS

FINAL WORKING GROUP REPORT

SEPTEMBER, 1977
DEPARTMENT OF COMMUNICATIONS

I N D E X

PART 2 - PROPOSED TECHNICAL INTERFACE STANDARDS

PREFACE

Installation of cable television systems as a simple means of extending the coverage and improving the quality of broadcast TV signals began in Canada in the 1950s. Cable distribution has now become, with telephony and off-air broadcasting, one of the three major components of the national public telecommunications infrastructure.

Cable distribution is still essentially an extension of broadcasting --- in particular, of U.S. networks to Canadian urban communities. But, while it is that, it has also spilled beyond the 12-channel limits of the television receiver, expanding in capacity without a coordinated approach to system planning. The number of channels accessible over cable in many service areas is now 17 to 30, not 12. The TV signals on the augmented channel service are carried at frequencies not allocated to off-air broadcasting. They require supplementary receiving apparatus which can cost the subscriber from $75 to $125. The adjacent packing of channels makes new demands for selectivity in the receiver, as well as new constraints on the conventional distribution system. The fact that all receivers in an area are effectively wired together on a party line trunk imposes limits on radiation from receivers back into the connecting cable. At the same time, the potential demand for new services, and the possibility of providing them over cable, might make new demands on the performance of both the distribution plant and receivers. But both cable systems and terminal receiver equipment, procured under new specifications and standards tomorrow, would have to have a useful life of ten years and beyond. The question of "compatibility" has grown out of problems accumulated from past developments and improvisations, but addresses itself to developments in the next decade.

Late in 1976, the Department of Communications (DOC) formed a Working Group, which included a small number of specialists from industry, to make an assessment of the problems related to the compatibility of cable hardware and TV receivers, with emphasis on the technical and operational issues at stake. While eventual decisions on system architecture and system compatible hardware will take account of many other factors - regulatory, jurisdictional, international, social, etc. - it is first necessary to ascertain the boundaries of technical and economic feasibility in so far as the operational requirements and technological prospects can be foreseen now. This report is the product of that Working Group's evaluations. Its system overview, and the questions arising from that overview, are in the first part. Its judgements, more narrowly related to the standardization of receivers which might respond to both known and anticipated requirements, are in the second part.

This document is as comprehensive a presentation of the technical and economic factors, as the Working Group could achieve within its terms of reference. Its purpose is to make this essential information compactly available to the public, the industry and government in the ongoing dialogue and ultimate decision-making.

Correspondence relating to this report is invited, and should be addressed to the Director, Broadcasting Regulation Branch, Department of Communications, 300 Slater Street, Ottawa, Ontario, K1A 0C8.

INTRODUCTION

1. Definitions

The cable compatible TV receiver is defined, for the purpose of this report, as a modified version of presently available receivers which would:

a) allow full off-air reception capability (both VHF and UHF) as well as regular (non-pay) cable TV signals in the standard VHF, mid and super bands, without need of an outboard conversion device, and;

b) provide access for external devices, requiring, as a minimum, a baseband video and audio input.

The "cable-only" receiver, for the purpose of this document, is a receiver designed to be compatible with cable delivered signals as specified in applicable government standards.

2. Objective of the Working Group

The Working Group was created to produce a balanced assessment of the compatibility implications of a new TV receiver, with respect to:

- the transmission media: coaxial cable now, fibre optics in the future;
- sensitivity and RF converters;
- spectrum: VHF, UHF, mid-band and super band (see diagram, page 6);
- accessibility at the video "baseband" level and other kinds of inputs and outputs other than RF;
- channel selection and access mechanisms of subscriber TV; traps, scramblers, circuit switchers;
- subscriber identification, accounting and billing in Pay TV;
- interconnection with auxiliary subscriber apparatus: tapes, discs, frame grabbers;
- interconnection with other services - educational, information retrieval, telephony;
- compatible two-channel audio for either stereo transmission purposes or simultaneous two-language "sound tracks".

3. Terms of Reference of the Working Group

A number of issues arising from the compatible TV receiver question were listed for the attention of the Working Group. Each member initially had to assess them individually, and then review them with other members. The final report was produced jointly, to summarize opinions, reflect the areas of agreement and divergence and identify necessary conclusions and recommendations wherever possible.

4. Participants

The following participated in the Working Group:

a) Working Group Members

DOC Personnel

Gilles Courtemanche (Director, Broadcasting Regulation Branch), Chairman;
J.R. Aubin (Director, University Programs), Secretary
A.R. Bastikar (Director, Canadian CCI Activities)
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D.M. Kettle (Director, Industrial Programs)
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Outside Consultants on Contract to DOC

Gordon Cummer	Electrohome Ltd.
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Israel Switzer	Switzer Engineering Services Ltd.
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SUMMARY

The over-riding concern of this Working Group has been the provision of guidelines to steer development of cable TV services and related consumer equipment into the future, in a way which will facilitate adaptation to new services and techniques. Such developments are on the horizon now and include a complex array of consumer equipment and interface devices to provide the numerous special services that are becoming feasible with current and evolving technology. A trend toward a modular concept is visualized for cable compatible receivers, and suitable specifications will need to be developed for the various inputs and outputs (interface points) discussed in this report.

There are also strong arguments for the interim development of two distinct TV receivers, pending the evolution of the modular concept. One would be tailored specifically to the needs of the cable TV system, and the other to the off-air environment. However, since there are equally strong concerns that this would impede the development of the UHF TV broadcasting/educational services, and since TV receiver incompatibility with either cable or off-air service may not be in the best interests of the highly mobile public, the question of developing a cable-only receiver requires further review and analysis.

It is evident from the study that most of the technological alternatives to the compatible TV receiver, although all quite valid, are too far down the road to have any impact on the present situation. Of those listed under "distribution" system, a standard channelling plan offers the only immediately obvious alternative. Insofar as the "subscriber terminal" is concerned, many technological innovations are immediately possible, but it is uncertain how costly they would be.

It is too early to fully assess all the implications of "two-way services" and the amount of spectrum they would require. However, short-term consequences would include imposition of additional constraints on the cable system. The long-term view necessitates a network planning concept, using a multiplicity of disciplines.

On the subject of "Interactive Capability," since no direct solution has been established at this time, two alternative solutions are discussed. Further study is required before deciding on a particular solution that would meet all requirements. Both external interface units and receivers with built-in capability for the most popular interface types are realistic approaches at the present time. Various types of inputs and outputs are discussed in this report.

It is considered that regulation should be limited to "interface standards." Other technical standards would be self-imposed. Adoption of minimum interface parameters, with self-certification, is recommended, provided the testing is performed in Canada and subject to regular audit by the Department.

The possible "ancillary services" tehnically feasible over coaxial cable are already very numerous, but a conflict is foreseen between cable broadcast spectrum requirements and special non-broadcast service allocations.

The impact on Canadian industry from the cost and marketability viewpoint are discussed against various technical outcomes. However, opinions are divergent as to whether "user mobility" should be a concern of government. In a mass, highly-sophisticated electronic market, it is considered that a higher degree of consumer protection is required.

The standards under consideration by the Department reflect the requirements for a cable compatible receiver operating with today's cable TV systems. Any standards published in the near future would, of course, need to be modified at a later date to accommodate new developments that will evolve in the long term. However, in view of the recent emergence of cable TV receivers on the market, there is an immediate need for interface standards to ensure compatibility between existing distribution systems and such subscriber equipment.

PART I

REVIEW OF THE CABLE SYSTEM-TV RECEIVER INTERFACE

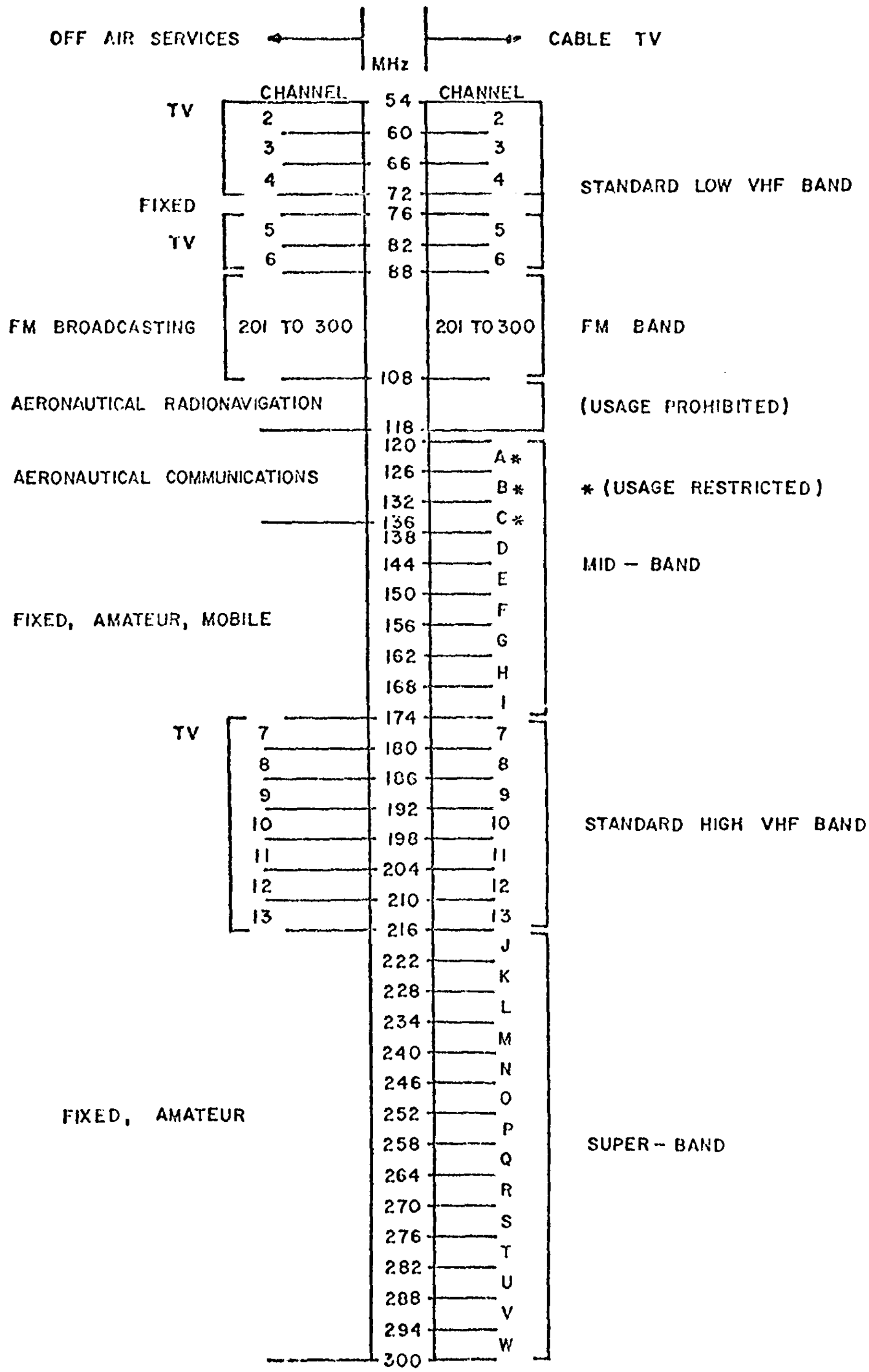
1.1 COMPATIBILITY BETWEEN THE CABLE SYSTEM AND THE TV RECEIVER

Out of practical necessity, ways and means have been found to make today's cable television system compatible with conventional off-air receivers. For example, cable signal levels are carefully maintained within certain limits to allow for poor adjacent channel and image rejection; substantial technological innovations in hardware design and distribution techniques have been required to permit the use of mid and super-band channels; potential interference due to high level local oscillator signals leaking from receivers have been resolved by judicious frequency offsets on a number of cable channels; receiver shielding inadequacies, giving rise to co-channel beat problems, have been partially overcome by phase-locking the cable frequency to the off-air frequency.

