ABSTRACT

Due to the impact that proposed rate structures and technological advances are likely to have on telephone traffic in the future, GTE has undertaken two customer line usage studies in its domestic telephone operating companies. In these studies, information is recorded on each call made on individual studied lines. This information is combined with customer data in downstream processing to produce a detailed call data base.

In this paper, the reasons that these two studies were undertaken are outlined, the study plans and hardware are described, the results of some preliminary analyses are presented and discussed, and future studies on the data are described. In the results section, the distribution of call arrivals and the distribution of message holding times are analyzed. In addition, some usage statistics by class of service are derived and applied to an analysis of load balancing techniques.

1. INTRODUCTION

In an effort to learn more about the calling characteristics of the individual customers that we serve, GTE has undertaken two Customer Line Usage studies within its domestic telephone companies. This paper will describe the study designs, data collection equipment and processing procedures, some of the analyses that have been carried out, and some of the future analyses that are planned.

Until recently, data collection efforts in the telephone industry have been aimed primarily at accomplishing operational tasks - traffic engineering, load balancing, etc. In this regard, the data collected has been aggregate in nature. For example, traffic engineering of linefinder groups in step-by-step offices requires only total originating usage measurements for a group of subscribers as a whole for an hour of the day. Details as to the usage generated by each individual have not been available, and hence, have not been collected. Recent technical and economic changes, however, have necessitated the collection of individual customer call by call usage data for effective planning and evaluation of new and existing procedures and equipment. Examples of planning activities in which call by call detail is essential, include (1) the effect on calling habits of measured rate local service - what amount of repression will various classes of subscribers exhibit relative to flat rate pricing? (2) In conjunction with measured service offerings, can off-peak pricing be used as a means of shifting traffic loads and thereby reducing central office equipment requirements? (3) What are the usage characteristics of special classes of users - data phones, broadcast services, credit card validation services, etc? (4) In the area of line concentrators, it is essential that the usage characteristics of individuals be known, since some of the smoothing effect of a large group of subscribers will be lost. (5) Identification of separate traffic forecasting functions by class of subscriber may lead to more accurate forecasting than current aggregate methods. Examples of existing procedures and technological innovations that can be evaluated using subscriber data include: (1) load balancing techniques - will uniform assignment of subscriber types to line groups improve balance? Is load balancing by moving lines cost effective or would over-engineering be more economical? (2) Do arrival rate and holding time distributions agree with the assumptions made in the development of capacity tables? (3) Are the calling and dialing habits of touch tone subscribers significantly different from those of rotary dial subscribers? (4) What are the major components of non-conversation traffic? Can this portion of traffic be reduced by equipment alteration or administrative procedures?

All of these are analyses of important issues which have the potential for great increases in customer service and operating efficiency. Since one customer line study, if properly designed, can serve as the data source for all of these analyses, it is not hard to justify the cost of the study on a need basis. It is with these goals in mind, therefore, that GTE is conducting the two customer line usage studies described in the remainder of this paper.

2. STUDY DESIGNS AND HARDWARE

The two studies being conducted are: a study of originating completed messages in three exchanges in GTE of Illinois and a study of total originating and terminating traffic in ten exchanges in GTE of California. The former study is designed primarily as an experiment in local measured service and 100% of the lines in the three exchanges are being measured. The latter is a stratified random sample of a total of 2500 lines. The following sub-sections describe each of these studies in more detail.

2.1 THE ILLINOIS STUDY

A conversation time measuring system (CTMS) is used in three exchanges to collect records of each completed originating local message. The data recorded with each message are:

1. Calling number
2. Called number
3. Time of day call answered (hrs., min., sec.)
4. Duration of call (hrs., min., sec.)
5. Date of call

This data is transferred from buffer storage to magnetic tape automatically by the CTMS in blocks of forty records. Periodically, these tapes are manually sent to off-line batch computers for processing. At this point, supplementary information is added to each record from the customer master file and other data sources. The end result is a monthly call detail data file containing, in addition to the items collected by the CTMS, the following items for each call:

6. The class of service of the calling party
7. The line group of the calling party
8. The master service date of the calling party
9. The billing number of the calling party

Finally, toll detail data are added to the file, and it is sorted first by calling number and then chronologically within a calling number. Thus, at the end of the call processing procedure, each entry in the data file is a stand-alone record which gives complete information about the message.

