ENGINEERING COST STUDY OF USAGE CHARGING FOR LOCAL TELEPHONE SERVICE

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PREPARED FOR
THE TERMINAL AREA DEVELOPMENT DIRECTORATE
DEPARTMENT OF COMMUNICATIONS
300 SLATER STREET
OTTAWA, ONTARIO

BY

CRC CONSULTANTS
14 NELSON ST WEST
BRAMPTON, ONTARIO

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PREFACE

This cost study was conducted for the purpose of determining the costs of alternative methods of usage charging for local telephone service in Canada. The study attempts to identify the capital and operating costs associated with the required usage charging equipment in various configurations and with various capabilities. It also considers the potential savings in other costs due to induced alterations in telephone calling habits.

The North American manufacturers known to be offering equipment for usage charging have provided technical and cost details of their equipment, and several telephone operating companies have contributed information and views. Particular thanks are due to GTE Automatic Electric (Canada) Ltd., ITT Canada Limited, Northern Electric Company Limited, TeleSciences, Inc., and Vidar Corporation, and to Bell Canada, British Columbia Telephone Company and New York Telephone. Helpful information was also received from the Federal Communications Commission, the Florida Public Service Commission, Mountain Bell, the National Association of Regulatory Utility Commissioners, Southern Bell, and the U.S. Department of Commerce, Office of Telecommunications. AT&T and United Telecommunications, Inc. were contacted but were unable to provide any information.

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I. INTRODUCTION

Local telephone service in Canada is provided on a predominantly flat-rate basis, at a monthly charge which does not consider the actual amount of use made of the service. Indeed, there is no record of local calls generated and no real information about the amount of use made of a particular service or telephone line.

This situation is in contrast to the charges made for non-local (long distance) telephone calling, where the charges for each call depend, in part, on the distance covered by the call, the time duration of the call, and the time of day or day of week of the call. A detailed record is kept of each call and an itemized bill is produced.

Canadian local telephone service also contrasts with the situation in many other countries and in parts of the USA where a charge is levied for each local call. Such local call charges sometimes also depend on the distance and/or duration of each call. In these situations, the subscriber bill usually does not provide any detail of the calls billed, but simply requests payment for total local usage. Substantiating detail of past usage may or may not be available on request, and a means of verification of future bills may or may not be offered.

This cost study considers the various equipment and operating costs that might be involved in introducing usage charging for local telephone service in Canada. Numerous options exist

in the available technology and those options will determine the capabilities of the system in terms of call detail recorded, ability to charge according to distance, duration, and/or time of call, adaptability to party lines, etc., and suitability for use with various types and sizes of switching equipment.

Operating costs will be influenced by the amount of call detail reproduced on the subscriber's bill, as well as by the amount and format of the call detail originally recorded.

Offsetting the costs of a usage charging system are some savings which will be realized because of the existance of usage charging. The extent of usage of telephone services has been observed to be restricted when usage charging is in effect, as compared to flat-rate charging. This restriction of usage reduces the capacity required of the network, and results in reduced investment and operating costs.

I. PRESENT NETWORK CONFIGURATION

A. Types and Sizes of Switching Offices

In order to introduce usage charging in an existing flat-rate network, it would be necessary to add suitable equipment to each switching office where usage charging would be required. While charging equipment could be incorporated into future offices at the time of manufacture, existing switching offices would require the addition of accessory equipment for charging purposes. A number of manufacturers are offering such add-on equipment, and the features of their offerings are described later in this report.

The cost of adding charging equipment to existing switching equipment depends on the type of switching equipment, and on the number of lines in each switching office. Bell Canada and British Columbia Telephone Company have supplied information about the present configuration of their switching networks. It becomes apparent that the majority of telephone subscribers are served by large switching offices, even though most switching offices are small. It is also evident that the majority of subscribers are still served by step-by-step switching equipment.

Bell Canada reports the following figures for the Ontario and Quebec switching offices at the end of 1974:

Step-by-Step	511	offices	serving	2,500,000	lines
Crossbar	353	"	"	1,800,000	"
Electronic	12	"	"	300,000	"
Total	876	"	"	4,600,000	"

The electronic offices in service are reported to consist of 11 SP-1 offices and one ESS office. There are also 48 switching

offices located in trailers and one manual office, not included in the above figures.

At the end of 1974, 788 of these offices each served less than 5,000 lines, and 840,566 lines were served by these 788 small offices. Thus 85% of the switching offices served only 18% of the lines, and conversely, 15% of the offices served 82% of the lines.

Electronic common control switching equipment served only 6.5% of the lines at the end of 1974 in Bell Canada.

From Statistics Canada information for 1973 for Ontario and Quebec (including a few non-Bell offices) it can be found that approximately 80% of the lines are located in 88 population centres of greater than 25,000 people.

British Columbia Telephone Company reports that three of its large offices and eight of its small offices have electronic common control, and the remaining 263 offices are step-by-step equipment. In total, 274 offices were serving 768,000 lines. At the end of 1974, 215 offices each served less than 2,000 lines, and 89,000 lines were served by these 215 small offices. Further, 238 offices each served less than 5000 lines, and approximately 170,000 lines would apparently be served by the 238 small offices. Thus 78% of the offices served 12% of the lines and 86% of the offices served 22% of the lines. Conversely, 22% of the offices served 88% of the lines and 14% of the offices served 78% of the lines. These percentages are not greatly different from the Bell Canada situation, and it becomes evident that the vast majority of subscribers are served by a relatively small number of large switching offices.

