A Study to Explore the Relationship between Costs and Rates Associated with the Provision of Digital Data Transmission Services in Canada.

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MANAGEMENT CONSULTANTS

A STUDY TO EXPLORE THE RELATIONSHIP BETWEEN COSTS AND RATES ASSOCIATED WITH THE PROVISION OF DIGITAL DATA TRANSMISSION SERVICES IN CANADA

January, 1972

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January 28, 1972

Mr. K. Wyman
Chief, Economic Planning Unit
Department of Communications
Room 305, Berger Building
100 Metcalfe Street
Ottawa, Ontario

Dear Mr. Wyman:

We are pleased to submit our report entitled "A Study to Explore the Relationships Between Costs and Rates Associated with the Provision of Digital Data Transmission Services in Canada".

This study has focussed on two important points which will have an impact on the future work of the Department. Firstly, there is a general lack of information relating to the volume and characteristics of data traffic flowing on the communications networks. Secondly, there is a very great need to conduct further research into specific patterns of cost behaviour and their relationship to network configuration decisions and service offerings. Because of the integrated nature of the networks, this research should not be confined to digital data transmission services.

In the course of doing this study we have developed an appreciation of the heavy demands already being placed on the staff of the Department. In the absence of an adequate information system, these demands impose a heavy burden on Departmental officials. Our recommendations have been developed against this background. In particular, an early start should be made to accumulate the necessary statistics pertaining to data traffic, its characteristics and its costs.

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We look forward to meeting with you at your convenience to discuss this report. We have appreciated the opportunity of participating in this challenging study and look forward to providing further assistance to the Department in the future.

Sincerely,

P. S. ROSS & PARTNERS

R. J. Gray
Partner

RJG/em

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APPENDICES

I. INTRODUCTION

This study is one of a number of investigations being carried out by the Department of Communications (DOC) into the Canadian telecommunications industry. These studies are intended to lead to the assembly of a comprehensive body of knowledge within the Department which will form the basis for the development of Canadian telecommunications policy. As one element of this body of knowledge, the Department wishes to identify the carriers' rate structures for various services and to collect information on the cost functions related to these service offerings. Although cost is only one important element of the development of rate structures, the Department views cost-rate relationships as essential to the development of policies aimed at satisfying the public interest in the provision of data transmission services. One example of this public interest requirement is the need to reconcile the opposing claims of the communications carriers and the data transmission users with respect to the pricing of data transmission services. This study is intended to be a preliminary inspection of the cost-rate relationships in digital data trasmission. As such, it should be viewed as a framework within which further studies in this field can be defined and undertaken.

The services considered in this study are those for which rate information was supplied by the Department of Communications. The actual rate information was intended to be supplied by the Department of Communications from the tariff books of Canadian National/Canadian Pacific Telecommunications (CN/CP) and Bell Canada. The DOC information proved to be useful but not entirely adequate. It was necessary to supplement this information through a detailed study of the tariff books of the carriers. Neither of the two tariff books is clearly or efficiently organized, from the user's point of view, as other telecommunications researchers have noted. Moreover, both books demand a certain familiarity with the general structure of a telecommunications system and the technical terminology employed. This is particularly true of Bell Canada's book which presupposes an understanding of the Company's unique structure and particular use of terminology. Whether it is simply tradition or the form of existing regulations which is responsible for the complexity which the researcher encounters, considerable effort had to be expended in extracting and validating the rate information contained in this report.

Although both rates and costs are dynamic, rates inparticular can change rapidly and drastically at any time. This fact made it necessary to examine the rate structure at a specific point in time. The period chosen was August 1971. This continuous pattern of rate changes – almost 11,000 tariff filings in 1970 – means inevitably that a study such as this is valid only while the rate structure remains the same. Any significant change in rates for a single service or group of services can affect the validity of the entire study.

Cost data were considerably more difficult to obtain. Very little information was available directly from the carriers. Equally little was available from the Department of Communications and this required substantial reorganization before it was useful for the purposes of this study. The majority of the cost data were derived with considerable effort from information provided by the carriers to the Canadian Transport Commission (CTC) as submissions during the hearings concerning their applications for rate changes. Other information was obtained from submissions to the Telecommission, from Statistics Canada, from the annual reports of the carriers, and from press releases, professional publications and trade journals. All Relevant cost data have been included in Appendix E to this report. As might be expected, however, further efforts undoubtedly will yield even more complete information.

Most cost information collected refers to specific components of a telecommunications network rather than to specific service offerings. Rates, on the other hand, are presented by service. Therefore, it is necessary to consider rates not only in terms of the complete service but also in terms of the various components of the service charge (i.e. station rentals, transmission charges, etc.). In this way, some comparisons of costs and rates can be made where data are available.

Much of the cost data collected permits only generalizations regarding cost-rate relationships. However, it is still possible to deal with the specific questions which are the subject ot this study by examining the various cost-rate issues more in terms of the behaviour of these relationships than in terms of explicit definitions of cost-rate relationships. In this way, these preliminary explorations of cost-rate behaviour yield the material necessary for establishing the framework within which further studies should be launched.

II. OBJECTIVES

The objectives of this study are:

* To supervise the identification and review of published literature concerning the approaches to pricing telecommunications services, and to present a preliminary synopsis of the various points of view identified.

* To examine and describe, depending on the adequacy of available quantitative information, the extent to which the following aspects or dimensions of the existing rate structures are related to the costs involved in digital data transmission:

  a) the influence of holding times;

  b) the influence of distance;

  c) the influence of peak versus off-peak periods;

  d) carrier pricing practices with respect to line-sharing or resale arrangements available for private line services;

  e) minimum charge times for switching services;

  f) the pricing practices with respect to error characteristics of the lines;

  g) carrier pricing practices with respect to terminal equipment;

  h) the influence of transmission speeds.

The objectives of this report are:

* To develop an analysis of the structures of data transmission rates.

* To identify and document the fundamental nature of data transmission costs.

* To explore the extent to which data transmission rates can be related to costs.

* To identify research projects aimed at consolidating or extending the existing body of knowledge in this field.

III. DATA TRANSMISSION SERVICES IN CANADA

The field of data telecommunications is relatively new in Canada and, because of this, service offerings are being expanded and modified constantly. Many services are not yet available everywhere in Canada. Some are available only in certain regions of the country while others are available nationally but restricted to urban areas. It has been estimated that additional plant investment equal to one-third of the current total assets of the carriers would be necessary if sophisticated data telecommunications were to be made generally available throughout Canada.[1]

For purposes of this study, fourteen data communications services are offered by the Canadian carriers. These are:

* Telex and Data Telex
* TWX
* Datacom
* Dataspeed
* Dataphone
* Broadband
* Multicom
* Computer Inquiry Service
* Dataline II
* Schedules 1, 2, 3, 3A
* Channel Deriving Arrangements
    - Computer Access
    - Teleprinter
* Dataline III

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1. Instant World, A Report on Telecommunications in Canada, p.81

* Schedules 4, 4A, 4B, 4C

* Telpak A, B, C, S

In reality there are twenty-three services, but we have chosen to treat each of the various Schedule and Telpak offerings as a sub-classification of its respective service.

In comparing these services, certain characteristics will be seen to be common to all. These common characteristics of each of the fourteen data transmissions services are presented comparatively in Exhibit 1. Other unique or unusual characteristics of each service are listed in Exhibit 1 under "Remarks". In most cases, services can be modified on a custom basis to meet the particular needs of the users. However, such customized services are not considered in this study.

The services listed in Exhibit 1 have been arranged according to three characteristics which will permit subsequent analysis of their rate structures. These characteristics are:

* the nature of the service (public switched or private line)

* the speed of the service (low, medium or high)

* the carrier offering the service (CN/CP or TCTS members)

The generally accepted groupings of transmission speeds are:

* Low - 0 to 600 bits per second (bps)

* Medium - 600 to 9600 bits per second (bps)

* High - over 9600 bits per second (bps)

The summarized presentation of data transmission services presented in Exhibit 1 is intended to highlight the essential characteristics of each service and to serve as a basic reference for subsequent discussions in this report. More detailed information on each service can be obtained from the tariff books of the appropriate carrier.

CHARACTERISTICS OF DATA TRANSMISSION SERVICES

Name of Service	Public Switched or Private Line	Speeds in bps	Carrier	Transmission Direction	Transmission Pricing Factors	Fixed Charges	Minimum Charge	Station Equipment	Remarks
1. Telex and Data Telex	Public Switched	50 and 180	CN/CP	half duplex	time and distance	installation station rentals	0	teletype paper tape	- five level code transmission - list of subscribers for Telex - Data Telex subscribers do not interconnect - rebates for omissions and errors not to exceed monthly tariff
2. TWX	Public Switched	110	TCTS members	half duplex	time and distance	installation station rentals	$.04	teletype paper tape	- eight level code transmission - list of subscribers - joint users permitted - conference calls available
3. Datacom	Public Switched	110	TCTS members	half duplex	time and distance	installation $5 per month exchange service station rentals	0	telephone printer	- toll telephone rates with free local dialing - similar to TWX with additional services
4. Dataspeed	Public Switched	750 wpm 1050 wpm	TCTS members	simplex half duplex	time and distance	installation station rentals	0	telephone paper tape printer	- toll telephone rates with free local dialing - intended for paper tape transmission - unattended operation capability available
5. Dataphone	Public Switched	to 4800	TCTS members	half xuplex	time and distance	installation station rentals		telephone data set	- toll telephone rates with free local dialing - numerous options in data sets - special designs for certain classes of users - automatic answering available
6. Broadband	Public Switched	1800, 2000, 2400, 4800	CN/CP	half duplex duplex	time and distance	installation station rentals	30 seconds	telephone Broadband station	- special services available - rebates for omissions and rebates not to exceed monthly tariff - conference calls available - Telex rates used for 4800 bps
7. Multicom	Public Switched	2400, 4800, 19200, 40800, 50000	TCTS members	duplex	speed, time, distance	installation access line station rentals	6 seconds	Datasets Data Connector Equipment	- service limited to local service area of certain exchanges - terminal to computer or computer to computer - voice channel available
8. Computer Inquiry Service	Private Line	180	CN/CP	half duplex	stations and distance	installation access line station rentals	flat rate per month	teletype paper tape	- Telex or Data Telex outstations to a centralized computer - may become a switched network - two service offerings - outstations in same city as computer (flat rate) - outstations in different cities
9. Dataline II	Private Line	300	TCTS members	half duplex	stations and distance	installation access line station rentals	flat rate per month	teletype paper tape	- data station to access line at centralized terminal - system must meet minimum requirements - minimum of 5 access lines and 10 data stations with 2 in one mileage band - station equipment provided by TCTS or subscribers - TCTS data set required
10. Schedules 1 2 3 3A	Private Line	45 or 50 55 75 180	CN/CP & TCTS members CN/CP	simplex half duplex or duplex	distance and contracted usage in hours per day and days per week	installation circuit station rentals	flat rate per month	printer paper tape Morse facsimile	- provision for rebates - charges different for local and inter-city services - overtime available at extra charge - temporary service available - switching arrangements available
11. Channel Deriving Arrangements	Private Line		CN/CP				flat rate per month		- sub-division of Schedule 4 data channel into 2 or more bands - may be connected to switched network - Telex - two point service only with one point a computer connection
Computer Access		180		half duplex duplex	distance charges per channel	channels			- standard 8, 6 or 4 channels available - surcharge for more than 8 channels
Teleprinter		82.5 or 180		half duplex duplex	distance charges per channel	installation service points channels station rentals		printer paper tape	- subscriber can furnish station equipment
12. Dataline III	Private Line	2000	TCTS members	half duplex	stations and distance	installation access lines station rentals	flat rate per month	printer paper tape	- station to access line at centralized terminal - similar to Dataline II
13. Schedule 4 4A 4B 4C	Private Line	Nominal / Maximum 600 1600 2000 2400 / 4800	CN/CP TCTS members	half duplex duplex	distance charges per channel	installation station rentals channel conditioning	flat rate per month	printer paper tape	- analog or digital data/voice alternate transmission - two point or multi-point - rebates provided if service is interrupted - different rates for local and inter-city services - channel conditioning required for 4A, 4B and 4C
14. Telpak A B C S	Private Line	12 voice grade circuits 24 voice grade circuits 60 voice grade citcuits 120 voice grade circuits voice grade circuit = 2400 to 9600 bps	TCTS members	simplex half duplex duplex	distance and local line surcharge	installation station rentals	flat rate per month	teletype telephoto facsimile magnetic tape others	- additional channels may be derived - circuits in excess of 12 available for surcharge - Telpak S available only in Southern Ontario and Quebec - point to point or multi-point

IV. AN ANALYSIS OF THE RATE STRUCTURE

A. APPROACH AND ASSUMPTIONS

At the outset of this study nine factors were identified which appeared to be significant in the development of rates by the carriers. In particular, the influence of the following factors was to be examined:

a) holding times

b) distance

c) peak and off-peak periods

d) line sharing of private line services

e) sub-leasing of private line services

f) minimum charge times for switching services

g) error characteristics

h) ownership of terminal equipment

i) transmission speeds

Very early in the analysis it became evident that three of these were critical to almost every service:

* holding times
* distance
* transmission speeds

Certain factors such as station equipment, line sharing, minimum charge times, sub-leasing and off-peak transmission were part of the rate structure in only a few cases. Even then, these factors tended to be either optional or relatively insignificant. Other factors such as minimum error characteristics had no effect on the charges for any service, since these were not a part of the rate structure. Although this factor is inherent in the need for increased bandwidths for higher transmission speeds, its effect is implicitly recognized in the different rates set for different speeds. Factors other than those specified above were to be considered only if they appeared to have an influence on rates. Where factors such as the number of stations and the number of channels were identified, these were considered in the analysis of services where their influence was substantial.

It should be noted that, during this analysis of the factors, no attempt was made to explore the rationales of the carriers which underlie the rate structures in their present form. Any attempts to do so without the full co-operation of the carriers would be purely speculative.

The three factors identified as being most crucial in data transmission services were not necessarily factors in the case of every service. However, the rate structure of a typical service is influenced by all three primary factors in varying degrees. It will be noted that these factors are concerned only with transmission charges but these are not the only component of the user's total data telecommunications cost. Other components are:

* installation charges
* terminal or station charges
* minimum charges where applicable
* optional features

In fact, these components of a total user tariff may be considerably greater in some cases than the transmission charges.

In the analysis of each available service, the various rate components were studied <u>from the user's point of view</u>. Therefore, it is the total monthly tariff, including both transmission costs and terminal rentals which was analyzed in terms of the three primary rate determinants - speed, distance and time - and, where particularly relevant, other factors. These individual service analyses then were interrelated and a common denominator was selected to permit some meaningful comparison. An exposition of the actual rate structures for each service is presented in Appendix A. A discussion of the principal findings resulting from the analysis of each service is presented in this section, supported by a more detailed exposition in Appendix B. Both relationships - components to total cost and service to service - are useful in the examination of cost-rate relationships, since in some cases accurate actual cost data are not available although relative cost data can be gathered.

The rate structures of the communications carriers are complex. An extremely wide range of optional features are available. Many of these simply contribute to the convenience of the user, but many also permit more efficient use of the facilities. Some options are supplementary, others complementary, and others are substitutes for standard offerings. All of these are listed in the tariffs. The nature of the interrelationships between fixed monthly charges and the corresponding transmission charges for any service makes it difficult to compare services directly without inserting numerous qualifications. However, it is possible with care to undertake some comparative analysis which can be meaningful, provided such comparisons are confined to areas of reasonable similarity among the services.

It would have been impossible to present in this analysis every alternative available to a telecommunications user. Therefore, it was necessary to select certain alternatives, thereby introducing a number of assumptions related to the various factors under investigation. Usage time, for instance, was assumed to vary from one hour to 176 hours per month, with 22 hours taken as representative of a typical user. This assumes 22 working days per month and eight hours per working day. With respect to station equipment, the lowest rental was assumed in conjunction with minimum usage and the highest rental with maximum usage. The intermediate utilizations were considered to require station equipment rentals between the two extremes. With respect to distance, the maximum airline distance across Canada was assumed to be 3,300 miles. Therefore, within the range selected, the tables and graphs in Appendix B depict the minimum and maximum charges for that service. Monthly charges for each service are presented in two forms, one relative to distance and one relative to time. Although it might be expected that a basic measure such as charges per bit mile would be the same for both tables, this does not occur since the station equipment rental may be handled somewhat differently from table to table.

Charges per bit mile has been selected as a measure common to most services. The calculation of charges per bit mile is accomplished by choosing an arbitrary number of hours of usage per month, multiplying that by the speed of the service and dividing the result into the charges per mile. However, in a few cases charges are based on the number of stations in a system and the basic measure in these instances becomes charges per mile per station. Similarly, where charges are based on the number of channels the basic measure becomes charges per mile per channel.

However, this measure may mean different things in different situations. A service whose charges are based on distance and time will find that total charges vary depending on mileage and utilization. On the other hand, utilization has no effect on a private line service, since the charges are fixed based on distance. In this case, as long as the user's volume remains under the capacity of the system, his charges will not vary. However, his utilization may change and therefore his charges per bit mile will vary.

It follows from this that as speed goes up charges per bit go down, since the faster service permits a considerably greater information throughput. There exists generally a crossover point below which it becomes more economical to use a slower service and above which the faster service will be cheaper. This point occurs as a result of the interrelationship between speed of service and data volume.

B. SWITCHED LOW SPEED SERVICE

1. Telex and Data Telex

The rates for these two services are identical and are based on time and distance. The major difference between them is speed – 50 bps and 180 bps respectively. Total monthly charges increase as both distance and hours of utilization increase. However, changes in utilization have a greater effect on total charges than do changes in average transmission distances. Station equipment rentals, the other component of total charges, are significant only at low utilizations and mileages. Charges per bit mile decline as distances increase but are nearly constant in terms of utilization. Therefore, economies of scale can be realized only as distances grow and not as hours of usage increase. Charges per bit mile for Telex and Data Telex services are inversely proportional to their speeds. Data Telex, therefore, with its greater speed and higher data capacity, is cheaper for a given volume of data at a given distance.

2. TWX

TWX rates are based on long distance telephone rates which are dependent upon time and distance. However, usage is a more influential factor in the calculation of total monthly charges than is distance. The two major components of total charges are station equipment rentals and transmission charges. The former is significant only where utilization is very low. Charges per bit mile drop for low utilization and mileage but at higher utilizations are almost constant. Therefore, economies of scale do not exist at greater distances and longer hours of usage.

3. Datacom, Dataphone

The transmission component of the charge for these services is the standard long distance telephone rate based on time and distance. While a direct relationship exists between total charges and distance, usage is the more influential factor in the determination of total charges. Fixed charges, including station rentals, a monthly service charge, where applicable, and telephone exchange service charges are significant at low utilizations, particularly for local service. Charges per bit mile decrease slowly with increasing distance but stay almost constant as hours of usage climb. Slight economies of scale occur with increasing distance but not with increasing utilization. The relationship between charges per bit mile and speed is inversely proportional.

Dataphone is also available as a switched medium speed service.

