input into the development process. It is believed that implementation of the following recommendations would represent a final step in the process of developing and applying uniform performance assessment methods for AFC equipment. It is recommended

1. That transit systems use the set of uniform definitions, classifications, performance measures, causal factors, chargeability criteria, and assessment methods and procedures for AFC equipment detailed in this paper;
2. That transit systems schedule performance surveys on a regular basis, using data from both in-service surveys and from internal records;
3. That performance results and failure distribution information be generated on a regular basis and made available to other properties through a system such as TRIP;
4. That surveys and statistical analysis techniques as presented in this paper be undertaken to measure and compare the performance of retrofit and nonretrofit equipment; and
5. That based on the established definitions and an adequate amount of performance data, equipment specifications be set that reflect achievable and uniform criteria as well as industry experience.

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An Examination of Transit Telephone Information Systems

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ABSTRACT

Some of the findings are reported of an examination of transit passenger information systems with particular emphasis on their technology-related subsystems and of an independent survey of the U.S. transit systems regarding telephone information systems currently in place. The first study examined the telephone information systems at three transit authorities, representing three categories: (a) a simple labor-intensive manual telephone system (Nashville--Davidson County Metropolitan Transit Authority), (b) a computer-assisted manual system (Washington Metropolitan Area Transit Authority), and (c) an automated system (Hamburg, West Germany). Each of these systems is designed to provide transit users with answers to their inquiries regarding transit system schedules, routes, and itineraries. A description of each of these systems as well as other components of passenger information systems is presented. The survey was carried out as part of a corporate-sponsored effort designed to provide new information about the type of telephone information system in place on transit authorities of various sizes in the United States. Information about planned changes and improvements is also provided.

In this paper some of the findings are reported of an examination of transit passenger information systems with particular emphasis on their technology-related subsystems and of an independent survey of U.S. transit systems regarding the type of telephone information system (TIS) currently in place. The former was conducted as a part of the project entitled Assessment of Transit Technologies carried out within the New Systems Alternatives Program for UMTA; the latter was carried out as part of a corporate-sponsored effort.

PASSENGER INFORMATION SYSTEMS

Passenger information systems are generally part of a broader transit marketing effort that includes everything involved with making a transit system attractive for the transit users in a region. Because passenger information systems in general, and the TIS in particular, are part of the overall transit marketing effort, it is important to keep in mind that although the information system performs an important service function, it is also an important marketing activity. In recent years it has become widely accepted that transit, like any other industry, is in the business of selling a service to its customers. The marketing activities of a transit agency are aimed at tailoring services to potential customers and meeting their transportation needs. Serving the transit consumer is at the heart of the transit business. Market research and planning studies are used to identify the various segments of the market defined by travel characteristics and ability to pay. The purpose of advertising is to inform the public, to stimulate demand, and to change attitudes toward the product advertised. Advertising is used to bring information about the system and its services to the public's attention.

Passenger information consists primarily of maps, schedules, and signs. It is used to educate the potential rider on the use of the transit system and to turn potential users into riders. It helps people use the service by answering some basic questions that they may have. Typical questions and the information aids used to respond to them include the following (1):

Question	Aid
What kind of service is offered?	Information on regular route service, special service (dial-a-ride, subscription, charter, contract, and so forth)
Where does the system go?	Maps
When can I use the system?	Schedules
Where can I catch the bus?	Shelters and bus stop signs
How much are the fares?	Fare schedules and promotions
How can I use it?	Schedules, maps, signs, promotional materials

The passenger information system has two main functions to perform. It provides general information (e.g., types of transit service, how-to-use information) that tells the potential passenger how to make a trip and where to get more specific information (e.g., detailed routing, station and stop locations, schedules, fare information) and it provides specific trip information so the passenger can find his way through the system, as illustrated by the following.

Figure 1 shows the major components and subcomponents of a transit passenger information system and which of the functions each component of the information system performs. The darkened squares indicate the type of information listed at the top of the column that each component is capable of delivering. A newspaper ad, for example, can include basic information about the transit system and the service it offers or sell a particular service such as express buses for baseball games. How-to-ride information may fit into the ad as well.

TELEPHONE INFORMATION SYSTEM

The TIS is most effective when used for delivering specific information. It is usually used by passengers who have a general idea of where the system goes and how to use transit (a first-time rider knowing nothing about the system calls to find out if he can use it to reach his destination). Telephone systems are the most complete single source of detailed transit information.

Useful as it is, however, a telephone system cannot stand alone as a passenger information system. Because telephone information is not printed, it has a short life. Unlike a timetable, it cannot be referred to again en route. The information it conveys is extremely specific; normally it is used for only one itinerary. Whenever the rider wants to change his destination or his travel time he must make another call.

The objectives and to a large extent the accomplishments of a TIS can be summarized as follows:

- Personalized service: The telephone system can give the prospective rider all the exact information needed to make a particular trip. An information agent can tell the caller where and when to catch a bus or train, where to transfer if necessary, and where to get off as well as fare and other information.
- Convenience: The telephone provides a method of giving out transit information when it is convenient for the rider. Every other information component requires the rider to obtain some form of printed information from the agency.
- Special information: The TIS is a good means for the transit agency to disseminate information about service interruptions, special services, or new routes and schedules. Accurate information can be passed along to the passengers in less time than it takes to print new schedules and maps.

CATEGORIZATION OF TIS

The component parts of a TIS are determined by many factors, including size and complexity of the transit system, marketing budget, and number of incoming calls. Four broad categories have been chosen that encompass all the functions of the information systems and the majority of equipment currently in use. These are manual systems, microfiche-assisted manual systems, computer-assisted manual systems, and automated systems.

