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Traffic Service Position System No. 1:

Automated Coin Toll Service: Human Factors Studies

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Automated Coin Toll Service replaces operator handling on most toll calls paid for with coins and provides operator handling when customers fail to deposit. Human factors work on ACTS consisted of first documenting the range and frequency of existing operator interactions, then simulating various possible versions of machine-provided service, and last analyzing simulation results to provide service recommendations, performance estimates, and a list of important, but unanswered, questions. The simulation also led to the early development of operator practice and training materials, evaluation tools, and operational requirements, as well as timely discovery of potential problems.

I. INTRODUCTION

Companion papers describe the hardware and software used to provide Automated Coin Toll Service (ACTS).[1–3] This paper describes human considerations which contributed to the design and evaluation of the automated service.

Prior to the development of the hardware and software described in the previous papers, many questions were raised:

(*i*) Would the automated service be an acceptable substitute for Traffic Service Position System (TSPS) operators performing routine functions, e.g., deposit request, coin counting, deposit prompt, deposit acknowledgment, and others?

(*ii*) How would customer depositing (and other behaviors) depend on service design?

(*iii*) How would customer satisfaction with the service depend on the design?

(*iv*) How would operators be affected by the automated service?

These few broad questions implied many specific questions: How should performance be measured? What aspects of customer behavior are most important? and How should these be measured?

The human factors work proceeded in three stages: detailed observations of existing (operator-assisted) coin toll service to comprehend the range and relative frequencies of events; a highly instrumented service trial to obtain performance measurements and customer opinions; and a data analysis and recommendations phase to formulate a final service offering, estimate performance, and isolate potential difficulties for further study. The remainder of this paper is organized around these stages.

Section II briefly describes early observing studies upon which the original service proposal, as well as the provisional announcement and timing schemes, were based. Additional confirming observing studies are also mentioned. Section III describes the usefulness of service simulations—first with operators only, later with computer-driven equipment to provide service and measure customer-service performance. Section IV describes the technical implementation of the computerized simulation, Section V describes simulation results and recommendations, Section VI estimates performance and acceptance, Section VII enumerates unanswered questions, and Section VIII briefly mentions some cost-worth factors to be considered in evaluating the simulation.

II. EARLY HUMAN FACTORS WORK—OBSERVING HOW COIN CALLS ARE PRESENTLY HANDLED BY OPERATORS

At TSPS, toll coin calls are divided into several parts (called position seizures) for efficient operator handling. Each seizure accomplishes a single function: (*i*) initial period deposit request and verification of complete deposit, (*ii*) notification at the end of the initial period that overtime charges would apply unless the call ended immediately, (*iii*) call interruption, deposit request, and verification after each additional 10 minutes of overtime conversation, and (*iv*) ringback (if necessary), deposit request, and verification at the end of conversation. The human factors effort concentrated on replacing operators performing these functions.

The initial service proposal by J. C. Dalby was based on the characteristics of (operator-assisted) station-to-station coin toll calls monitored at Neptune, New Jersey and Chicago, Illinois.[4] Of particular interest were:

(*i*) The wording of the operators' deposit requests.

(*ii*) The time from the deposit request until customers deposited their first coins.
(*iii*) The number of times operators repeated deposit requests before customers started depositing.
(*iv*) The times between coins (intercoin intervals).
(*v*) How frequently customers began depositing, then stopped and asked operators how much was still due.

C. E. Bronell and M. S. Schoeffler[5] conducted a more extensive service measurement study in Seattle, Washington, Miami, Florida, and Rochelle Park, New Jersey. The objective of this study was to reinforce earlier observations and accumulate enough direct observations of operator-handled calls to provide a thorough, general description of the process and of the most common situations likely to be difficult for an automated system. Location differences were also analyzed.

From these observational studies, it became apparent that there are two general types of coin customers: experienced and (those presumed to be) inexperienced. Experienced customers are familiar with coin service. They had correct change and often knew the exact charges before making the call. After a short initial deposit request (e.g., "50 cents please"), experienced customers immediately started depositing and continued until the requested amount was deposited. If the operator used a longer initial deposit request (e.g., "Please deposit 1 dollar and 75 cents for the first 3 minutes"), experienced customers often began depositing while the operator was still talking.

