IRA PROJECT

INTER-REGIONAL TELECOMMUNICATIONS ACCOUNTING

INTERIM REPORT ON THE FIRST PHASE OF THE PROJECT

prepared for and in collaboration with the

NATIONAL TELECOMMUNICATIONS BRANCH
DEPARTMENT OF COMMUNICATIONS

by

LE LABORATOIRE D'ECONOMETRIE
de L'UNIVERSITE LAVAL

and

SORES Inc.
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FOREWORD

This report contains a preliminary description of an Operations Research model destined to simulate the financial consequences of various costing and accounting procedures and of various revenue sharing schemes concerning inter-regional telecommunications.

The report is not a comprehensive treatise on telecommunications engineering or accounting. Nor does it pretend to be able to provide automatically "optimal" solutions for the carriers and/or the regulatory agencies.

On the other hand it is to be viewed in a wider setting as a contribution towards the formulation of policies aiming at having an even more efficient telecommunications system, in keeping with the broad social, economic and political objectives of Canada.

ABSTRACT

The Interim Report contains a general description of the first version of the IRA Model (Interregional Telecommunications Accounting) and the specification of its key components. A good deal of emphasis is put on the data requirements, which would have to be satisfied to make the model truly operational, and also on the nature of its outputs. Having to do with a simulation model, this Report deals at some length with simulation plans and the various options available here.

It will be noted that the building of this model is, in a sense, a continuation of the work done over the last three years, by the same tripartite team, resulting in the HERMES series of models. It is hoped that at some future date a close interfacing of these two groups of models will be accomplished.

The purposes of the model were stated in the Foreword which precedes this Abstract.

Apart from the question of joint costs and of joint products and other indivisibilities, the main intellectual challenge of the present Project is the handling of the highly complex relations between average traffic on one hand, and peak traffic on the other, bearing in mind that revenues are generated essentially with reference to average traffic whereas costs are incurred to a very large extent with reference to peak traffic.

RESUME

Ce Rapport intérimaire décrit les grandes lignes de la première version du modèle IRA (Comptabilité des télécommunications interrégionales) ainsi que les spécifications de ses parties-clefs. Les besoins en données nécessaires pour rendre le modèle vraiment opérationnel ainsi d'ailleurs que la nature des résultats qu'il peut fournir occupent une place considérable dans ce Rapport. Traitant d'un modèle de simulation, le Rapport consacre aussi beaucoup d'attention aux plans de simulation et aux diverses options qu'offre cette approche.

On notera que la mise en place de ce modèle représente, dans un certain sens, la continuation du travail entrepris il y a trois ans environ par la même équipe tripartite et qui a abouti à la série des modèles HERMES. Nous espérons qu'un jour on réussira à faire marcher ces deux groupes de modèles ensemble.

Le "Foreword" qui précède ce Résumé contient une description succincte des objectifs du modèle.

En plus de la question des coûts et des produits conjoints et autres causes d'indivisibilités, le défi scientifique principal du présent Projet est de trouver une manière satisfaisante de traiter les relations extrêmement complexes entre le trafic moyen d'une part et le trafic de pointe de l'autre. On se souviendra que les recettes sont surtout fonctions du trafic moyen tandis que la part prépondérante des coûts est essentiellement fonction du traffic de pointe.

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The IRA MODEL FLOW CHART which appears on a separate sheet forms an integral part of this report. It is primarily, though not exclusively, relevant to Section 3.

1. INTRODUCTION

This is a progress report on the building of a simulation model, IRA, dealing with financial aspects of inter-regional telecommunications in Canada. It is to be stressed that this is an interim report on the building of the first of what might eventually become a succession of perfectible models, and thus certainly does not represent the final formulation of the thinking of the team members on this subject.

One important purpose of this Interim Report is to identify and evaluate, although the latter is a hazardous task at this stage of the Project, the various options available concerning future work, if any, in this direction.

This is neither a demand for telecommunications model nor a financing model although it deals with, among others, these aspects of the problem and its outputs might one day serve to prepare the policies of the regulatory agencies which might in turn have implications in these areas.

It is also to be stressed that this whole project constitutes in a sense a new departure. The present phase of the Project scheduled to end by March 31, 1974 represents no more than an exploratory effort. By that date such results as the IRA model will be able to provide ought to be considered as at best "semi-realistic" being based largely on real but seriously simplified data and in places on artificial (though reasonable) data and involving certain simplified procedures.

It is possible that the IRA Project will evolve into the construction of more realistic and more directly useful models. If this is to come about then it is hoped that an inter-relationship with the HERMES series of models will be made sufficiently close so that the simulation for an inter-regional tele-communications network would handle at the same time both the physical, so to say, and the financial aspects of the problem. It is to be noted that the integration of the models of these two series could be done in a number of different ways according to either possibilities or needs.

The model is essentially designed to produce financial statements and certain significant financial ratios in their generally accepted formats under different assumptions concerning:

- Operating Activities,
- Unified Costing Procedures,
- Revenue Sharing Schemes,
- Unified Accounting Procedures,

applicable to the handling of inter-regional telecommunications and this for both the individual carriers and for the system as a whole.

Although the contracts binding the participants and various other documents exchanged and in particular "Le Protocole d'entente" dated August 15, 1973, (the English version called "Memorandum of Understanding" bears the date of August 22, 1973) are referred to throughout this Report, implicitly more often than explicitly, it is assumed that the reader has access to them. This Interim Report in no way replaces these and other documents listed in Appendix A which indeed contain masses of information essential to the continuation of the Project.

The present Report represents the result of a combined effort by three participants whose formal responsibilities were spelled out in the various official documents and detailed sharing of the tasks handled by more or less informal exchanges. The work on the IRA series of models was initiated by Mr. J.W. Halina, Director General of the National Telecommunications Branch of the Department of Communications. The tripartite team consisted of the following organizations given here with the names of the specialists involved:

Corporate and Financial Affairs Directorate of the National Telecommunications Branch:

Mr. J.A. Guérin
Mr. G.G. Henter
Miss M.R. Prentis
Mr. N. Rasheed

Sorès Inc., Montreal:

Mr. J. Cluchey
Mr. D. Geller
Mr. E. Manis
Mr. R. Riendeau

Laboratoire d'économétrie de l'Université Laval:

Mr. C. Autin
Mr. G. LeBlanc
Mr. T. Matuszewski

On the methodological side it is to be noted that a good deal of expertise acquired in the construction of the HERMES series of models is transferable to the construction of the IRA models. However, it cannot be stressed too strongly that a high degree of continuity - so that constituted teams of experts may be kept together - is a major element of success in projects of this nature.

2. SOME PRINCIPAL CONSIDERATIONS

This section deals with primarily if not exclusively objectives. Although the section deals with some general considerations it was decided to discuss these with reference to specific objectives.

It appears useful to place the discussion of the objectives, and related matters, at three different levels:

- The objectives of the Project,

- The objectives of the IRA Model,

- The objectives of this Interim Report.

The Project is intended to forge an instrument that might be of some use to the Department of Communications. Among the problems facing the Department are those of capacity, related problems of rational capital deployment for both existing facilities and capacity expansions, and rational operation of the inter-regional telecommunication system. In addition there is also the problem of "regional" factors to be taken into account, including the relation between local and long distance services, the problem of rate fixing, the problem of assuring adequate financing of truly needed capacity expansion and the problem of cross-subsidization. This list does not pretend to be exhaustive.

To sum up, the long-term objectives of the Project appear to be:

- The rationalization of capital deployment and of the capacity expansion of telecommunication facilities,

- The rationalization of operating activities; this may involve, for instance, the questions of the ownership structure and/or the corporate structure of some or all the carriers; we note also that the existing hierarchy of switching points and of the routing rules may be challenged in the interests of rationalization,

- The third group of long -term objectives involves social factors, or more precisely, the factors of social justice and perhaps political factors; this is to a large extent the question of equity vis-à-vis the carriers and vis-à-vis the subscribers and the taxpayers; there is also, of course, the wider question of the general public interest.

We note that this third group of objectives could, to a large extent be expressed as a set of constraints on the solutions aiming at optimizing the first two sets of objectives. Among other advantages this would facilitate the evaluation of the various trade-offs between technical optimization, on one hand, and the factors listed in the third group of long-term objectives, on the other hand.

It will be noted that the investigation of the cross-subsidization question does not constitute an objective by itself, although it is certainly relevant to the treatment of any, or all, of the three above groups of objectives.

The objective of the IRA Model itself is to produce financial statements and certain significant financial ratios, for each of the carriers as well as for the system as a whole, emphasis being on the inter-regional revenues and costs. The other elements of the financial statements will be treated as exogenous inputs in the present phase of the Project. The question of cross-subsidization will be handled by simulating long distance rate changes versus local service charge changes; the latter being treated as lump exogenous inputs. The elasticity of demand in response to rate changes will be assumed to be zero. The problem of peak versus average traffic will be reflected upon and handled operationally, if the Department of Communications provides the required data, by using several "time of day" traffic matrices. This, subject to some onerous extensions, will at the same time take care of the problem of the time zones. It will be recalled that among the major challenges of this Project is the fact that revenues are almost entirely (except for the effect of the day/evening/night/ Sunday rates) a function of the average traffic; whereas, the bulk of the costs are a function of the peak traffic.

It will also be noted that the block CHARGE of the HERMES III model could turn out to be useful here in simulating the effects of changing the hierarchy of switching points and of routing rules, that is, of certain attempts to rationalize further the operating activities.

The objectives of this Interim Report are:

- To show how the model being constructed fits into the broader objectives of the Department of Communications,

- To describe the directions along which would proceed the conceptualization and the software development work between now and March 31, 1974,

- To present the first version of the options concerning the eventual continuation of the Project beyond March 31, 1974.

3. PRINCIPAL BLOCKS AND THEIR INTERRELATIONSHIPS

3.1 General logic of the model

The model, herein described, is a simulation model for the evaluation of the financial impact on the participating telecommunications carriers of different accounting methods, of different methods of cost calculation, of different sharing schemes and of different means of regulating inter-regional telecommunications carriers. In the following, we describe the contents of the four principal submodels or blocks, which are by name: operating activities block, costing block, sharing block (1) and accounting block.

To enhance methodological unity of the model and to avoid the proliferation of concepts, it is proposed that "activity" be the basic concept used in both planning and in costing procedures. Apart from activities in the proper sense of the term, the uses of physical facilities would also be formally treated as activities.

Operating (Operations) block

The set of operating activities is concerned with the production of inter-regional telecommunication services by means of a reliable inter-regional common system, owned and operated by a group of distinct telecommunication carriers or by a single inter-regional authority.

Costing block

This comprises the functional relationships of variables affecting the cost components, by various configurations of services, geography, corporate financial structure, size and time related parameters. The emphasis is directed towards the functional relationships of the cost components.

Sharing block

This comprises the rules, definitions and methods by which revenues and costs are to be separated and/or allocated to the different services and/or corporate activities. This block comprises the rules and definitions which prescribe how much of a total sum is to be allocated to a particular segment of the operation and/or corporate activities, such as to a service.

Accounting block

This comprises the rules and definitions relating to revenues, expenses, assets and liabilities, the components making up these categories and the accounting and reporting practices.

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(1) In the final report, we propose to call this the Revenue Sharing Block.

We wish to note the distinction between, on one hand, the logic of the day-to-day operation of the inter-regional telecommunications system, and on the other hand, the internal logic of the model, in that the model is necessarily an abstraction, and therefore a simplification, of reality.

The basic outline of the logic is represented by the "flow chart" in section 3.6.

In terms of the general logic of the model, the point of departure is the Operations block which relates to the network configuration and ownership structure, traffic configuration, routing patterns and tariff structure. Based on these primary inputs, without considering the application of any particular settlement scheme the model should first of all aim to compute:

a) The asset values for each of the partners and for the whole inter-regional network (or the inter-regional authority);

b) The incurred capital and operating costs for each of the partners and for the whole inter-regional network (or the inter-regional authority);

c) The revenue generated by each partner and for the whole inter-regional network (or for the inter-regional authority).

The results of these computations are then used as intermediary inputs in the application of the various settlement schemes, from which is derived the allocated costs and allocated revenues. Once the clearing house has established who is a debtor or a creditor to the common system, financial statements are prepared for each of the carriers and/or for the inter-regional authority. At the accounting level, simulation capability is required through the introduction of various constraints, e.g. fixed debt ratio, financial scheme, rates of return, etc...

3.2 Operating block

As previously stated, the set of operating activities is concerned with the production of inter-regional telecommunication services by means of a reliable inter-regional common system, owned and operated by a group of distinct telecommunication carriers or by a single inter-regional authority. The production of telecommunication services consists of routing various types of communications, having different units of measure, from one point to another, subject to grade of service and reliability constraints. This set of activities constitute the front end of the IRA model and the starting point from which information is fed into the costing, sharing and accounting blocks.

The main components of this set of activities are:

1. Network Configuration and Ownership Structure

2. Traffic Configuration,

3. Routing Patterns, and

4. Tariff Structure.

Network Configuration and Ownership Structure

The inter-regional telephone common system consists of a set of tandem and toll switching offices through which calls are routed on their way to and from local switching offices, and trunk transmission facilities joining the offices. To the inter-regional switching network correspond the inter-regional facilities network which must be identified as well.

The ownership of every element (node or link) of the inter-regional network must be identified by carriers as follows:

1. TCTS Members (and connecting companies when applicable),

2. CN/CP,

3. COTC, and

4. TELESAT.

It is understood that the inter-regional network will be defined so as to reflect not only domestic traffic but Canada-U.S. and Canada-Overseas traffic as well. The operations at these three levels are fully integrated into one common network which we must identify in its totality. We cannot study the inter-regional network without specifically taking into account its interrelations with the Canada-U.S. and Canada-Overseas traffic.

Traffic Configuration

The main categories of services considered are:

1. Public Messages

2. Private Line

   - Switched

   - Non switched

3. Program Transmission (Audio and Video)

   - One way

   - Two way

Note that the unit of measure may not be the same for each of these services. Factors of conversion might have to be applied in order to express all services by a common unit.

For each of these services, as noted above, we distinguish three broad categories of traffic streams:

- Domestic

- Canada-U.S., and

- Canada-Overseas.

It is possible to have different traffic matrices for different periods of the day such as:

1. 6:00 am to 6:00 pm,

2. 6:00 pm to 8:00 pm,

3. 8:00 pm to 12:00 pm, and

4. 12:00 pm to 6:00 am.

where the traffic matrices for the off-peak periods (2,3,4) would be expressed as coefficients of the peak period traffic matrices. However, it is worth noting that although the busy-hour occurs at about the same time each day, the average busy-hour loads fluctuate from day to day.

Routing Patterns

To every pair of points in the switching network there corresponds a set of routes each having a probability of usage. To every route in the switching network there corresponds a set of facility chains, which obviously are defined with respect to the facilities network. For the calculation of revenue by stream (and carriers) no information on routing is required; whereas, for the calculation of cost per stream (and carriers) the routing information is essential. Therefore, what we need to identify for every pair of points is the routing of traffic with respect to facilities.