C. SWITCHED MEDIUM SPEED SERVICE

1. Broadband

Broadband is available in four speeds from 1800 bps to 4800 bps. Rates are identical for the three lower speeds but different rates apply for the 4800 bps service. Total charges climb with increases in either holding times or distance. However, hours of usage has a greater influence on total charges than does distance. The 4800 bps service has higher total charges at given distances and utilizations but these are more than offset by higher speed. Therefore, the same volume of data transmitted at 2400 bps and 4800 bps will be less costly per bit at the higher speed. Station equipment rentals account for a large proportion of total charges at low utilizations and can also be significant at high utilizations and low mileage. Charges per bit mile decline slightly as distances increase and approach a constant for increasing hours of usage. Because transmission charges are the same for the three lower speeds, the relationship between charges per bit mile and speed is inversely proportional. No substantial economies of scale are realized over increased distance or higher utilization. Charges per bit mile are similar for 2400 bps and 4800 bps.

2. Multicom

Multicom is available as both a medium and high speed service. The following analysis applies to both versions. Rates vary depending on utilization, mileage and speed. The most important factor in determining total monthly charges is hours of usage. The least important factor is distance, with speed the intermediate factor. At all but low utilizations station equipment rentals are insignificant. Charges per bit mile decline as distances increase but stay constant at all but low utilizations. Therefore, economies of scale can be realized from greater mileages but not from higher utilizations. The different rate structures are not precisely inversely proportional to the speed of service. Potential economies of scale are greatest at highest speeds.

3. Dataspeed, Dataphone

Dataphone service is also available as a switched low speed service. The analysis of the medium speed services is identical to that presented for Datacom and Dataphone in paragraph 3 of the previous sub-section.

D. SWITCHED HIGH SPEED SERVICE

The only switched high speed service currently available in Canada is Multicom, which is discussed in a previous paragraph.

E. PRIVATE LOW SPEED SERVICE

1. Telex Computer Inquiry Service

In addition to national service, a special rate is available for local transmission. The rate structure is based on distance and the number of stations in the system in addition to fixed charges for station equipment rentals and access lines. Total charges rise rapidly with mileage or the number of stations in the system. These two factors have an approximately equal effect on total charges. Total charges for systems with few stations or low mileages are composed predominantly of fixed monthly charges. Charges per mile per station decline when transmitting over greater distances or upon adding stations to the system. Economies of scale are about the same in either case.

2. Dataline II

This service is almost identical to Telex Computer Inquiry Service except that local rates are not available. A minimum requirement in terms of access lines and stations must be met. The rate structure is based on distance and numbers of stations with fixed charges for station equipment rentals and access lines. The important factors in determining total charges are distance and the numbers of stations, with both having an equal influence. At low mileage and few stations the dominant factor in total charges is the monthly access line charge. Charges per mile per station drop with increasing distances and numbers of stations. Both factors have about the same effect on economies of scale.

3. Schedules 1, 2, 3, 3A

The rates for each of the four schedules follow the same pattern. A variety of rates and options is available to the user for local or inter-city service. Both rates and speeds increase with schedule number, the speeds rising faster than the rates. Thus, for a given volume of traffic, Schedule 3 is potentially less expensive than Schedule 1. Monthly charges are related to station equipment, circuit mileage and transmission time. Equipment charges are specially significant in local or short mileage inter-city service. On the other hand, transmission charges are very prominent for all but the very low mileages. Charges per bit mile drop sharply as distances increase to 350 miles and become almost constant beyond 2,000 miles. Economies of scale are realized at relatively short distances but they are continually available with increased utilization.

F. PRIVATE MEDIUM SPEED SERVICE

1. Dataline III

This service is a higher speed version of Dataline II. The rate structure is based on distance and number of stations and a fixed charge comprised of station equipment rentals and access line charges. Both distance and the number of stations have an equally significant influence on total charges. As a percentage of total charges, fixed charges are signigicant only at low mileages and/or few stations. Charges per mile per station decrease steadily with increasing distances whereas the introduction of additional stations to the system has little effect on the charge per mile per station. Therefore a user transmitting over longer distances can realize greater economies of scale than can a user with a greater number of stations in the network.

2. Schedules 4, 4A, 4B and 4C

The rates being almost identical for these services, the important difference among these services is their speed. The major rate components are station equipment and transmission charges, the latter being a function of distance and the number of channels employed. Terminal charges form a significant part, 50% to 90%, of the total charge for local and short distance inter-city service, but the proportion drops to less than 30% of the billing at the longest distances. A major rate break occurs between local and inter-city service offerings. For local service the influence of distance is linear once the effect of station equipment rentals has been dissipated. For inter-city service total charges initially increase quickly with distance and become linear only beyond 1400 miles. Charges per bit mile decline with distance, rapidly at first but less so as mileage increases. For a given through-put of high volume, the higher speed (Schedule 4C) is more economical.

3. Channel Deriving Arrangements

Schedule 4 data channels may be subdivided when used for Computer Access and Teleprinter Services. The rates are the same as for Schedule 4 with extra charges associated with the derivation of additional channels. Monthly charges are associated with the numbers and types of station equipment, the number of derived channels and transmission distance. Total monthly charges rise sharply with distance for the first 200 miles and level off above 1700 miles. Charges per mile per channel trend downwards continually with distance, sharply at first, and linear beyond 200 miles. Economies of scale are associated with greater traffic volumes and transmission distances.

G. PRIVATE HIGH SPEED SERVICE

1. Telpak A, B, C and S

These are the only high speed private services available in Canada at the present time. Channel capacity (i.e. speed) increases from Telpak A through S. Because the rate structures are the same, each exhibits similar trends and relationships. The primary rate components are the transmission charges and station equipment rentals. The latter are an important component of total charges only at short transmission distances or where specialized uses require substantial amounts of station equipment. Transmission charges account for the majority of user costs. Distance, speed and the choice between simplex and duplex influence the basic rate per volume of data. The major determinant is distance and the rate per mile is linear. Charges per bit mile drop with utilization. When the capacities are efficiently employed, the higher capacity Telpak services are also less expensive per bit mile.

H. SUMMARY OF CRITICAL RATE FACTORS

The foregoing analysis reveals that only three factors have a significant influence on transmission charges. These are:

- holding times (hours of usage)
- distance
- transmission speeds

Each service is influenced by these factors in varying degrees. The number of stations and the number of channels influence these charges to a lesser extent and only in certain situations.

Exhibit 2 identifies for each service, in order of influence, the factors that most affect its rates. In those few cases where two factors seem to have equal influence, both are shown on the same line. Factors which have no influence on total charges are specifically so indicated.

It is quite apparent from this list that the factors which most affect public switched services are different from those which influence private line services even though the distance factor is common to both. Hours of usage (holding times) is the factor which most influences transmission charges for switched services. In most cases the second most influential factor is distance. For private line services, on the other hand, distance is the most important factor. Usage, or time, is not a factor in the case of dedicated private line services. In most cases, distance must share its most influential position with the number of stations in the system.

The user, in considering whether to purchase a public switched or private line service, must evaluate usage carefully as a factor in his decision. If utilization is expected to be low, the user can save money by acquiring a switched service. On the other hand, if utilization will be high, the user should consider a private line service where usage has no effect on charges. Distance is most important for private lines, meaning that long distances will result in high charges. With switched services, distances are secondary to the hours of usage. On the other hand, usage charges may be more than offset by savings on mileage charges. For the most part, speed and user cost are related. As speed goes up, total charges usually increase. However, charges for higher speed may be quite secondary to other considerations such as the need for higher speed to enable throughput of a high volume of data or to permit use of sophisticated terminal devices.

The charges pertaining to other factors, specifically numbers of stations and numbers of channels are, like speed, independent of cost saving alternatives. If the user's requirements demand a certain number of stations or channels, it may not be possible to trade off factors in order to bring down total charges, even when one service may be more economical than another.

In summary, it would appear that a user, when considering alternative data transmission services, should consider first his usage and distance requirements and then evaluate each service in terms of its rates and other considerations before deciding which is most effective and most economical for his needs.

Exhibit 2
Page 1

SERVICES AND CRITICAL RATE FACTORS

SWITCHED LOW SPEED

Telex and Data Telex
- time
- distance
- speed (no influence)

TWX
- time
- distance

Datacom, Dataphone
- time
- distance
- speed

SWITCHED MEDIUM SPEED

Broadband
- time
- distance
- speed

Multicom
- time
- speed
- distance

Dataspeed, Dataphone
- time
- distance
- speed

SWITCHED HIGH SPEED

Multicom
- time
- speed
- distance

Exhibit 2
Page 2

PRIVATE LOW SPEED

Telex Computer Inquiry Service
- distance and number of stations

Dataline II
- distance and number of stations

Schedules 1, 2, 3 and 3A
- distance
- time
- speed

PRIVATE MEDIUM SPEED

Dataline III
- distance and number of stations

Schedules 4, 4A, 4B and 4C
- distance
- speed

Channel Deriving Arrangements
- distance
- number of channels

PRIVATE HIGH SPEED

Telpak A, B, C and S
- distance
- speed

I. INTER-SERVICE RELATIONSHIPS

Of the factors which influence total charges, only distance is common to all services. The list on page 21 groups the services by those factors which determine the total charges for each service. Within the groups listed there may be rather obvious sub-groups. For example, in the Usage and Distance group, Telex and Data Telex, TWX, Datacom and Dataspeed are a sub-group, as are Broadband, Multicom and Dataphone. The main distinction between the two sub-groups is the gap between their charges, although the critical factors are identical.

When computing total charges in terms of distance and message volume, the critical factors are mileage and the number of bits transmitted, This latter, in turn, is a function of the service speed and monthly hours of use. Therefore, any comparison of the various services can best be done by reducing each service rate to the charge per bit mile. Although the charges per bit mile will vary with different assumptions, the basic relationships and trends will be similar.

In making the comparisons between services, no change was made particularly in the assumptions regarding hours of usage and number of stations. A more detailed examination of inter-service relationships with supporting tables and graphs can be found in Appendix C.

The first group, where the important factors are usage and distance, has two sub-groups. In the first sub-group, Telex, Data Telex, TWX, Datacom and Dataspeed charges per bit mile are similar relative to either distance or speed. Similarly, in the second sub-group, Broadband, Multicom and Dataphone, charges per bit mile, although substantially lower than for slower services, are quite similar. At identical speeds the charges per bit mile are very close and even Multicom high speed charges are almost the same as for Multicom medium speed.

The Distance and Stations grouping comprises three services, each with a different speed. For the two slow speed services, Telex Computer Inquiry Service and Dataline II, charges per station per bit mile are very similar. Dataline III, at 2000 bps, is considerably more economical than the others at given distances and hours of usage.

Two services, each made up of four sub-services, comprise the group where distance is the only factor that influences total charges. However, charges per bit mile are affected substantially by differences

LIST OF SERVICES BY PRIMARY TRANSMISSION CHARGE DETERMINANTS

Usage and Distance

Telex and Data Telex
TWX
Datacom
Dataspeed
Broadband
Multicom
Dataphone

Distance and Stations

Computer Inquiry Service
Dataline II
Dataline III

Distance Alone

Telpak A-S
Schedules 4-4C

Others

Schedules 1-3A
Channel Deriving Arrangements

in speed within the services. For the most part, Telpak services have lower charges per bit mile at given distances and utilization. This is primarily because Telpak is a higher speed service. The only exception is Schedule 4C at 2400 bps which is more economical than Telpak A at high mileages.

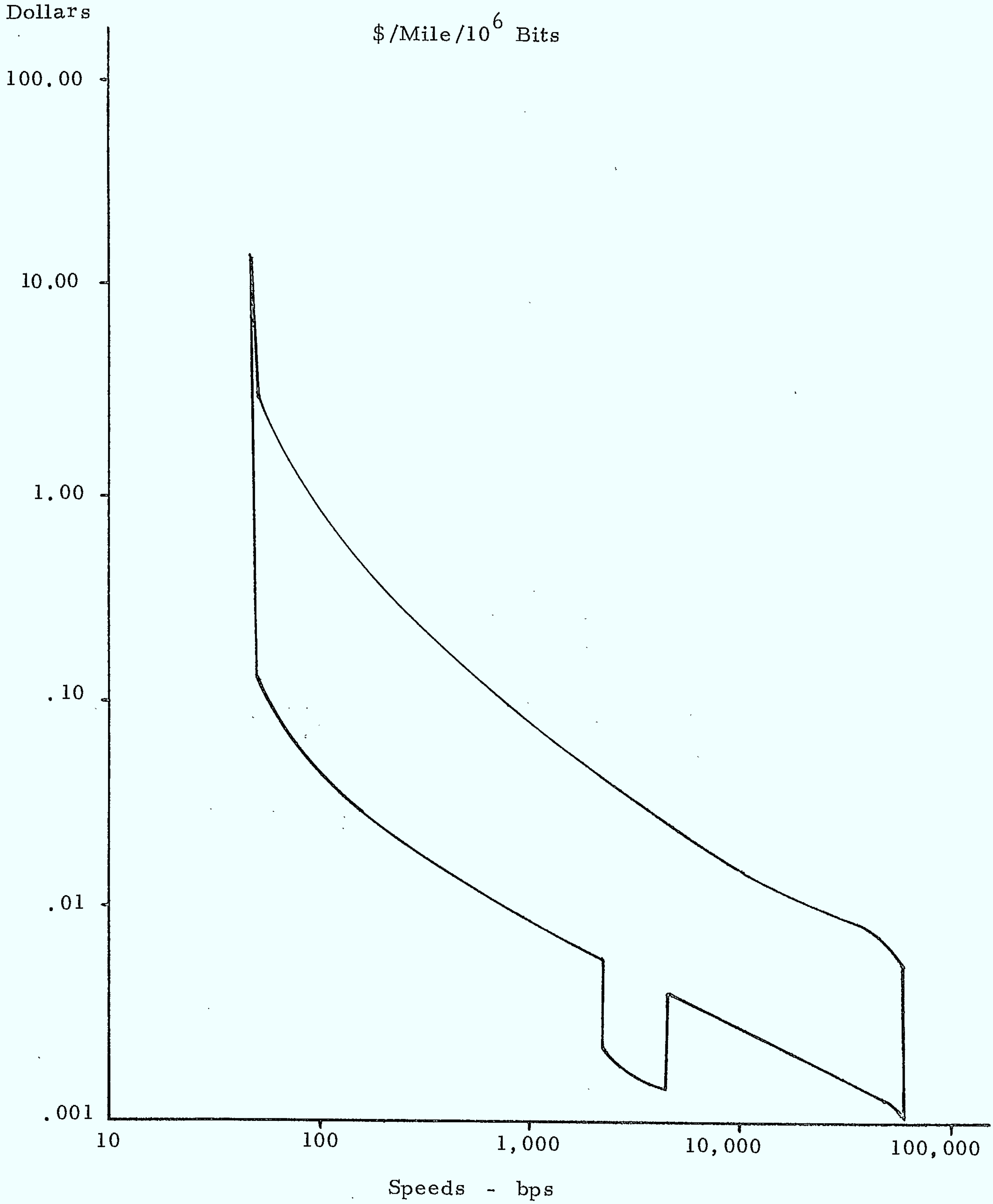
The last two services must be treated individually. Schedules 1, 2, 3 and 3A differ from each other in rates and speeds. The higher speed services have slightly lower charges per bit mile than the lower speed services but the drop is not inversely proportional to the speed increase.

Channel Deriving Arrangements have almost identical charges per bit mile at 180 bps, a speed common to both Teleprinter and Computer Access. Teleprinter, at 82.5 bps, is less economical than the higher speed, and in fact the charges are proportional to the difference in speeds.

In presenting any meaningful comparison of data telecommunications services, it is necessary to be cautious. This analysis has considered all fourteen services but in some cases local service was omitted and for others simplex not considered. The graph presented in Exhibit 3 is intended to show in a general way the charges per bit mile in terms of the different speeds of the services solely for purposes of analysis. As previously mentioned, the validity of these comparisons holds only in terms of relative relationships and trends. Nevertheless, some interesting findings emerge from such an analysis. The graph presented in Exhibit 3 depicts clearly a trend from top left to lower right (or from low speed/high charges to high speed/low charges). The high point on this curve is low-mileage low-speed services like Telex. At the other extreme are long distance, high speed services like Multicom. Two definite groupings seem to emerge: the first below 200 bps, and the second from about 2000 bps to 10,000 bps. Those services which exist outside these groups are, for the most part, specialized. The two basic groups contain the most competitive services offered by the carriers. The tables and graphs from which Exhibit 3 was prepared are presented in more detail in Appendix C.

The graph also reveals the very broad range of charges which a user may incur. Obviously, the decision as to which service to buy is not based on price alone but is a complex function of other factors such as speed, capacity, convenience, available options and many, many others. Nevertheless, the range of charges depicted in Exhibit 3 reflects the breadth of service options and user costs which are currently available in Canada's still infant telecommunications industry.

Exhibit 3


Dollars
$/Mile/10^6 Bits
100.00
10.00
1.00
.10
.01
.001
10
100
1,000
10,000
100,000
Speeds - bps

It is certainly clear that every user of data transmission services must analyze his own peculiar situation in every detail before deciding on the optimum type of combination of types of service that will serve him best. This is true, in the first place, because of the general complexity of the rate structure as discussed in the preceding paragraphs. However, the user's problem is not simplified by either the tariff books of the carriers or the number of alternative offerings which are available to him.

V. THE NATURE OF DATA TRANSMISSION COSTS

INTRODUCTION

Before undertaking an examination of the carriers' costs associated with digital data transmission, it seems appropriate first to review briefly some characteristics of the communications networks in Canada and to discuss the impact of these characteristics on the determination of the "true costs" of service.

Data transmission networks in Canada utilize the existing analogue telecommunications facilities provided by the common carriers. These facilities were developed initially to carry telegraph, teletype and voice. Both telegraph and teletype can use direct current (d.c.) signals for short distance, but for the longer haul must convert the d.c. signals to voice frequency tones. The transmission of data as a coded order of bits or binary digits expanded rapidly after 1950 as data sets were developed to convert the binary d.c. signals into tones at speeds beyond telegraph and teletype capabilities. These signals then were easily transmitted on the analogue communications networks.

The Canadian telecommunications carriers have few traffic load statistics related specifically to data traffic on the Canadian telephone or telegraph networks. Most of the data is carried on private line facilities which often are used by the customer alternately for voice and data transmission. Data also are transmitted over the public telephone system through data sets and acoustic couplers. As a result, the carrier's costs of providing data transmission are very often intimately linked with the costs of providing voice transmission. The Trans-Canada Telephone System estimates that data represents about four percent of the total traffic on the Canadian networks.[1] Of this amount, 24,000 million bits per month are transmitted on TWX, Telex and switched networks, and another 96,000 million bits per month over the combination of private line systems and the DDD telephone network.

The complex of telecommunications systems in Canada today carries simultaneously hundreds of data messages, thousands of telephone conversations, and a number of network television and

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1. Source: TCTS, Computers Communications and Canada, Ottawa, November 1971

radio programs. Moreover, an examination of a cross-section of these systems will reveal that they are composed of individual private lines, private networks and large groups of circuits which form the voice or data public switched networks. The facilities for this admixture of services usually are housed in the same building. They obtain power from the same source and are maintained with the same tools and test equipment.

