INTELLIGENT TRANSPORTATION SYSTEMS AND OTHER TECHNOLOGICAL ASSISTANCE USED IN MINNESOTA COMMUNITY-BASED TRANSPORTATION

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ABSTRACT

The objective of this study is to understand how Intelligent Transportation Systems (ITS) and other technologies can be used to provide better paratransit services (also known as Community-Based Transportation or CBT) for various populations in Minnesota. The study has three stages: survey, in-depth interview, and data analysis. CBT serves diverse populations that are growing in Minnesota. They are senior, disabled, non-English speaking, and general population without private vehicles. The demands for CBT services are diverse, so that the supply, and hence the supporting technologies, need to be flexible. There is no one-size-fits-all solution. The study first presents an overview of Minnesota CBT systems in terms of their service characteristics and extent of deploying ITS and other technologies. Second, data analysis reveals what technologies are more widely used and the "usefulness" of each. The threshold of using different technologies is discussed. Third, specific issues regarding the utilization of several technologies are shown from the perspectives of managers of Minnesota CBT providers. Managers shared their experiences in planning, deploying, and evaluating the technologies that they have used. Finally, some conclusions on how these technologies are used in Minnesota CBT and recommendations for State agency assistance are drawn from the data analysis. Principle among these is that better training is often needed, and states should consider setting up a common training facility or service center to accommodate smaller operations, which often have limited technical staff.

INTRODUCTION AND DEFINITIONS

This report illustrates and analyzes various Intelligent Transportation Systems (ITS) and other technological assistance used in various community based transportation (CBT) services. CBT is a general term for transportation for transit-dependent people who have difficulties using public mass transit. They fall into one or more of the following categories: people in poverty, elderly, children, women, disabled, and non-English speaking populations.

As the population increases and grows older, and as congestion levels increase, there is a need to provide more and better transportation alternatives for diverse populations. In this project, CBT opportunities for improving CBT operations through deployment of ITS and similar technologies are explored, and the effectiveness of current uses is assessed.

THE STUDY CONTEXT

Minnesota's forecast population growth, especially among senior and disabled people, suggests future demand for more and better CBT services. CBT also offers advantages as a transportation alternative for members of the general public living in dispersed residential locations. (*1*) Technological advancement brings opportunities to improve CBT services, as well as challenges of staff training in CBT providers. Interagency coordination in share-cost service and technical assistance presents potential benefits for better CBT service. These elements, as discussed below, form the context for this study.

The demand for CBT is expected to increase when observing the demographic changes in Minnesota. First, the overall population is growing. In the 1990s, Minnesota was the fastest growing state in the Midwest and Northeast. The Twin Cities' growth was more pronounced, growing by 20% over the decade. (*2*) Second, Minnesota's senior population is growing and decentralizing from the Twin Cities into small towns and rural areas where general public transit and paratransit services are less available than those in more urbanized areas. (*3*) Third, the disabled population and non-English speaking population are also growing, which adds additional prospected demand for specialized CBT services. (*3*)

The promise of service improvements by the use of technology in CBT may also attract members of the general public into its ridership with its "door-to-door" and "real-time, on-demand" features. Professor Richard Bolan, Professor Emeritus in Humphrey Institute at the University of Minnesota, discussed the potential demand for CBT in an earlier report.

Paratransit services actually come closer to offering the advantages of Single-Occupant-Vehicle (SOV) travel than does traditional bus and rail systems. In general, paratransit agencies serve to provide transportation for those who cannot drive or do not have a car. Seldom is there an effort to try and divert young, able-bodied automobile drivers to these services. This is in marked contrast to proposals for light rail, commuter rail, and fixed-route bus systems, where the hope is that these facilities will actually get people out of their cars and off the highways. Service-on-demand public transportation might actually have a better prospect for reducing SOV automobile usage than fixed route bus or rail services. Such promise is based on two factors. The first is that the growth of American cities today have developed at very low densities – in both population and jobs – and thereby have become so sprawled and dispersed that it is very difficult to design fixed-route services of any type except on the relatively few reasonably high-density corridors. The second factor is based on the promise of material improvements in efficiency, reliability, safety and convenience that might be offered by the use of computerized scheduling and dispatch technology accompanied by GPS technology. (*1*)

The demand for CBT service is diverse and complex, which requires diverse and complex supply of CBT services. CBT systems vary in size, function, mission, service, funding, regulation, riders, and many aspects in operation. There is no one-size-fits-all technology solution to all problems and barriers in CBT services. The unique characteristics of CBT are its flexibility and multiple facets. What any one CBT provider can do to meet their individual needs is to shop around available technologies and use them creatively. Given the fast pace of technology development, today's adapted technology may well be tomorrow's constraint. Also, one would also be cautious about buying "redundant" technologies that out-perform the tasks of a given CBT system. Technologies used in CBT are available, accessible, affordable, acceptable, applicable, and adaptable, among other definitions. These criteria are not independent of each other. A successful technology employed in a given CBT system should embody all the above characteristics. Different kinds of CBT systems should flexibly choose appropriate technologies. Typical technologies used in current CBT systems are (*4*):