At the other extreme, inexperienced customers are not prepared for the initial deposit request and often ask for a repetition. They began depositing, but occasionally lost count and asked for the remaining amount due. Inexperienced customers often did not have the correct change and had to deposit too much. The operator informed these customers that extra deposits would be credited toward additional charges, if any. Some inexperienced customers dialed the call as if they wanted to pay with coins when they did not wish to do so and were unprepared. (They should have dialed 0 plus the called number.) On these calls, the operator adjusted the method of payment.

As a result of these observations, it was concluded that the sequence of announcements and coin deposit intervals should provide experienced customers with fast efficient service and inexperienced customers with repetitive requests for deposits, prompts for the remaining amount due, and automatic transfer of calls to operators when difficulties were detected. In addition, the automated service should be able to acknowledge extra deposits and provide credit toward additional conversation time.

It was estimated that provisional announcements and deposit intervals would handle approximately 85 percent of initial deposit seizures without operator intervention. On this basis, automated service was an economically sound development. However, it was also recognized that further refinements in the announcements and timing intervals which increased the proportions of mechanized seizures, even by only a few percent, would yield substantial additional savings.

III. FIRST AUTOMATED SERVICE—SIMULATION BY OPERATORS

In the spring of 1975, O. O. Gruenz, Jr., conducted an experiment at Harrison, New York, Fort Washington, Pennsylvania, and New York City, in which the automated service was manually simulated.[6] Several TSPS operators requested deposits and prompted customers using proposed announcements and approximate timing intervals. These operators were instructed to ignore any questions or comments made by customers.

During the experiment, two variants of the provisional deposit request ("Please deposit 35 cents for the first 3 minutes") were tried to reduce customer requests for repetitions of the amounts due:

(*i*) "Thirty-five cents please." (2-second pause) "Please deposit 35 cents for the first 3 minutes,"

(*ii*) "Please deposit 35 cents." (2-second pause) "Thirty-five cents for the first 3 minutes."

Both these announcements were successful in reducing customer needs for additional information. Furthermore, these results indicated that mechanized initial deposit seizures could be increased by several percent with the proper announcement wordings and timing intervals. However, because all record-keeping for this experiment was done manually, it was not feasible to explore many options. Thus, the experiment did not finally answer any design questions; rather, it demonstrated that proper design choices could substantially improve system performance.

3.1 Additional questions about customer/ system performance and customer acceptance which justified additional simulation

In addition to announcement wording and deposit timing, early work raised other specific design questions:

(*i*) Would an alerting tone preceding announcements help customers deposit more quickly and/or more reliably?

(*ii*) How would customer/system performance and customer acceptance be affected by the use of a nasal monotone ("machine-like") voice as opposed to more natural-sounding announcements? (There was some speculation that informing customers that they were being machine-served would be beneficial, and it was thought that voice quality was a reliable, non-time-consuming way of doing so.)

(*iii*) Should coin station instruction cards inform customers that service is being machine provided?

Furthermore, a properly designed simulation was expected to:

(*iv*) Identify potential overall system weaknesses, overlooked by even careful examination of individual system elements and stimulate further work where required.

(*v*) Give useful experience with microprocessor-controlled, announcement-generating equipment and software.

(*vi*) Stimulate early development of operator procedures and training materials.

(*vii*) Aid preparation of an appropriate public relations campaign for the introduction of automated service.

(*viii*) Provide some engineering information useful in early site equipment provisioning.

(*ix*) Complement performance measures with customer interviews which would reveal preferences and sensitivities to machine-provided service.

IV. COMPUTER SIMULATION OF ACTS

Various versions of the automated coin toll service were simulated using microprocessor-controlled, announcement-generating equipment. This equipment was originally built by an exploratory development group to demonstrate the feasibility of generating announcements using digitized segments of speech stored in semiconductor memory. However, this equipment lacked much of the hardware and software necessary to provide the fully automated service. First, the coin detection circuits had not been designed and, second, the circuitry and software to interface the microprocessor and the TSPS processors had not been developed. Thus, to simulate the automated service, it was necessary to have TSPS operators relay call and coin deposit information to the microprocessor. A minicomputer and a TTY were used as interface between the operator and the microprocessor. In addition, the minicomputer provided all the necessary timing intervals and a record of the call events on a 9-track tape (see Fig. 1).

The sequence of events on a simulated ACTS call were as follows:

(*i*) The call seized a position and the initial period length and charges were displayed to an operator.