Tariff Structure

The tariff structure will vary with the category of service, the distance, the period of the day and the average holding time. Theoretically the model shall have the capability of accomodating three categories of rate:

- The Collection Rate,
- The Accounting Rate, and
- The Terminal Charges.

3.3 Costing block

The costing activities are concerned with the various methods of defining and allocating the costs associated with the provision, operation and use of the common system. The costing exercise has to be based on unified accounting concepts and techniques. However, the costing activities are not to be confused with the accounting activities.

The derivation of costs at the element level will be done in three main groups as follows:

a) Pricing of assets,

b) Capital costs, and

c) Operating costs.

Incurred costs (= capital + operating costs) are calculated for each carrier at the element level.

Capital cost must be understood as including:

- Cost of capital (= rate of return x net assets value), and
- Depreciation.

The main components of Operating costs are:

- Maintenance: repairs to plant, station equipment, buildings and grounds, transmission power, etc...,
- Marketing and commercial: advertising, sales expenses, salaries and wages, directory expenses,

- Traffic: principally operators wages incurred in the handling of messages,

- Provision for pensions and other employee benefits,

- Accounting: salaries and wages of Accounting and Statistical Departments,

- Engineering: principally expenses incurred in connection with planning for plant additions and changes and for equipment design for customer requirements and special projects,

- Operating taxes: income taxes and other taxes, and

- Other expenses: general office salaries and expenses, operating rental and miscellaneous expenses.

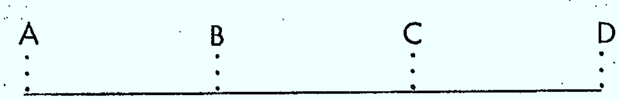
Decreasing (or decreasing per segments) unit costs make the separation of costs particularly difficult and involve a sharp distinction between separation for the costing of the incremented services and for the costing of the total services. Also, the presence of important indivisibilities of the joint costs will involve some arbitrary imputations. This puts a question mark on the usefulness of the attempts to measure the incremental effects of marginal changes, particularly if we want to use the dual variable approach. Moreover, the existence of unused capacities makes the unit cost concept less meaningful.

In the case of the allocation of costs, it is not so clear whether the costs should be allocated on the basis of peak traffic or on the basis of average traffic. This ambiguity results from the fact that:

a) The network is dimensioned for the peak traffic;

b) The major proportion of the network cost does not vary with the average traffic and therefore, this cost is only a function of peak traffic which is responsible for the amount of facilities installed.

Let us consider the following example:



On the BC link, during the peak period, the AD traffic may represent 85% of the total traffic, whereas over the whole year, the AD traffic on the average only accounts for 50% of the total traffic. Since the network is dimensioned for the peak traffic, the AD traffic is mostly responsible for the cost incurred on the BC link. However, if costs are allocated on the basis of annual traffic, the total cost of BC would be equally shared by the BC and AD owners. This example shows that in a large part BC acts only as a "feeder". This is the problem of average costing versus marginal costing.

Because of this problem, the model should have the capacity of working with both types of traffic (i.e. average and peak) for the purpose of cost allocation.

For the current phase of the IRA Project, we will work with semi-realistic cost functions (assets, capital and operating) which will be provided by the Department of Communications specialists. However, during the next phase, we intend to build a costing block from which such cost functions shall be derived in a more rigorous manner. Such a costing block shall be integrated in the future into the IRA Model.

The objective of this proposed costing block will be to determine the costs for individual categories of services, both in terms of total output as of a certain time and in terms of incremental output in a joint production environment; where the service categories are further subdivided into geographical, operational, jurisdictional, corporate and like entities. It will be important to identify the input requirements representing components of cost vis-à-vis the output (the services) in physical as well as in financial terms.

The determination of the input requirements in physical terms has a particular significance. It is perceived that the physical input requirements will be determined in terms of additional plant units required for given configurations of incremental outputs (e.g. from a HERMES type Model) in a given joint production environment. The plant units are perceived as "building blocks" defined by dividing up the structures and facilities into fine units from which any configuration of plant can be constructed by taking the required number of them. The plant units will be made up from material and labour components, i.e., material and labour units which may be expressed in non-financial terms. The non-financial expressions of labour and material units in relation to plant units are expected to hold true over a considerable length of time. The expressions and relationships would only change as a consequence of changes in technology, which consequences could be estimated and thereby taken into account in projection type analyses.

The non-financial terms can subsequently be associated with financial terms estimated over projection periods, e.g., when the cost of a particular construction activity is estimated, which is to take place a number of years in the future. In this context, the material units could be associated with projected material prices, while the labour components expressed in terms of work units and hours per work unit would be associated with projected labour costs. The pricing of the labour component would give consideration to expected efficiency, location, size of the undertaking and similar parameters. First cost of the construction activity estimated along these lines could then be associated with the capacity expansion and operating cost algorithms, and with the applicable financial parameters related to corporate structure and operating environments to yield the costs of service output.

It is envisaged that a suitable block performing functions as described above will eventually be developed to perform the cost activities in a more sophisticated fashion. For example, in the future calculation of capital and operating cost could be based on "usage" via the calculation of element, route and stream unit costs in a manner similar to what is described in sub-section 3.4 under "The Commonwealth Type of Settlement Plan". For the present, only relatively simple cost functions are contemplated i.e., for deriving capital costs and operating costs, and these cost functions will be provided as exogenous input.

3.4 Sharing block

Settlements occur at five different levels:

1) T.C.T.S. settlement: apply to traffic originated and/or terminated in Canada and involving three or more carriers,

2) Adjacent members settlements,

3) Canada-United States settlements (T.C.T.S. and AT & T),

4) COTC-CTO settlements (overseas traffic), and

5) Negociated settlements:

a) COTC-Domestic carriers (TCTS & CN/CP),

b) CN/CP-Western Union (Canada-United States).

The four basic settlement schemes considered so far are described below.

1) The "Full Division Plan of Settlement" (T.C.T.S.)

Under this plan, all common system revenues are pooled. Each member receives from the pool an amount equal to the expenses it assigned to the provision of the revenue generating services. The balance of the pooled revenues is accounted to each partner on the basis of its proportionate contribution in the provision of the service. The member's contribution is normally measured in terms of its assigned plant investment. The amounts of "assigned expenses" and "assigned plant investment" are derived by application of uniform accounting rules and procedures, agreed to by partners.

It is to be clearly understood that under any "Full Division Plan of Settlement" all costs other than those arising from the facilities included in the inter-regional network (i.e. terminating costs) will be treated as exogenous inputs.

However desirable is the Full Division Scheme, it gives rise to difficulties in measuring "assigned expenses" which in fact comes close to attempting to measure the true cost and includes the cost of termination.

2) The Commonwealth Type of Settlement Plan

For each inter-regional flow, the originating partner pays to the partner of destination 50% (or such other percentage as may be mutually agreed) of the accounting rate for that flow.

On the cost side, this Plan basically redistributes the sum of incurred costs among the partners according to a method of allocation based on facility utilization data. The usage is measured in terms of the number of units of traffic of each service for all streams originating in or destined for that partner carried over each element of the inter-regional network. The three inputs for this "usage" are:

- The existing inter-regional switching and facilities network in physical and financial terms,

- A set of inter-regional traffic matrices corresponding to the various services, and

- The routing pattern.

Once the stream costs are calculated (discussed below) these costs are allocated on a 50/50 split between the terminal partners of the stream.

The cost of carrying one unit of traffic of each service on each element is what we call the element (node or link) unit cost, the summation of the element unit costs for all elements used on a traffic route shall be the route unit cost.

A stream is defined as an annual flow of traffic characterized by a unique pair of terminal points (origin-destination) which has a pre-determined routing (comprising one or more routes) for a given accounting period. Obviously, each element of the common-system usually carries more than one stream. When a traffic stream utilizes only one route, the stream unit cost shall be the route unit cost; when a traffic stream utilizes more than one route, the stream unit cost shall be the weighted average of the route unit costs. Stream cost equals the stream unit cost multiplied by the number of both way traffic units. The element unit cost and consequently the stream unit costs ought to include all costs including the overheads. It is clear that some arbitrary decisions will have to be taken here, possibly tested later against alternatives by simulation techniques.

3) The Old Commonwealth Settlement Scheme

All common-system revenues are pooled. Each partner then receives from the pool an amount which is proportional to its allocated expenses. Of course, these expenses, like in the three other schemes, are derived by application of uniform accounting rules and allocation procedures.

4) The Mixed Settlement Schemes

In each inter-regional relation, the originating partner pays to the partner of destination 1/3 (or such other proportion as may be mutually agreed) of the accounting rate and keeps 1/3 for himself. The total of these amounts (2/3) represents the terminal part (or the regional part) of the inter-regional revenues. The remaining portion, that is 1/3, is pooled and redistributed by one of the following criteria:

a) Among Transit Partners:

i) on the basis of the assets,

ii) on the basis of the incurred costs,

iii) on the basis of the allocated costs,

iv) equally among all partners.

b) Among Transit and Terminal Partners:

The same as from (i) to (iv).

The implementation of various settlement schemes will be based on different assumptions concerning the composition of the inter-regional network; for example:

- A unified common-system in which the carriers continue to own their respective facilities in a manner similar to the C.T.O.,
- Common-system to be run by a unique inter-regional governmental authority which is leasing the inter-regional facilities (objective function: minimization of capital costs) or is a clearing house (no objective function),
- A unified common-system expanded to include all domestic carriers operated in a manner similar to the present T.C.T.S. system.

It is desirable for any settlement scheme to induce the members to make full use of the common-system. It is of a rather fundamental importance that the costing and revenue sharing schemes be conducive to rational behaviour rather than pursue some kind of historical accounting justice. It is important to note that settlement schemes ought to be judged also according to other effects on behaviour.

3.5 Accounting block

In contrast to the "costing" included in the cost and revenue sharing activities, the accounting activities are concerned with the application of telecommunication financial accounting logic for the purpose of preparing the customary financial statements, and for generating significant ratios and indicators. There will be two main groups of sub-activities and corresponding simulations as follows:

1. The logic involved should provide for standard accounting manipulations to produce the output of the model which will be applicable to each inter-regional partner as well as to the inter-regional authority, being capable of performing the following:

    a) to produce statements (Income statement, Balance sheet, Sources and Uses of funds statement) and significant ratios and indicators in "top to bottom" fashion, i.e., on the basis of actual financial data as it was incurred in the course of actual operation and resulted from sharing of costs and revenues; following the methodology which would normally be applied by the accounting process at the end of a fiscal year to generate the financial statements.

    b) to handle certain "what if" situations (see Appendix E), that is to say, producing financial statements and indicators on the basis of impressed financial constraint(s) such as pre-set debt ratio, rate of return on equity, rate of return on total capital and interest times coverage -- using the standard accounting logic to produce the financing schemes, statements and ratios with the given constraint(s), otherwise using the actual incurred information derived from the operating, costing and sharing activities. Under this category of simulation, the model would produce revenue requirements and/or additional revenues required (derived from tariff adjustments) in order to satisfy the imposed financial constraints and/or the resulting capital structures, the types and proportions of external financing and the like, depending on the nature and objective of the particular simulation run.

2. The logic should be capable of accomodating in the course of carrying out simulations as set out above the application of different accounting methods, in particular with respect to the following areas:

    a) depreciation,

    b) taxes (including treatment of deferred taxes),

    c) different methods of capitalizing versus expensing, and

d) different methods of deriving the cost of money for income statement purposes.

The logic of generation of financial statements will normally be as follows:

1) Depreciation,

2) Operating Income,

3) Income statement (first part),

4) Cost of Debt Capital,

5) Net Income (completion of the Income statement),

6) Deferred taxes,

7) Balance sheet,

8) Sources and Uses of Funds, and

9) Various significant ratios and performance indicators.

Concerning depreciation, we should note that:

- depreciation is calculated only on plant in service;
- depreciation of facilities installed during a given year is calculated as if they were installed in the middle of the year;
- no depreciation is calculated for work-in-progress (or "plant under construction" as termed by the carriers).

3.6 Flowchart and explanatory notes

The following notes refer to the numbered boxes on the inserted flowchart.

Box no. 1: Cost Functions

Three types of cost functions are given by facility at each element (node or link)

- Asset values as calculated using step functions,
- Capital cost as derived by the application of proportional cost functions to the asset values,

- Operating costs as derived by the application of proportional cost functions to the asset values and possibly taking into account traffic.

Box no. 2: Simulation and Control Specifications

a) Settlement Schemes

Eleven are possible (Refer to Section 3.4)

b) Accounting Methods

Refer to Section 3.5

c) Composition of Inter-Regional Network.

This specifies the partners and owners involved and their roles in the Inter-Regional Network. (Refer to section 3.2).

Under the assumption of a common system to be run by a unique inter-regional authority which is leasing the inter-regional facilities, auxiliary functions will be provided to allocate costs and revenues under the specific leasing arrangements.

d) Content of Financial Statements

The possible financial statements are:

a) For the partners: i) relating to inter-regional activities only

ii) relating to inter-regional and regional activities.

b) For the Inter-Regional Authority, if applicable.

Box no. 3: Peak and/or Average Traffic Data

Based on test data provided according to Exhibit I (Test Data Format) below or from direct linkage with HERMES (after March 31, 1974) the Operating Activities are provided as input. This includes routing patterns, traffic and network configuration. The relationship between peak and average traffic will also be provided to study the effects on costs. This relationship could be studied through examination of traffic during four periods of prototype day.