In sum, the cable industry has devoted considerable effort to adapt its delivery system to a terminal which was designed for off-air reception.

An overview of the evolution of the cable system since its infancy is presented in the following section, to reflect the activity that has taken place in the cable industry to achieve compatibility with the conventional receiver.

The following diagram illustrates the different portions of the cable TV receiving spectrum for reference use in sections that follow.


OFF AIR SERVICES
MHz
CABLE TV
CHANNEL
CHANNEL
TV
FIXED
TV
STANDARD LOW VHF BAND
FM BROADCASTING
201 TO 300
201 TO 300
FM BAND
AERONAUTICAL RADIONAVIGATION
(USAGE PROHIBITED)
AERONAUTICAL COMMUNICATIONS
* (USAGE RESTRICTED)
MID - BAND
FIXED, AMATEUR, MOBILE
TV
STANDARD HIGH VHF BAND
FIXED, AMATEUR
SUPER - BAND
54 60 66 72 76 82 88 108 118 120 126 132 136 138 144 150 156 162 168 174 180 186 192 198 204 210 216 222 228 234 240 246 252 258 264 270 276 282 288 294 300
2 3 4 5 6 7 8 9 10 11 12 13
A* B* C* D E F G H I J K L M N O P Q R S T U V W

1.1.1 Evolutionary Overview

a) Standard 12 Channel Operation

In the early fifties there were relatively few off-air channels available. The first systems started operation with up to three non-adjacent channels in the low-VHF band (54-88 MHz).

The growing number of available TV channels and stations forced cable systems to expand their capacity. Cable operators soon experienced problems of adjacent channel selectivity in their subscribers' receivers, and the early multichannel systems expanded in two directions: broadband and channelized amplifier systems were both used. Channelized amplifiers precluded the use of adjacent channels because of filtering problems. Broadband amplifiers (i.e. 54-216 MHz) had two problems: they suffered from cross-modulation and were expensive. Early broadband amplifier operators tried adjacent channel operation so that they could carry five channels in the 54-88 MHz band. This was only partially successful because these early operators had no effective means of reducing visual/aural carrier level below that which had been broadcast; broadcasting stations in those years commonly had a 3 dB visual/aural power ratio. This high level of aural carrier caused adjacent channel interference in most receivers. The development of heterodyne signal processors with separate processing of visual and aural carriers allowed cable operators to increase the visual/aural ratio. Experimentation led to the presently accepted range of operating aural carriers about 14-17 dB lower than visual carriers. This didn't completely solve the adjacent channel problem in system/receiver compatibility, but it seemed to be a reasonable compromise. Most receivers worked acceptably well in a 12-channel adjacent channel environment, and most subscribers accepted any compromise in performance as an acceptable trade-off for the benefit of the additional variety of television viewing that cable service provided.

The cable system started with complete deference toward the subscriber's receiver. Then, under the pressure of economics, achieved a compromise position. This compromise has been partially deliberate and partially fortuitous.

The only alternate way to increase channel capacity from the cable company's point of view had been to construct a "dual" system, i.e. with completely duplicated trunk, distribution and service drop cables, ending up at a cable selector switch at the back of the subscriber's receiver. This would have doubled the capital cost of the plant and substantially increased maintenance and operating costs. Experience up to now has indicated that while overcoming TV receiver compatibility problems in 12 channel cable systems, this technique was not cost effective. The judgement has been made, and correctly so, that cable subscribers would not pay the very high additional cost for the service improvements that a dual cable system would provide in the case of 12-channel service.

The main consequence of using a single cable for 12-channel service is the possible adjacent channel interference problem in some subscribers' receivers and the reduction of channel capacity because of direct pickup problems. A dual cable system would overcome these problems by providing reasonable capacity, while alleviating the need for adjacent channel operation or use of "local" broadcast channels. It would, however, burden all subscribers, including those whose receivers have adequate adjacent channel selectivity and adequate shielding, with the costs necessary to accommodate those with inferior receivers.

b) Augmented Channel Operation

The system operator who wished to augment the capacity of his system to expand subscriber service had relatively few options available to him. These are described below along with their limitations.

1) Dual cable plant - as previously discussed. Each of several cables could carry up to twelve "regular" VHF channels. Actual capacity might be reduced by local direct pickup constraints on each cable.

2) Use of "mid-band" - the operator could use the unoccupied portion of the cable spectrum between VHF channels 6 and 7 (88-174 MHz). This introduced the problem of providing tuning capability for the subscriber, and potential interference to aeronautical and other radio services, due to signal leakages caused by shielding defects.

3) The "super-band" (216 Mhz and up) could also be used to augment system capability at the cost of providing subscriber tuning capability and increasing system bandwidth.

4) The Rediffusion system developed in England, or a modified version thereof called "Discade" developed in the U.S.A. by AMECO. These systems make use of secondary distribution centres, each serving a number of subscribers who could interact with the system by selecting desired programs over dedicated cables. Their serious limitation was the bulk of the dedicated cables involved, - a limitation which may now be overcome by fibre optics technology.

5) Another technique which has been proposed, and which warrants a closer analysis, is the use of UHF frequencies for distribution. This would assume UHF tuning capability in subscribers' receivers as well as appropriate distribution facilities.

The cable operator faces problems in using additional spectrum in his system. The two VHF bands (low and high) were planned to avoid second order distortion products. Use of the mid-band and/or super-band created susceptibility to such products. To control distortion, cable operators started to use improved amplifiers (push-pull circuit designs) and a variety of coherent carrier schemes which were developed in response to the need for more channel capacity. The amplifiers found ready acceptance, both in new system construction and in amplifier replacement programs for old systems, while coherent head-ends found their place primarily in older systems with depreciated plant.

The tuning problem for subscribers has been largely overcome by use of supplemental tuning converters at the input to the receiver. U.S. studies have compared the overall cost of dual cable plants with single cable systems using converters at subscribers' terminals. At low subscriber saturation, it is more economical to provide subscribers with tuning converters, while at very high saturation, dual cable plant is best.

Dual cable plant puts an immediate and substantial capital and operating cost burden on the cable system which must be borne by all subscribers whether they make use of the augmented channel capacity or not. Use of tuning converters creates a pressure for more economical converters and for receivers with built-in augmented tuning capability.

Nearly all cable operators have opted for multi-channel cable operation, i.e. augmenting system capacity by use of the mid and/or super band, rather than the dual cable option. In Canada, because subscribers may buy their own converters, there has been even less attraction for dual cable plant, even for systems with high penetration.

There is only one dual cable system in Canada (Cornwall, Ontario) This system, which serves more than 13,000 subscribers - almost 90% of all households in the service area - in a recent application for a rate increase to the CRTC, released cost data indicating that to rebuild the sytstem in dual cable configuration, replace all service drops with new dual drops and provide a selector switch, would cost $148 per subscriber. If the operator had opted for single cable augmented capability, the system costs would have been about $68 per subscriber. It would have cost another $45 per user to provide a tuning converter, for a total of $113.

More detailed analysis requires consideration of differing maintenance and depreciation costs between dual cable plant and single-cable/converter type plant.

The Cornwall experience suggests there is no likely economy in tailoring the cable system to fit the present subscriber receiver for a significant number of channels. There just doesn't seem to be any economic alternative to single-cable/tuning-converter type of operation. The prospect of built-in, low-cost, augmented tuning capacity weighs even more heavily in the direction of augmented capacity single-cable system technology. However, if a need arose for special services requiring a capacity of more than 35 channels, the dual cable approach could prove to be an excellent choice. There may also be technical advantages in using separate cables for broadcast signals and non-broadcast services such as digital information and broadband interactive services.

c) The UHF Alternative

The major objection to UHF distribution arises from loss factors related to higher operating frequencies. Cable losses increase as the square root of frequency (ignoring dielectric losses). Yet higher frequencies are more attractive because two additional octaves of capacity can be obtained at the expense of only doubling the cable attenuation. Cable systems presently operate to about 250 MHz and provide approximately 30 channel capacity. Quadrupling the frequency limit to 1,000 MHz would double cable losses but would increase capacity from 30 channels to more than 150. One could afford the luxury of non-adjacent operation and avoid strong local signals. Nearly all receivers have UHF tuners with 70 channel capability and the UHF tuner is steadily being improved. Subscriber service at UHF would provide a further incentive to improve the capability of UHF tuners provided on receivers, with consequent benefit to off-air broadcast services as well. This would solve some of the compatibility problems by making the cable system and the broadcast system more closely alike.

Other problems of UHF distribution involve qualification of cable for UHF use and procurement of amplifiers to cover this frequency range with adequate channel load capability. Load problems could be reduced by coherent carrier techniques, since third order intermodulation will be the prevalent distortion in systems with a large number of TV channels. Some consideration could also be given to the development of suppressed carrier transmission systems. Economical tuners for suppressed carrier operation could perhaps be developed. Subscribers with inadequate UHF tuners could be provided with supplemental tuners in the same way they are now provided with special tuners for augmented cable operation. Such tuners could also function as suppressed carrier converters.

UHF distribution is more commonly used in Europe because many subscriber receivers are UHF-only. Systems must deliver TV signals at UHF, or use a hybrid arrangement, carrying the signal at VHF in the trunk portion of the delivery system and providing a VHF-to-UHF converter at secondary distribution points, or at each subscriber's post.

A cable/subscriber interface at UHF would overcome many interference problems and would still achieve a valid form of cable/receiver compatibility. But UHF proposals have met little favourable response in North America, because of the strongly entrenched position of VHF cable technology and the apparent willingness of subscribers and cable systems to stay with augmented VHF converters.

