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16. Abstract (Limit: 200 words)

This report investigates how advances in telecommunications-based technologies could aid in making transportation more sustainable.

The first task examined the effect of telecommunications on work and shopping trips. The second task focused on how transit could be improved through new technology; specifically, whether the addition of GPS-based technology to flexible, on-demand “paratransit” services has the potential to serve the general public. The third task considered how wireless telecommunications, particularly e-911 services, could improve transportation system safety in rural areas.

These efforts found that particular opportunities exist. Advances in residential broadband telecommunications may lead to increased travel, which demonstrates a need for increased collaboration between telecommunication and transportation infrastructure planning. Similarly, emergency response services would benefit from increased cooperation between transportation agencies, local telecommunications providers, and emergency response services. Finally, new GPS technologies create opportunities for paratransit services to provide trips to the general public as a complement to existing fixed-route services in areas with low population densities.

Finally, more research is needed, as careful targeting of the improvements would maximize the benefits from these developments. A particular area of need is in understanding inter-organizational process, as these recommendations call for providers to reach beyond their traditional expertise.

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Telecommunications for Sustainable Transportation

Final Report

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Executive Summary

Research Issue

Under the sponsorship of the Minnesota Department of Transportation (Mn/DOT), with funding initiated by Congressman Martin Sabo, the State and Local Policy Program (SLPP) at the Humphrey Institute of Public Affairs has examined many aspects of Intelligent Transportation System (ITS) technology and sustainable transportation. This study continued this effort through investigation of how advances in telecommunications-based technologies could aid in making transportation more sustainable.

The first task examined the most direct connection between telecommunications and transportation, that is, the effect of telecommunications on work and shopping trips. This examination took the form of a random-sample survey of residents in two urban and two suburban zip codes, and an on-line diary of a selection of those who responded to the survey. This task also included a broad, forward-thinking look at the potential for transportation changes resulting from the next generation of residential telecommunications connections.

The second task focused on how transit could be improved through new technology; specifically, whether the addition of GPS-based technology to flexible, on-demand "paratransit" services have the potential to serve the general public. This effort was accomplished in cooperation with a local paratransit provider, which shared their data from before and after they installed GPS units in their vehicles. The task also included focus groups with members of the general public, current paratransit users, and drivers to determine their receptivity to this type of innovation.

The third task considered how wireless telecommunications, particularly e-911 services, could improve transportation system safety in rural areas. Technical and non-technical dimensions were examined through an examination of efforts to create the system of Transportation and Operation Control Centers (TOCC) in Minnesota, including site visits and in-depth interviews with practitioners and stakeholders throughout the state. The technological, institutional, and policy issues identified were then analyzed through a framework based upon Inter-organizational Systems theory and the National ITS architecture.

Findings

Telecommunications and Travel Behavior

- Telecommunications appears to be impacting work trips by allowing workers to change the time at which they travel, without affecting the time when they start to work—that is, the ability to check e-mail and do other work from home is creating opportunities for workers to travel at off-peak times without requiring them to work off-peak hours.

- E-shopping appears to allow people to make more informed shopping decisions, by allowing them to browse and compare products online. However, a strong preference remains for making physical trips to purchase the item.

- A significant portion of the population continues to avoid e-shopping because they either prefer making physical shopping trips, or they have serious safety and/or reliability concerns about e-shopping.

- Broadband, or high-speed telecommunication, connections seem to be having their own set of impacts, beyond behaviors observed in households with slower "dial-up" access. Workers with high-speed connections were more likely to telecommute and to telecommute more often, and, perhaps most interesting for transportation planners, e-shoppers with high-speed connections indicated that they were more likely to make *additional* shopping trips as a result of their shopping behaviors.

GPS and Paratransit

- It is not clear whether the addition of GPS has enhanced the capacity of paratransit services to the point where they could comprehensively serve the general public as a suburban public transit system and lure SOV drivers from their cars. A subregional agency could be an important component of a public transportation campaign against rising automobile congestion. A system similar to the one evaluated in this study could provide 600 to 700 trips per day with door-to-door service, which would be an important contribution to fulfilling transportation needs with less congestion and other attendant problems associated with rising automobile costs—especially in handling relatively short suburb-to-suburb trips.

- The addition of GPS technology to on-demand, flexible-route transit services appears to improve the efficiency and responsiveness of this service. Fewer busses can serve more people, and more same-day trip requests can be accommodated.

- Existing paratransit providers may be well-suited to serve the general public without significant additional capital investment by providing some additional capacity at peak travel periods, as the heaviest use of these providers currently is during non-peak times. While this type of on-demand service has many features that would make it more competitive than fixed-route services, such as door-to-door service available at the times and places of the rider's choosing, the critical factor will be the costs, and, more particularly, what level of public subsidy can be seen as desirable vis-à-vis other transportation systems.

- While the addition of GPS technology can reduce operational costs of paratransit service, making this service competitive in terms of cost-per-passenger a significant increase in the number of passengers on each bus would be necessary, which would require a significant shift in culture of these providers. From our analysis, it would appear that a load factor of four riders per trip would be necessary in terms of cost (more than double the current average load). Present day auto costs can be estimated at about 40¢ per mile. The critical factor will clearly be the cost and, more particularly, what level of public subsidy can be seen as desirable in contrast with other transportation options.

ITS and Emergency Response Services

- Wireless technologies and applications in transportation., such as e-911, have created new opportunities improvements in Emergency Response Services (ERS/EMS), especially in rural areas. These technologies solve issues related to data creation, use, and exchange within ITS infrastructures. The challenge is in developing and maintaining technology that can keep up with the increased “demand” from additional calls and increased expectations for improved service.

- Advances in technologies for ERS/EMS create opportunities for new partnerships between agencies and across jurisdictional levels. However, creating these partnerships creates new interorganizational systems and new issues for managing them. Agencies may find themselves pushing for changes and updates in areas where they are not traditionally expected to have expertise, such as departments of transportation pushing for upgrades in telecommunications infrastructure.

- ERS/EMS advances can be best achieved in a situation where policies are in place to facilitate implementation, standards, and funding. Such policies set a framework for interagency cooperation and can hasten upgrades in ways that promote implementation of an ITS architecture that will work region-wide.

Recommendations

Telecommunication and Travel Behavior

<u>Pay attention to residential broadband and e-commerce growth</u>.
Transportation planners should pay increased attention to two economic trends: the market penetration of broadband in residential areas locally, regionally, and throughout the state, and the growth of e-commerce. As findings from this report indicate that residential broadband connections may lead to increased shopping trips from the home, and as other research cited here has indicated that e-commerce in general may lead to increased home deliveries, developments in these areas are likely indicators of new “hotspots” of trip-making activity.

<u>Incorporate telecommunications infrastructure plans into transportation plans</u>.
City and municipal planners should work with developers to learn of plans for telecommunications infrastructure that will be built in new residential developments and ensure that these developments fit within current transportation infrastructure improvement plans, adjust transportation plans to serve those developments with the greatest concentration of residential broadband, or work to create incentives for those developments to locate in the areas best able to handle significant increases in commercial and social activity.

<u>Recognize developments in residential broadband as opportunities for ITS applications</u>.
Government ITS planners and private ITS companies should recognize the opportunity to deploy new applications to the home as cable and DSL connections continue to increase and fiber-to-the home and Wi-Fi connections enter the “mainstream.”

Continue to refine knowledge regarding telecommunications and travel behavior. Government entities with interest in telecommunications-based ITS applications and ITS industries in this area should continue to study, sponsor studies, and share information about particular aspects of how residential broadband impacts travel, such as the types of people most likely and least likely to shop online, the types of trips they are likely to make as a result of on-line activity, and the times at which they make these trips.

GPS and Paratransit

Take advantage of benefits On-demand transit can bring to the gnereral public, particularly in suburban areas.
Mn/DOT (statewide) and Metropolitan Council planners (Twin Cities metro area) should work with paratransit providers to determine if excess capacity exists, especially during peak times, which could be used to serve trips by the general public on the edges of urban areas. Should such capacity not currently exist or if such a mission if found to be incompatible with the mission of current providers, planners should also investigate the possibility of adding this type of service to that currently provided by fixed-route transit operators.

On-demand services could be viewed as becoming a much more important element in an overall Transportation Demand Management (TDM) program, serving not only to reduce suburb-to-suburb SOV commuting travel, but also all of the conceivable trip purposes arising from short distance, suburb-to-suburb travel demand. GPS-enhanced paratransit services could bring several benefits. For example, they can be used as shuttles between places of high demand (airport to downtown hotels or the Mall of America). They are currently available as intra-campus transportation for the University of Minnesota as well as hospitals in the region. On-demand services can serve as feeders into a fixed-route bus line or a light rail line. They can serve the transportation needs of special events (such as the State Fair) or provide group transportation for business or social purposes.

Continue research and pilot projects.
To fully develop these benefits, further research is necessary. There is a need for experimentation to further reduce subsidies and enhance vehicle load factors. For one such experiment, a paratransit provider might try a pilot project to try and attract more rush hour commuters. Through 1) an expansion of service hours, 2) marketing, and 3) relaxing eligibility requirements for rides between 6:30 and 9 a.m. and from 3:30 to 6:30 p.m., it may be possible to determine the degree to which SOV drivers are willing to turn to an on-demand, door-to-door service with fares at current Metro Transit rates. These trips could be restricted to Dakota County and to lengths of seven to eight miles (so that they would not be available for travel to the central downtown areas of Saint Paul and Minneapolis). Such a pilot project would require careful monitoring of operations, logistics, costs, and subsidies.

ITS and Emergency Response Services

Assess Critical Coverage Gaps and Implications for Service. The ITS/ERS/EMS service is fundamentally dependent on mobile coverage. Yet, adequate coverage in rural areas continues to be problematic. In the case of ERS/EMS, the consequence is not just the inconvenience of not being able to place a personal or business phone call, but could be a fatal gap should failed coverage not allow for adequate response.

Develop a Strategic Plan that integrates technical and socio-policy elements for next generation e-911 coverage. The e-911 mandate has created a policy/regulatory context for pushing location-specific emergency services. However, this review has identified a range of technology, organizational, and policy issues that include yet transcend this policy mandate. A strategic plan would incorporate the e-911 requirements within a broader planning exercise, which importantly should include a funding requirements element.

Integrate ERS/EMS Planning Into ITS Planning. For rural areas, the safety aspects of ITS are arguably more important than the mobility elements typically featured in regional ITS architectures and deployment plans. Moreover, the communication and system elements to ITS provide an important cornerstone for ERS/EMS management.

Enhance understanding of ERS/EMS benefits on local levels. Local areas face very constrained budgets and often need to develop innovative partnerships to deploy new ERS/EMS services. This measure would remove artificial barriers to establishing interorganizational systems. Common stance in developing ERS/EMS in rural Minnesota is the key to successful cooperation between local entities.

Provide adequate training to specialists. New systems, such as those mandated by e-911, will require training at the local level. Moreover, transportation managers need to become apprised about the relationships between safety-related ITS systems and mobility related ITS systems.

CHAPTER 1
Broadband Telecommunications at Home

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Fifteen years ago, mentioning the idea of delivering broadband telecommunications to the home prompted both smiles and frowns accompanied by some predictable questions. Ordinary users asked, "What is broadband? Why would someone want or need it?" Telecommunications companies asked, "Who will pay to build and deliver it to the home?" These companies tended to think that broadband service was important for larger businesses but not for the home or smaller businesses.

Broadband Telecommunications and Community Well-Being

Today in developed economies, the underlying importance of widespread access to broadband telecommunications for economic and community well-being is broadly accepted even while a vigorous debate continues about the scope, cost, spread, and benefits of broadband networks within a single community, region, or state; across the nation; and around the world. This acceptance is the legacy of an extraordinary period of growth in telecommunications networks and services that encouraged and supported new modes of living and working referred to as the "information society." The concept of an information society is variously understood, but it embraces the idea that fully-realized, widespread access to telecommunications and computer networks can and will transform almost all human activities (1).

Transformations in many areas such as tele-work, e-commerce, e-government, e-health, e-education, e-democracy, e-culture, and e-information continue today but have already left their mark on how we live and work. Some aspects of electronic life are more firmly established than others, but massively computerized networks and remote centers for services in shopping, personal finances, health care, and education are now the norm. From the perspective of the individual household, the nature and extent of telecommunications connectivity directly relates to the ability to share in electronic life. In light of the undoubted importance of electronic life in the information society, how does the development, current scope, and prospects for broadband networks to the home relate to this new mode of living and working?

Scope, Profile, and Prospects of Broadband Networks to the Home

During the decade of the 90s, a great deal of hope and hype supported the expansion of telecommunications network capacity likening the development of the "information highway" to the building of the transportation network of the nineteenth and early twentieth centuries in the United States. The telecommunications and information services sectors were looked at as lead sectors supporting economic expansion and productivity gains. At the same time, entrepreneurs rushed to stake their claims in the dot-com sector aiming to provide services and gain profit in the unfolding of the information society in the workplace and in the home. But by the end of the 90s, the so-called dot-com "bubble" burst, and the telecommunications and information services business sector moved into a deep recession from which it has yet to emerge. However, during the last several "post-bubble" years, expansion of broadband telecommunications services to the home has registered strong growth, which is a vindication of the essential vision that a home based platform for engaging in electronic life would be as essential in this century as the plain old telephone was for most of the last century.

Scope of Broadband Services

Today, the ordinary user has an intuitive understanding that broadband service means "fast Internet," and telecommunications companies vigorously market broadband, or fast Internet, services to customers, though the broadband label can cover significantly different rates of "fast service." Increasingly, users also identify broadband with digital television and high definition television. Within the next decade, users also will come to think of Internet telephone (voice over Internet protocol) as part of the meaning of broadband services. The primary focus of this discussion is on the growth of broadband data services to the home.

In this last year, the growth rate has been characterized as "torrid," because the rate ran at a 50% increase by year-end. Table 1.1 tracks this growth. However, this news about the uptake of broadband Internet services to the home should be read in light of two factors, which suggest that the pace of growth may moderate. First, there are fewer among those who use the Internet regularly through dial-up modems who say they want to change to broadband. Second, among those who want but do not have broadband services to the home, lack of service by any means may make the changeover impossible.

American Adults with Broadband at Home													
	35												
Millions	30												+
of	25											+	
Americans	20								+		+		
	15							+					
	10				+								
	5	+											
	0												
		J-00	S-00	D-00	M-01	J-01	S-01	D-01	M-02	J-02	S-02	D-02	M-03

Source: Pew Internet & American Life Project, April, 2003

Table 1.1 American Adults with Broadband at Home

Profile of Broadband Services to the Home: Voice Networks

Interest in the expansion of broadband services to homes and businesses has become a matter of national policy and priority. Congress directed the Federal Communications Commission (FCC) and the states, in section 706 of The Telecommunications Act of 1996, to encourage deployment of advanced telecommunications capability in the United States on a reasonable and timely basis. This has taken the form of a data collection program to gather standardized information about the purchase of high-speed services. Much of the data in this section relies upon the June 2003 report, "High-Speed Services for Internet Access: Status as of December 31, 2002," issued by the Industry Analysis and Technology Division, Wireline Competition Bureau, FCC.

Apart from the broad national picture, nearly all states attempted, in the last decade, to fashion some sort of broadband policy in the teeth of sharply conflicting claims by existing and possible new service providers about the obstacles standing in the way of deployment as well as about the progress they have made in deploying broadband.

In addition to the actions by states, many, many municipalities have moved ahead on municipal broadband networks, some expanding from government and school district wide area networks, others building upon network and service delivery experience with municipal electrical utilities. This interest by municipalities blossomed under the umbrella of the 1996 Telecommunications Act that provides that any entity may offer telecommunications services to the public, a provision intended to encourage the development of competition among providers of telecommunications services. As an indication of the growing importance of municipal activity, the right of municipalities to operate broadband networks has been challenged in court by private providers. The right is challenged on the grounds that the 1996 Act does not preempt states from holding primary authority over municipalities, and that if a state chooses, it may forbid municipalities from becoming telecommunications providers. Some state legislatures have been persuaded by the existing providers to pass such prohibitions tying the hands of municipalities. The Supreme Court has now agreed to hear a case, which will examine these issues, and no doubt that decision will determine how much more growth in broadband services can be expected from the municipal sector (2).

From the telecommunications industry point of view, while most growth has been at a standstill for more than two years, the provision of broadband services to the home stands out as a “hot” spot of growth. Figure 1.2 shows the growth rate of high-speed lines to homes and businesses of all kinds in 2002, which registered 50% for the entire year, with the second half showing somewhat less rapid growth than the first half. The measurement of overall growth includes all kinds of high-speed services, including those that provide services at speeds exceeding 200 kilobits per second (kbps) at least one way and those advanced services which provide services at speeds exceeding 200 kbps in both directions. These services may be delivered by wireline telephone companies, by cable providers, by terrestrial wireless providers, by satellite providers, and by any other facilities-based providers of advanced telecommunications capability such as fiber to the home facilities.

2002 Growth Rate of High Speed Lines
Connecting Homes and Businesses

First Half Increase	27%	from 12.8 million lines to 16.2 million lines
Second Half Increase	23%	from 16.2 million lines to 19.9 million lines
Full Year Increase	50%	

FCC: “High Speed Services for Internet Access”

Table 1.2 Growth Rate of High Speed Lines Connecting Homes and Businesses

While the overall growth rate is strong, it understates the surge of growth in the residential and small business sector, because the overall growth rate includes businesses of all kinds. When one looks only at residential and small business growth, the growth is even more robust registering a full year increase of 58% (see Figure 1.3). Still another insight into the importance of high speed access in homes and small business is the estimate that of the 17.4 million high speed lines, about 10.8 million provide advanced services which means services are running at speeds that exceed at least 200 kbps in both directions.

Growth Rate of High Speed Lines to Residential and Small Business
(More than 200 kpbs in at Least One Direction)

December 2001	June 2002	December 2002
11.0 million lines	14.0 million lines	17.4 million lines
Full Year % age Increase	58%	

FCC: “High Speed Services for Internet Access”

Table 1.3 Growth Rate of High Speed Lines to Residential and Small Business

Profile of Broadband Services: Data Services Over Voice Networks
In the evolution of data telecommunications services for the home, voice service (telephone) came first over a wire engineered for voice, and it reached more than 95% of U.S. homes nationwide. One of the remarkable feats of broadband engineering has been to adapt the copper telephone wires to deliver data service over the same outside plant or infrastructure that delivers voice service. The driving force behind this adaptation was the growing armada of computers in offices and homes whose users wanted to connect, especially via the nascent Internet. In terms of home service, the modem for dial-up Internet service, the integrated services digital network (ISDN) connection, and the digital subscriber line (DSL) service all have evolved through the "broadband engineering" of the voice service network.

It is interesting to note that there in no uniform pattern of implementation or growth rates of these data delivery enhancements of the voice network from the U.S. to Europe. In other words, the growth and use of modems or ISDN or DSL service was not a function primarily of technology but a function of other factors including public policies, housing features, settlement patterns, and cultural preferences, among others. The U.S. had the earlier, more widespread adoption of dial-up modems as a form of connection to the Internet compared with Europe, in large part due to a relatively early pricing of Internet access on a flat rate basis and to a local connection point, thus eliminating long distance and metered charges for time on-line. Dial-up modems today are the least costly and still serve about a third of the Internet population in the U.S. despite their third place rank in speed behind DSL or cable modem service.

On the other hand, numerous countries in Europe led the U.S. in the installation of ISDN service across their networks. For those who were ready to move to a faster service and pay the price, it was generally more available in Europe than it was in the U.S. where service offerings for ISDN were quite scattered and unsatisfactory. In the U.S., ISDN never became, nor is it now, a significant factor in home broadband service.

Quite apart from connectivity options and pricing policy, Europe also was somewhat slower in home installation of computers since space was more often a premium. As desk top computer rigs got smaller and prices lower and as laptops became more affordable, the spread of computers for home office and home education use grew rapidly in Europe. It also should be noted that differences in adoption rates of home connectivity reflect cultural preferences as well. During much of the 90s, public views on children's use of computers and the place of the computer in the home were less welcoming in Europe than in the U.S. This difference has now diminished. It is interesting to note that in some areas of technology—the uptake on mobile phones with text messaging service for example—Europe and Asia led the U.S., especially among younger users.

The most recent innovation for delivery of broadband services over voice networks to the home is the DSL service, and in the U.S., it is the mode of connection for about 9 million of the 30 million people who have broadband connections to the Internet at home (3).

On a worldwide basis, more people rely upon DSL lines for high-speed service than on any other technology (see Figure 1.4). Initiative in building a market for broadband service to the home is strongest among the telephone companies that already had been providing broadband to businesses; although, in the U.S., a significant number of companies were formed specifically to deliver DSL services at various levels of access speeds to homes and businesses. The growth rate in 2002 for DSL services worldwide was 90%, with the highest rate of growth in the Middle East. However, in absolute numbers of users, the United States and Japan are neck and neck for the most numbers of users.

Worldwide Shares of Mass Market Broadband
Based on Service in 54 Countries

DSL	56%
Cable Modem	38%

Source: Worldwide DSL Council
Telecommunications Report Daily, June 4, 2003l

Table 1.4 Worldwide Shares of Mass Market Broadband

Profile of Broadband Services to the Home: Cable Networks
The worldwide picture puts DSL in a dominant position, but in the U.S., more than twice as many users rely on cable network modems for their broadband service to the home. Just over 21 million homes use cable modem service for broadband; that is a margin of more than two to one over DSL service. Just as the voice network was adapted for broadband data service, so too, was the video network—based on coaxial cables and now frequently combined with optic fiber in the network—adapted to deliver "broadband" data service. As a result, many Americans have a choice between either DSL or cable modem broadband service to the home, although some have no option for this service, and a small percentage of others rely on wireless or even higher speed lines than either DSL or cable. The distribution of how home broadband users connect demonstrates the overwhelming importance of cable and DSL service for home users (see Figure 1.5).

How Home Broadband Users Connect
March 2003

Cable Modem	67%
DSL	28%
Wireless	4%
T-1/Fiber	1%

Source: Pew Internet and American Life Project, April, 2003

Table 1.5 How Home Broadband Users Connect

This difference in number of cable versus DSL users is not mainly a matter of price difference. The faster rate of growth in cable service is partly a result of the cable industry having recognized the revenue gains to be made by investing in upgrades to enable the delivery of data services. Once the decision to upgrade is made, it can be done almost anywhere within the cable service map.

By contrast, the spread of DSL service has been limited by the distance problems in DSL technology. These limits meant that service was not possible beyond a given distance from the central office. However, recent advances in DSL capabilities promise to reduce those limits significantly, and this promise has already translated into more competitive service pricing and aggressive marketing on the part of DSL providers. There are some differences in user experience in that cable modems users may experience network slowdown or overload due to network sharing, and security breaches can occur more easily with cable modems. Nevertheless, cable modems far outnumber DSL connections as the broadband pathway, and in the last year, that advantage was slightly increased.

Profile of Broadband Services to the Home: Other Pathways

Other modes of delivery for broadband services to the home exist including satellite, wireless, T-1 lines, and fiber-to-the-home pathways. According to the Pew Internet and American Life surveys, fixed wireless and satellite services together account for about 4% of home use, while T-1 and fiber services account for about 1% of home use. The market for satellite and fixed wireless delivery is found in more specialized applications rather than the general home market. Delivery of Internet service via T-1 lines typically goes to multiple dwelling complexes in densely populated areas. These are modest numbers and are not likely to grow dramatically (3). However, there are two pathways that are likely to become more important players in the provision of broadband services to users in the next period of expansion.

Wireless Fidelity

The first of these newer possibilities is Wireless Fidelity, or Wi-Fi, which significantly alters the geographic and economic possibilities of broadband use. Wi-Fi-enabled computers can send and receive data wirelessly anywhere within range of a base station and can be several times faster than even the speediest modem connection. Wireless home networks alter the geography of use in the home, unchaining users from the wired desktop and transforming laptops into mobile companions. Most significantly, Wi-Fi alters the basic economics of infrastructure in favor of users. The cost to deploy Wi-Fi to the premise of the end user is less costly than other forms of newly-installed infrastructure such as copper wire, coaxial cable, or fiber, the types of infrastructure over which most current broadband access is obtained. The high cost of such installations has been one of the main reasons cited by existing providers for rates of deployment that have left some significant numbers of home and small business users without the choices they say they want. It has also kept the cost of existing service high. So, Wi-Fi networks that provide wireless access for about a third less (or even much less) than other systems have strong appeal, though the costs vary depending upon the geography of an area and whether standard or enhanced security is needed, among other factors.

Wireless networks for employee use within schools, colleges, homes, offices, businesses, and service sectors such as hospitals are already widely developed. In the last half dozen years, a new form of access has been evolving, which might be thought of as public access Wi-Fi. In this approach, each "hot spot" has one or more Wi-Fi radio transceivers or "access points" physically connected to the Internet and capable of interacting with any Wi-Fi-enabled laptop or handheld device within range. By contrast, in the usual home broadband access, only one household has access to the physical connection such as DSL or cable modem lines. But within the range of Wi-Fi transmission, some larger number of users can travel to the physical access point through the hot spots. If the hot spots are close enough, a wireless access cloud is created which gives seamless coverage for many within range. In this scenario, not every user is compelled to pay for individual physical access to the Internet.

It is not clear how the dominant providers of DSL and cable modem broadband service will respond to the growing appetite for Wi-Fi hot spot access and to the phenomenon of aggregating users onto a single access point in public or neighborhood locales. Technically, cable modem service companies already ban public sharing of single user hook-ups in their service contracts, while phone companies providing DSL service vary in their contract provisions. The history of new telecommunications technology tells us that the existing service providers will attempt to preserve the status quo ante as long as possible but that eventually a *modus vivendi* develops, which makes a place for the new technology and its services. Therefore, Wi-Fi will continue to grow and become an established part of broadband access options. The question is, how should this growth affect planning in other service arenas, such as transportation?

The most well developed form of public Wi-Fi is the creation of hot spots in public areas such as airports, cafes, coffee houses, malls, bars, restaurants, and hotels. Often the access is free, though in other places, owners are attempting to create a revenue stream from the provision of hot spot services. In the Twin Cities, a company called SurfThing, based in Minnetonka, recently enabled nearly 50 local cafes, bars, and restaurants with free Internet access. Owners of the businesses where these hot spots are located believe that the service attracts customers. In hotels, access is usually charged separately as an additional service. There also are companies—such as Surf and Sip based in San Francisco—attempting to set up nation wide services in public places for which they charge. Surf and Sip services are now in 17 states and the U.S. Virgin Islands (4).

For mobile workers, a hot spot access point becomes a temporary office, and stopping where a hot spot is available becomes part of the driving travel plan of the day. These hot spot access points have become increasingly important as the mobile worker population has grown. A recent column in the *St. Paul Pioneer Press* detailed the role of hot spot access for workers who travel by car and by bus (4). Hot spot analysis should also become part of the analysis for transportation planning, especially in metropolitan areas such as the Twin Cities and the development corridor from Rochester to St. Cloud. The ability to continue to access e-mail in a cost effective and efficient way while moving around a large metro area in the course of a work day might become a critical factor in making or not making another drive within the work area. The element of cost effectiveness and efficiency is also important when comparing wireless access through hot spots with one's laptop versus a mobile phone Internet access capability. Cell phone access might be compared to headline news content. Cell phone text messaging access can alert the user to something important but it is not very useful for getting the whole story or responding as fully as needed.

While hot spots in cafes, restaurants, airports, and hotels have grown, Wi-Fi networks also have emerged with ordinary citizens setting up semi-public networks to create a neighborhood cloud of hot spots. One such network has surfaced in Prior Lake, Minnesota, where a small group of neighbors have created a neighborhood Wi-Fi network through a string of wireless-enabled houses that overlap to create a single, seamless wireless environment. As a result, every home in the wireless cloud can tap into a single, shared high-speed Internet connection and also can communicate on a neighborhood basis at very high speeds as well. It is possible to view the overall development of dots or nodes of the nascent wireless public network by following the Web maps compiled by the Twin Cities Wireless Users Group [www.tcwug.org] (4).

Beyond the development of numerous individual hot spots or the creation of localized neighborhood networks, the next step is to install public hot spots covering an entire metropolitan area so as to create a seamless cloud of access for broadband connectivity among wireless users in the whole municipal area. Municipalities and/or state agencies that regard wireless infrastructure as another fundamental tool in economic development planning lead these initiatives. It also is seen as a way to bring service to users left without broadband access, and it is seen as a way to introduce some competitive pricing into the broadband service industry, because wireless infrastructure is relatively cost-effective. This already has been done in some cities and is under active development in many more. For example, Athens, Georgia, and Tallahassee, Florida, already have created Wi-Fi clouds aiming to flood large areas with bandwidth. The City of Bellevue, Washington, has launched a process to create both a full fiber ring around the city along with a ubiquitous Wi-Fi access cloud. Utah is home to one of the most ambitious projects in the country involving 17 cities again combining fiber and wireless connectivity in its approach (5).

At this point, neither the U.S. nor Minnesota is a leader in hot spots, Wi-Fi clouds, or home based Wi-Fi community networks. Asian countries lead the U.S. in the creation of wide area Wi-Fi clouds, and in the U.S., both east and west coasts lead in Wi-Fi development of hot spots and in the growth of more extensive community networks. However, younger users are intensely aware of the flexibility of Wi-Fi and are likely to push its development in Minnesota more quickly. One can speculate that residential areas and residential micro areas that foster clouds or community networks may provide magnets that will draw residents into the residential area, and wireless ubiquity might lead them to concentrate more activities there.

Important challenges remain for those who would like to see Wi-Fi become a major player in broadband services. Equipment standardization is needed, more spectrum is needed, and international agreements on service bands are needed. Reliability and security remain challenges but are improving rapidly enough so that more and more large scale community public safety services are adopting this pathway for their needs. The idea that wireless might become a major player in broadband services is very attractive because, among other reasons, the implementation costs are so much lower than with any other technology currently being deployed.

Fiber-to-the-Home

The second pathway, which promises to grow into an important broadband service to the home, is known as fiber-to-the-home. As the name implies, broadband telecommunications services are delivered by optic fibers to the side of every home or apartment. Since fiber optic lines have enormous capacity, the possibility of supporting big bandwidth uses at home becomes a reality. Such capacity is a real necessity for the serious home office/home business user. More broadly, other uses include the delivery of high bandwidth content such as movies, complex computer games, streaming video and audio, and other uses. Fiber-to-the-home enables the equipped provider to bring all the home services of voice, video, and data to the home user over the fiber system and allows the home user to work with one provider company, all of which promises lower costs for providing the service and lower costs to the user for the service. If the converged services—made possible because of the technology—are offered by a small, service-oriented service provider, the consumer benefits even more.

Up to the present, fiber-to-the-home networks largely have been built by more rural telephone companies where the DSL or cable data service was unlikely or was equally costly. Those companies then aimed to provide multiple services over the fiber networks.

However, fiber-to-the-home (FTTH) also has become an option among new, greenfield housing developments, especially in those developments known as residential master planned communities. The defining characteristic of those communities is that a single developer maintains a significant degree of control over all the design elements of the area. This opens up the possibility for the developer to choose to install fiber to the home as part of its overall service plan for the community and to place the cost for the infrastructure into the overall price for lot development.

In this scenario, telecommunications services may be provided through partnership contracts with existing provider companies. Or alternatively, the more innovative approach is for the developer to launch and own the telecommunications company, which offers some or all of the voice, video, and data services to the development's residents as they move in. Minnesota has an example of such a master planned community for which a full service telecommunications company was created, and it is described more fully in the case study on page 13. This community is attracting considerable attention from across the country and is being watched very closely, because it combines the most advanced technology platform along with a single developer-owned service provider that ties it very closely to the community.

There has been little dispute that FTTH should be the next stage in the evolution of broadband services to the home. However, the equipment and installation costs are significant (around $1,500 to $2,500 per user), and up until very recently, few companies were manufacturing equipment for field installation at cost effective prices. The costs were special obstacles if the area to be served was not a new residential development. While most providers would agree that a fiber to the home platform for delivery of broadband access was desirable, it was not considered cost effective for extensions of existing service or for overbuilding in order to provide competitive services.

However, in May 2003, three of the largest telecommunications provider companies made an announcement that could turn the tide strongly in favor of FTTH or fiber-to-the-premise (FTTP) installations. Verizon, SBC, and BellSouth indicated that they were defining common technical standards for fiber deployments to businesses and residences. That means the cost of equipment for fiber installation per user could drop down to the $800 to $1,000 per user range, which could spur demand for services and new fiber deployments among both residences and businesses (6).

A similar breakthrough in field installation costs is needed. By comparison, somewhat less than a decade ago, the DSL industry took a decisive step forward when similar agreements on technical standards were reached by that industry. However, it is only in the last two years that really rapid growth registered in DSL service.

The overall deployment of FTTH at the present time is still dominated by small and spotty deployments among small independent telephone companies, by utilities, by municipalities, and by master planned residential developers in new housing developments. There is a small but steady growth with an overall base of 50,000 FTTH users in North America and about 400,000 worldwide (7).

While these figures are today very tiny in the broadband access world, which is usually measured in millions of users, two factors—in addition to the recent agreement on technical standards—suggest that a threshold point is approaching, which will place this technology much more securely in the center of broadband services. First, the convergence of price points for installation of FTTH platforms versus other platforms, such as hybrid fiber coaxial cable, will give a definitive advantage to FTTH since it is a better long-term investment. Second, a critical breakthrough will occur when the first large telephone company decides to use FTTH in its expansion and rebuilding plans. Unfortunately for Minnesota, this breakthrough decision is not likely to come from Qwest Communications, which remains wedded to the use of hybrid technologies combining fiber and copper wires for reaching the home. Rather, this is most likely to come from Verizon, SBC, or Bell South who all show more active interest in the migration path that most observers believe will take place in the next several years. When the first migration occurs, all the major telecommunications provider companies will need to follow suit as a competitive measure. At that point, FTTH will become a stronger player in broadband services to the home.

Still another large element in the development of FTTH will be the success or failure of the country's largest fiber project in Utah, which has been dubbed the UTOPIA project. The project has the backing of 17 member cities representing an aggregate of 520,000 people, 170,000 households, and more than 20,000 businesses. UTOPIA has been formed as a political subdivision of the state and plans to construct a publicly-owned fiber network that will operate as an open service provider network for all providers who wish to use it to provide services to the community. If the project should succeed, it will accelerate all other trend factors in the migration by major providers to FTTH installations (7).

In comparing the two technologies—Wi-Fi and FTTH—most likely to become stronger players in provision of broadband access to the home (and to small businesses), we see that Wi-Fi has the immediate advantage of lower installation costs and the ability to aggregate multiple users to take advantage of a single physical connection to the Internet. As currently developed, it has some disadvantages of security and reliability and, at the top end, of inadequate speed. FTTH has the advantage of running on a platform that brings top class services to the home with the same capability, reliability, and security found in the best corporate settings. As currently deployed, it is being offered to the customer at about the same or slightly lower prices as conventional broadband access for DSL or cable modem. It has the disadvantage of a higher installation cost than other current technologies for broadband to the home, an installation cost which must be offset somewhere in the operational budget of the provider.

FTTH represents a major step in the direction of enabling home users to carry out the same sophisticated work at home as in the best-equipped offices. It also offers the possibility to use the capacity of the network for neighborhood development. Because FTTH enhances so substantially the work environment capacity of the home, it is the best test case possible for looking closely at the impact of high-speed broadband access on work at home, telecommuting, and other behaviors which affect the transit and transportation patterns of users.

Minnesota has one residential development community that is deploying broadband access through FTTH in Rosemount, Minnesota. In ideal circumstances, the larger study for which this paper was written would have developed a diary study based on that development. However, in the real world, the developer's timetable for arrival of new residents and deployment of services to those residents did not coincide with the timetable for data collection for this report. However, some anecdotal information is now available touching on those questions, and it is included as part of the following case study report on Evermoor, the master planned residential community development in Rosemount, Minnesota, and on FTTH Communications, the telecommunications service provider company that was formed to provide services to the new community residents.

Case Study Report: Evermoor

Evermoor—Master Planned Community, Rosemount, Minnesota
and
FTTH Communications

The development of a new residential housing area offers unique opportunities for bringing broadband fiber to the home (FTTH). Developers have shown a strong interest in both the economic and neighborhood benefits of enhanced broadband access to their new residents. Among these developers, the most innovative approach is that taken by a Minnesota company named Contractor Property Developer's Company (CPDC). The broadband access policy of CPDC is the personal handiwork of CPDC's founder, Homer Tompkins, Jr., who has a personal commitment to leading edge technology as part of high quality master planned community developments.

About four years ago, at the behest of its owner, CPDC decided to investigate the question whether telecommunications services was a line of business the developer should enter proactively on behalf of its future new neighborhoods or whether CPDC should continue to take the customary path of building homes and leaving telecommunications services to the individual homeowner to secure from adjacent service providers. CPDC made the judgment that home buyers' increasing appetite for telecommunications services with high speed broadband access could offer long term economic benefits to the company and at the same time offer immediate benefits to the neighborhoods they build. This judgment launched an intensive investigation into technology options, into design requirements, and into business models in order to identify the right combination for CPDC future developments.

Investigation of technology options led fairly quickly to a couple of conclusions. First, it was unsurprising to learn that existing options for broadband access from established providers for its Twin Cities metro area developments usually meant either DSL or cable modem service, though there were areas in the outer rings of the Twin Cities where neither were currently available.

Second, CPDC learned that the technology offered by FTTH systems would offer the most certain way to provide the most advanced services to the development. It was the technology that was most likely to be equal in the next ten to twenty years to the capacity demands of significant home office use as well as for digital video and for streaming video uses then beginning to appear on the Internet. Furthermore, this technology would allow the developer to create more intensive neighborhood-specific communications space such as a dedicated video channel for Evermoor residents and other digital services designed just for residents. The technology could help create a community that would allow community residents to communicate with each other online as well as on the street. Other community benefits might follow including that more people would choose to use the rich technology environment for more complex home business purposes, be more available in the community, spend more of the family income in the community, and therefore possibly be involved in less long distance transit in the metro area.

A preliminary preference for FTTH was established, and a set of design guidelines for inside wiring and widely distributed access points for voice, video, and data in all rooms of the houses was developed and required in the construction phase. This was critical since if the walls were closed up with inadequate or improper wiring and access points, the advantages CPDC hoped to provide residents from the richly enabled home telecommunications environment would be lost.

While the design guidelines were important, the paramount question turned to the matter of the right business model. Two models were under consideration. One model involved the establishment of a partnership on terms to be negotiated between the developer and one or more telecommunications provider company in which the capital costs and revenue stream of the telecommunications network would be shared. The second model was the go-it-alone model whereby the developer would fund the capital costs and retain all the benefits of the revenue stream. The first model was appealing for obvious reasons in that it lowered the developer's immediate capital requirements and spread the risk

In the end, CPDC decided to follow the second model and make the development and marketing of front-running technology communities a hallmark of the company. The up-front capital requirements were significantly higher than a partnership approach, but the judgment was made that creating its own telecommunications company on the FTTH platform promised the developer a longer term, relatively stable return on investment. Typically, developers are vulnerable to the upturns and downturns of capital markets and interest rate fluctuations affecting home buying behavior, but a telecommunications services company could help offset that fluctuation once the customer base was established. It also meant that the new company would be in a position to sell all three telecommunications services, which is desirable for the consumer residents.

In order to realize its goal as a front-running technology community developer, CPDC created a developer-owned telecommunications company called FTTH Communication, Inc. (www.ftthcom.com) FTTH Communication is organized to offer all three telecommunications services.

The first development targeted for CPDC investment in telecommunications services was Evermoor, located in Rosemount, Minnesota. It is a sizeable development covering more than six hundred acres which, when complete, will encompass about 1,200 living units of mixed use single-family homes, town-homes, and senior housing. The single-family homes range in price from $350,000 to $800,000.

What has been the experience to date? The first homes began to be occupied in the first quarter of 2002. By May of 2002, voice and data services began to be offered under the FTTH Communication umbrella. However, since the FTTH Communication head-end and other facilities were not yet fully in place, the company began its operations by leasing services for data and voice from other providers and providing video service via home satellite dishes.

By the third quarter of 2002, major facilities decisions were taken and an executive manager was in place. The company had stayed in close touch with the small number of new residents arriving into the Evermoor community in the early part of 2002, and as the capacity for services over its own facilities grew and the number of occupied homes grew, the company facilities and the residential base grew together (8).

There are currently 350 occupied units with expected growth at the end of 2003 to result in 380 occupancies and the expected occupancy at the end of 2004 at about 706. It is generally thought that the FTTH platform produces a satisfactory rate of return when it supports from 1,200 to 1,500 customers. Not all customers take all services. There are 220 phone customers with 275 lines in service, 190 data customers, and 100 video customers. However, FTTH Communication has just begun to offer digital video service, so the video numbers are likely to catch up to the customer base numbers quite quickly. In light of the need to reach satisfactory rate of return targets, FTTH Communications will expand into the next two CPDC developments in Albertville and Hugo, Minnesota, over the course of the next several years.

What do customers experience and what do they value in this rich technology environment? The general manager believes they value both the technology and the personal service from the always-available staff of the fledgling company. What they experience is the availability of 24 or more phone lines (without digging or wiring), a standard 2-megabit connection speed with higher speed available, and more than 100 video channels. Prices are about the same or a bit less than those of area competitors, but FTTH Communication emphasizes the quality as well as the service in its relationship to the customer.

The general manager indicates that many customers are running their businesses out of their homes, and they buy many phone lines for that purpose as well as rely on the high speed capacity of the data transmission. A tax consultant who maintains five servers and numerous phone lines to conduct his business runs one of those home businesses (9).

The next stage of growth involves building a more robust intranet site online and implementing plans for a community video channel. It is apparent that residents do use the intranet site and interact that way. The company also is considering including a business support and conference center facility in future developments to attract more homebuyers who would prefer work at home. It also plans to make it easier for customers with secure connections through virtual private networks—which are easy to create on the FTTH platform—to interface with their corporate structures. All of this is meant to attract more of occupants who want to use the full capabilities of fiber to the home.

The longer term experience of CPDC and FTTH Communication will be an important test case for the possibility that private investment from players other than the dominant DSL and cable companies can play a role in moving high end broadband access into homes. It also will be important to follow the path of this innovative approach for policy analysis of the longer term impact of home based high end broadband access facilities.

Importance of Broadband Services to the Home: Public Policy and Private Market
The most remarkable feature of the expansion of broadband telecommunications is the growing importance of this to home users, at least if one measures importance by the fact that people must specifically chose to buy the service in addition to the purchase of video or voice service. At the end of March 2003, 31% of home Internet users had a high-speed connection at home according to the Pew Internet and American Life surveys. This translates into approximately 31 million people who live in homes with a broadband connection. Looked at another way, it means that 16% of all Americans are fast Internet users—double the number at the end of 2001. That represents a 50% increase in the past year alone.

Nevertheless, despite the sharp increase this past year in broadband adoption, other countries outpace the United States including South Korea and Canada. Both of these countries developed public policies—in cooperation with providers—that fostered rapid expansion of broadband services. For South Korea, it was part of an overall growth strategy, and for Canada it reflected an expectation that Internet communications could reduce rural isolation, enhance social cohesiveness, and foster growth in the economy.

In the United States, the growth of home broadband connectivity has been largely a matter of private market expansion, though that expansion was supported by some macro regulatory policies at both federal and state levels as well as by encouraging rhetoric. In policy terms, the FCC has chosen to shield Internet access services from regulatory classifications, which would subject them to the family of charges and surcharges that have grown up around telephone services. This helps contain the cost charged to end users for Internet service. In short, the policy in the U.S. at the national level has been to provide some modest support for broadband service to migrate into the home, but the policy left it largely up to the individual consumer to choose whether or not the service was important enough to buy.

Minnesota's public policy approach to the provision of broadband has largely followed the national one meaning that at this juncture, no major new initiatives have been taken at the state level, though for much of the last decade, proposals for statewide initiatives were debated rather intensively. A major factor in the discussion was the concern that a lower level of affordable broadband access in small towns and rural areas would contribute to the growing economic development gap between Minnesota's larger cities and others, add to pressure for rural depopulation, and contribute to poorer quality education for children and adults in the less well serviced areas. These concerns have not disappeared, but whatever the proper response should or will be, the telecommunications factor in the equation remains to be seen. The Minnesota Legislature did include a strong provision for online education in the 2003 session.

How is Broadband Access Used at Home?
While the public policy debate and private market actions evolve, we are gaining a better understanding of the answer to this question: What do the 31 million Americans who buy high speed Internet access do with the service? Many anecdotal accounts about the appetite for and consequences of Internet activity exist but have recently been supplemented by more systematic survey reports. One of the more ambitious and recent reports comes from the Internet and American Life Project of the Pew Foundation (www.pewInternet.org/), which takes what it calls a new look at Internet access and the digital divide and how people use the Internet.

The Pew report argues that to speak of a digital access divide between users and non-users misses the fluidity of actual use. Instead, among the 42% of Americans who say they don't use the Internet, there are three distinct groupings. Net evaders actually live in homes with Internet access, but rely on other family members to send their e-mail or do their searches. Net dropouts once were active users but might have current problems such as broken equipment, service provider problems, or financial problems with paying for access. True non-users or the truly disconnected also exist but are a smaller group than evaders or dropouts.

An important fact is that a majority of respondents are aware of the Internet and know where a public access point to it is in their community. This is especially important for the young, urban, poor non-white population who wants to be online at home but is unable to pay for it. In that perspective, public and private programs to insure public computer access are important as are those aiming to make broadband access more affordable. Demographic characteristics—education, income, race, among others—are the strongest predictors of whether or not people use the Internet. But orientation and social habits also matter. An outward orientation to the world along with watching and reading the news increases the chance of being an Internet user. On the other hand social habits reflecting a "close-in" social network tend to reduce the chance. If both are true, outward orientation trumps the close-in social capital network in that such a person is likely to be online.

For those who do have broadband access at home, how do they use the service? If you take all Internet users in the aggregate including broadband access users and dial-up users, 57% of Americans—or 109 million people—go online on an average day. Rather than report typologically on use, the data can be used to highlight some important points about usage. By far the most important use is that of e-mail with 93% of daily use. This may seem self-evident now, but it was not self-evident to the telecommunications service industry a decade ago. It was looking to e-commerce or entertainment as the "killer application."

However, we travel down the usage chart to 61% of daily use before any e-commerce application registers (buying a product) and down further to 41 to 37% before any entertainment applications register. Last, we must travel very far down the usage chart to 19% to find users who are "creating" content for the Internet. The intriguing question is whether this somewhat passive orientation to the Internet will become more active as the Internet lifeline grows. Last, the use of access at home for running a business, telecommuting, or virtual private network connection to one's workplace does not seem to be reflected in the overall findings, except possibly "research for their job," which registered at 52%. Yet growth in that area of use promises to be closely related to broadband access in the home.

Looking Ahead

The best guidance in looking ahead is to emphasize how little was understood about the potential importance of the Internet to home life, or to business and service life for that matter, at the beginning of the 90s. The easiest and most personal use of the Internet—e-mail—is the leading use today. In thinking about the role of broadband access to the home, we know that broadband access is helpful but not essential to that use. Nevertheless, extrapolation from the usage profile of today is risky. Policy analysts might take their advice from E. B. White's fable, "Don't count your boobies until they are hatched."

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CHAPTER 2
ICT and Travel: Enacted Patterns Between Internet Use and Working and Shopping Trips

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The relationship between travel and telecommunications is now generally viewed as multifaceted: telecommunications can substitute for trips, telecommunications can modify trips, and telecommunications can stimulate trips. While this complexity is recognized, there is less empirical evidence on the exact manners by which these various interrelationships occur. And in particular, there is a paucity of data on how improved forms of telecommunications—particularly high bandwidth—affects the patterns of behavior between telecommunications use and travel (1).

This paper aims to further the discussion on the nature of information and communications technology (ICT) by focusing on work and shopping behavior at the household level. To do so, the research reported upon here examined the implications of home information and communications technology access for everyday travel behavior in residential areas in and surrounding Minneapolis, Minnesota. While targeted technologies included those that transmit voice and data (e.g. telephone and e-mail), a focal point of interest is understanding how *home* Internet access via broadband might influence repetitive travel behaviors (e.g. work commutes, shopping) beyond access relying upon slower dial-up connections. Theoretically, access to Internet service in general has implications for trip making. However, where once it was assumed the mere availability of the Internet would replace the need for travel, the literature increasingly suggests a more complex, dynamic, and interactive relationship between technology access and human behaviors. It is the intricacies of such relationships that will be explored here.

Part 1: Background

The effect of technology, and more specifically ICT, has been examined on a number of levels in previous work. For example, Alvin Toffler (2) has suggested that ICT developments will make cities obsolete, and Lehman-Wilzig (3) projected that telecommunications might eliminate all travel. Indeed, by now there is a bevy of analyses and forecasts on how technology may impact contemporary urban life and land development patterns (4–7).

Motivation for interest in the topic of ICT's influence at the micro level of household work and shopping travel remains varied. For example, telecommuting attracts attention from employers, as it allows them to reduce overhead costs and improve operational efficiency while offering employees increased flexibility and decreased travel time. Similarly, commercial businesses see opportunities for increased sales through the strategic use of ICTs to increase point-of-sale options, for example through e-commerce, where customers are able to buy products without having to travel.

Perhaps the most publicized interests, however, have been from environmental groups and government entities that are motivated by the potential trip-replacing effects of telecommuting and e-shopping: lower energy consumption, reduced congestion and improved air quality. A premise of this interest rests on the likelihood that ICT will reduce the need for automobile travel, either in terms of vehicle miles traveled (VMT) or number of vehicle trips. Particular attention focuses on the potential to eliminate, reduce, or temporally shift peak-period commute travel. But interestingly enough, while deployment of ICT has skyrocketed in recent years, overall household travel in terms of distance and/or trips has increased as well (see, for example, 57). This suggests that our knowledge of relationships between ICT and travel, while growing, remains tentative at best.

In perusing existing work that relates ICT and household travel (see, for example, 8–11), one can begin to gain a better understanding of the central questions and range of issues associated with this general line of inquiry. However, these reviews are limited in a number of contexts. First, the bulk of the literature focuses on telecommuting, with only a few studies (for example, 12–13) investigating e-shopping and its relationship with personal travel behavior. Second, many of the existing works regarding non-work commute impacts are more hypothetical and theoretical in character. Most of the empirical shopping studies have grouped e-shopping with home-shopping, which includes shopping by catalogue, television, fax, or telephone, rather than isolating it as an activity over the Internet (14). Finally, few studies have examined whether the speed of a household's connection to the Internet had an impact on their work or shopping travel behavior.

This study was undertaken to contribute to the ICT-travel literature through empirical research examining the implications of ICT for a range of everyday trips with an emphasis on those made for work and shopping. By way of understanding and framing the problem, existing studies are reviewed next, with particular emphasis placed upon theoretical conceptualizations relating to this study's variables. Research questions are posed after the literature review. The following sections focus upon results from data collected via a residential survey. A time use diary was also administered, but the results from that are included in a separate paper. Discussion, conclusions, and suggestions for further research are presented in the final section.

Part 2: Previous Research

A. Framing the discussion: ICT Activities and Their Effect on Travel

<u>ICT-enhanced Activities</u>

To understand the scope of the potential impact of ICTs on travel behavior, it is useful to consider the wide array of activities that are potentially affected by ICTs. Previous studies have identified as many as eight different ICT-influenced activities including telecommuting, teleconferencing, teleshopping, telebanking, tele-entertainment, tele-education, tele-medicine, and tele-justice (15). In prior work, the current research team has reviewed the impact of these various e-activities on the transportation system (20).

While ICT-influenced activities as a group may influence travel, two forms—tele-shopping (a.k.a. e-shopping) and telework (e.g. telecommuting, mobile work)—warrant close attention. Shopping and work trips traditionally are conducted on a daily, or near daily basis, and are circumscribed by the traditional office hours of 9 a.m. to 5 p.m., five days per week. Prior research suggests individuals often engage in shopping and errand-running behavior concurrent with the work trip (6, 20). Thus, understanding ways in which ICT might impact these everyday activities has clear benefits for ongoing and future transportation system and community development.

<u>Enacted Travel: A Conceptual Framework for Analyzing ICT's Relationship to Travel</u>

Ideally, ICTs function to replace those everyday trips like work and shopping trips typically made by automobile and often by single individuals. However, research suggests this ideal scenario is not the only possible affect technology might have on travel. In fact, technology's influence across everyday activities in general is increasingly understood to be quite complex. Orlikowski and Iacono (54) have argued against more simple, deterministic or strategic perspectives in favor of an "enacted" view of the relationship between technology, economic systems, and imbedded behaviors, such as trip making. According to the former conceptualization, research would tend to measure and attempt to model the changes *caused* by technology or attempt to predict behaviors based upon strategic choice. Conceptualization of the relationship between ICTs and human behaviors, Orlikowski and Iacono argued, should adopt the latter—the enacted view. The main thrust of this approach is to target analysis towards the patterns that emerge through the synergistic shaping of technology, human actions, and contextual factors. This perspective allows due consideration to be placed upon the often unintended, nonlinear consequences of the relationship between technology and human activities. Accordingly the questions posed in research from this perspective should extend beyond a purely substitutive effect of telecommunications technology on travel and explore instead how such technologies might be integrated into and result in complex new and unforeseen behaviors.