- Accounting Software
- Automatic Vehicle Location Systems (AVL)
- Camera and Audio Recorders (for safety and liability purpose)
- Communications (voice and/or text)

- Customized Spreadsheet and Databases
- Automated Paratransit Scheduling and Dispatching Software
- Geographic Information Systems (GIS)
- Global Positioning System (GPS)
- Internet Website
- Maintenance Software
- Mobile Data Terminal (MDT)
- Palmtop Electronic Manifest Device
- Personnel Management Software

Of all these technologies, communication, scheduling, dispatching, and accounting are essential functions of CBT services. These tasks require a certain combination of technologies, depending on the needs and environment of each CBT agency. However, as many medium and small CBT agencies experienced, technological deployment is only the first step. Employing and training the right staff with technical knowledge and background apparently is more crucial to success: Technologies only work as well as how people use them.

Interagency coordination and collaboration stands out as a prominent issue in this study. The desire for medium to small size CBT providers to have better training for their staff presents great opportunities for interagency assistance. Similar agencies often consult each other on technical issues. CBT providers using same or similar technologies will have greater opportunities to coordinate because of operational similarities and compatibilities. Jon E. Burkhardt, the national expert in CBT, pointed out: "the benefits of coordination" are (*5*):

- Additional funding: a greater number of funding sources and more total funding;
- Increased efficiency: reduced cost per vehicle hour, or cost per mile;
- Increased productivity: more trips per month or per vehicle hour;
- Enhanced mobility: increased access to places, lower cost per trip;
- Additional benefits: increased levels of community economic development and employment, improved service quality, more people served, larger service area, more accurate reporting and billing.

STUDY OBJECTIVE AND METHODOLOGY

The primary objective in this study is to understand how ITS and similar technologies can be used to provide better transportation services for various populations in Minnesota. The key questions are: what types of agencies are more likely to use these technologies, how are they used in these agencies, and how well might they be used to serve the diversifying population? The research has two stages: survey research, and in-depth interviews.

The survey instruments were mailed out to agencies on Feb. 18th, 2004. The questionnaires were divided into three parts. Part I asked basic information of the CBT service of various agencies. It contained questions regarding the nature of the agency (public, non-profit, private), the nature of the CBT services (fixed route, flexible fixed route, dial-a-ride, etc.), the service area, location of the service (urban, small urban, suburban, rural), average riding time, and fleet size. Part II asked the characteristics of the ridership of different agencies. It contained questions of the ridership size, the mix of the riders (senior, disabled, general public, etc.), the expected demographic trend and trip purposes. Part III asked the characteristics of how ITS and other technologies are deployed in these agencies. It contained questions of the demand-response requirement (i.e., requirement on riders scheduling time in-advance), transfer requirement (i.e., if at all riders need transfer to other vehicles), technologies deployed and their usefulness, technologies desired, expected request from riders, and the observed effects of these technologies in their services.

The second stage identified 15 managers of service providers for interviews. The candidates were selected from a pool of agencies that replied to the survey and expressed interest in the interview. These selected interviewees represent different categories of transit services. Open-ended questions gave respondents opportunities to detail their agencies' experience and expectation of deploying ITS and similar technologies in their system and how these technologies better meet their riders' current and expected needs.

FINDINGS

From The Survey Results

Survey instruments were sent to 247 organizations. Given the wide variation across these providers, it is unlikely that a representative sample could be drawn. Thus, instead of probability sampling, this survey took a census approach in an attempt to reach as many Minnesota CBT agencies as possible. The list of organizations

surveyed was developed from the following sources: 1) organizations listed in the "*inventory of community-based transportation service providers in the Twin Cities*" in the report "*Improving Transportation Services for Disadvantaged Populations*" (*4*); 2) *Metropolitan Area and Greater Minnesota Transit System Fact Sheets, Section 5310 Recipients* from *2003 Minnesota Transit Report* (*6*); and 3) some private organizations identified on the Internet. 38 valid survey responses were collected out a total of 247 (Overall response rate: 15.4%). The response rate is lower than expected and thus the result of quantitative analysis should be taken with caution of response-selection bias.