The configuration of the communications systems operating in Canada today is such that although the nature of the information communicated is very different depending upon the original form (i.e. data, voice or video), the transmission facilities themselves tend to be interchangeable among the service offerings. For example, several voice channels for use in a public or private network can be derived from a broadband channel. Similarly, several teletype channels can be derived from a voice channel.

Systems engineers use this fortunate capability to combine or subdivide the transmission channels, thereby accommodating changes in the load and/or mix of traffic with the least requirement for additional network plant. On the other hand, this capability to provide a large assortment of telecommunications services from common plant poses the problem of identifying the costs associated with a particular service. The carriers often have indicated that this is extremely difficult if not impossible to do, stressing the fact that as much as 70% to 85% of the network plant is common to many types of service.

Cost separations techniques have been proposed to identify the costs of an individual service, but opposing views are held concerning the validity of the results. Regardless of the position taken on the subject of cost separations, however, it is clear that the usefulness of this approach to cost determination depends upon the assumption that historic or embedded costs are a meaningful measure of the existing telecommunications plant. Opposing views hold that any average cost approach is invalid and that only marginal cost approaches can produce meaningful information.

With respect to cost separations the following points should be made. Accounting theory and practice encompasses a large variety of cost allocations principles and methods designed to achieve an equitable distribution of costs to products or functions in a wide range of enterprises. Unfortunately, there is no clear-cut generally accepted method of cost allocation which serves every purpose. However, all cost allocation methodologies do recognize the distinction between costs that are directly identifiable and those that are joint or common to all or a number of products or functions. In most industries, such joint costs are a small proportion of the total costs and any inaccuracies made in in their allocation yield results that are not far off the mark. The nature and degree of error introduced during the allocations process depend on the assumptions and arbitrary decisions made in determining the criteria to be applied to the process. However, in an industry where the common costs are a very large proportion of the total costs, the assumptions and judgments that are made can lead to wide variations in costs assigned to particular classes or types of services. The magnitudes of these variations are well documented in contemporary literature[1] and the dockets of the Federal Communications Commission.

The cost separations process is neither correct nor incorrect; it is arbitrary. In assessing the validity of the results, the purpose of its use must be understood. One must keep this continually in mind, otherwise there is a risk of attributing to cost separations a degree of precision, science and logic which is unwarranted. The "reasonableness" of the results depends to a large extent on the individual's judgment of what he perceives to be the equitable relationships among the derived values.

Canadian carriers, either because they do not believe in the value of relating fully embedded costs to rates or because they recognize the difficulties and the expense involved in carrying out cost separations, have undertaken relatively fewer studies of this nature which identify costs associated with specific types of service. In response to recent requests by the Canadian Transport Commission for such information, Bell Canada provided data in respect of the Teletypewriter and Telpak offerings; the Canadian National and Canadian Pacific Railways provided cost data associated with the Message Telegraph Service. The costs were presented in the form displayed in Tables 1 and 2 on the following page.

With respect to the Bell Canada studies, fully allocated cost refers to the costs that are derived through the apportionment of the embedded costs among all of the services so that the sum of the costs imputed to each type of service is made equal to the total book costs. The CN-CP studies assigned the indirect costs on the basis of the Uniform Classification of Accounts prescribed by the CTS for railways.

There is very little other published cost data that can be associated directly with specific types of data transmission services,

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1. See especially Development of Separations Principles in the Telephone Industry by Richard Gabel, Michigan State University, East Lansing, Michigan, 1967

TABLE 1

BELL CANADA SAMPLE STUDIES

	TELPAK (1967)	Teletypewriter (1968)
	(dollars in millions)	
Sample Study (1967) Revenues	$3.9	$ 6.0
Assigned Costs on Full Allocation Basis Including Taxes	3.0	5.2
Total Income Before Interest Charges	0.9	0.8
Assigned Average Investment on Full Allocation Basis	9.1	13.1
Total Income Before Interest Charges to Average Investment	10%	5.8%

Source: CTC hearings, 1969, re Bell Canada, Exhibits B-375 and B376

TABLE 2

CN-CP MESSAGE TELEGRAPH SERVICE

	Canadian National	Canadian Pacific
	(dollars in millions)	
Revenues	$8.9	$6.8
Direct Costs	9.2	6.8
Loss (in excess of direct costs)	0.3	0.0
Indirect Costs	3.9	2.5
Total Loss	$4.2	$2.5

Source: CTC Railway Transport Committee, Order No. R-12690, October 7, 1971 and thereby related to the rates for that service. This is not surprising in view of the essential characteristic of cost and rate behaviour in this industry - namely, that rates are service-oriented and costs are tied to investment in multi-purpose equipments. Consequently, it was necessary in this study to seek other means of deducing costs, so that they could be related to the various types of data transmission services and their rates. The problem is shown schematically to be one of relating the common dollar element of rates and costs through the

SPECTRUM OF RELATIONSHIPS
rates ↔ services ↔ equipment ↔ costs

spectrum of relationships one of which (services) is not dollar-related. A further problem concerns the reluctance of the carriers to provide detailed cost information, partly because their accounting systems do not record some of these data in the detail and form requested, and partly because the release of certain costs (and other quantitative data) may jeopardize the competitive position of the carrier with respect to its data transmission service offerings. Moreover, in view of the controversies generated over cost separations in the United States, there is among Canadian carriers an historical fear of public misinterpretation of the data.

A large proportion of the cost data obtained in this study pertains to the telephone carriers simply because documentation of costs relative to the telephone industry is more extensive than it is for other types of carriers. The data is generally relevant, however, since TCTS estimates that two-thirds of the low speed traffic and three-quarters of the medium and high speed data is carried on telephone switched networks.[1] It is unfortunate, however, that so little information on these matters has been documented.

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1. Trans-Canada Telephone System, "Communications, Computers and Canada", Ottawa, November 1971

THE APPROACH

In the light of the dearth of information available to the study team, a two-phase approach was devised. This approach was based on the premise that the basic element of cost in a communications system is the investment in plant necessary to provide the services and that the operating costs follow from the investment. The aim of the first phase was to develop the relationship between annual costs and investment in plant, first with respect to total plant, and next with regard to individual categories of plant. The objectives of the second phase was to establish the investment per unit in each category of plant. The technique was partially successful, in that it was possible to establish some relative relationships with respect to the issues examined in this report. However, there remain a large number of gaps due to the lack of data, which could not be redressed in the time frame given for the study. The principal findings are presented in the remaining pages of this section, with more detailed information presented in Appendix D.

ELEMENTS OF COST

In attempting to develop a relationship between the annual costs and plant investment during the first phase, three major classifications of carrier's costs were defined. These are:

* operating expense
  - maintenance
  - depreciation
  - operations
  - general

* taxes
  - income
  - other

* cost of money
  - interest
  - dividends

Operating expense is generated by both the existence and the use of the communications system. These are continuing costs, associated with operating, maintaining and administering the system and providing for depreciation. The costs are dependent upon the amount and type of plant in service, its location and configuration, how it is used and maintained, the policies and operating practices of the company as well as the influences exerted by the public and government.

The operating expense of Canadian carriers in terms of dollars expended per $1000 of gross plant investment proves to be quite stable over a period of years. The total costs (less dividends) for the telephone industry, for example, have varied only slightly from an annual rate of 20% of the total plant investment.[1] There is, however, a small downward trend until 1964 which increases thereafter. Maintenance and depreciation account for the major portion of the operating expense, being as high as 75% of the classification in some instances.[2] They are the two categories that are most directly linked to the equipment. Operations expense is more closely related to the traffic volumes that are handled. The remaining categories combined form the overhead expenses of the carrier.

Maintenance costs are generated largely by the switching and associated equipments which are housed in the central offices and the station equipment located at the subscriber's premises. Bell Canada's experience in 1968 indicates that 75% of all maintenance expense was generated by these types of equipment.[3] Proportionately, station equipment is more expensive to maintain, when compared to the initial dollar investment involved.

Depreciation charges have been rising more rapidly in recent years and consuming a greater proportion of the operating expense. The size of the annual depreciation charge depends on the life of the equipment. Electronic systems are deemed to have a life span of 20 years. Experience has shown that the electronic equipment within the system has an average life of 10 years, station connections as low as 7 years, and buildings over 30 years. In addition to simple wear, telecommunications systems are

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1. Source: Statistics Canada, Telephone Statistics, Catalogue 56-202, 56-203, Annual

2. Source: Statistics Canada, Telegraph and Cable Statistics, Catalogue 56-201, 1971

3. CTC Hearings, re Bell Canada Rate Application, 1969, Item No. 5, Information Requested by Attorney General for Ontario

prone to early obsolescence to the extent that installed equipment is no longer satisfactory when newer equipment and techniques yield technically superior performance or more economical operation. Typical composite depreciation rates for the major categories of plant are shown in Table 3. Further breakdown of the categories is provided in Appendix D, Table 7. Investment associated with vehicles, tools and work equipment depreciates most rapidly, but this investment represents a very small proportion of the total. The investment in station equipment, however, depreciates over 11 years, and it represents about one-fifth of the total book cost. This has some important implications for the costs associated with data networks since investment in station equipment can be an extremely high proportion of the total.

Although the overall costs of conducting business as measured against total plant investment are relatively the same for both the telephone and the telegraph industries, there are a number of differences in their distribution. Table 4 reveals that costs attributable to depreciation are comparable but other cost categories differ appreciably. The operations and maintenance expenses paid by the telephone companies are significantly lower, but this is offset by higher costs for general expenses, for taxes and interest payments. Data concerning dividend payments was available only for the telephone companies. The operations and general expense categories of the two types of carriers are not directly comparable but together the categories include the same expenses. The costs of operations are generally those directly associated with the handling of daily traffic on the network. These include the wages and salaries of the operators, clerks and supervisors engaged in traffic activities. The general expenses normally include the salaries of the officers and general office employees of the companies, the costs of commercial and marketing activity, insurance and legal aid, office supplies and other business expenses. It is significant that the two categories combined approximate an expenditure of $60 per $1000 of plant for both the telephone and the telegraph segments of the carrier industry. [1]

Significant variations also can be found from company to company. Data available for the calendar year 1968 pertaining to the largest telegraph and telephone firms are presented in Table 5. Together these companies represent two-thirds of the Canadian investment in carrier plant. In each of the cost categories, variations of 100% or more can be discovered. It is clearly evident from the table that some carriers are able to avoid completely the payment of property or income taxes, or

1. Source: Statistics Canada, Catalogue 56-201, October 1971 and Catalogue 56-203, November 1970

TABLE 3

COMPOSITE DEPRECIATION RATES*
BELL CANADA 1968

EQUIPMENT CATEGORY	% OF BOOK COSTS OF PLANT	RATE
Buildings	7.9	2.7
Central Office Equipment	35.4	4.6
Subscriber Station Equipment	21.8	9.2
Outside Plant	32.8	3.4
Furniture and Office Equipment	0.8	4.6
Vehicles, Tools and Work Equipment	1.3	12.2
COMPOSITE RATE	100.0	5.2

Source: CTC Hearings re Bell Canada application, 1969, Exhibit B-87

*For detailed breakdown see Appendix D, Table 7

TABLE 4

EXPENDITURES OF TELECOMMUNICATIONS CARRIERS PER $1000 OF GROSS PLANT INVESTMENT

	Telephone Companies (dollars)		Telegraph and Cable Companies (dollars)	
OPERATING EXPENSE		$148		$175
Maintenance	$40		$71	
Depreciation	48		45	
Operations	16		32	
General	44		27	
TAXES		$ 33		$ 22
Income	$23		$17	
Other	10		5	
COST OF MONEY		$ 45		$ 3
Interest	$24		$ 3	
Dividends	21		Not available	
COSTS, LESS DIVIDENDS		$205		$200

Source: Derived from the tables of Statistics Canada Catalogues 56-201, October 1971 and 56-203, November 1970

TABLE 5

COMPARATIVE STATISTICS OF SELECTED TELECOMMUNICATIONS CARRIERS (1968)

	BC Tel	Bell	CNT	CPR	COTC
		(millions of dollars)			
1. Gross Plant Investment	$613.3	$3279.3	$277.8	$122.7	$106.5
		(Costs in $ Per $1000 of Gross Plant)			
2. Operating Expense					
Maintenance	$ 45	$ 41	$ 82	$ 57	$ 44
Depreciation	47	46	39	32	64
Operations	20	16	9	78	32
General	32	39	33	19	10
Totals	144	142	163	186	150
3. Taxes					
Income	26	22	-	21	58
Other	9	21	5	7	-
Totals	35	43	5	28	58
4. Interest	23	19	-	-	24
5. Totals, Items 2, 3, 4	202	204	168	214	232
6. Dividend Payments	18	27	-	-	-
7. Income, After Taxes, Before Dividends	29	35	31	19	54

Source: Statistics Canada Catalogues 56-201 and 56-202, transcripts and exhibits of the Canada Transport Commission during the 1969 rate hearings for BC Telephone and Bell Canada. The costs per $1000 of plant were developed by the consultants.

interest on investment capital. Some government sponsored enterprises do not face the requirement to provide a return on investment in the form of dividend payments. Others, such as the railroad companies, combine their telecommunications operations with their railway operations, assigning more or less of the total expenses to the railway operation. For example, in 1968 the CNT assigned 3% of the maintenance and depreciation costs, and 80% of the operations costs to the railway, but none of the general costs. The corresponding figures for 1970 are 4%, 95% and zero respectively. The CPR attributed 32% of the maintenance and depreciation costs as well as 25% of the operations costs and 20% of the general costs to railway operations. The corresponding figures for 1970 are 24%, 22% and 11% respectively.[1]

In 1969 expenditures by members of the Trans-Canada Telephone System averaged $221 per $1000 of plant to cover all costs including dividends. The costs for each member ranged between a low of $181 to a high of $234 per $1000 of investment.[2] For the CN-CP Telecommunications network in 1970, total costs less dividends averaged $182 per $1000 of investment, consisting of $168 for the CN portion and $214 for the CP segment.[3]

It is evident, because of the nature of the existing variables in the Canadian telecommunications environment, that the pattern of costs for each of the carriers is a unique blend. Much of the variation is caused by the type of operation required to satisfy the differing demands for all services made upon the individual carrier, and much can be traced to the circumstances of history, geography, the carrier's opportunities for acquiring capital, and the tax structure of the particular segment of the economy in which he operates.

ELEMENTS OF INVESTMENT

In order to examine the investments in the various classes of plant equipment that are required for data transmission systems, it is useful to establish five major categories. These are:

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1. Source: Statistics Canada, Telegraph and Cable Statistics, Catalogue 56-201, Reports for 1968, 1970

2. Source: Statistics Canada, Telephone Statistics Catalogue 56-202, July 1970

3. Source: Statistics Canada, Telegraph and Cable Statistics, Catalogue 56-201, 1970

* station equipment (located at the customer's site)

* local loops (linking the station to the network)

* switching equipment

* inter-office transmission facilities; and

* support facilities (buildings, vehicles, tools, etc.)

These categories of equipment form the building blocks of the systems. In each category there are a wide variety of equipments and techniques which are in turn the components of the building blocks. Each component provides certain performance characteristics that may or may not be advantageous in particular situations. The choice of equipment normally is based on an assessment of the alternatives available, selecting the one that achieves the required performance at least cost.

In the continually expanding and technologically advancing communications industry, selection criteria almost always will include consideration of the rate of growth that can be expected, the expansion capability of the equipment, its service lifetime, the probability of obsolescence and the need for compatibility with other equipment already in the system. A further choice is offered to the carrier operating a distribution network employing alternative routing, because a trade-off between categories of equipment may be possible. The fundamental conclusion is that the relationship between performance and cost for any segment of a communications system cannot be considered in isolation, but must be reviewed in the light of the basis on which investment decisions were made – namely, the requirement for the system as a whole, whether existing or planned.

Often overlooked is the fact that the rate structure itself has an important impact on the decisions made regarding the type and amount of equipment to be installed. The rates influence the customer in his choice of service. A change in their structure, such as from a flat rate to a message rate will influence the numbers of customers subscribing to a particular service, and possibly shift customers to other types of service. This would vitally affect the design of the central office, the switch size, facilities for charging on a message rate basis and the number of facilities to be provided for each type of service.

Station Equipment

Four principal types of equipment are provided at the subscriber's station:

* terminals

* data sets or modems

    (The term data set is more general than modem. Modems modulate and demodulate data signals. Some data sets do not contain a modem.)

* multiplexers

* telephone handsets

Speed bears heavily on the costs of terminals but so do other optional features. The greater proportion of terminal devices in use today are the teletypewriter or keyboard-type devices, employed in user-to-user and user-to-computer services. Unit prices range from $500 at low speeds to $8,000 at speeds up to 1200 wpm. Receive only machines are 10% to 20% less expensive in each of the speed ranges. In the low speed range, heavy duty teleprinters are two to four times the cost of light duty machines. The addition of tape punch/readers increases costs by 25% to 50%.[1]

Data sets connect digital signals to analogue at the sending end and at the receiving end restore the signal to digital form. Costs generally increase with:

* increased speeds of transmission

* increased sophistication of the data sets

* the number of optional features provided

* adaptability for use with the switched network

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1. Source: Auerbach Computer Technology Reports, Philadelphia, 1971

At 300 bps data sets might cost $400, a 4800 bps set $12,000 if it were required to work on the switched network, and about $5,600 for private line use.[1]

There are a multitude of variations in data sets, each of which affect the purchase price. Some data sets do not contain an integral telephone set, but can accommodate a separate telephone. Some data sets can accommodate several telephones. Some can operate unattended. Others have reverse channel capability for providing both voice and data facilities, error correction, and compensation for distortion created by the communications line. The modem furnished by the carrier generally depends on the particular requirements of the type of user.

Multiplexers are used to combine several low speed signals into a composite high speed signal in order to transmit them on a single channel to the receiving station where the original low speed signals are then recovered. The equipment is offered to the user of a large number of communications lines to reduce his overall costs for service. His cost savings increase in proportion to the distance between terminals.

Multiplexers are constructed to provide an extremely wide range of options with respect to the characteristics of input data, transmission rates, mixing patterns, number of channels, status and diagnostic indicators and error control. Costs when used at full capacity range from about $350 to $775 per data channel.[2] Sophistication rather than speed of transmission is the principal cost factor. Otherwise, the cost per data channel decreases with increasing channel handling capacity.

The ordinary telephone handset can be used for data transmission in many instances. Portable terminals with acoustic couplers accommodate the handsets in specially designed cradles. The data which is already in analogue form when presented to the handset is transmitted via the public switched network. The carriers costs range from $16 to $33 depending upon type.[3] Bell Canada reports that their cost of an

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1. Sources: Auerbach Computer Technology Reports, Philadelphia, 1971; Datapro 70 Communications, Datapro Research Corporation, Philadelphia, 1971; Specialized Communications Carrier Market, Frost & Sullivan, Inc.,New York, 1971

2. Source: Auerbach Computer Technology Reports, Philadelphia, 1971

3. CTC Hearings re BC Tel Rate Application, 1970, Exhibit BCT-9 and Bell Canada Rate Application, 1969, Transcript of Evidence, Vol. 44, p. 743 and Vol.47 p. 1326

installed telephone averages between $96 and $120.[1] The telephone and wiring at the customer's location costs the carrier $60, with the remainder of the cost attributable to the directly associated equipment at the central office.