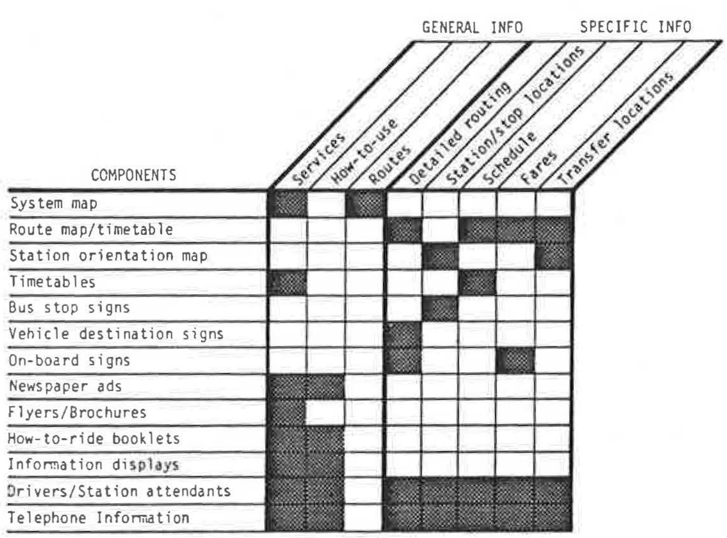

FIGURE 1 Functions of passenger information system components.

Manual Systems

Manual systems are the least complex in terms of technology and also the most common among North American transit systems. A manual TIS requires an information agent for all communication with the caller and for determining the response to the caller based on some type of hard-copy data base. The data base can consist of route maps, local street maps, headway sheets, drivers' schedules, timetables, notes and memos the agent uses as memory aids, daily bulletins on service interruptions or street closings, and other such information. The data base also includes the information the agent may have memorized over the course of his employment with the transit authority. Memorized information can be the most valuable, because it requires no retrieval time and thus results in the fastest call handling. It is of course crucial that the information memorized be up to date.

Microfiche-Assisted Manual Systems

Microfiche systems operate in much the same way as manual systems, with the exception of information storage. Instead of paper copies of maps and schedules, these data are microfilmed onto sheets, typically 4 x 6 in. (10.2 x 15.2 cm). The amount of space needed to store the route and schedule information is reduced immensely. Sorting can also be improved if some thought is given to the order of the pages as they are microfilmed.

Microfiche, with an automatic retrieval reader, may speed up the task of searching for information, changing the task from one of flipping through pages of schedules to keying in the route number on the reader. Bulletins, notes, and changes would still be kept on paper at each agent's station.

Computer-Assisted Manual Systems

Computer systems can give the information agent more capabilities than a microfiche system, or they can be used as a simple electronic data storage device. If used to project route and schedule information, computers have two advantages over microfiche. First, information retrieval is faster, and second, changes in the data base can be processed immediately, without need for refilming and printing microfiche for every agent station.

A computer-assisted system can also be designed to calculate itineraries, transfers, and fares for the caller, with appropriate inputs regarding origin, destination, and time of travel. The Automated Information Directory System (AIDS) in use at the Washington Metropolitan Area Transportation Authority (WMATA) has this capability. For a complex transit system, the ability to calculate itineraries can save an agent a significant amount of time in the handling of difficult calls. Information agents at WMATA, including the more highly skilled agents, value the ability of the computer to calculate trips based on a desired time of arrival, complex suburban trips, and long-distance trips. Questions about these trips are the most difficult ones to answer because of the necessity of backing up through successive timetables on different routes to determine the correct departure time.

The heart of a computer-assisted manual system is the computer. It can be time shared with other departments of the transit authority or dedicated for the use of the information section. The latter is preferable, because it will be in use constantly as the agents search and retrieve data and time-sharing activities can delay the system retrieval time.

Each agent should have a video display terminal (VDT) along with a complete set of paper schedules and maps. Because the fastest method of call handling has proven to be a mix of memory and manual and computerized information handling, it is important that all the materials required for a manual system be present for a computer-assisted system.

There may not be any money saved in training or printing costs by switching to a computer-assisted system, but it can be expected that the overall call-handling rate and the consistency of responses of the information center will improve.

Automated Systems

Because they are the most technologically sophisticated of the four categories, automated systems are somewhat difficult to describe. Nearly every automated system is unique, both in capabilities and in hardware. Telerider systems are designed to answer one particular kind of question (arrival time of the next bus at a particular bus stop). Telerider uses a unique telephone hookup: Instead of there being a general information number and having all callers answered by a central facility, each bus stop has an individual telephone number. The Telerider data base and voice synthesizer equipment provide the desired response. The act of calling Telerider is also the information request; the automatic response is initiated by the telephone call.

The automated telephone information system in use in Hamburg [Automatische Fahrplan Information (AFI)] is a fully automated operation with a user-machine dialogue utilizing synthetic voice generation. The caller asks a question by dialing a preselected sequence of numbers. AFI selects the optimum route for the caller from among the feasible connections between the origin and destination points and presents it to the caller together with fare information via a speech synthesizer.

ASSESSMENTS OF THREE REPRESENTATIVE SYSTEMS

Assessments of three representative TISs are summarized that range in technical complexity from labor-intensive manual systems to fully automated computerized systems. The manual system examined was that at the Nashville--Davidson County Metropolitan Transit Authority (MTA). The MTA, with approximately 115 buses in peak service, is a medium-sized system but larger than 75 percent of all U.S. bus systems; if systems of this size have a TIS, it is likely to be a manual one. The second system examined was AIDS, in operation at WMATA in Washington, D.C. Conceived as a demonstration program, AIDS has evolved into an operating system that forms the basis of all WMATA TIS operations. AIDS is a computerized data storage and retrieval system that automatically provides route, schedule, itinerary, and fare data to the information agents. The third system examined was the AFI system in Hamburg; AFI is a fully automated, computerized system with which a caller can carry out an inquiry dialogue.

MTA Manual System

The Nashville--Davidson County MTA operates approximately 115 buses during the peak periods over 531 $mile^2$ (1,377 km^2). The MTA telephone information center operates from 6:00 a.m. to 7:00 p.m. Monday through Friday and from 8:00 a.m. to 5:00 p.m. on Saturday. The average number of calls per day is 1,400, the maximum about 4,500. An information agent handles an average of 250 calls per day and a maximum of about 500 calls per day.