Through the survey feedback, we can glimpse some basic information about CBT in Minnesota. Most are public agencies or non-profit organizations. Some serve less than 10 square miles, and some over 500 square miles. The majority of these agencies have ridership between 10,000 and 20,000 annually. Each rider spends from 10 minutes to one hour on the vehicle with the average travel time a CBT rider spends typically in the range of 20 to 30 minutes. Small buses (less than 40 feet) with wheelchair lifts serve as the backbone of the CBT system in Minnesota. The fleet size ranges from one to 251 (FIGURES 1,2, and 3). Annual ridership of the agencies varies from 200 to 1,500,000 (FIGURE 4). Agencies with largest ridership are either public transit agencies providing paratransit services, or very large public CBT providers in Twin Cities. The second tier of CBT systems, in terms of fleet size, provides between 3600 to 125,000 rides. CBT systems in the third tier provide fewer than 50,000 rides, and primarily serve either rural or specific urban populations. According to ridership, the responding agencies can be characterized as:

- Large public provider serving large urban (including large Minnesota Regional Trade Centers (RTC)) and suburban populations;
- Medium public/non-profit providers serving dispersed rural populations and linking them to urban and small urban areas (small Minnesota Regional Trade Centers) with some clients transferring to other agencies' vehicles; and
- Small public/non-profit (primarily non-profit organizations) providers serving either only urban or only rural populations, with very limited urban-to-rural, or small urban-to-rural connection. This type of service serves certain types of clients specifically, with no transfers to other vehicles.

The ridership mix is as follows: Senior 37.6%, Disabled 38.1% (within which Senior Disabled 18.5%), Non-English speaking 3.6%, and General public 22.3%. CBT managers generally expect more senior and disabled riders in the coming years. One-day ride notice is mostly required (38% of agencies) in Minnesota CBT, while 22% of agencies only require riders to give a 30-minutes advance notice. 71% of managers stated their riders do not transfer to another vehicle during a trip. There are both challenges and opportunities for more interagency cooperation in ridesharing or vehicle sharing.

Of all these technologies, dispatcher-driver communication technologies (radio or cell phone) are most widely used. Accounting software and spreadsheets follow in second place. Scheduling and dispatching software is also widely used. Other technologies, such as GPS and AVL, MDT, SmartCard, Website Scheduling, Maintenance Software are less used but do constitute important components of some agencies (especially large ones) (FIGURE 5). Most managers found dispatcher-driver communication, scheduling and dispatching software, accounting software, and spreadsheet quite useful. Website for CBT service information can be a plus. However, not all website have user-scheduling function. In fact, not many agencies have set up that function for riders to schedule a trip. GPS and AVL, MDT, SmartCard, and Electronic fare collection were rated as highly useful, but only a few agencies reported using them. Managers gave lower rating for other components such as GIS, website, and PDA's.

Different sized of CBT systems may use these technologies at different levels of sophistication. Generally, larger systems use a combination of ITS and other technologies to perform the complex daily tasks intrinsic to large ridership, such as multiple route and schedule changes. Smaller agencies use fewer of these, and simpler versions, to operate because data processing and route and schedule changes are still within the scope of sophistication that can be done manually. When a certain agency has over 15 vehicles, or around that threshold, it may need a combination of several technologies. Specifically, dispatcher/driver communication and schedule/dispatch software seem to become more beneficial as the fleet size gets larger. Accounting, spreadsheet, and website software appear to be more useful for small and medium agencies, as those agencies rated these technologies as more useful than larger providers did. On the other hand, maintenance software does not seem to be needed in small agencies, while they do in medium and large systems. GPS, AVL, MDT, GIS, SmartCard, electronic fare collection, and PDA's are seemingly "luxurious" technologies for small and medium agencies.

Regarding clients' needs and wants, managers replied the riders would want more on-demand services and more predictable pickups. These require use of computerized scheduling and dispatching. Managers also feel clients would want to know where the bus is, which would require GPS and /or an AVL system in conjunction with real-time customer services. This will require mapping capacity. Smaller numbers of managers feel riders would require

more non-English (other languages) services, timed transfer, easier payment option, weekend and night rides, expansion of service area, etc.

From The In-Depth Interview

The second phase of the study is an in-depth interview with CBT managers. This phase served as a "reality check" and complement to the information found in the survey research. The information gathered from the interviews is a sample of opinions and experiences of large systems (with more than 15 vehicles) in urban and suburban areas, small, medium and large systems in small urban settings, and small and medium systems in rural areas. Large urban systems and small rural systems seem to be more engaged in the study. Large urban systems have a lot of ITS experiences to share with others, while some small rural systems are interested in beginning to climb up the technological learning curve. Almost all the managers stated that it would be helpful to learn what other agencies are doing with ITS, especially those of similar fleet size and/or ridership per year. Managers are interested in what problems other agencies had in common, and how others solved them.

Issues of some technologies being used

Communication Voice communication between dispatchers and drivers is the basic technology used in CBT systems. Schedule changes need to be communicated to drivers in real-time for more effective and efficient operation. Ride add-ins and cancellations not only may affect a certain pick-up or drop-off, but also the subsequent schedule on the waiting list that drivers have. Two-way radio and cell phones are two of the most common communication media used by Minnesota CBT providers. There are several trade-offs between the two, however.