There do not appear to be any economically or technically practical alternatives in the compatibility issue. If subscribers want multi-channel cable service, they have to adapt their receivers to meet cable system technical and economic requirements. Only the UHF system alternative promises any kind of practical alternatives to this trend --- that of altering the cable system to meet widespread receiver capability.

1.1.2 <u>Receiver Terminal Compatibility with the Cable System</u>

Compatibility, or lack of it, also depends on the adaptability of the present dedicated off-air receiver to a changing environment. Factors to be considered include:

a) The need to adapt to an increasing array of auxiliary devices, such as the home video tape recorder and video games.

b) The need to adapt in the near future to multiple still-frame picture information available over cable in the form of news, stock market information, community bulletins, consumer information (frame storage devices), and the like.

c) Present problems encountered with providing augmented channel services (e.g. local oscillator, adjacent channel, shielding requirements).

d) Problems encountered by lack of flexibility relative to future cable service offerings.

It has been noted that the total investment in domestic TV receivers exceeds that of the cable system plant. The economic balance between the cost of adaptation of the cable system versus that of the terminal system needs to be examined.

It is known that the largest portion of the cost of the TV set is in the "video-display" section (the colour tube, etc.) (see Appendix "A"). A much smaller portion is represented by wired-in components specific to off-air reception. It seems evident that the consumer could benefit more from his investment if the receiver were more flexible --- not limited to dedicated off-air reception. Flexibility could be achieved by making appropriate inputs available to the IF and video sections of the TV set. In this way, it is expected that auxiliary devices which adapt the TV set to new cable services could be simplified and the cost reduced, while avoiding RF modulation and improving the quality of display.

At present there is a serious problem of incompatibility between the conventional tuner and the ability of the cable system to provide more channels. (See diagram on page 6).

For example, measurements made in Canada and the U.S. in and before 1972 show that local oscillator signals appearing at antenna terminals of conventional TV sets are of high level, exceeding one millivolt in many cases. Trends in the last few years would indicate that a 20 dB reduction of this level might be possible. Since TV pictures are particularly susceptible to single frequency interference sources (see the "W" curve in Broadcast Procedure (BP) 23), with very objectionable beat patterns varying in width and axial position with frequency, it is important to minimize such interference from neighboring subscribers who do not use converters. The brute-force technique adopted as an interim measure in BP 23 Supplement is to require a high degree of isolation, 44 and 55 dB respectively, on mid-band channels A and B and super-band channels J to P. These are the channels of a TV set onto which the local oscillator (L.O.) fundamental of a neighboring subscriber's set will fall, due to its operation on channels 5 to 13.

However, isolation of such a high value sets most difficult constraints on the operation of a cable system. The isolation of taps is not channel selective, and typical taps affect all channels alike. Hence, the system with high isolation would need to operate at a high level, with attendant severe radiation problems, or at reduced amplifier spacing and hence much higher cost. While special filters may be used to trap out offending L.O. signals, their use is only possible with conventional TV receivers. A high price would have to be paid since one may be needed at each receiver without a converter.

An even more difficult situation has now occurred as a result of the introduction of TV sets with mid-band channels, using conventional L.O. circuits. The L.O. signals of these sets, when tuned to channels C to I in the mid-band, may now affect reception of channels 7 to 13 on any neighboring set. The proliferation of such sets can frustrate subscribers unable to identify the trouble since it is probabilistic in nature. It occurs on some nights, at various times, on some channels, depending on the viewing periods and programme preferences of the viewers involved. The level and number of occurrences of interference depends on the number of neighbouring sets with low isolation in relation to any given subscriber. When subscribers find out the reason, they complain to the operator, the neighbour, the DOC, CRTC, etc.... If remedial measures were not forthcoming, the effect on their viewing habits and on programme ratings could be reflected in an adverse impact on both cable and the broadcast industry. Ironically, the only practicable remedy for serious interference in such cases is probably a set top converter!

The cable industry has overcome these problems with the development of a converter which serves as a buffer between the RF tuner of the TV set and the cable outlet. The converter typically feeds into either channel 2 or 3 to avoid local pickup problems, but could, with redesign, feed into the IF section of the TV receiver (if it were made accessible) thus bypassing the RF section altogether and avoiding all local pickup problems. However, there are some major technical problems inherent in this approach.

Orderly development of cable services requires compatibility between TV set and cable system, which can be achieved through the Department's efforts in defining interfaces and encouraging development of a more flexible TV receiver.

1.1.3 Another Apprcach

It is important to recognize that there is probably no disagreement on the need to achieve certain minimum levels of compatibility. Both the system operator and receiver manufacturers are interested in satisfying their customer needs. The problem lies in attempting to correctly identify what those needs are and then ensuring that most of them are met without undue disruption to the needs of others.

The receiver manufacturer finds himself facing not only a new signal environment, but also having to produce economically a product that can operate as well in this environment as it does with off-air signals. For a number of technical reasons, this is no easy task. Moreover, this new environment is in many ways unique to Canada. Since the bulk of receiver designs do not originate in Canada and, even for those designs that are of Canadian origin, the key tuning elements are obtained from outside, economic ability to react to cable system needs is severely limited. (This matter is discussed further under Section 1.12.)

In defining those areas of compatibility which can be included in interface standards, the Department had to take into consideration the reality that in Canada two transmission modes are used to provide television broadcasting, with the cable mode now having reached 50% penetration of Canadian households. This dichotomy raised the question of whether two different receivers, one to receive off-air transmissions and the other to receive cable transmissions, might be a better approach to the compatibility problem.

The question of two types of sets is one which needs further study. In the light of the technical growth and change in cable television systems which is bound to continue into the foreseeable future, it would seem that we cannot continue to expect a single product to be equally "good" in performance on two diverging signal delivery systems. It has been suggested that a logical approach would be to allow the continued design of off-air receivers which could also be connected to the cable system but with less than optimum performance, and at the same time, to encourage the design of cable-only terminals which would give optimum performance on current and expected future cable systems. This latter design would not be an off-air receiver and would not be expected to perform as such and could perhaps lend itself more readily to modular construction concepts during an interim period.

However, there is strong concern in many quarters that a cable-only TV receiver would impede the development of UHF educational broadcast services by provincial agencies, and of UHF broadcasting in general. The promotion of such a receiver might therefore not be in the best interests of a highly mobile public.

Other possible alternatives include the development of:

a) a receiver with full off-air and cable capabilities as a short term objective only;

b) a receiver (i.e. terminal) with baseband access only;

c) a fully cable compatible receiver with baseband access;

d) an off-air receiver with baseband access.

In certain circumstances it may be possible and desirable to provide I.F. access as well.

In terms of total economic impact, the opportunity to develop and sell a cable-only receiver to 50% of the viewers on cable and continue to market an off-air receiver to the other 50%, would undoubtedly result in lower cost than forcing all receivers for sale in Canada to meet a much-tightened specification for cable applications.

In addition, it would allow each manufacturer to make his own judgment as to whether he wished to develop the new receiver or restrict himself to meeting the needs of the market with an off-air receiver with impaired cable performance. In this period of economic difficulty, the manufacturer must closely examine each and every development project in terms of its eventual payback. To impose a new design on him could have serious ramifications for his ability to remain in the marketplace.

In summary, the changing character of the cable system dictates against any long-term attempt to develop receivers which might be optimized for both signal delivery systems. A technically and economically more sound approach might be the development of cable-only terminals designed to have the flexibility for future systems advances without the limitations imposed by off-air operation. However, these hypothetical advantages have to be weighed against the evident need to promote the further development of UHF broadcasting and the practical difficulties which ownership of cable-only receivers might pose to a mobile population.

Even in the dedicated receiver approach, however, it might still be possible and desirable to provide access to the I.F. and baseband circuitry in order to provide built-in flexibility in adapting the display terminal (receiver) to the various services and video devices now appearing on the market.

The logical evolution may very well be in the development of a display monitor with the controlling and selecting functions being provided by means of interface devices. The interface device could of course be for off-air reception, cable only reception, special auxiliary devices or a combination thereof. In brief, the "modular concept" appears to offer many advantages and should be seriously considered by industry and the regulatory authorities.

1.2. TECHNOLOGICAL ALTERNATIVES

Technological alternatives can be divided into those that are possible in the cable distribution system and those that might develop in the video-audio or subscriber terminal.

1.2.1 Distribution

a) Fibre Optics

Perhaps the most discussed and most promising transmission alternative today is fibre optics.

In many advanced research laboratories of the world, major research programs are being carried out to develop fibre optic systems. Fully optic delivery systems would have the advantage of being truly immune to radio frequency interference (RFI). Fibre optics technology might be feasible in the next 10 years in a variety of cable television applications:

1) the trunk line could comprise a bundle of fibres carrying signals modulated onto light-wavelength carriers;

2) at judiciously selected distribution points, these signals could be demodulated and then modulated onto carriers at VHF or IF frequencies and selected by the subscriber by switching-in as desired. The distribution lines could be either optical fibres or coaxial cable, with switching as in the "discade" system in the U.S., or the Rediffusion system originated in England, or modified versions thereof;

3) fibre optics and switching techniques might be combined with UHF on some systems or portions thereof;

4) in the interim period, trunk lines in large systems could be replaced by Very High Capacity Microwave (VHCM) carriers, as is being introduced in the Wirevision Cable system in Vancouver.

Coupled with optical-to-r.f. or optical-to-video conversion, fibre optics could conceivably eliminate many of today's problems. It is recognized that the cost of such a system currently could be many orders of magnitude greater than coaxial systems but recent activities in the telephone field lead to expectations of much reduced costs in the coming decade.

The change to fibre optics over the cable path, when it proves economical, would be compatible with digital transmission.

b) Digital Transmission

There is now a clear trend towards the application of digital techniques in most branches of telecommunications. In the TV field, the CMTT* working group of the CCIR* and CCITT* is presently preparing standards for digital transmission from camera to transmitter. Broadcasting of digitally encoded visual signals seems an unlikely possibility for some time to come, but improved quality and much reduced interference could be achieved at the television set by digitally encoding an off-air signal at the cable television head-end (and decoding at the receiver). Also, a tremendous effort is being made in the areas of digital modulation, digital multiplexing and digital switching, including wideband switching techniques.

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* Working Group and Bodies of the International Telecommunications Union (ITU).