The telephone information center is perceived as a public service operation provided for customers seeking any information about MTA service. Telephone information agents respond to all calls, including those that are not related to MTA business; information on schedule or route changes during weather (or other) emergencies is considered extremely important (call volume increases noticeably during such periods). The information center personnel believe that transit users are dependent on them for system operations information, particularly for work trips.

No surveys have been conducted by MTA with regard to the nature of telephone inquiries. It was indicated that the center gets all kinds of calls; the telephone information center number is highly publicized as a general information number and callers seek all types of information, including on occasion time and temperature. The information agents are located in a single office with six desks for the information agents and a partitioned space and desk for the Director of Information; no additional dividers or sound-deadening materials are used.

At the time of this study the system hardware consisted of six call directors with a rotary system (definitions of equipment hardware are given in a later section). Seven incoming lines are used by the information center; an eighth line, dedicated to ridesharing information, is also manned by the information agents. An automatic answering device is used when the phones are not being manned. There is a TTY system (an electromechanical device that enables a telephone to be used to communicate between two typewriting devices) for the hearing impaired at a specially designated number.

The system has been in operation since 1974 and MTA reports that it has had no problems with the equipment. While the study was in preparation, MTA purchased an automatic call distributer (ACD) system that can serve up to 8 lines and 8 agent positions and is expandable to 32 lines and 32 positions.

The MTA information agents respond to inquiries from memory or through the use of printed schedules, route maps, and route descriptions that they keep at their desks. The caller is generally asked to provide information regarding his location, his destination, and his arrival or departure time or both. Once these inputs are established the agent can determine the appropriate response and convey it to the caller. In addition to providing immediate verbal responses to caller questions, the information agents take requests for route or schedule information and mail it out; they also fill out inquiry forms for the ridesharing program.

MTA estimates that the average time per call is less than 2 min and that 60 percent of the calls are 1 min or less. An internal study of agent activities revealed that there are few lost calls and that a call is usually answered within three rings. No lost-call information is available, although it would be possible to request that it be collected by the local phone company. The data collection period would have to be from 8:00 a.m. to 4:30 p.m., the hours of operation of the phone company.

Although MTA does not isolate all costs directly related to the information center, it was possible to estimate the cost of the system from the data available. An internal report indicates that the annual operation (service charge) cost of equipment is approximately $6,200. Annual cost of agent salaries, fringe benefits, and overhead is approximately $132,000 for a total of $138,200. Based on the weekly call records the annual number of calls answered is between 300,000 and 400,000. The cost per call therefore ranges between $0.30 and $0.37.

WMATA AIDS Computer-Enhanced System

AIDS, used by WMATA in Washington, D.C., is one of the most sophisticated transit telephone information systems in North America and has been the subject of an extensive development program. AIDS is a computerized data storage and retrieval system that allows information agents to provide detailed routing and schedule information for trips on the fifth-largest multimode transit system in the United States.

WMATA operates some 1,767 buses over 775 bus routes (143 bus lines). There are four rail lines at present covering 42.4 miles (67.8 km). When it is completed, the rail system will have five lines covering 101 miles (162 km). The transit ridership in 1981 was 182,532,237 passengers.

The objective of the WMATA telephone information system is to provide a transit customer with personalized information about transit system service. For customers who do not possess printed transit schedules or maps, calling the transit telephone information service is a quick and convenient method of learning how to make a particular trip via transit. Even customers who possess printed transit schedules or maps often find it useful to call a telephone inquiry service in order to interpret or verify information. The AIDS project was sponsored by UMTA as a demonstration effort to develop and evaluate a usable and effective computer-aided transit information system that could be used throughout the United States, particularly where companies operate a complex transit network (2).

The information staff consists of 57 agents and 7 supervisors with one trainer and an AIDS coordinator. There are at most 30 agents on duty at any particular time. The average call load per agent is 180 calls per day; the maximum is approximately 300 calls per day, although one agent logged a record 700 calls during a blizzard (this was before AIDS). On that day there were a great many short calls inquiring about a change in the transit schedules for workers going home early or inquiring whether federal employees would be released early. Such calls are common during bad weather. It is assumed that because there are so many workers with one employer (the federal government), the transit system will be forewarned when the commuting pattern is changed, which does not occur at this time.

WMATA's Stromberg-Carlson ACD is equipped with a peg counter that counts the number of calls received and the number of calls answered. The difference between these two indicates the number of calls lost. The counter is read hourly, and although it can be reset, this is not done. The counter will reset itself to 000 after 999 calls have been counted. It will also count the number of calls handled at each agent position. The counting of calls is by work station rather than by agent identification. No reports are available on average caller waiting time, average call length, or trunk condition.

The AIDS system uses Hazeltine 1510 VDTs and two identical Hewlett-Packard HP-3000 Series II computers, installed in 1978, and it is in the process of being expanded with an HP-3000 Series III computer. The two Series II computers are being upgraded to Series III models as well. The computers are dedicated to the information system during the hours it is in operation; in the off hours they are used for related activities, including generation of bus-stop files, landmark files, and lists of routes for cost allocation. These data are readily available through the AIDS data base and can be used for planning and scheduling.

The applications program for the AIDS system was custom written for the system. It includes data base search, retrieval, and handling. The computer does not store the entire data base in internal memory during operation. Data called up most recently stay in internal random-access memory, and periodically they are all copied onto a disk. Data used most often tend to stay in internal memory, which provides shorter response times. The programs will calculate itineraries based on shortest travel time, shortest wait time, or shortest walking distance as requested by the caller.

AIDS uses a geographic data base constructed by overlaying a grid of squares 25 ft (7.6 m) on a side on the Washington region; 13,000 bus stops, 700 routes, 26,000 streets, 40,000 intersections, and other landmarks are located by coordinates on the grid.