Acoustic couplers to accommodate speeds up to 300 bps, and which the subscriber himself may supply, are available in the United States at from $250 to $1100 with the majority near the $400 level.[2] Differences in cost are speed-related but cost variances are also attributable to built-in optional features such as automatic answer, reverse channel, carrier detection indicator and loop-back features.

Station equipment accounts for one-fifth of the investment made by members of TC TS. If the network handled data transmission only, this proportion likely would increase dramatically, since the cost of the telephone is a small fraction of the cost of teleprinters, data sets, multiplexers or acoustic couplers.

Local Loops

The local loop is the circuit that connects the station equipment to the local central office or exchange. Each local or subscriber loop is associated with a particular subscriber station, often with a specific piece of equipment at the subscribers premises. At the exchange, two situations arise. If the subscriber has selected the switched network for data transmission, the loop is connected to the switching equipment which permits access to the network. If he uses a private line, the loop is connected to the circuit leading to the other station or stations forming the private system.

Because there are a number of subscriber stations connected to it, each central office is, in effect, the hub of a rimless wheel and the subscriber loops are the spokes connected to the centre. The circuits, being concentrated at the hub, generally leave the exchange in large feeder cables. As the distance from the central office increases, the circuits cascade through a number of smaller distribution cables, eventually reaching a terminal from which one or more pairs of wires connect to the subscriber's premises. The cable routes may

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1. Telecommission Study 4(a)

2. Source: Auerbach Computer Technology Reports, Philadelphia, 1971

change from time to time because of changes in the total demand for services in the community. Typically, the loop is physically re-arranged at some point every two years and 9 or 10 splice points are uncommon.

The significant factors affecting the cost of the loops in an exchange are:

* length of the loops
* type of transmission line employed
* the density and distribution of stations within an exchange area

Loop lengths are a major factor affecting costs. In Bell Canada the average cost for a 2-mile loop is reported to be $200 and for a 4-mile loop more than $500.[1] The above costs are based on existing plant, much of it installed years ago with a life expectancy of nearly 30 years. Current costs are up to 75% higher.

Pole mounted loops are reported elsewhere to cost from a low of $31 per mile using aerial cable to $118 per mile employing open wire.[2] Multi-pair cable in densely populated areas permits economies of scale to be achieved in construction. Better utilization of cable pairs also is possible through the use of cable carrier systems at costs ranging from $200 to $700 per voice channel[3] depending on the transmission characteristics that are required. The latter systems are particularly useful in rural areas where long distribution lines might be required for for each subscriber.

Local loops generally can accommodate low transmission speeds without great difficulty, but beyond 600 bps special "conditioning" may be

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1. Source: Telecommission Study 8(b) (ii), Appendix E

2. Source: CTC Hearings re BC Tel Rate Application, 1971, Exhibit AG-12

3. Source: Crownfield, William R. Experience With Station Carrier Applied to Loop Plant, Proceedings of the National Electronic Conference, Inc., Oak Brook, Illinois 1970, Appendix 1, pp. 919-920.

required to overcome the loss characteristics of the circuit. Technically, conditioning increases the usable bandwidth of the channels, thus increasing the rated speed of the circuit. The costs are related to the incremental increases made to the bandwidth, each incremental increase being more costly than the previous one. Cost data are lacking in respect of Canadian carriers, but the experience of Pacific Telephone and Telegraph Company in the United States indicates that the cost of increasing the rates speed of a circuit from a nominal 1600 bauds to 2000 bauds (Schedules 4A to 4B) is about three times the cost of increasing the speed from 600 to 1600 bauds (Schedules 4 to 4A).[1]

The Canadian telephone companies by 1970 had invested approximately $1.76 billion in the local distribution networks. Considering the number of telephones reported by statistics Canada to be in service and making allowance for the effect of extensions and private branch exchanges, the average cost per loop is calculated to be about $250. This cost approaches that of the least expensive acoustic couplers but only approximates 5% to 17% of the cost of a teletypewriter.

Switching Equipment

Switching equipment is the means by which the customer can connect to any other subscriber in the system. The geographical allocation of the exchanges in a network and their functional interrelationships depend on the existing and potential demand for total telecommunications service. Switching offices have been developed to serve both local and long distance calling and have been arranged and located to provide alternative routing in case of failure. They have been designed so that the failure to accommodate a subscriber will occur at less than 1% frequency at peak traffic volumes.

Switching costs are a function of a number of subscribers and terminating trunks connected to the machine, and the traffic pattern (number, time of placing and duration of the calls). TCTS in 1970 reported that switching represented 25% of its members' investment in plant.

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1. Source: Pacific Telephone and Telegraph Company, Submission to Public Utilities Commission for the State of California, December 1969 in response to Decision 74917

In the telephone industry there is an abundance of statistical evidence concerning telephone use.[1] The average time to dial a 7-digit number and obtain an answer from the called party is 30 seconds. The average length of talking time is 130 seconds. When the called party does not answer, the average wait before hanging up is 40 seconds. Compared to the residence telephone, business telephones contribute one and one-half times as much traffic, and lines from a PBX four times as much. The busy hour traffic peaks occur between 10 and 11 in the morning and 2 and 3 in the afternoon. About 80% or more of the calls made are local as opposed to long distance. These characteristics may be altered somewhat by the unique local calling patterns.

However, the same type of information is not available concerning data transmission. Except for the Telex exchange network, data transmission history is still too short to assess its characteristics with confidence. In Canada, fewer than 5% of Telex calls are local, the reverse of telephone experience.[2] The use of Telex network is largely confined to business hours, and the traffic is of a "business nature". The relative difference in density of traffic between peaks and lows is considered to be greater than for the telephone industry. This effect is produced by the number of messages sent rather than by the duration of the calling time. For a given number of subscribers, more switches and connecting paths are required for Telex than for long distance telephone service.[2]

Therefore, the switching investment per subscriber line for Telex should be greater, all other factors being equal. Unfortunately, comparative statistics are not available. Because the vast majority of Telex calls are long distance, the number of outgoing trunk lines that are required would seem also to be relatively higher than one would expect to find in a telephone office. If the characteristics of data transmission on the public switched telephone network appear over time to deviate greatly from the norms established in the telephone industry increased data traffic will force a redesign of the network segments to avoid degradation in the quality of service.

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1. The figures are taken from The Traffic Engineering Handbook, Telephony Publishing Corporation, Chicago, 1969

2. CN/CP Telecommunications, Manual of Telecommunications Services, Section 3

Three principal types of switches used for data transmission are:

* Step-by-Step (SxS)
* Crossbar (XBar)
* Electronic

The step-by-step switches are the oldest and least expensive; the electronic switches the latest and most expensive per subscriber line. Investment cost per subscriber line approximates $200 for step-by-step, $250 for No. 5 Crossbar, and $740 for electronic switches in their current configuration and utilization.[1] Step-by-step is costlier to maintain, slower, noisier, and less efficient. For data transmission there is a requirement for higher switching speeds and more efficient operation which leads to the installation of the more expensive type of switch equipment. For long distance circuits using four wires the costs of crossbar approximate $2,000 per trunk line serviced.[2] Switched data transmission networks also require the carriers to provide customer dialing (DDD) and automatic number identification (ANI) equipment for efficient traffic handling. The combined costs of doing so are in the order of $35 per station.[3]

Inter-Office Transmission Facilities

Several choices are possible in the selection of inter-office transmission facilities, ranging from open wire lines to microwave radio. The volume of traffic, the distance between offices and the existing plant configuration are key variables. Alternative methods for satisfying system needs normally are selected on the basis of the technical solution which best achieves orderly expansion at least cost.

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1. Based on data presented in CTC Hearings of BC Tel Rate Application, 1970, Exhibit BCT-29; Bell Canada Rate Application, 1969, Exhibit B-70-9; and Telecommission Report 3(d)

2. The Telephone Association of Canada, Canada's Telephone Industry in Perspective, 1967

3. The Globe and Mail, Toronto, November 3, 1971 and CTC Hearings re BC Tel Rate Application, 1971, Exhibit BCT 10-VI

Physical facilities may be grouped into five main categories:

* open wire
* cable (symmetric pair)
* wire pair carrier systems
* coaxial cable carrier systems
* radio systems
  - High Frequency (HF) radio
  - Microwave relay
  - Satellite

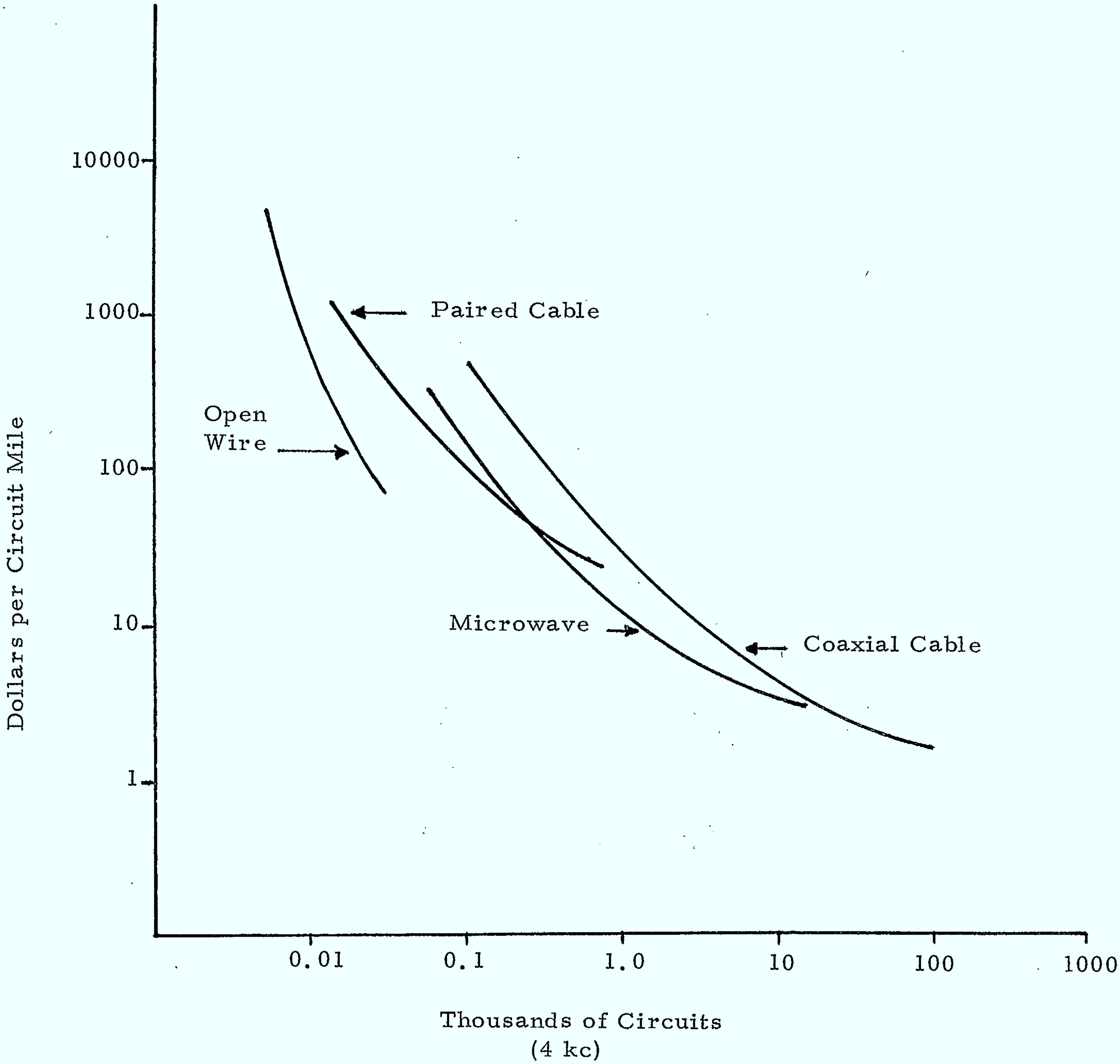
The investment cost of a transmission system is dictated mainly by the type of physical facilities in use, the system length and the number and rate of growth of the circuits in the cross-section. The distribution networks of the public switched telephone and telegraph companies are a complex composite of all categories of equipment shown above. In the TCTS network, these facilities represent about 13% of the total investment.

The costs for open wire and cable are usually directly proportional to the distance between the connected offices, although the need for loading and voice frequency repeaters introduces small variations. On the other hand, the investment costs per channel for wire line carrier systems, whether for open wire or cable, depend upon terminal equipment requirements and the number of intermediate carrier repeaters that are necessary. Investment costs for radio systems rest almost entirely on the costs of the terminal and repeater installations, the costs per channel being a function of the multiplex equipment located at these installations, and the costs per mile a function of the working range of the selected radio equipment. The relative costs of some representative systems are shown in Exhibit 4.

The high initial investment required for microwave often makes it more economical to use paired cable or open wire over short distances or where traffic volume is low. Microwave systems, however, are very attractive for the long distance high density traffic routes since distance and traffic volume both affect the economies achieved through scale. Current demand for long-haul transmission facilities in Canada has not required immediate installation of the full capacity of large microwave

Exhibit 4

COMPARATIVE INVESTMENT COSTS VERSUS TRANSMISSION METHOD AND NUMBER OF CIRCUITS



Source: Telecommission Study 4(a) Appendix E, and
CCITT, Economic Studies and Comparisons, 1969, Chapter D.IV

systems. The carriers, however, typically make allowance for future expansion by selecting equipment that is readily augmented. Given adequate building and power capacity, approximately 60% to 70% of the costs of expanding a microwave system are consumed by the multiplexing equipment. Current costs of microwave systems are widely quoted as being in the order of $12 per voice channel-mile.[1] However, this does not take into account the need to provide protection channels as well as monitoring and maintenance circuits within the system. Assuming that the proportion of channels assigned to full-time commercial traffic is 75% of the available capacity, the investment cost per working channel is nearer $16. Costs of satellite transmission systems are independent of distance, but the cost per channel mile is intimately linked to the utilization that can be achieved which in turn is a function of demand at the prices charged to the user. Cost information for the Canadian environment awaits launching and operation of a satellite system.

Coaxial cable costs have been decreasing to competitive levels and installations are being made in the Canadian network. Each tube of the L-4 system is capable of carrying 1800 circuits with a repeater specing of two miles. Representative costs per voice channel less land, buildings and support equipment are estimated to range from $7 to $11 at 1967 prices.[2]

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1. Telecommission Report 4(a)

2. Derived from data presented by CCITT , Economic Studies and Comparisons, 1969, Chapter D.IV; Roston, Eugene V., President's Task Force on Communications Policy, Washington, D.C., Staff Paper One; Gunn, J.F. Weller, D.C., A Digital Mastergroup Channel for Modern Coaxial Carrier Systems, International Conference on Communications, San Francisco, June, 1970; Meckling, William H., Communications Satellites, RM-2709-NASA and supplemental information, The Rand Corporation, Santa Monica, California, 1960; Telesat, Interaction of the Terrestial and Satellite Systdm, Department of Communications, 1970; D.A. Dunn et al., Report 7379B of the Stanford Research Institute, available from the U.S. Department of Commerce, Clearing House for Scientific and Technical Information, Springfield, Va.; Manufacturers précis based on large volume productions of cable type PD-375 (with lead sheath)

For short-haul equipment, existing wire pairs can provide expanded facilities through the use of carrier systems. The T-1 system is eminently suitable for data transmission up to 50 miles with a full capacity of 1.544 million bps. U.S. experience indicates that the equipment may yield voice equivalent channels at a cost of $700 using existing wire pairs.[1]

One-seventh of the TCTS members' investment is accounted for by transmission facilities, both long and short haul. The average cost per voice channel mile is less than that for local loop construction because of the economies of scale generated by microwave and carrier systems. Nevertheless, costs for individual routes for short-haul service may not differ greatly from the investment required to install the local distribution system.

Support Facilities

Investment in support facilities for the carrier's operations includes the land and buildings required to house the equipment, the tools, work equipment and vehicles of all types, furniture and equipment. Data relating to the members of the Trans-Canada Telephone System reveals that these facilities represented almost 11% of the total investment. Except for land and buildings, the depreciation rate for the equipment in this category is generally higher than that for most of the categories of communications equipment. On the other hand, the maintenance costs as a proportion of the investment are smaller. These facilities form an investment pool common to all the services provided on the integrated network and their annual costs are a charge against all of the service offerings.

CONCLUSIONS

The fundamental cost associated with digital data transmission is the investment required to construct the transmission facility. Essentially the facility consists of four operating components (the station equipment, the local loop, the central office equipment and the inter-office transmission lines) and the support component necessary to maintain and operate the network. Each component itself can be

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1. D.A. Dunn et al. Report 7379B of the Stanford Research Institute, available from U.S. Department of Commerce, Clearing House for Scientific and Technical Information, Springfield, Va.

constructed with a wide variety of equipments and techniques. Equipment selection is based on the user's current requirements, the potential for expansion, the need for inter-equipment and inter-service compatability and, when alternatives are possible, the least cost. Eventually, the quantity and location of the subscribers and the amount, type and timing of the traffic generated become the principal determinants of mix of hardware required to carry the load and mix of traffic presented.

The telecommunications carriers conduct annual reviews of operations in order to meet the demand for service, to control expense and to develop satisfactory earnings. Because basic estimates of the incremental demand for various service offerings determine the additional equipment requirements, the annual review is prepared "upwards" by the managers who have intimate knowledge of the local operation for which they are responsible. The locally prepared estimates are assembled and reviewed by succeeding levels of the company organization, eventually being scrutinized and analyzed by the headquarters staff before being incorporated into the overall plan. The plan will include an estimate of the revenues and expenses and the necessary construction expenditures from which financing plans are developed.

Planning of the construction program itself requires consideration of priorities, alternatives and timing. Financial planning includes a review of financial resources and the general financial situation, anticipated earnings levels, and opportunities for improvements in the carrier's operations. These considerations may lead to decisions to reduce the construction program and to seek improvements in the expense picture or in the utilization of the carrier's facilities. Once the company plan is approved, each unit of the company down to the smallest is expected to carry out the agreed objectives. The number of combinations and permutations of alternatives that are possible results in each locality exhibiting a unique mixture of hardware appropriate to the local needs. The different equipment and operating patterns, therefore, yield different cost patterns, not only from company to company, but also from location to location within the same company. In addition, the date of the investment influences the legitimacy of book cost values. Company-wide cost averages, therefore, are representative of the total mix taken across a lengthy time frame and are not suitable for purposes of planning or comparison. The carriers themselves are more interested in current unit costs for planning purposes than they are in utilizing historical embedded costs.

Several factors affect the initial and annual costs of the building blocks of the system. First, investment costs are related to the geographical location of the facility, the amount and type of traffic to be handled and the volume of the peak loads. The annual operating costs derive mainly from depreciation, maintenance, traffic and business operations expenses. Taxes and the cost of money are important costs to some carriers but have a lesser impact on others.