The distribution of lines between single-party service, two-party service, and multi-party service is also of interest, as current technology does not readily provide for usage charging

on multi-party lines. BC Tel reports that 84% of its lines serve single-party customers, 13% serve two-party customers and 3% serve multi-party customers. In terms of main stations, the two-party lines serve 151,000 main stations or 18% of the total, and the multi-party lines serve 73,000 main stations or 9% of the total.

In Ontario and Quebec, the Statistics Canada figures indicate that approximately 8% of the main stations are on two-party lines and approximately 6% of the main stations are on multi-party lines.

It is quite likely that most of the multi-party subscribers are served by small exchanges (say less than 2,000 or perhaps less than 5,000 lines) although such statistics have not been sought. If the available technology for usage charging is unsuitable for small exchanges and unsuitable for multi-party lines, it may still be that only a small percentage of the network would not be reasonably adaptable to usage charging.

B. Capabilities of Switching Equipment

The switching equipment presently in service with Bell Canada and with BC Tel makes very little provision for usage charging. Measured service is offered on an optional basis to some businesses. There were 8,509 measured lines in service in BC Tel at the end of 1974, and 28,244 in Bell Canada at the end of 1973. These represent 1.1% and 0.6% of the total lines in service in each company respectively.

The method of operation is that an electro-mechanical counter is provided for each measured line, and at monthly intervals, the counters or meters are manually read to determine the number of calls originated by that line. This measure of usage is then translated into a charge on the subscriber's monthly

bill according to the tariff then in effect. Although exactly the same method and equipment is in use in other countries to meter the usage of all subscribers, the technology is no longer considered preferable for large scale application and would not be expanded in the Canadian network as a means of extending usage charging. In New York, electro-mechanical meters were in use on a large scale but generally have been replaced by modern equipment described later in this report.

Step-by-step and crossbar switching equipment, lacking an electronic common control, require the addition of considerable quantities of special purpose equipment in order to accomplish usage charging. It is this add-on equipment that is the main subject of this study, as some 65% of the telephones in Canada were served by step-by-step equipment and 30% by crossbar equipment at the end of 1973. (The figures in Bell Canada at the end of 1974 were 54% of the lines and 39% of the lines respectively). All the switching equipment in service would apparently be compatible with one or more types of add-on equipment for usage charging.

There have been proposals in the USA to use existing toll recording equipment on #5 crossbar offices, supplemented by magnetic tape recording, to record local calling. However, Mountain Bell concluded that other add-on equipment might be a better choice based on the information available to them in 1973.

Switching equipment with electronic common control (noteably #1 ESS, #1 EAX, and SP-1) is serving an increasing percentage of Canadian subscribers, and is much more readily adaptable to usage charging. Little or no additional equipment is required to record local calls. There would however be a capital cost associated with usage charging in terms of reduced capacity of the common control to perform other functions.

Manufacturers of switching equipment for the Canadian market have indicated that there are no plans to incorporate specific usage charging functions in any future production. However, most future production will have electronic common control and so is expected to be readily adaptable to usage charging. No detailed estimates of the incremental cost of such adaption are available.

Northern Electric reports that introduction of usage charging on all lines of an SP-1 office would involve a penalty of between 2% and 8% of the ultimate call processor capacity. There would be no effective penalty before the call volume (i.e. number of lines served) grew to nearly full capacity, but at that time the maximum number of calls per hour that could be processed would be reduced by the above percentage. The net effect would be to increase the average capital cost per line of the completed switching office, as the full cost of the processor would have to be allocated to a reduced ultimate number of lines. The increase in cost would be less than the apparent capacity restriction, as no investment would be incurred for the line switching equipment which would not be installed. The cost penalty would also not be incurred until the office reached maximum capacity, as the full processor is provided from the beginning and the usage charging function is merely occupying capacity which would otherwise be spare until the traffic grew towards the maximum.

The 8% capacity penalty would apply if full detail of each local call was recorded via multiple entries per call, as is the present technique with toll call recording on SP-1.

The penalty would reduce to 6% if full detail was recorded on a single-entry-per-call basis, although some additional short-term memory would be involved in timing the call. Finally, the penalty would reduce to 2% if a single entry per call with no call duration information would suffice.

GTE Automatic Electric has not supplied comparable numbers, but discussions indicated that the penalty for recording local calling in a #1 EAX switching office would be of the same nature as with an SP-1 office. That is to say, little additional hardware would be required but the call processor (i.e. the electronic common control) capacity would be exhausted before the normal ultimate number of lines would be equipped.

The C-1 EAX equipment from GTE Automatic Electric does not derive any present advantage in the usage charging field because of its electronic common control. C-1 EAX offices have been delivered in Europe with an electro-mechanical meter on each line when usage charging was required. A later version of the C-1 EAX equipment might be more adaptable to usage charging for local calls.

New York Telephone is using #1 ESS switching offices in a usage charging environment and report no problems. It will be necessary for them to add some equipment to the offices if they decide to begin timing the duration of local calls instead of merely charging per call. Mountain Bell estimated that additional call stores would involve a capital cost of about $6 per main telephone, plus a capital cost due to capacity reduction of about $2 per main telephone to add usage recording to #1 ESS offices.

The #1 ESS, #1 EAX and SP-1 equipment is presently equipped with magnetic tape recorders for output of toll call data and of such local call data as is now recorded, and the manufacturers report that the same equipment could be used to record the larger quantities of data related to full recording of local calls.