The AIDS system provides agents with a prompting method of data entry. The system displays on the VDT a series of statements and blanks to be filled in by the agent. When all entries have been completed, the system evaluates the entries to determine the type of query and selection ranking. It then performs the calculations and displays a reply.

At any point during the entry and processing of a query, the agent may correct or alter any entry already made. The AIDS system recognizes erroneous entries and displays a prompting message so the agent can reenter the data. Once the entry has been made properly, the system continues handling the transaction normally.

Information agents at WMATA are given a 5-week training course in the transit and telephone information system before they are put to work full time. The training manual used by WMATA emphasizes the sales aspects of the job. Information agents are trained to think of themselves as WMATA's first sales contact with the customer. As a result, the attitude and courtesy of the agents is considered very important.

System familiarization is made up of two parts: learning the routes and schedules from maps and headway sheets and learning the routes and route surroundings from riding trains and buses. Trainees are encouraged to take their area maps with them while riding the system and to mark down the route as they travel, writing in landmarks and other aids for future calls. Altogether, system familiarization takes up more than half of the time spent on training.

Operating costs for the AIDS system are estimated at approximately $1,743,950 annually, and the total capital cost of the AIDS system was approximately $1,258,000. Daily call counts are approximately 6,000 calls, averaged over a week, resulting in an annual total of 2,190,000 calls. The operating cost per call, therefore, is on the order of $0.72. If the AIDS development costs were amortized over a 10-year period, this would add $0.06 to each call for a total of $0.78 per call.

The implementation of AIDS, as stated earlier, was originally a demonstration of new technology rather than the application of existing technology. UMTA's goal was to determine whether a computer system could be developed that would provide for automation of the telephone information function and to determine the cost of such a system. AIDS must be evaluated as being a first-of-a-kind application. In comparing the results of the AIDS system with the system goals and the expected benefits, it appears that UMTA's goal of demonstrating computer technology for a TIS has been met satisfactorily. The system is workable, useful, and, after the initial debugging period, has not required an inordinate amount of maintenance and repair. As a result of the AIDS demonstration, information has been obtained that will prove useful in reducing errors and avoiding unnecessary costs in other deployments.

An AIDS evaluation study (3) indicated that before AIDS, 72 percent of the calls lasted 2 min or less; after installation 72.5 percent of calls were of this same duration. The percentage of calls 3 min or less was 86.5 percent and 87 percent before and after, respectively. There is some indication of a reduction in call length since AIDS was implemented. It was expected that the longest calls would be most affected because they involve more complex calculations. The computer should speed up these calls, so there would be fewer calls on the long end of the spectrum.

WMATA does not have the ACD equipment and software necessary to monitor and compare a single agent's performance while using AIDS and while relying on manual techniques. Should they acquire such equipment in the future, it would be useful to monitor the system in a controlled experiment to get a better idea of productivity changes.

The information agents indicate that AIDS provides reliable information while making a greater quantity of information available for callers. It is also reasonable to assume that when the agents use AIDS, they will be drawing from a consistent data base and, particularly for complex inquiries, the agent response will be consistent throughout the section for the same inquiry. The penalty attached to a longer call that provides improved quality and quantity of information is considered acceptable.

The expected benefit of reducing the amount of time needed for agent training has not come about. The agent training course now is as long as it was before AIDS implementation. However, with AIDS, once training has been completed, the agent achieves an acceptable level of productivity more quickly.

The computer system does not collect information on agent performance. It can keep track of the length of time required to key in a query, the data retrieval time, and the length of time before another query is input, but these numbers may have little to do with how long it takes an agent to answer a caller. The AIDS system is not connected with the ACD in any way and does not collect data on how long the telephone is in use for each call. Agent performance data can be collected with a state-of-the-art ACD or private automatic branch exchange (PABX), and although WMATA does not have this kind of equipment at present, it is in the process of purchasing a computer-based ACD.

WMATA has also considered installing remote terminals connected to the AIDS computer so that passenger information can be accessed without a telephone. Likely places for such an installation are the two metropolitan airports, large shopping centers, hotels, and so forth. Hardware procurement was being planned in late 1982. WMATA is actively pursuing other spin-off applications of the AIDS system and its data base, including market and planning research, graphics, and bus-stop information. Consideration is also being given to the integration of AIDS with interactive cable television and information systems.

Hamburg AFI Automated System

The automated TIS in Hamburg was examined to present a description and assessment of a system that operates in a large multimodal transit system and provides 24-hr access to full, spoken schedule information. The Hamburg AFI system is a highly complex passenger information system that is fully automated and capable of user-machine dialogue using synthetic voice generation. AFI has no human information agents.

The conventional central TIS has been in operation since 1980. It is completely manual and concentrates previously decentralized functions under one published telephone number at the Hamburg Transit Association. Total staff for the manual TIS is five. The service operates on weekdays from 7:00 a.m. to 10:00 p.m. In the absence of the automated TIS, approximately 500 to 600 calls per weekday are serviced by the manual system. Of these calls, about 60 percent are related to schedule information, about 28 percent to fares, and about 12 percent are classified as other.

From June 1979 until May 1981, AFI was operated as a demonstration and test system in Hamburg. During the demonstration, periodic changes were made to hardware and software, and accompanying studies were performed. In these studies user surveys were conducted to measure acceptance, cost-effectiveness, and influence on user behavior.

At the completion of the demonstration, work was continued on development of final modifications to the hardware, software, and operation of the system. This work is nearing completion. The implementation of such a system with full access for the total service population is being planned. Hamburg is interested in having the first fully implemented AFI system; other cities and regions are also interested in acquiring such a system.

The AFI automated TIS as demonstrated in Hamburg consists of three main parts:

1. A central processor unit (CPU), which stores all schedule data and computes the best connection based on trip request inputs;
2. Five automated auxiliary machines, which provide hard-copy printouts of the trip information after user input of destination code numbers; and
3. The telephone interface system, which includes the speech-generation component.