- If the number of drivers is more than the number of vehicles in an agency, on-board radio may be more cost-effective than cell phones. Fewer radios are needed. If there are more vehicles than drivers, cell phones may be better, as fewer cell phones are needed. Agencies with larger fleet size tend to use radio systems due to decreasing costs for larger systems.
- Cell phones are easier for drivers to use. They are more interactive between drivers and dispatchers, because drivers and dispatchers can talk simultaneously via cell phones. Two-way radios require one end to finish talking before the other end can start.
- Cell phone at occasions adds benefits to riders who may wish to made last-minute changes and talk to drivers directly. "It cuts out the middleman".
- Both radio and cell phone have signal blind-spot problems in difficult terrains, or simply out of range of services. This problem is more significant in rural CBT services. To have both radio and cell phone system of communication serves as emergency backups for some agencies.
- Most managers were a bit surprised to consider that drivers using a hand to operate either a radio or a cell phone, often at a time when the vehicle is in motion, could present a safety issue. However, some managers think drivers should pull off before answering, while others think otherwise. Riders may agree to or oppose this additional stop, because that means more time to spend on the vehicle.
- Usage abuse issue: Some managers are concerned that issuing cell phone to drivers may bring expensive phone bills resulted from abusive use of cell phone for personal calls. This is a management matter rather than a technical matter.

Scheduling and dispatching software These are important applications for CBT operations. Scheduling translates riders' demand from the customer end to the service end, while dispatching further delivers that request to route assignment upon drivers. Generally speaking, almost all CBT service in early 1990s used "paper and pencil" scheduling and dispatching before computer software became available. The manual method is labor-intensive and information processing is repetitive on a daily basis (e.g., Mr. Johns' ride pick-up address would always be his home address everyday). Computerizing scheduling and dispatching eliminate the labor-intensive and repetitive parts of operation. Nevertheless, small and some medium CBT currently still use traditional ways of scheduling and dispatching. In the interview, managers from large and medium size CBT operations said their system uses computerized scheduling and dispatching.

- Different CBT agency will have a different threshold for beginning to use software for scheduling and dispatching. Many factors will influence this threshold: fleet size, ridership, geographic coverage, route complexity, roadway network density, staff number, staff computer competency, funding source, scale, and structure. Of all these factors, fleet size appears to be a major factor because each vehicle is a moving dot on a map and (real-time) scheduling and dispatching operation revolves around vehicles.

- There is a great deal of efficiency acquired with the help of this software for some large CBT agencies. The increase in efficiency can range from two to four times (traveling less mileage to accommodate more rides, using the same number of employees to serve a doubling of ridership, etc.). Agencies using same or similar software developed inter-agency assistance through their practices. New software now provides online, remote diagnosis of how well CBT agencies are doing and provide suggestions for improvement and solutions to program bugs. Remote archiving of data is also possible. Managers also said that the software is useful at the aggregate level, "very good at scheduling 50 buses, but down to individual driver's level, the driver can tweak the schedule better than computer. Drivers know which streets are busy and nuances of individual rider preferences."
- For small operations and those with rather fixed routes (such as a school bus, day training transport for disabled persons, etc.), the traditional "Paper-&-Pencil" method, without software, remains relevant and functional.

GPS and AVL technologies. AVL (Automatic Vehicle Location) technologies track vehicles in real time and provide drivers, schedulers and dispatchers with a visual display of vehicle location, and pick-up and drop off locations, with GPS being one of the more common technologies used to facilitate AVL. These technologies facilitate scheduling and dispatching, route design and real-time adjustment (although local conditions such as congestion level may still be a factor the drivers rather than computers acknowledge). GPS and AVL can prove very useful for larger CBT systems. Smaller operations may find it advantageous to partner with non-CBT agencies in the public sector, such as emergency response fleets, which may already possess GPS. For small agencies that want to coordinate service, GPS may provide a critical technical link among CBT agencies and other public agencies. This provides a possibility to share, or "hook up" to, the GPS technology already used by these agencies.

Unified statewide system. Future ITS development lies here. In 1999, the Minnesota Department of Transportation (MnDOT) developed a pilot program for a statewide deployment of unified software. It was hoped that systems across the state would have the same software so riders can dial in and see all the systems in the state. Purchase was accompanied by state subsidy of an 80-20 match with State contributing 80% funding. But that program has been dropped. Although the statewide program did not materialize, some large CBT agencies are piloting to use ITS to coordinate with other agencies with the idea of moving towards a standardized (billing and/or operational) system.

Planning, Implementation, and Lessons Learned

Planning and implementation process

Because substantial cost is involved, formal planning is more likely to take place in larger CBT agencies in terms of purchasing and implementing these technologies. Smaller CBT operations typically involve the following stakeholders in their planning process: "MnDOT", "our own agency", "our employees and volunteers", "vendors", "our riders (informal or formal focus groups)". Planning and implementation typically takes more time than expected. Many managers had expressed that purchasing the technology is rather easy, when compared to actually using it. Keeping up with technological innovation is hard and time-consuming. Generally, riders are not involved in the planning of what technologies are used for their services. Of all managers interviewed, riders were informed in a later stage of deployment. It is not clear whether it would be worthwhile to involve customers in planning and implementation of these technologies.