I.R.A. MODEL FLOWCHART

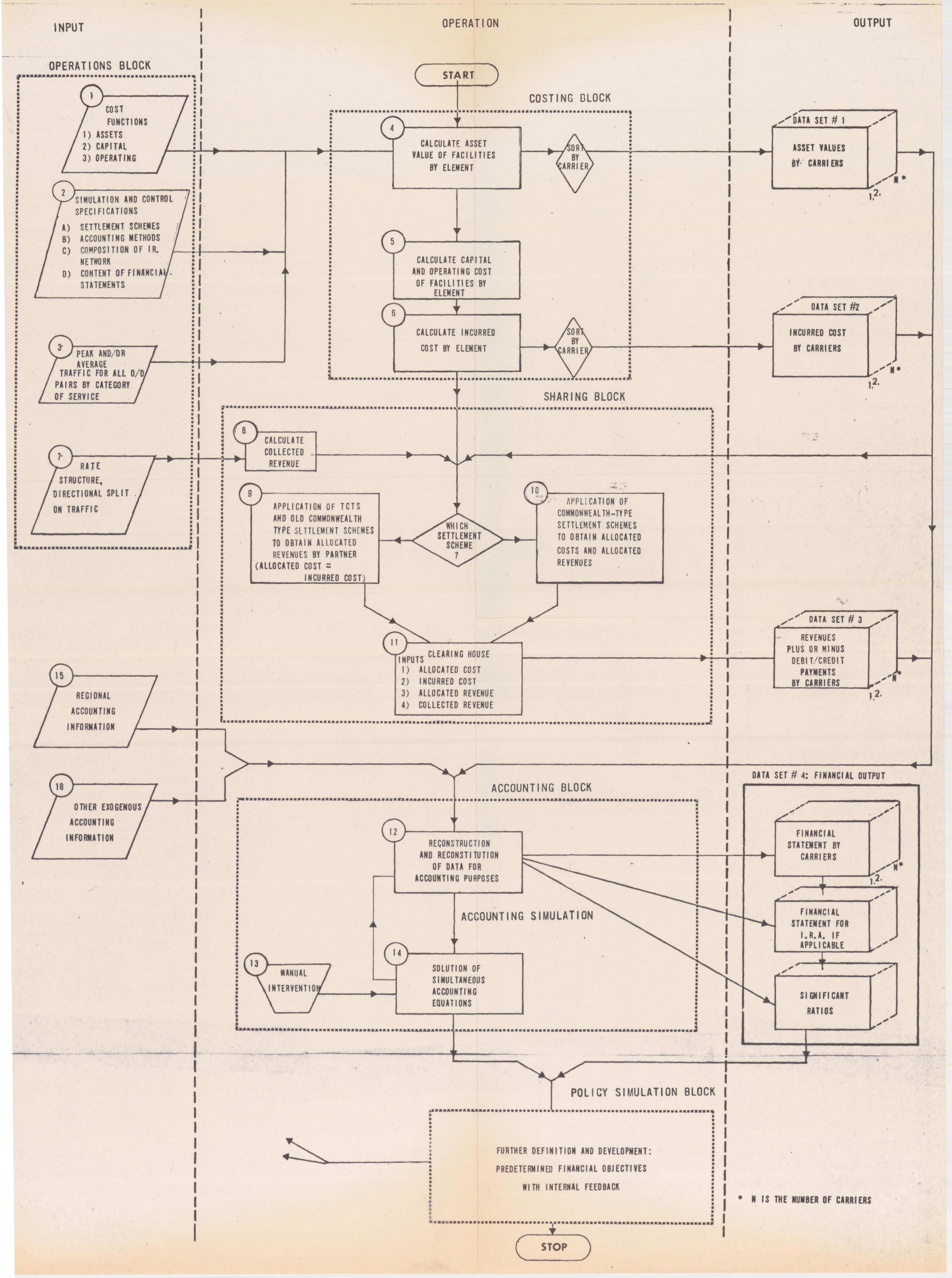


EXHIBIT I

TEST DATA FORMAT

Input for OD Pairs for Each Service

[1] Category of service	Orig.	Dest.	[2] Traffic		[3] Split	Physical Chains					
			Qty.	Units		Node	Link	Node	Link	Node	Etc.
Public Message	A	C	1000	CCS	%	A	AC	C			
						[4] Owner →	→	→			
						[5] Physical Parameters →	→	→			
						[6] Cost Function →	→	→			
					%	A	AB	B	BC	C	
						"	"	"	"	"	

Explanations

1. Categories of Service

   a) Public message

   b) Switched private line

   c) Non switched private line

   d) Program Transmissions (audio and video) one way

   e) Program Transmissions (audio and video) two way

2. Peak and/or average traffic

3. Percentage split of stream traffic among routes

4. Owner of nodes and owner(s) of links

5. Physical parameters of facilities a) at present and b) for additional traffic type, size, number, age, life, depreciation rate.

6. Cost functions: coding as to which cost functions to apply

Box no. 4: Asset Values

Based on the physical facilities the asset functions will calculate the asset values of the facilities at each element. The asset cost function is a step function of the capacity of the facility (similar to HERMES). We distinguish two main categories of facilities: transmission and switching.

Boxes no. 5 & 6: Capital and Operating Costs

Calculations of capital and operating costs based on unified accounting, firstly for all facilities by element, and then by element (summing over facilities). Components of capital and operating costs will be computed as proportional functions of asset values (for March 31, 1974) and the logic will be left open for sophistication of these procedures (for example, the calculation of a component of operating cost based on average and/or peak traffic). Refer to Section 3.3.

Boxes no. 7 & 8: Revenue Input and Calculation

The revenues are a function of the average traffic, rate for the given category of service and the distance. Revenues are collected by the originating partner.

Box no. 9: Application of TCTS and Old Commonwealth Type Settlement Schemes

Includes the following settlement schemes:

- TCTS,

- Mixed A(i), A(ii), A(iv),
  B(i), B(ii), B(iv). (Refer to Section 3.4)

These schemes are distinct from those in Box no. 10 in that no "usage" criterion is applied in the allocation of revenues.

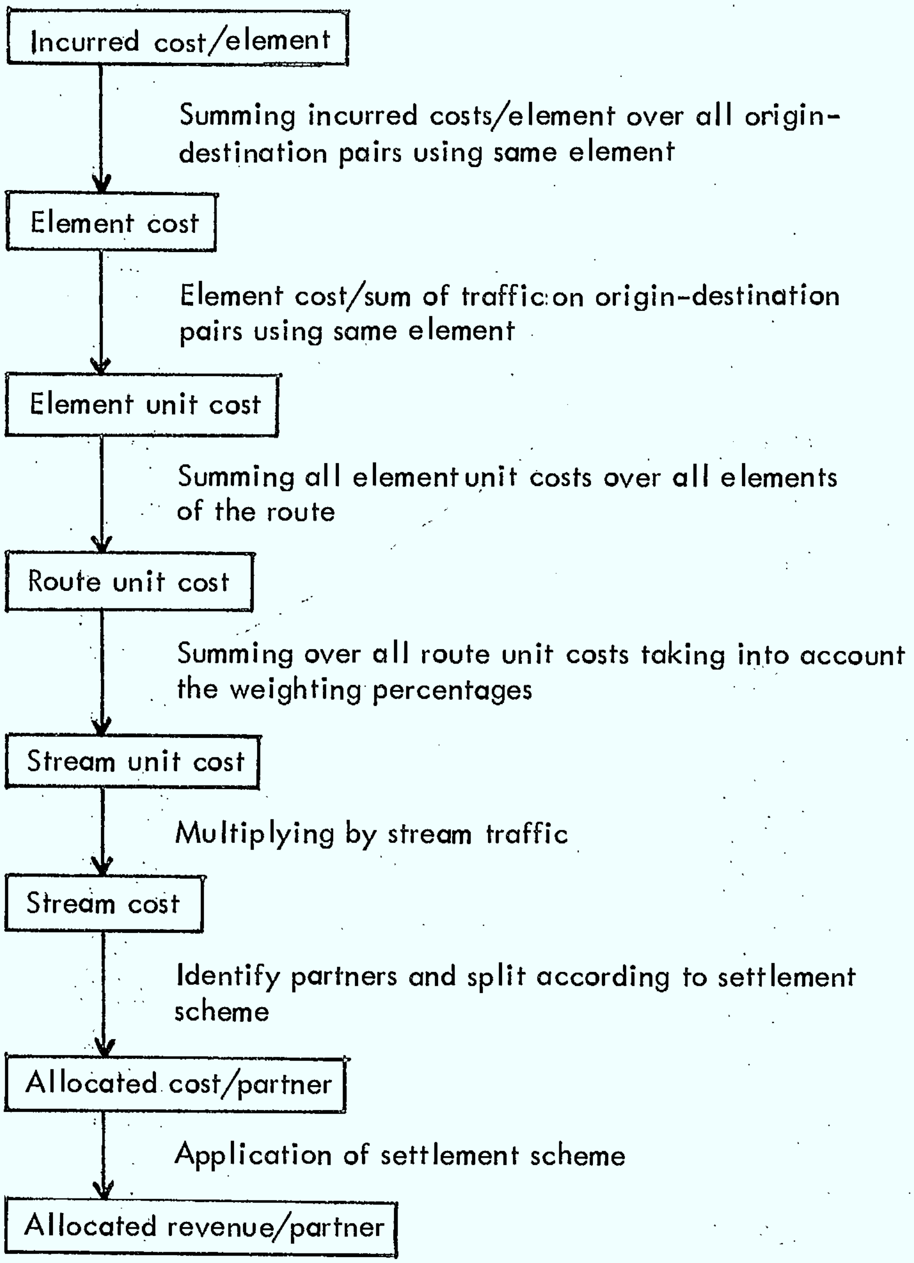
Box no. 10: Application of Commonwealth Type Settlement Schemes

Includes the following settlement schemes:

- Commonwealth,

- Mixed A(iii), B(iii). (Refer to Section 3.4)

Herein, allocated costs are a function of "usage" as is shown in the schematic below:



Box no. 11: Clearing House

According to the settlement scheme, there is a redistribution of revenue, through transfer payments based on debits or credits between partners. Provision will be made in the logic to allow for the application of different settlement schemes to each category of Settlement.

Box no. 12: Accounting Activities

According to the Unified Accounting Rules the data sets no. 1, no. 2 and no. 3 will be processed to produce the three types of financial statements and significant ratios. Exogenous input tothis block includes financial data for regional operations, when applicable, and other exogenous accounting information.

Boxes no. 13 & 14: Solution of Accounting Equations

Manual input will be provided to set targets for three accounting variables or ratios at a time. Given these fixed values the set of simultaneous accounting equations are solved in order to determine the values of the remaining variables or ratios. Based on these solutions new financial statements and ratios will be produced. (see Appendix E)

Box no. 15: Regional Accounting Information

This input will be provided when the financial statements will be for the consolidation of inter- and intra-regional activities for the carriers. Basically, it will contain all components in the financial statements similar to those for the inter-regional ones.

Box no. 16: Other Exogenous Accounting Information

This input will contain all components for the inter-regional financial statements not calculated previously in the program.

4. INPUTS

The inputs into the model are, at least implicitly, identified in Section 3 PRINCIPAL BLOCKS AND THEIR INTER-RELATIONSHIPS. It is also to be noted that,being a perfectible one,the list and the nature of the inputs into the IRA model will change in time as some exogenous inputs become "endogenized" - and the reader is hereby begged to tolerate this barbarous, but convenient expression. These changes cover of course the turning together of the IRA model with parts or the whole of the HERMES and perhaps even other models.

To make easier the task of the readers of this Interim Report, who will be, it is hoped, the principal decision makers in the Department of Communications, it was decided to treat this topic in two steps: first, the conceptual level or to put it in more day-to-day words the "shopping list" of the data needed to make the model work and then to consider their availability. It will be recalled that the provision of data is almost exclusively a responsibility of the Department of Communications. However, since it is understood that in the present phase of the Project the IRA model may well be set to work with semi-realistic or even outright fictitious data, le Laboratoire d'économétrie agreed to devote some effort to the generation of the two types of data just mentioned. It is to be noted that some of the resulting suggestions imply additional software development and computing effort which have not been provided for in the original plans for the present phase of the Project.

4.1 Data required

It is understood that the Department of Communications will provide a simplified but realistic version of the inter-regional network with indication as to carriers and types of facilities.

It will be noted that for most purposes the model will require both the switching and the physical networks.

It has been agreed that the model will need a specification of the ownership but not, in this phase, of the corporate structure of the carriers. It has also been agreed that for the time being all revenue and cost data other than those relating to inter-regional activities will be provided as exogenous inputs.

In addition it has been agreed that in this present phase, income from non-telephony subsidiaries will enter as an exogenous input directly into the Accounting Block.

Semi-realistic cost functions will be provided by the Department of Communications concerning both the nodal equipment and the transmission equipment as well as cost functions relating to the operating of the system. It is understood that these will be relatively simple functions however, already in this phase, they will be step functions or sums of step functions and monotonicly increasing functions (it is total cost functions of course that are relevant here). These cost functions will be given by type of equipment, if possible with a further breakdown by carrier, geographic location and vintage of the capital asset involved. These cost functions will be defined with reference to capacity units of circuits(or groups of circuits) and not, at this stage, with reference to traffic units.

Origin-destination traffic data by carrier and by type of service will be provided by the Department of Communications with reference to the simplified network referred to above. It will be noted, on the one hand, that the HERMES III model required traffic increase data between pairs of demand points whereas what is required now is origin-destination data for all traffic. Switched traffic only has to be defined on the switching network and then HERMES III or some other procedure used to translate it in terms of the physical, i.e. facilities network. The use of procedures other than the CHARGE part of the HERMES III model to make this translation will almost inevitably involve some brutal simplifying assumptions.

It will be recalled that the relation between the peak traffic on the one hand and the average traffic on the other lies at the very heart of the problem facing the builders of the IRA model. This relation is highly complex and no more than a "best effort approach" to this problem can be envisaged for the next four months. A procedure referred to elsewhere in this Report and proposed by le Laboratoire d'économétrie aims at converting the capacity information on the facilities network, which is available into peak traffic point-to-point information. This still does not settle the origin-destination traffic information. In any case this represents only the first stage of the peak traffic/average traffic problem. Some suggestions concerning approximation procedures have been made, though it is too early to report on them here. They essentially involve more or less automatic generation of say four "periods of the day" origin-destination traffic matrices. This approach which at present is in an early exploratory stage has the additional advantage or promising to be able to handle at the same time the problem of different time zones. On the other hand its adoption may have considerable repercussions on software development and on computer requirements for simulation purposes.

4.2 Availability of data

Point-to point trunks for the inter-toll switching networks are available for the end of year 1970 as a result of the work done by the working group of inter-regional telecommunications. Given the homing arrangements, the overflow probabilities, and the routing rules we can identify approximately what the routes are for every pair of points of the switching networks. For the same period and from the same source, the inter-regional transmission facilities network is also available. But there remains the problem of matching the switching network with the facilities network, i.e. of identifying for every route of the switching network the corresponding set of facility chains, which obviously are defined in reference to the facilities network. The identification of the routes for every pair of points can be done manually, but it is a very time consuming task.

Concerning the point to point traffic we have no access to data. The amount of offered public message traffic can be estimated, using the Poisson and Erlang-b formulae and converting backwards from trunks to traffic, given the blocking and overflow probabilities. By means of a gravity model, we can then proceed to allocate the total traffic offered to each link between all relevant pairs of points. Again such work can be done manually but it is highly time consuming.

Assuming that we have an efficient algorithm by means of which we can derive point-to-point traffic, there nevertheless remains the problem of the relationship between peak and average traffic. Since the network is dimensioned on the basis of peak traffic, what we get in converting backwards from trunks to traffic is peak traffic. Peak traffic is particularly relevant to the calculation of costs whereas average traffic is needed for the calculation of revenues. For this current phase, the relationship between peak and average traffic might simply take the form of a pre-determined ratio. But it is agreed that in the near future this relationship will have to be assessed rigorously.

Traffic, routing and network are three inter-related components of the IRA Model which cannot be varied independently of each other. If the IRA Model is going to be an efficient model we need a computerized method by which these three components can be altered simultaneously, for example, as a result of an increase in the number of point-to-point trunks in the switching network. The development of such a method is scheduled for the second phase and it shall become one of the most important blocks of the IRA model.

For the time being owing to the difficulties of deriving traffic and routing information from a large network, we intend to begin working with a reduced network (25 nodes) just for the sake of getting the model going. However by March 31, 1974, the model shall have the capability of working with a more elaborated network [1] which shall be available by that time. At some future stage of development of the IRA model we intend to contact the carriers in order to solicit their comments and advice. A request for data could at the same time be formulated concerning the inter-regional traffic, routing and network. We also know that the TCTS organization has a "traffic forecasting model" and a "toll network model" which could be of a valuable aid to us.

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(1) This is the network represented in Appendix C.

