10 EXECUTIVE SUMMARY

This document presents the evaluation of Phase 2 of the Minnesota Department of Transportation (Mn/DOT) Smart DARTS project, a federal operational test of advanced technologies in paratransit.

THE SMART DARTS VISION

The objective of the Smart DARTS project is to investigate how certain paratransit technologies can benefit a demand-responsive paratransit system. The system in question is the Dakota Area Resources and Transportation for Seniors (DARTS), an approximately 23 vehicle, 400 trip per day private non-profit transit provider serving Dakota County, Minnesota, an area within the Minneapolis-St. Paul Twin Cities area. DARTS ridership consists of seniors and individuals with disabilities. Trips are scheduled up to two weeks in advance and no later than 24 hours in advance of the desired trip time.

The Smart DARTS project vision consists of the implementation of computer-aided scheduling and dispatch and automatic vehicle location technologies. The goal is to improve DARTS efficiency, capacity and ability to meet Americans with Disabilities Act (ADA) requirements. A cornerstone of the vision is the establishment of the capability to effectively serve an increased volume of same-day trips, currently a very small percentage of DARTS ridership.

Implementation of the Smart DARTS vision has been phased. Phase 1 consisted of a Feasibility Study, completed in July 1993. Phase 2, the subject of this document, consisted of the implementation of the Quo Vadis computer-aided scheduling/management information system software manufactured by Trapeze Software, Inc. (formerly UMA). Phase 3 will consist of implementation of automatic vehicle location and mobile data terminal technology. The capabilities required to serve an increased volume of same day trips are spread over Phase 2 and Phase 3.

IMPLEMENTATION PROCESS

Phase 2 hardware and software were implemented over the fall and winter of 1994-95. System testing and staff training were conducted in the spring and early summer of 1995 and the switch to the Quo Vadis system occurred in late July 1995.
EVALUATION METHODOLOGY

Performance was assessed using a number of measures of effectiveness (MOEs) developed for each of the following project objectives:

- Improve Responsiveness
- Enhance Customer-Focused Service
- Increase System Capacity
- Increase Cost Effectiveness
- Enhance Ability to Meet ADA Requirements

Data pertaining to these measures was collected in May 1995 prior to implementation of Quo Vadis and again in November 1995, four months following DARTS’ switch to the new system.

EVALUATION RESULTS

Measures of Effectiveness

No improvements in MOEs were observed which could be attributable to Quo Vadis. Given the specific capabilities of Phase 2 technologies, which did not provide the means for effectively serving increased same day trips, and the limited time and resources available to DARTS to fine tune their application of Quo Vadis, the absence of improvements in the MOEs is not interpreted as a failure. Rather, this evaluation indicates the fundamental feasibility of implementation of Phase 2 technologies and suggests that improvements in the MOEs is likely given the addition of key capabilities in Phase 3 of the Smart DARTS project.

It is the conclusion of this evaluation that the absence of improvements in MOEs is due primarily to the very limited evaluation time frame (four months). Within this short period of time, DARTS was unable to complete the changes required to capitalize on Quo Vadis capabilities. The already outstanding performance of DARTS in some areas is another important factor underlying the absence of MOE improvements.

Unmeasured Benefits

The implementation of Quo Vadis has generated several significant benefits not specifically reflected in the MOEs. These benefits include:

- Improved Data Quality
- Reduced Error Potential
- Improved Working Conditions
- Staff Flexibility
- Improved Reporting Capabilities
- Improved Management Tools
CONCLUSIONS

The following conclusions are based upon the evaluation of Phase 2 implementation of the Smart DARTS project:

1. **Essential feasibility has been proven.** The DARTS experience has shown that major changes to scheduling and dispatch work processes, involving significant changes in technology and work processes, can be accomplished without adverse impacts to the transit agency or its clientele and can occur within a reasonable time frame and budget. With the exception of performance shortcomings assumed to be related to the need for additional DARTS experimentation and fine-tuning, hardware and software worked as intended.

2. **Important immediate benefits can be realized.** Many important benefits, related primarily to the management information system capabilities of Quo Vadis, can be realized almost immediately after implementation. These benefits hold the potential for important long term benefits.

3. **Organizational responses are necessary and require time and resources.** The inherent capabilities of computer-aided scheduling and dispatch hardware and software are not enough to guarantee benefits. The implementing agency must alter its processes to take advantage of those capabilities. This is an on-going process and is unlikely to occur within the four month time frame utilized for this evaluation. These responses involve an ongoing commitment of resources on the part of the transit agency.

4. **Critical same-day trip capability still lacking.** Phase 2 provides many but not all of the critical capabilities necessary to effectively serve a significant volume of same-day trips, an important source of ridership and cost-effectiveness benefits. The remaining capabilities, automatic vehicle location and mobile data terminals, are included in Phase 3.
2.0 PROJECT OVERVIEW

This report evaluates the impacts of a federally funded operational test of computer-aided scheduling and dispatch software in a paratransit environment. The scheduling and dispatch software represent the first of multiple phases of the Minnesota Department of Transportation Guidestar Program project “Smart DARTS”.

The Dakota Area Resources and Transportation for Seniors (DARTS) operation was selected as the system in which to perform this operational test. DARTS is a nonprofit corporation that provides a range of social services for seniors in addition to a paratransit service for Dakota County seniors and individuals with disabilities.

The overall purpose of this evaluation is to learn under what circumstances advanced technologies may benefit paratransit systems. This evaluation does not constitute a “pass/fail” assessment of the DARTS experience with advanced technologies. Feasibility studies have clearly established that advanced paratransit technologies hold significant potential benefits. This evaluation seeks to determine how best to capitalize on these potential benefit, with the expectation that important lessons can be learned regarding the transferability of the technology to other transit systems.

2.1 THE SMART DARTS VISION

Transit service for senior and disabled individuals is important and will become more so with the aging of the Baby Boom generation. Based on an assessment of the capabilities of various “advanced” paratransit technologies and their previous successful application, it was determined that application of these technologies at DARTS could improve the performance of the system. Based on this potential and on DARTS’ identification of services important to their clients but which they lacked the capabilities to provide, the Smart DARTS Vision was formulated.

The following were identified as cornerstones of the Smart DARTS Vision:

- the ability to schedule and dispatch trips on a same-day basis
- use of “smart cards” to automatically record and invoice trip information
- improve DARTS’ ability to provide the services required to maintain or enhance the independence and mobility of seniors and disabled clients.

The Smart DARTS Vision represents an end state to be achieved incrementally. Each phase of the implementation effort delivers capabilities required by the next phase and which are necessary in order to fully realize the vision. Only through the implementation of all phases can all of the above cornerstone capabilities be achieved.
2.2 THE SMART DARTS PROJECT TEAM

The Smart DARTS Vision was formulated incrementally and originated with a core group of participants including the Minnesota Department of Transportation (Mn/DOT), the Regional Transit Board (now the Metropolitan Council), Dakota County, DARTS and BRW, Inc. Following the completion of a Feasibility Study in July 1993, this core group was expanded as additional participants important for a successful implementation were recruited and were attracted to the project. The resulting Smart DARTS Project Team included the following members:

- BRW, Inc.
- Dakota County
- Dakota, Inc.
- DARTS
- Federal Highway Administration
- Metropolitan Council
- Minnesota Department of Transportation, Office of Transit
- Minnesota Valley Transit Authority
- 3M

2.3 IMPLEMENTATION PHASING

The Smart DARTS Feasibility Study identified specific implementation phases for achieving this end state. Establishing the Feasibility Study as the first phase, the following additional three phases were identified:

- Phase 2: Computer-Aided Scheduling and Dispatch Software
- Phase 3: “Smart Cards” Fare Collection Technology
- Phase 4: Automatic Vehicle Location Navigational and Dispatch Technology

Since completion of the Feasibility Study in 1993, Phase 3 has been dropped. Given the level of deployment of smart card technology that occurred subsequent to the completion of the Feasibility Study, this technology was determined by the Project Team to no longer satisfy the “innovation” criteria that is fundamental to the Smart DARTS Vision and that is important for project funding. This is not to say that smart card technology does not hold great potential to improve fare collection and billing procedures at DARTS.