Economies in the communications network are achieved through large scale operations. The network favoured with heavy traffic across large cross-sections will achieve the greatest economy. Here trade-offs between switching and transmission arrangements are possible. High volume direct transmission routes bypassing the switching centres become economic. Alternate routing schemes on low or medium traffic routes rely on switching centres to provide flexibility, reliability and high utilization of transmission channels. The accommodation of data transmissions on facilities that are relatively interchangeable among telephone, radio, television and facsimile services lead to further economies of scale.

Data transmission speeds are a prominent factor in determining the costs of station terminals. Higher speeds require wider channel bandwidths and increase both line and switching costs. Call holding times are a significant factor in determining investment costs for switching and trunking facilities on the switched networks. Increases in the rate of calling can demonstrate similar effects. Distance between user stations is an important factor. Non-carrier transmission systems show a direct relationship between cost and distance, but in carrier systems terminal costs are relatively independent of distance. Microwave and coaxial repeatered facilities yield incremental reductions in costs with distance.

Reliability and grade of service constraints imposed on the carrier increases his costs through the necessity of providing protection (standby) channels and additional switching and trunking facilities. The requirement to minimize delays in data transmissions necessitates fast and costly signalling and switching service.

Finally, data transmission requires costlier subscriber terminals than does voice communications. The station equipment for data transmission thus can be the most expensive individual item in the transmission link.

VI. AN EXPLORATION OF RELATIONSHIPS BETWEEN RATES AND COSTS

Examination of the rate structure has revealed that distance, usage and speed of transmission are the major influences on charges relating to data transmission services. Significantly, these same characteristics bear heavily on the carrier's costs of providing the transmission services, but they share this influence with another set of factors. The current configuration and use of the networks, the existing technology, and the organizational structures of the individual carriers all have a significant bearing on the costs and the revenue requirements of each firm, and consequently on the levels at which the rates are set. Furthermore, the regulatory agencies of the federal and provincial governments place limits on the carrier's earnings. Given this limitation the carriers select rate levels with a view toward meeting the total costs of operation and achieving the permissible level of earnings. The carriers are afforded considerable freedom to adjust the rate levels for particular service offerings as long as they do not exceed the overall earnings limit and provide "just and reasonable" rates acceptable to the regulators.

In practice the rate differentials between different types of service are designed by the carriers to provide stable revenues on a continuing basis. Their structure therefore attempts to attract new customers and encourage subscribers to retain and augment their use of services. Moreover, the rates for one service are set in relation to rates for similar or expanded services offered by the carrier or its competitors. In all of this the recognition of the relative, rather than the actual, costs of particular services forms a significant input to the eventual structure of the rates. This process must result in a condition in which the relationship between the rates and costs will differ from service to service. However, if the earnings limit is to be achieved by the carrier, a rate structure must be designed which balances the cost/rate differentials, so that total revenues meet total costs plus profit or surplus requirements. Regulatory bodies traditionally have been concerned with the problem of determining whether the charge to each class of subscriber is fair and reasonable or unduly discriminatory. The issue becomes one concerning philosophies of rate making and the tolerance limits of the differentials that are acceptable to the regulatory body and the public at large.

A number of different philosophies and approaches to rate making have been postulated in recent years. Some hold the view that equitability in data transmission services can be achieved only by developing a rate structure based solely on costs. The logical extension of this approach is that to be absolutely "equitable", the relative difference between the rates and the costs would have to be identical for each subscriber. This implies individual rate structures. To remain "equitable", amendments would have to follow each technological change made in the equipments assigned to or shared by the particular subscriber. Moreover, rate adjustments would have to reflect faithfully the changes in the number of subscribers or terminals sharing common equipment such as the switch in a central office.

The administrative requirements associated with this approach are obviously very costly in themselves. Added to this problem, there remains the fact that the communications networks are integrated systems in which the largest proportion of total plant is common. If embedded costs are used, some method of "separating" these costs would have to be formulated to assign costs to services and to subscribers– a problem vastly more formidable than that posed by alternative approaches. Thorough study of these issues leads to the conclusion that rate schedules based directly on costs for each subscriber are unsound and beyond practical administration.

Another approach which might be tried is that of averaging all the carriers' costs over the number of subscribers and then striking rates that become applicable to all. This reduces the administrative costs to a very low level, but because of the variety of services that are offered and the number of subscribers who do not use many of the services, inequities would be introduced that are unduly discriminatory. The issue eventually crystallizes about two questions. At what levels should aggregate costs be averaged? How should rates be set to achieve a just and reasonable burden on each subscriber relative to the other?

Traditionally, pricing policies of communications carriers are based on the principle that the entire territory served by the company should be treated as a unit in fixing rates. This is known as "company-wide pricing". It means that the rate schedules for all of the service offerings must be considered in total as the means of obtaining the revenues necessary to meet the total expenses of the carrier. While the revenues in total are expected to cover all the business costs and yield the necessary earnings, the individual rates are not expected to mirror directly the specific costs of any particular service offering. Neither do the rates necessarily reflect the costs of providing the particular service to any particular subscriber or group of subscribers.

However, attention usually is paid to the obvious cost differentials relating to station terminals, transmission speeds, holding times, distances, options and other features, and these factors usually are reflected in the rate structure. A number of such cost characteristics become apparent on examination of the tariffs, but the rates for these services do not always reflect the relative cost proportions.

Several other factors unrelated to costs are at work, some of which assume a special significance during the rate making process. The most important of these is the "value of service" concept, defined by one carrier as a matter of "establishing relative values to determine the best relationship between rates for different classes or groups of services".[1] An economist defines it as "a deliberate policy of rate determination known . . . . as the practice of charging "what the traffic will bear".[2] It is to the carrier's advantage to apply the concept judiciously, first to achieve the earnings at the maximum permissible level, next to develop a stable, continuing base of business and then to satisfy the regulatory agency as to the equitability of the rate structure. To achieve the latter goal, the carrier must assure the regulator that the rate structures are not unduly discriminatory and that they seek to achieve the legitimate revenue needs of the company while reflecting a reasonable recognition of the average costs clearly associated with particular types of service. Finally, it is of great advantage to the carrier that the value of service as seen by the rate-maker corresponds directly to the concept of value held by the customers, since this will promote the acceptance of new services and the growth of traditional ones.

Employed alone, value-of-service pricing would tend to ignore cost criteria completely and become purely a function of varying demand elasticities. Clearly, this is unacceptable to regulators. Moreover, there are practical problems to this approach. For many services the carriers do not have precise data concerning elasticities of demand that are operative, although the companies are aware of general reactions within the market they serve. As in many other forms of business, the precise forecasting of demand remains a continuing problem. On the other hand, the value of service concept, used together with averaged cost criteria, tends to yield rate structures which attract customers while maintaining a reasonable relationship to costs. However, the combination of cost and value-of-service criteria for pricing tends to obscure the full effect of costs on the rate structure,

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1. CTC Hearings 1970 re BC Tel, Exhibit BCT-8

2. James Bonbright, Principles of Public Utilities Rates, New York, 1961, p. 293

and hence the rate/cost relationships that exist within and among the various services.

A second important factor in the ratemaking process is the difficulty in determining the actual costs attributable to furnishing a particular service. The major portion of a carrier's equipment and property is used in common to provide all the services the company offers. Similarly, the major portion of operating expense is incurred in the joint provision of these services. Cost determination has proved to be a complex, time-consuming, costly process in this industry, since as much as 85% of a carrier's plant is common to more than one service. CN Telecommunications in 1964 made initial attempts to determine the distribution of costs among services through cost separations techniques. In October 1971, the entire process had not yet been finished, although the separations were nearing completion. In September 1969, the Canadian Transport Commission directed Bell Canada to undertake a study to determine methods and procedures of carrying out cost and revenue separations between regulated and unregulated services. A year later the report declared that it is not possible by using any methods or procedures known today to carry out cost separations between those services which would give reliable information as to all actual costs. Moreover, no method was found or known for measuring the effects on costs or revenues of the interdependencies between services.

However, Bell Canada had made attempts to determine through separations procedures their costs for providing the Telpak and Teletypewriter services. The results achieved through the application of fully allocated cost separations procedures are displayed in Table 1 in the previous section of this report. The figures indicate that the rates in force during 1967 were producing in the case of Telpak revenues 30% above cost, and in the case of Teletypewriter services in 1968, 15% above cost. The cost of money is not included in the calculations. With these exceptions, there is no definitive information available concerning the cost/rate relationships of specific data information services for any carrier. In addition, it is important to remember that all these analyses are based on embedded costs, which are considered by many to be of little relevance to future decisions.

Even with incremental costs, the problem of cost/rate relationships remains complex. The carriers undoubtedly are able to determine the incremental costs for additions to plant but, wherever the equipment is jointly used by two or more services, there would remain the difficulty of identifying the incremental costs attributable to a specific service offering. It is important to keep in mind that costs of buildings and hardware, labour, taxes and money are not difficult to determine, whether they are total, average or incremental, but because these costs are common to a large variety of services it is difficult to relate the costs meaningfully to any of the service offerings.

In the absence of data segregating the costs applicable to each service, it is not possible to estimate with any degree of accuracy the relationship between the rate and cost structures of any carrier. Anyone who is tempted in this situation to apply to Canadian firms the results of studies carried out in the United States must heed the warning of the Canadian Transport Commission:[1]

> "...it is important to appreciate that a Company's rate structure cannot be discussed, tested or evaluated in vacuo; there must necessarily be some base to which it can be related and from which relevant and appropriate criteria can be derived. Comparisons of the company's rate structure with those of other companies in Canada and the United States have little probative or persuasive value, unless it can be demonstrated that the facts and circumstances underlying each rate structure are comparable."

Nevertheless, the empirical evidence available suggests that one might be able to ascertain the existence of general relationships exhibited by the rate structures and the actual or similar costs associated with certain elements contained within the rate structures. Here costs are described in terms of the conventional average or "unit cost" of supplying the various data services. The extent to which the rates reflect the behaviour of the underlying costs is represented in the influence that costs have on the rate structure. The more closely do the rates correspond to these average costs, the more likely it is that the charges will respond to changes in cost behaviour. In the absence of more definitive information, therefore, a knowledge of such cost/rate relationships is of great benefit. In the remaining pages of this section, the rate structures and the behaviour of associated costs are examined as they relate to specific issues:

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1. CTC Judgment respecting BC Tel, Pamphlet 15, page 517, May 4, 1966

* the influence of holding times
* the influence of distance
* the influence of peak versus off-peak periods
* carrier pricing practices with respect to line-sharing or resale arrangements available for private line services
* minimum charge times for switching
* the pricing practices with respect to error characteristics of the lines
* carrier pricing practices with respect to terminal equipment
* the influence of transmission speeds

The Influence of Holding Times

Call holding times are significant to the carrier when providing the following switched services:

Telex	Broadband
Data Telex	Dataphone
TWX	Dataspeed
Datacom	Multicom

Variations in holding time affect costs pertaining to switching and trunk facilities. Each data station is provided with a dedicated circuit to the switching centre and the costs for it are fixed. The switches and their associated connecting and control equipments on the other hand are shared by all subscribers. The number of switch connectors provided in a switch is determined by the anticipated number of connections required to meet traffic peaks. This number is a function of the subscriber calling rate and the call-holding time. Should the call holding time increase and thereby increase the traffic load at peak hours, the number of connectors required will be greater, resulting in additions to the switch. Similarly, trunk facilities between switching centres also are shared by subscribers on a first-come first-served basis, so that additional trunks may be required to cater to peak hour traffic as holding times increase. The situation is described more fully in Appendix D.

The rates for the switched services include time charges for circuit usage. The total charge naturally will increase with time but, other than this, no elements of the rate structure are related specifically to the length of holding times. Obviously, imposition of such a charge would have to be applied only to data traffic entering the system at peak periods since there are no additional costs during periods of low traffic. It should be noted that an increased calling rate can have the same effect as increased call holding times. In Telex service, for example, the holding times are relatively short but the number of messages transmitted are relatively high when compared to telephone service. This higher calling rate coupled with the fact that most Telex traffic occurs during daytime or business hours leads to the need for a greater number of circuits per subscriber station than does the telephone system. Peak periods in Telex service are more a result of an accumulation of calls than from long call holding time.

To sum up, although they are not directly specified in the rate structure, holding times and calling rates influence the investment costs for switching and trunking facilities. Decisions regarding the extent of investment necessary are made on the basis of forecast data traffic loads and growth patterns. Unfortunately, the accumulation of statistical information concerning data traffic at this time provides relatively little assistance in planning. Dieter Kimbel in his investigations for the Organization of Economic Co-operation and Development (OECD) claims that remote data transmission needs are characterized by overly long holding times in the order of hours instead of minutes. Representatives of carriers have expressed a feeling that holding times with respect to computer inquiry services are from four to six times the average holding time of a telephone call. If these estimates hold, carriers' costs for supplying data transmission services are substantially higher than costs attributed to telephone calling.

Closely related to holding times is the connection time required to dial and set up connections between two points. Connection time is the time required by the automated equipment of the transmission network to recognize the request for a connection, find a route for the call, make the connection and signal the originator that the remote receiver is ready to accept data. Currently, this requires between three and thirty seconds. These delays ultimately become costs to the carrier in that the lines and switching paths during this period are not available for other assignment. At peak periods, connection times obviously influence the investment requirements. However, the carriers make no direct charge for this service. A minimum charge such as one-minute for a DDD call, or a three-minute minimum for international calls might be interpreted partially as a connection charge. If so, the charge applies only to long distance transmission, since local data transfers over telephone lines are included in the flat rate. The new electronic switching centres do provide faster connection times but, as it has been stated, the current investment costs per line are considerably higher than they are for crossbar switching machines.

The Influence of Distance

Carriers' costs increase with distance between the data stations. Holding all other factors constant, costs are generally a linear function of distance where connection is made with a dedicated pair of wires which is typical of local loop construction. Bell Canada, however, presents figures to show that incremental costs rise with distance in local loops. The user of carrier systems in local loop and short-haul transmission facilities tends to concentrate a large part of the costs in terminal equipment. Consequently, although costs in these facilities also increase with distance, the first mile cost is high, and the cost for each increment of distance is lower than for the previous unit. On the long-haul microwave systems, which are the superhighways for data transmission, the incremental costs also decrease with distance. In addition, however, the initial cost levels are lower than for local distribution systems because of the excellent opportunities afforded to exploit economies of scale. Generally speaking, given the current configuration of the Canadian network, a circuit connecting two terminals, both of which are within the local calling area, are the most expensive in cost per circuit mile. Circuits connecting remote terminals through the long distance network are least expensive in costs per circuit mile.

In terms of rates, there are essentially two structures, one for public switched services and another for dedicated or private line. With respect to rates for the switched services, combined time and distance charges apply. The time factor proves to be a complication which is not separable from distance. If one assumes that the time component of the rate factor is linear, then the distance factor follows a trend whereby the incremental charges decrease with distance, a trend consistent with the pattern of carriers' costs for long-haul transmission. The introduction of mileage bands, e.g. 100 - 200 miles, 200 - 500 miles, to simplify use of the rate manuals results in some discontinuities in the trend, which become evident at certain points within each band. Similarly, the distances are somewhat "averaged" to cater to the establishment of areas or rate centres instead of maintaining a voluminous schedule of rates between individual exchanges. This tactic greatly simplifies administration, but it does produce occasional anomalies in rates where two exchanges are within a short distance of each other but nevertheless fall into different rate centres. Nevertheless, the customer's expectation is often a decisive element in establishing relative rates. The subscriber believes, for example, that he should pay the same price per minute for Telex service covering the same distance, whether it is from Toronto to Winnipeg, or from Sudbury to The Pas. He does pay the same price, but the carrier's costs are different. The message between Toronto and Winnipeg need journey through no intermediate switching centre, since it follows a high volume direct route between the two cities. On the other hand, the message from Sudbury passes through both the Toronto and Winnipeg junction offices en route to The Pas. The additional costs of the intermediate switching requirements and channel mileages extending beyond Toronto and Winnipeg may be variously interpreted as "absorbed" by the carrier, or "subsidized" by users on other routes. However, the customers expect and support such "equitable" treatment since the charge is based on time and distance measurements which in their view do not differ for the two situations described above. The carrier caters to this expectation in setting the rate.

Datacom, Dataphone and Dataspeed users, because they connect through a telephone, are free of time and distance charges in the local dialing area. Presumably the monthly flat rate charge provides the carrier with sufficient revenue to cover the costs of providing the local service. The normal long distance telephone rates apply for calls outside the local area. Here again the charges and carrier's total costs increase with distance, but the incremental charges and costs become smaller with distance.

Time and distance charges are applied to all Telex, TWX, Broadband and Multicom transmissions whether they are local or long distance calls. The charges per unit of time/distance for local calls are higher than those for long distance calls, leading one to conclude that the carrier's higher local costs are recognized in the tariff. Curves for both charges and costs exhibit characteristics similar to the curve shown in Figure 1.

EFFECT OF DISTANCE
ON COSTS AND CHARGES

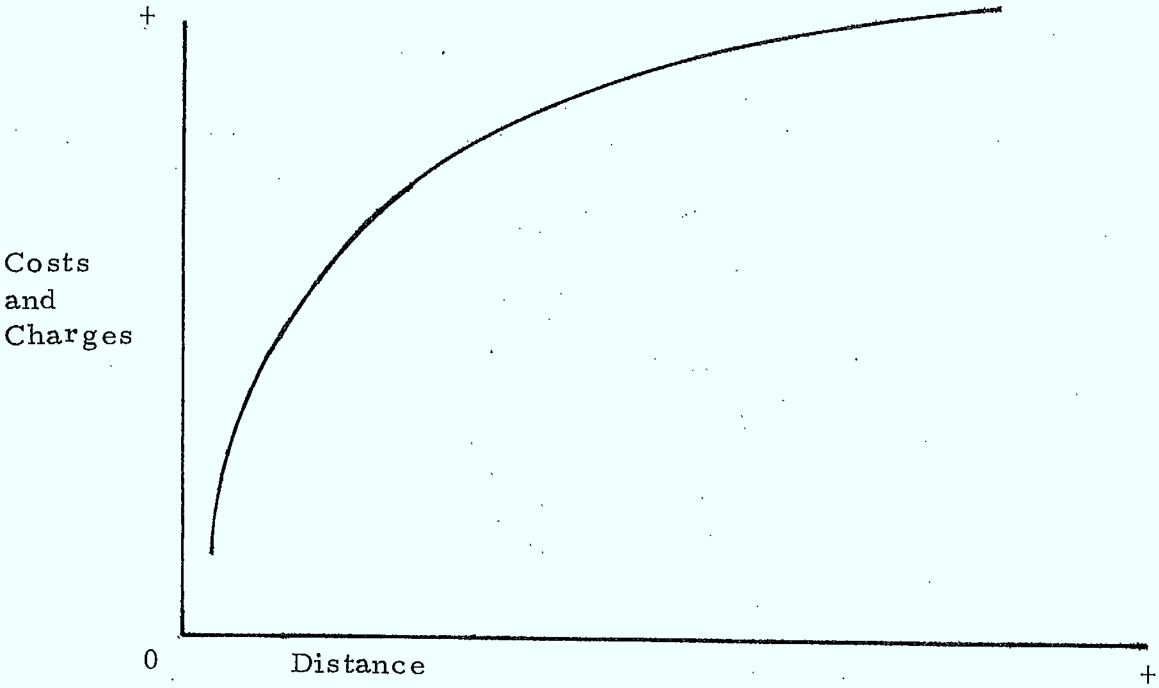

FIGURE 1

The curve tends to flatten with increased distance, and assume a more nearly linear slope at the greatest distances.

