COST ANALYSIS OF ALTERNATIVE ARRANGEMENTS FOR THE DELIVERY OF DBS SIGNALS
(DSS file: 21ST.36100-1-0287)

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TAMEC INC.

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Government of Canada
Department of Communications

Gouvernement du Canada
Ministère des Communications

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DEPARTMENT OF COMMUNICATIONS - OTTAWA - CANADA

SPACE PROGRAM

TITLE: COST ANALYSIS OF ALTERNATIVE ARRANGEMENTS FOR THE DELIVERY OF DBS SIGNALS

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EXECUTIVE SUMMARY

1. Objective

The study's objective is to compare the capital and operating costs of alternative methods of delivering extended television and radio service to all of the population of Canada, using DBS as a basic technology. Of specific interest is the power at which DBS will operate and the impact this power level will have on ground segment costs for two categories of potential DBS subscribers:

- individual households that will be equipped with a direct to home terminal (DTH subscribers)

- small communities that could be serviced by a "low cost" passive cable system, similar in design to MATV systems in large apartment buildings; subscribers in such communities have been designated as "Indirect Passive Cable" (IPC) subscribers.

The problem adressed in the present study can thus be summarized as follows:

<u>If Canada launches more powerful satellites, will the resulting increase in space segment costs be matched by a corresponding decrease in ground segment costs?</u>

2. Approach

The approach as well as the data used in the present study are presented in detail in chapters 2, 3 and 4. Essentially we have used available reports and other sources, and in consultation with the Scientific Authority have developed models of possible DBS configurations. The most significant variables addressed in the present study are:

- Space segment

  Power level: 53 dBW requiring the use of a 1,2 m antenna for individual reception or 58 dBW requiring the use of a 0,8m antenna

  Number of beams: 4 or 6

  Number of channels: 8 or 16 per beam

- Ground segment

  - A "low cost" passive cable system, similar in design to MATV systems in large apartment buildings, was used as a concept to serve clustered households (less than 500 feet apart from one another) in rural areas. The subscribers served by such a distribution mode were labelled IPC (Indirect passive cable) subscribers.

- non clustered households in rural areas as well as individual households in urban areas (not subscribing to cable) would be served by the DTH (direct to home) mode;

- other distribution models were also considered but were not submitted to further analysis for the following reasons:

a) Conventionnal cable: the power level has little or no impact on costs.

b) Rebroadcasting: the spectrum puts an absolute limit of 8 channels even in the UHF mode.

c) Direct passive cable where the antenna and low noise amplifier are shared by many subscribers equipped individually with receivers and decoders (DPC or direct passive cable model); this DPC model was eliminated because of similarities with other models and because of institutionnal constraints (who owns the common unit, wiring problems, etc).

d) Very high capacity microwave (VHCM) used in conjonction with cable systems was also eliminated because of the general nature of the present study.

The data and assumptions used were incorporated in a simulation model that performs the calculation of annual expenditures (capital and operating costs) associated with any system configuration. Sensitivity analysis was also use to evaluate the impact of charges in key assumptions.

3. RESULTS

Results have shown that the use of 58 dBW satellites would reduce the net present value of distribution costs by $ 219 million. On the other hand the use of 58 dBW satellites (instead of 53 dBW) under the 4 beam model, would increase the NPV of space segment costs by $ 200 million; since this increase is less than the ground segments savings, we can thus conclude than the more powerful 58 dBW satellites are cost effective.

The most significant assumptions that could affect the results are the following:

- Negative factors (that would tend to reverse the conclusions)

1- The price difference between a 1,2 m station (which is required at 53 dBW) and a 0,8 m station (58 dBW) was estimated to be $ 375; this would be caused by higher antenna costs and as well higher cost for transportation, installation and mounting. If this price difference was to be smaller this would have a negative impact on the savings generated by 58 dBW satellites.

2- The "urban" market generates a significant portion of the direct to home market; this would include not only households that are not passed by cable but as well households that are passed, but do not subscribe for one reason or another. The ability of the cable industry to offer DBS services on a tiered basis would have a negative impact on the number of urban households equipped with a DTH terminal and consequently on the savings generated by 58 dBW satellites. Only a market survey can provide adequate answers to this problem; the survey should attempt to measure not only the attractiveness of the DTH terminal per se, but the impact of a cable industry that would be in a position to offer all DBS services at very competitive rates, as well as services that a DBS system will not be able to offer.

- Positive factors (that would tend to reinforce the conclusions)

1- The low cost passive cable system concept used extensively in this project presents in our opinion a viable alternative to direct reception in many parts of rural Canada.
On the other hand if capital and operating costs associated with such systems are higher than forecasted and/or if direct reception is judged to be more attractive (for one reason or another), this would result in an increase in the numbers of DTH terminals in rural Canada which would in turn increase the attractiveness of 58 dBW satellites.

2- The data used to project the number of DTH and passive cable subscribers was derived from data pertaining to the historical penetration of colour TV sets in Canadian households, and the data was used for urban as well as for rural households. Recent studies, but pertaining to to the rural market only, have indicated that the acceptance of DTH terminals could be much higher than the figures that were used. On the other hand there are many reasons to use a conservative approach in forecasting the acceptance of DTH terminals , and especially so during the 1983-1988 period when an interim DBS (Anik C) will be in operation, such as:

- the expected terminal price of $600 to $800 will not be reached for several years;

- the antenna required will be larger than the one associated with a true DBS;

- the services offered on Anik C, at least in the early stages, will involve either additional charges (Pay TV) or will be of a specialized nature (TV Ontario, La Sette);

- the number of services offered could vary significantly from one beam (region) to another.

In any event, and because of the discounting process, a more rapid acceptance of DTH terminals would greatly enhance the cost effectiveness of 58 dBW satellites.

Other important results are as follows:

- All of the preceeding conclusions apply to the 4 beam model only. Under the 6 beam model, the space segment "penalty" for more powerful satellites would seem to be higher than was the case under the 4 beam model ($250 million instead of $200 million). This would raise the breakeven number of DTH and IPC subscribers required, in order to make 58 dBW satellistes cost effective.

- In addition, the 6 beam model would substantially increase space segment costs for prospective users that would require multi-region or national coverage.

- Finally the number of channels per beam used as an assumption in this report was either 8 or 16. While the jury is still out on whether 16 channels will be sufficient in the post 1988 period, 8 channels would seem to us a bare minimum.

GLOSSARY

DISTRIBUTION MODELS ANALYZED

DTH : Direct to home reception

DPC : Direct Passive Cable
Similar to DTH but the antenna and LNA are shared by up to 10, close-by neighbours. Each individual household is equipped with a receiver and a descrambler.

IPC : Indirect Passive Cable
A "low cost" cable system similar in design to MATV systems in large apartment buildings. Receiving and modulating functions performed at head end. Descrambling performed optionally at head end or within subscriber premises (see "Economic considerations" section).

IRB : Indirect rebroadcast
VHF or UHF rebroadcast of DBS satellite signals.

ICTV: Indirect conventional cable system
(with a sub-model that includes the use of Very High Capacity Microwave named model IRC).

Three types of distribution technology are used in these models: the passive coaxial cable network for the models DPC and IPC, the rebroadcast transmitter for the model IRB, and the standard CATV network for the model ICTV.

1. INTRODUCTION

1. INTRODUCTION

1.1 Reference

This study has been conducted for the Department of Communications and the Department of Supply and Services, by Tamec Inc., with the Douserv Group Inc. acting as sub-contractors, under contract number OST81-00217. Effective start date of the contract was January 18, 1982.

This study is one of a program of studies undertaken by the DOC in the planning process of a national Direct Broadcasting Satellite system.

1.2 Purpose and scope of the study

The primary objective of this study, as defined in the terms of reference, "is to compare the capital and operating costs of alternative methods of delivering extended television and radio service to all of the population of Canada, using DBS as a basic technology, but recognizing that community antenna systems may be used in a cost effective manner in conjunction with DBS". After the first Anik C (1) is launched in the Fall of 1982, it could be used in what is called an "interim DBS system". A true dedicated DBS system will follow later, in 1987 or 1988, with the launching of more powerful satellites, better suited for direct reception by individual users.

(1) Anik C-3 will be the first satellite launched.

A major unresolved question is that of the power at which DBS will operate taking into account the existing distribution infrastructure (both off air and cable) which provides excellent service to an important segment of the Canadian population and which, by its very nature, does not really require high power satellites.

It is for the individual reception market, (both in rural and urban areas), which is difficult to serve in either the cable or off air mode that the power level of DBS is important. This is why current DBS planning is proceeding along two parallel tracks:

- one using medium power satellites operating at 58 dBW and requiring the use of antennas in the 0,6 m to 0,9 m range;

- one using low power satellites operating at 53 dBW and requiring the use of antennas in the 1,0 m to 1,5 m range.

Clearly this difference would impact on individual decisions whether to purchase terminals or subscribe to a community redistribution system.

It is thus on individual users and "gray areas" that the present study has to focus. Clearly, the power level of a DBS will have an insignificant impact on large cable systems and their subscribers. On the other hand, it is also clear that for individual users, the power level will have a direct impact on antenna size and cost. The case of what we have called "gray areas" is more complex; many communities in Canada will face a difficult economic choice between individual and community reception. This choice will depend on the power level obviously, but also on other variables and constraints which we have tried to identify in the present study.

Our objective thus has been focused on determining the system cost differences and technical and service availability factors of alternative hybrid DBS/terrestrial signal distribution models and recommending the most promising options.

1.3 Methodology

As was suggested in the work statement, the study has been divided into two phases:

Phase I: construction, in close cooperation with the contract manager, of a spectrum of plausible DBS models, using material from other reports and the views of the Regulator and the Department.

Phase II: determination of how the delivery system costs vary with changes in system configurations.

To achieve the objectives of the study, we have judged that the following steps needed to be taken:

Phase I: Preliminary

1. Literature and objectives review

   - review of data, reports and literature on the subject;
   - review of study's objectives and finalization of the methodology.

2. Identification of significant variables and constraints, in cooperation with the contract manager, including:

   - space segment characteristics
   - uplink requirements
   - ground segment reception and redistribution
   - types of services offered
   - demand estimates
   - non economic constraints.

   Development of plausible DBS system configuration based on the variables and constraints identified above.

   We have developed a series of possible DBS systems, concentrating on the integration of DBS with existing technologies.

   In order to assure maximum flexibility in this analysis, these configurations have been defined as systems comprised of modules who could be interchanged or multiplied.

3. Development and testing of a computer simulation model.

   The purpose of the model is to calculate the net present value of costs (NPV) for any system configuration and consists of three sub-models:

   a) Households forecast sub-model
   b) Direct and community reception sub-model
   c) Cost sub-model.

Phase II: Cost analysis

4. Definition of input data.

- Evaluation of cost components for the various system configurations including:

  a) DTH households: antenna, LNA, receiver, descrambler
  b) Passive cable households (1) head end, receiver, descrambler, plus passive cable network.

- Distinguish between capital and operating costs for each category.

5. Results and analysis

- Determination of the net present value of costs associated with the various system configurations;

- Use of sensitivity analysis to determine the most cost effective system configurations.

6. Conclusions

- Presentation of the most cost effective configurations and detailed analysis of the impact of key assumptions developed for all the variables used.

- Evaluation of the impact of non economic constraints on system costs and/or the ranking of system configurations.

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(1) Passive cable designates a "low cost" cable system similar in design to MATV systems in large apartment buildings, which we think would be well suited to clustered households in rural areas.

2. SIGNIFICANT VARIABLES AND CONSTRAINTS AND DBS SYSTEM CONFIGURATIONS

2. SIGNIFICANT VARIABLES AND CONSTRAINTS AND DBS SYSTEM CONFIGURATIONS

The present chapter deals with the technical and economic variables and constraints associated with a DBS system; the chapter is structured as follows:

- technical
  - space segment
  - uplink segment
  - downlink segment

- economic considerations
  - program packages
  - market penetration

- approach used in the present study

2.1 Space segment

2.1.1 Design parameters

The World Administrative Radio Conferences (WARC), held periodically, constitute the international forum to regulate satellite frequencies and orbital allocations as well as signal characteristics. For administrative purposes, the world has been divided into three regions, as shown on Figure 2.1 (WARC administrative regions).

2.1.1.1 Frequency allocations

The frequency allocations proposed to WARC by Canada and other countries are schematically represented on Figure 2.2 (WARC

FIGURE 2.1

WARC ADMINISTRATIVE REGIONS

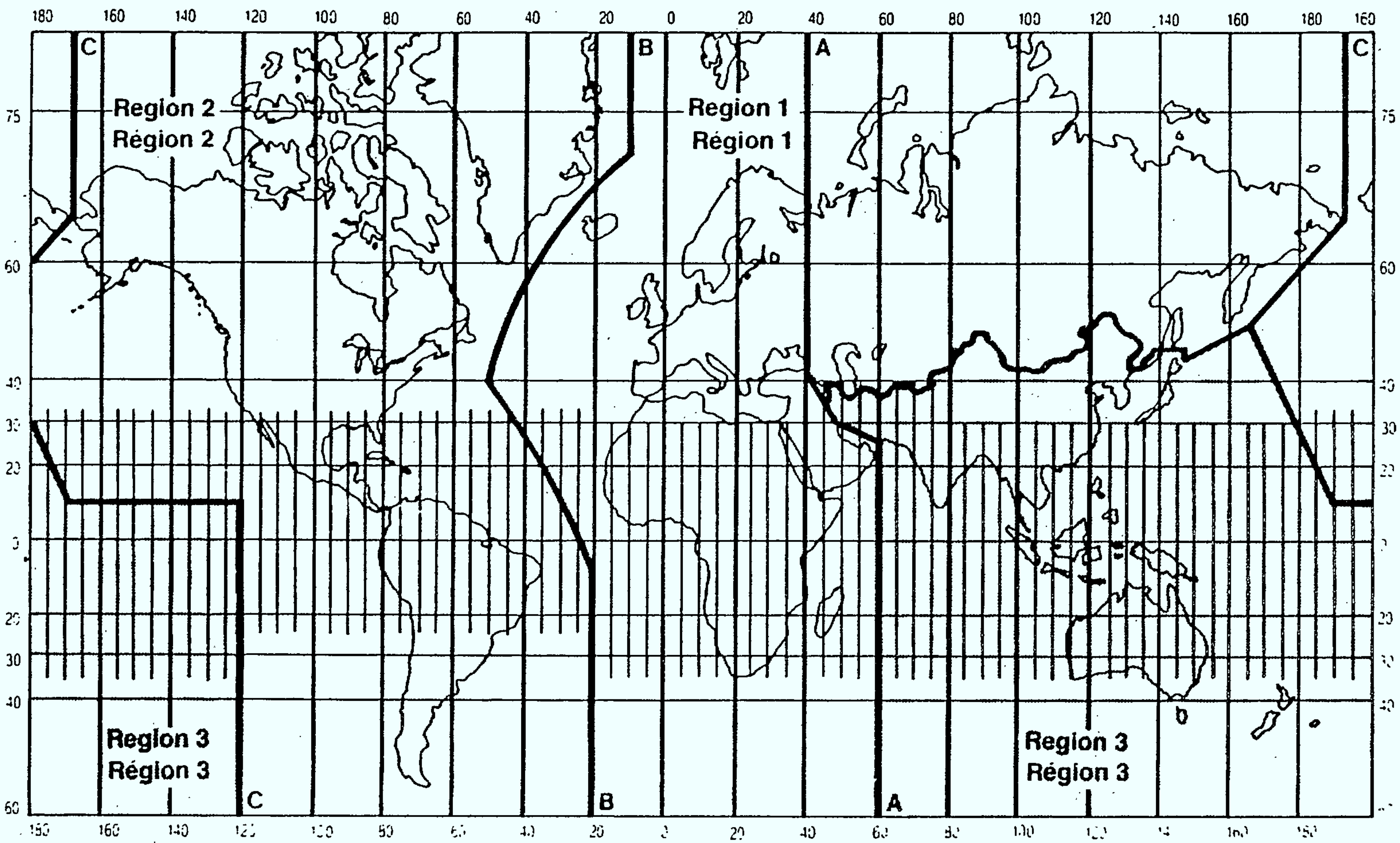


FIGURE 2.2: WARC frequency allocation status

Line	Recommendation	Frequency band					
		11,7 GHz	12,2 GHz	12,2 GHz	12,3 GHz	12,5 GHz	12,7 GHz
A	Decided by WARC, 1977	Shared orbit for Broadcast and Fixed satellite services					
B	Proposed by Canada, 1979	Shared Broadcast and Fixed satellite services					
C	Proposed by U .S., 1979	Fixed Satellite service		Broadcast satellite service			
D	Proposed by other countries, 1979	Decision postponed till 1983 Conference					
E	decided by WARC, 1979	Primarily fixed with some broadcast satellite services	Decision postponed till 1983		Primarily broad-cast with some fixed satel. serv.		

frequency allocation status). Line A indicates the down-link part of the existing 12 GHz band allocations as provided by WARC, 1977. Lines B, C and D illustrate the new allocations proposed at WARC, 1979, by Canada, the U.S. and a number of other nations. Line E is the new allocation adopted by the WARC, 1979 plenary session. Specific operating frequencies will be decided at the Regional Administrative Radio Conference (RARC) in 1983.

Assuming a DBS assigned frequency band of 500 MHz, as shown in Figure 2.2, a study commissionned by the D.O.C. and performed by Spar has analyzed various possible channels plans for a DBS which are summarized in table 2.1. These frequency plans were selected for their advantages, as follows:

- minimum intrasystem interference;
- permit common spacecraft design where more than one spacecraft are required per orbital slot;
- allow growth to meet increased demand;
- achieve minimum loss in the satellite output multiplexer.

Table 2.1

Channel plans analyzed by Spar

	BANDWIDTH			
Separation	48 CHAN PLAN	36 CHAN PLAN	32 CHAN PLAN	24 CHAN PLAN
Crosspolarized Channel spacing	9,9 MHz	13,2 MHz	14,8 MHz	19,5 MHz
Copolarized Channel spacing	19,9 MHz	26,3 MHz	29,5 MHz	39,0 MHz

Source: Direct Broadcast Satellite System Modelling, Spar Aerospace, June 1981.

2.1.1.2 Orbital allocations

Result of the upcoming RARC 1983 meeting will probably be along the lines of the agreement of WARC, 1977, for the rest of the world, Regions 1 and 3. That agreement called for the allocation of the arc by country, regardless of use. The U.S. position (allocation according to use) was rejected at that time.

The arc in Regions 1 and 3 was divided into national orbital slots and the spectrum into channels. Each interested country received predetermined allocations of orbital slots, channels and EIRP power.

Direct broadcast satellites (DBS) of the future are expected to use much higher power than fixed satellites (FSS), in order to make practical use of small home terminals. The high power (and other considerations) lead to an expected spacing of at least 6 degrees between DBS satellites (operating in the 12,2 to 12,7 GHz frequency band). Fixed satellites, operating in the 11,7 to 12,2 GHz band, are expected to need only 3 degrees spacing.

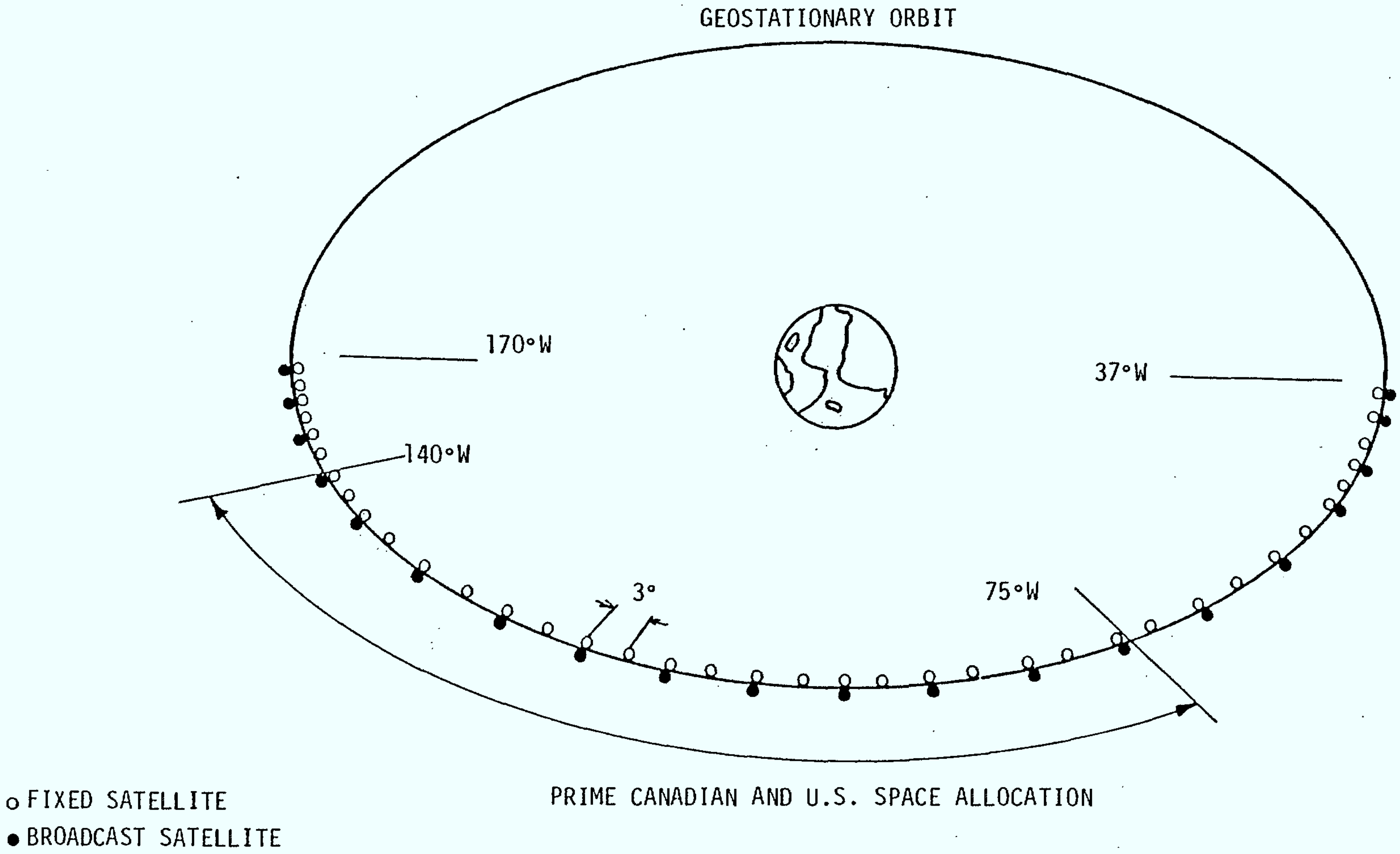
This could result in a satellite orbital placement which is illustrated on Figure 2.3.

A less probable pattern would be the operation of high power broadcast satellites and low power fixed satellites in the same band, which would result in a need for much greater spacing between the satellites (as much as 16 degrees in the worst case).

The orbital space between 75 and 140 degrees west is the best suited for Canada/U.S. coverage. With equal sharing of this prime space between Canada and the U.S., this would leave Canada with five DBS orbital slots. This question will be clarified only at RARC 1983. Since it is evident that orbital space will be restricted, it is most important to select from the start the

FIGURE 2.3

POSSIBLE SATELLITE PLACEMENT



most efficient space segment model, the one resulting in the maximum number of channels per beam for the Canadian DBS system.

2.1.1.3 Effective isotropic radiated power (EIRP)

WARC, 1977 envisaged satellite radiated power of up to 63 dBW EIRP Center Beam (CB) for broadcast satellites operating in the 12,2 to 12,7 GHz band.

WARC, 1979 permitted the use of the 11,7 to 12,2 GHz band for medium power broadcasting up to 53 dBW EIRP, CB.

The reason to operate a Broadcast satellite at high power resides in lower cost satellite home receivers. On the other hand, the pilot project conducted with ANIK "B" between September 1979 and September 1981 has confirmed that satisfactory service can be achieved with a power level as low as 49,5 dBW EIRP, (CB) while still permitting small, low cost earth stations.

However the choice of an optimum power level goes beyond Canada's sole requirements; this is so because DBS signals at a high power level will also most probably be available from U.S. satellites. Canada is therefore forced to match, to a certain extent, the power level from these satellites; the danger in not doing so, resides in the fact that Canadian users might purchase very small earth stations that would provide a much better signal quality on U.S. satellites than on Canadian satellites.

2.1.2 Models of space segment

2.1.2.1 Design parameters

The design parameters of the space segment that were used as a basis for model development, are presented in Table 2.2. These parameters were selected in consultation with the Contract Manager and in consideration of the WARC 79 recommendations for Region 2, and the studies completed by Spar and Telesat for the DOC.