Implementation Challenges.

Implementing ITS and other technologies brings both challenges and opportunities to CBT operations. On one hand it can frustrate employees trying to learn and adjust to new computer programs, but, on the other, it can greatly increase operation efficiency and effectiveness. There is a comfort level of appropriate ITS to be used in CBT. When asked, "what were the greatest challenges in implementation", most managers interviewed talked about the unexpected hurdles and difficulties of training staff to interact and get accustomed to the ITS installed. Training schedulers and dispatchers to put away "Paper-&-Pencil" methods and use software is one of the central challenges all CBT services face. It is clear that most managers feel training is a critical piece of implementation and many of them feel they should have done a better job at training.

Even when the same technologies are used, there is a comfort level of how much of its technical potential is utilized. For example, one software product has system performance analysis capacity, which is not used by some agencies because it takes another set of knowledge and skills to analysis a system than to operate a system. The main difficulty of training is a management problem: it is hard to get employees accustomed to new technology and put away the old ways of operation. Among employees, there is some degree of distrust of technology to begin with, and

some sentiments of being afraid of being replaced by technology. However, once employees get used to the technology, they typically become increasingly fond of it and are reluctant to go back to the old manual way of operation. But there is a limit to technology as well: technology can be as good as how people using it. “Staff and technology have to go hand-in-hand”. In the training ground, the common strategies are, 1) outside training, where the vendor or people from other CBT system come in and help the training, 2) upfront overview training, which introduce how the system work as a whole, 3) in-house training, in which senior staff will help new staff.

Lessons learned

Managers were asked what lessons they learned through the planning and implementation of ITS and other technologies in their operation. Many managers feel it a smart move to purchase a certain technology and hire key employee s. However, managers generally wish that they knew beforehand that technology is not a panacea. Technology has to be used by human beings and human development and staff capacity building really stand out as the single most important part of implementing them. If they had to do it again, some managers expressed that they would set aside more time for training and setting up criteria for evaluating the technology to be used. Some feel a centralized source would be needed to formulate standardized procedure and/or template for tasks common to all CBT services, such as billing and reporting in operation.

Managers were also given the opportunity to advise other agencies. Many shared one common piece: shop around the market and talk to peers before purchasing and implementing, especially those peers that have similar operational characteristics and that are already using that technology. Managers implementing ITS and other technologies on a large scale advised “having a clear project plan, or ‘road map’ before setting out”. “Devils are in the details”, that patience is needed. Some managers noted the importance of a careful upfront investment in a reliable computer network and server. Finally, managers encouraged others to keep ahead of technology and lead the industry into better operation carried out by both human and computers.

CONCLUSIONS AND RECOMMENDATIONS

The above interview results show several general observations:

- Larger CBT systems use more sophisticated ITS and more systematic strategies towards planning, deploying, and evaluating these technologies.
- There are system scale thresholds of different levels of complexity in utilizing ITS and similar technologies. Technology can sometimes bring more hassle than efficiency.
- ITS utilization in CBT usually consumes more time than people expected.
- Training staff to keep up with technological innovation proved the most time consuming and difficult part of deployment.
- There is a limit to technology: it is only as good as the people using it. Staff and technology have to “go hand-in-hand.”
- Agencies do voluntarily talk to peers to exchange ideas and obtain opinions. Inter-agency assistance sometime takes place, though not formally organized.
- With technological innovation comes a chance of new kinds of inter-agency coordination. Many larger CBT agencies are currently exploring this area.
- As technologies become marketable and available, technologically savvy managers assimilate them into CBT operations.
- Larger CBT agencies conduct more formal process of planning in terms of deploying ITS and other technological assistance. But almost all CBT agencies have not involved riders into the planning process.
- Larger agencies are more likely to conduct formal, systematic, and quantitative evaluations on performance of these technologies, and whether a certain technology is appropriate.

Based on these observations, several suggestions can be made:

- Information exchange among CBT managers: Many managers said they attend an annual statewide convention organized by MnDOT to look at vendor exhibitions and find out about new technologies that are available. CBT managers can see ITS demonstrated at this convention. The convention seems a very positive one since many mangers mentioned it. This experience could be maximized through the offering of peer information sharing sessions in the convention, where CBT agencies can discuss planning, deploying, and evaluation of ITS and similar technologies.
- MnDOT can also set up functions or services to directly facilitate staff training within CBT systems. Training is a difficult task in many agencies, especially in smaller operations with limited technical staff. A common

training facility or service center or training personnel could be more efficient than each CBT agency trying to conduct in-house training or call vendors in for help. In another perspective, it is important for agencies to have adequate human resources for specific technologies. Having key ITS staff in each agency is the cornerstone for operation. This also means there is a degree of vulnerability to the agency if the employee or employees leave. A safety net or human resource center would be beneficial in this regard to prevent system breakdown because of staff absence.