The caller communicates with the system via either the keyboard on the automated auxiliary machines or a telephone at home or any public telephone in the local call area.

A PDP 11560-CD from Digital Equipment Corporation (DEC) was used as the CPU. This unit has a 16-bit processor and a 128K memory capacity. For the speech output, nine CAMAC telephone interface modules were used, one for each line. Each module had one telephone connection dedicated to one output. The output from the CAMAC telephone interface module is routed through the appropriate channel of the multiple call director to the correct outgoing telephone line.

The system software is programmed in FORTRAN IV. The main part of the program is the route search routine, which is designed to select the optimum route for the caller from a large number of possible connections between the origin and destination points. The trip recommendation is determined in four steps:

1. Search for feasible connections,
2. Preliminary evaluations of connections,
3. Determination of trip data, and
4. Evaluation and selection.

Feasible connections between origin and destination are searched and calculated by using a stepwise approach. In the first step connections with a minimum number of transfers are calculated. The second step establishes connections with one additional transfer required. If a second step connection is not feasible, the third step is initiated and connections with more transfers are searched.

Once a set of feasible connections has been established, a preliminary evaluation is performed. This is done to reduce computer time, because both accessing schedule data and evaluating connections are time consuming. In the preliminary evaluation, the connections are evaluated by using factors that are available without disk access. These factors include average ride time between stations or stops and average transfer times. The preselection routine results in a rank ordering of connections.

Operation of the system via telephone requires the user to first look up the code numbers for his origin and destination station or stop in an address directory, which includes simple instructions for system use. After making telephone connection with the system, the user starts his dialogue, during which the system takes the speaking part and the user responds by dialing code numbers on his telephone.

The dialogue sequence starts when the machine requests the required inputs from the user. The caller then dials the code numbers for departure station, destination station, the weekday, the desired time, and a number for designating the desired time as departure or arrival time. Special note pads are provided to assist the caller. If the caller makes an input error, dialing 99 allows him to start the sequence again from the beginning without losing the connection. The number of digits to be dialed is 14 plus the telephone number to access the system.

The Hamburg automated TIS application was a test and demonstration program. Therefore, a system with only limited capacity was installed. To avoid overloading the system, the distribution of directories and the number of automatic auxiliary machines installed was limited. Several surveys and accompanying studies have been performed during the more than 2 years of system operation to measure system performance and acceptance by the user.

At system startup, directories enabling callers to use the system were distributed to 1,500 households that statistically represented the service area. After the system software and hardware were performing well, an additional 8,000 directories were distributed to interested persons.

After the issuance of both the first and the second set of directories, user frequency was high. However, after some initial fluctuations in demand, the user frequency stabilized. The average demand on the system was about 1,000 calls per day and 100 calls per peak hour. An extrapolation of the experienced-user frequency from the test households to the 750,000 households in Hamburg was performed. It was projected that if the system were made accessible to all households in Hamburg, approximately 10,000 to 12,000 calls per day would be made. The peak-hour frequency would be approximately 1,000 calls per hour.

It takes approximately 3 min to obtain a trip recommendation over the telephone. Many users became adept with the system and needed only 2 min or less. Lost calls were not a problem. According to German communications regulations, all telephone systems must be sized so that no more than 3 percent of incoming calls encounter a busy line.

Data on the system availability during the demonstration period were not made available. The system was maintained by the supplier (Dornier). Based on the demonstration experience, the operator expects an availability of 99 percent when the final expanded system is installed. This expanded system will have 80 incoming lines to fill the demand as outlined previously.

Cost estimates for the planned expanded system with 80 incoming telephone lines and sufficient capacity for 10,000 to 12,000 calls per day have been made by the operator in cooperation with the suppliers. It is estimated that the capital costs will be $5 million. The annual costs, including operation and maintenance, are estimated to be $1.8 to $1.0

million and approximately $1 million for annualized capital costs.

A potential limitation in some applications in Germany is the lack of accessibility with some telephone systems from outside the local call area. In Hamburg, the system could only be accessed by local calls. Long-distance call use was not possible. Touch-tone telephone systems provide unlimited access. Special technical provisions by telephone company authorities are needed for non-touch-tone telephone users to allow code number input to such an information system.

Three surveys were performed during the operation of the system. In the first 4 weeks after system operation started, 26 percent of the subjects used the system an average of eight times each. This user frequency stabilized at 10 percent of the test population using the system an average of 1.4 times per week per subject.

Surveys indicated that more than three-quarters of those calling the system also made a trip. One-third of the test population made transit trips for which private automobiles would have otherwise been used. Normalizing the statistical results shows that 0.053 transit trip per household per month is made for which an additional fare needs to be paid. It should be noted that in Germany use of passes or multitrip tickets is much more common than in the United States. Most of the trips resulting from use of the information system were nonwork or occasional trips, for example, 26 percent for visits, 21 percent for shopping, and 17 percent to special entertainment. This shows that such a system not only can attract riders but also increases revenue. The high proportion of occasional riders also increases transit use in the off-peak hours.

NEW TECHNOLOGY: TELERIDER TIS

Telerider is an automated schedule information system that enables a caller, by dialing a special telephone number, to obtain information regarding the scheduled arrival of buses (usually the next two to arrive) at a particular stop as well as preprogrammed status information and public service messages for the route or the transit system in general. Each bus stop can be assigned its own telephone number, and the computerized Telerider data base and voice digitizer equipment provide the specific information desired within a short period of time and without the cost or delays of human information agents.

A call to Telerider represents the information request function; the system is capable of only one response: the time of the next (one or two) bus arrival or arrivals at that stop. The caller selects a particular bus stop by the number that he dials; he cannot provide any other information or make other inquiries. The response information is stored in the Telerider computer and the call into the system initiates the automatic response.