Table 2.2

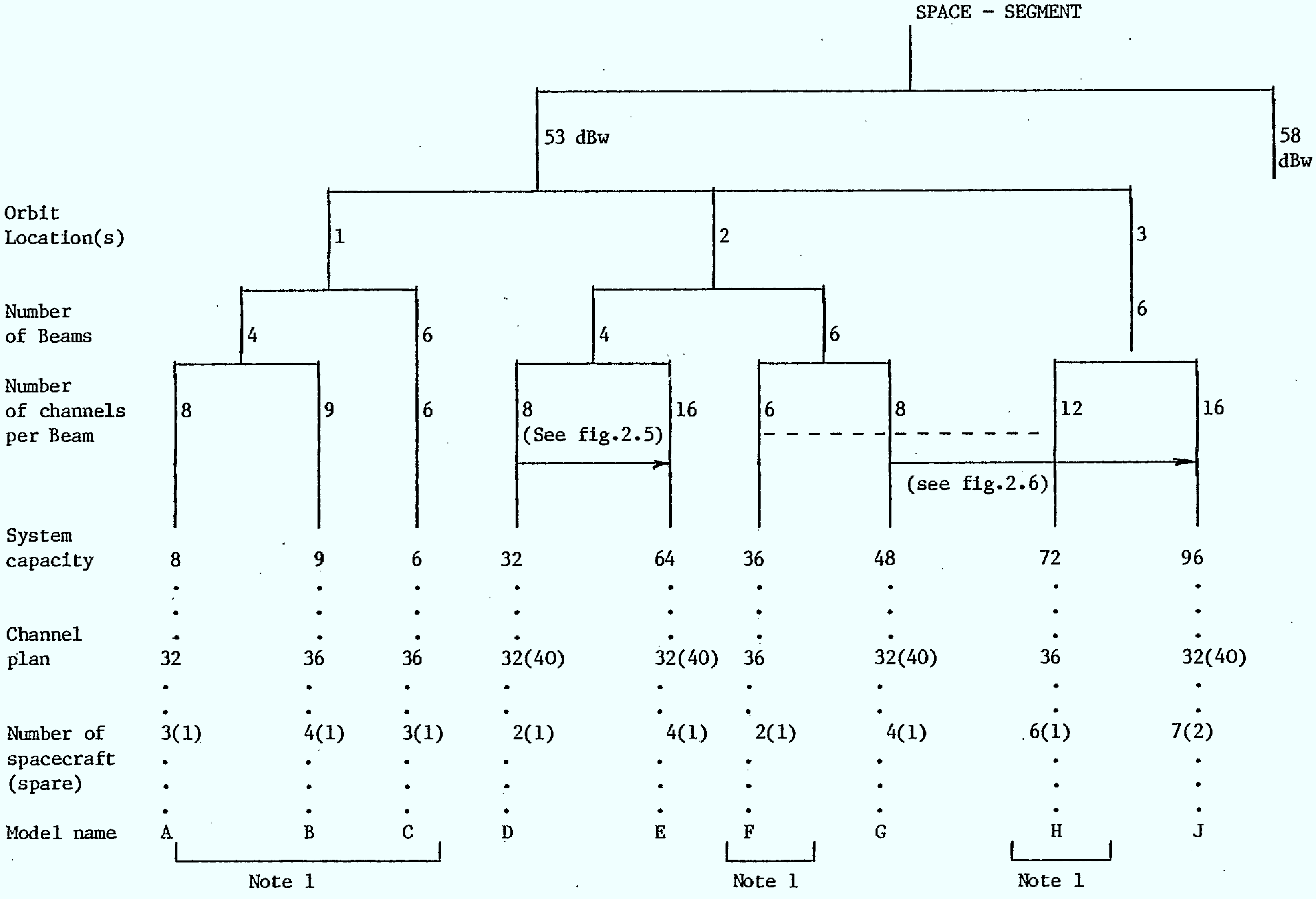
DBS system parameters

Item	Value
EIRP	53 dBW (11,7 to 12,2 GHz) and 58 dBW (12,2 to 12,7 GHz) on axis
Number of orbits	1,2 and 3
Channel capacity per beam at full growth	16 or more
Frequency band	12,2 to 12,7 GHz for 53 and 58 dBW EIRP 11,7 to 12,2 GHz for 53 dBW EIRP
TV channel bandwidth	18 MHz FM
System signal Carrier-to-Interference (C/I)	30 dB

There are four possible channel plans (see Table 2.1) that can be used for the development of models. But considering the assumed value for each of the design parameters shown in Table 2.2, the 48 channel plan would result in an unacceptable carrier-to-interference ratio (1) and the 24 channel plan will not be expandable up to 16 channel per beam as demonstrated later by our calculations on 36 and 32 channel plans. Figure 2.4 shows the range of space segment models considered for 53 dBW EIRP, and a similar options tree could also be envisaged for 58 DBW EIRP.

(1) See Spar Report, p. 23.

FIGURE 2.4: Possible space segment models



(1) Excluded - Capacity less than 16 channels per beam

The models A, B and C are operating from one orbit location and can provide respectively 8, 9 and 6 channels per beam, with no further growth possibility. The models D and E operate from 2 orbit locations with 4 beams.

Figure 2.5 illustrates how model D can be expanded to the 16 channel model E by placing a second spacecraft on each of the two orbital slots.

The models F and G, operating from 2 orbits with 6 beams can be expanded upwards to the 3 orbit models H and J, which provide respectively a capacity of 12 and 16 channels per beam. The growth pattern from model G to J is represented on Figure 2.6. The 2 orbits, 6 beams arrangement from model G is expanded to the 3 orbits, 6 beams arrangement by turning off one of the three beam from each of the first spacecrafts, and replacing them by two other beams from a new spacecraft on a third orbital slot. The capacity of this new configuration can then be expanded to 16 channels, by placing one additional spacecraft on each of the three orbital slots.

This technical description of models shows that a gradual implementation from model D to model E and from model G to model J is possible as illustrated respectively in Figures 2.5 and 2.6.

Even though the 16 channels requirement could be met at a somewhat lower cost with one large spacecraft, the possibility of a gradual implementation using 2 or 3 smaller ones presents significant advantages from an investment point of view in adapting system capacity to service demand.

FIGURE 2.5: Upgrowth of 2 orbits, 4 beams model to 16 channels

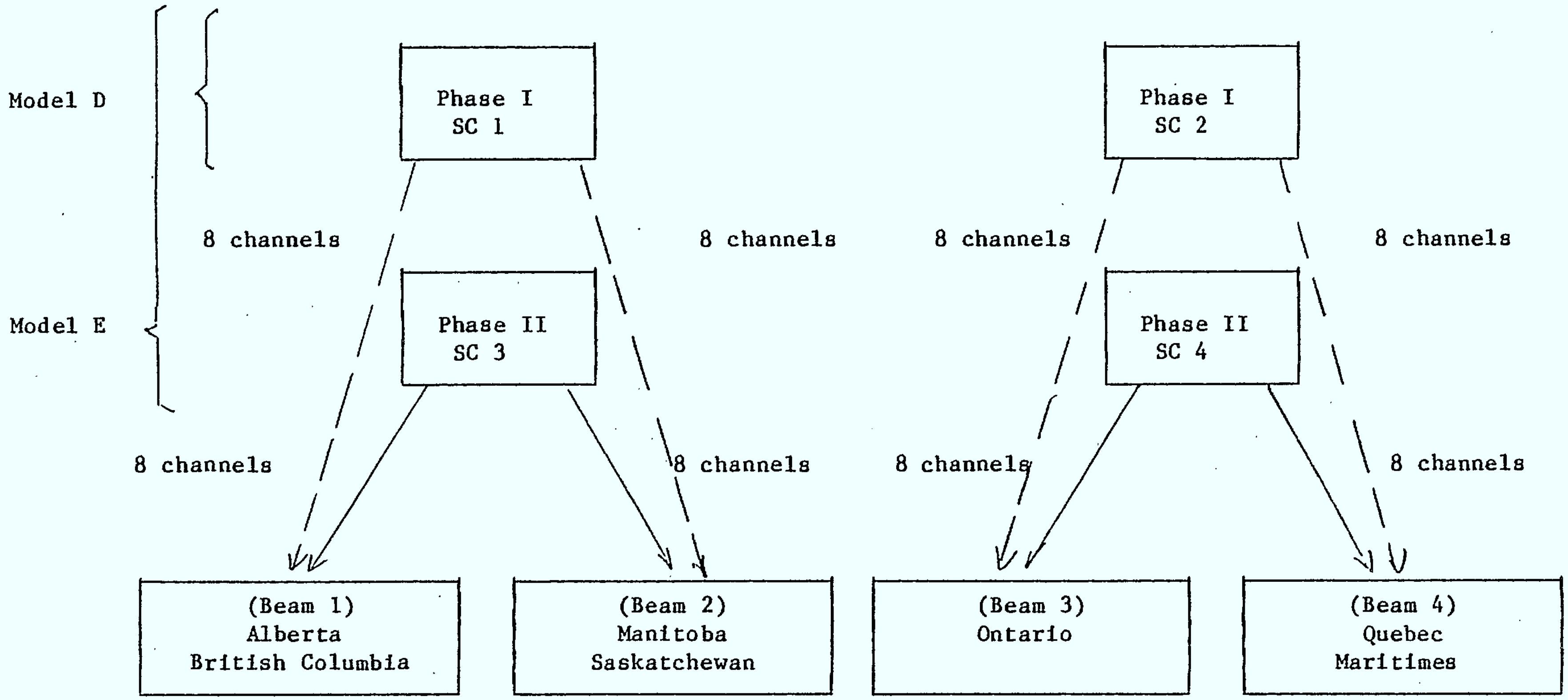
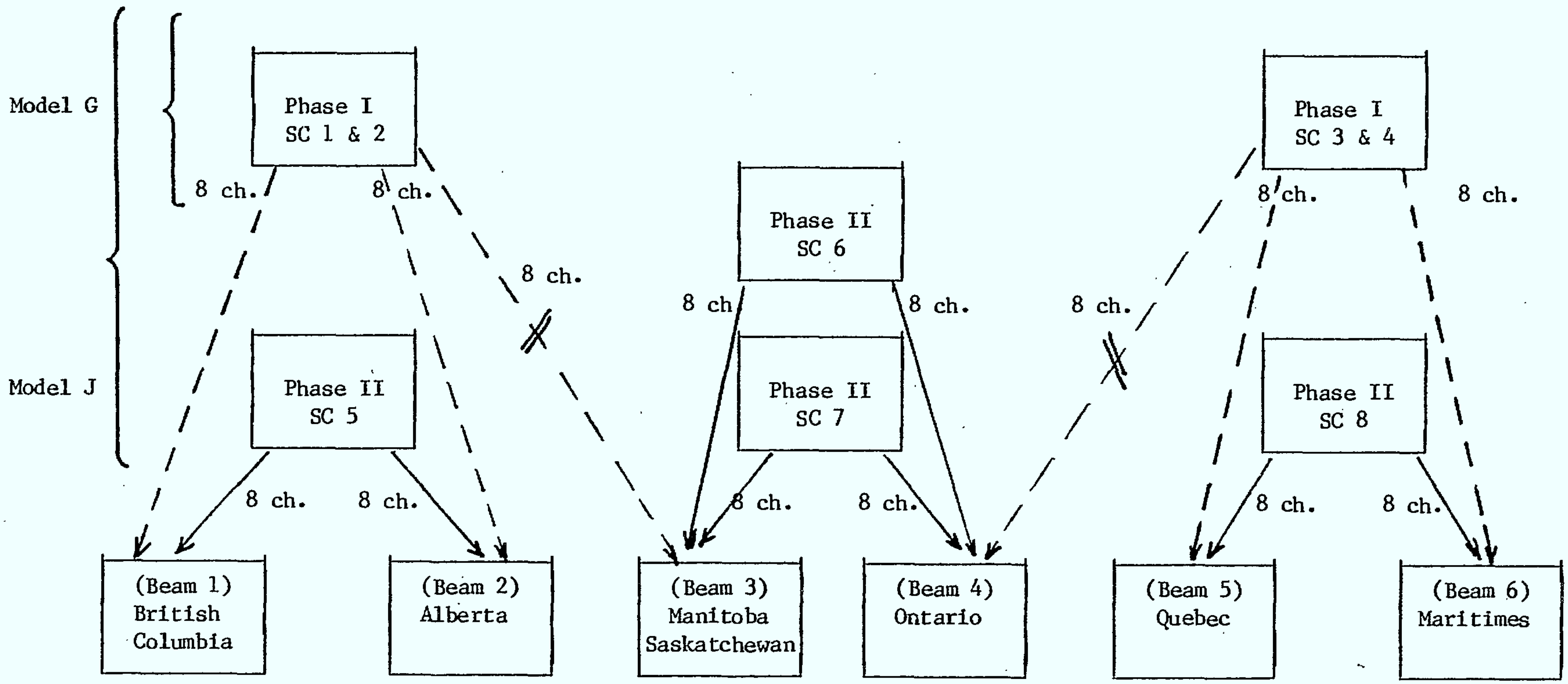


FIGURE 2.6: Upgrowth of 2 orbits, 6 beams model to 16 channels



Phase 1 - Implementation of model D or model G.

Phase 2 - Expansion to model E by adding two spacecrafts to model D or modification of model G and expansion to model J by launching four new spacecrafts.

2.1.2.2 Evaluation of costs

For each space segment model, a total estimated cost has been developed assuming one spare spacecraft plus launch, and using the spacecraft and launcher costs given in the Spar report (1) dated June 1981.

These costs are shown in table 2.3, for DBS systems operating respectively at 53 dBW and 58 dBW EIRP for each of the nine space segment models previously presented in Figure 2.4.

2.1.2.3 Selection of models

Out of the 9 models presented, only the models E and J meet the design parameters of either 53 dBW or 58 dBW EIRP levels.

These parameters are:

Model E	Model J
2 orbits	3 orbits
4 beams	6 beams
16 channels	16 channels
32 channel plan	32 channel plan

(1) DBS System Modelling, Spar Aerospace, June 1981.

Table 2.3

Space segment model costs

Space segment model	Number of orbit	Number of beam	Number of channel per beam	Number of spacecraft + one spare	Total cost per system ($ m - 1981) 53 dBW	Total cost per system ($ m - 1981) 58 dBW	Cost per channel ($ m - 1981) 53 dBW	Cost per channel ($ m - 1981) 58 dBW
A	1	4	8	3	189,0	381,9	5,9	11,9
B	1	4	9	4	252,0	509,2	7,0	14,1
C	1	6	6	3	189,0	381,9	5,2	10,6
D	2	4	8	3	189,0	381,9	5,9	11,9
E	2	4	16	5	315,0	636,5	4,4	8,8
F	2	6	6	3	N/A	N/A	-	-
G	2	6	8	5	315,0	434,5	6,6	9,0
H	3	6	12	7	-	-	-	-
J	3	6	16	8 (2 spares)	567,0	935,0	5,9	9,7

Source: Direct Broadcasting Satellite System Modelling, Spar Aerospace, June 1981

It should be noted that in the case of the 32 channel plan, the 30 dB carrier-to-interference ratio is also met. Therefore, it appears that only those two models are consistent with the design objectives established previously. Both of these models should be retained as serious alternatives for a Canadian DBS system because:

- they can meet the 4 or 6 beam coverage pattern;
- they provide gracious growth for a two phase implementation;
- they both meet the 16 channel per beam minimum required capacity.

2.2 Uplink segment

2.2.1 Design parameters

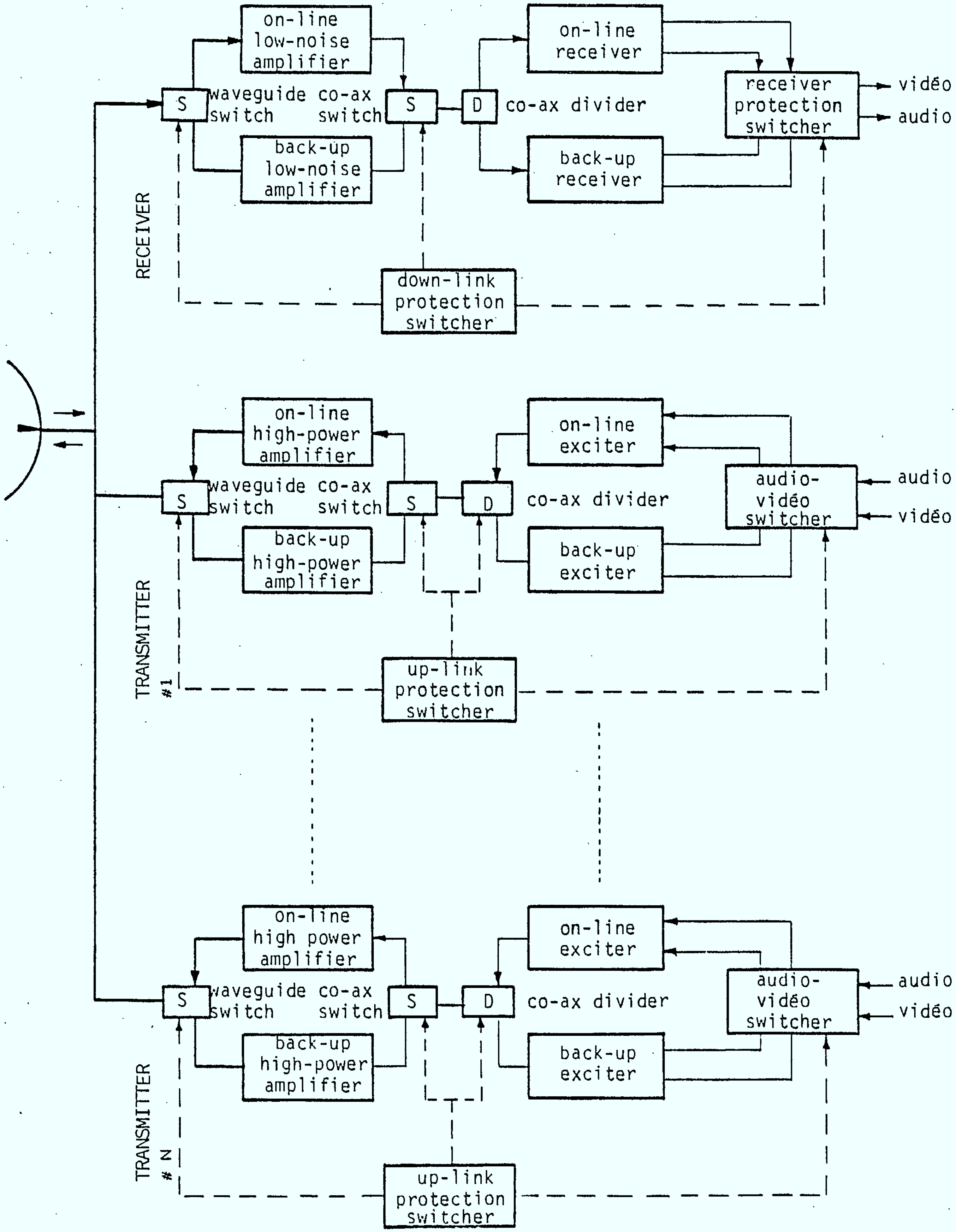
Beyond the usual technical parameters, the design of an uplink station is largely dependent on the reliability objectives and the monitoring and control requirements. For the purpose of this study, it has been agreed to retain the following criteria:

- one transmitter per downlink channel;
- transmitters equipped with automatic switching protection;
- monitoring receiver equipped with automatic switching protection;
- automated alarm system for channel failures and satellite tracking;
- antenna beam width suitable for satellite spacing down to 3°;
- uplink unfaded carrier-to-noise ratio of 30 dB.

Figure 2.7 shows a synoptic block diagram of a typical uplink station.

FIGURE 2.7

SYNOPTIC BLOCK DIAGRAM ON AN UPLINK STATION



2.2.2 Models of uplink segment

2.2.2.1 Network considerations

The uplink segment is made of many uplink stations, the design of which is directly dependent of the selected space segment model, and more specifically of the number of channels and the number of beams. The arrangement and design of uplink stations are also affected by the origin of source programs, and by coverage requirements.

2.2.2.2 Major components

For the purpose of this study, an uplink station is divided in three sub-systems, namely:

- the antenna
- the transmitter
- the common equipment

The antenna comprises the antenna sub-system, including its structure. The tranmitter includes transmitters, high-power amplifiers, exciters and switching equipment. The common equipment encompasses building, waveguides, receivers, central alarm, test equipment and engineering.

2.2.2.3 Quantification of requirements

The combination of components needed to make up a complete uplink station is directly related to the variables shown in Table 2.4.

Table 2.4

Variables affecting the uplink design

	Antenna part	Transmitter part	Common equipment part
Regional	1	1/Regional channel per beam	1
National	1/Orbital slot	1/National channel/ National station	1

2.2.3 Evaluation of costs

The estimated costs developped in Appendix A for the three main parts of an uplink station are as follows:

Antenna	$250 000
Common systems	$400 000
Transmitter-Exciter	$200 000

2.2.4 Selection of models

One uplink model is required for each of the four space segment models retained in section 2.1.

As mentionned in section 2.2.2.1, the arrangement of an uplink segment model is also dependent on the origin of source programs (which is defined by the number of regional and national uplink stations) and the channel ratio between the national and regional programs.

For illustrative purposes, the characteristics of the different uplink models associated with space segment models D, E, G and J are presented in table 2.5. The data presented in that table are based on the following criteria:

- the variable rules presented in table 2.4
- 1 regional uplink station per beam
- 2 national uplink stations
- 50% ratio between national and regional programs.

Table 2.5

Characteristics of uplink models

Space segment Models	Coverage	Number of stations	Number of antennas per station	Number of transmitters per station	Cost ($ million)
D	National	2	2	8	5.0
	Regional	4	1	4	5.8
E	National	2	2	16	8.2
	Regional	4	1	8	9.0
F	National	2	2	12	6.6
	Regional	6	1	4	8.7
J	National	2	3	24	11.9
	Regional	6	1	8	13,5

2.3 Ground segment

2.3.1 General

The D.O.C. has in the past undertaken a number of studies pertaining to the distribution of TV signals in rural Canada. Amongst these studies, a number dealt with the various characteristics of rural communities and the spatial distribution of households in those communities. The conclusions and findings associated with these studies are more amply discussed later in this report, but for now it will suffice to mention that it is these findings which have motivated the development of terrestrial DBS system configurations which are examined in the present section.

The five distribution models, which were developed in the present study, are schematically presented in Figure 2.8 (DBS distribution models). These five models have design and costs characteristics which offer economic alternatives for DBS signals delivery for any configuration, from single households to large communities.

These five DBS distribution models are divided in two groups, which are the direct delivery systems and the indirect delivery systems. Respectively the first group delivers the signal from the LNA directly to the DBS tuner/receiver which is located within the home(s), while the other demodulates and processes each satellite channel for delivery through autonomous polyvalent distribution systems.

The five distribution models can be briefly described as follows: and are illustrated in the following figure:

DTH : Direct to home reception

DPC : Direct Passive Cable
Similar to DTH but the antenna and LNA are shared by up to 10, close-by neighbours. Each individual household is equipped with a receiver and a descrambler.