CMTT	Transmission of sound broadcasting and television signals over long distances.
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee

c) Channelling Plan

Due to increased channel capacity requirements, various channelling plans (e.g. Multi-Pivoted Carrier (M.P.C.)or the equivalent Synchronous Oscillator System (S.O.S.)) have been developed and used as a short-term solution to accommodate additional mid-band channels for systems with single-ended amplifiers. Additionally, Pivoted Harmonically Related Carriers (PHRC), featuring a reduction in visual effect of the intermodulation products, have been developed. However, channel to channel relations are no longer 6 MHz, but range typically from 6.028 MHz to 6.048 MHz for the PHRC plan and 7 MHz for one combination (i.e. channels I and 7) in the MPC and SOS plans. Maximum offset of the standard VHF channels is in the order of 1.25 MHz for the PHRC plan and 0.25 MHz for the MPC and SOS plans.

Although the visual effects of intermodulation products are reduced, adjacent channel rejection of even a well-aligned set could also be somewhat reduced with the PHRC plan.

A study conducted by the Cable Television Technical Advisory Committee to the FCC in the U.S.A. recommends the implementation of an Incremental Coherent Carriers (ICC) plan (6N + 1.25 MHz visual carrier relationship) on the basis that it is least detrimental to the usage of existing TV receivers in North America. Full extent implementation of this plan would also require Rubidium-controlled signal sources on broadcast transmitters (the current cost is $20,000 per unit) and cable television head ends, so as to minimize co-channel interference in both off-air and cable reception, and direct pickup on cable. Existing 10 KHz offsets for co-channel interference improvement would be discontinued.

d) Single Sideband

Single sideband is a proven evolutionary step from double sideband AM technologies. Suppressed carrier Vestigial Side-Band (VSB) would be a natural step forward from our present VSB-AM transmission technology and should provide significant transmission advantages. Low cost IC's could be developed that would detect either VSB-AM or VSB/Suppressed Carrier with equal ease. The carriers could be reinserted at secondary distribution centers to provide compatibility with existing TV sets.

e) FM Transmission

FM transmission is another technological change that could be considered in view of its many transmission advantages. The only advantage that can be attributed to VSB-AM is conservation of spectrum. An augmented spectrum cable system may have adequate spectrum to support FM transmission, particularly systems with 1 GHz bandwidth. Use of FM would relieve some of the problems associated with implementation of 1 GHz cable systems. Wide deviation FM would allow substantial improvements in cable transmission and possible future terrestrial FM transmissions. FM receivers should not be more expensive than VSB-AM receivers if there were sufficient demand for them.

f) Direct Satellite Broadcasting

What the role of satellites in a direct broadcasting mode might be in Canada is a matter of network economics in an environment of extensive cabling, the introduction of fibre optics, urban versus rural population balances, roof top antennas and appropriate converters, and many other related factors. Their impact has not been studied in any detail, making it premature to speculate about implications for receiver specifications and design.

1.2.2 Subscriber Terminal

It is recognized that the receiver continues to be one of the weakest links in the system chain for RFI. But significant gains have been made in this area in the past few years. Unfortunately, they have been offset to a large degree by increasing levels of interfering R.F. sources.

With video (baseband) access, the TV receiver could easily be made adaptable to a fibre optic system or coaxial system of any capacity. Technological innovations could all be embodied in the interface devices, with a minimum additional investment on the part of the subscriber.

In the long term, a new display method will likely be devised to take advantage of digital redundancy techniques or perhaps a new large-screen addressable display. The transition need not be drastic.

Varactor tuning has been widely accepted by the manufacturers as a reliable method. Zenith anticipated that over 70% of its colour sets would employ varactor tuning by June 1976. In order to minimize local oscillator leakage problems, double conversion tuning (somewhat similar to some existing converter designs) can be used with the 1st IF around 400 MHz and the 2nd IF at the conventional 45.75 MHz for the picture carrier. Digitally generated voltage may be used for the varactor tuner, eliminating potentiometer arrays. This would require the sort of digital-to-analog converter processor currently used in Europe. Varactor tuners can be addressed in a simple sequential manner or in a somewhat more complex random access manner.

1.3 IMPLICATIONS OF TWO-WAY APPLICATIONS

The immediate short-term consequences of the introduction of "two-way" services are that they would make additional demands on the cable system.

It is too early to fully assess all the implications of two-way services and the amount of spectrum which will be required. The assessment should be based upon a lengthy experimental period, following which a trend will develop. In the meantime, experimentation should be encouraged with the provision that the broadcast downstream cable channels are not to be interfered with. Also, devices that are added at subscriber locations to receive "special" services must not introduce spurious signals on the cable system. This is particularly important in the upstream path where undesired signals from thousands of terminal devices may add and their cumulative effect may disrupt other services.

In this matter, as in a number of others, there is obvious need for network planning which might take account of:

optimum network configurations; space, frequency, and time division considerations; traffic, service patterns; service availability; network configurations (tree, star); centralized or distributed switching; security/privacy considerations; subscriber density; integration with switched telephone network; network routing hierarchy; billing methods; asymmetric two-way communications (e.g. one-way video, one-way audio).

Until such research has been carried out and coherent plans evolved, we are condemmed to putting out brush fires in the wake of unforeseen developments.

1.4 INTERACTIVE CAPABILITY

Limited bi-directional services are technically feasible with present two-way cable systems, with suitable interface devices between the cable system and the subscriber's TV set. Possible interactive services include:

subscriber identification, billing and coding, such as for subscription (Pay) TV, or the display of single images for information retrieval and educational services. Cable systems can also be integrated with telephone facilities to provide another array of services.

For large scale application of subscriber terminals that originate upstream signals, there are technical limitations such as noise accumulation, and the economics of switching. Another factor is the optimisation of the distribution network such as the use of single/dual cable or cost-effective network topologies that result in higher signalling speeds, more available channels, higher reliability and so on. Such coaxial cable network technology is still in a state of development, with some experimental systems now in operation.

The possibility exists that the use of fibre optics will alter present approaches significantly, by the use of wide band dedicated drops to each subscriber in a context similar to that of present switched telephone networks.

A number of interesting possibilities exist for uni-directional services that can be readily adapted on present cable systems. Examples are two-channel audio and single-frame distribution. These services are "piggy-backed" on the existing TV signal using the redundant parts such as the blanks in the vertical and horizontal time intervals. The most effective way of using the TV signal for this purpose needs to be resolved.

There is also a rising demand for large TV screen displays with high resolution or different aspect ratio. Such a service requires band-width in excess of the standard 6 MHz broadcast channel. High economic investment in reception and transmission facilities is a major deterrent to the immediate availability of high resolution TV. There is the possibility of providing such a service by means of a dedicated wide-band access to the subscriber's premises via present coaxial cable facilities. Development of a suitable TV receiver may take considerable time due to lack of standardized design requirements.

Two alternatives have been identified:

a) Integration of cable with existing telephone switched network. If this were adopted, there might be a possiblity of overloading or "blocking" which would interfere with the operation of the telephone system for regular voice/data services. This is an area where further research is needed.

b) Exclusive, dedicated use of the coaxial cable television network for such services. If this is adopted, then the additional capability must be built into the coaxial cable system. In any event this will probably be limited in practice to "data or digital response" only. Further study is required before deciding on a particular solution that would reflect all requirements.

1.5 NEED FOR INTERFACING UNITS

The television system has grown to its present near-universal scope in Canada by providing amusement and information from within its own resources, so far as TV receiver owners were concerned. Users have not required extra gadgets to provide their own programs, by means of the sorts of attachments which are beginning to appear now. It is likely that the great majority of TV users will continue to want studio-originated programs for the most part. It seems unreasonable at this time that the receiver should be required to accept the wide range of attachments possible in the future. The TV receiver should not be involved in providing special interfaces. Non-users of attachments should not have to pay extra for built-in interfaces they do not want. Until provision of extra services is standardized, a device built to handle the various signals (having different bandwidths, modulation, amplitude, etc.) should not materialize.

The external interface unit still appears to be the best answer in light of continually evolving systems. Output at RF for older receivers and at baseband video for newer "video terminal" sets appears to be the most logical approach. Output at IF has few advantages and would create interfacing problems. Nevertheless, specific products to interface at IF could be designed.

At the same time, development of receivers with built-in capability for the most popular interface types is an approach that should not be discouraged. If the volume warrants it, this, generally, is a more economic alternative.

Following is a list of possible interfacing units:

	INTERFACE	
UNIT	DESIRABLE	UNDESIRABLE
Pay TV Descrambler	baseband	RF*
TV Games	baseband	RF*
Teletext Type Decoder	baseband	RF*
VTR's and Video Discs	baseband	RF*
Audio Amplifier	baseband	
Fibre Optic TV	baseband	
Satellite TV	baseband	VHF/UHF

*Present prevalent interface.

1.6 TYPES OF INPUTS AND OUTPUTS

Access to the compatible TV receiver should be provided at:

a) The coaxial cable input, at RF;

b) The audio/video baseband input points;

c) The audio/video baseband output points;

d) Picture-display/sound output.

The cable compatible TV receiver should be built to accept the off-air TV signals (i.e. 300 ohms balanced impedance) as well as cable signals delivered via a 75 ohm unbalanced coaxial line. Other inputs and outputs which would be desirable for frame grabbers, video games, video tape recorders or any other similar device, include accessibility at the video baseband and IF stages.

1.7 EXTENT OF REGULATION OF TECHNICAL STANDARDS

The extent of regulation should be limited to "interface standards" that is, regulation of parameters that have a direct bearing on the integrity of the cable system and which, if out of line, could adversely affect picture quality or interfere with other radio services.

Regulation would only be necessary where competitive forces of a free marketplace do not act to produce the best performance. However, in the area of interaction between systems or components of a system, detailed study and understanding of these interactions is required.

For that reason, more stringent self-imposed technical standards, particularly those related to adjacent channel rejection, tuner shielding and local oscillator leakage, should be considered on all new sets manufactured. More emphasis should perhaps be made on providing objective figures and measurement methods.

1.8 CERTIFICATION PROCESS

Adoption of minimum interface parameters with self-certification is recommended, provided the testing is performed in Canada and subject to regular audit by the Department.

1.9 TYPES OF SERVICES

Lists of possible "ancillary services" technically feasible over coaxial cable systems have been widely publicized recently. Attached as Appendix "B" is an extract from the Cable Television Advisory Committee to the FCC

(C-TAC) report detailing the telecommunications services possible over coaxial cable systems.

TV games have become very popular since their introduction to the consumer market several years ago and are anticipated to gain a high market penetration in the next few years. Most present versions of consumer type TV games are interfaced with receivers via an RF switch.

Pay television, teletext and similar services, presently being explored in Canada will likely become more widespread within the next few years. (The teletext service developed by UK broadcasters provides the public up-to-the minute news, weather, stock market index and other types of information. The British Post Office has developed a teletext service called "Viewdata" which delivers a signal to subscribers' TV receivers via telephone facilities. France is also at the stage of developing a somewhat similar system named "Antiope.")