Charges for private line service increase with mileage; some are linear and others are non-linear. The non-linear rate structure displays characteristics corresponding to the curve described in Figure 2. The rates set for Teleprinter, Schedules 1, 2, 3, 3A and the Telpak offerings exhibit linear increases with distance. Schedule 4 mileage rates show linear increases related to local service, but non-linear increases for inter-city service. CN-CP's Computer Inquiry service and the telephone companies' Dataline II and III charges increase at non-linear rates. There appears to be little consistency between charges and costs in the rates for private line services. Linear charge and distance relationships for local area service, and non-linear relationships for long distance service might be expected for all offerings rather than for Schedule 4 service only.

The rate structure for Schedules 1, 2 and 3 provide for different mileage charges depending on the number of days (5, 6 or 7) per week that service is given, and the length of the daily service (4, 8, 12 or 24 hours). These "mileage charges" are obviously time dependent but the carrier's costs are often independent of time, since the circuits are dedicated and their use for other purposes is limited during the time the customer does not have them. The rationale for setting these rates is related more to customer expectation and needs than to the costs of providing the service.

The impact of distance, equipment and operating costs, as well as other factors considered in rate setting were explained by Mr. A. Lester in giving evidence during the 1969 CTC hearings of the Bell Canada rate application.[1] Before Telpak service was introduced, elaborate cost studies were made in 1961 to establish the revenue requirements. The studies were based on a market assessment of the quantities and the average pattern of length in which Telpak would be required. From this, the costs of the line haul and terminal equipment necessary to provide the service were determined. The annual charges were taken to be the ratio of total gross revenue to total plant, which at that time was 25% overall, including the cost of money. Next, the rates were developed on the basis of circuit miles for the assumed mix of service and distance patterns forecast by the market assessment. The five-year forecast indicated an annual revenue of $4.4 million and $3.2 million annual expenses. This pattern of rate development is common in the telecommunications industry. Here it indicates the significance of the cost-quantity-distance relationships in determining rates for transmission facilities.

Influence of Peak vs Off-Peak Periods

The Canadian telecommunications networks are engineered to provide a "one percent or better" grade of service. The grade of service is expressed as a percentage possibility that a transmission which the subscriber originates will not reach the called data station. A one percent grade of service implies that day after day only one call out of 100 will fail to reach the destination because some piece of essential equipment is engaged for other purposes. Obviously the

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1. CTC Hearings 1969, Transcript of Evidence, Vol. 44, pp. 766-770

the greatest probability that a connection cannot be made occurs when traffic loads are at peak and the capacity of the network has been reached. Should this possibility exceed one percent the policy of the Canadian carriers is to provide increased capacity in the form of additional facilities.

Since these additions will be useful during peak periods only, their costs should be recovered from peak period traffic. However, except for three telephone related services, data transmission tariffs make no allowance for higher charges during peak periods. Datacom, Dataphone and Dataspeed are the exceptions. Since the rate structure for long distance telephone charges permits reduced rates for evening, late night and weekend use of the telephone network, there is an incentive for data users to arrange transmission outside of normal business hours. However, if the user has also subscribed for WATS service, there is no incentive for delaying transmissions during the business day. Similarly, there is no saving to the user in making local calls at any time, so that carriers do not, in any transmission tariffs, discourage local transmissions during peak periods.

The obvious advantage of encouraging the reassignment of data traffic to off-peak periods is the achievement of higher utilization of the network without increased investment in facilities. There is of course the danger that the rates struck for off-peak periods, if too low, will not only attract traffic away from peak periods, but also generate sufficient new business to create new capacity peaks requiring additions to facilities. Bell Canada has experienced this situation only recently in the telephone network with respect to the "Family Calling Plan" which contained reduced rates after 10 p.m. on weekdays and all day Sundays.[1]

The lack of data concerning the characteristics of data traffic does not permit calculation of investment savings that can be obtained by shifting traffic away from peak periods. However, telephone usage can demonstrate the potential savings possible. Consider a group of 100 trunks with 78% utilization. A one percent grade of service is encountered by subscribers when 2816 hundred call seconds (CCS) of traffic is offered.[2] Should it be possible to shift one-tenth of the

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1. See CTC Railway Transport Committee Order R-1300, Appendix A, November 1, 1971, for a full discussion of peak hour periods.

2. The figures are obtained from the Trunk Capacity tables of the Traffic Engineering Handbook, Telephony Publishing Corporation, Chicago

traffic to off-peak periods by offering rate reductions, the peak traffic can be reduced to 2535 CCS, an amount of traffic that can be handled by 92 trunks without degradation of the one percent grade of service. This represents an 8% reduction in the facilities required for peak periods. The extent of savings possible with respect to data traffic depends on the calling patterns and holding times associated with particular segments of the data market.

Carrier Pricing Policies Relating to Line-Sharing Arrangements

Line sharing, as the phrase implies, is taken to mean the use of a communications channel by more than one user. Tariffs permit joint use and therefore line-sharing of a subscriber's service by one or more individuals, firms or organizations at the discretion of the carrier. Charges are usually nominal. For example, joint use of Broadband is permitted for one dollar per month and Datacom for five dollars per month. Normally these are approved by the carrier when the joint user's requirements do not warrant subscribing for a separate service. However, joint user service is not in accord with the general carrier plan for furnishing data service and therefore sharing is not encouraged.

Individuals or organizations sharing a community of interest or having complementary requirements have arrangements for line sharing. These generally are private networks connecting only those correspondents identified as having an association with the subscriber. The variety of services and equipment required often necessitates the development and operation of a special assembly of transmission facilities designed to meet specific needs. The carriers levy charges on a designated subscriber, or against all subscribers depending on the particular circumstances associated with each customer's requirements. Some of the charges are direct applications of items filed in the general tariffs, and others are calculated separately for the custom design features not included in the general tariff. Each special assembly is costed out before rates are determined. Where the scale of use by the subscriber enables the carrier to provide equipment and service at less cost, the carrier <u>may</u> strike its rates in relation to the reduction in average costs resulting from such bulk usage. Any opinion expressed concerning the reasons that motivate a carrier to charge a lower or higher rate than the costs of the assembly would require would be purely speculative.

Carriers generally do not permit resale of transmission capacity. Some subscribers have raised this issue pointing out that if they were allowed to do so they could sell excess capacity when it existed, or in combination with another subscriber they could better utilize the jointly purchased capacity to reduce their overall costs. On first consideration, their point is well taken. However, although such an arrangement undoubtedly would assist the sharing customers, it also might be at the expense of other users. Granting resale were permitted, and if there is no change in volume of traffic offered to the carrier, it follows that carrier revenues would be lowered. In order to cover operating costs, the carrier would seek increased revenues elsewhere leading to higher rates for all subscribers, or for customers of other selected services.

Line sharing schemes, of course, have been practiced by the carriers themselves ever since the introduction of switching facilities and the use of common trunk groups between cities. Subscribers making long distance calls share the trunk circuits with other subscribers although they have exclusive use of the circuit during the call. The economics of this practice are evident when one considers that a representative end-to-end tally of costs for equipment in use during a data connection between Montreal and Vancouver might be:

Data set (1 at each end)	$ 2,500
Local loop (1 at each end)	500
Switch and C.O.E. (subscriber's share at each end)	500
One voice channel (2300 miles at $15 per mile)	34,500

Approximately 90% of the equipment cost for the call is invested in the long distance circuit. This form of line sharing permits higher utilization of the network which enables the carrier to reduce charges to users. Obviously, the rate of utilization bears directly on the charges to the user.

Minimum Charge Times for Switching Services

Minimum charge times are applicable to the Broadband, Multicom, TWX, Datacom, Dataphone and Dataspeed services. A

30-second minimum applies to Broadband and a 6-second charge to Multicom and TWX. The Datacom, Dataphone and Dataspeed services utilize the facilities of the telephone switched network and the minimum time charges are those applicable to calls beyond the local calling area. Thereafter, charges are based on 6-second increments. Charges for time commence only after the connection with a called party is verified by the returning supervisory and control signals.

Minimum charge times have been a traditional characteristic of switched communications networks to help defray the costs of putting a call through the system. Today the telephone systems continue a policy of setting a minimum charge on operator-handled long distance calls and minimum time of one minute on DDD calls. In the automated switched services, whether for voice or data, the central office supervisory equipment responds to the user's signal for service. On receipt of the dialed instructions from the subscriber station, the central office energizes control equipment which seeks and connects the necessary circuits locally or through several exchanges to signal the called station. A return signal announces the completion of the connection, a busy station or no answer.

The minimum charge levied on the subscriber for completed calls of less than the minimum duration is designed to compensate the carrier for the automated supervisory costs and the time that the circuits are occupied both for signalling and for usage during the minimum time period. This implies that the charges for the initial period, be it 6, 30 or 60 seconds, should be less than subsequent periods since the latter pertain only to usage, and not the combination of signalling and usage. This implication has been recently recognized in the tariffs for both DDD and operator handled telephone calls. Initial minute charges are higher by 2 cents for Ottawa-Montreal and by 9 cents for Quebec-London DDD calls. A small sampling of rate differentials betweeen the initial and subsequent minutes implies that the signalling costs range between 7% and 50% of the charges per minute of use. Operator handled calls are more expensive than DDD calls for the initial period, but the rates for subsequent time periods in the new Bell Canada rate structure are identical.

The rates for Broadband, Multicom and TWX do not make this distinction, nor is there any data on which estimates of costs can be made. Moreover, it is not clear whether the minimum charges also take into account those occasions when there is no answer from the called station or when a busy signal is encountered. In these situations no revenues are collected, and their costs, presumably, are absorbed elsewhere in the rate structure.

Pricing Practices With Respect to Error Characteristics of the Lines

An examination and description of the carriers' pricing practices with respect to the error characteristics of the transmission lines is far from straightforward. It necessitates some discussion of the sources of transmission errors in data communications systems. First, errors can occur because of random electrical fluctuations which interfere with the transmitted signal. These fluctuations called "noise" occur as short duration impulses or as a steady background hiss. Impulse noises can be caused by electrical machinery, switching contacts, lighting and other man-made or natural phenomena. They are the most frequent cause of errors in digital data transmission. Background noise is less significant if the data signals are maintained at sufficient amplitude levels. Next there are errors created by severe attenuation or delays of some frequency components of the digital signal. Signal components near the upper and lower edge of the signal frequency band are more prone to these problems than those in the centre of the band. Amplitude and delay compensation is provided to "condition" the channel and increase the usable bandwidth. Data recovery up to speeds of 300 bauds is normally satisfactory without conditioning, and a nominal error rate of 10^{-5} (1 error in 100,000 bits) is generally acceptable for teleprinter service. At higher speeds, delay equalization usually is required. Thirdly, signal fading occurs when using line-of-sight microwave links especially during summer nights because of non-uniform distributions of humidity and temperature in the lower atmosphere. Most communications systems are plagued by the characteristic that many errors occur during relatively short periods followed by lengthy error-free periods. For most communications media the available data concerning error rates is very limited.[1]

Because leased lines are not subject to the variety of connections and transmission links that occur in the switched network, and because the leased lines can be specially "conditioned" to reduce the incidence of errors, the leased lines provide greater freedom from errors. Channel conditioning arrangements are offered in private line service which permit transmission of data at greater speeds with fewer errors.

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1. See especially the Bell System Technical Journal:
   a) Alexander, A.A., Gryb, R.M., and Nast, D.W., "Compatibilities of the Telephone Network for Data Transmission", BSTJ, 39, p. 431 (May 1960)
   b) Morris, R., "Further Analysis of Errors Reported in Capabilities of the Telephone Network for Data Transmission", BSTJ, p. 1399 (July 1962)

Both the charges to the user and the carrier's costs increase in relation to the increase of usable bandwidth.

Because there are significant variations in signal delay times for different calls over the switched network, adaptive modems are required to compensate for the deviations that occur. This feature is the principal reason for the increased costs of modems designed for use on the switched network. The additional costs are reflected in the higher monthly rates charged for the data sets.

Other costs for upgrading switching and transmission facilities to improve the data transmitting qualities of the networks are not explicit in the rate structure. These include improvements that are made to outside plant and switching in order to reduce impulse noise. The provision of alternate equipments and routing arrangements are usually incorporated in the network. Presumably these costs affect rate levels even if they are not directly associated with a tariff item.

Rebates for errors, omissions and outages are sometimes subject to negotiation between carriers and customers although the policy of most carriers is to disclaim responsibility for errors. Tariffs for Telex and Broadband services explicitly offer the subscriber rebates for errors and omissions up to a sum not exceeding the monthly charges. Rebates are made for outages experienced under private line Schedules 1, 2 and 3 if service is not restored on the same day, provided the outage is not caused by the customer.

Carrier Pricing Practices With Respect to Terminal Equipment

It is useful in a discussion of pricing practices concerning terminal equipment to classify the data services into the following categories:

* switched, flat rate local and measured toll rate
* switched, measured rate
* private line

Datacom, Dataphone and Dataspeed services fall into the first category. Subscribers for these services are charged a fixed monthly fee for the exchange connection, a business telephone line, the terminal and where necessary a modem. In return they receive access privileges to the telephone network and free local calling. Charges for toll calling are based on distance and circuit holding time. Monthly rates applied to the business telephone vary with the size of the exchange. The charges appear to have little relation to the unit price of the handset or the costs of installation. Presumably the charges for the telephone line cover the subscriber's share of the costs of operating the local exchange. Assuming also that toll call revenues are adequate to cover toll costs, the terminal charges should then relate solely to costs of providing the terminal.

The second category concerns Telex, TWX, Broadband and Multicom services. Subscribers pay a fixed monthly fee and a usage charge for all calls whether local or long distance. For TWX and Telex, the fee relates to the connection to the exchange and use of a teleprinter; for Broadband, the connection and use of a terminal and modem plus a monthly service charge; and for Multicom the charge is made for the connection and use of a modem and access lines. The monthly charges for TWX and Telex are closely associated with the teleprinter and its capabilities. Assuming that the call revenues are sufficient to cover the costs of network operation, the monthly fee should relate solely to the costs associated with the teleprinter terminals. If this is not the case, then the rates are set below costs for the actual movement of data across the network. In the case of Broadband and Multicom, the picture is confused. In addition to monthly charges for terminals and modems, there is a monthly subscriber charge for the Broadband offering, and a similar access line charge for Multicom. Under these circumstances, the relationship of terminal costs and rates remains unclear.

In the private line services, flat rate monthly charges are levied separately against the terminals, the lines, and the optional arrangements. Clearly one would expect the terminal fees to be related to its costs.

Some observations can be made by employing the available data with respect to teleprinter costs given in Table 6 and the rates charged for specific models when used as terminals. These relationships are shown in Table 6 for four teleprinter models.[1] The receive only (R/O) version of each model is the least expensive, the manually operated transmitter-receiver *PSR) up to 20% more expensive, and the machine providing in addition a tape punch and reader (ASR) is from 50% to 100% more costly. The rate structure pattern is remarkably similar

1. Note two points: First that unit prices are $U.S. which may be lower than Canadian prices by as much as 30%; second that installed costs are even higher

TABLE 6

RELATIONSHIP OF TELEPRINTER COSTS AND CARRIER PRICES

Equipment	Unit Price** ($U.S.)	Monthly Rate ($Cdn) CN/CP	Monthly Rate ($Cdn) Bell	Relative Price (By Model)	Relative Charges (By Model)
Model 28					
R/O	1275 - 1470	65,70	65	1.0	1.0
PSR	1440 - 1730	75	75	1.1	1.2
ASR	2425 - 3000	155 - 195	155 - 195		
Model 32					
R/O	500 - 550	42	-	1.0	1.0
PSR	500 - 600	50	-	1.0	1.2
ASR	750 - 825	95	-	1.5	2.3
Model 33					
R/O	550 - 650	45,55	-	1.0	1.0
PSR	600 - 725	45,50,60*	45	1.1	1.0
ASR	800 - 975	90,96,110*	90	1.4	2.0
Model 35					
PSR	1700 - 2210	60,65,85*	60	1.0	1.0
ASR	2850 - 3250	110,115,160*	110	1.7	1.8

*Price differentials exist depending on whether the equipment is in Telex, Broadband or Private Line service. Because of lack of data pertaining to the annual costs of operation, maintenance and depreciation, the reasons for the differential were not ascertained.

**Note two points: First that unit prices are $U.S. which may be lower than Canadian prices by as much as 30%; second that installed costs are even higher.

except that charges for the ASR version are significantly higher than can be accounted for by costs alone. Since more data can be sent over the transmission facility in a given period of time through the use of punched tape, perhaps this reflects the value of service concept in pricing. On the other hand, it may also illustrate the carriers' concept of charging for supplying a supplementary service which adds to the value of the basic service.

One should also note from the table that CN-CP charges different prices for similar versions of Models 33 and 35 depending on whether they are used in Telex, Broadband or private line service. The reasons for the price differentials do not appear to be cost related.

With respect to Telespeed terminals used in the Broadband and Dataspeed services, rates set by both CN-CP and Bell for the receive and send sets accurately reflect the relative costs within their speed ranges. However, Bell's Telespeed 750 receiver, which is 10% less expensive in price[1] than its Telespeed 1050 counterpart, returns a monthly revenue 35% greater. Because of lack of data pertaining to annual costs of operation, maintenance and depreciation, the reasons for the differential were not ascertained.

There are other indications from the limited data available in Table 7 that terminal charges bear burdens other than the cost of the terminal alone. First, the charge for the business telephone set which is said to be established at a level sufficient to cover costs of exchange operation yields annual revenues 3 to 11 times the unit price depending

TABLE 7

	Unit Price	Range of Annual Revenue	Range of Revenue/Price Relationships
	$	$	
Telephone	20	69 - 230	3.45 - 11.50
Teleprinter (in $U.S.)	500 - 1000	504 - 1320	.74 - 1.52
	1001 - 2000	720 - 1464	.42 - 1.05
	2001 - 3300	1320 - 2880	.40 - 1.01

on the size of the exchange. Second, the relative rate/cost relationships for teleprinters decrease as the teleprinter price increases. The reasons

1. Based on prices quoted in Appendix D, Table 9

are not apparent, but the resulting curve suggests that a fixed charge for providing service is perhaps a significant factor in determining the rate for terminal equipment regardless of the type of service that is offered or other related charges associated with the service.

Carriers offer a number of options that supplement the basic services provided for data transmission. These include such items as tape splicers, auxiliary card dialers, perforators, bells, buzzers and lights which add convenience value to the basic service. These items are supplied for the benefit of the customer and do not affect other subscribers. The rates are usually set to ensure adequate return to cover incremental costs and to produce as large a contribution to earnings as the market permits.