The accounting process of creating the monthly subscriber bills from the call records would be handled by off-line accounting computers in the same fashion as the present billing of toll calls from the same tapes.

I AVAILABLE TECHNOLOGY FOR EXISTING OFFICES

A number of manufacturers are offering add-on equipment which will provide usage recording in existing switching offices. Such equipment would be required if usage charging were to be introduced in an area in advance of the time when that area would be served by a switching office with electronic common control. Each manufacturer has developed a slightly different design philosophy and the results offer various options in the areas of adaptability to different types of switching equipment, amount of call detail recorded, ability to time calls and ability to charge the called number. The various design approaches have also produced types of equipment that have different capital costs per installed line in various size ranges.

The data from the various manufacturers, in alphabetical order, is summarized below. The data is subject to change, as most equipment is still in the field trial stage (only Vidar have large quantities of the equipment in service). All of the equipment is presently manufactured in the USA. Budgetary prices were supplied to us in American dollars, FOB the factory, with Canadian import duty and taxes extra, except for GTE Automatic Electric who estimated Canadian installed costs. A factor of 33% (as recommended) was added to USA prices to account for duty, taxes, and transportation, in the case of ITT prices, and of 36% in the case of Vidar prices. TeleSciences did not specify a factor, so 33% was added. Installation estimates were not provided in three cases, and it has not been practical to attempt precise installation estimates from the data available. The equipment is generally of a type that should require a minimum of on-site assembly and adjustment, and installation should be limited to cabling requirements. Installation cost should therefore be small enough to be considered included in the budgetary (and preliminary) nature of the capital cost figures used. Vidar have confirmed the validity of this approach, reporting budgets of $1 to $2 per line for installation costs.

A. GTE Automatic Electric (Canada) Ltd.

GTE Automatic Electric has developed a Conversation Time Measurement System (CTMS) for addition to step-by-step switching offices. The system is not applicable to crossbar equipment.

The call records contain full detail about each call (calling number, called number, time of day, duration of call) in a single-entry-per-call format on magnetic tape. Accounting computers would be used to rate each call according to distance, and at tariff rates in effect at that time of day or day of week. As all detail is recorded, full flexibility is available in the area of customer billing. The bill can be made to show as much or as little detail as desired, and full detail can be kept on file in the commercial office. It would also be possible to bill the called number rather than the calling number if desired, by means of a programming change in the billing computer.

The CTMS equipment is wired between the linefinders and the first selectors of the switching office, and includes its own calling number identification equipment. Battery reversal on the tip and ring is detected to indicate answer supervision. CTMS equipment is compatible with Touch Tone® service, if the Touch Tone to dial pulse converters are between the subscriber lines and the CTMS equipment. CTMS is not compatible with two-party or multi-party lines. The CTMS system is provided in increments of approximately 1,000 lines and is suitable for offices up to 10,000 lines. Over 10,000 lines, more than one CTMS system can be provided. Output is by means of a local magnetic tape. The system common control is not duplicated. The Canadian installed cost per line for CTMS equipment is estimated to range from $18 per line for 8,000 lines to $53 per line for 1,000 lines, and rising to $250 per line for 200 lines. This information is presented graphically in Appendix A.

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B. ITT Canada Limited

ITT has developed the TAS II Measured Message Rate System for addition to step-by-step switching offices. A later version may be applicable to common control systems such as crossbar equipment.

The call records contain full detail about each call (calling number, called number, time of answer, time of disconnect) in a disassociated multiple-entry-per-call format on magnetic tape. Accounting computers would be used to reassociate the call data, and to rate each call according to distance and duration at the tariff rates in effect at that time of day or day of week. As full detail is recorded, full flexibility is available in the area of customer billing. The bill can be made to show as much or as little detail as desired, and full detail can be kept on file in the commercial office. It would also be possible to bill the called number rather than the calling number if desired, by means of a programming change in the billing computer.

The TAS II equipment is wired between the linefinders and the first selectors of the switching office. Battery reversal on the tip and ring is detected to indicate answer supervision. The TAS II equipment can include its own calling number identification equipment, or in small offices it can rely on existing automatic number identification equipment. It is compatible with Touch Tone service, if the Touch Tone to dial pulse converters are between the subscriber lines and the TAS II equipment. TAS II is optionally compatible with two-party lines, but not with multi-party lines.

The TAS II system is provided in various sizes up to a maximum of about 40,000 lines. Output can be by means of a local magnetic

tape, or via data links to a remote data collection centre. The basic system common control can be provided duplicated or unduplicated, depending on the reliability required.

The Canadian cost is estimated to be $75,000 for an unduplicated common control or $120,000 for a duplicated common control (regardless of office size) plus $20 per line served. If calling number identification equipment is also required, there is an additional cost of $4,000 per system plus $3 per line.

Remote data collection removes $10,000 from an unduplicated controller or $20,000 from a duplicated controller, and a data collection center to serve a number of offices is estimated at $100,000.

Cost per line would thus range from $33 per line for 8,000 lines to $102 per line for 1,000 lines, and rising to $400 per line for 200 lines, all with unduplicated common controllers and with calling number identification equipment. Remote data collection is assumed to have only a small effect on the per-line capital costs. This information is presented graphically in appendix A.

C. TeleSciences, Inc.

TeleSciences, Inc., has developed the USR-500 system for addition to step-by-step switching offices, with possible application to some crossbar systems.