An advantage of the Telerider system is that once implemented, it can provide responses quickly, efficiently, and reliably without using information agents and without busy signals. Schedule changes can be accommodated almost immediately from output from a computer program (RUCUS) or direct input into the data base.

The system includes an automatic message-shortening capability that is activated when most of the telephone trunk lines are busy. This provides an automatic capacity increase in the event of high demand without the cost of adding more capacity; it also provides more flexibility for system sizing. In the rare event that all trunk lines are busy and additional calls come in, excess calls receive a busy signal.

The Telerider computer (both DEC and IBM Series I hardware have been used) has two basic data bases, a stop file, and a schedule file. An incoming call actuates the stop file first (because each telephone number identifies a unique bus stop) and then a request is made to the schedule file for information. Additional messages can be accommodated and any voice can be used to present the message; the voice used may be chosen on the basis of its information clarity or its promotional value. Messages regarding route status information, route or weather emergencies, and route or fare changes are particularly useful.

Telerider uses digitized speech because it is considered to be simpler and of higher quality than formant synthesized speech. Telerider modifies existing off-the-shelf equipment to suit its purposes.

Test applications of Telerider systems in Ottawa, Ontario, and Columbus, Ohio, have been deemed successful by the local transit agencies. Expansion to full system coverage has been implemented in Ottawa and has been initiated in Columbus. Other tests are under way in a number of U.S. and Canadian cities.

TIS SURVEY

There is little information available regarding the state of the art of the transit TIS; in particular, little has been documented about the nature and types of TISs currently in place throughout the United States. Information about the TISs in 28 transit systems has been included in the Mitre TIS workshop proceedings (4). However, the author knows of no update or additional information of this type.

In an attempt to expand on and update the Mitre information, a one-page information request was prepared and sent to 130 transit authorities in the United States. The request form is shown in Figure 2. The information requested includes items that were of most interest in the study described earlier and that were most often mentioned by transit authority representatives with whom the project was discussed. Careful attention was given to preparing a single-page request form; an introductory letter and an addressed return envelope were also included.

The results of 73 returned information request forms (5) are presented in the following in the same order as the items on the information request form. In some cases a composite result has been prepared; in others, averages or ranges of values are given. Where appropriate, the results are presented by category; each category is defined by a range of number of buses according to the following: small (S), less than 100 buses; medium (M), 100 to 250 buses; medium-large (ML), 259-500 buses; and large (L), more than 500 buses.

Objective

The composite response to the first question is expressed as follows: The objective of the TIS is to provide accurate and timely information on schedules, routes, fares, and other services in a courteous and efficient manner to customers and potential customers.

Hours of Operation

The responses to this question are presented in Table 1 in relation to the categories of systems discussed previously. L systems have longer hours of TIS operations, reflecting the longer hours of oper-

With regard to your telephone information system (TIS) please provide the following information. If it is helpful to attach additional sheets or forms which provide the requested information, please feel free to do so.

1. What is the primary objective of your TIS?
2. TIS hours of operation: Weekdays _______ Weekend _______
3. TIS information agent:
   - (a) Staff positions ____ (d) Salary range ____________
   - (b) Staff positions filled ____ (e) Supervisory positions ____
   - (c) Peak agent loading ____
4. What skill level do you require for entry level TIS agents? ____________

   How long is your training program? ____________
5. Where is the TIS located in your organization (marketing, operations, etc.)?
6. Number of incoming trunk lines for your TIS _____.

   Number of stations for TIS information agents _____.
7. TIS equipment in place and year of installation.
8. TIS equipment you would like to have.
9. What changes/improvements would you make to your TIS?
   - Add work stations ☐ Improve TIS agent reference materials ☐
   - Improve call traffic data ☐ Improve TIS agent training program ☐
   - Install computer data base ☐
10. Do you assume that a TIS inquiry generates a transit fare, or a portion of one? YES ☐ NO ☐

    If yes, what is the basis for your answer?

    If no, would an estimating procedure be helpful to you?
11. Please provide data on calls per hour and calls per day for an average or typical day and week.
12. Is there any information you would like to have which you think would help you to evaluate the service provided by your TIS? What is it?

FIGURE 2 Information request form.

ation of the transit system. Every responding system has a TIS in operation between 8:00 a.m. and 5:00 p.m.

Information Agent Staffing Data

This information is summarized in Table 2, which presents average sizes for the responding systems in each category; the average number of staff positions; the average number of staff positions filled; the average number of supervisory positions; and the average salary range for information agents.

Qualifications for Information Agents

Although it is difficult to develop a consensus in view of the range of qualifications reported, most transit agencies require someone with a high school education or equivalent, supplemented if possible by clerical skills and communications skills. Agent training ranges from 1 or 2 days to 6 months; in most cases 3 to 4 weeks of training are given. Larger transit systems have longer periods of training. This is reasonable because the requirements of the job must be learned along with the transit system. Because route structure complexity increases with increasing system size, the job demands are much greater for larger systems.

Location Within Transit Organization

All the L systems and most of the ML systems have the TIS located in a marketing group or a customer service group within a marketing section or department. In M and S systems, the TIS is primarily located in a marketing group or operations and administrative units. These differences appear to reflect the increasing specialization and organizational diversity of larger systems.

Number of Trunk Lines and Agent Stations

In Table 3 the information provided on trunk lines and agent stations is summarized with respect to the system sizes. Preliminary statistical analyses yielded no useful information relating size to either trunk lines or agent stations. (Further analysis was under way at the time of the preparation of this paper.)

TIS Equipment in Place

Information provided on equipment in place is summarized as follows:

Equipment	No. of Items by Category: S	M	ML	L
Call distributor or standard phone	8	5		
Call sequencer	5	2		
PBX or PABX	2	2		2
ACD			6	9
Unidentified or miscellaneous	15	10	2	2

In order to fully explain these results, a number of definitions of generic equipment types from the study mentioned earlier (4) are presented in the following.