- Better evaluation of how the technologies are performing in each agency is needed. It is not only important to see if the technology is performing to its full potential, but also to keep abreast the innovation that is taking place everyday. Evaluating the appropriateness of the ITS or other technologies helps in planning as well. Better customer feedback is also needed. Customer satisfaction is a common end goal of CBT service, however, customers are seldom involved in the evaluation the technologies discussed here.

Technical assistance for training how to better use various technologies is important for CBT providers to better serve their clients. Various riders, as discussed in this report, welcome new technologies as long so they still retain the “touch” of human employees. The demographic changes occurring due to decentralization to edges of major urban areas require more flexible modes than regular mass transit. In the future, CBT can possibly serve this more diverse population and may even expand services to the general population as these technologies allow service to become more flexible, convenient and responsive to demands. As budgets tighten, however, costs will become an issue and, interagency coordination is likely to have more importance. Some technologies now provide solutions to previous barriers to coordination in terms of sharing rides and sharing vehicles among agencies. Interagency coordination is likely to bring better services, especially in rural areas, although in some cases, the community and provider may be small enough and remote enough that those agencies will likely to continue their specialized services. To conclude, better training to bring out full benefits of ITS and similar technologies will most likely to benefit the operation of CBT providers, and thus the diverse populations that they serve.

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REFERENCES

1. Bolan, R. et. al, Evaluation of GPS Technology as Used in Services-On-Demand Public Transit. In *Telecommunications for Sustainable Transportation*, Douma, F. Principal Investigator, Minnesota Department of Transportation Report No. MN/RC 2004 – 10. www.lrrb.gen.mn.us/pdf/200410.pdf Accessed July 30, 2004
2. The McKnight Foundation, *2000 Census - Geographic shifts: Overview* McKnight Foundation, Minneapolis,. 2002.
3. Douma, Frank, D. McCabe, and J. Osmond. *Using ITS to Better Serve Diverse Populations.* CD-ROM. ITS America 2004, 14th Annual Meeting & Exposition, San Antonio, Texas, 2004, pp. 1 - 56.
4. Barnes, G., *Improving Transportation Services for Disadvantaged Populations*. FTA-MN-26-7004 2003, p. 106. www.hhh.umn.edu/centers/slp/cbt/SmallsizeCBTreport.pdf Accessed July 30, 2004
5. Burkhardt, J.E., and A.K David, *Economic Benefits of Coordinating Human Service Transportation and Transit Services*. Transit Cooperative Research Program, Transportation Research Board: Washington, D.C. 2003
6. Minnesota Department of Transportation, *2003 Minnesota Transit Report*. www.dot.state.mn.us/transit/treport/5310_Recipients.pdf Accessed July 30, 2004

TABLES AND FIGURES

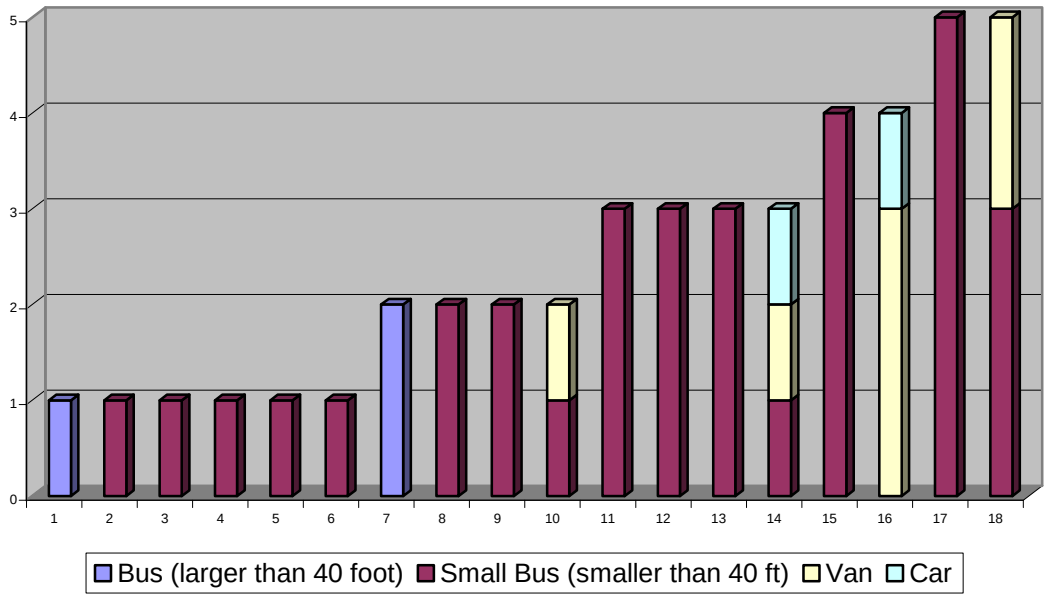

FIGURE 1 Fleet sizes of 18 small CBT systems (1 to 5 vehicles) studied according to survey response.