5. OUTPUTS

Financial statements are major outputs of the IRA Model. These financial statements basically consist of the following:

- Balance Sheet,

- Income Statement,

- Sources and Uses of Funds Statements, and

- Significant Ratios.

These financial statements should be prepared for each individual carrier. Such statements should also be prepared for a consolidated inter-regional authority and for the carriers' operations consolidating the results of both regional and inter-regional activities. Depreciation and taxes being made components of costs and subject to possible different accounting regulatory treatment, the related calculations are shown in separate details in Appendix F.

For the inter-regional authority, the financial statements could as one alternative be the summation of revenues, costs, assets, and liabilities of the members which would assist in the evaluation of results in the consolidated forms. However, this would not be a realistic presentation for an operating authority as there would apparently exist some differences in the revenues and in the costs between the consolidated statements on a "summation" basis and on an actual activity of inter-regional authority basis.

These differences will be mainly due to:

- Owning or leasing of telephone property by the inter-regional authority The cost items such as depreciation repairs and maintenance will differ.

- Commission for termination may be paid as an extra cost for inter-regional operations. Sharing of costs and revenues may be on a different basis.

The formats of the above mentioned statements should conform to those which were developed by the Department of Communications in collaboration with the carriers in the initial phase of the Unified Accounting Project. The intended formats of the financial statements are shown in the attached exibits (see Appendix F). The generation of these financial statements is shown in the Working Paper No. 5 from the Department of Communications. Also, the significant ratios to be computed are shown in Appendix F.

Explanation of the Financial Statement Exhibits:

Balance sheet

The Balance sheet consists of two main parts:

- Assets
- Liabilities

The format specifically shows, in detail, the changes that take place during the current year. For these reasons, the assets and liabilities are analysed in three sections:

- Position at the beginning of the year,
- Changes during the year, and
- Position at the end of the year.

Income statement

The income statement illustrates the operating revenues, operating expenses, other expenses, income taxes, debt service charges, extraordinary items and finally net income available for dividends and retained earnings.

Sources and Uses of Funds

This statement shows how various funds are collected and from what sources. It also shows how these funds have been deployed, such as in, gross construction expenditures, investments, miscellaneous and increase of working capital. It should be noted that the sources and uses of funds algebraically equal the changes to the Balance Sheet.

6. SIMULATIONS

It will be remembered that this is an interim report only. Its chief purpose is to prepare options for the Department of Communications decision makers. In addition a good deal of work on simulation planning done so far is already described in two Department of Communications working papers, cited in Appendix A, and is also contained in Section 7 of this report. The reader will not therefore expect to find in this section an exhaustive discussion and a complete plan of conceivable simulations which could be made within the framework of the IRA project.

The content of this section falls naturally under two headings: The simulations which could be undertaken between now and March 31st, 1974, on the one hand, and the simulations or rather types of simulations which could be envisaged for eventual subsequent phases of the project.

In the period between now and March 31st, 1974, simulations in the proper sense of the term will take place only in the costing block and the sharing block. At present, at any rate, the accounting block is just a data processing, albeit complex, device and the operations block has only a phantom existence, the operating activities being treated, at the moment, as exogenous inputs. There may, of course, be some simulations within the accounting block if they involve nothing more elaborate than "manual", so to say changes in some variable values or in parameters. There will also be no internalization of simulations in the present phase of the project.

It will be noted that simulations intended for the project will necessarily involve the use of an enlarged network (different carriers, different types of services, different modes of transmission and model equipments). However, changes in the operating activities will be done exogenously during the current phase.

It will also be noted that any simulations involving full division settlement schemes in the proper sense of the terms will also necessitate the use of an enlarged network.

In this present phase of the project, emphases will be put on the simulation of the effects of different settlement schemes both on individual carriers and on the inter-regional system as a whole. A summary of these simulations appears in Section 7 of the present report. To further complicate matters, the handling of some settlement schemes involved necessitates the simultaneous specification of different alternatives of certain costing procedures. This concerns in particular items such as depreciation, the cost of capital, operating costs, etc... It will be recalled that operating activities as well as costs and revenues associated with facilities other than those used in inter-regional activities will be treated in the present phase of the project as exogenous inputs only.

Some of the simulations intended already for the period between now and March 31st, 1974, will be handled formally by solving systems of simultaneous equations, as agreed earlier with the specialists of the Department of Communications and as described in Appendix E. In each case, a system consists of seven equations in ten variables in the left hand-side, the other variables being kept fixed. However, it will be noted that in the example developed in Appendix E dividends are fixed and there are only nine variables dealt with. These systems are obviously non-linear. The simulations consist of fixing two variables in the left-hand member of any given system and solving for the other variables.

It will be noted that this incidentally eliminated the embarrassing non-linearities. Eight proposed simulations can be made out in this way although we cannot be certain a priori that the elements of the solutions will have the correct signs.

Also in Appendix E, it is proposed to fix bounds on certain ratios and variables and proceeds on linear programming lines. The role of the objective function would be to optimize a weighted sum of several slack variables which have certain economic significance, as discussed further in Appendix E.

This concludes the discussion of the simulations to be made between now and March 31st, 1974. The success of these simulation obviously depends in a vital way on the provision of the appropriate data by the Department of Communications.

Concerning the simulations to be made in subsequent phases of the project, it is to be stressed that the help of the HERMES series of models (or parts of it) will most useful if not indispensable. Simulations concerning the effects of alternative routing patterns would be obtained either with the help of HERMES or by other means or, more likely, by a mixture of the two approaches.

Analogous considerations apply to the facilities network.

It is to be noted that if simulations of different traffic patterns are to be undertaken, the HERMES model might facilitate extraction of information on traffic.

Le Laboratoire d'économétrie has already developed a special algorithms based on the HERMES philosophy. Its purpose is to identify facility chains for a varying number of pairs of demand points.

The internalization of simulations would involve the setting up of an extremely complex mathematical model. This would make it virtually impossible to ascertain in advance the convergence of any algorithm that may be developed for any but the most simple type of simulations. It is thus inevitable that the models of IRA series will remain, for any conceivable future, "man-machine" teams rather than fully automatic devices.

Concerning internalized simulations, it is by no means clear what is the function to be optimized: The reader is referred to the Section 2 of the present report where the matters of "objectives of the project" is discussed. The obvious responses to this type of difficulties are post-optimization studies as well as repeated simulation runs.

To take up for a moment a more technical point, it is also to be noted that simulation of the consequences of alternative routing patterns may give rise to considerable difficulties concerning the transmission (but probably not switching) where the pattern of the ownership of assets may be incompatible with certain routing schemes.

Finally, it is hoped that between now and March 31st, 1974, it will be possible to produce together a grill of possible simulations, identifying the ones which are internally inconsistent and also suggesting the ones which seem to merit particular attention.

7. SOFTWARE CONSIDERATIONS

For the present phase of the Project the programming of the IRA model will be done in FORTRAN. When data are made available from the carriers this will probably be best handled by COBOL in the accounting block. PL1 is a future option once the model is fully operational.

Computer Facilities

During initial programming syntactical debugging for the compilation of the programm will probably be done on a computer terminal. Once test data is received from the Department of Communications the logical debugging and predetermined simulations will be done through batch processing at the McGill Computing Centre.

Feature of Programming Logic

Certain types of simulations do not require a complete rerunning of the entire program. Consider the example of changing the rate structure which does not change the asset values or costs. Therefore, intermediate outputs, asset values and costs in this example, are stored peripherally in data sets (disc, drums, tapes, cards). This means that the user has access to the model at various stages of its operations and can within limits impose his will upon the results or parameters inherited from the earlier stages. Simulations with different tariff structures can then be made beginning with this stored intermediate input.

Flexibility and perfectibility have been and will continue to be among the major considerations behind the software work in this Project.

The initial programming for the model will be highly flexible. This flexibility is necessitated by the fact that the model will be evolving during the first phase (an operational model by March 31, 1974) and in subsequent development work, both phases relating to the following factors:

1) Modifications will be made to operations performed in the model, for example, capital and operating cost functions will initially be derived by applying ratios to asset values but these will later be made more realistic by taking into account factors such as traffic and the relationship of peak and average traffic.

2) Simulation on accounting relationships will first be done externally by changing original input and manual intervention for the Accounting Block. Following these activities and elaboration of the logic for the

Policy Simulation Block, the model will be required to handle internalized or automatic simulation in order to determine the changes required in the calculations, such as changing the rate structure.

3. Future simulations will be based on experimentation on ownership structures, the composition of the inter-regional network, policy decisions, etc.

Initially, traffic and associated facility information will be provided through the format specified in the traffic data for origin-destination pairs (see Exhibit I - Test Data Format in Section 3.6). However, in the future, a link with HERMES or other suitable source will facilitate direct extraction of information on traffic, routing, facilities at present and for expansion, and associated costs. At this future stage, experimentation could be done on traffic configurations, routing patterns and network, that is, in the envisaged Operations block.

This flexibility will entail an open-ended program which will be able to handle changes from simple runs with minimal feedbacks to the final product with more complex operations and numerous loops accomodating internal simulations. In the initial development this flexibility will be at the cost of efficiency. However, when the model is fully operational in meeting all simulation needs then a more efficient program can be written.

As pointed out more than once elsewhere in this Report the internalization of simulations and the degree to which this could and ought to be done gives rise to some of the serious options arising at this stage.

The development of the Policy Simulation Block and its full incorporation into the IRA series of models would involve the following steps:

Step 1: Through further analysis, fixing ideas on:

i) what governmental policies are to be investigated

ii) what financial or accounting parameters may be selected as decision criteria best relating to the policies selected.

This analysis requires, among other things, as input, the consideration of what parameters are provided for in the logic of the first phase IRA Model (all the four blocks of the model as it is intended for the current phase, that is excluding only the Policy Simulation Block). If these parameters do not suffice to investigate specific selected policies, this deficiency should be corrected if possible before the actual programming of the model is far advanced.

Further, a by-product of this analysis would be the selection of a set of simulation runs useful in testing the program of the first phase IRA Model.

Step 2: General testing of the first phase IRA Model to provide an idea of the sensitivity of the results to changes in input parameters (i.e. partial sensitivity analysis).

Step 3: Fitting of constants in the set of simultaneous accounting equations to obtain correspondence with the results as provided by the financial statements (Data Set No. 4) - based on research to date this does not appear to pose much difficulty.

Step 4: Development of Policy Simulation Block logic providing for the design of endogenous simulations (including iterations where necessary) and programming of this block.

Step 5: Testing of the Policy Simulation Block on sample simulations.

Step 1 is the main interest of the Department of Communications and Le Laboratoire d'économétrie while Sorès assumes main responsibility for steps 2 and 5, and partial responsibility for steps 3 and 4.

For the present phase of development (to March 31, 1974) it will be necessary to begin discussing step 1 in order to avoid situations wherein the four blocks of the IRA Model as envisaged for the present phase require major modifications to accommodate the Policy Simulation Block.

Step 2 will be largely provided for by March 31, 1974 through testing of the first phase programming.

The remaining steps which pertain essentially to the programming and testing of the Policy Simulation Block cannot be undertaken in this phase (except step 3 which will largely be covered in simulations accomplished via the method of simultaneous equations in the first phase to March 31, 1974) partly because the problem has not been studied and partly because actual programming on the first phase has not yet begun.

8. WORK PROGRAM AND ALLOCATION OF TASKS TO MARCH 31, 1974

In this section, reference is made to le "Protocole d'entente du 15 août 1973" whose english version, called "Memorandum of Understanding", dated August 22, 1973. Although edited by le Laboratoire d'économétrie this document was accepted by all the participants. The following statement of work to be completed by March 31, 1974, flows from the proposals set forth in that document and the description of the present state of the project contained in this Interim Report, together with the summary of simulation plans included in Section 6 of this Report. The tasks to be performed are here allocated among the participants responsible.

On page 2 of the Memorandum of Understanding it is stated that: "In the current phase of the IRA Project, the principal objective is to construct a model capable of producing for each carrier involved in the inter-regional network, statement of their expenses for the use of the common network for a given financial period, as well as a financial statement covering their assets and operating income, corresponding to different separation schemes of the revenues and of the expenses related to inter-regional telecommunications". As pointed out earlier in this Report different financial statements are produced in the Accounting Block by means of different inputs generated by the preceding blocks and/or data sets, as shown in the Flowchart contained in this Interim Report. In order that these simulations may be carried out, the following must be done:

<u>By le Laboratoire d'économétrie</u>

Completion of the algorithms upon which the software for the Accounting Block is based. It is understood that the accounting statements to be produced, schematic examples of which are shown in Appendix F of this Report, will reflect the structure of the carriers' accounts as set forth in the Department of Communications publication "Financial Statements of the Telecommunications Carriers".

<u>By the Department of Communications</u>

Preparation of the input data necessary for simulation runs to be performed. These data may be either real or fictitious. At this stage, they will take the form of direct inputs in a form which can be used by model. In some cases exogenous data will be direct inputs into the Accounting Block.

<u>By Sorès Inc.</u>

Completion of the software which will make the Accounting Block fully operational with respect to these simulations.

With reference to Section 5 of this Interim Report it is to be observed that further conceptualization is required in the development of financial statements for the Inter-Regional Authority dependent on the form it takes. This would entail the following:

By the Department of Communications

Further study for outlining the principal logic.

By le Laboratoire d' économétrie

Preparation of necessary algorithms.

By Sorès Inc.

Accommodating requirements in the software system.

Reference is further made to the Memorandum of Understanding, wherein it is stated on page 6 that "In the contemplated simulation runs, the domains of variation of the different parameters will have to be such that the financial survival of the system and of its various parts is assured and, more generally, that they be acceptable from the economic, political and social viewpoints". Thus we shall have to identify these different acceptable domains of variation.

It is also to be noted that progress of work to the present, together with the requirements that the model produce financial statements based on different cost and settlement schemes subject to constraints, calls for design of a block which will generate endogenous simulations under decision rules. These simulations will initially operate through the Costing Block and the Sharing Block, selecting different options, with respect to derivation of costs and choice of settlement schemes. Subsequently it may work through the Operations Block via rates and tariffs, network expansion and routing.

The present phase of the model requires conceptualization of this "policy simulation block", together with selection of the combination of options which may be subject to simulation. At this stage, it is the responsibility of le Laboratoire d'économétrie to provide a best effort at conceptualization, with due regard to the magnitude of this task and the time available.

This will be accomplished by the participants as follows:

By the Department of Communications

Provisional delineation of guidelines which will then be translated, in so far as possible, and with the help of le Laboratoire d'économétrie into the ratios and other variables which establish the bounds of the acceptable domains of variation.

By Sorès Inc.

Making sure that the software developed in this present phase be able to accomplish the necessary truncations of simulation runs, modification of parameter values and other tasks resulting from the above. It will be noted that these operations may be a function of the result of the preceding simulation runs. This, in fact, constitutes the first step towards the "internalization of simulations", though be it understood strictly on a best effort basis.

By le Laboratoire d'économétrie

Preparation of necessary guidance to Sorès Inc.

It was observed in Section 6 of the present Interim Report that simulation input data could be prepared in the Sharing Block of the model on the basis of certain assumptions to be made in the Operations Block with the Costing Block unchanged.