(*ii*) The operator transmitted the information to the minicomputer via the TTY.

(*iii*) The minicomputer sent instructions to generate an announcement (deposit request) which was patched into the customer-operator voice path.

(*iv*) As the customer deposited coins, the operator depressed keys on the TTY which were interpreted by the minicomputer as nickels, dimes, or quarters.

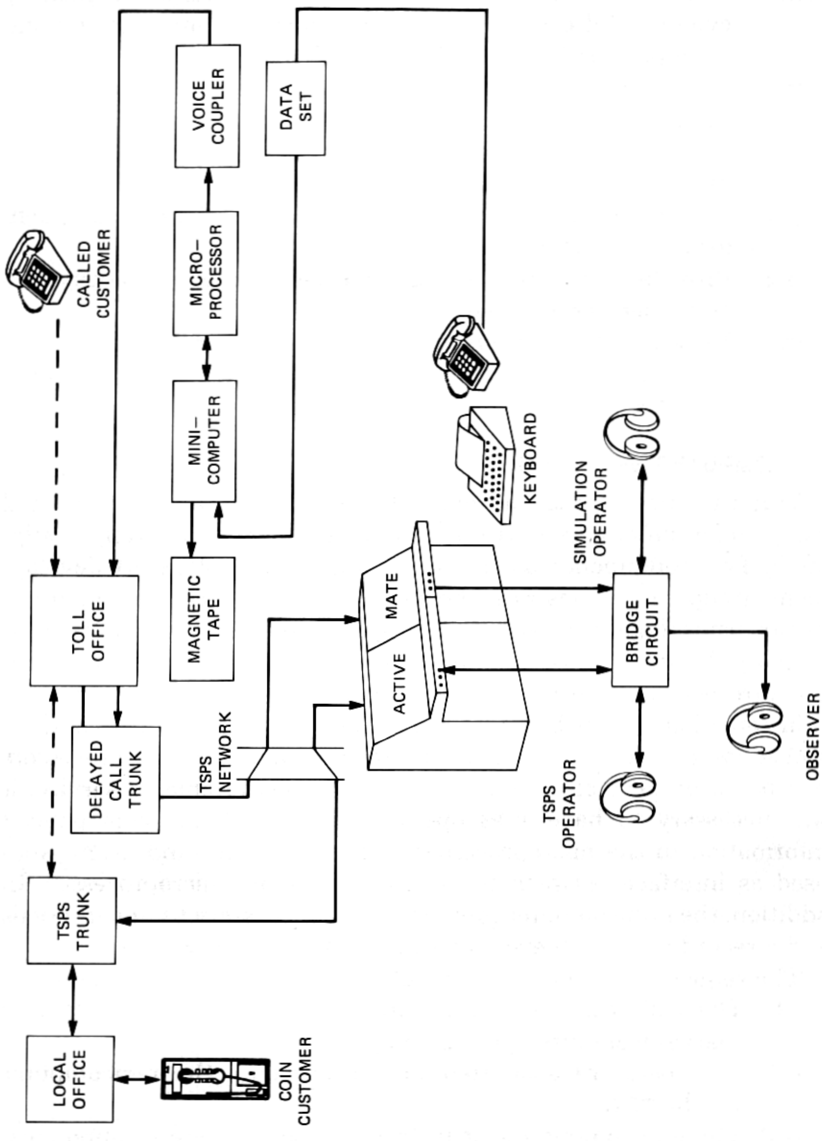

Fig. 1—Simulation block diagram.

The timing and initiation of the announcements were under minicomputer control, as were instructions to the operators. If the customer did not deposit coins, a second operator (sometimes with no previous knowledge of the call) assisted the customer, providing a customer-operator situation much like the eventual service.

Two operator positions (each with two operators) were equipped with TTYS. To ensure that these positions received only station paid coin calls, a special set of program overwrites was installed in the TSPS. In addition, other overwrites were inserted to ensure that calls at the special positions originated from one of a selected set of coin stations. Coin stations were selected to facilitate interviewing, traffic management, station instruction card study, and traffic sampling.

4.1 Administration of the simulation— hourly traffic distribution

Figure 2 illustrates the hourly distribution of simulation traffic and the corresponding distribution for coin-paid toll traffic at Illinois Bell's Great Lakes TSPS. This representative sampling for weekdays was attained by choosing an appropriate mix of 8-hour shifts over the three months of study. The simulation was operated for one shift per weekday, as well as a few weekends.