Call Director

A call director gives every telephone receiver direct access to all incoming trunk lines via keysets

TABLE 1 Number of Transit Systems and Hours of TIS Operation

CATEGORY	HOUR: 1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12N	1P	2P	3P	4P	5P	6P	7P	8P	9P	10P	11P	12M
S				1	4	10	20	23	23	23	23	23	23	23	23	23	17	11	7	4	2	1	1	
M	2	2	2	2	3	12	19	19	19	19	19	19	19	19	19	19	18	13	10	6	4	3	2	2
ML					1	6	6	6	6	6	6	6	6	6	6	6	6	4	2	2	1			
L	1	1	1	2	3	9	11	12	12	12	12	12	12	12	12	12	12	12	8	7	6	6	5	

TABLE 2 TIS Information Agent Staffing Data

	CATEGORY			
	S	M	ML	L
Avg. Size of Respondents (No. of Buses)	69.2	168.5	356.8	1,091.0
No. of TIS Positions	2.7	5.9	11.6	23.4
No. of Positions Filled	2.7	5.8	10.8	22.6
No. of Supervisors	0.7	1.2	1.4	2.8
Avg. Salary Range ($)	10,018-13,671	9,126-12,145	11,410-15,980	15,139-19,541

that include a hold button so that each receiver can be used to put callers on hold. There is no priority queuing on this system; calls are taken off hold at random, with no relation to how long each caller has been waiting. Agents select which call to answer and how long to take before answering calls.

Call Sequencer

A call sequencer can be used with a call director or with a PABX (see the following). All incoming trunks connect to the call sequencer, which places incoming calls in a holding queue and then signals all the receivers which call is the oldest (first in line) with a light that flashes faster than the others. It is designed to be used with keysets, but because it is an interface between trunks and receivers, it can accommodate more trunks, and therefore more callers, than a straight call director. Agents can select which call to answer and how long they will wait to answer, but a signal indicates the oldest call in line and agents are trained to answer that call first. In addition, call sequencers are available with additional features such as voice recordings and music.

ACD

An ACD takes incoming calls and puts them on hold if necessary. In this respect an ACD incorporates some of the same features as the call sequencer, but it differs in having a feature called call forcing. An ACD will automatically route calls to available agents instead of allowing agents to connect themselves to incoming calls by pushing a button. An agent's receiver in an ACD system can be a single-line set. Receivers do not have any access to trunks unless routed by the ACD, which acts as a sequencer

TABLE 3 Number of Trunk Lines and Agent Stations Versus Size of Transit Authority

Type of System	No. of Buses	Incoming Trunks	Agent Stations	Type of System	No. of Buses	Incoming Trunks	Agent Stations
Small	54	2	3	Large	520	14	10
	74	5	6		599	25	20
	54	3	2		2,500	36	30
	58	3	1		837	34	20
	78	1	4		1,300	22	21
	52	4	2		1,004	26	23
	57	4	2		528	10	10
	70	3	1	Medium-large	365	20	10
	44	4	2		335	36	9
	56	3	5		445	10	13
	82	4	5		366	23	23
	86	5	4		254	8	6
	99	5	2		310	10	9
	58	3	2		456	8	7
	77	8	3		323	10	8
	65	4	2	Medium	210	3	3
	64	1	2		223	15	15
	80	3	4		101	6	13
	85	5	4		228	12	12
	81	5	4		102	1	1
	93	8	3		163	7	7
	54	8	1		196	1	7
	60	5	3		115	2	3
	59	4	3		116	4	3
	53	1	3		111	4	3
	83	5	3		106	8	4
	60	3	2		212	8	4
	45	3	1		235	16	4
	81	5	1		235	4	4
Large	997	35	23		220	3	4
	554	21	13		217	7	9
	1,069	39	19		102	4	5
	1,202	16	16		118	6	4
	557	11	11		100	8	3
	1,059	23	15		211	11	9

and an automatic switch. There are several ways to route calls to agents; in most cases, calls enter and leave in a first-in first-out (FIFO) pattern. This ensures that all calls are served with an approximately equal wait, and none are lost by being accidentally ignored. Other methods of routing are first available agent, uniform call distribution (levels agent workload), longest available agent, terminal hunting, and circular hunting. At peak traffic periods, it is desirable to connect incoming calls to information agents as rapidly as possible. In this case, as soon as an agent becomes available, another call should be routed to him. As a result, the speediest and most efficient agents will end up taking the most calls, thus increasing their workload.

PBX or PABX

A PBX or PABX is a user-owned internal telephone switch. The PBX uses a switchboard with an operator and is all but obsolete, having been replaced by the PABX, which uses an automated switch. A PABX allows all in-house phones to dial each other, to receive incoming calls, and to dial outside. All calls to or from the outside go through the PABX switch. Trunks terminate in the PABX, which switches them among users as required. The newest generation of PABX equipment is computerized. Although the switch itself may be electromechanical, analog, or digital, the computer control gives it much greater capabilities. Among these are call forwarding, transfers, conference calls, call parking, and so on. Hardware is usually modular, with a set number of ports (for trunks, receivers, and features like recordings and music) that can be expanded two, four, or eight at a time. Generally the electronics are rack mounted with pull-out printed circuit boards (cards) that determine the configuration of lines and trunks. An ACD installation based on a computerized PABX, as most of them are today, can easily be tailored to meet individual transit authority requirements by simply adding or removing specific features.

Centrex System

A Centrex system is owned and operated by the local telephone company, which performs the same function as a PABX. The only difference is that the switch is located in the telephone company central office instead of on user property.

Management Information System

The Management Information System (MIS), also known as Station Message Detail Recording (SMDR), is a sophisticated form of traffic reporting and performance measurement for the telephone systems described above. MIS is one of the major features of a computerized ACD or a PABX. In these systems, it is software oriented. No additional hardware is necessary; the only task is to write and integrate the programs that will read the data generated by the PABX and organize it into reports that are valuable for the user. An MIS reports on agent performance (number of calls routed to the agent, calls handled, and average length of calls), traffic information (calls offered, calls handled, calls overflowed, calls abandoned, average waiting time, and average talking time), and trunk use (calls handled, total calls by line or by trunk group, call seconds of use, number of busy signals, percent of times all trunks are busy, and trunk condition).