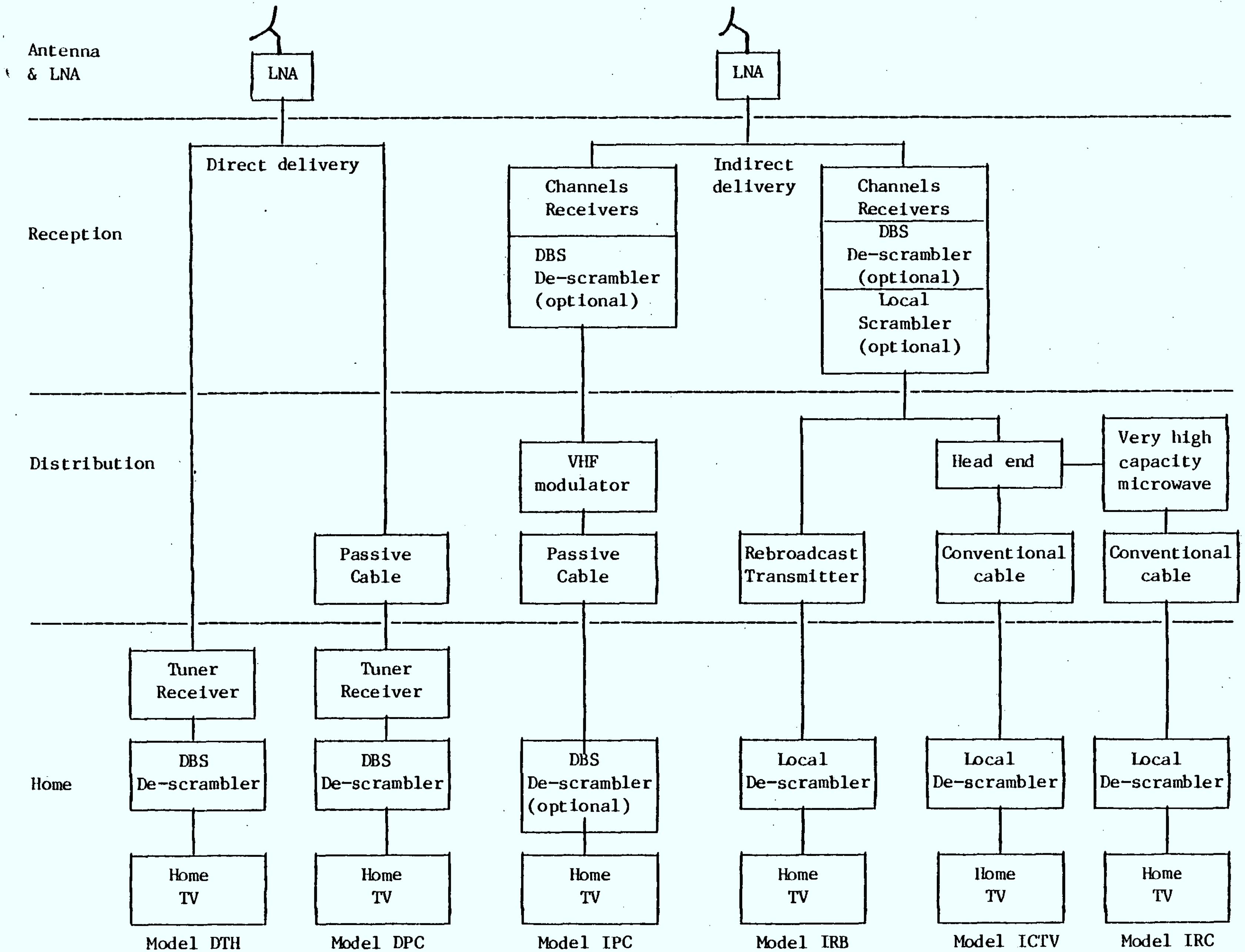
IPC : Indirect Passive Cable
A "low cost" cable system similar in design to MATV systems in large apartment buildings. Receiving and modulating functions performed at head end. Descrambling performed optionally at head end or within subscriber premises (see "Economic considerations" section).

IRB : Indirect rebroadcast
VHF or UHF rebroadcast of DBS satellite signals.

ICTV: Indirect conventional cable system
(with a sub-model that includes the use of Very High Capacity Microwave named model IRC).

Three types of distribution technology are used in these models: the passive coaxial cable network for the models DPC and IPC, the rebroadcast transmitter for the model IRB, and the standard CATV network for the model ICTV.

FIGURE 2.8: DBS distribution models



2.3.2 Components

Components for each of the distribution models will now be described.

2.3.2.1 Antenna & low noise amplifier (LNA) unit

The antenna is the most critical part of the earth station, as its effective gain establishes the signal level above noise threshold of the LNA. Seemingly small problems in the antenna can result in seriously degraded performance of the receiver system.

The operating point above threshold at the LNA is determined by the following factors:

1. the EIRP of the satellite signal;
2. the gain of the antenna,
3. the noise figure of the station, including the noise temperature of the sky, the antenna system, and the LNA.

The antenna may not achieve the gain specified by the manufacturer due to several factors: 1) poor installation; 2) shadowing of the satellite signal by local obstruction; 3) alignment of the antenna with the satellite. These factors alone may cause the loss of as much as one or more dB of signal.

For the most part, the antenna and LNA will set the performance parameters for the TVRO station.

The carrier-to-noise (c/n) minimum objective for a good reception has been found with the Anik "B" trial to be 12 dB. This 12 dB c/n objective will be assumed for our antenna size selection.

Assuming a fading margin of 4 dB and an edge of beam contour 4 dB down from the center beam level, the antenna sizes required to obtain a c/n 12 dB for a receiver located at edge of contour would be as follows for a direct-to-home receiver:

- at 58 dBW EIRP, the antenna has to be 0,8 meter;
- at 53 dBW EIRP, the antenna has to be 1,2 meter.

For small community reception, an increased fading margin to 8 dB is needed to ensure higher signal quality and reliability. The resulting antenna size required would be as follows:

- at 58 dBW, the antenna would be 1,2 meter (or larger);
- at 53 dBW, the antenna would be 1,8 meter (or larger).

The criteria for all types of distribution models are summarized in Table 2.6.

Table 2.6

Antenna classification per model

DBS Distribution model	Fading marge	ANTENNA SIZE (Meter)	
		EIRP 53 dBW (49 dBW-EOC)	EIRP 58 dBW (54 dBW-EOC)
DTH	4 dB	1,2	0,8
DPC	8 dB	1,8	1,2
IPC	8 dB	1,8	1,2
IRB	12 dB	2,5	1,8
ICTV	12 dB	2,5	1,8

2.3.2.2 Satellite receivers

Receiver performance is the next area of importance after the antenna and LNA for good quality reception. Depending on the application (individual households versus small or large communities), the performance requirement will be different, and so will be the design of the receiver station for direct-to-home reception, small community of 50 households and large community of 1 000 households or more.

The type of receiver suitable for each of the above group was chosen as follows:

- the direct-to-home (DTH) receiver is a low-cost, mass production unit equipped with channel selector. Figure 2.9 illustrates the configuration of this receiver;

- the small community receiver (too large for DTH reception and too small for conventional cable distribution), is a low-cost unit with several single channel receivers without selector. Figure 2.10 illustrates its configuration;

- the large community receiver is a commercial grade equipment manufactured in small quantity with high quality components. Its configuration is similar to the small community receiver shown on Figure 2.10.

FIGURE 2.9

DIRECT TO HOME RECEIVER

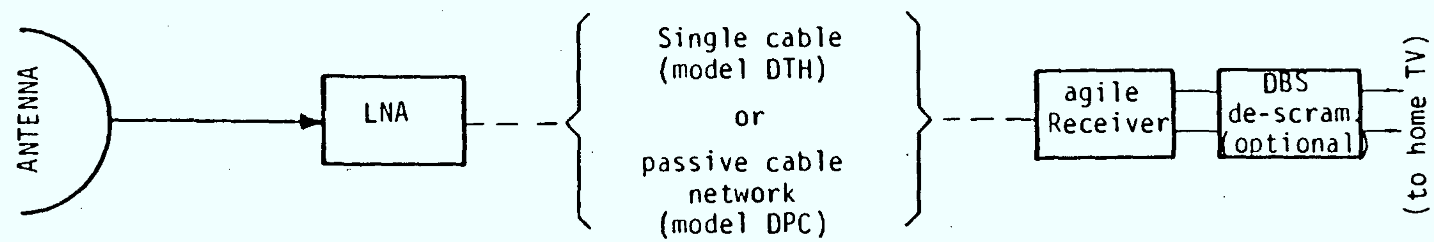
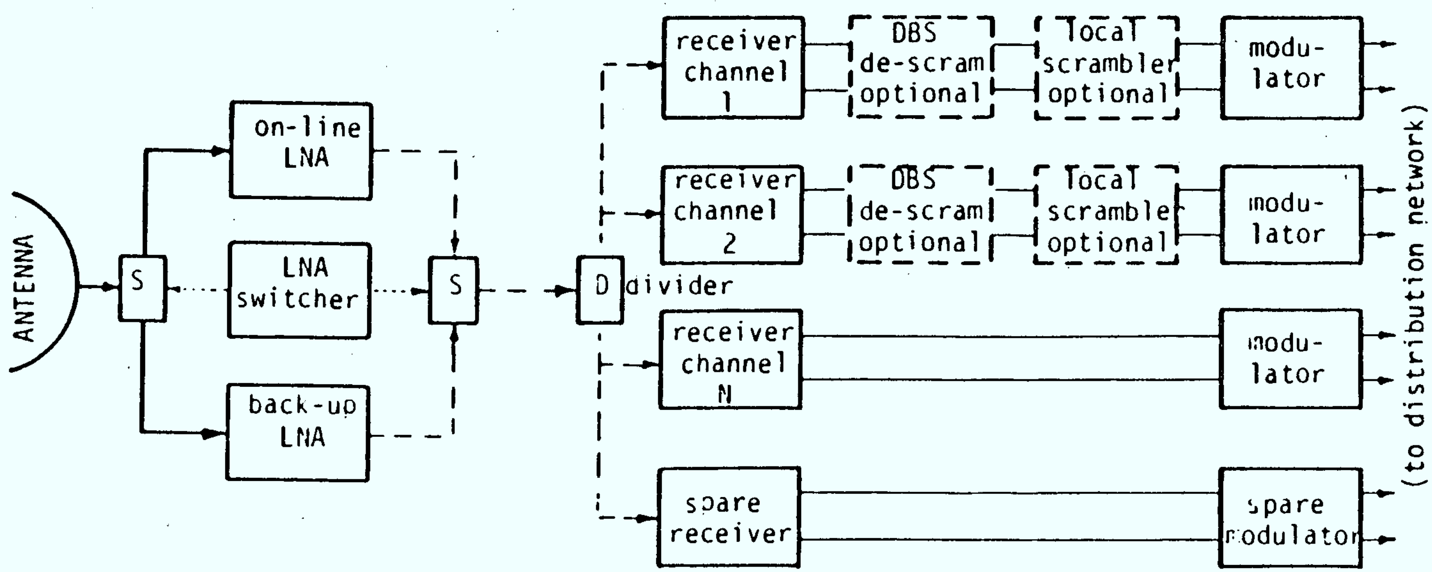


FIGURE 2.10

COMMUNITY RECEIVERS



2.3.2.3 Descramblers

From a technical point of view, the introduction of scrambling and de-scrambling involves addressing, access control, upstream transmission of ordering information and accounting.

Because DBS are likely to offer many tiered services, the scrambling and de-scrambling system will have to be universal, with independantly addressable multiple or single channel decoding characteristics. Therefore, the technology used would probably involve digital encoding and decoding with some sort of electronically coded key for individual subscriber decoding per tiered service.

2.3.2.4 Passive cable distribution network

The passive cable network is designed for the DPC and IPC models. The objective of this network is to economically deliver DBS signals to small communities from 10 to 15 households (1) up to 250 households.

As an alternative to DTH distribution for small communities, it has to involve a minimum of engineering, it must be easy to implement and maintain, it must deliver high signal quality, and all this at a low cost per household served.

By limiting cable distribution per system to 250 households (1) or less, it is possible to eliminate the needs for line amplifiers and as a result come the following advantages:

- Adaptability to package type design, bringing engineering requirement to a bare minimum while easing implementation.

---

(1) Depending on the density.

- By limiting the number of households served, the application procedure to the CRTC is simplified, eliminating the need for proof-of-performance and other complex procedures.

- Minimal system maintenance and increased cable network reliability.

- Simplified maintenance equipment and procedures .

- High signal quality delivery, as cable induced attenuation can be easily compensated and controlled.

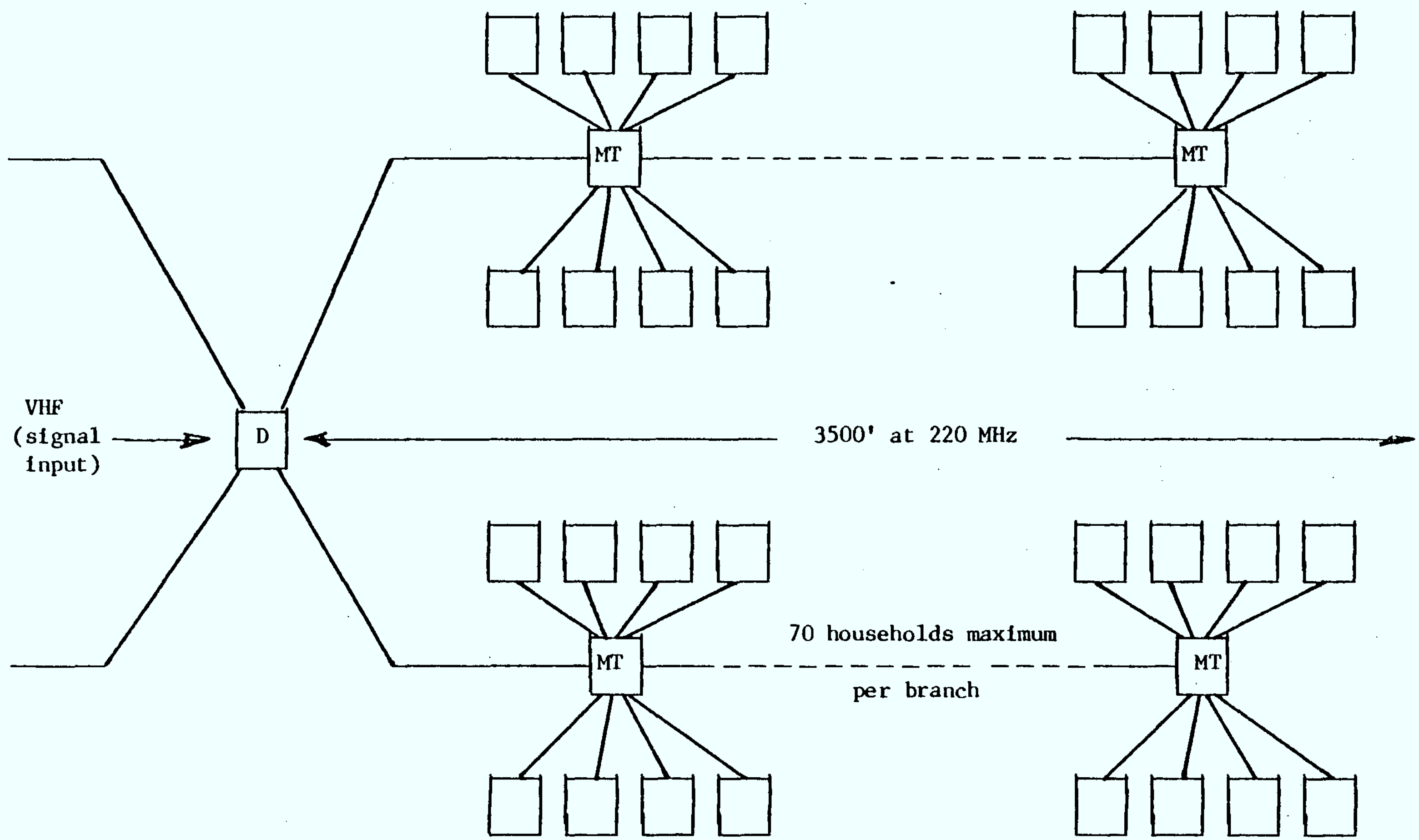
- Broadband capacity up to 500 MHz for more than 50 TV channels.

- Bi-directionnal capacity which is natural to coaxial cable without amplifiers.

As illustrated in Figure 2.11 (Passive cable network layout), a possible cable network would be technically characterized, as follows:

- single cable layouts
- four branches up to 1000 feet for model DPC, 3500 feet for model IPC.
- capacity of serving respectively 20 and 70 households per branch for the DPC and IPC models.

FIGURE 2.11: Typical passive cable network layout



Legende: D = Divider
MT = Multitaps
——— = AL500 coaxial cable & drop cable
☐ = Household

2.3.2.5 Rebroadcasting

Rebroadcasting is an optional form of distribution of DBS signals.

According to the proposed policy for local transmission of multiple broadcast signals, the DOC is prepared to consider up to 90 MHz as a basic block in the UHF TV band (470 to 806 MHz) for rebroadcasting of TV signals in underserved areas. Only second adjacent channels would be assigned in any block and therefore no more than 8 television services could be transmitted in any community. In the VHF TV band (54 to 220 MHz) assignment of more than 4 channels is unlikely except for truly remote areas. In practice, due to spectrum congestion, there will always be less channels available in either the VHF or UHF hand.

For a system certified in accordance with the authorization guidelines provided by DOC, the Department would be prepared to afford a certain level of protection against interference with a priority 2 or 3 depending on the authorized power. However, priority one would be given to broadcasting or rebroadcasting stations assigned in accordance with Broadcast Procedure 5.

Rebroadcasting is perhaps worthy of consideration as an intermediate transmission technology for special temporary applications. However, it cannot be considered as a DBS distribution alternative to direct-to-home or cable distribution, since rebroadcasting would not be able to meet the minimum requirement of 16 channels.

2.3.2.6 ICTV cable network

The ICTV cable network consists of a conventional CATV cable network. Its capacity to amplify TV signals along the cable line enables it to extend coverage as far as 15 miles from the head-end location, and to serve very large communities.

Presently available line amplifiers operate at up to 450 MHz which allows the transmission of 54 television channels.

As opposed to the passive cable system, the more sophisticated design of the ICTV cable network requires better planning, a higher implementation cost and highly trained maintenance personnel.

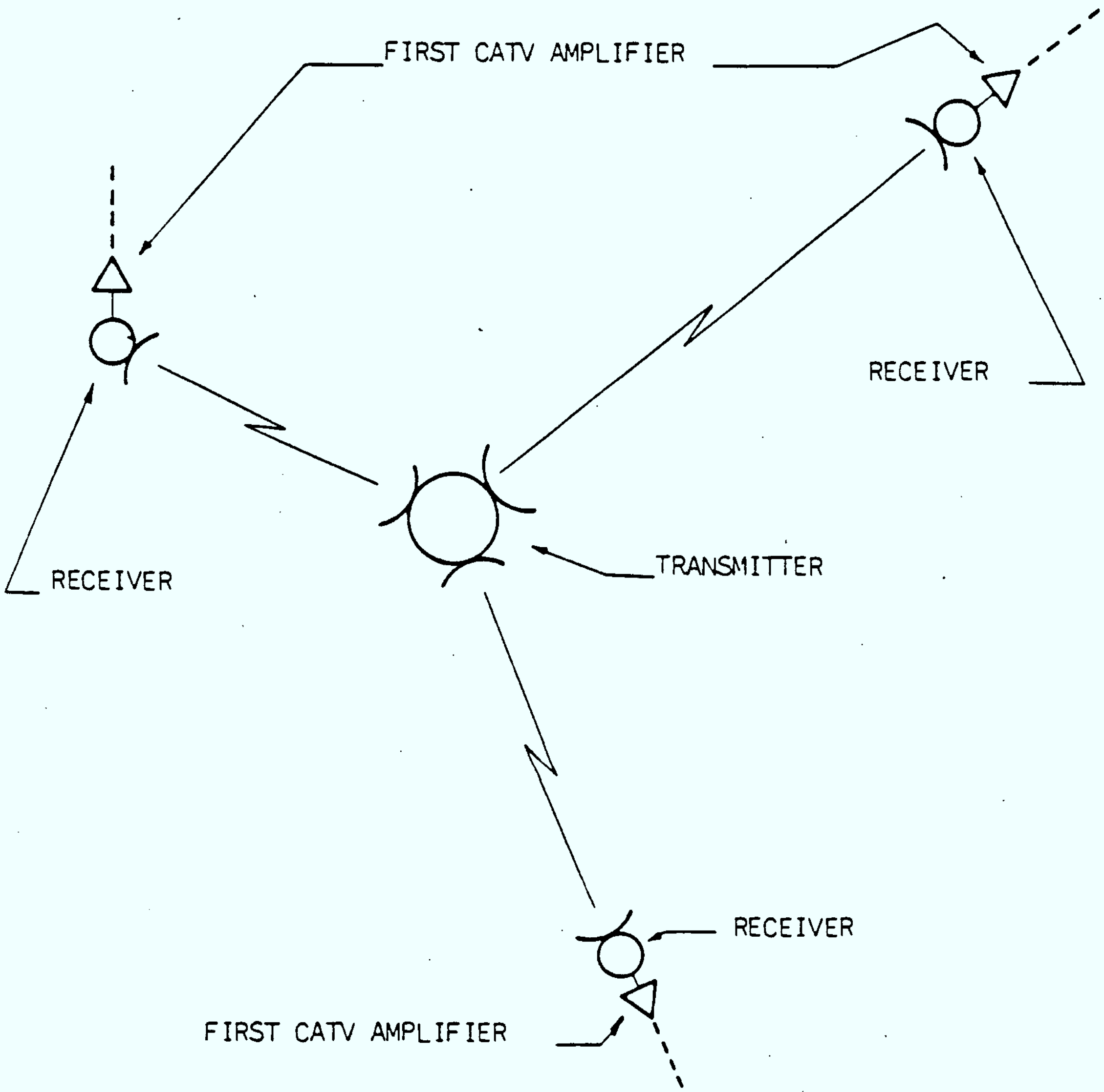
2.3.2.7 Very high capacity microwave (VHCM)

Very High Capacity Microwave has been increasingly used in Canada during the past five years to link cable systems in urban areas.

The main characteristic and advantage of VHCM is a capacity of up to 35 channels and the sharing of one transmitter for as many receivers as desired, within a radius of approximately 25 miles. Also, since the transmitter is fed with CATV compatible signals, no cable processing and associated equipment are required. The layout of this type of system is presented in Figure 2.12.

FIGURE 2.12

VERY HIGH CAPACITY MICROWAVE CONFIGURATION



2.3.3 Evaluation of costs

2.3.3.1 Cost of components

This paragraph presents the projected capital costs of the components of the ground segment models previously described.

In order to develop these estimated costs, the following assumptions have been made:

- hardware components such as low noise amplifiers, descramblers or receivers will be manufactured in a competitive and open market;

- no single manufacturer will be in a monopolistic situation;

- research and development will be an on-going process;

- total market although very large will be shared between a great number of manufacturers.

a) Antenna and low-noise amplifier

After consultation with companies such as SED Inc. and Andrew, and analysis of the Telesat report and other related documents, Table 2.7 presents the estimated costs of the antenna module as a function of the antenna size and anticipated production volume by manufacturer.

Table 2.7

Antenna and LNA cost as a function of size

Antenna size (meter)	Antenna production (annual)	Antenna $	LNA N.F. 4dB $	Transportation, Installation, etc. $	Total $
0,8	100 000	75	200	100	375
1,0	100 000	100	200	150	450
1,2	25 000	300	200	250	750
1,8	10 000	1 000	200	500	1 700
2,5	2 000	3 000	200	1 000	4 200

Based on the current trend of the industry, it is also assumed that the 0,8 and 1 meter antenna size will be the DBS standard. Consequently, the 1,2 meter and larger size antenna will not benefit directly from the same research and development and the large production series of the smaller sizes. This consideration is reflected in the installed cost of antenna modules which rises from $375 for the 0,8 m size to $750 for the 1,2 m size.

In view of the overall system economic study to be developpped later in this report, we estimated the annual maintenance cost at $20 (one failure every 5 years with a $100 repair cost). Appendix B provides details on capital and annual cost estimates.

b) Satellite receivers

As mentioned previously, three types of indoor receivers are considered in this study. These are:

- a low-cost tuner receiver used in model DTH and DCP
- a low-cost multi-channel receiver (without selector) used in model IPC (1)
- a commercial grade channel receiver used in model IRB and ICTV.

The projected costs of these receivers have been defined in consultation with manufacturers such as: S.E.D., Jerrold and Scientific Atlanta.

Table 2.8 presents the capital cost of the indoor receiver module for each of the distribution models and for 8 and 16 channel capacity. Appendix B provides details on capital and operating costs.

c) Descrambler

At present, there is only one Canadian manufacturer (Leitch) producing a descrambler which meets DBS requirements. Today, this descrambler (model DTD-2000N) is priced at $5 000 per unit. Assuming Very Large Scale Integration (VLSI) and production of 1 to 5 million units, it is believed that descramblers could be produced at $300 per unit by 1990 and possibly $150 by 1995.

For the purpose of this study, a $200 per unit will be assumed. In addition, the annual maintenance cost is estimated at $20 (based on one failure every 5 years at $100 each).

---

(1) One receiver required per channel distributed.