This same argument is paralleled in the transportation literature. In fact, Salomon provided the initial outline for the interaction between ICT and travel nearly 20 years ago (11, 41) in which he identified four potential different types of interaction. First listing substitution, Salomon's framework expands to include more complex interactions including modification, enhancement, and neutrality. This typology frames subsequent discussion and analyses (15, 42, 43), and is employed here as a means to discuss the anticipated impacts of ICT on everyday activities associated with trip-making. In brief:

- *Substitution* of travel refers to the elimination of trips, that is, ICT improvements result in physical trips no longer being necessary. This interaction has been the focus of most ICT research, and the substitution of trips, by definition, is a phenomenon inherent in the term telecommuting (10). While substitution describes the relationship between technologies and travel envisioned by early theorists and researchers, the scale to which this has actually occurred is estimated to be smaller than anticipated (15, 47).

- *Modification* refers to travel that is likely to be altered, primarily by a shift in the timing and routing of trips (spatial and/or temporal transformations). It also may refer to the manner in which trips are linked together (i.e. trip chaining) or even the mode of travel. The benefits of shifting even a small amount of peak hour travel (including shopping and work trips) to different times (through e-shopping and telecommuting) are mentioned as a key strategy for reducing congestion levels. While it is becoming clear that ICT will modify travel behavior (20, 44, 45), it still is unclear in what manner (e.g. more travel or less).

- *Generation* refers to any generation of travel that would not have occurred but for the existence of ICT. Little is known about how ICT may generate additional traffic outside of a theoretical elasticity effects on discretionary travel (see following pages for discussion). This lack of information is largely due to the difficulty in determining causality and a lack of time-series data before and after ICT enhancement and deployment.

- *Neutrality* refers to those instances in which ICT has no foreseeable effect on household travel behavior.

In keeping with the enacted view of technology and travel, one can envision how the potential to substitute telecommunications for travel is strongly mediated by the circumstances and desire for travel. To capture such interactions, a conceptual distinction has been made in the literature between subsistence, maintenance, and discretionary forms of travel based on work first introduced by Reichman (16). This typology has been employed by Pas (17, 18) and Bhat and Koppelman (19) to classify daily travel activity behavior and is applicable to this line of inquiry as is serves as a point of departure for categorizing and understanding the travel data collected in the survey and travel diary.

Subsistence activities, when viewed relative to ICT, refer to individuals working at home or other remote locations, or telecommuting, most often with telecommunications links to a central office. Interest in this relationship between ICT and the work trip stems from the potential of relieving peak hour traffic congestion by reducing or modifying people's work trips (on average, considered to comprise one-third of all household travel).

Maintenance activities include the purchase and consumption of convenience goods or personal services needed by an individual or household. These types of activities account for more than half of all household trips and about 40 percent of personal miles traveled, but there is a lack of knowledge about how ICT affects them. The bulk of maintenance travel-related literature focuses on shopping, as opposed to other maintenance-type activities, such as banking or paying bills. Research in this area began with the examination of the impact of early telephone order (and delivery) businesses on the ease of rural living and the vitality of town commercial centers.

Finally, leisure, or discretionary, activities comprise voluntary activities performed on free time, that is, time that is not allocated to work or maintenance activities. This topic has received the least amount of study. While the boundaries between maintenance and discretionary activities blur, discretionary activities merit their own category. These may be among the most dynamic in terms of ICT travel tradeoffs—on the one hand such trips can be most susceptible to substitution, yet it may be these very trips that are viewed most positively (e.g. going to a shopping mall to both get an item and people watch).

These notions of subsistence, maintenance, and discretionary activities highlight the different contexts in which travel behavior occurs. In this study, the focus of work and shopping will allow for an investigation of ICT within two such contexts, as work is generally a subsistence activity and shopping a discretionary (or maintenance) activity.

B. E-Work: The ICT-Work-Travel Relationship

Interest in the relationship between ICT and the work trip stems from the potential of relieving peak hour traffic congestion by reducing or modifying people's work trip. The widespread availability of telecommunications services, combined with their use, has been the principle reason this aspect of ICT has been the target of the overwhelming majority of all studies of ICT use (15, 20–30). Additional reasons for the focus on this line of work are two-fold. First, transportation planners and modelers have long focused on the work commute, and secondly, work related activities tend to be more stable and predictable, making them more amenable to analysis than maintenance and discretionary activities.

Telecommuting has proven to be a more elusive topic for study than originally expected, however, and the orientation of telecommuting research has varied considerably. Efforts have been hampered by the complexity of the problem, complicated by methodological issues across studies including a remarkable continued lack of consensus in defining telework. Across research, sampled respondents display a range of behaviors limiting the utility of cross-study comparisons in achieving a clear understanding of the nature of the telecommunications-transportation relationship (9, 31, 32). Several studies have attempted to gain a better understanding of which behaviors should be included under the telework construct, which may include salaried employees who work at home (generally termed telecommuting), paid employment from a telecenter, home-based businesses, distributed work teams, truly mobile work forms (e.g. mobile sales teams, on-site customer support), geographically dispersed work teams, after-hours work, and so forth (see, for example, 21–23, 33, 34).

Mokhtarian (24) has attempted to assemble the substantive findings to date under a unified framework by examining current knowledge in forecasting the demand for telecommuting and the resulting transportation impacts. While this information has settled that telecommuting does affect trips, it also shows that these effects are not uniform, and, in some cases, the results have been contradictory. Some studies have found that telecommuters reduce their number of trips and distance traveled on telecommute days (20, 45–47), on non-telecommute days (45, 46), or on net travel (see 24 for other reviews, 48), while others put forward evidence of travel stimulation or generation (8, 11, 15, 26), sometimes only on non-telecommute days or for non-work trips (20, 47).

Wells, et.al. (20) and Pratt (47) suggest that the actual impact may vary with the type of telecommuting in which one is engaged, that is, those who engage in full time work at home tend to demonstrate the most changed travel behavior, while those who telecommute a few days per week or less tend to maintain pre-telework behavior. Given the great array of potential factors that can influence the telecommuting and travel relationship, Pratt recently summarized the results to date as showing that telecommuting has proven to be a less effective trip reduction solution than originally hoped for (47). It is probably safe to say that failing an external change with a profound affect on the current workplace environment, telecommuting's impact will be found in modification of trips, rather than direct substitution. The challenge for research is compiling sufficiently detailed information to identify the mobile work types that create the greatest impacts.

C. E-Shopping: The ICT-Shopping-Travel Relationship

The effect of ICT on shopping and related travel has perhaps the longest history of study, beginning with discussions for the impact of early catalogue order businesses on the ease of rural living and the vitality of town commercial centers. Gould (49, 50) offered an overview of the transportation implications emerging from home shopping and on-line commerce. Her review focused on possible changes and demands placed on delivery services, the possibility of goods with no physical delivery, and the possible growth of new retail venues. She touched on a number of the difficulties in estimating the use of home shopping, including the need for understanding the different stages of shopping, attitudinal issues and options of consumers, and how ICT travel is related to other physical travel.

Marker and Goulias (42) described a framework for understanding and estimating the use of ICT and grocery shopping, which outlines salient issues as they relate to the likely effects on traffic (e.g. trip substitution, chaining), forms of delivery, and methods in modeling such activities. Lin and Mahmassani (51) also examined the grocery shopping relationship, including some suggestion as to why on-line grocery shopping firms were not succeeding. They concluded that this failure was due to delivery costs that increased more quickly as the number of customers increased, and that a significant part of this cost increase was the need for more delivery trucks to meet the tight delivery time windows desired by customers. Intrinsic to this finding is that vehicle trips increase to the point that few physical trips to the grocery store are replaced.

Only a few empirical studies on ICT and maintenance travel have been carried out. Handy and Yantis (40) examined the potential substitutability of three different activities: movie watching, shopping (non-grocery), and banking, which were chosen to represent the spectrum of potential non-work activities. While movie watching was classified as a discretionary activity, as discussed above, banking was classified as maintenance travel, and non-grocery shopping trips were treated as trips with elements of both types of activities. The authors conducted a household survey in three different cities to explore individual use of and choices about each of the activities. The results suggest that the relationships are quite complex, and, since certain qualities of the physical versions of each trip were not duplicable by the in-home version facilitated through ICT, direct substitution would not be a likely result.

Casas and colleagues (13) compared the travel behavior of e-shoppers with non-e-shoppers using data from a household travel survey of 3,931 households in Sacramento, California. The survey concentrated on weekday travel, using interviews and one-day travel diaries, and the results showed that 37 percent of respondents had used the Internet to either search for product information or purchase a product. The study also showed that, after controlling for gender, age and income, these shoppers made more shopping trips, as well as more trips of all kinds, than those shoppers that had not used the Internet to search for information or make a purchase. These high trip rates were also associated with income and age, which led the authors to attribute the increased Internet use to the more active lifestyle overall of these shoppers. The authors thus concluded that e-shopping is an additional shopping method that can impact shopping behavior, and ease the lifestyle of busy people, but it does not have a great impact upon whether the shopping trip itself is made.

Salomon and Koppelman provided a theoretical framework to understand the relationship between home-based shopping and store-based shopping in 1988 (35); this framework was supported later by empirical investigation (36). While their work was largely dedicated to analyzing telephone shopping, which is distinguishable from shopping through ICT use (37), it still informs this work in two ways. First, they distinguished between the act of shopping (the acquisition of information) and actually purchasing an item, which is of growing importance to ICT activity. Second, they introduced the concept of dividing merchandise selection into a number of steps.

Recently, Couclelis (38) provided a more detailed breakdown of these tasks that is better tailored to ICT purchases. These tasks include: (a) becoming aware of need or want of a product, (b) gathering information about options, (c) searching and browsing, (d) seeking advice/expert help, (e) inspecting alternatives, (f) deciding on an item to be purchased, (g) deciding on a vendor, (h) purchasing a product, (i) tracking the status of an order, (j) getting an item to delivery point (e.g., home), (k) returning/exchanging an item, and (l) seeking post-sales service. Only one of the tasks, purchasing the product, is commonly considered in analysis. It is, after all, the task in which the important transaction takes place and also the one that is instrumental to the livelihood of bricks and mortar establishments. While other tasks (for example, b, c, e, g, and l) are recognized as affected by ICT, a detailed and thorough understanding of the nature of these relationships is at the heart of Internet shopping and currently unavailable.

Several studies have, however, looked at the motives for engaging in these activities. In a recent review, Farag (14) noted that convenience and timesaving are cited most often as reasons for on-line shopping. She also found that these factors are tempered by individual and household characteristics, as well as product characteristics. “Search” goods, such as books and CDs, are more suited to on-line purchase than “experience” goods, such as fresh vegetables. The personal and household factors that seemed to indicate the greatest likelihood of ICT use included higher education and income and longer history of Internet use. Farag concludes, however, that more detailed analysis of the roles these personal and household characteristics play in online shopping behavior is necessary before reliable results are generated.

D. Connection Speed and ICT Use

The discussion above indicates that substitution of trips should not be an expected result of increased ICT use. However, the studies referenced did not account for the speed of the Internet connection used by the potential telecommuter or e-shopper. Given that high-speed connections to the home became a realistic possibility for the typical homeowner only in the past few years, it is safe to say that most results and theories were based on dial-up speeds. However, Pratt (47) cites a number of critics support the notion that broadband may be the ingredient that makes [telecommuting] viable. Such observations suggest that the additional advantages of broadband will help make ICT-enabled interactions more commonplace. These advantages include the “always-on” connection, which reduces the time required for conducting business, more graphic-intensive content, and potential for video and audio transfer as well as data. (52).

Horan (6) suggests that increased connectivity will lead to new arrangements with a potential for significant alteration of trip making behavior, due to new opportunities for relocating institutions into more centralized locations. In particular, he suggests the possibility of new “enacted” interactions between people and their environment, including work organizations and broader communities—homes would function as part-time workplaces (due to telecommuting), schools would provide a wider range of educational options (due to electronic content access), and stores would integrate e-commerce with traditional brick and motor operations. While many of these ideas are largely conceptual at the present time, technological developments are creating opportunities for greater speeds at more affordable prices in a residential setting. As the broadband infrastructure rolls out throughout the country, new forms of work, shopping, and entertainment will be enabled.

Hampton and Wellman (53) aimed to study how broadband connectivity would impact the social dimension of communities. They studied the effect of enhanced telecommunications on a new development in Toronto, where residents had access to high speed Internet access (including electronic mail and Web surfing), computer-desktop videophone, an online jukebox, entertainment applications, online health services, and local discussion forums. Using a longitudinal survey and conducting interviews, the authors noted that the enhanced platform actually increased the feeling of "community" within the development. Residents with high-speed access recognized three times as many neighbors and talked with twice as many compared with those residents who did not have high-speed access, indicating that such a platform also may get people out of their cars, out of their houses, and on to the street. However, the results also showed that residents used their higher speed connections to access people and information that were "just out of reach" geographically (50–500 km). This finding suggests that, rather than replacing local trips, higher speed access may instead serve as an additional mode that allows people to expand their "action space," that is, the area that could be or could have been used for a person's activities. (14)

E. Research Questions

Hampton and Wellman's work was limited to one (new) development, however, and residents were provided with a much greater connection speed (10 Mbs) than is available through conventional cable or DSL connections. Accordingly, this work revisits the real-world effects of ICT but in a larger existing community setting. These communities provide the ideal context for exploring the relationship between ICTs and travel in an applied setting. Recognizing the dynamism inherent in such a setting, the conceptualization for this project generally draws upon Orlikowski and Iacono's (54) "enacted" perspective, suggesting a complex relationship with often unintended consequences between ICTs and everyday activities. Further, and more directly related to the focus here upon travel and ICTs, the work of Salomon (11) suggests research should explore those effects including but also beyond simple, directly substitutive outcomes. Consequently the questions posed explore how telecommunications technologies might be integrated into and result in complex new travel and travel-related behaviors. Questions include:

Research Question 1:
What patterns exist between e-work and travel?

- What are the styles of e-work behaviors?
- What are the connections between e-work and travel behavior?

Research Question 2:
What patterns exist between e-shopping and travel?

- What are the styles of e-shopping behaviors?
- What are the connections between e-work and travel behavior?

Research Question 3:
How does broadband access affect e-work and e-shopping?

- How are broadband uses similar or different to dial-up uses?
- What patterns exist between broadband access in e-working and e-shopping behaviors?
- How do these behaviors associate with related attitudes toward ICT?

As will be detailed below, these three research questions were addressed through a multi-method data collection effort involving both a general survey and in-depth travel diaries.

Part 3: Method

A. Design and Sampling

A cross-section of community residents representing four zip codes (see Table 2.1) were selected for participation in the study. The list of *residential addresses* maintained by Claritas, Inc., constitutes the frame from which the sample was drawn. Participant households were chosen randomly from zip codes with a statistically strong likelihood of significant broadband penetration (e.g. DSL, cable service). Included codes were: 55406, 55407, 55044, and 55124.

Zip	55406	55407	55044	55124
City	Minneapolis	Minneapolis	Lakeville	Apple Valley
Population	33,033	37,879	35,085	46,054

Table 2.1 Zip Codes Sampled for Survey

The study design calls for comparison of behaviors across three groups demarcated by differential access to telecommunications. Study groups include: (1) residents who do not have access to or use home Internet [no access], (2) those whose connection to the Internet is made via dial-up modem only [slow access], and (3) residents who have access to broadband at home (principally DSL and cable) [high speed access]. Ensuring that members from each of these groups have an equal chance of representation in the final sample has been complicated by a number of factors, in particular the uneven access to broadband across the study area.

Census data from 2001 demonstrate that nowhere is Internet access ubiquitous across households. Of the 51% of U.S. households that have one or more computers, only 41.5% of those have in-home Internet access. Still fewer U.S. households have access to *broadband* (e.g. cable modem, DSL). Of the nine U.S. census block regions the, Pacific area (California, Washington, Oregon) has the highest penetration, but even there only 34% of online households report access to broadband (55). Similarly, a 2001 Minnesota Department of Commerce study found DSL available within 45% of all telephone exchanges or wire centers upon statewide inventory of telephone exchanges. Access to cable modem depends more upon location—cable companies provide high speed access to 75% of Minnesota "metro" communities, but just 5% of "non-metro" areas (56).

Note that available statistics regarding connection speed tend to estimate *potential* access only. Identifying which households actually do connect to the Internet through, for example, DSL and cable modem, is complicated by the fact that service providers tend to be reluctant to make customer lists available for research purposes. As a solution, the researchers obtained a list of zip codes in the Twin Cities area that identified those that were more likely have households that connect to the Internet through DSL and cable modem, as well as other community information, such as population and location. This data was collected in an annual survey conducted by Claritas, Inc. Following careful consideration of study-related factors (e.g. location, spectrum of broadband services available, etc.) the study team selected four communities for inclusion in this telecommunications-travel research. Communities were selected principally on the basis that they would be most likely to provide a cross-section of those residents with access to the Internet via fast and slow speed connections, and those lacking access altogether.

B. Data Collection Procedure

Data were collected through a general survey and daily diary. First, a general survey instrument (see Appendix A) was mailed to 2,000 residential addresses in the selected zip codes. Addresses were chosen using simple random sampling. This general survey was based loosely upon a similar instrument piloted during the summer of 2001. As was its predecessor, the general survey was designed to capture the broad-brush strokes of everyday activities plus underlying attitudes. As such, it queried both specific behaviors (ICT access and use at home and work, travel behaviors related to shopping, work, and errands, and work characteristics amenable to ICT use, such as scheduling) and general attitudes (especially physical shopping versus ICT-enabled shopping).

In instructions accompanying the survey, heads of households were asked to complete the survey within three weeks, and a follow-up reminder postcard was mailed one week after the survey. Respondents received a University of Minnesota pen as a token for their efforts. Of the 2,000 surveys mailed to urban and suburban households in the Minneapolis, Minnesota area, 446 were returned. The response rate, accordingly, was 22%.

Data collected through the second phase daily diary provide a more in-depth look at the details and intricacies of the relationship between ICT and travel as they were enacted over a four-day period. It provided a longitudinal slice of technology use and travel behaviors *in-situ* and in real time. The daily diary was developed in tandem with the general survey. The survey, as previously suggested, was designed more to capture information regarding ICT-user motivation, and rationales behind technology-travel integration typically not as readily accessible via the more strictly behavior-driven diary instrument.

Respondent households represented volunteers from the general survey. At the end of the survey each respondent was presented with a written description of the daily diary and a request for his/her agreement to participate, noted via signature and e-mail or home address. Those who agreed to participate were contacted via mail or e-mail. Each household was provided a password for diary site entry and subsequent identification for survey linking purposes. As both discrete and overlapping trips were anticipated, every household member aged 18 and older was asked to describe his/her trip-making behavior for each of the four days. As previously mentioned, results from this second phase are included in a separate report.

C. Participants: General Survey

The background survey queried respondents regarding demographic characteristics. Highlighted sample characteristics are presented in Table 2.2. For several key variables in Table 2.2, 2003 Census results for the greater Minneapolis area are compared with survey findings. Such comparisons provide an indication of how nearly the sample represents the population of interest.

	Study Sample	*Census*
Number of Males	55% (n=244)	*49.5%*
Number of Females	45% (n=196)	*50.5%*
Median age	48	*34*
Household Income ($50,00 and higher per year)	61%	*66.8%*

Table 2.2 Demographics of Survey Respondents

Additionally, 66% of respondents are married or living with a partner. Many have children living at home, with 32% (n=145) of those children younger than 16, while 18% (n= 79) are 16 or older.

In terms of employment characteristics, most survey respondents have jobs (80%); 302 work full time and 53 part-time. (*Census: 74.3% in work force.)* For 50% of the married/living with partner respondents, the partner also works. Just over one third of participants (36%) are employed as managers or professionals. In an average week, respondents overall work an average of 51.4 hours (one major outlier, a self-employed individual, reported a 105 hour work week), with a median of 44 work hours per week. Many respondents (59%) report that they work a traditional Monday–Friday work schedule.

General Survey Participant Characteristics by Individual Zip Codes

As previously indicated, respondents were drawn from addresses listed within four zip codes in and around Minneapolis, Minnesota. To further explore the degree to which the sample was representative of the population, specific demographic characteristics for each of the four groups are compared with 2000 Census findings. Results are listed in Table 2.3, with zip codes and number of respondents in each area appearing along the top row. Note, overall, the sample tends to be substantially older than census findings indicate is typical of the population in each zip code. Comparison also suggests men tend to be over-represented among respondents.

	55406 (n=116)		**55407** (n=108)		**55044** (n=112)		**55124** (n=104)	
	Sample	*Census*	***Sample***	*Census*	***Sample***	*Census*	***Sample***	*Census*
Males **Females**	53.9% 45.2%	*48%* *52%*	41.5% 58.5%	*50.1%* *49.9%*	67.9% 32.1%	*50.6%* *49.4%*	57.7% 42.3%	*48.9%* *51.1%*
Median Age	48	*36.9*	48	*30*	46.6	*32.5*	50	*34.5*
Race: White	94%	*77.7%*	89.9%	*50.7%*	98.2%	*95.1%*	97.1%	*91.7%*
Household Income ($50,000 and higher/ annum)	49.1%	*39%*	43%	*35.7%*	85.8%	*78.8%*	68.2%	*69.6%*

Table 2.3 Demographics of Survey Respondents by Zip Code

Specific employment characteristics of the sample were compared with census findings as well. As evident from the results in Table 2.4, overall the number of managers and professionals reported in the sample are similar to census percentages. However, self-employed individuals are somewhat over-represented in the general survey sample.

	55406		55407		55044		55124	
	Sample	*Census*	***Sample***	*Census*	***Sample***	*Census*	***Sample***	*Census*
Managers/ professionals	30.2%	*41.3%*	33%	*32.2%*	40.2%	*40.6%*	40.4%	*40.9%*
Government worker	13.7%	*16.1%*	16.5%	*12.9%*	9%	*10.8%*	4.8%	*11.7%*
Self-employed	9.5%	*6.4%*	10.1%	*5.6%*	16.1%	*5.7%*	10.6%	*4.1%*

Table 2.4 Employment Characteristics of Survey Respondents

Part 4: Results from the General Telecommunications Survey

Complete frequencies and descriptives regarding surveyed behaviors and attitudes have been incorporated into the body of the survey and included in Appendix A. However, distinguishing features of the sample related to ICT use and travel behaviors are presented and discussed briefly in the following paragraphs. (In general, these findings are responsive to the first descriptive subsection to each research question). Subsequent to this overview of general descriptives, analyses pertinent to e-working, e-shopping, and ICT responses will be presented.

A. Respondent ICT Access

Access to both home and work computers is high (65%) across survey participants in general. Excluding non-workers (e.g. retirees), 80% of working participants have dual access.

	Work computer		
		Yes	No
Home computer	Yes	288 (65%)	49 (11%)
	No	29	30

Table 2.5 Survey Respondent Access to Computers

As indicated in table 2.6 below, most survey respondents do have access to home computers and the Internet. The sample is split nearly equally between those who typically access the Internet at home and those who use it at work. As was noted for the nation as a whole (see above sampling discussion), most home Net users still tend to gain access by dial-up rather than broadband.

Respondent has access to home computer	82% (n=365)
Reportedly USES the home computer	75% (n=336)
Uses a computer at work	71% (n=317)
Uses the Internet	82% (n=366)
Uses the Internet primarily at home via a personal computer	41% (n=184)
Accesses the Net primarily at work from a computer	39% (n=172)
Accesses the Internet at home via dial-up modem	47% (n=209)
Accesses the Internet at home via a "fast" mode (e.g. DSL, Cable)	20% (n=88)

Table 2.6 Respondent ICT Access and Use

B. Respondent Age and ICT Access and Use

While the relationship between various demographic variables and ICT use was explored, analyses reveal a consistent relationship across the sample between the respondent age variable and telecommunications access and use-related behaviors. For example, correlations show a positive and moderate relationship between age and home computer use ($r = .281$, $p < .001$) and work computer use ($r = .387$, $p < .001$), suggesting the likelihood that respondent use of computers at both locations increases with the age of the respondent. A weaker, but still significant correlation also exists between respondent age and Internet use ($r = .103$, $p = .031$) and age and frequency of Internet use ($r = .144$, $p = .006$). Again, as age increases, so, too does the frequency of Internet use.

Results of cross tabs analysis clearly demonstrate the distribution of Internet use by age. In this instance, the continuous age variable was transformed into a categorical variable (categories reflecting those used by the U.S. Census). As shown in Table 2.7, nearly 60% of Internet users fall between the ages of 35 and 54. However, it is important to note that the survey sample overall has relatively few respondents under the age of 35. As noted earlier, according to comparison with census data, the sample tends to be slightly older than normal for the Minneapolis area.

		Internet use		Total
Age		NO	YES	
26-34	Count	2	55	57
	% within Internet use	2.7%	15.2%	13.0%
35-44	Count	10	105	115
	% within Internet use	13.3%	29.0%	26.3%
45-54	Count	17	110	127
	% within Internet use	22.7%	30.4%	29.1%
55-59	Count	8	45	53
	% within Internet use	10.7%	12.4%	12.1%
60-64	Count	12	16	28
	% within Internet use	16.0%	4.4%	6.4%
65-74	Count	15	23	38
	% within Internet use	20.0%	6.4%	8.7%
75 and older	Count	11	8	19
	% within Internet use	14.7%	2.2%	4.3%
	Count	75	362	437
	% within Internet use	100.0%	100.0%	100.0%

Table 2.7 Respondent Internet Use by Age

One set of survey questions presented respondents with 16 items querying specific Internet use purposes (e.g. on-line education, news sources, social activities, financial). Respondents were presented with each activity and asked to indicate how often they used the Internet for each by selecting from a scale ranging from 1 = never to 5 = every day. The Table 2.8 reveals a negative relationship between age and frequency for engaging in several specific behaviors suggesting that frequency of Internet use for each one tends to decrease with an increase in age. Shown here, for example, younger participants are more likely to engage in on-line financial activities (e.g. banking, paying bills) than are older participants.

		Age
Age	Pearson Correlation	1.000
	Sig. (2-tailed)	.
	N	440
Net use for e-mail	Pearson Correlation	-.087
	Sig. (2-tailed)	.100
Net use for work	**Pearson Correlation**	**-.157****
	Sig. (2-tailed)	.003
Net use for school work	**Pearson Correlation**	**-.152****
	Sig. (2-tailed)	.007
Net use for online classes	Pearson Correlation	.004
	Sig. (2-tailed)	.941
Net use for online library	Pearson Correlation	-.105
	Sig. (2-tailed)	.057
Net use—visiting online auctions	**Pearson Correlation**	**-.137***
	Sig. (2-tailed)	.011
Net use—online news	**Pearson Correlation**	**-.201****
	Sig. (2-tailed)	.000
Net use—chat	Pearson Correlation	-.078
	Sig. (2-tailed)	.144
Net use for community info	**Pearson Correlation**	**-.237****
	Sig. (2-tailed)	.000
Net use for entertainment	**Pearson Correlation**	**-.218****
	Sig. (2-tailed)	.000
Net use for health info	Pearson Correlation	-.051
	Sig. (2-tailed)	.336
Net use for online local govt. info	**Pearson Correlation**	**-.185****
	Sig. (2-tailed)	.001
Net use—online financial activities	**Pearson Correlation**	**-.265****
	Sig. (2-tailed)	.000

Table 2.8 Correlation of Survey Respondent Net Uses and Age

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

C. Work Travel

In terms of work trips, 56% of those sampled report they travel to and from a primary workplace (or school in the case of students) an average of five days during a typical week. Asked to indicate which form of transportation they typically used for work/school trips during the week prior to the survey, "drive alone" was selected as the most common commute mode. Evident in Table 2.9, use of alternative modes (e.g. carpool, vanpool, bus, etc.) was sporadic in this sample.

		Number of Days						
		0	1	2	3	4	5	6 or more
Mode	Drive alone	16	16	15	23	29	198	33
	Carpool or Vanpool	66	7	2	4	4	7	1
	Bus	65	2	1	1	7	15	1
	Bicycle	68	2	0	2	1	0	0
	Walk/Run/Skate	66	4	0	0	1	0	1
	Motorcycle	68	1	0	0	0	1	0
	Other	36	2	3	1	1	2	0

Table 2.9 Survey Respondent Commute Mode

Note that, when asked whether travel behaviors for the period reported were "typical" of their usual week, most participants (74%) agreed it was.

In terms of estimated distance for a one-way commute to work (or school), respondents reportedly travel an average of 13.2 miles. Distribution shows a substantial peak (around 145 participants) at 10 miles. In a follow-up question, participants were asked to indicate how much time they spent in their morning commute. Responses vary between 5 minutes and 155 minutes, with an overall average time of 47.6 minutes for the morning commute. Note that, the distribution peaks between 15 and 20 minutes (80 participants) and again between 70 and 85 minutes (98 participants).

D. Errand-running

Respondents also were asked a couple of questions querying travel behaviors beyond the work trip, including errand-running behavior. In one question, they were presented with a range of options to describe *when* they typically ran errands (e.g. on the weekends, during the commute to/from work, during evenings after arriving home from work). The most frequently cited was "on the weekends" (32%; n=144), followed by "during the day" (21%; n= 94), and "while commuting to/from work" (16%; n=72) was a close third.

Participants also were queried regarding the mode they most typically used for their errand-running. Perhaps not surprisingly, the clear majority (n=425 or 95% of the sample) selected "car" from a list of possible forms including public transportation, walk/run/bike, and so on.

E. E-enabled Groups: Results for E-Shoppers, E-Workers, and Fast-Netters

The general descriptives and findings detailed in the section above reviewed general information regarding ICT use and travel behaviors among study participants. The next three sections hone in upon three study groups. These include:

(1) E-workers (a.k.a. "flexers"): those who tend to use ICTs to enhance the benefits of engaging in flexible work schedules and telecommuting;
(2) E-shoppers: participants who make purchases via the Internet; and
(3) "Fast-netters": respondents with access to high speed home Internet connections such as DSL.

1. E-Workers: Exploring the Relationship between ICT and Subsistence Activities (Research Question 1)

Research relating ICT use and implications for work travel behavior has traditionally targeted telecommuters. However, keeping with the attitude of an enacted relationship between behaviors and ICTs, the focus for this study includes all forms of opportunities for mobile work facilitated by access to telecommunications or that might allow strategic use of ICTs for work. Here, the traditional notion of the electronic worker is expanded to encompass individuals whose work schedules allow a certain amount of flexibility, including compressed work weeks (schedules which allow employees to come into the workplace four nine-hour days as opposed to five eight-hour days) and flex time (programs that allow employees to arrive later to work and/or depart at an earlier time than the traditional 5 p.m. departure). Survey findings suggest that the availability of flex schedules, in combination with home telecommunications access, may influence travel behaviors. The following sections provide characteristics and findings regarding these e-workers (a.k.a. flexers).

Profiling the E-Worker: Demographics. At the time of the study, 34% of respondents (n=153) report that they did participate in one of three flexible work schedules. These flexers, or e-workers, engage in *compressed work weeks* (work 40 hours over fewer than 5 days), *telecommuting* (work some portion of the work schedule from home or a satellite office), and/or *flexible arrival/departure schedules.* Those engaged in flexible arrival/departure time comprised the largest group (n=109). Note, however, participation in one form did not seem to preclude engagement in another as, for example, telecommuters typically engaged in flex schedules as well. Altogether, 37 respondents telecommute; with a single exception, these individuals worked from home.

In terms of demographic characteristics, a glance at Table 2.10 shows a number of differences between flexers and the overall sample. For example, flexers are more likely to be male (60% flexers versus 55% in sample) and have relatively high incomes (61% of the overall sample versus 74% of flexers report household incomes equal to or more than $50,000 per year).

Characteristic	**Percentage**
Males	60%
Race: White	93%
Married	63%
With children living in household	51%
Partner works	60%
Reports household income of $50,000 or more	74%
Has college degree	35%
Has professional degree	22%

Table 2.10 Characteristics of Respondents Who Are "Flex" Workers

Why do respondents choose to engage in flexible work scheduling? To explore this question, survey participants were presented with a closed-ended query comprised of 12 items describing the most commonly cited reasons in the literature for participation in flexible work schedules. Respondents were asked to select as many as three items that best described reasons they themselves participated. Those chosen most frequently included:

- To avoid rush hour (50/153)
- Can take care of personal errands more easily (45/153)
- Work at personal "peak times" (e.g. late night)

Respondents who indicated they do *not* engage in flexible work schedules also were asked to describe reasons for their non-participation. Among those who chose to respond, the most frequent qualitative responses are related to work activities and workplace restrictions:

- Must be at work (98/213)
- Work does not allow (44/213)

Profiling the E-Worker: ICT Access and Use. What about the relationship between e-work and ICT? Compared to those respondents not engaged in flexible work schedules (n=213), e-workers seem to have greater access to and be more frequent users of ICTs as illustrated in the table below.

ICT Access and Use	Percentage of Flexers	Percentage of Non-Flexers
Access to home computer	91%	84%
Uses home computer	92%	80%
Uses computer at work	91%	82%
Uses Internet	92%	87%
Primarily connects to Net from Home	41%	19%
Primarily connects to Net at work	48%	22%
Connects to Net daily	68%	33%
Connects to Net weekly	19%	1%
Home access to dial-up Net only	65%	72%
Home access to broadband	34%	28%

Table 2.11 ICT Access And Use, "Flex" Respondents Versus "Non-Flexers"

Results of cross tabs analysis reveal e-workers are significantly more likely to use a computer at home (X^2 (3, N=343) = 10.32, p = .016, Cramer's V=.173) and work (X^2 (1, N=357) = 4.809, p = .028, Cramer's V=.116). From a statistical sense, e-workers are no more likely to have access to home broadband than their more-work-hour and/or place-confined counterparts.

It is important to recall here, too, that work restrictions tended to predominate among limits to flexible work scheduling access cited by non-participants. Task demands and workplace policies restricting access were particularly prevalent. Thus, it may be that differences in ICT access and use evident between e-workers and their office-bound counterparts primarily emerge from distinctions in occupations. As illustrated in the table below, a greater percentage of e-workers are indeed engaged in managerial or professional occupations as well as technical positions.

More non-flexers are involved in occupations that likely mandate their presence at work during specified time periods—including service, clerical/administrative, and farm/laborer work—thus perhaps limiting access to flexible work schedules.

Work type	**Engages in flexible work scheduling**	
	No	**Yes**
Management or professional	42% (n=89)	47.6% (n=71)
Official/administrator	3.8% (8)	.7% (1)
Technical	9.0% (19)	20.8% (31)
Craftsperson	3.3% (7)	4.7% (7)
Sales	6.6 % (14)	7.4% (11)
Service	7.5% (16)	4.7% (7)
Clerical/admin assistant	7.5% (16)	5.4% (8)
Machines operations	1.9% (4)	1.3% (2)
Farm or labor	3.8% (8)	.7% (1)
Other	14.6% (31)	6.7% (10)
Total	100.0% (212)	100.0% (149)

Table 2.12 Survey Respondent Occupations and Participation in Flexible Work

Flexers and Work. In a comparison of hours worked over the typical week, flexers put in an average of 42.66 hours, while non-flexers average 41.49 hours. Unsurprisingly, an independent samples t-test reveals this small difference to be statistically non-significant ($t(149) = .759$, $p = .449$).

A more intriguing relationship is shown between work behaviors and flexible work schedules in responses to a survey item that explores "overwork." Asked "*Do you ever do work for your job at home over the Interne?"* survey participants were presented with four items:

- I use the Internet to do work from home before work hours;
- …after work hours;
- …during the work day;
- …on the weekends.

Respondents were asked to indicate with what frequency (using a scale of 1 = never to 6 = every work day) they engaged in any of the above behaviors. Revealed in the correlations show in Table 2.13, engagement in flexible work schedules shows a moderately strong, positive, and significant relationship with each overwork variable. Findings suggest possible implications for work travel.

			1.	2.	3.	4.	5.
1	Engages in flexible work scheduling	Pearson Correlation	1.000				
		Sig. (2-tailed)					
2	Net use before work	Pearson Correlation	.209**	1.000			
		Sig. (2-tailed)	.000	.	.000		
3	Net use after work	Pearson Correlation	.207**	.802	1.000		
		Sig. (2-tailed)	.000	.000			
4	Net use during work day	Pearson Correlation	.169**	.718	.739	1.000	
		Sig. (2-tailed)	.002	.000	.000		
5	Net use for work on weekends	Pearson Correlation	.209**	.740	.893	.676	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.

Table 2.13 Correlation of Survey Respondent Net Use and Flexible Work

** Correlation is significant at the 0.01 level (2-tailed).

Work Commutes and the E-Worker. In terms of the implication of ICT-enabled behaviors for travel, prior research suggests teleworkers, as a group, do exhibit distinctive commuting patterns. For example, they tend to have longer commutes than do non-teleworkers (20). Here, results regarding commuting behavior are presented, but again, the group of interest has been expanded to include all respondents who engage in flexible scheduling.

Among those who do engage in flexible work schedules (n=147), the mean one-way commute is 13.73 miles, while sample non-engagers (n=208) travel a mean distance of 12.89 miles. However, results of an independent samples t-test reveal this difference is not statistically significant [t (353) =.558, p = .577]. In this sample, those who engage in flexible work schedules do not have a significantly longer commute than non-flexers.

Participation in flexible work schedules might be supposed to enable commuters to either reduce the travel they make during workdays or travel to and/or from work during off peak hours. Ideally, for example, ICT-enabled work scheduling, such as telecommuting, will decrease the number of trips made by substitution of ICTs for commuting. In this sample, 56% of non-e-work respondents commute to a workplace five days each week. Comparatively, fewer telecommuters do so, as 35% report they tend to travel to work five days per week in the typical work week. More telecommuters (38%) commute to and from work 0–3 days per week. However, in this sample, only 37 individuals telecommute—as noted in previous research, a number too small to make large differences in commuting trips. In addition, focus upon the commute trip alone discounts the potential for increased trip-making for other reasons on days individuals do not travel to work. Accordingly, telecommuters and those using compressed work weeks were asked to estimate the number of trips made on the days they traveled into the office as compared with days they did not. Results show 37% (41 individuals) make fewer trips than on weekdays they travel into the office. More (40% or n=43) make about the same number, while 18 actually make a greater number of trips on days they do not travel into the workplace.

Findings from cross tab analysis show the relationship between hour of departure from home and participation in flexible work scheduling (see Table 2.14). Participants show a slight trend toward a later morning departure, and a greater proportion of flexers, as compared with non-flexers, leave home between 8 and 9 a.m.

Time leaves home for work		**Engagement in flexible work scheduling**	
		No	yes
Before 5:59 a.m.	Count	20	10
	% engage in flexible work	10.2%	7.5%
6:00 to 6:59 a.m.	Count	58	35
	% engage in flexible work	29.4%	26.3%
7:00 to 7:59 a.m.	Count	61	43
	% engage in flexible work	31.0%	32.3%
8:00 to 9:00 a. m.	Count	38	34
	% engage in flexible work	19.3%	25.6%
Later than 9 a.m.	Count	20	11
	% engage in flexible work	10.2%	8.3%
	Count	197	133
		100.0%	100.0%

Table 2.14 Work Departure Time and Engagement in Flexible Work

Results of a t-test reveal a mean difference of approximately 20 minutes in the morning departure hour of flexers versus non-flexers. Non-flexers, on average, leave home at 7 a.m., while flexers depart around 7:20 a.m. According to the results of a t-test, however, this difference is not statistically significant ($t(311) = -1.272$, $p = .204$). Similar results are revealed in time for departure home where flexers (5:30 p.m.) tend to leave the office an average of 21 minutes later than non-flexers (5:09 p.m.). Again, however, this small difference is not statistically significant. E-workers in this sample appear to travel during peak periods with the same frequency as those not engaged in flexible work schedules.

E-workers and Shopping. E-workers in general do tend to make purchases online, but the proportion of flexers who do so seems not to differ markedly from non-flexers (see Table 2.15). However, the correlation between the flexible work schedule and net-shopping (reverse coded) variables shows a small effect ($r = .111$) and is just significant ($p=.047$). As noted for the sample overall, e-shopping in general occurs relatively infrequently; both e-workers and non-e-workers primarily report shopping online several times per year (see Table 2.15).

		Engagement in flexible work scheduling	
		No	Yes
Makes Net purchases several times per year	Count	101	79
	% within Flexing	68.2%	69.9%
once per month	Count	20	11
	% within Flexing	13.5%	9.7%
several times per month	Count	21	17
	% within Flexing	14.2%	15.0%
once weekly	Count	5	4
	% within Flexing	3.4%	3.5%
several times per week	Count	1	2
	% within Flexing	.7%	1.8%
	Count	148	113
	% within Flexing	100.0%	100.0%

Table 2.15 Correlation of Net Purchase and Engagement in Flexible Work Scheduling

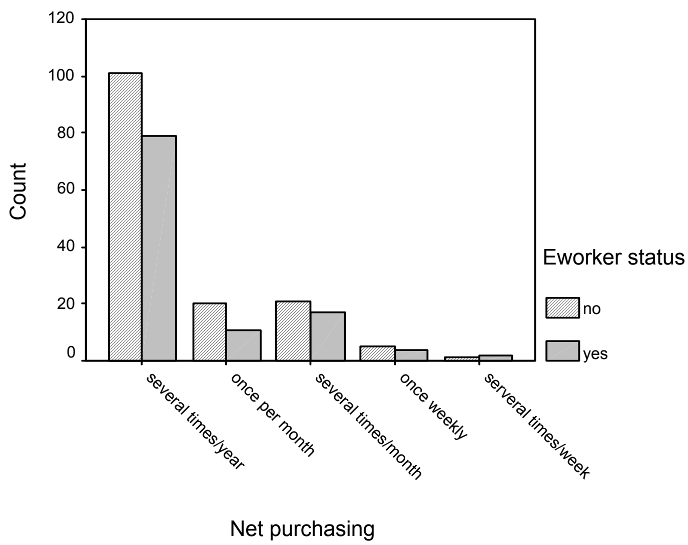

Figure 2.1 Survey Respondents that E-shop and E-work

An examination of the various forms of flexible work groups (e.g. telecommuters) provides a clearer illustration of the correspondence between flexible work schedules and on-line shopping behaviors. Among the 37 telecommuters, 33 (89%) shop on the Internet as do 89 (82%) of the 109 who work on a flex arrival/departure schedule. Likewise, among the 30 respondents who work a compressed workweek, 23 (77%) make on-line purchases.

Attitudes toward Net shopping also were explored through bivariate analysis. Four items revealing negative perspectives regarding Net shopping (fears credit card fraud; prefers in-person product viewing; believes Net-purchase returns would be a hassle; believes Net does not carry wanted items) were scaled to create a negative attitudes variable. The strong reliability coefficient for the resulting scale (alpha=.7592) suggests convergent validity among items.

Revealed in Table 2.16, the relationship between the attitudes scale and overall engagement in flexible work scheduling is negative, suggesting participants in such programs are less likely to display negative attitudes toward on-line shopping than non-participants.

		1.	2.	3.	4.	5.
1. Negative Net shopping attitudes	Pearson Correlation	1.000	-.160**	.067	-.171*	.119
	Sig. (2-tailed)	.	.004	.413	.045	.177
2. Flexible work scheduling	Pearson Correlation	-.160**	1.000	-.909**	.037	-.085
	Sig. (2-tailed)	.004	.	.000	.651	.310
3. Flex arrival-departure	Pearson Correlation	.067	-.909**	1.000	-.080	-.205*
	Sig. (2-tailed)	.413	.000	.	.333	.015
4. Telecommuters	Pearson Correlation	-.171*	.037	-.080	1.000	-.089
	Sig. (2-tailed)	.045	.651	.333	.	.302
5. Compressed work week	Pearson Correlation	.119	-.085	-.205*	-.089	1.000
	Sig. (2-tailed)	.177	.310	.015	.302	.

Table 2.16 Correlation of Net Shopping Attitudes and E-work Engagement

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Eworkers, Shopping, and Trip-Making. Interestingly, participation in flexible work scheduling revealed a distinctive patterning of relationships between flexer form and survey items exploring complex interactions between ICTs and shopping-related travel. These exploratory items probe the potential for substitution, modification, and/or generation of trips by:

(1) browsing the Net before actually making a trip to shop (*substitution* for exploration trips)
(2) use of the Net for item previews before actually making a trip to buy (*modification*—increasing trip efficiency)
(3) extent to which Net browsing has led the respondent to make a shopping trip he or she would not otherwise have made (trip *generation*)
(4) Net searches with the purpose of making shopping trips faster/more efficient (*modification*—efficiency)

As suggested by the correlation patterns illustrated in Table 2.17, telecommuters are more likely to engage in the full range of ICT-related behaviors, for example, telecommuters reportedly use the Net to improve trip efficiency. Interestingly, the same ICT-shopping relationships do not seem to relate with flexible arrival/departure schedules or compressed workweeks. Recall, however, that the number of telecommuters in this sample is quite small, and results should be considered with caution.

		1.	2.	3.	4.	5.	6.	7.
1. Flexible arrival-departure	Pearson Correlation	1.000						
	Sig. (2-tailed)	.						
2. Telecommuters	Pearson Correlation	-.080	1.000					
	Sig. (2-tailed)	.333	.					
3. Compressed work week	Pearson Correlation	-.205*	-.089	1.000				
	Sig. (2-tailed)	.015	.302	.				
4. Net browsing before trips	Pearson Correlation	-.113	**.290****	-.045	1.000			
	Sig. (2-tailed)	.164	.001	.614	.			
5. Preview via Net before trips	Pearson Correlation	-.126	**.285****	-.069	.835**	1.000		
	Sig. (2-tailed)	.120	.001	.437	.000			
6. Makes trips b/c of Net browsing	Pearson Correlation	-.104	**.250****	-.092	.565**	.606**	1.000	
	Sig. (2-tailed)	.200	.003	.299	.000	.000		
7. Uses Net to improve trip efficiency	Pearson Correlation	-.140	**.258****	-.157	.676**	.679**	.528**	1.000
	Sig. (2-tailed)	.085	.002	.075	.000	.000	.000	.

Table 2.17 Correlation of Flexible Workers and Internet Use

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Errand-Running Travel. The survey also provided a glimpse into the errand-running behaviors of those engaged in ICT-enabled work schedule changes. Following the survey skip pattern, telecommuters and those engaged in compressed work schedules responded to a question querying reasons for trips during the days they spent out of the office. While the frequencies are a bit small to enable meaningful statistical analysis, resulting descriptive percentages show more telework/compressed week respondents did engage in personal (n=23) and family (n=19) appointments/errands than work errands (n=18) on days they did NOT travel into the office. However, a larger number of respondents still noted that they engaged in all forms of errands (n=44).

<u>2. E-Shoppers: Exploring the Relationship between ICT and Shopping (Research Question 2)</u>

As stated in the second research question, e-shopping is the second major activity of interest. This section begins by presenting some of the more intriguing aspects of telecommunications-enhanced shopping in general and then proceeds to results specifically concerned with shopping and travel.

Among general survey respondents, far more reported that they do make on-line purchases (n=288, 64.6%) than do not (n=76, 17%). (It should be noted that two questions explored Internet purchasing behaviors. Since it was a key question in the survey, it was asked twice to minimize missing data as a result of skip patterns, respondent oversight and the like. First, among items exploring Net use purposes, participants were asked to respond to an item, I use the Internet to make purchases [e.g. products, services], by selecting from fixed response categories of 1 = every day to 5 = never. Results agree with the second item which asked: On AVERAGE, how often do you make purchases on-line from vendors on the Internet? Responses showed a large percentage of respondents [65%; n=288] do engage in on-line purchasing.)

However, such purchases tend to be altogether somewhat infrequent. When asked to indicate with what frequency they made on-line purchases, the greatest percentage of participants noted doing so “several times per year” (44%).

Several times per week	Once weekly	Several times per month	Once per month	Several times per year	Never	N/A
4	5	40	33	198 (44%)	84	76

Table 2.18 Survey Respondent On-line Shopping Frequency

In addition to actual purchasing behaviors, survey queries also explored on-line product browsing. (As in the case with the purchasing variable, two items were also used to examine browsing behavior. One was asked in the context of exploring activities for which respondents typically use the Internet, and the second was included among a series of questions probing the relationship between participant travel behavior in relation to Internet use and shopping.)

Presumably, browsing will antecede shopping behavior and, consequently, might also serve to influence everyday travel through, perhaps, modification and/or generation of shopping trips. When asked to indicate how often they used the Internet *to browse online vendors (not shopping but exploring items)*, response patterns indicate more frequent browsing behavior than that revealed for actual on-line shopping. For example, as shown in Table 2.19, a greater percentage of respondents indicated that they browse “every week” and “several times per month.”

I use the Internet to…	Every day	Every week	Several times per month	Several times per year	Never
Make purchases (e.g. products, services)	1	12 (2%)	61 (14%)	214 (48%)	65 (15%)
Browse on-line vendors (not shopping, but exploring items)	14	64 (14%)	128 (29%)	121 (27%)	36 (8%)

Table 2.19 Respondent Uses of the Internet for Shopping: Browse vs. Purchase

Profiling the E-Shopper: Demographics and ICT Use/Access Characteristics. Table 2,20 shows demographic characteristics of e-shoppers.

Characteristic	Percentage
Males	167 (58.4%)
Median age	45
Race: White	274 (95%)
Married	210 (72.9%)
With children living in household	149 (51.7%)
Household income ($50,000 and higher per year)	212 (73.6%)

Table 2.20 Characteristics of E-shoppers

A number of interesting differences emerge from a comparison of surveyed e-shoppers with participants who do not currently engage in e-shopping. For example, in reported education level, e-shoppers reveal a slight tendency to have a more advanced degree. A greater percentage of e-shoppers have a college degree (35.2% versus 28.9%) or a graduate degree (20.9% e-shoppers versus 17.1% non-eshoppers). Similarly, when compared to those who do not make purchases on-line, e-shoppers are more likely to work full-time (77.6% versus 62.7%), be married (66.2% versus 59.2%), and have children living at home (52.1% versus 44.7%). While these differences are not statistically significant, they tend to suggest an overall strategy, perhaps, toward employing ICTs as tools to handling busy lives with multiple demands (e.g. full-time jobs, marriage, and children).

Several intriguing and statistically significant demographic and ICT use pattern differences between on-line shoppers and those who do not shop on-line were revealed across analyses as well. For one, cross tab analysis shows e-shopping tends to be related to gender, with men represented to a greater degree among e-shoppers, while woman tend to engage in on-line shopping more infrequently (X^2 (2, $\underline{N}$=360) = 6.434, $\underline{p}$ = .040, Cramer's $\underline{V}$=.134).

		Does not make on-line purchases	E-shopper
Male	Count	35	167
	% within e- shopping	47.3%	58.4%
Female	Count	39	119
	% within e- shopping	51.4%	41.6%
	Count	74	286
	% within e- shopping	100.0%	100.0%

Table 2.21 Correlation of Gender and E-shopping (Purchasing)

Cross tab analysis also reveals a significant difference in salary level (X^2 (6, $\underline{N}$=353) = 22.087, $\underline{p}$ = .001, Cramer's $\underline{V}$=.250). Note the relatively large effect size. Overall, the trend is for e-shoppers to have a somewhat greater household income than do those who do not make on-line purchases. This finding seems convergent with logic, as purchasing behavior in general is likely to be related to disposable income availability.

FAMILY INCOME			Does not make on-line purchases	E-shopper	Total
	Less than $15,000 per year	Count	2	2	4
		% within Family income	50.0%	50.0%	100.0%
	$15,000-24,999	Count	5	7	12
		%	41.7%	58.3%	100.0%
	$25,000 - 34,999	Count	10	15	25
		%	40.0%	60.0%	100.0%
	$35,000 - 49,999	Count	18	43	61
		%	29.5%	70.5%	100.0%
	$50,000 - 74,999	Count	19	63	82
		%	23.2%	76.8%	100.0%
	$75,000 - 99,999	Count	11	77	88
		%	12.5%	87.5%	100.0%
	$100,000 or more	Count	9	72	81
		%	11.1%	88.9%	100.0%
Total		Count	74	279	353
		%	21.0%	79.0%	100.0%

Table 2.22 Correlation of Household Income and E-shopping Behavior

Interestingly, results of bivariate correlation analysis also suggest a moderately strong, significant negative relationship between age and e-shopping, including actual purchasing behavior (-.218, $p < .001$) and browsing goods ($r = -.272$, $p < .001$). E-shoppers and browsers tend to be toward the younger end of the sample distribution.

The relationship between age groups and e-shopping was explored more closely through cross tabs and ANOVA. First, in a cross tabs analysis, age was re-coded using the same categories as the census. In addition, Net shopping frequencies were recoded (in order to meet test assumptions and limit the number of cells) so that yearly purchasing behaviors = infrequent, monthly = moderate, and weekly and daily = frequent. Concurring with findings described earlier, the frequencies shown in Table 2.23 reveal most shopping behavior occurs infrequently. E-shoppers also tend to fall in categories covering ages 35 to 54.

		Net shopping frequency			
Age		never	infrequent	moderate	frequent
26-34	Count	8	34	9	4
	% within Net shop	10.5%	16.1%	14.8%	30.8%
35-44	Count	19	58	24	5
	% within Net shop	25.0%	27.5%	39.3%	38.5%
45-54	Count	17	69	19	4
	% within Net shop	22.4%	32.7%	31.1%	30.8%
55-59	Count	14	24	6	
	% within Net shop	18.4%	11.4%	9.8%	
60-64	Count	4	12	1	
	% within Net shop	5.3%	5.7%	1.6%	
65-74	Count	9	11	1	
	% within Net shop	11.8%	5.2%	1.6%	
75 and older	Count	5	3	1	
	% within Net shop	6.6%	1.4%	1.6%	
	Count	76	211	61	13
	% within Net shop	100.0%	100.0%	100.0%	100.0%

Table 2.23 Correlation of Age and E-shopping Behavior

Similarly, a test employing ANOVA reveals an intriguing difference in mean age according to purchasing frequency groupings. In this analysis, age (measured on a continuum) appears as the dependent variable and frequency of Net purchasing occurs as the independent variable. Results of the ANOVA are significant, $\underline{F}(3,357)=7.113$, $\underline{p}<.001$.