The call records contain very little detail, and consist only of the amount of originating usage made of each line during a specific time interval, such as one hour. The usage is recorded in terms of time units, representing the totals of initial time periods and of overtime periods incurred during the accumulation period of interest.

There is no record of the called number. The distance covered by the call is not indicated or considered in the rate charged. Accounting computers would be used to compute the charges for usage, with the only tariff variable being the charge for initial units and for overtime units, and any discounts determined by the time of day or day of the week, represented by the accumulation period. The subscriber bill can only show total time units at each of the various rates, and the corresponding charges. No back-up detail is available. It is not possible to bill the called number rather than the calling number.

The USR-500 equipment is wired directly to the subscriber line circuit, and so needs no further calling number identification equipment. Battery reversal on the tip and ring is detected to indicate answer supervision and activate the timers. As the called number is not recorded, the USR-500 equipment is compatible with either Touch Tone or rotary dial numbers. It is optionally compatible with two-party lines, but not with multi-party lines.

The USR-500 equipment is provided in increments of approximately 1,000 lines, and is suitable for offices up to 6,000 lines. Over 6,000 lines, more than one USR-500 unit can be provided. Output is stored temporarily in local memory and is regularly transmitted to a data collection center for longer term storage and processing. There is no duplication of the common control system.

The Canadian cost is estimated to range from $16 per line for 6,000 lines to $25 per line for 1,000 lines for the equipment to be installed in the switching offices. The data collection center, arranged to service a total of 100,000 lines in 16 offices, would add about $1.50 per line to these capital costs. The cost per line is shown graphically in Appendix A.

D. Vidar Corporation

Vidar has produced the 2900B local Message Metering System for application to step-by-step, crossbar, and panel offices. Some three million lines of 2900B equipment are in service in New York Telephone, mostly on crossbar and panel offices.

The call records contain partial detail of each call (calling number, zone called, time of day, duration of call) in a single entry per call format on magnetic tape. Accounting computers are used to rate each call according to the tariff rates in effect at that time of day or day of week for that zone and duration. The subscriber bill can show the details of each call (except called number) or can be condensed to show as little detail as desired. Verifying detail can be kept in the Commercial office to help explain to the subscriber the make-up of a bulk bill.

It is not possible to bill the called number. It is possible to record full detail of all calls on selected lines if necessary by means of the type 2950 optional equipment.

The type 2950 optional equipment also gives the capability to pulse electro-mechanical meters located in hotel or motel premises to coincide with the meter pulses charged against the hotel/motel lines. This is intended as an aid to the hotel/motel in charging the call to the room bills. The capability could also be used to provide a limited number of other subscribers with on-premises meters as a means of verification of their monthly bill. Such a verification feature has been found desirable in some administrations, although the provision of full call detail recording should be a suitable alternative.

The 2900B equipment is wired to the sleeve lead or meter lead of each line, and thus needs no further calling number identification equipment. Meter pulses on these leads are detected to indicate answer supervision, and to indicate the zone called. Switching equipment that does not provide meter pulses must be adapted to be compatible with the 2900B system. Appropriate trunk adapters are available for #5 Crossbar offices, and trunk and connector adapters or linefinder adapters are available for step-by-step offices to generate pulses on the sleeve leads.

As the called number is not ordinarily recorded, the 2900B equipment is compatible with both Touch Tone and rotary dial signalling. The optional 2950 system for complete detail recording is also compatible with both Touch Tone and rotary dial signalling. The 2900B equipment is optionally compatible with two-party service but not with multi-party service.

The 2900B system is provided in increments of 16 lines, with some major system elements provided in increments of 1,000 lines. The ultimate capacity of each system is 46,000 lines. Output can be by means of a local magnetic tape or via a data link to a remote data collection center. The system common control is largely duplicated.

The Canadian cost per line for Vidar 2900B equipment is estimated to range from $10 per line for 35,000 lines to approximately $15 per line in a 1,000 line office or $35 per line in a 400 line office where the small offices are served by a remote data collection center. An office of 1,000 lines which used a local magnetic tape (unduplicated) rather than a remote data link would cost about $40 per line to equip. New York Tel reports an actual installed cost of about $15 (USA) per line on a typical #1 Crossbar office of 33,000 lines without remote data linking. Current Vidar costs appear to be somewhat lower. The expected Canadian cost per line is presented graphically in Appendix A.

E. Northern Electric Company Limited

Northern Electric and Bell-Northern Research advise that they have no current plans to develop usage charging equipment for addition to either step-by-step equipment or crossbar equipment. They have made a broad estimate that the equipment cost might fall in the range of $35 to $75 per line. These figures are probably not current.

F. Western Electric

Western Electric is reported by New York Tel and by Mountain Bell to be developing an add-on system for measuring usage in step-by-step switching offices. No detailed information has been received regarding costs of such a system, although Mountain Bell estimates in 1973 were in the area of $40 per line ($30 US) in offices of 2500 lines or larger.

ANNUAL COSTS FOR EQUIPMENT

Annual costs for the usage charging equipment can be expressed in terms of a percentage of the original capital cost. Bell Canada suggests that the following annual costs might be reasonable.

Maintenance 7% to 10% of original cost
Depreciation 8% to 10% of original cost
Overhead 3% to 5% of original cost
Interest 10% of original cost

These annual costs would total 28% to 35% of the original capital investment. The figures for depreciation are somewhat higher than usual in view of the possible comparatively early obsolescence of equipment associated with step-by-step or crossbar switching equipment. The maintenance cost would not be determined until the equipment had been in service for some time. Interest costs are the approximate current cost of money and do not represent the average cost nor perhaps the future cost.