Table 2.8

Indoor Receiver capital cost

Ground segment	RECEIVER COST (installed) ($ 1982)			
	8 channels		16 channels	
	Without descrambler	With descrambler	Without descrambler	With descrambler
DTH	200	400	200	400
DPC	200	400	200	400
IPC	9 250	11 050	16 050	19 450
IRB	20 300	28 500	N/A	N/A
ICTV	29 400	41 000	55 000	77 000

d) Passive cable network

The principal elements in the design and implementation of a passive cable network are:

- engineering
- distribution cable
- multi-taps
- Drops

The cost of a passive cable network is a function of the number of household served and the density of household per route length. It is calculated using the following equation:

$$\$\,\text{passive cable} = \$\,\text{Engr.} + \$\,\text{head end amplifier} + \left\{\left(\text{Household density ft. per household} \times \$\,\text{cable per ft.}\right) + \$\,\text{Multitaps per household} + \$\,\text{drop per household}\right\} \times \text{Number of households}$$

The assumed cost for each element of this equation is presented in Appendix C. The graph of this equation is plotted in Figure 2.13 as a function of the number of household and household density. The annual operating costs are estimated as follows:

- maintenance $1 000
- administration $15/household

Further details on cost calculation are presented in Appendix C.

e) Conventional cable network

The conventional cable network previously described comprises two additional elements not required for the passive cable network, namely the line amplifiers and the trunk cable. The cost of a conventional cable network depends on the number of households and the density of household in the community served and is expressed by the following equation:

$$\$\,\text{conventional cable} = \left\{\text{Household density ft./H.H.} \times \left(\$\,\text{cable per ft.} + \$\,\text{Engr. per ft.}\right) + \$\,\text{Multitaps per household} + \$\,\text{drop cable}\right\} \times \text{Number of households}$$

The assumed cost for each element of this equation is presented in Appendix C. Figure 2.14 shows the graph of costs for a conventional cable network as a function of community size and density.

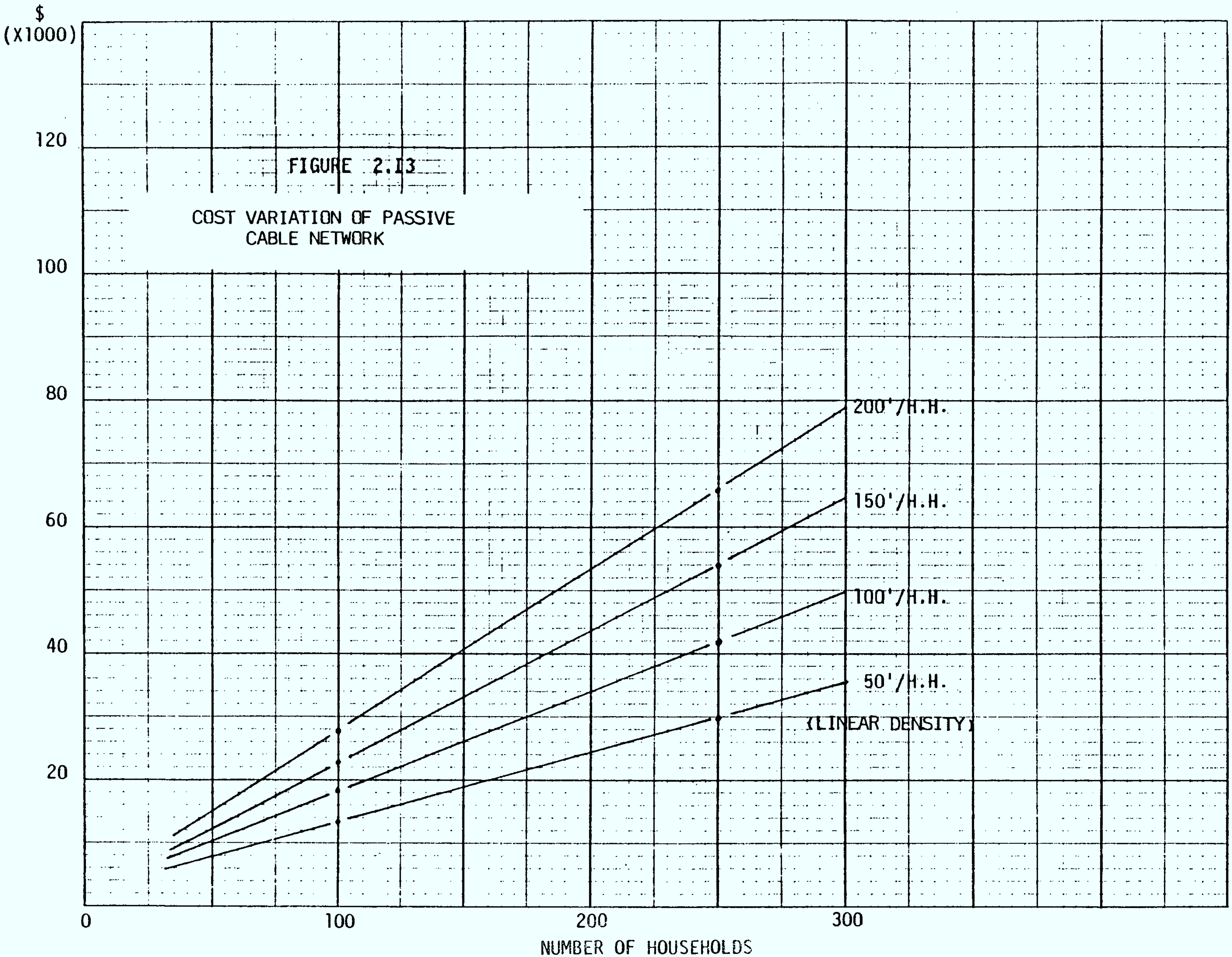
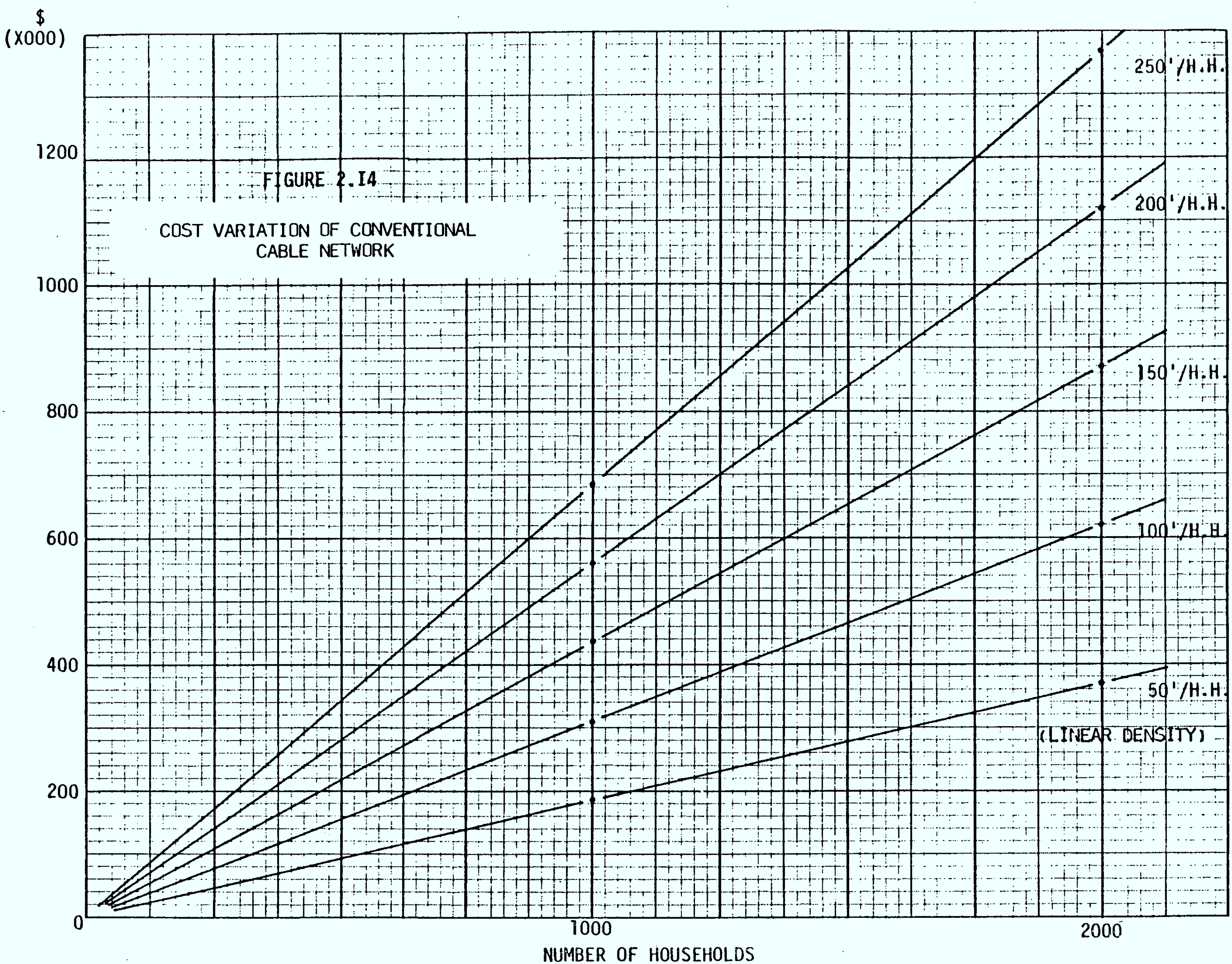


FIGURE 2.13
COST VARIATION OF PASSIVE CABLE NETWORK
$ (X1000)
120
100
80
60
40
20
0
100
200
300
NUMBER OF HOUSEHOLDS
200'/H.H.
150'/H.H.
100'/H.H.
50'/H.H.
(LINEAR DENSITY)


$
(X000)
1200
1000
800
600
400
200
0
FIGURE 2.I4
COST VARIATION OF CONVENTIONAL
CABLE NETWORK
250'/H.H.
200'/H.H.
150'/H.H.
100'/H.H.
50'/H.H.
(LINEAR DENSITY)
1000
2000
NUMBER OF HOUSEHOLDS

f) Very High Capacity Microwave (VHCM)

A cost study of low-power (100 mW and 15 miles range) VHCM system is presented in Appendix C. Table 2.9 summarizes the cost of transmitting and receiving equipment for 8 or 16 channels. The annual maintenance cost represents about 5% of the total capital cost of an installed system.

Table 2.9

VHCM system cost

	Components	COSTS INSTALLED ($ 1982) 8 channels	16 channels
Transmitting station	- First channel	$ 94 000	$ 94,000
	- Additionnal channel	$ 56 000	$ 120,000
	Total	$ 150 000	$ 214,000
Receiving station	Cost per link	$ 37 000	$ 37,000
Total cost for four links		$ 298 000	$362 000
Cost per link		$ 74 500	$ 90 500
Cost per channel per link		$ 9 313	$ 5 656

g) Rebroadcast transmitters

A cost study for a 25 watts UHF system is presented in Appendix C. Such a system has a 2 mile coverage that is appropriate for 500 to 1000 household communities.

The implementation cost for an 8 channel system is estimated as follows:

- capital cost $ 89 000
- annual cost
  - maintenance $ 5 000
  - administration $ 15 per household

2.3.3.2 Cost of distribution models

In the present section, the capital cost of the various distribution models will be calculated and illustrated graphically. Descrambler costs will be excluded for now but the computer simulations presented later on in this report will take these costs into account, as well as annual operating costs.

The capital costs can be derived using the following equations:

Direct to home model

$$\text{DTH (Cost/H.H.)} = \overset{\$}{\text{Antenna}} + \overset{\$}{\text{Receiver}}$$

Direct Passive Cable model

$$\text{DPC (Cost/H.H.)} = \frac{\overset{\$}{\text{Antenna}} + \overset{\$}{\text{Passive cable}}}{\text{Nb of households}} + \overset{\$}{\text{Receivers}}$$

Indirect Passive Cable Model

$$\text{IPC (Cost/H.H.)} = \frac{\$\,\text{Antenna} + \$\,\text{Receiver} + \$\,\text{Passive cable}}{\text{Nb. of households}}$$

Indirect Rebroadcasting Transmitter Model

$$\text{IRB} = \left(\frac{\$\,\text{Antenna} + \$\,\text{Receiver} + \$\,\text{Local scrambler} + \$\,\text{Rebroadcasting transmitter}}{\text{Nb. of households}}\right) + \text{Local descrambler}$$

Indirect Conventional Cable Model

$$\text{ICTV} = \frac{\$\,\text{Antenna} + \$\,\text{Receiver} + \$\,\text{Conventional cable}}{\text{Nb. of households}}$$

Indirect Remote Cable Model

$$\text{IRC} = \frac{\left(\dfrac{\$\,\text{Antenna} + \$\,\text{Receiver} + \$\,\text{VHCM transmitter}}{\text{NB. of links}}\right) + \$\,\text{VHCM receivers} + \$\,\text{conventional cable}}{\text{Nb. of households}}$$

Table 2.10 shows the cost per household for the 6 models for community sizes of 25, 50, 100, 250, 500 and 1000 households. These values have been calculated assuming a 16 channel capacity and a lineal density of 150 route feet per household for both 53 dBW and 58 dBW satellite EIRP. It is clear that these costs per household will vary with the size of communities and the linear density. For the purpose of model selection and considering the types of communities encountered in Rural Canada, we believe that the selected values are representative of the average Canadian situation.

Table 2.10

Ground Segment Model Costs

Cost per household (without DBS descrambler) ($ 1982)

Model	Satellite EIRP	Community size (number of households)					
		25	50	100	250	500	1000
DTH	53 dBW	950	950	950	950	950	950
	58 dBW	575	575	575	575	575	575
DPC	53 dBW	500	455	432			
	58 dBW	485	447	429			
IPC*	53 dBW or 58 dBW	981	586	388	285		
IRB*	53 dBW or 58 dBW				711	430	290
ICTV*	53 dBW or 58 dBW					546	490
IRC*	53 dBW or 58 dBW					642	539

* Assumed household density: 150 route feet per household

2.3.4 Selection of models

A rapid comparison of the capital cost per household shown in Table 2.10 for each of the 6 ground models leads to the following conclusions:

Depending on the size of community, there are several alternatives which compete with the direct-to-home model; taking for example a satellite signal of 58 dBW EIRP:

- For a community size of 25 households, the direct passive cable (DPC) model costs $485 per household as opposed to $575 for the direct-to-home model (DTH);

- For a community size of 100 households, the Indirect Passive Cable (IPC) costs $388 per household compared to $429 for the direct passive cable model (DPC);

- And finally with a community size of 500 households the Indirect Conventional Cable model (ICTV) costs $546 per household as opposed to $642 for the Indirect remote cable model (IRC) and $575 for the direct-to-home model (DTH). The Indirect passive cable (IPC) applied only for smaller communities.

At this stage, it should be noted that even though the cost per household of the indirect rebroadcast transmitter model (IRB) is lower than the indirect conventional cable model (ICTV), for communities of 500 households and more, the IRB has to be rejected as a feasible alternative for DBS signal delivery because of its inherent limitation to a maximum of 8 channels, resulting from the frequency allocation for rebroadcasting as discussed previously.

Beyond the technical and economical criteria used in this paragraph for the elimination of various models, one must keep in mind that other important considerations should also be taken into account prior to any final decision regarding the most appropriate models for specific applications.

Consequently, four ground segment models can be retained for a Canadian DBS system:

- direct-to-home model (DTH)
- direct passive cable model (DPC)
- indirect passive cable model (IPC)
- indirect conventional cable model (ICTV)

To assist in the final selection of models suitable for a given community, Figure 2.15 plots on the same graph the capital cost per household for each of these four models, as a direct function of the number of households and for 250', 150' and 50'/household linear densities.

This graph permits the identification of the capital cost breakeven points for the ground segment between the different models. For example, the constant cost line of the DTH model at 58 dBW EIRP intersects the DPC model curves corresponding to the 50', 150' and 250' per household density at points A, B and C respectively. These three points represent the breakeven costs between the DTH at 58 dBW EIRP and the DPC models.

Similarly, the breakeven points between the DTH model at 53 dBW EIRP and the DPC model or the IPC model are identified respectively by the letters I, J, K and L, M, N for 50', 150' and 250' per household densities.

Following the same reasoning, the breakeven points between the DPC model and the IPC model are identified by E, D and C for 50', 150' and 250' per household density. Finally, the points F, G and H correspond to the breakeven points between the IPC model and the ICTV model.

These breakeven points have been reported on Figure 2.16 to define the domains of applications of each model as a function of the number of households and the linear households density which are the two main variables defining the cluster characteristics of communities in Rural Canada.

This graph could also be used as a guideline for the selection of suitable models for any particular circumstance.

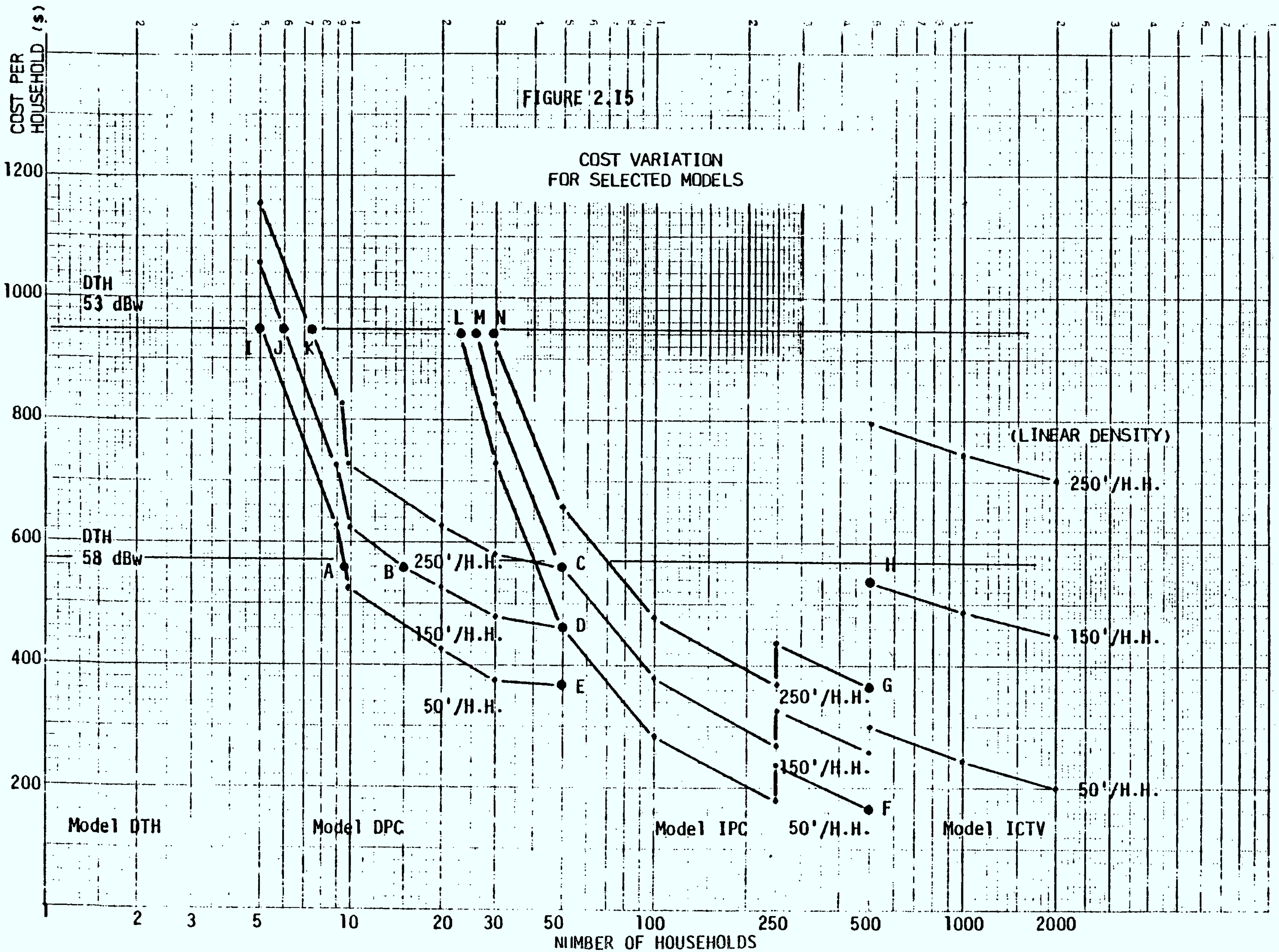


FIGURE 2.15
COST VARIATION
FOR SELECTED MODELS
COST PER HOUSEHOLD ($)
1200
1000
800
600
400
200
DTH
53 dBw
DTH
58 dBw
I
J
K
L
M
N
A
B
C
D
E
F
G
H
250'/H.H.
150'/H.H.
50'/H.H.
(LINEAR DENSITY)
Model DTH
Model DPC
Model IPC
Model ICTV
2
3
5
10
20
30
50
100
250
500
1000
2000
NUMBER OF HOUSEHOLDS

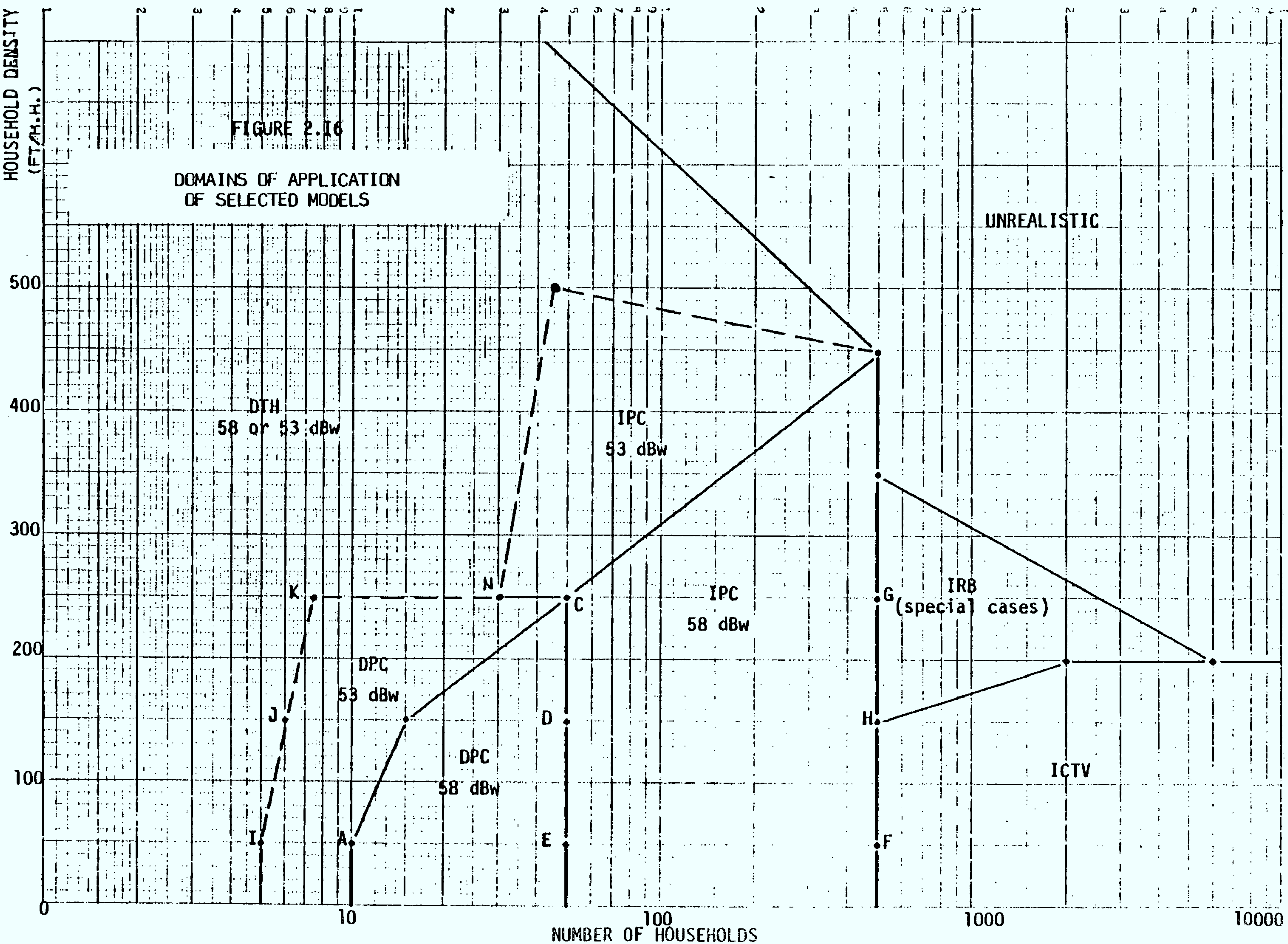


FIGURE 2.16
DOMAINS OF APPLICATION
OF SELECTED MODELS
HOUSEHOLD DENSITY
(FT/H.H.)
UNREALISTIC
DTH
58 or 53 dBw
IPC
53 dBw
IPC
58 dBw
DPC
53 dBw
DPC
58 dBw
IRB
(special cases)
ICTV
K
N
C
G
J
D
H
I
A
E
F
500
400
300
200
100
0
10
100
1000
10000
NUMBER OF HOUSEHOLDS

2.4 Economic considerations

2.4.1 DBS program package

At the beginning of the present contract, we were provided with the characteristics of possible DBS services. The list of 29 possible TV services on a DBS was as follows:

Channel #	Television Service
	- During the initial years of a DBS
1	CBC (English)
2	CBC (French)
3	Educational (English)
4	Educational (French)
5	Pay-TV (English)
6	Pay-TV (French)
7	Private advertiser-supported network or station (English)
8	Private advertiser-supporter network or station (French)
	- Possible additions during subsequent years
9	Public interest programs/House of Commons (English)
10	Public interest programs/House of Commons (French)
11	Multilingual Channel
12	Native Channel
13	CBC II
14	TELE II
15	Regional Pay-TV (English)
16	Regional Pay-TV (French)
	- Special Channels (1), such as:

17 Childrens channel
18 Foreign Program Channel (English and French audio)
19 Potpourri: senior citizens' programs, womens' interest programs, etc.

- Vertical Programming Channels (2)

20 Sports Channel
21 Movies Channel
22 Religious Programming (English)
23 Religious Programming (French)
24 News and Weather Network
25 Adult Oriented Programs

- Narrow Casting Channels (3)

26 Culture channel (English)
27 Culture channel (French)
28 Professional Continuing Education
29 "Teach Yourself" Programs

1. Unscrambled, advertiser-supported programs on a variety of topics aimed at specific audiences.

2. Unscrambled, advertiser-supported programs in one field of interest only, aimed at the general/mass audience.

3. Scrambled, subscriber supported programs of a specialized nature aimed at specific audience.

Note: No priority implied by order of listing.

Since that document was provided to us, there have been a number of developments which are likely to have a significant impact on the characteristics of DBS services.

The first of those is the CRTC's pay TV decision which awarded a much greater number of licenses than was generally anticipated; two national licenses, one for general interest programming, one for more specialized type of programming, were issued; three regional licences for general interest programming were also issued and a multicultural pay TV service was also approved. The CRTC has also called for additional proposals for regional services in Quebec and British Columbia, and for proposals that would permit present regional licensees to spill over from the territory for which they were originally licensed.

What this development means is that in most areas of Canada there will be a minimum of three discretionary services financed entirely by the subscriber, and in some regions, that number could be as high as four or five. And all this will happen the very first day that the first Anik C satellite begins operating.

The second significant development is in our opinion Rogers Cable TV's application to the CRTC for the introduction of tiered services. In this application, dated March 3, 1982, Rogers proposes to offer three channels to its subscribers on a tiered basis. The three channels would contain advertising material and would have the following characteristics:

- a sports channel
- a news channel
- a concert and variety specials channel.

The three channels would be offered at $ 3,00 per month on a discretionary basis.

What is happening in our opinion, is that the number of discretionary services, partly or totally financed by the subscriber, is likely to be large. This is very important in the context of the present study because of the impact this will have on where, and at what cost descrambling of DBS signals will take place.

In the case of individual reception of DBS signals, the problem is non existant since we have assumed that a universal descrambler would be installed at every location. It is for the indirect passive cable (IPC) subscribers that the problem exists; if, in the case of discretionary services, one had to perform:

- satellite descrambling
- local rescrambling
- and all technical and administrative tasks associated with tiered discretionary services,

this would most probably make these small cable systems unmanageable for the technical point of view and/or uneconomical in view of the costs involved.

The basic assumption we have thus retained in the present study is that in the case of tiered services for IPC subscribers, descrambling would be performed within subscriber premises and not at the head end; by developing assumptions related to the percentage of IPC customers that would subscribe to at least one discretionary service, we are thus able to calculate the number of IPC subscribers equipped with a decoder (identical to the one associated with DTH subscribers) and the costs associated with such decoders.

2.4.2 Market penetration of DTH terminals

As was illustrated earlier in this report, two main alternatives regarding DBS power levels will have to be analyzed. One proposed system would operate at 58 dBW and would require 0,8 m earth stations (1,2 m for IPC) while the other would operate at 53 dBW and would require 1,2 m earth stations (1,8 m for IPC).

The two power levels, because of their requirement for antennas of different sizes and costs would thus have two types of impact:

- an impact on the market share between the DTH and IPC distribution models; this type of impact can be analyzed in the present study by gradually modifying (increasing or decreasing) the proportion of rural households that can be serviced by passive cable;

- an impact on the penetration of DTH terminals in cases where they represent the only realistic alternative (very isolated households). This type of impact cannot be addressed in the present study but the mandate in that respect seems very clear when it states that:

  "The purpose of the study is to compare the capital and operating costs of alternative methods of delivering extended television and radio service to all of the population of Canada, using DBS as a basic technology ..."

Since the focus of the present study is on system cost differences, this requires that we compare "apples with apples", which explains why we have not attempted to evaluate the impact of higher terminal costs on the truly isolated DTH market.

2.5 Approach used in the present study

The approach used in the present study has thus consisted on focusing on the capital and operating costs associated with the following two (2) distribution models:

- DTH: Direct to home terminals associated with individual reception in both urban and rural areas

- IPC: Indirect passive cable associated with community reception by clustered households in rural areas.

a) The ICTV model (conventional cable networks) was not further considered in the study because the power level of DBS satellites (53 or 58 dBW) will have little or no impact on the capital and operating costs of such networks. It was also assumed that no conventional cable subscriber would become a DTH subscriber.

b) The IRB model (Indirect Rebroadcasting) was also eliminated, but this time on strict technical grounds; the model simply cannot meet the 16 channel minimum requirement envisaged for DBS services, anywhere in Canada, not even in the UHF mode and especially not in the VHF mode.

c) The DPC (direct passive cable) model was not considered further as well because of its similarity with the DTH model and because of other constraints such as:

- who would own and be responsible for the common unit (antenna + LNA)?

- where and under what conditions would the wire, connecting individual households, be strung?

d) The VHCM sub-model finally was not considered as well because of the general nature of the present study; VHCM technology presents a very interesting potential though, because it can provide a cost effective alternative to individual cable system located in small and medium size communities within a 15 to 25 mile radius. The technology, because it suppresses the requirement for a head end in each community, could provide delivery of various types of services in smaller areas at very reasonable costs; these services would include not only DBS signals, but local and distant off air signals as well a local programming capabilities.

The rest of this report will now be centered on the economic evaluation of how, the space segment models developed at the beginning of this chapter, impact on the two distribution models (DTH and IPC).

3. COMPUTER SIMULATION MODEL

3.0 COMPUTER SIMULATION MODEL

3.1 Objectives

The simulation model developed for this study will calculate on an annual basis the capital and operating costs associated with the distribution of DBS signals in the DTH (direct to home) and IPC (indirect passive cable) modes. This annual stream of expenditures is then brought back to a net present value (NPV), using an appropriate discount rate. Any system configuration can thus be analyzed in terms of its impact on the net present value of system costs; for example the increase in the power level from 53 dBW to 58 dBW will produce a different annual stream of expenditures because of lower earth station costs, which in turn produces a lower NPV. Through sensitivity analysis, the model also permits a rapid evaluation of the assumptions associated with any of the variables used.

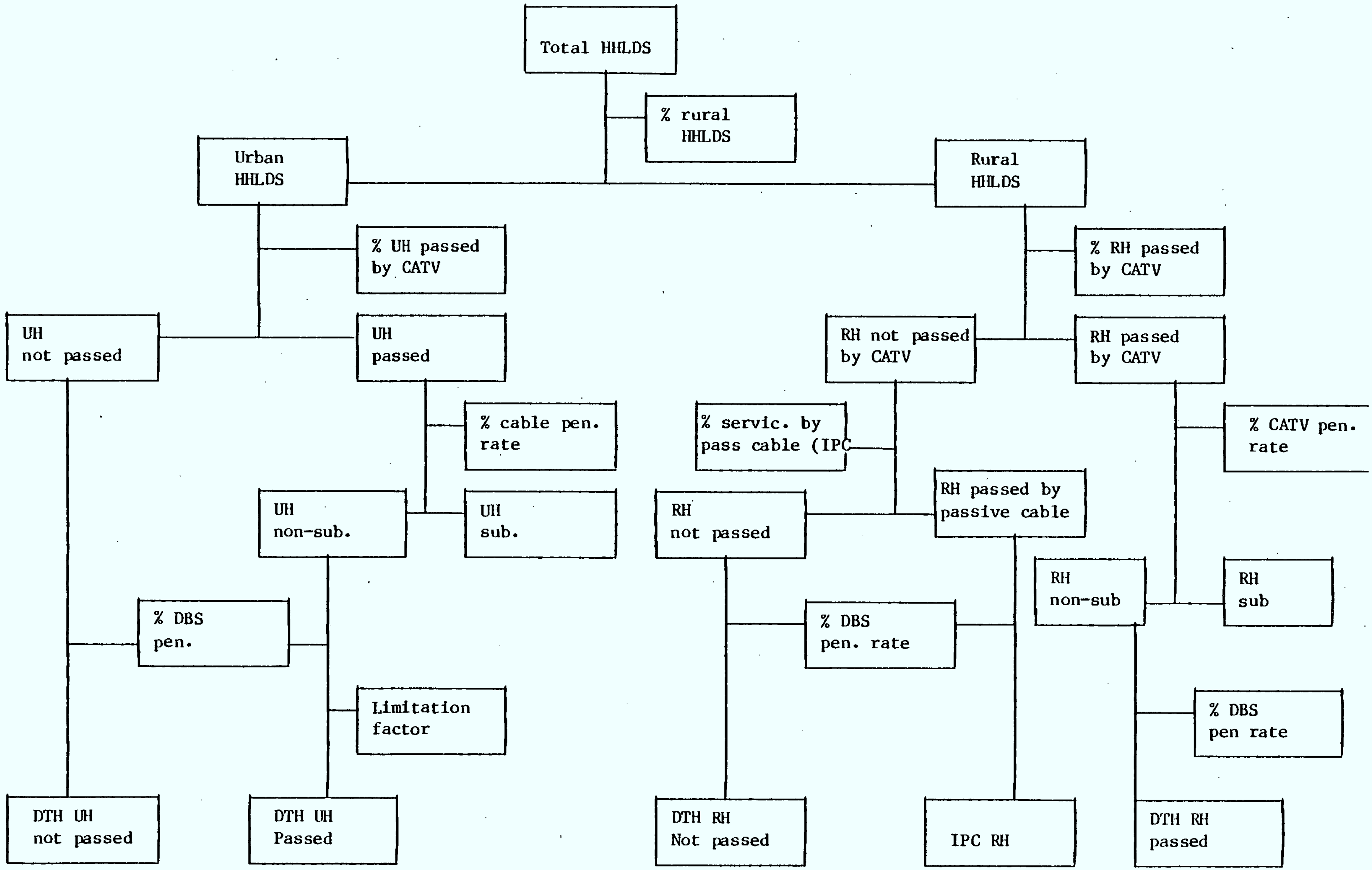
The model consists of three sub-models which are:

- Household (urban and rural) forecast sub-model
- DTH and IPC forecast sub-model
- Cost sub-model

3.2 Household forecast

This sub-model, as illustrated in the figure 3.1 first produces a household projection to the year 1996 and then proceeds to project the number of urban and rural households for each of the following six regions:

FIGURE 3.1: DTH and IPC household forecast



- British Columbia, Northwest Territories and Yukon
- Alberta
- Manitoba and Saskatchewan
- Ontario
- Quebec
- Atlantic Provinces

3.3 DTH and IPC household forecast

The following steps were taken in projecting DTH and IPC households.

1. Given the projected number of urban and rural households, the model calculates households passed and not passed by cable (CATV) for each of the 6 Canadian regions.

2. The model applies, by region, a cable penetration rate for urban and rural households passed by cable.

3. From steps 1 and 2, the following market segments of the potential DTH market are identified:

- urban households not passed by cable
- urban cable subscribers
- urban cable non-subscribers
- rural households not passed by cable
- rural cable subscribers
- rural cable non-subscribers.

The market segments consisting of cable subscribers (rural and urban) are then excluded from the analysis.

4. Among the remaining four potential market segments identified in step 3, the model applies the same DTH penetration rate to the following three (3) market segments:

- urban households not passed by cable
- urban cable non-subscribers (1)
- rural cable non-subscribers.

5. Rural households which are not passed by cable, the last market segment, are treated differently because of the possibility of using passive cable (IPC). The model distinguishes between households serviceable by passive cable and households which are not serviceable by IPC, and calculates via the same DBS penetration ratio, the following two DBS market segments:

- IPC rural households
- rural households not passed by cable (CATV or IPC)

6. As derived from steps 3 to 6, DTH and IPC households are projected from the following market base:

   - DTH urban households not passed by cable (DTH UH)
   - DTH urban households passed by cable (DTH UH passed) (1)
   - DTH rural households not passed by cable (DTH RH)
   - DTH rural households passed by cable (DTH RH passed)
   - IPC rural households (IPC RH)

---

(1) A limitation factor is applied to this particular category in order to reflect factors such as no line of sight, tenure of the dwelling (own versus rent), dwelling type (single versus multiple unit).

3.4 Cost sub-model

This sub-model, illustrated in the four following figures treats DTH and IPC households separately and also distinguishes between capital and operating costs.

3.4.1 DTH costs

1. Annual DTH households capital costs are calculated from the year over year increase in projected DTH households and include the following equipment components:

- antenna and LNA
- receiver
- descrambler

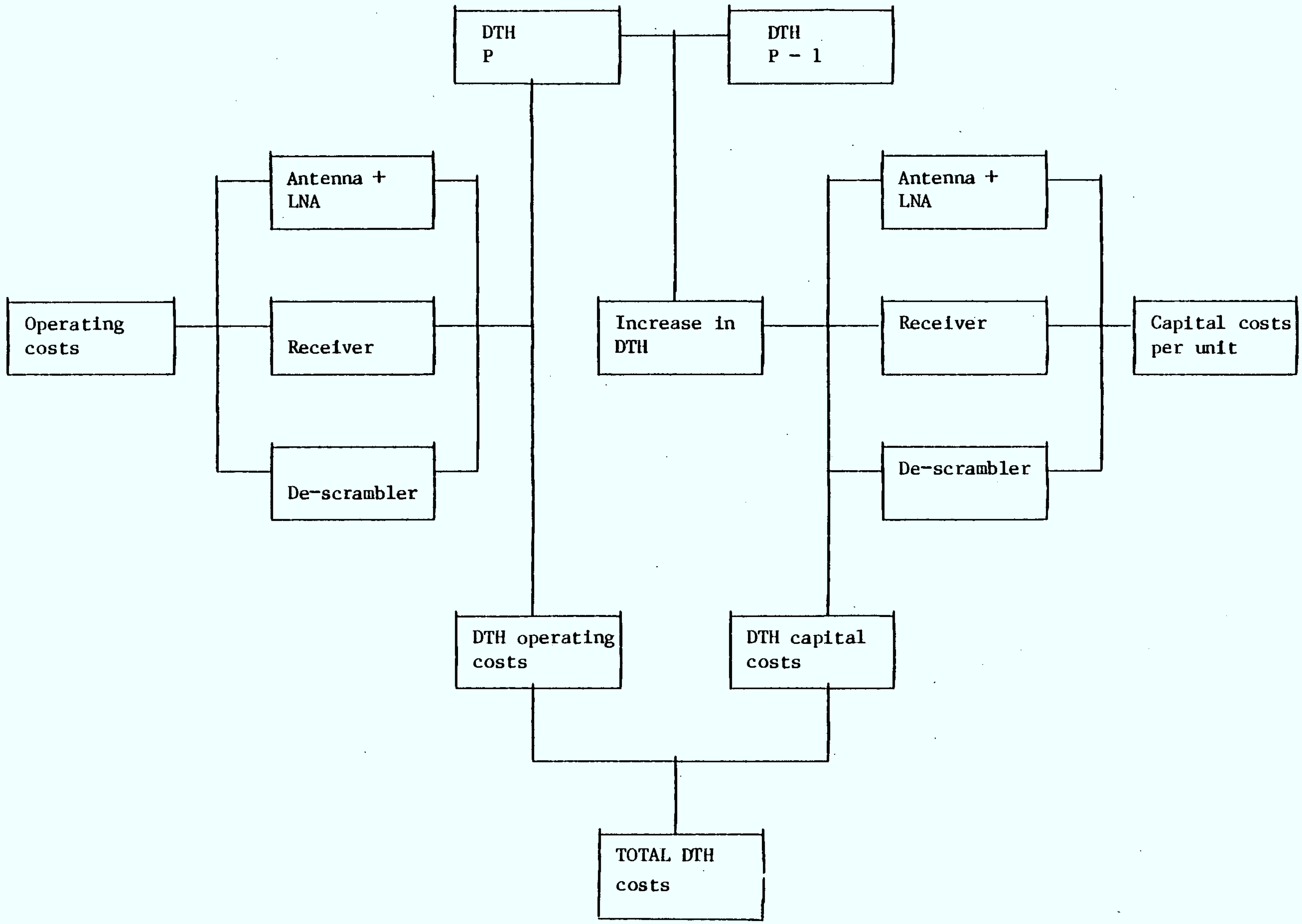
2. Annual DTH operating costs, derived for each of the above equipment categories are calculated from the total number of projected DTH households.

3. Total DTH costs (as illustrated in figure 3.2) are derived from steps 1 and 2.

3.4.2 IPC costs

In calculating IPC costs, the model differentiates between system related and subscriber related costs for both capital and operating costs.

Figure 3.2: DTH costs forecast



3.4.2.1 IPC capital costs

1. The model calculates, via an average size index, the number of IPC systems, in any given year, for each of the six regions.

2. System related capital costs are calculated from the year over year increase in projected IPC systems in the following fashion:

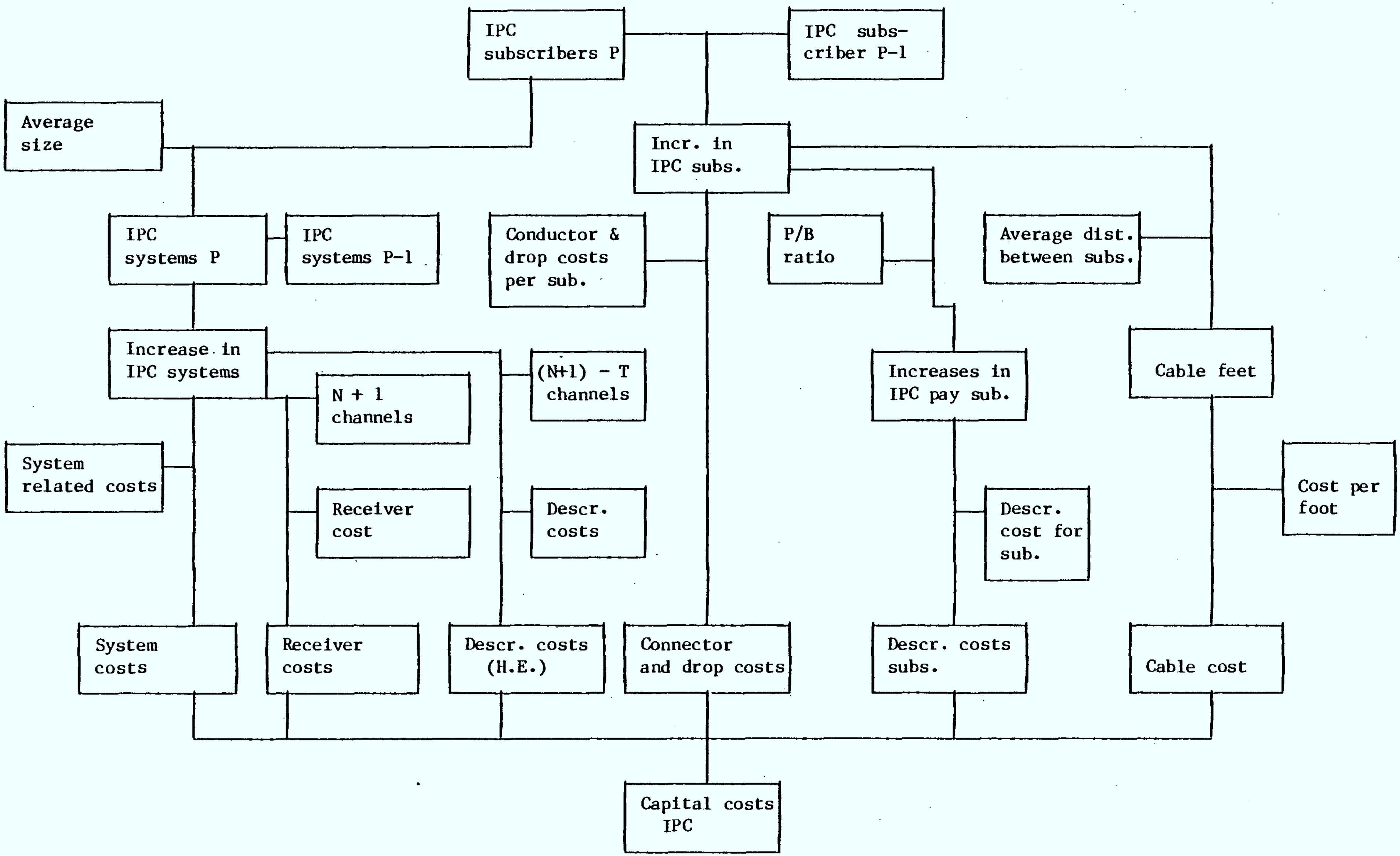
   - head end: increase in IPC systems multiplied by head end costs (antenna, LNA, booster amplifier and engineering);
   - Receivers: increase in IPC systems multiplied by total number of channels multiplied by receiver cost;
   - descramblers: increase in IPC systems multiplied by the number of untiered signals (channels descrambled at the head end) multiplied by descrambler costs.

3. When the total number of channels is increased at any given point in time the following additionnal calculations are performed:

   - Receivers: Total number of IPC systems multiplied by number of additionnal channels multiplied by receiver costs;

   - Descramblers: Total number of IPC systems multiplied by additionnal number of untiered signals multiplied by descrambler costs.

Figure 3.3: IPC capital costs forecast



4. IPC subscriber related costs, calculated from the year over year increase in projected IPC subscribers, consist of following components:

   - connector and drop costs
   - descrambler costs for IPC pay-subscribers
   - cable costs (derived via an average distance index between IPC subscribers).

5. Total capital IPC costs are derived from steps 1, 2, 3 and 4.

3.4.2.2. IPC operating costs

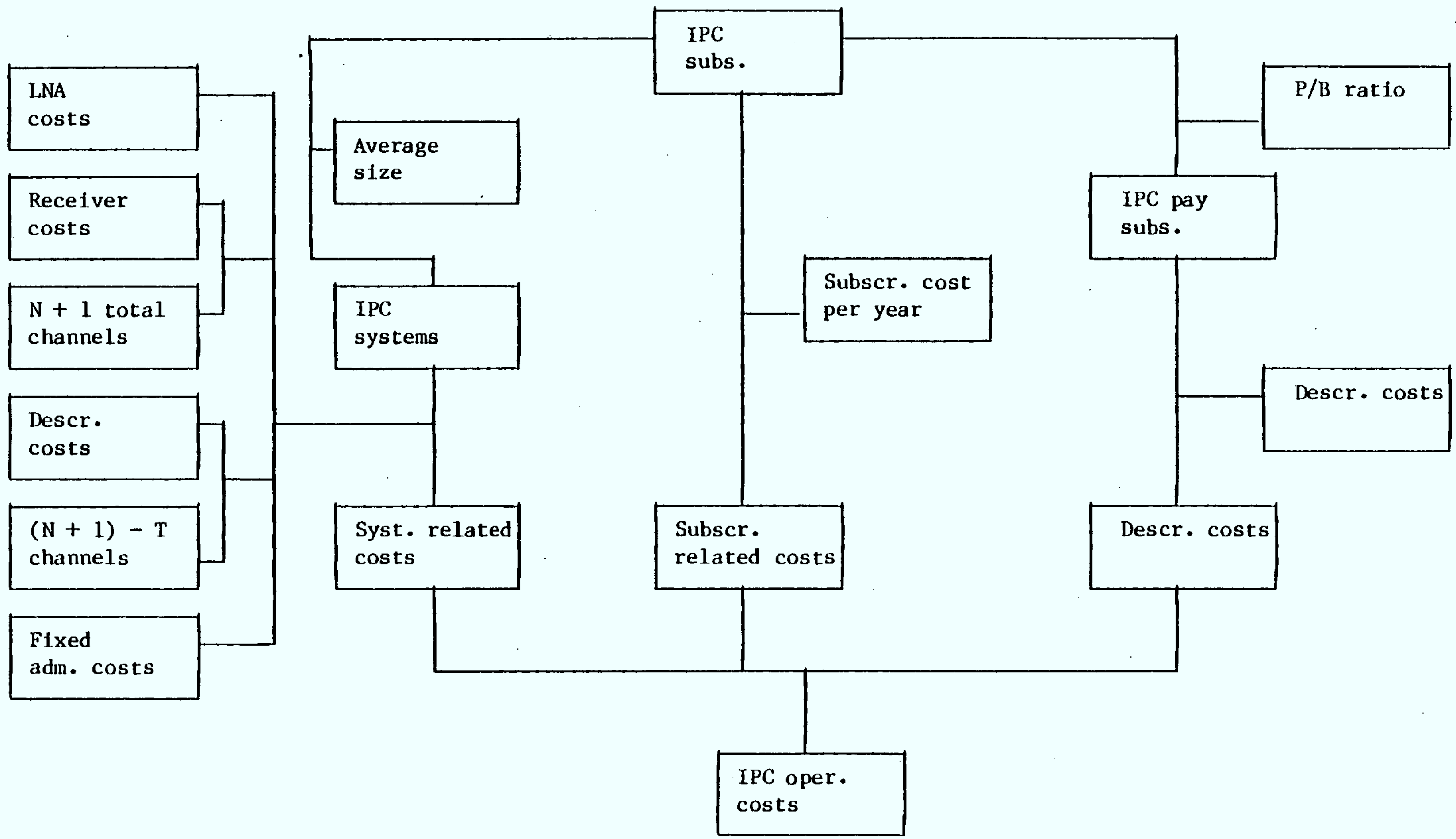
1. Annual IPC system related costs, which include maintenance expenses and fixed administration costs are calculated on a per system basis; receiver and descrambler maintenance costs on the other hand are calculated on a per channel and per system basis.