Because the overall F was significant, follow-up tests were conducted to evaluate pairwise differences among the means. Tukey's post-hoc test was employed (as the test of homogeneity of variance was significant $F(3,357)=2.966$, $p=.032$)). The reports of these tests are presented Table 2.24. There were significant differences in the means between the group that never shops online (n=76, mean age = 51.54) as compared with those who are infrequent (n=211 mean age = 46.46), moderate (n=61, mean age =43.95), and frequent (n=13, mean age = 40.77) e-shoppers. The difference in mean age between those who engage in e-shopping of any frequency are not significant, suggesting similar age groups engage in on-line shopping of varying frequencies across this sampled group of respondents. (Few respondents (n=13) report engaging in frequent shopping behavior. Because of the small number, this subgroup should properly be excluded from analyses, and is included here by way of exploration.)

Post-Hoc Tests

Net shopping	Net shopping category	Mean Difference	Standard Error	Significance	95% Confidence Interval	
					Lower bound	Upper bound
Never	Infrequent	5.08*	1.50	.004	1.21	8.94
	Moderate	7.59*	1.93	.000	2.63	12.55
	Frequent	10.77*	3.37	.008	2.10	19.44
Infrequent	Never	-5.08*	1.50	.004	-8.94	-1.21
	Moderate	2.51	1.63	.414	-1.68	6.71
	Frequent	5.70	3.21	.286	-2.56	13.95
Moderate	Never	-7.59*	1.93	.000	-12.55	-2.63
	Infrequent	-2.51	1.63	.414	-6.71	1.68
	Frequent	3.18	3.43	.791	-5.64	12.00
Frequent	Never	-10.77*	3.37	.008	-19.44	-2.10
	Infrequent	-5.70	3.21	.286	-13.95	2.56
	Moderate	-3.18	3.43	.791	-12.00	5.64

Table 2.24 Dependent Variable: Age

The means plot (Figure 2.2) shows the trend revealed by the analysis—older respondents tend to report engaging in Net purchasing behavior with lesser frequency than do younger participants.

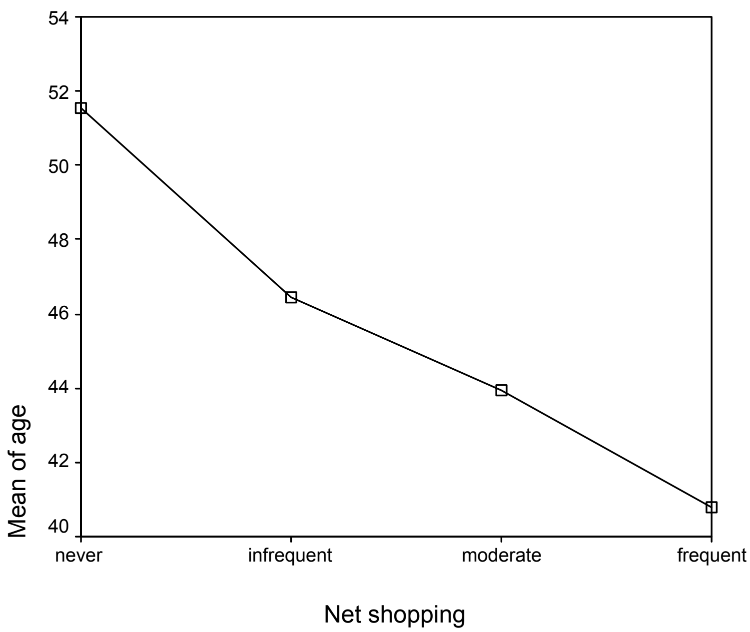

Figure 2.2 Means Plots

Similar relationships are seen between browsing for goods and age as noted for shopping and age (see Figure 2.25). Note, however, browsing overall occurs with greater frequency as compared with shopping, but again primarily among “younger” groups.

		Net browsing				Total
Age		never	infrequent	moderate	frequent	
26-34	Count	5	15	18	17	55
	% within Net browsing	13.2%	12.5%	14.3%	21.8%	15.2%
35-44	Count	3	34	38	31	106
	% within browsing	7.9%	28.3%	30.2%	39.7%	29.3%
45-54	Count	10	38	40	21	109
	% within browsing	26.3%	31.7%	31.7%	26.9%	30.1%
55-59	Count	6	14	17	7	44
	% within browsing	15.8%	11.7%	13.5%	9.0%	12.2%
60-64	Count	1	8	6	1	16
	% within browsing	2.6%	6.7%	4.8%	1.3%	4.4%
65-74	Count	9	7	6	1	23
	% within browsing	23.7%	5.8%	4.8%	1.3%	6.4%
75 & older	Count	4	4	1		9
	% within browsing	10.5%	3.3%	.8%		2.5%
	Count	38	120	126	78	362
	% within browsing	100.0%	100.0%	100.0%	100.0%	100.0%

Table 2.25 Correlation of Age and Net Browsing Behavior

Results of an ANOVA test in this instance, too, reveals a statistically significant difference in mean age overall with respect to frequency of browsing behavior (with age as a dependent and Net browsing frequency categories as independent variables). Results of the test are significant, $\underline{F}(3,358)=12.672$, $\underline{p}<.001$.

Again, the overall significant F suggested utility in follow-up tests to evaluate pairwise differences among the means. With the test of homogeneity of variance again significant F(3,3578)=4.435, p=.004, the Tukey post-hoc test was employed in this instance as well. The reports of these comparative tests are presented in Table 2.26. As shown, there were significant differences in the means between the group that never browse on-line (n=38, mean age = 55.66) as compared with those who are infrequent (n=120 mean age = 48.01), moderate (n=128, mean age =46.28), and frequent (n=78, mean age = 42.42) browsers. There is also a demonstrably significant difference in mean age between those who engage in frequent versus infrequent browsing in this sample.

Again, the trend shown in the means plot (below) suggests younger respondents engage in Net browsing behaviors more frequently than do older respondents. Note, too, that far more respondents report frequent browsing (n=78) than frequent purchasing behaviors (n=13).

Post-Hoc Tests

Net browsing	Net browsing category	Mean Difference	Standard Error	Significance	95% Confidence Interval	
					Lower bound	Upper bound
Never	Infrequent	7.65*	2.06	.001	2.35	12.95
	Moderate	9.38*	2.05	.000	4.11	14.65
	Frequent	13.23*	2.19	.000	7.60	18.87
Infrequent	Never	-7.65*	2.06	.001	-12.95	-2.35
	Moderate	1.73	1.41	.611	-1.90	5.36
	Frequent	5.59*	1.61	.003	1.44	9.73
Moderate	Never	-9.38*	2.05	.000	-14.65	-4.11
	Infrequent	-1.73	1.41	.611	-5.36	1.90
	Frequent	3.85	1.60	.074	-.25	7.96
Frequent	Never	-13.23*	2.19	.000	-18.87	-7.60
	Infrequent	-5.59*	1.61	.003	-9.73	-1.44
	Moderate	-3.85	1.60	.074	-7.96	.25

Table 2.26 Dependent Variable: Age

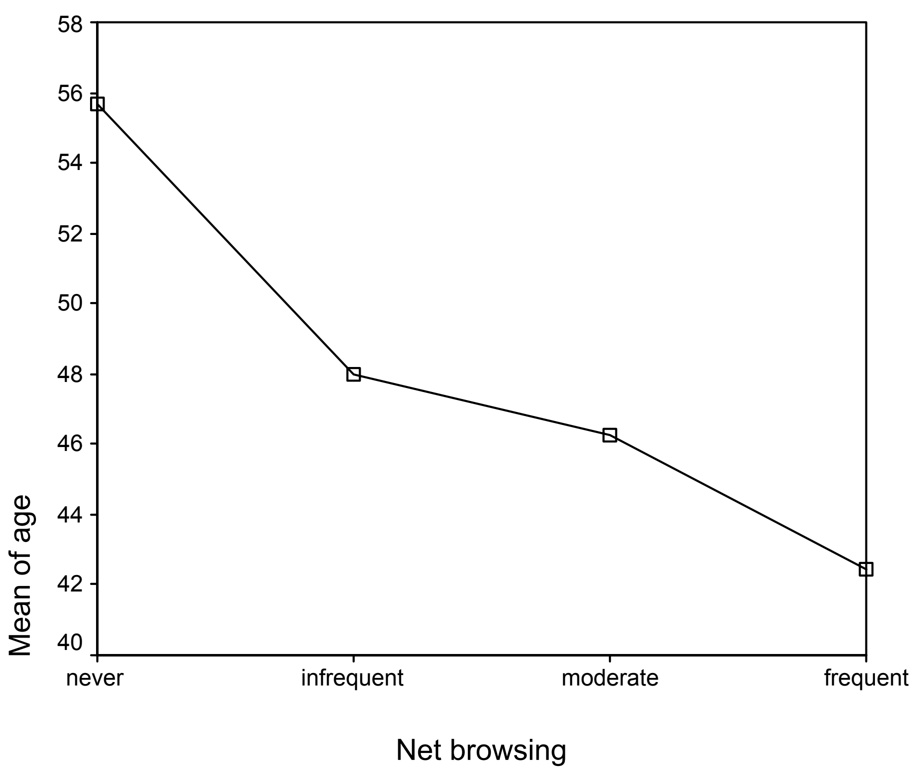

Figure 2.3 Means Plots

Profiling the E-Shopper: ICT Access and Use Characteristics. Analyses show that e-shoppers tend to have greater access to and use ICTs to a greater extent than those who do engage in on-line shopping. Note, however, it would probably not be accurate to assume access to technology alone is the driving factor in e-shopping. As previously suggested, access to technologies is likely strongly mediated by income—with greater levels of disposable income enabling access to technology as well as new forms of shopping behavior.

In the cross tabs analysis shown in Table 2.27, e-shopping was dichotomized so that 0=non-shoppers and 1=e-shopper. Results suggest that e-shoppers are significantly more likely to have access to a home computer (X^2 (1, $\underline{N}$=291) = 5.407, $\underline{p}$ = .020, Cramer's $\underline{V}$=.136) and make use of it (X^2 (2, $\underline{N}$=344) = 22.434, $\underline{p}$ < .001, Cramer's $\underline{V}$=.255) than are non-e-shoppers (Table 2.28).

Home computer access			Does not make on-line purchases	E-shopper
	no	Count	14	7
		% within e- shopping	18.9%	2.4%
	yes	Count	60	281
		% within e- shopping	81.1%	97.6%
		Count	74	288
		% within e- shopping	100.0%	100.0%

Table 2.27 E-shopper Access to Home Computer

			Does not make on-line purchases	E-shopper
Home computer use	no	Count	1	5
		% within e- shopping	1.4%	1.8%
	yes	Count	57	263
		% within e- shopping	82.6%	95.6%
	n/a	Count	11	6
		% within e- shopping	15.9%	2.2%
		Count	69	275
		% within e- shopping	100.0%	100.0%

Table 2.28 E-shopper Home Computer Use

In terms of home Internet connection speed, more e-shoppers have access to broadband (e.g. DSL, cable) as compared with non-eshoppers who tend to rely more upon slower dial-up modem (X^2 (1, $\underline{N}$=291) = 5.407, $\underline{p}$ = .020, Cramer's $\underline{V}$=.136).

		Does not make on-line purchases	E-Shopper
No fast home Net connection	Count	41	162
	% within e- shopping	83.7%	66.9%
Fast Net connection	Count	8	80
	% within e- shopping	16.3%	33.1%
	Count	49	242
	% within e- shopping	100.0%	100.0%

Table 2.29 E-shopper Net Connection Speed

Finally, e-shoppers are more likely to have access to and use a computer in their jobs (X^2 (2, N=356) = 21.57, p < .001, Cramer's V=.246).

			Does not make on-line purchases	E-shopper
Computer use at work	no	Count	17	24
		% within e- shopping	23.6%	8.5%
	yes	Count	47	250
		% within e- shopping	65.3%	88.0%
	n/a	Count	8	10
		% within e- shopping	11.1%	3.5%
		Count	72	284
		% within e- shopping	100.0%	100.0%

Table 2.30 E-shopper Computer Use at Work

How do Rates of E-Shopping Compare with more Traditional Retail and Mail-Order?
Respondents were asked to estimate what percentage of their prior year shopping they had accomplished by local retail, mail order, or Internet. Results suggest many purchases are made via in-store retail—55% of respondents reported they make 70% or more of their purchases at local retail establishments. With respect to the role of telecommunications, while 80 said they made no purchases over the Internet, 196 (44%) made up to 30% of their purchases online. Similarly, during the year prior, 112 of respondents made no purchases by mail order, but 187 (42%) made as many as 30% of their purchases using that mode.

Potential Barriers to E-Shopping. Decades of social science research suggest human behaviors are often conditioned by attitudes. As stated in the e-work section, the survey explored a number of potentially "negative attitudes" and perceptions regarding Net shopping. These include:

(1) fears credit card fraud,
(2) perceives that merchandise return is a hassle,
(3) Net vendors don't carry wanted items, and
(4) needs to see items in person.

Results from survey participants altogether show an intriguing trend: the potential for credit card fraud is a concern for a number of respondents, but more important are barriers related to daily hassles (returning merchandise) and/or preferences (wants to see items in person) (Table 2.31).

	Disagreed	Agreed	Neutral	N/A
Fears credit card fraud	183 (41%)	126 (28%)	54	80
Believes it would be a hassle to return merchandise purchased on-line	125 (28%)	154 (35%)	71	93
Net vendors don't carry wanted items	42 (9%)	251 (56%)	78	72
Wants to see items in person	110 (25%)	12 (3%)	108	112

Table 3.31 Barriers to E-shopping

As revealed in Table 2.32, each item is strongly and negatively correlated with on-line shopping, suggesting those respondents who hold negative attitudes/perceptions engage less frequently in Net purchasing behaviors.

		1.	2.	3.	4.	5.
1. Net shopping†	Pearson Correlation	1.000				
	Sig. (2-tailed)					
2. Fears credit card fraud	Pearson Correlation	-.445**	1.000			
	Sig. (2-tailed)	.000				
3. Needs to view products in-person.	Pearson Correlation	-.314**	.380	1.000		
	Sig. (2-tailed)	.000	.000			
4. Return of on-line purchases is a hassle	Pearson Correlation	-.293**	.538	.486	1.000	
	Sig. (2-tailed)	.000	.000	.000		
5. Net vendors do not carry wanted items	Pearson Correlation	-.458**	.424	.358	.504	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	

Table 2.32 Correlation of Barriers to E-shopping and E-shopping Behavior

** Correlation is significant at the 0.01 level (2-tailed).
† Recoded as a dichotomy

Correlation also reveals age is moderately related to a scale representing averaged negative attitudes as well as each item individually. Overall, negative perceptions regarding on-line shopping seems to increase with age.

		1	2	3	4	5	6
1. Age	Pearson Correlation	1.000	.234	.161	.162	.106	.274
	Sig. (2-tailed)	.	.000	.002	.002	.041	.000
2. Negative e-shop attitudes scale	Pearson Correlation	.234**	1.000	.781	.822	.665	.770
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000
3. Fears credit card fraud	Pearson Correlation	.161*	.781	1.000	.538	.380	.424
	Sig. (2-tailed)	.002	.000	.	.000	.000	.000
4. Net merchandise return is a hassle	Pearson Correlation	.162**	.822	.538	1.000	.486	.504
	Sig. (2-tailed)	.002	.000	.000	.	.000	.000
5.In-person product viewing	Pearson Correlation	.106*	.665	.380	.486	1.000	.358
	Sig. (2-tailed)	.041	.000	.000	.000	.	.000
6. Net vendors don't carry wanted items	Pearson Correlation	.274**	.770	.424	.504	.358	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.

Table 2.33 Correlation of Age and E-shopping Attitudes

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The previously described decreased likelihood of older respondents to engage in e-shopping may relate to skill level as well as attitudes. Analyses suggest older participants tend to be less skilled users of the Internet (judging from responses to self-appraisal items such as "does not use Net well enough to shop") (Table 2.34). This, combined with fear of credit card fraud and other negative perceptions, may make older users less likely to view the Net as a viable shopping tool.

		1	2	3
1. Age	Pearson Correlation	1.000		
	Sig. (2-tailed)	.		
	N	440		
2. Doesn't use Net well enough to shop	Pearson Correlation	.195**	1.000	
	Sig. (2-tailed)	.000	.	
3. Has difficulty searching Net	Pearson Correlation	.254**	.429	1.000
	Sig. (2-tailed)	.000	.000	

Table 2.34 Correlation of Age and Skill in Using the Internet

** Correlation is significant at the 0.01 level (2-tailed).

Exploring Possible Antecedents to E-Shopping Participation: Personal Attributes and Contextual Factors. Presumably, the more experience users have with ICTs, the more likely they will be to view them as everyday tools. Here, it is suggested that the more time a respondent spends on the Net, the more familiar s/he is with the technology, resulting in its use as a tool for everyday activities, in this case, shopping. A scatter plot showed a non-linear relationship between net purchasing frequency and time on the Net, accordingly non-parametric cross tabs were used to analyze the relationship. Continuous "time on the Net" was re-coded to produce three categories (three were suggested by the range and response patterns: 1-29 minutes [short time on the Net], 30-59 minutes [medium length of time], and 60+ minutes [long time on the Net]).

As suggested in Table 2.35, the amount of time respondents spend on the Internet and Net purchasing frequency does show a statistically significant relationship (X^2 (4, N=279) = 10.56, p = .032, Cramer's V=.138).

	Time on Net (each connection instance)	1- 29 minutes	30-59 minutes	60 and more	Total
Net purchase frequency	Weekly	2	4	6	12
	Monthly	36	27	10	73
	Yearly	95	55	44	194
	Total	133	86	60	

Table 2.35 Relationship between Time on Net and Net Purchasing Frequency

Interestingly, the proposition that longer reported periods of time on the Net will relate to increased shopping is not supported here. Rather, the table shows that those who spend the least amount of time on the Net tend to make more purchases. However, again, purchasing behavior overall is rather infrequent and primarily occurs yearly. Too, results from Cramer's V, show the effect size is small, and greater time spent on the Net is unlikely to have much of an impact on purchasing behavior in the population overall.

As suggested previously, it might be that e-shopping is undertaken in response to the pressures of balancing work and life demands. Those with longer work hours, long work commutes (including distance and time spent commuting to and from work), and/or young children in the home, for example, might logically turn to on-line shopping as a way to free time for work and family. Similarly, it seems logical to suppose that those individuals who participate in flexible work schedules would also engage in e-shopping, again, to balance the same work realm versus personal realm conflict. Evident in Table 2.36, this last hypothesis alone is supported. Those who participate in flexible work also tend to e-shop. Note, however, the effect is small.

	Net purchasing
Number of young children	r=.161, p=.077 (n.s.)
Work hours	r=.087, p=.099 (n.s.)
Time for commute to work	r=.019, p=.751 (n.s)
Time for return home commute	r=-.-059, p=.324 (n.s.)
Distance for commute	r=-.034, p=.099 (n.s.)
Flexible work schedule	r= .111*, p=.047

Table 2.36 Household Characteristics and Likelihood to E-shop

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

In previous analyses, age was shown to be negatively related to e-shopping, such that older respondents were less likely to engage in e-shopping (r=-.218, p <.001). An interesting question that might be posed here relates to a deterministic versus enacted view of e-shopping behavior. That is, one might ask: to what extent is e-shopping simply a factor of access to technology (e.g. speed)? Or, do contextual and/or personal factors (here age) mediate the relationship suggesting a more complex enacted relationship between context, technology, and outcome behaviors? Partial correlation was used to evaluate the effect of age on the relationship between connection speed and net purchasing behavior. Controlling for age, the relationship just barely departed from significance (r = .116, p=.051) suggesting a larger role for age in determining purchasing behavior than connection speed.

Other contextual factors exist in the shopping environment which might condition Net purchasing behavior. For example, hypothetically, individuals for whom physical shopping places are less easily accessed might be more likely to turn to the Net as a shopping tool; the reverse might be true for those for whom shopping places are readily available. To explore this assumption, the general survey included two items querying shopping accessibility. The first explores convenience shopping accessibility and appears as: *How close to your home are places where you can buy everyday convenience items (e.g. milk, bread, pharmaceuticals).* Response categories are categorical (e.g. within walking distance of home, a short drive from home). Results of evaluation employing cross tabs reveals clustering of convenience shopping access along two response categories (within walking distance and a short drive) (Table 2.37). Additionally, Net shopping (with categories collapsed to avoid assumption violations) is infrequent, resulting in a statistically non-significant relationship between convenience shopping and Net purchasing frequency (X^2 (4, N=281) = .687, p = .953, Cramer's V=.035).

Proximity of convenience shopping to home * Recode of online purchasing Crosstabulation

			Recode of online purchasing			Total
			weekly	monthly	yearly	
Proximity of convenience shopping to home	within short walking distance	Count	5	28	70	103
		Expected Count	4.8	25.7	72.6	103.0
	a short drive from home	Count	8	41	125	174
		Expected Count	8.0	43.3	122.6	174.0
	I can drive, not convenient	Count	0	1	3	4
		Expected Count	.2	1.0	2.8	4.0
Total		Count	13	70	198	281
		Expected Count	13.0	70.0	198.0	281.0

Table 2.37 Cross Tab of Distance Between Home and Convenience Shopping

Similarly, results of cross tab analysis describe a statistically non-significant relationship between "comparison" shopping and Net purchasing frequency (Table 2.38). (*How close to your home are places where you can do more extensive shopping [e.g. clothing, electronics)* and Net shopping frequency (X^2 (6, N=282) = 2.348, p = .885, Cramer's V=.091)

Proximity of comparison shopping to home * Recode of online purchasing Crosstabulation

			Recode of online purchasing			Total
			weekly	monthly	yearly	
Proximity of comparison shopping to home	within short walking distance	Count	0	2	5	7
		Expected Count	.3	1.8	4.9	7.0
	a short drive from home	Count	12	62	165	239
		Expected Count	11.0	60.2	167.8	239.0
	I can drive, not convenient	Count	1	7	25	33
		Expected Count	1.5	8.3	23.2	33.0
	completely inaccessible to home	Count	0	0	3	3
		Expected Count	.1	.8	2.1	3.0
Total		Count	13	71	198	282
		Expected Count	13.0	71.0	198.0	282.0

Table 2.38 Cross Tab of Distance Between Home and Comparison Shopping

Shopping-related Travel. A major premise for this research suggests ICT use will shape shopping travel behaviors in some fashion. While deterministic models suggest Net shopping might largely replace shopping trips altogether, a number of survey items explored other possible and more complex interactions between ICTs and travel, including potential modification and/or generation of shopping trips as a result of Net use. These exploratory items probe:

(1) on-line purchasing behavior (direct *substitution* for respondent travel);
(2) browsing the Net before actually making a trip to shop (*substitution* for "exploration" trips);
(3) use of the Net for item previews before actually making a trip to buy (*modification*—increasing trip efficiency);
(4) extent to which Net browsing has led the respondent to make a shopping trip s/he would not otherwise have made (trip *generation*);

(5) Net searches with the purpose of making shopping trips faster/more efficient (*modification*—efficiency)

Results, as demonstrated in Table 2.39, show that respondents by and large do engage in trip substitution behaviors (purchasing and browsing) as well as Net behaviors that might modify shopping-related travel. Interestingly, a much smaller percentage perceives that their use of the Net for browsing has resulted in trip generation.

	Engages in behavior	**Never engages**
Purchases on-line from Net vendors	64% (n=284)	19% (n=84)
Browses Net before actually making a trip to shop	62% (277)	20% (90)
Uses Net to preview items before making a trip to the store to buy	57% (256)	26% (114)
Net browsing has led to a shopping trip s/he would not otherwise have made	32% (144)	51% (226)
Searches the Net with the purpose of making shopping trips faster/more efficient	52% (232)	31% (137)

Table 2.39 Respondent Participation in ICT-related Travel Behaviors

Participants also were asked to indicate how *frequently* they engaged in ICT-influenced travel behaviors, using a scale of 1 = several times per week to 6 = never. (For analyses, scales were reverse-coded as 1 = never to 6 = several times per week.) Distributions were decidedly skewed toward the infrequent end of the scale in all instances. In fact, "several times per year" was chosen the most often for each item (see question 5(f) in Appendix A). As examples, 44% of respondents chose "several times per year" for *purchasing online*, and 62% selected the same response for *browsing the Internet before making a trip to shop*.

3. Fast-Netters: Exploring the Effect of Broadband in the Home (Research Question 3)

The third research question for this study concerns the impact of access to home broadband on daily subsistence and maintenance activities, especially e-work and e-shopping. The assumption is that high speed access will tend to influence targeted behaviors and related travel. The extent to which high speed access might enable substitutive behavior versus modification or generation is particularly of interest in this transportation-focused research.

To initiate exploration of the research question, one item in the general survey asked: "If you **DO** connect to the Internet at **HOME**, which technology do you use to connect?" with choices including dial-up modem, DSL, cable or ISDN, T1 or faster, or other. Nearly half (47% or n=209) of those responding to this question selected dial-up modem. Approximately 20% indicated that they rely upon DSL, cable, or ISDN for their Internet connection. Profiled characteristics and everyday behavior patterns of these fast-netters show interesting contrasts with respondents who tend to access the Internet using slower methods.

Profiling the Fast-netter: Demographics Characteristics. In terms of demographic characteristics, respondents with "fast" home Net connections in this sample are more likely to be male (62%) than female (37%). And, as shown in Table 2.40, access to a fast Net connection at home is positively related to income. Fast-netters tend to be engaged in professional/managerial (37.5%, or n= 30) and technical work (26%, or n=21). They also tend to be well-educated with 32% (n=28) being college graduates, while 17% (n-15) have earned a graduate or professional degree.

		1.	2.	3.	4.	5.
1. Fast Net (0=no, 1=yes)	Pearson Correlation	1.000				
	Sig. (2-tailed)	.				
2. Age	Pearson Correlation	**-.124***	1.000			
	Sig. (2-tailed)	.033	.			
3. Children	Pearson Correlation	.074	-.377	1.000		
	Sig. (2-tailed)	.201	.000	.		
4. Family income	Pearson Correlation	**.179****	-.298	.276	1.000	
	Sig. (2-tailed)	.002	.000	.000	.	
5. No. of cars	Pearson Correlation	**.127***	-.093	.434	.451	1.000
	Sig. (2-tailed)	.031	.058	.000	.000	.

Table 2.40 Fast-Netter Demographic Characteristics

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Evident in Table 2.40, there exists a significant negative correlation between access to fast Net and age suggesting that willingness to pay extra for home Net connections is more likely among younger respondents in this sample. The presence of children in the household is surprisingly unrelated to a fast Net connection. This relationship, however, likely emerges as an artifact of the particular sample, which is overall a slightly older group as illustrated previously.

Profiling the Fast-Netter: Technology Access and ICT Use. In terms of access to technology, most (85/88, 3 = missing) reported access to a home computer naturally. Most also use a computer at work as shown in Figure 2.4.

All fast-netter respondents report that they use the Internet (88/88). Asked where they tend to connect most frequently, more than half (53%, n= 47) selected "from home via a personal computer," while 40 chose "at work from a computer." Most fast-netter respondents have had considerable experience in using the Net (see Figure 2.4).

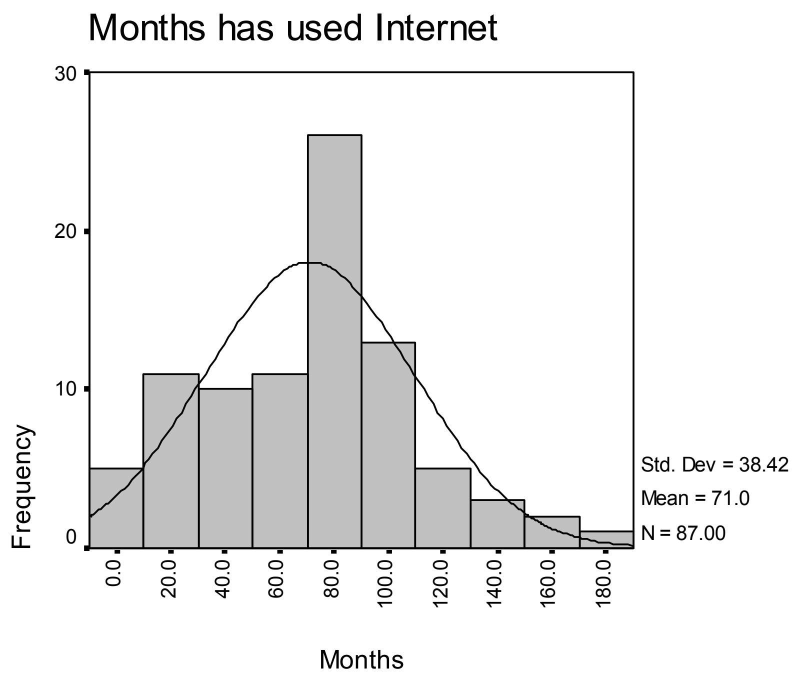

Figure 2.4 Length of Time Fast-netters have Used Internet

Results of a t-test suggest fast-netters have significantly more months of experience with the Net (t (289) = -2.228, p = .027) than do those using dial up connection only (Table 2.41).

		N	Mean	Std. Deviation	Std. Error Mean
Number of months	Slow	204	60.25	37.16	2.60
	Fast Net	87	70.95	38.42	4.12

Table 2.41 Length of Time Fast-netters have Used Internet

Respondents with access to home broadband tend to connect to the Net somewhat more frequently than those using slower, dial-up technology. For example, of the 88 fast-netters, 67 (76%) connect several times each day, while among those with slow connections, 62% (128/208) engage in the same frequency of connection. However, cross tabs analysis suggests the difference is not statistically significant (X^2 (6, N=296) = 8.82, p = .184, Cramers V=.184).

Presumably, individuals with access to high speed Internet will be more likely to use the Net more frequently when compared to participants with slower, dial-up access. This assumption was explored through an independent samples t-test (note: test groups were formed by dichotomizing Internet speed responses as 1 = slow [dial up] and 2=fast [DSL, cable, ISDN]). The test was not statistically significant (t (290) = -.066, p = .948) suggesting that, for this group of respondents, individuals with faster Internet connections (N = 205) are not more likely to spend any greater amount of time on the Internet as compared to those using slower, dial-up methods (N = 87). The assumption tested here, that access to the Net alone will influence behavior, largely suggests a technology deterministic model. Taking an enacted perspective, it is likely that ICT use outcomes result from a more complex web of relationships, including but beyond technology speed alone (e.g. socio-demographic).

A second presumption is that those with home broadband would spend more time on the Internet than those with slow, dial-up connections. Initially cross tabs analysis was used to evaluate a possible relationship between respondent connection speed and the amount of time he or she spends on the Internet, re-coded to avoid test assumption violations by collapsing cells into fewer categories. Original response categories of "several times each day" and "once per day" became daily; "several times per week" and "once per week" became weekly. Cross tabs analysis again resulted in a statistically non-significant relationship between technology speed and purchasing behavior (X^2 (4, N=296) = 6.97, p = .137, Cramers V=.154).

Work and Work Travel. The majority of fast-netters are employed (90%, n=79); they tend to work in either large, private firms (39%, n = 34) or are self-employed (16%, n = 14). Noted previously, fast-netters tend to be engaged in knowledge work of some form (e.g. professional or technical). They also tend to have a longer morning commute (R = .164, significant at p = .05), although not because they live further away from work as evident in Table 2.42. Also shown in this table, while a fast home Net connection is unrelated to engagement in flexible work schedules overall, it is related to telecommuting behavior in this sample.

		1.	2.	3.	4.	5.
1. Fast net	Pearson Correlation	1.000				
	Sig. (2-tailed)	.				
2. Number work hours per week	Pearson Correlation	-.052	1.000			
	Sig. (2-tailed)	.371	.			
3. One way distance from home to work	Pearson Correlation	.081	.028	1.000		
	Sig. (2-tailed)	.195	.598	.		
4. Flexing	Pearson Correlation	.069	-.046	.030	1.000	
	Sig. (2-tailed)	.267	.386	.577	.	
5. Telecommuting	Pearson Correlation	**.193***	-.062	.101	.037	1.000
	Sig. (2-tailed)	.042	.449	.222	.651	.

Table 2.42 Correlation of Fast-netters and Flexible Work

* Correlation is significant at the 0.05 level (2-tailed).

Overwork and Fast-netters. Related to the type of work in which fast-netters are engaged, most of these knowledge workers also tend to "overwork." That is, high speed home Net connections are positively related to engagement in *work from home* before/after scheduled work hours and during the work day (Table 2.43). Note this last relationship is likely explained by the strong likelihood that telecommuters working from home will have access to broadband.

		1.	2.	3.	4.	5.
1. Fast Net	Pearson Correlation	1.000				
	Sig. (2-tailed)	.				
2. Overwork - Net use at home before work	Pearson Correlation	**.154***	1.000			
	Sig. (2-tailed)	.017	.			
3. Overwork - Net use after work hours	Pearson Correlation	**.125***	.802	1.000		
	Sig. (2-tailed)	.047	.000	.		
4. Overwork - Net use during work day	Pearson Correlation	**.131***	.718	.739	1.000	
	Sig. (2-tailed)	.042	.000	.000	.	
5. Overwork - Net use for OT on weekends	Pearson Correlation	.095	.740	.893	.676	1.000
	Sig. (2-tailed)	.136	.000	.000	.000	.

Table 2.43 Correlation of Fast-netters and "Overwork"

* Correlation is significant at the 0.05 level (2-tailed).

Everyday Travel—Fast-netter Shopping and Errand-running Behavior. One of the driving assumptions behind this research is that access to broadband will relate to travel behaviors in some fashion. While results overall suggest ICT substitution for everyday travel occurs rarely, findings do suggest such access might serve to modify and in some cases even stimulate shopping and errand-running forms of travel.

In terms of the possible substitution effect between ICT and shopping travel, results suggest broadband access is related to the tendency to shop online among the 88 fast-netters. Frequency of Net purchasing shows a positive, significant correlation with broadband access ($r = .142$; significant at $p < .05$). However, the effect is rather weak; further it must be noted that Net shopping overall is relatively infrequent as both "slow" and "fast" netters follow the trend noted for the sample overall and engage no more than once yearly (Table 2.44).

	Dial-up	Broadband
Never makes purchases over the Net	35	7
Several times per year	125	54
Several times per month	29	21
Every week	7	5
Every day	1	0

Table 2.44 Relationship of Fast net vs. Dial up and E-shopping

On average, those without access to home broadband are more likely to display negative attitudes toward e-shopping (measured by scaled items discussed previously, such as fears credit card fraud). Results of a t-test are significant (t(293)=.116, p=.004) and show the mean average for negative attitudes among non-fast-netters is higher than for fast-netters (Table 2.45).

		N	Mean	Std. Deviation	Std. Error Mean
Scale for negative e-shopping attitudes	No fast connection	207	12.63	3.63	.25
	Fast-Net connection	88	11.31	3.50	.37

Table 2.45 Group Statistics

Analysis also suggests fast-netters do reveal a tendency to engage in behaviors that might lead to a modification in shopping behaviors. For example, when asked to respond to the statement: *I use the Internet to browse online vendors (not shopping, but exploring items)* by selecting a frequency rating (1= every day to 6= never), results of a correlation show a positive, significant, moderately strong relationship with fast Net use (r = .241, significant at p <.001).

Results provide an opportunity for more in-depth exploration of a possible modification, and even generation, effect of ICT in general (see above), and broadband in particular, for travel behaviors. As described previously in results for e-shopping, survey respondents were presented with a number of items intended to explore the extent to which use of the Net may have influenced respondent shopping habits and shopping trips. These include substitution through purchasing and browsing, modification through use of the Net to preview items and conduct searches to make trips faster/more efficient, as well as potential generation in cases where Net browsing leads the respondent to make a trip he or she would otherwise not have made. As shown in Table 2.46, every item showed a significant, and in some cases, moderately strong, relationship with access to home broadband. The stronger correlations between Fast-Net and items 3, 4, and 6 suggest broadband users may use the Net primarily as a means of increasing trip efficiency. Given the earlier noted relationship between broadband access, high incomes, and knowledge work occupations, fast-netters may use the Net as a tool to deal with the conflict between busy work schedules and the demands of daily life.

		1.	2.	3.	4.	5.	
1. Fast-net	Pearson Correlation	1.000					
	Sig. (2-tailed)	.					
2. Net purchasing	Pearson Correlation	**.151***	1.000				
	Sig. (2-tailed)	.019	.				
3. Net browsing before trips	Pearson Correlation	**.337****		1.000			
	Sig. (2-tailed)	.000		.			
4. Preview items before trips	Pearson Correlation	**.343****			1.000		
	Sig. (2-tailed)	.000			.		
5. Net browsing led to additional shopping trip	Pearson Correlation	**.159****				1.000	
	Sig. (2-tailed)	.006				.	
6. Net searches to increase travel efficiency/speed		**.239****					1.00
	Sig. (2-tailed)	.000					

Table 2.46 Relationship of Fast net and E-shopping behaviors

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

The background survey also explored errand-running behaviors through two items that explored when respondents were likely to run errands and the mode employed. Given busy work schedules, it is not surprising to find that nearly half (47%) of fast-netters run errands on the weekends. Overall, a larger proportion of fast-netters tended to run errands on the weekends than did their "slower" counterparts (31%). Nearly all (98%, n = 86) of the fast-netters reported that they travel by car for errands, with the same proportion seen among slow-netters (98%, n = 204).

Fast-netters use of Net Services. Beyond shopping, the Internet offers an access point to important information and services. Respondents as a group were asked to indicate to what extent they used the Net to engage in a number of activities related to *education* (school work, library access, and on-line classes), *information acquisition* (read on-line news/magazines, information regarding community events, to access local government information/services), for *entertainment* (chat, games, music), *health information/services*, and for *financial services access* (banking, bills, insurance). As shown in Table 2.47, a number of education, information, and entertainment Net services are related to household broadband access.

		1.	2.	3.	4.	5.	6.
1. Fast Net	Pearson Correlation	1.000					
	Sig. (2-tailed)						
2. Net use -- library	Pearson Correlation	**.129***	1.000				
	Sig. (2-tailed)	.034	.				
3. Net use -- online news	Pearson Correlation	**.157****	.275	1.000			
	Sig. (2-tailed)	.008	.000	.			
4. Net use -- community information	Pearson Correlation	**.133***	.379	.406	1.000		
	Sig. (2-tailed)	.025	.000	.000	.		
5. Net use -- entertainment	Pearson Correlation	**.168****	.201	.201	.287	1.000	
	Sig. (2-tailed)	.005	.000	.000	.000	.	
6. Net use -- online financial	Pearson Correlation	**.182****	.108	.214	.217	.226	1.000
	Sig. (2-tailed)	.002	.053	.000	.000	.000	.

Table 2.47 Fast Net and Use of Internet Services

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Part 5: Conclusions and Future Research Questions

The impact of ICT on work and shopping trips is only beginning to be understood, and the influence of residential broadband connections is even less clear. However, the literature reviewed and data obtained in this study suggest a few lessons.

First, e-workers take advantage of ICT to modify their commutes without impacting their workday. Many appear to use ICT before or after work to maintain contact with their office while leaving for or from work at times later than the common peak. While use of telecommuting as a direct substitute for the work commute is rare in this sample, most that do have broadband connections, indicating that the true telecommuting "boom" may yet occur, if broadband connections become more common. However, these e-workers are a select group: managerial, professional, or technical employees, where physical presence at specified times is less important. In areas where these workers do not make up a large percentage of the workforce, increased ICT connection speed and use may have little impact.

Second, e-shopping broadens the range of shopping activities from home. While direct substitution-type activities appear less frequent and seem to have little impact in this sample, people seem use the Internet to modify their shopping behavior, by either browsing for products before leaving home or by using the Internet to make their trip more efficient. However, broadband users were more likely to use the Net to generate a trip than dial up uses, and income was correlated with both e-shopping behavior and broadband subscriptions. Taken together, these indicate that an improved economy and improved connectivity may have a significant multiplier effect on leisure or discretionary travel.

This research also raises new questions. Most important among these are the relationship between broadband use and the users: will younger people continue to be more likely to pay for this service, or will it become more ubiquitous? And, if it is the latter, will older people take advantage of the improved connections in different ways? Further, more work is needed to understand the products most conducive to e-shopping, attitudes and preferences of e-shoppers, as well as more empirical analyses of the travel implications of growth in these areas. Regardless, it continues to appear that the impacts of ICT on travel behavior are only beginning to be seen.

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CHAPTER 3
Results and Analysis of ICT Travel Diary with Shopping Discussion Supplemented by the General Survey

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Sample Composition of Travel Diary Results
To complement the general survey, a travel diary survey was conducted. Of the 446 respondents who completed the general survey, 98 people completed the diary. Household members (aged 18 or above) of the 98 people were also invited to complete the diary, amounting to a total of 170 respondents.

Respondents were asked to complete an online travel diary containing questions about their travel behavior over a period of four days (Friday, Saturday, Sunday, and Monday). However, not all respondents recorded their trip information for all four days. In total, 2,390 trips were reported, providing detailed information on the trip purpose, travel mode, start time, duration, distance traveled, and whether the respondent checked the Internet for help before making the trip.

Social demographic, ICT-related, work-related, and household-related information were also collected from the participants. Of the 170 respondents, 52% are female, 64% are employed full-time, and 99% possess a driver's license (thus, we are capturing almost exclusively a driving population). The 98 households have the following characteristics:

- 70% have two or more adults,
- 64% no not have children,
- 62% have two or more vehicles,
- 84% lives in single-family home, and
- 89% has Internet access (66% are dial-up modems).

It is important to note that despite efforts to improve data collection with on-line administration of the diaries and offering $20.00 cash incentives, issues related to sample size and quality remained. The main problems include:

1. the sample size is small (in aggregate, only 98 respondents completed both the general survey and the diary survey);
2. a limited number of respondents were a bit reckless or misunderstood the question when completing the survey, which to some degree reduces the quality of the data; and

3. the distance of trips were calculated using the change in longitude and latitude values (1 degree=49.31 miles), which might slightly differ from the exact number of miles traveled (e.g., as the crow flies versus network driving distances).

General Findings

Residential Location and Travel

Respondents generally resided in three areas: Apple Valley, Lakeville, and Minneapolis (the latter was represented by two zip codes, but they are more or less similar in terms of geography and composition. Overall, the travel patterns across the three communities were relatively homogenous; although, some differences exist among the travel behaviors of residents in these three areas:

- 85% of those who live in Lakeville have two or more vehicles in their household, as opposed to 70% in Apple Valley and 47% in Minneapolis.
- Those in Minneapolis are slightly more likely to carpool (rode in other's car), 11% as apposed to 3% or 4% in Lakeville and Apple Valley.
- Those in Apple Valley on average travel longer distances than those in Lakeville, who in turn travel longer distances than those in Minneapolis. The average miles traveled per person over the four days are 75 miles for those in Apple Valley, as opposed to 71 miles for those in Lakeville, and 60 miles for those in Minneapolis.

Weekends Versus Weekday Travel

In general, one would expect less travel on weekends. While this held true, we found Sunday travel considerably less than all other three days, while Saturday travel is slightly more than Monday travel, and Friday travel the highest point of all four days (see Tables 3,1 and 3.2). A rational behind the pattern might be that people are doing a lot of social recreational activities or shopping on Fridays in addition to all the work-related trips, thereby increasing that value.

Per person	All N=170	Apple Valley N=43	Lakeville N=37	Minneapolis N=82
All four days	64.93	75.15	70.46	60.28
Friday	**21.26**	28.46	22.18	18.02
Saturday	**16.13**	18.76	17.29	15.27
Sunday	**12.47**	8.15	14.29	14.94
Monday	**15.08**	19.78	16.70	12.06
Number of individuals=170 Number of valid trips=2338 (distance>0)				

Table 3.1 Average Distance Traveled (miles traveled per person)

Per person	All N=170	Apple Valley N=43	Lakeville N=35	Minneapolis N=82
All four days	248.68	265	238.57	260.18
Friday	**89.76**	81.74	75.29	81.65
Saturday	**75.85**	65.00	58.57	63.84
Sunday	**58.44**	44.19	46.00	51.46
Monday	**71.00**	74.07	58.71	63.23
Number of individuals=170 Number of valid trips=2233 (Time>0)				

Table 3.2 Average Time Traveled (minutes traveled per person)

Trip Purposes of all Trips Versus Trip Purposes of ICT-Influenced Trips Only
As a whole, 1,574 trips were conducted (this does not include trips that went back home). The most frequent trip purposes are:

1) work (20%);
2) social recreation (19%); and
3) shopping, mainly for grocery, gas, or pharmacy (15%).

Trip purposes are further categorized into for subsistence activities (attending school, going to work, and work-related); for maintenance activities (picking up or dropping off passengers, attending childcare, personal business, shopping for grocery, gas, and pharmacy, shopping for electronics, clothing, cars, and religious activities); and for discretionary activities (social recreation, shopping for jewelry and antiques, eat out/get takeout, and other). That breakdown is as follows (the theoretical significance of these categories is described at the beginning of the diary discussion):

- 24% are for subsistence activities,
- 42% are for maintenance activities, and
- 34% are for discretionary activities.

Shopping Travel (Daily versus Non-daily)
Among all trips, 14.9 % are for daily goods shopping and 6.3% are for non-daily goods shopping. By daily goods shopping, we mean shopping for things like grocery, gas, or pharmacy. By non-daily goods shopping, we mean shopping for electronics, clothing, car, jewelry, and antiques.

Characteristics of Fast-netters
Since there are a predominant number of respondents (89%) who have Internet access at home (likely a result of the diary being conducted online), it would not be as useful to compare Internet users with non-Internet users as to compare people who have fast Internet access with people who have slower Internet access: 66% of the respondents have dial-up modem, while 23% of all respondents have cable, DSL, ISDN, or T-1. We therefore examine the characteristics of Fast-netters versus non-Fast-netters in a polar manner and this reveals the following:

- For the total number of trips over the four days, Fast-netters have statistically significant fewer trips than non- Fast-netters (12.4 trips vs. 14.6 trips).

- In general, however, in a multivariate analysis, there are very few travel behavior differences (after controlling for other factors) between Fast-netters and non-Fast-netters.

Group Statistics

	FASTNET	N	**Mean**	Std. Deviation	Std. Error Mean
TRIP	YES Fastnet	42	**12.4048**	7.8432	1.2102
	NO Fastnet	124	**14.6371**	6.3314	.5686
DISTANCE	YES Fastnet	40	**1.3046**	.7317	.1157
	NO Fastnet	121	**1.3523**	.9257	8.415E-02
SHOPTRIP	YES Fastnet	42	**1.7857**	2.2365	.3451
	NO Fastnet	124	**2.0161**	2.0718	.1861

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Conf Interval of Difference	
									Lower	Upper
TRIP	Equal variances assumed	2.965	.087	-1.855	164	**.065**	-2.2323	1.2035	-4.6087	.1441
	Equal variances not assumed			-1.669	60.120	.100	-2.2323	1.3371	-4.9069	.4422
DISTANCE	Equal variances assumed	.050	.823	-.297	159	**.767**	-4.77E-02	.1609	-.3655	.2700
	Equal variances not assumed			-.334	83.580	.740	-4.77E-02	.1431	-.3322	.2368
SHOPTRIP	Equal variances assumed	.159	.691	-.610	164	**.542**	-.2304	.3775	-.9757	.5149
	Equal variances not assumed			-.588	66.429	.559	-.2304	.3921	-1.0131	.5522

ICT-Influenced Trips
One of the questions in the Web diary asked whether each trip may have been ICT-influenced (i.e., the respondent consulted trip-related information online before making the trip). In sum, there are 101 such trips, excluding go-back-home trips. Of the total 2,390 trips, fewer than 5% are ICT influenced. This shows that on very limited occasions, do people go online to get information before making their trips. The top three most frequent trip purposes are: 1) social recreation (25%); 2) personal business (15%); 3) work-related (9%) or shopping for grocery (9%). When further categorized, 17% are for subsistence activities, 43% are for maintenance activities, 40% are for discretionary activities. The general destinations of the trips are listed in Appendix B. More than one-third of these ICT-influenced trips are for social recreational activities or for personal business.

Social Recreational Trips
Of the social recreational trips (25 of them), we observe destinations like ice rink, lunch, volleyball, church, Hey City Theater, Rhonda's, Southdale Mall, and University of Minnesota.

People seem to be using the Internet to check the time schedule or the location of social recreational activities. To this extent, ICTs are facilitating people's travel with more updated and easily accessible information. It is very hard to judge whether ICT was increasing or reducing trips due to the lack of information on what people would have done if they did not had the option of checking the Internet. This suggests further research possibility into the relationship between ICT and social recreational trips. Another finding is that 88% of these ICT-influenced social recreational trips began after 3 p.m., suggesting that the relatively uncertain nature of evening commute rush hour may be playing a role.

Personal Business Trips
Of the 15 ICT-influenced personal business trips, we observe destinations as the following: go to a friend's house, or house hunting trips (one family made 8 house-hunting trips). Given the limited number of observations, it is difficult to come to any conclusions on the possible impact of ICT on personal business trips.

Characteristics of People Who Make ICT-Influenced Trips
Of the total 170 respondents, 39.4% reported making at least one ICT-influenced trip during the four days, and they seem to share some common characteristics. Most of these people use a computer both at work and at home, and they go on Internet several times a day or once a day. They have been using Internet for quite some time. They tend to have high education; median or high income; and work full time.

Multivariate Models of On-Line Shopping Behavior, Including General Survey Results
As shopping trips comprised 21% of all trips (excluding go-back-home trips), we pay particular attention to examining on-line shopping, which might contribute to further research on the impact of ICT on shopping trips. This set of models focuses on on-line shopping both in terms of behavior and in terms of attitude and supplements the diary data with data from the survey.

Discrete binary variables are of interest here, such as *ever bought on line/ not* and *think on-line shopping is fun/ not.* Two binary logistic models are used, which produce the following results:

1. Have you ever bought online?
The results indicate that people with certain socio-demographic and household characteristics have a greater propensity to possess on-line shopping experience. Such characteristics include younger age, a higher household income, and fewer than two vehicles in the household.

Some ICT-related variables also show statistically significant relationship with people's on-line shopping experience. Those with more years of Internet use experience, those who frequent the Internet more often (at least once per day), and those who have faster Internet, are more likely to have on-line purchase experience.

In addition, the attitudinal variable, *need to see products in person before buying*, appear to have a strong negative relationship with the dependent variable, *ever bought on line.* Those who feel less strongly about seeing the product before purchase have a greater propensity to purchase online.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	AGE	-.029	.016	3.172	1	.075	.972
	MEDINCO	1.063	.583	3.325	1	.068	2.894
	HIGHINC	2.426	.691	12.327	1	.000	11.313
	ONENOKI	.512	.557	.846	1	.358	1.669
	TWOPLUSV	-.912	.559	2.658	1	.103	.402
	NETBEG3	.320	.090	12.700	1	.000	1.378
	FREQNETD	.685	.387	3.138	1	.076	1.984
	FASTNET	.970	.496	3.818	1	.051	2.638
	INPERSON	-2.716	.665	16.677	1	.000	.066
	Constant	1.945	1.304	2.225	1	.136	6.993

a Variable(s) entered on step 1: AGE, MEDINCO, HIGHINC, ONENOKI, TWOPLUSV, NETBEG3, FREQNETD, FASTNET, INPERSON.

2. Do you think on-line shopping is fun?
There appear to be significant differences in people's attitude towards on-line shopping across various socio-demographic segments of users. For example, females are more likely to enjoy on-line shopping than males. Younger and middle age individuals are more likely to view on-line shopping as fun than upper middle age and older people, probably due to a greater degree of familiarity of new technology. In addition, greater propensity of viewing on-line shopping as fun

is seen among individuals from families with median or high income and those with fewer than two vehicles.

The regression results also indicate that those with more years of Internet experience and those with fast Internet access are more likely to consider on-line shopping as fun. This further indicates that as the Internet penetration rate increases over the years and as fast Internet becomes more widespread, we are most likely going to observe a greater percentage of the population enjoying virtual shopping. The impact that the on-line shopping option has on physical shopping might not be very strong now, but we expect to see a stronger pattern in the years ahead.

Some attitudinal variables also present statistically significant relationship with the individual's opinion on virtual shopping. Those who see store shopping as fun are also more likely to view on-line shopping as fun. They are the group who just love to shop be it in the store or online. Also, those who feel less strongly about seeing the product before hand are more likely to consider online shopping as fun.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	GENDER	.638	.308	4.283	1	.039	1.892
	AGE	-.023	.013	3.149	1	.076	.977
	MEDINCO	1.242	.503	6.104	1	.013	3.461
	HIGHINC	1.072	.540	3.935	1	.047	2.920
	ONEKI	-.426	.457	.870	1	.351	.653
	TWOPLUSV	-.624	.361	2.976	1	.084	.536
	NETBEG3	.160	.051	9.973	1	.002	1.174
	FASTNET	.658	.329	3.996	1	.046	1.930
	STOREFUN	.665	.311	4.567	1	.033	1.944
	INPERSON	-1.818	.310	34.329	1	.000	.162
	Constant	-.038	.871	.002	1	.965	.963

a Variable(s) entered on step 1: GENDER, AGE, MEDINCO, HIGHINC, ONEKI, TWOPLUSV, NETBEG3, FASTNET, STOREFUN, INPERSON.

Attitudes/Preferences

Taking a close look at the information gathered from general survey question #5h, we can infer patterns of associations. Using principal component factor analysis reveals the following factor loadings.