The three exchanges serve a total of approximately 17,000 subscribers who place approximately 2,000,000 messages per month. Although the exchanges are predominantly re-
sidential, there are a significant number of business subscribers. The breakdown of subscriber types by exchanges is shown in Table 1. A more detailed description of this study is given in a paper by Mr. Gerald Cohen included elsewhere in these proceedings.

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>NUMBER OF STUDY POINTS BY EXCHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residence</td>
</tr>
<tr>
<td>Exchange 1</td>
<td>2,779</td>
</tr>
<tr>
<td>Exchange 2</td>
<td>1,373</td>
</tr>
<tr>
<td>Exchange 3</td>
<td>1,199</td>
</tr>
<tr>
<td>Totals</td>
<td>5,351</td>
</tr>
</tbody>
</table>

Various control reports are printed in the process of producing this "augmented detail" data file, such as message counts, minute counts, etc., both by exchange and total for the three exchanges. One of the most useful control reports has been the "gap report", which shows those instances of time gaps between successive call originations in an exchange of fifteen minutes or more. The gap report provides an indication of the down time of the equipment in each exchange, and is very useful in insuring the accuracy of hourly mean usage calculations.

The CTMCS has been in operation since mid-1974 and has proven very reliable as a measured local service data recording device for these three step-by-step offices. The subscribers in the three exchanges were issued duplicate flat rate and measured rate bills beginning in October, 1975, with the flat rate bill being the amount to be paid, and the measured rate bill being intended for informational purposes only. Full non-optimal measured rate service is planned for introduction in 1976, in the three exchanges. Several extensive investigations of the usage characteristics of classes of subscribers have been carried out on the data. The results of some of these will be presented in Section 3.

2.2 THE CALIFORNIA STUDY

The Customer Line Usage Evaluation in California was originated as a means of collecting usage information on data lines and expanded to include a cross-section of all classes of subscribers. As such, it differs from the Illinois study in two ways: (1) All activities, both completed messages and incomplete attempts, originating and terminating, are recorded for a studied line; and (2) a stratified random sample of 2500 subscribers located in ten exchanges are studied, as opposed to the 100% measurement of subscribers in Illinois. This type of data is more complete, from a traffic standpoint, for usage analysis than the Illinois data, and should serve as an excellent data base for the studies described in Section 4 of this paper.

One usage recording device with a capacity of 256 lines has been installed in each of the ten exchanges. The device senses, collects, and records in a single-line-per call format - detailed usage information on all attempts made to and from the selected measured lines. The items recorded on each originating attempt from a measured line are:

1. Calling number
2. Date
3. Off-hook time of day (hr., min., sec.)
4. Digits dialed (if any)
5. Answer supervision time (if answered) (hr., min., sec.)
6. On-hook time

The items recorded on each incoming attempt to a measured line are:

1. Called number
2. Date
3. Time of day call received (hr., min., sec.)
4. Answer supervision time (if answered) (hr., min., sec.)
5. On-hook time (hr., min., sec.)

The data is recorded on magnetic tape at each site. These tapes are manually dismounted and sent to downstream processing on a monthly basis. Each record is augmented at this stage with the following information from supplementary data files:

1. Class of service of the studied line
2. Distance of the call (if originating)
3. Place called (if originating)

Thus, as with the Illinois data base, each data record is a stand-alone account transaction which gives all the relevant information for an attempt to a studied line. The data file is sorted first by studied number and then chronologically within a studied number.

The ten offices to be studied were selected based upon demographic data so that together they formed a representative sample of the company. Factors such as business to residence ratio, average family income, life-style, metropolitan vs suburban, etc., were considered in making the selection.

The selection was made in this fashion so that any usage characteristic demonstrated by the sample population could be easily extrapolated to the company as a whole. The specific customers studied were selected such that statistical inferences were made in the results within each class of subscriber. This implied that despite the number of subscribers of each type in the population, a nearly equal number from each class were selected to be studied. In addition to the lines to be studied, a list of alternate lines was drawn so that as attrition of the studied lines takes place, they can quickly be replaced by alternates.

Data collection has been been underway for a shorter period of time in California than in the Illinois study. As of this writing, no significant traffic analyses have been completed. A study outline for some of the analyses planned on the California data is given in Section 4.3.