The primary impacts of Phase 2 were identified as the ability to generate more optimal schedules, i.e. schedules that can serve more trips, the ability to generate schedules more quickly, and a host of capabilities related to the institution of a management information system. Phase 4, which became Phase 3 after Smart Cards were eliminated, implements the base-to-vehicle communications necessary to take advantage of the same day trip serving capabilities introduced in Phase 2.

2.4 PROJECT OBJECTIVES

The Feasibility Study concluded that currently available advanced paratransit technologies, specifically computer-aided scheduling and dispatch, smart cards and automatic vehicle location, hold the potential to improve the overall performance of the DARTS operation. This conclusion was based on two sources of information. First, several transit agencies with experience with these technologies reported significant improvements in operational efficiency, including ridership and cost-effectiveness increases. Second, when compared to current practices, the advanced technologies appeared to possess inherent advantages capable of improving system performance.
In order to measure and categorize potential benefits and to serve as project goals, the following Smart DARTS project objectives were developed:

- Improve Responsiveness
- Enhance Customer-Focused Service
- Increase System Capacity
- Increase Cost Effectiveness
- Enhance Coordination with Other Transportation Services
- Enhance DARTS’ Ability to Meet ADA Requirements

These objectives represent the areas DARTS desired to improve in and which were felt could be impacted through the implementation of the Smart DARTS Vision. In Section 5.0 of this report the specific measures of effectiveness that were developed to gauge the accomplishment for each objective are discussed.

The preceding objectives applied to the entire Smart DARTS Vision, the end state achieved through the implementation of all project phases. Like the measures of effectiveness discussed in Section 5.0, the ability of the technologies implemented in the different project phases to impact these areas varied. The next section describes the capabilities of the technologies included in Phase 2 of the Smart DARTS Vision.

### 2.5 PHASE 2 TECHNOLOGY CAPABILITIES

Phase 2 of technology fully introduced management information system (MIS) and computer-aided scheduling capabilities. Phase 2 technology also provided for some of the critical capabilities related to same day trip dispatching and trip brokering. The remaining capabilities in these areas are included in Phase 3.

**Management Information Systems**

Management Information Systems (MIS) serve to store and access large quantities of information almost exclusively on a database platform. Operators can quickly access large lists of clients and their accompanying profiles with MIS. MIS can store and manage information such as clients’ names, addresses, physical conditions, and even special preferences for a particular bus driver.

The MIS represents the foundation of the software package. Upon receiving a trip request, the scheduler can immediately “call up” the client’s name to the computer monitor from the database. Special features which allow a short list of possible clients to appear by entering the first three letters of a last name further hasten the operator’s query. Once the client is identified, the operator has all necessary information available to schedule the trip request.

**Computer-Aided Scheduling**

Computer-aided scheduling is a common feature among all paratransit software packages. Following the acceptance of all trip requests for a particular day, a special scheduling algorithm (a computer program) is applied to the trip request list. Most of these programs operate in “batch” mode; i.e., once the process is initiated, it cannot be interrupted before its completion otherwise errors will result. Generally, no other programs can run simultaneously with this batch program (no multitasking capabilities). Therefore, the daily trip request list for the following day is processed the night before; the computer program creates an “optimized” schedule for each fleet vehicle given the input for that day. Computer-aided scheduling is sufficient for processing 24-hour advance or subscription trip requests.
Computer-Aided Dispatching

Phase 2 implemented many, but not all, of the capabilities required for same day trip dispatching. Same day trip dispatching describes the process where the DARTS dispatcher attempts to determine whether a requested trip can be accommodated on the daily schedule. The ability of the dispatcher to make this determination is severely constrained by a number of factors including:

1. When done manually, it is difficult to effectively search all of the approximately 20 vehicle schedules for an available time slot;

2. The actual location of each vehicle relative to the requested trip is unknown (the printed schedule shows only where the vehicles are supposed to be); and

3. The communication between the dispatcher and the drivers which is required to determine if a given vehicle can serve a same day trip and to arrange that service is time consuming and inefficient.

Phase 2 provides the capabilities to eliminate the first constraint. The scheduling software makes possible an automated search for available time slots. The computer can do this much more quickly and thoroughly. The remaining constraints are not affected by Phase 2. Phase 3 provides the vehicle location and dispatcher-to-vehicle communication link that allows three things to occur which are critical to same day trip service:

1. Actual trip pickups and dropoffs are quickly and effectively recorded in the computer system as they are made without the need for radio calls, so the computer always knows exactly which trips have been and are being served by all vehicles at any given time.

2. The communication between dispatcher and drivers required to schedule a same day trip request are accomplished with the computer via wireless radio modem connections and do not require voice radio calls.

3. On-board automatic vehicle location equipment provides the scheduling and dispatch computer with the nearly continuous and precise locations of all vehicles.
Trip Brokering/Coordination with Other Services

Like computer-aided dispatching, Phase 2 of Smart DARTS provides many, but not all, of the capabilities required to fully implement the trip brokering capabilities included in the ultimate Smart DARTS Vision. Trip brokering refers to the paratransit agency’s ability to effectively segregate trips that exceed their own service limits, or that can be accommodated by the paratransit agency with the addition of another agency’s resources/vehicles to achieve maximum utilization of all vehicles available. The concept of trip brokering includes the ability to improve transfers between DARTS and other transit providers.

Phase 2 software provides DARTS the ability to identify, based on trip origin and destination, trips that exceed their own service area. The software also allows DARTS to add other agency’s vehicles to their own fleet for the purpose of scheduling and to quickly access a list of other available transit providers to serve a given trip that exceeds DARTS service area. The ability of Phase 2 technology to geocode trip origins and destinations is critical to these capabilities.

The ability of DARTS to effectively broker trips and improve transfers is fully implemented with the addition of several capabilities included in Phase 3 of Smart DARTS, including automatic vehicle location.
3.0 THE DARTS SYSTEM

DARTS is a nonprofit corporation established in 1974 that provides social and paratransit services to seniors and individuals with disabilities in Dakota County. Though transportation is one of its primary services, DARTS also provides chemical dependency counseling, home services, and family support in Dakota County.

DARTS' mission is to promote independent living for seniors. DARTS is dedicated to maintaining the highest possible level of quality, independent living for its clients. Quality, above all, is its most valued service characteristic. DARTS' dedication to this mission through responsive and quality service has drawn strong voluntary support and involvement.

3.1 SERVICE AREA

DARTS provides paratransit service to all communities in Dakota County. Dakota County, highlighted in Figure 2-1, is the fastest growing county in the seven-county Twin Cities metropolitan area. Between 1980-1990, Dakota County's population increased 40 percent to 275,000. Simultaneously, the total number of persons more than 65 years of age grew at an even faster rate--by 52 percent to 17,500. Dakota County employment has also grown rapidly during the decade, increasing by 67 percent to 103,100. Dakota County projects continued growth over the next twenty years. Total population is projected to be 397,000 and total employment will be 189,532 by the Year 2010.