Rotated Component Matrix

	Component		
	1	2	3
Fears credit card fraud	**.722**	3.606E-02	2.206E-02
Has difficulty searching Net	**.715**	.269	9.171E-02
In-person product viewing necessary	**.655**	-.268	.234
Return of Net merchandise is a hassle	**.771**	-5.026E-02	-3.063E-02
Likes in-home product delivery	**-.455**	.402	-.127
Net vendors do not carry wanted items	**.749**	.356	3.041E-02
Net shopping is fun	-7.027E-02	**.724**	4.211E-02
Net shopping reduces shopping hassles	-9.127E-02	**.753**	-.178
Net products of higher quality	.441	**.653**	2.386E-02
Likes no-car characteristic of online shopping	.153	**.763**	-6.378E-02
Store shopping is a hassle	-.215	.183	**-.682**
Likes help/friendliness in stores	.316	-.198	**.450**
Shopping provides out-of-house opportunity	-1.566E-02	.193	**.798**
Likes energy/fun of in-store shopping	5.881E-02	.101	**.891**
Does not like leaving house to shop	.129	.334	**-.615**

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.880	.129	.457
2	.148	.840	-.522
3	-.451	.527	.720

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

These yields a population that scores accordingly on the following factors (indicated by bold type):

1. Anti e-shop
2. Pro e-shop
3. Pro in-store shop

We can then use the factor scores to assign each general survey member to one of these groups, which yields the following:

Cluster Number of Case

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	37	8.3	10.2	10.2
	2	175	39.2	48.1	58.2
	3	152	34.1	41.8	100.0
	Total	364	81.6	100.0	
Missing	System	82	18.4		
Total		446	100.0		

Thus, only 37 (10.2%) of 364 of the General Survey respondents are truly described anti e-shoppers (when a discretionary classification is used). Almost half are classified as pro e-shoppers and 41% are pro in-store shoppers.

For a more detailed description of the methodology used to arrive at the above, please can consult Krizek, K. J. and P. Waddell (2003). "Analysis of Lifestyle Choices: Neighborhood Type, Travel Patterns, and Activity Participation." Transportation Research Record 1807: 119-129.

Models that Focus More on the Travel Behavior/Activity Aspect

Finally, several multivariate models were estimated to examine the impact of varying ICT-related variables on travel behaviors. It is important to look at such behaviors from a multi-variate standpoint in order to control for other, confounding explanations. Dependent variables of interest that were tested include:

- number of trips,
- duration of trips,
- characteristics of shopping trips,
- characteristics of non-daily goods shopping trips, and
- characteristics of daily goods shopping trips.

These resulted in poor models with low F-statistics and few, if any, statistically significant variables, suggesting that ICT impacts have little direct impact on general patterns of travel.

Activity Duration Models

As a result, it was decided to examine more general behaviors, focusing on activity level analysis that focused on the time spent completing subsistence, maintenance, and discretionary activities. Again,

- subsistence activities include attending school, going to work, and work-related activities;
- maintenance activities include picking up or dropping off passengers, attending childcare, personal business, shopping for grocery, gas, and pharmacy, shopping for electronics, clothing, cars, and religious activities;
- discretionary activities include social recreational activities, shopping for jewelry and antiques, and eating out or getting takeout. It is important to note that we are referring only to out-of-home subsistence, maintenance, and discretionary activities.

The amount of time spent completing each activity was calculated by "backing" into such values from the trip diary (i.e., calculating the time from the previous trip and subtracting that from the time of the next trip. See below.)

PERSON ID	ORIGIN	DEST	TT	START TIME	END TIME*	TIME SPENT*
1	H	O	15	8:30	8:45	30
1	O	W	15	9:15	9:30	360
1	W	O	15	15:30	15:45	105
1	O	O	10	17:30	17:40	20
1	O	H	10	18:00	18:20	850
2	H	W	20	8:00	8:20	340
2	W	O	15	14:00	14:15	

The following categories of explanatory variables are of primary interest to this exercise:

- ICT-related variables (e.g., Internet access at work, connection speed);
- work-related variables (e.g., type);
- socio-demographic variables (e.g., vehicles owned, income);
- household-related variables (number of children);
- attitudinal variables (previously described); and
- geographic variables (location of respondent, convenience to retail).

Regression models were constructed for the duration of each of the three categories of activities. Only individuals who have completed both the general survey and the diary survey are included in our analysis. Due to the small sample size, our threshold for statistical significance is set at 0.15, consistent with other research efforts with similar sample sizes

In general, we found that our models for the duration of maintenance activities and subsistence activities are good, while the model for the duration of discretionary activities is very weak. The results and interpretation are as follows:

Duration of Maintenance Activity

Our results indicate that those individuals with Internet access at home spent less time doing out-of-home maintenance activities. If the relationship observed is real, there seems to be some reduction effect of ICT on the duration of out-of-home maintenance activities. However, we also find that individuals who tend to purchase frequently online (more than several purchases per year) also spent more time on maintenance activities. These people might be frequent shoppers by nature, and the Internet offers them an alternative channel for shopping but does not necessarily reduce their engagement in out-of-home maintenance activities. The main point is that the impact of ICT on individuals' maintenance activities has indeed complicated implications.

We also find that individuals from households with higher incomes spend more time in maintenance activities. This is self-explanatory as higher income people have more financial ability to engage in maintenance activities. Besides, we find that individuals that are less time-pressed in terms of household obligations generally spend more time in maintenance activities. By less time-pressed, we mean individuals that are from families that have one person working and no children, or that have only students, or that receive pension benefits.

It is also interesting to find that those who live close to comparison shopping venues spend more time in maintenance activities, while those who live close to convenience stores spend less time in maintenance activities.

In addition, we observe that individuals who are more pro e-shopping tend to spend less time in out-of-home maintenance activities. These are probably the strong e-shopping supporters who might have substituted some of their maintenance activities with online activities.

Duration of Discretionary Activity

Our results indicate that individuals with fast Internet access spend less time in out-of-home discretionary activities. There might be some substitution effect here as people spend more time on the Internet while reducing their discretionary activities outside home.

We also find that white-collar workers and people with higher education spend less time in out-of-home discretionary activities. These are more time-pressed individuals who are engaged in work and study and could not afford much time in discretionary activities.

Some household related variables also present statistically significant relationship with the duration of discretionary activities. Individuals with a higher household income spend more time in discretionary activities. Interestingly, individuals from households with two or more vehicles spend less time in discretionary activities.

It is also important to note that, according to our results, individuals who are more pro e-shopping spend more time in discretionary activities. This seems to imply that the option of on-line shopping is saving people a lot of time in maintenance activities and providing them with more free time to engage in discretionary activities.

Duration of Subsistence Activity

Our results indicate that individuals with Internet access at home spend more time doing subsistence activities. Individuals with cell phone access spend less time doing subsistence activities. Those who use Internet more frequently (at least once per day) and those who have fast Internet access spend less time doing out-of-home subsistence activities, possibly due to the fact that survey results indicate that telecommuters were more likely to have fast Internet access.

We also find that those who are full-time workers spend more time in subsistence activities, which is self-explanatory. Our results also show that older people spend less time in subsistence activities. This relationship is because our surveys were completed by people over the age of 18. Therefore, we included retired people and excluded younger people below the age of 18. Finally, individuals from families with two or more vehicles spend less time in subsistence activities. The results also provide evidence that people who reside in Minneapolis spend less time in subsistence activities than those who live in Apple Valley and Lakeville (See Figures 3.1–3.12).

Output

Duration of Maintenance Activity

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Pro-e-shopping, INC_CONT, COMP_PRX, freqonline purchaser (more than several times a year), HOM_NET, student/pensioned/other households, CONV_PRX, FULLTIME, ONENOKI[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: DURMAINT

Figure 3.1 Variables Entered/Removed

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.613[a]	.376	.305	148.8110

a. Predictors: (Constant), Pro-e-shopping, INC_CONT, COMP_PRX, freqonlinepurchaser (more than several times a year), HOM_NET, student/pensioned/other households, CONV_PRX, FULLTIME, ONENOKI

Figure 3.2 Model Summary

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1052693	9	116965.889	5.282	.000[a]
	Residual	1749432	79	22144.705		
	Total	2802125	88			

a. Predictors: (Constant), Pro-e-shopping, INC_CONT, COMP_PRX, freqonlinepurchaser (more than several times a year), HOM_NET, student/pensioned/other households, CONV_PRX, FULLTIME, ONENOKI

b. Dependent Variable: DURMAINT

Figure 3.3 ANOVA[b]

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	152.275	93.942		1.621	.109
	HOM_NET	-167.254	55.735	-.284	-3.001	.004
	freqonlinepurchaser (more than several times a year)	75.363	37.482	.188	2.011	.048
	FULLTIME	-70.458	49.352	-.159	-1.428	.157
	INC_CONT	1.310E-03	.001	.191	1.535	.129
	ONENOKI	160.421	44.988	.437	3.566	.001
	student/pensioned/other households	314.363	83.827	.408	3.750	.000
	COMP_PRX	69.922	48.034	.139	1.456	.149
	CONV_PRX	-63.596	37.148	-.173	-1.712	.091
	Pro-e-shopping	-47.836	19.690	-.233	-2.430	.017

a. Dependent Variable: DURMAINT

Figure 3.4 Coefficients[a]

Duration of Discretionary Activity

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Pro-e-shopping, white collar=1, TWOPLUSV, 1=graduated college, professional/graduate school, FASTNET, INC_CONT[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: DURDISC

Figure 3.5 Variables Entered/Removed

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.356[a]	.127	.064	308.4181

a. Predictors: (Constant), Pro-e-shopping, white collar=1, TWOPLUSV, 1=graduated college, professional/graduate school, FASTNET, INC_CONT

Figure 3.6 Model Summary

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1145465	6	190910.778	2.007	.074[a]
	Residual	7895101	83	95121.697		
	Total	9040566	89			

a. Predictors: (Constant), Pro-e-shopping, white collar=1, TWOPLUSV, 1=graduated college, professional/graduate school, FASTNET, INC_CONT

b. Dependent Variable: DURDISC

Figure 3.7 ANOVA[b]

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	355.317	90.792		3.914	.000
	FASTNET	-144.093	81.188	-.195	-1.775	.080
	white collar=1	-109.663	71.405	-.168	-1.536	.128
	1=graduated college, professional/graduate school	-110.522	71.025	-.168	-1.556	.123
	INC_CONT	3.529E-03	.002	.290	2.120	.037
	TWOPLUSV	-177.034	81.489	-.271	-2.172	.033
	Pro-e-shopping	55.035	39.100	.150	1.408	.163

a. Dependent Variable: DURDISC

Figure 3.8 Coefficient[a]

Duration of Subsistence Activity

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	MPLS, HOM_NET, Age, 1=at least use net once per day, Cell phone access, FASTNET, TWOPLUSV, FULLTIME[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: DURSUBST

Figure 3.9 Variables Entered/Removed

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.658[a]	.433	.380	453.1784

a. Predictors: (Constant), MPLS, HOM_NET, Age, 1=at least use net once per day, Cell phone access, FASTNET, TWOPLUSV, FULLTIME

Figure 3.10 Model Summary

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13353995	8	1669249.427	8.128	.000[a]
	Residual	17456506	85	205370.658		
	Total	30810501	93			

a. Predictors: (Constant), MPLS, HOM_NET, Age, 1=at least use net once per day, Cell phone access, FASTNET, TWOPLUSV, FULLTIME

b. Dependent Variable: DURSUBST

Figure 3.11 ANOVA[b]

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1262.787	387.218		3.261	.002
	HOM_NET	272.004	181.038	.133	1.502	.137
	Cell phone access	-248.540	111.794	-.201	-2.223	.029
	1=at least use net once per day	-199.059	133.556	-.127	-1.490	.140
	FASTNET	-289.910	119.320	-.214	-2.430	.017
	FULLTIME	684.751	132.807	.489	5.156	.000
	Age	-13.224	5.189	-.250	-2.549	.013
	TWOPLUSV	-164.653	112.204	-.139	-1.467	.146
	MPLS	-206.949	107.162	-.181	-1.931	.057

a. Dependent Variable: DURSUBST

Figure 3.12 Coefficients[a]

CHAPTER 4
Evaluation of GPS Technology as Used in Services-On-Demand Public Transit

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Introduction and Goals
This report is a study of the use of global positioning system (GPS) technology by a services-on-demand public transit system. The study operates on the premise that GPS technology is a means of making such services a plausible public transit alternative. The report involves the evaluation of a field test in partnership with the non-profit Dakota Area Resources and Transportation for Seniors (DARTS) program. DARTS is a provider of such services that has recently installed GPS technology on its fleet of passenger vehicles as a final stage of technologically upgrading its system operations. The study has used operations and financial records along with focus group interviews to ascertain the impacts of GPS in the operations of the DARTS system. DARTS is presently a system limited to senior and disabled citizens. Yet its operations today are of such sophistication that it could conceivably serve a broader clientele.

The report provides a description of the study background in terms of its premises and origins and in terms of the context of the paratransit provider (in terms of size and scale and methods of operation). Methods developed for the study area are described next, followed by a description of the analytical results. Results are presented in both qualitative fashion (deriving mainly from focus group meetings) and in quantitative fashion based on statistical analysis of operating data derived from complete trip logs and from capital and operating cost data. The implications of these results and conclusions concerning the future potential of services-on-demand for full-scale public transit service are provided.

Background

Sprawl and Congestion
In the face of mounting urban traffic congestion nationwide, and its attendant economic and environmental troubles, a major policy goal is to find ways to get people out of their cars and into public transit. The single-occupant driver of an automobile clearly enjoys significant advantages. There is scheduling at the driver's convenience, door-to-door service, and privacy. Also, there is no waiting and no need to transfer to other vehicles. Out-of-pocket costs are perceived to be low (few people factor in the capital or insurance costs). The disadvantages motorists face are the time delays from congestion, possible parking fees, or possible parking space shortage. Very few such drivers factor in the social costs and public subsidies of driving alone. Overall, then, the advantages are perceived to greatly overshadow the disadvantages. Most automobile trips involve only one person—the driver—thereby characterized as "single-occupant-vehicle" (SOV) trips. The 2000 Census indicated for the Minneapolis-Saint Paul metropolitan area that 87% of all work trips were SOV trips.

History of Van Sharing and Paratransit Services
Small-scale, door-to-door transportation services have developed throughout the country, in both urban and rural areas. In the 1970s, the U.S. Department of Housing and Urban Development (HUD) began subsidizing dial-a-ride services for inner city residents as part of their community development policies of the time. With the passage of the Americans with Disabilities Act (ADA) in 1990, dial-a-ride services expanded greatly due to the large travel demand for persons with disabilities. Today, there are many agencies providing such services, both public and private.

Paratransit services actually come closer to offering the advantages of SOV travel than do traditional bus and rail systems. Generally referred to as "services-on-demand," they include jitney, mini-bus, van, and taxi organizations. They are also referred to as "dial-a-ride" or "paratransit" services. These agencies offer 8- to 12-passenger vans or buses and are able to provide door-to-door pick up and delivery. While many of these services have traditionally been privately provided, most are publicly financed or partially subsidized. This transportation is often targeted to special populations—particularly disabled or elderly people. 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 to 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.

A basic premise of this report is that 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 American cities today have grown and 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. This report explores whether such technological enhancements can potentially greatly improve paratransit service offered to the general public, while being financially feasible.

The cost of services-on-demand can be seen to be relatively high. Private taxi services are a good benchmark for envisioning such costs. Most jitney services have public subsidies for all or a major share of the costs. Federal funding under the Americans with Disabilities Act is available for eligible disabled riders. State and local funding is also typical in financing these operations. Users unable to drive—such as the disabled or the elderly—are the primary justification for government involvement. One factor to be considered, however, is the comparison of costs and benefits of government financing of paratransit transportation systems as against the public subsidies involved in highway construction and maintenance or as involved in the provision of rail or fixed-route bus operations. This issue is beyond the present study, but the experience of the DARTS system in working with newly enhanced computer and telecommunications technology can assist as an early examination of the role of paratransit services in the total transportation alternatives in sprawling urban areas.

Can GPS technology, coupled with related communications technology, contribute to making paratransit services more available to the general public and more competitive with alternative forms of transportation? GPS technology provides a means of tracking vehicle location more precisely than any previous automatic vehicle locator technology. Since 1994, GPS increasingly has become adopted by major fixed-route bus systems throughout the United States. These include Chicago, New York, Detroit, Minneapolis-Saint Paul, Oakland, Denver, Milwaukee, Portland (Oregon), Baltimore, and Buffalo. Adoption of GPS includes a few small systems, such as Napa, California (with 18 buses). In addition, a number of cities in Canada have installed GPS technology as have cities in Europe and Asia. A recent study estimated that more than 60 bus systems in the U.S. have adopted GPS technology (U.S. DOT, 2000).

The claims for GPS technology include:

- GPS provides more effective dispatching procedures and control of vehicle operations.
- GPS, when combined with geographic information software and real-time traffic data, enables optimal vehicle route plotting given the variable conditions of weather, congestion, or construction projects.
- GPS enables significantly faster response time in cases of emergency or accident.
- GPS offers an expanded capacity to inform passengers of real-time conditions in terms of vehicle location and anticipated arrivals and departures.

In a services-on-demand jitney service, it would appear that communications with customers can be more direct, personal, accurate, and up-to-the-minute. Should there be a delay for any reason, customers could be notified immediately in their homes by telephone or e-mail messages. In short, GPS technology offers the possibility of significant improvements in operations and also in public transit services marketing efforts.

The Context of the DARTS Case Study

The present study has used the DARTS program as a preliminary testing ground for such a hypothesis. While DARTS does not have immediate plans to market its services beyond its present clientele, it does intend to enhance its capacity to improve service to eligible 24-hour and same-day callers by introducing GPS technology. In so doing, the DARTS system offers an excellent case study on the impact of GPS on service responsiveness, efficiency, cost, and safety.

DARTS is one of the larger agencies of its kind in the United States. The American Public Transit Association (APTA) reports that 5,251 agencies are providing on-demand service nationwide. The APTA also reported that 10.8 million riders were served in April 2003 by these agencies. This means a nationwide average of slightly more than 2,000 riders per agency for that month. For the same month, DARTS served more than 11,000 riders, or five-and-a-half times the national average. Overall, DARTS served about 1% of all riders of on-demand services in the United States in April 2003.

DARTS has just completed an advanced phase of a multi-year "Smart DARTS" program. This program has been conducted with assistance from the Minnesota Department of Transportation (Mn/DOT), the Metropolitan Council, and Dakota County along with the participation of several other public and private agencies. DARTS has been carrying out a field operational test of intelligent transportation system (ITS) technologies that proceeded in three phases. The first phase, completed in 1993, was a feasibility study examining the role of advanced technologies in DARTS operations. The second phase, completed in 1995, involved the installation of advanced computerized dispatching and scheduling software. This software has been at the heart of DARTS operations since 1995. In the third and final phase, DARTS has installed GPS equipment to provide automatic vehicle location (AVL) and mobile data terminals. Installation began in the summer of 2002 and became fully operational on all vehicles by April 1, 2003.

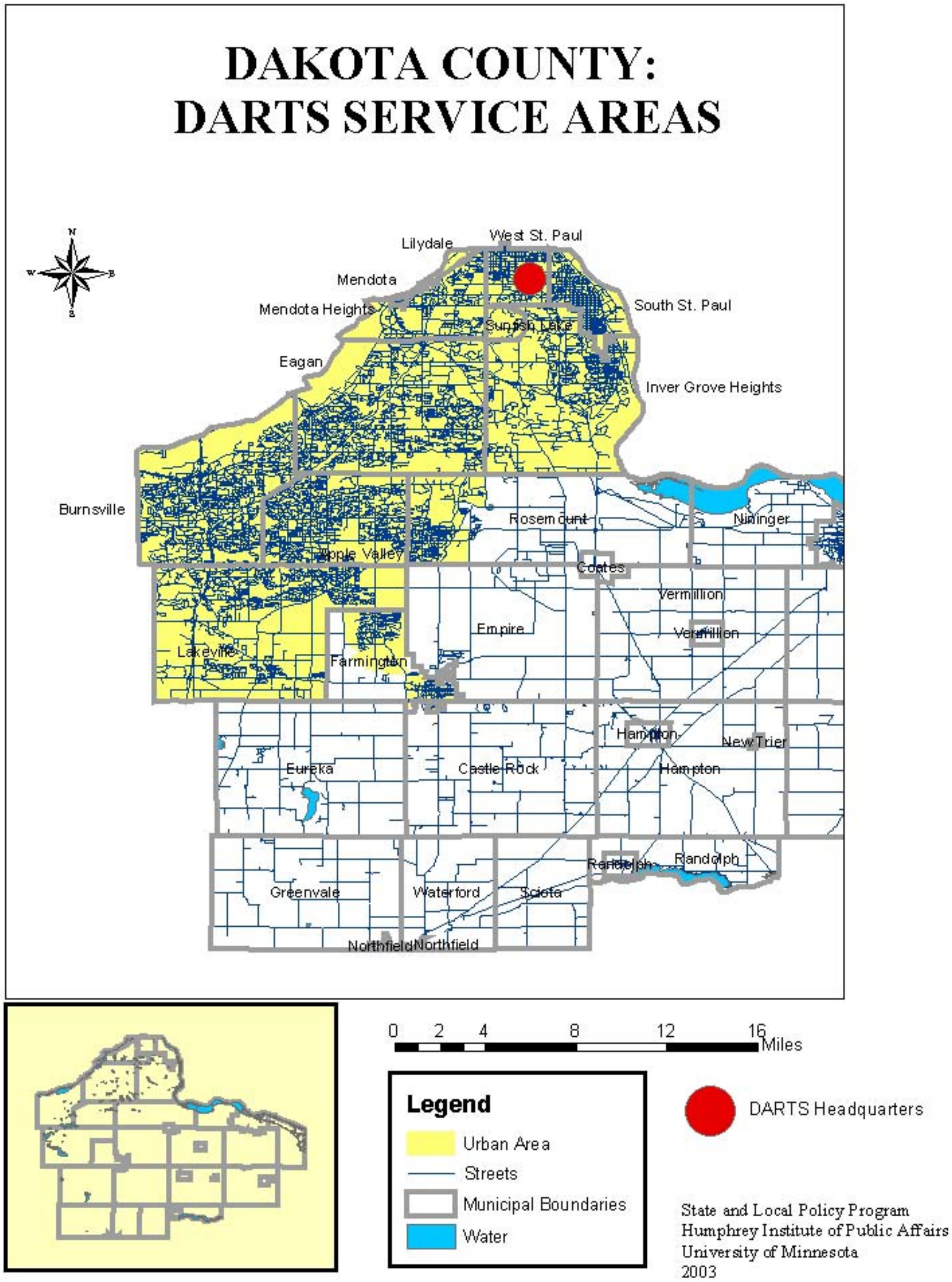


Figure 4.1 DARTS Service Area in Dakota County

DARTS, with a fleet of 34 vehicles, presently offers regular service from 8 a.m. to 4:30 p.m., Monday through Friday for persons over age 60. ADA services are from 5:30 a.m. to 11 p.m. every day, including weekends and holidays. Connections can be made with Metro Mobility, the regional provider for ADA clients needing to travel throughout the region. The system also provides for transfers to other systems operating outside of the DARTS territory. Its ridership includes standing order (or "subscription") trips and demand trips. Standing order trips are those occurring at the same time and on the same day on a reoccurring basis and that comprise no more than 50% of DARTS trips. Demand trips are those that do not reoccur on a regular basis and may be phoned in from one day to four days in advance of the trip. Same day reservations can be made depending on available capacity. Metro Transit established fares for all bus services in the entire Twin Cities region, including ADA fares. As of August 1, 2003, the fare for DARTS service is $3.00 for each one-way ride taken during peak hours (weekdays, 6 a.m. to 9 a.m. and 3 p.m. to 6:30 p.m.). The fare is $2.25 during non-peak hours.

Adopting computer-aided scheduling and dispatching in 1995, the agency hoped to develop an enhanced capacity to accommodate 24-hour and same-day trip requests. Much of the handwork involved in scheduling was eliminated. The software, using triangulation algorithms, produces schedules more rapidly and considerably improved over those produced manually. This has allowed more trips to be served within the same revenue vehicle miles/hours (or an equivalent number of trips can be served with fewer revenue vehicle miles/hours).

The latest phase of the "Smart DARTS" program involved the installation of GPS satellite technology. After many technical delays, all buses were equipped with the GPS receiver as part of an on-board mobile data computer (MDC) by April 1, 2003.

Presently, DARTS has a completely automated system for fulfilling ride requests. When a call comes in, the ride is entered into the system. The request is routed to an SQL server that assigns the trip to a particular bus. This information is routed to a mobile data terminal (MDT) server that formats the data to an X-gate server that transmits the data over a wireless frame relay system to the on-board computer on the bus.

Currently, to handle same-day requests, the dispatcher verbally communicates with available drivers to decide whether or not the request can be filled. The new MDC technology lets the dispatcher know whether or not it may be possible to fill the request, but dispatchers still confirm verbally with the driver, since the driver may feel it is not possible to fill the request despite the information from the MDC. In addition, occasionally the MDC does not work properly, which then also requires verbal communications with the driver. Consequently, at the time of this report, the process for scheduling same-day rides has been changed only to a limited degree by the GPS technology with continued back-up reliance on pre-GPS procedures.

For rides with at least 24-hour notice, the software now allows real-time reporting of pick-up and drop-off, which allows the dispatcher to either reschedule or notify waiting riders when a bus is running late or ahead of schedule. This has been a significant and positive change. The technology also provides information about the current location of a bus, its direction of travel, and average speed. This information has not as yet been used to change the dispatchers' work.

The technology has not changed the process of rescheduling trips when a bus breaks down, as capacity limits come into play.

The technology has the potential to eliminate the printed schedules that show all rides except for same-day rides, but drivers are not yet comfortable with that idea. Dead spots do exist, which can cause the on-board MDC units to fail. Drivers often call to confirm changes, especially cancellations, as they do not yet fully trust the on-board MDC unit to accurately inform them of changes (see information from the drivers' focus group beginning on page 105).

Staff reported that each driver received at least 30 minutes of individual training (in-house); some drivers required more training. From the drivers' focus group, there was some indication that some drivers received considerably less training. Drivers are supposed to record mileage on the MDC, but they sometimes do so incorrectly (skipping a digit or two) resulting in bad data. However, pick-up and drop-off data is recorded.

As the operational data reported on the following pages attests, the monthly call load is roughly 10,000 requests. While this is not a problem for the present dispatcher staff level, the number of drivers and buses available to fill the requests could restrict further growth. Drivers and buses usually fill about 600 rides per day. DARTS staff feels that the software could enable them to handle a significant increase in calls, but more dispatchers, customer service employees, drivers, and buses would be needed to fulfill the additional requests

Table 4.1 provides the complete cost breakdown of the GPS installation project. Total installation costs amounted to $464,254 or about $13,650 per vehicle. As Table 4.1 also indicates, there will be annual operating costs of $64,000 or just over $1,880 per vehicle. Installation costs annualized amounted to approximately $4.30 per rider served, whereas projected annual costs will run about 60¢ per rider served.

Method

Two principle methods of data collection were employed to examine the potential for GPS technology to offer an opportunity for on-demand services to play a wider role in the array of public transit choices. The first method involved convening focus groups of a variety of participants having some particular knowledge to bring to bear on the question. The second method was to assemble before- and after-GPS installation data from DARTS trip and financial logs.

Project Costs		Installation Budget	Annual Operating	Installation Cost per Vehicle	Annual Operating
3.2	AVL Application License—Trapeze	$ 32,300		950.00	
	GPS Option - MDC	$ 12,512		368.00	
3.3	XGate Interface Module	$ 8,500		250.00	
	Software Maintenance Support	$ 5,995		176.32	
	Desktop Training Mounts	$ 90		2.65	
	Mobile Data Computer (MDC)	$ 43,860		1,290.00	
	MDC Mounts	$ 2,890		85.00	
	MDC Cable Install Assembly	$ 2,448		72.00	
	Odometer Monitoring	$ 4,930		145.00	
	Trapeze Installation	$ 1,000		29.41	
	Mentor Installation	$ 22,040		648.24	
	Vehicle Installations	$ 11,050		325.00	
	Trapeze Travel Costs	$ 6,950		204.41	
	Mentor Travel Costs	$ 8,700		255.88	
	Shipping Costs	$ 500		14.71	
	SUBTOTAL	***$ 163,765***		***4,094.13***	
4.1	Frame Relay Installation	$ 725		21.32	
	AT&T Host Connection Fee	$ 125		3.68	
	Cisco Router & DSU	$ 3,800		111.76	
	Vehicle CDPD Modem & Antenna	$ 19,652		578.00	
	MDC IP Activation Fee	$ 1,530	$ 630	45.00	18.53
	Fame Relay		$ 4,188		123.18
	SUBTOTAL	***$ 25,832***	***$ 4,818***	***645.80***	141.71
4.4	Training—Trapeze	$ 17,280		508.24	
	Training—Mentor	$ 3,800		111.76	
	Documentation	$ 950		27.94	
	SUBTOTAL	***$ 22,030***		***550.75***	
5.1	SQL Server	$ 6,579		193.50	
	Scheduling Server	$ 4,134		121.59	
	MDC Interface Dedicated PC	$ 2,031		59.74	
	XGate Dedicated PC	$ 2,080		61.18	
	Dispatch PC	$ 2,144		63.06	
	Training MDC	$ 1,390		40.88	
	MDC Training & Interface PC	$ 1,490		43.82	
	Switchview Monitor Connector	$ 517		15.21	
	Airtime—AT&T CDPD		$ 18,816		553.41
	Server & Network Integration	$ 5,755		169.26	
5.2	DARTS In-Kind Support Transit	$ 9,920	$ 12,896	291.76	379.29
5.2	DARTS In-Kind Support IT	$ 4,960		145.88	
	SUBTOTAL	***$ 41,000***	***$ 31,712***	***1,025.00***	***932.71***
	TOTAL PROJECT COSTS	**$ 464,254**	**$ 36,530**	6,315.68	1,074.41
	Depreciation		**$ 21,559**		634.09
	Annual Support & License Fee		**$ 6,000**		176.47
	TOTAL ANNUAL COSTS		**$ 64,089**		**1,884.97**

Table 4.1 Smart DARTS Phase III Budget for GPS Installation

Focus Groups
Focus groups were seen as an important part of analyzing the potential of paratransit services. Four such groups were conducted: 1) a random group of SOV commuters from Dakota County; 2) a sample of DARTS drivers; 3) a sample group of DARTS users; and 4) a group of public transit providers operating in the Twin Cities metropolitan area.

The first focus group was a random group of respondents chosen because they represented SOV drivers. The sample was taken following these procedures. Participants were identified from the DARTS primary service area (Apple Valley, Lakeville, Farmington, Rosemount, Eagan, South St. Paul, Inver Grove Heights, etc.). From the White Pages directory, telephone calls were made to a random selection of 160 households. A phone interview was conducted to screen for SOV commuters between 25 and 65. From this, an invitation was extended to participate in the focus group session for a discussion on the issues of their commuting experience as well as their understanding of congestion issues and innovative transportation proposals. The meeting was held at the Burnsville Transit Hub, a location most central to the invited participants. Each participant was provided a department store gift certificate.

The second focus group was held with the participation of DARTS Drivers. DARTS management chose the participants, and the meeting was held in the Community Center housing the DARTS offices.

The third focus group involved the participation of DARTS customers—persons who regularly used DARTS services. Again, DARTS management chose the participants, and the meeting was held in the Community Center housing the DARTS offices.

The fourth focus group was held with transit planners and providers in the Twin Cities area. The purpose was to learn of the participants' reactions to the study results and to garner expert opinion on the future of service-on-demand systems for general public transit in low-density suburban areas.

Meetings were also held with DARTS staff members including dispatchers, call monitors, and technical support staff.

Analysis of Pre-GPS and Post-GPS Operations in the DARTS System
The study involved analysis of a base-line of operations for two periods of time. The most current time period was a five-month period extending from April 1, 2003 to August 31, 2003. April 1, 2003, was the date that the GPS installation was fully operational for all DARTS vehicles. The cut-off date was primarily limited by project budget and schedule. A comparable period in the previous year—April through August of 2002—was studied for before-and-after comparisons. This provided operational and cost data for two years during the same time period so that weather and other conditions affecting system operations were as near to identical as possible. Variables analyzed included:

- Changes in responsiveness to customer needs, with particular focus on same-day and 24-hour trip requests. From DARTS logs, trip accommodations and trip denials were recorded for both pre-GPS (2002) and post-GPS (2003) operations.

- Changes in real-time responsiveness through analyzing proposed pick-up times as against actual pick-up times.
- Changes in dispatching procedures and control of vehicle operations.
- Changes in operational safety.
- Changes in trip costs on both a marginal and average cost basis.
- Training and implementation costs and issues.

Beyond the before-and-after results analysis, the implications of such issues as size and scale of operations as well as subsidy levels necessary in comparison with subsidies provided for fixed-route transit systems are discussed below.

Results

The results section is divided into two parts. The first part provides the results of the focus groups. The second part provides the results of the quantitative analysis of system operations before and after GPS installation.

Focus Group Results

<u>Summary of General Public Focus Group</u>

The general public focus group was held on the evening of April 24, 2003, at the Minnesota Valley Transit Authority (MVTA) Burnsville Transit Station. This focus group consisted of persons chosen via a random telephone interview after it was ascertained that they were: 1) employed adults, 2) residents of Dakota County, 3) usually commuted to work by automobile, and 4) usually drove alone. On the basis of nearly 200 telephone calls, a panel of eight volunteers made up the focus group. They were spread out geographically representing six municipalities: two from Rosemount, two from Hastings, and one each from West Saint Paul, Apple Valley, Lakeville, and Burnsville. All participants signed the consent forms before discussion began.

Conversation began with a brief introduction to the project background. The difficulties caused by urban sprawl leads to the question of how to design a public transportation system that serves people in such spread out areas; that is, that can serve people whose primary travel is from suburb to suburb. It was explained that the study's objective is to examine the feasibility of on-demand public transit services, such as dial-a-ride, jitney, and door-to-door service, in serving the suburban areas. In particular, it was explained that the study was to examine how new technology (GPS) can help improve service responsiveness to a significant level.

The session began with introductions and each participant describing the nature of his or her commute to work. Trips involved Apple Valley to downtown Saint Paul, Burnsville to downtown Minneapolis, Hastings to Rosemount, and Rosemount to the Minneapolis-St. Paul International Airport. Travel distances were as short as four miles and as far as 16 miles. Travel times ranged from three minutes to nearly 60 minutes. Two panelists acknowledged that they occasionally rode the bus, but for the most part they drove alone to work. Two people indicated that they pay for parking at work, and the rest indicated that they have free parking. All except the two participants who commute to downtown indicated that parking was not a problem. All participants indicated they owned more than one car. Three of the seven stated that they owned more than two cars. The usual reason was that other members of the household also needed a car. Two panelists were eligible to use rides from DARTS but seldom did.

Panelists seemed reasonably well informed about the region's transportation problems. All but two indicated some difficulties in terms of congestion. One respondent formerly worked a longer distance from home but worked in off-peak hours. She now commutes during peak hours and finds that she needs to plan almost an hour to travel a shorter distance.

When asked about ideas about how to solve the congestion problem, the participants had many ideas:

- Build more lanes as the population goes up and traffic gets worse.
- Companies should shift their schedules and allow flexible working time.
- Improve bus transportation—many places actually don't have transit. People might be willing to use transit, but they have no choice because transit services are unavailable.
- Rapid transit system:
    - Run the system into the neighborhoods. Each neighborhood could be a "depot."
    - Limit stops in the main portion, making it fast.
- The major issue of bus is that buses suffer the same traffic problems as private automobiles (e.g., accidents and congestion). As long as buses share lanes with cars, buses offer no advantage. Exclusive bus lanes free of traffic might work. High-occupancy vehicle (HOV) lanes are important.
- Technology will help solve some problems, but it's a social engineering problem, and we have to change how our society uses transportation.
- Used to take bus, because it is painful to drive to St. Paul. After the freeway was constructed, it became easier to drive, so now I prefer driving to taking the bus. If you increase the pain threshold for driving, I'll take the bus. We might be better off without freeways."

Responses to questions about services-on-demand, the following summarizes panelists' responses:

Would you use such services as dial-a-ride or jitney service if they offer on-demand, door-to-door service? (Could that be a substitute for private car?)

- "Wouldn't for me but would be suitable for somebody."
- "If the services operate seven days a week, it might work, since parking in downtown is hard."

- “If traffic gets worse and parking became impossible, I would take advantage of that service too.”

How could DARTS services be expanded to serve the general public (more than the disabled and elderly)?

- “It would need marketing and advertising.”
- “One-week advance notice won’t work.”
- “An important thing is to get money paid up front (e.g., punch card or smart card), which might encourage more uses of the service. Other suggestions include: 1) using transponder for collecting fares and avoid the need to slide a card; 2) using ‘security card’ or a system where riders do not have to take out and use a card to pay.”
- “Install transponders at various locations so that people can push a button to order the service as needed.”
- “The idea of responsiveness is very important.”

What would you think would be the costs? How much (what’s the range of the price) would you be willing to pay to use an on-demand transit service?

- “It depends: if the service is reliable enough, I will use it and be willing to pay. Reliability matters.”
- “Communication is important for maintaining service quality and reliability. E.g., even if there has to be a delay, these delays should be notified.”
- “For persons who don’t pay for parking, it would be a marginal benefit. But it’s convenient to have such service anyway.”

How comfortable would you feel about sharing daily routine rides with other people in one-on-demand service vehicle?

- “Can understand sharing is necessary to improve cost efficiency.”
- “Most people won’t have problems with it unless those who have some negative experiences about sharing.”

Would you think people would be willing to pay taxes to reduce the bus fare?

- “The first step is to convince people to use it; then people will be willing to be taxed for it.”
- “Sell it first, and then people will be willing to pay for it.”
- “Convenience matters (even more than money): you have to prove that the service is better than what people have now; then people will use it.”
- “In other areas, there are services that are convenient, simple, clean, and thus desirable.” (E.g., Washington D.C. metro system and some systems in European countries)

Discussion focused on why European countries have higher transit patronage. The panel came up with the following reasons:

- Everyone who drives is taxed higher than the U.S.
- In Germany (Japan too), gas is highly taxed.

Regarding the light-rail transit (LRT) system now under construction, if the service is proposed only in one place, people won’t buy it. But if people see it as a network (a comprehensive plan), people will be more willing to buy it. They did a very good job selling the idea of an LRT system, but they did not point to the idea that this is the first piece of a comprehensive plan. The panelists seemed to agree that it's going to take a mixture of all the different services to achieve a truly good public transportation system, because the different types of services are complementary (instead of substitutes for one another) and are important for meeting personalized transportation needs. One person noted: "I just cannot imagine the whole thing would work out with just one concept."

This panel provided a very good discussion. Those present seemed to be representative of the wide variety of SOV commuters. They were only mildly enthusiastic about dial-a-ride services, some indicating that it would not likely stop them from using their own car. Others were cautiously receptive and spelled out the key conditions for success—reliability, safety, and good marketing.

<u>DARTS Users Focus Group</u>

This meeting was held on September 8, 2003, in the DARTS West St. Paul office. The panel consisted of 10 DARTS users (three male, seven female, seven disabled). All participants signed the required consent forms. The meeting began with a short overview of the project. Participants were informed that the project was being carried out from the perspective that development pattern of the Twin Cities metropolitan area is sprawl, suggesting that operations like DARTS could actually serve a broader market involving people who work, live, and shop and meet other transportation needs wholly in the suburbs.

There were early moments of misunderstanding of the study purpose. A few panelists misinterpreted the study purpose and expressed strong opposition to the idea that DARTS serve the general public. They feared that this would mean a loss of its crucial personal service. Fear was expressed of DARTS turning "private" and existing characteristics of intimate, personally-tailored service would fade. There was also fear of DARTS turning into a big bureaucracy thereby losing its human touch. Some participants attending helped clarify that the study purpose is not to change DARTS in any way but, rather, to learn from DARTS and perhaps apply the lesson learned to the creation of other transit systems. Fears were somewhat allayed, but the users made it clear that DARTS service is superior to other systems in many ways, and its operations should be learned and perhaps transferred to other systems.

Participants were asked what they liked about DARTS services. There seemed universal agreement that DARTS services were of very high quality. In the words of one participant: "One thing that I can say about DARTS is that it enhances my life. Sometimes I got very upset and really crying. The drivers will come and get me and talk to me and calm me down. I do call them when I get upset, and they come and get me out of the situation that I cannot handle. I think they really treat people well. I like the way they have set up the four-day notice (their standard service), because otherwise the dispatcher will have a difficult time (in scheduling trips). Some times you can get the same day-rides. That is nice because you might have not prepared something ahead of time."

Another participant used DARTS for work before retiring. Since then, the participant continues to use DARTS noting that since she did not have a car, she depends heavily on DARTS. Another noted that, due to failing eyesight, he is highly dependent on DARTS. “DARTS (staff) are so good at these things. They are wonderful people.”

Participants provided other stories regarding how DARTS helps not only with transportation needs, but also other services. There was generally praise for DARTS accompanied by criticism of Metro Mobility, noting that Metro Mobility is a big bureaucracy. Participants told of DARTS links to Metro Mobility and other providers, noting that the others were not as reliable or helpful as DARTS. Most of the participants have used DARTS services for many years. Many comments were made about the helpfulness and courtesy of DARTS drivers, with some slight bantering about which driver was the best. As one participant put it: “In the three years [going to] work …I have never ever had a driver who is not friendly, happy, and funny. I was escorting a blind lady on a weekly basis. The driver will escort the lady into the entrance and make sure she is in the building. I don’t care what [other] company you called, they are not going to do that.” A disabled participant noted that public bus systems are very hard to manage, and that the nearest bus stop is blocks away. The participant was grateful for the door-to-door service.

Problems with DARTS service seemed mostly related to recent budget cuts for metropolitan ADA services. DARTS has had to reduce their service area for weekend service (normally only available to ADA-qualified recipients). One participant expressed the desire for same-day rides, seemingly unaware that those were available. Others, however, noted that it had seemed easier to get same-day rides in the past few months.

One participant did express the hope to see DARTS grow and serve other people. He indicated: “[When] I started to ride, I found out that it is a really good system, which should be expanded to other people who are in a condition that they cannot do things or are in areas (from which they) cannot get to places…I would love to see it grow in other venues in this region and make it a better place.”

When asked in what ways DARTS could improve, one of the first answers was to expand same-day service. One person noted the need to address different priorities. Sometimes, there are problems with timeliness when a driver has to pick up many people for the same trip: “If one driver is picking up five people, obviously the fifth person is not going to be picked up at 9:10 as they are supposed to, because it just doesn’t work that way.”

When asked if they had seen any changes in the last year—in particular with respect to new technologies installed back in April—one respondent noted: “Who cares if it takes 10 computers…as long as they come and get us who cares.”

Participants seemed to understand that new equipment had been installed and that DARTS would be better able to keep track of the buses and their schedules. There was a comment that it took a while for some of the drivers to learn how “to punch the buttons.” When asked if it has been easier to get same-day rides, there seemed to be general agreement that it was easier.

Almost all of the participants in the focus group interview had some form of disability. There was little question that the group had a high level of dependency on DARTS—its services are a virtual life-blood for these people, allowing them to lead as normal a life as possible. Other paratransit providers are also available in the county and metropolitan area, yet the participants were overwhelmingly favorable as to the quality of DARTS service.

From the perspective of our study, the major conclusion is that a well-managed service-on-demand system with up-to-date technology in the scheduling and dispatch functions can provide quality service to people with limited transportation alternatives. It is not clear from this panel that the introduction of GPS technology has made significant difference where the quality of service was already high. While some on the panel were strongly opposed to any change in the present service, others did express the view that such a service should be available to others in the community. From this panel, one can tentatively conclude the present size and geographic scale of the DARTS system successfully meets the needs of its present clientele.

Darts Driver Focus Group

This meeting was held on June 24, 2003, in the DARTS West St. Paul office. The group consisted of eight DARTS drivers (seven male, one female). All signed the consent form before the discussion began. One of the eight was a relative newcomer to driving for DARTS, but the rest were all veteran drivers with one reporting more than 20 years of service. DARTS management selected the participants. Drivers had been using the new GPA and MDC equipment for about two-and-a-half months at the time of the meeting.

Conversation started with a brief introduction to the project background. It was explained that the study was to examine the feasibility of on-demand public transit services, such as dial-a-ride, jitney, and door-to-door service, in serving suburban areas. In particular, the study was to examine how new technology (GPS) could help improve the on-demand transit service responsiveness to a significant level. Operations like DARTS could actually serve a broader market that involved people in the suburbs who work, live, shop, and run other errands in the suburbs.

As drivers introduced themselves around the room, each not only described his or her length of service and operating hours, but also offered opinions on the new GPS equipment. One driver, who has served for more than six years, drives in the evening from 1:30 p.m. to 10 p.m. or 11 p.m. depending on the rides. He offered these opinions on the newly installed GPS system:

- It's positive for driving, but has some negative impacts for the scheduling. For example, in the computer, you'll have double or sometimes triple pick-up times. And there will be a subset underneath saying the actual time. With a subset you have a more definite pick-up time. But with the computer that it's (the actual time) coming from, the computer was notoriously short on time. I don't know why, but it's been historically that way.
- Personally I think this is a great idea, but historically, I think you're going to have to upgrade the technology, because it's the mistakes in it that creates errors, the difference between the times. Also, I have had my screen go blank. And it went blank at exact the same spot twice (Robert street and 494). There is a high voltage electric line right by there, and I assumed that when you drive along electric lines, the data transmission is affected.
- Another problem is about cancels. I got cancels I didn't get till 6 .m. and they were made in the afternoon. When I pressed the "arrive" button, all my rides get wiped out, one new ride pops up, and all the rides get canceled during the day. That happened to me twice

during the last 60 days. The best communication that DARTS has is still the radio between the drivers and the dispatchers.
- Sometimes there is not enough time between rides.
- (To realize your idea), it's going to take a lot of planning. The biggest problems are where you are going, why you're going, and would that be drivable. The key is not GPS, it's the bus and the drivers.

Another driver is a retired air traffic controller who now drives from 5:30 a.m. to 4 p.m., four days a week. His comments included:
- I like the new GPS system very much; it cuts down my voice time on the radio a lot.
- I do have some problems, though not very often. When I get a cancellation…I went to pick somebody up and got cancelled at the door. I couldn't cancel the trip on the machine and had to call. To me, that's not very good.

A third driver has served for 10 years and works from 9:30 a.m. to 6 p.m. He commented:
- I like it. The GPS system saves waiting times since it provides real-time information.
- The system keeps it clear where we are and clears up confusion with the dispatcher. That is a helpful point.
- It has gone down for couple of times, but otherwise the system is worthwhile mostly.

A fourth driver has worked more than three years for DARTS and drives from 9:30 a.m. to 5:30 p.m. The main comment was:
- Would like to be able to read the screen better. Currently the screen is very difficult to read sometimes, especially when the sun is shining. Should have better contrast behind it.

One driver has worked 21 years for DARTS. She noted:
- The GPS monitor is too small and should have a map on it.
- I like the part that we don't have to use radio as much, but we still have to go back to paper schedule a lot of times.
- There is no return time shown on the screen (you have to push three buttons to find out).
- No return driver information is provided, even though the customers often request this.
- You have to look at both the GPS system and the paper to get all the information you need. You have to go between one another, which is sometimes tedious.

Another driver, with nearly 22 years of service, noted:
- I found the addresses are sometimes wrong in the GPS system; I'd like to drive with a cell phone.
- There'll just be a few problems, like cancels appearing without your acceptance.
- Sometimes, I looked at the screen, didn't accept anything else, but the information is completely different; or sometimes the computer shuts off and comes back, but the ride information is all gone.
- The GPS screen doesn't give you enough information. Neither does the paper.
- Should have a map in the system.

A newer driver works for DARTS on evening and weekend shifts:

- I noticed that there are differences between the odometer mileage and that in the MDC (mobile data computer) system. From my experience, the MDC is about 10 to 15 miles off.
- I like the system. At first I was opposed to it because the service was always cut out and we have a lot of service problems. I didn't think worth the $10,000 paid for it, but now it's pretty good.

A final driver, with nearly 19 years of service, noted:

- Not a great enhancement. There are a number of pieces of information that we need to have but are not able to get from the GPS system.
- Additionally, you cannot turn down the "adds," that is, you have to accept new trips once they are sent to you.

In your view, was the training program adequate so that you felt confident using the equipment?

- The training lasted about 5 minutes.
- I never had it.
- It's a crash course.
- If you miss something, you can figure it out. But on the other hand, it's really simple. You don't need too much training.
- The training wasn't uniform for every driver. Not everybody got (training) or received the same amount of training.
- I was one of the initial trainees—the vendor rode around with me for about an hour. (This was during the pilot period in the summer of 2002 involving five buses.)

Does bad weather impact the system?

- No, I can say that weather doesn't affect driving at all.
- Sometimes the whole system is out.
- Driving around with the computer is just not working.
- My general feeling is I won't go without a paper copy of what I'm going to do.
- I still get return time on the paper only (no matter what the weather it is).

Do you think there is a better impact on the quality of service to your clients? Do you think it serves passengers or customers better now?

- I don't know, I think dispatchers will have a better idea of that, including the "adds," how that works out.
- Yes, because now the dispatcher doesn't have to call to cancel a trip—it goes directly into the system. It's easier for them.
- My understanding is that there are four or five people who can access the system. In one case, somebody sent through a cancellation for a trip that was actually not cancelled by the client.
- There have been discrepancies between the information the driver got in the bus and the information in the dispatch office. You just have to double check to make sure the information is correct.

- I sometimes think that (the problem) is because too many people are involved in the same situation, so things can get messed up. I don't know if the computer doesn't cooperate with the people who input the information.
- It think it works better than I thought.
- It's actually seems to be working better all the time.

How many passengers do you have for a typical trip?
- One or two at a time except for big groups. (The vehicle capacity is 12 passengers)
- It depends on the area you are driving in.
- It also depends on how many trips you are taking and how long the trips are.

Do you ever receive adds? Do same-day rides create problems for you?
- I don't know. They (dispatchers) just squeeze adds in. We can only accept adds.
- Every add I have works fine with me. I believe the computer works better than we can in this.
- When they (dispatchers) do give "adds," how much geographic knowledge of the area does the dispatcher give you in the "add," and what's the geographic information knowledge of the driver who accepts the "add." The important thing is whether or not you have a good fit. You cannot accommodate the "adds" if you don't have enough geographic information. The MDC doesn't provide you with the driving information; otherwise, it might provide the drivers with more geographic knowledge than they now have.
- (With GPS system) the only thing you have is a monitor with pick-up time and address in it. Before we had to write the times on, it's a lot easier to use a paper schedule.
- For "adds," you know where to pick up the riders but you don't know the destination until you "accept" the "adds."

If DARTS would expand their service to the general public and operate the system as general public transit service, what would you think would happen?
- Need a lot more buses.
- Have to establish some ground for that.
- You have to be flexible in terms of the requirements on trip purpose.
- You have to be ADA-certified to use the service. The service is highly subsidized, if you open the service to more people, it'll take away the funding for the elderly and disabled and we'd have to charge people a lot more.
- Combined regular bus and on-demand transit service could be something that would work.

How are fares collected?
- Some of the trips are billed through mail (regular rides).
- Drivers also collect fares with a fare box. They don't provide change.
- Fares are also paid via Metro Mobility coupons.

Has GPS done anything to help you avoid areas with high traffic congestion?
- No.

- It might work, if there was a map on it. (But the map will show only the main routes; they're where the roads are congested).

Do you have a proposed solution for any of the problems using GPS that we discussed today?
- Add map to the system.
- Upgrade the system.
- Better technology.
- More training not just with drivers' part, but also with the dispatch office.
- We need to have all the information we need available on the screen. Will be nice to be able to see this information with your sunglasses on.

Has this system been distracting, or created other problems?
- When it beeps, it draws your eyes off the road.
- Not really—it bounces too much when the bus is moving, so you don't try to read it then.
- We would glance at the paper schedule while driving too, so this isn't that different.

In many respects, this was the most useful of the focus group discussions held. There were clearly mixed reviews from the end-users of the new GPS system. Some of the problems discussed were confirmed in conversations with dispatchers. There would seem to be the expected "bugs" that seem to be endemic of any new technology, but overall the drivers' perspective of the new equipment was positive. They liked it, but they still needed the reassurance of a back-up facility when things didn't work as expected. Thus, former practices are still in place—particularly the ability for voice communication and reliance on paper schedules—and these help maintain a smooth effective operation.

The issue of driver training did not seem to be taken too seriously. Most felt the equipment was easy to use such that extensive training was not necessary. Yet it would appear that mistakes were occurring where more training might have prevented them. Examination of the training manual suggests that more than a few minutes of explanation are necessary.

The issue of "dead spots" is of interest. The reliability of satellite technology has usually been found to be quite high. It is known that tall buildings and heavy tree canopy can interfere with the operation of a GPS receiver; the experience at DARTS suggests that other factors may also interfere with reliability (e.g., high voltage power lines). This does not appear to pose a significant problem in the DARTS experience, however.