3. PRELIMINARY RESULTS

Some analyses of subscriber behavior from both a traffic and revenue requirements viewpoint have been carried out on the Illinois study data at this time. This section presents the results of some of the traffic analyses that have been conducted on the Illinois data. Throughout the following discussion, it must be kept in mind that originating completed messages are being analyzed, and not total traffic.

3.1 ARRIVAL DISTRIBUTION ANALYSIS

As a check on the classic assumption of random originations of calls at the linefinder banks, an analysis of the arrival distribution was carried out. Randomness of originations, in this context, means that the time of the next call origination is independent of the time of the last call origination. Stated another way, randomness of arrivals implies that the time between arrivals, t, is distributed negative exponentially, with probability density f(t) = λe^{-λt}, where λ is the mean number of arrivals per unit of time. Because of the organization of the data base, it would have been extremely difficult to derive a histogram of t, the time between arrivals. Therefore, advantage was taken of the fact that exponential inter-arrival times imply that the number of arrivals in a time interval is distributed in a Poisson fashion. The probability of a arrivals in a period of time, t, is:

\[ P_\lambda(t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!} \]

The time period, t, chosen was one minute. To insure that the mean rate λ did not change significantly over the study period, only one hour's data was used for any given analysis. A computer program was written to accumulate the number of originations in each minute of a specified hour in an exchange. Output was a histogram of arrivals per minute. In all, sixty hours of data were examined in this fashion. Of these sixty tests, only two showed a distribution that failed a goodness-of-fit comparison to the Poisson at the 5% assurance level. Figure 1 provides a good visual display of the goodness-of-fit of actual call originations to the Poisson distrib-
The actual cumulative distribution is compared to the theoretical cumulative for one hour of data from exchange 1. Note that in no region of the curve do the two distributions differ significantly.

All indications from this analysis, therefore, are that call originations are truly random in nature. This result supports the assumptions made in this regard by switching theorists, and refutes the notion that rashes of calls originate on or near the hour and half-hour. In the next sub-section, the data base will be used to examine the other side of the issue - the distribution of message times.

### 3.2 HOLDING TIME DISTRIBUTION ANALYSIS

In this section, the statistical distribution of message holding times will be analyzed and some quantitative and qualitative conclusions will be drawn. As with the analysis of the arrival distribution, the holding time distribution analysis is important in that the assumption of negative exponential holding times is one of the foundations upon which congestion theory is based. A knowledge of the nature of the message holding time distribution is important in planning for many types of activities and service offerings. For example, measured service and broadcast announcement services would tend to decrease holding times and thus increase capacity for a fixed total load; on the other hand, data lines would tend to increase holding times and thus decrease capacity for a fixed total load.

Figures 2 and 3 show the results of this analysis for Exchange 2, which was typical of the three exchanges. The step function represents the actual message holding time distribution for all originating messages, and the smooth curve shows the negative exponential with the same mean. For both business and residence, the following observations can be made from the graphs:

1. There are more messages in the 0 to 1 minute range than would be expected.
2. There are more messages in the greater than ten minute range than would be expected.
3. The coefficient of variation is higher than the value of one that would be expected - 3.18 for residence and 3.76 for business.

The general shape of the actual distributions compares remarkably closely with the results obtained by Barnes and Reutelhuber for an office in San Francisco. The same observations hold true in both studies, although the holding times in San Francisco are not as dispersed as those in Illinois. In both studies, the business subscribers exhibited a holding time more closely resembling the exponential than did the residence subscribers. Plans to study the impact of these non-exponential holding times on grades of service and on existing capacity tables are currently being made in GTE.

Compositing of the various classes of business and residence subscribers indicates that mean residence message times are roughly twice mean business message times, as shown in Table 2.

<table>
<thead>
<tr>
<th>Exchange</th>
<th>Average Residence Message Time</th>
<th>Average Business Message Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.56</td>
<td>0.74</td>
</tr>
<tr>
<td>2</td>
<td>1.92</td>
<td>1.23</td>
</tr>
<tr>
<td>3</td>
<td>1.67</td>
<td>1.08</td>
</tr>
</tbody>
</table>

In line with the smaller mean, smaller variance message times of business vis-a-vis residence, the businesses also showed less of a tendency towards long conversations. This is displayed in Table 3.