4.2 Station selection and activation

Stations participating in the trial were those most frequently used for coin-paid toll calls in the host TSPS serving area. A total of 732 stations were activated at various times. However, at busy times during the day, fewer than 100 generally received simulated service. The number of active stations was adjusted dynamically to keep (one or) two trial positions as busy as possible, without overflowing calls to the regular team more than 10 to 15 percent of the time, on the average.

4.3 Varying elements of the service design

To answer the service design questions at hand, a daily schedule of service variants was constructed to sometimes include an alerting tone/no tone, a "machine-like"/natural announcement voice, etc. Overall service was composed of variable elements in a way that allowed the effects of each element to be partialed out by appropriate analyses. Ongoing analyses quickly suggested that some service elements be eliminated from further consideration and that others be tried.

V. CUSTOMER/SYSTEM PERFORMANCE—ANALYSES, RESULTS, AND DESIGN RECOMMENDATIONS

Table I presents some key results derived from simulating over seventeen thousand automated initial deposit seizures. The table

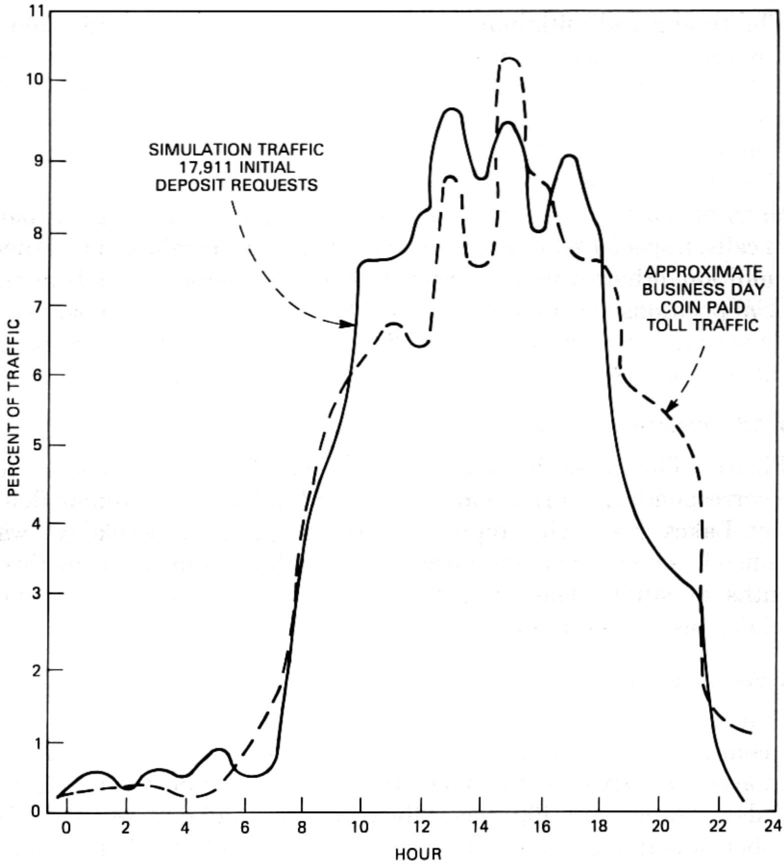

Fig. 2—Approximate business day and simulation study sampling distributions.

shows regression estimates of the effects of design decisions on important service performance measures. Mechanization rate is the percentage of calls handled without operator assistance. Walkaway rate is the percentage of calls going into overtime but not fully paid for by customers "walking away." Abandonment rate is the percentage of calls that customers abandoned prior to receiving busy or ringing signals.

The body of the table contains estimates, as percentages, of the incremental effects of several important service components. For example, the alerting tone is estimated to decrease mechanization rate by 0.2 percent, to increase walkaway rate by 1.4 percent, and to have no measurable effect on abandonments. Service component effect estimates are arbitrarily constrained to a zero sum on each performance measure.

Table I—Estimates of design decision effects on initial deposit request handling performance measures (√ indicates decisions taken)

Service Components	Estimated Performance Measure Increments: Mechanization Rate (%)	Walkaway Rate (%)	Abandonment Rate (%)
Alerting Tone (T)			
Present (Tone)	−0.2	+1.4	Nil
√ Absent (No Tone)	+0.2	−1.4	Nil
Voice Quality (V)			
Machine (Mach)	−0.1	+1.8	+0.2
√ Natural (Nat)	+0.1	−1.8	−0.2
Announcement Wording			
"Please deposit $X.XX for..."	−2.2*	+4.7	+0.1
√ "$X.XX please. Please deposit..."	+1.3*	−1.7	−0.8
"Please deposit $X.XX, $X.XX for..."	+0.9*	−3.0	+0.7
Deposit Interval Allowed			
4.5 secs	−3.7*	−1.6	−0.9
√ 6.0 secs†	+1.3*	+1.5	−0.3
8.0 secs	+2.4*	+0.1	+1.2
Speech Detector (S)			
Present (Det)	−1.0	+0.9	−0.1
√ Absent (No det)	+1.0	−0.9	+0.1
Interactions			
Tone/Voice			
√ Tone-mach or No tone-nat	+0.7	+0.5	+0.3
Tone-nat or No tone-mach	−0.7	−0.5	−0.3
Voice/Speech Detector			
√ Mach-det or Nat—no det	+0.3	−1.5	−0.2
Mach—no det or Nat—det	−0.3	+1.5	+0.2
Constants	86.4	19.8	11.5

* (Column) contrasts statistically different ($p < 0.01$).
† 5.5 secs selected, but 6.0 secs estimates used.

Most individual effects are estimated to be small—too small to be considered statistically different from zero with confidence. Those large enough to reach statistical significance at the 99-percent confidence level are indicated with asterisks. However, estimated effects are additive, in general.

The lower section of the table, labeled "Interactions," presents the estimable two-component interactions. These are, in effect, adjustments to the additive estimates above them. Because of the experimental design, not all such adjustments can be estimated.

To compare the performance of designs, sum estimates corresponding to each service design. For example, the service utilizing tone, natural voice, operators' announcement wording (shown first in the table), a 4.5-s deposit interval, and no speech detector would be expected to have a 10.3-percent lower mechanization rate than the service indicated by the checks (√). By adding the constants given in the bottom row of the table, the actual estimated rates are obtained.

Thus, the checked components result in estimates of 91.3, 14.5, and 10.4 percent for mechanization, walkaway, and abandonment rates, respectively, whereas the example alternative service results in estimates of 81.0, 19.6, and 10.1 percent, respectively—slightly better abandonment performance at the expense of mechanization and walkaway rates.

5.1 Alerting tone effects and recommendations

Prior to the simulation, it was reasoned that a short alerting tone would better prepare customers to understand the announcement requesting deposit and/or better prepare them to deposit promptly in cases when they knew the amount from previous experience. Thus, use of the tone should result in shorter times to first coin and better overall performance.

In addition to the effects presented in Table I, our data indicated that the ½-s alerting tone we used had no significant effect on time to first coin in most situations. However, on intermediate overtime request seizures, the tone boosted the seizure mechanization rate significantly: the tone, apparently, interrupts conversation more effectively than the announcement alone. Thus, the alerting tone is being used only on intermediate deposit seizures.

5.2 Voice quality

As mentioned earlier, a machine-like voice quality was tested in the simulation. It was thought customers might be able to respond more effectively to deposit requests if they realized they were being machine-served and they did not try to converse with the system.

The system performance effects of the machine-like voice were small, mixed, and generally not of practical importance; though walkaway rates are, apparently, increased. Overall, trends favored a natural voice slightly. However, interviewed customers strongly preferred the natural voice. Consequently, natural voice announcements are incorporated in the system.

5.3 Announcement wordings

Fairly early in the simulation study, the operator deposit request phrase (typically), "Please deposit 25 cents for the first 3 minutes," (listed first in Table I), was found to be less effective for the automated service than others. Repetition of the amount decreased average time to first coin and walkaway rate while increasing average proportion of seizures automated.

In retrospect, the improved performance associated with repeating the amount due is not surprising since Bronell and Schoeffler found that operators repeat deposit requests 3 to 15 percent of the time.

Because the automated service would not be able to respond directly to customer repeat requests, improvement is achieved by repeating amounts to everyone who does not deposit immediately.

The request wording chosen for ACTS is "25 cents please." (2-second pause) "Please deposit 25 cents for the first 3 minutes." Most customers begin depositing during the pause, truncating the announcement sequence.

5.4 Deposit and announcement intervals

The primary tradeoff for deposit timing is between allowing short intervals that favor customers who deposit quickly (but occasionally need the amount repeated) or need an operator,* and long intervals that avoid attaching an operator needlessly for customers who deposit slowly.

Announcements that repeat the deposit amount reduce the need for whole announcement repetition. Thus they increase the overall desirability of long interannouncement intervals, i.e., fewer customers must wait for prompting announcements. However, for customers needing an operator, lengthening interannouncement intervals degrades service quality. Therefore, in the final ACTS environments where relatively few customers reach ACTS when they need an operator, relatively longer intervals are desirable; in the environment where more who reach ACTS need an operator, shorter intervals are desirable. The appendix contains a discussion of a potential means of discriminating between customers who need operators and those who do not.

For initial deposit request seizures, 5.5-s interannouncement intervals were incorporated into the system. This choice represents an attempt to balance the mechanization rate benefit of 6.0 s and the walkaway reduction of 4.5 s (see Table I). For intermediate and end-of-conversation seizures, an 11-s interval is followed by operator attachment because repetition of the whole announcement was found to be ineffective in obtaining additional deposits.

5.5 Instruction cards

Bright orange instruction cards were placed on half the simulation coin stations, chosen randomly. Previous studies had indicated that coin station instruction cards are rarely noticed or used by customers. It was reasoned that, if such an attention-getting color was ineffective, no less noticeable card would work.

As anticipated, no practical, consistent changes in customer/system performance resulted from the use of bright orange cards. Customers

* Incorrectly dialing a "1" instead of "0" prefix will result in reaching ACTS instead of an operator. This dialing error is quite common now in areas where "1" is used to specify a station toll call to be paid by coin deposit.

did use stations with orange cards about 6 percent more often on the average, indicating that they noticed the cards from a distance. However, when interviewed about service, immediately after using stations with these cards, customers very rarely remembered any card details, including the color or the statement, "Note: Charges may be requested by a recorded announcement during an equipment trial." Therefore, no special card design or card information was recommended.

VI. CUSTOMER/SYSTEM PERFORMANCE AND CUSTOMER ACCEPTANCE ESTIMATES FROM SIMULATION RESULTS

Simulation results are not only useful in reaching design decisions but also in estimating customer/system performance for the design chosen. However, these estimates are strictly applicable only to the simulation site. Because the Bronell and Schoeffler service measurement study indicated that sites bear many overall similarities as well as significant differences, many findings of the simulation are expected to be accurate more generally. (Field performance of the final ACTS in the simulation site will provide valuable information about the adequacy of the simulation.)

6.1 Times to first coin

Fifty percent of first coins were obtained within 6 seconds of the beginning of the first announcement. Ninety percent of first coins were obtained in 12 seconds, 95 percent in 14 seconds.

6.2 Proportions of seizures mechanized

Seizure mechanization rates are estimated at 91 percent for initial deposit seizures, 64 percent for intermediate deposit seizures, and 76 percent for end-of-conversation deposit seizures. Notification (at the end of the initial period) seizures, because they require no deposit, will be essentially 100 percent automated. Overall, these rates are expected to rise with customer experience, but the rate of increase cannot be predicted from simulation data, since it was conducted over a relatively short (3-month) period with intermittent service at a limited number of stations.

6.3 Abandoned call attempts

Abandoned call attempts, which can occur only on initial deposit seizures, are estimated to be about 10 percent of initial deposit seizures. This rate is expected to decline as customers become accustomed to service. Abandonment from the stations used in the trial, on calls handled normally by operators, was about 7 percent.

6.4 Walkaway rate

The walkaway rate for the design chosen is estimated initially to be about 14.5 percent of calls extending beyond the initial period. However, the validity of this estimate is difficult to assess. It is considerably higher than the 7 percent for operator-handled calls from the same stations over the trial period. Furthermore, even though no trends were detected during the trial, the walkaway rate is not expected to decrease with customer experience.

Walkaway rate is being carefully monitored in the first ACTS installations to determine the need to adopt alternative overtime collection strategies.

6.5 Customer acceptance of automated service

Interviewed simulation customers generally preferred operator service to automated service. More than a third expressed very strong preference for operator service (8 or 9 on a 9-point scale from 1 = "strongly prefer automated service" to 9 = "strongly prefer operator service"). About 15 percent preferred automated service.

The quality of announcements was the most often noticed clue to customers that they were being machine-served. Seventy-one percent of the interviewed customers receiving the natural voice announcements recognized machine handling; 79 percent recognized the machine-like voice. However, it should be noted that 28 percent of the interviewed customers who received operator service thought their calls had been automated.

Overall, interview data indicate that customers will prefer operators to ACTS initially. As they gain experience with ACTS, acceptance is expected to grow due to increasing familiarity.

VII. QUESTIONS UNRESOLVED BY THE SIMULATION TRIAL

Several important questions were not answered by the simulation study. They will be studied in early ACTS sites:

(*i*) Will long-term customer acceptance require modification of the service?

(*ii*) How will the operator task be affected by ACTS? (Customers reaching operators will often be those who have failed to satisfy ACTS.)

(*iii*) Will walkaway rates remain at tolerable levels?

(*iv*) Should ACTS employ different announcements, timings, etc., in different locations? In the same location over time?

(*v*) Should a voice detector be incorporated into ACTS? (See the appendix for discussion of the voice detector.)

VIII. COST/WORTH ANALYSIS OF SIMULATION AND OTHER HUMAN FACTORS STUDIES

In addition to the savings provided by the initial proposal for ACTS, improvements in the ACTS seizure mechanization rate due to human factors work will yield substantial additional savings. Operator procedures and associated training materials developed for the simulation study were valuable in preparing for the actual service. Customer/system performance and customer acceptance evaluation tools prepared for the trial are now being used to evaluate early ACTS installations.

In addition, the simulation experiment forced the development, systems engineering, and AT&T operator services organizations to understand the new service in depth early in the development cycle. This understanding permitted early formulation of very detailed operational requirements. The experiment also provided an early indication of some unanticipated development problems. For example, it was discovered that the editing features for analog announcement source tapes were not adequate for producing high-quality announcements. A digital phrase-editing system was consequently proposed and developed in time for the first installation.

IX. ACKNOWLEDGMENTS

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APPENDIX

Considerations Leading to Proposal and Evaluation of a Voice Detector to Discriminate Between Customers Who Need an Operator and Those Who Do Not

Manual simulations revealed a problem inherent in the scheme of using machine-controlled announcements to obtain customer deposits: a *long* interannouncement interval is desirable to allow the slowest customers to make deposits without being "rushed," but a *short* interannouncement interval gives better service to customers who need immediate repetition of the announcement or operator assistance. What is needed is a way to discriminate between the two situations.

A potential solution was suggested during the manual simulations when we observed that customers desiring operator assistance often ask questions or make statements during the intervals following announcements, whereas customers preparing to deposit generally do not. For example, customers who say things like, "How much was that, operator?" "Make that a credit card call, operator," or "This is a collect call," need either an announcement repetition or an operator.

A "voice detector" was devised and built to end the ongoing deposit interval if speech occurs. Initially, this causes the announcement to be repeated. If talking persists, an operator is more quickly attached. Intuitively, this makes possible the provision of long intervals for (silent) customers slow to deposit while responding more promptly to those (speaking) who need announcement repetition or operator assistance.

The simulation trial did not provide a sensitive test of the voice detector for several reasons:

(*i*) Potential benefit is limited *a priori* to those users who need announcement repetition or an operator. The need for announcement repetition was largely eliminated by selecting announcements that state the amount twice. Also, customers needing an operator due to dialing errors ("one plus" instead of "zero plus") were unusually rare in Chicago compared to other cities Bronell and Schoeffler characterized.

(*ii*) No sensitive measures of the service improvements afforded by the voice detector were readily available. (Customers are unaware of the voice detector, and we were able to obtain very limited observer data.)

Our limited data indicate that the voice detector operated as intended. It was triggered in about 56 percent of the cases for which a shortening of the interval was beneficial but acted only 6 percent of the time when it was not potentially beneficial. The majority of cases it missed were due to customers talking during an announcement (when it was disabled because it would have been triggered by the announcement—an easily rectifiable design flaw). However, the voice detector had only a minor impact on primary performance criteria.

Inclusion of the voice detector cannot be recommended on the basis of the data available from the simulation. However, the problem the voice detector was devised to solve still exists and could, at some future time, be shown to justify voice detector inclusion in ACTS or other mechanized services where customer speech is a reliable and useful indicator.

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