Operational Quantitative Analysis Results
The quantitative analysis rests on the operational and financial logs provided by DARTS. The aggregate characteristics of DARTS operations can be seen in Table 4.2 on the next page. Overall, almost 48,000 trips were requested in the April to August period of 2002, and 99.7% of those requests were honored. In the same months of 2003, trip requests grew by almost 5% over the previous year, and 98.6% of those requests were met. Although very few requests for trips are denied, there are a number of reasons why this may occur. In a few instances, riders were not eligible to use DARTS services (i.e., were not disabled and were not age 60 or more). Usually, however, denials were based on capacity problems arising from buses being perceived as not available. Thus, the vast majority of trip denials are "same-day" trip requests with a much

smaller number associated with 24-hour requests. There are discrepancies in the trip denial data, which DARTS personnel were not able to explain except that there was more discipline in recording denials introduced in 2003 thus accounting for the significant increase in denials in 2003.

Trip Denials as a Measure of Responsiveness

Examination of Table 4.2 indicates that "same-day" trip requests were denied at a lower rate in 2003 than in 2002. Averaging the two five-month periods, twenty-two percent of same-day requests were denied in 2002, while on average only 15% were denied in 2003. Moreover, in 2003, the rate of denials generally improved from month to month suggesting increasing familiarity with the GPS equipment. It should be noted, however, that improvements were happening as request volumes were declining for the summer months (in addition, a fare increase took effect on August 1, 2003).

In 2003, denial of trip requests with 24-hour advance notice tended to be somewhat less than denials of same-day requests. However, over the five-month study period, the proportion of same-day denials declined to the extent that they were virtually equal to that of the 24-hour requests for the month of August 2003 (see Figure 4.2).

TOTAL REQUESTS		
	Year	
Month	2002	2003
April	10,207	11,358
May	10,163	10,375
June	8,772	9,987
July	9,671	10,091
August	9,126	8,396
5 mo TOTAL	47,939	50,207

TRIP DENIALS BY MONTH		
	Year	
Month	2002	2003
April	45	241
May	27	104
June	30	117
July	55	126
August	47	106
5 mo TOTAL	204	694

ALL DENIALS AS % OF TOTAL REQUESTS		
	Year	
Month	2002	2003
April	0.4%	2.1%
May	0.3%	1.0%
June	0.3%	1.2%
July	0.6%	1.2%
August	0.5%	1.3%
5 mo TOTAL	0.4%	1.4%

SAME-DAY RIDE REQUESTS		
	Year	
Month	2002	2003
April	151	144
May	151	166
June	174	125
July	225	192
August	175	157
5 mo TOTAL	876	784

SAME-DAY DENIALS		
	Year	
Month	2002	2003
April	43	27
May	22	29
June	30	19
July	55	32
August	45	11
5 mo TOTAL	195	118

SAME-DAY DENIALS AS % OF SAME-DAY REQUESTS		
	Year	
Month	2002	2003
April	28.5%	18.8%
May	14.6%	17.5%
June	17.2%	15.2%
July	24.4%	16.7%
August	25.7%	7.0%
5 mo TOTAL	22.3%	15.1%

24-HOUR TRIP REQUESTS		
	Year	
Month	2002	2003
April	420	500
May	542	458
June	484	394
July	562	413
August	429	260
5 mo TOTAL	2437	2025

24-HOUR TRIP DENIALS		
	Year	
Month	2002	2003
April	2	60
May	0	18
June	0	18
July	0	26
August	0	18
5 mo TOTAL	2	140

24-HOUR TRIP DENIALS AS % 24- HOUR REQUESTS		
	Year	
Month	2002	2003
April	0.5%	12.0%
May	0.0%	3.9%
June	0.0%	4.6%
July	0.0%	6.3%
August	0.0%	6.9%
5 mo TOTAL	0.1%	6.9%

ALL TRIPS MET		
	Year	
Month	2002	2003
April	10,162	11,117
May	10,136	10,271
June	8,742	9,870
July	9,616	9,965
August	9,079	8,290
5 mo TOTAL	47735	49513

Table 4.2 DARTS Overall Demand and Supply Characteristics by Month

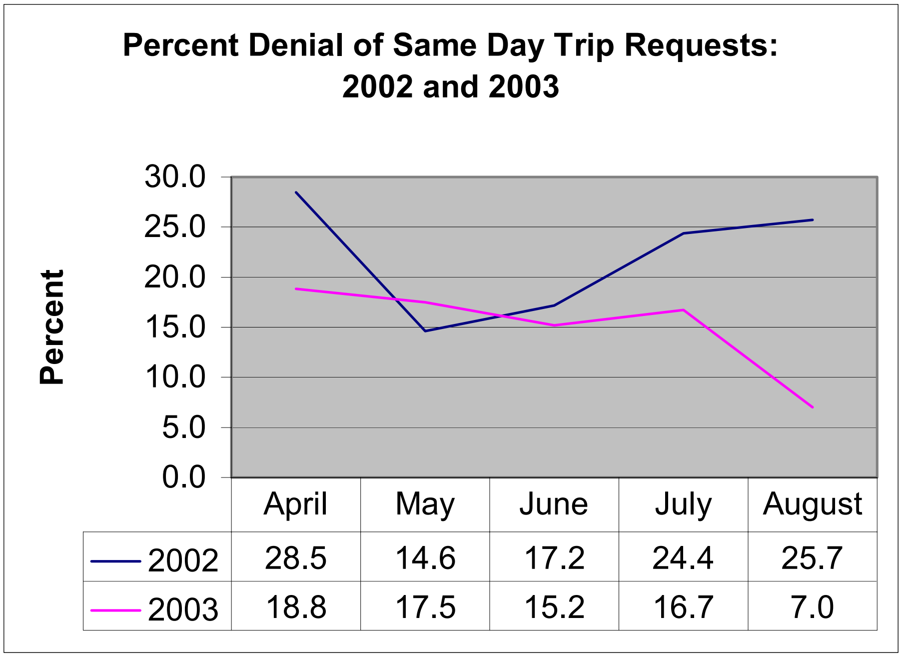


Figure 4.2 Percent Denial of Same-Day Trip Requests: 2003 and 2003

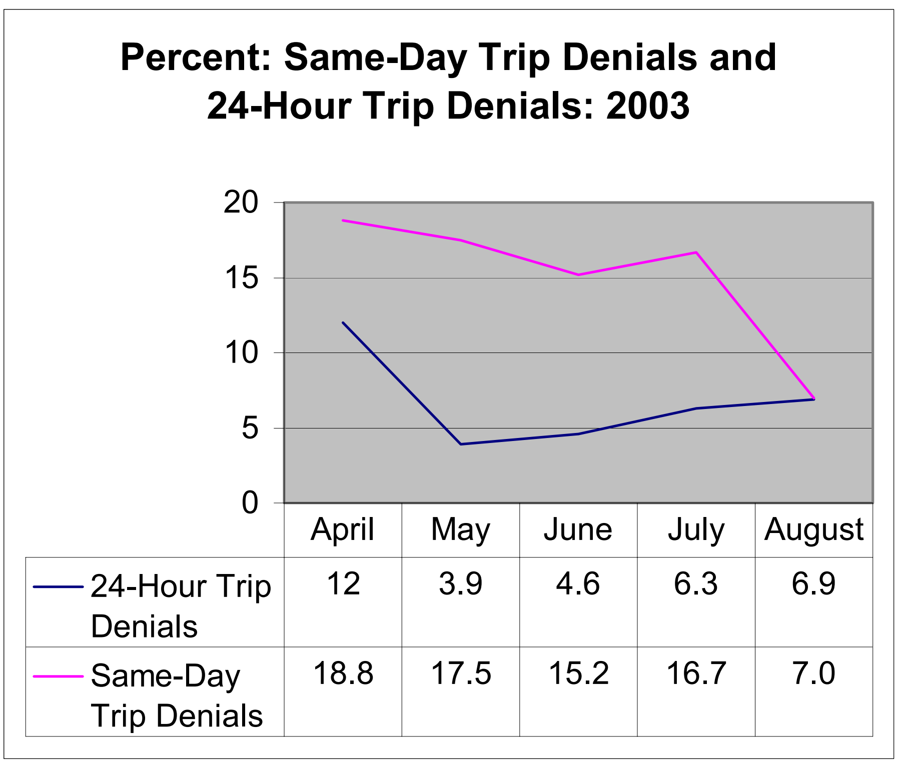


Figure 4.3 Percent Same-Day Trip Denials and 24-Hour Trip Denials: 2003

Thus, in August, with 157 same-day requests telephoned in, only 11 were denied. This reflects improvement both over previous months in 2003 as well as every month of 2002. A paired sample t-test of same-day trip denials yielded p= 0.086. This suggests a difference of some significance, despite being above the standard threshold of p = 0.05.

More detailed results are presented in the following sections where the breakdown of trip purposes, day-of-the-week, peak- and non peak-hour operations, and trip length are provided. Also analyzed are any gaps between scheduled times for pickup and actual times. These help understand system responsiveness in light of the logistical problems involved; particularly some of the problems that might arise for 1) particular trip purposes, 2) volume of requests during hours of peak demand, and 3) capacity stresses due to demands for longer, more time consuming trips.

Detailed Analysis of Same-Day and 24-Hour Request Responsiveness

For the purposes of the study, responsiveness is defined as the ability of the system to add a ride request into existing operations within a short period of time. Perfect responsiveness, of course, would mean accommodating all trip requests at the requested time, regardless of when the request was made. While this perfection is clearly impossible to achieve, the data does provide an opportunity to measure how getting near to this ideal can be achieved by a technologically sophisticated paratransit service. For the DARTS system, overall, there are very few trips denied due to capacity limits for requests submitted more than 24 hours before the requested ride time. Thus, the focus of this study is on "*same-day*" trip requests and "*24-hour*" trip requests. Same-day trip requests refer to requests called in during the same day for which the ride is expected. Requests called in at least a day prior to the ride expected are considered 24-hour trip requests.

It is assumed that if the data indicate that relatively fewer requests were turned down in the 2003 study period, as opposed to 2002, this can be an indicator that GPS deployment did help increase responsiveness, other things being equal. Other things, of course, are rarely equal. Between the two study periods, there were changes in reporting trip denials, changes in financial accounting, and a budget cut necessitating changes in fares, service hours, and service areas. Table 4.2 portrays the overall responsiveness in the two study periods.

There was a change in how DARTS recorded trip denials. In 2002, 24-hour trip requests were not fully entered into the trip database; whereas, in 2003, trip denials were more accurately recorded. This difference has created difficulty in analyzing the 24-hour advanced bookings. Thus, the primary focus is on the same-day trip requests and denials. In both years, the same-day requests that were denied were recorded in the database. One type of denial—eligibility denials—is not considered related to capacity limits, and thus is not included in this analysis. Table 4.3 provides a breakdown of all denials that took place in the two study periods. (A complete explanation of the types of denial used in the DARTS dataset is provided in Appendix D.)

2002	(SDD)Same-Day	(DEN)Capacity Denial	(ELD)Eligibility Denial	(D/D)Denial/Denial*	Total
April	34	0	0	11	45
May	12	5	1	9	27
June	21	8	0	1	30
July	48	2	4	1	55
August	43	2	1	1	47
Total	**158**	**17**	**6**	**23**	**204**
2003	**(SDD)Same-Day**	**(DEN)Capacity Denial**	**(ELD)Eligibility Denial**	**(D/D)Denial/Denial***	**Total**
April	29	210	2	0	241
May	30	70	3	0	103
June	23	72	22	0	117
July	32	64	30	0	126
August	12	70	24	0	106
Total	**126**	**486**	**81**	**0**	**693**

Table 4.3 Trip Denial by Types of Denial

*Denial/Denial refers to a denial because the return trip could not be accommodated.

The last two columns in Table 4.4 record the result. Note: the small discrepancy between the following table and graphs is due to an error in the original recording of the data. For example, in the original data, some trip requests that are not taking place during the same-day, and yet, are being denied, were mistakenly recorded as SDD (same-day denial). The error applies to a dozen or so trips.

		Same-Day Denial (SDD)	Capacity Same-Day (DEN)	Capacity 24 Hour (DEN)	Denial/Denial Same-Day (DD)	Denial/Denial 24 Hour (DD)	Total Same-Day	Total 24 Hour
2002	April	34	0	0	11	0	45	0
	May	12	5	0	9	0	26	0
	June	21	8	0	1	0	30	0
	July	48	2	0	1	0	51	0
	August	43	2	0	1	0	46	0
	Total	158	17	0	23	0	198	0
2003	April	29	0	60	0	0	29	60
	May	30	1	18	0	0	31	18
	June	23	2	16	0	0	25	16
	July	32	3	26	0	0	35	26
	August	12	0	18	0	0	12	18
	Total	126	6	138	0	0	132	138

Table 4.4 Same-Day Denial and 24-Hour Denial

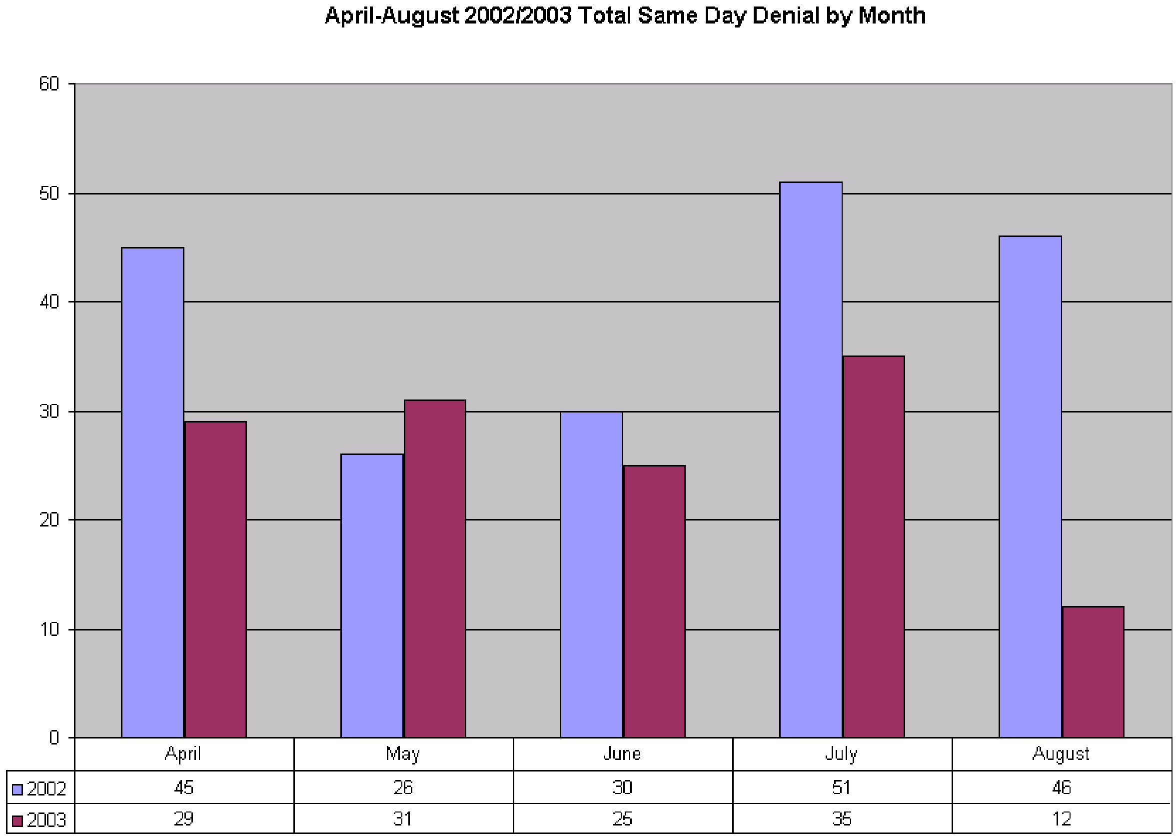


Figure 4.4 Same-Day Denials by Month

Trip Purpose

Trip purposes in riding DARTS are mainly of 10 types: Business, Church, Shopping (Grocery, Retail, Beauty), Health (Medical, Dental), Recreation, School, Social Services, Visit, Volunteer, and Work. (See Appendix C for a more detailed explanation.) The demand for all trips requested by trip purpose is shown in Table 4.5

Overall, there is little change in trip purpose between the two five-month study periods of 2002 and 2003.Given the population eligible for DARTS service, the dominance of medical and shopping trips is not surprising (almost 20% for each). However, the most frequent trip purpose is found in work trips. Fully one-third of all trips served by DARTS are commutes to and from work. The other major trip purpose is for access to social services (which grew from 11% to nearly 14% between the two years). Social services included traditional social services (counseling, congregate dining, day care, English as a second language classes, and job counseling).

Clearly, the dominant trip purposes are for essential activities of life for persons with limited access to transportation. Relatively few trips are made for recreation, visiting, or even personal business or church. Thus, DARTS does not have many customers who could be said to be using the service for purely discretionary travel. Such discretionary trips combined made up approximately 15% of all trip requests.

Trip Purpose	2002	2003	Percent 2002	Percent 2003
Business	1279	1051	2.7	2.1
Church	1185	1906	2.5	3.8
Grocery/Retail/Beauty	7176	9036	15.0	18.0
Med/Dental	10007	10014	20.9	19.9
Recreation	2213	2408	4.6	4.8
School	1079	449	2.3	0.9
Social Services	5414	6921	11.3	13.8
Visit	1162	805	2.4	1.6
Volunteer	985	880	2.1	1.8
Work	17439	16737	36.4	33.3
Grand Total	47939	50207	100.0	100.0

Table 4.5 2002 (April-August) and 2003 (April-August) Total Trip Requests by Purpose

In terms of the trip purpose breakdown of same-day requests; the following two graphs show that GPS technology helped level out more than half of same-day denials in trips requested for grocery, retail, beauty, medical, and dental trips.

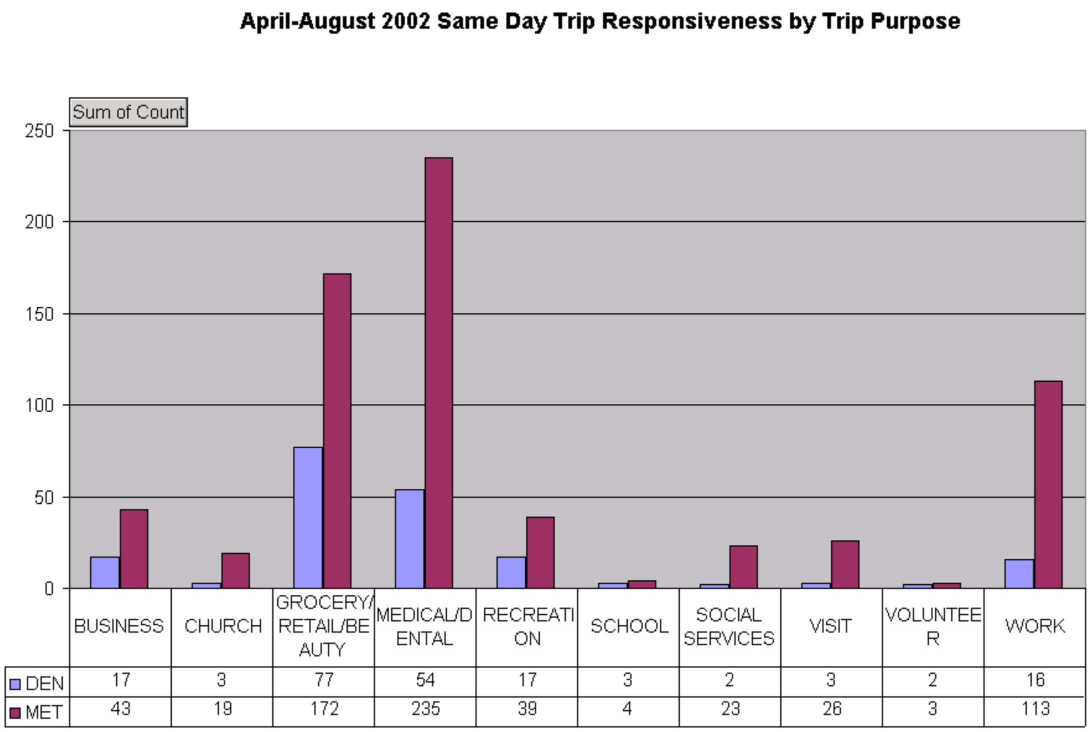


Figure 4.5 April-August 2002 Same-Day Trip Responsiveness by Trip Purpose

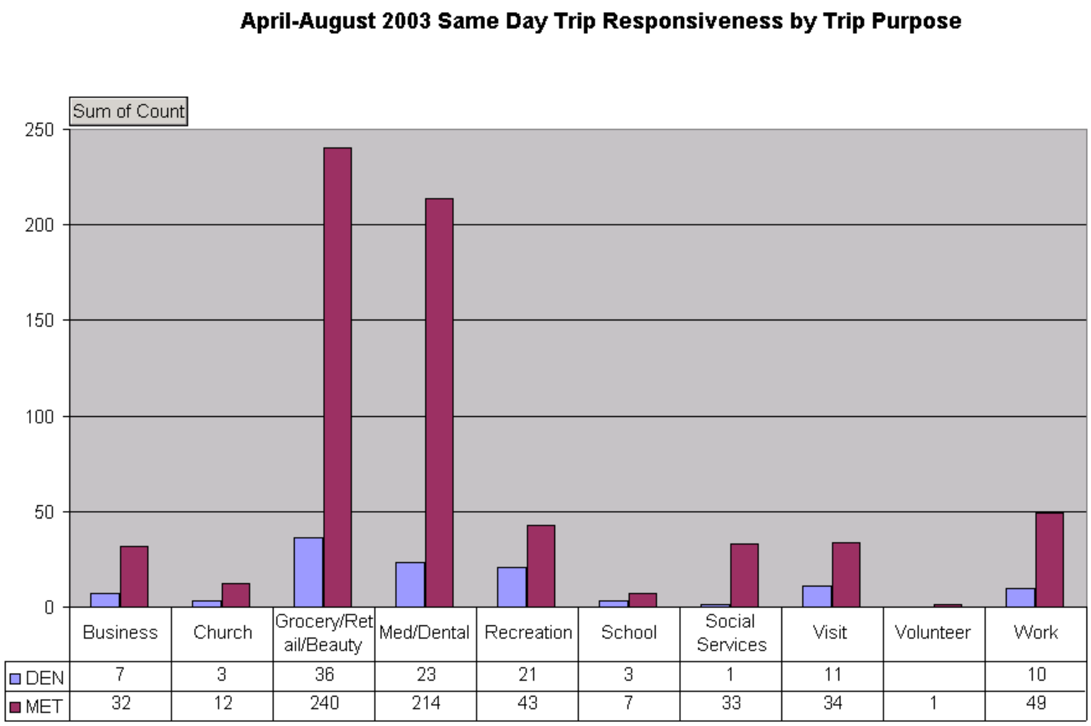
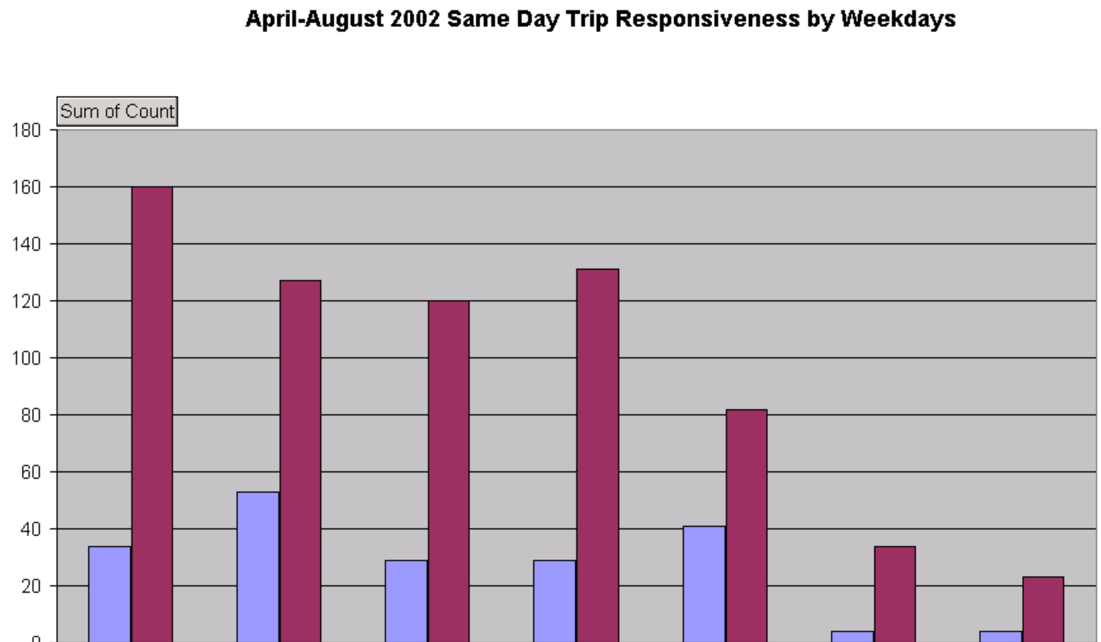


Figure 4.6 April-August 2003 Same-Day Trip Responsiveness by Trip Purpose

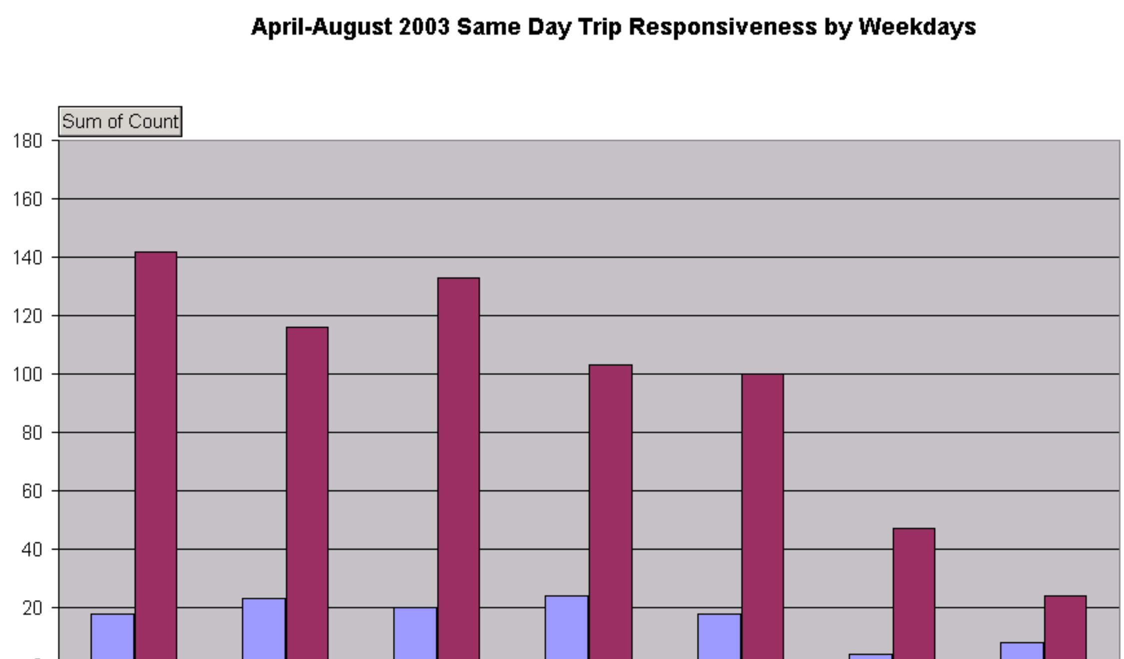
By Day of the Week

In the following two graphs, it can be seen that the post-GPS decrease varies according to day of the week. Monday is the day with the most frequent same-day requests for both study periods (people may perceive that they cannot call in a request on Sunday). Monday, ironically, is also the weekday with the lowest percent of denials. Friday is the day with the fewest same-day trip requests in both years. However, in 2002, Friday had the highest rate of denial—a situation that was reversed in 2003. Both same-day requests and denials on weekends were considerably lower than those on weekdays. Weekend trips, of course, are limited to ADA-certified riders so that a lower rate of denials is to be expected. Weekend trip denials increased in 2003, although this is likely due to the fact that because of budget cuts, DARTS reduced weekend services in 2003.



	1 Mon	2 Tue	3 Wed	4 Thu	5 Fri	6 Sat	7 Sun
DEN	34	53	29	29	41	4	4
MET	160	127	120	131	82	34	23

Figure 4.7 April-August 2002 Same-Day Trip Responsiveness by Weekdays



	1 Mon	2 Tue	3 Wed	4 Thu	5 Fri	6 Sat	7 Sun
DEN	18	23	20	24	18	4	8
MET	142	116	133	103	100	47	24

Figure 4.8 April-August 2003 Same-Day Trip Responsiveness by Weekdays

By Time of Day

Another way of examining trip responsiveness is to look at DARTS service characteristics in terms of the time of day when trips were being made. If more trips were being made during off-peak hours, there is potential room for services like DARTS to accommodate the general public's transportation needs in the peak hours, especially work trips. For this study, service hours were classified in the following seven categories:

Weekdays—Monday through Friday

- a.m. peak hour 6 a.m. to 9 a.m.
- a.m. non-peak hour 9:01 a.m. to 11:59 a.m.
- p.m. non-peak hour Noon to 3:29 p.m.
- p.m. peak hour 3:30 p.m. to 6:29 p.m.
- evening 6:30 p.m. to 11 p.m.

Weekends

- Saturday
- Sunday

The following two graphs represent the same-day trip responsiveness breakdown by time pattern. DARTS original data for 2003 has some denials recorded without specification of when the trips were requested to take place. Thus, the blanks in the data cannot be categorized into time pattern concerning peak- and non peak-hour requests and are, thus, shown in the last column of the graphs.

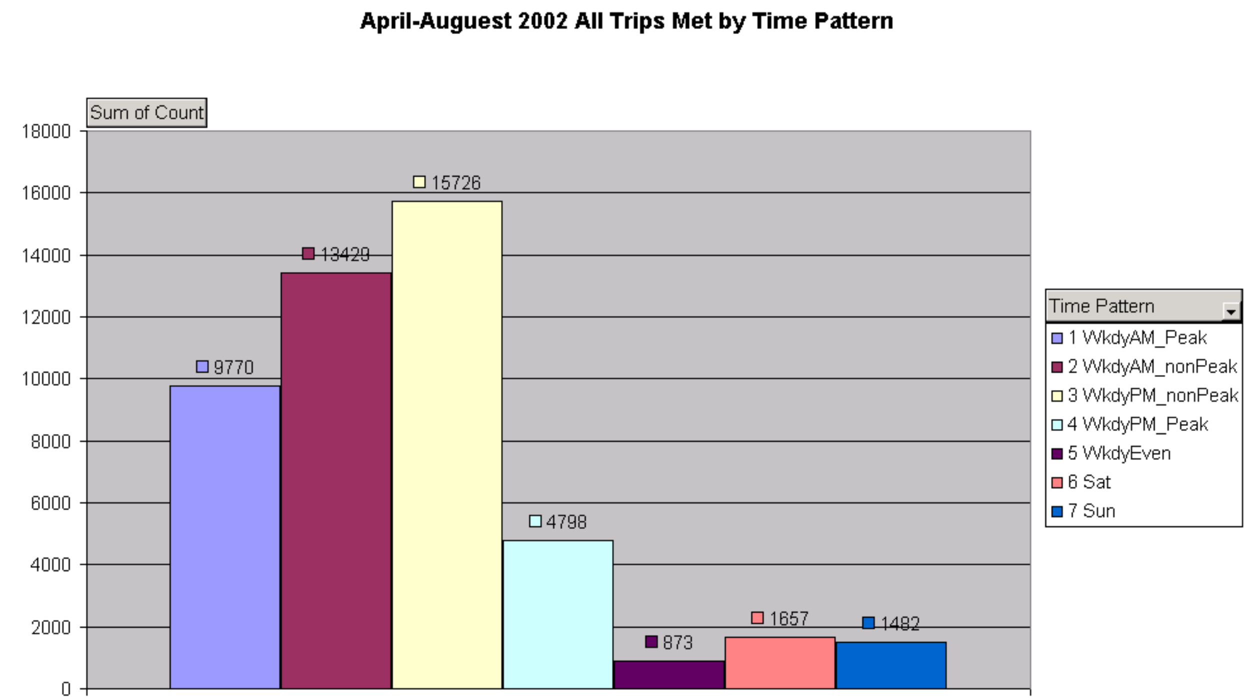


Figure 4.9 April-August 2002 All Trips Met by Time Pattern

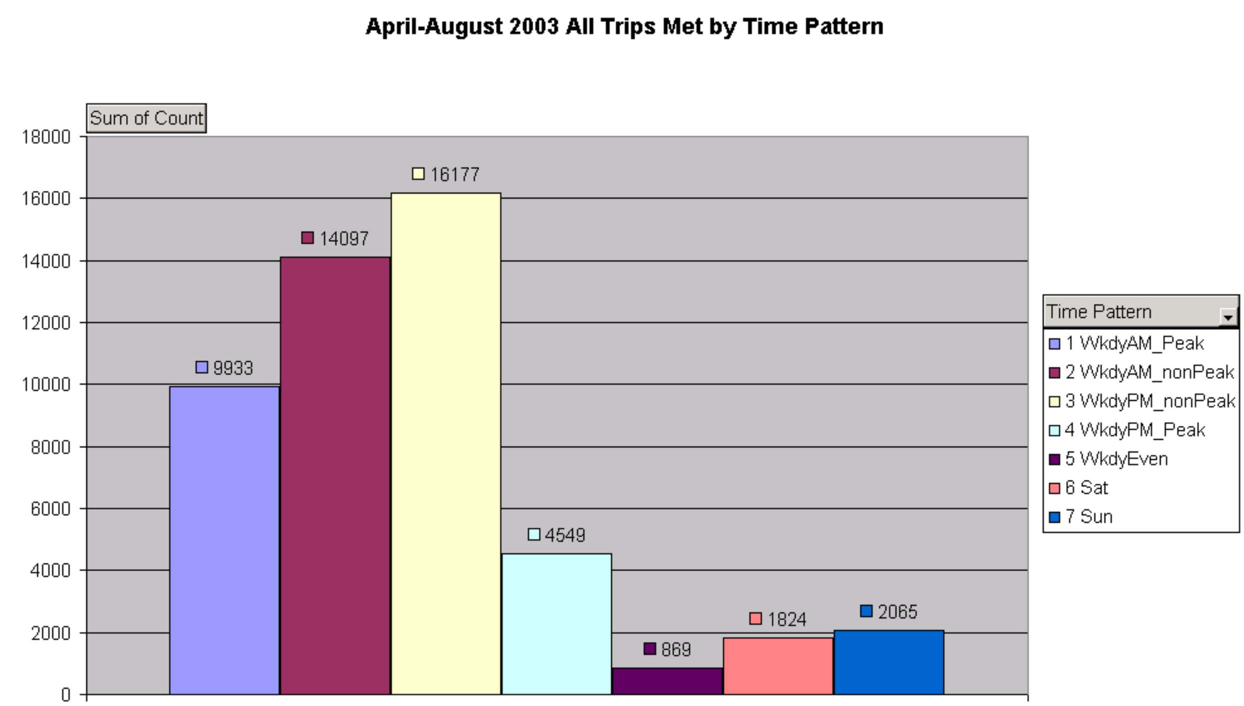


Figure 4.10 April-August 2003 All Trips Met by Time Pattern

Acknowledging the data limitations, some patterns of same-day requests stand out. There are very few same-day requests for the early morning rush hour (before 9 a.m.). This is, of course, reasonable. Potential riders probably intuitively realize that a 6 a.m. call for a 7 a.m. ride might prove impractical. Yet, in both years, a greater percentage of requests were accommodated (in relation to denials) in the morning rush hour than in any other time-of-day period. The time period of the greatest number of same-day requests coincides with the time period of greatest volume of demand on the entire system—the afternoon off-peak hours of noon to 3:30 p.m. As with public transit systems in general, the DARTS system seems to face periods of peak loads—they are, however, the mirror image of a traditional transit system. Mid-morning and mid-afternoon are the times of peak load.

Total trips made in the two study periods do not appear to have noteworthy differences in terms of time-of-day patterns. Slightly more trips were made in the morning peak hours in 2003 than in 2002, but there was also a slight decline in afternoon peak trips. Generally, for both years, morning peak-hour trips are approximately double the peak-hour trips in the afternoon suggesting considerable part-time employment. Evening and weekend trips increased from 6% of all trips in 2002 to 10% in 2003.

The general temporal trip distribution is clear; the greatest volume of trips occurs in the mid-day off-peak hours. Mid-day trips accounted for 62% of all trips in 2002 and 65% of all trips in 2003. This suggests the possibility that DARTS could, perhaps, serve more of the general public during the morning and evening peak hours.

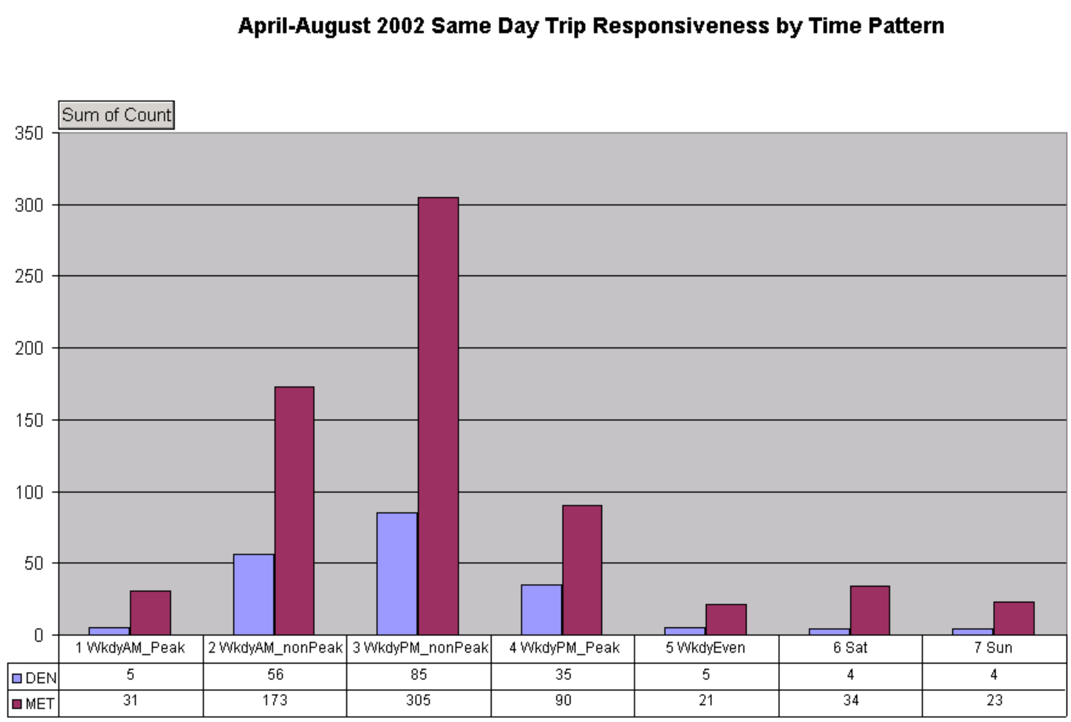
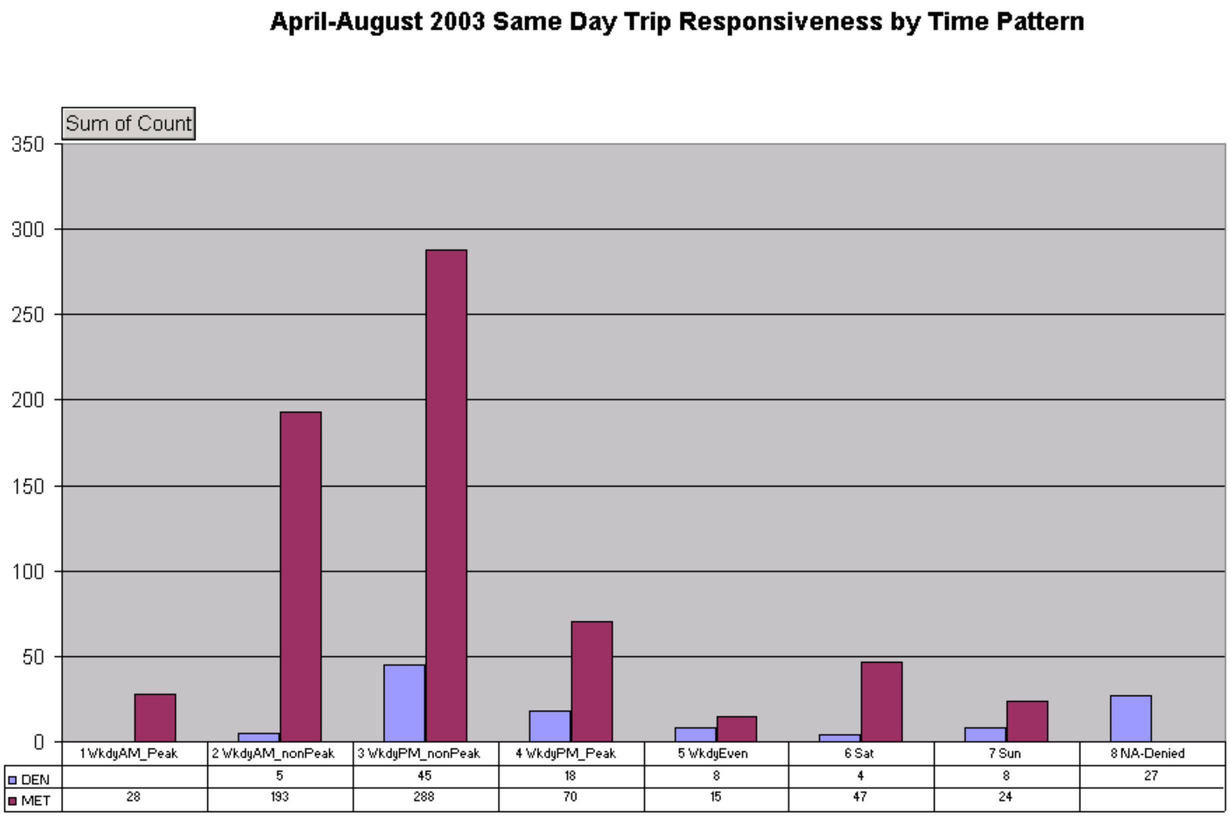


Figure 4.11 April-August 2002 Same-Day Trip Responsiveness by Time Pattern



	1 WkdyAM_Peak	2 WkdyAM_nonPeak	3 WkdyPM_nonPeak	4 WkdyPM_Peak	5 WkdyEven	6 Sat	7 Sun	8 NA-Denied
DEN		5	45	18	8	4	8	27
MET	28	193	288	70	15	47	24	

Figure 4.12 April-August 2003 Same-Day Trip Responsiveness by Time Pattern

Further analysis of the daily pattern of ridership is shown in Table 4.6.

	Five-Month	**Number**	**No. Per**	**No. Hours**
Time of Day	Ridership	per Month	Weekday	Per Period
Morning Peak	9,933	1,987	99	3
Morning Off-Peak	14,097	2,819	141	3
Afternoon Off-Peak	16,177	3,235	162	3.5
Afternoon Peak	4,549	910	45	3
	44,756			
AVERAGE	11,189	2,238	112	3
		Average		
	Rider Load	#Buses	Riders per Bus	
Time of Day	Per Hour	Running		
Morning Peak	33	20	1.65	
Morning Off-Peak	47	28	1.68	
Afternoon Off-Peak	46	28	1.65	
Afternoon Peak	15	20	0.75	
AVERAGE	35	28	1.43	

Table 4.6 Rider Load by Time of Day

This table shows the effects of the hourly rider load in terms of riders per bus at various times of the day. These calculations reinforce the suggestion that there is slack in the morning and evening rush hours. During rush hours, buses would of course run slower due to heavier traffic congestion. Thus, it would not be reasonable to expect DARTS service capacity during rush hour to run as high as 46 or 47 trips per hour. However, the gap between the off-peak and peak-hour demand is substantial. This suggests in the rush hours, DARTS could plausibly accommodate more trips—especially work trips for the general public—and thereby possibly reduce the number of SOV trips in peak travel periods.

By our calculations, if the hourly trips in the rush hour periods were to increase to 45 per hour, this would translate into another 126 trips per day (36 in the morning peak and 90 in the afternoon/evening peak). Thus, the current average of 600 trips per day would be increased to approximately 726 trips per day. It would add another 2,800 trips per month, raising the present average of 9,900 (with a standard deviation of 1,027) per month to about 13,000 to 14,000 per month. This would seem to be in the range of feasible absorption for the present system, given the following economic analysis. Thus, it is conceivable that DARTS, at this time, could take 80 to 90 SOV drivers off the highways and into on-demand public transit.

Measure of Trip Length in Miles

Besides changes in denial rate, GPS technology may also affect trip length due to the enhanced vehicle tracking capability. The system could accommodate longer trips without sacrificing service responsiveness. By comparing the same-day trip in 2002 and 2003 (shown in the following two graphs), the most visible observation is that the average trip length shortened somewhat after GPS deployment. There was not a significant difference, however. There does seem to be a fairly uniform pattern of trip length for both study periods with almost all trips ranging between 3.5 and 4.5 miles. This length of trip is reflective of the type of riders using the system and the fact that the system is organized around geographical subregions. Thus, while a trip from Inver Grove Heights to Lakeville (about 25 miles) would involve substantial time and mileage, most non-work trips are focused on pretty basic close-to-home needs: shopping, medical and dental appointments, and social services. There is a plurality of work trips, however, with many workers disabled, it is likely they seek part-time employment close to home. The part-time nature of these commuters is indicated in the fact that trip loads are considerably larger in the morning peak hour than in the late afternoon.

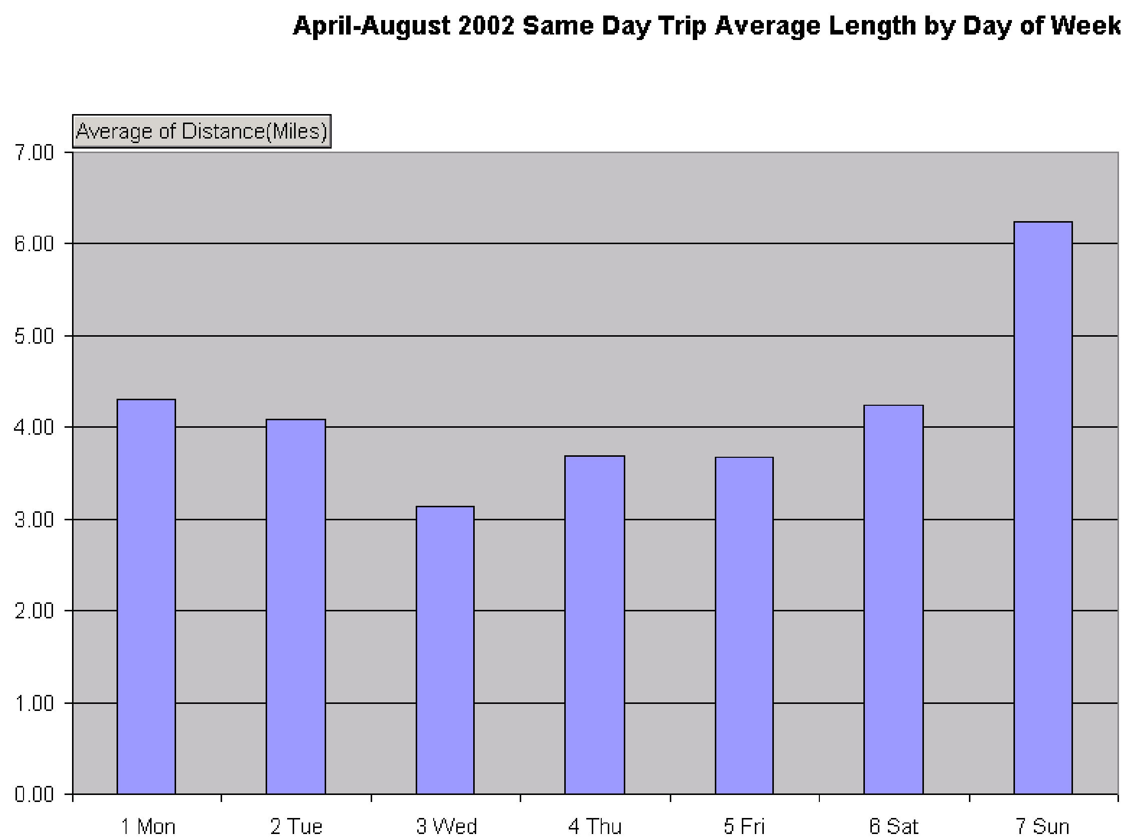


Figure 4.13 April-August 2002 Same-Day Trip Average Length by Day of Week

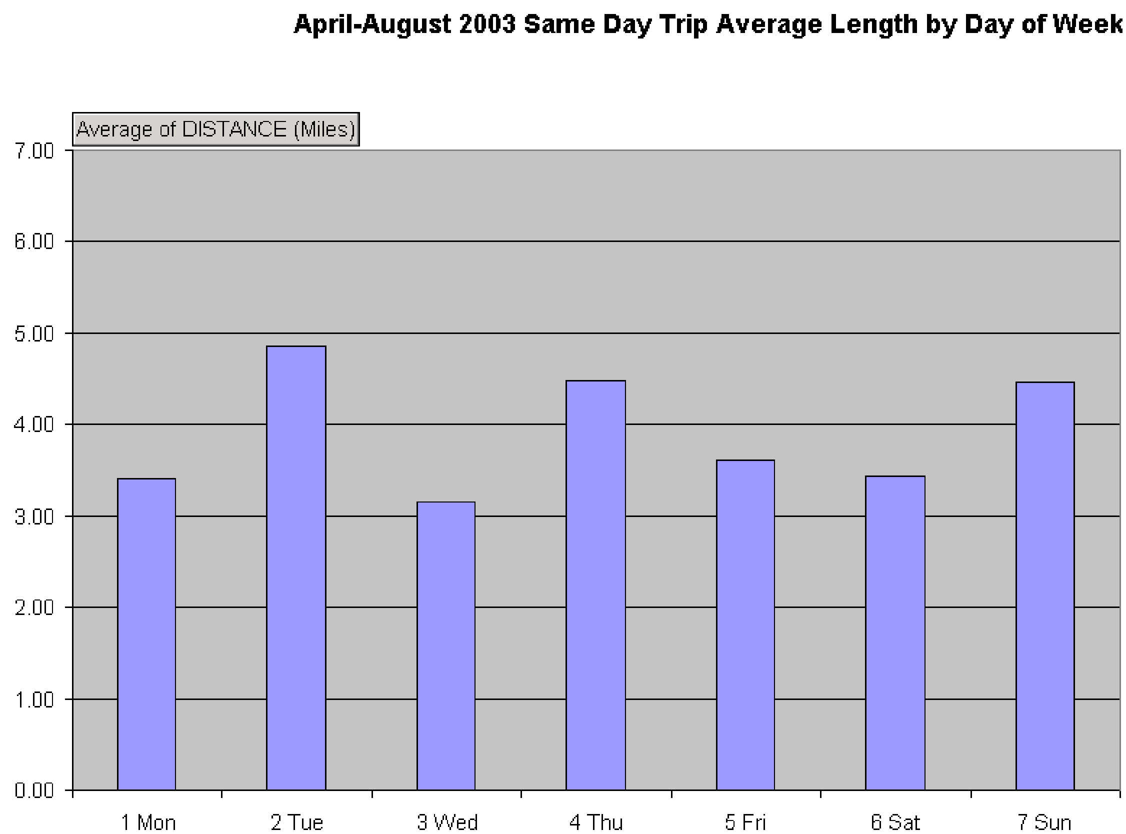


Figure 4.14 April-August Same-Day Trip Average Length by Day of Week

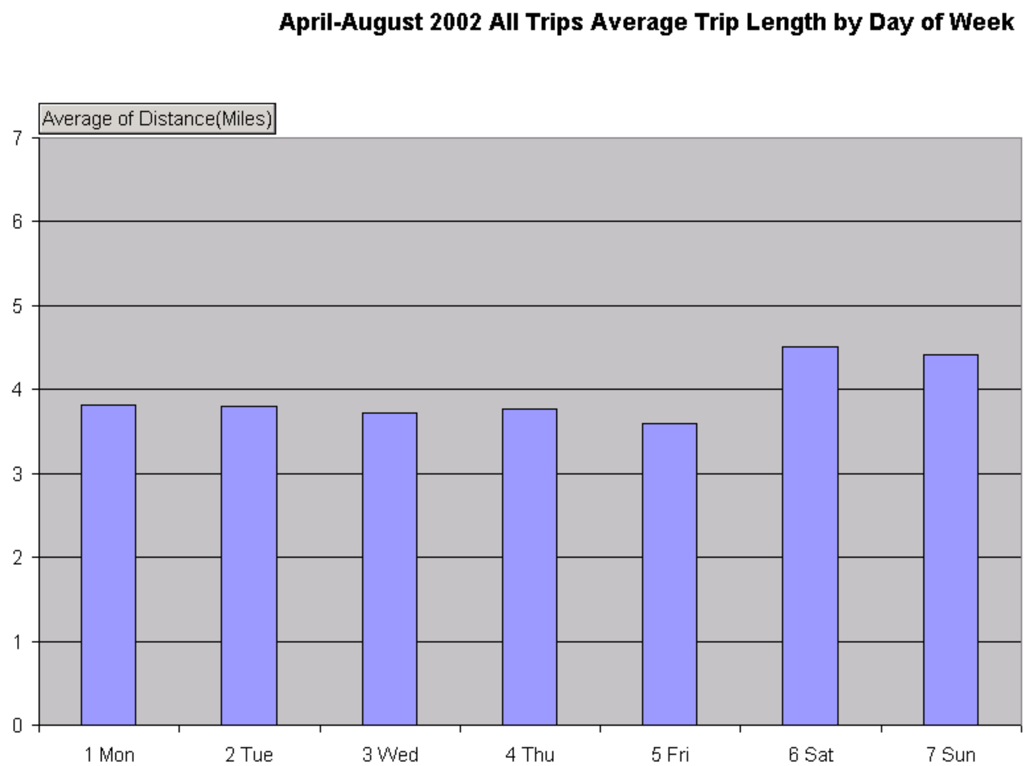


Figure 4.15 April-August 2002 All Trips Average Trip Length by Day of Week

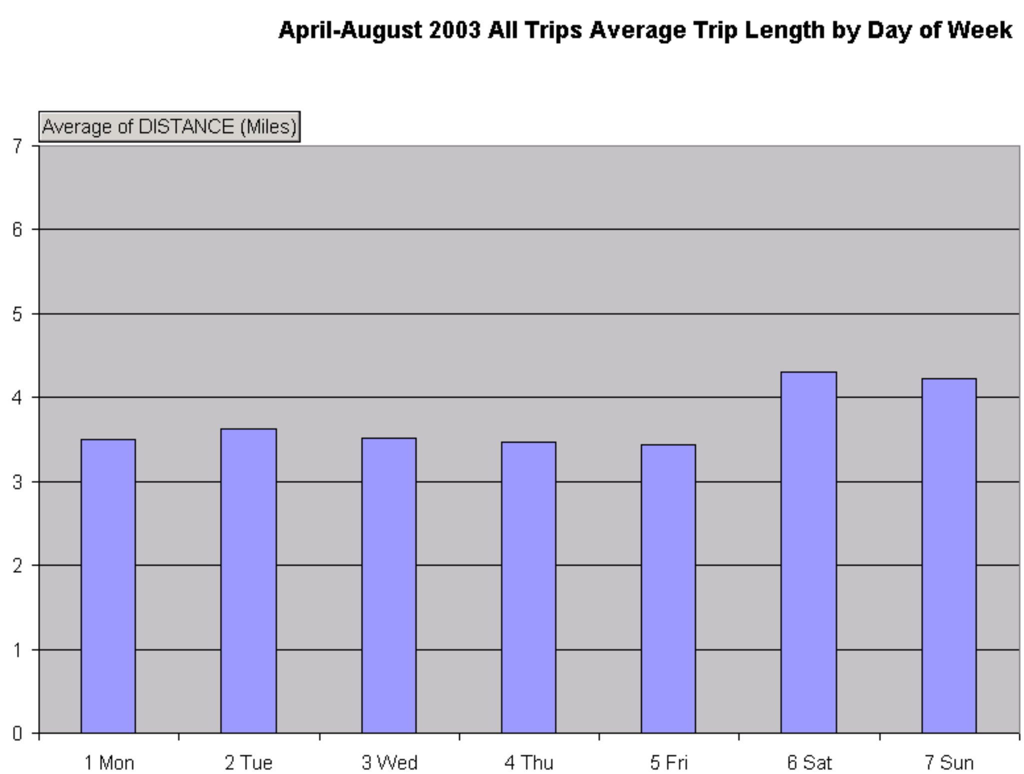


Figure 4.16 April-August 2003 All Trips Average Trip Length by Day of Week

Length of Trip Measured by Time Between Pick Up and Drop Off

Another measure of trip length is the minutes spent in transit between origin and destination. This enables us to compare trip length with the manner in which commuting trips are reported in the U.S. Census.