In order that this may be done, the following tasks must be performed:

By the Department of Communications

Provision of data relating to average traffic and rates, together with changes in these variables. At the present stage, these data will not necessarily imply changes in network and routing.

By le Laboratoire d'économétrie

Preparation of algorithms whereby these data may be transformed into outputs from the Costing and Sharing Blocks and inputs into the Accounting Block.

By Sorès Inc.

Preparation of the necessary software.

Further reference to page 2 of the Memorandum of Understanding establishes the following as a further task to be performed by March 31, 1974: "In the current phase of the Project and keeping in mind the ultimate objective just outlined, the IRA model ought to be capable to simulate the effects, at the inter-regional level and separately for different carriers, of changes in costing procedures and in revenue sharing schemes." This imposes the following obligations, giving due regard to the developmental work completed since August 22, 1973:

By Sorès Inc.

Preparation of software which will complete the model in skeleton form in the Costing Block, the Sharing Block and Accounting Block. In the current phase, this software will be completed to the point where the above exogenous simulations in Costing and Sharing Blocks can be carried out with manual intervention. However, it should be capable of expansion for use with additional exogenous inputs from the Operations Block. Although in the present phase the operating activities will be handled as exogenous inputs, it is thought advisable to provide for the existence of an Operations Block in view of future refinements and in particular the widening of the range of simulations. It is to be noted that "operations" cover a wide range of phenomena: traffic, tariffs, routing patterns, as well as revenues and costs associated with operations other than inter-regional telecommunications - some of this information being at present included in inputs boxes 15 and 16 (Flowchart). It should also be able to be used with endogenous inputs arising from the decision rules contained in the Policy Simulation Block which will be incorporated at a later stage.

By le Laboratoire d'économétrie

Any further conceptualization necessary, and preparation of algorithms.

By the Department of Communications

Provision of any further detail needed on cost and revenue separation, settlement schemes, etc...

In order to meet the requirement that the model shall be "operational but not necessarily efficient" (page 3 of the Memorandum of Understanding), the following will also be required:

By the Department of Communications

Data inputs into the Operations Block. Derivation of average traffic from available cost and revenue data, design of a reduced network, and other procedures for the production of the data, will be carried out in close co-operation with Sorès Inc. and le Laboratoire d'économétrie.

All the preceding is strongly dependent on a very intense and rapid development of the data base which is a manifest responsibility of the Department of Communications. It is to be noted that this is not only a matter of data gathering but also of the choice of proper units and classifications, formats, etc... It is understood that le Laboratoire d'économétrie will provide the necessary conceptual support in this area.

It is hoped that the Department of Communications will be in a position to rapidly develop its data base on Canadian telecommunications, especially since it is known that much if not most of these data exist or could be fairly easily obtained from current records regularly kept for other purposes.

9. OPTIONS

Reference is here again made to page 2 of the Memorandum of Understanding, which states: "We hope that, in some time in the future, the models of this group in conjunction with other models will contribute to a more efficient planning of capital deployment for inter-regional telecommunications purposes and also possibly for the purpose of more efficient operating of inter-regional telecommunications." Within this broad statement of future objectives, it is noted that the following tasks may logically be expected to follow, not necessarily in the order shown.

It is also to be noted that the sections of this Report are not self-contained. What in fact might be termed options open to the Department of Communications decision makers are also discussed elsewhere in the Report and in particular in Section 2 SOME PRINCIPAL CONSIDERATIONS, Section 6 SIMULATIONS and Section 7 SOFTWARE CONSIDERATIONS. It might even be argued that some crucial questions involving broad decisions concerning the future of the IRA series of models are treated in the other sections rather than here: this is justified by the desire to discuss them in their proper setting rather than simply to list the options available.

Given that the current phase calls for a model that is "to be constructed to be perfectible" (Memorandum of Understanding, page 3), further work by Sorès Inc. would include improving the efficiency of the model's software. Eventually, this last aspect of the model will have to be improved so as to bring down to a reasonable level the cost of a simulation run.

Incorporation of the "policy simulation block" described in Section 8, if it is to be mechanized to any significant extent, will call for the following work.

By le Laboratoire d'économétrie

Continuing work on conceptualization and simultaneous preparation of algorithms.

By the Department of Communications

Specification of decision rules and selection of policy options; specifications of various cost and revenue sharing (settlement) configurations.

By Sorès Inc.

Preparation of necessary software, with continuing work on improving software efficiency. Sorès Inc. will consider on a "best effort basis" the development of capacity to simulate on variables in the Operations Block. This would include simulations on changes in rates and tariffs, and simulations giving rise to joint uses with the HERMES III model or some of its components.

The participants would make the following contributions:

By the Department of Communications

Specifications of tariff configurations, including constraints, further assumptions or inputs relative to the peak/average problem, projections of growth in demand.

By le Laboratoire d'économétrie

Preparation of algorithms to expand the operations of the "policy simulation block" in view of the contemplated future internalization of some simulations. It would be unwise to try to internalize all types of simulations leaving no room for human judgment.

By Sorès Inc.

Preparation of software, including the software necessary to link the CHARGE module of HERMES III to the IRA model. It is understood that this work will be of substantial magnitude, particularly given the objective of continuously improving the efficiency of the software. Reference is made to page 1 of the Memorandum of Understanding, in which it is stated: "at a certain stage the IRA model will have to be integrated with the models of the HERMES series. In more than one sense these two series of models are complementary to each other."

There is thus a clear option to continue along the various lines described in this Report with such models as might appear necessary in the near future, especially in so far as the planning and internationalization of simulations are concerned.

Another clear alternative is to cut short some of the work until the carriers provide the appropriate data and even the algorithms and software which could be used together with the IRA model. It is hoped that the progress achieved with the Department of Communications in developing the methodology in question might prompt the carriers to cooperate more closely. The project thus referred to will lead to a clear specification of the requirements concerning data and other resources likely to be found in carriers' hands and also a clear statement of the Department of Communications' objectives.

One final option which must be considered is the possibility of halting work on this project. Thus, while we foresee a model which is "operational but not necessarily efficient" by March 31, 1974, this model will be tested with fictitious or partial data only. In order that this option may be given due consideration, le Laboratoire d'économétrie will provide, for guidance purposes only, broad estimates of the orders of magnitude of resources which will probably be required for completion of these various options. It is foreseen that these orders of magnitude could be expressed by reference to the resources involved in the earlier projects to which the present proposals are related, i.e., the HERMES series of models.

This final, or rather harakiri option, does not mean that the Department of Communications will necessarily renounce its efforts to examine the various ways of preparing policy decisions. It may choose do so by means other than formalized optimization and simulation models.

APPENDIX A

LIST OF PAPERS CIRCULATED

Texts provided by the Department of Communications

- Working Paper no. 1, avril 1973, D.O.C.

- Working Paper no. 2, 13 juillet 1973, D.O.C.

- "Inter-Relations between deferred taxes and depreciation", 11 septembre 1973, Government Telecommunications Agency.

- Texte de J.A. Guérin, du 27 septembre 1973

- Working Papers no. 3, 4, 11 octobre 1973, D.O.C.

- Lettre de G. Henter à T. Matuszewski, du 26 octobre 1973

- Working Paper no. 5, 31 octobre 1973, D.O.C.

- Working Paper no. 3-A, 1er novembre 1973, D.O.C.

- "Equations for Simulation on the Accounting Module of the IRA Model", D.O.C., Nov. 1, 1973

Texts provided by le Laboratoire d'économétrie

- Texte de C. Autin, 12 juillet 1973 (Notes pour la réunion du 13 juillet 1973)

- Working paper of 17 juillet 1973, C. Autin, G. LeBlanc, T. Matuszewski

- Texte de C. Autin, 31 juillet 1973 (Tableau comptable)

- Protocole d'entente, 14 août 1973, C. Autin, G. LeBlanc, T. Matuszewski

- Memorandum of Understanding (English version of the preceding), August 22, 1973, C. Autin, G. LeBlanc, T. Matuszewski

- Texte de B. Paquet, 20 septembre 1973 (taxonomie de la structure de propriété)

- "Complément au tableau comptable du professeur C. Autin", C. Autin, G. LeBlanc, 2 octobre 1973

LIST OF PAPERS CIRCULATED (cont'd)

- "Complementary Notes to the text by Prof. C. Autin of July 31, 1973, C. Autin, G. LeBlanc, October 2, 1973
- Texte de C. Autin, 11 octobre 1973 (logique du modèle)

<u>Notes of meetings</u>

- Notes de la réunion du 11 mai 1973, (Laval), C. Autin
- Notes de la réunion du 13 juillet 1973, (Laval), T. Matuszewski
- Notes de la réunion du 30 juillet 1973, (Ottawa), T. Matuszewski
- Compte-rendu de la réunion du 11 septembre 1973, (Laval), C. Gilles
- Notes de la réunion du 18 septembre 1973, (Laval), C. Gilles
- Notes de la réunion du 28 septembre 1973, (Laval), B. Paquet
- Compte-rendu de la réunion du 5 octobre 1973, (Laval), C. Gilles
- Notes de la réunion du 12 octobre 1973 (Laval), T. Matuszewski
- Notes de la réunion du 18 octobre 1973 (Montreal), T. Matuszewski
- "Comments on Professor Matuszewski's notes on Meeting Held in Quebec, October 12, 1973", J.A. Guérin, 26 octobre 1973
- Notes de la réunion du 1er novembre 1973 (Ottawa), Miss M.R. Prentis

APPENDIX B

SOME NUMERICAL EXAMPLES

ILLUSTRATED EXAMPLE OF DEFERRED TAXES

Suppose the following data is given:

1.	Taxable Income - table "A" of Income Statement		$146
2.	Tax Rates - table "A" of Income Statement	say	43%
3.	Income Tax as per Company Books - table "A" of Income Statement (or item 1 x item 2)		63
4.	Net Income after tax (Income Statement) item 1 - item 3		83
5.	Taxable Income as per Income Tax Act (tax return)		60
6.	Tax Rates - table "A" of Income Statement	say	43%
7.	Tax provision as per Income Tax Act (item 5 x item 6)		26
8.	Difference between C.C.A. and Book Depreciation - (Company records)	say	14
9.	Δ Expenditure Net i.e. (item 1) - (item 5 plus item 8) = 146 - (60 + 14) = 72		72

Then the deferred tax will be calculated as follows:

Alternative 1 of table 4

Taxable Income (table A, Income Statement)	$146
Less Taxable Income as per Income Tax Act - item 5 above	60
Deferred Taxable Income	86
Tax Rate	43%
Deferred Taxes (same as alternative 2)	$ 37

Alternative 2 of table 4

Net Income (item 4 above)		$ 83
Plus tax provision in Company Books - item 3 above		63
Net Income before provision for Income taxes		146
Less:		
The net result of the following:		
Net income before provision for Income Taxes	$146	
Less Δ Expenditure Net - item 9 above	(72)	
Less Difference between C.C.A. and Book Depreciation - item 8 above	(14)	60
Deferred Taxable Income		86
Tax Rate		43%
Deferred taxes (same as alternative 1)		$ 37

TABLE 1 TELEPHONE PROPERTY AND DEPRECIATION

	Cost at beginning of year (gross)	Additions	Retirements	Other change	Net addition to plant	Cost at end of year	Avge. Cost	Depreciation rate	Annual Depreciation
	1	2	3	4	5=(2-3±4)	6=1+5	7=(1+6)÷2	8	9=7x8
Switching	x	x	x	x	x	x	x	x	x
Transmission	x	x	x	x	x	x	x	x	x
Terminal Device	x	x	x	x	x	x	x	x	x
Other	x	x	x	x	x	x	x	x	x
Common	x	x	x	x	x	x	x	x	x

SOURCES:
Col. 1 - Accounting - property records
Col. 2 - Hermes
Col. 3 - Accounting (or retirement algorithm)
Col. 4 - Accounting
Col. 8 - Depreciation algorithm (Company records)

TABLE 2 NET CHANGE TO ACCUMULATED DEPRECIATION

Annual Depreciation	Retirement	Cost of Removing	Salvage Value	Net Change to Accum. Depreciation
1	2	3	4	5=(1-2-3+4)
(From Colum 9 Table 1)	(From Accounting Records)			

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TABLE 3

C. C. A.

		Total	Class 10 30%	Class 9 25%	Class 8 20%	Class 17 8%	Class %
UCC - Beginning of the year		x x	x	x	x	x	x
Add: Net additions		x x	x	x	x	x	x
UCC Subject to allowances		x x	x	x	x	x	x
Less: CCA for current year		x x	x	x	x	x	x
UCC - end of year		x x	x	x	x	x	x
→ Current year C.C.A.	x x x						

CAUTION - Note that net additions in the above are no the same as in Table 1 net additions because some expenses are capitalized under book depreciation but expensed under CCA; also retirements are not deducted from undepreciated capital cost, and interest during construction are expensed under CCA.

TABLE 4

DEFERRED TAXES

ALTERNATIVE 1

Taxable income (table A, Income Statement)		x x
Less Taxable Income as per Income Tax Act (Company's tax statement)		x x
Deferred Taxable Income		x x
Tax Rate		x x
Deferred Taxes		x x

ALTERNATIVE 2

Net Income (Income Statement)	x x	
Plus: tax provision in company books (Income Statement Table A)	x x	
Net Income before Provision for Income Taxes		x x
Less: The net result of the following:		
Net Income before Provision for Income Taxes	x x	
Less: △ Expenditure Net* (accounting records)	x x	
Less: Difference between C.C.A. (table 3) and Book Depreciation (table 1)	x x	x x
Deferred taxable income		x x
Tax rate		x x
Deferred Taxes		x x

* △ Expend. Net - (Net Income plus book provision for income taxes) - (taxable income on tax payable basis plus CCA in excess of book provision for depreciation)

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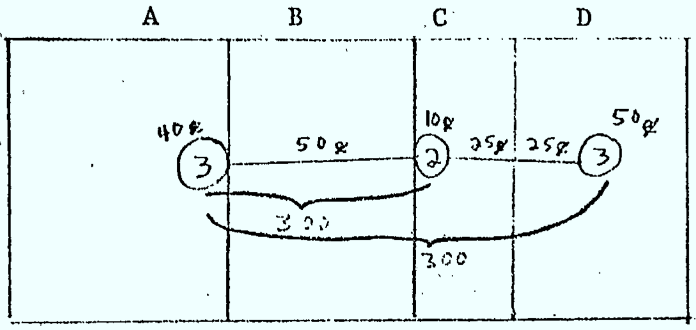
CTO SETTLEMENT SCHEME: AN EXAMPLE OF COST ALLOCATION



$t_{AC} = 50$, $t_{CA} = 250$ $= \bar{t}_{CA} = \underline{300 \text{ CCS}}$

$\bar{t}_{BA} = \bar{t}_{BC} = \bar{t}_{BD} = \bar{t}_{CD} = 0$

$t_{AD} = 100$ $\quad t_{DA} = 200 = \bar{t}_{DA} = \underline{300 \text{ CCS}}$

Note:

1) In this example, the switching network and the facilities network coincide.