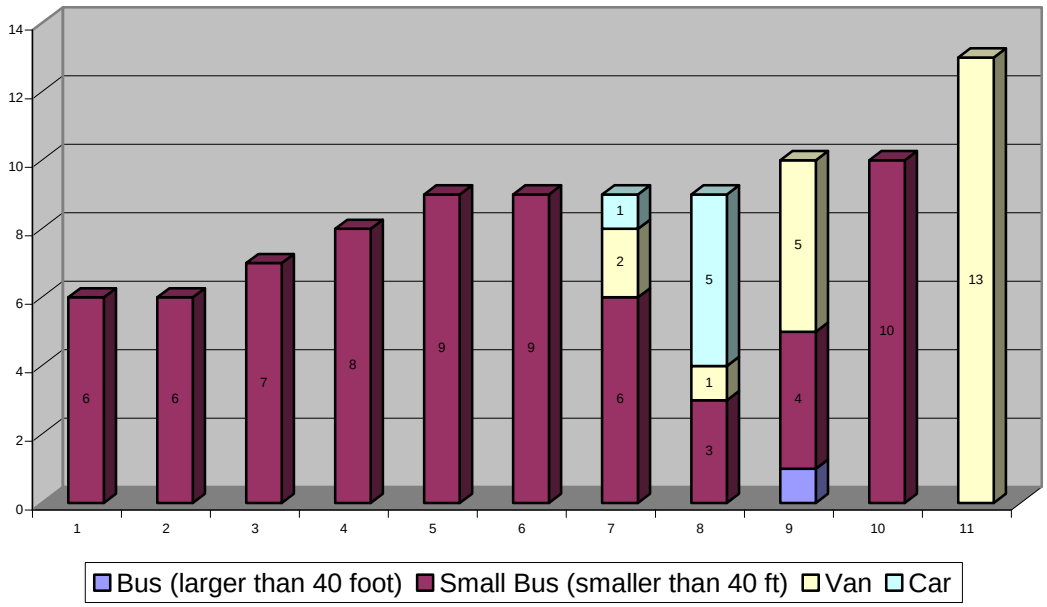

FIGURE 2 Fleet sizes of 11 medium CBT systems (6 to 14 vehicles) studied according to survey response.

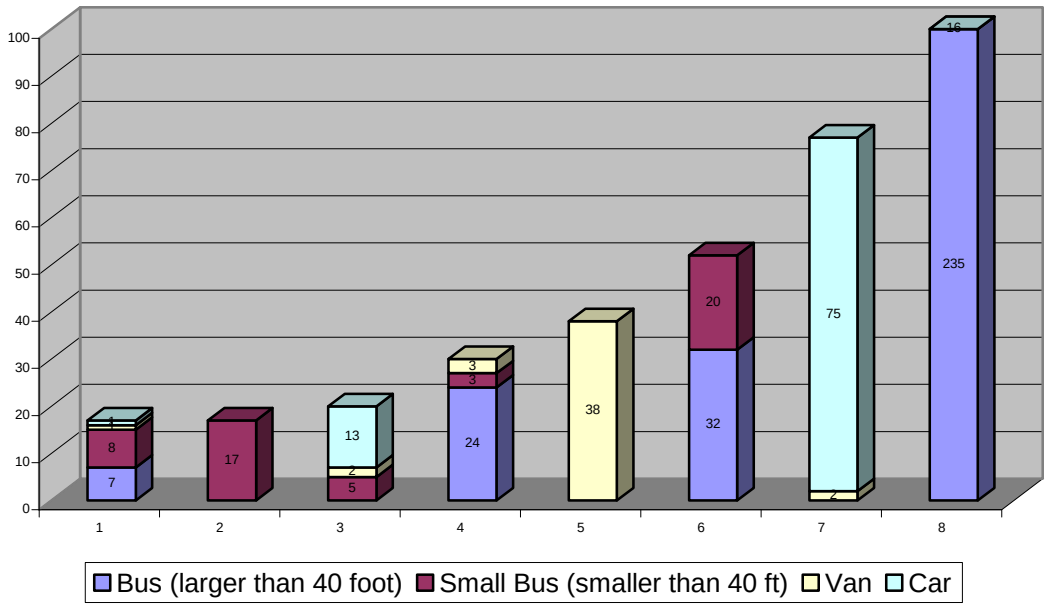

FIGURE 3 Fleet sizes of 8 large CBT systems (over 15 vehicles) studied according to survey response.