Travel Time on Bus

It is assumed that the less time spent on the DARTS vehicle the better the service quality. However, whether GPS deployment helps DARTS riders shorten their trip is not clear. The assumption that GPS will help dispatchers add in an additional ride request during the scheduled trip may increase ride time of those already on board. On the other hand, before GPS deployment, the dispatcher may have had to send another bus to pick up the on-demand trip, which would have increased the ride time for any other passengers on that latter bus.

So, theoretically it is not clear if ride time will decrease after GPS deployment. To test the above assumption, an empirical analysis of the data is presented below:

In the dataset, ride time is considered to be the difference between the pick-up and drop-off times. This difference is assumed to be the time each rider spent on the DARTS vehicle. However there are a considerable amount of outliers, or errors, in the data for both years. First, there are times recorded for denied trip requests. Second, there are trips recorded having a drop-off time earlier than pick-up time (230 records in 2002 and 67 in 2003). Third, there are records of zero time difference, which is unrealistic (122 in 2002 and 3,336 in 2003, the huge jump in data error may be explained by the errors generated by the new system being used). Fourth, there are ride times of more than two hours. These are considered outliers for this study (43 in 2002 and 51 in 2003). The rest of data were used and were assumed to reflect a reasonable sample of actual performance.

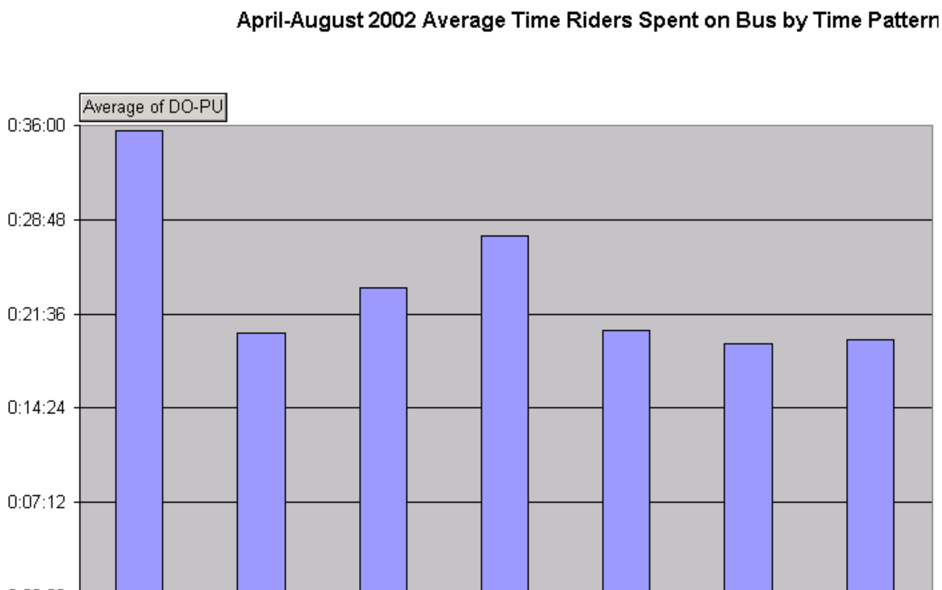
Table 4.7 documents the outliers removed from the dataset:

NUMBER OF OUTLIERS	YEAR 2002	YEAR 2003
Denied Trips Reported with Time	204	693
Drop-Off Time Earlier than Pick-Up Time	230	67
Zero Ride Times	122	3,336
Above Two-Hour Ride Time	43	51
TOTAL	599	4,147
Percent of Total Rides Provided	1.3%	8.4%

Table 4.7 Data Errors for Time Length of Trip

The following four graphs reflect the data analysis result. The result shows that the average ride time decreased from 2002 to 2003. In another words, DARTS riders spent less time on board in 2003 than in the previous year. This could signify greater efficiency in trip routing as a result of the GPS installation.

The next two graphs show the difference in 2002 and 2003 in terms of time pattern. In all time segments, riders spent less time on buses in 2003 than in 2002. In both years, the weekday morning rush-hour rides take longer than trips in other times. In the 2002 morning rush hour, riders spent more than half an hour on DARTS buses on average, while in the same time period in 2003 they spent about 23 minutes, or seven minutes less than in 2002. In the weekday afternoon peak period in 2002, riders spent nearly half an hour in average trip time as opposed to only about 18 minutes in 2003. In the weekday off-peak hours, DARTS riders saved about five to ten minutes after the GPS installation. Assuming similar levels of congestion for peak-hour travel, the improved performance in terms of shorter duration trips can reasonably be related to possible improved trip algorithms in planning and scheduling brought about by the GPS and on-board computer.



	1 WkdyAM_Peak	2 WkdyAM_non Peak	3 WkdyPM_non Peak	4 WkdyPM_Peak	5 WkdyEven	6 Sat	7 Sun
Total	0:35:35	0:20:06	0:23:34	0:27:35	0:20:21	0:19:19	0:19:39

Figure 4.17 April-August 2002 Average Time Riders Spent on Bus by Time Pattern

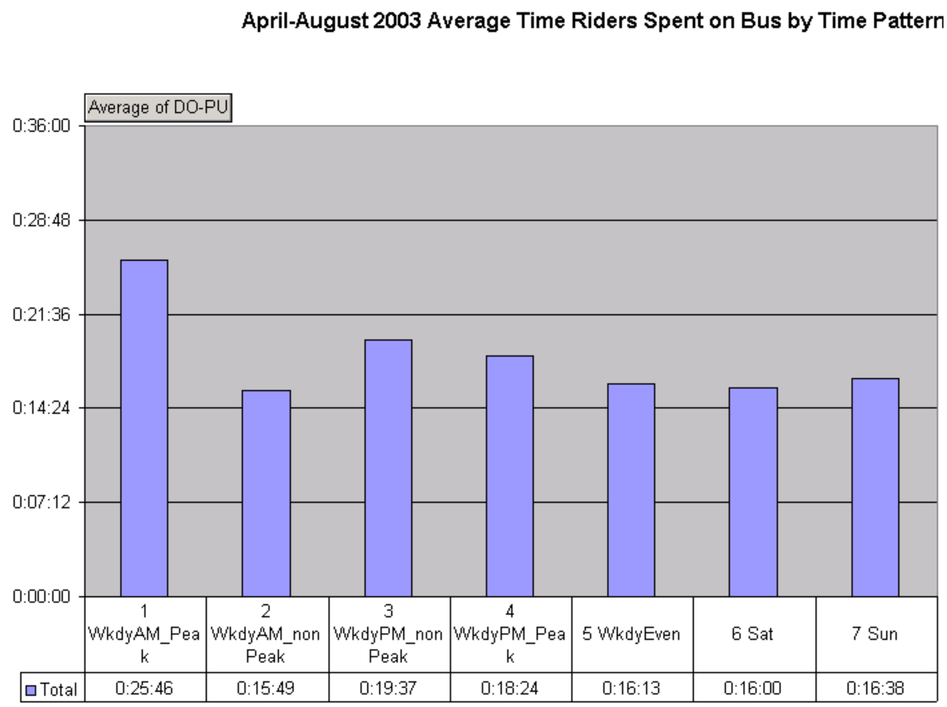


Figure 4.18 April-August 2003 Average Time Riders Spent on Bus by Time Pattern

The following two graphs show trip times by trip purpose. Again, a shorter ride time was experienced in the 2003 study period than in 2002. Trip purposes for business, church, shopping, hospital, recreation, visiting, and work all enjoyed a shorter trip by five to ten minutes. However, ride time of trips for social services and visits were not decreased.

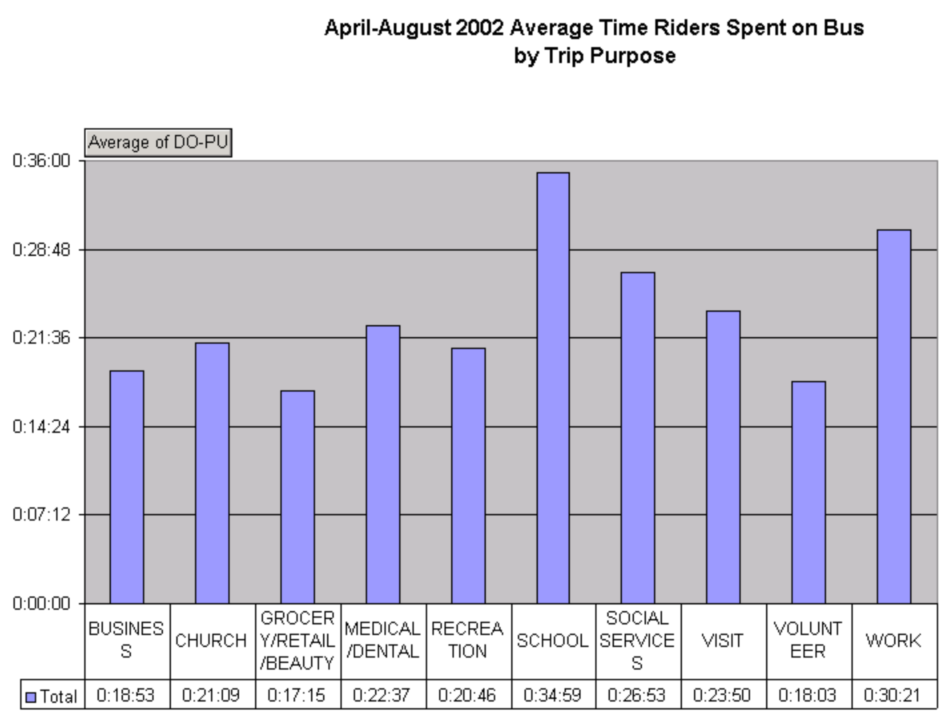


Figure 4.19 April-August 2002 Average Time Riders Spent on Bus by Trip Purpose

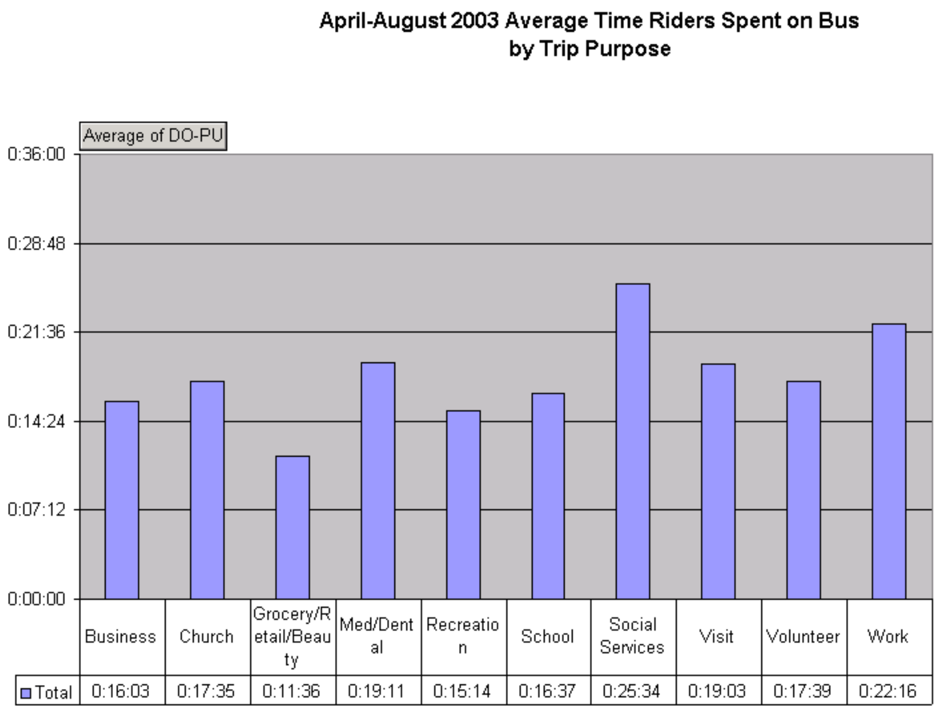


Figure 4.20 April-August 2003 Average Time Riders Spent on Bus by Trip Purpose

A serious discrepancy between ride time and trip distance was found in the data set. One could assume that the longer the trip distance, the more time riders would have to spend on the vehicle. However, the following two graphs showing the relationship between ride time and trip distance do not support this assumption. On the X-axis is the trip distance in miles, on Y-axis is the ride time. Both graphs representing 2002 and 2003 do not appear to have positive relationship between the two variables. Thus, this led to questions of trip log errors and how the trips distances and ride time were recorded.

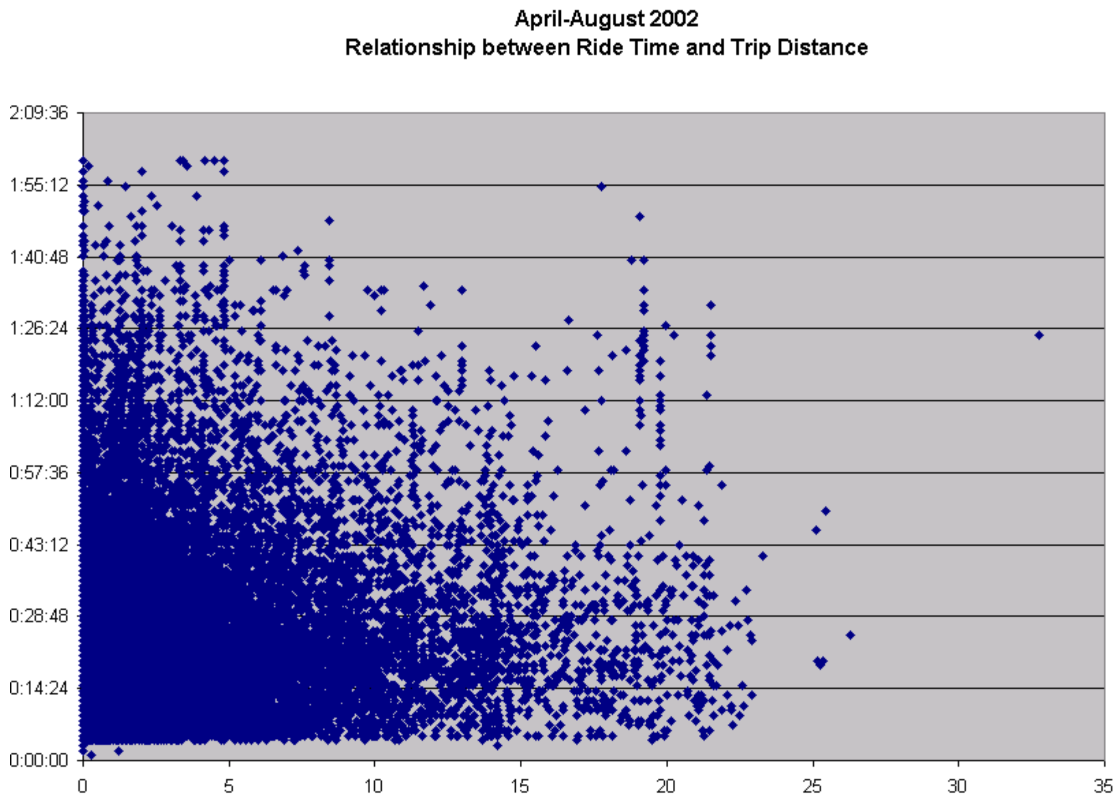


Figure 4.21 April-August 2002 Relationship Between Ride Time and Trip Distance

Figure 4.22 April-August 2003 Relationship Between Ride Time and Trip Distance

<u>Difference Between Scheduled Pick-Up Time and Actual Pick-Up Time</u>
Recorded in the DARTS data are both the time scheduled for riders to be picked up and the time they actually were picked up. The difference between these two times is a key indicator of the responsiveness of DARTS service.

It should be noted that there were important differences in how this was recorded between 2002 and 2003. In 2002, drivers called in the time of arrival at the pick-up address. In 2003, drivers punched this into the on-board computer containing the GPS and communication technology. While this would suggest that the 2003 data is more accurate, it is actually becoming so as the drivers get used to the new equipment. Mistakes were noted in the first months (April and May). The accuracy for July and August 2003, however, was considerably improved.

It is important to note that the data contain outliers. Outliers were considered as those gaps of greater than one hour between the scheduled and actual pick-up time. In the 2002 study period, 0.5% of total trips accommodated have a time gap greater than one hour. In 2003, 2% of total trips accommodated have a time gap exceeding one hour. These outliers were omitted from the analysis on the assumption that they were the result of out-of-the-ordinary circumstances or recording errors.

In 2002, 98.4% trips experienced a time gap between scheduled and actual pick-up time of less than 30 minutes. In 2003, this percentage is 94.1%. Therefore, the following analysis focuses on trips that were accommodated with a time gap within a 30 minute range.

In 2002, about 40% of all trips were recorded as on time (i.e., scheduled and actual pick-up time is exactly the same). In 2003, only about 10% of trips were recorded as such. There is discontinuity in the time gap records in 2002, while in 2003 the data show a more plausible exponential trend line of the time differential varying within a 30-minute period. The data shows a very decided inverse relationship, and nearly half of all riders were picked up within 10 minutes of their scheduled time (either early or late).

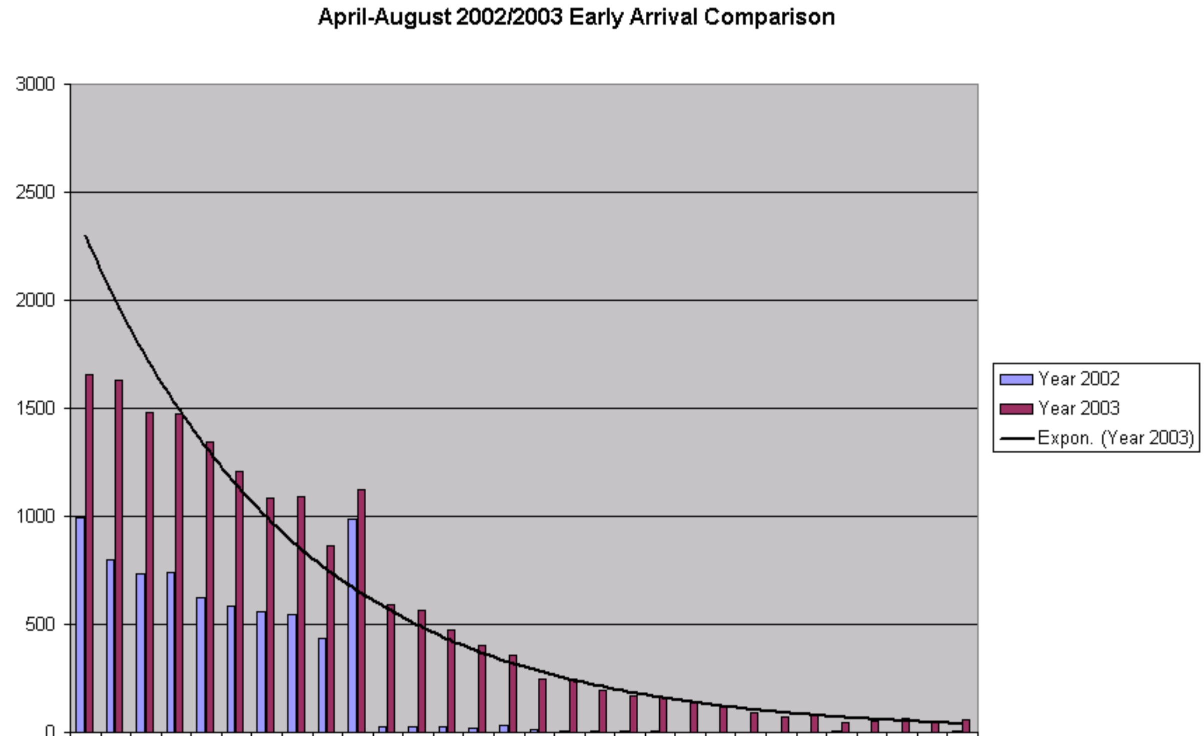
In 2002, if drivers arrived at the pick-up address within one or two minutes, they may have reported their arrival as "on time." With the on-board computer recording the trip log in 2003, the human factor in reporting the arrival time is reduced. As well, a sudden spike in the 2002 data occurs at 10 minutes of spread between the promised time and the actual time. It is possible that drivers are more likely to round numbers so that 8 or 9 and 11 and 12 minutes may be more likely to be recorded as 10 minutes.

Not all discrepancies in the difference between the promised pick-up time and the actual pick-up time can be said to be late arrivals. In fact, in many instances, the bus arrived ahead of the promised time. Thus, the following two graphs show the difference between early and late arrivals. In the case of early arrivals, where DARTS vehicles arrived at the pick-up location earlier than scheduled, the data shows there are more early arrivals in 2003 than in 2002. From 1 minute to 30 minutes earlier, in each cohort there are more trips that were accommodated with an early arriving bus in 2003 than in 2002.

Within reason, an early pick up is assumed to be more desirable than a late pick up from the riders' perspective, although arriving 30 to 45 minutes early could be very inconvenient for a rider. In 2002, 7,182, or 15% of total trips accommodated, experienced an earlier pick-up time than scheduled. In contrast, for 2003, significantly more trips were accommodated with an earlier pick-up time than scheduled: 17,570, or 35% of total trips had early pick-up times. In 2002, 40,536 out of 47,735 trips (or 85%) experienced a later pick-up time than scheduled. In 2003, 31,930 out of 49,513 trips (or 65%) had a later pick-up time. Thus, this may be perceived as an increase in service quality. More DARTS buses arrived on time or earlier than scheduled in 2003 than 2002.

In the case of late arrivals, in the 1-to-10-minute cohorts, more buses were late in 2002 than in 2003. However, from the 11-to-30-minute cohorts, more buses were late in 2003 than in 2002.

As mentioned before, the GPS technology has helped in the accuracy of the DARTS data. The smooth trend in both graphs in 2003 shows the technology has produced reasonable results in the time gap between scheduled and actual pick-up times. In both early and late arrivals, 2003 data show more continuity than in 2002.

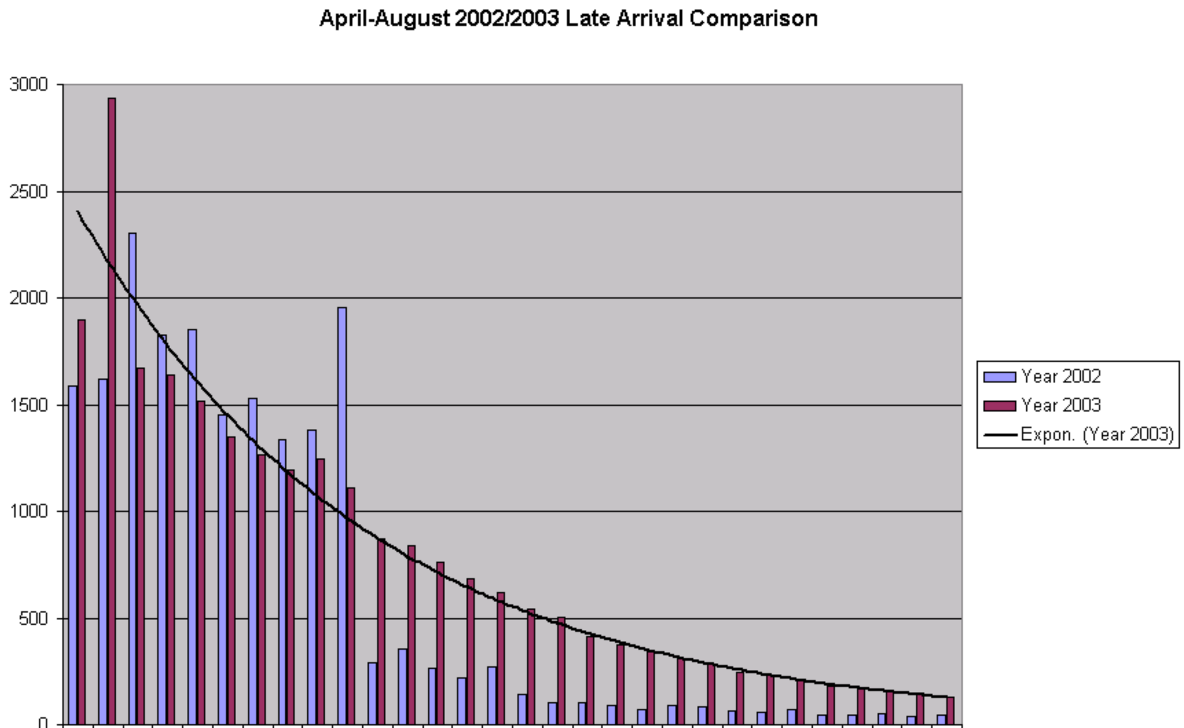


Minutes Early	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year 2002	994	800	731	738	621	587	556	545	432	988	28	26	23	17	30
Year 2003	165	163	148	147	134	120	108	109	863	112	591	562	472	405	357

Minutes Early	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Year 2002	10	5	4	7	5	1	2	3	1	2	4	0	0	1	4
Year 2003	246	248	192	168	161	145	119	91	74	76	43	55	62	51	60

Number of Early Trips

Figure 4.23 April-August 2002/2003 Early Arrival Comparison



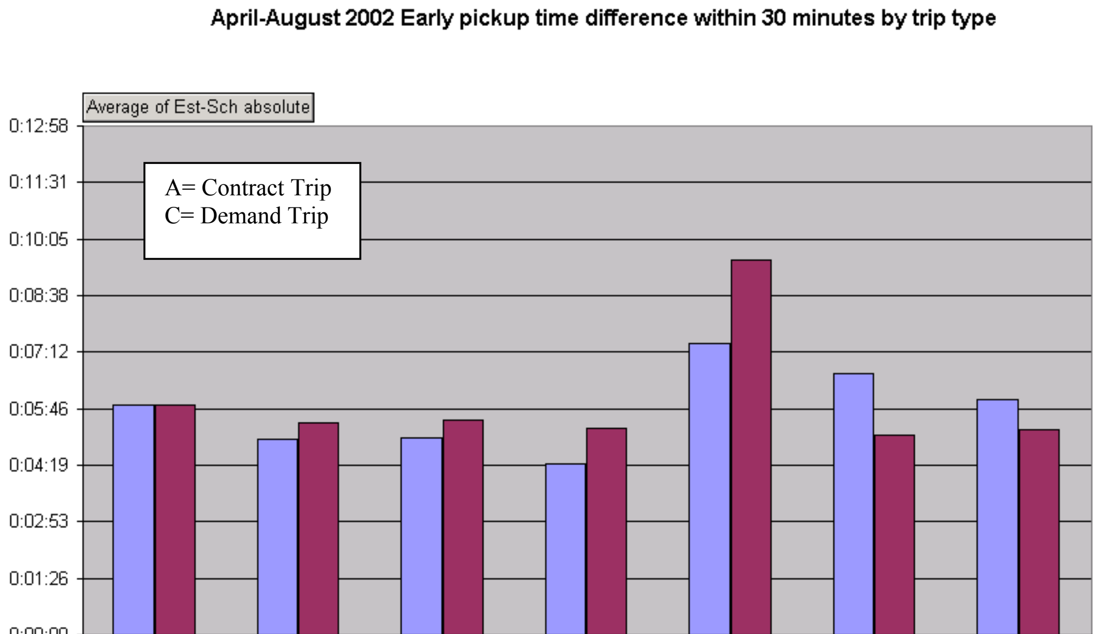
Minutes Late	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Year 2002	159	162	230	182	185	145	152	133	137	195	292	353	265	217	273	143	104	101	89	73	90	85	62	58	71	48	46	50	37	44
Year 2003	189	293	167	163	151	134	126	119	124	111	870	840	761	684	617	540	503	411	374	347	312	283	244	234	207	178	165	158	147	130

Number of Late Trips

Figure 4.24 April-August 2002/2003 Late Arrival Comparison

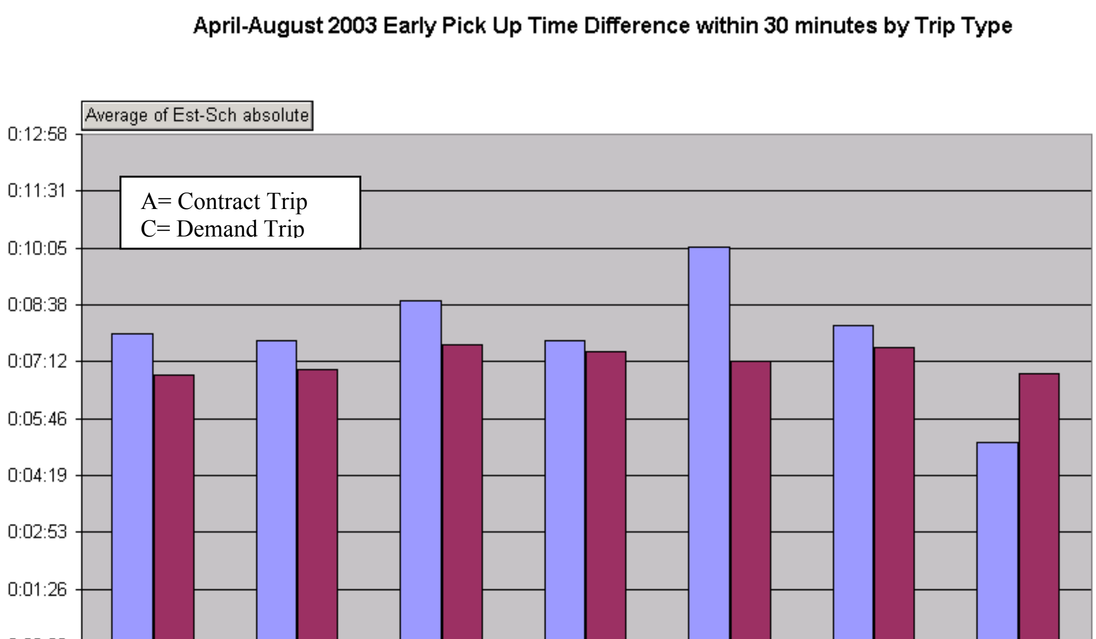
The following four graphs provide additional comparison of early and late pick-up times in 2002 and 2003. The Y-axis represent the time gap in minutes and seconds, the X-axis breaks down trips into time pattern in terms of peak and non peak hours. The bars represent the average minutes in time gap. “A” trips are contract trips, which normally were scheduled four to seven days beforehand; “C” trips are on-demand trips, which could be scheduled any time from the same day, to seven days beforehand.

Buses arrived a bit earlier in 2003 than in 2002. In 2002, early buses arrived about five to seven minutes earlier on average, while in 2003 early buses arrived about seven to nine minutes earlier. In 2002, buses arrived about half a minute earlier for on-demand trips, and less so for contracted trips on weekdays, with the reverse on weekends. In 2003, on the other hand, buses arrived earlier for contracted trips, and about half a minute less so for on-demand trips.



	1 WkdyAM_Peak	2 WkdyAM_nonPeak	3 WkdyPM_nonPeak	4 WkdyPM_Peak	5 WkdyEven	6 Sat	7 Sun
A	0:05:51	0:04:59	0:05:02	0:04:22	0:07:25	0:06:40	0:05:59
C	0:05:51	0:05:25	0:05:28	0:05:17	0:09:33	0:05:05	0:05:13

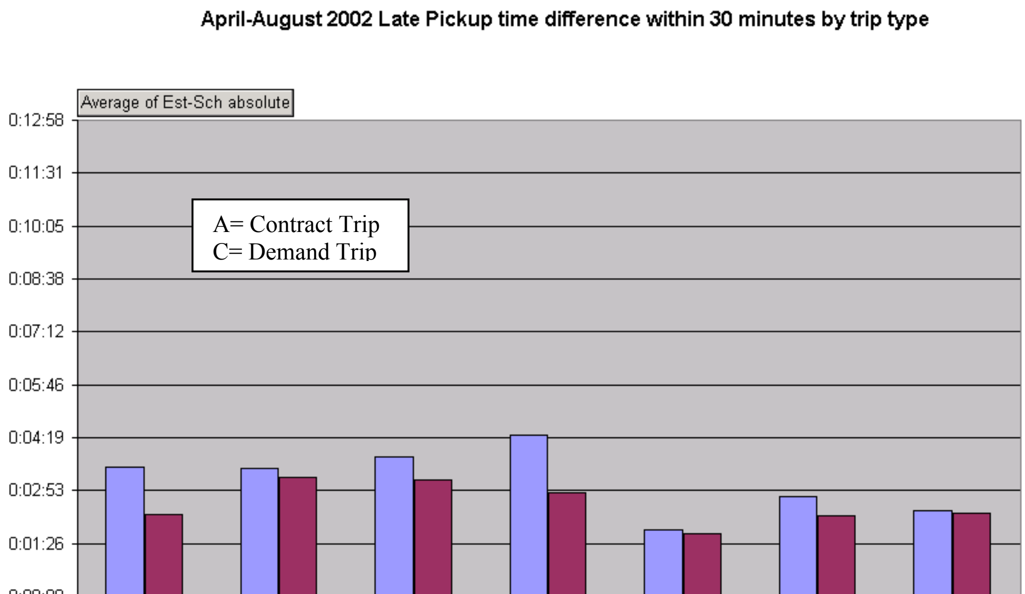
Figure 4.25 April-August 2002 Early Pick-up Time Difference within 30 Minutes by Trip Type



	1 WkdyAM_Peak	2 WkdyAM_nonPeak	3 WkdyPM_nonPeak	4 WkdyPM_Peak	5 WkdyEven	6 Sat	7 Sun
A	0:07:55	0:07:45	0:08:45	0:07:43	0:10:07	0:08:06	0:05:10
C	0:06:51	0:06:59	0:07:37	0:07:27	0:07:13	0:07:34	0:06:55

Figure 4.26 April-August 2003 Early Pick-up Time Difference within 30 Minutes by Trip Type

For late pick ups, in 2002, buses one to four minutes late on average, while in 2003 buses were, on average, five to nine minutes late. Although fewer trips were picked up late, the time for waiting increased in 2003, as opposed to 2002. On weekdays, in both years buses, tended to be late more for contracted trips than for on-demand trips. On weekends, buses tended to be late for contracted trips in 2002, while in 2003 on-demand trips tended to be delayed more.



	1 WkdyAM_Peak	2 WkdyAM_nonPeak	3 WkdyPM_nonPeak	4 WkdyPM_Peak	5 WkdyEven	6 Sat	7 Sun
A	0:03:30	0:03:29	0:03:48	0:04:24	0:01:49	0:02:42	0:02:20
C	0:02:13	0:03:14	0:03:10	0:02:49	0:01:43	0:02:12	0:02:16

Figure 4.27 April-August 2002 Late Pick-up Time Difference within 30 Minutes by Trip Type

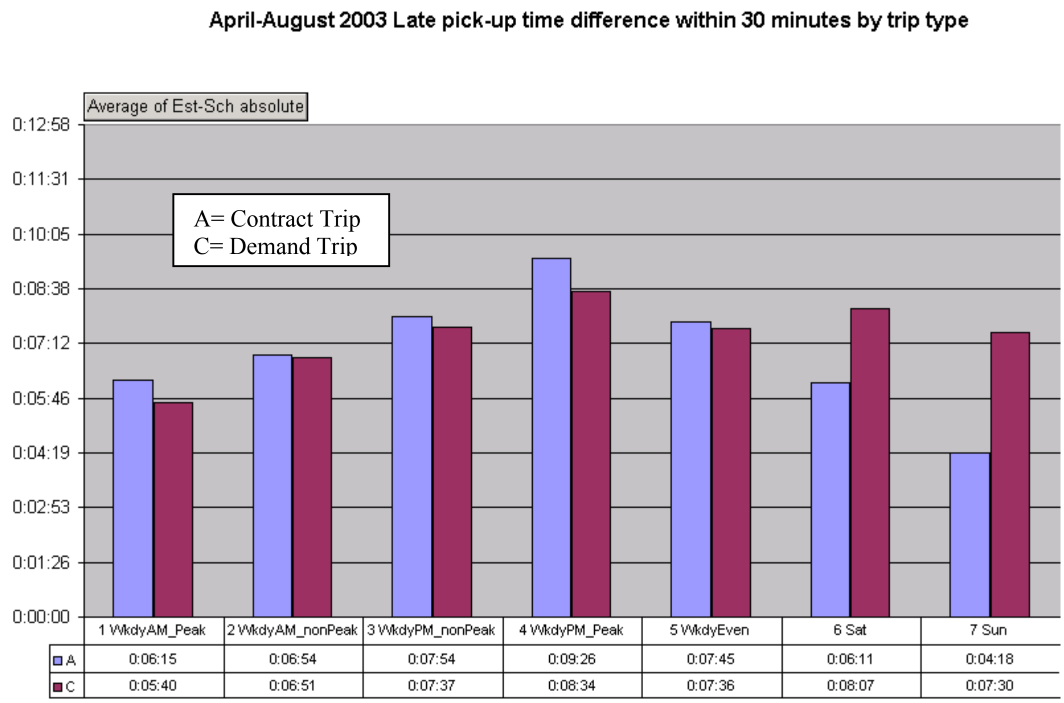


Figure 4.28 April-August 2003 Late Pick-up Time Difference within 30 Minutes by Trip Type

<u>Characteristics of Vehicle Miles Traveled</u>

The following table depicts the vehicle miles traveled during the two five-month periods.

April-August 2002			**VMT per**	**Number**	**VMT per**	**VMT/Bus**
	VMT	**Riders**	**Rider**	**Buses**	**Bus per Mo**	**Per day***
April	68361	10,162	6.73	35	1,953.2	69.8
May	73824	10,136	7.28	37	1,995.2	71.3
June	62129	8,742	7.11	34	1,827.3	65.3
July	64935	9,616	6.75	33	1,967.7	70.3
August	68097	9,079	7.50	32	2,128.0	76.0
AVERAGE	67,469	9,547	7.07	34.2	1,974.30	70.51
April-August 2003			**VMT per**	**Number**	**VMT per**	**VMT/Bus**
	VMT	**Riders**	**Rider**	**Buses**	**Bus per Mo**	**Per day***
April	94,973	11,117	8.54	33	2,878.0	102.8
May	87,734	10,271	8.54	31	2,830.1	101.1
June	77,351	9,870	7.84	30	2,578.4	92.1
July	103,543	9,965	10.39	33	3,137.7	112.1
August	89,567	8,290	10.80	31	2,889.3	103.2
AVERAGE	90,634	9,903	9.22	31.6	2,862.7	102.24
*Assumed 28 days per month						

Table 4.8 Vehicle Miles Traveled, 2002 and 2003

Table 4.8 suggests greater operational efficiency after installing the GPS equipment. Generally, more miles were logged in 2003 than in 2002 with fewer buses. The overall fleet size during the 2002 period was 39 buses; in 2003 the fleet size was 34 buses. In interpreting this data, it should be taken into account that the mileage logged in 2003 is probably more accurate than in 2002 from the point of view that mileage was logged by computer in 2003 rather than driver reports. One source of error in 2003, however, is the driver entering the wrong odometer mileage at the beginning of the day.

Notwithstanding these caveats, the 2002 data indicates that the average daily mileage per bus was about 70 miles, whereas in 2003 the average daily mileage per bus was about 102 miles. Mileage per rider increased from seven to nine miles. The differential between the average trip length reported earlier and the total mileage per rider shown in Table 4.8 arises from the fact that buses do some “dead heading” during the day (i.e., from garage to first trip, return to garage on last trip, travel between pickups, etc.). With fewer buses in 2003, this mileage apparently accounts for much of the increase in VMT over and above actual rider growth. Data for revenue miles was not available. This resulted in an overall increase in mileage between the two study periods of 33%; despite an increase of only 5% increase in rider trips. In summary, after installing the GPS system, fewer DARTS buses delivered an increase in rider demand than in the similar period without GPS.

Economic Characteristics of DARTS Operations

From the pervious analysis, signs can be seen that the new GPS installation has enabled DARTS to enhance its responsiveness. The question remains, however, as to whether the technology is also cost-effective. If paratransit service is to have broader use as a key part of a sprawled urban area’s transportation system, question about its economic feasibility is paramount. The possibility modern communications and computer technology could improve economic practicability is thus of primary importance.

As can be expected, DARTS’ riders are heavily subsidized. From the financial data provided, the average cost per rider in our study period of April to August 2002 was $20.61. In the same period in 2003, the average cost was $22.34 per rider. The average revenue from individual fares paid plus contract riders was $3.11 in 2002, thus requiring a subsidy of $17.50 per ride in that year. In 2003, revenues from the fare box and contracts totaled $2.75, thus requiring a subsidy of $19.59 per rider. As noted earlier, installing the new GPS and MDC system amounted to approximately $3.87 per trip per year (almost all of which was subsidized through grants), and the projected annual costs will run about 1.3¢ per trip per year.

Unfortunately, the following analysis rests on two relatively short time periods of five months each. Thus, working with such limited data involves spikes in costs and revenues that would be smoothed out if operations could be examined over a longer time period. Policy changes, such as a recent fare increase can have an obvious impact. Major differences in the handling of capital expenses occurred between 2002 and 2003. Many of the typical fixed-cost items that a private operation would be reporting (most notably rent) were not available. Because of this, the following analysis has been restricted to variable costs alone.

The tables and charts following provide a picture of the revenues and expenditures that have been experienced before and after installing the GPS technology. The first, Table 4.9, gives a summary breakdown of DARTS' cash flow picture. The follow-up table, Table 4.10, provides the percent distribution of the various costs and revenues. The third table in the series, Table 4.11, depicts costs and revenues per rider along with the percentage change between the study period of 2002 and that of 2003. A fourth table, Table 4.12, is presented depicting the economic performance as a basis for determining the difference between marginal and average costs as well as determining the marginal and average fare box revenues. Four charts are provided (Figures 4.29, 4.30, 4.31, and 4.32) to aid in visualizing marginal costs and revenues. These are bivariate plots of number of riders against costs and revenues for the two study periods.

As expected, labor costs are the primary expenditure. They include drivers, schedule and dispatch personnel, customer service personnel, technical personnel, vehicular maintenance personnel, management, and clerical workers. This data does not include capital and depreciation charges. Thus, the tables include variable costs only. Personnel costs relative to total costs were, on average, consistent for both years (78% of variable costs in 2002; 79% in 2003). Other cost dimensions included an average of 6% for administrative costs (with a range of 4.8% to 8.2%) and an average of 6% for vehicle operations and maintenance (with a range of 3.8% to 9.5%). Insurance costs were consistent for both years, averaging 5.5% in 2002 and 5.2% in 2003.

As expected, the most prominent source of revenue comes from grants and subsidies from Dakota County and from State and Federal sources. On average, in 2002, such grants and subsidies amounted to 86% of all revenues. In 2003, this increased to 90% of revenues. Thus, only 10% of revenue in 2003 came from fares paid by riders either at the fare box or through contracts. A source of drop in contract revenues was the discontinuance of a contract with a vocational technical school in the county. The 2002 revenues reflect this contract; 2003 revenues do not.

On the surface, there is general consistency of economic performance between the two study periods. This would suggest that installing GPS either has had no effect or that effects have not yet been realized after only five months of operation. When marginal costs are considered, there is a shift in the relationship between ridership and costs suggesting the possibility of some stabilizing effects of the post-GPS period.