BC Tel suggested that a composite figure of 20% to 25% as now applied to step-by-step equipment, should be adequate to cover these annual costs.

For the purpose of this study, it seems reasonable to pick a figure of 25% of the initial investment as an annual charge to provide the equipment required for usage recording.

COST OF BILLING

There have been very few attempts in the industry to detail the exact cost of processing local call records to produce subscriber billings. In Canada, there has been insufficient volume of local usage charging to produce any relevant costs. The USA experience has been based on a now obsolescent technology (physical reading of electro-mechanical meters) and in any case, the relevant historical costs were not separately identified in detail.

BC Tel reported that the present cost of billing a toll call is in the area of 3½ cents. With the greater volume of local calls and with simplification to a form of bulk billing (but full detail recordings) BC Tel feels it might be possible to achieve processing costs of one cent per local message. Bell Canada did not make any similar estimates.

New York Tel estimates that their data processing cost is between one-half cent and one cent per local message. For a modern system based solely on current technology, New York Tel estimates that it should be possible to achieve processing costs of less than one-half cent per message. These costs are based on recording partial detail of each call (using the Vidar system) and on giving the subscriber a bill that shows only the numbers of calls made to various zones in the month at various rates, and the total cost of the calls. Expanded records would be available in the commercial offices.

BC Tel reports that the present cost to physically read a subscriber's electro-mechanical meter and to bill the subscriber for the metered calls is about 28 cents per month per line. The average number of metered calls per line per month was not reported, but if it is in the area of 100 to 400 calls as is the case in New York, then the processing cost per message is quite low in BC Tel. The 28 cents covers only the direct costs and does not include any elements of overhead.

In summary, it appears reasonable to expect processing costs to be in the area of one-half cent per message for a simple system based on recording the destination zone of the call and the duration of the call.

Costs would probably be somewhat higher if based on a recording system that recorded the calling number and the called number in single entry format and left it to the accounting computer to determine the distance involved. Costs would be higher again if the call was recorded in a multiple entry format that had to be re-associated.

These costs are also based on giving the subscriber a summary bill. The processing costs would not be much higher to give a fully detailed bill, but the printing and paper costs would be greater. GTE Automatic Electric reports that the processing costs in a current trial in Illinois are proving to be prohibitive using full detail recording and full detail billing. Specific costs cannot yet be released because of the early stage of the trial.

The average usage on a measured residential line in New York is about 100 message units per month, which would represent a processing cost of $.50 to $1.00. The usage for measured business lines, excluding PBX trunks, is slightly higher. The average processing cost per measured line can probably be taken as $1.00 per month in the New York environment.

Statistics Canada reports that the annual average of local calls per telephone in 1973 was 1,575 in Canada. As the ratio of telephones to lines is about 1.5 to one, the average line in Canada would originate about 2,400 calls per year, or 200 calls per month, including PBX trunks in the average line usage.

An AT&T traffic study described by Larry Garfinkel in a published article[1] suggests that individual business lines have about twice the calling rate of individual residence lines, and PBX trunks originate about three times as many calls as do residence lines. The average individual residence was found to originate about five local calls per day.

The processing costs per line, assuming one-half to one cent per call, would therefore most likely be in the area of $1.00 per month for a residence line and $2.00 for a business line. It might be possible to do it for half these costs, but amortization of start-up costs and other escalations would probably bring the monthly costs back into this area.

Associated with bill processing costs of a usage charging system will be certain administrative costs that would not be encountered with a flat-rate system. Chief among these will be the costs of dealing with subscribers who challenge the accuracy of the bill. Staff time to deal with the subscriber, plus the cost of maintaining a verification system, are very difficult to identify precisely.

New York Tel has found these costs to be small in comparison to the billing costs, and such costs are probably covered in the estimate above. There has not been significant load on operator services to deal with subscribers requesting such charge-related services as assistance or credits on failed local calls.

Mountain Bell conducted a detailed study in 1972-73 in an attempt to predict the various economics of usage charging. It was their conclusion that the costs for billing would be only 51.6 cents per measured main telephone per year plus .015 cents per local message. This cost is based on recording all call details and keeping detailed records on microfilm in the commercial office,

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1. *Telephony, February 10, 1975.*

but sending the subscriber a bulk bill.

Mountain Bell also estimated that the continuing cost of increased customer contact in the commercial office would amount to 22 cents per month per measured business main station and 37 cents per month per measured residence main station. These figures are for the early stages of a usage charging plan, and should reduce markedly in the long run.

At a usage of 200 calls per line per month, the Mountain Bell estimates add up to about 30 to 45 cents per month per line. This is considerably less expensive than the New York Tel estimates, and the allocation between accounting expenses and customer contact expenses is quite different. As the Mountain Bell estimates have not been proven to be accurate in an actual operating situation, it would seem prudent to regard them as a possible lower limit, and to base present considerations of billing costs on the figures of $1.00 per month for a residence line and $2.00 per month for a business line.

SAVINGS DUE TO USAGE CHARGING

In situations where the charge to the user of a service is proportional to the amount of use made of the service it is generally found that the service is used less than would be the case with flat-rate charging. In telecommunications, the cost to the common carrier to provide service is to a certain extent dependent on the amount of use made of the service. Certainly a significant part of the network is traffic sensitive, and a reduction of traffic in the peak periods would result in considerable capital savings. Out of peak time periods, spare capacity exists and the overall cost to the carrier of a call is much less.