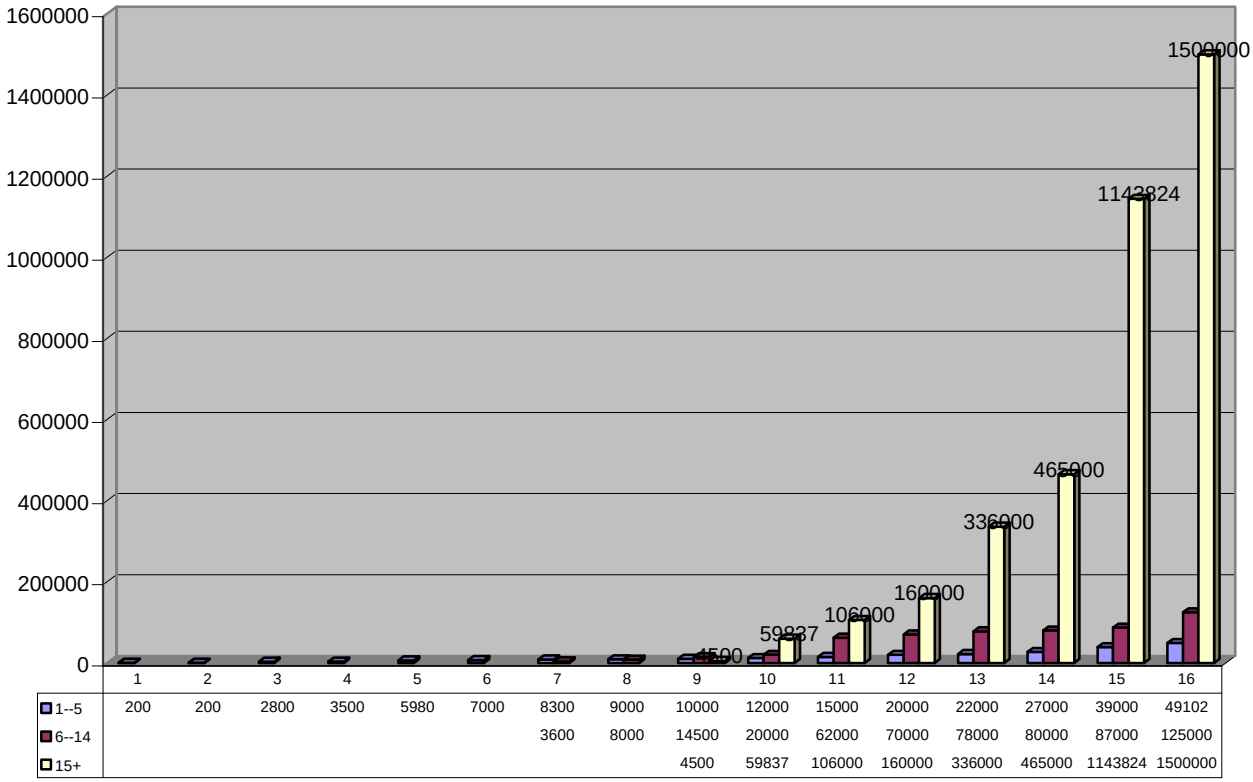

FIGURE 4 Annual ridership of CBT systems in Minnesota (shown with different fleet size) according to survey response.

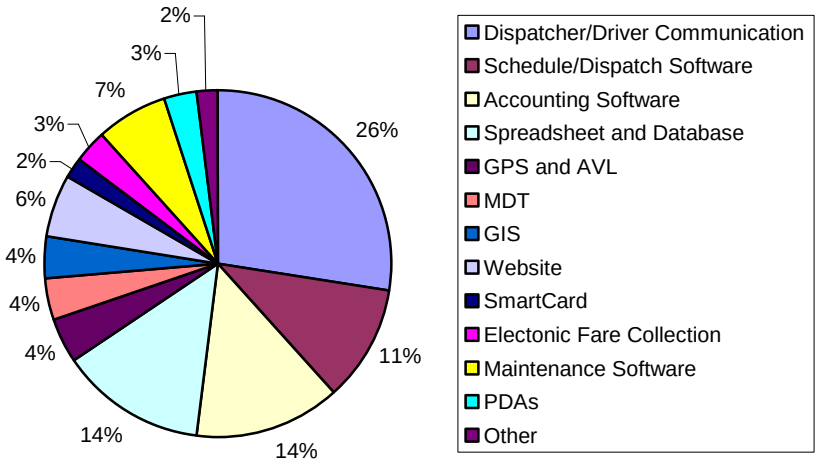

FIGURE 5 Technologies used by CBT providers according to survey response**.**

Note: percentage based on total count of all forms of technology used in survey respondents. If an agency uses two kinds of ITS, it contributes two in the total count of ITS used. The percentage breakdown is the count of each ITS among the total count of usage of ITS. For example, 26% of dispatcher/driver communication means among all counts of ITS used, 26% is dispatcher/driver communication.