Dakota County growth and transit needs closely reflect a national trend: radial transit systems, which focus almost exclusively on city cores, continue to serve large metro areas while rapid suburban growth creates significant transit needs in the suburbs that established radial systems do not meet.

As shown in Figure 2-1, the northern portion of Dakota County (including the cities of Lilydale, West St. Paul, South St. Paul, Mendota, Mendota Heights, Eagan, Inver Grove Heights, Burnsville, Apple Valley and Rosemount) falls within the area where United States Department of Transportation Americans with Disabilities Act (ADA) complimentary paratransit provisions apply. In the Twin Cities the ADA applicable area is defined by the Metropolitan Council transit taxing district boundary.

The ADA complimentary paratransit provisions require that paratransit services be available within a 3/4-mile area surrounding each regular fixed bus route. The intent of the provisions is to insure that disabled individuals have the same access to mobility as do non-disabled persons capable of using conventional fixed route transit. The ADA further mandates that subscription trips cannot account for more than 50 percent of the total trips served during any given time of day unless all requested demand trips are also served.
FIGURE 2-1
DARTS SERVICE AREA
Metro Mobility, a paratransit program coordinated by the Metropolitan Council, provides complimentary paratransit service in about 90 percent of the ADA applicable area in the Twin Cities metropolitan region. In the areas not served by Metro Mobility, the Metropolitan Council contracts service from county-based paratransit providers.

Metro Mobility serves only a small portion of the ADA eligible area within Dakota County. Since 1993, the Metropolitan Council has contracted with DARTS to provide ADA service in the remaining portion of the ADA eligible area in the County. In order to simplify coordination between Metro Mobility and DARTS services, and because the Metro Mobility served ADA area within Dakota is quite small, DARTS provides ADA service to the entire ADA eligible portion of Dakota County. Given the complexities associated with the delivery of complimentary paratransit service, coordination with Metro Mobility and the determination of the ADA eligibility of requested trips are significant issues for DARTS.

3.2 SERVICE DESCRIPTION

DARTS provides seven days a week, door-to-door accessible service to people over the age of 60 and to others with disabilities. Regular DARTS service runs from 8:00 a.m. to 4:00 p.m. Monday through Friday. Expanded services, including ADA clients and service organizations, are offered from 6:00 a.m. to 9:00 p.m. seven days a week in all ADA qualified areas of Dakota County. Extended service hours provided for ADA clients mirror fixed route bus schedules within the ADA mandated areas of Dakota County. Clients must call 24 hours in advance to reserve a ride. DARTS has a 25-vehicle fleet of buses equipped with wheelchair lifts. Of DARTS' twenty-five vehicles, four have dedicated service areas; the remaining vehicles are assigned as needed. DARTS employs 13 full time and 30 part time bus drivers.

3.3 SERVICE CHARACTERISTICS

DARTS typically provides paratransit service to three different groups of clientele. Seniors, the majority of which are females in the upper 70's, with limited access to an automobile have been DARTS' traditional client base. Since becoming Dakota County's ADA provider in 1993, physically disabled and developmentally disabled persons comprise a substantial share of DARTS' total ridership. Medical and dental appointments account for the largest percentage of all trips taken.

DARTS ridership consists of standing order (or "subscription") trips and demand (or "casual") trips. Standing order trips, which account for approximately half of DARTS weekday ridership, are those which occur at the same time and on the same day on a reoccurring basis, such as once a week or once a month. A regularly scheduled medical appointment or grocery shopping trip is an example of a standing order trip. DARTS clients are not required to call in and schedule standing order trips on a trip-by-trip basis. Rather, once requested, these trips are assumed to occur and are added to the schedule until notified otherwise by the client.

Demand trips are those which do not reoccur on a regular basis. DARTS clients must make demand trip reservation requests at least 24 hours prior to the day of service and no earlier than two weeks prior to the date of service.

In 1994 651 trip requests were denied due to full schedules. During the first quarter of 1995 29,706 rides were provided, 302 trip requests were denied. These values are considered much lower than the actual desired rides to be taken. Riders simply did not make same day requests because of the 24-hour advance reservation rule. Riders canceled for a variety of reasons including change in plans or delays at medical appointments.
3.4 THE DARTS PRE-IMPLEMENTATION SCHEDULING AND DISPATCH PROCESS

The DARTS scheduling process was relatively complex in that it consisted of a number of different subtasks differentiated by:

- the type of trips being scheduled (standing order vs. demand trips);
- the degree of "finalization" of the schedule under production;
- the time the work was performed relative to the day the schedule was utilized (referred to here as the "service day"); and
- the personnel performing the task.

A schedule for any given DARTS service day was the product of many tasks conducted by many different people spread out over a period of several weeks. Ultimately, if dispatch-related routing changes were considered an aspect of scheduling, the “final” schedule for any given service day was not complete until the end of that service day.

The following explanation describes the steps in the preparation of a DARTS schedule, including the activities of DARTS dispatching personnel. This description is organized chronologically around the following major functions:

- Pre-Scheduling
- Demand Trip Booking and Pre-Scheduling
- Final Scheduling
- Trip Confirmation
- Same Day Trip Requests & Dispatch

The pre-implementation DARTS demand trip scheduling process is illustrated in Figure 3-1 and described below.

Pre-Scheduling

Preparation of a DARTS schedule for any given service day began with the production of a “pre-schedule” approximately one week prior to the service day. This pre-schedule included only standing order trips. Preschedules were produced in batches, usually enough for about one week. As such, this initial scheduling task was performed only once every week or so.
Figure 3-1
Pre-Implementation DARTS Scheduling Process

Pre-Scheduling

Future Trip Booking & Pre-Scheduling

Manually Produce Pre-Schedules

Transit Office Staff Take Trip Request Phone Calls

Manually Fill-Out Trip Request Form

Future Trips

Manually Consult Appropriate Pre-Schedule

No Available Time Slot

Time Slot Available

Investigate Other Trip Time Options

Record Trip on Pre-Schedule

No Available Time Slots

Identify Possible Time Slot

Deny Trip

Final Scheduling (Next Day’s Schedule)

Verify and Input Trips into Database

Sort Trips by Vehicle

Manually Refine Next Day Schedule

Call-Backs

Make Confirmation and Denial Call-Backs

Print Next Day Schedule

Post Next Day Schedule in Dispatch Office

Same-Day Trip Scheduling and Dispatch

Manually Consult Same-Day Schedule & Radio Drivers

Same-Day Trips

Identify Available Time Slot

No Available Time Slot

Record on Same-Day Schedule

Deny Trip

Dispatch Vehicle
Based on the requested origins, destinations and times of the standing order trips, hand-written pre-schedules were produced for each vehicle. Each vehicle included approximately four driver runs per day. Runs were divided into large time blocks, for example, the morning may have included runs starting at 8:00 AM and 10:00 AM. Each run included approximately six client pick-ups. The proportion of the pick-ups for any given run that were filled with standing order trips varied, although overall, DARTS trips averaged approximately 50 percent standing order/50 percent demand. For each run, any remaining slots which were not filled with standing order trips were available for demand trips.

The pre-schedule was usually prepared by a single staff person and required about two hours to prepare a batch of approximately 10 schedules. Preparation of pre-schedules generally occurred in the late afternoon, after the final schedule for the following service day was completed.