Other services, such as telephony, videophone, meter-reading, polling and alarm systems, would require fairly sophisticated, reliable two-way systems which are unlikely to be fully developed and implemented within the same time frame. However, services such as high-quality stereo, quadraphonic music and high resolution TV may be available if they are proven marketable.

1.10 SPECTRUM CONSERVATION

It seems inevitable that conflicts will arise between cable broadcast spectrum and special service allocations.

The existing VHF spectrum for off-air broadcasting is nearly saturated in Canada and the U.S., leaving only UHF channels for future growth. If the rate of growth does not slow down, the UHF spectrum will also be used up soon. The demand for mobile communication in the VHF/UHF band is also increasing rapidly. One solution could be to distribute network programs or even local programs to cable television head ends via satellite, microwave or other means. However, such an approach might not be feasible until cable TV has achieved near 100% penetration. If it does not, another alternative may have to be developed for the public not served by cable.

1.11 RECEIVER COST AND MARKETABILITY

Appendix A indicates the complexity of the question of additional costs for extra inputs to a TV receiver. There are divergent opinions among experts on the subject. However, there is near unanimity that cost estimates for all the proposed standards can only come from the manufacturing industry. Factors that may affect those costs include production volume, import market, development of specialized circuits and modules for the augmented capacity tuners and/or choice of tuners that have mid-band capability, cost differential between the compatible receiver and the standard receiver with a set-top converter, and the portability of set-top converters. The cost of a compatible colour TV receiver might be more acceptable than that of a compatible black and white TV receiver on account of the percentage rather than the dollar increase in the case of the latter. The same might be true for larger or 'full home entertainment' combination (TV-AM/FM stereo record/tape) sets versus the smaller, relatively inexpensive, portable sets.

The marketability of the converter is already well established. That of the compatible TV receiver should in the long run prove to be as good provided it is competitive.

The total subscriber cost of service is the sum of his delivery bills plus the annual cost of terminal equipment. The minimum overall cost could be realized by an increase in delivery of cable distribution cost, with a reduction of terminal cost, or vice-versa. This kind of system cost analysis and optimization is a task yet to be done.

1.12 IMPACT ON INDUSTRY

Canada has achieved the highest cable subscriber penetration among western industrial countries. The need for cable compatible TV receivers is therefore more pressing here than elsewhere. But recent discussions with foreign manufacturers indicate no immediate plans elsewhere to develop and manufacture such a receiver except in Japan.

Domestic production and the resulting employment benefits will depend to a large degree on whether or not technical standards adopted in Canada will be emulated in the U.S.. If they are, there will be little change from the present production situation. If standards were different in Canada, the TV manufacturing industry might stand to benefit.

While the manufacturing industry has not been a subject within the primary mandate of the Working Group, it is noted that the specification and standardization of receivers for compatibility with developments in cable unique to Canada could become more difficult to implement if a Canadian TV receiver manufacturing industry ceased to exist and the market were largely or exclusively supplied by foreign manufacturers.

1.13 USER MOBILITY

There are divergent opinions on whether "subscriber mobility" should be a concern of government. On one hand, there is the opinion that uniform standards are needed to protect the consumer. On the other, is the equally strong opinion that the buyer of a television receiver is smart enough to perceive what he is buying and does not want to be protected, except where his safety is involved. The middle-of-the-road opinion on the subject is that, providing the receiver meets standards laid down by the regulations controlling signal frequency reception, spurious emission and operational safety, and meets industry requirements, the purchaser must thereafter accept the fact that the movability of his set is limited by the availability of suitable services, be they by cable or off-air broadcasting.

From a technical point of view, the only significant obstacle to user mobility would be the matter of channelling plans for augmented capacity cable systems. However, with auxiliary adaptive equipment, the mobility of the largest investment (the video display section) need not be affected, especially if there is a "buy-back policy" for adapters by cable systems. Thus, a combination of a policy to standardize the flexibility of TV terminals and a cable industry policy on add-on devices could take care of the problem of mobility.

1.14 CONSUMER PROTECTION

Measures recommended elsewhere in this report constitute a form of consumer protection. The question is complicated by the fact that it is unlikely that more than one Canadian producer will emerge in the field. This in itself may demand a full, honest and ethical advertising policy.

Compatibility needs to be established early to avoid a future home environment from becoming a clutter of "black boxes" or converters, and to allow mobility across the country.

1.15 RECOMMENDATIONS FOR FURTHER STUDIES

The Working Group recommends further study of the following:

a) The scope and feasibility of modularity and related interface concepts;

b) The advisability of developing a cable-only TV receiver, with flexibility to adapt to various video devices and services;

c) The feasibility of a hybrid VHF/UHF cable distribution system which would permit the use of conventional, VHF/UHF TV receivers.

d) Receiver design requirements related to direct satellite broadcasting.

PART 2

PROPOSED TECHNICAL INTERFACE STANDARDS

The Department requested the Working Group to study and comment on a set of proposed technical interface standards which might be used as the basis for amendments to the General Radio Regulations. In so doing, the Department reserves its prerogative to further amend these standards as it might deem necessary. The proposed standards provided the Working Group with a point of departure for the comments which follow, as well as the generalized system considerations reported in the preceeding part.

2.1 LIMITATIONS OF TECHNICAL REGULATION IN RELATION TO FUTURE REQUIREMENTS

In considering the issues related to the evolution of a cable compatible receiver, the Working Group faced a number of challenging and basic questions concerning the long-term public interest: Can the economy afford a major investment in a more expensive receiver? Would an overall saving be achieved by promoting a simplified receiver, with a compatible cable plant?

The question of total system cost (distribution system plus subscriber terminal equipment) is an important consideration that must be addressed before finalizing standards of performance for any particular piece of equipment that may form part of some interim system. It seems Government has an important role to play in pointing the way to the future.

The proposed technical interface standards, as they appear in Appendix C, may be insufficiently comprehensive to reflect long-term future requirements. Since they could not apply retroactively to presently installed receivers, it would take a few years before these standards would have a beneficial effect on the cable television industry, by which time transmission techniques may have changed sufficiently to require changes in the standards. However, they will have a useful role in promoting compatibility with today's cable systems.

There is a substantial inventory of installed television sets. Replacement turn-over time is in the order of 10 to 15 years. While this differs from the average procurement interval of eight years for new sets (see Appendix D), it is evident that any standards issued now would have a major effect on the installed inventory of television receivers only in the next decade. Considering the trend towards the use of television sets for other purposes than as simple broadcast receivers, and current developments in communications technologies, the cable distribution system will probably have evolved by then to a point where adjustments to these standards will be required. However, there is also the possibility of another scenario, involving a less extensive use of the TV receiver for non-broadcast applications.

Planning must be done to define the interface requirements of our future television receivers and distribution networks, if they are to consist of anything more than the product of a series of short-term solutions. Because of the tremendous amount of money invested, (especially in TV sets by the public) change will have to be evolutionary.

The efforts of this Working Group have therefore been directed toward providing technical guidelines to steer development of television distribution within Canada into the future. It is as important to improve the flexibility of the TV receiver system, so that it can more quickly adapt to future services, as it is to improve cable transmission service now.

Evolution toward a modular television receiver appears necessary. The same consumer might readily replace a $50 module to receive a new cable service but would not spend $700 for a new television set. Systems which will require interfaces with television sets include optical fibre distribution systems, video games, video recording discs, digital television, two-way cable, interaction and eventually higher resolution, flat-screen wall-sized television. Some of these devices are available now.

Cable systems, video games and video tape recorders all presently interface to home television receivers through the VHF tuner. This is unsatisfactory and full of technical problems. VHF tuners are designed as receivers for off-air television transmissions. It is necessary that any new standard include the specification of other interface points. The Working Group feels that serious consideration should be given to the development of a compatible television receiver of a modular type with compatible, regulation-defined, interfaces. A variety of front end modules should be available for different purposes. Some of these might be:

- a 35-channel tuner for cable television use;
- a VHF tuner for off-air use;
- a VHF-UHF tuner for off-air use;
- a special, low noise, high sensitivity VHF/UHF tuner for use in rural locations;
- an input for video recorders and video games;
- a device for interfacing with an optical fibre distribution system.

New technical standards should make possible a future trend to modularity. An interface point should be defined (such as, after the tuner, directly into the IF) and this new input jack properly specified. This would be particularly important for cable-only TV receivers. Other new standards should be generated. But they would be considered as VHF tuner specifications or cable system tuner specifications. A second interface point would be at base-band video, especially for use with video tape recorders and video discs.

There was a suggestion that modularity would tend to reduce the cost of a television set for a consumer, by requiring him to purchase only those modules he requires. At present, a person who wishes to attach to a cable system must buy both a television set with a VHF-UHF tuner and a cable converter if augmented channel service is desired. If television receivers were modular, he would not necessarily need the off-air tuner.

The Working Group recommends a joint government-industry study of the scope and feasibility of the modularity and interface concepts be undertaken.

2.2 COMMENTS ON PROPOSED TECHNICAL STANDARDS

The proposed standards commented upon are found in Appendix C.

2.2.1 Channelling Plans

a) Number of Channels

Receivers shall be tunable, without the need of an outboard device, to cable TV channels specified in Broadcast Procedure 23 Supplement, as well as to standard off-air VHF and UHF channels. The cable channels are the standard VHF TV broadcast channels with offsets, 9 mid-band channels in the 120-174 MHz band and 14 super-band channels in the 216-300 MHz band, for a total of 35 channels.

Two alternative arrangements were proposed for consideration, as follows:

(1) 28 pre-set cable channels, consisting of 12 standard, 9 mid band and 7 super-band channels;

and

70 tunable off-air UHF channels, of which at least 6 shall be pre-set.

The standard 12 VHF pre-set channels shall also be available off-air, while the remaining 7 super-band cable channels shall be tunable by the subscriber.

(2) 35 cable channels, including 12 standard VHF channels which shall also be available off-air;

and

up to 70 off-air UHF channels, with at least 6 channels being pre-set and the remainder being tunable by the subscriber.

b) Cable Channelling Plans

Background

Cable channelling arrangements in Canada commenced with the standard plan adopted by TV and FM broadcast stations on this continent, with logical extensions below and above the high VHF broadcast band to accommodate 9 mid and 14 super-band channels. However, with pressures on cable operators to augment channel capacity, developments which now introduce a degree of complexity in arriving at a standard channelling plan evolved:

(1) Draft Broadcast Procedure 23 Supplement, issued in 1972, recognized the incompatibility of conventional TV sets with cable system augmented channel operation, because of excessive local oscillator levels which could cause interference between neighboring subscribers. High isolation requirements were therefore specified for channels A, B and J to P, although practical means to do so were not then available. Provision was therefore made for a frequency displacement of the super-band channels to provide the equivalent isolation, (in practice, a displacement of 1 MHz is being used by operational systems).