Equipment Desired

The results of the question about equipment desired are summarized by category in Table 4.

Desired Changes and Improvements

The results of the question about desired changes are summarized by category in Table 5.

Generation of Transit Fare

Does a TIS inquiry generate a transit fare and if so, what is the basis for the affirmative response? The responses to this question are summarized in Table 6. It is interesting to note that the number of respondents who do not think that a TIS inquiry generates a transit fare is largest in the L and S systems.

TABLE 4 TIS Equipment Desired

	Number of Respondents Indicating Desire for Specific Equipment			
Equipment Type	S	M	ML	L
Independent system	1			
Display board	1			
Automatic hold	1			
Recorded messages	1	2		
Computerized system	3	2	2	4
Automated system	2	3	1	
MIS	2	5	1	3
Call sequencer	2	3	3	
Furniture		1		
ACD		1	1	4

TABLE 5 TIS Changes and Improvements Desired

	Number (%) of Respondents Reporting by Category			
Changes/Improvements	S	M	ML	L
a. Add work stations	7 (.14)	3 (.08)	1 (.05)	3 (.08)
b. Improve call traffic data	13 (.27)	11 (.3)	3 (.16)	10 (.25)
c. Install computer data base	10 (.2)	10 (.27)	7 (.37)	11 (.28)
d. Improve TIS agent reference materials	10 (.2)	7 (.19)	6 (.32)	9 (.23)
e. Improve TIS agent training program	9 (.27)	6 (.16)	2 (.11)	7 (.18)

TABLE 6 TIS Generation of Transit Fares

	Number of Respondents Reporting by Category			
Response	S	M	ML	L
No	7	2	2	6
Yes: ridership increases in relation to call increases	1	1	2	1
Yes: calls are about schedules	2			
Yes: specific information request	6	5	1	2
Yes: correct information stimulates ridership	3	3		1
Yes: callers are transit dependent	1			
Yes: callers are first-time users	3	3	1	
Yes: blind faith/optimism	2			
Yes: passenger feedback/surveys		3	1	1
Yes: no evidence		3	1	3

TABLE 7 Number of Calls per Time Period Versus Size of Transit Authority

Type of System	No. of Buses	Calls per Hour	Calls per Day	Calls per Week
Small	54	25	225	NA
	74	43	346	NA
	54	20	NA	NA
	58	35	250	NA
	78	20	270	NA
	52	20	200	NA
	57	NA	150	NA
	70	38	304	NA
	44	NA	170	850
	56	21	175	NA
	82	NA	385	NA
	96	NA	140	NA
	99	38	400	NA
	58	21	172	NA
	65	NA	300	NA
	64	NA	575	NA
	80	NA	450	NA
	85	65	621	4,346
	81	NA	800	NA
	93	115	700	NA
	54	50	413	NA
	83	NA	670	3,360
	60	30	250	NA
	45	40	500	NA
Large	997	NA	NA	NA
	554	NA	2,505	NA
	1,069	340	6,000	37,000
	1,202	309	3,708	16,173
	557	NA	1,120	NA
	1,059	178	2,536	17,807
	520	240	3,000	16,500
Large	599	410	3,875	NA
	2,500	NA	7,000	NA
	837	NA	4,700	NA
	1,300	NA	NA	33,903
	1,004	375	5,000	25,000
Medium-large	365	164	2,460	17,220
	335	68.25	1,092	NA
	445	200	2,500	NA
	366	NA	3,000	NA
	254	NA	1,000	NA
	310	123	1,234	NA
	456	165	2,729	19,101
	323	NA	2,000	10,000
Medium	210	NA	510	NA
	232	167	2,500	NA
	101	28.6	258	NA
	228	50	2,000	NA
	102	20	170	NA
	163	NA	800	NA
	196	58	700	NA
	115	8	65	NA
	116	NA	800	NA
	106	67	845	NA
	212	NA	NA	5,000
	235	NA	550	NA
	220	63	991	NA
	217	NA	2,500	NA
	102	60	800	NA
	118	36	394	NA
	211	75	600	NA

Number of Calls

Data on number of calls per hour and per day are summarized in Table 7.

Evaluation

Information that would be helpful in evaluating the service provided by the TIS is summarized as follows:

Response	No. of Respondents Reporting by Category S	M	ML	L
MIS	5	4	2	2
TIS source information	1	1		
TIS state-of-the-art information	1	3		
Accuracy of outgoing information	1		1	
Evaluation of public perception of service	1	1	1	

SUMMARY COMMENTS

The majority of TISs in use are manual systems. Few transit systems are of the size and complexity to require a more sophisticated information data base than paper schedules and route maps. It has been suggested by some transit agencies that improved filing of these materials helped their information agents increase their speed and that the main benefit of using microfiche was that it forced attention toward filing and information retrieval.

Communications technology, on the other hand, has changed so radically in recent years that there may be opportunities for all but the smallest transit authorities to make improvements. The cutoff at which a PABX or computerized ACD becomes economically feasible is not certain, but estimates indicate that it is somewhere between 10 and 25 information agents. Additional analysis needs to be carried out to determine equipment requirements.

The three TISs that were examined in detail--the MTA manual system, the WMATA AIDS, and the Hamburg AFI system--represent the range of technical complexity of these systems and also point out the lack of data and information available about these systems. Much more information is needed about the performance characteristics of the various TIS components and how various components can be efficiently combined to provide a transit authority with the most appropriate equipment.

The survey results (5) give some indication of what is in place and what transit authorities think about their systems and what they hope for in the future. However, further investigations are necessary to determine the primary transit system, service area, and service population characteristics that are important to the selection and operation of TIS equipment.

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