There are a number of ways that the cost of the telephone network can be reduced, and which can be accomplished by charging for usage of the network. The most significant reductions would come by means of:

- charging for each call placed rather than charging on a strictly flat-rate basis, to reduce the number of calls.
- charging according to the duration of the call, to reduce the holding time of calls
- charging according to the distance covered by the call, to recover the greater expense associated with greater distance and discourage excessive use of trunk facilities.
- charging a higher rate at peak times than at off-peak times, to encourage callers to use the network at off-peak times and reduce the magnitude of the peak.

There is very little historical data to indicate the extent to which usage charging constricts network usage as compared to a flat-rate situation. There have been a number of theoretical models constructed (in particular, H. Y. Kraepelein published a paper "The influence of Telephone Rates on Local Traffic" which was originally read at the Second International Teletraffic Congress, The Hague, July, 1958) but there is little statistical verification.

On the basis of its experience, New York Tel has estimated that the introduction of both timing of local calls and an off-peak discount would produce a ten percent reduction in call volume, fifteen percent reduction in holding time for calls lasting longer than five minutes, and a shift of two percent of calling from peak hours to off-peak hours. These are further reductions due to introduction of timing in an area where a per-call charge is already in effect but where local calls are not timed. The effect would be at least as great if a full usage charging plan was introduced in a flat-rate area.

Data in the Kraepelein paper shows that in Mexico City there was a reduction in business traffic of 12% and in residence traffic of 18% when message-rate service replaced flat-rate in 1955. The same conversion produced a reduction in business traffic of 14% and a reduction in residence traffic of 26% in Monterrey. Similarly, a message-rate introduction in Shanghai in 1936 produced a business traffic reduction of 30% and a residence traffic reduction of 40%. In those cases, conversations were not timed under the message-rate tariff, so one corollary effect of the reduction in numbers of calls was an increase in the holding time of each call, on the order of 20% to 25% higher than the flat-rate holding time in Shanghai.

For the purposes of this cost study, it appears to be useful to examine the possible cost savings involved with traffic reductions in the area of 10% to 20%, referring to both the number of calls and the holding time of the calls. Any shift from peak hours to off-peak hours would also be included in such a reduction, as it is really the reduction at peak hours that will produce the savings.

The telephone network is a combination of items that are directly traffic sensitive (such as inter-office trunks) and items which are not at all traffic sensitive (such as exchange distribution

cable and subscriber station equipment). Switching equipment is to some extent a fixed investment that does not depend on traffic, and to some extent is quite dependent on traffic.

There have been no studies in Canada to determine exactly how much of the network investment is traffic sensitive, or to what extent it is traffic sensitive. To do so with any degree of precision would be a very extensive undertaking as each type of transmission and switching technology will have a different cost sensitivity, and within each technology the size range at the moment of the study will have an effect on the degree of sensitivity.

The switching equipment manufacturers do not have any information of this nature, as there has been no previous requirement to price their equipment in such a manner.

It appears that something like 25% of the present capital investment in local telephone plant (switching equipment, distribution cable, and subscriber plant) is traffic sensitive.

This portion of the investment is somewhat less than linearly sensitive to traffic, as a reduction of say 10% in traffic would reduce the investment requirement by slightly less than 10% due to such considerations as efficiencies in trunk grouping.

It would seem then that a reduction of 10% of the peak traffic would produce a capital cost saving of 2% to 2½% of the investment in local telephone plant, and a reduction of 20% would produce a saving of 4% to 5% of the same investment.

In BC Tel, the investment in such local telephone plant was $716 million at the end of 1974, representing an investment per line of $932. A savings of 2% to 5% in this investment would represent a capital reduction of $18 to $46 line.

These investments are the current average in-place costs of plant of various ages, and are considerably less than the present replacement or expansion cost per line. The current cost of gross plant additions per telephone gained is approaching $2,000 in British Columbia. The new investment in local plant to add one telephone is generally reported to be $1200. The Bell Canada investments per line appear to be similar to those of BC Tel.

It is apparent that savings in new capital investment of at least $20 to $50 per line could be achieved by introducing usage charging. There would be some delay in realizing this saving, as it will take the form of a postponement of new investment rather than a recovery of any present investment. The exact extent of the delay will be dependent on the extent of spare capacity already existing in the network before the traffic constriction takes place, and on the speed with which natural traffic growth resumes after the constriction begins.

New York Telephone has estimated that the reductions in traffic previously referred to would reduce their new capital requirements by $6.5 million in the first two years and by much higher amounts in later years. This figure takes into consideration the fact that New York Tel presently has a considerable margin of capacity. If the present plant had no spare capacity, the savings due to slowing the traffic growth could easily be double or triple this figure.

The capital saving for New York Telephone over the next ten to fifteen years, when the effect of the present capacity margin will have vanished, could well be $50 to $75 million. In terms of dollars per line, the present saving amounts to about $2 per line rising to about $20 per line solely from the introduction of local call timing in an environment where a per-call charge already exists.

Mountain Bell estimated that residence calls would be repressed between 15% and 27%, but not below the number of message units allowed in the basic rate. Mountain Bell also considered that business usage was virtually insensitive to usage charging up to a 25% increase in the total bill, but would be repressed by a 100% to 200% increase in billing. Overall, the saving in capital cost of switching equipment and of interoffice trunk equipment was expected to amount to about $40 per main telephone by the third year after introduction of usage charging.