<table>
<thead>
<tr>
<th>Exchange</th>
<th>5 or More Minutes</th>
<th>15 or More Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence</td>
<td>81.90</td>
<td>99.21</td>
</tr>
<tr>
<td>Business</td>
<td>85.10</td>
<td>91.05</td>
</tr>
<tr>
<td>Residence</td>
<td>5.97</td>
<td>1.05</td>
</tr>
<tr>
<td>Business</td>
<td>5.87</td>
<td>1.08</td>
</tr>
</tbody>
</table>

Thus, the business subscriber would be less susceptible to large variance in monthly billing under measured rate service, all other considerations being equal.

### 3.3 LOAD BALANCING ANALYSIS

One of the areas in which an individual subscriber data base provides a unique opportunity for study is that of load balancing. The grouped data normally used to accomplish load balancing masks the characteristics of indi-
vidual subscribers. Without individual subscriber data, an analytic evaluation of new load balancing techniques, or even a cost-benefit analysis of current techniques, is extremely difficult without some very limiting assumptions. What we have done, therefore, is to use our Illinois data base to compute some basic usage statistics by class of service, input those to a Monte Carlo simulation of various load balancing techniques, and then use the output of the simulation as input to a cost-benefit analysis, as shown in Figure 4.

Table 4 shows the results of the data analysis to determine the parameters of the two-part model of Figure 5 for Exchange 2. Data for twenty weekdays during the busy hour was analyzed for the six major classes of subscribers in the exchange. All measurements shown are in minutes of originating conversation. Exchanges one and three showed very similar results. These parameters, which quantify the usage characteristics of individuals, become the inputs to the load balance simulation.

### Table 4: Parameters for Two-Part Subscriber Usage Model

<table>
<thead>
<tr>
<th>Class</th>
<th>Number of Exchange 2 Subscribers</th>
<th>Cost of Assignment</th>
<th>Number of Lines Moved</th>
<th>Good Subscriber Class Mean</th>
<th>Bad Subscriber Class Mean</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>221</td>
<td>1.82</td>
<td>1.66</td>
<td>1.06</td>
<td>1.01</td>
<td>0.15</td>
</tr>
<tr>
<td>Work</td>
<td>221</td>
<td>1.19</td>
<td>1.11</td>
<td>1.06</td>
<td>1.13</td>
<td>0.15</td>
</tr>
<tr>
<td>Class</td>
<td>221</td>
<td>1.82</td>
<td>1.66</td>
<td>1.06</td>
<td>1.01</td>
<td>0.15</td>
</tr>
<tr>
<td>Total</td>
<td>663</td>
<td>1.82</td>
<td>1.66</td>
<td>1.06</td>
<td>1.01</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### 3.3.2 MONTE CARLO SIMULATION OF ASSIGNMENT AND CORRECTION TECHNIQUES

To realistically account for the various activities taking place in a central office that have an effect on the state of balance, a Monte Carlo simulation approach was chosen as a means of performing the permutation of various balancing techniques. The mathematical complications that turnover and our current balancing techniques introduce, combined with an already complex process, would have made an analytic model intractable.

The simulation accepts as inputs the number of classes of subscribers, the number of each type of subscriber in the office, the number of line groups, the parameters of the two-part model of subscriber usage for each type of subscriber, and the turnover rate per time period of each type of subscriber. In its current state, the simulation is programmed to perform either random assignment of subscriber types to line groups with an equal number of subscribers in each group, or uniform assignment with each group having an equal number of each type of subscriber. In addition, two correction methodologies are possible: no correction and the current OTM method which involves moving lines from one group to another when an imbalance situation is detected.

Given these inputs, the simulation initially assigns subscribers to groups, and randomly selects a mean daily busy hour usage for each subscriber in the office. For each time period, each subscriber’s five day busy hour usage is simulated and averaged. Mean actual usage is calculated, a state of balance index is calculated for each group, corrective action is taken, if so designated, and turnover of each subscriber is simulated. If a subscriber is terminated from the simulation through turnover, he is replaced by a new subscriber (with new mean usage) of a randomly determined type. Output for each time period shows the mean and actual usage for each group, the balance index and the number of lines moved and turned-over in each group. A summary shows the inter-group variance in both mean and actual usage and the number of lines moved in the office to achieve balance.

The two output measures of most importance are the number of lines moved to improve the state of balance (which can be translated into cost) and the amount of inter-group variation in mean usage (which can be translated into a measure of effectiveness). Inter-group variation of zero with no line movements would be the twin objectives of a perfect line balancing procedure.