**Demand Trip Booking and Pre-Scheduling**

Demand trip booking and scheduling consisted of the incremental revision of the hand-written pre-schedule for any given service day to reflect the addition of client demand trips. Generally, clients were instructed to telephone in their demand trip requests no sooner than one week prior to the desired trip day and no later than 24 hours prior to the desired trip day. Therefore, DARTS scheduling staff worked with pre-schedules for any of approximately six or seven service days, depending on the trip requests received.

All demand trip requests were taken by DARTS over the telephone. Request calls were taken by any and all transit office staff available, including dispatch staff. For each trip request, a hand-written trip request slip was produced. The slip included all the relevant information for the requested trip, including client information (name, phone number, mobility status, etc.), trip origin, destination, and the desired pick-up and arrival times for both the “to” and “from” legs of the requested trip. This step in the scheduling/dispatch process was referred to as “trip booking”.

After recording the trip request, and while the client was still on the phone, the staff member taking the request consulted the appropriate pre-schedule to determine if the trip could be served. Because demand trip requests were taken up to two weeks in advance, and because pre-schedules were prepared for up to one week in advance, any of a number of hand-written pre-schedules were required. Pre-schedules were generally placed upon a centrally located table within the transit office where all trip request takers could access them. When a desired pre-schedule was being used by another request taker, the caller was asked to wait and/or the requested trip time was verbally relayed to the request taker with the needed pre-schedule.

The determination of whether the requested trip could be served represented the first step in the portion of the scheduling/dispatch process formally considered “scheduling”. This determination was made by comparing the client’s desired arrival time at their destination with the time slots available for each vehicle during the appropriate driver run. Which of the four driver runs per vehicle should be consulted was determined based on the desired arrival time. For example, a desired arrival time of 9:30 AM indicated that the trip would have to be served during one of the 8:00 AM runs.

Each run accommodated a limited number of trip pickups. Although this number varied according to trip origins and destinations, DARTS staff had a fairly accurate idea of how many pick-ups could be accommodated per run, especially since the runs themselves were built upon logical geographic patterns of trip origins and destinations. Schedule capacities evolved over time into a pattern that satisfied DARTS.

If the pre-schedule indicated that the desired trip could be accommodated, the request taker wrote in the trip on the pre-schedule. At this point, a precise pick-up time was typically not recorded on the pre-schedule nor given to the request maker. Rather, the trip request on the pre-schedule, written into the appropriate run, noted only the desired trip arrival time.
If the pre-schedule indicated that the trip could not be accommodated the trip request was denied. At this juncture the request maker was given the option of: 1. selecting another day and/or time for the trip; or 2. to be left “unscheduled”. Unscheduled trip requests were held and the trip requester was advised to call back closer to the service day to see if a trip cancellation allowed their trip to be served.

Ironically, the likelihood of a given demand trip request being filled increased the closer to the service day due to trip cancellations. This phenomenon was the result of two factors: trip cancellations and absence of a trip request “waiting list”. Although a given schedule may have been “full” three or four days prior to the service day, trip slots generally became available as the service day approached due to client-requested trip cancellations. DARTS did not maintain a “waiting list”, in part due to the fact that such a practice is not formally allowed under ADA provisions within the ADA service area. As such, canceled time slots were filled only through additional trip requests, whether they were “first time” request or call-backs made by clients previously denied due to a full schedule. This phenomenon, which rewarded those who waited until relatively late to request a call, diminished the effectiveness of the “first-come-first-served” trip reservation philosophy practiced by DARTS.

Because the pre-schedules which were consulted during ride request taking were hand-written and because they did not indicate precise pick-up and drop-off times, demand trip request takers were not able to effectively investigate the potential for “squeezing in” a requested trip through shuffling of pre-scheduled trips.

Demand trip request calls were taken from approximately 7:00 AM until 2:30 PM each day. The staff available to take these calls included two dedicated call takers and back-up call takers consisting of a dispatcher, a data entry employee, a billing employee and a supervisor. Request taking staff were added incrementally as the volume of trip request calls increased. The first dedicated request taker began work at 7:00 AM; additional staff was added at 8:00 AM, 9:00 AM and 10:00 AM.

The products of this stage of the scheduling process were two-fold:

1. Revised hand-written pre-schedules; and
2. Hand-written trip request forms.

The pre-schedules which resulted at the end of any given day of booking varied considerably in terms of their “fullness”. Schedules for the next service day were almost always full.

Scheduling

The next step in the scheduling process, Final Scheduling, consisted of preparing the schedule for the next service day. This step began with verification of trip request forms against pre-schedules. Each trip pickup and drop off should have been reflected on a pre-schedule and they were assigned to an appropriate driver run. Only pre-schedules and forms for the next two or three days were considered. This process usually began in the early afternoon and was performed by the two staff members formerly taking trip requests. This process typically required two to three hours to complete.

Following verification, each trip request form for the next service day was entered into a database, one record for the “to” trip leg and one record for the “from” trip leg. Only trips for the next service day were entered during this step. Trips for future service days were entered into the database in the evening by different staff.
Next day trip verification and data entry essentially served to create a computerized record of the pre-schedule and was necessary in order to facilitate schedule finalization. Once entered, the trip data was sorted by vehicle and was printed. Data entry was generally performed by one staff member and took several hours to complete.

Finally, the Lead Scheduler, traditionally the transit office staff supervisor, examined the sorted, printed pre-schedules. For each vehicle and for each driver run, the Lead Scheduler assigned specific trip pick-up and drop-off times, in effect finalized the schedule. This final step was typically only performed on the schedule for the next service day.

**Trip Confirmation**

Because trip request takers were unable to provide clients exact pick-up times during booking, many follow-up calls were required in order to verify the final schedule. These call were typically made in the evening by different staff than were involved in trip request taking. Trip confirmation was also performed the morning of the day of service. When this was the case, confirmation calls were primarily made by a staff person specifically assigned to this task.

**Same Day Trip Requests & Dispatch**

Same day trip requests, which were not encouraged by DARTS and typically accounted for an extremely small percentage of all trip requests, were dealt with either by the same staff assigned to booking trips (taking demand trip requests) or by the dispatcher. The shift in responsibility for these arrangements to the dispatcher reflected the same day nature of the task. Largely, responsibility for all issues relevant to the current service day defined the responsibilities of the dispatcher in the DARTS operation. If a same day trip request was initially taken by a trip request taker, they may have recorded the information and passed it to the dispatcher, verbally relayed the request to the dispatcher for immediate resolution, or transferred the call to the dispatcher.

As cancellations were received, the dispatcher crossed trip pick-ups off the printed copy of each vehicle’s schedule, which were posted to the wall in the DARTS dispatching office. As same day trip requests were received, these requests were posted to the wall next to the vehicle schedules. As slots made available through cancellations were filled with same day trip requests, the dispatcher radioed the appropriate driver to notify them of the change.

Dispatchers also receive rider inquiries about the status of their trip. These calls were typically relayed to the dispatcher via other transit office staff. Dispatchers communicated with the appropriate driver to ascertain the status of the trip pick-up then relayed this information to the rider. Sometimes these status calls to the rider were made by the dispatcher and sometimes they are made by other transit office staff, depending on the dispatch work load.

**Expected Smart DARTS Phase 2 Scheduling & Dispatch Impacts**

Introduction of computer-aided scheduling and dispatching to the DARTS operation was intended to improve the efficiency of the scheduling process, produce “better” schedules (more optimal routings capable of serving more trips) and improve the ability of DARTS to serve same day trips.

The following specific improvements in scheduling and dispatch were believed possible in Phase 2:

- It was expected that trip request takers, who would have access to computerized versions of the pre-schedules, would be able to dynamically (while the caller was on the phone), investigate the possibility of “squeezing in” the requested trip by shuffling and/or shifting previously scheduled pick-up and drop-off times. With the improved ability to identify available time slots, it was assumed that fewer trips would be denied.
Because the product of the booking phase would already be computerized, it was hoped that much of the trip request form/pre-schedule verification and data entry time could be eliminated.

Because trip booking would include assignment of specific trip pick-up times (as opposed to the generalized driver run start times previously used), much of the time spent converting the approximate trip bookings into final schedules was hoped to be eliminated.

It was believed that the software, through the application of triangulation algorithms, could produce a "better" schedule than could be produced manually and could do so faster than could be done manually. A "better" schedule is one which allows more trips to be served given the same revenue vehicle miles/hours or which allows an equivalent number of trips to be served with fewer revenue vehicle miles/hours.

Using the staff resources made available through other improvements (elimination of data entry, reduced schedule preparation time), it was assumed that more effort could be directed to trip request call taking, allowing more trip requests to be taken, including same day trips, and allowing staff to take the time required to accurately determine clients' needs.

By partially automating the dispatch process, it was assumed that more same day trips could be accommodated. Specifically, it was assumed that given an up-to-the-minute schedule for the day (reflecting driver confirmation of trip pick-ups and on-going up-dating) and the software's capability to identify the vehicle in the best position to accommodate a same day trip addition to the schedule, more same day trips could be served.

The specific measures of effectiveness developed to evaluate the impacts of the computer-aided scheduling and dispatch software, along with the results of that evaluation, are discussed in subsequent sections of this report.
4.0 PHASE 2 IMPLEMENTATION PROCESS

Implementation and evaluation of the DARTS computer-aided scheduling and dispatch software represented the culmination of a multi-year planning and development effort. Table 4.1 presents the project development chronology.

<table>
<thead>
<tr>
<th>TIME</th>
<th>TASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>Smart DARTS Concept Conceived</td>
</tr>
<tr>
<td>May 1992</td>
<td>Mn/DOT, DARTS, and BRW Develop/Refine Smart DARTS Concept</td>
</tr>
<tr>
<td>October 1992</td>
<td>Funding Secured</td>
</tr>
<tr>
<td>November 1992</td>
<td>Feasibility Study Started</td>
</tr>
<tr>
<td>July 1993</td>
<td>Feasibility Study Completed</td>
</tr>
<tr>
<td>March 1994</td>
<td>Phase 2 System Specifications Developed</td>
</tr>
<tr>
<td>May 1994</td>
<td>Phase 2 Software Request for Proposed Released</td>
</tr>
<tr>
<td>August 1994</td>
<td>Vendor Selected</td>
</tr>
<tr>
<td>January 1995</td>
<td>Contract Signed</td>
</tr>
<tr>
<td>February 1995</td>
<td>Phase 2 Implementation Begins</td>
</tr>
<tr>
<td>February 1995</td>
<td>Hardware Installation</td>
</tr>
<tr>
<td>March 1995</td>
<td>Software Installation</td>
</tr>
<tr>
<td>March 1995</td>
<td>DARTS Staff Training</td>
</tr>
<tr>
<td>May 1995</td>
<td>Evaluation Plan Completed</td>
</tr>
<tr>
<td>May 1995</td>
<td>Pre-Implementation Data Collection</td>
</tr>
<tr>
<td>August 1995</td>
<td>Phase 2 System Goes Live</td>
</tr>
<tr>
<td>Nov.-Dec. 1995</td>
<td>Post-Implementation Data Collection</td>
</tr>
<tr>
<td>December 1995</td>
<td>Phase 2 Evaluation</td>
</tr>
</tbody>
</table>

4.1 PROJECT TEAM BUILDING AND FUNDING IDENTIFICATION

The sixth month period from approximately May to October 1992 was an especially critical one for the Smart DARTS project. It was during this time that the Smart DARTS concept was defined in detail, the Project Team was expanded, commitments were obtained from the various team members and federal ITS operational test and Minnesota Guidestar funding was secured.

The contributions of each team member were important. Dakota County’s agreement to provide the GIS mapping required for Quo Vadis represents one of the critical contributions to the project.

4.2 SYSTEM SPECIFICATIONS
Specifications for the Smart DARTS paratransit software were developed based upon the capabilities necessary to deliver desired services. The specifications that were developed focused on Phase 2 capabilities, which were primarily related to the management information system and computer-aided scheduling, but also included functions required to accommodate the capabilities to be delivered in Phase 3, such as automatic vehicle location and computer-aided dispatch.

Paratransit software specifications from a number of other transit agencies were reviewed as part of this effort. Specifications were categorized according to the following desired functions:

- Management Information System
- Scheduling
- Dispatching and Routing
- Report and Billing
- Brokering

Capabilities in some of these areas were not intended for use in Phase 2 but were critical for later Smart DARTS phases.

These specifications were provided to each potential vendor. Each specified function was identified as either “Priority” or “Desired”. Responding vendors were asked to identify each function as either “provided” or “not provided”.

4.3 VENDOR SELECTION

Potential vendor candidates were identified by the Smart DARTS Feasibility Study. Eight software companies responded to the Request for Proposal released in May 1994. Two candidates were interviewed in July 1994. The project team selected Trapeze Software, Incorporated (formerly UMA) of Mississauga, Ontario based on its software package capabilities and its ability to deliver needed support services.

Trapeze Software Inc. (TSI) offered software that satisfied nearly all of the capabilities identified by DARTS as important for both Phase 2 and Phase 3 of the project. The software package offered by TSI included two distinct components: Trapeze and Quo Vadis.

The Quo Vadis software included primarily functions associated with the MIS and computer-aided paratransit scheduling and included functions primarily related to trip brokering. Trapeze provided the capability to display fixed route bus routes on the same GIS map utilized by Quo Vadis for paratransit scheduling. Other capabilities associated with Trapeze are related primarily to technologies to be implemented in Phase 3 and the impacts of Trapeze were not investigated in this report, which focuses only on Phase 2. In the remainder of this report the software implemented in Phase 2 is referred to as “Quo Vadis”.

The selection of TSI was based upon the software’s ability to provide desired functions, the demonstrated speed and flexibility of the software, the mapping and map editing capabilities of the software and the capability of Trapeze to display fixed route bus routes. The cost of the software, especially TSI’s willingness to contribute some desired features at no cost in order to keep the software within budget, was also an important factor in the selection of TSI.

Quo Vadis allowed for optimized paratransit trip scheduling for pre-scheduled trips. The software operates in the following manner:

“Schedule optimization is done by one of four methods. One method utilizes a triangulation algorithm. When using the triangulation method, the computer makes three “passes” through the trip request and map data to select the best or optimum choice of routing. All trips not fitting within the fifteen minute
on-time pickup window are flagged by the computer. Vehicles' locations are estimated by their preestablished schedules. Demand-responsive trips are then inserted into the open “slots” within the optimized schedule for that day. Pickup and drop-off locations may be displayed graphically via GIS maps on a color monitor. These locations are used by the software for the triangulation procedure. Trip insertions are displayed automatically to the dispatcher’s screen. The dispatcher can also monitor other issues, such as trip cancellations, late clients, and vehicle breakdown. All data within the system may be downloaded to spreadsheet and word processing software”.