These estimates from New York Telephone and from Mountain Bell suggest that the figures derived above for the Canadian situation are reasonable.

V ADDITIONAL REVENUE-PRODUCING SERVICES

The revenues from local calling under a usage charging plan will depend on the tariff structure chosen. It is possible to structure a tariff so that the same average revenue will be obtained as under a flat-rate tariff, or so that the same return on investment will be achieved after considering the overall net effect on investment and the changes in operating costs due to billing and commercial requirements. The likely effect on average revenue requirement is discussed later in this report.

Regardless of the resulting revenue from the existing local calling services, usage charging does provide an opportunity for additional revenue-producing services that are not generally provided in a flat-rate environment. Such services include time-of-day checks and various recorded announcements of general interest such as recipes, jokes, news and many others. These services are generally regarded as profitable by the companies providing them in a message-rate environment. New York Tel, for instance, estimates that its cost to provide one message unit of service at peak times in 1973 was about 6 cents, including all investment and operating cost allocation. The charge per message unit was then over 7 cents, so a message unit at peak times returned a profit of at least one cent, and a message unit at off-peak times returned a much larger profit as it effectively used spare capacity in the network.

Mountain Bell estimated that the direct costs (in Denver) of switching and trunking (only) for an additional call at peak busy periods varied from 1.5 cents for a short distance two minute call to 4.5 cents for a ten mile five minute call and to 10.5 cents for a forty mile ten minute call.

It is apparent that usage charging has a potential for producing new profits from new services, although the magnitude of the profit is probably insignificant in the total revenue requirements of the network.

VI SHORT-HAUL TOLL APPLICATIONS

Extended Area Service (EAS) arrangements have been created in many instances as an alternative to toll billing for calls that cover a relatively short distance. The flat-rate monthly charge in exchanges with EAS has been increased as the number of telephones in the local calling area increased, and as the investment in switching and trunking equipment increased.

Usage charging for local telephone service as discussed in this report may be an alternative to high flat-rates in EAS areas. A large part of the rationale for eliminating toll charges on short-haul calls has been the fact that the cost of billing the call in a conventional toll format has been a large part of the cost of the call. It has been possible in many instances to lower the revenue requirement per call by eliminating the charging procedure and providing a flat rate (EAS) service.

Modern technology for usage charging has greatly reduced the cost of measuring and billing a call. The equipment discussed in this report is fully capable of charging on a time and distance basis for inter-exchange calls which may be presently EAS calls or short-haul toll calls. The incremental cost of recording and billing such a call would be less than one cent. The introduction of usage charging for local telephone service, in the present configuration of local service, may thus be a cost-effective means to satisfy demands for wide calling areas at reasonable rates in place of present EAS areas and present short-haul toll rates.

OTHER COSTS OF USAGE CHARGING

There are other costs associated with usage charging, primarily due to changes in basic service arrangements that may be expected when usage charging is introduced. It may be desirable for instance, to eliminate some classes of service, such as urban four-party or urban two-party, in order to simplify the usage charging system. The additional investment may be directly recoverable through service charges and/or monthly rental rates if that is found desirable. Some such up-grading will be voluntarily undertaken by low volume subscribers who find their monthly bill reduced under usage charging and opt to spend the saving on a higher grade of service of access line.

It is also possible that some subscribers will order additional access lines if the basic monthly charge for the access line is sufficiently reduced. Depending on the tariff structure, the same monthly usage spread over two lines could cost only a little more than concentrated on one line. The revenue to the carrier could be sufficient to carry the additional investment if the tariff were designed to relate the monthly minimum bill to the fixed cost of the access line.

SUMMARY OF COSTS

The capital costs to add usage charging equipment to step-by-step or to crossbar switching equipment vary from about $10 per line to $50 per line in the size ranges and configurations most likely to be required. Costs per line would generally be determined more by the number of lines per office to be measured rather than by the percentage of lines in an office to be measured.

The capital cost savings in switching and transmission equipment achieved because of likely traffic repression in a usage charging environment range from $20 per line to $50 per line.

Within the precision attempted in this study, it appears that the capital cost of usage charging equipment would be at least offset by the capital saving in usage-sensitive investment. The Mountain Bell study of the Denver metropolitan area concluded that actual investment savings would occur in the specific Denver environment, since the reduction in investment in traffic-sensitive equipment was generally double the required new investment in usage charging equipment.

Annual costs related to investment would be about 25% of the investment change, either a cost or a saving. Recurring costs of billing and of customer contact are estimated to be approximately $1.00 to $2.00 per month per main station.

The Mountain Bell study concluded that, in the Denver metropolitan area, annual cost savings on investment reductions would outweigh the recurring administrative expenses. The net effect was forecast to be a reduction in overall average long-run cost in the amount of about $7 per main telephone per year after the first year.

CONCLUSION

This cost study has examined the current best industry estimates of the costs and savings likely to be involved with the introduction of usage charging for local telephone service in Canada. Very little actual experience exists in North America to verify the accuracy of these estimates.

A number of field trials or experiments are proposed or under way in the United States to determine the actual costs and the actual subscriber reaction to usage charging. In particular, GTE Automatic Electric is currently conducting a trial in Illinois using CTMS equipment and detailed billing. Many of the factors detailed in this cost study are being measured in the Illinois experiment, and results are expected to be available in late 1975. No interim results have been made available.