(2) Converters, which could operate with subscriber TV sets and provide the tuning range required to accommodate offsets, were developed.

(3) The Harmonically Related Carrier (HRC) technique was introduced by Maclean Hunter Cable TV Ltd. in its St. Catharines system on an experimental basis. It involved frequency displacements of -1.25 MHz on all standard and supplementary channels except for channels 5 and 6, where the displacement was +0.75 MHz. This channelling plan is based on visual carriers being harmonics of a 6 MHz Master oscillator, using the formula $f_n = 6n$ MHz.

(4) Variants of the HRC technique were developed (SOS, MPC etc.) which had smaller frequency displacements, generally about ±0.25 MHz but not exceeding ±0.5 MHz on standard channels, and extending to -1.25 MHz in the mid band. These techniques permitted expansion of channel capacity without the major capital investment normally needed to replace amplifiers and hold down levels of distortion products. They became particularly attractive to intermediate-sized systems with a small financial base, because they permitted augmented channel service at a moderate cost in head end facilities.

(5) An additional hybrid of the HRC system is the Incremental Coherent Carrier (ICC) technique, where visual carriers are spaced according to the formula fn=6n + 1.25 MHz. The basic plan would result in offsets of 2 MHz for channels 5 and 6. One system using this technique is operational in Canada, with variations introduced by phase-locking some signals to local off-air signals and operating channels 5 and 6 in the unlocked mode and without offset.

(6) During the review with the Ministry of Transport of criteria which would permit the use of cable channels A, B and C without conflict with aeronautical radio communications and navigational aids, a formula was developed which could result in minor offsets of up to 70 KHz from nominal visual carrier frequencies.

Discussion

While these developments have permitted cable systems in large and medium population centres to expand channel capacity at minimum direct cost to the public, there have been some adverse side-effects:

a) The large frequency displacements involved in the HRC technique are not compatible with the tuning range of certain TV receivers, particularly those with AFC, unless suitable converters are used by the subscribers concerned. In the U.S., the practice is for cable operators to provide converters to all subscribers when this technique is introduced.

b) Tuning from +0.75 MHz to -1.25 MHz when switching from channel 5 or 6 to other channels of an HRC system is an inconvience to subscribers. It also inhibits the use of remote control facilities.

c) Direct pickup of strong local station signals is aggravated on HRC systems since there is generally a beat between cable and off-air signals, even without channel conversion.

d) The frequency offsets in the SOS and MPC techniques could result in degraded performance on channel 7 due to the lower adjacent channel trap for channel I being off-frequency. The same could occur to a larger number of channels in the case of the pivoted HRC system.

e) The SOS or MPC technique does not permit full benefit to be derived from harmonic relationships between carriers, since a number of second and third order intermodulation products will fall within the passband of some channels.

f) The variety of channelling arrangements across the country make it difficult for manufacturers to develop TV set tuning systems with marketable advantages to the consumer (e.g. AFC, remote controls, digital frequency synthesizers).

g) The proliferation of various plans will make it more difficult to introduce a uniform plan across the country, with its attendant benefits to industry and the public.

The HRC and ICC plans would provide maximum benefit and reflect the greatest compatibility between cable systems and off-air stations if broadcast stations likewise adopted a harmonically related frequency plan, locked to frequency standards with atomic (rubidium) stability and accuracy. This would result in optimum co-channel protection between broadcast stations as well as on cable systems, and in addition would provide the equivalent of phase-locking to prevent beat type interference to cable reception due to direct receiver pickup.

The HRC plan would have been one of the best for cable systems, if it had been introduced in about 1950, when the North American continent was just starting to implement a TV broadcast service. It would have resulted in significant benefits for broadcasting, which recognized the advantages of precise offsets to reduce co-channel interference even at that time. However, with a different broadcast plan having been adopted, the HRC plan is not sufficiently compatible with the large inventory of installed TV sets in the country.

The ICC plan thus appears to be the best compromise for cable systems, being basically similar to the present broadcast plan, except for channels 5 and 6. It would permit the maximum expansion of channel capacity on cable with a resultant addition of only a relatively small number of intermodulation products that could limit the number of system amplifiers in cascade. By leaving channels 5 and 6 incoherent, or unlocked to the other channels, the 2 MHz frequency displacement is avoided, while additional distortion products fall on relatively insensitive portions of the receiver pass-band and do not significantly degrade the performance of the cable TV system. In addition, the cable channels and corresponding off-air channels could be phase-locked, thus avoiding the beat type interference due to direct pickup. This modified ICC technique, in conjunction with the use of push-pull amplifiers, is presently used by the Videotron Cable system, south of Montreal, with very encouraging results.

If off-air broadcast stations should also decide to adopt an identical harmonically related frequency plan, phase-locking of the cable channels to strong off-air channels would no longer be required.

While the channelling arrangements being followed by systems in Canada have offsets of up to 0.5 MHz on standard channels and up to 1.25 MHz on supplementary channels, an acceptable degree of compatibility has been reached between receivers and cable systems through the use of set-top converters. Use of channels J to P in the super-band and A and B in the midband has been held back somewhat by the need for high isolation from local oscillators of conventional TV sets. Displacement of 1 MHz in the super-band, as permitted by BP 23 Draft Supplement, has prevented interference to the colour sub-carrier on these channels, while recent availability of a special filter for the affected mid and super band channels will permit their use without offsets.

The use of a cable-only receiver, with double conversion circuitry as used in set-top converters, would also be fully compatible with system operational requirements. However, cable compatible receivers with conventional circuitry would place high level oscillator signals on channels A, B, H, and I in the mid-band, 7 to 13 in the standard band and all super-band channels. The tuner industry claims that sets with less than -20 dBmV of local oscillator signal level are beyond the present state of the art. Their introduction would not be compatible with the operational constraints of augmented channel systems. The only effective cure appears to involve the use of a complementary set-top converter.

The schedule for adoption of any particular standard plan would thus be dependent upon the time frame needed to develop and introduce, on an adequate scale, compatible receivers (along with converters) with oscillator levels below -31 dBmV in the channels concerned. During the interim period, all plans would suffer from various operational constraints except in systems with high converter penetration. The use of a cable-compatible receiver with double conversion circuitry would permit a standard plan to be adopted at an earlier stage.

Conclusions

Since a cable compatible receiver requires a compatible cable channelling plan, the Department should closely examine all plans now in operation. It appears some techniques may play a very essential but interim role, and could be eventually phased out as system equipment is modernized and TV receivers become more fully compatible with cable operational requirements. A long-term plan should, however, be selected as a guideline for the cable and manufacturing industries concerned.

A majority of the Working Group members recommend that the Department adopt the frequency plan integral to the Incremental Coherent Carrier technique (without offsetting channels 5 and 6) as the standard channelling plan, and develop an implementation strategy for it.

2.2.2. Direct Pickup

The draft DOC standard proposes that "there shall be no subjective evidence of direct pickup by the receiver from ambient co-channel synchronous signals measuring 100 mV/m, when the desired cable signal level at the receiver input terminals is 0 dBmV."

There are a number of problems related to this parameter, including the following:

a) The proposed subjective evaluation of direct pickup would need to be supplemented by a suitable test procedure, to be used for design and quality control purposes.

b) The subjective requirement that there should be no evidence of direct pickup is equivalent to a protection ratio of 40 dB in a synchronous field, for an induced input signal at the antenna terminals of 10 microvolts. With the present state of the art, this can only be achieved with transformer type power input circuits. While transformerless receivers may conceivably be provided with equivalent shielding by means of a feed-thru capacitor coupling the power line to the chassis, there is some question about the voltage rating and magnitude of leakage current which may constitute a safety hazard. It is doubtful, therefore, whether such sets can be made fully cable compatible.

c) There is no assurance that carrier synchronism between the cable channel and the "off-air" channel will always be possible. A specification related to a non-synchronous signal for which there would be no subjective evidence of direct pickup would need to be about 17 dB more stringent, and would represent an equivalent input voltage of 1.4 microvolts picked up in a field of 100 mV/m. This would no doubt involve major redesign and much higher production costs, since it is beyond the present state of the art as claimed by tuner manufacturers.

In view of these considerations, the subjective standard related to synchronous signals seems a reasonable interim approach, which can be qualified by an objective test procedure at a later date.

2.2.3 Spurious Response

For compatibility with current cable systems, the compatible TV receiver should meet the following requirements:

a) Local Oscillator and/or Spurious signals at Antenna Terminals

Frequency Range	Maximum Voltage Level
5 to 54 MHz.	-50 dBmV
54 to 300 MHz	-31 dBmV*
300 to 1,000 MHz	-10 dBmV

* As an interim requirement, pending the development of appropriate technology, a level of -26 dBmV would be acceptable. However, the need for such limitation requires further study. Indications are that the tuner industry may be unable to provide a tuner with a local oscillator level lower than -20 dBmV, using conventional circuitry.

b) Spurious Response to Input Signals at Antenna Terminals or to Ambient RF Fields

Appropriate limits have not yet been given adequate study.

The Working Group recommends that spurious response to CB, Amateur and other out-of-band radio signals be thoroughly investigated and appropriate limits established.

2.2.4 Fine Tuning Range

The customer-adjustable tuning range to be selected requires further review, because it is related to other questions.

Pending adoption of a final channelling plan, and to be compatible with existing approved operations, the tuning range would need to be ± 0.5 MHz on standard channels and -1.25 MHz on supplementary cable channels.

The modified ICC channelling plan, with channels 5 and 6 being distributed in a non-coherent mode, appears to provide most of the advantages of a coherent carrier system, without the complexity that would be introduced by having channels 5 and 6 coherent and offset by +2 MHz. The Department should also follow closely any developments in the U.S., where the FCC is inviting comments on the basic ICC plan with the 2 MHz offset for channels 5 and 6. However, since such a plan would also require a substantial change in the TV and FM broadcast allocation plans in relation to channels 5, 6 and the lower portion of the FM band, it is very unlikely it will be adopted.

2.2.5 Input Impedance

The input terminal for the cable mode shall have an unbalanced shielded coaxial connector of 75 ohms impedance and a return loss of at least 6 dB. For the off-air mode, the input impedance shall be either 75 ohms unbalanced or 300 ohms balanced, at the discretion of the manufacturer. In either case, any required impedance transformation can be accomplished externally with a matching transformer.

2.2.6 Signal Levels

The TV receiver shall provide a picture (blanking to reference white) signal to unweighted noise ratio of at least 36 dB when the essentially noise-free RF input signal level is -3 dBmV or more. In the cable mode, the receiver shall be able to accept a maximum input signal level of 14 dBmV without overloading.

2.2.7 Image Rejection

The proposed standard of 60 dB rejection for all image frequencies below 300 MHz seems adequate, but must be reconciled with the state of the art. A four-stage circuit tuner can achieve this performance, but the three-stage circuit tuners used in portable line-connected chassis sets may not.