Using the subscriber data from Table 4, the simulation was run first to compare random assignment of subscribers to groups with uniform assignment.

The hypothesis behind this test is that some ordered, methodic approach to placing subscribers in line groups would produce more desirable results in terms of state of balance than would a random assignment. While this notion may be intuitively appealing, the simulation results showed that method of assignment made very little difference in terms of either inter-group variation or number of line movements required to maintain balance. Both methods resulted in a coefficient of variation (inter-group standard deviation divided by average group mean) of .052 and both methods required an average of...
Using random assignment, line movement correction and a proposed procedure of random assignment, with no corrective action. The hypothesis behind this procedure is that normal turnover will gradually bring an unbalanced state of balance than does the no correction methodology, as shown in Table 5.

The next section will present a means of comparing these alternatives on a cost basis to determine the least cost method of load balancing.

3.3.3 COST BENEFIT ANALYSIS - OVER-ENGINEERING VERSUS CORRECTIVE ACTION

The figures of Table 5 leave some doubt as to which alternative is the least costly method of load balancing. Line movements per group per month are easily translated into cost, given a cost per line move. The cost of inter-group variation in usage, however, is a bit more complicated to obtain. The approach to associate a cost with this variation is that of determining the amount of over-engineering required to provide the desired grade of service to the office as a whole. With zero inter-group variation, all subscribers will, on the average, receive the desired grade of service if the office is engineered properly (i.e., according to the capacity tables for linefinder groups. 98.5% will receive dial tone within 3 seconds).

As Figure 6 shows, however, when any inter-group variation exists, the average grade of service will fall below the desired level, since service degrades with the addition of load faster than it improves with the removal of the same amount of load.

and $D(x,n)$ is the Erlang C delay function

$$x = \text{the offered load in Erlangs (CCS/36)}$$

$$u = \text{the reciprocal of average holding time}$$

$$t = \text{the desired maximum delay (3 seconds)}$$

$$n = \text{the number of linefinders per group}$$

$$P_0 = \frac{\sum_{i=0}^{n-1} x^i}{n! (1-x)}$$

For example, in a perfectly balanced office (zero inter-group variation) with mean load of 290 CCS per group and 16 linefinders per group, $GS = .992$.

To determine the grade of service in an office that is not perfectly balanced (as in Figure 6), one need only integrate Equation (1) over the range of $x$.

$$GS = 1 - \int_{-\infty}^{+\infty} D(x,n) f(x) \, dx \quad (3)$$

where $f(x)$ is the normal distribution of group means in an office. Repeating the earlier example, with a load of 290 CCS and a coefficient of variation of .082, the average grade of service is .9901 with the same average load and a coefficient of variation of .111, the average grade of service is .9885. Thus, as explained earlier, the grade of service has declined with an increase in the coefficient of variation.

To further quantify the problem, we know that in the office mean range of 286 CCS to 311 CCS, 16 linefinders are required (assuming Erlang C model) if perfect balance exists. With a coefficient of variation of .082 (achieved through line movements), 16 linefinders were required from 286 CCS to 304 CCS, and 17 linefinders are required from 305 CCS to 311 CCS (to provide at least .985 service at all loads) for an average of 16.269 in the 286 to 311 range. With a coefficient of variation of .111 (achieved with no corrective action), 16 linefinders are required for 286 to 299 CCS, and 17 are required from 300 to 311 CCS, for an average of 16.462 linefinders on the range.

Therefore, the total costs of providing .985 service utilizing corrective action are:

$$16.269 - 16.000 = 16.462 \text{ linefinders per group}$$

The total cost of providing the same service without corrective action is:

$$16.462 - 16.000 = 16.462 \text{ linefinders per group}$$

Assuming: a 15 year equipment life, a net present after tax cost for one linefinder of $485, a cost of a line-move of $15, and an 8% discount rate, the net present value of costs associated with the line movement alternative is $253.72. The net present costs associated with the no corrective action alternative is $224. Thus, on a cost basis, the no corrective action alternative has a net present value of savings of $29.72 per line group. When multiplied by the number of line groups in a telephone company, this becomes a significant savings, and is a conservative figure since the data collection, processing and administrative costs associated with the corrective action alternative were not considered.