2. Annual IPC subscriber related operating costs, consisting of cable administration fees and other maintenance costs, are calculated on a per subscriber basis.

3. To this last step, descrambler maintenance costs are added to the number of projected IPC pay-subscribers.

4. Total IPC operating costs are derived on a system-wide basis from steps 1, 2 and 3.

Figure 3.4: IPC operating costs



3.5 Evaluation criteria and procedure

3.5.1 Net present value (NPV)

The model proceeds to calculate, through an appropriate discount rate, the 1983 net present value (NPV) of the stream of annual DTH and IPC costs, as derived from section 3.4. The year 1983 was chosen since it was assumed that Anik C would play an interim DBS role.

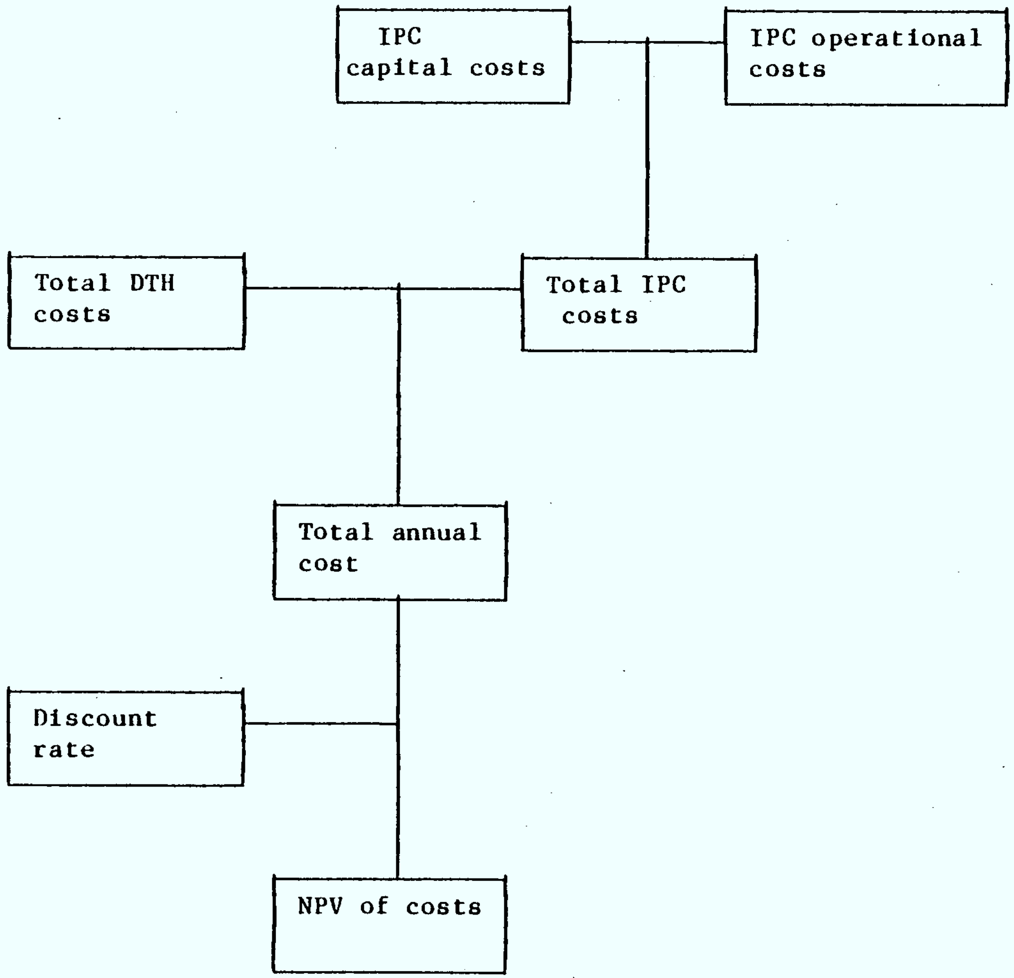
3.5.2 Sensitivity analysis

Because of uncertainty associated with many of the variables, the model incorporates sensitivity analysis features, through which each variable may be gradually modified in order to determine to what extent such modifications affect the NPV of any system configuration.

These variables are the following:

- antenna cost: variability of antenna cost is directly related to antenna size which reflects the satellite transmission power
- IPC penetration
- DTH penetration
- IPC pay-tv penetration
- passive cable system costs.

Figure 3.5: NPV of costs



4. DEFINITION OF INPUT DATA

4. DEFINITION OF INPUT DATA

4.1 Household projection sub-model

4.1.1 Total households by region

The total number of Canadian households should grow from 7,8 million in 1980 to slightly more then 10,2 million in 1996. The assumptions associated with this forecast are presented in the following table.

Table 4.1
Household projection by region, 1980-1996

	Households (000)		Growth rate in %
	1980	1996	
British Columbia	896	1439	2,8 %
Alberta	662	884	1,7 %
Man./Sask.	656	634	-0,5 %
Ontario	2910	4114	2,1 %
Quebec	2046	2424	0,9 %
Atlantic Provinces	637	749	0,9 %
Total	7807	10245	1,6 %

Sources: - Statistics Canada
- Tamec Inc., A feasibility study for a Canadian DBS program package

4.1.2 Rural versus urban households

Estimation of future DBS clients requires that a distinction be made between urban and rural households, as there are important differences in the availability of services as well as in the means of providing services to urban and rural areas.

The proportion of rural households to total households varies by region. This proportion has been estimated for 1976 using Statistics Canada data for total households and "DOC Rural Data" as reported in a study (1) of rural households.

Table 4.2 shows the resulting proportions. For all of Canada, rural households in 1976 accounted for 24.51% of total households, but the proportion of rural households in relation to total households has been steadily decreasing. To evaluate this rate of decrease, we have had to use the 1966 and 1976 Statistics Canada figures, and to assume that the rates will remain constant between 1976 and 1996.

Table 4.3 shows the projected proportions to 1996. For Canada, rural households would decline from 24.51% of total households in 1976 to 20.21% in 1996, representing a -0.961% annual trend in the proportion.

4.2 DTH households in urban areas

4.2.1 Cable passed and cable subscribers

The urban areas of Canada are presently heavily cabled with approximately 96% of the urban population having access to cable services; as the next table illustrates we have assumed that this ratio of urban households passed by cable will remain constant throughout the period considered.

The penetration rate on the other hand was assumed to reach 90% of households passed in all regions, except in Quebec where the initially lower penetration rate would reach 75% by 1996.

---

(1) "The clustering of households in rural and remote Canada", G.D. Cormack and S. Brown, Dec. 1978.

Table 4.2

Rural households to total households

by region (1976)

Region	Total HHLDS (1) (000)	Rural HHLDS (2) (000)	Rural/total (%)
Nfld.	131,7	63,3	
PEI	32,9	23,9	
NS	243,1	110,7	
NB	190,4	95,9	
Atlantic	598,1	293,8	49,12 %
Québec	1894,1	398,0	21,01 %
Ontario	2634,6	495,7	18,82 %
Manitoba	328,0	98,3	
Sask.	291,1	138,6	
Prairies	619,1	236,9	38,27 %
Alberta	575,3	145,9	25,36 %
B.C.	828,3	179,6	
Yukon	6,5	2,4	
N.W.T.	10,0	4,1	
B.C.-Yukon-N.W.T.	844,8	186,1	22,03 %
CANADA	7166,1	1756,4	24,51 %

(1) From Statistics Canada, Market Research Handbook, 1981, p. 222.
(2) DOC definition. From GD. Cormack, op. cit., p. 118.

Table 4.3

Rural households to total households

Projections of ratios by region (1976 - 1996)

Region	Rate of decrease (1) (%/year)	Proportion of rural HH to total HH 1976	1980	1988	1996
Atlantic	- 0,319	49,12	48,50	47,27	46,08
Québec	0	21,01	21,01	21,01	21,01
Ontario	- 0,847	18,82	18,19	16,99	15,88
Man./Sask.	- 1,669	38,27	35,78	31,27	27,33
Alberta	- 2,613	25,36	22,81	18,41	14,90
BC, Yukon, NWT	- 0,660	22,03	21,45	20,35	19,30
Canada	- 0,961	24,51	23,58	21,83	20,21

(1) Based on 1966-1976 trend from Statistics Canada

Table 4.4

Urban households: Percentage passed and penetration rate

	Percentage passed 1980 to 1996	Penetration rate 1980	1996
British Columbia	96%	90%	90%
Alberta	96%	68%	90%
Man./Sask.	96%	74%	90%
Ontario	96%	77%	90%
Quebec	96%	51%	75%
Atlantic Provinces	96%	75%	90%

4.2.2 DTH potential market in urban areas

The DTH potential market in urban areas is thus comprised of two (2) categories of households:

- 4% of urban households which are not passed by cable

- urban households which are passed by cable but which do not subscribe. This category varies from one region to another as well as over the time horizon considered. By the year 1996 though, a maximum of 10% of urban households passed would not subscribe to cable, except in Quebec where that percentage would stand at 25%.

4.3 DTH and IPC households in rural areas

4.3.1 Cable passed and cable subscribers

Using various sources (1) we have been able to develop regional forecasts of the percentage of households that will be passed by cable in rural areas. We have made the assumption in the present study, that in terms of conventional CATV systems, these estimates would represent saturation of rural households; this means that the remaining rural households will have to be served either by direct to home terminals or by low cost passive cable systems especially designed for small communities.

These estimates of rural households passed by cable as well as the penetration rates are illustrated in the following table.

---

(1) Sources: - The clustering of households in rural and remote Canada, Cormack and Brown, december 1978
- Matthew's CATV

Table 4.5

Rural households: Percentage passed by cable and penetration rate

	Percentage passed 1980 to 1996	Penetration rate 1980	Penetration rate 1996
British Columbia	31,6%	75%	90%
Alberta	5,3%	75%	90%
Man./Sask.	1,0%	75%	90%
Ontario	9,9%	75%	90%
Quebec	8,4%	75%	90%
Atlantic Provinces	9,7%	75%	90%

4.3.2 The clustering of households not passed by cable

The Cormack study also provides a definition of various types of settlements in Canada; in addition to that definition, the same study graphically illustrated the average distance between households for each cell type.

The basic assumption in the present study, which constitutes our design criteria for passive cable systems, is that all households less than 0,1 mile apart (approx. 500 feet) could be linked together by such a cable system. The following table illustrates the proportion of clustered (less than 0,1 mile apart) versus isolated (more than 0,1 mile apart) households for each cell type.

Table 4.6

Clustering of households
by cell type

Cell type	Description	% clustered (less than 0,1 mile apart)	% isolated (more than 0,1 mile apart)
i	Urbanizing, lineal	95%	5%
ii	Lineal	65%	35%
iii	Dense, areal	70%	30%
iv A	Sparse, areal	55%	45%
iv C	Sparse, areal	60%	40%
iv B & V	Sparse, areal and very dispersed, areal	30%	70%
vi	Settlement, close knit	100%	nil

4.3.3 Rural households serviceable by passive cable

The next step was to estimate the distribution of rural households per cell type for every region considered; an adjustment was made to cell type 'vi' to allow for rural households already passed by cable. The results associated with this approach are illustrated in the following table and they show that the percentage of clustered households (1) would vary from a low of 61,4% in Alberta to a high of 81,9% in the Atlantic Provinces.

---

(1) Less than 0,1 mile apart and thus serviceable by a passive cable system

Table 4.7

Number of clustered households

by cell type and by region

Cell type	British Columbia	Alberta	Man./ Sask.	Ontario	Quebec	Atlantic Provinces
i	-	4 421	3 491	68 979	47 917	-
ii	-	3 158	2 139	154 524	72 524	85 372
iii	-	-	-	72 710	91 941	
iv A	10 379	32 550	51 861	-	-	
iv C	1 307	4 100	6 533	-	-	
iv B & C	7 138	9 841	13 271	-	-	
vi (adjusted)	76 658	32 072	75 833	22 994	62 215	122 377
Total clustered	95 482	86 143	153 127	319 206	275 050	207 749
Number of rural households (adjusted)	121 501	140 404	232 215	437 203	356 271	253 719
% clustered	78,6%	61,4%	65,9%	73,1%	77,2%	81,9%

4.3.4 Average number of clustered households per community

In order to estimate system related costs (1) we had to estimate the average number of households per community. This was again done using Cormack's data and the results are presented in the following table; an adjustment was again made to account for the practical impossibility of servicing all households with the exact number of systems theoretically required (a factor of 0,8 was used)

Table 4.8

Average number of IPC households per system

Region	Theoretical	Practical
British Columbia	120	96
Alberta	98	78
Man./Sask.	106	84
Ontario	57	46
Quebec	74	59
Atlantic Provinces	95	76

4.3.5 Average distance between clustered households

In order to estimate cable requirements (and consequently cable costs) the same data were again used to estimate the average distance between clustered households for each region and the results are presented in the following table.

(1) System related costs would include the community TVRO and associated equipment for example

Table 4.9

Average distance between IPC households

Region	No. of feet
British Columbia	144,5
Alberta	160,1
Man./Sask.	153,8
Ontario	167,8
Quebec	167,2
Atlantic Provinces	144,9

4.3.6 DTH and IPC potential market in rural areas

The DTH and IPC potential market in rural areas is thus comprised of three (3) categories of households which are:

- rural households passed by conventional cable but not subscribing to it

- rural households not passed by cable

  - Isolated households to be serviced by DTH terminals
  - Clustered households to be serviced by passive cable.

4.4 DTH and IPC market penetration

4.4.1 Overall market penetration

The following table illustrates the DTH and IPC market penetration forecast used in the present study. The penetration figures originate from an earlier study performed by Tamec Inc., but the figures were adjusted to take into account larger and more expensive earth stations that would be associated with an interim DBS system (Anik C) during the 1983-1988 period, after which a true DBS would come into operation. The figures reflect the historical penetration of colour TV sets in Canadian households.

Table 4.10

DTH and IPC penetration rate assumption

Year	Penetration in %
1983	0,5%
1984	1,0%
1985	2,0%
1986	4,0%
1987	8,0%
1988	12,0%
1989	18,0%
1990	24,0%
1991	33,0%
1992	45,0%
1993	55,0%
1994	65,0%
1995	75,0%
1996	80,0%

4.4.2 Pay to basic ratio

A significant assumption is the decision, described in chapter 2, to allow for descrambling of tiered services within subscriber premises, which will require the installation of a descrambler with IPC customers who subscribe to at least one discretionnary service.

The following table presents our assumption regarding that variable.

Table 4.11

Percentage of IPC households subscribing to at least one tiered service

Year	%
1983	10%
1984	20%
1985	30%
1986 and after	40%

4.5 Capital costs

4.5.1 DTH costs

DTH costs installed, have been described in detail in chapter 2 and are summarized as follows.

Table 4.12

DTH unit costs (installed)

	Antenna size and power level	
	53 dBW 1,2 m	58 dBW 0,8 m
DTH cost		
Antenna & LNA	$ 750	$ 375
Receiver	$ 200	$ 200
Descrambler	$ 200	$ 200
Total cost	$ 1 150	$ 775

4.5.2 IPC costs

IPC costs can he broken down in three categories as follows:

- system related costs
- system and channel related costs
- subscriber related costs

The cost figures used are briefly described in the following three tables.

Table 4.13

IPC system related costs

	Antenna size and power level 53 dBW 1,8 m	58 dBW 1,2 m
Antenna & LNA	$ 1 700	$ 750
Engineering, booster amplifier and backup equipment	$ 4 450	$ 4 450
Total system related costs	$ 6 150	$ 5 200

Table 4.14

IPC system and channel related costs

	Cost per system per channel
Receiver and modulator cost per channel (all channels)	$ 850
Descrambler cost per channel (untiered channels)	$ 200

Table 4.15

IPC subscriber related costs

Connectors and drop	$ 60/sub.
Cable cost	$ 1,00/foot
Descrambler for tiered signals	$ 200/sub.

4.6 Operating costs

4.6.1 DTH costs

The average annual maintenance expenditures for DTH terminals were estimated as follows.

Table 4.16

Average annual DTH maintenance cost

Antenna & LNA	$ 20
Receiver	$ 20
Descrambler	$ 20

4.6.2 IPC costs

The average annual maintenance IPC costs were estimated as follows.

Table 4.17

Average annual IPC maintenance cost

Antenna & LNA	$ 20/system
Receivers (all channels)	$ 20/system/channel
Modulators (all channels)	$ 20/system/channel
Descramblers (untiered signals)	$ 20/system/channel
Booster amplifier	$ 20/system
Administration (fixed)	$ 1000/system
Administration (variable)	$ 15/subscriber
Descrambler (tiered signals)	$ 20/pay subscriber

4.7 Discount rates

The annual stream of expenditures (capital and operating costs) for any system configuration, and defined for the 1983-1996 period, was brought back to a 1983 net present value (NPV) using a discount rate of 10%. No residual values of equipment were taken into account (1) but on the other hand, savings for more powerful satellites will be slightly exagerated during the 1983-1988 period when no true DBS is in operation. The impact of a discount rate of 15% was also evaluated.

(1) The same assumption was used for space segment costs.

5. RESULTS AND ANALYSIS

5. RESULTS AND ANALYSIS

5.1 Methodology overview

5.1.1 Space segment costs

As was mentioned earlier in this report, space segment costs have not been explicitely taken into account in the computer calculations. But if one is to draw conclusions about the simulations performed, a brief methodological overview seems necessary.

If, for example, all other things being equal, one compares the results associated with the base cases at 53 and 58 dBW, one will certainly obtain a lower NPV of costs for the 58 dBW case, since lower antenna costs are the only variable that can affect the result.

But what does this tell us exactly? If, for illustrative purposes, the use of a 58 dBW power level reduces the net present value (NPV) of ground segment costs by $250 million, this means that on a strict cost efficiency basis, one should launch 58 dBW satellites as long as the NPV of space segment costs is not greater than $250 million when compared to 53 dBW satellites.

Costs associated with both power levels were presented in Chapter 2 and can be summarized as follows:

	53 dBW	58 dBW	Difference
Four beam model	$ 315 million	$ 637 m.	$ 322 m.
Six beam model	$ 567 million	$ 935 m.	$ 368 m.

One must remember though that these cost differences have not been discounted. We have developed a theoretical schedule of expenditures for the 4 beam model at both 53 and 58 dBW, using Spar's data as follows:

- Phase I spacecraft expenditures

  . 53 dBW: 3 satellites at \$ 47 million each
  . 58 dBW: 3 satellites at \$ 67 million each
  . Schedule: 1983: 5%
  1984: 10%
  1985: 30%
  1986: 40%
  1987: 15%

- Phase I launch expenditures

  . 53 dBW: 3 satellites at \$16 million each in 1988
  . 58 dBW: 3 satellites at \$60,3 million each in 1988

- Phase II spacecraft expenditures

  . 53 dBW: 2 satellites at \$47 million each
  . 58 dBW: 2 satellites at \$67 million each
  . Schedule: 1987: 10%
  1988: 40%
  1989: 50%

- Phase II launch expenditures

  . 53 dBW: 2 satellites at \$16 million each in 1990
  . 58 dBW: 2 satellites at \$60,3 million each in 1990

When discounting the annual expenditures obtained, at a 10% rate, the NPV of costs associated with both power levels is as follows:

58 dBW: $ 413,7 million
53 dBW: $ 214,3 million

The net present value (NPV) of the cost difference between the two power levels is thus in the $200 million range for the 4 beam model.

When the same approach was used for the 6 beam model, the NPV of the cost difference between the two power levels was found to be $250 million.

The cost differences between a four beam and a six beam model are an entirely different thing on the other hand; one must remember though that this will not affect ground segment costs, but rather space segment costs for users, as well as possibly the number of distinct usable channels (this will depend on service provider requirements in terms of coverage); this aspect of the problem will be treated later in this report.

5.1.2 Base cases at 53 and 58 dBW

The first results presented in this chapter will be those associated with the bases cases at both power levels. The only difference between the two cases being lower antenna costs at 58 dBW, the results will provide an estimate of the NPV value of savings in ground segment costs associated with a higher power level.

5.1.3 Independent variables

The next step in the chapter will be focused on the analysis of the impact of significant variables, on a one by one basis, all other things being equal. This step is necessary in order to compare the sensitivity of many assumptions made in this report and, especially, to determine how changes in such assumptions will affect the choice between both power levels. The following variables will be examined:

- Price of 1,2 m and 1,8 m stations
- The percentage of rural households serviceable by passive cable
- The DTH penetration rate
- The Quebec urban cable penetration rate
- The DTH limitation factor in urban areas passed by cable.

5.1.4 Dependent variables

The next step in the analysis will be focused on the analysis of the impact of dependent variables. The following example will illustrate what we mean. We have assumed that the percentage of IPC households subscribing to at least one tiered service would reach a maximum of 40% of IPC subscribers; this means that all these subscribers would be equipped with an in house descrambler.

Let us suppose now that the percentage figure is 60% instead of 40% and that some of these subscribers, faced anyhow with a $200 cost for the descrambler, might prefer the alternative of purchasing a TVRO. What would be the effect of such an assumption on ground segment costs for both power levels? What is the change in costs vis à vis the base cases?

One of the most important variables in the present study is the percentage of rural households serviceable by passive cable. This "dependent" variable will be subjected to changes in the following other variables.

- higher IPC operating costs
- higher pay to basic ratios
- higher 1,2 and 1,8 m antenna costs.

5.2 Base cases at 53 and 58 dBW

5.2.1 Household and DBS universe forecast

Our household and DBS universe forecast is presented in the following table for selected years. The DBS universe (households having direct or indirect access to DBS signals) is comprised of the following urban and rural household categories:

- cable and passive cable subscribers
- DTH households

As illustrated in table 5.1, the DBS universe would grow from approximately 57% of total Canadian households in 1983 to more than 90% of such households by 1996.

5.2.2 Cable and IPC subscribers

Our forecast of cable and IPC subscribers is illustrated in table 5.2. As shown, the coverage of Canadian households provided by cable would increase from 57% to close to 80% during the period considered.

Table 5.1
Household and DBS universe forecast

	1983	1988	1996
Total households (000)			
Urban	6294	6894	7985
Rural	1877	1934	2045
Total	8171	8828	10029
Cable subscribers			
Urban	4487	5334	6628
Rural	153	173	209
Total	4640	5507	6837
DTH and IPC			
DTH - Urban not passed	1	33	256
DTH - Urban passed not subscribing	5	108	581
DTH - Rural passed	2	53	366
DTH - Rural passed not subscribing	-	4	19
Sub-total DTH	9	198	1221
IPC - Rural	6	154	1083
Total DBS universe	4655	5859	9141
Percentage coverage	57,0%	66,4%	91,1%

Table 5.2

Cable and IPC subscribers forecast

	1983		1988		1996	
	000	%	000	%	000	%
Urban cable subscribers	4487	96,6	5334	94,2	6628	83,7
Rural						
Conventional cable	153	3,3	173	3,1	209	2,6
Passive cable	6	0,1	154	2,7	1083	13,7
Total Rural	159	3,4	327	5,8	1292	16,3
Total subscribers	4646	100,0	5661	100,0	7920	100,0
Total households	8171		8828		10 029	
Cable coverage	56,9%		64,1%		79,0%	

5.2.3 DTH subcribers

Our forecast of DTH subscribers is presented in the following table. This table illustrates that:
as:

- close to 70% of the market for DTH terminals is in urban areas
- roughly 50% of the DTH market consists of households passed by cable which, for one reason or another, refuse to subscribe to cable.