There is very little information available concerning present usage of the local telephone network. A large amount of information about the calling patterns of different types of subscribers in different sizes of exchanges will be necessary before it will be apparent whether usage charging should be applied universally. It may be that usage by some groups is sufficiently uniform and inelastic that an appropriate flat rate could be charged, avoiding the expense of usage charging. The investment in usage charging equipment will be influenced by such considerations as whether or not all the subscribers in a particular exchange are to be measured, and whether or not all exchanges are to have measuring capability. The costs of operating a usage charging system will be influenced by similar factors, and by the volume of calling by each class of customer.

Bell Canada is undertaking a study of customer usage, with preliminary results expected in late 1975 and a possibility of a major study following in 1976. AT&T has done some Subscriber Line Usage studies as has Mountain Bell, with more studies planned for the future.

The savings due to resulting traffic constriction are a very important part of the overall cost of usage charging, and will depend largely on the degree of constriction experienced. Field trials and market studies will be required to obtain reasonably reliable predictions of traffic changes.

Within these informational constraints, which have restricted the extent to which this cost study can be regarded as conclusive, it has been found that the cost of usage charging for local telephone service is not prohibitive. The introduction of usage charging could in fact result in an overall cost reduction in the Canadian telephone network.

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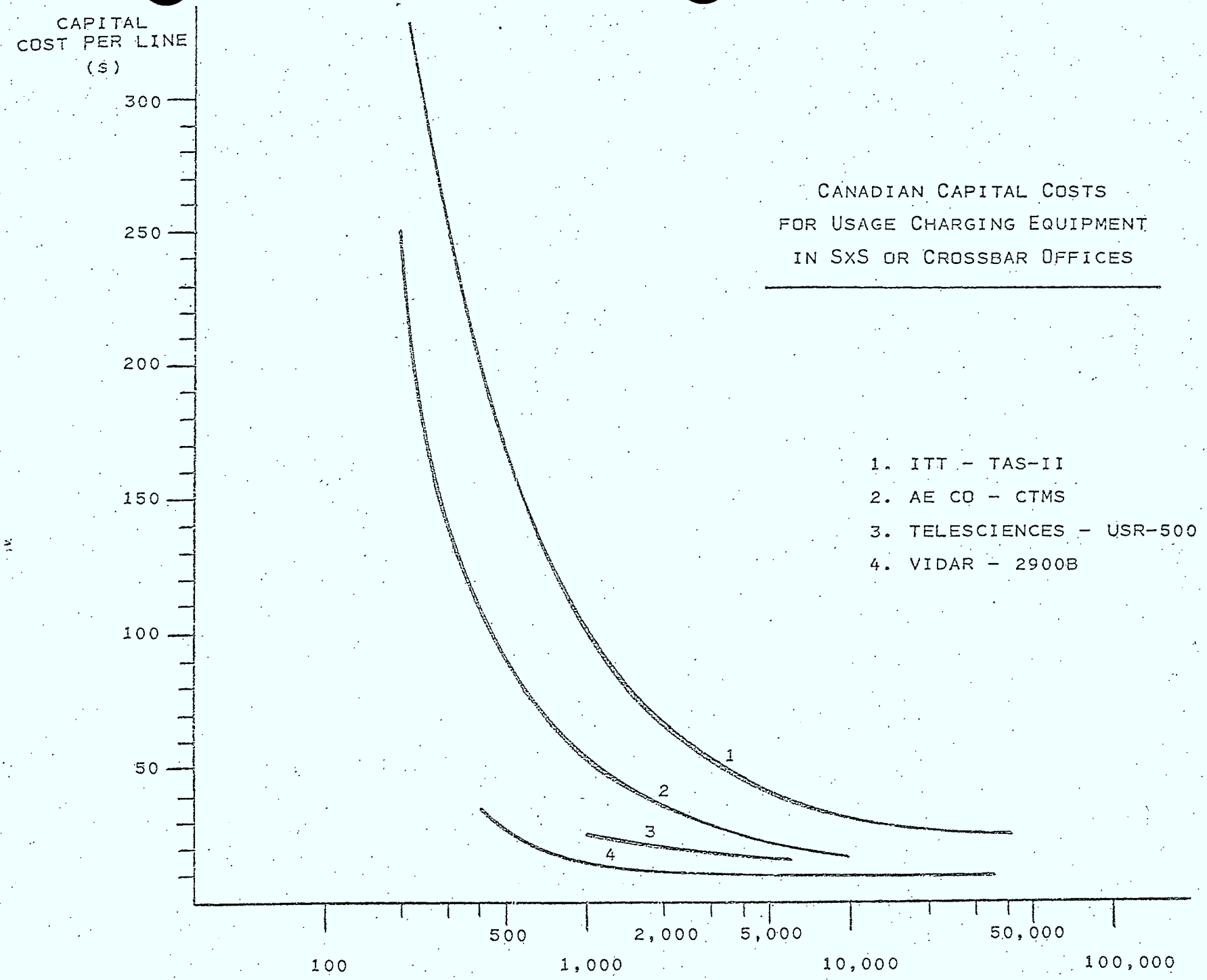

CANADIAN CAPITAL COSTS
FOR USAGE CHARGING EQUIPMENT
IN SXS OR CROSSBAR OFFICES

1. ITT - TAS-II
2. AE CO - CTMS
3. TELESCIENCES - USR-500
4. VIDAR - 2900B

APPENDIX A