2) There is one category of service (public message), four participating carriers (A, B, C, D) to the common system and four traffic streams (t_{AC}, t_{CA}, t_{AD} and t_{DA})

3) For each of the partners the measure of the usage of the common system is the <u>bothway</u> traffic

4) The collection rate and the accounting rate is the same, and there are no terminal charges

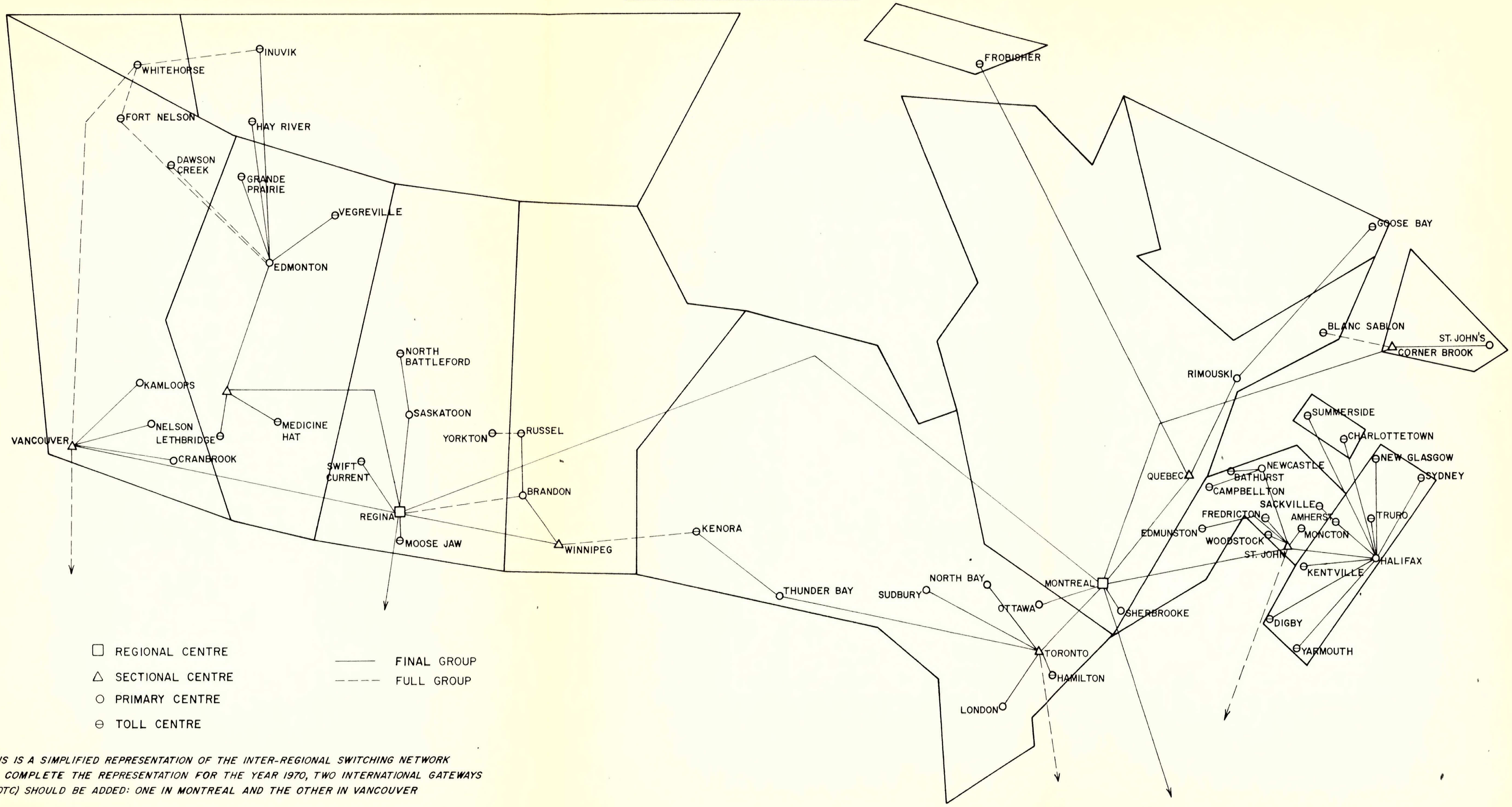
5) Traffic going to control switching points (Class 1, 2, 3) is toll tandem traffic and in most cases this is also true for the traffic going to Class 4 offices (toll centres). Therefore, the switching costs in Region C are the same whether the call terminates in Region C or Region D.

Rates: $4.00/CCS for AD or DA; $2.00/CCS for AC or CA

Stream Unit Costs: $1.00 for AC or CA; $2.00 for AD or DA

	A	B	C	D	Total
Allocated:					
1) Expenses	150 300 $450	0	150 $ 150	 300 $300	$900
2) Revenues	300 600 900	0	300 300	 600 600	$1800
3) Incurred Expenses	$240	$300	$135	$225	$900
(1) - (3) -	$210	$-300	$ 15	$ 75	0
4) Profit: (2) - (1)	$450	0	$150	$300	$900

APPENDIX C INTER-REGIONAL SWITCHING NETWORK (LATE 1970): FULL AND FINAL GROUPS



NOTE: 1. *THIS IS A SIMPLIFIED REPRESENTATION OF THE INTER-REGIONAL SWITCHING NETWORK*

2. *TO COMPLETE THE REPRESENTATION FOR THE YEAR 1970, TWO INTERNATIONAL GATEWAYS (COTC) SHOULD BE ADDED: ONE IN MONTREAL AND THE OTHER IN VANCOUVER*

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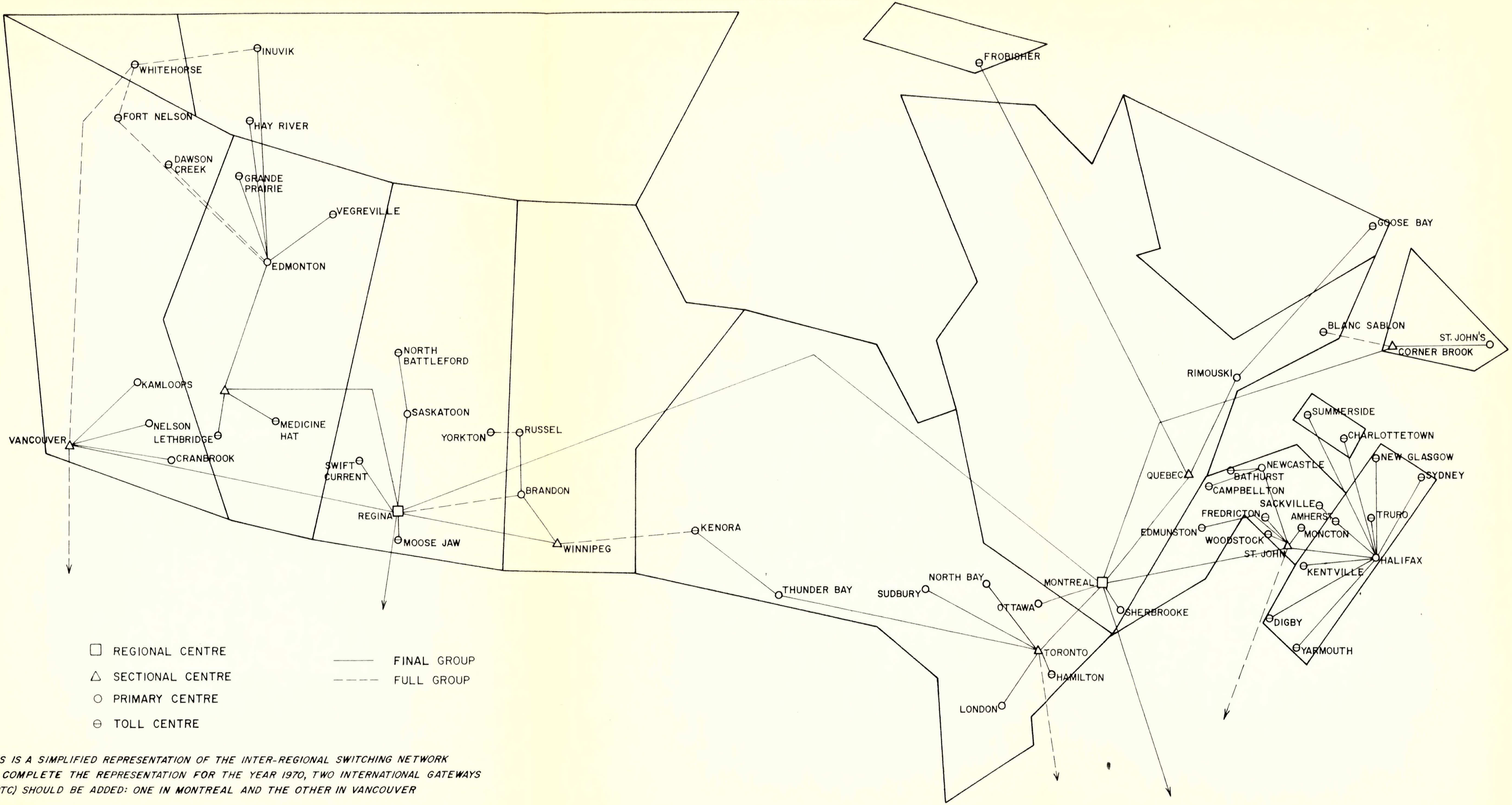

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APPENDIX D

NOTE POUR LE CALCUL DE DONNEES FICTIVES DE TRAFIC

Soient : un ensemble de paires de points de demande, un réseau de commutation donné, un réseau physique entièrement donné et les capacités mesurées en nombre de circuits sur chaque arête connues également; on suppose les capacités des noeuds suffisantes.

Problème: trouver des trafics directionnels compatibles avec les données?

Il y a évidemment une infinité de solutions. Il nous faut introduire quelques hypothèses et contraintes supplémentaires.

Hypothèses sur les trafics

Les trafics sont les trafics de pointe puisque le réseau physique est dimensionné à partir de ceux-ci.

Le trafic entre la paire de points de demande i est approximativement proportionnel à la somme P_i des populations voisines de ces deux points et inversement proportionnel à la distance d_i (ou distance au carré) entre ces mêmes points. Nous supposons de plus que le trafic se partage moitié-moitié dans les deux directions.

Pour être dans la partie linéaire de la fonction de transformation des charges en nombre de circuits (à probabilité de perte ou de débordement donnée), nous supposons que chaque trafic possède une borne inférieure (5 erlangs?). Cette borne jouera le rôle du trafic initial dans le module CHARGE que l'on suggère d'utiliser. On suppose que les capacités installées sont largement suffisantes pour satisfaire les bornes inférieures des trafics.

Hypothèses sur les chaînes

A partir du réseau physique, on détermine par inspection, ou à l'aide d'un algorithme à établir, quelques (2, 3 ou 4) chaînes raisonnables pour acheminer le trafic de chaque arc du réseau de commutation.

Hypothèses sur le critère de détermination des trafics

On propose le choix suivant:

Critère 1:

On cherchera à minimiser la distance entre les trafics calculés et les trafics obtenus en utilisant les hypothèses précédentes sur les trafics.

Ainsi, si pour le trafic i de valeur x_i, on note x_{oi} la borne inférieure et Δx_i la variation positive à partir de cette borne, et, si, d'autre part, $x_i \approx \frac{\gamma P_i}{2 d_i}$, pour tout i, est la relation supposée plus haut, on pourra essayer de déterminer les Δx_i en minimisant sous contraintes la distance:

$$z_1 = \sum_i \left[\frac{\gamma}{2} \frac{P_i}{d_i} - (x_{oi} + \Delta x_i) \right]^2 ,$$

ce qui est égal à:

$$\sum_i \left[\left(\frac{\gamma P_i}{2 d_i} - x_{oi} \right)^2 - 2 \left(\frac{\gamma P_i}{2 d_i} - x_{oi} \right) \Delta x_i + \Delta x_i^2 \right] ,$$

Le problème est donc équivalent à un problème où l'on minimise

$$z_2 = \sum_i - \left(\frac{\gamma P_i}{d_i} - x_{oi} \right) \Delta x_i + \sum_i \Delta x_i^2 .$$

Il s'agit donc d'un problème de programmation quadratique pour lequel γ est inconnu. On pourrait l'estimer a priori et le paramétrer par rapport à un ensemble de valeurs raisonnables.

Critère 2:

Si l'on recule devant la programmation quadratique et l'estimation de γ, on peut penser que la fonction critère doit accorder plus de poids aux Δx_i associés à des populations importantes et proches l'une de l'autre. On cherchera alors à maximiser sous contrainte une fonction du genre

$$z_3 = \sum_i \frac{P_i}{d_i} \Delta x_i \ ,$$

P_i/d_i étant considéré comme un poids sans dimension.

Les contraintes

Pour une configuration donnée du réseau de commutation, les règles de débordement et les probabilités de débordement et de perte étant données, l'algorithme CHARGE, après quelques modifications "d'output" surtout, pourrait fournir les coefficients suivants:

f_{ik} : la fraction du trafic i passant par l'arc k du réseau de commutation quand ce trafic est égal à une unité.

n_{ok} : le nombre de circuits nécessaires pour satisfaire le trafic initial (pour nous la borne inférieure du trafic cherché, soit $\sum_i f_{ik} x_{oi}$) sur l'arc k.

n_k : l'accroissement du nombre de circuits nécessaires pour satisfaire l'accroissement d'une unité de trafic à partir du trafic initial sur l'arc k (voir figure 1).

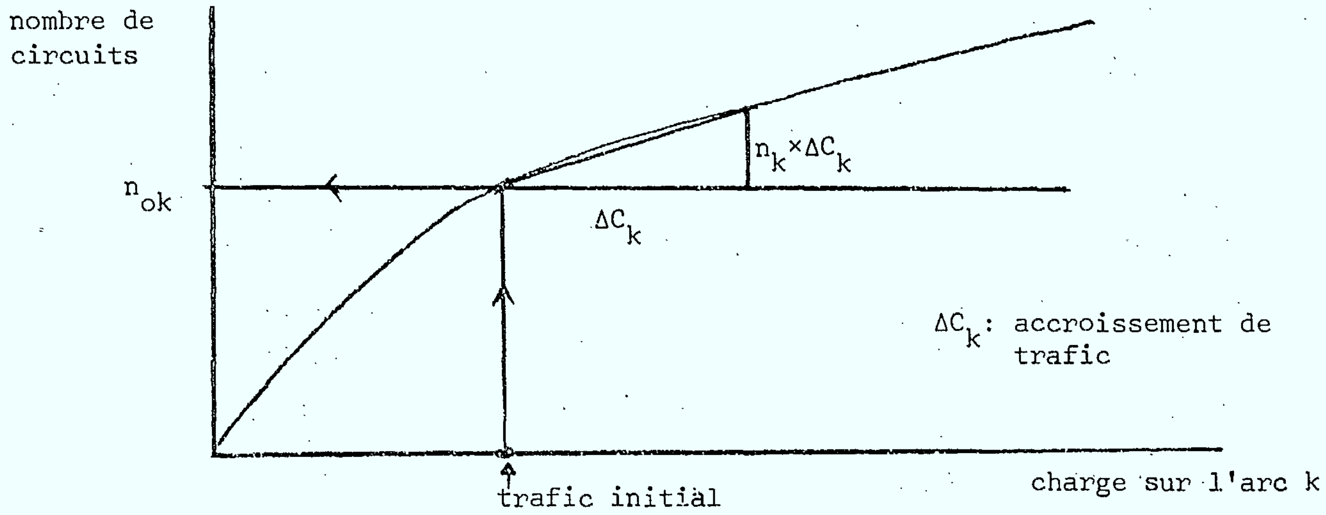

Figure 1

Définissons quelques autres variables et paramètres:

y_{jk} : le nombre de circuits affectés sur la chaîne j permettant d'acheminer le trafic de l'arc k.