2.2.8 Adjacent Channel Rejection

Consideration should be given to the development of an objective specification for this parameter, or of subjective test methods to be used with a subjective standard. Appropriate limits and test procedures should be the subject of further studies. The extent of adjacent channel degradation on channel 7 from channel I in SOS and MPC type augmented channel systems should also be investigated.

2.3 RECOMMENDATIONS FOR FURTHER STUDIES

In view of the current state of the art, as indicated by TV tuner manufacturers, it is recommended that further study of local oscillator signal levels that would be compatible with cable TV system operational requirements be made.

In addition, spurious response to Citizens Band, amateur and other out-of-band radio signals should be investigated and appropriate limits established.

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COST ESTIMATES

Cable Compatible TV Receivers

Prepared by: G.F. Cummer

1. Conventional 20" Color Set - Table Model

- UHF & VHF tuners
- meets all current DOC requirements
- estimated retail $600

	%	Retail
Tuner package	4.5	$ 27
IF/AFT	4.3	26
Video/chroma/sound	15.7	94
Deflection/c.r.t	45.2	271
Chassis/Power supply	18.6	112
Cabinet	11.7	70
	100%	$ 600

2. Cable-Ready Version of Above (Existing Design)

- 12VHF, 18 cable, 3 pre-set UHF channels
- not remote
- off air or cable

Cost premium: $50-75 at retail

3. Converter-Equipped Version of #1

- 12VHF, 23 cable, all UHF channels
- wired remote
- off-air by changing antenna connections

Cost premium: average $85 at retail

4. Cable Only Version of #1

- 12 VHF, 23 cable, no UHF (except on cable)
- no off-air capability
- wired remote
- would meet proposed LO standards

Cost premium: estimate $65-85 at retail

cont'd ....

5. Cable Compatible Version of #1

- 12VHF, 18-23 cable, all UHF
- not remote
- off-air or cable
- would meet proposed DOC standard (this is subject to design confirmation)

Cost premium: estimate $85-110 at retail

Notes:

Costs are estimates of premium at retail that must be asked in order to cover the additional material costs and amortize the engineering and tooling required. The premiums in items 4 and 5 in particular are subject to change, since no design work on these options has been carried out as yet.

EXTRACT FROM THE CABLE TELEVISION TECHNICAL ADVISORY COMMITTEE

REPORT TO THE FEDERAL COMMUNICATIONS COMMISSION

VOL. II, BASIC REPORT PART 3, PANELS 8-9 AD HOC

MAY 1975

SECTION IV

TELECOMMUNICATION SERVICES

4.0 INTRODUCTION

When telecommunication services which will make use of Class III and Class IV channels are discussed, one hears phrases such as "newspaper by wire," "voting and shopping from the home," "computer-to computer data exchange," and "utility meter reading". The list seems endless. To present such listings in a logical fashion, the major technical parameters that describe the services are utilized to form the basis of classification. The parameters are: (1) information type (image, audio, data); (2) distribution method (broadcast, point-to-point, multipoint-to-point or polling); and (3) transmission rate (bandwidth or bit rate).

This section addresses the classification of services in terms of information types and distribution methods. The transmission constraints are considered in Section V.

4.1 Information Types

The three (3) types of telecommunications signals used in this classification process are: image, audio, and data. These signals are determined by the information source and the devices available at the source and the ultimate reception point.

4.1.1 Image Information Type

Image signals are generally subjectively interpreted by the human eye. In some cases, the reception point may consist of electronic character or pattern recognition devices interconnected with data processors. As a general case, image signals are generated by a line scanning process and can be transmitted in either an analog or digital form. Class III and Class IV channels would provide the capability to carry such information types as:

1. Bilevel Facsimile
2. Slow-Scan Television
3. High Speed Facsimile
4. Studio-Quality Television
5. High Resolution Television
6. Three-Dimensional Television

4.1.2 Audio Information Type

The audio signals generally are also subjectively interpreted. However, in this case, the reception point is the human ear. The era of data processors capable of responding to voice inputs in some years distant.

Common examples of audio information signals are those generated by the human vocal system and musical instruments, and can be listed as:

1. Tone
2. Intelligible Speech
3. AM Station Music
4. Stereo Music
5. Quadrophonic Music

These also can be transmitted in either a digital or analog fashion on the Class III and Class IV channels.

4.1.3 Data Information Type

Data signals are continuous or discrete waveforms that are objectively and exactly interpreted. They include bilevels (which describe on/off or open/closed events), sensor outputs with a time base and one-dimensional amplitude (such as electrocardiograms or temperatures), and alphanumeric symbols such as might be generated by a teletypewriter. Some examples of data information types to be handled by Class III and Class IV channels include:

1. Alarm Bilevel
2. Sensors
3. Teletype
4. Computer-to-Computer
5. Electrocardiogram

4.2 Distribution Method

As a general case--and dependent on the physical configuration of the CATV system--all of the above information types may be subjected to three (3) basic modes of distribution: Broadcast (Point-to-Multipoint); Point-to-Point; and Multipoint-to-Point (gathered or polling).

4.2.1 Broadcast Distribution

Real-time broadcast is the widespread transmission of a signal where a large number of receivers simultaneously receive the information. In store-and-forward distribution, one receiving station at a time is accessed and each sequentially has the opportunity to receive the same message.

4.2.1.1 Real-Time Broadcast. The information services provided by a real-time broadcast distribution mode may be comprised of a single information type or a combination of all three, i.e., television (image), with accompanying sound (audio) and information (data) during the vertical interlace period. Some examples of realtime broadcast information services that are contemplated to be carried over Class III and Class IV channels include:

1. Newspapers and General News Services
2. Mass Mail and Advertising
3. Background Music
4. Educational and Professional Lectures
5. Special Television Programs (Pay TV)
6. Special-Purpose Communications (i.e., Energize Sensors and Signals for Traffic Control)
7. Information for Limited Audience (i.e., Professional, Business, etc.)

4.2.1.2 Store-and-Forward Broadcast. The store-and-forward broadcast distribution mode also may involve information services of a single type or a combination of all three (3). Examples of store-and-forward broadcast information services that are expected to be carried over Class III and Class IV channels are:

1. Computer-Aided Instruction (Frame-by-Frame Television)
2. Special News Services (Stock Market Reports)
3. Library Services
4. Special-Purpose Data Telecommunications (Business and Government)

4.2.2 Point-to-Point Distribution

The Class III and Class IV channels are expected to carry information that is distributed in point-to-point mode. This mode may be further classified according to the direction of information flow. Unidirectional is the case where information (with or without return control signals) always flows one way. Services which are simplex or half-duplex in nature are those that are restricted by the transmitters or receivers from transmitting and receiving at the same time. This restriction may be due to operational practices (conversational information) or to the capabilities of the terminal equipments (simple teletypewriters). Full-duplex distribution is provided when information flows in both directions at once. Computers are generally interconnected in this fashion. Digital voice systems must be full-duplex. Even if information is not being passed simultaneously, synchronization signals are. If an equal rate of information is expected to flow both ways, the distribution mode is symmetrical; if unequal rates are expected, the distribution mode is asymmetrical. Asymmetrical services generally are of the type where manually generated alphanumeric symbols are sent from a telecommunications user to a data base such as a computer complex. The data base then responds with high-speed data, audio or image signals.

4.2.2.1 Unidirectional Point-to-Point. The unidirectional point-to-point distribution mode involves the three (3) information types, either singly or in combination and may be distributed in either a real-time or a store-and-forward mode.

4.2.2.1.1 Real-Time Unidirectional. Some examples of real-time unidirectional point-to-point distribution of information are:

1. Bilevel Alarms
2. Point-of-Sale Services
3. Electrocardiograph
4. Remote Audio Pickup
5. Surveillance
6. Announcement Services (Routine and Emergency)
7. Studio-to-Transmitter Television
8. Traffic Signal Controls
9. Health Care Delivery

4.2.2.1.2 Store-and-Forward Unidirectional. The store-and-forward unidirectional point-to-point distribution information services include:

1. Facsimile Mail
2. Message Recording (Audio and Frame Stoppers)

4.2.2.2 Symmetrical Point-to-Point. The information services that are candidates for carriage over Class III and Class IV channels in a symmetrical point-to-point distribution mode may involve either a half-duplex or a full-duplex transmission capability. The services can be of any of the three (3) information types or a mixture thereof--and the terminal equipments are not only compatible in a capacity but also in an operational sense.

4.2.2.2.1 Half-Duplex Symmetrical Point-to-Point. Examples of services that are in this category are:

1. Computer Time Share Services
2. Telephony
3. Teletype Networks
4. Credit Card Verification

4.2.2.2.2 Full-Duplex Symmetrical Point-to-Point. Full-duplex information transfer is dependent on the capabilities of the terminal equipments. These terminals are so configured to separate the flow of the incoming information from the information flow being transmitted. Hence, some information storage device, analog or digital, is a part of the terminal configuration. Some of the information services that would use a full-duplex symmetrical point-to-point distribution mode are:

1. Computer-to-Computer
2. Secure Telephony
3. Video Telephone

4.2.2.3 Asymmetrical Point-to-Point. The asymmetrical point-to-point distribution mode involves information transfer that is composed either of a mixture of the three information types or of only a single one. The information transfer may be effected either in a full-duplex or a half-duplex fashion. The terminal equipments employed in this mode of information transfer need to be technically compatible. Their capability and operational characteristics generally are quite dissimilar.

4.2.2.3.1 Full-Duplex Asymmetrical. As described above, full-duplex operation can be achieved if the terminals are properly configured. Some services in this category that are expected to be carried by Class III and Class IV channels are:

1. Computer-Assisted Instruction
2. Information Retrieval (Data Bank Access)
3. Remote Control (Manufacturing Processes)

4.2.2.3.2 Half-Duplex Asymmetrical. In those situations where half-duplex asymmetrical point-to-point information transfer is to occur, at least one of the terminals is constrained from receiving while transmitting.

Some examples of the services in this category are:

1. Interactive Computer-Assisted Instruction
2. Computer Time Share Services
3. Library and Catalog Information Services
4. Shopping Services
5. General and Special Information Services (Response to Queries)

4.2.3 Multipoint-to-Point Distribution

The services that utilize the multipoint-to-point distribution mode are those where the information received from any one transmitter is to be treated like information from all the other transmitters. The multipoint-to-point information transfer can be initiated by a query from the "point" (either in a broadcast mode or in a "polling" fashion), or be initiated by a "multipoint" station (alarm). The multipoint-to-point distribution mode involves the three (3) information types, either singly or in combination, and may be operating in a real-time or a store-and-forward mode. In a multipoint-to-point distribution mode, the capabilities of the "point" station generally are quite extensive and include some type of data processing or handling facility. For certain services, information storage devices (image, audio, data) are part of the "point" station equipment complement.