These results will force us to take a closer look at the 'households passed by cable' category when sensitivity analysis is performed.

Table 5.3

DTH subscribers forecast

	1988		1996	
	000	%	000	%
Urban				
Not passed by cable	33	16,6	256	21,0
Passed not subscribing	108	54,5	581	47,6
Sub-total	141	71,2	837	68,6
Rural				
Not passed by cable	53	26,8	366	30,0
Passed not subscribing	4	2,0	19	1,6
Sub-total	57	28,8	385	31,5
Rural and urban				
Not passed by cable	86	43,4	622	50,9
Passed not subscribing	112	56,6	599	49,1
Grand total	198	100,0	1221	100,0

5.2.4. Cost comparison between 53 and 58 dBW

The NPV of ground segment cost savings resulting from the use of higher power satellites is estimated at $219 million. All other things being equal, this means that in the case of the 4 beam model, the launch of 58 dBW instead of 53 dBW satellites would be justified since they would involve an additional space segment cost of only $200 million. On the other hand, again all other things being equal, in the case of the 6 beam model, the more powerful 58 dBW satellites would not be cost efficient since they would involve additional space segment costs of $250 million.

Table 5.4

Cost comparison between 53 and 58 dBW

Power level	Antenna and LNA unit cost ($) DTH	Antenna and LNA unit cost ($) IPC	NPV of ground segment costs at 10% ($ million)
53 dBW	$ 750	$ 1700	$1160
58 dBW	$ 375	$ 750	$ 941
Cost saving	$ 375	$ 950	$ 219

5.3 The impact of independent variables

5.3.1 Increase in the price of 1,2 m and 1,8 m stations

As discussed in chapter 2, the U.S. standard for DBS will probably require earth stations in the 0,8 m to 1,0 m range. As such, 1,2 m and 1,8 station, which would be required at 53 dBW, would not be the standard production model and could conceivably cost more than was assumed. To evaluate the impact on costs associated with such a possibility, we have increased the price of 1,2m and 1,8m stations by 20% (1) from the figures that were used in the base cases while keeping the price of the 0,8m station at $375 (2).

As illustrated, this would result in additionnal costs savings of $86 million brought about by the use of higher power satellites, bringing total savings to $305 million. This means that the use of 58 dBW satellites would be cost efficient under both the 4 and 6 beam models.

Table 5.5

Impact of increases in the price of 1,2 m and 1,8 m stations

$ million

	Discount rate of 10%		
	Base case	Incr. price	Incr. in cost
53 dBW	$1160	1247	(87)
58 dBW	$ 941	942	(1)
Cost saving with 58 dBW	$ 219	305	(86)

5.3.2 Decrease in the percentage of rural households serviceable by passive cable

The chapter on Input Data (chapter 4) demonstrated that a very high proportion of rural households, not presently passed by conventional cable, could be serviceable by passive cable systems (from a low of 61% in Alberta to a high of 82% in Atlantic Canada of such households can be considered clustered, less than 0,1m

(1) The 1,2 m station would now cost $900 from $750, while the 1,8m station would now cost $2040 from $1700. (see note 2 also)

(2) Antenna and LNA only; receiver and descrambler costs do not change.

apart). For various reasons, the actual proportion of households that would be serviceable by passive cable systems could be much lower.

A sensitivity test was performed to measure the impact of changes in that variable. The actual proportion of 'serviceable' households was cut across the board in all regions by factors ranging from 15% to 75%.

The results associated with such changes are briefly summarized in the following table and indicate that each time the ratio of 'serviceable' households is reduced by 15% this produces additional costs savings of $26 million in favor of the 58 dBW alternative.

This means that under the 6 beam model, 58 dBW satellites become cost efficient when the proportion of rural households serviceable by passive cable is reduced by 30% or more.

Table 5.6

Impact of a decrease in the percentage of rural households serviceable by passive cable ($ millions)

% reduction in IPC serviceable	Discount rate of 10%			
	53 dBW	58 dBW	Difference	Increase in difference
0% (base case)	$1160	$ 941	$219	-
15%	$1210	$ 965	$224	$25
30%	$1261	$ 990	$271	$27
45%	$1312	$1015	$297	$26
60%	$1363	$1039	$324	$27
75%	$1413	$1064	$350	$26

The preceeding table also illustrates another interesting result. One might expect for example that the penetration of DTH terminals would be higher under 58 dBW satellites than under 53 dBW satellites, because of the lower cost of antennas and their smaller size. Although one might tend to expect additional cost savings resulting from such a situation, one must also remember that the increase in the number of DTH households would come at the expense of a decrease in the number of IPC subscribers.

The overall effect would in fact be to raise the overall system cost associated with 58 dBW satellites. For example the cost associated with 53 dBW satellites and the base case would be $1 160 millions, while the cost associated with 58 dBW and 30% less IPC subscribers would be $990 millions; this means that the savings generated by 58 dBW satellites would now be $170 millions (instead of $219 millions).

5.3.3 Change in the DTH and IPC penetration rate

Two test were performed to examine the impact of relative changes in the DTH and IPC penetration rates.

- the first test used a factor of 1.25 across the board which means that by 1996 a 100% penetration rate would be reached instead of 80% in both base cases;
- the second test used a factor of 0.5 across the board which means that by 1996 a 40% penetration rate would be reached instead of 80%.

The results associated with such changes are presented in the following table. They show that a 100% penetration rate would increase the 58 dBw advantage by $29 million to $248 million while a 40% penetration rate would reduce the 58 dBw advantage by $58 million to $161 million.

Thus under the 100% penetration scenario, and <u>under the 6 beam model</u> the savings generated by the use of 58 dBW satellites would just be sufficient to offset increased space segment costs. Under the 40% penetration scenario on the other hand, 58 dBW satellites would not be cost efficient under neither the 4 and 6 beam models.

Table 5.7

Impact of changes in the DTH and IPC penetration rates

DTH and IPC penetration rates in 1996	53 dBW	58 dBW	Difference	Increase (decrease) in difference
80% (base case)	$ 1160	$ 941	$ 219	
100%	$ 1350	$ 1102	$ 248	$ 29
40%	$ 779	$ 618	$ 161	($58)

5.3.4 Increase in the Quebec cable penetration rate

As was discussed in section 5.2.3, a large proportion of the DTH market would consist of urban households passed by cable but not subscribing to it. This is a result which is surprising, at least to us, and it could be caused by the lower cable penetration figure we have used for the Province of Quebec (maximum of 75% instead of the 90% used in other regions).

In order to evaluate the impact of such an assumption, we have performed a simulation whereby the Quebec urban cable penetration rate would reach 90% in 1996.

The results associated with this new assumption show that the 58 dBW advantage would be reduced by $23 million to $196 million and that the forecasted number of DTH terminals would also be reduced by approximatively 150 000 units. This means that under the 4 beam model, 53 dBW satellites would become slightly more cost effective than 58 dBW satellites.

Table 5.8

Impact of a higher Quebec urban cable penetration rate

Quebec urban cable penetration rate in 1996	NPV at 10% discount rate ($ million) 53 dBW	58 dBW	Difference	Decrease in difference from base case	Number of DTH (000)
75% (base case)	$1140	$ 941	$ 219	-	1221
90%	$1077	$ 881	$ 196	$ 23	1070

5.3.5 Increase in the limitation factor in urban areas

A limitation factor of 0,7 (1) was used for DTH subscribers passed by cable in urban areas in order to reflect such factors as:

- lack of line of sight to the satellite
- tenure of dwelling (own versus rent)
- dwelling type (single versus multiple)

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(1) This means that only 70% of the potential market can be reached.

Multiple dwellings that are serviced by MATV systems could play a significant role in certain metropolitan areas, since these dwellings are considered passed by cable even though their habitants cannot subscribe to cable even if they want to.

In order to assess the impact of such a variable, the limitation factor was changed to 0,5 and the impact of such an assumption is presented in the following table. This table shows that the cost advantage of 58 dBW satellites is reduced by $30 million to $189 million and that the number of forecasted DTH units is also reduced by 166 000 units. Thus, in the 4 beam model, 58 dBW satellites would not prove cost effective.

Table 5.9

Impact of a different limitation factor for DTH urban households passed by cable

Limitation factor	NPV at 10% discount rate ($ million)			Decrease in difference from base cases	Number of DTH terminals in 1996 (000)
	53 dBW	58 dBW	Difference		
0,7 (base case)	$1160	$941	$219	-	1221
0,5	$1046	$857	$189	$30	1055

5.3.6 Impact of a different penetration curve for DTH terminals

The original assumption, used throughout the study, is based on the historical penetration of colour TV sets in Canadian households. While we believe the analogy between colour TV sets and DBS terminals to be a valid one, there are a number of factors that could affect the penetration of DBS terminals in Canadian households. These factors are as follows:

- A recent market survey (1) has indicated a strong positive reaction for DBS terminals in rural areas and for terminal prices that are roughly compatible with those used in the present study ($600 to $800). The survey indicated that saturation would be reached much more rapidly than we are assuming in the original assumption. However it must be pointed out that the price of $800 for a terminal operating in the 12 GHz band will not be reached for several years, certainly not before 1986-1987 when the market takes off in the U.S. In addition one must also remember that throughout the 1983 to 1988 period, DBS service in Canada will have to rely on Anik C satellites that require larger earth stations; this is especially true in view of the fact that many service providers will use Anik C in the Half Canada and 2 TV/carrier mode.

- In addition, the present study has assumed a minimum of 8 TV signals per beam; again this will not be the case with Anik C, at least not for another 2 to 3 years.

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(1) An analysis of the demand for improved residential television service in rural Canada, Demand Research Consultants Inc., March 1982.

- The signals that will be available with Anik C in the short run, are not sufficiently varied in our opinion to generate substantial interest; they will involve additional monthly charges (pay TV) or are of a fairly specialized nature (public TV, La Sette, etc.).

- The problems associated, in the early stages at least, with transport, distribution and retailing of DBS terminals in rural areas, would tend as well to dampen demand of such terminals.

- Finally one must also remember that our assumption regarding the penetration of DBS terminals applies to both the urban and rural market; the results associated with our original assumption (see section 5.2) have shown that in urban areas, the "households passed by cable" category represents a substantial proportion of the DTH market; taking into account the preceeding factors (high prices of terminals, limited number of services) and the ability of cable to compete both on the basis of cost and variety of services, we believe that this would again tend to dampen demand for DBS terminals.

The preceeding considerations can thus be summed up in the following fashion, in terms of the modified penetration assumption we have developed for DTH terminals.

- 1983 to 1985: modest increase for the original assumption (3,5% instead of 2,0% in 1985)

- From 1986: much more rapid increases in the penetration rate (60% versus 24% in 1990)

- Saturation: both assumptions saturate at 80% in 1996.

Table 5.10

DTH and IPC penetration rate assumptions

Year	Original assumptions	Modified assumptions
1983	0,5%	0,5%
1984	1,0%	1,5%
1985	2,0%	3,5%
1986	4,0%	7,0%
1987	8,0%	15,0%
1988	12,0%	25,0%
1989	18,0%	40,0%
1990	24,0%	60,0%
1991	33,0%	70,0%
1992	45,0%	75,0%
1993	55,0%	80,0%
1994	65,0%	80,0%
1995	75,0%	80,0%
1996	80,0%	80,0%

The results associated with this new assumption are illustrated in the following table. They show that the attractiveness of high power satellites has been increased by $53 million to reach $272 million; this means that 58 dBW satellites would now be cost effective under both the 6 and the 4 beam models.

Table 5.11

Impact of a different penetration curve for DTH terminals

Scenario	NPV at 10% discount rate ($ millions) 53 dBW	58 dBW	Difference
Modified scenario	$ 1 524	$ 1 252	$ 272
Base case	$ 1 160	$ 941	$ 219
Difference	$ 364	$ 311	$ 53

5.3.7 Impact of a different discount rate

The results associated with the base cases at 53 and 58 dBW were also evaluated, unsing a discount rate of 15% (instead of 10%); the following table shows that ground segment savings are reduced by $61,8 million while space segments costs are only reduced by $38,3 million. This means that for a 15% discount rate and under the 4 beam model, 58 dBW satellites become slightly less cost effective that 53 dBW satellites (1).

Table 5.12

Savings due to 58 dBW satellites for different discount rates

	Discount rate		
	10%	15%	Difference
Ground segment costs			
58 dBW	$ 940,9	$ 656,4	
53 dBW	$1 159,5	$ 813,2	
Saving with 58 dBW	$ 218,6	$ 156,8	$ 61,8
Space segment costs (4 beam model)			
58 dBW	$ 413,7	$ 341,8	
53 dBW	$ 214,3	$ 180,8	
Loss with 58 dBW	($ 199,4)	($ 161,1)	($ 38,3)
Net saving due to 58 dBW	$ 19,2	($ 4,3)	($ 25,3)

(1) The difference is so small, we could still talk about a break even situation.

5.4 The impact of dependent variables on the proportion of rural households serviced by IPC

As was mentioned at the beginning of the present chapter, some of the assumptions used in the analysis might have an important impact on the behaviour of potential subscribers and in particular on the choice between DTH terminals and passive cable systems in rural areas.

If the difference in cost between 0,8 m and 1,2 m earth station was to be greater than forecasted for example, one would expect:

- more IPC subscribers and less DTH households at 53 dBW
- more DTH households and less IPC subscribers at 58 dBW.

Such changes would obviously affect the NPV of ground segment costs and it is such changes that we will attempt to measure in the present section.

5.4.1 Impact of higher IPC costs

To test the impact of higher IPC costs, both capital and operating costs of passive cable systems were assumed to be 30% higher than the ones forecasted for both the 53 and 58 dBW cases.

- The 53 dBW case shows no other change from the base case
- The 58 dBW case assumes that the proportion of rural households not passed by cable and serviceable with passive cable will be reduced by 30% (a factor of 0,7 is applied across the board in all regions).

The results associated with these assumptions are presented in the following table.

Table 5.13

Impact of higher IPC costs

Power level	Number of DTH subs. in 1996 (000)	Number of IPC subs. in 1996	NPV at 10% ($ million)
53 dBW	1221	1083	$1265
58 dBW	1546	758	$1062
Difference in favor of 58 dBW	325	- 325	($203)

Since the base case at 58 dBW produced a cost saving of $219 million, the combined impact of changes in the preceeding variables is thus to reduce the cost saving of the 58 dBW alternative by $16 million to $203 million. This means that under the 4 beam model, the cost effectiveness of the two power levels is about the same.

5.4.2 Higher pay to basic ratios

As discussed in Chapter 2 of the present report, we expect that tiered services, whether entirely (pure pay-TV) or partly (specialized channels) supported by the subscriber, will have a significant impact on the development of DBS services in particular and on satellite services in general.

It was assumed that up to 40% of IPC customers would subscribe to at least one such tiered service and because of the complexity and cost associated with local re-scrambling and descrambling, it was also assumed that such tiered services would be delivered in their satellite scrambled format; IPC subscribers, who would like to have access to such tiered services, would thus have to be equipped with the same descrambler used by DTH households.

In another set of simulations, we assumed that the percentage of IPC customers subscribing to at least one tiered service would reach 60% instead of 40%.

- The 53 dBW case shows no other change from the base case;
- The 58 dBW case assumes that the proportion of households serviceable by IPC is reduced by 20% (a factor of 0,8 is applied across the board in all regions).

The results associated with these assumptions are illustrated in the following table which shows that the 58 dBW alternative conserves an advantage of $187 million over the 53 dBW case.

Table 5.14

Impact of a higher pay to basic ratio and lower IPC serviceable factor

	Number of DTH	Number of IPC	NPV at 10%
53 dBW	1221	1083	$1168
58 dBW	1438	867	981
Difference with 58 dBW	217	-(216)	($187)

Since the base case at 58 dBW produced a cost saving of $219 million, the combined impact of charges in the preceeding variables is thus to reduce the cost saving of the 58 dBW alternative by $32 million to $187 million. This means that under the 4 beam model, 53 dBW satellites would now be cost effective.

5.4.3 Higher 1,2 m and 1,8 m antenna costs

The assumptions used for both base cases are summarized as follows:

Table 5.15

Antenna type and cost

	Cost	53 dBW	58 dBW
1,8 m	$1700	IPC	Not used
1,2 m	$ 750	DTH	IPC
0,8 m	$ 375	Not used	DTH

These assumptions determine to a large extent the economic trade off between 53 and 58 dBW. It could happen on the other hand that, since the 0,8 m antenna is likely to be the U.S. standard it would realistically sell for the proposed $375 price (1) while the 1,2 m and 1,8 m antennas would be more expensive than originally forecasted.

Another set of simulations was thus performed with the assumption of a 20% increase in the cost of 1,2 m and 1,8 m stations as follows:

(1) Antenna and LNA only.

- 1,2 m: $900 instead of $750;
- 1,8 m: $2040 instead of $1700;
- The 53 dBW case shows no other change from the base case;
- The 58 dBW case assumes that the proportion of rural households serviceable by IPC is reduced by 20% (a factor of 0,8 is applied across the board in all regions).

The results are presented in the following table and show that these assumptions would have a significant impact in favor of the 58 dBW alternative.

Table 5.16

Impact of higher cost for 1,2 and 1,8 m antennas and lower IPC serviceable factor

	No. of DTH	No. of IPC	NPV at 10%
53 dBW	1221	1083	$1247
58 dBW	1438	867	$ 975
Difference with 58 dBW	217	(216)	($272)

Since the base case at 58 dBW produced a cost saving of $219 million, the combined impact of changes in the preceeding variables is thus to increase the cost saving of the 58 dBW alternative by $53 million to $272 million. This means that under both the 4 and 6 beam model, 58 dBW satellites are now cost effective.

6. CONCLUSIONS AND RECOMMENDATIONS

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 DBS power level

The present study has focused on the ground segment cost implications of using either 53 dBW or 58 dBW direct broadcast satellites. Under what has been called the base case, the number of households equipped with a DTH would reach approximately 1,2 million units by 1996, even if one assumes that a large portion of the rural market can be served using low cost passive cable systems.

If such a demand for DTH terminals materializes, this means that under the 4 beam model the increased space segment costs associated with the higher power satellites are very likely to be offset by the reduction in ground segment costs associated with smaller and less costly DTH terminals.

The conclusions in the case of the 6 beam model are reversed; because the power level "penalty" is greater under the 6 beam model ($250 million instead of $200 million) ground segment costs savings, brought about by the use of 58 dBW satellites, are not sufficiently high to offset increased space segment costs.

The impact of key assumptions will now be examined.

6.2 Passive cable in the rural market

The present study has assumed that all rural households located within 500 feet of each other could be served using low cost passive cable systems. This assumption means that in 1996, approximately 1,0 million rural households would be served by this redistribution technology. The analysis showed that, when reducing by 30% the number of households that can be serviced by passive cable (a factor of 0,7 is applied), 58 dBW satellites are now cost effective under both the 6 and 4 beam models. This result can be interpreted in the following fashion:

- Under the 4 beam model, 58 dBW satellites are cost effective if the number of DTH households reaches 1,2 million units in 1996.

- Under the 6 beam model, the break even number of DTH households is increased to about 1,5 million units.

While one could be tempted to aggressively push for increased penetration of DTH terminals in rural areas, one must also remember that passive cable systems offer other significant advantages over direct reception, such as local and distant signals not carried on DBS, local programming, etc.

6.3 Urban areas passed by cable

The present study showed that a significant part of the DTH market rests with households that are passed by cable but do not subscribe to it. In order to reflect factors such as lack of line of sight, dwelling tenure and dwelling type, a limitation factor of 0,7 was applied for the base case. In addition to these factors, one also has to take into account the tiering strategy that seems likely to be adopted by the cable industry; if DBS services are likely to be tiered services, this means that the cable industry will be able to provide a very cost effective alternative to direct reception in urban areas.

In other words, cable's defensive strategy is on one hand to offer more than a DBS can offer, and on the other hand to offer anything that a DBS can offer, under very competitive conditions.

Only a market survey can actually provide answers as to the likely impact of such factors on "the households passed but not subscribing" category and on the cable subscribers themselves which in the present study were assumed to remain unaffected by direct reception. Since we are aware that a market survey will soon be undertaken on that very subject, we can only recommend that these factors be adequately adressed.

6.4 The cost difference between 0,8 m and 1,2 m stations

The cost difference of $375 between the two types of antennas which was assumed in the present study, has proven to be one of the most significant variables in terms of its impact on the choice between 58 and 53 dBW satellites. Sensitivity analysis indicated that if the cost difference was to be $525 instead of $375, this would dramatically increase the cost effectiveness of 58 dBW satellites. While we hope to have carefully developped cost figures for both types of antennas, the present research project does not permit us to define precisely what the cost difference would effectively be under realistic market conditions. Further research on this subject including determination of retail price, installation and mounting cost, would thus be useful.

6.5 The number of channels

The present study has assumed that a DBS would offer an initial capacity of 8 channels per beam in 1988, capacity which would be extended to 16 channels per beam in 1990.

In view of present circumstances (demand for Anik C channels) the initial capacity of 8 channels in the 1988 time horizon might prove to be low although a lot of factors might come into play:

- The CRTC has licensed more pay-TV services than at least we anticipated, and because it has licensed regional services this tends to favor the shift of both national and regional services on Anik C satellites; in fact, a recent CCTA policy statement recommends the use of a single Anik C satellite for the distribution of TV signals to cable head ends. Pay-TV by itself, even if one assumes a 2 TV/transponder mode, could thus use as many as 5 transponders out of 16. If one adds up the Knowledge Network, TV Ontario, La Sette and other prospective users, the first Anik C used for TV signals distribution might fill up very quickly.

- Since the licensing of pay-TV seems to have been strongly influenced by political boundaries rather than market boundaries (the regional licenses apply to specific provinces) the 4 beam characteristic of Anik C satellites wastes valuable spectrum for many services such as:

  - Star Channel renders unusable a channel in Quebec.
  - La Sette renders unusable a channel in the Atlantic Provinces.
  - The Alberta pay-TV service renders unusable a channel in B.C.
  - The proposed B.C. service will render unusable a channel in Alberta.

Only time will really tell whether the present definition of regional markets is a viable one, or if some regions ought to be aggregated to form larger markets. As well one has to take into account future tiered services which by their specialized nature will require markets as broad as possible.

In conclusion, the jury is still out on whether 16 channels per beam will be sufficient by 1990 but 8 channels per beam would seem to us a bare minimum. If the demand was to exceed 16 channels though, the space segment models analyzed in the present report would not be able to accommodate that demand; consequently, a specific study should be undertaken to establish the cost and feasibility of additionnal space segment models that would permit more than 16 channels per beam.

6.6 Tiered services and descrambling

The present study assumed that, because of the complexity and cost of local scrambling and descrambling, DBS services would be delivered in their satellite scrambled format to both DTH households as well as IPC subscribers who want to subscribe to tiered services. The study also assumed that VLSI circuit technology would make possible such a decoder at a cost of $200; if such an objective was not met, we suspect that this would have a significant impact on both the DTH and IPC market. Needless to say in addition, a single universal technology was also assumed.

6.7 Four beams versus six beams

6.7.1 Cost considerations

The costs associated with the four proposed satellite systems have been discussed in Chapter 2 and are briefly summarized in the following table.

Table 6.1

Space segment model costs

Power level	Number of beams	Full grown total capital cost ($ million)	Cost per channel ($ million)
53 dBW	4	$ 315	$ 4,9
	6	$ 567	$ 5,9
58 dBW	4	$ 637	$ 9,9
	6	$ 935	$ 9,7

The table illustrates that on a per channel basis the number of beams seems to have little effect on cost, the power of the satellite being the most important variable. Nevertheless on an absolute basis the total cost to Canadian society can differ significantly (there is a $620 million difference between the least and most expensive alternatives).

In addition to the choice between power levels, which have a direct impact on ground segment costs, Canada will also have to choose between 4 and 6 beams which will not affect ground segments costs but rather space segment costs for prospective services providers.

That choice is even more complex than the previous one since both geographical and content considerations come into play. It is these considerations which we will now attempt to address.

6.7.2 Geographical considerations

The choice between 6 and 4 beams does not affect all regions of Canada. In both alternatives both Ontario and the Manitoba/Saskatchewan region are presumed to come under "their own" beam. The additional 2 beams associated with the 6 beam mode have the effect of addressing separately the needs of the following regions:

- Quebec and the Atlantic Provinces served jointly under the 4 beam mode
- Idem for British Columbia and Alberta.

The additionnal two beams under the six beam models thus affect approximately half of the DBS universe (all categories of direct and indirect reception).