ΔC_k : l'accroissement de trafic à partir de l'état initial sur l'arc k.

K_t : le nombre de circuits disponibles sur l'arête t du réseau physique.

$\delta(t,j,k)$: est un paramètre qui prend la valeur 1 si l'arête t est utilisée par la chaîne j de l'arc k et qui prend la valeur 0 dans l'autre cas.

Les contraintes sont les suivantes:

1. Définitions de l'accroissement de charge sur les arcs

$\sum_i f_{ik} \Delta x_i - \Delta C_k = 0$ pour tout arc k.

2. le nombre de circuits demandés ne dépasse pas le nombre de circuits affectés

$n_k \Delta C_k + n_{ok} \leq \sum_j y_{jk}$ pour tout arc k.

3. le nombre de circuits affectés ne dépasse pas le nombre de circuits disponibles

$\sum_k \sum_j \delta(t,j,k) y_{jk} \leq K_t$ pour toute arête t.

4. les variables cherchées sont non négatives

$\Delta x_i \geq 0$ et $y_{ik} \geq 0$ pour tous les i et k.

Ces contraintes définissent conjointement la ré ion admissible sur laquelle sera "optimisé" le critère choisi.

La détermination du trafic annuel

L'estimation des $x_i = x_{oi} + \Delta x_i$, pour tout i, a été faite pour du trafic de pointe. Sans observation il est difficile de trouver la relation entre ces trafics et les trafics annuels x_i'. Si l'on est prêt à faire l'hypothèse qu'approximativement $x_i' \approx \alpha x_i$, pour tout i, il est plus facile d'estimer α avec, peut-être, une seule observation sur un courant de trafic bien connu, ce qui donnerait $x_i'/x_i \approx \hat{\alpha}$.

Quelques résultats auxiliaires

La part d'utilisation de l'arc k provenant du trafic i est calculée comme suit

$$f_{ik}(x_{oi}+\Delta x_i) \;/\; \sum_i f_{ik}(x_{oi}+\Delta x_i),$$

il s'agit ici d'une fraction du trafic.

La part d'utilisation de l'arête t provenant du trafic de l'arc k est

$$\sum_j \delta(t,jk)y_{jk} \;/\; \sum_k \sum_j \delta(t,jk)y_{jk}$$

il s'agit ici d'une fraction des circuits.

Il est naturel de définir la part d'utilisation des circuits de l'arête t provenant du trafic i par la multiplication des deux fractions précédentes malgré la non linéarité de la fonction transformant les charges en circuits.

APPENDIX E

NOTE CONCERNING THE SIMULATIONS INSIDE THE ACCOUNTING BLOCK OF THE IRA MODEL

This note will consider the variables and equations given by Mr. Henter at the November 1st meeting.

1. Sign of the variables and parameters

Variable	Sign	Parameter	Sign
1. Net Inc	≷0	11. Depr	>0
2. New Eqy	≥0	12. Def Tax	>0
3. New Debt	?	13. Add	≥0
4. Div	≥0	14. Const*	?
5. Oprv	>0	15. Opxp	>0
6. Equity	>0	16. Tax rate	>0
7. Debt	≥0	17. $Equity_o$	>0
8. DCR	>0	18. $Debt_o$	≥0
9. RORE	≷0		
10. RORC	≷0		

* Although the same symbol is used in several equations, the constants are not always the same.

2. The equations

Re-naming the variables and parameters according to the numbers of the preceding table, the system of equations has the following structure:

$$
\begin{array}{ll}
(1) & x_1 + x_2 + x_3 = x_4 - x_{11} - x_{12} + x_{13} + x_{14} \\
(2) & x_1 + abx_3 + ax_5 = + ax_{11} + ax_{14} + ax_{15} \\
(3) & -x_1 - x_2 + x_6 = -x_4 + x_{14} + x_{17} \\
(4) & -x_3 + x_7 = + x_{14} \quad x_{18} \\
(5) & x_8 x_6 + (x_8 - 1) x_7 = 0 \\
(6) & -x_1 + x_9 x_6 = 0 \\
(7) & -x_1 - bx_3 + x_{10} x_6 + x_{10} x_7 = x_{14}
\end{array}
$$

where, a = -1 + Tax rate and b = the coefficient of New Debt.

The equations (1) to (4) are linear whereas (5) to (7) are non linear and come frome ratio definitions. The variables on the right hand side are predetermined for all simulations.

3. The existence of solutions for the envisaged simulations

3.1 First simulation

x_3 and x_5 are predetermined. The system becomes

(1-1)	$x_1+x_2 = C_1^1$	2 (2)
(1-2)	$x_1 = C_2^1$	1 (1)
(1-3)	$-x_1-x_2+x_6 = C_3^1$	3 (6)
(1-4)	$x_7 = C_4^1$	1 (7)
(1-5)	$x_8x_6+(x_8-1)x_7 = C_5^1$	4 (8)
(1-6)	$-x_1+x_9x_6 = C_6^1$	4 (9)
(1-7)	$-x_1+x_{10}x_6+x_{10}x_7 = C_7^1$	4 (10)

On the right of each equation we indicate which order has to be followed to solve the system and what variable is determined at each stage. For instance, 1 (7) means: solve that equation first, it will give you the value of x_7. That system is the easiest to solve since there are no simultaneous equations to be solved. The sign of the values will depend on the constant C_i^1.

3.2 Second simulation

x_2 and x_5 are predetermined. The system and the sequence to be followed in order to solve it, are:

(2-1)	$x_1+x_3 = C_1^2$	1 (1,3)
(2-2)	$x_1+abx_3 = C_2^2$	1 (1,3)
(2-3)	$-x_1+x_6 = C_3^2$	2 (6)
(2-4)	$-x_3+x_7 = C_4^2$	2 (7)
(2-5)	$x_8x_6+(x_8-1)x_7 = C_5^2$	3 (8)
(2-6)	$-x_1+x_9x_6 = C_6^2$	3 (9)
(2-7)	$-x_1-bx_3+x_{10}x_6+x_{10}x_7 = C_7^2$	3 (10)

Here, equations (2-1) and (2-2) has to be solved simultaneously. The system has certainly a solution since the determinant of the coefficient matrix of equations (2-1) and (2-2) is

$$ab-1 = (-1 + \text{Tax rate}) \times \text{Constant} - 1$$

which, in general, is different from zero unless Constant = 1 / (-1+Tax rate).

3.3 Third simulation

x_2 and x_9 are predetermined.

(3-1)	$x_1 + x_3 = c_1^3$	1	(1,3,5,6,7)
(3-2)	$x_1 + abx_3 + ax_5 = c_2^3$	1	(1,3,5,6,7)
(3-3)	$-x_1 + x_6 = c_3^3$	1	(1,3,5,6,7)
(3-4)	$-x_3 + x_7 = c_4^3$	1	(1,3,5,6,7)
(3-5)	$x_8 x_6 + (x_8 - 1)x_7 = c_5^3$	2	(8)
(3-6)	$-x_1 + \bar{x}_9 x_6 = c_6^3$	1	(1,3,5,6,7)
(3-7)	$-x_1 - bx_3 + x_{10}x_6 + x_{10}x_7 = c_7^3$	2	(10)

The system of equations (3-1), (3-2), (3-3), (3-4), (3-6) has for determinant $-a(1-\bar{x}_9)$ which cannot be zero unless a = -1+Tax rate = 0 or $\bar{x}_9$ = Rate of return on equity = 1, both events are extremely unlikely.

The correct sign for the unknowns is not garanteed.

3.4 Fourth simulation

x_3 and x_9 are predetermined.

(4-1)	$x_1+x_2 = C_1^4$	2	(1,2,5,6)
(4-2)	$x_1 + ax_5 = C_2^4$	2	(1,2,5,6)
(4-3)	$-x_1-x_2 + x_6 = C_3^4$	2	(1,2,5,6)
(4-4)	$x_7 = C_4^4$	1	(7)
(4-5)	$x_8x_6+(x_8-1)x_7 = C_5^4$	3	(8)
(4-6)	$-x_1 + \bar{x}_9x_6 = C_6^4$	2	(1,2,5,6)
(4-7)	$-x_1 + x_{10}x_6 + x_{10}x_7 = C_7^4$	3	(10)

The determinant is $a = -1+\text{Tax rate} \neq 0$.

3.5 Fifth simulation

x_3 and x_{10} are predetermined.

(5-1)	$x_1+x_2 = C_1^5$	2	(1,2,5,6)
(5-2)	$x_1 + ax_5 = C_2^5$	2	(1,2,5,6)
(5-3)	$-x_1-x_2 + x_6 = C_3^5$	2	(1,2,5,6)
(5-4)	$x_7 = C_4^5$	1	(7)
(5-5)	$x_8x_6+(x_8-1)x_7 = C_5^5$	3	(8)
(5-6)	$-x_1 + x_9x_6 + = C_6^5$	3	(9)
(5-7)	$-x_1 + \bar{x}_{10}x_6 + \bar{x}_{10}x_7 = C_7^5$	2	(1,2,5,6)

The determinant is $a = -1+\text{Tax rate} \neq 0$.

3.6 Sixth simulation

x_2 and x_{10} are predetermined.

(6-1)	$x_1 + x_3 = C^6_1$	1	(1,3,5,6,7)
(6-2)	$x_1 + abx_3 + ax_5 = C^6_2$	1	(1,3,5,6,7)
(6-3)	$-x_1 + x_6 = C^6_3$	1	(1,3,5,6,7)
(6-4)	$-x_3 + x_7 = C^6_4$	1	(1,3,5,6,7)
(6-5)	$x_8 x_6 + (x_8 - 1)x_7 = C^6_5$	2	(8)
(6-6)	$-x_1 + x_9 x_6 = C^6_6$	2	(9)
(6-7)	$-x_1 - bx_3 + \bar{x}_{10} x_6 + \bar{x}_{10} x_7 = C^6_7$	1	(1,3,5,6,7)

The determinant is a(b-1) = (-1+Tax rate)x(Constant-1) unlikely to be zero.

3.7 Seventh simulation

x_8 and x_{10} are predetermined.

(7-1)	$x_1 + x_2 + x_3 = C^7_1$	1	(1,2,3,5,6,7)
(7-2)	$x_1 + abx_3 + ax_5 = C^7_2$	1	(1,2,3,5,6,7)
(7-3)	$-x_1 - x_2 + x_6 = C^7_3$	1	(1,2,3,5,6,7)
(7-4)	$-x_3 + x_7 = C^7_4$	1	(1,2,3,5,6,7)
(7-5)	$\bar{x}_8 x_6 + (\bar{x}_8 - 1)x_7 = C^7_5$	1	(1,2,3,5,6,7)
(7-6)	$-x_1 + x_9 x_6 = C^7_6$	2	(9)
(7-7)	$-x_1 - bx_3 + \bar{x}_{10} x_6 + \bar{x}_{10} x_7 = C^7_7$	1	(1,2,3,5,6,7)

The determinant is $a = -1 + \text{Tax rate} \neq 0$.

3.8 Eight simulation

x_8 and x_9 are predetermined.

(8-1) $x_1 + x_2 + x_3 = C_1^8$	1	(1,2,3,5,6,7)
(8-2) $x_1 + abx_3 + ax_5 = C_2^8$	1	(1,2,3,5,6,7)
(8-3) $-x_1 - x_2 + x_6 = C_3^8$	1	(1,2,3,5,6,7)
(8-4) $- x_3 + x_7 = C_4^8$	1	(1,2,3,5,6,7)
(8-5) $+ \bar{x}_8 x_6 + (\bar{x}_8 - 1)x_7 = C_5^8$	1	(1,2,3,5,6,7)
(8-6) $-x_1 + \bar{x}_9 x_6 = C_6^8$	1	(1,2,3,5,6,7)
(8-7) $-x_1 - bx_3 + x_{10}x_6 + x_{10}x_7 = C_7^8$	2	(10)

The determinant has not been computed, but it is likely to be different from zero.

4. Hint for the software

If the sole simulations are the eight ones just examined, there is no problem since the sequences to be followed have just been identified. If other simulations are envisaged, the linearity at each stage of the sequences has to be conserved.

5. Conclusion on the simultaneous equations approach

All eight simulations have solutions but the correct sign for each unknown is not warranted.

6. The programming approach as a substitute

With a programming approach, the non-negativity, when it is required, would not be a problem. More over, upper and lower bounds on any variable could be imposed. In particular, putting bounds on ratios allows a linear programming statement of the problem. What follows will exemplified these ideas.

Suppose we keep the same variables x_4 and x_{11} to x_{18} predetermined. We want to find x_1 to x_7 with the correct sign and we assume the ratios being such that:

$$0 \leq \underline{x}_8 \leq x_8 \leq \bar{x}_8$$

$$0 \leq \underline{x}_9 \leq x_9 \leq \bar{x}_9$$

$$0 \leq \underline{x}_{10} \leq x_{10} \leq \bar{x}_{10}$$

The system of linear constraints is:

(1) $x_1 + x_2 + x_3 = C_1$

(2) $x_1 + abx_3 + ax_5 = C_2$

(3) $-x_1 - x_2 + x_6 = C_3$

(4) $-x_3 + x_7 = C_4$

(5) $\underline{x}_8 x_6 + (\underline{x}_8 - 1)x_7 + d_1 = C_5$

(6) $\bar{x}_8 x_6 + (\bar{x}_8 - 1)x_7 - d_2 = C_6$

(7) $-x_1 + \underline{x}_9 x_6 + d_3 = C_7$

(8) $-x_1 + \bar{x}_9 x_6 - d_4 = C_8$

(9) $-x_1 + \underline{x}_{10} x_6 + \underline{x}_{10} x_7 + d_5 = C_9$

(10) $-x_1 + \bar{x}_{10} x_6 + \bar{x}_{10} x_7 - d_6 = C_{10}$

The d_i are non negative slack variables. If any of them is zero the corresponding ratio reaches the associated bound. The objective function will have for arguments any non empty set of slack variables with the coefficients depending on our preferences.

For instance, a regulating agency could prefer x_9 to be near its lower bound $\underline{x}_9$ so that, if we maximize the objective function, d_3 should be assigned a minus sign in that function, but d_4 should have a plus sign. The same thing for d_5 and d_6. The signs for d_1 and d_2 is less obvious, we could leave them out of the objective function. If we prefer a Debt Capital Ratio x_8^* belonging to the interval $[\underline{x}_8, \bar{x}_8]$ we could state another constraint with a slack variable of unknown sign in the constraint; that result is obtained in defining two non negative variables d_7^+ and d_7^-, and the constraint is written:

$$(11) \quad x_8^* x_6 + (x_8^* - 1)x_7 + d_7^+ - d_7^- = 0,$$

since we want to be near x_8^*, we will have a minus sign in the objective function for both slack variables.