April to August 2002	April 2002	May 2002	June 2002	July 2002	August 2002
1000 Total Personnel Services	146,347	152,997	178,548	142,447	149,721
1100 Total Admin. Charges	15,110	16,521	10,435	13,190	7,894
1400 Total Insurance Charges	8,696	15,872	10,246	9,231	10,246
1500 Total Taxes & Fees	2,038	2,404	9,118	3,201	15,065
1200 Total Vehicle Charges	8,675	19,932	8,250	10,349	10,304
1300 Total Operations Charges	2,585	2,940	1,475	3,325	2,578
TOTAL OPERATING EXPENSES	*$183,451*	*$210,666*	*$218,072*	*$181,743*	*$195,808*
2010 Total Fare Box Revenues	8,162	14,667	9,813	9,315	14,667
2020 Total System Revenues	16,942	15,025	25,453	14,762	20,223
2100 Total Funding Sources	170,042	188,274	188,835	169,470	172,604
TOTAL INCOME	*$195,146*	*$217,966*	*$224,101*	*$193,547*	*$207,494*
Surplus (deficit)	$11,695	$7,300	$6,029	$11,804	$11,686

April to August 2003	April 2003	May 2003	June 2003	July 2003	August 2003
1000 Total Personnel Services	151,988	159,996	188,486	192,549	171,462
1100 Total Admin. Charges	14,296	10,657	13,851	11,821	13,129
1400 Total Insurance Charges	8,844	10,423	10,573	16,449	11,161
1500 Total Taxes & Fees	2,531	2,186	7,724	2,522	4,761
1200 Total Vehicle Charges	16,171	9,743	20,600	11,872	14,341
1300 Total Operations Charges	4,275	2,608	1,994	3,229	3,051
TOTAL OPERATING EXPENSES	*$198,105*	*$195,613*	*$243,228*	*$238,442*	*$217,905*
2010 Total Fare Box Revenues	14,257	14,171	16,209	12,170	12,141
2020 Total System Revenues	14,722	13,440	13,336	14,312	10,855
2100 Total Funding Sources	199,732	203,289	219,867	431,541	227,193
TOTAL INCOME	*$228,711*	*$230,900*	*$249,412*	*$458,023*	*$250,189*
Surplus (deficit)	$30,606	$35,287	$6,184	$219,581	$32,284

Table 4.9 DARTS Expenses and Revenues (Less Capital and Depreciation)

April to August 2002	April 2002	May 2002	June 2002	July 2002	August 2002	5-Mo Avg
1000 Total Personnel Services	79.8%	72.6%	81.9%	78.4%	76.5%	**77.8%**
1100 Total Admin. Charges	8.2%	7.8%	4.8%	7.3%	4.0%	**6.4%**
1400 Total Insurance Charges	4.7%	7.5%	4.7%	5.1%	5.2%	**5.5%**
1500 Total Taxes & Fees	1.1%	1.1%	4.2%	1.8%	7.7%	**3.2%**
1200 Total Vehicle Charges	4.7%	9.5%	3.8%	5.7%	5.3%	**5.8%**
1300 Total Operations Charges	1.4%	1.4%	0.7%	1.8%	1.3%	**1.3%**
TOTAL OPERATING EXPENSES	100.0%	100.0%	100.0%	100.0%	100.0%	
						5-Mo Avg
2010 Total Fare Box Revenues	4.2%	6.7%	4.4%	4.8%	7.1%	**5.4%**
2020 Total System Revenues	8.7%	6.9%	11.4%	7.6%	9.7%	**8.9%**
2100 Total Funding Sources	87.1%	86.4%	84.3%	87.6%	83.2%	**85.7%**
TOTAL INCOME	100.0%	100.0%	100.0%	100.0%	100.0%	

April to August 2003	April 2003	May 2003	June 2003	July 2003	August 2003	5-Mo Avg
1000 Total Personnel Services	76.7%	81.8%	77.5%	80.8%	78.7%	**79.1%**
1100 Total Admin. Charges	7.2%	5.4%	5.7%	5.0%	6.0%	**5.9%**
1400 Total Insurance Charges	4.5%	5.3%	4.3%	6.9%	5.1%	**5.2%**
1500 Total Taxes & Fees	1.3%	1.1%	3.2%	1.1%	2.2%	**1.8%**
1200 Total Vehicle Charges	8.2%	5.0%	8.5%	5.0%	6.6%	**6.6%**
1300 Total Operations Charges	2.2%	1.3%	0.8%	1.4%	1.4%	**1.4%**
TOTAL OPERATING EXPENSES	100.0%	100.0%	100.0%	100.0%	100.0%	
						5-Mo Avg
2010 Total Fare Box Revenues	6.2%	6.1%	6.5%	2.7%	4.9%	**5.3%**
2020 Total System Revenues	6.4%	5.8%	5.3%	3.1%	4.3%	**5.0%**
2100 Total Funding Sources	87.3%	88.0%	88.2%	94.2%	90.8%	**89.7%**
TOTAL INCOME	100.0%	100.0%	100.0%	100.0%	100.0%	

Table 4.10 Percent Distribution of Variable Costs and Revenues: 2002 And 2003

April to August 2002	April 2002	May 2002	June 2002	July 2002	August 2002	Average per Rider 2002
1000 Total Personnel Services	14.40	15.09	20.42	14.81	15.57	16.06
1100 Total Admin. Charges	1.49	1.63	1.19	1.37	0.82	1.30
1400 Total Insurance Charges	0.86	1.57	1.17	0.96	1.07	1.12
1500 Total Taxes & Fees	0.20	0.24	1.04	0.33	1.57	0.68
1200 Total Vehicle Charges	0.85	1.97	0.94	1.08	1.07	1.18
1300 Total Operations Charges	0.25	0.29	0.17	0.35	0.27	0.27
TOTAL OPERATING EXPENSES	$18.05	$20.78	$24.95	$18.90	$20.36	$20.61
2010 Total Fare Box Revenues	0.80	1.45	1.12	0.97	1.53	1.17
2020 Total System Revenues	1.67	1.48	2.91	1.54	2.10	1.94
2100 Total Funding Sources	16.73	18.57	21.60	17.62	17.95	18.50
TOTAL INCOME	$19.20	$21.50	$25.63	$20.13	$21.58	$21.61
Surplus (deficit)	$1.15	$0.72	$0.69	$1.23	$1.22	$1.00

April to August 2003	April 2003	May 2003	June 2003	July 2003	August 2003	Average per Rider 2003	Percent Change 2002 to 2003
1000 Total Personnel Services	13.67	15.58	19.10	19.32	20.68	17.67	10.02%
1100 Total Admin. Charges	1.29	1.04	1.40	1.19	1.58	1.30	-0.10%
1400 Total Insurance Charges	0.80	1.01	1.07	1.65	1.35	1.18	4.62%
1500 Total Taxes & Fees	0.23	0.21	0.78	0.25	0.57	0.41	-39.34%
1200 Total Vehicle Charges	1.45	0.95	2.09	1.19	1.73	1.48	25.37%
1300 Total Operations Charges	0.38	0.25	0.20	0.32	0.37	0.31	15.49%
TOTAL OPERATING EXPENSES	$17.82	$19.05	$24.64	$23.93	$26.29	$22.34	8.42%
2010 Total Fare Box Revenues	1.28	1.38	1.64	1.22	1.46	1.40	19.15%
2020 Total System Revenues	1.32	1.31	1.35	1.44	1.31	1.35	-30.62%
2100 Total Funding Sources	17.97	19.79	22.28	43.31	27.41	26.15	41.37%
TOTAL INCOME	$20.57	$22.48	$25.27	$45.96	$30.18	$28.89	33.71%

Table 4.11 Variable Costs and Revenues Per Rider: 2002 and 2003

Expenses for Riders Served: 2002

Month	Ridership Rank	Number Served	Var Cost 2002	Avg VC Per Rider	Marginal Cost Per Rider
June	Lowest	8,742	218,072	24.95	
August		9,079	195,808	21.57	-66.07
July		9,616	181,743	18.90	-26.19
May		10,136	210,666	20.78	55.62
April	Highest	10,162	183,451	18.05	-1046.73
Average		9,547	197,948	20.85	-270.84
		Average Marginal Cost Omitting Outlier			***-$12.21***

Expenses for Riders Served: 2003

Month	Ridership Rank	Number Served	Var Cost 2003	Average Cost Per Rider	Marginal Cost Per Rider
August	Lowest	8,290	217,905	26.29	
June		9,870	243,229	24.64	16.03
July		9,965	238,442	23.93	-50.39
May		10,271	195,613	19.05	-139.96
April	Highest	11,117	198,105	17.82	2.95
Average		9,903	218,659	22.34	-42.85
		Average Marginal Cost Omitting Outlier			***-$10.47***

Revenues From Riders Served: 2002

Month	Ridership Rank	Number Served	Fare Box & and Contract Revenues	Average Revenue Per Rider	Marginal Revenue Per Rider
June	Lowest	8,742	20,756	2.37	
August		9,079	22,554	2.48	5.34
July		9,616	15,802	1.64	-12.57
May		10,136	22,554	2.23	12.98
April	Highest	10,162	17,329	1.71	-200.96
Average		9,547	$19,799	$2.07	-$48.80
		Average Marginal Revenue Omitting Outlier			***$1.92***

Revenues From Riders Served: 2003

Month	Ridership Rank	Number Served	Fare Box & and Contract Revenues	Average Revenue Per Rider	Marginal Revenue Per Rider
August	Lowest	8,290	19,996	2.41	
June		9,870	23,304	2.36	2.09
July		9,965	21,929	2.20	-14.47
May		10,271	21,596	2.10	-1.09
April	Highest	11,117	21,721	1.95	0.15
Average		9,903	21,709	$2.19	-$3.33
		Average Marginal Revenue Omitting Outlier			***$1.15***

Table 4.12 DARTS' Economic Performance: April to August 2002 and 2003

Figure 4.29 Plot of Variable Costs vs. Number of Riders: 2002

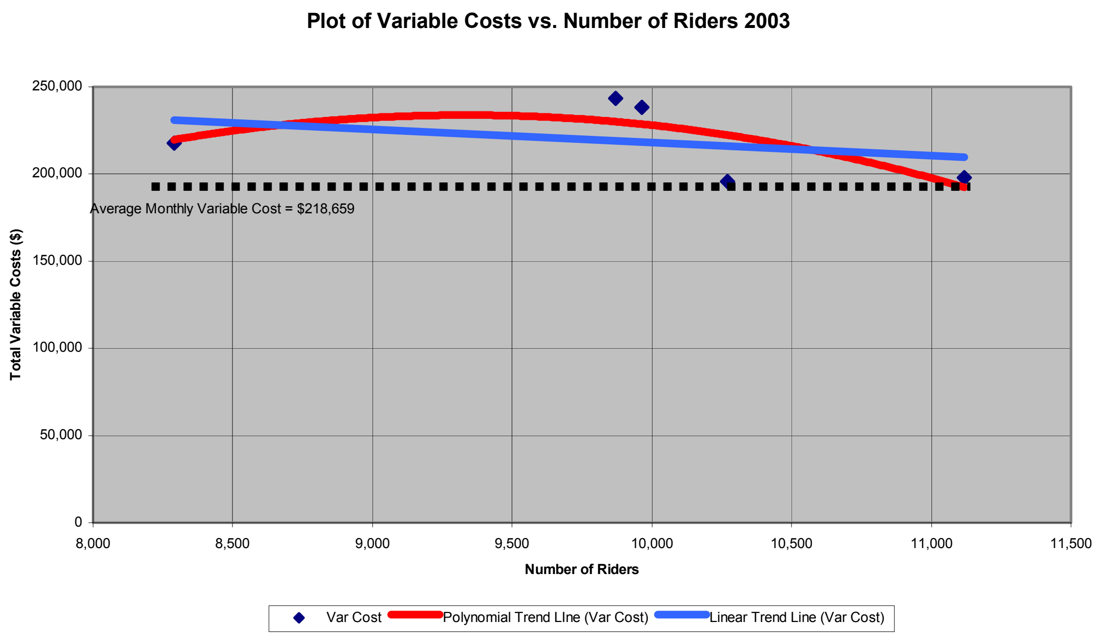


Figure 4.30 Plot of Variable Costs vs. Number of Riders: 2003

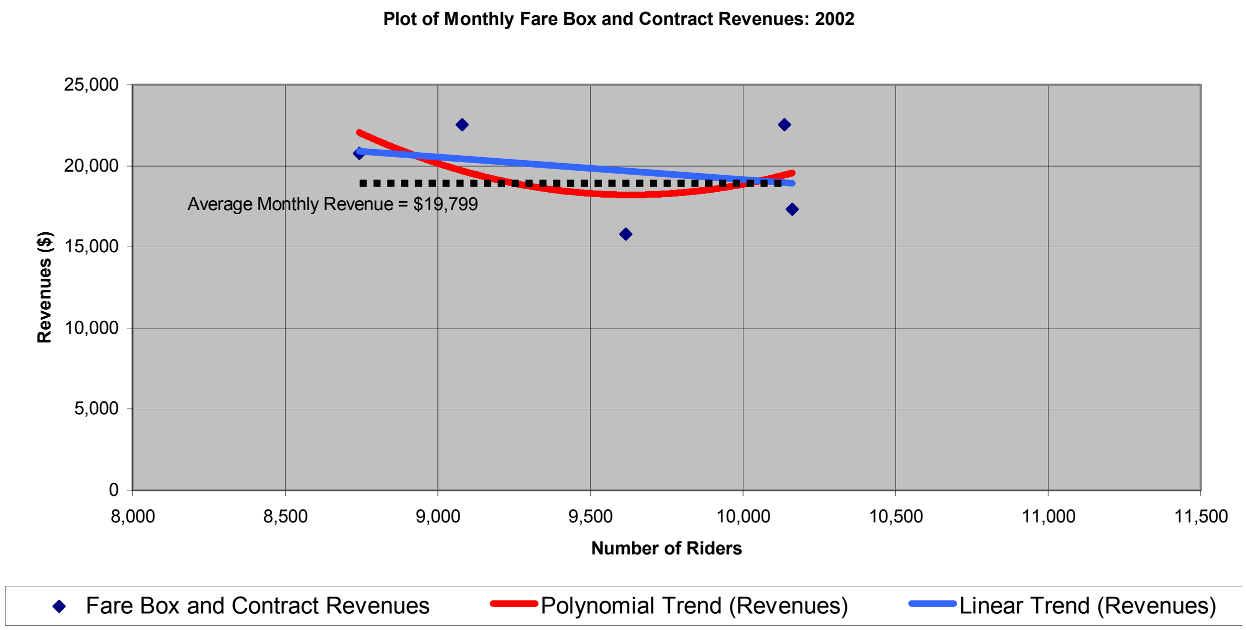


Figure 4.31 Plot of Monthly Fare Box and Contract Revenues: 2002

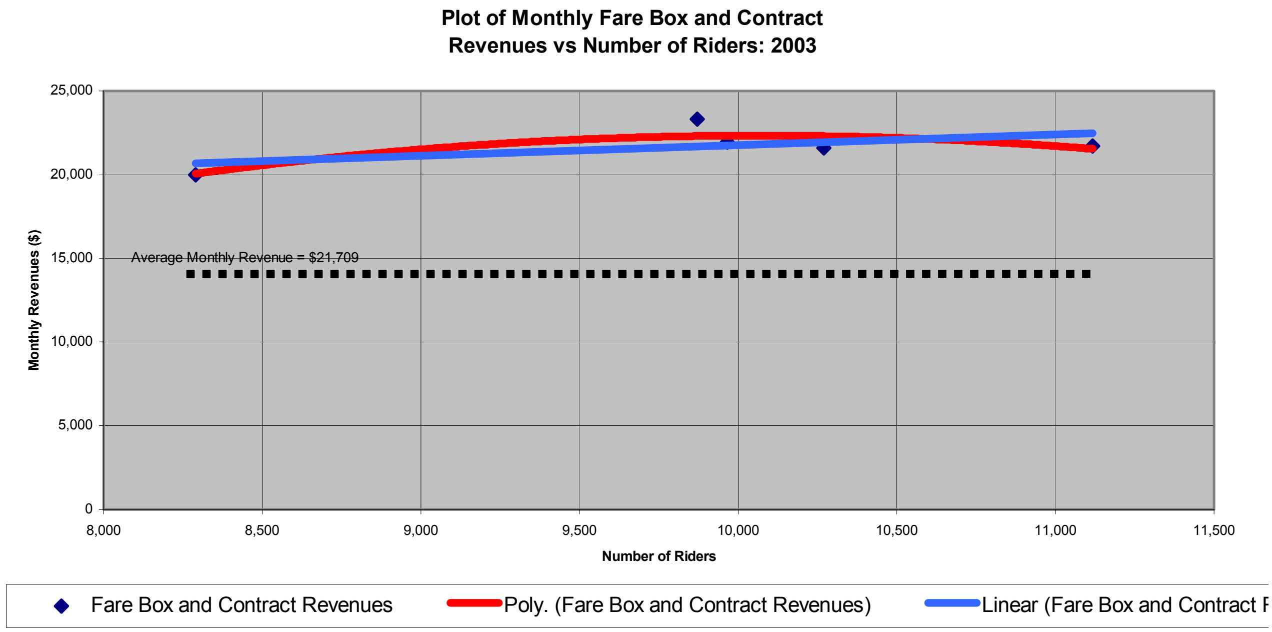


Figure 4.32 Plot of Monthly Fare Box and Contract Revenues: 2003

A simple, traditional method of calculating marginal costs was used. Essentially, working from the lowest level of customer volume, a calculation was made to determine the added cost of serving the next level of customer volume. This calculation was repeated for each of the data points and then averaged. Outliers were omitted to determine an estimate of the most likely value and direction (rising or falling) of marginal costs. Supplementing this calculation were the plots shown in Figures 4.29 and 430. These plots provide a graphical portrayal of the relation between the numbers of riders in each month as against the variable costs of operations of each month. Each figure shows the average costs and revenues per month in a heavy dashed line. In addition, polynomial and linear lines are shown giving the best general fit of the data.

Clearly, with the limited number of data points, there is not a lot of stability in the relationship between costs and the number of riders served, especially for 2002. Figure 4.29 shows a widely scattered plot with the lowest level of ridership in June 2002, yet this month experienced the highest level of variable costs in the five-month period. A polynomial trend line best fits the 2002 data, suggesting steeply falling marginal costs. A break point occurs at 9,600 riders per month followed by steeply rising costs as the number of riders approaches a volume of 10,000 per month. As this figure shows, a linear trend line suggests falling marginal costs although at a more modest rate of decline. The average marginal cost figure for the 2002 period is less than the average variable cost figure, although it must be recognized that both are heavily influenced by the subsidies received to support the service.

This instability in the plot of costs and total riders served disappears in the 2003 data. In Figure 4.30, the relation of riders to costs is much more stable and indicates that there is little difference between marginal costs and average costs. In theory, this suggests that DARTS is operating at an optimal relation between the two. Marginal cost is slightly declining and slightly less than average costs, suggesting that average costs may be declining. This may well be the result of operating with the new GPS technology. In any event, on the basis of relatively limited data, this analysis suggests a limited potential for DARTS to expand its service. GPS technology has provided a basis for more efficient operation at the present scale of operation in contrast to the previous year. While the previous analysis indicates the presence of slack resources, particularly in the morning and afternoon rush hours, it is not clear that fulfilling more use of those slack resources would necessarily mean more efficient operation or the possibility of reducing the subsidy. The data limitations, however, make it difficult to determine this with any surety.

Average marginal revenues were modestly rising in both periods. Both plots, as shown on Figures 4.31 and 4.32 were relatively stable in the relation between monthly revenues and riders. However, while in 2002, marginal revenues were very close to the level of fares (the selling price) in 2003, marginal revenues averaged slightly above one dollar or about one-half the fares in effect before the August 1 increase. (By definition, marginal revenues are always lower than the price of the service.) If this change in the marginal revenue is valid, this also bodes well for expanding service. It should be cautioned, however, that a five-month period is extremely short for reaching solid conclusions about marginal costs and revenues and their relation to variable costs. The estimates provided here should be viewed as preliminary rough estimates. The fact that the estimates show improvement in marginal costs and revenues with the GPS technology period as against the pre-GPS period is also hopeful of the potential of effects that GPS might have on economic performance for paratransit services generally.

Costs per Vehicle Mile

Another measure of changed economic performance as a result of installing GPS is the costs per vehicle mile. Comparison with other transit systems can be made through understanding what it costs to transport a single rider one mile. This calculation is shown in Table 4.13. All mileage data is total mileage. The database did not permit us to calculate revenue miles.

Costs Per Vehicle Mile			
		Operating	
Year =2002	VMT	Costs	Cost/mile
April	68,361	192,794	$2.82
May	73,824	220,009	$2.98
June	62,129	227,415	$3.66
July	64,935	191,086	$2.94
August	68,097	205,151	$3.01
AVERAGE	68,105	213,406	$3.15
		Operating	
Year =2003	VMT	Costs	Cost/mile
April	94,973	206,804	$2.18
May	87,734	204,312	$2.33
June	77,351	251,927	$3.26
July	103,543	247,140	$2.39
August	89,567	226,570	$2.53
AVERAGE	90,634	227,350	$2.54

Table 4.13 Costs per Vehicle Mile

Costs per vehicle mile were significantly improved in the 2003 study period after installing GPS. (A 2-tailed paired sample t-test yielded p= 0.003.) The costs per mile went from $3.15 in 2002 to $2.54 in 2003—a difference of 61¢ or a drop of 17% between the two periods. By this measure, the GPS installation suggests a very impressive reduction in costs.

Also important, however, is an analysis of costs per passenger mile in order to compare DARTS costs with similar experience of other public transit. Table 4.14 shows this based on different load factors per bus (assuming the same levels of subsidy as in 2003). The shaded cells indicate areas where the DARTS system could be competitive in term of subsidy per passenger mile with other forms of public transit. For example, two passengers per bus at the April 2003 level of riders would be roughly competitive with the average subsidy (nationwide) for light rail services. From Table 4.14, it can be seen that the possibility of a most favorable comparison with fixed bus systems would require an average of four passengers per bus per mile (comparisons are based on 2001 nationwide data from the American Public Transit Association).

Cost per Passenger Mile Under Varying Load Factors per Bus							
	Cost per passenger mile if the number of passengers were:						
	1	2	3	4	6	8	12
April	$2.18	$1.09	$0.73	$0.54	$0.36	$0.27	$0.18
May	$2.33	$1.16	$0.78	$0.58	$0.39	$0.29	$0.19
June	$3.26	$1.63	$1.09	$0.81	$0.54	$0.41	$0.27
July	$2.39	$1.19	$0.80	$0.60	$0.40	$0.30	$0.20
August	$2.53	$1.26	$0.84	$0.63	$0.42	$0.32	$0.21
AVERAGE	$2.54	$1.27	$0.85	$0.63	$0.42	$0.32	$0.21

Table 4.14 Cost per Passenger Mile Under Varying Load Factors per Bus

Summary Discussion

The combination of qualitative and quantitative methods employed in this report have provided some key insights as to the operation of a sophisticated paratransit service operating both with and without the use of GPS and on-board computer technology. From the focus groups we learned:

1. Among the SOV commuters, there was only mild enthusiasm about dial-a-ride services, with some indicating that it would not likely stop them from using their own car. Others were cautiously receptive and spelled out the key conditions for success—reliability, safety, and good marketing.
2. Among present DARTS users, the major conclusion is that a well-managed service-on-demand system with up-to-date technology in the scheduling and dispatch functions can provide quality service to people with limited transportation alternatives. It is not clear from this panel that the introduction of GPS technology has made significant difference since the quality of service already was perceived to be high. While some on the panel were strongly opposed to any change in the present service, others did express the view that such a service should be available to others in the community. From this panel, one can tentatively conclude the present size and geographic scale of the DARTS system successfully meets the needs of its present clientele.
3. Among those who drive the DARTS buses, there were mixed reviews. Some of the problems discussed were confirmed in conversations with dispatchers. There would appear to be the expected "bugs" that seem to be endemic of any new technology, but overall the drivers' perspective of the new equipment was basically positive. They liked it, but they still needed the reassurance of a back-up facility when things didn't work as expected. Thus, former practices are still in place—particularly the ability for voice communication and reliance on paper schedules—and these helped to maintain a smooth effective operation.

While the question of driver training did not seem to be taken too seriously, it is clear that DARTS is experiencing a learning period for the new technology. In the operational analysis, noteworthy improvements began appearing in the fourth and fifth months of operation. While most drivers felt the equipment was easy to use and that extensive training was not necessary, it would nonetheless appear that mistakes occurred that more training might have prevented. For other agencies contemplating a GPS and on-board computer system, it would be important to insure that full training in the use of the system takes place.

From the analysis of operational statistics, we learned that there was an overall improvement in responsiveness after the GPS installation as measured in the decline of denials of same-day trip requests. This decline actually improved with each additional month of experience in working with the GPS and MDC equipment. Overall, the difference between the 2002 experience and the 2003 experience had a statistical significance at the p=0.08 level—suggesting there would be greater possibility of error in asserting there was no difference between the two years.

Also found were improvements in the length of time that transpired between when a rider was promised a pickup and when the bus actually arrived. A considerable number of trips actually found the bus arriving before the scheduled pick-up time. In fact, in the 2003 study period, the bus showed up ahead of time at almost double the rate of 2002. Overall, the DARTS system operated surprisingly well on this factor during both study periods. Taking into account sources of error in the data for both periods, it would seem, other things being equal, that the GPS installation was helpful in providing a more reliable and predictable relationship between a promised pick-up time and the actual time. Clearly, on the question of reliability, DARTS operated at a very high level in both study periods. There was a slight enhancement, especially in early arrivals, in 2003.

The analysis of operational characteristics by time-of-day showed demand was at its highest in the mid-day off-peak hours. This can be inferred to be caused by: 1) the availability of cheaper fares in the off-peak hours and 2) a significant number of riders for whom travel in the usual rush hours is not essential. This characteristic does suggest a potential slack capacity where more trips could be accommodated during the regular morning and evening rush hours. This is in direct contrast with general public transit services where rolling stock is required for the morning and evening rush hours and sits relatively idle during mid-day off-peak hours.

One-third of DARTS trips are work trips indicating there is already a service to people in the labor force. It is, however, a labor force where one can infer part-time employment (given morning rush-hour demand being almost double the evening rush-hour demand) as well as the likelihood of working hours other than the typical 8 a.m. to 5 p.m. employment.

In addition to work trips, DARTS users predominantly use the services for basic needs: medical appointments, shopping, and travel to social services. It is little used for purely recreational or social trips. Overall, there was little change in trip purposes between 2002 and 2003 so that the presence of GPS had little effect on the reasons for travel.

A similar result was found for trip length. Trips for both years were logged in at between three-and-a-half and four-and-a-half miles. This did not change in any significant way as a result of the GPS installation. DARTS organizes its services on a subregional basis so that trips in excess of five miles are rare. This is helpful in maintaining efficient use of rolling stock and seems to indicate an appropriate fit between the number of buses in the fleet (supply) and the demand for services among the elderly and disabled. It cannot be concluded from the present study whether the length of trip would be a significant constraint on paratransit services for the general public.

In spite of high subsidies for the DARTS operation, its economic performance did show improvement with the presence of GPS. The five-month period in 2003 showed a distinct smoothing out of marginal costs and in the relation of marginal costs to average costs. The high subsidies do pose a challenge for adapting in-demand paratransit services to serving the general population. Nationally, on-demand services receive only around 7% of all subsidies for public transit. (More than 50% of all public spending on transit went to fixed-route bus systems; see Table 4.15). However, in the relationship between revenues and expenditures, the national average subsidy for on-demand service runs to about 90%. DARTS subsidies are very similar. In terms of subsidy per passenger mile, from 1995 data it can be seen that on-demand services had the highest subsidy of all. The rankings by mode were:

Mode	Subsidy per passenger mile
On-Demand, Paratransit	$1.70
Light Rail	$1.15
Trolly Bus	$1.06
Bus	$0.51
Commuter Rail	$0.33
Heavy Rail	$0.32

Source: American Public Transit Association as compiled by T. Litman, 2002

One reason for this was that the load factor for on-demand services tends to be considerably lower than that of other transit services. National data indicates that passenger loading of paratransit vehicles is, on average, less than two (APTA, 2003), and the DARTS experience is similar. With an average passenger load of almost 11 on fixed-route buses and around 14 on light- rail vehicles, it is clear that paratransit—to be a general purpose public transit option—would have to make a concerted effort to increase its passenger loading. This, of course, lies in contradiction of the demands for personal attention required by disabled or frail passengers.

United States 1999 Public Transit Expenses and Revenues	Bus	Commuter Rail	Demand Response	Heavy Rail	Light Rail	Trolly Bus	Total
Capital Expenses (millions)	3,249	1,622	122	2,707	1,005	90	8,795
Operation Expenses (millions)	11,714	2,575	1,419	3,693	546	167	20,114
Total Expenses (millions)	14,963	4,197	1,541	6,400	1,550	257	28,908
Average Fare per Trip	$0.74	$3.31	$1.59	$0.92	$0.56	$0.50	$0.90
Total Fare Revenues (millions)	4,175	1,309	159	2,323	164	60	8,190
Subsidies (millions)	10,788	2,888	1,383	4,077	1,387	197	20,720
Vehicle Revenue Miles (millions)	1,973	244	608	561	48	14	3,448
Capital Cost per Revenue Mile	$1.65	$6.66	$0.20	$4.82	$21.02	$6.60	$2.55
Operating Expenses per Revenue Mile	$5.94	$10.57	$2.33	$6.58	$11.41	$12.27	$5.84
Total Expenses per Revenue Mile	$7.58	$17.24	$2.53	$11.40	$32.44	$18.88	$8.39
Passenger Miles (millions)	21,205	8,766	813	12,902	1,206	186	45,078
Average Vehicle Occupancy	10.7	36.0	1.3	23.0	25.2	13.7	13.1
Total Expenditure per Passenger Mile	$0.71	$0.48	$1.90	$0.50	$1.29	$1.38	$0.64
Fares per Passenger Mile	$0.20	$0.15	$0.20	$0.18	$0.14	$0.32	$0.18
Subsidy per Passenger Mile	$0.51	$0.33	$1.70	$0.32	$1.15	$1.06	$0.46
Percent Subsidy	72%	69%	90%	64%	89%	77%	72%

Source: American Public Transit Association as compiled by T. Litman, 2002.

Table 4.15 United States 1999 Public Transit Expenses and Revenues

Overcoming these differentials will be the primary challenge in determining the feasibility of having paratransit available to the general public. The nature of the service (reliable door-to-door service) would likely be attractive to some SOV auto users. The question remains, however, as to what will be the public cost of diverting one SOV driver to a paratransit service. Can such an investment effectively relieve some demand for new investment in highway construction and maintenance? A recent study argued that for optimal freeway performance in the Twin Cities, an additional 1,150 lane miles of new freeway capacity would have to be built. Most of this occurred within the Metropolitan Urban Service Area (MUSA) line and did not take into account future land use changes in collar counties. Notwithstanding this, a modest estimate for building these new lanes would be in the range of $10 billion. (Davis and Sanderson, 2001)

There were no significant changes in operational safety. Both periods experienced only minor incidents. From April to August 2002, there were eight incidents, seven of which involved other vehicles. No serious damages were inflicted and no one was injured. In 2003, there were six incidents in the five-month period of which only two involved other vehicles. Again, no serious damages were inflicted and no one was injured. While the post-GPS period had fewer incidents, this would appear to be merely by chance. What clearly stands out from the accident reports is that DARTS has an excellent safety record, both in the pre-GPS and the post-GPA periods.

Conclusions
There has been considerable information learned about the operation of a paratransit service of the size, scale, and advanced technological sophistication of DARTS. The issue is not completely settled as to whether the addition of GPS and on-board computers has enhanced the capacity of the service to the point where it could effectively become a key player in suburban public transit and lure SOV drivers from their cars.

Installing GPS equipment has clearly had a positive influence on DARTS' operations. There is also evidence that this influence improves with each month of experience. What is not so clear is the extent to which the service could be expanded to more comprehensively serve the general public.

More riders could be served by DARTS in the morning and evening rush hours (especially the latter). The number of riders per trip could likely be improved. However, from our limited ability to determine the relation of marginal costs and average costs, and given the large numbers of disabled patrons needing special attention, it would appear present operations are reasonably close to capacity.

The primary question, then, is whether an on-demand agency serving the public at large (including disabled) could provide the kind of service that would attract SOV drivers from their automobiles. From our analysis, it would appear that a load factor of four riders per trip would be necessary in terms of cost (more than double the current average load). Present day auto costs can be estimated at about 40¢ per mile. The attractiveness of paratransit thus comes down to some of the same factors that may or may not influence whether an SOV driver can be lured into any form of public transit. Clearly, the on-demand service has many features that would make it more competitive than fixed-route buses or rail services—with its door-to-door service available at the times and places of the rider's choosing. The critical factor will clearly be the cost and, more particularly, what level of public subsidy can be seen as desirable in contrast with other transportation options.

There are other benefits of paratransit services, some of which are already served in the Twin Cities. For example, they can be used as shuttles between places of high demand (airport to downtown hotels or the Mall of America). They are currently available as intra-campus transportation for the University of Minnesota as well as hospitals in the region. On-demand services can serve as feeders into a fixed-route bus line or a light-rail line. They can serve the transportation needs of special events (such as the State Fair) or provide group transportation for business or social purposes.

From the perspective of this study, on-demand services could be viewed as becoming a much more important element in an overall Transportation Demand Management (TDM) program, serving to reduce not only suburb-to-suburb SOV commuting travel, but also all of the conceivable trip purposes arising from short distance, suburb-to-suburb travel demand.

DARTS currently serves a specific clientele—the elderly and disabled. It would probably not be reasonable to expect DARTS to significantly expand its services to presently non-eligible riders. DARTS' technological improvements over the past decade, however, and its most recent experience with GPS, suggest that a similar subregional agency of the same capacity and geographical extent could well be an important component of a public transportation campaign against rising automobile congestion. A system that can provide 600 to 700 trips per day with door-to-door service, within a reasonable subsidy, could provide an important contribution to fulfilling transportation needs with less congestion and other attendant problems associated with rising automobile costs—especially in handling the many relatively short suburb-to-suburb trips.

In terms of the original objectives of this report, it can be concluded that GPS has made a significant contribution to the DARTS system. GPS has aided in making DARTS a more responsive and reliable service. It has stabilized costs. Our examination covered too short a period to do more than speculate about as yet unrealized benefits. Yet, the analysis provides us with a considerably improved picture of the potentials and limitations of on-demand paratransit services.

Thus, a call for more research is apparent. Five months of before-and-after experience has been able to lay only the groundwork for a fuller understanding of potential future benefits. There is a need for experimentation to further reduce subsidies and enhance vehicle load factors. For one such experiment, DARTS might try a pilot project to try to attract more rush hour commuters. Through 1) an expansion of service hours, 2) marketing, and 3) relaxing eligibility requirements for rides between 6:30 and 9 a.m. and from 3:30 to 6:30 p.m., it may be possible to determine the degree to which SOV drivers are willing to turn to an on-demand, door-to-door service with fares at current Metro Transit rates. These trips could be restricted to Dakota County and to trip lengths of seven to eight miles (so that they would not be available for travel to the central downtown areas of Saint Paul and Minneapolis). Such a pilot project would require careful monitoring of operations, logistics, costs, and subsidies.

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CHAPTER 5
Stranded But Connected?
Case Study of Wireless ITS Systems for Emergency Medical Services in Small Town and Rural Environments

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Abstract
This paper investigates challenges to the deployment of effective Emergency Response and Management Systems (ERS/EMS) in rural areas. Using concepts of Interorganizational Systems and the National ITS Architecture, researchers build a framework for investigation of ERS/EMS in rural Minnesota. This framework allowed the identification of technology, institutional, and policy issues. These technical and non-technical dimensions were further examined through a series of in-depth interviews with practitioners and stakeholders throughout the state, supplemented by review and analysis of key evaluations of and reports on candidate ERS/EMS systems. Key technology concerns include slow systems upgrades and coverage gaps, protracted integration of wireless communications to existing infrastructures, and competing (and expensive) standards for deployments. These issues were intertwined with organizational aspects, such as the complexities in developing coordinated and cooperative relationships among agencies in ERS/EMS and staffing and training challenges in rural areas. Underlying these constraints was the need for an integrating policy framework, including a more strategic approach to devising and funding new systems. Recommendations are made on the need to: 1) integrate emergency management systems into local and statewide planning processes, 2) assess adequacy of rural wireless coverage, 3) execute a comprehensive socio-technical approach to ERS/EMS and ITS deployment in small communities, and 4) provide cross-training and related local partnership-building support. The aim of these recommendations is to assist state agencies and policy makers in their efforts to create effective and innovative mobile safety systems in small town and rural environments.

Introduction

In 1991, the U.S. Congress mandated the Intelligent Transportation Society of America (ITSA) to provide leadership in the development and deployment of Intelligent Transportation Systems (ITS) on a national level. The mission of ITSA states that it serves "to foster public and private partnerships to increase the safety and efficiency of surface transportation through the application of advanced technologies"(1). Each state has undertaken responsibility to provide strategic direction for the statewide deployment of ITS. The State of Minnesota has launched the Guidestar project to conduct research for the testing and deployment of advanced transportation technologies to "save lives, time, and money"(2).

Over the last decade, the Minnesota Guidestar program has tested and deployed a variety of ITS products and services drawing upon private firms, state agencies, and learning institutions, including the University of Minnesota. These organizations are important in fostering partnership development in the fast growing ITS market. A projected $209 billion will be invested in ITS between now and the year 2011—with 80 percent of that investment coming from the private sector in the form of consumer products and services (1). According to estimations, this investment, in combination with input from many private companies, will increase the number of ITS-related partnerships and alliances and therefore raise the number of information systems that link these partnership organizations and technologies within each separate entity.

The need for local partnerships to implement ERS/EMS aspects of Intelligent Transportation Systems is also evident from statistical data from rural areas of Minnesota. According to the Minnesota Department of Transportation (Mn/DOT), only 30 percent of miles driven within the state are on rural roads, yet 70 percent of fatal crashes occur on them (3). In addition, 50 percent of rural traffic deaths occur before arrival at a hospital. Appropriate medical care during the "golden hour" immediately after injuries is critical to reducing the odds of lethal or disability consequences. Crash victims are often disoriented or unconscious and cannot call for help or assist in their rescue and therefore rely heavily upon coordinated actions from medical, fire, state patrol, telecommunications, and other entities.

In this study, we focused on implementation of one of the subsystems of ITS, Emergency Response and Management Systems (ERS/EMS), in rural areas of Minnesota for three specific reasons. First, Minnesota has been aggressively pursuing ITS initiatives for several years and thus offered a test bed for various research projects, including emergency response and mayday demonstrations. Second, rural areas do not have the technological infrastructure that exists in larger metropolitan areas. This offered the opportunity to explore specific barriers that may not exist in metropolitan areas. Third, rural areas of the state have often established immature partnerships in relation to ERS/EMS deployment, whereas many metropolitan areas have well-established partnerships. Thus, the opportunity existed to explore local implementation of effective ERS/EMS from an emergent interorganizational perspective.

To understand the means of operating effective ERS/EMS infrastructures in Minnesota, we used a case-study approach. In this paper, we will first describe ERS/EMS as a subsystem of the Intelligent Transportation System (ITS) and then describe Interorganizational Systems (IOS) theory in order to establish a background for a conceptual framework. We then use this conceptual framework to explore ERS/EMS infrastructures in rural Minnesota from technology, institutional, and policy aspects. Based on the analysis and theoretical studies of IOS, we develop a conceptual architecture for ERS/EMS practices, taking into consideration Minnesota's rural characteristics. Finally, we conclude by discussing implications of this study for deploying ERS/EMS in rural regions.

Framework of the Study

Emergency Management and Response Systems (ERS/EMS) and Intelligent Transportation Systems (ITS)

A broad range of diverse technologies, known collectively as intelligent transportation systems, includes "information processing, communications, control, and electronics"(1). Sensory devices, software programs, cameras, cellular, landline, and satellite telecommunications are among many technologies included to ITS. These technologies provide "the intelligent link between travelers, vehicles, and infrastructure"(2). The integration of various advanced technologies into the transportation system has formed several subsystems within ITS and hundreds of smaller divisions within subsystems.

The Emergency Response and Management System is one of the most distributed subsystems of ITS. The ERS/EMS subsystem includes many different organizations, services, and technologies. First responder services, such as law enforcement, fire, and state patrol, health care facilities, state departments of transportation, wireless and wire line telecommunications service providers, emergency response call centers, and some private organizations compose the complex ERS/EMS infrastructure.

Many technologies used within ITS enhance performance of ERS/EMS. One example relates to the extensive use of cellular phone technology. Although rapidly growing use of cell phones is placing a heavy burden on emergency response agencies, the advent of private sector telecommunications and cellular service has played a pivotal role in bringing the safety information network online. In the past ten years, wireless phone use has grown exponentially (4). There are more than 120 million wireless users making more than 140,000 emergency calls a day across the United States (see Figure 5.1). For the same period, Emergency Medical Services notification times for fatal crashes have dropped an average of 30 percent (see Figure 5.2), as a caller does not have to depend on a conventional phone line for communications access.

According to the Minnesota Guidestar Program, there is a need to integrate new technologies with the existing emergency response infrastructure. In addition, there is a need to integrate organizations within the infrastructure through private-private and public-private partnerships and thus create cross-organizational synergies for institutionalizing ERS/EMS.

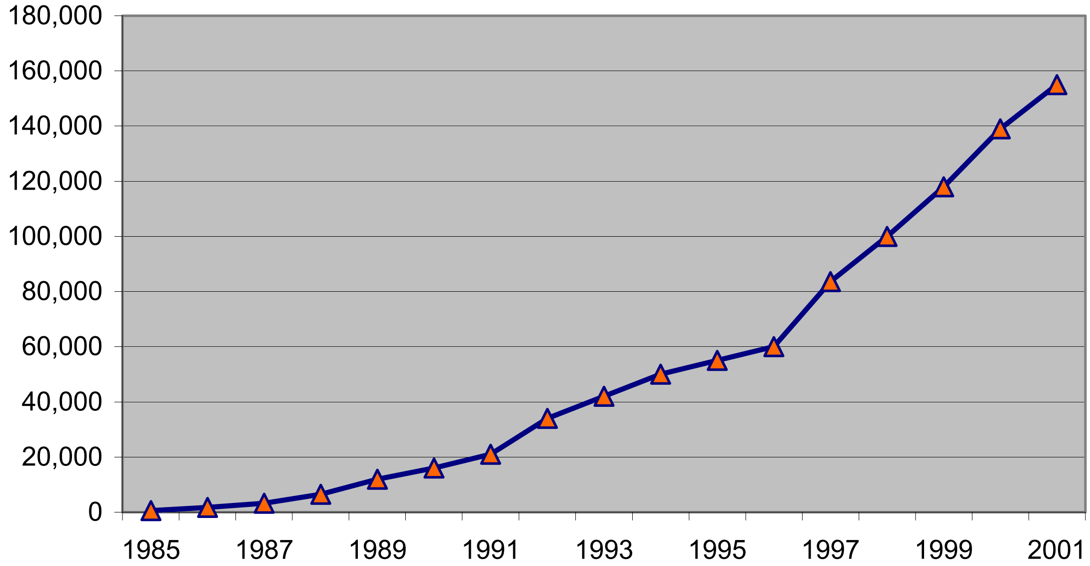

Figure 5.1 Estimated Number of Wireless Emergency Calls Per Day in the U.S.

Source: Cellular Telecommunications and Internet Association, Cellular Carriers Association of California, California Highway Patrol, New York State Police. http://www.wow-com.com/industry/stats/e911/. Accessed August 15, 2002.

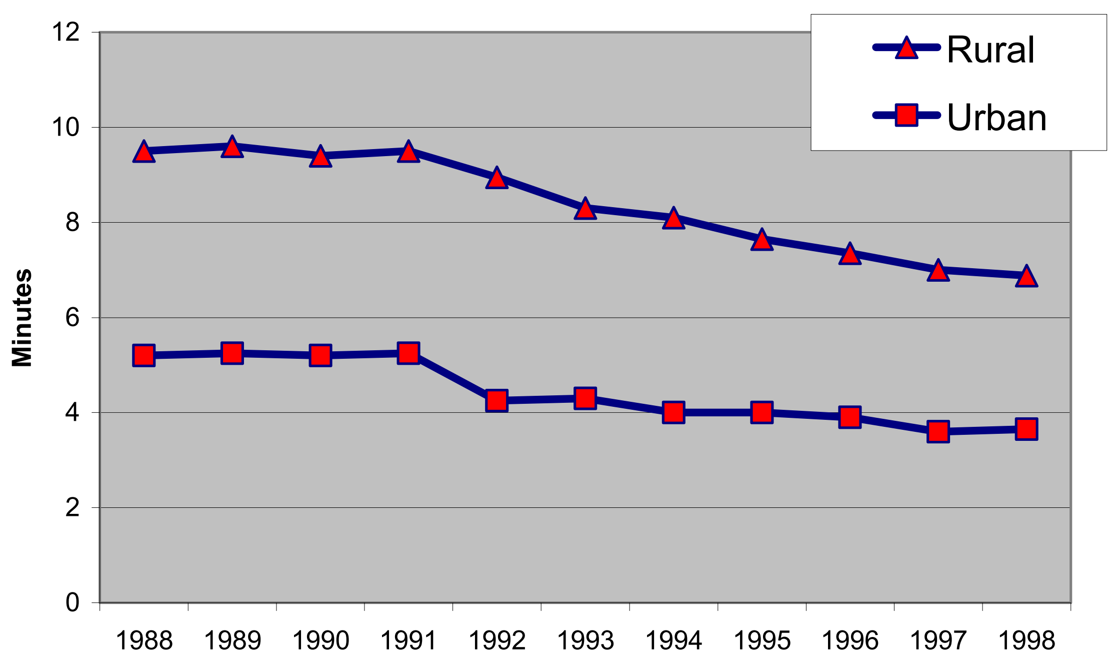

Figure 5.2 Time of Fatal Crash to EMS Notification, U.S. Averages (in minutes)

Source: ComCare Alliance. http://www.comcare.org/research/topics/wireless.html. Accessed August 15, 2002.

Interorganizational Systems (IOS)
There is no doubt that we now live in a "Networked Society." The question of whether we have learned to manage these networks in effective ways continues to dwell in the minds of researchers. Amin states that every economic and social function depends upon the secure and reliable operation of energy, telecommunications, transportation, financial, and other infrastructures (5). As these infrastructures have grown more complex to handle a variety of demands, they have become more interdependent (5). Effective operation of these networks requires the capability to manage many factors that lie beyond the control of one entity. The interconnections that cross organizational boundaries are often referred to as Interorganizational Systems (IOS).

In the broadest sense of the term, IOS help to foster relationships between independent organizations using information technology. Cash and Konsynski define IOS as "an automated information system shared by two or more companies"(6). Bakos defines similarly IOS as "an information system that links one or more firms to their customers or their suppliers, and facilitates the exchange of products and services"(7). Johnston and Vitale state that "An IOS is built around information technology, i.e. around computer and communications technology that facilitates the creation, storage, transformation, and transmission of information"(8).

While most of the earliest studies conducted on IOS centered on the objective of private sector "competitive advantage,"(9) some of the recent studies have focused on a cooperative rather than a competitive dimension of IOS implementation among partner organizations (10). These studies describe barriers and conflicts related to relationship building among partner organizations and their effect on functionality of IOS. In addition, these studies imply that adoption and implementation of IOS are complex matters due to the difficulty of building smooth interagency relationships within the system (11). This is evidenced by a high failure rate of interorganizational relationships (partnerships, joint ventures, and other entities) and their representative information systems (12).

IOS may not simply be a technical system that crosses organizational boundaries. It has become a representation of a more complex system of technical, institutional, and relationship-building dimensions in interagency levels. IOS involve the cooperation and commitment of all the participating members. As such, these participants "may have complex economic and business relationships between themselves that result in a number of technical, social, political, and economic factors influencing the adoption of IOS" (11).

The case of ERS/EMS provides an interesting illustration of IOS in that public and private agencies need to interact both technically and organizationally in a time critical fashion to deliver heath care services to travelers. Moreover, as it is often the case in complex systems, the rapid growth of wireless emergency systems has "emergent properties" in that there has not been a uniform system for implementing such usage. Rather, it has grown out of the rapid penetration of commercial wireless services throughout the population. In this manner, the case of ERS/EMS also provides an interesting illustration of how ITS needs to respond to new forms of services that grow out of private industry platforms, but have direct implications for the goals of ITS—that is "providing the intelligent link between travelers, vehicles, and infrastructure"(2).

National ITS Architecture
In this study, the National ITS Architecture is applied as a framework to analyze current functionality of ERS/EMS in rural areas of Minnesota. The National ITS Architecture was developed by the U.S. Department of Transportation in collaboration with the Intelligent Transportation Society of America (ITSA) as a framework to define the interactions between the transportation and telecommunication domains to create and offer ITS services throughout the nation. The purpose for applying the National ITS Architecture in this study is that its design helps "to mitigate the complexity involved in dealing with numerous complex entities"(13). One of its basic concepts relates to the "decoupling of the transportation and telecommunication domains into two, fairly independent, yet tightly coupled 'layers'"(13). In addition, the architecture focuses on connecting separate, yet partnered entities and is therefore relevant in the study of interorganizational aspects of ERS/EMS formation in rural Minnesota.

The framework is used for constructing interview questions, determining the scope of the document analysis, analyzing findings, and developing an architecture for effective ERS/EMS, taking into consideration the specific case of rural Minnesota. The National ITS Architecture includes the following three layers:

- Transportation Layer—This is the physical ITS infrastructure. This layer identifies key players and establishes a common terminology for existing and future ITS subsystems. The Architecture encompasses essentially (1) travelers; (2) vehicles; (3) management centers; and (4) roadside appliances.

- Communications Layer—This information infrastructure connects the technological elements of the transportation layer. The Architecture carefully lays out (1) what types of information and communication support various ITS services; (2) data sharing and use by physical entities (subsystems); and (3) sets of standards to facilitate data sharing and use.

- Institutional Layer—This layer determines the socioeconomic infrastructure of organizations (agencies of all governmental levels, public and private entities) and their social roles, reflecting jurisdictional boundaries. The institutional layer includes developing local policy, financing ITS, and creating partnerships to guide ITS development (14).

Methodology
To explore challenges to establishing effective ERS/EMS policy within the case study context of Minnesota, we deployed two research techniques. The methodology included expert interviews as the primary tool and analysis of existing technical and policy document reviews on ERS/EMS test projects in Minnesota as the secondary one.

Interviews
The principle data used in this case study were in-depth interviews with representatives of multiple organizations that participate in public-private and private-private ERS/EMS partnerships. In Spring 2001, a preliminary set of group interviews was conducted on the general subject of wireless infrastructure and implications for access and safety in rural areas.

After further refinement of the study objectives, a second round of in-depth interviews was carried out in Fall 2001. Representatives from six public and private organizations in rural Minnesota provided their responses to open ended questions, which reflected technical, institutional, and policy aspects of wireless technology integration into ERS/EMS. Organizations included Virginia County State Patrol, Virginia Country Fire Department, Minnesota Department of Transportation Office of Electronic Communications, Duluth Economic Development Association, Rochester Police Department, Mayo Medical Transport, and the City of Rochester mayor's office. Results from the second round of interviews were documented for later synthesis.

In Spring and Winter 2002, a third round of in-depth interviews was conducted on the general subject of transportation safety, particularly public access into the IOS. In this round, expert representatives from seven public and private organizations presented their opinions and views on institutional, technology, and policy issues. The organizations included the Rhode Island E-911 Board, Public X-Y Mapping Project, AK Associates, Mn/DOT, Mayo Clinic, Minnesota Department of Administration, and the Metropolitan 911 Board.

Document Reviews
As a supplement to these interviews, a series of research and project reports relative to ERS/EMS in Minnesota were reviewed. In recent years, Minnesota has implemented ERS/EMS and ITS test projects, including ARTIC, MayDay Plus, DiVert, and others. Generally, these projects aimed at integration of advanced wireless technologies into transportation and communication infrastructures. Several central reports included:

- 800 MHz Statewide Report (2001)—This report presented a study and assessment of the current and future wireless communication requirements, needs and concerns of the local units of government, Emergency Medical Services community, school districts, and major user groups within the state of Minnesota.

- 9-1-1 Dispatching: A Best Practices Review Summary (1998)—This summary provided an assessment of safety dispatching in several Minnesota counties. It also identified best practices to achieve improved service delivery and intended to help communities to learn about effective methods of Public Service Answering Point (PSAP) regulation.

- Mayday Plus Operational Test (2000)—This report described results of testing and establishing an emergency detection and response infrastructure in Southeastern Minnesota. Specifically, it evaluated use of the Mayday Plus system, which allowed a direct voice and data link from a vehicle to emergency dispatchers.

- Advanced Rural Transportation Information and Coordination (ARTIC) Operational Test Evaluation Report (2000)—This report presented results of an evaluation project in Northeastern Minnesota. The project promoted the integration and sharing of resources and dispatching operations for four transportation agencies: District 1 of Mn/DOT, Minnesota State Patrol (MSP) District 3100, City of Virginia Dial-a-Ride, and Arrowhead Transit Services.

- During Incidents Vehicles Exit to Reduce Time (DIVERT) Evaluation Report (1998)—This evaluation described results of the use of a system that helped to divert and route traffic around freeway incidents in a planned and coordinated manner in the city of St. Paul.

- Emergency Medical Services Radio Communications Needs Assessment Report (2001)—This report presented technical expertise and evaluation recommendations addressing increasing concerns and problems arising in the wireless radio backbone communications networks of state agencies in greater Minnesota.

- Transportation Operations Communications Center (TOCC): Concept and Migration Plan (2000)—According to the plan, Mn/DOT and MSP collaborated to better serve traveler needs through the integrated TOCCs.

- National Intelligent Transportation Systems Program Plan, v.1 (1995)—This plan outlines major concepts and strategies of national deployment of ITS and research challenges for stakeholders across all levels of government and industry.

These sources helped inform the context for the Minnesota case study and provided specific data on selected implementation trends and challenges.

Findings
Both the interviews and reports served to identify major difficulties and achievements in establishing well-functioning and efficient ERS/EMS in Minnesota. As a point of departure, it is important to note that Minnesota has established a strong record of demonstration and implementation for ITS generally. For example, Minnesota Guidestar, the state's ITS program, has carried out a number of projects to provide traveler information, promote transit ridership, and improve traffic control and incident management. Consequently, the Minnesota ITS program has deployed several ITS features (e.g. ramp meter controls) at a rate greater than the national average and continues to take a leadership role in testing rural deployments (15) (16).

With regard to ERS/EMS specifically, results of expert interviews and document surveys revealed several critical issues. First, by way of overview, Figure 5.3 displays current interorganizational relationships in the Minnesota ERS/EMS and their connections with communications technologies on one layer and organizations and policies on lower layers. In terms of challenges to making this system function effectively, experts discussed problems of technical problems in coverage when serving the public during emergency responses. Several documents revealed difficulties such as establishing interagency cooperation, which was the key to successful implementation of ITS technologies. In interviews, experts discussed policy issues such as a lack of timely technology upgrades due to insufficient funding. Experts also raised issues related to a lack of policy incentives to provide full cell phone coverage in rural areas. As the discussion topics were qualified as technology, organizational, and policy issues, researchers organized the structure for analysis accordingly.

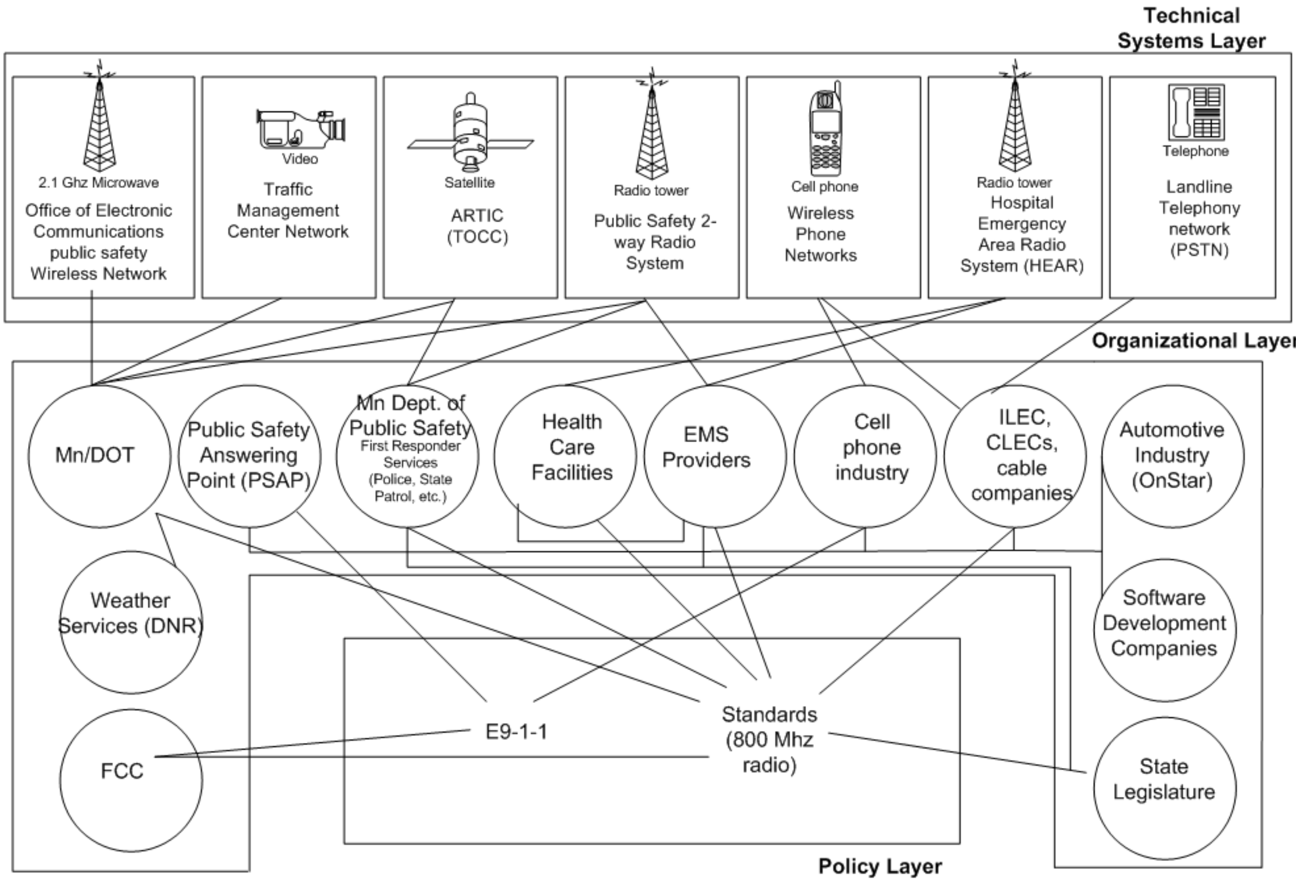

Figure 5.3 An Interorganizational Architecture for Emergency Management Systems

Technology Issues
A complex characteristic of ERS/EMS can be explained by its composition. ERS/EMS comprises many organizations and services that greatly rely upon technology, performing the vital liaison function for coordinating actions within the system. While there is no doubt that the technology exists to create state-of-the-art ERS/EMS, major barriers exist to implementing and managing them.

The challenge of deploying new ERS/EMS services was seen in the design of Minnesota's Mayday Plus demonstration. Automated location devices increased the effectiveness of medical and road assistance, while collision severity notification systems transmitted requests for additional help and special medical instructions to emergency room or trauma center personnel at the Mayo Clinic in Rochester, Minnesota. The technology is advanced and effective while the costs are prohibitive for a wide scale deployment.

Not surprisingly, several interviewees noted that technological provision remained one of the essential issues in creating effective interorganizational ERS/EMS in Minnesota, especially in rural areas (D. Gustafson, G. Mulleneaux, R. Stenberg, personal communications, October 2001). Interviewees explained benefits to newly implemented technologies, including enhanced efficiency among call dispatchers and state patrol officers in arriving to accident locations. Although Minnesota partnerships widely deployed special software, radio, cellular, Geographic

Positioning Systems (GPS), Automatic Vehicle Location (AVL), and other advanced types of technologies; experts concluded that the ERS/EMS infrastructure demanded additional resources. Systems need to be added, upgraded, and integrated with existing transportation information systems. Yet, there is often a paucity of local funds in rural areas to do so.