4.4 DEPLOYMENT

The actual deployment of Quo Vadis was performed over a period of several months. Necessary hardware, including computer workstations, was purchased and installed in the late fall of 1994 and was completed in February 1995. Software installation began in the spring of 1995, beginning with the software required to network the workstations. Installation of the Quo Vadis program software, as well as preliminary staff training occurred in March. Between March and July, DARTS management staff oriented themselves to the software, conducted multiple in-house training sessions with transit office personnel and worked with Mn/DOT, BRW, Inc. and TSI to secure missing pieces of the required software package. DARTS began using Quo Vadis for daily scheduling on July 25, 1995.

The date of final deployment represented a significant slip in the original deployment schedule, which called for deployment in August 1995. The reasons for the slip are detailed in Section 5.0, under “Ease of Deployment”. Potential beneficial byproducts of this delay, including the opportunities it provided DARTS staff in terms of preparation for the change-over, are addressed also addressed in Section 5.0, and in Section 6.0, “Conclusions”.

4.5 THE DARTS POST-IMPLEMENTATION SCHEDULING AND DISPATCH PROCESS

The DARTS scheduling and dispatch process prior to the introduction of computer-aided scheduling and dispatch software was described in detail in Section 3.0. The potential impacts of the new technology were also identified. This section describes the post-implementation scheduling and dispatch process, focusing on how that process has changed since the implementation of computer-aided scheduling software.

Although some tasks are now performed differently, the post-implementation DARTS scheduling and dispatch process still included the following fundamental components:

- Pre-Scheduling
- Demand Trip Booking and Pre-Scheduling
- Final Scheduling
- Trip Confirmation
- Same Day Requests and Dispatch

The post-implementation DARTS demand the scheduling process is illustrated in Figure 4-1 and described below.

Pre-Scheduling

Pre-schedules showing standing order trips only are still prepared in batches, approximately one to two weeks in advance of their service day. Pre-schedules are now compiled using the Quo Vadis software, which can utilize an actual (“matching”) previous day’s schedule to compile a pre-schedule for any given day. An appropriate previous day’s schedule is selected, corresponding to the day of the week, or other parameter
expected to most impact scheduling, of the service day for which the pre-schedule is being prepared. Demand trips may be eliminated, leaving a pre-schedule containing only standing order trips, or selected combinations of demand and standing order trips may be left in with the expectation that these riders may call again.

Whereas previously pre-schedules were primarily prepared only by a single staff person, usually the transit office staff supervisor, labor efficiencies in other scheduling tasks have made staff available in the afternoons to assist in the preparation and refinement of pre-schedules. Although the time required to prepare any given pre-schedule has been reduced, an equivalent amount of time is spent on pre-scheduling. The additional work involves different staff and focuses on generating, and making preliminary demand trip revisions to pre-schedules for farther into the future than was previously the case.

Although a check copy of the pre-schedules can still be printed out, hard copies of the schedules are no longer produced for use during demand trip booking. Instead, the pre-schedules are maintained on the Quo Vadis system and can be accessed by demand trip booking staff via workstations.

**Demand Trip Booking and Pre-Scheduling**

The process to book and pre-schedule demand trips has changed significantly. First, dispatch staff are no longer routinely involved in taking demand trip requests. Rather, they provide backup only when required.

Second, trip requests are no longer recorded longhand on trip request forms. Instead, all pertinent trip information is entered into the Quo Vadis system during the trip request call. In cases where the client is a first-time rider, additional information is required. This information is also collected during the trip request call. Previously, this information was not required during the initial trip request but was collected either via a return call or during the first ride. As a result, bookings for first time ride requests can take longer than previously.

Whereas booking staff previously consulted a hard copy of the appropriate pre-schedule to determine whether a requested trip could be provided, this is now done with Quo Vadis. Previous determinations as to whether a trip request could be served relied upon a considerable degree of judgement by the trip request taker and provided little opportunity to investigate the possibility of “squeezing” the requested trip into a given schedule through shifting of pre-schedule pick-up times. Using the scheduling software, request takers are now able to quickly identify the viability and impacts to the pre-schedule of various alternative trip times.

In an acceptable time slot is located by Quo Vadis, the requested trip is added to the pre-schedule. If an acceptable time slot is not located, the trip is either denied, or what is much more often the case, the trip is booked, i.e., entered into the system, but not officially added to the pre-schedule. All trip requests which are not for the same or next service day, i.e., trip requests between 2 and 14 days in advance, are booked but not scheduled, the same as was done previously.

The majority of the demand trip booking and pre-schedule still occurs from approximately 6:00 AM until 2:30 PM but requests are accepted until 5:00 PM in accordance with ADA rules. The same number of staff members are responsible for demand trip booking and pre-scheduling as was previously the case, with the exception of the previously mentioned use of dispatch staff only during peak times.
Figure 4-1
Post-Implementation DARTS Scheduling Process
Scheduling

Like demand trip booking and pre-scheduling, the scheduling task has changed considerably since the implementation of the Quo Vadis system, although the same fundamental activities occur. The scheduling of next day trips still begins at approximately 2:30 PM and is performed primarily by the Lead Scheduler, usually the transit office staff supervisor.

One of the most important changes is that some same day and next day demand trip requests are actually scheduled during the trip request call. Although, as will be pursued in Section 6.0 of this report, the proportion of all demand trip requests that are being booked is still relatively low because of the pre-established policy that discouraged riders from requesting same day trips. Additionally, DARTS did not advertise the software’s ability to serve same day trips.

Two steps previously performed manually and which demanded approximately two to three hours effort on the part of two staff members—verification of trip request forms against hand-written, completed pre-schedules and data entry of request form information into a database for sorting—are no longer performed. Instead, the Lead Scheduler is able to immediately begin finalizing the schedule for the next service day, beginning with the revised pre-schedule.

Schedule finalization consists of scheduling all next day trips that were booked but not scheduled by trip request taking staff. This process also entails significant review, adjustment and refinement of the Quo Vadis assigned trip times. This process still requires the Lead Supervisor’s attention for most of the rest of the afternoon.

It is not entirely clear why the schedule finalization process, which was expected to require less effort using the scheduling software, still requires significant manual effort on the part of scheduling staff. Potential explanations include the possibility that, despite expectations to the contrary, relatively few trips are being scheduled during the initial trip request call. It is possible that most trips, as they were prior to Quo Vadis, are still merely booked during the initial call request and must be scheduled (by a staff member) at a later time.

By eliminating the need for verification of trip request forms against the revised pre-schedules and for manually inputting the trip request forms into a database, implementation of the scheduling software has made two transit office staff members available to perform other scheduling/dispatch duties in the afternoon. The two people previously involved in verification and data entry are now available to assist the Lead Scheduler in finalizing the next day’s schedule, generating future pre-schedules, revising future day’s pre-schedules (which have been impacted by trip requests booked during the morning) or assisting in other transit office activities. Elimination of the verification and data entry steps have, in this sense, allowed DARTS to work farther ahead on upcoming pre-schedules than before.

Trip Confirmation

Trip confirmation calls are still required for all booked but unscheduled trip requests. These calls are also necessary when adjustments to the schedule made during finalization have changed previously scheduled trip times. These latter changes, defined as changes in excess of 15 minutes, are flagged automatically by the scheduling software. Under any of these circumstances, DARTS must inform the client of the actual (in some cases, revised) trip time.

Same Day Trip Requests and Dispatch

With a couple of minor exceptions, the DARTS procedures for dealing with same day trip requests and
dispatch functions have not changed with the advent of Quo Vadis. As was previously described, prior to implementation of computer-aided scheduling, the dispatcher was often involved in taking trip requests calls. Under the new approach, the dispatcher is used only when absolutely necessary.