6.7.3 Content considerations

The choice between 4 and 6 beams will also have a significant impact on the space segment costs and the flexibility offered to prospective users. The impact is difficult to define because it depends on the coverage requirements of prospective users and the economic value one can attach to the access to distinct regions in Canada. The considerations that should dictate the choice between 4 and 6 beams are presented in table 6.2. The two extreme cases can be briefly summarized as follows:

- Coverage requirements will be mostly national and multi-regional, and because of the specialized nature of the services, the time zone advantage (Atlantic/Quebec or Alberta/B.C.) will not be very important. The ability to differentiate content and advertising material in those regions has an economic value that is lower than the increase in space segment cost generated by the 6 beam model. Distribution of very specialized services (French in Atlantic Canada or multi cultural in B.C. or Alberta) would be severely penalized by the 6 beam model. Conclusion: the 4 beam model is better adapted to market realities.

- Coverage requirements will be mostly regional with little or no demand for the services of other regions. Very high economic value associated with content differentiation or a regional basis. The 4 beam model would "waste" a large number of channels. Conclusion: the 6 beam model is better adapted to market realities.

Table 6.2

Coverage requirements and the 4 and 6 beam models

Coverage required	Type of service	Channels required			6 beam advantages
		6 beam model	4 beam model	% difference	
National (all Canada)	Advertiser supported	6	4	50%	- Québec and Atlantic Canada can be differentiated in terms of content - Alterta/B.C. differentiated in terms of content - Perfect adjustment to time zone
	Pay-TV	6	4	50%	Content and time zone considerations seem less important but present CRTC licensing of pay-TV does not seem to think so.
Multi region (Alberta/BC or Quebec/Atlantic	Advertiser supported	2	1	100 %	- Same as "National-Advertiser supported" but stiffer space segment penalty.
	Pay-TV	2	1	100%	- Same as "National-Pay-TV" but stiffer space segment penalty
Multi region (Other such as Ontario/Quebec for example)	All services	2	2	nil	- No difference between 4 and 6 beam model
Regional (Alberta or B.C. or Quebec or Atlantic Canada	All services	1	1	nil	- 4 beam model "wastes" a channel
Regional (Other such as Ontario or Man./Sask.	All services	1	1	nil	- No difference between 4 and 6 beam model

6.8 Main conclusions

The main conclusions of the present research project can thus be expressed as follows:

- Subject to remarks that were made in present chapter as well as in Chapter 5 (Results and analysis), 58 dBW satellites stand a reasonable chance of being cost effective under the 4 beam model. More powerful satellites would also present a good defensive strategy against high power U.S. satellites.

- The power level "penalty" appears to be higher under the 6 beam model which, compared to the 4 beam model, would raise the breakeven number of DTH households required to reach a cost effective alternative with 58 DBW satellites.

- In addition the choice between 4 and 6 beams could have a significant impact on space segment costs and thus ultimately on the demand for channels from prospective users.

APPENDIX A

ESTIMATION OF UPLINK COSTS

APPENDIX A - ESTIMATION OF UPLINK COSTS

1. Uplink design calculations

Specifications

C/N (unfaded)	30 dB
C/N (faded)	21 dB
Fading marge	9 dB
Dish - 10 meter	(3 degrees beamwidth)
Transmitter	500 W

EIRP calculations

EIRP = (C/N + FSL - GA + Lin + KTB) dB
(30 + 207 - 27 - 228,6 + 29,1 + 72,5) dB
83 dB

where:

FSL = Free space loss (207 dB at 14 GHz)
GA = Satellite receive antenna gain
Lin = Satellite transponder input loss (1 dB)
K = 228,6 dBW/Hz/K
B = Channed bandwidth (18 MHz or 72,6 dB)
T = System temperature (817 K or 29,1 dB)

Antenna gain required

GA (EIRP - Pout + Lo) dB
(83 - 27 + 3) dB
59 dB

where:

GA = earth station antenna gain
Pout = HPA output level 500 W (27 dBW)
Lo = output loss (3 dB)

To meet the 59 dB antenna gain a 10 meter antenna is required assuming 50% efficiency for an antenna gain of 62 dB.

2. Uplink costs ($ 1982)

The costs assumed in this paragraph are based on Douserv Telecom experience, investigation with manufacturers and from litteratures on the subject.

Capital costs

- 10 meter antenna and structure	$ 150,000
- Automatic tracking system	75,000
- De-icing system	25,000
	$ 250,000

Common systems

- Land & building	$ 175,000
- Wave guides and cabling	40,000
- Receiver & monitor (connected backup equipment)	35,000
- Central alarm and protection switching system	50,000
- Test equipments	50,000
- Engineering & documentation	50,000
	$ 400,000

Transmitter

- 500 watts - high power amplifier connected with backup	$ 100,000
- Exciter connected with back up	90,000
- Backup switches	10,000
	$ 200,000

Annual costs

- Operation 1 man/year	$ 25,000
- Maintenance	10,000
	$ 35,000

APPENDIX B

PROJECTION OF RECEIVING STATION COSTS

APPENDIX B - PROJECTION OF RECEIVING STATION COSTS

A - DIRECT TO HOME (DTH) AND DIRECT PASSIVE CABLE (DPC) RECEIVER

The estimated costs in this paragraph take into account the future technological developments and standardized product characteristics.

Capital cost ($ 1982)

$200/unit

Annual cost

$20/year (1 failure/5 years at $100 each).

B - INDIRECT PASSIVE CABLE (IPC) RECEIVER

Capital cost

Common cost

- Backup LNA	$ 500
- Backup receiver	500
- Backup modulator	250
- Room preparation	1,000
- Installation	200
	$2,450

Cost per channel

- Receiver	$ 500/ch
- Modulator	250/ch
- Installation	100/ch
	$ 850/ch

Annual cost

- LNA	$20/year
- Receiver	$20/year/channel
- Modulator	$20/year/channel

Cost per channel

- Receiver	$1,000/ch
- Modulator	2,000/ch
- Installation	200/ch
	$3,200/ch

Annual cost

Receiver	$20/year/channel
Modulator	$20/year/channel

C - INDIRECT REBROADCAST TRANSMITTER (IRB) RECEIVER

Capital cost

Common cost

- Backup LNA	$ 500
- Backup receiver	1,000
- Backup local scrambler	1,000
- Installation	200
	$2,700

Cost per channel

- Receiver	$1,000/ch
- Local scrambler	1,000/ch
- Installation	200/ch
	$2,200/ch

Annual cost

$100/year (for each channel)

D - INDIRECT CONVENTIONAL CABLE (ICTV) RECEIVER

Capital cost

Common costs

- Backup LNA	$ 500
- Backup receiver	1,000
- Backup modulator	2,000
- Installation	300
	$3,800

APPENDIX C

ESTIMATION OF GROUND SEGMENT DISTRIBUTION COSTS

APPENDIX C - ESTIMATION OF GROUND SEGMENT DISTRIBUTION COSTS

A - PASSIVE CABLE NETWORK

The passive cable network includes the following components (ref. section 2.3.1.4)

- head end amplifier
- distribution cable
- multi-taps
- drop cable

It excludes the antenna and receivers as well as any equipment at subscriber location.

The costs of a passive cable network are as follows:

Capital costs (installed)

- Coaxial cable (AL500 with strand)		$1,00/ft
- Multi-taps connector		$10/household
- Drops		$50/household
- Head-end amplifier		$500
- Engineering	Model DPC	$ 1000
	Model IPC	$ 1500

$$\text{system cost} = \text{Engr} + \text{head-end ampl} + \left\{ \left(\frac{\text{Density ft.}}{\text{H.H.}} \times \frac{\text{Cable cost}}{\text{ft.}} \right) + \text{Multi taps cost/H.S.} + \text{drop cost} \right\} \times \#\text{ of H.H.}$$

Annual cost

- Maintenance	$ 1000
- Administration	$15/household served

B - REBROADCAST TRANSMITTER

Costs are provided for a 25 W UHF rebroadcast transmitter station.

Capital cost

- Transmitter equipment and antenna $ 5000/channel
- Civil, electrical and mechanical works

. site clearance	500
. building 8' x 12'	7 000
. tower	10 000
. power line	2 000
. other	1 500
	$21 000

- Local de-scrambler	$ 150/household
- Engineering	$10 000
- Installation	$18 000

Note: Satellite receiving equipment costs are covered in Appendix B, section C.

Annual cost

- Maintenance	$ 5 000/year
- Administration	$I5 /household served

C- CONVENTIONAL CABLE NETWORK

Costs are provided for a 20 channels conventional cable network (excluding the satellite receivers).

Capital cost

Head-end station

- Studio (not part of the DBS incremental cost)
- Processors (included in the satellite receiver cost appendix B, section D)

Distribution system

- Cable and amplifier	$ 2,,25/ft
- Taps	$10/H.H.
- Drops	$50/H.H.

Engineering $0,25/ft. of route length served

$$\text{system cost} = \left\{ \text{household density} \times \left(\text{cable cost per foot} + \text{engr cost per foot} \right) + \text{multitaps cost per household} + \text{drop cost per household} \right\} \times \text{number of households}$$

Annual cost

5% of the capital cost.

D - VERY HIGH CAPACITY MICROWAVE SYSTEM (VHCM)

Costs are provided for a VHCM system operating at 100 mW

Capital cost

1) Transmitter

First channel

- Microwave equipment (one channel)	$ 8 000
- Common equipment	40 000
- Test equipment	15 000
- Building, road and electricity (E/W air conditionning)	25 000
- Tower and antenna	94 000

Additionnal channel $8 000/channel

2) Receiver (pole mounted)

- Microwave equipment	$22 000
- Common equipment	15 000

Annual cost

5% of the capital cost

APPENDIX D : SELECTED COMPUTER SIMULATION RESULTS

****
BASE CASE AT 53 DEW 82/06/29
****

DTH CLIENTS AND COST FORECAST

		1980	1981	1982	1983	1984	1985	1986	1987	1988
TOTAL DTH										
*********										
BC-NWT-YUKON	128	0	0	0	1	1	3	5	11	17
ALB	129	0	0	0	1	2	3	6	12	17
MAN-SASK	130	0	0	0	1	1	3	6	11	15
ONT	131	0	0	0	3	6	12	23	45	66
QUE	132	0	0	0	3	6	13	25	48	70
ATL	133	0	0	0	1	1	2	5	9	13
CANADA	90	0	0	0	9	18	35	69	135	198
RURAL PASSIVE CABLE										
*******************										
BC-NWT-YUKON	114	0	0	0	1	1	2	5	10	15
ALB	115	0	0	0	0	1	2	3	7	10
MAN-SASK	116	0	0	0	1	1	3	5	11	15
ONT	117	0	0	0	2	4	7	15	30	46
QUE	118	0	0	0	2	3	6	13	26	39
ATL	119	0	0	0	1	2	5	9	19	29
CANADA	91	0	0	0	6	13	25	51	102	154
CAPITAL COST	175	0	0	0	12834	12514	24681	48641	95780	92718
MAIN.&OP.	186	0	0	0	795	1599	3217	6471	12809	19006
TOTAL COST	187	0	0	0	13628	14113	27898	55112	108590	111723
NPV AT 10%	188	0	0	0	13628	26458	49515	90921	165090	234461
NPV AT 15%	189	0	0	0	13628	25901	46996	83233	145319	200866

****

BASE CASE AT 53 DHW 88/06/29

****

DTH CLIENTS AND COST FORECAST

		1989	1990	1991	1992	1993	1994	1995	1996
TOTAL DTH									
*********									
BC-NWT-YUKON	128	26	36	50	70	87	105	124	135
ALB	129	25	33	45	60	73	85	97	102
MAN-SASK	130	23	29	39	52	62	71	80	83
ONT	131	99	132	180	244	296	348	398	421
QUE	132	103	135	183	244	293	339	363	399
ATL	133	19	26	35	47	57	67	76	81
CANADA	90	295	390	532	718	869	1016	1159	1221
RURAL PASSIVE CABLE									
*******************									
BC-NWT-YUKON	114	23	31	43	60	75	91	107	116
ALB	115	15	19	26	35	43	50	57	60
MAN-SASK	116	23	30	40	53	64	74	83	87
ONT	117	70	94	131	181	224	268	313	338
QUE	118	60	80	111	153	189	225	262	282
ATL	119	43	58	80	110	135	160	186	199
CANADA	91	232	312	432	593	729	868	1008	1083
CAPITAL COST	175	141389	176419	222809	295192	242073	238911	235527	110366
MAIN.%CF.	186	28435	39641	54373	73950	90129	106196	122141	129135
TOTAL COST	187	169824	216060	277182	369142	332202	345107	357668	239505
NPV AT 10%	188	330323	441195	570503	727055	855133	976091	1090355	1159547
NPV AT 15%	189	274285	355510	446121	551055	633170	707348	774199	817190

BASE CASE AT 58 DRW 17/06/79

DTH CLIENTS AND COST FORECAST

		1980	1981	1982	1983	1984	1985	1986	1987	1988
TOTAL DTH										
*********										
BC-NWT-YUKON	128	0	0	0	1	1	3	5	11	17
ALB	129	0	0	0	1	2	3	6	12	17
MAN-SASK	130	0	0	0	1	1	3	6	11	15
ONT	131	0	0	0	3	6	12	23	45	66
QUE	132	0	0	0	3	6	13	25	48	70
ATL	133	0	0	0	1	1	2	5	9	13
CANADA	90	0	0	0	9	18	35	69	135	198
RURAL PASSIVE CABLE										
*******************										
BC-NWT-YUKON	114	0	0	0	1	1	2	5	10	15
ALB	115	0	0	0	0	1	2	3	7	10
MAN-SASK	116	0	0	0	1	1	3	5	11	15
ONT	117	0	0	0	2	4	7	15	30	46
QUE	118	0	0	0	2	3	6	13	26	39
ATL	119	0	0	0	1	2	5	9	19	29
CANADA	91	0	0	0	6	13	25	51	102	154
CAPITAL COST	175	0	0	0	9328	9121	18019	35569	70165	68178
MAIN.%OP.	186	0	0	0	795	1599	3217	6471	12809	19006
TOTAL COST	187	0	0	0	10123	10720	21236	42040	82974	87184
NPV AT 10%	188	0	0	0	10123	19869	37419	69164	126677	179811
NPV AT 15%	189	0	0	0	10123	19445	35502	63144	110585	153931

DTH CLIENTS AND COST FORECAST

		1989	1990	1991	1992	1993	1994	1995	1996
TOTAL DTH									
BC-NWT-YUKON	128	26	36	50	70	87	105	124	135
ALB	129	25	33	45	60	73	85	97	102
MAN-SASK	130	23	29	39	52	62	71	80	83
ONT	131	99	132	180	244	296	346	398	421
QUE	132	103	135	183	244	293	339	383	399
ATL	133	19	26	35	47	57	67	76	81
CANADA	90	295	390	532	718	869	1016	1159	1221
RURAL PASSIVE CABLE									
BC-NWT-YUKON	114	23	31	43	60	75	91	107	116
ALB	115	15	19	26	35	43	50	57	60
MAN-SASK	116	23	30	40	53	64	74	83	87
ONT	117	70	94	131	181	224	268	313	338
QUE	118	60	80	111	153	189	225	262	282
ATL	119	43	58	80	110	135	160	186	199
CANADA	91	232	312	432	593	729	868	1008	1083
CAPITAL COST	175	103887	139566	167917	222814	183447	181628	179673	85396
MAIN.%OP.	186	28435	39641	54373	73950	93129	106196	122141	129835
TOTAL COST	187	132323	179207	222289	296763	273576	287824	301811	215236
NPV AT 10%	188	254504	346465	450165	576022	681497	782376	878544	946896
NPV AT 15%	189	211136	278508	351175	435534	503157	565023	621434	656416

****
BASE CASE(53)+HIGHER 1.2-1.8M COST 82/06/29
****

DTH CLIENTS AND COST FORECAST

		1980	1981	1982	1983	1984	1985	1986	1987	1988
TOTAL DTH										
*********										
BC-NWT-YUKON	128	0	0	0	1	1	3	5	11	17
ALB	129	0	0	0	1	2	3	6	12	17
MAN-SASK	130	0	0	0	1	1	3	6	11	15
ONT	131	0	0	0	3	6	12	23	45	66
QUE	132	0	0	0	3	6	13	25	48	70
ATL	133	0	0	0	1	1	2	5	9	13
CANADA	90	0	0	0	9	18	35	69	135	198
RURAL PASSIVE CABLE										
*******************										
BC-NWT-YUKON	114	0	0	0	1	1	2	5	10	15
ALB	115	0	0	0	0	1	2	3	7	10
MAN-SASK	116	0	0	0	1	1	3	5	11	15
ONT	117	0	0	0	2	4	7	15	30	46
QUE	118	0	0	0	2	3	6	13	26	39
ATL	119	0	0	0	1	2	5	9	19	29
CANADA	91	0	0	0	6	13	25	51	102	154
CAPITAL COST	175	0	0	0	14232	13867	27338	53853	105993	102499
MAIN.%OP.	186	0	0	0	795	1599	3217	6471	12809	19006
TOTAL COST	187	0	0	0	15027	15466	30555	60324	118803	121506
NPV AT 10%	188	0	0	0	15027	29087	54339	99661	180805	256250
NPV AT 15%	189	0	0	0	15027	28475	51579	91244	159169	219579

****

BASE CASE(53)+HIGHER 1.2-1.8M COST   82/06/29

****

DTH CLIENTS AND COST FORECAST

		1989	1990	1991	1992	1993	1994	1995	1996
TOTAL DTH									
*********									
BC-NWT-YUKON	128	26	36	50	70	87	105	124	135
ALB	129	25	33	45	60	73	85	97	102
MAN-SASK	130	23	29	39	52	62	71	80	83
ONT	131	99	132	180	244	296	348	398	421
QUE	132	103	135	183	244	293	339	383	399
ATL	133	19	26	35	47	57	67	76	81
CANADA	90	295	390	532	718	869	1016	1159	1221
RURAL PASSIVE CABLE									
******************									
BC-NWT-YUKON	114	23	31	43	60	75	91	107	116
ALB	115	15	19	26	35	43	50	57	60
MAN-SASK	116	23	30	40	53	64	74	83	87
ONT	117	70	94	131	181	224	268	313	338
QUE	118	60	80	111	153	189	225	262	282
ATL	119	43	58	80	110	135	160	186	199
CANADA	91	232	312	432	593	729	868	1008	1083
CAPITAL COST	175	156339	191108	244687	324038	265434	261732	257777	119884
MAIN.%OP.	186	28435	39641	54373	73950	90129	106196	122141	129839
TOTAL COST	187	184774	230749	299060	397988	355563	367928	379918	249724
NPV AT 10%	188	360550	478961	618475	787260	924345	1053302	1174355	1246691
NPV AT 15%	189	299462	386269	483972	597105	684995	764078	835088	875675

DTH CLIENTS AND COST FORECAST

		1980	1981	1982	1983	1984	1985	1986	1987	1988
TOTAL DTH										
BC-NWT-YUKON	128	0	0	0	1	2	5	9	21	35
ALB	129	0	0	0	1	2	6	11	22	35
MAN-SASK	130	0	0	0	1	2	5	10	20	32
ONT	131	0	0	0	3	9	20	40	84	138
QUE	132	0	0	0	3	10	22	43	90	146
ATL	133	0	0	0	1	2	4	8	17	27
CANADA	90	0	0	0	9	27	61	121	253	413
RURAL PASSIVE CABLE										
BC-NWT-YUKON	114	0	0	0	1	2	4	8	18	31
ALB	115	0	0	0	0	1	3	6	12	20
MAN-SASK	116	0	0	0	1	2	5	9	20	32
ONT	117	0	0	0	2	5	13	26	57	96
QUE	118	0	0	0	2	5	11	22	49	82
ATL	119	0	0	0	1	4	8	17	36	60
CANADA	91	0	0	0	6	19	44	89	191	321
CAPITAL COST	175	0	0	0	12834	25188	49529	85121	191922	233672
MAIN.&OP.	186	0	0	0	795	2399	5630	11325	24018	39595
TOTAL COST	187	0	0	0	13628	27586	55159	96446	215940	273267
NPV AT 10%	188	0	0	0	13628	38707	84293	156754	304244	473922
NPV AT 15%	189	0	0	0	13628	37617	79325	142740	266204	402066

****

BASE CASE AT 53 DPW + NEW PEN CURVE 82/07/30

****

DTH CLIENTS AND COST FORECAST

		1989	1990	1991	1992	1993	1994	1995	1996
TOTAL DTH									
*********									
BC-NWT-YUKON	128	58	89	106	116	127	129	132	135
ALB	129	55	82	95	101	106	105	104	102
MAN-SASK	130	50	73	83	87	90	88	85	83
ONT	131	220	329	382	407	431	428	425	421
QUE	132	229	338	387	407	426	417	408	399
ATL	133	43	64	74	79	83	82	81	81
CANADA	90	656	975	1128	1196	1263	1250	1236	1221
RURAL PASSIVE CABLE									
*******************									
BC-NWT-YUKON	114	50	77	91	100	109	111	114	116
ALB	115	32	48	55	59	62	62	61	60
MAN-SASK	116	50	74	85	89	93	91	89	87
ONT	117	155	236	279	302	326	330	334	338
QUE	118	132	200	236	255	275	277	280	282
ATL	119	96	145	170	183	196	197	198	199
CANADA	91	516	780	916	988	1061	1068	1076	1083
CAPITAL COST	175	354083	560090	243468	115721	113899	-11422	-11985	-12566
MAIN.XCP.	186	63189	99103	115336	123250	131097	130703	130284	129839
TOTAL COST	187	417272	659193	358804	238971	244996	119281	118299	117273
NPV AT 10%	188	709461	1047731	1215115	1316462	1410919	1452726	1490420	1524389
NPV AT 15%	189	582464	830279	947573	1015503	1076062	1101701	1123812	1142872

BASE CASE AT 5R DRW + NEW PEN CURVE 82/07/30

DTH CLIENTS AND COST FORECAST

		1980	1981	1982	1983	1984	1985	1986	1987	1988
TOTAL DTH										
BC-NWT-YUKON	128	0	0	0	1	2	5	9	21	35
ALB	129	0	0	0	1	2	6	11	22	35
MAN-SASK	130	0	0	0	1	2	5	10	20	32
ONT	131	0	0	0	3	9	20	40	84	138
QUE	132	0	0	0	3	10	22	43	90	146
ATL	133	0	0	0	1	2	4	8	17	27
CANADA	90	0	0	0	9	27	61	121	253	413
RURAL PASSIVE CABLE										
BC-NWT-YUKON	114	0	0	0	1	2	4	8	18	31
ALB	115	0	0	0	0	1	3	6	12	20
MAN-SASK	116	0	0	0	1	2	5	9	20	32
ONT	117	0	0	0	2	5	13	26	57	96
QUE	118	0	0	0	2	5	11	22	49	82
ATL	119	0	0	0	1	4	8	17	36	60
CANADA	91	0	0	0	6	19	44	89	191	321
CAPITAL COST	175	0	0	0	9328	18346	36144	62246	140564	171663
MAIN.&OP.	186	0	0	0	795	2399	5630	11325	24618	39595
TOTAL COST	187	0	0	0	10123	20745	41775	73571	164581	211259
NPV AT 10%	188	0	0	0	10123	28982	63566	118781	231152	362367
NPV AT 15%	189	0	0	0	10123	26162	59750	108123	202223	317256

BASE CASE AT 85 CPW + NEW PEN CURVE 82/07/30

DTH CLIENTS AND COST FORECAST

		1989	1990	1991	1992	1993	1994	1995	1996
TOTAL DTH									
BC-NWT-YUKON	128	58	89	106	116	127	129	132	135
ALB	129	55	82	95	101	106	105	104	102
MAN-SASK	130	50	73	83	87	90	88	85	83
ONT	131	22[illegible]	329	382	407	431	428	425	421
QUE	132	229	338	387	407	426	417	408	399
ATL	133	43	64	74	79	83	82	81	81
CANADA	90	656	975	1128	1196	1263	1250	1236	1221
RURAL PASSIVE CABLE									
BC-NWT-YUKON	114	50	77	91	100	109	111	114	116
ALB	115	32	48	55	59	62	62	61	60
MAN-SASK	116	50	74	85	89	93	91	89	87
ONT	117	155	236	279	302	326	330	334	338
QUE	118	132	200	236	255	275	277	280	282
ATL	119	96	145	170	183	196	197	198	199
CANADA	91	516	780	916	988	1061	1068	1076	1083
CAPITAL COST	175	260060	436210	184280	88743	87682	-6502	-6857	-7224
MAIN.&OP.	186	63189	99103	115336	123250	131097	130703	130284	129839
TOTAL COST	187	323269	535313	299617	211992	218779	124201	123427	122615
NPV AT 10%	188	544844	819545	959318	1049223	1133572	1177104	1216431	1251049
NPV AT 15%	189	447014	648258	746204	826465	860544	887240	910369	930238