Interviewees and document reports showed that in recent years the Minnesota ERS/EMS significantly increased dependence on cellular telephone usage. The Minnesota State Patrol answered 650,000 cellular 9-1-1 calls annually (or 1,780 daily), and numbers of cellular 9-1-1 calls have increased 15 to 20 percent each year (17). Many of these calls originate from rural areas of the state, where access to wire line telephone service is not always easily available. Several interviewees also discussed insufficiencies in developing wireless infrastructure in rural areas, including a limited coverage area and improper call routing to the correct Public Service Answering Point (PSAP) (A. Terry, M. Hogan, G. Lyden, D. Gustafson, and M. Jonassen, personal communications, March 2002). This doubtless creates time delays and other difficulties related to immediate response to emergency calls and the location of their related accident sites. As one expert noted, local specialists rely upon their "general sense of the area and can generally locate the victim without specific directions" (D. Gustafson, personal communication, October 2001).

Some interviewees described synergies created between organizations by sharing technological resources and associated costs similar to the findings of the ARTIC test project (Heroff and G. Mulleneaux, personal communications, October 2001). The ARTIC evaluation report states that there was a "tremendous positive impact in system efficiency with the integration of [partner] communications" systems (3). However, most experts explained that a lack of funds contributed to slowing the process of implementing new technology and integrating systems with partner organizations.

The pivotal unit for dealing with emergency calls is the PSAP. There are 119 PSAPs in the state of Minnesota. About 40 percent of PSAPs are compliant to Phase 0 and Phase 1 standards of the Federal Communications Commission's (FCC) wireless 911 rules, which have required a dialable number and location of the nearest cell tower base station to accompany each 911 call (J. Beutelspacher, N. Pollig and M. Moody, personal communications, March 2002). Only a few PSAPs have upgraded their equipment to accept data with latitudinal and longitudinal dimensions in compliance with Phase 2 rules. Obviously, geographical dimensions are critical in responding to emergency calls from rural areas. Due to high costs associated with technological upgrades, the process of implementing the FCC regulation is going relatively slow. According to revised FCC rules on wireless E-911, PSAPs should have started accepting location information by October 1, 2001. This deadline was also effective for service carriers, the majority of which have filed for time extensions with the FCC.

Interviewees gave several additional examples relating to the need to upgrade systems. Regarding PSAPs functions, experts mentioned that nationally 80 percent of PSAPs do not have full data backup capabilities, which causes a high percentage of calls to be lost. In addition, as the number of emergency calls from cellular telephones has increased, wireless trunks are often busy, leaving wire line trunks available (A. Kraus, personal communication, February 2002). Upgrading data backup capabilities, adding wireless trunks to PSAPs, and upgrading technology to include acceptance of both wireless and wire line calls rather than retrofitting existing wire line systems were among some of the related recommendations from interviewees. Another issue was that PSAP decision-makers are often not aware of new, lower cost technical solutions. They often rely on vendors, who may push high cost, long-term solutions.

Organizational Issues

Interviews and document reviews described several benefits to partnership creation and their associated IOSs. Several experts explained that resource sharing enabled partnership organizations to save time and money (A. Terry and M. Hogan, personal communications, October 2001). They explained that in order to establish a well functioning ERS/EMS through the use of advanced technologies, coordinated relationships among individual member organizations of the system must be established. Because these relationships have a horizontal structure, system efficiency depends on the organized, clearly defined, and conscientious actions of each member agency. Several expert opinions and evaluations of ITS test projects indicated that there was a need to further enhance "knowledge of inter and intra organizational roles and responsibilities" in Minnesota ERS/EMS partnerships.

Partnerships that consist of public and private organizations encounter both barriers and synergies to creating effective ERS/EMS. An expert from the Mayo Clinic described the situation when the clinic purchased Gold Cross Ambulance Service (GCAS), its previous partner (C. Canfield, personal communication, October 2001), due to GCAS's low funding, which inhibited its ability to adopt new technology for its vehicles and "keep up" with the hospital. Another expert from the Virginia Fire Department stated that the local hospital, the main private partner in the Virginia emergency response partnership, was slowing the process to adopt new technology for emergency response purposes (D. Gustafson, personal communication, October 2001). These two examples demonstrate the unbalanced nature of partnerships and the uneven distribution of opportunities for member agencies. Mn/DOT's representative confirmed that a partnership heavily evoked issues of financing arrangements (including technology and costs incurred from participation in the partnership).

There was no common theme in terms of the best structure, distribution of roles, responsibilities, and burdens for maintaining effective ERS/EMS partnerships. Perspectives on partnership roles and responsibilities vary in each organization and, in some cases, this causes discrepancies in ERS/EMS performance. Several interviewees explained that this major barrier stemmed from a lack of trust among partnership organizations, especially as relates to public-private partnerships. An expert from Mn/DOT's Communications Technology Office (CTO) pointed out that government agencies could not always rely on private companies to cooperate for emergency purposes. Recognizing a strong potential in using cellular technology in emergencies, the CTO proposed the solution that the government agency receive a priority access service during a large-scale emergency. This, however, would lower consumer cell phone call completion rates and pose undesired risks to the private cellular carriers. Another proposed solution is to bypass using private cellular systems for emergency response purposes and instead use the 800 MHz radio frequency band for 2-way radio State Agency purposes (18).

Other institutional barriers included lack of proper training and resistance of an agency's personnel to learn new technologies. For instance, the Rochester Police Department (Rochester, Minnesota) reported a long learning curve in training officers to transition to technologically advanced operations. The Mayo Clinic interviews supported similar patterns of adjustment to new technologies. The Mayo Clinic's Medical Transport reported employee's resistance to incorporate new devices into the workplace, stating that the employee's feared becoming heavily reliant upon machines in the event of emergency accidents.

Policy Issues

Research demonstrated that federal, state, and local policy had a critical role in determining incentives and terms for ERS/EMS functionality. One of the most significant steps in improving conditions for ERS/EMS functionality was elaboration of coherent policy decisions at all levels. Interview and document survey results indicated a need for greater interaction between government agencies of all jurisdictions to encourage rapid implementation of advanced technological products into the emergency response infrastructure.

The Advanced Rural Transportation Information and Coordination (ARTIC) project illustrates the successful use of a network-based approach to establishing the ERS/EMS in northeastern counties of Minnesota (3). Before deployment of ARTIC, agencies independently developed duplicate record keeping, which stretched scarce resources and degraded the quality of service to the public. Under the ARTIC project, several state and local agencies created an alliance, shared resources, and implemented ITS technology to design well-managed and efficient emergency response systems that served rural roads.

Government policy comprises not only direct participation in creating the efficient ERS/EMS, but also determination of a set of incentives to establish and develop ERS/EMSs within the state. As previously mentioned, the federal government has required wireless carriers to implement E-911 service to further improve the quality of emergency services. While taking measures to comply with the federal rules, Minnesota's PSAPs encountered serious barriers. Low funding from budget sources and lack of private investments inhibited their ability to upgrade systems and equipment to support E-911. As a result, implementation was notably repressed and thus required the state's intervention. Considering the successful experience of Rhode Island in gaining funds from a $0.47 telephone surcharge per customer, Minnesota experts supported a similar solution to the issue: allocation of upgrade costs through increasing the statewide telephone charge from 10 to 27 cents per customer. This measure has not yet been approved.

The study results also demonstrated how effective policy could help overcome another major barrier to implementation: a lack of standards. Experts defined standardization of geographical databases in multijurisdictional dimensions as a primary task to establishing ERS/EMS (A. Kraus and J. McNeff, personal communication, February 2002). Experts stated that the lack of a uniform method for describing incident locations has long been a major impediment to rapid and effective emergency response in diverse metropolitan and rural areas. When the Federal Geographic Data Committee adopted the U.S. National Grid (USNG) standard (FGDC-STD-001-2001), the problem of interoperability of location services seemingly disappeared. The USNG corrected discrepancies in map products and provided a countrywide consistent grid reference system as preferred in data applications in emergency response. However, the USNG has not been rapidly incorporated at governmental levels and therefore has not realized the full potential of its advantages. In the study context, implementation of the USNG for uniform geoaddressing would significantly increase the effectiveness of GPS applications in emergency response measures.

Recently, safety and privacy issues in application of wireless technologies to transportation have received much attention from government and the public. Studies indicate that wireless technologies present a number of benefits as well as risks when used in a vehicle. Cell phone users can place emergency calls directly from a vehicle or accident site. This is particularly critical in rural areas. However, distraction created by cell phone use while driving can increase the risk of a crash (19, 20). Considering these risks, Minnesota and other states have been involved in discussion about the possibility of imposing a legal ban on cellular phone use while operating a vehicle. Of course, common practice dictates legal authorization to use cellular phones in emergencies. Here, the main concern is whether rural areas would largely remain unsupported by cellular telephone service after introduction of restrictive rules on cellular phone use.

Implications

This study has raised several policy, organizational, and technological issues for ERS/EMS in Minnesota as well as rural areas more generally:

> **Technology.** The rise of wireless systems has a prominent effect on ERS/EMS. The rapid growth of wireless technologies and applications in transportation-related emergencies detected by citizens and communicated via wireless systems signifies the increasing role of customer-based distributed systems in creating knowledge about service demand and delivery of services (21). The challenge is to devise and deploy new sets of location-specific devices (and call centers) that can in essence keep-up with emergent consumer demand. Advanced technologies further intensify the challenges of using increasingly distributed, complex, and interorganizational systems. At the same time, new technologies solve issues related to cooperated data creation, use, and exchange within ITS infrastructures. E-911 provides a strong example of how a strong set of technological standards, or lack thereof, plays an important role in the implementation of an advanced technology in an interorganizational system.
>
> **Issues of interagency cooperation.** The ERS/EMS partnerships of rural Minnesota present dynamics in building interagency relations under current federal, state, and local policies. Their experience revealed a set of new considerations in management of interorganizational systems. For example, Departments of Transportation usually do not consider communications infrastructure to be a core function of their agency, yet they may be in the best position to provide backbone infrastructure services, as the 800 MHz report has suggested. Mn/DOT currently is one of the major radio users in the state and has the most significant need for radio communications. But, the state will have to construct the infrastructure in order to meet Mn/DOT's current and emerging needs. Major interorganizational barriers were generated from varying positions in terms of finance, competencies, trust, and interest in cooperative relations. Concepts such as the self-organizing nature of the enterprise, the role of disequilibria in generating change, and the role of independent agents in affecting change have value in understanding these interorganizational networks.

Policy. Ubiquitous emergency management service is costly and raises public policy issues as to who absorbs this burden. The terrorist attacks on September 11, 2001, have heightened general interest in domestic preparedness (22) and provision of emergency services. These services ultimately fall upon a range of public and private service systems similar to ERS/EMS projects in Minnesota. The ERS/EMS study demonstrates that policies on implementation, standards, and sufficient funding can create favorable climate for interagency cooperation and hasten the upgrading of systems to promote regional implementation of the ITS architecture. However, there is widespread concern that regulations such as the E-911 mandate will impose costs on regions that they are not quite prepared to absorb, especially given current governmental shortfalls.

Recommendations

The following recommendations are offered as steps toward resolving present issues and developing capability to meet future challenges in creating and developing ERS/EMS in Minnesota as well as rural and small town areas generally:

- *Assess critical coverage gaps and implications for service.* The ITS/ERS/EMS service is fundamentally dependent on mobile coverage. Yet, adequate coverage in rural areas continues to be problematic. In the case of ERS/EMS, the consequence is not just the inconvenience of not being able to place a personal or business phone call, but could be a fatal gap should failed coverage not allow for adequate response.
- *Develop a strategic plan that integrates technical and socio-policy elements for next generation E-911 coverage.* The E-911 mandate has created a policy/regulatory context for pushing location-specific emergency services. However, this review has identified a range of technology, organizational, and policy issues that include, yet transcend, this policy mandate. A strategic plan would incorporate the E-911 requirements within a broader planning exercise, which importantly should include a funding requirements element.
- *Integrate ERS/EMS planning into ITS planning*. For rural areas, the safety aspects of ITS are arguably more important than the mobility elements typically featured in regional ITS architectures and deployment plans. Moreover, the communication and system elements to ITS provide an important cornerstone for ERS/EMS management.
- *Enhance understanding of ERS/EMS benefits on local levels*. Local areas face very constrained budgets and often need to develop innovative partnerships to deploy new ERS/EMS services. This measure would remove artificial barriers to establishing interorganizational systems. Common stance in developing ERS/EMS in rural Minnesota is the key to successful cooperation between local entities.
- *Provide adequate training to specialists*. New systems, such as those mandated by E-911, will require training at the local level. Moreover, transportation managers need to become apprised about the relationships between safety-related ITS systems and mobility-related ITS systems.

In sum, while the proposition that we are living in a "Networked Society" is fairly straight-forward and confirmable, the reality of making these networks work in a manner that is efficient and effective is a much more complicated affair. There is no doubt that the technology exists to support a fully operable, state of the art, end-to-end E-911 Emergency Management System, from the mobile caller to the local PSAP. However, these systems need to be justified in light of competing demands for resources that are particularly acute in rural areas. And at this policy-level, while regulations such as E-911 provide a useful "stick" to drive next generation systems, ultimately these systems need to be financed and supported at the local level. All ERS/EMS systems—like politics—are, in the end, local; and regional and statewide systems need to be devised to ensure timely deployment and management. ITS can play an important role in facilitating this deployment, but policymakers and planners must take the necessary steps to integrate into these (ITS) planning and deployment processes.

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Chapter 5 Glossary of Acronyms

ARTIC	Advanced Rural Transportation Information and Coordination
AVL	Automatic Vehicle Location
CTO	Communications Technology Office
E-911	Enhanced Wireless 911 (Refers to location identification of wireless emergency phone calls)
ERS/EMS	Emergency Response and Management Systems
FCC	Federal Communications Commission
GCAS	Gold Cross Ambulance Service
GPS	Geographic Positioning Systems
IOS	Interorganizational Systems
ITS	Intelligent Transportation Systems
ITSA	Intelligent Transportation Society of America
MnDOT	Minnesota Department of Transportation
PSAP	Public Service Answering Point
TOCC	Transportation Operations Communications Center
USNG	United States National Grid

APPENDIX A

GENERAL TELECOMMUNICATIONS SURVEY

General Telecommunications Survey

This attachment includes the general telecommunications survey form complete with final response frequencies and general descriptives. Total number of respondents=446.

YOUR USE of TECHNOLOGY....

1. Do you have access to a computer **at home**? YES=365 NO=77 (missing =4)
   Do you use it? **YES= 336**
   NO=23 (n/a=59; missing =27)

2. Do you use a computer **at work** (or school if mainly a student)?
   YES =317
   NO=79 (missing = 13; n/a=37 [note 74 respondents doe not work])

3. Do you have a cell phone (either personal or for work use)?
   YES = 300
   NO=139 (missing =7)

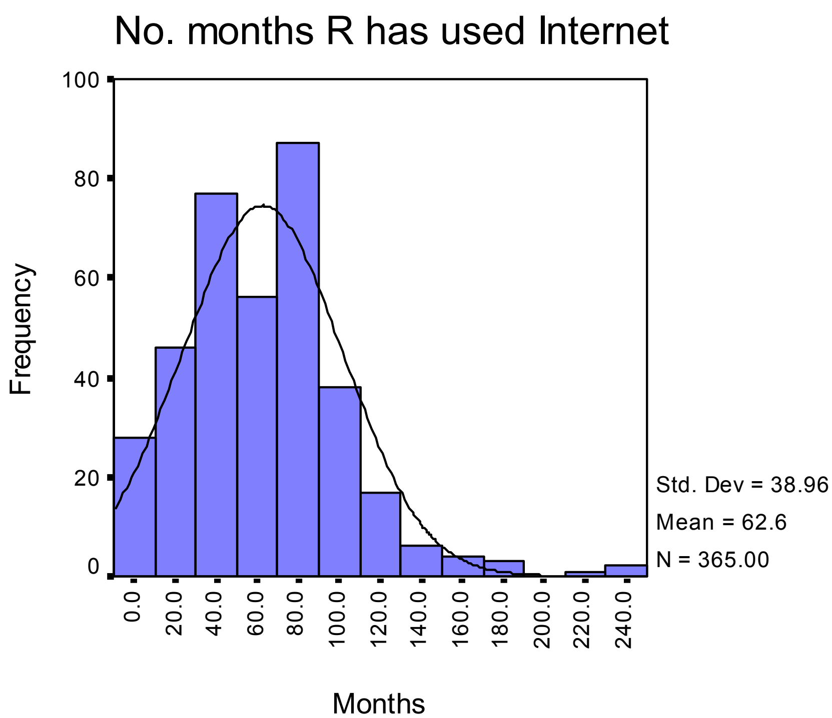
4. How frequently would you say you typically use the following forms of communication to contact others? Please CIRCLE the number matching the answer that best describes your habits. Select N/A if, for example, you do not work.

		Never	Rarely	Some-times	Often	Always	N/A	Missing
Phone	Family	6	12	65	**219**	135	2	7
	Friends	5	25	98	**208**	99	2	9
	Coworkers	21	63	94	**117**	70	5	16
Email	Family	65	62	**133**	**112**	15	41	18
	Friends	49	51	**135**	**129**	24	40	19
	Coworkers	65	36	**45**	**140**	62	75	22
Cell phone	Family	39	57	86	**116**	39	95	14
	Friends	49	77	87	**90**	31	95	17
	Coworkers	**90**	66	65	50	31	**126**	18
Face-to-face conversa-tion	Family	3	26	115	**206**	85	2	9
	Friends	2	15	125	**226**	67	3	8
	Coworkers	5	12	50	**199**	103	61	15
Written document (fax, memo, letter)	Family	63	**200**	131	17	8	14	13
	Friends	78	**211**	110	12	7	16	12
	Coworkers	69	**111**	105	61	23	66	11

5. Do you ever use the Internet? NO=77 (Respondents skipped to question 6, pg. 7).

YES = 366 (Continued with the next questions [a-h]).
Don't know and missing = 3

(a) Approximately how many years or months ago did you first begin to use the Internet?



(b) How often do you use the Internet?

Frequency	
226 (51%)	**Several times each day**
48 (11%)	Once per day
69 (16%)	Several times per week
9	Once per week
10	Several times per month
2	Once per month
4	No more than a few times per year
1	Other (please describe):
77 (17%)	N/A (Respondent does not use the Internet)
454	Total

(c) On AVERAGE, how much TIME would you estimate you spend on the Internet each instance you connect?

Frequency	(Scale = minutes)
24	Fewer than 10 minutes
150	**10 to 20 minutes**
87	21 to 30 minutes
72	31 to 60 minutes

32	More than 60 minutes (outliers = 360 and 840 minutes)
76	N/A (no Internet access)
5	Missing

(d) Where and how do you connect to the Internet MOST FREQUENTLY?

Frequency	
184 (41%)	**From home via a personal computer**
2	From home via TV
172 (37%)	**At work from a computer**
1	From school
6	From a library/other public place
3	From someone else's house (e.g. friend, relative)
1	At an Internet café/kiosk
0	Via a mobile device (e.g. cell phone, pager)
1	Other (please describe):
77	N/A (Respondent does not use the Internet)

How do you connect to the Internet?

Frequency	
209 (47%)	**Via dial up modem**
35	DSL
53	Cable or ISDN
4	Other
13	Don't know
91	N/A (Respondent does not use the Internet from home)
41	Missing

(e) For what purposes do you TYPICALLY use the Internet? How often?

I use the Internet….	Every day	Every week	Several times per month	Several times per year	Never	I plan to, but don't now	n/a
to send and/or receive email	**255**	**66**	**27**	**9**	**9**	**4**	**76**
for business/work (e.g. file exchange, research)	**174**	**55**	**41**	**36**	**47**	**7**	**80**
for school/homework	9	22	17	24	247	11	94
to take online classes	1	2	5	33	268	36	84
to use online libraries	8	25	52	98	153	20	79

to make purchases (e.g. products, services)	**1**	**12**	**61**	**214**	**65**	**11**	**77**
to browse online vendors (not shopping, but exploring items)	**14**	**64**	**128**	**121**	**36**	**2**	**76**
visit auction sites (e.g. E-bay)	7	16	36	92	198	14	77
read online news/magazines	**86**	**74**	**60**	**64**	**75**	**5**	**76**
to chat online	12	14	18	32	282	9	76
to find out about community events/information	6	38	89	136	85	11	76
for entertainment (e.g. games, download music)	22	37	64	69	157	18	76
to access on-line health care/information	4	23	65	162	102	11	76
to access local government information/services	3	13	70	187	79	13	76
to access financial services (e.g. banking, pay bills, insurance)	19	73	70	68	115	21	76
Other (specify)	10	6	14	12	48	7	82

(f) In the next few items we are interested in understanding to what extent the Internet may have changed your **shopping habits and the trips you make to shop***. Please answer the following five questions by CIRCLING the number for the answer that best describes your habits.

- On AVERAGE, how often do you **make purchases on-line** from vendors on the Internet?
-

Several times per week	Once weekly	Several times per month	Once per month	**Several times per year**	Never	n/a	Missing
4	9	40	33	**198**	**84**	76	2

- How often do you **browse the Internet before actually making a trip to shop** (as examples: to find retailers that carry the product; for product/service comparisons)?

Several times per week	Once weekly	Several times per month	Once per month	**Several times per year**	Never	n/a	Missing
7	20	53	50	**147**	**90**	76	1

- How often do you use the Internet to **preview items before actually making a trip** to a store to buy?

Several times per	Once weekly	Several times per	Once per month	**Several times per**	Never	n/a	Missing

week		month		**year**			
8	7	56	42	**143**	**114**	76	0

- How often would you say that your browsing of Internet vendors/services has led you to make a shopping trip you might not otherwise have made?

Several times per week	Once weekly	Several times per month	Once per month	**Several times per year**	Never	n/a	Missing
0	3	10	22	**109**	**226**	76	0

- On average, how often do you search the Internet for information with the purpose of making your shopping trips faster/more efficient (e.g. directions to the store; fewer stops; less searching)?

Several times per week	Once weekly	Several times per month	Once per month	**Several times per year**	Never	n/a	Missing
7	11	53	39	**122**	**137**	76	1

* Note: remember, responses include only those from people who answered "yes" to Q5 (they DO currently use the Internet).

(g) Thinking of ALL gifts YOU have purchased for any occasion since last December (2001) what percentage (from 0% to 100%) would you estimate were purchased using each of the following means. Write in 0 if you did not use a particular type.

***Percent purchases**	**Local Retail**	**Mail Order**	**Internet**
0	5	**112**	**80**
Fewer than 10%	2	**77**	**88**
10-19.99%	6	**75**	**64**
20 – 29.99%	15	35	44
30 – 39.99%	9	16	21
40 – 49.99%	15	5	10
50 – 59.99%	23	9	16
60 – 69.99%	28	3	3
70 – 79.99%	**45**	1	4
80 – 89.99%	**55**	3	2
90 – 99.99%	**101**	0	2
100%	**46**	0	0
n/a	86	75	75
Missing	8	35	37

*Note: remember the chart above represents only those respondents who DO use the Internet currently.

(h) *In responding to the next questions, we would like to understand your FEELINGS about shopping – both in stores and on the Internet. Even if you rarely shop at stores, or do not shop the Internet, please consider each of the statements below and CIRCLE the response abbreviation that best matches your own belief.

SD= Strongly disagree	D= Disagree	N= Neither disagree nor agree	A= Agree	SA= Strongly agree	N/A= Not applicable to me

	SD	D	N	A	SA	N/A**	Miss.
I think shopping on the Internet is fun.	16	27	125	117	51	111	4
I don't know how to use the Internet well enough to shop on it.	162	99	21	38	11	108	7
For me, shopping in stores is a hassle.	23	117	99	99	32	72	4
I like the help/friendliness I can get when I go to stores.	7	44	116	161	44	71	3
I'm afraid to order products/services on- line because of credit card fraud.	57	126	54	88	38	80	3
Shopping on the Internet reduces the hassles of shopping at stores.	13	49	89	150	43	97	5
I have a hard time searching the Internet to find what I need.	64	147	75	51	10	96	3
I want to see things in person before I buy.	2	40	78	172	79	72	3
I don't shop on the Internet because I think it would be a real hassle to return merchandise bought over the Internet.	14	111	71	110	44	93	3
I like having products delivered to me at home.	6	25	113	169	54	75	4
Shopping is a good way to get out of the house.	18	57	102	159	29	75	6
I like the energy/fun of shopping at stores.	28	90	107	117	26	74	4
I shop over the Internet because I can get products/services of higher quality there.	19	137	156	11	3	116	4
I like the fact that no car is necessary when shopping on the Internet.	5	38	123	138	35	103	4
I do not like having to leave the house to shop.	39	146	117	46	9	85	4
I do not shop on-line because Internet vendors do not carry the things I want.	51	159	108	12	0	112	4

* Note: again, responses are from Internet-users only.
**N/A = those who filled out the n/a cell on the chart plus respondents who do not use the Internet.

6. If you do **NOT** currently connect to the Internet, what is the main reason(s) you do not? Check ☑ as many as 3 reasons, or write in a different response at "other".

There were a total of 81 respondents to this question. From the list provided (see survey) they selected the following three items with the greatest frequency:

(1) **"I don't have a computer at home"** (selected 51 times)
(2) **"It's not relevant to my needs"** (selected 32 times)

(3) **"It costs too much"** (selected 26 times)

N/A = 331 (includes those who do connect to the Internet). Missing responses = 36 (represent those who noted that they DO connect (n=366) to the Internet in Q5, but failed to complete this section)

YOUR WORK....

7. Do you currently work? Please check ☑ the ONE best response.

302	Yes, full time
12	Yes, full time, and I'm a student too
34	Yes, part time
7	Yes, part time, and I'm a student too
10	No
9	No – I'm a homemaker
54	No – I'm retired
1	No – I'm in school
13	Other
4	Missing

IF YOU **DO** WORK FULL OR PART TIME, please continue with this set of questions beginning with question 8 on the next page (pg. 8).

If you do **NOT** work FULL OR PART TIME, and are NOT a student, please continue with question #23, *Everyday Travel* section, pg. 13.

If you ARE a student, continue with question #18, pg. 11, in *Everyday Travel.*

8. Thinking of your PRIMARY job, are you self-employed? Or do you work for someone else? Please check ☑ one response.

51	Self-employed (have own business, farm, etc.)
130	Employed by a large, private company (500+ employees)
80	Employed by a small private company (500 or fewer employees)
12	Employed by federal government
38	Employed by state/local government
27	Public/private human services (e.g hospital, church)
4	Contract/Temporary employee
25	Other
79	Missing (either respondent does not work or failed to answer)

9. Please choose a category that best describes the **majority** of the work you do, or write in your own response at "other". Please check ☑ only ONE response.

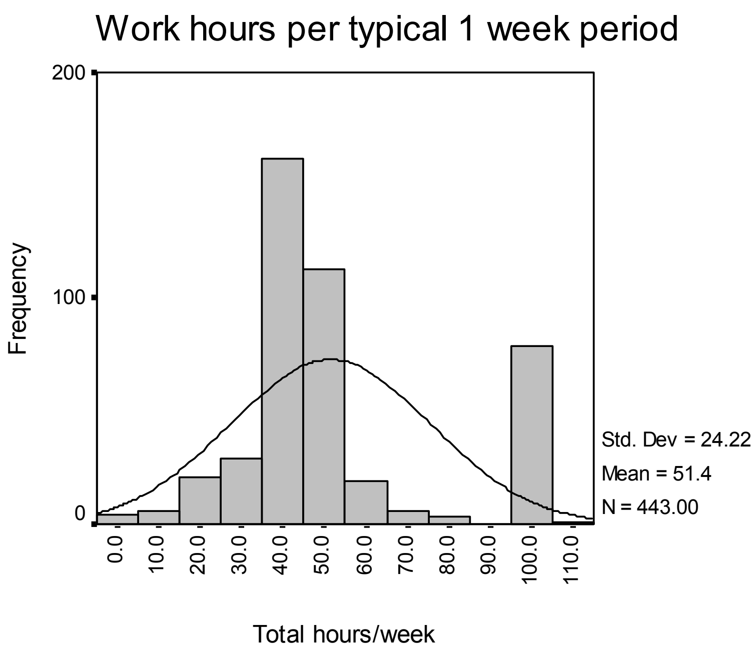
62	Management	24	Service
100	Professional	24	Clerical/Administrative support
9	Official/Administrator	7	Machine Operations
14	Craftsperson	1	Farm
50	Technical	8	Laborer
27	Sales	**42**	Other

n/a =71 (Respondent does not work); missing = 10

10. In an average ONE-WEEK period, how many TOTAL hours do you typically work in your **primary job** (exclude commuting time)?

Missing responses = 12; n/a (does not work) = 69

Note: the histogram below shows a major outlier -- one respondent claims to work 105 hours each week. We checked and he's a farmer who maintains he works 24-7 (exclude from further analysis).



11. Days of the week respondents NORMALLY work in the primary job.

261	**Mon thru Fri**
9	Mon thru Thurs
2	Tu thru Sat
2	Sun thru Thu
20	Mon thru Sat
1	Sun thru Fri
66	Other
72	n/a

14	Missing

12. Aside from your primary job, do you currently have <u>other regular PAID work</u> (e.g. a second job)?
    323= NO, I do NOT have another job(s)
    39 =YES, I currently have other regular paid work
    n/a = 69
    missing responses = 12

13. Do you ever do **<u>work for your job at home over the Internet</u>** (e.g. to email clients/coworkers, download files, etc.)? Please CIRCLE the answer that best describes your **normal** experience for <u>each</u> of the statements below.

I use the Internet to do work <u>from home</u> ….	Every work day	A few days weekly	Once per week	A few days per month	No more than once per month	**Never**	n/a	Miss-ing
before work hours	19	15	9	22	40	**229**	69	43
after work hours	21	34	19	47	49	**180**	69	27
during the work day	28	12	8	27	35	**224**	69	43
on the weekends	14	16	13	56	57	**187**	69	34
Other (describe):	5	2	1	1	3	169	80	185

14. Flexible work scheduling is becoming more popular at work places. These include, for example, <u>compressed work weeks, flex time, and telecommuting</u>. Thinking of your **primary job**, do you yourself ever engage in any kind of flexible work scheduling?
    153 = YES
    213 = NO, Skip to #17, pg. 11.
    75 = n/a
    8 = missing

If you answered yes to the previous question (#14), please answer the next few items regarding your flexible work scheduling.

(a) Do you yourself <u>currently</u> work a <u>compressed work week</u> (e.g. work four, 10 hr instead of five, 8 hr days)?
    30 =YES
    115 = NO
    279 = n/a (does not engage in flexible work)
    22=missing

(b) Do you <u>currently</u> engage in <u>flex time</u>, that is, change your start and/or quit time on a daily basis?
    109 =YES
    40= NO
    277 = n/a (does not engage in flexible work)

20=missing

Days of the work week respondents NORMALLY engages in flex time.

45	Mon – Fri
3	Mon – Thursday
54	Other
308	n/a
36	Missing

(c) Do you currently telecommute (e.g. work from home)? **37 =YES**
114 = NO
280 = n/a (does not engage in flexible work)
15=missing

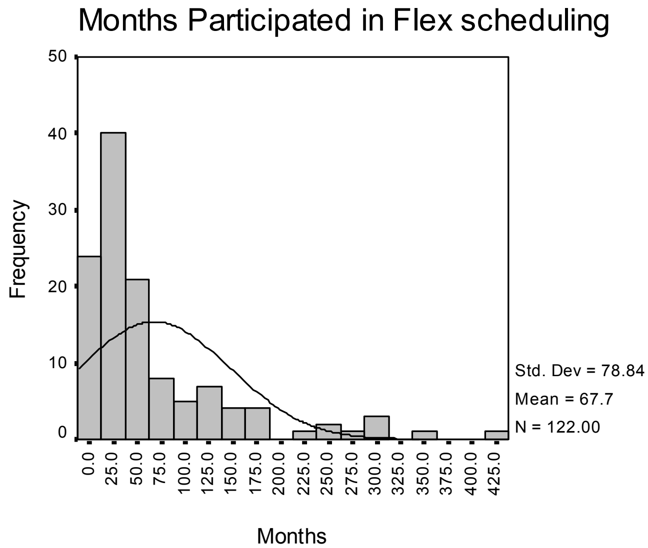
Days of the work week respondent USUALLY telecommutes (Note: Five of our telecommuters did not provide a schedule, nor did they indicate n/a):

10	Mon – Fri
1	Tuesday – Fri
1	Mon – Saturday
20	Other
364	n/a
50	Missing

From which location do you normally telecommute? (Note: two respondents than our self-professed telecommuters answered this question).

38	Home
1	A Satellite office/remote center
362	n/a
45	Missing

15. If you **do** engage in any of the flexible work schedules listed above (compressed schedule, flex time, telecommuting)… (a) How long have you participated?



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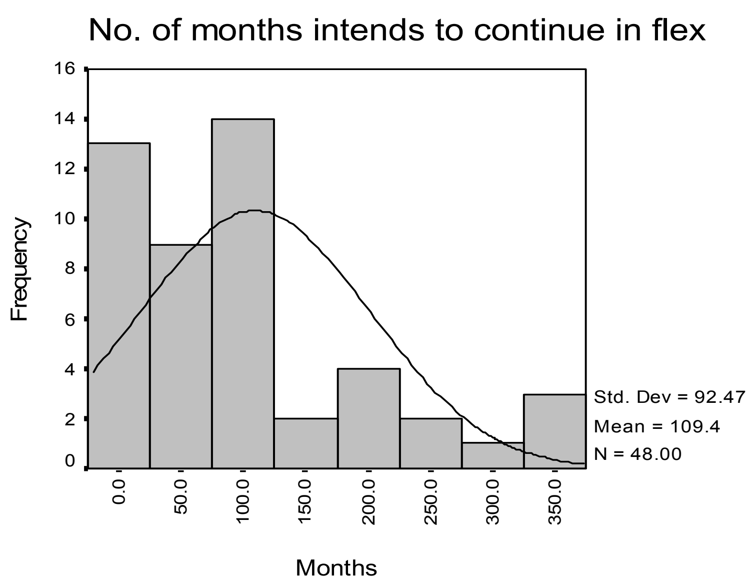
Remarks:
A total of 122 provided months, 278 = n/a, and 46 = missing. Altogether 28 of respondents who do engage in flex schedules failed to respond. Note too, responses for several people that have flexed 15 or more years pose major outliers – their effect has been to positively skew the distribution.

(b) How much longer do you intend to participate? (Note: N/A = 276; missing = 72)



What are the primary reasons you engage in flexible work schedules? Please select **as many as** three (3) answers by checking the boxes in the left-hand column.

The chart below shows the number of respondents (total n=145) who chose any one of the possible responses provided in the survey.

16	I have a long commute.
50	**To avoid rush hour.**
42	To work at personal "peak times" (e.g. late night).
35	My job requires it.
6	I can better organize care for an ill family member.
21	I can better organize my child care commitments.
45	I can take care of personal errands more easily
39	To gain additional family time
39	It allows me more personal leisure time
12	Provides me with more time to become involved in my community.
30	To get more work done.
13	To save money.

16. If you **DO** work a flexible schedule, compressed work week, or telecommute, please respond to the following 2 items:

(a) How frequently do you travel on the weekdays that you do NOT make a trip to your workplace? Would you say you…

18	make MORE trips than on weekdays I go into the office/work
41 (37%)	make FEWER trips than on weekdays I go into the office/work
43 (40%)	make about the SAME number of trips
6	Other
318	N/A
20	Missing

(b) When I TRAVEL on the week days that I do NOT work/go into the office it's for…

18	work-related appointments/errands
19	family appointments/errands
23	Personal appointments/errands
44 (36%)	**all of the above**
4	I don't ever travel on those days
1	Work and family appts
11	Family and personal appts
1	Work and personal appts.
302	N/A
23	Missing

17. If you **DO NOT** currently engage in flexible work scheduling, please share with us the reason(s) you do not in the space below:

Major reasons include:

(1) Must be at work = 98
(2) Work does not allow = 44

(3) Now supportive policy = 9 Other = 38 N/A = 167 and missing responses = 90

YOUR EVERYDAY TRAVEL....

18. Thinking of your PRIMARY job (or school if MAINLY a student) in a **typical ONE WEEK** work period, how many days do you travel to and from work/school?

22	None
5	One
10	Two
20	Three
30	Four
248	**Five**
23	Six
9	Seven
75	n/a (R does not travel to work or school)
10	Missing

19. Thinking of your travel during <u>last week</u>, please WRITE IN the NUMBER of DAYS you traveled to and from your <u>primary</u> job (or school) using the transportation forms listed below. You only need to fill in a response for the type(s) you actually used.

	0	**1**	**2**	**3**	**4**	**5**	**6 or more**	**N/A – miss**
Drive alone	16	16	15	23	29	198	33	75/41
Carpool or Vanpool	66	7	2	4	4	7	1	78/277
Bus	65	2	1	1	7	15	1	76/278
Bicycle	68	2	0	2	1	0	0	78/295
Walk/Run/Skate	66	4	0	0	1	0	1	78/296
Motorcycle	68	1	0	0	0	1	0	78/298
Other	36	2	3	1	1	2	0	81/320

20. Was your travel <u>last week</u> typical of a normal work/school week?

328 =YES
32 = NO
74 = n/a (does not travel to work/school)
12=missing

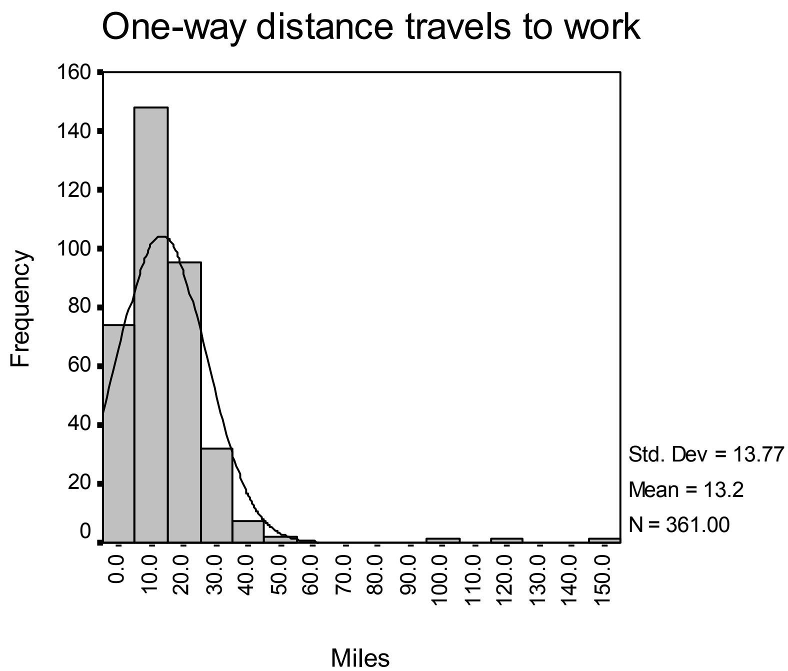
If NO please describe how it differed:

Of the 32 people who noted their travel was different than normal, several were on vacation or involved in atypical work travel, including 1 who worked on-site for a client. Another was on medical leave. Two worked an additional day, while one noted s/he traveled into the office rather than work at home as usual. Note that 5 maintained they tended to ride their bikes more than was typical of the reported week.

21. (a) How many MILES on average do you travel ONE WAY in your travel from home to your workplace/school?

361 = travel to work; Min=0; Max =150 (Again, note major outliers [100, 120, 150] in distribution below).

73= do NOT ever travel to a workplace/school
(**Skip** to question #23, pg. 13).
11 = missing



(b) In an AVERAGE week, what TIME do you typically leave your home for your primary job (or school if you are a student).

What time do you USUALLY arrive at work/school (*example, 7:45 a.m.*)?

(c) What time do you USUALLY leave work/school at the end or your work day/night (*example, 4:00 p.m.*)?

What time do you USUALLY arrive at home (*example, 5:00 p.m.*)?

22. What is the zip code for the place where you usually work (or go to school)? There were **80+** different zip codes given in responses.

23. How do you typically handle your everyday errands (e.g. grocery shopping, post office, dry-cleaners, etc.)? Please select the **ONE** response that best describes your errand-running habits in general.

In a TYPICAL week, I run my errands…

144	**on the weekends**
72	while commuting to/from work
41	during the evenings AFTER I arrive home from work
9	during weekdays when I work from home or a remote center
38	during weekdays I am not scheduled to work (i.e. you work a compressed/part time schedule)
94	during the day
23	during the evenings
1	I never run errands
19	Other, please describe: ____________________________
4	Missing

24. Which form of transportation do you USUALLY use for your errands?

425	**Car**
9	Public transportation (e.g. bus)
6	Walk/run/bike
0	Not applicable
4	Other
2	Missing

25.

How close to your home are...	Within walking distance of home	A short drive from home	I can drive there, but it's not convenient	Completely inaccessible to my home	Don't know	Miss-ing
Bus stops	261	76	32	32	41	4
Park-n-ride facilities	10	140	90	40	144	22
Places where you can buy everyday convenience items (such as milk, bread, pharmaceuticals)	156	274	7	2	0	7
Places where you can do more extensive shopping (e.g. where you are able to buy clothing, electronics, hardware)	15	374	46	5	0	6

26. What is your home zip code?

Frequency		Valid Percent
112	55044	25.3
104	55124	23.7
1	55343	.2
116	55406	26.2

19	55407	24.4
1	55409	.2
4443	Total	

Missing= 3

A FEW FINAL QUESTIONS....

27. Gender:

244	Male
196	Female
5	Missing

28. Are you.....

268	**Married**	51	Divorced
26	Living with Partner	19	Widowed
74	Single	2	Other

Missing=6

29. If you are married/living with partner, does s/he also work?

159	Yes, full time
64	Yes, part time
75	No
20	Missing
128	n/a

30. What is the highest year of school you have completed?

10	Less than high school
53	High school diploma/GED
90	Some college, no degree
71	Associates or technical degree
137	Graduated college
76	Graduate or professional degree (e.g., MA/MS, J.D., Ph.D., MD)
8	Other

Missing: 1

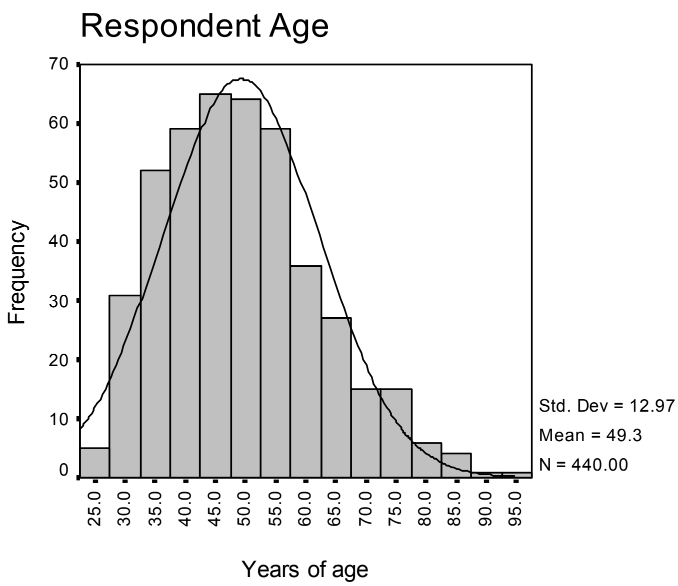
31. What ethnic or racial group do you consider yourself to be a member?

(Nothing skewed about this distribution!)

5	Latino/Hispanic
422	**White/Caucasian**
2	Asian/Asian American
3	Native American
3	African American/Black
4	Mixed ethnicity
2	Other

Missing: 5

32. What was the year of your birth? (Responses converted to age in the graph below)
Minimum age = 26, max = 93. Non-responses = 6.



Your household…

33. Do you have children living at home? 246 = No;
197 = Yes (missing = 3)

Number of children younger than 16:

No. of responses	Number of children
64	1
55	2
22	3
2	4
1	5
1	6
251	n/a

50	Missing

Number of children 16 or older:

No. of responses	Number of children
51	1
19	2
6	3
3	4
281	n/a
86	Missing

33. How many people living in your household are licensed drivers?

Frequency	# Drivers in household
8	0 drivers
119	1
243	**2**
46	3
14	4
3	5
1	6
12	Missing or n/a

How many of them own and operate a car from your home?

# Respondents	# cars in household
8	0
133	1
235	**2**
36	3
10	4
3	5
21	Missing or n/a

35. Please check the category that best describes YOUR current annual HOUSEHOLD income (before taxes).

14	Less than $15,000	91	50,000 to 74,999
28	15,000 to 24,999	96	75,000 to 99,999
37	25,000 to 34,999	86	$100,000 or more
76	35,000 to 49,999		

Missing = 1

APPENDIX B

PURPOSES OF ICT-INFLUENCED TRIPS

Purposes of ICT-Influenced Trips

HOME
DOWNTOWN MPLS
WORK
CHURCH
SUPERTARGET
PITCHING CLINIC
MALL OF AMERICA
ICE RINK WHITE
MALL OF AMERICA
MSP AIRPORT
LUNCH
SUNBELT
GRAYBAR
BEST BUY
TARGET PLYM
MALL OF AMERICA
MSP AIRPORT
TIM'S
VOLLEYBALL/CHUR
HEY CITY THEATR
SCHOOL
HEY CITY THEATR
SOUTHDALE
MOA
TARGET
TARGET
BEST BUY
JUNK
RHONDA'S
HOUSE HUNT 1
HOUSE HUNT 2
HOUSE HUNT 3
HOUSE HUNT 4
HOUSE HUNT 1
HOUSE HUNT 2
HOUSE HUNT 3
HOUSE HUNT 4
LONG LAKE
SOUTHDALE MALL
SOUTHDALE MALL
NEW DEHLI
NEW DEHLI
LINDEN HILLS
U OF M

APPENDIX C

CODING OF TRIP PURPOSE

Coding of Trip Purpose

The trip purposes in the original DARTS data contain more types than presented in this report. This study combined some trip purposes together into a single category to show an aggregated and simplified picture of trip characteristics. The following table shows the coding of the trip purposes.

2002, 2003 Trip Purpose Types in this study	2002, 2003 Original Trip Purpose Types in DARTS data
Business	Business
Church	Church
Grocery/Retail/Beauty	Grocery
	Retail/Beauty
Medical/Dental	Medical/Dental
Recreation	Recreation
School	School
Social Service	Social Service
	Congregate Dining
	Daycare
	Job Club*
	ESL School*
	Overview*
Visit	Visit
Volunteer	Volunteer
Work	Work

Note: These trips were in 2003 only.*

APPENDIX D

DARTS CODING IN TERMS OF TRIP TYPE

DARTS Data Coding in Terms of Trip Type

Trip Sub Type Definitions	Our 'normal trips' are DEM (Demand) and REG (Regular) Everything else is 'Specialized'
CON	CONTRACTED RIDE
DD*	DENIAL/DENIAL
DEM	DEMAND
DEN**	CAPACITY DENIAL
ELC	ELC CONTRACT
ELD***	ELIGIBILITY DEN
LW	LIFEWORKS
LWD****	LAIDLAW DENIAL
REF	REFUSAL
REG	STANDING ORDER
SA	SPACE AVAILABLE
SDD*****	SAME DAY DEN
SDR	SAME DAY REQUES
TFL	TRF-LAIDLAW
TFO	TRF-OTHER
TFT	TRF- TNST TEAM
TTD******	TRANSITTEAM DEN
VOL	VOLUNTEER DRVR
VOT	VOTECH CONTRACT

*Denial/Denial: Denial due to a capacity denial in another trip. The typical situation is original ride requests denied because the return trip could not be scheduled due to capacity reasons.

**Capacity Denial: Denial due to a capacity reason for the requested trip.

***Eligibility Denial: Denial due to riders' eligibility reasons.

****LaidLaw Denial: Denial due to LaidLaw's (another transit provider) capacity constraint to which the rider wanted to transfer.

*****Same Day Denial: A request for same day trip is denied because of capacity.

****** TransitTeam Denial: Denial due to TransitTeam's (another transit provider) capacity constraint to which the rider wanted to transfer.

APPENDIX E

SUMMARY OF OUTREACH ACTIVITIES

Summary of Research Activities

	Event Type	Title	Location and Date	Audience	Author / Presenter	Follow-on Action?
1	Publication	"How Was Your Trip? Exploring the Relationship Between telecommunications and Travel Through the Tim Use Diary"	Compendium of Papers for the 81st Annual Meeting of the Transportation Research Board Washington, D.C. January 2002	Academics and high level practitioners	Frank Douma, Kim Wells, Praveena Pidaparthi	
2	Publication	"Utilizing Transportation Technology to Support Strategic Management Initiatives"	Compendium of Papers for the 81st Annual Meeting of the Transportation Research Board Washington, D.C. January 2002	Academics and high level practitioners	Frank Douma, Emily Kuhn	
3	Publication	"Regulation of Safety and Privacy Issues in Wireless Communication Applications for Transportation"	Proceedings of the 2002 ITS America Annual Conference Long Beach, Calif. April 2002	Transportation Technology Practitioners	Frank Douma, Milda Hedblom, Nodira Dadabayeva	
4	Presentation	"Utilizing Transportation Technology to Support Strategic Management Initiatives"	81st Annual Meeting of the Transportation Research Board Washington, D.C. January 14, 2002	75 attendees Academics and high level practitioners	Emily Kuhn	

	Event Type	Title	Location and Date	Audience	Author / Presenter	Follow-on Actions?
5	Presentation	How Was Your Trip? Exploring the Relationship Between telecommunications and Travel Through the Tim Use Diary	81st Annual Meeting of the Transportation Research Board Washington, D.C. January 15, 2002	30 attendees Academics and high level practitioners	Frank Douma, Praveena Pidaparthi	Revised, streamlined survey and diary
6	Panel Discussion	State-Level Telework Programs: Where Do We Go From Here?	81st Annual Meeting of the Transportation Research Board Washington, D.C. January 15, 2002	25 attendees Academics and high level practitioners	Frank Douma	
7	Presentation	Regulation of Safety and Privacy Issues in Wireless Communication Applications for Transportation	ITS America Annual Conference Long Beach, Calif. April 29, 2002	50 Attendees Transportation practitioners	Frank Douma	
8	Presentation	Wireless Applications to Enhance Transportation Safety	University of Minnesota Advanced Transportation Technologies Seminar Series Minneapolis, Minn. October 8, 2002	15 Attendees Transportation Graduate Students	Frank Douma	

	Event Type	Title	Location and Date	Audience	Author / Presenter	Follow-on Actions?
9	Publication	"Stranded but Connected? Case Study of Wireless ITS Systems for Emergency Medical Services in Small Town and Rural Environments"	Compendium of Papers for the 82nd Annual Meeting of the Transportation Research Board Washington, D.C. January 2003	Academics and High Level Practitioners	Tom Horan, Ben Schooley, Nodira Dadabayeva	
10	Publication	"ITS and Rural Emergency Medical Services: Case Study of ITS Wireless"	Conference Proceedings from 2003 ITS America Annual Conference Minneapolis, Minn. May 2003	Transportation practitioners	Tom Horan	
11	Publication	"The Promise of the Global Positioning System (GPS) in Services-on-Demand Public Transportation Systems"	Conference Proceedings from 2003 ITS America Annual Conference Minneapolis, Minn. May 2003	Transportation practitioners	Richard Bolan	MPR story
12	Publication	"Fast Lane: Growth of Daily Road Trips Outpaces Population"	St. Paul Pioneer Press, May 5, 2003	General Public	Toni Coleman (summarizing Douma presentation)	

	Event Type	Title	Location and Date	Audience	Author / Presenter	Follow-on Actions?
13	Presentation	Stranded but Connected? Case Study of Wireless ITS Systems for Emergency Medical Services in Rural Environments	82nd Annual Meeting of the Transportation Research Board Washington, D.C. January 13, 2003	30 attendees: Academics and high level practitioners	Tom Horan	
14	Presentation	ITS and Rural Emergency Medical Services: Case Study of ITS Wireless Deployment in Minnesota	ITS America Annual Conference Minneapolis, Minn. May 22, 2003	40 Attendees: Transportation practitioners	Tom Horan	
15	Presentation	Does Higher Speed Mean Fewer Trips? Impact of Telecommunications and Residential Travel	14th Annual Center for Transportation Studies Transportation Research Conference Minneapolis, Minn. April 30, 2003	60 attendees: Academics, practitioners and students	Frank Douma	St. Paul Pioneer Press Article, TRB submission
16	Publication	"Ride-Sharing Catches on in Dakota County"	Minnesota Public Radio News September 11, 2003	General Public	(Summary of Bolan work)	
17	Poster presentation	ICT and Travel in the Twin Cities Metropolitan Area: Enacted Patterns Between Internet Use and Working and Shopping Trips	83rd Annual Meeting of the Transportation Research Board Washington, D.C. January 13, 2004	TBD: Academics and high level practitioners	Frank Douma	
18	Presentation	ITS Opportunities Resulting from Developments in Home Broadband Telecommunications	ITS America Annual Conference San Antonio, Texas April 2004	TBD: Transportation practitioners	Frank Douma, Milda Hedblom	

	Event Type	Title	Location and Date	Audience	Author / Presenter	Follow-on Actions?
19	Publication	"ICT and Travel in the Twin Cities Metropolitan Area: Enacted Patterns Between Internet Use and Working and Shopping Trips"	Compendium of papers for the 83rd Annual Meeting of the Transportation Research Board Washington, D.C. January 13, 2004	Academics and high-level practitioners	Frank Douma, Kim Wells, Tom Horan, Kevin Krizek	TBD
20	Publication	"ITS Opportunities Resulting from Developments in Home Broadband Telecommunications"	Proceedings from the ITS America Annual Conference San Antonio, Texas April 2004	Transportation practitioners	Frank Douma, Milda Hedblom	TBD
21	Publication	"Using ITS to Better Serve Diverse Populations"	Proceedings from the ITS America Annual Conference San Antonio, Texas April 2004	Transportation Practitioners	Frank Douma, Denise McCabe, Jon Osmond	TBD