Same day trip requests, like all trip requests, are now entered into Quo Vadis instead of being hand-written. Otherwise, same day trip requests and other day-of-service schedule changes are handled as before: calls are answered by scheduling staff and relayed, either verbally, on paper, or transferred, to the dispatch staff for resolution.

Since implementation DARTS has not changed their requirement for a minimum of 24-hours advance notice for trip reservations. As a result the number of same day trip requests has not increased. As before, same day trip requests represent an extremely small fraction of all DARTS trip requests.

**Summary of Scheduling/Dispatch Process Impacts**

Utilization of the Quo Vadis has resulted in the following major changes to the DARTS scheduling and dispatch process:

- Pre-Schedules are generated “automatically” by Quo Vadis and are primarily based upon actual previous schedules.
- Staff formerly involved in verification and data entry are now available to assist with other activities, including generation of pre-schedules for future service days and revising future pre-schedules to reflect demand trip bookings.
- Dispatchers are seldom required to support trip request taking.
- Trip requests are no longer written in longhand; they are entered directly into the Quo Vadis schedule.
- Trip requests forms no longer must be verified against revised pre-schedules. This results in significant error reduction.
- Trip request takers are now able to investigate the impacts of various trip times with clients while they wait and in some cases can provide the client with a confirmed and precise pick-up time.
- Request takers no longer must share hard copies of pre-schedules. Pre-schedules can be accessed on-line simultaneously by all trip request takers and the pre-schedules are updated dynamically.
- Registration information from first-time riders is now taken during the initial trip request call. This can make these calls take more time, however, this time allows DARTS to collect more complete and accurate information on each rider.
- Some demand trip requests are fully scheduled during the initial trip request call and the client is given a confirmed, specific pick-up time.
- Trip requests forms no longer must be input to a database for use in pre-scheduling. This information is already in Quo Vadis as a result of trip booking/scheduling.
5.0 EVALUATION: METHODOLOGY AND RESULTS

As noted in Section 2.0 of this report, this evaluation did not constitute a “pass/fail” assessment of the DARTS experience with computer-aided scheduling and dispatch software. Instead, it was intended to identify under what circumstances advanced technologies may benefit paratransit systems and what the magnitude of these benefits may be given the conditions and practices of a specific paratransit provider—in this case DARTS.

The technologies under evaluation in this project were presumed to hold significant potential. This was evident given the results of the Feasibility Study. This evaluation focuses on identifying the conditions necessary to capitalize on this benefit.

Given this approach, the lack of observed changes in any given measure of effectiveness should not be interpreted as a “failure” on the part of the technology or the implementing transit agency. Rather, this information merely indicates under what conditions certain benefits do and do not occur. These are the findings most valuable to Mn/DOT in determining the potential transferability of advanced paratransit technologies and these are the type of conclusions sought in this evaluation.

This section includes three components:

1. Identification and description of the Smart DARTS project measures of effectiveness (MOEs) that were used to evaluate Phase 2 implementation (and which will be used to evaluate Phase 3).

2. The general methodology and data collection process.

3. The results of the evaluation of each MOE.

Implications of the results are considered in detail in Section 6.0, “Conclusions”.

5.1 MEASURES OF EFFECTIVENESS

Specific measures of effectiveness were identified for each of the Smart DARTS objectives described in Section 2.0 of this report. The MOEs represent indicators of the accomplishment of each objective, i.e. for each objective, the question was asked “how would a more (responsive, cost-effective, etc.) DARTS system perform-- what are the measurable characteristics of an improved DARTS?”. For example, in the case of the objective to “Improve Responsiveness”, MOEs were identified which were assumed to be characteristic of a more responsive system, such as improved on-time performance.

Like the Smart DARTS project objectives, the MOEs that were developed were intended to apply to the entire Smart DARTS concept and for application in the evaluation of each Smart DARTS phase. The ability of the technologies in the individual project phases to effect different MOEs varies. For example, the potential for Phase 2, computer-aided scheduling and dispatch software to effect some MOEs is greater than its potential to affect others. It is important to consider this fact when interpreting the results of the analysis of any given
It was believed important to apply each MOE in each Smart DARTS phase despite the fact that a given technology may hold relatively little potential to influence some MOEs. First, despite the reported experience of other agencies and the seemingly inherent potential of the specific technologies, the specific linkages between specific technologies and specific benefits was not always identified. By collecting information for all MOEs, even those which would appear relatively insensitive to a given technology, our understanding of these linkages can be improved. Second, collecting the same data during all evaluations provides the most complete data set possible and makes possible future longitudinal comparisons of the timing of benefit accrual.

Table 5.1 presents Smart DARTS measures of effectiveness. Each of these measures was considered in this evaluation. Table 5.1 does not include several measures which were not included in the evaluation of Phase 2 but are expected to be included in subsequent evaluations. These measures are:

- Reduce billing errors
- Increase the number of unduplicated riders served
- Increase the percentage of transfer trips
- Decrease the percentage of unused trip slots from rider cancellations.

These measures were dropped either because required data was not available or because computer-aided scheduling and dispatch so clearly did not impact these areas that collection and analysis of this data would be an inappropriate use of resources. Computer-aided scheduling and dispatch in isolation holds little potential to reduce billing errors. This capability is achieved primarily through smart card fare collection, a component which was eliminated from the Smart DARTS concept.

The data necessary to accurately assess the number of unduplicated riders served and the percentage of unused trip slots from rider cancellations was not available. Without automatic vehicle location technology (Phase 3), Trapeze does not significantly improve transfer capabilities and therefore was not included in this evaluation. Because this last MOE was the only MOE identified for the “Improve Coordination with Other Transportation Providers” objective, it’s elimination effectively eliminated this objective from consideration in this phase.

Note that some of the MOEs measure the primary, direct potential impacts of computer-aided scheduling and dispatch and that others measure secondary, indirect impacts. Examples of primary impacts include MOE 4.3, Reduce the scheduling/dispatch labor hours per trip. Examples of secondary impacts include MOE 4.5, Reduce the average total cost per trip. As will be discussed in detail in Section 6.0, Quo Vadis capabilities in and of themselves are not sufficient to impact indirect MOEs, such as those dealing with the impacts of increased ridership.
For these measures, actions must occur which convert the efficiency improvements made possible by Quo Vadis into realized ridership and cost-effectiveness related benefits.

Specific expectations for improvement associated with each MOE are discussed in Section 5.3 in the presentation of analysis results.

### TABLE 5.1
Smart DARTS Evaluation
Phase 2 Measures of Effectiveness

<table>
<thead>
<tr>
<th>Smart DARTS Objective</th>
<th>Measure of Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Improve Responsiveness</strong></td>
<td>1.1. Increase the percentage of all pickups made within 15 minutes of riders' desired pickup time (DARTS on-time window is 15 minutes early to actual requested pickup time).</td>
</tr>
<tr>
<td></td>
<td>1.2 Increase the percentage of same-day trip requests that are satisfied.</td>
</tr>
<tr>
<td><strong>2.0 Enhance Customer-Focused Service</strong></td>
<td>2.1 Reduce the length of time required to make a trip reservation.</td>
</tr>
<tr>
<td></td>
<td>2.2 Reduce the number of trip request denials.</td>
</tr>
<tr>
<td></td>
<td>2.3 Improve rider perceptions of service.</td>
</tr>
<tr>
<td></td>
<td>2.4 Reduce average trip duration (minutes).</td>
</tr>
<tr>
<td><strong>3.0 Increase System Capacity</strong></td>
<td>3.1 Increase the percentage of demand trips served.</td>
</tr>
<tr>
<td><strong>4.0 Increase Cost Effectiveness</strong></td>
<td>4.1 Increase the average number of passengers per revenue mile.</td>
</tr>
<tr>
<td></td>
<td>4.2 Increase the average number of passengers per revenue hour.</td>
</tr>
<tr>
<td></td>
<td>4.3 Reduce the scheduling/ dispatch labor hours per trip.</td>
</tr>
<tr>
<td></td>
<td>4.4 Reduce the average total cost per trip.</td>
</tr>
<tr>
<td></td>
<td>4.5 Reduce the average subsidy per trip.</td>
</tr>
<tr>
<td><strong>5.0 Enhance DARTS’ Ability to Meet ADA Requirements</strong></td>
<td>5.1 Increase peak period demand trip availability.</td>
</tr>
</tbody>
</table>

Source: BRW, Inc., February 8, 1996.
5.2 GENERAL METHODOLOGY

This evaluation utilized a basic “before and after” approach. Data was collected both before and after implementation of Quo Vadis and conclusions drawn based on the differences between the two data sets. As suggested by the MOEs in Table 5.1, both qualitative and quantitative data was collected.