The Influence of Transmission Speeds

Transmission of data at many different speeds over the existing analogue networks is closely related to the bandwidth of the data channel. The wider the bandwidth the greater is the potential speed of transmission. Telegraph channels can be accommodated within a bandwidth of 300 Hz, but voice channels employ a 3000 Hz band. Several teleprinter channels therefore are easily multiplexed into one voice channel. Line investments obviously can be reduced and savings achieved. As explained earlier in this section, the amplitude and delay characteristics of the unconditioned voice channel must be overcome to permit speeds up to 1200 bps and higher. This is accomplished by compensating for the defects through the use of modems which, depending on their sophistication, allow transmission speeds of up to 4800 bps. Modem costs increase with their complexity, hence costs rise as transmission speeds rise. Carriers charges also increase with transmission speed. The total charges are a function of the monthly fixed fees and the transmission rates. Since modem costs increase with speed and its capability for use on private line or switched circuits, the fixed monthly charges in effect exact a high entry or initiation fee and their subscribers, therefore, are those having heavier data traffic loads.

In the switched services, the charges per bit generally decrease as transmission speed increases as indicated in Table 8. The medium speeds may be carried on single voice channels but the high speed services require the use of voice channel groups. For high speed transmission between Ottawa and Montreal the charges per bit transmitted are considerably greater than for the medium speed services. However, for longer distances, e. g. between Toronto and Calgary, the differential is reduced noticeably. This may reflect the economies of scale that are available in the use of long-haul facilities.

TABLE 8

REPRESENTATIVE DATA TRANSMISSION CHARGES

Service	Speed	Monthly Station Charges	Transmission Charges: Ottawa Montreal	Montreal Toronto	Quebec London	Toronto Calgary
	(bps)		($ per 10^6 Bits)			
Medium Speed						
Broadband	1800	140	.92	.92	1.38	3.69
Broadband or Multicom	2400	215	.69	.69	1.04	2.78
Broadband	4800	**	.35	1.04	1.56	2.60
Multicom	4800	460	.52	.87	1.22	2.25
High Speed						
Multicom	19.2K	625	1.52	1.95	2.39	3.47
	50K	575	1.17	1.50	1.83	2.67

**Service is treated as a "special assembly" for which no standard charge is quoted. Monthly charges depend on the particular subscriber needs and situation.

Private line rates are based on the number and length of circuits that are provided. Additional charges are imposed for conditioning to expand bandwidth and improve the speed of transmission. Thus, speed has a direct influence on the monthly cost to the user.

In summary, although certain exceptions can be identified, carriers' costs and subscribers' charges generally increase with transmission speeds.

VII. CONCLUSIONS

At the outset it was intended that this study was to be preliminary in nature, the first in a series designed to explore certain facets of rate/cost relationships associated with digital data transmission. By focussing on specific dimensions of the existing rate structures, this initial effort was intended to lead to the development of a framework within which further cost studies could be launched. The complex and rapidly changing nature of the problems and issues discovered during the study confirm the wisdom of this approach.

This report has analyzed the rates applicable to digital data transmission services and has defined the significant factors in their structure. An examination of the carriers' costs has revealed that these costs are equipment oriented and are not readily related to particular data transmission services. It is also evident that for planning purposes the carriers are less concerned with establishing individual rate/cost relationships by service but they do consider the relative costs of relevant equipment when developing rate structures. Moreover the carriers demonstrate a distinct sensitivity toward revealing cost details, especially those which may prove useful to competitors. As a result of this analysis, a number of conclusions have been reached.

The common carrier tariff books are not user oriented

The published common carrier tariffs are in effect a form of contract. As such they must be legally definitive. Furthermore, the carriers offer a myriad of options that may be supplementary, complementary, or simple substitutes for standard offerings. All of these must be listed. However, although the tariff books do serve as a catalogue of the carriers' services, the user experiences significant difficulty in identifying the combinations of services and options particularly suited to his needs. Whatever the rationale, the tariff books do not present the services in a clear, logical manner intended to assist the user in the selection of service options. Both the user and the carrier want to achieve optimum utilization at least cost. For the low volume user, the dial-up telephone may provide access to a multi-point network of stations at rates he feels are reasonable. The large volume user, on the other hand, may wish to improve the cost effectiveness of his data communications by examining the full range of services offered by all the carriers. It is not merely a question of selecting the one best technique and applying it to all stations or to all applications. The user, like the carrier, must consider the need for additional equipment at each location by type of service, individually at first, then collectively for the system as a whole. Unfortunately, the user cannot be certain, even with a copy of the tariff books at hand, that he has the most suitable system at the minimum price. If the tariff books are to be useful to users or to those interested in service and rate analysis, consideration must be given to improving their presentation.

Carriers' rate patterns can be identified by type of service but with great difficulty

The analysis of patterns can help the user of data transmission services to make price-related decisions. However, before the user can proceed with this analysis, he must make a number of assumptions concerning his requirements and relate these to the elements in the rate structure. The assumptions required pertain to volume of data, transmission speeds, holding times and distance.

From the analyst's point of view, the accuracy of rate patterns depends directly upon the selection and retention of a set of reasonable assumptions. Although different sets of assumptions will yield different sets of absolute values, the resulting trends of the patterns will not differ greatly so long as the particular set of assumptions selected is held constant for the series of analyses.

Data Transmission costs are a function of the equipment, the carrier's organization and operating policies

Investment costs are a function of the equipment. Therefore the costs are not directly service related, because of the integrated nature of the telecommunications networks which use common equipment jointly to furnish a combination of services. In certain instances it is possible to identify the carriers' costs for specific pieces of equipment which are used for particular types of service (for example the teletypewriter used for Telex, TWX or private line service). However, only approximately 20% to 30% of total plant can be identified. The carriers' accounting systems do not record equipment costs by type of service, but rather aggregate the costs for particular types of equipment into one account.

Similarly, since maintenance and depreciation expense also are related to equipment, it is equally difficult to define the exact proportion of expense attributable to the provision of a particular service offering. Moreover, the cost patterns for an individual carrier differ from those of other carriers because of the unique environment and set of circumstances within which each conducts its operations. This pattern is determined by the type of operation required to satisfy the demands made upon the carrier, its opportunities for acquiring capital, and the applicable tax structures.

Rates are not based solely on costs

Rate schedules are developed to enable the carrier to earn his total revenue requirements. In Canada, rates traditionally are based on the principle that the entire territory of the company should be treated as a whole. Rate differentials between different types of service are partly a function of the value of service attributed to it by the customer, the carrier, and the regulator. In addition, a recognition of relative costs, forecast usage, competitive services within and external to the carriers' scope of operations, and many other factors influence the setting of rates. Rates based solely on costs, either historical or incremental, might result in identical cost-rate relationships for all customers but would yield schedules too complex to administer. On the other hand, rates designed to yield the total revenue requirements of the carrier, apportioned among the subscribers on the basis of demand with no reference to equipment costs and service requirements might be unduly discriminatory. Obviously neither extreme is desirable. The current carrier practice is to identify specific types of service and develop rates based on the consideration of many factors including costs. It follows that the rates developed fall somewhere between the two extremes.

Cost/Rate relationships are subject to frequent change

It is evident that frequent changes are made to the rate structures of the carriers. Similarly, local patterns of costs incurred by the carriers are constantly subject to change. The combination of these changes calls into question the validity over any extended period of time of a specific cost/rate relationship developed at one point. Moreover, rates are developed for a particular type of service but costs are generated by the carrier's equipment, the majority of which is used in providing several services. This physical integration of facilities does not permit direct comparison of costs to rates without making a series of assumptions concerning the allocation of common costs. Even when this is done, it is impossible to determine the accuracy of the allocated costs or the extent of any imprecision which may result. The continuing expansion and proliferation of services amenable to handling by the existing integrated communications networks compounds this problem and reduces further the life cycle of a cost/rate relationship.

Continuing research will be required

There is very little likelihood that one study can pretend to establish specific cost/rate relationships that will stand for more than a brief duration of time. It is more likely that generalized cost/rate relationships will be developed so that trends in cost behaviour can be established and applied to whatever rate criteria are adopted by the carriers. The main issue is whether, given a decreasing trend in cost behaviour, the lower costs are translated ultimately into lower rates and passed on to the users of a particular service or facility. The development of a satisfactory approach to generalized cost/rate relationships will demand joint research by government and the carriers.

The key issues for government differ somewhat from those of the carrier

For government, one key question is to determine whether in the first instance the carrier's additional costs or savings in providing all his services are being passed along to the customers. The second question is to what extent are additional costs or savings being passed along to the particular group of subscribers involved. The first issue is resolved by monitoring the carrier's global earnings and his total costs – the current regulatory approach. The second requires a monitoring process based on trend analysis and relative cost/rate data supported by periodic sampling techniques. Both government and the carriers have an interest in the mechanics of this monitoring process. Certainly the success of any techniques adopted will depend largely on the co-operation achieved by the industry and government.

The carriers, given the limitations imposed by regulatory agencies, face the problems of providing satisfactory services to their customers, and a satisfactory return on investment to the shareholders. Since the overall return on investment is regulated, the carrier seeks to achieve the maximum permissible profit by so pricing the services that the total revenue requirements are achieved.

Neither the carriers nor the government can operate in isolation in solving the joint or individual aspects of this problem. Essential to achieving this co-operation is an understanding by the carriers of the government's role and objectives and their approach to matters of policy and regulation. Similarly, the government should have an understanding of the objectives and needs of the carriers and the technological and economic environment in which they operate. Effective co-operation will assist in achieving national goals and forming the basis for a sound approach to policy development. From a practical point of view, the carriers' support is necessary to build up the information data base which the government requires; and government can gain a clearer understanding of the divisive issues which inevitably arise between users and carriers.

Future Trends

The impact of the exploding demand for digital data transmission has been felt by the carriers only within the last decade. Their traditional mix of network traffic and, indeed, the technology for handling that traffic are about to undergo changes as significant as the industrial revolution. Increasing pressure now is being brought to bear as a result of the rapidly declining costs for raw computer power, and the increasing need to transmit large volumes of data in digital form, the common language of computers.

Unfortunately, carriers' costs have not declined in concert with computer prices. Transmission facilities remain costly and changes or additions to the networks require vast amounts of capital. The long transmission distances and relatively low population density of Canada demand the realization of economies of scale in every economic sector of the country. Economies are achieved in the telecommunications industry through the physical integration of equipment serving a variety of functions and service classifications. It is inevitable that the policy of integration of data services on the existing networks will continue and increase in impact. It is also possible that the existing networks may, over time, change their major characteristics from analogue to digital.

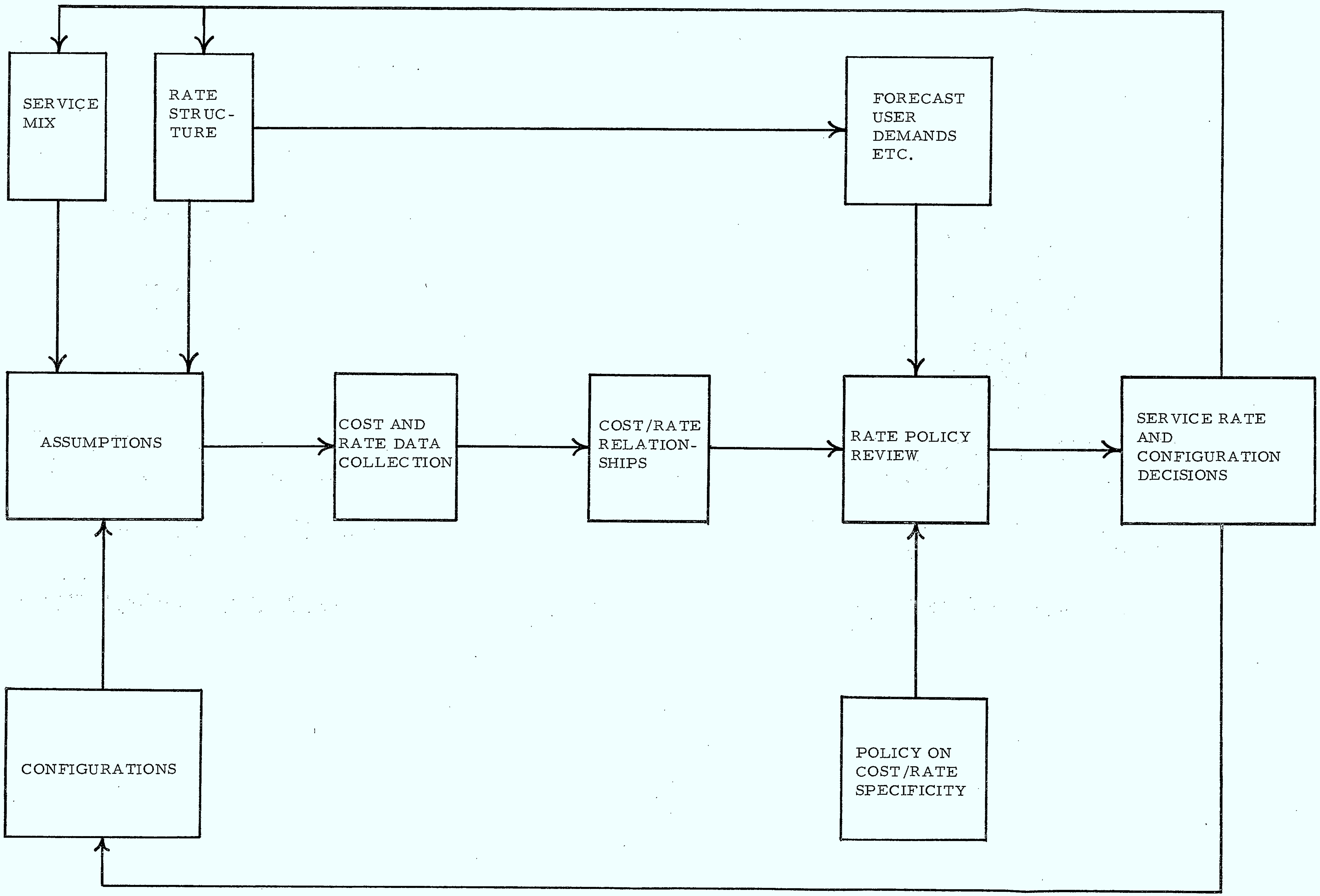
Increased physical integration means that the costs for any carrier will continue to be a function of his existing configuration and any additions that are made to the communications plant. Rates, on the other hand, will continue to be user oriented and developed on the basis of the services provided to the user. Therefore, cost/rate relationships by type of service will continue to be based on assumptions made regarding physical relationships between equipments and services. However, as integration increases the ability to identify the costs associated with each type of service will become more difficult. This will occur not only because of change in the validity of the assumptions but because of actual changes in both the dollar costs of the equipment and the rate structures of the carriers.

However, the government's need for knowledge of cost/rate relationships pertaining to telecommunications service offerings remains valid. Moreover, government wishes to be certain that policy is based on valid assumptions. To achieve this goal it is necessary to fix the assumptions and to determine cost/rate relationships, so that changes in these may be monitored. To accomplish this, a policy model such as that presented schematically in Exhibit 5 must be used. Because rates are service oriented while costs are a function of equipment, a number of assumptions must be made in order to relate equipment configurations to the various types of services included in the service mix. Second and third sub-orders of assumptions may be necessary to establish the guidelines or methodology for arriving at the essential set of assumptions needed for the model. Based on these assumptions appropriate data then must be collected to determine current cost/rate relationships. These relationships then must be reviewed in combination with the forecast user demands for service, and the policy concerning the degree to which it is desirable for rates to reflect specific costs, i.e. cost-rate specificity. Following the review, decisions can be made concerning the service offerings, the rates and the adequacy of the existing configuration.

The question of the nature of the cost/rate data to be employed in the model then must be considered. There are four major problems associated with the use of absolute cost/rate values in this policy model. First, the dynamic character and growth of the industry results in continuous change to the network configurations and the service mix that is transmitted, thus raising the question of the validity of the assumptions at any point in time. Secondly, the data collection process is made extremely complex by the variety and volume of the data required, the uncertain quality of many of the measurement systems and the continuing needs to update. Thirdly, the time required to validate the assumptions and collect the data will lead to conclusions which are out of date before they can be used for decision making. Finally, the policies resulting from this process will tend to lag the industry rather than lead it. It may

Exhibit 5

A POLICY MODEL



be said that the decisions made today for tomorrow will be based on yesterday's data.

On the other hand, the carriers in their decision models also employ a forecast of user demands, the existing or expected rate structure, and a self-defined policy with respect to the limits of cost/rate specificity. It is significant, however, that they apply future costs to the model. The carriers are less concerned with historical full costs than with future incremental costs. Their decisions may be described as being made today for tomorrow based on today's modified data that is forecast to be valid tomorrow.

The policy model depicted here is not limited in its applicability to data transmission services, but is useful in examining the entire spectrum of carriers' telecommunications services. Yet, neither the carriers nor the government can work in isolation to solve their particular problems. Essential to achieving co-operation is a recognition of the realities of cost and rate behaviours in this dynamic industry. It follows that the decisions should be made on the basis of these realities. The actual value of the cost/rate relationship for any particular service is unimportant. What matters is the trend of each cost/rate relationship over time and the collective trends in relation to other classes of service. These conditions underline the need for trend-oriented decision making supported by periodic sampling so that decisions taken today will remain valid for a significant period in the future. The key elements of this approach are three:

* periodic sampling
* relative relationships
* trend analysis.

VIII. RECOMMENDATIONS

On the basis of the conclusions formulated in the previous section of this report, the following recommendations are made:

1. The Department of Communications should adopt an approach to the monitoring of cost/rate relationships based on periodic sampling, relative relationships and trend analysis.

2. The Department of Communications should invite carrier participation in the explicit development of a practicable methodology.

3. The Department of Communications should define and implement an information system to facilitate the assembly of cost and rate data.

4. The Department of Communications should initiate simultaneously research projects necessary to support this approach.

From a practical point of view, the carriers' co-operation and support will be necessary in building up the information data base which the Department will require. It has been noted that much of the necessary information is not now collected by the carriers. Even where information could be developed through studies, the carriers have been somewhat reluctant to release information on occasion, largely due to fear of misinterpretation. It is difficult to assess how much of this fear is misplaced. At the moment, however, the majority of expertise and knowledge concerning the telecommunications industry is concentrated in the collective group of individuals who operate the various networks. It would be of great benefit to harness their understanding of the industry, its technology and its promise in a co-operative venture with the Department of Communications aimed at setting a course for the telecommunications industry in Canada.

There is also a clear need for early research aimed at developing an information system enabling the Department to:

* support the examination of trends in rates and their related costs;

* assist in promoting the efficient allocation of resources by the carriers;

* monitor and influence the carriers where issues of public interest arise.

There is a need for basic research into the kinds of data and assumptions required to allow the Department to carry out its stated role and objectives. This is visualized to be a comprehensive program which should be sub-divided into smaller projects. Research into the methods of collecting the data should commence immediately, once the data requirements are specified. It will also be necessary at this time to determine the kind and number of measurement or collection systems required to obtain investment, traffic, revenue, rate and cost information on a sampling basis.

A second basic area of research is required to investigate the mechanics of translating the carriers rate and cost information into a cost-rate datum. This is another extensive research project that will require an interdisciplinary approach encompassing a skill spectrum from accounting through regression analysis to linear programming techniques. This project, as well, may be sub-divided into smaller packages after an initial study identifies the various techniques that are applicable. The object is to determine a means of making a judgment concerning the trends in rates and costs and their effects on both the users and the carriers.