4.2.3.1 Real-Time Multipoint-to-Point Distribution. In a general case, the multipoint stations are assigned transmission capacity or energized simultaneously regardless of whether information is being generated or not. Examples of information services in this category include:

1. Multi-Sensor Alarm Systems
2. Pollution Monitors
3. Traffic Control Monitors

4.2.3.2 Store-and-Forward Multipoint-to-Point. The store-and-forward multipoint-to-point distribution mode is characterized by the fact that one "point" is transmitting at a time. Depending on the service, the "multipoint" stations may have some storage capability. (i.e., shaft position or counter of a utility-meter). Services of this type include:

1. Voting
2. Transponders (Subscriber Response Systems)
3. Polling
4. Surveillance
5. Traffic Flow Monitors
6. Utility Meter Reading

APPENDIX "C"
November 5, 1976

PROPOSED

TECHNICAL STANDARDS FOR CABLE COMPATIBLE TV RECEIVERS

Technical Characteristics

1. Channelling Plans [1]: Receivers shall be tunable to Cable TV channels specified in Broadcast Procedure 23, Supplement, as well as to standard off-air VHF and UHF channels. The cable channels are the standard VHF TV channels with offsets, 9 mid-band channels in the 120-174 MHz band and 14 superband channels in the 216-300 MHz band for a total of 35 Cable TV channels.
2. Direct Pick-up (Shielding): There shall be no subjective evidence of direct pick-up by the receiver from ambient co-channel synchronous TV signals measuring 100 mV/m, when the desired cable signal level at the receiver input terminal is 0 dBmV.
3. Spurious Response: The TV local oscillator voltages and other interference signals at the receiver cable input terminals shall not exceed the following voltage levels:

Frequency Range	Voltage Level
up to 54 MHz	-60 dBmV
54 - 300 MHz	-37 dBmV
300 - 1000 MHz	-10 dBmV

4. Fine Tuning Range: All receivers shall be adjustable over a frequency range of not less than ±1.25 MHz from the nominal visual carrier frequencies.
5. Input Impedance: The input terminal for the cable mode shall have an unbalanced shielded coaxial connector of 75 ohm impedance with a return loss of at least 8 dB; for the off-air mode the input impedance shall be 300 ohms balanced.
6. Signal Levels: The TV receiver shall provide a picture (baseband) signal-to-noise ratio of 36 dB for an input signal of 700 microvolts or more. In the cable mode, the maximum input signal level without overloading shall be at least 14 dBmV.

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7. Image Rejection: The image rejection for the cable mode shall be at least 60 dB for all image frequencies below 300 MHz.
8. Adjacent Channel Rejection: The adjacent channel rejection shall be such that there is no evidence of picture degradation when the receiver is properly tuned to any cable channel in the presence of carriers on the higher and lower adjacent cable channels whose frequencies and amplitudes are within the standards established by the Department.

[1]Note:

A new channelling plan for cable television that offers improved performance is the Incremental Coherent Carrier (ICC) plan. The ICC plan places all visual carriers 1.25 MHz above exact multiples of 6 MHz (6 N + 1.25) thus drastically reducing third order intermodulation distortions inherent in a cable system with augmented channel capacity. This plan, except for channels 5 and 6, is compatible with off-air broadcast frequencies and existing TV receivers. In utilizing this plan channels 5 and 6 would not be carried on the cable system or could perhaps be used in a non-locked mode.

It should be noted that although a fixed channelling plan such as the ICC offers many advantages, full benefits can only be derived if a number of current operational problems are adequately taken into account. Some of these are:

1. Many cable television systems are using single-ended amplifiers which result in significant levels of second order intermodulation products. The ICC plan reduces only third order, not second order distortion products. While the use of push-pull amplifiers alleviates this problem, it will be some time before all cable systems make the conversion to improved equipment.
2. The ICC plan does not contribute to a solution of the subscriber isolation problem on certain mid-band and super-band cable channels. The problem can be resolved by also establishing standards for

... 3

conventional TV receivers limiting the local oscillator voltages leaking into the cable system. Offsets of 1 MHz in the super-band are presently used by some systems to achieve enough protection from the local oscillator voltages of TV receivers. Other solutions include the use of special trap filters and improved tap isolation.

3. Those cable channels which correspond to local TV stations are restricted on cable television systems due to direct pick-up problems, which take the form of a video beat due to the frequency difference between the cable and off-air signals or of a ghost due to the time difference in the arrival of the cable and off-air signals at the receiver. This problem would largely be resolved in the long run by also establishing standards limiting direct pick-up by conventional TV receivers. The proposed direct pick-up standard would require that phase locking be used to eliminate the beat problem when strong off-air signals are available. The ICC plan offers limited phase locking capability. Another solution would be to require all VHF broadcast transmitters to be locked to a highly stable frequency reference eliminating the present offsets of $\pm$ 10 kHz in off-air co-channel assignments.

It is therefore proposed that until such time as the pertinent problem areas are fully investigated and action taken to resolve them, the ICC frequency channelling be considered to be only a long-term objective.

In the meantime, the Department will continue to allow cable systems to offset cable frequencies up to 500 kHz on the standard VHF channels. This allows:

i) the continued use of single ended equipment;
ii) phase locking to a maximum of three off-air channels;
iii) compatibility with the tuning capability of conventional TV receivers.

The technique used in achieving this is sometimes referred to as Synchronized Oscillator System (S.O.S.) or Multi Pivoted Coherent (M.P.C.). In the mid and super-band, the Department proposes to allow a maximum offset of 1.25 MHz which is needed to accommodate the mid-band displacements caused by the S.O.S. or M.P.C. technique and the displacement of 1 MHz used in the super-band to achieve the required subscriber isolation.

Industry Statistics for Compatible Receiver Working Group

1. TV Receivers - Existing Investment

Source: Stats Canada 64-202, May 1976

Using a conservative estimate that households "with two or more receivers" have only 2 receivers on the average, the following figures are obtained:

Colour Sets	3940 + (2 x 253)	=	4500 K units
B & W	3745 + (2 x 573)	=	4900 K units

At an assumed average price of $500 per colour set and $250 per B & W set, the consumer investment would be:

Colour Sets	4500 K x $500	=	$2.250 billion
B & W	4900 K x $250	=	1.225
			$3.475 billion

or in the order of $3½ to $4 billion.

1976	Total Number of Households	6918 K
	Households with TV Receivers	6684 K, or 96.6% of total

APPENDIX "D"

2. CATV Penetration

Year	Total Number of Subscribers (000)	Households Passed by Cable (000)	Canadian Households: Urban* (000)	Canadian Households: Total (000)	% Cable Penetration: House holds Passed	% Cable Penetration: Urban House-holds	% Cable Penetration: Total Canadian Households
1967	516	1225	4030	5262	42.1	12.8	9.8
68	710	1607	4160	5394	44.2	17.1	13.2
69	924	1700	4280	5514	54.4	21.6	16.8
70	1164	2392	4400	5646	48.7	26.5	20.6
71	1398	2681	4540	5779	52.1	30.8	24.2
72	1689	3313	4820	6108	51.0	35.0	27.7
73	2116	3715	4980	6266	57.0	42.5	33.8
74	2555	4017	5190	6493	63.6	49.2	39.4
75	2869	4318	5390	6703	66.4	53.2	42.8

In 1975, cable was available to $\frac{4318}{5390}$ = 80% of urban households.

* Urban households are estimated from the ratio of urban to total households in the 1966 and 1971 census. (Source: Canada Year Book 1975, p. 170.) These ratios were 76.1% in 1966 and 78.5% in 1971; the ratio for the years 1967-70 and 1972-75 was obtained by linear projection. The total number of households shown above was obtained from Stats Canada 64-202, and is about 5% less than the census because of differences in coverage. (Households in the Yukon and Northwest Territories, logging, construction and military camps, hotels, trailers and clubs, etc. are excluded.)

3. CATV Revenues

Year	Total Number of Subscribers (000)	Total Number of Systems	Operating Revenues ($M)
1967	516	314	22.1
68	710	377	31.3
69	924	400	37.4
70	1164	314	54.9
71	1398	326	66.6
72	1689	344	82.5
73	2116	362	107.0
74	2555	342	133.7
75	2869	359	162.6

4. CATV Assets

Year	Number of Subscribers (000)	Number of Systems	Net Fixed Assets ($ M)	Total Assets ($ M)	% Total Subscribers
1967	516	314	34.1	54.1	100
68	710	377	48.9	74.4	100
69	924	400	71.7	102.4	100
70	1164	314	87.9	132.6	100
71	1398	326	103.5	163.5	100
*	*	*	*	*	*
72	1620	194	121.6	182.4	95.9
73	2063	225	150.2	225.7	97.5
74	2503	200	176.4	264.5	98.0
75	2818	217	203.1	317.9	98.3

* Due to a change in reporting, assets for 1972-75 are available only for CATV systems with more than 1000 subscribers. These systems constitute the bulk of all CATV subscribers.

Source: Items No. 2,3 and 4
Stats Canada 56-205
Item No. 5
A.R. Kaye, DOC

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5. The Canadian Market for Television Receivers

The average interval between the purchase of new television receivers by a household may be deduced by the method described in the following example. In 1971 the number of households was 5,779,000, increasing by 329,000 to 6,108,000 in 1972. The total sales of receivers in 1972 was 1,460,000. If we assume that 329,000 of these were for the new households, then the total sales to the households already having a receiver was 1,131,000. Thus the implied purchase cycle is 5.1 years. This figure has varied over the years as shown in the table.

Year	Households (000)	Increase from Previous Year (000)	Total Sales (000)	Derived Replacement Sales (000)	Implied Purchase Cycle, Years
64	4757	-	560	-	-
65	4853	96	620	524	9.1
66	4938	85	643	558	8.7
67	5034	96	722	626	7.9
68	5262	228	809	581	8.7
69	5514	252	905	653	8.0
70	5646	132	888	756	7.3
71	5779	133	1050	927	6.1
72	6108	329	1460	1131	5.1
73	6266	158	1458	1300	4.7
74	6493	227	1415	1188	5.3
75	6703	210	1038	828	7.8

From the table, we may observe that, during the years when colour receivers were rapidly penetrating the market, the implied purchase cycle was about 5 years. In earlier years it was about 8.5 years and there is some indication from the 1975 figure that it may now be returning towards the earlier figure.

Based on the 1973 sales of 1,038,000 receivers and assuming an average price of, say, $500, the annual market is about $500,000,000. The total sunk cost in receivers is now of the order of $4 billion and it is turned over roughly every 8 years.