Possible programming problems could be:

I. $z_1 = -d_3 + d_4 - d_5 + d_6$ to maximize,

subject to (1)-(10) and all $x_i, d_j \geq 0$, except x_1 which is not restricted in sign.

II. $z_2 = -d_3 + d_4 - d_5 + d_6 - d_7^+ - d_7^-$ to maximize,

subject to (1)-(11) and all $x_i, d_j \geq 0$, except x_1.

III. $z_3 = -\alpha_3 d_3 + \alpha_4 d_4 - \alpha_5 d_5 + \alpha_6 d_6 - \alpha_7 d_7^+ - \alpha_7 d_7^-$ to maximize,

subject to (1)-(11) and all $x_i, d_j \geq 0$, except x_1. The α_i being positive weights.

APPENDIX F

THE FORMATS OF OUTPUTS OF THE IRA MODEL

B A L A N C E S H E E T - 1973

	AT BEGINNING OF YEAR			CHANGES					AT END OF YEAR		
ASSETS:											
Tele. Property	At Cost [1]	Accum. Dep. [2]	Cost less Accum. Dep. [3]	(+) Additions [4]	(−) Retirements [5]	(+,−) Other Changes [6]	Net Change During Year [7]	Net Change To Accum. Dep. [8]	At Cost [10]	Less Accum. Dep. [11]	Cost Less Accum. Depreciation [12]
Switching	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
Transmission	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
Terminal Dev.	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
Other a)	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
b)	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
c)	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
Land	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
Plant under construction	x x		x x	x x	x x	x x	x x	x x	x x	x x	x x
	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
Investments				Withdrawl of Investment	Acquisition of Investment		Increase	Decrease			
Subsidiary Co. [13]		x x		x x	x x					x x	
Other [14]		x x		x x	x x					x x	
			x x	x x	x x						x x
Current Assets											
Cash & Temp. Invest. [15]		x x		x x	x x					x x	
Acct. Rec. [16]		x x					x x	x x		x x	
Mat. Supplies [17]		x x					x x	x x		x x	
Prepayments [18]		x x					x x	x x		x x	
Deferred Charges			x x				x x				x x
Unamortized long term [19]		x x					x x	x x		x x	
debt expenses Other		x x	x x				x x	x x		x x	x x
TOTAL ASSETS											

	AT BEGINNING OF YEAR		CHANGES: New Issues	Paid	Redeemed	Net Income after Dividend	Additions/ deductions	Dividend paid	AT END OF YEAR	
LIABILITIES:										
Cap. Stock Preferred[21]	x x		x x		x x				x x	
Cap. Stock Common incl.[22]										
Premium	x x		x x						x x	
Retained Earnings[23]	x x					x x			x x	
Total Shareholders Capital			x x		x x	x x				x x
Advances from Gov't[24]	x x						x x		x x	
Long term debt: bonds[25]	x x		x x		x x				x x	
-	x x						x x		x x	
Notes Payable[26]	x x		x x	x x					x x	
Total Debt		x x	x x	x x	x x		x x			x x
Total Capitalization		x x	x x	x x	x x		x x			x x
Current Liabilities:										
Accts. Payable[27]	x x			x x			x x		x x	
Dividend Preferred[28]	x x							x x	x x	
" Common[29]	x x							x x	x x	
Accrued Taxes[30]	x x						x x		x x	
Accrued interests[31]	x x						x x		x x	
Advance billing for service[32]	x x						x x		x x	
		x x	x x	x x	x x		x x	x x		x x
Deferred Taxes										
Income Tax[33]	x x						x x		x x	
Unamortiz. Invest.- tax credits[34]	x x						x x		x x	
		x x								xx
Other Deferred Credits										
Other[35]	x x						x x			x x
Total Liabilities			x x	x x	x x		x x	x x		

SOURCES AND NOTES

1.	Table 1, Col. 1
2.	Companys' accounting records
3.	Item 1 minus Item 2
4.	Table 1, Col. 2
5.	Table 1, Col. 3
6.	Table 1, Col. 4
7.	Table 1, Col. 5
8.	Table 2, Col. 5
9.	CANCELLED
10.	Table 1, Col. 6
11.	Item 2 plus Item 8
12.	Item 10 minus Item 11
13 to 22	Company records

23. Last years retained earnings (from Accounting Records) plus Net Income after dividends. Net Income after dividends is calculated as follows:

Net Income (Income Statement)		x x
Less - Dividends on preferred stocks	x x	
Less - Dividends on common stock	x x	(x x)
		x x

24 to 32	Company records
33.	Table 4 of Balance Sheet
34.	Companys' Tax Department
35.	Company records

TABLE 1

TELEPHONE PROPERTY AND DEPRECIATION

	Cost at beginning of year (gross)	Additions	Retirements	Other change	Net addition to plant	Cost at end of year	Avge. Cost	Depreciation rate	Annual Depreciation
	1	2	3	4	5=(2-3±4)	6=1+5	7=(1+6)÷2	8	9=7x8
Switching	x	x	x	x	x	x	x	x	x
Transmission	x	x	x	x	x	x	x	x	x
Terminal Device	x	x	x	x	x	x	x	x	x
Other	x	x	x	x	x	x	x	x	x
Common	x	x	x	x	x	x	x	x	x

SOURCES:
Col. 1 - Accounting - property records
Col. 2 - Hermes
Col. 3 - Accounting (or retirement algorithm)
Col. 4 - Accounting
Col. 8 - Depreciation algorithm (Company records)

TABLE 2

NET CHANGE TO ACCUMULATED DEPRECIATION

Annual Depreciation	Retirement	Cost of Removing	Salvage Value	Net Change to Accum. Depreciation
1	2	3	4	5=(1+2-3+4)
(From Colum 9 Table 1)	(From Accounting Records)			

TABLE 3

C. C. A.

		Total	Class 10 30%	Class 9 25%	Class 8 20%	Class 17 8%	Class %
UCC - Beginning of the year		x x	x	x	x	x	x
Add: Net additions		x x	x	x	x	x	x
UCC Subject to allowances		x x	x	x	x	x	x
Less: CCA for current year		x x	x	x	x	x	x
UCC - end of year		x x	x	x	x	x	x
→ Current year C.C.A.	xxx						

CAUTION - Note that net additions in the above are not the same as in Table 1 net additions because some expenses are capitalized under book depreciation but expensed under CCA; also retirements are not deducted from undepreciated capital cost, and interest during construction are expensed under CCA.

TABLE 4

DEFFERED TAXES

ALTERNATIVE 1

Taxable income (Table A, Income Statement)		x x
Less Taxable Income as per Income Tax Act (Company's tax statement)		x x
Deferred Taxable Income		x x
Times - tax rate		x x
Deferred Taxes		x x

ALTERNATIVE 2

Net Income (Income Statement) Table A		x x
Plus Tax provision in company books (Income Statement)		x x
Less - Change expenditure Net* (accounting records)	x x	
Less - Difference between CCA (Table 3) and Book Depreciation (Table 1)	x x	x x
Deferred Tax		

* Change Expend. Net = (Net Income plus book provision for Income Taxes) - (taxable income on tax payable basis plus CCA in excess of book provision for depreciation)

SOURCES AND USES OF FUNDS STATEMENT - 1973

SOURCES:			
Net Income [1]	x x x		
Dividend and Transfers to Government Owners [2]	(x x x)		
Income Retained		x x x	
Deferred Income Tax - current [3]	x x x		
- prior [3]	x x x	x x x	
Depreciation and other non Cash Changes (Net) [4]		x x x	
TOTAL SOURCES FROM OPERATIONS (NET)		x x x	
Additions to long term debt [5]	x x x		
Less repayment of long term debt and increase in sinking fund assets [6]	(x x x)		
Net increase in long term debt borrowings		x x x	
Preferred and Common Stock [7] issued		x x x	
Miscellaneous [8]		x x x	
Reductions of working capital [9]		x x x	
TOTAL SOURCES OF FUNDS			x x x
USES:			
Gross construction expenditures [10]		x x x	
Less charges not requiring funds [11]		x x x	
NET CONSTRUCTION EXPENDITURE		x x x	
Investments [12]		x x x	
Miscellaneous [13]		x x x	
Increase of working capital [14]		x x x	
TOTAL USE OF FUNDS			x x x

SOURCES AND NOTES

1. Income Statement
2. Balance Sheet Changes
3. Balance Sheet Table 4
4. Depreciation - from Balance Sheet Table 1
5. Balance Sheet Changes
   Other non cash changes - from Company Records
6. Repayment of long term debt - from Balance Sheet Changes
   Increase in sinking fund assets - deductions in debts (Balance Sheet Changes)
7. Balance Sheet Changes (preferreed and common stock)
8. Balance Sheet Changes
9. Balance Sheet Changes
10. Balance Sheet Changes (additions to telephone property)
11. Company Records
12. Balance Sheet Changes
13. Balance Sheet Changes
14. Balance Sheet Changes

INCOME STATEMENT - 1973

REVENUE:			
Toll Service[1]		x x	
Other[2]	x x		
Less Uncollectibles[3]	(x x)	x x	
Total Operating Revenue			x x
EXPENSES:			
Maintenance[4]		x x	
Traffic[4]		x x	
Commercial[4]		x x	
Marketing[4]		x x	
Other expenses[4]		x x	
Taxes other than income taxes[5]		x x	
Depreciation[6]		x x	
Operating Expenses			x x
Net Operating Revenue			x x
OTHER INCOME (NET)			
Dividend from Subsidiaries:[7]			
a)	x x		
b)	x x		
c)	x x	x x	
Dividend from other investments[8]		x x	
Miscellaneous income[9]		x x	x x
Income Before Income Taxes and Debt-Service Charges			x x

INCOME TAXES [10]		
Income Before Debt Service Charges		x x
DEBT SERVICE CHARGES [11]		
Long Term Debt	x x	
Other	x x	
Amortization of longterm debt asset	x x	x x
Income Before Extraordinary Item		x x
EXTRAORDINARY ITEM [12]		x x
Net Income		x x

SOURCES AND NOTES

1. "Share" Module
2. "Share" Module and/or exogeneous
3.& 4 Accounting and costing records - exogeneous
5. Company Tax Department records - Show taxes by govenment
6. Table 1 in balance sheet
7. Accounting records - specify each subsidiary if any
8. Exogeneous
9. Accounting records. It includes items such as interest charged to construction less miscellaneous charges. The amount of interest charged to construction is also included in the item "charges not requiring funds" in the Statement of Sources and uses of funds.
10. See Table "A"
11. Accounting records- Corporate debt structure
12. Accounting records. These extraordinary charges include items such as exchange on repayment of long term debt. Exercise caution on such items.

TABLE A - INCOME TAX CALCULATION (IN COMPANY BOOKS)

Operating Revenue		x x
Plus other income excluding dividends from Canadian Corpor.		x x
Less: Operating expenses	x x	
Debt Service Charges	x x	x x
Taxable Income		x x
Times - Federal and Provincial Tax Rates		x x
Income Tax as per Company Books		x x

Suggested Ratios For Canadian Telecommunication Carriers Financial Statistics

Related To Telephone Plant

Numerator	Denominator	Comment
1. Total Oper. Rev.	Avge Tel Plant in Service	Revenue providing characteristics of the telephone plant
2. Local Serv. Rev.	"	
3. Toll Serv. Rev.		
4. Total Oper. Expense plus Taxes (Other than Inc Tax)	"	Expense requirement characteristics of the telephone plant
5. Mtce Exp.	"	
6. Depcn. Exp. *	Avge Depreciable * Tel Plant in Service	
Note: Ratio 1 minus Ratio 4		Contribution (before income tax) of plant in service to net income
7. Net Income (Net Profit)	Avge Total Tel Plant	Return on telephone plant
8. Net Income (Net Profit)	Avge Net Tel. Plant	
9. Accum. Depcn	Tel Plant in Service (end of yr)	Reserve ratio, Indicator of average age of plant
10. Long Term Debt	Total Tel. Plant (End of yr)	Maximum proportion of plant built from borrowed money
11. Material & Supplies	"	Stock on hand required to service plant
12. Constr. Expend	Total Tel. Plant (End of Prev. Yr)	Growth of telephone plant

* by major plant categories

Related to Telephone Plant (Continued)

	Numerator	Denominator	Comment
13.	Plant Retired	Total Tel Plant (End of Prev. Yr)	Retirement Ratio of Telephone plant
14.	Avge Full-Time Plant Employees	Avge Total Tel. plant	Force involved in maintening plant
15.	Wages Chgd Constr.	Constr. Expend	Extent of plant construction by own employees
16.	Depcn.	"	Financing of Construction Expenditures (items 16–19)
17.	Deferred Tax	"	
18.	Increase-L.T.D.	"	
19.	Increase Equity	"	
20.	Operating Income before Operating taxes	Avge Total Tel. Plant	To compare the average productivities of capital
21.	Operating Income before Operating taxes and Wages	Avge Total Tel. Plant	A kind of Net Added Value on Capital Ratio.
22.	Operating Income before Operating taxes and Wages	Total employees	Average Productivity of Labor.

Related To Depreciation

Numerator	Denominator	Comment
23. Depcn. *	Accum. Depcn. * (end of Prev. Yr.)	Growth of Accumulated Depreciation
24. Net Chge to Acc. Depcn. *	"	

* by major plant categories

Related To Telephones

Numerator		Denominator	Comment
25.	Total Oper. Rev.	Avge Tot. Tel in service	
26.	Local Serv. Rev.	"	Extent to which telephone generate revenues
27.	Toll Serv. Rev.	"	
28.	Tot. Oper. Exp. plus taxes (other than Inc. Tax)	"	Extent of expense outlay per telephone
29.	Mtce. Exp.	"	
30.	Depcn. Exp.	"	
31.	Taxes	"	Impact of taxes of all kinds
32.	Tot. Tel. Plant (End of yr)	Tot. Tel in Service (end of yr)	Average Cost per telephone of plant in service
33.	Tot. Stat. Equip. (end of yr)	"	
34.	Constr. Expend.	Increase in tot. tel. in service (end of yr)	Avge current cost per telephone added
35.	Main Telephones in service (end of yr)	Total Tel. in Serv. (end of yr)	Proportion of high-revenue telephones

Other Ratios

Numerator	Denominator	Comment
36. Tot. Oper. Exp.	Tot. Oper. Rev.	Operating Ratio Proportion of revenues taken up by operating expenses (applies to 36–38)
37. Mtce. Exp.	"	
38. Depcn. Exp.	"	
39. Interest Charges	Avge L.T. Debt	Indication of embedded debt costs
40. Deferred Inc. Tax	Total Inc. Taxes	Extent of deferred payment of income taxes
41. Deferred Inc. Tax	Deferred C. Inc. Tax (end of prev. yr.)	Growth of deferred income taxes
42. Retained Earnings + Depreciation + Deferred taxes.	Gross Construction Inv. − Construction charges + Other physical enpen-ditures + Δ Inventories	Financial Needs Ratios

This list of suggested ratios is not necessarily all-inclusive.

The calculation of some of the items listed in the Points 20, 21, 22 and 42 above may require the availability of certain exogenous inputs.