A third basic area of research concerns the effect of rate making based directly on costs and the extent of cost-averaging that is acceptable to users and carriers alike. Results from this type of study will assist the development of criteria for determining the extent to which rates should reflect costs.

During the course of the study a number of areas were identified which warrant further research, the results of which would assist in defining data requirements and criteria concerning the trends in rates and costs. Some of the topics recommended below extend beyond the field of data services but the issues have an important effect on rates and costs associated with data transmission because of the integration of the networks. Obviously, research into the following areas is recommended:

* Data transmission traffic statistics, to determine volumes, speeds in use, holding times, types of users and types of facilities used for data systems such as:

- data gathering (one way receiving)
- centralized control (one way transmitting)
- inquiry and reply (two way short messages)
- inquiry and reply (two way: one way low speed, with high speed return)
- batch data (two way long messages)

* Statistical cost functions
* The extent and effect of cross-elasticities among the service offerings of a carrier
* The extent and significance of economies of scale in each of the local distribution, switching, short-haul and long-haul facilities
* The significance of cost differentials because of company route density, traffic mix, and geographical area
* The significance and impact of differential route pricing
* The significance of differences in carrier accounting systems
* The significance of carrier organization and the effect that other business (non-carrier) operations of a carrier have on the costs associated with data transmission

If studies in these areas are organized into a logical array which reflects the Department's awareness of the complexities of the industry, carrier co-operation in their development and execution is likely to be forthcoming.

ANNEX A

GLOSSARY OF TERMS

ACOUSTIC COUPLER

A data set which converts digital data to a sequence of tones for transmission on the telephone network via a converted telephone set through inductive or acoustic coupling. Process is reversed at the receive end.

AIRLINE MILEAGE

Point-to-point mileage between rate centres, using a system of vertical (v) and horizontal (h) co-ordinates. Basis for calculating rates.

ANALOGUE

As opposed to digital, signals which make use of electrical analogies (e.g. varying voltages, frequencies, etc.) to produce a signal of a continuous nature rather than a pulse nature.

AUTOMATIC EXCHANGE

Exchange in which communication between subscribers is effected, without the intervention of an operator, by means of automatic devices set in operation by the originating subscriber's equipment.

BAND

The spectrum of frequencies within two definite limits.

BANDWIDTH

The difference, expressed in cycles per second, between the highest and lowest frequencies of a band.

BAUD

Unit of signalling speed (i.e. number of signal events per second). If each signal event represents only one bit condition, baud is same as bits per second. When each signal represents other than one bit (i.e. group of two bits) baud $\neq$ bps.

BIT

Smallest unit of information; may have either of two values (1, 0; on-off; yes-no). Abbreviation of "binary digit" as opposed to decimal digit.

BPS

Bits per second

BROADBAND CHANNEL

A communication channel whose frequency bandwidth generally is sufficient to accommodate the transmission of commercial video or high speed data signals.

BOOK COST

The cost of property as recorded on the books of a company.

BUSY HOUR

The 60-minute period during a 24-hour day when the largest volume of communications traffic is handled.

CABLE

An assembly of one or more conductors within an enveloping protective sheath, constructed so as to permit the use of the conductors singly or in groups.

CARRIER SYSTEM

A means of obtaining a number of channels over a single path by modulating each channel upon a different "carrier" frequency and demodulating at the receiving point to restore the signals to their original form; circuits obtained by sub-dividing a very broad band of frequencies so as to provide many available bandwidths.

CCITT

International Telephone & Telegraph Consultative Committee

CHANNEL

An electrical path suitable for the transmission of communications between two or more points, ordinarily between two or more stations or between channel terminations in telephone or telegraph company central offices. A channel may be furnished by wire, radio or a combination thereof.

CHARACTER

6 bit information unit that may represent 64 possible symbols (i. e. 2^6 : 64) - (Some systems use other than 6 bit units.)

CHARGE

The monthly billing from carrier to subscriber. May be broken down into the various components or expressed in total.

CHARGES PER BIT MILE

Total charges expressed on a per mile basis and per million bits for a given time period.

CIRCUIT

An overall transmission path between two points, complete in itself.

C.O.E.

Central Office Exchange

COMMON CARRIER

A company authorized by the appropriate regulatory agency to provide communications services.

COMMON COSTS

See Joint Costs

COMMUNICATIONS

The conveying and conversion of information between people and/or equipment

CTC

Canadian Transport Commission

DATA

Plural of Datum; used to designate alphabet or numeric material serving as a basis of discussion; material may or may not be technical in nature. Information, particularly that used as a basis for computer processing.

DATA COMMUNICATION

The movement of encoded information over a transmission system.

DATASET

A device which converts the signals of a business machine to signals that are suitable for transmission over communication lines.

DDD

Direct Distance Dialing

DROP

Synonymous with "station"; a station that receives and/or sends on a circuit.

DUPLEX CIRCUIT

Denotes a circuit which permits electrical communication between stations in both directions simultaneously.

EXCHANGE

A general term applied to telecommunications plant used primarily to furnish local services.

FACSIMILE (FAX)

Transmission of pictures, maps, diagrams, etc. by communications channels. The image is scanned at the transmitter and reconstructed at the receiving station.

FULLY ALLOCATED COSTS

Costs derived from the apportionment of the total costs of operating an enterprise by distributing this total among the various units or classes of service in such a manner that the sum of the costs imputed to each unit or class is made to equal the total costs. Ordinarily in this proceeding the term "fully allocated costs" has been used synonymously with the term "fully allocated embedded costs."

HZ

Abbreviation for Hertz, meaning "cycles per second".

HOLDING TIME OR ACCESS TIME

The time during which an item of communications plant is connected and available for use by a customer or an operator for purposes of transmission. In this report the time during which items of plant are in use but the connection not completed is not treated as holding time, e.g. the time required for dialing and automatic routing of the call. Holding time commences when the connection is completed and the subscriber signalled that he may begin transmission.

JOINT COSTS

A term used to describe the costs of any particular equipment or process which is employed in the provision of two or more service offerings.

JOINT USE

A term used to describe the condition existing when a facility is a) shared by two or more subscribers; or b) used to provide two or more service offerings.

JOINT USER

A subscriber who shares the use of a facility with another subscriber.

LINE

The electrical path between two stations, hence also at times used to indicate a circuit.

LOCAL OFFICE

A central office serving primarily as a place of termination for subscriber lines and for providing connecting services to the subscribers on these lines.

LOOP

A communication path between a subscriber station and its serving central office.

MESSAGE

A completed call, i.e. a communication in which information is transferred between the calling and called parties.

MODEM

Contraction of modulator-demodulator.

MULTIPLEXER

Equipment used to service several devices operating at relatively low transfer speeds from one operating at high transfer speed in such a manner that the high speed device is not required to "wait" for the low speed devices.

MULTIPLEXING

The subdivision of a transmission facility into two or more channels.

NETWORK

The composite points interconnected by communications channels.

OUTSIDE PLANT

A category of investment in communications supplies that is normally outside the central office, i.e. poles, cable, wire, etc.

PBX

Private Branch Exchange

PRIVATE LINES

Facilities, including channels and station equipment, furnished for the communication purposes of customers and authorized users, between specified locations for a continuous period or for regularly recurring periods at stated hours.

PUBLIC SWITCHED LINES

Facilities forming part of the public shared telecommunications network which enables a subscriber to communicate with any other subscriber connected to the same public network.

ROUTING

The assigning of the communications path over which a message will travel to its destination

SEPARATIONS

The process by which telephone property costs, revenues, expenses, taxes and reserves are apportioned among the various operations.

SERVICE OFFERING

A general term used to describe any distinctive grouping of facilities and/or characteristics of use defined by a carrier as a convenient reference for marketing purposes. Typically a specific pricing policy is associated with each service offering.

SIMPLEX CIRCUIT

A circuit capable of only one-way communications.

STATION OR TERMINAL

A point at which information can enter or leave a communication network. An input/output device designed to receive or send data,

SUBSCRIBER

Person or organization to which telephone or data service is extended.

SUBSCRIBER LINE

A communication channel between a data station and the central office which serves it.

SWITCHING CENTRE

A location where incoming data from one circuit is transferred to the appropriate outgoing circuit.

TARIFF

The published rate and conditions of offering for a specific unit of equipment, facility or type of service provided by a communication common carrier.

TCTS

Trans-Canada Telephone System.

TELECOMMUNICATION

The transmission or reception of information in any format, such as signals, writing, or sounds, by wire, radio, visual or electro-magnetic systems.

TOLL

A general term applied to traffic or telephone plant associated with long distance service.

TRUNK

A transmission path that can be used as a common artery between switching units, e.g. central offices, wire centres, toll centres, test centres.

TWX

Teletypewriter Exchange Service.

VOICE GRADE CHANNEL

A channel suitable for transmission of speech, generally with a frequency range of about 300 to 3000 Hz.

WIDEBAND CHANNEL

A channel wider in bandwidth than a voice grade channel.

WORD

A larger information unit than character (6 bits), formed on an analogy that several characters make a word in English. A word contains 32 bits.

WPM

Words per minute.

ANNEX B

BIBLIOGRAPHY

Abler, Ronald, Geographical Futuristics, Address to Canadian Association of Geographers, Waterloo, Ontario, June 1, 1971.

Alberta Government Telephones, Annual Report, Edmonton, 1969, 1970

Alexander, A. et al. Compatibilities of the Telephone Network for Data Transmission, Bell System Technical Journal, New York, May 1960

Auerbach Corporation, Auerbach Computer Technology Reports, Philadelphia, 1971

Becker, Hal, Communications Processing for Large Data Networks, Data Processing Magazine, Philadelphia, November 1970

Bell Canada, Annual Report, Montreal, 1968, 1969, 1970

Bell Canada, Report on the Company's Rate Groups, Canadian Transport Commission File C-955-180-2, July, 1971

Bell Telephone Company of Canada, General Tariffs, Montreal, 1971

The Board of Transport Commissioners for Canada, Judgments, Orders, Regulations and Rulings, Volumes LVI (1968) and LIX (1969), Ottawa

Bonbright, James, Principles of Public Utilities Rates, New York, 1961

Breary, Denis, A Self-Optimizing Network Model for the Long Term Planning of the UK Trunk Telecommunications Network. Paper, British Post Office, London, England, 1970

British Columbia Telephone Company, Annual Reports, Vancouver, B.C., 1969, 1970

Business Week, AT&T Opens Up Wideband Lines, July 21
The Revolution in the Phone Business, November 6
Goeken Tunes Up His Microwave Net, October 16

Hightstown, N.J. 1971

Canadian National-Canadian Pacific Telecommunications, Regulatory Bodies: Structures and Rates, Submission to Telecommission Study 7(A) (B) September 1970.

Canadian National Telecommunications, Canadian Pacific Telecommunications, General Tariffs, Toronto, Montreal, 1971

Canadian Transport Commission, Index Re: Bell Canada Application, File C955.178, Ottawa, 1969

Canadian Transport Commission, Railway Transport Committee, Re: Bell Canada Application, Transcript of Evidence, Angus, Stonehouse and Co. Ltd., Toronto, Ontario, 1969

Canadian Transport Commission, Railway Transport Committee, Order No. R-13000, Re: Bell Canada, November 1, 1971

Canadian Transport Commission, Railway Transport Committee, Order No. R-12690, re Canadian National Railways and Canadian Pacific Limited, October 7, 1971

Chipp, R.D. Cosgrove, T. Economic Analysis of Communications Systems, Seventh Communications Symposium of the IRE, Utica, N.Y. 1961

CN/CP Telecommunications, Manual of Telecommunications Services, Sections 3, 5A, Montreal, undated

Couch, Robert F., Evolution of a Toll MIS - Bell Canada, Bell Canada, Montreal 1970

Cronin, Frederick R., Modems and Multiplexers - What They do for Communications, Data Processing Magazine, Philadelphia, November, 1970

Crownfield, William R., Experience With Station Carrier Applied Loop Plant, Proceedings of the National Electronic Conference Inc., Oak Brook, Illinois, 1970

Datapro Research Corporation, Datapro 70 Communications, Philadelphia, 1971

Department of Communications, Instant World, Ottawa, 1971

Department of Communications, Telecommission Study 1(b), History of Regulation and Current Regulatory Setting, 1971

Department of Communications, Telecommission Study 1(c), Concept of a Telecommunications Carrier, 1971

Department of Communications, Telecommission Study 2(b)(i), Communications in Canada: A Statistical Summary, 1971

Department of Communications, Telecommission Study 2(d), Communications and Regional Development, 1971

Department of Communications, Telecommission Study 2(e), Telecommunications and Carriers Market Projection and Analysis, 1971

Department of Communications, Telecommission Study 4(a), Future of Communications Technology, 1971

Department of Communications, Telecommission Study 5(a)(c)(d)(e), Policy Considerations With Respect to Computer Utilities, 1971

Department of Communications, Telecommission Study 5(g), Problems in Data Transfers With Particular Regard to Visual Data, 1971

Department of Communications, Telecommission Study 6(d), Seminar Report - The Wired City, 1971

Department of Communications, Telecommission Study 7(c), Relationship Between Department of Communications and the Telecommunications Carriers, 1971

Department of Communications, Telecommission Study 8(a), Problems Relating to Regulation of Private Line Services, 1971

Department of Communications, Telecommission Study 8(b)(i), Study of Interconnection of Private Telecommunications Systems With the Systems of the Telecommunications Common Carriers, 1971

Department of Communications, Telecommission Study 8(b)(ii), Interconnection Between TCTS and CN/CP Telecommunications, 1971

Department of Communications, Telecommission Study 8(b)(iii), Problems Relating to the Interconnection of Terminal Devices With Common Carrier Provided Telecommunications, 1971

Doll, Dixon, Planning Effective Data Communications Systems, Data Processing Magazine, Philadelphia, November 1970

Dunn, D. A., Policy Issues Presented by the Interdependence of Computer and Communications Services, Stanford Research Institute Report 7379B-1, U.S. Department of Commerce, Clearing House for Scientific and Technical Information, Springfield, Va. 22151

The Financial Post, FP Guide to Telecommunications Services, November 14, 1970

The Financial Post, Survey of Industrials, Toronto, Annual

Frost & Sullivan, Inc., The Specialized Communications Carrier Market, New York, 1971

Gabel, Richard, Development of Separations Principles in the Telephone Industry, Michigan State University, East Lansing, Michigan, 1967

Gentle, Edgar C., Data Communications in Business, An Introduction, American Telephone and Telegraph Company, New York, 1965

Gunn, J. F. Weller D. C., A Digital Mastergroup Channel for Modern Coaxial Carrier Systems, International Conference on Communications, San Francisco, June 1970

The Globe and Mail, Maritime Telegraph and Telephone Modernizes, Toronto, November 3, 1971

Haltzman, L. N. Lawless W. J., A New High Speed Voice Band Modem, IEEE International Conference on Communications, San Francisco, June 1970

International Telephone & Telegraph Consultative Committee, Economic Studies and Comparisons, 1969

Johnson, Leland L., Communications Satellites and Telephone Rates: Problems of Government Regulation, RM-2845-NASA, The Rand Corporation, Santa Monica, California, October 1961

Juul, Howard R. McDowell, Ralph L., Relationship Between Tandem Switching Systems Size and Network Costs, IEEE Conference Record 1969

Louchez, Sylvain, Basic Communications to Help Understand Data Transmission, Canadian Datasystems, Toronto July 1970

Maritime Telegraph and Telephone Company, Annual Report, Halifax 1970

Meckling, William H., Communications Satellites: Supplemental Information on the Cost Estimates Given in Research Memorandum RM-2709-NASA, The Rand Corporation, Santa Monica, California, June 30, 1961

Meckling, W. Reiger, S., Communications Satellites: An Introductory Survey of Technology and Economic Promise, RM-2709-NASA, The Rand Corporation, Santa Monica, California 1960

Melody, William H. Trebing, Harry M., An Evaluation of Domestic Communications Pricing Practices and Policies, President's Task Force on Communications Policy, Appendix A to Staff Paper 5, 1968

Morris R., Further Analysis of Errors Reported in Capabilities of the Telephone Network for Data Transmission, Bell System Technical Journal, New York, July 1962

National Association of Railroad Utilities Commissioners, Separations Manual, Washington, D.C. 1963

New Brunswick Telephone Company, Annual Report, Saint John, 1970

Newfoundland Telephone Company, Annual Report, St. John's, 1969

Norbeck, J.O. Petrie, J.L. et al, Data Communications, Reprints from Telephony, Telephony Publishing Corporation, Chicago, undated

Nordling, Karl I., Analysis of Common Carrier Tariff Rates, Datamation, Pasadena, California, April 15, 1971

Pacific Telephone & Telegraph Company, Summary of Unit Revenue Requirement Studies 1967-69, Submitted to Public Utilities Commission, State of California in response to Decision 74917, December 31, 1969

Quirk, William B., What's Available in Data Transmission Services, Data Processing Magazine, Philadelphia, November 1970

Roberts, A.G., Data Communications at the Crossroads, Canadian Datasystems, Toronto, July 1970

Rose, Joseph R., Telephone Rates and Cost Behaviour, Land Economics, Vol. 26, 1950

Rostow, Eugene V., President's Task Force on Communications Policy, Staff Paper One, Washington, D.C., 1968

Sahin, Izzet. Debanné, Joseph G., Models of Efficient Regulatory Control for the Telecommunications Industry, University of Ottawa, Ottawa, May 1971

Sanderson, Douglas, Telecommunications Rate Structure, Department of Communications, August 1971

Soderberg, D. Campbell, C. Bates, R., Touch Tone Telephone - Transmission of Digital Information, IEEE Transactions, December 1967

Statistics Canada, Telegraph & Cable Statistics, Catalogue 56-201, Annual

Statistics Canada, Telephone Statistics, Catalogue 56-203, Annual

Statistics Canada, Telephone Statistics, Preliminary Report on Large Telephone Systems, Catalogue 56-202, Annual

The Telephone Association of Canada, Canada's Telephone Industry in Perspective, 1967

Telephony Publishing Corporation, Traffic Engineering Handbook, Chigago 1969

Telesat, Interaction of the Terrestial and Satellite System (3 volumes), Department of Communications, Ottawa 1970

Trans-Canada Telephone System, Communications, Computers and Canada, Ottawa, Issues of March 1971 and November 1971

Trans-Canada Telephone System, Computer Based Services of the Seventies, July 1971

Trans-Canada Telephone System, Telephone Association of Canada, The Pricing of Telecommunications Services, Submission to Telecommission, Study 7(AB), January 1971

Turezyn, A. Jong, T., Data Communications: An Overview of Line and Modem Capabilities, Data Processing Magazine, Philadelphia, March 1970

Weber, J.H., Transmission and Switching - Costs and Capabilities and Their Effects on the Network Structure, IEEE Conference Record, 1969

Woods, Gordon & Co., Guide to Data Processing Equipment, 1970 Edition
Canadian Datasystems, Toronto, December 1970

Worley, A.R., Practical Aspects of Data Communications, Datamation, Pasadena, California, October 1969