In some cases pre-implementation data consisted of information routinely collected and maintained by DARTS. In these cases, the impact of seasonal variation and longer term trends were identified and could be considered when conclusions were drawn. In cases where the pre-implementation data was not normally maintained by DARTS, special data collection measures were employed. In these cases, care was taken to help insure that seasonal and other types of variation unrelated to any impacts of Quo Vadis were minimized or eliminated.

Pre-implementation data collection began in May 1995, when non-routine pre-implementation data was collected, and continued through the end of 1995 as routinely maintained DARTS data was assembled. Post-implementation data collection began in November 1995, representing approximately four months of DARTS experience with the new software (utilization of the new software began in late July 1995). As discussed in greater detail in Section 6.0, this relatively limited time frame may have significantly impacted the measurable impacts of the software.

The Feasibility Study indicated that up to 12 months was required before some agencies observed the benefits of advanced paratransit software. The rather brief four month window was utilized in this evaluation in an effort to speed the implementation of Phase 3, automatic vehicle location.

It should be noted that Quo Vadis, through its management information system and reporting capabilities, significantly improved the ability to collect post-implementation data. In some cases, the data maintained through Quo Vadis was more detailed and/or more accurate than that maintained using DARTS previous methods.

5.3 EVALUATION RESULTS

Total Ridership

Although not evaluated independently, total DARTS ridership was directly related to several MOEs and is important to consider before turning to the specific MOEs. For many MOEs, especially those which were characterized in Section 5.2 as “secondary” or “indirect” measures, in the absence of a reduction in DARTS staff hours or service hours, ridership increases represented the only source of change.
TABLE 5.2
Pre- and Post-Implementation Total DARTS Ridership

<table>
<thead>
<tr>
<th>Month</th>
<th>Pre-Implementation</th>
<th>Post-Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1993</td>
<td>1994</td>
</tr>
<tr>
<td>August</td>
<td>9,485</td>
<td>10,444</td>
</tr>
<tr>
<td>September</td>
<td>9,469</td>
<td>9,855</td>
</tr>
<tr>
<td>October</td>
<td>9,969</td>
<td>9,694</td>
</tr>
<tr>
<td>November</td>
<td>9,491</td>
<td>9,627</td>
</tr>
<tr>
<td>Total</td>
<td>38,414</td>
<td>39,620</td>
</tr>
</tbody>
</table>


Based on the limited data in Table 5.2 it appears that total ridership over the period August-November did not change significantly in 1995 following Quo Vadis implementation. The apparent trend in ridership increases demonstrated in 1993-1994 (3.1%) appears to have continued at approximately the same rate in 1994-1995 (3.7%).

However if only the data from October and November is considered, it appears that ridership may be increasing at a rate faster than observed for 1993-1994. When only October and November ridership numbers are used, the increase since Quo Vadis (8.1%) is seen to be significantly larger than occurred over 1993-1994 (0.7%).

Clearly, additional data is required to draw valid conclusions. However, this data suggests that when the entire four month post-implementation period is considered, ridership has not increased beyond what would have been expected given the annual trend.

Assuming that it may be unreasonable to expect to see increases within the first two months of deployment, and if only October and November data is considered, the data supports the notion that ridership has increased beyond the expected rate since implementation of Quo Vadis. In asserting this latter hypothesis, the potential impact of a general transit strike among fixed route operators that occurred in the month of October must be considered. It is possible this strike is responsible for the observed increases in October and November 1995. Close examination of DARTS trip records for these months and comparisons to prior years could help explain the influence of the strike.

The results of the analysis of specific Phase 2 MOEs is presented in Sections 5.3.1 through 5.3.5, organized by Smart DARTS objective.
5.3.1 IMPROVE RESPONSIVENESS

MOE 1.1 Increase the percentage of all pickups made within 15 minutes of riders’ desired pickup time

Computer-aided scheduling and dispatch software was believed to have the potential to improve on-time pickup performance through the generation of more “achievable” schedules. It was assumed that the scheduling algorithms employed by the software could produce schedules which more accurately reflected the time required to serve specific trips and that as a result, the schedules produced with the software would include more realistic (achievable) scheduled pickup times.

On-time pickups were defined as pickups made within 15 minutes of the scheduled (riders’ desired) pickup time.

Methodology

DARTS drivers recorded pickup times in daily logs both before and after implementation. Table 5.3 illustrates pre-implementation and post-implementation percentage of on-time, early, and late pickups. Table 5.4 breaks the arrival times into smaller increments to display how closely drivers adhered to desired pickup times.

Results

The percentage of on-time pickups did not change with implementation of the computer-aided paratransit software. Before implementation the percentage of on-time pickups was high; it remained high after implementation. Table 5.4 indicates that drivers arrived exactly on-time slightly more often after implementation of the computer-aided paratransit software. Within the on-time range of 15 minutes early or 15 minutes late, drivers tended to arrive on the late spectrum of the range slightly more often after implementation. Arrival times outside of the on-time range remained virtually the same.

Conclusions

On-time pickups were not directly affected by Quo Vadis. On-time pickup performance was good before implementation of the software and remained so after implementation. Given the good pre-implementation on-time performance, there was little room for improvement.
### TABLE 5.3
PERCENTAGE OF EARLY, ON-TIME AND LATE TRIP PICKUPS
(ON-TIME = +/- 15 MIN. OF SCHEDULE)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Early</th>
<th>On-Time</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Implementation</td>
<td>7%</td>
<td>86%</td>
<td>7%</td>
</tr>
<tr>
<td>Post-Implementation</td>
<td>8%</td>
<td>85%</td>
<td>7%</td>
</tr>
<tr>
<td>Change</td>
<td>+1</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

**MOE 1.2 Increase the percentage of same-day trip requests that are satisfied**

By partially automating the DARTS scheduling and dispatch processes, it was assumed that Quo Vadis could allow more same day trips to be served. Specifically, it was assumed that given an up-to-the-minute schedule for the day in question (reflecting driver confirmation of each trip pickup and dropoff) and the software's capability to identify the vehicle to best serve the requested trip, more same day trips could be served. Additionally, it was assumed possible for transit office staff to spend more time taking same day trip requests due to the labor savings made possible through other software capabilities, such as reduced data entry time. With more time to take these calls more same day trips could be accommodated.

**Methodology**

DARTS operators kept phone logs before and after implementation to measure the type and number of calls received from clients. Pre-implementation same-day trip requests were recorded during the entire month of May. Post implementation requests were recorded from August to November and averaged for the four month period.