In summary, in this section we have used the subscriber data base to devise some usage statistics by class of subscriber, applied these statistics to a simulation of load balancing alternatives to obtain the operating characteristics of these alternatives, and presented a means of translating the operating characteristics into costs. This analysis was presented not so much as an argument for one method of balancing over another, but more importantly as an illustration of the type of analysis which a subscriber data base makes possible to accomplish. In the future, we plan to make much greater use of this type of data, as it becomes available, for analyses of this type. The next section outlines some of the studies that are currently being planned for the California data base.
4. STUDY OUTLINE - CALIFORNIA DATA BASE

The California customer line usage evaluation provides data on all traffic taking place on a studied line - originating, terminating, completed calls, and incomplete attempts. As such, it is a much richer data source for traffic studies than the Illinois study, which recorded only the message time associated with completed originating calls. For this reason, we plan an even more extensive set of analyses on this data than on the Illinois data.

In addition to duplication of the studies described in Section 3, the following studies are underway on the California data base.

4.1 CALCULATION OF THE THREE PARAMETERS PER SUBSCRIBER CLASS OF THE TWO-PART MODEL OF FIGURE 5 FOR TERMINATING TRAFFIC.

The load balance problem exists on the terminating end as well as the originating end. Line movements on the terminating end are even more expensive since they involve a change in the subscriber's telephone number. Therefore, an evaluation of load balancing techniques for terminating equipment groups is of great importance.

4.2 ANALYSIS OF THE COMPONENTS OF NON-CONVERSATION TRAFFIC

The product of a telephone company from a customer's viewpoint is a connection resulting in a conversation.

Non-conversation traffic is essentially non-productive time during which expensive switching equipment is tied up by the subscriber. Defining non-conversation time as total traffic time minus two-way conversation time, the following items can be identified and quantified as a percentage of total traffic: false starts, dialing and ringing time resulting in a connection, dialing and ringing time resulting in no answer or a busy, and incomplete dialing attempts.

Analysis of each of these components could lead to methods (managerial efforts, customer instruction, equipment redesign, etc.) of reducing non-conversation traffic and thus reducing the amount of equipment required to handle a given amount of conversation traffic.

4.3 DEVELOPMENT OF USAGE PROFILES VS TIME OF DAY BY CLASS OF SUBSCRIBER.

Knowledge of diurnal usage cycles by class of service would serve as an aid in determining off-peak pricing strategies in a measured local service environment. As with the current toll rate structures, this would provide a smoother traffic flow across the day and lead to greater equipment utilization. In a flat rate pricing environment, this analysis would show which subscribers contribute most heavily to peak loads, and thus should bear a larger portion of the revenue requirement of the telephone company.

4.4 ANALYSIS OF DIALING CHARACTERISTICS OF TOUCH CALL SUBSCRIBERS VS ROTARY DIAL SUBSCRIBERS

Touch calling would seem to have the advantage of reducing the dialing time per call, and thus reducing the investment in central office equipment per call. The touch dialing instrument, however, is more expensive than the rotary dial instrument, so there appears to be offsetting advantages to each type of telephone. Analysis of the dialing time per call for each would lead to a more accurate assessment of total costs, and, in addition, would aid traffic engineers in providing adequate switching equipment.

4.5 ANALYSIS OF THE DISTRIBUTION OF LOAD THROUGHOUT AN HOUR

Studies have shown that usage may not be evenly distributed throughout a particular hour, as is currently assumed for traffic engineering purposes. Residential subscribers, for example, may have a greater tendency to place calls on the hour or half hour in the evening when commercial breaks occur in telephone programs. To

address this issue, a time continuous usage profile by class of subscriber will be derived from the data base. Analysis of this curve could lead to changing the engineering base to a busy-minute or busy five minute interval as opposed to the current busy hour concept.

5. CONCLUSION

This paper has described two customer line usage studies that are being conducted by GTE. The data collection and analysis methods have been presented and some of the results have been discussed. We feel that in today's technical and economic environment, these studies provide an invaluable source of information about the usage characteristics of our customers. This information can be worked in a myriad of ways to provide answers to traffic problems ranging from evaluation of current techniques to specification of design parameters for new switching systems.

As the study outline of Section 4 indicates, our work in this area has just begun. Analysis of the data proceeds on a continuing basis as the need and collective imagination dictate. We hope that at a future date we may be able to present further results.

REFERENCES: